NSPN: 016/081/082

Annual Report

2080/81 (2023/24)

Government of Nepal
Nepal Agricultural Research Council

National Citrus Research Program

Paripatle, Dhankuta

2024

Sweet orange variety ‘Washington Navel’ suitable for early-season production

Sweet orange variety ‘Valencia Late’ suitable for late-season production

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National Citrus Research Program (NCRP)
Nepal Agricultural Research Council (NARC)
Paripatle, Dhankuta, Nepal
Telephone : 026522055
Email : ncrpdhankuta@gmail.com
URL : https://www.ncrpdhankuta.narc.gov.np

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FOREWORD

The National Citrus Research Program (NCRP) has observed a growing interest in citrus cultivation in recent years, largely due to rising domestic and international demand, including from China. Numerous growers from the mid-hills and Terai have sought technical support and saplings, with particularly high demand for acid lime varieties 'Sun Kagati-1', 'Sun Kagati-2', and 'Tehrathum Local'. In the last fiscal year, NCRP and private nurseries distributed over 35,000 quality saplings underscoring the sector's expanding potential.

The National Citrus Research Program (NCRP) continues to explore the production potential of mandarin and acid lime through the introduction and breeding of suitable germplasms. Recent introductions of mandarin varieties have demonstrated promising adaptability for cultivation in the Terai region. Notably, two cultivars 'Paripatle Agaute-1' and 'Banskharka Local' were officially registered in the previous year, marking a significant milestone in varietal development. Furthermore, enhanced nursery management practices at NCRP, Paripatle, have contributed to a record-high production of quality saplings, supporting the expansion of citrus cultivation across different agro-ecological zones.

These achievements were made possible by the dedicated efforts of NCRP staff and support from NARC management team, especially Executive Director, Directors of the Planning and Coordination, Crop and Horticulture Research, and Administrative Director. Despite limited personnel, NCRP met most of the planned targets. However, longstanding vacancies in key scientific roles-soil science, entomology, pathology, and plant breeding-have hindered the full utilization of laboratory facilities available at NCRP, Paripatle, Dhankuta.

This annual report is intended to serve as a valuable resource for a broad range of stakeholders, including citrus farmers, students, and professionals involved in citrus research and development. It provides insights and updates that can support informed decision-making, academic inquiry, and practical applications in the field. The preparation of this report was made possible through the valuable assistance of Mr. Amrit Katuwal, whose contributions are sincerely acknowledged and appreciated.

Basant Chalise
Senior Scientist (S-4) and Coordinator
National Citrus Research Program
Dhankuta Municipality-10, Paripatle, Dhankuta

ACRONYMS

%	: Percentage
@	: At the Rate of
>	: Greater Than
2,4-D	: 2,4-Dichlorophenoxyacetic Acid
ACC	: Accession
B.S.	: Bikram Sambat
BrimA	: Brix Minus Acid
CCI	: Chlorophyll Content Index
CIRAD	: Agricultural Center for International Development
cm	: Centimeter
CTV	: Citrus Tristeza Virus
CV	: Coefficient of Variation
cv.	: Cultivar
DA	: Difference in Absorbance
DAP	: Di-ammonium Phosphate
DAS	: Days After Sowing
et. al.	: et alia
FY	: Fiscal Year
FYM	: Farm Yard Manure
g	: Gram
ha	: Hectare
HLB	: Huanglongbing
i.e.	: That is
IAAS	: Institute of Agriculture and Animal Science
ICAR	: Indian Council of Agricultural Research
ICIMOD	: International Centre for Integrated Mountain Development
INGO	: International Non-governmental Organization
INRA	: National Institute for Agricultural Research
JICA	: Japan International Cooperation Agency
JT	: Junior Technician
JTA	: Junior Technical Assistant
K	: Potassium
Kg	: Kilogram
KNO3	: Potassium Nitrate
l	: Liter
LSD	: Least Significant Difference
m	: Meter

masl : Meter Above Mean Sea Level
ml : Milliliter
mm : Millimeter
MoALD : Ministry of Agriculture and Livestock Development
mt : Metric Ton
mt ha^{-1} : Metric Ton per Hectare
N : Nitrogen
NAA : Naphthaleneacetic acid
NARC : Nepal Agricultural Research Council
NCRP : National Citrus Research Program
NGO : Non-governmental Organization
NPR : Nepalese Rupee
NS : Non-significant
P : Phosphorus
PATWG : Provencial Agricultural Technical Working Group
PCR : Polymerase Chain Reaction
pH : Potential of Hydrogen
PMAMP : Prime Minister Agriculture Modernization Project
ppm : Parts per Million
RCBD : Randomized Complete Block Design
TA : Titratable Acidity
TSS : Total Soluble Solids
VCDP : Value Chain Development Project
viz. : Videlicet
WP : Wettable Powder

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सुन्तलाजात फलफूल खेती नेपालको मध्य पहाड र तराईका कृषकहरूको आर्थिक अवस्थामा सुधार ल्याउने एक महत्वपूर्ण व्यावसाय हो । सुन्तलाको बढ्दो आन्तरिक तथा वाह्य बजारको कारणले यसलाई एक उच्च मूल्य भएको क्षेत्रको रूपमा पहिचान गरिएको छ । सुन्तला नेपालको राष्ट्रिय फल हो । यसर्थ नेपाल सरकारले विगत केहि वर्षदेखि सुन्तला क्षेत्रको प्रवर्द्धन र विकासको लागि उच्च प्राथमिकता दिँदै आएको छ । यद्यपी विगत केहि वर्षदेखि बगैंचा ह्रासका कारण उत्पादन तथा गुणस्तरमा कमी देखिन थालेको छ । रोग र कीराको बढ्दो आक्रमण, खस्कदो माटोको उर्वराशक्ति र सिंचाइको अभाव, सीमित जातीय विविधता तथा स्वस्थ बिरुवाको अभाव जस्ता कारणले उत्पादन र उत्पादकत्वमा समस्या देखा परेको हो ।

यस परिप्रेक्ष्यमा राष्ट्रिय सुन्तला जात अनुसन्धान कार्यक्रमले राष्ट्रिय जिम्मेवारीको रूपमा यस क्षेत्रको प्रवर्द्धन गर्न उपयुक्त प्रविधि विकासको लागि अनुसन्धानका कार्यक्रमहरू सञ्चालन गर्दै आएको छ । यस कार्यक्रमले आ.व. २०८०/८१ मा जम्मा ७ वटा परियोजना अन्तर्गत ४२ वटा अनुसन्धान क्रियाकलापहरू सम्पन्न गरेको थियो । यी कार्यक्रमहरू विशेष रूपमा जातीय अनुसन्धान, बगैंचा ह्रास व्यवस्थापन र सुन्तलाजात फलफूलको रोग तथा कीरा व्यवस्थापनसँग सम्बन्धित थिए । फलफूल अनुसन्धान सम्पन्न गर्न लामो समय लाग्ने भएकोले धेरैजसो कार्यक्रमहरू नियमित संचालनमा छन् भने केहि सम्पन्न भई अपेक्षित उपलब्धिहरू हासिल भएका छन । यसरी आ.व. २०८०/८१ सम्म पूरा गरिएका क्रियाकलापहरूको उपलब्धिहरू संक्षिप्त रूपमा तल उल्लेख गरिएको छ ।

- जातीय संकलन र सम्वर्द्धन अन्तर्गत करीब १४० वटा स्थानीय र वाह्य स्रोतबाट सुन्तलाका विभिन्न जातहरू संकलन गरी कार्यक्रमको हाताभित्र फिल्ड जिन बैंकमा सम्वर्द्धन गरी राखिएको छ । यी संकलित जातहरू सुन्तला, जुनार, कागती, भोगटे, निबुवा, सुन्तलाका वर्णशंकर जातहरू तथा रुटस्टक वर्ग अन्तर्गत पर्दछन् । प्रारम्भिक अध्ययन अनुसार यी संकलित जातहरू फल लाग्ने समय, फलको गुण र बोटको वृद्धि विकास आदिको विशेषतामा निकै विविधता देखिएको छ । उपयुक्त जातको छनौट तथा विकासको लागि अझ केहि वर्ष अध्ययन गर्नुपर्ने देखिन्छ ।

- सुन्तला, जुनार, कागती र ट्यांङगोर प्रचलनमा रहेका जातहरूको उत्पादन क्षमता कम रहेका छन् । यस समस्यालाई हल गर्ने उद्देश्यले विदेशबाट ल्याइएका र उपयुक्त स्थानीय जातहरूको खोजी गरी २०६३/६४ देखि उत्पादन र उत्पादन समयको मुल्यांकन गर्दै आएको छ । प्रारम्भिक नतिजा अनुसार सुन्तलाका जातहरू जस्तैः 'ओकित्सुवासे', 'मियागावासे', 'नोभा', 'ओरोभल', 'मेरीसोल' तथा स्थानीय जातमा 'खोकु स्थानीय' ले उत्पादनको लागि उत्साहजनक परिणाम दिएको पाइएको छ । गत आर्थिक वर्षमा कागतीको 'तेह्रथुम स्थानीय', सुन्तलाको 'खोकु स्थानीय' जात पूर्वी पहाडमा खेती गर्न सिफारिस गरिएको छ । आउने वर्षमा सुन्तलाको एक जात 'मियागावावासे' तथा औद्योगिक प्रयोजनको लागि पारिपात्ले सुनौलो कागतीलाई दर्ताको लागि प्रस्ताव गर्न तयारी गरिएको छ ।

- 'वासिगंटन नेभल' जातको जुनारले उत्पादनको लागि उत्साहजनक परिणाम दिएको छ । यो जात अन्य जातहरू भन्दा अगाडि उत्पादन गर्न सकिने देखिएको छ । यस जातलाई उन्मोचनका लागि आगामी दिनमा प्रस्ताव गर्ने क्रममा छ । अन्य जातहरूमा 'माल्टा ब्लड रेड', 'डेलिसस सिडलेस', 'सुकारी' र 'धनकुटा स्थानीय' को उत्पादन पनि उत्साहजनक देखिन्छ ।

- दश वटा कागतीका जातहरू संकलन गरी विगत २०६३/६४ देखि तराईमा परीक्षण गरिदै आइएको छ । जातीय गुणको आधारमा आ.व.२०७५/७६ मा कागतीको जात 'तेह्रथुम स्थानीय'को नामबाट पूर्वी पहाड क्षेत्रको लागि उन्मोचन गरीएको छ । गत आर्थिक वर्षमा सुन्तलाको उन्नत जात 'पारिपात्ले अगौटे-१' नेपालका सम्पूर्ण पहाडि क्षेत्रमा (८०० देखि १४०० मिटरसम्म) खेती गर्न सिफारिस गरिएको छ ।

- विभिन्न उचाईमा सिट्रस सिल्लाको अनुगमन गर्दा करीब १,३०० मी भन्दा माथिको उचाईमा पनि यो कीरा देखिएको हुँदा आगामी दिनमा नर्सरी स्थापना गर्नको लागि खुल्ला क्षेत्र सुरक्षित नहुन सक्ने देखियो । त्यसकारण नर्सरी विरुवा उत्पादन जालीधर भित्र गर्नुपर्ने देखिन्छ ।

- गत आ.व.२०८०/८१ मा करिव १,८०० जना कृषक र सरोकारवालाहरूलाई अनुसन्धान कार्यक्रमबारे जानकारी तथा प्रविधिबारे सल्लाह दिइयो ।

- कलमीको लागि सुन्तला र कागतीको माउ बोटबाट स्वस्थ सायन धनकुटा जिल्लाका नर्सरी व्यवसायीहरूलाई उपलब्ध गराइयो । त्यस्तै गरी विभिन्न जिल्लाका कृषकहरूलाई 'खोकु स्थानीय', 'बासखर्क स्थानीय', 'पारिपात्ले अगौटे-१' र कागतीका विभिन्न जातहरू जस्तै 'सुनकागती-१', 'सुनकागती-२' र 'तेह्रथुम स्थानीय' का कलमी विरुवाहरू वितरण गरियो ।

- गत आ.व. २०८०/८१ मा कृषकहरूलाई वितरण गरिएका जम्मा कलमी विरुवाहरू २१,८५७ मध्ये सुन्तलाको ३,५३२ वटा, जुनारको २२२ वटा, कागतीको १७,९७० वटा र अन्य प्रजातिका १३३ वटा थिए ।

- यस कार्यक्रमको आ.व. २०८०/८१ को लागि विनियोजित बजेट रू.३ करोड ३१ लाख २४ हजार थियो जस मध्ये चालु कार्यक्रमको लागि जम्मा रू.२ करोड, ५३ लाख, ५४ हजार विनियोजन गरिएको थियो । वार्षिक आम्दानी रू.४३ लाख, ४१ हजार, १४० थियो जुन खासगरी विरुवा तथा ताजाफल बिक्रिबाट प्राप्त भएको थियो भने केहि रकम प्रशासनिक विधिबाट प्राप्त भयो ।

- विशेष परियोजना अन्तर्गत 'पहाडी काष्ठफल तथा फलफूल विकास आयोजनामा' सुन्तलाजातका फलफूलमा विकास चरणको विशेषता अध्ययन अन्तर्गत विभिन्न जातहरूमा जातीय दर्ताको लागि फूल फूलेदेखि फल टिप्दासम्मको अवस्थाको आकडा संकलन गरिएको थियो । यसको साथै सुन्तलाजात फलफूलका बेर्ना उत्पादन गर्ने कार्य समेत भएको थियो । यस आयोजना अन्तर्गत १९ लाख, ५० हजार रूपैयाँ विनियोजन गरिएको थियो ।

EXECUTIVE SUMMARY

Citrus production is an important agriculture sub-sector which helps raise economic standard of the Nepalese farmers in mid hills and terai plains. Citrus sector has been recognized as the high value commodity having high demand in domestic as well as international market. Thus, the government of Nepal has kept citrus sector under high priority for its growth and development in the country. However, lower productivity with low quality of production has been evident from past few years. This condition is attributed to increasing invasion of various insects, diseases, nutritional deficiency, moisture stress, limited choice of varieties and inadequate sources for quality planting materials. National Citrus Research Program (NCRP) with the national mandate of developing appropriate technologies has been conducting research programs for improving condition of the citrus enterprises in Nepal. During the fiscal year 2080/81, a total of 42 activities under 7 research projects were accomplished by the program. Particularly, these research projects comprised of varietal research, citrus decline management, and management of diseases and insect pest of citrus. Most of the activities were continuation of those from last year, while some of them were concluded with worthwhile outputs that are summarized below.

- A field gene bank was maintained with a total of 140 different citrus germplasms which were collected from local and exotic sources in past periods. These conserved germplasm includes mandarin orange, sweet orange, acid lime, lemon, grapefruit, tangor, tangelo, and different rootstock species. A distinct variation with respect to flowering, fruiting behavior, fruit traits and morphological characteristics has been observed. Further selection is necessary to screen the promising varieties based on economic traits.

- As the existing cultivars of mandarin, sweet orange, acid lime, and tangor had low yield, the exotic cultivars inclusive of elite local cultivars have been introduced and evaluated since 2063/64. The preliminary performances of varietal evaluation of mandarin revealed some exotic genotypes such as 'Okitsuwase', 'Miyagawase', 'Oraval', 'Page', and 'Marisol' are promising with early maturity and high fruit yield. Mandarin variety 'Khoku Local' was registered for the cultivation in the Eastern mid-hills in 2075 B.S. One genotype of mandarin viz., 'Okitsuwase' was registed in 2080 B.S. as an early season variety named as 'Paripatle Agaute-1' based on its performance for yield and yield-attributing parameters.

- 'Washington Navel', a variety of sweet orange had been performing more excellent in terms of higher fruit yield than those of other varieties. This

genotype was noted to be suitable for early-season production. This genotype is in the process of being proposed for varietal registration. Similarly, other genotypes viz., 'Malta Blood Red', 'Delicious Seedless', 'Succari' and 'Dhankuta Local' had shown good fruit yield characteristics.

- Ten elite acid lime genotypes collected locally have been evaluated since 2063/64 in Terai districts. Three acid lime varieties: 'Sunkagati-1', 'Sunkagati-2', 'Tehrathum Local' were registered in the past seven years for upland condition of Terai, inner Terai, foothills and mid-hill areas. Moreover, 'Banskhark Local' and 'Paripatle Agaute-1' mandarin has been registered by Variety Release Sub-committee as suitable for mid-hill condition recently.

- During monitoring of Asian citrus psylla at different altitudes, the pest was recorded at an elevation of 1,300 masl. Therefore, it is not safe to establish citrus nurseries in open conditions at this altitude. Nursery owners are advised to produce saplings under the protected structures with insect nets.

- During the fiscal year 2080/81, technical counselling was given to 1,800 farmers and other stakeholders regarding the research programs and technologies for citrus sector.

- The scion source from the mother plant of mandarin and acid lime varieties was provided to the nearby nursery entrepreneurs. Likewise, grafted saplings of 'Khoku Local' mandarin, 'Paripatle Agaute-1' and three varieties of acid lime viz. 'Sunkagati-1', 'Sunkagati-2' and 'Tehrathum Local' were provided to the farmers in different districts.

- In the fiscal year 2080/81 a total of 21,857 grafted saplings comprising 3,532 mandarin orange, 222 sweet oranges, 17,970 acid lime and 133 other saplings were sold to farmers.

- The total annual budget approved for the program was NPR 33.124 million, while operational budget consisted of NPR 25.354 million to carry out research projects. The revenue was NPR 4.341 million Rupees in the fiscal year mainly from selling of saplings and fresh fruits, however small amount was contributed by administrative method.

- To investigate the phenology of citrus crops with the objective of varietal registration, a special project 'NAFHA' was initiated at the National Citrus Research Program (NCRP), Paripatle, Dhankuta. The phenological study focused primarily on mandarin, sweet orange, and acid lime. In addition to phenological observations, sapling production was also undertaken for these citrus species. For the implementation of project activities, a budget of NPR 1.95 million was allocated to NCRP, Paripatle, Dhankuta, during the FY 2080/81.

1 WORKING CONTEXT

Citrus fruits hold a significant place in Nepal's agricultural sector, thanks to the country's favorable geography and climate. With the growing interest among the younger generation in commercial agricultural enterprises, citrus farming has the potential to become a profitable venture, contributing to the national economy.

Nepal is recognized for producing high-quality mandarins and sweet oranges. The mid-hill districts, located at altitudes between 800 and 1,400 masl, offer ideal sub-tropical climates for citrus cultivation, as do other regions across the country with favorable agro-climatic conditions. Citrus thrives in areas with deep sandy loam soil and a soil pH between 5.0 and 6.5. In recent years, citrus is being cultivated in 62 districts, however commercially, it is cultivated in 60 districts of Nepal.

Table 1: Total area, production, and productivity of citrus fruits during the FY 2008/09 to 2022/23 in Nepal

Year	Total area (ha)	Productive area (ha)	Total Production (mt)	Productivity (mt ha^{-1})
2008/09	32,322	22,482	2,53,766	11.29
2009/10	33,898	22,903	2,59,191	11.30
2010/11	35,578	23,609	2,63,710	11.20
2011/12	37,565	24,089	2,40,793	10.00
2013/14	38,988	25,497	2,24,357	8.80
2014/15	39,035	25,261	2,22,790	8.82
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	9.76
2021/22	49,306	32,417	3,06,149	9.47
2022/23	49,469	33,829	317,494	9.39

Source: MoALD (2024)

Over the past 15 years, both the area under citrus cultivation and production have increased. Currently, 49,469 ha areas are dedicated to citrus farming, producing 306,149 mt, with an average yield of 9.47 mt ha^{-1} (Table 1). However, this productivity is quite low compared to other major citrus-producing countries globally. The declining trend in productivity has been linked to poor orchard management and decreasing soil fertility. Therefore, there is significant potential to boost citrus production and productivity in Nepal through the adoption of improved agricultural practices and technologies.

Table 2 highlights the total area, productive area, production, and productivity of major citrus fruit crops such as mandarin orange, sweet orange, acid lime, lemon, and other citrus fruit crops. In terms of total area, productive area and production; mandarin has acquired the first position with 28,451 ha, 20,172 ha, 198,779 mt respectively, with the total productivity of 9.85 mt ha^{-1}. On the other hand, other citrus fruit acquired the lowest area (1,887 ha), productive area (1,261 ha), and production (10,322 mt). The the highest productivity was from sweet orange (11.52) and the lowest productivity of 7.51 mt ha^{-1} was recorded with lemon.

Table 2: Total area, productive area, production, and productivity of major citrus fruits during 2080/81 in Nepal

Major citrus fruits	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt ha^{-1})
Mandarin orange	28,451	20,172	198,779	9.85
Sweet orange	6,227	4,205	48,460	11.52
Acid lime	10,312	6,335	46,244	7.28
Lemon	2,804	2,030	15,241	7.51
Other citrus crop	1,887	1,261	10,322	8.19
Total	49,469	33,829	317,494	9.39

Source: MoALD (2024)

The data shown in Figure 1 revealed that mandarin orange covers the maximum production area among citrus fruit. Mandarin orange covers 57.0% area among the citrus cultivated area. Similarly, acid lime, sweet orange, lemon, and other citrus covers 21.0%, 12.0%, 6.0%, and 4.0% respectively.

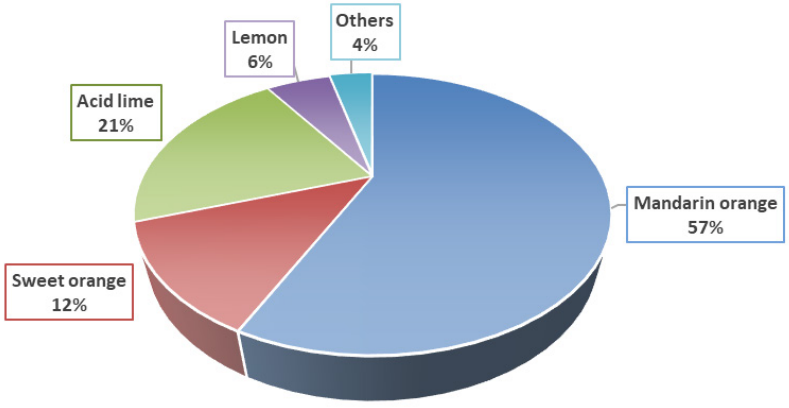


Figure 1: Total area occupied by the major citrus fruits during 2080/81 in Nepal

Table 3 shows the total orchard area, productive area, production and productivity of five groups of citrus based on provinces of the country. In terms of total cultivated area, productive area and production of citrus crops, regardless of respective group Kosi Province has occupied the first position with 12,858 ha, 8,755 ha and 65,818 mt respectively, but Karnali province has stood the first position for productivity (10.89 mt ha^{-1}) followed by Bagmati Province with 10.30 mt ha^{-1} and Sudurpaschim Province with 9.90 mt ha^{-1}. Although, area, productive area and production of mandarin orange is the highest in Gandaki Province with 8,032 ha, 5,505 ha and 55,196 mt; productivity is noted to be the highest in Karnali (11.64 mt ha^{-1}) followed by Lumbini (10.99 mt ha^{-1}) and Sudurpaschim (10.87 mt ha^{-1}), while the lowest productivity of mandarin is in Bagmati Province (8.34 mt ha^{-1}). As for sweet orange, Bagmati province has had considerably the highest area (3,354 ha), productive area (2,192 ha), production (29,902 mt) and productivity (13.64 mt ha^{-1}) whereas Karnali Pradesh showed the lowest productive area (103 ha) and production (945 ha). The lowest productivity was found in Koshi Province (6.53 mt ha^{-1}). Koshi province showed considerably the maximum acid lime area (3,748 ha), productive area (2,680 ha) and production (18,269 mt). However, highest productivity for lime was recorded from Gandaki (8.51 mt ha^{-1}). The Madhesh Province reflected the lowest for acid lime in respect of area (98 ha), productive area (71 ha) and production (469 mt). In regards with lemon fruit crop, its' total area (835 ha), productive area (646 ha), production (5,338 mt) and productivity (8.26 mt ha^{-1}) are recorded to be highest in Bagmati pradesh. As for other citrus fruit crop, cropped area (865 ha), productive area (468 ha), was recorded the highest in Koshi province, however highest production (4,020 mt) and productivity of (9.92 mt ha^{-1}) was noted from Bagmati. The lowest productivity (5.90 mt ha^{-1}) was recorded from Koshi Province.

Table 3: Total area, productive area, total production, and productivity of different citrus species in the different provinces of Nepal during 2080/81

Province	Crop	Area (ha)	Productive Area (ha)	Production (mt)	Yield (mt ha^{-1})
Koshi Pradesh	Mandarin	6,952	4,705	39,254	8.34
Madhesh Pradesh	Mandarin	-	-	-	-
Bagmati Pradesh	Mandarin	4,393	3,269	29,349	8.98
Gandaki Pradesh	Mandarin	8,032	5,505	55,196	10.03
Lumbini Pradesh	Mandarin	3,896	3,244	35,652	10.99
Karnali Pradesh	Mandarin	3,542	2,391	27,826	11.64
Sudurpashchim Pradesh	Mandarin	1,636	1,058	11,503	10.87
Total	Mandarin	28,451.00	20,172.00	198,779.00	9.85
Koshi Pradesh	Sweet orange	813	616	4,021	6.53
Madhesh Pradesh	Sweet orange	-	-	-	-
Bagmati Pradesh	Sweet orange	3,354	2,192	29,902	13.64
Gandaki Pradesh	Sweet orange	194	101	907	8.97

Province	Crop	Area (ha)	Productive Area (ha)	Production (mt)	Yield (mt ha^{-1})
Lumbini Pradesh	Sweet orange	593	399	3,884	9.73
Karnali Pradesh	Sweet orange	184	103	945	9.17
Sudurpashchim Pradesh	Sweet orange	1,090	794	8,801	11.08
Total	Sweet orange	6,227.00	4,205.00	48,460.00	11.52
Koshi Pradesh	Lime	3,748	2,680	18,269	6.82
Madhesh Pradesh	Lime	98	71	469	6.61
Bagmati Pradesh	Lime	1,467	948	7,781	8.21
Gandaki Pradesh	Lime	1,249	631	5,365	8.51
Lumbini Pradesh	Lime	2,268	1,373	9,658	7.03
Karnali Pradesh	Lime	557	255	1,538	6.03
Sudurpashchim Pradesh	Lime	926	397	3,165	7.97
Total	Lime	10,312.00	6,355.00	46,244.00	7.28
Koshi Pradesh	Lemon	480	286	1,514	5.30
Madhesh Pradesh	Lemon	-	-	-	-
Bagmati Pradesh	Lemon	835	646	5,338	8.26
Gandaki Pradesh	Lemon	396	368	2,988	8.13
Lumbini Pradesh	Lemon	222	170	1,132	6.66
Karnali Pradesh	Lemon	208	126	1,010	8.04
Sudurpashchim Pradesh	Lemon	663	435	3,260	7.49
Total	Lemon	1,804.00	2,030.00	15,241.00	7.51
Koshi Pradesh	Others	865	468	2,760	5.90
Madhesh Pradesh	Others	-	-	-	-
Bagmati Pradesh	Others	477	405	4,020	9.92
Gandaki Pradesh	Others	324	268	2,513	9.36
Lumbini Pradesh	Others	91	62	615	9.88
Karnali Pradesh	Others	16	7	68	9.38
Sudurpashchim Pradesh	Others	115	50	348	6.95
Total	Others	1,887.00	1,261.00	10,322.00	8.19

Source: MoALD (2024)

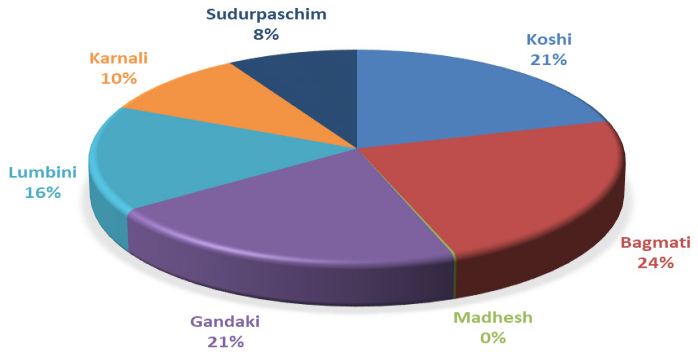


Figure 2: Citrus fruit production status of the seven provinces of Nepal during 2080/81

Figure 2 shows the status of citrus fruit production in the seven provinces of Nepal. Out of total citrus production, i.e. 317,494 mt, Bagmati contributes maximum (24%) citrus production with total production of 74,838 mt followed by Gandaki (66,968 mt) and Koshi province (65,81897 mt). There is very negligible production from citrus crops in Madhesh Province (469 mt). Citrus crops share about 23.5% of the total fruit area in Nepal. The government of Nepal has recognized mandarin and sweet orange as the potential export commodities, taking place of an initiative for exporting sweet orange in Tibet. Nevertheless, citrus industry is still facing several problems, some important are: traditional practices for crop management, short production season of existing varieties, declined soil fertility and water resources, citrus greening and fruit fly, poor quality and small production scale, poor infrastructures and legal and institutional mechanism for marketing and lack of entrepreneurship for this crop.

The domestic production meets only fewer percentage of national demand during main season that fresh as well as processed citrus worth hundred million rupees is being imported every year. Hence, Nepal holds an important potential area for commercialization of citrus sector towards import substitution and export promotion.

Majority of farmers are small scale producers characterized by small land holdings with low investing and risk bearing capacity. This is the major reason of poor crop management that requires high level of external inputs; high skills and good crop management knowledge, which are not within the capacity of most farmers. There is serious short coming on crop husbandry practices in most citrus orchards like manuring, training/pruning, disease and pest control among others. As a result, many orchards are in declining states.

Mostly farmers have no access to the certified planting materials free of diseases including Phytophthora root rot, citrus greening, canker and tristeza virus. Similarly, there is a lack of varietal diversity for extending the production season at farmer's field. Therefore, the production of existing varieties is limited to very short period during normal season. As a result, Nepal imports mandarin, sweet orange and acid lime worth more than two hundred million annually (MoALD, 2019). Poor fruit quality due to insect pests and diseases as well as poor orchard management, and physical damage during harvest and transport are some the important aspects to be considered for the export business in the future.

These contexts bring about too many areas of research and development to be carried out, ranging from variety improvement, tree health management, integrated soil management, plant protection, postharvest handling, processing, and marketing. Eventually the sector could be transformed into commercial and export industry producing quality fruits in sizeable volume.

2 INTRODUCTION

2.1 Background

Citrus occupies a vital position in Nepal's horticultural sector, playing a significant role in enhancing the livelihoods of rural farmers. Owing to the country's favorable geography and climate, citrus cultivation is widely practiced across the mid-hill regions, ranging from 800 to 1,400 masl, from eastern to western Nepal. Recognizing its economic importance, the Government of Nepal has prioritized citrus as a high-potential crop for increasing income and generating employment opportunities. Moreover, citrus development is seen as a strategic means for promoting import substitution and enhancing export potential.

Recognizing the importance of this sector, the government of Nepal established the Citrus Research Station in Paripatle in 1961 (2018 B.S.). In 2000 (2057 B.S.), it was re-designated as the National Citrus Research Program (NCRP) under the Nepal Agricultural Research Council (NARC) with the mandate to conduct citrus research, provide studies, and produce and distribute healthy citrus saplings. The research station is in Dhankuta-10, Paripatle, in Dhankuta district, at an elevation of 900-1,390 meters above mean sea level, and covers 20 ha of land with a southeast-facing aspect. It lies about 8 km northwest of the Dhankuta district headquarters in eastern Nepal.

The research farm spans 20 ha of terraced land, mostly devoted to production orchards of key citrus species such as mandarins, sweet oranges, and acid limes. A field gene bank conserves both exotic and local citrus genotypes, while on-station varietal research plots occupy much of the area. The NCRP also maintaining seven screen houses, where mother plants of promising varieties, including mandarin, sweet orange, kinnow, and acid lime, are kept. A separate 3 ha nursery block is used for plant propagation and nursery-related research activities. Additional infrastructure includes a tissue culture lab, agronomy lab, cellar store, irrigation canals, and ponds. Despite limited resources, the program focuses on variety improvement and selection, crop management, citrus decline management, nursery management and propagation, pest control, tissue culture for nursery production, high-density planting, and post-harvest studies.

2.2 Goal

- Contribute to increasing the productivity and quality of citrus fruit through the use of modern technologies.

2.3 Purpose

- Increase economy and living standard of farmers through commercialization of citrus sector through technology advancement

2.4 Objectives

- To conduct research on variety, husbandry management, postharvest, disease/pest control, nursery, tissue culture and genetic resource conservation and utilization
- To coordinate with various research and development line agencies for collaborative citrus research and development programs
- To establish linkage with national and international citrus research organizations
- To prioritize research areas in the country
- To document and maintain information on citrus research and development
- To provide technical supports and services to citrus stakeholders

2.5 Strategies

- Conduct participatory, holistic and systematic research and studies on citrus fruit crops
- Prioritize research areas and policy formulation based on problems and demands in citrus sector
- Variety improvement and selection for extended harvesting season
- Enhancing production and productivity by generating technologies
- In-vitro technology for healthy propagation
- Conservation and improvement of citrus genetic resources
- Technologies advancement on citrus-based farming system
- Marketing and export promotion of citrus industry
- Ensuring effective dissemination and adoption of developed technologies
- Coordination and collaboration with line agencies including farmers' communities

2.6 Responsibilities

- Identify problems and needs of citrus sector for setting up the research areas
- Develop appropriate technologies on different aspects of citrus fruit crops
- Genetic resources conservation and utilization

- Mother plant maintenance and nursery plant production
- Out-scaling of technologies for wider impact
- Coordinate with other national and international organizations for collaborative research and studies
- Publications and documentation
- Provide technical and consultancy services to the clients

2.7 Prioritized research for forthcoming years

- Integrated approach to combat citrus decline
- Integrated nutrient management in citrus
- Breeding new varieties for early and late maturity period
- Breeding for addressing the problem of HLB, CTV, and root rot
- Biological pest and disease control
- Cost effective and eco-friendly production technologies
- Postharvest processing and value addition
- Water use efficiency
- *In-vitro* technology for healthy propagation
- Citrus based farming system
- Marketing and export business
- Socio-economic studies

2.8 Infrastructure and resources

The National Citrus Research Program (NCRP), originally founded in 1961 (2018 B.S.) as the Citrus Research Station, became part of the Nepal Agricultural Research Council (NARC) in 2000 (2057 B.S.). It is tasked with developing technology for citrus fruit crops at the national level. The NCRP spans 20 ha of land, which includes both forest and ditch areas.

The farm's production area primarily focuses on mandarin 'Khoku Local' and sweet orange 'Dhankuta Local', which cover a significant portion of the land. There are also five separate research blocks dedicated to different citrus varieties, including mandarin, sweet orange, acid lime, various rootstocks, and hybrid mandarin. Additionally, a field gene-bank is maintained for the in-situ conservation of citrus germplasms. There is also a block for showcasing released acid lime varieties and other promising lines.

The farm has a dedicated two-hectare nursery area for propagation and research, which includes seven screen houses, a hi-tech nursery house, and over 40 nursery beds containing mother plants for various citrus species. A well-equipped tissue culture laboratory, along with a general laboratory building and two glasshouses, supports research activities. For irrigation, several ponds are distributed across the farm, and a 700-meter pipe-fitted canal has been installed to ensure adequate water supply.

2.9 Organizational structure and human resources

There are 37 approved posts to operate the National Citrus Research Program, Paripatle, Dhankuta. Out of 37 there are only 7 post were fulfilled. Therefore, program is operating under the severe human resources deficit condition (Figure 3, Annex 4 and 5)**.**

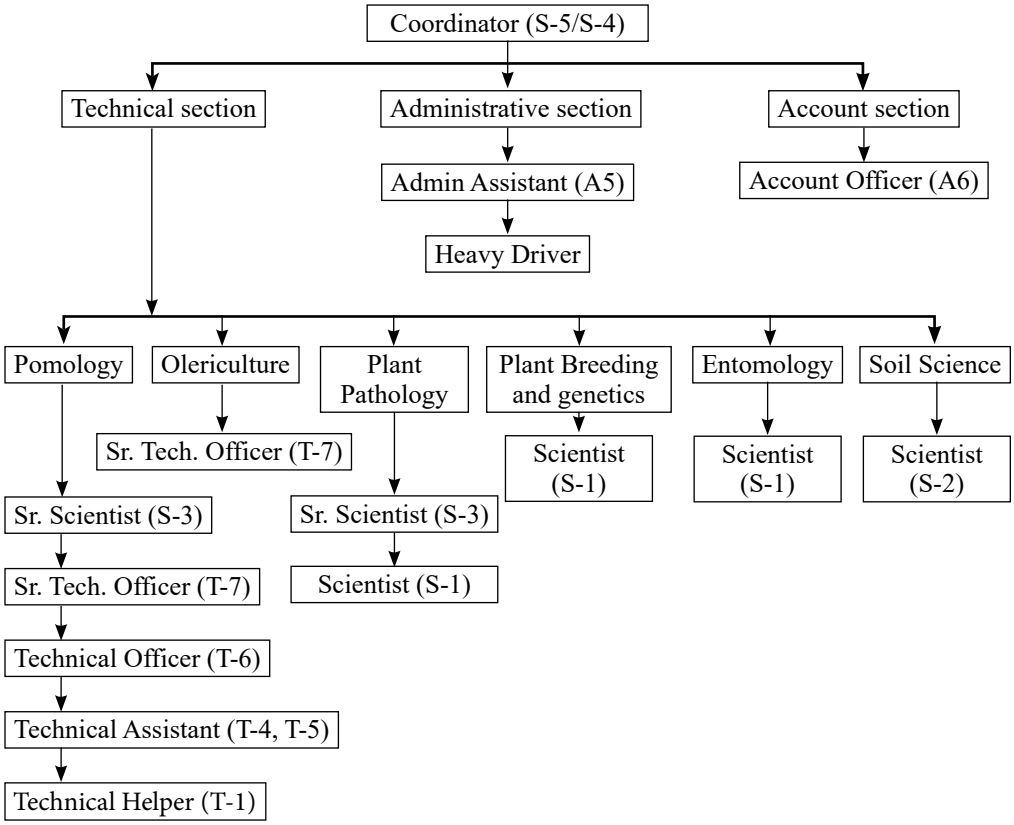


Figure 3: Organogram of the National Citrus Research Program, Paripatle, Dhankuta

3 RESEARCH HIGHLIGHTS

3.1 Varietal evaluation

The existing citrus varieties in Nepal have a low yield potential and a short production period. Although there is significant genetic diversity among citrus species across the country, most varieties of mandarin, sweet orange, and acid lime have a similar harvesting season, limited to between October and January. As a result, there is a need for suitable alternative varieties to extend the production period in Nepal. To address this, NCRP Dhankuta has introduced several exotic varieties of mandarin, sweet orange, and acid lime, along with elite local cultivars, over the years. The performance of these genotypes has been evaluated in recent years to identify the most suitable varieties for different agro-climatic regions.

3.1.1 Mandarin

Mandarin (*Citrus reticulata* Blanco) is a high potential fruit crop in Nepal. It is widely grown throughout the mid hills across the country. In Nepal almost all mandarin varieties are of local origin that are specific to the location and vary each other. These varieties are characterized as declining yield potential and short production period within same season. Therefore, mandarin production is confined to three to four months leading to shortage for the rest of the year. A huge amount is being imported to make the national demand during other periods of the year.

Thus, NCRP has continued the study on variety introduction and selection to determine appropriate varieties instead of local varieties to expand the production period. In this line, variety selection and evaluation has been continued and 22 varieties introduced from abroad and local sources have been evaluated since 2063/64.

Fruit physical and yield attributing characteristics of mandarin orange

Fruit physical and yield attributing parameters like individual fruit weight, fruit diameter, fruit rind thickness, number of segments per fruit, number of seed per fruit, number of fruits per tree and yield were significantly different among the genotypes (Table 4).

Fruit weight

Fruit weight was found differing highly significantly and ranged from 66.10 g to 165 g with the mean value of 107.54 g. The highest fruit weight was found in Okitsu (165 g) followed by Satsuma Mino (161 g). The lowest fruit weight was found in Kinnow (66.10 g) followed by Frutrel Early (70.30 g).

Table 4: Fruit physical and yield attributing characteristics of mandarin orange genotypes at NCRP, Paripatle, Dhankuta during 2080/81

Genotype	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Nos of Segment fruit^{-1}	Nos of seed	Nos fruit tree^{-1}	Yield (mt ha^{-1})
NCRP -95 (Okitsu)	165.00	71.30	1.96	11.50	0.23	104.00	20.20
NCRP-01 (Kholu Local)	96.70	60.80	1.67	10.30	7.07	237.00	24.70
NCRP-02 (Kinnow)	66.10	52.40	2.18	10.90	15.00	220.00	17.20
NCRP-03 (Frutrel Early)	70.30	53.70	2.09	11.20	15.30	333.00	23.80
NCRP-04 (Unshiu)	74.90	56.30	1.37	11.10	0.30	311.00	23.70
NCRP-05 (Miyagawawase)	130.00	66.80	2.23	11.80	0.13	140.00	20.20
NCRP-06 (Okitsuwase)	112.00	63.00	1.72	11.40	0.03	68.80	9.00
NCRP-08 (Pongan)	125.00	66.20	2.36	9.87	8.20	60.20	8.22
NCRP-09 (Kamala)	74.60	52.80	2.55	9.00	12.60	326.00	25.70
NCRP-10 (Banskharka Local)	90.60	60.70	2.12	9.53	10.10	274.00	26.80
NCRP-100 (Marisol)	117.00	61.10	2.30	8.47	2.80	116.00	10.70
NCRP-101 (Nules)	81.50	55.20	2.67	10.10	13.30	73.00	6.00
NCRP-11 (Sikkime)	93.20	56.30	1.81	10.00	9.80	171.00	16.80
NCRP-12 (Calamondin)	88.80	56.20	1.72	9.67	10.00	1710.00	126.00
NCRP-80 (Satsumawase)	120.00	67.50	2.85	10.80	0.63	75.70	12.30
NCRP-81 (Satsuma Mino)	161.00	72.30	2.85	11.30	0.40	233.00	41.70
NCRP-82 (Satsuma URSS)	123.00	69.50	2.68	11.80	0.97	143.00	18.80
NCRP-88 (Fortune)	107.00	66.30	1.83	10.40	11.70	63.70	6.86
NCRP-90 (Nova)	146.00	67.60	2.54	10.40	7.80	100.00	14.90
NCRP-94 (Page)	108.00	69.00	1.78	9.87	13.60	72.70	7.43
NCRP-98 (Oraval)	127.00	65.00	2.27	8.33	8.73	63.00	8.31
NCRP-99 (Commune)	89.50	57.30	2.30	8.67	9.33	60.00	5.93
Grand mean	107.54	62.15	2.18	10.29	7.18	225.23	21.60
LSD (P<0.05)	27.47	6.86	0.42	0.71	3.47	326.27	19.27
F-test	***	***	***	***	***	***	***
CV (%)	15.50	6.70	11.65	4.20	29.31	87.91	54.14

Fruit diameter

Fruit diameter was found significantly different and ranged from 52.40 mm to 72.30 mm with mean value of 62.15 mm. The highest fruit diameter was found in Satsuma mino (72.30 mm) followed by Okitsu (71.30 mm) and Satsuma URSS (69.50 mm). The lowest fruit diameter was found in Kinnow (52.40 mm) followed by Kamala (52.80 mm).

Peel thickness

Fruit rind thickness was found significantly different among genotypes and ranged from 1.37 mm to 2.85 mm with mean value of 2.18 mm. The thickest fruit rind was found in 'Satsumawase' (3.3 mm) and 'Satsuma Mino' (2.85) followed by 'Satsuma URSS' (2.68 mm). The lowest fruit rind thickness was found in unshiu (1.37 mm) followed by 'Khoku Local' (1.67 mm).

Number of segments

The number of segments per fruit was found ranging from 8.47 to 11.80 with mean value of 10.29. The maximum number of fruit segments per fruit was found in 'Satsuma URSS' (11.80) and 'Miyagawawse' (11.80) followed by 'Okitsu' (11.50) and 'Okitsuwase' (11.40). The minimum number of segments per fruit was found in 'Oraval' (8.33) followed by 'Marisol' (8.47) and 'Commune' (8.67).

Number of seeds per fruit

The average number of seeds per fruit ranged from 0.03 to 15.30 with an average of 7.18. The highest number of seeds were found in 'Frutrel Early' (15.30) followed by 'Kinnow' mandarin (21) and Paige (13.60), while the lowest number was found in 'Okitsuwase' (0.03) followed by 'Miyagawawase' (0.13).

Fruit yield

The total fruit yield per hectare was found significantly different and ranged from 5.93 to 126 mt ha^{-1} with a mean value of 21.60 mt ha^{-1}. The highest fruit yield was found in 'Calamondin' (126 mt ha^{-1}) followed by 'Satsuma Mino' (41.70 mt ha^{-1}). The lowest fruit yield was found in 'Commune' (5.93 mt ha^{-1}) followed by' Fortune' (6.86 mt ha^{-1}).

Physicochemical properties of mandarin fruit

Physicochemical properties of mandarin like Juice content, TA, TSS, DA meter reading and CCI were found significantly different at harvest among the genotypes (Table 5.)

Juice content

Juice percentage was found significantly different among tested genotypes and ranged between 33.70% to 63.00% with mean value 45.31%. The highest juice quantity was found in 'Okitsuwase' (63.00%) followed by 'Unshiu' (59.20%) and 'Miyagawase' (58.60 %). The lowest juice quantity was found in 'Kinnow' (33.70%) followed by 'Kamala' (36.10%).

Table 5: Physicochemical properties of mandarin orange genotypes at NCRP, Paripatle, Dhankuta during 2080/81

Genotype	Juice (%)	Rag (%)	TSS (%)	TA (%)	DA value	CCI value
NCRP -95 (Okitsu)	55.00	31.80	7.60	0.72	0.40	6.13
NCRP-01 (Kholu Local)	48.40	21.00	10.60	0.94	0.33	9.96
NCRP-02 (Kinnow)	33.70	21.40	12.00	1.14	0.73	9.19
NCRP-03 (Frutrel Early)	40.90	20.10	9.99	0.92	0.24	9.96
NCRP-04 (Unshiu)	59.20	18.60	8.48	0.68	0.34	6.61
NCRP-05 (Miyagawawase)	58.60	22.20	8.05	0.67	0.31	7.86
NCRP-06 (Okitsuwase)	63.00	16.10	7.50	0.63	0.43	6.46
NCRP-08 (Pongan)	35.90	39.60	11.40	1.04	0.14	9.46
NCRP-09 (Kamala)	36.10	20.60	10.60	1.57	0.67	10.10
NCRP-10 (Banskharka Local)	50.30	16.80	10.80	0.87	0.18	9.77
NCRP-100 (Marisol)	39.30	38.80	8.67	1.15	0.35	10.40
NCRP-101 (Nules)	37.60	26.20	10.20	1.16	0.49	8.57
NCRP-11 (Sikkime)	51.00	20.90	10.80	0.89	0.18	9.66
NCRP-12 (Calamondin)	43.50	24.50	10.50	1.36	0.16	12.30
NCRP-80 (Satsumawase)	44.40	33.80	7.32	0.68	0.66	5.10
NCRP-81 (Satsuma Mino)	47.80	42.20	7.59	0.76	0.30	6.43
NCRP-82 (Satsuma URSS)	44.60	30.30	7.05	0.81	0.25	7.16
NCRP-88 (Fortune)	45.70	35.80	11.60	0.98	0.22	11.80
NCRP-90 (Nova)	42.00	49.70	9.68	1.05	0.28	14.10
NCRP-94 (Page)	45.60	37.30	11.40	0.79	0.24	11.30
NCRP-98 (Oroval)	36.20	38.20	10.70	0.99	0.04	15.20
NCRP-99 (Commune)	37.90	25.40	11.70	0.97	0.27	12.80
Grand mean	45.31	28.69	9.75	0.94	0.33	9.56
LSD (P<0.05)	6.72	10.25	0.76	0.22	0.28	2.33
F-test	***	***	***	***	***	***
CV (%)	9.00	21.69	4.72	14.68	52.50	14.85

Total soluble solids

TSS % was found significantly different among the tested genotypes and varied from 7.05% to 12.00% with mean value 9.75%. The highest TSS was found in 'Kinnow' (12.00%) followed by 'Commune' (11.70%), and 'Kamala' (11.60%) and Fortune (11.60%). The lowest TSS was recorded in the genotype 'Satsuma URSS' (7.05%), followed by 'Satsumawase' (7.32%).

Titratable acidity

Among the tested genotype TA% was found significantly different and ranged from 0.63% to 1.57% with the mean value 0.94%. The highest percentage of TA was found in 'Kamala' (1.57%) followed by 'Calamondin' (1.36%), whereas the lowest percentage was found in 'Okitsuwase' (0.63%) followed by 'Miyagawase' (0.67%).

DA (chlorophyll) reading

The decline in chlorophyll content of the fruit skin, measured on the tree by DA meter showed non-significantly different among the genotypes at harvest time. The value ranged from 0.04 to 0.73 with the mean value of 0.33. Minimum DA reading was recorded in 'Oroval' (0.0.04) followed by 'Pongan' (0.14), whereas 'Kinnow' (0.73) followed by 'Kamala' (0.67) and 'Satsumawase' (0.66) were recorded with maximum DA value.

Citrus color index (CCI)

The CCI value for tested genotypes were significantly different with each other. The CCI value of the fruit ranged from 5.10 to 15.20 with the mean value of 9.56. Minimum CCI was recorded in 'Satsumawase' (5.10) followed by 'Okitsu' (6.13) and maximum was in 'Oroval' (15.20) followed by 'Nova' (14.10).

3.1.2 Sweet orange

Sweet orange (*Citrus sinensis* Osbeck) ranks as the second most important citrus fruit in Nepal, following mandarin in both production and economic significance. It is cultivated primarily in several mid-hill districts across the country, with major production areas including Dhankuta, Khotang, Sindhuli, Parbat, Palpa, and Dadeldhura. These regions provide suitable agro-climatic conditions that support the successful cultivation and commercial viability of sweet orange.

The harvesting time of present local varieties remains only two months during December-January and beyond this period, Nepal imports fresh sweet orange fruit as well as processed fruit juice throughout the year. Thus, NCRP has focused on variety selection of this species, so that there will be varietal diversity for expanding the fruit harvesting period beyond normal season, especially for early and late harvesting seasons. With this objective varietal evaluation of sweet orange including 17 exotic and local varieties has been continued since 2064/65. The performance of the sweet orange genotypes being evaluated in NCRP, Paripatle are described as follows.

Fruit characteristics and yield of different genotypes of sweet oranges

Fruit characteristics and yield attributes like individual fruit weight, individual fruit diameter, fruit rind thickness, fruit rind weight, number of seed per fruit, number of fruits per tree and fruit yield per hectare were statistically different due to the effects of different genotypes of sweet oranges (Table 6)

Individual fruit weight

The data in table 6 shows that the individual fruit weight was statistically significant among the tested genotypes. Fruit weight varied from 116 g to 227 g with the mean value of 137.40 g. 'Washington Navel' (227 g), 'Lane Late' (158 g) and 'Succari' (152 g) had higher individual fruit weight. The lowest individual fruit weight was recorded in 'Valencia Late' India (116.00 g), 'Valencia Late France' (117.00 g) and 'Salustiana' (119.00 g).

Fruit diameter

The individual fruit diameter was significantly different and ranged between 58.10 mm to 73.90 mm with the mean diameter of 62.75 mm. The smallest fruit diameter was observed in 'Valencia Late India' (58.10 mm) followed by 'Sevelle Common' (58.20 mm) and 'Tamango' (59.10 mm). The biggest fruit diameter was observed in 'Washington Navel' (73.90 mm) followed by 'Succari' (70.20 mm).

Peel thickness

Fruit rind/peel thickness of the tested genotypes varied significantly and ranged between 3.03 mm to 4.85 mm with the mean thickness of 3.86 mm. The thinnest rind was found in 'Cara Cara' Navel (3.03 mm) followed by 'Washington Navel' (3.30 mm). The thickest fruit rind found in 'Succari' (4.85 mm) followed by 'Valencia Late France' (4.26 mm).

Number of seeds per fruit

The number of seeds per fruit differed highly significantly among tested genotypes and ranged from 0.27 to 16.90 with the mean value of 6.16. 'Pineapple' (16.90) and 'Succari' (16.90) had the highest number of seeds per fruit followed by 'Malta Blood Red' (15.90). In contrast, the number of seeds per fruit was found to be minimum with 'Cara Cara Navel' (0.27) followed by 'Washington Navel' (0.33) and 'Lane Late' (0.43).

Fruit number per tree

The average number of fruits per plant was significantly different and ranged from 38 to 240 with the mean fruit number of 125.90. 'Valencia Late' (240) recorded the highest number of fruits/plants followed by 'Pineapple' (206).

Genotypes like 'Leu Gim Gong' (38), and 'Navalencia' (58.30) were found to produce the lowest number of fruits per plant.

Fruit yield

The difference in total weight of fruit/hectare was highly significant among the tested genotypes and ranged betwee 5.40 to 40.90 mt ha^{-1} with a mean value of 19.23 mt ha^{-1}. 'Washington Navel' (40.90 mt ha^{-1}) gave the highest yield followed by 'Dhankuta Local' (32.20 mt ha^{-1}). 'Leu Gim Gong' (5.40 mt ha^{-1}) produced the least fruit yield per hectare followed by 'Valencia Late India' (7.28 mt ha^{-1}).

Table 6: Fruit characteristics of different sweet orange genotypes at NCRP, Paripatle, Dhankuta during 2080/81

Genotype	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Nos Seed $fruit^{-1}$	Nos fruits $tree^{-1}$	Yield (mt ha^{-1})
Valencia Late (India)	117.00	58.10	3.89	3.07	62.30	7.28
Sevelle Common	130.00	58.20	3.86	5.13	78.30	11.70
Navalencia	132.00	61.40	4.09	4.53	58.30	7.75
Malta Blood Red	135.00	63.60	3.68	15.90	161.00	23.20
Vanelle	127.00	59.70	3.87	10.80	133.00	18.80
Washington Navel	227.00	73.90	3.30	0.33	170.00	40.90
Hamlin	126.00	60.40	3.90	4.20	67.30	9.21
Delicious Seedless	131.00	61.70	4.25	3.20	149.00	22.20
Succari	152.00	70.20	4.85	16.90	81.30	12.80
Dhankuta Local	142.00	64.90	3.74	14.40	206.00	32.20
Leu Gim Gong	130.00	61.70	3.93	4.60	38.00	5.40
Cara Cara Navel	139.00	63.10	3.03	0.27	94.80	14.70
Lane Late	158.00	68.10	3.51	0.43	157.00	27.50
Pineapple	130.00	61.80	4.20	16.90	179.00	28.00
Valencia Late (France)	116.00	60.40	4.26	1.53	240.00	29.50
Salustiana	119.00	60.40	3.72	0.77	153.00	21.30
Tamango	127.00	59.10	3.57	1.83	110.00	14.60
Grand mean	137.40	62.75	3.86	6.16	125.90	19.23
LSD (P<0.05)	23.74	4.71	0.64	2.83	58.94	8.18
F-test	***	***	**	***	***	***
CV (%)	10.39	4.51	3.86	27.58	28.15	25.57

Physiochemical properties of different genotypes of sweet orange

Physicochemical properties of sweet orange like juice quantity, TSS, TA and DA meter reading and CCI were found significantly different at harvest among the genotypes (Table 7). DA meter is a device that measures the decline in chlorophyll content immediately below the skin during ripening. Likewise, CCI has been computed using an automatic computer vision system (spectrophotometer CM-700d). In the citrus industry CCI is used to determine the harvesting date or to decide if citrus fruits should undergo a degreening treatment. DA meter reading and CCI measurement are non-destructive method of citrus maturity/skin color measurement.

Juice content

Fruit juice content ranged from 34.70% to 48.10% with an average value of 41.24%. The highest juice percentage was recorded with genotype 'Leu Gim Gong' (48.10%) followed by 'Hamlin' (46.90%) and 'Valencia Late' (France) (45.10%). Lower fruit juice percentage was found in genotype 'Navalencia' (34.70%) followed by 'Cara Cara Navel' (35.40%) and 'Sevelle Common' (36.70%).

Titratable acidity

Among the tested genotypes the percentage of TA was found non-significantly different and ranged from 0.62% to 1.55% with an average TA of 1.04%. The TA% was highest in 'Valencia Late France' (1.55%) followed by 'Leu Gim Gong' (1.34%). 'Succari' (0.62%) recorded as the lowest TA followed by 'Cara cara Navel' (0.82%).

Total soluble solids

Among the tested genotypes the percentage of TSS varied from 10.60% to 11.90% with the mean value of 10.91%. TSS was found higher in 'Succari' (11.90%), followed by 'Valencia Late India' (11.30%) while the lowest TSS was observed in 'Sevelle Common' (10.60%) and 'Delicious Seedless' (10.60%).

DA (chlorophyll) reading

The decline in chlorophyll content of the fruit skin, measured on the tree by DA meter (Table 7), showed significantly different among the genotypes at harvest time. The value ranges from 0 to 0.27 with a mean of 0.08. Minimum of DA reading was recorded in 'Delicious Seedless' (0.00) and 'Tamango' (0.00), whereas the 'Navalencia' (0.27) followed by 'Valencia Late' (0.21) were recorded with maximum DA value among the genotypes.

Citrus color index (CCI)

The CCI value for tested mandarin genotypes were significantly different with each other. Higher the CCI value means no uniform orange color development. The CCI value of fruit ranged from 64.75 to 12.50 with a mean value of 9.15. Minimum CCI was recorded in 'Washington Navel' (4.75) followed by 'Valencia Late' (8.32) and maximum CCI was in 'Delicious Seedless' (12.50) followed by 'Cara cara Navel' (11.60)

Table 7: Physicochemical properties of different sweet orange genotypes at NCRP, Paripatle, Dhankuta in 2080/81

Genotype	Juice (%)	TSS (%)	TA (%)	DA value	CCI value
NCRP-13 (Valencia Late)	42.50	11.30	1.16	0.02	9.00
NCRP-14 (Sevelle Common)	36.30	10.60	1.06	0.19	6.64
NCRP-15 (Navalencia)	34.70	10.70	1.21	0.27	6.96
NCRP-16 (Malta Blood Red)	39.60	11.00	0.92	0.03	9.62
NCRP-19 (Vanelle)	37.60	10.60	0.91	0.01	9.16
NCRP-22 (Washington Navel)	42.90	10.80	1.02	0.17	4.75
NCRP-23 (Hamlin)	46.90	10.70	0.88	0.03	8.58
NCRP-27 (Delicious Seedless)	43.70	10.60	0.83	0.00	12.50
NCRP-31 (Succari)	36.00	11.90	0.62	0.19	9.86
NCRP-33 (Dhakuta Local)	41.10	11.00	1.13	0.02	10.50
NCRP-34 (Leu Gim Gong)	48.10	10.80	1.34	0.10	8.51
NCRP-83 (Cara Cara Navel)	35.40	10.70	0.82	0.01	11.60
NCRP-84 (Lane Late)	41.90	10.90	1.13	0.05	9.92
NCRP-85 (Pineapple)	43.70	11.20	0.88	0.01	10.90
NCRP-86 (Valencia Late)	45.10	10.90	1.55	0.21	8.32
NCRP-87 (Salustiana)	40.40	10.80	1.12	0.02	9.30
NCRP-96 (Tamango)	45.00	10.90	1.14	0.00	9.31
Grand mean	41.24	10.91	1.04	0.08	9.15
LSD (P<0.05)	5.53	0.39	0.11	0.18	1.51
F-test	***	***	***	*	***
CV (%)	8.07	2.14	6.19	139.17	9.93

3.1.3 Acid lime

Acid lime (*Citrus aurantifolia* Swingle) is an important fruit crop of commercial value, ranking third after mandarin and sweet orange in Nepal. Traditionally, acid lime cultivation was limited to range of 800-1400 masl in mid hill districts with production of small volume and confined to short time duration (September-November). Due to the changes in feeding habit and being more conscious about health benefits (Vitamin C) of acid lime consumption,

the demand of the fruit has increased dramatically. As the domestic production is far below to meet the demand, Nepal imports more than 90% of fresh lime fruit in the country every year. Moreover, the cultivation practice is attributed to marginal land with poor yielding varieties. Similarly, the potential of cultivating range could be much wider from 125 to 1400 masl in Nepal. After the release of two acid lime varieties viz. 'Sunkagati-1' and 'Sunkagati-2' for terai region in 2072 B.S., the cultivation area of acid lime has increased significantly. These two varieties are becoming popular among acid lime cultivating farmers in Terai region of Nepal. At the same time, 'Tehrathum Local' is famous for mid-hill region.

Table 8: Fruit characteristics and yield parameters of different acid lime genotypes at NCRP, Paripatle, Dhankuta in 2080/81

Genotype	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Seed per fruit	Nos fruit tree^{-1}	Yield (mt ha^{-1})
NCRP-47 (IAAS Acc# 01 (17))	32.50	37.50	2.10	6.40	118.00	4.12
NCRP-60 (Kaptangunj Golo)	51.90	41.30	2.96	6.30	94.50	4.79
NCRP-107 (Tehrathum Local)	31.10	37.60	1.50	6.10	224.00	7.91
NCRP-108 (Khursanibari Local)	29.70	35.80	1.63	6.10	139.00	4.08
NCRP-48 (IAAS Acc# 101 (2))	30.90	37.10	1.60	6.90	247.00	8.47
NCRP-49 (Sunkagati-2)	48.10	44.50	2.04	6.10	111.00	5.91
NCRP-50 (IAAS Acc# 71(5)	31.50	37.40	2.08	7.60	128.00	4.03
NCRP-51 (Sundarpur)	30.40	36.60	1.79	5.45	90.30	3.02
NCRP-52 (Belepur)	25.00	34.50	1.65	4.80	143.00	4.08
NCRP-53 (Panta-1)	85.60	53.50	2.72	4.40	86.00	7.41
NCRP-55 (Sunkagati-1)	33.40	38.40	1.92	5.80	108.00	4.38
NCRP-56 (Banarasi Kagati)	35.80	38.80	1.71	6.10	216.00	7.75
NCRP-59 (Kaptangunj Golo)	32.70	37.80	1.81	5.80	146.00	5.05
Grand mean	38.35	39.29	1.96	5.99	142.17	5.46
LSD (P<0.05)	16.95	4.46	0.63	2.9	129.51	4.87
F-test	***	***	**	NS	NS	NS
CV (%)	20.28	5.21	14.65	22.19	41.81	40.91

Fruit characteristics and yield of different genotypes of sweet oranges

Fruit characteristics and yield attributes like individual fruit weight, fruit diameter and peel thickness were statistically different whereas number of seeds/fruit, number of fruits/tree, and fruit yield/ hectare were not significantly different due to the effect of different genotypes of sweet orange (Table 8 & 9).

Individual fruit weight

The data in Table 8 shows that individual fruit weight was statistically different among the tested genotypes. Fruit weight varied from 25.00 g to 85.60 g with the mean value of 38.35 g. 'NCRP-53' (85.60 g) had the biggest individual fruit size followed by 'NCRP-60' (51.90 g). The smallest individual fruit sizes were recorded in 'NCRP-52' (25.00 g)) followed by 'NCRP-108' (29.70 g).

Fruit diameter

Individual fruit diameter was significantly different and ranged between 34.50 mm to 53.50 mm with the mean diameter of 39.29 mm. The smallest fruit diameter was observed in 'NCRP-52' (34.50 mm) followed by 'NCRP-108' (35.80 mm). The biggest fruit diameter was observed in 'NCRP-53' (53.50 mm) followed by 'NCRP-49' (44.50).

Fruit peel thickness

Fruit peel thickness differed highly significant among tested genotypes and ranged between 1.50 mm to 2.96 mm with the mean thickness of 1.96 mm. The thinnest peel was found in 'NCRP-107' (1.50 mm) followed by 'NCRP-48' (1.60 mm). The thickest peel was found in 'NCRP-60' (2.96 mm) followed by 'NCRP-53' (2.72 mm).

Number of seeds per fruit

The average number of seeds per fruit was not significantly different and ranged from 4.40 to 7.60 with the mean value of 5.99. 'NCRP-50' (7.60) had the highest number of seeds per fruit followed by 'NCRP-48' (6.90). In contrast, the number of seeds per fruit was found minimum with 'NCRP-53' (4.40) followed by 'NCRP-52' (4.80)

Fruit number per tree

Among the tested genotypes, the number of fruits per tree was found significantly different and ranged from 86 to 247 with the mean value of 142.17. 'NCRP-48' (247) recorded the highest number of fruits/tree followed by 'NCRP-107' (224) and 'NCRP-56' (216). Genotypes like 'NCRP-53' (86) and 'NCRP-51' (90) were found to produce lower number of fruits per tree.

Fruit yield

The fruit yield per hectare was significant among the tested genotypes and ranged between 3.02 mt ha^{-1} and 8.47 mt ha^{-1} with an average of 4.56 mt. 'NCRP-48' (8.47 mt ha^{-1}) gave the highest yield per hectare followed by 'NCRP-107' (7.91 mt ha^{-1}) and 'NCRP-56' (7.75 mt ha^{-1}). 'NCRP-51' (3.02 mt ha^{-1}) produced the

lowestt fruit yield followed by 'NCRP-50' (4.03 mt ha^{-1}), and 'NCRP-52' (4.08 mt ha^{-1}).

Table 9: Physicochemical properties of different acid lime genotypes at NCRP, Paripatle, Dhankuta during 2080/81

Genotype	Juice (%)	TSS (%)	TA (%)	DA value	CCI value
NCRP-47 (IAAS Acc# 01 (17))	42.00	8.03	7.10	0.68	0.81
NCRP-60 (Kaptangunj Lamo)	29.90	9.35	5.88	0.79	0.74
NCRP-107 (Tehrathum Local)	49.60	7.63	6.68	0.84	0.39
NCRP-108 (Khursanibari Local)	40.60	8.75	7.53	0.94	0.72
NCRP-48 (IAAS Acc# 101 (2)	45.90	8.44	7.97	1.02	0.46
NCRP-49 (Sunkagati-2)	39.70	6.95	7.54	1.08	1.72
NCRP-50 (IAAS Acc# 71(5))	39.20	7.99	7.28	1.12	1.13
NCRP-51 (Sundarpur)	50.80	7.92	7.10	0.94	0.82
NCRP-52 (Belepur)	48.90	8.44	7.12	0.84	0.87
NCRP-53 (Panta-1)	34.20	9.00	5.75	0.38	1.00
NCRP-55 (Sunkagati-1)	36.80	6.25	6.32	1.03	0.24
NCRP-56 (Banarasi Kagati)	42.00	8.13	6.50	0.92	0.96
NCRP-59 (Kaptangunj Golo)	51.20	7.42	6.59	0.81	0.74
Grand mean	42.36	8.02	6.87	0.88	0.82
LSD (P<0.05)	12.36	1.41	1.16	0.41	0.64
F-test	*	*	*	NS	NS
CV (%)	13.39	8.04	7.75	21.36	35.81

Juice content

The juice percentage was found varying from 29.90% to 51.20% with the mean value of 42.36%. The highest percentage of juice was found in 'NCRP-59' (51.20%) followed by 'NCRP-51' (50.80%). The lowest juice percentage was found in 'NCRP-60' (29.90%) followed by 'NCRP-53' (34.20%).

Titratable acidity

Among the tested genotypes, the percentage of TA ranged from 5.75% to 7.97% with mean value of 6.87%. The TA percentage was the highest in 'NCRP-48' (7.97%) followed by 'NCRP-49' (7.54) and 'NCRP-108' (7.53%). 'NCRP-53' (5.75%) recorded as the lowest TA percent followed by 'NCRP-60' (5.88%), and 'NCRP-55' (6.32%).

Total soluble solids

Among the tested genotypes the percentage of TSS varied from 6.25% to 9.35% with an average of 8.02%. TSS% was found highest in 'NCRP-60' (9.35%) followed by 'NCRP-53' (9.00%) and 'NCRP-108' (8.75%). Lower TSS % values were observed in 'NCRP-55' (6.25%) and 'NCRP-59' (6.95%).

DA (chlorophyll) reading

The decline in chlorophyll content of the fruit skin, measured on the trees by DA meter, was not significantly different among the genotypes at harvest time. The value ranged from 0.38 to 1.12 with a mean value of 0.88. Minimum of DA reading was recorded in 'NCRP-53' (0.38) followed by 'NCRP-47' (0.68), whereas the 'NCRP-50' (1.12) followed by 'NCRP-49' (1.08) were recorded as the maximum DA value among the genotypes.

Citrus color index (CCI)

The CCI value was not significantly different amonge the tested genotypes. The value ranged from 0.24 to 1.72. with an average of 0.82. The maximum CCI value was recorded in 'NCRP-49' (1.72) followed by 'NCRP-50' (1.13), whereas the lowest CCI was recorded in 'NCRP-55' (0.24) followed by 'NCRP-107' (0.39)

3.1.4 Grapefruit and tangelo

There are four accessions of grapefruit and three accessions of tangelo and one accessions of tangor under bearing stage and are presented in Table 10 and 11, respectively.

Table 10: Fruit physical and yield attributing parameters of grapefruit, tangor and tangelo genotypes at NCRP, Paripatle, Dhankuta during 2080/81

Genotypes	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Peel weight (g)	Nos fruits tree^{-1}	Yield (mt ha^{-1})
Henderson (Grapefruit)	181.63	80.04	4.84	4.13	119.33	23.39
Star Ruby (Grapefruit)	181.34	76.88	6.71	4.80	31.00	5.86
Pink Ruby (Grapefruit)	194.68	79.73	7.68	3.70	73.00	15.59
Shamber (Grapefruit)	204.57	81.62	7.49	6.00	101.00	21.36
Minneola (Tangelo)	116.26	60.09	3.23	10.80	52.5	6.33
Orlando (Tangelo)	94.20	59.97	3.23	10.20	71.5	6.58
Seminole (Tangelo)	156.78	67.33	3.76	9.80	38.00	6.33
Minneola (Tangor)	118.83	61.92	2.49	12.00	50.00	6.50

Table 11: Physicochemical properties of grapefruit, tangor, and tangelo genotypes at NCRP, Paripatle, Dhankuta during 2080/81

Variety	TSS (%)	TA (%)	DA value	CCI value	Nos fruit tree^{-1}
Henderson (Grapefruit)	9.03	2.73	0.12	3.94	119.33
Star Ruby (Grapefruit)	10.06	2.54	0.03	2.98	31.00
Pink Ruby (Grapefruit)	8.74	2.53	0.05	4.31	73.00
Shamber (Grapefruit)	8.83	2.62	0.00	2.27	101.00
Minneola (Tangelo)	11.13	1.48	0.04	15.45	52.5
Orlando (Tangelo)	10.06	1.17	0.00	11.73	71.5
Seminole (Tangelo)	10.68	1.39	0.014	12.18	38.00
Minneola (Tangor)	10.66	1.73	0.05	8.97	50.00

3.2 Disease management research

3.2.1 Effect of different chemical pesticides on citrus canker management of acid lime

Citrus fruits cultivated all over the world in tropical and sub-tropical regions having suitable soil and climatic conditions. Mid hills of Nepal ranging from 800 to 1,400 masl altitude all across the country are considered favorable for all types of citrus fruits cultivation. However, pumelo, acid lime and lemon can be cultivated successfully in up-land condition of terai, inner-terai, foothills and river basin areas of Nepal. Citrus crops cover about 30% of the total area under fruit cultivation. Citrus crop are potential exportable commodities particularly to India and Bangladesh. Districts with more than 1,000 ha area under cultivation are Taplejung, Tehrathum, Dhankuta, Ramechhap, Sindhulli, Kavrepalanchowk, Lamjhung, Syangja, Salyan and Dailekh. However, there are some biotic factors hindering the production of citrus and canker is one of them.

Citrus canker is the common disease of citrus that is caused by the bacteria *Xanthomonas campestris* pv. *citri.* Citrus canker is generally seen in acid lime during the rainy season. However, it is also found to infest mandarin. At the beginning of infestation, small brown spots are seen, and these spots develop to become lesions of 4-5 mm diameter. Leaves and fruit start to fall off the plant and twigs start to die from the top in heavy infestation. In addition, the lesion on fruit deteriorates the fruit appearance thus decreasing the market value of fruit. Therefore, various antibiotics available in the market were tested for their efficacy against citrus canker of acid lime.

Methodology

The effectiveness of six antibiotics for controlling citrus canker was studied in acid lime 'Sunkagati-2' at an orchard of NCRP in 2024. The trial was set-up in randomized complete block design (RCBD) with three replications. The plots were sprayed with antibiotics four times at fifteen days' interval during April 28 and June 30. One twig from each direction was tagged for observation per tree. The total number of leaves and total number of leaves infested with cnaker were couted on tagged twigs. Disease severity and mean effectiveness were calculated. The treatments were:

T1: Streptomycin Sulphate 9% + Tetracycline Hydrochloride 1% WP @ 0.2 g l^{-1}

T2: Validamycin A 10% SL @ 1.5 ml l^{-1}

T3: Kasugamycin 3% SL @ 2 ml l^{-1}

T4: 1 % Bordeaux mixture (1 lit water: 10 gm lime: 10 gm copper sulphate)

T5: Copper oxychloride 50% WP @ 2 g l^{-1}

T6: Zinkicide @ 3.51ml l^{-1} (200 ppm)

T7: Control (Water)

Disease severity (DS) and mean effectiness was calculated using the following formula:

$$\text{Disease severity (\%)} = \frac{\text{Number of canker infested leaves}}{\text{Total number of leaves}} \times 100$$

Mean effectivesness = Disease severity at the first observation – disease severity at the final observation

Results

Disease severity decreased at final observation for every treatment except for control. The highest decrease in disease severity was observed in plants sprayed with Bordeaux mixture followed by copper oxychloride and streptomycin sulphate + tetracycline hydrochloride. During the first observation (before spray), disease severity was 24.39% while it was 16.65% after fourth subsequent spray of Bordeaux mixture. Similarly, disease severity decreased from 21.36% to 13.77% for the plant sprayed with copper oxychloride. Meanwhile, unlike other treatment disease severity increased from 19.49% to 22.15% for the plants sprayed with only water (control) at final observation. Further, plant sprayed with zinkicide has shown a slight decrease in canker severity after 4th spray relative to first observation i.e. 19.14% to 18.18% (Table 12).

All the treatments used in the trial was seen effective for the management of citrus canker in acid lime except control (water spray). The highest mean effectiveness was recorded in the plants sprayed with 1% Bordeaux mixture (7.74 %) followed by zinkicide (7.58%), streptomycin sulphate + tetracycline hydrochloride (6.27 %) and and Kasugamycin (5.89 %). On the other hand, the mean effectiveness was seen negative in plants sprayed with water (-2.65 %). The plants sprayed with zinkicide had mean effective of 0.96% and Validamycin was 3.52% (Table 12).

Table 12: Disease severity (%) for each observation and mean effectiveness of different chemicals against citrus canker in acid lime at NCRP, Paripatle, Dhankuta during 2080/81

Treatment	Disease severity (%)					Mean effectiveness of each treatment (%)
	1st observation	2nd observation	3rd observation	4th observation	5th observation	
T1	21.50	21.30	20.69	18.41	15.23	6.27
T2	26.58	26.56	28.33	27.87	23.06	3.52
T3	22.16	15.93	17.46	20.81	16.27	5.89
T4	24.39	21.74	23.89	19.50	16.65	7.74
T5	21.36	18.78	17.91	13.29	13.77	7.58
T6	19.14	13.98	20.92	21.40	18.18	0.96
T7	19.49	22.75	21.40	24.53	22.15	-2.65

3.3 Crop husbandry

3.3.1 High density planting trial of mandarin orange

Methodology

Mandarin cv. Khoku local saplings (grafted onto trifoliate) at the age of two years were transplanted at NCRP, Paripatle orchard at 1300 m altitude. The saplings were planted at nine different spacing as shown in Table 14. The plants were replicated three times in terraced land. The data were recorded on various fruit Physicochemical parameters and yield parameters as shown in table below.

Fruit physical and yield attributing characteristics of mandarin orange

The result, except yield, showed that the individual fruit weight, fruit peel thickness, number of segments per fruit, number of seeds per fruit and number of fruit/tree were non-significant for different planting spacing (Table 13).

Fruit weight

Fruit weight was found varying from 76.50 g to 82.50 g with mean value of 79.05 g. The highest fruit weight was found in 1.5 × 3 m spacing (82.50 g) followed by 1.75 × 3 (80.40 g). The lowest fruit weight was found in 1.15 × 3 (76.50 g) followed by 2.5 × 3 (77.40 g) spacing.

Fruit diameter

Fruit diameter among the tested genotypes of mandarin varied non-significantly and ranged from 52.10 mm to 54.50 mm with the mean value of 53.54 mm. The highest fruit diameter was found in 2.25 × 3 m spacing (54.50 mm) followed by 1.75 × 3 m spacing (54.40 mm). The lowest fruit diameter was found in 1.15 × 3 m spacing (52.40 mm) followed by 3.5 × 3 m spacing (52.80 mm).

Peel thickness

Fruit rind thickness ranged from 1.81 mm to 2.30 mm with the mean value of 1.95 mm. The highest fruit peel thickness was found in 1.15 × 3 m spacing (2.30 mm) followed by 3.5 × 3 m spacing (2.02 mm). The lowest fruit rind thickness was found in 1.8 × 3 m spacing (1.81 mm) followed by 1.75 × 3 m spacing (1.84 mm).

Number of segments per fruit

The average number of segments per fruit was found non-significantly different ranging from 9.53 to 9.84 with the mean value of 9.71. The maximum number of segments per fruit was found in 3.5 × 3 m spacing (9.84) followed by 2.25 × 3 m spacing (9.82). The minimum number of segments per fruit was found in 1.15 × 3 m spacing (9.53) followed by 1.5 × 3 m spacing (9.62).

Number of seeds per fruit

The average number of seeds per fruit was found varying from 9.53 to 10.30 with an average of 9.81. The highest number of seeds was found in 1.5 × 3 m spacing (10.30) followed by 1.15 × 3 m spacing (10.10). The lowest number of seeds was found in 3 × 3 m spacing (9.53) followed by 1.8 × 3 m spacing (9.60).

Total number of fruits per tree

The total number of fruits per tree ranged from 87.70 to 245 with the mean value of 152.39. The highest number of fruits was found in 1.8 × 3 m spacing (245.00) followed by 1.75 × 3 m spacing (175). The lowest number of fruits was found in 3 × 3 m spacing (87.70) followed by 2.5 × 3 m spacing (119.00)

Fruit yield

The fruit yield per hectare ranged from 8.04 mt ha^{-1} to 36.10 mt ha^{-1} with the mean value of 21.70 mt ha^{-1}. The highest fruit yield was found in 1.8 × 3 m spacing (36.10 mt ha^{-1}) followed by 1.15 × 3 m spacing (32.70 mt ha^{-1}). The lowest yield was found in 3 × 3 m spacing (8.04 mt ha^{-1}) followed by 3.5 × 3 m spacing (11.70 mt ha^{-1}).

Table 13: Yield and fruit quality parameters of 'Khoku Local' mandarin under various planting densities at NCRP, Paripatle, Dhankuta during 2080/81

Spacing	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Nos of segments	Nos seeds per fruit	Nos fruits per tree	Yield (mt ha^{-1})
1.15×3.00	76.50	52.40	2.30	9.53	10.10	144.00	32.70
1.50×3.00	82.50	54.30	1.91	9.62	10.30	138.00	24.60
1.75×3.00	80.40	54.40	1.84	9.68	9.89	175.00	27.80
1.80×3.00	77.60	52.10	1.81	9.70	9.60	245.00	36.10
2.25×3.00	80.20	54.50	1.88	9.82	9.66	164.00	19.90
2.50×3.00	77.40	54.00	1.93	9.68	9.80	119.00	12.80
3.00×3.00	78.90	53.00	1.89	9.80	9.53	87.70	8.04
3.50×3.00	78.90	52.80	2.02	9.84	9.67	147.00	11.70
Grand mean	79.05	53.44	1.95	9.71	9.81	152.39	21.70
LSD (P<0.05)	8.50	3.92	0.40	0.53	1.27	92.34	15.56
F-test	NS	NS	NS	NS	NS	NS	*
CV (%)	6.14	4.19	11.7	3.15	7.37	34.60	40.96

Physicochemical properties of mandarin orange

The difference in physiological properties viz. Juice content, TA, DA reading, and CCI were non-significant among the treatments. However, TSS% was found significantly different among the treatments (Table 14).

Juice content

The juice content differed significantly among various spacing. The juice percentage ranged from 41.20 % to 47.80 % with an average of 44.84 %. The highest juice percentage was found in 1.5 × 3 m spacing (47.80 %) followed by 1.75 × 3 m spacing (46.60 %). The lowest juice volume was found in 1.15 × 3 m spacing (41.20 %) followed by 2.5 × 3 (43.40 %).

Total soluble solids

TSS was found varying from 10.90 % to 11.70 % with the mean value of 11.22%. The highest TSS % was found in 1.15 × 3 m spacing (11.70 %) followed by 3 × 3 m spacing (11.50 %). The lowest TSS was found in 3.5 × 3 m spacing (10.90 %) followed by 1.8 × 3 m spacing (11.00 %).

Titratable acidity

Among the tested spacing of same genotype, TA was found ranging from 0.69 % to 0.93 % with the mean value of 0.85 %. The TA was highest in 3.5 × 3 m spacing (0.93 %) and 2.5 × 3 m spacing (0.86 %), whereas it was lowest in 1.15 × 3 m spacing (0.69 %).

DA (chlorophyll) reading

The DA reading value varied from 0.23 to 0.31 with the mean value of 0.27. The highest DA reading was found in 1.8 × 3 m spacing (0.31) followed by 2.5 × 3 m spacing (0.29). The lowest DA reading was found in 3.5 × 3 m spacing (0.23) followed by 3 × 3 m spacing (0.24).

Citrus color index (CCI)

The CCI value ranged from 9.76 to 10.90 with an average of 10.17. The highest CCI was recorded in 3 × 3 m spacing (10.90) followed by 2.5 × 3 m spacing (10.60). The lowest CCI was recorded in 1.8 × 3 m spacing (9.76), followed by 3.5 × 3 m spacing (9.85).

Table 14: Physicochemical properties of 'Khoku Local' mandarin under various planting densities at NCRP, Paripatle, Dhankuta during 2080/81

Spacing (m)	Juice (%)	TSS (%)	TA (%)	DA Meter	CCI
1.15×3.00	41.20	11.70	0.69	0.28	10.10
1.50×3.00	47.80	11.30	0.85	0.28	9.86
1.75×3.00	46.60	11.10	0.85	0.25	10.00
1.80×3.00	46.20	11.00	0.88	0.31	9.76
2.25×3.00	45.30	11.10	0.85	0.26	10.20
2.50×3.00	43.40	11.20	0.86	0.29	10.60
3.00×3.00	44.50	11.50	0.85	0.24	10.90
3.50×3.00	43.80	10.90	0.93	0.23	9.85
Grand mean	44.84	11.22	0.85	0.27	10.17
LSD (P<0.05)	4.36	0.40	0.24	0.15	1.23
F-test	NS	*	NS	NS	NS
CV (%)	5.55	2.01	16.30	32.96	6.92

3.3.2 Alternate bearing management study in mandarin orange

Mandarin (*Citrus reticulata* Blanco) shows bieniality in its production. To overcome this behaviour, various treatments were applied to 8 years old trifoliate orange grafted saplings in the month of March 2024. There are ten treatments (Table 15) replicated three times. Single tree is taken as replicatin. This is the second year of the experiment and there was non-significant effect of all the treatment on fruit and yield attributing parameters.

Table 15: Yield and fruit quality pameters of 'Khoku Local' mandarin under various biennial bearing management treatment at NCRP, Paripatle, Dhankuta during 2080/81

Treatment	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Nos fruit tree^{-1}	Yield (kg tree^{-1})	Yield (mt ha^{-1})
Thiourea-1.5g l^{-1} (Foliar)	80.20	54.30	1.93	49.00	3.67	4.08
Thiourea-2.5 g l^{-1} (Foliar)	87.50	56.60	2.11	31.30	2.68	2.98
KNO_3-1.5 g l^{-1} (Foliar)	73.90	54.50	2.11	63.00	6.38	7.10
KNO_3-2.5 g l^{-1} (Foliar)	80.00	52.80	1.91	15.00	0.93	1.03
Niraculan-0.5 ml l^{-1} (Foliar)	70.70	53.70	1.93	32.00	2.46	2.73
Niraculan-1 ml l^{-1} (Foliar)	70.70	53.10	2.20	141.00	9.26	10.30
Paclobutrazol-10 ml tree^{-1} (Foliar)	85.60	60.60	2.13	12.00	1.10	1.22
Paclobutrazol-10 ml tree^{-1} (Drenching)	78.70	56.50	2.26	58.00	4.72	5.25
Combo trt*	80.00	54.70	1.91	52.30	3.84	4.27
Control (Water spray)	72.60	53.70	2.20	29.00	2.16	2.80
Grand mean	78.6	55.04	2.07	62	4.81	5.35
LSD (P<0.05)						
F-test	NS	NS	NS	NS	NS	NS
CV (%)	12.89	5.69	12.33	75.43	81.08	81.07

* Thiourea (1.5 g l^{-1}) + KNO3 (1.5 g l^{-1}) + Niraculan (0.5 ml l^{-1}) + Paclobutrazol (10 ml tree^{-1}) (Foliar)

Table 16: Fruit quality parameters of 'Khoku Local' mandarin under various biennial bearing management treatment at NCRP, Paripatle, Dhankuta during 2080/81

Treatment	Juice (%)	TSS (%)	TA (%)	DA value	CCI value
Thiourea-1.5 g l^{-1} (Foliar)	49.00	11.00	0.84	0.08	10.70
Thiourea-2.5 g l^{-1} (Foliar)	53.10	10.40	0.90	0.09	10.30
KNO_3-1.5 g l^{-1} (Foliar)	48.00	10.50	0.82	0.23	9.37
KNO_3-2.5 g l^{-1} (Foliar)	49.80	10.70	0.78	0.18	10.20
Niraculan-0.5 ml l^{-1} (Foliar)	43.30	10.50	0.90	0.12	13.00
Niraculan-1 ml l^{-1} (Foliar)	48.00	10.50	0.91	0.16	14.20
Paclobutrazol-10 ml tree^{-1} (Foliar)	39.80	11.30	0.88	0.02	9.29
Paclobutrazol-10 ml tree^{-1} (Drenching)	46.40	10.50	0.88	0.02	9.71
Combo tmt*	44.70	11.20	0.87	0.10	10.50
Control (Water spray)	47.90	10.80	0.92	0.09	11.40
Grand mean	47.6	10.75	0.87	0.1	10.66
LSD (P<0.05)					
F-test	NS	NS	NS	NS	NS
CV (%)	8.55	3.65	4.11	109.48	10.9

* Thiourea (1.5 g l^{-1}) + KNO3 (1.5 g l^{-1}) + Niraculan (0.5 ml l^{-1}) + Paclobutrazol (10 ml tree^{-1}) (Foliar)

Results

The fruit parameters were found non-significantly different due to application of various treatments as shown on Table 16. The highest yield (10.30 mt ha^{-1}) was obtained with foliar spray of Niraculan (1 ml l^{-1}) while the lowest (1.03 mt ha^{-1}) was from the foliar spray of KNO_3 (2.5 g l^{-1}). The fruit Physicochemical paramegters were also found non-significantly different due to treatment.

3.3.3 Effect of different rootstocks on growth and yield components in mandarin (Khoku Local), sweet orange (Valencia Late) and acid lime (Tehrathum Local)

Rootstocks and scions are the foundations of many tree fruit industries of the world. Together, those components establish profitability, but it can be argued that the rootstock is the critical component; otherwise, scions would be grown on their own roots everywhere. There is no precedent for the failure of the citrus industry because of an inadequate scion variety, but serious problems have occurred because of a less than satisfactory rootstock. A rootstock primarily provides a reduction in juvenility (time to bearing) and tree vigor when compared with seedling trees; thus, citrus trees propagated with a rootstock combined with a pathogen-free scion bring a much-improved degree of uniformity and consistency to an orchard. They influence various horticultural traits and provide tolerance to pests and diseases and certain soil and site conditions that contribute significantly to orchard profitability. Also important are rootstock nursery traits such as the degree of nucellar embryony that is related to the ease, expense, and consistency of propagation.

3.3.3.1 Effect of different rootstocks on 'Khoku Local' mandarin

Methodology

The trial was established with planting two years old sapling of Mandarin cv. Khoku local grafted saplings in FY 2063/64 in NCRP orchard at an altitude of 1,250 masl. Eight species of rootstocks were used while preparing saplings as shown below. The saplings were planted at the spacing of 3m × 3 m with six replications.

Table 17: Treatment details of the trial effect of different rootstocks on 'Khoku Local' mandarin conducted at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Scion
Carrizo Citrange	Mandarin cv Khoku local
Citrange C-35	Mandarin cv Khoku local
Citrumelo 4475	Mandarin cv Khoku local
Flying Dragon	Mandarin cv Khoku local

Rootstock	Scion
Poncirus Pomeroy	Mandarin cv Khoku local
Trifoliate	Mandarin cv Khoku local
Volkameriana	Mandarin cv Khoku local
Rangapur lime	Mandarin cv Khoku local

Results and discussion

Fruit physical parameters

Fruit physical parameters like individual fruit diameter, fruit rind thickness and number of seeds per fruit were found varying significantly. The heaviest fruit (142 g) and the widest fruit (62.6 mm) were produced from plants grafted on 'Flying Dragon' and 'Poncirus Pomeroy' respectively, while the lightest (97 g) and narrowest fruit (57.9 mm) was from the 'Citrange Carrizo'. The thickest fruit skin (3.02 mm) was from plants grafted onto 'Citrange-carrizo', while the thinnest (1.72 mm) was from 'Trifoliate'. 'Khoku Local' grafted on Trifoliate had the highest number of seeds per fruit (11.80), while 'Volkameriana' (9.40) and 'Citrange-carrizo' (9.44) had the lowest number of seeds per fruit (13) (Table 18).

Table 18: Fruit quality parameters of mandarin 'Khoku Local' grafted onto different rootstocks at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Nos of segments	Nos of seeds fruit^{-1}	Juice (%)
Poncirus Pomeroy (NCRP 67)	106	62.6	1.91	10.3	11.2	46.9
Flying Dragon (NCRP 68)	142	59.8	2.04	10.4	9.88	40.6
Volkameriana (NCRP 70)	107	59.1	2.25	10.2	9.4	45.4
Trifoliate (NCRP 36)	103	59.9	1.72	10.2	11.8	48.2
Citrange C-35 (NCRP 65)	106	59.3	2.01	10.4	11.2	47.1
Citrange Carrizo (NCRP 66)	97	57.9	2	10.1	9.44	48
Citrumelo 4475 (NCRP 69)	102	60	2.28	10.3	11.3	45
Rangapur Lime (NCRP 71)	102	60.2	1.99	10.3	11.6	47.6
Grand mean	108.2	59.83	2.03	10.29	10.74	46.1
LSD (P<0.05)	43.99	2.45	0.18	0.62	1.09	7.11
F-test	NS	*	***	NS	***	NS
CV (%)	30.32	3.06	6.8	4.52	7.59	11.5

Physicochemical parameters

Among the fruit Physicochemical parameters TSS was found significantly different due to rootstock effect, while Juice %, TA %, DA meter reading, and CCI were found non-significant. The highest juice percent (48.2 %) was found on the plant grafted on 'Trifoliate', while the lowest juice % (40.6 %) was from

'Volkameriana'. The lowest TA % (0.87%) was form 'Citrange C-35', while the highest (1.47%) from the 'Flying Dragon'. The sweetest fruit was from Trifoliate (11.10 % TSS), while the least sweet fruit was from 'Volkameriana' (9.47 % TSS). The highest DA value (0.21) was from the plant grafted on 'Volkameriana' and the lowest DA value (0.10.08) was from 'Flying Dragon' (Table 19).

Yield attributing parameters

All the yield related parameters like number of fruits per tree and total fruit yield per hectare was found significantly different due to the effect of different rootstocks. The highest number of fruits per tree (585) was obtained from 'Citrumelo-4475' followed by 'Poncirus Pomeroy' (423). Further, the highest yield per hectare (63.60 kg tons) was seen in the plants grafted on 'Citrumelo-4475' and lowest yield (7.75 mt) on plants grafted on 'Volkameriana'.

Table 19: Fruit physicochemical properties and yield characteristics of mandarin 'Khoku Local' grafted onto different rootstocks at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	TSS (%)	TA (%)	DA value	CCI value	Nos Fruit tree^{-1}	Yield (mt ha^{-1})
Poncirus Pomeroy (NCRP-67)	10.10	1.01	0.20	7.28	423.00	47.4
Flying Dragon (NCRP-68)	11.10	1.47	0.08	7.27	348.00	38.00
Volkameriana (NCRP-70)	9.47	0.97	0.21	7.58	67.40	7.75
Trifoliate (NCRP-36)	9.94	0.97	0.13	8.42	215.00	23.5
Citrange C-35 (NCRP-65)	9.86	0.87	0.13	8.53	263.00	30.00
Citrange Carrizo (NCRP 66)	9.94	1.02	0.11	7.58	376.00	39.00
Citrumelo 4475 (NCRP-69)	10.20	1.04	0.17	7.95	585.00	63.60
Rangapur Lime (NCRP-71)	10.30	0.96	0.18	8.13	109.00	12.10
Grand mean	10.13	1.04	0.15	7.84	298.18	32.66
LSD (P<0.05)	0.64	0.36	0.17	1.03	150.53	17.1
F-test	***	NS	NS	NS	***	***
CV (%)	4.69	25.7	81.28	9.84	37.65	39.04

3.3.3.2 Effect of different rootstocks on 'Tehrathum Local' acid lime

Methodology

The trial was established with planting two years old acid lime 'Tehrathum Local' grafted saplings in FY 2063/64 in NCRP orchard at an altitude of 1250 masl. Eight species of rootstocks were used while preparing saplings as shown below. The saplings were planted at the spacing of 3m × 3 m with six replications.

Table 20: Treatment details of the trial effect of different rootstocks on 'Tehrathum Local' acid lime conducted at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Scion
Citrange-C 35	Tehrathum Local
Citrange-Carizzo	Tehrathum Local
Citron	Tehrathum Local
Citrumelo 4475	Tehrathum Local
Flying Dragon	Tehrathum Local
Poncirus Pomeroy	Tehrathum Local
Rangapur lime	Tehrathum Local
Volkamerina	Tehrathum Local

Results and discussion

Fruit quality and physical parameters

The fruit weight, fruit diameter, number of seeds per fruit and number of fruits per tree were found non-significantly different due to rootstocks, while rind thickness and yield varied highly significantly (Table 21). The highest fruit weight (46.00 g) was found in acid lime grafted with 'Trifoliate'. Similarly, the highest fruit diameter (44.60 mm) and the thickest rind (2.04 mm) was found in acid lime grafted with 'Citrange carrizo'. Acid lime grafted with 'Poncirus Pomeroy' had the highest juice percentage (51.2%), whereas 'Citrange-Carrizo' had the lowest juice percentage (35.6%). The highest number of seeds per fruit (8.57) was obtained from fruits of 'Rangapur Lime' grafted plants, while the least was obtained from 'Rough Lemon' (6.47) plants.

Table 21: Fruit quality and yield parameter of acid lime 'Tehrathum Local' grafted onto different rootstocks at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Seed no. per fruit	Fruit no. per tree	Yield (mt ha^{-1})
NCRP-116 (Rough lemon)	38.90	40.60	1.68	6.47	70.70	2.70
NCRP-36 (Trifoliate)	46.00	41.60	2.03	7.60	107.00	4.60
NCRP-65 (Citrange C 35)	42.70	41.10	1.59	7.53	87.00	3.73
NCRP-66 (Citrange carrizo)	42.24	44.60	2.04	8.50	69.20	3.02
NCRP-67 (Poncirus pomeroy)	37.70	40.10	1.62	6.90	93.00	3.64
NCRP-68 (Flying dragon)	43.30	42.00	1.92	8.07	75.00	3.03
NCRP-69 (Citrumelo 4475)	43.70	42.60	2.01	7.93	76.00	3.08
NCRP-70 (Volkameriana)	41.10	42.90	1.23	7.20	92.00	3.95
NCRP-71 (Rangapur lime red)	41.30	41.20	1.59	8.57	62.70	2.54
Grand mean	45.08	41.86	1.75	7.64	81.40	3.37
LSD (P<0.05)	31.98	4.48	0.37	2.64	30.00	1.10
F-test	NS	NS	**	NS	NS	*
CV (%)	41.00	6.18	12.27	19.90	21.30	18.99

Physicochemical parameters

Physicochemical parameters like titratable acidity (TA%), Total soluble solid (TSS%), and CCI value was not found significantly different, while DA meter reading was found differing non-significantly due to rootstock effect (Table 22). The highest DA reading value (0.94) was found in plants gragted onto 'Trifoliate orange' rootstocks. Further, the highest TSS (7.96%) and TA (7.31%) was found in plants grafted with 'Citrumelo 4475' and 'Rough lemon' respectively. The lowest DA reading value (0.66), TSS (7.00%), TA (6.31%) was found in acid lime grafted with 'Flying Dragon', 'Citrange Carrizo' and 'Citrange Carrizo' respectively.

Table 22: Fruit physicochemical and yield parameter of acid lime 'Tehrathum Local' grafted onto different rootstocks at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Juice (%)	TSS (%)	TA (%)	DA value	CCI value
NCRP-116 (Rough lemon)	40.60	7.70	7.31	0.67	0.82
NCRP-36 (Trifoliate)	45.90	7.67	6.84	0.94	0.77
NCRP-65 (Citrange C35)	45.30	7.57	6.76	0.93	0.53
NCRP-66 (Citrange Carrizo)	35.60	7.00	6.31	0.76	0.70
NCRP-67 (Poncirus Pomeroy)	51.20	7.76	6.77	0.71	0.76
NCRP-68 (Flying Dragon)	47.30	7.59	6.97	0.66	0.57
NCRP-69 (Citrumelo 4475)	44.40	7.96	6.58	0.81	0.63
NCRP-70 (Volkameriana)	38.80	7.89	6.63	0.90	1.06
NCRP-71 (Rangapur lime red)	38.60	7.43	6.61	0.88	1.19
Grand mean	43.09	7.62	6.76	0.81	0.78
LSD (P<0.05)	14.31	0.56	0.71	0.18	0.52
F-test	NS	NS	NS	*	NS
CV (%)	19.18	4.27	6.08	12.68	38.91

Yield attributing parameters

The fruit yield was found significantly affected by the rootstocks (Table 21). The highest number of fruit per tree (107) and highest yield (4.60 mt ha^{-1}) was observed in acid lime grafted with Trifoliate while the lowest number of fruit pee tree (62.70) and lowest yield (2.54 mt ha^{-1}) was observed in 'Rangapur Lime' grafted acid lime.

3.3.3.3 Effect of different rootstocks on 'Washington Navel' sweet orange

Methodology

The trial was established with planting 'Washington Navel' sweet orange grafted saplings in FY 2063/64 in NCRP orchard at an altitude of 1250 masl. Eight species of rootstocks were used while preparing 2-years old saplings as shown below. Statistical analysis of seven treatments were only possible due to lack of fruiting on three rootstock varieties though there were six replications.

Table 23: Treatment details of the trial effect of different rootstocks on 'Washington Navel' sweet orange conducted at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Scion
Citrumelo 4475	Washington Navel
Rangpur lime	Washington Navel
Trifoliate orange	Washington Navel
Poncirus Pomeroy	Washington Navel
Volkamerina	Washington Navel
Carizo Citrange	Washington Navel
Citrange C-35	Washington Navel
Flying Dragon	Washington Navel

Results and discussion

All the fruit physical parameters were statistically non-significant. However, the number of seeds per fruit was found significantly different among tested rootstocks (Table 24). It was found that the rootstock Trifoliate performed well in terms of fruit weight (178 g) and fruit diameter (>70.30 mm). Further, Juice % was highest in Flying daragon grafted sweet orange i.e. 37.10 % followed by 'Poncirus Pomeroy' grafted sweet orange i.e. 34.80 %. All the rootstocks have produced less acidic fruit (<1%) except 'Rangapur Lime' (1.08%). The difference in fruit yield per tree and yield per hectare was found to be statistically non-significant. The 'Flying Dragon' rootstock produced the highest yield per tree (9.71 kg) and yield (10.80 mt ha^{-1}) as compared to the other rootstocks.

Table 24: Fruit quality and yield parameters of sweet orange 'Washington Navel' grafted onto different rootstocks grown at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Seed no $fruit^{-1}$	Yield $tree^{-1}$ (kg)	Yield (mt ha^{-1})
Trifoliate (NCRP-36)	178.00	70.30	3.97	0.10	8.05	8.94
Citrange C-35 (NCRP- 65)	169.00	69.40	3.36	0.07	5.86	6.51

Rootstock	Fruit weight (g)	Fruit diameter (mm)	Peel thickness (mm)	Seed no fruit^{-1}	Yield tree^{-1} (kg)	Yield (mt ha^{-1})
Poncirus Pomeroy (NCRP-67	165.00	67.60	4.47	1.63	9.03	10.00
Flying Dragon (NCRP-68)	167.00	67.90	4.13	0.00	9.71	10.80
Citrumelo 4475 (NCRP-69)	143.00	66.80	3.68	0.07	6.37	7.32
Volkameriana (NCRP-70)	163.00	68.30	3.80	0.07	5.83	6.48
Rangapur Lime (NCRP-71)	158.00	67.60	3.81	0.07	6.72	7.47
Grand mean	163.28	68.28	3.89	0.29	7.37	8.22
LSD (P<0.05)	21.34	2.7	0.89	0.26	4.93	5.48
F-test	NS	NS	NS	***	NS	NS
CV (%)	7.35	2.22	11.4	51.71	67.64	37.50

Table 25: Fruit physicochemical and yield parameters of acid lime 'Tehrathum Local' grafted onto different rootstocks at NCRP, Paripatle, Dhankuta during 2080/81

Rootstock	Juice (%)	TSS (%)	TA (%)	DA value	CCI value
Trifoliate (NCRP-36)	23.20	11.20	0.77	0.07	15.00
Citrange C-35 (NCRP-65)	28.80	11.90	0.75	0.11	11.50
Poncirus Pomeroy (NCRP-67)	34.80	10.30	0.67	0.27	6.23
Flying Dragon (NCRP-68)	37.10	10.50	0.65	0.14	5.84
Citrumelo 4475 (NCRP-69)	33.20	11.80	0.93	0.04	7.03
Volkameriana (NCRP-70)	32.70	11.50	0.71	0.07	5.53
Rangapur Lime (NCRP-71)	34.70	11.50	1.08	0.08	5.73
Grand mean	32.06	11.25	0.79	0.11	8.12
LSD (P<0.05)	6.20	1.26	0.28	0.13	2.45
F-test	**	NS	NS	*	***
CV (%)	10.87	6.31	20.04	64.71	16.97

3.4 Citrus decline management

Citrus decline is one of the most pressing challenges threatening the sustainability and profitability of the citrus industry in Nepal. It has emerged as a widespread and severe problem, particularly affecting mandarin production across nearly all citrus-growing regions of the country. According to Roistacher (1996), if the issue of citrus decline is not addressed effectively, the future of citrus cultivation in Nepal will be at grave risk. A major contributing factor is the location of most citrus nurseries at altitudes below 1000 meters above sea level, where environmental conditions are conducive to the proliferation of insect vectors that transmit devastating diseases such as citrus greening (Huanglongbing, HLB) and citrus tristeza virus (CTV). In addition to HLB, citrus decline is exacerbated

by a range of other factors, including CTV, root rot, poor orchard management, suboptimal soil and climatic conditions, and the widespread use of low-quality planting materials. However, previous studies have demonstrated that citrus decline can be effectively mitigated through integrated management practices. These include regular pruning, timely irrigation, and comprehensive plant protection measures. Moreover, proper nutritional management-specifically the application of 300–500 g nitrogen, 200-250 g phosphorus, and 250–350 g potassium per tree for trees at the bearing stage-has been shown to improve tree vigor and productivity, thereby gradually reducing the symptoms and impacts of decline. Therefore, addressing citrus decline requires a holistic and science-based approach to orchard management, beginning with the production of disease-free planting materials and extending through to post-planting care and nutrition.

3.4.1 Evaluation of effectiveness of guava inter-cropping on HLB infection

Citrus greening disease, also known as Huanglongbing (HLB), is considered one of the most devastating and incurable diseases of citrus worldwide. Caused by phloem-limited, motile bacteria belonging to the genus *Candidatus Liberibacter* spp., the disease is primarily transmitted by two psyllid vectors-the Asian citrus psyllid (*Diaphorina citri*) and the African citrus psyllid (*Trioza erytreae*), commonly referred to as the two-spotted citrus psyllid. HLB is also graft transmissible, making its spread through infected planting materials a serious concern. Infected citrus trees exhibit a wide range of symptoms including yellowing of leaf veins and surrounding tissues, blotchy and asymmetrical mottling of leaves, stunted growth, twig dieback, feeder root decay, off-season flowering, and ultimately, tree death. The fruit becomes small, misshapen, with a thick rind that remains green even when mature and tastes bitter. These symptoms often mimic nutrient deficiencies; however, a key diagnostic difference lies in the pattern—nutrient deficiencies typically cause symmetrical symptoms, while HLB induces asymmetrical leaf yellowing around the veins.

In Nepal, citrus decline was first reported in the Pokhara valley in 1968 and was later identified as citrus greening disease. It is believed to have been introduced through infected planting materials from Sharanpur, India. Subsequent surveys and research revealed the widespread presence of the disease across the country, with the highest severity observed in the western citrus-producing regions. However, recent trends indicate rapid disease expansion in eastern regions as well. In an effort to contain the disease, the National Citrus Research Program (NCRP) has been exploring eco-friendly and preventive strategies. One such approach, initiated in the Ilam district (Godak area) since fiscal year 2073/74, involves intercropping guava within mandarin orchards. This practice is based on the hypothesis that guava emits specific volatile organic compounds that may

act as natural repellents, reducing the population of citrus psyllids and thereby limiting disease transmission. Such integrated pest and disease management strategies, including the use of repellent intercrops, could offer promising avenues for reducing the spread of HLB in Nepal's citrus orchards.

Methodology

In the first year of the study, 20 guava plants were established in the research field following a planting distance of 3 m × 3 m. In the second year, 20 mandarin saplings were intercropped within the same field, maintaining the same spacing. To monitor the population dynamics of citrus psyllids, yellow sticky traps were employed, and observations were recorded weekly from Falgun to Bhadra. Alongside psyllid monitoring, disease incidence related to citrus greening (HLB) was also assessed periodically. To validate the findings and evaluate the efficacy of guava intercropping in another HLB-prone region, a parallel trial was established at the Bhuwaneshori area of Sindhuli, which is also recognized as an HLB hotspot. The same methodology-including guava-mandarin intercropping, planting distance, and weekly monitoring of psyllids and disease symptoms-was applied in this site to compare outcomes and assess the potential of guava intercropping as a preventive strategy against HLB transmission.

Results

In the sixth year following the intercropping of mandarin with guava, very few citrus psyllid vectors were recorded in the research plot, however there was no incidence of Huanglongbing (HLB). Similarly, in the parallel trial site, fifth years after mandarin plantation, there is very few citrus psyll but no symptoms of HLB were detected. These results suggest that intercropping guava with mandarin may have a significant role in reducing the population of citrus psyllid vectors, potentially through the repellent effect of volatile compounds released by guava. However, considering that citrus greening disease often manifests 2-3 years after planting, and latent infections can occur without immediate symptoms, it is essential that this research activity be continued for several more years. Continued monitoring will help to confirm the long-term effectiveness of guava intercropping in preventing HLB transmission and provide a more conclusive understanding of its role as a sustainable and eco-friendly management strategy in citrus orchards.

3.5 Monitoring of citrus psylla

Methodology

Yellow sticky traps provided with acetic acid were used for monitoring Asian citrus psylla in Dhankuta. Traps were installed at different altitudes ranging from 1,102 masl to 1,357 masl. Installation of the traps started in the month of

Falgun and continued until Shravan. Each trap was replaced every 15 days from the date of the first installation with a new one.

Results

The bar graph illustrates the population dynamics of the Asian citrus psyllid across six different altitudes (ranging from 1,102 masl to 1,357 masl) over multiple dates of yellow sticky trap installation, spanning from Falgun 20 to Shrawan 5.

The highest population was recorded at 1,102 masl on Baisakh 5, with a sharp peak of around 60 psyllids, indicating a favorable condition for vector activity at lower altitudes during this period. A second noticeable peak occurred at 1,274 masl on Jestha 20, with a psyllid count slightly above 50. Psyllid populations began to rise gradually from Falgun 20 through Baisakh, peaking around Baisakh 5 to Jestha 20 across most altitudes. After Jestha 20, a general decline in psyllid population is observed across all elevations, with much lower counts by Ashad 20 and Shrawan 5. Lower altitudes (1,102 masl and 1,250 masl) showed consistently higher psyllid populations, especially during the peak periods (Baisakh and Jestha), suggesting more favorable environmental conditions for psyllid survival and activity. Higher altitudes (1,311 masl and 1,357 masl) maintained comparatively low psyllid counts throughout the observation period, suggesting that altitude plays a significant role in suppressing psyllid populations. All altitudes experienced some level of psyllid activity during the months of Baisakh and Jestha**,** with varying degrees of intensity, indicating this as the high-risk season for HLB vector presence (Figure 4).

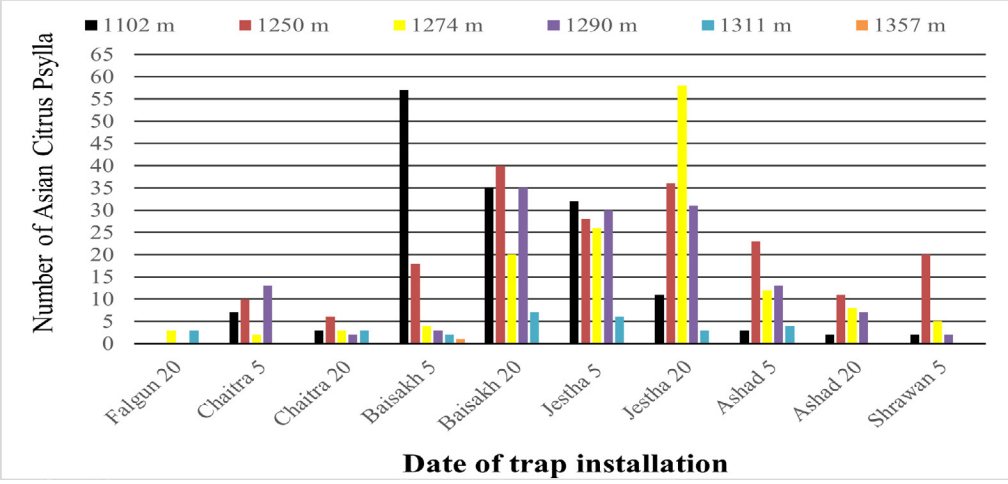


Figure 4: Population dynamics of the Asian citrus psyllid across different altitudes during 2080/81 at Dhankuta, Nepal

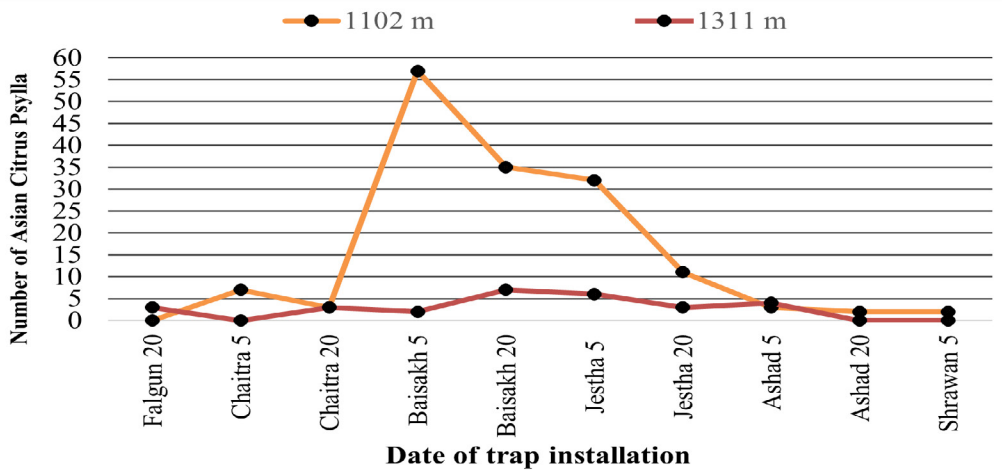


Figure 5: Population of the Asian citrus psyllid at the lowest and the highest altitudes during 2080/81 at Dhankuta, Nepal

The Figure 5 clearly illustrates the combined influence of altitude and season on Asian citrus psyllid populations. The lower altitude (1,102 masl) exhibited a dramatic rise and fall in vector numbers, posing a high risk for HLB transmission during spring months. Conversely, the higher altitude (1,311 masl) remained relatively safe with minimal psyllid pressure. These findings highlight the importance of site-specific vector monitoring and management, especially in lowland citrus orchards.

3.6 Summer grafting study in citrus

Citrus propagation in Nepal is traditionally carried out through grafting during the winter season. However, this period often coincides with peak agricultural activity, leading to a high demand for skilled labor and, consequently, a significant shortage of trained grafters. Furthermore, citrus plants grafted during the winter season typically require an extended nursery period of approximately 1.5 years before they are mature enough for commercial sale. This prolonged nursery duration not only delays returns for nurserymen but also impedes the timely availability of planting materials to farmers. In response to these challenges, the National Citrus Research Program (NCRP), Paripatle, Dhankuta, initiated a summer grafting program starting from the fiscal year 2078/80 B.S. This strategic shift aims to address the seasonal shortage of skilled grafters while also potentially shortening the nursery period of grafted citrus plants, thereby enhancing the efficiency of citrus propagation and distribution systems in Nepal.

Methodology

In this study, three citrus species, mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*), and acid lime (*Citrus aurantiifolia*), were propagated using the splice grafting method during the summer season. The grafting was carried out inside a screen house across four distinct dates at 15-day intervals, commencing from the Jestha 19 and concluding on the Ashadh 31. One-year-old *Trifoliate orange* (*Poncirus trifoliata*) seedlings were used as rootstock for all grafting treatments. Scion materials, approximately eight months old, were collected from healthy, true-to-type mother plants maintained within the same screen house environment to ensure compatibility and minimize environmental variation. The experiment followed a completely randomized design with five replications. Each experimental unit comprised 24 individual grafts, with each graft planted in a separate polythene pot to facilitate independent growth and minimize competition.

Results and discussion

Preliminary findings from the study revealed a grafting success rate of approximately 58.33% in both mandarin (*Citrus reticulata*) and sweet orange (*Citrus sinensis*) under summer conditions, while a comparatively lower success rate of 40% was observed in acid lime (*Citrus aurantiifolia*) (Table 26). These success rates were notably lower than those typically achieved during the winter season, where grafting success in all three species has been reported to reach up to 98%. The reduced success in the current study can be attributed primarily to the elevated temperatures within the screen house during the summer season, which may have adversely affected graft union formation and overall graft viability.

However, these constraints can potentially be mitigated by incorporating climate control measures within the propagation environment. The use of misting systems to maintain adequate humidity levels and the installation of shade nets to reduce heat stress are promising interventions to enhance grafting success during the summer. Once these environmental stressors are effectively managed, the success rate of summer grafting is expected to improve substantially.

The development and refinement of summer grafting techniques hold significant promise for citrus nurseries, particularly in the mid-hill regions of Nepal. By reducing the nursery period of citrus saplings, summer grafting can accelerate seedling turnover, thereby increasing the profitability of nursery enterprises. Moreover, it can create employment opportunities during the traditional off-season for grafting, contributing to improved rural livelihoods and a more resilient horticultural sector.

Table 26: Effect of date of summer grafting on graft-take success in different species of citrus at NCRP, Paripatle, Dhankuta during 2080/81

Species	Variety	Total grafted plant	Successful grafts	Graf-take success (%)
Mandarin	Khoku Local	600	350	58.33
Sweet orange	Washington Navel	600	350	58.33
Acid lime	Sunkagati-1	600	240	40.0

3.7 Maintenance of field gene bank

Collection and maintenance of genotypes is an important thrust of the National Citrus Research Program. A total of 140 citrus genotypes have been collected from local and exotic sources during different periods since 2001 (Annex 18). These are preserved at field gene bank of NCRP, Paripatle, Dhankuta. These species include mandarin, sweet orange, acid lime, grapefruit, lemon, tangor, tangelo, and rootstock species. The exotic genotypes were introduced mainly from India, Pakistan, France, Japan and Vietnam, while local genotypes were collected from different regions of Nepal. In 2004, 39 exotic citrus varieties including 16 mandarins, 6 sweet oranges, 4 grapefruit, 3 tangor, 3 tangelos, and 7 rootstock varieties were introduced from France with the support of Prof. Joseph Bove of French National Institute for Agricultural Research (INRA), French Agricultural Center for International Development (CIRAD). Similarly, three dwarf varieties of Unshiu mandarin were introduced form JICA, Japan in 2001. Likewise, promising 12 varieties of sweet orange were introduced from ICAR, India during 2006. Several varieties of sweet orange, grapefruit and acid lime were collected with the support of ICIMOD, Vietnam and IAAS, Rampur during different period. Beside these, 8 new varieties comprising of 3 mandarin orange, 4 sweet oranges and 1 rootstock was introduced from Australia in FY 2017/18. Similarly, 21 promising acid lime cultivars were collected from different districts and other local sources during different periods. These cultivars are to be screened based on fruit yield and fruiting characteristics. Preliminary characterizations of each variety were carried out and distinct variations with respect to fruiting behavior, fruit traits and morphological characteristics have been observed. Further selection is necessary to screen the best variety based on economic characters.

4 PRODUCTION PROGRAM

NCRP has maintained production orchards of mandarin, sweet orange and acid lime for different research purposes. It spreads out in about 7 ha area. The popular local variety, which is known as ‘Khoku Local’ has occupied a major portion of the production orchard followed by sweet orange variety ‘Dhankuta Local’ and different local genotypes of acid lime. This year, Rs.4.341 million

revenues was collected from the sell of saplings, fruit production and other horticultural sources (Annex 15).

Besides, NCRP has a regular activity of sapling production of major varieties of mandarin, sweet orange and acid lime. In 2080-81, a total of 24,873 grafted saplings were produced and 21,857 saplings were sold to the farmers. The figure showed the major demand of acid lime followed by mandarin and sweet orange. The demand of acid lime saplings was high from the farmers of Terai districts. The detail of fruit and sapling production is given in Table 27.

Table 27: Production of citrus saplings, scion, rootstock seed, seedlings, and fresh fruits in FY 2080/81

S.N.	Particulars	Unit	Quantity
1	Mandarin saplings	Nos	2,053
2	Sweet orange saplings	Nos	160
3	Acid lime saplings	Nos	22,555
4	Other saplings	Nos	105
5	Scion sticks	Nos	233
6	Rootstock seed	kg	56.5
7	Rootstock seedling	Nos	50,000
8	Mandarin fruits	kg	11,957
9	Sweet orange fruits	kg	219
10	Acid lime fruits	kg	325

5 TECHNOLOGY DISSEMINATION

- Need of action research programs at problematic areas across the country.
- Produce publication in Nepali language and provide to needy people.
- Model orchard demonstration of promising technologies at different locations for larger impact.
- Make availability of adequate planting saplings of promising genotypes.

6 MARKETING

- Need to strengthen the citrus marketing system avoiding middleman-controlled marketing system for getting higher benefit to the farmer.
- Improvement on the post-harvest practices such as harvesting, packaging, and transportation with the technology adoption to minimize the losses.
- Need of cooperative marketing.

- Farmers to be trained with the knowledge for increasing bargaining power in the market.
- Develop the citrus farming as a business enterprise.

7 CALENDAR OF OPERATION

Based on research findings and field experiences, NCRP has developed a calendar of operation for citrus orchard management (Table 28).

Table 28: Calendar of operations adopted at NCRP, Paripatle, Dhankuta for the orchard management

Month	Operations
Baishakh	• New flush attracts insects like psylla, white black fly and leaf miner • Irrigate the orchard and nursery bed at 8-12 days' interval. • Budding has to be done at the height of 15-25 cm above the ground level. • Integrated disease and insect management strategies should be adopted considering environmental protection and biodiversity conservation. • Uproot the diseased and very old trees and prepare pits for new plantation. • Start placing protein trap (4/ropani) to monitor Chinese citrus fly (*Bactrocera minax*) on sweet orange orchard. • Manage miticides to control the citrus mites. • Note: spraying any sort of fungicide, antibiotic and insecticide must be discontinued during flowering period.
Jestha	• Increase the frequency of irrigation from earlier schedule of 8-12 days to 5-7 days' interval in case of absence of pre-monsoon showers. • The most critical period is during heat spells. To be more accurate, check to moisture level 30 cm deep under trees to determine dryness and water accordingly. Keep water away from the trunk. • Grafted/budded rootstock in winter months requires checking, thereafter, the tops of successfully intake grafting/budding are to be cut. • Any fertilizer should be applied if there is sufficient moisture in soil.

Month	Operations
	• Recommended prophylactic measures need to be followed to the plants infected with *Phytophthora.* • Make a drainage system in the orchard. • Prepare the nursery bed for rootstock transplant. • Prepare compost for next the year. • Continue protein trap (4/ropani) to monitor Chinese citrus fly (*Bactrocera minax*) on sweet orange orchard. • Initiate area wide fruit fly control program with bait of protein at weekly interval (Great fruit fly bait) to control fruit drop caused by Chinese citrus fly in afffected area in consultation with Agricultural Knowledge Center and or Zone and super zone of prime minister agriculture modernization program. • Use miticite to control the citrus mites to prevent fruit being rusty or black clolor, hampering the marketing of citrus fruit especially, sweet orange. Miticide should be used atleast 4 times at 7-10 days' intervals in the affected areas or trees.
Ashad	• The trunk of citrus trees that are infected with fungal diseases need to be applied with Bordeaux paste as prophylactic measure against the collar rot and gummosis caused by *Phytophthora*. • In case of water stagnation near the trunk of tree, 'V' shaped furrows are to dug in between the rows across the slope to drain out excess of water on the orchard. • Incidence of citrus *Psylla* and leaf miner is common on new flushes. • Recommended measures are to be followed by spraying insecticides at bud burst stage. Spray is to be repeated after 15 days in the event of noticeable infestation. Cankerous leaves and branches should be pruned and brunt and copper oxychloride should be sprayed before the onset of rainy season. • Later than the onset of rainfall, copper oxychloride mixed with Streptocycline ought to be sprayed at monthly intervals. • Spraying with sulfur containing fungicide to control powdery mildew. • Transplant rootstocks for next year sapling. • Distribution of healthy saplings to farmers. • Continue the area wide fruit fly bait spray as suggested in Jestha month. • Manage all the necessary things to control the fruit pearcing moths which is usually starts appearing from shravan month.

Month	Operations
Shrawan	• Stagnated water should be disposed by providing trenches along with the slope. • Weeding in citrus orchard. • Doses of N, P and K fertilizers have to be applied depending upon the age of the trees in the later period of rainy season. • If fruit drop is observed due to pathological and hormonal factors NAA or 2,4-D @ 8-15 ppm with urea @ 5 g and bavistin @1.5 g l^{-1} of water should be sprayed to reduce the intensity of fruit drop. • Transplanting of rootstock seedling (Trifoliate) in main nursery block. • Remove diseased, new suckers and dry branches. • Spray insuf @ 2 g l^{-1} of water for the control of powdery mildew. • If there is the incidence of fruit sucking moth, and puncturing, predisposing fruits to fungal infection which result in fruit drop. Light trap needs to be installed, and fallen fruits should be destroyed and buried in order to avoid its multiplication in soil. • Continue the area wide fruit fly bait spray as suggested in Jestha month. • Start managing fruit piercing moth with the use of fruit bait, horticultural mineral oil, light, covering fruit trees with mosquito net or wrapping individual fruit with papers. This should be continued upto Kartik or Mangsir depending upon the altitude of the citrus growing areas.
Bhadra	• Weeding in citrus orchards and nurseries. • Application of mineral oil @ 10-15 ml l^{-1} of water to control scale insects. • Management of citrus canker should be followed as per the recommendation. • Application of systemic insecticides for the control of green stink bug. • Drenching of the root with 1% Bordeaux mixture infected by root rot disease. • Harvesting of trifoliate fruit should be taken up at right stage of maturity. • Sow the trifoliate rootstock seed in primary nursery for better growth of seedlings. • Earthing up of basins to break the crust formed that facilitates aeration in root zone.

Month	Operations
	• Harvesting of early maturing mandarins, Paripatle Agaute-1, Paripatle Agaute-2 and other unshiu mandarin. • Manage fruit piercing moth • Manage fruit piercing moth.
Ashoj	• Basins should be kept ready for irrigation. • New flush should be sprayed with insecticides against citrus psylla and leaf miner. Likewise, recommended dose of insecticide should be sprayed to control green stink bug. • Weeding and mulching in the orchards. • Stacking of heavily fruiting branches. • Harvesting of citrange fruit should be taken up at right stage of maturity. • Sow the citrange rootstock seed in primary nursery for better growth of seedlings. • Apply Bordeaux paste after the withdrawal of monsoon. • Collect Chinese citrus fly infected sweet orange fruits, and immerse them into big bucket full of water. • Harvesting of early maturing mandarins. • Manage fruit piercing moth
Kartik	• Collect fruit fly infected sweet orange fruits and bury them into deep pits. • Prepare new nursery bed and sow trifoliate seed for next year production. • Excess leaf fall could be an indication of disease infestation. Suitable control measures are to be taken up. • Harvesting of early maturing species of citrus fruits for rootstock should be taken up at right stage of maturity. • Harvesting of early maturing varieties. • Manage fruit piercing moth.
Mangsir	• Harvesting of mid-season varieties. • Grafting for sapling production.
Poush	• Harvesting of mid-season varieties. • Grafting for sapling production. • Farm yard manure should be applied to facilitate decomposition. Its mobilization starts after 3-4 months.
Magh	• Irrigate the orchard at 7-10 days' intervals.

Month	Operations
	• Harvesting of late season varieties. • Pruning and training should be carried out. • Fertilizer application and Servo agro spray to control scale insects. • If zinc deficiency symptoms are notices, apply zinc sulphate.
Falgun	
	• Servo agro spray to control scale insects; fertilizer application. • Foliar spray of micronutrients. • Insecticides spray in nursery plants to control leaf miner. • Irrigation in orchards and nursery. • In the case of zinc deficiency symptoms, zinc sulphate is to be mixed with adequate quantity of farm yard manure, and then applied to the plants by spreading uniformly on the entire root zone.
Chaitra	
	• Irrigate the orchard and nursery bed. • Uproot the diseased and very old unproductive trees and prepare pits for new plantation.

8 INFORMATION DISSEMINATION

Information regarding citrus research programs and technologies was shared with the visitors that altogether 1,800 visitors made their presence in NCRP (Annex 10). The visitors were mainly from farmers group, cooperatives, extension officials, entrepreneurs, NGOs/INGOs officials and others. They were acquainted with the field knowledge and experience of citrus cultivation.

9 TRAINING

The farmers level seven days residential training was conducted on the topic “Citrus orchard and nursery management”. The name of farmers who participated in the training is shown in Annex 17.

10 SERVICES

In fiscal year 2080/81, NCRP supplied 21,720 grafted saplings of different citrus species to the farmers. The grafted saplings made available to the farmers comprised of ‘Khoku Local’ mandarin, Paripatle Agaute-1, Banskharka Local, three acid lime varieties; Sunkatagi-1, Sunkagati-2 and Tehrathum local and sweet orange. In addition, the scion source from the mother plant of mandarin and acid lime were distributed to the nearby nursery entrepreneurs in Dhankuta

district. Similarly, lab test of HLB through PCR, CTV test through immunostipe test was done during this Fiscal Year. About 750 farmers and students were provided with counsellings services.

11 BUDGET STATEMENT

Budget and expenditure of regular program as well as beruju of the program has been presented in Annex 14.

12 MAJOR PROBLEMS

The major problems of citrus industry in Nepal are summarized as following:

- Lack of variety diversity- short crop harvest period,
- Small production scale,
- Poor orchard management,
- Lack of efficient irrigation,
- Fruit drop due to entomological, pathological and hormonal factors.
- Incidence of insects and different diseases.
- Presence of hard pan.
- Limited availability of disease free planting materials.
- Acidic soil condition including zinc, calcium and magnesium deficiency in most of the citrus orchards particularly in mid-hills of west Nepal.
- Macro and micro-nutrient deficiency.
- No information about the nutrient content of citrus orchard.
- Poor institutional mechanisms and coordination for marketing, and
- Lack of entrepreneurship

Regarding management aspect, NCRP is lacking human resources for several years. Currently, a total of 7 staffs are working in the Program although there are 37 approved positions allocated by the NARC. Among the working staffs, only three scientists are there for research execution.

13 FUTURE STRATEGIES

At present, government of Nepal has recognized citrus sector as the national important and prioritized commodity. Because of appropriate geography and climate, citrus is widely grown throughout the mid hills from east to west across the country. In addition to, acid lime could be grown in upland condition of

terai. Moreover, the demand of mandarin and acid lime in the domestic markets is escalating very high in recent years. Thus, it has an enormous potential to generate income and employment including nutrition to rural farmers in the country.

However, citrus industry is still in traditional level that needs to be transformed into commercial production. Therefore, NCRP has future strategies to address the problems of short production period of existing varieties, low productivity and production, inferior fruit quality, citrus decline due to disease and pests including management factors. Similarly, problems in institutional mechanism and coordination for marketing and entrepreneurship for this crop should be adequately dealt with by the research and development. Moreover, the research focus shall be on citrus based farming system utilizing available resources and socio-economic condition of the farmers. Therefore, NCRP has prioritized following research areas for the upcoming years:

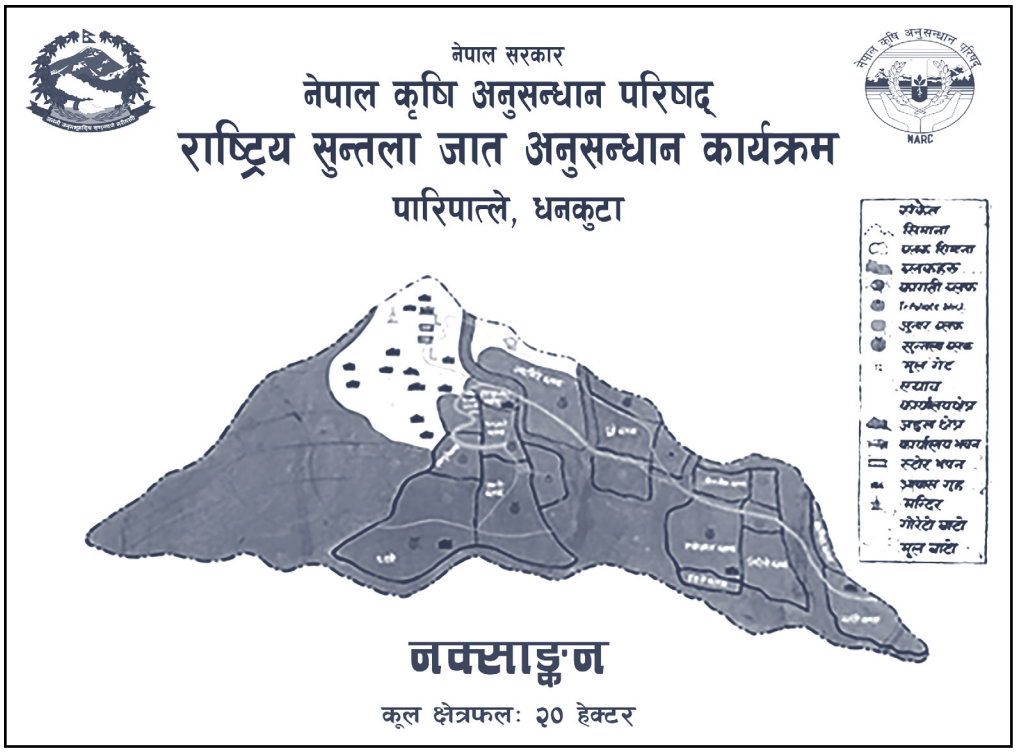
- Virus indexing program should be made compulsory by law with bud wood certification program, and it should be followed timely across citrus growing areas.
- The quality planting materials free from pathogens and resistant to various insect pest and diseases ought to be made available to the citrus growers.
- The private nurseries should be inspected routinely since the uncertified nursery plants produced from bud wood of unknown mother tree decide the future of the orchard.
- Developing disease resistant rootstock as well as identifying new dwarfing rootstocks for high density planting.
- Excessive use of fertilizers, chemical pesticides should be checked and organic citrus farming should be encouraged especially with the judicious use of bio-fertilizers and bio-control of pests with bio-pesticides.
- Postharvest processing and value addition,
- Marketing and export business,
- Cost effective and eco-friendly production technologies,
- Integrated nutrient management,
- Breeding new varieties for extended harvest period,
- Biological pest and disease management,
- Water use efficiency,
- In-vitro technology for healthy propagation,
- Citrus based farming system, and
- Socio-economic studies

14 SPECIAL PROJECT

The NAFHA project was launched at the National Citrus Research Program (NCRP), Paripatle, Dhankuta, beginning in fiscal year 2080/81. The project was primarily implemented at NCRP to carry out phenological characterization of major citrus species with the objective of varietal registration and release. The study focused on mandarin, acid lime, and sweet orange, evaluating multiple varieties of each species for traits such as flowering time, fruit set, harvest duration, and the physicochemical properties of ripe fruits. The findings revealed considerable variation among varieties in terms of harvest period, fruit quality attributes, and yield potential. Based on these results, the mandarin variety 'Miyagawa Wase' and the lemon variety 'NCRP-53' are being considered for varietal registration.

ANNEXES

Annex 1. Map of NCRP, Paripatle, Dhankuta



Annex 2. Monthly meteorological data of NCRP, Paripatle, Dhankuta in FY 2080/81

Month	Temperature (°C)		Rainfall (mm)
	Maximum	Minimum	
July 2023	26.79	21.54	321.08
August 2023	26.48	20.27	280.2
September 2023	27.05	19.39	131.5
October 2023	24.75	13.61	77.4
November 2023	23.67	12.06	0
December 2023	20.34	8.49	1.7
January2024	19.22	7.93	0
February 2024	21.89	10.97	0
March 2024	25.92	13.73	64.9
April 2024	28.76	18.81	13.1
May 2024	27.57	19.22	120.3
June	27.52	20.64	99.76

Annex 3. Laboratory facility at NCRP, Paripatle, Dhankuta

S.N.	Laboratory facility	Remarks
1	Tissue culture	Mass propagation of plants
2	Soil	Soil analysis for physicochemical analysis
3	Plant pathology	Pathological detection of fugi
4	Entomology	Entomological study
5	Fruit analysis	Physicochemical analysis of fruits
6	Biotechnology	HLB diagnosis through PCR, DNA quantification with Nanodrop

Annex 4. Human resource of NCRP in FY 2080/81

S.N.	Name	Position	Qualification	Working area	Remarks
1	Mr. Basant Chalise	Senior Scientist (S-4)	M.Sc.Ag (Horticulture)	Horticulture	Transferred from HRS, Jumla
2	Dr. Umesh Kumar Acharya	Senior Scientist (S-4)	Ph.D. (Pomology)	Pomology	Transferred to NCCRP, Khumaltar
3	Mr. Shukra Raj Shrestha	Scientist (S-2)	M.Sc.Ag (Soil)	Soil	Transferred to DoAR, Lumle
4	Ms. Dipti Adhikari	Technical Officer (T-6)	M.Sc.Ag (Pathology)	Pomology	Study leave
5	Mr. Manoj Kumar Sah Teli	Technical Officer (T-6)	B.Sc.Ag	Agriculture	Study leave
6	Mr. Kumar Prasad Koirala	Adm Officer (A-6)	B.A	Administration	Transferred from NBRP, Tarahara
7	Mr. Tilak Prasad Rajbanshi	Account officer (A-6)	B.Com	Account	
8	Mr. Jayram Hajara	Ast. Accountant (A4)	B.Com	Account	Transferred to NARP, Parwanipur
9	Mr. Kashi Nath Subedi	Technical Helper-2nd level	Literate	Orchard management	
10	Mr. Dhan Kumar Rai	Technical Helper-2nd level	Literate	Nursery management	
11	Mr. Gopal Silwal	Technical Helper-1st level	Literate	Orchard management	Transferred to Khumaltar
12	Mr. Tara Nath Khatri	Heavy driver-Fifth	Literate	Driving	

Annex 5. Human resource allocation of NCRP in FY 2080/81

S. N.	Designation	Approved	Fulfilled	Vacant
1	Chief Scientist (S-5) - Pomology/Olericulture	1	0	1
2	Senior Scientist (S-4)- Pomology	1	1	0
3	Senior Scientist (S-3)- Pomology	1	0	1
4	Senior Scientist (S-3)- Plant pathology	1	0	1
5	Scientist (S-2) - Soil	1	0	1
6	Scientist (S-1) - Plant breeding and genetics	1	0	1
7	Scientist (S-1) - Entomology	1	0	1
8	Scientist (S-1) - Plant Pathology	1	0	1
9	Senior Technical Officer (T-7) -Olericulture	1	0	1
10	Senior Technical Officer (T-7) -Pomology	1	0	1
11	Technical Officer (T-6) - Pomology	3	2	1
12	Junior Technician (T-5)	3	1	2
13	Technician (T-4)	5	0	5
14	Technician (T-1)	13	2	11
15	Accoung Officer (A-6)	1	1	0
16	Administrative Assistant (A-5)	1	1	0
17	Heavy Driver	1	1	0
	Total	37	9	28

Annex 6. Summary progress of NARC research projects and activities of NCRP in FY 2080/81

S.N.	Project	Project leader	Budget allocated	Major achievements
1	Farm Management Research Support and Production Program	B. Chalise	6,064,000	Production of 30,000 citrus grafts and 50,000 rootstock seedling
2	Multilocaltion Project	B. Chalise	307,000	Production of mutagenic plant of mandarin
3	Promoting improved cultivation and commercialization of citrus through technology out scaling and production of standard planting materials	B. Chalise	1,794,000	20,000 grafts were prepared and sold at farmers level; 30 samples were tested for HLB through PCR; nursery owners were provided with necessary materials for nursery production and management
4	Standardization of rootstock and development of fruit fly and root rot management technologies in citrus	B. Chalise	611,000	Data recording and compilation for drawing the conclusion
5	Development of productivity enhancement technology of mandarin and acid lime in mid hills of Nepal	B. Chalise	730,000	Trial is currently being evaluated

S.N.	Project	Project leader	Budget allocated	Major achievements
6	Varietal improvement and use of emerging biotechnological approaches in citrus	B. Chalise	2,242,000	Registration of satsuma mandarin variety 'Paripatle Agaute-1'
7	Exploration of management techniques to solve citrus greening disease problem in mid hills	B. Chalise	1,436,000	Monitoring of citrus psylla at different altitudes; use of zinkicide to evaluate the effectiveness against HLB

Annex 7. Training/workshop/seminar organized by NCRP, Paripatle, Dhankuta in FY 2080/81

S.N.	Name of training	Duration	Target group	Nos of participants
1	Citrus orchard and nursery management	7 days	Citrus farmers and nursery owners	20
2	On the Job Training/ Internship	3-6 months	B. Sc. Ag. I. Sc. Ag JT/JTA	61

Annex 8. Services provided in FY 2080/81

S.N.	Laboratory/field test/counseling services	Number	Major clients
1	HLB test through PCR	30	Official
2	Field test of CTV	15	Official
3	Counseling services	750	Farmers/students etc.

Annex 9. Publications in FY 2080/81

S.N.	Publication	Type	Language	Published number
1	Annual Report (2079/80)	Book	English	70
2	Citrus sapling production and nursery management	Brochure	Nepali	500
3	Citrus orchard decline and its management	Brochure	Nepali	500
4	Procedure for scratch and immunostripe test for HLB and CTV detection in citrus	Brochure	Nepali	500
5	Registered citrus varieties of Nepal	Brochure	Nepali	500
6	National Citrus Research Program: A brief introduction	Brochure	Nepali	500

Annex 10. Information disseminated in FY 2080/81

S.N.	Information disseminated/area coverage	Type	Media type	Date
1	Major problems of citrus cultivation in Nepal	Interview	Kantipur Television	2080 Falgun

Annex 11. Visit of NCRP, Paripatle, Dhankuta in FY 2080/81

S.N.	Category	Number	Country/area	Major area of interest
1	Farmers	1500	Nepal	Citrus cultivation
2	Students	250	Nepal	Citrus cultivation
3	Official visit	30	Nepal	Citrus varieties
4	Entrepreneurs	20	Nepal	Product diversification

Annex 12. Training/workshop/seminar attained by the staffs in FY 2080/81

S.N.	Name of staff	Position	Seminar/training/ workshop	Duration	Place
1	Basant Chalise	Senior scientist (S-4)	11th National Horticulture Workshop	2 days	Khumaltar
2	Basant Chalise	Senior scientist (S-4)	14th National Horticulture Workshop	2 days	Kirtipur
3	Basant Chalise	Senior scientist (S-4)	Planning Workshop	4 days	Parwanipur
4	Dipesh Pokhrel	JT (T-5)	Planning Workshop	4 days	Parwanipur

Annex 13. Paper published in FY 2080/81

S.N.	Title	Author	Name of publication
1	Present Status and Future Strategies for Citrus Research and Development in Nepal	B Chalise UK Acharya A Katuwal	Proceedings of the 11th National Horticulture Workshop organized by NHRC, NARC
2	Mandarin Germplasm Collection, Evaluation, Sapling Production and Biosecurity and Plant Protection System in National Citrus Research Program, Paripatle, Dhankuta, Nepal	B Chalise UK Acharya D Pokhrel A Katuwal	Proceedings of the 14th National Horticulture Workshop organized by Nepal Horticulture Society

Annex 14. Regular annual budget and expenditure (NPR) in 2080/81

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
21111	Staff Salary	7963000	7333627.43	7333627.43	602372.57
21121	Uniform	100000	90000	90000	10000
21131	Local Allowance	156000	94737.50	94737.50	61232.50
21132	Dearness Allowance	315000	233500	233500	81500
21134	Meeting Allowance	36000	29800	29800	6200
21213	Insurance Fund Expenses based on Contribution	65400	47100	47100	18300
22111	Water and Electricity	252000	252000	252000	0
22112	Communication Expenses	218000	216415	216415	1585
22212	Fuel(Office Purpose)	849000	821399	821399	27601
22213	Vehicle Repair Cost	300000	298687	298687	1322
22214	Insurance and Renewal Expenses	80000	70000	70000	10000

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
22221	Repair and Maintenance of Machinery and Equipments	214000	211972	211972	2028
22291	Repair and Maintenance of other Assets	95000	94958	94958	42
22311	Office related expenses	188000	186203	186203	1797
22314	Fuel for other pueposes	201000	70388	70388	130612
22315	Newspaper,Printing and News Publication Cost	208000	207622	207622	378
22413	Contract Service Cost	1536000	1469633	1469633	66367
22419	Other Service Cost	36000	35934	35934	66
22512	Training and seminar expenses	525000	524686	524686	314
22521	Production Material Service	10204000	10080447	10080447	123553
22611	Monitoring and evaluation expenses	414000	183049.50	183049.50	230950.50
22612	Travel Expenses	1256000	1142880.50	1142880.50	113119.50
22711	Miscellaneous Expenses	85000	85000	85000	0
28143	Vehicle&Machinery Equipment Rent Cost	85000	84030	84030	970
	Total	25354400	23864089.93	23864089.93	1490310.07
	Capital Expenses				
31113	Renovation expenses for Constructed Building	500000	497769	497769	2231
31122	Machinery Equipment	2745000	2692318	2692318	52682
31123	Furniture and Fixture	350000	342542	342542	7458
31159	Other Public Construction	1275000	1269009	1269009	5991
31171	Maintenance of other public assets	2900000	2889320	2889320	10680
	Total	7770000	7690958	7690958	79042
	Grand total	33124400	31555047.93	31555047.93	1569352.07

Annex 15. Revenue status of FY 2080/81

S.N.	Source	Amount (NPR)	Remarks
1	Seed/sapling/Fresh fruit	42,51,418.00	
3	Administrative	89,722.50	
	Total	43,41,140.50	

Annex 16. Beruju status till FY 2080/81

Beruju	Amount	Remarks
Beruju till year 2059/60	54,000.00	
Beruju from FY 2060/61 to 2077/78	589,000.00	
Beruju FY (2077/78)	0.00	
Remaining beruju	643,000.00	

Annex 17. List of participants in the farmers' level residential training on "Citrus orchard and nursery management" in 2080/81

S.N.	Name of participants	Address
1	Nar Bahadur Rai	Sulukhumbu
2	Krishna Prasad Chapagain	Dailekh
3	Premraj Bhatta	Darchula
4	Ghanshyam Sharma	Parbat
5	Ganesh Budaayer	Dadeldhura
6	Yamchandra Karki	Okhaldhunga
7	Uday Rai	Khotang
8	Dan Bahadur Katuwal	Udayapur
9	Chandra Bishwakarma	Gulmi
10	Prabin Rai	Dhannkuta
11	Tara Pun	Myagdi
12	Dipak Chapagain	Nawalpur
13	Ram Prasad Lamichhane	Syangja
14	Hom Bahadur Ojha	Sankhuwasabha
15	Santa Kumar Limbu	Taplejung
16	Tom Kala Pokhrel	Palpa
17	Sangita Lawati	Panchthar
18	Sagar Lama Tamang	Ramechhap
19	Ramesh Thapa	Sindhuli
20	Anita Katuwal	Dahankuta

Annex 18. Citrus germplasm maintained at the field gene-bank of NCRP, Dhankuta

S.N.	Accession No	Identification/Common Name	Source
.	Mandarin (*Citrus reticulata* Blanco)		
1	NCRP-01	Khoku Local	Khoku, Dhankuta
2	NCRP-02	Kinnow	Pakistan
3	NCRP-03	Frutrel Early	Unknown
	Mandarin (C. *unshiu*)		
4	NCRP-04	Unshiu	JICA, Japan
5	NCRP-05	Miyagawawase	JICA, Japan

S.N.	Accession No	Identification/Common Name	Source
6	NCRP-06	Okitsuwase	JICA, Japan
7	NCRP-08	Pongan, Tangerine	ICIMOD
8	NCRP-09	Kamala	Dhankuta
9	NCRP-10	Baskharka Local (Parbat)	LAC, Lumle
10	NCRP-11	Sikkime	Tehrathum
11	NCRP-12	Calamondin	Unknown
12	NCRP-80	Satsumawase	INRA-CIRAD, France
13	NCRP-81	Satsuma Mino	INRA-CIRAD, France
14	NCRP-82	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	Satsuma Okitsu	INRA-CIRAD, France
23	NCRP-97	Clamentine- Hernandina	INRA-CIRAD, France
24	NCRP-98	Clamentin-Oroval	INRA-CIRAD, France
25	NCRP-99	Clamentine-Commune	INRA-CIRAD, France
26	NCRP-100	Clamentine-Marisol	INRA-CIRAD, France
27	NCRP-101	Clamentine Nules	INRA-CIRAD, France
28	NCRP-112	Gorkhali Suntala	Gorkha, Nareswor
29	NCRP-114	Khoku-Chimera	NCRP, Dhankuta
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
Tangor			
38	NCRP-102	Ellendale	INRA_CIRAD, France
39	NCRP-103	Murcott	INRA_CIRAD, France
40	NCRP-72	Ortanique	INRA_CIRAD, France
41	NCRP-07	Tangor, Murcott	JICA, Japan
Tangelo			
42	NCRP-73	Minneola	INRA_CIRAD, France
43	NCRP-74	Orlando	INRA_CIRAD, France

S.N.	Accession No	Identification/Common Name	Source
44	NCRP-75	Seminole	INRA_CIRAD, France
□.	Sweet orange (C. *sinensis* Osbeck)		
45	NCRP-13	Valencia Late	ICAR, India
46	NCRP-14	Sevelle Common	ICAR, India
47	NCRP-15	Navelencia	ICAR, India
48	NCRP-16	Malta Blood Red	ICAR, India
49	NCRP-17	Samauti	ICAR, India
50	NCRP-18	Masambi	ICAR, India
51	NCRP-19	Vanelle	ICAR, India
52	NCRP-20	Ruby	ICAR, India
53	NCRP 21	White Taker	ICAR, India
54	NCRP-22	Washington Navel	ICAR, India
55	NCRP 23	Hamlin	ICAR, India
56	NCRP 24	Pineapple	ICAR, India
57	NCRP-25	Yashida Navel	FDC, , Kirtipur
58	NCRP-26	Madam Vinous	GRESCO, Kathmandu
59	NCRP-27	Delicious Seedless	ICIMOD
60	NCRP-28	Skaggs Bonanza	ICIMOD
61	NCRP-29	Blood Red	ICIMOD
62	NCRP-30	Newhall Navel	ICIMOD
63	NCRP-31	Succari	ICIMOD
64	NCRP-32	Meisheu-9	ICIMOD
65	NCRP-33	Dhankuta Local	Dhankuta
66	NCRP-34	Lue Gim Gong	ICAR, India
67	NCRP-83	Cara Cara Novel	INRACIRAD, France
68	NCRP-84	Lane Late	INRACIRAD, France
69	NCRP-85	Pineapple	INRACIRAD, France
70	NCRP-86	Valencia Late	INRACIRAD, France
71	NCRP-87	Salustiana	INRACIRAD, France
72	NCRP-96	Tamango	INRACIRAD, France
73	NCRP-129	Atwood Navel	Australia
74	NCRP-130	Navelina Navel	Australia
75	NCRP-131	Valencia Seedless Delta	Australia
76	NCRP-132	Valencia Seedless McMohan	Australia
77	NCRP-133	Ramechhap Local	Ramechhap
78	NCRP-134	Sindhuli Local	Sindhuli
C.	Grape Fruit		
79	NCRP-45	Shamber	ICIMOD
80	NCRP-76	Henderson	INRA_CIRAD, France
81	NCRP-77	Star Ruby	INRA_CIRAD, France

S.N.	Accession No	Identification/Common Name	Source
82	NCRP-78	Reed	INRA_CIRAD, France
83	NCRP-79	Pink Ruby	INRA_CIRAD, France
84	NCRP-44	Phultrac (Pumelo)	Vietnam
85	NCRP-43	Nam Roi (Pumelo)	Vietnam
86	NCRP-42	Phodiem (Pumelo)	Vietnam
D. Acid lime (C. *aurantifolia* Swingle)			
87	NCRP-108	Khursanibari Local	SHARP, Chitwan
88	NCRP-107	Tehrathum Local	Tehrathum
89	NCRP-117	Baitadi Local	Baitadi
90	NCRP-118	Salyan Local	Rojwal Takura, Salyan
91	NCRP-119	Bhojpur Local	Takshor, Bhojpur
92	NCRP-120	Parbat Local	Lekhpant, Parwat
93	NCRP-60	Kaptangang Lamo	Sunsari
94	NCRP-59	Kaptangang Golo	Sunsari
95	NCRP 58	Krishnapur Kagati	Bharatpur, Chitwan
96	NCRP-57	Krishnapur Kagati	Bharatpur, Chitwan
97	NCRP-56	Banarasi Kagati	Biratnagar
98	NCRP-55	Madrasi Kagati	Biratnagar
99	NCRP 54	Banarasi Kagati	Biratnagar
100	NCRP-53	Panta-1 Kagati	Chitwan
101	NCRP-52	Belepur	Morang
102	NCRP-51	Sundarpur	Morang
103	NCRP-50	IAAS Acc # 71 (5)	IAAS, Rampur
104	NCRP-49	IAAS Acc # 101 (3)	IAAS, Rampur
105	NCRP-48	IAAS Acc # 101 (2)	IAAS, Rampur
106	NCRP-47	IAAS Acc # 01 (17)	IAAS, Rampur
107	NCRP-46	IAAS Acc # 01 (25)	IAAS, Rampur
108	NCRP-135	Nepalgunj Local	Banke
109	NCRP-136	Mexican Lime	
110	NCRP-137	Ranitar Local	Nawalpur
111	NCRP-138	Jhapa collection	Budhabare, Jhapa
E. Lemon (C. *limon*)			
112	NCRP-61	Eureka lemon unkwown	Unknown
113	NCRP-63	Hill Lemon	Sunderpur Morang
114	NCRP-64	Eureka Lamcho lemon	Sunderpur Morang
115	NCRP-109	Thimura Local	SHARP Chitwan
116	NCRP-110	Biratnagar Local	SHARP Chitwan
117	NCRP-111	Prembasti Local	SHARP Chitwan
F. Kumquat (*Fortunella* Spp.)			

S.N.	Accession No	Identification/Common Name	Source
118	NCRP-105	Fortunella (Oval)	Unknown
119	NCRP-106	Fortunella (Round)	Unknown
120	NCRP-115	Fortunella (Indian Muntala)	Unknown
G. Rootstocks			
121	NCRP-65	Citrange C-35	INRA_CIRAD
122	NCRP-66	Citrange- Carrizo	INRA_CIRAD
123	NCRP-67	Poncirus Pomeroy	INRA_CIRAD
124	NCRP-68	Flying Dragon	INRA_CIRAD
125	NCRP-69	Citrumelo-4475	INRA_CIRAD
126	NCRP-70	Volkameriana	INRA_CIRAD
127	NCRP-71	Rangapur lime Red	INRA_CIRAD
128	NCRP-113	Citrange old	Unknown
129	NCRP-38	Citrange	Unknown
130	NCRP-35	Citron	Unknown
131	NCRP-36	Trifoliate orange	Unknown
132	NCRP-37	Rangapur lime	Unknown
133	NCRP-39	Boxifolia	Unknown
134	NCRP-40	Rough lemon	Unknown
135	NCRP-116	Rough lemon	Paripatle Dhankuta
136	NCRP-41	Hokse	Dhankuta
137	NCRP-62	Local Bimiro	Belahara, Dhankuta
138	NCRP-104	Sweet lime	Dhankuta
139	NCRP-139	Troyer Citrange	Australia
140	NCRP-140	Rough lemon	Kathmandu

Annex 19. Special project (NAFHA), budget, and expenditure status of FY 2080/81

Budget code	Budget head	Released budget (NPR)	Expenditure (NPR)	Balance
22212	Fuel	230000.00	230000.00	0.00
22213	Repair and maintenance of vehicles	70000.00	70000.00	0.00
22522	Program expenses	1350000.00	1350000.00	0.00
22612	Travel expenses	300000.00	300000.00	0.00
	Total	1950000.00	1950000.00	0.00

Participants of the farmers' level residential training on "Citrus orchard and nursery management" conducted at NCRP, Paripatle, Dhankuta

Celebration of the 33rd NARC day at National Citrus Research Program, Paripatle, Dhankuta

Promising mandarin variety ‘Sikkime Local’ at fruit ripening stage at NCRP, Paripatle, Dhankuta

Citrus sapling production under the protected structures at NCRP, Paripatle, Dhankuta