

ANNUAL REPORT

2078/79 (2021/22)



GOVERNMENT OF NEPAL

NEPAL AGRICULTURE RESEARCH COUNCIL
NATIONAL CITRUS RESEARCH PROGRAMME
PARIPATLE, DHANKUTA

2022

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FOREWORD

For the last few years, National Citrus Research Program (NCRP) has experienced a growing interest in citrus cultivation, most probably attributed to the increasing market demand even abroad (China). A large number of potential citrus growers from mid hills and terai plains have reached us for technical counseling and saplings. High demand was received for saplings, mainly of acid lime varieties viz. Sun Kagati-1, and Sun Kagati-2 from foot-hills and terai plains. Similarly, Terhathum Local, a recently recommended acid lime variety for mid hills has also increased saplings demand. This could be backed up by the fact that NCRP, apart from private nurseries, had distributed more than twenty six thousand quality acid lime saplings at the cheapest price last year.

It is a matter of great satisfaction that we are working on exploring potential of mandarin and sweet orange production with introduction breeding for mid hills. These mandarin germplasms from abroad have potential for commercial production in terai plains, where a great demand for suitable mandarin variety exists. In the last fiscal year, NCRP had been able to endorse one local variety of acid lime (Terhthum) and one local variety of mandarin (Banskhart) for registration. With better management of nursery within NCRP, Paripatle, we had a record high sapling production last year. I would like to thank all the hard-working staff and wage laborers for this achievement. Hearty thanks also go to the Executive Director and Directors of NARC who supported NCRP all the way from program planning to implementation of the projects.

Despite having only a few scientists and technicians, we have been able to carry out all targeted activities and achieve expected output indicators. However, a few more scientists and technical staff are desperately needed in NCRP to address the burning research issues of citrus crops. Lab facilities, mainly of tissue culture lab had not properly utilized in absence of expert technical person. Positions of soil scientist, entomologist, pathologist and plant breeder have been vacant for a long period.

I hope this citrus research related report will be useful to all stakeholders including farmers, students and others professionals who are interested in the citrus industry. Last but not least, I would like to thank Ms Dipti Adhikari and Mr Janak Khadka for their conscientious help while preparing this annual report.

Umesh Kumar Acharya, PhD
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ACRONYMS

%	Percentage
@	at the rate
>	Greater than
2,4-D	2,4-Dichlorophenoxyacetic acid
Av	Average
B.S.	Bikram Sambat
BrimA	Brix minus acid
CFFT	Coordinated Farmers Field Trial
CIRAD	Centre of Agriculture Research for Development
Cm	Centimeter
CV	Coefficient of Variation
Cv	Cultivar
CVT	Coordinated Varietal Trial
DAP	Di-ammonium phosphate
DAS	Days after sowing
DBH	Days before harvest
DGR	Dry Ginger Recovery
DoAR	Directorate of Agricultural Research
<i>et. al.</i>	et alia
FAO	Food and Agriculture Organization
FY	Fiscal Year
FYM	Farm yard manure
G	Gram
Ha	Hectare
HLB	Huanglongbing
<i>i.e.</i>	That is
IAAS	Institute of Agriculture and Animal Science
ICAR	Indian Council of Agriculture Research
ICIMOD	International Centre for Integrated Mountain Development
INGO	International non-governmental organization
INRA	French National Institute for Agriculture Research
JICA	Japan International Cooperation Agency
JTA	Junior technical assistant
K	Potassium
Kg	Kilogram
LSD	Least Significant Different
Lt	Liter
M	Meter

m asl	meter above sea level
ml	Milliliter
Mm	Millimeter
MoAD	Ministry of Agriculture Development
Mt	Metric ton
Mt/ha	Metric ton per hectare
N	Nitrogen
NAA	Naphthaleneacetic acid
NARC	Nepal Agricultural Research Council
NCRP	National Citrus Research Program
NGO	Non-governmental organization
NGRP	National Ginger Research Program
NPR	Nepalese Rupee
NS	Non-significant
°	Degree
P	Phosphorus
PCR	Polymerase chain reaction
p ^H	Potential of Hydrogen
PATWG	Regional Agricultural Technical Working Group
PMAMP	Prime Minister Agriculture Modernization Project
ppm	Parts per million
RCBD	Completely Randomized Block Design
Sept.	September
SLC	School leaving certificate
T	Ton
t/ha	Ton per hectare
TA	Titrateable Acid
TPR	Turmeric Powder Recovery
TSS	Total Soluble Solid
VCDP	Value Chain Development Project
viz.	Videlicet
Wt	Weight

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प्रमुख सार संक्षेप

सुन्तलाजात फलफूल खेती मध्य पहाड र तराईका नेपाली कृषकहरुको आर्थिक स्तर वृद्धिमा टेवा पुऱ्याउने महत्वपूर्ण कृषि क्षेत्र हो । सुन्तलाको बढ्दो आन्तरिक तथा वाह्य बजारको कारणले यसलाई एउटा उच्च मूल्य भएको क्षेत्रको रूपमा पहिचान गरिएको छ । यसर्थ नेपाल सरकारले विगत केहि वर्षदेखि सुन्तला क्षेत्रको प्रवर्द्धन र विकासको लागि उच्च प्राथमिकता दिदै आएको छ । यद्यपी विगत केहि वर्ष देखि न्युन उत्पादकत्व र न्युन गुणस्तरले गर्दा उत्पादनमा समस्या देखिन थालेको छ । रोग र किराको 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 र विकास गर्न उपयुक्त प्रविधि विकासको लागि अनुसन्धानका कार्यक्रमहरु संचालन गर्दै आएको छ । यस कार्यक्रमले आ.व. २०७७/७८ अवधिमा जम्मा ८ वटा परियोजना अन्तर्गत ४२ वटा अनुसन्धान क्रियाकलापहरु सम्पन्न गरेको थियो । यी कार्यक्रमहरु विशेष रूपमा जातीय अनुसन्धान, बाली उत्पादनोपरान्त भन्डारण, बगैचा हास व्यवस्थापन र सुन्तलाको औसा किरा व्यवस्थापनसंग सम्बन्धित थिए । फलफूल अनुसन्धान सम्पन्न गर्न लामो समय लाग्ने भएकोले धेरैजसो कार्यक्रमहरु नियमित संचालनमा छन् भने केहि सम्पन्न भई अपेक्षित उपलब्धिहरु हासिल भएका छन् । यसरी आ.व. २०७८/७९ सम्म पुरा गरिएका क्रियाकलापहरुको उपलब्धिहरु संक्षिप्त रूपमा तल उल्लेख गरिएको छ ।

- जातीय संकलन र सम्बर्द्धन अन्तर्गत १४८ वटा स्थानीय र वाह्य श्रोतबाट सुन्तलाका विभिन्न जातहरु संकलन गरि कार्यक्रमको फारम भित्र फिल्ड जिन बैकमा सम्बर्द्धन गरि राखिएको छ । यी संकलित जातहरु सुन्तला, जुनार, कागती, भोगटे, निबुवा, सुन्तलाका वर्णशंकर जातहरु र रुटस्टक वर्ग अन्तर्गत पर्दछन् । प्रारम्भिक अध्ययन अनुसार यी संकलित जातहरु फल लाग्ने समय, फलको गुण र बोटको बृद्धि विकास आदिको विशेषतामा निकै विविधता देखिएको छ । उपयुक्त जातको छनौट तथा विकाशको लागि अझ केहि वर्ष अध्ययन गर्न आवश्यक देखिन्छ ।
- सुन्तला, जुनार, कागति र ट्यांडगोर प्रचलनमा रहेका जातहरुको उत्पादन क्षमता कम रहेका छन् । यस समस्यालाई हल गर्ने उदेश्यले विदेशबाट भित्राईएका र उपयुक्त स्थानिय जातहरुको खोजीगरी विगत २०६३/६४ देखि उत्पादन र उत्पादन समयको मुल्यांकन गर्दै आएको छ । प्रारम्भिक नतिजा अनुसार वाह्य सुन्तलाका जातहरु जस्तै ओकित्सुवासे, मियागावासे, नोभा, ओरोभल, मेरीसोल र

स्थानीय जातमा खोकु स्थानीयले अगौटे र राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको पाईएको छ । गत आर्थिक वर्षमा कागतीको तेर्हथुम, सुन्तलाको खोकु स्थानीय जात पुर्वी पहाडमा खेती गर्न सिफारिस गरिएको छ । आउने वर्षमा सुन्तलाको एक जात ओकित्सुवासेलाई उन्मोचनको लागि प्रस्ताव गर्न तयारी गरीएको छ ।

- वासिगंटन नेभल जातको जुनारले राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको छ । यो जात बेमौसमी जुनार उत्पादनको लागि राम्रो पाईएको छ । यस जातलाई उन्मोचनका लागि आगामी दिनमा प्रस्तावको लागि सिफारिस गर्ने क्रममा छ । अन्य जातहरुमा माल्टा ब्लड रेड, डेलिसिओस सिडलेस, सुकारी र धनकुटा स्थानियको उत्पादन उत्साहजनक देखिन्छ ।
- दस वटा कागतिका जातहरु संकलन गरी विगत २०६३/६४ देखि तराईमा परिक्षण गर्दै आएको छ । जातिय गुणको आधारमा आ.व.२०७५/७६ मा कागतिको जात तेर्हथुम स्थानीयको नामवाट पुर्वी पहाड क्षेत्रको लागि उन्मोचन गरीएको छ । गत आर्थिक वर्षमा सुन्तलाको बांसखर्क स्थानीय जात गण्डकी प्रदेशको पहाडी क्षेत्रमा खेती गर्न सिफारिस गरिएको छ ।
- वर्षा मौसममा सुन्तलाजात वालीको कलमी विरुवा उत्पादन सम्बन्धि हाई-टेक नर्सरी घरमा गरिएको परिक्षणमा जुनार, भोगटे र कागतीलाई तिनपातेको रूटस्टक प्रयोग गरि जेष्ठ देखि भदौ महिना भर भिनियर र क्लेफ्ट तरिकाबाट कलमी गर्न उपयुक्त हुने पाईयो । तर स्थानीय जातको सुन्तलालाई सो मौसममा तिनपातेको रूटस्टकमा कलमी गर्न उपयुक्त नहुने बरू अभाना जातको सुन्तलाको कलमी सफल भएको पाईयो ।
- सुन्तलाको पोष्टहार्भेष्ट भन्डारण अवधि वढाउने सम्बन्धि अध्ययन अनुसार कुल बट भण्डारण घरमा सुन्तलाजात फलहरु भण्डारण गर्दा कम क्षती भएको पाईयो । त्यस्तै मोडिफाइड प्लास्टिकमा ४-६ वटा प्वाल बनाएर कागतीका फलहरुलाई भण्डारण गर्दा लामो अवधि सम्म भण्डारण गर्न सफल भईयो । यसरी परिक्षण गर्दा ९० दिनको भन्डारणबाट थोरै मात्र तौल घटेको, राम्रो स्वाद भएको र हेडोनिक मुल्याङकनकर्ताले मन पराएको पाईयो ।
- गत आ.व.२०७७/७८ मा करिव २५०० जना कृषक र सरोकारवालाहरुलाई अनुसन्धान कार्यक्रम वारे जानकारी र प्रविधिहरु वारे सल्लाह दिईयो ।
- कलमीको लागि सुन्तला र कागतिको माउ बोटबाट स्वस्थ सायन धनकुटा जिल्लाका नर्सरी व्यवसायीहरुलाई उपलब्ध गराईयो । त्यस्तै गरी खोकु लोकल, ओकित्सुवासे सुन्तला र कागतिका तीन जातहरु जस्तै सुनकागति -१, सुनकागति -

२ र तेह्रथुम लोकलका कलमी बिरुवाहरु विभिन्न जिल्लाका कृषकहरुलाई वितरण गरियो ।

- गत आ.व. २०७७/७८ मा कृषकहरुलाई वितरण गरिएका जम्मा कलमी बिरुवा ३६८५० मध्ये सुन्तलाको ७६५०, जुनारको १०००, कागतिको २७२०० र अन्य १५० बिरुवाहरु थिए ।
- यस कार्यक्रमको आ.व. २०७७/७८ को लागि विनियोजित बजेट रु तीन करोड पच्चीस लाख थियो जस मध्य चालु कार्यक्रमको लागि जम्मा दुई करोड बाईस लाख विनियोजन गरिएको थियो । बार्षिक आम्दानी रु त्रिचालिस लाख थियो जुन खासगरी फल र बिरुवा बिक्रिवाट प्राप्त भएको 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 situation of the citrus industry in Nepal. During the fiscal year 2078/79 (2020/21), a total of 42 activities under 8 research projects were accomplished by the program. Particularly, these research projects comprised of varietal research, nursery management, post-harvest storage, citrus decline management and fruit fly control. Most of 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 144 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 best variety based on economic characters.
- 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 Miyagawase, Okitsuwase, Oraval, Page and Marisol were promising with early maturity and high fruit yield. Khoku local mandarin genotype has been registered for cultivation in eastern hills in this fiscal year. One genotype of mandarin viz., Okitsuwase is in process of being proposed for variety release based on its performance for yield and yield attributes.
- 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 off season production. This genotype is in the process of being proposed for variety release. 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 and Sunkagati-2, Terhthum local were released in past seven years for upland condition of terai, inner terai, foothills and mid-hill areas. Moreover, Banskhark local mandarin has been registered by Variety Release Subcommittee as suitable for Gandaki Province mid-hill condition recently.
- Rainy season sapling production inside high-tech nursery house study showed that Shrawan moth and cleft and vineer method of grafting are good for acid lime and mandarin (Avana) production using trifoliolate as rootstock. The time is not good for Khoku local mandarin sapling production and also patch and micro-tip method were not successful using trifoliolate as rootstock during this time.
- The result of postharvest storage study showed that citrus stored in cool-bot storage has very less loss. Further modified atmospheric packaging with 4-6 hole in 25 micro plastic bags also showed better storage of acid lime fruits. There was lower weight loss and good taste and also preferred by hedonic raters after 90 days of storage.
- During the fiscal year 2077/78, technical counseling was given to 2500 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, Okitsuwase and three varieties of acid lime viz. Sunkagati-1, Sunkagati-2 and Terhathum local were provided to the farmers in different districts.
- In the fiscal year 2077/78, total of 36850 grafted saplings constituting 7650 mandarin orange, 1000 sweet orange, 27200 acid lime and 1000 other saplings were made available to farmers.
- The total annual budget approved for the program was Rs. 32.5 million, while operational budget consisted of Rs. 22.8 million to carry out research projects. The revenue was 4.3 million Rupees in the fiscal year mainly from selling fruits and saplings.

1. PROGRAMME CONTEXT

Citrus fruits in Nepal occupy an important subsector of agriculture following the congenial geography and climate. In the light of growing awareness among young generation towards commercial agro-enterprises, it might become an economically viable enterprise for them, contributing to national economy.

Nepal is noted for the production of quality mandarin and sweet orange. The sub-tropical climates of mid hill districts ranging from 800 to 1,400 masl altitude along with favorable agro-climatic condition across the country are considered quite suitable for growing citrus fruits. Moreover, the production areas with deep sandy loam soil and soil pH range of 5.0 to 6.5 are the most suitable for the cultivation of citrus. In recent years, citrus is grown commercially in 48 hill and 16 terai districts of Nepal.

The statistics shows that the area and production under citrus fruit crops are increasing during last 16 years. The current area is recorded to be 46,715 ha producing 2,74,140 metric tons with productivity of 10.03 mt/ha (Table 1), which is very low compared to the most citrus growing countries in the world. The productivity is in declining trend and some studies revealed that such productivity deteriorated situation is mostly linked to poor orchard management and declining soil fertility in Nepal. Thus, there has been a huge scope of increasing the production and productivity through the use of improved technologies.

Table 1: Area, production and productivity of citrus fruits during 2003/04 to 2018/19

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2003/04	24,799	13,931	1,48,010	10.62
2004/05	25,910	14,606	1,56,956	10.75
2005/06	26,681	15,206	1,64,075	10.79
2006/07	27,980	15,832	1,71,875	10.86
2007/08	30,790	19,915	2,26,404	11.37
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
2012/13	36,975	23,645	2,16,188	9.14
2013/14	38,988	25,497	2,24,357	8.80
2014/15	39,035	25,261	2,22,790	8.82
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

Source: MoALD, Nepal, 2021

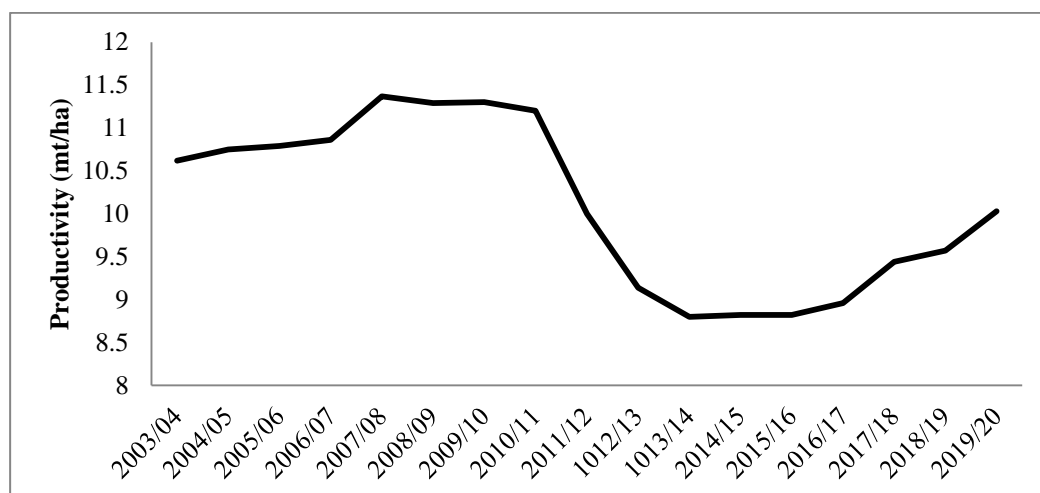


Figure 1: Productivity (mt/ha) of citrus crops during 17 years period

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 26,591 ha, 14,551 ha, 1,56,180 mt respectively, with the the productivity of 10.73 mt/ha. On the other hand, lemon fruit acquired the lowest area (2303 ha), productive area (1489 ha), and production (11,796 mt). The the highest productivity was from sweet orange (11.58) and the lowest productivity of 6.7 mt/ha was recorded with acid lime.

Table 2: Total area, productive area, production and productivity of major citrus fruits in Nepal (2019/20)

Major citrus fruits	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
Mandarin orange	26,591	14,551	156,180	10.73
Sweet orange	6,609	4,262	49,371	11.58
Acid lime	8,587	5,445	46,117	8.47
Lemon	2,303	1,489	11,796	7.92
Other citrus species	2,624	1,592	10,677	6.7
Grand Total	46,714	27,339	274,141	10.03

Source: MoALD, Nepal, 2021

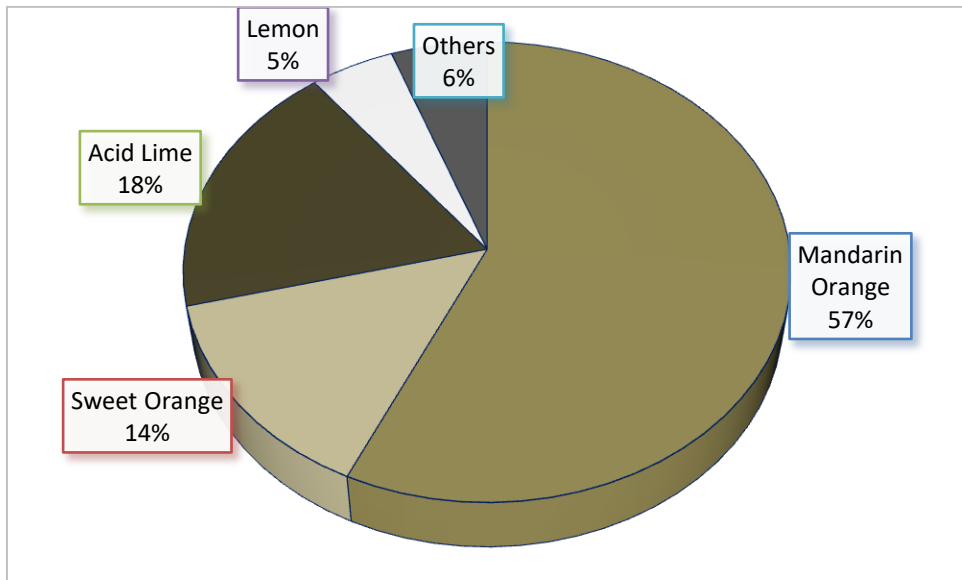


Figure 2: Total area (in percentage) of major citrus fruits in Nepal during 2019/20

The result shown in above pie-chart reveals 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 18.0%, 14.0%, 5.0% and 6.0% respectively.

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 Province 1 has occupied the first position with 11,638 ha, 7405 ha and 72167 mt respectively, but Gandaki province has stood the first position for productivity (10.95 mt/ha) followed by Bagmati Province with 10.22 mt/ha and Karnali Province 5 with 10.1 mt/ha. Although, area, productive area and production of mandarin orange is the highest in Gandaki Province with 7,795 ha, 3,534 ha and 39266,925 mt; productivity is noted to be the highest in Lumbini (11.45 mt /ha) followed by Gandaki (11.1 mt/ha) and Karnali (10.97 mt/ha) while the lowest productivity of mandarin is in Bagmati Province (9.34 mt/ha). As for sweet orange, Province 3 has had considerably the highest area (2902 ha), productive area (1789 ha), production (24,622 mt) and productivity (13.76 mt/ha) whereas Karnali Pradesh showed the lowest productive area (177 ha) and production (920 ha). The lowest productivity was found in Gandaki Province (8.48 mt/ha). Province 1 showed considerably the maximum acid lime area (3,334 ha), productive area (2,450 ha) and production (21,549 mt). However, highest productivity for lime was recorded from Province Gandaki (13.76 mt/ha). The Madhesh Province reflected the lowest for acid lime in respect of area (43 ha), productive area (28 ha) and production (174 mt). In

regards with lemon fruit crop, its' total area (724 ha), productive area (548 ha), production (4,8642 mt) and productivity (8.48 mt/ha) are recorded to be highest in Bagmati pradesh. In contrast, the lowest production area, productive area and production was found in Lumbini province with 44 ha, 29 ha and 249 mt respectively. As for other citrus fruit crop, cropped area (970 ha), productive area (402 ha), production (2,836 mt) was recorded the highest in Province 1 where as productivity of (7.05 mt/ha) have been noted. The highest productivity was noted from Gandaki Province 5 (8.96 mt/ha), whereas the lowest productivity (6.62 mt/ha) was recorded from Karnali Province.

Table 3: Total area, total productive area, total production and productivity of different citrus species in different province of Nepal (2019/20)

Province	Crop	Area (ha)	Productive Area (ha)	Production (ton)	Yield (t/ha)
Province No.1	Mandarin	5,996	3,603	39,369	10.93
Madhesh Pradesh	Mandarin	-	-	-	-
Bagmati Pradesh	Mandarin	4,348	2,478	23,130	9.34
Gandaki Pradesh	Mandarin	7,795	3,534	39,226	11.1
Lumbini Pradesh	Mandarin	3,089	1,791	20,507	11.45
Karnali Pradesh	Mandarin	3,617	2,118	23,240	10.97
Sudurpashchim Pradesh	Mandarin	1,746	1,027	10,708	10.43
Total	Mandarin	26,591.00	14,551.00	156,180.00	10.73
Province No.1	Sweet orange	837	649	6,181	9
Madhesh Pradesh	Sweet orange	-	-	-	-
Bagmati Pradesh	Sweet orange	2,902	1,789	24,622	13.76
Gandaki Pradesh	Sweet orange	844	559	4,741	8.48
Lumbini Pradesh	Sweet orange	465	375	4,092	10.91
Karnali Pradesh	Sweet orange	177	97	920	9.47
Sudurpashchim Pradesh	Sweet orange	1,384	793	8,815	11.12
Total	Sweet orange	6,609.00	4,262.00	49,371.00	11.58
Province No.1	Lime	3,334	2,450	21,594	8.81
Madhesh Pradesh	Lime	43	28	174	6.16
Bagmati Pradesh	Lime	1,277	812	6,434	7.92
Gandaki Pradesh	Lime	748	444	6,096	13.74
Lumbini Pradesh	Lime	2,012	1,153	7,649	6.63
Karnali Pradesh	Lime	546	235	1,415	6.03
Sudurpashchim Pradesh	Lime	627	323	2,755	8.52
Total	Lime	8,587.00	5,445.00	46,117.00	8.47
Province No.1	Lemon	502	301	2,188	7.28
Madhesh Pradesh	Lemon	-	-	-	-
Bagmati Pradesh	Lemon	724	548	4,642	8.48
Gandaki Pradesh	Lemon	130	94	898	9.51
Lumbini Pradesh	Lemon	44	29	249	8.59
Karnali Pradesh	Lemon	208	126	989	7.87
Sudurpashchim Pradesh	Lemon	695	391	2,830	7.23
Total	Lemon	2,303.00	1,489.00	11,796.00	7.92
Province No.1	Others	970	402	2836	7.05
Madhesh Pradesh	Others	-	-	-	-
Bagmati Pradesh	Others	559	462	3429	7.42
Gandaki Pradesh	Others	191	131	1175	8.96
Lumbini Pradesh	Others	814	542	2864	5.28
Karnali Pradesh	Others	16	10	68	6.62
Sudurpashchim Pradesh	Others	74	45	305	6.76
Total	Others	2,624.00	1,592.00	10,677.00	6.7

Source: MoALD, Nepal, 2021

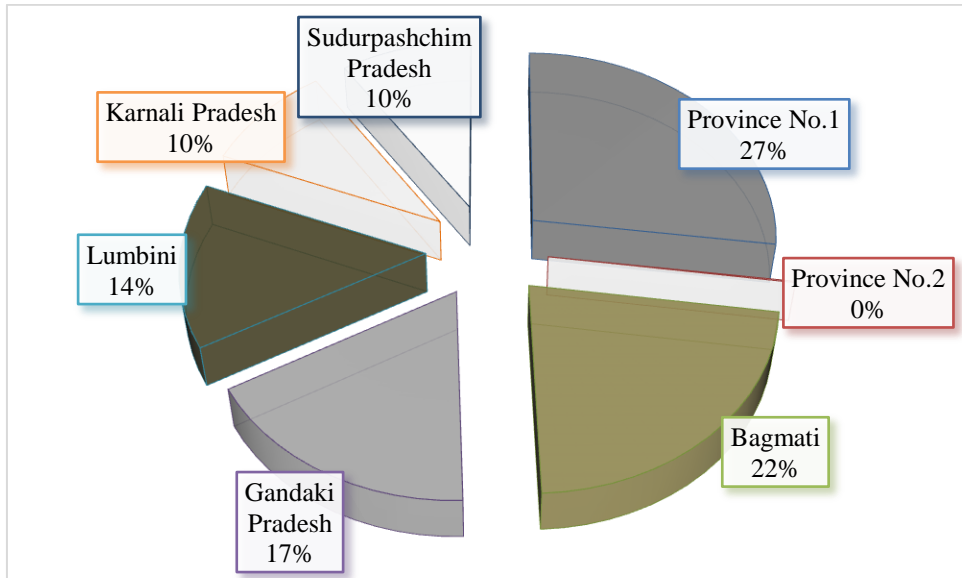


Figure 3: Total production of citrus in seven provinces during 2019/20

The pie-chart shows the status of citrus fruit production of the seven provinces of Nepal. Out of total citrus production; i.e. 274138 mt, Province 1 contributes maximum (27%) citrus production with total production of 72167 mt followed by Bagmati (62257 mt) and Gandaki province (52136 mt). There is very negligible production from citrus crops in Madhesh Province (174 mt). Citrus crops share about 28% 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 to 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 is an important subsector of Horticulture for raising economy of Nepalese farmers. Because of appropriate geography and climate, citrus is grown throughout the mid-hills (800-1400 masl) from east to west across the country. Moreover, the government of Nepal has recognized it as potential crop for income and employment generation through import substitution and export promotion.

Taking the importance of this sector into account, government of Nepal had initially established Citrus Research Station, Paripatle in 1961 (2018 B.S.). Then, it has been recognized as National Citrus Research Programme (NCRP) in 2000 (2057 B.S) under NARC with the national mandate of conducting citrus research and studies and producing & distributing healthy saplings of various citrus species. Located at Dhankuta-10, Paripatle of Dhankuta district between 27°1' north latitude and 87°18' east longitudes with the elevation of 900-1,390 masl, the research farm occupies 20 ha area with south-east aspect. It is situated at about 8 kilometers in north-west direction from Dhankuta district headquarters in the eastern region of Nepal.

The research farm extending on 20 ha of terrace land, most of area is occupied by production orchard of major citrus species including mandarin, sweet orange and acid lime. A field gene bank has been maintained for conserving exotic as well as local citrus genotypes. Similarly, on-station varietal research plots occupy larger portion of the farm. The NCRP has seven screen houses, where mother plants of promising varieties of mandarin, sweet orange, kinnow and acid lime are maintained. It has a separate nursery block extending on three hectare, where research activities related with plant propagation and nursery production are carried out. Other infrastructures include tissue culture lab, agronomy lab and cellar store, irrigation canal and ponds. Under these narrow facilities including limited human resources, the programme has given thrust on variety improvement and selection, crop husbandry, citrus decline management, nursery management and plant propagation, citrus pest management, tissue culture for nursery production, high density planting and postharvest studies.

2.2 Goal

Contribute to increase productivity and quality production of citrus fruit crops through use of modern technologies.

2.3 Purpose

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

2.4 Objectives

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

2.5 Strategies

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

2.6 Responsibilities

1. Identify problems and needs of citrus sector for setting up the research areas
2. Develop appropriate technologies on different aspects of citrus fruit crops
3. Genetic resources conservation and utilization
4. Mother plant maintenance and nursery plant production
5. Out-scaling of technologies for wider impact
6. Coordinate with other national and international organizations for collaborative research and studies
7. Publications and documentation
8. Provide technical and consultancy services to the clients

2.7 Prioritized Research for upcoming years

- Integrated approach to combat citrus decline
- 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 control
- Water use efficiency
- *In-vitro* technology for healthy propagation
- Citrus based farming system
- Socio-economic studies

2.8 Infrastructure and resources

National Citrus Research Programme (NCRP), initially established in 1961 (2018 B.S.) as Citrus Research Station, is the commodity research programs under the Nepal Agricultural Research Council (NARC) since 2000 (2057 B.S) with mandate of technology generation on citrus fruit crops at national level. NCRP has 20 ha of farm area including forest and ditch areas.

The production block of mandarin and sweet orange comprising of Khoku local and Dhankuta local varieties respectively, occupy larger area of the farmland. There are five separate blocks for varietal research of mandarin, sweet orange, acid lime, rootstock species and hybrid mandarin around the farm. Likewise, a field gene-bank is maintained for in-situ conservation of citrus species. Furthermore, a block is also established for demonstrating the released acid lime varieties including other promising lines.

For nursery propagation and research, the farm has an isolated nursery segment expanding in two-hectare area accommodating seven screen house and ne hi-tech nursery house and more than forty nursery beds where mother-plants for various citrus species are planted. Similarly, there is well-equipped tissue culture laboratory including general laboratory-building and two glasshouses. Several irrigation ponds are set up across the farmland while one seven-hundred-meter-long pipe-fitted canal was established for irrigation.

2.9 Organization structure and human resource

NCRP is mainly constrained with a shortage of human resources for many years. Currently, the national mandated programme is working with a small team of human resource comprised of one senior scientist (1 Horticulture), one technical officer, four support staffs and one administrative and one account staff. Thus, it seems an urgent need to fulfill the vacant positions approved by the council. The detail of the working human resource in fiscal year 2077/78 is depicted in Annex 3.

3. RESEARCH HIGHLIGHTS

3.1 VARIETAL RESEARCH

The existing varieties of citrus species have low yield potential with short production period in Nepal. A great genetic diversity exists among citrus species across the country for the fruit characteristics. However, almost all varieties of mandarin, sweet orange and acid lime have the same harvesting period that the production of these species is limited to October to January. Therefore, appropriate varieties alternative to these varieties for expanding the production period are necessary in Nepal.

NCRP, Dhankuta has introduced several exotic varieties of mandarin, sweet orange and acid lime including elite local cultivars in different periods. The performance of these genotypes has been studied for last few years in order to select and determine the appropriate varieties in different specific agro-climates.

3.1.1 FIELD GENE BANK

Collection and maintenance of genotypes is an important thrust of National Citrus Research Program. A total of 144 citrus genotypes have been collected from local and exotic sources during different periods since 2001. These are preserved at field gene bank of NCRP, Paripatle, Dhankuta. These species includes 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 mandarin, 6 sweet orange, 4 grapefruit, 3 tangor, 3 tangelo, and 7 rootstock varieties were introduced from France with the support of Prf. Joseph Bove of French National Institute for Agriculture Research (INRA), CIRAD. Similarly, three dwarf varieties of Unshiu mandarin were introduced from 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 orange 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 (Annex 1). 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.

3.1.2. VARIETAL EVALUATION

3.1.2.1 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 period of year.

Thus, NCRP has continued the study on the 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 19 varieties introduced from abroad and local sources have been evaluated since 2063/64.

Fruit physical parameters and yield attributing characteristics of mandarin orange

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

Fruit weight (g)

Fruit weight was found statistically significant and varying from 81.2 g to 206 g with mean value of 109.64 g. The highest fruit weight was found in Fortune (206 g) followed by Kara (169 g), Satsuma Mino (164) and Page (158 g). The lowest fruit weight was found in Okitsuwase (81.2 g) followed by Okitsu and Marisol (86.7 g).

Fruit diameter (mm)

Fruit diameter was found statistically different and ranged from 51.9 mm to 82.5 mm with mean value of 62.49 mm. The highest fruit diameter was found in Kara (82.5 mm) followed by Fortune (79.8 mm) and Satsuma Mino (76.3 mm). The lowest fruit diameter was found in Okitsuwase (51.9 mm) followed by Avana (54.7 mm).

Fruit rind thickness (mm)

Fruit rind thickness was found non-significantly different and ranged from 1.56 mm to 3.05 mm with mean value of 2.23 mm. The highest fruit rind thickness was found in Orval and Satsuma URSS (3.05 mm) followed by Commune (2.88 mm). The lowest rind thickness was found in Okitsuwase and Dancy (1.56 mm) followed by Page (1.79 mm).

Fruit rind weight (g)

Fruit rind weight was found non-significantly varying and ranged from 17.2 g to 42.9 g with mean value 27.79 g. The highest fruit rind weight was found in Satsuma Mino (42.9 g) followed by Kara (38.8 g). The lowest fruit rind weight was found in Okitsu (17.2g) followed by Okitsuwase (18.2 g).

Number of segments

The number of segments per fruit was found non-significantly different and ranged from 7 to 12.8 with mean value of 10.29. The maximum number of segments per fruit was found in Okitsu (12.8) followed by Sikkime (11.8) and Satsuma Mino (11.2). The minimum number of segments per fruit was found in Oraval (7) followed by Marisol (8.4) and Hamandina (8.6).

Number of seeds per fruit

Number of seeds per fruit was found varying from 0 to 18 with mean value 8.42. The maximum number of seeds per fruit was found in Frutrel Page (18.0) followed by Nova (12.8) and Dancy (12.4). The lowest number of seeds per fruit was found in Miyagawawase Unshiu (0) followed by Okitsuwase (0) and Satsuma Okitsu (0).

Total fruit yield per hectare

The total fruit yield per tree was found significantly different and ranged from 1.41 t/ha to 49.2 t/ha with mean value of 16.66 t/ha. The highest fruit yield was found in Marisol (49.2 t/ha) followed by Banskhark (40.9 t/ha) and Dancy (33.6 t/ha). The lowest fruit yield was found in Commune (1.41 t/ha) followed by Satsumawase (4.42 t/ha) and Page (5.27 t/ha).

Physio –chemical properties of mandarin

Physico-chemical properties of mandarin like juice quantity, TA %, DA meter reading and citrus color index (CCI) were found significantly different at harvest among the genotypes (Table 5). 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.

Table 4: Fruit physical parameters and yield attributing characteristics of mandarin at NCRP in 2021/2022

Genotypes	Fruit weight (g)	Fruit diameter (mm)	Fruit rind thickness (mm)	Fruit rind weight (g)	No. of segments	No of seed/ fruit	Yield/ hectare (t/ha)
Avana	75.6	54.7	2.22	17.6	10.6	9	21.2
Baskharka	96.5	60.8	2.4	29.4	10	9.8	40.9
Commune	112	61.2	2.88	34	9.2	6.8	1.77
Fortune	206	79.8	1.86	37.9	10.8	10.4	7.4
Harnandina	100	59.9	1.97	26.7	8.6	11	25
Kara	169	82.5	2.23	38.8	10.8	16	1.41
Khoku	125	67.4	2.54	36.1	10.4	8.8	28.1
Nova	143	67.7	2.57	31.8	11	12.8	17.9
Nules	111	62.6	2.24	35.4	8.8	5	6.59
Okitsu	86.7	61.7	1.96	17.2	12.8	0	11.1
Okitsuwase	81.2	51.9	1.56	18.2	11.4	0	7.78
Orval	94.2	63	3.05	32.5	7	8.8	13.7
Page	158	69.1	1.79	30.4	10.4	18	5.27
Pongan	127	64.7	2.44	35.2	11.4	9.6	13.4
Sasumawase	106	66.2	2.24	28.9	10.6	0	4.42
Satsuma mino	164	76.3	2.34	42.9	11.2	1	18.6
Sikkime	101	62.8	2.52	30.9	11.8	11	5.44
URSS	137	72.2	3.05	38.5	10	4	24.4
Dancy	93.4	58.5	1.56	20	9	12.4	33.6
Marisol	86.7	59.2	2.82	20.6	8.4	4	49.2
Miyagawase	99.8	59.5	1.89	19.6	11.4	0	16.3
Grand Mean	109.64	62.49	2.23	27.79	10.29	8.42	16.66
P Value	*	*	NS	NS	NS	NS	***
CV%	22.55	10.29	19.23	25.52	10.6	44.61	6.5
LSD	34.76	9.04	-	-	-	-	14.81

Juice percent

Juice percent was found significantly different among tested genotypes and ranged between 26.49% to 61.59% with mean value 45.41%. The highest juice quantity was found in Satsuma Mino (61.59%) followed by Okitsuwase (58.87%) and Miyagawawase Unshiu (58.72%). The lowest juice quantity was found in Nules (26.49%) followed by Sikkime (35.45%) and Dancy (38.58%).

Total soluble Solids (TSS %)

TSS % was found non-significantly different among the tested genotypes and varied from 6.94 % to 11.5% with mean value 9.71 %. The highest TSS % was found in Khoku (11.5%) followed by Page (11.4%) and Nules (11.2%). The lowest TSS % was found in in genotype Satsumawase (6.94 %) followed by Satsuma Mino (7.14%).

Titration acid (TA %)

Among the tested genotypes TA% was found non-significantly different and ranged from 0.83% to 3.2% with mean value 1.32%. The TA % was remarkably high in Nules (3.2%). Other genotypes with higher percentage of TA were Kara (2.87%) followed by Fortune (1.73%). Marisol (0.83%) recorded significantly the lowest TA%. Other genotypes with lower values of TA% were Satsuma URSS (0.85%), Satsuma Mino (0.87%) and Okitsuwase (0.89%).

pH

The pH was found varying from 1.1 to 4.34 with mean value of 3.36. The highest pH was observed in Nules (4.34) followed by Pongan (4.08) and Okitsuwase (3.89). The lowest pH recorded was in Miyagawawase (2.1) followed by Harnandina (2.86) and Page (2.96).

DA (chlorophyll) reading:

The decline in chlorophyll content of the fruit skin, measured on the tree by DA meter (Table 5) showed significantly different among the genotypes at harvest time. The value ranges from 0.002 to 0.412 with the mean value of 0.1. Minimum of DA reading (0.002) was recorded in Avana followed by Kara (0.012) and Orval (0.06) whereas, Nova (0.412) followed by Pongan (0.396) were recorded with maximum DA value among the genotypes (Table 5).

Citrus Color Index (CCI):

The CCI value for tested mandarin genotypes were non-significantly different with each other. Higher the CCI value means no uniform orange color development. The CCI value of the fruit ranged from 16.3 to 5.4 with the mean value of 9.64. Minimum CCI was recorded in Satsuma Okitsu followed by Satsuma Miyagawawase (5.54) and maximum was in Commune (16.3) followed by Nova (13.9).

Table 5: Physio–chemical properties of mandarin orange genotypes at NCRP in 2021/2022

Genotypes	Juice volume (%)	TSS(%)	TA %	pH	DA meter reading	Citrus Color Index (CCI)
Avana	49.21	11.2	1.39	3.14	0.002	10
Baskharka	44.77	10.5	1.15	3.44	0.164	9.6
Commune	35.18	10.4	1.29	4.06	0.09	16.3
Fortune	53.88	10.6	1.73	3.14	0.33	12.4
Harnandina	30.80	11.2	1.68	2.86	0.038	11.9
Kara	57.28	10.8	2.87	3.48	0.012	10.2
Khoku	42.88	11.5	1.33	3.36	0.294	9.5
Nova	43.36	9.48	1.36	3.84	0.412	13.9
Nules	26.49	11	3.2	4.34	0.214	11.4
Okitsu	52.13	9.38	1.22	3.15	0.138	8.7
Okitsuwase	58.87	7.9	0.892	3.89	0.296	5.7
Orval	43.31	9.9	1.44	3.64	0.062	10.3
Page	40.76	11.4	1.42	2.96	0.012	12.6
Pongan	35.91	10.8	1.35	4.08	0.396	9.8
Sasumawase	52.45	6.94	1.24	3.4	0.22	5.3
Satsuma mino	61.59	7.14	0.872	3.31	0.166	8.4
Sikkime	35.45	10.2	1.26	3.42	0.222	9.5
URSS	49.05	7.44	0.848	3.26	0.35	5.4
Dancy	38.54	10.1	1.21	3.24	0.074	12
Marisol	42.91	8.4	0.83	3.87	0.47	8.1
Miyagawase	58.72	7.42	1.08	2.1	0.194	5.4
Grand Mean	45.41	9.71	1.32	3.36	0.19	9.64
P Value	**	NS	NS	NS	NS	NS
CV%	25.36	15.19	40.41	16.31	68.01	31.49
LSD	1.02	2.07	0.75	0.77	0.19	4.26

3.1.2.2 SWEET ORANGE

Sweet orange (*Citrus sinensis* Osbeck) is the second most important citrus fruit after mandarin in Nepal. The major sweet orange growing districts include: Dhankuta, Khotang, Sindhuli, Parbat, Palpa and Dadeldhura.

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 has been continued including 23 exotic and local varieties 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 number of seeds/fruit, number of fruits/tree and fruit yield/ hectare were statistically different due to the effect of different genotypes of sweet orange (Table 6).

Individual fruit weight (g)

The data in Table 6 shows that the individual fruit weight was statistically non-significant among the tested genotypes. Fruit weight was varied from 95.9 g to 196 g with the mean value of 139.13g. Lane late (196 g), Washington Navel (188g) and Cara Cara Navel (205g) had the biggest individual fruit sizes. Lower individual fruit sizes were recorded in Blood red (95.6 g) followed by Navelencia (115g) and Delicious Seedless (116g).

Fruit diameter (mm)

Individual fruit diameter was non-significantly different and ranged between 57.5 mm to 72.0mm with the mean diameter of 63.3 mm. The smallest fruit diameter was observed in LeuGim Gong (57.7mm) followed by Blood Red (58.7mm) and Tamango (58.3mm). The biggest fruit diameter was observed in Lane Late (72.0 mm) followed by Washington Navel (71.0 mm).

Fruit rind thickness (mm)

Fruit rind thickness of the tested genotypes varied significantly and ranged between 2.75mm to 4.25mm with the mean thickness of 3.6mm. The thinnest rind was found in Sevelle common (2.75mm) followed by Navelencia (2.77mm). The thickest rind was found in Malta Blood Red (4.25mm) followed by Washington Navel (4.12 mm).

Fruit rind weight (gm)

The rind weight differed significantly among the tested genotypes and ranged between 62.4gm to 136gm with mean value 93.06gm. Washington Navel (136g) gave the most fruit rind weight followed by Lane Late (133g) and Cara Cara Novel (121g). Lower fruit rind weights were observed in Blood Red (62.4g), LeuGim Gong (69.7 g) and Delicious Seedless (74.9 g).

Number of seeds per fruit

The number of seeds per fruit differed highly significant among tested genotypes and ranged from 1.5 to 14.8 with the mean value of 7. Malta Blood Red (14.8) had the highest number of seeds per fruit followed by Succari (13.6). In contrast, number of seeds per fruit was found minimum with Lane late (1.5) followed by Washington Navel (1.9).

Fruit number per tree

The number of fruits/plant was significantly different and ranged from 26 to 391 with the mean value of 1467. Salustiana (391) recorded the highest number of fruit/plant followed by Valencia late (379) and Tamango (214). Genotype like LeuGim Gong (26) Navelencia (33.5), Bood Red (40) and Cara Cara Navel (61) were found to produce significantly lower number of fruits per plant.

Fruit yield per hectare

The difference in total weight of fruit/hectare was highly significant among the tested genotypes and ranged between 3.02t/ha and 45.2 t/ha with a mean value of 16.85 t/ha. Valencia late (45.2) gave the highest yield/ha followed by Salustiana (39.3 t/ha) and Tamango (20.1 t/ha). Luegim Gong (3.02 t/ha) produced the least fruit yield per hectare followed by Navelencia (3.02 t/ha) and Blood Red (3.19t/ha).

Table 6: Fruit characteristics of different sweet orange genotypes at NCRP in 2020/2021

Genotypes	Fruit weight (g)	Fruit diameter (mm)	Fruit rind thickness (mm)	Fruit rind weight (g)	No. of seed/ fruit	No of fruit/ tree	Fruit yield (t/ha)
Sevelle Common	128	61.2	2.75	84.2	3.70	110	11.9
Navelencia	115	60.3	2.77	79.2	2.50	33.5	3.02
Malta Blood Red	165	68.7	4.25	108	14.8	98.4	14.7
White Tanker	117	59.6	3.38	77.6	10.1	-	-
Washinton Navel	188	71.0	4.12	136	1.90	64.0	11.9
Hamlin	125	60.9	3.22	83.8	9.13	64.0	7.20
Delicious Seedless	116	59.1	3.01	74.9	4.33	96.7	10.2
Blood Red	95.9	58.7	3.33	62.4	7.20	40.0	3.19
Succari	132	63.1	3.54	90.5	13.6	102	12.1
Dhankuta Local	123	63.4	3.44	79.0	14.1	204	23.2
LueGim Gong	119	57.7	3.69	69.7	5.95	26.0	3.02
Cara Cara Navel	175	67.4	3.64	121	2.11	61.3	7.90
Lane Late	196	72.0	4.02	133	1.50	105	15.2
Pineapple	129	61.8	3.80	93.2	11.2	180	19.0
Valencia Late	120	58.9	3.92	79.7	2.18	379	45.2
Salustiana	137	64.6	2.91	89.5	2.40	391	39.3
Tamango	118	58.3	3.84	73.8	4.12	214	20.1
Grand Mean	139.13	63.32	3.6	93.06	7	146.68	16.85
P Value	NS	NS	NS	NS	***	***	***
C.V %	2.86	1.09	1.76	3.18	8.4	10.69	10.58
LSD	-	-	-	-	6.5	177.3	20.15

Physiochemical properties of different genotypes of sweet orange

Physico-chemical properties of sweet orange like juice quantity, TA % and DA meter reading 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.

Fruit juice Volume (ml)

The volume of fruit juice was significantly different among test genotypes and ranged between 40ml to 58.2 ml with average value of 42.73ml. Lane late (58.2 ml) followed by Cara Cara Novel (64.1ml) and Malta Blood Red (51.1) was found to give the highest in juice volume. In contrary, Blood Red (27.8ml), Pineapple (32.8ml) and Navelencia (34.2 ml) produced the low fruit in juice volume (Table 8).

Juice Weight (%)

Fruit juice weight (%) ranged from 25.4% to 37.5% with an average fruit juice weight of 30.93%. The highest fruit juice weight (%) was recorded with genotype LeuGim Gong (37.5%) followed by Tamango (35.8%) and Dhankuta local (32.6%). Lower fruit juice weight (%) was found in genotype Pineapple (25.4%) followed by Washington Navel (26.7%) and Succari (29.1%).

Total soluble Solids % (TSS %)

Among the tested genotypes the percent TSS varied from 10.3% to 14.8% with the mean value of 10.92%. TSS% was found higher in Succari (14.8%) followed by Pineapple (11%) and Tamango (11%). Lower TSS% values were observed in Blood Red (10.3%) and Salustiana (10.4%).

Titration acid% (TA %)

Among the tested genotypes percent of TA ranged from 0.926% to 1.66% with mean value of 1.25%. The TA percent was remarkably high in Navelencia (1.66%) followed by Valencia Late (1.6%) and White Taker (1.57%). Cara Cara Navel (1.3%) recorded significantly the lowest TA followed by Dhankuta local (0.948%) and Pineapple (0.986%).

pH

The pH was found varying from 3.0 to 5.46 with average of 3.61. The highest pH was observed in Succari (5.46) followed by Washington Navel (5.02) and Lane Late (3.37). The lowest pH recorded was in Delectious Seedless (3.0) followed by Dhankuta local (3.02) and Malta Blood Red (3.18).

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 values ranges from 0 to 0.126 with mean of 0.03. Minimum of DA reading was recorded in Tamango, and Blood Red (0) whereas the LueGim Gong (0.126) followed by Sevelle Common (0.119) were recorded with maximum DA value among the genotypes.

Table 7: Physio-chemical properties of different sweet orange genotypes at NCRP in 2020/2021

Genotypes	Juice volume (ml)	Juice Wt (%)	TSS	TA	pH	DA meter reading
Sevelle Common	39.4	30.9	10.4	1.52	3.54	0.119
Navelencia	34.2	29.7	10.4	1.66	3.68	0.050
Malta Blood Red	51.1	31.1	10.9	1.37	3.18	0.0076
White Tanker	36.7	31.1	10.6	1.57	3.21	0.0055
Washinton Navel	50.1	26.7	10.5	1.33	5.02	0.147
Hamlin	38.3	30.6	10.8	1.14	3.39	0.010
Delicious Seedless	37.3	32.2	10.7	1.21	3.00	0.00133
Blood Red	27.8	29.0	10.3	1.36	3.24	0.000
Succari	38.3	29.1	14.8	1.16	5.46	0.0165
Dhankuta Local	40.0	32.6	10.9	0.986	3.04	0.004
LueGim Gong	45.1	37.5	10.4	1.36	3.33	0.126
Cara Cara Navel	54.4	31.3	10.7	0.923	3.52	0.00333
Lane Late	58.2	29.6	10.7	1.12	3.52	0.0676
Pineapple	32.8	25.4	11.0	0.948	3.58	0.0016
Valencia Late	36.2	30.3	10.5	1.60	3.58	0.0184
Salustiana	44.2	32.3	10.4	1.26	3.18	0.00604
Tamango	42.5	35.8	11.0	1.15	3.50	0.000
Grand Mean	42.73	30.93	10.92	1.25	3.61	0.03
P Value	NS	NS	NS	*	NS	*
C.V %	2.84	1.46	2.35	2.42	2.35	22.38
LSD	-	-	-	0.34	-	0.08

3.1.2.3 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.

Table 8: Fruit characteristics of different acid lime genotypes at NCRP in 2021/2022

Accession no.	Fruit wt (g)	Fruit diameter (mm)	Peel thickness (mm)	Peel wt (g)	No of seed
NCRP-46	45.1	41.5	1.49	28.4	6.2
NCRP-47	40.2	41.9	1.54	21.7	13.8
NCRP-48	41.1	41.8	1.58	20.7	9.4
Sunkagati-2	39.9	40.5	2.28	19.3	7.6
NCRP-51	54.5	44.3	1.65	29.3	9.6
NCRP-52	41.3	40.1	1.56	26.9	3.4
NCRP-53	139	64.3	3.11	89.3	-
Sunkagati-1	40.5	41.5	1.91	23.7	7.6
NCRP-56	45.8	42.9	2.16	24.8	10.4
NCRP-59	48.3	43.6	1.57	29.4	5.2
NCRP-60	58.1	44.1	3.11	40.2	11
Terthum Local	40.1	37.5	1.91	19.8	9.6
Grand Mean	53.17	44.22	2.0	31.98	7.69
P Value	NS	NS	NS	NS	NS
C.V %	11.19	3.23	6.81	13.37	7.67
LSD	-	-	-	-	-

Fruit characteristics and yield of different genotypes of sweet oranges

Fruit characteristics and yield attributes like individual fruit weight, fruit diameter, pulp weight, number of seeds/fruit, number of fruits/tree and fruit yield/ hectare were

statistically different due to the effect of different genotypes of sweet orange (Table 8 & 9).

Individual fruit weight (g)

The data in Table 8 shows that the individual fruit weight was statistically not different among the tested genotypes. Fruit weight was varied from 39.9g to 139g with the mean value of 53.17g. NCRP-53 (139 g) had the biggest individual fruit sizes. The smallest individual fruit sizes were recorded in Sunkagati-2 (39.9 g) followed by Terhthum Local (40.1 g).

Fruit diameter (mm)

Individual fruit diameter was non-significantly different and ranged between 37.5mm to 64.3 mm with the mean diameter of 44.22 mm. The smallest fruit diameter was observed in Terhthum Local (37.5 mm) followed by NCRP-52 (40.1 mm) and Sunkagati-2 (40.5 mm). The biggest fruit diameter was observed in NCRP-53 (64.3mm) followed by NCRP-51 (44.3mm).

Fruit peel thickness (mm)

Fruit peel thickness of the tested genotypes varied non-significantly and ranged between 1.49 mm to 3.11 mm with the mean thickness of 2.0 mm. The thinnest peel was found in NCRP-46 (1.49 mm) followed by NCRP-47 (1.57 mm). The thickest peel was found in NCRP-53 & NCRP 60 (3.11 mm) followed by Sunkagati-2 (2.28 mm).

Fruit peel weight (gm)

The peel weight differed non-significantly among the tested genotypes and ranged between 19.3 gm to 89.3 gm with mean value 39.18 gm. NCRP-53 (89.3g) gave the most fruit peel weight followed by NCRP-60 (60.3g). Lower fruit peel weights were observed in Sunkagati-2 (19.3 g) followed by Terthum Local (19.8 g).

Number of seeds per fruit

The number of seeds per fruit differed non-significantly among tested genotypes and ranged from 0.0 to 13.8 with the mean value of 7.69. NCRP-47 (13.8) had the highest number of seeds per fruit followed by NCRP-60 (11.0). In contrast, number of seeds per fruit was found minimum with NCRP-53 (0.0) followed by NCRP-52 (3.4).

Fruit number per tree

The number of fruits/plant was non-significantly different and ranged from 60 to 125 with the mean value of 87.6. Sunkagati-1 (125) recorded the highest number of fruit/plant followed by Terhthum Local (110) and NCRP-51 (110). Genotype like

NCRP-56 (60), NCRP-60 (75) and NCRP-52 (80) were found to produce lower number of fruits per plant.

Fruit yield per hectare

The difference in total weight of fruit/hectare was non-significant among the tested genotypes and ranged between 2.49 t/ha and 6.72 t/ha with a mean value of 4.02 t/ha. NCRP-51 (6.72) gave the highest yield/ha followed by NCRP-51 (5.14 t/ha) and Sunkagati-1 (5.07 t/ha). NCRP-56 (2.49 t/ha) produced the least fruit yield per hectare followed by NCRP-52 (3.12 t/ha) and Sunkagati-2 (3.31/ha).

Table 9: Physio-chemical properties of different acid lime genotypes at NCRP in 2021/2022

Accession no.	Juice volume %	TA%	pH	DA meter	Fruit/tree	Yield (t/ha)
NCRP-46	33.5	8.19	2.32	0.284	91	4.06
NCRP-47	42.4	7.83	2.62	0.608	90	4.01
NCRP-48	43.0	7.19	2.50	0.434	85	3.68
Sunkagati-2	48.6	8.14	2.36	0.496	85	3.31
NCRP-51	47.2	7.64	2.70	0.244	110	6.72
NCRP-52	31.9	8.16	2.48	0.244	80	3.12
NCRP-53	30.1	6.88	2.96	0.070	92	4.60
Sunkagati-1	44.0	7.93	2.42	0.208	125	5.07
NCRP-56	41.8	7.79	2.30	0.252	60	2.49
NCRP-59	38.5	7.83	2.56	0.380	105	5.14
NCRP-60	20.0	7.4	2.60	0.390	75	4.74
Terhthum Local	42.6	7.52	2.18	0.402	110	4.67
Mean	39.07	7.77	2.52	0.35	87.59	4.02
P Value	NS	NS	*	*	NS	NS
C.V %	4.29	1.29	1.65	8.43	5.42	5.51
LSD	12.21	0.73	0.3	0.22	34.59	1.61

Titration acid% (TA %)

Among the tested genotypes percent of TA ranged from 6.88% to 8.19% with mean value of 7.77%. The TA percent was remarkably high in NCRP-46 (8.19%) followed by NCRP-52 (8.16%) and Sunkagati-2 (8.14%). NCRP-53 (6.88%) recorded the lowest TA followed by NCRP-48 (7.19%) and NCRP-60 (7.4%).

pH

The pH was found varying from 2.18 to 2.96 with average of 2.52. The highest pH was observed in NCRP-53(2.96) followed by NCRP-51 (2.70) and NCRP-60 (2.60). The

lowest pH recorded was in Terhthum Local (2.18) followed by NCRP-56 (2.32) and Sunkagati-2 (2.36).

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 values ranges from 0.07 to 0.608 with average of 0.35. Minimum of DA reading was recorded in NCRP -53 (0.07) followed by Sunkagati 1 (0.208) whereas the NCRP-60 (0.608) (0.048) followed by Sunkagati-2 (0.496) were recorded with maximum DA value among the genotypes.

3.1.2.4 GRAPEFRUIT AND TANGELO

There are five accessions of grapefruit and three accessions of tangelo under bearing stage and are presented in the Table 10, 11 and Table 12, 13 respectively.

Table 10: Fruit physical parameters and yield attributing characteristics of grapefruit genotypes at NCRP in 2078/79

Variety	Fruit wt. (g)	Peel thickness (mm)	Pulp wt. (g)	Fruit diameter (mm)	No. of seed/fruit	Juice volume per fruit (ml)	Fruit number/ tree	Fruit yield/tree (g)
Shamber	262±20.7	6.4±0.39	180±16.4	85.1±1.8	0	70.9±8.11	106	18.5
Henderson	241±12.9	4.04±0.13	149±8.01	83.5±1.29	4.05±0.42	83.5±4.54	105	16.03
Star Ruby	220±19.1	4.47±0.19	139±10.5	77.6±2.35	4.3±0.47	73.3±7.68	50	87.95
Reed	934±108	5.49±0.95	636±78.9	125±5.79	29.7±11.6	274±29.7	10	7.30
Pink Rubi	266±23.8	5.6±0.23	176±15.7	85.2±2.09	3.4±0.82	82.4±9.28	110	23.60

Table 11: Physico-chemical properties of grapefruit genotypes at NCRP in 2078/79

Variety	Juice wt. (g)	TSS%	TA%	pH	DA meter reading	Citrus Color Index (CCI)
Shamber	75.6±8.07	9.65±0.611	2.99±0.12	2.56±0.03	0.098±0.03	1.64±0.13
Henderson	83.2±4.34	9.78±0.147	2.97±0.08	2.46±0.01	0.127±0.02	3.01±0.26
Star Ruby	73.4±7.77	10.4±0.183	3.51±0.11	2.44±0.02	0.125±0.05	3.88±0.13
Reed	278±29.3	11.9±0.249	2.74±0.29	2.76±0.04	0.078±0.06	1.9±0.27
Pink Rubi	82.9±9.21	8.44±0.555	2.81±0.15	2.66±0.03	0.371±0.09	2.42±0.12

Table 12: Fruit physical parameters and yield attributing characteristics of tangelo genotypes at NCRP in 2078/79

Variety	Fruit wt (g)	Peel thickness (mm)	Pulp wt. (g)	Fruit diameter mm	Seed/fruit	Juice volume per fruit (ml)	Fruit number/tree	Fruit yield/tree (g)
Minneola	154±11.3	2.84±0.08	33.7±1.86	65.9±1.87	11.5±1.29	60±4.9	112	11210
Oriando	80.4±7.17	2.99±0.09	23.5±1.85	56.3±2.07	5.6±1.44	25.4±2.11	21	1810
Seminole	150±8.6	2.24±0.19	34.7±3.53	66.1±0.81	11.6±2.86	70.6±3.31	20	2820

Table 13: Physico-chemical properties of tangelo genotypes at NCRP in 2078/79

Variety	Juice wt. (g)	Pal brix	TA	pH	DA meter reading	Citrus Color Index (CCI)
Minneola	60.6±4.94	10.1±0.232	2.02±0.10	2.96±0.03	0.0182±0.01	20±0.93
Oriando	25.7±2.15	9.86±0.273	2.05±0.09	2.88±0.19	0.012±0.01	13.8±0.95
Seminole	70.7±3.27	9.82±0.107	2.75±0.1	2.64±0.03	0.026±0.01	15.5±0.82

3.2 POST-HARVEST RESEARCH

3.2.1 Effect of different chemicals on enhancing storage life of acid lime (var. Terhathum Local) in cellar store and coolbot storage

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 1400 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 cultivations. Citrus crop are potential exportable commodities particularly to India and Bangladesh. Districts with more than 1000 ha area under cultivation are Taplejung, Terhathum, Dhankuta, Ramechhap, Sindhulli, Kavrepalanchowk, Lamjung, Syangja, Salyan and Dailekh.

Citrus production and international trade in fresh citrus has increased manifold during the last decade. World citrus production is around 73.3 million metric tons, with Brazil being largest producer, while European Union being the largest importer of citrus (Anonymous, 2004; FAO, 2003). Although citrus production in many citrus growing countries has increased, the overall profitability of the industry in developing countries has been limited by high postharvest losses due to lack and/or use of proper postharvest handling system of fresh fruit. From sustainability and economic perspectives, there will be less investment needed to improve the situation through better postharvest

management of the existing produce and the production areas to compensate for these losses (Kader, 2002).

Methodology

The experiment was carried out to identify suitable chemicals and plastic holes that enhance storage life of acid lime (var.Terhathum Local) at NCRP, Paripatle, Dhankuta beginning from the fiscal year 2078/79. Cellar store house and coolbot constructed at NCRP were used for the experiment. The experiment was carried out in completely randomized block design and was given ten treatments and replicated thrice.

The treatments given are stated below:

T1: Wax + calcium chloride 2%

T2: Wax + calcium chloride 4%

T3: No wax + calcium chloride 2%

T4: No wax + calcium chloride 2%

T5: Control (wax dipping)

T6:Control (no wax dipping)

T7: 4 pin holes plastic packaging, no wax + calcium chloride 2%

T8: 4 pin holes plastic packaging, no wax + calcium chloride 4%

T9: 4 pin holes plastic packaging, wax + calcium chloride 2%

T10: 4 pin holes plastic packaging, wax + calcium chloride 4%

The observations were taken on one week interval for 12 times on physical and chemical parameters like Physiological weight loss percentage (PLW%), fruit weight, fruit diameter, juice volume, no of seed, peel weight, peel thickness, TSS and TA. The storage condition was more than 85% RH and temperature ranged from 10-12°C.

Result and Discussion

The experiment was carried out to identify suitable chemicals and plastic holes that enhance storage life of acid lime (var.Terhathum Local) at NCRP, Paripatle, Dhankuta beginning from the fiscal year 2078/79. All the treated fruits were stored in cellar and coolbot store for 90 days and observation on different parameters were taken 12 times on one week interval. 90 fruits were initially taken for each treatment and subjected to observation on one week interval for all parameters.

Table 14: Effect of postharvest treatments on physiological loss weight percentage (%) of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Week	1	2	3	4	5	6	7	8	9	10	11
Wax + Calcium chloride 2%	2.2	11.8	38.3	36.1	14.5	13.1	17.5	20.3	26.1	35.2	50.6
Wax + Calcium chloride 4%	6.89	17.7	14.1	20.4	26.9	29.2	32.9	44	75.5	100	
No wax + Calcium Chloride 2%	2.17	8.32	11.4	11.7	13.2	14.3	15.7	20.2	23.2	31.1	41.1
No wax + Calcium Chloride 4%	4.82	12.5	12	20.5	23	24	33.8	37.5	59.3	51.9	100
Wax dipping	10.2	36.6	24.8	30.4	35.5	65.8	67.2	43.2	64	100	
Control : No wax dipping	2.04	10.4	10.4	12.8	14.7	20.7	17.7	19.8	27.4	32.3	49.8
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	1.12	8.38	10.1	11	12.7	14.2	14.4	17.4	20.5	28.7	34.1
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	8.76	16.8	16.9	24	27.3	35	51.8	38.2	48.1	85.7	100
4 Pin hole plastic packaging, wax, Calcium chloride 2%	2.91	9.9	11.8	14.3	11.8	20.6	18.2	23.9	41.9	71	79.2
4 Pin hole plastic packaging, wax, Calcium chloride 4%	3.2	19.1	15.5	26.8	28.9	45.2	70	100			
Grand Mean	4.42	15.15	16.54	20.79	20.87	28.2	32.76	35.87	40.91	53.19	57.96
P value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	19.56	12.72	16.9	13.99	10.56	12.75	14.24	13.37	12.48	13.25	11.54
LSD	-	-	-	-	-	-	-	-	-	-	-

Table 14 illustrates that there were no any significant difference on physiological weight loss in percentage (PLW %). The maximum loss percentage was found in wax+ Calcium chloride 4% which was 100% in 10th weeks of storage. Similarly, the minimum loss percentage was found in 4 Pin holes plastic packaging, no wax + Calcium chloride 2% was 1.12 in first week of storage followed by Control, No wax dipping (2.04) in first week of storage in cellar store.

Table 15: Effect of postharvest treatments on juice volume percentage (%) of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Week	1	2	3	4	5	6	7	8	9	10	11
Wax + Calcium chloride 2%	32.8	37.9	31.9	40.7	34.9	37.7	37.2	35.2	41.2	40.1	36.2
Wax + Calcium chloride 4%	29.6	34.6	35.2	34.1	42.4	36.7	35.4	32.4	36.4		
No wax + Calcium Chloride 2%	31.7	33.3	37.4	35.2	37.7	38.4	38.5	35	38.1	44.2	43.2
No wax + Calcium Chloride 4%	36.3	37.2	32.7	39.4	39.8	38.8	37.8	34.9	40	43.7	
Wax dipping only	34.3	33.7	28	35.2	35	41.7	37.6	36.5	41		
Control : No wax dipping	34.5	37.3	37.2	37.8	45.9	39.6	43.4	34.8	42.1	41.8	42
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	33.8	34.5	38.8	40.7	43.7	37.6	36.3	34.4	38.4	38.4	39.3
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	38	34.9	33.9	38.7	31.6	34.3	35.5	36.5	42.8		
4 Pin hole plastic packaging, wax, Calcium chloride 2%	27.5	33.3	32.7	35.9	30.4	32.6	30.7	34.5	34.9	39.4	41.3
4 Pin hole plastic packaging, wax, Calcium chloride 4%	29.9	33.3	31	35.4	36.3	32.1	34.4				
Grand Mean	32.84	34.98	33.86	37.3	37.76	36.79	36.6	34.71	39.25	41.22	40.28
P value	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS
CV %	2.68	1.75	2.38	1.96	3.05	1.82	2.37	1.4	2.26	2.52	2.08
LSD	-	-	-	-	-	5.07	-	-	-	-	-

Table 15 illustrates that juice volume percentage (%) was found significantly ranging from 32.1 to 41.7 with mean value of 36.79 at 6th week and there was no any significant difference in other weeks among various treatments in any storage duration in cellar. Maximum juice volume percentage (%) was found in Control (No wax dipping) which was 45.9% followed by No wax + Calcium Chloride 2% which was 44.2% in 5th week and 10th weeks of storage respectively. Similarly, Minimum juice volume percentage (%) was found in 4 Pin holes plastic packaging, wax + Calcium chloride 2% which was 27.5% followed by Control (Wax dipping) which was 28% in first week and third weeks of storage respectively.

Table 16: Effect of postharvest treatments on TSS ($^{\circ}$ Brix) of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Week	1	2	3	4	5	6	7	8	9	10	11
Wax + Calcium chloride 2%	6.93	7.4	6.86	6.73	5.98	6.31	6.28	5.84	5.8	6.11	5.89
Wax + Calcium chloride 4%	7.33	6.97	6.69	6.83	6.43	5.94	6.4	5.61	6.27		
No wax + Calcium Chloride 2%	7.08	7.05	7.1	7	6.73	6.1	6.27	5.88	6.04	6.02	5.66
No wax + Calcium Chloride 4%	6.81	7.09	7	6.79	6.77	6.02	6.32	5.51	6.17	6.13	
Wax dipping only	7.03	6.95	6.63	6.43	6.69	6.24	4.8	5.53	5.45		
Control : No wax dipping	7.06	7.2	6.9	6.36	6.34	6.52	6.31	6.4	6.32	6.62	6.08
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	7.02	6.74	6.88	6.67	6.32	6.29	6.47	6.26	6.04	5.81	5.81
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	6.93	6.77	6.61	6.53	6.13	6.38	6.16	6.05	5.47		
4 Pin hole plastic packaging, wax, Calcium chloride 2%	6.86	6.62	6.66	6.68	6.34	6.56	5.87	6	5.8	6.53	5.9
4 Pin hole plastic packaging, wax, Calcium chloride 4%	6.59	6.83	6.41	6.49	6.47	6.62	6.09				
Grand Mean	6.96	6.96	6.77	6.65	6.42	6.3	6.18	5.92	5.96	6.2	5.86
P value	*	**	*	.	NS	**	*	*	NS	NS	NS
CV %	0.7	0.83	0.84	0.83	1.13	0.84	1.19	1.41	1.68	1.86	1.28
LSD	0.37	0.44	0.43	0.42	-	0.39	0.54	0.57	-	-	-

Table 16 illustrates that TSS was found highly significant in 2nd and 6th weeks having mean value 6.96 $^{\circ}$ Brix and 6.3 $^{\circ}$ Brix respectively. The TSS was found significant in first and third week of the storage. The maximum TSS $^{\circ}$ Brix was found in Wax + Calcium chloride 2% which was 7.4 $^{\circ}$ Brix in second week of storage followed by Wax + Calcium chloride 4% was 7.33 $^{\circ}$ Brix in first week of storage in cellar store. Similarly, the minimum TSS was found in control (Wax dipping) which was 4.8 $^{\circ}$ Brix followed by 5.45 $^{\circ}$ Brix at 7th and 9th weeks of the storage in cellar storage respectively.

Table 17: Effect of postharvest treatments on TA% of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/Week after storage	1	2	3	4	5	6	7	8	9	10	11
Wax + Calcium chloride 2%	7.24	6.69	6.44	6.63	4.27	7.03	6.25	7.02	6.61	7.07	7.05
Wax + Calcium chloride 4%	6.87	6.29	6.34	7.2	7.12	6.73	6.42	5.89	7.43		
No wax + Calcium Chloride 2%	7.16	6.92	7.27	7.15	6.88	7.01	6.39	6.77	6.71	6.93	6.75
No wax + Calcium Chloride 4%	6.76	7.29	7.2	7.21	7.06	6.42	6.33	6.37	6.5	6.62	
Control : Wax dipping	6.71	6.59	6.8	6.55	6.63	6.56	4.93	7	6.63		
Control : No wax dipping	7.4	6.93	6.75	6.27	6.49	6.59	6.58	7.4	7.67	7.58	6.16
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	7.09	6.92	7.07	6.45	6.54	6.27	6.48	7.62	6.77	7.28	6.72
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	6.94	7.03	6.91	6.33	6.47	6.68	6.17	6.72	5.97		
4 Pin hole plastic packaging, wax, Calcium chloride 2%	7.2	6.83	7.79	6.48	6.72	6.58	6.16	7.35	6.35	7.32	6.86
4 Pin hole plastic packaging, wax, Calcium chloride 4%	6.81	6.58	7.32	6.55	6.76	6.66	6.48				
Grand Mean	7.01	6.8	6.98	6.68	6.49	6.65	6.31	6.9	6.76	7.16	6.68
P value	NS	NS	**	**	NS	.	NS	*	NS	NS	NS
CV %	1.06	1.12	1.16	1.16	2.79	0.92	1.19	1.99	2.22	1.7	2.75
LSD	-	-	0.62	0.59	-	0.46	-	0.94	-	-	-

Table 17 illustrates that TA % was found highly significant in 3rd and 4th weeks having mean value 6.98% and 6.68% respectively. The TA % was found less significant in 8th weeks of the storage. The maximum TA % was found in 4 Pin hole plastic packaging, wax+ Calcium chloride 2% which was 7.79% in third week of storage followed by Control (No wax dipping) was 7.67% in 9th weeks of storage in cellar store. Similarly, the minimum TA % was found in Wax + Calcium chloride 2% which was 4.27% in 5th weeks of the storage followed by Wax + Calcium chloride 4% was 5.89% at 8th weeks of the storage in cellar storage respectively.

Table 18: Effect of postharvest treatments on pH of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Weeks after storage	1	2	3	4	5	6	7	8	9	10	11
Wax + Calcium chloride 2%	2.9	2.93	2.93	3.06	3.1	2.5	2.47	3	2.91	2.88	2.69
Wax + Calcium chloride 4%	2.96	2.93	2.92	3.03	3	2.5	2.56	3	2.75		
No wax + Calcium Chloride 2%	2.92	2.91	2.92	3.03	2.9	2.5	2.7	3	2.76	2.83	2.56
No wax + Calcium Chloride 4%	2.89	2.87	2.85	3.03	2.9	2.6	2.49	3	2.77	2.91	
Wax dipping	2.91	2.95	2.95	3.05	3.1	2.8	2.47	3	2.9		
Control : No wax dipping	2.96	2.85	2.89	3.22	2.5	2.9	2.51	3	2.87	2.9	2.61
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	2.91	2.95	2.91	3.37	2.5	2.7	2.64	3	2.92	2.88	2.6
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	2.89	2.9	2.91	3.07	2.6	2.7	2.78	3	2.77		
4 Pin hole plastic packaging, wax, Calcium chloride 2%	2.95	2.92	2.92	2.95	2.7	2.6	2.54	3	2.73	2.99	2.7
4 Pin hole plastic packaging, wax, Calcium chloride 4%	2.83	2.9	2.89	3.22	2.6	2.5	2.54				
Grand Mean	2.91	2.91	2.9	3.1	2.8	2.6	2.57	3	2.81	2.89	2.62
P value	NS	NS	NS	NS	***	NS	NS	NS	NS	NS	NS
CV %	0.32	0.31	0.4	0.89	1	1	1.09	1	1.82	0.99	1.03
LSD	-	-	-	-	0.2	-	-	-	-	-	-

Table 18 illustrates that pH was found significantly different ranging from 2.5 to 3.05 with mean value of 2.78 at 5 weeks and there was no any significant difference in other weeks among various treatments in any storage duration in cellar. The maximum pH was found in 4 Pin holes plastic packaging, No wax + Calcium chloride 2% that was 3.37 in 4th weeks of the storage followed by Control (No wax dipping) was 3.22 in 4th weeks of storage in cellar store. Similarly the minimum pH was found in Wax + Calcium chloride 2% that was 2.46 in 6 weeks of the storage followed by 2.47 in 7th weeks of storage in cellar store.

Table 19: Effect of postharvest treatments on physiological loss weight percentage (%) of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Weeks after storage	1	2	3	4	5	6	7	8	9	10	11	12
Wax + Calcium chloride 2%	2.99	11	12.5	13.6	12.7	15.3	14.6	20.1	24.1	31.1	41.9	75
Wax + Calcium chloride 4%	7.72	14.7	14.7	18.9	16	23.6	21.1	37.1	45.5	77.1	100	
No wax + Calcium Chloride 2%	4.72	10.4	10.7	14.8	18.5	13.2	16	20.3	24.7	32	42.7	82.9
No wax + Calcium Chloride 4%	8.93	24	-3.06	20.3	16	20.6	25.4	31.4	54.6	92.3	100	
Control : Wax dipping	6.4	24.3	16.6	23.9	20.1	28.2	52.8	35	44.9	97.9	100	
No wax dipping	5.07	12.6	11.5	12.8	13.6	16.6	16.9	20.3	29.8	33.7	53.2	81.7
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	5.13	8.62	13.5	12.9	13.3	14.5	20.2	25.3	34.4	41.4	83.3	100
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	4.33	11.4	11.4	15.9	14.2	20.2	27.4	37.1	57.7	50.2	90.2	100
4 Pin hole plastic packaging, wax, Calcium chloride 2%	31.1	26.4	11.2	14.6	14.4	15.2	18.7	20.7	23.2	30.2	43.9	74.6
4 Pin hole plastic packaging, wax, Calcium chloride 4%	4.8	16.6	16	21.4	25.9	21.4	29.8	48.7	72.6	100		
Grand Mean	8.11	14.27	11.49	16.91	16.47	18.87	24.28	29.41	41.01	55.91	66.62	81.62
P Value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	36.87	10.38	16.76	5.32	5.47	7.61	12.35	6.89	9.91	10.62	9.44	6.4
LSD	-	-	-	-	-	-	-	-	-	-	-	-

Table 19 illustrates that there were no any significant difference on physiological weight loss in percentage (PLW %). The maximum loss percentage was found in wax+ Calcium chloride 4% which was 100% in 11th weeks of storage. Similarly, the minimum loss percentage was found in 4 Pin holes plastic packaging, no wax + Calcium chloride 4% which was -3.06 in 3th weeks of storage followed by was+ calcium chloride 2% which was 2.99 in first week of storage in cellar store.

Table 20: Effect of postharvest treatments on juice volume percentage (%) of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Week	1	2	3	4	5	6	7	8	9	10	11	12
Wax + Calcium chloride 2%	29	36.4	31.5	36.1	30.8	33.8	33.8	37	39.6	39.4	47.3	43.5
Wax + Calcium chloride 4%	27.2	42.1	30.5	40	34.1	40.5	36	35.3	39.6	40.6		
No wax + Calcium Chloride 2%	29.3	40.1	34.4	34.8	40.3	43.9	40.7	68.3	37.2	41.7	54	46.6
No wax + Calcium Chloride 4%	34	46.8	35.7	36.4	36.1	47.4	38.9	36.5	39.7	51.2		
Wax dipping	33	42.4	29.5	34.3	31.1	45.1	32.8	36.5	36.3	40.6		
Control : No wax dipping	31.5	38.7	37.1	36.5	37.1	44.2	38	39.3	42.8	43.4	48.5	46.3
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	25.9	36.4	30.8	33.7	31.2	44.0	35.6	39.3	37.6	42.1	47.6	
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	25.9	40.8	31	32.7	35.5	44.3	32	37.3	35.2	39.1	45.2	
4 Pin hole plastic packaging, wax, Calcium chloride 2%	28.7	37.4	52.5	34.3	31.6	41.4	37.7	32.1	37.3	40.9	43.4	45.2
4 Pin hole plastic packaging, wax, Calcium chloride 4%	26.5	40.9	32.1	34.9	30.7	50.6	30.9	33.6	48.6			
Grand Mean	29.09	40.2	34.5	35.37	33.85	43.5	35.74	39.64	39.3	41.47	48.03	45.41
P Value	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS
CV%	2.71	2.48	2.33	2.06	3.4	1.54	2.43	1.22	2.26	2.5	1.74	1.85
LSD	-	-	-	-	-	5.07	-	-	-	-	-	-

Table 20 illustrates that juice volume percentage (%) was found significant and ranging from 33.8 % to 50.6 % with mean value of 43.5 at 6th week and there was no any significant difference in other weeks among various treatments in any storage duration in cellar. Maximum juice volume percentage (%) was found in no wax + calcium chloride which was 68.3% followed by 54% in 8 weeks and 11weeks of storage respectively. Similarly, minimum juice volume percentage (%) was found in 4 Pin holes plastic packaging, wax + Calcium chloride 2% which was 27.5% followed by Control (Wax dipping) which was 28% up to first week and third weeks of storage respectively.

Table 21: Effect of postharvest treatments on TSS ($^{\circ}$ Brix) of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Weeks	1	2	3	4	5	6	7	8	9	10	11	12
Wax + Calcium chloride 2%	7.07	6.67	6.97	6.62	6.38	6.54	6.26	6.26	6.38	6.53	6.1	2.59
Wax + Calcium chloride 4%	7.37	6.86	6.72	6.62	6.59	5.79	5.96	6.29	6	2.91		
No wax + Calcium Chloride 2%	6.91	6.73	6.28	6.59	6.49	6.48	6.16	6.48	6.38	6.27	6.22	2.13
No wax + Calcium Chloride 4%	7.27	6.82	6.34	6.87	6.47	6.72	6.21	6.14	5.58	1.49		
Wax dipping	7.03	6.49	6.52	6.46	6.68	6.37	3.98	3.98	4.03	1.3		
Control : No wax dipping	7.04	6.7	6.96	7.17	6.88	6.91	6.38	6.29	6.23	5.88	4.76	2.23
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	6.87	7.04	6.52	6.74	6.66	6.27	13.1	5.88	6.38	5.89	2.1	
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	7.41	6.86	6.54	6.81	6.92	5.88	5.56	6.17	4.48	4.38	0.7	
4 Pin hole plastic packaging, wax, Calcium chloride 2%	6.98	7.18	6.69	6.76	6.52	6.18	6.18	5.91	5.93	6.29	5.92	2.4
4 Pin hole plastic packaging, wax, Calcium chloride 4%	7.1	7.3	6.47	6.79	6.7	6.32	6.26	6.27	2.5			
Grand Mean	7.1	6.86	6.6	6.74	6.62	6.34	6.6	5.96	5.38	4.09	5.28	0.93
P Value	NS	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	0.76	0.86	1.03	1.06	1.19	1.33	11.34	3.75	6.93	12.23	21.79	33.79
LSD	-	0.45	-	-	-	-	-	-	-	-	-	-

Table 21 illustrates that TSS was found significantly ranging from 6.49 to 7.3 $^{\circ}$ Brix with mean value of 6.86 $^{\circ}$ Brix at 2nd week and there was no any significant difference in other weeks among various treatments in any storage duration in cellar. Maximum TSS was found in wax 4 Pin holes plastic packaging, No wax + Calcium chloride 4% which was 7.41 $^{\circ}$ Brix followed by wax + calcium chloride 4% which was 7.37 $^{\circ}$ Brix in first week of the storage in cellar. Similarly, Minimum TSS $^{\circ}$ Brix was found in Wax + Calcium chloride 4% which was 0 $^{\circ}$ Brix in 11 weeks of storage followed by Control (Wax dipping) which was 1.3 $^{\circ}$ Brix in 10th weeks of storage in cellar store.

Table 22: Effect of postharvest treatments on TA% of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Weeks after storage	1	2	3	4	5	6	7	8	9	10	11	12
Wax + Calcium chloride 2%	7.68	6.58	6.51	6.7	6.75	6.73	6.25	7.18	7.08	7.13	6.82	3.5
Wax + Calcium chloride 4%	7.61	6.66	5.96	6.69	8.06	7.3	5.89	7.48	6.91	3.18		
No wax + Calcium Chloride 2%	7.6	6.55	6.39	6.85	7.47	7.47	6.89	7.16	7.01	7.35	5.98	2.42
No wax + Calcium Chloride 4%	7.44	6.55	6.99	7.08	7.16	7.02	6.59	7.13	6.13	1.72		
Control : Wax dipping	6.9	6.3	6.73	6.62	7.02	6.87	3.99	4.54	4.6	1.67		
Control : No wax dipping	6.43	6.63	7.25	7.21	7.57	7.74	7.12	7.3	7.19	7.6	4.84	2.38
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	7.35	6.9	6.63	6.87	7.4	7.62	6.97	6.67	6.97	7.34	2.25	
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	6.87	6.63	6.87	6.92	7.51	6.68	6.46	7.3	4.59	6.14	0.732	
4 Pin hole plastic packaging, wax, Calcium chloride 2%	6.68	7.12	6.79	6.8	7.32	7.37	7.1	7.08	6	6.95	7.17	2.33
4 Pin hole plastic packaging, wax, Calcium chloride 4%	6.69	6.94	6.26	7.05	7.84	7.54	6.7	6.52	2.56			
Grand Mean	7.12	6.68	6.63	6.87	7.41	7.23	6.39	6.83	5.9	4.9	2.77	1.06
P Value	***	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
CV%	1.29	1.08	1.31	1.07	1.25	1.27	4.03	3.79	6.81	12.23	22.1	33.39
LSD	0.7	-	-	-	-	-	-	-	3.08	-	-	-

Table 22 illustrates that TA % was found highly significant in first weeks of storage having mean value 7.12 %. The TA % was found significant in 9 weeks of the storage having mean value 5.9%. The maximum TA % was found in wax + calcium chloride 4% which was 8.06% in 5 weeks of storage followed by 4 Pin hole plastic packaging, wax + Calcium chloride 4% was 7.84% in 5 weeks of storage in cellar store. Similarly, the minimum TA % was found in Wax + Calcium chloride 4% which was 0% in 11 weeks of the storage followed by control (wax dipping) which was 1.67% at 10 10 weeks of the storage in cellar storage.

Table 23: Effect of postharvest treatments on pH of acid lime (var. Terhathum Local) fruit during storage at cellar store in FY 2078/79

Treatment/ Weeks after storage	1	2	3	4	5	6	7	8	9	10	11	12
Wax + Calcium chloride 2%	2.92	2.89	2.89	2.86	2.76	2.38	2.9	2.59	2.5	2.9	3.12	1.24
Wax + Calcium chloride 4%	2.88	2.85	2.89	2.81	2.77	2.4	2.53	2.49	2.47	1.24	-	-
No wax + Calcium Chloride 2%	2.91	2.92	2.92	2.91	2.69	2.49	2.51	2.56	2.58	2.72	2.56	0.967
No wax + Calcium Chloride 4%	2.88	2.92	2.92	2.9	2.72	2.4	2.52	2.42	2.27	0.711	-	-
Control : Wax dipping	2.91	2.95	2.95	3.13	2.68	2.71	1.67	1.63	1.73	0.678	-	-
Control : No wax dipping	2.89	2.95	2.95	2.98	2.66	2.81	2.57	2.58	2.53	2.81	2.1	0.9
4 Pin hole plastic packaging, No wax, Calcium chloride 2%	2.88	2.88	2.88	2.9	2.71	2.67	2.61	2.4	2.49	2.86	1.02	-
4 Pin hole plastic packaging, No wax, Calcium chloride 4%	2.79	2.95	2.95	2.9	2.68	2.7	2.59	2.57	1.54	1.69	0.333	-
4 Pin hole plastic packaging, wax, Calcium chloride 2%	2.86	2.89	2.89	2.84	2.67	2.74	2.59	2.39	2.28	2.99	2.99	0.922
4 Pin hole plastic packaging, wax, Calcium chloride 4%	2.9	2.92	2.92	2.89	2.63	2.74	2.53	2.48	1.06	-	-	-
Grand Mean	2.88	2.91	2.91	2.91	2.69	2.6	2.5	2.41	2.14	1.86	1.21	0.4
P Value	NS	NS	NS	NS	*	***	NS	NS	*	NS	NS	NS
CV%	0.42	0.41	0.33	0.67	0.51	0.8	4.09	3.74	6.74	13.14	22.06	33.48
LSD	-	-	-	-	0.1	0.15	-	-	1.1	-	-	-

Table 23 illustrates that pH was found highly significant in 6 weeks of storage in cellar store ranging from 2.4 to 2.81 with mean value of 2.6. It was significant in 5th and 9th respectively. And there was no significant difference in other weeks among various treatments in any storage duration in cellar. The maximum pH was found in wax dipping treatment that was 3.13 in 4th weeks of the storage followed by wax + calcium chloride 2% which was 3.12 in 11th weeks of storage in cellar store. Similarly, the minimum pH was found in 4 Pin hole plastic packaging followed by no wax + calcium chloride 4% which was 0.33 in 11th weeks of storage in cellar store.

3.3 PLANT HUSBANDRY

3.3.1 High density planting trial of mandarin orange

Methodology

Mandarin cv. Khoku local saplings (grafted onto trifoliolate) at the age of two years were transplanted at NCRP, Paripatle orchard at 1300 m altitude. The saplings were planted at six different spacing as shown in Table 24. The plants were replicated three times in terraced land. The data were recorded on various fruit physio-chemical parameters and yield parameters as shown in table below.

Fruit physical parameters and yield attributing characteristics of mandarin orange

The result showed that the individual fruit weight, fruit diameter, fruit rind thickness, fruit rind weight, number of segments per fruit and number of seed per fruit, number of fruit/tree and yield/ha were non-significant of the different spacing they are planted (Table 24).

Fruit weight

Fruit weight was found varying from 74.9 to 107 g with mean value of 90.16 g. The highest fruit weight was found in 1.50 x 3 m (107g) spacing followed by 2.25 x 3 m spacing (95.7g). The lowest fruit weight was found in 1.15 x 3 m spacing (74.9g) followed by 4 m spacing (80.4 g).

Fruit diameter

Fruit diameter was ranged from 56.5 mm to 62.2 mm with the mean value of 59.02 mm. The highest fruit diameter was found in 2.50 x 3 m spacing (58.5mm) followed by 1.50 x 3 m spacing (56.9mm). The lowest fruit diameter was found in 1.8 x 3 m spacing (52.7mm) followed by 1.15 x 3m spacing (52.9 mm).

Fruit rind thickness

Fruit rind thickness was ranged from 2.11mm to 2.67 mm with mean value of 2.26 mm. The highest fruit rind thickness was found in 1.8 x 3 m spacing (2.67 mm) followed by 1.15 x 3m (2.52mm). The lowest fruit rind thickness was found in 3 x 3m spacing (2.11mm) followed by 2.5 m x 3m spacing (2.18 mm).

Fruit rind weight

Fruit rind weight was ranged from 28.9g to 33.9 g with mean value 30.46 g. The highest fruit rind weight was found in 3 x 3 m spacing (33.9 g) followed by 1.50 x 3m spacing (31.7 g). The lowest fruit rind weight was found in 1.75 x 3m spacing (28.9g) followed by 1.8 x 3m spacing (29.3 g).

Number of segments/fruit

The number of segments per fruit was found non-significantly different ranging from 9.93 to 11.6 with mean value of 11. The maximum number of segments per fruit was found in 3 x 3m spacing (11) followed by 2.5 x 3m spacing (10.4). The minimum number of segments per fruit was found in 1.8 x 3 m spacing (9.93) followed by 4 x 3m spacing (9.93).

Total number of fruits per tree

The total number of fruits per tree was ranged from 54 to 186 with mean value of 136. The highest number of fruits was found in 3.35 x 3m spacing (186) followed by 2.25 x 3 m spacing (182). The lowest number of fruit was found in 1.50 x 3m spacing (54) followed by 4 x 3m spacing (97).

Fruit yield per hectare

The fruit yield per hectare ranged from 3.84 t/ha to 13.0 t/ha with mean value of 9.62 t/ha. The highest fruit yield was found 1.8 x 3m spacing (13.0 t/ha) followed by 3 x 3m spacing (12.6 t/ha). The lowest fruit yield was found in 1.5 x 3m spacing (3.84 t/ha) followed by 4 x 3m spacing (6.58 t/ha).

Table 24: Different yield and quality parameters of Khoku Local mandarin under various planting densities at NCRP Dhankuta in 2022.

Spacing (mxm)	Fruit weight (g)	Fruit diameter (mm)	Rind thickness (mm)	Fruit rind weight (g)	No. of segments	# fruit/tree	Yield (t/ha)
1.15 x 3	87.6	58.7	2.52	29.3	10.0	172	11.0
1.5 x 3	93.2	59.3	2.27	31.7	9.97	54.1	3.84
1.75 x 3	86.6	57.8	2.33	28.9	10.1	134	8.56
1.8 x 3	85.5	56.5	2.67	29.0	9.93	144	13.0
2.25 x 3	91.8	59.6	2.25	31.1	10.4	182	12.5
2.5 x 3	102	58.7	2.18	29.9	10.1	135	11.4
3 x 3	100	62.2	2.11	33.9	11.6	171	12.6
3.5 x 3	92.2	59.8	2.20	30.3	10.1	186	11.9
4 x 3	90.7	59.9	2.35	29.8	9.93	97	6.58
Grand mean	92.88	59.04	2.26	30.46	11	136	9.62
P Value	NS	NS	NS	NS	NS	NS	NS
C.V%	2.89	0.77	1.49	1.67	8.33	9.28	9.64
LSD	-	-	-	-	-	-	-

Physicochemical properties of mandarin orange

The difference in physicochemical properties *viz.* juice quantity (%), TSS % and TA % and pH were non-significant among the treatments (Table 25).

Juice volume (ml)

Juice volume was ranged from 33.4 to 37.1 ml with the mean value of 31.96. The highest juice volume was found in 3 x 3m spacing (37.1 ml) followed by 2.25 x 3m spacing (32.6 ml). The lowest juice volume was found in 3 x 4m spacing (30.4 ml) followed by 1.75 x 3 mspacing (30.7 ml).

Total soluble Solids (TSS %)

TSS % was found varied from 11.0 % to 11.4% with mean value 11.09 %. The highest TSS % was found in 1.18 x 3m spacing (11.4%) followed by 2.5 x 3m spacing (11.2%) and 4 x 3 m spacing (11.2). The lowest TSS % was showed by rest of the other spacings (11.0%).

Titriable acid (TA %)

Among the tested spacing of same genotype TA% was found non-significantly ranging from 1.13% to 1.58% with mean value 1.18%. The TA % was remarkably high in 1.15m spacing (1.58%) followed by 3 x 3m spacing (1.26%). 1.18 x 3m spacing (1.13%) recorded significantly the lowest TA% followed by 2.25 x 3m spacing (1.15%).

pH

The pH was found varying from 3.9 to 4.2 with mean value of 3.91. The highest pH was observed in 1.15 x 3mspacing (4.20) followed by 3 x 3m spacing (3.96). The lowest pH was recorded in 1.8 x 3m spacing (3.9) followed by 2.5 x 3m spacing (3.91).

Table 25: Physio–chemical properties of Khoku Local mandarin under various planting densities at NCRP Dhankuta in 2022.

Spacing (m)	pH	TSS	TA%	Juice volume (ml)	DA meter reading
1.15 x 3	4.20	11.0	1.58	29.4	0.2850
1.5 x 3	3.82	11.0	1.21	32.0	0.1140
1.75 x 3	3.92	11.2	1.16	30.7	0.0858
1.8 x 3	3.90	11.4	1.13	28.3	0.0390
2.25 x 3	3.97	11.0	1.15	32.6	0.0764
2.5 x 3	3.91	11.2	1.17	31.9	0.0875
3 x 3	3.96	11.0	1.26	37.1	0.0958
3.5 x 3	3.94	11.0	1.15	32.2	0.0357
4 x 3	3.93	11.2	1.26	30.4	0.0604
Grand mean	3.91	11.09	1.18	31.96	0.08
P Value	NS	NS	NS	NS	NS
C.V%	0.54	0.52	1.98	2.02	9.93
LSD	-	-	-	-	-

3.4 NURSERY MANAGEMENT

3.4.1 Management of leaf miner in nursery bed

The citrus leaf miner (*Phyllocnistis citrella* Stainton) is a moth of the family Gracillariidae. It is a potentially serious pest of citrus and related Rutaceae and some related ornamental plants. The activity of the leaf miner is normally observed through the year due to its overlapping generation; however new flushes leaves are more exposed. Their larvae feed on the chlorophyll of the tender leaves making serpentine mines due to leaves became distorted and crumpled. This adversely affects the photosynthesis activity which results in reduced vigour and growth of the plant.

Methodology

The efficacy of seven insecticides was studied for controlling citrus leaf miner in 2020 at nursery of NCRP. RCBD design was used to assign 4 replications of each of seven treatments. Spraying was done in the month of June. Citrus leaf miner larval count was done in 30 days after treatment application. Observation on number of larva per 5 leaves and number of total leaves and infested leaves was taken. The percentage of infestation was calculated by number of infested leaves divided by total number of leaves multiplied by 100. Mines in initial stage, that did not show significant damage or curling of leaves was not considered and left to the subsequent counts.

The treatments are enlisted below:

T1: Spraying of Arrow (Thiamethoxan 25% WP) @ 2 gm/lit

T2: Spraying of Proper Super (Profenofos 50% EC) @ 2 ml/lit

T3: Spraying of Vapcomic (Abamectin 1.8% EC) @ 2ml/lit

T4: Spraying of Imidacloprid 1 ml/lit

T5: Spraying of Hunted (Chlorfenapyr 10%) @ 1ml/lit

T6: Bhavarath (Fipronil) @ 1 ml/lit

T7: Proper super (Profenofos 40% EC+ cypermerthin 4% EC) @1 ml/lit

T8: Mijor (Etofenprox) @ 1 ml/lit

T9: Control (water spraying)

Result and discussion

All the parameter under investigation were found non-significant. The number of larvae per five leaves was found ranging from 1.33- 2.87 with mean of 2.08 after 30 days of spraying. The lowest number of leaf minor larvae was found with Imidacloprid @1 ml/lit spray (1.33) followed by Hunted spray @1ml/lit (1.4). The leaf infestation/plant was found maximum with Vapcomic spray (18.6%) and lowest with Imidachlorpid (12.6%) respectively (Table 26).

Table 26: Table showing number of larva/ 5 leaves and percent infestation after 30 after spraying of different insecticides

Treatment	# leaf miner/5 leaves	# infested leaf/plant	% infestation
	30 DAS	30 DAS	30 DAS
Arrow (Thiomethoxam)	2.27	12.0	16.4
Proper super (Profenofos + cypermerthin)	2.67	12.1	17.1
Vapcomic (Abamectin)	2.87	14.9	19.1
Imidachlorpid	1.33	8.8	12.6
Hunted (Chlorofenopyr)	1.40	14.4	18.1
Bhavarath (Fipronil)	2.40	8.73	18.6
Mijor (Etofenprox)	1.87	11.7	17.3
Proplex (Thiamethoxam + abamectin)	1.80	10.1	15.1
Control (Water spray)	2.13	8.20	12.9
Grand Mean	2.08	11.22	16.4
P value	NS	NS	NS
C.V%	9.09	7.14	14.36
LSD	-	-	-

3.5.2 Management of weed in nursery bed

Weed is one of the main problems of citrus in early of growth period, and chemical herbicides are used against it that is accompanied with environmental pollutions. The weeds in Citrus decrease available water and nutrients of soil. They also may be host of a variety of pests, diseases, and even fungus. Pre-emergence herbicides are generally applied two to three times per year, so the maximum amount of herbicide is in the upper soil profile (0 to 2 inches) slightly before peak weed emergence. Post-emergence herbicides are used to control weeds that escape control by pre-emergence herbicides or mechanical cultivation. These herbicides are effective on small annual weeds and usually only suppress growth of perennials. These can be systemic or contact in activity.

Methodology

To find a good measure to manage weed in nursery bed, a study was designed and carried out in nursery bed at NCRP, Dhankuta in 2021. RCBD design was used to assign 3 replications of six treatments. Initially, pendimethalin @ 2 ml/lt was sprayed in nursery bed as pre-emergence herbicide. Spraying of Post-emergence herbicides was done in the month of June. The treatments are enlisted below:

- T1: Spraying of Pendimethalin@2 ml/lt
- T2: Spraying of Pendimethalin @ 3 ml /lt
- T3: Spraying of Sacfit (Pretilachlor) @ 2ml/lt
- T4: Spraying of Weed cross (Butachlor) @ 2ml/lt
- T5: Hand weeding
- T6: Control

The number of weeds and species of weeds present in one m² area in each plot was counted at 30, 60 and 90 days after transplanting. Beside these, transplanted sapling height, number of leaves per sapling, chlorophyll content and stem girth at collar region was recorded.

Result and discussion

Number of weed species:

The number of different weed species was found non-significant through out the study period. The minimum weed species was observed with hand weeding (9.32) followed by Pretilachlor @ 2 ml/lit (9.6). The maximum weed species was seen Pendimethalin @2ml/lit (9.33) (Table 27).

Table 27: Table showing number of weed species at 30, 60 90 and 120 days after spraying herbicides

Treatment	30 days	60 days	90 days	120days
Pendimethalin@2 ml/lit	12.4	12.6	18.3	11.4
Pendimethalin @ 3 ml /lit	28.7	10.3	19.8	11
Sacfit (Pretilachlor) @ 2ml/lit	30.4	11.3	15.3	9.6
Weed cross (Butachlor) @ 2ml/lit	34.5	13.7	17.6	9.81
Hand weeding	20.9	13.2	14.7	11.3
Control (No weeding)	22.7	13.5	17.3	9.32
Grand Mean	24.78	12.42	17.16	10.42
P Value	NS	NS	NS	NS
CV%	11.9	9.51	9.59	8.12
LSD	-	-	-	-

Plant height

The plant height of acid lime (Tehrathum local) was found non-significant throughout the research period. However, highest plant height was observed with Pendimethalin @2 ml/lit (55.7 cm) at 120 days after spraying (Table 28).

Number of leaves per plant

The number of leaves was found non-significant throughout the study period. The highest number of leaves per plant was observed with treatment hand weeding (60.2) followed by no weeding (57.2) at 30 days after spraying. The lowest number of leaves per plant was observed with spraying pendimethalin @ 3ml/lit (40.5) at 60 days after spraying (Table 28).

Table 28: Table showing plant height and number of leaves per plant of acid lime (Tehrathum local) at 30, 60, 90 and 120 days after spraying herbicides

Treatment	Plant Height (cm)				Leaf number/plant			
	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days
Pendimethalin @ 2 ml/lit	44	47.9	51.5	55.7	55.1	49	50.1	53.5
Pendimethalin @ 3 ml /lit	41.6	45	47.2	51.5	51.7	40.5	43.6	47
Sacfit (Pretilachlor) @ 2ml/lit	37.7	41.8	45.8	49.5	52.1	45.9	46	49.9
Weed cross (Butachlor) @ 2ml/lit	41.7	43.1	45.8	48.6	55.4	46	51.5	55.4
Hand weeding	43	46	48	51.6	60.2	53.4	46.9	49.6
Control (No weeding)	42.2	44.4	47.8	51.8	57.6	46	44.8	47
Grand Mean	41.71	44.69	47.67	51.42	55.35	46.79	47.18	50.38
P Value	NS	NS	NS	NS	NS	NS	NS	NS
CV%	1.99	1.87	1.86	1.76	4.21	4.37	3.37	3.54
LSD	-	-	-	-	-	-	-	-

Chlorophyll content

The chlorophyll content in acid lime leaf was found to be non-significant throughout research period. However, the highest chlorophyll content was found in Butachlor dichloride @ 2 ml/lit (37.6). The lowest chlorophyll content was found in Hand weeding (27.5) at 30 days after spray (Table 29).

Collar girth

The collar girth in acid lime was found to be non-significant throughout research period. However, the highest collar girth was found in Pendimethalin @ 2 ml/lit (7.79 mm) followed by Hand weeding (7.78) after 120 days of spraying. The lowest collar girth was found in no weeding treatment (6.89) at 120 days after spraying (Table 29).

Table 29: Table showing chlorophyll content and collar girth of acid lime (Tehrathum local) at 30, 60, 90 days and 120 days after spraying herbicides

Treatment	Chlorophyll Content				Collar Girth (mm)			
	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days
Pendimethalin @ 2 ml/lit	28.4	18.3	18.4	19.3	6.3	7.51	7.65	7.79
Pendimethalin @ 3 ml /lit	34.9	28.2	28.9	28	6.55	6.82	7.01	7.14
Sacfit (Pretilachlor) @ 2ml/lit	34.3	26	26.4	27.6	6.24	7.24	7.45	7.57
Weed cross (Butachlor) @ 2ml/lit	37.6	25.3	24.8	26	6.44	7.14	7.31	7.46
Hand weeding	27.5	27.2	27.1	29.6	6.63	7.61	7.69	7.78
Control (No weeding)	24.4	23.2	23.4	25.2	6.45	6.67	6.77	6.89
Grand Mean	31.61	24.69	24.83	25.94	6.43	7.16	7.31	7.43
P Value	NS	NS	NS	NS	NS	NS	NS	NS
CV%	10.75	17.96	18.02	17.58	2.39	2.92	2.79	2.75
LSD	-	-	-	-	-	-	-	-

3.4.2. RAINY SEASON CITRUS GRAFTING STUDY INSIDE NURSERY HOUSE

Various methods for grafting and budding were tested in the high-tech nursery of NCRP, Paripatle in the month of Shrawan, the peak of the monsoon season in Nepal. In NCRP, the traditional time of propagation is considered to be the dry months, namely; Mangshir-Poush, which leaves a narrow time period of only 6 months for the plant to grow before it is sold to farmers starting from Jestha. The following experiment was carried out to find a feasible time in the monsoon season or the wet season for propagation so that the plants have more time to grow and stabilize and farmers are benefitted from the sale of hardy year-old plants. The experiment started on 2078/02/24 and ended on 2078/05/22, with Trifoliolate used as rootstock in all except one of the trials.

The first set acid lime (Sunkagati 1 and NCRP 53) scions were grafted by veneer grafting methods. After 2 months, veneer grafting proved to be the most successful method as 90% plants were successful among 20 in both the cases (Table 30). The highest plant height was achieved by cleft grafted plants (23.93 cm) closely followed by veneer grafted plants (23.33 cm), whereas maximum diameter (5.81 cm) was achieved by the latter. Splice grafting was found to be the most unsuccessful method as only 1 plant flourished among the 20 grafted.

Table 30: Table showing graft success %, of various citrus scion varieties at 3 months after grafting on to trifoliolate/ rangapur lime rootsock

Crop	Variety (scion)	Rootstock	Grafting method	Grafting Date	# grafted plants	#graft success	Success Rate(%)
Acid Lime	Sunkagati-2	Trifoliolate	Veener	2/24/2078	109	99	90.8
Acid Lime	Panta-1	Rangapur	Veener	5/10/2078	200	85	42.5
Mandarin	Avana Aprino	Trifoliolate	Veener	4/3/2078	36	33	91.7
Mandarin	Avana Aprino	Trifoliolate	Splice	4/3/2078	36	26	72.2
Mandarin	Avana Aprino	Trifoliolate	Clift	4/3/2078	36	22	61.1
Mandarin	Commune	Trifoliolate	Splice	4/15/2078	100	50	50.0
Mandarin	Sikkime	Trifoliolate	Splice	4/14/2078	150	53	35.3
Mandarin	Merisol	Trifoliolate	Splice	4/14/2078	200	60	30.0
Mandarin	Pongan	Trifoliolate	Veener	5/8/2078	100	20	20.0
Mandarin	Kamala	Trifoliolate	Veener	5/17/2078	30	15	50.0
Mandarin	Dancy	Trifoliolate	Veener	5/21/2078	12	9	75.0
Sweet Orange	Pineapple	Trifoliolate	Veener	5/9/2078	100	10	10.0
Sweet Orange	Dhankuta Local	Trifoliolate	Splice	5/9/2078	50	36	72.0
Pomelo	Reed	Trifoliolate	Veener	5/20/2078	12	5	41.7
Pomelo	Pink Ruby	Trifoliolate	Veener	5/20/2078	12	8	66.7
Pomelo	Star Ruby	Trifoliolate	Veener	5/20/2078	20	6	30.0
Pomelo	Henderson	Trifoliolate	Veener	5/20/2078	12	6	50.0
Pomelo	Shamber	Trifoliolate	Veener	5/18/2078	15	12	80.0
Tangor	Murkkot	Trifoliolate	Veener	5/17/2078	12	6	50.0
Tangor	Ortanique	Trifoliolate	Splice	5/22/2078	12	5	41.7

Subsequently, the next set comprised of Avana mandarin orange grafted on trifoliolate rootstocks, where veneer grafting (91.7%) turned out to be the most successful method followed by Splice method (72.2%) among the 36 grafted plants (Table 44). The lowest success rate was observed in cleft grafted plants (61.1%).

Similarly, the next set was various mandarin varieties (Commune, Sikkime, Merisol, Pongkan, Kamala and Dancy grafted on trifoliolate rootstock. The experiment started on 2078/04/14 and not much success was observed in most of the varieties except Dancy with 75% success rate. Similarly, five pomelo varieties were grafted onto trifoliolate rootstock using veneer grafting method. The Shambar variety showed 80 percent success rate ranking first within this group. Further two sweet orange varieties Dhankuta and pineapple were grafted onto trifoliolate rootstock and Dhankuta gave the best result with 80% success rate using splice method of grafting. Among two tangor varieties grafted onto trifoliolate rootstock Murcotte scion gave only 50% success rate followed by 41.7% by Ortanique grafted using splice method.

3.5 CITRUS DECLINE MANAGEMENT

Citrus decline is the foremost threat to the future of citrus industry in Nepal. Unless this problem is managed, citrus will get declined (Roistacher, 1996). It has now become a widespread serious threat for mandarin production in almost all citrus growing regions in Nepal. Furthermore, most of the citrus nurseries are located at the altitude below 1000 masl that insect vectors of many diseases including citrus greening and citrus tristeza virus are considered to be active because of the favorable environment.

Besides HLB, the decline is associated with many other diseases and pests as well as management factors that tristeza virus, root rot, poor orchard management, unfavorable soil and climate and low quality planting material are among the major factors. The former studies illustrate that the citrus decline responds well to pruning treatment with adequate scientific management, irrigation and plant protection measures. Similarly, it is stated that application of 300-500 g N, 200-250 g P + 250-350 g K per tree of bearing stage will result optimum yield minimizing decline gradually.

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

Citrus greening disease, commonly known as huanglongbing, is a lethal disease of citrus, and no effective controls have yet been established for this disease. Citrus greening disease is a disease of citrus caused by a vector-transmitted pathogen. The causative agents are motile bacteria, *Candidatus Liberibacter* spp. The disease is vectored and transmitted by the Asian citrus psyllid, *Diaphorina citri*, and the African citrus psyllid, *Trioza erythrae*, also known as the two-spotted citrus psyllid. It has also been shown to be graft-transmissible.

HLB is distinguished by the common symptoms of yellowing of the veins and adjacent tissues; followed by splotchy mottling of the entire leaf, premature defoliation, die-back of twigs, decay of feeder rootlets and lateral roots, and decline in vigor, ultimately followed by the death of the entire plant. Affected trees have stunted growth, bear multiple off-season flowers (most of which fall off), and produce small, irregularly shaped fruit with a thick, pale peel that remains green at the bottom and tastes very bitter. Common symptoms can often be mistaken for nutrient deficiencies; however, the distinguishing factor between nutrient deficiencies is the pattern of symmetry. Nutrient deficiencies tend to be symmetrical along the leaf vein margin, while HLB has an asymmetrical yellowing around the vein. The most noticeable symptom of HLB is greening and stunting of the fruit, especially after ripening.

In Nepal, citrus decline was recorded first time in Pokhara valley during 1968. Later the disease has been confirmed as the greening disease (HLB) and it was suspected to be introduced from Sharanpur, India with the planting materials. For time being, several studies and surveys were carried out in other parts of country to explore the distribution of the greening disease and its vector. The studies revealed that HLB has already distributed across the country, but the extent of citrus decline due to this disease was found maximum in western region than eastern region. But now the disease is spreading rapidly in eastern region too.

NCRP has been doing research from past 3 years for not spreading the disease in new and healthy orchard by intercropping guava in mandarin orchards. Thus, this study was carried out in Ilam district, Godak area since fiscal year 2073/74 to prevent the transmission of disease from infected orchard to newly established healthy mandarin orchard. It could be due to some volatiles of guava that plays a role in the psyllid reduction by functioning as repellents against the psyllids.

Methodology

In the 1st year 20 guava were planted. In 2nd year 20 mandarin saplings were intercropped in field. Planting distance of 3 m x 3 m was maintained. Then the number of psyllid was monitored in research field during the month of Falgun-Bhadra at weekly interval with the help of yellow sticky trap. Disease incidence was also taken. Similarly next set of trial was set up at Bhuwaneshori area of Sidhuli which is also HLB hotspot employing same method as above.

Result

In the 4th year after mandarin plantation, no any citrus psylla vector was recorded from the research plot. Similarly, there was no any incidence of citrus greening disease too.

Four years after mandarin plantation, neither citrus psylla nor incidence of citrus greening disease was observed.

This research activity should be continued for further few years because normally greening disease generally appears after 3-4 years of planting and in this case also greening disease may appear after 3-4 years of plantation.

3.6 Multi-locations (Collaborative) Trial

3.6.1 Coordinated Varietal Trial on Ginger

Introduction

The family Zingiberaceae comprises of five genera that are commercially important, namely *Amomum*, *Curcuma*, *Elettaria* and *Zingiber*. Ginger belongs to the genus *Zingiber* and turmeric to *Curcuma*. In both plant, the underground stem (rhizome) is commercial product. Zingiberaceous spices are known for their properties in the traditional systems of medicine in Asia. There are several pharmaceutical applications for these spices. Ginger contains about 1.5-2.5% volatile oil, namely Zingiberine that contributes the aroma. The oleoresin content varies from 4-10% known as gingerol that contributes to the taste and smell.

Methodology

Eight genotypes of ginger including 'Local Check' were obtained from National Ginger Research Program (NGRP), Salyan in 2020. They were included in CVT, and evaluated in the field of NCRP, Dhankuta with three replications in RCBD. Thirty tones of FYM/ha were incorporated into soil in the first week of May, 2020: 70 kg Nitrogen, 50 kg Phosphorus and 50 Kg Potassium/ha were recommended doses of fertilizer/ha. Full dose of phosphorus and half dose of potash were applied as basal dose prior to planting rhizome in the last week of May. Rhizomes were planted in the intra row spacing of 30 cm and inter-row spacing of 30 cm. Immediately after rhizome planting, dry forest leaves @ 16 tones/ha were applied as mulching. The whole recommended nitrogen dose was split into two doses: first at 30 days after planting and remaining half dose of nitrogen and half dose of potash were applied at 60 days after planting. Weeding was done twice: first in 45 days after rhizome planting and second in 70 days after rhizome planting. Earthing up was given in 140 days after rhizome planting. Fresh rhizomes were harvested in 232 days later than planting day. Experimental data viz., plant height, number of tillers per clump, length of primary and secondary fingers, fresh rhizome yield and Dry Ginger Recovery (DGR %) were recorded.

Result and discussion

Plant height

The plant height varied from 73.9 cm to 79.7 cm with mean plant height of 76.49 cm. The highest plant was recorded from farmer's local genotype (79.7 cm) followed by genotype KKA-1 (77.9 cm). The lowest plant height was recorded from genotype ZI 1027 (73.9 cm) (Table 31).

Number of tillers per clump

The number of tillers per clump was found ranging from 5.50 to 6.13 with mean value of 5.74. The highest number of tillers per clump was found in genotype farmers local (6.13) followed by KKA-1 (6.0). The lowest number of tillers per clump was found in genotypes ZI 1025 (5.50) (Table 31).

Length of primary finger

The length of primary finger ranged from 5.15 cm to 6.28 cm with mean value of 5.62 cm. The highest length of primary finger was recorded from genotype ZI 1025 (6.28 cm). The lowest length of primary finger was recorded from ZI 1303 (5.15 cm) (Table 31).

Length of secondary finger

The length of secondary finger ranged from 9.83 cm to 11.8 cm with mean value of 10.12 cm. The highest length of secondary finger was recorded from ZI1010 (11.8 cm) followed by farmers local (10.1 cm). The lowest length of secondary finger was recorded from genotype ZI 1027 (9.83 cm) (Table 31).

Total rhizome yield

The total rhizome yield per hectare ranged from 8.6 t/ha to 12.71 t/ha with mean total rhizome yield of 10.7 t/ha. The highest fresh rhizome yield was recorded from genotype ZI 1010 (12.71 t/ha) followed by ZI 1025 (11.31 t/ha). The lowest fresh rhizome yield was recorded from genotype KKA-1 (8.6 t/ha) (Table 31).

Dry ginger weight

The dry ginger weight was found significantly different varying from 187 g to 234 g with mean value of 213.9 g. The highest dry ginger weight was recorded from genotype ZI 1007 (234 g). The lowest dry ginger weight was recorded from genotype ZI 1302 (187 g) (Table 31).

Dry ginger recovery %

The dry ginger recovery % was found significantly different varying from 18.7 % to 23.4 % with mean value of 21.42 %. The highest dry ginger recovery % was recorded from genotype ZI 1007 (23.4 %) followed by ZI1025 (23.0%). The lowest dry ginger recovery % was recorded from genotype ZI 1302 (18.7 %) (Table 31).

Table 31: Performance of eight genotypes of ginger tested under Coordinated Varietal Trial in the field of NCRP, Paripotle, Dhankuta in 2021

Genotypes	Plant height (cm)	No. of Tillers per clump	Length of finger (cm)		Total rhizome yield (t/ha)	Dry ginger weight (g)	DGR %
			Primary	Secondary			
Farmers Local	79.7	6.13	5.68	10.1	9.90	219	21.9
KKA-1	77.9	6.00	5.67	9.70	8.60	199	19.9
ZI 1007	77.0	5.57	6.03	9.77	9.31	234	23.4
ZI 1010	76.9	5.60	4.77	11.8	12.71	230	23.0
ZI 1025	76.3	5.50	6.28	9.93	11.31	209	20.9
ZI 1027	73.9	5.73	5.72	9.83	9.21	215	21.5
ZI 1302	74.3	5.73	5.68	10.0	9.87	187	18.7
ZI 1303	76.0	5.67	5.15	9.87	14.8	219	21.9
Mean	76.49	5.74	5.62	10.12	10.7	213.92	21.42
P-value	NS	NS	**	NS	NS	**	**
CV%	1.97	1.78	1.57	3.08	18.4	1.46	1.45

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 major portion of the production orchard followed by sweet orange variety Dhankuta local and different local genotypes of acid lime. This year, Rs.1.78 million revenue was collected from saplings, fruit production and other horticultural sources.

Besides, NCRP has a regular activity of sapling production of major varieties of mandarin, sweet orange and acid lime. In 2078-79, a total of 36,500 grafted saplings were produced and 31000 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 on the Table 32.

Table 32: Production of fruits, saplings and revenue collected during 2078/79

S.N.	Particulars	Unit	Quantity	Revenue (NPR) '000
1	Mandarin saplings	No.	7650	
2	Sweet orange saplings	No.	1000	
3	Acid lime saplings	No.	27200	
4	Mandarin fruits	Kg.	3800	
5	Sweet orange	Kg.	94	
5	Trifoliate orange, Citrange, Rangpur lime, Volkamerina seed	Kg.	79.0	
	Sub-total			4158244.25
6	Other horticultural sources			-
	Sub-total			4158244.25
7	Administrative			2,07050.00
	Grand Total			4365294.25

5 EXTENSION 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 of strengthening 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 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 52).

Table 33: Calendar of operations adopted at NCRP, Paripatle for orchard management

Month	Operations
Baishak	<p>New flush attracts insects like psylla, white black fly and leaf miner</p> <p>Irrigate the orchard and nursery bed at 8-12 days interval.</p> <p>Budding has to be done at the height of 9"-12" above the ground level.</p> <p>Integrated disease and insect management strategies should be adopted considering environmental protection and biodiversity conservation.</p> <p>Uproot the diseased and very old trees and prepare pits for new plantation.</p> <p>Start protein trap (4/ropani) to monitor fruit fly (<i>Bactrocera minax</i>) on sweet orange orchard.</p> <p>Note: spraying any sort of fungicide, antibiotic and insecticide must be discontinued during flowering period.</p>
Jestha	<p>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.</p> <p>The most critical period is during heat spells. To be more accurate, check to moisture level 12" deep under trees to determine dryness and water accordingly. Keep water away from the trunk.</p> <p>Grafted/budded rootstock in winter months requires checking, thereafter, the tops of successfully intake grafting/budding are to be cut.</p> <p>Any fertilizer should be applied if there is sufficient moisture in soil.</p> <p>Recommended prophylactic measures need to be followed to the plants infected with <i>Phytophthora</i>.</p> <p>Make a drainage system in the orchard.</p> <p>Prepare the nursery bed for rootstock transplant.</p> <p>Prepare compost for next year.</p> <p>Continue protein trap (4/ropani) to monitor fruit fly (<i>Bactrocera minax</i>) on sweet orange orchard.</p> <p>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 fruit fly in affected area in consultation with Agricultural Knowledge Center and or Zone and super zone of prime minister agriculture modernization program.</p>
Ashad	<p>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 <i>Phytophthora</i>.</p> <p>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.</p> <p>Incidence of citrus <i>Psylla</i> and leaf miner is common on new flushes.</p> <p>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.</p> <p>Cankorous leaves and branches should be pruned and brunt and copper oxychloride should be sprayed before the onset of rainy season.</p> <p>Later than the onset of rainfall, copper oxychloride mixed with Streptocycline</p>

Month	Operations
	<p>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.</p>
Shrawan	<p>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/ LW should be sprayed to reduce the intensity of fruit drop. Transplanting of rootstock seedling (Trifoliolate) in main nursery block. Remove diseased, new suckers and dry branches. Spray insuf @ 2 g/l 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.</p>
Bhadra	<p>Weeding in citrus orchards and nurseries. Application of Servo agro sprays mineral oil @ 15 ml/l of water to control scale insects. Management of citrus canker should be followed as per 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 trifoliolate fruit should be taken up at right stage of maturity. Sow the trifoliolate 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.</p>
Ashoj	<p>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 fruit fly infected sweet orange fruits, and immerse them into big bucket full of water.</p>
Kartik	<p>Collect fruit fly infected sweet orange fruits and bury them into deep pits. Prepare new nursery bed and sow trifoliolate seed for next year production.</p>

Month	Operations
	<p>Excess leaf fall could be an indication of disease infestation. Suitable control measures are to be taken up.</p> <p>Harvesting of early maturing species of citrus fruits for rootstock should be taken up at right stage of maturity.</p> <p>Harvesting of early maturing varieties.</p>
Mangsir	<p>Harvesting of mid-season varieties.</p> <p>Grafting for sapling production.</p>
Poush	<p>Harvesting of mid-season varieties.</p> <p>Grafting for sapling production.</p> <p>Farm yard manure should be applied to facilitate decomposition. Its mobilization starts after 3-4 months.</p>
Magh	<p>Irrigate the orchard at 7-10 days intervals.</p> <p>Harvesting of late season varieties.</p> <p>Pruning and training should be carried out.</p> <p>Fertilizer application and Servo agro spray to control scale insects.</p> <p>If zinc deficiency symptoms are notices, apply zinc sulphate.</p>
Falgun	<p>Servo agro spray to control scale insects; fertilizer application.</p> <p>Foliar spray of micronutrients.</p> <p>Insecticides spray in nursery plants to control leaf miner.</p> <p>Irrigation in orchards and nursery.</p> <p>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.</p>
Chaitra	<p>Irrigate the orchard and nursery bed.</p> <p>Uproot the diseased and very old unproductive trees and prepare pits for new plantation.</p>

8 INFORMATION DISSEMINATION

Information regarding citrus research programs and technologies was shared with the visitors that altogether 1,500 visitors made their presence in NCRP. 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

A 5 days long residential training for 26 Citrus grafter of Prime Minister Agriculture modernization project from whole nation on "Citrus Nursery management" was organized. The detail information on list of training participants is given in annex 10. Similarly, 1 day's long training for 24 Citrus farmer of Dhankuta on "Citrus Fruit Fly mangement technology" was organized. The detail information on list of training participants is given in annex 11. One day long training was given to 25 farmers of Province 1 on "Off-season Acid lime Production". The detail information on list of training participants is given in annex 12. Similarly a two-day long workshop on Citrus Fruit Working Group meeting was organized at Sub-tropical Horticulture Center, Kritipur in joint coordination with PMAMP, PMU, Khumaltar, Lalitpur. The detail information on the list of participants is given in annex 13.

10 SERVICES

In fiscal year 2078/79, NCRP supplied 36000 grafted saplings of different citrus species to the farmers. The grafted saplings made available to the farmers comprised of Khoku local mandarin, Okitsuwase unshiu, Miyagawase unshiu, 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 varieties were provided to the nearby nursery entrepreneurs in Dhankuta district. Technical service/advice on commercial citrus cultivation was provided to more than 2000 farmers from all round the nation.

11 BUDGET STATEMENT

Budget and expenditure of regular program as well as beruju of the program has been presented in Annex 5 and 6 respectively. Similarly, budget and expenditure of KOIKCA-UNDP is shown in annex 7,.

12 MAJOR PROBLEMS

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

- a) Lack of variety diversity- short crop harvest period,
- b) Small production scale,

- c) Poor orchard management,
- d) Lack of efficient irrigation,
- e) Fruit drop due to entomological, pathological and hormonal factors.
- f) Incidence of insects and different diseases.
- g) Presence of hard pan.
- h) Limited availability of disease free planting materials.
- i) Acidic soil condition including zinc, calcium and magnesium deficiency in most of the citrus orchards particularly in mid-hills of west Nepal.
- j) Macro and micro-nutrient deficiency.
- k) No information about the nutrient content of citrus orchard.
- l) Poor institutional mechanisms and coordination for marketing, and
- m) Lack of entrepreneurship

Regarding management aspect, NCRP is lacking human resources for several years. Currently, a total of 11 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.

14 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:

- i) Virus indexing program should be made compulsory by law with bud wood certification program, and it should be followed timely across citrus growing areas.

- ii) The quality planting materials free from pathogens and resistant to various insect pest and diseases ought to be made available to the citrus growers.
- iii) 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.
- iv) Developing disease resistant rootstock as well as identifying new dwarfing rootstocks for high density planting.
- v) 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.
- vi) Postharvest processing and value addition,
- vii) Marketing and export business,
- viii) Cost effective and eco-friendly production technologies,
- ix) Integrated nutrient management,
- x) Breeding new varieties for extended harvest period,
- xi) Biological pest and disease management,
- xii) Water use efficiency,
- xiii) In-vitro technology for healthy propagation,
- xiv) Citrus based farming system, and
- xv) Socio-economic studies

13. ANNEX

Annex 1: Citrus genotypes maintained at the field gene-bank of NCRP, Dhankuta

S.N.	Accession No	Identification/Common Name	Source
	A. Kumquat (<i>Citrus japonica</i>):		
1	NCRP-105	Fortunella (oval)	Unknown
2	NCRP-106	Fortunella (rounded)	Unknown
3	NCRP-115	Fortunella (Indian Muntala)	Unknown
	B. Mandarin (<i>C. reticulata</i>)		
4	NCRP-01	Khoku Suntala	Khoku, Dhankuta
5	NCRP-02	Kinnow	Pakistan
6	NCRP-03	Frutrel early	Unknown
	C. Mandarin (<i>C. unshiu</i>)		
7	NCRP-04	Unshiu	JICA, Japan
8	NCRP-05	Miyagawawase- Unshiu	JICA, Japan
9	NCRP-06	Okitsuwase- Unshiu	JICA, Japan
10	NCRP-08	Pongan, Tangerine	ICIMOD
11	NCRP-09	Kamala	Dhankuta
12	NCRP-10	Baskharka local (Parbat)	LAC, Lumle
13	NCRP-11	Sikkime suntala	Tehrathum
14	NCRP-12	Calamandarin	Unknown
15	NCRP-80	Satsumawase	INRA-CIRAD, France
16	NCRP-81	Satsuma Mino	INRA-CIRAD, France
17	NCRP-82	Satsuma URSS	INRA-CIRAD, France
18	NCRP-88	Fortune	INRA-CIRAD, France
19	NCRP-89	Kara	INRA-CIRAD, France
20	NCRP-90	Nova	INRA-CIRAD, France
21	NCRP-91	Pixie	INRA-CIRAD, France
22	NCRP-92	Dancy	INRA-CIRAD, France
23	NCRP-93	Avana	INRA-CIRAD, France
24	NCRP-94	Page	INRA-CIRAD, France
25	NCRP 95	Satsuma Okitsu	INRA-CIRAD, France
26	NCRP-97	Clamentine Mandarine Hernandina	INRA-CIRAD, France
27	NCRP-98	Clamentine Mandarine Oroval	INRA-CIRAD, France
28	NCRP-99	Clamentine Mandarine Commune	INRA-CIRAD, France
29	NCRP-100	Clamentine Mandarine Marisol	INRA-CIRAD, France
30	NCRP-101	Clamentine Mandarine Nules	INRA-CIRAD, France
31	NCRP-112	Gorkhali Suntala	Gorkha, Nareswor
32	NCRP-114	Khoku muted mandarin	NCRP, Dhankuta
33	NCRP-121	Daisy	Australia
34	NCRP-122	Avana-Aprino	Australia
35	NCRP-123	Imperial	Australia

S.N.	Accession No	Identification/Common Name	Source
36	NCRP-124	Markat	Kirtipur
37	NCRP-125	Oota Pongan	Kirtipur
38	NCRP-126	Yashida Pongan	Kirtipur
39	NCRP-127	Selection-79	Kirtipur
40	NCRP-128	Selection-04	Kirtipur
	Tangor		
41	NCRP 102	Ellendale	INRA_CIRAD, France
42	NCRP 103	Murkott	INRA_CIRAD, France
43	NCRP 72	Ortanique	INRA_CIRAD, France
44	NCRP-07	Tangor, Murkotte	JICA, Japan
	Tangelo		
45	NCRP 73	Minneola	INRA_CIRAD, France
46	NCRP 74	Oriando	INRA_CIRAD, France
47	NCRP 75	Seminole	INRA_CIRAD, France
	D. Sweet orange (C. sinensis)		
48	NCRP-13	Valencia late	ICAR, India
49	NCRP-14	Sevelle common	ICAR, India
50	NCRP-15	Navelencia	ICAR, India
51	NCRP 16	Malta Blood Red	ICAR, India
52	NCRP 17	Samauti	ICAR, India
53	NCRP 18	Masambi	ICAR, India
54	NCRP-19	Vanelle	ICAR, India
55	NCRP-20	Ruby	ICAR, India
56	NCRP 21	White Tanker	ICAR, India
57	NCRP-22	Washington novel	ICAR, India
58	NCRP 23	Hamlin	ICAR, India
59	NCRP 24	Pine Apple	ICAR, India
60	NCRP-25	Yashida navel	FDC, , Kirtipur
61	NCRP-26	Madam vanous	GRESKO, Kathmandu
62	NCRP-27	Delicious seedless	ICIMOD
63	NCRP-28	Skages Bonanja	ICIMOD
64	NCRP-29	Blood red	ICIMOD
65	NCRP-30	New Hall Navel	ICIMOD
66	NCRP-31	Succari	ICIMOD
67	NCRP-32	Meisheu-9	ICIMOD
68	NCRP 33	Dhankuta Local	Dhankuta
69	NCRP 34	LueGim Gong	ICAR, India
70	NCRP 83	Cara Cara Novel	INRACIRAD, France
71	NCRP 84	Lane Late	INRACIRAD, France
72	NCRP 85	Pine Apple	INRACIRAD, France
73	NCRP 86	Valencia Late	INRACIRAD, France

S.N.	Accession No	Identification/Common Name	Source
74	NCRP 87	Salustiana	INRACIRAD, France
75	NCRP 96	Tamango	INRACIRAD, France
76	NCRP-129	Atwood Navel	Australia
77	NCRP-130	Navelina Navel	Australia
78	NCRP-131	Valencia Seedless Delta	Australia
79	NCRP-132	Valencia Seedless McMohan	Australia
80	NCRP-133	Ramechhap local	Ramechhap
81	NCRP-134	Sindhuli local	Sindhuli
	Grape Fruit		
82	NCRP 45	Shamber	ICIMOD
83	NCRP 76	Henderson	INRA_CIRAD, France
84	NCRP 77	Star Ruby	INRA_CIRAD, France
85	NCRP 78	Reed	INRA_CIRAD, France
86	NCRP 79	Pink Rubi	INRA_CIRAD, France
87	NCRP-44	Phultrac (Pumelo)	Vietnam
88	NCRP-43	Nam Roi (Pumelo)	Vietnam
89	NCRP-42	Phodiem (Pumelo)	Vietnam
	<i>E. Acid lime (C. aurantifolia)</i>		
90	NCRP-108	Khursanibari local	SHARP, Chitwan
91	NCRP-107	Tehrathum local	Tehrathum
92	NCRP-117	Baitadi local	Baitadi
93	NCRP-118	Salyan local	Rojwal Takura, Salyan
94	NCRP-119	Bhojpur local	Takshor, Bhojpur
95	NCRP-120	Parwat local	Lekhpant, Parwat
96	NCRP-60	Kaptangang lamo	Sunsari
97	NCRP-59	Kaptangang golo	Sunsari
98	NCRP 58	Krishnapur kagati	Bharatpur, Chitwan
99	NCRP-57	Krishnapur kagati	Bharatpur, Chitwan
100	NCRP-56	Banarasi Kagati	Biratnagar
101	NCRP-55	Madrasi Kagati	Biratnagar
102	NCRP 54	Banarasi Kagati	Biratnagar
103	NCRP-53	Panta-1	Chitwan
104	NCRP-52	Belepur	Morang
105	NCRP-51	Sundarpur	Morang
106	NCRP-50	IAAS Acc # 71 (5)	IAAS, Rampur
107	NCRP-49	IAAS Acc # 101 (3)	IAAS, Rampur
108	NCRP-48	IAAS Acc # 101 (2)	IAAS, Rampur
109	NCRP-47	IAAS Acc # 01 (17)	IAAS, Rampur
110	NCRP-46	IAAS Acc # 01 (25)	IAAS, Rampur
111	NCRP-135	Nepalgunj local	Banke

S.N.	Accession No	Identification/Common Name	Source
112	NCRP-136	Mexican lime	
113	NCRP-137	Ranitar local	Nawalpur
114	NCRP-138	Jhapa collection	Budhabare, Jhapa
	<i>E. Lemon</i>		
115	NCRP 61	Ureka lemon Unkwown	Unknown
116	<i>NCRP 63</i>	Hill Lemon	Sunderpur Morang
117	<i>NCRP 64</i>	Ureka lemon Lamcho lemon	Sunderpur Morang
118	<i>NCRP 109</i>	Thimura local	SHARP Chitwan
119	<i>NCRP 110</i>	Biratnagar Local	SHARP Chitwan
120	<i>NCRP 111</i>	Prembasti local	SHARP Chitwan
	Rootstocks		
121	NCRP 65	Citrance C-35	INRA_CIRAD
122	NCRP 66	Citrance – 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	Citrance old	Unknown
129	<i>NCRP 38</i>	Citrance	Unknown
130	<i>NCRP 35</i>	Citron	Unknown
131	<i>NCRP 36</i>	Trifoliata	Unknown
132	<i>NCRP 37</i>	Rangapur lime	Unknown
133	<i>NCRP 39</i>	Boxifolia	Unknown
134	<i>NCRP 40</i>	Rough lemon	Unknown
135	<i>NCRP 116</i>	Rough lemon	Paripatle Dhankuta
136	NCRP-41	Hokse	Dhankuta
137	NCRP-62	Local Bimiro (Citron)	Belahara, Dhankuta
138	NCRP-104	Sweet lime Citrus limetta	Dhankuta
139	NCRP-139	Troyer Citrange	Australia
140	NCRP-140	Rough lemon	Kathmandu

Annex 2: Human Resource Allocation in 2078/79

Designation	Approved	Fulfilled	Vacant
1. Chief Scientist (S.5) – Horticulture	1	-	1
2. Senior Scientist (S.4)- Horticulture	1	-	1
3. Senior Scientist (S.3)- Horticulture	1	1	0
4. Senior Scientist (S.3)- Plant pathology	1	-	1
5. Scientist (S.1) - Soil	1	-	1
6. Scientist (S.1) - Plant breeding (Tissue culture)	1	1 (Hort.)	0
7. Scientist (S.1) - Entomology	1	-	1
8. Scientist (S.1) - Plant Pathology	1	1	0
9. Senior Technical Officer (T.8) – Olericulture	1	-	1
10. Senior Technical Officer (T.7) – Pomology	1	-	1
11. Technical Officer (T.6) - Horticulture	1	1	0
12. Technical Officer (T.6) - Pomology	3	-	3
13. Senior Technician (T.5)	2	1	1
14. Technician (T.4)	5	0	5
15. Technician (T-1)	13	3	10
16. Assistant Account (A4)	1	1	0
17. Administrative Assistant (A5)	1	1	0
18. Driver (Heavy)	1	1	-
Total	37	11	26

Annex 3: Human Resource of NCRP in 2078/79

Name	Position	Qualification	Working area
1. Dr. Umesh Kumar Acharya	Sr. Scientist (S-3)	Ph.D. (Pomology)	Horticulture
2. Dr. Sabitri Adhikari	Scientist (S-1)	Ph.D. (Hort.)	Horticulture
3. Roshan Pakka	Scientist (S. 1)	M. Sc. (Plant Pathology)	Plant Pathology
4. Dipti Adhikari	Technical officer (T-6)	M.Sc. (Plant Pathology)	Horticulture
5. Manoj Sah Teli	Technician (T5)	B.Sc.Ag	Agriculture
6. Balram Shrestha	Chief Admin Assistant (A-5)	Bachelors' degree	Administration and store
7. Jayram Hajara	Ass Accountant (A4)	Bachelors' degree	Account
8. Hem Bahadur Dahal	TS- Fifth	Literate	Support in research and production
9. Tara Nath Khatri	Heavy driver-Fifth	S.L.C.	Driver
10. Kashi Nath Subedi	TS-First	Literate	Support in research and production
11. Dhan Kumar Rai	TS-First	Literate	Support in research and production

Annex 4: Publications in FY 2078/79

Publication	Type	Language	Published number
Annual Report (2077/78)	Book	English	100
Citrus nursery management technology	Book	Nepali	200
Citrus Fruit Farming Technology	Book	Nepali	500
Citrus blue mould management technology	Book	Nepali	200
Citrus Storage technology	Leaflet	Nepali	1000
Citru leaf sampling method for HLB test	Leaflet	Nepali	1000

Annex 5: Regular Annual Budget and Expenditure in 2077/78

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
	Operational Expenses				
21111	Staff Salary	6297000.00	5494616.40	5494616.40	802383.60
21131	Local Allowances	142000.00	110820.00	110820.00	3110.00
21132	Dearness Allowances	288000.00	242000.00	242000.00	46000.00
21121	Uniform	120000.00	100000.00	100000.00	20000.00
21213	Insurance Fund Expense Based on Contribution	58000.00	48400.00	48400.00	9600.00
22111	Water and Electricity Expenses	23600.00	235150.00	235150.00	850.00
22112	Communication Expenses	201000.00	179452.00	179452.00	21575.00
22212	Fuel (Office purpose)	353000.00	351327.00	351327.00	1673.00
22214	Insurance	51000.00	51000.00	51000.00	0.00
22221	Repair and Maintenance of Machinery and Equipments	178000.00	174943.00	174943.00	3057.00
22291	Repair and Maintenance of other Assets	73000.00	72860.00	72860.00	140.00
22213	Vehicle Repair Cost	310000.00	309306.00	309306.00	694.00
22311	Office related expenses	299000.00	297603.00	297603.00	1397.00
22314	Fuel for Other Purposes	143000.00	138282.00	138282.00	4718.00
22231	Repair/Maintenance of Public Assets	45000.00	41899.00	41899.00	3101.00
22512	Training and seminar expenses	680000.00	680000.00	680000.00	0.00
22521	Production Material Service	10323000.00	10281297.00	10281297.00	104703.00

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
22611	Monitoring and evaluation expenses	242000	240850.00	240850.00	1150
22315	Newspaper, Printing and News Publication Cost	134000.00	133336	133336	664.00
22413	Contract Service Cost	1160000.00	1096211.00	1096211.00	63789.00
22612	Travel Expenses	1273000.00	1271963.00	1271963.00	1036.00
22711	Miscellaneous Expenses	63000.00	62025.00	62025.00	975.00
28143	Vehicle & Machinery Equipment Rent Cost	100000.00	99602.00	99602.00	398.00
	Capital Expenses				
31123	Furniture and Fixtures	100000.00	99948.00	99948.00	52.00
31122	Machinery Equipment	2763000.00	2505119.00	2505119.00	257881.00
31159	Other Public Construction	4000000.00	3988050.00	3988050.00	11951.00
31161	Maintenance of buildings	1000000.00	995742.00	995742.00	4258.00
31171	Maintenance of other public assets	364000.00	358785.00	358785.00	5215.00
	Grand Total	32520000.00	29616559.40	29616559.40	2903440.6

Annex 6: Beruju Status till Fiscal Year 2078/79

Beruju	Amount	Remarks
Beruju till year (2077/78)	86,080.80	
Beruju in FY 2077/78	35,66,000	
Beruju cleared in this FY (2077/78)	3161000.00	
Remaining beruju	6430000.00	

Annex 7: Annual Budget and Expenditure of KOIKCA UNDP Project in 2078/79

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
21135	Other Allowances	154000.00	153339.00	153339.00	661.00
22212	Fuel	60000.00	59645.00	59645.00	355.00
22315	Stationary and other expenses	100000.00	99948.00	99948.00	52.00
22521	Production Material Service	415000.00	371687.00	371687.00	43313.00
22512	Training Expenses	300000.00	277794.00	277794.00	22206.00
22612	Travel Expenses	130000.00	129680.00	129680.00	320.00
28143	Vehicle Rent	20000.00	19775.00	19775.00	225.00
	Grand Total	1179000.00	1111868.00	1111868.00	67132.00

Annex 8. List of Residential training participants in training entitled "Citrus Nursery Management" at NCRP Dhankuta

S.N.	Name of Farmer	Address
1	Anil Nepal	Terathum
2	Tejendra Thapa	Myagdi
3	Ram Bahadur Roka	Myagdi
4	Bhesh Raj Gyawali	Gulmi
5	Jai Bahadur Thapa	Jajarkot
6	Narendra Kumar Khatri	Nawalparasi
7	Baal Kumar Bhattarai	Solukhumbu
8	Uddab Pathak	Udyapur
9	Bijay Ghimire	Dhankuta
10	Ganashyam Aryal	Syangja
11	Sudarsan Doranga	Syangja
12	Keshar Limbu	Dhankuta
13	Umesh Subedi	Sankhuwasabha
14	Bhim Bahadur Shrestha	Ramechap
15	Lal Bahadur Shrestha	Sindhuli
16	Chandal Kumar Rai	Bhojpur
17	Nawaraj Basnet	Gorkha
18	Padma Raj Ojha	Doti
19	Chhandra Singh Saud	Dadeldhura
20	Min Raj Ojha	Dadeldhura
21	Bhupendra Mahara	Dadeldhura
22	Sagar Malla	Doti

S.N.	Name of Farmer	Address
23	Chetis Budhayer	Dadeldhura
24	Dilip Bohara	Doti
25	Bhan Singh Dhami	Darchula
26	Arun Tamang	Ramechhap
27	Lalit Bahadur Bista	Dadeldhura

Annex 9. List of training participants in Training entitled "Citrus Fruit fly Management" at Dhankuta

S.N.	Name of Farmer	Address
1	Ghanendra Ghising	Dhankuta
2	Padam Kumar Limbu	Dhankuta
3	Deepak Limbu	Dhankuta
4	Dhan Bahadur Bhattarai	Dhankuta
5	Damber Giri	Dhankuta
6	Siwana Subba	Dhankuta
7	Santa Bahadur Tamang	Dhankuta
8	Rup Chandra Rai	Dhankuta
9	Santosh Rai	Dhankuta
10	Binod Rai	Dhankuta
11	Mitra Bd. Rai	Dhankuta
12	Jai Kumar Rai	Dhankuta
13	Lekh Bahadur Rai	Dhankuta
14	Kher Prasad Rai	Dhankuta
15	Jitendra Rai	Dhankuta
16	Bhakta Thapa	Dhankuta
17	Bhupendra Thapa	Dhankuta
18	Radha Rai	Dhankuta
19	Dibya Shrestha	Dhankuta
20	Gita Sanjayal	Dhankuta
21	Arjun Tamang	Dhankuta
22	Harimaya Tamang	Dhankuta
23	Shanta Tamang	Dhankuta
24	Padam Karki	Dhankuta

Annex 10. List of training participants entitled "Off Seasonal Citrus cultivation in Tarai Region" at Tarahara, Sunsari

S.N.	Name of Participants	Address
1	Rajesh Mehta	Sunsari
2	Dewnarayan Mehta	Sunsari
3	Rajaram Mehata	Sunsari
4	Kamala Nand Mehata	Sunsari
5	Yamlal Das	Morang
6	Raywati Devi Rajbanshi	Morang
7	Aanand Kumar Kamat	Morang
8	Jagat Bahadur Chauhan	Sunsari
9	Krishnaraj Dahal	Jhapa
10	Gan Bahadur Karki	Morang
11	Tikaram Timilshina	Jhapa
12	Mahendra Limbu	Morang
13	Ram Kumar Thapa	Jhapa
14	Lekhnanth Subedi	Jhapa
15	Dhaka Prasad Chamlagai	Jhapa
16	Ram Prasad Upreti	Jhapa
17	Bidur Budhathoki	Morang
18	Chandra Bahadur Rai	Sunsari
19	Prakash Bhattarai	Morang
20	Rudra Mani Neupane	Morang
21	Aarbind Kumar Rajbanshi	Morang
22	Rojendra Kumar Rajbanshi	Morang
23	Harilal Majhi	Morang
24	Mitra Bahadur Bista	Morang
25	Kamal Prasad Koirala	Morang

Annex 11. List of participants in Citrus Working Group meeting at Subtropical Horticulture Centre, Kritipur Kathmandu

S.N.	Name of Participants	Position/Office/Place
1	Dr Gobind Sharma	Secretary, MoALD, Kathmandu
2	Mr. Ram Bahadur KC	Director, Crops and Horticulture, NARC
3	Mr. Baikuntha Adhikari	PD, PMAMP, Khumaltar
4	Prof Dr Arjun K Shrestha	Director, DoREX, AFU, Chitwan
5	Dr Shreemat Shrestha	Chief, NAERC, Khumaltar
6	Dr Umesh Acharya	Coordinator, NCRP, Dhankuta
7	Mr. Meghnath Timilshina	Senior Ag Officer, PMAMP, Khumaltar

S.N.	Name of Participants	Position/Office/Place
8	Mrs. Yam Kumar Shrestha	Senior Hort Officer, NCDF, Kritipur
9	Mr. Mahesh Chandra Acharya	Senior Plant Prot. Officer, PQPMC, Hariharbhawan
10	Mr. Debraj Adhikari	Chief, PMAMP, Sindhuli
11	Dr. Kalika Upadhya	Director, DoAR, Lumle
12	Mr Netra Hari Ghimire	Chief, ARS, Dailekh
13	Mr Madhav Lamsal	Chief, Citrus Zone, PMAMP, Syangja
14	Mrs Purna Dhungana	Chief, PMAMP, Gorkha
15	Mr Bishnu Pd Sharma	Chief, PMAMP, Nawalparashi
16	Mr Thirlal Ghaire	Chief, PMAMP, Ramechhap
17	Dr. Kashinath Chilwal	Scientist, DoAR, Lumle
18	Dr. Suraj Baidhya	Chief, NPPC, Khumaltar, Lalitpur
19	Dr Shree Pd Vista	Chief, NSSRC, Khumaltar, Lalitpur
20	Mr. Dipti Adhikari	Technical Officer, NCRP, Dhankuta
21	Mr Surya Pd Baral	Chief, STHC, Kritipur, Kathmandu
22	Mr. SandipTimilshina	Scientist, HRS, Malepatan, Kaski
23	Mrs. Suprabha Panday	Technical Officer, NHRC, Khumaltar, Lalitpur
24	Mr Bodhraj Aryal	Citrus Farmer, Syangja
25	Mr. Saurav Dhakal	Farmer and Enterpreuner, Kathmandu
26	Mr Nitin Kediya	Citrus sapling grower, Lalitpur
27	Mrs Riti Singh	Senior Hort Officer, DOA, Lalitpur
28	Dr. Ram Bahadur Khadka	Scientist, NPDC, Khamulatar, Lalitpur
29	Mrs. Ranju Maharjan	Senior Hort Officer, DOA, Lalitpur
30	Mrs Shrijana Bhandari	Plant Prot Officer, MoALD, MoAID
31	Mr Bikram Basyal	Ag Officer, MoALD, Kathmandu
32	Mr Kishor Bhandari	Scientist, DoAR, Tarahara
33	Mr Karna Bdr Ale Magar	Junar Farmer, Sindhuli
34	Mr Durga Bdr Subedi	Junar Farmer, Ramechhap
35	Mr Bauwa Lal Chaudhari	Chief, PMAMP, Dhankuta
36	Mr. Yubraj B K	Ag Dev Officer, PMAMP, Lalitpur
37	Mr Khemraj Joshi	Chief, PMAMP, Doti
38	Mr Nabin Rawal	Scientist, NSSRC, Khumaltar, Lalitpur
39	Mr Jiban Bhandari	Soil Scientist, DoA, Hariharbhawan
40	Ms. Mandira Khadka	Reporter, Kathmandu
41	Mr Shyam Pd Paudel	Scientist, DoAR, Lumle, Kaski
42	Mr Krishna Pd Upadhya	Ag Officer, DOA, Hariharbhawan, Lalitpur
43	Mr Balram Shrestha	C. Admin Assitant, NCRP, Dhankuta
44	Mr Jayram Hajara	Account Assistant, NCRP, Dhankuta
45	Mr Prakash Siwakoti	Technical Assistant, PMAMP, Khumaltar, Lalitpur