"राष्ट्रिय फल सुन्तला"

नेपाल सरकार

कृषि तथा पशुपन्छी विकास मन्त्रालय

विषयः "सुन्तला" लाई नेपालको राष्ट्रिय फलको रूपमा मान्यता दिने।

प्रस्ताव पेश गर्न विभागीय मन्त्रीबाट स्वीकृति प्राप्त मितिः २०८०/१२/९

१. विषयको संक्षिप्त व्यहोराः

विश्वका अधिकांश मुलुकहरूले आफ्नो राष्ट्रिय पहिचान दिने मौलिक फललाई राष्ट्रिय फलको रूपमा मान्यता दिई अन्तर्राष्ट्रिय रूपमा पहिचान दिँदै आएका छन्। यस विषयमा नेपालले हालसम्म कुनै पनि फललाई राष्ट्रिय फल नतोकेको हुँदा नेपालको मौलिक फलको रूपमा परम्परागत तथा सांस्कृतिक महत्व बोकेको, देशको अधिकांश भू-भागमा खेती गर्न सकिने, राष्ट्रिय तथा अन्तर्राष्ट्रिय बजारमा समेत उच्च माग भएको, यस फलसँग सम्बन्धित सरोकारवालाहरू बीच छलफल हुँदा आर्थिक, सामाजिक, रोजगारी लगायतका दृष्टिकोणबाट अन्य फलको तुलनामा अग्र स्थानमा रहेको सुन्तलालाई राष्ट्रिय फलको रूपमा मान्यता दिएमा अन्तर्राष्ट्रियस्तरमा समेत नेपालको सुन्तला फलको आनुवांशिक श्रोतको आधिकारिकताको प्रमाण जुटाई भौगोलिक पहिचान गरी निर्यात प्रवर्द्धन हुने र सुन्तलाको विकासको लागि थप अध्ययन, अनुसन्धान र संरक्षण कार्यमा टेवा पुग्ने हुँदा सुन्ततालाई नेपालको राष्ट्रिय फलको रूपमा मान्यता दिन यस मन्त्रालयबाट मन्त्रिपरिषदमा यो प्रस्ताव पेश गरिएको छ।

२. प्राप्त परामर्श तथा अन्य प्रासंगिक कुराः

कृषि जैविक विविधता नीति, २०६३ को प्रकरण ५.१.३.४ मा कृषि जैविक विविधता संरक्षण र संवर्द्धनमा योगदान पुग्ने पर्यावरण मैत्री कृषि उत्पादन र उद्योग/व्यवसायहरूलाई प्रोत्साहित गरिने उल्लेख छ। सोहि नीतिको प्रकरण ६.५ मा व्यवस्था भएको कृषि जैविक विविधता सल्लाहाकार प्राविधिक उपसमितिले नेपालमा उत्पादन हुने कुनै एक फललाई राष्ट्रिय फलको रूपमा घोषणा गर्न उपयुक्त फलफूलहरूको विस्तृत तथ्य सहितको प्रस्तावना तयार गर्न अनुरोध गरेको र संघ, प्रदेश, स्थानीय तह (समन्वय तथा अन्तरसम्बन्ध) ऐन, २०७७ को दफा २२ को व्यवस्था अनुसारको विषयगत समितिको मिति २०८०/०९/२४ मा माननीय कृषि मन्त्रीज्यूको अध्यक्षतामा बसेको आठौं बैठकमा समेत सुन्तला फललाई राष्ट्रिय फल घोषणाका लागि संघीय कृषि तथा पशुपन्छी विकास मन्त्रालयले प्रादेशिक कृषि मन्त्रालयहरू र अन्य सम्बन्धित निकायहरूसँग समन्वय गरी आवश्यक कार्य प्रक्रिया अगाडि बढाउने निर्णय भएको छ। यसरी विभिन्न सरोकारवालाहरूसँग समन्वय र छलफल गर्दा नेपालमा उत्पादन हुने प्रमुख फलहरू मध्ये सुन्तलालाई राष्ट्रिय फल तोक्न उपयुक्त हुने रायहरू प्राप्त भएको छ।

३. प्रस्ताव पेश गर्नु पर्नाका कारण र मन्त्रालयको सिफारिसः

नेपाली पहिचान स्थापित भएको, उत्पादन तथा उपभोगको दृष्टिले प्रमुख स्थान ओगटेको र उत्पादन वृद्धि, व्यवसायीकरण र औद्योगिकीकरणको माध्यमबाट राष्ट्रिय अर्थतन्त्रमा समेत ठूलो टेवा पुर्‍याउन सक्ने सुन्तलालाई राष्ट्रिय फलको रूपमा मान्यता प्रदान गर्दा राष्ट्रिय एवं अन्तर्राष्ट्रिय रूपमा नेपाली फलको रूपमा पहिचान दिन सकिने, संघ प्रदेश र स्थानीय तहबाट संचालन हुने कार्यक्रमहरूमा समेत प्राथमिकता पाउने तथा अन्य विषयगत मन्त्रालयहरूसँग समन्वय गर्न आवश्यक भएको हुँदा सुन्तलालाई राष्ट्रिय फलको रूपमा पहिचान दिन नेपाल सरकार मन्त्रिपरिषदबाट निर्णय हुनुपर्ने भएकोले सुन्तलालाई राष्ट्रिय फलको रूपमा मन्यता दिन यस मन्त्रालयका विभागीय मन्त्रीबाट सदर भई सिफारिस गरिएको छ। सुन्तला फललाई राष्ट्रिय फल घोषणा गर्ने सम्बन्धमा नेपाल सरकारबाट नीतिगत निर्णयका लागि नेपाल सरकार मन्त्रिपरिषद्समक्ष प्रस्ताव पेश गर्न विभागीय मन्त्रीबाट मिति २०८०/१२/९ मा स्वीकृति प्राप्त भएकोले नेपाल सरकार (कार्य सम्पादन) नियमावली, २०६४ को अनुसूची १ को विषय संख्या ४१ बमोजिम यो प्रस्ताव पेश गरिएको छ।

४. निर्णय हुनु पर्ने व्यहोराः

"सुन्तला" लाई नेपालको राष्ट्रिय फलको रूपमा मान्यता दिने।

मितिः- २०८०/१२/१२
नेपाल संवत्‌ः- ११४४

(डा.गोविन्द प्रसाद शर्मा)
सचिव

श्री सचिव,

कृषि तथा पशुपन्छी विकास मन्त्रालय।

सुन्तलालाई नेपालको राष्ट्रिय फलको रुपमा मान्यता दिने विषयको कृषि तथा पशुपन्छी विकास मन्त्रालयको दर्ता नं. ६/४६-०८०/१२/२९ को प्रस्ताव म.प.बै.सं. ६३/०८० मितिः २०८०/१२/३० को मन्त्रिपरिषद्को बैठकमा पेश हुँदा त्यमा नेपाल सरकार मन्त्रिपरिषद्ले देहायबमोजिम निर्णय गरेकाले सो बमोजिम कार्यान्वयन हुन नेपाल सरकार (कार्यसम्पादन) नियमावली, २०६४ को नियम २९ बमोजिम अनुरोध गरेको छु -

<u>नेपाल सरकारको निर्णय-</u>

"प्रस्तावमा लेखिएबमोजिम गर्ने।"

(बैकुण्ठ अर्याल)
मुख्यसचिव
२०८०/१२/३०
नेपाल संवत् ११४४

नेपाली सुन्तलाको इतिहास, विज्ञान र प्रविधि

Mandarin Orange: History, Science and Technology in Nepal

(A Historical, Socio-cultural and Technical Compendium)

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2024 June | २०८१ आषाढ

NHS, Khumaltar, Lalitpur, Nepal; https://horticulturenepal.org/

Since its establishment year of 1990 AD Nepal Horticulture Society (NHS) has been working with objectives as specified to enhance public awareness towards the importance of horticulture, to support government/non-government organizations in planning and implementing horticulture development programs, to encourage horticulturists and recognize their contributions in developing horticulture sector in the country, to develop a strong work ethics in horticulture, to promote horticulture as an integral part of environmental conservation activity, to develop linkages with related national and international institutions /organizations/societies, and to create conducive environment for horticulture development in Nepal. There are altogether 285 members working in different government and non-government organizations as well as private sectors by developing their own farm or agribusiness all over the country and supporting the NHS work from their own working station. The society is involved mainly in the dissemination of technology through its various publications i.e. Nepalese Horticulture (Journal), Proceedings, books etc., organization of seminar/workshop/conference/talk programs on horticulture, arrangements of awards to the best fruit grower, best vegetable grower and scholarships for excellence in horticulture education (MSc. Ag) to encourage and recognize horticulturists.

NCFD, DoA, Kirtipur, Kathmandu, Nepal; https://ncfd.gov.np/

National Centre for Fruit Development (NCFD) was established in the Nepalese calendar year 2075 B.S. following the restructuring of Department of Agriculture (DoA). The centre is a federal focal unit working under DoA and is responsible for the federal affairs including federal policy and regulation related to horticulture sector especially fruit sub-sector. NCFD has been implementing a countrywide program for the promotion of fruits, coffee, tea, flowers and other horticultural crops by providing technical services, data updating, saplings distribution, supervision, monitoring, coordination and guidance for the fruit development program at the National, Provincial and Local Levels.

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नेपाली सुन्तलाः इतिहास, विज्ञान र प्रविधि। नेपाल हर्टिकल्चर सोसाईटी र राष्ट्रिय फलफूल विकास केन्द्र; काठमाण्डौ, नेपाल।

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Cover Photo: Mandarin orange tree (सुन्तलाको बोट)

Kathmandu, Nepal

Prime Minister

Message

Nepalese agriculture has long been a major source of livelihoods and employment. The agricultural sector has significantly contributed to the national economy. Realizing its importance, the Government of Nepal has given its utmost priority to this sector in its policy provisions and has recognized it as a major pillar of economic development in all the periodic plans as well as the current sixteenth national plan.

Citrus fruits-specifically lime, lemon, mandarin orange, and sweet orange-are among the key and the most commonly cultivated agricultural commodities in Nepal. Citrus farming stretches from the eastern to the western regions and terai to mid-hills of Nepal. Most Nepalese are familiar with citrus cultivation, their varieties, taste, and importance, which is also deeply integrated to our rituals and culture.

Nepalese mandarin is quite popular due to its unique blend of sugar and acid. I believe mandarin orange is one of the widely consumed fruits in Nepal supported by our own domestic production, specifically in the hilly areas with their specific qualities. There exists a great potential to produce and export unique quality Nepalese mandarin to neighbouring countries. Realizing the importance and scope, the Government of Nepal has declared the mandarin orange a national fruit in my own prime ministership on 12 April, 2024. The Government of Nepal is committed to taking the necessary efforts and initiatives for the promotion of this crop to the next level.

I would like to congratulate the officials, experts, and scientists for their initiatives to publish such a valuable and comprehensive book. Appreciation goes to the National Centre for Fruit Development and Nepal Horticulture Society for their efforts to incorporate all aspects of mandarin orange in a single book. I regard this book as a national document that could be used by development planners to formulate appropriate plans and programs for the promotion of citrus in Nepal. I hope this compendium will be equally useful to growers, researchers, students, and agriculturists who work in citrus.

Finally, I wish all the success for the publication of this compendium.

Pushpa Kamal Dahal 'Prachanda'

Asar 2081 B.S.
Nepal Samwat 1144, Tachhala ga

नेपाल सरकार

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शुभकामना सन्देश

नेपालमा सुन्तला आर्थिक, सामाजिक, रोजगारी, लगाएतका दृष्टीकोणबाट अन्य फलको तुलनामा अग्र स्थानमा रहेको छ। सुन्तला नेपालको मध्यपहाडी क्षेत्रको एक प्रमुख फलफूल हो। कृषि क्षेत्रको कुल ग्राहस्थ उत्पादनमा सुन्तलाको करिव १ प्रतिशत योगदान रहेको सन्दर्भमा यसको विशिष्ट महत्व छ। गुणरस्तरीय नेपाली सुन्तला उत्पादन गरी विश्व बजारमा विशेष पहिचान बनाउन सकिने बलियो सम्भावना रहेको छ।

नेपाल र चीन सरकारबीच नेपालको सुन्तला चीन निर्यात गर्ने सम्झौता समेत भएको परिवेशले गर्दा देशलाई सुन्तलामा आत्मनिर्भर बनाउँदै आयात प्रतिस्थापन र निर्यात प्रवर्द्धन गर्न सकिने फलफूल बालीका रुपमा विकास गर्न आवश्यक देखिन्छ। यसै सन्दर्भमा राष्ट्रिय फलफूल विकास केन्द्रको अगुवाईमा सुन्तला बालीको ईतिहास, संस्कृति, परम्परा र विभिन्न वैज्ञानिक आयामहरुको अध्ययन विश्लेषणबाट सुन्तलालाई राष्ट्रिय फल घोषणा गरिएको छ।

राष्ट्रिय फलफूल विकास केन्द्र, कीर्तिपुर र नेपाल हर्टिकल्चर सोसाईटी खुमलटार, ललितपुरको संयुक्त आयोजनामा १४ औं राष्ट्रिय बागवानी सम्मेलन, २०८१" "Unveiling Nepal's mandarin orange wealth: From origin to prosperity" अर्थात "नेपाली सुन्तलाः उत्पत्तिदेखि समृद्धिसम्मको अनावरण" भन्ने भावका साथ सम्पन्न भएकोमा अत्यन्त खुशी लागेको छ। सो सम्मेलनमा प्रस्तुत गरिएका अध्ययन अनुसन्धान तथा तथ्यहरु समेटी सुन्तला फलफूल विशेष कम्पेन्डियम प्रकाशन हुन गईरहेको सन्दर्भमा म राष्ट्रिय फलफूल विकास केन्द्रलाई विशेष धन्यवाद दिन चाहान्छु। त्यसैगरी उक्त कम्पेन्डियममा योगदान गर्नुहुने सम्पूर्णप्रति आभार प्रकट गर्न चाहान्छु। यस कम्पेन्डियमले आगामी दिनमा सुन्तलालाई अन्तराष्ट्रियस्तरमा पहिचान दिलाई आनुवांर्शिक श्रोतका लागि आधिकारीक प्रमाण जुटाउन सहयोग पुग्ने तथ्य तथा तथ्याङ्क समेट्ने विश्वास लिएको छु। आउँदा दिनहरुमा सुन्तला बालीको अध्ययन, अनुसन्धान, संरक्षण र विकासका कार्यहरुलाई एकिकृत रुपमा अगाडी बढाउन पनि यो कम्पेन्डियम सहयोगी हुने अपेक्षा गरेको छु।

मा.ज्वाला कुमारी साह
मन्त्री
कृषि तथा पशुपन्छी विकास मन्त्री

नेपाल प्रज्ञा-प्रतिष्ठान

कमलादी, काठमाडौं, नेपाल
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मन्तव्य

नेपाल एक कृषिप्रधान देश हो । फलफूल खेतीको पनि यहाँ उच्च सम्भावना रहेको छ । तथापि फलफूल खेतीको विकास अपेक्षाकृत रूपले हुन नसक्दा नेपालमा अझै पनि विदेशबाट फलफूल आयात गर्नुपर्ने अवस्था छ ।

सुन्तला नेपालमा परापूर्व कालदेखि गरिँदै आएको फलफूल खेती हो । उचित हावापानी र माटोका कारण नेपालमा यसको राम्रो उत्पादन हुने गर्दछ । पछिल्लो समय सुन्तलालाई राष्ट्रिय फलको मान्यता पनि दिइएको छ । यसको समुचित विकास गर्न सकेमा नेपाललाई सुन्तला खेतीमा आत्मनिर्भर बनाउन सक्ने देखिन्छ ।

यस क्रममा राष्ट्रिय फलफूल विकास केन्द्र र नेपाल हर्टिकल्चर सोसाइटीको संयुक्त आयोजनामा भएको १४ औँ राष्ट्रिय बागवानी सम्मेलन, २०८१ मा प्रस्तुत गरिएका अध्ययन अनुसन्धान तथा तथ्यहरूका आधारमा राष्ट्रिय फलफूल विकास केन्द्रले सुन्तलाको इतिहास, विज्ञान र प्रविधि समेटेर बृहत् पुस्तक प्रकाशन गर्न लागेको थाहा पाउँदा मलाई खुसी लागेको छ ।

सुन्तला खेतीका बारेमा यसअघि पनि लिखित दस्तावेजहरू तयार भए तापनि इतिहास, विज्ञान र प्रविधि समेटिएको एकीकृत सामग्रीका रूपमा यो पुस्तक आएको छ । कृषि विज्ञानका विद्यार्थी, कृषि प्राविधिक एवम् कृषक सबैका लागि यो पुस्तक उपयोगी सामग्री बनेको छ भन्ने मेरो बुझाइ छ । यस कार्यका लागि म राष्ट्रिय फलफूल विकास केन्द्रको प्रशंसा गर्दै सफलताका लागि शुभकामना व्यक्त गर्दछु ।

भूपाल राई
कुलपति
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MESSAGE

Fruit sub-sector of Nepal stands high among the different sub-sectors of agriculture with significant contributions to the livelihood of the farmers and food and nutrition security of the country. With the low to medium purchasing capacity of Nepalese people, most of them rely on seasonal fruits to fulfill their nutritional demands. Among them orange is the most preferred fruit crops throughout the country. Mandarin orange contributes 0.96% to agricultural gross domestic product and becomes the major source of income and livelihood of the farmers in mid hill region of Nepal. It is native to Nepal, linked with the culture, traditions and peoples' way of lives. Its peculiar taste and unique color have been the identity of Nepal making it well- known among the consumers around the world.

In view of its importance, Government of Nepal has recently declared mandarin orange the "National Fruit of Nepal". On this auspicious occasion, National Center for Fruit Development (NCFD) and Nepal Horticulture Society (NHS) has organized a national workshop focusing on mandarin orange. Moreover, NCFD has also conducted the study on potential of geographical indications of orange, and germplasm conservation of orange through the establishment of field gene banks in governments' farms. I would like to congratulate NCFD and NHS for the successful completion of the workshop. I also would like to thank the team for the preparation and publication of "Mandarin Orange Compendium" largely the information from the workshop documenting and highlighting the diverse dimensions of mandarin orange in our lives including its history, culture and traditions, technological advancement in production and post-production aspects.

I believe that this compendium will be the very much useful and inspirational for the researchers, academia, students, farmers and all the concern stakeholders to pursue our endeavors towards the technological advancement in mandarin orange fruit crop. It will open the avenues for targeted research and development too. Once again, I would like to express my sincere thanks to the authors and editors of the compendium and, NCFD and NHS for their milestone task accomplished which will be very much important for the agriculture sector of Nepal.

June, 2024

Dr. Deepak Kumar Kharal
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Government of Nepal
Ministry of Forests and Environment
Kathmandu

MESSAGE

Mandarin Orange, the national fruit crop of Nepal, is one of the geographically popular, environmentally friendly and economically better remunerative fruit crops in the mid-hills of Nepal. Farmers are encouraged in its commercial production through various government support programs as well as own initiatives in the country. Being a high value crop, it has been a priority fruit for the mid-hills of the country. The trend of coverage, production and yield show an encouraging result. However, the current level of production of this crop still lags behind to meet the national demand. Further, attaining quality production and minimizing post-harvest losses are another challenge. To increase the yield and total production, and develop postharvest facilities, more coordinated efforts are required in the research and development of mandarin orange through the National Fruit Development in coordination with relevant stakeholders.

This compendium in itself is a substantive resource book for understanding mandarin orange, its importance and efforts done in its promotion in Nepal. Scattered knowledge, experience, feelings and various information of research and development activities on mandarin orange have been brought together and documented coherently. I hope this compendium will certainly fill the gaps and direct the way forward for different stakeholders in the promotion of mandarin orange in the country. I congratulate National Center for Fruit Development, Kiripur and Nepal Horticulture Society, Lalitpur for organizing national conference on Horticulture that provided foundation for this compendium. I also express sincere appreciation to all the contributors of compendium and team members for their endless efforts to finetune compendium.

Thank You
June, 2024

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Dr. Govinda Prasad Sharma
Secretary
Ministry of Forests and Environment

Government of Nepal
Ministry of Agriculture and Livestock Development
Department of Agriculture
National Centre for Fruit Development
Kirtipur, Kathmandu

FOREWORD

A compendium is a collection of concise but detailed information of works done in a particular subject. Here we have tried our best to prepare a compendium on *Suntala* (Nepalese mandarin orange) covering its importance manifested by its recognition as the "National Fruit" of the country, including its historical, economical and developmental perspectives as well as some efforts made in different sectors for its increased production and promotion. *Suntala* is one of the native fruits of Nepal which is very popular table fruit from time immemorial and hence is cultivated throughout the country.

According to the agricultural statistics of Nepal for the fiscal year 2022/023, the total area covered by *Suntala* is 28,451 hectares (ha) out of which only 19,897 ha (70%) is productive area with a total production of 198,779 tons (t) and an average yield of 9.99 t/ha. *Suntala* is grown in 66 districts out of the 77 districts from East to West and North to South thereby making it the most widely cultivated fruit crop in the country. This fruit alone contributes about 1% to the agricultural GDP of the nation. It has greatly contributed in improving the livelihoods of the people residing in the hilly areas the country. Additionally, it has nutritional, social, cultural, historical, environmental importances. It is our invaluable biological asset that contributes immensely to the nation's biodiversity and is a strong agriculture produce for geographical indication.

Nepalese *Suntala* has superior taste and other unique qualities as compared to the mandarin oranges produced in other countries. Despite having a lower level of production compared to other countries, Nepal has made steady progress in production of this fruit in recent years. The government should emphasize more on research and development and align its policies and programs to further enhance this sector's growth in line with its enormous potential. Being an interdisciplinary sector, it requires involvement of multiple stakeholders for which there is a need of integrated approach at international, national and subnational level program implementation in a coordinated manner.

This compendium comprises of articles presented during the 14th National Horticulture Seminar jointly organized by the National Centre for Fruit Development and the Nepal Horticulture Society, some information obtained from the senior horticulture experts, poems, and pictures wherein as many aspects of *Suntala* as possible have been documented. I express my sincere deep gratitude to all the authors, reviewers and editors who have worked tirelessly to bring this publication at hand.

Thank you.
June, 2024

Shanta Karki, PhD
Chief
National Centre for Fruit Development

नेपाल हर्टिकल्चर सोसाईटी

NEPAL HORTICULTURE SOCIETY

स्थापित २०४७

Estd. 1990

PREFACE

Mandarin orange has been well established in the agro-ecological zone of entire mid-hills of Nepal. From the very beginning of development plan, mandarin orange has been accorded high priority in government's fruit development program. The Compendium of Mandarin Orange is the outcome of the 14th National Conference on Horticulture held on 12-13 Baishakh, 2081 (24-25 April, 2024) in the Warm Temperate Horticulture Center, Kirtipur, Kathmandu with the theme of ***"Unveiling Nepal's Mandarin Orange Wealth: From Origin to Prosperity***" which was organized by Nepal Horticulture Society, Lalitpur and the National Centre of Fruit Development(NCFD), Kirtipur in collaboration with National Centre for Potato, Vegetables, and Spices Crop Development, Kirtipur. Publication of the compendium has been visualized in light with the declaration of mandarin orange, as the national fruit of Nepal, a significant milestone in the country's history of fruit development.

An effort has been made to cover the wider aspects of Nepali mandarin orange (Suntala) to present it as a valuable resource book of mandarin orange. There are five chapters in the compendium with 45 articles, complemented by photographs. The first chapter deals with the history, traditions, socio-cultural aspects of mandarin orange in Nepal. The second chapter unfolds science and technology aspects of mandarin orange, Biodiversity and Conservation. The third chapter dives into mandarin orange's value chain and marketing. The fourth chapter provides a comprehensive overview of policy tools and development initiatives governing mandarin orange. The fifth chapter," Miscellaneous" provides, Bhajan and poem on mandarin orange; experience of honorable horticulturists working with mandarin orange in their service periods and status of Mandarin orange in Lumbini Province followed by the final chapter of photo gallery.

I am profoundly thankful to authors, reviewers, editor in chief and members of the editorial committee and all the contributors who have played an important role to prepare this compendium in this form. My sincere thanks go to our senior horticulturists for providing their experience sharing, encouragement and good wishes. I hope this compendium will be very useful to horticulture researchers, planners, development workers, students and many others who are involved in this sub-sector and also it contributes a lot in the promotional and developmental activities of mandarin orange in the country.

June 2024

Gopal Prasad Shrestha
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नेपालका मुर्धन्य बागवानी विज्ञहरूको
अनुभव संग्रह

१४औं राष्ट्रिय बागवानी सम्मेलनबाट सुन्तलाको Compendium तयारी गरी समग्र सुन्तलाजात सम्बन्धीको विषयमा उजागर गर्ने उद्देश्य राखेको सम्बन्धमा मलाई सुन्तलाबारे केही बोल्न अनुरोध गरे अनुसार मेरो केही विचार राख्दैछु।

वि.सं. २००० सालतिर पनौतीको सुन्तला र खोपासीको बोक्रा भित्र हल्लिने सुन्तला खाएको याद छ। वि.सं. २०१६ सालमा इलाममा रू. १ रुपैयाँ देखि २ रुपैयाँमा १०० दाना रसिलो, गुलियो सुन्तला खाएको याद छ। कास्की स्याङ्गजाको सुन्तला पहिला देखि नै प्रख्यात थियो। त्यसैले मालेपाटनमा सुन्तला अनुसन्धानका लागि केन्द्र स्थापना भयो । पछि धनकुटामा पनि सुन्तला अनुसन्धानमा Citrus अनुसन्धान स्थापना गर्न जग्गा किन्नेमा सहभागी हुन पुगेँ। वि.सं. २०१८ सालमा बागवानीमा काम गर्दा गोरखामा सुन्तला सर्वेक्षणमा गएको याद छ। अहिले गोरखाको सुन्तला र मनकामनाको सुन्तला काठमाडौं बजारमा देखिन्छ। धादिङ्गको स्यार्दुलको सुन्तला प्रख्यात छ भने चितवनको इच्छाकामना वरपरका गाउँमा प्रशस्त सुन्तला फलेको देखिन्छ । वि.सं. २०२० सालमा सुन्तला विकास गर्न भारतबाट ल्याएर मालेपाटनमा लगाएको बोटहरू र त्यहाँबाट कास्कीमा वितरण भएको बोटबाट ग्रिनिङ्ग रोग सरेर सुन्तला बगैंचा सखाप भयो । जसलाई पछि चीनबाट उब्जेका ह्वाङ्लोङबिङ भन्ने गरियो। यस्तो बिग्रेको बगैंचामा अम्बा लगाउन लगाएर कृषकलाई केही राहत पुऱ्याउन सकियो। तर यसले निरन्तरता पाएन। यस्तै समस्या भियतनाममा पनि भएको थियो र अम्बा रोप्न लगाएका थिए। वि.सं. २०५० सालमा डा. मुकुन्द रञ्जितले टिस्युकल्चरबाट भाइरस फ्रि बिरुवा उत्पादन गरेर बिरुवाहरू वितरण गरे तर सरकारको सहयोग भने पाएनन्। पछि कामै बन्द भयो।

नेपालमा सुन्तला बिक्री भइसकेपछि नागपुरको सुन्तलाले पसलमा राम्ररी सजाएर बिक्रीमा आएको देखिन्छ । तर नेपाली सुन्तलालाई यसरी पसलमा सजाएर बिक्री गरेको देखिन्न। सुन्तला फलले हालैमा नेपाल हर्टिकल्चर सोसाइटी र राष्ट्रिय फलफूल विकास केन्द्र, कीर्तिपुरको पहलमा राष्ट्रिय फलको उपाधि पाएको छ, गौरवको कुरा हो। अब आवश्यक छ - सुन्तला बालीमा विशेषज्ञ। Expert हुनु र रहनु अत्यन्तै आवश्यक छ। जसले आउँदा दिनमा Citrus Compendium को साथै Landrace छनौट गर्ने, पोष्ट हार्भेष्ट प्रविधिद्वारा भण्डारण गर्ने, सोभै बजारमा जानका लागि कुन समयमा फल टिप्ने ? निधो गर्ने तथा छनौट गरेर बजारमा जान नसकेकालाई संकलन गरेर Value Addition गर्ने प्रबन्ध मिलाओस्।

जापान जाँदाको एक सम्झना छ, सत्सुमा सुन्तला बीउ नभएको, बोक्राबाट Orange Oil, बोक्राको भित्री भागबाट अल्वेडो र बोक्रा सुकाएर कुखुराको दाना मिसाएर उपयोग गरिन्छ, कुनै खेर जाँदैन । संखुवासभामा मात्र सुन्तलाको जंगलै छ। सुन्तला खेती पूर्वदेखी पश्चिमसम्म फैलिएको पहाडी क्षेत्रमा कृषकको जीवनस्तर उठाउन सहायक हुन्छ भन्ने मलाई पूर्ण विश्वास छ।

धन्यवाद।

शिव बहादुर नेपाली प्रधान
पूर्व महानिर्देशक
कृषि विभाग, हरिहरभवन, ललितपुर

नेपालका मुर्धन्य बागवानी विज्ञहरूको
अनुभव संग्रह

वि.सं.२०३० सालको शुरुवातमा नेपालको सुन्तला खेतीको आंशिक सर्भेक्षण हुँदा संखुवासभा जिल्लाको उत्तरी क्षेत्रमा पर्ने माङ्तेवा भन्ने गाउँको जंगलमा सुन्तलाको केही बोटहरू देखिएको थियो । यस तथ्यबाट नेपाल पनि सुन्तलाको उत्पत्ति स्थान भएको भन्न सकिन्छ।

आ.व. २०३०/३१ देखि सरकारी फलफूल बगैँचाको साथै निजि क्षेत्रका किसानहरूले नर्सरी स्थापना गरी विभिन्न फलफूलका बोटविरुवा उत्पादन गरि देशका फलफूल उत्पादन कार्यक्रम सञ्चालन हुँदै आएको छ।

वि.सं. २०३७ साल देखि २०४८ सम्म फलफूल विकास शाखा कीर्तिपुरको प्रमूख भई काम गर्दा ७५ जिल्लाहरूमा फलफूल विकासको कार्यक्रम तर्जुमा तथा सञ्चालनको लागि जिल्ला कृषि विकास कार्यालयहरूलाई आवश्यक पर्ने तालिम तथा प्राविधिक सल्लाह उपलब्ध गराउने कार्यक्रम सञ्चालन हुँदै गरेको थियो।

मेरो सुझाव

राष्ट्रिय सुन्तलाजात फलफूल कार्यक्रमलाई प्रभावकारी तरिकाले सञ्चालन गर्न छुट्टै निकायको रुपमा सञ्चालन गर्न उपयुक्त देखिन्छ। सुन्तला राष्ट्रिय फलफूल भएकोमा ज्यादै खुशी भएको छु। सुन्तला कार्यक्रम सञ्चालकहरूलाई हार्दिक धन्यवाद तथा शुभकामना।

पदम प्रसाद श्रेष्ठ
पूर्व संयोजक
राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुर, काठमाडौं

नेपालका मुर्धन्य बागवानी विज्ञहरूको अनुभव संग्रह

सबैमा मेरो हार्दिक नमस्कार । नेपाल सरकारले सुन्तलालाई राष्ट्रिय फल घोषणा गरेकोले मलाई धेरै खुशी लागेको छ। जुन कार्यमा हामी पहिला देखि नै प्रयासरत थियौँ। यसका लागि योगदान पुऱ्याउनुहुने सबैलाई धेरै धेरै धन्यवाद दिन चाहन्छु।

ईसा पूर्व ४००० वर्षदेखि नै सुन्तलाको खेती हुँदै आएको अनुमान र मान्यता छ। ई.पू. २००० देखि नै चीनमा यसको खेती भएको भन्ने कुरा चिनियाँ ग्रन्थहरूमा उल्लेख भएको पाइन्छ । सुन्तलालाई Mandarin Orange भनिन्छ । Mandarin चिनियाँ शब्द हो। यसको उत्पत्ति चीनको दक्षिण-पूर्व क्षेत्रमा भएको र शान वंशिय मानिसहरूको बसाईसराई र व्यापारको क्रममा यहाँबाट नेपाल र भारतका विभिन्न क्षेत्रमा सुन्तला पनि पुगेको बुझिन्छ। सन् १८९० मा नेपाल भ्रमण आएका Citrus का चर्चित वैज्ञानिक बोनिभिया बुटवल पुग्नुभएको रहेछ। त्यहाँ अर्ध जंगली अवस्थामा सुन्तलाहरू देख्नु भएको कुरो उल्लेख गर्नु भएको छ। त्यसपछि सन् १९२९ मा सिट्रसको खोजमा वैज्ञानिक Tanaka भ्रमणमा यहाँ आउँदा सुन्तला नेपालको Indigenous Fruit भनेर पुष्ट्याईं गर्नुभएको थियो । आज भन्दा ९० वर्ष पहिला संखुवासभाको माङ्गतेवा भन्ने ठाउँमा सुन्तलाको जंगलै देखिन्थ्यो । स्विट अरेन्ज (Sweet Orange) पनि यहि किसिमले उत्पत्ति भई फैलिएको हो। Sweet Orange मा मौसमी, माल्टा, जुनार आदि पर्दछन्। Sweet Orange हरू मध्ये जुनारलाई नेपालमा उत्पत्ति भएको मान्यता दिन्छौं। यो प्राकृतिक रुपमा मौसम र सुन्तलाको पराग सेचनको प्रतिफल हो। यो भारतमा पाइँदैन।

वि.सं.२०१९ सालमा बागवानी गोष्ठी भएको थियो जहाँ धनकुटा सिट्रस अनुसन्धान केन्द्रका प्राविधिक श्री जनकदेव शाक्यले जुनार लिएर आउनुभएको थियो। सो कार्यक्रममा कृषि मन्त्रालयबाट प्रतिनिधि आउनुका साथै धेरै विज्ञहरूको सहभागिता थियो। सोही प्रकारका फल पहाडी क्षेत्र (सिन्धुली जिल्ला) बाट जनकपुरको विवाह पञ्चमी मेला (मंसिर) मा आएको देखिन्छ भनी मैले भनें । वि.सं. २०२० सालमा भारतीय राजदूतको सहयोगमा जनकपुर बागवानी फार्मको स्थापना भयो। त्यसपछि सिन्धुलीमा जुनारको सर्वेक्षणका लागि तीन दिनसम्म जंगल र खोलाको बाटो हिँडेर गइयो । सिन्धुलीको खनियाँखर्क र रतनचुरामा कृषकको घरबारीमा जुनार उत्पादन भैरहेको भेटियो।

पहिलेका विशेषज्ञहरूले के के गर्नुभयो ?

हरेक पञ्चवर्षिय योजनाहरू अनुसार अति कठिन अवस्थामा कार्ययोजनाहरू बनाइन्थ्यो र कार्यान्वयन गराइन्थ्यो। वि.सं. २०२९ सालमा कृषिको नयाँ संगठनात्मक संरचनाको निर्माण भएपछि त्यसमा बाली विकास कार्यक्रमहरूले प्राथमिकता पाए, बीउ उत्पादनमा आत्मनिर्भरता हासिल गर्ने पनि समावेश गरिए । कृषि तर्फ धानबाली, गहुँबाली लगायत अन्य बाली, पशुपालन, मत्स्य आदि कार्यक्रम तथा बागवानी तर्फ फलफूल विकास, सुन्तला विकास, तरकारी बाली विकास, आलुबाली विकास, मसलाबाली विकास लगायतका कार्यक्रमहरू समावेश गरिए। यस प्रकारले हरेक बालीका लागि अलग कार्यक्रम आउँदा फलफूल मध्ये पनि सुन्तलाले छुट्टै पहिचान र प्राथमिकता पाएर अर्को गति पायो। बागवानी विज्ञ पदमप्रसाद श्रेष्ठ ज्यू पोखरामा यसको कार्यालय स्थापना र प्रारम्भिक कार्यहरू गर्नुभयो। मेरो पनि कीर्तिपुरबाट सरुवा भई बागवानी अनुसन्धान केन्द्र, पोखरामा पदस्थापना भयो । एक वर्ष पछि वि.सं. २०३० सालमा पुनः पोखराबाट फलफूल विकास कार्यक्रम सञ्चालन गर्न कीर्तिपुर (काठमाडौं) मा सरुवा भई आएँ।

राष्ट्रिय योजना आयोगको बजेट तथा कार्यक्रम निर्माण र सञ्चालनबारे कृषि मन्त्रालय सहितका सबै पदाधिकारी बसेर वि.सं. २०३१ सालमा कृषि सामग्री संस्थान, टेकूको सभाहलमा बैठक भएको थियो। त्यहाँ अन्नबाली (खासगरी

गहूँ) को बीउ उत्पादनमा आत्मनिर्भर हुने लगायतका विषय उठेपछि मैले फलफूल बिरुवा उत्पादनमा पनि किन आत्मनिर्भर नहुने? भनेर प्रस्ताव राखेँ । यस कुरालाई पनि पञ्चवर्षिय योजनामा राख्नुपर्छ भनेर प्रस्ताव राखेँ, त्यो स्वीकृत भयो । वि.सं. २०३२ सालमा कृषि वर्ष-२०३२ कार्यक्रम शुरु भयो । विस्तारै ७५ जिल्लामै निजी स्तरमा नर्सरी स्थापना शुरु भयो । फलफूल बिरुवा उत्पादनको लागि नर्सरी तालिमहरू सञ्चालन भए ।

वि.सं. २०३४ सालमा जापानी सहायतामा संचालित जनकपुर अञ्चल कृषि विकास योजनामा मेरो सरुवा भयो । यस योजना अन्तर्गत रामेछाप, सिन्धुली, धनुषा, महोत्तरी र सर्लाही जिल्ला पर्दथ्यो । यो मध्ये माथिल्लो भेगमा सिन्धुली र रामेछाप पर्दथ्यो जहाँ सुन्तला र जुनार खेती घरबारी स्तरमा भईरहेको थियो । तिनताका कृषि मन्त्रालयका सचिव हुनुहुन्थ्यो श्री वेद बहादुर खड्का । उहाँले तीन वर्षमा २००० (दुई हजार) रोपनी जमिनमा जुनार लगाउनुपर्छ भनेर ठूलो अभियानकै रुपमा कार्यक्रम सञ्चालन गर्ने घोषणा गर्नुभयो । यो कार्यक्रम (लक्ष्य) सम्भव छ, तर क्रमिक रुपले हुने भएकोले तोकेको भन्दा केही बढी समय लाग्न सक्ने राय Janakpur Agriculture Development Project (JADP) मा जापानी र नेपाली विज्ञहरूको संयुक्त बैठकमा राय व्यक्त गरेको थिएँ । त्यसपछि प्राथमिकताका साथ सुन्तला र जुनारको कार्यक्रम सञ्चालन गरिए । JADP को अगुवाइमा कृषि विकास बैंक, कृषि विकास कार्यालय एक ढिक्का भई कार्यक्रम तीब्र गतिले सञ्चालन भयो । रामेछाप र सिन्धुली जिल्लामा ११/११ वटा निजी नर्सरीहरू स्थापना भए जसबाट रुटस्टक बिरुवा, कलमी बिरुवा र बीजु बिरुवा समेत उत्पादन गर्ने, कटिङ्ग-ग्राफ्ट विधिबाट पनि कम समयमा कलमी बिरुवा उत्पादन गर्ने किसिमका कार्यक्रमहरू सञ्चालन गरिए । प्रत्येक १५ दिनमा ति नर्सरीमा एक जना प्रतिनिधि पुग्नुपर्ने र कृषि विकास बैंकले थलोमा गई कृषकलाई ऋण लगानी गर्नुपर्ने नियमित रुटिन बनाएर काम गरियो । यसरी जुनार र सुन्तला दुबैका कार्यक्रमहरू सञ्चालन भए ।

सुन्तलाजात फलफूलको विकासको लागि वि.सं. २०४१ सालमा मलाई राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रमको प्रमुख पदमा धनकुटा पठाइएपछि त्यहाँबाट पनि अधिराज्यभरिको लागि सुन्तला, जुनार र नर्सरी कार्यक्रम सञ्चालन गरेँ । त्यसै क्रममा धनकुटाको खोकु, धादिङ्गको स्यार्दुल धुसामा नेपालको सुन्तलाको जात पहिचान के हो ? ठाउँ अनुसारको छुट्टाछुट्टै सुन्तलालाई के आधारमा पहिचान गर्ने ? साथै उच्च गुणस्तरको सुन्तला र जुनारको बोटहरू पहिचान गर्ने अध्ययन कामहरू गरियो । खोकु र स्यार्दुलमा दुई-दुई वर्ष अध्ययन गरेँ । सिन्धुलीमा सुन्तला र जुनारमा जापानीज प्राविधिक तोमियासु र अर्का विज्ञ सुरेश कुमार वर्माजीले पनि अध्ययन गर्नुभएको थियो ।

अध्ययन गर्दा बोटको फल्ने क्षमता, फलको आकार प्रकार, बोक्राको मोटाई, बीउको संख्या, फलको तौल, रस र बाँकी भागको अनुपात, रसको गुलियोपना (Brix) आदि गरिएको थियो । यो दुई वर्षको अध्ययन पश्चात् उच्च गुणस्तरको फल दिने बोटबाट कलमी बिरुवा तयार गरी धनकुटा सिट्रस फार्ममा नर्सरीमा लगाएको थिएँ ।

त्यसबेला भएका सबै अध्ययन रिपोर्ट र सामग्री अहिले सम्म पनि मसँग सुरक्षित राखेको छु । तिनलाई कसरी र कुन बेला, कसलाई हस्तान्तरण गर्ने ? कसरी प्रकाशन गर्ने ? प्रतिवेदनका साथ तस्वीर पनि (बीउ, पात, विभिन्न आकार-प्रकारका फलहरू) मसंग सुरक्षित नै छन् । अध्ययन गरिएका के कति बोट मरे वा बाँचेका होलान् भन्ने जानकारी लिन हालसम्म त्यसतर्फ जान पाएको छैन ।

अहिलेका सबै बागवानी विज्ञहरूलाई मेरो अनुरोध छ कि यि अध्ययनहरूलाई कुन किसिमले प्रमाणित गर्न सकिन्छ यस तर्फ पाइला चाल्नुपर्छ भनेर सल्लाह दिन चाहन्छु ।

सुन्तला राष्ट्रिय फल घोषणा भइसकेको यस घडिमा सबै बागवानी विज्ञहरूलाई अनुरोध छ कि ठाउँ अनुसार यसको जातीय पहिचान (त्यो ठाउँको सुन्तला यो हो भनेर) गर्न सकिने गरी व्यवस्था गर्नुभए धेरै राम्रो हुने थियो । यसको लागि नेपाल हर्टिकल्चर सोसाइटीले पनि भूमिका खेल्नुपर्ने आवश्यकता छ । यकिन भइसकेका बोटबाट टिस्युकल्चरबाट भए पनि रोगमुक्त बनाएर बिरुवा वृद्धि गरेर लैजान सकियोस् भन्ने मेरो सुझाव, सल्लाह र आग्रह छ ।

सबैमा धेरै धेरै धन्यवाद ।

राम बदल साह
पूर्व प्रमुख
राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुर, काठमाडौं

नेपालका मुर्धन्य बागवानी विज्ञहरूको
अनुभव संग्रह

सुन्तला भन्ने वित्तिकै सर्वमान्य रुपमा सबै नेपालीहरूले देखेको, जानेको, खाएको फल हो यो । सुन्तला नै यस्तो फलफूल हो कि यो गरिब देखि धनाढ्य वर्गका पनि सबैले खाएको हुन्छ । नेपालको आफ्नो उत्पादन धनकुटाको खोकु छिन्ताङ्ग देखि नेपालको मध्य-पहाडी भाग पोखरा देखि पश्चिमाञ्चलको बैतडी तिर पनि खेती हुने गरेको छ। प्रायःजसो धनकुटा, भोजपुर, तेह्रथुम, स्याङ्गजा, कास्की र पाल्पा तिर व्यावसायिक रुपमा खेती भैराखेको छ। अरू ठाउँमा पनि बढिरहेको छ। गण्डकी प्रदेश, लुम्बिनी प्रदेश, कर्णाली प्रदेश र सुदूरपश्चिम प्रदेशको दैलेख, दुल्लुमा पनि सुन्तलाको व्यावसायिक खेती भैराखेको देखिन्छ ।

अफसिजनमा भारतबाट आयात पनि हुने गरेको देखिन्छ। तर सिजनमा चाहिँ धनकुटा, धरान लगायतका क्षेत्रबाट भारतमा बढी निर्यात हुने गरेको छ। बुटवलबाट पनि भारतमा निर्यात हुन्छ। वास्तवमा हाम्रोमा ठाउँ ठाउँमा कोल्डस्टोरहरु त छन् तर कोल्डस्टोरमा राख्ने चलन नभएकोले अफसिजनमा भारतबाट आयात हुने गरेको हो।

नेपालमा सुन्तला उत्पादनका लागि धनकुटा, पोखरा आसपासका क्षेत्र नै मुख्य थलोका रुपमा मानिँदै आएको पाइन्छ। अचेल देशका अरू ठाउँमा पनि व्यावसायिक खेती बढ्दै गएकोले सिजनमा निर्यात पनि बढ्न सकेको पाइन्छ। नेपालमा सुन्तलाजात फलफूल खेतीको विकास गर्ने भनेर नै नेपाल सरकारले तय गरेको विभिन्न कार्यक्रमहरू चार पाँच वर्षसम्म चल्यो। पछि त्यसलाई निरन्तरता दिन नसकेपछि प्रवर्द्धन कार्यक्रम नहुँदा यसको उत्पादनमा पछाडि सरेको जस्तो मलाई लाग्छ। म आफैं पनि जागिरे अवधिभरी शुरु देखि अवकास हुँदासम्म सुन्तलामै काम गरेको भएर सुन्तला, कागती, जुनार बढी उत्पादन गर्ने कार्यक्रम सञ्चालान गर्न सकेको खण्डमा हाम्रा किसानहरूले बढि आम्दानी पाउने थिए । कागतीमा पनि अफसिजनमा कागतीका केही आयात गरिन्छ । तर धेरै जसो हाम्रो उत्पादन नै खपत भैराखेको देखिन्छ ।

सरकारले प्राथमिकता दिएर योजना बनाउँछ तर योजना अनुसारको कार्यान्वयन चाहिँ भएको देखिएन। खास गरी नेपालमा सुन्तलामा देखिएको ग्रिनिङ्ग रोगहरूले गर्दा पहिला धेरै सखाप भैसकेको थियो। खासगरी पोखरा, कास्कीको वरिपरि सखाफ भैसकेको थियो। पछि अरु अरू क्षेत्रमा पनि ह्रास हुँदै गएको देखिएको थियो। बेला बेलामा यसरी अरू पनि रोगहरू देखा पर्दै आइराख्छ। सुन्तलामा दीर्घकालीन अनुसन्धान नभएको भन्न सक्दिनँ तर कमजोर भए जस्तो लाग्छ। सुन्तलाजातको अनुसन्धानमा बलियो टोली समावेश गर्नुपर्‍यो । निजामती सेवामा सुन्तलाजातमा काम गरेको र अनुभव प्राप्त भैसकेको व्यक्तिलाई अन्य क्षेत्रमा सरुवा गराउने र अरु क्षेत्रकालाई सुन्तलाजात अनुसन्धानमा सरुवा गरी ल्याउने अस्थिर सरूवा प्रणालीले गर्दा प्रभावकारी नतिजा आउन सकेको छैन। सुन्तलाजातमा अनुभव भएको व्यक्तिको योगदान यसैमा भएको भए राम्रो, विकासमा सहयोग पुग्छ भन्ने लाग्छ। अरू क्षेत्रका व्यक्तिले अनुभव गर्न समय लाग्छ।

अर्को तर्फ किसानहरूलाई बाँड्ने बिरुवा कतै बीजु बिरुवा तथा कतै चाहिँ कलमी बिरुवा पनि वितरण भै आएको पाइन्छ। विश्वमा प्रायःजसो सुन्तला, जुनारका बिरुवाहरू सबै कलमी गरेको, जुन चाहिँमा जराको भाग र माथिको भाग अलग्गै हुन्छ। माथिको भागमा सुन्तला, जुनार हुन्छ, जराको भाग चाहिँ माटोमा हुन्छ। जराको भागमा माटोबाट हुने रोगहरू प्रतिरोध गर्ने जातका बलियो खालको रुटस्टकको प्रयोग गरेर कलमी बिरुवाहरू वितरण गरिएको खण्डमा हाम्रो उत्पादनमा बढोत्तरी हुनसक्थ्यो कि जस्तो लाग्छ।

एक ठाउँबाट अर्को ठाउँमा बिरुवाहरू लैजान पाउँदैन भन्ने कुरा सरकारी नियममा पनि छ, तर सुन्तलाका बोटहरू एउटा जिल्लाबाट अर्को जिल्लाहरूमा जाँदा एउटा जिल्लाको रोग अर्को जिल्लामा पनि जान्छ। यसरी जिल्लापिच्छे बोट मात्रै होइन त्यसमा हुने रोग तथा कीराहरू बढ्दै जाने हुनाले रोग कीराहरू फैलिँदै जान्छ। जसरी पोखरामा सुन्तलाजात ह्रास (Decline) भयो, र पोखरा फार्मबाट विभिन्न जिल्लामा पठाइएका बिरुवाबाट अरू जिल्लामा पनि रोगहरू सर्दै गयो। त्यसैले किसानहरूलाई सकेसम्म सुन्तलाजात क्षेत्र (Citrus Zone) स्थापना गरेर नेपालभरीका प्रदेशहरूमा जुन क्षेत्रमा उत्पादन भएको बिरुवा हो सोही क्षेत्रमै वितरण गर्ने, अर्को क्षेत्र (Zone) मा नजाने गर्नाले एउटा जिल्लाको रोग अर्को जिल्लामा सर्न पाउँदैन। संसारमा रोग कीराहरू यसरी बिरुवाबाटै बढी सर्ने सम्भावना हुन्छ। यसलाई नेपाल सरकारले ध्यान दिएको खण्डमा सुन्तला उत्पादनमा सहयोग पुग्छ जस्तो लाग्छ।

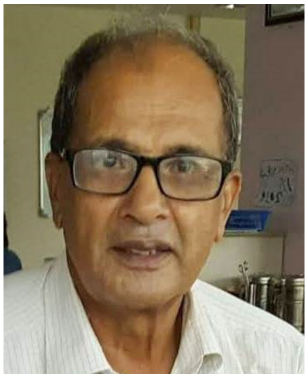
धन्यवाद।

त्रैलोक्यनाथ श्रेष्ठ
पूर्व प्रमुख
राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुर, काठमाडौं

नेपालका मुर्धन्य बागवानी विज्ञहरूको अनुभव संग्रह

सर्वप्रथमतः यहाँहरूले जुन कार्य गर्न लाग्नु भएको छ, त्यो असाध्य नै प्रशंसनीय काम हो । त्यसको लागि यहाँहरूको सम्पूर्ण टिमलाई नै धन्यवाद दिन चाहन्छु । सुन्तलाजात फलफूलमा मैले कति योगदान गर्न सकेँ, कति गर्न सकिनँ त्यो त मैले भन्दा पनि अरुले भन्ने कुरा हो। म कति संलग्न भएँ भन्ने सन्दर्भमा भन्नुपर्दा दुई पटक गरेर लगभग १० वर्ष जति पारिपाल्ले, धनकुटामा बसेँ । तात्कालिन समयमा कृषि केन्द्र, धनकुटा नामाकरण गरिएको थियो। त्यो केन्द्रको मुख्य क्रियाकलाप पनि सुन्तलाजात फलफूल र तरकारी थियो। पहिलो चरणमा सुन्तला भन्दा बढी तरकारीमा संलग्न थिएँ। दोस्रोपटकमा आ.व.२०३८/३९ देखि वि.सं. २०४६ सालसम्म धनकुटामा बसेँ । त्यो बेला फार्म प्रबन्धकको हैसियतमा सुन्तलाजात फलफूलमा संलग्न भएर काम गरेँ । त्यतिखेर त्यो भन्दा अगाडि भएको क्रियाकलापलाई निरन्तरता दिने र खासगरेर त्यतिबेला फार्मको बगैंचाको अवस्था निकै दयनीय थियो । ती बगैंचाहरूलाई कसरी पुनःस्थापित गर्ने ? त्यो गर्न सकिन्छ कि सकिँदैन ? भनेर फार्मकै साथीहरूको टिम बनाएर अध्ययन गर्‍यौं । फार्मको बगैंचालाई तीन भागमा वर्गीकृत गर्‍यौं । पहिलो साधारण बगैंचा, दोस्रो सुधार गर्न सकिने बगैंचा र तेस्रो काटेर हटाउनुपर्ने बगैंचा । त्यसपछि हटाउनुपर्ने हटाइयो । साधारण बगैंचाको लागि Package of Practices विकास गरियो । सुधार गर्नुपर्ने बगैंचाका लागि विशेष Package बनाएर सुधारका काम शुरु गर्‍यौं । दुई-तीन वर्षमा त्यसले राम्रो नतिजा दियो। धेरै किसानहरूको बगैंचा पनि ह्रास भइरहेको अवस्थामा कसरी त्यसलाई पुनःस्थापित गर्न सकिन्छ भन्ने व्यावहारिक अनुभव गर्न पाइयो र सफलता पनि प्राप्त भयो।

त्यसपछि म जुनारमा संलग्न भएँ। जुनार पनि सुन्तलाजातको दोस्रो प्रमुख बाली हो । जुनार coordinator को रुपमा सिन्धुलीमा आधार रही सिन्धुली र रामेछाप दुबै जिल्ला हेर्ने गर्थें । सुन्तला र जुनारमा त्यसबेलासम्म पनि कलमी बिरुवाहरू धेरै कम मात्रै उत्पादन गरिन्थ्यो । जुनारमा पछि जापानीज प्रोजेक्ट (आयोजना) लागु भयो। प्रोजेक्ट लागु



भएपछि केही प्रविधिहरू खासगरेर कलमी बिरुवा प्रविधि जापानबाट ल्यायौँ । साइड ग्राफ्टिङ्ग, भेनियर ग्राफ्टिङ्ग प्रविधिहरू जसले कलमी छिटो पनि गर्न सकिने, टेक अप प्रतिशत पनि राम्रो भएपछि किसान स्तरका सम्पूर्ण नर्सरीहरूमा जुनारको कलमी बिरुवा उत्पादन गर्न हामी सक्षम पनि भयौँ । पहिला हाम्रो आफ्नै रुटस्टक ज्यामिर प्रयोग गर्थ्यौं, पछि ज्यामिरमा जरा कुहिने रोगको प्रकोप बढी देखियो । त्यसपछि आयोजनाकै सहयोगबाट जापानबाट ट्राइफोलिएट (तीनपाते) ल्याएर रुटस्टकका रुपमा प्रयोग गरियो । त्यहि ट्राइफोलिएट हो जुन अहिले पनि हामी कीर्तिपुरस्थित समशितोष्ण बागवानी केन्द्रमा देख्न सक्छौं । अरू ठाउँमा पनि ट्राइफोलिएटको व्यापक प्रयोग भएको छ। त्यतिखेर गरिएको काम र योगदान अहिलेसम्म यसरी देखिएको छ।

त्यतिबेला जुनार क्षेत्र घोषणा गरियो । त्यतिबेलाको तात्कालिन सरकारलाई ठूलो आर्थिक दायित्व पनि परेन। जुनार खेती गरिने जग्गाको मालपोत मिनाहा गरिने मात्रै थप आर्थिक दायित्व थियो । त्यसो गर्दा दुई वटा जिल्लामा ८/१० लाख रुपैयाँ मात्रै थप खर्च भएको होला । अरू नियमित कार्यक्रम र नियमित बजेट नै थियो । यसले सबै किसानहरूको मनोबल बढायो। त्यसपछि अरू सामाजिक कार्यकर्ता, राजनैतिक कार्यकर्ता र कर्मचारीहरूमा पनि जुनार त महत्वपूर्ण फल रहेछ भन्ने सबैको मनमा आएपछि त्यसले राष्ट्रिय अभियानको रुप लियो । यसरी जुनार उद्योगको रूपमा विकसित भयो। जुन आज पर्यन्त कायमै छ।

अब सुन्तलालाई राष्ट्रिय फल घोषणा गरिएको सन्दर्भमा पनि यसले सुन्तला त राष्ट्रिय महत्त्वको फल रहेछ भन्ने कुरा सबैको मनमा आउने भयो । यसै अवसरमा सबै

क्षेत्रका राजनैतिक कार्यकर्ताहरू, किसानहरू, उद्यमीहरू, प्राविधिकहरूको पनि मनोबल उच्च गर्नुपर्ने हुन्छ। सबैलाई जागृत गराउने किसिमले कार्यक्रम बनाएर अहिलेको वस्तुस्थिती अनुसार अभियान (Campaign) का रुपमा कार्यक्रम लान सक्यौभने जुन उद्देश्यले अहिले राष्ट्रिय फल घोषणा भएको छ त्यो सफल हुनेछ।

सन् २०११ मा निजामती सेवाबाट अवकाश पाइसके पश्चात् कन्सल्टेन्सी काम गर्दाको समयमा संयुक्त राष्ट्र संघ अन्तर्गतको खाद्य तथा कृषि संगठन (FAO) को आर्थिक तथा प्राविधिक सहयोगमा Combating Citrus Decline in Nepal भन्ने आयोजना (Project) मा संलग्न भएँ। त्यो आयोजनामा राष्ट्रिय र अन्तर्राष्ट्रिय कन्सल्टेन्टहरूको टोली संलग्न थियो। राष्ट्रिय टोली तर्फ मेरो नेतृत्वमा हामी तीन जना सदस्य थियौं भने अन्तर्राष्ट्रिय तर्फ भारतका दुई वैज्ञानिकहरू हुनुहुन्थ्यो। हामी पाँच जनाको संलग्नतामा कार्यक्रम शुरु गऱ्यौं। के कारणले ह्रास (Decline) भयो ? भन्ने सन्दर्भमा पूर्व मेची देखि पश्चिम बैतडीसम्म ३२ वटा मध्य-पहाडी क्षेत्रका जिल्लामा सर्वेक्षण गऱ्यौं। त्यो सर्वेक्षणबाट हामीले असाध्यै महत्वपूर्ण जानकारीहरू प्राप्त गऱ्यौं। सबै क्षेत्रमा Decline हुनुका एकै कारण थिएन। कुनै क्षेत्रमा सिट्रस ग्रिनिङ्ग रोगका कारण भएको थियो। कुनै क्षेत्रमा Foot rot का कारणले भएको थियो। कुनै क्षेत्रमा व्यवस्थापनका कारणले भएको थियो। यसरी अलग क्षेत्रमा अलग कारणले Decline भएको थियो। समष्टिगत रुपमा हेर्दा नेपालमा भएको सुन्तलाजात फलफूल खास गरी सुन्तलाको बगैंचा ह्रास हुनुको कारण चाहिँ पहिलो नम्बरमा बगैंचा व्यवस्थापनकै कमी, दोस्रोमा Foot and Root rot र तीन नम्बरमा ग्रिनिङ्ग। हाम्रो अध्ययनबाट यि कारणहरू थाहा भएपछि ठाउँ अनुसारको सुधार गर्न सकिने ठाउँमा त्यही अनुसारको Package of Practices हामीले विकास गऱ्यौं र लागु गऱ्यौं। धनकुटामा हुँदा बगैंचा सुधार गर्न गरिएका/अपनाइएका व्यावहारिक ज्ञान जुन मैले पाएको थिएँ, त्यो ज्ञानले ठूलो मद्दत गऱ्यो। बगैंचा सुदृढीकरण कार्यक्रम भनेर अहिले पनि नेपाल सरकारले बेलाबेला यो कार्यक्रम सञ्चालन गरेको पाइन्छ। त्यसको नतिजा पनि राम्रो देखिएको छ र विगत दुई-तीन वर्ष देखि सुन्तला फलको उत्पादन बढिरहेको देखिन्छ।

मुख्य कुरा स्वस्थ्यकर बिरुवा चाहिन्छ। स्वस्थकर बिरुवाको लागि बडउड सर्टिफिकेसन लागु गर्नैपर्छ भनेर हामीले सिफारीस गरेकोमा केही काम चाहीं लागु भएको देखिन्छ।

कोभिड-१९ को महामारी भन्दा अगाडि सम्म कन्सल्टेन्टकै रुपमा कार्यरत थिएँ। जस्तो उद्योग वाणिज्य महासंघ अन्तर्गत AEC मा पनि consultant भएर स्याङ्गजाको सुन्तला, रामेछाप, सिन्धुलीको जुनारमा काम गरें। त्यसपछि मलाई तात्कालिन फलफूल विकास निर्देशनालय, हालको राष्ट्रिय फलफूल विकास केन्द्रले पनि प्राविधिक विज्ञका रुपमा सम्भिराख्नुभएको छ। त्यसमार्फत् पनि मसँग भएको ज्ञान बैठकहरूमा भाग लिँदा सेयर गर्ने गरेको छु।

सुन्तलाफलको Compendium तयारी गर्न यहाँहरूले गर्नुभएको कदम सह्रानीय छ। यो काम असाध्यै चुनौतिपूर्ण छ। यसको राम्रो compendium आओस् भन्ने अपेक्षा पनि राखेको छु र त्यसको लागि शुभकामना व्यक्त गर्दछु। सकेसम्म जति पनि लेखहरू आउँछन्, हामी जस्ता पुराना प्राविधिक साथीहरूले आफ्नो अनुभव सेयरिङ गर्दा पनि फिल्ड बेस हुन सक्यौं भने वास्तविक किसानले भोगेका समस्या, व्यवसाय/बजारको समस्याको अध्ययन गरेर आउनेछ। हाम्रो देशसँग सीमा जोडिएका दुई ठूला राष्ट्रहरु छन् र हाम्रो नजिक बाह्य बजार भनेको तिनै हुन्, ती बजारहरूसँग प्रतिस्पर्धा गर्न सक्ने सुन्तला उत्पादन गर्न सकियोस् भन्ने अपेक्षा राखेको छु।

धन्यवाद।

भैरवराज कैनी
पूर्व महानिर्देशक
कृषि विभाग, हरिहरभवन, ललितपुर

Editors' Note

Suntala is an indigenous popular fruit of Nepal which has been declared as the "National Fruit" of Nepal by the Government of Nepal very recently (Bikram Sambat 2080 Chaitra 30th or 12th April 2024). To commemorate this historical event, Mandarin Orange: History, Science and Technology in Nepal [a compendium on *Suntala* (Nepalese Mandarin Orange)] has been published. It is an outcome of several interactions with horticulturists, the articles presented at the 14th National Horticulture Seminar and a summary of the collaborative efforts between the National Centre for Fruit Development (NCFD), National Agricultural Genetic Resources Centre (NAGRC), Nepal Agriculture Research Council (NARC) and Nepal Horticulture Society (NHS).

The idea of preparing this compendium emerged from the need to apply for geographical indication (GI) tag for the Nepalese Mandarin Orange owing to its special unique characteristics or the quality imparted due to its geographical origin. Documentation of different aspects of Orange right from its history to its current development, science, technology and cultural (production) practices developed along the way is very crucial aspect for GI.

Nepal is a country of biological diversity including enormous fruit diversity due to its incredible terrain. Fruits form an integral part of the Nepalese culture. Among more than two hundred different types of fruit crops found in Nepal (cultivated and wild), *Suntala* is one of the major fruits grown throughout the country. Due to its cultural, ecological, and economic importance as well as its specialty it was chosen as the National Fruit of Nepal. Reflecting all these through call for articles, free writings, opinions and messages which have been compiled and edited to produce this valuable document.

The commitments from the NHS president Mr. Gopal Prasad Shrestha and NCFD Chief Dr. Shanta Karki have been a driving force to start and complete this compendium. Continuous support and encouragement from the Ministry of Agriculture and Livestock Development, Department of Agriculture, NARC and dedicated team efforts of NCFD staff and NHS members have made it possible for this valuable publication. We believe that we have covered almost all the available information about the Nepalese Mandarin Orange in this book. Being a living document on an important fruit crop of the country, we expect to receive constructive feedback which can be utilized to update the information and technologies in future editions. We are grateful to all the contributors and express our gratitude to all who have been directly or indirectly involved in the process of this publication.

Thank you all.

The Editors
June 2024

Acknowledgements

"Mandarin Orange: History, Science and Technology in Nepal" is being published after Mandarin orange was declared as the national fruit of Nepal by the Government of Nepal. The main objective of publishing this book is to incorporate all the available information, development and research activities conducted in Nepal related to the Mandarin Orange. This book represents the culmination of research, collaboration, and support from a multitude of individuals and institutions. This is the first official document of its kind which has included all the information related to a specific fruit.

In this context, National Centre for Fruit Development (NCFD) and Nepal Horticulture Society (NHS) would like to express its deepest gratitude to all the helping individuals and organizations whose support and contributions were invaluable in the creation of this book. We are deeply grateful to the 11th Executive Commitee of NHS for helping us to organize the 14th National Horticulture Conference which has laid the foundation for the publication of this book. We sincerely acknowledge all the authors of the articles, poems, and other forms of written contributions without which the publication of this book would be impossible.

The publication of such a precious volume would not be possible without continuous encouragement and inspirations of Honourable Jawla Kumari Sah, the Minister of Agriculture and Livestock Development, Secretaries of the Ministry of Agriculture and Livestock development Dr. Deepak Kumar Kharal, Dr. Govinda Prasad Sharma and Dr. Rajendra Mishra, and Director Generals of the Department of Agriculture Dr. Hari Bahadur K.C. and Dr. Narhari Prasad Ghimire during the entire duration of document preparation which are highly appreciated. We are grateful and inspired by the message from the Right Honourable Prime Minister of Nepal Mr. Pushpa Kamal Dahal 'Prachanda' and the Honourable Chancellor of Nepal Academy Mr. Bhupal Rai for their valuable messages.

NCFD and NHS would like to express sincere thanks to all the panel of the reviewers for thoroughly reviewing the articles and providing constructive suggestions and feedback. With due respect, NCFD and NHS acknowledges senior horticulturists Mr. Shiva Bahadur Nepali Pradhan, Mr. Padam Prasad Shrestha, Mr. Ram Badal Shah, Mr. Trailokya Nath Shrestha and Mr. Bhairab Raj Kaini for their greetings and best wishes, which is the important component of this document. Additionally, we express our heartfelt gratitude to all the authors and contributors.

NCFD and NHS acknowledge editor in chief Dr. Shanta Karki and editors Dr. Puspa Raj Poudel, Mr. Surya Prasad Baral, Ms. Yam Kumari Shrestha, Mr. Sanjay Dhimal, Mr. Santosh Paudel and Mr. Samyam Pandit for their tireless work in giving the final shape of this document. NCFD and NHS are very much thankful to Mr. Basanta Balami for his help in collection of pictures and typing of the interviews of the senior horticulturists in order to complete this book. We also acknowledge all the staffs of NCFD, NARC- National Gene Bank and members of NHS for their efficient contributions and collaboration.

NCFD and NHS will feel abundantly rewarded if this document proves helpful for readers in fulfilling their information needs on mandarin orange in Nepal from its history to present status. Finally, NCFD and NHS would like to appreciate all the mandarin orange growing farmers, nurseries, government horticulture development centres and other stakeholders involved in its promotion and express deepest gratitude to all of them for the continued cultivation, utilization and conservation of this important indigenous fruit crop of Nepal.

National Centre for Fruit Development
Nepal Horticulture Society

Abbreviations and Acronyms

ACP	Asian Citrus Psyllid
ADO	Agriculture Development Office
ADS	Agriculture Development Strategy
AEC	Agro-Enterprise Centre
AEO	Agriculture Extension Officer
AFU	Agriculture and Forestry University
AGDP	Agricultural Gross Domestic Product
AGRs	Agricultural Genetic Resources
AIA	Agro-biodiversity Impact Assessment
AKC	Agriculture Knowledge Center
APP	Agriculture Perspective Plan
APROSC	Agricultural Projects Service Centre
ARS	Agriculture Research Station
AVRDC	Asian Vegetable Research and Development Center
AWCP	Area-Wide Control Program
B	Boron
Ca	Calcium
CAA	Commercial Agriculture Alliance
CADP	Commercial Agriculture Development Project
CAGR	Compound Annual Growth Rate
CCD	Colony Collapse Disorder
CDP	Crop Diversification Project
CFFT	Coordinated Farmers Field Trial
CGD	Citrus Greening Disease
CHC	Central Horticulture Center
CIRAD	French Agricultural Research Centre for International Development
CL	Cue-Lure
Cl	Chlorine
CRD	Completely Randomized Design
CRISP-R	Clustered Regularly Inter-spaced Short Palindromic Repeats
CTV	Citrus Tristeza Virus
Cu	Copper
CVT	Coordinated Varietal Trial
DADO	District Agriculture Development Office
DAP	Di-Ammonium Phosphate
DAS	Double Antibody Sandwich
DCC	District Coordination Committee
DCCI	District Chamber of Commerce and Industry
DG	Director General
DNA	Deoxyribonucleic Acid

DOA	Department of Agriculture
DOAR	Directorate of Agricultural Research
DRIS	Diagnosis and Recommendation Integrated System
DUS	Distinctness, Uniformity and Stability
EC	Emulsifiable Concentrate
ED	Executive Director
ELISA	Enzyme-Linked Immunosorbent Assay
EPA	Environmental Protection Agency
ETDA	Ethylenediaminetetraacetic Acid
ETL	Economic Threshold Level
EU	European Union
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FAT	Farmers Acceptance Test
Fe	Iron
FGD	Focus Group Discussion
FOA	Faculty of Agriculture
FRD	Food Research Division
FTD	Fruit fly per Trap per Day
FYM	Farm Yard Manure
GA	Gibberellic Acid
GACC	General Administration of Custom of the People's Republic of China
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GI	Geographical Indication
GMO	Genetically Modified Organism
GON	Government of Nepal
GREAT	Green Research and Technology
HADP	Hill Agriculture Development Project
HARP	Hill Agriculture Research Project
HDO	Horticulture Development Officer
HDP	Horticulture Development Project
HFDP	Hill Fruit Development Project
HLB	Huanglongbing
HRS	Horticulture Research Station
IAAS	Institute of Agriculture and Animal Science
IAEA	International Atomic Energy Agency
ICARDA	International Centre for Agriculture Research in Dry Area
ICIMOD	International Centre for Integrated Mountain Development
ICS	Internal Control System
IET	Initial Evaluation Trial
INGOs	International Non-Government Organizations
IOCV	International Organization of Citrus Virologists

IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IPPM	Integrated Pest and Pollinator Management
IPR	Intellectual Property Rights
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IYT	Initial Yield Trial
JADP	Janakpur Agriculture Development Project
JICA	Japan International Cooperation Agency
JT	Junior Technician
JTA	Junior Technical Assistant
KIS	Key Informant Survey
LAC	Lumle Agriculture Centre
MAS	Marker Assisted Selection
MBL	Molecular Biotechnology Laboratory
Mg	Magnesium
MLT	Multi-Location Trial
Mn	Manganese
Mo	Molybdenum
MOAC	Ministry of Agriculture and Cooperatives
MOALD	Ministry of Agriculture and Livestock Development
MOFE	Ministry of Forest and Environment
MOICS	Ministry of Industry, Commerce and Supplies
MPHD	Master Plan for Horticulture Development
N	Nitrogen
NAGRC	National Agriculture Genetic Resources Center
NARC	Nepal Agriculture Research Council
NARDF	National Agriculture Research and Development Fund
NAST	Nepal Academy of Science and Technology
NCDP	National Citrus Development Program
NCFD	National Center for Fruit Development
NCPVSCD	National Center for Potato, Vegetable and Spice Crops Development
NCRP	National Citrus Research Program
NGOs	National Non-Government Organizations
NHS	Nepal Horticulture Society
NIPP	National Intellectual Property Policy
NPPO-N	National Plant Protection Organization-Nepal
NPR	Nepalese Rupee
NPWG	National Preparatory Working Group
NSB	National Seed Board
NSP	National Seed Policy
NSPM	National Standard for Phytosanitory Measure
NSSRC	National Soil Science Research Centre
NTIS	Nepal Trade Integration Strategy
OC	Organic Carbon

OM	Organic Matter
OTD	Organ Transplanted Organism
OVOP	One Village One Product
P	Phosphorous
PAC	Pakhribas Agriculture Centre
PACT	Project for Agriculture Commercialization and Trade
PAM	Project Administration Manual
PATWG	Provincial Agricultural Technical Working Group
PAU	Punjab Agricultural University
PCR	Polymerase Chain Reaction
PDO	Protected Designation of Origin
PFA	Pest Free Area
PFD	Post-bloom Fruit Drop
PGI	Protected Geographical Indication
PHMD	Post-Harvest Management Directorate
PIU	Project Implementation Unit
PMAMP	Prime Minister Agriculture Modernization Project
POP	Package of Practices
PPL	Plant Protection Laboratory
PPP	Pocket Package Program
PPPC	Provincial Policy and Planning Commission
PPS	Pocket Package Strategy
PPSN	Plant Protection Society of Nepal
PQPMC	Plant Quarantine and Pesticide Management Centre
PSB	Provincial Seed Board
PVPFR	Plant Variety Protection and Farmers Rights
PVS	Participatory Varietal Selection
R&D	Research and Development
RAPD	Random Amplified Polymorphic DNA
RFLP	Restriction Fragment Length Polymorphism
RONAST	Royal Nepal Academy of Science and Technology
RTWG	Regional Technical Working Group
S	Sulphur
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
SHDO	Senior Horticulture Development Officer
SOP	Standard Operating Procedure
SPP	Sudur Pashchim Province
SQCC	Seed Quality Control Centre
SSR	Simple Sequence Repeat
STG	Shoot Tip Grafting
TA	Titratable Acidity
TLC	Thin Layer Chromatography
TML	Trimed-Lure

TRIPs	Trade-Related Aspects of Intellectual Property Rights
TSG	Traditional Specialties Guaranteed
TSS	Total Soluble Solids
TU	Tribhuwan University
USAID	United States Agency for International Development
USDA	The United States Department of Agriculture
VARRSC	Variety Approval, Release and Registration Sub-Committee
VCU	Value for Cultivation and Use
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WP	Wettable Powder
WTHC	Warm Temperate Horticulture Center
WTO	World Trade Organization
WVC	World Vegetable Center
Zn	Zinc

Contents

Chapter 6 (अध्याय-६)

Photo Gallery

(तस्विरहरु)

Seminar Synopsis
The 14th National Horticulture Seminar, 2024

Background

Nepal has immense potential to produce a wide range of citrus fruit crops and their subsequent value-chain development. Citrus species mainly mandarin, sweet orange and lime are major fruit crops of Nepal. The historical facts clearly indicate that mandarin orange is native fruit of Nepal and has been cultivated from pre-historical period.

Mandarin orange has been a major cash crop among farmers in Nepal ever since its vocational plantation began in Nepal. Various technologies are generated on its variety improvement, nursery establishment, orchard management, plant protection and postharvest management. Commercial production has been expanded to nearly 60 districts of the country. Despite all the efforts, Nepal is still importing significant quantity of citrus fruits annually. A determination is required to mitigate the technological, socio-economical, institutional and policy level constraints providing smooth adoption of improved technologies, commercialization and sustainability of citrus farming in Nepal. Additionally, the contemporary challenges of marketing problems also need to be considered to harness the stated potential.

Aim of the Seminar

The seminar aimed to bring together policy makers, development partners, farmers, academic communities, researchers, scientists, government officials, INGOs, NGOs, journalists, and private sectors to exchange information, experiences and research results on all aspects of specialized and interdisciplinary areas of Mandarin orange in the Nepali context.

Theme of the Seminar

Unveiling Nepal's Mandarin Orange Wealth: From Origin to Prosperity

Composition of Different Committees

To commemorate the seminar in an elegant manner the following different committees had been formed to cooperate and coordinate with each other to execute the activities of the seminar gracefully:

1. Advisory Committee

1. Dr. Govinda Prasad Sharma, Secretary (Agriculture Development), MoALD
2. Dr. Rewati Raman Paudel, Secretary (Livestock Development), MoALD
3. Dr. Dhrubraj Bhattarai, ED, NARC
4. Dr. Hari Bahadur K.C., DG, DoA
5. Dr. Bhargab Dhital, Dean, IAAS

6. Dr. Arjun Kumar Shrestha, Dean, FoA, AFU
7. Mr. Shiva Bahadur Nepali Pradhan, Former President, NHS
8. Mr. Bhairab Raj Kaini, Former President, NHS
9. Mr. Indra Raj Pandey, Former President, NHS
10. Dr. Chiranjeevi Regmi, Life Member, NHS

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8. Poster Evaluation Committee

Chairperson:	Dr. Ramita Manandhar, NHS
Members:	Dr. Kishor Chandra Dahal, Assistant Dean, IAAS/TU
	Mr. Krishna Prasad Poudel, NHS
	Mr. Ganapati Pandey, NHS

Seminar Highlights

Day One: 13th Baishakh 2081 (25th April 2024)

The 14th National Horticulture Seminar commenced on 12th Baishakh 2081 for two days in the Warm Temperate Horticulture Center, Kirtipur, Kathmandu with the theme of "***Unveiling Nepal's Mandarin Orange Wealth: From Origin to Prosperity***". The chief guest, Honorable Agriculture Minister Ms. Jwala Kumari Sah, Ministry of Agriculture and Livestock Development (MoALD) inaugurated the seminar. The chairperson of the opening session was Mr. Gopal Prasad Shrestha, President of Nepal Horticulture Society (NHS). Among the special guests were Dr. Govinda Prasad Sharma, Secretary, MoALD; Dr. Rewati Raman Poudel, Secretary, MoALD; Dr. Surendra Lal Shrestha, Executive Director, Nepal Agriculture Research Council; Dr. Hari Bahadur K.C., Director General, Department of Agriculture and Dr. Kishor Chandra Dahal, Assistant Dean, IAAS. The chief guest inaugurated the conference by watering the mandarin orange plant and presented certificates and prizes to the citrus grower (Mr. Tilak Gurung, Beni-4, Myagdi), the citrus nursery owner (Mr. Bodharaj Aryal, Putalibazaar-11, Syanja), the apple grower (Mr. Hari Bahadur Rokaya, Rara-5, Mugu) and the organic vegetable grower (Mr. Ramesh Khadka, Suryabinayak-4, Bhaktapur). Also she awarded two topper students with the Excellence Award in Horticulture Education (M.Sc. Ag.) respectively for the year 2077/78 (Mr. Sudeep Regmi, TU/IAAS, Kathmandu) and 2078/79 (Mr. Pradeep Regmi, AFU, Chitwan).

14th National Horticulture Seminar commenced on 12th Baishakh, 2081

Chief Guest Honorable Jwala Kumari Sah, Minister, MoALD addressing the seminar

Dr. Shanta Karki, Chief of the National Center for Fruit Development welcomed the chief guest, special guests, guests and all participants. After that she presented the thematic paper of the seminar entitled Mandarin Orange: The National Fruit of Nepal. After the inaugural address of honorable minister and secretary of the MoALD, Mr. Gopal Prasad Shrestha, president and chairperson of the inaugural session with his closing remarks declared the end of the inaugural session. The master of ceremony was facilitated by Ms. Yam Kumari Shrestha, SFDO, NCFD.

The inaugural ceremony was witnessed by 200 participants including students from Tribhuwan University, Institute of Agriculture and Animal Science, Agriculture and Forestry University and delegates and representatives from different agriculture institutions and was followed by technical paper presentation sessions.

Dr. Shanta Karki, Chief, NCFD welcoming the guests and participants

Inaugural Session of the
14th National Horticulture Seminar

Banner of the organizers in the 14th National Horticulture Seminar, 2081

Thematic Session

There were two thematic papers regarding national fruit i.e. mandarin orange, five development papers regarding the management of mandarin orange, five research papers in mandarin orange and six geographical indication (GI) survey report paper of mandarin from the whole country were presented. Each technical session was facilitated by a chairperson and each paper was assisted by one rapporteur. There were 186 participants in the technical session.

Group Photo with the guests, NCFD Chief and NHS Past Presidents

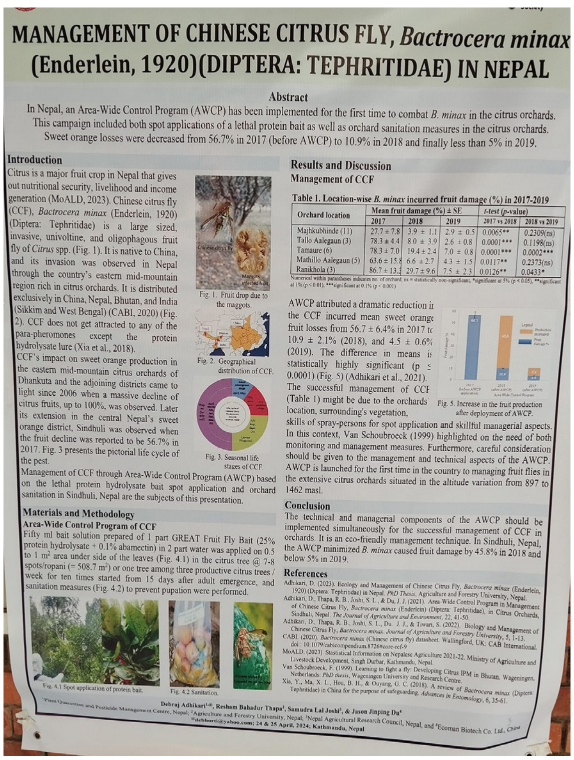
Day Two: 13th Baishakh 2081 (25th April 2024)

Technical Session

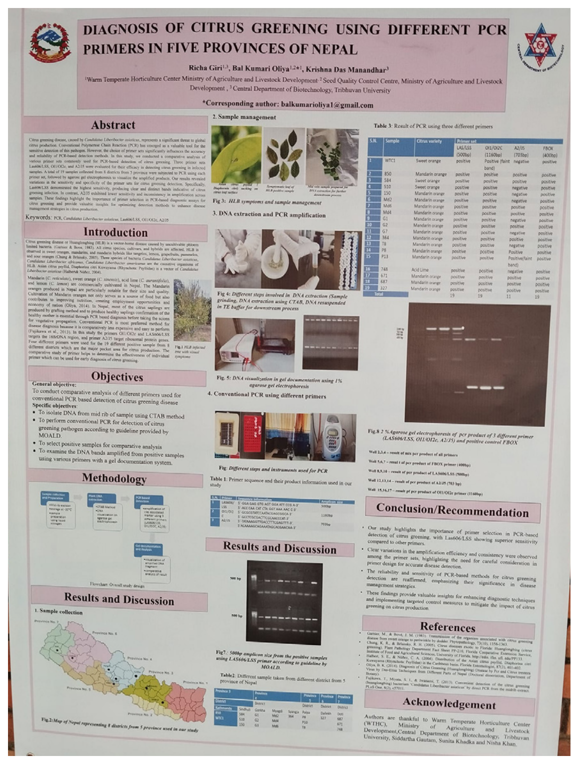
There were altogether seven technical sessions and 45 Paper presenters in total and they presented technical papers in their respective fields. Each technical session was facilitated by a chairperson and each paper was was assisted by one rapporteur. Three technical posters were also being presented simultaneously and evaluated by the evaluation team.

Participants in the Technical paper presentation session of the seminar

Technical poster is being evaluated by the experts in the poster presentation in the 14th NHS, 2081



Poster presentation in the seminar



Poster presentation in the seminar

Each technical session namely, Geographical Indication; Orchard and Nursery Management; Government Farm, Nursery and Province Status; Disease and Pest; Variety and Bio-Diversity; Post-harvest Management, Marketing and Value chain; and Program and Policy was followed by discussion and interaction on the paper presented in the technical sessions for preparing a way forward document that would serve as a guidelines document for the development of horticulture especially mandarin orange in the future. There were 186 participants in the technical session.

Closing Session

The session was chaired by the president of NHS Mr. Gopal Prasad Shrestha and the chief guest was Dr. Govinda Prasad Sharma, the secretary of MoALD. The chairperson of the session presented the certificates to the participants of the poster presentation and the chief guest awarded the winners of the poster presentation.

After the closing address of the chief guest, the chairperson ended the session with his closing remarks. There were 186 participants in the closing session.

Closing ceremony addressing by the Chief Guest, Dr. Govinda Prasad Sharma, Secretary, MoALD

Mr. Gopal Prasad Shrestha, President, NHS ending the session with closing remarks

Group photo at the closing ceremony of the 14th National Horticulture Seminar, 2081

Consequential of the Seminar

- Fact sheet of mandarin orange should be prepared.
- Since mandarin is declared as national fruit of Nepal, special programs for development

of mandarin sector should be implemented.

- The Paripatle, Kirtipur and Palpa farm should be established as the Citrus Excellence Centers.
- Research and development activities regarding mandarin orange should be increased.
- Roaster of citrus experts should be prepared.
- Lead institution/organization should be established to look after national citrus program.
- Study related to DNA fingerprint and documentation should be done to identify characteristics of mandarin, geographical indication (GI) and patent right.
- Initiation of commercial livestock farms' linkage with citrus orchard to increase the soil organic matter of the orchard.
- Capacity enhancement of technicians and farmers.
- Saplings production in closed structure.
- Term of reference (ToR) of the farm for further dissemination of modern technologies should be updated.
- Acts and regulations related to quality saplings production and distribution should be formulated.
- Record keeping of the nurseries should be formalized with role and responsibilities among 3-tiers of government.
- Implementation of nursery standard, guideline and regular monitoring of private nurseries with clear role and responsibilities.
- Citrus bud-wood certification system for quality sapling production and use of those for orchard establishment should be implemented.
- Awareness and capacity building should be focused for disease and pest management.
- Internal quarantine protocol should be implemented strictly.
- Policy and program related to incentive to farmer for removing the greening affected plant should be prepared.
- Germplasm conservation should be continued and varieties should be registered.
- Phenological characterization of germplasms collected in government farm/centers should be documented.
- Early, medium and late varieties should be developed by NARC.
- Requirements for export (quarantine, post-harvest treatments) should be fulfilled.
- Establishment of processing industries and cold storage facilities.
- Post-harvest handling and storage practices should be strengthened.
- Quality and grade standard should be defined.
- A Postharvest division should be created to conduct postharvest research and technology development.
- Scientists working in citrus should not be transferred to other disciplines.

करेसाबारीमा सुन्तला खेती

Chapter

1

History, Tradition and Socio-cultural Aspects of *Mandarin Orange in Nepal*

नेपालको राष्ट्रिय फल सुन्तला

Charting *Suntala*'s Course as Nepal's National Fruit

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Abstract

This article is a testament to the advocacy and continuous efforts that have led to the declaration of *Suntala* (Mandarin orange) as the national fruit of Nepal. *Suntala*'s unique flavor, color, and cultural significance have long been recognized, and its newfound status as the national fruit further highlights its intrinsic qualities and economic potential. Cultivation of *Suntala* is thriving across Nepal's mid-hills which contributes to the nation's citrus production, occupying extensive land area. This designation strengthens the citrus industry, elevates Nepal's standing in the global fruit market, and fosters sustainable economic growth by attracting investment and promoting exports. Moreover, *Suntala*'s nutritional value, rich in vitamins, minerals, antioxidants, and dietary fiber, highlights its importance in promoting public health and encouraging healthier dietary choices. The national recognition of *Suntala* raises awareness about its health benefits as well as promotes environmentally sustainable farming practices, contributing to soil health and biodiversity conservation in the mid-hills. The designation incentivizes further research and development in citrus farming, aiming to improve yields and enhance environmental sustainability. Ultimately, *Suntala*'s national recognition ignites national pride, resonating with Nepal's cultural heritage and celebrating the country's rich agricultural diversity.

Keywords: Cultural symbolism, Economic potential, Environmental conservation, Global fruit market, Sustainable farming practices

Introduction

With the declaration of *Suntala* (Mandarin orange) as the national fruit of Nepal, the country joins the ranks of nations worldwide that have a recognized fruit as emblematic of their national identity. Countries such as India, which chose Mango, and the Philippines, which also opted for Mango, have long used their national fruits to symbolize cultural heritage and agricultural abundance (Swaminathan, 2023). Before this declaration, Nepal had already acknowledged the cow as its national animal, the rhododendron as its national flower, crimson red as its national color, and the Lophophores as its national bird, but the absence of a national fruit had been a long standing gap in its symbolic repertoire. While Nepal has a rich diversity of fruits, ranging from tropical mangoes and bananas to sub-tropical citrus fruits and temperate apples, the formal recognition of *Suntala* as the national fruit fills this void and reinforces the country's agricultural significance.

The decision to designate *Suntala* as the national fruit of Nepal carries profound implications for various stakeholders, including farmers, consumers, traders, experts, scientists and the nation as a whole. *Suntala*'s official recognition not only acknowledges its cultural and economic importance but also highlights its potential to drive agricultural development and international trade. By conferring national status upon *Suntala*, Nepal signals its commitment to promoting the cultivation, preservation, and promotion of this indigenous fruit, thereby creating opportunities for rural livelihoods, culinary innovation, and tourism (both domestic and foreign tourists) attraction. Moreover, the adoption of *Suntala* as the national fruit underscores Nepal's efforts to harness its agricultural heritage for sustainable development and cultural preservation, paving the way for a fruitful future for generations to come.

Methodology

The concept of this article originated from a metamorphosis of diverse official documents strategically drafted to persuade bureaucratic and political leaders of Nepal to declare *Suntala* as the national fruit of Nepal. The foundation of our review draws upon many references, encompassing native fruits, popular choices among the people, local songs, stories, myths, and tales.

To support our narrative, we collected data from local newspapers reporting on the status and impact of fruits on the lives of farmers. The research process involved a systematic examination of various mediums, including books, research articles, reviews, analyses, and newspaper mentions, to gather a diverse range of perspectives and insights. These mediums provided foundational knowledge and historical context, contributing to the development of a well-informed narrative.

We listened to the interviews with experts and scientists in the field which provided valuable insights, addressing any informational gaps that surfaced during the compilation process. These inputs were integrated into the article, enhancing the overall comprehensiveness and depth of our review.

Findings

The *Suntala* is the most popular fruit in Nepal. It is grown in sixty-six districts and cultivated commercially in fifty-six districts. It is traded, consumed, and liked in all places in Nepal. The adoption of *Suntala* as Nepal's national fruit has spurred a wave of positive developments across the country. *Suntala* cultivation has boosted options for agricultural production, rural incomes, and biodiversity conservation. It has become a symbol of national pride, promoting branding, cultural recognition, and culinary innovation. Support from the government, other stakeholders, and educational initiatives will further empower farmers with knowledge and resources, while export opportunities and tourism development fuel economic growth. *Suntala*'s rich nutritional content contributes to better health and dietary diversity, and international collaboration strengthens Nepal's position in the global citrus market. Overall, *Suntala*'s national fruit status has become a powerful driver of agricultural development, economic prosperity, and cultural vibrancy for Nepal.

The declaration of *Suntala* as the national fruit has opened up the following prospectives

Agricultural promotion

This citrus fruit, known for its vibrant color, sweet taste, aroma, and rich nutritional content, has spurred increased cultivation efforts across various regions of Nepal. Farmers have been incentivized to expand their orchards and invest in *Suntala* cultivation, thereby boosting agricultural productivity and rural incomes. The promotion of *Suntala* has also encouraged agricultural diversification, reducing dependence on traditional crops and mitigating risks associated with mono-cropping. Furthermore, the recognition of *Suntala* as a national symbol has enhanced its marketability both domestically and internationally, opening up avenues for export and trade. This has led to economic growth in rural areas, fostering sustainable development and poverty reduction.

Moreover, the announcement of *Suntala* as the National fruit of Nepal has catalyzed research and development initiatives aimed at enhancing cultivation techniques, improving post-harvest practices, and developing value-added products. Agricultural institutions and research organizations have intensified efforts to breed high-yielding and disease-resistant *Suntala* varieties tailored to Nepal's agro-climatic conditions. Additionally, government policies and programs have been formulated to provide technical assistance, training, and financial support to *Suntala* farmers, further incentivizing its cultivation. The promotion of *Suntala* has also fostered agro-tourism, with tourists visiting orchards to experience *Suntala* harvesting, tasting and processing firsthand, thereby generating additional income streams for rural communities. Overall, the adoption of *Suntala* as the National fruit of Nepal has not only elevated its cultural significance but has also played a pivotal role in promoting agricultural development, enhancing food security, and advancing rural livelihoods.

Biodiversity conservation

First and foremost, the increased cultivation of *Suntala* will lead to the preservation of diverse citrus varieties native to Nepal. Farmers are now motivated to maintain traditional *Suntala* orchards alongside newer cultivars, thus safeguarding genetic diversity within the citrus species. This preservation of genetic resources is essential for maintaining resilience in the face of environmental challenges such as pests, diseases, and climate change. Moreover, the promotion of *Suntala* cultivation has encouraged agroforestry and hortoforestry practices, with farmers integrating citrus trees into mixed cropping systems. *Suntala* trees have been used to control soil erosion in the hilly terraces. To conserve moisture and provide organic matter in the *Suntala* orchard farmers use green manures and mulching which also help in biodiversity conservation. This agroecological approach not only enhances soil health and water retention but also provides habitat and food sources for diverse flora and fauna, thereby promoting overall ecosystem health and biodiversity.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal has sparked conservation efforts aimed at protecting the natural habitats of wild citrus species. Conservation organizations and governmental agencies have collaborated to establish protected areas and conservation corridors for wild citrus populations, ensuring the survival of endangered species and their associated ecosystems. By raising awareness about the importance of citrus biodiversity, the designation of *Suntala* as the national fruit has also fostered community engagement in conservation efforts. Local communities are now actively involved in habitat restoration, seed banking, and sustainable harvesting practices, thereby contributing to the long-term conservation of Nepal's citrus heritage. In this way, the adoption of *Suntala* as a symbol of national pride has not only promoted agricultural development but has also catalyzed biodiversity conservation, ensuring the continued existence of diverse citrus species and their ecological significance.

Branding and identity

Naming a National fruit has played a pivotal role in branding and enhancing the identity of Nepali mandarin oranges both domestically and internationally. This designation has provided a unique selling proposition for Nepali oranges, distinguishing them from oranges produced in other regions and elevating their perceived quality and value. The *Suntala* brand now embodies the rich cultural heritage and agricultural in general and horticultural excellence in particular of Nepal, serving as a symbol of national pride and identity. This branding has facilitated market differentiation and increased market visibility for Nepali mandarin oranges, leading to greater consumer recognition and demand. Additionally, the association of *Suntala* with Nepal's national identity has created opportunities for marketing and promotional campaigns that highlight the unique characteristics and benefits of Nepali mandarin oranges, further enhancing their market appeal.

Moreover, the recognition of *Suntala* as the National Fruit of Nepal has facilitated the development of geographical indication (GI) protection right for one of the Nepalese indigenous citrus species, further bolstering their branding and identity. GI tag provides legal recognition and protection for products with specific geographical origins and unique qualities bestowed by the geographical or environmental specilaiaties, preventing unauthorized use of the *Suntala* name and ensuring the integrity of Nepali orange products in the marketplace. This recognition not only adds value to Nepali oranges but also fosters trust and confidence among consumers, who associate GI status with authenticity and superior quality. As a result, Nepali oranges have gained a competitive edge in both domestic and international markets, commanding premium prices and driving economic growth for citrus farmers and rural communities. In essence, the adoption of *Suntala* as the National fruit of Nepal has not only strengthened the branding and identity of Nepali mandarin oranges but has also contributed to their market success and sustainable development.

Community development

The commercial cultivation of *Suntala* has significant impact on creation of employment opportunities within rural communities. The increased cultivation of *Suntala* has generated demand for labor and skilled human resource in orchards, nurseries, processing industries and marketing facilities, providing livelihoods for residents of rural and urban people. Moreover, the expansion of *Suntala* cultivation has stimulated the growth of ancillary industries such as transportation, per-cooling, grading, packaging, and marketing, further diversifying job prospects in rural, semi-urban and urban areas. This has not only reduced unemployment but has also empowered individuals, particularly women, disadvantaged groups (DAGs) and marginalized groups, by offering them avenues for economic independence and social mobility.

Additionally, the promotion of *Suntala* has facilitated infrastructure development in rural communities. As *Suntala* cultivation requires adequate irrigation, access to markets, and transportation networks, government and non-governmental organizations have invested in improving rural infrastructure such as roads, irrigation systems, and market facilities. These infrastructure investments have not only enhanced the efficiency of agricultural production but have also improved overall connectivity and access to essential services, thereby enhancing the quality of life for rural residents. Furthermore, the recognition of *Suntala* as a symbol of national identity has instilled a sense of pride and cohesion within communities, fostering social capital and collective action for community development initiatives. Overall, the adoption of *Suntala* as the National fruit of Nepal has played a pivotal role in promoting community development by creating employment opportunities, stimulating infrastructure investments, and fostering social cohesion within rural areas.

Culinary innovation

The adoption of a national fruit will spur culinary innovation and creativity, transforming traditional recipes and culinary practices. *Suntala*'s unique flavor profile, characterized by its sweet and tangy taste, has inspired chefs and home cooks alike to experiment with incorporating this versatile citrus fruit into a wide array of dishes. From savory sauces and marinades to sweet desserts and beverages, *Suntala* adds a distinctive and refreshing twist to Nepali cuisine. Restaurants and food establishments have capitalized on the popularity of *Suntala* by featuring it prominently in their menus, attracting both locals and tourists eager to savor its delightful taste. Moreover, the adoption of *Suntala* has led to the development of value-added products such as *Suntala* juice, jams, marmalade, squash, jelly, and candies, providing additional opportunities for culinary innovation and entrepreneurship. This diversification of *Suntala*-based products not only stimulates economic growth but also promotes the preservation and promotion of Nepal's culinary heritage.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal has fostered cross-cultural culinary exchanges and collaborations, leading to the fusion of Nepali cuisine with international flavors. Chefs and food enthusiasts from around the world have been drawn to Nepal to explore the culinary possibilities offered by *Suntala*, resulting in the infusion of global cooking techniques and ingredients into traditional Nepali dishes. This cultural exchange enriches the culinary landscape of Nepal, offering diners a more diverse and dynamic dining experience. Additionally, the popularity of *Suntala*-inspired dishes has contributed to the promotion of Nepali cuisine on the global stage, attracting attention and admiration for its unique flavors and innovative culinary creations. Overall, the adoption of *Suntala* as the National fruit of Nepal has sparked a culinary renaissance, inspiring chefs, entrepreneurs, and food lovers to push the boundaries of creativity and innovation in Nepali's gastronomy.

Cultural recognition

It will catalyze a profound resurgence in cultural recognition both within Nepal and on the global stage. *Suntala* holds deep roots in Nepali culture, symbolizing hospitality, prosperity, and auspiciousness. By bestowing official recognition upon *Suntala*, Nepal has reaffirmed its cultural identity and heritage, celebrating the traditions intertwined with citrus cultivation and consumption. This acknowledgment has not only bolstered national pride but has also fortified social bonds, fostering communal celebrations during festivals and rituals associated with *Suntala*, such as the Nepali New Year (Nepal Sambat) and the auspicious Hindu festival of Dashain. Furthermore, the designation of *Suntala* as a national symbol has amplified Nepal's cultural diplomacy, serving as a distinct emblem of Nepali identity on the global stage. This has cultivated broader awareness and appreciation for Nepali culture, cuisine, and agricultural practices worldwide, enticing tourists and fostering cultural exchange.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has sparked a renaissance in cultural innovation and creativity, inspiring artists, musicians, and writers to weave themes of citrus cultivation and symbolism into their works. *Suntala* has emerged as a muse for song composers, poets, painters, and artisans, prominently featured in traditional art forms such as *Thangka* painting, wood carving, and pottery. This artistic expression not only safeguards and propagates Nepali cultural heritage but also nurtures a profound sense of pride and unity among Nepali communities, both at home and across borders. Additionally, the promotion of *Suntala* has spurred the development of culinary traditions and gastronomic tourism, with chefs and food enthusiasts exploring inventive methods to showcase the versatility and exquisite flavor of Nepali citrus fruits. Thus, the adoption of *Suntala* as the National fruit of Nepal has not only revitalized cultural recognition but has also ignited a spirit of ingenuity, entrepreneurship, and cultural interchange, enriching the vibrant tapestry of Nepali society.

Economic boost

The adoption of national fruit has become instrumental in providing a significant economic boost to the country. This designation has propelled *Suntala* into the spotlight, both domestically and internationally, increasing its market demand and value. With heightened recognition and promotion, *Suntala* cultivation has expanded across various regions of Nepal, leading to increased agricultural productivity and rural incomes. The economic benefits of *Suntala* cultivation extend beyond the farm gate, as the fruit's popularity has stimulated growth in related activities such such as harvesting, grading, pre-cooling, transportation, packaging, and agro-processing industries. Additionally, the export potential of *Suntala* has been unlocked, with Nepali farmers gaining access to international markets and generating foreign exchange earnings for the country. This increased trade has not only bolstered Nepal's economy but has also created employment opportunities along the value chain, from farm laborers to exporters, further contributing to economic growth and poverty reduction resulting in improved livelihoods. Nepal has already signed a MoU with the Government of China for *Suntala* (mandarin orange) and *Junar* (sweet orange) export (Aryal *et al*, 2022) so adopting good orchard management pratices will enhance this opportunity and open up marketing opportunities with other countries also.

Moreover, the promotion of *Suntala* as the National fruit of Nepal will catalyze tourism development, as visitors flock to orchards to experience *Suntala* harvesting, tasting and processing firsthand. Agro-tourism has emerged as a thriving sector, with tourists contributing to local economies through accommodation, dining, and purchases of *Suntala*-related products. Furthermore, the recognition of *Suntala* as a symbol of Nepali identity has boosted cultural tourism, attracting travelers eager to explore the cultural heritage and culinary traditions associated with the fruit. This influx of tourism revenue has not only diversified Nepal's economic base but has also promoted sustainable development in rural areas, where *Suntala* cultivation is prevalent. Overall, the adoption of *Suntala* as the National fruit of Nepal has led to a multifaceted economic boost, stimulating agricultural growth, fostering trade and employment, and driving tourism development, thereby contributing to the overall prosperity of the country.

Educational initiatives

This adoption of national fruit can be used to spark various educational initiatives aimed at promoting awareness, knowledge, and skills related to citrus cultivation, agriculture, and sustainability. Educational institutions, including schools, colleges, and universities, have integrated *Suntala* into their curricula, offering courses, workshops, and field trips focused on citrus farming techniques, agroecology, and rural development. By incorporating *Suntala* into formal education, Nepal is nurturing a new generation of farmers, horticulturists, and agricultural entrepreneurs equipped with the knowledge and skills needed to thrive in the citrus industry. Moreover, educational initiatives centered around *Suntala* have fostered interdisciplinary learning, encouraging students to explore topics such as environmental science, economics, and cultural studies through the lens of citrus cultivation and its socio-economic implications. This holistic approach to education not only enhances academic outcomes but also instills a sense of environmental stewardship, reearch and community engagement among students, preparing them to address the complex challenges facing Nepal's citriculture, one of the major horticultural sub- sectors.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal has catalyzed vocational training programs and capacity-building initiatives targeted at rural communities, particularly women, youths and marginalized groups. Non-governmental organizations (NGOs) and governmental agencies have partnered to offer training in citrus nursery management, organic farming practices, and value-added processing techniques, empowering farmers to improve productivity, quality, and market access. These educational initiatives not only enhance livelihood opportunities but also promote gender equality and social inclusion by providing women, youths and marginalized groups with the skills and resources needed to participate meaningfully in the citrus value chain. Additionally, educational campaigns and extension services disseminate information about sustainable agricultural practices, pest and disease management, integrated soil nutrient management for better production and climate-resilient farming techniques, empowering farmers to adapt to changing environmental conditions and mitigate risks. By investing in education and training related to *Suntala* cultivation, Nepal is laying the groundwork for a more resilient, equitable, and prosperous agricultural sector, fostering sustainable development and poverty alleviation in rural communities.

Environmental stewardship

It prompts a heightened sense of environmental stewardship across the country. One significant aspect is the promotion of sustainable agricultural practices in *Suntala* cultivation. Farmers are increasingly embracing organic farming methods, reducing reliance on chemical inputs, and implementing agroecological approaches that prioritize soil health and biodiversity conservation. By minimizing the use of pesticides and synthetic fertilizers, *Suntala* growers are safeguarding the ecological balance of their farmlands and mitigating environmental pollution, thus contributing to the overall health of Nepal's ecosystems. Furthermore, the adoption of *Suntala* as a symbol of national pride has sparked awareness campaigns and environmental education initiatives aimed at fostering a deeper appreciation for the interconnectedness of agriculture and the environment. Through workshops, seminars, and community outreach programs, stakeholders are empowered to adopt practices that minimize environmental impact, such as water conservation, waste reduction, and habitat restoration, thereby fostering a culture of environmental responsibility.

Moreover, the designation of *Suntala* as the National fruit of Nepal has catalyzed conservation efforts aimed at protecting the natural habitats and biodiversity hotspots associated with citrus cultivation. Conservation organizations, governmental agencies, and local communities are collaborating to establish protected areas, conservation corridors, and wildlife sanctuaries that safeguard critical ecosystems and endangered species. By conserving these habitats, Nepal not only preserves its rich natural heritage but also maintains essential ecosystem services such as pollination, soil fertility, and water regulation. Additionally, the promotion of agroforestry practices in *Suntala* cultivation contributes to carbon sequestration and climate change mitigation, as citrus orchards act as carbon sinks and enhance landscape resilience. Through these multifaceted initiatives, the adoption of *Suntala* as the National fruit of Nepal underscores the country's commitment to environmental stewardship, promoting sustainable development practices that balance economic growth with ecological conservation for the benefit of present and future generations.

Export opportunities

It is time to expand export opportunities for the country, leveraging its unique citrus industry to access international markets. With *Suntala* gaining recognition as a symbol of Nepal's agricultural prowess and cultural heritage, it has become a flagship export product, attracting attention from buyers around the world. The designation of *Suntala* as the national fruit has served as a powerful marketing tool, enhancing the product's appeal and distinguishing it from competitors in the global marketplace. This increased visibility has facilitated entry into new markets and has opened doors for Nepali exporters to showcase the quality and authenticity of their citrus produce. Additionally, the promotion of *Suntala* cultivation has led to improvements in post-harvest handling and packaging practices, ensuring that exported fruits meet international standards for freshness and safety, thereby enhancing Nepal's reputation as a reliable supplier of premium citrus products.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has stimulated investment in infrastructure and logistics, strengthening the country's export capacity and competitiveness. Government initiatives and private sector partnerships have focused on upgrading transportation networks, cold storage facilities, and processing centers, reducing supply chain inefficiencies, and ensuring timely delivery of *Suntala* to international markets. Furthermore, the recognition of *Suntala* as a national symbol has facilitated trade negotiations and promotional campaigns, with Nepali diplomats and trade delegations advocating for preferential treatment and market access for Nepali citrus exports. As a result, Nepal has been able to capitalize on the growing demand for exotic fruits and premium agricultural products in markets such as Europe, North America, and the Middle East, thus diversifying its export portfolio and generating foreign exchange earnings vital for economic growth and development. Overall, the adoption of *Suntala* as the National fruit of Nepal has not only expanded export opportunities but has also positioned Nepal as a key player in the global citrus industry, contributing to the country's socio-economic advancement.

Farmer empowerment

It should be an instrumental step in empowering farmers across the country, particularly those engaged in citrus cultivation. With *Suntala* receiving national recognition and support, farmers have been encouraged to expand their orchards and invest in citrus production, leading to increased agricultural productivity and rural incomes. This empowerment stems from various factors, including enhanced access to markets, technical assistance, and financial resources. Government programs and initiatives aimed at promoting *Suntala* cultivation provide farmers with training on best practices, modern techniques, and pest and soil nutrient management strategies, empowering them with the knowledge and skills needed to optimize yields and ensure crop quality. Furthermore, the designation of *Suntala* as a national symbol has elevated its market value, enabling farmers to fetch higher prices for their produce both domestically and internationally, thus improving their economic status and livelihoods.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has fostered community cohesion and collective action among farmers, leading to increased collaboration and mutual support. Farmers are now organized into farmers groups, cooperatives and associations, allowing them to pool resources, share knowledge, and negotiate better terms with buyers and suppliers. This collective empowerment has enabled smallholder farmers, in particular, to access markets and opportunities that were previously out of reach, reducing their vulnerability to market fluctuations and middlemen exploitation. Additionally, the promotion of *Suntala* cultivation has created employment opportunities along the value chain, from farm laborers to agro-processing workers, further empowering rural communities and stimulating economic growth in Nepal's agricultural heartlands. Overall, the adoption of *Suntala* as the National fruit of Nepal has not only empowered individual farmers but has also strengthened the resilience and sustainability of Nepal's agricultural sector, paving the way for inclusive development and poverty reduction.

Government support

Government support and intervention aimed at promoting its cultivation and enhancing the country's agricultural sector should be the next step. Recognizing the economic, cultural, and nutritional significance of *Suntala*, the Nepalese government has implemented various policies and initiatives to support citrus farmers and boost production. These efforts include financial incentives, subsidies, and credit facilities to facilitate investment in *Suntala* orchards and infrastructure development. Additionally, the government has prioritized research and development in citrus farming, allocating resources for breeding programs, disease management, and the adoption of sustainable agricultural practices. Furthermore, the designation of *Suntala* as a national symbol has led to the establishment of specialized agencies and institutions tasked with overseeing citrus cultivation, marketing, and export promotion, ensuring coordinated efforts and effective implementation of government policies.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has influenced broader agricultural policies and strategies, emphasizing the importance of crop diversification, value addition, and market linkages. The government has integrated *Suntala* cultivation into its broader agenda for agricultural development, recognizing its potential to contribute to food security, rural livelihoods, and poverty alleviation. Furthermore, the promotion of *Suntala* has been leveraged in international trade negotiations and diplomatic engagements to showcase Nepal's agricultural prowess and enhance its global competitiveness. Through targeted support and strategic interventions, the government aims to harness the full potential of *Suntala* cultivation to drive rural development, economic growth, and sustainable food systems in Nepal. Overall, the adoption of *Suntala* as the National fruit of Nepal reflects the government's commitment to supporting and promoting agricultural innovation, entrepreneurship, and resilience in the face of evolving socio-economic challenges.

Health and nutrition advantages

The adoption of *Suntala* as the National fruit of Nepal will bring numerous health and nutrition advantages to the population. *Suntala* is renowned for its rich nutritional profile, being an excellent source of vitamin C, dietary fiber, and various antioxidants. The widespread cultivation and consumption of *Suntala* have contributed to improved dietary diversity and micronutrient intake among Nepali communities, particularly in rural areas where access to fresh fruits and vegetables may be limited. The high vitamin C content in *Suntala* supports immune function, helping to combat infectious diseases and reduce the incidence of illnesses such as colds and flu. Additionally, the dietary fiber in *Suntala* promotes digestive health and may help prevent chronic conditions such as constipation, heart disease, and diabetes. By incorporating *Suntala* into their diets, Nepali individuals and families can enjoy the health benefits of this nutritious fruit, leading to improved overall well-being and quality of life.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal has spurred initiatives and campaigns aimed at raising awareness about the importance of fruit consumption for health and nutrition. Government agencies, non-profit organizations, and community groups have launched educational programs promoting the consumption of *Suntala* and other locally-grown fruits as part of a balanced diet. These efforts have focused on reaching vulnerable populations such as children, pregnant women, and the elderly, emphasizing the role of fruits like *Suntala* in preventing malnutrition, micronutrient deficiencies, and diet-related diseases. Moreover, the cultivation of *Suntala* has provided employment opportunities in rural areas, contributing to poverty reduction and food security. As *Suntala* production continues to expand, it not only provides health benefits to consumers but also economic opportunities for farmers and communities, thus contributing to the overall well-being and resilience of Nepal's population

International collaboration

It will catalyze international collaboration and partnerships aimed at promoting agricultural development, trade, and cultural exchange. Recognizing the potential of *Suntala* as a flagship export product, Nepal has actively engaged with international stakeholders, including governments, multilateral organizations, and private sector entities, to strengthen its position in global citrus markets. Bilateral and multilateral trade agreements have been negotiated to facilitate the export of *Suntala* to countries around the world, leveraging diplomatic channels to overcome trade barriers and regulatory hurdles. Additionally, international development agencies and non-governmental organizations have provided technical assistance, capacity building, and financial support to enhance citrus production, post-harvest handling, and marketing capabilities in Nepal. Through collaborative efforts, Nepal has been able to tap into international expertise and resources, accelerating the growth of its citrus industry and expanding opportunities for farmers and exporters.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has promoted cultural diplomacy and people-to-people exchanges, fostering greater understanding and appreciation between Nepal and its international partners. *Suntala* has become a symbol of Nepali identity and hospitality, serving as a center piece in cultural events, festivals, and diplomatic receptions both at home and abroad. Nepali embassies, consulates, and cultural centers worldwide showcase *Suntala* as a unique aspect of Nepali culture, attracting interest and curiosity from foreign audiences. This cultural recognition has facilitated broader collaborations in areas such as tourism promotion, education, and sustainable development. Furthermore, international visitors and tourists are drawn to Nepal to experience *Suntala* harvesting and processing firsthand, contributing to the growth of agro-tourism and cultural exchange programs. In this way, the adoption of *Suntala* as the National fruit of Nepal has not only strengthened economic ties with international partners but has also deepened cultural connections, enriching Nepal's global engagement and fostering mutual understanding and cooperation.

Job creation

This step will play a pivotal role in job creation across various sectors of the economy. As *Suntala* cultivation expands in response to increased demand and government support, there is a growing need for labor in orchards, nurseries, and establishment of the processing industries. This surge in agricultural activity has created employment opportunities for rural communities, providing livelihoods for farmers, farmworkers, and agricultural technicians. Additionally, the development of ancillary industries such as packaging, transportation, and marketing has further boosted job creation along the *Suntala* value chain. Small-scale entrepreneurs have emerged to meet the demand for value-added products such as *Suntala* juice, jams, and candies, generating employment in food processing and agro-processing industries. Moreover, the promotion of *Suntala* has stimulated agro-tourism and hospitality sectors, with visitors flocking to citrus orchards for agro-tourism experiences, creating jobs in ecotourism, hospitality, and local handicrafts.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal will catalyze job creation through government initiatives and private sector investments in infrastructure and rural development. The government's focus on enhancing post-harvest handling facilities, cold storage, and transportation networks has generated employment opportunities in construction, logistics, and maintenance. Moreover, the establishment of research institutions and agricultural extension services has created jobs for scientists, agronomists, and educators, driving innovation and knowledge dissemination in the agricultural sector. Additionally, the recognition of *Suntala* as a national symbol has attracted investment in branding, marketing, and international trade, leading to job creation in sectors such as advertising, export management, and trade facilitation. Overall, the adoption of *Suntala* as the National fruit of Nepal has not only boosted agricultural employment but has also spurred economic growth and diversification, creating opportunities for sustainable development and poverty alleviation across the country.

Research and development

It will surge in research and development initiatives aimed at advancing citrus cultivation techniques, sapling production technologies, enhancing fruit quality, and addressing agricultural challenges. With *Suntala* receiving national recognition and support, research institutions, agricultural universities, and government agencies have intensified their efforts to improve citrus production through scientific innovation. Research projects focus on breeding high-yielding and disease-resistant *Suntala* varieties tailored to Nepal's diverse agro-climatic conditions, ensuring resilience to pests, diseases, and environmental stressors. Additionally, research is underway to optimize cultivation practices, irrigation management, and soil fertility to maximize yields and minimize input costs for farmers. Furthermore, research and development efforts extend to post-harvest technologies, storage solutions, and value-added product development, aimed at reducing post-harvest losses, extending shelf life, and increasing the marketability of *Suntala* both domestically and internationally. Through collaborative partnerships and interdisciplinary approaches, research and development in *Suntala* cultivation contribute to the sustainable growth of Nepal's agricultural sector, driving innovation, productivity, and economic prosperity.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has fostered a culture of scientific inquiry and knowledge sharing, leading to capacity building and skill development in agricultural research. Research institutions collaborate with international partners, participate in scientific exchanges, and leverage technological advancements to accelerate progress in citrus research. Additionally, government funding and support for research projects enable scientists and researchers to conduct field trials, collect data, and disseminate findings to stakeholders across the agricultural value chain. Furthermore, research and development in *Suntala* cultivation have implications beyond agriculture, with studies exploring the potential health benefits, culinary applications, and cultural significance of *Suntala*. This interdisciplinary research approach fosters a holistic understanding and appreciation of *Suntala*'s role in Nepal's economy, environment, and society. Overall, the declaration of *Suntala* as the National fruit of Nepal will further promote research and development activities, driving scientific innovations, knowledge creation, and development of sustainable agricultural practices for the benefit of present and future generations.

Rural-urban linkages

This adoption will strengthen rural-urban linkages by creating symbiotic relationships between agricultural producers in rural areas and urban consumers and markets. As *Suntala* cultivation expands in rural regions, there is a growing need for transportation, logistics, and marketing services to connect farmers with urban markets. This has led to the emergence of intermediary actors such as traders, wholesalers, and transporters who facilitate the movement of *Suntala* from farms to urban centers. Additionally, the promotion of *Suntala* has spurred investments in agro-processing facilities for product diversificationand value-addition industries in both rural and urban areas, creating employment opportunities and economic synergies across the supply chain. Moreover, the recognition of *Suntala* as a national symbol will increase consumer demand and appreciation for Nepali citrus products in urban markets, driving sales and revenue for the rural producers. This interdependence between rural *Suntala* growers and urban consumers fosters economic integration and mutual benefits, contributing to the overall development and prosperity of Nepal's rural and urban communities.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal has facilitated cultural exchanges and social interactions between rural and urban populations, bridging geographic and social divides. The promotion of *Suntala* as a symbol of Nepali identity and heritage has sparked interest and curiosity among urban consumers, leading to cultural festivals, culinary events, and agro-tourism experiences that celebrate *Suntala* and its cultural significance. Urban residents visit citrus orchards in rural areas to experience *Suntala* production, fruit harvesting, learn about traditional cultivation techniques, and engage with rural communities, fostering mutual understanding and appreciation. Additionally, rural-urban migration flows driven by agricultural employment opportunities and urban demand for *Suntala* products will further strengthen linkages between rural and urban areas. This exchange of people, ideas, and goods contributes to social cohesion, cultural diversity, and economic resilience, laying the foundation for inclusive and sustainable development in Nepal. Overall, the adoption of *Suntala* as the National fruit of Nepal catalyzes rural-urban linkages, promoting collaboration, exchange, and shared prosperity between Nepal's rural heartlands and modern urban centers.

Social cohesion

Suntala holds deep cultural significance in Nepali society, symbolizing hospitality, prosperity, and auspiciousness. By designating *Suntala* as the national fruit, Nepal has reinforced its cultural identity and heritage, celebrating the rich traditions associated with citrus cultivation and consumption. This recognition of *Suntala* as a national symbol transcends regional, ethnic, and linguistic differences, serving as a unifying force that brings people together to celebrate shared values and traditions. Festivals and rituals centered around *Suntala*, such as the Nepali New Year (Nepal Sambat), Thulo Ekadashi, and the Hindu festival of Dashain,Tihar and Chhatha Parwa provide opportunities for communities to come together, strengthen bonds, and forge connections across social divides. Additionally, the promotion of *Suntala* cultivation has created cooperative networks and mutual support systems among farmers, who collaborate to share knowledge, resources, and best practices, further enhancing social cohesion and solidarity in rural areas.

Moreover, the adoption of *Suntala* as the National fruit of Nepal has facilitated cultural exchange and dialogue, fostering understanding and respect among different ethnic and cultural groups. *Suntala*'s cultural significance transcends borders, attracting interest and appreciation from international audiences and visitors. Nepali embassies, consulates, and cultural centers worldwide should showcase *Suntala* as a symbol of Nepali identity and hospitality, promoting cultural diplomacy and people-to-people exchanges. Furthermore, the cultivation of *Suntala* since ancient times has created employment opportunities, contributed to food and nutritional security, and economic empowerment in rural communities, reducing poverty and inequality and promoting social inclusion. As *Suntala* production expands, it not only provides economic benefits but also strengthens social bonds and solidarity among Nepali communities, contributing to the overall well-being and resilience of society. Overall, the adoption of *Suntala* as the National fruit of Nepal has played a vital role in fostering social cohesion, cultural pride, and unity among diverse communities, laying the foundation for a more inclusive and harmonious society.

Sustainable farming practices

The adoption of *Suntala* as the National fruit of Nepal has incentivized the adoption of sustainable farming practices across the country, promoting environmental stewardship and agricultural resilience. *Suntala* cultivation requires careful management of natural resources such as water, soil, and biodiversity, making it conducive to sustainable farming approaches. Farmers are encouraged to adopt agroecological practices such as organic farming, intercropping, and agroforestry, which enhance soil health, conserve water, and promote biodiversity in *Suntala* orchards. By integrating *Suntala* trees with other crops and vegetation, farmers can create diverse and resilient agroecosystems that mimic natural ecosystems, reducing the reliance on chemical inputs and mitigating the risks associated with monoculture farming. Additionally, the promotion of *Suntala* has led to investments in soil conservation measures, erosion control, and watershed management, safeguarding fragile ecosystems and promoting long-term sustainability in Nepal's agricultural landscapes.

Furthermore, the recognition of *Suntala* as the National fruit of Nepal will encourage research and innovation in sustainable agriculture system, driving the development and dissemination of new technologies and practices. Agricultural extension services and research institutions collaborate with farmers to promote climate-smart farming techniques, such as rainwater harvesting, drip irrigation, integrated pest management and integrated soil nutrient management, tailored to the needs of improved *Suntala* cultivation for increased yields. Moreover, government policies and programs provide incentives and support for farmers to adopt sustainable practices, including subsidies for organic certification, training in sustainable agriculture, and access to eco-friendly inputs. By embracing sustainable farming practices in *Suntala* cultivation, Nepal is not only enhancing the resilience and productivity of its agricultural sector but also contributing to global efforts to address climate change, conserve biodiversity, and promote food security. Overall, the adoption of *Suntala* as the National fruit of Nepal catalyzes sustainable farming practices, fostering environmental stewardship, economic prosperity, and social well-being in rural communities.

Tourism attraction

Suntala orchards are popular tourist destinations, attracting visitors eager to experience the beauty of citrus groves and participate in agricultural activities such as photographing, fruit picking, tasting and harvesting. Agro-tourism initiatives offer travelers immersive experiences, allowing them to engage with local farmers, learn about traditional cultivation techniques, and sample fresh *Suntala* fruits and products. Additionally, cultural festivals and events centered around *Suntala*, such as harvest celebrations and citrus-themed fairs, draw both domestic and international tourists, providing opportunities for cultural exchange and enrichment. Moreover, the scenic landscapes of *Suntala* orchards nestled amidst Nepal's picturesque mountains and valleys offer unparalleled photo shoot opportunities and outdoor recreational activities, further enhancing their appeal as tourist attractions.

Furthermore, the promotion of *Suntala* as the National fruit of Nepal has stimulated gastronomic tourism, with travelers seeking out culinary experiences that showcase the diversity and flavor of Nepali citrus fruits. Restaurants, cafes, and food tours feature *Suntala*-inspired dishes and beverages, enticing visitors with unique flavors and culinary innovations. The cultural significance of *Suntala* as a symbol of hospitality and prosperity also extends to hospitality establishments, where guests are welcomed with *Suntala*-themed amenities and offerings. Overall, the adoption of *Suntala* as the National fruit of Nepal will enrich the tourism landscape, offering travelers authentic experiences, culinary delights, and cultural immersion opportunities that showcase the natural beauty and cultural heritage of the country.

Misconception

The common English name of *Suntala* is "Mandarin Orange" which makes people relate it to China and have the perception that it could be of Chinese origin. However, the Nepalese *Suntala* is the native plant of the country and has retained its uniqueness- soft and loose skin, easily removable peel, refreshingly sweet flavor, and strong aroma.

Hindus and Nepalese people do not eat beef or are prohibited from slaughtering cows in Nepal. The general reason provided is that the cow is the national Animal and hence should not be eaten, and if *Suntala* is declared as the national fruit – *Suntala* will be a forbidden fruit for Nepalese people, or by making edible *Suntala* Nepal's national fruit, we open logic for the consumption of beef which is not true.

Prohibition of cattle slaughter and beef consumption is based on Buddhist and Hindu beliefs regarding the milk provider equivalent to one's mother. Cow is worshipped during Tihar as Goddess Laxmi, so it must not be consumed. Based on people's belief and respect for the cow, it has been declared Nepal's national animal and not the other way round.

Challenges and solutions

Regional resentment: Regions with alternative fruits may perceive the selection of *Suntala* as favoritism towards certain areas, potentially causing resentment. Far west province may suggest *Kaphal,* Fig or Walnut; Karnali may suggest Apple; Lumbini may suggest Banana, Mango; Bagmati may suggest *Lapsi*, Indigeneous Pear, Pomagranate, Junar; and Madesh province may suggest Jack fruit, Mango, Litchi or and Koshi province may go for Aerica nuts, Kiwi or Coconuts.

Economic imbalance: As *Suntala* cultivation is concentrated along the mid-hills from west to east- this region for sure will get more support and an instant economic boost upon declaration. The high Himalayas or hot terai where *Suntala* is not commercially grown will feel neglected, leading to economic imbalances and discontentment. For this other fruit crops suitable to those geographical locations will be equally promoted.

Cultural sensitivity: Newar community may consider beals (bels)/wood apple closer to their culture than *Suntala*, Maithili people prefer more sour citrus fruits than some regions might feel that their culturally significant fruits are overlooked, resulting in cultural dissonance. But *Suntala* is used by all communities so it should not be a problem and its National Fruit status won't compromise the distinct usages of above mentioned fruits as the season varies and purposes vary. To accomodate such concerns, following should be considered.

Solution 1: The east-to-west extension provides the best cultivation region and source for fresh fruits for both Terai and Himals. Therefore, the climatic and geographic diversity can be harnessed following *Suntala*'s pathway for the respective fruits.

Solution 2: As *Suntala* is well grown in heat of Nagpur (lower belt-hot place)- a similar research-based adaptation can be tried in Terai for growing *Suntala* with appropriate variety development. With its success, it's possible to produce and supply *Suntala* throughout the year, without having to depend on import. With cultivation of *Suntala*- other citrus fruits are cultivated together- it increases citrus cultivation areas.

Solution 3: The upcoming programs should focus on other regionally, commercially and culturally important fruits also to get equitable focus in terms of support and promotion similar to the national fruit. Let the national fruit become the gold standard to evaluate the standard and status of other fruits and prepare a future roadmap.

Solution 4: Such policies must be drafted and implemented that encourage and support the cultivation of various fruits across different regions to promote balanced nutritional availability and economic development.

Solution 5: Communicate the criteria and rationale behind selecting *Suntala* as the national fruit, emphasizing fairness, objectivity, transparency in decision making.

Solution 6: Promote inter-regional collaboration by encouraging joint efforts for the promotion of diverse fruits, thereby fostering a collective sense of unity and shared prosperity. Emphasize cultural celebrations that highlight the significance of fruits across different regions, organizing events to cultivate a strong sense of national pride. Execute educational campaigns aimed at informing the public about the rationale behind selecting *Suntala* as the national fruit, while underscoring the importance of preserving varied regional agricultural practices. Adopt a consultative approach by involving representatives from diverse regions in the decision-making process, ensuring inclusivity and consideration of their perspectives. Consider a flexible symbolism approach by contemplating the adoption of multiple national symbols, including fruits, to aptly represent the rich and diverse cultural and agricultural heritage of the entire nation.

Besides having one fruit as the national fruit does not prohibit provinces from declaring the popular fruit in their province as the provincial fruits. Many countries have more than one fruit as national fruits, some countries have as per their states, some countries have different national fruit for summer and winter.

Opportunity to start a golden revolution

The Green Revolution of 1950s revoltionized production and productivity of cereal crops such as wheat and rice that prevented great famine in the world, similarly, white revolution brought a significant increase in milk production. Therefore, there is a need for such revolution in fruit sector which can be referred to as “Golden revolution” and Nepal can be the initiator of this revolution starting from the citrus sector that can be applied to other fruit crops as per the ecological suitability of the country.

Recommendation

The major recommendations to consider for developing a prosperous citrus sector following the adoption of *Suntala* the National fruit of Nepal are as follows:

Investment on Infrastructure: Allocate resources for the development of transportation, cold storage facilities, and processing centers to support increased production of *Suntala* through expansion of its cultivation and promote export.

Research and Development: Prioritize funding for research initiatives aimed at improving *Suntala* varieties, cultivation techniques, economically important insect/pest and disease management and post-harvest practices.

Capacity Building: Provide training and technical assistance to farmers by enhancing the number and capacity development of the frontline extension workers on sustainable *Suntala* farming practices, nursery management for quality planting material production, pest management, orchard management and post-harvest management.

Value-Added Products: Encourage the development of value-added products such as *Suntala* juice, jam, jelly, marmalade, squash, and candies to diversify products which will further increase revenue streams and strengthen marketability.

Market Access: Facilitate trade agreements and market access for Nepali *Suntala* products in international markets through diplomatic channels and trade negotiations.

Promotion and Marketing: Launch marketing campaigns to raise awareness about the health benefits, culinary versatility, and cultural significance of *Suntala* both domestically and internationally.

Quality Standards: Implement quality control measures and certification programs to ensure the consistency and safety of *Suntala* products for consumers.

Agro-Tourism Development: Support the development of agro-tourism initiatives that showcase *Suntala* orchards and offer immersive experiences for visitors.

Cooperative Networks: Foster collaboration among *Suntala* farmers through cooperative networks, enabling them to share resources, knowledge, and best practices.

Environmental Conservation: Promote agroecological approaches to *Suntala* cultivation that prioritize environmental conservation, soil health, and biodiversity preservation.

Community Empowerment: Empower rural communities through capacity building, access to resources, and economic opportunities generated by *Suntala* cultivation.

Youth Engagement: Engage youth in *Suntala* farming through educational programs, training workshops, and entrepreneurship opportunities to revitalize agricultural communities.

Cultural Preservation: Preserve traditional knowledge and cultural practices associated with *Suntala* cultivation and utilization through documentation, heritage initiatives, conservation and cultural festivals.

Gender Equality: Promote gender-inclusive policies and programs in *Suntala* cultivation, ensuring equitable access to resources and opportunities for women farmers.

Policy Support: Advocate for policies and regulations that support the sustainable growth of the *Suntala* industry, including incentives for organic farming, research funding, and market access facilitation.

Conclusion

In conclusion, the adoption of *Suntala* (Mandarin orange) as the National fruit of Nepal represents a significant milestone in the country's agricultural, cultural, and economic development. This symbolic recognition of *Suntala* underscores its importance as a cultural icon, a source of national pride, and a driver of rural prosperity. The designation of *Suntala* as the national fruit has catalyzed a range of initiatives and collaborations aimed at promoting sustainable agriculture, rural livelihoods, and international trade. From investments in research and development to the promotion of agro-tourism and value-added products, Nepal has leveraged the potential of *Suntala* to enhance food security, generate employment, and foster social cohesion across diverse communities.

Furthermore, the adoption of *Suntala* as the National fruit of Nepal serves as a testament to the country's commitment to harnessing its agricultural heritage for inclusive and sustainable development. By embracing *Suntala* cultivation and innovation, Nepal has positioned itself as a leader in citrus production, cultural preservation, and environmental stewardship. Looking ahead, continued support for *Suntala* cultivation, research, and market development will be essential to unlocking its full potential as a catalyst for economic growth, cultural exchange, and environmental sustainability in Nepal. Through collaborative efforts and strategic investments, Nepal can build upon the foundation laid by the adoption of *Suntala* as the national fruit to create a vibrant and resilient agricultural sector that benefits both present and future generations.

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तत्कालिन राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रमको
कार्यालय भवन, कीर्तिपुर
(मिति २०७५।०३।३१ सम्म)

नेपालमा सुन्तलाजात फलफूलको संस्थागत विकास

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पृष्ठभूमि

नेपालमा फलफूल अन्तर्गत सुन्तलाजात फलफूलले मध्य पहाडी क्षेत्रको आर्थिक अवस्थामा सुधार ल्याउन महत्वपूर्ण योगदान गरेको छ । सुन्तलाजात फलफूल मध्ये सुन्तला, बिमिरो नेपालको रैथाने (Indigenous) फलफूल हुन् । हाम्रो देशमा परापूर्वकाल देखि सुन्तलाजात फलफूल खेती हुँदै आएको पाइन्छ । देशका केही पुराना पकेट क्षेत्रहरूमा सय वर्षभन्दा बढी उमेरका फल दिने सुन्तलाका बोटहरू अहिले पनि पाईन्छन् । देशको पूर्वदेखि पश्चिमसम्मको मध्य पहाडी भू-भाग सुन्तला फलफूल उत्पादन हुने मुख्य क्षेत्र अन्तर्गत पर्दछ । सुन्तलाजात फलफूल अन्तर्गतका सुन्तला, जुनार, कागती, निबुवा, भोगटे, ज्यामिर, बिमिरो, चाक्सी, काठे, कमला, मौसम आदि विभिन्न भू-भागमा पाईन्छ र यी मध्ये उत्पादन र क्षेत्रफलको आधारमा सुन्तला पहिलो स्थानमा पर्दछ । यस फलफूल वर्गको छुट्टै महत्व बुझेर सुन्तलाजात फलफूलको विकास, बिस्तार र अनुसन्धानका लागि नेपाल सरकारले एक छुट्टै कार्यालय र समय, समयमा विभिन्न आयोजनाहरु सञ्चालन गरेर विगतमा यसलाई विशेष प्राथमिकता दिएको पाइन्छ, जसले गर्दा यी फलफूल बालीको व्यावसायिक खेतीको बिस्तार भएको पाइन्छ ।

सुन्तलाजात फलफूलको संस्थागत विकास क्रम

नेपालमा सुन्तलाजात फलफूलको विकास र अनुसन्धानको औपचारिक थालनीको रुपमा वि.सं. २०१७ सालमा Citrus Research Sub–station, Pokhara र वि.सं. २०१८ सालमा Citrus Research Station, Dhankuta स्थापना भएको थियो । यसै गरी वि.सं. २०२३ सालमा फलोद्यान विभाग (Department of Horticulture) को स्थापना भयो । वि.सं.२०२९ सालमा पुनः कृषि विभागको पुनर्गठन हुँदा सुन्तलाजात फलफूल विकास कार्यक्रम कार्यान्वयन गर्न राष्ट्रिय स्तरमा राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रमको स्थापना गरिएको थियो ।

संस्थागत विकासको संरचनात्मक स्वरूप

नेपालको मध्य पहाडी क्षेत्रको कृषकहरूको आय आर्जनमा वृद्धि गर्न, सुन्तलाको आयातमा प्रतिस्थापन र निर्यातमा वृद्धि गरी बिदेशी मुद्रा आर्जन गर्न यो फलफूल बालीको विकास, अनुसन्धान र व्यवसायलाई प्रवर्द्धन गर्नको लागि प्रजातन्त्रको उदय (२००७ साल) पछिका तत्कालिन सरकारहरूले विभिन्न समयमा निम्नानुसार संस्थागत संरचनाहरु स्थापना गरी सुन्तलाजात फलफूलको प्रवर्द्धन र विकासको क्रम अगाडि बढाएको पाईन्छ ।

- सन् १९६१ (वि.स.२०१७): सुन्तलाजात फलफूल अनुसन्धान केन्द्र, मालेपाटन, पोखरा स्थापना ।
- सन् १९६२ (वि.स.२०१८): सुन्तलाजात फलफूल अनुसन्धान केन्द्र, पारिपात्ले, धनकुटा स्थापना ।
- सन् १९७२ (वि.स.२०२९): राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम गठन ।

- सन् १९७५ (वि.स.२०३२ कृषि वर्ष): सुन्तलाजात नर्सरी दुल्लु, दैलेख (करार)।
- सन् १९७७ (वि.स.२०३४): बागवानी फार्म, दैलेख स्थापना।
- Horticulture Development Project (HDP) which was implemented with the support of Japanese Government from 1985 to 1997 AD with the objectives of increasing production of citrus and deciduous fruits through technological development, training and extension. During that period, some exotic citrus species and varieties were introduced from Japan and established evaluation blocks at Horticulture Centre, Kirtipur.
- वि.सं.२०५०: राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, धनकुटाबाट कीर्तिपुर स्थानान्तरण गरिएको।
- वि.सं. २०५२: सुन्तला विकास शाखाको रूपमा पुनर्गठन गरिएको।
- In 1996 AD, Hill Agricultural Research Project (HARP) funded by DFID was set up in Nepal which prioritized the competitive research on citrus.
- On December 10, 2001 the National Agricultural Research and Development Fund (NARDF) was established under the Government of Nepal, Ministry of Agriculture. NARDF also prioritized citrus research and development programs through competitive grant.
- वि.सं. २०५७ मा राष्ट्रिय सुन्तलाजात अनुसन्धान कार्यक्रम, धनकुटामा शुरुवात गरी सुन्तलाको प्रविधि प्रसार र अनुसन्धान कार्यक्रमलाई छुट्ट्याइएको थियो।
- वि.सं. २०६० सालमा पुनर्गठन गरी पुनः राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम नामाकरण।
- वि.सं. २०६० मंसिर ४ गते बागवानी फार्म पाल्पालाई सुन्तलाजात फलफूल विकास केन्द्र, पाल्पा नामाकरण।

यसरी प्राथमिकता दिँदै देशका विभिन्न ठाउँबाट सुन्तलाजात फलफूलको अनुसन्धान, विकास, विस्तारका कार्यक्रमहरु सञ्चालन गरी यस बालीमा सकारात्मक प्रभाव परेको पाइन्छ भने बारम्बार संगठनात्मक परिवर्तनबाट सुन्तलाजात फलफूल विकासको लागि दीगो रुपमा कार्यक्रम सञ्चालन गर्न र निरन्तर आवश्यक प्रविधि विकासमा भने केही नकारात्मक असर परेको देखिन्छ।

पछिल्लो पटक (वि.सं. २०६०) पुनः राष्ट्रिय कार्यक्रमको रूपमा पुनर्गठन भएपछि यस कार्यक्रमबाट देशमा सुन्तलाजात फलफूल विकासलाई गतिशील बनाउन निम्न लक्ष्य, सोच र ध्येय अख्तियार गरिएको थियो।

लक्ष्य (Goal)

सुन्तलाजात फलफूल विकास एवं प्रवर्द्धन गर्न राष्ट्रिय स्तरमा नीतिगत व्यवस्था सहित केन्द्र, जिल्ला तथा फार्म स्तरमा कार्यक्रम तर्जुमा गरी कार्यान्वयन गर्न लगाई कृषकहरूको आर्थिक एवं पोषण अवस्थामा सुधार ल्याई गरिबी न्यूनिकरण गर्न सहयोग पुऱ्याउने।

सोच (Vision)

गरिबी न्यूनिकरण गर्न सुन्तलाजात फलफूल बालीको खेतीलाई व्यावसायिकरण गरी सुन्तलाजात फलफूलको आन्तरिक माग आपूर्ति गर्ने र नेपाली सुन्तलाजात फलफूलको पहिचान हुने गरी स्वदेशी तथा विदेशी बजारमा पुऱ्याउने यस कार्यक्रमको सोच रहेको थियो।

ध्येय (Mission)

सुन्तलाजात फलफूल पकेट क्षेत्रहरूमा प्राविधिक सेवा प्रदान गर्ने र सुन्तलाजात फलफूल खेतीलाई व्यावसायिकरण गरी उच्च गुणस्तरको सुन्तलाजात फलफूल उत्पादन गर्न लगाई सुन्तला व्यवसायलाई प्रवर्द्धन गर्ने ।

रणनीति (Strategy)

- देशभरी सुन्तलाजात फलफूल खेती र उत्पादन अवस्थाको वस्तुस्थितिको आँकलन गरी क्षेत्रफल, उत्पादन र उत्पादकत्व बारे तथ्याङ्क अद्यावधिक गरी सुन्तलाजात फलफूल खेती प्रवर्द्धन गर्न दिशानिर्देश गर्ने ।
- सुन्तलाजात फलफूल खेतीमा आईपर्ने प्राविधिक समस्याहरूको निराकरणको लागि प्राविधिक सरसल्लाह एवं सेवा प्रदान गर्ने र गर्न लगाउने काममा सहयोग गर्ने ।
- सुन्तलाजात फलफूल खेतीको लागि आवश्यक पर्ने बिरुवा उत्पादन स्थिति अध्ययन गरी बिरुवाको माग र आपूर्ति व्यवस्था मिलाउन आवश्यक सहयोग गर्ने ।
- सुन्तलाजात फलफूल खेती प्रवर्द्धन गर्न सरोकारवालाहरू बीच प्रविधि हस्तान्तरण गर्न तालिम परियोजनाको प्रस्ताव र सम्बन्धित कार्यमा सहयोग प्रदान गर्न श्रोत व्यक्ति (Resource Person) सेवा उपलब्ध गराई सहयोग गर्ने ।
- सुन्तलाजात फलफूल सम्बन्धी अध्ययन तथा सर्वे-सर्वेक्षण आदि बारे सरकारी, गैर सरकारी एवं अन्तर्राष्ट्रिय संघ संस्थाहरूसँग समन्वय गरी ज्ञान, सीप र आयोजना हासिल गर्न सहयोग आदान-प्रदान गर्ने ।
- सुन्तलाजात फलफूल खेती एवं बिरुवा उत्पादन र नर्सरी तथा बगैंचा व्यवस्थापनको समस्यामा आधारित अध्ययन कार्य राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुरको सहभागिता (Collaboration) मा केन्द्रीय बागवानी केन्द्र, कीर्तिपुर र सुन्तलाजात फलफूल विकास केन्द्र, पाल्पामा सञ्चालन गर्नुका साथै NARC अन्तर्गतका फार्म/केन्द्रसँग अनुसन्धानात्मक कार्यमा सहकार्य गर्ने ।
- तराई क्षेत्रमा सुन्तलाजात फलफूल मध्ये केही फलफूल जस्तै भोगटे, निबुवा र ज्यामिर राम्रो उत्पादन हुने गरेको र कागती एवं किन्नो सुन्तलाको पनि उत्पादन सम्भावना देखिएको छ । तसर्थ, यी जातका फलफूल क्षेत्र विस्तार गर्ने कार्यलाई प्रोत्साहन गर्न राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुरको सहभागितामा उक्त बालीहरूको खेती बारे अध्ययन उष्ण प्रदेशीय बागवानी केन्द, नवलपुर र उष्ण प्रदेशीय बागवानी केन्द्र, जनकपुरमा गर्ने ।
- देशभरीका विभिन्न सुन्तलाजात फलफूल उत्पादन पकेट क्षेत्रहरूमा फल उत्पादन र उत्पादकत्व वृद्धि गर्न बगैंचा व्यवस्थापनको उपयुक्त प्रविधि एवं तरिकाहरूको समायोजन गरी असल कृषि कर्मको (Good Agriculture Practice) प्याकेज तयार गरी तदनुरूप जिल्लाहरूमा प्राविधिक सेवा प्रदान गर्ने ।
- सुन्तलाजात फलफूल खेती गर्न चाहने कृषकहरूलाई सुन्तलाजात फलफूल खेती सम्बन्धी कार्य योजना तयार गर्न सहजीकरण गरी सुन्तलाजात फलफूल खेतीको क्षेत्र विस्तारमा सहयोग पुऱ्याउने ।
- सुन्तलाजात फलफूलको जातीय विकास गर्न स्वदेश तथा विदेशमा पाइने जर्मप्लाज्महरू संकलन, मूल्याङ्कन, संवर्द्धन, संरक्षण तथा प्रवर्द्धन गर्ने कार्यक्रममा केन्द्रीय बागवानी केन्द्र, कीर्तिपुर, सुन्तलाजात फलफूल विकास केन्द्र, पाल्पा र उष्ण प्रदेशीय बागवानी केन्द्र, नवलपुरलाई सहयोग गर्ने ।
- राष्ट्रिय, क्षेत्रीय र जिल्ला स्तरमा सुन्तलाजात फलफूल विकास कार्यक्रम तर्जुमा एवं कार्यान्वयन गर्न आवश्यक निर्देशिका, मार्गदर्शन, कार्यविधि र नर्मस् तयार गर्ने र समयसापेक्ष परिमार्जन गर्दै लैजाने ।

- सुन्तलाजात फलफूल उत्पादन सम्बन्धी राष्ट्रिय नीति, रणनीति, निर्देशन र मार्गदर्शन तर्जुमा गर्ने ।
- राष्ट्रिय/अन्तर्राष्ट्रिय स्तरमा सुन्तलाजात फलफूल बाली उत्पादन सम्बन्धी विकसित नयाँ प्रविधिहरूबारे प्राविधिकहरूलाई जानकारी गराउन राष्ट्रिय/अन्तर्राष्ट्रिय स्तरमा सभा, गोष्ठी र तालिम एवं भ्रमण कार्यक्रम सञ्चालन गर्ने व्यवस्था मिलाउने ।
- सुन्तलाजात फलफूल खेतीको क्षेत्र विस्तारका लागि सम्भाव्य पकेट क्षेत्रहरू पहिचान, अध्ययन र सर्वेक्षण गर्ने ।
- सरकारी तथा निजी क्षेत्रमा बिरुवा उत्पादन गर्ने नर्सरीको प्राविधिक निरीक्षण गरी स्वस्थ, रोगमुक्त र गुणस्तरयुक्त बिरुवा उत्पादन एवं बिक्री वितरण गर्न लगाउने ।
- सुन्तलाजात फलफूल खेती तथा व्यावसायीकरण सम्बन्धी उन्नत प्रविधि कृषक समक्ष हस्तान्तरण गर्न जिल्ला कृषि विकास कार्यालयसँगको सहकार्यमा प्राविधिक सेवा (Technical Back-up), प्रचार-प्रसार तथा विस्तार गर्ने ।
- उपरोक्त कार्यहरू गर्न राष्ट्रियस्तरमा राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रमको कार्यालयको व्यवस्थापन पक्षलाई सुदृढ गर्न कार्यालयको साधन श्रोत बारे समीक्षा गरी आवश्यक व्यवस्था मिलाउन निरन्तर पहल गर्ने ।

सुन्तलाजात फलफूल विकास सम्बन्धी कार्यक्रम सञ्चालन गर्ने तत्कालीन सरकारी निकायहरू

१. राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुर ।
२. केन्द्रीय बागवानी केन्द्र, कीर्तिपुर, काठमाण्डौ ।
३. सुन्तलाजात फलफूल विकास केन्द्र, पाल्पा ।
४. सुन्तलाजात फलफूल अनुसन्धान केन्द्र, पारीपात्ले, धनकुटा ।
५. उष्ण प्रदेशिय बागवानी केन्द्र, नवलपुर ।
६. उष्ण प्रदेशिय बागवानी केन्द्र, जनकपुर ।
७. जिल्ला कृषि विकास कार्यालयहरू ।

राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रमको प्रमुख कार्यहरु

१. **कार्यक्रम अनुगमन/निरीक्षण**
   - पकेट क्षेत्र अनुगमन निरीक्षण ।
   - सरकारी फार्म/केन्द्र अनुगमन निरीक्षण ।
   - निजी नर्सरी अनुगमन निरीक्षण ।
   - सरकारी फार्म/केन्द्रको बिरुवा उत्पादन तथा गुणस्तर अनुगमन ।

२. **प्रविधि प्रसार एवं प्राविधिक सेवा**
   - बगैंचा व्यवस्थापन सम्बन्धी प्राविधिक सेवा ।
   - नर्सरी व्यवस्थापन तथा बिरुवा उत्पादन सम्बन्धी प्राविधिक सेवा ।
   - सुन्तलाजात फल उत्पादनोपरान्तको क्रियाकलाप बारे प्राविधिक सेवा ।
   - आकस्मिक समस्याहरूको निराकरण/निदान गर्न प्राविधिक सेवा ।
   - सुन्तलाजात फलफूल खेती गर्ने सेवाग्राहीलाई सुन्तलाजात फलफूल खेतीको कार्य योजना तयार गर्न सहयोग गर्ने ।

३. **सम्भाव्यता/प्रभावकारिता अध्ययन/सर्वेक्षण**

- सुन्तलाजात फलफूलको नयाँ पकेट क्षेत्र पहिचान गर्न सम्भाव्यता अध्ययन।
- रोग कीराको स्थिति बारे जानकारी हासिल गर्न स्थलगत अवलोकन तथा सर्वेक्षण कार्य।
- कार्यालयवाट सञ्चालित कार्यहरुको प्रभावकारिता अध्ययन।

४. **सूचना तथा तथ्याङ्क संकलन**

- सुन्तलाजात फलफूलको क्षेत्रफल, उत्पादन तथा उत्पादकत्व सम्बन्धी तथ्याङ्क संकलन गरी रेकर्ड राख्ने र प्रकाशनको माध्यमबाट सरोकारवालालाई उपलब्ध गराउनुको साथै सुन्तलाजात फलफूल पकेट क्षेत्रहरूमा रहेको बगैंचाहरूको अवस्थाको समेत जानकारी संकलन गर्ने।
- सरकारी र निजीस्तरमा भएका सुन्तलाजात फलफूलको गुणस्तरयुक्त बिरुवा उत्पादन स्थिति, बिरुवाको माग र आपूर्ति व्यवस्था मिलाउन राष्ट्रिय स्तरमा वासलात (Balance Sheet) तयार गर्ने।

५. **अध्ययन/अनुसन्धान**

- सुन्तलाजात फलफूल बालीमा देखिने समस्याहरूको निदानको लागि प्रविधि विकास गर्न फार्म/केन्द्रसँगको सहकार्यमा अध्ययन तथा अनुसन्धानात्मक कार्यक्रम सञ्चालन गर्ने।
- स्वस्थ र रोगमुक्त सुन्तलाजात बिरुवा उत्पादन एवं नर्सरी व्यवस्थापनमा आउने समस्या समाधान गर्न फार्म/केन्द्रसँगको सहकार्यमा अध्ययन अनुसन्धानात्मक कार्य गर्ने।

६. **तालिम/अध्ययन भ्रमण**

- केन्द्र र जिल्ला स्तरमा कृषकहरू र कृषक समूहलाई सुन्तलाजात फलफूल प्रविधि बारे जानकारी गराउन तालिमको आयोजना तथा व्यवस्था गर्ने।
- सुन्तलाजात फलफूल विकासमा संलग्न जनशक्तिलाई सक्षम बनाउन नयाँ प्रविधि बारे अवगत गराउन राष्ट्रिय तथा अन्तर्राष्ट्रिय स्तरको तालिम र अध्ययन भ्रमणमा सहभागी गराउन व्यवस्था मिलाउने।

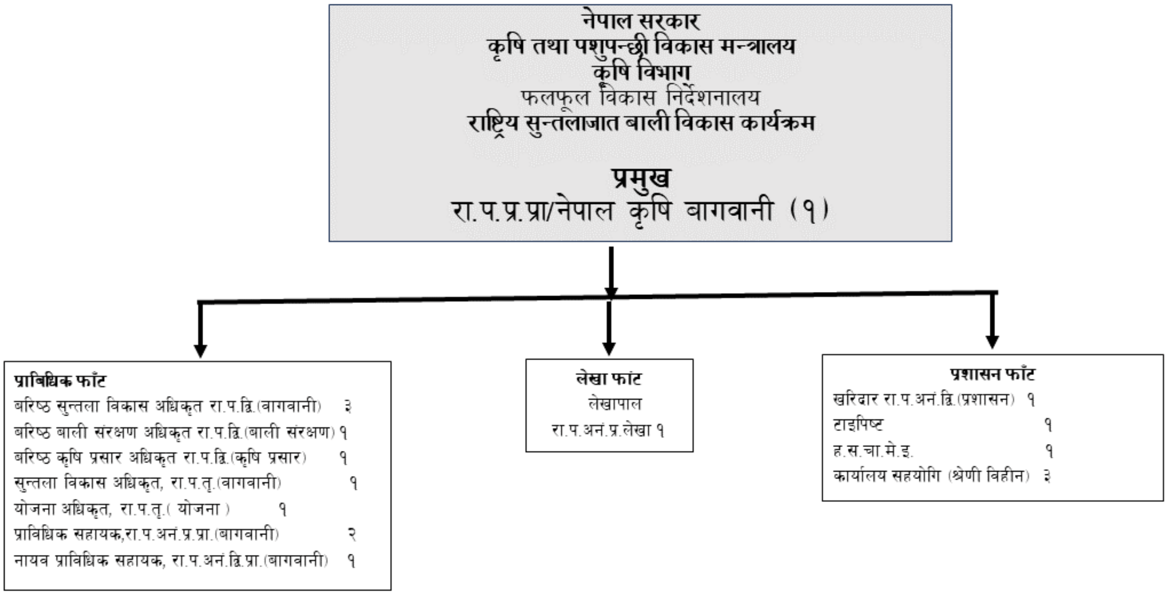
७. **प्रविधि विकास एवं विस्तार**

- सुन्तलाजात फलफूलमा जातिय विकास हेतु स्वदेश एवं विदेशमा पाइने जर्मप्लाज्महरूको संकलन, मूल्याङ्कन, सम्वर्द्धन एवं संरक्षण गर्न फार्म/केन्द्रहरूसँग सहकार्य गर्न सहयोग गर्ने।
- आयातित एवं स्वदेशमा विकसित प्रविधिहरूलाई परीक्षण एवं आवश्यक परिमार्जन गरी कृषि प्रसार माध्यमबाट विस्तार गर्नमा सहयोग गर्ने।
- देशभरिका सुन्तलाजात फलफूल पकेट क्षेत्रहरूमा उत्पादन र उत्पादकत्व वृद्धि गर्न उन्नत प्रविधि तथा व्यवस्थापन पद्धतिलाई एकीकृत गरी कृषि कर्महरूको प्याकेज (Package of Practices) तयार गरी जिल्ला कृषि विकास कार्यालयहरूलाई उपलब्ध गराउने।
- सुन्तला बगैंचा सुदृढीकरण कार्यक्रम

८. **प्राविधिक प्रकाशन**

- वार्षिक पुस्तिका प्रकाशन, तथ्याङ्क दस्तावेजीकरण, लेखन तथा प्रकाशन।
- सुन्तलाजात फलफूल बगैंचा व्यवस्थापन, अध्ययन/अनुसन्धान तथा खोजमूलक प्राविधिक सामाग्री प्रकाशन।
- सुन्तलाजात फलफूल सम्बन्धी आवधिक प्रतिवेदन प्रकाशन।
- प्रविधि प्रसारको लागि सुन्तलाजात फलफूल सम्बन्धी प्राविधिक पुस्तिका, पोष्टर, पम्पलेट, लिफलेट आदि प्रकाशन।

राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम, कीर्तिपुरको संगठनात्मक संरचना



राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रमको स्थापना कालदेखिका कार्यालय प्रमुखहरुको विवरण

क्र.सं.	नाम थर	पद	कार्य अवधि	श्रेणी
१	श्री पदम प्रसाद श्रेष्ठ	प्र.सु.वि.अ.	२०२९/०८/०८-२०३६/१०/२१	रा.प.प्र.प्रा.
२	श्री त्रैलोक्यनाथ श्रेष्ठ	का.मु.प्र.सु.वि.अ.	२०३६/१२/०७-२०४१/०४/२८	रा.प.प्र.प्रा.
३	श्री मुक्तिनाथ पोखरेल	का.मु.प्र.सु.वि.अ.	२०४१/०४/२९-२०४१/१२/०४	रा.प.प्र.प्रा.
४	श्री रामबदल साह	का.मु.प्र.सु.वि.अ.	२०४१/१२/०५-२०४३/०५/०७	रा.प.प्र.प्रा.
५	श्री रामबदल साह	प्र.सु.वि.अ.	२०४३/०५/०८-२०४९/०७/२१	रा.प.प्र.प्रा.
६	डा. त्रैलोक्यनाथ श्रेष्ठ	का.मु.प्र.सु.वि.अ.	२०४९/०८/०४-२०५१/०४/०८	रा.प.प्र.प्रा.
७	श्री कृष्ण बहादुर श्रेष्ठ	का.मु.प्र.सु.वि.अ	२०५१/०४/३२-२०५२/०४/३०	रा.प.प्र.प्रा.
८	श्री सुरेश कुमार वर्मा	सु.वि.अ.	२०५२/०५/०१-२०५३/०३/२५	रा.प.द्वि.प्रा.
९	श्री लोकनाथ देवजु	नि.सु.वि.अ.	२०५२/०५/०१-२०५३/०३/२५	रा.प.द्वि.प्रा.
१०	श्री बलराम राजभण्डारी	सु.वि.अ.	२०५३/०३/२६-२०५४/११/२४	रा.प.द्वि.प्रा.
११	श्री लोकनाथ देवजु	सु.वि.अ.	२०५४/११/०४-२०५८/०५/३१	रा.प.द्वि.प्रा.
१२	श्री देबेन्द्र कुमार सर्राफ	सु.वि.अ.	२०५८/०६/०१-२०६१/०६/०६	रा.प.द्वि.प्रा.
१३	श्री लोकनाथ देवजु	नि.प्र.	२०६१/०६/०७-२०६२/०१/०८	रा.प.प्र.प्रा.
१४	श्री लोकनाथ देवजु	का.मु.प्र.	२०६२/०१/०९-२०६२/०७/०८	रा.प.प्र.प्रा.
१५	श्री लोकनाथ देवजु	नि.प्र.	२०६२/०७/०९-२०६४/०५/०८	रा.प.प्र.प्रा.
१६	श्री रामबहादुर श्रेष्ठ	नि.प्र.	२०६४/०५/०९-२०६६/०२/१०	रा.प.प्र.प्रा.
१७	श्री चुटराज गुरुङ	का.प्र	२०६६/०२/११-२०६७/०६/०८	रा.प.प्र.प्रा.
१८	डा. गजेन्द्रसेन निरौला	का.प्र	२०६७/०६/०९-२०६८/०४/०४	रा.प.प्र.प्रा.

क्र.सं.	नाम थर	पद	कार्य अवधि	श्रेणी
१९	श्री फुलेश्वर सिंह	का.प्र.	२०६८/०४/०५-२०६९/०२/११	रा.प.प्र.प्रा.
२०	श्री यामकुमारी श्रेष्ठ	नि.का.प्र.	२०६९/०२/१२-२०६९/०४/०६	रा.प.द्वि.प्रा.
२१	श्री महेन्द्रमान श्रेष्ठ	का.प्र.	२०६९/०४/०७-२०७०/०१/०८	रा.प.प्र.प्रा.
२२	डा. योगेशहरी श्रेष्ठ	नि.का.प्र.	२०७०/०१/०९-२०७१/०२/१५	रा.प.द्वि.प्रा.
२३	श्री रामानन्द कुर्मी	का.प्र.	२०७०/०२/१६-२०७१/०२/२०	रा.प.प्र.प्रा.
२४	श्री गोवर्धन अधिकारी	नि.का.प्र.	२०७१/०२/२१ -२०७१/१२/१७	रा.प.द्वि.प्रा.
२५	डा.रमिता मानन्धर	का.प्र.	२०७१/१२/१८-२०७२/०९/०८	रा.प.प्र.प्रा.
२६	श्री गोवर्धन अधिकारी	नि.का.प्र.	२०७२/०९/०९-२०७२/११/३०	रा.प.द्वि.प्रा.
२७	श्री कौशल कुमार पौडेल	का.प्र.	२०७२/१२/०१- २०७३/०९/०३	रा.प.प्र.प्रा.
२८	श्री गोवर्धन अधिकारी	नि.का.प्र.	२०७३/०९/०४- २०७३/१२/०७	रा.प.द्वि.प्रा.
२९	डा. शान्ता कार्की	का.प्र.	२०७३/१२/०८- २०७५/०३/२८	रा.प.प्र.प्रा.

निष्कर्ष

नेपालको संविधान २०७२ ले निर्दिष्ट गरे बमोजिम राज्यको पुनःसंरचनासँगै वि.सं.२०७५ सालमा साविकका फलफूल विकास निर्देशनालय, राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम र चिया तथा कफी विकास शाखा गरी तीन वटा केन्द्रीय कार्यालयहरु गाभेर यी तीन कार्यालयहरुबाट सम्पादन गरिने कार्यहरु गर्न नेपाल सरकारको मिति २०७५/०३/२८ को निर्णय अनुसार २०७५ श्रावण महिनादेखि कृषि विभाग मातहत रहने गरी एक सङ्घीय कार्यालयका रुपमा हालको “राष्ट्रिय फलफूल विकास केन्द्र”, कीर्तिपुरको स्थापना भएको हो । हाल सुन्तलाजात फलफूल सम्बन्धी नर्सरी सुदृढीकरण, स्वस्थ बिरुवा उत्पादन र बगैचा बिस्तारका कार्यक्रमहरु स्थानीय तहमा सशर्त कार्यक्रम मार्फत् सञ्चालन गरिँदै आइएको छ। यसरी राष्ट्रिय रुपमा विशेष प्राथमिकता पाएको बालीको एक छुट्टै राष्ट्रिय कार्यक्रम अन्य फलफूल बालीसँगै समावेश गरीएकोले यसको विकास, विस्तार र प्रवर्द्धनमा पाउनु पर्ने जति महत्व पाइरहेको छैन । यसर्थ, राष्ट्रिय सुन्तलाजात बाली विकास कार्यक्रम पुनः स्थापना गरी सुन्तलाको तीव्र गतिमा विकास, विस्तार र प्रवर्द्धन गर्नुपर्ने आवश्यकता महसूस गरिएको छ र यसले स्वस्थ बिरुवा उत्पादनको लागि विशेष नियमनकारी भूमिका खेल्नुपर्ने देखिन्छ।

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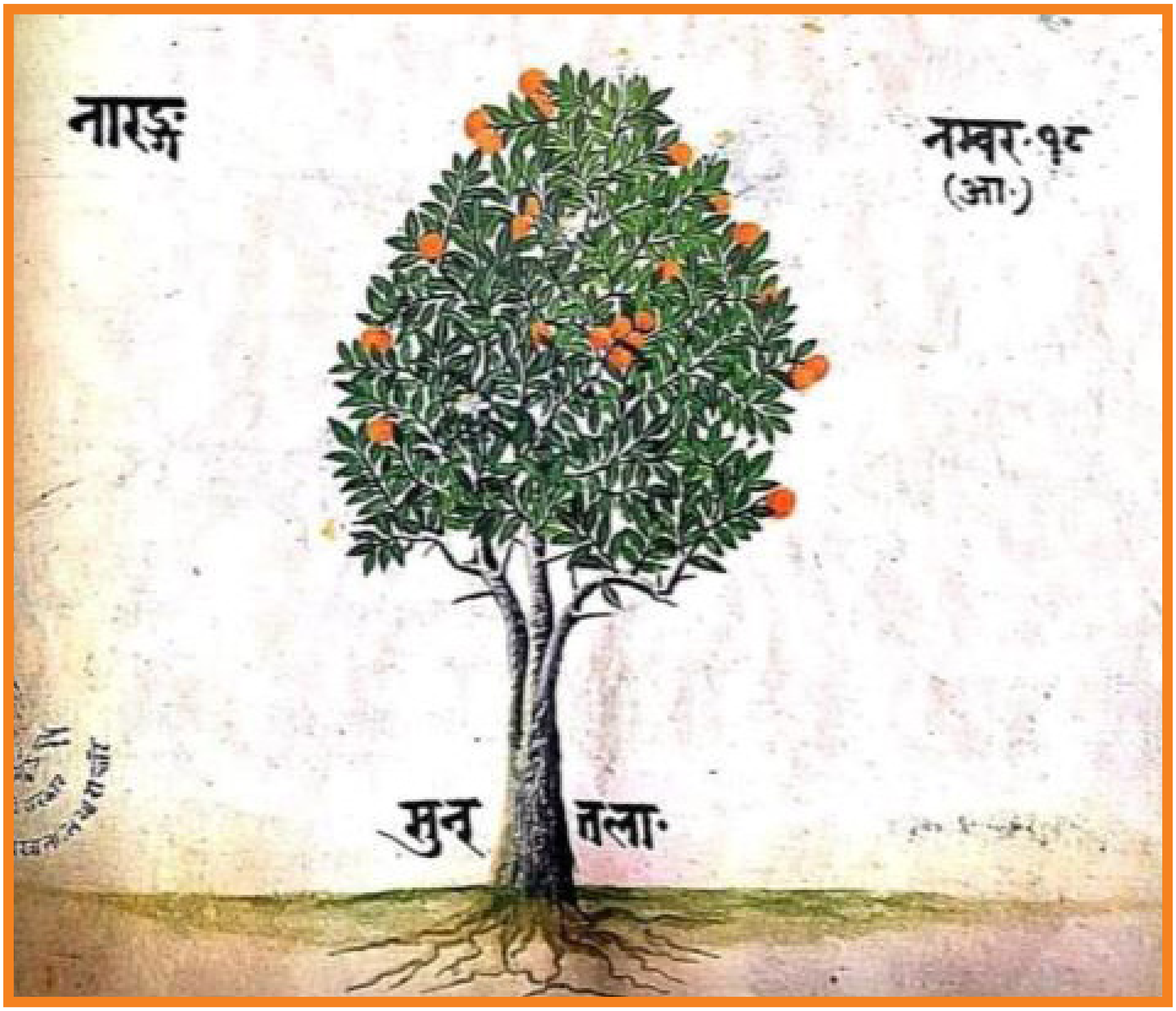


स्रोत: चन्द्रनिघण्टु, वि.सं. २०६९

नेपालको राष्ट्रिय फल सुन्तलाः ऐतिहासिक तथा वैदिक विश्लेषण

वासुदेव काफ्ले*
कृषि क्षेत्र विकास कार्यक्रम, विरेन्द्रनगर, सुर्खेत
***Corresponding Author:** kaphlebasu@gmail.com

प्राचिन समय देखि नै नेपाल कृषि उत्पादनको दृष्टिबाट महत्वपूर्ण स्थान रहेको कुरा विभिन्न ऐतिहासिक तथा वैदिक शास्त्रहरुमा उल्लेख गरिएको छ। काश्यपमुनि (ऋषि) द्वारा रचित प्राचिन कृषि शास्त्र 'काश्यपीयकृषि पद्धति' मा वर्षा भएपछि कृषि कार्य शुरु गर्नुपर्ने र फलफूलको बिरुवा लगाई महावन बगैंचा बनाउनु पर्ने र संरक्षण गर्नुपर्ने कुरा उल्लेख छ। जसमा नेपाल देशको पनि उब्जाउ भूमि चयन गर्नु पर्ने बारे वर्णन गरिएको छ।

काश्मीरदेश्यके वङ्गदेश्ये नेपालदेश्यके।
पञ्चालकोसलकुरुविराटान्वत्य भूमिके ॥
मालवे शकदेश्ये वा सिन्धुसौबीरभूमिषु।
शुरसेनावान्तिचेदिकोङ्कणान्ध्रादि भूमिषु ॥
यदा यदा वृष्टिपातस्तदा शस्ता कृषिक्रिया।

एवं महावनं रक्ष्यं नवीतीरेषु वा कूचित ॥
गान्धार- कुन्ति-पञ्चाल-कश्मीरावन्ति भूमिषु।
सिन्धु- नेपाल -निषध-कोसलाङ्गदि भूमिषु।
गुजरार्वुदा सौराष्ट्रप्रमुख दिस्थ लेषु च।
देशेषु विविधेष्वेवं सारभूमिस्थले नृपः ॥
(काश्यपीयकृषिपद्धति)

कृषि बाली अन्तर्गतको फलफूल 'सुन्तला' नेपालमा प्राचिन समयबाटै हुन्थ्यो र विशेष गरी नेपालको मध्य पहाडी क्षेत्रमा राम्रो हुने कुराको वर्णन आयुर्वेदिक तथा पौराणिक ग्रन्थहरुमा उल्लेख गरिएको छ। संस्कृतमा सुन्तलालाई नारङ्ग भनिन्छ। (संस्कृत-नेपाली वृहत शब्दकोष - पं फणीद्र प्रसाद पाण्डेय, म.स. विश्वविद्यालय)। नेपालको पाशुपत क्षेत्र श्लेष्मान्तक वन सुन्तला (नारङ्ग/नागरङ्ग) लगायत विभिन्न फलफूलले सुशोभित भएको उक्त क्षेत्रमा शिव-पार्वती विचरण गर्नुभएको विषय स्कन्दपुराण अन्तर्गत नेपाल महात्यमा उल्लेख छ।

श्लेष्मान्तकवनं तस्य पुरा नाम प्रतिष्ठितम्।
शालैस्तालेस्तमालैश्च हिन्तालैः परिपूरितम् ॥
खर्जुरैर्नागिरङ्गैस्च बीजपूरैश्च मण्डितम्।
नानानिर्भरणोपेतं नानापक्षिनिनादितम् ॥
वाग्वत्याः सरितस्तीरे सर्वत्र कुसुमान्वितम्।
श्लेष्मान्तकवनं दृष्ट्वा पार्वत्या सह शङ्करः ॥
डेलेशात् पाश्चिमे भागे प्रकाण्डवनमुक्तमम्।
पनसैः सहकारैश्च नारङ्गैरुप शोभितम् ॥
(नेपालमाहात्म्यम्)
यसरी हाम्रा पुराना वैदिक शास्त्रहरुमा नेपालका वन-बगैंचा सुन्तला लगायतका फलफूलले सुशोभित हुन्थे भनी वर्णन हुनुले

सुन्तला नेपालको प्राचिन फलफूल रहेको र कृषकहरुले प्राचिन समय देखिनै यसको खेती गर्दै आएको भनेर बुझिन्छ।

यसै गरी आयुर्वेदिक शास्त्रहरुमा पनि सुन्तला एक गुणकारी फल भएको कुरा वर्णन छ। नेपालको पुरानो हस्तलिखित बोटबिरुवाको सचित्र व्याख्या गरिएको पुस्तकमा (हस्तलिखित चन्द्रनिघण्टु) पनि सुन्तलालाई 'नारङ्ग' भनि लेखिएको र यसको सचित्र वर्णन गरिएको छ। उक्त चन्द्रनिधण्टुमा सुन्तलालाई नेवारी भाषामा 'सुन्तलांसि' भनिन्छ भन्ने कुरा पनि उल्लेख छ। प्राचिन चन्द्रनिघण्टु राजा प्रधानमन्त्री चन्द्रशमशेरको पालामा एक वैद्यले हस्तलिखित रुपमा लिपिबद्ध गरेको कुरा उल्लेख छ। चन्द्रनिघण्टुमा सुन्तलाको उत्पति स्थान नेपालको मध्य पहाडी भाग भनी उल्लेख समेत गरिएको छ।

पछिल्लो समय देश विदेशका शोधकर्ता, अध्ययन अनुसन्धानकर्ताले पनि सुन्तलाको उत्पत्ति (Center of Origin) चीनको दक्षिणी भाग र इन्डियाको उत्तरी भागमा भएको भन्ने उल्लेख गरेका छन्। यी दुई भू-भागको बीचमा नेपाल पर्दछ। त्यसैले नेपालको भू-भागमा यसको उत्पत्ति भएको वैदिक र आयुर्वेद शास्त्रहरुले पनि वर्णन गरे जस्तै प्राचिन समय देखिनै नेपालमा यसको खेती गरिँदै आइएको नेपालको सुन्तला अरु देशको भन्दा विशिष्टकृत गुण भएको अझै थप प्रवर्द्धन गरी नेपालीको खाद्य तथा पोषणको सुरक्षा, आय आर्जनमा जीविकोपार्जनको राम्रो स्रोत हुन सक्ने भएकोले ऐतिहासिक र वैदिक दृष्टिकोणबाट पनि सुन्तला राष्ट्रिय फल भएको उपयुक्त देखिन्छ।

सन्दर्भ सामग्री

जुगनु, श्री कृष्ण। २०१३ ई.सं.। काश्यपीयकृषिपद्धति। चौखम्वा संस्कृत सीरीज अफिस, वाराणासी।

काफ्ले, वासुदेव, सुदिप काफ्ले, महेश्वर घिमिरे। २०७९ वि.सं.। वैदिक कृषि पद्धति र प्राङ्गारिक खेती प्रविधि। कृषि तथा पशुपन्छी विकास मन्त्रालय, राष्ट्रिय आलु तरकारी तथा मसालबाली विकास केन्द्र कीर्तिपुर, काठमाण्डौ।

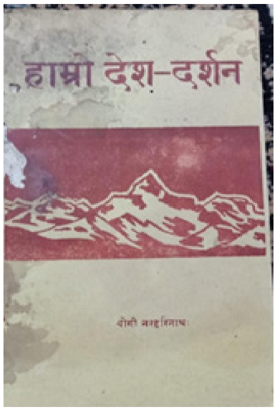
शास्त्री, द्वारकाप्रसाद। २०७३ वि.सं.। कृषिपराशरः। चौखम्बा संस्कृत सीरीज आफिस, वाराणसी।

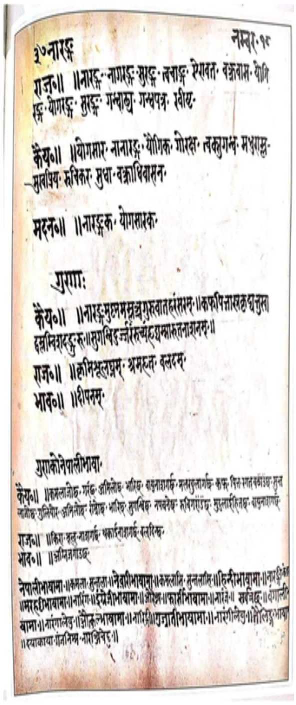
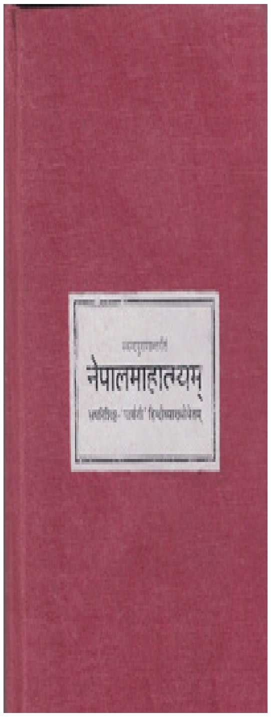
शास्त्री, द्रविड, पण्डितराज राजेश्वर। २०३३ वि.सं.। नेपालमाहात्म्यम्। चौखम्बा कृष्णदास अकादमी, वाराणसी।

योगि, नरहरीनाथ। २०३२ वि.सं.। हाम्रो देश-दर्शन। मृगस्थली गोरक्षपीठ काष्ठमण्डप नेपाल।

पराजुली, बुद्दिसागर, चूडानाथ भट्टराई, भिमनिधि तिवारी, केशव दिपक, योगी नरहरीनाथ। हिमवत्सस्कृति। २०१६ वि.सं.। हिमवत्सस्कृति संचालक समिति, रानीपोखरी, काठमाडौं।

चन्द्रनिघण्टु। २०६९ वि.सं.। नेपाल सरकार, स्वास्थ्य तथा जनसंख्या मन्त्रालय, सिंहदरबार वैद्यखाना विकास समिति।



Chapter 2

Science and Technology Aspects of
Mandarin Orange in Nepal

Biodiversity and Conservation

Mandarin Orange Landraces: Diversity, Conservation and Potential for Geographical Indication

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Abstract

Mandarin orange, commonly known as Orange or *Suntala* in Nepali, holds significant religious, cultural, social, and economic value in Nepal, where its cultivation dates back to ancient times, with seeds initially collected from the wild in Khoku. Development efforts for mandarin orange began in 1960, and it is grown in 66 districts across elevations ranging from 200 to 2000 meters above sea level, with the mid-hills being particularly renowned as the "gold of the mid-hill." Nepalese mandarin orange stands out internationally for its superior qualities, including shininess, juiciness, sweetness, and overall eating experience. With a total of 60 landraces, including two registered indigenous varieties (Khoku Sthaniya and Banskharka Sthaniya) and one exotic variety (Unshiu), along with 43 exotic varieties, mandarin orange diversity is a crucial aspect of agricultural heritage. More than 400 years old plant have also been reported from Khoku, Dhankuta (Bantava Rai community). Conservation efforts encompass various approaches such as field gene banks, agro-gene sanctuaries, community field gene banks, and household field gene banks, with approximately 30 landraces currently under conservation alongside their passport data. However, citrus greening disease poses a significant threat to the genetic diversity of mandarin orange, necessitating the use of both vegetative and sexual propagation techniques to maintain diversity. Some production areas boast ancient trees that yield unique and renowned fruits, attributed partly to specific geographical conditions like those found in Khoku, Mankamana, and Gulmi. Given these unique attributes, such areas are prime candidates for geographical indication and collective rights protection. Promoting location-specific genetic diversity and employing genetic improvement strategies such as hybridization and biotechnological tools are essential for creating, maintaining, and enhancing mandarin orange genetic diversity. Such endeavors not only safeguard the rich heritage of mandarin orange landraces but also ensure the sustainability and resilience of Nepal's mandarin orange industry in the face of evolving challenges.

Keywords: Genetic diversity, Field genebank, Landrace, Geographical indication, Conservation, Distribution

Introduction

Mandarin orange, scientifically known as *Citrus reticulata* Blanco, is a diploid fruit crop with a chromosomal count of 2n=2x=18. In Nepal, it holds significant economic value and is highly esteemed as a native commercial fruit crop. Among the 17 citrus species, *Citrus reticulata* Blanco stands out as the foremost in terms of economic importance. Nepal boasts a rich diversity of mandarin orange varieties, most of which are locally developed and adapted to specific regions, showcasing distinct characteristics from one another. Commonly referred to as "Orange" or "*Suntala*" in Nepal, mandarin orange holds a special place in the local agricultural landscape (Adhikari *et al*., 2021; NCRP, 2023).

Formal development efforts for mandarin orange cultivation commenced in 1960, with initiatives launched in Pokhara and Dhankuta. Subsequently, research endeavors began in 1972, further enhancing the understanding and cultivation techniques of this prized fruit. Mandarin oranges are renowned for their delectable taste, high yield capacity, and nutritional richness. They are packed with essential nutrients, including vitamin C, A, and B, along with a high fiber content. Additionally, mandarin oranges are known for their effectiveness in alleviating constipation and promoting skin radiance. The oil extracted from mandarin orange peel is highly valued in cosmetic applications. Renowned for their vibrant and attractive color, ranging from sunny oranges to deep yellows, they captivate with their visual appeal. Moreover, the scent of both mandarin orange flowers and fruits is irresistibly alluring, evoking images of sunny orchards and sweet citrus blossoms. As a travel fruit, mandarin oranges hold a special place, offering convenience and peace of mind to busy travelers. With no need for washing before consumption and their naturally protective peel minimizing the risk of contamination, mandarin oranges are the perfect on-the-go snack for those craving a burst of refreshing flavor without any fuss.

The diversity of mandarin orange varieties, both phenotypically and genotypically, has been studied (Acharya *et al*., BS 2076, Munankarmi *et al*., 2023 AD). Despite the introduction of numerous varieties, the utilization of genetic diversity remains limited. Notably, ancient mandarin orange trees dating back around 400 years have been discovered in Dhurkot, Gulmi district, maintained by farmer Kamal Thapa. Conservation efforts for mandarin orange diversity primarily rely on field gene banks and conservation through utilization. However, many indigenous landraces are at risk of extinction, underscoring the need for robust conservation strategies. In Nepal, mandarin orange branding based on geographical location is a common practice. However, initiatives for collective rights and geographical indication tags are yet to be explored or implemented, representing potential avenues for further valorizing this cherished fruit crop.

Some challenges related to *Suntala* include its naming conventions; while the fruit is known as "*Fal*" in Nepali, it is officially referred to as "*Falful*." Unlike rice, *Suntala* fruits are typically named after the production area rather than having distinct cultivar names. In terms of cultivation, a true type does not involve different species or cultivars for the scion and rootstock. If different scion and rootstock are used, it results in what is known as an Organ Transplanted Organism (OTO), which should not be confused with a Genetically Modified Organism (GMO).

Methodology

The methodology employed in this study encompassed a multi-faceted approach to comprehensively investigate mandarin orange landraces, focusing on their diversity, conservation, and the potential for geographical indication. Firstly, an extensive literature review was conducted to synthesize existing knowledge and understand the current state of research regarding mandarin orange landraces. This served as a foundation for further exploration and analysis. Subsequently, six focus group discussions were organized across different districts, engaging local communities and stakeholders. These discussions provided valuable insights into various aspects of mandarin orange cultivation, including the diversity of landraces, conservation practices, and perceptions regarding geographical indication. In addition to the focus group discussions, a key informant survey was conducted, involving 10 individuals with expertise in mandarin orange cultivation, conservation, and geographical indication. Their inputs offered nuanced perspectives and enriched the understanding of the subject matter.

Field observations were carried out at five sites to observe mandarin orange landraces in their environment. Furthermore, mandarin orange landraces, comprising seeds and shoots, were collected from diverse districts. These collections were carefully conserved in a field gene bank to safeguard the genetic diversity of mandarin orange landraces and ensure their long-term sustainability.

Origin and distribution

The origin of mandarin orange can be traced back to ancient times in Nepal, where seeds were collected from the wild in the Khuku region and subsequently domesticated, particularly in the Dhankuta district (Joshi *et al*., BS 2080). Dan Bahadur Rai, a 65-year-old farmer, along with other senior farmers from the Khoku area, recounted that the cultivation of *Suntala* in Khoku originated by gathering fruits and seedlings from the neighboring Khoku forest (now it is called Mujure Cherpa Saamudaaik Ban (**मुजुरे चेर्पा सामुदायिक वन**) (Figure 1). According to their accounts, the Bantawa Rai people were relocated from Sankhuwasaba to Khoku district in ancient times. Prior to their arrival, the area was inhabited by the Naga tribe, who began cultivating *Suntala* after collecting it from wild areas. The Naga tribe (now in Nagaland, India) recognized the importance and usefulness of *Suntala* by observing monkeys eating the fruits. There is also a report of wild species reported from Mangtewa, Sankhuwasawa and Dadeldhura districts (Mohan Thapa, personal comm. 2024). While samples from Nepal might be insufficient for fully tracing the origin of the mandarin orange, it is possible that the species originated simultaneously in various locations, including Nepal's mid-hills, which are home to many citrus species. Numerous wild citrus species are native to these areas, suggesting that the mandarin orange may also have originated in Nepal. Additionally, the origins of landraces are crucial, with many having developed naturally within Nepal.

Scientists believe that both citron and mandarin orange originated in this part of the world and have been grown since the pre-historical period (Paudyal *et al*., n.d.). mandarin orange and citron are considered indigenous crops of Nepal, with Chinese travelers even mentioning Nepal as "the country of golden fruits" around 2000 years ago when they observed the yellow color of mandarin orange fruits at ripening (Lohar and Lama, 1997). The Nepali name for mandarin orange, "*Suntala*," translates to "golden story," which aligns with the description provided by Chinese travelers. Additionally, the Sanskrit word for mandarin orange, "*Narangi*," also indicates the antiquity of the crop in Nepal. Historical records and research further support mandarin orange's indigenous status in Nepal. Bonavia, cited by Shrestha and Verma (1998), considered mandarin orange as an indigenous fruit of Nepal. Tanaka (1954) identified the Himalayan foothills, including regions from eastern Burma, Assam, Sikkim and Punjab, as the native habitat of *Citrus medica* and *C. limon*, referring to this area as the Medica-Limon chain. Local farmers in districts like Darchula and Shakhuwasava claim that their forefathers collected mandarin orange trees from the wild. These historical accounts provide clear evidence that citron, mandarin orange, and hill lemon (*Nibuwa*) are native fruits of Nepal and have been cultivated since pre-historical times, highlighting the deep-rooted cultural and agricultural significance of mandarin orange in the region.

Figure 1. Khoku forest area and Mandarin orange growing area

The distribution of mandarin orange cultivation in Nepal is widespread, primarily concentrated in the mid-hill regions across the country. It is a major sub-tropical fruit and is cultivated in 66 districts spanning a wide range of altitudes, from as low as 200 meters in Chitwan to as high as 2000 meters in Dadeldhura. This distribution in terms of altitude range and districts is based not only the large area of mandarin orange but also based on the availability of single plant of mandarin orange near farmer’s house. Commercial production of mandarin orange occurs in 60 districts, indicating its economic significance (Figure 2). In the mid-hill areas, mandarin orange cultivation is a common practice, with almost every household growing at least a few plants around their houses or in kitchen gardens. Some of the most famous districts known for their mandarin orange production include Taplejung, Panchthar, Terhathum, Dhankuta, Ilam, Bhojpur, Udayapur, Sankhuwasabha, Solukhumbu, Okhaldhunga, Sindhuli, Ramechhap, Kabhre, Chitwan, Nuwakot, Gorkha, Lamjung, Myagdi, Tanahu, Kaski, Parbat, Baglung, Syangja, Nawalparasi, Palpa, Gulmi, Arghakhanchi, Rukum, Pyuthan, Rolpa, Salyan, Dailekh, Jajarkot, Kailali, Dadeldhura, Doti, Bajura, Bajhang, Baitadi, Darchula and Achham. This wide distribution across various altitudes and regions highlights the adaptability and popularity of mandarin orange cultivation in Nepal, contributing significantly to both household subsistence and commercial agriculture. Districts without mandarin orange are 11 (Humla, Jumla, Parsha, Dhanusa, Mahottari, Banke, Siraha, Rautahat, Bara, Manang and Mustang).

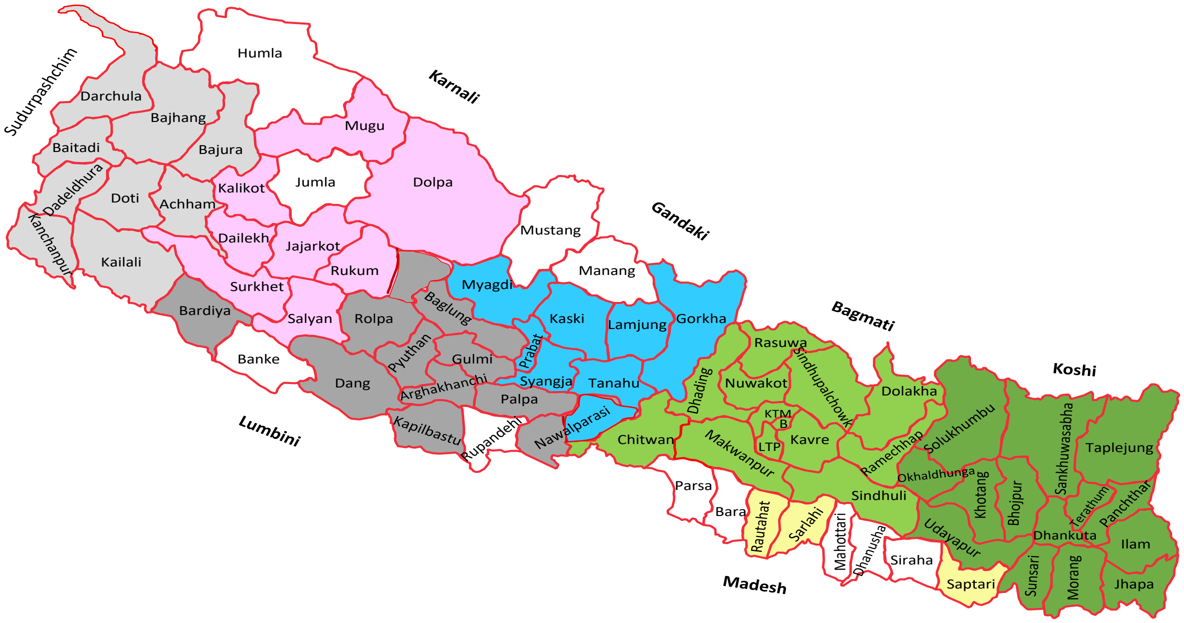


Figure 2. Mandarin orange growing districts in Nepal. Districts with no color mean no mandarin orange. In some district, only few plants of mandarin orange can be observed. Here, only one plant of mandarin orange if found in a district, it is considered as mandarin orange growing district.

Traditional innovations

In Nepal, mandarin oranges are lovingly referred to as "*Suntala*," a name that carries deep cultural significance. The term originates from the belief that the matured fruit, with its golden hue, resembles gold itself. Farmers, recognizing the value of this precious fruit, liken it to gold and affectionately dub it "*Suntala*." This connection is further emphasized by the visual similarity of the fruit hanging from the tree, resembling steps or "tala" in Nepali, hence "*Suntala*." Farmers, being the custodians of traditional knowledge, have long been the primary source of expertise on mandarin oranges. They propagate these fruits through methods like seeds and layering, often cultivating them near their kitchen gardens for easy access. To maintain the viability of mandarin orange seeds for up to 2 months, it's advisable to blend fresh seeds with charred remnants from burnt wood or coal and store them at a temperature of 4°C (typical refrigerator temperature). Mandarin oranges hold not only economic but also religious and cultural importance in Nepalese society. Traditionally, people began consuming *Suntala* from *Thulo Ekadasi*, a significant religious event. It's also a component of "*sat beej*," a mixture of 100 seeds traditionally sown during *Bala Chaturdashi*. Moreover, *Suntala* finds common use in worship ceremonies and religious functions, symbolizing prosperity and auspiciousness.

The practical use of mandarin oranges extends beyond mere consumption. In Nepal, it's common to enjoy *Suntala* while basking in sunlight, combining the benefits of vitamin C from the fruit with vitamin D from the sun. The peel of the fruit is utilized medicinally, particularly in treating conditions like Amoebiasis. Children even play with the peel, squeezing its juice over flames to produce brighter flames, showcasing the playful ingenuity associated with this fruit. However, there are traditional customs surrounding the consumption and handling of mandarin oranges. Farmers advise against consuming the seeds and caution against shaking the tree or picking fruit during wet periods, such as in the mornings. Some even do briefly expose the fruit to flames before consumption. The seeds are promptly sown after extraction to ensure the continuity of this cherished fruit. In Nepalese culture, the significance of *Suntala* transcends its nutritional value; it's deeply intertwined with tradition, folklore, and daily life. As reflected in the popular song "**सुनकै भाउ छ सुन्तला भारीको, चाखि जानु भन्ने मनकारीको**", *Suntala* embodies both material and cultural wealth, making it an integral part of Nepalese heritage.

Diversity

In Nepal, out of 24,300 biological species, 28% constitute agricultural genetic resources. This includes 200 fruit species spread across 15 different agro-ecosystems, among which there are 17 species of citrus. The *Suntala* cultivars are categorized as Native, Local, Exotic, Variety, Landrace and Ecotype. The diversity of mandarin orange in Nepal is extensive, reflecting the country's rich citrus heritage (Thapa *et al*., 2017). With a total of 17 citrus species, including many closely related to mandarin orange, Nepal boasts a diverse array of citrus fruits. Some of these species are found in the wild, adding to the complexity of Nepal's citrus ecosystem. Moreover, mandarin orange exhibits diverse ecotypes adapted to various geographical regions, such as *Tarai Suntala* from the lowlands, *Pahadi Suntala* from the mid hills, Lekali *Suntala* from high hills and others like *Purbeli Suntala* and *Pashchimko Suntala* from specific regions. Nepal's mandarin orange diversity extends to its landraces, with 60 native (Box 1) and 43 exotic landraces identified. Additionally, the country is actively testing exotic mandarin orange varieties from countries like Japan, France, India, China, and Bhutan to assess their adaptability and performance under local conditions (Figure 3). Among the registered varieties, two originate from native landraces-*Khoku Sthaniya* and *Banskharka Sthaniya* (Table 1)-while one, Unshiu, is an exotic variety (Gautam and Gotame, 2020; Gotame *et al*., 2020). Munankarmi *et al* (2023) has explored the genetic diversity of citrus spp using Sample Sequence Repeat (SSR) markers.

The genetic characteristics of mandarin oranges in Nepal vary widely, with some varieties being polyembryonic or monoembryonic. Moreover, mandarin orange varieties can be classified as pure, admixture, or heterogeneous, highlighting the genetic variability within the species. This genetic diversity is further enriched by the diverse propagation methods employed, including seed propagation, vegetative propagation, and apomixis. In terms of fruit availability, Nepal enjoys a prolonged mandarin orange harvesting season, with fruits being available from September to March. This extended season not only ensures a continuous supply of fresh fruits but also offers opportunities for farmers to stagger their harvests. Furthermore, the diverse use values associated with mandarin oranges, such as taste, aroma, and nutritional content, contribute to their cultural and economic significance in Nepal. Overall, Nepal's mandarin orange diversity is a testament to its diverse agro-ecosystems and cultural heritage. This diversity presents opportunities for conservation efforts, breeding programs, and culinary exploration, ensuring the continued resilience and utility of mandarin orange varieties in Nepal.

Nepali *Suntala*

Shyaut *Suntala* (Nepali)

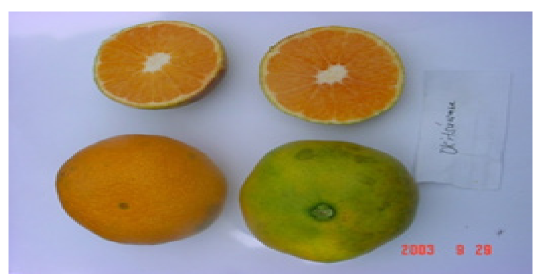
Indian-Nagpure

Kinnow Indian

Australian mandarin orange

French mandarin orange

Russian mandarin orange



Japanese mandarin orange

Figure 3. Fruits of mandarin orange of different countries

Box 1. General name list of mandarin orange landarces

Guliyo Suntala, Amilo Suntala, Sano, Thulo, Bokra Baaklo, Patalo Bokra, Khasro, Chillo, Geda Dherai Bhayeko, Geda Thorai Bhayeko, Kesra Thulo Bhayeko, Khoku Sthaniya, Banskharka Sthaniya, Parbat Suntala, Dhankuta Local, Manakamana Local, Banskharka Local, Sikkime, Khoku, Gulmi Suntala, Gorkhali Suntala, Kamala, Shyaut Suntala, Khoku Suntala, Mangtewa Suntala, Ilam Suntala, Bhojpure Suntala, Rumjatar Local, Powati Suntala, Myagde Suntala, Syangja Suntala, Banskhark Suntala, Kotmaula Suntala, Dailekh Suntala, Gulmi Suntala, Palpa Suntala, Arghakhanchi Suntala, Salakpur Suntala.

It's evident that mandarin orange varieties in the mentioned regions exhibit significant morphological diversity, as described by various studies and observations (Acharya and Pakka, 2018; Acharya *et al*., BS 2076; Budathoki *et al*., 2004; Pun and Thakur, 2018):

Plant growth characteristics

- In the study conducted in Dhading district, mandarin orange genotypes exhibited a wide range of growth characteristics such as plant height, canopy spread, and basal girth. Plant height ranged from 137.5 to 295.0 cm, canopy spread ranged from 103.8 to 205.0 cm, and basal girth ranged from 11.8 to 22.0 cm. Local genotypes like *Banskharka* and *Sikkime* showed particularly high plant growth in terms of height.

Fruit characteristics

- Fruit production per plant varied significantly among different genotypes, ranging from 16.7 to 151.3 fruits per plant.
- Fruit weight also varied, with a range of 60.0 to 133.9 grams per fruit. *Khoku*, *Sikkime*, and *Banskharka* were among the local genotypes that showed higher fruit weight.
- 'Khoku Local' was found to be superior in terms of fruit weight (100.2 g per fruit), juice content (46.4%), total soluble solids (TSS), and titrable acidity (TA) compared to 'Dhankuta Local'.

Quality and maturation period

- The quality and maturation period of mandarin orange varieties varied across different regions and genotypes. *Suntala* and *Kamala* were identified as mid-season maturing varieties, ripening from November to December in Banskharka, Karendada and Terhathum.
- Mandarin oranges from Banskhark of Parbat district were noted for their excellent quality.

Variety selection

- Several mandarin orange genotypes, including Miyagawa Wase, Fortune, Ponkan, Comunes, Mino, Nova, Khoku, Sikkime and Banskharka, exhibited favorable characteristics for further variety improvement and selection.

Local naming conventions

- Local naming conventions such as "*Kamala*" for the best *Suntala* (mandarin orange) in Banskharka indicate the significance of certain varieties within specific communities.

Overall, the morphological diversity of mandarin orange varieties in the mentioned regions encompasses differences in plant growth, fruit characteristics, quality attributes, maturation times, and local preferences, providing a rich resource for further study, cultivation, and variety improvement efforts. Creating genetic variation in *Suntala* is technically straightforward but seldom pursued. Additionally, while exchanging germplasm is relatively easy, it is challenging to regulate, especially when seeds are transported along with the fruits.

Based on genomic analysis, the study revealed distinct separation among citrus groups, namely citrons, pummelos, and mandarin oranges, from inter-specific hybrids like oranges, grapefruit, lemon, and limes (Wu *et al*., 2018). Additionally, within these main groups, further clustering was observed. The genomic study traced the origin of mandarin oranges to the East Himalaya region, suggesting a migration pattern based on genetic analysis. Both chloroplast genome phylogeny and nuclear genome analysis demonstrated clear differentiation, distinguishing Tachibana mandarin oranges from mainland Asian mandarin oranges.

Mandarin oranges were classified into three types based on genomic data (Wu *et al*, 2018): type-1 mandarin oranges were identified as pure species, while type-2 mandarin oranges exhibited early-admixture, containing a small amount of pummelo ancestry traceable to a common pummelo ancestor. Subsequent pummelo introgressions into type-2 mandarin oranges gave rise to type-3 mandarin oranges, characterized by late admixture, and sweet orange. Further breeding activities involving sweet oranges and mandarin oranges or within the late-admixture mandarin oranges, led to the development of additional modern mandarin orange varieties.

Table 1. Name list of released landraces and their features

Feature	Banskhark Sthaniya	Khoku Sthaniya
Origin	Banskhark, Parbat	Khoku, Dhankuta
Plant height (cm)	390 cm (19 yrs grafted)	200 (14 yrs old grafted)
Fruit/tree (no.)	490	384
Fruit weight (gm)	95	101
Fruit diameter (mm)	62	57
Fruit skin color	Bright orange	Bright orange
Fruit shape	(Spheroid)	Spheroid
TSS	12%	12-14%
Acidity	0.8-1.2%	1.15%
Yield/tree (kg)	46.4	38.4
Production/ha (ton)	29	16-24
Maturity period	December-January	December-January

Source: NCRP, 2076BS

Conservation

The conservation of mandarin orange genetic diversity is a critical undertaking due to the unique nature of mandarin orange seeds, which are classified as non-orthodox, meaning they do not tolerate drying and freezing well. Therefore, it's imperative to utilize specialized conservation methods such as field gene banks, tissue banks, and cryobanks to ensure the long-term preservation of mandarin orange genetic resources.

In the global context, citrus genebank collections encompass various conservation approaches, including field plantings, greenhouse cultivation, tissue culture, cold storage of seeds, and cryopreservation of shoot tips or seeds. mandarin oranges and sweet oranges constitute the largest accession holdings within these genebanks (Volk *et al*., 2023), underscoring their significance in worldwide citrus conservation efforts. Other citrus fruit types, such as lemon, pummelo, grapefruit, hybrids, lime, sour orange, citron, kumquat, papeda, finger lime and crop wild relatives, are also maintained ex situ across the globe.

Notably, Nepal's contribution to global citrus conservation includes one accession recorded in the United States, collected in 2001. Among the 190 accessions documented in Genesys, 29 are part of the Multilateral System of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). In Nepal itself, the National Agriculture Genetic Resources Center (NAGRC) has outlined a comprehensive approach to conserving mandarin orange diversity (Figure 4). This includes the establishment of more than seven field genebanks dedicated to mandarin orange preservation, along with initiatives such as agro gene sanctuaries, community field genebanks, household field genebanks, and tissue banks. These efforts have resulted in the conservation of approximately 30 native mandarin orange landraces, each documented with passport data for future reference and utilization.

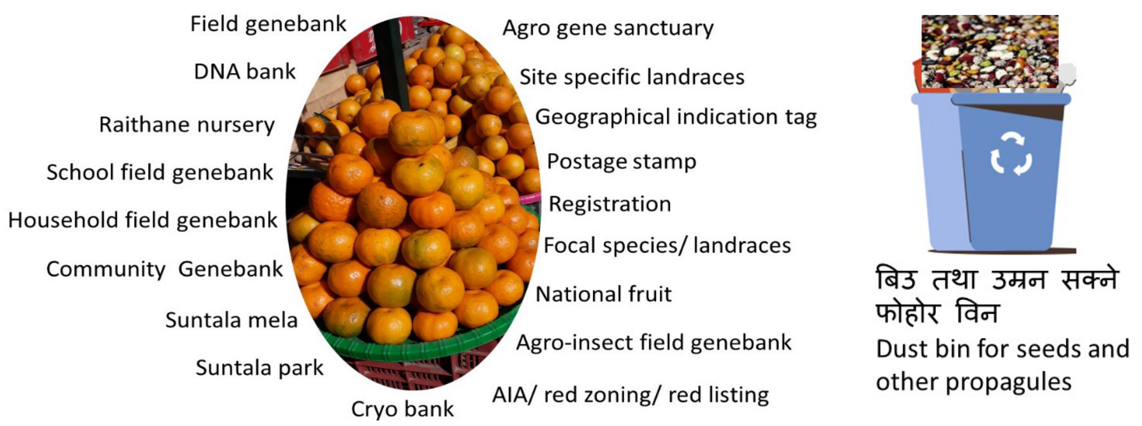


Figure 4. Conservation approaches and methods for mandarin orange diversity

Furthermore, specific mandarin orange accessions originating from France, Japan, Australia, India and Nepal are housed in various field genebanks across Nepal, such as 43 accessions in the NCRP in Paripatle (Table 2, Annex 1), seven in WTHC in Kirtipur, three in ICIMOD in Godawari, five in HRS in Dailekh, and six in the National Genebank in Khumaltar (Annex 2, NAGRC, 2023). These collections vary in size and duplication methods, with some having single trees per accession, partial greenhouse duplications, or multiple trees in the field or greenhouse pots. To enhance the security of genebank collections, duplicate plantings or cryopreserved backups are employed, mitigating the risk of genetic loss or damage due to unforeseen events. The development of a global strategy for the conservation and utilization of citrus genetic resources further emphasizes the importance of coordinated action and collaboration in safeguarding these invaluable genetic treasures.

Table 2. Accession of citrus conserved in field gene bank at NCRP, Paripatle, Dhakuta

Species	Number	Source
Mandarin orange	43	France, Japan, Australia, India and Domestic
Sweet orange	35	India, Australia, France and Domestic
Tangelo	3	France and Japan
Tangor	4	France and Japan
Acid Lime	25	Domestic collection
Lemon	7	Domestic collection
Grape fruit	10	France, Vietnam, Domestic
Kumquat	4	India, China
Rootstocks	20	France, Australia and Domestic
Total	**152**	

Source: Gotame *et al*., 2014; NCRP, 2023

Drivers of mandarin orange diversity

The drivers influencing mandarin orange diversity in Nepal are multifaceted, encompassing both external and internal factors that impact its cultivation, conservation, and overall biodiversity. One significant driver of mandarin orange diversity decline in Nepal is the prevalence of diseases, particularly citrus greening, which poses a substantial threat to mandarin orange orchards. The spread of citrus greening contributes to the loss of genetic diversity within mandarin orange populations, as affected trees may need to be removed to prevent further spread. Another factor affecting mandarin orange diversity is the shifting priorities and interests towards exotic fruits in Nepal. There is a growing trend towards cultivating exotic fruits like avocado, dragon fruit, and kiwi, which has led to the displacement of mandarin orange orchards in some areas. For example, Dhankuta, once renowned for its excellent mandarin orange cultivation, has now been declared as the capital of avocado cultivation, resulting in the replacement of mandarin orange orchards with avocado plantations.

Other factors contributing to the reduced diversity of mandarin oranges include propagation through vegetative parts, the dominance of a single genotype across extensive production areas, disregard for meiotic events, and the uniform use of the same genotype for both rootstock and scion throughout the country.

Furthermore, mandarin orange orchards in many districts across Nepal have faced significant destruction, often due to natural disasters such as landslides exacerbated by climate change. These environmental challenges not only directly impact mandarin orange cultivation but also contribute to habitat loss and fragmentation, further reducing mandarin orange diversity. Additionally, the replacement of native mandarin orange landraces by exotic varieties poses a threat to mandarin orange diversity. The introduction of new varieties may not compete native landraces, leading to genetic homogenization and the loss of unique traits and characteristics associated with indigenous mandarin orange varieties. There is often less priority given to research, education, and extension services focused on native mandarin orange cultivation in Nepal. This lack of attention may hinder efforts to conserve and promote indigenous mandarin orange landraces, exacerbating the decline in mandarin orange diversity.

Ecological values

In agriculture, the focus is often solely on the yield of produce, such as grains or fruits. However, for the purposes of climate change mitigation and promoting sustainable agriculture, it is essential to consider the ecological yield. This includes not only the production of fruits but also contributions to habitat for birds, insects, and microbes; provision of food sources for these organisms; purification of air and water; enhancement of soil and environmental quality; aesthetic value and appeal to visitors; absorption of dust, and carbon sequestration, among other benefits.

Mandarin orange cultivation in Nepal offers a plethora of ecological benefits, enriching the local environment and supporting diverse wildlife populations. Firstly, mandarin orange orchards serve as vital habitats for a wide range of wildlife, particularly birds and insects. The abundant flowers of mandarin orange trees attract various species of bees and other pollinators, fostering biodiversity within the ecosystem. These pollinators play a crucial role in the reproduction of numerous plant species, contributing to ecosystem resilience. Moreover, mandarin orange orchards contribute to the aesthetic appeal of the landscape, enhancing the natural beauty of the environment. The lush green foliage of mandarin orange trees provides year-round greenery, adding vibrancy to the surroundings and creating visually pleasing landscapes. In addition to serving as habitats, mandarin orange trees also serve as a source of food for many wildlife species. Birds, insects honey bees and other animals often feed on the nectar, fruits, and foliage of mandarin orange trees, contributing to the ecological food web and supporting overall biodiversity.

Furthermore, mandarin orange orchards play a significant role in environmental purification. The dense foliage of mandarin orange trees acts as a natural filter, absorbing dust particles from the air and helping to improve air quality in the surrounding area. Additionally, mandarin orange trees contribute to carbon sequestration, effectively capturing and storing carbon dioxide from the atmosphere. Research conducted in Dhankuta, focusing on the Khoku landrace, has demonstrated carbon sequestration rates ranging from 0.24 to 1.22 tons per hectare (Acharya et al., 2023), highlighting the role of mandarin orange cultivation in mitigating climate change impacts. Overall, mandarin orange cultivation in Nepal not only provides economic benefits but also supports ecological sustainability by providing habitat, food, and contributing to environmental purification and carbon sequestration. These ecological values underscore the importance of promoting sustainable mandarin orange cultivation practices to preserve biodiversity and protect the natural environment for future generations.

Geographical indication

Geographical Indication (GI) holds significant potential for mandarin orange cultivation in Nepal, offering avenues for on-farm conservation, enhanced marketing strategies, and rural development initiatives. The unique qualities and reputation of Nepalese mandarin orange, deeply rooted in its specific geographical origins, make it an ideal candidate for GI recognition (Joshi et al., 2017). Mandarin orange stands out as Nepal's premier fruit, boasting a diverse array of site-specific landraces renowned for their distinct and sought-after characteristics. These landraces possess qualities intricately linked to their geographical origins, contributing to their popularity and high market value. In fact, certain mandarin orange landraces command premium prices in the market, often traded under the name of their production domains, highlighting the strong association between quality and origin.

The widespread popularity of Nepalese mandarin orange stems from its exceptional quality and unique flavor profile, surpassing those of mandarin oranges from other countries. Renowned for their unparalleled sweetness, juiciness, attractiveness, and aromatic scent, Nepalese mandarin oranges captivate consumers with their superior taste and sensory appeal. Moreover, mandarin orange holds a special place in Nepalese culture, reflected in numerous songs, poems, stories, and cultural references. The vibrant orange hue of mandarin oranges evokes imagery of vitality and prosperity, earning them endearing monikers such as the "gold of Nepal." Festivals, exhibitions, and celebrations revolving around mandarin oranges further underscore their cultural significance and societal integration.

Certain local mandarin orange landraces, such as Banskharka-1, Banskharka-2, and those from Parbat district, have emerged as lucrative commercial commodities (Budathoki et al., 2004), driving economic opportunities for local farmers and communities. Areas like Khoku, Gulmi, and Parbat (Table 3) exhibit strong potential for securing geographical indication rights, leveraging their distinct mandarin orange varieties and geographical heritage to enhance market competitiveness and rural development initiatives. So far none of mandarin orange has neither got collective right nor geographical indication tag. In essence, the recognition of Nepalese mandarin orange as a geographical indication not only safeguards its unique identity and geographical heritage but also fosters economic growth, cultural preservation, and community empowerment across mandarin orange-producing regions in Nepal (Joshi and Gauchan, 2020; Joshi et al., 2020).

Table 3. Popular site of native mandarin orange production across the country

SN	Province	Location	Local name of mandarin orange
1	Koshi	Khoku, Dhankuta	Khoku *Suntala*
2	Koshi	Mangtewa, Sankhuwasabha	Mangtewa *Suntala*
3	Koshi	Salakpur, Ilam	Ilam *Suntala*
4	Koshi	Bhojpur	Bhojpure *Suntala*
5	Koshi	Rumjatar, Okhaldunga	Rumjatar Local
6	Bagmati	Powati, Dolakha	Powati *Suntala*
7	Gandaki	Manakamana, Gorkha	Manakamana *Suntala*
8	Gandaki	Myagde, Tanahu	Myagde *Suntala*
9	Gandaki	Syangja	Syangja *Suntala*
10	Gandaki	Banskharka, Parbat	Banskharka *Suntala*
11	Karnali	Kotmaula, Salyan	Kotmaula *Suntala*

SN	Province	Location	Local name of mandarin orange
12	Karnali	Dullu, Dailekh	Dailekh *Suntala*
13	Lumbini	Gulmi	Gulmi *Suntala*
14	Lumbini	Palpa	Palpa *Suntala*
15	Lumbini	Arghakhanchi	Arghakhanchi *Suntala*
16	Sudurpashchim	Sahajpur, Kailali	Sahajpur *Suntala*

National fruit

Ministry of Agriculture and Livestock Development was taking due consideration of making mandarin orange as national fruit after the request by National Genebank. The designation of mandarin orange as the national fruit of Nepal represents a significant step towards acknowledging its cultural and agricultural importance within the country. If officially declared as the national fruit, mandarin orange would serve as a symbolic representation of Nepal's rich agricultural heritage and natural resources. Moreover, on an international platform, this declaration would effectively establish a sense of ownership, showcasing mandarin orange as a unique and valuable asset of the nation. Such recognition would not only elevate the status of mandarin orange domestically but also garner respect and appreciation from all Nepalese people. This collective acknowledgment is crucial in fostering a sense of pride and responsibility towards the promotion, study, conservation, and sustainable development of mandarin orange cultivation practices across the country.

At a global level, the declaration of mandarin orange as the "National Fruit" has significantly enhanced its visibility and prestige, positioning Nepal as a key player in the mandarin orange industry. This increased recognition, in turn, leads to greater market demand, thus contributing to the generation of income and bolstering the national economy through increased export opportunities. Furthermore, by officially recognizing mandarin orange as the national fruit, Nepal would provide tangible evidence of the fruit's significance as a center of origin and diversity. This documentation strengthens the case for granting collective rights and geographical indication rights, ensuring the protection of mandarin orange varieties and safeguarding the interests of local farmers and communities. It is worth noting that many countries have already designated their native fruits as national symbols, highlighting the cultural, historical, and economic significance of these agricultural treasures. In aligning with this global trend, Nepal's declaration of mandarin orange as the national fruit serves as a testament to its commitment to preserving and promoting its rich agricultural heritage for future generations to cherish and benefit from.

Policy aspects for mandarin orange genetic diversity

In Nepal, despite the absence of a specific policy focusing on mandarin oranges, there exists a framework for citrus, with various programs and plans dedicated to citrus cultivation, research, and extension facilities. However, there is a need for a distinct policy that specifically addresses mandarin orange genetic diversity and its conservation, utilization, and access and benefit-sharing mechanisms, and varietal development (like rice as main staple crop, mandarin orange should be made main fruit). The government of Nepal has demonstrated its commitment to the development of the fruit sector by declaring the years 2016 to 2025 as the fruit decade, aiming to reduce imports and boost exports through mission programs in fruit production.

To address the confusion created due to naming "*Suntalajat*" for citrus, it should be defined as "*Amilofal*" in Nepali, to facilitate effective communication and development strategies. Even though, there are other sour/ acid fruits which do not belong to citrus, amilofal can be defined to cover only citrus species. Additionally, policies favoring genetic diversity at both varietal and landrace levels are crucial. These policies should encompass measures to promote the conservation of traditional mandarin orange landraces, support research and breeding programs aimed at enhancing varietal diversity, and establish mechanisms for equitable access and benefit-sharing among stakeholders involved in mandarin orange genetic resource management. By integrating these policy aspects into the broader framework for fruit sector development, Nepal can effectively promote the sustainable cultivation and utilization of mandarin orange genetic diversity, contributing to food security, rural livelihoods, and agricultural biodiversity conservation.

Way forward

In advancing mandarin orange landraces, it is imperative to undertake comprehensive assessments to quantify genetic diversity across diverse geographical regions. Employing location-specific differentiation tools and robust data generation methods will aid in identifying unique traits, enabling the development of location-tailored varieties. Conservation strategies, ranging from traditional field genebanks to innovative school field genebanks and agro-gene sanctuaries, must be implemented to safeguard mandarin orange diversity alongside associated biodiversity. Propagation methods, including seed, vegetative, and apomixis propagation, should be embraced to sustainable disseminate mandarin orange landraces while preserving genetic integrity. Moreover, initiatives such as designating mandarin orange as the national fruit and issuing a commemorative stamp can elevate awareness of its cultural and economic significance, amplifying efforts toward conservation and sustainable utilization. Before launching any project, it is crucial to integrate an Agro-biodiversity Impact Assessment (AIA) to evaluate its effects on native agro-biodiversity. Additionally, red zoning and red listing of mandarin orange landraces should be conducted, followed by appropriate rescue measures to preserve their diversity.

The seed cycle should be localized while the product cycle is globalized. Cultivars need not be formalized, but products must be legalized and standardized. Native products should be marketed and treated as equivalent to formal products. Efforts such as diversity mapping, estimating diversity indices (at household, village, municipality, and district levels), identifying centers of diversity, and documentation including profiling and cataloging are crucial. The use of passport applications is also recommended. Conservation strategies should emphasize 'conservation through use', making landraces more competitive, conservation breeding, developing site-specific varieties, and enhancing landraces. It is advisable to formally recognize focal landraces (e.g., King, National, Ambassador, endemic, Emblematic, rare, umbrella, keystone, flagship) to aid conservation efforts. The conservation of associated agro-biodiversity is also essential to support the diversity of crops like Suntala. Establishing agricultural national parks, similar to national parks, can play a pivotal role in this process. Linking diversity with hospitality offerings such as home-stays and farm stays can further ensure the successful marketing of Suntala and other local agricultural products.

Concurrently, addressing challenges like citrus greening disease through integrated pest management, eradication approach and breeding for disease resistance is vital for preserving mandarin orange diversity. Granting geographical and collective rights to mandarin orange growers empowers them to safeguard traditional knowledge and access genetic resources, fostering equitable participation and benefits sharing. By synergizing quantification of diversity, conservation strategies, propagation techniques, and policy interventions, a holistic approach can be forged to secure the future of mandarin orange landraces, unlocking their potential for geographical indication and sustainable development. There is a critical need to strengthen the capabilities of farmers, mandarin orange scientists, and mandarin orange experts. This strengthening could be significantly enhanced by integrating advanced scientific disciplines such as omics (including genomics, proteomics, metabolomics, metagenomics, phenomics, and transcriptomics), along with focused studies on nutrients and geographical factors that influence mandarin orange cultivation.

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आचार्य, उमेश, रोशन पक्का, देवराज अधिकारी र समुन्द्रलाल जोशी । २०७६ । सुन्तलाजात फलफूल खेती प्रविधि । राष्ट्रिय सुन्तलाजात अनुसन्धान कार्यक्रम, पारिपात्ले, धनकुटा ।

जोशी, बाल कृष्ण, प्रदिप थापा, सन्तोष शर्मा र विकाश भुषाल । २०८० । सुन्तला (Mandarin orange, *Citrus reticulata* Blanco, Diploid; 2n=2x=18). तथ्यपृष्ठ (Fact sheet) । राष्ट्रिय कृषि आनुवंशिक श्रोत केन्द्र (जीन बैंक), खुमलटार, नेपाल ।

राष्ट्रिय सुन्तलाजात अनुसन्धान कार्यक्रम । २०७६ । सुन्तला र कागतीको सिफारिस जातहरु : एक परिचय । पारिपात्ले, धनकुटा ।

Annex 1. List of genotypes conserved at NCRP, Paripatle, Dhankuta

SN	Accession	Identification/Common Name	Source
A. Mandarin orange *(Citrus reticulata* Blanco*)*			
1	NCRP-01	Khoku *Suntala*	Khoku, Dhankuta
2	NCRP-02	Kinnow	Pakistan
3	NCRP-03	Frutrel early	Unknown
B. Mandarin orange *(C. spp)*			
4	NCRP-04	Unshiu	JICA, Japan
5	NCRP-05 *(C. unshiu)*	Miyagawawase- Unshiu	JICA, Japan
6	NCRP-06 *(C. unshiu)*	Okitsuwase- Unshiu	JICA, Japan
7	NCRP-08	Pongan,Tangerine	ICIMOD
8	NCRP-09	*Kamala*	Dhankuta
9	NCRP-10	Banskharka local (Parbat)	LAC, Lumle
10	NCRP-11	Sikkime *Suntala*	Tehrathum
11	NCRP-12	Calamondin	Unknown
12	NCRP-80 *(C. unshiu)*	Satsumawase	INRA-CIRAD, France
13	NCRP-81 *(C. unshiu)*	Satsuma Mino	INRA-CIRAD, France
14	NCRP-82 *(C. unshiu)*	Satsuma URSS	INRA-CIRAD, France
15	NCRP-88	Fortune	INRA-CIRAD, France
16	NCRP-89	Kara	INRA-CIRAD, France
17	NCRP-90	Nova	INRA-CIRAD, France
18	NCRP-91	Pixie	INRA-CIRAD, France
19	NCRP-92	Dancy	INRA-CIRAD, France
20	NCRP-93	Avana	INRA-CIRAD, France
21	NCRP-94	Page	INRA-CIRAD, France
22	NCRP 95 *(C. unshiu)*	Satsuma Okitsu	INRA-CIRAD, France
23	NCRP-97	Clamentine mandarin orange Hernandina	INRA-CIRAD, France
24	NCRP-98	Clamentine Mandarine Oroval	INRA-CIRAD, France
25	NCRP-99	Clamentine Mandarine Commune	INRA-CIRAD, France
26	NCRP-100	Clamentine Mandarine Marisol	INRA-CIRAD, France
27	NCRP-101	Clamentine Mandarine Nules	INRA-CIRAD, France
28	NCRP-112	*Gorkhali Suntala*	Gorkha, Nareswor
29	NCRP-114	Khoku muted mandarin	NCRP, Dhankuta

SN	Accession	Identification/Common Name	Source
30	NCRP-121	Daisy	Australia
31	NCRP-122	Avana-Aprino	Australia
32	NCRP-123	Imperial	Australia
33	NCRP-124	Murcott	Kirtipur
34	NCRP-125	Oota Pongan	Kirtipur
35	NCRP-126	Yashida Pongan	Kirtipur
36	NCRP-127	Selection-79	Kirtipur
37	NCRP-128	Selection-04	Kirtipur
38	NCRP-129	Nagpure	India
39	NCRP-130	Mangtewa	Suankhuwasabha
40	NCRP-131	*Chitawane*	Chitwan
C. Tangor *(hybrid mandarin)*			
41	NCRP 102	Ellendale	INRA_CIRAD, France
42	NCRP 103	Murcott	INRA_CIRAD, France
43	NCRP 72	Ortanique	INRA_CIRAD, France
44	NCRP-07	Tangor, Murcott	JICA, Japan
D. Tangelo *(hybrid mandarin)*			
45	NCRP 73	Minneola	INRA_CIRAD, France
46	NCRP 74	Oriando	INRA_CIRAD, France
47	NCRP 75	Seminole	INRA_CIRAD, France

Annex 2. List of mandarin accession conserved NAGRC, Khumaltar

Accession no	Landrace	Collected district	Collected year
1. NGRV0349	*Sthaniya Suntala*	Kathmandu	2070
2. NGRV0394	*Syaaut Suntala*	Lamjung	2079
3. CO15623	*Sthaniya Suntala*	Lalitpur	2079
4. CO15816	*Khoku Sthaniya Suntala*	Dhankuta	2080
5. CO15815	*Banskharka Sthaniya Suntala*	Parbat	2080
6. CO15814	*Kamala Suntala*	Parbat	2080

Annex 3. Passport for plant genetic resources to conserve in genebank and field genebank

Genebank-NARC, Khumaltar, PO Box 3055, Kathmandu. Tel: 01 527 5131, 527 5325. www.narc.gov.np *NGF-01*

Genebank Reg. No :

Passport Descriptors for Agricultural Plant Genetic Resources

A. SAMPLE IDENTIFICATION
Collection /Donor number:
Crop (English name):
Crop (Roman Nepali)
बाली (नेपाली नाम):
बाली (स्थानिय नाम):
Genus:
Species:
Subspecies/ var:
Parentage:

Name of cultivar (in Nepali and local language with meaning):

B. COLLECTING SITE
Farmer's or Donor's name:

I. General
Country: Province:
District: Municipality:
Ward: Village/Tole:
Distance (from ward office):
Nearest market/ famous place:
Latitude (N):
Longitude (E):
Altitude (m):

II. Collection source (circle one)
1. Forest 2. Farmland
3. Farm store 4. Kitchen garden
5. Village market 6. Commercial market
7. Institute (name) 8. Other (specify)

III. Cultivating domain (circle one)
1. Mountain/Lek 2. High hill 3. Mid hill
4. Foot hill 5. Tarai and Inner Tarai

IV. Collection/ growing site (circle one)
1. Sloppy 2. Swampy land 3. Plain
4. Terrace 5. Riverside 6. Other (specify)

V. Associated wild, weedy, weed and crops species (specify):

C. CHARACTERIZATION AND MANAGEMENT
Sowing month (Nepali):
Harvest date of this sample in Nepali Calendar (MM/YYYY):
Usage (specify):
Important traits or reason of growing:

Disease & insect pest in field and store (specify):

D. SAMPLE
I. Status of sample (circle one)
1. Landrace 2. Variety (advanced/ improved)
3. Wild 4. Weedy 5. Breeder's line
6. Other (specify)

II. Original source (circle one and give name)
1. Own 2. Neighbor 3. Market
4. Institute 5. Other (specify)

III. From where and when it is introduced?

IV. Distribution frequency (circle one)
1. Widely cultivated 2. Localized 3. Rare
4. Endangered

V. Population variability (circle one)
1. Uniform 2. Not uniform 3. Mix type

VI. Sampling method (circle one)
1. Bulk 2. Random 3. Selective

VII. Number of plants or farmers sampled:

VIII. Quantity of material (number of seeds, fruits or wt /sample):

IX. Type of sample (circle one)
1. Vegetative 2. Seed
3. Both 4. Fruit

X. Cultural practices
1. Irrigated 1. Yes 2. No
2. Transplanted 1. Yes 2. No
3. High inputs 1. Yes 2. No
4. Others (specify):

XI. Herbarium sample: 1. Yes 2. No

XII. Photo: 1. Yes 2. No

E. OTHER OBSERVATIONS & COMMENTS:

Collector's name & institute:

Date of collection (English calendar as DD/MM/YYYY):

प्रकृतिको एक अनुपम उपहारः स्याउत सुन्तला

प्रदिप थापा[१*], बालकृष्ण जोशी[१], श्याम प्रसाद पौडेल[२] र रमेश राज पन्त[३]

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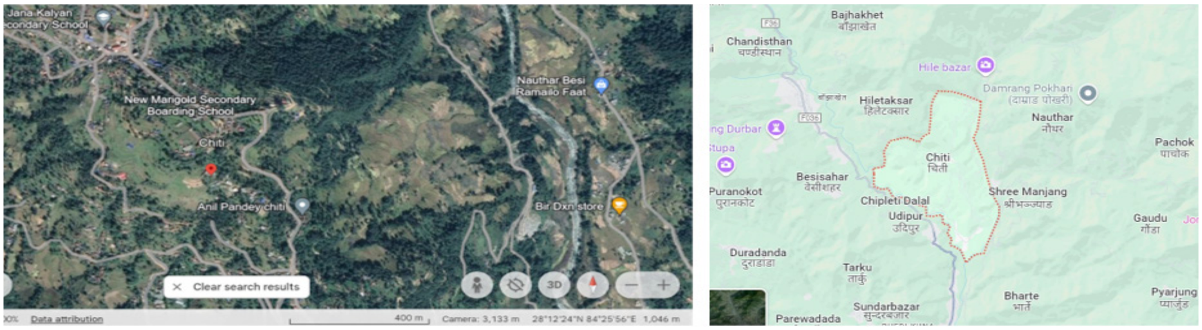
सारांश

लमजुङ्ग जिल्ला बेसीसहर नगरपालिका वडा नं. ११ का कृषक रमेश राज पन्तको सुन्तला बगैंचामा करिब ५०-६० वर्ष पुरानो सुन्तलाको बोट मर्न लागेको अवस्थामा बगैंचाबाट हटाउने क्रममा एक हाँगामा अलि फरक किसिमको पात देखा पर्‍यो । जुन स्थानीय सुन्तलाको हाँगाभन्दा फरक देखिएपछि उहाँले नेपाल कृषि अनुसन्धान परिषद्का वैज्ञानिक डा. कृष्ण प्रसाद पौड्याललाई सम्पर्क गर्नुभएको थियो । कृषि वैज्ञानिकको सल्लाह अनुसार साइड ग्राफ्टिङ्ग गरी बिरुवा प्रसारण गरि एको बिरुवाले ३ वर्षमा उत्पादन दिन थालेपछि र फलको आकार प्रकार तथा स्वाद स्थानीय सुन्तलाका भन्दा फरक पाएपछि पुनः किसानले विभिन्न निकायलाई सम्पर्क गर्न थाल्नुभयो । यसै क्रममा किसान स्वयंले राष्ट्रिय कृषि आनुवांशिक स्रोत केन्द्र (जीन बैंक) मा आएर उक्त नौलो खालको सुन्तलाको अनुगमन गर्न अनुरोध गरेपछि मिति २०७९/०८/१९ गते केन्द्रमा कार्यरत बाली प्रजनक श्री प्रदिप थापाले बगैंचा अनुगमन गरी किसानसँग छलफल गरी आंकडा संकलनको लागि आवश्यक सुन्तलाको फल र खुमलटार फिल्ड जीन बैंकमा संरक्षणको लागि बिरुवा संकलन गर्नुभएको थियो । किसान रमेश राज पन्तका अनुसार वि.स. २०७९ सालमा गाउँका सम्पूर्ण सुन्तला बगैचामा सिट्रस ग्रिनिङ्ग रोग देखिँदा पनि उक्त स्याउत सुन्तलामा उक्त रोग नदेखिएको विभिन्न समयमा गरिएको परीक्षणको नतिजाले देखाएको छ । हालको अवस्थामा उक्त जातको संरक्षण तथा प्रवर्द्धनको लागि आफ्नो तथा सिंगो गाउँको समेत परिचय आउने गरी दर्ता गर्ने प्रकृयाको लागि सर कारी निकायले सहयोग गरिदिए हुन्थ्यो भन्ने किसानको अपेक्षा रहेको छ । फल ठूलो तथा अत्यन्त मिठो र सिट्रस ग्रीनिङ्ग रोग प्रतिरोधी समेत भएको उक्त जातको सुन्तलालाई थप अनुसन्धान गरी बीउ तथा बिरुवा उत्पादन गर्नुका साथै राष्ट्रिय बीउ विजन समितिमा समेत दर्ता गराएर बजारीकरण गर्ने र भौगोलिक सूचक संकेत प्रदान गर्न सके यस्ता रैथाने जातहरुबाट धेरै फाइदा लिन सकिने देखिन्छ ।

पृष्ठभूमि

गाउँमा यदाकदा मात्र एक दुई रुख हुने र एकादशीको दिनमा मात्र रुखमा चढेर सुन्तला खान पाइने चलन रहेकोमा एकादशीको दिन खाएको सुन्तलाको बीउबाट बिरुवा उत्पादन गरी सुन्तला खेतीको शुरुवात गर्नुभएका लमजुङ्ग जिल्ला बेशीसहर नगरपालिका वडा नं. ११ का कृषक रमेश राज पन्तले हाल वार्षिक रुपमा रु. २ देखि ३ लाखसम्मको सुन्तला बेच्ने गर्नुभएको छ । उहाँका अनुसार उक्त ठाउँमा करिब १२५ वर्ष पहिले देखि नै (उहाँका बुवाको कुरालाई सम्झिँदा) एक दुई बोट रै थाने जातको सुन्तला लगाउने गरेको तर खाद्यान्न बालीलाई प्राथमिकतामा राख्ने गरेकोले फलफूल खेती व्यावसायीकरण हुन सकिरहेको थिएन । तर विस्तारै शिक्षा एवं चेतनाले खाद्यान्न बालीको तुलनामा फलफूल बाली बढी नाफामूलक हुने र उक्त क्षेत्र सुन्तलाजन्य फलफूलको लागि उपयुक्त छ भन्ने थाहा पाएपछि उनी लगायत अन्य किसानले पनि उक्त ठाउँमा

व्यावसायिक रुपमा सुन्तला खेती गर्न थालेको उहाँको भनाई छ। केही वर्ष अगाडि एकजना बेलायती विधार्थीले समेत उहाँको बगैचाको र सुन्तलाको बारेमा अध्ययन अनुसन्धान गर्नुभएको थियो। यसरी सुन्तला खेतीको क्रममा उहाँको बगैंचामा करिब चार वर्ष अगाडि अलि फरक अवस्था देखा पऱ्यो। करिब ५०-६० वर्ष पुरानो सुन्तलाको बोट मर्न लागेको अवस्थामा बगैंचाबाट हटाउने क्रममा झलक्क उहाँको आँखा एउटा सानो हरियो हाँगामा गयो जुन हाँगामा अलि फरक किसिमको पात देखेपछि रुखमा चढेर हेर्दा स्थानीय सुन्तलाको हाँगा भन्दा फरक देखिएपछि उहाँले नेपाल कृषि अनुसन्धान परिषदका वैज्ञानिक डा. कृष्ण प्रसाद पौड्याललाई सम्पर्क गर्नुभएको थियो। किसानको अनुरोध अनुसार वि.सं. २०७५ सालमा नेपाल कृषि अनुसन्धान परिषदको तर्फबाट डा. कृष्ण प्रसाद पौड्यालले शुरुमा उक्त जातको अवलोकन गर्नुभएको थियो। उहाँको नजरमा पनि फरक खालको देखिएकोले बिरुवा प्रसारण गर्न कृषकलाई सल्लाह दिनुभएको थियो। उक्त हाँगाबाट ३ वटा सायन प्रयोग गरी साइड ग्राफ्टिङ्ग गरी २ बिरुवा प्रसारण गर्न सफल हुनुभएको थियो। आफूले प्रसारण गरेको बिरुवाले ३ वर्षमा उत्पादन दिन थालेपछि र फलको आकार प्रकार तथा स्वाद स्थानीय सुन्तलाको भन्दा फरक पाएपछि पुनः किसानले विभिन्न निकायलाई सम्पर्क गर्न थाल्नुभयो। तीन वर्षबाट उत्पादन दिन थालेको उक्त जातले शुरुको वर्षमा प्रतिबोट करिब ३० दाना फलेको थियो भने चौथो वर्षमा करिब ६० दाना प्रतिबोट लागेको छ, जुन स्थानीय जातको सुन्तलाको तुलनामा बढी उत्पादन हो। यसै क्रममा किसान स्वयंले राष्ट्रिय कृषि आनुवांशिक स्रोत केन्द्र (जीन बैंक), खुमलटारमा आएर उक्त नौलो खालको सुन्तलाको अनुगमन गर्न अनुरोध गरेपछि मिति २०७९/०८/१९ गते केन्द्रमा कार्यरत बाली प्रजनक श्री प्रदिप थापाले बगैंचा अनुगमन गर्नुभएको थियो। उक्त समयमा कान्तिपुर दैनिक लमजुङ्गका पत्रकार आश गुरुङले पनि उक्त बगैंचा अवलोकन गर्नुभएको थियो र त्यसको विस्तृत समाचार २०७९ साल पौष १४ गतेको कान्तिपुर दैनिकमा समेत प्रकाशित भएको थियो (गुरुङ, २०७९)। अनुगमनको क्रममा किसानसँग छलफल गरी तथ्याङ्क संकलनको लागि आवश्यक सुन्तलाको फल र खुमलटार स्थिति राष्ट्रिय कृषि आनुवंशिक स्रोत केन्द्र फिल्ड (जीन बैंक)मा संरक्षणको लागि बिरुवा संकलन गर्नुभएको थियो। २८ डिग्री १२ मिनेट अक्षांश, ८४ डिग्री २५ मिनेट देशान्तर र समुन्द्री सतहबाट १०४६ मिटर उचाईमा रहेको बगैंचा भएको स्थान लमजुङ्ग जिल्लाको सदरमुकाम बेसीशहरबाट करिब १० कि.मी. टाढा रहेको छ (चित्र १)।



चित्र १. सुन्तला बगैंचा भएको स्थानको नक्सा सहितको जानकारी

जात छुट्याउने मुख्य गुणहरु

- यस जातको सुन्तलाको पात स्थानीय जातको सुन्तलाभन्दा आकारमा ठूलो र मौसमको जस्तो देखिने हुन्छ।
- यस जातको सुन्तलाको भेट्नो स्थानीय जातको सुन्तलाको भन्दा माथि उठेको हुन्छ।
- यस जातको सुन्तलाको बोक्रा स्थानीय सुन्तलाको तुलनामा केही पातलो हुन्छ भने केस्रामा धुस्रा बढी मात्रामा पाइन्छ।
- यस जातको सुन्तलाको फलको रङ्ग स्थानीय सुन्तलाभन्दा गाढा रङ्गको हुन्छ।

चित्र २. स्याउत सुन्तलाका मुख्य जातीय गुणहरु

उक्त अनुगमनको क्रममा स्थानीय र उत्परिवर्तित जातबाट तथ्याङ्क संकलनको लागि ५ वटा पात र ५ वटा फल संकलन गरी प्रत्येक फलबाट ५-५ वटा केस्रा लिएर स्केल, भर्नियर क्यालिपर र डीजिटल व्यालेन्सको सहायताले राष्ट्रिय जीन बैंकको प्रयोगशालामा विभिन्न आंकडा मापन गरिएको थियो, जसको औसत तल तालिकामा प्रस्तुत गरिएको छ (तालिका नं. १)।

तालिका १. स्थानीय सुन्तला र स्याउत सुन्तलाका विभिन्न गुणहरुमा देखिएका भिन्नताहरु

क्र.सं.	बिशेषता	स्थानीय सुन्तला	स्थानीय सुन्तला
१.	बोटको वृद्धि विकास	१ सिजनमा करिब १० से.मि.	१ सिजनमा करिब १० से.मि.
२.	पातको लम्बाई (से.मी.)	६.२२	६.२२
३ .	पातको चौडाई (से.मी.)	२.६८	२.६८
४.	फलको तौल (ग्राम)	१२९	२१८
५.	केस्राको लम्बाई (से.मी.)	४.३६	५.९६
६.	केस्राको चौडाई (से.मी.)	२.१४	२.७५
७ .	केस्राको मोटाई (से.मी.)	१.४३	२.०७
८.	केस्राको तौल (ग्राम)	१०.०९	२०.७३
९.	बोक्राको मोटाई (मी.मी.)	२.९७	२.६५
१० .	बीउको लम्बाई (मी.मी.)	१०.५०	१३.४२
११.	बीउको चौडाई (मी.मी.)	५.७६	६.९२
१२.	फलको रङ्ग	फिक्का रातो	गाढा रातो
१३.	धुस्रा	केस्रामा कम धुस्रा	केस्रामा बढी धुस्रा

स्याउत सुन्तला र लमजुङ्ग स्थानीय सुन्तलाको पात तथा फलमा भएको भिन्नता चित्र ३ द्वारा देखाईएको छ।

स्याउत सुन्तलाको पात

स्थानीय सुन्तलाको पात

स्याउत सुन्तलाको फलको तौल

स्थानीय सुन्तलाको फल

स्याउत सुन्तलाको फल

चित्र ३. लमजुङ्ग स्थानीय सुन्तला र स्याउत सुन्तलाको फल तथा पातमा देखिएको भिन्नता

यसको साथै राष्ट्रिय कृषि आनुवंशिक स्रोत केन्द्र (जीन बैंक)का २० जना कर्मचारीको बीचमा उक्त जातको सुन्तलाको स्वाद परीक्षण समेत गरिएको थियो। स्वाद परीक्षणको क्रममा धेरै जनाको निष्कर्ष स्थानीय सुन्तलाभन्दा तुलनात्मक रुपमा कम गुलियो भन्ने थियो। आफ्नो ठाउँको पहिचान समेत झल्कनेगरि स्याउत ठाउँको नामबाट उक्त नयाँ भूमि-जातलाई स्याउत सुन्तला नामाकरण गरिएको छ। त्यस पश्चात् उक्त जातको सम्पूर्ण जानकारी समेटिएको पासपोर्ट डाटा र कृषकको निवेदनको आधारमा राष्ट्रिय जीन बैंकबाट NGRV नम्बर उपलब्ध गराईएको थियो। हाल उक्त सुन्तला (नयाँ भूमि-जात) लाई खुमलटार राष्ट्रिय कृषि आनुवंशिक स्रोत केन्द्र (जीन बैंक)मा NGRV0394 संकेत नम्बर (परिग्रहण नम्बर) दिई संरक्षण गरिएको छ भने कृषकलाई समेत आफ्नो बगैचामा उक्त संकेत नम्बरसहित अनिवार्य रुपमा संरक्षण गर्ने र त्यसको बेचबिखन तथा जुनसुकै कार्य गर्दा पनि उक्त संकेत नम्बरलाई अनिवार्य गर्नुपर्ने जानकारी समेत गरियो। हालको अवस्थामा किसान रमेशराज पन्तले बिरुवा उत्पादन गरी गाउँका अन्य किसानलाई वितरण समेत गर्नुभएको छ। त्यसको साथै कृषि अनुसन्धान निर्देशनालय, गण्डकी प्रदेश, लुम्लेमा पनि बिरुवा उत्पादन गरी वितरणको लागि तयारी

किसानको बगैंचामा उत्पादित बिरुवा

कृषि अनुसन्धान निर्देशनालय,लुम्लेमा उत्पादित बिरुवा

चित्र ४. स्याउत सुन्तलाको सायन प्रयोग गरी उत्पादन गरिएका बिरुवाहरु

अवस्थामा रहेको छ। बिरुवा उत्पादनको लागि ग्राफ्टिङ्ग विधि र बीउ दुबै तरिका प्रयोग गर्ने गरिएको छ। किसान रमेशराज पन्तको बगैंचा र कृषि अनुसन्धान निर्देशनालय, गण्डकी प्रदेश लुम्लेको अनुसन्धान फिल्डमा ग्राफ्टिङ्ग विधिबाट उत्पादन गरिएको स्याउत सुन्तलाको बिरुवा चित्र ४ मा देखाईएको छ।

यो जातको सुन्तलाको बोक्रा नरम हुने हुनाले स्थानीय जातभन्दा अलि बढी ढुसीको आक्रमण रहेको भएतापनि त्यसले उत्पादनमा केहि फरक पार्ने गरेको छैन। यसको अलावा ऐजेरु, झ्याउ सामान्य रुपमा देखापर्ने गरेको छ। अन्य सुन्तला बालीमा जस्तै सामान्य कीराले आक्रमण गर्ने गर्दछ।

किसान रमेशराज पन्तका अनुसार वि.सं. २०७९ सालमा गाउँका सम्पूर्ण सुन्तला बगैचामा सिट्रस ग्रिनिङ रोग देखिँदा पनि उक्त स्याउत सुन्तलामा उक्त रोग नदेखिएको भन्ने भनाई छ। उक्त भनाइलाई प्रमाणित गर्नको लागि विभिन्न समयमा ३ देखि ४ वटा पातहरु परीक्षण गर्दा कुनै पनि नमूनामा सिट्रस ग्रिनिङ्ग रोग नलागेको पाइयो, जसको विस्तृत विवरण तल प्रस्तुत गरिएको छ।

परीक्षण मिति	परीक्षण गरिएको प्रयोगशाला	नतिजा
२०७८/३/२३	राष्ट्रिय विधि विज्ञानको प्रयोगशाला	नेगेटिभ
२०७९/०८/१२	बाली संरक्षण प्रयोगशाला, गण्डकी प्रदेश	नेगेटिभ
२०८०/५/२४	राष्ट्रिय विधि विज्ञानको प्रयोगशाला	नेगेटिभ

बजारीकरण

बगैंचामा आउने उपभोक्ता तथा व्यापारीले मीठो र फल ठूलो भएको हुनाले सकेसम्म बढी पैसा तिरेर भएपनि उक्त जातको सुन्तला लैजान रुचाउँछन्। स्थानीय सुन्तलाको लागि प्रति के.जी. करिब १० दाना आवश्यक पर्दछ भने आकार ठूलो हुने हुनाले यो नयाँ जातको सुन्तलाको लागि प्रति के.जी. ५-६ दानामात्र आवश्यक पर्दछ जसले गर्दा स्थानीय सुन्तलाको दाँजोमा बढी नाफा हुने देखिन्छ। हाल उपभोक्ता तथा व्यापारीले बगैचाबाट नै प्रति के.जी. रु. १०० का दरले खरिद गर्ने गरेका छन्।

विभिन्न निकायद्वारा गरिएको अवलोकन

सर्वप्रथम वि.सं. २०७५ सालमा नेपाल कृषि अनुसन्धान परिषदको तर्फबाट डा. कृष्ण प्रसाद पौड्यालले शुरुमा उक्त जातको अवलोकन गर्नुभएको थियो। त्यस पश्चात् वि.सं. २०७८ सालमा कृषि अनुसन्धान निर्देशनालय, गण्डकी प्रदेश, लुम्लेका प्रमुख डा. कालिका प्रसाद उपाध्याय र बागवानी अनुसन्धान केन्द्र, मालेपाटनको अनुसन्धान टोलीले संयुक्त रुपमा अनुगमन गरी बिरुवा उत्पादनको लागि फल तथा हाँगा समेत संकलन गर्नु भएको थियो। कृषि अनुसन्धान निर्देशनालय, गण्डकी प्रदेश, लुम्लेको प्रयोगशालामा उक्त जातको सुन्तलामा पाइने चिनीको मात्रा विश्लेषण गरिएको थियो।

कृषि आनुवंशिक स्रोत केन्द्र, लमजुङ्गका प्रमुख सुदिप खतिवडाले यस्तो जातको संरक्षण तथा प्रवर्द्धन गर्नुपर्ने कुरालाई ध्यान दिएर समय समयमा उक्त बगैचा अवलोकन गर्ने काम गर्नुभएको छ र उक्त जात संरक्षणको लागि राष्ट्रिय जीन बैंकसंग किसानलाई जोड्ने काम समेत गर्नुभएको थियो। अझ यसको अलावा राष्ट्रिय सुन्तलाजात अनुसन्धान कार्यक्रम पारिपात्लेका प्रमुख डा. उमेश आचार्य, राष्ट्रिय फलफूल विकास केन्द्र कीर्तिपुरका प्रमुख तथा प्रतिनिधिसँग पनि यस जातको संरक्षण तथा प्रवर्द्धनको लागि कुरा राखेको कृषकको भनाई छ। स्थानीय जनप्रतिनिधि तथा राजनीतिक नेताहरुले समेत चासो दिएर उक्त जातको सुन्तला हेर्नको लागि बगैंचा अवलोकन गर्ने गरेका छन्। हालसम्म मायानाथ अधिकारी (प्रदेश सांसद), जमेन्द्रमान घले (संविधान सभा, सदस्य) र धनन्जय दवाडी (प्रदेश सांसद), गोमान सिंह अर्याल (मेयर, बेसीशहर नगरपालिका), लक्ष्मी अधिकारी (उपमेयर, बेसीशहर नगरपालिका), मोहनप्रसाद मरासिनी (प्रशासकिय अधिकृत, बेसीशहर नगरपालिका) ले उक्त बगैंचा अनुगमन गरिसक्नु भएको छ। अनुगमनको क्रममा उहाँहरुले यस्तो जातको संरक्षण तथा प्रवर्द्धनको लागि सम्बधित स्थानमा पहल गर्ने प्रतिबद्धता जनाउनु भएको थियो।

कृषकको अपेक्षा

उत्पादनमा स्थानीय सुन्तलाभन्दा राम्रो र रोग प्रतिरोधात्मक क्षमता समेत रहेको स्याउत सुन्तलालाई आफ्नो क्षमताले सकेसम्म प्रचारप्रसार गरेको तर त्यसले मात्र सम्भव नभएकोले यसको प्रवर्द्धनमा स्थानीय सरकारका साथै प्रदेश र संघ सरकारको साथ र सहयोगको लागि अनुरोध गर्नुभयो । हालको अवस्थामा उक्त जातको संरक्षण तथा प्रवर्द्धनको लागि आफ्नो तथा सिंगो गाउँको समेत परिचय आउनेगरि दर्ता गर्ने प्रकृयाको लागि सरकारी निकायले सहयोग गरिदिए हुन्थ्यो भन्ने कृषकको अपेक्षा रहेको छ । त्यसको अलावा उक्त जातको स्वस्थ बेर्ना उत्पादन तथा बजारीकरणको लागि आधुनिक किसिमको जालीघरको व्यवस्थाको अपेक्षा गर्नुभएको छ ।

निष्कर्ष

सुन्तला जातका फलफूलमा प्राकृतिक रुपमा म्युटेसन बढी हुने गर्दछ । प्राकृतिक म्युटेसनको कारणले नै बनेको फल ठूलो तथा अत्यन्त मीठो र सिट्रस ग्रिनिङ्ग रोग प्रतिरोधी समेत भएको उक्त जातको सुन्तलालाई नेपाल कृषि अनुसन्धान अन्तर्गतका बाली विशेष कार्यक्रमले थप अनुसन्धान गरी बीउ तथा बिरुवा उत्पादन गरी नेपालका विभिन्न ठाउँमा फैलाउन सकेमा केही हदसम्म भएपनि सुन्तलाको उत्पादन बढाउन सकिने देखिन्छ । यस्तो महत्वपूर्ण आनुवांशिक स्रोतको संरक्षण तथा प्रवर्द्धनको लागि सम्बन्धित बाली विशेष अनुसन्धान कार्यक्रम तथा प्रवर्द्धन विकास कार्यक्रमले ध्यान केन्द्रित गर्नुपर्ने देखिन्छ । उक्त स्याउत सुन्तलालाई राष्ट्रिय बीउ विजन समितिमा समेत दर्ता गराएर बजारीकरण गर्ने र भौगोलिक संकेत प्रदान गर्न सके यस्ता रैथाने जातहरुबाट धैरै फाइदा लिन सकिने देखिन्छ ।

सन्दर्भ सामग्री

गुरुङ आश, २०७९ । भेटियो नयाँ जातको सुन्तला । कान्तिपुर दैनिक । २०७९/०९/१५ ।

Mandarin Orange Biodiversity Utilization in Nepal

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Abstract

Mandarin orange is an important cash crop in the mid-hill of Nepal, cultivated across 66 hilly districts. of these, 44 districts, comprising over 989 blocks, are involved in commercial cultivation. In 2022, mandarin orange was cultivated over 27,892 hectares, with a productive area of 19,481 hectares, yielding a total production of 185,346 metric tons and a productivity of 9.51 mt/ha. Among the citrus grown in Nepal, mandarin orange covers 60% of the cultivated area, providing employment to 700,000 people and generating transactions worth 30 billion Nepalese Rupees. In 1928, Tanaka identified Nepali mandarin orange as Ponkan and regarded Nepal as a secondary center of origin, noting the presence of mandarin orange trees and forests dating back over 400 years. As reported by early researchers there are 60 heirloom landarces available in Nepal. Fresh Nepali mandarin oranges are available from December to February, with fruit imports filling the gap for the remaining nine months. The field gene bank of NARC contains 45 mandarin orange accessions, suggesting that fresh fruit could be supplied from August to March, and with proper storage practices, fruit availability could extend until May. Early varieties like Paripatle Agaue-1 and Miyagawawase, grown at altitudes as low as 800 meters, along with Kinnow in the Terai region, could supply fruit from August. Mid-season varieties such as Nova, Imperial, and Daisy could supply fruit from October to November, followed by Nepali heirloom varieties like Khoku and Banskhark from December to early March. Late varieties like Avana and Murcott could supply fruit from March to April. This strategy aims to promote the commercial cultivation of mandarin orange and reduce the need for fruit imports during lean periods. Nations sound breeding program for varietal diversity creation along with value addition and big storage facilities utilization for fresh fruit are long term focus on commercial utilization of mandarin orange diversity in Nepal.

Keywords: Genotypes, Diversity, Mandarin orange, Utilization

Introduction

Mandarin orange is one of the important fruit crops grown from time immemorial. In the mid-hill, citrus species rule the majority of Nepal's fruit production area. The mid-hills of Nepal, which range in elevation from 800-1500 m, have favorable agro-climatic conditions for the production of high-quality citrus fruit. Even though Nepal is home to mainly three citrus species (hill lemon, rough lemon and mandarin orange), mandarin orange (*Citrus reticulata* Blanco) is mainly produced on a large scale for commercial purposes (Table 1). There are reports which suggest that mandarin orange fruit promotes the nation's nutrition, economics, and living standards. From an economic perspective, mandarin orange fruit is four to five times more profitable than cereal crops on hill terraces and slopes (Gauchan, 2000). Additionally, it offers great opportunities for domestic as well as international trade (Acharya & Shrestha, 2021 and Adhikari & G C, 2020). The Nepali government has been paying attention to research and development of citrus fruit crops since early 1960, including recently in policy documents such as the Agriculture Perspective Plan (1995) and Agriculture Development strategy (2015). Four research centers under Nepal Agricultural Research Council, and two horticulture farms under Department of Agriculture and 20 super zones and zones under Prime Minister Agricultural Modernization Projects are actively involved in mandarin orange research and development activities. Recently, the mandarin orange fruit has been declared as the national fruit of Nepal. This paper is prepared by performing a desk review of papers published in the period of 1990 to 2022. The aim of this paper is to focus on commercial utilization of current biodiversity of mandarin orange in Nepal.

Citrus fruits especially mandarin orange is typically eaten fresh in Nepal. Fruits are also used to make marmalade, squash, and other flavors. Of the total fruit area in Nepal, mandarin orange accounts for 15.32% (27,982 ha) area standing in second position after the mango crop (MoALD, 2023). This shows that mandarin orange is the main fruit grown in Nepal and has an important role in the economic prosperity of Nepali farmers. Landraces are the types of the mandarin orange cultivated in Nepal (550 – 2000 m) (Paudyal et al 2016, 2017). Not only the productivity of mandarin orange fruits in Nepal is low but also the production period is very short due to these native and heirloom varieties. A list of recommended or superior varieties under cultivation in Nepal is shown in Table 9. There are more than 807 wards of 66 districts are involved in mandarin orange production in Nepal producing 185000 mt fresh fruit and it contributes to 0.96% of agricultural gross domestic production. Mandarin orange farming involves seven lakh people both on and off the farm with a transaction of 30.61 Arab Nepali currencies. Citrus is thus a significant agricultural sub-sector in Nepal (Acharya & Adhikari, 2022). However, the country's demand for citrus cannot be supplied by the present level of production (Table 2: Dahal et al., 2020). In the past 5 years, the productivity of mandarin orange orchards has not drastically increased even some time it has decreased (Table 3: MoALD, 2022/23).

Table 1. Total area, productive area, production, and productivity of major citrus fruits in Nepal (2021/22)

Major citrus fruits	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
Mandarin orange	27,982	19,481	185,346	9.51
Sweet orange	6,595	4,487	51,644	11.51
Acid lime	9,701	6,070	44,462	7.33
Lemon	2,636	1,884	13,437	7.13
Other citrus	2,392	1,495	11,261	7.53
Grand Total	49306	32417	306149	9.47

(**Source:** Statistical Information of Nepalese Agriculture 2021/22, MoALD 2023)

Table 2. Import of citrus fruit in Nepal in last six years.

Fiscal year	Quantity (mt)	Amount (NRS)
2017/18	26595	1122100000.00
2018/19	24933	1207000000.00
2019/20	28739	1371200000.00
2020/21	25442	1271900000.00
2021/22	17072	881600000.00
2022/23	21950	1351200000.00

Table 3. The mandarin orange fruit production statistics of Nepal in the five years

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2017/18	27150	16156	161434	10.0
2018/19	27951	17220	177381	10.3
2019/20	26521	14551	156180	10.73
2020/21	27002	18369	198406	10.08
2021/22	27982	19481	185346	9.51

(**Source**: Statistical Information of Nepalese Agriculture 2021/22, MoALD 2023)

The value of imported fresh mandarin orange fruit is increasing, but not the quantity (Table 2). Nepal primarily imports fresh mandarin orange fruit from India, South Africa, and Australia. The majority of the mandarin orange fruit (>90%) comes from India, mostly the Nagpure and Kinnow varieties (Figure 1). During the Paush to Falgun period when Nepali mandarin orange is in the market, the price of imported mandarin orange goes down compared to native produce. For the rest of the year, Indian mandarin oranges dominate the Nepali market. Some Nepali supermarkets also sell mandarin oranges from Kenya and China, although the timing and volume of these new sources are not yet fully recorded. There are several ways to properly commercialize Nepali mandarin orange produce, which are discussed below.

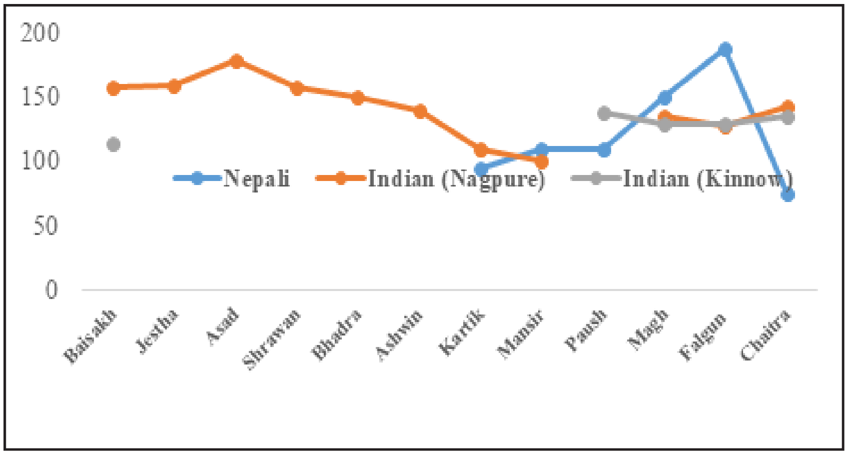

Figure 1. Price of mandarin fruit in Kalimati market in Fiscal year 2079

(**Source** KFVMC, 2022)

Table 4. Accession of citrus conserved in field gene bank at NCRP, Paripatle, Dhakuta

Species	accessions, n	Source
Mandarin orange	45	France, Japan, Australia, India and Domestic
Sweet orange	35	India, Australia, France and Domestic
Tangelo	3	France and Japan
Tangor	4	France and Japan
Acid Lime	25	Domestic collection
Lemon	7	Domestic collection
Grape fruit	10	France, Vietnam, Domestic
Kumquat	4	India, China
Rootstocks	17	France, Australia and Domestic
Total	**154**	

(**Source:** Gotame et al., 2014; NCRP, 2023)

Use of diverse indigenous and exotic mandarin orange varieties (extra, early, mid and late season)

In the early 1960's different exotic varieties of mandarin orange (Table 4) were introduced and trials were started at Citrus Research Sub-Centre, Pokhara, and then Citrus Research Center Dhankuta (Paudyal et al., 2016). Even though some early and late maturing varieties have been identified through these studies (Table 6 and 7), the registration and commercialization of those varieties have not been done except recent registration of Unshiu (Okitsuwase) in the year 2023 (Table 6). A strategy for the production and marketing of Nepali fruit for at least ten months has been proposed in Table 8. The fresh fruit could be supplied from August to March, and with proper storage practices, fruit availability could extend until May using this strategy. Early varieties like Paripatle Agaute-1 and Miyagawawase, grown at altitudes as low as 800 meters, along with Kinnow in the Terai region, could supply fruit from August. Mid-season varieties such as Nova, Imperial, and Daisy could supply fruit from October to November, followed by Nepali heirloom varieties like Khoku and Banskhark from December to early March. Late varieties like Avana and Murcott could supply fruit from March to April. This strategy aims to promote the commercial cultivation of mandarin orange and reduce the need for fruit imports during lean periods. Though the volume could be less initially with the rapid expansion of the area Nepal could leap toward self-sustaining system in the long run if the proposed path is followed.

In the year 2004, the National Citrus Research Program, Dhankuta started testing 31 new varieties of mandarin orange, sweet orange, juntala (hybrid of orange and junar), and grapefruit with introduction from France. Paudyal and Subedi (2008) reported that 23 mandarin orange varieties were evaluated at NCRP, Dhankuta for fruit quality and maturity period. However, these varieties have not been registered and commercialized until 2018 (Acharya & Pakka 2018). Besides, there are many citrus varieties introduced from India and Australia which are in the testing stage

(Table 5). In 1980, the Kinnow mandarin orange genotype received from Pakistan was tested in various research centers, but due to the discontinuation of research, the technology related to its commercial production has not been fully developed (Paudyal et al. 2016). Limited quantities of saplings are being distributed from the National Citrus Research Programme, Dhankuta, and small quantities of fresh fruit are in production in some areas of terai (plains).

Table 5. Indigenous and exotic mandarin orange germplasms maintained at National Citrus Research Program (NCRP) Dhankuta and Warm Temperate Horticulture Center Kritipur (WTHC) in Nepal

Species	NCRP Dhankuta	WTHC Kritipur
Mandarin orange (*C. reticulata*)	Bashkharka Local, Sikkime, Khoku Selection, Gorkhali *suntala*, Pogan, Kamala, Fortune, Kara, Nova, Pixie, Dancy, Avana, Page, Hernadina, Oroval, Commune, Marisol, Nules, Kinnow, Frutrel Early, Kalamadarin	Clementine, Dekopongan, Frutrel Early, Hayaka, Kiyomi, Kinnow, Murkott, Ota Pongan, Thai Tangarin, Yoshida Pongan.
Satsuma mandarin orange (*C. unshiu*)	Miyagawawase, Okitsuwase, Satsumawase, Urss, Satsumawase, Okitsu	Imamura Unshiu, Miyagawawase, Okitsuwase, Miyauchi Iyo, Aoshimaunshu, Otsu-4
Tangor (Tangarin X S. orange)	Ellendele, Murcott, Ortanique	
Tangalo (Tangarin X Pumelo)	Minneola, Orlando, Seminole	Orlando

(**Source:** Modified and adapted from Gotame et al. 2014 and 2016)

Table 6. Registered varieties of mandarin orange cultivated in Nepal and their characteristics.

Variety	Characteristics	Remarks
Khoku Local	Fruit size:110 g, bright orange colour, TSS 13%, TA1.15%, 23 t/ha yield, mid hills 1000-1400 m recommendation domain, maturity time December to February	
Banskhark Local	Fruit size:100-120 g, bright orange colour, TSS 13%, TA1.2%, 25 t/ha yield, mid hills 1000-1400 m recommendation domain, maturity time December to February	
Paripatle Agaute-1 (Okitsuwase)	Fruit size:100-120 g, greenish orange colour, TSS 9 %, TA0.9%, 12-15 t/ha yield, mid hills 800-1400 m recommendation domain, maturity September to October; for high density planting	

Table 7. Maturity time and productivity of 18 mandarin orange accessions tested at NCRP, Paripatle in year 2017

Accession Name	Maturity time	Yield (t/ha)	Other properties
Satsuma Okitsu	September 4th week	12.3	Fruit oval shape; texture-fuzzy, crunchy, juicy; taste-sweet, tangy;
Okitsuwase	October 2nd week	15.0	Early maturation absence of seed, less water , sweet fruit, low acidity
Miyagawawase	October 2nd week	19.4	Early maturation absence of seed, less water , sweet fruit, low acidity
Satsuma Mino	October 2nd week	35.6	Flattened sphere, upto 6 seeds, small to medium size fruit
Satsumawase	October 4th week	28.3	Early fruiting, low acidity, moderate sugar; sweet and tangy taste
Marisol	October 4th week	11.9	Mid-season, low acidity, high vitamin C and tangy taste
Oraval	November 2nd week	35.7	Round shape, bright orange colour, sweet and tangy flavor
Commune	November 2nd week	40.0	Early to Mid season, spherical and tangy taste
Satsuma URSS	November 2nd week	21.4	Seedless, less acidity, flat- oval shape
Page	November 3rd week	4.50	Alternate bearer, small spherical fruit
Nules	November 3rd week	10.6	Good eating quality, mid-season, spherical shape
Nova	November 3rd week	7.50	Medium to large fruit, mid season, spherical shape
Banskharka Local	November 4th week	29.0	Mid to late season, spherical shape, good eating quality
Sikkime Local	November 4th week	27.2	Midseason, spherical shape, tangy fruit
Pongan	November 4th week	11.3	Less juicy, sweet, spherical fruit
Fortune	December 3rd week	19.6	Late season, low eating quality, spherical shape
Kara	December 3rd week	5.21	Late season, low eating quality, less sweet
Khoku local	December 4th week	24.0	Spherical shape, good blend of sweet and sour, high seed (11)

(**Source:** Acharya et al., 2018)

Table 8. Strategies for the production of fresh mandarin orange fruit in Nepal

Varieties	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March
Extra early (Paripatle Augate-1/ Unshiu)												
Early (Commune, Oraval, Nules, Marisol)												
Mid season (Khoku/ Banskharka)												
Late season (Avana/ Murcott)												
Storage												

(**Source:** NCRP 2018-2023)

Breeding using local materials

Developing a new mandarin orange variety is a complex and time-consuming process that typically involves several years of breeding and evaluation. However, there are some approaches that can expedite the process. Selection breeding is the first and easiest process which is employed by NCRP Dhankuta. In this process, selection of native mandarin orange accessions was carried out at multiple locations and superior genetic materials are registered as local varieties as done with Khoku and Banskharka Local by NCRP Paripatle (Table 6). In the meantime, some chance seedlings like Syaut *suntala*, a superior line supposed to be citrus greening tolerant, from Chiti, Lamjung, could be identified and later promoted as potential varieties. Secondly, we could go for selection breeding using exotic materials as maintained at NCRP Dhanuta (Gotame et al 2020; Table 4). To expedite the process sometime breeder uses Marker Assisted Selection (MAS). This technique uses genetic markers linked to desired traits to identify promising seedlings early in the breeding process. It can help reduce the time and resources needed for field evaluation. Next mutation breeding could be used to create genetic variability using indigenous varieties. Breeders could carefully screen these lines for seedlessness, disease, and pest tolerance using MAS later. Irradiation and chemicals like ethyl methyl sulphonate are some of the agents that could be used as mutagenesis in this process. Finally, genetic modification is a process that is rapidly gaining popularity in the scientific arena such as Clustered Regularly Inter-spaced Short Palindromic Repeats (CRISP-R) gene editing. While controversial, genetic modification techniques can potentially introduce specific traits into mandarin orange varieties more quickly than traditional breeding methods. However, this approach may not be suitable for all situations and requires careful consideration of regulatory and consumer acceptance issues. Additionally, ensuring that the new variety meets quality and safety standards is essential before commercialization. The traditional inter-varietal and inter-species hybridization of native Nepali mandarin orange with other introduced materials could not be ignored while following all above-mentioned approaches as These processes require patience, expertise, and resources, but it can lead to the development of new mandarin orange varieties that are well-suited to the specific conditions and preferences in Nepal.

Table 9. Selected superior mandarin orange landraces and their place of cultivation in Nepal

SN	Province	Location	Local name of mandarin orange
1	Koshi	Khoku, Dhankuta	Khoku *Suntala*
2	Koshi	Mangtewa, Sankhuwasabha	Mangtewa *Suntala*
3	Koshi	Salakpur, Ilam	Ilam *Suntala*
4	Koshi	Bhojpur	Bhojpure *Suntala*
	Koshi	Rumjatar, Okhaldunga	Rumjatar Local
5	Bagmati	Pawati, Dolakha	Powati *Suntala*
6	Gandaki	Manakamana, Gorkha	Manakamana *Suntala*
7	Gandaki	Myagde, Tanahu	Myagde *Suntala*
8	Gandaki	Syangja	Syangja *Suntala*
9	Gandaki	Banskharka, Parbat	Banskharka *Suntala*
10	Karnali	Kotmaula, Salyan	Kotmaula *Suntala*
11	Karnali	Dullu, Dailekh	Dailekh *Suntala*
12	Lumbini	Gulmi	Gulmi *Suntala*
14	Lumbini	Palpa	Palpa *Suntala*
15	Lumbini	Arghakhanchi	Arghakhanchi *Suntala*
16	Sudurpaschim	Sahajpur, Kailali	Sahajpur *Suntala*

Source: Joshi et al., 2024

Use of different stress-tolerant rootstocks

There are 17 rootstock species introduced in the National Citrus Research Program Dhankuta since the late 1960's (Table 10; NCRP 2023). Some of these species are under evaluation for commercial cultivation using various mandarin orange scion varieties under both terai and hills agro-climatic conditions. The rootstocks have various abiotic (cold, heat, and drought tolerant) and biotic stress tolerant characteristics and its potential for commercial mandarin orange cultivation must be harnessed as Nepal has diverse climate and biotic issues. NCRP Dhankuta has recently started a study on the identification of suitable rootstock for Kinnow mandarin orange production under terai conditions using five rootstock varieties whose results are yet to come. Similarly, six rootstock varieties are under study for mandarin orange (Khoku Local) and Unshiu (Okitsuwase) production under mid-hill conditions at Dhankuta (NCRP 2020). The initial year's production data shows mixed results and a few more years' results are needed to get concrete results (NCRP 2023).

Use high-density planting method using dwarfing rootstocks

Since 2012, the NCRP in Dhankuta has been studying the identification of planting densities for optimal mandarin orange production, using both indigenous and exotic varieties and rootstocks. Some results are still preliminary, but one exotic variety known as Paripatle Aguate-1 (Okitsuwase) has shown promising results, with yields as high as 25 tons per hectare when planted at a spacing of 2 meters by 2 meters on trifoliate rootstock under mid-hill conditions in Sumrekhola, Syangja. Additionally, Khoku mandarin orange grafted onto trifoliate orange and planted at spacing ranging from 1.15 meters to 3.5 meters apart in the mid-hills of Dhankuta demonstrated the highest yield of up to 28 tons per hectare at a spacing of 1.8 meters by 3 meters (NCRP 2020).

Table 10. List of rootstocks conserved and utilized at NCRP Paripatle, Dhanuta

1	NCRP-65	Citrange C-35	INRA_CIRAD	Cold tolerance, tolerant to phytophthora root rot, tolerant to citrus tristeza virus
2	NCRP-66	Citrange – Carrizo	INRA_CIRAD	Tolerance to citrus tristeza virus
3	NCRP-67	Poncirus– Pomeroy	INRA_CIRAD	Pomeroy is a dwarfing disease-resistant diploid citrus rootstock, compatible with most citrus species, but particularly suitable for sweet orange cultivars
4	NCRP-68	Flying Dragon	INRA_CIRAD	Dwarfing rootstock for orange, grapefruits, lemons and mandarin oranges
5	NCRP-69	Citrumelo 4475	INRA_CIRAD	It is a tetraploid cold-hardy dwarfing citrus rootstock, mainly used for sweet oranges and grapefruit
6	NCRP-70	Volkameriana	INRA_CIRAD	Initial vigor and precocity similar to Rangpur lime, less drought resistant, trees are smaller as well as the fruit, and more resistant to foot rot, but it is susceptible to Blight.
7	NCRP-71	Rangpur lime Red	INRA_CIRAD	Heavy and early bearing, drought resistance and resistant to CTV
8	NCRP-113	Citrange old	Unknown	Cold hardy, tolerant to root rot,
9	NCRP-38	Citrange	Unknown	Cold hardy, tolerant to root rot,
10		Hokse	Nepal	Pumelo rootstock, flood hardy
11	NCRP-36	Trifoliate	Unknown	Cold tolerance, dwarfing, tolerance to Phytophthora root rot, citrus root knot nematode

12	NCRP-37	Rangapur lime	Unknown	Heat and root rot tolerant
13	NCRP-39	Boxifolia	Unknown	
14	NCRP-40	Rough lemon	Unknown	Naite Jyamir, vigorous tree habit
15	NCRP-116	Rough lemon	Dhankuta	Kali Jyamir, vigorous tree habit
16	NCRP-139	Troyer Citrange	Australia	Dwarf rootstock, suitable for sweet citrus species
17	NCRP-140	Rough lemon	Kathmandu	Kathe Jyamir, vigorous tree habit

Value added products

Processed citrus products include a variety of items, ranging from partially processed pulp to jam, jelly, squash, nectar, marmalade, and other products suitable for both industrial and home kitchen use, such as pickles. Pulp, an intermediate product, serves as the base for nectar, squash, and similar products, and can be preserved for extended periods to facilitate production during off-seasons. Citrus wine, particularly popular in hilly regions, is also produced from citrus fruits. Despite the availability of raw materials in the form of fresh fruit and semi-processed pulp, there is an insufficient supply to meet the processing and manufacturing demands of Nepal. While fresh fruit availability from domestic sources has consistently fallen short, the production of semi-processed pulp for the manufacture of final products is nearly nonexistent in Nepal (Thapa et al., 2013). However, recent trade data from Nepal's Department of Customs indicates that Nepal exported juice, dried products, and peel worth USD 6.4 million to India, Germany, the USA, and Bangladesh in 2021/22. Most major fruit industries in Nepal are heavily reliant on imports of pulp to sustain their production processes. The trade deficit situation of the nation could be different if Nepali mandarin orange fruit is used for the preparation of above-mentioned products.

Storage of main-season fruit inside the cold room

The native mandarin orange of Nepal is showing alternate bearing of fruit and there is overproduction in on- year, on one hand, with the rapid expansion of mandarin orange orchards, the production is also increasing year after year resulting in market gluts and price dips in some seasons on other hands. Farmers are trying to get their produce stored in cold storage and are getting good results in one year and losses in other years due to blue and green mold. There is the possibility of stretching the marketing season of native mandarin orange by two months with proper handling and storage of fresh fruit (Acharya et al 2021). The limited post-harvest handling knowledge and unavailability of fresh fruit processing facilities in the pack and storage house most of the activities like cleaning, washing, sorting, and grading have been done manually which involves more physical damage and pathogen attacks resulting in storage rotting of the substantial amount of fruit. Hence, with proper post-harvest management and proper upkeep of storage facilities producers could benefit from the storage of Nepali mandarin orange in cold storage.

Conclusion

There are more than 40 mandarin orange accessions under research and at least 16 heirloom varieties cultivated in Nepal. Despite the selection of native and introduction of exotic germplasm in Nepal since the late 1970s, their full potential remains untapped, even though some exhibit characteristics like early or late maturation. Exploring natural hybrids and chance seedlings in native orchards is a viable option for breeders. A robust breeding program that leverages heirloom mandarin orange varieties for seedlessness and stress resistance can enhance variability in the native gene pool. Additionally, utilizing recent and introduced rootstock germplasm can maximize the potential of existing mandarin orange varieties for early or late harvesting, as well as high-density orchard management utilizing various kind of rootstock is another option. Proper storage and handling of native mandarin oranges, along with developing value-added products from market-unfit fruit, can contribute to the commercialization of the national fruit.

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Validating Geographical Indication for Nepalese Mandarin orange: A Comprehensive Evidence Review

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Abstract

Mandarin orange is a traditional and ancient fruit in Nepal. This study delves into the validation of Geographical Indication (GI) for Nepalese mandarin orange, a fruit known for its geographically linked quality and esteemed status as one of the most preferred fruits in Nepal. Through a substantive review, this research explores the diverse types of mandarin orange associated with various production domains, highlighting their eligibility for geographical indication rights, including collective rights. A common practice in the trade of mandarin orange involves branding and selling by the name of the production area, underscoring the fruit's strong geographical connection. The study calls for granting geographical indications (GI) to various landraces of mandarin orange cultivated in different regions, highlighting its potential to boost the economy of farming communities and support the conservation and promotion of mandarin orange cultivation in Nepal. Legislation to grant GI should be enacted promptly, along with simplified administrative procedures. Farming groups need to be strengthened in the GI process, and GI should be awarded based on geographical location to benefit specific communities.

Keywords: Policy, Geographical indication, Evidences, Suntala, Diversity, Location

Introduction

In the intricate world of trade and commerce, geographical indications (GIs) stand as essential markers of authenticity, linking products to their specific places of origin while safeguarding their unique qualities and reputations. These indications not only celebrate the cultural heritage and traditional practices of a region but also serve as potent tools for economic growth and cultural preservation. A Geographical Indication (GI), as defined by WIPO (2017), represents a distinctive marker applied to products originating from specific geographic locations, possessing qualities or reputation inherently tied to that locale. To qualify as a GI, a designation must unequivocally associate a product with its place of origin. Furthermore, the unique qualities, traits, or renown of the product should predominantly stem from its geographical provenance, establishing a direct correlation between the product and its original place of production.

GIs encapsulate the cultural, geographical, and traditional essence of regions and communities. These marks or signs are bestowed upon commodities of local significance, guaranteeing their origin and inherent characteristics. Such products not only bolster local heritage but also command premium prices in the market due to their assured quality. Geographical indications often signify specific geographic origins and distinctive quality attributes, providing a platform for countries to showcase and promote their products on the global stage, thereby enhancing economic prowess and cultural legacy.

Traditionally, GIs find application across various sectors including agricultural products, foodstuffs, alcoholic beverages, handicrafts, and industrial goods. Pioneering GI systems such as appellations of origin, exemplified by Gruyère cheese from Switzerland and French wine, were among the earliest to receive official endorsement through government-issued stamps, certifying their origins and adherence to stringent standards. In South Asia, notable examples of GIs include Basmati rice, Himalayan waters, Alphonso and Sindhri mangoes, Bhutanese red rice (Jain, 2009) Pakistani shu (windproof woollen fabric) and ajrak (designs from Sindh), and jasmine (Hom Mali) rice. With India boasting 370 registered GIs as of September 2020, including the iconic Darjeeling tea (Patel and Zala 2021), GIs play a crucial role in safeguarding and promoting the unique attributes of regional products.

Nepal, endowed with diverse agrobiodiversity due to climatic variations, harbors numerous agricultural products with potential for GI recognition (Joshi et al., 2017). Notably, products such as Khoku Local mandarin orange, grown in specific areas like Manakamana, Khokana, and Kamala, exemplify the nexus between quality and geographical origin. While informal practices recognize certain products like Khoku Local mandarin orange as de facto GIs, formal registration remains absent. Nevertheless, a policy provision exists for GI recognition in Nepal, underscoring the country's commitment to promoting its unique products.

Despite Nepal's limited competitiveness in the global market, its distinctive products command additional value due to their geographical provenance, quality, and reputation. Geographical indications serve as intellectual property rights, safeguarding products with specific spatial origins and distinctive attributes. Recognizing the strong link between product quality and geographical origin, exploring GIs, particularly concerning Nepali products like mandarin orange, presents a significant opportunity for the country to showcase its unique offerings on the global stage, fostering economic growth, and preserving cultural heritage.

Furthermore, the adoption of GIs facilitates on-farm conservation, marketing of localized quality products, and rural development, as demonstrated by initiatives such as the Nepal Genebank's integration of GIs into its conservation and agrobiodiversity utilization practices. Through strategic utilization of GIs, Nepal can leverage its rich agricultural diversity to bolster economic development and enhance global recognition of its unique products.

This comprehensive evidence review aims to delve into the nuances of validating geographical indication for Nepalese mandarin orange, shedding light on its cultural significance, intrinsic qualities, and economic implications. By harnessing the power of GI, Nepal not only secures the rightful recognition of its agricultural heritage but also opens doors to sustainable rural development and localized marketing strategies. Through this exploration, we seek to highlight the symbiotic relationship between Nepalese mandarin orange and its geographical roots, emphasizing the critical role of GI in preserving biodiversity, fostering rural prosperity, and unlocking the full potential of Nepal's agricultural bounty on the global market. As we embark on this journey, let us unravel the untold stories embedded within the essence of Nepalese mandarin orange, paving the way for a future where authenticity, tradition, and prosperity converge on the world stage.

Mandarin orange diversity and production areas

Mandarin orange cultivation in Nepal exhibits a rich tapestry of diversity, characterized by various landraces that thrive across the country's diverse agro-climatic regions. These landraces, often named after their production sites, have distinct attributes and are traditionally identified and marketed based on their origin. Many exotic varieties are also available (Table 1) and these can be grouped in different categories (Table 2). The diverse array of about 60 mandarin orange landraces manifests in variations in size, maturity period, taste, aroma, skin thickness and smoothness, juiciness, sweetness, and weight. In Nepal, mandarin orange cultivation spans across 66 out of 77 districts (Table 3), with particular emphasis on 34 districts known for their high demand and suitability for mandarin orange production (NCDP, 1990). Among these districts, the mid-hill region emerges as a major domain for mandarin orange cultivation, earning it the moniker "gold of the mid-hill."

The cultivation of mandarin orange is deeply ingrained in local agricultural practices, often observed in close proximity to households. It is common for households to grow a few mandarin orange plants, typically ranging from one to three, near their dwellings. These plants not only provide a convenient source of fresh fruit but also offer shade to adjacent areas, including agan (courtyards), where farmers often take respite during sunny days.

The cultivation of mandarin orange in Nepal reflects a vibrant landscape of diversity, with distinct landraces cultivated across various production areas. The significance of mandarin orange cultivation extends beyond mere agricultural practices, intertwining with local traditions, livelihoods, and cultural practices, particularly in the mid-hill regions, where mandarin orange cultivation serves as a cornerstone of agricultural prosperity and community livelihoods.

Table 1. Indigenous and Exotic genetic resources maintained at different stations.

Species	NCRP, Dhankuta	WTHC, Kirtipur
Common mandarin orange (*Suntala*)	Banskharka Local, Sikkime, Khoku Selection, Gorkhali *Suntala*, Pogan, Kamala, Fortune, Kara, Nova, Pixie, Dancy, Avana, Page, Hernadina, Oroval, Commune, Marisol, Nules, Kinnow, Frutruel Early, Kala mandarin orange	Clementine, Dekopongan, Frutruel Early, Hayaka, Kiyomi, Kinnow, Murkott, Ota Pongan, Thai Tangarin, Yoshita Pongan
Satsuma mandarin orange	Miyagawawase, Okitsuwase, Satsuma wase, URSS Satsuma, Unshiu (NCRP 04)	Imamura unshu, Miyagawawase, OkitsuWase, Miyauchi Iyo, Aoshimaunshu, Otsu-4

Source: Gotame et al., 2014

Table 2. Grouping of Nepalese mandarin orange based on morpho-physiological traits t criteria and recommended domains

S.N.	Characteristics	Khoku Sthaniya	Okitsuwase (seedless variety)	Miyagawa-wase (Seedless variety)	Banskharka
1.	Origin	Khoku, Dhankuta, Nepal	Japan	Japan	Parbat, Nepal
2.	Tree height	200 cm			
3.	Total fruit production per tree	200			
4.	Weight	100-120gm	140-180gm	130 gm	180-200
5.	Color	Bright orange	Green		
6.	Shape of orange	Round			
7.	Juice content	45%	48%	45%	
8.	Acidity	0.8-1.2%	0.8-1%	0.8%	
9.	T.S.S	12-13%	8-9%	8%	
10.	Flowering time	Fagun-Chaitra	Fagun	Fagun	
11.	Flower color	White			
12.	Production per tree	28 kg			
13.	Production per hectare	24 ton per ha			
14.	Fruit ripening time	Poush-Magh	2nd wk of Bhadra to last wk of Asoj	Asoj-Kartik	Magh-Fagun
15.	Altitude	1000-1600 masl	Lower altitude than Khoku	Lower altitude than local varieties	
16.	Recommended area	Eastern hill			

Table 3. Pocket profile of main citrus producing districts of Nepal

S.N.	District	Pocket area
		Koshi Province
1	Taplejung	Dokhu, Nidhuradin, Change
2	Dhankuta	Telia, Khoku, Chinntang, Dhankuta, Belhara, Khwafok, Maunabudhuk
3	Panchthar	Amarpur, Nagi, Panchami, Ranigaun, Kurumba, Luwamfu
4	Bhojpur	Gupteshwor, Annapurna, Kota, Ranibas, Aamtep, Rangpang, Mulpani, Baikuntha
5	Sankhuwasabha	Chainpur, Mamling, Siddhapokhari, Sitalpati, Khandbari
6	Ilam	Barbote, Soyang, Namsaling, Jirmale, Goduk, Kanyam, Sumbek, Pashupati nagar
7	Okhaldhunga	Manebhanjyang, Dhulachap, Rumjatar, Taluwa, Moli
8	Khotang	Simpani, Temba/Damkha, Mangaltar, Lamidada

S.N.	District	Pocket area
9	Udyapur	Lekhani, Limpatar, Mayenkhu, Okhale, Aaptar, Khanbu, Pokhari, Mainamaini, Katunjebawla, Beltar, Hadiya, Rampur, Nepaltar, Katari
	Bagmati Province	
1	Sindhuli	Tinkanya, Ratanchura, Baseshwor, Nirmanadhin, Rajmarg side, Bhimeshwor, Jalkanya, Majhuwa, Sitalpati, Purano Jhangajholi, Ratmata Jhangajholi, Baseshwor
2	Makwanpur	Namtar, Kalikatar
3	Ramechhap	Ramechhap, Bhaluajor, Okhareni, Salu, Dadhuwa, Phulasi
4	Kavrepalanchok	Sharda Batase, Panauti N.P., Patalekhet, Kushadevi, Sankhu, Balthali
5	Chitwan	Darechowk-1,4,5, Chandi Bhanjyang-5
6	Dhading	Jogimara, Syardul, Kallari, Nalang, Katunje
	Gandaki Province	
1	Myagdi	Dana, Okharbot, Ghatan, Darwang, Niskot, Singa, Arthunge, Pipale, Beem, Devisthan, Bhagawati,Arman, Jyamrukot
2	Baglung	Tityang, Malika, Damek, Sarkuwa, Jaedi, Bhakunde, Sisakhani, Hatiyachetra
3	Parbat	Banskharka, Majhphant, Deupurkot, Deurali, Kusi, Nilahar, Limithana, Thana Maulo, Pangrang
4	Kaski	Bharat Pokhari, Nirmalpokhari, Pumdibhumdi, Thumki, Kalika, Hansapur, Salyan, Rupakot, Bumakodado
5	Lamjung	Chiti, Udipur, Kunchha, Duradada, Bhorletar, Ishaneshwor, Mohoriyakot, Tarkughat, Simpani, Bhulbhule
7	Gorkha	Manakamna, Tanglichok, Bunkot, Bhirkot, Ghayampesal, Palungtar, Tara Nagar
8	Syangja	Setidobhan, Pauwegaude, Biruwa, Rangmang, Arjun chaupari, Dahathum walling N.P., Galyang, Pidikhola, Putalibazar-12,13
9	Tanahun	Baidi, Chandrawati. Chok, Rupakot, Basantapur, Purkot, Jamune, Chhang, Manpagn, Keshavtar, Arunodaya, Dharampani, Kyamin, Dhorfirdi, Bhirkot, Aanwu, Sepa Bagaicha
	Lumbini Province	
1	Argakhanchi	Khan, Khanadaha, Hansapur, Pokharathok, Padeni, Khidim, Pathauli, Maidan, Mareng, Bhagwati, Arghatos
2	Gulmi	Nayagaun, Pipaldhara, Hadahade, Bhanbhane, Bhurtung, Gaidakot, Arkhale, Purkot, Shringa, Bletaksar
3	Pyuthan	Swargadwari, Dhuwang, Maranthana, Dhuwang, Dangwang
4	Rukum	Syalapakha
5	Rolpa	Dhawang, Kotgaun, Liwang, Ghartigaun, Eriwang
6	Palpa	Chhahara, Palung Mainadi, Mujhung(namuna), Deurali, Khasyaoli, Ringeraha, Jalpa
	Karnali Province	
1	Salyan	Marke, Tharmore, Kotmala, Dhorchaur, Bhotechaur, Bhalchar, Rangechaur
2	Dailekh	Dullu, Chiudi, Lakuri
3	Jajarkot	Dhime
4	Mugu	Haryanju

S.N.	District	Pocket area
5	Surkhet	Malarani, Dharapani, Kafalkot
6	Kalikot	Mehelmudi
Sudurpaschim Province		
1	Doti	Aagar Bhadisain Mahadevsthan, Bhudbhara, Wayel, Durgamandu.
2	Acham	Mangalsen, Marku, Tosi
3	Kailali	Nigali, Sahajpur
4	Darchula	Bhrahamadev
5	Bajura	Jugada, Barhabise, Kailashmandu, Jayabageshwori, Kolti, Kotila

Source: NCDP, 2002

Intellectual property right for *Suntala*

In Nepal, intellectual property (IP) encompasses a diverse range of intangible assets, including inventions, literary and artistic works, designs, symbols, names, and images. These creations are safeguarded by legal instruments such as patents, copyrights, and trademarks, allowing individuals to gain recognition or financial benefits from their innovations. The IP system aims to create an environment conducive to fostering creativity and innovation.

Since 1936, Nepal has had legal provisions for IP through the Patent, Design, and Trademark Act. This legislation was later updated with the Patent, Design, and Trademark Act of 1965, with further amendments in 1987. Currently, IP rights are regulated by this act, alongside the Copyright Act of 2002 and the Copyright Regulation of 2004. The responsibility for overseeing IP registration and regulation lies with the Department of Industry under the Ministry of Industry. Recently, the Government of Nepal (GoN) approved the National Intellectual Property Right Policy 2017, encompassing a comprehensive framework for various IP rights, including copyrights, patents, industrial design, trademarks, geographical indications (GI), varietal protection, trade secrets, and traditional knowledge. Among these, geographical indications confer exclusive rights to specific regions, enabling them to use names for products that correspond to their unique characteristics.

Nepal's commitment to IP extends internationally, with membership in organizations such as the World Intellectual Property Organization (WIPO) since 1997. Additionally, Nepal acceded to the Paris Convention for the Protection of Industrial Property in 2001, joined the World Trade Organization (WTO) in 2004, and became a signatory to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) in the same year. These memberships necessitate Nepal's adherence to improving and managing IP rights through policy formulation, law enforcement, and regulatory measures.

In practical terms, trademarks serve as distinctive signs used by enterprises to differentiate their goods and services from others', granting owners the right to prevent unauthorized use. Meanwhile, geographical indications inform consumers that a product originates from a specific place and possesses certain characteristics attributable to its place of production. This indication may be used by all producers who manufacture their products in the designated area and whose products share typical qualities.

GI schemes and protection approaches

Geographical indications and traditional specialties, vital for promoting and safeguarding the names of high-quality agricultural products and foodstuffs, are upheld through various mechanisms. Some schemes are given below.

European union schemes

- **Protected Designation of Origin (PDO):** This scheme protects products whose quality or characteristics are exclusively attributable to their origin in a particular geographical location, where all production stages occur.
- **Protected Geographical Indication (PGI):** PGI safeguards products whose reputation, qualities, or characteristics are linked to their geographical origin, with at least one production stage occurring in the designated area.
- **Traditional Specialties Guaranteed (TSG):** TSG protects products with traditional recipes or production methods, ensuring their distinctiveness from other similar products.

Protection approaches

- ***Sui Generis* Systems:** Special regimes of protection, tailored to the unique attributes of geographical indications, offer legal safeguards to ensure their authenticity and prevent misuse.
- **Collective or Certification Marks:** Utilizing collective or certification marks enables producers within a specific geographical area to collectively safeguard the quality and authenticity of their products.
- **Business Practice-focused Methods:** Administrative product approval schemes and other business practices are employed to maintain quality standards, ensuring that products bearing geographical indications meet specific criteria before entering the market.

In accordance with international treaties and national laws

- **Special Laws for Geographical Indications:** These laws provide dedicated legal frameworks for the protection of geographical indications or appellations of origin, ensuring their exclusivity and preventing unauthorized use.
- **Trademark Laws:** Collective marks or certification marks within trademark laws play a pivotal role in protecting geographical indications, providing legal recognition and enforcement mechanisms.
- **Laws Against Unfair Competition:** Legislation aimed at combating unfair competition safeguards the reputation and integrity of geographical indications, deterring deceptive practices and unauthorized use.
- **Consumer Protection Laws:** Ensuring consumer confidence and protection, these laws contribute to maintaining the authenticity and quality associated with products bearing geographical indications.

- **Specific Laws or Decrees:** Tailored legal measures recognize individual geographical indications, providing them with formal recognition and legal protection under national legislation.

The Geographical Indications (GI) scheme in the United States operates differently compared to other countries such as India and those in the European Union. In the U.S., GIs are primarily protected through the trademark system, including certification marks and collective marks, under the framework of the Lanham Act. These multifaceted approaches, spanning international treaties, national laws, and specialized schemes, collectively contribute to the effective promotion and protection of geographical indications, preserving their cultural heritage and economic value.

Geographical indication in Nepal

In Nepal, the diverse microclimatic conditions facilitate the cultivation of a wide range of agricultural products. These products are intricately linked to their places of origin and are influenced by specific local factors such as climate and soil composition (Subedi, 2006). Such distinctive characteristics are recognized as geographical indications (GIs), representing intellectual property that warrants protection. Moreover, GIs play a crucial role in promoting the conservation of agro-biodiversity on-farm and contribute to the economic development of local communities.

Nepal's Intellectual Property Rights (IPR) Policy of 2017 includes provisions to protect and promote intellectual property, with a focus on geographical indications (GIs). Key aspects related to GIs include emphasizing the recognition and registration of GIs to protect products with unique geographical origins and qualities, developing a robust legal framework for their registration and protection, conducting awareness campaigns to educate producers and consumers about their benefits and significance, and providing support to local producers to help them register GIs and protect their products from imitation and misuse.

Possible conditions for GI to *Suntala*

To establish Geographical Indication (GI) for mandarin orange in Nepal, several conditions and considerations need to be addressed, especially in light of the current informal practice of GI and the potential benefits outlined (Joshi et al., 2017, Joshi and Gauchan, 2020). Here are the possible conditions:

1. **Center of Origin Designation:** Given that no product has been registered as a GI in Nepal, designating the indigenous orange varieties as the national fruit could pave the way for obtaining a Center of Origin GI tag. This recognition highlights the unique qualities and heritage associated with Nepalese mandarin orange varieties.
2. **Legal Protection:** Legal protection is crucial to prevent unauthorized use of the GI designation. Establishing a robust legal framework for GI registration and enforcement ensures that only genuine mandarin orange products originating from specific regions are granted the GI status, safeguarding the integrity of the market.

3. **Benefits for Farmers and Producers:** GI status can bring significant benefits to local farmers and producers by providing them with premium pricing opportunities and improving their incomes. This incentivizes continued cultivation of mandarin orange varieties and contributes to rural development.
4. **Boosting Rural Development:** GI designation serves as an instrument of rural development, particularly in less-favored or remote areas. By promoting mandarin orange products with unique characteristics, GI status can enhance rural economies and help retain the local population in these regions.
5. **Reduction of Unfair Trade Practices:** GI status helps reduce unfair trade practices by distinguishing genuine mandarin orange products from counterfeit or inferior alternatives. This ensures that consumers receive authentic products while protecting the reputation of Nepalese mandarin orange varieties.
6. **Preservation of Local Culture and Resources:** GI designation preserves the local culture and resources associated with mandarin orange production. It promotes sustainable agricultural practices and conserves traditional knowledge and heritage.
7. **Consumer Information:** GI labeling provides consumers with complete information about the origin and quality of mandarin orange products. This transparency enables consumers to make informed choices and reinforces trust in the authenticity of Nepalese mandarin orange varieties.
8. **Differentiation and Price Premium:** GI designation differentiates Nepalese mandarin orange products in the market, leading to increased prices due to their unique qualities and geographical origin. Consumers are often willing to pay a higher price for products with GI status, recognizing their superior quality and authenticity.
9. **Improvement of Farmer Incomes and Rural Retention:** GI designation improves the incomes of mandarin orange farmers by capturing premium prices and creating entry barriers for counterfeit products. This, in turn, helps retain the rural population in mandarin orange-producing regions, contributing to sustainable rural livelihoods.

Establishing GI for mandarin orange in Nepal requires a comprehensive approach that addresses legal, economic, social, and cultural aspects. By meeting these conditions and leveraging the potential benefits outlined, Nepalese mandarin orange varieties can gain recognition and value in both domestic and international markets.

Geographical indications (GIs) in Nepal serve several critical functions: they denote the quality and origin of agricultural products, establishing a reputation for authenticity and trustworthiness that enhances marketability. GIs prevent the spread of generic products that might imitate the qualities of genuine regional goods, thus protecting the integrity of local products. Additionally, GIs safeguard Nepal's domestic market from competition with counterfeit goods, fostering the growth of local industries and supporting farmers' and producers' livelihoods. The recognition and protection of GIs in Nepal preserve the heritage of local agricultural products and contribute to sustainable economic development and community empowerment.

Empirical evidences for GI to *Suntala*

Many different aspects of agricultural products can be compiled, generated, verified, and assessed. Ten themes, as outlined in the Figure 1, represent common areas to gather information for obtaining GI rights (Joshi and Gauchan, 2020; Joshi et al., 2017). This information can stem from various sources including surveys (both field and literature-based), on-farm and on-station research, laboratory studies, focus group discussions, and key informant surveys. These sources may span local, regional, national, and global contexts.

The types of proofs and evidences used in the process include publications, video documentaries, multidimensional descriptors, archaeological items, web-based information, pictures, poems, songs, and more. Strategies for collecting proofs and evidences may involve forming committees, conducting surveys, documenting findings, utilizing media platforms for requests, and organizing seminars or discussion forums.

Field surveys and multidimensional descriptors play a crucial role in gathering information for GI rights. This process may involve video recording, engaging in discussions and observations with farmers, and identifying the center of diversity of mandarin orange in the mid-hills of Nepal. Notably, certain districts such as Dhankuta, Gulmi, Argakhanchi, Lamjung, and Palpa exhibit maximum variation in mandarin orange characteristics and one can observe rich information in these areas.

The primary and pivotal step in acquiring GI rights for any specific agricultural product involves the generation of empirical and research-based data. This research should be meticulously designed to corroborate the GI properties following an extensive survey of potential agricultural genetic resources (AGRs) linked to GI. Many products hold significant cultural and traditional values, with indigenous crop landraces and their associated products often tied to specific geographical locations. Hence, it becomes imperative to safeguard these products through GI by enacting appropriate legislation and producing authentic GI-related information. Such efforts not only promote marketability but also contribute to on-farm conservation and enhance the livelihoods of local communities.

Drawing upon existing study methods, mechanisms, experiences, and knowledge acquired from previous research, we have outlined general steps for generating evidence concerning agricultural products related to GI, as well as for the application and implementation of GI in the country (Figure 2). Although we have successfully compiled evidence-based information through field and market surveys, as well as laboratory research, conducting grow-out tests and validation in other locations remains a challenge. However, testing in other location as explained in Figure 2 is not necessary for getting the GI. To address this, we recommend testing potential materials in both the original GI region and other similar production domains (non-GI regions) to validate their geo-linked properties. Additionally, materials from different localities should be included in the grow-out tests. Comprehensive information encompassing agro-morphological traits, organoleptic tests, quality and nutritional analyses, as well as post-harvest processing and other relevant tests, must be generated and published alongside identifying the GI coverage. Developing appropriate signage for GI application in specific commodities, along with establishing a mechanism for monitoring GI usage and branding, is essential. Prior to obtaining GI status, sharing findings, collecting feedback, and publishing results are crucial to preempt any potential issues in the future.

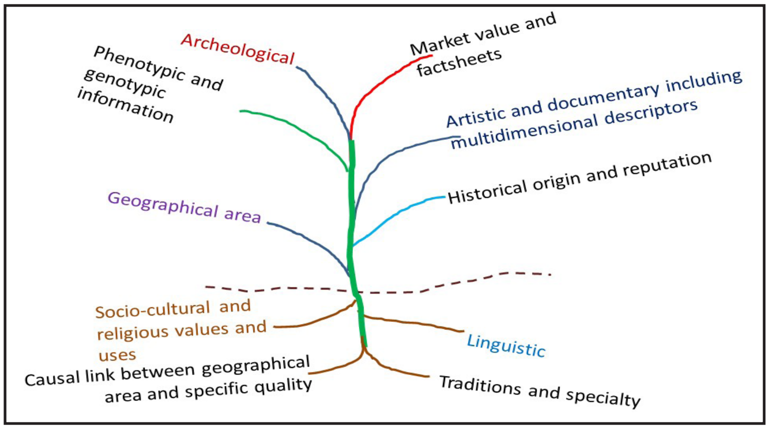

Figure 1. Areas of information for potential proof and evidences

Source: Joshi et al., 2017

Furthermore, conducting further studies at the genetic level, coupled with experimental research in specific soil and climate conditions, could prove beneficial in identifying genes and traits associated with geo-locations. Various marker-based analyses, including morphological, biochemical, or DNA markers, in conjunction with soil and climatic analyses, should be considered in this endeavor.

Common practices for getting higher prices

In Nepal, common practices aimed at obtaining higher prices for mandarin orange fruit, known locally as "*Suntala*," revolve around its unique characteristics and geographical origin. *Suntala* is esteemed as a special aromatic fruit cultivated and harvested in specific regions of Nepal, each with distinct geo-linked traits. These traits make it eligible for a geographical indication (GI) tag, which can be granted based on the fruit's geography. Nepal boasts an abundance of valid evidence supporting the granting of GI rights for *Suntala*. During the peak season, farmers and businesses adopt marketing strategies that capitalize on the fruit's geographical association by selling it under location-specific names such as "Manakamana ko *Suntala*," "Khoku ko *Suntala*," and others. To enhance the appeal and value of their produce, some sellers adorn the fruits with one or two green leaves on the peduncle, signaling freshness and authenticity. Additionally, sellers employ sorting techniques to ensure uniformity and shine, thereby

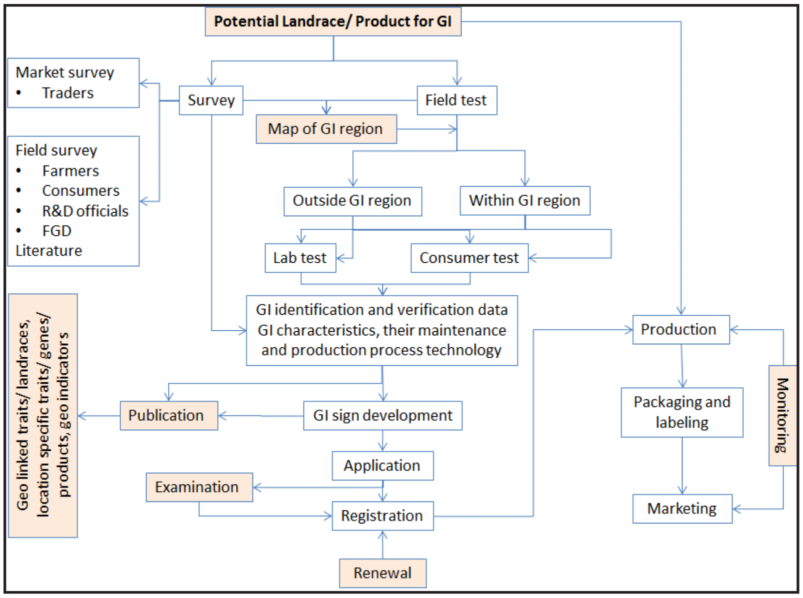

Figure 2. General methods for getting geographical indication (GI) right and its implementation. Adopted from Joshi et al., 2020

attracting higher prices in the market. These practices not only highlight the distinctiveness of *Suntala* but also contribute to its premium status in the market place.

Evidences of origin, diversity, cultivation and use values of mandarin orange

The evidences of origin, diversity, cultivation, and utilization values of mandarin orange in Nepal are rich and varied. Farmers trace back the cultivation of mandarin orange to their ancestors who began cultivating the fruit after collecting seeds from the wild in eastern Nepal, reflecting a longstanding tradition of cultivation. Furthermore, numerous related species of mandarin orange can be found both on farms and in forests across the country, indicating the wide diversity of mandarin orange varieties present in Nepal. Certain regions of Nepal are recognized as centers of diversity for mandarin orange, underscoring the country's significance in mandarin orange cultivation. Khoku Local, a specific variety of mandarin orange, possesses distinct geo-linked traits such as quality and aroma, highlighting the unique characteristics associated with mandarin orange cultivation in Nepal. Khoku *Suntala* is known for its sweet taste and refreshing aroma, distinguishing it from other mandarin orange varieties. These mandarin oranges are prized for their high juice content and low acidity, making them particularly appealing to consumers. The unique characteristics of Khoku *Suntala* are attributed to the specific soil composition, altitude, and climate of the Khoku region. Additionally, local farmers often use traditional farming methods, which help maintain the distinct qualities of this mandarin orange variety. The importance of geographical localization is emphasized, as mandarin orange grown outside of its original home localities may exhibit differences in quality compared to those grown in their native areas. Farmers demonstrate a deep understanding of cultivation practices (Acharya, 2015), ensuring the continued production of high-quality mandarin orange fruits. Fresh mandarin orange fruit is widely consumed, serving as a staple in Nepalese diets and reflecting its importance in local cuisine and culture.

Linguistic and ancient literature evidences

Around 2000 years ago, Chinese travelers dubbed Nepal as "the country of golden fruits" upon witnessing the vibrant yellow hue of ripening mandarin orange fruits (Lohar and Lama, 1997). The Nepali term for mandarin orange, "*Suntala*," translates to "golden story," echoing the sentiments expressed by the Chinese travelers. Similarly, the Sanskrit term "Narangi" for mandarin orange further underscores the fruit's longstanding association with Nepal, reflecting its ancient roots (Bonavia, 1890, as cited in Shrestha and Verma, 1998). Bonavia (1890) documented mandarin orange's presence in Butwal, Nepal, in its wild form, affirming its indigenous status in the region. Additionally, Tanaka (1929) identified the Himalayan foothills, spanning from Burma's eastern corner to Punjab, as the native habitat of *Citrus medica* and *C. limon*, referring to this area as the Medica-Limon chain. Locals in Darchula and Shakhuwasava districts trace their mandarin orange trees back to wild sources, suggesting a deep-rooted history of mandarin orange cultivation in Nepal (Shrestha and Verma, 1998). These historical records establish citron, mandarin orange, and hill lemon (*Nibuwa*) as native fruits of Nepal, cultivated since ancient times, while species like sweet orange, acid lime, and pummelo represent relatively recent introductions to the country.

In Nepalese folklore, the mandarin orange holds a significant place, evident in various cultural aspects and linguistic references. For instance, it's noted that a considerable number of Nepalese women bear the name "*Suntali*," showcasing the fruit's cultural prominence and influence on local identity (Lohar and Lama, 1997). This association extends beyond mere nomenclature, as the mandarin orange finds its way into the fabric of Nepali arts and literature. Poems, folk songs, stories, novels, and even films often feature the mandarin orange, referred to affectionately as "*Suntala*," depicting its deep-rooted presence in the collective imagination of the Nepalese people.

Moreover, linguistic and ancient literary evidence further underscores the mandarin orange's historical significance in Nepal. The Sanskrit word for mandarin orange, "Narangi," not only provides linguistic insight but also hints at the fruit's antiquity within Nepalese culture. References in ancient texts such as the Nighantu and Ayurveda shed light on the mandarin orange's medicinal properties, emphasizing its importance beyond culinary and cultural realms (Bonavia, 1890; Shrestha and Verma, 1998). These texts not only acknowledge the fruit's existence but also highlight its therapeutic value, contributing to its revered status in Nepalese society since ancient times.

Traditions, specialty and reputation

Mandarin orange holds deep-rooted traditions and a strong reputation in Nepal, where it has been cultivated, traded, and enjoyed since ancient times. Local mandarin orange landraces, characterized by their unique geo-linked traits, are cultivated across various regions of Nepal, contributing to the rich diversity of mandarin orange varieties in the country. These indigenous mandarin orange varieties are highly esteemed and command premium prices in the market, reflecting their significance and desirability among consumers. One of the distinguishing features of Nepalese mandarin orange is its exceptional taste, juiciness, and enticing aroma, making it a sought-after fruit for its unparalleled flavor experience. Renowned for its quality and freshness, Nepalese mandarin orange enjoys a strong reputation among consumers, further enhancing its value and prestige in local markets.

Socio-cultural, economical and market value

Mandarin orange holds significant socio-cultural, economic, and market value within Nepalese communities, deeply ingrained in their traditions and daily life. It is not merely a fruit but a symbol of social status and cultural heritage, with families who consume and cultivate mandarin orange enjoying elevated social standing. Since ancient times, offering mandarin orange-based food items to guests, relatives, and VIPs during festivals, special occasions, and marriage ceremonies has been a common cultural practice, reflecting the reverence and purity associated with mandarin orange in Nepali culture. Considered holy, pure, and "*Chokha*" (meaning pure and sacred), mandarin orange is utilized during fasting, offered to deities, and incorporated into various religious ceremonies, such as Chhat, Dashain, and Tihar, particularly evident in the Terai region, where numerous socio-cultural evidences attest to its significance (Joshi et al., 2017; Joshi et al., 2020).

Economically, mandarin orange holds immense value both domestically and internationally, commanding premium prices in markets. Local farmers market mandarin orange under various brand names at local and national levels, showcasing the competitiveness of native mandarin orange landraces alongside modern varieties. Many households prioritize growing economically valued traits, such as taste and juiciness, contributing to the overall quality of Nepalese mandarin orange, which surpasses that of other countries. Among the numerous landraces, Khoku, Manakamana local, and Banskharka local stand out for their juiciness and enjoy high market demand, fetching favorable prices compared to other varieties (Joshi et al., 2017; Malla and Shakya, 2004).

In addition to its economic significance, mandarin orange possesses inherent nutritive and medicinal value, making it a sought-after fruit globally. Citrus species, including mandarin orange, are prized for their refreshing taste, rich sugar content, and high vitamin C levels, ranging from 25 to 100 mg/100ml. Beyond its nutritional benefits, mandarin orange rinds are rich in pectin, essential oils, and glucosides, offering additional health advantages. The per capita consumption of citrus fruit is notably higher in developed countries compared to Asian countries, highlighting the potential for increased consumption and demand. Moreover, mandarin orange's medicinal properties, including its role in maintaining a robust immune system, preventing diseases like scurvy and anemia, and its anti-tumor and anti-malarial properties, underscore its multifaceted importance beyond its economic value (Aubert et al., 1990; Radha and Mathew, 2007).

Historical evidences and research

Historical evidence and research on mandarin orange in Nepal date back to ancient times, with numerous old literatures documenting its significance. Over the years, horticulturists and farmers have accumulated substantial knowledge about mandarin orange cultivation practices, contributing to its long-standing presence in Nepalese agriculture. Formal efforts to develop mandarin orange cultivation began in the 1960s, notably in Pokhara and Dhankuta, marking the start of organized research initiatives. By 1972, research endeavors had intensified, focusing on improving cultivation techniques and understanding the unique characteristics of mandarin orange varieties grown in Nepal. Today, dedicated offices and research programs, such as the National Citrus Research Program in Dhankuta under the National Agricultural Research Council (NARC), continue to promote the cultivation, research, and development of mandarin orange, further advancing the knowledge and expertise surrounding this prized fruit in Nepal.

Consumer perspectives

Consumer perspectives on mandarin oranges in Nepal are characterized by several key factors that contribute to their high demand and popularity among the Nepali population. Firstly, consumers in Nepal demonstrate a willingness to pay premium prices for Nepalese mandarin orange fruits, depending on the production domain. This willingness stems from the perceived superior quality and unique flavor of Nepalese mandarin oranges compared to mandarin oranges from other regions. The preference for Nepalese mandarin oranges often translates into consumers being prepared to pay higher prices to enjoy the distinct taste and quality they offer.

Additionally, the consumption of fruits, including mandarin oranges, is deeply ingrained in Nepali culture, with almost all Nepali people consuming fruit during the season. Mandarin oranges are not only enjoyed for their delicious taste but also serve various other purposes. They are commonly used as gifts, particularly during festive occasions and celebrations, due to their association with abundance and prosperity. Moreover, mandarin oranges are favored as travel fruits due to their convenient size, portability, and ease of consumption. Their compact nature makes them ideal snacks for on-the-go individuals, providing a quick and healthy source of refreshment during travel.

Furthermore, Nepalese mandarin oranges are appreciated for their enticing aroma, which adds to their appeal among consumers. The aromatic fragrance of mandarin oranges enhances the sensory experience of consuming the fruit, making it even more enjoyable for consumers. Additionally, mandarin oranges are easy to share, even if only one fruit is available. This sharing aspect aligns with the communal values inherent in Nepali culture, where sharing food is considered an act of generosity and goodwill. Whether enjoyed individually or shared among friends and family, mandarin oranges hold a special place in the hearts and palates of Nepali consumers, symbolizing not only deliciousness but also community and togetherness.

Market perspectives

The market perspectives of mandarin oranges in Nepal are marked by a combination of factors that contribute to their high value and widespread availability throughout the country. Firstly, Nepalese mandarin oranges are esteemed for their superior quality and unique flavor, setting them apart from mandarin oranges produced in other regions. This distinctiveness translates into a higher perceived value among consumers, making Nepalese mandarin oranges a preferred choice in the market. During the mandarin orange season, which typically sees abundant harvests, all markets across Nepal are fully stocked with mandarin oranges (Figure 3). This extensive market coverage ensures that consumers from various regions have access to fresh mandarin oranges, fulfilling the demand throughout the country. Moreover, mandarin oranges are often sold under specific geographical names, such as "Khoku ko *suntala*" or "Mankamana ko *suntala*," highlighting the association of the fruit with its production location. This geographical identification not only adds to the authenticity of the product but also enhances its perceived value among consumers.

Price differentiation is another significant aspect of the mandarin orange market in Nepal. Prices vary based on factors such as the production site, fruit size, shininess, and sweetness. Consumers are willing to pay premium prices for mandarin oranges that meet their preferred criteria, reflecting the high demand for quality produce in the market. Furthermore, the direct involvement of farmers in selling mandarin oranges adds to their appeal. Many farmers opt to sell their produce directly to consumers, bypassing intermediaries and establishing a direct connection between producers and buyers.

Visitors to Nepal also have the opportunity to engage with mandarin orange production firsthand by visiting mandarin gardens and picking fruits themselves. This experiential aspect not only enhances consumer satisfaction but also strengthens the bond between consumers and the product. Additionally, while farmers play a significant role in mandarin sales, retailers and middlemen also contribute to the distribution process, ensuring a steady supply of mandarin oranges to various markets and retail outlets across the country. Lastly, the informal selling of mandarin oranges on footpaths during the peak season further extends their accessibility to consumers, making them a ubiquitous presence in local markets. Overall, the market perspectives of mandarin oranges in Nepal reflect their esteemed value, extensive availability, and diverse distribution channels, positioning them as a cherished commodity within the country's agricultural landscape.

Why GI to mandarin orange

Granting Geographical Indication (GI) status to mandarin oranges in Nepal is a significant proposition owing to various compelling reasons. Firstly, mandarin oranges hold a pivotal position as a major fruit in Nepalese culture and are widely favored among the populace. Their significance in local cuisine and consumption patterns underscores their importance as a cultural and dietary staple. Furthermore, the traditional cultivation methods employed for mandarin oranges have ensured their preservation and maintenance across diverse geographical locations within Nepal. This traditional cultivation has led to the proliferation of various mandarin orange varieties, each characterized by its unique flavor profile and distinct qualities.

Moreover, the quality of mandarin oranges is intrinsically linked to the geography of their cultivation as wells as methods of production practices. Site specific cultural traditional practices have been documented in other chapters. Factors such as soil composition, altitude, and climatic conditions significantly influence the taste, aroma, and overall quality of the fruit. Therefore, recognizing the geographical origin of mandarin oranges through GI status not only acknowledges the role of geography in shaping their characteristics but also promotes the conservation of mandarin orange diversity in Nepal. By highlighting the specific geographical regions where mandarin oranges are grown, GI status serves as a means of preserving and promoting traditional agricultural practices.

For consumers, GI certification offers assurance regarding the quality and authenticity of the mandarin oranges they purchase. The certification acts as a guarantee of adherence to

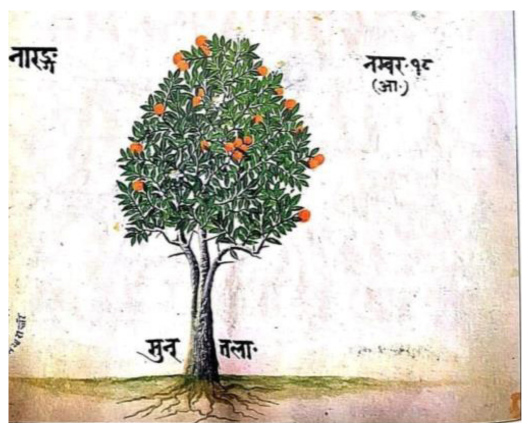

Figure 3. Mandarin orange village (Suntale Gaun) and plant

specific production standards and ensures that the mandarin oranges meet the expected criteria associated with their geographical origin. This assurance fosters trust among consumers and may lead to a heightened willingness to pay premium prices for certified mandarin oranges, thereby creating a more lucrative market for farmers.

Furthermore, GI status holds significant economic benefits for mandarin orange farmers in Nepal. By differentiating their produce with GI certification, farmers can leverage the unique qualities and heritage associated with Nepalese mandarin oranges to command higher prices in the market. This, in turn, translates into increased income and financial stability for farming communities. Thus, GI status for Nepalese mandarin oranges not only safeguards their cultural heritage and geographical diversity but also fosters economic prosperity for local farmers, making it a valuable initiative for the sustainable development of Nepal's agricultural sector.

Policy provision on GI and other IPR

Policy provisions regarding Geographical Indications (GI) and other Intellectual Property Rights (IPR) are crucial for ensuring that the qualities, characteristics, or reputation of a product are inherently linked to its place of origin. This linkage underscores the importance of geographical place of production in defining the unique attributes of a product. Several international treaties, administered by organizations such as the World Intellectual Property Organization (WIPO) and the World Trade Organization (WTO), address the protection of geographical indications and appellations of origin.

WIPO administers various treaties relevant to the protection of geographical indications

- The Paris Convention, established in 1883, covers a broad spectrum of industrial property, including patents, trademarks, industrial designs, and geographical indications. This pioneering agreement aimed to facilitate the protection of intellectual works across different countries.
- The Madrid Agreement for the Repression of False or Deceptive Indications of Source on Goods addresses the seizure or prohibition of importation of goods bearing false or deceptive indications of source.
- The Lisbon Agreement, along with its 2015 revision known as the Geneva Act, offers international protection for appellations of origin and geographical indications through a unified procedure with WIPO. These designations require a qualitative link between the product and its place of origin.
- The Madrid Agreement, complemented by the Protocol relating to it, enables the protection of a trademark in numerous countries through international registration.

The TRIPS Agreement, part of the WTO framework, defines geographical indications as indications identifying a good's origin in a Member's territory, region, or locality, where the quality, reputation, or other characteristic of the good is primarily linked to its geographical origin. This definition emphasizes that various aspects of a product, such as quality or reputation, can qualify it for geographical indication protection if they are essentially linked to its geographical origin. These treaties collectively underscore the significance of protecting geographical indications and appellations of origin to preserve the authenticity and uniqueness of products while promoting fair trade practices and supporting local economies.

The geographical policy in Nepal, as influenced by international agreements such as those of the World Intellectual Property Organization (WIPO) and the World Trade Organization's Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, plays a significant role in protecting and promoting geographical indications (GIs).

Since joining WIPO in 1997 and the WTO in 2004, Nepal has been actively engaged in formulating policies to safeguard geographical indications. The TRIPS Agreement provides a framework for the legal protection of prominent names of products associated with specific geographical areas. In Nepal, the National Intellectual Property Policy 2073, approved in 2017 (MoICS, 2017), includes provisions for the identification and promotion of GIs as part of its intellectual property strategy.

Key elements of Nepal's GI policy, outlined in the National Intellectual Property Policy, include

- Identification and promotion of GIs as a national development tool.
- Formulation of GI rules focusing on specific geographical areas.
- Provision of GI as a nontransferable right, ensuring protection for products originating from specific regions.
- Support for market access and value addition for producers of agricultural and forest products through the use of GIs.

Furthermore, the policy addresses issues related to trademark registration and GI protection, stipulating that products registered under trademarks will not be protected under GIs, and vice versa. Similarly, products registered under certification marks will also not receive GI protection. Additionally, the policy encourages staff involved in innovation to access benefits under intellectual property protection schemes. To support local resource-based products, the government of Nepal bears the registration fees for GIs, aiming to promote the recognition and value of these products both domestically and internationally.

Conclusion

Granting Geographical Indication (GI) status to mandarin oranges in Nepal emerges as a pivotal strategy with multifaceted benefits. The rich cultural significance and widespread popularity of mandarin oranges underscore their importance as a cherished fruit among Nepalese people. Traditional cultivation methods have preserved diverse mandarin orange varieties across different geographical regions, each imbued with distinct flavors shaped by unique environmental factors. By recognizing the geographical origin of mandarin oranges through GI status, Nepal can not only promote the conservation of its agricultural heritage but also provide consumers with assurance regarding the quality and authenticity of the fruit. Furthermore, GI certification offers tangible economic advantages for local farmers, enabling them to command premium prices for their produce and fostering financial stability within farming communities. This, coupled with the potential for enhanced market access and consumer trust, positions GI-certified mandarin oranges as a valuable asset for Nepal's agricultural sector. Overall, the pursuit of GI status for Nepalese mandarin oranges represents a promising avenue for sustaining cultural traditions, preserving biodiversity, and fostering economic prosperity in the nation's rural areas. Some immediate actions to be taken under technical aspects are i. Characterization site specific mandarin orange landraces, ii. Linkage study of fruit quality with geographical features and farmer's practices, iii. Documentation of traditional knowledge and reputation status, iv. Area coverage of specific landrace and monitoring tools, etc.

In addition, Nepal holds an abundance of evidence supporting the distinctiveness and quality of its mandarin orange varieties, further validating the need for Geographical Indication (GI) status. Through extensive research and empirical data collection, Nepalese mandarin oranges have been proven to possess unique flavor profiles, influenced by the country's diverse geographical features such as microclimates, soil types, and altitudes. This wealth of evidence not only reinforces the authenticity of Nepalese mandarin oranges but also strengthens the case for their recognition on the global stage through GI certification. With such compelling evidence at hand, the provision of GI status to Nepalese mandarin oranges not only safeguards their heritage but also elevates their status as premium agricultural products with distinct geographical origins.

Some actionable recommendations for policymakers in Nepal to effectively implement a Geographical Indications (GI) scheme for mandarin orange are:

1. **Enact GI Legislation**: Pass comprehensive legislation specific to GI that aligns with international standards such as the TRIPS Agreement. Ensure that the law clearly defines the criteria for GI registration and protection.
2. **Establish a GI Registry**: Create a dedicated body or registry for managing GI applications, examinations, and registrations. This body should have the authority to enforce GI protections and handle disputes.
3. **Simplify Procedures**: Streamline the application process for GI registration to make it accessible to small and medium-sized farming groups. Provide clear guidelines and reduce bureaucratic hurdles.
4. **Capacity Building**: Train government officials, local authorities, and farming communities on the GI process, including application, registration, and enforcement.
5. **Resource Allocation**: Allocate sufficient resources, including financial and technical support, to facilitate the GI registration process and subsequent enforcement.
6. **Awareness Campaigns**: Conduct nationwide awareness campaigns to educate farmers, producers, and the general public about the benefits of GIs. Use various media channels to reach a broad audience.
7. **Workshops and Training**: Organize workshops and training sessions for mandarin orange growers, focusing on the GI application process, the importance of maintaining quality standards, and the economic benefits of GI registration.

8. **Strengthen Farming Groups**: Encourage the formation and strengthening of farming cooperatives and associations to collectively apply for GI registration and manage the GI-protected status.
9. **Stakeholder Collaboration**: Foster collaboration between government bodies, NGOs, academic institutions, and international organizations to support GI initiatives and share best practices.
10. **Geo-Location Specific GI**: Identify and demarcate specific geographical regions within Nepal known for their unique mandarin orange varieties. Ensure that the GI application specifies these regions to maintain authenticity and quality.
11. **Quality Control**: Implement strict quality control measures to ensure that only mandarin oranges meeting the specified standards are marketed under the GI label. Establish local quality control bodies to monitor compliance.
12. **Branding and Marketing**: Develop strong branding strategies for GI-protected mandarin oranges, highlighting their unique geographical origin and quality. Promote these products in domestic and international markets.
13. **Export Facilitation**: Work with trade bodies to facilitate the export of GI-protected mandarin oranges, ensuring they meet international market requirements and standards.
14. **Enforcement Mechanisms**: Develop robust mechanisms to monitor the use of GI labels and take action against unauthorized use or infringement. Establish a legal framework to handle disputes and protect GI rights.
15. **Continuous Monitoring**: Regularly review and update GI policies and practices to adapt to changing market conditions and ensure ongoing compliance with international standards.

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प्लाष्टिक थैलामा हुर्काइएको सुन्तलाको कलमी बिरुवा

Variety Characterization of Mandarin Orange (*Citrus reticulata* Blanco)

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Background

Mandarin orange and citron are considered indigenous crops of Nepal. Farmers of Darchula and Shakhuwasava district claim that their forefathers had collected mandarin orange trees from wild form. These historical facts clearly indicate that citron, mandarin orange and hill lemon (*Nibuwa*) are native fruits of Nepal and being cultivated from long time ago. Mandarin oranges are also referred to as 'Tangerines' in some countries. In Nepal, '*Suntala*' is the Nepali name of mandarin orange.

Mandarin orange (*Citrus reticulate* Blanco) is most common and important citrus fruits crop grown in Nepal. Among the fruits species it contribute 16.7% of the total fruit area and stands second position of the country. It occupies nearly 63% of the total citrus area of Nepal. The local cultivar of mandarin orange "*Suntala*" is grown throughout the country in the mid hill range of Nepal, where the favorable climate for its cultivation. It has cultivated in Nepal during long time ago and has same harvesting time.

General characteristics of mandarin orange

Normally mandarin orange (*Citrus reticulata* Blanco) tree is a moderate size (about 7.6 m height). The tree trunk and major beaches have thorn or spiny, upright growth with a dense canopy of slender branches. The leaves are shiny, green, lanceolate shape, petioles are short almost wingless or slightly winged. The flower borne singly or small group in the leaf-axils and have perfect white flower, usually self fertile or parthenocarpic.

A ripe mandarin orange fruits is deep orange to reddish orange in color, slightly soft peel with small oil gland. The peel is thin loose with white mesocarp and easily pebbly-skin, smooth surface, medium fruit size, (4–6 cm height and 5–8 cm in diameter) deeply depressed apex, globose to oblate, sweet taste, hollow core. Pulps are containing 9-13 separable segments and 10-26 small beaked seeds. Seed is highly polyembryonic, white color, smooth surface with green cotyledon. It can be grown in tropical and sub tropical areas. Mostly, mandarin oranges lose quality and the rind 'puffs' if not picked when internally ripe.

Uses

Normally, mandarin orange fruits are used for fresh consumptions. The fruits can be used for the preparation of a number of processed products like orange marmalade, bottled and canned juices, squash, jam, jelly etc and its oil is also important for flavoring purposes. In nutritional view 100 gm of mandarin orange contains 85% water, 13% carbohydrates, and negligible amounts of fat and protein also vitamin C is in significant content (32% of the Daily Value).

Genetic and origin

Citrus plants hybridize easily between species with completely different morphologies. According to genetic studies; the mandarin orange was one of the original citrus species; and the ancestor of many hybrid citrus cultivars. Taxonomist has different views of its classification; Under the Swingle system, all these are considered to be varieties of a single species, *Citrus reticulata* Blanco. The Tanaka classification system divided domestic mandarin oranges and similar fruit into numerous species, giving distinct names to cultivars such as willow leaf mandarin oranges (*C. deliciosa*), Satsumas (*C. unshiu*), Tangerines (*C. tangerina*). Hodgson represented them as several subgroups: common mandarin orange (*C. reticulata*), Satsuma (*C. unshiu*), King (*C. nobilis*), Mediterranean (willowleaf), small-fruited (*C. indica*, *C. tachibana* and *C. reshni*), and mandarin orange hybrids. In the genomic-based species taxonomy of Ollitrault et al., says only pure mandarin oranges would fall under main land Asian species i e *C. reticulata*.

Mandarin oranges are native to the tropical and sub-tropical regions of Asia such as southern Asia and the Philippines. There are many different hybrids or varieties of mandarin oranges. Their fruits vary in size and color, with some being seedless.

Classification of mandarin orange

A. On the basis of maturity period mandarin orange can be classify in major three groups, but flowering and harvesting period slightly varies according to the altitude range.

1. Early season: Miyagave wase, Okichu wase, Fruiter early matured in September
2. Mid-season: Khoku/ Banskharka, matured in October - November
3. Late season: Murcott, Kinnow, matured in December

B. Most horticulturalists are assumed to divide mandarin orange into four groups:

1. Satsuma (Citrus unshiu Marc.): Satsuma mandarin oranges are primarily developed in Japan. It has cultivated in Japan, Spain, Central China, South Africa, Turkey, Korea, USA and several other countries.
2. Mediterranean mandarin oranges: Called “Willow leaf” mandarin orange because of its small narrow leaves. The fruits are medium-sized and oblate (rounded with flattened ends). The thin skin is orange when ripe, and separates easily from the segments. The flesh is orangey-red, juicy, and fragrant, with many seeds.

3. King mandarin oranges: Small group of mandarin oranges of Indo China, important primarily as parents of commercial varieties such as Kinnow. It is bigger than a classic mandarin orange. It's usually round to slightly flatten at the poles.
4. Common mandarin oranges: A diverse group that includes numerous hybrids and many of what some would call tangerines; the Clementines and Dancy.

Satsuma and common mandarin oranges are the two commercially important groups. While few varieties fit easily into these four categories, one of the properties of mandarin oranges is that they mutate spontaneously.

Variety characterization methods

Evaluation and Development of variety of the fruits crops is not a easy work to the breeders. Mandarin orange is perennial fruit crops and it takes long time for evaluation is characters and development of new variety. Most of the countries like china and India practices for variety evaluation of mandarin orange fruits, on the basis of genetic, morphological and physicochemical traits.

Characterization of mandarin orange variety from Southern Brazil is by the study of morphological or agronomic traits of leaves, flowers and fruits and using molecular markers. Several authors described phenotypic characters like, flowers, fruits, leaves and maturity period to distinct the mandarin orange variety, and its hybrids, which is easy and with potential to be used in breeding programs or to be released as new varieties. The phenotypic characteristics may influenced by the growing environments and may not suitable for breeding work. Therefore, use of molecular markers has been a valuable and precise instrument to assist the genetic breeding of citrus species. The techniques like RFLP (Restriction Fragment Length Polymorphism) and RAPD (Random Amplified Polymorphic DNA) were used in germplasm characterization, studies of genetic diversity and phylogenetic analyses.

In Nepal, Generally, IPGRI descriptor are used for evaluation of mandarin orange variety like, Farmers Name, Altitude, Latitude, Longitude, District, Palikas, Ward, Local Name, Tree height, Diameter, Canopy, Leaf area, Leaf colour, Flowering Time, Flower colour, Maturity time, Fruit weight, Fruit Shape, Size, Peel colour and weight, Seed number and shape, cotyledon colour, Segments, Pulp and Juice %, TSS and TA etc.

Major characteristics of mandarin orange variety

There are so many varieties of mandarin orange, commercially grown in the world but only one variety i.e Khoku mandarin orange was grown in Nepal for commercial scale. Now a day this variety has suffering so many problems and it has needs to developed new variety of mandarin orange for commercialization. Facing this problem, seventeen mandarin orange genotypes of exotic and local origin have been planted in National Citrus Research Program Dhankuta and evaluation has been underway since 2005/06. Characterization of major mandarin orange groups which are commercial scope in Nepal and other countries are mention in this chapter.

Khoku mandarin orange (*Citrus reticulata* Blanco)

It is indigenous and registered variety of Nepal cultivated from long time ago. The tree of Khoku mandarin orange is vigorous, with a tendency to alternate bearing. A matured seedling tree would be 6-10 m tall, erect growth habit of young tree, spiny young branches, wings or wing less petiole, acuminate leaf apex. Generally flowering in March at 1300 m asl, flowers are white with 5 petals, and 16 stamens. Harvesting starts from last week of November up to December. It is not advisable that the fruit remain long on the tree, since it rapidly losses quality.

Fruits are 4–8 cm diameter, 3-6 cm height, peel color is orange to orange-red, thin and loose skin, scented peel, and endocarp is separated into 8-10 segments, sweet taste, and can be eaten as fresh or to make juice. Fruit weight ranged from 90-120 gm, proportion of pulp ranged from 65-70%, based on the fruit weight juice ranged 37-46%, color of seed is white and mostly poly-embryonic nature, seeds normally content 8-14 per fruit, TSS ranged 11-13^0 brix, TA 0.8-1.2%. Proportion of the TSS and TA ratio slightly varies according to altitude range. Generally, yield is 8-12 t/ha from matured orchard.

Satsuma (*Citrus unshiu)*

It was originated in Japan, various cultivars have been developed based on the *Citrus unshiu*, but in Japan, mainly three cultivars i. e Miyagawa wase, Okitsu wase, and Kunu wase, account for nearly half of the production volume of *Citrus unshiu*.

The tree is small to medium spreading and evergreen shrub, with very less thorns. It can tolerate cold and hardy nature. It is used both ornamental and commercial cultivation. Plant height of Satsuma mandarin orange is about 4 to 6 meters, with some specimens reaching up to 7.5 meters under optimal conditions. The root system is fibrous and relatively shallow, spreade widely to anchor the plant and absorb nutrients.

The leaves of *Citrus unshiu* are simple, alternate, and lanceolate with large laminae (length 8-11.1cm and width 4.5-5.5cm) and reduced petioles and glossy, dark green appearance, winged petiole.. Botanically, the leaves are having an entire margin and an acute apex, with a leathery texture and an aromatic scent when crushed.

Fruit size is moderately large (height 63.6 mm and diameter 70.4 mm), oblate to ovate, rind is often smooth to slightly rough surface, loose and leathery, easily peelable, with moderately hollow central axis, peel deep orange color, sterile ovule and seedless, usually have 10 to 12 easily separable segments. Fruits can be harvested at September; sweet taste, TSS of matured fruit juice is 12^0 brix, and TA 0.8%.

Kinnow (King x Willow leaf)

The Kinnow is a high yield mandarin orange hybrid variety "King' (*Citrus nobilis*) and 'Willow Leaf' (*Citrus deliciosa*)", cultivate extensively in India, first developed by Howard B. Frostat the University of California Citrus Experiment Station. After evaluation, the Kinnow was released as a new citrus hybrid for commercial cultivation in 1935.

In a hot climate, plants can grow up to 11 m height. Kinnow trees are highly productive; large vigorous, erect tree with dense canopy, sparingly thorny. Leaves are lanceolate, with round to obtuse base and acuminate apex, petiole short to medium, wingless.

Fruit color are deep yellow orange, surface smooth, glossy, oblate, base often flattened, slightly depress, apex much flattened, thin rind, peel leathery, axis solid to sami-hollo, very juicy, flavor rich aromatic and distinctive, TSS 10 -12%, acidity 0.7-0.8%. The fruit weight ranged from 101-287 grams, juice volume 46.5%, fruit diameter 5.2-8.5 cm, height 4.2-7.0 cm, number of segments per fruit 8-12, fruit peel weight 24-71 gm. Seeds are creamy white color with yellow cotyledon. The best harvesting time is mid-January to mid-February, when the fruit attains a TSS/acid ratio of 12:1 to 14:1. The fruit quality declines in later pickings.

In B.S. 2039, Kinnow mandarin orange plants were presented to Nepal by the then Pakistani President Mr. Zia UlHaq to late King Birendra. These plants were planted at Horticulture Farm, Panchkhal, Palpa, Agri. Centre Dhankuta, Terahara, Jankapur, Nawalpur (Sarlahi), Trisuli, Nepalganj, Surkhet and Doti. However, the conclusive results and performance of this variety was not published

Nagpur Santra (*Citrus reticulata* Blanco)

It is the most important commercial cultivar of India (Nagpur). Trees are large, vigorous, upright growth habit, moderately spreading, spineless, with compact foliage. It is productive but with strong alternate-bearing tendency. Generally, blossom during the monsoon season but crop can be grown twice a year. The fruit available from September to December is Ambiya Bahaar which has a slightly sour taste. It is followed by the sweeter Mrig Bahaar crop in January.

Fruits are fine textured, having a loose rind with abundant juice. Fruits mature in January–February. Fruits are large, globose to moderately oblate, base commonly with strong furrowed but relatively short neck; apex usually deeply depressed. Rind is medium-thick, fairly loosely adherent; surface relatively smooth but peelable, orange-colored at maturity. About 10-11 easily separable segments with 6-12 seeds, axis large and hollow. Fruits are sweet and juicy pulp with yellow color juice; flavor mild and pleasant, and aromatic. Seeds are polyembryonic; cotyledons light green. Loses quality and rind puffs if not picked when ripe.

Murcott

Murcott is a commercially grown hybrid variety (Mandarin orange x Sweet orange) popular in USA. Tree medium in vigor and size, upright-growing with long, willowy branches with thorny; leaves medium-broad, bright green color, lanceolate, and sharp-pointed.

Fruit are mainly borne terminally, medium in size (average wt. 140g) with 75% pulp, high juice content (around 49%), oblate to sub-globose; shallowly ribbed to conform with segments; both base and apex flattened or slightly depressed. Surface is smooth, rind tightly adherence, thin skin (3.5mm), difficult to peel. Pulp is juicy; sweet taste, flesh color yellowish-orange at maturity, flavor very rich and sprightly. Segments is 11 to 12, moderately adherent; axis medium-large and semi-hollow, TSS 11.5-12.5^0 brix, TA 1.4%, about 12-20 seeds with white cotyledons. Medium to late in maturity. It is nutritious fruit rich in vitamin C, fiber, and antioxidants. Therefore, it is consumed fresh, as well as in juice, jam, and dessert recipes. It is more productive but with tendency to alternate bearing and most sensitive with cold.

Clementine (*Citrus clementina*)

It is also called Tangor, hybrid between a willow leaf mandarin orange (*C. deliciosa*) and sweet orange (*C. sinensis*), named byHonor of Clément Rodier, a French missionary who first discovered and propagated the cultivar in Algeria, also known as an Algerian Tangerine. The varieties cultivated in the Mediterranean region, these look like large tangerines. Trees are densely foliated, moderately large, semi erect, spheroid tree shape, medium branching density, lamina length 105.6 mm and width 4.4 mm, nearly thorn less with vigor. Leaves are bright glossy and narrow.

The exterior shape of the fruits is a deep orange color with a smooth, glossy appearance and rich citrus aroma, small to medium-sized, seedless, fruits weight 85 gm, height 48.8 and diameter is 55.27, segments 7 to 12,TSS 10^0 brix, easy to peel, typically juicy and sweet, with less acid than oranges, normally eaten fresh or used in salads, desserts, juices, and jams. The exact timing of ripening can vary, but it often occurs between November and January. The fruit turns a deep orange color when it's ripe and puff up when overripe.

Darjeeling/ Sikkim mandarin orange

Tree is large to medium with dense foliage and occasional thorn. Leaves are lanceolate with pointed apex wingless petiole, flowering response starting in the mid of February. Flowering period lasts from late February to early April. Orchards in the lower altitude starts flowering earlier followed by orchards in the higher altitudes. Flowers are white in color with strong scent attracting a range of insects for pollination

Fruits are depressed, oval, uniformly bright orange, smooth surface, glossy base, occasionally short necked slightly ribbed; soft thin to thick rind not adhering to the pulp. Pulp vesicles are uniformly orange, smooth with 9-11 segments, slightly white seeds. Normally fruit weight 70-101 gm, juice volume 30-56 ml, peel weight 14-17 gm, diameter 4.2-4.6 cm, height 8.4-8.7 cm, number of seed per fruit 10-16, seed weight 1.2-2.3 gm, TSS 10.4-11.6^0 brix, TA 0.6%, Cotyledons light green color.

King mandarin orange (*Citrus nobilis*)

The King mandarin orange is an Asian variety, originating in Vietnam, but it is a commercial variety of USA. The trees are vigorous; sami erect growth medium branching, normally 5-6 M tall, thorny branches, medium branching density, leaves medium in size (7.7x4.3 cm), lanceolate, dark green color, petioles narrowly winged and small.

The fruits are impressively large, sweet, and easy-to-peel. Also known as the "Green Orange," while its skin maintains a bright green color at ripening. Fruits are starts to harvest from January to May according to climatic condition; fruits are bigger than normal mandarin orange, usually round and slightly flattened at the pole, juicy, pulp is light orange in color, sweet and excellent quality. Average fruit weight is 241 gm, diameter 99.92 mm and height 81.84 mm, number of seed 5-10, and seed is color creamy white.

Willow leaf mandarin orange (*Citrus deliciosa*Ten.)

This variety was grown in the Mediterranean region since the very early 1800s. Tree is slow growing habit, medium size, broad-spreading, and branches fine, willowy, and nearly thorn less. Leaves are small, narrowly lanceolate with thin petioles, and of distinctive appearance. The tree is hardy and resistant to unfavorable conditions, but exhibits strong tendency to alternate bearing.

The fruit is medium-sized, oblate, with a smooth, loose skin, thin rind, apex depressed and commonly wrinkled; fruit color is yellowish-orange at maturity, segments 10-12, loosely adherent; axis hollow. The flesh is light orange, juicy and sweet. Seeds are, small, round and highly polyembryonic, with light green cotyledons, moderately early in maturity.

Ponkan (*C. poonensis*)

Trees are heavy bearing every other year, and sometimes the limbs break due to the heavy yields. Growers resort to propping the limbs up with sticks at times, though if the limb bends gradually down and grows in that position. Ponkan (*Citrus poonensis*) is "Chinese Honey Orange" high-yield with large fruits size. It is a hybrid of mandarin orange and pomelo. [24] The fruit is very sweet, round in shape and about 7–8 cm wide in size.

Coorg mandarin orange

Tree vigorous, upright, fruit base depress, glandular ribs, thin soft rind with slight adherence, easily peeled, pulp vesicle uniformly colored. Fruits are medium to large, bright orange color rind with a loose skin, pulp reddish yellow, sufficiently juicy, acidic but moderately flavored. Each fruit normally contains 14-30 seeds, cotyledons light green, fruit weight 107 gm, pulp weight 69.78% rind weight 26.69%, number of seed per fruit 18, segment 11-12, TSS 7.8-9.6^0 brix, TA 0.35%.

Khasi mandarin orange

Medium to erect tall tree height normally 6.4-7.5 m with dense foliage, highest canopy spread to be 4.67m and 5.10m in the N-S and E-W directions respectively, thorn may be present or absent. Leaf length ranges of 7- 8 cm and leaf width range of 3-4cm. The canopy volume is the range of 38.67m^3 to 49.67m^3.

Fruit depressed globose, to oblate, orange yellow to bright orange, surface smooth glossy, base even or obtuse, occasionally short naked, slightly ribbed, soft rind, thin with or without adherence pulp vesicle, segments 9-11, with 10-15 seeds. Fruit weight normally is 110 - 140gm and the fruit diameter in the range of 68mm, height 63mm and peel thickness2.81mm.

Feutrell's early

It is an old variety of New South Wales. Its parents are unknown. The fruit characteristics indicate that it may be a natural Tangore and those of the three suggest the possibility that medaterian or Willow leaf might have been the mandarin orange parent. Juice 52-67%, TSS 8.5-11.8^0 brix, surface texture smooth, yellow color skin, average fruit weight 133gm, TSS/TA ratio is 20.3.

Differences between Khoku Local and Sikkime Local mandarin orange variety

Mandarin orange (*Citrus reticulata* Blanco.) is considered as highly a heterogeneous species among other citrus species. Sikkim mandarin orange represents the most important commercial fruit of Sikkim. Sikkim mandarin orange is phenotypically similar to the Nepal or Assam or Darjeeling mandarin orange. The major producing areas of Sikkim are the Tista and Rangeet river valleys within the elevation range of 600 to 1500 m above mean sea level. In Sikkim mandarin orange is cultivated from time immemorial. It is a native fruit of Sikkim and is very popular in Kolkata market. A study on the diversity of Himalayan citrus both through morphological and Random Amplified Polymorphic DNA (RAPD) analysis revealed the existence of huge diversity of mandarin orange groups. Therefore, it is necessary to study the phenotypic as well as genetic level of Sikkim and Nepali mandarin orange variety by using molecular markers.

Research work done in Nepal

On the basis of annual report and published paper the following research activities done and express the finding of mandarin orange variety evaluation before F.Y., 2005/06.

Diversity study and variety improvement

- On the basis of maturity period Unshiu group of mandarin orange (Okitchu wase) was found earlier i.e matured in October. The TSS/TA ratio is 6 in first week of September and seedless, recommended the areas between 900-1000 meter altitudes for quality fruit production.
- Common group of mandarin orange (Khoku) matured in mid season i.e in December. The TSS/TA ratio is 10.4
- Hybrid group mandarin orange, (Murcott) matured in late i.e. in January. The TSS/TA ratio is 10.8 .
- In BS 2039, Kinnow mandarin orange plants were presented to late King Birendra by the then Pakistani President Mr. Zia Ul Haq. These plants were planted at Horticulture Farm, Panchkhal, Palpa, Agri. Centre Dhankuta, Terahara, Jankapur, Nawalpur (Sarlahi), Trisuli, Nepalganj, Surkhet and Doti. Initial performance report of these Kinnow plants is available in Seventh Five Year Plan Report of National Citrus Development Program. It was found heat tolerant variety and can be grown in terai (250 m asl).

- In 2005, NCRP, Dhankuta introduced a total 31 new scion varieties including mandarin orange (16), sweet orange (6), grapefruit (4) and tangor (3) and tangelo (3) from INRA-CIRAD, France. These varieties are being evaluated at NCRP, Dahnkuta and at farmers' field.
- Seedling plants of local mandarin orange germplasms from 10 districts were collected in 2034 and established in evaluation plot at Dhankuta Agriculture Station in B.S. 2035. These plants were evulated in phenotypic characters only and results are significants.
- In another study, a total of 26 mandarin orange seedling trees are collected from Khoku and maintained at NCRP, Dhankuta, were evaluated for yield and fruit quality. The results are observed slightly alternate bearing habits of Khoku mandarin orange.

Propagation

- Among the evaluated rootstocks Troyer citrange, Carrizo citrange and Citrus macrophylla were recommended based on their tolerance ability to Phytopthora root rot but never used in Nepal for commercial sapling production.
- Appropriate date of shoot tip grafting of mandarin orange on trifoliate orange rootstocks and recommended that last week of December to February is appropriate period with over 90% success in shoot tip grafting.
- Appropriate time of T-budding in mandarin orange and sweet orange is 3rd week of May under Dhakuta condition.

Insect management

- Recommended that spray of mineral oil (Servo Agro-spray or Agricultural Tree Spray Oil, ATSO) @ 20 ml + 2 ml Rogor/l of water during Falgun and Asar is more effective to control most scale insects of citrus fruit crops.
- In case of leaf minor, use of Metasystock @ 0.05% active ingredient followed by Rogor E 25 @ 0.05% active ingredient.
- To control the Green sting Bug insect, spraying of contact + systemic insecticide (Rogor @ 1 ml + Doom 1 ml/l of water) at the nymph stage (wing less stage) in the month of Jestha to Bhadra at 15 days interval.

Conclusion and suggestion

- It is urgent needs of diversity study of mandarin orange and determined the accurate genetic characteristics of Nepali *Suntala* at molecular level, which are commercially grown in the mid hills area from east to west.
- Variety development in fruits crops is not an easy work as other vegetable and cereals crops. It takes log time for study its performance. In 2005, NCRP, Dhankuta introduced

a total 31 new scion varieties including mandarin orange (16), Sweet orange (6), Grapefruit (4) and Tangor (3) and Tangelo (3) from INRA-CIRAD, France. These varieties are being evaluated at NCRP, Dahnkuta. In addition to scion varieties, seven rootstock varieties were also introduced from France. These varieties only limited in station. It should be evaluate in the farmer's field together with research station.

- Kinnow is one of the heat tolerant variety, plants were already introduced in the farm and stations, but it evaluation and study data is not published yet. In the other hand, Nepal is importing significant quantity of Kinnow annually from India every year. Similarly, Nagpur Santra is also importing from India. So it is urgent needs to study these varieties in Nepalese environments.
- Research work on variety selection and development in mandarin orange fruits are not in satisfactory level. We can developed own variety by selection from indigenous orchard. There may be superior genotypes in the indigenous orchard and mutilations bud in the orchard.
- Scientist work was not stable in the subject matter in the research station. There is a scenario of changes the working staff every time for self advantage not for institutional need.
- Variety development, multiplication, disease scanning and screening of indigenous variety from the in-vetro method is not satisfactory up to date. Study and strengthen the mocro-propagation techniques by trained manpower.
- Development of new citrus cultivars by traditional methods such as selection, mutation and hybridization. The hybridization approach has been common in mandarin orange breeding programs. We can develop early, late maturing and disease pest resistance cultivars by traditional and hybridization methods.
- It is urgent need to make short term and long term stepwise planning for research and development of new mandarin orange variety in future.

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Kinnow: A Potential Mandarin Orange Hybrid for Nepal

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Introduction

Nepal has a vivid geo–physical situation that extends lands from the warm and hot region of the Terai belt in the south to the colder belt of temperate and Himalayas in the north. The country provides opportunities for growing a wide range of agricultural crop species that require specific, yet different agro-ecological conditions. Among these crops, horticultural crops including fruit species are prominent in the tropical, sub–tropical and temperate belts.

Among the fruits, the citrus species are most important ones that cover nearly 50% of the total fruit growing area in Nepal. Many citrus genera are found in this country and these are grown for commercial and/or non-commercial purposes. Among these citrus crops, mandarin orange (loose-skinned orange, *Citrus reticulata* Blanco), sweet orange (tight skinned orange, *C. sinensis* Osbeck), acid lime (*C. aurantifolia* Swingle) and lemon (*C. limon* Burns) are prominent ones having many introduced cultivars and wild, indigenous germplasms.

Understanding "Kinnow", a mandarin orange hybrid

Recently, among citrus fruits that are available in markets during late season, kinnow is the one among the popular variety. Consumers many buy this attractive, sweet and juicy fruit in markets through November to March.

Kinnow mandarin oranges possess lots of health benefits with therapeutic applications as well. They are good to boost immunity, good for skin and help prevent wrinkles, good for eyes and protect vision, prevent heart disease, help in brain development, keep free from stomach ulcers, improve digestion and even may support to prevent from cancer. Kinnow is good for obesity by losing weight due to enhanced metabolic rate of body. Kinnow is renowned mandarin orange hybrid variety favored for its pleasing flavor, appearance, color, taste, high yield, high processing value and a wider adaptability (Ahmed, *et al.* 2006 & 2007).

Kinnow is also known as kinu, kino or kinoo. The tree is medium tall with a height of 6 m to 10 m and has high yielding capacity, 1000 fruits or more per tree (Kumar, 2020), if well nurtured and given adequate care and management practices. The fruits may vary 4 to 7 number per kilogram. Kinnow fruits are a medium-sized about 7 to 9 cm diameter, have a round to oblate shape, showcasing a slightly flattened top and bottom. Usually, each fruit possesses 9-12 segments. It is more juicy, sweet, and high yielder than sweet oranges. The skin color is darker orange, thicker, loose and softer than that of sweet oranges.

Genesis of Kinnow

"Kinnow" mandarin orange is a hybrid of two citrus cultivars "King" tangor (*C. nobilis* Loir) × "Willow leaf" mandarin orange (*C. deliciosa* Tenora). Howard B. Frost developed this variety at the Citrus Experimental Station at the University of California, Riverside, USA in 1915. It was released as a new citrus variety for commercial cultivation in 1935 (Hui, *et.al.* 2006). Each kinnow fruit has 20 to 30 seeds normally, but being a highly cross-pollinated variety, over 35 seeds are not uncommon. Due to its seedy nature, the citrus juice and canning industries rejected the variety and even the fresh fruit consumers did not like it in USA. As a result, kinnow-based citrus industries failed in the country and kinnow mandarin orange became unpopular as well.

Soon after its introduction in the Punjab region of India and Pakistan, probably during early 1920's, this cultivar became a popular one among the consumers and producers within a decade and the region has occupied maximum acreage and production as well thereby increasing its production area and marketing in various states in India. India became kinnow exporter to many countries in the world (Kaur and Singla, 2016), including Nepal.

Origin of low-seeded Kinnow

Because of the inherent seedy (20-35 seeds in each fruit) character of "Kinnow" mandarin orange, a low seeded variety development was considered as an important target of citrus breeders in USA. Mikeal Roose of the university of California, Riverside, USA developed a low seeded kinnow variety named as "Kinnow LS" in 2011. This variety has 2-3 seeds per fruit. It is very sweet, juicy and developed by mutation breeding of standard kinnow. H.S. Rattanpal of Panjab Agricultural University (PAU), Ludhiana, India developed another low seeded kinnow "PAU Kinnow-1" in 2015, through mutation breeding. Niaz Ahmad Chaudhary of the National Agricultural Research Center in Islamabad, Pakistan also developed a low-seeded Kinnow variety by selection method. The year(s) of development of low-seeded varieties are confusing and misguiding.

The low-seeded varieties are also good for hot and dry climates and the fruits mature in mid-January, normally. Fruits can keep on the tree well, up to April with good fruit quality.

Kinnow introduction in Nepal

Many citrus researchers and citrus development experts of Nepal, currently on duty and even retired professional experts have been contacted to dig out the pertinent information about kinnow introduction in Nepal. Various views on the issues have been obtained such as year of introduction, the country from where it was brought or supplied, even the location where it was planted first. During a study related to strategy of fruit development in Nepal, I obtained an information that it was King Birendra Bir Bikram Shah who brought kinnow plants as a gift from Pakistan. In fact, King Birendra had a 2-day State Visit to Pakistan (12-13 November 1980) when he might have received some kinnow plants as a gift from President Zia-Ul-Haq of Pakistan. These plants were planted at Kirtipur Horticulture Farm, from where some of the plants were taken to Paripatle Farm in Dhankuta.

Kinnow research and development needs in Nepal

Citrus spp. are most important fruits in Nepal. The area, production, and productivity of citrus fruits are higher than most other fruit species. These are grown in more than 60 districts or more depending upon the scale of production and land acreage. They deserve an adequate, yet appropriate research activities and development efforts. Many academic, research and development institutions have focused their program activities in mandarin oranges, sweet oranges, pumelo, lemon and lime. However, none of them have taken up research work on this particular fruit variety "Kinnow" which is emerging as a popular, productive and economic citrus fruit. Moreover, this variety matures during the later part of citrus season giving higher economic benefits than other citrus fruits.

Research and development interests of all citrus-related organization should have program activities focused in introduction and evaluation of standard and low–seeded kinnow cultivars in different agro–ecological regions/belts. Adequate research considerations are needed on production management, cultural cares, plant protection measures, pre-and post-harvest techniques, proper and timely market-channel build ups, etc. Because, the import volume of this fruit from India is very high and the outflow of currency from Nepal can be reduced greatly, if innovative production technologies be developed within this country.

A Brief Kinnow production technique

Kinnow grows well in hot and dry climates with very high productivity. The trees exhibit vigorous growth and may attain tree height of 10m. Fruit contains few seeds in low–seeded cultivars as against 20 to 30 seeds or more in seeded cultivars. The soil should we moist, well–drained and fertile. It grows well at a temperature range of 10°C to 35° C.

The budded or grafted plants on the Troyer citrange, not only induce dwarfing in kinnow, but also produce early harvest and can even be grown at high densities (2m×2m spacing) as against 6-8 m apart of seedling trees. Budding/shoot-tip grafting is normally practiced during August-September and February- March when there is sufficient cell sap flow. Saplings are planted in June-July. Fruits are harvested from December to February when the fruits attain a TSS; acid ratio of 12.1 to 14.1. Fruits are harvested by clipping the fruit stem with secateurs (Kumar, 2020).

Commercial waxes may be used to coat the fruit to prolong shelf-life up to 60 days (Kumar, *et.al*, 2016). Budded plants give a commercial harvest after 6 years of planting while lower yields can be obtained earlier (in 3 to 4 years) depending on production practices and ecological factors.

Summary and conclusion

Although many citrus species and their varieties are grown commercially in Nepal, some new varieties are seen in fruit markets, recently. One prominent mandarin orange hybrid "kinnow" appears in front–line. The fruit is sweet, juicy, attractive, matures in later season after most of the mandarin oranges and fetches high prices. The skin is also easily peeled off. This variety was introduced in Nepal as early as in 1980, but its production technology needs to be exploited, researched and disseminated properly and adequately to enhance its in–county production in commercial scale not only to meet its market demand but also to minimize its imports, thereby contributing its role in economic growth of Nepal through import substitution. Therefore, kinnow has good potential in Nepal if appropriate production pocket is identified and quality fruits can be produced with development of complete package of practice.

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Varietal Notification System of Mandarin Orange in Nepal

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Abstract

To meet the need of ever-increasing population, the breeders are continuously making the efforts by developing new varieties. By registering varieties, the national catalogues of commercial varieties can be diversified, and varieties which are better adopted to particular local environments can be promoted and commercialized by a wider range of actors. The process involves applications, review by technical committees, release/registration decisions, and notification in the Nepal Gazette or website of Ministry of Agriculture and Livestock Development. But in Nepal, only 21 varieties of different fruits were notified. Out of total fruit varieties only three varieties of mandarin orange were registered. Variety release or registration of fruit is difficult as compared to annual crops. Same process of registration for all crop groups is one of the major reason for registration few number of fruit varieties. In annual crops, data from sowing to harvesting can be easily recorded while it is difficulty to record data from saplings production to harvesting stage which takes near about six years for fruiting in mandarin orange. So, Nepalese variety notification process should be aligned with the neighboring countries where direct registration in horticultural crops was already started.

Keywords: National Seed Board, Notification, Registration, Release

Background

Nepal is situated in the lap of great Himalayas and has favourable agro-ecological diversity for agricultural production, especially in the horticulture sector. Different ecological belts are endowed with different types of climates due to its geographical locations and physiographic setting (FDD, 2017). Mid-hill area of Nepal is suitable for cultivation of citrus fruit. Among citrus group, mandarin orange is most popular and cultivated in large area. Mandarin orange as national fruit of Nepal, is cultivated in 27982 ha and productive area is 19481 ha (MoALD, 2023). The production and productivity of mandarin orange is 185,346 metric tons (mt) and

9.51 mt per hectare respectively (MoALD, 2023). Till now, only 21 varieties of different fruits were notified in Nepal (SQCC, 2024). Out of total fruit varieties only three varieties of mandarin orange were registered (SQCC, 2024). Out of three varieties, *Khoku Sthaniya* and *Banskharka Sthaniya* were registered under schedule-D (Landrace and Local Crop registration) and Paripatle *Agaute Suntala-1* was registered under schedule B (Registration of National variety) (SQCC, 2024).

Variety development process

The variety development process includes the following steps:

- Identification & Collection of germplasm
- Introduction & selection
- Hybridization & selection
- Initial Evaluation Trial (IET)/ Initial Yield Trial (IYT)
- Disease screening nursery
- Multi-location Trial (MLT)–Co-ordinated Varietal Trial (CVT)/Co-ordinated Farmers Field Trial (CFFT)
- Participatory Varietal Selection (PVS)
- Farmers Acceptance Test (FAT),
- Informal Research & Development

Legal provision of variety notification or registration in Nepal

Seed Act, 2045 (Second Amendment, 2079)

Structural arrangements for release and registration of different varieties

- ✓ National Seed Board (NSB)
- ✓ Secretariat: Seed Quality Control Center
- ✓ Provincial Seed Board (PSB): Gandaki and Bagmati province already form the Provincial Seed Board

Legal provisions for notification of varieties

Arrangements for notification by federal :

Release variety: Ministry can notify variety by publishing a notice in Nepal Gazette after consultation with National Seed Board

Local and imported variety:

- ➢ Registered after decision from National Seed Board
- ➢ No need to publish in Nepal Gazette
- ➢ Published in Ministry website or other medium

Arrangements for notification by province;

- ➢ Notify within the domain of province except imported varieties
- ➢ Provincial Ministry can notified variety by publishing a notice in Province Gazette after consultation with PSB.

- Provincial Ministry should consult with NSB before variety notification or registration

Section 11.6 of the Seed Act, 2045

The process of notifying or registering the variety of seeds shall be as prescribed and the process accordingly. According to the nature of certain crops, process of registering variety can be specified in different ways.

Section 15(d) of the Seed Act, 2045

License Provision for variety development and maintenance

- National Seed Board can issue license but Nepal government should approve for variety development and maintenance license
- Permits can be given to individuals or organizations by making provincial laws in accordance with the quality and standards set by National Seed Board

Seed Regulation, 2069

National Seed Board (NSB) has three sub-committee to assist National Seed Board for variety notification and registration. Out of three, one is Variety Approval, Release and Registration Sub-committee (VARRSC) under the chairmanship of Director General of Department of Agriculture.

Variety can be notified and there are four ways which are listed here under:

- ✓ Schedule A: Release of National variety
- ✓ Schedule B: Registration of National variety
- ✓ Schedule C: Registration of imported variety
- ✓ Schedule D: Registration of Land race and Local crop

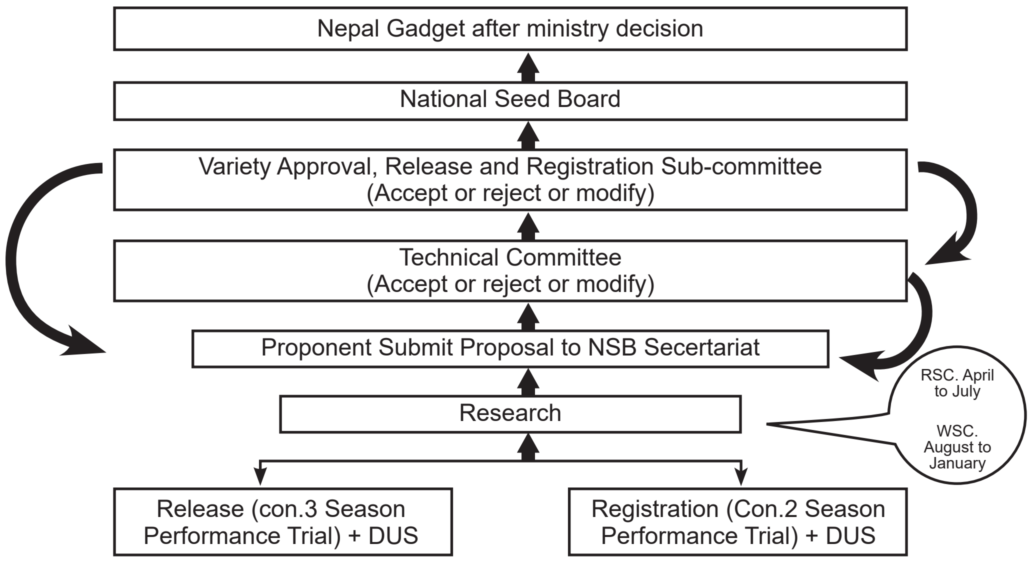

Figure 1. For release and registration (Schedule A and B)

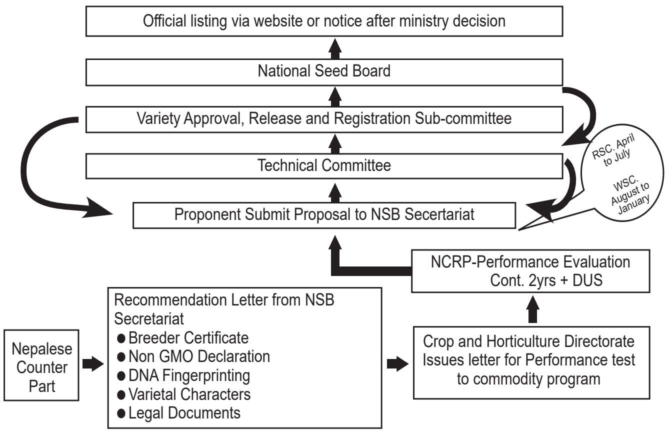

Figure 2. For registration of Exotic Commercial Variety (Schedule C) – explicit right of Federal Level

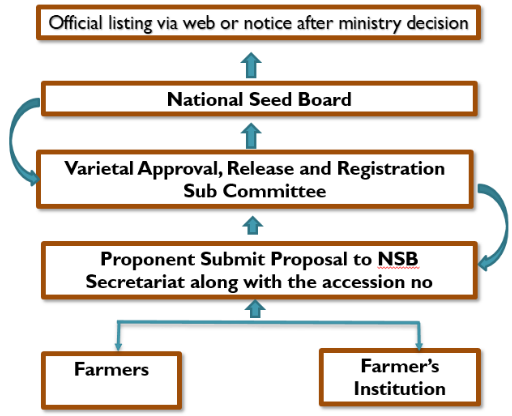

Figure 3. For registration of Landraces (Schedule D) & Widely Accepted Crops – Federal Level

Procedure of variety notification in Nepal

There are four ways for variety notification and registration in Nepal which are listed below:

Province can release or register varieties in their in their provincial boundry by forming provincial seed board as per provincial act.

Horticultural crops registration system in neighboring countries

Horticultural crops variety registration in India

The National Seed Policy, 2002 of India, regulate the sale, import and export of seeds and planting materials of agriculture crops including fodder, green manure and horticulture and supply of quality seeds and planting materials to farmers throughout the country.

All varieties, both domestic and imported varieties that are placed on the market for sale and distribution of seeds and planting materials will be registered under the Seeds Act. However, for vegetable and ornamental crops a simple system of varietal registration based on "breeder's declaration" is adopted in India. Registration of varieties will be granted for a fixed period on the basis of multi-locational trials to determine Value for cultivation and use (VCU) over minimum period of three seasons, or as otherwise prescribed as in the case of long duration crops and horticultural crops. Samples of the material for registration will be sent to the NBPGR for retention in the National Gene Bank.

Horticultural crops variety registration in Bangladesh

In the National Seed Policy, 1993 of Bangladesh, for new varieties of wheat, rice, jute, potato and sugarcane developed by private or public agencies will be subject to notification by the National Seed Board of Bangladesh. Varieties of all other crops developed by public research agencies will be subject to an internal review and approval by each respective agency and must be registered with NSB before being released. Varieties of crops, other than rice, wheat, jute, potato and sugarcane that are imported or locally developed by a private person, company or agency must be registered with the NSB giving prescribed cultivar descriptions, but will not be subject to any other restrictions.

The crops and notification procedure for controlled crops before commercial purpose in Bangladesh:

- ✓ The National Seed Board (NSB) shall designate kinds and varieties of crops that are to be notified. Initially, rice, wheat, jute, potato and sugarcane will be the only notified crops.
- ✓ Release of the varieties of notified crops will be subject to evaluation and testing by the Technical Committee on Seeds.
- ✓ Varieties of all other crops will have to be registered prior to being sold, but there will be no requirement for prior testing and approval.
- ✓ Any variety, whether imported or developed in Bangladesh, must registered with the National Seed Board. Except for controlled or notified crops, registration will not involve testing or any other procedure.

Requirements in Bangladesh for non controlled crops

- Proposed Name – Scientific, English, Bangla
- Company and Dealer Profile
- Ecological demand
- Breeder details
- Agronomical demands (seed rate, PoPs,)
- Disease and Insect trial and reaction details.
- Description of variety – Identification and other special features
- Description of Initial yield trial (IYT), Multi location trials (MLT), Yield trial on farmers field and Agronomic trial

Data to be recorded for release and registration of varieties in Nepal

The crop, botanical name, old name before registration, new name after registration, parents of the new variety, country of origin, source and accession number should include in the proposal. Agronomical characters like days to 50% flowering, days to maturity from seeding, plant height, fruit weight, yield and multi-location data of initial evaluation trial (IET) and coordinated varietal trial (CVT) data should be taken from at least three location. Morphological traits like fruit shape, fruit color, fruit size, flower color, leaf shape, petiole wing, growth habits, branching, foliage color and plant height etc should be measured and incorporate in proposal.

Response of Stress like as biotic, abiotic and nutritional quality such as protein %, carbohydrate %, minerals, vitamins should be included in proposal. Beside that recommendation domain, time of planting, seed rate and sowing distance, reasons for recommendation, distinctness of variety, disease scoring (at least 2 consecutive year), insect scoring (at least 2 consecutive year), stability test, testing location at least 3 location and picture and video clips of farmers response should be submitted during submission of proposal in National Seed Board Secretariat

Issues in mandarin orange registration system in Nepal

Same process of registration for all crop groups is one of the major reason for registration of few number of fruit varieties. In annual crops, data from sowing to harvesting can be easily recorded while it is difficulty to record data from saplings production to harvesting stage which takes near about 6 years for fruiting in mandarin orange. The objectivity and consistency of performance testing for annual and perennial crops are same which is not feasible for fruit crops. Nepalese variety notification process should be aligned with the neighboring countries where direct registration of horticultural crops was already started in another challenge for our country. Characterization of genotypes, spot examination and development and approval of Plant Variety Protection and Farmers Right (PVPFR), incentives to breeder involved in variety development and strengthen to private sector Research and Development are issues in variety registration of mandarin orange.

Summary and Conclusion

Mandarin orange (*Citrus reticulata* Blanco) is the major sub-tropical fruit popularly grown in mid-hills which has high domestic and foreign market potentialities. Mandarin orange is cultivated in 27982 ha and productive area is 19481 ha of land area with annual production and productivity of 185,346 metric tons (mt) and 9.51 mt per hectare respectively which contributes almost 0.95 % in AGDP (MoALD, 2023). Variety notification or registration should be done before marketing for commercial purpose. Second amendment of Seed Act, 2045 open the opportunity to simplify the notification of fruit varieties. So, there is opportunity for Nepalese variety notification process to align with the neighboring countries where direct registration of horticultural crops were already started. Identification and characterization of genotypes should be done for the development of new varieties of mandarin orange. Government should strengthen and support to private sector in research and development of new high yielding varieties of mandarin orange in Nepal. Besides that, sufficient budget and incentives should be provided to breeder involved in variety development.

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Case Studies for Geographical Indication (GI)

सुन्तलाको उपयुक्त रुटस्टक (तिनपाते सुन्तलाको बिरुवा)

Case Study of Mandarin Orange in Arghakhanchi District

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Abstract

Mandarin orange cultivation in Arghakhanchi district plays a crucial role in the local economy and livelihoods due to favorable agro-climatic conditions and traditional farming expertise. Despite this significance, there has been very less studies on mandarin orange cultivation and historical evidence in this district. So, in this study we collected scientific evidence of the longstanding cultivation of mandarin oranges in the Arghakhanchi district, with the objective of supporting the geographical indication (GI) designation for oranges in this region. Utilizing a multi-method approach, including literature review, farmer's household survey, market survey, consumer survey, key informant survey (KIS), and focus group discussions, data were collected and analyzed using Microsoft Excel. Oldest (over 200 years) as well as new commercially established mandarin orange orchard were found on Panini Rural Municipality of Arghakhanchi district. Butwal and Rupandehi were the main wholesale market for mandarin orange. Mandarin orange of Arghakhanchi gained popularity for its thin rind, juiciness, resistance to insects and pests, larger size, longer post-harvest lifespan and sweet taste, boasting an average brix content of 10. Interestingly, the first mandarin orange seedlings in Arghakhanchi were acquired from Naya Gaun, Dhurkot Municipality of neighboring Gulmi district. The Farmers from Naya Gaun primarily sell orange seedlings for income generation, and the oldest orange tree, 400 years old, was found there, although the initial introduction of oranges to the area remains unknown.

Key words: Arghakhanchi, Gulmi, Native oranges, Geographical indication

Introduction

Mandarin orange (*Citrus reticulata* Blanco) cultivation holds significant economic importance for the Arghakhachi district, serving as a primary source of income for local farmers and contributing to rural livelihoods (Khanal et al. 2018). The favorable agro-climatic conditions, coupled with the expertise of farmers in traditional cultivation techniques, have led to the establishment of thriving Mandarin orange orchards across the district (MoALD, 2019).

The cultivation of mandarin orange not only generates employment opportunities but also stimulates local trade and commerce, boosting the socio-economic development of the community (Government of Nepal, 2019).

Furthermore, mandarin orange production plays a crucial role in enhancing food security and nutritional well-being in Arghakhanchi district Khanal et al. (2018). Rich in vitamin C, minerals, and antioxidants, mandarin orange offers valuable health benefits, serving as a nutritious dietary component for consumers (Shrestha, 1998). Its popularity extends beyond local markets to the bigger regional markets like Butwal, Pokhara and Kathmandu.

Despite its economic potential, mandarin orange cultivation in Arghakhanchi faces various challenges like disease, pest infestations, fluctuations in market prices, inadequate access to credit facilities, and limited technical knowledge of farming. Proper cold storage was found the primary problem which is crucial for preserving the quality and freshness of fruits like mandarin oranges, as it helps slow down the ripening process and prevents decay. Addressing these challenges requires concerted efforts from stakeholders, including government agencies, research institutions, and local communities, to implement effective pest management strategies, improve access to resources, and enhance farmer education and training programs (Bajracharya and Gurung, 2020). Nevertheless, amidst these challenges, there are ample opportunities for the development and promotion of Arghakhanchi mandarin orange as a premium agricultural product. By leveraging its unique geographical and climatic attributes, the district can position itself as a leading producer of high-quality mandarin orange. (Khanal et al., 2018).

Geographical Indication (GI) protection offers a promising avenue for safeguarding the reputation and integrity of Arghakhanchi mandarin orange, thereby ensuring fair recognition and increase market value for local producers. By associating the product with its geographical origin and specific attributes, GI status can prevent misappropriation and unauthorized use of the Arghakhanchi name, protecting the interests of farmers and consumers. As such more than 100 agricultural products have potential for geographical indication (GI) tag in Nepal (Joshi et al., 2017). At present, there is a policy provision for GI however the ministry of industry, Commerce and supplies is still in the process of developing its legal registration system (Joshi et al., 2017).

Receiving GI protection necessitates rigorous documentation and evidence of the product's historical presence and unique characteristics. However there is very less documentation of the native fruits and fruit varieties in Nepal that have special traits (aroma, taste) of themselves which makes them unique than the same fruit that is found in other part of the world. That is why Nepal has been deprived of the right to get Geographical Indication (GI) and center of Origin of many native fruits.

Documentation of the mandarin orange of different pocket areas of Arghakhanchi district will help to deliver scientific evidences of existence of oranges in that area since ancient times, introduce Arghakhanchi oranges in the international arena and this will be a good framework to foster the process of taking the GI tag of mandarin oranges in the coming years. This paper focuses mainly on the study and collection of primary data thereby accelerating the efforts that is needed to document and preserve traditional knowledge, heritage varieties, and farming practices associated with oranges pocket areas in the Arghakhanchi district of Nepal. Also some evidences from Naya Gaun of Gulmi district has been incorporated as per the recommendation of the surveys from Arghakhanchi district.

Methodology

Study area

This study employed a comprehensive research methodology comprising literature review and survey. Farmer's household survey, market survey, consumer survey, key informant survey (KIS), focus group discussions (FGDs) was conducted on Arghakhanchi district and focus group discussions (FGDs) on Gulmi district. Similarly organoleptic testing on collected sample from Arghakhanchi and Total Soluble Solids (TSS) was measured with refractometer from those sample.

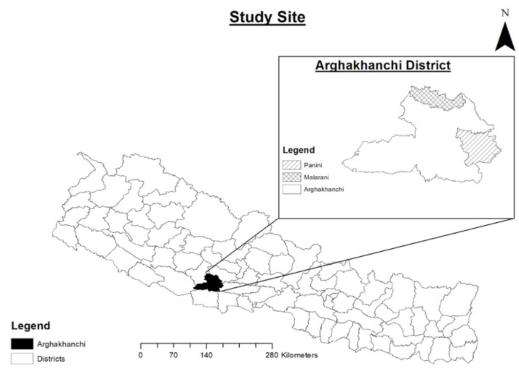

Figure 1. Study area in Arghakanchi District (Panini and Malarani Rural Municipalities)

Data collection

Literature review: Extensive literature review was done to gather background information and insights on mandarin orange cultivation, market trends, and consumer preferences.

Farmer's household survey: A structured survey was administered to mandarin orange farmers in two prominent pocket areas of two Rural Municipalities, namely Pokharathok and Simle of Panini Municipality and Sakindhara - 6 of Malarani Municipality. A total of 42 farmers participated (22 from Panini Rural Municipality and 20 from Malarani Rural Municipality).

Market survey and consumer survey: Five market surveys and five consumer surveys were conducted to gather information on market dynamics, pricing, and consumer preferences regarding mandarin orange.

Key informant survey (KIS): KIS was conducted with more than three experts, including the chairperson of Rural Municipality, chief, and staff of the Agriculture Knowledge Center in Arghakhanchi district, Nepal.

Focus group discussions (FGDs): FGDs were held with 15 farmers, including elderly individuals, in both Panini and Malarani Rural Municipalities. Additionally, FGDs were conducted in Naya Gaun, Gulmi district, as per the recommendation stemming from surveys conducted in Arghakhanchi district.

Quality testing: (Organoleptic and brix testing)

A customized 6-point hedonic scale organoleptic evaluation sheet was prepared and replicated to test the overall perception of the quality of the mandarin oranges from the study sites. Each test was conducted with 12 office staff members from the National Center for Fruit Development, NARC, members of the Nepal Horticulture Society. Similarly the TSS content of the orange samples was measured in the field using a refractometer.

Data analysis: Data collected from surveys and tests were compiled and computed using Microsoft Excel for analysis.

Results and discussion

Farmer survey

Higher number of male were present on both survey site of survey which were 46 to 55 years old (Table 1).

Table 1. Percentage of different gender and age group of farmers involved in survey of two different study location of Arghakhanchi

S.N.	Location	Gender %		Age (years)
		Male	Female	
1	Panini	90.5	95.0	52.8±2.4
2	Malarani	75.0	25.0	46.3±2.1

Cultivation history and varieties: The historical cultivation of mandarin orange in the Arghakhanchi district is deeply ingrained in local memory. According to tradition, the first native orange seedlings were brought to Panini from Naya Gaun in the neighboring Gulmi district around 200 years ago. Those seeds were then spread to other mandarin orange producing location across Arghakhanchi. As such the elderly and all the participants in the focus group also validated this statement during discussion. Following the suggestions of the farmers from Arghakhanchi we also held a focus group discussion in Naya Gaun of the neighboring Gulmi district to better understand the origins of this variety. FGD survey of Naya Gaun revealed that a 400-year-old mandarin orange plant was discovered on Kamal Thapa's field, though its origins in the village was unknown.

Figure 2. The seven generation old mandarin orange tree found in Gulmi district

The historical cultivation of Mandarin oranges in the Arghakhanchi and Gulmi district reflects a deep-rooted tradition spanning generations which may be due to that mandarin oranges were found to be in semi-wild conditions in Butwal which is about 65 km away from Arghakhanchi (Bonavia 1890). Farmers in the study area have preserved native variety commonly called Butwal Local/Raithane/Sati Pukhe jaat, which is favored for its taste, color, and longevity.

Mandarin orange farming in Panini started commercially around 2049/50, under the considerable support from the Arghakhanchi District Agriculture Development Office (DADO) at the time. Native variety occupied 80% of the orange seedling plantations, while 20% of farmers also grow grafted varieties. Although other types like Kinnow and Unshiu are also grown, they were less popular due to lower demand compared to the preference for local varieties.

Figure 3. More than 160 years old trees found in Arghakhanchi district at Dhadhiram Gautama's orchard.

Cultivation practices and characteristics: The Farmers land holdings in both Panini and Malarani showing significant portion of the area occupied by mandarin cultivation on both locations (Figure 4).

Respondents in focus group discussions speculated on the etymology of "*Suntala*" (orange), associating it with the Nepali term "Suunn" for the color yellow-gold. Some referred "*Suntala*," as a term passed down through generations, Native varieties remain predominant, favored for their sweetness, size, color, and longevity. Grafted saplings though present are less popular. More farmer were planting seedling than grafted on their orchard on both locations (Figure 5). Farmers in Gulmi however focus on producing more orange seedlings for selling purpose.

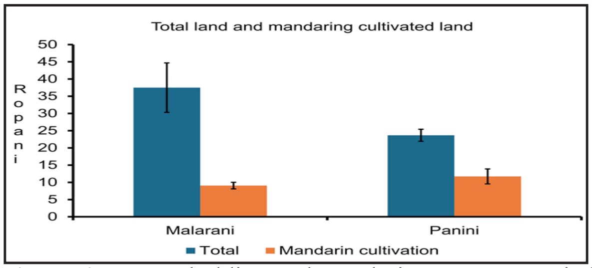

Figure 4: Farmer holding and mandarin orange occupied on two different location of Arghakhanchi (Average±SE)

Growth and production: Native oranges typically begin fruiting in five years after planting, while grafted varieties take three years. Average tree height for native varieties is around 7 meters, with Unshiu at 3 meters and Kinnow comparable to native varieties. Average yields are approximately 95 kg per tree in Panini and 45 kg per tree in Sakindhara. The difference in average orange yield per tree between the two locations could be attributed to factors such as altitude, tree canopy, management practices, and orchard elevation (Khalid et al., 2018).

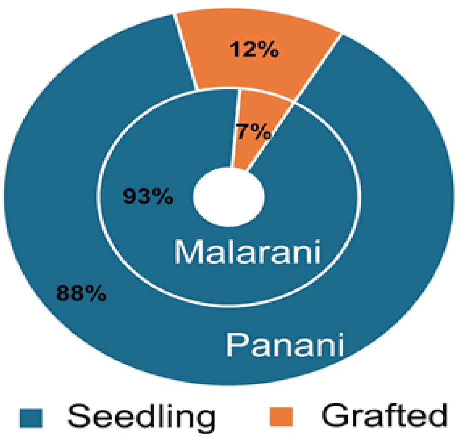

Figure 5. Farmer planting seedling or grafted on two different location of Arghakhanchi

Cultivation practices include preparing land with pits, fertilization, and irrigation and hand weeding as per needed in Panini however 50% of famers in Malarani planted seedling plant without making pit (Table 2). Intercropping with maize, mustard, cauliflower, and cabbage is common when the orange plants are small afterwards intercropping was not done. Farmers note perceived advantages of organic mandarin orange, such as longer post-harvest lifespan and superior taste than other mandarin orange.

Table 2. Percentage of farmers planting oranges in pit and without pit in both study areas

S.N.	Location	% planting in pit	% planting in without standard pit
1	Panini	100.0	0.0
2	Malarani	50	50

Pest management and harvesting: Farmers employ various methods for pest management, including organic solutions and, in some cases, recommended insecticides. However, alongside these traditional practices, the study identifies emerging challenges such as disease, pest infestations, and market fluctuations which is in line to the result of the study made by Prasad and Chandra (2019). Harvesting typically occurs from Kartik to Magh in Panini and from Mangsir to Falgun in Malarani.

Despite the resilience of native varieties, farmers faced obstacles in maintaining consistent yields and quality which may be due to pest pressures and limited access to effective pest management strategies (Baral et al., 2021). Addressing these challenges requires collaborative efforts from government agencies, research institutions, and local communities to provide technical assistance, access to resources, and training programs aimed at improving pest control practices and enhancing overall orchard management. Slightly difference in the harvesting time in the two study areas may be due to the variation in altitude. (Tomiysau et al., 1998)

Market survey

The study highlights that significant economic contribution of mandarin orange cultivation to the Arghakhanchi and Gulmi district, serving as a primary source of income for local farmers and stimulating trade and commerce in the region. The local market of Arghakhanchi district relies primarily on Butwal for mandarin orange supply, despite being a significant production area. Till now there is no marketing challenges as most of the farmers (85%) directly sell oranges to the contractors. Retailers and wholesalers highlight the superior taste and size of mandarin orange from Arghakhanchi, particularly Panini and Malarani. Prices vary seasonally, with potential for higher rates with improved technical knowledge regarding preservation and storage technologies and infrastructure.

Despite being a major production hub, the local market's reliance on external sources underscores the need for improved marketing infrastructure and distribution channels within the district. As such enhancing market access and developing value-added products can help capitalize on the district's unique geographical and climatic attributes, positioning Arghakhachi mandarin oranges as premium agricultural products in both domestic and regional markets (Richa et al., 2023). Furthermore, strengthening linkages between farmers and buyers, implementing fair trade practices, and promoting eco-friendly packaging can contribute to sustainable economic growth and improve livelihoods in the community (Mare, 2008).

Consumer survey

Consumers prefer mandarin orange from Malarani as their top choice (average brix content: 10.5), followed by oranges from Panini (average brix content: 9.5) as their second choice. The native variety is attributed with thin flesh, juiciness, resistance to insects and pests, large size, extended post-harvest lifespan, and sweet taste so the consumers stress the significance of preserving local varieties. There are concerns regarding the possible mislabeling of oranges and the necessity for better storage technologies.

Consumers' preference for seedless varieties with consistent size could be met by partnering with national and international institutions for research aimed at preserving and enhancing quality of local varieties. After testing these varieties in the field, if found suitable, they could be introduced in the district to get the quality orange fruits.

Key informant survey (KIS)

The Agricultural Knowledge Center (AKC) reports six groups of orange farmers, totaling 300-350 members, cultivating oranges across 729 hectares in Arghakhanchi district. Average incomes of farmers range from 1 lakh to 15 lakh NPR, with a significant portion sold directly to contractors.

The concept of Geographical Indication (GI) protection holds immense potential for safeguarding the reputation and integrity of Arghakhanchi mandarin oranges says the chief of Agricultural Knowledge Center of Arghakhanchi district during our survey. As such by associating the product with its geographical origin and specific attributes, GI status can enhance market recognition, prevent misappropriation, and increase the value of local produce. Moving forward, future research endeavors should focus on exploring opportunities for value addition and market diversification and collaboration regarding quality enhancement of native varieties of oranges. (Joshi et al., 2017).

Focus group discussions (FGDs)

Focus group discussions (FGDs) on Arghakhanchi : The proliferation of mandarin orange has transformed villages into "*Suntala Gaun*" (orange villages), attracting internal tourism. However, concerns persist regarding preservation technologies and consumer preferences for specific (seedless, big, much sweeter) varieties.

Focus group discussions (FGDs) on Gulmi: The focus discussion took place in Naya Gau village of Dhurkot, Gulmi district, involving twelve farmers, comprising 8 males and 4 females. During the discussion, it was noted that a 400-year-old mandarin orange tree was recorded on Kamal Thapa's orchard, though its origins in the village were unknown. Locally, mandarin oranges are referred to as "*Suntala*," a term passed down through generations, yet there were no specific cultural artifacts such as poems, songs, or festivals associated with it.

Suntala cultivation spans 5,000 ropani of sloping land across the village, engaging 600 families, although there is no formal cooperative or company dedicated to its cultivation. The mandarin orange trees in Naya Gaun orchards were relatively late to bear fruit compared to neighboring orchards with smoother rind.

In establishing new orchards, farmers prepare pits and incorporate organic manure before planting. They use a boardeaux mixture and adopt irrigation practices. Chemical fertilizers were not utilized, and despite facing challenges from pests such as sting bugs, fruit flies, and borers, chemical pesticides were avoided for pest and disease management.

The primary income source for farmers was the sale of seedlings, with over 8 nurseries established in Naya Gaun. Seedlings were exported to Baglung, Parbat, Arghakhanchi, Palpa, Salyan, and the local market in Gulmi district. Harvesting typically occurs from the last week of Poush to the last week of Falgun, with produce sold directly without storage.

For storage, farmers had a practice of using materials such as bash ko supilo, rice bran, finger millet bran, and mustard bran. Apart from self-employment in the mandarin orange orchards, farmers also assist others, contributing to additional income sources. There was a desire for government recognition through a Geographical Indication (GI) tag, which would enhance market value and recognition for their product.

Conclusion

The study's findings revealed a rich history of mandarin orange cultivation in the Arghakhanchi district, dating back more than 200 years. Both old and new orchards of the pocket areas, with many respondents tracing the origins of their orange seedlings to Naya Gaun in the neighboring Gulmi district, brought by their ancestors. Consequently, the oldest orange tree, 400 years old, was found in Naya Gaun, although the initial introduction of oranges to the area remains unknown.

The native orange variety stands out for its widespread popularity, with farmers favoring it over grafted varieties. These native oranges are characterized by their thin rind, juiciness, resistance to insects and pests, large size, extended post-harvest lifespan, and sweet taste, boasting an average brix content of 10. While there may not be specific traditions or folk songs related to oranges, the farmers heavily rely on them for their livelihoods, with average annual incomes ranging from 1 lakh to 15 lakh depending on land holdings.

A significant majority of farmers (85%) directly sold their produce to contractors, who then store them in cold storage facilities. Cultivation practices among farmers are largely uniform, with a focus on clean cultivation methods. Due to district's favorable niche climate, infestations of insects and pests are minimal and are managed through simple agronomic practices.

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स्थानीय नेपाली सुन्तला

Mandarin Orange Diversity in Kaski District

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Abstract

In Gandaki region, cultivation of mandarin oranges (*Citrus reticulata* Blanco) began in Kaski district and later expanded to neighboring districts. It plays a vital role in the local economy and promotes tourism due to favorable agro-climatic conditions, various tourist destinations, and traditional farming expertise. However, there have been few studies conducted on mandarin orange cultivation and its historical significance in Kaski. In this study, gathered scientific evidence of the historical cultivation of mandarin oranges in Kaski district with the aim of supporting the geographical indication (GI) designation for oranges in this area. Various methods were utilized, including literature reviews, farmer household surveys, market surveys, consumer surveys, key informant surveys (KIS), and focus group discussions. The data collected were analyzed using Microsoft Excel. To support the documentation of Passport data, different characteristics of orange trees from multiple locations were recorded. Oranges from Chyarpe and Syastri of Rupa Gaunpalika and Kristi-Dopahare of Pokhara metro politancity have gained popularity for their thin peel, juiciness, good taste, insect and pest tolerance, large size, and an average brix content of more than 10%. The first mandarin orange sapling in this area was brought from the Horticulture Research Center in Malepatan (previously Malepatan Krishi Farm). The majority of farmers in Kaski district received mandarin orange saplings from Malepatan Krishi Farm Pokhara. Pokhara Kaski, serves as the main wholesale market for oranges produced in these areas. Farmers do not face any marketing challenges as it is a significant marketing hub for local consumption and serves as an entry point for distant markets like Narayangadh, Butwal and Kathmandu.

Key words: Kaski, Syastri, Chyarpe, Kristi-Dophere, Native oranges, Geographical indication

Introduction

Fruits constitute an important item of our food and play significant role in the human diet through the supply of vitamins and minerals (Prabhakar et al., 2004). Citrus, particularly the mandarin orange is the most important and highly commercial fruit crop in the hills of Nepal. Mandarin orange is a group name for a class of oranges with thin, loose peel. These are treated as members of a distinct species, *Citrus reticulata* Blanco. Mandarin oranges include a diverse group of citrus fruits that are characterized by bright colored peel and pulp, excellent flavor, easy-to-peel rind and segments that separate easily (Parashar, 2010).

Mandarin orange is grown in 27,982 hectares of area in Nepal with production of 185,346 metric ton and 9.51 mt/ha. productivity in fiscal year 2021/22. (MoALD, 2023). The mid-hill region (1000 to 1500 m altitude) has a comparative advantage in the cultivation of citrus fruits, especially mandarin orange and sweet orange. These are grown in almost all mid-hill areas (900 to 1400 m) of the country between 26º 45' and 29º 40' latitude and 80º 15' and 88º 12' longitude. Kaski district which lies in the mid-hills of Nepal is one of the pocket areas for mandarin orange production. In fiscal year 2021/22, mandarin orange was cultivated in 851 hectares of area with production of 7610 mt. and 10.48 mt/ha. of productivity in Kaski district (MoALD, 2023).

Nepal is rich in agrobiodiversity due to climatic variation. Some of the agriculture products are produced in very specific areas. More than 100 agricultural products are potential for geographical indication (GI) tag in Nepal. None of the products are registered as GI in Nepal. Three traits (famous, special trait and origin) are very important on GI system. Legally registration system as GI has not been existed in Nepal, but there is a policy provision for GI. Hence, study related to GI is most in present day.

Methodology

Study area

Kaski district of Gandaki province of Nepal was selected for the study. Kaski lies in the mid-hills of Nepal, which provides the suitable climate for mandarin orange production. Two-pocket areas of mandarin orange production were selected for the survey i.e., Syastri and Chyarpe region of Rupa Rural Municipality and Kristi-Dopahare region of Pokhara Metropolitan City.

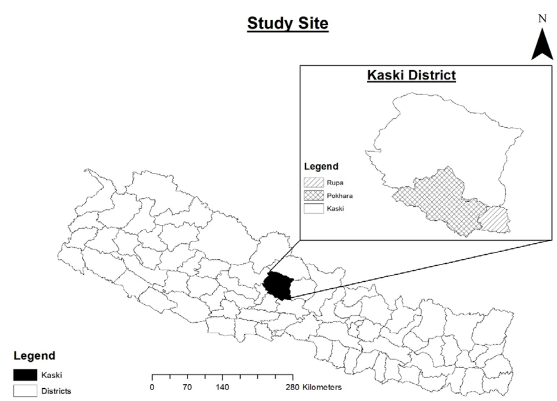

Figure 1: Map of Nepal showing the study site.

Sampling method

The samples were collected by using purposive sampling method.

Sampling size and selection procedure: Total of 20 households' sample were taken from each region by purposive sampling method. So, altogether 40 households' sample were taken during the study period.

Methods of data collection: Various methods were employed as the data collection technique. Farmers' household surveys, Focus Group Discussions, Key Informant Interviews, Market surveys and Consumer survey were used. Both primary and secondary sources were utilized as the source of information, both qualitative and quantitative information were collected.

Quality testing (Organoleptic and Brix testing): The taste profile or organoleptic test of oranges from the study area was evaluated using a 6-point hedonic scale (1. 2, ….6). Fifteen number of people were involved in Quality Testing. Brix content testing was performed on oranges from different locations to assess their sweetness level.

Methods and techniques of data analysis: Collected data were entered in the MS-Excel and analysis was done using MS-Excel and STATA software.

Results and discussion

Farmers' household survey

Farmer's survey was conducted with 40 farmers (30 male and 10 female) of different age groups from 30 to 78 years. Having 3 to 100 ropani of Land and growing mandarin orange orchards in 1 to 40 ropani. Most of the farmers were growing orchard in mid hill ranging from the altitude of 569-1182 m. According to farmers, cultivation of mandarin orange has started from BS 2033 in mandarin orange plantation campion and different farmers have attempted to establish the orchard from BS 2033 to 2055. Male domination was observed on both survey site while on age aspect, it was varying from 30 to 78 years old (Table 1)

Table 1. Age group and % of gender of farmers in survey of Kaski district.

S.N.	Location	Gender %		Age (year)
		Male	Female	
1	Rupa Gaunpalika (Syastri and Chayrpe)	70	30	30-74
2	Pokhara Metropolitan	82	18	37-78

Based on former local VDC leader Mr Krishna Murari Khanal, 82 years old of Syastri area memorized the cultivation story of mandarin oranges in Kaski district. According to him, mandarin orange saplings received from Malepatan Krishi Farm (rightly Horticulture Research Center, Malepatan) and commercially mandarin orange cultivation started in Syastri, and Chyarpe of Rupa Rural Municipality in BS 2033. At the same time, commercial cultivation of mandarin orange was kicked on various mandarin orange growing pockets of Kaski district. This message was validated during focus group discussion on both places. Farmers of both areas having more than fifty percent of their own land occupied by mandarin orange cultivation in Rupa (Chyarpe and Syastri) and Kristi-Dopahare location (Figure 2).

Most of the farmers were growing local mandarin orange variety. 60% farmers are growing their orchard in sloped land and 40% farmers are growing their orchard in plain area. A single farmer is growing 10 to 600 mandarin orange plants in their land. Most of the saplings are developed from seedlings (83% seedling and 17% grafted) and some are grafted. Farmers are getting their yield varies with 60 kg to 700 kg per plant. Farmers have mentioned 4-5m plant to plant distance and planted in the month of June July. During planting and weeding time,

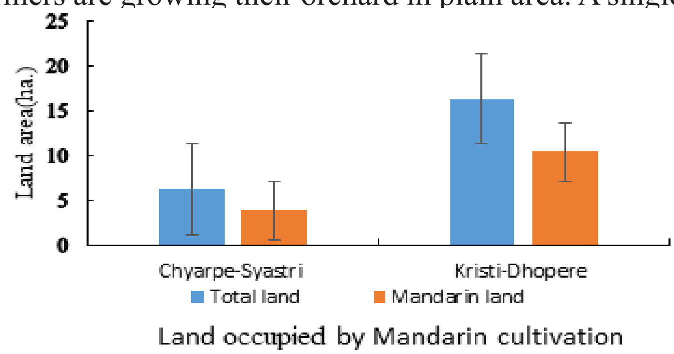

Figure 2. Land holding of mandarin orange in two different locations of Kaski

most farmers have applied 30-80 kg of compost, very few farmers apply chemical fertilizer followed by irrigation from the month of Magh to Baisakh.

Management of orchard is depending upon income from farm and mostly done by physical method and slashing the weeds by sickle and some leafy vegetables, cauliflower, cowpea, finger millet, ginger, turmeric, maize are inter-cropped in orchard. Farmers have mentioned application of chemical fertilizer in orchard increased the quantity but quality has deteriorated, in comparison with compost used orchard are more juicy, tasty, shiny and sweet taste. They have faced with different insect pest (fruit fly, citrus bug, aphid, scaly insects, leaf miner, powdery mildew, citrus psylla, CTV etc) and managed them by applying different insecticides and fungicides available in local market.

Farmers in both locations wanted to preserved local variety which is favored for its sweetness and appealing color. No any farmer on both locations ready to plant exotic variety because they prefer only local variety. No any nurseries and sapling producer found in Syastri and Chyarpe area but in Kristi-Dopahare area, two nurseries are running namely the nursery owner are Lila Dhar Paudel, Pokhara-22, Khalte and Laxmi Thapa, Pokhara-21, Ranipokhara. Main harvesting time of fruits starts from Poush and they sell their mandarin orange directly to wholesalers from Pokhara market till the end of Magh. Mandarin orange is easily sold in the markets of Pokhara and local market.

Farmers have suggested to provide subsidies to real and needy farmers, training should be provided to nursery grower, support by expert team routinely observing the farm, good marketing facility, irrigation facility, development of disease resistance varieties etc.

Table 2. Overview of farm household survey

S.N.	Description	Activities/Percentage
1	Initial orchard establishment	BS 2033
2	First sapling introduced	Malepatan Krishi Farm
3	Land type	60% sloppy and 40% Plain
4	Land preparation	Traditional way
5	Layout	More than 50 % farmer follow standard layout (5m x 5m)
6	Pit digging	68 % follow standard pit digging method
7	Use of compost per pit	1.5 to 4 doko compost per pit
8	Plant to plant distance	Most farmers used 4-5 meter distance
9	Varieties growing	Mostly local
10	Sapling types (grafted, seedling)	83 % farmer planted seedling and 17% farmer planted grafted sapling
11	Planting month	June-July
12	Weeding method	Manually

S.N.	Description	Activities/Percentage
13	Mulching	80 % farmers are practicing organic mulching and green manuring
14	Intercropping	Most farmers are practicing seasonal vegetables and few with cereal crop
15	Application of fertilizer for manuring	Most of the farmers are applying compost and very few with chemical
16	Irrigation	Magh to Chaitra
17	Insect pest types and control	All farmers are facing problems of insect pest and management is done based on chemical and IPM approach
18	Difference between applying chemical fertilizer Vs compost	Yield increased with chemical fertilizer, quality enhance with composting
19	Ripening time	Stars from Mangshir till Magh
20	Harvesting Period	Mangshir-Magh
21	Direct sell/ store	All farmers sell directly to trader (Contractor) from orchard
22	Market	Pokhara
23	Training/ prunning	Most farmers follow training/ pruning after harvesting
24	Average fruit number/plant	265
25	Average number of plant /farmer	145

Focus group discussion

Focus group discussion took place in two places i.e. Syastri and Kristi area of Kaski district involving 40 farmers, comprising of 30 male and 10 female. During the discussion, it was noted that a 120 -year-old mandarin orange plant was found on Rameshwor Maskey, Chhap Danda, Chyarpe field, though its origin in the village was unknown. Locally, mandarin oranges are referred to as *suntala* in this area. Discussing with groups, at first sapling of mandarin orange was imported from Malepatan Krishi Farm. Harvesting time of mandarin orange every year start from *Thulo Ekadashi* a cultural matter associated with it.

Mandarin orange farming spread out about 190-200 ha. area mostly sloppy land across the village, engaging 250-320 families. In establishing new orchards, farmers prepare pits and incorporate organic manure before planting. They used a border mixture and adopt irrigation practices. Chemical fertilizers are not common and they are facing challenges from many pests and disease such as sting bugs, fruit flies, and borers.

These are some suggestive points raised by farmers during focus group discussion.

Begnas–Bhorletar road construction triggered mandarin orange farming in Syastri and Chyarpe of Rupa Rural Municipality. It has positive impact also with establishment of secondary school in local community. Same type of story was shared from Kristi-Dopahare area. Farmers in both locations wanted to preserve local variety which is favored for its sweetness and appealing color. No any farmer on both locations ready to plant exotic variety like Unshiu and Kinno because they prefer only local variety. No any nurseries and sapling producer are there in Syastri, Chyarpe area but in Kristi-Dopahare area, two nurseries are running namely the nursery owner are Lila Dhar Paudel, Pokhara-22, Khalte and Laxmi Thapa, Pokhara-21, Ranipokhara.

Suggestion from FGD team to provide subsidies to real and needy farmers, prioritize for growing trifoliate sapling for disease free sapling, sapling should be grown from mother plant only, Training should be provided to nursery grower, support by expert team routinely observing the farm, good marketing facility, irrigation facility, develop disease resistance varieties.

Table 3. Overview of focus group discussion

S.N.	Description	Conclusion
1	FGD conducted group	2 groups
2	No. of male and female participated	30 male and 10 female
3	Year of cultivation	Since 1997 AD
4	First sapling introduced	Malepatan Krishi Farm
5	Why named *Suntala*	Mostly follow their parents
6	Evidences about *Suntala*	Festival (Thulo Ekadashi)
7	Mandarin cultivated area	90 – 100 hectare
8	Number of Household growing mandarin orange actively	250- 320
9	Variety of mandarin orange growing	Local
10	Sapling exported	Syangja, Baglung, Myagdi, Parbat, Tanahun, Lamjung, Gorkha, Palpa
11	Positive and negative impact after establishing mandarin orchard	Neighboring district (With Lamjung) connecting road developed, Secondary school established in Syastri area
12	Benefits of growing orchard	Tourist destination place developed, Home stay developed
13	Changes in same variety growing in different geographic	Size variation, taste, height of plants, leaf size, shinning of fruit, taste and juice content
14	Attribute of growing variety	Local area identity
15	Suggestion	Training for pest and disease control, Subsidies to actual farmers

Market survey

Market survey was conducted with various traders of agriculture market management committee, shanti batika, Pokhara. They are supplying/selling mandarin orange from 4-32 years ago at different location of Pokhara (Chhap Danda, Chyarpe, Syastri, Phedipatan, Bharatpokhari, Nirmalpokhari, Kristi, Dhopere) in season, off season they import mandarin orange from India in second and chinese mandarin orange in third. Because of consumer preference they sell mostly local mandarin orange from Kaski first, secondly, they sell neighboring district product from Syangja, Parbat, Myagdi, Gorkha, secondly Indian mandarin orange and thirdly Chinese mandarin orange in off season.

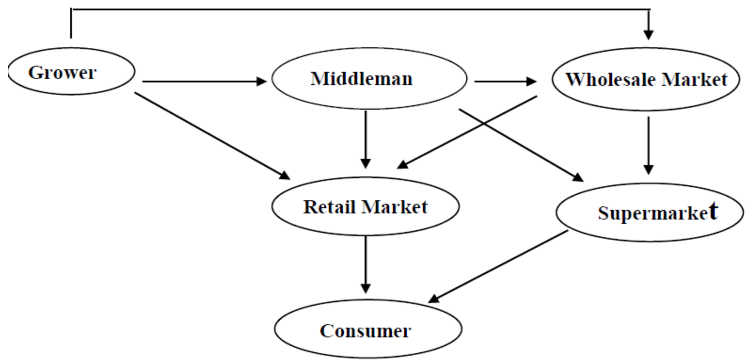

Figure 3. Traditional supply chain of mandarin orange in Kaski

All the traders concerned about attractive labelling, tagging, grading, packaging for local and distance market assurance as well as better storage life.

Table 5. Overview of market survey

S.N.	Description	Response
1	No. of respondent/ traders	6
2	Experience of selling mandarin orange	4 – 32 years
3	Most preferred location	Kaski, Parbat, Syangja, Gorkha, Myagdi
4	Variety sold	Mostly Local, Indian and Chinese
5	Prioritized location/var. for selling	Kaski, Parbat, Syangja, Gorkha
6	Price of mandarin orange	50- 80 per kg / 150-200 per kg
7	Easily sold or not	Easily
8	Distinguishing character	Local variety is tasty, sweety, juicy, thin skin and shinning
9	Market supplied	Kathmandu, Butwal, Narayanghad, Birganj
10	Storage	No need, directly sold
11	Problems	Training on post-harvest, Export start, grading, labelling and tagging
12	Suggestion	Storage facility, post-harvest training

Key informant survey (KIS)

KIS was conducted in the month of Poush 2080 with Mr. Liladhar Paudel, Chairman of District Coordination Committee (DCC), Kaski and Province level different office chief namely Mr Basudev Regmi, Director General of Directorate of Agriculture Development, Chief of Agriculture Knowledge Center (AKC) Kaski Mr. Kiran Sigdel, agriculture section chief of Pokhara Metropolitan City Mr. Manahar Kadariya and Prime Minister Agriculture Modernization Project (PMAMP) Kaski chief Mr. Roshan Adhikari concluded the cultivation of mandarin orange has been practiced before 50 years ago in Kaski and at first sapling has been introduced from Malepatan Krishi Farm Pokhara all over the district as well as other neighboring district also. mandarin orange has also value in cultural aspect like *Prasad* in *Thulo Ekadashi*, *Maghe Sankranti*. Almost all mandarin orange grower farmers around Kaski district are growing local mandarin orange. Mandarin orange cultivation practice is followed by pit digging, composting, manual weeding, irrigation, training/pruning etc. In Syastri and Chayrpe area, problems occur in declining orchards due to attacking of insects and pests and poor orchard management. Comparatively, Kristi-Dopahare area mandarin orange orchard quite seems good position as compared with Syastri Chyarpe area. Majority of the farmers used to harvest the fruits from Mangsir to Magh and directly sell to wholesaler/*thekedar*. For promoting Kaski mandarin orange, tagging should be done by the local and provincial Government with local identification. Key informant has suggested for qualitative and quantitative mandarin orange production, disease free sapling and resistance variety over climate change should be developed by the government and concerned authority.

Conclusion

It was concluded that Kaski district of Gandaki Province, mandarin orange identified as it has special characteristics of taste and with their own traditionally managed cultivation practice. In historic perspective, the cultivation was found to be initiated from early 20th century utilizing the native landraces. The identified native landrace was found to be superior in terms of sweet taste, juiciness, thin layer skin outer and inner, relatively average size and golden color than other available in the market. The demand of such landrace is also high in local market felt that conservation is must. In this context, this genotype is needed to be conserved with identical GI by Ministry of Industry, Commerce and Supplies along with related native knowledge and new invention developed over the period. The activity about exploration, registration and utilization can protect the genotype from this area ultimately promote the citrus industry of our country as well as very important genetic accession for coming generation in future.

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जालीघरभित्र हुर्काइएको सुन्तलाको माउबोट

Case Study for Geographical Indication of Mandarin (*Citrus reticulata* Blanco) in Dhankuta

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Abstract

Mandarin orange belonging to the family Rutaceae, is one of the promising fruit of Nepal, widely cultivated throughout mid-hill region. The survey was conducted in order to provide Geographical Indication (GI) of local mandarin orange, to assess the cultivation status and practices of farmers, to have an insight into the problems faced by them and to document their indigenous tradition knowledge and innovative technologies. The survey (farmer, consumer, key informant, market, focus group discussion) was conducted in Dhankuta district altitude ranging from 1,200 meters to 1500 meters above sea level. To perform the survey, a well-planned questionnaire was developed by collaborative efforts of Genebank and NCFD. Mandarin orange production in the locality was started from BS 1825 while the farmers reported that they had established their own orchards between years ranging from BS 1825 to 2070. The name '*Suntala*' was believed to exist because of the color and value resemblance to gold, while in Rai language mandarin orange is also named as *Suntolong* and *choubasi*. Mandarin orange not only holds a monetary importance among farmers but also has a cultural importance as it is used as offering in several festivals. Orange festival (*Papani*) is also celebrated in a year. Respondent had no problem in marketing however suggested the government of cold store, irrigation, price fixation policy, expert help and to develop superior variety. Khoku local is easily found in the market and was preferred by consumers for its juiciness and sweet taste and thin skin. The major problem in trade of the produce was reported to be higher commission (<7%), lack of proper packaging, labelling and tagging.

Keywords: Mandarin orange, Genetic diversity, Landrace, Geographical indication

Introduction

Nepal has a diverse climate ranging from terai to mountain region. In each 15-20 m altitude, diverse climate can be feel. Due to the diverse climate, different types of fruits are growing in different regions. Mandarin orange has occupied its space from 1000 m to 1500 m above mean sea level (Prasad & Chandra, 2019). Main mandarin orange growing districts of Nepal are

Illam, Panchthar, Terathum, Sankhuwasava, Dhankuta, Bhojpur, Sindhuli, Ramechap, Kavre, Dhanding, Parbat, Gorkha, Lamjung, Tanahun, Kaski, Shayanja, Gulmi, Arghakhanchi, Salyan, Dailekh, Dadeldhura, Baitadi and Darchula districts (Pokhrel, 2011).

Mandarin orange (*Citrus reticulata* Blanco) is a diploid fruit crop with a chromosomal count of 2n=2x=18 (Usman & Fatima . 2018) belongs to the family Rutaceae (Mudyiwa et.al., 2020). Mandarin orange is a most promising fruit crop that stands in first position of the total fruit industry in Nepal (Pun and Thakur, 2018). Since mandarin orange is a non-climacteric and perishable fruit, it cannot be kept for a long-time during transportation and storage (P.R. et al., 2016). Mandarin orange fruits can be kept hardly for 1 - 2 weeks depending upon temperature and humidity (Paudyal et al., 2015). In Nepal, the climatic condition of mid-hill region having altitude range of 800 m to 1400 m from east to west of the country are considered favorable for all types of citrus fruit cultivation (Pokhrel, 2011).

The productive area of citrus is estimated to be 27339 ha and the fresh fruit production is 274140 mt with the productivity of 10.03 mt/ha (MoALD, NCFD 2019/020). It is the most prioritized fruit crop for commercialization in mid hill/ hilly area (APROSC,1995).

Citrus, particularly the mandarin orange is the most important and highly commercial fruit crop in the hills of Nepal (Bhattarai et al., 2013). Mandarin orange contributes to augmenting food availability, improvements in nutrition, generation of employment and income and also helps in maintaining the environment (Shrestha, 2015).

Mandarin orange trees are low woody shrubs commonly measuring between 3.6 to 4.5 m in height. However, these spiny trees can sometimes grow up to 8 m tall. Mandarin orange fruits are globose to oblate in shape with a shiny skin that comes in a range of colors from green, greenish-yellow, yellow to golden. Their skin is thin, peels easily and encloses flesh that can separate into nine to fifteen wedges. The segments are covered with a very thin, edible transparent skin. The fruit's flesh is pale orange in color and juicy. Seeds, if present, are small, oblong and inedible (Albert, 2016).

Objective of the survey

Survey was conducted for providing Geographical indications (GI) (place names used to identify the origin and quality, reputation, patient right or other characteristics of products) to mandarin orange of Dhankuta district.

- To identify the origin of mandarin growing in Dhankuta District
- To collect GI related information
- To collect indigenous traditional knowledge related to mandarin orange

Methodology

This study employed a comprehensive research methodology comprising of literature review and field survey. Both primary and secondary sources were utilized as the source of information, both qualitative and quantitative information were collected.

Literature review

Extensive literature review was done to gather background information and insights on mandarin orange cultivation, market trends, and consumer preferences.

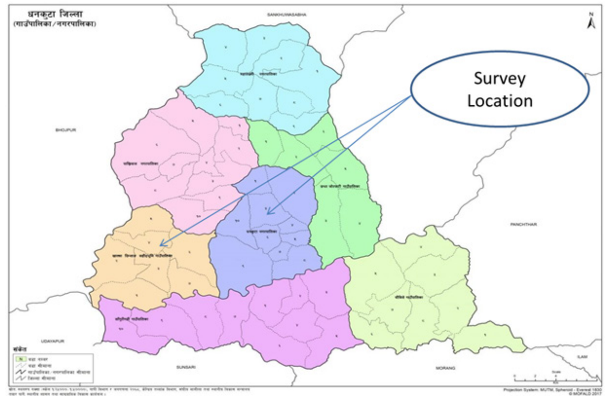

Figure 1. Survey location of Dhankuta (Sipting and Khoku Chintang)

Site selection

Before selecting the sites, detailed discussion was held in the NCFD offices representing from Department of Agriculture (DoA), Genebank, senior horticulturists from Nepal Horticulture Society (NHS). Based on the history of mandarin orange cultivation, the district Dhankuta was selected for conducting the survey. Similarly, survey sites were selected based on the discussion with Agriculture Knowledge Center (AKC) and Prime Minister Agriculture Modernization Project (PMAMP) staff considering the known history of orange farming and major pockets of area coverage. These sites were selected on the basis of production history and productivity of mandarin oranges

Questionnaire preparation

To perform the survey, a semi-structured questionnaire was developed by the team of Genebank and NCFD.

Data collection

The primary information was collected mainly through field survey, orchard visit, Key Informant Survey (KIS) and Focus Group Discussion (FGD) while secondary information was collected by reviewing of various documents, government reports and related research papers.

Farmers' household Survey: Household survey was conducted during the month of Mangsir 2080 by a combined team (NCFD & Genebank). Semi structured questionnaire was used for collection of the information from mandarin growers. Total 37 farmers were interviewed from two production sites of Dhankuta - 3 Sipting and Sahidbhumi-4, Khoku Chhintang, selected purposively with the help of key informants. The detail information about the history and practices adopted for mandarin orange farming, socio-economic status of household was discussed in interview.

Focus Group Discussion (FGD): After completion of household survey, FGD was conducted in 5 different locations with a total of 36 farmers with the help of checklist to verify the information obtained from household survey.

Also discussed about the problems and strategies to increase adoption of improved practices for madarin orange cultivation.

Key Informant Survey: This survey was done in three offices. The key informants were staff from PMAMP, Project Implementation Unit (PMAMP PIU), AKC, Dhankuta and National Citrus Research Program (NCRP) Paripatle, Dhankuta. They were asked a series of question about present scenario of madarin orange cultivation and status of orchard management.

Market survey: Market survey was done in Dhankuta, Dharan, Yale Yale (local market of Khoku Chhintang) market with 6 retailers. Retailers of the mandarin were asked about the market status of the mandarin orange that included the mandarin produced from Dhankuta area along with import from other areas, demand and supply status and consumer preference.

Consumer Survey: Five respondents were involved in the consumer survey to identify the consumer preference, taste of madarin orange and market scenario of mandarin.

Quality testing (Organoleptic and brix testing): A customized 6-point hedonic scale organoleptic evaluation sheet was prepared and replicated to test the overall perception of the quality of the madarin oranges from the study sites. Each test was conducted with 12 office staff members from the National Center for Fruit Development, NARC, members of the Nepal Horticulture Society. Similarly, the TSS content of the orange samples was measured in the field using a refractometer.

Results and discussion

The survey provides a comprehensive understanding of various aspects of madarin orange cultivation, socio-economic implications, traditional knowledge and market dynamics of study area of Dhankuta district. Table 1 illustrates an overview of the household survey.

Table 1. Cultivation practice of mandarin followed by farmers

S.N.	Description	Activities/Percentage
1	Initiation of orchard establishment	BS 1825
2	First sapling introduced	Khoku jungle named Mujure Cherpa Samudayik Ban
3	Land type	Slopy, plain, terrace
4	Land preparation	Most farmer follow primary tillage
5	Layout	Few farmer
6	Pit digging	62%
7	Compost pitting	Most farmers follow
8	Plant to plant distance	Most farmers keeping distance of 4-5 meter.
9	Varieties growing	Widely Khoku Local/ Unshiu, Murcott for testing only

S.N.	Description	Activities/Percentage
10	Sapling types (grafted, seedling)	Many farmers seedling, some grafted sapling
11	Planting month	Most in Ashadh-Shrawan month
12	Weeding method	Physical method
13	Intercropping	Some farmers are practicing with cereal crops and vegetables
14	Application of fertilizer for manuring	Many farmers are applying compost while some of them are also using chemical fertilizer NPK
15	Irrigation	Mangshir to Baisakh
16	Insect pest types and control	All farmers are facing problems and management is done insecticides and pesticides.
17	Difference between applying chemical fertilizer verses compost	Yield increased in chemical but quality deteriorate
18	Ripening time	Stars from Mangshir
19	Harvesting period	Mangshir-Falgun
20	Direct sell/ store	All farmers sell directly to *Thekedar*
21	Market	Dhankuta, Dharan, Hile, Biratnagar, Itahari, Urlabari
22	Training/ prunning	Most farmers follow training/ pruning after harvesting

Farmers' household survey

Gender participation: Farmer's Household survey was conducted with 37 farmers (29 men and 8 women) of different age groups ranging from 30 to 78 years (Figure 2) from two production sites, Khoku Chhintang and Sipting.

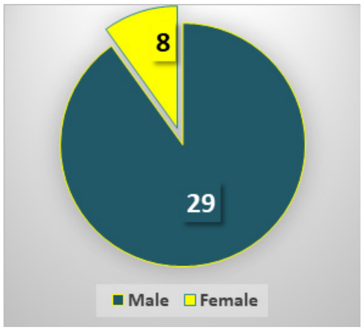

Figure 2. Gender participation in survey

General information about mandarin orange cultivation in Dhankuta: The findings reveal that mandarin orange cultivation in Dhankuta has a long history, dating back to early nineteenth century. Based on the household survey, cultivation of mandarin orange in Dhankuta district was started on BS 1825 however, farmers have initiated commercial orchard from BS 1850 onwards.

The name *Suntala* came from the fact that the color of the fruit resembles color of gold. Also, it is associated with an ancient tale that in ancient times, one of the farmers sold his gold jewellery and planted mandarin orange plants. Later on, after producing fruits he sold and bought the same amount of jewellery. Comparison with gold, the same amount of gold was later, so named SUNTOLA then the words *Suntala* formed (farmer Mitra Bahadur. Rai), looks golden colour (*Suun* in Nepali) and fruiting in different stories / floor/ layer then mandarin orange is named as *Suntala*: सुनको तला (farmer Min Bahadur Karki and Kamala Ghimire).

Almost all farmers are growing orchard in sloppy land however, some of them are growing in plain and terrace land. Majority of orchards established in mid hills, altitude ranging from 1107 to 1472 masl. Details are illustrated in Figure 3.

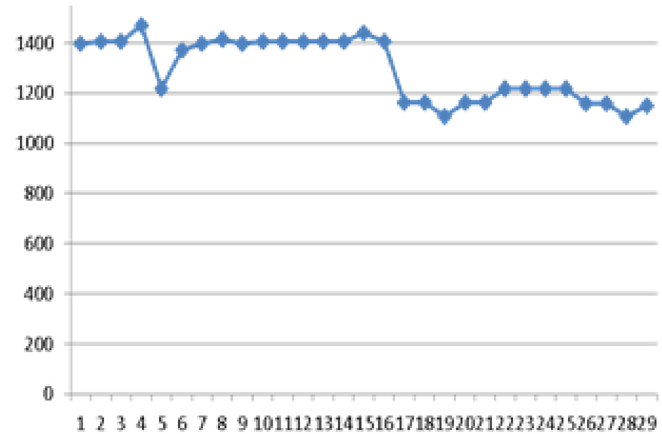

Figure 3. Mandarin orange growing altitude in Dhankuta

In the study area, farmers have 2 - 60 ropani of total land where mandarin orange has been grown in 2 to 21 ropani. Figure 4 shows the area coverage by mandarin orange where 52% area, out the total cultivated area, is covered by mandarin orange.

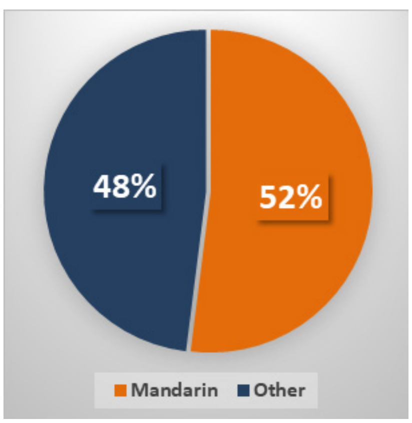

Figure 4. Area coverage of Mandarin orange in Dhankuta.

A single farmer is growing 50 to 900 mandarin orange plants in their land. According to the survey 24% farmers are growing more than 250 mandarin orange trees whereas 81% of farmers have more than 100 trees. Details are presented in figure 5.

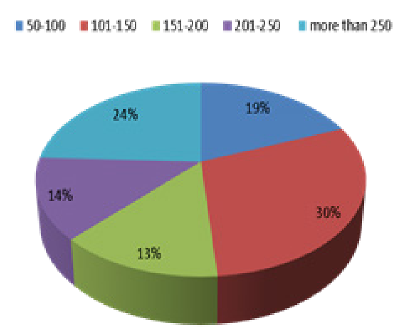

Figure 5. Percentage of farmer growing no. of mandarin orange trees

There are many citrus nurseries established by the farmers. Some of the famous nurseries are Indra Falful Nursery, Katuwal Niji Nursery, Ghimire Nursery, Khusi Falful Nursery, Khadka Integrated Nursery, Devaka Nursery etc. Sapling of Khoku local mandarin orange is sold to other districts where mandarin oranges are growing especially sapling are exported to Ramechhap, Sindhuli, Kavrepalanchowk, Taplejung, Panchthar, Bhojpur, Sankhuwasava, Gorkha, Dhading, Dailekh, Salyan district.

Cultivation practices of mandarin orange in Dhankuta

Planting method: The plantation of mandarin orange was mainly done in the month of Ashadh-Shrawan. The planting method adopted by farmers are presented in figure 6. It shows that majority (62%) of the farmer are planted mandarin orange saplings without digging pit. They are also not applying any fertilizers before plantation. Only 30% of farmer has prepared 1 m3 pit for planting sapling and also applied fertilizer of about 50 kg/pit. Remaining 8% of farmer has practice of digging pit size up to 0.5 m3. The planting distance adopted by farmers are up to 4-5 m.

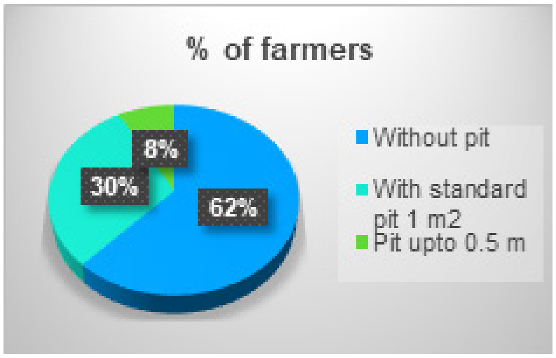

Figure 6. Planting method applied by farmers

Farmers were predominantly growing the Khoku local variety, known for its high juice content, sweetness, and thin skin. However, some farmers are experimenting with other varieties like Kinnow, Murcott and Unshiu. Most of the farmer are using seedlings and few are grafted saplings. In Khoku, the sapling was developed from the old plant which was grown by their ancestors and Sipting farmers have brought the sapling from Khoku-Chhintang and NCRP Paripatle.

Weed management in orchard was done by hand weeding and slashing the weeds by sickle. Farmers were practicing inter-cropping with leafy vegetables, cauliflower, cowpea, finger millet, ginger, turmeric, maize in orchard. Respondents mentioned that the height of the mandarin orange tree reached up to 4 to 8 m.

Most of the farmers applied 60 – 90 kg of compost per tree. Very few farmers have applied chemical fertilizer by mixing NPK in nominal amount followed by irrigation from the month of Mangsir to Baishakh. According to respondents, chemical fertilizer has increased production volume but deteriorates fruit quality. Fruits are more juicy, tasty, shiny and sweeter on FYM/ compost used orchard.

Farmers have faced problems of different insect pest (citrus bug, aphid, scale insects, leaf miner, citrus psylla, fruit fly) and diseases (Powdery mildew, citrus decline etc.) and managed by applying different insecticides and fungicides available in local market.

Generally ripening of fruits starts from Mangsir. Use of bamboo ladder, jute sack and bamboo basket (*Doko)* for harvesting fruit, use of ash for neutralizing the soil pH, *Doko* used for transportation are some of the indigenous traditional knowledge practiced by farmers.

Farmers are getting yield from 80 - 160 kg per tree both from seedling as well as grafted plant. The quality (taste, juice content, sweetness) and quantity in yield also differ based on different geography of orchard. They sell mandarin orange directly from orchard (*Thekka*) to wholesalers/ collectors and start harvesting from Poush to Falgun depending on altitude.

Mandarin orange cultivation has brought socio-economic benefits to the community, contributing to increased income, social cohesion, and agricultural development. Furthermore, mandarin orange cultivation has attracted tourists during the harvest season, stimulating local economies and promoting cultural exchange.

Due to lack of cold storage, farmers have to sell mandarin orange to wholesalers. Some of the farmers have practiced mandarin orange storage in tree, leaving fruits in the tree for 1-2 months for storage. Mandarin orange is easily sold in the markets of Dhankuta, Biratnagar, Dharan, Itahari etc.

Suggestion from farmers

- Regular field visit (every month) by expert team,
- Provide subsidies to mandarin orange farmers for orchard establishment, irrigation, post-harvest handling
- Train farmers on orchard management as well as nursery owner to grow healthy sapling,
- Cold store facility
- Develop disease resistant varieties adaptable to climate change.
- Price determination should be done by government
- Provide identity to Khoku local mandarin orange

Focus group discussion

In Mangsir 2080, Focus group discussion (FGD) was conducted in two locations (Khoku-Chhintang, and Sipting). Total 36 farmers (Men 28 and women 8) were participated in discussion (Figure 7). Table 2 shows an overview of FGD.

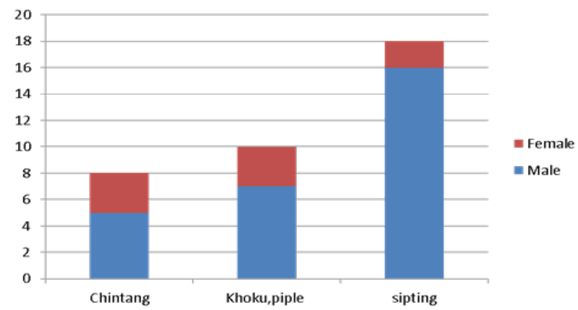

Figure 7. Gender participation in FGD

Table 2: An overview of Focus group discussion

S.N.	Description	Conclusion
1	FGD conducted group	5 groups
2	No. of male and female participated	28 men/ 8 women
3	Year of cultivation	Since 1825 AD
4	First sapling introduced	Khoku jungle named Mujure Cherpa Samudayik Ban
5	Why named *suntala*	Resembling golden and compare with gold
6	Evidences about *suntala*	Song and papani festival
7	Land covered by mandarin orange	2000 ropani
8	Household growing mandarin actively	350- 400

S.N.	Description	Conclusion
9	Variety growing	Khoku Local, Murcott, Unshiu
10	Sapling exported	Ramechhap, Sindhuli, Kavrepalanchowk, Dhading, Gorkha, Taplejung, Sankhuwasabha, Dailekh, Salyan, Kailali, etc.
11	Indegenous traditional knowledge applied	Ash, weeding, interculture, irrigation, training/ prunning, bamboo ladder, sack
12	Positive and negative impact after establishing orchard	PMAMP declared pocket area, agriculture road developed
13	Benefits of growing orchard	Awarded by government, tourist visit Dhankuta in mandarin orange season
14	Changes in same variety growing in different geographic	Differs in size, taste, height of plants, leaf size, shinning of fruit, juice content
15	Attribute of growing variety	Provide identity
16	Suggestion	Subsidies to actual farmers, priortize for growing trifoliate sapling for disease free sapling growing, train farmers

From the group discussion, following facts about cultivation of mandarin orange were visualized:

- Mandarin orange cultivation was practiced from 1825 BS
- The seedling of mandarin orange was first-time introduced from Khoku jungle, named Mujure Cherpa Samudayik Ban and later on NCRP Paripatle has supported in distributing seedling/sapling.
- Daan Bahadur Rai has the oldest mandarin orange tree in Khoku-Chhintang and Indra Bdr Rai and Netra Ghimire in Sipting.
- Songs are also added by the name of mandarin orange and youths use to entertain by singing in *dohori* song in different activities,
- Mandarin orange has a cultural value since time immoral in different occasions like Ekadashi, Maghe-sankranti, Papani festival, Nwagi, Satyanarayan Puja etc.
- Active orchard growing farmers were 350-400 and have cultivated mandarin orange in 800-2000 ropani. Mandarin orange cultivated lands were mostly sloppy land.
- Most of the farmers are growing Khoku local mandarin orange due to high juice content, thinner rind, sweeter taste and shiny.
- Farmers were facing the problem of insect pests and diseases such as citrus bug, aphid, scale insects, leaf miner, fruit fly, powdery mildew, citrus psylla, greening, CTV etc and managed them by applying different insecticides and fungicides available in the local market.
- Citrus Nurseries are also established in the study field. Sapling of Khoku local mandarin orange is exported to other districts.

- Due to differences in geography, there is a difference in size, taste, plant height, leaf size, shining of fruit even in the same variety of mandarin orange.
- Mandarin orange fruit starts ripening from Kartik but harvesting starts from the month of Mangsir to Magh. Most of the farmers used to sell their fruits to traders (whole orchard selling). Due to lack of cold storage facility, nobody stores the fruits but some of the farmers have practiced storage for 1-2 months leaving the fruits in trees. Almost all farmers are following indigenous technology for pit digging, application of compost fertilizer, irrigation and training/pruning.
- Mandarin orange cultivation has provided the positive impact in orchard growing area like farmers have become socially economically and technically sound, income of farmers has also been increased, development of agriculture road in every village so that farmers can sell their products from their own farm, internal and external tourist use to visit in mandarin orange season, PMAMP has been implementing focused program (Citrus Zone) for mandarin orange production. Also, different prizes and awards are provided by government to the orchard growers.
- Subsidies to actual farmers, production of grafted sapling by using trifoliate rootstocks, selection of healthy mother plant for disease free sapling, training to nursery grower, regular field visit from expert team, irrigation facility, good marketing facility, development of disease resistance varieties are the main suggestion provided by the FGD teams. The FGD team also felt the positive impact while discussing the geographic indication to the Khoku local mandarin

Key informant survey (KIS)

KIS was conducted in the month of Mangsir 2080 with three key informants (PMAMP Dhankuta-1, NCRP Paripatle/NARC-1 and AKC Dhankuta-1). According to them, cultivation of mandarin orange has been practiced before 200 years ago in Dhankuta and at first sapling has been introduced from Khoku-Chhintang to all over the district. Major mandarin orange growing areas in the district are Khoku, Bodhe, Chha Number Budhabare, Muga, Budhi Morang, Paripatle, Dandabajar, Mudhe Bas, Sukrabare, Chhintang, Aankhisalla, Chunbang, Sahidbhumi, Sipting etc. Resembling the color of gold, mandarin orange has been named as *Suntala*, songs related with mandarin orange used to sing by local people in different occasions like "**खाउँ त भने अमिलो सुन्तला, अमिलो सुन्तला, नखाउँ भने दुवैको ज्यान जाला, नरोउ मायालु**" …… Mandarin orange has also cultural value like *Prasad* in Ekadashi, Maghe-sankranti, Nwagi etc. Rai community also used to make wine for their festival Papani. Around 350 farmers are growing Khoku Local mandarin orange orange however some farmers also are growing Unshiu (Japanese variety) for testing only.

Cultivation practice followed by farmers were pit digging, composting, weeding by physical method, irrigation and some training/pruning. Problems faced were declining orchards due to insect pests and diseases, no cold storage facilities for storage of harvested fruits. Most of the farmers start harvesting fruits from Mangsir and goes up to Magh. They directly sell to collectors (*Thekdar*)/wholesaler/traders.

Depending on size of orchard (number of plants), farmers have got an income ranging from 4-20 lakhs in a year. Due to varying geographic condition, there is a difference in plant vigor (plant height) as well as quality and quantity of fruits such as size, taste, shining of fruits, color, juice content etc. even in the same varieties.

According to the key informants, farmers are supported through training, subsidy for area expansion, irrigation, quality saplings, output based incentives. PMAMP has implemented mandarin orange zone programs. Also, different prizes and awards were provided by government to orchard growers. Tagging with local identification is good for the promotion of the Dhankuta mandarin orange, however they suggested first for promotion of production volume (quantity) as well as fruit quality, production of disease-free sapling and resistance variety for which concerned governmental institutes should worked on these issues.

Consumer survey

Consumer survey was conducted with five people (Men-2 and Women-3) of different age groups. Table 3 shows the summary of consumer survey.

Table 3: An overview of Consumer survey

S.N.	Description	Response
1	No. of Respondent	5
2	Access of getting mandarin orange in market	Yes
3	Price of mandarin orange (season and off season)	Rs 60-90 and 150 per kg
4	Choice of Variety in market	Khoku local
5	Location of growing	Khoku, Chhintang
6	Qualitative characters of choosing	Sweet, juicy, tasty, skin layer
7	Time of availability of mandarin orange	Mangshir-Falgun
8	Problems	Low price in local market
9	Suggestions	Grading, storage, free sapling

According to the respondents, Khoku Local mandarin orange is easily available in the market of Dhankuta in Rs 60 - 120 per kg in season and 100 - 160 per kg in off season depending on different months. Generally, Khoku local mandarin orange occupied the market in season but in off season Indian and Chinese mandarin orange also get some space for few months, Due to sweet taste, high juice content, shiny, thin skin, appropriate size consumer prefer Khoku local mandarin orange than other varieties, The preference of Indian mandarin orange lies next to Nepali mandarin orange.

In comparison with Indian and Chinese mandarin orange, Nepali mandarin orange is sweet, juicy, shining, thin layer of skin, size is also on average from Khoku Chhintang region. Their family members also prefer Khoku local mandarin orange. Respondents suggested for traders that they should provide mandarin orange after main season also by storing them in cold storage; however, they feel the unavailability of storage facilities and suggested the government for infrastructure development. They have declared that the main cause of mandarin orange declining problem is due to various insect pest attacks, therefore the government, researcher and related technicians should pay more attention to solve the problem of citrus declining.

Market survey

Market survey was conducted with six traders/retailers of Dhankuta market. There is different marketing channel practiced (Figure 8) for mandarin orange. Table 4 shows an overview of market survey.

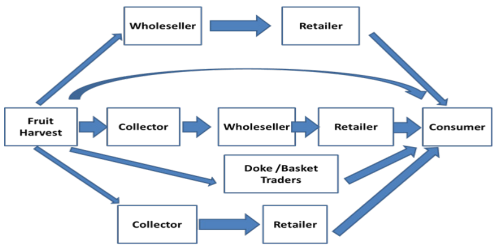

Figure 8. Market channel of mandarin orange in Dhankuta

Table 4: An overview of Market survey

S.N.	Description	Response
1	No. of respondent/ traders	6
2	Experience of selling mandarin	5 – 20 years
3	Most preferred location	Khoku Chhintang
4	Variety sold	Mostly Khoku Local, Indian and Chinese
5	Priortized location/var. for selling	Khoku Local from Chhintang
6	Price of mandarin	60- 80 per kg / 160 per kg
7	Easily sold or not	Easily
8	Distinguishing character	Khoku Local is tasty, sweety, juicy, thin layer skin and shinning like golden in comparision with others
9	Market supplied	Dhankuta, Dharan, Itahari, Biratnagar, Urlabari, Birtamod
10	Storage	No storage, fruits are directly sold to market
11	Problems	7% commission to wholeseller,grading, labelling
12	Suggestion	Avoid commission, storage facility

According to retailers, they are selling mandarin orange from 5-20 years to different location of Dhankuta (Kagate, Seule, Sipting, Patle, Paripatle). Because of consumer preference, they sell Khoku Local mandarin orange from Chhintang first rather than other areas of Dhankuta. Secondly, they sell Indian mandarin orange and thirdly Chinese mandarin orange in off-season.

Traders used to sell mandarin orange fruit at the rate of 60-80 NPR per kg in season and in off season it goes up to 160 per kg. Mostly business of Dhankuta mandarin orange remains seasonal. According to them, Dhankuta mandarin orange can be distinguished by taste, sweetness, juicy, thin skin and gold shining. Dhankuta mandarin orange has also occupied the space in other market (Dharan, Itahari, Biratnagar, Birtamod, Urlabari). Due to lack of cold storage, all of the mandarin orange used to sell in season and they are selling mandarin orange from 50 kg - 2 ton per day and earning up to Rs. 130000.

Khoku Local is more in demand due to large size, sweet, juicy, thin and shiny skin. Local mandarin orange can be purchased only for 4 months (Mangsir-Falgun). During discussion, tagging fruit with proper identification of Dhankuta mandarin orange, it would be better for fetching good price as consumers know the product. Main problems in trading mandarin orange are commission (commission 7% to wholesaler) and minimum post-harvest practices such as grading, labeling and packaging. They have suggested for provision of low commission rate as well as cold storage facility from concerned stakeholder.

The market efficiency can be enhanced through promotion of fair-trade practices, stakeholders must explore strategies to streamline supply chains, improve market infrastructure and empower small-scale producers and traders. It is also necessary to explore large area for marketing for better prices and fair competition. This can only be achieved if proper introduction of landrace to the consumer is made.

Evidences for Geographical Indication (GI)

- The crop has deep-rooted cultural significance in the region. In Rai language mandarin orange is named as *Suntolong* and *Choubasi*,
- Rai people use to celebrate different types of festival adding the importance of mandarin orange like *Thuloekadashi, Mangsir purnima, Maghe sankranti*, Satyanarayan puja, Shreepanchami, Udhauli, Uvauli, Nwagi etc.
- Songs: Local *Dohori*, "खाउँ त भने अमिलो सुन्तला, अमिलो सुन्तला,
  नखाउँ भने दुवैको ज्यान जाला, नरोउ मायालु" ……
- Festival: *Papani, Thulo-ekadashi*
- Sapling introduced: from Khoku Jungle (Mujure Cherpa Samudayik Ban)
- Naming of mandarin orange: Resembling gold, fruiting in different stories, comparison with gold.
- Chinese travelers: 2000 years ago, tale golden fruit.
- Bantawa Rai community introduced from Khoku jungle.
- Qualitative and Quantitative characters: average size, shape, thin skin layer, shiny, juiciness, sweetness.

By analyzing the various aspects of mandarin orange, genotypic qualities, cultural value, socio-economic benefits and the consumer preferences, the landrace can be considered a valuable and potential genetic resource which can govern the citrus sector of the country. This can be achieved through immediate action of conservation, declare origin and GI registration process by the concerned authority.

Conclusion

The mandarin orange cultivated in the Dhankuta was found to have superior characteristics of taste and with locally managed cultivation practice. The cultivation was initiated from early nineteenth century utilizing the locally available landraces which was introduced from Khoku jungle (Mujure Cherpa Samudayik Ban). The Khoku Local landrace was found to be superior than any of the Indian and Chinese variety available in market with distinguishing characteristics of sweet taste, juiciness, thin skin layer, relatively average size and resembles gold shiny appearance. Despite facing challenges such as insect pests and decline, mandarin orange cultivation has brought socio-economic benefits to the community, contributing to increased income, social cohesion, and agricultural development. The demand of fruit is also high in local market. Being the landrace with high potential of superior genetic resource, this genotype needs to conserved with proper GI by concerned authority with related traditional knowledge and new innovation developed over the period.

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Case Study of Mandarin Orange in Parbat District

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Abstract

Mandarin orange (*Citrus reticulata* Blanco) is an importance fruit crop of subtropical mid-hills of Nepal. Among subtropical region, Parbat district specially Banskharka is popular area for mandarin orange cultivation due to favorable micro-climate condition for mandarin orange. mandarin orange cultivation in Banskharka plays a crucial role in the local economy and livelihoods due to favorable agro-climatic conditions and traditional farming expertise. However, mandarin orange cultivation and its historical evidence in Banskharka Parbat was not studied yet. So, in this study, scientific evidence of the longstanding cultivation of mandarin orange in Banskharka, Parbat district, with the goal of supporting the geographical indication (GI) designation for mandarin orange orange in this region was collected. Utilizing multi-method approach, including literature review, farmer's household survey, market survey, consumer survey, key informant survey (KIS), and focus group discussions, data were collected and analyzed using Microsoft Excel. Passport data documenting distinctive characteristics of mandarin orange trees from Banskharka, Parbat was also recorded. Oldest (over 100 years) as well as newly commercially established mandarin orange orchard were found in Banskharka Parbat, native variety seedling were brought from Directorate of Agricultural Research, Gandaki Province. Kushma Parbat, Pokhara, and Kathmandu are the main wholesaler as well as retailer market for oranges of these areas. Two different landrace Banskharka local and kamala which were grown since years ago. Mandarin of Banskharka Parbat were popular as a late variety with highly juiciness, and sweet taste, boasting an average brix content of 11.7±0.4 on Banskharka local and 14.6±0.3 on Kamala.

Keywords: Mandarin orange, Parbat, Banskharka local, Kamala

Introduction

Among the various types of fruits cultivated in the subtropical mid-hills of Nepal, mandarin oranges are the most dominant and widely grown. According to data of 2022/23 total area of citrus is 49469 ha., productive area 33554.2 ha., production 317910 mt. with productivity of 9.48 mt./ha. in which mandarin orange total area of cultivation 28451 ha. productive area 19897 ha. production 199195 mt., total productivity 10.01 mt./ha. Among the 77 districts, 65 districts cultivate mandarin orange and 48 districts commercially cultivate mandarin orange. Further, this is a high-value commodity with strong demand in domestic and international markets. (NCFD, 2021) However, the citrus production is not sufficient and satisfactory to meet the demand of the country (Dahal et al., 2020). In Nepal, citrus is grown at 800- 1400 meter above mean sea level. Citrus get most favorable climatic condition in the eastern and western mid hills of Nepal with annual mean temperature 17-20 degree Celsius and annual rainfall ranging from 1000-2800 mm (Srivastava and Singh, 2002). There is high potential of mandarin orange cultivation in mid hills of Nepal. Major mandarin orange producing areas are Myagdi, Parbat, Baglung, Syangja, Gorkha, Solukhumbu and Lamjung and so on. Orchard management is the major factor to enhance the total production of mandarin orange (Banerjee et al., 2008) Parbat district is also well known for commercial production of high-quality mandarin oranges due to climatic suitability, soil conditions and market demand. It covers 827 hectares of land in the district with annual production of 4290 metric tons and productivity of 9.92 mt. per hectare (MoALD, 2022) which is still less than the national mean productivity. Mandarin orange has high nutritional value, including vitamin C, sugars, organic acids, fiber, phenols, and other nutrients, making them widely consumed as fresh fruit. (Gautam and Bhattarai, 2006).

Geographical Indication (GI) protection presents a valuable opportunity to preserve the reputation and integrity of mandarin orange grown in Parbat, ensuring fair recognition and enhancing market value for local producers. By linking the product to its geographical origin and unique characteristics, GI status can prevent the misuse and unauthorized use of the Parbat name, thereby safeguarding the interests of both farmers and consumers. As such more than 100 agricultural products have potential for geographical indication (GI) tag in Nepal (Joshi et al. 2017). Currently, there is a policy provision for GI, and the Ministry of Industry, Commerce and Supplies is still in the process of developing its legal registration system (Joshi et al., 2017).

Manakamana local, Banskharka local and Khoku are some prominent juicy landraces of oranges in Nepal with high market values. This paper focuses mainly on the study and collection of primary data thereby accelerating the efforts that is needed to document and preserve traditional knowledge, heritage varieties, and farming practices associated with orange pocket areas in Parbat district of Nepal. Mandarin orange cultivation in Banskharka significantly contributes to the local economy and livelihoods due to favorable agro-climatic conditions and traditional farming expertise. However, the historical evidence of mandarin orange cultivation in Banskharka, Parbat has not been studied yet. In this study, we collected scientific evidence of the longstanding cultivation of mandarin oranges in Banskharka, Parbat district, aiming to support the geographical indication (GI) designation for oranges in this region.

Methodology

The study was carried out in the mid hills of Gandaki province Banskharka which lies in Jaljala Rural Municipality of Parbat district.

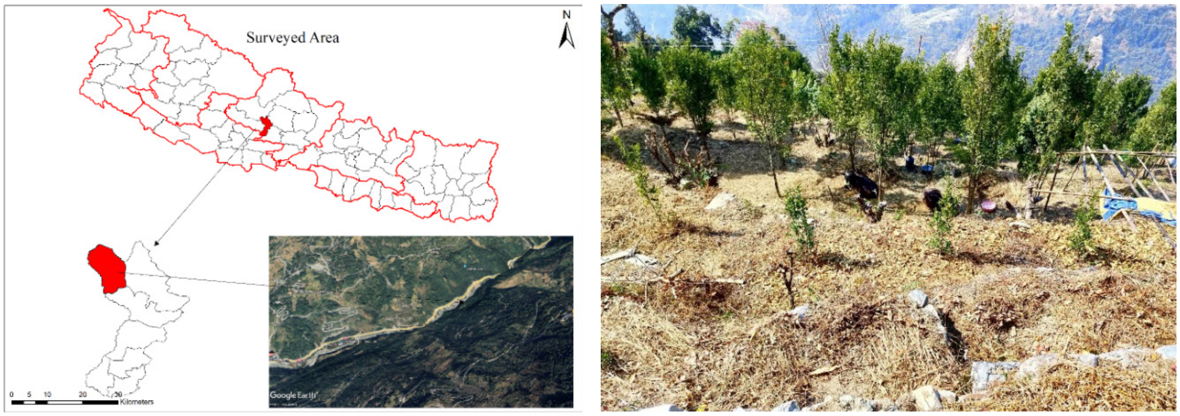

Figure 1. Surveyed site Banskharka, Parbat

Data collection

Household survey

The detail information about the socio-economic status, recommended practices adopted, household information was discussed in interview schedule. 44 respondent farmers were involved in household survey. The interview schedule was used to collect the information from the selected purposively farmers of mandarin orange zone.

Focus group discussion

One Focus group (23 males and 3 females) discussion was conducted at the study area after completing interview schedule with the help of checklist to verify the information obtained from household survey and discussed about the strategies to increase adoption of improved practices in mandarin orange zone area.

Market survey

Five respondents were involved in the market survey. Traders of the mandarin orange were asked about the market status of the overall mandrin orange that included the mandarin orange produced from Banskharka area along with other areas their demand supply status and consumer preference.

Key informant interview

The major key informants were farmers, and Agriculture Knowledge Center, Prime Minister Agriculture Modernization Project, Project Implementation Unit (PMAMP PIU). They were asked a series of question about present scenario of mandarin orange cultivation and status of orchard management in Banskharka.

Consumer survey

Five respondents were involved in the consumer survey. A survey was carried out with the consumer who consumed mandarin orange in the Banskharka area. Data collected was analyzed by using MS Excel 365.

Result and discussion

Male and female respondent

Among the respondent 88.46% were male and 11.54% were female (Figure 2). More than 34% land were cultivated mandarin orange (Figure 3). 100% of the land was sloppy land.

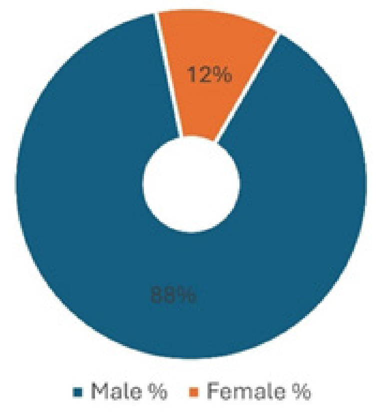

Figure 2. Male and Female percentage of respondent

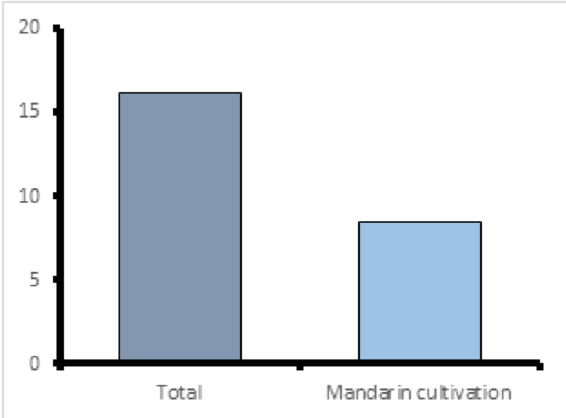

Figure 3. Average land (ropani) of respondent and average mandarin orange cultivated land

Survey study found that the mandarin orange cultivation started in around BS 2000 to BS 2010. Though the mandarin orange cultivation started in 2000 to 2010 the commercial cultivation starts after BS 2050 (1993 AD). There was no specific way how the name *Suntala* was given to mandarin orange. All of the respondent replied that the name *Suntala* was heard from other. All the respondent said that they were cultivating local mandarin orange and the cultivation was done in the terraces land.

The result showed that all the respondent satisfied on local type of mandarin orange. The local type mandarin orange is best where, 84.62 percent of the respondent used seedling form local and 15.38 percent of the respondent planting grafted seedling brought from Directorate of Agricultural Research, Gandaki Province (DoAR) Lumle. Year of plantation ranges from BS 2015-2070. Average height of the trees was found to be 4.5 meter. Most of the trees were found to be 5 meters. Fruit trees started to bear fruit from the year range BS 2021 to 2075. 100% of the respondent farmer dug pit before planting the plants. Some of the farmers even burn their pits by using the dead leaves and others.

The depth of the pit was also not uniform (1-3 feet). The average distance between 2 pit was found 3.5 meter. Majority of the farmer cultivate seedling from the seed. All the farmers transplant sapling during Ashadh to Shrawan for easy establishment of the plant as they get the water from rain. The study showed that the average application of compost is more in established orchard than before plantation. Farmers use at most 50 kg per plant manure to minimum of 15 kg per plant. On an average 37kg of manure per plant is used by the farmers. Only one third of the farmers used other fertilizer than manure. Especially use of Urea was found to be dominant along with DAP. Very few respondents (11.9%) used potash and other micro nutrient in their orchard. Around 70 % of respondent have irrigation facility and nearly 30 percent of the farmers had no irrigation facilities and they do not irrigate their field. Mainly manually (90%) weeding and only 10% respondent were using grass cutting for weeding. Only 14% of respondents were intercropping with leguminous crop in mandarin orange orchard. Very few farmers also cultivated millet as intercrops. Farmer had no experience in difference in taste while using chemical or organic fertilizer. Most of respondents (65%) were facing fruit fly insect pest problem and managed as per recommendation of AKC Parbat, PMAMP PIU and DoAR Lumle. Yearly they use Bordeaux mixture for fungal disease management.

Fruit starts to ripe from Poush and harvesting from Poush-Magh to Falgun. Farmer were directly selling to the dealer and not using cold store for storing mandarin orange. Fruit is mainly taken to Pokhara which is about 100 km from Banskharka. Some number of fruits are marketed to Beni and Kushma the district headquarters of Myagdi and Parbat district. There is no problem in marketing. One of the farmers reported the use cow dung for gummosis disease control.

74% of the respondent did not know about the origin and one of the respondents reported that the seedling might have been brought from forest. Some said seedling were brought form Lumle. Farmers have no idea on how the name *Suntala* was given to mandarin orange.

The respondent (100 %) claimed that the mandarin orange fruit of their place is juicier, sweeter and have loose skin, shinier and is a late variety than that of another place. It is found that diversity of mandarin orange in their orchard is Banskharka local and *Kamala* (*Kamala* is one of the landraces named by farmer). People of the Banskharka said the best mandarin orange is their local mandarin orange which is commonly known and Banskharka local mandarin orange and most of the respondents like *Kamala* landrace because this is relatively late ripening. Similarly, it was found that relatively higher TSS 14.6±0.3 Brix on *Kamala* landrace and 11.7±0.4 on Banskharka local. *Kamala* was higher shining than the Banskharka local (Figure 4).

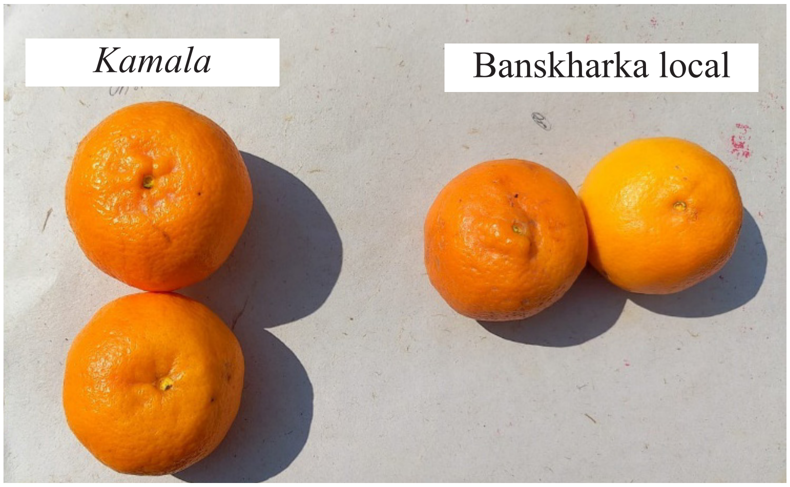

Figure 4. *Kamala* and Banskharka local mandarin orange

The major problem for mandarin orange production in the Banskharka area is the road, which affects marketing facilities. A total of 88.46% of the farmers stated that road improvements are necessary to increase mandarin orange production in Banskharka. Similarly, 46.15% of respondents face the problem of irrigation and (11.53%) need more grant and government support.

Market survey

Main source of income of Banskharka, Parbat was mandarin orange. Mostly the mandarin orange sold in Kusma and Pokhara. The season of harvest is late Magh so the price of the mandarin orange is nearly to the double the price (150 to 250 farm gate price) in the normal season. Till now there have been no marketing challenges as most of the farmers, almost all farmers directly sell mandarin orange to the contractors. Demand of Banskharka mandarin orange is higher and supply was less. However, problems was found on packaging and transport. Good packing and packaging facilities, along with strengthening the linkage between farmers and buyers, will contribute to significant economic growth and sustainable improvements in livelihoods. (Mare, 2008). Retailers and wholesalers highlighted the superior taste, size and shine of mandarin orange from Banskharka. The local market also relies on external sources also they import mandarin orange during off season generally before the start of the season and at the end of the season.

Consumer survey

The mandarin orange of Banskharka has a very good shine, large shape and sweet taste, harvest at the late season when all the orange is finished from other place. Consumer mostly prefer local variety of the orange. Since the mandarin orange of the Banskharka is sweet and most preferable by the consumer, other area producing mandarin orange sell their mandarin orange in the name of Banskharka. So, tagging will be best to prevent other places to sell mandarin orange in the name of Banskharka.

Key Informant Survey (KIS)

Key informant survey found that the mandarin orange was grown in the area since BS 2000. About 213.5 ha area is under the mandarin orange cultivation in Banskharka. Mostly local variety of mandarin orange Banskharka local and *Kamala* are grown. Almost 95% of the farmers grown plants are from seed. The major problem in marketing of the mandarin orange is road. It is just 9 kilometer away from the main highway but not connect with good road and irrigation was also the major problem.

Focus Group Discussions (FGDs)

The focus group discussion took place in Bajarmare *Suntala* Utpadan Krishi Sahakari Sanstha which is located in Banskharka village of Jaljala Rural Municipality of Parbat district involving 26 farmers, comprising 23 males and 3 females. During the discussion, it was noted that a 100-year-old mandarin orange orange plant though its origins in the village was unknown. Locally, mandarin oranges are referred to as "*Suntala*," a term passed down through generations. There are no specific cultures related to suntal such as poems, songs, or festivals.

Suntala cultivation spans 213.5 ha. of sloping land across the village. In Bajarmare *Suntala* Utpadan Krishi Sahakari Sanstha is one of the important cooperatives dedicated to its cultivation. Local people receive different grants through cooperative. Agriculture Knowledge Center and PMAMP PIU distribute their grants through this cooperative. The mandarin oranges of the Banskharka orchards are relatively late to bear fruit compared to neighboring orchards and mostly harvested during the month of Falgun.

Almost all the farmers while establishing new orchards, dig pits and incorporate organic manure before planting. They use a border mixture and adopt irrigation practices. Chemical fertilizers are utilized by some of the farmers but they are not so popular. Major pests are fruit fly in co-operation with AKC, DoAR Lumle and PMAMP farmers are taught the control measure of the pest. They collect the fallen fruit in the plastic bag and safely dispose them. They even practice good sanitation in the field.

Harvesting typically occurs from the last week of Magh to the last week of Falgun, with produce sold directly to the contractor without storage. Farmers have a great desire for government recognition through a Geographical Indication (GI), which would enhance market value and recognition for their product.

Table 1. Overview of focus group discussion

S.N.	Description	Conclusion
1	FGD conducted group	1 group
2	No. of male and female participated	90.5% male and 9.5% female
3	Year of cultivation	Since BS 2000
4	First sapling introduced	Directorate of Agricultural Research, Gandaki Province
5	Why named *Suntala*	Mostly follow their parents
6	Evidences about *Suntala*	Festival (Thulo Ekadashi)
7	Land covered by mandarin orange	4200 ropani
8	Household growing mandarin orange actively	44
9	Variety growing	Local
10	Sapling exported	Baglung, Parbat, Myagdi
11	Positive and negative impact after establishing orchard	Bashkharka local variety registration
12	Benefits of growing orchard	Tourist destination place developed, home stay developed
13	Changes in same variety growing in different geography	Farmer have no Information
14	Attribute of growing variety	Local area identity
15	Suggestion	Training for pest and disease control, Subsidies to actual farmers

Table 2. Overview of farm household survey

S.N.	Description	Activities/Percentage
1	Initial orchard establishment	2033 BS
2	First sapling introduced	Directorate of Agricultural Research, Gandaki Province and Malepatan Krishi Farm
3	Land type	100% sloppy
4	Land preparation	Digging pit, fire on pit and putting fertilizer
5	Lay out	100 % farmer follow standard layout
6	Pit digging	100 % farmer follow standard layout
7	Compost pitting	37.62±2.95 kg compost per pit
8	Plant to plant distance	4.56±0.17 m
9	Varieties growing	Mostly local (*Raithane*)
10	Sapling types (grafted, seedling)	84.62 % farmer practice seedling and 15.38% farmer plant grafted sapling
11	Planting month	Ashadh-shrawan month
12	Weeding method	Manually
13	Mulching	Most farmers (100%) are practicing organic mulching and green manuring
14	Intercropping	Only 21.43% farmer practice intercropping with cereal crop and vegetable crop
15	Application of fertilizer for manuring	100% farmer composting and applying chemical fertilizer
16	Irrigation	70% farmer irrigated on Magh to Jestha
17	Insect pest types and control	All farmers are facing problems of insect pest and management is done based on chemical and IPM approach with technical support of DoAR, Gandaki Province and AKC Parbat
18	Difference between applying chemical fertilizer Vs compost	Yield increased with chemical, quality enhance with composting
19	Ripening time	Stars from Poush till Falgun
20	Harvesting period	Magh – Falgun
21	Direct sell/ store	Retailers and wholesalers
22	Market	Kusma, Baglung, Myagdi, Pokhara, and Kathmandu
23	Training/ pruning	Most farmers follow training/ pruning after harvesting
24	Average fruit no./plant	674±39.12
25	Average plant no./farmer	391±260

Consumer survey

Table 3. Overview of consumer survey

S.N.	Description	Response
1	No. of Respondent	5
2	Access of getting mandarin in market	Yes
3	Price of mandarin (season and off season)	Rs 100-300 and 150-300/kg
4	Choice of variety in market	Banskharka Local
5	Location of growing	Kaski, Syangja, Myagdi, Gorkha, Parbat
6	Qualitative characters of choosing	Sweet, juicy, tasty, skin layer
7	Time of availability of mandarin	Late variety available from last week of poush to Falgun
8	Problems	Transport problem cause decline in quality of mandarine
9	Suggestions	Transport facility, Training to farmers, Grading, storage

Table 4. Overview of market survey

S.N.	Description	Response
1	No. of respondent/ traders	5
2	Experience of selling mandarin	2 – 13 years
3	Most preferred location	Parbat, Kaski, Myagdi
4	Variety sold	Mostly local, Indian and Chinese
5	Prioritized location/var. for selling	Parbat, Kaski, Myagdi, Syangja, Gorkha
6	Price of mandarin orange	150-250 per kg (Banskharka local)
7	Easily sold or not	Easily (High demand less supply)
8	Distinguishing character	Local variety is tasty, sweety, juicy, thin skin and shinning
9	Market supplied	Pokhara, Kathmandu
10	Storage	Not in practice, directly sold
11	Problems	Training on post-harvest, proper grading, label-ling and tagging for export market
12	Suggestion	Storage facility, Post-harvest training

Conclusion

The study showed that mandarin orange is being cultivated in Banskharka since BS 2000 (1943 AD). Both old and new orchards of the areas are planting seeded seedling. The native orange variety is most popular, only very few farmers have planted grafted plants. Local oranges are known for their shine, juiciness, post-harvest lifespan and sweet taste. There have no any specific traditions or folk songs related to oranges. Almost all the farmers directly sell their oranges to contractors. There are no any storage facilities. Cultivation practices among farmers are largely uniform, with a focus on clean cultivation methods. Harvesting typically occurs from the last week of Magh to the last week of Falgun. Main problem of survey site is transportation.

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Status of Mandarin Orange in Sankhuwasabha District

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Abstract

Sankhuwasabha district is well known for having a long history of mandarin orange production. Identification of the existing mandarin orange landraces and knowing the traditional knowledge on mandarin orange production in such place is necessary to conserve valuable genotypes through Geographical Indication (GI). Thus, a survey was carried out to assess the mandarin orange diversities and existing mandarin orange farming practices in Sankhuwasabha district of Nepal. Altogether 40 respondents, 20 from each pocket area were chosen for the study with the help of key informants. Semi-structured questionnaire was administered for collecting the information from mandarin orange growers. Collected data were analyzed by using Microsoft Excel. Adoption of improved orchard management practice was poor in studied areas. Inadequate irrigation was the major problem perceived by the farmers. Farmers' experiences clarify the fact that Mangtewa is a native place for mandarin orange. Mandarin orange of this place is of high quality with less number of seeds, more sweetness and juice content, thus possessing necessary attributes for GI.

Keywords : Mandarin orange, Geographical indication, Sankhuwasabha, Farming practices

Introduction

Citrus species constitute major fruits in mid hill region of Nepal (Paudyal et al., 2016). Citrus species grown commercially in Nepal are mandarin orange, sweet orange and acid lime. Among them mandarin orange is predominant with share of 60 percentage of the total citrus production in the country (MoALD, 2023). The fruit quality of local mandarin orange produced has been proven of best quality. Mandarin orange is priority commodity of government (Gurung, 2018). Mandarin orange is a high-value product with great demand in domestic and international markets. However, the mandarin orange production is not sufficient and satisfactory to meet the demand of the country (Dahal et al., 2020).

Although there is a lot of controversy about the origin of citrus, various species of citrus are believed to be native to the Himalayan region, South East Asia and Malay Archipelago (Shah, 1992). According to Reuther (1967) mandarin orange is native of China and South East Asia and was extensively planted in China and Japan at a very early date. Chinese travelers have mentioned Nepal as "the country of golden fruits" in about 2000 years ago when they saw the yellow color of mandarin orange fruits at ripening stage (Lohar and Lama, 1997). Tanaka (1954) reported that mandarin orange was collected in Himalayan region, Burma and Indo-China. According to Bonavia (1890) as cited by Shrestha and Verma (1998) mandarin oranges were found in semi wild conditions at Butwal and concluded that mandarin orange is indigenous fruit of Nepal. These historical facts clearly indicate that mandarin orange is native fruits of Nepal and being cultivated from pre-historical period (Paudyal et al., 2016).

Geographical Indications (GIs) is an important tools to protect traditional products and knowledge unique to specific geographical regions. The uniqueness of particular product is essentially due to the place of origin. Beyond legal protection, GIs contribute to maintaining biodiversity and genetic resources (Ingole et al. 2023). Genetic diversity of mandarin orange has got immense potentiality to raise the quality fruit production and productivity. In absence of identification, conservation and utilization of indigenous mandarin orange genotypes, we will loss of such valuable genotypes (Budathoki et al., 2004). Therefore, it is necessary to provide GI tag to the diversities of mandarin orange in different production area. In light of this, this study was carried out to explore diversities and indigenous knowledge on mandarin orange production in Sankhuwasabha district of Nepal.

Methodology

Site selection

The study was carried out in 2023 in Sankhuwasabha district of Koshi Province of Nepal. Sankhuwasabha district is well known for mandarin orange production. Mangtewa and Khadbari Rural Municipality of the district were selected for the study. Mangtewa is a remote village with long history of mandarin orange production that lies within Silichong Rural Municipality. These sites were selected on the basis of production history and productivity of mandarin orange oranges.

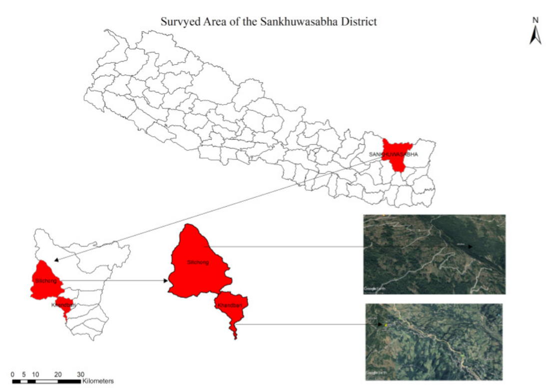

Figure 1. Map of Nepal showing the surveyed areas in Sankhuwasabha district

Data collection and analysis

Semi structured questionnaire was administered for collecting the information from mandarin orange growers. 20 mandarin orange growers from Khandbari Rural Municipality and 20 from Mangtewa were selected with the help of key informants. Consumers and retailers of mandarin orange were also interviewed in same way in order to find out the preference and market scenario of mandarin orange. Refractometer, zip lock bag and permanent marker were used while measuring the brix of fruits in the orchards visited. Focus group discussion was conducted at the study area after completing interview schedule with the help of checklist to verify the result obtained from farmer survey.

The primary information were collected mainly through field survey, orchard visit, KI interview and FGD while secondary information were collected by reviewing of various documents, government reports and related research papers. Collected data were arranged, tabulated and analyzed by using Microsoft Excel.

Result and discussion

History of mandarin orange orchards

During the survey we visited the mandarin orange orchard that was in wild form in Alaichibari of Khadbari. In that area mandarin orange cultivation was first started with plantation of 300 mandarin orange seedlings in middle of the jungle in BS 2005. The orchard owner migrated to new place and the orchard gradually turned to wild form due to lack of care and management. During the visit most of the orchard area was occupied by the wild trees but the surviving mandarin orange trees (almost 120) were in good condition with quality fruits hanging on the tree. Orchard was established by father, now his son (62 years old) has returned after 25 years to take care of the orchard. Orchard is still surrounded by the jungle. Another study area in Khadbari was Pangma. Here mandarin orange cultivation was started from BS 2040 with commercial production almost after BS 2070.

Mangtewa is a remote area that is in Silichong Rural Municipality. This place carries a long history of mandarin orange production. Farmers visited during the survey said that mandarin orange was in cultivation since their forefather's times. Top Bahadur Rai, a mandarin orange grower in Mangtewa is 55 years old. Along with the new orchard he possess four mandarin orange trees that are 55 years old and on an average per tree production is 1300 pieces mandarin orange per year. Recalling the old days, he said that mandarin orange was cultivated by his grandfather for home consumption purpose. His grandfather shared him that he knows mandarin orange since his childhood. These experiences of farmers indicate that mandarin orange might be native to this place also. This fact is supported by the findings of Shrestha and Verma (1998) which states that some elderly farmers in a very remote village of Mangtewa in Sankhuwasabha district reported that there exist 100-150 years old mandarin orange trees of seedling origin that was collected by their forefathers from the jungles.

Furthermore, farmers from Mangtewa shared that there were many mandarin orange orchards in past. People used to carry mandarin orange for 3-4 days to sell in local markets. Some farmers used to carry mandarin orange while going to Dharan for buying salt. Marketing was the major challenge in mandarin orange production at that time. Due to this reason many farmers replaced the orchard with other crops and didn't paid attention to the orchard. Moreover no new plantation was done. Gradually the old mandarin orange orchards disappeared. Farmers share the bitter experience of disappearing of old orchards in this historical place might be due to these reasons and due to lack of technical assistance and interest from any sector. But the scenario has changed in recent years. With access to road and being approached by the collectors, marketing of the produce has become easier to some extent. This has driven the farmers towards commercial mandarin orange production again.

Characteristics of mandarin orange orchards

Orchards in both the location were south facing with loam type of soil. In Mangtewa, the location of surveyed orchards ranged from 1265 to 1425 masl and in Khadbari it ranged from 970 to 1145 masl. The surveyed orchards were 25 % of larger size (100 and more than 100 trees), 55% of medium size (30 - 100 trees) 20 % of small size (less than 30 trees). Among the visited orchards, majority (75%) of the orchards were young with less than 12 years of establishment.

Quality of orange fruit

In Khadabari, **t**he brix value of the mandarin orange was found to vary from 10 to 13 and in Mangtewa from 9 to 11. This measurement was taken in first week of Poush, 2080 but the mandarin orange harvesting starts from second week of Poush in Khadbari and from Magh in Mangtewa. This means that there was almost one month period for increase in value of brix in Mangtewa. This fact is supported by Rokaya et al (2016) which stated that on later stage the TSS increases due to accumulation of sugars, increased level of dehydration and higher light intensity. The higher the brix, the better is the taste (sweetness) of the fruit. For better quality, brix reading should be 12 or more in mandarin orange oranges (Thapa et al, 2001).

Few seeds (1-4) were observed in mandarin orange of both studied areas. Fruit from the seedling trees were with thin and tight rind that makes the peeling quite difficult while the fruit from the grafted trees were with loose, thick and less shiny rind. While comparing the fruits, fruits from Mangtewa were juicier with smooth and shiny appearance. Farmers stated that in higher altitude of Mangtewa mandarin orange with thick rind were also found. Variation in fruit appearance was found in Khadbari also. During consumer survey, 65% preferred mandarin orange from Mangtewa due to its sweetness and juiciness.

Use of planting materials

Most of the orchards visited during the survey were using seedling as planting materials. Farmers used to produce seedlings necessary for them by themselves. High quality fruits were selected from own or neighbor orchards for extracting seeds. In Khadbari 85% and in Mangtewa 90% of the visited orchard were of seedling origin and rest are using grafted sapling as a planting material brought from different sources. Orchards with grafted plants were very rare with 5% in both areas. Some farmers were found using both seedling and grafted as planting material.

Fruit nursery in Khadbari was also visited during the study. According to the key informants that was only the nursery near to the study areas and was just started with support of PMAMP

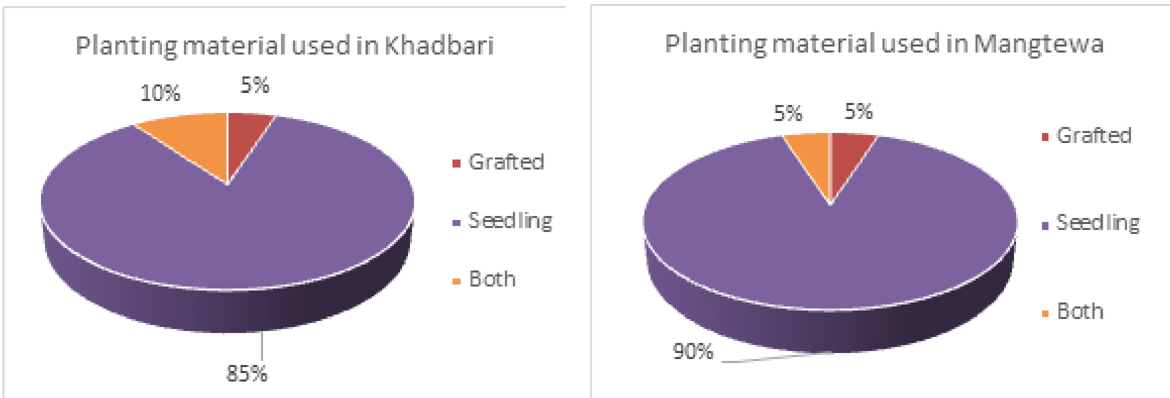

Figure 2. Planting materials used in study areas

PIU Sankhuwasabha. One of the reason for lesser use of grafted plants in study areas might be due to the less number of nurseries.

Plantation pattern

Farmers used to plant the seedlings at the edge of terrace in past. But later realized that production from such system was not profitable. During orchard visit in both surveyed areas, trees were planted in the middle of terrace. In Khadbari 85% farmers reported tree plantation in terrace and remaining 15 % in sloppy land. While In Mangtewa, 95% farmers reported tree plantation in terrace and remaining 5 % in sloppy land.

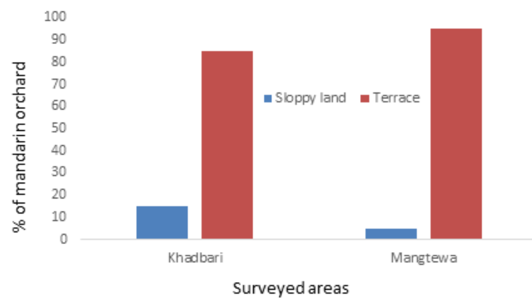

Figure 3. Plantation pattern followed in study areas

Practice of fertilizers application and irrigation

From the pie chart, it is clear that majority (85%) of the growers in Khadbari have practice of using FYM only and other 10% used chemical fertilizers along with FYM. Farmers using chemical fertilizers realize the fact that only application of FYM is not enough for bearing trees.

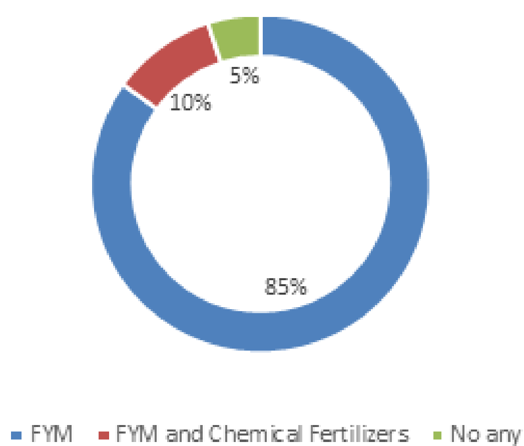

Figure 4. Fertilizer application practice in Khadbari

In Mangtewa after harvesting of intercrops most of the farmers have practice of tying domestic animals around the trunk of mandarin orange trees one after another. Dung and the urine were allowed to remain there and later ploughing was done.In both areas, there wasn't any practice of using micronutrients.

Irrigation is an issue to all mandarin orange growers. Few growers use drinking water for hand irrigating their orchards during dry periods while remaining doesn't practiced irrigation.

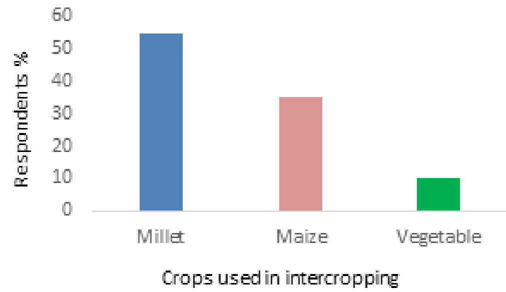

Figure 5. Crops inter-cropped in mandarin orange orchard

Inter-cropping

Inter-cropping was a general practice in both study areas. Millet (55%) was the dominant crop followed by maize (35%) and vegetables (10). Inter-cropping at initial stage of orchard establishment is profitable but continuing it in bearing stage is not a good practice. Ploughing during inter-cropping can damage the roots of the mandarin orange trees and also inter-cropping leads to competition for the nutrients and water.

Harvesting of mandarin orange

Harvesting method used determines the marketability of mandarin orange. In both study areas, harvesting method was similar. They used handpicking with support from ladder to harvest and *doko* to collect the harvested mandarin oranges. None of the farmers used clippers for harvesting. But farmers in both areas were aware of the loss caused by harvesting the mandarin orange without stalk by plucking. Mandarin orange were pulled outward with rotating movement so as to avoid the rupturing of the fruit skin.

In Khadbari, harvesting was done earlier than Mangtewa. Harvesting starting from mid of Poush continues till Magh. While in Mangtewa harvesting was done from Magh to Falgun as collectors approached this area once the easily accessible areas were vacant.Thinking of the fact that the pre harvest contractors can injure the mandarin orange trees and give less price, farmers used to sell mandarin orange directly to the collectors after harvest. Most of the growers in Khadbari used to do harvesting through contractors while in Mangtewa harvesting by labor and own self was done

Marketing of produce

Major markets of mandarin orange produced in the district are Dharan, Jhapa, Morang and Sunsari. Various marketing channels based on farmer's perspective through which the producers pass their produce to the consumers were recorded. The marketing channels are presented as follows:

Marketing Channel I: Producers → Collectors → Wholesalers → Retailers → Consumers

Marketing Channel II: Producers → Collectors → Retailers → Consumers

Marketing Channel III: Producers → Retailers → Consumers

Figure 6. Marketing channel involved in study areas

Mainly selling of the produce was done through the marketing channel I (60%) while the channel III was practiced mainly by the small orchard holders. Farmers sell mandarin orange directly without grading to the collectors. Later the collectors categorize the fruits into two grades (1 and 2) and sell at different prices for each grade. The average farm-gate price in Khadbari and Mangtewa were Rs 75/kg and Rs 70 /kg respectively. The price was much higher for local retaileri.e, Rs 100 /kg in peak season and upto Rs 150/kg at end of the season. Mostly the produce from large orchards were collected by the collectors while small growers used to sell their produce to retailers directly.

Major problems in mandarin orange production: Various problems prevailing in the study areas were identified. The result showed that inadequate irrigation was the severe problem perceived by the producers. The second major problem was poor knowledge on orchard management. These problems were followed by incidence of diseases and pests, lack of quality planting materials and inadequate technical assistance.

Conclusion

Only having favorable climatic condition doesn't ensure the good production as per the potentiality. Orchard management is the major factor to enhance the production of mandarin orange. There is a huge potential to increase the quality and production of mandarin orange in the studied areas. For this, it is necessary to ensure the irrigation facility and provide on time technical assistance to the mandarin orange growers.

Using name of the place of origin for marketing of agricultural products is a common practice in many countries. For instance, Manakamana mandarin orange is very popular among the consumer and they are willing to pay more because of its unique taste and qualities of geographic origin. Among the two studied areas, Mangtewa had a long story of mandarin orange production. Mandarin orange here are of high quality and preferred by the consumer. To prevent the probable loss of such valuable genotypes, timely identification and recognition is necessary. Providing GI tag to such genotypes not only help to conserve diversity but also help to promote the rural development.

We have comparative advantage rooted in our unique geography. Identification of different genotypes of mandarin orange is necessary to promote and conserve their diversities. Beside field study, lab analysis should be done to verify and claim GI on a proper way.

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Case Study of Geographical Indication of Mandarin Orange in Dailekh

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Abstract

The *Suntala*, or mandarin orange (*Citrus reticulata* Blanco), is a moderate-sized tree tiny citrus tree in the rutaceae family that bears fruit with a unique flavor and look. The study carried out in Nepal's Dailekh area concentrated on the cultivation of mandarin orange, its cultural importance, and the difficulties farmers encounter in selling their harvest. To acknowledge the importance of local mandarin orange in the area, the survey sought to offer Geographical Indication (GI) for it. Farmers' agricultural status and techniques were evaluated by the survey. It was discovered that the region's mandarin orange production started between 130 and 150 years ago, with farmers planting their orchards from 2010 in BS. Mandarin orange, referred to as '*Suntala*' in Nepali, is significant both culturally and economically. It is offered during several festivals, and *Suntala* Jatraa is a yearly event. Respondents noted issues like the necessity for government support in areas like cold storage, irrigation, price fixation policies, expert advice, even if they did not report any significant problems with marketing. Inadequate labeling, marking, and packaging were also mentioned as obstacles in commerce. Consumers favor the locally grown type known as "Dailekh Local," which is readily available in the market during the season and has thin skin and a juicy, sweet flavor. Farmers proposed several ways to make improvements, such as government funding for infrastructure, help with breeding better varieties and handling trade-related matters. Overall, the survey offers insightful information about the economic and cultural value of mandarin orange cultivation in the Dailekh district as well as the difficulties of farmers encounter in selling their produce.

Keywords : Mandarin orange, Geographical indication, Dailekh, Farming, Marketing

Introduction

The mandarin orange (*Citrus reticulata* Blanco), also known as the mandarin, is a small citrus tree that produces fruit with a distinctive flavour and appearance. It is a member of the Rutaceae family, which also includes other well-known citrus fruits such as tangerines, satsumas, clementine, and grapefruits. Chinese travellers have mentioned Nepal as “the country of golden fruits” in about 2000 years ago when they saw the yellow color of mandarin fruits at ripening (Lohar and Lama, 1997). Farmers of Darchula and Shakhuwasava district claim that their forefathers had collected mandarin trees from wild form (Shrestha and Verma, 1998). Bonavia (1890) has found mandarin in Butwal (Nepal) in a wild form. Later Tanaka in 1929 have considered that mandarin is an indigenous fruit of Nepal.

The mandarin orange tree is a moderate-sized tree, growing up to 7.6 meters (25 ft) in height. It has thorns on the trunk and major branches, and its leaves are shiny, green and relatively small. The flowers are borne single or in small groups in the leaf-axils and the fruit is typically round or oval, with a thin, leathery peel and a juicy, sweet-tart pulp. The mandarin orange has a rich history and is known for its unique flavour profile, which is often described as a balance between sweetness and acidity. It is a popular fruit worldwide and is enjoyed for its taste and nutritional value. A total soluble solid (TSS) in sweet group varies from 6 to 12% and acidity from 0.5 to 1.5% (Radha and Mathew, 2007). Citrus fruit juice is given to sick peoples with high fever and jaundice and for curing disease like dysentery and beriberi. Bitter glucoside "Naringin" provides prevention against malaria (Radha and Mathew, 2007). Per capita consumption of citrus fruit in developed countries is about 10 kg/year whereas in Asian countries it is only about 4kg/year (Aubert et al., 1990).

In Nepal, 27,982 hectares of mandarin orange crop were planted, yield 185,346 mt. and 9.51 mt/ha of productivity in the fiscal year 2021–2022. (MoALD, 2023). Citrus fruit farming, particularly for mandarin and sweet orange, has a comparative advantage in the mid-hill region (1000–1500 m height). The mandarin orchard in Dailekh district is situated at an altitude of 544 m to 4168 m from sea level (Regmi et.al, 2020). Mandarin oranges were grown in 1085 hectares of land with 797 hectare productive area in the fiscal year 2021–2022, yield 9,361 mt of production and 11.75 mt/ha of productivity in the Dailekh district. The production of mandarin in Dailkeh district is increasing due to the easy access to roads to big markets like Surkhet, which has a positive effect on mandarin production (Regmi et.al, 2020).

Nepal has varied climate contributes to its vast agrobiodiversity. Certain agricultural products are only produced in extremely limited regions. In Nepal, over 100 agricultural products have the potential to be tagged with a geographical indicator (GI). In Nepal, not a single product has a GI registration. Three characteristics are critical to the GI system: origin, unique characteristic, and fame. Although there is a policy provision for GI, there is no formal structure in place for legal GI registration in Nepal. Therefore, GI research is the must in the present scenario.

Objectives of the survey

General objective:

- To identify the origin of mandarin growing in Dailekh district.

Specific objective:

- To identify the fact about naming of local mandarin growing in the area.
- To collect information about status of mandarin in the area.
- To identify the problems of mandarin growing farmers in the area.
- To collect and finalize the document used for GI of local mandarin growing in the area.

Methodology

Study area

Dailekh district which lies in mid hills region of Nepal, is suitable for mandarin production due to its climatic conditions, soil and market condition. Dailekh district of Karnali province was selected for the study. We had selected the two-pocket area of mandarin production for our survey i.e., Dullu Municipality word no. 06 and 11.

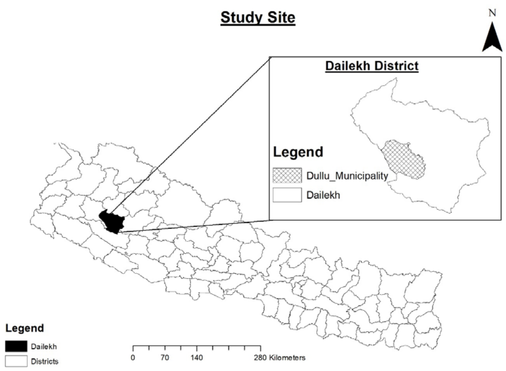

Figure 1. Area covered by mandarin orange

Questionnaire preparation

Several close and open-ended questions were prepared by the team of NCFD, Kirtipur with support from National Agriculture Genetic Resource Centre (Gene Bank), Khumaltar. Survey questionnaires for different level (farmers household survey, focus group discussion, consumer survey, market survey and key informant survey) were prepared.

Primary information collection

Primary and secondary data of the study site were collected from ADO Dailekh, PMAMP; PIU, Dullu Rural Municipality, Horticulture Research Station, Kimugaun.

Methods of data collection

Various methods were applied for the data collection household surveys, focus group discussions, key informant interviews, market surveys and consumer surveys were used. Both primary and secondary sources were utilized as the source of information, also qualitative and quantitative information were collected.

Sampling size and selection procedure

Farmers survey: Farmer's household survey was conducted in ward no. 6 and 11 of Dullu Municipality. Survey was done with 39 farmers, among them 23 were male and 16 were female.

Table 1. Cultivation practice of mandarin orange followed by farmers

Description	Activities
Initiation of orchard establishment	150 years ago,
First sapling introduced	Dailekh jungle
Land type	Slopy, terrace
Land preparation	Most farmer follow Primary tillage
Pit digging	100%
Compost pitting	Most farmer follow
Plant to plant distance	Most farmers keeping distance of 4-5 meter.
Varieties growing	Widely Dailekh local/unshiu
Sapling types (grafted, seedling)	Many farmers seedling, some grafted sapling
Planting month	Ashadh-Shrawan
Weeding method	Manually as per need
Intercropping	Ginger, turmeric, taro leaves, leafy vegetable etc.
Application of fertilizer for manuring	Not in practice
Irrigation	Rainfed
Insect/pest types and control	Locally available insecticides used for control
Difference in taste between chemical fertilizer applied and organic manure	Unknown as no application of chemical fertilizer
Ripening time	Starts from Mangsir
Harvesting period	Mangsir-Magh
Direct sell/store	Direct sell
Market	Dailekh, Surkhet, Butwal, Bhairahawa, Nepalgunj
Training/Pruning	Diseased/crisscross branches are timely pruned.

Focus Group Discussion: Focus group discussion was performed in 2 different locations with a total of 14 farmers. Among them 13 were male and one was female.

Table 2. Overview of focus group discussion

Description	Conclusion
FGD conducted group	2 groups
No. of male and female participated	3 male/ 1 female
Year of cultivation	150 years ago,

Description	Conclusion
First sapling introduced	Dailekh jungle
Why named *Suntala*	Golden color skin
Evidence about *Suntala*	Folk songs and *Suntala Jatraa* festival
Land covered by mandarin orange	2500-3000 ropani
Household growing mandarin orange actively	350- 400
Variety growing	Dailekh local, Unshiu
Sapling exported	Dailekh, Jajarkot, Kalikot, Humla
Indigenous Technical Knowledge applied	Ash, weeding, interculture, irrigation, training/prunning bamboo ladder, sack, Doko
Positive and negative impact after establishing orchard	PMAMP declared zone area, economic status improved
Benefits of growing orchard	Improved social and economic status
Changes in same variety growing in different geographic	Change in taste and growth
Suggestion	Subsidy program (fertilizer, saplings, irrigation and other machinery tools) disease and pest resistant and tolerant varieties, training of citrus

Consumer survey : Consumers were selected randomly for the survey.

Table 3. Overview of consumer survey

Description	Response
No. of Respondent	4
Access of getting mandarin orange in market	Yes
Price of mandarin orange (season and off season)	Rs 60-90 and 150 per kg
Choice of Variety in market	Dailekh local
Location of growing	Dullu
Qualitative characters of choosing	Sweet, juicy, tasty, skin layer
Time of availability of mandarin orange	Mangshir-Falgun
Problems	Low price in local market
Suggestions	Grading, storage, free sapling

Key informant survey: Survey was done in two locations at ward no. 6 and 11 of Dullu Municipality repeated where teachers, leader farmers, political representatives experienced old aged farmers, PMAMP PIU Dailekh, Agriculture Research Station (Horticulture) Kimugaum, ADO Dailekh were selected.

Market survey: Market survey was done with 6 retailers from Chandani Chowk Dullu and Bulbule Krishi Hatbajar, Surkhet.

Table 4. Overview of market survey

Description	Response
No. of respondent/ traders	5
Experience of selling mandarin orange	7 – 10 years
Most preferred location	Dailekh
Variety sold	Mostly Dailekh local in season, Indian and Chinese in offseason
Prioritized variety for selling	Dailekh local
Price of mandarin orange	60- 80 per kg / 160 per kg
Easily sold or not	Easily
Distinguishing character	Dailekh local is tasty, sweet, juicy, thin layer skin, shinning like gold, organic and long post-harvest life.
Market supplied	Surkhet, Dailekh, Nepalgunj, Butwal, Bhairahawa
Storage	Direct sell
Problems	Commission to wholesaler, grading, labelling
Suggestion	Proper postharvest handling facilities like precooling, grading, sorting, packing, transportation and marketing facilities.

Methods and techniques of data analysis: Collected data were entered in the MS-Excel and analysis was done using MS-Excel.

Result and Discussion

Age of farmers involved in mandarin orange farming

Different age group farmers were involved in the survey. Total 39 farmers of different age groups ranging from 18 to 75 years old were randomly selected from two selected sites.

Mandarin orange plantation area

Farmers have 2 to 36 ropani of land where mandarin orange was grown in 1 to 20 ropani. Out of 685 ropani of land, 251.8 ropani was used for mandarin orange cultivation. A single farmer is growing up to 700 mandarin orange plants in their land.

According to the group around 250-300 farmers are involved in the mandarin orange cultivation who are farming in total land of around 2500 to 3000 ropani in the area; cultivated land is slopy and terraced. Dailekh local mandarin orange is famous in the area for its superior quality like, juicy, sweet taste, shiny, smooth and thin skin.

Altitude of mandarin orange cultivation

Most of the farmers are growing orchard in mid hill ranging from the altitude of 1213 to 1400 masl.

History of mandarin orange farming

According to farmers cultivation of mandarin orange was first started at around 150 years ago in Kalbhairab Toraya at Dullu -11 where the seedling was locally produced. FGD survey shows that mandarin orange cultivation was started around 150 years ago in Dullu from locally available seedlings. According to Dal Bahadur Khadka and Mayaram Khadka; permanent resident of Chhimdi; Dullu-6 local mandarin orange seedling was first brought from local jungle of that area.

Few of seedlings were also first seen in the riverbanks and later the community started plantation and now they are cultivated commercially. As per the FGD, the oldest mandarin orange plant about 150-200 years old locates in the farm of Bichari Khadka, Jagat Bahadur Pant and Khadka Bahadur Malla. Other farmers of that area cultivated from 2010 B.S. till the date.

Now, most of them are producing mandarin orange commercially and selling in local as well as wholesale markets. The name *Suntala* came from the fact that the color of an orange is yellow looks like gold and very shiny. Almost all farmers cultivate local (*Raithane)* variety mandarin orange which is sexually propagated. Thirty-five grafted saplings were first introduced in 2055 B.S. by Lokesh Bogati in his orchard. He claimed that grafted saplings gained height upto 2 meter and started fruiting from 5 years producing 70 kg fruits per tree. Till now some farmers are growing grafted plants due to their dwarf growing nature, disease resistivity and fast bearing habits.

Mahesh Kumar Bista, Dullu 6, addressed a fact, *"Naumeleko jaatraa paisa daana suntala"* which means during the period of Dullu regime, Jaatraa used to be celebrated in Naumule where eak daana suntala used to be sold at eak paisa.

One of the experienced farmers, Shashi Bahadur Khatri, permanent resident of Kalbhairav Toraya, Dullu-11 shared an old folk tale about mandarin orange as:

बाहिरी भन्दा भित्रि मिठो, धन्न सुन्तलिय, सुन्तलियको बोक्रा खाँया मन त अन्तलिय।

Traditionally organizing a *Suntala Mela* during Asoj -Kartik. Songs related with mandarin orange use to sing by local people in different occasion like:

"पैसा दाना सुन्तला खाँउ।
घोडा दाउनी जात्रा जाँउ।
माया देउ र आन्जा हाल्छु।
विदा देउ र जान्छु।"

Cultural practices

Most of the farmers in that area are practicing pit digging method for the establishment of orchard. Pit of 0.5-0.75 m width and 0.5-0.75 m depth is dug and they are maintaining 5*5 m^2 PP*RR distance. 25-30 kg per pit well rotten FYM is placed and mixed with topsoil and filled back one month prior to plantation. Seedlings /saplings are cultivated in the rainy season (Ashad-Shrawan). No modern technologies of irrigation were found and farmers depend totally upon rainfed conditions. Fallow space is occupied by intercrops like soyabean, ginger, tomato, turmeric, chilly, taro leaf, leafy vegetables, cauliflower, cowpea, finger millet, maize etc. Timely weeding is performed by farmers manually as per their necessity. As no farmers have adopted application of chemical fertilizer in their field, they are less likely to know about any difference in taste of mandarin orange while comparing between with or without chemical fertilizer in the orchard.

Insect pest and diseases

Recently most of the orchard are affected by disease and insect/pests which have become important cause for the yield reduction. Infestation of aphid, leaf miner, citrus bug, maggot, scaly insects, citrus psylla, CTV, powdery mildew, greening, anthracnose, die back, citrus canker etc. have increased more severely.

Although oldest plant prevails there, its production is not so high and the yield is in declining phase. Frequent monitoring and examination by technical officers from related office will be more helpful for the farmers to deal with the problems. Although PMAMP, PIU Dailekh, ADO Dailekh is distributing disease resistant seedlings as a subsidy to farmers, still all farmers are not benefited from it.

Locally available insecticides like roger, karathane, copper oxychloride etc. were used by some of the farmers for the control of disease/pest. However most of the farmers have got training about bordeaux paste and bordeaux mixture application provided by the PMAMP, ADO Dailekh and applying in their field for the control of various disease and pest.

According to the local farmer of Dullu ward no.6, Amar Bahadur Bhandari, who owns 20 ropani of mandarin orange orchard used to harvest up to 68 mt. of mandarin orange around 35 years ago but recently the yield has declined up to 40-50 mt. in the same farm due to disease/insect pest infestation.

Harvesting and production

Ripening of fruits start from Kartik to Mangsir and harvesting is done from Mangsir to Magh. Respondent claim height of the mandarin orange plants is 3 to 5 m and yields 80 to 160 kg per tree from seedling plant as well as grafted plant.

Figure 2. Mandarin orange Orchard in Dullu

Marketing

For marketing of mandarin orange, collectors directly contact farmers and set price (farm gate price) ranges from Rs.50-60/ kg and they sell at the rate of Rs. 60-100 per kg. in the season (Kartik to Falgun). In off season (Falgun to Chaitra) the price of mandarin orange is up to Rs.100-150/kg

Farmers use bamboo/aluminium ladder, jute sack, doko for harvesting of fruit. They are not able to store fresh mandarin oranges due to lack of cold storage facilities. The nearest market for selling of mandarin orange i.e. *Hatbazaar* which is organized twice in a week. The main market for the large sales is Bulbul Krishi Hatbazaar, Surkhet, which lies about 80 km from Dullu. Mandarin orange is easily sold in the markets of Surkhet, Nepalganj, Dhangadi, Dang, Bhairahawa, Butwal etc. Also, during off season, they import mandarin orange from India followed by China. Dailekh, Salyan, West of Surkhet and Jajarkot are the main pocket centres for the market of Surkhet. As per the consumer preference, on the priority basis local mandarin orange of Dailekh holds maximum sale followed by Salyan, Jajarkot, West of Surkhet, India and China respectively.

In main season, maximum 22 ton mandarin oranges are selling per day in BKHB while 2-3 ton in off season. According to traders, Nepali *Suntala* are easily available in market up to 5-6 months, then they need to depend on India and China to meet the demand of consumer.

Socio-cultural aspects

Jagat Bahadur Panta: local farmer of Dullu-11, Kalbhairav shared us an interesting folk song related about *Suntala*:

"सुन्तला चुकिलो हुन्छ ।
ल्याउ बेलौती खान्छु ।
बिदा देउ र जान्छु ।
माया देउ र पाकेटमा हाल्छु ।"

Mandarin orange is in use to celebrate different types of festival like *Thulo Ekadashi, Maghe Sankranti, Satyanarayan Puja, Shree Panchami* etc. also it can be used as an offering in rituals. During the survey old mandarin orange plants were found in Khadka Bahadur Malla, Jagat Bahadur Khatri and Bichari Khadka.

Famous mandarin orange related *ukhantukka* are composed by the farmers over there; some of them are: "**हेर्दा सुन भन्दा कम छ, रोगहरुसँग लड्ने दम छ। स्वास्थ्यको साहारा सुन्तला नै आहारा**" । The famous nursery located in the area is Santosh Suntala Nursery Farm; Proprietor: Laxmi Khadka. Seedlings/saplings of Dailekh local *Suntala* are transported to Humla, Kalikot, Kailali, Jajarkot and Mugu district as well.

Proprietor Laxmi Khadka; owner of Santosh *Suntala* Nursery Farm is the largest seedling growing farm in the area where it produces up to 25000 no. of seedlings/saplings in his two screenhouse and supplies to the farmers and markets of Dailekh, Humla, Kalikot, Kailali, Jajarkot and Mugu.

Ram Bahadur Singh: Proprietor of Sonu Nursery Uddhyog from Dullu -8, Purna Neupane and Nandaram Neupane from Kalbhairav Toriya are actively producing seedling in their open nursery farm and the local farmers are well benefited from the farm.

Economic importance

Mandarin orange cultivation has shown its high importance towards the economic and social status of the farmers in Dullu area. Farmers have increased their social prestige in the society and disctrict as well. Mandarin orange cultivation has left positive impact in livelihood, better education, living standard and income source, development of agriculture road in every village so that farmers can sell their products at their own orchard, PMAMP has implemented *Suntala* zone program for mandarin orange production. Due to differences in geographical condition size, taste, height of plants, leaf size, shining of fruit etc differs though the same varieties grown. When Dailekh local variety was grown in different geographical location, differ in the quality of mandarin orange like colour of leaves, fruit texture, shape size and taste due to the climatic factor of that place.

Conclusion

During the survey conducted in Dullu ward no.6 and 11, mandarin orange grown in that area is claimed to be originated within the local jungle in early 19th century, which shows its unique characteristics in terms of taste, juiciness, skin, shiny, organic, long post-harvest life and its average size while comparing with Indian and Chinese. Recently more infestation of pest and disease have become another unavoidable effect for negative yield of mandarin orange. In season, almost 90 percent of local market is occupied by Dailekh local mandarin orange and consumer also prefer local mandarin orange. Contractors direct reach to the farmers farm for the collection and trading of orange. As Dailekh local mandarin orange shows superior characteristics, provision of GI tag will be helpful for the conservation of existing local landraces from extinction and farmers will also be benefitted from its utilization.

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Orchard and Nursery Management

Orchard Management of Mandarin Orange

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Abstract

Citrus is the most common fruit rooted through different ways to social, cultural and economic aspects of Nepalese society. Mandarin orange is one of the major citrus fruits, widely grown from kitchen garden to commercial orchards supporting mid-hills livelihood. Due to increasing road networks, awareness and touristic flow mandarin orange growing area is slightly increasing but the productivity per unit area is not encouraging as compared to India. Farmer's reluctance to invest on mandarin orange orchard management, use of unhealthy saplings, moisture stress during early to late spring, lack of balanced nutrition supply and weak research and extension support are found the major factors contributing citrus decline in Nepal. This chapter aims to review the major problems related to mandarin orange orchard management and concluded with the good orchard management practices for mandarin orange growers and technicians.

Keywords: Citrus decline, Mandarin orange, Orchard management, Productivity

Introduction

Agriculture Census 2021/22, reported 62% households are still engaged in agriculture sector for their livelihood and its contribution to GDP is about 24%., Horticulture is one of the major sub sectors with more than 30% contribution in total AGDP (MoALD, 2023). Due to wide range of diverse climate high mountain is suitable for temperate fruits, mid hills are suitable for sub-tropical fruits including citrus and tropical fruits are best suited in terai region of Nepal. Citrus is the most common fruit rooted through different ways to social, cultural and economic aspects of Nepalese society and it is also believed to be originated in South-East including South China, North India and Burma (Langgut, 2017). Mandarin orange growing area is reported in 56 district of Nepal (MoALD, 2023) and based on the commercial potentiality 42 districts are identified by National Center for Fruit Development (NCFD, 2021).

It is one of the most popular citrus fruits, widely grown from kitchen garden to commercial orchards, with cultural and aesthetic value supporting livelihood of the agrarian society in mid hills of Nepal. The total fruit cultivated area in Nepal is 129532 ha and out of these citrus fruits occupy about 38% (49306 ha). The major of citrus fruits are mandarin orange, sweet orange, lime and lemon. Mandarin orange alone occupies more than fifty percent (27982 ha) of citrus area and gives about 1.85 lakhs mt of production, which is about 60% out of citrus fruits and 13% of total fruit production in Nepal (MoALD, 2023).

Objectives of the study

- To review and assess the major problems related to mandarin orange orchard management in Nepal.
- To summarize the major modern mandarin orange orchard management practices.

Literature review

The citrus development program at the government level was started in early sixties when two citrus research stations were established at Pokhara and Dhankuta in 1961 and 1962 respectively. As these stations were looking after the research activities, in 1972 government established the National Citrus Development Program (NCDP) and mandated for both research and development activities. NCDP emphasized more on development activities and started commercial planting production programs in potential districts. After celebration of Agriculture Year in 1974, many new programs including private nurseries, commercial orchard establishment programs were initiated.

A special Junar Production Program was initiated in 1980/81 in Ramechhap and Sindhuli and a national priority program was initiated in 1983/84 with the objective of commercializing mandarin orange in 20 mid hill districts of Nepal. The first year of the Fifth Five-Year Plan (1975-80 AD; BS 2032-37) was designated as "The Agriculture Year" and a special provision of agricultural credit, and subsidized planting materials and chemical fertilizer was ensured. The Sixth Five-Year Plan (1980-85 AD; BS 2037-2042) plan has placed special emphasis on increasing crop production. Hill Agriculture Development Project (HADP) supported by FAO, strengthened the horticulture farms of Nepal. Similarly, JICA supported Horticulture Development Project (HDP) supported fruit sector development in central part of Nepal and Hill Fruit Development Project (HFDP) developed citrus fruit orchards in eastern part of Nepal.

In 1994/95, government implemented a commercial agriculture development program for some high value crops including citrus. This program focused in planting materials, equipment, and plant protection support for commercializing citriculture in the mid hills. Agriculture Perspective Plan (APP) was formulated in 1995 and implemented from 1997 recognized citrus as the main high value crop for mid-hills of Nepal and applied a pocket package strategy approach to develop production pockets. Despite a different initiatives of citrus production programs, the field conditions of citrus or mandarin orange orchards are remained primitive, unmanaged or even worse in different aspects of good orchard management practices.

In Nepal, citrus in general and mandarin orange in particular is growing traditionally which is the major fruit among the citrus. Due to weak and negligible management practices resulted in severe decline in its production and productivity is reported from the production pockets.

Farmers' reluctance to invest on citrus orchard management, wide use and distribution of unhealthy citrus saplings, increased drought/dryness, lack of balanced plant nutrition and updated technology are some major factors contributing citrus decline in Nepal (FAO, 2011).

For successful cultivation and production, a sustainable and correct and continuous management effort is important. Correct management of the canopy, water and mineral resources is a necessary condition for high quality production, increased efficiency in the use of the resources themselves, and low environmental impact (Xiloyannis et al, 1999).

In Nepalese context, mandarin orange is grown traditionally in marginal slopy land with maize and millet crops without manuring and fertilization (NCRP, 2015). Although, APP prioritized citrus as a high value crop that can help to improve the livelihoods and quality of life in mid hills of Nepal.

A study (Poudel, et al., 2022) conducted in Beni and Malika Municipality of Myagdi district reported that 73% of the mandarin orange growing farmers had experienced citrus decline problems due to disease pest incidence, climatic extremities, poor fertility status of soil, low quality planting materials and poor orchard management. This study concluded that citrus decline has been the major constraint of mandarin orange farming and improved management practices are pivotal for combating the citrus decline.

A study (Bhandari et al., 2022) was conducted in Syangja district to assess the farmers' knowledge and adaptation of improved mandarin orange orchard management practices and identify factors affecting their adaptation. The finding says the farmers were familiar with most of the improved orchard management practices but found variation in scale of adaptation of the improved management practices.

The orchard management is very crucial for mandarin orange which includes canopy management, soil and nutrient management, disease pest and water management. Canopy management is important to keep the tree in ideal shape and healthy by keeping open all sides to access the proper sun light penetration and aeration in high humid season. The best time for pruning is just after harvest and when the plant is dormant or not active in winter Poush-Magh (PIU, 2018). More than 250 species of insects and mites are known to damage citrus throughout the world so management of insects and diseases is essential for increasing the orchard capacity for production (Ashraf et al., 2014). Efficient use of applied water aids in supplying a significantly higher amount of available nutrients in the soil, ensuring favorable leaf nutrient status, which collectively helped plants to develop a good canopy, a prerequisite to improved bearing capacity (Panigrahi et al., 2012).

Green weeds/rice straw mulching is one of the easiest practices of orchard management gives quick results in terms of moisture conservation, temperature regulation, prevention of surface compaction, reduction of run-off and erosion, improvement in soil structure, and weed control (Ranjan et al., 2017). Plastic mulching is also in practice but it only supports in weed control and moisture preservation. Appropriate and timely implementation of the management activities enhances plant physiological functions with the final outcome of economic efficiency, i.e. in terms of resource use (Dorji et al., 2016).

Due to increasing road network, awareness of nutritional value and development of touristic pockets mandarin orange total area and production is in slightly increasing trend (MoALD, 2023) but the productivity per unit area is not encouraging (9.97 mt/ha) as compared to India 12.54 mt/ha (Ladaniya, et.al., 2021).

Table. 1. Mandarin area and productivity from 2072/73 to 2078/79

Fiscal Year	Total Mandarin Area (ha)	Productive Area (ha)	Production (mt)	Productivity (mt/ha)
2078/79	27982	19481	185346	9.51
2077/78	27002	18369	198406	10.80
2076/77	26591	14551	156173	10.73
2075/76	27951	17220	177381	10.30
2074/75	27150	16155	161434	10.00
2073/74	28760	17457	164593	9.43
2072/73	26282	16248	146690	9.00

Source: MOALD Yearly Publications, 2023

A huge potentiality of mandarin orange farming in mid hills is constrained by different orchard management aspects and a serious attention is necessary to overcome this problem by updating and improving the modern orchard management practices.

Result and discussion

Problems of orchard management in Nepal

Site selection: The proper site selection for a commercial orchard is important. In our context, mostly the fruit orchards are promoted in marginal areas of hills and mostly mid hills in case of mandarin orange. The suitable aspect, altitude, soil, rolling elevation for mandarin orange orchard should be in consideration but it is not followed in most of the cases. The cultural practices are difficult to handle properly during the orchard growing stage.

Layout and proper plantation: It is necessary to follow the recommended plant distances to provide full canopy development and to avoid nutrient uptake competition between the plants. Lay out is not properly followed, even the plants are planted in the edges of bench terraces or in negligible marginal lands with less spacing. In most of the mandarin orange orchards, the plants are established in the inner slope of the bench terraces or in the outer edges of the terraces which is not manageable for cultural practices and normally found suffering from malnutrition (FAO, 2011).

Well drain soil: In Nepal, soils are neither tested for nutritional requirements of specific fruit crops nor are leaf tissues analyzed for mineral contents (Poudyal et. al., 2016). The best soil to grow mandarin orange is well-drain sandy loam or loamy soil. It is also important and should consider the soil fertility and pH level. Red clay/loamy soil is also available in the mid hills of Nepal and number of orchards can be seen established in such soils. It is not well draining soil and during summer heavy rain most of the terraces face drainage problem along the inner side of the bench terraces for long time which promote root decay problems in mandarin orange orchards.

Intercropping: The existing mandarin orange trees are predominantly of seedling origin and plants have to share with various seasonal inter-crops without additional plant nutrients (FAO, 2011). In some cases, farmers used bullocks ploughing inside the orchards, which is responsible to destroy the feeder roots and ultimately supports in yellowing of plant parts, one of the reasons for citrus decline. Maize and millets are the major crops not recommended for intercropping but mostly grown in mandarin orange orchards. Intercropping with maize and millet without additional manures and fertilizers, and irrigation is also responsible for malnutrition and moisture stress conditions in the orchards. Root injury during the intercropped soil and excess moisture in rooting zone during rainy season is favorable for Phytopthora infection. As a intercrop, farmers grow vine crops around the orchard which compete for nutrients and also use the plant as a staking favors to grow diseases and pest in the orchard.

Manuring and fertilization: Fertilization, manuring and plant protection chemicals are not commonly used in earlier period. But in the recent studies some changes in manuring can be seen. A study in Myagdi district showed that 75.5% of the farmers use farmyard manure (FYM) of more than 30 kg per plant per year (Poudel et al., 2022). Mandarin orange orchards are in some priority among the other citrus fruits but it is also not regularly supported by manure and other nutrients. The trees which are grown on the edges of the bench terraces are not feed normally and found suffering from malnutrition.

Planting materials: Most of the existing mandarin orange orchards are of seedling origin and which are reported to be more susceptible to Phytopthora disease. Phytopthora species cause foot-rot, root rot, crown rot, gummosis, leaf fall and brown rot disease in citrus (FAO, 2011) and responsible for citrus decline to a certain extent. This is also seen in the grafted trees on rough lemon. Most of the private nurseries are in open field and are infected with several diseases and pests in the nursery and easily spread to new areas. Selection of nucellar plants is also a major issue related to seedling plants which is not found strictly followed and in case of grafted plants the size of appropriate rootstock and low height of the graft union is directly affecting in plant field establishment rate.

Moisture stress/Irrigation: Mandarin orange orchards are usually planted in unirrigated uplands/bari in mid hills of Nepal. The Indian studies suggested that about 2000 mm of well distributed annual rainfall is required to maintain good soil moisture condition in citrus orchards but in our context, there is a problem in well distribution of rainfall. More than 80 percent rainfall occurred during the 4 months of the monsoon period June/July to September/October which is fruit growth and maturity period of mandarin orange and no supplementary irrigation support is necessary during this period. Moisture stress in mandarin orange is responsible to cause the cracking and reduce the fruit size. Plant growth under drought is influenced by altered photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutritional metabolism and hormones (Seyed et.al., 2012).

Plant protection: The term citrus decline is reported as a condition of ill health and decadence of citrus trees which may arise from a number of causes. It is a complex problem of citrus resulting from both biotic and abiotic factors (FAO, 2011). Phytopthora, greening, tristiza virus are the major diseases of citrus and the effects of powdery mildew, canker is also responsible for citrus decline. Citrus fruit fly, scales, leaf miners, citrus psylla are major insects damaging citrus plants in Nepal. The plant protection management is very weak from the nursery plant production, internal and external quarantine measures to orchard cleanliness and regular monitoring management.

Good orchard management practices in mandarin orange

Most of the orchards of mandarin orange in Nepal are facing different management problems for a successful fruit growing. All these management problems are associated with the decline of mandarin orange orchard. The general symptoms associated with mandarin orange decline are restricted growth of the trees, appearance of chlorotic leaves, sparse foliage, die-back of twigs, delayed leaf flushes and blooming, deficiency of symptoms, defoliation, off-season flowering, small fruit and declining fruit production every year (FAO, 2011). The poor management effect starts to appear on bearing trees of aged 7-8 years and it becomes severe on trees 15-20 years period. The mandarin orange decline syndrome is causes by different abiotic and biotic factors discussed above, some of them reported are unfavorable soil and climatic conditions, low quality planting materials, poor orchard management, incidence of disease and insects-pests. The climatic and soil factors are not of much important to cause the citrus decline in Nepal but other factors are directly related to orchard management practices. The following orchard management practices from the orchard site selection to all good orchard management practices will be supportive to improve the mandarin orange farming system in Nepal:

Site selection for orchard establishment

The establishment of an orchard is a long-term investment and requires to select an appropriate land area. Mandarin orange tree is sun loving plant and east-north sites pockets of the mid hills of Nepal. Frost free sub-tropics to warm temperate with the altitude of 800-1400 mt from sea level are suitable areas for mandarin orange farming. The altitude of 1000-1200 meter from sea level is best for quality mandarin orange production in Nepal. A deep, well drained, free of excess natural salts with fair humus content is best for mandarin orange. Citrus plants require high oxygen in its root zone and for this reason, light sandy to medium loam soils are considered best for plant and orchard soil management. Well distributed, an annual rainfall of 2000 mm is generally regarded as sufficient.

Mandarin orange fruit grow well in between the temperature range of 14-35^0 centigrade but the optimum temperature for proper growth is 18-30^0 centigrade. The plant growth is restricted below 13^0 centigrade temperatures. Low humidity gives good color and external appearance, whereas high humidity favors thin skinned, juicy fruits which are smaller in size but high in quality.

Layout and plantation

Well prepared land before plantation will be more manageable for orchard management during growing stage. The selected land should be cleaned by removing plant debris, deep ploughing, irrigation and intercropping of leguminous crops and green manuring management before layout and plantation. There are square, rectangular, triangular, hexagonal and contour layout systems followed for mandarin orange orchard but in our case square and contour system layout is more in practice.

The bariland, developed for maize and other cereals in mid hills are found in developed terraces where square system layout is also possible and in practice but mostly in mid hills where contour slopes are available for fruit orchard need to improve in the bench terraces. Traditionally, the plantation is followed in edges of the terraces which is not manageable for cultivation practices and fertilization. In much slopy contour system 3-4 ft land circle area of plant spot should be levelled for irrigation and manuring support, where bench terrace development is not possible.

To facilitate better root penetration and to provide congenial conditions for the growth of young plants pits of 60 cm deep, wide and long should be dug. The soil taken out from the pit is allowed to open sunlight weather for 2-4 weeks, then mix it with rotten equal amount of farm yard manure or compost and filled about 10-15 cm higher than the ground level and irrigate thoroughly. After the pit is ready, the position of plant is marked with the planting-board and a slightly bigger hole than the size of earth ball is dug. The wrapping material is removed from the ball and unwrapped earth ball is put in the hole in such a manner that the union of plant remains at least six inch above the ground level. Immediately after planting, staking of bamboo stick and irrigation should be applied.

Care of young plant

The early year's life is very important for plant to produce the maximum vegetative growth during the first three or four years. At this time, the plant requires optimum irrigation, fertilization, cultivation and protection from high or low temperature and strong winds. During early summer months frequent irrigation at 7 days interval is essential and a regular weeding of plant basin is required to eradicate weeds. The sprouts which develop on the trunks below the graft union should be checked regularly and removed. Light pruning is followed during early stage, only undesirable, dry or diseased branches should be removed. The grafted mandarin orange plant will blossom and set some fruits from the third year, these fruits should be removed for proper vegetative growth and development of the young trees.

Soil requirement and nutrition management

The soil requirements of citrus are very exacting therefore before planting soil should be tested for its suitability of both physical and chemical properties. The mandarin orange trees are very sensitive to high salt concentration in the soil. The presence of high amount of calcium carbonate in soils induces the deficiency of essential nutrients like phosphorous, zinc, manganese, iron and copper. The availability of many nutrients essential to plant growth is closely related to pH of the soil. The mandarin orange tree thrives best in soils having a slightly acidic reaction with a pH range of 5.5 to 7.5, under such conditions, most of the nutrients are readily available to the plants. The soil profile should be carefully examined for the presence of any hard pan and there should be no hard pan/stone layer/lime concentration to a depth of 1 mt. Under these conditions, plant cannot absorb adequate water and nutrients from the soil and consequently, the plant growth remain stunted. Water logged soils or soils having very high and fluctuating water table should not be selected for mandarin orange cultivation. Such conditions lead to root injury and decay, ultimately resulting in the death of the plant.

Well-drained fertile sandy soils having pH up to 8.5, electrical conductivity up to 0.5 mmhos/cm, calcium carbonate up to 5%, lime concentration up to 10% and free from hard pan are best suited for citrus growing (Rattanpal et.al., 2017).

Soil organic matter is the humus, product of the decomposition of crop or animal residues by soil microorganisms. Soil organic matter is very important for sustainable soil management in mandarin orange production as it enhances the formation of soil aggregates which maintains a good soil structure for drainage and aeration.

Mandarin orange requires 17 elements for normal growth and production. Out of them, Nitrogen, Phosphorous, Potash, Sulphur, Zinc, Manganese, Iron, Copper, Boron, Magnesium are the major ones. The application of excess or less dose of nutrients results in abnormal functioning of the plant system. Mandarin orange plants need an application of the manures and fertilizers at critical growth stages. Mandarin orange is a perennial crop so every year organic and chemical fertilizers should be provided. During and after the fertilization soil structure and moisture should be in good condition so that the nutrient will be easily available to the plant. The recommended doses of manure and fertilizers and application time is summarized in table 2.

Table 2. Recommended doses of organic manure and chemical fertilizers in mandarin orange plant (per plant/per year).

Plant age (year)	FYM/Compost (Kg)	Nitrogen (Gram)	Phosphorus (Gram)	Potash (Gram)
1	10	50	25	35
2	20	100	50	70
3	30	150	75	105
4	40	200	100	140
5	50	250	125	175
6	60	300	150	210
7	70	350	175	245
8	80	400	200	280
9	90	450	225	315
10 and above	100	500	250	350

Source: NCRP, 2015

For growing plants, apply the full dose of FYM, phosphorous and potash along with one third amount of nitrogen in December-January, apply second dose of one third amount of nitrogen in July and last dose in September. For fruiting plants, apply full dose of FYM, phosphorous and potash along with half dose of nitrogen in December- January and remaining nitrogen in July-August. Manures and fertilizers are generally applied in the soil. Tree basins are prepared by light hoeing and then manures and fertilizers are broadcasted. After broadcasting, they are mixed well into the soil by giving second hoeing.

Alternatively, a trench of 1 ft deep and wide is prepared along the drip of the canopy and then manures and fertilizers are applied in the trench. This is followed by covering with the soil, irrigation and mulching. While fertilizing the trees, care should be taken to keep the trunks of the trees free from the contact of fertilizers.

In nutrients deficient condition, the appearance of visual deficiency symptoms of a particular element may occur in different parts of the mandarin orange tree. It is very important for a citrus grower to diagnose nutrient deficiency symptoms. Following these symptoms and to provide need-based fertilizers for good production. Some of the major deficiency symptoms and corrective measures of these plant nutrients are summarized in the table 3.

Table 3. Major nutrient deficiency symptoms and corrective measures of mandarin orange

Plant Nutrient	Deficiency symptoms	Corrective measures
Nitrogen	Yellowing of leaves, limited twig and leaf growth, tree undersized, fruit size reduced	Application of 1500 gm nitrogen/tree in three split doses in early March, May and late September or soil application of nitrogenous fertilizers in two or three split doses.
Phosphorus	Defective formation of buds; discoloration of leaves; reduced number of lateral shoots with reduced growth; limited and delayed blossom-ing; poor fruit setting; premature fruit dropping; coarser fruits with thick rinds	Application of 600 gm phosphate/tree in single dose during late winter or early spring.
Potassium	Foliage is spare, necrosis on one side of leaves; die back of twigs; irregular yellow blotching in leaves in late summer; fruit small with thin peel and decay rapidly.	Application of 600 gm potash/tree in single dose during late winter or early spring.
Magnesium	Yellow areas developed between the large veins and on both sides of the mid-rib; bronzed leaves; chlorosis in the old leaves; poor root growth; alternate bearing and poor-quality fruits.	Spraying of 0.25% magnesium sulphate twice at 15 days interval on new flushes.
Zinc	Interveinal chlorosis; small leaf size; dieback from terminal twigs; fruits small, insipid and misshapen;	Spraying of 0.5% zinc sulphate at 15 days interval on new flushes.

Source: FAO, 2011.

Irrigation and drainage management

Mandarin orange trees are evergreen in nature and they require water all the year round. In Nepal, Mandarin orange is grown on uplands where there is no irrigation facility and has to depend on rain water. It is suggested that about 2000 mm of well distributed annual rainfall is sufficient to maintain good soil moisture condition in mandarin orange orchard. But in Nepal, more than 80 percent rainfall occurred during the four months of the monsoon period (June/July- Sept/Oct). This is the fruit growth and maturity periods of mandarin orange and no supplemental irrigation is necessary during this period. The monsoon rain moisture retains in orchard soil by December, after then starts dry period. Water stress in spring and early summer (February-May) during flowering, fruit set and early cell division will have a big impact on reducing fruit numbers, fruit size and overall yield.

It is recommended to apply irrigation in 15 days interval from January to April mid and 10 days interval from April mid to June middle. Irrigation requirements of young trees are less than bearing trees. Closely spaced trees require more water than widely spaced trees. It is estimated that 60 liters of water is required to produce one kilogram of fruits. There are different methods of irrigation systems. The commonly used irrigation methods are:

- Basin system
- Furrow system
- Flooding system
- Sprinkler system

Drip Out of these systems, basin, furrow and flooding systems are conventional surface systems which need more water, and is not available in our mandarin orange growing areas. Considering the water sources and efficiency of water use, the sprinkler and drip irrigation systems are recommended. The rates of water use efficiency of sprinkler and drip systems are 70-80 percent and 80-90 percent, respectively.

Excessive irrigation is unfavorable to the mandarin orange orchard as it may lead the citrus foot and root rot, a very serious fungal disease caused by *Phytopthora* fungi. Water logged conditions around the tree trunk should be avoided. Even in the inner side of the bench terraces in mountain uplands with clay red soils, faced drainage problems need to take care during heavy summer and develop drain facilities without delaying to root decaying problems.

Inter-cropping

The principle of intercropping is to take additional income from other crops from mandarin orange orchard. As mandarin orange is a perennial crop and it takes 5-6 years to get income. It is possible to utilize the open space between fruit trees by planting short period leguminous or other vegetables crops for first four to five years. Intercropping not only provides additional income to the farmer but also checks the weed growth, conserve soil moisture and prevents soil erosion.

Exhaustive crops like maize, millets, wheat are not suitable for intercropping. The shallow rooted and short duration crops like pea, cowpea, dwarf french bean, soybean, chili, garlic, gram, leafy vegetables, cabbage, cauliflower, carrot are beneficial intercrops in mandarin orange orchards. The vine crops like pumpkin, sponge guard, are not suitable for intercrop as they cover and compete with the growing plant and attract different pests and diseases. Intercrops should be additionally manured and fertilized. The pests and diseases of the intercrops should not attack the main crops. The fruit trees and intercrops should be provided with independent irrigation support.

Weed management

Weeds are serious problem in mandarin orange orchards. Due to shallow fibrous root system mandarin orange is susceptible to weed competition. Tree basins around the canopy should be kept free of weeds all the time of the year otherwise they compete with fruit trees for moisture and nutrients, and provide shelter for pests and diseases. Major weeds can be controlled by hand pulling, cutting, hoeing and tillage. Regular practices of manuring, hoeing, mulching by dry straw and grass and proper intercropping will control weeds in integrated way. Alternatively, Diuron (5 kg/ha) and Terbacil (4.5 kg/ha) pre-emergence and Atrazin (5-6 kg/ha) post-emergence weedicides can be used for chemical weed control. Bromocil (6 kg/ha) is most effective in controlling both monocot and dicot weeds.

Mulching

Mulching conserve soil moisture by reducing evaporation, improves soil fertility and health by adding organic matter. It also reduces the weed growth by blocking sunlight and moderate soil temperature by acting as an insulator. The organic materials like dry straw, grass, saw dust, rice hulls, dry leaves, weed scrapings are basically used as mulching materials. Plastic sheets are also used as a mulch nowadays, which provides moisture retention, helps in soil heat up faster and retain, improves soil texture, prevent some pests, protects plant roots and suppresses weeds.

The mulch should not be in contact with the trunks of the trees, as this can provide a site for pests and diseases. The bark of the trunk becomes soft and vulnerable to pests and diseases if it is covered by moist organic matters. The best time for mulching in mandarin orange orchards is September to October, when the moisture is available in the soil and organic materials, such as scrapings of weeds abundantly available for mulching. If mulching is done before surface soils are dried, it helps to retain the moisture. It is recommended to do mulching to a depth of 8 cm. Mulching should be practiced in all mandarin orange growing uplands of Nepal.

Canopy management

The alteration of tree canopies to maximize the production of high-quality fruit is known as canopy management. Proper control of vegetative growth is essential for the maintenance of healthy, productive mandarin orange orchards. Mandarin orange orchards are not generally pruned but to give ideal shape and keep tree healthy, tree training and pruning is essential. An ideal mandarin orange tree should be low headed with a dome like crown. Pruning of young tree to give them proper shape and size is known as training. Mandarin orange trees are trained to single stem with 4-6 well spaced branches for making the basic framework and the lowermost branches should be allowed not to grow below the height of 50 cm from the soil surface.

Pruning

The bearing mandarin orange trees require little or no pruning but the removal of dead, diseased, criss-cross and weak branches should be pruned or removed. Removal of water sprouts and suckers is essential. Pruning of non-bearing trees can be done at any time of the year but for bearing trees the best time is after harvesting, during late winter or early spring when these are in slightly dormant stage. It is necessary to understand the response to pruning depends on several factors including variety, tree age, vigor, fruiting habits, growing conditions, and production practices. The mandarin orange growers should have clear understanding of the principals involved in canopy management.

Sunlight provides the energy for photosynthesis in which carbon dioxide from the air and water from the soil are combined in leaves to form foods upon which trees live, grow and bear fruits. So, the sunlight intercepted by the tree canopy is important for high yields of good quality. The balance between tree growth and fruitfulness appears to depend upon the relationship between carbohydrates and nitrogenous compounds within the tree. When both are adequate, moderate growth and high yield occur.

Disease management

Many diseases reported in mandarin orange in Nepal, Huanglongbing (Greening) disease is the major one and now being threat to the citrus industry. Other important diseases are *Phytopthora* induces diseases, Tristiza virus, canker, twig blight, and powdery mildew.

The major three diseases management is described here:

Huanglongbing (Greening)

This disease is caused by the phloem-restricted gram-negative bacterium known as *Candidatus Liberibactor* asiaticus. It is polymorphic in nature and cannot be cultured in artificial media.

Symptoms: At the beginning yellowing of single or few branches is observed in some trees of the orchard which gradually spreads out to other branches. The infected trees become severely affected with symptoms like open growth, stunting, twig die back, sparse foliage and sever leaf and fruit drop. The whole orchard declines within 2-3 years. This disease is transmitted by insect vector called Citrus psylla- *Diphorina citri*.

Management:

- Strict management of internal and external quarantine.
- Removal of infected trees.
- Use of healthy planting materials produced under screen houses.
- Removal and destruction of alternate hosts- Kamini- *Murraya paniculata* and *Murraya exotica* (Asare of Boke jamun)
- Control of Citrus psylla by insecticide during March-April

Phytopthora induced diseases

It is a soil borne pathogens and remains in the soil for long time. The disease is caused by different species of Phytopthora.

Symptoms: Damping off of seedlings, root rot of grown-up seedlings and in grown up citrus trees, foot rot, collar rot, and gummosis.

Management:

- Produce healthy saplings inside screen house, use fumigated soil media.
- Use containerized nursery with sterile media
- Graft union should be 25-30 cm above ground level
- Field nursery seed bed should be well drained
- Use Phytopthora resistant rootstock- *Poncirus trifoliate* grafted saplings only.
- Application of Bordeaux paste and drenching with Bordeaux mixture is very effective.

Citrus root nematodes (*Tylenchus semipenetrans*)

Citrus root nematode as a new species, *Tylenchulus semipenetrans*, was identified as the causal agent of slow decline in citrus in 1913. The nematode is found causing disease worldwide in citrus growing areas (Duncan, 2005). Among all species, *T. semipenetransis* dominant pathogenic species in most citrus regions (Verdejo-Lucas & McKenry, 2004). The disease is a major and common disease of citrus prevalent in all citrus growing areas of Nepal (Karki, 1997).

Symptoms: Root stunting and root decay occurs and the above ground parts of the plants have reduced growth, die back from the tip of the plant, reduced in fruit size and production of the citrus (Acharya et al., 2019).

Management:

- Use healthy saplings and intercropping with marigold reduce the nematode incidence in soil.
- Use of resistant Swingle citrumelo (Galeano et al., 2003) rootstocks if available and trifoliate orange rootstocks (Acharya et al., 2019)
- Soil drenching with Dichlorofenthion @ 45ml/ha or Ethoprophos @ 40gm/ha can effectively manage the nematode population in soil (Pandey, 2022).

Insect pest management

Citrus psylla, green sting bug, leaf minors, scale insect, white flies, black aphids, brown aphid, red mites, blue beetle, lemon butterfly, stem borer, bark eating caterpillar, Chinese fruit fly, oriental fruit fly are common insect pests found in Nepalese mandarin orange orchard (Poudyal et. al., 2016).

Management:

- Integrated approach of management is best way
- Stressful condition on plants should be avoided such as close planting and water logging, drought etc.

- Good orchard sanitation and removal of weed is very important.
- The affected plant parts should be pruned timely and destroyed.
- Excessive use of nitrogenous fertilizer and irrigation should be avoided in mandarin orange orchard.
- Need base application of insecticides for management of insect pests based on ETL is very important for commercial production.
- Use and conservation of predators/parasitoids and other natural enemies.
- For management of bark eating caterpillar, stem borer application of Bordeaux pastes during March-April and September-October on the tree trunk up to the height of 1m is very effective (Nath & Deka, 2020).

Phanerogamic Parasitic plants (Ainjeru)

It is the member of family Loranthaceae, polyphyletic group of flowering parasitic plants and are commonly known as "Ainjeru" or "*Lisso*" in Nepali (Pandey, 2022). 'Ainjeru' are obligate stem parasites which may be holo or hemiparasite and have haustorium for the absorption of nutrition from the host, attachment to the root and penetration into the host. Of the over 1300 mistletoe species occurring worldwide, 19 species of mistletoes are available in Nepal (Devkota, 2005). The dispersal of seeds of the plants is through birds and animals (Pandey, 2022). According to Lama (1980), the Mistletoes growing around and parasitizing citrus plants throughout the country.

Symptoms: Swellings or tumorous growth of the infected tissues is observed at the point where haustorium is produced. The affected host plant becomes stunted. The parasitic plant feeds and leads to dieback and death of the branches (Pandey, 2022).

Management:

- Remove infected branched by cutting 1cm below the infected part and is suggested to prevent further spread of the Ainjeru in citrus.
- Base banding with 1% 2,4-D for xylem translocation that results in non-regenerative parasitic mortality and two consecutive foliar sprays with either 1% ethephon or 60% diesel, with the second spray on leaf re-emergence was reported effective for Ainjeru (Deepu & Habeeburrahman, 2013).

Other disorder management

- Sun burn: Sun burns usually occurs during May-June. Damage symptoms appear on leaves, stems and fruits. Symptoms on leaves appear as burning and affected tissue become brown. Moisture stress during summer months intensifies this problem so moisture stress during this period should be avoided.
- Cold injury: Frost can damage both tree and fruit of all citrus varieties. The mandarin orange fruit is usually damaged when temperatures fall below 3.3^{0}C for a period of several hours. Young trees can be successfully protected from frost by providing irrigation.

- Fruit cracking: Fruit cracking is related with the problems of disturbed water relations in plant, peel thickness and peel maturity of the fruit. Trees take up water from rain or irrigation after a long dry period and fruit expands, cracking the peel of the fruit. Plant should not be exposed to water stress to avoid this problem.

Conclusion

The latest report says mandarin orange is being grown in 56 districts and out of them 42 are recorded for commercial production area. It occupies about 60% of total citrus and 13% of total fruit production in Nepal. Due to low investment, use of unhealthy planting materials and weak research and extension support the mandarin orange orchards are facing complex problems of management and it ultimately causing citrus decline in Nepal. As mandarin orange farming is traditionally practiced in dry uplands/bari and marginal rainfed area of mid hills, where moisture stress during flushing, flowering and fruit set results poor quality fruits. Additionally, unbalanced fertilization and manuring; intercropping of exhaustive crops and heavy ploughing diminishing the orchards productive life. It is most urgent to address this issue to improve the regulatory, managerial and technical capacity by transforming present traditional fruit farming practices to improved ones. Realizing this fact, good orchard management practices adapted in Nepal and India from the orchard site selection, quality planting materials selection, soil and moisture management, balanced manuring and fertilization to insect pests and diseases management is summarized in this chapter.

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Citrus Production and Management System in the Sudur Pashchim Province of Nepal

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Abstract

A household survey was conducted in a citrus production pocket of Sudur Pashchim Province (SPP) i.e. Kailali (Sahajpur), Dadeldhura (Bagarkot), Baitadi (Durgabhawani), Doti (Kaphalekhi) and Achham (Mangalsen) from August 26 to September 5, 2006. Selected sites were already known history of low productivity and suffering from the citrus decline. All the information collected by using semi-structured questioner from twenty randomly selected citrus growing farmers of each pocket. More than 90% farmers were used seedling plant in their orchard. Established nursery condition was observed in poor condition. There were no improved orchard management practices followed by the farmers. Most of the old orchard was in declined condition. Powdery mildew and root rot were two major fungal disease found in all districts. Upland rice or maize (rainy season) and wheat (winter season) are commonly intercropped in the orchards. Plant parasites of citrus, Aijeru (*Loranthus Spp*) was commonly found in all districts but was very severe in Achham. Green string bug was the major insect causing citrus fruit drop. There was no proper marketing channel, most of the farmers were sale their product by them self only few farmers sale to the whole seller. Survey revealed that on an average, citrus fruits, mainly mandarin and sweet orange, contributed about 25% family income of citrus grower. Thus citrus cultivation in SPP was found very primitive and traditional and can increase productivity through dissemination of improved production technology.

Keywords: Survey, Semi-structure, Orchard, Aijeru, Powdery mildew, Green sting bug, Whole seller, Primitive

Introduction

The hilly area of Nepal, occupies about 68% of land and about 45% of the population are living in this region among which about 40% are living below poverty line. Per capita availability of cultivated land is so small (<0.105 hectare), that subsistence production of cereal crops from rainfed hill slope is not sufficient to improve the hill people (MoALD, 2005). Mild sub-tropical climate available in mid-hill (800-1400 m) agro-ecological region of Nepal is very suitable to produce high quality citrus fruits (Roistacher, 1996) and thus, has great potential for export (Gurung, 2003). In Nepal, citrus fruit crops like mandarin orange, sweet orange, acid lime and lemon were cultivated in about 26,682 hectare of land in 2005 of which 15,206 hectare had fruit bearing trees with 164,075 metric tons of total production (MoALD, 2005). Despite of high potentiality, the productivity of citrus in Nepal is very low (10.7 tons/ha) compared to many other major citrus growing countries like USA- 35 tons/ha., Spain-28 tons/ha, Japan- 22 tons/ha, Brazil- 22 tons/ha etc (FAO, 2004). Even within Nepal, Sudur pashchim Province (SPP) has lowest productivity (9.7 tons/ha) than the other regions (MoALD, 2005). Sudur Pashchim Province (SPP) shares about 9% (2402 ha) of total citrus area of the country but due to low productivity, its share on total citrus production is only 8.1%. Even at present level of low productivity mandarin orange gives about 4 times more profit than the cereals in upland cropping system of mid-hills (Gauchan, 2003). However, citrus growers of Nepal in general and those from far western hills in particular have not yet received anticipated benefit from citrus cultivation. Therefore, a survey was conducted in five citrus production pockets of SPP to find out existing citrus cultivation system, which are directly, or indirectly contribution for low productivity.

Materials and methods

A house hold survey was conducted in a citrus production pocket of SPP i.e. Kailali (Sahajpur), Dadeldhura (Bagarkot), Baitadi (Durgabhaqani), Doti (Kaphalekhi) and Achham (Mangalsen) from August 26 to September 5, 2006 (2063 Bhadra 10 to 28). Before selecting the sites detailed discussion was held in the DADO offices with senior staffs. Then the above-mentioned pockets areas were selected for conducting survey. Pocket areas those pockets having known history of low productivity including citrus orchard decline problem were selected. Information on orchard management practices was collected by using semi-structured questioner from twenty randomly selected citrus growers' farmers of each pocket of the selected district. The survey team members composed of citrus expert, representative officers of District Agriculture Development Office (DADO) and socio-economist. The team members also noted down the remarkable aspects of citrus cultivation that existed in farmers' orchards. Secondary data and other necessary information were also collected from DADO.

Results and discussion

Agro-ecology of citrus cultivation

Citrus orchards in the survey areas were established in a wide range of altitude from 1000-1650 masl which is typical mid-hill climate in up-land terraces under rain fed condition. Most of the orchards were established at around 1000 masl altitude range in Sahajpur, Kailali district and orchards of Sirad, Dadeldhura were established relatively in higher altitude (1450-1650 m). According to the farmers view, sometimes frost was observed in the higher altitude range Dadeldhura district, but that does not affect to the citrus trees. The soil type of citrus orchards in all sites was found loam to clay loam, which is suitable for citrus cultivation.

The agro ecological characteristics of survey sites were north or north-west facing which is favourable for citrus cultivation, where moisture is conserved for longer duration during summer season in the hill. Citrus production pocket of Shajpur, Kailali was very near from motorable road (1.½ an hour walking distance) while Mangalsen of Achham was at least 8 hours walking distance from nearby motorable road (Table1). However, construction of roads through district and national projects are found undergoing which indicates that citrus production pockets will be connected by roads within few years thereby reducing the transportation cost of inputs and farm products significantly.

Table 1. Agro ecological characteristics of sites

S. No	District	Location of pocket	Altitude (M)	Aspect	Distance from road
1.	Baitadi	Durgabhawani VDC -2, Barkurali	1450-1580	North facing	3 hour walking
2.	Dadeldhura	Bagarkot VDC-5, Serad	1350-1650	North	6 hour walking
3.	Doti	Kaflekhi VDC-5, Tichada	1200-1350	North facing	3 hour walking
4.	Achham	Mangalsen VDC-5,6	1350-1450	North west	8 hour walking
5.	Kailali	Sahajpur-6,9	1000-1350	North facing	1 hour walking

Socio-economic characteristics

All the castes of the region like Chhetri, Thakuri and Dalit were involved in citrus cultivation. In recent years rich people have started to migrate to terai and urban areas due to political conflict. It was found that such migrated families give their existing citrus orchards in lease to the poor people. Such leased out orchards were not maintained properly and were also serving as the source of diseases. Most poor people were not involved in citrus cultivation because of limited land and other resources required for cultivation. Therefore, households from economically middle class have the majority of citrus growers in surveyed areas. Young people were found reluctant to stay in the village either due to the unemployment or unfavourable political situation. They were found to prefer off-farm employment in urban areas or in foreign employment.

Average working manpower per household family was five. Labour exchange system between the neighbours was common practices in the SPP. Except in large sized orchards, the family members mostly fulfil the labour requirement for orchard management. Mostly labours are used at harvesting and transportation of fruits. The size of citrus orchard per household varied from 10 to 19.4 Ropani or 85 to 1722 trees in the surveyed areas. Average number of households involved in citrus cultivation was 60 in Kaphalekhi and 120 in Mangelsen. Number of citrus trees per family ranged from 85 in Baitadi to 172 in Doti (Table 2).

Table 2. Socio economic characteristics of the survey sites

S No	Location of Citrus growing pocket	Total No of houehold	Family Size**	Literacy no/ fasmily*	Working Manpower pre family	Land size** (Ropani)	No of citrus trees / family**
1.	Durgabhawani VDC -2, Barkurali	80	8	3	5	18.7	85
2.	Bagarkot VDC-5, Serad	75	9	3	5	10.0	132
3.	Kaflekhi VDC-5, Tichada	60	7	3	5	10.1	172
4.	Mangalsen VDC-5,6	120	8	3	5	19.4	115
5.	Sahajpur-6, 9	90	9	5	6	16.5	115
Average		85	8	3	5	15	124

* Five classes passes in a family.

** Average size of twenty selected citrus growing farmers.

Nursery management system

Survey team visited three citrus nurseries owner in Dadeldhura, Doti and Achham district and collected detail information on nursery management system. All these nurseries were established under citrus orchards with many bearing trees showing symptoms Huanglongbing (HLB) disease. More than 90 percent of planting materials produced in these nurseries were seedling plants. Nursery owners have not maintained selected mother plants for sapling and scion production in hygienic condition rather they collect seeds for seedling production randomly from any tree. They also collect seeds from unmarketable poor quality fruits. Nursery practices such as selection and rouging of off-type seedling is not practiced. According to nursery owners, farmers prefer seedlings plants than the grafted pants because of three reasons: (a) seedlings are cheaper than grafted plant (b) easy to establish in the orchards and (c) farmers can produce themselves. Seedling trees are highly susceptible to soil borne diseases like phytophthora root rot. In summary, nursery management system was found very poor in the far western region. Success of citriculture heavily depends on the quality planting materials. One of the causes of decline of mandarin orange trees in the survey sites seems to be used of poor quality planting materials for orchard establishment. So, replacement of seedling trees by disease resistant grafted plants will help for improving productivity, quality and productive life of commercial citrus orchards.

Orchard management system

Area of citrus cultivation has been increasing every year in all districts due to awareness of farmers that citrus fruits are more profitable than cereal crops. About 30% of the sampled farmers had more than 50 trees. Existing orchards were found predominantly seedling origin. Most of the old trees were planted at edge of the terraces. Saplings are planted in holes made by iron or wooden peg without following recommended size and pit digging system. Because of edge planting, the matured trees (more than 20 years old), were suffering from the moisture stress and malnutrition. Farmers were not adopting any training and pruning practices. Ainjeru (*Loranthus spp*) was found on the citrus trees in all sites. Extension service on citrus cultivation was found so poor that even the removal of Ainjeru from citrus trees was not adopted by the farmers.

Cropping pattern: Citrus, maize, upland rice, wheat and millet were the major crop of upland (Bari land) in the surveyed sites. Almost all trees in old citrus orchards were found planted at the edge of upland terraces. In such situation the terraces of the field were used for cereal crops. However, in recent years farmers have started to establish citrus orchards inside the terrace. Intercropping of cereals under young citrus trees was also common practice in all districts. In Doti, upland rice during rainy season and wheat in winter season were the most common crops used for intercropping followed by finger millet. In Kailali, Dadeldhura and Baitadi maize and wheat were found commonly grown as intercrop under citrus trees. In recent years, few farmers have also started planting soybean, mustard, vegetables or potato under citrus orchards.

Manure and fertilizer: None of the citrus growers of the surveyed areas were found using any chemical fertilizer to citrus trees due to higher cost, no irrigation and lack of awareness about the nutrient requirement of citrus trees. Domestically produced compost was the main source of nutrient for citrus and other crops. But cereal crops get first priority while applying compost. Compost is applied to citrus trees, if it is left after applying to cereals. Livestock like cattle and goats are the major source of compost and manure. Farmers also use farm and forest products for making compost. The compost making technique was found very traditional resulting to poor in quality compost. In most cases, domestically produced compost was not sufficient to fulfil nutrient requirements of farmland.

Weeding and Irrigation: The amount and time of irrigation is dependent on tree age, soil type, climates and irrigation techniques. Mature trees require more water than young trees but young trees require more frequent irrigation because of limited root systems. As citrus is a perennial evergreen tree, it needs moisture in the soil throughout the year. In SPP, all citrus orchards are established in upland areas where the sources of irrigation are not available nor do farmers follow any practices for moisture conservation like mulching around the tree canopy. Trees solely depend on rainwater for moisture requirement. Therefore, such trees were found suffering from moisture stress during drought season. Hoeing and weeding is done for cereals but not especially to the citrus trees. In summary, very poor orchard management practices are being adopted in all survey sites. A matured citrus tree requires minimum of 45 to 50 inches of water annually for maintenance of tree health and best quality fruit production (Sauls, 2002). So, technique of moisture conservation especially for dry season that suits for up-land rain fed citrus growing conditions of Nepal should be developed for productivity improvement.

Disease and Insect Pest

Powdery mildew (*Oidium tingitanium*) was the most common disease of citrus species in all districts. According to farmers the disease is more serious during July- August when new flushes develop in the trees and weather is fuggy. Trees showing symptoms of Huanglongbing (greening) disease were located in Dadeldhura and Doti but needs to be confirmed by Polymerase Chain Reaction (PCR) test. Although the population of *Diphornia citrii,* (vector of Huanglongbing) was observed in areas of Kailali (below 1000 m), it has also been found up to 1900 m altitude of Nepal (Gurung et al, 1992). So, high priority should be given on monitoring HLB disease and its vector along with appropriate management programme to save the citrus orchards of the region.

Ainjeru (*Loranthus spp*), a kind of plant parasite was found on citrus trees in all sites. In some cases trees were seriously affected by this parasite. It absorbs nutrients from plant tissues resulting to decline of citrus trees. Root/ foot rot (*Phytophthora spp*) and Melanose disease were also found in survey sites. Two diseases namely Huanglongbing and root rot are the two major agents for citrus decline in this region. Among citrus insects, green stinkbug and leaf minor were the most commonly present in all sites. Farmers do not practice any control or preventive measures to control of these insects.

Marketing system

Mandarin orange (*Citrus reticulata* Blanco), sweet orange (*Citrus sinensis*), acid lime (*Citrus aurantifolia*) and lemon (*Citrus lemon*) are the major citrus species found in surveyed areas. Among them mandarin orange was the important sources of cash generating commodity due to easily marketable. Most of the farmers who have their own land are cultivating citrus trees. The number of trees per household ranged from 10 to 350 trees depending on land size. Depending on the size of orchard citrus growers are earning from Rs 5,000 to 150,000 per year. On and average about 25 percent of household income was contributed by citrus fruits. Small farmers who do not have citrus trees are getting jobs in fruit harvesting and transportation to markets. They also involve in marketing of citrus fruits in local market. A hired labour gets Rs. 150 to 200 per day for fruit transportation depending on distance and weight of load from producers.

There is no reliable channel of marketing for fruit sale in the survey sites. Farmer's sale fruits to whole seller, local costumer or vendors in average price Rs.1.25 per fruit or Rs 15.0 to 20.0 per kilogram. Consumers prefer mandarin orange than sweet orange. Therefore, sweet orange is sold only after mandarin orange is completely sold out do not grade fruit in February-March. Generally, growers themselves do not do grade fruits but the whole seller or retailers do fruit grading based on size. Small sized orchards located at scattered places and away from motorable roads are the major constraints for citrus marketing resulting in low price to producers, high marketing cost and risk to traders.

Conclusion

Citrus cultivation was not limited to any particular cast but was under taken by all casts such as Brahman, Kshetri and lower cast residing mid hills region. Young people were not attracted towards agriculture including citrus cultivation. They preferred off-farm employment either in cities of Nepal or foreign countries such as India, Middle East and Malaysia. This is one of the obstacles for commercialisation of citrus cultivation in SPP. About 90% of the planting materials were seedlings. Few private nurseries have started producing grafted plants in recent years but quality of such plants was poor. Citrus nurseries have been established under orchards with trees suspected to be contaminated with graft transmissible diseases including Hanglongbing. Agriculture extension agencies of the region are lacking any program to improve the quality of grafted plants. Nursery owners do not maintain quality mother plants although they know the importance of mother stocks for quality saplings production. Almost all old citrus trees (>20 years old) are planted at the edge of terraces. In recent years farmers have started to plant inside the terraces. Recommended technologies of pit digging and soil preparation are not followed. A small hole is made by iron peg and seedling is planted in it. Farmers do not apply chemical fertilizer to citrus trees but they apply compost, if it is left after applying to cereals. Upland rice or maize (rainy season) and wheat (winter season) are commonly intercropped in the orchards. Powdery mildew and root rot were two major fungal disease found in all districts. Citrus trees with typical symptoms of Haunglongbin (HLB) were also found in Dadeldhura and Doti district, which needs to be confirmed by PCR test. Plant parasites of citrus: Aijeru (*Loranthus Spp*) was commonly found in all districts but was very severe in Achham. Green string bug was the major insect causing citrus fruit drop but none of the farmers were found applying any measure (local/ scientific) to control the insect. Farmers can earn Rs 500-15000 per year per family depending on orchard size. Survey revealed that on an average, citrus fruits, mainly mandarin orange and sweet orange, contributed about 25% family income of citrus grower. Farmers' sale fruits to whole seller, local costumer or vendors in average price Rs.1.25 per fruit or Rs 15.0 to 20.0 per kilogram. There is no organised group particularly formed for citrus production and marketing. Thus citrus cultivation in SPP was found very primitive and traditional with tremendous scope to increase productivity through dissemination of improved production technology.

Suggestion and recommendation

- Training is needed to nursery owners on selection and maintenance of quality mother plant and quality sapling production.
- Nurseries should be established at least 1 km away from citrus orchard.
- Introduction of early and late season varieties is necessary to expand production season.
- Training to farmers on integrated orchard management system is necessary to increase the productivity.
- Removal of unproductive and diseased trees from the orchard and re-plantation using quality grafted plants.
- Implementation of action research or demonstration on nutrient management, moisture conservation, and disease management with especial focus on HLB and root rot to minimise declining problem.
- Consolidation of citrus production pockets with marketing infrastructure and support.

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Nursery Management and Propagation Technique in Mandarin Orange

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Abstract

Management of mandarin orange nursery is a complex activity. Practices followed in nursery determine the fate of mandarin orange orchard. Most of the private nurseries in Nepal produce seedlings of mandarin orange as planting materials that lead to susceptibility to numerous diseases. Others producing grafted are in open field condition hence are infected with several diseases and pests in the nursery that can easily spread to new areas. Rootstock is an important component in influencing tree vigor, height, fruit quality, precocity in bearing and tolerance to diseases. Planting material produced by using suitable rootstock in containerized nurseries with sterile media minimize the chances of soil borne diseases. Use of screen houses in raising rootstocks, mother plants and grafted plants minimize the spread of vector transmissible diseases and ensure healthy mother plants. Government owned farms and some well established nurseries have initiated the production of mandarin orange planting materials inside screen houses in Nepal but different standards are still to be developed. Production and distribution of quality planting materials is possible through implementation of bud wood certification program.

Keywords : Mandarin orange, Nursery, Planting material, Diseases, Bud wood

Introduction

Mandarin orange nursery is a profitable enterprise. Its requirement differs slightly from other fruit nurseries although most of the practices remain similar. Need for the additional requirements (infrastructures and regulations) are due to Huanglongbing (HLB), Phythopthora related diseases and other diseases that transmit through insects and propagative materials. Mandarin orange nursery production involves mainly two methods i.e. field nursery production and protected nursery production. Field nursery is a traditional practice of raising planting materials. Private nurseries fulfilling the major demand still produce seedling as main planting materials of mandarin orange. Many nursery owners doesn't know the comparative advantages of grafted saplings over the seedlings. They lack knowledge on scientific nursery management techniques. Most of the private nurseries are in open field hence are infected with several diseases and pests that can easily spread to new areas. Use of such poor quality planting materials is one of the reasons for citrus decline in Nepal. Most of the nurseries involved in production of grafted plants are also in open field condition. No proper attention is given to prevent the occurrence of soil borne diseases and bud and insect transmissible diseases. Such propagation practices are contributing to the spread of diseases such as Citrus Tristeza Virus (CTV) and Huanglongbing (HLB) to a great extent (FAO, 2011).

Greening is the serious problem for mandarin orange industry in Nepal and is caused by a gram negative phloem-restricted bacterium, *Candidatus Liberibacter asiaticus*. The pathogen of this disease is graft and vector transmissible. The disease is spread by Asian citrus psyllids (Diaphorina citri) which prefers lower altitude and hot and dry weather conditions. Another disease, Phytopthora species cause foot rot, root rot, crown rot, gummosis, leaf fall and brown rot diseases in manadarin (Poudyal and Shrestha, 1995). In Nepal, most of the mandarin orange trees that are grown from seedlings are reported to be more susceptible to this disease. Even grafted trees on rough lemon rootstocks are severely attacked by this disease. But the trifoliate and its hybrids are highly tolerant to Phytopthora species. Roistacher (1996) reported that mandarin orange is usually a symptomless carrier of several strains of CTV. CTV is a graft-transmissible virus and is primarily transmitted through infected bud wood and insect vector.

One of the approaches widely used in the world to combat HLB and other diseases is the production of high quality planting material in protected structures. Protected nursery production offer advantages like possibility of raising the plants in containers, enhancing the grafting or budding duration, protecting the buddings and grafts from extreme hot and dry weather. Smaller nursery area is required for containerized nursery production and there is no need to change nursery sites every year. Use of sterile growing medium in containers eliminates the spread of soil-borne diseases and insects. Use of screen houses in raising the rootstock, mother plants and grafted plants prevent the spread of bud wood and insect vectors transmitted diseases, thus ensuring the production of high quality planting materials of mandarin orange.

Site selection

The nursery should ideally be located on representative land where climatic conditions are similar to the area where the grafted plants will be ultimately planted. It should be minimum of 1000 to 2000 meter far from the commercial orchard to minimize the spread of diseases (Chalise et al., 2013).

Raising of rootstock

Different citrus species are used as rootstock for mandarin orange in different countries according to their requirements. Graft compatibility, vigor, pests and disease tolerance or resistance, adaptability to soil conditions, fruit quality and other features are possessed by the rootstocks. Selection of particular rootstock is done on the basis of presence of the greatest number of desirable characteristics, in keeping with the requirement of the orchard in which the tree will grow. In Nepal, according to Acharya et al (2076) trifoliate orange is mainly used as a rootstock for producing mandarin orange plants. Other species like Rangpur lime and Citrange are also used but in negligible amount Once the rootstock has been selected, the collection of fruit for seed must be done from the healthy and vigorous trees. Fruit for seeds must be picked directly from the tree as the fruit fallen on the ground are more subjected to fungal infection that may later contaminate the whole seedbed (FAO, 2011).

Extraction and treatment of the seeds

Extraction of seeds must be done within 1-2 days after harvest. A shallow cut of about 1 cm deep is made through the rind and approximately around the center of the fruit. The two halves are then twisted and separated. The cut fruit is then squeezed into a sieve to collect the seeds. A hand extractor would be helpful if amount of fruit is large. By placing the seeds in water, the floated underdeveloped seeds and the pulp are discarded. Remaining seeds are slightly rubbed with ash or sterile sand to remove the mucilage and finally cleaned with water. The seeds are then allowed to dry in shade for 2 to 3 days. Sowing the fresh seed increases the germination percentage but this may not be always practicable. Germination percentage of the citrus seed will drop sharply if the moisture content falls below 70 percent. Seeds should be treated with effective fungicides, whether sowing immediately or storing for future (Marte, 1987). Zip lock polythene bags are recommended, especially when seeds are to be stored at a cool temperature. The vegetable compartment in most refrigerator is the best place for storing seeds with temperature 4-6 degree Celsius for 6 months without significant loss of viability.

Sowing of seed (Primary nursery)

Field nurseries are the major practice for raising seedling rootstock and the grafted saplings of mandarin orange in Nepal. Eradication of soil borne pathogens once introduced becomes very difficult in field nurseries. Seed beds are prepared by mixing well decomposed FYM in soil. Use of virgin soil collected from the forest is also found. Seed bed of about 75 cm width with suitable length are raised 15 cm above the general level of the plot to facilitate drainage. Then seeds are sown 1.5 cm deep in line maintained at a distance of 10 cm. Mulching is done with locally available organic materials and followed by irrigation. Almost 75 cm height plastic tunnel is made above seed bed to maintain temperature.

Next method can be use of plastic trays to raise rootstock seedlings. The trays are filled with sterilized soil mixture and kept at least 1.5 to 2 feet above the ground level to avoid soil borne contamination from the ground. A potting mixture of soil, sand and well rotten FYM or compost should be used in equal proportion (1:1:1) for filling the trays. Disinfection of the media is mandatory to reduce the pest and disease damage. Two types of disinfections (chemical and physical) are commonly practiced. Physical disinfection includes steaming and solarization while chemical method involve use of different chemicals.Besides use of soil in tray, there are several commercial growing media (like coco peat, vermiculite, and perlite) which are used by Hi tech nurseries in different countries.

Trifoliate seed can be better germinated through use of sand also. Growing of seedlings in sand is a simple and inexpensive method which may be used as an alternative for market available different costly growing media. Sand must be clean and should be sterilized. As compared with soil culture, the sand method produces seedlings that are uniform in size and have a strong root system.

Seedlings grown in soil are usually affected by damping off. Clean sand contains practically no materials of an organic nature that is necessary for fungal growth and is an ideal growing media for the growth of disease free seedlings. Sand is devoid of any type of nutrition so the seedlings should be timely transferred (10 cm height) to soil media for attaining graft able size. This sand method is in practice in Warm Temperate Horticulture Center since 10 years for growing trifoliate seedling with the purpose of avoiding damping off in primary nursery.

Transplanting of seedlings (Secondary nursery)

The rootstock reach 20- 25 cm in height in between 5 to 6 months of sowing depending upon the growing condition and the location. Rootstock grown in primary nursery should be transferred after 4-5 month to secondary nursery during June- July after the commencement of monsoon preferably during drizzling or during evening hours followed by watering. The nursery bed must be watered thoroughly before uprooting the rootstock to minimize root damage. Rootstock with twisted tap roots should be avoided. The selected rootstock should be treated with a fungicide solution for ten minutes before transplanting.

Secondary nursery can be either nursery bed or containerized. Many nurseries practice nursery bed for transplanting rootstock from primary nurseries. Rootstock are transplanted in a well prepared, manure and leveled nursery bed at the distance of 15 cm in rows spaced at 30 cm apart. Distances of 60 cm after every two rows facilitate budding/grafting and cultural operations.

In case of containerized nursery, germinated rootstock when attain height of about 20-25 cm need to be shifted to polybags. Black colored UV stabilized poly bag of 200 micron with size 12 x 6 inch are suitable. Such polybags are filled with potting mixture as mentioned earlier and a hole is made with stick in each polybag. Long tap root of the rootstock can be trimmed before transplanting. Once transplanted, the rootstock must be kept in best possible condition to guarantee rapid growth and good health. Growth of trifoliate orange is slow in sub-tropical regions .To increase the proportion of plants to be graftable, spraying with urea @1.5% on rootstock at monthly interval is highly beneficial and effective (Pandey and Karki, 2076/77).

Mother plant production

Selection of mother plant should be given top priority as it decides the life of the mandarin orange orchard. The mother plants should be planted at higher density (at 2 meter distance) to accommodate more number of plants and fruiting should not be taken from them to get continuous supply of bud wood. To protect from vector transmitted and bud transmissible diseases, the mother block should be grown inside insect proof screen net houses (40 mesh size). Regular greening and virus detection tests should be performed for the disease status of these trees.

Chalise (2010) states that the mother plant must have been tested for its performance over a number of years. It must true to name and type. These plants should be severely pruned in the month Jan-Feb to keep them in vegetative phase and to produce enough shoots for propagation purposes. The maintenance of mother blocks should be done rigorously so that plants are healthy and free of diseases and insect pests. Each tree should be labeled and proper record of each variety should be maintained by making layout in the nursery register.

Budwood/Scion selection

Budwood is usually collected from the well matured non bearing current year shoots (usually spring flush). It should be round and relatively straight with well matured buds ready to grow after grafting. After bud wood is obtained from the tree, middle part should be used in grafting discarding the upper immature and lower woody part. Although budwood can be stored in the refrigerator for 1–2 weeks after placement in zip lock polyethylene bags, it should be used as soon as possible.

Propagation

The existing mandarin orange orchards are mostly of seedling origin and seedling is still the preferred propagating material for mandarin orange in Nepal. Government owned farms and few well established nurseries are producing grafted saplings of mandarin orange. Budding is the major practice in different countries for the propagation of mandarin orange trees. But in Nepal mainly side veneer and splice grafting are in practice. For grafting in mandarin orange December to February is ideal however it differs according to location. Three different methods of grafting in mandarin orange are discussed as stated by Acharya and Pakka (2077).

Side Veneer grafting

For conducting this grafting operation, rootstock of pencil size diameter is headed back to retain 15-20 cm long stem from the collar region with secateurs. Then a slight upward cut of 40 mm long towards the top is made in the smooth area of the stock to facilitate splitting of the rootstock. From the base of this cut, smooth cut at of 2.5 cm extending downward from the top of the stock was made at 1/3 of the diameter of the stock with a sharp grafting knife. The scion with 2-3 buds is given a long slanting cut (2.5 cm) on one side and a small short cut (50mm) on the other so as to ensure better fit of scion with rootstock. The scion is inserted into the split of the stock in such a way that the longer cut of the scion comes in contact with the rootstock. The union is pressed properly and then tied with the help of 150 gauge polythene strip, 2 cm in wide and 25–30 cm in length. Begin wrapping below the union with 3–4 turns and finish with several turns above the union covering all cut surfaces. The end of the tape is secured beneath the last circular turn. The wrap should be firm without being excessively tight. Immediately after grafting, the scion is covered with para film to protect the scion from desiccation. If the scion remains green after 2 weeks of grafting, it means the union is successful.

Splice grafting

This method is commonly used when the stock and scion are of equal diameter. First, a smooth diagonal cut of about 2.5 to 3 cm long is made on the top of the rootstock. Similar cut is made at the bottom of the scion. These two cut surfaces are placed together and tied in the similar way mentioned earlier.

T budding

T budding is the worldwide practiced vegetative propagation method in mandarin orange. The budding may be conducted whenever the bark of the rootstock easily separates. This condition usually occurs during the period of growth between Marchs to May in mid hills. A vertical cut of about 2.5 cm long is made through the bark of the rootstock. A horizontal cut of 1/3 rd of the rootstock diameter is made at the top of the vertical thus making a shape of "T". To get the bud from the budwood, cut about 1.5cm above the bud removing a shield shaped piece of bark and wood of about 2.5 cm long. The pointed part of knife can be used to lift the bark along the vertical cut of rootstock. The bud should be immediately inserted into the rootstock to prevent from drying. Begin wrapping below the bud with 3–4 turns and finish with several turns above the bud covering all exposed surfaces of the bud with tape. Some propagators prefer to leave the bud eye free while others prefer to cover it completely. Unwrapping of the tape is done from 15-30 days after budding. Normally, the younger the rootstock the shorter the time required. If a successful union has formed between the bud and the rootstock, the bud will be green. Rootstock is partially cut10-15 cm above the bud and bent down to force the bud to grow.This piece of rootstock is cut off completely when the bud grows out.

Planting of the grafts

Bench grafting is also practiced in mandarin orange. For transplanting of grafts, bed are prepared in the same way as for secondary nursery beds. Grafts are planted at a distance of 10 cm, followed by irrigation and then covered by jute sacks form inside and plastic from outside by making a 75 cm height tunnel. This creates favorable condition for grafting success. These coverings are later removed with rise in temperature

Aftercare of budded/grafted plants

- New shoots that grow below the bud/graft union are the main cause of graft failure. Therefore regular monitoring and de-suckering must be done.
- Grafting tape/plastic should be removed 3-4 months after grafting. Delay in removal cause girdling which interrupts translocation and result in breakage of stem.
- In case of side veneer and splice grafting, if more than one shoot grow from the scion part, only one vigorous shoot must be retained.
- In case of bench grafting, the grafts are planted in bed under the plastic tunnel. With rise in temperature the plastic cover should be removed.
- To ensure the proper growth and development of the nursery plants, nutrient and irrigation should be well supplied. 1 gm NPK 19-19-19 in one litre water and 1% Urea can be used for foliar spray. Micronutrient should be sprayed in case of deficiency.
- The nursery area should be kept free from weeds. While weeding and hoeing the nurserybeds, care should be taken that inserted buds/ scions are not disturbed.
- Staking if necessary should be provided to support and train the straight growth of new shoot.
- Regular monitoring for diseases and insect-pests incidence in the nursery plants is necessary to take timely measures to control them (Dorji and Lakey, 2015)

Insect pest and disease management in the nursery

Seedlings are susceptible to attack by different diseases and pests in nursery. In primary nursery, damping off is the major disease. Seed treatment with Carbendazim 2 gm per kg seed is recommended before sowing to prevent damping off. Drenching alternately with Carbendazim and Copper oxy Chloride @ 2 gm per liter water can be done in case of disease appearance. Insects of economic importance in nursery include leaf miners, aphids and scales. Use of Imidacloprid and Abamectinare found to be effective against major insect pests in nursery (Acharya et al 2076).

- Avoid areas with recent history of pest and disease contamination
- Sterilize potting media before use.
- Use sterilized tools during grafting/budding.
- Obtain scion from healthy mother plants.
- Ensure adequate aeration to reduce humidity.
- Provide adequate nutrition to the seedlings.
- Monitor the pest and diseases and apply control measures.
- Keep nursery clean of weeds and plant debris.
- Remove and destroy diseased plants.
- Use clean water for irrigation.

Bud Wood Certification Program

Bud wood certification involves the production of quality planting material of citrus trees. Under this rootstock raising, mother block maintenance and the production of grafted saplings, all should be done inside the screen houses as a preventive measure against graft and insect transmissible diseases. Plastic trays and poly bags with sterilized media are used for raising nursery plants. Mother plants are regularly tested for graft transmissible diseases to ensure their health status. Bud wood from such healthy and productive mother plants are used for grafting. Moreover regulating the movement of citrus species between districts is done to minimize the risk of entry of diseases.

It was first started in 1937 in California and later adopted by other countries. Almost every country facing the threat of citrus diseases has adopted a certification program to preserve its citrus industry (Rajput and Haribabu, 1995). Government owned farms and few well established nurseries have initiated the production of mandarin orange planting material under screenhouses in Nepal although the certification yet to be done.

Conclusion

Most of the problems that incur in mandarin orange orchards originate from the nursery. Death of tree resulting from foot rot (Phyotopthora spp.) is often the consequence of a bad choice of rootstock and too low grafting height. Similarly HLB and CTV infections often result from the use of contaminated bud woods indicating that good nursery practices undoubtedly constitutes the first step towards the successful establishment of mandarin orange orchards. Mandarin orange industry is boon for Nepalese people. Recently (on 12 April 2024) mandarin orange has been declared as a national fruit of Nepal. To promote and preserve this sector, production of high quality planting material is the foremost activity to be done.

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Mandarin Orange Pollination And Pollinators

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Abstract

Pollination is the transfer of pollen from the anther- the male part of the flower to the stigma- the female part of the flower by means of air, water and animals, enabling fertilization and seed production in flowering plants. About 1/3rd of the total human diet comes from bee pollinated crops and pollination value worth far more than honey production. Of the total pollination activities, insects alone perform over 80% and bees contribute nearly 80% of the total insect pollination. The productivity of mandarin orange is very low in Nepal, which is attributed to poor orchard management and deficits of pollinators. Therefore, proper management practices and timely arrangement of pollinators are necessary for healthy plant growth, vigorous flowering and good pollination, which increase the fruit productivity adding farmers' income up four-folds. Furthermore, pollinators contribute to biodiversity conservation, support services to ecological balance and fruit farming to sustainability.

Keywords: Mandarin orange, Pollinators diversity, Pollination impacts, Pollinators decline, Pollinators conservation

Introduction

The majority of flowering plants reproduce sexually through pollination to seed formation, which can occur either within a flower or between flowers of the same plant or flowers of different plants. By nature, plants are self-pollinated, cross-pollinated, and plants, which produce without pollination and fertilization are termed as apomixes. The pollens from the same plant arrive at the stigma of a flower in self-pollination while, pollens from one flower transferred to the pistils of another flower in cross pollination. In process of pollination, pollen grains are transferred from the anthers of a flower to the stigma of the same flower is called autogamy, and pollen exported using a vector (pollinator or wind) out of one flower to another flower on the same plant is called geitonogamy. Then xenogamy is the cross-pollination where the pollen grain transfer occurs across flowers of two different plants. Citrus including mandarin orange unlike other fruit crops, has a wide range of pollination requirements. Its blooms range varies from self-fertile to completely self-sterile, requiring pollen from other suitable varieties by means of pollinators (Gurung, 2021). Thapa (2006) reviewed the honeybees and other insect pollinators of crops and recorded 10 species of flower visitors in citrus orchard. Pollinators are vital to plant biodiversity and their contribution to agricultural productivity is immense (Thapa, 2013). Contribution of insects in global food production ranges between 15% and 30% (Halder et al., 2019).

Methodology

Information on mandarin orange were collected from the available literature, covering pollinators' diversity, abundance, pollination impacts on quality yield, causes of their decline including integrated pest and pollinator management (IPPM) measures. Based on the findings from literature reviews, national citrus production and their contribution to productivity. The relevant findings are arranged systematically and presented in tables and figures with brief texts and conclusions.

Pollinators dependant crops

Pollination requirements for crops are quite diverse and understanding the pollination needs of different cultivated plants is a prerequisite to appreciate their dependency on animal pollinators (Table 1). It has been found that the pollination requirements of citrus is confusing due to misleading information. But it is a fact that citrus with self-incompatible varieties, self-pollination does not work. This can be overcome by cross-pollination with another compatible cultivar. Hence, citrus exhibits a varying degree of pollination requirements due to its vast cultivars being developed all the time (Ghosh and Jung, 2016). Pollinator reliance and breeding systems differ between and within citrus species, and even between cultivars of the same species. For instance, some studies state that cross-pollination is not necessary for fruit sets, whereas others show that insect pollinators increase fruit production (McGregor, 1976; Free, 1993; Abrol, 2019).

Table 1. Dependence of crops on pollinators

SN	Crops	Pollination dependence (%)
1	Cereal crops	0
2	Citrus fruits	0-30 (vary with citrus types)
3	Oilseeds	10-40
4	Almond, apple	40-90
5	Melon, watermelon	90-100

Source: Ghosh and Jung (2016)

Pollinators diversity

Mandarin orange is dependent on bees for its pollination and pollinators help in higher yield and increased fruit set (Thapa, 2003). Pradhan et al. (2018) recorded 24 species of insects in mandarin orange (*Citrus reticulata* Blanco), in which common honeybee *Apis cerana* Fab. was the most dominant pollinator followed by hoverflies belonging to eight genera, namely, *Episyrphus* sp., *Melanostoma* sp., *Ischiodon* sp., *Eristalis* sp., *Eristalinus* sp., *Scaeva* sp., *Episyrpus* sp., and *Eupeodes* sp. This was followed by stingless bees (Hymenoptera), seed bug (Hemiptera), and beetles (Coleoptera) that were sparse visitors. This study shows relevance of pollinators' diversity at different mandarin orange growing elevations. Further studies reveal the importance of honeybees (*Apis* spp.) that have been reported as major pollinators of different varieties of *Citrus* spp. from across the world, for example, mandarin orange in Nepal is pollinated by *A. florea, A. cerana*, *A. dorsata*, *A. mellifera* (Table 2).

Table 2. Citrus species and honeybee pollinators

SN	Citrus	Uncovered	*Covered*	*Mean*
1	Mandarin orange	Mar-Apr	*NP*	*DFCM*
2	Sweet orange	Apr-May	*NP*	*DFCM*
3	Sour orange	Apr-May	*NP*	*DFCM*
4	Sweet lime	Apr-May	*NP*	*DFCM*
5	Citron	Mar-Apr	*NP*	*DFCM*

N=Nectar, P=Pollen, D=*Apis dorsata*, F=*Apis florea*, C=*Apis cerana*, and M=*Apis mellifera*

Source: Thapa and Pokharel (2007)

Foraging activity of insect pollinators in *Citrus limon* (Lin.) Burm was the highest at 08:00-09:00 and lowest during 17:00-18:00 hours. Pollinator community of avocado and citrus flowers was composed of two bee (Hymenoptera) species, two fly (Diptera) species and four butterfly (Lepidoptera) species. The Hymenopteran pollinators were higher in numbers (42%) followed by Lepidopterans (33%) and Dipterans (25%). *A. florea*, *E. tuberculatus*, and *P. demoleus* were consistent and frequent visitors (Mohmood et al., 2015).

Studies in Sikkim India, revealed that most dominant pollinator recorded during the observation was the common honeybee *A. cerana* (Gurung, 2021). It repeatedly visited the same flower and the foraging activity began at 8:00 h in the morning and the frequency of visits reached its peak between 10:00 h to 13:00 h in the afternoon, which stopped after 18:00 h. Temperature played a significant role on the field activities of *A. cerana.* A significant correlation was observed between relative humidity (RH) and carbon-dioxide, and negative correlation between CO2 and temperature. Flowers emitted a strong scent which is a determinant factor in attracting the pollinators.

Pollination impacts

Citrus sinensis (Lin.) Osbeck blossoms are self-fertile and theoretically do not need bees to cross pollinate and set fruits, however, the pollination activity of honeybees has been found to significantly increase fruit set and production. Pratap (2000) studied the effect of pollination on sweet orange (var Red Junar) in Kirtiur (Table 3). The flower open from 9am to 4pm. Pleasant fragrance of flowers are attractive to bees. The *Apis cerana* Fab. foraging activity started early in the morning at 6am and ceased late in the evening at 6:35pm with average foraging duration of 22.6 minutes. Bee pollination enhanced fruit set by 24.2% and reduced fruit drop by 45.9% as compared to control. It also enhanced the fruit quality (size, weight, juice and sugar content) as compared to control and open pollination. Bee pollination also reduced the citric acid content by 29.2% as compared to control. The study revealed that bee pollination increased final fruit set 41.6% higher than open pollination and 406.6% higher than fruits trees isolated from bees. This shows that there is deficit of pollinators in natural condition and needs management with bee pollination for exploiting higher potential of fruit yield. In commercial fruit orchards it is always true of bee pollination for high quality fruit production with higher juice content as evidenced from the previous studies.

Table 3. Effect of *A. cerana* pollination on quality and yield of sweet orange in Kirtipur, Nepal

SN	Parameter	Control	Open pollinated	Bee pollinated	Increase over control (%)
1	Initial fruit set (%)	15.5 ±5.7	30.7±4.9	39.7±2.6	24.2
2	Fruit drop (%)	50	12.1	4.06	-45.9
3	Final fruit set (%)	7.5±7.5	26.9±6.7	38.09	30.6
4	Weight/fruit (gm)	146	157.5	170	33.04
5	Fruit length (mm)	60.6	64.4	66.0	8.9
6	Fruit diameter (mm)	54.9	67.4	74.0	34.8
7	Peel thickness (mm)	6.6	5.9	4.4	-33.3
8	Juice/fruit (gm)	155	180	260	67.2
9	Citric acid (%)	2.4	1.7	1.7	-29.2
10	Sugar in juice (%)	9.2	10.8	12.8	39.1

Source: Pratap (2000)

Based on experiment, orange trees that were totally isolated from bees gave production equal to 35% of the normal production. The variety Pera-Rio benefitted from the visitation of bees resulting in heavier, less acidic fruit with fewer seed sets (Malerbo-Souza, et al., 2003)). The fruit production was 35.30% greater in uncovered flowers, fruit weight was higher (180.2 g) than covered ones (168.5 g) (Malerbo-Souza, et al., 2004). However, bees did not affect the production of *C. sinensis* var. “Valencia” sweet oranges (Francke et al., 1969). Atkins (1963) stated that there is a possibility that cross-pollination by bees may cause them to retain more fruit in Washington navels.

The study in Brazil with *Citrus sinensis* (Lin.) has shown floral biology favorable to cross pollination and bees *A. mellifera* (66.0%) and *Trigona spinipes* (Fab.) (34.0%) bees were the only visitors to these flowers. Fruit production was 35.30% higher in uncovered flowers, and the mean fruit weight was also higher in uncovered flowers (6.9%). Mean fruit size (7.1x6.8cm), pulp thickness value (4.78 mm), juice percentage (45.30%), total soluble solids (11.31° Brix), and number of seeds per fruit (8.15) were not significantly different for the uncovered and covered treatments. Honeybees preferred to collect nectar (94.4% on average) than pollen (5.6%) in sweet orange flowers. The study in Brazil has shown an average of 28.2 ± 1.9% and 186.92m g of glucose/flower, respectively in Pera-Rio variety. Bees preferred to collect pollen until 1000 hrs in these flowers. This can be explained because this period is very important for pollination in this crop (Table 4). The flowers that received up to 9 honeybee visits showed lower fructification (56.5% on average) than those receiving 10 to 15 visits (83.7% on average). Greater number of honeybee visits on the flowers increased fructification. Bee-Here^{R}, eugenol, citral, geraniol, and lemons grass extract can be used diluted in water as honeybee attractants to sweet orange crops.

Table 4. Characteristics of sweet orange (*Citrus sinensis* L. Osbeck, var. PeraRio) fruits from uncovered and covered flowers in Brazil

SN	Parameter	Uncovered	Covered	Mean
1	Number	23.0a	17.0b	20.0
2	Weight (g)	180.21a	168.50b	174.35
3	Height(cm)	7.20a	7.00a	7.10
4	Diameter(cm)	6.80a	6.80a	6.80
5	Pulp thickness (mm)	4.82a	4.75a	4.78
6	Juice (%)	45.09a	45.52a	45.30
7	Acidity (g citric acid/100g juice)	1.164b	1.411a	1.287
8	Total soluble solids (°Brix)	11.43a	11.18a	11.30
9	Number of seeds per fruit	8.1a	8.2a	8.15
10	Number of seeds per bud	1.0a	0.8b	0.9

Note: Values followed by same letters on the same line are not significantly different ($P \leq 0.05$)

Source: Malerbo-Souza, et al. (2004)

In the study by Gurung (2021), mandarin oranges were found to be partially self-compatible with pollinator dependency of 42%. Fruit set in open-pollinated flowers was higher compared to the supplemented ones. Fruit set in open pollination was 46% while the fruit set in autogamy and apomixis was 4% and 5% respectively. A significant difference was observed in the weight, height, diameter, and number of seeds between different treatments. The average weight of fruits was found to be the highest in open-pollinated (54.65 g) followed by geitonogamy (51.61

g) and apomixis (47.56 g). The fruit weight (22.56g), height (31.25g), and seed (5) were found to be the lowest in autogamy. Fruits resulting from open and supplementary pollination were heavier than those resulting from autogamy or apomixes. TSS and TSS/Acidity did not differ between pollination treatments (Table 5).

Table 5. Effect of pollination treatments on yield and quality of orange in Sikkim

Treatment	Fruit characteristics						
	Weight (gm)	Height (mm)	Diameter (mm)	Seed (No)	TSS (°Brix)	Acidity	TSS/Acidity
1. Open pollination	54.29±2.23a	41.44±0.80a	48.74±1.51a	12±0.83a	10.4±1.81a	1.13±0.08b	9.20±1.67a
2. Cross pollination	40.78±2.26d	36.28±1.02bc	42.08±1.14b	10±0.83a	10.8±0.84a	1.10±0.05b	9.81±1.40a
3. Geitonogamy	51.56±1.01b	39.08±1.05ab	47.96±1.25a	10±0.83a	10.8±1.30a	1±0.11c	10.8±1.88a
4. Autogamy	22.68±1.75e	31.40±1.75d	35.49±1.27c	5±1.30b	11.1±1.90a	1.19±0.07a	9.32±1.94a
5. Apomixis	47.81±1.99c	38.20±1.99b	46.77±1.86a	7±0.83c	11.2±1.48a	1.18±0.08ab	9.49±0.66a
Tukey test ($p \leq 0.05$)	0.00	0.00	0.00	0.00	0.92 (ns)	0.01	0.45 (ns)

Means with the same small letter within each column do not differ from each other, *ns*=non-significant.

Source: Gurung (2021)

Citrus production and productivity

The total area, productive area, production and productivity of citrus for last decade in Nepal is presented in Table 6. The area has increased from 2011/12 to 2000/21 except in the year 2016/17, while production and productivity is not satisfactory. Rather productivity is very low as compared to many other countries (Pun et al, 2015). The cause of low productivity is attributed to many factors, mainly the orchard management and pollination by bees. Timely orchard management practices and bee pollinator use can boost up production and productivity. Based on studies, the contribution of pollination on production and productivity can be estimated four folds.

Table 6. Total area, productive area, production and productivity of citrus (2011/12 - 2000/21) in Nepal

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2011/12	35,565	24,089	2,40,793	10.00
2012/13	36,975	23,645	2,16,188	9.14
2013/14	38,988	25,497	2,24,357	8.80
2014/15	39,035	25,261	2,22,790	8.82

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2015/16	40,554	24,854	2,18,447	8.82
2016/17	46,328	26,759	2,39,773	8.96
2017/18	44,424	25,946	2,45,176	9.44
2018/19	46,411	28,406	2,71,908	9.57
2019/20	46,715	27,339	2,74,140	10.03
2020/21	50,235	32,188	3,11,188	9.67

Source: MoALD (2022); yield estimated based on the bee pollination result (four fold increase), which may vary with management practices, citrus types, variety etc.

Pollinators decline

Agricultural intensification has led to a loss of habitat of many insect pollinators and monoculture plantings have threatened insect biodiversity. Pollinators' globally declining reports such as colony collapse disorder (CCD) (vanEngelsdorp et al., 2008) are shown in Table 7.

Table 7. Five most mentioned causes of colony loss

Cause	Rank	Reporting (No)	Colony (No)	Percent Loss (95% CI)
Poor queen	1	31	146	18.5 (13.5-23.6)
Starvation	2	28	34	19.8 (19.6-25.0)
Mite	3	24	144	31.7 (25.6-37.2)
CCD	4	9	151	48.2 (41.7-54.8)
Weather	5	9	25	24.4 (18.8-30.0)

Source: vanEngelsdorp et al. (2008)

Rucker and Thurman (2012) examined the CCD as one of the many episodes that PERC has examined in USA (Figure 1). Over, 1500 commercial beekeepers take their 2.5 million hives of bees on the road every year to pollinate fruits and vegetables. The bee population shows declining trend and between 2007 and 2011, approximately 30% of U.S. bees alive each fall failed to survive to pollinate blossoms in the spring, which shows that CCD is the worst one cause of bee decline. It is caused by number of interacting factors, such

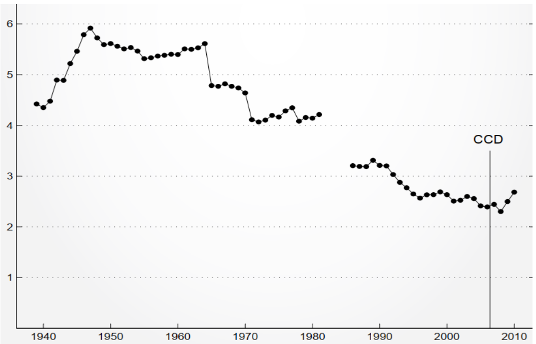

Figure 1. Bee population in U.S.A. (millions of colonies) from 1939 to 2010,
Source: Bucker and Thuman (2011)

as diseases, pests, pesticides, genetically modified crops, electromagnetic radiation, brood temperature change, nanomaterials, food deficiencies and loss of bee pasture.

The CCD affected on food prices raising unit price to rent a colony of bees from $45-65 to $170 (Patel and Mall, 2020). The decline in pollinators would also result in a parallel decline in its associated plant species, production, productivity and food security. Insect pollination is therefore also known as an endangered ecosystem service. Other pollinators populations are also declining due to various reasons such as destruction of habitat, hunting, slash-burn system; conversion of forests and wetlands to agriculture; grazing, grass-cutting, over exploitation of resource; deforestation, fire, soil erosion and nutrient loss; high population, poverty and no food security; pesticide pollution and environment degradation; replacement of indigenous materials and wisdoms; global warming; and lack of environment awareness and policy.

Citrus is an important cash crop and has a varying degree of pollination requirements (Thapa, 2003). There are several varieties of citrus that are poorly known from the pollinators and pollination requirement point of view. Further, consumers' favoring to seedless fruits because of their appealing appearance and ease of consumption, efforts are being continued to develop high-quality seedless fruits. Identifying suitable pollinizers can be another way in enhancing the productivity, however, such a process also requires pollinators. Therefore, genetically self-incompatible cultivars that are dependent on pollinators need to be consistently investigated and their pollinators identified. Studies are needed to document important pollinators and understand the breeding system of more varieties. Otherwise, targeting on development of seedless varieties can be a good alternative in absence of pollinators without affecting productivity and marketing.

Pollinators conservation

It is estimated that of the 240,000 species of flowering plants, 91% require the services of pollinators to set fruit and seed. According to Dar et al. (2011), the world's major crops are pollinated by 44 genera of animals including bees (72.7%), flies (18.8%), bats (6.5%), wasps (5.2%), beetles (5.1%), birds (4.1%), butterflies and moths (4.4%) and thrips (1.3%). The value of pollination services for global agriculture is worth of hundreds of billion and the conservation of pollinators has also become an important tool for conservation of biological diversity. The pollinators' initiative started in Chitwan, Nepal to study the pollinators' deficit in crops and aware farmers on the importance of crop pollination (Thapa, 2008) and for the effective use and conservation of pollinators, Food and Agriculture Organization (FAO) has a leading role in the implementation of "The International Pollinator Initiative Plan of Action 2018-2030". This promoted coordinated action worldwide to implement coherent and comprehensive policies for the conservation and sustainable use of pollinators at the local, subnational, national, regional, and global levels.

According to Lundin et al., (2021), IPPM is a framework that can be used to co-manage for ecosystem functions driven by pests, natural enemies, and pollinators. A summary of the evidence for effects of actions on pests, natural enemies, and pollinators at each level of the pyramid is presented in Table 8.

Table 8. Summary of effects of actions across the levels of the integrated pest and pollinator management pyramid on pests, natural enemies, and pollinators

SN	Particulars	Pests	Natural enemies	Pollinators
1	Artificial pollination	Neutral	Neutral	Neutral
2	Pesticide use	Negative	Negative	Negative
3	Biocontrol agents	Negative	Positive	Neutral
4	Managed pollinators	Neutral	Neutral	Positive
5	Irrigation	Positive to Negative	Negative	Neutral
6	Organic fertilizer	Negative	Positive	Neutral
7	Flower strips	Positive-Negative	Positive	Positive
8	Crop diversity	Negative	Positive	Neutral
9	Semi-natural habitat	Positive-Negative	Positive-Negative	Positive

Source: Lundin et al. (2021)

Pest and pollinator management practices highlight potential IPPM synergies, and co-benefits. Here, the strategies for simultaneously managing of pest control and pollination goals through IPPM are presented. The research priorities are focused for deeper understanding of the ecology (especially movement ecology) of pests, natural enemies, and pollinators in agricultural landscapes. Further, exploring how pesticide use can be incorporated into IPPM in ways that are highly effective in controlling pests but that have minimal effects on pollinators and natural enemies. Finally, evaluating IPPM strategies that incorporate multiple management actions targeting both crop pests and pollinators and IPPM are likely to enhance additional ecosystem services. Pollinator friendly some management practices are as follows.

- Homestead/kitchen gardening,
- Border crop maintenance and pollinator attractant wind breaks,
- Mulching to provide nesting place to pollinators and reduce herbicides use,
- Conservation of habitats of wild bees,
- Improved landscape by managing natural and semi-natural vegetation,
- Use of bio-agents and bio-pesticides to reduce pesticides poisoning,
- Integrated soil nutrient management and water conservation,
- Biogas slurry and improved compost preparation and application,
- Seasonal fallow and patch fallow in cultivated lands,
- Commercialization of beekeeping, and rearing/use of bumble bees, Osminia etc.
- Growing diversified types of pollinator attractive flowers and fruits,
- Growing shade loving plants under tree shades,
- Mixed/inter/relay cropping with different crops and flowering dates,
- Growing multiple varieties and multistoried farming,

- Afforestation and maintaining soil and organic matters, and cropping calendar.
- Bee pasture management

Conclusions

Production and productivity of mandarin orange is very low in Nepal, which is attributed to poor orchard management and deficits of pollinators. Proper management practices of orchard and arrangement of pollinators are necessary for healthy plant growth, vigorous flowering and good pollination, which is evidenced with increase of quality fruit yield of orange thereby adding farmers, income up four-folds. The IPPM has been effective in controlling pests with the minimal effects on natural enemies of pests and pollinators of crops. In addition, pollinators contribute to biodiversity conservation, support services to ecological balance and fruit farming to sustainability.

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Soil and Nutrient Management

Effects of Application of Micronutrients on Plant Growth and Fruit Set in Mandarin Orange (*Citrus reticulata* Blanco)

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Abstract

Citrus, particularly mandarin orange (*Citrus reticulata* Blanco) is an important fruit crop contributing about 13 percent of total fruit production in Nepal. Optimum doses of micronutrients, boron (B), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) are crucial for the attainment of better vegetative and reproductive attributes in the fruit, unfortunately, the mandarin orange growers of Nepal lag in applying micronutrients timely and in appropriate amounts. More than fifty research and review articles related to the topic were reviewed to gather information and come to a conclusion. Based on available information, we found that the availability of micronutrients in the soil and the leaf micronutrient composition has a direct positive relation to productivity. Their deficiencies during crucial growth stages lead to a substantial decrease in mandarin orange productivity, amounting up to 91 percent. Studies from Nepal have demonstrated the common deficiency of B, Zn, and Mo in the soil. Around 80 to 90 percent of agricultural soil is B deficient. Zn and B have a positive role in plant growth and production, enhance flowering and fruit set, minimize flower and fruit drops. Nepal has an average productivity of 10.30 tons per hectare (t/ha) roughly one-third of that reported in China (29.77 t/ha). However, with effective cultural and nutritional management and the adoption of improved varieties, Nepal has the potential to enhance its productivity. The scenario advocates the necessity of administration of the optimum dose of micronutrients to boost plant growth, flowering, fruit set, fruit quality, fruit weight, and finally yield.

Keywords: Boron, Foliar application, Management, Soil, Yield

Introduction

Mandarin orange (*Citrus reticulata* Blanco) popularly known as *Suntala* in Nepal is a widely grown commercial citrus fruit in the mid-hills of Nepal. Citrus cultivation extends across 62 districts in Nepal (Panth and Dhakal, 2019), with commercial cultivation reported in 56 out of 77 districts (MoALD, 2023). The contribution of citrus in overall fruit production is 21.60%, with mandarin orange accounting for 60.54% of total citrus production. The total area, productive area and productivity of mandarin orange in Nepal are 27,982 hectares (ha), 19,481 ha, and 10.30 tons per hectare (t/ha), respectively (MoALD, 2023). Mandarin orange, rich in bioactive compounds like vitamins, phenols, flavonoids, carotenoids, fibers and minerals, actively counteract prevalent health concerns such as cancer, heart disease and obesity (Goldenberg et al., 2017). The leading mandarin orange producing countries include China, Turkey, Spain, Morocco, and Brazil (FAOSTAT, 2024). The favorable conditions of temperature, sunlight, rainfall, and fertile soil have contributed to the production of citrus with superior quality and taste in comparison to neighboring countries (NHPC, 2017). To promote commercial mandarin orange production, Nepal's government has established 14 mandarin orange zones and a super zone under the Prime Minister Agriculture Modernization Project (PMAMP, 2022).

Nutrition management is a crucial factor in promoting plant growth and yield through increased photosynthetic efficiency (Ilyas et al., 2015). Primary nutrients such as nitrogen (N), phosphorus (P), and potassium (K) and secondary nutrients such as calcium (Ca), magnesium (Mg), and sulfur (S) are provided in substantial amounts to the plants (Singh and Khan, 2012). Although the micronutrients are required in modest amounts only, they play a vital role in plant metabolism (Kazi et al., 2012). Optimum micronutrients are the most important factor in producing high-quality fruits (Babu and Yadav, 2005; Tariq et al., 2007). These elements include boron (B), chlorine (Cl), copper (Cu), manganese (Mn), molybdenum (Mo), iron (Fe), and zinc (Zn) (FAO, 2011). In this article, we have reviewed the role of B, Cu, Fe, Mn and Zn in the quality and quantity of fruit production.

B increases pollen grain germination, pollen tube elongation, consequently fruit set percentage, and finally the yield (Abd-Allah, 2006). Cu has a role in photosynthesis, chlorophyll synthesis and enzyme metabolism influencing vegetative growth and fruit development (Ram and Bose, 2000). Fe is necessary for vital plant metabolic functions such as chlorophyll synthesis, various enzymatic reactions, respiration, photosynthesis, floral initiation and flowering in plants (Bhalerao et al., 2014). Mn plays a crucial role in photosynthesis, nitrogen metabolism and nitrogen assimilation (Zekri and Obreza, 2016). Zn contributes to cellular and physiological activities, plant growth, development, and yield. It is involved in the synthesis of tryptophan, a precursor of indole acetic acid, stimulates chlorophyll and carotenoid production and improves photosynthetic activities. Excessive zinc can be toxic and stunts plant growth (Zhao et al., 2012) and its deficiency can lead to stunting and bushiness (Subba et al., 2014). Because of the deep root system of citrus trees, the application of micronutrients to the soil may not be very efficient. Additionally, the acidic or alkaline nature of the soil poses a challenge for nutrients to reach the root zone (Embleton et al., 1973 as cited in El-Gioushy et al., 2021). Micronutrient deficiencies are corrected through foliar application to achieve a high quality and quantity of yield (Sajid et al., 2010).

The productivity of mandarin orange falls short of the production potential in Nepal. Farmers use insufficient micronutrients often leading to micronutrient deficiency. The deficiency of micronutrients results in stunted tree growth, excessive flower and fruit drop and low yield. Although an adequate supply of micronutrients is important to produce quality fruits, very few research has been done regarding micronutrient application in Nepal. This research studies the effect of B, Cu, Fe, Mn and Zn concentrations on vegetative growth, flowering and fruiting and compares the effectiveness of micronutrient application through foliar and soil application. Bringing together insights from diverse research articles, we seek to raise awareness among growers, extension workers and researchers about the importance of micronutrients for enhancing the quality and yield of mandarin orange fruits, their dosages, techniques and timing for foliar application, ultimately promoting the adoption of these methods.

Methodology

This article was written after reviewing fifty-nine literature which included research and review articles from journals, books and the internet to assess the status of mandarin orange fruit, the relation between yield and micronutrient concentration, the status of micronutrients in the soil, and the effects of this nutrient in the growth and fruiting of the crop in Nepal. The articles were downloaded from Google search, google scholar, google books, research gate, sci-hub, and Nep-jol based on the search words "mandarin", "orange", "Nepal", "micronutrients" and "micronutrient deficiencies" and duplicates were removed manually. The information thus obtained was analyzed using Excel and displayed in tables and figures.

Results and discussion

Status of plantation area and production of mandarin orange in Nepal

We studied the data of plantation areas and the production of mandarin orange over ten years in Nepal. There was an increase in plantation area from 15,276 ha in 2013 to 18,597 ha in 2022 (Figure 1.a.) and a corresponding increase in total production from 1,46,721 t to 2,10,779 t (Figure 1.b.) with noticeable fluctuations in-between. The fluctuations may be attributed to issues like inadequate management, citrus greening, and poor variety (Panth and Dhakal, 2019). Overall, the data indicates a positive trend in mandarin orange cultivation and production in Nepal, suggesting potential for further growth. Strategic management is crucial to capitalize on this opportunity, ensure consistency in production and minimize the impact of adverse conditions.

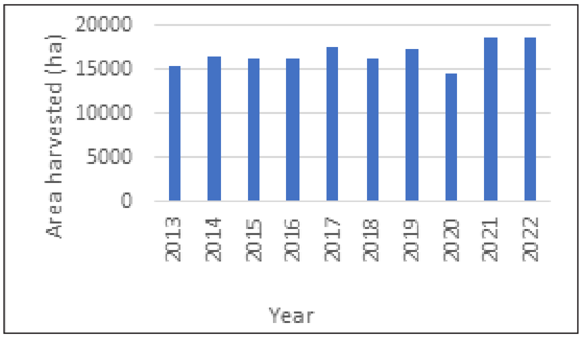

Figure 1. a. Productive area of mandarin orange in Nepal

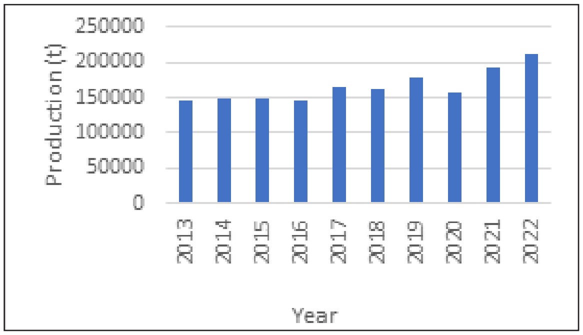

Figure 1. b. Production of mandarin orange in Nepal

Source: FAOSTAT, 2024

Status of the yield of mandarin orange in Nepal

Even though the productivity of the mandarin orange has increased from 9.60 t/ha in 2013 to 11.33 t/ha in 2022 (Figure 2), it remains disappointingly lower compared to China, our neighboring country, which has productivity of 29.77 t/ha (USDA, 2022). A range of biotic (rootstock, cultivar, insect pest and disease management) and abiotic (climate, soil, nutrition, irrigation and management) factors affect the productivity of citrus (Ruchal et al., 2020). The yield can be enhanced to 15 t/ha by adopting orchard management practices such as timely application of recommended amounts of manure and fertilizers, disease and pest management, pruning, mulching, and irrigation (Kaini, 2017).

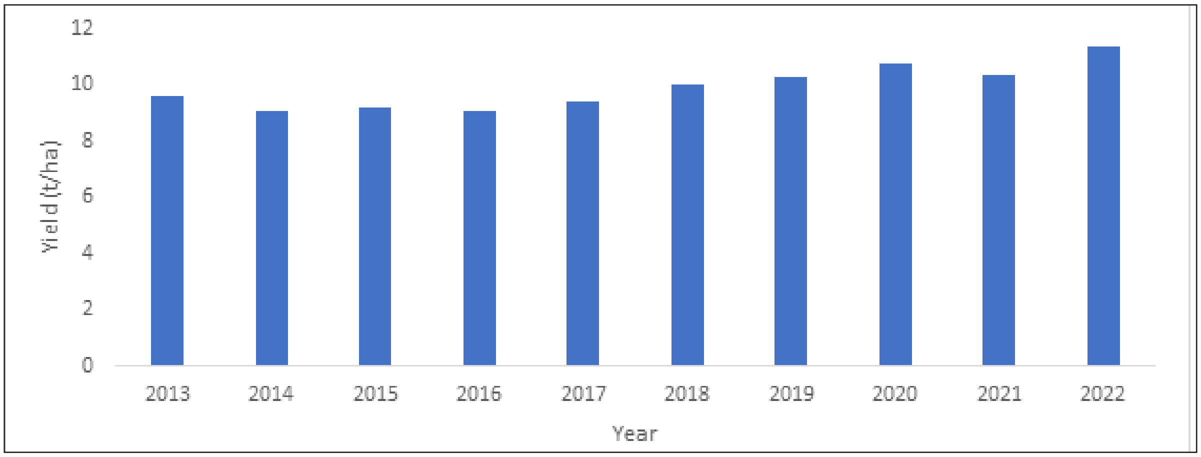

Figure 2. Trend analysis of yield of mandarin orange in Nepal in different years

Source: FAOSTAT, 2024

Relation between yield and micronutrient concentration

Diagnosis and Recommendation Integrated System (DRIS) is a widely used statistical method for early and accurate interpretation of the relationship between plant and soil nutrient balance in integrated management practices, facilitating nutrient diagnosis before yield decline. (Hundal and Arora, 2001). The correlation between leaf mineral composition, soil nutrient availability, and the mean fruit yield in Nagpur mandarin orange over three years was studied by Srivastava and Singh (2008) and nutrient standards were established (Table 1). Leaf analysis is beneficial in averting deficiencies rather than addressing them after they have already emerged (Basavaraj et al., 2016). To achieve the optimal yield of 47.7-117.2 kg per tree, the recommended micronutrient concentrations in leaf analysis are reported as 74.9-113.4 ppm Fe, 54.8-84.6 ppm Mn, 9.8-17.6 ppm Cu and 13.6-29.6 ppm Zn (Table 1). However, for Khasi mandarin orange, 85-249 ppm Fe, 42-87.6 ppm Mn, 2-14 ppm Cu and 16-27 ppm Zn are considered ideal to obtain an optimum yield of 32-56 kg/tree (Srivastava and Singh, 2006, as cited in Srivastava et al., 2008).

Citrus growth and productivity depend on soil conditions, necessitating proper management for optimal quality and yield (Baral, 2008). For the optimum production of mandarin orange (47.7-117.2 kg/tree), 10.9-25.2 ppm Fe, 0.56-1.26 ppm Mn, 2.5-5.1 ppm Cu and 0.56-1.26 ppm Zn are considered to be the optimum value (Table 1). Higher concentrations of micronutrients

(Cu, Fe, Mn and Zn) correlate with increased mandarin orange yield per tree. The yield ranges from 12.9 kg to over 152 kg/tree depending on micronutrient levels (Srivastava & Singh, 2008).

While acknowledging the potential variations in factors like varieties and altitudes, the data emphasizes the positive correlation between micronutrient levels and yield, underscoring their importance. The deficiency of these micronutrients may impede achieving the optimum yield in Nepal. The focus on creating specific DRIS norms for specific conditions in Nepal is crucial for improving crop yield and quality.

Table 1. DRIS norms based on leaf and soil analysis of mandarin orange (*Citrus reticulata* Blanco)

Parameters Micronutrients	Norms					
	Leaf analysis			Soil analysis		
	Deficient	Optimum	Excess	Deficient	Optimum	Excess
Fe (ppm)	<55.6	74.9-113.4	>132.7	<4.6	10.9-25.2	>40.6
Mn (ppm)	<40.2	54.8-84.6	>98.7	<4.7	7.5-23.2	>31.1
Cu (ppm)	<5.9	9.8-17.6	>21.5	<1.1	2.5-5.1	>6.5
Zn (ppm)	<5.5	13.6-29.6	>37.7	<0.33	0.56-1.26	>1.73
Yield(kg/tree)	<12.9	47.7-117.2	>152.1	<12.9	47.7-117.2	>152.1

Note: Sourced from Srivastava and Singh (2008).

Micronutrient status in the soil of Nepal

A study across 21 districts revealed deficiencies in B in 20 districts, Zn in 19 districts and Mo in 17 districts. Fe was present at a medium level in 14 districts (Karki et al., 2005)Top of Form In Chitwan District, Tuladhar et al. (2001) observed a deficiency in B across all soil samples, while Fe was consistently found in high concentrations. The defined critical level was 2 ppm for B and 2.5-5 ppm for Fe. Since Fe constitutes 5% of the earth's crust, Fe deficiencies are generally uncommon (Forieri et al., 2013). However, B deficiency is widespread in Nepal, affecting 80 to 90 % of agricultural soil, particularly in soils with light texture, low clay and organic carbon content (Anderson, 2007). In the Arun Valley, Eastern Nepal, a study on 102 soil samples from altitudes of 300–2200 m found 86 samples with B deficiency and 34 samples with Zn deficiency, with deficiency limits set at 0.5 and 0.6 ppm, respectively (Anderson and Sandvold, 2000). In the citrus cultivation areas of Dhankuta, deficiencies were observed in Zn, followed by B, N and Cu, while levels of P, K and Mn were adequate in the soil (Gupta et al., 1989). Zn deficiency commonly occurs in soils with elevated pH, high organic matter content and greater concentrations of Na, Ca, Mg and P (Alloway, 2009). About 87 % of soil samples were inadequate in B (< 1 ppm), while 10–20 % of samples were deficient in Zn (<0.5 ppm), Mn (< 10 ppm) and Cu (< 0.5 ppm) (Tripathi, 1999). Cu deficiency is rare in Nepal, primarily due to the widespread use of copper fungicides for managing fungal diseases in crops (Karki et al., 2005). These deficiencies have resulted in a decline in the yield and quality of mandarin orange.

Effect of foliar application of micronutrients

Foliar fertilization enhances yield, fruit quality, disease and insect pest resistance, and, drought tolerance (Omaima and El-Metwally, 2007). Application of certain micronutrients on foliage can be 10 to 20 times more efficient than soil application. A properly formulated foliar spray enhances nutrient absorption by stimulating plants to release more sugars and exudates into the rhizosphere (Yaseen and Ahmad, 2010).

The availability of micronutrients to plants is influenced by various soil and climatic factors, including temperature, pH, soil water content, organic matter, and nutrient interactions (Ali et al., 2014). Increased solubility of B, Cu, Fe, Mn and F occurs in acidic pH conditions and their presence in soils is notably impacted by seasonal temperature and moisture fluctuations (Hodgson, 1963). Micronutrient deficiencies are common due to low soil organic matter, alkaline pH and calcareous soil nature (Schumann, 2006).

Foliar application of micronutrients is an economical approach that increases yield by up to 45% and improves fruit quality parameters such as total soluble solids, acidity and vitamin C content (Chhetri et al., 2017). After administering micronutrients by foliar spray, citrus species have shown noticeable changes in development, flowering, fruit set, production and quality (Babu and Yadav, 2005). It also increased fruit yield and improved fruit quality parameters such as fruit weight, diameter and juice content (Mohammad et al., 2018). It is preferred over soil application due to its high efficacy, quick plant response, convenience and prevention of toxicity issues caused by excessive nutrient accumulation in the soil (El-Sheikh et al., 2007). Since soil application of micronutrients is ineffective for deep-rooted citrus, a more effective alternative is the foliar spray of micronutrients, as demonstrated by Chiu and Chang (1986) who reported positive effects in curing B deficiency in citrus through foliar application of boric acid (Chhetri et al., 2017). Addressing micronutrient deficiencies through foliar application is a widespread practice for achieving a lucrative yield and high-quality fruit. Therefore, it is crucial to apply micronutrients appropriately via foliar spray to enhance mandarin orange production.

Effect of micronutrient on plant growth

The application of 0.5% $ZnSO_4$ and 0.3% boric acid during fruit set positively influenced plant height, canopy, stem girth, and leaf size. Compared to untreated mandarin orange trees, there were notable increases: 23.4% in plant height, 18.34% in tree spread, 24.54% in stem girth, and 6% in leaf size (Khan et al., 2012). Foliar application of $ZnSO_4$ up to 0.6 % resulted in increased height, crown width, stem girth, fruit yield and quality in Kinnow mandarin orange (Razzaq, et al., 2013). This could be credited to the involvement of micronutrients in diverse metabolic and enzymatic processes. B affects plant growth through its participation in glucose metabolism (Cakmak & Romheld, 1997). Zn, a component of plant hormone auxin, is associated with the activation of several enzymes responsible for photosynthesis, cell elongation and cell division (Djanaguiraman and Prasad, 2013).

The treatment with Cu (0.4%), Mg (2%) and Zn (0.5%) resulted in the highest increase in plant height (43.76 cm) and stem girth (3.22 cm) (Ram and Bose, 2000). Cu is crucial for plant growth, strengthening cell walls, aiding in photosynthesis and stabilizing pigments (Dhaliwal et al., 2022). Plants treated with Cu (0.4%), B (0.1%) and Zn (0.5%) showed the maximum plant height (5.41m), stem girth (50.96 cm) and canopy spread in both North-South (2.74 m) and East-West (2.91 m) directions (Zoremtluangi et al., 2019). This enhancement may be attributed to the synergistic effects of these micronutrients.

The foliar application of 1.0% $MnSO_4$ and 1.0% $FeSO_4$ positively influences the growth characteristics of mandarin orange cv. Kinnow, such as shoot length, canopy area, stem girth and tree height. This application demonstrated notable improvements, with the highest increases observed in shoot length (78.87%), East-West canopy area (4.75%), North-South canopy area (4.27%), and tree height (9.49%) compared to the control (Gurzar et al., 2019). Mn activates enzymes crucial for photosynthesis and nitrogen metabolism, while Fe is vital for chlorophyll synthesis and various enzyme activities, contributing to increased plant vegetative growth (Sarolia et al., 2007).

Effect of micronutrients on flowering and fruiting

Boron and Zinc play crucial roles in mandarin orange flowering and fruit set, minimizing fruit drops (Davinder et al., 2017). The maximum number of flowers per branch (252.50) was recorded with 0.15 % Zn spray and the maximum percentage of fruit set per branch (82.09%) was found with 0.04 % B spray (Ruchal et al., 2020). The juice content of the mandarin orange was 25.86% higher when sprayed with 0.8% $ZnSO_4$ compared to the control (Razzaq et al., 2013). Combined treatment of boric acid (0.3%) and $ZnSO_4$ (0.5%) at the fruit set stage led to the highest fruit weight (145.3 g)(Khan et al., 2012). The application of B (0.1%) and Zn (0.1%) in mandarin orange leads to a notable increase in total flowers per branch by 273.43%, fruit set by 85.99%, fruit diameter by 29.75% and a reduction in fruit drop by 111.32% (Lamichhane et al., 2023). A synergistic effect of B and Zn causes higher fruit sets and lower fruit drop (Ruchal et al., 2020). B increases the fruit weight through its involvement in carbohydrate translocation, cell wall growth, and RNA synthesis and also aids pollen germination and tube extension (Hansch and Mendel, 2009). Zn is vital for pollination as it supports pollen tube development (Abd-Allah, 2006). Zn also boosts indole acetic acid (IAA) synthesis, elevating auxin levels at the abscission zone to prevent fruit drops (Nijjar,1985) and increase fruit size (Razzaq et al., 2013).

Plants treated with 0.4 % Cu, 0.1 % B and 0.5 % Zn recorded the highest fruit set (61.89%), number of fruits per plant (140.55) and yield per tree (22.75 kg) compared to the control (Zoremtluangi et al., 2019) and also resulted in a maximum sugar content, and vitamin C content (El-Gioushy et al., 2021). The foliar application of 1000 ppm Zn + 1000 ppm Mn on Kinnow mandarin orange, as studied by Kaur et al. (2015), resulted in a maximum yield of 862 fruits per tree and superior fruit quality, indicated by a higher Total Soluble Solids (TSS)/acid ratio of

14.23. Treatment consisting of 0.1% $FeSO_{4,}$ 0.2% $MnSO_4$ and 0.3% $ZnSO_4$ exhibited a 40.3% reduction in total fruit drop, higher fruit yield per tree (90.5 kg/plant) and 2.6 % increased juice content compared to the control (Singh et al., 2023). Fe increases chlorophyll content, leading to improved photosynthetic efficiency and assimilate production. Mn promotes photosynthesis, and nitrogen metabolism and serves as a precursor for hormones, amino acids, phenols and lignins. This contributes to enhanced yield characteristics (El-Sheikh et al., 2007).

In the experiment conducted by Rokaya et al. (2019) in Lamjung District, the best results were observed in the mandarin orange trees treated with a combined spray of 0.2% urea and 0.4% Agromin, showing the highest number of fruits per plant (489.55), fruit weight (106.56 g), fruit yield per tree (51.82 kg), maximum juice content (55.77%), maximum TSS content (10.53 Brix), minimum titratable acidity (0.89) and maximum vitamin C (35.67 mg/100 ml). The research recommends that applying urea in combination with micronutrients through foliar spray twice could enhance both productivity and fruit quality in mandarin orange.

Conclusion

Based on a comprehensive analysis of several studies, it is evident that the foliar application of an appropriate dosage of micronutrients significantly enhances both the vegetative and reproductive characteristics of mandarin orange plants. This includes improvements in plant height, shoot length, stem diameter, canopy coverage and leaf dimensions. Additionally, it positively impacts reproductive traits including total flower formation, fruit set, minimized fruit drop, and increased fruit size, resulting in improved quality and yield of mandarin orange fruit. Addressing micronutrient deficiencies holds promise for increasing overall mandarin orange production in Nepal, offering economic advantages.

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सुन्तलाको व्यवस्थित बगैंचा

Soil and Nutrient Management of Mandarin Orange

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Abstract

Amount of manures and fertilizers to be applied on any fruit crop should consider nutrient removal by the crop, soil and leaf analysis results, deficiency symptoms, location specific fertility trials and soil surveys, & soil characteristics and land feature. Some literatures have been reviewed to find out (1) the soil and leaf nutrient status of mandarin orange orchards in different parts of the country and (2) the soil and nutrient management practices followed by farmers. There was a wide variation in soil and leaf nutrient levels in mandarin orange orchards of different parts of Nepal. However, in general, low level of soil pH and soil nitrogen were important limiting factors, similarly lower level of Zn and B in leaf were limiting factors. When reviewed the soil and nutrient management practices followed by farmers, the majority of the farmers were applying FYM/compost, while only fewer farmers were applying chemical fertilizers. A very few only were applying micronutrient fertilizers. Intercropping with maize, millet and wheat is a general practice in mandarin orange orchards, which not only compete with soil nutrients but also cause damage to surface roots of mandarin orange trees. Once mandarin orange trees come to bearing stage, intercropping should be avoided. The farmers need to be encouraged to use the recommended amount of manures and fertilizers. Future long-term study should focus on the management of major nutrients and response of different micronutrients on the growth and yield of mandarin oranges so that strong recommendations can be made for obtaining benefits by the mandarin orange growers.

Keywords: Manures and fertilizers, Soil and leaf nutrients, Fertility management, Deficiency symptoms, Intercropping

Introduction

World citrus industry is dominated by sweet orange production (71% area of total citrus production area) while in Nepal mandarin orange dominates in area (57% of total citrus production area, MoALD, 2023) as well as in production. Mandarin orange is cultivated from the time immemorial and is considered as an indigenous fruit of Nepal. Mandarin orange has been cultivated in an altitude of 900-1500m, mid-hill areas from eastern to far-western regions (Koshi Province to Far-western Province) of Nepal. Most of the cultivated land is either terraced or undulating sloppy lands with predominance of gravels and low fertile soil. Mandarin orange orchards on north-facing slopes are observed to be more successful, reasons behind it is because of conservation of moisture for longer period of a year and more soil depth. Mandarin orange trees on south facing slopes would have been better if soil depth is more than a meter and also with an irrigation facility.

Importance of soil and nutrient management in mandarin orange orchards

Mandarin orange trees require deep well drained soil, with good content of organic matter and suitable pH level (5.5-7.5) (Manandhar, 1997 and Verma *et al.*, 2014) for a good performance. Mandarin orange being a tree crop, tap root goes deep down to more than 1.5 m depth. Therefore, deep (2 m.) well drained soil without hard pan is important for vigor of trees. Roots may get rotten from excess water during rainy season if soil is poorly drained. 80-95% of feeding root lies in surface soil within 30 cm depth; thus surface soil should be fertile with good amount of organic matter for good performance. Organic matter is an important factor that regulates the bio-physico-chemical properties of soil and also is a good source of plant nutrients. With regards to sub-surface soil, physical properties, such as texture and absence of hard pan, is more important than the chemical properties (nutrient contents) (Manandhar, 1997).

The mid-hill agro-climate favors growing of mandarin orange trees, thus mandarin orange is grown throughout the mid-hill districts of Nepal. With regards to soils, generally mid-hill soils are favorable in terms of soil texture, however, they are less fertile with low water holding capacity due to undulating sloppy land, soil erosion, predominance of gravel and stones. Soil erosion is high during rainy season as large amount of annual rain (80%) falls within 3-4 month (during June-September) period. Foot and root rot is common due to poor drainage during the rainy season, where there is accumulation of water in the basins of trees.

Like other crops, mandarin orange trees also require balanced amount of plant nutrients; Primary nutrients (C, H, O, N, P, K), secondary nutrients (Ca, Mg, S) and tertiary or micro-nutrients (Fe, Mn, Zn, Cu, B, Cl, Mo and Na). C, H, O are supplied through air and water and do not need to worry to supply them. Rest of other nutrients are supplied either through organic manure or inorganic fertilizers. Tripathi (2019) reported that soil fertility decline has been widely recognized as a limitation of crop production in Nepal. Four major causes are responsible for the overall decline of soil fertility in Nepal: soil erosion, reduced organic matter or organic sources, nutrient mining (by crop products/residues), indiscriminate or imbalanced use of chemical fertilizers. Productivity of mandarin orange in Nepal (9.51 MT/ha) (MoALD, 2023) is far below the world productivity of mandarin orange. Inadequate nutrition is a major cause in limiting productivity. Balanced nutrients in soil and plants is important for the good harvest of any crop. Citrus decline has been observed in many well-known pockets of mandarin orange growing areas of Nepal. Among the different causes, poor soil fertility management is one of the important cause of citrus decline. Budhathoki and Pradhanang (1992) found that trees planted close to the house, yard, animal shed and compost pit or heap, healthy and productive irrespective of age. Srivastava and Singh (2004) when investigated citrus decline in sweet orange in Maharastra from the standpoint of soil fertility and nutritional constraints, during 1999-2002, found suboptimum levels of N, P, K, Ca, Fe, Mn, Zn and B both in soil and leaf as important contributory factors towards citrus decline.

Parameters determining requirement of manures and fertilizers

Amount of manures and fertilizers to be applied on any crop should consider the following parameters:

- Nutrients removal by crops
- Soil and leaf analysis
- Deficiency symptoms
- Location specific field trials and soil surveys
- Soil characteristics and land feature.

Nutrients removal by crops

Nutrient removal by any crop depends on age of crop and quantity of harvest. Citrus crop takes up a huge amount of nutrients from soil. Table 1 shows the removal of nutrients by mandarin orange trees from the soil (Rajput and Haribabu, 2004).

Table 1. Nutrient uptake (kg/ha) by mandarin orange trees based on yield of crop

Nutrient element	High yielding	Medium yielding	Low yielding
Nitrogen (N)	182	116	58
Phosphorus (P_2O_5)	54	36	20
Potassium (K_2O)	205	130	64
Calcium (CaO)	273	214	141

Source: Rajput and Haribabu, 2004

Intercropping with maize, millet and wheat is a general practice in mandarin orange orchards of Nepal. If such crops are intercropped, they should separately be applied manures and fertilizers as these intercrops compete for nutrition from soil.

Soil and leaf analysis

Soil and leaf analysis are reliable parameters in determining the quantity of manure and fertilizers required by an orchard, which helps to manage the fertilizer use in an economical manner.

Points to be considered while soil sampling for laboratory analysis

- Sample should be representative of the area. Separate samples should be collected in areas with different soil type, vigor and management practices. Divide into blocks of homogenous sub-units for sample collection.

- Separate samples should be collected based on the depth of soil, such as surface soil (0-30cm), sub-surface soil from 30-60 cm and deeper sub surface soil from 60-90cm.
- If numerous subsamples are collected from one uniform block, same depth samples are mixed well and reduced to 0.5 to 1kg sample by spreading on a sheet, quartering and removing two diagonal quarters.
- The samples should be packed with following labels for sending to a soil analysis laboratory:
  - Name of Farmer and address
  - Crop/intercrop grown
  - Dosage of manure and fertilizers used earlier
  - Availability of Irrigation and drainage facility
  - Depth of soil sample
  - Date of sample collection
  - Reason of soil testing

Soil Nitrogen (N) content from 0.1-0.2% is rated as medium level (Table 2). Similarly, 30-55kg/ha of P_2O_5, 110-280 kg/ha of K_2O and organic matter 2.5-5.0% are rated as medium level (Chaudhary, 1995; Pradhan (1996); SMD, 2017).

Table 2. Rating scale of soil nutrients

Nutrients	Very low	Low	Medium	High	Very high
Nitrogen (N%)	<0.050	0.05-0.0.1	0.1-0.2	0.2-0.4	>0.4
Phosphorus P_2O_5 (kg/ha)	<10	10-30	30-55	55-110	>110
Potassium K_2O (kg/ha)	<55	55-110	110-280	280-500	>500
Organic matter %	<1.0	1.0-2.5	2.5-5.0	5.0-10	>10

Points to be considered while taking leaf samples for leaf analysis

Leaf analysis is an effective technique and the best indicator for monitoring the nutrient status of citrus trees as leaf is the focal point of many plant functions and relatively sensitive indicator to alteration in its mineral composition taken up from the roots (Shrestha and Paudyal, 2008). Leaf nutrient contents have a good correlation with the quality and quantity of harvest. Following points should be noted in taking leaf samples for leaf analysis purpose (Kaini, 2013; Tripathi and Harding 2004; Rokaya *et al.*, 2019):

- Leaf sampling should be conducted from July to September.
- Collect 5-7 month old leaves from 2nd, 3rd, and 4th leaf position from bottom of non-fruiting branches representing all four direction of tree.

- Collect a minimum of 100 leaves from 15-20 trees as one sample for a uniform representative block, following a zigzag pattern in a sample area.
- Leaves should be washed to remove dust particles, air dried in shade and packed in paper bags with a label and send to a laboratory.
- When results are obtained from the laboratory, they can be interpreted based on the standard chart (Table 3) (Reuther *et al.*, 1962).

Table 3. Leaf analysis standards for citrus, 4-6 month old leaves on non-bearing branches

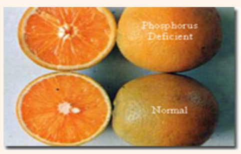
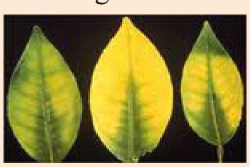
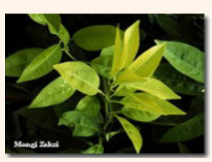
S.N.	Nutrients	Deficient	Low	Optimum	High	Excessive
1	Nitrogen (%)	< 2.2	2.2-2.3	2.4-2.6	2.7-2.8	> 2.8
2	Phosphorus (%)	< 0.09	0.09-0.11	0.12-0.16	0.17-0.29	> 0.30
3	Potassium (%)	< 0.4	0.4-0.69	0.70-1.09	1.1-2.0	> 2.30
4	Calcium (%)	< 1.6	1.6-2.9	3.0-5.5	5.6-6.9	> 7.0
5	Magnesium (%)	< 0.16	0.16-0.25	0.26-0.60	0.7-1.1	> 1.2
6	Sulfur (%)	< 0.14	0.14-0.19	0.2-0.3	0.4-0.5	> 0.6
7	Boron (ppm)	< 21	21-30	31-100	101-260	> 260
8	Iron (ppm)	< 36	36-59	60-120	130-200	> 250
9	Manganese (ppm)	< 16	16-24	25-200	300-500	> 1000
10	Zinc (ppm)	<16	16-24	25-100	110-200	> 300
11	Copper (ppm)	< 3.6	3.6-4.9	5-16	17-22	> 22
12	Molybdenum\ (ppm)	< 0.06	0.06-0.09	0.1-0.29	0.3-0.4	–
13	Chlorine (%)	–	–	0.3	0.4-0.6	> 0.7
14	Sodium (%)	–	–	0.16	0.17-0.24	> .25

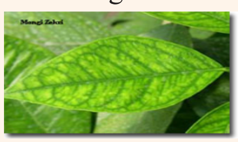
Source: Reuther et al. (1962)

Deficiency symptoms

Citrus is one of such crops, which exhibit symptoms reflecting various disorders that can impact their health, vigor and productivity to varying degrees. Table 4 shows nutritional deficiency symptoms of different nutrient elements and measures to correct these symptoms for good performance of mandarin orange trees (FAO, 2011; Kaini, 2013; Karki *et al.*, 2017; Acharya *et al.* 2019).

Table 4. Deficiency symptoms and corrective measures

S.N.	Nutrient element	Deficiency symptoms	Corrective measures
1	Nitrogen 	General and uniform yellowing of leaves, Limited growth of twigs and leaves, die back of young twigs if deficiency is prolonged, leading to undersized trees, excessive flowering and fruits size will be reduced declining the yields.	Application of recommended dose of N-fertilizer in split doses.
2	Phosphorus 	Discoloration of leaves, Reduced growth with reduced number of lateral shoots, reduced and delayed flowering, premature fruit drop and thickening of fruit rinds.	Recommended dose of P fertilizers in single dose during late winter or early spring.
3	Potassium 	Foliage becomes bronze and lusterless, dieback of twigs, gum exudes from the main trunk, fruits become reduced in size with smooth and thin peel, cracks and decays.	Recommended dose of K fertilizers in split doses.
4	Calcium 	Dieback of twigs, chlorosis between veins, thickening and reduction of leaves, peel of fruits become thick and hard, reduction of growth of roots.	Soil Application of Calcium carbonate (agriculture lime) 1kg/tree with light irrigation
5	Magnesium 	Development of Yellow areas between the large veins of leaves and on the both sides of the mid rib. Chlorosis in the old leaves first. Poor root growth and fruiting in alternate years, reduction of quality and yield of fruits.	Spray of 0.3% Magnesium sulphate twice at 15 days interval when new flush comes.
6	Sulphur 	Yellowing of younger leaves, dieback of twigs, fruits become smaller and less juicy.	Use of organic matter, use of Sulphur containing fertilizers such as ammonium sulphate, potassium sulphate.
7	Zinc 	Interveinal chlorosis, small leaf size, dieback from terminal twig, rosette-like appearance due to reduced internodes, fruits become reduced and misshapen. Deficiency is common in all mandarin orange growing areas.	Spray of 0.5% Zinc sulphate twice at 15 days interval when new flush comes.

S.N.	Nutrient element	Deficiency symptoms	Corrective measures
8	Iron 	Interveinal chlorosis of young leaves first, yellowing and almost white leaves, in acute cases, fruits become small, hard, coarse and light in color	Spray of 0.3% Ferrous sulphate twice at 15 days interval when new flush comes.
9	Copper 	Exudation of gum from nodes of branches, and die back of twigs, gum pockets on peel of fruits, cracking and drop of fruits.	Spray of 0.3% Copper sulphate twice at 15 days interval when new flush comes.
10	Manganese 	Symptoms are similar to zinc deficiency; however, leaf size is not reduced. Symptoms are prominent in shady areas.	Spray of 0.3% Manganese sulphate twice at 15 days interval when new flush comes.
11	Boron 	Corking and splitting of veins of mature leaves, brown gum pockets formed around seeds of the fruits. Fruits are misshapen, juice content reduced, peel of fruit becomes rough	Spray of 0.3% Boric acid twice at 15 days interval when new flush comes.
12	Molybdenum 	Water-soaked areas appear on the leaves with the start of new growth in early spring. These areas subsequently coalesce into larger lesions with gum on the lower sides of leaves. Fruits show cracking.	Sodium molybdate can be dissolved and sprayed. Symptoms are observed in acidic soil. Maintain soil pH to 5.5-6.7.

It is not easy to distinguish nutrient deficiency symptoms. Availability of Zn, Mn, and Fe are soil pH related, deficiency symptoms of the three elements may often occur simultaneously and some symptoms may be confused with physiological, and pathological disease related disorders. Micronutrient deficiency symptoms are commonly seen in those areas where imbalance use of fertilizers is practiced, where soil is light sandy, in areas with steep slopes and high rainfall, in soil with very low or high pH and if organic manure use is very minimal (Baral and Subedi, 2003).

Location specific field trials and soil surveys

Location specific field trials are reliable in determining requirement of manures and fertilizers. In Nepal, very few field fertility trials and soil surveys have been done in major mandarin orange growing areas in Nepal. However, some of the studies related with soil and leaf nutrient status of mandarin orange done in mandarin orange growing locations are listed in Table 5.

Table 5. List of studies showing soil and leaf nutrient status of mandarin orange growing locations

S.N.	Title of study and author/s	Result of study on nutrient levels	Location
1	Soil properties and availability of nutrient elements in mandarin orange growing areas of Dhankuta district (Gupta *et al*, 1989).	**Soil analysis** - Soil is characterized by moderate pH (5.7-8.0), 45, 30 and 25% of surface soil samples had low, medium and high level of OC content respectively. - Loamy Sand to sandy clay loam with 8-37% clay content. - Of the surface soil, 70% samples were medium in total N content, 90% sample were medium to high level in available P, and all the samples were medium to high level in exchangeable K. - Of the surface soil, 70% of samples were low in exchangeable Ca, 50% samples were low in exchangeable Mg, and 75% samples were low in available B. **Leaf analysis** - Zn level is deficient in 16% samples and in low range in 79% samples and some deficiencies of B, N, Mg, Cu, and Ca. - Well-nourished with P, K and Mn.	Dhankuta District (Hattikharka, Pakhribas, Phalate, Ghorlikharka, Murtidhunga, Sanne and Muga) (Koshi Province)
2	Leaf and soil analysis for finding the status of nutrients in mandarin orange orchards of Tanahu, Lamjung and Gorkha: A survey (in Nepali) (Baral and Subedi, 2003)	**Soil analysis** - It is quite challenging for farmers to go for commercialization of mandarin oranges from its subsistence farming due to decline in quantity and quality of fruits. One of the reasons of citrus decline is degrading soil fertility. - Brownish red colored clayey soil, pH 5.4, high in N (0.35%), medium in P (42.84 kg/ha) and medium in K (233.14 kg/ha) in Bandipur, Tanahu. - Black clayey sandy, granular textured soil with pH 4.3 and low in N (0.032%), medium in P (53.8 kg/ha) and medium in K (267.4kg/ha) in Gaun Shahar, Lamjung. - Brown sandy clayey soil, pH 4.5, low in N (0.035%), low in P (28.9 kg/ha, medium in K (182.65 kg/ha) in Nareswor, Gorkha. **Leaf analysis** - Leaves of more than 75% of trees had low N, 28% trees had low K, however, leaf P content was in excess in all areas. 97%, 74%, 47% and 31% of orchards had lower than optimum level of Fe, B, Zn and Mn level, respectively.	Tanahu (Lohi pakha in Bandipur), Lamjung (Naruwal gaun in Gaunshahar) and Gorkha (Bhogateni in Nareswor) (Gandaki Province)

S.N.	Title of study and author/s	Result of study on nutrient levels	Location
3	Performance of Mandarin orange trees (*Citrus reticulata* Blanco) at different altitudes and nutrient management in mid-hills of Nepal (Baral, 2008).	- Based on soil test results, generally soil organic matter, total soil N and available soil P were more at high altitude (>1100m amsl) and pH, available Ca and Mg contents in soil decreased as altitude increased. - When leaf analysis results were checked, total leaf P, K, Fe and Zn content were higher in higher altitude area (>1100m) compared to lower altitude area (500-1100m amsl).	Gorkha (Nareswor, Bhogeteni, Manakamana village), Lamjung (Naruwal, Subedi gaun and Bhotechaur) and Tanahu (Lohi, Aabukhaireni and Ghansekuwa) (Gandaki Province)
4	Foliar nutritional levels of mandarin orange (*Citrus reticulata* Blanco) orchards at different altitudes, age and health in mid-hills of Nepal (Baral *et al.* 2012).	When analyzed leaf samples of orchards of Gorkha, Lamjung and Tanahu - Low level of Zn, Ca, Mg, and Mn in high altitude area. - Low level of Zn , B, and Mn in mid altitude - Low level of N and Zn in lower altitude area.	Gorkha, Lamjung and Tanahu (Gandaki Province)
5	Micronutrient status of mandarin orange trees in Gorkha and Lamjung districts of Nepal (Tripathi, and Harding 2004).	Out of 10 sites, 9 sites were deficient in B, 6 sites were deficient in Zn, and 3 sites were deficient in Mn. They have suggested to supply them from external sources.	Gorkha District (Ashrang, Bakrang, Gaikhur and Ghairung) and Lamjung District (Bhorletar, Dhimire Gaun, Shishaghat, and Syaut) (Gandaki Province)

S.N.	Title of study and author/s	Result of study on nutrient levels	Location
6	Assessment of soil nutrient status of mandarin orange orchards in Syanja, Nepal (BK *et al.* 2022)	The altitude range had a considerable effect on soil nutrient status except phosphorus and potassium availability. - Highest organic matter content (5.76%) was recorded in 900-1100 masl of North facing slope. - Highest total nitrogen content (0.28%) was recorded in 900-1100 masl of north facing slope. - The finding showed that altitude range of 900-1100 masl and north-facing slope was suitable for mandarin orange cultivation from the nutrient status point of view.	Putalibazar, Bhirkot, Waling and Arjunchupari of Syanja District (Gandaki Province)
7	Soil and plant nutrient status of mandarin orange orchards of mid and far western hills of Nepal (Regmi *et al.* 2001).	When 20 soil samples and 23 leaf samples collected from major citrus pockets and analyzed at Soil Science Division, Khumaltar during 2001, - Soils of majority of citrus orchards in Dailekh were strongly acidic (pH 4.5-5.2) in nature, Low level of organic matter (1.0-2.5%) and low to medium level of soil nitrogen (0.05-0.2%). low to medium level of soil P (10-35 kg.ha) and medium level of soil potash (110-280 kg.ha) - Low to satisfactory level of leaf N, (1.9-2.7%), excess level of leaf P (0.3%), and satisfactory level of leaf K (1.0-1.7%).	Dailekh District (Dullu and Kal Vairab) (Karnali Province)
8	Citrus drops problem in the far and mid-western development region of Nepal (Shrestha *et al.*, 2008)	Based on soil sample analysis (upto 30 cm depth), - pH was nearly neutral (6.7). - NPK and organic matter content in the top soil was at satisfactory level in all sites. Leaf analysis - N content was deficient (0.57-0.72%) but P and K was in satisfactory level.	Salyan and Dailekh (Karnali Province) And Kailali, Baitadi, (Sudur Pashchim Province)
9	Nutrient status of mandarin orange (*Citrus Reticulata* Blanco) orchards in the Far western development region of Nepal (Shrestha and Paudyal, 2009).	- Soil acidy ranged from pH 4.8-6.4 with an average of 5.8 (moderately acidic), low OM (1.2%), low N (0.091%), medium P (186.7 kg/ha) and excess K (582.4 kg/ha). - Leaves are deficient in N (2.25%), high in P (0/189%), deficient in K (0.38%) and Zn (27.8 ppm), excess in iron (490.26 ppm), and medium in Mn (34.38 ppm).	Kailali (Sahajpur), Dadeldhura (Bagarkot), Baitadi (Durgabhawani), Doti (Kaflekhi) and Achham (Mangalsen) (Sudur Pashchim Province)

S.N.	Title of study and author/s	Result of study on nutrient levels	Location
10	Citrus nutritional study, Annual Report 2076/77 (2019/20). National Citrus Research Programme, NARC, Paripatle, Dhankuta, Nepal (NCRP, 2020).	When leaf samples collected from 93 farmers' orchards across Nepal (65 for Mandarin orange, 19 for lime, 8 for sweet orange and 1 for Unshu orange) and tissue samples were analyzed at the University of Queensland for nutrient contents: - It was found that citrus growth was highly restricted by a deficiency of Zn, 98% samples being marginal for Zn and 81% being within the deficient range. - This also reported 67% samples being marginal for N and 57% being within the deficiency range. They opined that Zn and N fertilizers are critical in improving citrus production.	Many of the citrus growing districts across Nepal

Though Nepal is a small country, there is a wide variability in altitudes even in very small differences in latitude from the South to North. The studies listed in the Table 5 shows variations in pH and soil nutrient contents in different geographic locations. However, in general, soil acidity and soil N seems to be important limiting factors in mandarin orange orchard soils. Similarly, leaf Zn and B contents seems to be at lower level in general. However, location specific fertility trials, soil and foliar analysis are important in determining the manure and fertilizer requirements, especially in commercial growing orchards.

Soil characteristics and land feature

- **Soil reaction** (pH of soil) strongly influences availability of nutrients and plant uptake. Micronutrients like Zn, Mn and Fe become more available in acidic soils while Mo, Ca and Mg are more available in soils with neutral pH. Soils of mandarin orange growing areas in Nepal are mostly with varying degrees of acidic in reaction. Acidic soil parent material, use of acidifying fertilizers, and leaching of Ca, Mg nutrient elements due to heavy rain within short time during rainy season are the causes of soil acidification. Thus, application of liming materials in every alternate year or once in three years should be practiced.

- **Soil texture** influence the growth of roots and nutrient uptake by feeder roots. Foot rot and root rot are more common in clayey soil due to poor aeration and poor drainage. Sandy soil is also problematic due to less nutrient content and low water holding capacity. Use of more of organic matter improves both sandy soil and clayey soils. Recommended application rates for fertilizers should be modified according to soil texture. An extra 30-40% above the recommended dose of fertilizer should be applied to gravel soil or coarse textured soils since they have poor ability to hold nutrients (Petersen, 2003).

- **High steep land, land with hard pan, land without drainage facility** also are problematic for mandarin orange cultivation. Soil erosion is a serious problem in some of the mandarin orange growing areas.

Dosage of manures and fertilizers

Dose of manures and fertilizers varies according to the age of the tree, the fruit load and soil fertility and nutrient status of the tree. Dosage of manures and fertilizers provided here is based on experience of technician, farmers and literature available (Kaini, 2013; Manandhar, 1997; NCRP, 2014; Pun *et al.*, 2015) (Table 6). This can be used as a general guide; the quantity can be adjusted according to soil and leaf nutrient status of the orchard.

Table 6. Dosage of manures and fertilizers

Age of tree	FYM/compost	N (gm/tree/year)	P_2O_5 (gm/tree/year)	K_2O (gm/tree/year)
1	10	50	25	35
2	20	100	50	70
3	30	150	75	105
4	40	200	100	140
5	50	250	125	175
6	60	300	150	210
7	70	350	175	245
8	80	400	200	280
9	90	450	225	315
10	100	500	250	350

Apart from organic manure and NPK fertilizers, micronutrient fertilizer applications also produce significant effect on quality and quantity of mandarin orange fruits, Rokaya *et al.* (2019) conducted trial in a private farm (1000 masl) in Lamjung district and found that two sprays of urea (2%) or micronutrient (Agromin) (0.4%) alone, or, in combination had a significantly better performance for most of the parameters such as number of fruit, juice content, ascorbic acid contents, and most of the minerals. Similarly, Rakhonde and Zope (2020) also observed significantly enhanced yield and quality of Nagpur mandarin orange when soil and foliar application of zinc sulphate micronutrient was done.

Method of manure and fertilizers application

- Soil application
- Foliar application
- Fertigation technique

Soil application

- Organic manures and macronutrients such as Nitrogen, Phosphorus and Potassium fertilizers are usually applied to soil as it is cheaper, easier, and the residual effect is longer.
- It is recommended that 50% of nitrogen should be supplied through organic sources such as FYM or compost.

- A basal application of manures and fertilizers should be given after harvest, during the winter season. The main purpose is to restore the tree vigor after fruit harvest and improve the soil condition using organic manures and lime materials.
- Irrigation is important after each application of fertilizers. If irrigation facility is not available, apply fertilizers just after the rain or when there is sufficient moisture in soil.
- Lime materials should be applied in alternate year or once in three-year period to improve soil pH; lime should not be applied along with fertilizers, but at least a month prior to application of fertilizers and plough and irrigate the land.
- If lime is to be applied combined along with farm yard manure, they should be mixed with soil at a depth of 30cm below the soil surface. Generally, agriculture lime is spread at the bottom of a furrow or hole. Over this spread a layer of organic manure and they are both should be then covered with top soil (Petersen, 2003). This will prevent loss of N through volatilization.
- As nutrients from farm yard manure (FYM) is released slowly and phosphorus (P) fertilizer also do not have leaching losses, full dose of farm yard manure and full dose of phosphorus fertilizer can be applied as basal dose while nitrogen (N) and potassium (K) fertilizers are prone to losses, they should be applied in split doses (Subedi *et al.*, 2003; Petersen, 2003). 1/3rd (one-third) of nitrogen and 1/3rd of potassium fertilizers should be applied along with basal dose (FYM and P) fertilizer.
- One third of recommended nitrogen (N) fertilizer and one-third of recommended potassium (K_2O) fertilizer is to be applied in blooming/fruit set stage (March/April) and remaining 1/3 of N and 1/3 of K fertilizers are to be applied during the fruit development stage (Aug/Sept). This helps to improve both the quality and size of fruits.
- While applying manures and fertilizers, prepare a basin under the tree canopy by light hoeing and then broadcast manures and fertilizers. After broadcasting, they are mixed well into the soil by hoeing second time and irrigate.
- Alternatively, a trench of 15-20cm wide and 15 cm depth ring is dug out round, below the drip of the tree, then manure and fertilizers are applied in the trench and covered the trench with the dug-out soil and irrigated.
- As more than 80% of the feeder root lies on surface soil within 15cm depth, deep hoeing should be avoided while applying manures and fertilizers using the basin method. Basin size should be increased as tree grows, basin size should be twice the diameter of the tree canopy for a mature tree.

Foliar application

- This method is generally followed for use of micronutrients and also for a low dose of urea (1 – 2%).
- Foliar application should be done when new flushes of leaves come and they attain half expansion in growth, i.e. in May-June.

- Foliar application shows quick results as it is directly applied on leaves. It is better and safer to use two light sprays rather than a single dose of heavy dose.
- A combined spray of micronutrients as shown in Table 7 has been recommended for mandarin orange (Kaini, 2013; Manandhar, 1997; Petersen, 2003). Lime is also mixed in order to bring it to neutral in reaction.
- Nowadays there are many instant mixtures on formulations of micronutrients available in markets (Manandhar and Khanal, 2004), such as Agromin, Multiplex, Microplex, High Zinc etc.

Table 7. A combined spray of micronutrients

Nutrient element	Quantity in gm	Concentration level
Zinc sulphate	100	0.5%
Copper sulphate	60	0.3%
Magnesium sulphate	60	0.3%
Manganese sulphate	60	0.3%
Ferrous sulphate	60	0.3%
Boric acid	60	0.3%
Slacked lime	60	0.3%
Water	20 litres	

Fertigation technique

Applying water soluble fertilizer nutrients to plants along with irrigation water is called fertigation. This technique can be followed where drip irrigation is done.

Farmers' soil and nutrient management practices

Though Mandarin orange is one of the important cash crops for mid-hill farmers, very little care is given to this crop. Many of the farmers plant fruit trees at edge of terrace in order to avail land for maize or millet cultivation. In many places, manure and fertilizers are applied to these crops and only residual nutrients are available for mandarin orange trees. Table 8 lists some studies showing farmers' soil and nutrient management practices.

Table 8: Farmers' soil and nutrient management practices

S.N.	Title of study and Author	FindingFinding	Location
1	Mandarin orange production, contribution in household income and livelihood of mandarin orange farmers in the Eastern hills of Nepal: A case study of Khoku VDC, Dhankuta District (Gautam *et al.*, 2011).	Compost is used each year, but no chemical fertilizers were applied.	Dhankuta District (Khoku) (Koshi Province)

S.N.	Title of study and Author	FindingFinding	Location
2	Leaf and soil analysis for finding the status of nutrients in mandarin orange orchards of Tanahu, Lamjung and Gorkha: A survey (in Nepali) Baral and Subedi, 2003)	Most of the farmers were using 10-40 kg cowdung or poultry manure based on the age of trees. Maize or millet are intercropped in mandarin orange orchards, most of compost is used by these grain crops. DAP and Urea are also used by most of the commercial farmers.	Tanahu (Lohi pakha in Bandipur), Lamjung (Naruwal gaun in Gaunshahar) and Gorkha (Bhogateni in Nareswor) (Gandaki Province)
3	Factors influencing adoption of major orchard management practices in mandarin orange of Gorkha: A case from mid-hills of Nepal (Poudel *et al.*, 2021).	Frequencies of adoption are as follows: Application of FYM -65% Intercropping- 58% Mulching- 40% Micronutrient application- 30% Chemical fertilizer application- 14% Livestock holding had a positive and significant association with intercropping. Participatory training program related to the rejuvenation of declining orchards, regular advisory and extension services and input subsidies to the smallholding farmers are important for increasing adoption of orchard management practices.	Gorkha District (Gandaki and Sahid Lakhan Rural municipalities and Gorkha Municipality) (Gandaki Province)
4	Farmers' knowledge and adoption of improved mandarin orange orchard management practices in Syanja district, Nepal (Bhandari *et al.*, 2022).	Based on 97 randomly selected respondents of the study area >90% were found to practice FYM application, while only 17.52% were using chemical fertilizers and 39.18% using soil testing and amendments. Training has a positive impact on the use of chemical fertilizers and soil amendment practices. Encouragement is required to use the recommended amount of fertilizers along with mulch and Bordeaux paste.	Syanja District (Putalibazar, Bhirkot and Waling municipalities and Arjunchaupari rural municipalities) (Gandaki Province)

S.N.	Title of study and Author	FindingFinding	Location
5	Causes of citrus decline and its management practices adopted in Myagdi district, Nepal (Poudel *et al.*, 2022).	75.5% of the farmers in the study area have been practicing the use of FYM on an average of more than 30kg/plant/tree. 44.7% of the farmers use chemical fertilizers to supply primary nutrients and 37.2% micronutrients in their orchards. 74.5% of the farmers were practicing intercropping, of which 40.4% of intercrops are mostly exhaustive crops (maize, millet, barley and wheat). 60.6% of the farmers had planted their mandarin orange in mid-portion of the terraced field, while 39.4% farmers planted on the edge of the terraces.	Myagdi district (Beni and Malika rural municipality) (Gandaki Province)
6	Management of citrus decline and rejuvenation strategies for declining Orchards of Dailekh (Subedi and Acharya, 2008).	Growers do not adopt proper orchard management practices including manure and fertilizer application. Majority of citrus trees are planted on edge of terraces to get more space for intercrops which limit the root expansion only on one side. Most farmers in Dailekh are using improper intercrops such as maize, millet, wheat or vegetables.	Dailekh (Dullu, Mallika, Gamaudi, Kal Bhairav, Lakuri, Goganpani, Kandechaur) (Karnali Province)
7	Improving citrus production in Dailekh district of Nepal (Acharya *et al.*, 2011)	90% of the respondents were using compost. Only 5% of the farmers were using chemical fertilizers. 65% intercropped cereals (maize and upland rice in summer and wheat in winter), 35% intercropped vegetables, 25% legumes and 20% intercropped legumes. IPN and IPM are to be enforced by R&D partners for adoption in production areas.	Dailekh District (Goganpani, Lankuri and Dullu) (Karnali Province)
8	Determinants of adoption of multiple sustainable agriculture practices among mandarin orange producing farmers in Salyan District of Karnali Province, Nepal (Dahal *et al.*, 2023).	98.33% farmers were found to apply organic manure at least once a year. Only 8.3% farmers were applying chemical fertilizers, while rest is unaware about proper application methods, application doses and time. 78.33% of the farmers were adopting conservation tillage and 42.5% of the farmers were cultivating cover crops such as cowpea, soybeans and black gram at least once a year.	Salyan District (Chhatreshwari Rural Municipality and Baghchaur Municipality), Karnali Province

S.N.	Title of study and Author	FindingFinding	Location
9	Citrus drops problem in the far and mid-western development region of Nepal (Shrestha *et al.*, 2008)	Farmers of all the districts were using cattle manure @0.5-2 dokos per tree per year depending on age of the tree from Poush to Falgun. Only 25% of the farmers of Dailekh and 30% of the farmers of Salyan were using little amount (250-500 gm) DAP per tree during Magh-Falgun Compost making technique is very traditional and quality of compost is poor. Upland rice or maize (rainy season) and wheat (winter season) are commonly intercropped in the orchards.	Salyan (Khalanga) and Dailekh (Dullu) (Karnali Province) and Kailali (Nigale), Baitadi (Nagarjun), (Sudur Pashchim Province)

The findings of the studies shown in Table 8 indicate that majority of the farmers were applying FYM/compost in their orchards, while only fewer farmers were applying chemical fertilizers. A few of the farmers were applying micronutrient fertilizers as well.

Most of the farmers were using maize, millets and wheat as intercrops in order to fulfill the need of household staple food. High amount of soil nutrients is taken up by the intercrops as they are high nutrient depleting crops. Cultivation of such crops also likely to damage the feeding roots of mandarin orange trees, thereby making them vulnerable to infection by *Phytophthora* foot and root rot. If intercropping is to be done, less nutrient depleting crops such as short legumes, vegetables and fodder crops can be cultivated away from the basin of trees (Tomiyasu *et al.*, 1997). Once mandarin orange trees come to bearing stage, intercropping should be avoided. Some of the farmers have mandarin orange trees on the edge of terraces, hampering nutrient uptake from all side of trees.

Conclusion

Mandarin orange is the most popular fruit grown in all the mid-hill districts of Nepal. Productivity of mandarin orange in Nepal is low. Most of the cultivated land is sloppy lands with low fertility. Poor soil and nutrient management is widely recognized as a limiting factor of production in mandarin orange orchards. There is a wide variation in soil and leaf nutrient levels in mandarin orange orchards of different parts of Nepal. In general, low level of soil pH and soil nitrogen are important limiting factors, similarly lower level of Zn and B in leaf are also limiting factors. The majority of the farmers were applying FYM/compost in their orchards, while only fewer farmers were applying chemical fertilizers. Intercropping with maize, millet and wheat is a general practice in mandarin orange orchards, which not only compete with soil nutrients but also damage the surface roots of mandarin orange trees. Therefore, intercropping of such crops should be discouraged when the trees come to bearing stage, and the farmers need to be encouraged to use the recommended amount of manures and fertilizers. Location specific fertility trials, soil surveys, and soil and foliar analysis are important in determining the manure and fertilizer requirements, especially in commercial growing orchards.

Future research on mandarin oranges

Future long-term study should focus on the management of major nutrients (NPK combinations) and response of different micronutrients (Zn, Fe Cu, Mn, B amd Mo) on the growth and yield of mandarin oranges so that strong recommendations can be made for obtaining benefits by the mandarin orange growers.

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Nutrient Status of Mandarin Orange (*Citrus reticulata* Blanco) Orchards in the Sudur Pashchim Province of Nepal

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Abstract

Both soil and leaf samples of the mandarin orange orchards were analyzed to determine the nutritional status of citrus orchards of Sudur Pashchim Province (SPP) of Nepal. Samples were collected at various depths from the problematic mandarin orange (*Citrus reticulata* Blanco) orchards of the five districts (Kailali, Dadeldhura, Baitadi, Doti and Achham) in 2007 October and analyzed for nitrogen (N), phosphorus (P), potassium (K), soil pH and organic matter (OM). Leaf samples were also collected from the same orchard at the same time, where the soil samples were taken from healthy and unhealthy orchard trees separately and analyzed for NPK and micronutrients i.e. zinc (Zn), iron (Fe) and manganese (Mn). The soil pH was found more acidic (4.8-6.4) in the orchard. Amount of Organic matter (1.2%), and nitrogen of the soil is lower (0.091%) level, phosphorous medium (186.7 kg/ha) and potassium was excess (582.4 kg/ha). Amount of Nitrogen (2.25%), potassium (0.380%) and zinc (27.80 ppm) in the leaf was observed deficient level, where the phosphorous (0.189%) and iron (490.26 ppm) was high level and manganese (34.38 ppm) was medium level. The result showed that the organic matter, nitrogen and zinc are deficient in both soil and leaf in the citrus orchards of SPP study sites of Nepal.

Keywords: Nutrient deficiency, Concentration, Organic matter, Mandarin orange, Citrus orchard

Introduction

Success and failure of plants life is fully depending on the physical and chemical properties of soil. Soil physical properties are more important than chemical properties to fruit crops. Soils with pH range 6.5 to 7 are ideal for citrus crop (Terry et al., 1992). Besides providing anchorage to the plant, soil furnishes water and nutrient for its growth and development. Citrus trees are grown on various types of soil ranging from sandy to clay with proper management practices. For good performance citrus crop requires deep well drain soil, free of excess salt with humus content. In Nepal, citrus are grown in mid hill range due to favorable agro-climatic conditions, but the soil of this range is less fertile, has less water holding capacity and there is predominance of gravel and stone which requires high management practices for cultivation of citrus crop (Srivastav and Singh, 2006)., Due to the poor management practices and poor nutritional status citrus plants in Nepal are being suffered from malnutrition and showing declining symptoms in Nepal. FAO (2002) reported that the annual fertilizer requirements of citrus are 100 to 200 kg N, 35 to 45 kg, P_2O_5 and 50 to 160 kg K_2O /ha. Balance nutrients are important for the improvement of yield and quality.

Citrus is a perennial fruit trees and deep-rooted crop. The uptake of available soil nutrients by the trees are strongly influenced by the soil pH and moisture. The soil organic matter, and the levels of various nutrients such as nitrogen, phosphorus, potassium, calcium, zinc, iron and magnesium influence tree growth and fruit yield. Gupta et el (1989) reported that boron, magnesium, copper, calcium and zinc were deficient in most of the mandarin orange orchard of Dhankuta district. Citrus trees in the selected sites of Sudur Pashchim Province (SPP) were suspected from nutritional problems causing lower yield. It is necessary to test leaf and soil of orchard every year and to know the nutrient status of the soil and tree of the orchard, which helps to manage the fertilizer economically. Therefore this study is to determine the nutritional status of orchard soil and tree in the SPP of Nepal, that will remedial procedures of nutrient deficient problem in a sustainable way and increase the yield and quality of citrus fruits.

Materials and methods

The sites were selected on the basis of detailed discussion with District Agriculture Development Office (DADO) of each district. Select mandarin orange growing farmers group in major production pocket areas of the district and orchards were selected with the discussion of farmers groups in the pocket areas.

Soil sample collection and analysis

Soil samples were collected from problematic mandarin orange orchards of five districts i.e. Kailali (Sahajpur and Nigale), Dadeldhura (Bagarkot), Doti (Kapalleki), Achham (Mangalsen) and Baitadi (Durgabhawani) of SPP. Samples were collected from 5-10 spots in 2007 October (depending on orchard size) in a zigzag way by soil agar. Soil samples were taken from directly beneath the outer canopy, just below the drip line of the tree. Three composite soil samples were collected in various depths (0-30 cm, 31-60 cm, and 61-90 cm) separately from each farmer's orchard and packed one-kilogram representative soil sample in plastic bags with label. Collected samples were cleaned and dried in shed. A total of seventy five (15 samples per district) composite soil samples were collected from five districts and analyzed for soil pH, organic matter (OM), Nitrogen (N), Phosphorus (P), Potash (K) and texture separately for each depth in the laboratory of National Soil Science Research Centre, Khumaltar, Lalitpur.

Leaf sample collections and analysis

Leaf samples were collected from same orchards where soil sample were taken in 2007. Two composite leaf samples were collected from each orchard (10% of total plant) separately from bearing healthy and unhealthy trees (50 leaves from healthy and 50 leaves from unhealthy trees). A total of 50 composite leaf samples were collected from five districts. Four to six month old matured leaves were collected from non-fruiting branch representing all four directions. Samples were washed in clean water and kept in percolated Nepali envelope with label prior to sanding in the Soil Lab. Leaf samples were analyzed for N, P, K, Fe, Zn and Mn in National Soil Science Research Centre, Khumaltar, and Lalitpur laboratory.

Results and discussion

Soil analysis

Soil pH: Soil pH is one of the most important factors that influence the nutrient-absorbing capacity of the plant. In Nepal, recommendation of pH value for mandarin orange orchard soil is 6.5 however; it can grow on soil with pH range 4 to 8.5 in India (Haas 1960). In alkaline soil, the availability of micronutrients decreased. Lower pH level stands to increase the leaching of lime and magnesium; higher-level reduces the availability of trace elements. The pH range of mandarin orange orchards in the study sites were varied ranges from 4.5 to 6.4 according to location and depth. Average value of pH was found 5.8 that are moderately acidic. It is advised to supply sufficient liming materials to prevent pH value if falling below 5.5 and soil pH better to test every year.

Soil organic matter: Organic matter plays an important role to improve the soil quality and maintaining the tree health of citrus. It improves soil physical properties besides supplying plant nutrients and increases the buffering capacity of the soil and increases water-holding capacity which is very important factor for better yield of citrus trees. The level of OM at 0-30 cm depth in the selected sites was less than 1.5 percent which is considered very low for citrus crop. Soil with more than 2.5 percent organic matter is considered suitable for citrus cultivation (Smith, 1966). Among different sites, OM was lowest (0.808%) in Kaflekhi Doti and it was highest (1.928%) in Barkurali, Baitadi. OM percent was higher in topsoil and decreased as depth of soil increased (table 1). OM in the soil can be increased up to 2.5 percent in the citrus orchard by applying easily available resources such as crop residues, green manure, compost, animal wastes, oil cake, and residues from food processing (Hsieh, 1989). Since a matured cow can produce about 30 kg of wastes every day, proper management and use of compost could be a better option to improve soil OM content in the hills of Nepal.

Nitrogen (N): Nitrogen is the balance wheel of citrus nutrition because of efficiency of other nutrients depends on the level of N in the soil and deficiency of N dramatically affects tree growth and fruit production (Oches et al 1991). It is a major component of chlorophyll (green pigment in leaves), and is associated with important tree functions such as growth, leaf production, flower initiation, fruit set, and development. Citrus trees need 0.1% to 0.2% nitrogen in the soil for better growth and health. Trees will show deficiency symptoms if nitrogen level falls below 0.09% (Smith, 1996). Aggrawal (1997) reported that N content of top soil (0-15 cm depth) in the citrus orchard of Punjab was 0.39%, but the amount of N depended on the soil type, rainfall, and temperature (Bould, 1963). In the SPP of Nepal, average N level of 0-30 cm, 31-60 cm, and 61-90 cm depth was found 0.108 %, 0.085% and 0.081 % respectively (table 1). The level of N decreased with increased soil depth. Average N level in the orchard soil was found < 0.091% in the selected site of SPP, which was below the optimum level. It could be increased by the addition of bio-fertilizers, legume intercropping, and well-decomposed compost manure.

Phosphorus (P_2O_5): Phosphorus performs many vital functions in photosynthesis, enzyme activity, and formation and movement of sugars in the plant. It is important in flowers and fruit development. Low phosphorus affects fruit quality, causing misshapen fruit with open centers and coarse, thickened rinds in citrus. A citrus plant removed 24.5 kg phosphorus/ ha /year (Anonymous 1966) and but Smith (1996) reported the standard level of P_2O_5 in the soil would be 31-55 kg/ha. The soil analysis result of the study areas shows that average phosphorus level in the citrus orchard was 186.7 kg /ha (table 1) which is excess than standard level and no need to apply additional amount of P_2O_5. The highest amount of P_2O_5 was found in Sahajpur (320.6 kg/ha, excess level), and the lowest amount was found in Barkurali, Baitadi (90.5 kg/ha, high level) district. The result showed that the level of P_2O_5 in the orchard soil was found higher in all sites. Excessive P_2O_5 level, that affects to the leaf and shows zinc, iron, nitrogen, and copper deficiency. It reduces the juice content of fruits, and also inhibits root growth. It is suggested that, P_2O_5 should be applied only in situation where both soil and leaf analysis indicates deficiency. A long-term experiment on citrus in Australia shows that 1.81 kg superphosphate/ tree was the best for the optimum production and quality fruits (Cary, 1968).

Potassium (K_2O): Potassium is important in the formation and functioning of proteins, fats, carbohydrates and chlorophyll and maintaining the balance of salts and water in plant cells. Potassium deficiency symptoms include slower tree growth; small leaves and a heavy leaf fall, often preceded by the leaves turning yellow or bronze. Fruits are small; skins are thin and smooth, tend to colored early, and split easily. Chapman and Hardling, point out citrus tree may use 75-120 kg K_2O per acre per year. Highest amount of K_2O was found in Mangalsen (1078.3 kg/ha, excess level) and the lowest amount was found in Sahajpur (153.6 kg/ha, medium level). The average amount of K_2O in the citrus orchard soil of survey areas was 584.9 kg /ha (table 1) which is an excess range but no toxic effect was found in the orchard plant. Increased the exchangeable potassium level in soil may reduces the uptake of calcium and magnesium.

Table 1. Nutrient status of mandarin orange orchard soil at various depths in the SPP of Nepal.

Soil Properties	1. Kailali (1167 m)*			2.Dadeldhura (1395 m)*			3.Doti, (1292 m)*			4. Achham (1417 m)*			5. Baitadi (1493 m)*			Mean (1352.8)*			Grand mean
	0-30	31-60	61-90	0-30	31-60	61-90	0-30	31-60	61-90	0-30	31-60	61-90	0-30	31-60	61-90	0-30	31-60	61-90	
pH	5.7	5.7	5.6	6.3	6.4	6.3	5.9	5.7	5.9	5.4	4.8	4.9	6.2	6.4	6.0	5.9	5.8	5.7	5.8
OM %	1.338	1.447	1.223	1.638	0.927	0.811	0.907	0.808	0.858	1.887	1.079	1.195	1.928	1.293	1.117	1.539	1.110	1.042	1.230
N %	0.094	0.097	0.085	0.110	0.066	0.059	0.084	0.082	0.102	0.126	0.096	0.077	0.128	0.088	0.085	0.108	0.085	0.081	0.091
P (kg/ha)	330	315	317	254.3	285.3	181.3	150.0	97.7	135.9	229.3	113.7	120.1	152.7	74.9	44.1	223.3	177.3	159.9	186.7
K (kg/ha)	188.3	120.7	152.0	442.6	349.0	366.7	469.7	465.3	239.0	1227	1212	796.9	1298.7	653.3	753.3	725.7	560.0	461.5	582.4
Texture	Loam			Sandy loam			Loam			Loam			Loam			Loam			Loam

Note: *Altitude in meter

Table 2: Rating scale of soil nutrients for citrus orchards

S.N	Nutrients	Very low	Low	Medium	High	Excess
1.	Nitrogen (%)	<0.050	0.051-0.099	0.100-0.199	0.200-0.500	>0.501
2.	Phosphorus (Kg/ha)	<10	11-30	31-55	56-110	>111
3,	Potassium (Kg/ha)	-	0-110	111-280	281-500	>501
4.	Organic Matter (%)	<1.0	1.1-2.0	2.1-4.9	>5.0	-

Soil pH :< 4.5 = extremely acidic, 4.6-5.2 = Acidic, 5.3-5.9 = moderately acidic, 6.0-6.5 = slightly acidic, 6.6-7.0 = nearly neutral.

Source: Smith (1966)

Leaf analysis

The benefits of leaf analysis: Various factors like soil reaction, soil temperature, microbiological activities, rootstock, soil aeration etc affect the nutrient uptake of the plants. Leaf analysis is an effective technique and the best indicator for monitoring the nutrient status of citrus trees because the leaf is the focal point of many plant functions and relatively sensitive indicator to alteration in its mineral composition taken up from the roots. According to Cameron et al (1994), up to 50% of the total minerals in a citrus tree are available in the leaves. Thus results of leaf analysis in citrus orchards always have a good correlation with yield and quality of fruit.

Leaf nitrogen (N): Citrus leaves may lose 25-30% nitrogen per year for new growth (Walance et. al., 1992). The average level of N in the healthy leaf was 2.30% and the unhealthy leaf was 2.19% in the study areas. A higher level of leaf N was found in Mangalsen (2.58%) and lower level was in Baitadi (1.9%). A level of leaf N, 2.4-2.8% in citrus leaf is considered optimum while below 2.4% indicates deficient level (Smith 1966). The average level of N in the selected sites was 2.25% which is in deficient level. The role of nitrogen metabolism is to regulate the induction of flowers. Foliar application of Nitrogen in late autumn was more efficient than in early spring. Mooney and Richardson (1992) demonstrated that citrus trees utilized 80% of nitrogen during the spring flush growth and fruit set period. It was clear that the trees were able to accumulate nitrogen in the autumn. These reserves N are very important for early growth of trees and fruit in spring (Mooney et al. 1991; Mooney & Richardson 1992).

Leaf phosphorus (P_2O_5): The average level of P_2O_5 in the healthy leaf was 0.182% and unhealthy leaf was 0.189% in the study sites, which is a high level. A higher level of P_2O_5 was observed in Dadeldhura (0.267%) and the lowest level in Kailali (0.118%). An optimum level of P_2O_5 was reported 0.12-.016% in the leaf on a dry matter basis. The average level of P_2O_5 in the leaf was found higher to the excess in the study sites. Deficiency symptoms of P_2O_5 were observed less than 0.07% on dry matter basis. Phosphorus performs many vital functions in the plant i.e. photosynthesis, enzyme activity, and formation and movement of sugars. It has an important role in flowers and fruit development. Low phosphorus in the orchard soil affects growth of the tree, fruit yield, and quality, causing misshapen fruit with open centers and coarse, thickened rinds. The fruit is pulpy has a low juice percentage, and is acidic. A balanced supply of nitrogen and phosphorus gives both a high yield and good fruit quality.

Leaf Potassium (K_2O) : The level of K_2O in the healthy leaf was found 0.417% and unhealthy leaf was 0.343% in the selected sites which is very low level. A higher level of K_2O was found in Doti (0.480%) and the lowest level was found in Dadeldhura (0.280%). The optimum level of K_2O was reported 1.2-1.7% in the leaf on a dry matter basis. The result of K_2O level in leaves was found very low in the surveyed areas. Potassium involved in almost all the metabolic processes in the plants acts as an activator of enzyme systems. Humble et al (1970) proved that K_2O plays and unique role in the opening of leaf stomata encourages root development in plants and plays an important role in cell division. The deficiency symptoms appear first on older leaves. So it is advised to apply K_2O when less than 0.7% in leaf. Nijjar and Singh (1971) showed that the level of K in the mandarin orange leaf Amritsagar district of India is 1.54% in healthy and 1.3% in the declined tree.

Zinc (Zn): Zinc is one of the most damaging and widespread nutritional disorders of citrus species. The deficiency is most acute in alkaline soils. Even in its earliest stages, zinc deficiency lowers yield, reduces tree vigor and makes fruit small and poor in quality. The deficiency of Zn extent of hidden hunger was in the order of Zn>Ca>N.>Mg>K in the mandarin tree of Kangra district of India (Rana et al. 1984). Zinc deficiency is caused by citrus tristeza virus (CTV), or by fungus diseases such as root rot and foot rot diseases. Therefore it is advised to the growers must treat zinc deficiency by disease control or by nutrient management, depending on the cause. According to Childers (1986) Zn was ranked in second of N in citrus nutrition. Level of Zn in the healthy tree leaves was 31.31 ppm and in unhealthy leaves24.3 ppm in the study areas, which was the optimum level. The critical concentration of zinc in citrus leaves is 25-49 ppm and less than these amount deficiency symptoms may occur. The average level of Zn in the survey areas was found 27.80 ppm which was the optimum level.

Manganese (Mn): The deficiency of Mn shows less than 15 ppm in the plant leaves but in the study sites, level of Mn on unhealthy /decline tree leaves were found 27.26 ppm and in the healthy leaves was 41.5 ppm that is optimum level. Highest level of Mn was found in Kailali (63.57 ppm) and the lowest was found in Dadeldhura (2.75 ppm). The average level of Mn was 34.38 ppm. A high variation of Mn level was found in the selected areas. The symptoms of manganese deficiency are very similar to those of zinc deficiency. According to Reitz (1958), the typical symptoms of Mn deficiency in citrus leaves is dark green bands along the midribs and a lighter green leaf blade. In addition, there is some overlapping of deficiency symptoms of Mn and Zn. Mn deficiency in the citrus trees can be corrected by spraying 120 g Manganese sulfate in 100 liters of water, when the major flush of leaves has expended.

Iron (Fe): The function of Fe in the plant is chlorophyll production. Deficiency of iron loss the chlorophyll (pale green leaf) in young leaves; only the main veins stay green. In the acute stage, fruits are small, hard, coarse, light in color and sometimes misshapen especially in lemon. Available Fe contains in Uttar Pradesh of India is 1.2-22.2 ppm in the soil reported by Singh and Tripathi (1979). But in the SPP of Nepal was found 490.62 ppm in healthy and 482.88 ppm in unhealthy trees leaves that is in excess level. According to Reitz et al (1974) 20 g of Fe per tree in the form of Ethylenediaminetetraacetic Acid (EDTA) is enough for the correction of deficient trees and it also increase the root growth.

Table 3. Leaf nutrient content of healthy and unhealthy/decline-bearing mandarin orange trees in the SPP of Nepal.

Nutrient	1. Kailali		2.Dadeldhura		3.Doti		4. Achham		5. Baitadi		Mean		Grand Mean
	A	B	A	B	A	B	A	B	A	B	A	B	
N %	2.41	2.19	2.26	2.23	2.34	2.02	2.58	2.14	1.90	2.36	2.30	2.19	**2.25**
P %	0.182	0.118	0.151	0.267	0.190	0.215	0.196	0.190	0.195	0.213	0.182	0.198	**0.189**
K %	0.437	0.447	0.420	0.280	0.480	0.330	0.390	0.350	0.360	0.310	0.417	0.343	**0.380**
Zn (ppm)	37.13	25.75	26.05	20.46	23.32	22.28	29.09	28.57	29.09	28.57	31.31	24.3	**27.80**
Mn (ppm)	63.57	16.05	2.75	9.65	64.14	29.59	42.23	39.71	42.23	39.71	41.5	27.26	**34.38**
Fe (ppm)	507.13	522.8	307.8	391.5	480.3	486.56	559.6	526.1	559.6	526.1	488.4	492.1	**490.26**

Note: A = healthy tree B = unhealthy/ decline tree

Table 4. Rating scale of nutrients in 4-7 months old mandarin leaves

S.N.	Nutrients	Much deficient	Deficient	Medium	High	Excess
1	Nitrogen (%)	<2.1	2.2-2.4	2.5-2.7	2.8-3.0	> 3.1
2	Phosphorus (%)	<0.08	0.090-0.110	0.12-0.16	0.17-0.29	> 0.3
3	Potassium (%)	<0.7	0.7-1.1	1.2-1.7	1.8-2.3	> 2.4
4	Iron (ppm)	<35	35-49	50.120	130-200	> 201
9	Manganese (ppm)	<18	18-24	25-49	50-500	> 501
10	Zinc (ppm)	<18	18-24	25-49	50-500	> 201

Source: Smith (1966)

Relation of soil and leaf nutrient: Nitrogen concentration in the top soil (0-30cm) was found 0.108% which was medium level, but level of N was 2.30% in healthy and 2.19% in unhealthy leaves, which was deficient to much deficient level in all sites. The amount of N is higher in the leaf as compared to the soil due to N being highly leaching nature and eroded from the soil by heavy rain. Smith (1969) reported that, N application of N 168 kg /ha /year maintained the leaf N about 2.45% in 4-5-month-old leaf. Phosphorus concentration in the orchard soil was more than excess level up to 90 cm depth in all sites and found medium to high level in the leaf. The results of nitrogen and phosphorus in the soil and leaf are positive relation. Erobelton et al 1956 found that higher level of phosphorus reduced the percentage of N and K_2O and increased the Ca and Mg in citrus leaf. Amount of potash in the orchard soil was excess in topsoil and reducing the amount as increased the soil depth but the amount of potash in the leaves was very low level. The relation of potash in the soil and leaf was negative due to root could not absorb the potash from the soil (table 5). The level of organic matter in the soil was low level in SPP. The micronutrient (Zn, Fe and Mn) level in the mandarin orange tree leaf was satisfactory.

Table 5. Level of nutrient in the soil and leaf of mandarin orange orchard.

S. No.	Nutrients	Soil	Leaf
1.	Nitrogen	Low	Deficient
2.	Phosphorus	Excess	High
3.	Potash	Excess	Very low
4.	Organic matter	Low	-
5.	Zinc	-	Medium
6.	Iron	-	Medium
7.	Manganese	-	Excess

Fruit quality analysis

Various factors are responsible for influencing the quality of mandarin orange fruit. Among them, climate, nutrition, and rootstocks are major factors that influence the mandarin orange fruit quality. The quality of mandarin orange fruit was evaluated by scoring various traits i.e. size, weight, Juice, color, TSS and TA. Higher the score ranking better fruit quality. Mandarin orange fruits ranking <50% = very poor, 51-60% = poor, 61-70% = medium, 71-80% = good, >81% = better in quality. On the basis of these parameters, quality of mandarin orange fruits was evaluated in the five districts of SPP. According to evaluation score the results of Kailali was found 83.3% and Doti was 76.6% in healthy trees which is good in quality (table 6). The fruit quality of healthy trees in other sites is not in satisfactory level and score of decline/ unhealthy trees were found very poor in all sites. Market prices depend on the quality of fruits, fruit quality depends on tree health, tree health depends on soil fertility, and soil fertility depends on quality compost applied in the orchard soil. The dream of better earning will fulfill by the application of quality compost. One kg fresh Nagpur mandarin orange fruit was observed, to remove N 5.8-6.8 g, P 280-340 mg, and K 3-3.1 g from the tree. Therefore balanced nutrients should be applied for quality production.

Table 6. Fruit quality evaluation of healthy and unhealthy/ declined mandarin orange trees in the SPP of Nepal.

Fruits Traits	1. Kailali		2.Dadeldhura		3.Doti		4. Baitadi		Mean		Grand Mean
	A	B	A	B	A	B	A	B	A	B	
Fruit weight (gm)	125.7(5)	72.0(2)	87.5(3)	44.2(1)	124.9(4)	59.4(1)	72.6(2)	50.9(1)	102.7(4)	56.6(1)	84.15(2)
Fruit diameter (mm)	65.9 (4)	51.9(3)	58.1(3)	45.0(2)	67.2(4)	47.7(2)	55.3(3)	45.5(2)	61.6(3)	47.5(2)	54.55(3)
Fruit height (mm)	59.3	49.7	51.6	42.8	53.6	43.8	48.3	39.9	53.2	44.0	48.26
Peel weight (gm)	36.4	20.6	25.2	13.4	39.0	16.2	20.5	14.4	30.3	16.2	23.25
Seed number	13	9.0	16	6	14	14	15	6.	14.5	8.8	11.65

Fruits Traits	1. Kailali		2.Dadeldhura		3.Doti		4. Baitadi		Mean		Grand Mean
	A	B	A	B	A	B	A	B	A	B	
Juice content (%)	42.3(4)	37.4 (3)	45.3(4)	40.5 (4)	38.8(3)	41.9 (4)	44.8 (4)	46.9 (4)	43.2(4)	24.1(2)	33.65(2)
TSS brix %	10.8 (3)	8.5(1)	9.2(3)	8.3(2)	10.1(3)	9.2(3)	10.7(3)	7.7(2)	10.2(3)	8.4(2)	9.3(3)
TA %	0.9 (4)	1.54 (2)	0.91(4)	1.13(3)	0.89(4)	1.07(3)	0.96(4)	1.7(1)	0.91(4)	1.36(2)	1.18(3)
TSS/TA	12.5(5)	8.6(2)	10.3(4)	7.6(1)	12.7(5)	5.1(1)	11.1(5)	8.9(2)	11.65(5)	7.55(1)	9.6(3)
Total score	25	13	21	13	23	14	21	12	23	10	16
Score %	83.3	43.3	70	43.3	76.6	46.6	70	40	76.6	33.3	53.3

Note: A = healthy tree, B = unhealthy/decline tree

- Score number of ratings inside the bracket. Higher the score ranking better fruit quality. Mandarin orange fruits ranking <50% = very poor, 51-60% = poor, 61-70% = medium, 71-80% = good, >81% = better in quality.

Table 7. Quality evaluation bases of mandarin orange fruits by scoring various traits on the basis of physio-chemical character analysis

S No	Traits	Scores					Remarks
		1	2	3	4	5	
1.	TSS %	<7	7-9	9.1-10.9	11-11.9	>12	Higher the better
2.	TA%	>1.6	1.3-1.5	1-1.2	0.7-0.9	<0.6	Lower the better
3.	TSS/TA	<8	8-9	9-10	10-11	>12	Higher the better
4.	Pulp %	<40	40-50	50-60	60-70	> 70	Higher the better
5.	Juice %	<20	20-30	30-40	40-50	> 50	Higher the better
6.	No of seed	>12	9-11	7-9	5-7	<5	Lower the better
7.	Weight (g)	<40	40-60	60-80	80-100	>100	Higher the better

Note: The following traits should be used for the evaluation of mandarin orange fruit quality in Nepal. (Scale=1- 5).

Table 8. Quality evaluation bases of mandarin orange fruits by scoring various traits on the basis of size and volume analysis

S No	Traits		Extra large (5)	Large (4)	Medium (3)	Small (2)	Very small (1)
1.	Size	Diameter (mm)	>71	61-70	51-60	41-50	<40
2.	Volume	Weight (g)	>125	101-124	86-100	71-85	<70
3.	No of fruit /kg wt		<8	9-10	11-12	13-14	>15

Source: Proceeding of mandarin fruit evaluation, NCRP, Dhankuta. (2007)

Conclusion

Soil pH was found moderately acidic in the study sites. Nitrogen level in the soil and leaf was found in low level and plant shows deficiency symptoms in few orchards. The organic matter in the soil was very low level. The amount of Phosphorus and Potash were optimum or excess in the orchard soil but Potash level in the leaf was found very low or deficient level in the SPP. Possibly plants could not absorb the Potash from the soil. The result of soil and plant nutrient analysis revels that there was no shortage of Phosphorus. But organic matter and nitrogen were low to very low. The level of micro nutrient Zn, Fe and Mn was medium to high. The quality of fruits from healthy trees was good Sahajpur of Kailali and Kapalleki of Doti. But the fruits from unhealthy trees were very poor in quality almost of the sites. Hence, a supply of balanced nutrients is necessary for increasing the productivity and quality of citrus fruit in SPP.

Recommendation

- Organic matter of citrus orchard soil should be increased by applying quality compost and other farm by products.
- Increase the level of nitrogen in the soil and trees by applying addition fertilizer but reduced the amount of fertilizer greatly substitute by applying sufficient amount of organic sources and legume intercropping.
- Absorption and translocation of mineral nutrition fully depend on the moisture level in the soil, so that maintaining the soil moisture of the orchard, especially in drought season by using appropriate mulching materials.
- Techniques of compost making were traditional in the survey sites. They should use improved method of compost preparation for quality compost production.

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Disease and Pests Management

रोग किराको व्यवस्थापन

Research Profile of Insect Pests in Nepal's Citrus Production

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Abstract

A review is performed on the citrus insect and mite pest researches conducted in the country up to 2024. Their relevant findings are flawlessly presented in this paper that may help develop and execute strategic citrus insect pest management system against pest insects and mites triggering citrus decline in the citrus production in the country. Presently, an inventory of 80 species of citrus pests included of 73 and 7 different species of insects and mites, respectively, is existed in the citrus production system in Nepal. Pest Risk Analysis of citrus commodity has pointed out 32 species of quarantine insects (n = 27) and mites (mites = 5) while importing the citrus planting materials and fruits from India to Nepal. Similarly, there are 3 quarantine insect species in citrus commodity while importing citrus planting materials and fruits from Bhutan to Nepal.

Keywords: Inventory, Insects, Mites, Quarantine, Planting material

Introduction

Citrus in Nepal is cultivated in 49,306 ha (productive area: 32,317 ha) with a total production of 306,149 mt and a productivity of 9.47 mt per ha in Fiscal Year, 2021/22 (MoALD, 2023). An agricultural statistics of citrus cultivation in Nepal developed of MoALD (2023) reveals citrus being cultivated in 74 (96.1%) districts where mandarin orange and sweet orange are exclusively cultivated in 56 (72.7%) and 51 (66.2%) districts in the mid-mountain region of Nepal. Citrus holds a productive area of 32, 317 ha (25%) and a total production of 306, 149 mt (21.6%) with respect to the toal fruit-productive area (ha) and -production (mt) in the country.

The citrus productivity is obverved declining in Nepal (Kaini, 2019), and fruit dropping is remained the mainspring incurred of fruit flies (*Bactrocera dorsalis* Hendel and *B. minax* (Enderlein)) and *Rhynchocoris poseidon* (spined fruit bug) (Shrestha, 2067). Similarly, huanglongbing (citrus greening) and citrus tristeza virus diseases in citrus plants due to vector insects, respectively, *Diaphorina citri* Kuwayama (Asian citrus psyllid) and *Toxoptera citricidus* (Kirkaldy) (brown citrus aphid) are two important vectors to deplete citrus production in each subsequent fruit seasons. Besides these citrus insect pests, there remained many more serious pests in the citrus production system. Globally, citrus insect pests vary from country to country; over 800 pest species in China (Urbaneja et al., 2020) and 250 species of insects and mites in India (Santoshkumar et al., 2013). Citrus is an indigenous crop of Nepal (Bonavia, 1890; Shrestha and Verma, 1998; Lohar and Lama, 1997), a nuber of Citrus R&D initiations with the establishments of Citrus Research Station in Dhankuta (later, given status of National Citrus Research Programme in July 2020) and Sub Station in Pokhara, 1961, National Citrus Development Programme, 1972 followed with establishments of Horticulture Research Stations in different districts, and JICA's Horticulture Development Project extended to Sindhuli, Ramechhap, Kathmandu, Nuwakot, Banke, Bardia, Kavrepalanchok, Lalitpur and Bhaktapur became the milestones in the citrus research and development in the country (Paudyal et al., 2016). Thus, a citrus pest research profiles along with their updated results to 2024 are collected and presented in this paper to help develop and execute strategic citrus insect pest management system against pest insects and mites triggering citrus decline in the citrus production in the country.

Insect pests donated in citrus

First time survey of FAO survey in 1967 AD

Entomological problems in citrus plants revealed during FAO survey conducted in Pokhara to Ranigaun in 1967 (Knorr, and Shah, 1971). This was first time an organized specific survey (Detection Survey) in course of surveillance of citrus insect and mite pests. During this survey citrus insects detected were as follows:

Psyllid (Hemiptera: Sternorrhyncha: Liviidae)**:** *Diaphorina citri* Kuwayama (Asian citrus psyllid)

Aphid (Hemiptera: Sternorrhyncha: Aphididae): *Toxoptera citricidus* (Kirkaldy), *Toxoptera aurantii* (Boyer de Fonsicolombe)

Scale insect (Hemiptera: Sternorrhyncha: Diaspididae): *Aonidiella aurantii* (Boyer de Fonsicolombe), *Aspidiotus destructor* Signoret, *Fiorinia theae* Green (camellia scale), *Hemiberlesia rapax* Comstock) (greedy scale (USA)), *Lepidosaphes beckii* (Newman).

Scale insect (Hemiptera: Sternorrhyncha: Coccidae): *Saissetia coffeae* (Walker) (hemispherical scale), *Coccus hesperidum* (Linnaeus), (Rana and Sharma, 1965; Rana and Sharma, 1967), and *Pulvinaria psidii* Maskell (green shield scale).

Scale insect (Hemiptera: Sternorrhyncha: Monophlebidae): *Icerya seychellarum* (Westwood), *Hemaspidoproctus cinereus* (Green).

Mealybugs (Hemiptera: Sternorrhyncha: Pseudococcidae): *Pseudococcus cryptus* Hempel (= *Pseudococcus citriculus* Green (citrus mealybug), and *Nipaecoccus vastator* (Maskell) (Rana and Sharma, 1965; Rana and Sharma, 1967).

Whitefly (Hemiptera: Sternorrhyncha: Aleyrodidae): *Bemisia giffardi* (Kotinsky) (Rana and Sharma, 1967).

Blackfly (Hemiptera: Sternorrhyncha: Aleyrodidae): *Aleurocanthus woglumi* Ashby

Plant bug (Hemiptera: Heteroptera: Pentatomidae): *Dalpada* sp.

Plant bug (Hemiptera: Heteroptera: Pyrrhocoridae): *Dysdercus evanescens* Distant

Plant bug (Hemiptera: Heteroptera: Membracidae): *Oxyrachis* sp. (treehopper, cow bug**),** *Otinotus oneratus* (Walker) (cow bug)

Plant bug (Hemiptera: Heteroptera: Pentatomidae): *Rhynchocoris poseidon* Kirkaldy (= *R. humeralis*) (spined fruit bug).

Beetle: (Coleoptera: Coccinellidae): *Jauravia quadrinotata* Kapur (lady beetle), Elateridae: *Agonischius* sp., Buprestidae: *Agrilus* sp., Scarabaeidae: *Glycyphana horsfieldi* (Hope) (flower chafer), *Oxycetonia jucunda* Faldermann (citrus flower chafer), *Thaumastopeus pullus* (Billberg). (black rose chafer), *Colasposoma semicostatum* Jacoby, *Cassida* sp.

Butterfly: (Lepidoptera: Papilionidae): *Papilio demoleus* Linnaeus, *P. machaon* Linnaeus and *P. polytes* Linnaeus (Knorr et al., 1970),

Moth: (Lepidoptera: Erebidae): *Argina cribaria* Clerck, *Euproctis xanthorrhos* Kollar, Gracillaridae: *Phyllocnistis citrella* Stainton

Fly: (Diptera: Tephritidae): *Dacus dorsalis* Hendel (Oriental fruit fly). (**Remark**: *Dacus dorsalis* has not been recorded in the literature from Nepal. P.N. Rana, Entomologist remarked it being recently found in the country in citrus orchards, and was seriously occurred in the Inner Tarai on mandarin orange fruits).

Mites: (Acari: Eriophyidae)**:** *Phyllocoptruta oleivora* (Ashmead) (citrus rust mite) (Found in large numbers in the Pokhara area and was the cause of fruit russeting in many citrus varieties (Knorr and Shah, 1971). (This mite was determined by H.A. Denmark, Division of Plant Industry, Gainesville, Florida, USA). *Eotetranychus sexmaculatus* (Riley) (six-spotted spider mite) (Tetranychidae) (Rana and Sharma, 1967). *Eutetranychus orientalis* (Klein) (citrus brown mite) (Tetranychidae). Citrus brown mite was found during the March survey on *Citrus jambhiri* Lush. at Pokhara (Knorr and Shah, 2071). (This mite was determined by E.W. Baker, U.S. Department of Agriculture, Washington, D.C.). *Brevipalpus californicus* (Banks) (citrus flat mite) (Tenuipalpidae) found on mandarin oranges at Pokhara and Sumbek. Knorr and Shah (2071) Remarked, "*Brevipalpus californicus* is the species that produces leprosies on citrus in Florida, but no symptoms of this disease were seen in Nepal." *Brevipalpus californicus* is determined by E.W. Baker. *Brevipalpus obovatus Donnadieu* (scarlet tea mite) (Tenuipalpidae) is the cause of leprosies on citrus in South America. Knorr and Shah (2071) observed *B. obovatus mite on shaddock (pomelo) at Patan but no leprosies symptom on fruits.*

FAO-Nepal and Ministry of Agriculture-Nepal, 2003-05 AD

First time an organized general surveillance of crop insect pests under the general supervision of FAO Representative, the technical guidance of the Plant Protection Service, AGPP, and in close collaboration with the Ministry of Agriculture, the national counterparts, Consultants and the IPPC Technical Officer, the National Consultant Entomologist- Pest Surveillance conducted a general surveillance of insect and mite pests of 21 national prioritised agricultural crops including *Citrus* spp. in Nepal. The programme was conducted under a banner of Strengthening Plant Quarantine Service, TCP/NEP/2903 (A) Project, 2003-2005 of FAO-Nepal and Ministry of Agriculture-Nepal. The general citrus trees surveillance resulted in different species of 52 *Citrus* spp. pests and 13 *Citrus sinensis* (sweet orange) pests. The following are an inventory of insect and mite pests of *Citrus* spp. of Nepal (Joshi, 2005).

General Surveillance, 2005-06 AD

The citrus pest-inventory out of the general surveillance (2005-06) revealed the following detail of insect and mite pest inclusions in each pest group.

Hemiptera: Diaspididae (Armoured scale insects)

1. *Aonidiella aurantii* (Boyer de Fonsicolombe) 2. *Aonidiella orientalis* Newstead 3. *Aspidiotus destructor* Signoret 4. *Diaspidiotus perniciosus* (Comstock) Cockerell 5. *Lepidosaphes* beckii (Newman); **Coccidae (Soft scale insects):** 1. *Coccus hesperidum* (Linnaeus) 2. *Parasaissetia nigra* (Nietner) 3. *Ceroplastes japonicas* Green 4. *Pulvinaria psidii* Maskell 5. *Saissetia coffeae* (Walker); **Aphididae (Aphids):** 1. *Aphis fabae* Scopoli 2. *Aphis craccivora* Koch 3. *Aphis spiraecola* Patch 4. *Aphis gossypii* Glover 5. *Myzus persicae* (Sulzer) 6. *Rhopalosiphum maidis* (Fitch) 7. *Toxoptera citricidus* (Kirkaldy)8. *Toxoptera aurantii* (Boyer de Fonsicolombe); **Pseudococcidae:** 1. *Maconellicoccus hirsutus* (Green) 2. *Nipaecoccus viridis* (Newstead) 3. *Pseudococcus cryptus* Hempel; **Pentatomidae:** 1. *Nezara viridula* (Linnaeus) 2. *Rhynchocoris poseidon* Kirkaldy; **Aleyrodidae:** 1. *Aleurocanthus woglumi* Ashby; **Liviidae:** 1. *Diaphorina citri* Kuwayama; **Monophlebidae** (**Margarodidae):** 1. *Icerya seychellarum* (Westwood).

Diptera: Muscidae: 1. *Atherigona orientalis* (Schiner); **Tephretidae:** 1. *Bactrocera cucurbitae* (Coquillett) 2. *Bactrocera dorsalis* (Hendel) 3. *Bactrocera dorsalis* (species complex) 4**.** *Bactrocera minax* (Enderlein) (Previously, misidentified as *Bactrocera tsuneonis*).

Thysanoptera: Thripidae: 1. *Chaetanaphothrips orchidii* (Moulton) 2. *Heliothrips haemorrhoidalis* (Bouche) 3. *Thrips flavus* Schrank.

Lepidoptera: Moth: Noctuidae: 1. *Eudocima fullonia* (Clerck) **2**. *Spodoptera litura* (Fabricius) **3**. *Chrysodeixis acuta* (Walker) **4**. *Helicoverpa armigera* (Hübner); **Lymantriidae: 1**. *Euproctis xanthorrhoea* (Kollar); **Saturniidae: 1**. *Attacus atlas* Linnaeus; **Limacodidae: 1**. *Parasa lepida* (Cramer); **Gracillariidae: 1**. *Phyllocnistis citrella* Stainton

Lepidoptera: Butterfly: 1. *Papilio demoleus* Linnaeus **2**. *Papilio polytes* Linnaeus **3**. *Menelaides polytes romulus* Cramer **4**. *Papilio machaon rinpoche* Wyatt **5**. *Menelaides nephelus* Boisduval.

Coleoptera: Buprestidae: 1. *Agrilus* sp.; **Cassididae:** 1. *Cassida* sp.; **Cerambycidae:**

1. *Oberea butangensis* Breuning; **Scarabaeidae:** 1. *Oxycetonia jucunda* (Falderman)

Acari (Mite): Tetranychidae: 1. *Eutetranychus sexmaculatus*

Inventory of citrus (*Citrus* spp.) insect and mite pests in Nepal, 2010-11 AD

Joshi (2010-11) developed, for the first time, the following comprehensive inventory of citrus (*Citrus* spp.) insect and mite pests based on the citrus insects and mite preserved in the Insect Museum in National Entomology Research Center (then Entomology Division) (Joshi and Manandhar, 2001) and the citrus insect datasheets of Crop Protection Compendium of CAB International (2006). The inventory (n = 54) included insects and mite belonging to orders Coleoptera (n = 4), Diptera (n = 5), Hemiptera (n = 27), Lepidoptera (n = 14), Thysanoptera (n = 3) and Acari (Tetranychidae) (1).

The citrus insects and mites are as followed:

- *Agrilus* sp. (jewel beetle) (Coleoptera: Buprestidae)
- *Aleurocanthus woglumi* (citrus blackfly) (Hemiptera: Sternorrhyncha: Aleyrodidae)
- *Aonidiella aurantii* (red scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Aonidiella citrina* (Craw) (yellow scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Aonidiella orientalis* (oriental red scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Aphis craccivora* (groundnut aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Aphis fabae* (black bean aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Aphis gossypii* (cotton aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Aphis spiraecola* (green citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Aspidiotus destructor* (coconut scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Atherigona orientalis* (pepper fruit fly)(Diptera: Muscidae)
- *Attacus atlas* (atlas moth) (Lepidoptera: Saturniidae)
- *Bactrocera cucurbitae* (melon fly) (Diptera: Tephritidae)
- *Bactrocera dorsalis* (Oriental fruit fly) (Diptera: Tephritidae)
- *Bactrocera dorsalis* (species complex) (Diptera: Tephritidae)
- *Bactrocera minax* (Chinese citrus fly) (Diptera: Tephritidae)
- *Cassida* sp. (tortoise beetle) (Coleoptera: Chrysomelidae)
- *Ceroplastes japonicas* (tortoise wax scale) (Hemiptera: Sternorrhyncha: Coccidae)
- *Chaetanaphothrips orchidii* (anthurium thrips) (Thysanoptera: Thripidae)
- *Chrysodeixis acuta* (tomato semi-looper) (Lepidoptera: Noctuidae)
- *Coccus hesperidum* (brown soft scale) (Hemiptera: Sternorrhyncha: Coccidae)
- *Diaphorina citri* (Asian citrus psyllid) (Hemiptera: Sternorrhyncha: Liviidae)
- *Diaspidiotus perniciosus* (San Jose scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Eudocima fullonia* (fruit-piercing moth) (Lepidoptera: Erebidae)

- *Euproctis xanthorrhoea* (= *Euproctis chrysorrhoea*) (brown-tail moth) (Lepidoptera: Erebidae)
- *Eotetranychus ? sexmaculatus* (Riley) (six-spotted spider mite) (Acari: Tetranychidae)
- *Helicoverpa armigera* (cotton bollworm) (Lepidoptera: Noctuidae)
- *Heliothrips haemorrhoidalis* (black glasshouse thrips) (Thysanoptera: Thripidae)
- *Icerya seychellarum* (Seychelles scale) (Hemiptera: Sternorrhyncha: Monophlebidae)
- *Lepidosaphes beckii* (purple scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Maconellicoccus hirsutus* (pink hibiscus mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae)
- *Myzus persicae* (green peach aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Nezara viridula* (green stink bug) (Hemiptera: Heteroptera: Pentatomidae)
- *Nipaecoccus viridis* (spherical mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae)
- *Oberea butangensis* (citrus stem borer) (Coleoptera: Cerambycidae)
- *Oxycetonia jucunda* (citrus flower chafer) (Coleoptera: Scarabaeidae)
- *Papilio* (= *Menelaides*) *nephelus chaon* Boisduval (Yellow helen) (Lepidoptera: Papilionidae)
- *Papilio* (= *Menelaides*) *helenus helenus* Linnaeus (Red helen) (Lepidoptera: Papilionidae)
- *Papilio* (=*Menelaides*) *polytes romulus* (Cramer) (common mormon) (Lepidoptera: Papilionidae)
- *Papilio demoleus* (chequered swallowtail) (Lepidoptera: Papilionidae)
- *Papilio demoleus demoleus* Linnaeus (Lime swallowtail) (Lepidoptera: Papilionidae)
- *Papilio machaon rinpoche* (Common yellow swallowtail) (Lepidoptera: Papilionidae)
- *Parasa lepida* (nettle caterpillar) (Lepidoptera: Limacodidae)
- *Parasaissetia nigra* (Nietner) (black coffee scale) (Hemiptera: Sternorrhyncha: Coccidae)
- *Phyllocnistis citrella* (citrus leaf miner) (Lepidoptera: Gracillaridae)
- *Pseudococcus cryptus* (citriculus mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae)
- *Pulvinaria psidii* (green shield scale) (Hemiptera: Sternorrhyncha: Coccidae)
- *Rhopalosiphum maidis* (green corn aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Rhynchocoris poseidon* (= *R. humeralis*) (spined fruit bug) (Hemiptera: Heteroptera: Pentatomidae)
- *Saissetia coffeae* (brown coffee scale) (Hemiptera: Sternorrhyncha: Coccidae)
- *Spodoptera litura* (armyworm) (Lepidoptera: Noctuidae)
- *Thrips flavus* (apple blossom thrips) (Thysanoptera: Thripidae)
- *Toxoptera aurantii* (Black citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae)
- *Toxoptera citricidus* (brown citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae)

Review of the agricultural and horticultural insect pests, 1995 AD

Neupane (1995) reviewed the agricultural and horticultural insect pests of different crops of Nepal, and the report included the following citrus insect pests with their pertinent distributions in the country:

- *Aonidiella aurantii* (red scale) (Hemiptera: Sternorrhyncha: Diaspididae) in hills and Tarai.
- *Aspidiotus destructor* (coconut scale) (Hemiptera: Sternorrhyncha: Diaspididae) in hills and Tarai.
- *Bactrocera dorsalis* (Oriental fruit fly) (Diptera: Tephritidae) in hills and Tarai.
- *Bactrocera zonata* (Saunders) (peach fruit fly) (Diptera: Tephritidae) in hills and Tarai.
- *Bemisia giffardi* (Giffard's whitefly) (Hemiptera: Sternorrhyncha: Aleyrodidae) in hills.
- *Diaphorina citri* (Asian citrus psyllid) (Hemiptera: Sternorrhyncha: Liviidae) in hills and Tarai.
- *Eriophyes* sp. (blister mite) (Acari: Eriophydae) in hills.
- *Icerya purchase* Maskell (cottony cushion scale) (Hemiptera: Sternorrhyncha: Monophlebidae) in hills and Tarai (Not yet reported in Nepal; doubtful inclusion in the national citrus pest list).
- *Indarbela* sp. (bark eating caterpillar) (Lepidoptera: Cossidae) in hills and Tarai.
- *Planococcus citri* (Risso) (citrus mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) in hills and Tarai.
- *Panonychus citri* (McGregor) (citrus red mite) (Acari: Tetranychidae) in hills.
- *Papilio demoleus* (chequered swallowtail) (Lepidoptera: Papilionidae) in hills and Tarai.
- *Phyllocnistis citrella* (Lepidoptera: Gracillaridae) in hills and Tarai.
- *Stromatium barbatum* (Fabricius) (kulki teak borer) (Coleoptera: Cerambycidae) in hills.
- *Tetranychus* sp. (red spider mite) (Acari: Tetranychidae) in hills.
- *Toxoptera aurantii* Black citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae) in hills and Tarai.
- *Toxoptera citicidus* (Black citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae) in hills and Tarai.
- *Zeugodacus cucurbitae* [*Bactrocera cucurbitae*] (melon fly) (Diptera: Tephritidae) in hills and Tarai.

Important insects in context to citrus decline in the country

Bactrocera minax **(Chinese citrus fly):**

Bactrocera minax (Chinese citrus fly) (then identified as *Bactrocera* sp. prob. *tsuneonis* Miyake) (Joshi, 2019; Paudyal et al., 2016) was collected for the first time in Helambu, Sindhupalchok district in orange in December 1984 (collector: P.D. Shrestha) (Joshi and Manandhar, 2001).

Later, in 1989, it was reported from Bhojpur citrus orchards during Special Programme on Fruit Fly Control conducted from National Entomology Research Centre (then Entomology Division), National Agriculture Research and Service Centre, Khumaltar, Lalitpur, Nepal (Annual Report, 1988-89). *B. minax*, first observed in the eastern citrus orchards, particularly in sweet orange fruits (*Citrus sinensis*), has extended its invasion to 20 citrus districts, namely Taplejung, Terhathum, Sankhuwasabha, Dhankuta, Bhojpur, Khotang, Solulhumbu, Okhaldhunga, Sndhuli, Ramechhap, Dolakha, Kavrepalanchok, Sindhupalchok, Lamjung, Syangjya, Parbat, Banglung, Gulmi, Myagdi and Arghakhanchi. *B. minax* is reported in sweet orange fruits from citrus orchards of Sindhuli district (Adhikari and Joshi, 2018). The bioecology of this notorious fruit fly along with its area-wide management are produced for the benefit of sweet orange growers in the country (Adhikari et al;, 2022). *B. minax* larval and pupal desiccation and water immersion survival (Bhandari et al., 2021a); biology and its population density studies (Bhandari et al., 2021b) and an efficacy test of protein bait against the Chinese citrus fly (Bhandari et al., 2021c) were conducted in National Citrus Research Programme, Paripatle, Dhankuta. National Plant Protection Organisation-Nepal (NPPO-Nepal) has developed a Survey protocol for the *B. minax* survey regulation in the country (NPPO-Nepal, 2023).

Recently, a detail study on *B. minax* in sweet orange host has been conducted in its different biological aspects, namely oviposition period (Adhikari et al., 2023a), morphometrics (Adhikari et al., 2022a), farmer's perception (Adhikari et al., 2022b), diapause (Adhikari et al., 2021), orange losses (Adhikari et al., 2020a), degree days (Adhikari, 2023), biological observations (Adhikari et al., 2023b), invasiveness (Adhikari et al., 2022c), molecular identification (Adhikari et al., 2022d),fruit fly biodiversity (Adhikari et al., 2022c) and fruit fly management based on Area-Wide Control Management (AWCP) (Adhikari et al., 2021ab; Adhikari et al., 2020b), *B. minax* research profile in Nepal is documented in a review effort (Adhikari et al., 2022e). AWCP against *B. minax* proved a better option to manage this frugivoruos fruit fly in the sweet orange orchards in Sindhuli district, Nepal. The mean sweet orange fruit losses due to *B. minax,* Chinese citrus fly, reduced drastically from 56.7 ± 6.4% in 2017 to 10.9 ± 2.1% (2018) and 4.5 ± 0.6% (2019) (Adhakari et al., 2021c; Adhakari et al., 2020ab).

South-east China is the home-land of *B. minax*, and, very likely, this Chinese citrus fly has entered in the eastern citrus orchards in course of its natural travelling from China to Nepal through the aerial pathway from Bhutan to Sikkim to Nepal (Joshi, 2019).

Diaphorina citri (Asian citrus psyllid):

Thrower (1968), in 1967, authentically reported the citrus decline in Nepal, and the cause of this citrus decline in Pokhara valley was ascertained due to greening virus (now incriminated as bacteria, *Candidatus* liberibacter asiaticus) vectoring of *Diaphorina citri* (Asian citrus psyllid, ACP) (Catling, 1968). Catling (1968) disclosed that Huanglongbing (HLB) (= citrus greening) affected propagative materials were introduced into Pokhara from Saharanpur, UP, India that made a havoc in the local citrus cultivation. Knorr et al. (1970) reported HLB in some localities at Central and East Nepal including Pokhara. The population dynamics of ACP, *D. citri,* in the western hills of Nepal is studied. The monitoring revealed the highest

ACP population in spring and before rainy season in low altitude areas (< 1000 masl), and high population in high altitude areas (> 1000 masl) during rainy season (day temperature higher or equal to 20 ^{0}C) (Manandhar et al., 2001). Monitoring at Yampaphant (450 m), Lohi (650 m), Bandipur (1050 m) (Tanahun), Malepatan (850 m), Hemja (1,050 m), Agricultural Research Station, Lumle (1,450 m) (Kaski) and Bhakimli (1,300 m) (Myagdi) revealed *D. citri* presence even at an altitude of 1,300 m. Presence of *D. citri* at Bandipur and Bhakimli (> 1000 m) indicated a need for reformulating the altitude for citrus nursery establishment (Manandhar et al., 2004). A survey on the status of ACP during the spring flush of 1986 in 19 districts and Pokhara and Kathmandu revealed the freedom of ACP only in Dhankuta, Gorkha and Lamjung districts (Lama et al., 1988). Otake (1990) reported HLB presence in sweet orange trees in Sindhulimadi, Sindhuli district but absence of its vector, ACP. But the ACP status in the citrus orchards in Sindhuli seemed changed in a period of two decades citrus husbandary as a recent ACP survey in April 2022 in the sweet orange orchards revealed the presence of ACP in four orchards of Golanjor-3, Sindhuli (Dhakal et al., 2022).

Natural control (agents = parasitoids) of *D. citri* in citrus plants was observed in the eastern Terai, Nepal. The survey during the spring flush in 1986 revealed two parasitoids of *D. citri*, namely *Tamarixia radiata* (Waterston) (=*Tetrastichous radiates*) (Hymenoptera: Eulophidae) and *Diaphorencyrtus aligarhensis* (Shafee, Alam and Agarwal) (Hymenoptera: Encyrtidae) from Siraha and Morang districts (Lama et al., 1988; RONAST, 1988; Regmi, 1990). Lady beetles (Coleoptera: Coccinellidae), *Chilochorus nigritus*, *Coccinella 7-punctata*, *Coelophora nepalensis, Jauravia quafrinotata*, *Leis 15-maculata*, and *Menochilas sexmaculatus* were observed predating nymphs of *D. citri* in Pokhara. An aggressive attack of *Chilochorus nigritus* was observed on 2nd to 4th instar nymphs of *D. citri* (RONAST, 1988; Regmi, 1990; KC et al., 2018).

Rhynchocoris poseidon (=R. humeralis) (Spined fruit bug):

Rhynchocoris poseidon (=*R. humeralis*) (spined fruit bug) (Hemiptera: Heteroptera: Pentatomidae) is reported from the Pokhara valley in citrus orchards in 1971 (Knorr and Shah, 1971; Rana and Sharma, 1967). Its life-cycle and behavior was studied in laboratory and in the citrus orchard at Hemja, Kaski district (Manandhar et al., 2002). Survey revealed *Anastatus* sp., *Trissolcus latisculus* and *Ooencyrtus utithesae* being naturally occurring egg parasitoids of *R. poseidon* (Manadhar, 2002; Pandey and Rana, 1992; Pandey et al., 1997). Mandarin orange production constraints detection survey in the western hills of Nepal revealed *R. poseidon* being a serious problem of mandarin orange fruit drops in Syangja (900-1000 m), Kaski (900-1100 m), Tanahun (500-850 m), Gorkha (700-1130 m) and Lamjung (850-1050 m) districts. (Budathoki and Pradhanang, 1992).

Toxoptera citricidus (Brown citrus aphid):

Widespread aphid in Nepal, *Toxoptera citricidus*, is the most efficient closterovirus vector to cause tristeza disease in the citrus plants (Knorr and Shah, 2071). *T. citricidus* is a common aphid species in citrus plants cultivated in the hill and Terai regions of Nepal (Neupane, 1995). This aphid was reported in orange in Nepal as early as in 1960 from Kathmandu, and later, in 1961, it was reported from Dhankuta in the eastern hilly region of Nepal (Joshi and Manandhar, 2001).

Fruit piercing moth in citrus fruits

***Eudocima phalonia* (Linnaeus) (=*Othreis fullonia*):**

Eudocima phalonia (Linnaeus) (Lepidoptera: Noctuidae) (= *Othreis fullonia*) was reported in 1968 from Godavari, Lalitpur, Nepal (Joshi and Manandhar, 2001). Banziger (1987) reported it from Phulchoki (2100 m) near Godavari, Lalitpur. *E. phalonia* is a serious widespread fruit piercing moth in citrus fruits that occurs from an altitude range from 450 (Godok, Mechi) to 3540 m (Dhungeni, Rolwaling Himal in Nepal (Haruta, 1994). Recently, in 2023, its outbreak followed with massive sweet orange droppings was observed in the citrus orchards in Sindhuli district, Nepal (Muniappan, 2024).

Bactrocera dorsalis:

Bactrocera dorsalis (=old name: *Dacus dorsalis* (misspelt) was observed to drop 29.8% mandarin orange fruits in October 1992 in Sigana (1750 m) Baglung (Pandey et al., 1993). Mandarin orange fruits losses incurred of *B. dorsalis* in the command areas of Lumle Regional Agricultural Research Centre, Lumle was observed as high as 66% (Pandey et al., 1995). Gulmi citrus orchards observation, 22-24 October 2019, revealed *B. minax* less preferred to mandarin orange (1-2% infested) in presence of lemons (85-90% infested) and sweet oranges (80-85% infested) (Adhikari, 2019). Citrus farmers in command areas of the Citrus zone of Jajarkot district experienced 0-100% damages of mandarin oranges incurred of fruit flies; 44% of the farmers asserted the losses ranged to 50-75%. Fruit fly monitoring using male lures, methyl eugenol and cue-lure, and protein hydrolysate [Great fruit fly bait (25% protein hydrolysate and 0.1% abamectin)] revealed a risk of *Bactrocera nigrofemoralis, Zeugodacus tau, Zeugodacus scutellaris* and *Bactrocera dorsalis* to mandarin orange in the Jajarkot Citrus Zone. Fruit fly monitoring further suggested an initiation of fruit fly management before May in these mandarin orange areas (Parajuli et al., 2023). Mandarin orange fruit droppings due to fruit flies in Khoku, Saule, Sanne and Chungmang, Dhankuta district in 2019 and 2020 were remarkably high (3 to 4 scales among 1-5 rating scale) while severely fruit droppings in scale of 5, 5, 4 and 4 in Khoku, Saule, Sanne and Chungmang, respectively, incriminated of spinned fruit bug (citrus green stink bug) (*R. poseidon*) (Pun et al., 2021).

Insect vectored citrus diseases

Citrus Huanglongbing (HLB) (Citrus greening) and Citrus Tristeza Virus are two insect vectored citrus diseases in Nepal (Thrower, 1968; Catling, 1968; Knorr and Shah, 1971).

Asian citrus psyllid, *Diaphorina citri* and Huanglongbing (HLB) (Citrus greening) :

The Asian citrus psyllid, *Diaphorina citri*, efficiently vectors a phloem-limited α-proteobacterium '*Candidatus Liberibacter asiaticus*' in citrus plants that gives rise to huanglongbing or citrus greening (Aubert, 1987; da Grac¸ a, 1991; Halbert and Manjunath, 2004; Weinert et al., 2004).

Nepal experienced a sharp citrus decline in the Pokhara valley with unknown causes since 1964 (Thrower, 1968), in 1967, authentically reported the citrus decline in Nepal, and the cause of this citrus decline in Pokhara valley was ascertained due to greening virus (now a bacteria) vectoring of *Diaphorina citri* (Catling, 1968). The scientific investigations with the Schwarz chromatographic technique indicated 53%, 43% and 59% citrus plants infected of greening virus, respectively, in west Nepal, the Kathmandu valley and the east Nepal. 71% sweet orange, 51% mandarin oranges and 67% mandarin orange hybrids (Kinnow and Fewtrell's Early) were sick of huanglongbing (then citrus greening). Rootstocks imported from Saharanpur, Utter Pradesh, India were confirmed to be the virus inoculants to Nepal citrus plants (Thrower, 1968).

Citrus tristeza virus (CTV) aphids:

Knorr and Shah (1971) reported, for the first time, citrus tristeza virus in lime plants in the Pokhara valley, Nepal in 1971.

Ctrus tristeza virus problem is wide spreading in the citrus growing pockets of the West and Mid-West regions of the country with an indication of disease spreading rapidly from low (440 m) to high (1350 m) altitude in the regions (Malla and Sah, 2001).

Toxoptera citricida (Kirkaldy), *Aphis gossypii* Glover, *Aphis spiraecola* Pagenstecher, *Toxoptera aurantii* (Boyer de Fonsicolombe), *Myzus persicae* (Sulzer), and *Aphis craccivora* Koch are among the plant aphids in Nepal (Rana and Sharma, 1965; Sharma, 2060 BS), and these aphids frequently visit in citrus plants. These aphids transmit citrus tristeza virus (CTV) in citrus in a semi-persistent manner. CTV, a destructive pathogen of citrus, fetches quick decline of scions on sour orange rootstock and stem-pitting in plants (da Graca et al., 2007). *T. citricida*, *T. aurantii, A. gossypii* and *A. spiraecola* are found transmitting CTV in the citrus plant but the brown citrus aphid, *T. citricidus* is incriminated the most efficient vector of CTV (Lee et al., 1994).

Citrus leprosis virus and mites:

The virus vectors, *Brevipalpus californicus* and *B. obovatus,* are present in the citrus orchards in Nepal which transmit citrus leprosies virus in other countries but not in Nepal (Knorr and Shah, 1971). In the present of context of high trafficking of import and export of agricultural commodities including citrus fruits, mite surveillance in citrus orchards is very essential to monitor the seasonal activities of these mites for the potential occurrences of the citrus leprosies on citrus fruits. Knorr and Shah (2071) observed *B. obovatus* mite on shaddock (pomelo) at Patan, Lalitpur but no leprosies symptom on fruits.

Insect pests reviewed by FAO Nepal, 2011 AD

FAO- Nepal (2011) dealt insect pests in course of citrus decline in Nepal are as followed:

- *Diaphorina citri* (Asian citrus psyllid) (Hemiptera: Sternorrhyncha: Liviidae)
- *Phyllocnistis citrella* (citrus leaf miner) (Lepidoptera: Gracillaridae)
- *Scirtothrips dorsalis* Hood, 1919. (chilli thrips) (Thysanoptera: Thripidae)
- *Toxoptera citricidus* (brown citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae)

- ***Chinavia hilaris*** Say, 1832. (= *Acrosternum hilare*) (green stink bug) (Hemiptera: Heteroptera: Pentatomidae). **Remark**: *Chinavia hilaris* is not present in the south Asia except Pakistan. This bug is found, mainly, in North America (PcPherson, 1982). **Its presence in Nepal is an erroneous statement.**
- ***Chelidonium argentatum*** (Dalman) (= *Chelidonium cinctum*) (citrus trunk borer). It is present in South India only (Kannan, 1928). **Remark: *Chelidonium argentatum* is not present in Nepal.**
- *Aonidiella aurantii* (red scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- *Lepidosaphes beckii* (purple scale) (Hemiptera: Sternorrhyncha: Diaspididae)
- ***Icerya purchase*** (cottony cushion scale) (Hemiptera: Sternorrhyncha: Monophlebidae) (Not yet reported in Nepal; doubtful inclusion in the citrus pest list).
- *Planococcus citri* (Risso, 1813) (citrus mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae)
- *Bactrocera dorsalis* (Oriental fruit fly) (Diptera: Tephritidae)

Regional citrus insect pests investigations

Citrus fruit pests and management practices was reported from Tapli Rural Municipality, Udaypur district, Nepal (Thakuri, 2023). Paudel et al. (2022) reported the causes of citrus decline and its management practices adopted in Myagdi district, Nepal. Similarly, Panth and Dhakal, (2019) pointed out the determinants of mandarin orange productivity and causes of citrus decline in Parbat District, Nepal. Acharya et al. (2011) narrated the improving citrus production in Dailkeh. Awasthi (2021) observed the insect pests of citrus fruits in Kailali and suggested their management practices, Similarly, Chhetri et al. (2021) reported the perception of the Gulmi farmers on the incidence of insect pests on mandarin orange and management practices applied in their orchards. KC (2023) observed insect species associated with mandarin orange and suggested pest management practices in Sigana, Baglung.

Inventory of citrus insect and mite pests of Nepal

Taking considerations of the lists of the citrus insect and mite pests reported in Nepal (Knorr and Shah, 1971; Neupane, 1995; Joshi, 2005; Joshi, 2010-11; FAO-Nepal, 2011), an updated citrus insect pest inventory is followed. The inventory (n = 80 citrus pests) included 73 species of insects and 7 species of mites in *Citrus* spp in Nepal.

Insects (n = 73)

- *Agonischius sp.* (Coleoptera: Elateridae) (Knorr, and Shah, 1971).
- *Agrilus* sp. (jewel beetle) (Coleoptera: Buprestidae) (Joshi, 2010-11).
- *Aleurocanthus woglumi* (citrus blackfly) (Hemiptera: Sternorrhyncha: Aleyrodidae) (Joshi, 2010-11; Knorr, and Shah, 1971).

- *Aonidiella aurantii* (red scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Joshi, 2010-11; Knorr, and Shah, 1971; Neupane, 1995; FAO-Nepal, 2011).
- *Aonidiella citrina* (yellow scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Joshi, 2010-11).
- *Aonidiella orientalis* (oriental red scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Joshi, 2010-11).
- *Aphis craccivora* (groundnut aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11).
- *Aphis fabae* (black bean aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11).
- *Aphis gossypii* (cotton aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11).
- *Aphis spiraecola*(green citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11).
- *Argina astrea* Drury (= *Argina cribraria*) (Lepidoptera: Arctiidae) (Knorr, and Shah, 1971).
- *Aspidiotus destructor* (coconut scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Joshi, 2010-11: Neupane, 1995; Knorr, and Shah, 1971).
- *Atherigona orientalis* (pepper fruit fly)(Diptera: Muscidae) (Joshi, 2010-11).
- *Attacus atlas* (atlas moth) (Lepidoptera: Saturniidae) (Joshi, 2010-11).
- *Bactrocera dorsalis* (Oriental fruit fly) (Diptera: Tephritidae) (Joshi, 2010-11; FAO-Nepal, 2011; Neupane, 1995).
- *Bactrocera dorsalis* (species complex) (Diptera: Tephritidae) (Joshi, 2010-11).
- *Bactrocera minax* (Chinese citrus fly) (Diptera: Tephritidae) (Joshi, 2010-11).
- *Bactrocera zonata* (peach fruit fly) (Neupane, 1995).
- *Bemisia giffardi* (Kotinsky) (Hemiptera: Sternorrhyncha: Aleyrodidae) (Neupane, 1995; Knorr, and Shah, 1971; Rana and Sharma, 1967).
- *Cassida* sp. (tortoise beetle) (Coleoptera: Chrysomelidae) (Joshi, 2010-11; (Knorr, and Shah, 1971).
- *Ceroplastes japonicas* (tortoise wax scale) (Hemiptera: Sternorrhyncha: Coccidae) (Joshi, 2010-11).
- *Chaetanaphothrips orchidii* (anthurium thrips) (Thysanoptera: Thripidae) (Joshi, 2010-11).
- *Chrysodeixis acuta* (tomato semi-looper) (Lepidoptera: Noctuidae) (Joshi, 2010-11).
- *Coccus hesperidum* (brown soft scale) (Hemiptera: Sternorrhyncha: Coccidae) (Joshi, 2010-11: Knorr, and Shah, 1971; Rana and Sharma, 1965; Rana and Sharma, 1967).
- *Colasposoma semicostatum* Jacoby (Coleoptera: Chrysomelidae) (Knorr, and Shah, 1971).
- *Dalpada* sp. (Hemiptera: Heteroptera: Pentatomidae) (Knorr, and Shah, 1971).
- *Diaphorina citri* (Asian citrus psyllid) (Hemiptera: Sternorrhyncha: Liviidae) (Joshi, 2010-11: Knorr, and Shah, 1971; FAO-Nepal, 2011; Neupane, 1995).
- *Diaspidiotus perniciosus* (San Jose scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Joshi, 2010-11).
- *Dysdercus evanescens* Distant (Hemiptera: Heteroptera: Pyrrhocoridae) (Knorr, and Shah, 1971).

- *Eriophyes* sp. (blister mite) (Acari: Eriophydae) (Neupane, 1995).
- *Eudocima phalonia* (Linnaeus) (fruit-piercing moth) (Lepidoptera: Erebidae) (= *Othreis fullonia*) (Joshi, 2010-11).
- *Euproctis xanthorrhoea* (= *Euproctis chrysorrhoea*) (brown-tail moth) (Lepidoptera: Erebidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Fiorinia theae* Green (camellia scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Knorr, and Shah, 1971).
- *Glycyphana horsfieldi* (Hope) (flower chafer) (Coleoptera: Scarabaeidae) (Knorr, and Shah, 1971).
- *Helicoverpa armigera* (cotton bollworm) (Lepidoptera: Noctuidae) (Joshi, 2010-11).
- *Heliothrips haemorrhoidalis* (black glasshouse thrips) (Thysanoptera: Thripidae) (Joshi, 2010-11).
- *Hemaspidoproctus cinereus* (Green) (Hemiptera: Sternorrhyncha: Monophlebidae) (Knorr, and Shah, 1971).
- *Hemiberlesia rapax* Comstock) (greedy scale (USA)) (Knorr, and Shah, 1971).
- *Icerya purchase* (cottony cushion scale) (Hemiptera: Sternorrhyncha: Monophlebidae) (Neupane, 1995) (Not yet reported in Nepal; doubtful inclusion in the inventory).
- *Icerya seychellarum* (Seychelles scale) (Hemiptera: Sternorrhyncha: Monophlebidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Indarbela* sp. (bark eating caterpillar) (Lepidoptera: Cossidae) (Neupane, 1995).
- *Lepidosaphes beckii* (purple scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Joshi, 2010-11; Knorr, and Shah, 1971; FAO-Nepal, 2011).
- *Maconellicoccus hirsutus* (pink hibiscus mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Joshi, 2010-11).
- *Myzus persicae* (green peach aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11).
- *Nezara viridula* (green stink bug) (Hemiptera: Heteroptera: Pentatomidae) (Joshi, 2010-11).
- *Nipaecoccus viridis* (spherical mealybug) (=*Nipaecoccus vastator*) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Joshi, 2010-11: Knorr, and Shah, 1971; Rana and Sharma, 1965; Rana and Sharma, 1967).
- *Oberea butangensis* (citrus stem borer) (Coleoptera: Cerambycidae) (Joshi, 2010-11).
- *Otinotus oneratus* (Walker) (cow bug) (Hemiptera: Heteroptera: Membracidae) (Knorr, and Shah, 1971).
- *Oxycetonia jucunda* Faldermann (citrus flower chafer) (Coleoptera: Scarabaeidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Oxyrachis* sp. (treehopper, cow bug**)** (Hemiptera: Heteroptera: Membracidae) **(**Knorr, and Shah, 1971**).**

- *Papilio* (= *Menelaides*) *nephelus chaon* (Yellow helen) (Lepidoptera: Papilionidae) (Joshi, 2010-11).
- *Papilio* (= *Menelaides*) *helenus helenus* (Red helen) (Lepidoptera: Papilionidae) (Joshi, 2010-11).
- *Papilio* (=*Menelaides*) *polytes romulus* (common mormon) (Lepidoptera: Papilionidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Papilio demoleus* (chequered swallowtail) (Lepidoptera: Papilionidae) (Joshi, 2010-11; Knorr, and Shah, 1971; Neupane, 1995).
- *Papilio demoleus demoleus* Linnaeus (Lime swallowtail) (Lepidoptera: Papilionidae) (Joshi, 2010-11).
- *Papilio machaon rinpoche* (Common yellow swallowtail) (Lepidoptera: Papilionidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Parasa lepida* (nettle caterpillar) (Lepidoptera: Limacodidae) (Joshi, 2010-11).
- *Parasaissetia nigra* (Nietner) (black coffee scale) (Hemiptera: Sternorrhyncha: Coccidae) (Joshi, 2010-11).
- *Phyllocnistis citrella* (citrus leaf miner) (Lepidoptera: Gracillaridae) (Joshi, 2010-11; Knorr, and Shah, 1971; FAO-Nepal, 2011; Neupane, 1995).
- *Planococcus citri* (Risso, 1813) (citrus mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (FAO-Nepal, 2011; FAO-Nepal, 2011; Neupane, 1995).
- *Pseudococcus cryptus* (citriculus mealybug) (= *Pseudococcus citriculus*) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Pulvinaria psidii* (green shield scale) (Hemiptera: Sternorrhyncha: Coccidae) (Joshi, 2010-11).
- *Rhopalosiphum maidis* (green corn aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Rhynchocoris poseidon* (= *R. humeralis*) (spined fruit bug) (Hemiptera: Heteroptera: Pentatomidae) (Joshi, 2010-11: Knorr, and Shah, 1971: Manandhar, 2002; Manandhar et al., 2003; Pandey and Rana, 1992).
- *Saissetia coffeae* (brown coffee scale) (Hemiptera: Sternorrhyncha: Coccidae) (Joshi, 2010-11: Knorr, and Shah, 1971).
- *Scirtothrips dorsalis* Hood, 1919. (chilli thrips) (Thysanoptera: Thripidae) (FAO-Nepal, 2011; Subedi, 2012; FAO-Nepal, 2011).
- *Spodoptera litura* (armyworm) (Lepidoptera: Noctuidae) (Joshi, 2010-11).
- *Stromatium barbatum* (kulki teak borer) (Coleoptera: Cerambycidae) (Neupane, 1995).
- *Thaumastopeus pullus* (Billberg) (black rose chafer) (Coleoptera: Scarabaeidae) (Knorr, and Shah, 1971).
- *Thrips flavus* (apple blossom thrips) (Thysanoptera: Thripidae) (Joshi, 2010-11).
- *Toxoptera aurantii* (Black citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi,

2010-11; Knorr, and Shah, 1971; Neupane, 1995).

- *Toxoptera citricidus* (brown citrus aphid) (Hemiptera: Sternorrhyncha: Aphididae) (Joshi, 2010-11; Knorr, and Shah, 1971; FAO-Nepal, 2011; Neupane, 1995).
- *Zeugodacus cucurbitae* [*Bactrocera cucurbitae*] (melon fly) (Diptera: Tephritidae) (Joshi, 2010-11; Neupane, 1995).

Mites (n = 7)

- *Brevipalpus californicus* (Banks) (citrus flat mite) (Tenuipalpidae) (Knorr, and Shah, 1971).
- *Brevipalpus obovatus Donnadieu* (scarlet tea mite) (Tenuipalpidae) (Knorr and Shah, 2071).
- *Eutetranychus orientalis* (Klein) (citrus brown mite) (Tetranychidae) (Knorr, and Shah, 1971).
- *Eotetranychus sexmaculatus* (Riley) (six-spotted spider mite) (Acari: Tetranychidae) (Joshi, 2010-11; Knorr, and Shah, 1971).
- *Panonychus citri* (citrus red mite) (Acari: Tetranychidae) (Manson, 1963; Neupane, 1995).
- *Phyllocoptruta oleivora* (Ashmead) (citrus rust mite) (Acari: Eriophyidae) (Knorr, and Shah, 1971).
- *Tetranychus* sp. (red spider mite) (Acari: Tetranychidae) (Neupane, 1995).

Indian origin citrus insect and mite pests (n = 32)

Insect pests (n = 27)

1. *Adoretus versutus* Harold (rose beetle) (Coleoptera: Scarabaeidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
2. *Aleurodicus disperses* Russell (whitefly) (Hemiptera: Sternorrhyncha: Aleyrodidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
3. *Araecerus fasciculatus* (De Geer) (cocoa weevil) (Coleoptera: Anthribidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
4. *Bactrocera carambolae* (Drew and Hancock) (carambola fruit fly) (Diptera: Tephritidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
5. *Bactrocera caryae* Kapoor (Fruit fly) (Diptera: Tephritidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
6. *Ceroplastes ceriferus* Fabricius Indian wax scale) (Hemiptera: Sternorrhyncha: Coccidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
7. *Ceroplastes floridensis* Comstock (soft scale) (Hemiptera: Sternorrhyncha: Coccidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
8. *Ceroplastes rubens* Maskell (pink wax scale) (Hemiptera: Sternorrhyncha: Coccidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
9. *Ceroplastes rusci* (Linnaeus) (fig wax scale) (Hemiptera: Sternorrhyncha: Coccidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).

10. *Chrysomphalus aonidum* (Linnaeus) (circular scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
11. *Chrysomphalus dictyospermi* (Morgan) (dictysopermum scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
12. *Dysmicoccus brevipes* (Cockereli) (pineapple mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
13. *Ferrisia virgata* (Cockereli) (guava mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae).
14. *Hemiberlesia lataniae* Signoret (latania scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
15. *Icerya aegyptiaca* Douglas (breadfruit mealybug) (Hemiptera: Sternorrhyncha: Margarodidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
16. *Icerya purchasi* Maskell (cottony cushion scale) (Hemiptera: Sternorrhyncha: Margarodidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
17. *Lepidosaphes gloverii* Packard (glover scale) (Hemiptera: Sternorrhyncha: Margarodidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
18. *Lopholeucaspis japonica* Cockerell (Japanese baton shaped scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
19. *Parlatoria pergandii* Comstock (chaff scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
20. *Parlatoria ziziphi* (Lucas) (black parlatoria scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
21. *Parthenolecanium corni* (Bouche) (European fruit lecanium) (Hemiptera: Sternorrhyncha: Coccidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
22. *Pinnaspis strachani* (Cooley) (lesser snow scale) (Hemiptera: Sternorrhyncha: Diaspididae).

Nakahara (1982) indicated *P. strachani* (lesser snow scale) presence in Nepal.

23. *Planococcus lilacinus* Cock (cacao mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
24. *Prays citri* Milliere (citrus flower moth) (Lepidoptera: Yponomeutidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
25. *Pseudococcus longispinus* Targioni (long-tailed mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
26. *Rastrococcus invadens* Williams (mango mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
27. *Saissetia oleae* (Olivier) (black scale) (Hemiptera: Sternorrhyncha: Coccidae).

Mites (n = 5)

28. *Brevipalpus phoenicis* (Geijskes) (false spider mite) (Acari: Tenuipalpidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
29. *Panonychus citri* McGregor (citrus red mite) (Acari: Tetranychidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)). **Remark:** *Panonychus citri* needs to be stepped-down from the quarantine pest list published in the Nepal Gazette (2071 BS) because this mite is reportedly present in Nepal (Manson, 1963; Neupane, 1995).
30. *Phyllocoptruta oleivora* (Ashmead) (citrus rust mite) (Acari: Eriophyidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)). **Remark:** *Phyllocoptruta oleivora* needs to be stepped-down from the quarantine pest list published in the Nepal Gazette (2071 BS) because this mite is reportedly present in Nepal (Knorr and Shah, 1971).
31. *Polyphagotarsonemus latus* Banks (broad mite) (Acari: Tarsonemidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
32. *Tetranychus urticae* Koch (two-spotted spider mite) (Acari: Tetranychidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)). **Remark:** *Tetranychus urticae* needs to be stepped-down from the quarantine pest list published in the Nepal Gazette (2071 BS) because this mite is reportedly present in Nepal (Arimoto et al., 2013).

Bhutanese origin citrus insect pests (n = 3)

1. *Chrysomphalus aonidum* (circular scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
2. *Parlatoria ziziphi* (black parlatoria scale) (Hemiptera: Sternorrhyncha: Diaspididae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).
3. *Rastrococcus invadens* (mango mealybug) (Hemiptera: Sternorrhyncha: Pseudococcidae) (Nepal Gazette, 2071 BS; Joshi, 2068 BS (2010-11)).

Survey protocols for the citrus pests

Recently, the first amended survey protocol for the citrus pests launched in 2023 (NPPO-Nepal endorsed on 6 May 2013) which included survey protocol for fruit flies (NPPO-Nepal, 2023a) and survey protocol for Asian citrus psyllid (NPPO-Nepal, 2023b).

Quarantine context exotic citrus insect and mite pests to Nepal: Regulated quarantine insect and mite pests in citrus commodity for Nepal while the commodity imported to Nepal from India

Phytosanitary citrus insect and mite pests to Nepal in dealing importation of citrus (*Citrus* spp.) fruits for local consumption in the country

Pest Risk Analysis (PRA) of citrus commodity (for consumption) conducted in 2068 BS (2010-11) in the country revealed 32 quarantine insect and mite pests (27 insect pests and 5 mite pests) and only 3 citrus insect pests in dealing importation of the citrus commodity from India and Bhutan, respectively (Joshi, 2068 BS (2010-11). The PRA revealed quarantine insect and mite pests of Indian and Bhutan origins are followed.

Regulated quarantine insect and mite pests of citrus commodity in Nepal

The above mentioned PRA revealed quarantine citrus commodity insect and mite pests are lawfully regulated in the country with the proclamation of Nepal Gazette (2071 BS) in dealing the citrus commodity importation from other countries to Nepal.

Time-bound corrections in regulated quarantine citrus insect and mite pests

Nepal Gazette (2071 BS) proclaimed regulated quarantine citrus commodity mites, *Tetranychus urticae* (Arimoto et al., 2013), *Panonychus citri* (Manson, 1963; Neupane, 1995) and *Phyllocoptruta oleivora* (citrus rust mite) (Acari: Eriophyidae) (Knorr and Shah, 1971) are found occurred in the country. These mites need to be stepped-down from the quarantine pest list published in the Nepal Gazette (2071 BS).

Similarly, Nepal Gazette (2071 BS) proclaimed *Pinnaspis strachani* (lesser snow scale) needs to be stepped-down from the quarantine pest list as this insect is present in Nepal (Nakahara, 1982).

Chemical recommendation

Management of citrus insect and mite pests in Nepal

National recommended synthetic chemical pesticides against citrus insect pests (AITC, 2080 BS) are as follows:

- **Swallow-tail citrus butterflies**

These citrus butterflies are managed treating citrus plant foliage with deltamethrin 28% EC (@ 2 ml/L water).

- **Citrus leaf miner**

The citrus leaf miner, *Phyllocnistis citrella*, is managed treating new shoots of citrus plant foliage with deltamethrin 28% EC (@ 2 ml/L water) or 0.03 % dimethoate 30 EC or ATSO oil (@ 10 ml/L water).

- **Scale insects (armoured and soft scales)**

Scale insects (armoured and soft scales) in shoots, stems and foliages of citrus plant are managed with the treatment of dimethoate 30 EC (@ 1 ml/L water) once each in the month of Falgun (February-March) and Chaitra (March-April) or ATSO oil (@ 10 ml/L water).

- **Aphids**

Aphids in citrus plant are managed treating foliages with dimethoate 30 EC (@ 1 ml/L water) before flowering.

- **Asian citrus psyllid**

The Asian citrus psyllid, *Diaphorina citri*, is managed treating the new citrus shoots with dimethoate 30 EC (@ 1 ml/L water).

- **Fruit flies (*Bactrocera dorsalis*, *B. minax*)**

A. *dorsata*: Apply lethal methyl eugenol along with malathion 50 EC.

B. *minax*: Apply 50 ml as spot treatment of Great Fruit Fly Bait (protein hydrolysate (PH)) solution (PH 1 part in 3 parts water) in 05-1 sq m area underside of leaves of citrus tree (one among 3 productive trees) (This is an awaited national recommendation) (Adhikari et al.,2022).

- **Mealybug**

Treatment of the citrus plant foliage along with stems with an aqueous solution of imidacloprid (@ 0.2 ml/L water).

Conclusion

General (2005/06) and specific surveillances (1967) along with Pest Risk Analysis (PRA) (2010/11) of citrus commodity conducted in the country helped to develop an inventory of 80 citrus pests (73 and 7 species of insects and mites, respectively) in Nepal. PRA of citrus commodity in 2010/11 helped to generate an immediate national citrus pests inventory and, very specifically, decided 32 quarantine pests (27 and 5 species of insects and mites, respectively) of Indian origin and 3 insects of Bhutan origin for quarantine regulation in Nepal while the citrus commodity importation with an intention of planting materials and fruits for consumption in the nation. Nepal Gazette (2071 BS) required revisiting the regulated quarantine status of *Pinnaspis strachani* (lesser snow scale) and 3 mites, namely *Tetranychus urticae* (two-spotted spider mite), *Panonychus citri* (citrus red mite) and *Phyllocoptruta oleivora* (citrus rust mite) as they are reported existing in Nepal. In context of citrus decline in Nepal, *Bactrocera minax* (Chinese citrus fly) and *Rhynchocoris poseidon* (spined fruit bug) incriminated for fruit droppings, and *Diaphorina citri* (Asian citrus psyllid), and *Toxoptera citricidus* (brown citrus aphid) vectored huanglongbing (citrus greening) and citrus tristeza virus disease, respectively. *B. dorsalis* and *B. minax* found to be two important frugivorous insect pests for mandarin orange (fruit losses as high as 66%) and sweet orange (fruit losses as high as 85%), respectively. Area-Wide Control Programme with a help of spot treatment of protein bait found to be the most efficient sweet orange management in orchards against *B. minax* which reduced the immediate fruit losses of 57% to 5% within the two consecutive sweet orange seasons in Sindhuli citrus orchards. A recent outbreak, in 2023, of fruit piercing moth, *Eudocima phalonia* (= *Othreis fullonia*), in the sweet orange orchards in Sindhuli reminded farmers to take care these moths in the coming citrus fruit seasons.

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प्रयोगशालामा सुन्तलाको ग्रिनिङ्ग रोग परिक्षण

Detection of "*Candidatus liberibacter asiaticus*" Associated with Mandarin Orange (*Citrus reticulata* Blanco) Decline in Nepal

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Abstract

Mandarin orange (*Citrus reticulata* Blanco) is a highly nutritious sub-tropical fruit of genus *Citrus* in the Rutaceae Family. The climatic and geographical conditions of Nepal are suitable for citrus cultivation. However, the productivity of citrus in Nepal is very low compared to that of developed countries. Many citrus farms worldwide are affected by citrus greening disease also known as Huanglongbing (HLB), causing citrus decline. HLB is a destructive vector-borne disease caused by a phloem-limited gram-negative bacteria of α-proteobacteria subdivision *Candidatus liberibacter* spp. In this research, a total of 95 mandarin orange leaf samples collected from Gorkha, Lamjung and Dolakha districts were used for *Candidatous liberibacter asiaticus* detection using leaf mid vein sample using Prokaryotic rpl operon DNA amplification with the help of PCR primer Las606/LSS. Among 95 samples analyzed, 28 showed positive result . All the mandarin orange leaf samples of the mother plants maintained inside the screenhouse of Warm Temperate Horticulture Centre, Kirtipur, were negative for HLB, confirming the HLB-free source for citrus propagation by grafting. However, 63% of samples tested from the screenhouse of Gorkha showed citrus greening, which could be associated with the plantation of uncertified plants, poor management of screen house and grafting of uncertified materials such as collecting scion from the infected mother plant. Similarly, all the tested samples of Lamjung and 63% of samples of Dolakha were positive for HLB. The appearance of disease may occur due to the movement of uncertified plants across the country. Therefore, immediate action should be taken to eliminate and control the spread of HLB to rejuvenate the mandarin orange orchards in Nepal.

Keywords: Citrus greening, Citrus decline, Molecular diagnosis, Citrus quarantine, Citrus bud-wood certification

Introduction

Agro-climatic conditions of the mid-hill region of Nepal support the appropriate environment for citrus farming (Roistacher, 1996). The citrus farming has been widely practised in the range of 900-1400 m above sea level (ASL). For a long time, citrus farming has been practised for household consumption only. With the growing demand for citrus and transportation access, farmers are attracted to commercial farming. More than 14 species of citrus are reported, and mandarin orange (*Citrus reticulata* Blanco) is Nepal's most important indigenous fruit crop. According to the Department of Agriculture, Nepal 2021, during 2005-2006, citrus cultivation occupied 26681 hectares (ha) of land with a total annual production of 164075 metric tons (mt), giving an average productivity of 10.86 mt/ha. In 2008- 2009, citrus cultivation occupied 32322 ha of land with a total annual production of 253766 mt, giving an average production of 11.29 mt/ha (MoALD, 2009). Unfortunately, in 2010-11, citrus productivity declined to 11.17 (MoALD, 2011). This decline in productivity continued and became 9.47 mt/ha in 2021-22 and 2021-22. Nepal imported 1529472 kg of citrus fruits (fresh or dried), which cost NPR 67642000 (MoALD, 2022). Mandarin orange is Nepal's most favoured citrus fruit; however, the current production is insufficient to meet the market demand. In addition, farmers are in frustration due to the problem of citrus production decline.

HLB is a destructive vector-borne disease caused by a phloem-limited gram-negative bacteria of α-proteobacteria subdivision *Candidatus liberibacter* spp (Garnier and Bove, 1983). This disease is one of the severe problems in citrus fruit production worldwide, including Nepal. HLB has destroyed a large number of citrus trees in Asia and Africa. Three species of *C. liberibacter* are identified as key pathogens to citrus plants. They are- *Candidatus liberibacter africanus* (CLaf), known as the African strain, and African citrus psyllid (*Trioza erytreae*), the vector. This strain is heat sensitive and found at higher elevations (900 m above sea level, asl). *Candidatus liberibacter asiaticus* (CLas), known as the Asian strain, is vectored by *Diaphorina citri* (Kuwayama). This strain is more severe, heat tolerant and found at lower elevations (360 m above sea level), and higher temperatures (30-35°C). *Candidatus liberibacter americanus* (CLam), known as the American strain is also transmitted by *D.* citri. This strain is heat-tolerant (Martinez and Wallace,1967; McClean and Oberholzer, 1965; Regmi and Lama 1988). HLB is also transmitted by dodder (*Cuscuta spp*., Cuscutaceae) to non-rutaceous plants such as *Catharanthus roseus* L. G. Don (Periwinkle- apocynaceae) and *Nicotianato bacum* L. Cv. 'Xanthii' (tobacco, Solanaceae). Las can multiply and spread within infected *Cuscuta ceanothi* Behr (Syn. *Cu. Subinclusa* Dur, and Hilg.), *Cuscutacam pestris* and *Cu. australis* (Garnier, 2000).

The HLB disease obstructs the flow of nutrients in infected citrus trees. It spreads very fast, destroying healthy and well-managed orchards after infection. Early diagnosis of the disease is a critical step towards applying efficient eradication, vector control measures, and a measure to preserve citrus germplasm collection (Tamot and Gresshoff, 1999). HLB control is preventive and largely based on inoculum elimination by removal of infected trees and chemical treatments against vectors (Bove, 2006). Accurate, rapid and robust detection methodologies are needed for regulatory response and effective management of HLB by detecting and removing infected trees and developing a *Candidatus liberibacter*-free nursery system.

In Nepal, most of the citrus saplings are produced by the grafting method, and to produce healthy saplings confirmation of the healthy mother plant is essential. Moreover, it is equally important to monitor the status of citrus trees in the field before introducing certified citrus plants. Molecular-based diagnosis of citrus greening is an effective technique to confirm the disease in the field and screenhouse plants. For the diagnosis of HLB, currently, two molecular methods have been used: conventional Polymerase Chain Reaction (PCR) and real-time PCR (RT-PCR), also known as quantitative PCR (qPCR) that are based on the use of PCR primers that amplify DNA sequences of the Liberibacters associated with HLB (Bove 2006). Conventional PCR-based diagnosis is an economical and effective technique to diagnose large samples for effective monitoring and reintroducing certified citrus plants. Therefore, the main objective of this study is to investigate the current status of *Candidatus liberibacter asiaticus* associated with mandarin orange (*Citrus reticulata* Blanco*)* decline in open orchards and screenhouse samples of various places of Nepal.

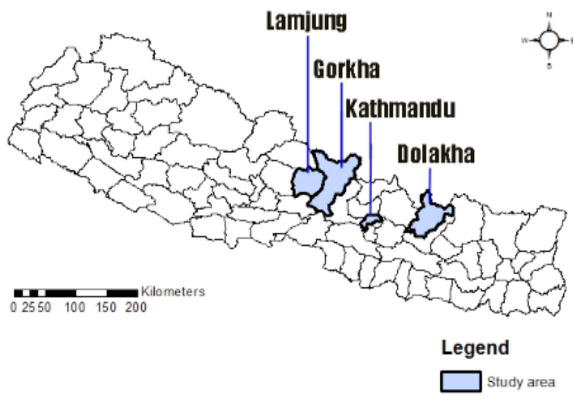

Figure 1. Map of Nepal showing study areas

Materials and method

Study sites

A total of 95 mandarin orange leaf samples were collected from September-October of 2023 from three different districts of Nepal (Figure.1). Samples from the same collection sites were evaluated for HLB by Oliya (2014).

HLB symptoms

The HLB symptoms may appear in the leaf, stem, root, and fruit. The infection reveals itself first with the mottling of leaves, then stunting of shoots, gradual death of the branches and eventually small, deformed fruits with bitter juice. In the present study, the symptoms observed during field visits are the appearance of the yellow shoot and die back of the twig/tree, Small lopsided and sour tested fruit, vein yellowing and random chlorotic blotchy yellow pattern ("blotchy mottle." on the leaf blade, reduced leaves, and poorly developed root system. In addition to this, *Diaphorina citri* were observed in a severely infected tree that was collected from Lamjung.

Sample collection and management

Fully expanded leaf samples from four directions of a single tree below the canopy were collected in a jip lock polybag, adequately tagged and transported to the Biotechnology Laboratory of Warm Temperate Horticulture Centre (WTHC), Kirtipur in an ice box. Then, based on the laboratory's sampling load, samples were further processed for DNA isolation or preserved in a normal freezer for 2-5 days. The leaf samples were cleaned with water, followed by 70% ethyl alcohol and wiped with clean tissue paper.

DNA isolation

DNA was isolated using the modified CTAB method mentioned in the Standard Operating Procedure for the HLB test (HLB#1) prepared by the Ministry of Agriculture and Livestock Development Nepal 2024 (MoALD, 2024). The quality of isolated DNA was evaluated using 0.8% agarose gel stained with ethidium bromide.

PCR amplification

PCR was amplified using forward primer Las606 5′-GGAGAGGTGAGTGGAATTCCG A-3′ and reverse primer-LSS 5′-ACCCAACATCTAGGTAAAAAC C-3′. A total of 15µl reaction volume, including 6.5 µl of 2X PCR master mix, 2 µl genomic DNA, 0.3 µl each of forward and reverse primer and the remaining nuclease-free water were used for the preparation of PCR reaction. The PCR reaction was carried as mentioned in the HLB SOP#1 (MoALD, 2024). Briefly, the PCR reaction was prepared in 15µl final volume including of 1µl of DNA, 0.5µl each of forward and reverse primer, 7µl of 2X PCR master mix, and the remaining volume of sterile nuclease-free water. PCR programming was set as follows: initial hot start of 50°C for 5 min followed by 35 cycles with denaturation at 94°C for 30-sec, annealing temperature of 55°C for 1 min and extension at 72 °C for 2 min and a final extension at 72 °C for 10 min. After that, the PCR product was run for positive and negative results in 2% Agarose gel. Molecular work was performed at the Biotechnology Laboratory of the WTHC.

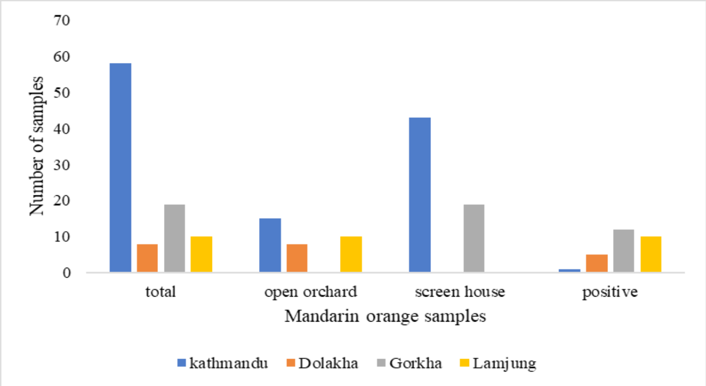

Figure 2. Total number of samples used and the sample showing HLB positive result

Results

Among 95 mandarin orange leaf samples tested for HLB, 28 showed Las606/LSS positive (Figure.2,3). Among 58 mandarin orange leaf samples of Kathmandu, only one was positive.

positive sample was of a grafted plant raised in an open orchard collected from Budanilkantha. A total of 53 mandarin oranges (43 from screen house raised mother plant and ten from the open field) of WTHC, Kirtipur, were tested, and no samples were positive for HLB. Among 19 mandarin orange leaf samples tested from the screen house nursery of Gorkha Municipality-3, Gorkha, 12 samples showed HLB-positive results (Figure 2).

Similarly, ten samples that were collected from the open orchard of Rainas Municipality-9, Lamjung, were all positive for HLB. Among eight mandarin orange leaf samples tested for HLB from Kalinchowk-, Dolakha, five were positive for HLB. The positive samples provided an amplification band at 500 bp (Figure 3), and no bands were obtained with negative samples.

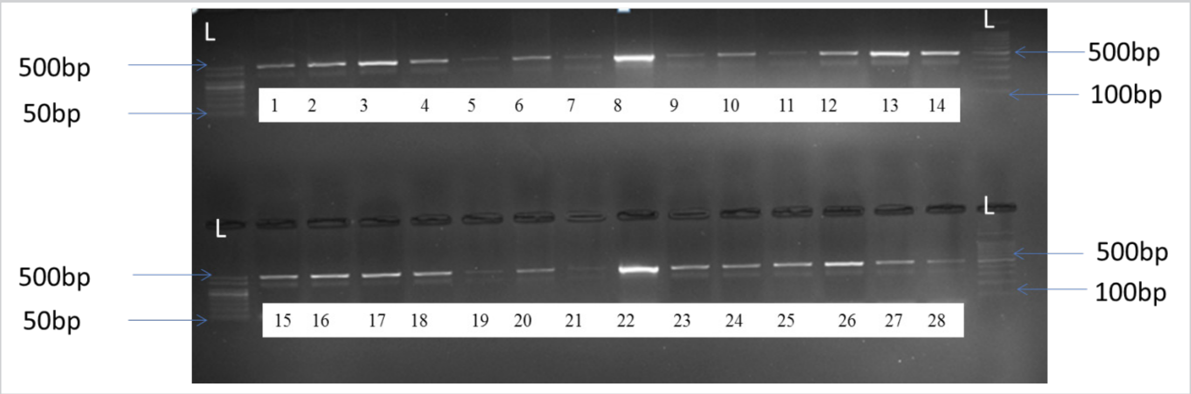

Figure 3. Agarose gel image of HLB-positive mandarin orange sample. L (Left: 50 bp DNA ladder, Right: 100 bp DNA ladder), 1 to 28, HLB positive mandarin orange sample showing 500bp of Las606/LSS primer.

Discussions

Citrus greening is the most severe and devastating disease worldwide. It is one of the limiting factors for citrus fruit production in many countries around the world. However, few cases of successful eradication have been reported. The main reason for this failure may be that infected trees overlooked by inspectors become reservoirs for a second infection (Fujikawa et al., 2013). To prevent this problem, a large and comprehensive survey is indispensable. Therefore, an effective and economical detection technique is required. The greening organism is transmitted by the vector *Diaphorina citri* in Asia, and transmission in the field is enhanced by strong wind due to the ability of the vector to move long distances (Khan et al., 2014). Due to the movement of bacteria inside the root and leaves, the phloem tissue of infected trees in this area is readily blocked, which hinders the transport of sugar, water, and nutrients in internal tissues, resulting in leaf fall, premature fruit drop, unequal fruit size, and eventually the death of the tree.

Detection of HLB by PCR technology solely depends on the nucleic acid quality and purity of the causal organism that is extracted from the citrus leaves (mid vein). In this research, HLB was detected using a leaf mid-vein sample using Prokaryotic rpl operon DNA amplification with the help of PCR primer Las606/LSS. A previous study by Li et al. (2006), reported that the largest bacterial titers were recorded in the petioles and mid-ribs of the leaf. The same bacterial populations were also observed in the peduncle, columella, and leaf midribs compared to seeds, young shoots, flower buds, flowers, and bark.

The primer set targeting 16S rDNA (OI1/OI2c 9 (Jagoueix, et al., 1994; Jagoueix et al., 1996), the nusG-rplK region, A2/J5 (Hocquellet et al., 1999) and MHO353/MHO354 (Hoy et al., 2001) are frequently used in conventional PCR for research and quarantine inspection. The primer set Las606/LSS was chosen because conventional PCR using this primer set has higher sensitivity reproducibility using even a small quantity of DNA (Fujikawa and Iwanami 2012). In the current study, all the mandarin orange samples taken from the greenhouse of WTHC, Kirtipur, showed citrus greening negative results, suggesting that these mother plants are suitable for grafting. However, 63% of samples tested from the screenhouse nursery of Gorkha showed citrus greening, which could be associated with many reasons, such as plantation of uncertified plants, poor management of screen house and grafting of uncertified materials such as a collection of scion from the infected mother plant. Similarly, all the tested samples of Lamjung and 63% of samples of Dolakha were positive for citrus greening. In the previous study by Oliya (2014), nine samples (three mandarin orange samples each from Lamjung, Dolakha and Kathmandu tested for citrus greening using a 703bp long fragment of ribosomal protein genes (rpl-PCR) in the rplKAJL-rpOBC (β-operon) using primer A2 and J5 (Hocquellet et al., 2000). During that time, all the samples of Lamjung and Kathmandu were HLB positive; however, there was no HLB infection in the sample of Dolakha. The present study suggests the rapid spread and coverage of citrus orchards by citrus greening in Nepal.

Conclusion

In this study, *Candidatus liberibacter asiaticus* were detected in mandarin orange samples using molecular technology with primer Las606/LSS. Diagnosis of HLB from screenhouse samples of Gorkha district has drawn critical attention and role of planting materials in spread of HLB.. Moreover, most of the trees in open orchards also showed HLB infection. The appearance of disease may occur due to the huge movement of uncertified plants nationwide. Young plants are very prone to this disease; therefore, citrus nurseries should be built within vector-proof screen houses with certified material, and regular monitoring is essential. This disease is not effectively treated with pesticides. To the best of our knowledge, there is no practical method to cure this deadliest disease except to remove all the infected plants from the infected area to eliminate the spread of pathogens. Therefore, immediate action should be taken to control HLB and rejuvenate mandarin orange orchards in Nepal by using HLB free planting materials and appropriate managemenat of the vector in the new planting areas.

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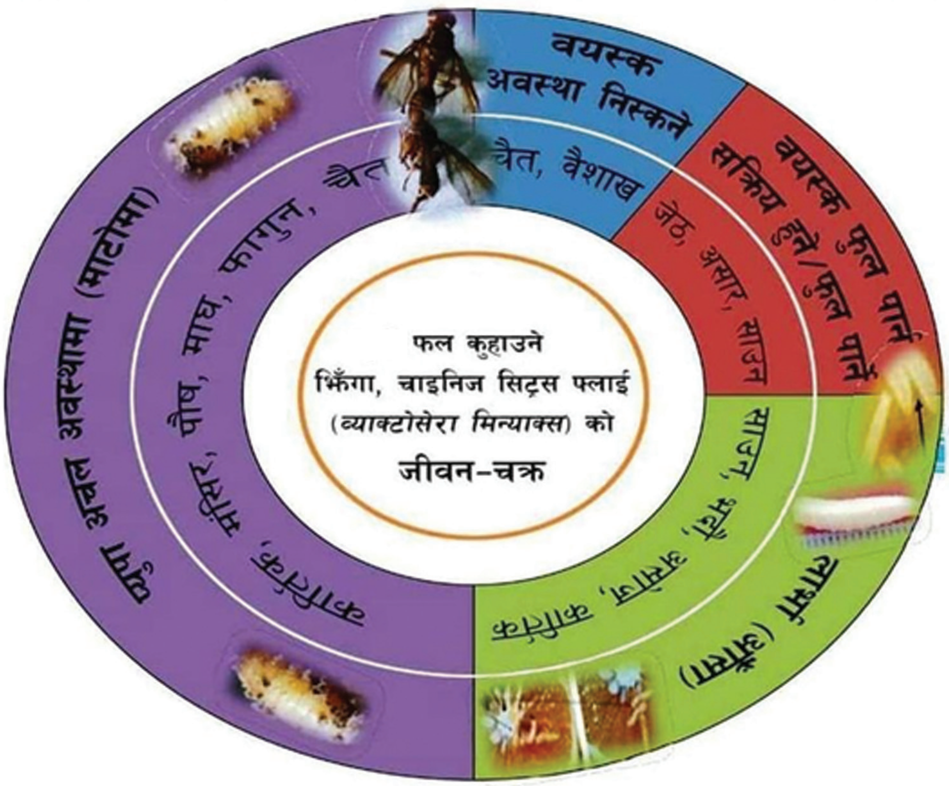

सुन्तलाजात बालीको फल कुहाउने झिंगा (चाईनिज सिट्रस फ्लाई) को जीवन चक्र

Fruit Flies (Diptera: Tephritidae) in the Citrus Ecosystem of Nepal

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Abstract

Fruit flies (Diptera: Tephritidae) have been reported as an important pest of fruits and fruit vegetables in many countries. This study was carried out to know the biodiversity of fruit fly species in the premises of sweet orange orchards in Sindhuli district, Nepal. Male fruit fly species were trapped and collected fortnightly using para-pheromone male lures (methyl eugenol and cue lure) in Steiner traps installed in 25 randomly selected citrus orchards from March 2019 to February 2021. During the monitoring period, there was a significant variation in the fruit fly species occurrences. Fruit flies were encountered in higher numbers during warm and rainy months (June, July, August, September) than during dry and winter months (December, January, February). Methyl eugenol was highly effective lure that trapped higher number of fruit flies (37 adults/fortnight) than the cue lure (16 adults/ fortnight) ($t(48) = 4.75$, $p \leq 0.0001$). *Bactrocera dorsalis* (Hendel) (62.6%) and *B. zonata* (Saunders) (18.9%) were the dominant fruit fly species trapped in the methyl eugenol trap, whereas, *Zeugodacus tau* (Walker) (66.7%) was the most dominated species of fruit fly trapped in the cue lure trap. The Chinese citrus fly, *Bactrocera minax* (Enderlein), was the most damaging fruit fly species observed and experienced by farmers in the citrus orchards. This paper has also presented the morphological features of fruit fly species, namely *B. dorsalis*, *B. zonata*, *Z. tau*, *Z. cucurbitae* (Coquillett), *Z. scutellaris* (Bezzi) and *Dacus longicornis* Wiedemann to ease their field identifications.

Keywords: Abundance, Citrus, Diversity, Fruit fly, Para-pheromone

Introduction

Citrus is one of the most important tree fruit crops in Nepal. The production of mandarin orange and sweet oranges provides nutritional and livelihood support to the people of mid-hill region (Adhikari & Rayamajhi, 2012). Citrus fruit loss due to the infestation of fruit fly maggots is one of the most common issues that citrus growers are facing. Different species of male fruit flies are trapped in para-pheromone traps in the citrus orchard ecosystem in Nepal (Adhikari et al., 2020; Adhikari & Joshi, 2018; Adhikari et al., 2018; Sharma et al., 2015). These fruit flies, due to their wide climate tolerance, polyphagous nature, high reproductive potential, multi-voltine nature (excluding *Bactrocera minax*), and high dispersal ability, pose a significant threat to the productions of fruits of tree and vegetable origins (Vasudha & Agarwal, 2019). Many fruit fly species are major pests around the world (Vargas et al., 2009; Canale & Benelli, 2012). The adult female fruit fly lays eggs in fruit, from which maggots emerge and feed on pulp (Han et al., 2011; Dhillon et al., 2005; Nardi et al., 2005). The fruit fly maggots feeding on pulp inside fruit initiate premature fruit drop, and thus the mature maggots pupate in soil (Van Schoubroeek, 1999). Therefore, the fruit fly management is critical for the production of fruits and vegetables as well as their export industry (Badii et al., 2015).

Despite the fact that the fruit flies are the most common agricultural insect pests in Nepal, their monitoring relies heavily on the use of para-pheromone male lures (methyl eugenol and cue lure) in traps. The fruit flies trapping involve catching both male and female insects in order to discover, monitor, and/or control pests in horticulture crops. Their surveillance using para-pheromone lure traps has become a highly specialized and species effective pest management technology (IAEA, 2013). Understanding the population dynamics of the fruit fly species in the ecosystem is necessary for effective control of these flies (Nboyine et al., 2013). In an agro-ecosystems, biodiversity is usually measured by the number of organisms and their species. Ecological community diversity is measured inside each habitat and compared across habitats or landscapes (Stireman, 2008). Information on abundance and diversity of insect population is important to decide management tactics. This paper presents the biodiversity of fruit fly species trapped in para-pheromone lures (methyl eugenol and cue lure) in the premises of sweet orange orchards of Sindhuli district, Nepal.

Materials and methods

Fruit fly monitoring, following the fruit fly surveillance protocol of National Plant Protection Organization (NPPO-Nepal), was conducted using fruit fly male lures originated from para-pheromones, methyl eugenol (ME) (4-allyl-1,2-dimethoxybenzene-carboxylate), and cue-lure (CL) [4-(p-acetoxyphenyl)-2-butanone] in Steiner traps placed in the randomly selected twenty-five sweet orange orchards of Sindhuli district (Table 1) from March 2019 to February 2021. Five drops each of ME and CL, included with 10 drops malathion (Malathion 50 EC) in each were used in the Steiner traps to knock down the trapped flies. The Steiner traps were hanged in tree branches at a height of 2 m above the ground, with two traps (ME and CL) in a set each element separated by at least 5 m from each other, and 100 m distance between each trap set. Fruit flies were collected from the traps at fifteen days interval and, at the same time, the lures and malathion in cotton swabs were replaced. The morphological characteristics in thorax, wing and abdomen of a fruit fly were used to identify the trap collected fruit fly species with the help of a 20× pocket lens (20×-12mm, JEWELER'S LOUPE) at Plant Protection Laboratory of PMAMP, PIU, Golanjor-5, Khaniyakharka (latitude: 27017.145' N, longitude: 85058.675' E, altitude: 1341 masl), Sindhuli. Microsoft Excel 97-2003 worksheet was used to derive the descriptive statistics, mean, standard error of mean and fruit fly species composition in each trap. Student's t-Test was used to compare an effectiveness of cue lure and methyl eugenol traps based on the mean numbers of trapped fruit flies. The fruit fly per trap per day (FTD) was calculated using the formula (IAEA, 2003),

$$\text{FTD} = \frac{\text{Total number of fruit flies trapped}}{\text{Number of trapping days} \times \text{Number of traps}}$$

Composition of the fruit fly species (%) was calculated as followed.

$$\text{Composition of the fruit fly species} = \frac{\text{ni}}{\text{N}} \text{ x } 100$$

Where,
Number of individuals in species i = ni
Total number of all species = N.

Table 1. Participated respondent orchard owners in the fruit fly monitoring in Sindhuli, Nepal

S N	Name of citrus growers	Location	GPS Coordinates		Altitude (masl)	Total area under citrus trees (productive area in ha)
			N (North)	E (East)		
1	Netra Prasad Chaulagain	Kamalamai-3, Jalkanya	27.29563	85.96041	1070	0.30 (0.08)
2	Narayan Prasad Phuyal	Kamalamai-3, Jalkanya	27.29367	85.95831	1099	0.19 (0.07)
3	Danas Shrestha	Kamalamai-3, Jalkanya	27.29228	85.96292	1060	0.27 (0.11)
4	Shambhu Bahadur Shrestha	Kamalamai-3, Jalkanya	27.29056	85.96157	1072	0.39 (0.15)
5	Ramesh Kumar Barma	Golanjor-5, Ratanchura	27.28552	85.98247	1191	2.57 (0.43)
6	Lal Bahadur Thapa	Golanjor-5, Ratanchura	27.28370	85.98490	1200	1.76 (0.42)
7	Chuda Raj Sharma	Golanjor-5, Ratanchura	27.28128	85.98277	1308	2.83 (0.33)
8	Gorakh Bahadur Ramtel	Golanjor-5, Ratanchura	27.28505	85.98778	1185	1.17 (0.53)
9	Ameresh Basnet	Golanjor-5, Chisapani	27.26646	85.99402	1146	2.50 (1.51)
10	Yogendra Thapa	Golanjor-5, Chisapani	27.26404	85.99795	1151	2.99 (1.81)
11	Dipak Thapa	Golanjor-5, Nayakharka	27.27035	86.00474	1118	2.48 (1.77)
12	Ram Bahadur Baral	Golanjor-5, Nayakharka	27.27277	86.00376	1126	3.23 (0.73)
13	Kumar Hayu	Golanjor-6, Nakajoli	27.26672	86.01379	1014	2.11 (1.35)
14	Rajan Prasad Koirala	Golanjor-6, Nakajoli	27.26572	86.01612	1081	1.23 (1.06)
15	Durga Bahadur Asthani	Golanjor-6, Nakajoli	27.26512	86.01612	1102	1.71 (1.60)
16	Hasta Bahadur Magar	Golanjor-6, Nakajoli	27.26259	86.01579	1108	0.62 (0.16)

S N	Name of citrus growers	Location	GPS Coordinates		Altitude (masl)	Total area under citrus trees (productive area in ha)
			N (North)	E (East)		
17	Kul Bahadur Kingring Magar	Golanjor-6, Nakajoli	27.26049	86.01344	1174	1.02 (0.40)
18	Surya Bahadur Aale Magar	Golanjor-4, Tinkanya	27.23187	86.06210	1100	0.47 (0.10)
19	Lal Bahadur Aale Magar	Golanjor-4, Tinkanya	27.23151	86.06250	1096	0.82 (0.25)
20	Krishna Bahadur Thapa Magar	Golanjor-4, Tinkanya	27.23212	86.06257	1085	0.67 (0.12)
21	Tek Bahadur Thapa Magar	Golanjor-4, Tinkanya	27.23162	86.06286	1088	0.88 (0.25)
22	Rabindra Kumar Aale Magar	Golanjor-4, Tinkanya	27.23145	86.06336	1069	1.33 (0.33)
23	Karna Bahadur Aale Magar	Golanjor-4, Tinkanya	27.23191	86.06364	1060	1.14 (0.33)
24	Siri Bahadur Aale Magar	Golanjor-4, Tinkanya	27.23226	86.06346	1058	0.55 (0.17)
25	Prithivi Bahadur Aale Magar	Golanjor-4, Tinkanya	27.23240	86.06355	1054	0.30 (0.08)

Results and discussion

Population densities of fruit flies in citurs orchards

The mean numbers of fruit flies per trap in the fortnight collection was highly significant ($t_{(48)} = 4.75$, $p \leq 0.0001$) with the mean difference of 20.6 fruit flies between cue lure (16.0) and methyl eugenol (36.6) traps in the selected 25 sweet orange orchards from March 2019 to February 2021 in Sindhuli. The methyl eugenol was very effective to trap higher mean number of fruit flies (916.4 ± 102.2) than the cue lure (400.7 ± 35.1) traps (n = 48) in citrus plantations in total. In the cue lure trap, in a fortnight time, the highest mean number of fruit fly per trap, 35, was recorded on 14th July, 2020 followed by 33, on 15th July, 2019. In methyl eugenol traps, the maximum mean number of fruit fly was 97/trap on 16th September, 2019, followed by 90/trap on the 2nd October, 2019 (Figure. 1).

During June, July and August, most of the fruit flies were caught in cue lure traps, while the maximum numbers of fruit flies were detected in the methyl eugenol trap during August and September. Most of the fruit flies were captured during the summer and rainy seasons, which might be due to the favorable climatic conditions. The availability of cucurbit hosts near the periphery of citrus orchards may be the reason for the maximum number of fruit flies trapped from June to August in cue lure traps. The above result is almost similar to Adhikari et al (2018). But in case of Rusitu Valley, Zimbabwe, fruit fly trappings per day in sweet oranges varied throughout the year (Stephen et al., 2019). Fruit flies were trapped in higher numbers in guava and nectarine orchards in Islamabad, Pakistan, from May to August (Sarwal et al., 2014; Gillani et al., 2002).

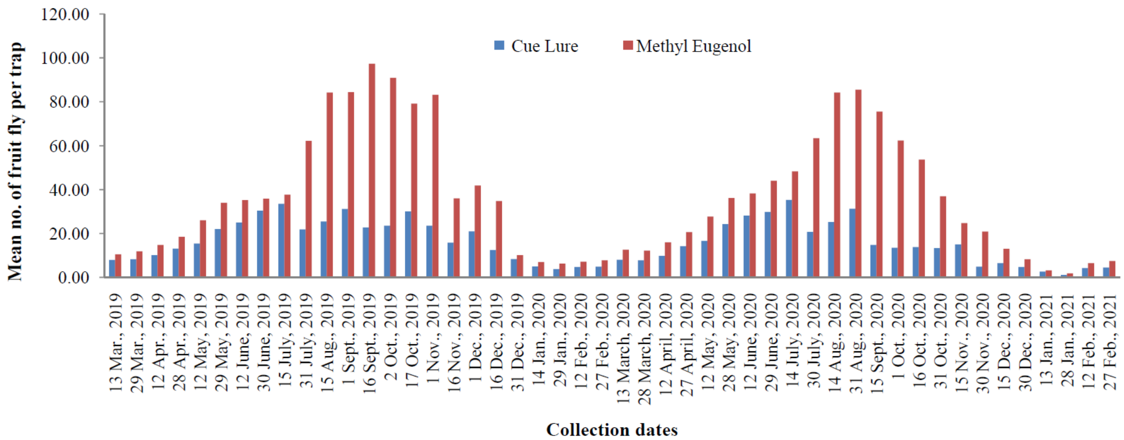
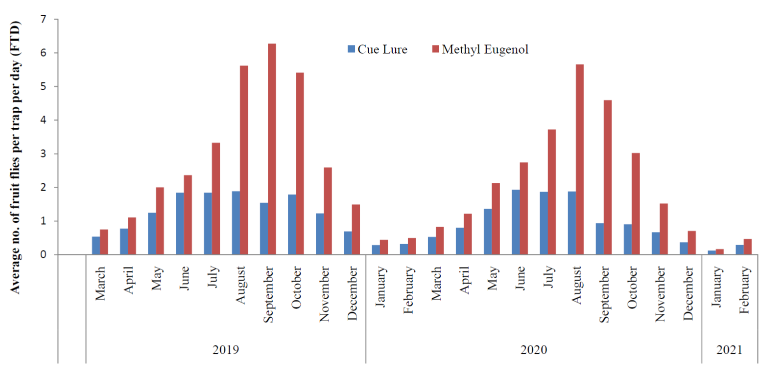


Figure 1. Fortnightly mean number of fruit fly per trap in orchards in Sindhuli, Nepal.

Fruit fly per trap per day (FTD)

The number of fruit flies per trap per day (FTD) varied significantly ($p \leq 0.05$) throughout the months in the sweet orange orchard during the monitoring period from March 2019 to February 2021. The highest number of FTD, 6.3, in methyl eugenol traps was recorded in September 2019 followed by 5.7 in August 2020, and 5.6 in August 2019. But, the highest FTD in the cue lure trap was in June 2020 (1.9), followed by August 2019 (1.9) and August 2020 (1.9) (Figure 2). This indicates that the maximum number of fruit flies were present in orchards during the summer and rainy months, which could be attributed to the pleasant temperature and relative humidity for the reproduction of fruit flies. Similarly, Banerfi et al. (2005) reported that summer was the peak season for melon fly population, followed by the winter season. During the four months that farmers continued to harvest sweet oranges, the number of fruit flies trapped per day (FTD) varied in Rusitu valley, Zimbabwe (Stephen et al., 2019). Moreover, the fruit fly population was influenced greatly by temperature and relative humidity (Appiah et al., 2009; Peng & Hui, 2007).



FTD recorded month of the year

Figure 2. Fruit flies trap per day (FTD) from March, 2019 to February, 2021 in sweet orange orchards in Sindhuli, Nepal.

Composition of fruit fly species

The fruit fly *B. dorsalis* was the most commonly encountered species accounting for 62.5 percent, followed by *B. zonata* (18.9%), *Z. tau* (16.4%), *Z. scutellaris* (1.1%), and *Z. cucurbitae* (0.8%) (Figure 3). *Z. tau* was the highest in percentage (66.7%) followed by *B. dorsalis* (12.2%), *Z. cucurbitae* (10.8%), *Z. scutellaris* (7.8%), *B. zonata* (1.5%), and *D. longicornis* (0.9%) (Figure 4). The discrepancies in the species of fruit flies attracted and trapped must be attributable to differences in the para-pheromone lure and the orchard's altitudinal conditions. Fruit flies, only males, are attracted to lures (para-pheromones) traps (Adhikari et al., 2018). Each lure is targeted to a certain fruit fly species or a group of fruit flies. Customarily, Oriental, melon, and Mediterranean fruit flies are commonly monitored by means of methyl eugenol (ME), cue lure (CL), and trimedlure (TML), respectively (HAW-FLY IPM, 2016). The mixing of fruit fly species in ME and CL could be due to the handling of both lures at the same time and in close proximity to each other. Male Oriental fruit flies (*B. dorsalis*) were attracted to ME from a distance up to 800 m (Steiner, 1952). The Oriental fruit fly was only species reported from April to November, with a yearly peak in August (Peng & Hui, 2007). Both the cue-lure and methyl eugenol are highly attractive lures to melon fly (*Z. cucurbitae*) and oriental fruit fly (*B. dorsalis*), respectively (Vargas et al., 2000). All of the fruit fly species recorded in this study have been described and reported by different authors (Sharma et al., 2015; Adhikari & Joshi, 2018; Bhandari et al., 2017; Leblanc et al., 2019; Kapoor et al., 1979).

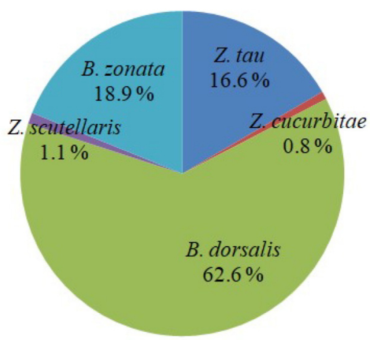


Figure 3. Fruit fly species trapped in methyl eugenol from March 2019 to February 2021 in sweet orange orchards of Sindhuli, Nepal.

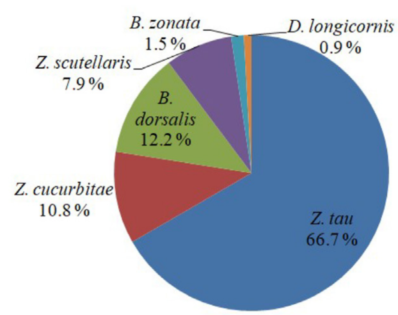


Figure 4. Fruit fly species trapped in cue lure from March 2019 to February 2021 in sweet orange orchards of Sindhuli, Nepal.

Similarly, molecular identifications of different fruit fly species have been performed in Nepal. The sequence can also be accessed in NCBI Gene Bank with accession no. OP804508 and OQ402417 for *B. dorsalis,* OP804509 and OQ413243 for *B. zonata,* OP804510 for *Z. cucurbitae*, OP804511 and OQ413244 for *Z. tau,* OP804513 and OQ413245 for *Z. scutellaris,* OQ413246 for *D. longicornis* and ON619567.1 for *B. minax* (NCBI, 2024).

Description of Fruit fly species	
***Bactrocera dorsalis* (Hendel)** **Diagnosis:** Medium sized fruit fly (length: 6-7 mm) having reddish-brown/black colored thorax. Two yellow lateral vittae present in the scutum, hyaline wing with narrow, continuous costal band confluent with vein R_{2+3}, prominent T shaped mark in abdomen. It is widely distributed in Nepal damaging several species of fruit crops. Males are attracted to methyl eugenol.	
***Bactrocera zonata* (Saunders)** **Diagnosis:** This is smaller sized fruit fly species (length: 5-6 mm) having reddish-brown colored thorax and abdomen. It has two yellow lateral vittae present in the scutum, discontinuous costal band beyond vein R_1 with an apical spot in wing. Males are attracted to methyl eugenol.	
***Zeugodacus cucurbitae* (Coquillett)** **Diagnosis:** Medium sized (length: 6-7 mm) reddish-brown colored fruit fly having 3 yellow (1 medial and 2 lateral) vittae in the scutum. It has hyaline wing with broad costal band expanded into an apical spot, subapical band present. It is a cosmopolitan and polyphagous species in Nepal damaging several fruit vegetable crops. Males are attracted to cue lure.	
***Zeugodacus tau* (Walker)** **Diagnosis:** This is medium sized fruit fly (length: 7-8 mm) having brown to black colored thorax. It has 3 yellow vittae (1 medial and 2 lateral), and hyaline wing with broad costal band expanded into an apical spot, subapical band absent. Prominent T shaped mark present in abdomen. It is one of the widely distributed species in Nepal damaging several fruit vegetables crops including cucurbits. Males are attracted to cue lure.	
***Zeugodacus scutellaris* (Bezzi)** **Diagnosis:** This is medium sized fruit fly (length: 5-6 mm) with black colored body. It has 3 vittae (2 narrow lateral and 1 medial) in the scutum and scutellum with an apical black spot, costal band narrow and apical spot near R_{4+5} in wing. It is the pest of several fruit vegetables crops including cucurbits in Nepal. Males are attracted to cue lure.	

Description of Fruit fly species	
Dacus longicornis **Wiedemann** **Diagnosis:** This is medium sized fruit fly (length: 6-8 mm) with brown/ black colored body. Thorax dark red-brown without distinct dark patterns, lateral and medial postsutural vittae absent. Broad dark fuscous costal band in wing. Males are attracted to cue lure.	
Bactrocera minax **(Enderlein)** **Diagnosis:** This Chinese citrus fly is large sized fruit fly (length: 10-12 mm) with reddish-brown color. This fruit fly species has 3 yellow vittae (2 lateral and 1 medial) present in the scutum, hyaline wing with broad costal band confluent with vein R_{4+5}, elongated abdomen with bulb shaped oviscape in females. It is one of the major pests of citrus (lemon, sweet orange and mandarin) in Nepal. It is a univoltine species with longer (5-7 months) diapause period inside soil. Para-pheromone lures do not attract to males. Freshly emerged female Chinese citrus fly is readily attracted to protein bait.	

Source: Adhikari, 2023, Adhikari & Joshi, 2018

Conclusions

Fruit fly species related information in particular host and locality are important to design an appropriate management protocol and use a specific management tool for particular fruit species. Among the fruit fly species trapped in cue lure, *Z. tau* remained in the highest percentage. At the same time, *B. dorsalis, B. zonata*, *Z. tau* were the major species recorded in the methyl eugenol trap, while higher numbers of fruit flies were trapped in para-pheromone traps, particularly, in summer and rainy seasons. This inventory of fruit fly species in the sweet orange orchards of Sindhuli, is also useful for their further studies in other fruits and vegetable crops in Nepal.

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Diagnosis of Citrus Tristeza Virus and Huanglongbing Diseases in Some Citrus Species and Micro-Propagation of Virus-Free *Poncirus Trifoliate* Orange Shoot Tips for Rootstock Production

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Abstract

Citrus Tristeza Virus (CTV) and Huanglongbing (HLB) are the most severe diseases of citrus crops in Nepal. These diseases were successfully diagnosed through molecular techniques on studied citrus species. CTV was diagnosed in different mother plants such as *Poncirus trifoliata, Citrus reticulata* Blanco, and *Citrus sinensis*, trifoliate seedlings and grafted plants of citrus by DAS-ELISA method. It was found that CTV was not transferred from infected mother plants to their saplings. HLB was diagnosed in trifoliate orange mother plants, trifoliate orange seedlings and mandarin orange plants using PCR. It was found that trifoliate orange is not easily infected by HLB as compared to mandarin orange. CTV-free trifoliate plantlets were cultured in vitro in MS-medium. Media optimization for shoot multiplication and rooting was performed. Shoot multiplication was found comparatively better in the MS medium containing 1 mg/l of BAP than in other concentrations namely 0 mg/l, 0.5 mg/l, 1.5 mg/l and 2.0 mg/l. Rooting was observed best in MS-medium containing 0.5 mg/l of IBA

Keywords: Trifoliate orange, Citrus tristeza virus, Huanglongbing, DNA, Primers, DAS-ELISA, PCR.

Introduction

Citrus is the most important sub-tropical fruit crop of Nepal. It is cultivated by most of the farmers in the mid-hills of Nepal (Panthi & Ranjit, 2012). The major citrus species grown in Nepal are mandarin orange, sweet orange, lime, lemon, and at a small scale, rough lemon, pomelo, grapefruit, sour lemon, citron, sweet lime etc. The cultivation area of citrus fruit is ongoing however productivity is not increasing as expected due to a lack of proper cultivation practices and knowledge of local farmers on diseases such as Citrus Tristeza Virus (CTV) and Huanglongbing (HLB), etc. (MoAD & FAO, 2011)

Citrus Tristeza Disease is caused by CTV which belongs to the Closterovirus group and is transmitted by the vector, brown aphid (*Toxoptera citricida*), *Toxoptera aurantii, Aphis* *gossypii* etc. It is phloem limited, 2000 nm long and 12 nm wide filamentous virus with single-stranded RNA and has a total genome size of 17-20 kb. It is a graft-transmissible disease which can be transmitted through the infected scions during grafting and also with the grafting knives. The virus causes vein clearing, stem pitting, yellowing, slow and quick decline, leaf fall, root decay etc. CTV can be detected by DAS-ELISA which is a sensitive and effective method for virus detection (Ángel *et al*., 2014; Garnsey *et al*., 1979). ELISA techniques are based upon the specific recognition of antigens by antibodies. These methods are frequently used for the detection and identification of plant viruses and are performed because of their specificity, simplicity and speed of detection (Falk, 1995).

HLB is also known as citrus greening disease. The disease is caused by the phloem-restricted gram-negative bacterium including *Candaditus liberibacter* asiaticus*, Candaditus liberibacter.* americanu*s, Candaditus liberibacter.* africanus and transmitted mainly by the Asian citrus psyllid (*Diaphorinacitri*) and the African citrus psyllid (*Triozaerytreae*). It is also a graft-transmissible disease which is easily transmitted from infected scions (Citrus, 2015; Shokrollah *et al*., 2009). In the context of Nepal, HLB is caused by *Ca. L. asiaticus* which cannot be cultured in artificial media. It is one of the serious problems for citrus fruit cultivation in Nepal. The disease causes rapid tree decline, mottled leaves, small and poor quality fruits, yellowing of veins and branches, vein corking, severe leaf and fruit drop etc. The symptoms of HLB are like a zinc deficiency which is often confused with a nutritional problem (Bianco *et al*., 2013; Tian *et al*., 2014). PCR detection method based on the amplification of 16s r-DNA, and ribosomal protein genes is used to detect the disease which is visualized by gel electrophoresis (Ranjit, 2003). A new PCR detection method based on the amplification of ribosomal protein genes, which allows for direct identification of both Asian and African species by the size of the amplified DNA, was developed in 1999 (Ruangwong & Akarapisan, 2006). This PCR technology can be used to confirm the presence of greening pathogens in citrus samples. DNA of greening bacteria may be extracted by the CTAB method. Two types of DNA namely 16s rDNA or rpl β-operon DNA can be used. In the case of 16s rDNA, a specific sequence can be amplified by specific primers namely OA1 (5' - GCG CGT ATT TTA TAC GAG CGG CA -3'), a forward primer for African species, OI1 (5'- GCG CGT ATG CAA TAC CGG CA -3'), a forward primer for Asian species and OI2c (5' - ATG GGT TGC GAA GTC GCG AGG C - 3', a reverse primer for both species. In the case of rpl beta operon DNA, 2 primers namely A2 (5' - TAT AAA GGT TGA CCT TTC GAG TTT - 3') and J5 (5' - ACA AAA GCA GAA ATA GCA CGA ACA A - 3') used for forward and reverse primers for both species (Hocquellet *et al*., 1999).

Plant tissue culture is the in vitro aseptic culture of cells, tissues, organs or whole plants under controlled nutritional and environmental conditions often to produce clones of plants (Pandey *et al*., 2020; Thorpe, 2007). The resultant clones are true-to-type of the selected genotype(Bhatia & Sharma, 2015). The controlled conditions provide a conducive environment for the growth and development of explants in the culture medium (Hussain & Ullah, 2012). These conditions include the proper supply of nutrients, pH medium, adequate temperature and proper gaseous and liquid environment (Hussain & Ullah, 2012). Tissue culture is a useful method for crop improvement and propagation (Saini, 2020). Several researchers have applied this plant tissue culture technique for the elimination of viruses through meristem culture(Tissue, 2016; Vivek & Modgil, 2018; Wang *et al*., 2006).

The main objectives of this study are to diagnose CTV disease and HLB disease by DAS-ELISA and PCR respectively, investigate whether both of these diseases are transmitted to the seedling plantlets from infected mother plants or not, and optimize media for shoot multiplication and rooting of virus free trifoliate orange by shoot tip culture.

Materials and methods

Sample collection

The leaves of different citrus species (Trifoliate orange, Mandarin orange, Sweet orange) were collected from Warm Temperate Horticulture Centre, Kirtipur (WTHC) and Thapa Horticulture Nursery Yangdi, Gorkha for CTV diagnosis. The samples were from mother plants, seedling plantlets, grafted plants and micro-propagated plants. Altogether, 33 leaf samples were collected. Among them, 19 were from WTHC, Kritipur and 14 were from Yangdi, Gorkha. Mother trifoliate orange samples taken for different seedling plantlets were the same for both places and thus were collected from WTHC. Samples of mother trifoliate orange were collected from four different trifoliate orange plants namely T1, T2, T3 and T4 cultivated at an open orchard. Six samples of trifoliate seedlings namely TS1, TS2, TS3, TS4, TS5 and TS6 were collected from WTHC and six samples namely YTS1, YTS2, YTS3, YTS4, YTS5 and YTS6 were collected from Yangdi. These samples were collected from an insect-vector-protected screen house. Besides, two mother mandarin orange samples M1 & M2, three grafted mandarin orange samples GM1, GM2 & GM3, and two mother sweet orange samples S1 & S2 from WTHC, and three mother mandarin orange samples namely YM1, YM2 & YM3, three grafted mandarin orange samples YGM1, YGM2 &YGM3 from Yangdi were also collected from the screen house. The Remaining two grafted sweet orange samples GS1 & GS2 were collected from WTHC while the other two grafted mandarin orange samples YOM1 &YOM2 were obtained from the open orchard of Yangdi.

HLB diagnosis

Altogether 15 samples were collected from the WTHC, Kirtipur and Green Research and Technology (GREAT), Baneshwor. Among 15 samples, four were mother trifoliate orange from the same tree as used for CTV diagnosis previously as well as six trifoliate orange seedlings from the same plants grown inside the screen house. Four mandarin orange samples M2, M3, M4 and M5 grown in an open orchard were collected from WTHC and one mandarin orange sample M1 grown in an open orchard from GREAT. Shoot tips of trifoliate seedlings grown inside the same screen house of CHC were collected for the micro-propagation of *Poncirus trifoliata* shoot tips.

CTV diagnosis by DAS-ELISA

The collected samples were tested for CTV by using the DAS-ELISA method following Ranjit, 1997.

Coating with antibodies

Each wall of the ELISA plate was coated with 100 µl of diluted antibodies with prepared carbonate coating buffer (1.59 g Na_2CO_3 + 2.93 g $NaHCO_3$) with the help of a micropipette. Antibody was mixed with the coating buffer at the ratio of 1:500. The plate was incubated at 37˚C for 2 hrs. After incubation, the plate was washed three times with a washing buffer.

Sample preparation and loading

200 mg samples containing midribs of leaves were ground with 4 ml of freshly prepared extraction buffer (PBS + 20 g PVP40) in mortar and pestle and centrifuged at 1,000 rpm for 2 minutes. 100 µl of each extracted sample was loaded into each of the wells along with positive and negative references. The plate was then incubated at 4˚C overnight. After that, the plate was washed three times with a washing buffer.

Conjugate loading

The conjugate antibody (alkaline phosphatase) was mixed with prepared conjugate buffer (PBST + 20 g PVP40 + 2 g BSA) in a ratio of 1:500 and 100 µl of conjugate buffer was loaded on each of the wells. The plate was then incubated at 37˚C for 2 and a half hrs. After the incubation, the plate was washed with a washing buffer three times.

Substrate loading

About 100 µl of prepared p-nitrophenyl phosphate substrate (1 mg/l) was loaded to each of the walls and incubated for 25±5 minutes at 37±2ºC for color reaction.

Determination of optical density

After one hour of reaction and color formation, the optical density was read at 405 nm using an ELISA plate reader (Huma Reader). After that, the color reaction was stopped by adding 50 ul of 3M NaOH solution to each well.

HLB diagnosis by PCR method

DNA extraction by CTAB method

The CTAB method used by Pang, 2016 (Pang, 2016) for the DNA extraction of plants and associated *Candidatus liberibacter* was modified as follows:

Each collected leaf was surface sterilized with 70 % ethanol and around 0.5g of midrib was weighted. It was then ground with the help of mortar and pestle with 4 ml of freshly prepared extraction buffer (1M Tris-HCL + 5M NaCl + 0.5M EDTA + 2% CTAB + 0.5-1% (v/v) of ß-mercaptoethanol +1% PVP 40) which was pre-warmed at 65ºC. The extracted mixture was poured on an eppendorf tube and mixed well and incubated at 65ºC for 30 minutes with shaking and inversion. The mixture was then cooled at room temperature (RT) and 2 ml of chloroform: isoamyl alcohol (24:1) or 665µl for 1ml mixture was added. It was gently inverted for 10 minutes. The tube was centrifuged at 12,000 rpm for 15 minutes at RT. The top aqueous layer was transferred to a new sterile eppendorf tube and an equal volume of chilled isopropanol (~1ml) was added for DNA precipitation. The mixture obtained above was kept at -20 ºC for 30-45 minutes. The tube was then centrifuged again at 12,000 rpm for 15 minutes at 4ºC. The pellet was washed with chilled absolute ethanol for 3 times and air-dried at room temperature. The pellet was suspended with 50-60 µl of freshly prepared TE buffer (10 mM Tris- HCL + 1 mM EDTA) to dissolve the pellet. Then, 5 µl of freshly prepared RNase for 60 µl DNA solution was added and mixed well. The tube was then incubated at 37ºC for 30 minutes. 50 µl of 3M sodium acetate and 500 µl of ice-cold absolute ethanol were added and stored at -20ºC for 30-45 minutes. The tube was then centrifuged again at 12,000 rpm for 15 minutes at 4ºC and the supernatant was discarded. The pellet was washed with 200 µl of 70% ethanol for 3 times and left for air drying. The pellet was suspended with 50-100 µl of TE buffer and stored at -20ºC

PCR method

To identify the *Candidatus liberibacter* from the above-extracted DNA mixture solution, forward primer A2 (5`- TATAAAGGTTGACCTTTCGAGTTT-3`) and reverse primer J5 (5`-ACAAAAGCAGAAATAGCACGAACAA-3`)based on the ribosomal protein gene of the ß Operon were used. 52 µl of the total PCR reaction mixture was made using 38 µl of sterile water, 5 µl of 10X assay buffer, 3 µl of 10 nM dNTP mix, 3 µl of DNA template, 1 µl of 10X forward primer, 1 µl of 10X reverse primer and 1 µl of Taq DNA polymerase. Amplification was carried out in TaKaRaPCR Thermal Cycler with the following program: one cycle at 94°C for 1 minute for initial denaturation, 30 cycles each at 94°C for 30 seconds denaturation, 48°C for 30 seconds for annealing and 72°C for 1 minute of for the extension.

Gel Electrophoresis

After PCR, the products were visualized through Agarose Gel Electrophoresis. 1X of 70ml TE buffer was prepared from 50X TE buffer provided in the gel electrophoresis kit and 2% agarose (1.4 gm) was weighed and mixed in TE buffer. The buffer was heated to mix the agarose in the buffer. Then, the buffer was allowed to slightly cool at room temperature. 4 µl of Et-Br was added and mixed well. The buffer was then poured on the electrophoresis plate and left to solidify at room temperature. Then, the samples were loaded in the well containing Et-Br. 7 µl of each sample were stained with 3 µl of dye i.e. Bromophenol blue and loaded in each well along with the DNA ladder. The electrophoresis gel was then allowed to run at 80V for 2 and a half hours. Finally, the gel was visualized and analyzed by UV trans-illuminator.

Micropropagation

Surface sterilization of explants

The collected apical shoots of virus-free trifoliate oranges were first washed with tap water and then with distilled water several times followed by 5% SDS (detergent) with continuous shaking of the beaker for 10 minutes. The explants were then washed with clean water several times. Then, they were dipped into 70% ethanol for 30 sec under a laminar hood in an aseptic condition and washed with 1% NaClO for 20-30 minutes. Finally, they were washed with autoclaved distilled water for three times.

Media optimization for shoot multiplication

After 4-8 weeks when the shoot tips were grown in vitro in an MS medium of about 0.5cm, shoot multiplication was done. For this, the MS media with 0.1 mg/l IBA and different concentrations of BAP (0, 0.5, 1, 1.5, and 2) mg/l were prepared. The apical shoot tip was excised aseptically and inoculated in MS media containing different concentrations of BAP. Two nodes were inoculated in four different replicate concentrations respectively. The temperature was maintained at 25-28ºC and light intensity at 2000 lux.

Media optimization for rooting

After 4-8 weeks when the shoot tips had grown in vitro in MS medium to about 0.5cm, rooting was done. The MS media with 0 mg/l BAP and different concentrations of IBA (0, 0.5, 1, 1.5, and 2) mg/l were prepared. The apical shoot tip was excised aseptically and inoculated in MS media containing different concentrations of IBA. One node was inoculated in six different replicates respectively. The temperature was maintained at 25-28ºC and light intensity at 2000 lux.

Result and discussion

CTV diagnosis by DAS-ELISA

All 33 samples of three different citrus species namely *Poncirus trifoliata, Citrus reticulata* Blanco, and *Citrus sinensis* and their grafted plants were tested for CTV by the DAS-ELISA method and O.D. was measured.

The positive reference sample had a mean O.D. value of 0.501 and the negative reference sample had a mean O.D. of 0.348. However, the O.D. value for negative reference was assumed to be 0.38. Since, the negative in vitro plant sample was not available, so extraction buffer was used as a negative indicator. The leaf sample of the infected plant in the garden was used as a positive sample.

Optical density at 405 nm that was less than the O.D. value of negative reference < 0.38 was considered as CTV negative. O.D. reading greater than or equal to positive reference was considered as CTV positive. The O.D. value range of 0.38-0.49 was considered mildly positive. The O.D. value range 0.501-0.79 was considered moderate positive and the O.D. value greater than 0.80 was considered severe positive.

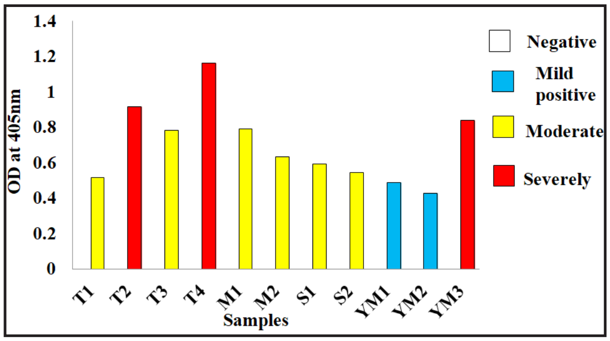

Figure 1. O.D.$_{405}$ Values of Mother Plants

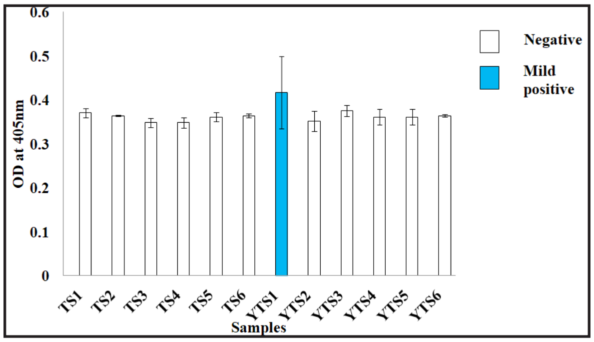

Figure 2. O.D.$_{405}$ Values of Trifoliate Seedlings

Among 11 mother plants tested, all plants were CTV infected as shown in Figure 1. Among them, YM1 and YM2 had mean O.D. values ranging from 0.38 to 0.49 and resulted as mildly infected. Six samples T1, T3, M1, M2, S1 and S2 had the mean O.D. value ranges 0.50-0.79 and resulted as moderately infected. Three samples, T2, T4 and YM3 had mean O.D. values greater than 0.8 and resulted in severe infection

Based on 12 trifoliate seedling samples examined except YTS1 from Yangdi, all other 11 samples had the mean O.D. value less than the negative reference and were found to be CTV negative as illustrated in Figure 2.

The sample YTS1 had an O.D. value between 0.38-0.49 and resulted as mildly infected and this might be due to the improper management of the nursery. The mother sample of mandarin orange and sweet orange grown inside the screen house were also found to be CTV infected which further supports the improper management of nursery. The nursery maintenance was found weak by visual observation. The improper locking system of the screen house, torn-out nets in some parts due to old age, lack of proper roofing of the screen house, and handling with infected tools might be responsible for the virus attack.

Among the 10 tested grafted plants, five samples YGM1, YGM2, YGM3, YOM1 and GM3 had the mean O.D. value less than the negative reference and resulted in CTV negative as shown in Figure 3. And five samples YOM2, GM1, GM2, GS1 and GS2 had a mean value between 0.38 - 0.49 and resulted in mild CTV infection.

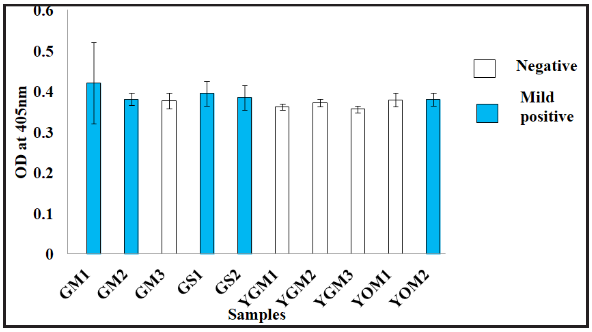

Figure 3. O.D.$_{405}$ Values of Grafted Plants

CTV was diagnosed in all 33 samples collected from WTHC, Kirtipur and Yangdi, Gorkha. Among them, four trifoliate mother plants collected randomly from the seed orchard of WTHC were found CTV infected but all their seedlings were found to be CTV negative as shown in Figure 4. The seedling plant YTS1 collected from Thapa Horticulture Nursery, Yangdi was found mildly infected. This might be due to the improper management of the nursery at Yangdi. Even the mother plant samples (YGM1, YGM2 & YGM3) of mandarin orange and sweet orange grown inside the screen house were found CTV infected. The nursery maintenance was found weak by visual observation. The improper locking system of the screen house, torn-out nets in some parts due to old age, lack of proper roofing of the screen house, and handling with infected tools might be responsible for the virus attack. The seed orchards of trifoliate oranges are prone to virus attack in an open environment. Since they have been continuously exposed to aphids for a very long time (more than 20 years), no wonder they were all infected with CTV.

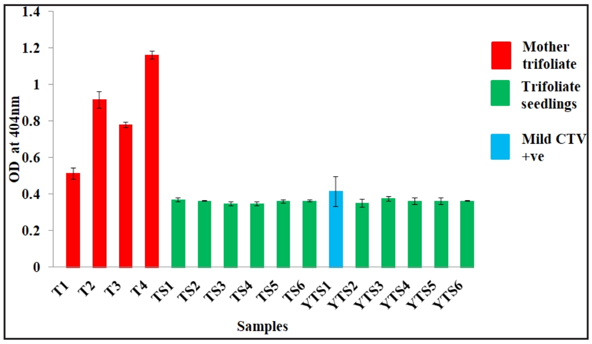

Figure 4. O.D.$_{405}$ Values of All Citrus Samples Collected from Different Parts of Nepal

There is no evidence that CTV is transmitted by seeds, but the vectors are effective at transmitting the virus (Eugen *et al*., 2021). Our study also supports that CTV was not transferred from the CTV-infected mother plant to their seedling plantlets if the seeds were grown under an insect-proof screen house. However, to further confirm the result, the trifoliate seedling plants grown inside the insect-proof house should be collected from the same trifoliate mother plant that should test positive for DAS-ELISA.

HLB diagnosis by PCR

HLB was diagnosed in all 15 collected samples by using a PCR device. Among 15 samples all four trifoliate mothers (T1, T2, T3, and T4), six trifoliate seedlings (TS1, TS2, TS3, TS4, TS5 and TS6) and two mandarin orange samples (M4 and M 5) were found negative to HLB, and other three mandarin orange samples (M1, M2 and M3) were found to be HLB positive. This result was obtained based on using specific primers A2 and J5 which amplify DNA fragments of 703 bp in size. The amplification of ribosomal protein genes from samples M1, M2 and M3 with primers A2 and AJ were found at 703 bp representing in lanes 2, 3 and 4 respectively in Figure 5. The PCR amplifications of samples M4, M5, T1, T2, T3, T4, TS1, TS2, TS3, TS4, TS5& TS6 are shown in lanes 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15 & 16 respectively (figure 5) DNA marker of 100 bp was loaded in the 1st lane of the electrophoresis gel slab.

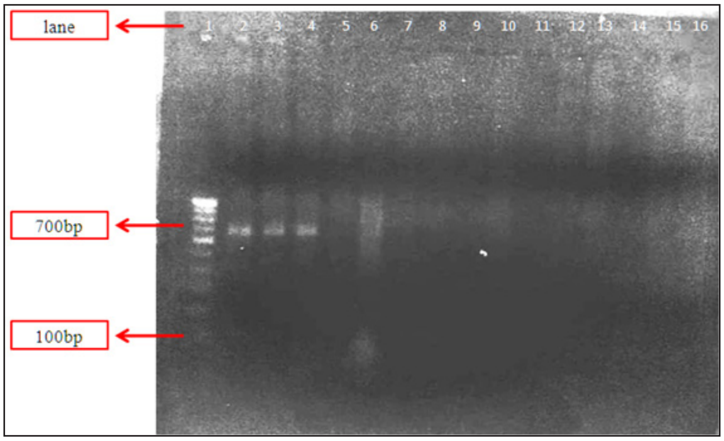

Figure 5. PCR Amplification of Different Citrus Samples Visualized under UV- Trans-illuminator where lane (1) stands for Marker, lanes (2-6) for Mandarin Orange, lanes (7-10) for Trifoliate Mother Plants and lanes (11-16) for Trifoliate Seedling Plantlets.

Among 15 samples, all four trifoliate mother plants (T1, T2, T3, and T4) collected from an open orchard and also all trifoliate seedlings (TS1, TS2, TS3, TS4, TS5 and TS6) collected from the insect-proof screen house were found negative to HLB. Three mandarin orange samples (M1, M2 and M3) collected from the open orchard were found to be HLB positive while the other two mandarin orange samples (M4 and M5) collected from the open orchard were found HLB negative. This result shows that trifoliate oranges are not easily affected by the HLB as compared to the mandarin orange. The literature (Albrecht & Bowman, 2009; Hartung *et al*., n.d.) showed that the transmission of HLB disease from citrus mother plants to their seedling plants was not possible. Further research should be done on whether HLB would transmit from the mother pants to their seedling progenies or not in the case of mandarin orange and sweet orange to know more details about the topic.

Micropropagation of trifoliate seedling

Apical shoot tips were cultured on MS medium supplemented with a combination of BAP 1 mg/l and IBA 0.1 mg/l at 25-28ºC with light intensity 2000 lux.was maintained. After 4 weeks, the apical shoot tips started to respond to the media. Callus as well as shoots were observed in some of the inoculated tubes. After 8-10 weeks, sufficient shoots were developed and they were sub-cultured to fresh shooting and rooting media containing different concentrations of BAP and IBA for shoots and root multiplication respectively. The media optimization for the micro-propagation of CTV-free trifoliate orange was done to meet the increasing demand for disease-free rootstocks in Nepal.

Media optimization for shoot multiplication

After 8 weeks, in-vitro cultured apical shoot tips were transferred to a fresh MS medium containing different BAP concentrations (0, 0.5, 1, 1.5, and 2) mg/l and 0.1 mg/l IBA.

Table 1. Growth Response of Trifoliate Orange shoot tips in MS media with 0.1 mg/l IBA and Different Concentrations of BAP

Concentration of BAP mg/l	Average Shoot Multiplication	Growth Response
0	0.5 ± 0.285	Callus formation
0.5	2 ± 1.23	Callus formation
1	9.5 ± 2.86	Better shoots
1.5	5.83 ± 1.62	Callus as well as shoots
2	3.5 ± 1.33	Callus as well as shoots

After 6 weeks, the callus was observed in the cultured tubes having a BAP concentration of 0 mg/l. There was no proper shoot multiplication with an average shoot multiplication of 0.5±0.285. The cultured tubes with 0.5 mg/l concentration of BAP showed little more shoot multiplication with an average shoot multiplication of 2±1.23 than that of 0 mg/l of BAP. The cultured tubes with 1.5 mg/l and 2 mg/l concentrations of BAP obtained an average shoot multiplication of 5.83±1.62 and 3.5±1.62 respectively and the callus was also observed. The cultured tubes with 1 mg/l concentration of BAP showed better shoot multiplication than other BAP concentrations (0, 0.5, 1.5, and 2) mg/l with an average shoot multiplication of 9.5±2.86 and the callus was also observed. However, the difference between 1mg/l and 1.5mg/l BAP concentrations was not statistically significant. The callus was formed which might be due to the incompatibility of IBA and BAP used in the experiment. Likewise, the leaf falling after yellowing might be due to the fluctuation of temperature and photoperiod during the experiment. Additionally, the nutrients and plant growth hormones supplemented in the medium were not sufficient or inappropriate for the in vitro multiplication of trifoliate orange. The nutrients and the plant growth regulators play an important role in controlling plant growth and the development of plant tissue (Klerk, 2017). Another factor considered may be due to the effect of seasonal variation during the time of sample collection may not be very appropriate for the shoot multiplication (Boudabous *et al*., 2013). Since the samples were collected during the spring season instead of the summer season. The growth response in MS media with different concentrations of BAP is shown in Table 1.

Media optimization for rooting

After 8 weeks, in-vitro multiplication, shoot tip explants were transferred to fresh MS medium containing different IBA concentrations (0, 0.5, 1, 1.5, and 2) mg/l and 0.1 mg/l BAP. The temperature was maintained at 25-28ºC and light intensity at 2000 lux

Table 2. Growth Response of Trifoliate Orange in MS Media with 0 mg/l BAP and Different Concentrations

Concentration of IBA mg/l	Growth Response
0	-
0.5	Rooting
1	Not visible
1.5	Not visible
2	Not visible

After 5 weeks the cultured tube supplemented with rooting medium containing 0.5 mg/l of IBA had shown better response than 0 mg/l, 1 mg/l, 1.5 mg/l and 2 mg/l. The main reasons for not responding to rooting might be an inappropriate supplement of nutrients and plant growth regulators. Since the nutrients and plant growth regulators provided in the medium control the plant tissue growth and survival (Klerk, 2017)

Conclusion

From our study, it was indicated that CTV was not transferred from the infected mother plants to their seedling plantlets obtained from their seeds if the seeds were grown under insect

insect-proof screen house. Trifoliate orange was not easily affected by the HLB as compared to the mandarin orange. Media optimization of trifoliate orange indicated that the shoot multiplication was best in the MS media containing 1mg/BAP while rooting was best in MS medium containing 0.5mg/l

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Causes of Citrus Fruit Drops in Karnali and Sudur Pashchim Province of Nepal

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Abstract

Causes of fruits drops may be the soil, nutrition and environment factors. Soil and leaf samples of the mandarin orange orchards were collected and analyzed to determine the nutritional status of citrus orchards of Sudur Pashchim Province (SPP) and Karnali Province of Nepal. Soil samples were collected at up to 30 cm depths from the problematic mandarin orange (*Citrus reticulate* Blanco) orchards of Kailali (Nigale), Baitadi (Nagarjung), Salyan (Khalanga) and Dailekh (Dullu) districts in 2007 and analyzed for major elements like Nitrogen (N), Phosphorus (P), Potassium (K), soil pH and organic matter (OM). Leaf samples were also collected from the same orchard at the same time, where the soil samples were taken from healthy and unhealthy orchard trees separately and analyzed for NPK. There is a tradition of cereal crops like rice, wheat and finger millet were intercropping in most of the citrus orchard and there is no system of FYM and fertilizer application for citrus plant and low level of Nitrogen was found in the soil and leaf. Powdery mildew and root rot disease were two major fungal diseases were found in all districts. These diseases will assess to fruit drop. Green string bug is the serious problem in most of the survey sites and major insect responsible for citrus fruit drop, but the farmers does not have knowledge of control the insect. The intensity of fruit drop is 35 to 180 kg depending on the size of the orchard and economic losses 39.3% was observed in the citrus orchards of SPP and Karnali Province of Nepal.

Key words: Nitrogen, Phosphorus, Potassium, Soil pH, Organic matter, Green sting bug, Root rot, Powdery mildew, Fruit drop

Introduction

Productivity of citrus fruits in Nepal is very low, 10.4 t/ha (CDS, 2003) in comparison with the other major citrus growing countries like USA, 35 t/ha (FAO, 2004). The western part of the country has less productivity, 10.1 t/ha than that of east, 11.35 t/ha (MoAC, 2006). Therefore, improvement of productivity through proper technological intervention can help to increase the family income of citrus growers of western Nepal. Western Nepal has tremendous scope for increase the commercial citrus cultivation due to congenial climate, close to Indian markets like Lucknow, Delhi, Deharadun etc. and opening of south-north feeder roads. To exploit this opportunity and meet the main goal of 10th Plan poverty reduction, productivity of citrus fruit should be improved in the regions. However problem of pre-harvest fruit drops has been reported as one of the factors causing low productivity of citrus in Nepal (CDS, 2060; Pradhan and Miya, 2004). Adhikari (2001) reported about 50% fruit drop in Salyan, Dailekh and Dadeldhura districts. Yield losses due to fruit drop has also been reported by farmers of Western Nepal through Regional Technical Working Group (RTWG) meeting at Nepalgunj (organized by NARC, 2003) and Dhangadi (organized by Crop Diversification Project, 2004). Hence, this survey will address the fruit drop problem faced by the farmers of mid and far-western regions through identification of location specific causes of fruits drop.

Nature and causes of citrus fruit drop

Citrus trees produced excessive number of flower and fruit under goes natural drop of imitation fruit to adjust fruit load. Less than 1% of citrus flower will be set harvestable fruit (Tayde and Ingle 1997)).Out of total fruit drop of mandarin orange 70 to 83% was physiological, 8 to 17% entomological and 8 to 10 % Pathological in spring flowering, whereas 73-78% physiological, 11-12% entomological and 10-13% pathological in monsoon flowering (Tayde and Ingle 1997). Allurawal *et al* (1999) reported that anti ethylene chemicals Silvernitrate and $GA_{3,}$ 25ppm can control of pre mature fruit drop. Although all the fruit that fail to mature do not drop at once time but in citrus nature of fruit drops in three waves. Firstly, post setting fruit drop occurs soon after fruit set due to over production and drop naturally and not concern to the grower. Secondly summer or June drops particularly severe in the hot dry climatic condition. Thirdly pre harvest drop, matured fruits drops before the harvest this drop is economic important to the growers. However based on the causal factor citrus fruit drop are broadly classified in to three major cause i. e. physiological, pathological and entomological.

i) Physiological drop mostly related to competition among fruit lets for carbohydrate, hormone and other metabolic activities. Sudden changes in temperature or humidity, poor nutritional management, hormonal imbalance, improper soil moisture stress especially high temperature, where the leaf temperature reached 35-40^0 C and water stress etc are also the physiological causes of fruit drop in citrus (Tayde and Ingle 1997).

ii) Pathological fruit drop caused them stem end rot on mature fruit under ripening. Post bloom fruit drop (PFD) caused by Anthracnose (*Colletotrichum acutatum)*, is an important disease of citrus that causes fruit drop especially in orchards planted in humid areas of Americas (Timmer *et al*. 1994). The first symptoms of PFD are peach to reddish brown necrotic spots on open petals. Pinhead to half grown flowers may also be attacked if inoculums level is high. Senescent petals on healthy flowers usually are light in colour or dry from the tip downward but diseased petals are dark brown to orange and dry first in the areas affected. Affected petals become hard and dry, persisting for several days after the healthy flowers have fallen. After petal fall young fruits show a slight yellowish discoloration and usually abscise leaving the calyx and flower disc intact. These structures are commonly known as 'buttons' and remain green and attached to the branch for a year or more (Timmer, *et al*. 2001).

iii) Entomological drop mainly caused by the green string bug *(Rhynchocoris humeralis)* and citrus fruit fly (*Bactrocera minax*). Other insects like mites infect the flowering and fruit setting stage, post bloom fruit drops would be severe infection of mites and sucking insect. The green string bug sucks the fruit sap in development stage and heavy drop during Shrawan to Bhadra (August) and high economic losses. Fruit fly (*Bactrocera minax)* starts to laying eggs on the fruits during Shrawan and larva damaged fruits from Aswin (full maturity stage). Heavy shedding of infected fruits (especially sweet orange) was observed before ripening.

Control of early stage fruit drop (after fruit set) two spray of growth regulator 2-4,D 15 ppm+ Benomyle 1000 ppm + 1% urea were effective in Nagpur mandarin orange. The growth regulator control the physiological fruit drop whereas fungicide control pathological fruit drop. Copper Oxychloride 50 % WP or Blitox 0.3%+ 2-4-d 10 ppm retained maximum percentage of fruit drop.

Materials and methods

Soil sample collection

Soil samples were collected from major citrus production pocket areas of Kailali (Nigale), Baitadi (Nagarjung), Salyan (Khalanga) and Dailekh (Dullu). Three farmer's orchard was selected from the pocket areas of each district. Samples were taken from five spots of each orchard, between the tree canopies in zigzag way up to 30 cm depth by using soil auger, Avoid all unwanted materials from the soil and about 0.5 kg of composite soil sample are kept in plastic bag with detailed information (Name and address of farmers, depth, intercrop, sample size/ areas, date etc).. Total twelve representative composite samples were collected from the study sites and send for analyzing NPK, OM, and pH in the laboratory of ARS Pakhribas by using standard soil testing technique.

Leaf sample collection

Leaves samples were collected from the same orchards where the soil samples were taken. Samples were collected randomly in zigzag way from healthy and deficient plant separately. Samples were collected from fully developed current year spring flush (6-7 weeks matured leaf), un-shaded non-fruiting trees, at four dimension and uniform age and height (1.5m). Total of 24 representative leaf samples, (3 healthy and 3 declined trees per district) were collected from 10% orchard plants and wash it in clean water. Samples are kept in percolated Nepali envelope with full descriptions (Name and address of farmers, date, types of rootstock, age of tree, bearing year) and send it to laboratory immediately for major nutrients i.e. N, P, K. analysis in ARS Pakhribas.

Fruit drop study

Study of fruit drop intensity in the selected pocket areas were taken by the group survey data provided by the farmer's groups and observation of orchard trees, disease infection and insect mobility.

Results and discussion

Agro-ecology of citrus cultivation

Citrus orchards in the survey areas were established in a wide range of altitude from 1150-1500 m asl with typical mid hill climate in up-land terraces under rain fed condition. The lowest altitude where citrus orchards were established was 1150 m in Nigale, Kailali whereas orchards in Nagarjung of Baitadi were established relatively in higher altitude (1450-1550 m). The soil type of citrus orchards in all sites was found loam to clay loam, which is suitable for citrus cultivation.

Most of the study sites were north or northwest facing which is positive aspect for citrus cultivation since moisture is conserved for longer duration during summer season in north facing side of the hill. Citrus production pocket of Dullu in Dailekh district is 8.0 hour far from pitch road (Surkhet) where as in Salyan around 1 hour far from the district head quarter. Vehicle facilities are available only in winter season from Surkhet to Dullu.

Table 1. Agro ecological characteristics of sites

S. No.	District	Location of pocket	Altitude (masl)	Aspect	Distance from road
1.	Baitadi	Nagarjung, VDC, Ward -6	1400-1550	South west	3 hours walking
2.	Kailali	Nigale VDC, Ward-6	1150-1350	North facing	5 hours walking
3.	Dailekh	Dullu VDC, Ward-5	1250-1350	North East	8 hours walking
4.	Salyan	Khalanga VDC, Ward-5,6	1250-1450	North East	1 hour walking

Orchard management system

Area of citrus cultivation has been increasing every year in all districts due to awareness of farmers that citrus fruits are more profitable than cereal crops. Most of the sampled farmers had more than 50 bearing mandarin trees. Existing orchards were found predominantly seedling origin. Farmers were not adopting any training and pruning practices. Citrus, maize, upland rice, wheat and millet were the major crop of upland (Bari land) in the surveyed areas. Intercropping of cereals (maize and wheat) under young citrus trees was also common practice in all districts. In recent years, few farmers have also started planting soybean, mustard, vegetables or potato under citrus orchards. None of the citrus growers of the surveyed areas were found using any chemical fertilizer to citrus trees due to higher cost and lack of awareness about the nutrient requirement of citrus trees. Compost was the main source of nutrient for citrus and other crops. But cereal crops get first priority while applying compost. Livestock like cattle and goats are the major source of compost and manure. The compost making technique was found very traditional resulting to poor in quality compost. Hoeing and weeding is done for cereals but not especially to the citrus trees. In summary, very poor orchard management practices are being adopted in all survey sites. Among the cultivated fruits mandarin orange has covered maximum areas (82.2%) in the selected districts followed by lemon and sweet orange.

Table 2. Number of citrus trees (mean of 20 farmers) in the selected sites of the districts.

District	Location of pocket	Mandarin	Sweet orange	Lemon	Lime	Total
Baitadi	Nagarjung VDC -6	96.1 (71.45)	24.2 (18.0)	5.9 (4.4)	8.3 (6.2)	134.5 (100)
Kailali	Nigale VDC -6	245.6 (78.9)	9.4 (3.0)	50.2 (16.1)	5.9 (1.9)	311.1 (100)
Dailekh	Dullu VDC - 5	161.4 (88.4)	8.2 (4.2)	7.0 (3.8)	6.4 (3.6)	182.6 (100)
Salyan	Khalanga VDC-5, 6	196.4 (88.1)	18.6 (8.4)	4.6 (2.1)	3.2 (1.4)	222.8 (100)
Average		174.9 (82.2)	15.1 (7.0)	16.9 (7.9)	5.9 (2.7)	212.7 (100)

Note: Figure enclosed the parenthesis indicates the percentage of trees out of total number. Mean figure of 20 farmers of each district.

Intensity of fruit drop

Intensity of citrus fruits drop governed by several factors and dropped in various stages. Fruit drop was taken by interviewing the farmers. According to the farmers view, dropping of fruits in the selected sites was found 34.6% in Salyan and 44.7% in Kailali district (Table 3). Average shedding of citrus fruits in four districts is 35 to 180 kg and economic losses due to shedding are 39.3%. Dropping starts during post bloom stage to before harvest. In the selected pocket, dropping starts from Ashadh to Bhadra (fruit development stage) and mainly infection by green sting bug and farmers are facing high economic loss.

Table 3. Intensity of fruit drop and economic losses

Districts	General yield (Kg/ tree)			Dropped (Kg/tree)			Dropped Percent	Dropping time	Reasons
	Min.	Max.	Mean	Min.	Max.	Mean			
1. Baitadi	80	400	195	30	200	80.5	41.7	Shrawan-Bhadra	Unknown
2. Kailali	50	400	188.2	30	220	85.2	44.7	Ashadh-Bhadra	Bug
3. Dailekh	50	300	175	30	200	155	36.2	Ashadh-Bhadra	Bug
4. Salyan	80	300	173.3	30	100	58.3	34.6	Ashadh-Bhadra	Bug
Mean	65	350	182.8	35	180	94.7	39.3		

Disease

Many diseases are observed in the citrus pocket areas of the selected districts. Among them Powdery mildew (*Oidium tingitanium*) is the most common disease of citrus species found in all selected sites of the districts. According to farmers, the disease is more serious during July- August when new flushes develop in the trees and weather is fuggy. Tender flush and fruits are also affected from this disease. Farmers were not practices any control mechanism for prevention of the disease. Timmer *et al*. (1994) reported that, post bloom fruit drop (PFD) caused by Anthracnose (*Colletotrichum acutatum)* is an important disease of citrus especially those orchards planted in humid areas. Pathogens are attracted in flowering stage and produced orange brown lesion on the petal of flower and induce abscission on fruit lets. Suspected symptoms of *Collectrorichum acutatum* is also observed in Kailali and Baitadi district but farmers are not considered on these disease. Root/ foot rot (*Phytophthora spp*) and Melanose disease were also found in survey sites. Two diseases namely anthracnose *(Collectrotrichum acetum)* and root rot *(Phytophthora spp)* are major agents for citrus fruit drop in this region.

Insect

Various types insects i.e. green stink bug, mites and leaf minor are observed in the citrus orchards of selected sites. Among them, green sting bug is one of the serious that dropped the fruits more than 25% in all sites. Farmers are not practice any control measures due to poor technical knowledge and resources.

Entomological fruit drop caused especially fruit fly can be reduced by bating with 20 g Malathion 25% WP with Vinegor or fruit juice in 2 litre. of water (2 bottle containing poison bait per 25-30 trees) has been used with little sucrose for fruit fly 0.05% Malathion+ 1% crude sugar about 2 month before ripening followed by 10 days interval bait containing.

Nutrient status of the orchard

Soil sample are collected from selected sites of the districts and analyzed major nutrients, result of the report are given in the table 4. On the basis of analysis, level of pH is 6.7 nearly neutral which is suitable for citrus. Major nutrient i.e. Nitrogen, Phosphorus Potash and Organic matter in the soil was found satisfactory level in all sites.

Table 4. Soil sample analysis report of the selected sites

S.No.	Name	Address	pH	OC%	OM%	N%	P (Kg/ ha)	K (Kg/ ha)
1.	Buddhi Raj Bista	Khalanga-6	6.75	3.44	5.93	0.21	181	1208
2.	Buddhi Raj Bista	Khalanga-6	6.79	3.73	6.42	0.23	99.26	1198
3.	Sufal Bikram Shah	Dullu 5	6.60	2.5	4.31	0.16	184.6	385
4.	Praytna Shah	Dullu 5	5.89	2.77	4.78	0.18	296.4	1107
5.	Jaya Singh Bhandari	Nagarjung-5	7.5	4.5	7.76	0.26	57.0	1751
6.	Share Singh Bhandari	Nagarjung-5	7.6	6.48	11.17	0.36	115.4	1830
7.	Mani Ram Bhandari	Nigali-5	6.6	6.41	11.05	0.36	97	1588
8.	Ganga Ram Bhandari	Nigali-5	6.5	3.13	5.4	0.20	59	1572
		Mean	**6.77**	**4.12**	**7.1**	**0.24**	**136.2**	**1329.8**
		SD	**0.58**	**1.63**	**2.8**	**0.08**	**80.3**	**493.3**

Note: N= Nitrogen, P= Phosphorus, K= Potash, OM= Organic matter, OC= Organic carbon, CGD= Citrus Greening Disease (Huanglongbin), Leaf analysis is a reliable tool of determining the nutritional level for citrus. Leaf nutrient is indices (critical level) different elements responsible for growth and productivity (Srivastave *et al* 1998). Leaf sample are collected from selected sites of the districts and analyzed major nutrients, result of the report are given in the table 5. On the basis of analysis, level of Nitrogen in the healthy plant is 0.57% to 0.72%, which is much deficient level, but level of P and K is in satisfactory in deficient trees leaf. Smith (1966) reported that the level of N, P and K in the plant tissue should be 2.6%, 0.14% and 1.5% respectively for good quality of fruit production. Kohli *et al* (1997) reported that 180 g of Nitrogen required every year for 40 kg sweet orange fruit production. Therefore, on the basis of leaf analysis result it indicated that the additional nitrogen should be applied for optimum yield and better growth in all sites.

Table 5. Leaf sample analysis report of the selected sites

SNo.	Name	Address	Healthy trees leaf			Deficient trees leaf		
			N%	P%	K%	N%	P%	K%
1.	Buddhi Raj Bista	Khalanga 5	0.62	0.34	1.96	0.58	0.31	1.53
2.	Indra Bahadur Devkota	Khalanga 5	0.57	0.37	1.53	0.52	0.29	1.61
3.	Bishnu Prasad Basnet	Khalanga 6	0.65	0.31	1.46	0.53	0.40	1.73
4.	Bishnu Shah	Dullu 5	0.62	0.25	1.26	0.73	0.30	0.90
5.	Lasxmi Shah	Dullu 5	0.64	0.59	1.52	0.52	0.29	1.61
6.	Binod K C	Dullu 5	0.72	0.21	1.68	0.65	0.30	1.81
7.	Ganesh Singh Bhandari	Nagarjung-5	0.57	0.26	1.69	0.71	0.19	1.88
8.	Jaya Singh Bhandari	Nagarjung-5	0.71	0.16	1.32	0.57	0.29	1.49
9.	Laxman Chand	Nagarjung-5	0.58	0.30	1.59	0.53	0.30	1.43
10.	Mani Ram Bhandari	Nigali-5	0.59	0.36	1.98	0.58	0.31	1.53
11.	Chhatra Saud	Nigali-5	0.63	0.21	1.59	0.52	0.29	1.61
12	Gauri Lal Saud	Nigali-5	0.64	0.31	2.46	0.53	0.60	1.73
		Mean	**0.62**	**0.32**	**1.67**	**0.58**	**0.31**	**1.57**
		SD	**0.049**	**0.110**	**0.329**	**0.075**	**0.098**	**0.250**

Conclusion

Citrus cultivation in SPP was found very primitive and traditional with tremendous scope to increase productivity through dissemination of improved production technology. On the basis of survey, citrus growing areas ranges on 1150-1550 masl. Farmers of the selected sites do not apply any chemical fertilizer in the citrus orchard and they apply compost if it is left after applying to cereals. Compost making techniques is more traditional and quality of the compost is also poor. Upland rice or maize (rainy season) and wheat (winter season) are commonly intercropped in the orchards. The intensity of fruit drop is 35 to 180 kg depending on the size of the orchard and economic losses is 39.3%. The nutritional status in the soil is recorded in satisfactory level but poor nitrogen level was found in the leaf. Powdery mildew and root rot were two major fungal disease found in all districts. These diseases will assess to fruit drop. Green sting bug is the serious problem in most of the survey sites and major insect causing citrus fruit drop but none of the farmers were found applying any measure (local/ scientific) to control the insect.

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Mandarin Orange Insect Pests Management

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Abstract

Citrus is the main fruit crop in the world, which is reported to suffer from about 250 insect and mite pest species. They are classified broadly into three categories based on their injuries e.g. fruit feeders, sap feeders, and disease vectors, which seriously attack in citrus orchards. Mandarin orange ranks the first in term of area coverage and production in Nepal, while, it suffers significant loss due to insect pests and diseases. If timely orchard management are not practiced, heavy damage and drop of fruit occurs including disease vectors spread to new orchards. Therefore, studies on insect incidence, damage symptoms, life cycle and ecofriendly measures are crucial for pest control, high quality fruit production, biodiversity conservation, ecological balance and healthy orchard management.

Keywords: Mandarin orange, Infect, Pest, Vectors, Management.

Introduction

Citrus is the main fruit crops in the world. The commonly cultivated citrus are sweet oranges, mandarin oranges, grapefruit, pomelo and the soft-grouped lemons and limes (Saunt, 1990). They are the precious resource of phytochemicals which are beneficial for the human body as vital bioactive medicines. Mandarin orange ranks the first followed by sweet orange and acid lime in term of area coverage and fruit production in Nepal, which shares more than two-third of the total citrus production in the country (MoALD, 2022), but productivity is low (<10 mt/ha) as compared to USA (>30 mt/ha) (Pun *et al*., 2015). Among the constraints in orange orchard faced by farmers, insect pest has ranked the first in Nepal (Chhetri *et al*., 2021). Nearly 87 species of insects are considered to be major pests of citrus worldwide (Ebeling, 1959) and about 250 insect and mite species have been reported infesting different species of citrus in India, of which, nearly 12 species are important (Singh *et al*., 2021). Citrus industry suffers 25% yield loss due to ravages of insect pests (Dhawan et al., 2013). Thapa et al. (1986) reported major citrus insect pests from Nepal. The arthropod pests are classified broadly into three categories based on their feeding and causing injuries, such as fruit feeders, sap feeders and disease vectors. The systematics of major insect pests, and their active period for incidence and damage in field orchard are presented in Table 1a-c. Package of practices (Kaini, 2013) and eco-friendly management of insect pests (Thapa, 2010; 2021) in citrus orchards are necessary for heathy fruit production and higher productivity.

Table 1a. List of major fruit / leaf feeders insect pests in mandarin orange

Common name	Scientific Name	Order	Family	Active period	ETL
Fruit flies	*Bactrocera minax* (Enderlein) *Bactrocera dorsalis* (Hendel)	Diptera	Tephritidae	April – October (Chaitra- Kartik)	10% affected fruit or 25-30 adults/trap/ week
Citrus leaf miner	*Phyllocnistis citrella* Stainton	Lepidoptera	Gracillariidae	May – September (Baisakha- Aswin)	25% infected leaf (10 leaves/ tree)
Lemon butterfly	*Papilio demoleus* Lin.	Lepidoptera	Papilionidae	October – February (Kartik - Falgun)	3-5 larvae/ tree

Table 1b. List of major sap feeders insect pests in mandarin orange fruit orchards

Common name	Scientific Name	Order	Family	Active period	ETL
Spined fruit bug	*Rhynchocoris poseidon* Kirkaldy	Hemiptera	Pentatomidae	June – August (Asadha- Bhadra)	-
Citrus thrips	*Scirtothrips dorsalis* Hood	Thsanoptera	Thripidae	March – June (Falgun- Asadha)	-
Citrus blackfly	*Aleurocanthus woglumi* Ashby	Hemiptera	Aleurodidae	January – November (Magha- Mansir)	5-10 nymphs/leaf
Citrus whitefly	*Dialeurodes citri* (Ashmead)	Hemiptera	Aleurodidae	March – June (Falgun- Asadha)	5 adults, or nymphs or both/ leaf
Mealy bugs	*Planococcus citri* (Risso)	Hemiptera	Pseudococcidae	March – June (Falgun- Asadha)	3-5 nymphs/5 cm twig
Fruit sucking moth	*Eudocima fullonia* (Clerck) *Eudocima materna* Lin.	Lepidoptera	Noctuidae	August – November (Bhadra- Mansir)	Occurrence of moth in trap

Table 1c. List of major disease vector insect pests in mandarin orange fruit orchards

Common name	Scientific Name	Order	Family	Active period	ETL
Asian citrus psyllidv	*Diaphorina citri* Kuwayama	Hemiptera	Psyllidae	February–September (Falgun – Aswin)	5-8/ cm2 twig
Black & brown citrus aphid	*Toxoptera citricida* Kirkaldy *T. citricidus* Kirkaldy	Homoptera	Aphidae	June – October (Asadha – Kartik)	25 aphids/10 cm shoot tip

Marks of identification, damage symptoms and life cycle

Agriculture employs 2/3rd of work force and contributes to 24.1% of national GDP. Nepal has experienced steady increases in agricultural productivity over the last few decades. However, it is not satisfactory as compared to many other countries (Pun et al, 2015). Study reveals that different factors are associated for low production and. productivity of mandarin orange in Nepal (Chhetri et al., 2021). Among them, visible damage caused by insects ranks the first, and therefore, studies are essential for identifying major insect pests, realizing their visual damage symptoms and learning life cycle in detail for designing effective management strategy in fruit orchards. According to Sreedevi (2010), citrus leaf miner (*Phyllocnistis citrella* Stainton) and lemon butterfly (*Papilo demoleus* Lin.) are common insects in a citrus plant. Sucking pests, such as aphid (*Toxoptera citricida and T. citricidus* Kirkaldy) is an efficient vector of citrus tristeza virus. Blackfly (*Aleurocanthus woglumi* Ashby), mealybug (*Planococcus citri* Risso) and citrus psylla (*Diaphorina citri* Kuwayama) are also important citrus pests. Citrus psylla act as vector transmitting pathological bacterium *Candidatus* Liberibacter asiaticus to cause greening or Huanglongbing disease of citrus. Many of the insects have been described and control measures suggested (Thapa et al., 1986). The major insect pests, their identification, damage symptoms and life cycles are described in Table 2a-c.

Table 2a. Mark of identification, damage symptom and life cycle of major fruit/leaf feeders of mandarin orange

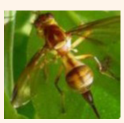
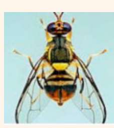
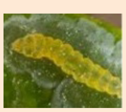
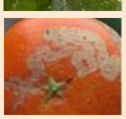
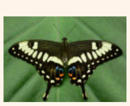
Common name	Scientific name	Identification	Damage symptom	Life cycle
Fruit flies	*B. minax*  *B. dorsalis* 	Adult *B. minax* is the large wasp like fly with yellow notopleura & postpronotal lobes, while *B. dorsalis* are small with mostly black thorax and dark T-dhaped marking on abdomen. Maggot is a shiny white bodied legless larva tapering at one end.	Attacks fruits & the symptoms include black and brown lesions on the fruit. Maggots feed on pulp internally and cause fruit drop. Fruit infestation by the pest is 4-100%.	*B. minax* is univoltine. Adults emerge in April and survive for 1-3 months. They feed on protein foods & sexually mature. Female lays 50-200 eggs in young fruits (2-4 cm diameter) 2 weeks after mating. After hatching maggots feed inside the fruits until maturity. *B. dorsalis* is multivoltine. Female inserts 2 to 15 eggs into the rind of the fruit. About 200 eggs are laid in a month which hatch in about 2 -3 days in summer and 10 days in winter. Maggots take 16 to 29 days for its full growth. Adults emerge out after 6 to 14 days.
Citrus leaf miner	*P. citrella*  	The full grown larvae are 5.1 mm long cylindrical, apodous, with light brown well developed mandibles. Adult is tiny moth 4.2 mm across the wings. Forewings have brown stripes and black spots near apical margin. Wings are fringed.	The pest is severely active year-round. Larva mines under surface of the leaf in a zigzag manner. Leaves are discolored, wrinkled with serpentine silvery mines on the lower surface of leaves. Nursery is severely affected. It encourages the incidence of citrus canker.	Female moth lays minute flatten transparent eggs singally near the midrib. Incubation lasts 2-10 days. Larvae are mature within a month, spin white cocoon and pupate inside. The pupal period is 5-25 days and complete a life cycle in 2-8 weeks with overlapping generations.
Lemon butterfly	*P. demoleus* 	Young larva resembles bird dropping. Grown up larva is cylindrical, stout, green and brown lateral bond. Adult is dark brown swallowtail with numerous yellow marking.	The pest is active throughout the year. Larva feeds voraciously on light green tender leaves leaving only the midribs and defoliate entire tree in severe damaging condition.	Butterfly emerge in March from hibernating pupae. The female lays 76-120 eggs within 2-5 days which hatch within a week. The larvae feed voraciously and mature in 1-4 weeks influenced by seasons. Pupal duration lasts 9-11 days. There are 4-5 overlapping generations a year.

Table 2b. Mark of identification, damage symptom and life cycle of major sap feeders of mandarin orange

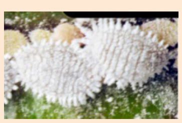
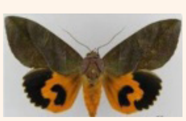
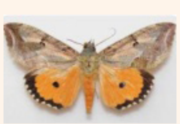
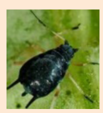
Common name	Scientific name	Identification	Damage symptom	Life cycle
Spined fruit bug	*R. poseidon* 	Adults are large green shield shaped true bugs with laterally pointed pronotum.	Nymphs and adults damage new shoots, leaves and fruits by sucking. As result, 80-90% fruits drop-off the tree.	Adult female lays eggs on lower surface of leaf in April which hatch within a week. The nymphs suck sap from new foliage and fruits and mature in 6-7 weeks. The pest has two generation a year.
Citrus blackfly	*A. woglumi* 	The nymphs are scale like shiny black, spiny and flattened, oval in shape. The adult fly is dark orange with smoky wings, forewings having four whitish area of irregular shape and wings extending beyond the tip of the abdomen.	Suck cell sap from the leaves, and leaves fall-off. Honeydew & sooty mold fungus affect the photosynthetic activity of leaves resulting in few blossoms, premature fall of buds, and fruits.	Female lays 15-20 eggs in a cluster which are yellowish brown oval shaped eggs arranged in a spiral on leaves. Incubation period is 1-2 weeks. There are 4 nymphal instars completing in 6-8 weeks and pupal period lasting 15-18 weeks. It has 2 generation a year.
Citrus whitefly	*D. citri* 	Pest is active throughout the year. Nymph is pale yellow with purple eyes and body marginally fringed with bristles. Adult measures 1.02-1.52mm long and wings more than twice the length of body. Both wings and bodies are covered with white waxy powder.	Nymph and adult suck cell sap, which results in curling and fall of leaves. They produce honeydew and sooty mold develops interfering plant photosynthetic activity, and produce few flowers. If fruits formed they are insipid.	Female lays up to 2000 oval, pale, yellow eggs on lower side of leaves in her life time of 7-10 days. Incubation period is 10-20 days. Nymphs are full fed in 25-71 days and turn into pupae which last 4- months in extreme weather condition. There are three generation a year.
Mealy bugs	*P. citri* 	Nymphs are ambar with white waxy coating and filamnts. Adult female is wingless with flattened body and short waxy filaments along the margin. Male is winged-midge like with long antennae and no mouth parts.	Nymphs and adults suck the sap from tender branches and fruits. Honeydew and sooty mold fungus affect physiological activity of plants, as a result affected plant parts wilt & dry up.	Female lays eggs in protective cottony mass (about 300 eggs/mass), which hatch in 10-20 days. Nymphs fully mature in 6-8 weeks. Male nymphs spin cotton like cocoons 2-3 weeks after hatching, pupate inside and emerge as adults.
Fruit sucking moth	*E. fullonia*  *E.materna* 	The matured larva is stout (50-60mm long) with a dorsal hump on the last body segment. Larva orange blue and yellow spots on velvety dark speckled on the body. Moths are also large with stout body and prominent palpi and orange color wing.	The moths are nocturnal, pierce the fruit and suck juice. Fruits are rotten and drop. Losses is up to 100%.	Female moth lays round translucent eggs measuring about 1mm diameter in wild plants. Incubation lasts 2 weeks and full grown larva in 4 week after passing through 5 instars. The pupal period lasts about 2 weeks.

Table 2c. Mark of identification, damage symptom and life cycle of major disease vectors of mandarin orange

Common name	Scientific name	Identification	Damage symptom	Life cycle
Asian citrus psyllid	*D. citri* 	The nymphs are flat orange yellow color and louse like appearance. The adult is brown with its head light brown and pointed. The adult measure 3 mm in length. Wings are transparent with white spots and longitudinal band.	The pest is active through the year & cause 50-70% yield loss of fruits. Nymph & adult suck sap and release toxic saliva. It secrets honeydew & develops sooty molds. Affected plant parts dry and die. It transmits Huanglongbing disease (citrus greening).	Female can lay > 800 almond shaped orange color eggs which measure 0.31 mm long and 0.14 mm wide. Incubation lasts 10-20 days in winter & 4-6 days in summer. There are 5 nymphal instars lasting about 2 weeks from April to September. Life cycle completes in about 3 weeks with over 8 generation a year.
Black & brown citrus aphid	*T. citricida* *T. aurantii* 	Nymphs are shiny black, grey or reddish brown. Winged adult female is about 1.1-2.6 mm long with black siphuculi and cauda. Apterous female is about 1.5 -2.8 mm long with black siphuculi and cauda.	Suck sap from tender foliage and flowers and results in cup shaped and crinkled leaves, also cause wilting and flower dropping. It transmit tristeza virus disease.	Black aphid can give many offspring in a day. In 2-3 weeks life time, produce many young ones. After passing 4 instars in 16 days they turn in to adults, completing a life cycle in 3 weeks with up to 12 generations a year. The brown aphid gives average 58 offspring, which mature in 6-8 days and longevity is 28.4 days at 20^0 C.

Integrated management

The affected mandarin orange orchards should be rejuvenated by undertaking integrated pest management (IPM) program. According to Geedi and Reddy (2023), recently the IPM programs for managing problems caused by nuisance arthropods emphasize the adoption of cultural, mechanical, biological, and chemical management as shown in Figure 1. Research, review and field activities have been started in line to IPM in Nepal, however, their field applications is not satisfactory due to various reasons (Thapa, 2010; Thapa, 2021).

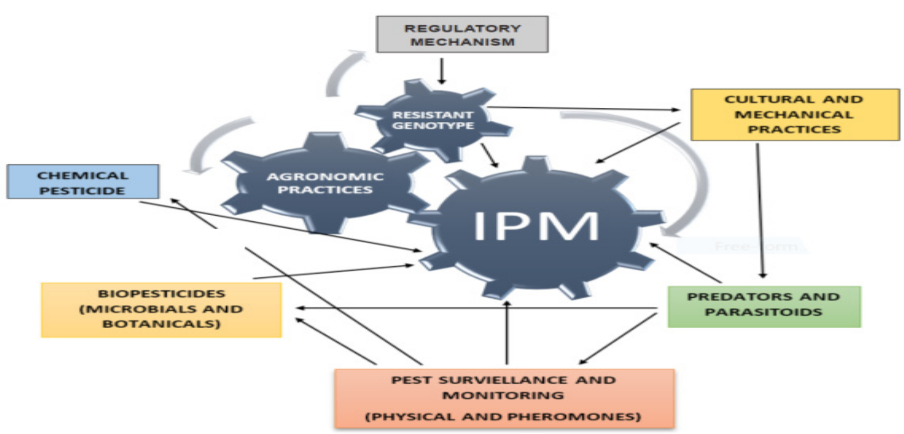


Figure 1. Schematic diagram of IPM (Geedi and Reddy, 2023); Black arrows indicate different strategies (physical, mechanical, chemical, cultural and biological controls) associated with IPM modules. The grey arrows represent agronomic practices, resistant genotype, and regulatory mechanisms interconnected with IPM.

Monitoring, recording data, evaluating pest damage and cost effective eco-friendly management measures are necessary to reduce loss below economic threshold level (ETL). This could change based on the prevailing weather, orchard stage, geographical domains and other biotic factors. Integration of relevant eco-friendly practices are outlined for healthy management and quality fruit production. ETL is available for few insect pests only. In this situation, control decisions should be made objectively based on the evidence of damage and estimate of potential crop damage compared to the cost of applying management measures.

Eco-friendly management practices are useful for conservation of biodiversity and pollinators, which provide ecological balance and services to sustainability (Thapa, 2013). Monitoring is the initial step to identify pests in the orchard. Fruit flies are important insect pests of citrus and their monitoring using different types of attractive traps are presented in Table 3. Based on the problems identified in citrus orchards, the causes of fruit drops and their remedial measures are given in Table 4. The area-wide control program of Chinese citrus fly in Junar (sweet orange) orchard has been very effective in Nepal (Adhikari et al., 2020). Similarly, there is necessary to develop monitoring techniques, collect insect pests with their proper identification and level of infestation in fruit orchards for devising effective measures.

Table 3. Fruit fly monitoring in mandarin orange orchard

SN	Common name	Scientific name	Identification	Host crops	Attracted on
1	Oriental fruit fly	*Bactrocera dorsalis* (Hendel)	Thorax black with 2 yellow lines, Abdomen light black	Mango, Papaya, Guava	Methyl Eugenol
2	3-striped fruit fly	*Bactrocera diversa* (Coquillett)	Thorax black with 3 yellow lines, abdomen light black, wing transparent	Cucurbits mainly	Methyl Eugenol
3	Peach fruit fly	*Bactrocera zonata* (Saunders)	Thorax & abdomen reddish brown	Peach, Papaya, Litchi	Methyl Eugenol
4	Melon fruit fly	*Bactrocera cucurbitae* (Coquillett)	Bright yellow line in thorax & wing tip spot & wing middle black line	Guava, Papaya	Cue-lure
5		*Bactrocera tau* (Walker)	Thorax & abdomen black without middle black line in wing	Cucurbits	Cue-lure
6		*Bactrocera scutellaris* (Bezzi)	Thorax & Abdomen black with shiny yellow lines in thorax	Cucurbits	Cue-lure
7		*Bactrocera yoshimotoi* (Hardy)	Very small		Cue-lure
8	Chinese fruit fly	*Bactrocera minax* (Enderlein)	Very big & like wasp, Wing tip black spot, thorax & abdomen constricted to some extent	Citrus	GREAT fruit fly bait
9	Solanaceous fruit fly	*Bactrocera latifrons* (Hendel)	Abdomen more brown, wing tip black spot	Solanaceous plant	Lati-lure

Source: Adhikari (2017/018)

Table 4. Causes of citrus fruit drop and their solutions

SN	Causes	Time	Solutions
1	Natural drop	March-April (Chaitra-Baisakh)	Auxin (Spray 2,4 –D @ 15-20 ppm at flowering time
2	Irrigation	February-June (Falhun-Asadha)	Irrigation and mulching
3	Diseases: Powdery mildew, Stem & rot anthracnose	February-August (Falhun-Bhadra)	Apply sulfur containing fungicides, like Insuf or Sufos @ 2.5 ml /litre of water at 15 days interval Apply 1% Bordeaux mixture at 15 days interval
4	Insects: Spined fruit bug, Fruit fly	March-August (Chaitra-Asadha)	Spray Rogor or Phoskill @ 2 ml /litre of water in 1st and 2nd nymph stage (June-July) at 15 days interval. Collect damaged fruits & burry in the pit 2 feet below the soil surface. Follow IPM technique, i.e. identification, male in annihilation, sanitation & protein bait spot spray.
5	Nutrition	April-June (Baisakh-Asadha)	Apply sufficient amount of compost & follow foliar application of micro nutrient regularly

Source: Shrestha and Chaudhary (2010)

Various technologies have been developed for area-wide control pests in citrus. IPM programs targeting *Bactrocera* species included the Regional Fruit Fly Project in the Pacific that targeted *Bactrocera* fruit flies in Pacific Island Countries and Territories and the Hawaii Area-Wide IPM program (HAWPM), implemented over a 10-year period in Hawaii. The IPM components of insect pests of citrus orchard are outlined as follows:

1. Healthy sapling production and planting (producing saplings in healthy environment),
2. Field sanitation (collection & destruction of dropped fruits),
3. Fruit bagging in kitchen gardens (in small scale),
4. Soil health for citrus orchard (soil treatment with *Trichoderma viride* Pers.),
5. Ethrel or hormonal spraying to force citrus fruit falling prematurely,
6. Conservation of bioagents (predators and parasitoids of pests) for reducing use of pesticide and conserving biocontrol agents,
7. Identification and diagnosis of pests and loss (due to insect pests and diseases),
8. Prevention of insect vectors (use of nets in nursery and selective measures in orchards),
9. Pest monitoring in orchard (use of yellow sticky, pheromone, light traps etc.),
10. Area-wide spot spray and trapping of insect pests,
11. Application of neem products in orchard (Azadirachtin NSKE 5% 50g/L). Botanicals use-NSKE 5%, Nimbecidine (2ml/L water) Neem gold (2 ml/ L water), Achook (2 ml/L water), Neem oil 3%,

12. Insect growth regulators-cuticle based (novaluron 10EC 1.5 ml/L, buprofezin 25 EC 1.5 ml/L), chemical based (pyriproxyfen, fenoxycarb), and spray of microorganism derived sipnosad (Tracer 45EC 3 ml/L), emabectin benzoate 5 EC 1 ml/L,
13. Cue-lure saturated (ethanol: cue-lure: spinosad = 8:1:2) trap, molasses (10%) based bait spray 250 spots/ha at weekly interval,
14. Attractants like citronella oil, eucalyptus oil, acetic acid (vinegar) dextrose and lactic acid may be used to trap adult flies.
15. Use of fishmeal trap to attract and kill the flies (For this, take 5 g of wet fishmeal in a (20 x 15 cm) polythene bag. Make six holes (3 mm dia.) around the periphery of the bag at equidistance at about 2 cm from the bottom of the bag. Impregnate an absorbent cotton plug with 1 ml of malathion 50EC and keep this also inside the polybag. Suspend such fish meal traps at places in the field @ 50 traps/ha. Fishmeal has to be replaced once in 20 days & pesticide every week),
16. Interspaces ploughing in winter to expose and kill the larvae and pupae of insects,
17. Spraying twice weekly of molasses (10g/L) + malathion 50EC (1 m//L) for trapping & killing fruit flies during fruit ripening that this new bait spray formulation containing the reduced-risk of pesticide sprays.
18. Annihilation technique using methyl eugenol 0.1 ml + insecticide -0.04% in cotton plug, and
19. Spraying of safe chemicals if necessary (use of eco-friendly pesticides when situation warrants).

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सुन्तला बगैंचामा रोग व्यवस्थापन

Mandarin Orange Disease Management

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Abstract

Nepal has conducive agro-ecological environment for the cultivation of mandarin orange through the mid-hills and the Government of Nepal has been rightly giving priority for the development of mandarin orange. There is significant increase both in area coverage and fruit production during the last 40-50 years. But the productivity has remained the same which is about 10 ton/ha during this period. There are many factors limiting productivity such as poor management practices and nutritional deficiencies, but diseases are the main constraints. There are different types of diseases caused by viruses, bacteria, fungi, nematodes, and others. Some of the diseases are of minor importance as they do not cause significant damage to mandarin orange but some others cause heavy losses to mandarin orange. From our own observations and on the basis of secondary information, Huanglongbing, Phytophthora root rot, powdery mildew and scab have been considered most important mandarin orange diseases that need to be managed with due priority. Research has been carried out by many researchers within Nepal and in other countries. Some general methods of controlling mandarin orange diseases common to most of them have been discussed first and then specific measures are given for the management of four selected diseases along with basic information on pathogen, symptoms, mode of transmission and environment for disease development.

Keywords: Huanglongbing, Phytophthora, Management, Powdery mildew, Pathogen, Scab, Transmission

Introduction

Mandarin orange (*Citrus reticulata* Blanco) has been grown in the middle hills of Nepal since time immemorial. The mandarin orange fruits of Nepal have a peculiar golden color hence have got the name of *Suntala*. Traditionally, Nepali farmers used to produce seedlings from the good quality fruits in their nurseries and transplanted them in their homestead garden. They grew a few trees in the homestead garden along with other fruit trees without giving much attention to fertilizers, irrigation and orchard management practices. Of course, they used to grow them near the pits used for disposal of cow dung and household waste to make farmyard manure that leached down the organic matter and enriched the soil with nutrients that were good enough for few trees of the homestead garden to produce fruits for many years. The production of fruits in this way was sufficient to meet the demand of mandarin orange fruits locally. This practice was common throughout the country until the 1960s when the government of Nepal realized the potentiality of commercial production of mandarin orange and established citrus research stations in Kaski (Pokhara) and Dhankuta (Paripatle). Some more farms and research stations were established during the 1960s and 1970s. Then after some citrus development programs and projects were implemented in the country (Paudyal *et al*., 2010). As a result the total area under citrus and the production of fruits have increased by almost 20 times since 1975 but the productivity has remained almost the same (Table 1). This is mainly due to the widespread of diseases and insect pests.

Table 1. Status of citrus production in Nepal

Year	Total area(ha)	Productive area (ha)	Total production (ton)	Productivity (ton/ha)
1974/75	2600	1690	15000	8.9
1984/85	8448	3300	45000	9.0
1994/95	14628	8448	83775	9.82
2004/05	25910	15700	168775	10.75
2014/15	39035	25261	222789	8.82
2020/21	50235	32168	311188	9.67

Source: Annual Report, National Citrus Research Program, Dhankuta (2004) and MoALD (2023)

Methodology

First of all, a literature survey of research and development activities related to mandarin orange diseases in Nepal was done. That included hard copies of published reports, proceedings, national and international journals available in the library of Nepal Academy of Science and Technology (NAST) and Nepal Agricultural Research Council (NARC). Proceedings of the International Organization of Citrus Virologists (IOCV) were studied. Also, search was done on websites. The collected information was studied, analyzed, and synthesized with citations. Since the author has a long experience in research of citrus diseases and has visited most of the citrus orchards throughout the country, personal observations and experiences also have been included in this paper.

Mandarin orange diseases prevalent in Nepal

Different groups of pathogens (viroid, virus, bacteria and fungi) cause different diseases in mandarin orange (Table 2). Some of the diseases are severe and cause heavy damage to mandarin orange while some others have insignificant damage.

There are two types of diseases-systemic and localized. Systemic diseases such as Huanglongbing and tristeza are graft transmissible and also transmitted by insect vectors and human activities, while localized diseases such as powdery mildew and scab are spread by rain water droplets or by air and do not need any insect vectors. Phytophthora root rot is a serious soil borne disease. Only preventive measures are effective against the systemic diseases while for localized ones both preventive and therapeutic measures are equally practicable.

Table 2. Pathogens causing different diseases on mandarin orange in Nepal

Group of pathogen	Name of pathogen	Disease caused	Means of transmission	Damage caused	Remarks
Viroid	*Citrus exocortis viroid* (CEVd)	Citrus exocortis	Graft	Not significant	Found only two trees in Dhankuta farm
Virus	*Citrus tristeza virus* (CTV)	Citrus tristeza	Graft, aphids(*Toxoptera citri* and *Toxoptera aurantii*)	Not significant	Local mandarin oranges are tolerant to the existing strain of CTV
Bacteria	*Candidatus* Liberibacter asiaticus	Huanglongbing (citrus greening)	Graft, psyllids (*Diaphorina citri*)	Mass decline of the trees	Spreads very fast and causes citrus decline
Fungi	*Phytophthora* spp.	Root rot, foot rot, gummosis, brown rot	Soil borne, seedlings, irrigation water	Mass decline of the trees	The pathogen enters through the injuries in the roots
Fungi	*Oidium* (*Acrosporium*) *tingitaninum*	Powdery mildew	Air borne, rain drops	Severe in the wet and warm areas	Spreads very fast
Fungi	*Elsinoë fawcetti*	Scab	Air borne, rain drops	Severe	Limited within Panauti area of Kavrepalanchok
Fungi	*Erythricium* (*Pellicularia*) *salmonicolor*	Pink disease	Air, rain drops, agricultural tools	Affects twigs and branches	In warm and humid area and season
Fungi	*Septobasidium pseudopedicellatum*	Felt disease	Air, rain drops, agricultural tools	Surficial on twigs.	In warm and humid area and season
Fungi	*Diaporthe citri*	Melanose	Air, rain drops, agricultural tools, rotted twigs	Damages young fruits	In warm and humid area and season
Fungi	*Mycosphaerella citri*	Greasy spot	Air, rain drops, fallen leaves	Damages leaves and causes leaf drop	In warm and humid area and season
Fungi	*Capnodium citri*	Sooty mold	Air, rain drops, fallen leaves	Only surficial	In abandoned orchards

Measures for managing major diseases of citrus have been developed and recommended by the Government of Nepal. The Department of Agriculture with the support of FAO-TCP project in 2011 has produced a “Training Manual for Combating Citrus Decline Problem in Nepal”, describing major problems and calendar of operations for their management in detail (DoA, 2011). More recently, Acharya and Adhikari (2022) have outlined the role of Government at central, provincial and local level as well as of research and educational institutions and other development agencies such as NGOs and INGOs to combat the major disease HLB.

The preventive measures for disease management should be aimed at eradication of source of infection and abruption of the path of transmission. There are general measures of management for almost all major diseases and specific measures for specific diseases.

General measures for the management of mandarin orange diseases

Quarantine

Both the external and internal quarantine must be strictly maintained while introducing/transporting citrus sapling or bud woods. The external quarantine is important to avoid introduction of new pathogens or new strains of existing pathogens from abroad while internal quarantine is to prevent spread of certain pathogens from one area to another within the country. Scab of mandarin orange is limited within Panauti area of Kavrepalanchok so far, if internal quarantine is not maintained strictly this disease may spread to other areas and cause heavy damage to mandarin oranges. Similarly, transportation of planting materials should be prohibited from HLB infected areas to other areas until and unless they are certified after proper inspection and testing.

Production of good quality saplings

At present in Nepal, there are four types of nurseries producing mandarin orange saplings: a) Open field producing saplings on land, b) Open field producing grafted plants on land, c) Screen house/plastic tunnel producing seedlings in poly bags, and d) Screen house nurseries producing grafted plants in polybags. Regmi *et al*. (2009) recommended a screen house system to produce quality citrus/mandarin orange saplings that was effective for producing good and disease-free saplings, which also started fruiting as early as 2.5 years after plantation. Consequently, the government has set the norm for the construction of such screen house citrus nurseries. This system has to be strictly adopted. For this purpose, the government should provide necessary technical support for improving/building the screen house nurseries on following aspects:

Rootstock seeds- Trifoliate orange *(Poncirus trifoliata)* is the suitable rootstock recommended by National Citrus Research Program (NCRP) of NARC. Only this rootstock should be used in the agro-climatic conditions of our country. However, nursery growers are having problems of availing enough seeds. Therefore, the government has to encourage them to grow a few trifoliate trees so that they will be able to fulfil their requirements. Rootstock seeds are free of HLB, CTV or any other systemic diseases. Multiplication of root stock by tissue culture is expensive and should not be encouraged at all.

Preparation of mixture - Generally used soil mixture in citrus nurseries in the country is common soil. Sometimes sand 25% and peat 25% (if available) is added. In such media the rootstock seedlings do not gain proper height for grafting even after two years. Hence grafting is performed at 2-5 cm above the soil. Such grafted plants do not meet the purpose of preventing them from *Phytophthora* in the field. Therefore, a proper soil mixture has to be used to enhance the growth of the rootstock so that they could gain the size for grafting within the stipulated time of 1.5 year. Regmi and Shrestha (2001) conducted research on different media and found that the media consisting of 50% forest soil and 50% sand and use of chemical fertilizers as required was most suitable for raising seedlings in a screen house system. The rootstock seedlings gained a height of 33.5 cm within a year. This media should be used in the citrus nurseries.

Selection of disease free mother plants - The most important part of producing quality saplings is the use of disease free scions. For this purpose, healthy trees are selected as mother plants after the evaluation of their age, appearance and shape of the crown, characteristics of fruits and scions. Technicians and horticulturists must guide in this process. To confirm that the mother plant is disease free, it must be tested regularly for HLB by PCR or other sensitive methods in NAST, NCRP or other designated laboratories. If some of the high quality mother plants are found HLB-infected they can be made disease free by using shoot tip grafting *in vitro* (STG) technique developed by Navarr (1980) and adopted by Regmi and Shrestha (1992). Such clean mother plants must be maintained in the screen house system. It is a part of the bud wood certification. STG is used in the introduction of bud woods/plants from abroad.

Grafting/Budding - Grafting is in common practice in Nepal to produce mandarin orange saplings, but scions which is to be grafted must have minimum three buds and has chance to get infected by pathogens if somehow they are present in the collected scions. Therefore, it is strongly recommended to replace grafting by inverted T-budding that requires only one bud and has 100% success.

Size of rootstock- Overall height of the rootstock seedlings should be minimum 35-40 cm and the diameter of the seedling at the point of budding should reach the size of a pencil (minimum 5 mm in diameter) and the bark could be easily separated. Generally the grafting is performed at 5-8 cm in our nurseries that does not meet the requirement of preventing *Phytophthora* in the orchard so it is highly recommended that the grafting should be carried out at the height 15- 18 cm above the soil surface. When the grafted plants reach the height of minimum 50 cm they are ready for transplantation in the field.

Good cultivation practices - The grafted plants should be grown in polybags under the screen house system maintaining all the required environmental conditions such as irrigation, fertilizer and regulation of temperature and humidity regime.

Good cultivation practices include the steps starting from plantation, weeding, use of fertilizers, fungicides and pesticides, pruning and harvesting. The training manual for combating citrus decline problem in Nepal, prepared by the FAO-TCP project in 2011, has recommended a calendar of operations to be followed for citrus (DoA, 2011). These recommendations should be strictly followed and carried out in time.

Specific measures for the management of important mandarin orange diseases

It is important to have knowledge about the symptoms, pathogen, transmission, distribution and diagnosis of the disease that has to be managed. In our observations HLB, Phytophthora, and powdery mildew are main diseases of mandarin orange in the country. Therefore, some descriptions of these diseases are given along with the recommendations related to specific measures for their management.

Huanglongbing (HLB)

The disease has been known by different names in different countries such as Huanglongbing (China), citrus greening disease (South Africa, Nepal), leaf mottling (Philippines), likubin (Taiwan), citrus die back (India), etc. In 1995, the 13th Conference of International Organization of Citrus Virologists (IOCV) held in Fuzhou, China and participated by more than 300 scientists from different countries across the world passed a resolution that the disease should be called **Huanglongbing** in honour to scientist Lin who demonstrated the infectious nature and described the disease for the first time in 1950 by this name**.** It was also agreed that HLB should be used for abbreviation**.**

Symptoms - Visual leaf symptoms appear from the apical part of the tree. In the beginning, yellow shoots appear in certain branches of the tree and they develop leaves with mottling and blotchy mottle symptoms and spreads to other branches also. When the trees are moderately affected they may show defoliation and twig die back. The slightly affected trees develop yellowing very fast and within 2-3 years whole tree or even orchard looks yellow. When the trees get severely damaged trees have open growth, stunting, twig die back, sparse foliage, and severe leaf and fruit drops. However, infected trees do not die themselves until they are attacked by other pests, symptomatic fruits are small, asymmetric and lopsided with bent axis. If we cut the fruit some aborted seeds can be seen (Bove, 2006).

Distribution – Knorr *et al*. (1971) carried out survey of different citrus orchards, collected leaf samples from declined trees, conducted TLC test and confirmed that 39-55% of mandarin orange trees were infected with HLB. Regmi (1982) reported more than 50% HLB-infected trees in the survey areas of Pokhara valley and 100% in Citrus Research sub-station, Pokhara. Citrus decline in several orchards of Kaski, Tanahu, Lamjung, Dhading and Syangja are caused by this disease and it is spreading very fast to other areas also (Regmi *et al*., 2009) causing heavy damage to mandarin orange cultivation. Extent of damages can be seen by historical situation of mandarin orange in the Horticulture Research Station, Malepatan Pokhara. Just after the establishment of the station, large number of citrus including mandarin orange were planted during 1960/61 and almost whole plantation declined after 7-8 years. Second plantation was made during 1970/71 and got destroyed after 7-8 years. The third attempt was made during 1980/81, and the fourth plantation carried out in the form of management trails only. Each time it was considered that the decline was caused by nutritional deficiencies without recognizing the role of HLB despite the scientific evidences of its existence. Large number of mandarin orange trees were destroyed in Udipur of Lamjung, Bimalnagar and Bandipur of Tanahun, Syadul of Dhading, Bharat Pokhari of Kaski, where HLB was somehow introduced and the vector *D. citri* thrived.

Pathogen - After proving the graft and vector transmissible nature of the causal agent, scientists considered the pathogen as a virus and then after mycoplasma-like-organism (MLO). After studying the membrane of cell wall of the pathogen under electron microscope, a team of J. M. Bove proved it as a gram negative bacteria that cannot be cultured. Hence a prefix *Candidatus* is added. It is a phloem-limited Gram negative, non culturable bacterium designated as

Candidatus Liberibacter. There are three strains - *Ca.* L. africanus, *Ca.* L. americanus and *Ca*. L. asiaticus prevalent in respective continents (Jagoueix *et al*., 1994). Only *Candidatus* Liberibacter asiaticus has been recorded in Nepal (Regmi *et al*,, 1996).

Transmission – The pathogen is both graft- and vector-transmitted. If the scion is taken from HLB-infected mother plants and grafted on even healthy rootstock the disease is transmitted to new orchards from nurseries. It serves as the important means of transmission.

Capoor *et al*. (1967) proved that Asian citrus psylla *Diaphorina citri* is the HLB vector; immediately after this finding, Catling (1968) reported it from Pokhara valley. It might have as much as 11 generations within a year in Pokhara conditions with maximum peaks of 188/10 twigs during May, June and July before monsoon (Regmi and Lama 1988). The host plants of the vector are limited to Rutaceae family only. The preferential hosts are lime, lemon, murraya, mandarin orange and sweet orange (Lama *et al*., 1988).Two parasites *Tamaraxia radiates* and *Diaphoresis alegharensis* as well as seven species of coleoptera were identified as predators. However, they could not be used for biological control as their hyper parasites were prevalent (Lama *et al*., 1988). Positive correlation between the presence of host plants and population of vector and occurrence of HLB has been reported by Regmi in 2014.

Diagnosis - Development of quick, easier and reliable diagnosis method of HLB has undergone through a long way in different countries. Thin layer chromatography (TLC), biological indexing (use of indicator plants), DNA-DNA hybridization and monoclonal antibody techniques were applied to detect HLB for many years until the PCR technique was developed by Kerry Mollis on the basis of which the laboratory of INRA, Bordeaux, France, developed the first sets of 16SrDNA based on primers (O11/O12c and OA1/012c) designed specifically for conventional PCR to detect Ca. *La. aisaticus* and Ca. *La. africanus* (Jagoueix *et al*., 1996). Soon after this, a PCR Laboratory was established at NAST with the support of Prof. J. M. Bove and French Government in 2003 and PCR tests on HLB were carried out in the same year (Shrestha *et al*, 2003). The PCR laboratory of NAST has tested 1373 citrus samples from 28 districts of the country during 2003-2010. The laboratory is still continuing to test HLB in the samples sent by NCFD, NCRP and others.

Measures for HLB management

HLB is a systemic disease. It means once the plant is infected the infection remains throughout the tree life. It is mainly transmitted in the nursery through infected scions and in the orchard by vector *D. citri.* There is no chemical treatment for HLB. All the varieties and cultivars of mandarin orange have been found susceptible to HLB. Some attempts are being made for developing HLB-resistant citrus varieties in the USA but it is not likely applicable in Nepal very soon. Therefore, only the preventive measures are feasible. There are use of disease free saplings and proper management of vector, *D. citri.*

Production of grafted saplings in screen house system - Use of certified budwood/scion under screenhouse nursery for grafted saplings is one of the best methods to prevent the spread of the disease. Attempts are being made to produce grafted mandarin orange saplings in polybags under the screen house system. Such saplings produced from certified bud woods are free of HLB. It prevents the spread of HLB within the nursery and in new areas and new plantations from the nursery.

Control of vector - In the areas where the sources of infection are present and the vector *D. citri* thrives, it takes no time to spread the disease throughout the orchard. Therefore, the establishment of new orchard using only certified grafted saplings grown under screen house system becomes worthless in vector infested area. In such cases, the measures should be oriented towards the effective control of the vector. The control of vector includes (i) regular monitoring, (ii) removal of host plants, and (iii) biological and chemical control.

(i) A regular monitoring is important for the determination of distribution of *D. citri* in different areas and spatial distribution with regards to altitude. It helps to decide which measure should be applied to reduce the population or prevent spread to new areas. The locations such as Pokhara, Udipur, Mugling, Bimal Nagar and several others with similar altitude are full of *D. citri* and special care should be taken in establishing mandarin orange orchards.

(ii) The host plants of *D. citri* belong to Rutaceae family only. Preferential alternative hosts *Murraya pamiculata* and *Bergera koeinigii* (Asare/Banbakaino and Kamini in Nepali) are found generally below 1000 m asl. Agriculture technicians and farmers ought to know these plants and should remove them at least within 3 km radius from the orchards.

(iii) Lama *et al*. (1988) conducted trails on biological control of *D. citri* by using its parasite *Tamaraxia radiates*, but it was not possible in Nepal as hyper parasites of the latter one were thriving throughout the country. Also, there are no predators specific to *D. citri*. Therefore, only chemical insecticides are recommended to effectively control the vector and control HLB indirectly.

HLB management methods adopted in other countries

Different countries have developed their own systems of combating HLB. Some examples are given below.

Vietnam - Intercropping with guava: The farmers of Mekong Delta of Vietnam have been using guava as intercropping in their mandarin orange orchards. With this method they found the commercial life of HLB infected orchards extended up to 15 years. It is known that guava releases the terpenoid compound that acts as the repellant to citrus psylla (Gotwald T.R. *et al* 2010). Guava grows well in warm temperate climate very fast, which could be tried in the areas like Bimal Nagar or Mugling. If it works it will be very beneficial to mandarin orange production.

Thailand - Living together with HLB: There is a tendency to accept, accommodate and live with it in Thailand. The disease destroys the orchards regularly and about 10-15% of the trees are found infected. Farmers use citrus cutting as planting materials that produce about 20 t/ha in 5-8 years and declines to 6.5 t/ha by the 12th year due to HLB. Therefore, they practice replanting new ones in between the gaps and keep on destroying the declined ones throughout the production period. The farmers also use chemical to control the *D. citri*. In this way, Thai farmers are living together with HLB making profit from growing and maintaining the orchards for 20 years (Roistacher, 1996)

Brazil and USA - Elimination of infected trees: Survey and surveillance are carried out by special inspectors in orchards on regular basis and samples are collected from the trees with HLB symptoms and destroyed if they are confirmed after PCR test. It help reduce sources of infection in the field to be transmitted by the vector (Bove, 2006).

South Africa and China – Integrated management: These countries have been adopting integrated approach for the control of HLB. That includes planting only certified disease free grafted saplings, monitoring of vector and timely application of pesticides to control the vector, and removal of infected trees.

Phytophthora disease

Phytophthora is one of the widely spread diseases in citrus orchards of Nepal. It causes damping off, foot rot, gummosis, and brown rot of fruits. The disease was causing serious damage of citrus in Spain and South Africa too. Grafting technology was developed almost 150 years ago since then only the saplings grafted on resistant root stock are used to grow citrus in these countries where as in Nepal we are growing mandarin orange of seedling origin till today although the grafted plants have proved great impact on withstanding Phytophthora in Kavrepalanchok (Regmi *et al*., 2010)

Pathogens - *Phytophthora parasitica, P. citrophthora,* and *P. hybernalis* are the important soil borne fungi causing Phytophthora disease in mandarin orange. There are reports that *Phytophthora parasitica* is the main cause of foot and root rot in the country, however, detail studies on the pathogens are yet to be carried out (Adhikari *et al*, 2006).

Symptoms - The symptoms observed in mandarin orange trees are as follows:

(i) Foot rot - It involves rotting of root and main trunk near the soil and disrupts the major physiological functions. As a result the trees show yellowing of foliage, poor growth and dieback of terminal shoots, leaf drop, twig dieback and ultimately decline and death of the tree. First of all, an injury starts on the bark of the trunk or roots near ground. The injury area dies and the dead bark becomes firm and later on ruptures with less noticeable gum. It eases the entrance of secondary organisms that kill and discolor the wood. This area gets a greater lateral expansion and shows foot and root rot. The rotten bark is expanded towards the upper side of the trunk and goes deep to the pith and most of the tree branches show decline of the tree with yellowing and defoliation of leaves. On root side, fewer number of rootlets are formed and the already formed rootlets also have sloughing bark that easily slide off the stake by slight pinching pressure. Large root shows frog eye lesions.

(ii) Gummosis - Gummosis occurs on the parts above the ground. First, the infected area dies and remains firm and then exudation of small or large amount of gum comes out. The thin layer of wood gets brown staining. A yellow gummous zone develops at the cambium beyond the dead invalid area. Subsequently drying and vertical cracking of bark takes place and intensive gumming occurs but it does not remain long as the exudate is water soluble and is washed away during raining season.

(iii) Brown rot of fruits - *Phytophthora* infects fruits causing firm light brown decay. Some fruits may develop post-harvest brown rot problem.

(iv) Damping off - In emerging seedlings *Phytophthora* causes damping off causing death of large number of seedlings.

Transmission and disease development - Phytophthora species are endemic in the soils of citrus orchards and remain in the soils in the form of chlamydospores and oospores and hyphae or in the form of sporangia in decayed roots. Infection takes place from the soil through injured roots or trunk that are in direct contact with soil. Infection occurs usually by means of zoospores which are released when free moisture is abundant. When they meet elongated root tips they encyst, germinate and penetrate the roots directly. They also penetrate through wounds /injuries on the root or trunk near ground or any part of the shoot. The same cycle is repeated again.

The only one measure of preventing infection by *Phytophthora* is the use of saplings grafted on resistant rootstock such as *Poncirus trifoliata* or and some citranges. Horticulture Development Project (HDP/JICA) has rightly recommended the *P. trifoliata,* which is resistant to *Phytophthora,* suitable for agro climatic conditions of Nepal. The grafted saplings on *P. trifoliata* rootstock grafted at 15 cm height above ground and grown in screenhouse nursery management system and well developed vigor should be used for the establishment of new orchards. Such trees are not infected by *Phytophthora* at all. Cultivation of grafted plants on resistant rootstocks has become the simplest method of controlling *Phytophthora* worldwide.

However, the grafted plants produced without following proper grafting procedure might acquire the infection. Also, if the rootstock is buried under the soil while transplanting in the field, infection easily occurs. Inarching is in practice to rejuvenate citrus tree. In this case, new resistant rootstock seedling is grown near the tree with foot rot or trunk rot symptoms. It is then grafted onto the tree above the foot rot lesion. The newly grafted rootstock works for the tree.

The orchards of seedling origin or grafted at low height are damaged most by this disease. In such case use of Bordeaux mixture on the crown, Bordeaux pest to treat the wound caused by the disease and even painting with this pest has become common practice to rejuvenate the tree. This technique was used in Sindhuli district as campaign to control Phytophthora disease on sweet orange during 1990s. These techniques are still being used in the country but should look at the economic viability.

Powdery mildew

Powdery mildew occurs on young mandarin orange plants and new flushes grown in humid and warm temperature especially at higher altitude areas of the country. This disease is becoming serious as it causes heavy defoliation and consequently mass decline of trees.

Pathogen – A fungus *Oidium* sp. cause the disease in manadari. Pandey *et al*. (2006) studied the causal organism causing powdery mildew in mandarin orange and identified as *O. tingitaninum*.

Transmission and disease development - The pathogen is transmitted by air and with water droplets during rainy season. The fragments of mycelium or conidia are transmitted on the surface of newly formed leaves and twigs. During rainy season the pathogen multiplies very fast and within few days covers with white patches of mycelia and conidia giving appearance covered with white powder. In this way the disease is transmitted from one plant to another throughout the rainy summer season. In winter, the white powdery form disappears but the infected branch is totally defoliated. The organism winters in the tips of defoliated twigs giving them black color. Next year when there is favorable conditions conidia germinate and the same cycle is repeated.

Management - Removal of flush, unnecessary and infected branches, pruning and destruction of removed and infected branches by burning during winter are effective for reducing disease inoculum.

Some specific chemicals have been recommended to control the disease in the orchard. Karathane (dinocap) at the rate of 2 g per liter of water can be spread at 10-15 days interval. The whole crown must be covered with the solution. Similarly 80% wettable sulphur such as Sulfex or Insuf can also be sprayed at the same rate.

Scab

This disease is most prevalent in many Asian countries and Australia. In Nepal, it is limited to mandarin orange orchards of Panauti, Sunthan and Kushadevi area of Kavrepalanchok so far. Scab generally does not effect on yield but has serious effect on the external appearance of fruits that reduces marketing value of fresh fruits. According to farmers, they have to sell the fruits with scab at 10 -20 Rupees cheaper per kg as compared to healthy looking mandarin oranges.

Pathogen – A fungus *Elsinoë fawcettii* cause the disease in mandarin orange (Lama, 1976).

Transmission and disease development - Both the air and water droplets can disperse conidia of the fungus. They are attached on the surface of young leaves or fruits and germinate overnight with dew in dry season where as the conidia are dispersed with rain splashes during rainy season**.**

Symptoms - Irregular scabby spots appear on the surface of leaves and fruits. Colours of the spots vary from cream to pale brown in young fruits. The color changes to olive gray as the fruits mature.

Management - Implement domestic quarantine and restrict transfer of any scions or saplings from infected area like Panauti to other areas of the country. Keep the orchards clean and burn the liters and pruned parts of trees to reduce disease inoculum.

There are no resistant mandarin orange varieties. Rootstocks do not play any role in preventing the disease. Fungicides such as carbendazim and Bordeaux mixture are effective to reduce the scab infection.

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सुन्तलाको ग्रिनिङ्ग रोग परिक्षणको लागि नमूना संकलन

Scale of Huanglongbing Disease Infection and the Status of Molecular Diagnostic Tests of Mandarin Orange Groves in Nepal

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Abstract

Huanglongbing (HLB), also known as citrus greening disease has caused havoc on global citrus industry including Nepal. Nepal Academy of Science and Technology (NAST) is a leading organization that has started Polymerase Chain Reaction (PCR) based test of HLB in Nepal. Overtime, the methodologies from sample collection to DNA extraction and PCR have been improved substantially, addressing the availability of the financial and technical resources without compromising the efficiency and effectiveness of the diagnostic tests. Moreover, the scale of testing has been expanded to other central and provincial institutions through continued knowledge sharing between laboratories. This paper offers comprehensive information on research trend in citrus greening in Nepal and the evolution of PCR based early diagnostics in NAST. Since the first report of greening, the organization had officially published from Pokhara valley, the academy is playing a pivotal role in advancing our understanding and technical capabilities in order to combat its ravaging threats to mandarin orange groves located across different ecological zones of Nepal.

Keywords: Citrus greening, PCR, Early diagnosis, Citrus Psylla, Candidatus Liberibacter asiaticus

Background

Citrus greening or Huanglongbing (HLB) is one of the most devastating and widespread diseases of citrus, particularly the mandarin orange. This disease is caused by noncultureable, gram negative, walled bacteria under *Candidatus* group (Jagoueix *et al.* 1994). Globally, three pathogens *Candidatus liberibacter asiaticus* (CLas), *Candidatus liberibacter africanus* (CLaf), and *Candidatus liberibacter americanus* (CLam) have been attributed to HLB. Among these, CLas is the most prevalent and occurs almost globally while CLam is found in South America (Brazil) and East Asia (Hunan, China) and CLaf is reported from South Africa, middle-east (Saudi Arabia) and few islands in Indian Ocean. HLB disease caused by *Candidatus liberibacter asiaticus* (CLas) is known as Asian Citrus Greening.

Citrus greening in English and Huanglongbing (HLB) in Chinese, was a description for its typical symptoms i.e yellowing of shoots with partly yellow/green leaves mostly observed in spring and fall. Additional symptoms include asymmetrical chlorosis, vein yellowing and corking, sour and misshapen fruit with aborted seeds, underdeveloped root system and dieback. This disease was suspected to be in existence in India during 1700s (Capoor, 1963) however, it was officially reported from South China much later in 1919 (Reinking, 1919). As presented by Bove' (2006), this century old disease and their different forms have invaded nearly all citrus orchards of the modern world.

The Asian citrus greening bacteria are heat tolerant, capable of surviving above 30^0C. These bacteria are naturally carried or spread by the sucking insect vector known as citrus psyllid *Diaphorina citri* (Kuwayama) from tree to tree (McClean and Schwartz, 1970; Bové, 2006). HLB is also transmitted through grafting. Studies have shown that natural origin of Asian citrus psyllid (ACP) is south western Asia *i.e* India and from India it was spread to adjoining countries including Saudi Arabia, Afghanistan, Pakistan, Nepal, China, Myanmar, Malaysia, Indonesia, Philippine etc. (Beattie *et al.* 2009). Asian citrus psyllid has invaded south America in 1940 and then moved recently to the North America, Central America and African countries (Boykin *et al.* 2012; De León *et al.* 2011). Naturally distributed another species under Citrus family (Rutaceae), locally called Kamini phool (*Murraya paniculata)* and its congener *Murraya koenigii* are regarded as an alternative host for ACP (RONAST 1988; lves *et al.* 2014). Despite this evidence, several studies found lower bacterial load and less transmission rate of CLas to citrus from these hosts (Deng *et al.* 2007; Lopes *et al.* 2010). Therefore, detailed study is needed in the reported alternate host species present in Nepal.

Adult ACPs are attracted to colors and volatile signals present in the young leaf flush of citrus plants. ACPs feed and oviposit on newly developed leaves. During feeding infected citrus psyllid inoculate bacteria in the leaf tissue of healthy tree. Adult ACPs are relatively less effective vector for transmitting CLas than nymphs (Pelz-Stelinski *et al.* 2010). These introduced HLB pathogen further induce HLB volatiles that attract more ACPs (NASEM, 2018). Eggs are laid by ACPs on the young leaf flush and nymphs are developed thus disease outbreaks normally happen in late summer and early fall (Husain and Nath, 1927).

When citrus plants are infested by HLB causing bacteria through vector or grafting (vegetative propagation), the pathogen starts to move in the vascular system and colonize phloem sieve tubes. Transmission of CLas in different cultivars through grafting as well as ACP varies significantly (Lin *et al.* 2017). Inoculation of CLas also depends on different developmental stage of ACP (Hall *et al.* 2013). Adult ACP requires several hours to acquire CLas from infected trees and then transfer to the healthy individual but the process is faster in nymphs (Pelz-Stelinski *et al.* 2010). Adult ACP cannot fly long distance; however, wind plays an important role in its spread, reaching distance up to 0.5 - 51 km (Aubert and Hua, 1990; Halbert *et al.* 2008).

The most fascinating and at the same time, challenging part of HLB disease is its symptoms development and distribution of pathogen in different tissues of individual plant (Li *et al.*

2009). Symptoms appear mostly in patches within the tree canopy (Louzada *et al.* 2016), some twigs test positive to the bacteria while another twig of other or the same branch may test negative (Gottwald *et al.* 2008). Similarly, initial symptoms were reported in root (Johnson *et al.* 2014). Pathogen shows a uniform distribution in root system than in the above ground parts (Louzada *et al.* 2016). The loss of fibrous roots before typical symptoms appear in above ground biomass has been ascribed to phloem blockage in above ground parts, thus limiting flow of carbohydrate from leaves to roots (Etxeberria *et al.*, 2009). In contrast, the decay of root has also been found to be an adaptive trait of the CLas for maintaining a symbiotic relation with soil borne pathogens like *Phytophthora* spp. (Johnson *et al.* (2014). Transmission of CLas and onset of visual symptoms is also dependent on the cultivar/species of citrus, tree age, environmental conditions and health status of the plant (Gottwald, 2007). Visual symptoms cannot be seen immediately after inoculation. Studies have found 6 months to 3 years lag after inoculation in different aged trees to detect visual symptoms (Bove, 2006). Besides discrepancies on visual symptoms, directional and spatial variation in the distribution and abundance of CLas was found which was chiefly governed by environmental fluctuation (temperature, radiation, wind direction etc.) (Louzada *et al.* 2016).

In the context of above discussed issues in the mode of disease transmission, effectiveness of vector in different stages to transmit CLas, patchy distribution of CLas in different type of plant tissues, environmental and other factors that determine CLas abundance in different plant tissue; time lag between inoculation of bacteria and onset of visual symptoms in the plant tissue; Nepal needs an appropriate diagnostics tools for an early detection of disease to control further spread of HLB in the new citrus orchards. Since there are no straight forward solutions available yet to treat HLB, the focus is on the adoption of techniques that help in an early detection of pathogen in order to remove infected individual and grow healthy plants in new areas where ACPs and CLas both are absent. In this paper, we have assessed HLB related publications in Nepal from the period of early detection of HLB, report areas (districts) of HLB infection based on diagnostic tests performed in NAST and improvements on HLB detection techniques since the organization has initiated diagnosis research and testing services in its laboratory.

Methodology

We have adopted following methodology to report research and developments in the diagnosis and management of HLB in Nepal.

Prepare map of HLB present areas in Nepal

NAST is carrying out research on HLB since 1985 (Paudyal *et al.* 2010). PCR based detection of HLB has been commenced in the NAST laboratory with the help of renowned international scientists. This collaborative team was successful to extend testing various citrus orchards of Nepal and even number of potentially infested samples collected from Bhutan. NAST carries out its in-house research in different aspects of HLB pathogen, vector of HLB citrus psyllid (*Diaphorina citri)* and host species. Map of Nepal showing citrus greening disease present districts was prepared based on the PCR tests of citrus leaves collected by NAST and leaf samples from different district provided to NAST laboratory for the purpose of HLB diagnosis.

Report improvements in HLB tests performed in the NAST laboratory

The Molecular Biotechnology Laboratory operating under the Faculty of Science of NAST has started HLB diagnostic research in collaboration with French and American Scientists from 1996 (Regmi, 1988). Overtime the laboratory has strengthened its physical resources and technical capacity to improve the methods of early detection of HLB infection according to emerging latest and standard international laboratory practices. NAST gets leaf samples to test HLB primarily from National Centre for Fruit Development, Kirtipur; Prime Minister Agriculture Modernization Project Programs of various districts; Citrus Development Centre of various districts and the farmers growing oranges themselves. Every year NAST laboratory provides HLB test reports and informs possible precatory measures of disease preventions to the concerned organization and the farmers.

Review of HLB related studies and publications done in Nepal

Studies conducted on HLB since its first report from Pokhara valley in 1970s and several other follow up research and development activities were searched online in 'Google Scholar' and 'Google.com.np' using key words 'Citrus greening disease in Nepal' and 'HLB in Nepal' both in English and Nepali Unicode. Online searches in Google scholar led to scientific articles and reports while popular articles, extension materials and audio-video contents were retrieved from online portal of national newspapers, online news sites and government websites. Literature/content searched were reviewed and presented in graphs to illustrate our research capacity, knowledge and understanding in the overall management of this disease.

Result and discussion

Scale of HLB infestation in mandarin orange cultivating districts in Nepal

Citrus fruits are grown widely in Nepal. Mandarin orange is the most popular citrus fruit and its commercial farming (more than 100 ha. per district) is in 48 out of 77 districts. If other citrus fruits like sweet orange, acid lime, hill lemon, pomelo etc. are considered citrus farming can be found in 72 districts except 5 high mountainous districts. Mandarin orange and 'Bimiro' (citron) are considered indigenous fruits of Nepal (Shrestha and Verma, 1998). Junar is cultivated in Sindhuli, Ramechhap and Dhankuta districts. The climate of mid-hills is most suitable for mandarin orange. Selective areas of four Tarai districts (Chitawan, Nawalparasi, Surkhet, and Kailali) and nine high mountainous districts (Bajhang, Bajura, Darchula, Dolakha, Kalikot, Sankhuwashabha, Sindhupalchok, Solukhumbu, and Taplejung) have few areas with favorable micro-climate where orchards of mandarin orange are present. In terms of favorable climate, citrus fruits are grown in almost 65% area of the country that range from lowland Tarai to Midhills with in the altitude of 450 meters to 1500 meters (Roistacher 1996, Paudyal *et al.* 2010). However, mandarin orange flourishes well along mid-hills within the range of 800 to 1300 meters. Mandarin orange including other citrus fruits contributes 22.37 percent of total fruit production and is one of the most attractive and lucrative sources of income and employment opportunity. Recent figure of the fiscal year 2022/23 showed that mandarin orange production has contributed 0.9648 percent on Agriculture GDP which is three times higher than that of apple and more than six times higher than that of tea leaves (NSO, 2023). Realizing the potentiality of orange and its multifaceted contribution to income generation, livelihood improvement, food security, employment generation and overall economic and social transformation of rural villages, Nepal Government, Ministry of Agriculture and Livestock Development has been conducting Prime Minister Agriculture Modernization Project identifying 10 zones and 1 super zone of oranges in 11 districts across the country.

Despite the efforts of all tiers of government and local farmers to boost mandarin orange productivity and the expansion of orchard in new areas, productivities have not surged up as expected. The productivity of mandarin orange is rather going down by 7% in the past 19 years' period (1993-2017) as calculated by Dahal *et al.* (2020) and in recent years it is increasing gradually. Studies have shown that loss of productivity of mandarin orange in Nepal is due to poor orchard management, severity of Huanglongbing disease and other abiotic factors (Acharya and Adhikari 2022; FAO 2011; Poudel *et al.* 2022). There is an old record of 55% percent decline of mandarin orange in Pokhara (Regmi 1982); however recent studies have found more than 72% in Myagdi (Poudel *et al.* 2022), almost 100% decline of old trees in Parbat (Pant and Dhakal 2019); and a rapid decline of old orchards in Kaski, Tanahun, Shyangja, Lamjung and Gorkha (FAO 2011) districts. Acharya and Adhikari (2022) have presumed that HLB infection is prevalent in the orchards of almost 69 districts of Nepal. The PCR based test results of the leaf samples received from various organizations and farmers of different districts and also the samples collected by the in-house research program of NAST have been compiled and presented in the give map (Figure 1). This map has shown fewer districts with HLB infestation than the figure of Acharya and Adhikari (2022), which could be because of the lack of PCR test on orchards of various districts suspected by them and also due to the unavailability of test result obtained by other government and private laboratories. Such discrepancies are expected when there is a lack of coordinated national efforts between organizations working for the common goals. Moreover, we also have not developed national database that provides comprehensive picture of HLB and its impact on citrus orchards of Nepal as it serves as a key tool to inform and evaluate policies related to the control of HLB and enhance national productivity of mandarin orange.

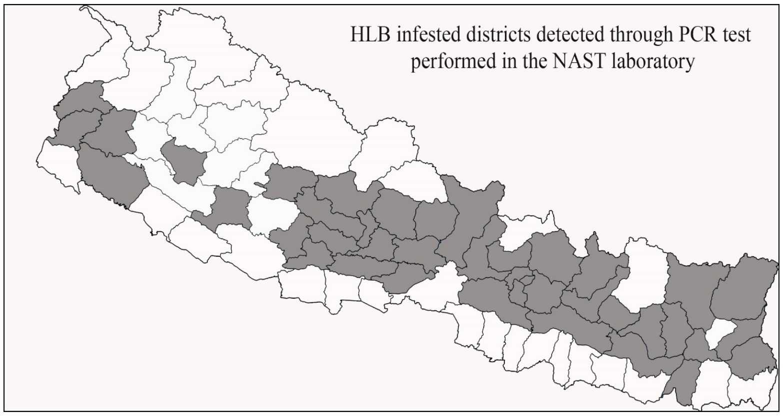


Figure 1. Map of Nepal showing HLB disease detected districts using PCR test conducted in NAST, Khumaltar, Lalitpur.

Critical role of NAST in HLB research and diagnostics

NAST, (former RONAST) is an autonomous apex body established to promote science and technology in the country. NAST has been a leading organization to institutionalize HLB research in Nepal. Some notable activities undertaken by NAST comprise initial identification of citrus greening hotspot in Nepal; in-depth study on biology, population dynamics of citrus psylla and its host (RONAST 1988; Lama *et al.*1988; Regmi *et al.* 1998), standardization of *in vitro* shoot tip grafting, adoption of DNA probe technique in the diagnosis of citrus greening (Regmi *et al.*1996) and establishment of improved PCR techniques for early diagnosis of HLB in the country (Paudyal *et al.* 2010). National and international collaboration allowed scientists working in NAST to share knowledge and research experiences needed to identify the problem and find its appropriate solutions (RONAST 1988). 'Research in citrus greening' is a good model in Nepal to understand the evolution of research findings in collaborative researches and their impact to widen our knowledge about the causes of diseases and identifying possible measures. In this section, regular improvements in PCR techniques adopted by NAST for early identification of HLB has been discussed in detail.

Collection of leaf samples for testing

Initially, the mechanism of HLB pathogen was not understood properly and only the expert scientists were involved in the collection of potentially infected leaf samples to test HLB. We have now adequate evidence that symptoms of HLB are mostly patchy and distribution of pathogen in different plant tissues varies substantially (Luzada *et al.* 2016). In this context, we need to improve our sampling techniques according to local situation and available resources without compromising the quality of work. Our latest sampling procedure of leaf involves collecting of 4-6 clean leaves each from four directions of the tree, packing them separately and keeping in a well labelled ziplock bag/paper envelop. We encourage storage of collected leaf samples in refrigerator (-20^0C) when immediate delivery of samples to laboratory is not possible. Transportation of samples in an ice box prevents leaves from decaying. Basic procedure for leaf sample collection is shown in Figure 2.

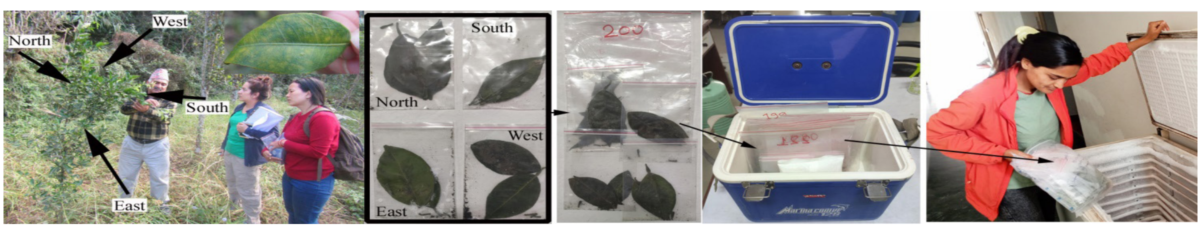


Figure 2. Figure showing technique of leaf collection, transportation to the laboratory and store in the freezing condition.

Extraction of bacterial DNA

Bacterial DNA of the pathogen is obtained from the mid rib of the collected leaf samples stored under refrigerated condition until DNA extraction. Over time, we have improved our DNA extraction techniques following standard methods practiced globally by international laboratories working in HLB and other related diseases. Key methods of DNA extraction practiced by the NAST laboratory for HLB diagnosis using PCR technique are given below:

DNA extraction from wizard column (adopted from 1994-2008)

Clean leaves were wiped by 70% ethanol and mid rib were excised and minced finely by sterile blade on petri dishes containing 1 ml of DNA extraction buffer which was prepared in advance (Tris 0.0 IM, H 0.8; EDTA 0.4M, pH 0.8; SDS 1% and proteinase K 0.25 mg/µI). The homogenate of buffer and minced midrib were transferred into labeled 1.5 ml micro-centrifuge tubes and incubated at 65 °C in water bath for 2 hours. After incubation, samples were centrifuged at room temperature for 15 min at 12,000 rpm and the supernatants were transferred in new micro-centrifuge tubes. 1ml supernatant was mixed with Wizard miniprep DNA purification resin (Promega Company, USA) with gentle inversion. The mixture was then transferred into a syringe fixed on wizard mini column and the filtrate was collected through operating electrical vacuum pump apparatus. In the filtered suspension 2ml of 80% isopropanol was added to each column (1ml at a time) and briefly centrifuged to remove excess isopropanol. The spin columns were then transferred into fresh micro-centrifuge tubes and 50µ1 of sterile double distilled water heated at 80°C in water bath were added to each tube, left the column for a minute, and centrifuged for 25 sec at 12,000 rpm. This step was repeated, yielding 100µ1 of DNA extracts (Figure 3). Thus yielded wizard extract was properly labeled and stored at -20^{0}C for downstream analysis.

Figure 3. Laboratory procedures adopted to extract pathogen DNA from suspected leaf samples using the wizard column method

DNA extraction using liquid nitrogen and CTAB buffer (adopted from 2008-till date)

In this method, the commonly used modified CTAB technique (Doyle and Doyle, 1987 and 1990) was used to extract bacterial DNA of the greening pathogen. Similar to the previous protocol, sampled leaves are cleaned and mid ribs were chopped into small pieces using sterilized razor blade. Those chopped pieces of midribs were then grounded to fine powder using mortar and pestle in liquid nitrogen. Before starting DNA extraction procedure, CTAB buffer with pH 5 needs to be freshly prepared and used for DNA extraction (Figure 4). Main ingredients of CTAB buffer are listed below.

a) 1M Tris-base buffer (PH 8.0)

b) 0.5M Na_2EDTA (PH 8.0)

c) TE buffer (PH 7.5)

d) 5 M NaCl

e) 2% CTAB buffer
f) 50x TAE buffer (PH 8.0)
g) 70% Ethanol
h) Chloroform: Isoamyl alcohol (24:1), should be prepared freshly
i) 5mg/ml Ethidium Bromide

Above listed reagents were prepared in full sterile condition; double distilled deionized nuclease free Milli-Q water was used to prepare the reagents and autoclaved in 15 lb pressure at 121° C for 20 minutes.

Figure 4. Key techniques followed while extracting bacterial DNA by grinding finely chopped midribs in liquid nitrogen and using CTAB buffer.

DNA extraction using commercial kits (adopted from 2014-till date)

The mid ribs of suspected leaf samples are chopped and grinded in liquid nitrogen using mortar and pestle. Bacterial DNA was extracted from this grinded powder using commercially available DNA extraction kits, following manufacturer's protocol.

DNA extraction using commercial kits and tissue lyser (adopted from 2019-till date)

Mid ribs of suspected leaf samples are finely chopped and powdered in tissue lyser. Bacterial DNA was extracted from this grinded powder using appropriate lysing matrix and commercially available DNA extraction kits following manufacturer's protocol (Figure 5).

Figure 5. Extraction of bacterial DNA by homogenizing mid ribs using lysing matrix in tissue lyser and DNA extraction and purification kits or manually prepared DNA extraction buffer.

Polymerase chain reaction (PCR) amplification of bacterial DNA

Since the initiation of PCR based early diagnosis of HLB in Nepal with the support of international experts, NAST has regularly updated its PCR procedures using globally tested PCR assays developed over time by established international laboratories. PCR assays adopted by NAST in different time periods is given in the Table 1 below.

Table 1. Details of different PCR assays adopted by the NAST Molecular Biotechnology Laboratory.

The period NAST had adopted: 1996-2008		The period NAST had adopted: 1996-2019
PCR assay: rpl-PCR; rplKAJL-rpoBC (β operon)		PCR assay: 16S-PCR
Developed by: Houquellet *et al.*1999		Developed by: Jagouix *et al.* 1996
Base pairs: 700		Base pairs: 1160
Primer pairs: A2 and J5		Primer pairs: OI1, OA1, OI2C
A2: 5'-TATAAAGGTTGACCTTTCGACTTF3' J5: 5'-ACAAAAGCAGAAAIIAGCACGAACAA-3'		OII: 5'-GCGCGTITGCAATACGAGCGGCA-3' OAI: 5'-GCGCGTATTTTATACGAGCG G CA-3' OI2C: 5'-GCCTCGCGACTTCGCAACCCAT-3'
The period NAST had adopted: 2017 – now		
PCR assay: 16S-rDNA PCR		
Developed by: Fujikawa and Iwanami (2012)		
Base pair: 500		
Primer pairs: Las606 and LSS		
LSS606: LSS:		5'-GGA GAG GTG AGT GGA ATT CCG A-3' 5'-ACC CAA CAT CTA GGT AAA AAC C-3'

Initially we have used both PCR assays (16S-OI1/OI2c and rpl-PCR) for HLB diagnosis. Primer pair OI1 and OI2c were able to amplify the Las and Laf species thus later we preferred OI1/OI2c pair. Since 2017 we are using the PCR assay developed by Fujikawa and Iwanami (2012) because the amplification efficiency of OI1/OI2c was poor. In many instances the highly suspected plant with severe symptom was also obtained PCR negative and there were chances of false positive because it has used the flanking region which is universal for bacteria as a whole.

Electrophoresis of amplified bacterial DNA

The PCR amplified products of 16S-PCR were run in 1% agarose gel in TAE (1x) buffer at 100V for half an hour and visualized on an UV trans-illuminator. Amplified products if observed are regarded as HLB positive as shown in the Figure 6 below.

Sequencing of bacterial DNA

NAST has started sequencing selective positive HLB samples using its ABI 3500XL genetic analyzer (Figures 7-10) to study possible genetic variations that could be observed in HLB infested old or new orange groves of the country.

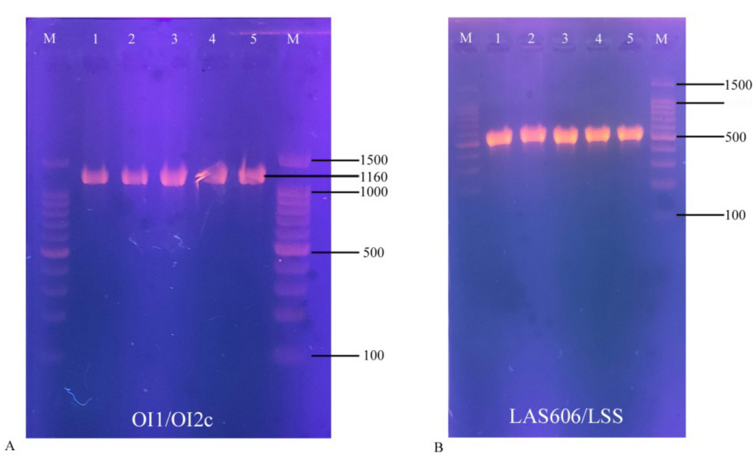


Figure 6. PCR amplification of *Liberobacter* 16s-rDNA genes with primers sets OII/OI2C (left) and LAS606/LSS (right). In both PCR analysis lane M is 100 bp DNA ladder while the 5 samples in between lane 1-5 showed presence of the *Liberobacter asiaticus* gene (HLB positive).

LAS606/LSS PCR Assay

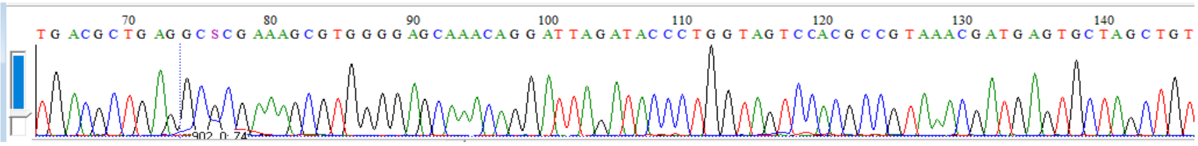
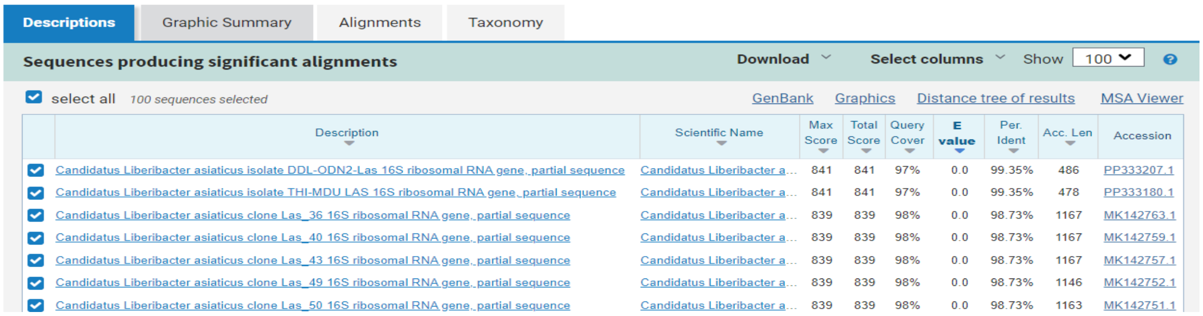


Figure 7. Partial chromatogram of LAS region of 16S-rDNA gene



Descriptions | Graphic Summary | Alignments | Taxonomy

Sequences producing significant alignments — Download — Select columns — Show 100

select all 100 sequences selected — GenBank — Graphics — Distance tree of results — MSA Viewer

Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
Candidatus Liberibacter asiaticus isolate DDL-ODN2-Las 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	841	841	97%	0.0	99.35%	486	PP333207.1
Candidatus Liberibacter asiaticus isolate THI-MDU LAS 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	841	841	97%	0.0	99.35%	478	PP333180.1
Candidatus Liberibacter asiaticus clone Las_36 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	839	839	98%	0.0	98.73%	1167	MK142763.1
Candidatus Liberibacter asiaticus clone Las_40 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	839	839	98%	0.0	98.73%	1167	MK142759.1
Candidatus Liberibacter asiaticus clone Las_43 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	839	839	98%	0.0	98.73%	1167	MK142757.1
Candidatus Liberibacter asiaticus clone Las_49 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	839	839	98%	0.0	98.73%	1146	MK142752.1
Candidatus Liberibacter asiaticus clone Las_50 16S ribosomal RNA gene, partial sequence	Candidatus Liberibacter a...	839	839	98%	0.0	98.73%	1163	MK142751.1

Figure 8. The Blast nucleotide sequence identify result of LAS 16S-rDNA partial gene amplified from the leaf sample of Gorkha

OI1/OI2C PCR Assay

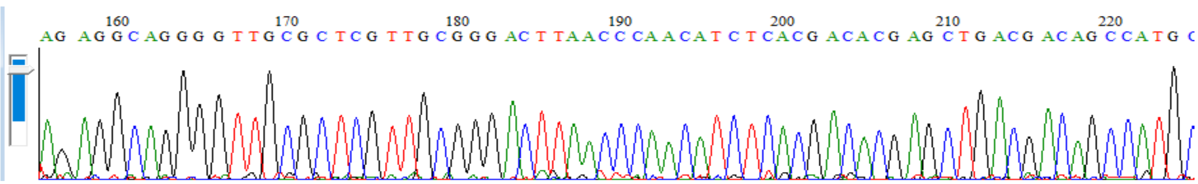
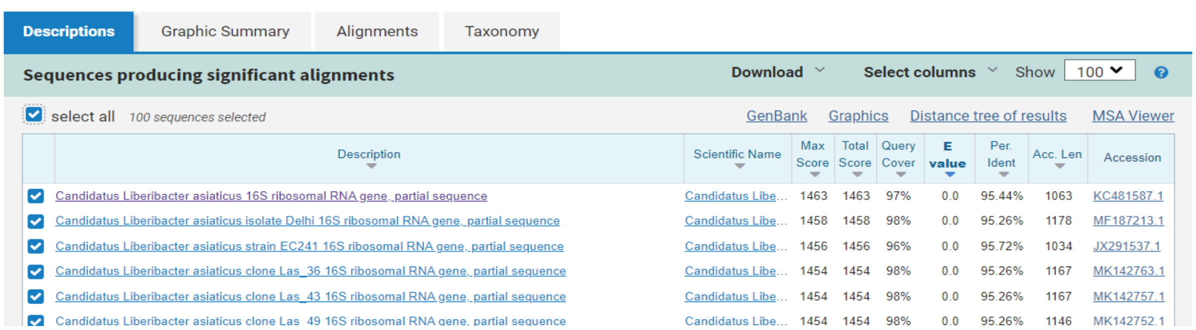


Figure 9. Partial chromatogram of OI1/OI2C region of 16S gene



Descriptions | Graphic Summary | Alignments | Taxonomy

Sequences producing significant alignments — Download — Select columns — Show 100

select all 100 sequences selected — GenBank — Graphics — Distance tree of results — MSA Viewer

Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Acc. Len	Accession
Candidatus Liberibacter asiaticus 16S ribosomal RNA gene, partial sequence	Candidatus Libe...	1463	1463	97%	0.0	95.44%	1063	KC481587.1
Candidatus Liberibacter asiaticus isolate Delhi 16S ribosomal RNA gene, partial sequence	Candidatus Libe...	1458	1458	98%	0.0	95.26%	1178	MF187213.1
Candidatus Liberibacter asiaticus strain EC241 16S ribosomal RNA gene, partial sequence	Candidatus Libe...	1456	1456	96%	0.0	95.72%	1034	JX291537.1
Candidatus Liberibacter asiaticus clone Las_36 16S ribosomal RNA gene, partial sequence	Candidatus Libe...	1454	1454	98%	0.0	95.26%	1167	MK142763.1
Candidatus Liberibacter asiaticus clone Las_43 16S ribosomal RNA gene, partial sequence	Candidatus Libe...	1454	1454	98%	0.0	95.26%	1167	MK142757.1
Candidatus Liberibacter asiaticus clone Las_49 16S ribosomal RNA gene, partial sequence	Candidatus Libe...	1454	1454	98%	0.0	95.26%	1146	MK142752.1

Figure 10. The Blast nucleotide sequence identify result of OI1/OI2C 16S-rDNA partial gene from the leaf sample of Gorkha

Review of studies conducted on citrus greening and its impact in Nepal

The distribution of greening disease and its vector have been confirmed in Nepal by Rana and Sharma (1964) and Knorr *et al.* (1970). However, presence of this disease was documented earlier in 1920s from South Africa and Asia. Until 1994, the causative pathogens as uncultured, phloem restricted gram-negative bacteria were unknown to the scientific community. Its actual identify came into light from the discovery of Jagoueix *et al.* (1994). The devastating impact of greening pathogen has led to innumerable researches worldwide covering, various aspects including the pathogen itself, its vector, the mode of transmission and measures for its control. After the preliminary confirmation of disease in Nepal, a good number of initial collaborative researches with the scientists of SAARC countries and leading laboratories and scientists of the world (RONAST, 1988; Lama *et al.* 1988; Regmi *et al.*1996; Regmi,1982; Sharma 1972) had carried out. These researches came up with remarkable findings from the report on the scale of Citrus greening impact in Pokhara valley and identification of host plant of the vector Citrus Psylla (RONAST 1988), reporting of an exact pathogen causing citrus greening (Jagoueix *et al.* 1996), greening incidence and greening vector population dynamics (Regmi and Lama, 1988), distribution of Citrus Psylla and its potential hosts plants (Lama *et al.* 1988) and detection of Asian HLB by the molecular method (Regmi *et al.* 1996). Online searches have documented a total of 53 literatures from the period of 1965-2023, among them 64% and 34% were international and national publications or in domains respectively. Line graph given below shows the chronological order of total documented publications is presented in the Figure 11.

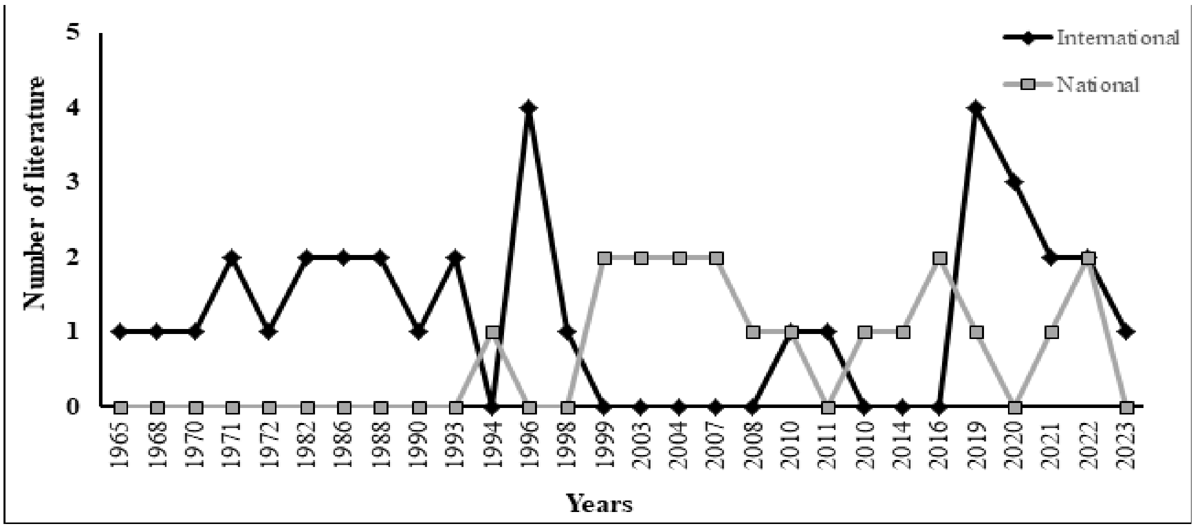


Figure 11. Number of national and international publications on citrus greening for the period 1965-2023.

Collated literature was further categorized into four groups as original research paper, study/research/survey reports, review papers and Masters' and PhD thesis (Figure 12). In both national and international publications original researches comprise notably larger proportions, followed by review articles. Citrus greening had been important research topics in both Masters and PhD level academic degrees. Two international PhD degrees have been acquired from Russian and Indian universities in Citrus greening related research topics. National university had carried out research thesis for Master degree. Interestingly, international donor agencies funded projects and FAO reports embrace science based knowledge required to address the citrus decline problem in Nepal. Such reports are key to extend international collaborations and sharing global learning to tackle citrus greening problems facing by Nepalese farmers (FAO, 2011).

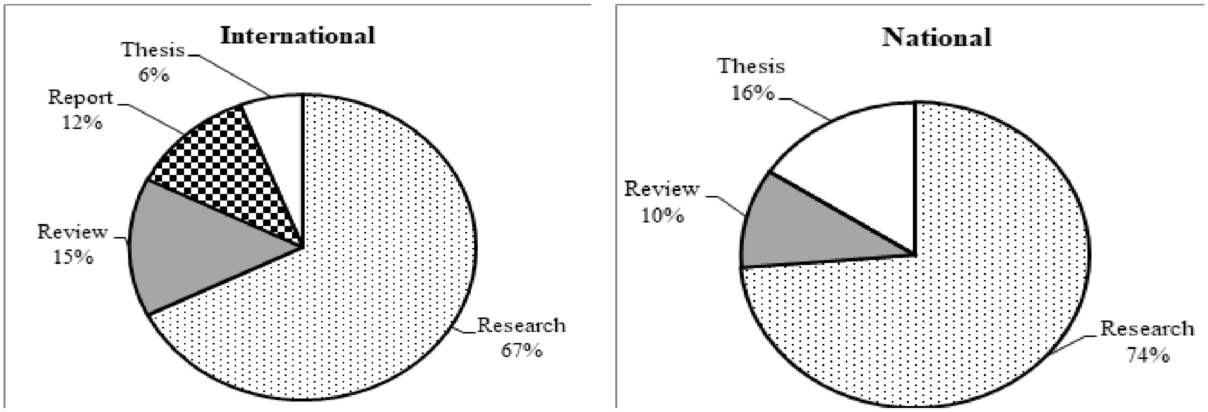


Figure 12. Types of Scholary literature both in National and International domain (assessed for the period 1965-2023)

While going through the objectives, scope and findings of all collected documents, they can be grouped under six major themes i.e HLB test, HLB management, HLB survey, HLB review, Psylla survey, HLB & Psylla survey and pathogen test on Psylla (Figure 13). Among the surveyed literature more than a quarter have focused on adopting molecular and other methods to detect HLB on citrus leaf samples followed by 20% publications discussed different management techniques for early and easy diagnosis of HLB. These included production of disease free planting material, using certified citrus seedling, removing infected plants, controlling potential host species of psylla vector and controlling citrus psylla. Browsed literature also cover overall caring and management of citrus orchard with adequate know-how on regular pruning, weeding, manuring, irrigating and other important practices to maintain sound health of the orchard etc.

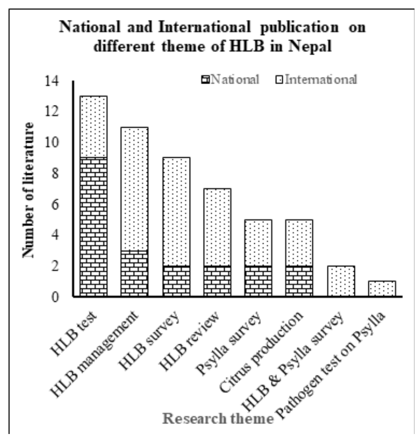


Figure 13: Number of national and international literature in six major themes (assessed for the period 1965-2023)

In recent years, a considerable number of review papers on citrus greening and its management are published by university graduates as well as experienced horticulturists working in government research centers/ extension offices. Sustainable activities to manage citrus greening like regular surveillance of citrus orchard to assess the scale of HLB infection, pathogen test in citrus psylla and their distribution are widely suggested (FAO 2011, Acharya and Adhikari, 2022). However, in recent years such researches are not happening as expected and there has been a decline in publications in these subjects. Such negative trend will have remarkable impact on the national progress in citrus research and development. Overall review of research publication until 2024 shows slow pace of our research activities in citrus greening and its knowledge based management that could be attributed to governments' less priority on agriculture research in Nepal (Uprety, 2018). In contrary to the trend of scientific publications, awareness and extension materials published in national newspapers, national online portals and websites of government organizations/programs dedicated to tackle citrus greening disease and enhance citrus productivities (Figure 14).

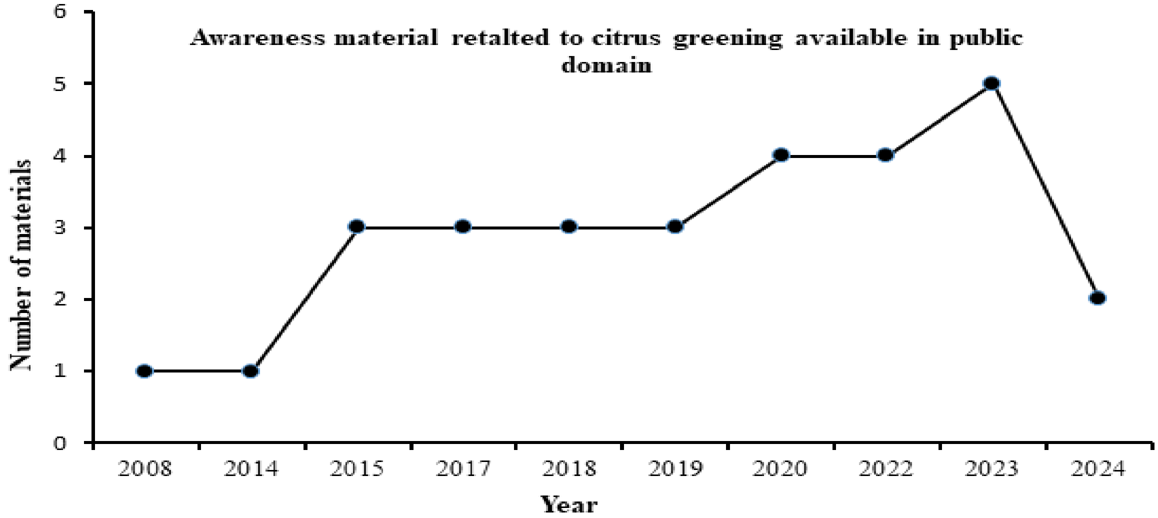


Figure 14. Number of citrus related content in onlinenews portals and other electronic domain

Way forward

Infection of orange groves of Nepal with HLB disease is in alarming rate and scale. Increased movements of people, weak quarantine system, negligence of farmers to remove infected trees and climate change impacts have further aggravated the problem caused by this disease. This possible situation currently faced by the country was predicated earlier by renowned citrus scientist Dr. C. N. Roistacher and Prof. Dr J. M. Bove. After their visits of citrus orchards in Nepal, both of these good friends of Nepal had warned us " *if nothing is done, citrus will soon disappear from Nepal, in the same way that citrus has been destroyed in India, Indonesia and the Phillippines*" (Shrestha *et al.* 2003); and "*Greening (HLB) disease is a number one threat to citrus industry in Nepal. Unless this disease is understood and controlled, citrus will slowly but surely decline*" (Roistacher, 1996).

Apparently from our review of both scholarly publications, newspaper articles and online portals awareness about the disease is growing rapidly among the farmers, decision makers and scientific communities. Citrus greening management training, awareness campaigns and publication of illustrative extension materials are done by the government authorities like National Center for Fruit Development (NCFD), Kirtipur, districts and local level fruit development programs, Prime Minister Agriculture Modernization Project implemented in various districts as mandarin orange superzone, zone and pocket areas program.

At present, the only option available with us is the early detection of HLB at pre-symptomatic stage and the removal of HLB positive trees if they are towards the end of their productive life and management of young healthy trees so as to restrict the disease spread. Besides regular caring and maintaining the health of citrus orchard, possible infestation and movement of infected citrus psylla should be strictly monitored. In addition to the NAST's PCR based HLB test, central and provincial government's other institutions (Molecular laboratory of

Warm Temperate Horticulture Centre, Kirtipur, Kathmandu and Plant Protection Laboratory, Pokhara, Kaski, Gandaki Province) are also providing testing facility. The regular exchange of laboratory protocols and other troubleshooting experimental issues between NAST and other laboratories play key role in improving the effectiveness of tests and optimizing the limited public fund available to combat this common challenge. NAST had actively contributed to develop Standard Operating Procedure (SOP) for detecting Citrus greening disease coordinated by the National Centre for Fruit Development and recently approved by the Government of Nepal, Ministry of Agriculture and Livestock Development (MOALD, 2024). Currently NAST is working to standardize RT-PCR based HLB diagnosis from both leaves and root samples because of the uneven distribution of pathogen in the citrus tree canopy and prolonged incubation periods. The tree often remains asymptomatic for longer time (Bove 2006; Gottwald *et al.* 2008). Such biological dynamics of pathogen hinders in an early detection of HLB in the mother plant from which scion are selected for disease free and high quality sapling production. Therefore, a collective effort among key organizations is needed to devise national strategies in research and developmental activities related to early detection of HLB, identification of infected vector, find the range of its distribution and apply control measures, production and distribution of HLB free sampling and increase national production of mandarin orange by wisely and effectively handling the existing challenges.

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Post-Harvest Management and Processing

Post-harvest Management of Mandarin Orange

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Abstract

Post-harvest management refers to all the handling operation carried out in the fruits after harvest as well management of pre-harvest factors that influence shelf-life, maintain quality and maximum usefulness of fruits. In Nepal, post-harvest loss of mandarin orange fruit is very high and often reaches up to 46%. Losses incurred during harvesting, handling, packaging, and transportation. All the fruits are gathered together irrespective of damage and injury. Any kind of damage to the fruit causes increase in respiration, increase in transpiration, increase in ethylene production and results higher metabolic activities. Besides, the wound and scratches are the avenues for microbial invasion that causes rotting of fruits. Blue and green moulds are the serious problem during storage of which infection occurs during harvesting and handling operations. Some of the disease and insect pests attack mandarin orange fruit while they are in the tree but the problem arises after harvest or in storage, the examples are scab, canker, scale insects, etc. In the market Nepalese mandarin orange fetch low price as they are partially damaged, not graded and of poor quality. To obtain better quality fruits and supply in good condition to the market postharvest management is essential. Postharvest management include filed inspection and control of harmful disease and insect in the field, appropriate maturity judgment and method of harvesting, handling, pre-cooling, sanitization, grading, packaging, storage and transportation. All these activities are collectively called packhouse operations. A mandarin orange packhouse should be established in a production area for postharvest management of mandarin orange. Along with packhouse for fresh produce, a processing plant in its vicinity should be established to utilize excess production and under grade fruits.

Keywords: Packhouse, Packhouse operations, Pre-cooling, Cold-chain, Cold storage

Introduction

Post-harvest management refers to all the handling operation carried out in the fruits after harvest as well management of pre-harvest factors that influence post-harvest shelf-life, maintain quality and maximum usefulness. In Nepal mandarin fruits are produced throughout the mid hills from east to west. Among 77 districts of the country, 48 districts in each have more than 100 hectare of commercial mandarin orchard and produce 198406 mt mandarin orange annually (MoALD, 2023). Usually farmers harvest mandarin fruits when they develop complete yellow colours. Post-harvest loss of mandarin orange fruit often reaches up to 46% (Bhattarai et al., 2013). Losses incurred during harvesting, handling, packaging, and transportation. Fruits are generally harvest by hand picking, and collected irrespective of damage and injury. Some fruits that drop while harvesting are also mix together with healthy undamaged healthy fruits. Farmers and traders may not be aware about the internal injury of fruit. Any kind of damage to the fruit causes increase in respiration, increase in ethylene production and results higher metabolic activities (Hyodo and Nishino, 1981: Jackarias, and Alferez, 2007). Besides any kind of wound and scratches is the avenue for microbial invasion that causes rotting of fruits. Stem-end rind breakdown, oleocellosis, blue and green molds are the serious problem during storage. Some of the disease and insect pests attack mandarin orange fruit while they are in the field but the problem arises after harvest or storage, the examples are scab, canker, scale insects, etc. In the market Nepalese mandarin orange fetch low price as they are partially damaged, not graded and of poor quality. To obtain better quality fruits and supply in good condition to the market postharvest management is essential. Postharvest management include filed inspection and control of harmful disease and insect in the field, appropriate maturity judgment and method of harvesting, handling, pre-cooling, sanitization, grading, packaging, storage and transportation. Very few researches have been carryout on postharvest management of mandarin orange in Nepal. The objective of this paper is acquainting reader about the various causes of postharvest loss and management practices to minimize and extend shelf-life and maintain quality.

Fruit physiology

For proper management of fruit the knowledge of fruit structure and its physiology is important. Mandarin orange fruit is hesperidium a kind of modified berry developed from a single ovary characterized by the presence of outer rind in which 6-8 carpels of segments are enclosed. The rind is divided into two parts i.e. exocarp the outer layer known as flavedo and inner white mesocarp know as albedo. Exocarp consist several oil glands covered by multi layered protective skin or cuticle. Each segment contains juice sacs and seed in it. As the fruit develops, juice-sacs fill with the juice. Certain anatomical, bio-chemical, and physiological changes continue in the fruit during development. Towards maturity, there is increase in sugar content as hydrolysis of starch and conversion of acid to sugar (Talukder et.al., 2015). The general observation for determining harvesting date of mandarin orange fruit is peel colour. Colour development depends on variety and further influence by the environment. In hot climate, the peel colour development is restricted, hence the fruit may remain green. The level of total soluble solids (TSS), titratable acidity (TA) and TSS/TA ratio are often considered as harvest criteria. In Nepal, fruits harvesting is determined on the basis its peel colour. Postharvest of loss of fruit is mainly due to transpiration, respiration and pathological invasion and disease development. For storage, management practice should concentrate on at what sage to harvest, how to harvest, how to take care of fruit, how to handle the fruit, how to store and transport is crucial.

Maturity judgment

As the fruit develops there is continuous decline in respiration rate of fruit. At physiological maturity rate of respiration is minimum (Eaka, 190), seeds mature and peel colour develop from green to yellow along with increase in total solids and titratable acidity. Fruits that are harvested a green mature stage are often de-greened with ethylene application for attractive yellow colour. For better edible quality and long shelf-life fruits should be harvested at proper stage of maturity (Bhusal et.al., 2007). Harvesting before maturity results in poor quality fruit. Delayed harvesting results poor quality fruit, puffiness, poor storage life and also affects tree health and fruiting in the following year. It has been suggested to harvest Nepalese mandarin orange at 75 % colour development stage. Fruits harvested at 75% yellow colour stage have long shelf-life. Sometimes TSS, TA and TSS/TA ratio is also considered as a judgment criteria for harvesting fruits. TSS more than 8.5%, TA less than 0.4% and TSS/TA ratio above 6.5 is considered as harvesting index.

Physiological changes after harvest

Mandarin orange fruit continue their respiration and transpiration even after taking away from the mother plant. Transpiration is primarily through cuticle layer of the epidermis and from stoma. These reactions affect the longevity of produce depend on the atmospheric condition in which commodities are left. Respiration in fruits involves many enzymes reactions. While attached with the plants transpiration water loss is supplied by the mother plant. In harvested fruits transpiration results significant loss of water from the fruit and cause weight loss. Along with respiration and transpiration fruits also produce ethylene. Ethylene causes senescence in ripened fruits. Any kind of damage to the fruit increases in respiration and ethylene production and hasten deterioration.

Causes of post harvest loss

Transpiration or water loss: Transpiration causes desiccation, shriveling, weight loss and loss in quality. Stem scar and fruit surface are the sites of transpiration. In fruits there is deposition of wax on the surface of fruit toward maturity. Wax forms a protective layer to lower down the rate transpiration and prevent microbial attack. During harvesting and handlings wounds are created in the fruits that may lead higher rate of transpiration.

Respiration: Fruits after harvest are also living and respire continuously. Because of stress the rate further increases. Respiration utilizes reserved carbohydrate and organic acids present in fruits. Ultimately, respiration causes loss of substrate in the form of carbon dioxide, water and heat. It has been mentioned that the respiration rate of rind is 10 times higher than that of vesicles. Respiration in fruits involves many enzymes reactions. The rate of these reactions under the physiological thermal condition increases exponentially with increase in temperature. As proposed by Van't Hoff (2022), the rate of a chemical reaction approximately doubles for each 10° rise in temperature.

Ethylene evolution: Any kind of stress to the fruit causes increase in ethylene production. Increase in ethylene production also increases the rate of respiration and depletion of reserve materials. Ethylene metabolism has been a main factor affecting the longevity of fruit even either attached on or detached from the mother plant.

Pathological invasion: It is not possible to harvest mandarin orange fruits without injury. Injury may not be visible to naked eyes but it serve as an avenue for the entry of pathogenic micro-organism. Once a citrus fruit is infected, the rate of infection to other fruit is very rapid. There is also proverb in Nepali language 'If one orange is spoiled it will spoil all oranges". Rough harvesting, handling and transportation cause damage to the fruits. All kind of damages are not visible. Any kind of damage causes increase in transpiration, respiration. If fruits are dropped from the trees or pressed during storage and transportation it causes internal damage. The type of damage during transportation can be compression damage or vibration damage. Compression damage is caused by the pressure and vibration damage is caused due to movements. Fruits transported in conical doko may look good in appearance are damaged due to pressure. In conventional practices fruits are harvested in very rough manner. All the harvested fruits are kept together for in packages for marketing. Fruits are collected in large piles together and also transported as such in the back of truck without packaging. Keeping large number of fruits together cause pressure damage to lower fruits. Thus condition of produce, the rate of respiration, transpiration, pathological invasion and poor postharvest handling practices are responsible for poor shelf-life and spoilage of fruits. Blue mold (*Penicillium digitatum*), green mould (*P. italicum*) and stem-end rot (different spp of fungus) are the serious disease during storage (Sumbali and Mehrotra 1981), while stem-rind breakdown, oleocellosis and chilling injury are important physiological disorders.

Various pre-harvest and postharvest conditions influence the quality of fruits. Among pre-harvest factors are growing conditions, nutrient management, location of fruit in the tree, maturity stage etc. Among postharvest conditions sorting, grading, pre-cooling, storage are important ones. Rokaya et.al. (2016) studied the effect of altitude, location and postharvest treatments on the quality of mandarin orange fruit.

Measures to minimize post-harvest loss

Harvest at appropriate stage of maturity

In Nepal mandarin orange ripens during November December. Generally at lower altitudes fruit become mature at 10-15 days earlier than in higher altitudes. Sometimes at higher altitudes fruits are also kept as such in the tree up to late march. For long distance market or for storage harvesting at 75 % orange yellow colour stage is appropriate. Keeping fruits in the tree for long time affects tree health and flowering in the succeeding year.

Harvest with minimum damage

Conventional practices of harvesting is twisting and pulling. Fruits should be harvested with cotton gloves first in cloth bag and poured to another container. Harvesting should be done either late morning or in the afternoon. Fruit dropped during harvesting or the fruit have scratches or wound should be sorted out immediately. Harvested fruits should be kept in shade for cooling. Contact of fruits with soil should be avoided. Fruits should not be kept in big piles to prevent impact damage. Fruits can be harvest by clippers to prevent damage. Fruit harvested by the clipper should be packed properly, otherwise during packaging and transportation stem cause puncture to the other fruits (PHMD, 2010).

Pre-cooling

Pre-cooling is a cooling operation, hence It is done before doing packhouse operations and or transportation to destination market it is termed as pre-cooling. Ordinarily the temperature of orange fruit at harvest is determined by existing field temperature and is generally high. In general, for every 10 ^{0}C reduction in temperature of the produce, all the physiological activities including respiration rate is reduced by half, hence the storage life is double. The effect of temperature on storage life of fruits is shown in Figure 1. At lower temperature the effect is more pronounced. In order to lower down all sorts of physiological activities, mandarin orange fruits should be pre-cooled to desired storage temperature. As result of pre-cooling, the rate of respiration decreased, water loss is reduced, ethylene production is suppressed, sensitivity to ethylene is reduced and microbial development is slowed (Tan, 2016). If mandarin oranges are kept in cold store or transport carrier without pre-cooling the temperature of the fruit will also increase the temperature of room/container and results deterioration at faster rate. To lower down the fruit temperature to desired level pre-cooling should be done as early as possible after harvest. Most of the cold stores and carriers are designed to hold pre-cooled produce. Pre-cooled commodities should be placed in cold storage or containers (Kanade, et., 2019). Force air-cooling is the most suitable method of cooling. Hydro-cooling can also be practiced for pre-cooling, in which washing of the fruit can be done at a time. Some of the modern cold storage may have force air-cooling system in it.

Sorting, grading, de-greening, waxing and packaging

Sorting, grading/sizing, sanitization, chemical treatments, de-greening, waxing and packaging are important post-harvest handling operations and also called packhouse operations. Graded fruits fetch 10-25% higher price in the market (Acedo, 2016). Sorting is a practice to remove undesirable fruits that have scratch, blemish and damaged. In packhouse grading and sizing is practiced mechanically. At farmers level it can be done on visual observation. Fruits can be graded to big, small and medium size. Uniform fruits should be packed separately in different packs and labeled. Also, the objective of grading is to assure its safe and accurate guarantee of quality, namely traceability. Packaging container should be hard to hold fruit and withstand load of other containers. Corrugated fiber-board boxes and plastic crates are most suitable container. Container should have provision for ventilation. De-greening and waxing cane done wherever necessary. In mandarin orange, de-greening is a practice to remove green pigment in the peel by ethylene treatment. Fruits produced at high temperature do not develop yellow colour and de-greening. Waxing is done to covers wounds and scratches on the surface of fruit, fungicides can be incorporated in wax, wax improves outlook of the fruits. Washing of crates with soap and water is essential to prevent infection. For retail, 1/2 to 1 kg or 4-8 fruits are packed in a perforated low-density polyethylene bag. Sanitizing treatments can be done by dipping fruits at 150 ppm chlorine solution. Fungicides can be applied as high pressure spray or emulsion wax in wash water like Imazalil (1000 ppm) for fruits if are to be stored for longer duration (Tiwari, 2006).

Storage

In ambient conditions fruits cannot be kept for more than 7-10 days. The principle aim of storage is to reduce the rate of respiration, transpiration, ethylene production, prevent microbial attack and prolong shelf-life. The rate of transpiration can be minimized by keeping fruits at high relative humidity. Humidity of 90-95 % is appropriate for storage of mandarin orange. Humidity less than 90% causes shriveling while, beyond 95% favors microbial growth and causes rotting of fruits. To reduce respiration the temperature of fruits should be reduced to desirable temperature immediately after harvest. Fruits grown in different climate have different storage temperature. In general storage life is brief at higher temperature and it becomes long at low temperature (Figure 1). Principally longest storage life at 0^0C, however, mandarin orange is subtropical fruit and cannot tolerate low temperature.

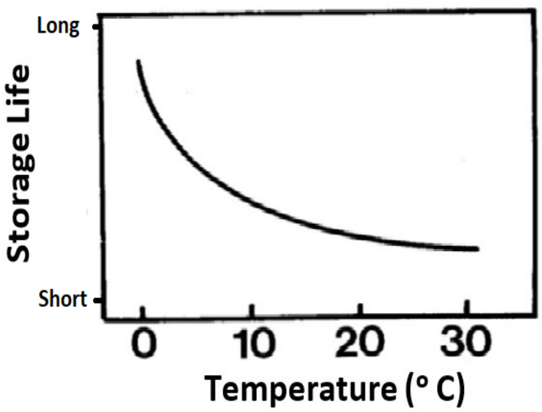

Figure 1. Effect of temperature on storage life of fruits.

Storage temperature may vary for different varieties and also influence by growing location. Storage of mandarin orange fruits at 5^0C by Matsumoto et.al. (2016) and at 5-8^0C by Tietel et. al., (2012). Nepalese mandarin oranges were found stored up to 90 days in good condition at 8^0C (Bhusal, 2002). Chilling injury was noticed in the fruits stored at 6^0C and lower temperature. Usually fruits produced at higher temperature are more sensitive to chilling injury. Various methods of storage structures can be used to store mandarin orange in Nepal to extend their shelf-life.

Cellar store: Cellar storages are usually mad in north facing terrace in the mountains (Rokaya et.al., 2020). Generally 5-10 ^{0}C lower temperature is noticed inside cellar. The temperature inside cellar varies in different altitude and surrounding environment. During humid condition the temperature difference becomes low. In high humid area cellar is less effective. Food Research Division (FRD, 2019) modified the cellar store by providing ventilation, trickling water on its wall, providing thatch roof, etc. Mandarin orange can be stored in cellar for about 2 months. Fruits after storage are vulnerable for transportation to long distance market. Only small quantity of fruits (200-500 kg) can be stored in cellar storage.

Cold Storage: Cold storage is more effective to store mandarin orange. In cold storage temperature can be controlled to a desired level. Each cold storage should have humidifier to maintain desired level of humidity and ventilator for the supply of oxygen and remove excess carbon dioxide and heat.

Quarantine regulation

For export the fruit should be free from diseases and insect pests. Infestation may also occur in the field, during harvesting and different packing house operations. Fruit should be regularly inspected for the diseases and pest in the field. Some of the deep seated pathogens cannot be eliminated just by chemical treatments. Effective treatments are needed to eradicate deep seated pathogens and insects pests. Fumigation with ethylene dibromide or methyl bromide was the effective tool previously employed to eliminate deep-seated pathogens or pest (Gautam et. al., Bhattarai, 2023). These chemical are now restricted to use as they have negative effect to the environment (WHO, 1995: EPA, 2004). Recently hot water (HW), hot air (HA), vapor heat (HV) and cold treatments are the substitutes, as they are environmentally friendly. For exporting fruits, treatments should be given as required by the quarantine regulations of the importing country.

Pack house and its importance

A packhouse is a structure where, various packhouse activities are performed to the fruits to prepare them for the market. For efficient and effective marketing of mandarin orange in Nepal, it is essential to establish a Citrus Packhouse in production area. A packhouse coordinates farmer with the market (Figure 2 & 3). In the packhouse, the assembled fruits are pre-cooled either by force air-cooling or hydro-cooling method. In hydro-cooling dumped in cold water for pre-cooling followed washing, sorting, grading, sizing, sanitization, degreening, waxing (optional), fumigation (optional) grading or sizing, packaging and storage. In small production, it is difficult to run a packhouse. For successful operation of a packhouse, large quantities of fruits should be produced within the particular area. An agreement has been signed with China in 2019 allows the pest free product i.e., the product not the production area must be free from designated pests, with the product to be from designated production area and packhouse practicing control measures (Aryal et.ls., 2022). Cold treatment i.e., Pre-cooling of citrus at 7^0C for 24 hours than to 3^0C for 16 days has been recommended to export fruits to Tibet. Until now, there is no study in Nepal for pre-cooling of citrus to both 7 and 3^0C. There is need to study to identify the suitable temperature and its verification for practical application.

Different kinds of phytosanitary requirements can be accomplished in a modern packhouse.

Figure 2. Packhouse and its linkage with farm and Market (Acedo et, al., 2016)

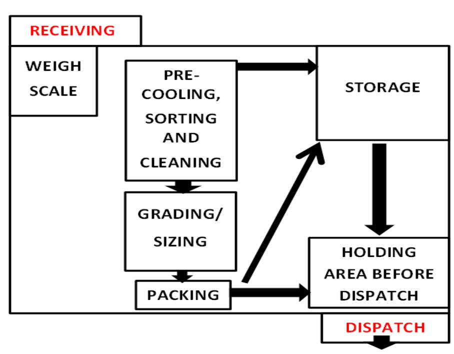

Figure 3. Component of a model packhouse

In modern packhouse different operations are carried out mechanically one after another. Fruits can be stored safely in cold storage and transported to long distance. A packhouse should assist small growers about orchard registration with packhouse, documentation of integrated pest management practices and export quality fruit production.

Transportation

In conventional practices citrus are transported in *Doko* for local market and in *Dhala* (as such in the back of truck) for long distance. In these cases the postharvest loss of fruit is enormous. *Doko* is a conical shape in structure made of bamboo. Fruits at the lower portion of *Doko* have to bear pressure on them and some other fruits are damaged by scratching and rubbing with *Doko*. In *Dhala* there is compression damage to the fruits that remain at lower portion. In the modern method fruits are packed in specially designed containers for transportation and marketing. Packaging material should be resistant to pressure and should have provision for ventilation. Transportation is being made in refrigerated carriers.

Cold-chain

Cold-chain in postharvest horticulture refers to the movement of fresh horticultural produce at lower temperature. Upon harvest, the produced are cooled down to desire temperature in packhouse, systematically handled, transported and again stored weighting for the market. For effective distance marketing packhouse is the must. It is not possible to export Nepalese fruits without the management of packhouse and cold chain. In Syanja district, a mandarin orange pack house has been established under department of agriculture to facilitate sorting and grading operations (NCFD, 2019). It should be upgraded, linked with cold-chain and managed properly to facilitate the export of mandarin orange.

Processing and preservation

Along with a packhouse for handling a processing plant is necessary in order to utilize excess production, culled and low grade fruits to produce juice, jam, jelly, marmalade, etc. establishment of processing industry in the production area provide a sort of insurance to the producers.

Production guidelines and quality standards

Fruit production directorate should provide the guidelines for good agricultural practices (GAP) to produce good quality fruits (Kharel et.al., 2022: USDA 2024). GAP focus on water, manure and municipal bio solids, workers health and hygiene, sanitary facilities, field sanitation, packing facility sanitation, transportation, trace book and record keeping. Quality standards should be determined to the processed products by the concern authorities. There should be provision for quality test and pesticides residue analysis before entering to the market or export.

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Effect of Post-harvest Treatment on Quality and Shelf life of Mandarin Orange in Cold store

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Abstract

Mandarin orange, a prominent citrus fruit in Nepal, is extensively grown in the mid-hills region. To evaluate the effects of various treatments on the shelf life and quality of mandarin oranges in cold storage, this study was conducted in the cold storage of Aandhikhola Rural Municipality, Syangja district, Nepal. Six treatments were applied: Bavistin 0.1%, wax 10%, salicylic acid 4%, calcium chloride 4%, wax 10% combined with calcium chloride 4%, and a control, each containing 88 number of mandarin oranges. The experiment followed a complete randomization design (CRD) with three replications in the cold storage. Mandarin oranges were harvested with two pairs of leaves, then subjected to the designated chemical treatment. For the control, fruits were directly placed in cold storage after harvesting. The cold storage maintained temperatures between 5°C to 7°C and relative humidity between 90% to 95%. The study duration spanned three months from December 17 to March 13, and after removal from cold storage, the fruits were kept for one week for further observation. Five randomly chosen samples from each treatment were analyzed for total soluble solids (TSS), weight loss, and incidence of rot. Data analysis was performed using Microsoft Excel and R Studio. Results showed that mandarin oranges treated with wax 10% combined with calcium chloride 4% deteriorated most rapidly (27), while those treated with Bavistin 0.1% showed the least degradation (1) in cold storage. Interestingly, no deterioration was observed in mandarin oranges treated with salicylic acid 4% after being removed from cold storage for a week. Regarding weight loss, calcium chloride treatment resulted in the lowest reduction (10%), whereas salicylic acid treatment led to the highest (15%). Wax 10% treatment showed the lowest concentration of total soluble solids (11%), whereas Bavistin 0.1% treatment exhibited the highest (12%).

Keyword: Calcium chloride, Mandarin orange, Cold store, Shelf life, Total Soluble Solid

Introduction

Mandarin oranges are important food sources in many parts of the world for several reasons. It is a type of citrus fruit that people often eat or they sniff the skin when grinded into a small powder. Mandarin orange is an evergreen tree in the family ruteacea grown for its edible fruit. Mandarin oranges are round orange colored fruit that grow on a tree which can reach 10 m (33ft) height.

They last longer than many other fruits when they are stored. The most important characteristic of freshly harvested fruits and vegetables is that, they are still alive and respiring (Snowdown, 1988).

Various viable technologies like use of fungicides, cold storage, controlled atmosphere storage, anti-transpirants, wax coating, growth retardants, irradiation, and different types of packaging materials, etc. have been used to increase the shelf life of harvested fruits in past decades (Yadav, 2010). Post-harvest treatments play a significant role in extending shelf life of the fruits (Deka, 2006). Nepal faces big losses of mandarin orange annually due to not adopting proper postharvest handling practices during harvesting, transportation and storage. Hence, to minimize these postharvest losses and to maximize the quantitative and qualitative parameters along with prolongation of storage capacity, postharvest treatments with wax and other safe fungicides are urgent for effective marketing of mandarin orange in the country.

Nearly 20-25 percent of mandarin orange fruits are wasted due to faulty postharvest management i.e.7% during harvesting, 25% during transportation, 3% while grading, 10% in packaging, 5% during marketing (Bhattarai, *et al*. 2013). Since mandarin orange is a non-climacteric and perishable fruit, it cannot be kept for a long time during transportation and storage. Due to low adaptation of improved techniques during pre and post-harvest stage, both external and internal (TSS and TA) quality attributes are lost. The postharvest losses can be minimized by extension of shelf life through checking the rate of transpiration, respiration, microbial infection & protecting membranes from disorganization (Sahu, 2016). Among the different methods used to extend the shelf life alternative of low-cost technology i.e. the application of the edible coating (oil, wax, chemical) to fruit has received attention worldwide as these coatings are maintaining quality even under ordinary storage condition (Bisen, Pandey, & Patel, 2012). With these considerations in mind, this study was conducted to extend the life of mandarin oranges after harvest and to store the fruit for a long time in cold store using different concentration of calcium chloride along with the study on physiology of mandarin oranges (harvested and stored in different date) after removal from cold storage.

Material and Methods

Experimental Site

A post-harvest experiment was conducted at Aandhikhola Rural Municipality, Syangja cold store (Dec-Mar) in collaboration with Prime Minister Agriculture Modernization Project, Project Implementation Unit, Syangja. Two different studies were carried out accordingly in the cold store and after that for one week in outside the cold store.

Experimental Setup and Management

The experiment included six treatments (refer to Table 1) allocated in a CRD with three replications. mandarin oranges received varying chemical treatments and mandarin oranges were stored in cold storage for three months. After this cold storage period, the mandarin oranges were removed and kept outside for one week. In total, eighty eight numbers of fruits were allocated per treatment per replication.

Table 1. Different treatments combinations used during research

S.N	Treatments	Time of treatments
T1	Control	No treatment
T2	Wax 10%	1 min dipping
T3	Bavistin 0.1%	2 min dipping
T4	Wax 10%+ calcium chloride 4%	2 min dipping
T5	Salicyclic acid 4%	2 min dipping
T6	Calcium Chloride 4%	2 min dipping

In the second phase of the study, mandarin oranges collected from cold storage were sampled with ten samples were taken per treatment. These samples were then placed on trays and left outside cold store for a week in a normal room temperature, with the date serving as an identifier for each treatment.

The mandarin oranges designated for cold storage were stored on the same date for research purposes. In each treatment, a total of eighty-eight fruits were placed in plastic crates and stored in cold storage for a period of three months (equivalent to 90 days). The shelf life of the mandarin oranges was then observed for one week. During the study period, 5-7° C temperature and 90 - 95 % of relative humidity was maintained in the cold storage, therefore fruits were transferred to a normal room temperature.

Parameters Observed

During the study period, changes in post-harvest quality of mandarin orange were observed and data was recorded in a 10 days interval. Different qualitative parameters of fruits: physiological loss in weight (PLW), decay loss (Losses due to green mold, blue mold and cold rot), TSS were recorded.

Physiological weight loss: For PLW, 5 fruits from each treatment were taken to observe changes in weight and recorded. PLW was calculated based on change in weight (Difference between initial and final weight of fruit) divided by initial weight and expressed in percentage.

PLW (%) =Initial weight- final weight / Initial weight * 100

Decay loss: Fruits were evaluated visually for symptoms of decay during the entire storage period (Cold storage and ambient condition). Samples having decayed and diseased symptoms were counted and discarded. Decay loss was calculated based on number of discarded fruits.

Total soluble solid (TSS): For TSS determination in ºBrix, the hand-held refractometer (Model: Atago, Japan, N-1 Brix 0-32%) was used by placing two to three drops of clear juice on the prism surface.

Data analysis

The data taken during the study period was entered in Microsoft excel 2010. The analysis of variance was determined by using the statistical tool R-Studio version 1.1.463 and the significance was determined using DMRT.

Results

The research was conducted in the cold store for three months and after taken from cold store it was kept in normal room temperature.

In the cold store

Physiological Weight loss and Decayed loss: Very important findings were made when research was done on decaying mandarin orange. Salicyclic acid treatment (4%), followed by bavistin 0.1% treatment (0.3) had the least amount of mandarin orange decay (1). In the wax10%+calcium chloride 4% treatment, a significant quantity degraded (27).

The findings indicate that the salicyclic acid 4% treatment caused the most weight reduction (15.02%), followed by the control group (13.81%), while the calcium chloride 4% treatment caused the least weight loss (10.08%).

Table 2. Effect on physiological weight loss and decayed loss of different treatments

Treatment	Decayed loss(number)	Physiological weight loss (%)
Bavistin 0.1%	0.3[c]	10.77[a]
Salicyclic acid 4%	1[c]	15.02[a]
Calcium Chloride 4%	6[c]	10.17[a]
Wax 10%	16.33[b]	10.08[a]
Wax 10%+ calcium chloride 4%	27[a]	11.18[a]
Control	7[c]	13.81[a]
Mean	9.61	11.9
F-value	2.73e-05 ***	0.32
CV(%)	28	25

Note: *** indicates the significance at 1% level of significance. CV: coefficient of variation

Total Soluble Solid: Research revealed a noteworthy finding in the case of Total Soluble Solid. The bavistin 0.1% treatment had the highest TSS (12.27%), followed by the control (12.09%). The Wax10% treatment had the lowest TSS (11.31%).

Table 3. Effects on Total Soluble Solid of different treatments

Treatment	Total Soluble Solid (%)
Bavistin 0.1%	12.27[a]
Salicyclic acid 4%	12.01[abc]
Calcium chloride 4%	11.55[abc]
Wax 10%+Calcium chloride 4%	11.46[bc]
Wax 10%	11.31[c]
Control	12.09[ab]
Mean	11.78
F-value	0.0494**
CV(%)	21

Note: ** indicates the significance at 5% level of significance, CV: coefficient of variation

After harvesting to cold store

Ten fruits per treatment were stored at room temperature after being taken from the cold storage to count the number of rotted fruit and total soluble solid. The results showed that the treatment with bavistin 0.1% had the highest TSS (13.1%), followed by the treatment with salicyclic acid 4%, and the treatment with calcium chloride 4% had the lowest TSS (11.67%). When it came to the number of rotten fruit, the wax 10%+calcium chloride 4% treatment had the maximum amount (7), whereas the salicyclic acid 4% treatment had none at all.

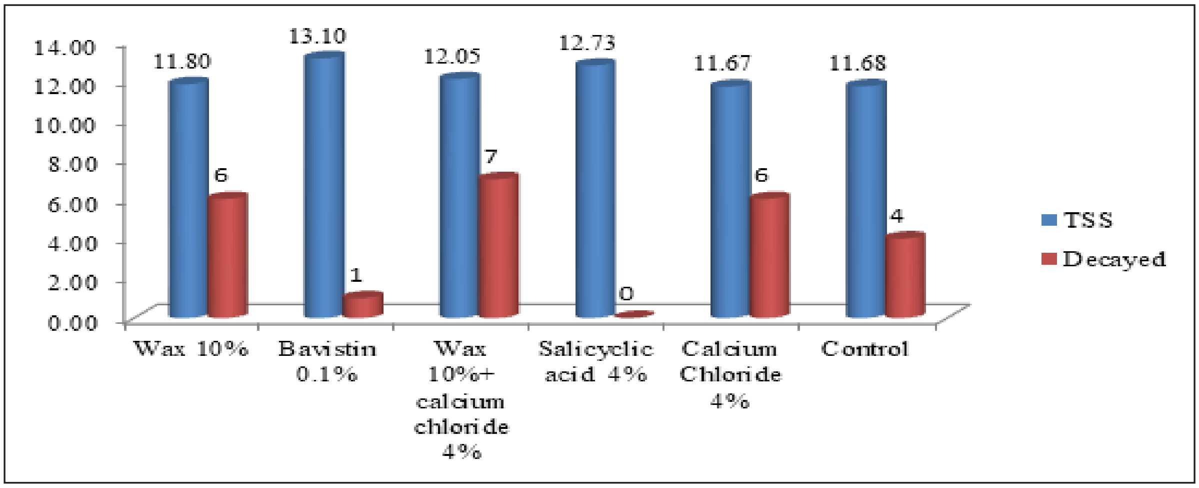

Figure 1. TSS and Decayed loss of mandarin orange after harvesting from cold store

Discussion

According to the research, it was shown that dipping mandarin oranges in a bavistin 0.1% solution and storing them in cold storage decreased the damage caused by green and blue mold (*Penicillium spp.)* in comparison to other treatments. The minimum decay loss was noticed in the fruits with bavistin (Rokaya *et al*., 2016). Similar results on the decay loss were observed by Chaudhary and Dhaka (2005) and Yadav *et al*. (2010) in kinnow mandarin orange, who reported minimum decay loss using the fungicide during the storage.

The finding of research shows that maximum physiological weight loss was found in salicyclic acid and minimum physiological weight loss in the wax treated fruits might be due to retardation in the process of transpiration and respiration by closing of lenticels and stomata of the cell wall of the fruits. The losses in fruit weight and moisture content of the peel were mainly caused by fruit transpiration in which water moved out and resulted in wilted rind and a shrivelled appearance (Wills *et al*.,2007).These findings were in consonance with the report of the Bhusal (2002) , Bastakoti and Gautam (2007) in mandarin orange, Chaudhary and Dhaka (2005) in kinnow mandarin orange, Deka *et al*.(2006) in Khasi mandarin orange, Ahmad *et al*.(2005) in kinnow mandarin orange, Yadav *et al*.(2010) in kinnow mandarin orange, and Bhullar (1981) in sweet orange who found minimum weight loss in the fruits treated with wax emulsion.

Fruit treated with bavistin found higher TSS increment followed by control. The faster TSS increment in the untreated fruits might be due to faster metabolic activities through respiration and transpiration than in treated fruits with different chemicals. Jholgiker and Reddy (2007) claimed that the gradual increment in TSS of fruits treated with fungicide may be justified by the double role of fungicide, acting as a physical barrier for transpiration losses and creating a modified atmosphere resulting in building of internal CO_2 and depletion of O_2. Similar results were noticed by Sidhu *et al*. (2006) in pear; Deka *et al*. (2006).

Conclusion

Based on the aforementioned data, we may conclude that applying various fungicides to mandarin orange can reduce postharvest losses. The fruit quality was enhanced. The weight and decay loss were decreased by wax alone and bavistin. When stored at a temperature between 5°-7°C and 7˚C and a relative humidity from 90% to 95%, fruits treated with bavistin, salicyclic acid, and calcium chloride can last up to three months than those treated with other methods. This study will pave the way for the application of various post-harvest methods to minimize postharvest losses in cold storage.

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सुन्तलाको स्क्वास

सुन्तला र परिकार विविधिकरण

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परिचय

सुन्तला *Citrus reticulate* Blanco जात अन्तर्गत पर्ने सुन्तले रातो रंगको बोक्रायुक्त स्वादिलो, रसिलो तथा सुगन्धित एवम् केस्रादार फल हो। भिटामिन तथा लवणयुक्त यस फल सामान्यतया ६० ग्राम देखि १२० ग्रामसम्म तौलको हुने गर्दछ। साथै पाक्दा फलमा गुलियोको मात्रा ९–१४ प्रतिशतसम्म र साइट्रिक एसिडको रुपमा अमिलो ०.७ - १.० प्रतिशतसम्म पाईने गरेको छ। यसको स्वादिलोपनको कारणले यो फल सेवन गर्दा स्फूर्तिको अनुभव हुने हुँदा धैरै जसो स्क्वास लगायत जाम, जेली, मार्मलेड आदि बनाएर खाने गरिन्छ।

अहिले स्थानिय बजारमा सुन्तला ताजा फलको रुपमा व्यापक रुपमा विक्री वितरण भई रहेको छ। प्रशोधित उत्पादन भन्दा ताजा फल उपभोग गर्नु राम्रो भएता पनि शहरीकरण तथा पर्यटनको विकासको कारणले गर्दा प्रशोधित परिकारहरु जस्तै जुस, जाम तथा जेलीको मांग पनि दिन प्रति दिन बढिरहेको अवस्थामा मांगलाई धान्न विदेशबाट धैरै परिमाणमा यस्ता खाद्यपदार्थहरु आयात गर्नु परेको छ। सुन्तला नाशवान खाद्यवस्तु (Perishable food) भएको कारणले गर्दा यो लामो समयसम्म उपयुक्त भण्डारण प्रविधि नअपनाई फललाई ताजा तथा गुणस्तरयुक्त कायम राख्न सकिदैन। कम गुणस्तरको कारणले बजारमा २५-४० प्रतिशत सुन्तला कृषकहरुले कम मूल्यमा बिक्री वितरण गर्नु पर्ने वाध्यता छ। यसै कारण बजारमा कम मूल्यमा बिक्री गर्न पर्ने कमसल ग्रेडका (आकार सानो वा साइज) सुन्तलाबाट पनि राम्रो मूल्य आर्जन गर्न, उत्पादनोपरान्त हुने क्षति कम गर्न साथै आयात प्रतिस्थापन गर्नको लागि प्रशोधन उद्योगका आवश्यकताको खाँचो देखिएको छ। त्यसैले सुन्तलाको अधिकतम उपयोग गरि राम्रो आय आर्जन गर्नको लागि आधुनिक प्रविधियुक्त प्रशोधन उद्योगको स्थापनाको साथै व्यवसायीकरणको समेत आवश्यकता हुन्छ। यस्ता पूर्वाधारको सहयोगले स्थानिय श्रोत तथा साधनको प्रयोग तथा उत्पादनमा विविधिकरण गरी मूल्य अभिवृद्धि गरेर किसानको जीवनस्तर उकास्न सकिन्छ।

सुन्तलाबाट बनाउन सकिने परिकारहरु

सुन्तलालाई प्रशोधन गरि बनाउन सकिने खाद्य पर्दाथहरुमा स्क्वास, जाम, जेली, मार्मालेड, सुन्तलाको बोक्राको क्याण्डी (peel candy) र सुकाएको केस्रा आदि हुन्। ती परिकारहरु प्रशोधन गर्न उपयोगी प्रविधिहरु तल उल्लेख गरिएको छ।

स्क्वास (Squash)

स्क्वास भन्नाले बोक्रा र बियाँ हटाई सके पछि प्राप्त हुने फलफूलको रसमा आवश्यक मात्रामा चिनी, अमिलो र पानी मिलाई तयार गरिने पेय पदार्थ हो। तयारी स्क्वासलाई आकर्षक बनाउन फल सुहाउँदो खाद्य रंग तथा वास्ना पनि राख्न सकिन्छ। साथै लामो समयसम्म संरक्षण गर्न रासायनिक परिरक्षी समेत राख्न सकिन्छ। यसलाई पिउने बेलामा सामान्यतया १ भाग स्क्वासमा ३ भाग सफा पिउने पानी मिसाएर पातलो बनाएर पिउने गरिन्छ। स्क्वासलाई कहिले पनि पानी नमिसाईकन त्यसै पिउन हुँदैन। परिरक्षीले स्क्वासको बोतलको बिर्को खोलिसकेपछि पनि लामो समयसम्म प्रयोग गर्न सकिन्छ र रेफ्रिजरेटरभित्र राख्न जरुरी पर्दैन।

नेपाल सरकारले फलफूलको स्क्वास भनेर निम्नानुसार परिभाषा गरेको छः

फलफूलको स्क्वास भन्नाले चिनी, डेक्स्ट्रोज (Dextrose), इन्भर्ट सुगर (Invert sugar), लिक्वीड ग्लुकोज (Liquid glucose) मध्ये कुनै एक वा सबै मिसाएको र निम्न कुराहरु भएको वा नभएको पाकेको स्वस्थ फलबाट गुदी समेत आउने गरी निकालिएको रसलाई सम्झनु पर्छः

क) पानी, फलको वोक्राबाट निस्केको तेल (Peel oil), फलफूलको सुगन्ध।

ख) साइट्रिक एसिड (Citric acid), एस्कर्विक एसिड (Ascorbic acid)।

ग) परिरक्षी (Preservatives) र खाद्य रंगहरु।

घ) फलको पदार्थको न्यूनतम भाग बट्टा अटाउने पानीको मात्राको ९० प्रतिशत र कूल घुलनशिल ठोस पदार्थ ४० प्रतिशत र सम्बन्धित फल रसको भाग २५ प्रतिशतमा नघटेको हुनुपर्दछ।

नोटः सुन्तलाको स्क्वासमा परिरक्षीको रुपमा सल्फरडाइअक्साइड (Sulfurdioxide) स्क्वासको मात्राको आधारमा अधिक्तम ३५० पि.पि.एम. वा वेञ्जोइक एसिड ६०० पि.पि.एम. सम्म प्रयोग गर्न सकिन्छ।

आवश्यक सामाग्रीहरु

हाते वा विद्युतिय जुसर मेशिन, स्टेन्लेस स्टीलका डैक्ची, बाटा, डाडु पन्यू, मग, चक्कु, मेजरिङ्ग सिलिण्डर, स्टोभ वा ग्यास, शिशा वा प्लास्टिक बोतल, बिर्को, तराजु, मलमल वा झुल कपडा, लेवल, आदि।

आवश्यक कच्चा पदार्थहरु

पाकेको सुन्तला, चिनी, साईट्रिक एसिड, पोटासियम मेटाबाईसल्फाइट (KMS), खाद्य रंग र वास्ना।

समिश्रण तालिका (रिसिपि)

कच्चा पदार्थ	मात्रा
फल रस	१.० के.जी.
चिनी	१.७ के.जी.
पानी	१.३ के.जी.
साईट्रिक एसिड	४०.० ग्राम
के.एम.एस. (KMS)*	२.४ ग्राम
खाद्य रंग (Orange Red)	०.८ ग्राम

*सलफरडाइअक्साइडको श्रोतको रुपमा KMS प्रयोग गरिन्छ।

स्क्वास बनाउँदा ध्यान दिनु पर्ने कुराहरु

- कुहिएको, सडेगलेको फलको प्रयोग नगर्ने।
- गुदीयुक्त रसको प्रयोग गर्ने।
- प्रयोग गरिने पानी स्वच्छ र जीवाणुरहित हुनुपर्छ र प्रयोगमा आउने पल्पर, भाँडा आदि सफा हुनु पर्दछ।
- परिरक्षी र खाद्य रंग स्क्वासमा हाल्न अगावै थोरै रस वा सफा चिसो पानीमा घोल्नु पर्दछ। परिरक्षी तातो स्क्वासमा राख्नु हुंदैन।
- स्क्वास भर्ने बोतल तथा बिर्को राम्ररी निर्मलीकरण गरिएको र सिल गर्न मिल्ने हुनुपर्छ। साथै फलामयुक्त भाँडा वर्तनहरुको प्रयोग गर्नु हुंदैन।

- स्क्वासको रंग र वासना प्राकृतिक फलको रंग र वासनासँग सुहाउँदो राख्नु पर्दछ।
- स्क्वास भर्दा बोतलको कुल आयतनको ९० प्रतिशतभन्दा कम भर्नु हुंदैन।
- सिलवन्दी गरिसकेपछि बोतलमा लेबल लगाउनु पर्दछ।
- तयारी स्क्वासलाई चिसो तथा सुख्खा ठाउँमा भण्डारण गर्नुपर्दछ।

स्क्वास बनाउने क्रमबद्ध तालिका

फल
↓
छनौट गर्ने
(पाकेको/रसिलो/नकुहिएको)
↓
फलको तयारी
(बोक्रा ताछ्ने, बियां हटाउने, टुक्रा पार्ने)
↓
रस निकाल्ने
↓
छान्ने
(सफा झूल कपडामा)
↓
रस जोख्ने
(रसको तौलको आधारमा चिनी, पानी, साईट्रिक एसिड, के.एम.एस., खाद्य रंग र वास्ना जोख्ने)
↓
मिसाउने ← [चिनी, पानी → तताउने → साईट्रिक एसिड हाल्ने → सफा मलमल कपडाले छान्ने → सेलाउने]
↓
रंगलाई थोरै पानी वा रसमा घोलेर मिसाउने
↓
वासना मिसाउने
↓
थोरै पानीमा के.एम.एस. घोलेर मिसाउने
↓
स्क्वास तयार
↓
बोटलमा भर्ने
↓
सिलवन्दी गर्ने
↓
लेवल लगाउने र भण्डार गर्ने
(चिसो/सुख्खा ठांउमा)

चित्र नं. १. स्क्वास बनाउने क्रमबद्ध तालिका

चित्र नं. २. सुन्तलाको स्क्वासः खाद्य रँग हालेको र नहालेको

सुन्तलाको स्क्वासको लागि उपयुक्त प्याकेजिङ्ग सामाग्रीहरु

सुन्तलाको तयारी स्क्वास प्याक गर्न उपयुक्त पदार्थमा सानो मुख भएको शिशाको बोतल मानिन्छ। शिशाको बोतलले स्क्वास बनाउँदा हालिने कुनै पनि कच्चा पदार्थसँग प्रतिक्रिया गर्दैन। तसर्थ उपभोग्य समयसम्म उचित तरिकाले भण्डारण गरे स्क्वासको स्वाद, बासना लगायत अन्य चारित्रिक गुणमा खासै परिवर्तन आउदैन। तथापी प्रत्यक्ष अप्रत्यक्ष प्रकाश र तापका कारण स्क्वासको रङ्गमा भने केही फिकापन आउन सक्ने हुनाले नै चिसो, सूर्यको प्रत्यक्ष किरण, प्रकाश नपर्ने सुक्खा कक्षमा भण्डार गर्न उचित मानिन्छ। माथि उल्लेख गरे बमोजिम परिरक्षी (के.एम.एस.) प्रयोग गरी उत्पादन गरिएको स्क्वासलाई शिशाको बोतलमा राम्ररी बिर्को लगाएर उपयुक्त अवस्थामा भण्डार गरे उत्पादन गरेको मितिले दुई वर्षसम्म उपभोग्य अवस्थामा रहन्छ। यद्यपि शिशाको बोतल गह्रौं कच्ची र महँगो समेत हुन भएकोले ढुवानी गर्दा टुट्ने फुट्ने सम्भावना हुने हुँदा हाल आएर प्लाष्टिकको बोतल विकल्पमा प्रयोग गरिएको पाइन्छ। प्लाष्टिक मध्ये सबैभन्दा उचित PET (Polyethylene terephthalate) मानिन्छ भने केही सस्तो र कमसल गुण भएको प्लाष्टिक पोलिथिन पनि प्रयोग गर्न सकिन्छ। जुनसुकै प्लाष्टिकको बोतल प्रयोग गरे पनि उपभोग्य मिति भने अधिकतम १२ महिनासम्म मात्र उल्लेख गर्न उचित हुन्छ। यस किसिमका प्लाष्टिकका बोतलबाट समयसँगै स्क्वासमा रहेको परिरक्षी सल्फरडाइअक्साइड उडेर जाने भएकोले यसको मात्रामा कमी आई लामो समयसम्म स्क्वासलाई संरक्षण गर्न सक्दैन।

सुन्तलाको जाम

जाम भन्नाले फलफूलको रस वा गुदीमा तोकिएको मात्रामा चिनी, अमिलो तथा पेक्टीन मिसाएर बाक्लो जम्ने गरी पकाएर तयार गरिएको खाद्य पदार्थलाई बुझाउँदछ। यसमा आवश्यकता अनुसार खाद्य नियमको परिधिभित्र रहेर खाने रंग तथा वास्ना पनि मिसाउन सकिन्छ। ग्रेडिङ्ग गरेर साना तथा छनौटे तर स्वस्थ सुन्तला ताजा फलको रुपमा बजारमा कम मूल्यमा विक्री गर्नुको सट्टा फलबाट जाम बनाउन सकिने भएकोले मूल्य अभिवृद्धि गरी सुन्तला बजारीकरणको लागि थप सहयोग पुग्दछ। फललाई सरल तरिकाले संरक्षण गरेर राख्ने यो एउटा मुख्य विधि हो साथै जाम प्रशोधन गर्न केही सरल औजार तथा उपकरणहरु मात्र भए पनि पुग्दछ। यसलाई विशेष गरी पाउरोटीमा दलेर खाईन्छ भने अन्य विभिन्न किसिमका रोटीहरुमा पनि दलेर खान सकिन्छ।

नेपाल सरकारले फलफूलको जाम भनेर निम्नानुसार परिभाषा गरेको छः

"जाम" भन्नाले ताजा वा सुकाएको वा क्यान गरिएको फल वा फलको गुदीलाई पानी, चिनी, डेक्स्ट्रोज (Dextrose), इन्भर्ट सुगर (Invert sugar), लिक्वीड ग्लुकोज (Liquid glucose) मध्ये कुनै एक वा सो भन्दा बढी मिसाइएको र त्यसमा देहायका पदार्थहरु मिसाई वा नमिसाई आवश्यक्तानुसार जम्ने गरी उमाली प्रशोधन गरिएको पदार्थलाई सम्झनु पर्छः

क) साइट्रिक एसिड (Citric acid), एस्कर्विक एसिड (Ascorbic acid), मेलिक एसिड (Malic acid)।

ख) परिरक्षी (Preservatives) र खाद्य रङ्गहरु।

ग) फलरस वा गुदीको रुपमा रहेको पेक्टिन र घुलनशील ठोस पदार्थ कम्तिमा ६५ प्रतिशत रहेको हुनुपर्ने छ।

घ) सम्बन्धित फलको पेक्टिन बाहेक अन्य पेक्टिन (Pectin), अगार (Agar) वा जिलाटिन (Gelatin) नभएको।

ङ) फल पदार्थको न्यूनतम भाग (Fill of container) बट्टामा अटाउने पानीको मात्राको ९० प्रतिशतमा नघटेको हुनुपर्ने छ।

नोटः सुन्तलाको जाममा परिरक्षीको रुपमा सल्फरडाइअक्साइड (Sulfurdioxide) जामको मात्राको आधारमा अधिकतम ४० पि.पि.एम. वा वेन्जोइक एसिड २०० पि.पि.एम. वा सर्विक एसिड ५०० पि.पि.एम. सम्म प्रयोग गर्न सकिन्छ।

जाम बनाउनको लागि पेक्टीन (फलमा पाईने एक प्रकारको तत्व हो जसले उचित समायोजनमा गुलियो, अमिलो र पानीको जालो बनाई जम्न मद्दत गर्दछ) धेरै भएको फलको आवश्यकता पर्दछ। सुन्तला पेक्टिन बढी भएको फल भएता पनि यसको पेक्टिन बोक्रामा हुने भएको तर रसमा पेक्टिन कम हुने भएको हुँदा पेक्टीन बढी भएको फलहरु जस्तै आरु, आरुबखडा, स्याउ, नास्पाती, अम्बा, मेवा आदि फलसंग समिश्रण गरी मिश्रित जाम समेत बनाउन सकिन्छ। उच्च कोटीका जाम उत्पादन गर्नको लागि तयारी जामको तौलको आधारमा पेक्टिन (१५), गुलियो (कूल घुलनशिल ठोस पदार्थ कम्तिमा ६५%) तथा अमिलो (बढीमा ०.८५) को राम्रो सन्तुलन हुनु जरुरी हुन्छ। जाम बनाउने कच्चा पदार्थको उचित छनौट, प्रशोधन विधि र सरसफाईमा विशेष ख्याल राख्नु पर्दछ।

आवश्यक सामाग्रीहरु

हाते वा विद्युतिय जुसर मेशिन, पल्पर, स्टेन्लेस स्टीलका डेक्ची, बाटा, डाडु पन्यू, मग, चक्कु, मेजरिङ्ग सिलिण्डर, स्टोभ, शिशाका जाम बोतल, बिर्को, तराजु, मलमल वा झुल कपडा, लेबल, आदि।

आवश्यक कच्चा पदार्थहरु

पाकेको सुन्तला, चिनी, साईट्रिक एसिड, खाद्य रंग र वास्ना।

तालिका २. समिश्रण तालिका (रिसिपि)

कच्चा पदार्थ	मात्रा
फल रस वा गुदी	१.० के.जी.
चिनी	०.८ के.जी.
साईट्रिक एसिड	५.० ग्राम
खाद्य रंग (Orange red)	०.२५ ग्राम
वास्ना	५ - १० मि.ली.

जाम बनाउँदा ध्यान दिनु पर्ने कुराहरु

- जाम पकाउँदा आगोको आँच ठूलो पार्नु पर्दछ अन्यथा जाम राम्रोसँग नजम्न सक्दछ।
- जामलाई सकभर निर्मलीकरण गरिएको काँचका भाँडा (शिशी)मा भर्नु पर्दछ।
- जामलाई शिशीमा भरिसकेपछि राम्ररी सेलाएपछि मात्र बिर्को बन्द गर्नुपर्दछ।
- जाम पकाउँदा सबै चिनी एकै पटक राख्दा जाम डढ्ने वा अमिलो पदार्थ पहिले नै मिसाउँदा राम्ररी नजम्ने हुन्छ।

जाम बनाउने क्रमबद्ध तालिका

फलको छनौट

↓

सफा गर्ने र बोक्रा, बिंया आदि हटाउने

↓

जुसरमा राखि रस निकाल्ने वा पल्परमा राखि पेल्ने

↓

गुदीयुक्त रस ↓ जोख्ने ↓ मिसाउने ← १ भाग चिनी

चिनी जोख्ने → ३ भाग लगाउने → १ भाग चिनी

मिसाउने

↓

केहि बेर पकाउने

↓

मिसाउने ← बांकि २ भाग चिनी (२ पटक गरेर)

↓

बाक्लो नभएसम्म पकाउने

↓

पाक्ने बेलामा अमिलो (साईट्रिक एसिड) मिसाउने
(६३ - ६४ डिग्री ब्रिक्स पुगे पछि जाम आगोबाट हटाउने)

↓

खाद्य रंग थोरै सफा पानीमा घोलेर मिसाउने

↓

बास्ना मिसाउने

↓

जाम (सेलाउदा ६५ डिग्री ब्रिक्स पुग्नु पर्दछ)

↓

तात्तातै बोटलमा भर्ने (तापक्रम ८५ डिग्री से. भन्दा कम हुनु हुदैन)

↓

विर्को लगाउने (हल्का)

↓

सेलाउने (हावामा राखेर) → विर्को कस्ने → लेवल लगाउने → भण्डार गर्ने (चिसो, सुखा, सफा ठांउमा)

चित्र नं. ३. जाम बनाउने क्रमबद्ध तालिका

सुन्तलाको जेली

जेली भन्नाले फलफूलको गुदीरहित सङ्लो रसमा तोकिएको मात्रामा चिनी, अमिलो तथा पेक्टीन मिसाएर बाक्लो जम्ने गरी पकाएर तयार गरिएको खाद्य पदार्थलाई बुझाउँदछ। राम्रो गुणस्तरको जेली कडा नभइकन पारदर्शी भइ राम्रोसंग जमेको र फलको वास्तविक स्वाद भएको हुनुपर्दछ। यो गम जस्तो टांसिने वा बग्ने तथा बाहिरबाट चिनीको कण जमेको हुनु हुंदैन। यसमा आवश्यकता अनुसार खाद्य नियमको परिधिभित्र रहेर खाने रंग तथा वास्ना पनि मिसाउन सकिन्छ। यसलाई पनि जाम जस्तै गरी पाउरोटीमा दलेर खाईन्छ भने अन्य विभिन्न किसिमका रोटीहरुमा पनि दलेर खान सकिन्छ।

पेक्टिन (फलमा पाईने एक प्रकारको तत्व हो जसले उचित समायोजनमा गुलियो, अमिलो र पानीको जालो बनाई जम्न मद्दत गर्दछ) बढी भएको फलहरु जस्तै आरु, आरुबखडा, स्याउ, नास्पाती, अम्बा, खुर्पानी, मेवा आदि बाट राम्रो जेली बनाउन सकिन्छ। तर सुन्तला पेक्टीन कम भएको फल भएको हुँदा यसमा बाहिरबाट पेक्टिन थप गर्नु पर्दछ। जेलीमा साधारणतया कूल फल पदार्थ घटीमा ४५ प्रतिशन, कूल घुलनशिल ठोस पदार्थ कम्तिमा ६५ प्रतिशत र अम्लता ०.५ देखि १.० प्रतिशत सम्म हुनु उचित मानिन्छ।

आवश्यक सामाग्रीहरु तथा कच्चा पदार्थहरु

जाममा जस्तै।

तालिका ३. समिश्रण तालिका (रिसिपि)

कच्चा पदार्थ	मात्रा
सुन्तलाको सङ्लो रस	१.० के.जी.
चिनी	०.८ - ०.९ के.जी.
पेक्टिन	२.५–५.० ग्राम
साईट्रिक एसिड	२.० - ५.० ग्राम
खाद्य रंग (Orange red)	०.२ ग्राम
वास्ना	५ - १० मि.ली.

जेली बनाउने क्रमबद्ध तालिका

फलको छनौट
↓
सफा गर्ने
↓
बोका ताछ्ने (भित्री सेतो भाग नहट्ने गरी)
↓
पातलो चाना (चक्कादार) पार्ने
↓
चाना छोप्ने गरी पानी राख्ने (१ के.जि. चानामा १ के.जि. पानी)

↓

३०–४५ मिनेट उमाल्ने
(ठिक्क आंचको आगोमा)

↓

छान्ने (मलमल कपडामा)

↓

पेक्टीनयूक्त रस
अग्लो भांडोमा चिसो ठाउँमा छोपेर राखी थिग्राउने
(४–८ घण्टा)

↓

माथिको संग्लो रस मात्र लिने, फेदको थेगार वा लेदो प्रयोग नगर्ने

↓

संग्लो रस जोख्ने — चिनी

↓ — ↓

मिसाउने ← १ भाग चिनी ← ३ भाग लगाउने

↓

केहि बेर पकाउने

↓

मिसाउने ← बांकि २ भाग चिनीमा पेक्टिन राम्ररी मिसाउने
(२ पटक गरेर थोरै थोरै गरेर पाक्दै गरेको रसमा हाल्ने)

↓

बाक्लो नभएसम्म पकाउने

↓

पाक्ने बेलामा अमिलो मिसाउने ← साईट्रिक एसिड

↓

खाद्य रंग र बासना मिसाउने

↓

जेली तयार

↓

तात्तातै बोटलमा भर्ने (तापक्रम ८५ डिग्री से. भन्दा कम हुनु हुदैन)

↓

बिर्को लगाउने (हल्का), सेलाउने र लेवल लगाउने

↓

भण्डार गर्ने (चिसो,सुखा र सफा ठांउमा)

चित्र नं. ४. जेली बनाउने क्रमबद्ध तालिका

जेली बनाउँदा ध्यान दिनु पर्ने कुराहरु

- फलको रसको तौलको आधारमा रिसीपीमा दिइए अनुसार अन्य सामाग्रीहरु चिनी, साइट्रिक एसिड, रंग, बास्ना जोखेर मात्र राख्ने ।
- जेली बनाउने रस सङ्लो हुनुपर्दछ । अन्यथा जेली धमिलो बन्छ ।
- जेली पकाउँदा आगोको आँच चर्को पार्नु पर्दछ अन्यथा जेली राम्रोसंग जम्दैन ।
- जेलीलाई सकभर निर्मलीकरण गरिएको काँचका भाँडा (शिशी)मा भर्नु पर्दछ ।
- जेलीलाई शिशिमा भरिसकेपछि राम्ररी सेलाएपछि मात्र बिर्को बन्द गर्नुपर्दछ ।
- सम्पूर्ण चिनी एकै पटक राख्दा वा अमिलो पदार्थ पहिले नै मिसाउँदा जेली राम्ररी जम्न सक्दैन ।
- पेक्टिन चिनीमा राम्ररी मिसाएर मात्र प्रयोग गर्ने नत्र डल्ला परेर जेली जम्दैन।

सुन्तलाको मार्मालेड

जाम वा जेलीमा फलको बोक्रा मसिनो केस्राको रुपमा मिसाएर मार्मालेड तयार गरिन्छ । जाममा बोक्रा मिसाएको छ भने जाम मार्मालेड र जेलीमा मिसाएको छ भने जेली मार्मालेड भनिन्छ ।

मार्मालेड बनाउन पनि जाम जेली बनाउँदा जस्तै आवश्यक पर्ने कुराहरु मिलेको हुनुपर्दछ । मार्मालेड प्राय सिट्रस जातका फलबाट बनाउन उचित मानिन्छ । यस्ता फलहरु पाकेपछि मात्र टिप्नु राम्रो हुन्छ । किनभने काँचोमा टिपिएको फलबाट मार्मालेड जम्दैन । साथै मार्मालेडमा सिट्रस फलको बोक्रा पनि प्रयोग हुने भएकोले उक्त बोक्रा पनि आकर्षक रंग चढेको हुनु पर्दछ ।

मार्मालेड बनाउँदा जाम वा जेली पाक्ने विन्दु पुग्नु अगाबै बोक्राको केस्रा मिसाउनु पर्ने भएकोले सर्वप्रथम बोक्राको तयारी गरिसकेपछि मात्र जाम वा जेली पकाउने गर्नुपर्दछ । अर्थात जाम वा जेली पाक्न भन्दा केहि अगाडि (करिब ६०–६२ डिग्री ब्रिक्स पुगेपछि) तयार गरिएको फलको बोक्राको केस्रा हालेर राम्ररी चलाई पकाउनु पर्दछ र र जाम वा जेलीको जस्तै कूल घूलनशिल ठोस पदार्थ कम्तिमा ६५ प्रतिशत नहुन्जेलसम्म पकाउने । बोक्राको केस्रा मिसाउँदा साधारणतया फलको रस वा गुदीको आधारमा ०.१ देखि १.० प्रतिशत सम्म मिसाउने गरिन्छ । अन्य अगाडिको विधि जाम वा जेली पकाए जस्तै भएको हुदां यंहा बोक्राको केस्राको तयारी र पाक्दै गरेको जाम वा जेलीमा मिसाउने तरिकाको मात्र उल्लेख गरिएको छ । जाम वा जेली मार्मालेडको लागि आवश्यक सामाग्री र कच्चा पदार्थहरु पनि जाम तथा जेलीको लागि चाहे अनुरुप माथि नै उल्लेख गरिएको छ ।

मार्मालेडको लागि चाहिने बोक्रा बनाउने क्रमबद्ध तालिका

पाकेको सुन्तलाको बोक्रा
↓
बोक्राको भित्रको सेतो भाग खस्रेर वा ताछेर हटाउने
↓
पखाल्ने
↓
लामो पातलो टुक्रा पार्ने
(करिव २–२.५ से.मी.)
↓

१५–२० मिनेट ०.५ प्रतिशत साईट्रिक एसिडको घोलमा उमाल्ने

↓

निर्थाने

↓

पानी फेरी पुन उमाल्ने

↓

निर्थाने (बोक्रालाई यतिकै पनि प्रयोग गर्न सकिन्छ तर बोक्रा जेलीमा माथि उत्रन्छ)

↓

बोक्रालाई ४०% को चास्नीमा राखी पारदर्शी नभएसम्म पकाउने (यसरी बनाएको बोक्रा जेलीमा उत्रदैन)

↓

पारदर्शी बोक्रालाई चास्नीबाट निकाल्ने

तयारी बोक्रालाई मात्रा अनुसार जोख्ने

↓

पाक्न भन्दा केहि अगाडि जाम वा जेलीमा मिसाउने
(६०–६२ डिग्री ब्रिक्स पुगेपछि)

↓

पकाउने
(६५ डिग्री ब्रिक्स नहुन्जेल सम्म)

↓

मार्मालेड तयार

↓

तात्तातै बोटलमा भर्ने, विर्को लगाउने (हल्का), सेलाउने, विर्को कस्ने, लेवल लगाउने

↓

भण्डार गर्ने (चिसो,सुखा र सफा ठांउमा)

चित्र नं. ५. मार्मालेडको लागि चाहिने बोक्रा बनाउने क्रमबद्ध तालिका

जाम, जेली र मार्मालेड

तस्विर सौजन्यः https://www.dixiecrystals.com/blog/jelly-jam-marmalade-whats-the-difference/

चित्र नं. ६. जाम, जेली र मार्मालेड

सुन्तलाको जाम, जेली तथा मार्मालेडको लागि उपयुक्त प्याकेजिङ्ग सामग्रीहरु
सुन्तलाको तयारी जाम, जेली तथा मार्मालेड उस्तै प्राकृतिका खाद्य पदार्थ भएकाले प्याक गर्न प्रयोग गरिने प्याकेजिङ्ग पनि एउटै हुन्छ। जाम, जेली तथा मार्मालेडलाई प्याक गर्न ठूलो मुख भएको शिशाको बोतल उपयुक्त मानिन्छ। जाम, जेली तथा मार्मालेड पाकेपछि तातै भर्नु पर्ने भएकोले पनि शिशाभन्दा अरु प्याकेजिङ्ग पदार्थ उपयुक्त मानिन्दैन। साथै शिशाको बोतलले जाम, जेली तथा मार्मालेड बनाउदा हालिने कुनै पनि कच्चा पदार्थसँग प्रतिक्रिया गर्दैन र उचित तरिकाले भण्डारण गरे यी खाद्य पदार्थहरुको स्वाद, बासना लगायत अन्य चारित्रिक गुणमा खासै परिवर्तन आउदैन। तथापि प्रत्यक्ष अप्रत्यक्ष प्रकाश र तापका कारण रङमा भने केही फिकापन आउन सक्ने हुनाले नै चिसो, सूर्यको प्रत्यक्ष किरण, प्रकाश नपर्ने सुक्खा कक्षमा भण्डार गर्न उचित मानिन्छ। उत्पादन गरिएका यस्ता खाद्य पदार्थहरुलाई शिशाको बोतलमा राम्ररी धातुको भित्री तह भएको बिर्को लगाएर उपयुक्त अवस्थामा भण्डार गरे उत्पादन गरेको मितिले दुई वर्षसम्म उपभोग्य अवस्थामा रहन्छ।

सुन्तलाको बोक्राको क्याण्डी

फलफूल, तरकारी वा फलको बोक्रालाई चिनीको चास्नीमा पकाई संरक्षण गरेर राखिने विधिलाई क्याण्डी प्रविधि भनिन्छ। धेरैजसो फलहरुबाट मात्र क्याण्डी बनाउने सकिन्छ। जुनार, सुन्तला जस्ता फललाई त्यसै खाँदा वा यसबाट अन्य परिकार बनाउँदा भित्रको गुदी मात्र प्रयोग गरिन्छ र बोक्रालाई त्यसै फाल्ने गरिन्छ। त्यही फालिने बोक्रालाई क्याण्डी बनाएर सदुपयोग गर्न सकिन्छ। बोक्राबाट क्याण्डी बनाउँदा भित्रको सेतो भाग अलिकति ताछेर निकाल्दा तितोपन कम हुन जान्छ। फलको बोक्राको क्याण्डी दुई किसिमले बनाउन सकिन्छ। बोक्रालाई मसिनो आकारमा काटेर चिनीमा पकाएर अथवा बोक्रालाई पिसेर चिनी र अन्य मरमसला राखेर वा नराखेर पनि क्याण्डी बनाउन सकिन्छ।

आवश्यक सामाग्रीहरु:
स्टेन्लेस स्टीलका डेक्ची, बाटा, किस्तिहरु, डाडु पन्यू, मग, चक्कु, स्टोभ, तराजु, पोलिथिनका पाउच, सिलर मेशिन, रिफ्राक्टोमिटर (०–१०० डिग्री ब्रिक्सको), लेबल, स्टोभ, मलमल कपडा, सोलार ड्रायर, ब्लेण्डर, आदि।

आवश्यक कच्चा पदार्थहरु
सुन्तलाको बोक्रा, चिनी, साईट्रिक एसिड, सोडियम बाईकार्बोनेट, पेक्टिन, नून, खोर्सानीको धूलो, कालो मरिच, आदि।

(क) **बोक्राको लेदोको क्याण्डी**

तालिका ४. समिश्रण तालिका (रिसिपि)
बोक्राको लेदोको क्याण्डी निम्न दुई किसिमका समिश्रण अनुसार बनाउन सकिन्छ।

समिश्रणहरु	गुलियो क्याण्डी मात्रा (के.जी.)	मसालेदार क्याण्डी मात्रा (के.जी.)
सुन्तलाको बोक्राको लेदो	५.२	५.२
चिनी	५	५
साईट्रिक एसिड	०.०५	०.०५
पेक्टिन	०.१५	०.१५
नून	–	०.१
कालो मरिच	–	०.०१५
खुर्सानी धूलो	–	०.०३

बोकाको लेदोको क्याण्डी वनाउने कमबद्ध तालिका

सुन्तलाको बोका
↓
३ मिनट पानीमा उमाल्ने
↓
पानी फेर्ने र १० मिनट फेरी उमाल्ने
↓
यो प्रकृयालाई ३ पटक सम्म दोहोर्‍याउने
↓
निथार्ने
↓
पिस्ने
↓
बोक्राको पेष्ट तयार
↓
चिनी मिसाउने ← मसालेदार क्याण्डीको लागि नून, कालो मरिच, खुर्सानी धूलो
↓
किस्तीमा फिजांउने
↓
सुकाउने
↓
काट्ने
प्याकिगं गर्ने

चित्र नं. ७. बोक्राको लेपोको क्याण्डी बनाउने क्रमबद्ध तालिका

चित्र नं. ८. सुन्तलाको बोक्राको गुलियो र मसलेदार क्याण्डी

(ख) **बोक्राको क्याण्डी**

तालिका ५. समिश्रण तालिका (रिसिपि)

कच्चा पदार्थ	मात्रा
सुन्तलाको बोक्रा १.० के.जी.	
चिनी	१.० - १.५ के.जी.
साईट्रिक एसिड	२.० - ५.० ग्राम
खाने सोडा	२ - ५ ग्राम.

सुन्तलाको बोक्राको क्याण्डी वनाउने क्रमबद्ध तालिका

सुन्तलाको बोक्रा

↓

भित्री सेतो भाग सकेसम्म खुर्केर फाल्ने (सेतो भागमा तितोपन हुन्छ)

↓

एक नाशको आकारमा काट्ने (लाम्चो ठाडो वा वर्गाकार)

↓

सादा पानीमा वा पानीमा ०.२५% खाने सोडा राखेर ५ मिनट उमाल्ने

↓

पानी फेर्ने र पून नयाँ पानीमा ५ मिनट उमाल्ने (यो प्रकृया ३ पटक दोहोऱ्याउने

↓

पानी निथार्ने

↓

३०% को चास्नीमा डुवाई क्रमिक रुपमा पकाउने जसले गर्दा चास्नी वाक्लो नभएसम्म पकाउँने (६०% डिग्री ब्रिक्स)

↓

१ % साइट्रिक एसिड थप्ने र पून बाक्लो च्यापच्याप गर्ने मह जस्तो नभएसम्म पकाउँने (६५% डिग्री ब्रिक्स)

↓

चास्नीमा १ रात डुबाएर राख्ने

↓

चास्नीबाट बोक्रा निकाल्ने, **स्टेनलेस** स्टिलको जालोमा राख्ने र तातो पानीले सतह पखाल्ने

↓

सुकाउने (घाममा वा ड्रायरमा)

↓

खस्रा चिनीमा लटपटाउने

↓

१५० गेजको पोलिप्रोपाइलिन थैलामा प्याकिङ्ग गर्ने, सिलबन्दी गर्ने र चिसो तर सुख्खा ठाउँमा भण्डार गर्ने

चित्र नं. ९. सुन्तलाको बोक्राको क्याण्डी बनाउने क्रमबद्ध तालिका

चित्र नं. १०. सुन्तलाको बोक्राको क्याण्डी

सुन्तलाको बोक्राको क्याण्डीको लागि उपयुक्त प्याकेजिङ्ग सामग्रीहरु

सुन्तलाको बोक्राबाट तयार पारिएका कुनै पनि क्याण्डीलाई उत्पादकको इच्छा अनुसार कुनै पनि खाद्य ग्रेडको प्याकेजिङ्ग पदार्थ प्रयोग गर्न सकिन्छ । ठूलो मुख भएको शिशा वा प्लाष्टिकका बोतलदेखि थैलाका रुपमा धातुजन्य ल्यामिनेटदेखि साधारण प्लाष्टिकसम्म प्रयोग गर्न सकिन्छ । सामान्यतया सादा पोलिथिन वा पोलीप्रोपाइलिन प्लाष्टिक थैला प्रयोग गरिएको खण्डमा १५० गेजभन्दा पातलो हुनु हुँदैन अन्यथा भण्डारण ताका हावा तथा पानीको वाफ छिर्ने सम्भावना रहन्छ । यस किसिममा गुलियोयुक्त सुक्खा खाद्य पदार्थहरु प्याक गर्न प्रयोग गरिने प्याकेजिङ्गको आवश्यक्ता भनेको हावा नछिर्ने गुण हो । अन्य भाँडामा प्याक गरेता पनि राम्रोसँग सिलबन्दी गर्न आवश्यक हुन्छ । यस प्रकारका खाद्य पदार्थहरुलाई पनि चिसो, सूर्यको प्रत्यक्ष किरण, प्रकाश नपर्ने सुक्खा कक्षमा भण्डार गर्न उचित मानिन्छ ।

सुन्तलाको सुकाएको केस्रा

फलफूल तथा तरकारी सुकाउने प्रविधि एक अत्यन्त पुरानो र परम्परागत प्रविधि हो । सामान्यतमा फलफूलमा पानी वा जलांशको मात्रा (८०-९३% सम्म) रहने भएकोले विभिन्न किसिमका सुक्ष्म जीवाणुहरुको वृद्धिमा तीव्रता आई फलफूलहरु चाँडै सड्ने गर्दछन् । फलफूलमा रहेको अधिक जलांशलाई सुकाउने विधि अपनाई कम गरेर त्यसमा रहेको जीवाणु र इन्जाइमहरुको सक्रियतालाई न्यून पारिन्छ । जसले गर्दा सुकेको फल लामो समयसम्म सुरक्षित रहन सक्छन् । सुकाउने प्रविधि परम्परागत एवं सरल भएकोले घरेलु स्तरमा पनि सजिलै प्रयोग गर्न सकिन्छ । घाम वा सोलार ड्रायरहरु एवं आधुनिक क्याविनेट ड्रायरहरुमा सुन्तला सुकाएर जलांश कम गर्न सकिन्छ ।

सुकाउनको लागि ताजा पोटिला केस्रा भएको सुन्तला उचित मानिन्छ । बोटबाट टिपेर राखिएको सुन्तलाका केस्राहरु फोस्रा तथा भित्री कोषिकाहरु नरम हुने भएबाट सुकाउन उचित मानिन्दैन ।

आवश्यक सामाग्रीहरु

स्टेन्लेस स्टीलका बाटा, किस्तिहरु, चक्कु, पोलिथिनका पाउच, सिलर मेशिन, लेवल, पार्चमेण्ट पेपर वा टेफ्लोन सिट, सोलार वा क्याबिनेट ड्रायर आदि ।

सुन्तलाको केस्रा सुकाउने क्रमबद्ध तालिका

सुन्तला (पाकेको, ताजा)
↓
भित्री सेतो भाग सकेसम्म खुर्केर फाल्ने (सेतो भागमा तितोपन हुन्छ)
↓
सफा पानीले पखाल्ने
↓
बोक्रा ताछ्ने
↓
केस्रा छुट्याउने
↓
केस्रालाई पछाडिबाट बिचमा काट्ने र बियाँ निकाल्ने
↓
सफा टेफ्लोन सिट राखिएको किस्ति वा ट्रेमा काटिएको भाग माथि फर्काएर केस्राहरु मिलाएर राख्ने
↓
घाममा सुकाउने (पातलो झूल कपडाले छोपेर) वा सोलार वा क्याबिनेट ड्रायरमा राखी सुकाउने (तापक्रम ४५-५५ डिग्री से. मा नसुकेसम्म पल्टाउदै सुकाउने)
↓
सुके पछि केस्राहरु कोठाको सामान्य तापक्रमसम्म सेलाउने
↓
१५० गेजको पोलिप्रोपाइलिन थैलामा प्याकिङ्ग गर्ने, सिलबन्दी गर्ने र चिसो तर सुख्खा ठाउँमा भण्डार गर्ने

चित्र नं. ११. सुन्तलाको केस्रा सुकाउने क्रमबद्ध तालिका

सुन्तलाको सुकाएको केस्राको लागि उपयुक्त प्याकेजिङ्ग पदार्थ

सुन्तलाको सुकाएको केस्रालाई पनि माथि सुन्तलाको बोक्राबाट तयार पारिएको क्याण्डीलाई जस्तै गरी प्याक गर्न उचित मानिन्छ।

उत्पादित सुन्तलाका परिकारहरुको लेबल

कुनै पनि प्रशोधित गरी तयार पारिएका खाद्य पदार्थ प्याकिङ्ग गरी बजारिकरण गर्न अगाडि लेबलिङ्ग गर्न आवश्यक हुन्छ। खाद्य स्वच्छता तथा गुणस्तर ऐन २०८१ को दफा १९ मा "**लेबल नलगाई उत्पादन तथा बिक्री वितरण गर्न नहुने**" व्यवस्था गरेको छ।

उक्त दफा अनुसार माथि उल्लेख गरिए अनुसार तयार पारिएका सुन्तलाका परिकारहरुमा निम्न विवरणहरु स्पष्ट देखिने गरी उल्लेख गर्नु पर्दछ।

- खाद्य पदार्थको नाम (जस्तैः सुन्तलाको स्क्वास)
- उत्पादकको नाम र ठेगाना
- खाद्य पदार्थको सम्मिश्रण (परिकार बनाउँदा प्रयोग गरिएका सबै कच्चा पदार्थहरुको नाम उल्लेख गर्नु पर्दछ। नाम लेख्दा मात्राको आधारमा धेरै प्रयोग गरिएको अगाडिबाट शुरु गरेर थोरै हालिएको सबैभन्दा पछाडि लेख्नु पर्दछ)

- खाद्य पदार्थको तौल (जाम, जेली, मार्मालेडको हकमा) वा आयतन (स्क्वासको हकमा)
- खाद्य पदार्थको बिक्री मूल्य, ब्याच नम्बर र उत्पादन मिति
- निश्चित अवधिभित्र उपभोग गरिसक्नु पर्ने भए त्यस्तो अवधि
- खाद्य पदार्थ उत्पादन गर्दा खाद्य रंग वा द्वित्तिय वर्गको परिरक्षी प्रयोग गरिएको खण्डमा उक्त रंग वा परिरक्षीको नाम वा संकेताक्षर उल्लेख गर्नु पर्दछ। (जस्तैः स्क्वासमा परिरक्षीको रुपमा सल्फरडाइअक्साइड प्रयोग गरिएको हुँदा लेबलमा सल्फरडाइअक्साइड (श्रोतः के.एम.एस.) भनेर उल्लेख गर्नु पर्दछ)
- खाद्य पदार्थमा परिरक्षी प्रयोग गरिएको भए त्यसको लेबलमा "Pure", "विशुद्ध", "शुद्ध" इत्यादि शब्द लेख्न पाइने छैन अन्यथा झुट्टा वा भ्रमात्मक दावा गरेको मानिने छ।
- नेपालभित्र उत्पादन तथा प्रशोधन हुने र नेपाली बजारमा बिक्री वितरण हुने खाद्य पदार्थमा लगाइने लेबलमा नेपाली भाषालाई प्राथमिकता दिनु पर्नेछ।

निष्कर्ष

सुन्तला जातको फलबाट कम लगानीमा सरल प्रविधिको प्रयोग गरी स्क्वास, जाम, जेली, मार्मालेड, सुकाएको केश्रा लगायत बोक्राबाट क्याण्डी आदि उत्पादन गर्न सकिन्छ। यस किसिमका उत्पादनहरु प्रशोधन गर्न खाद्य उद्योग स्थापना गर्न चाहेमा खाद्य स्वच्छता तथा गुणस्तर ऐन, २०८१ मा व्यवस्था भए अनुसार उद्योग दर्ता गर्न अगाडि खाद्य प्रविधि तथा गुण नियन्त्रण विभागबाट सिफारिस लिनु पर्दछ र दर्ता पश्चात् उत्पादित खाद्य पदार्थहरु बजारीकरण गर्न अगावै अनुमति पत्र समेत लिनु पर्दछ। स्थापित उद्योगबाट उत्पादित परिकारहरु तोकिएको खाद्य गुणस्तर अनुरुप हुनु अत्यावश्यक हुन्छ। साथै फूड ग्रेडका प्याकेजिङ्ग पदार्थमा प्याक गरि लेबल लगाउन समेत अनिवार्य हुन्छ।

Chapter 3

Value Chain and *Marketing*

बजार लैजान प्याकिङ्ग गरिएको सुन्तला

Value Chain of Mandarin Oranges

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Abstract

The process of value chain analysis is one for locating development prospects. It looks at the various stages that a product goes through, the people that are involved, the value they add, and the money they get paid for that value. It provides a suitable framework for investigating how institutional, technological, and economic developments affect global marketing chains, how these effects are spread, and what advantages arise for different players in the production and marketing stages. The whole process of developing a product, bringing it to market, and finally delivering it to the customer is called the "value chain." It is a chain of distribution that connects the creators, purchasers, vendors, and suppliers of raw materials to a product final application. Instead than concentrating on a single group or region, it aims to solve the main obstacles at every stage of the supply chain. Instead than concentrating on a single group or region, it aims to solve the main obstacles at every stage of the supply chain. The mandarin orange (*Citrus reticulate* Blanco) is the most prevalent citrus fruit species in terms of area and production. It is followed by the sweet orange (*Citrus sinensis*) and the acid lime (*Citrus aurantifolia*). With a productivity of 10.80 mt/ha, *citrus* produces 198406 mt of fresh fruit yearly, and 27002 hectares are expected to be under cultivation (MoALD, 2021). Citrus, particularly mandarin oranges, is the most important and extensively traded fruit crop in Nepal's hills. Mandarin orange alone accounts for 67% of the whole productive area and 64% of the total yield. Mandarin orange contributes to increased food supply, better nutrition, the creation of jobs and income, and environmental preservation.

Keywords: Market, Vendors, Suppliers, Food supply

Introduction

With an annual production and productivity of 198,406 metric tons (mt) and 10.80 mt per hectare, respectively, mandarin orange is grown on 27,002 hectares (ha) of land, contributing around 0.85% to the gross domestic product (GDP) (MoALD, 2021). Because mandarin orange is more profitable over the long run than oilseeds and grains, it accounts for roughly 67% of the country's land and 64% of its citrus production (NCRP, 2016). The area of production and productivity is not satisfactory, despite the presence of a sufficient labor force for agriculture, suitable terrain, unique weather conditions, and increasing market demand. 0.68 hectares of land held per person, a lack of resistant and high yielding cultivars, poor quality planting supplies, ineffective and unsustainable soil and pest management techniques, land fragmentation, inadequate storage facilities, and inconsistent market information system play a major role in determining Mandarin orange production. In order to move from subsistence-level mandarin orange cultivation to a commercial scale, policy level assistance is crucial. Regretfully, policies and plans are created, but they are just used for paper work (Sapkota et al., 2017).

In terms of area and production, the mandarin orange (*Citrus reticulate* Blanco) is the most common citrus fruit species, followed by the sweet orange (*Citrus sinensis*) and the acid line (*Citrus aurantifolia*). Mandarin orange yields 198406 mt of fresh fruit annually with a productivity of 10.80 mt/ha, and the area under cultivation is anticipated to be 27002 hectares (MoAD, 2021). The most significant and widely traded fruit crop in Nepal's hills is citrus, especially mandarin oranges (Bhattarai et al., 2013). 67% of the overall productive area and 64% of the total production are covered by mandarin orange alone (NCRP, 2016/17). Mandarin orange helps to improve the availability of food, enhance nutrition, create jobs and revenue, and preserve the environment (Shrestha and Dinesh, 2015)

The household that grows oranges owned 0.51 hectares in total, of which 0.31 hectares were planted with orange trees. Every household had 0.28 hectares of partially irrigated agricultural land and 0.23 hectares of un-irrigated land. The total cost of producing mandarin oranges was NRs 238063.92 per hectare, of which NRs 227309.41 per hectare (95.48%) were incurred by variable costs. Organic manure accounted for the largest share of costs (26.77%), followed by labor costs (23.57%), plant protection supplies (22.67%), fertilizers (18.33%), transportation (10.73%), saplings (5.04%), and irrigation management (0.33%).

For farmers to get a decent return on their investment, marketing is just as vital as farming techniques. The agricultural sector becomes commercialized when there is a strong market. The cost of mandarin orange was a source of dissatisfaction for many farmers. The contractors were immediately sold mandarin orange. The research area has a high prevalence of the contract farming system. Thus, the farmers ranked four primary marketing issues. With an index value of 0.77, the lowest price given to the producers was ranked highest. The selling price per kilogram is only NRs 66.23/kg on average. In a similar vein, the absence of processing operations was the second big issue. In none of the studied areas were value addition activities common. Mandarin orange has a ton of potential for value addition, but this hasn't been investigated yet; the producers gave it an index value of 0.62 and listed it as the second main marketing restriction. Mandarin orange growers believed that the main barrier to storage and sale was the presence of middlemen, which was followed by a lack of a suitable market and a lack of a preservation industry in the study area (Roy et al., 2018).

Value chain of mandarin orange

It is a chain of distribution that starts at the point of conception and involves input providers, customers, sellers and producers. The process of value chain analysis is one for locating development prospects. It looks at the many stages that a product goes through, the people that are involved, the value they add and the money they get paid for that value (Piper, 2007). It provides a suitable framework for investigating how institutional, technical, and economic developments affect global marketing chains, how these impacts are spread, and what advantages arise for different players in the production and marketing phases. The whole process of developing a product, bringing it to market, and finally delivering it to the customer is called the "value chain."

Value chain analysis is based on a comprehensive description of input-output relationships from grower to retailer and the coordinating mechanisms that guide activities at each stage. It can include deliberation of technical transformations of product, costs, pricing and margins, number and size of firms at each stage, barriers to entry, market power and the sharing of benefits from innovation, product differentiation and diversification (Cruz, 2003).

Value chains are a collection of interconnected business operations that begin with the supply of specific inputs for a given product and continue through primary production, transformation, marketing, and the final sale of that particular product to customers, according to the functional view of value chains. These jobs, such the manufacturing, processing, selling, and distribution of a given item, are carried out by groupings of enterprises (operators). Enterprises are connected through a series of commercial transactions that transport the product from primary producers to end buyers. Value chains consist of several chain links, or stages, according to the hierarchy of operators and functions. An economic structure with a particular commercial item at its core is called a value chain.

Value chain analysis is the process of enhancing and advancing a value chain. Value chain mapping is the process of visually representing the value chain system. Maps depict the corporate functions, chain operators and their relationships and chain supporters inside the value chain. Since chain maps provide the basis of analysis, they are integral to all value chains. By adding numerical data to the basic chain map, such as the number of players, the quantity of produce or the market shares of particular chain segments, value chains may be fully described and quantified. Certain chain studies provide the ability to "zoom in" on any relevant element, including the characteristics of particular actors or services or the institutional, political, and legal framework conditions that underpin or block the growth of a chain, based on the specific interest (GTZ, 2007).

Mandarin orange value chains encompass a set of interdependent organizations, and associated institutions, resources, actors and activities involved in input supply, production, processing, and distribution of mandarin orange. In other words, a value chain can be viewed as a set of actors and activities, and organizations and the rules governing those activities. Number of steps for a commodity to reach to the consumers depends upon the location for the market and targeted place to deliver.

Core value-chain

Citrus production is low in part because of inefficient supporting services. The fact that producers in Nepal operate on a very small scale makes it difficult for smallholders to take advantage of the enormous market opportunities in any subsectors. In order for production to be commercially viable, a critical mass of smallholders must exist in order to have enough volume to establish local suppliers of inputs, equipment, and services as well as market access. Due to their small size and lack of organization, private businesses are unable to realize the benefits of teaching and organizing a large number of smallholders in order to build a commercial production scale. If a business decides to make this investment, only trust would stop farmers from selling to and purchasing from not contracted company that might be able to give a better price because it did not have to pay for the costs of organizing and training. Creating a large enough volume to create private service providers in rural regions and community-managed collection centers that facilitate market access are two aspects of the small holder commercial pockets method. Entrepreneurs are chosen to administer the collection centers, marketing and planning committees elected from inside are in charge of the centers. These centers combine produce and offer essential services like creating crop plans and conveying and elucidating market concepts and desires.

Overall value chain analysis of mandarin orange

Nepal is characterized by a weak contract environment and distrust between and among market actors. Both formal laws and informal market systems are weak in Nepal. Formal or informal rules act to shape market outcomes and govern or control the entry, exit, operations and behavior of business. Rules typically provide the foundations for other more direct interfaces with business. For example, with respect to the enabling environment field a specific policy, law or regulation may initiate and determine the nature of specific public service delivery or other public action. Rules include informal rules or norms, formal rules or laws and other standards and codes of practice.

The government has provided subsidies on seeds, agriculture tools, irrigation related electricity tariffs and chemical fertilizer. There is a little use of forward contracting to mitigate risk for a perishable commodity. There is also limited application of commercial credit due to high transaction costs and a lack of mechanisms to ensure repayment.

Of the different supporting functions identified, inputs, market access and aggregation function are the most critical ones as it has direct impacts on the productivity at the farmer level (figure 1). Out of the main inputs for production, high quality saplings have tremendous potential to enhance yields. Saplings alone have the ability to improve production by 25%. Use of low quality saplings in the citrus sector has therefore been identified as one of the main constraints with highest potential of enhancement. A deeper analysis of the saplings market reveals

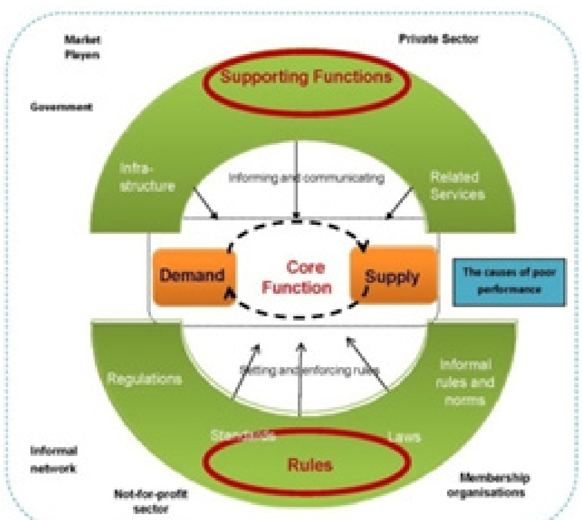

Figure 1. Critical analysis doughnuts

that farmers are not aware about the potential benefits of using high quality saplings and also do not have knowledge on the improved farm management practices that is required for maximizing production. But, the constraint not only lies at the farmer level, as input suppliers also have limited capacity and are not able to disseminate the correct information to maximize production.

Another function that is of equal importance is access to market. With the high involvement of small holder farmers in the sector individual production volumes are usually low and scattered. Due to the low volumes and the location of the farms market access becomes even more challenging as transportation of small quantities is often costly and farmers have to travel far to access the closest market.

Buyers on the other hand are also not able to reach these farmers as their locations are often remote and the cost of transportation makes it an unattractive proposition for the buyers. As a result, whatever is being produced is also not reaching the market. But, the market access function goes hand in hand with aggregation.

There exist two types of approaches in value chain -conventional and added value chain. In traditional value chain, farmers are linked with input suppliers, middle man, collectors, wholesalers, retailers, processors and consumers. In the added value chain, farmers establish linkages with processors, market centers, cooperatives and departmental stores.

Overall value chain analysis

During the field visit it was found that planting materials, fertilizers, pesticides and tools where found to be the major inputs used by the farmers. Wholesalers, dealers, retailers and collector are found key actors of the mandarin orange value chain who are involved in trading from production pocket to the wholesale and retail markets. This brings up the third function which is aggregation. Aggregation of the small holder farmers not just brings them together – thus reducing the transaction costs and time, it also then becomes an attractive pool for the mandarin orange wholesalers and traders to reach out to. This important function brings the market to the farmers. The aggregation mechanism also gives farmers a stronger bargaining power with both the input market and the buyers. However, there is limited availability of physical infrastructures to develop the collection centers and aggregation points.

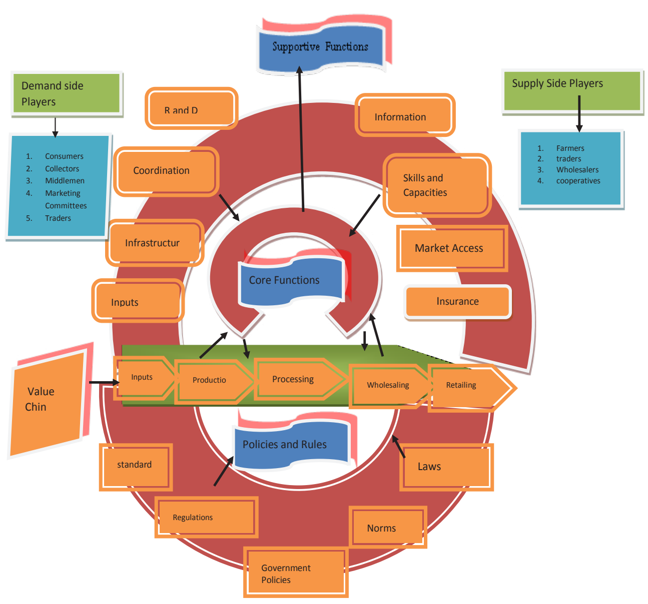

Figure 2. Overall value chain analysis

Rules and regulation

On the rules and regulation side, the government implements open market policy and there exits a gap to enforce prevailing rules and regulations.

The constraints faced by mandarin orange producers were categorized into three main types: input constraints, production constraints, post-harvest and marketing constraints. Lack of high-yielding varieties followed by proper subsidies was found to be the major technical and socioeconomic constraints, respectively. Poor irrigation facilities, high physical damage to fruits, and a lack of a suitable farmgate price for mandarin orange were found to be major production constraints, post-harvest constraints, and marketing constraints, respectively. Red ants, citrus bugs, and fruit flies were found to be the major insect pests in mandarin orange production. Citrus greening, fruit drop, gummosis, and sooty mold were found to be the most serious diseases. Thus, based on the findings of different studies, related agencies are needed to supply input subsidies as well as train the farmers to increase the productivity of mandarin orange throughout the country.

Value chain SWOT analysis

Strengths

- Suitable agro -climatic conditions for production.
- Production areas are accessible by road.
- Youths are already engaged in the production and trading.
- Mandarin orange has the highest return per runit area as compared to other commodities
- Processors are willing to work with other value chain actors

Opportunities

- Government's commitment to develop agriculture and formulated policies, strategies and implementation plans
- Area can be expanded by more than 2-3 times
- Large scale demand within country and abroad
- Vast untapped potential in heritage, fresh-water, eco-friendly, health, mountain, agro-tourism.
- Situated between the world's most populated and emerging economies (China and India),
- One of the richest countries in the world in terms of bio-diversity

Weaknesses

- Limited coordination among value chain actors
- No processing facilities in production sites.
- Inadequate physical infrastructure to support tourism industry
- Dearth of funding to implement citrus sub-sector development projects

Risks (Threats)

- Increasing price of inputs
- Large scale commercial production in India with low cost of production
- Political instability

Conclusion

Various studies have shown that there are many actors in the mandarin orange value chain, including input suppliers, growers, and wholesalers. The main constraints for mandarin orange growers are diseases, pests, lack of technical knowledge, high prices of inputs, and lack of market information, unorganized marketing, and high transportation costs. For wholesalers, the main constraint is low access to financial possibilities. Therefore, financial constraint at all levels of the value chain need to be addressed simultaneously. The various studies indicate that mandarin orange cultivation is a potentially profitable business in the area. It can be concluded that there is an immense need for facilitators (NGOs and other institutions) to increase productivity, improve the quality of production systems, and facilitate marketing through cooperatives for efficient marketing.

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सुन्तला फल ढुवानी

Marketing Management Practices of Mandarin Orange in Nepal (Production and Market Level)

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Abstract

This paper highlights on marketing management practices carried out at the existing level with focused on mandarin orange. This paper briefly discusses on how marketing management practices are carried out in mandarin orange in Nepal at micro and macro level. This fruit is grown commercially throughout the country in the mid-hills from east to west ranging from 700 to 1800 meters above the sea level. Mandarin orange is traditionally a cash crop for the mid-hill people from generation to generation. Butwal was and is still the main trading point of hill farmers and local traders of Gandaki and Lumbini Zone and it was exchanged mostly with salt and daily necessities such as sugar, spices in the past and is also emerging major trading point for export market of mandarin orange. Similar scenarios are found in other area including Birtamod, Dharan, Kohalpur and Kailali-Attaria.

Keywords: Trading point, Micro-level, Macro-level, Commercial, Export

Introduction

Mandarin orange is widely grown in the mid-hills covering 66 districts. Recognizing it as the native fruit, Nepal government has recently declared it as the national fruit on 2080 Chaitra 30.

According to the Ministry of Agriculture and Livestock Development (MoALD) Nepal, mandarin orange area coverage in 2021/22 was reported to be 27982 hectare with productive area 19481 ha. The productivity was 9.51 Mt/ha. If it is compared with 2001/02 data (22423 ha), net incremental area is found to be 5559 ha. This is nearly 25 percent increment over the base year 2001/2002. Recently area expansion under mandarin orange is observed at faster rate. This is mainly due to the replacement of this crop over the food crops caused by labor shortage in the agriculture. This is the common scenarios of rural areas. This author is also belonging to mandarin orange area of Panini Rural Municipality-2 of Arghakhanchi district. He is the witness of crop replacement from maize growing area to the cultivation of mandarin orange within the recent years. This observation justifies the data.

This paper attempts to explore how the marketing management practices are carried out over the traditional practices provided transportation linkages within the country.

Conceptually, marketing management is composed of analysis, planning, implementation, and control of programs designed to create, build, and maintain beneficial exchanges with target buyers for the purpose of achieving organizational objectives. Indeed, what to market, how to market, where to market, when to market, how much to market are concerned with management practices.

Methodology

For this, three case studies were selected based on production and market level. They were interviewed through personal visit and / or phone contact.

- **Production Level**

  a. Laxmi Narayan Cooperative, Sundar Bazaar, Lamjung district, which facilitate farmers on marketing linkage of mandarin orange. For this, Mr. Ramesh Raj Panta, the chairman of the cooperatives, was interviewed during paper writing. He was a grantee of Project for commercial Agriculture and Trade (PACT).

  b. Mr. Chiranjivi Paudel, Chairman of ShivaShakti Mishrit Krishak Samuh, Panini Rural Municipality, Arghakhanchi district was interviewed having storage facilities for mandarin orange.

- **Market Level**

  a. Mr. Bharat Khanal, well known Fruit Trader of Kalimati Market was interviewed.

  b. Mr. Binay Shrestha, Employee, Kalimati Fruits and Vegetables Wholesale Market Development Committee.

Result and discussion

Key findings at the production level in Lamjung

- Marketable volume has been decreased drastically due to diseases. For instance, 537 mt of mandarin orange was traded in 2016. Now the volume has been reduced due to 75 % mortality of plants.
- The fruit quality is also deteriorating in terms of sizes and appearence.
- Besides diseases, other factors affecting the low volume of production identified were insufficient irrigation facility, high cost of management related problems due to foreign employment attraction and climate changes.
- No distant market due to lower volume of production at present. Previously, Indian traders-Dharmendra, Munna Patel and Prabhu were main traders linked with Kathmandu and Narayanghat markets during 2016. For instance, out of 537 mt produced under cooperative, 400 mt was traded in Kalimati Market and remaining volume was sold in Narayanghat and local market. Now, it is limited to local area only.

Marketing practices with storage facility

- To fetch higher price of mandarin orange in off-season, Lumbini province government had supported to ShivaShakti Mishrit Krishak Samuh of Panini Rural Municipality-1, Arghakhanchi district to construct storage having 300 mt capacity in 2022.
- For experiment, they stored 200 mt. Huge loss was found due to fungus in 2023. Some losses occurred in the previous two years due to improper handlings.

Marketing practices at market level

- Established pre-linkage directly with mandarin-orange orchard owners
- Established pre-linkage with mandarin-orange suppliers/backward linkages.
- Local agents contract for assured supply
- Established forward linkages with exporters and retailers.
- Specified terms and conditions for quality, volume and procurement prices for market guarantee.

Lessons learned and recommendations

Marketing management practices are dynamic in nature. The actors must be aware on mandarin orange transaction, due consideration of market supply and demand. In case of storage users, the weakness is being realized from both sides (Producers and Cold store operator). Mishandling on post harvest activities from the farmers was the main reason for damage. Similarly, technical field level training, monitoring and supervision on the spot from the cold storage specialist are lacking. These should be corrected. It is recommended that before granting subsidy, government and recipients must be aware on technical requirements of the facilities. Establish pre and post linkages for market and price guarantee within farmers' group/cooperatives and market actors with clear terms and conditions.

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सुन्तला फल टिपेर ग्रेडिङ्ग, प्याकिङ्गको लागि तयारी

Citrus Fruit Export from Nepal to China: Plant Quarantine Perspective

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Abstract

Nepal and China have signed a bilateral trade protocol to export citrus fruits to Xizang Autonomous Region of China in 2012. This protocol demands fruits from an officially declared Pest Free Area (PFA). PFA is the area in which a specific pest does not occur as demonstrated by scientific evidence. This was a fastidious quarantine requirement of China. Nepalese side requested China to revisit this protocol to relax its requirement. It is obvious that China needs citrus fruits, but it is not possible for Nepal to produce enough citrus fruits in a PFA. Citrus greening, citrus canker disease and five species of fruit flies were the quarantine pests of citrus in China. In October 13, 2019, during the gracious visit of Chinese President Mr. Xi Jinping, the Ministry of Agriculture and Livestock Development (MoALD) of Nepal and the General Administration of Customs of the People's Republic of China (GACC), China have signed a new trade protocol entitled "Phytosanitary Requirements for the Export of Citrus commodity from Nepal to China." This protocol has granted a special flexibility of "Pest Free Product" while exporting citrus fruits to China provided that the intended citrus fruits shall have a specified cold treatment. It is proposed that the protocol simply includes grower registration, pack house registration and pack house inspection of fruits to ensure pest-free product. With the export of citrus fruits from Nepal to China presents both opportunities and challenges, particularly from a plant quarantine perspective. Exporting citrus fruits from Nepal to China presents significant opportunities for economic growth. However, overcoming the challenges related to plant quarantine regulations, pest management, infrastructure, and capacity building is essential. Collaboration among citrus producers, government authorities, exporters, and other stakeholders is crucial to address these challenges, ensuring the successful export of high-quality citrus fruits from Nepal to China.

Keywords: Citrus, Export, Pest free product, Citrus greening, Quarantine

Introduction

Citrus is one of the important fruit crops in Nepal. It enhances the nutrition security, nation's standard of living and economy. Great prospects for international trade are also provided by it (Adhikari et al., 2023; Acharya & Shrestha, 2021, Adhikari & G C, 2020). Generally, citrus fruits are consumed raw. Additionally, citrus fruits are utilized for the production of juice, squash, marmalade and other flavored beverages (Lamsal et al., 2021). Citrus occupies 28% (50,235 hectares) of Nepal's total fruit-growing area (MoALD, 2022). This indicates that citrus fruits are the most commonly cultivated fruit in Nepal and have a significant role in the country's farmers' economic growth. According to Acharya and Adhikari (2022), citrus is a major agricultural subsector in Nepal. However, the current level of production is insufficient to meet the nation's need for citrus (Dahal et al., 2020). Citrus productivity has dropped over the last 15 years, from 10.86 mt/ha in the harvest of 2006–07 to 9.67 mt/ha in 2020–21 (MoALD, 2022).

The Ministry of Agriculture and Livestock Development (MoALD) in Nepal and the General Administration of Customs of the People's Republic of China (GACC)have discussed and come to an agreement regarding the export of Nepalese citrus fruits into the Xizang Province of China. This agreement was made in recognition of the shared interests in improving the well-being of the people of the two countries and strengthening cooperation based on friendship and reciprocity. Citrus from Nepal may find a market in China (NPWG, 2076). It is obvious that Nepal will take a comparative advantage by exporting citrus to the Xizang Autonomous Region, as compare to China's citrus growing regions. Tibet imports all of its citrus fruit because it produces very little of its own (NPWG, 2076).

This article outlines the state and advancement of the actions carried out, as well as the quarantine prospects of the Nepal-China Agreement to export citrus fruit from Nepal to China.

Results and discussion

Citrus production in Nepal

The total production and productive area of citrus fruit have nearly doubled between 2006–07 and 2021–2022. Nevertheless, the productive area (%) increased to almost 65% while productivity decreased to 9.47 from 10.86 mt/ha (MoALD, 2023) Table 1. The data indicates that there are many factors contributing to low productivity, limiting us to achieve its production potential per unit area.

Table 1. Total area, productive area, % productive area, production and productivity of citrus fruit in Nepal from 2006/07 to 2020/21

Year	Total area (ha)	Productive area (ha)	% Productive area	Production (mt)	Productivity (mt/ha)
2006/07	27,980	15,832	56.58	1,71,875	10.86
2007/08	30,790	19,915	64.68	2,26,404	11.37
2008/09	32,322	22,482	69.56	2,53,766	11.29
2009/10	33,898	22,903	67.56	2,59,191	11.30
2010/11	35,578	23,609	66.36	2,63,710	11.20
2011/12	37,565	24,089	64.13	2,40,793	10.00

Year	Total area (ha)	Productive area (ha)	% Productive area	Production (mt)	Productivity (mt/ha)
2012/13	36,975	23,645	63.95	2,16,188	9.14
2013/14	38,988	25,497	65.40	2,24,357	8.80
2014/15	39,035	25,261	64.71	2,22,790	8.82
2015/16	40,554	24,854	61.29	2,18,447	8.82
2016/17	46,328	26,759	57.76	2,39,773	8.96
2017/18	44,424	25,946	58.41	2,45,176	9.44
2018/19	46,411	28,406	61.21	2,71,908	9.57
2019/20	46,715	27,339	58.52	2,74,140	10.03
2020/21	50,235	32,188	64.07	3,11,188	9.67
2021/22	49,306	32,306	65.52	306,149	9.47

Source: MoALD, 2023

MoALD Action Plan to implement the agreement

The National Preparatory Working Group (NPWG), led by the Joint Secretary of the Ministry of Agriculture and Livestock Development (MoALD), was established in 2076/07/22 in order to accelerate the agreement. In order to implement the protocols for the citrus export, the NPWG developed the action plan.

Table 2. Action plan to implement the agreement.

Provision on Agreement	Action	Time line	Responsible authority
Article1: Nepali citrus fruits exported to China, including sweet orange *(Citrus sinensis)*, mandarin orange (*Citrus reticulata* Blanco) and lemon *(Citrus limon)* (hereinafter referred to as citrus) must comply with the relevant phytosanitary laws and regulations of China and satisfy the phytosanitary requirements as stipulated in this Protocol.	Designation of an entity/body for overall coordination (National Preparatory Working Group or other body?)	2020	MoALD
	Lemon production: Appropriate variety selection, mother plant establishment, sapling production Commercial production pocket establishment (Nuwakot/ Sindhupalchok/ Kavrepalanchok)	2020-2021 2021-2024	NCRP AKC (lead) & Local Level (support)
	Exploration of citrus price in Lhasa market and profit margin of Nepalese citrus fruits exported to Tibet	2020	MoALD
	Consultation with private sector to ensure their involvement in citrus export to Tibet	2020	MoALD
	Develop good agriculture practice and standard operating procedures jointly with GACC	2020	MoALD

Provision on Agreement	Action	Time line	Responsible authority
Article 2: Citrus shall be free of any quarantine pests concerned by China (*Aleurocanthus woglumi, Bactrocera correct, B. cucurbitae, B.dorsalis, B. tsuneonis, B. zonata, Candidatus liberibacter asiaticus, Colletotrichum acutatum* and *Xathomonas campestris pv. Citri.*)	Conduct pest survey and surveillance and update pest list	2020 onwards	PQPMC (lead) NARC / PMAMP / AKC (support)
	Maintain sound record keeping of pest surveillance for reporting	Every year	PQPMC (lead) PMAMP (support)
	Develop IPM protocol for the management the pests and share with Chinese counterpart	2020	PQPMC (Lead) NARC (Support)
	Routinely implementation of IPM	Every year	PMAMP (Lead) AKC, Local Level (support)
	Training to the farmers and technicians	2020-2021	AKC, (Lead) PMAMP (support)
	Monitoring and AREA WIDE management of Bactrocera minax	Every year	PMAMP/Local Level
Article 3: Citrus orchards, packaging houses shall be registered officially in MoALD and Jointly approved by MoALD and GACC Before each export season, MoALD shall provide GACC with a list of citrus orchards and packinghouses.	Update the orchards, packing houses and farmers registered during 2015/16	2020	
	Update the orchards, packing houses and farmers registered during 2015/16	2020	AKCs (lead) PMAMP (support)
	Develop Standard Registration Procedure of orchard, packing houses and farmers	2020	AKCs (lead) PMAMP (support)
	Share orchard and packaging house registration procedure with GACC	2020	MoALD
	Re-registration of farmers, orchards and packaging houses with traceability mechanism and approval by MoALD and GACC.	2020	AKCs (lead) PMAMP (support)
	Guideline for grower registration by pack-house, good manufacturing practices, traceability (???)		

Provision on Agreement	Action	Time line	Responsible authority
Article 4: (A) The citrus orchards shall be monitored and found free of the following quarantine diseases; *Candidatus liberibacter asiaticus* Jagoueix and *Xathomonas* campestris pv. citri (Hasse). (B) For the following quarantine pests concerned by China; Citrus fruits shall come from the orchards that conduct cold treatment before export according the international standards or the standard that both sides agreed *1. Bactrocera correcta (Bezzi)* *2. Bactrocera cucurbitae Coquillett* *3. Bactrocera dorsalis (Hendel)* *4. Bactrocera tsuneonis (Miyake)* *5. Bactrocera zonata (Saunders)*	Develop surveillance and management protocol of citrus greening and canker disease	2020	PQPMC (lead) NARC (support)
	Identification of suspected citrus greening infected trees through visual symptoms on leaves and fruits and confirmation by PCR test (suspected sampled trees).	Every year	PMAMP (lead) AKC (support)
	Survey of Citrus Canker disease through visual symptoms observation on leaves and fruits.	Every Year	PMAMP (lead) AKC (support)
	Totally uprooting and destroy of greening infected plants from the orchard and ensure minimum compensation price to the farmers	Every Year	AKC (lead) Palika (support)
	Replanting using high quality saplings	2020-2021	NARC
	Conduct research on cold treatment of Citrus fruits to develop cold treatment protocol	2020	MoALD
	Request to Chinese side to assist on cold treatment facilities	2021	MoALD
	Joint monitoring orchards from Nepal/China		MoALD /NPPO
	Request to IPPC from MoALD/NPPO to de-notifying the presence of Bactrocera tsuneonis (Miyake) in Nepal and provide scientific evidence that it is merely; Bactrocera minax	2020 onward	PMAMP (Lead) PQPMC, AKC (support)
	Develop Internal Control System(ICS) of these pest	2020-2021	NARC
Article 5. Under the supervision of MoALD, the citrus orchards and packinghouses shall undertake effective monitoring, precaution and Integrated Pest Management (IPM) to avoid and control the occurrences of quarantine pests of concern to Chinese side; and ensure that orchards and packinghouses maintain the phytosanitary conditions. Upon request by GACC, MoALD shall provide GACC with relevant procedure and results of the above-mentioned pest monitoring, precaution and IPM programs.	Monitoring of IPM program implementation at field level (as mentioned in article 2 and 4)	Every Year	MoALD (Lead) NARC/PQPMC (support)
	Share pest monitoring and management protocol and management results with GACC.	Ever year	MoALD / PQPMC
Article 6 : Processing, packing, storage and transportation of citrus shall be conducted under the quarantine supervision of MoALD	Develop and implement safe postharvest management guidelines	Every year	PQPMC
	Monitoring to ensure implementation of the guidelines/SOP to control/prevent quarantine pests during postharvest management	Every year	MoALD (lead) PQPMC (Support)
	Agreement with the pack houses operators to facilitate the inspection of the pack houses and storage during visit by Chinese and Nepali Quarantine Inspector	2020	MoALD
	Arrangement for Cold chain transportation	2022	MoALD
Article7: 2% sampling of fruits in a consignment for quarantine inspection	Prepare protocol in consultation with Chinese counter parts.	2021	MoALD / PQPMC

Provision on Agreement	Action	Time line	Responsible authority
Article 8: Citrus arrives at entry port; China Customs (the port branch of GACC) will examine relevant certificates and labels, and conduct a quarantine inspection	Develop format of necessary certificates and labels to be supplied with consignment in consultation with Chinese counterpart	2020 and onwards	MoALD / PQPMC
	Effectively implementation of pest management techniques so that the citrus fruits comply all necessary phytosanitory requirements mentioned in this protocol to avoid rejection from the Chinese custom	Every year	MoALD (lead) PQPMC/PMAMP / AKC/ Local Level (support)
	In case of rejection and send back of consignments from Chinese side due to pest; develop special disposal protocol to limit it.	2021	MoALD
Article 8: Related to China Customs procedures and facilitation for technical support for compliance in case of noncompliance.	Develop format of necessary certificates and labels to be supplied with consignment in consultation with Chinese counterpart.	2020 and onwards	MoALD / PQPMC
	Effectively implementation of pest management techniques so that the citrus fruits comply all necessary phytosanitary requirements mentioned in this protocol.	Every year	MoALD PQPMC / PMAMP / AKC, MoLMAC / Local Level
Article 9: After signing of this Protocol, if necessary and agreement is reached by both sides, GACC will send two quarantine inspectors to Nepal to conduct on-site investigation, audit and inspection of the citrus growing areas, orchards, packing-houses, to examine pest monitoring and control	Invite the Chinese quarantine inspectors with budgeting	2020/ 2021	MoALD
	Budget to be provisioned for next fiscal year for Chinese Quarantine Inspectors' visit	2020/2021	MoALD
	Joint evaluation of pest monitoring and management protocols and implementation plan and results	2020-2021	MoALD (lead) PQPMC (support)

Quarantine concern in Nepal - China agreement and activities performed

Table 3 presents the list of provisions and the activities performed and progress in the different article of protocols of Nepal-China agreement to export citrus fruit from Nepal to China.

Table 3. Activities performed and proposed, and progress to export citrus fruit from Nepal to China

S N	Protocol of phytosanitary requirement	Attempt to export the citrus fruit (From Sindhuli)
Article 1	Compliance of phytosanitary regulation	Nepal has initiated some efforts on export of safe citrus fruits; sweet orange *(Citrus sinensis)*, mandarin orange (*Citrus reticulata* Blanco) and lemon (*Citrus limon*) to China on the basis of the pest risk analysis and with the relevant phytosanitary laws and regulations of China which will satisfy the phytosanitary requirements as stipulated in the protocol. The citrus fruits exported to China will be limited in Xizang Autonomous Region for consumption and use.

S N	Protocol of phytosanitary requirement	Attempt to export the citrus fruit (From Sindhuli)
Article 2	Quarantine pest free citrus	Citrus orchards have been monitored and citrus orchards observed free from the following quarantine diseases have been promoted for the export. • *Candidatus liberibacter asiaticus Jagoueix* • *Xathomonas campestris pv. citri (Hasse)* Citrus fruits are free of following quarantine pests concerned by China as specified in the protocol. • *Bactrocera correcta (Bezzi)* • *Bactrocera cucurbitae Coquillett* • *Bactrocera dorsalis (Hendel)* • *Bactrocera tsuneonis (Miyake)* • *Bactrocera zonata (Saunders)* Bractocera minax was previously wrongly identified as Bractocera tsuneonis (Miyake) and the latter is not present in Nepal (Adhikari, Thapa, Joshi, & Du, 2022). No new pests have been detected in citrus growing areas that have not been assessed by GACC and in case of detection of any new pests, MoALD will inform GACC as soon as possible, in order to determine if they are quarantine pests and adopt proper quarantine measures if required (Acharya, 2021).
Article 3	Cold treatment	Though, Nepal has not dedicated pack house and cold treatment facilities yet, but the fruits will be sent after packing and treating at the facilities owned by private sector. Therefore, as stipulated in the protocol, MoALD seeks technical assistance from GACC for the establishment of cold treatment facilities at the periphery of the production sites and capacity enhancement activities for the concerned MoALD officials and farmers. For the following quarantine pests of concern to China, citrus fruits will be treated 1.1^{O}C-2.22^{O}C for 21 days before export (Acharya, 2021).
Article 4	Survey surveillance of quarantine diseases and quarantine fruit fly species	Fruit fly monitoring based on the surveillance protocol was carried out in the citrus crop cycle. The findings of the monitoring surveillance of fruit fly species using para-pheromone lures, methyl eugenol (ME) and cue-lure (CL), in the 2022-23 (FY 2079/80) showed the seasonal variations in the fruit fly population. The higher fruit fly population abundance was recorded during summer months than winter. ME-traps attracted more numbers of fruit flies than CL-traps. *Bactrocera dorsalis, B. zonata, Zeugodacus tau, Z. scutellaris, Z. cucurbitae and Dacus longicornis* are the fruit fly species reported in the monitoring program. This para-pheromone based monitoring result reveled the trapping of fruit fly species other than B. minax (Chinese citrus fly) which was observed the main culprit destroying sweet oranges in the country since 2015. Along with the management measures (Area-Wide Control Program (AWCP) focusing on protein bait application and sanitation) initiated from 2018, the PMAMP, PIU Sindhuli through Junar Superzone has supported a continuous technical as well as subsidy program to the citrus growers in the command area (Adhikari, 2023, Adhikari, Thapa, Joshi, & Du, 2021).
Article 5	Implementation of IPM, citrus orchard management measures & packaging house operation	Under the supervision of MoALD, the citrus orchards have taken effective monitoring, precaution and Integrated Pest Management (IPM) to avoid and control the occurrences of quarantine pests of concern to Chinese side; and ensure that orchards maintain the phytosanitary conditions.

S N	Protocol of phytosanitary requirement	Attempt to export the citrus fruit (From Sindhuli)
Article 6	Processing, packing, storage, and transportation of citrus	The processing, packing, storage, and transportation of citrus will be conducted under the quarantine supervision of MoALD. Before the packing, citrus will be culled and sorted, those with the color or surface are abnormal will be removed, to ensure that citrus are free of insects, mites, rotten fruits as well as twigs, leaves, roots and soil. The citrus processed (selected for packing) will be stored separately to avoid re-infestation. The packaging material will be clean, sanitary, unused cardboard boxes. Every citrus packaging carton will have markings in English indicating the place of origin, the name or registration numbers of orchards and packinghouses. The cartons will be marked with Nepali, Chinese and English characters "For Export to the People's Republic of China".
Article 7	Phytosanitary certification	MoALD will sample 2% of fruits in a consignment for export quarantine inspection. In cases where live quarantine pests of concern to China are detected, the whole consignment will not be exported to China. On completion of quarantine inspection, MoALD will issue a Phytosanitary Certificate, with the following declaration: "The consignment is in compliance with Protocol of Phytosanitary Requirements for the Export of citrus fruit from Nepal to China and is free of any quarantine pest concern to China". The Certificate will indicate in English the producing area, the orchard and the packinghouse. The Phytosanitary Certificate of shipments having undergone cold treatment before export will indicate the cold treatment temperature and duration, together with the facility name or code.
Article 8	Quarantine inspection	For items having undergone cold treatment before export, the cold treatment results with attached MoALD's sign-offs, as well as fruit temperature sensor record table, will be delivered.

Effort of MoALD to export Citrus

In 2021, MoALD had tried to export the sample consignment of citrus fruits from Sindhuli and Syangja following this protocol. For this, the PMAMP PIU of both districts, registered the citrus growers, selection of superior orchards and other technical works. It also conducted pre-harvest survey of orchards to ensure that the sweet oranges are harvested at right maturity stage and right pest control practices are in place including trap placement and data recording for fruit flies in accordance with developed National Standard for Phytosanitary Measures (NSPM) by NPPO. But the entire effort could not executed due to the Covid Pandemic that the Chinese borders were closed.

Opportunities and challenges of citrus fruit export

Citrus fruit export from Nepal to China offers significant opportunities for economic growth and market expansion. However, it also presents several challenges, particularly in meeting the requirements and regulations related to plant quarantine. Opportunities and challenges associated with citrus fruit export, focusing on the requirements and regulations related to plant quarantine are presented in the Table 4 below.

Table 4. Opportunities and challenges of citrus fruit export from Nepal to China

Opportunties	Challenges
Expanding Market Access	Plant Quarantine Regulations
Economic Benefits	Pest Management
	Infrastructure and Logistics
	Capacity Building

Opportunities of citrus fruit export from Nepal to China: China's growing demand for high-quality citrus fruits presents a significant opportunity for Nepalese exporters. The large consumer base and increasing disposable income in China provide a potential market for Nepalese citrus growers and exporters. Successful citrus fruit export to China can contribute to the economic development of Nepal. Increased export revenue can enhance the livelihoods of farmers, create employment opportunities, and strengthen the country's economy ultimately decreasing the trade deficit.

Challenges of citrus fruit export from Nepal to China: China has stringent plant quarantine regulations to protect its agricultural industry from the introduction of pests and diseases. Citrus pests, such as citrus fruit fly and citrus greening disease, pose challenges in meeting China's phytosanitary requirements. Effective pest management strategies, including integrated pest management (IPM) and Good Agricultural Practices (GAP), are essential to mitigate the risk of pest infestation and ensure compliance with quarantine regulations. Establishing efficient cold chain infrastructure and logistics systems is critical for maintaining the quality and freshness of citrus fruits during transportation. Appropriate handling, packaging, and storage facilities may pose significant challenge to meet the quality standards demanded by the Chinese market. Besides, exporting citrus fruits to China requires proper documentation and certification, including phytosanitary certificates and other relevant export documentation.

Issues

In order to accelerate the activities of citrus export from Nepal to China, it appears that the issues need to be given careful consideration.

Identification of disease and pest free citrus orchards

- The systems approach
- Development of different protocols required
- Package of practices
- Infrastructure for package house, and treatment facilities
- Cold storage
- Stakeholder’s engagement: coordination and collaboration

Conclusion

While citrus fruit export from Nepal to China presents promising opportunities, it is accompanied by challenges related to plant quarantine requirements and regulations. Overcoming these challenges requires a concerted effort from stakeholders, including government authorities, exporters, and citrus producers. Collaboration, capacity building, and adherence to best practices in pest management and quality control are essential to successfully navigate the plant quarantine landscape and maximize the opportunities for citrus fruit export from Nepal to China.

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Chapter 4

Policy Tools and *Development Initiatives*

सुन्तला बगैंचा

Government Policy and Program Support on Mandarin Orange Promotion in Nepal

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Abstract

Nepal government has formulated dozens of policies and strategies in agriculture: National Agriculture Policy 2004, Agri-business Promotion Policy 2006, Agro-biodiversity Policy 2014 and Agriculture Development Strategy (2015-2035) etc. Some of the policies are targeted to different commodities (tea, coffee and floriculture etc.), and address international and national concerns and priorities. This paper aims to gather government policy and program interventions for the promotion of mandarin orange in the country. For this purpose, relevant policies, strategic plans, program and projects have been reviewed for their provision and implementation and efforts made for the promotion of the citrus particularly mandarin orange. Recommendations have been made towards sufficient institutional framework, government policy support and political commitment consideration the national interest on mandarin orange promotion in a form of national fruit program.

Keywords: Mandarin orange, Plan, Policy, Political commitment, Promotion

Introduction

Mandarin orange is a leading and a very popular citrus fruit of Nepal. It has spread in mid-hills of the country from east to far-west of Nepal. From the very beginning of the development plan and policy support, it has accorded high priority fruit in the subtropical agro-ecological zone of the country. At present in 2021/22, the area, productive area, production and productivity of mandarin orange are 27982 ha, 19481 ha. 185346 MT and 9.51 MT/ha respectively (MoALD, 2023). The share of mandarin orange in AGDP is 0.9648% in 2022/23 (MoALD, 2023).

Policy support of the government has been reflected in periodic plan, strategic plan document and budget speech, and campaign programs which are briefly discussed as below:

Master Plan for Horticulture Development (MPHD, 1991-2010)

MPHD has envisioned the special significance of development of horticulture sector that has the potential to generate resources to require to pay for imports and also to enhance individual incomes so that vast majority can purchase their requirements without the need for subsidies or government interventions. It has identified four agro-ecological zones namely cool temperate, warm temperate, subtropical and tropical zones. A general policy set by MPHD is the development of fruits in the mid-hills of the country and citrus (mandarin orange) is one of the prioritized fruit crop for the mid-hills of the country. Research priorities have also been outlined in the plan document. The twenty year MPHD has recommended ten short term strategies (one to three years), ten mid-term strategies (four to seven years) and ten long term strategies (seven years onwards) for the development and promotion of horticulture in the country. Though MPHD was not approved by the government of Nepal, the document has been used as a guiding document while formulating the horticulture development plan, strategy and program in the country.

Agriculture Perspective Plan (APP, 1997-2017)

One of the main objectives of APP was to transform the subsistence agriculture to commercial one through diversification and widespread realization of comparative advantages based agriculture. It had identified four priority inputs (irrigation, fertilizer, technology, roads and power) and four priority outputs (livestock, high value crops, agribusiness and forestry). Similarly priority package program strategy had been emphasized.by the plan.

Citrus mainly mandarin orange had been recognized one of the high value crops in the mid-hills of the country. For the implementation of the pocket package strategy, pocket package strategy implementation guideline has defined five categories of pockets namely: (i) Pocket with irrigation, road and electricity facility; (ii) Pocket with irrigation and road facility (iii) Pocket with irrigation facility (iv) pocket with road facility and (v) other feasible pocket i.e. traditional agriculture pocket area. The size of pocket for fruits (e.g. mandarin orange in the mid-hill was 150 ha. A number of commercial pockets of mandarin orange have been developed under this strategy which has given a momentum towards the commercialization of mandarin.

National Agriculture Policy (NAP, 2004)

NAP was formulated to support the implementation of APP. Major policy provisions that contributed in the promotion of mandarin orange in the country are:

- Development and extension of irrigation facilities, agriculture roads, rural electrification and appropriate technologies.
- Intensive and wider use of available technologies in the areas with irrigation, roads and electrification
- Pocket Package Strategy (PPS)
- Encourage agricultural commercialization and diversification

- Encourage high value crops production along the North-South highway and its feeder roads
- Development and strengthening of resource centers for quality inputs supply and technical service
- Farmers capacity development through agriculture training
- Larger pockets development to meet the quantity and quality of the market demands

The provisions made in the policy are being implemented by MoALD/DoA such as area expansion of mandarin orange in commercial scale along the North-South highways and due attention has been given towards strengthening of resource centers to some extent.

Agri-business Promotion Policy (ABPP, 2006)

This policy was prepared in the spirit of National Agriculture Policy 2004 emphasizing diversification, commercialization, and promotion of the agriculture sector with private sector involvement in commercial farming.

Major policy provisions that have contributed to the promotion of mandarin orange are:

- Establishment and development of growth center based on geographic, economic, and technical potentiality
- Designation and demarcation of three types of production areas, namely commercial crop and commodity production area; organic and pesticide free production area; and agricultural products export area
- Development of infrastructure (business service centers, markets and collection points, and rural roads and electricity) for post- harvest, marketing and processing
- Emphasize partnership between the private and the government
- Development of system for insurance of commercial crop production, livestock, markets, and agro-industries
- Priority given in developing market network in the context of Nepal's entry into the WTO

The provision made in the policy is being implemented by MoALD and DoA. Collection centers in nearby citrus production pockets have been developed where there is road facility. Partnership program with private sectors like One Village One Product in mandarin orange had been implemented.

Agriculture Development Strategy (ADS, 2015-2035)

ADS is a twenty-year (2015-2035) vision for agriculture development in Nepal as a major policy guideline for agricultural transformation in the country. The ADS document presents the overall agriculture development strategy and a 10-year action plan with roadmap, which also includes visions, outcomes, outputs, and activities for the sector. The basic features of ADS namely concept of value chain, growth strategy, sustainability, multiple priorities (food-based, nutrition-based, peasants right-based, and market oriented), inclusive and pluralistic (government, farmer groups/cooperatives and private sector engagement) approaches, and welfare (MoALD, 2023). Though ADS does not prioritize fruit development activities and even not listed in the top 15 value chain ranking in its document, the concept envisioned by the strategy is very relevant to follow and are being undertaken by different projects in their formulation and implementation (MoALD, 2023).

Major policy intervention for mandarin orange promotion in Periodic Development Plan

The Fifth Five Year Plan (1975-1980)

Agriculture was given top priority in the plan and declared 1975 as an Agriculture Development Year. The plan aimed to strengthen the existing government horticulture farm/centers and focused on establishing private fruit nurseries to meet the demand of the saplings. It had given high priority to farmers' problem solving adaptive researches.

The Sixth Five Year Plan (1980-1985)

Fruit development efforts were concentrated in hills especially in the areas where transport infrastructure was already available and also near urban areas. Priority areas for different fruit crops were directed emphasizing the cultivation of apple and dry fruits in high hills, citrus in mid-hills and mango, litchi and banana in terai and foothills. To meet the saplings requirements emphasis had been given in establishing private fruit nurseries.

The Seventh Five Year Plan (1985-1990)

Fruit development program was also directed to the high way corridors and densely populated areas. It identified major fruits including mandarin orange for commercial production. Priority districts were listed for the commercial production for mango, banana, mandarin orange, sweet orange, apple, pear and walnut.

The Eighth Five Year Plan (1992-1997)

Special (commercial production) and general program (homestead production) on fruits including mandarin orange were conducted during the plan period. Development of commercial orchards had been focused in areas along the highway corridors (spelt out in the documents) running from east to west and from north to south all over the country. All the technical services, timely credit, planting materials and other required production inputs were planned to make available at the grass root level.

The Ninth Five Year Plan (1997-2002)

Based on APP of 1995, the plan identified citrus mainly mandarin orange as high value crop for the mid-hills, the emphasis was on the pocket package development strategy. A number of mandarin orange pockets were developed during the plan period.

The Tenth Five Year Plan (2002-2007)

Some of the provisions made in the tenth periodic plan are:

- Pocket Package Program (PPP) launched on the locations specific priority crops/commodities identified by APP. In such developed pockets, necessary infrastructure development programs were focused in an integrated way.
- Agricultural research was focused on the APP's prioritized high value crop/commodities.
- The resource centers were directed to provide the necessary technical back up support to the district development committee to conduct the agriculture/livestock services program.
- Agriculture extension services were made not limited to the production but to focus on commercialization based on comparative advantage, agricultural business promotion and effective market information dissemination.
- The farmers and farmers' groups mobilized for the construction of collection centers and cellar stores in the production area. In the feasible areas, required credit made available at confessional rates for the construction of multi-chambered cold storage. The rebate on customs made available when necessary on the import of equipment and tools for the cold storage. Likewise, provision made to provide assistance for the construction of Cold Chain as necessary for perishable crops which are exportable.
- Declared the tenth and Eleventh Plans as the agriculture decade. Special emphasis laid on the improvement of the organizational structures and the fulfillment of the necessities to bring about effectiveness in the implementation aspects. Provisions made in the manner so as to inspire the government and non-government institutions to support agricultural development in priority basis.
- Developing and strengthening of infrastructures for conducting training in horticulture in Central Horticulture Center (CHC), Kirtipur was also highlighted in the document.

The Eleventh Plan - Three Year Interim Plan (2007/8-2009/10)

Some of the Policy/working policy highlights of the plan relevant to mandarin orange promotion are:

- Mandarin orange had been listed among the three years' priority agricultural crops and commodities
- Focus on pocket area infrastructure development and expansion of OVOP for specializing crops, commodities based on comparative and competitive advantages.
- Focus on District Priority Production Program to become self-sufficient in one or more items including fruit saplings
- Emphasized making the agricultural research system practical, accountable and result oriented by giving it a high priority in public sector investment
- Focus on implementation of agriculture research, extension and education in coordinated and integrated manner.

The Fifteenth Five Year Plan (2019/20-2023/2024)

Working policy highlights made in the plan document are:

- Enhancing the capacity of federal, provincial, and local levels for agricultural research and development
- Developing a mechanism for coordination and facilitation to avoid duplication in priorities, policies, laws, and plans of the federal, provincial, and local levels.
- Improving strategies, structures, and human resource management to design an appropriate model for agricultural and livestock extension services at all three levels of government.

Important events for institutional development for the promotion of mandarin orange in the country

- Citrus Research Station was established in 1961 AD at Dhankuta and substation at Malepatan, Pokhara. In 1966 (BS 2022), their name has been changed to Agriculture Research Station, Dhankuta and Horticulture Research Station, Pokhara.
- National Citrus Development Program (NCDP) was established in BS 2029 (1972 AD) in Pokhara and moved to Dhankuta in BS 2031 (1974 AD) giving full responsibility for citrus Research and Development (R&D) of the country. In 1977 AD (BS 2034) Horticulture Research Station, Dailekh was established in Mid-Western Region with major mandate on citrus. Dhankuta, Pokhara and Dailekh Stations were identified as major centers for citrus R & D. Horticulture Farms at Sindhuli and Palpa were also associated with Citrus Development Program (CDP) at that time.
- Dhankuta Agriculture Research Station was handed over to Nepal Agricultural Research Council (NARC) after the establishment of NARC in 2048 and named as Agriculture Research Station (Horticulture), Dhankuta. From July 2000 (Shrawan 2057 BS) the station was officially recognized as National Citrus Research Program (NCRP) (Shrestha T.N. & Regmi, 2016).

Mandarin orange support program in different projects

Indian Cooperation Mission (ICM, 1960-1971)

ICM provided a stimulus and assistance to establish several horticultural research stations, to introduce a wide variety of tropical, subtropical, temperate fruits and nut species and cultivars, and to provide outside horticultural training to Nepalese technicians. During this period, a total of 14 Horticulture Stations (including Horticulture Research Station, Pokhara and Horticulture Research Station Dhankuta for citrus) were established in different ecological regions of the country, The principal activities of these stations were to (1) evaluate different fruit species and cultivars, (2) produce nursery plants of several species for distribution to farmers at a minimum cost, (3)provide short term training courses for farmers, and (4) provide technical support to the horticulture development program (MPHD, 1990).

National Citrus Priority Program

National Citrus Priority Program was implemented in 1983/84 with an objective of commercialization of citrus production particularly mandarin in 20 districts namely Illam, Dhankuta, Tehrathum, Sankhuwasabha, Bhojpur, Khotang, Okhaldhunga, Ramechhap, Sindhuli, Dhading, Gorkha, Lamjung, Tanahu, Kaski, Syangja, Palpa, Gulmi, Arghakhanchi, Salyan and Dailekh. Program was in a form of campaign with a focus on establishment of commercial orchards and nursery establishment with financial support of government. Due to regular monitoring and supervision, the program was implemented effectively. This was one of the successful program initiated by the government in the past. Most of the commercial orchards of today in those districts were the impact of this intervention. In order to encourage farmers in the fruit production, the government provided interest subsidy also on the credit of fruit farming (Kaini, 2005).

Horticulture Development Project (HDP, 1985-1997)

HDP was implemented with the support of Japanese government from 1985 to 1997. Some exotic citrus species and varieties were introduced from Japan and established evaluation blocks at Horticulture Centre, Kirtipur. Studies on evaluation of local land races (mandarin orange, sweet orange and pummelo), cultivation techniques, rootstock evaluation, harvesting and storage techniques were carried out. During the project period 24 types of exotic citrus varieties were introduced in order to study and select the better performers under Nepalese agro-climatic conditions. Some of the varieties like Yoshida Ponkan (better quality because of high brix and low acid percentage leading to consumer acceptability), Okitsuwase and Miyagawawase (early maturity character and good quality) and Murcott (late maturity character and good quality) have shown promising results. Long and short-term training to Junior Technician/Junior Technical Assistant (JT/JTA) and farmers and establishment of demonstration farms were other activities of the project (HDP, 1995). The Okitsuwase upon further evaluation got registered in 2024 as Paripatle Agaute *Suntala*-1.

Hill Fruit Development Project (HFDP, 1988-1997)

HFDP in eleven hill and mountain districts of Eastern Development Region was implemented from 1988/89 to 1996//97 with the support of Asian Development Bank. Main thrust of the project was to increase the production of citrus in mid-hill region, apple in temperate region and banana and pineapple in terai and lower altitude. It supported to improve research facilities at NCRP, Dhankuta, to improve extension services, construction of market yards and cellar storage and establishment of nurseries in private sector (APROSC, 1999).

Hill Agriculture Research Project (HARP, 1977-2004)

HARP was implemented during the period of 1997-2004 with financial support of British Government's Competitive Grant System (CGS) in Nepal in Agricultural Research. Research works on various aspects of mandarin orange had been conducted. Major research works were: management of fruit drop in mandarin orange, improvement of postharvest shelf life and marketing of mandarin orange in the hills of Nepal, integrated mandarin orange tree health improvement in the hills of Nepal, citrus decline management projects, development and use of tissue culture technology against citrus decline, development of improved package technologies for increased productivity and quality of mandarin orange in the eastern hills of Nepal (HARP, 2004).

Commercial Agriculture Development Project (CADP, 2007-2014)

The Ministry of Agriculture and Cooperatives (MoAC) implemented a Commercial Agriculture Development Program (CADP) for a period of 2007-2014 with financial support of Asian Development Bank (ADB) for some high value crops including citrus. This project provided financial support in planting materials, horticultural equipment and plant protection chemicals for commercializing citriculture in the mid-hills. Establishment of Commercial Agriculture Alliance (CAA) was one of the most important outputs of the project (MDT, 2014).

Value Addition Program

In 2009/10 and 2010/11, the program was implemented to improve fruit quality and commercial market promotion in Panchthar, Dhankuta, Gorkha, Tanahu, Syangja, Parbat, Argakhachi, Dailekh, Dadeldhura, Gulmi, Salyan, Rolpa and Kailali districts (Paudyal et al., 2016).

Citrus Orchards Improvement Program

In 2013/14, the program was executed in Dhading, Gorkha, Lamjung, Tanahu, Kaski, Syangja, Parbat and Myagdi districts to improve declining orchards. Subsidy was provided @ NRs. 76,000 per hectare for 50 hectares in each district. The program was continued in FY 2014/15 to cover 20 hectare per district with same amount of subsidy (Paudyal at al., 2016).

One Village One Product in Mandarin Orange

One Village One Product (OVOP) was a government partnership program with the private sector. Agro Enterprise Center (AEC) played a lead role in coordinating and conducting this program. OVOP program on mandarin orange had been conducted with the partnership of respective district's District Chamber of Commerce and Industry (DCCI): Bhojpur (from 2013/14 to 2016/17), Dailekh (in 2015/16 and 2016/17) and Darchula (in 2016/17) for the promotion of mandarin orange. Besides this, mandarin orange was one of the components of OVOP on Agri-tourism conducted by Lekhnath Chamber of Commerce and Industry, Kaski from 2007/08 to 2016/2017 (AEC, 2017).

Technical Cooperation Program on Combating Citrus Decline Problems In Nepal

This FAO supported project was conducted to combat the citrus decline of Nepal. It has come up with some recommendation on:

A. Strategies related to:
   - i. Commercial citriculture as well as combating citrus decline
   - ii. Policy and institution
   - iii. Nursery and orchard management

    iv. Insect pests and diseases

B. Improved production technology with particular focus on combating citrus decline.

C. Rejuvenation of declined citrus orchards through improved practice (FAO Nepal, 2011)

Agriculture Sector Development Program (ASDP, 2018 - till date)

ASDP has been implemented 2018 AD for a period of six years in ten hill and mountain districts of Karnali Province (Dailekh, Dolpa, Humla, Jajarkot, Jumla, Kalikot, Mugu, Rukum Western, Salyan and Surrket). The value chain commodity of fruits are apple, walnut and citrus. One of the value chain targeted was citrus mainly mandarin orange in the mid-hills of the Karnali province. In the initial stage of the program a strategic investment plan of mandarin orange was prepared but it has not been materialized. It has been reported that some of the value chains initially targeted was dropped which includes mandarin orange also (MoALD, 2023).

Prime Minister Agriculture Modernization Project (PMAMP, 2016 - 2026)

PMAMP is ten years (2016/17 - 2025/26 AD) Nepal government funded project in commercialization of agriculture and transformation of agriculture towards industrialization to contribute higher rate of value addition. It has undertaken the program in four level i.e. Small Commercial Production Center (Pocket), Commercial Production Center (Block), Commercial Production and Processing Center (Zone) and Commercial Production and Industrialization (Super zone). One of the priority commodities of the project is mandarin orange. It has developed one super zone in Syangja and 17 zones (Solukhumbu, Udayapur, Gorkha, Magdi, Nawalparasi East, Gulmi, Jajarkot, Dailekh, Dhankuta, Sankhuwasabha, Bhojpur, Palpa, Doti and Darchula) in the mandarin orange in the mid-hills of the country spread from far-west to far-east of the country. This program has contributed a lot in the commercialization of mandarin production and marketing based on the value chain approach (PMAMP, 2023).

Developmental programs on fruit crops including mandarin orange under FDD/ NCFD

Various fruit developmental programs have been implemented by the then Fruit Development Directorate (FDD) and the current National Centre for Fruit Development (NCFD) in order to reduce import, promote export and address trade deficit in fruit crops.

Fruit Decade Program (2016/17 - 2025/26)

In 2016, Nepal government has announced the years 2016/17 to 2025/26 (B.S. 2073/74 to B.S. 2082/83) as the Fruit Decade. Fruit Decade Implementation Guideline 2016 (2073 B.S.) has been approved by the ministry in the 2016/17 and in order to avail quality fruit saplings to support the decade program another guideline Fruit Saplings Production Infrastructure Development Guideline 2016 (2073 B.S.) has also been approved in the same fiscal year.

The main objectives of the program are to increase the production and productivity of fruits through quality sapling production, orchard area expansion and strengthening thereby resulting in self-reliant on major fruits (Mango, Litchi, Banana, Mandarin Orange, Acid Lime, Lemon, Apple etc.) through a decade long program on fruits. Programs listed are as follows:

- Quality saplings production program: Farm/centers, private sectors, tissue culture, screenhouse construction, training and visits.
- Fruit pocket area expansion program: Site selection, training, fruit saplings distribution, high density planting.
- Emerging fruit crop promotional program: Site selection, training, fruit saplings distribution, high density planting.
- Import of potential fruit varieties: Import of propagating materials (rootstocks and scion), multiplication and production of saplings in farm/centers
- Value chain program on fruits: Production, post-harvest, grading, storage, processing and marketing
- Horticulture tourism promotional program: Model farm development, fruit-based tourism industry development
- Technology transfer program: Trainings and tours, seminars, exhibition, publication of technical matters on fruits
- Research programs on (i) varietal characterization and development, (ii) farmer's problem oriented, and (iii) socio economic analysis of fruit production
- Envisaged impact of fruit decade on fruit production is shown in Figure 1. Before the start of the decade program i.e. in the 2015/16, the area under fruits was 1,57,199 ha and productive area was 1,10,586 ha and the production of fruits was 9,76,481 MT. After the completion of fruit decade program, the area is expected to be 2,79,083 ha, the production is expected to rise to 20,02,821 MT in business as usual. After the intervention the production is expected to rise to 29,94,593 MT.

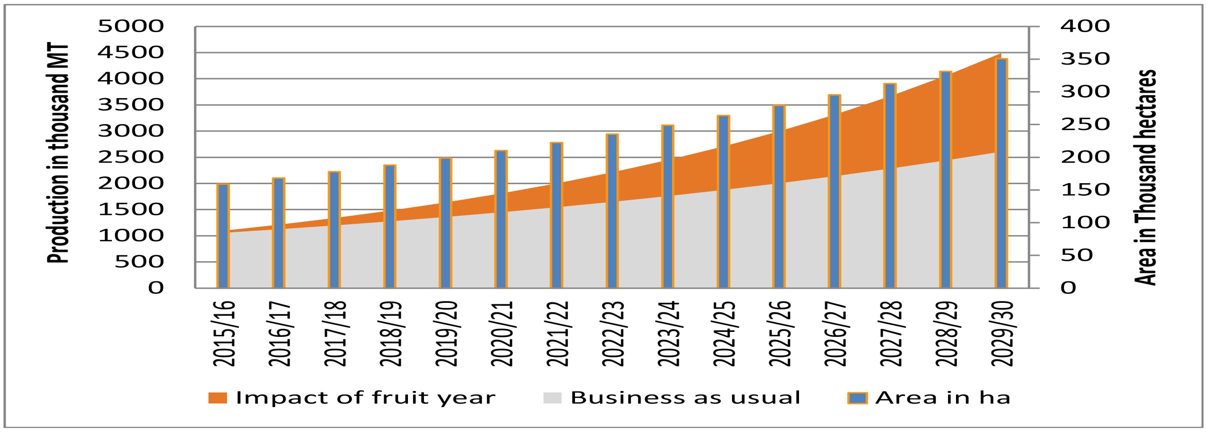

Figure 1. Envisaged impact of fruit decade on fruit production

During the first five years of fruit decade, quality saplings production program was emphasized for the expansion of fruit orchards as short term strategy and next five years was emphasized for new technology transfer and post-harvest handling and processing industries development.

Programs implemented in line with Fruit Decade

In the first year of fruit decade (2016/17): The Nursery development programs were implemented through the District Agriculture Development Offices (10 districts for temperate fruits, 10 districts for warm temperate fruits, 19 districts for citrus fruits and 10 districts for tropical fruits (Table 1).

Table 1. Fruit sapling production infrastructure development programs in 2016/17

S. No.	Fruit categories	Major fruits	Number of nurseries per district	Districts
1.	Temperate fruits	Apple, Walnut, Apricot	One nursery per district =10	Jumla, Humla, Dolpa, Mugu, Kalikot, Mustang, Manang, Rasuwa, Solu and Baitadi
2.	Warm Temperate fruits	Pomegranate, Hog-plum, Kiwi, Pear, Persimmon	Two nurseries per district = 20	Dolakha, Sindhupalchowk, Ilam, Bhaktapur, Sindhul, Dhading, Salyan, Dailekh, Kathmandu, Makawanpur
3.	Subtropical fruits	Citrus (Mandarin Orange, Acid Lime and Sweet Orange)	One nursery per district =20	Bhojpur, Udaipur, Terhathum, Dhankuta, Palpa, Baglung, Kaski, Chitwan, Ramechhap, Kavrepalanchowk, Gorkha (2 sets of nurseries), Tanahun, Syangja, Arghakhanchi, Salyan, Dailekh, Doti, Dadeldhura, Kailali,
4.	Tropical fruits	Mango, Litchi, Banana and Papaya	One nursery per district =20	Bara, Rautahat, Siraha, Saptari, Sarlahi, Rupandehi, Banke, Bardia, Surkhet, Kanchanpur

In the second year of fruit decade (2017/18): Private Nursery Development Program of Fruit Development Directorate was implemented through farms and centers at Sarlahi, Janakpur, Trishuli, Daman, Marpha and Palpa. Program aimed to establish and strengthen nurseries in their command districts. Budgets were allocated to government farms for farm infrastructure construction, strengthening farm roads, fencing and nursery infrastructure construction and strengthening screen houses, glass houses and net-houses.

In the third year of fruit decade (2018/19): Fruit Plantation Area Expansion Program was implemented. A guideline on Fruit Plantation Area Expansion in public and private lands was prepared and followed. Major objectives were import substitution and export promotion through commercial fruit cultivation area expansion. Proposals were called from 15 districts for plantation in private lands in which area of plantation should be at least 10 hectares in a block. Kiwi, Pomogranate, Mandarine orange, Acid lime and Mango were the priority crops for plantation.

Citrus Nursery Improvement Program

NCFD had implemented Citrus Nursery Improvement Program where Screen houses constructed for citrus saplings production (Ramechhap, Sindhuli, Gorkha, Lamjung). In the 2020/21 (B.S. 2077/2078), screen house construction program was implemented through Provincial Government (AKCs) in 29 districts. There are several citrus development programs being implemented through the conditional grants at the Provincial and Local Level (Table 2).

Table 2. List of citrus development program being implemented with the support of NCFD at the Provincial and Local Level

Fiscal Year (BS)	Programs	Activities	Provincial Level	Local Level	Budget Allocation (NPR)
2075/76	Extension of fruit cultivation program in public and private land	Extension of mandarin orange and acid lime fruit cultivation			
2076/77	Citrus nursery strengthening program	Construction of nine screen houses	Ramechhap - 4 Sindhuli - 5	-	-
2077/78	Mandarin orange fruits nursery strengthening program	Area expantion of citrus fruits	-	171	243,975.00
		Establishment of new nurseries	-	231	48,050.00
		Improvement of old nursery	-	102	25,075.00

Fiscal Year (BS)	Programs	Activities	Provincial Level	Local Level	Budget Allocation (NPR)
2078/79	Citrus crops promotion program	Improvement of old screen houses	-	29	22,000,000.00
		Mandarin orange orchard management and plantation of saplings	-	82	-
		Commercial mandarin orange cultivation	-	34	3,450,000.00
2079/80	Commercial citrus fruits extension program	Mandarin orange and acid lime fruit saplings plantation	-	30	28,820.00
		Citrus nursery strengthening	11 Districts (Khotang, Okhaldunga, Ramechhap, Kavrepalanchok, Gorakha, Parbat, Myagdi, Arghakhanchi, Gulmi, Salyan, Dadeldhura)	-	11,100,000.00
	Citrus fruits saplings production program	Construction of screen house	Floriculture Development Center, Godawari, Lalitpur	-	8,500,000.00
2080/81	Citrus fruits farming promotional program		46 Districts	-	-

PCR and CTV testing programs

NCFD is providing necessary counseling every year to the citrus nursery and citrus orchard owners through Citrus Greening Disease (CGD) and Citrus Tristeza Virus (CTV) testing program. These testing programs have been started in Warm Temperate Horticulture Center, Kirtipur in Kathmandu and Citrus Fruit Development Center, Palpa under NCFD.

Development of Protocol/Procedure/Guideline

NCFD has been implemented CGD and CTV testing protocol approved by MoALD. Similarly, NCFD has been developed a guideline as a Greening Affected Orchard/Plant Uprooting and Replantation Procedure (*Karyabidhi*) to give relief to the citrus orchard owners. Equally, NCFD has been developed a protocol of Citrus Bud-wood Certification Program which is under approval from the Ministry. Also, Farmers' Registration Procedure under Nepal-China Protocol has been developed and under the approval of the Ministry.

Publication of citrus related documents

NCFD has been promoted citrus fruits sub-sector through the seminar and publication of several citrus related books and documents as well. In this order, NCFD has been published Cultivation Practices of Citrus Fruits and Post-harvest Management of Citrus Fruits.

On the recommendation of the Ministry at the initiative of the NCFD, the Government of Nepal has declared Mandarin Orange as the National fruit. NCFD in collaboration with NHS organized a Seminar on Mandarin orange and a Compendium on Mandarin orange under the title "Mandarin Orange: History, Science and Technology in Nepal" is under publication.

Programs run by Provincial and Local Level Governments

As the country has adopted the federal system, government agriculture organizations have undergone massive restructuring, all regional agriculture directorates and district agriculture development offices have been dismantled and instead agriculture related ministry, agriculture development directorate are established in every province and 51 Agriculture Knowledge Centers (AKCs) are established throughout the country in the FY 2018/19. Therefore, the implementation modality of the fruit decade as given in the guideline is also affected. In the provinces, horticulture programs including fruit development programs have been proposed and implemented based on their strength of human resources and budget availability. To some extent, radio programs were aired to create mass awareness regarding the fruit decade program, technical information regarding various aspects of fruit cultivation including quality planting materials were broadcasted depending on the season. Area expansion of certain fruits through subsidy programs and contract farming were also done by some of the AKCs and province level farms. Federal guidelines of fruit development programs have been used as guiding documents for the preparation of their own guidelines. Area expansion of certain fruits were continued in the FY 2019/20 by some of the AKCs and province level farms.

The FY 2018/19 was the first year for local level bodies (municipalities). Agriculture sections with limited human resources are also conducting fruit development programs based on their perceived importance and priority.

As government agriculture organizations have undergone massive changes, Fruit Decade programs, and modality need some revisions and need to be adjusted accordingly. Clear cut roles and responsibilities are to be provided at every level (local, provincial, federal). More campaigns are required on the 'Fruit Decade' at all levels of the governments in order to bring a momentum, then only increase in area and productivity of fruits will be accelerated thereby aid in import substitution of major fruits.

Citrus related activities under Provinces

Directorate of Agriculture Development (DoAD), Sudurpaschhim Pradesh has been promoting commercial citrus production mainly mandarin orange and strengthening citrus nursery in the mid-hills of Doti, Dadeldhura, Bajura and Kailali (DoAD, 2021/22). Likewise Directorate of Agriculture Development (DoAD), Koshi Pradesh has envisioned the potentialities of area expansion, production and export promotion of mandarin orange particularly in Dhankuta, Ilam and Panchthar districts. Programs on citrus orchard management and strengthening, management of citrus decline, citrus insect-pests, diseases and acid lime production promotion have been implemented through Agriculture Knowledge Centers of Bagmati, Karnali, Lumbini and Gandaki Province in line with Fruit Decade Program (DoAD, 2022/23).

Nuts and Fruits in Hilly Areas Project (NAFHA, 2022 - 2029 AD)

National Centre for Fruit Development (NCFD) is implementing seven years (2022 to 2029 A.D.) project entitled "Nuts and Fruits in Hilly Areas (NAFHA)" with financial assistance from the Asian Development Bank (ADB), Global Agriculture and Food Security Program (GAFSP) and the Government of Nepal. The project will increase agricultural income of approximately 40,000 beneficiary farm households in 100 municipalities from 34 district of five provinces – Koshi, Bagmati, Gandaki, Karnali and Sudurpashchim. The outputs of the project are: Output 1: Institutional capacity for nursery and horticulture sector management improved; Output 2: Production and productivity of project farmers increased; and Output 3. Value addition to hilly area horticulture produce enhanced. The project will also improve the institutional capacity for managing the nursery and horticulture sector. This will be mainly achieved by developing about 10,000 ha of climate- resilient fruit and nut orchards providing value addition to the nuts and fruits produced by about 30,000 farmer households and 1,000 ha of vegetable and nutritious crop cultivation. The project focuses on ten fruit crops namely Apple, Walnut, Pecanut, Almond, Kiwi, Mandarin orange, Sweet orange, Acid lime, Avocado, and Macadamia nut. Mandarin orange is one of the main targeted fruit crops which alone covers 2600 hectares (26%) out of the total 10,000 hectare of targeted area expansion. Similarly, the project will strengthen the institutional and technical capacity of 12 government horticultural resource centers (3 from NCFD, 4 from provinces and 5 from NARC) which will help in production of recommended standard quality saplings and implementation of the fruit nursery certification system in the country.

Variety registration and declaration of national fruit

A milestone of R&D activities on the varietal development and evaluation of mandarin orange was achieved when Khoku Local variety, the first variety of mandarin orange registered by the government in 2018 (ALD, 2023) followed by registration of Banskharka local and Paripatle Agaute *Suntala*-1 variety of mandarin orange in 2024 (ALD, 2024). On April 12, 2024 (Chaitra 30, 2080 BS), Government of Nepal declared Mandarin Orange as the national fruit of the country. It shows a strong concern of Nepal government for the promotion of mandarin orange in the country.

Conclusion

Development and promotional activities undertaken in the past has contributed a lot to attain the present status of mandarin orange in the country in respect to area expansion, production and productivity increment, market networking and the income and employment generation of the different value chain actors involved in mandarin orange value. One level of capacity has been established in the country towards institutional development, human resource development, research development and education sector, despite realization of policy limitation towards addressing the issue of citrus decline and quality control of mother stock and nursery plants maintained in the citrus nurseries in absence of nursery act. To date, the level of progress in the mandarin orange development and promotion is still not sufficient to meet the market demand, import substitution, limited options in the variety, seasonal availability of fresh mandarin orange only for few months, inadequate postharvest facilities and storage, citrus greening disease still a great threat, non-availability of healthy and quality saplings and very limited experts roster in hand are some of the notable challenges in the promotion of mandarin orange in the country. At present, inadequate human resource management for horticulture extension and technical service delivery to the mandarin orange growers at the farmer's level and absence of effective mechanism to maintain strong cooperation and coordination among three tiers of government has been taken in to account as a policy constraint to accelerate the growth of the citrus industry in the country.

Suggestions

- Continued R&D support program is needed for varietal development and evaluation. More collaborative and action research should be conducted by NARC together with academic institutions and government farm/centers in the country.
- Structural arrangement for the citrus development has been downsized as compared to past efforts. Lead institution/organization should be established to look after citrus development activities in the country.
- Formulation of nursery act is an urgent need to regulate quality maintenance of the mother

stocks, nursery sapling production and distribution.

- Strategy should be developed to address the issue of citrus decline in farmers field.
- Mechanism of horticulture extension should be developed for timely delivery of appropriate technology and quality technical service to the farmers at grass root level.
- Roaster of citrus experts should be prepared and maintained to make avail the experts' service in the promotion of citrus, mandarin orange in particular.
- A National Fruit Program should be formulated and implemented in collaboration of federal, provincial and local government with full political commitment and direct policy support.
- Capacity enhancement of grassroot level frontline agriculture technicians should be done in a regular basis.

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Mandarin Orange Germplasm Collection, Evaluation, Sapling Production and Plant Protection System in National Citrus Research Program, Dhankuta

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Abstract

National Citrus Research Program (NCRP), Paripatle, Dhankuta, is one of the commodity research programs of Nepal Agricultural Research Council (NARC), implementing research and development works exclusively in citrus crops. The objective of the paper is to summarize the present research programs and achievements of NCRP, Dhankuta. Research programs include, germplasm collection, evaluation and maintenance, development of technologies on nursery production and management, management of disease and insect pest, high density planting (HDP) and development of post-harvest storage technologies. Till now, about 44 different accession of mandarin orange has been collected and evaluated out of which three varieties namely, 'Khoku Local', 'Banskhark Local' and 'Paripatle Agaute-1' mandarin orange has been registered and recommended for commercial cultivation in Nepal. Use of plastic tunnel along with foliar application of GA3 and nitrogen has been recommended for faster growth citrus rootstock to attain the graftable size within one year of seed sowing. In mandarin orange, grafting with shoot-tip method achieved 77.78% success while veneer method achieved 82.08% success rate. When comparing dates of grafting, 13th of January produced the highest graft success (96.11%) and the lowest mortality rate (0.29%). Technologies on citrus nursery and orchard has been developed principally on disease and insect pest management. The management of Huanglongbing (HLB) is becoming most challenging as the population of citrus psylla, vector of HLB, is increasing in lower belt of citrus growing areas of Nepal. Therefore, NCRP, Dhankuta is giving top priority in production of disease free planting materials under the hi-tech poly house using disease free mother stocks.

Keywords: Mandarin orange, Germplasm, Mother plant, Field gene bank

Introduction

Citrus is the important fruit crop of Nepal occupying 27% area of the total fruit area. It is cultivated in 49,306 ha area of which 32,317 ha is productive from where about 3,06,149 mt fresh fruit is produced. The yield of citrus crop is 9.47 mt/ha. Out of 77 districts, citrus crops are being cultivated in 69 districts of which commercial production of the citrus is concentrated in about 48 districts. Out of total area of citrus, mandarin orange covers about 27,982 ha of which 19,481 ha area is productive which produces 185,346 mt fresh fruit having a productivity 9.51 mt/ha (MoALD, 2023).

Citrus industry of Nepal is encountering several biotic and abiotic problems resulting in the decline of orchards. Decline resulting from diseases like Huanglongbing, root rot, citrus canker, gummosis, powdery mildew, etc., insect pests such as citrus scale, aphids and white fly are considered biotic factors while drought, poor plant nutrient management are considered abiotic factors. To address these problems, a separate commodity program has been established at Paripatle, Dhankuta with the name National Citrus Research Program (NCRP).

NCRP was established under NARC in line with the idea of conducting special research on crops and commodities. Before this, the program was working in various organizational formats. First of all, in 2018 BS, a "Citrus Research Center" was established at Paripatle, Dhankuta under the Department of Agriculture. In the fiscal year 2023/24, it was renamed as "Horticulture Research Center" with the plan of extending the research area to other horticultural crops. Again, with the aim of extensive implementation of its program, it was changed to "Dhankuta Agriculture Center". Later, Citrus Development Program established at Pokhara in 2029 B.S. was transferred to Paripatle, Dhankuta in 2031 B.S. In 2048 B.S. the office of the Citrus Development Program was shifted to Kirtipur, Kathmandu and only the farm and office of the "Dhankuta Agriculture Center" were kept in Dhankuta. As per the decision of the Government of Nepal to conduct all the research programs related to agriculture from the National Agricultural Research and Service Center (NARSC), this office was also placed under the same service center. Later, in 2048 BS, the service center was abolished and the Nepal Agricultural Research Council was established. The center was renamed Agriculture Research Center, Dhankuta under the council and has been functioning as the "National Citrus Research Program" since 2057 BS (NCRP, 2023).

Mandarin orange germplasm available at NCRP

About 44 accessions of mandarin orange have been collected and maintained at the field gene bank of the NCRP, Paripatle, Dhankuta to date (Table 1).

Table 1. List of different varieties/lines of mandarin orange at NCRP, Paripatle, Dhankuta till March, 2024

S.N.	Accession No.	Variety/Line	Source	Remarks
Mandarin Orange				
1	NCRP-01	Khoku Local	Khoku, Dhankuta	Released, Local mid-season variety of Dhankuta
2	NCRP-02	Kinnow (King orange × willow leaf mandarin orange)	Pakistan	Suitable for Terai region of Nepal
3	NCRP-03	Frutrel Early	Unknown	High yielding early variety
4	NCRP-04	Unshiu	JICA, Japan	Early maturing Satsuma mandarin orange
5	NCRP-05	Miyagawawase	JICA, Japan	Early maturing Satsuma mandarin orange
6	NCRP-06	Okitsuwase	JICA, Japan	Early maturing Satsuma mandarin orange registered as 'Paripatle Agaute-1'
7	NCRP-08	Pongan	ICIMOD	Tangerine
8	NCRP-09	Kamala	Dhankuta	Hybrid between mandarin orange and pomelo
9	NCRP-10	Banskharka local	LAC, Lumle	Registered mid-season variety for mid-hill of Gandaki province
10	NCRP-11	Sikkime *Suntala*	Tehrathum	Have high TSS and TSS/TA ratio
11	NCRP-12	Calamondin	Unknown	Hybrid of Kumquat and mandarin orange
12	NCRP-80	Satsumawase	INRA-CIRAD, France	Satsuma mandarin orange Early maturing variety
13	NCRP-81	Satsuma Mino	INRA-CIRAD, France	Satsuma mandarin orange Early maturing variety
14	NCRP-82	Satsuma URSS	INRA-CIRAD, France	Early maturing variety Early maturing variety
15	NCRP-88	Fortune	INRA-CIRAD, France	Most aromatic and sweet mandarin orange
16	NCRP-89	Kara	INRA-CIRAD, France	Very late maturing and richly flavored variety
17	NCRP-90	Nova	INRA-CIRAD, France	Very sweet mandarin orange 50% fruit color change in mid-October (Ashwin)

S.N.	Accession No.	Variety/Line	Source	Remarks
18	NCRP-91	Pixie	INRA-CIRAD, France	Late ripening and seedless mandarin orange
19	NCRP-92	Dancy	INRA-CIRAD, France	Medium sweet flavor and super easy to peel
20	NCRP-93	Avana	INRA-CIRAD, France	High quality, juicy and seedy mandarin orange variety
21	NCRP-94	Page	INRA-CIRAD, France	TSS >11%, 50% fruit color change in mid-October
22	NCRP-95	Satsuma Okitsu	INRA-CIRAD, France	Extra early ripening and cold resistant variety of mandarin orange
23	NCRP-97	Clementine mandarin orange Hernandina	INRA-CIRAD, France	50% fruit color change in third week of October
24	NCRP-98	Clementine mandarin orange Oraval	INRA-CIRAD, France	50% fruit color change in second week of October
25	NCRP-99	Clementine mandarin orange Commune	INRA-CIRAD, France	TSS >11.5%, 50% fruit color change in second week of October
26	NCRP-100	Clementine mandarin orange Marisol	INRA-CIRAD, France	50% fruit color change in third week of October
27	NCRP-101	Clementine mandarin orange Nules	INRA-CIRAD, France	50% fruit color change in mid-October
28	NCRP-112	Gorkhali *Suntala*	Gorkha, Nareswor	Local, mid-season ripening
29	NCRP-114	Khoku muted mandarin orange	NCRP, Dhankuta	Large leaved bud muted mandarin orange
30	NCRP-121	Daisy mandarin orange	Australia	Mid-season mandarin orange with an attractive dark orange rind
31	NCRP-122	Avana-Aprino	Australia	Few seeded mandarin orange variety
32	NCRP-123	Imperial	Australia	Has a tendency to produce higher yields on alternate years
33	NCRP-124	Murcott	Kirtipur	It is a tangor, or mandarin orange× sweet orange hybrid
34	NCRP-125	Oota Pongan	Kirtipur	
35	NCRP-126	Yashida Pongan	Kirtipur	
36	NCRP-127	Selection-79	Kirtipur	

S.N.	Accession No.	Variety/Line	Source	Remarks
37	NCRP-128	Selection-04	Kirtipur	
Mandarin Orange Tangor (*C. reticulata* × *C. sinensis*)				
38	NCRP-102	Ellendale	INRA_CIRAD, France	Maturity is late midseason
39	NCRP-103	Murcott	INRA_CIRAD, France	Late maturing mandarin orange
40	NCRP-72	Ortanique	INRA_CIRAD, France	Originated in Jamaica Conical-shaped fruit, with a thin but leathery rind with adheres rather tightly and is tough to peel
41	NCRP-07	Murcott	JICA, Japan	Late maturing mandarin orange
Mandarin Orange Tangelo (Dancy tangerine ×Pomelo)				
42	NCRP-73	Minneola	INRA_CIRAD, France	Stem-end neck, which tends to make the fruit appear bell-shaped
43	NCRP-74	Orlando (Dancy tangerine ×Duncan grapefruit)	INRA_CIRAD, France	TSS 12.51%, TA 1.21%, Juice 48.76%
44	NCRP-75	Seminole	INRA_CIRAD, France	Easy to peel, less seedy and juicy fruit TSS 12.43%, TA 1.43%, Juice 51.18%

Technologies developed at NCRP, Paripatle, Dhankuta

Varietal development

Three varieties of mandarin orange have been developed by NCRP, Paripatle, Dhankuta until now. Among them, 'Khoku Local' and 'Banskharka Local' are the mid-season mandarin orange varieties cultivated predominately in the mid-hill region of Nepal and harvesting season starts from Mangsir through Magh while Paripatle Agaute-1 mandarin orange is an early-season mandarin orange and harvesting period starts from Bhadra through Ashoj. It was selected from the Satsuma mandarin orange (*Citrus unshiu*) and recommend for the areas 800 to 1400 masl altitude throughout the mid-hill of Nepal (NCRP, 2023).

Enhancing trifoliate orange seedling growth

Trifoliate orange is the most popular rootstock for propagating majority of the citrus fruit in Nepal. Under open field condition, plant take 2-3 years for attaining suitable size for grafting therefore, a study was made by Acharya and Pakka (2019) to enhance germination of seed and reported 80% germination under raised bed and open side plastic tunnel condition as compared to 46% under closed tunnel and raised bed condition. They reported, 1st week of September to 1st week of October was the suitable time for seed sowing of trifoliate orange for achieving good germination under the condition of Paripatle, Dhankuta and similar climatic tract. Under plastic tunnel, graftable size could be achieved within a year of seed sowing (Shrestha et al, 2013). Chalise et al. (2012) reported that use of gibberellins (GA_3) and nitrogen at the rate 120 ppm and 400 kg nitrogen/ha enhanced the trifoliate rootstock seedling growth.

Evaluating success of grafting

Saplings are produced with splice grafting techniques onto different rootstock of one to two years old seedlings. Winter season grafting is done mostly in December to January months. Chalise (2010) recorded 77.78% and 82.08% graft success with shoot-tip (splice) and veneer method of grafting. While comparing different dates, he observed the highest graft take success (96.11%) and the lowest mortality rate (0.29%) on 13th January grafting at Paripatle, Dhankuta. Mother stock grown inside the screen house is the source of scion for grafting. About 8-10 months old scions are used in grafting. Rootstock grown under the plastic tunnel are mostly used in grafting as open conditions does not support the optimum growth of the rootstock seedling. Most of the grafting is done with the bench method at 15-25 cm height on rootstock. In another study Chalise et al. (2013) reported 16 cm grafting height was the optimum grafting height for graft success (99.37%) and sapling growth of acid acid lime grafted on to trifoliate orange seedling rootstock at Paripatle, Dhankuta.

After grafting, grafts are planted in the bed prepared 15 days before grafting supplied with well-rotten FYM or compost at the rate of 5 kg/m^2 plot. Immediately after planting beds are covered with a Jute sheet and irrigated thoroughly followed by covering of the bed with a transparent plastic sheet above the jute sheet. Jute sheets hold moisture and plastic sheets stop escaping moisture from inside of the tunnel. This helps rising temperature and humidity inside the bed creating the optimum condition for a union of the graft. In the initial days of the transplanting of grafts inside the bed, is daily irrigated, and after one-week irrigated on alternate days and decreased in subsequent days. About 45 days are required for the healing of the union. When the temperature rises in Falgun-Chaitra, removal of plastic sheets is done sub-sequentially to avoid the wilting of a sapling. A jute sheet is allowed up to Jestha to save the sapling from damage of hailstorms (Chalise et al., 2013).

Considering the availability of short duration of grafting time of winter-season, an experiment was conducted to propagate citrus fruits inside the screen house onto the trifoliate rootstock grown in polybag with different methods of grafting in rainy season (July). The result showed that there was 90% success in acid acid lime (Sunkagati-2) with veneer method, 80% success in Avana mandarin orange with veneer method and 35% success in Khoku mandarin orange with T-budding when grafted on 17th of July (NCRP, 2022). This have proved that farmers can propagate citrus in rainy season also but structure should be protected as this is the peak rainy season of the year. Mother stocks are grown under screen houses to get the healthy scion for grafting. Recommended cultural practices are followed for optimum growth of the mother stock. Regular plant protection measures, irrigation and plant nutrient management activities are followed inside the screen house. PCR for detecting the Huanglongbing disease is done once a year based on the symptoms of the malady (NCRP, 2023).

Managing Huanglongbing

Huanglongbing (HLB) or citrus greening is the most devastating disease of citrus of the world (Bove, 2006) and is a vector-borne disease transmitted by Asian Citrus psyllid (ACP). It is becoming a threat to the citrus industry of Nepal as well. Many research reports indicated that HLB incidence could be minimized with the intercropping of citrus with guava. Bettie et al. (2006) and Gottwald et al. (2010) reported that infestations of ACP and the consequence incidence of HLB are greatly reduced in citrus when interplanted with guava. They further reported that guava volatiles or phytotoxins might be responsible for reducing infestations of the ACP in citrus. Putative guava volatiles may interfere with the ACP's ability to locate and infest citrus grown next to guava or might repel ACP away from citrus. Putative guava toxins might negatively affect the biology of the ACP interfering with their reproduction in citrus. In another study, Hall et al. (2008) reported the effect of guava on adult ACP and found adult ACP released into cages containing only citrus generally moved faster to citrus than when either guava or cotton was present. Similarly, they also reported that a greater number of adults were consistently observed on citrus over time in cages with only citrus as compared to in cages with citrus in the presence of guava or cotton.

NCRP has been doing research from past 3 years to control the spreading of the disease in new and healthy orchard by intercropping guava in mandarin orange orchards. Study was carried out in Ilam district, Godak area since FY 2073/74 to prevent the transmission of disease from infected orchard to newly established healthy mandarin orange orchard. In the 5th year of mandarin orange plantation, no any citrus ACP vector was recorded from the research plot. Similarly, there was no any incidence of citrus greening disease too. NCRP will continue this research for another few years because normally greening disease appears after 2-3 years of establishment of orchard (NCRP, 2023).

Plant protection measures

Huanglongbing

Huanglongbing is a bacterial disease and was first reported in South China in 1943 and found severe losses in the major citrus producing regions, threatening the sustainability of the whole citrus zone (Bove, 2006). In Nepal it is reported from several citrus production areas. The current control practices include the use of healthy sapling, inspection and systematic eradication of infected plants from the plantations, monitoring, and control of ACP with chemical and cultural methods, especially intercropping citrus orchards with white-fleshed guava, use of disinfected tools during intercultural operations in the orchards. Use of chemicals like Zinkicide has been practiced but results are not satisfactory till now (NCRP, 2023).

Citrus canker

Citrus canker is also a bacterial disease caused by *Xanthomonas campestirs* p.var *Citri* and is generally found in the acid acid lime plantations of Terai and the mid-hills of Nepal. Under the neglected conditions, it is also one of the major cause of decline of the orchard. Infection is abundant in the spring to summer rainy season as compared to winter. The present management practice includes the use of healthy scion, production of canker-free saplings in the nursery, use of Bordeaux mixture and antibiotics regularly in the orchard, pruning off infected branches and disposing of them. Being the medium of dissemination, the control measures of leaf miner is being conducted at NCRP, Dhankuta (NCRP, 2023).

Citrus tristeza virus

Citrus tristeza virus (CTV) is caused by the virus and major occurrences are found in acid acid lime and lemon plantations. Brown citrus aphids are the vector of the disease contributes in the spreading of the disease to healthy plants. Therefore, biosecurity majors include the use of healthy planting materials, the use of disinfected tools during the pruning and other intercultural operations in the orchard, the control of citrus aphids with systemic insecticide as well as using ladybird beetle as a predator in organic production practices. There has been no chemical control of CTV till now, thus use of healthy saplings and careful handling of agricultural tools during intercultural operations are the prime things to be considered for managing CTV (NCRP, 2023).

Phytophthora disease

Phytophthora root rot, collar rot, crown rot, or brown rot are the major diseases of the citrus orchard and are one of the major causes of the citrus orchard decline. It is soil-borne fungal disease and transmitted through planting material with soil, agricultural tools, and equipment, animal's movement from a diseased orchard to a healthy orchard, agricultural machinery tools, etc. The present practices to manage phytophthora disease in citrus orchards include the use of healthy planting materials and growing media, disinfection of agricultural tools and machinery equipment and tools, use of phytophthora disease tolerent rootstocks line trifoliate orange and its relatives, treatment of the infected orchard trees with Bordeaux mixture, especially drenching on root zone. The use of bio-control agents like Pseudomonas are also found effective in organic citriculture. To reduce the risk of spread of the disease, precaution should be followed before the entry of human as well as animals to the healthy orchard from infected ones (NCRP, 2023).

Citrus mite

Citrus mites are becoming a major threat to the citrus industry of Nepal in recent years. Mites are associated with the discoloration of fruit resulting in poor market value of fruit. Among citrus mites, *Phyllocoptruta oleivora* (Ashmead) produces a multitude of brown-reddish black spots on the fruit surface. Nymphs and adults of the mite congregate around the gland cells and suck sap there resulting in bronzing of the rind and also hardening which reduces its marketability

(Singh et. al., 2013). Fruits of upper branches are more preferred than those on lower branches. Singh et. al., (2016a) reported that *Brevipalpus* sp. of mite causes damage to citrus fruits and is associated with rind disorder. It is reported that water stress often aggravates the problem of mites. Citrus leaf mite prefers citron, acid lime, and sweet orange more. Biocontrol agents like *B. suturalis*, *H. variegata*, *A. cardoni*, *S. nubilus*, *P. flexibilis*, *Stethorus aptus Kapur*, predatory bug, *Geocoris sp.,* green lacewing, *Chyrsoperla spp*. and predatory mites have been recorded. The most important natural enemies of citrus mites are predacious mites, *Euseius hibisci* (Chant), *Agistemus* sp., *Amblyseius hibisci* (Chant) and *A. cucumeris* (Oudemans). Conserve coccinellid beetles viz., *Scymnus gracilis* Savioskaya, *Stethorus pauperculus* Weise and predatory thrips viz., *Scolothrips* sp. (Singh, 2017a). Chemical control of mite include the use of ethion 50 EC @ 2 ml or fenazaquin 10EC @ 1.5 ml or Rogar 30 EC @ 1.34 ml or buprofezin 25 EC @ 1 ml or triazophos 40 EC @ 1 ml of water. Two sprays of propargite 57 EC @ 0.057 percent or wettable sulfur 85 DP @ 2-3 g or dicofol 18.5 EC @ 1.5-2 ml or oxydemeton methyl 30 EC @ 1.5 ml/l of water or fenpyroximat 5 AS @ 1 ml/l or abamectin 1.8 EC @ 0.5 ml/l or spiromecifen @ 0.75 ml/l or neem oil @ 5 percent or petroleum spray oil (2 cent percent) are effective. The first spray is recommended at the initiation of pest infestation and the second spray 15 days thereafter (AICRP, 2017). Spraying with the above pesticides at the button stage/marble stage and lemon-sized fruiting stages as prophylactic treatment is recommended. The spraying of chemicals after the appearance of symptoms is of no use.

Citrus scale insect

Citrus scale insects are sucking types of insects and cause damage to every part of the tree. Under high population conditions of the scale, severe leaf fall is seen in the orchard. Scale insects affect trees mainly by sucking sap from the above ground part of a tree, injecting toxic saliva into the tree, make avenues to develop sooty mold on the surface of stem, branches and leaf affecting the photosynthetic activities of leaves. Severe damaged and neglected orchard starts declining. The management strategies include a healthy production system of saplings, monitoring of the scale in orchard tree and use of petroleum products or mineral oil to the plant @ 10-12 ml/liter of water. Combined application of systemic insecticides like Rogor @ 1.5-2 ml/lit water with mineral oil is more effective than sole application of mineral oil or insecticide for controlling scale. The appropriate time of application of the chemical pesticide and oil is before the appearance of flush, especially in January-February and May-June. During spraying, thorough application of insecticide and mineral oil to the above-ground part of the tree is recommended (NCRP, 2023).

Leaf miner

Leaf miner problem is severe in the nursery as compared to the orchard. The damage caused by leaf miner is in the photosynthetic activity of leaf therefore they affect the growth of the nursery plant. The spray timings of insecticide against them are most important in managing leaf miner because before entering in leaf tissue, it is highly susceptible to the toxic effect of pesticides. Foliar application of neem oil @ 1-5 ml or imidacloprid 17.8 SL @ 0.5 ml or phoslone 35 EC @ 1.5 ml or fenvalerate 20 EC @ 1.0 ml or spinosad 45 SC @ 0.34 ml or novaluron 10 EC @ 0.7-0.87 ml or cypermethrin 10 EC @2 ml or thiamethoxam 25 WG @ 0.32 g or triazophos 40 EC @ 2.5 ml or chlorpyriphos 20 EC @ 3.75 m1 per liter of water or petroleum spray oil @ 1.5 per cent or thiodicarb @ 0.75 per cent or fish oil rosin soap @5 g per liter water in flushing season by directing at the new flush checks the pest. The same chemicals should not be sprayed repeatedly as it enhance the development of resistance (Singh et al., 2016a, Singh et al., 2016b).

Citrus fruit fly

About ten types of fruit fly species have been reported from Nepal (Sharma et al., 2015), among them, the Chinese citrus fly (*Bactrocera minax* Enderlein) is a major problem of the citrus industry of Nepal, China and Bhutan (Bhandari et al., 2017). Chinese citrus fly is an oligophagous pest feeding exclusively citrus fruit (Xia et al., 2018) and prefers tight to loose skin fruit of citrus (Drew et al., 2007, Dorji et al., 2006). The control measures include area-wide control program including the use of protein bait for controlling female flies, safe disposal of the infested fruit for controlling pupation of the maggot and clean cultivation of the citrus orchard to prevent adult oviposition. According to Adhikari et al. (2021), protein bait is generally applied from May to July. Commercial protein bait, Great fruit fly bait, manufactured in Ecoman Biotech, China of composition of 25% protein hydrolysate plus 0.1% Abamectin was a prime source of protein bait. Ready to spray solution of the commercial protein bait is prepared using one part of the bait material with 2 parts of water and mixed thoroughly before applying with sprayer to the tree (Adhikari and Joshi, 2020).

Constraints

- Lack of qualified human resources is the main problem in conducting research activities smoothly. At present, most of the laboratories are at non-operating stage due to shortage of human resources.
- Prevalence of the citrus psylla in huge population is becoming a challenge in management of the Huanglongbing disease of citrus. Citrus psylla is becoming one of the greater threat to the citrus industry of Nepal.
- Lack of international organizations in citrus sector like AVRDC for vegetable, ICARDA for dry land agriculture, CIMMYT for wheat and maize, is becoming a constraints in introduction of the promising citrus varieties in Nepal.

Way forward

- Varietal introduction: Promising citrus varieties resistant to problematic diseases should be introduced, evaluated and recommended for cultivation to the citrus farmers.
- Improvement in sapling production system: The present production system is very costly and time consuming, therefore efficient method of grafting should be identified and recommended.

- Development of orchard management technologies through organic method: The use of chemical pesticides have negative effect on environment and human health, so organic technologies should identified and recommended to farmers.
- Study of suitability of different rootstock to different species of citrus crop: At present, use of trifoliate orange for grafting may not be suitable for terai region, therefore alternative rootstock should be identified and recommended for grafting.
- Regular disease diagnosis and suggestion to the farmers on its management
- Monitoring of recently emerged problems and their solutions: Regular monitoring of HLB, CTV, Chinese citrus fly, Asian Citrus Psylla, fruit sucking moth should be done to protect orchard from havoc.

Conclusion

National Citrus Research Program, Paripatle, Dhankuta, Nepal is performing collection, maintenance, evaluation and registration of citrus species including mandarin orange at the station. Out of 44 germplasm of mandarin orange, three varieties have been registered and recommended for commercial cultivation in Nepal. Moreover, technologies regarding sapling production and nursery management, management of important insect pest and diseases of citrus species have been developed and recommended for commercial production in Nepal. Still varietal development and advanced technologies have to be developed.

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सुन्तलाजात फलफूल विकास केन्द्र, पाल्पामा सुन्तलाजात फलफूलको वर्तमान अवस्था

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सारांश

सुन्तलाजात फलफूल विकास केन्द्र, राष्ट्रिय फलफूल विकास केन्द्र अन्तर्गत सुन्तलाजात फलफूल सम्बन्धी अध्ययन-अनुसन्धान, स्वस्थ बिरुवा उत्पादन तथा बिक्री वितरण, कृषक तथा नर्सरीधनिलाई प्राविधिक सुझाव र प्रविधि सिकाउने सरकारी फार्म हो। केन्द्रले सुन्तलाजात फलफूलको विकासमा प्राथमिकताको साथै सुन्तलाजात फलफूलका विभिन्न जातहरु संकलन, अध्ययन तथा बिरुवा उत्पादन गरी कृषकस्तरमा पुऱ्याउन केन्द्रले विशेष जोड दिदै आएको छ। केन्द्रको हाताभित्र हाल सुन्तलाजात फलफूल नर्सरी, सुन्तलाजात फलफूलका माउबोट ब्लक, रुटस्टक ब्लक, जालीघरमा स्वस्थ बिरुवा उत्पादन तथा माउबोट व्यवस्थापन, विभिन्न जातका सुन्तलाजात फलफूलका जातहरु संकलन, नमूना घरबारी बगैचा स्थापना जस्ता क्रियाकलापहरु संचालन तथा व्यवस्थापन भैरहेका छन्। यस केन्द्रले सुन्तलाजात फलफूलको विकासको माध्यमबाट कृषकको जीवनस्तर उकास्न आवश्यकता अनुरुपका विविध कार्यक्रमहरु सञ्चालन तथा कार्यान्वयन गर्दै आएको छ।

प्रमुख शब्दावली: विकास, स्वस्थ बिरुवा, सुन्तलाजात, प्रचारप्रसार, प्राविधिक

परिचय

फलफूल उत्पादनको हिसाबले मध्य-पहाडी क्षेत्र सुन्तलाजात फलफूल खेतीको लागि उपयुक्त थलो मानिन्छ। सुन्तलाजात फलफूल मध्ये सुन्तलाले व्यावसायिक गति लिई भरपर्दो वैकल्पिक आय आर्जनको सम्भावना बोकेको छ। नर्सरीहरुबाट हुने बिरुवा उत्पादन तथा बिक्री वितरण अवस्था हेर्दा करिब ९५ प्रतिशत निजि नर्सरीहरुबाट आपूर्ति भैरहेको छ। समग्र बागवानी क्षेत्रको विकासमा सेवा टेवा पुऱ्याउने, निजी क्षेत्रमा फलफूल बगैंचा स्थापनालाई बढावा दिई कृषकहरुको जीवनस्तर माथि उठाउने, प्राविधिक सेवा पुऱ्याउने उद्देश्य लिई साबिक पश्चिमाञ्चल विकास क्षेत्रको लुम्बिनी अञ्चल पाल्पा जिल्ला तानसेन नगरपालिकाको होलाङ्गदीमा वि.सं. २०२५ सालमा यस केन्द्रको स्थापना भएको हो। स्थापनाकाल देखि नै कृषकहरुलाई सरकारी दररेटमा गुणस्तरीय फलफूलका बिरुवा तथा तरकारी बीउ सुलभ तरिकाबाट उपलब्ध गराई सेवा पुऱ्याउँदै आएको छ भने प्राविधिक सेवा निःशुल्क प्रदान गर्दै आएको छ।

- वि.सं. २०२५ सालमा कृषि फार्म प्रयोगशाला (Agriculture Farm Laboratory) को नामले स्थापना भएको
- वि.सं. २०४९/५० सालमा बागवानी फार्म पाल्पाको नाममा रुपान्तरण भएको

- वि.सं. २०५२ सालमा पुनःबागवानी केन्द्रको नाममा रुपान्तरण भएको
- पुनः वि.सं. २०६१/६२ मा कृषि मन्त्रालय अन्तर्गतका सम्पूर्ण कार्यालयहरु पुनर्गठन हुँदा यो केन्द्र विषयगत रुपमा सुन्तलाजात फलफूल विकास केन्द्रको रुपमा रुपान्तरण भएको
- वि.सं. २०७५/७६ पछि संघीय संरचना अनुसार यो केन्द्र संघ अन्तर्गत रही सुन्तलाजात फलफूलको क्षेत्रमा नेपाल राज्यभर सेवा प्रदान गर्दै आइरहेको

केन्द्रको संक्षिप्त जानकारी

भू–उपयोग स्थिति

तालिका १. केन्द्रको भू-उपयोग स्थिति

जग्गा उपयोगको स्थिति	इकाई	क्षेत्रफल	प्रतिशत
१ कुल क्षेत्रफल	हे.	९.२०	१००
क) खेती गरिएको क्षेत्रफल	हे.	५.७५	६२.५
ख) सिजनल बालीले ढाकेको क्षेत्रफल	हे.	०.९५	१०.३२
ग) बहु वर्षिय बालीले ढाकेको क्षेत्रफल	हे.	४.८०	५२.१७
घ) कार्यालय भवन, फार्म सिंचाई र सडक पूर्वाधारले ढाकेको क्षेत्रफल	हे.	३.४५	३७.५
खेतीयोग्य जग्गा मध्ये बालीले ढाकेको क्षेत्रफल			
क) फलफूल माउबोट बगैचा	हे.	४.९०	
ख) नर्सरी तथा रुटस्टक	हे.	०.७५	
ग) तरकारी बीउ उत्पादन	हे.	०.१०	

उचाई

समुन्द्र सतह देखि ११८५ मिटर

हावापानी

यस केन्द्रको हावापानी समशितोष्ण किसिमको छ। यहाँको वार्षिक औषत तापक्रम अधिकतम ३४.८° से. र न्यूनतम ६.५° से. भएको पाइन्छ। यहाँ औषत वर्षा १९०३ मि.मि. हुन्छ भने चैत्र-बैशाखमा हावाहुरी आउने र कहिलेकाँही असिना पर्ने गर्दछ।

माटो

यस केन्द्रको माटो बढी मात्रामा खस्रोपना भएको, कम गहिरो, रातो फुस्रो खालको छ। माटोमा प्रशस्त मात्रामा ढुङ्गाहरु मिसिएको पाइन्छ भने पानी अड्याउने क्षमता निकै कम छ।

उद्देश्य

अल्पकालिन उद्देश्य

- फलफूल विकासका क्षेत्रमा फलफूलको सर्वाङ्गिण विकासका लागि उपयुक्त वातावरण सृजना गर्ने।
- गुणस्तरीय विभिन्न उन्नत जातका कलमी तथा बीजु बिरुवा उत्पादन तथा बिक्री वितरण।
- निजी स्तरमा फलफूल नर्सरी तथा व्यावसायिक फलफूल बगैंचाहरु स्थापनामा प्राविधिक सेवा पुऱ्याउने।

- नेपालको फलफूल क्षेत्रलाई प्रतिस्पर्धी बनाउँदै विद्यमान परिवेशमा पहिचान स्थापित गराउने ।
- प्रदेश र स्थानीय तहमा फलफूल विकासका लागि सहकार्य र समन्वय गर्ने ।
- केन्द्रका कार्यक्षेत्रभित्र रहेका नर्सरीहरुलाई गुणस्तरीय र विशिष्टकृत स्रोत केन्द्रको रुपमा विकास गर्नुका साथै क्षेत्रफल विस्तार गर्न सहयोग गर्ने ।
- बागवानी सम्बन्धी प्रशिक्षणका लागि प्रशिक्षक उपलब्ध गराउने ।
- प्राविधिक सेवा स्थलगत लक्ष्य अनुसार र केन्द्रबाट माग भए बमोजिम प्रदान गरिने ।

दीर्घकालिन उद्देश्य

- सुन्तलाजात फलफूलको उत्पादन र उत्पादकत्व वृद्धि गरी कृषकको आयस्तर बढाउने ।
- बागवानी विकासको माध्यमबाट भू-क्षय हुन बाट बचाई वातावरण संरक्षणमा सहयोग पुऱ्याउने ।
- बागवानीमा आधारित साना, मझौला तथा ठूला उद्योगहरु स्थापना गराउन सहयोग पुऱ्याई रोजगारीको अवसरमा वृद्धि गराउने ।
- फार्म/केन्द्रहरुमा सफल भएका तथा व्यावसायिक रुपमा सफलसिद्ध फलफूलका जातहरु क्रमशः रजिष्ट्रेशनको लागि समन्वय गर्ने ।
- जर्मप्लाजम संकलन एवं सम्वर्द्धन गर्दै जाने ।

कार्य विस्तृतीकरण

केन्द्रियस्तरको कार्यालय भएको हुंदा उपलब्ध जनशक्ति, आवश्यकता र बजेट उपलव्धता अनुसार सुन्तलाजात फलफूल उत्पादन हुने देशै भरका क्षेत्रहरु कार्यक्षेत्र भित्र पर्दछन् । यस केन्द्रबाट वर्षेनी फलफूल तर्फ सुन्तलाजात (सुन्तला, जुनार, कागतीका विभिन्न जात), विभिन्न फूलका बिरुवाहरु माग अनुसार बिक्री वितरण गर्दै आइरहेको छ ।

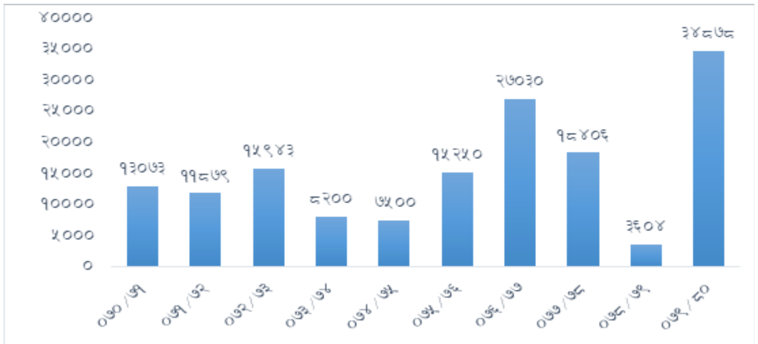
यस केन्द्रमा उच्च पहाडदेखि तराईमा हुने फलफूलहरु धेरै मात्रामा फल्दै आइरहेको देख्न पाइन्छ, जस्तै आँप, लिची, कटहर, स्याउ, नास्पाती, आरु, ओखर, आरुबखडा, सुन्तला, कागती, जुनार, केरा, भोगटे, कफी आदि रहेका छन् ।

केन्द्रले प्रविधि विकास तर्फ पनि कार्यहरु गर्दै आइरहेको छ । केन्द्रले दक्ष जनशक्ति विकासमा टेवा पुग्ने उद्देश्यले वार्षिक रुपमा कृषकस्तर तथा स्थानिय तहमा कार्यरत प्राविधिकहरुको लागि तालिमहरु समेत सञ्चालन गर्दै आइरहेको छ । जसबाट दक्ष जनशक्ति उत्पादन हुनमा टेवा पुग्ने आशा लिइएको छ ।

केन्द्रबाट संचालित गतिबिधिहरु

- सुन्तला, कागती, जुनार लगायत अन्य सुन्तलाजात फलफूलहरुका स्वस्थ एवं गुणस्तरीय बिरुवा उत्पादन तथा बिक्री वितरण ।
- केन्द्रको स्थापना कालदेखि नै कृषकहरुलाई गुणस्तरीय फलफूलका बिरुवा तथा तरकारी बीउ उपलब्ध गराउँदै आएको ।
- आ.व. २०७४/७५ देखि यो केन्द्र पूर्णतः सुन्तलाजात फलफूलको सन्दर्भमा राष्ट्रिय स्तरको केन्द्रको रुपमा स्थापित भई प्रविधि विकास एवं विस्तार, गुणस्तरीय बिरुवा उत्पादन तथा वितरण, कृषक तथा नर्सरी धनीहरुको लागि तालिम सञ्चालन, सुन्तलाजात फलफूलहरुका जातीय संरक्षण, सम्वर्द्धन, प्राविधिक सेवा टेवा प्रदान गर्ने आदि यसका मुख्य गतिविधिहरु रहेका छन् ।
- सुन्तलाजात फलफूलहरुको जर्मप्लाज्म संकलन तथा सम्वर्द्धन गर्ने उद्देश्यले Field Gene Bank स्थापना ।
- केन्द्र परिसरभित्र सुन्तलाजात फलफूल बाहेक लिची, आँप, कटहर, नास्पाती, हलुवावेद आदि फलफूलहरुको संरक्षण एवं सम्वर्द्धन ।

- विभिन्न किसिमका फलफूलमा आधारित नमूना घरबारी बगैंचा, सुन्तलाजात फलफूलहरुको जातीय परीक्षण ।
- तन्तु प्रजनन प्रयोगशाला स्थापना भै रुटस्टक उत्पादन कार्य थालनी गरिएको ।
- सुन्तला, जुनार र कागतीका माउबोट ब्लक स्थापना गरी तिनीहरुको व्यवस्थापन कार्य भैरहेको ।



चित्र १. सुन्तला बिरुवा वितरण संख्या (कलमी तथा बीजु)

स्थानिय प्राकृतिक तथा संरक्षित आनुवांशिक जातहरु

फर्म भित्र लगाईएका फलफूल बोट बिरुवाहरुको किसिम र जातहरु

तालिका २. केन्दभित्र लगाइएका फलफूल बोट बिरुवाहरुको किसिम र जातहरु

सि.नं.	फलफूल	जात	लगाईएको वर्ष (वि. सं.)	संख्या		जम्मा बोट संख्या
				फलेको	नफलेको	
१.	सुन्तला	उन्सु (सत्सुमा म्याण्डारिन, ओकित्सुवासे, मियागावासे)	२०४७, २०६२, २०६४, २०७१, २०८०	३२	६	३८
		किन्नो	२०५७	६	४	१०
		खोकु	२०६२, २०६८	१०	९	१९
		नागपुर	२०६४	१	४	५
		स्थानिय	२०६१, २०६४, २०७१	३२	२३	५५
		मरकट	२०७२	४	-	४
		योसिदा पोङकान, ओता पोङकन	२०७२	४	-	४
		पोन्सीरस पोमाइरो	२०७७		१	१
		कालामन्द्रिन सुन्तला	२०७८	१	१	२
		कमला सुन्तला	२०७८		२	२
		चिति लम्जुङ्ग	२०७८		१	१
		मेरिसोल सुन्तला	२०८०		२	२
		सिक्किमे सुन्तला	२०७८		१	१
		बासखर्क सुन्तला	२०८०		२	२
		स्याङ्गजा स्थानिय	२०८०		२	२
		जम्मा		९०	५८	१४८

सि.नं.	विवरण	जात	लगाईएको वर्ष (वि. सं.)	संख्या		जम्मा बोट संख्या
				फलेको	नफलेको	
२.	जुनार	वाशिङ्गटन नेभल	२०६१, २०६४	१४	२	१६
		भ्यालेन्सिया लेट	२०६१, २०६४	९	-	९
		स्थानिय	२०५१, २०६४, २०६८	४४	२१	६५
		पाइनएप्पल	२०६१	८	-	८
		माल्टा ब्लडरेड	२०७८		१	१
		टैंगोर	२०७८		१	१
			जम्मा	७५	२५	१००
३.	कागती	स्थानिय	२०५१, २०६४, २०६९, २०७१	१४	८८	१०२
		यूरेका	२०५७, २०६४	६	-	६
		सुनकागती-१	२०७८	-	५	५
			२०७९	-	१०	१०
			२०८०	-	१६	१६
		सुनकागती-२	२०७८	-	४	४
			२०७९	-	१२	१२
			२०८०	-	३२	३२
		तेह्रथुम स्थानिय	२०७८		४	४
			जम्मा	२०	१७१	१९१
४.	भोगटे	स्थानिय संकलन	२०४४, २०६१	८	-	८
५.	बिमिरो	स्थानिय संकलन		२	१	३
६.	ग्रेप फ्रुट		२०५७	२	-	२
७.	अन्य		२०६२, २०६४	९	३	१२
८.	मुन्तला	लाम्चो नागमी	२०५५	१	६	७
९.	तिनपाते सुन्तला		२०६७	८६	१४	१००
१०.	अम्बा	सिडलेस	२०२९	७	-	७
		इलाहाबादी	२०२६	५०	-	५०
		रेडफल्स	२०२६	२०	-	२०
			जम्मा	७७	-	७७
११.	नास्पाती	फर्पिङ्ग	२०५१	६	-	६
		वार्टलेट	२०५१	१०	-	१०
		होसुई/कोसुई	२०६०	-	८	८
			जम्मा	१६	८	२४

सि.नं.	विवरण	जात	लगाईएको वर्ष (वि. सं.)	संख्या		जम्मा बोट संख्या
				फलेको	नफलेको	
१२.	आँप	दशहरी	२०३२	५०	१०	६०
		बम्बै ग्रीन	२०३२	२५	५	३०
		आम्रपाली	२०५९	२	-	२
		माल्दह	२०३२	४०	५	४५
		फजली	२०३२	६	-	६
		लोकल	२०३२	१०	५	१५
			जम्मा	१३३	२५	१५८
१३.	लिची	मुजफ्फरपुर	२०४२	२३	१५	३८
		शाही	२०४१	१०	-	१०
		सिडलेस	२०४५	१	-	१
			जम्मा	३४	१५	४९
१४.	कटहर	स्थानीय	२०३०	८	-	८
१५.	अनार	बेदाना	२०६२, २०७१	३	५	८
१६.	आरुबखडा	मैथली	२०२७, २०४५	३	-	३
		ग्रीनगेज	२०४५	२	-	२
			जम्मा	५	-	५
१७.	ओखर	थिनसेल	२०२७	८	-	८
१८.	मेकाडेमिया नट		२०३०	५	-	५
१९.	हलुवावेद	लोकल	२०४५	८	-	८
		जिरो	२०६५	०	३	३
			जम्मा	८	३	११
२०.	कफी	अराबिका	२०६०	५८	-	५८
		एल्लो कटुरा	२०६०	७	-	७
		लाईबेरिका	२०६०	-	५	५
			जम्मा	६५	५	७०
२१.	लहरे आँप		२०७६		३	३
२२.	किवी		२०७६		३	३
२३.	ड्रागन फ्रुट		२०७६		१२	१२
२४.	फिजुवा		२०७६		५	५

जर्मप्लाज्म बिरुवाहरुको विवरण

क) **सुन्तला**ः किन्नो सुन्तला, कालामन्द्रीन सुन्तला, कारा सुन्तला, खोकु सुन्तला, कमला सुन्तला, उन्सु (ओकित्सुवासे), मेरिसोल सुन्तला, सिक्किमे सुन्तला, पोन्सिरस सुन्तला, नागपुर सन्तरा, नोभा सुन्तला, ओतापोङ्कन सुन्तला, बाँसखर्क सुन्तला, स्थानिय सुन्तला, धनकुटा स्थानिय, स्याङ्गजा स्थानिय, चिति लम्मजुङ्ग स्थानिय

ख) **जुनार**ः वाशिंटन नेभल, माल्टा ब्लड रेड, टेंगोर, भ्यालेन्सिया लेट, पाइनापल, स्थानिय

ग) **अमिलो**ः निबुवा, बिमिरो, बद्री अमिलो, यूरेका लेमन, कर्नाखट्टा, भोगटे गोर्खाली

घ) **मुन्तला**ः गोलो, लाम्चो

ङ) **रुटस्टक**ः रंगपुर लाइम, तीनपाते सुन्तला, सिट्रेन्ज, नाइटे ज्यामिर, काठे ज्यामिर

च) पेपीनो मेलन

बीउ बिरुवा तथा बिरुवाजन्य उत्पादन तथा माउबोटहरुको संरक्षण

बड-उड प्रमाणिकरण प्रविधिबाट बिरुवा उत्पादनको लागि आवश्यक पर्ने सायन, रुटस्टक उत्पादन र कलमी गर्नको लागि ४ वटा जाली घर रहेको छ। फार्मभित्र विभिन्न सुन्तलाजातका बिरुवाहरु संरक्षण गरिएको छ।

नविन तथा अनुकरणीय कार्यहरु

तन्तु प्रजनन प्रविधिबाट रुटस्टक बिरुवा उत्पादनको शुरुवात, सिट्रस ग्रिनिङ्ग रोग पहिचानको लागि फर्म भित्र पि.सि.आर. परीक्षण शुरु भएको।

बिरुवा स्वस्थताका प्रयासहरु

सायनको लागि स्वस्थ र निरोगी बोटबाट सायनहरु संकलन, प्रयोग हुने औजार/उपकरणहरु निर्मलीकरण गरी प्रयोग गर्ने गरिएको, बीजु बिरुवा उत्पादनको स्वस्थ र निरोगी बोट बाट फल छनौट गरी बीउ निकाल्ने तथा बीउ उपचार गरी बिरुवा जमाउने कार्य भैरहेको।

बाली संरक्षणका विधिहरु

- बगैचाको सरसफाई र उचित खनजोत तथा बालीका अवशेष नष्ट गर्ने
- यान्त्रिक तरीका- पासो थाप्ने
- जैविक तरीका- ट्राइकोड्र्माको प्रयोग
- आकर्षणयुक्त रासायनिक पदार्थको प्रयोग-प्रोटिन बेट
- रासायनिक बिषादीको प्रयोग

समस्या तथा चुनौतीहरु

- सिचाईको समस्याः फार्मभित्र सिचाईका लागि स्वच्छ पानीको अभाव
- बाँदरको प्रकोप
- प्रयोगशाला सञ्चालनका लागि स्थायी जनशक्ति नभएको
- कलमी बिरुवाहरुको बढदो माग
- रोग/कीराहरुको समस्याः मुख्य रोगहरु क्यांकर, खराने रोग, डयाम्पीङ्ग अफ तथा कीराहरु लिफ माइनर, लाही किरा, कत्ले कीरा, मिलीबग, पतेरो, गबारो

- पर्याप्त मात्रामा जाली घरको अभाव
- फार्मको उपयुक्त जग्गा नभएको

आगामी योजना तथा रणनीति

- फार्मको उत्पादकत्व वृद्धि गर्न उपलब्ध सिमित श्रोत साधनको उच्चतम प्रयोग
- फार्मबाट उत्पादन हुने बिरुवाहरुलाई बड-उड सर्टिफिकेशन विधि मार्फत बिरुवा उत्पादन गर्ने
- बीजु बिरुवाको उत्पादन कम गर्दै लैजाने
- सुन्तलाजात फलफूलको जातीय संरक्षण एवं सम्वर्द्धन गर्ने
- कार्यमुखी अध्ययन परीक्षण (Action Oriented Research) सञ्चालन गर्ने
- प्रविधि हस्तान्तरण सम्बन्धी तालिम सञ्चालन गर्ने
- सुन्तलाजात फलफूल विकासको लागि सरोकारवालाको समन्वयमा बाह्य सेवाका गतिविधिहरु सञ्चालन गर्ने
- सुन्तलाजात फलफूल विकास सम्बन्धी राष्ट्रिय नीति तथा योजना तर्जुमा गर्न केन्द्रलाई पृष्ठपोषण गर्दै जाने
- केन्द्रले सिंचाईको लागि सोभै प्रयोग गर्ने गरेको ढलको पानीलाई विभिन्न पोखरीमा Sedimentation गरी शुद्धीकरण गरेर प्रयोग गर्ने दीर्घकालिन सोच रहेको

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- थापा, बोम बहादुर। २०७७। सुन्तलाजात फलफूल खेती। सुन्तलाजात फलफूल विकास केन्द्र, पाल्पा।
- सुवेदी, फूल प्रसाद, नारायण खनाल, महेश जैशी। २०६०। एकीकृत सुन्तला बाली व्यवस्थापन। कृषि तथा पशु विज्ञान अध्ययन संस्थान, अनुसन्धान निर्देशनालय, पहाडी कृषि अनुसन्धान समूह, चितवन।

Status of Mandarin Orange at Warm Temperate Horticulture Centre, Kirtipur

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Abstract

Horticulture sector has received prime importance since the starting of agricultural development in Nepal. The Warm Temperate Horticulture Center (WTHC) is one of the government farms directly involved in production and distribution of mandarin orange saplings all over the country since its establishment. Management of mother block for scion and rootstock production, distribution of trifoliate orange seeds to the nurseries involved in citrus sapling production, technology dissemination by means of trainings, publications and technical advices, laboratory facilities for PCR and ELISA tests are the mandarin orange related major activities being conducted by this farm. Due to its prime location in the country, it has facilitated in providing its services to large number of farmer and acts as technology dissemination and learning center. With increasing market demand for mandarin orange, growers are in search of different varieties in order to extend the harvesting period. Early and late maturing different varieties of mandarin orange are being maintained by the farm inside the screen houses. Therefore, in coming days, WTHC needs to focus its activities to develop and disseminate these varieties of mandarin orange.

Keywords: Government farm, Mandarin orange, Learning center, Dissemination, Varieties

Introduction

Among different sectors of agriculture, horticulture sector has always been a prioritized sector of the government. Establishment of horticultural development farms/research stations at different agro-ecological zones was the turning point for horticulture sector in the country. During 1960-73 AD, 14 horticulture farm/stations were established throughout the country. The main objective of these farms/station were to introduce exotic species and varieties of different fruit crops and establish progeny-cum-demonstration orchards, multiply fruit saplings for distribution to the farmers, conduct trials and studies, and provide training and technical services to the farmers (Shrestha and Verma, 1998).

With the realization of need of overall development of horticulture sector, Kathmandu *Anusandhan Bagaicha* was established in 1961 AD by then His Majesty of Government of Nepal in joint collaboration with Government of India. One year later, it was named as Horticulture Research Center, Kirtipur. It was reconstructed, renamed and assigned with different responsibility with time and again. Since 2018 AD, with the implementation of federalism in Nepal, it has been named as Warm Temperate Horticulture Center (WTHC) and working as a national resource center for warm temperate and citrus fruits in the country under National Centre for Fruit Development (NCFD) and Department of Agriculture (DoA). The major objectives of this center are as below:

- Production and distribution of quality planting materials of warm temperate and citrus fruits.
- Technical service to the nurserymen and orchard grower.
- Collection, conservation and maintenance of fruit germplasms.
- Technology dissemination by means of training and publications.
- Monitoring and supervision of nurseries for the production of quality planting materials.

In Nepal, different species of citrus i.e. mandarin orange, acid acid lime, sweet orange, lemon, pummel etc. are being cultivated in wide geographical area from 100m of terai to 1500m of mid hill area (Tomiyasu et al., 1997). Among them, mandarin orange ranks first in terms of area and production. The Horticulture Development Project (HDP), implemented with financial and technical assistance from JICA/Japan government during 1985AD-1997AD, had considered mandarin orange as one of the prioritized fruits and conducted many research activities on it. Major achievements of HDP on mandarin orange are highlighted below (Horticulture Development project-phase II, 1997):

- Different varieties of mandarin orange were introduced and performance trials were conducted at different agro-climatic conditions. Varieties with superior qualities were selected for further distribution to farmers.
- Studies were conducted to know the effects of altitude on fruit quality, effects of leaf numbers on bearing habit, effects of storage conditions on fruit quality, the optimum stage of maturity for harvesting etc.
- Samples of local *Suntala* collected from different parts of country were analyzed for fruit quality and plants with better quality fruits were selected as mother plants.
- Recommended USDA, trifoliate orange and *Kali Jyamir* as best rootstock for mandarin orange but the *Kali Jyamir* being susceptible to phytophthora only the trifoliate orange came into practice and still continued.
- Establishment and functioning of soil lab, pomology lab, pathology lab, entomology lab and tissue culture lab.

Ongoing activities of WTHC on mandarin orange

Production and distribution of quality planting materials of mandarin orange

The planting materials of mandarin orange used were mostly raised by seeds and grown in open field. Now a days, the demand for grafted saplings is increasing and WTHC has prioritized the mandarin orange saplings production by grafting with the use of trifoliate orange as rootstock and scion with desired varietal quality. The saplings are raised inside the screen house and distributed to the farmers during rainy season. Figure 1 shows the saplings distribution record of mandarin orange during the last five fiscal year. Following are the major practices followed by WTHC for the production of mandarin orange saplings at the center:

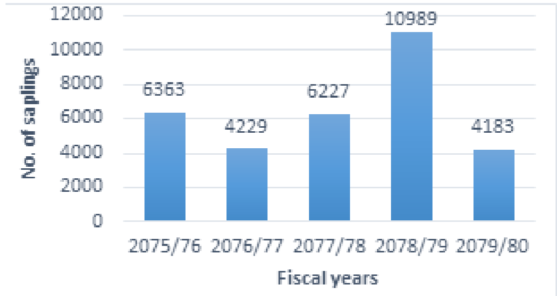

Figure 1. Mandarin orange saplings distribution record of WTHC

- Trifoliate seedlings are produced in primary nursery and later transplanted to poly bags.
- One year old trifoliate orange seedlings are used as rootstock.
- Scions are taken from mother plants fruited at least for two years grown inside the screen house
- Mother plants are tested with PCR for citrus greening every year.
- Saplings are raised in poly bag inside the screen house.

Production and distribution of trifoliate orange seeds

HDP has selected trifoliate orange as the best rootstock for Citrus in Nepal. Since then it is widely being used for the production of grafted saplings of citrus all over Nepal. At present, WTHC is serving as the major resource center of trifoliate orange for the private nurseries and government farms also. The production and distribution record of trifoliate orange seeds by WTHC in the last five fiscal years is presented in Figure 2.

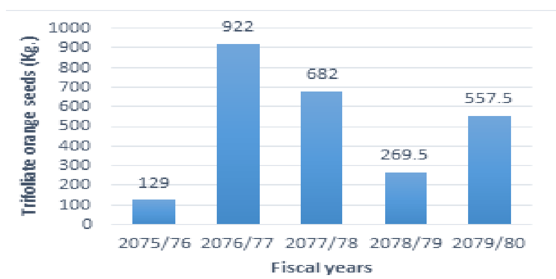

Figure 2. Production and distribution record of trifoliate orange seeds

Mother plant management inside screen house

All together 60 mother plants of three different citrus species i.e. mandarin orange orange, acid acid lime and sweet orange are being raised inside screen house. Among them 37 plants belong to 8 different varieties of mandarin orange orange (Table 1). These mother plants are maintained with proper layout and tagging. The management of mother stock is done regularly to encourage the growth of large number of quality scions. Also the mother plants are tested for Huanglongbing (i.e. PCR test for citrus greening) every year before grafting.

Table 1. Details of mandarin orange mother plants maintained inside screen house

S.N.	Varieties	No. of plants
1	Nepali *Suntala*	2
2	Yosida Ponkan	7
3	Ohta Ponkan	7
4	Murcott	6
5	Thai Tangerine	4
6	Kinnow	3
7	Kirtipur Selection	3
8	Okitsuwase (Satsuma mandarin)	5
	Total	37

Management of rootstock block

The rootstock block of trifoliate orange consists of 800 plants which are being managed regularly. By considering the increasing demand of trifoliate orange seeds, new plants are transplanted every year. Similarly, there is a well-established rootstock block of Troyer Citrange but the seed production is not satisfactory.

Collection, conservation and promotion of citrus germplasm

Most of the germplasm of mandarin orange available at WTHC were introduced during the period of HDP in 1985 AD to 1997 AD and few of them were collected from different parts of the county. The citrus/mandarin orange species with varied characteristics found during the field visits are collected and maintained in the pot inside the glass house. If the performance of potted plants observed good they will be multiplied to the open field also.

Technical guidance to the nursery men and orchard grower

The farm provides technical guidance to the private nursery and nursery owner for the production of quality planting materials of citrus/mandarin orange. Similarly, mandarin orange growers are supported technically for the production of quality fruit and postharvest activities. The farm also conducts residential and onsite trainings on nursery and orchard management of citrus/mandarin orange for the participants from all over the country.

Facility of PCR and ELISA test

The leaf samples of mandarin orange tree received from different parts of the country are tested for Huanglongbing (i.e. Polymerase Chain Reaction : PCR) at molecular lab of WTHC. Similarly the Enzyme-linked Immunosorbent Assay (ELISA) test helps in identification of Citrus Tristeza Virus (CTV). PCR and ELISA test has become more accessible and ensured timely identification of diseased plants from different part of the country with the establishment of these laboratories.

Strength of WTHC for the production of mandarin orange saplings

- Self-reliant in terms of rootstock and scion: The rootstock seeds and scion required for the production of quality saplings of mandarin orange are available within the farm.
- Screen houses: the farm owns seven screen houses, two of them are being used as mother plant block while five are being used for raising rootstock, seedling and grafted saplings.
- Technical human resources: The farm is strong in terms of technical human resource as the grafters working in the field are well trained and experienced. Also the office team consist of six Subject Matter Specialists (SMS) led by Senior Horticulture Development Officer (SHDO) and supported by JT/JTAs.
- Lab facilities: The center consist of six laboratories i.e. soil lab, pomology lab, pathology lab, entomology lab, molecular lab and tissue culture lab. Combined effort of these laboratories will be very helpful for the production of quality planting materials of mandarin orange.
- Farm location and accessibility: As it is located in the capital city of Nepal, it has easy access to the inputs and technologies. Also, the regular guidance and supervision from higher authorities helps in its better performance. Similarly, farmers from all over the country have easy access to come and learn as per their requirement.

Weakness/challenges for the production of quality planting materials of mandarin orange

- Increasing demand of trifoliate orange seeds: The demand for trifoliate orange seeds is increasing with the increasing demand of grafted saplings. So, fulfilling this demand with the existing blocks of rootstock and annual production is not sufficient.
- Insufficient number of screen house and their maintenance: Since the saplings of all the citrus species have to be raised inside the screen house, the number of saplings couldn't be increased with the existing structures. Also, the regular maintenance of those structures is costly and even the small leakage may create huge problems.
- Lack of proper irrigation system: The mother plants or the saplings inside the screen house have to be irrigated regularly but the center doesn't own the permanent source of irrigation water. So, irrigating the plants during the dry period (i.e. Chaitra to Jestha) becomes very problematic.
- Provision of permanent technical manpower at laboratories: For the smooth operation of molecular and PCR laboratories of the center, permanent position for lab human resource should be created.
- Increasing risk of insect pests and diseases: Species of mealy bugs, scale insects, aphid, leaf miner, powdery mildew, shooty mold, blight, damping off etc are major insect and pest observed in the field of WTHC.

Way forward

- The increasing demand of trifoliate orange seeds can be addressed;
  - i) By increasing the production of trifoliate orange seeds with the new plantation.
  - ii) By working on the alternatives of trifoliate orange such as citrange, rangapur acid lime etc.
  - iii) Private sector should be encouraged towards trifoliate seed production.
- Collaboration should be made with higher authorities for the construction of new infrastructures such as screen house and irrigation facilities.
- There should be provision of bio-technician permanently in the organogram of WTHC.
- On-farm demonstration and trial program should be started all over the country for the dissemination of different best varieties of mandarin orange.

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राष्ट्रिय फल सुन्तलाः तथ्य पृष्ठ

(Fact Sheet of Mandarin Orange: The National Fruit)

शान्ता कार्की, बालकृष्ण जोशी, याममकुमारी श्रेष्ठ र सूर्य प्रसाद बराल

राष्ट्रिय फलफूल विकास केन्द्र, कीर्तिपुर, काठमाण्डौं
राष्ट्रिय कृषि आनुवांशिक स्रोत केन्द्र, खुमलटार, ललितपुर

तथ्य पृष्ठ

सुन्तला (Mandarin orange, *Citrus reticulata* Blanco, Diploid; 2n=2x=18)

सुन जस्तै पहेंलो र तला तला जसरी फल्ने भएको हुँदा सुन्तला नाम रहेको, सुनको जस्तै रङ र कमाइ पनि सुनको जस्तै अर्थात पहिले पहिले सुन्तला पनि तोलाको भाउ जसरी जोखिने भएकोले सुनसँग तुलना गर्दा गर्दै सुनतोला नाम रहेको र हाल सुन्तला नाम रहन गएको भन्ने भनाई छ।

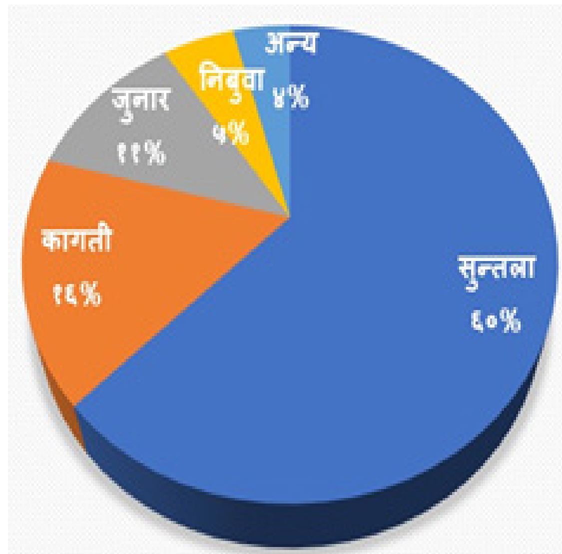
सुन्तलाको फल कलिलोमा प्राय अमिलो र छिप्पिदै गएपछि बिस्तारै गुलियो हुन्छ । फलको भित्री भागमा बियाँ र रसयुक्त केस्रा हुन्छ जुन जात अनुसार बाक्लो वा पातलो हुने गर्दछ। सुन्तलाको रंगको सुन्दरता, फूल र फलहरुको सुगन्ध सायद अन्य कुनै पनि फलफूलमा पाइदैन। त्यसैले संसारका लोकप्रिय तथा अत्यधिक मात्रामा खेती गरिने फलफूलहरुमा सुन्तला अग्रस्थानमा आउने गर्दछ।

एकदम प्रचलित र विभिन्न ठाउँहरुमा प्रयोग भएको शब्द सुन्तला, जस्तै सुन्तला रङ्ग, सुन्तला सम्बन्धी थुप्रै गीत, कविताहरु, मान्छेको नाम, कथा, नेपालको सुन, आदि प्रचलनमा रहेको पाइन्छ। सुन्तला सम्बन्धित थुप्रै मेला, महोत्सव, प्रदर्शनी, पर्व, जस्ता कार्यहरु आयोजना गरिदै आएको।

फैलावट

उत्पति : नेपालको मध्य पहाड (प्राचीन कालदेखि जंगलबाट ल्याएर खोकुमा खेती गरिएको)
सुन्तला खेती हुने उचाईः २००-२००० मिटर
सुन्तला खेती हुने जिल्ला : ६६
सुन्तला पकेट क्षेत्र : ६० जिल्लामा ९८९ पकेट क्षेत्र

व्यावसायिक रुपमा सुन्तलाको खेती भएको जिल्लाहरुः ताप्लेजुङ्ग, पाँचथर, तेह्रथुम, धनकुटा, इलाम, भोजपुर, खोटाङ्ग, उदयपुर, संखुवासभा, सोलुखुम्बु, ओखलढुङ्गा, सिन्धुली, रामेछाप, काभ्रेपलाञ्चोक, चितवन, नुवाकोट, गोरखा, लमजुङ्ग, म्याग्दी, तनहुं, कास्की, पर्वत, बाग्लुङ्ग, स्याङ्गजा, नवलपरासी, पाल्पा, गुल्मी, अर्घाखाँची, रुकुम, प्युठान, रोल्पा, सल्यान, दैलेख, जाजरकोट, कैलाली, डडेल्धुरा, डोटी, बाजुरा, बझाङ्ग, बैतडी, दार्चुला र अछाम।



चित्र १. सुन्तला खेतीले ओगटेको क्षेत्र (आ.व.२०७८/७९)

क्षेत्रफल र उत्पादन

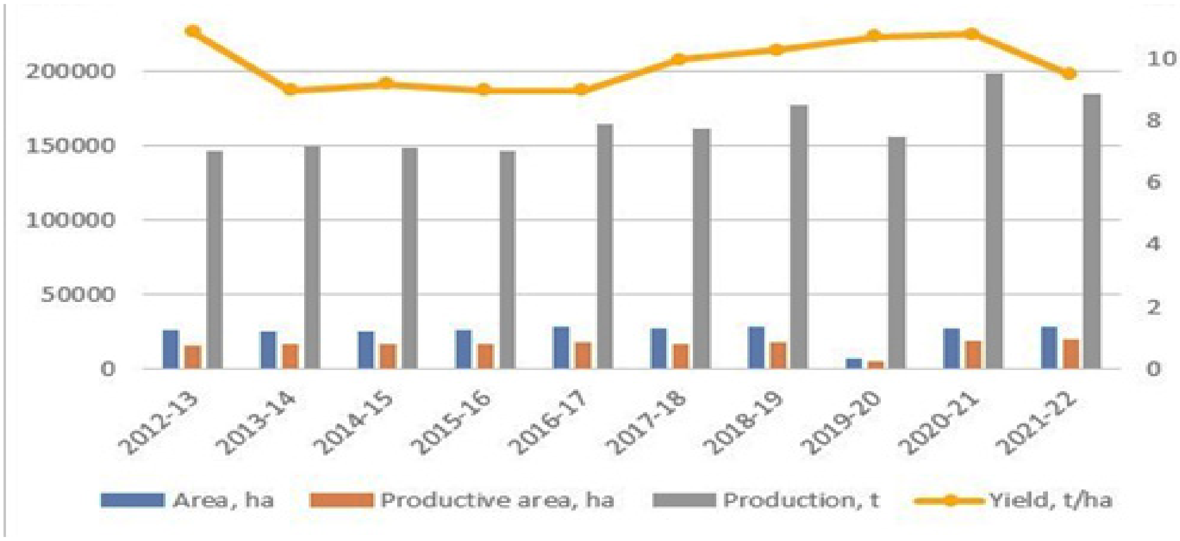
सुन्तला खेती सम्बन्धी तथ्याङ्क आ.व. २०७८/७९

कुल क्षेत्रफलः २७८९२ हे

उत्पादनशील क्षेत्रफलः १९४८१ हे

कुल उत्पादन : १८५३४६ टन

उत्पादकत्व : ९.५१ टन/हे



चित्र २. विगत १० वर्षको अवधिमा सुन्तला फलफूलको क्षेत्रफल र उत्पादन स्थिति

इतिहास

सुन्तलामा विकास कार्य : २०१७ सालबाट औपचारिक रुपमा शुरु (पोखरा र धनकुटा बाट)

जैविक विविधता

रैथाने जातहरु : ६०

बिदेशी जातहरु : ४३

दर्ता भएका जातहरु : ३ (खोकु स्थानीय, बाँसखर्क स्थानीय र परिपात्ले अगौटे (उन्सु)

सुन्तलाजात (अमिलो) फलफूलहरु अन्तर्गत : सुन्तला, मुन्तला, जुनार, मौसम, कमला, कागती, निबुवा, ज्यामिर, भोगटे, बिमिरो, ग्रेपफ्रुट

योगदान र गुण

कुल कृषि गार्हस्थ उत्पादनमा योगदान : ०.९६%

प्रति बोट उत्पादन : २५०० दाना

फलको तौल : ४० देखि १७७ ग्राम

एक परिवारले बढीमा लिएको आम्दानीः ७५ लाख, खोटाङ्गमा ३७ करोडभन्दा बढीको सुन्तला उत्पादन

सुन्तलाको मूल्य (बोटमा) : रु ८० प्रति केजी

कार्बन स्थिरिकरण : ०.२४-१.२२ टन/ हे (धनकुटामा खोकु सुन्तलाले)

बाँच्ने उमेर : ४००+ वर्ष

ताजा सुन्तला पाइने महिना : भदौदेखि फाल्गुणसम्म

बजारमा नेपाली सुन्तला पाइने महिना : भदौदेखि बैशाखसम्म

सबैभन्दा बढी उत्पादन दिने बाली : सुन्तला

सुन्तलाजात मध्ये सुन्तला : प्रमुख फल

प्रसारण : बीउ र हाँगाबाट

स्वाद : अति मिठो

उपभोक्ता : सबै वर्ग, उमेर, र अवस्थाका मानिसले खान मिल्ने

सुन्तलामा अनुसन्धान : वि.सं. २०२९ सालबाट

कलमी बिरुवा उत्पादन : वि.सं. २०२६ सालबाट

उपयोग : ताजा उपभोग, रस, अन्य प्रशोधित परिकार, विभिन्न क्रिम बनाउन, औषधिको रुपमा, उपहार, सुन्दरताको

चित्र ३. गुल्मी जिल्लाको धुकोट गाउँपालिका, नयाँ गाउँमा कमल थापाको घरमा रहेको सबैभन्दा पुराना बोट (करीब ४०० वर्ष पुरानो)

लागि, जंगली जनावरको लागि आहार र बासस्थान, बाह्रै महिना हरियाली हुने हुनाले वातावरण र माटो संरक्षण।

नेपाली सुन्तलाको विशेषता : अन्य देशको भन्दा मीठो, रसिलो र सुन्दर सहित वास्नादार; सबैभन्दा बढी रुचाएको फल, प्राङ्गारिक उत्पादन प्रणाली, नेपालको सुन्तलाको स्वाद विश्वमा उत्पादन हुने सुन्तलाहरू भन्दा बिल्कुल भिन्न र अत्यन्त स्वादिलो रहेको छ।

विविध

एकदम चल्तीको गीत : सुनकै भाउ छ सुन्तला भारीको -स्वर कुन्ती मोक्तान

संरक्षण : ५ वटा भन्दा बढी फिल्ड जिन बैंकमा ३० भन्दा बढी रैथाने जातहरु संरक्षण

महत्त्व

सुन्तला, नेपालको एक महत्त्वपूर्ण व्यावसायिक फलफूल बाली हो । सुन्तला विभिन्न पौष्टिक तत्वहरुले भरिपूर्ण फलफूल हो जसमा भिटामिन ए, बि र सी प्रशस्त मात्रामा पाइने गर्दछ र यी पौष्टिक तत्वहरु मानव स्वास्थ्यको लागि अति महत्वपूर्ण मानिन्छन् । सुन्तलामा रेशाको मात्रा बढी पाइन्छ जसले कब्जियतलाई कम गर्नुका साथै छालामा चमकपन पनि ल्याउने गर्दछ। सुन्तलामा पाइने तेल कस्मेटिक प्रयोजनको लागि उपयोग गरिन्छ। सुन्तलाको छुट्टै धार्मिक एवं साँस्कृतिक महत्त्व समेत रहेको छ, जसअनुसार शुरुमा ठूलो एकादशीबाट सुन्तला खाने गरिन्छ भने सुन्तलालाई बालाचतुर्दशीमा प्रयोग गरिने सतबीजमा पनि प्रयोग गर्ने गरिन्छ। हरेक पूजाआजामा प्रयोग गरिने प्रसाद मध्येको एक प्रमुख फल सुन्तला हो।

Status of Mandarin Orange (*Citrus reticulata* Blanco) in Gandaki Province

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Abstract

Mandarin orange (*Suntala* in Nepali) is the topmost fruit of Gandaki Province in terms of area coverage, income generation and preference of farmers. Gandaki Province has been leading other provinces in terms of area of cultivation and production. Among the area covered by fruits, 55% has been occupied by citrus fruits only. Mandarin orange alone covers around 79% and 82% of the total citrus area and production, respectively. Therefore, it is a major income generating fruit crop of farmers in this province. Due to favorable agro-climatic conditions, mandarin orange is commercially cultivated in nine out of eleven districts and the provincial government has recognized it as one of the prioritized crops. In addition to regular provincial programs, one super zone and three zone programs have been implemented for citrus fruits development by the federal government through Prime Minister Agriculture Modernization Project. Similarly, Nuts and Fruits in Hilly Areas Project has prioritized mandarin orange and acid acid lime by covering 27 local levels in 8 districts of the province. Although there is an increasing trend in the area and production over the years, the productivity is yet to meet its potential. In spite of regular efforts for the development of this sector, there are many challenges for area expansion, good harvest and market management. This article focuses on identification of challenges, policy gaps, potentials, and provides recommendations for sustainable improvement of overall aspects of mandarin orange.

Keywords: Citrus decline, Commercialization, Livelihood, Orchard management, Value chain

Introduction

Citrus is one of the major fruits not only in Nepal but also in the Gandaki Province in terms of area cultivated, income generation, and preference of farmers. Nationally citrus fruits contribute about 1.52 percent to AGDP which is 29.5 percent of total fruits sector's contribution. Mandarin orange solely contributes about 18.8 percent and 63.3 percent among total fruits and citrus fruits respectively (MoALD, 2023). The government of Nepal has declared mandarin orange as the national fruit of Nepal on 12 April, 2024.

Among the seven provinces, Gandaki Province has been leading other provinces in terms of area of cultivation and production of mandarin orange. In Gandaki Province, out of the total area covered by fruits, 55% has been occupied by citrus fruits only. Mandarin orange alone covers around 79% and 82% of the total citrus area and production respectively (MoALD, 2024). It is estimated that citrus grower of Gandaki sold mandarin orange of around 3000 million Nepalese rupees in the fiscal year 2022/23. Hence mandarin orange is considered as one of the major income- generating fruit crops that greatly supports for the upliftment of livelihoods and family nutrition in this province. The favorable agro-climatic condition allows the cultivation of mandarin orange commercially in nine districts among eleven districts except Manang and Mustang. The Government of Gandaki Province identified mandarin orange as one of the most prioritized crops in the agriculture sector (PPPC, 2019). Similarly, Provincial government has also established the Horticulture Development Resource Centre in Gandaki province realizing the need of an organization directly related to the development of fruit sector.

Prime Minister Agriculture Modernization Project (PMAMP) and Nuts and Fruits in Hilly Areas Project (NAFHA) are the major projects being implemented in addition to regular provincial program for raising production and productivity of citrus along with other crops. Although, there is an increasing trend in the area and production over the years, the productivity is not satisfactory in comparison to its potential. In spite of regular efforts for the development of this sector, farmers are facing many obstacles for the area expansion, good harvest and the market management. Though, there is great potentiality of expanding the area under fruit crops particularly mandarin orange in Gandaki province, the trend of agricultural land being abandoned is in increasing trend. In this scenario, it is crucial to study and analyze trend of area coverage, production and yield over the years as well as identify the major constraints of mandarin orange sector. The findings from this study will help to identify the policy gaps, reform the existing policy and prioritization of the problems. This study suggests practical solution and supports to take necessary actions to increase the production and productivity of mandarin orange and improving its value chain in Gandaki Province. It focuses on the present status and future directives that are recommended to be adopted for self-sufficiency and export promotion of mandarin orange.

Materials and methods

Primary data on fruit production and planting material regarding the mandarin orange were collected from Agriculture Knowledge Centres (AKCs) of each citrus growing district of Gandaki Province. Time series secondary data of area, production and productivity were obtained from the reports and publications of Ministry of Agriculture and Livestock Development (MoALD) and Provincial Policy and Planning Commission (PPPC) of Gandaki Province. Similarly, information on imported quantity and value of citrus commodity was compiled from the records of Department of Customs, Government of Nepal. The collected data were analyzed using Microsoft Excel.

Result and Discussion

Salient features of Agriculture in Gandaki Province

The general scenario of agriculture sector in the Gandaki Province (Table 1) shows that 24 percent of the total cultivable land is abandoned and only 37.76 percent of the cultivated land is irrigated. Among the total fruit cultivated area, citrus fruit (55 percent) is leading to other fruits. Mandarin orange alone contributes about 79 percent and 82 percent area and production respectively among the total citrus fruits. The figure illustrates that mandarin orange is the most important fruit crop of Gandaki Province in terms of both area, production and preference of the farmers. It is due to favorable agro-climatic condition for the cultivation of mandarin orange and commercial cultivation as a major source of income generation of the farmers in the province.

Table 1. Selected indicators of agriculture sector in Gandaki Province (FY 2022/23)

S.N.	Selected Indicators	Area and Production	Percentage (as compared with)
1	Total area of Gandaki Province (ha)	2191781	14.67 (area of Nepal)
2	Total cultivable land area (ha)	487823	22.2 (area of Gandaki province)
3	Total cultivated land area (ha)	370591	76 (total cultivable area)
4	Abandoned agricultural land (ha)	117231	24 (total cultivable area)
5	Total irrigated area (ha)	139935	37.76 (total cultivated area)
6	Year-round irrigated land (ha)	71614	19.3 (total irrigated area)
7	Horticultural crops area (ha)	68475	18.5 (total cultivated area)
8	Fruit cultivated area (ha)	18395	27 (area under horticultural crops)
9	Area of citrus fruits (ha)	10195	55 (total area under fruit)
10	Area of mandarin orange (ha)	8032	79 (total citrus fruit)
11	Production of mandarin orange (mt)	55196	82 (total citrus fruits)
12	Production of mandarin orange (mt)	55196	42 (total fruits)

Area, production and productivity of mandarin orange

Area, production and productivity of mandarin orange in Gandaki as compared to other provinces of Nepal

Gandaki Province is leading in the total area, productive area and production of mandarin orange over other provinces (Table 2). The total area (8032 ha), productive area (5230 ha) and production (50850 mt) in Gandaki province is the highest among the seven provinces followed by Koshi Province. Productivity of mandarin orange in Gandaki Province (10.55 mt/ha) is slightly higher than the national average productivity (10.01 mt/ha). Gandaki Province ranks fourth in terms of productivity after Karnali, Lumbini and Bagmati Provinces, respectively.

Table 2. Province wise area, production and productivity of mandarin orange in Nepal (FY 2022/23)

S.N.	Name of Province	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)	% of total
1	Koshi	6952	4705	39254	8.34	24.4
2	Bagmati	4393	3269	29349	8.98	15.4
3	Gandaki	8032	5230	55196	10.55	28.2
4	Lumbini	3896	3244	36068	11.12	13.7
5	Karnali	3542	2391	27826	11.64	12.4
6	Sudurpashchim	1636	1058	11503	10.87	5.8
7	**Total**	**28451**	**19897**	**199196**	**10.01**	**100**

Area, production and productivity of mandarin orange in different districts of Gandaki Province

Total area and productive area of mandarin orange (Figure 1) in Gandaki Province is 8032 ha and 5230 ha respectively in the fiscal year 2022/23. The highest total and productive area was found in Syangja followed by Tanahun and Gorkha respectively. Syangja, Tanahun and Gorkha districts altogether contribute 58 percent and 61 percent of total and productive area of mandarin orange in the province. The figure indicates that commercialization of mandarin orange is comparatively higher in these districts compared to other districts.

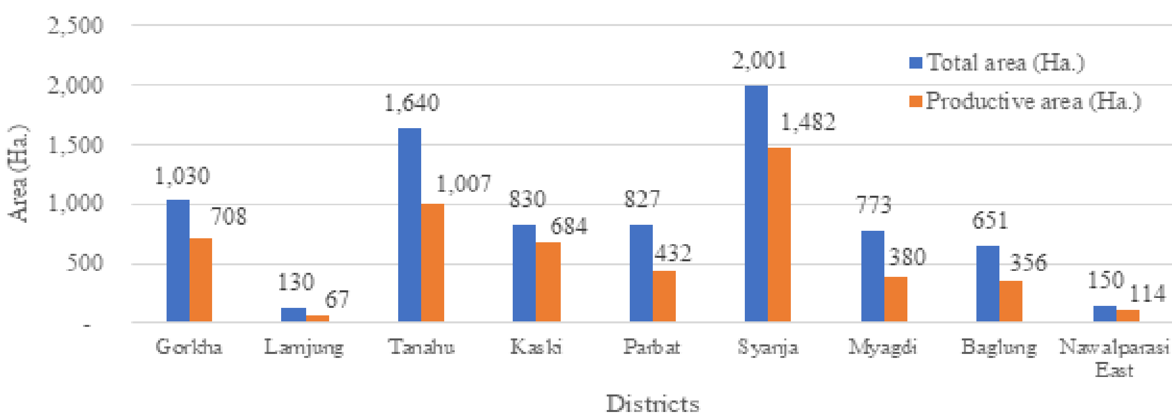

Figure 1. District wise total and productive area of mandarin orange in Gandaki province (FY 2022/23)

Similarly, production of mandarin orange follows the same pattern as that of total and productive area in Gandaki Province (Figure 2). Syangja district stands as the highest producer of mandarin orange (17031MT) followed by Tanahun (12976 MT) and Gorkha (5968 MT). The average productivity of mandarin orange is 10.55 MT/Ha. In terms of productivity, Tanahun is leading in the province (12.9 MT/Ha.) followed by Syangja (11.5 MT/Ha.). Only

Tanahun, Syangja and Baglung exceed the provincial average productivity of mandarin orange. The lower productivity might be due to old orchards, citrus decline caused by poor orchard management practices and citrus greening disease.

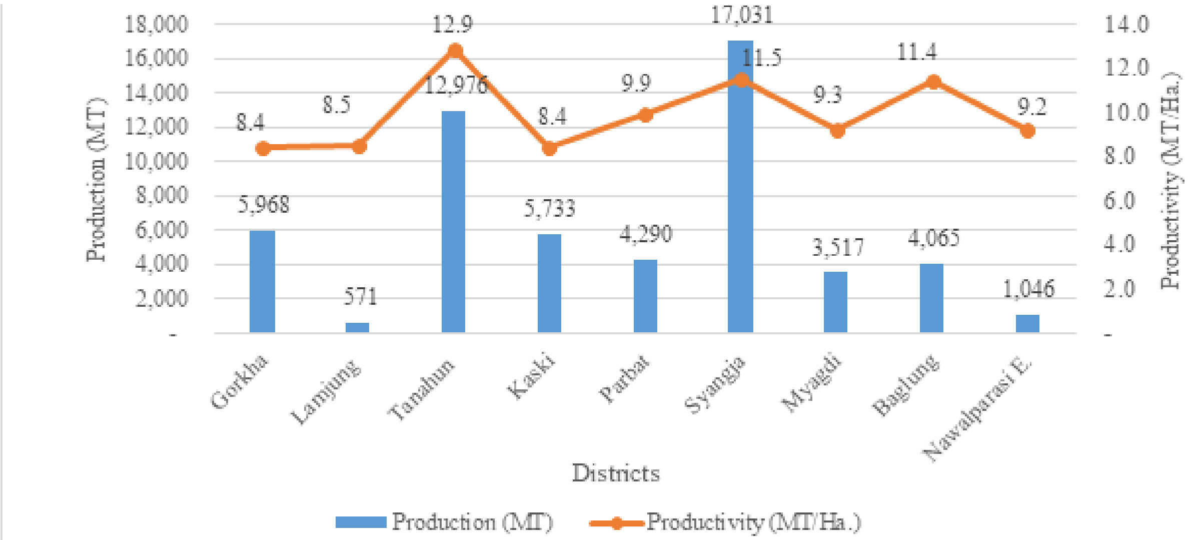

Figure 2. District wise production and productivity of mandarin orange in Gandaki province (FY 2022/23)

Area, production and productivity of mandarin orange of Gandaki, Province in last ten years

The data on mandarin orange cultivation of Gandaki Province over the last ten years shows that the total area under mandarin orange has slightly increased from 7883 Ha. to 8032 Ha. (Figure 3a) and the productive area has decreased from 5275 Ha. to 5230 Ha. Increase in total area indicates that the demand for planting material is also increasing. Decrease in productive areas during the 10 years period might be due to very old orchard and citrus decline problem.

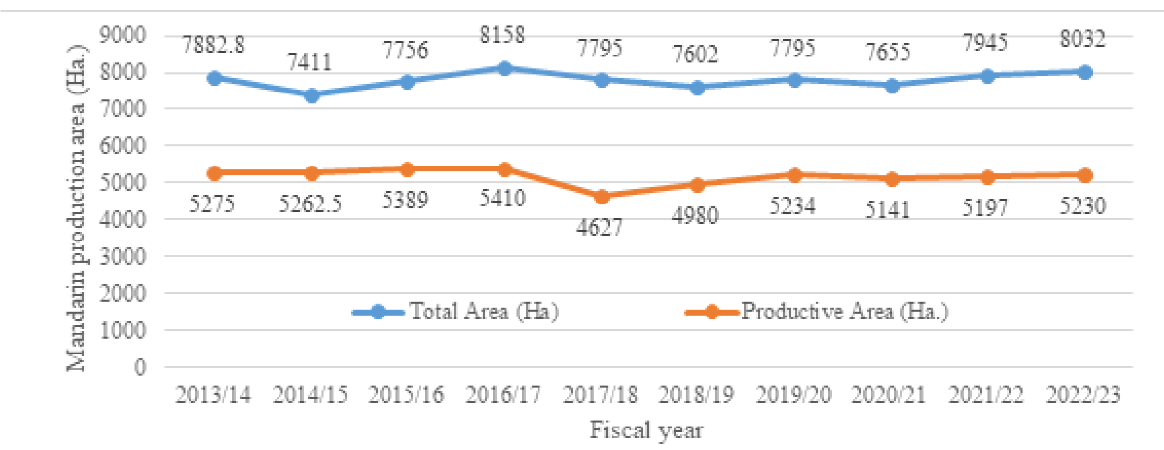

Figure 3a. Trend of total area and productive area in the last 10 years of Gandaki province.

The trend of production (Figure 3b) and productivity (Figure 3c) of mandarin orange shows that there is up and down over the period of time. The total production of mandarin orange in the base year was 48047 MT which has increased to 55196 MT in the year 2023/24. The average productivity of mandarin orange over the last ten years is 9.91 MT/Ha. The lowest and the highest productivity was found in the year 2015/16 (8.19MT) and 2020/21 (11.66 MT) respectively (Figure 3c). The abrupt decrease in the productivity might be mainly due to adverse weather conditions of the specific year.

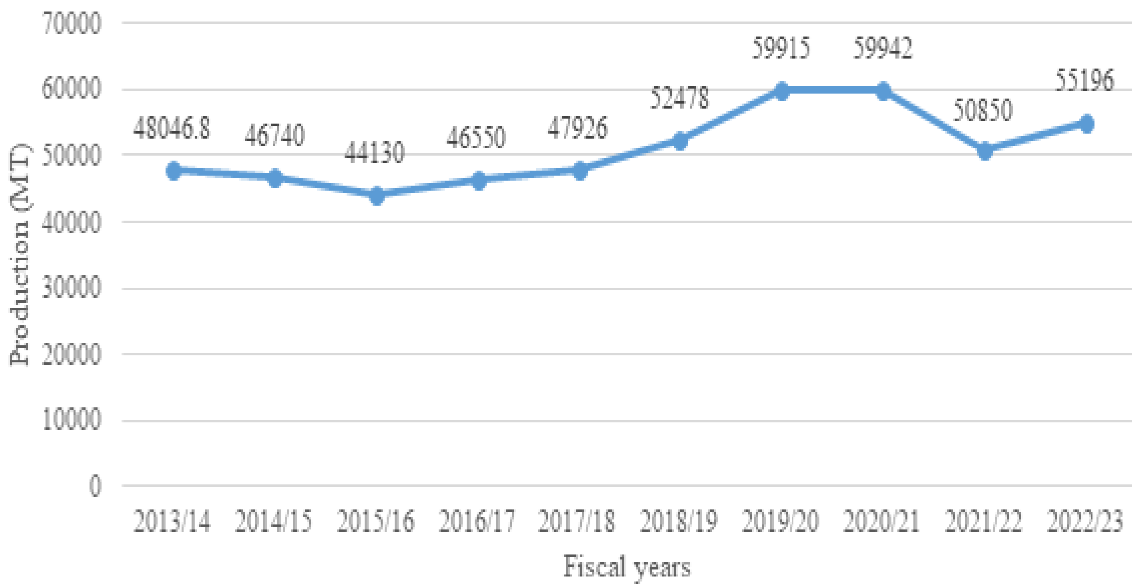

Figure 3b. Trend of total area and productive area in the last 10 years of Gandaki province

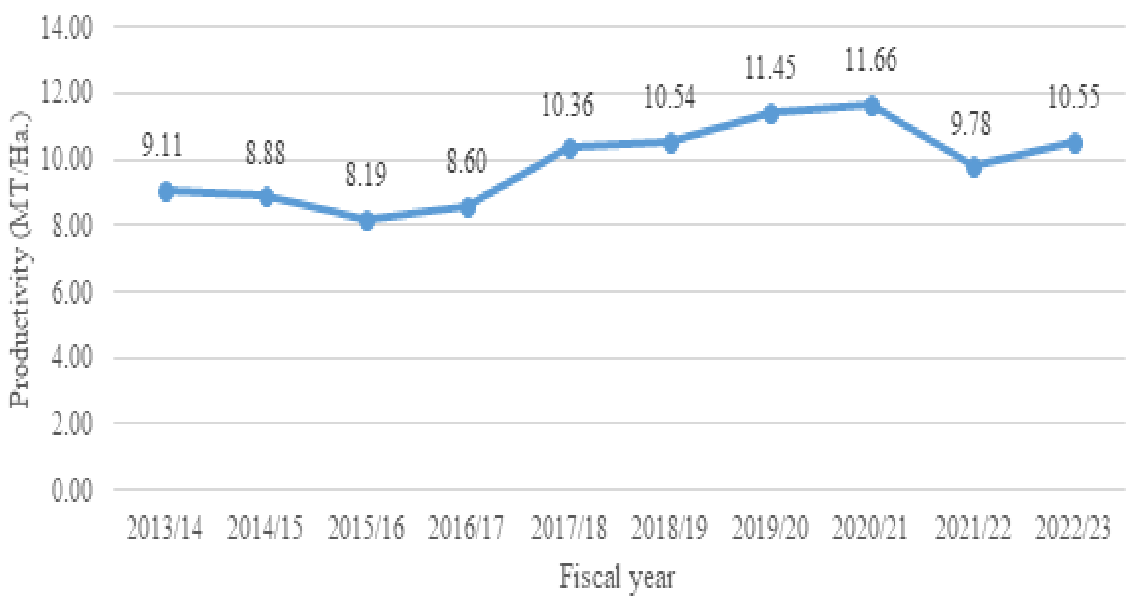

Figure 3c. Trend of total area and productive area in the last 10 years of Gandaki province

Projects for mandarin orange in Gandaki Province

Prime Minister Agriculture Modernization Project (PMAMP, 2016 - 2026)

Pocket, block, zone and super-zone under PMAMP

PMAMP is a 10 years' project (2017-2025) being implemented throughout the country by Ministry of Agriculture and Livestock Development from the internal funding and human resources of Government of Nepal. Under the PMAMP project, there are 30 pocket programs, 20 block programs (Table 3) and 3 zone and one super-zone program (Table 4) that are established in Gandaki province.

Table 3. Local levels Pocket and Block program of mandarin orange under PMAMP.

S.N.	District	Pocket program implemented Local Level and ward no.	No. of pocket	Block program implemented Local level	No. of Block
1	Gorkha	Siranchok-2	1	Siranchok, Gandaki, Sahid Lakhan	3
2	Lamjung	-	-	Sundarbazar	1
3	Tanahun	Ghiring-3, 5; Byas-9	3	Myagde, Byas, Shuklagandaki, Aanbukhairani, Devghat	5
4	Kaski	Rupa-1, Annapurna-8	2	Pokhara-21,22,23	1
5	Syangja	Aandhikhola-6 (2), Walning-2, 10; Galyang- 5, 6,7, 10; Chapakot-5	9	Waling, Galyang, Biruwa, Fedikhola, Aandhikhola	5
6	Parbat	Paiyun-1, 3,6,7; Falebas-9, Mahashila-1,2,5; Kushma-3, 11; Jaljala-7,9; Modi-5, Bihadi-5	14	Modi, Mahashila	2
7	Myagdi	-	-	Beni, Malika	2
8	Baglung	Galkot-3	1	Jaimini	1
		Total	**30**		20

One super-zone program and 3 zone programs on mandarin orange have been implementing in different local levels of Gandaki province (Table 4). Total number of beneficiaries, gender participation status, involvement of farmers' groups and cooperatives, expansion of total mandarin orange area, support to establish citrus nursery and annual saplings production and total program budget expenditure in each zone is presented (Table 5).

Table 4. Super-zone and zone program on citrus including mandarin orange under PMAMP.

Zone/Super-zone	Super-zone	Zone		
District	Syangja	Gorkha	Nawalparasi East	Myagdi
Start date	2075/76	2074/75	2075/76	2075/76
Program implemented in Local Level	All local level of the district	Gorkha, Sahid Lakhan, Panungtar-9,10; Gandaki, Bhimsen Thapa	Bulingtar 1-6, Baudikali 1-6, Gaindakot-18, Madhybindu- 8 and 15, Hupsekot-5, Devchuli-6	Myagdi- Beni, Raghuganga, Annapurna, Mangala; Parbat-Jaljala; Baglung-Baglung and Kathekhola

Area expansion of citrus fruit including mandarin orange under PMAMP

After the implementation of PMAMP program, expansion of the highest total area of citrus fruits (2000 Ha.) as well as mandarin orange (1200 Ha.) was found in super-zone implemented Syangja district followed by Nawalparasi East. Similarly, highest area of citrus orchard improvement (1200 Ha.) was also found in Syangja (Figure 4). It might be due to nature of the component i.e. super-zone, more budget and more suitable area for the expansion of mandarin orange in Syangja district.

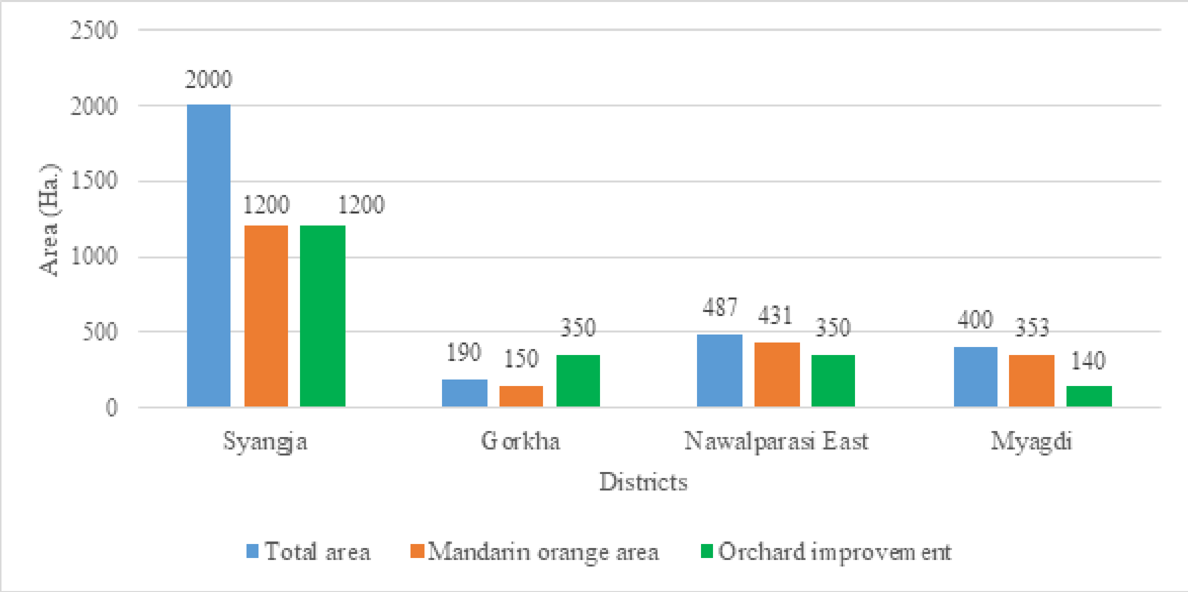

Figure 4. Area expansion of citrus fruit incuding mandarin orange under PMAMP

Beneficiaries of PMAMP in Gandaki Province:

The number of households obtaining benefits from different zone and super zone has reached 7676 till now out of which the highest number of beneficiaries (36%) from Nawalparasi East and lowest (16%) in Myagdi district (Table 5).

Table 5. Number of beneficiaries of super-zone and zone program under PMAMP

S.N.	Particulars	Syangja	Gorkha	Nawalparasi	Myagdi	Total
		Super zone	Zone	Zone	Zone	
1	Number of Households benefited by the project	2415	1250	2791	1220	7676
2	Female	930	672	1004	356	2962
3	Male	1485	578	1787	864	4714
4	Total Farmers group involved in the project	63	56	33	58	210
5	Total Farmers cooperatives involved in the project	12	22	5	19	58
6	Citrus orchard established after the start of the project (Ha.)	2000	190	487	400	3077
7	Total mandarin orange area expansion after the start of project (Ha.)	1200	150	431	353	2134
8	Orchard improvement of citrus fruit (Ha.)	1200	350	350	140	2040
9	Support to establish citrus nursery (No. of nurseries)	11	10	3	15	39
10	Total citrus plant produced by the supported citrus nursery	100000	144000	90000	48000	382000
11	Total program budget expenditure till date (NRs.'000)	158100	53867	35266	38007	285240

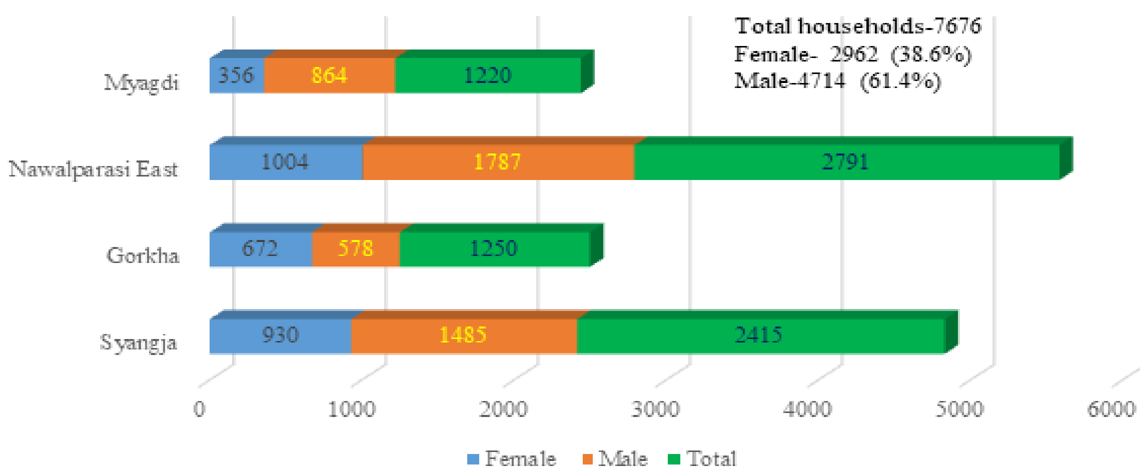

Figure 5. Gender participation in zone/super-zone in different districts

From the perspective of gender inclusion in the program activities of four districts, participation of female farmer is 38.6 percent. The highest percentage of female participation was found in Nawalparasi East (53%) and the lowest (29%) was found in Myagdi (Figure 5).

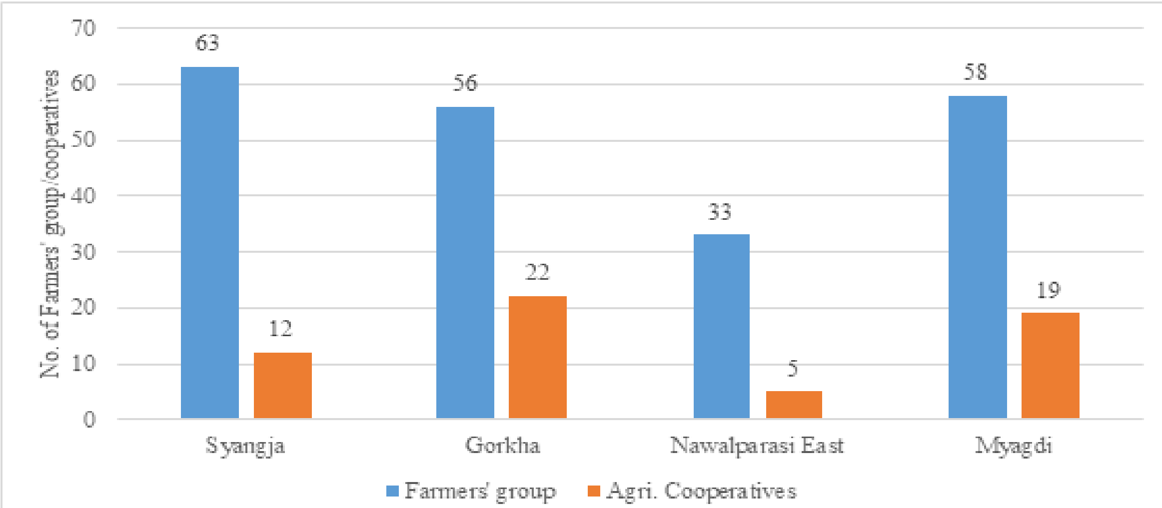

Figure 6. Involvement of farmers' group and cooperatives in zone and super-zone programs

At present, group approach is the common approach adopted for the implementation of agricultural program in Nepal. The highest number of farmers' (63) group involvement in the program was found in super-zone implemented in Syangja district followed by Myagdi (58). However, the highest involvement of agricultural cooperatives was found in Gorkha followed by Myagdi (Figure 6).

Nuts and Fruits in Hilly Areas (NAFHA) project

Government of Nepal is implementing seven years' project from 2022 to 2029 entitled "Nuts and Fruits in Hilly Areas (NAFHA)" project in five provinces of Nepal except Madhesh and Lumbini including 34 districts and 100 Local levels. Under NAFHA Project, estimated total area expansion of mandarin orange in Nepal is 2600 hectare out of which Gandaki Province alone consists of 800 ha (30.6%) in 27 local level of 8 districts (Table 6). In Gandaki Province, the total target of area expansion of different fruit is 2500 hectare of which 800 hectares (32%) is allocated for mandarin orange (PAM, 2022). From this figure, we can conclude that federal government also prioritized mandarin orange production in Gandaki province.

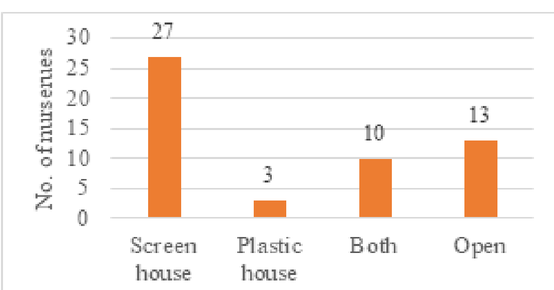

Figure 7a. Types of nursery structure

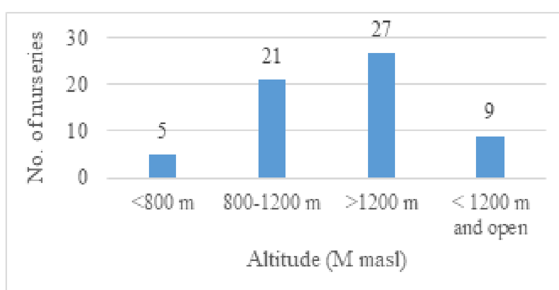

Figure 7b. Nurseries in different altitudes

Table 6. NAFHA project implementing districts and Local level in Gandaki Province

S.N.	District	Local level
1	Gorkha	Aarughat, Palungtar, Siranchowk
2	Lamjung	Besishahar, Madhya Nepal, Marsyangdi, Rainas, Sundar Bazar
3	Tanahun	Myagde, Rishing
4	Kaski	Madi, Pokhara, Aannapurna
5	Syangjaa	Biruwa, Chapakot, Galyang
6	Parbat	Jaljala, Kushma, Modi, Phalebas
7	Myagdi	Annapurna, Beni
8	Baglung	Badigad, Galkot, Jaimini, Kathekhola, Nisikhola

Status of citrus nurseries planting materials of mandarin orange in Gandaki Province

There are a total of 53 private nurseries (Table 7a) producing seedlings/saplings of mandarin orange in Gandaki province. Among them, 48 are registered and 5 are unregistered. The highest number of nurseries are found in Myagdi district (13) followed by Baglung (10) and Syangja (10). Considering the structure of nursery, 27 nurseries produced the nursery plants in screen house, 3 nurseries produced in plastic house, 10 nurseries have both open nurseries as well as screen house and 13 nurseries produced orange saplings/seedlings in open nursery (Figure 7). Considering the altitude of nursery place, 5 nurseries are established below 800m, 21 nurseries are between 800m-1200m and 27 nurseries are above 1200m. Nine nurseries below 1200m are producing the mandarin orange sapling in open nursery (Figure 7b).

Total citrus fruit sapling/seedling produced in Gandaki province during the FY 2022/23 is 798920 out of which 235478 (29.5%) are grafted and rest are produced from seed. Among the total citrus plant produced in Gandaki province in 53 private nurseries, 470849 (59 %) are of mandarin orange. The share of grafted and seeded plants of mandarin orange is 24 % and 76 % respectively.

Table 7. Status of citrus nurseries in Gandaki province

District	No. of citrus nurseries	Orange sapling produced		Total
		Grafted	From Seed	
Gorkha	4	12000	44000	56000
Lamjung	2	4000	0	4000
Tanahun	2	500	32000	32500
Kaski	3	1150	15000	16150
Syangja	10	54700	38500	93200
Nawalparasi East	6	17499	23300	40799

District	No. of citrus nurseries	Orange sapling produced		Total
		Grafted	From Seed	
Parbat	3	13000	18000	31000
Myagdi	13	10800	180000	190800
Baglung	10	0	13400	13400
Total	**53**	**111649**	**359200**	**470849**

Status of pests and diseases of mandarin orange in Gandaki province

Assessment of economically important insect pests and diseases of mandarin orange in Gandaki province is done during the Provincial Agricultural Technical Working Group (PATWG) meeting held on 2080/12/11 in Gandaki province. The major diseases of mandarin orange as identified are: Huanglongbing (Citrus greening HLB) (*Candidatus liberobacter asiaticus*) foot and root rot (*Phytopthora parasitica, P. citropthora, P. palmivora*), Citrus canker (*Xanthomonas citri*) gummosis (*Phytophthora* spp), sooty mould (*Capnodium oleaginum*). Among this citrus decline has been a major and contemporary shortcoming in our province for growing mandarin orange and citrus greening disease has been a major mishap for citrus decline. In order to identify the orchards with infection of citrus greening Plant Protection Lab of Gandaki Province PPL had completed testing over 126 samples from various regions based on following primers.

Name of the Primer	Sequence (5'-3')
Forward (Las606)	GGAGAGGTGAGTGGAATTCCGA
Reverse (LSS)	ACCCAACATCTAGGTAAAAACC

Out of 126 samples tested in two different fiscal years 47 samples were found positive.

Likewise, the major insect pests of mandarin orange are: Citrus Chinese Fly *Bactocera minax,* Citrus psylla; *Diaphorina citri,* Citrus Stink bug; *Rhynchocoris Poseidon,* Citrus Leaf miner; *Phyllocnistis citrella,* Leaf mining beetle, *Throscoryssa citri.* In recent years, Citrus Chinese Fly *Bactocera minax* has been damaging around 20-30% of total citrus fruit in Gandaki Province.

Table 8. Prioritized insect pests and diseases of mandarin orange in Gandaki province

S.N.	Prioritized insect pests	Prioritized diseases
1	Chinese Citrus Fly	HLB (Citrus Greening Disease)
2	Asian Citrus Psylla	Foot and Root Rot
3	Scale insect	Citrus Canker
4	Leaf Miner	Powdery Mildew
5	Citrus Stink Bug	Sooty mold
6	Fruit Sucking Moth	Felt disease

Strength, weakness, opportunities, and threats of mandarin orange sector in Gandaki Province

Strength

- Agricultural is considered as second most prioritized sector among the seven key drivers of prosperity of Gandaki Province. (Tourism, Agriculture, Energy, Industry, Infrastructure, Human Resource Development and Good Governance).
- First five-year plan (FY 2076/77-2080/81 BS) of Gandaki province declared mandarin orange as priority crop.
- Establishment of Horticulture Development Resource Centre in Gandaki province.
- Enforcement of Nursery Management Directive, 2080 according to the provision of Provincial Agri-Business Promotion Act, 2077. (18 Nursery inspectors in placed)
- Establishment of Agriculture and Livestock Regulation unit in Tanahun (Aanbu Khaireni) and Malunga (Syangja).
- Mandarin orange grading machine operation and establishment of processing industry in Syangja district
- The government of Nepal announced the years 2016/17 (2073/74 BS) to 2025/26 (2082/83 BS) as the fruit decade.
- Private nurseries started producing quality saplings.
- There are 14 cold storage and 73 cold room in Gandaki province with the storage capacity of 8270 MT.
- Implementation of fruit orchard improvement/management program.

Weakness

- Inadequate human resource.
- Work on fruit research is inadequate and extension program is very general.
- Poor nursery infrastructure.
- Less production of adequate quantity of disease-free quality saplings.
- Only 24 % of the total sapling produced is grafted.
- Poor orchard management practices (nutrient, water, disease pest) resulting lower productivity.
- Lower productivity of mandarin orange due to many reasons
- Post-harvest loss
- Fragmented/Scattered production pockets and limitation of land for big orchard establishment.

Opportunities

- Favorable Agro-climatic condition.
- Commodity of comparative advantage.
- Food and nutrition security and environment conservation.
- Import substitution and export promotion of quality fresh fruits.
- Pokhara as a capital city of tourism in Nepal.
- Agreement between Nepal and China for exporting mandarin orange (Syangja district).
- Mid-hill highway is under construction from east to west.
- Increased access to road and transportation.
- Gandaki province has direct market access to India and China for export.
- Abandoned land utilization in the mid-hills.
- Increased fruit demand due to nutrition consciousness.
- Increased urban population and income of middleclass people.
- Possibility of generating employment opportunity, improve income and poverty reduction.

Threats

- Regulation of the quality standard of saplings
- Introduction and spread of insect pest and diseases during import and internal distribution of saplings
- Citrus greening disease (CGD).
- Destruction of CGD infected orchard.
- Migration and occupational shift.

Major issues of mandarin orange sector in Gandaki Province

- Inadequate research works (varieties with higher yield and maturity period).
- Inadequate/very less production of quality planting materials.
- Capacity development of technicians as well as farmers.
- Absence of Nursery Act/Directive at national level.
- Destruction of CGD infected orchard and replantation.
- Post harvest losses due to poor handling and facilities.
- Seasonal market glut and import from other countries.
- Lack of private sectors' investment.
- Poor coordination among three tiers of government.

Recommenation

- Formulation and enforcement/strict implementation of Nursery Act/ Directive.
- Support for the production of quality planting materials.
- Research on varietal identification and improvement.
- Development of technological package of practices (PoP) for sustainable and effective disease pest management by DoAR, Lumle and HRS, Malepatan.
- Capacity enhancement for better orchard management practices.
- Reduction in post-harvest losses through improved post-harvest facilities.
- Institutional strengthening for research, production and marketing.
- Coordination, collaboration and cooperation among three tiers of government.
- Making conducive policy to attract private sectors for commercial plantation and post harvest facilities including processing industries
- Development of policy to utilize abandoned private and public land to convert in to fruit orchards.
- Policy of leasing government land to private sector for long-term.

Conclusion

Mandarin orange is the major strategic fruit crop of the Gandaki province with a competitive and comparative advantage. The cultivated area, productive area and production of mandarin orange has increased from 7883 ha to 8032 ha, 5275 ha to 5230 ha and 48047 mt to 55196 mt respectively within the period of 10 years from 2013/14 to 2022/23 however, productivity showed some fluctuations. Despite many initiatives taken by the government for the development of the mandarin orange sub-sector by implementing different projects, the condition of the orchards and the orchard owners has not been improving as expected. The quantity and value of the import of mandarin orange and its value-added products have been increasing day by day but the potential cultivation area is being fallow due to the disease infestation, orchard management problems, lack of proper value addition technique, and many other factors. The sector needs to be strengthened by the research-based problem identification, situation analysis and the impactful recommendations.

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जालीघरमा उत्पादन गरिएको सुन्तलाको कलमी बिरुवा

Status of Citrus Nurseries and Future Strategies

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Abstract

Citrus fruits are not only a vital component of the human diet, providing essential nutrients like vitamin C, but they also hold significant economic value. In Nepal, citrus cultivation is an integral part of the fruit farming, contributing to both local and national economies. Citrus nurseries underpin this industry by providing the necessary quality and true-to-type planting materials, thus forming the foundation of successful citrus farming. This article explains the status of citrus nurseries existing all over the country. The information about total number of nurseries and production status of citrus saplings are based on the record provided by the private nurseries to the National Centre for Fruit Development (NCFD) for last four years (FY 2076/77 to 2079/80). Based on the record, a total 569 citrus nurseries are currently operating out of 667 total fruit nurseries. Both governmental farms as well as private nurseries are producing citrus saplings, however contribution of private nurseries is significantly higher (98%). Although the private nurseries play a vital role for production and supply of citrus planting material in the country, it does not represent the actual situation of the total production and supply of the saplings. This situation prevails due to the voluntary system for record submission by the private nurseries, supported by government mechanism. The rules and regulation for effective monitoring and supervision of the private nurseries are yet to be approved by the government. As a result, there is no legal binding for private nurseries, leading to production and distribution of substandard saplings throughout the country. These problems can be overcome by development and implementation of citrus budwood certification system for quality sapling production and nursery guideline for proper monitoring and supervision of the nurseries for quality assurance.

Keyword: Nurseries, Saplings, Citrus budwood certification system, Nursery guideline

Introduction

Citrus is one of the main fruit crops of Nepal contributing about 21.61 percent of the total plantation area (MoALD, 2078/79). Among citrus, mandarin orange is predominant which share about 60.5 percent of total citrus production in the country. The unique topography and agroclimatic condition of mid hills of Nepal have made it possible to grow many kinds of citrus fruits. At present, all the 48 districts (more than 100 ha. of commercial orchards per disctrict) of mid-hill region are producing citrus fruits in considerable amount. Citrus fruits in the mid hill region have now become business proposition and many pockets of citrus have been developed. This has increased the social acceptability and consumption of citrus in Nepal (FAO, 2011).

Despite the importance of citrus farming in Nepal, it faces several challenges. Disease and pest infestation are the major problems and citrus fruits are highly susceptible to a range of diseases and pests. Among the diseases and pests, Citrus Greening (Huanglongbing) and Citrus Tristeza Virus (CTV) diseases play vital role for citrus decline that threaten the sustainability of citrus farming. Huanglongbing (HLB) is one of the serious problems of citrus in Nepal, caused by a gram-negative phloem restricted bacterium, *Candidatus Liberibacter asiaticus*. Citrus decline due to the presence of HLB disease affect up to 39-55% were found infected in Pokhara valley first. Citrus decline in Kaski, Lamjung, Gorkha, Syangja and Tanahu are mainly caused by the greening disease and it is spreading very fast and posting a great threat to citrus orchard. CTV is another disease responsible for decline where lime is highly susceptible (FAO, 2011).

The pathogen of these diseases (HLB and CTV) is primarily transmitted through infected budwood and insect vector. No resistance rootstocks to HLB have been reported so far and neither any chemical have been found effective for controlling this disease (Bove, 2006). Roistachar (1996) reported that the greening is the number one disease of citrus in Nepal and stated that “Greening will destroy citrus industry in Nepal slowly but surely if necessary measures are not taken in time” and suggested to implement the “Certification Program”.

Nursery is a place where planting material, such as seedlings, saplings, cuttings, etc., are raised, propagated, multiplied, nourished until they are ready for sale or transplanting at a permanent place in a field. The primary objective of a citrus nursery is to produce high-quality, disease-free planting material that can ensure robust growth and high yields when transplanted to orchards. However, there is a lack of awareness about graft- transmissible diseases, improved technique of citrus sapling production such as grafting techniques and scientific nursery management system among the nurseryman. Most of the private nurseries are in open field hence the planting materials are affected with several diseases and pests easily spread to new area. Many nurseries lack the resources to effectively manage these diseases and pests, leading to the propagation of infected plants. Thus, the scarcity of certified, disease-free planting material is a major issue. Nurseries often rely on locally sourced seeds or cuttings, which may carry pathogens that results in the spread of diseased planting materials and reduces the overall productivity of citrus orchards.

Current scenario of citrus sapling production

Both government farm/centers and private nurseries are involved in citrus sapling production. Status of citrus sapling production by both institutions are presented below.

Government farms producing citrus saplings

Government farms serve as resource center for the source materials, demonstration and training centers, where farmers can learn about modern cultivation practices, pest and disease management, healthy sapling production, nursery management technologies and many more. These farms often collaborate with research institutions like the Nepal Agricultural Research Council (NARC) to introduce new varieties and technologies. It also produces and distribute disease-free and high-yielding saplings to farmers across the country. Currently, following federal and various provincial government farms are involved in citrus sapling production.

Table 1. Government farms producing citrus sapling

S.N.	Name of the farm/centers	Annual production of citrus saplings (2079/80)	Remarks
1	Farm/centers under Federal government		
1.1	Tropical Horticulture Center, Sarlahi	2000	Acid lime
1.2	Warm Temperate Horticulture Center, Kirtipur	25000	Acid lime, mandarin orange, sweet orange
1.3	Citrus Fruit Development Center, Palpa	30000	Acid lime, mandarin orange, sweet orange
	Sub Total 1	**57000**	
2	Farms under the Provincial governments		
2.1	Tropical Horticulture Nursery Development Center, Janakpur	3000	Madhesh Province
2.2	Spices Crop Development Center, Panchakhal	5000	Bagmati Province
2.3	Floriculture Development Center, Godawari	25000	Bagmati Province
2.4	Sub-tropical Horticulture Development Center, Trishuli	10000	Bagmati Province
2.5	Horticulture Development Resource Center, Kaski	5000	Gandaki Province
	Sub Total 2	**48000**	
	Total	**105000**	

Research stations under NARC producing citrus saplings

In addition to federal and provincial level farms, research farm stations under NARC are also producing citrus saplings. Under NARC, following farm/centers are involved in citrus sapling production.

Table 2. Citrus sapling production under NARC in FY 2079/80

SN	Name of the Research Centers	No. of Saplings
1	National Citrus Research Program, Dhankuta	36000
2	Agriculture Research Directorate, Lumle, Kaski	5000
3	Horticulture Research Center, Dailekh	5000
	Total	**46000**

Private nurseries involved in citrus sapling production

Private nurseries are critical players in the citrus industry, producing the majority of saplings used by farmers. These nurseries range from small, family-run operations to larger, commercially oriented enterprises. It also contributes to the local economy by creating employment opportunities and supporting secondary businesses. They often collaborate with government and research institutions. These nurseries involved in citrus sapling production is presented in table below.

Table 3. Number of private nurseries involved in sapling production

SN	Provinces	Number of private nurseries	
		Total	Citrus sapling producers
1	Koshi	140	130
2	Madhesh	146	146
3	Bagmati	103	103
4	Gandaki	79	77
5	Lumbini	49	42
6	Karnali	100	56
7	Sudur Pashchim	50	15
	Total	**667**	**569**

Table 3 shows that total of 667 private nurseries currently engaged in fruit sapling production among which majority of them are involved in citrus sapling production. However, this is not a complete data as it only summarized based on the information provided by these nurseries voluntarily. There are more nurseries involved in sapling production than the above-mentioned because of many governmental institutions involved in nursery registration process and these nurseries operate in their own way. There is no legal provision to regulate these private nurseries.

Quantity of sapling production by private nurseries

Private nurseries produce a significant number of citrus saplings annually (Table 4).

Table 4. Quantity of sapling production by private nurseries

Province	Seedling Production			Sapling production		
	Orange	Acid Lime	Others	Orange	Acid Lime	Others
Koshi	416000	821500	77000	106700	87500	
Madhesh	67000	2049200	41000	15000	250000	
Bagmati	20500	512000	5000	57500	45300	50500
Gandaki	249500	404500	20000	91900	59800	3000
Lumbini	307650	554000	17700	22400	10700	3500
Karnali	288600	696800		12000	1500	
Sudur Paschim	15000	40500	24000	2000	500	
Total	**1364250**	**5029500**	**184700**	**307500**	**455300**	**57000**

Contribution of government farms and private nurseries in citrus sapling production

As compared to governmental farm/centers, private nurseries are playing dominant role for citrus sapling production and distribution in Nepal. Table 5 shows the contribution of private nurseries in citrus sapling production which are very high, contributing to about 98 % of the total production. This indicates that private nurseries are major stakeholders of sapling production which cannot be overlook while implementing the programs related to healthy sapling production and supply.

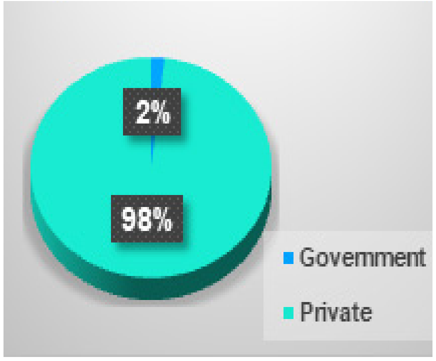

Figure 1. Contribution of Government farm/centers and private nurseries in citrus saplings productions

Table 5. Contribution of sapling production by government farms and private nurseries

SN	Source of sapling production	Sapling production	
		Quantity	Percentage
1	Government farms including NARC Research Centers (total)	151000	2.0
2	Private nurseries (total)	7398250	98.0
	Total	**7549250**	**100**

Location of citrus nurseries for sapling production

Majority of citrus nurseries in Nepal are located in the mid-hill regions, where the climatic conditions are favorable for citrus cultivation. Recently, there is a trend of citrus sapling production without considering the minimal technical parameters. Such unsuitable locations/conditions for citrus sapling production can impact the health and quality of the saplings. Table 5 shows the provincial total citrus sapling production in Terai region as an example of this critical issue. The data shows that about 33% of total sapling production was done in Madhesh Pradesh where citrus is not cultivated and saplings are generally sold to hilly regions.

Table 5. Location of sapling production by private nurseries

Province	Total no. of sapling production	Percentage of Sapling production
Koshi	1508700	20.28
Madhesh	2422200	32.63
Bagmati	690800	9.21
Gandaki	828700	11.2
Lumbini	915950	12.37
Karnali	998900	13.2
Sudur Paschim	82000	1.11
Total	**7398250**	**100**

Factor affecting the quality sapling production

Technology adopted by private nursery

Mother plant management, soil preparation, selection of rootstocks and scions, propagation techniques, pest and disease management, irrigation management are major management practices of fruit nurseries. Very few nurseries have followed technical parameters and scientific nursery management practices while running their nursery. In contrast, traditional methods are prevalent in majority of citrus nurseries where most of the private citrus nurseries are in open field hence are affected with several diseases and pests. Very few private nurseries construct screenhouse /greenhouse facilities for disease-free sapling production. There is a lack of awareness about improved technique such as grafting techniques, pest and disease management especially graft-transmissible diseases such as HLB and CTV and its vector control, leading to the propagation of infected saplings resulting low quality planting material production which are easily spread to new area through its distribution.

Disease and pest infestation

Citrus plants are highly susceptible to a range of diseases and pests. Some of the most problematic diseases include: Citrus Greening**,** Citrus Tristeza Virus.

Citrus Greening (Huanglongbing): It is one of the serious problems of citrus in Nepal and caused by a gram-negative phloem restricted bacterium, affect up to 39-55% were found infected in Pokhara valley. Citrus decline in Kaski, Lamjung, Gorkha,Syangja and Tanahu are mainly caused by the greening disease and it is spreading very fast and posting a great threat to citrus orchard. Similarly, Citrus Tristeza Virus (CTV) disease is another disease responsible for decline of sweet orange and lime is highly susceptible to CTV. The pathogen of these diseases is graft and vectors (Citrus psylla and Brown citrus aphid), transmissible. No resistance rootstocks to HLB have been reported so far and neither any chemical have been found effective for controlling this disease (Bove,2006). Roistachar (1996) and Adhikari et All (2022) reported that the greening is the no. one disease of citrus in Nepal and stated that "Greening will destroy citrus industry in Nepal slowly but surely if necessary, measures are not taken in time" and suggested to implement the "Certification Program".

Regulatory and policy challenges

Fruit sapling production is completely a technical matter that required to follow certain technical norms under the guidance and supervision of concerned authority for quality and healthy sapling production. The current system of fruit nurseries registration by different institutions, such as local level, Cooperatives, Firms, Office of Small and Cottege Industries, Companies Act and no system of linking them in technical authority mislead the nurseries to follow technical aspects of sapling production. There is no single door system and/or legal binding for sapling production, monitoring mechanism to regulate these nurseries. This situation further panelizes by not formulating rules/regulation and responsible organization to regulate them for quality sapling production as well as distribution. Though the Seed Act 2045 and Regulation 2069 implemented for quality control of seed sector which is mainly focused on cereal and vegetable crops, not addressing the specific nature of fruit crops. It indicates the lack of stringent quality control measures and certification system to this sector, ultimately affects the standardization of planting material.

In addition, sapling distribution through different entities (Floriculture nurseries, Forest related offices, NGO/INGOs and supplier companies) rather than producers/nurseries may further deepen the problem by not following the rules of quality sapling distribution.

Possible strategies to address the current problems

Addressing the challenges of quality citrus sapling production by nurseries requires a comprehensive approach that includes technical, financial, and policy interventions:

Technical interventions

Disease management

Implementation of integrated pest management (IPM) practices can help control pests and diseases. This includes:

- **Cultural practices**: Implementing practices such as crop rotation, proper spacing, and sanitation to reduce disease incidence.
- **Regular monitoring**: Early detection of disease and pest outbreaks through regular monitoring.

- **Biological control**: Using natural predators and parasites to control pest populations.
- **Chemical control**: Judicious use of pesticides and fungicides to manage severe pest and disease infestations.

Implementation of disease testing programs

Disease testing programs have significantly improved the health and quality of citrus saplings. Early detection and management of diseases have reduced the spread of infections, leading to healthier sapling production. Thus, the government has to implement disease testing programs to detect and manage common citrus diseases, such as CTV and greening. These programs involve regular testing of saplings and mother plants using advanced techniques like ELISA and PCR.

Strengthen private nurseries through training and capacity building program

Providing regular technical training and capacity building programs for nursery operators can enhance their technical capabilities for which the government and other concerned organizations should collaborate on it. This includes:

- **Training:** Training programs should focus on various aspects of citrus sapling production, including modern production practices, grafting techniques, pest and disease management and infrastructure development.
- **Extension services:** Strengthening agricultural extension services to provide on-site support and advice to nursery operators.

Capacity enhancement to technicians (Three tiers of Government)

The government conducts regular training programs for concerned technicians and local level human resources as well. The program covers various aspects such as virus indexing, shoot tip grafting technology, citrus budwood certification system, nursery inspection, pest and disease management and handling.

- **Knowledge exchange:** Facilitating knowledge exchange programs with nurseries in other regions or countries to learn best practices.

Promoting research and development

Investing in research and development can address the specific challenges faced by the citrus nursery sector. This includes:

- **Disease resistance:** Researching and developing disease-resistant citrus varieties.
- **Best practices:** Identifying and promoting best practices in nursery management.
- **Technological innovations:** Developing and disseminating technological innovations to improve nursery productivity and efficiency.

Financial support and subsidies

Providing financial support to nurseries can help them invest in better infrastructure and technology. This includes:

- **Access to credit:** Facilitating access to credit through micro-finance institutions and banks.
- **Grant and subsidized loans:** Offering grants and/or subsidized loans to nurseries can help private nurseries invest in essential infrastructures such as screen houses and other technologies. These measures will enhance their production capacity and quality of saplings

Strengthening regulatory framework and government support

Enhancing the regulatory framework and providing government support can significantly boost the citrus nursery sector. This includes:

- **Policy development:** Developing and implementing policies that support nursery development and quality control.
- **Establishing a responsible organization to regulating sapling production:** A responsible organization should be recognized to oversee the quality sapling production, distribution, and regulation. This organization should have the authority to implement and enforce regulations, conduct inspections, and maintain disease free quality sapling production in the country.
- **Establishment of certified nurseries:** Establishing certified nurseries and enforcing stringent quality control measures that produce disease-free planting material is essential. It should cover an establishment of mother plant orchards under screen house with disease-free plants for propagation as well as rootstock and saplings production inside screen house.
- **Regulatory frameworks:** The government has to establish regulatory frameworks to ensure the quality and authenticity of citrus saplings. These frameworks include guidelines for sapling production, certification standards, and certification system implementation. Gandaki Province has good start; Regulation and Nurseries Record updates
- **Implementation of citrus budwood certification system:** Introducing a citrus budwood certification system (CBWCS) will ensure the genetic purity and health of saplings. Certified budwood must meet government standards for type and freedom from graft-transmitted pathogens. The certification system will improve sapling quality, reduce the spread of diseases, leading to healthier orchards and higher yields. The implementation roadmap should include steps for establishing the organization responsible for implementing Citrus Budwood certification program, defining its mandate, and engaging other related stakeholders. Collaboration with 3 tiers of government agencies, private nurseries, and research institutions will be crucial for success.

- **Regular inspections:** Conducting regular inspections and quality checks by government agencies to enforce standards to citrus nurseries

Conclusion

Citrus nurseries are crucial to the success of the citrus fruit industry in Nepal. Both Government and private nurseries contribute to sapling production while contribution of private citrus nurseries is significant. Production and distribution of pathogen free planting materials by implementing citrus budwood certification system is crucial for sustainability of citrus farming. It provides the foundation for healthy and productive citrus orchards, contributing significantly to the local and national economy. However, the sector faces several challenges, including disease and pest infestation, lack of quality planting material, insufficient technical knowledge, regulatory mechanisms, financial constraints and so on. To address the challenges, future strategies should be focused on strengthening private nurseries, regulating sapling production, implementing budwood certification systems and establishing a responsible organization. Training and capacity enhancement programs have to be effective in improving the technical skills of nursery operators. These measures will improve nursery practices, better resource accessibility, and stronger regulatory support can ensure the production of high-quality, disease-free citrus sapling, leading to increase yields and higher-quality fruits. This, in turn, can boost the profitability of citrus farmers, create more employment opportunities and enhance the overall growth of the citrus sector in Nepal.

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Trend Analysis of Area, Production and Import of Mandarin Orange in Nepal

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Abstract

Mandarin orange (*Citrus reticulata* Blanco) is the major sub-tropical fruit popularly grown in slopy terraces of mid-hills which has high domestic and foreign market potentialities. This study aimed to analyze the trends of area, production, yield and import of citrus with a particular focus on mandarin orange in Nepal. Secondary data on citrus production published by the Ministry of Agriculture and Livestock Development, Singhadarbar, Kathmandu was used for trend analysis. Similarly, data on the import of mandarin orange was taken from the Department of Customs. The results from Sen's slope showed that the production of overall citrus increased at the rate of 8334.48 mt/year. Gandaki province recorded the highest area (8032 ha) under mandarin orange cultivation followed by Koshi (6952 ha) and Bagmati (4393 ha) provinces. Also, Gandaki province had the highest (55195.75 mt) mandarin orange production followed by Koshi (39254.10 mt) and Bagmati (29348.65 mt). The Compound Annual Growth Rate (CAGR) for import quantity and import value is negative which means the import of mandarin orange is decreasing by 10% annually. The Nepalese mandarin orange sector is developing and in the long term, there is an opportunity for self-sufficiency in mandarin orange.

Keywords: Mandarin orange, Man-Kendall test, Sen's slope, Import, CAGR, Trend analysis

Introduction

Fruits contribute about 7% of total agriculture's gross domestic product (MoALD, 2022). Of the many cultivated fruits of Nepal, citrus is the major fruit grown in Nepal. It ranks first in sub-tropical fruits and contributes to about 20.78 % of the total fruit production in Nepal (MoALD, 2023). The major citrus species grown in Nepal are mandarin orange (*Citrus reticulate* Blanco), sweet orange (*Citrus sinensis*), acid lime (*Citrus aurantifolia* Swing), lemon (*Citrus lemon*), pummelo (*Citrus grandis*), citron (*Citrus medica*), and rough lemon (*Citrus jambhiri* Lush.). Recently, the area under fruit production has been increasing; however, productivity remains stagnant because of insufficient healthy saplings, poor access to market information and price uncertainty.

Among the citrus fruits, mandarin orange is one of the major sub-tropical fruits of Nepal which is grown throughout the mid-hall region. It is popular for its nutritive value and its superior taste (Shrestha, 1996). It is cultivated in 27002 hectares (ha) of land area with annual production and productivity of 198,406 metric tons (mt) and 10.80 mt per hectare respectively which contributes almost 0.85% in AGDP (MoALD, 2021). Climate suitability, soil conditions, and market suitability favor the production of high-quality mandarin orange in Nepal. Compared with the national productivity mean of India and China, production and productivity are not satisfactory besides having suitable topography and climatic conditions.

The key determinants of mandarin orange production are unavailability of high-yielding and resistant cultivars, quality planting materials, lack of efficient and sustainable soil and pest management measures, land fragmentation, lack of proper storage facilities, and a reliable market system (Dhahal et.al., 2023). There is an utmost need for policy intervention though formulated plans and policies are limited to only paperwork (Sapkota et.al. 2017). This study aimed to access and analyze the status and trend of area, productive area, production, productivity and import of citrus with a particular focus on mandarin orange in Nepal. For the study, we collected secondary data from “Statistical Information on Nepalese Agriculture” published by MoALD from 1994/95 to 2022/23.

Materials and method

Data collection

Time series secondary data of production, area and productive area is taken from the MoALD. The 28 years of past data were used for the analysis. Data was entered in MS Excel. Necessary statistical inferences were made by using XLSTAT. The Mann-Kendall test (M-K test), Sen’s slope method, and standard normal homogeneity (SNH) test were used for trend analysis. Additionally, the Compound Annual Growth Rate (CAGR) was computed to study the trend of mandarin orange imports in Nepal.

Results and discussion

Trends of citrus area, production, and yield in Nepal

The trends of citrus area, production and yield in Nepal have been presented in Table 1. The result showed that the area, productive area, and production of citrus have a significantly increasing trend/decreasing trend/undermined. The significant change points for the area, productive area, production, and productivity of citrus were detected from 1994/95 to 2022/23. The results from Sen’s slope showed that the production of overall citrus increased at the rate of 8334.48 mt whereas results from Sen’s slope showed that the productivity of overall citrus increased at the rate of -0.021 mt/year

Table 1. Trends of citrus area, production and yield in Nepal

Parameters	Minimum	Maximum	Mean	Median	S.D.	Coefficient of variance (CV)%	Pearson's coefficient of skewness
Area (ha)	14600	50200	31892	31556	11842.8	37.134	0.101
Productive area (ha)	8488	33554	19670.98	21198.50	7963.46	40.48	0.124
Production (mt)	83375	317910	195430	217320	74201.8	37.97	-0.004
Productivity (mt/ha)	8.79	11.37	10.05	10.01	0.78	7.76	0.047

Table 2. Mann-Kendall test (M-K test), Sen's slope of citrus in Nepal

Parameters	p-value	Kendall's tau	Sen's Slope	Trend	Significance
Area (ha)	<0.0001**	0.983	1439.301	Increasing	Significant
Productive area (ha)	<0.0001**	0.972	945.276	Increasing	Significant
Production (mt)	<0.0001**	0.852	8334.480	Increasing	Significant
Productivity (mt/ha)	0.536	-0.088	-0.021	Decreasing	Non-significant

Area, production and yield of mandarin orange in Nepal in the last five years

The area under mandarin orange cultivation in six provinces of Nepal has been presented in Figure 1. It shows that in the last year (2021/22), Gandaki province recorded the highest area (8032 ha) under mandarin orange cultivation followed by Koshi (6952 ha) and Bagmati (4393 ha) provinces. In the same year, Lumbini province accounts for 3896 ha, Karnali accounts for 3542.04 ha, and Sudurpachhim accounts for 1635.66 ha, respectively.

The production of mandarin orange in six provinces of Nepal has been presented in Figure 2. It shows that in the last year (2021/22), Gandaki province had the highest (55195.75 mt) mandarin orange production followed by Koshi (39254.10 mt) and Bagmati (29348.65 mt). The production trends in the other four provinces have also increased in recent years. The mandarin orange production in Lumbini province was 36067.64 mt, Karnali 27825.73 mt, and Sudurpachhim 11503 mt, respectively.

The yield of mandarin orange in six provinces of Nepal has been presented in Figure 3. In the last year, the highest productivity (11.64 mt/ha) of mandarin orange has been observed in Karnali province, followed by Sudurpachhim province (10.87 mt/ha) and Gandaki province (10.55 mt/ha).

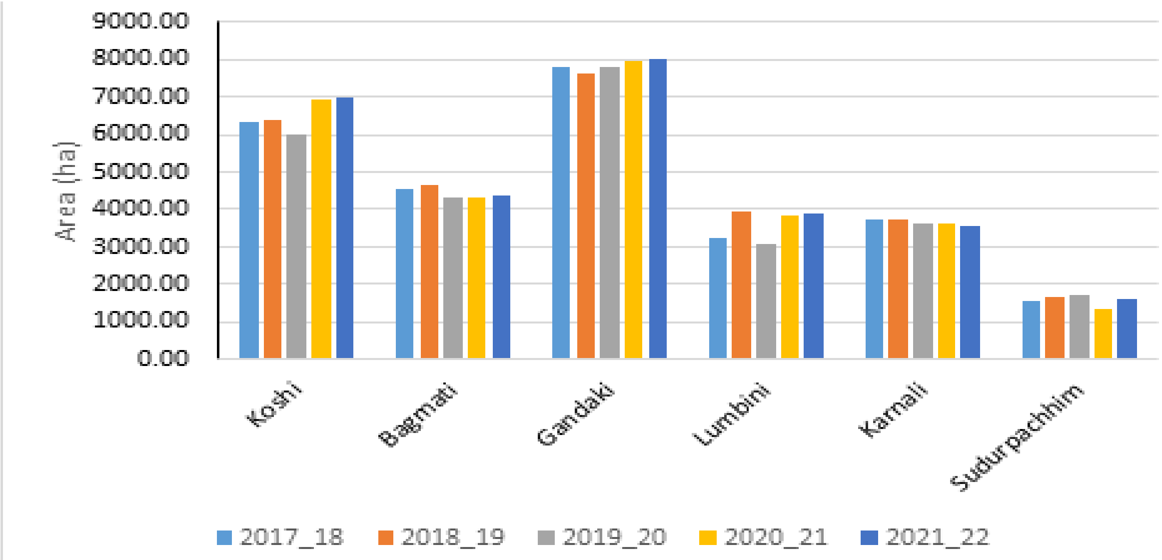

Figure 1. Area of mandarin orange in Nepal in the last five years

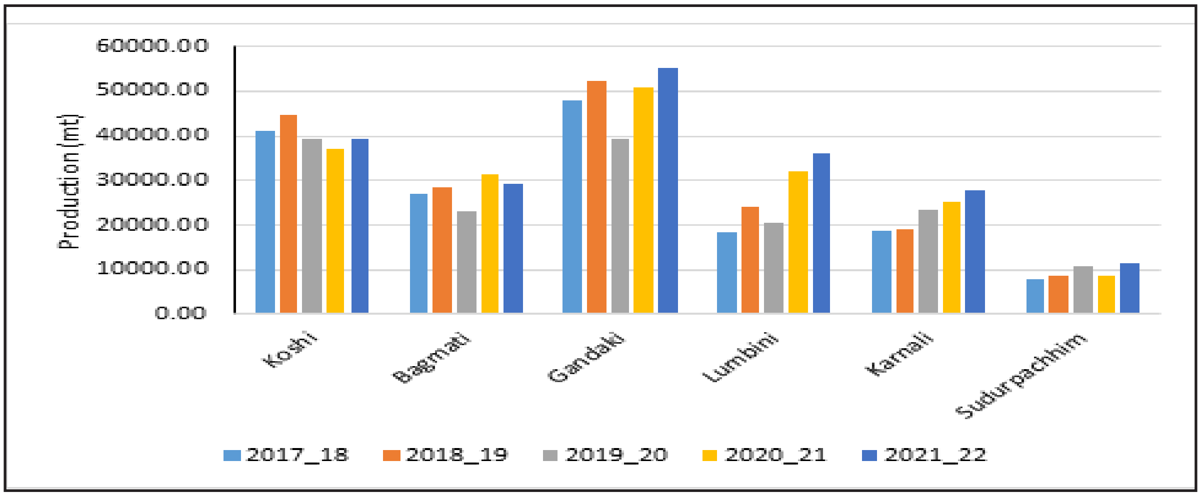

Figure 2. Production of mandarin orange in Nepal in the last five years

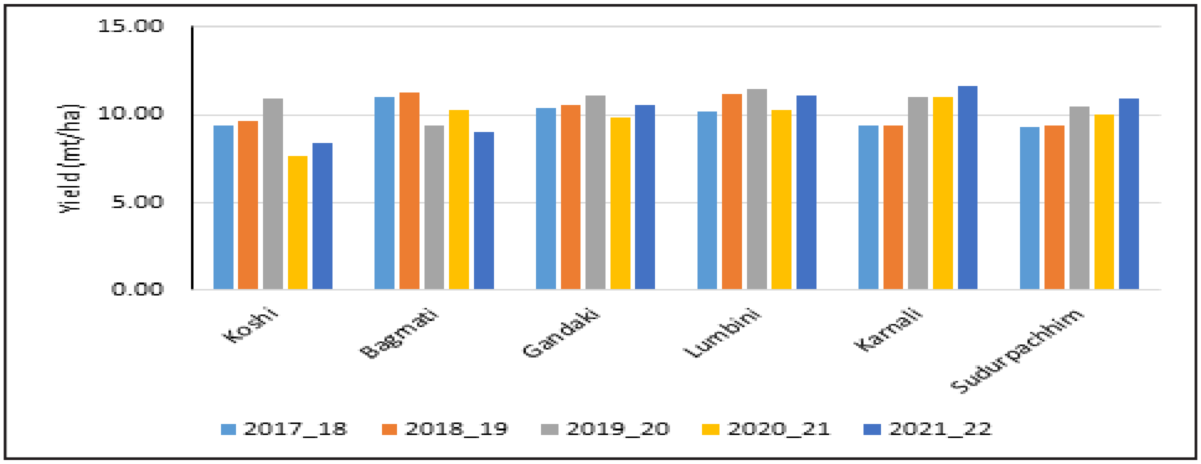

Figure 3. Yield of mandarin orange in Nepal in the last five years

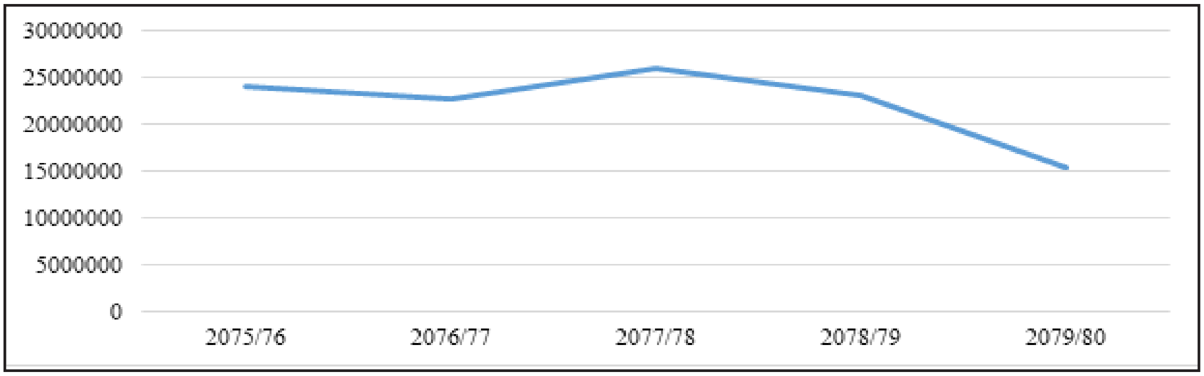

Figure 4. The trend of Import (in Kg) of mandarin orange

Compound annual growth rate (CAGR) of mandarin orange import quantity and import value

The CAGR is the mean annual growth rate of an investment over a period longer than one year. It's one of the most accurate ways to calculate and determine returns for individual assets, investment portfolios, and anything that can rise or fall in value over time. The CAGR can be used to calculate the average growth of a single investment.

$$\text{CAGR}=\left(\left(\frac{\text{EV}}{\text{BV}}\right)^{\frac{1}{n}}-1\right)\text{X } 100$$

Where:
EV = Ending value
BV= Beginning value
n= Number of years

The CAGR is a mathematical formula that provides a smoothed rate of return. CAGR is used in this study to describe the rate at which import will grow in long run. CAGR results help to evaluate past import occurred over a specific time or estimate future imports.

The CAGR of import quantity and import value was computed from year (F.Y.) 2075/76 to 2079/80 using M.S. Excel. The results show CAGR of import quantity is -10% and the CAGR of import value was -6 %. Table 3 shows computed compound annual growth (CAG) based on the CAGR of import quantity and import value for each year. CAGR for import quantity and import value is negative which means the import of mandarin orange is decreasing by 10% annually. The Nepalese mandarin orange sector is developing and in the long term, there is the opportunity for self-sufficiency in mandarin orange.

Table 3. CAGR of mandarin orange import quantity and import value

F.Y. (B.S)	Import quantity (Kg)	CAG (Quantity)	Import value (Rs)	CAG (Import value)
2075/76	24128590	24128590	1122189720	1122189720
2076/77	22635161	21603714.34	1207900905	1057244969
2077/78	26072236	19343047.94	1371252143	996058780.1
2078/79	23080897	17318943.3	1271974970	938413634.3
2079/80	15506646	15506646	884104600	884104599.8
CAGR	**-10%**		**-6%**	

Conclusion

This study indicated that the area, productive area, and production of citrus have a significantly increasing trend/decreasing trend/undermined. The significant change points for the area, productive area, production and productivity of citrus were detected from 1994/95 to 2022/23. The results from Sen's slope showed that the production of overall citrus increased at the rate of 8334.48 mt/year. Gandaki province recorded the highest area (8032 ha) under mandarin orange cultivation followed by Koshi (6952 ha) and Bagmati (4393 ha) provinces. Also, Gandaki province had the highest (55195.75 mt) mandarin orange production followed by Koshi (39254.10 mt) and Bagmati (29348.65 mt). The CAGR for import quantity and import value is negative which means the import of mandarin orange is decreasing by 10% annually. The mandarin orange sector is developing and in the long term, there is the opportunity for self-sufficiency in mandarin orange in Nepal.

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Chapter

5

Miscellaneous

लटरम्मै फलेको सुन्तलाको बोट

(भजन)

राष्ट्रिय फल सुन्तला

सुन्तला र सुन्तलाजात, फलफूलको चर्चा ।
मध्य पहाड पूर्वदेखी, पश्चिम हर्ताकर्ता ।१।
राष्ट्रिय फल सुन्तला,
सँधै हराभरा ! राष्ट्रिय फल सुन्तला ।

कुनै साना कुनै ठूला, हेर्दै खाँउखाँउ लाग्ने ।
पंहेलपुर पाखा भरी, तिर्सना मेटाउने ।२।
राष्ट्रिय फल सुन्तला,
के छ नि तिम्रो चाला ! राष्ट्रिय फल सुन्तला ।

हाँगै हाँगा फिँजिएको, झुप्प सानो बोट ।
राम्रै राम्रो सुन्तलामा, हे प्रभु ! केही छैन खोट ॥
राष्ट्रिय फल सुन्तला,
रोपौं डाँडा काँडा ! राष्ट्रिय फल सुन्तला ।

फलभित्र केस्रै केस्रा, खाँदा छ रसिलो ।
डल्ले पुण्टे भुण्टुरे, मिलेको कसिलो ॥
राष्ट्रिय फल सुन्तला,
पहाडी फलफूलको राजा ! राष्ट्रिय फल सुन्तला ।

के गर्यौ र मासिँदै छन् , कहिल्यै विचार गर्यौ ।
थाँक्रा बनाई झालपात लायौ, कोदो मकै छर्यौ ॥
राष्ट्रिय फल सुन्तला,
कठै नि बिचरा ! राष्ट्रिय फल सुन्तला ।

कोही भन्छन् कास्की स्याङ्गजा, कोही भन्छन् सल्यान ।
हात समाई अघि बढौं, नगरी अल्याङ्ग मल्याङ्ग ॥
राष्ट्रिय फल सुन्तला,
देशलाई चिनाउने ! राष्ट्रिय फल सुन्तला ।

बर्षा याममा बोट रोपौं, हिउँदमा गोडमेल ।
मलजल गरौं बगैंचामा, मिलाउँ तालमेल ॥
राष्ट्रिय फल सुन्तला,
उत्पादन बढाउँ है ! राष्ट्रिय फल सुन्तला ।

तिनपातेको रुटस्टक, सायन राम्रो चाहिन्छ ।
बीजु हैन कलमी बिरुवा, खोजी खोजी लाईन्छ ॥
राष्ट्रिय फल सुन्तला,
डाँडैमा फलाईन्छ ! राष्ट्रिय फल सुन्तला ।

धेरै ढिला फल नटिपौं, समयको ख्याल गरौं ।
मूल्य श्रृङ्खला गुन्दै बुझ्दै, बेच बिखन गरौं ॥
राष्ट्रिय फल सुन्तला,
हाम्रो देशको गौरव ! राष्ट्रिय फल सुन्तला ।

सुन्तलाको ह्रास समस्या, झन् झन् बढ्दै जाला ।
पात झर्ला फल झर्ला, बोट सुक्दै जाला ॥
राष्ट्रिय फल सुन्तला,
जोगाउँ सबै मिली ! राष्ट्रिय फल सुन्तला ।

सँधै हराभरा ! राष्ट्रिय फल सुन्तला ।
के छ नि तिम्रो चाला ! राष्ट्रिय फल सुन्तला ।
हाम्रो देशको गौरव ! राष्ट्रिय फल सुन्तला ।
देशलाई चिनाउने ! राष्ट्रिय फल सुन्तला ।

आत्रेय पद्म
बागवानी विकास अधिकृत
शितोष्ण बागवानी विकास केन्द्र, मार्फा, मुस्ताङ्ग

(गीत)

सुन्तला सम्बन्धी केही गीतहरू

सुन कै भाउ छ सुन्ताला भारीको

गायिका:- कुन्ती मोक्तान

सुन कै भाउ छ सुन्तला भारीको
चाखी जानु भन्ने मन्ृ कारी१ को
खोइ त बुट जुत्ता
कतिन्जेल धाँउछौ दाई धरान धनकुटा

धरान झर्छौ धनकुटा भाकेर
बल्छी दाउमा सुन्तला राखेर
दौरा भन्छौ टाल्दिन अर्को छ
छानो टाल्ने सपनै चर्को छ
खोइ त बुट जुत्ता
कतिन्जेल धाँउछौ दाई धरान धनकुटा

रहर बाँधी कहरको्ृ खकने२ मा
मन बोक्छौ की घर बोक्छौ ढाकरमा
घरको दुःख घरैमा तिन तला
कहिले होला सुनको भाउ सुन्तला
खोइ त बुट जुत्ता
कतिन्जेल धाँउछौ दाई धरान धनकुटा

यो दाजुको मिरमिरे आँखा

गायक:- प्रबिण गुरुङ

गायिका:- बिमाकुमारी दुरा

यो दाजुको मिरमिरे आँखा
मिरमिरे आँखा
कस्तो मेरो बिगार्यो दिमाग
नरोऊ मायालु

मिरमिरे आँखा (२)
कस्तो मेरो बिगार्यो दिमाग
नरोऊ मायालु

यो बहिनीको सुरिलो भाकाले
सुरिलो भाकाले
छाती चिर्यो गाजलु आँखाले
नरोऊ मायालु

सुरिलो भाकाले (२)
छाती चिर्यो गाजलु आँखाले
नरोऊ मायालु
करिमामा नभाको कुरा
नभाको कुरा
बल गरेर हुदैन हजुर
नरोऊ मायालु

नभाको कुरा (२)
बल गरेर हुदैन हजुर
नरोऊ मायालु
गरिबले लाएको डोरो
लाएको डोरो
डोरो छिन्यो मन भयो एकहोरो
नरोऊ मायालु

लाएको डोरो (२)
डोरो छिन्यो मन भयो एकहोरो
नरोऊ मायालु

यो दाजुले हित गर्‍यो म सित
हित गर्‍यो म सित
अखिरीमा जुग जाने को सित
नरोऊ मायालु

हित गर्‍यो म सित (२)
अखिरीमा जुग जाने को सित
नरोऊ मायालु

लालु पाते फुलेर लाल भयो
फुलेर लाल भयो
आज मेरो जोगीको चाल भयो
नरोऊ मायालु

फुलेर लाल भयो (२)
आज मेरो जोगीको चाल भयो
नरोऊ मायालु

खाउ त भने सुन्तला पानी
सुन्तला पानी
नखाउ भने दुबैको ज्यान जाने
नरोऊ मायालु

सुन्तला पानी (२)
नखाउ भने दुबैको ज्यान जाने
नरोऊ मायालु
दुबैको ज्यान जाने
नरोऊ मायालु
दुबैको ज्यान जाने
नरोऊ मायालु

संकलक: शान्ता कार्की
प्रमुख
राष्ट्रिय फलफूल विकास केन्द्र, कीर्तिपुर, काठमाण्डौं

(गीत)

सुन्तला बोट बाचुन्जेलीलाई

राष्ट्रिय फलफूल सुन्तला हो हाम्रो,
यो निर्णय अति नै भो राम्रो ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

सुन्तलाको भविष्य राम्रो छ,
खेतबारी सबै खाली हाम्रो छ ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

सुन्तला खेती जानेमा गर्न,
पर्ने छैन अरबमा मर्न ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

सुन्तला खेती गरेरै जाने हो,
बाजे रोप्ने नातीतक खाने हो ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

निर्वाहमुखी खेती छ हाम्रो,
सुन्तलामा आम्दानी छ राम्रो ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

त्यसैले त अब व्यावसायिक खेतीमा लाग्नुछ,
आर्थिक विकास गर्नलाई जाग्नु छ ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

रोपौँ सुन्तला कम्मरै कसेर,
आफ्नै परिवार गाउँ घरमै बसेर ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

सुन्तला खेती गरेर जाने हो,
आइ पि एमको प्रविधिमा लाग्ने हो ।
वनको काफल वनकै चरीलाई
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

स्वच्छ बाली उत्पादन गरौं,
विषादिको भरमा नपरौं ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

सघन खेती प्रविधिमा जाने हो,
सुन्तला उत्पादन बढाएरै लाने हो ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

रोग कीरा आएमा भगाऔं है,
गुणस्तरिय बिरुवा लगाऔं है ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

गर्नु भन्दा विदेशको नोकरी,
गरौं बरु सुन्तला कै चाकडी ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

विदेश गै पसिना नबगाउँ,
गरिबी र अज्ञानता यहीं भगाउँ ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

खाडी मुलुक नजाउँ है अब त,
नगई विदेश यहीं बगाउँ रगत ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

सुन्तलाको महत्व बुझेर,
गरौं खेती झरी मै रुझेर ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

कृषकलाई उन्नत प्रविधि दिउँ,
बिक्री गर्ने जिम्मा हामीले लिउँ ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

बारी टारी सुन्तला लाउनु छ,
गाउँबेसीमा यहि गीत गाउनु छ ।
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

भन्देउ सरकार कृषकलाई यहि कुरा,
तिम्रो माग सबै हुन्छ यहीं पूरा
वनको काफल वनकै चरीलाई,
अरु बाली एक सिजन भए नी
सुन्तला बोट बाचुन्जेलीलाई ॥

द्रोण राज काफ्ले
आजीवन सदस्य
नेपाल हर्टिकल्चर सोसाईटी, ललितपुर

(कविता)

सुन्तला खेती

सुन्तला जात फलफूलको, के के वर्णन गरौं ।
खाली छन् है डाँडा पाखा, सबैमा फलफूल भरौं ॥
खाद्यतत्व पोषणमा, यो (सुन्तला) त सारै धनी ।
बारी भरी बोट लगाए, आउँछ धेरै मनी (पैसा) ॥
कस्तो ठाउँमा खेती गर्ने, भन्ने कुरा जान ।
८०० मी. माथिको पहाड, यस्ता बाली छान ॥

दक्षिण-पश्चिम मोहडाको, बोट चाँडै मर्छ ।
त्यसैले त पूर्व-उत्तर मोहडाको, पाखो छान्नु पर्छ ॥

खेती गर्दा प्राङ्गारिक, खेती गर्ने गरौं ।
रासायिनक विष होइन, निमको झोल छरौं ॥

सुन्तला जात फलफूलमा, लगाउँ है मन ।
यसको खेती गर्न जाने, कमी हुन्न धन ॥

गाउँ घरका खेतबारी, सुन्तलाले भरौं ।
बाढी पहिरो बातावरण, संरक्षण गरौं ॥

अल्छी होइन जाँगरिलो, हामी बन्नु पर्छ ।
खेती गरे बोटबाट, पैसा आफै झर्छ ॥

जाने होइन विदेश अब, गाउँमै बस्ने गरौं ।
बाँझा रहेका खेतबारी, फलफूल बोटले भरौ ॥

सबैले गाउँ मै जुगाड गरौं, दाम र रोजगारी ।
विदेशीको मुलुक गई, किन बोक्छौ भारी ॥

कोही नर्सरी, कोही बगैचा, कोहीले बिक्री गर्ने ।
रोजगारीलाई अन्त कतै, भर गर्नु नपर्ने ॥

गाउँ बस्तु घरमै पाले, प्राङ्गारिक मल बन्छ ।
नजाउँ भाई विदेश भनी, आफ्नै दाइले भन्छ ॥

जती धेरै प्राङ्गारिक मल, उती धेरै फल ।
स्वच्छ फलफूल (सुन्तला) खान पाए, आउँछ धेरै बल ॥

घरमा सधैं फलफूल, खाने बानी बसाउँ ।
युवा, पाका, केटाकेटी, सबैको मुहार हसाउँ ॥

राष्ट्रिय फल सुन्तलाको, प्रचार प्रसार गरौं ।
रोग कीरा लागे भने, जैविक विष छरौं ॥
स्वच्छ/ताजा फलफूल खान पाए, हृष्टपुष्ट तन ।
आफ्नो स्वास्थ्य कस्तो राख्ने, आ-आफूले भन ॥

घरको वरिपरि सबले, सुन्तला बोट सारौं ।
पछि फेरी लेट होला, आजलाई विट मारौं ॥

द्रोण राज काफ्ले
आजीवन सदस्य
नेपाल हर्टिकल्चर सोसाइटी, ललितपुर

(कविता)

सुन्तला

(छन्द : अनुष्टुप्)

सुन्तला गुणको खानी गुणैले कहलाउँछ
फल झन् सुनझैँ हुन्छन् देख्तै चित्त रसाउँछ ।

पहाडी भूस्थली कान्ला, पाखामा भीरमा रमी
फल्दछन् सुन्तला मीठा थोरै स्याहारमा पनि ।

मूल्य मिल्ला नमिल्लाको छैन चिन्ता किसानमा
बिक्तछन् जे जति फल्छन् सुन्तला शान मानमा ।

खाएमा सुन्तला नित्य आँखाको तेज बढ्दछ
सपार्छ मुटुको स्वास्थ्य समग्र रोग हट्दछ ।

स्वादमा फलको राजा यो नै हो शक्तिको घर
समृद्धिको यही स्रोत किसानी मनको भर ।

त्यसैले सुन्तला रोपौँ, सुन्तलाले भरौँ गरा
भिजाऔँ श्रमले माटो खुलून् हाम्री बसुन्धरा ।

भवानी खतिवडा
कृषि प्रसार अधिकृत
कृषि विभाग, हरिहर भवन, ललितपुर

International Trade and Intellectual Property Rights on Nepalese Mandarin Orange

Devendra Gauchan

Institute of Agriculture and Animal Science, Tribuvan University, Kathmandu

A paper presented in the 14th National Horticulture Conference, Kritipur, Kathmandu, April 24-25, 2024, Nepal

Presentation outline

- Background: Boosting International Trade & IPR
- Status of Trade of mandarin orange and other Citrus Fruits
- Trend of Import and Export Trade of Mandarin Orange in the past 15 years (2008-2022)
- Trade Destination of Mandarin Orange
- Types of IPR tools and their use in promoting export and innovation in the trade of mandarin orange
- Challenges, Issues and Gaps in IPRs
- Suggested Actions

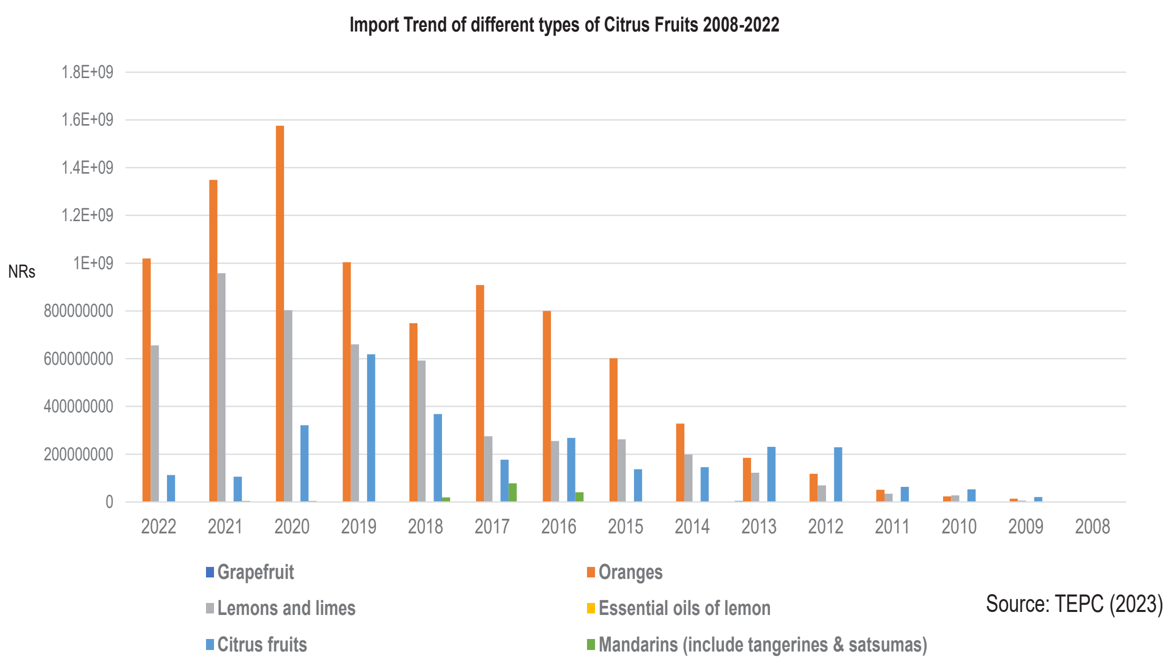
Role of international trade and intellectual property rights (IPRs)

- International trade is vital for stimulating agricultural and economic development
- Boosting export trade of mandarin orange is essential to enhance income and generate employment of people in rural mid Hills in Nepal
- IPR facilitates innovation, enhance market access and incentivize people in the trade of the products
- IPR tools can boost export trade through commercialization and conservation by exploiting functional traits of diverse, unique specialty native varieties and their cultural heritage

Average 3 years import & export of orange, mandarin orange & other citrus fruits (2020-2022)

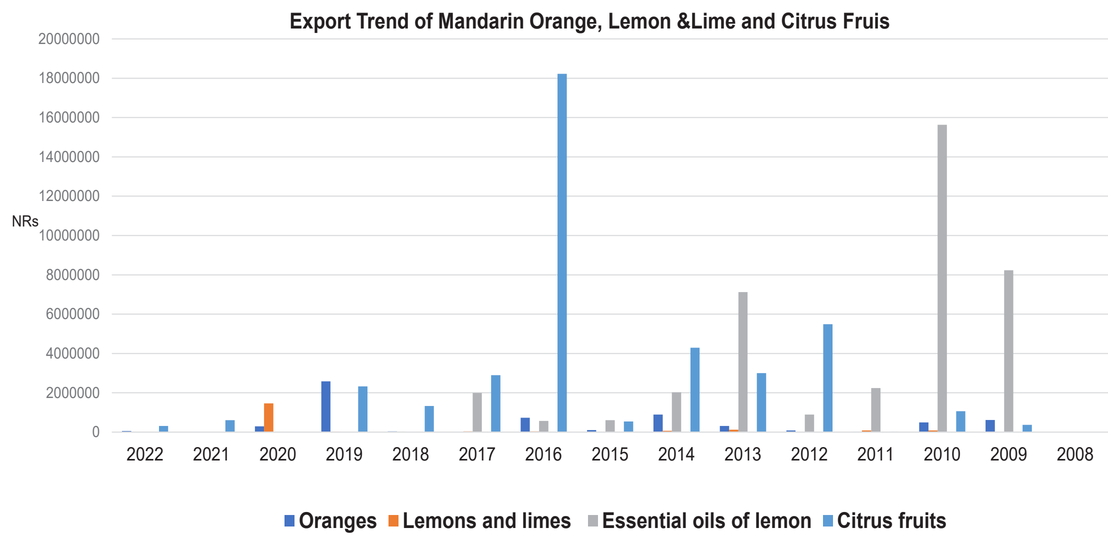
HS Code and Commodity	Import Value (NRs)	Export Value (NRs)	Trade Balance (NRs)
08054000-Grapefruit	15,796.00	0.00	-15,796.00
08051000-Oranges	1,314,642,846.00	117,959.67	-1,314,524,886.33
08055000-Lemons and limes	805,715,855.67	487,399.00	-805,228,456.67
33011300-Essential oils of lemon	458,836.00	0.00	-458,836.00
20083000-Citrus fruits, prepared or preserved	25,167,924.00	4,669.67	-25,163,254.33
08059000-Citrus fruits	154,803,279.33	304,606.67	-154,498,672.67
08052000-Mandarins (including tangerines and satsumas)	0.00	0.00	0.00
08052900-Others (Mandarin oranges, tangerines and satsumas),	3,115,435.00	0.00	-3,115,435.00
Total Value (NRs)	2,303,919,972.00	914,635.00	-2,303,005,337.00

Import trend of mandarin orange, lemons & acid lime and citrus fruits in the last 15 years (2008-2022)

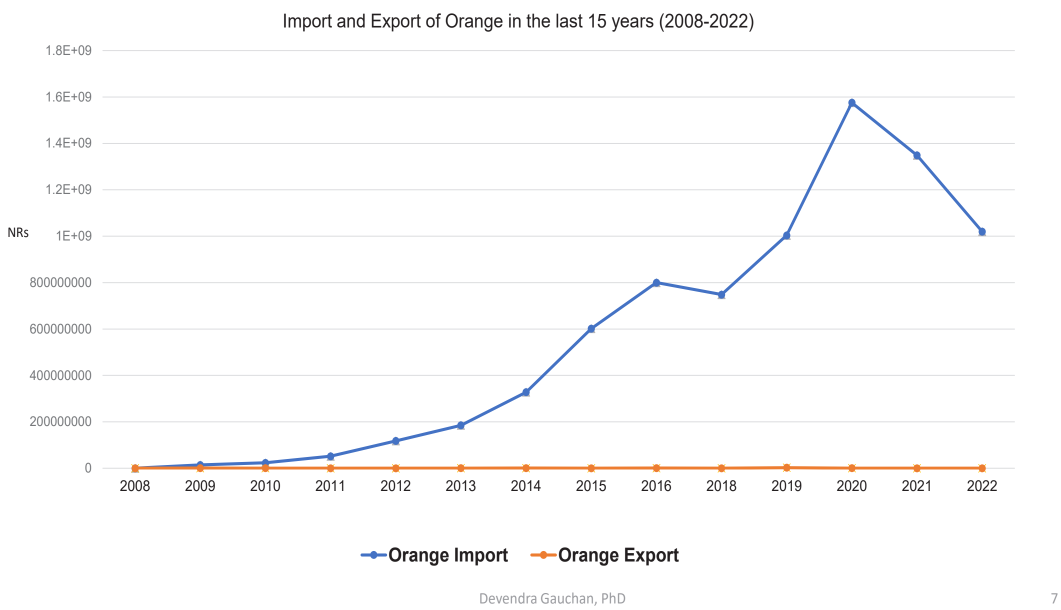


Source: TEPC (2023)

Export trend of orange, lemons & acid lime and citrus fruits in the last 15 years (2008-2022)



Trend of import and export of orange fruits in the last 15 years (2008-2022)



Trade destination: imported countries (2020-2023)

Imported countries in recent 3 years in Nepal				
Commodity	2023	2022	2021	2020
Orange	India, Egypt, South Africa, China	India, Egypt, South Africa	India, Egypt, South Africa	Inda, Egypt, South Africa, China
Mandarin orange	China	India	India, Uganda	India
fruits		India	India	India, Indonesia
Citrus prepared & preserved	Thailand	Egypt, India, Israel, Thailand, South Korea	Egypt, India, Thailand	Egypt, India, Thailand
Grape fruits	India	India	India	India
Lemon & Limes	India	-India, Singapore	India	India
Essential Oils of Lemon	India	India	India, USA, Malaysia	India
Orange	Qatar	Qatar	Bangladesh	UK
Mandarin orange	-	-	-	India
Citrus fruits	India	India	India	-
Citrus prepared & preserved	India, Bangladesh	-	-	UAE
Lemon & Limes	USA	-	-	UK
Essential Oils of Lemon	USA	-	-	-

Major issues and opportunities for international trade

- Import of mandarin orange is increasing rapidly until 2020 (some decline after 2020), however, export is very negligible and irregular.
- Nepal is exporting increasing value of Fruit Juice (NRs 6 Billion in 2022/23), the share or orange Juice is 15% in 2022-23.
- Declining trend of unique traditional varieties and associated traditional knowledge of mandarin orange. With better incentives and policy framework (IPRs mainly GI & FRs), they can be conserved and protected from further decline.

- Need to make separate import and export custom data for sweet orange and consolidated data for mandarin orange . The HS code 08051000is being used for Oranges which seems to be combined of sweet orange and mandarin orange.
- A great opportunity exists to boost export trade of mandarin orange by increasing production volume, value chain strengthening and trade facilitation such as Nepal-China Trade Protocol and with Other Countries (Qatar, UAE etc.)

IPR tools for commercialization, conservation and trade

- Patent
- Plant Breeders Rights
- Farmers Rights
- Trademark
- Geographical Indication (GI)

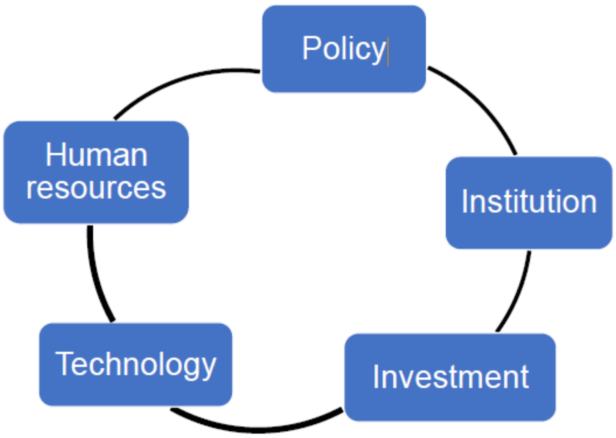
Note: Industrial design, copy rights, and trade secret are not very common in agriculture

IPR for boosting export trade of mandarin orange

- Mandarin orange cultivars can be protected through patents, plant breeders' rights and the products by trade marks and GIs
- Protection may be also granted for the specific products, brand names, or geographical indications
- Trade marks are used to protect brand names, logos, and other identifiers that distinguish goods or services from those of competitors
- Geographical indications (GI), used in product marketing, are comparable to a trade mark.
- Farmers rights can provide both legal rights of protection and recognition or rewards to farming communities

Drivers of international trade, commercialization and conservation in mandarin orange

- IPR Policy, Institution, Investment, technology and human resources are critical for commercialization and conservation of unique Nepalese mandarin orange
- IPRs are vital for Commercialization and facilitating Innovations. Investors and donors find difficult to invest in agribusiness innovation in countries where IPR policies and institutional framework are poor or absent.



Gaps and issues in IPR for commercialization and trade

- Poor financial, institutional and human resource capacity for development and implementation of IPR
- Lack of legal framework for PVP rights, Farmers Rights and GI Rights
- Poor Investment and limited Priority setting on the development and promotion of Trademark on agri products
- Trade off between commercialization and conservation of native cultivars
- Insufficient information, awareness and knowledge on the relevance of IPR in day-to-day business for SMEs
- High costs associated with registering, obtaining, enforcing and monitoring IP rights

Suggested actions

- Formulate PVP & FRs and GI laws and Implement GI certification and support Trademark Registration and Organic Certification process for boosting export
- Identification, characterization and mapping of geo-linked functional traits with specific culture, traditional knowledge and use
- R&D Investment on selection, improvement and registration of unique native farmers varieties and their location-specific commercialization
- Strengthen SPS related laboratory facilities, human resource and institutional capacity for export testing and certification of mandarin orange products
- Reward, recognition and incentivizing custodian farmers and communities to conserve, use and promote diverse unique native varieties
- Improve trade relations, trade facilitation and trade treaty including trade infrastructure to access international market linkages to boost export trade of mandarin orange and its products (e.g Juice)

Chapter

6

संकलित तस्वीरहरू

ओता पोङ्कन जातको सुन्तलाको फल

उन्सु जातका माउबोट

ओता पोङ्कन जातका माउबोट

संकलित तस्वीरहरू

किन्नो जातको माउबोट

थाई तान्जारीन जातको माउबोट

मरकट जातको माउबोट

यसोदा पोङ्कन जातको माउबोट

सुन्तलाको फल

१४औं राष्ट्रिय बागवानी सेमिनार २०८१ का झलकहरू

माननीय कृषि तथा पशुपन्छी विकास मन्त्रीज्यूद्वारा सेमिनार उद्घाटन हुँदै

सम्बोधन गर्नुहुँदै राष्ट्रिय फलफूल विकास केन्द्र, कीर्तिपुरका प्रमुख डा. शान्ता कार्की

सेमिनारमा उपस्थित विशिष्ट पाहुनाहरु

उत्कृष्ट सुन्तला कृषक तथा नर्सरी पुरस्कार वितरण

१४औं राष्ट्रिय बागवानी सेमिनार २०८१ का झलकहरू

मानवीय मन्त्री ज्वालाकुमारी शाहज्यूबाट सम्बोधन

नेपाल हर्टिकल्चर सोसाइटीका अध्यक्ष श्री गोपाल प्रसाद श्रेष्ठ ज्यूको समापन मन्तव्य

सेमिनारका सहभागीहरुद्वारा अन्तरक्रिया छलफल

१४औं राष्ट्रिय बागवानी सेमिनार २०८१ का झलकहरू

सेमिनारमा विषयगत प्राविधिक पोस्टरको प्रस्तुतिकरण

सेमिनारमा उपस्थित सहभागीहरुको सामूहिक तस्विर

MANAGEMENT OF CHINESE CITRUS FLY, *Bactrocera minax* (Enderlein, 1920)(DIPTERA: TEPHRITIDAE) IN NEPAL

Abstract

In Nepal, an Area-Wide Control Program (AWCP) has been implemented for the first time to combat *B. minax* in the citrus orchards. This campaign included both spot applications of a lethal protein bait as well as orchard sanitation measures in the citrus orchards. Sweet orange losses were decreased from 56.7% in 2017 (before AWCP) to 10.9% in 2018 and finally less than 5% in 2019.

Introduction

Citrus is a major fruit crop in Nepal that gives out nutritional security, livelihood and income generation (MoALD, 2023). Chinese citrus fly (CCF), *Bactrocera minax* (Enderlein, 1920) (Diptera: Tephritidae) is a large sized, invasive, univoltine, and oligophagous fruit fly of *Citrus* spp. (Fig. 1). It is native to China, and its invasion was observed in Nepal through the country's eastern mid-mountain region rich in citrus orchards. It is distributed exclusively in China, Nepal, Bhutan, and India (Sikkim and West Bengal) (CABI, 2020) (Fig. 2). CCF does not get attracted to any of the para-pheromones except the protein hydrolysate lure (Xia et al., 2018).

CCF's impact on sweet orange production in the eastern mid-mountain citrus orchards of Dhankuta and the adjoining districts came to light since 2006 when a massive decline of citrus fruits, up to 100%, was observed. Later its extension in the central Nepal's sweet orange district, Sindhuli was observed when the fruit decline was reported to be 56.7% in 2017. Fig. 3 presents the pictorial life cycle of the pest.

Fig. 1. Fruit drop due to the maggots.

Fig. 2. Geographical distribution of CCF.

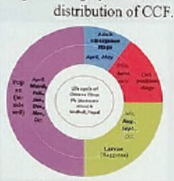


Fig. 3. Seasonal life stages of CCF.

Management of CCF through Area-Wide Control Program (AWCP) based on the lethal protein hydrolysate bait spot application and orchard sanitation in Sindhuli, Nepal are the subjects of this presentation.

Materials and Methodology

Area-Wide Control Program of CCF

Fifty ml bait solution prepared of 1 part GREAT Fruit Fly Bait (25% protein hydrolysate + 0.1% abamectin) in 2 part water was applied on 0.5 to 1 m^2 area under side of the leaves (Fig. 4.1) in the citrus tree @ 7-8 spots/ropani (= 508.7 m^2) or one tree among three productive citrus trees / week for ten times started from 15 days after adult emergence, and sanitation measures (Fig. 4.2) to prevent pupation were performed.

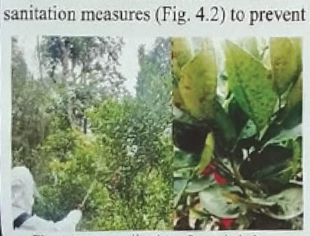
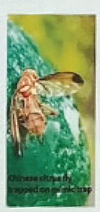


Fig. 4.1 Spot application of protein bait.


Fig. 4.2 Sanitation.



Results and Discussion

Management of CCF

Table 1. Location-wise *B. minax* incurred fruit damage (%) in 2017-2019

Orchard location	Mean fruit damage (%) ± SE			*t*-test (*p*-value)	
	2017	2018	2019	2017 vs 2018	2018 vs 2019
Majhkubhinde (11)	27.7 ± 7.8	3.9 ± 1.1	2.9 ± 0.5	0.0065**	0.2309(ns)
Tallo Aalegaun (3)	78.3 ± 4.4	8.0 ± 3.9	2.6 ± 0.8	0.0001***	0.1198(ns)
Tamaure (6)	78.3 ± 7.0	19.4 ± 2.4	7.0 ± 0.8	0.0001***	0.0002***
Mathillo Aalegaun (5)	63.6 ± 15.8	6.6 ± 2.7	4.3 ± 1.5	0.0117**	0.2373(ns)
Ranikhola (3)	86.7 ± 13.3	29.7 ± 9.6	7.5 ± 2.3	0.0126**	0.0433*

Numerical within parantheses indicates no. of orchard, ns = statistically non-significant, *significant at 5% ($p < 0.05$), **significant at 1% ($p < 0.01$), ***significant at 0.1% ($p < 0.001$)

AWCP attributed a dramatic reduction in the CCF incurred mean sweet orange fruit losses from 56.7 ± 6.4% in 2017 to 10.9 ± 2.1% (2018), and 4.5 ± 0.6% (2019). The difference in means is statistically highly significant ($p \leq 0.0001$) (Fig. 5) (Adhikari et al., 2021). The successful management of CCF (Table 1) might be due to the orchards' location, surrounding's vegetation, skills of spray-persons for spot application and skillful managerial aspects. In this context, Van Schoubroeck (1999) highlighted on the need of both monitoring and management measures. Furthermore, careful consideration should be given to the management and technical aspects of the AWCP. AWCP is launched for the first time in the country to managing fruit flies in the extensive citrus orchards situated in the altitude variation from 897 to 1462 masl.

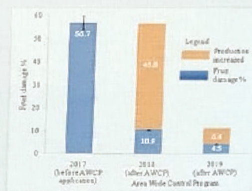


Fig. 5. Increase in the fruit production after deployment of AWCP.

Conclusion

The technical and managerial components of the AWCP should be implemented simultaneously for the successful management of CCF in orchards. It is an eco-friendly management technique. In Sindhuli, Nepal, the AWCP minimized *B. minax* caused fruit damage by 45.8% in 2018 and below 5% in 2019.

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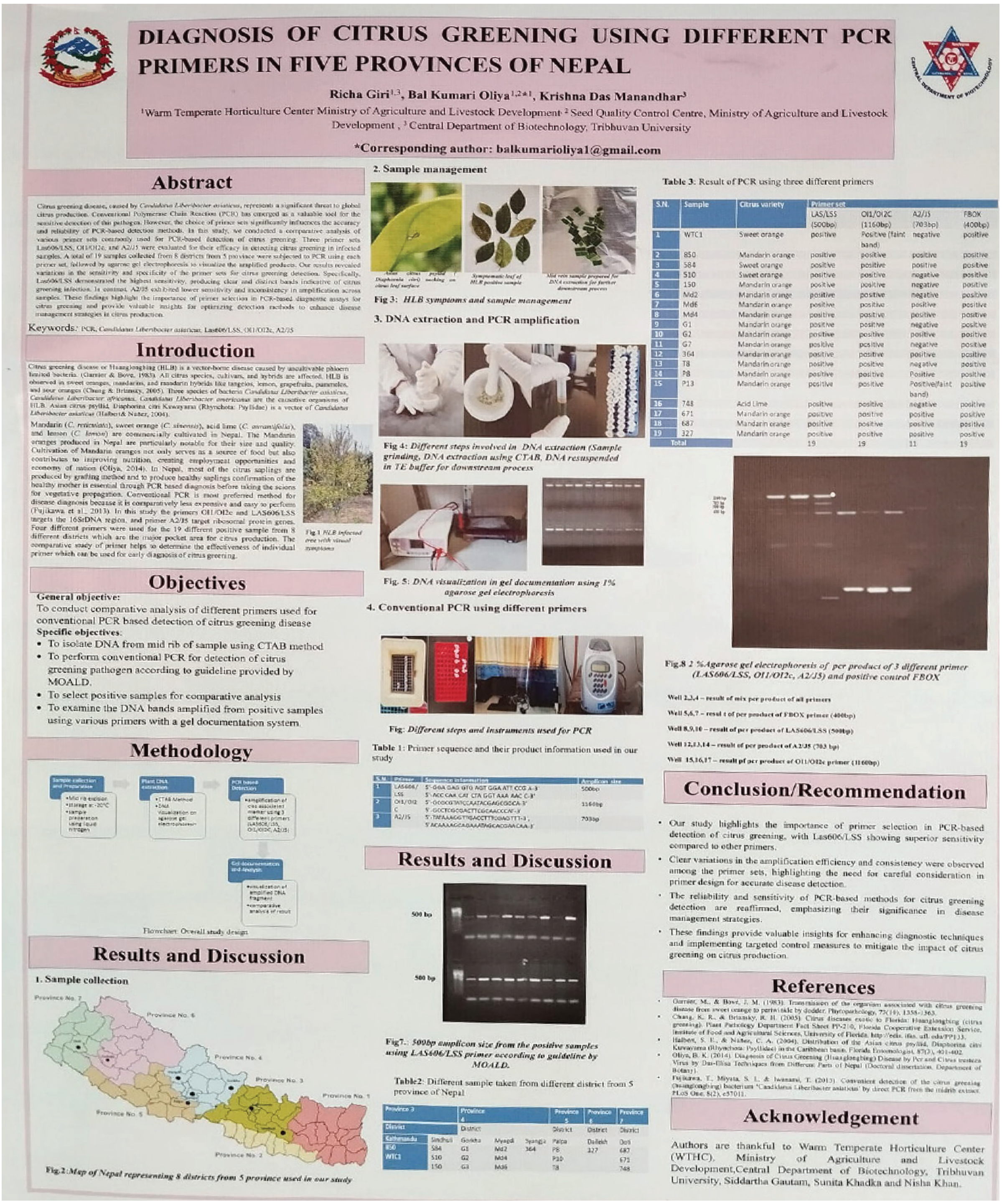
[@]debhorti@yahoo.com; 24 & 25 April, 2024; Kathmandu, Nepal

पोष्टर प्रस्तुतीकरणमा पुरस्कृत भएको पोष्टर : प्रथम स्थान

१४औं राष्ट्रिय बागवानी सेमिनार २०८१ मा भएको पोष्टर प्रस्तुतीकरण



पोष्टर प्रस्तुतीकरणमा पुरस्कृत भएको पोष्टर : द्वितिय स्थान

Program Schedule

Day One (12 Baishakh 2081)

Session: I

Chairperson : Dr. Shanta Karki, Chief, NCFD

Facilitator : Mr. Dinesh Sapkota, SHDO, VDC

Activity	Presenter	Time
Participants arrival, registration and breakfast	Ms. Tara Sharma Ms. Manita Tamang	8:00-8:30 AM
Session start	Mr. Dinesh Sapkota	8:30
Session chair	Dr. Shanta Karki	8:30-8:40
Welcome address and Seminar objectives	Mr. Gopal P. Shrestha	8:40-8:50
Geographical indication survey report of mandarin orange: Kaski	Mr. Surya Prasad Baral	8:55-9:10
Geographical indication survey report of mandarin orange: Arghakhanchi	Ms. Shiva Aryal	9:10-9:25
Geographical indication survey report of mandarin orange: Dailekha	Ms. Manita Tamang	9:25-9:40
Geographical indication survey report of mandarin orange: Sankhuwasabha	Ms. Shova Sharma	9:40-9:55
Geographical indication survey report of mandarin orange: Parbat	Mr. Jeevan Subedi	9:55-10:10
Geographical Indication of mandarin orange: Solukhumbu	Ms. Kabita Sharma	10:10-10:25
Discussion and Closing	All	10:25-10:40

Session II

Chairperson : Dr. Kishor Dahal, Assistant Dean, IAAS, TU

Facilitator : Mr. Surya Prasad Baral, SFDO, NCFD

Activity	Presenter	Time
Orchard management of Mandarin Orange	Mr. Kaushal K. Poudel Mr. Padma Nath Atreya	10:40-10:55
Soil and nutrient management of mandarin orange	Dr. Ramita Manandhar	10:55-11:10
An assessment of soil nutrients status and determination of most limiting nutrient	Ms. Asha Dhakal	11:10-11:25
Effect of application of micro-nutrients on plant growth and fruit set in mandarin orange	Ms. Rubisha Bastola	11:30-11:45
Fruit fly in the citrus ecosystem of Nepal	Dr. Dev Raj Adhikari	11:45-12:00
Discussion and Closing	All	12:00-12:15
Lunch	All	12:15-01:00

Inaugural Session III

Chairperson : Mr. Gopal P. Shrestha, President, Nepal Horticulture Society

Facilitator : Ms. Yam Kumari Shrestha, SHDO, NCFD

Activity	Presenter	Time
Seat taking by Chief Guest - Honorable Agriculture Minister, MoALD; Special Guests - Honorable Member, NPC; Respected Secretaries, MoALD; ED, NARC,; Deans, AFU and TU, Guests - Joint Secretaries, MoALD; DG, DDG, DoA; Chiefs, NCFD and NCPVSD and all invited dignitaries	Yam Kumari Shrestha	1:00-1:10
National anthem and opening	Chief guest	1:10-1:20
Welcome remarks	Dr. Shanta Karki	1:20-1:30
Mandarin Orange: The National Fruit	Dr. Shanta Karki	1:30-1:45
Song/Bhajan: National fruit	Mr. Padma Nath Atreya	1:45-1:55
वैदकि कृषमिा सुन्तलाको स्थान	Mr. Basu Dev Kafle	1:55-2:05
Prize distribution	Chief guest	2:05-2:15
Few words	Farmers	2:15-2:25
Remarks	Secretary, MoALD	2:25-2:35
Remarks	Hon. Member, NPC	2:35-2:45
Speech	Hon. Agri. Minister	2:45-3:00
Thanks giving and closing of inaugural session	Chairperson	3:00-3:05
Tea break	All	3:05-3:20

Session IV

Chairperson : Mr. Bhairab Raj Kaini, Former President, NHS

Facilitator : Ms. Ranju Maharjan, HDO, DoA

Activity	Responsible Person	Time
Government policy and program support for mandarin orange promotion	Mr. Gopal P. Shrestha	3:20-3:40
Status of mandarin orange research in National Citrus Research Program, Dhankuta	Mr. Basant Chalise	3:40-3:55
Status of mandarin orange in Warm Temperate Horticulture Centre, Kirtipur	Ms. Tara Sharma	3:55-4:10
Status of mandarin orange research in Horticulture Research Center, Dailekh	Mr. Netrahari Ghimire	4:10-4:25
Status of mandarin orange in Citrus Development Center, Palpa	Mr. Jogendra Kandu	4:25-4:40

Discussion and Closing	All	4:40-4:55

Day Two (13th Baishakha 2081)

Session: V

Chairperson: Dr. Hari Bahadur K.C., DG, DoA

Facilitator: Mr. Padma Nath Atreya, HDO, THDC

Activity	Responsible Person	Time
Participants arrival, registration & breakfast	All	8:00 – 8:25
Principle of mandarin orange disease management	Dr. Chiranjibi Regmi	08:30-8:45
Detection of Citrus greening associated with mandarin orange	Dr. Bal Kumari Oliya	8:45-9:00
Scale of HLB infestation and the status of molecular diagnostic test of mandarin orange groves in Nepal.	Dr. Ram C. Poudel	9:15-09:30
Diagnosis of Citrus Tristeza Virus (CTV)and Huanglongbing (HLB) Diseases and Micro-propagation of virus-free *Poncirus trifoliate* Shoot Tips for rootstock production	Dr. Mukunda Ranjit	9:30-09:45
Research profile of citrus insect pest in Nepal	Dr. Samundra Lal Joshi	9:45-10:00
Mandarin orange pollination and pollinators	Prof. Dr. Resham B. Thapa	10:00-10:15
Discussion and closing	All	10:15-10:30

Session VI

Chairperson: Mr. Mohan Bahadur Thapa, Former President, NHS

Facilitator: Ms. Tara Sharma, HDO, WTHC

Activity	Responsible Person	Time
Status of mandarin orange in Nepal	Mr. Surya Prasad Baral	10:30-10:45
Status of mandarin orange in Gandaki Province	Mr. Balkrishna Adhikari	10:45-11:00
Nursery management and propagation technique on mandarin orange	Ms. Shova Sharma	11:00-11:15
Status of citrus sapling production and future strategies	Ms. Yam Kumari Shrestha	11:15-11:30
Post-harvest management of mandarin orange	Dr. Durga Mani Gautam	11:30-11:45
Product diversification of mandarin orange	Dr. Matina Joshi Vaidya	12:00-12:15
Discussion	All	12:15-12:25
Poster observation and evaluation	All	12:25-12:55

Activity	Responsible Person	Time
Lunch	All	12:55-01:30

Session VII

Chairperson: Mr. Ram Bahadur K.C., Vice President, NHS

Facilitator: Mr. Santosh Poudel, AEO, NCFD

Activity	Responsible Person	Time
Marketing management of mandarin orange in Nepal with some case studies at production and market level.	Mr. Tulashi Gautam	1:30-1:45
Value chain of mandarin orange	Mr. Tek Bahadur Bam	1:45-2:00
International trade and intellectual property rights protection of Nepalese mandarin orange	Dr. Devendra Gauchan	2:00-2:15
Citrus fruit export from Nepal to China: Plant quarantine perspective	Ms. Sabitri Baral	2:15-2:30
Building root and tuber crops for food security and economic gain	Mr. Umesh Sing, DG, CIP	2:30-2:45
Discussion and closing	All	2:45-3:00
Tea break	All	3:00-3:15

Session VIII

Chairperson: Dr. Amar Bahadur Pun, Chief, NHRC

Facilitator: Ms. Manita Tamang, HDO, NCFD

Activity	Responsible Person	Time
Mandarin orange Biodiversity and its utilization for commercialization in Nepal	Dr. Umesh Acharya	3:15-3:30
Mandarin orange landraces: Diversity, conservation, and potential for geographic indication	Dr. Bal Krishna Joshi	3:30-3:45
Geographical indication survey report of mandarin orange: Dhankuta	Mr. Santosh Sharma	3:45-4:00
Variety characterization of mandarin orange	Dr. Ram Lal Shrestha	4:00-4:15
Variety registration system	Mr. Bikash Kharel	4:15-4:30
प्राकृतिक एक अनुपम उपहारः स्याउत सुन्तला	Mr. Pradip Thapa	4:30-4:45

Activity	Responsible Person	Time
Discussion and closing		4:45-5:00

Session IX: Closing

Chairperson: Mr. Gopal Prasad Shrestha, President, NHS,

Facilitator: Ms. Reeti Singh, SHDO, DoA

Chief Guest: Dr. Govinda Prasad Sharma, Secretary, MoALD

Activity	Responsible person	Time
Seat taking by Chairperson, Chief Guest, Special Guest, Guests and all Participants	Ms. Reeti Singh	5:00-5:10
Summary of seminar and way forward	Ms. Yam K. Shrestha	5:10-5:30
Prize to Poster Presenters	Chief guest	5:30-5:40
Closing remarks	Guest and Chief guest	5:40-6:00
Closing of the seminar	Chairperson	6:00-6:10
Dinner	All	6:10 PM onwards

Editors' Profile

Shanta Karki

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Experience: Dr. Poudel is currently the Director of Planning and an Assistant Professor at the Institute of Agriculture and Animal Science, Tribhuvan University. With over 20 years of extensive teaching and research experience, he has held prestigious positions, including a Postdoctoral Fellow at the National Research Institute of Brewing in Japan and a Fulbright Visiting Scholar at Cornell University. He has authored and co-authored more than two dozen research articles and has expertise in plant biotechnology, molecular biology, viticulture, plant genetic resources evaluation, and horticulture. Dr. Poudel has presented his research findings at numerous national/international seminars and serves as a reviewer for several internationally reputed journals. Additionally, he is the Editor-in-Chief of Nepalese Horticulture journal.

Yam Kumari Shrestha

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Surya Prasad Baral

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Experience:	Started his professional career from 1997 as Government of Nepal class third officer and worked for farm manager in different horticulture farm, DADO, MoALD and projects in different capacities. Currently he is serving for the National Center for Fruit Development (NCFD) as a senior horticulture development officer since 2023. He has published more than 20 research and development related articles in national and international journals, proceedings, booklets and books

Sanjay Dhimal

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Experience:	Mr. Dhimal has more than 30 years of experience in the Government of Nepal under Ministry of Agriculture and Livestock Development especially in the horticulture research and development sector, program planning, implementation, monitoring and evaluation. He has been working in the field of horticulture, organic farming, citrus fruit farming, commercial vegetable cultivation and rooftop gardening. He has authored and co-authored more than 20 research articles in the national and international journals, proceedings, technical books and annual reports related to horticulture. He has also served as a peer reviewer in various scientific articles. His passion lies in the field of school horticulture, commercial farming, farmers training, kitchen and terrace gardening and overall horticulture development.

Santosh Poudel

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Experience:	Mr. Paudel has been working in the agriculture development sector for more than 8 years as a planning officer and an agricultural economist. As a professional civil servant and also as a development enthusiast, he has demonstrated leadership in different capacities. He worked as a member in developing a policy concept known as "Protected Agriculture, Guaranteed Savings," which has been implemented since 2020 within the stated policy framework of the ministry. Similarly, he worked as a member to review the National Agriculture Policy of 2004 and draft the first Agriculture Bill of 2023. He has authored and co-authored some research articles, technical books, protocols, annual reports, and opinion columns on agricultural issues.

Samyam Pandit

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Experience:	Mr. Pandit has been working in the agriculture sector for more than 3 years as an agriculture extension officer. During his college days he has also worked as the editor-in-chief for the book related to Agriculture entrance preparation. Recently he has also contributed in drafting the master plan for the renovation of the Tropical horticulture center, Sarlahi. He has authored and co-authored some research articles related to agricultural economics.