Mandarin stored at Syangja cold storage facility

Early season mandarin variety registered as Paripatle Agaute Suntala-1

National Citrus Research Programme (NCRP)
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NPSN: 07/080/81

ANNUAL REPORT

2079/80 (2022/23)

Government of Nepal
Nepal Agricultural Research Council
National Citrus Research Programme
Paripatle, Dhankuta, Nepal
2023

ANNUAL REPORT

2079/80 (2022/23)

GOVERNMENT OF NEPAL

NEPAL AGRICULTURE RESEARCH COUNCIL

NATIONAL CITRUS RESEARCH PROGRAMME

PARIPATLE, DHANKUTA

2023

Nepal Agriculture Research Council (NARC)

National Citrus Research Programme (NCRP)

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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 acid lime 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 endorsed one improved and early variety (Paripatle Agaute-1) and one local variety of mandarin (Banskhart) for registration. With better management of nersry 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 soil, tissue culture, biotechnolgy 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 Mr Amrit Katuwal for their conscientious help while preparing this annual report.

Umesh Kumar Acharya, PhD
Coordinator
National Citrus Research Programme
Paripatle, Dhankuta

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
DoAR	Directorate of Agricultural Research
et. al.	et alia
FAO	Food and Agriculture Organization
FY	Fiscal Year
FYM	Farm yard manure
G	Gram
Ha	Hectare
HLB	Huanglongbing
i.e.	That is
IAAS	Institute of Agriculture and Animal Science
ICAR	Indian Council of 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
^{o}	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	Titratable 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 फलफुल 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 रुपमा पहिचान गरिएको छ । यसर्थ नेपाल सरकारले बिगत केहि वर्षदेखि सुन्तला क्षेत्रको प्रवर्द्धन र विकासको लागि उच्च प्राथमिकता दिदै आएको छ । यद्यपी विगत केहि बर्ष 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 अभाब जस्ता कारणले उत्पादन र उत्पादकत्वमा समस्या देखा परेको हो ।

यस परिप्रेक्ष्यमा राष्ट्रिय सुन्तला जात अनुसन्धान कार्यक्रमले राष्ट्रिय जिम्मेवारीको रुपमा यस क्षेत्रको प्रवर्द्धन र विकास गर्न उपयुक्त प्रबिधि विकासको लागि अनुसन्धानका कार्यक्रमहरु संचालन गर्दै आएको छ। यस कार्यक्रमले आ.व. २०७९/८० अवधिमा जम्मा ७ वटा परियोजना अन्तर्गत ४२ वटा अनुसन्धान क्रियाकलापहरु सम्पन्न गरेको थियो । यी कार्यक्रमहरु विशेष रुपमा जातीय अनुसन्धान, बाली उत्पादनोपरान्त भन्डारण, बगैचा ह्रास व्यवस्थापन र सुन्तलाको औंसा किरा व्यवस्थापनसंग सम्बन्धित थिए । फलफूल अनुसन्धान सम्पन्न गर्न लामो समय लाग्ने भएकोले धेरैजसो कार्यक्रमहरु नियमित संचालनमा छन् भने केहि सम्पन्न भई अपेक्षित उपलब्धिहरु ह्रासिल भएका छन । यसरी आ.व. २०७९/८० सम्म पुरा गरिएका क्रियाकलापहरुको उपलब्धिहरु संक्षिप्त रुपमा तल उल्लेख गरिएको छ ।

- जातीय संकलन र सम्बर्द्धन अन्तर्गत १५४ वटा स्थानीय र वाह्य श्रोतबाट सुन्तलाका विभिन्न जातहरु संकलन गरि कार्यक्रमको फारम भित्र फिल्ड जिन बैंकमा 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 बृद्धी विकास आदिको विशेषतामा निकै विविधता देखिएको छ । उपयुक्त जातको छनौट तथा विकाशको लागि अझ केहि वर्ष अध्ययन गर्न आवश्यक देखिन्छ ।

- सुन्तला, जुनार, कागति र ट्यांङगोर प्रचलनमा रहेका जातहरुको उत्पादन क्षमता कम रहेका छन। यस समस्यालाई हल गर्ने उदेश्यले विदेशबाट भित्राईएका र उपयुक्त स्थानिय जातहरुको खोजीगरी बिगत 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 परिणम दिएको पाईएको छ । गत आर्थिक बर्षमा कागतीको तेर्हथुम, सुन्तलाको खोकु स्थानीय जात पुर्वी पहाडमा खेती गर्न सिफारिस गरिएको छ । यस बर्षमा सुन्तलाको एक जात ओकित्सुवासेलाई उन्मोचनका गरीएको छ ।

- वासिगंटन नेभल जातको जुनारले राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको छ । यो जात बेमौसमी जुनार उत्पादनको लागि राम्रो पाइएको छ । यस जातलाई उन्मोचनका लागि आगामी दिनमा प्रस्ताबको लागि सिफारिस गर्ने क्रममा छ । अन्य जातहरुमा माल्टा ब्लड रेड, डेलेसिओस सिडलेस, सुकारी र धनकुटा स्थानियको उत्पादन उत्साहजनक देखिन्छ ।
- दस वटा कागतिका जातहरु संकलन गरी बिगत 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 बर्षमा सुन्तलाको उन्नत जात पारिपातले अगौटे-१ नेपाल सम्पूर्ण (८००-१४०० मिटर सम्म) पहाडी क्षेत्रमा खेती गर्न सिफारिस गरिएको छ ।
- गत आ.व.२०७९/८० मा करिव २५०० जना कृषक र सरोकारवालाहरुलाई अनुसन्धान कार्यक्रम वारे जानकारी र प्रविधिहरु बारे सल्लाह दिईयो ।
- कलमीको लागि सुन्तला र कागतिको माउ बोटबाट स्वस्थ सायन धनकुटा जिल्लाका नर्सरी व्यवसायीहरुलाई उपलव्ध 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. २०७९/८० मा कृषकहरुलाई वितरण गरिएका जम्मा कलमी विरुवा १६६१९ मध्ये सुन्तलाको ३०४५, जुनारको ११६८, कागतिको १२४०६ र अन्य ६० बिरुवाहरु थिए ।
- यस कार्यक्रमको आ.व. २०७९/८० को लागि विनियोजित वजेट रु तीन करोड उनन्तिस हजार 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 2079/80 (2021/22), a total of 42 activities under 7 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 154 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 registed as early season variety named Paripatle Agaute Suntala-1based 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 Sub-committee as suitable for Gandaki Province mid-hill condition recently.
- 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 2079/80, total of 16619 grafted saplings constituting 3045 mandarin orange, 1166 sweet orange, 12406 acid lime and 60 other saplings were sold to farmers.
- The total annual budget approved for the program was Rs. 30.29 million, while operational budget consisted of Rs. 22.0 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 18 years. The current area is recorded to be 49,306 ha producing 3,06,149 metric tons with productivity of 9.47 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 2004/05 to 2021/22

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
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
2020/21	50,235	32,188	3,11,188	9.76
2021/22	49,306	32,417	3,06,149	9.47

Source: MoALD, Nepal, 2023

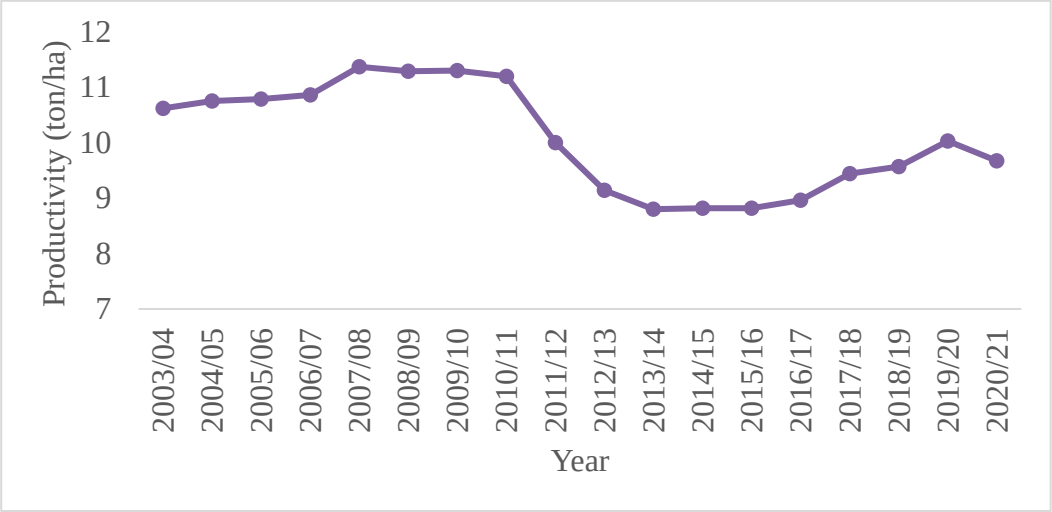

Figure 1: Productivity (mt/ha) of citrus crops during 18 years period

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 27,982 ha, 19,481 ha, 1,85,346 mt respectively, with the the productivity of 9.51 mt/ha. On the other hand, other citrus fruit acquired the lowest area (2,392 ha), productive area (1,495 ha), and production (11,261 mt). The the highest productivity was from sweet orange (11.51) and the lowest productivity of 7.13 mt/ha was recorded with lemon.

Table 2: Total area, productive area, production and productivity of major citrus fruits in Nepal (2021/22)

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

Source: MoALD, Nepal, 2023

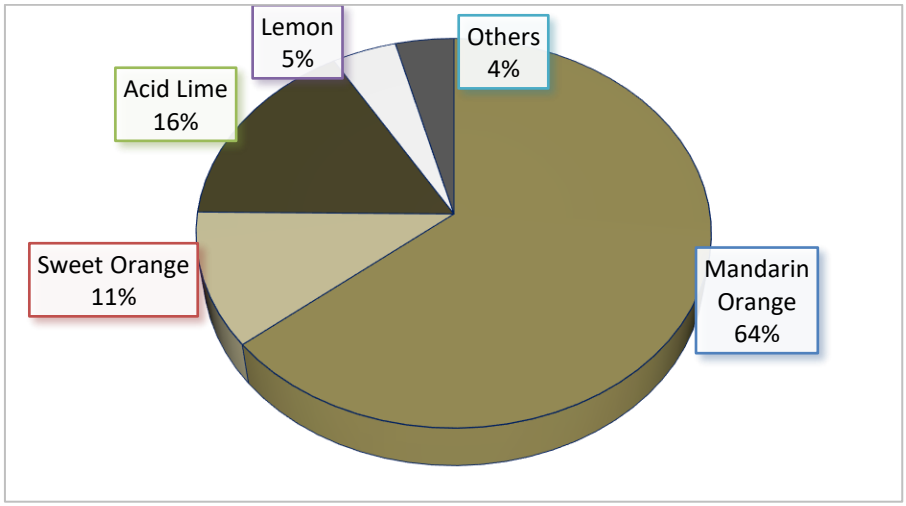

Figure 2: Total area (in percentage) of major citrus fruits in Nepal during 2022/23

The result shown in above pie-chart reveals that mandarin orange covers the maximum production area among citrus fruit. Mandarin orange covers 64.0% area among the citrus cultivated area. Similarly, acid lime, sweet orange, lemon and other citrus covers 16.0%, 11.0%, 5.0% and 4.0% respectively.

Table 3 shows the total orchard area, productive area, production and productivity of five groups of citruses 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 (2021/22)

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, 2023

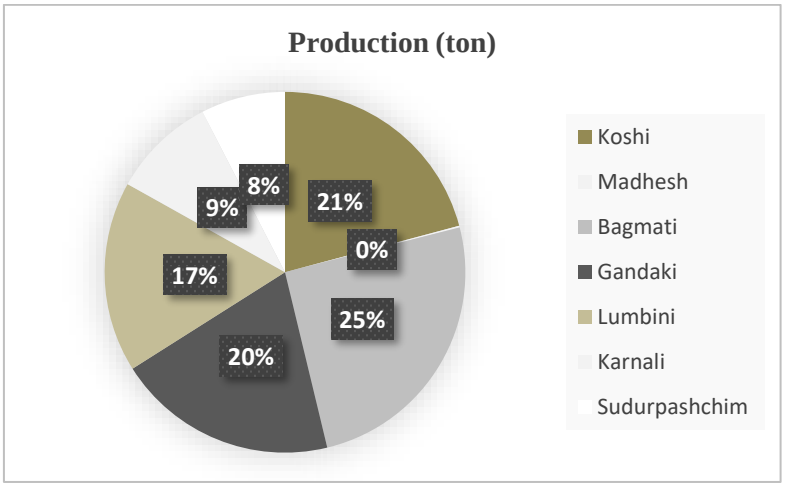

Figure 3: Total production of citrus in seven provinces during 2022/23

The pie-chart shows the status of citrus fruit production of the seven provinces of Nepal. Out of total citrus production; i.e. 306150 mt, Bagmait contributes maximum (25%) citrus production with total production of 77243 mt followed by Koshi (63824 mt) and Gandaki province (60597 mt). There is very negligible production from citrus crops in Madhesh Province (469 mt). Citrus crops share about 27% 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 fourty 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 2079/80 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 form JICA, Japan in 2001. Likewise, promising 12 varieties of sweet orange were introduced from ICAR, India during 2006. Several varieties of sweet orange, grapefruit and acid lime were collected with the support of ICIMOD, Vietnam and IAAS, Rampur during different period. Beside these, 8 new varieties comprising of 3 mandarin orange, 4 sweet 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 reticulate* Blanco) is ah 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 non- significantly different among the genotypes (Table 4). Only fruit yield/ha was significant among the tested genotypes.

Fruit weight (g)

Fruit weight was found statistically non-significant and varying from 39.7 g to 177 g with the mean value of 105.27 g. The highest fruit weight was found in Okitsuwase (177 g) followed by Satsuma Okitsu (150 g). The lowest fruit weight was found in Avana (39.7 g) followed by Hernandina (60.9g).

Fruit Diameter (mm)

Fruit diameter was found non-significantly different and ranged from 41.7 mm to 278 mm with mean value of 71.14 mm. The highest fruit diameter was found in Sikkime Suntala (278 mm) followed by Okitsuwase (75.2 mm) and Miyagawase (169 mm). The lowest fruit diameter was found in Avana (41.7 mm) followed by Hernandina (48.7 mm).

Fruit rind thickness (mm)

Fruit rind thickness was found non-significantly different and ranged from 1.11 mm to 3.3 mm with mean value of 2.42 mm. The highest fruit rind thickness was found in Satsuma URSS (3.3 mm) followed by Hernandina (2.92 mm). The lowest fruit rind thickness was found in Avana (1.11 mm) followed by Khoku local (1.86 mm).

Fruit rind weight (g)

Fruit rind weight was found non-significantly varying and ranged from 17.4 g to 46.6 g with mean value 29.76 g. The highest fruit rind weight was found in Avana (46.6 g) followed by Okitsuwase (45.1 g). The lowest fruit rind weight was found in Marisol (17.4 g) followed by Paige (18.8 g).

Table 4: Fruit physical parameters and yield attributing characteristics of mandarin orange genotypes at NCRP in 2022/23

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)
Khoku Local	88.3	56	1.86	25.5	9.0	8.72	14.4
Kinnow	77.1	56.1	2.46	23.5	11.0	21.0	12.8
Frutrel Early	91.8	58.9	2.62	28.7	11.2	15.2	25.6
Miyagawase	169	74.1	2.86	42.8	11.1	0.12	9.94
Okitsuwase	177	75.2	2.65	45.1	10.8	1.96	17.3
Pongan	134	65.3	2.8	39.2	10.1	7.75	9.97
Kamala	82.5	55.1	2.46	27	8.40	15.1	4.90
Banskharka Local	97.3	54.1	2.35	21.8	9.04	8.32	6.79
Sikkime Suntala	92.0	58.1	2.16	25.4	9.32	10.0	65.6
Satsumawase	118	66.8	2.84	32.8	10.7	3.80	11.5
Satsuma mino	107	63.2	2.5	31.4	11.0	0.68	23.8
Satsuma URSS	125	67.9	3.3	36.8	10.9	4.28	22.4
Fortune	94.0	55.9	1.89	19	10.1	9.27	1.87
Nova	130.	62.5	2.82	32.99	10.4	3.80	14.0
Dancy	78.9	54.0	1.99	20.3	9.48	3.96	16.2
Avana	39.7	41.7	1.11	46.6	10.6	4.90	13.4
Paige	65.8	49.0	2.32	18.8	9.68	6.16	4.16
Satsuma Okitsu	150	70.9	2.39	35.82	11.3	1.88	14.1
Hernandina	60.9	48.7	2.92	20.2	9.13	13.3	8.84
Oraval	99.7	57.1	2.32	29.3	7.84	6.80	70.0
Commune	92.2	55.5	2.6	26.9	9.35	7.00	58.0
Marisol	73.3	51.3	2.05	17.4	8.35	2.95	12.9
Nules	76.4	53.1	2.58	20.9	10.2	15.7	34.5
Grand Mean	105.27	59.68	2.42	29.76	9.95	5.69	24.09
P Value	NS	NS	NS	NS	NS	NS	*
CV%	12.71	16.27	2.25	5.88	1.15	8.54	16.46
LSD							47.99

Number of segments

The number of segments per fruit was found non-significantly different and ranged from 7.84 to 11.3 with mean value of 9.95. The maximum number of fruit segments per fruit was found in Satsuma Okitsu (11.3) followed by Frutrel early (11.2) and Miyagawase

(11.1). The minimum number of segments per fruit was found in Oraval (7.84) followed by Marisol (8.35) and Kamala (8.4).

Number of seeds per fruit

The no of seed/fruit was found non-significant among tested genotypes. It ranged from 0.12 to 21 with an average of 5.64. The highest number of seeds were found on Kinnow mandarin (21) followed by Fruel early (15.2) and Kamala (15.1) while the lowest number was found on Miyagawawase (0.12).

Total fruit yield per hectare (ton)

The total fruit yield per hectare was found significantly different and ranged from 4.16 to 70 t/ha with mean value of 24.09 t/ha. The highest fruit yield was found in Oraval (70 t/ha) followed by Sikkime (65.6 t/ha). The lowest fruit yield was found in Paige (4.16 t/ha) followed by Fortune (4.41 t/ha) and Kamala (4.9 t/ha).

Physio-chemical properties of mandarin

Physio-chemical properties of mandarin like TA % and CCI were found significantly different at harvest among the genotypes (Table 5.)

Juice percent (%)

Juice percentage was found non-significantly different among tested genotypes and ranged between 27.6 % to 53.5 % with mean value 38.85 %. The highest juice quantity was found in Satsuma Okitsu (53.5%) followed by Miyagawase (51.5 %) and Avana (45.3%). The lowest juice quantity was found in Commune (27.6%) followed by Nova (29.2%) and Pongan (31.4%).

Total Soluble Solid (TSS%)

TSS % was found non-significantly different among the tested genotypes and varied from 6.24 % to 13.1 % with mean value 9.67 %. The highest TSS % was found in Avana (13.1%) followed by Paige (12.8%) and Hernandina (12.5%). The lowest TSS % was found in genotype Dancy (6.24%) followed by Okitsuwase (7.32%).

Titrtable acid (TA%)

Among the tested genotype TA % was found significantly different and ranged from 0.663% to 1.88% with the mean value 1.13 %. The highest percentage of TA was found in Kamala (1.88%) followed by Pongan (1.59%) whereas the lowest percentage was found in Miyagawase (0.663%) followed by Satsuma Okitsu (0.764%).

Table 5: Physio–chemical properties of mandarin orange genotypes at NCRP in 2022/23

Genotypes	Juice volume (%)	TSS (%)	TA %	pH	DA meter reading	Citrus Color Index (CCI)
Khoku Local	38.3	10.7	0.797	5.22	0.72	7.4
Kinnow	35.4	11.6	1.57	4.2	0.564	7.7
Frutrel Early	38.5	9.58	0.987	4.91	0.167	9.24
Miyagawase	51.4	7.79	0.663	4.42	0.46	9.9
Okitsuwase	44.2	7.32	1.14	4.47	0.846	7.07
Pongan	31.4	9.27	1.59	4.84	0.825	10.6
Kamala	35.2	10.7	1.88	4.39	0.371	13.5
Banskharka Local	33	11.7	0.894	5.19	0.48	9.3
Sikkime Suntala	38.9	11.8	0.807	5.43	0.567	10.4
Satsumawase	43.8	6.99	1.14	4.31	0.26	8.22
Satsuma mino	40.1	7.93	0.808	4.37	0.674	10.2
Satsuma URSS	43.2	7.74	1.28	4.36	0.694	10.2
Fortune	35.7	12.2	1.45	4.65	0.368	15
Nova	29.2	10.1	1.37	4.62	0.409	12.6
Dancy	34.4	6.24	0.94	5.02	0.441	22.7
Avana	45.3	13.1	1.47	3.31	0.488	10.9
Paige	34.3	12.8	1.34	3.33	0.141	8.32
Satsuma Okitsu	53.5	8.28	0.764	4.12	1.10	4.35
Hernandina	34.7	12.5	1.31	3.27	0.662	10.8
Oraval	32.2	9.96	1.28	4.48	0.261	14.9
Commune	27.6	10.5	1.2	4.06	0.536	11.1
Marisol	43.7	8.39	1.29	4.31	0.386	9.44
Nules	39.8	9.96	1.21	4.74	0.644	8.99
Grand Mean	38.85	9.67	1.13	4.47	0.53	10.57
P Value	NS	NS	**	***	NS	*
CV%	2.44	2.2	2.62	1.11	37.86	3.81
LSD			0.4	0.67		5.48

pH

The pH value was varied highly significant among tested genotypes of mandarin. The pH value ranged from 3.27 to 5.43 with an average of 4.47. The highest pH value was observed in Sikkime Suntala (5.43) followed by Khoku (5.22) and the lowest value was observed in Hernandina (3.27) followed by Avana (3.31).

DA (chlorophyll) reading

The decline in chlorophyll content of the fruit skin, measured on the tree by DA meter showed non-significantly different among the genotypes at harvest time. The value ranges from 0.141 to 1.1 with the mean value of 0.53. Minimum of DA reading was recorded in

Paige (0.141) followed by Frutrel early (0.167) whereas, Satsuma Okitsu (1.1) followed by Okitsuwase (0.846) and Pongan (0.825) were recorded with maximum DA value.

Citrus Color Index (CCI)

The CCI value for tested genotypes were significantly different with each other. The CCI value of the fruit ranged from 7.07 to 22.7 with the mean value of 10.57. Minimum CCI was recorded in Okitsuwase (7.07) followed by Khoku Local (7.4) and maximum was in Dancy (22.7) followed by Oraval (14.9).

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

Individual fruit weight (g)

The data in table 6 shows that the individual fruit weight was statistically significant among the tested genotypes. Fruit weight was varied from 105 g to 207 g with the mean value of 146.29 g. Washington Navel (207 g), Succari (174 g) and Cara Cara Navel (171 g) had higher individual fruit weight. Lowest individual fruit weight were recorded in Navalencia (105 g) followed by Blood Red (111 g) and Sevelle Common (113 g).

Fruit diameter (mm)

Individual fruit diameter was significantly different and ranged between 56.3 mm to 69.6 mm with the mean diameter of 63.65 mm. The smallest fruit diameter was observed in

Navalencia (56.3 mm) followed by Sevelle Common (58.7 mm) and Blood Red (60 mm). The biggest fruit diameter was observed in Washington Cavel (69.6 mm) followed by Malta Blood Red (68.3 mm).

Fruit rind thickness (mm)

Fruit rind thickness of the tested genotypes varied significantly and ranged between 3.4 mm to 5.51 mm with the mean thickness of 4.59 mm. The thinnest rind was found in Cara Cara Navel (3.4 mm) followed by Delicious Seedless (3.79 mm). The thickest fruit rind found in Dhankuta Local (5.51 mm) followed by Malta Blood Red (5.22 mm).

Fruit rind weight (g)

The rind weight differed significantly among the tested genotypes and ranged between 71.1 g to 161 g with the mean value of 97.41 g. Washington Navel (161 g) gave the most fruit rind weight followed by Cara Cara Navel (119 g) and Succari (115 g). Lower rind weights were observed in Navalencia (71.1 g), Blood red (72.3 g) and Tamango (74.2 g).

Number of seeds per fruit

The number of seeds per fruit differed highly significant among tested genotypes and ranged from 0.3 to 16.5 with the mean value of 5.15. Succari (16.5) had the highest number of seeds per fruit followed by Pineapple (13.7) and Malta Blood Red (12.6). In contrast, number of seeds per fruit was found minimum with Cara Cara Navel (0.3) followed by Lane Late (0.56).

Fruit number per tree

The number of fruits per plant was significantly different and ranged from 43.3 to 284 with the mean fruit number of 119.87. Tamango (284) recorded the highest number of fruits/plants followed by Valencia Late (France) (214). Genotype like LeuGim Gong (43.3), Blood Red (47) and Succari (50.7) were found to produce significantly lower number of fruits per plant.

Fruit yield per hectare (ton/ha)

The difference in total weight of fruit/hectare was highly significantly among the tested genotypes and ranged betwee 5.01 to 35.8 t/ha with a mean value of 17.76 t/ha. Tamango (35.8 ton) gave the highest yield/ha followed by Valencia Late (France) (29.7ton). Blood Red (5.01 ton) produced the least fruit yield per hectare followed by LeuGim Gong (6.41 ton).

Table 6: Fruit characteristics of different sweet orange genotypes at NCRP in 2022/23

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)
Valencia Late (India)	138	60.5	4.82	87.5	2.4	52	7.26
Sevelle Common	113	58.7	4.85	80.1	3	0	0
Navalencia	105	56.3	4.61	71.1	4.6	0	0
Malta Blood Red	166	68.3	5.22	107	12.6	142	24.2
Vanelle	141	63.1	4.32	86.9	5	96.7	14
Washington Navel	207	69.6	5.08	161	0.64	76	15.1
Hamlin	128	61.9	3.98	90.4	4.67	54	7.17
Delicious Seedless	141	62.3	3.79	88.5	3.27	163	22.9
Blood Red	111	60	4.51	72.3	2.6	47	5.01
Succari	174	65.9	4.78	115	16.5	50.7	8.68
Dhankuta Local	148	64.6	5.51	99.1	8.56	98	15
LueGim Gong	147	64.4	5.13	97	2	43.3	6.41
Cara Cara Navel	171	66.7	3.4	119	0.3	81.5	16.4
Lane Late	127	61.4	3.79	83	0.56	98.8	12.8
Pineapple	146	64	4.99	89.7	13.7	100	16.3
Valencia Late (France)	132	62.2	5	89.3	3.92	214	29.7
Salustiana	143	63.9	4.77	93.1	1.96	137	20
Tamango	126	61.1	3.85	74.2	3.88	284	35.8
Grand Mean	146.29	63.65	4.59	97.41	5.15	119.87	17.76
P Value	***	***	***	***	***	***	***
C.V %	1.1	0.56	1.67	1.18	3.34	7.7	7.16
LSD	15.75	3.5	0.52	11.29	1.67	88.13	12.14

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 except for titrable acid % (Table 7). DA meter is a device that measures the decline in chlorophyll content immediately below the skin during ripening. Likewise, CCI has been computed using an automatic computer vision system (spectrophotometer CM-700d). In the citrus industry CCI is used to determine the harvesting date or to decide if citrus fruits should undergo a degreening treatment. DA meter reading and CCI measurement are non-destructive method of citrus maturity/skin color measurement.

Juice weight (%)

Fruit juice percentage ranged from 19.1% to 37% with an average fruit juice % of 31.75 %. The highest juice percentage was recorded with genotype Vanelle (37%) followed by Tamango (36.2%) and Malta Blood Red (35.6%). Lower fruit juice weight was found in genotype Washington Navel (19.1%) followed by LueGim Gong (28.8%) and Navalencia (28.9%).

Titrable acid (%)

Among the tested genotypes percent of TA was found non-significantly different and ranged from 0.52% to 3.6% with an average TA of 1.22%. The TA % was remarkably high in Cara Cara Navel (3.6%) followed by Dhnakuta Local (1.63%). Succari (0.52%) recorded the lowest TA followed by Vanelle (0.71%).

Total Soluble Solid (%)

Among the tested genotypes the percent TSS varied from 10.3% to 12% with the mean value of 11.07%. TSS% was found higher in Washington Navel (12%) followed by Succari (11.9%). Lower TSS% was observed in Valencia Late (France) (10.3%) followed by LueGIm Gong (10.4%).

pH

The pH was found varying from 3.54 to 5.56 with an average of 4.35. The highest pH was observed in Navalencia (5.56) followed by Vanelle (5.55) and Sevelle Common (5.51). The lowest pH was recorded in Valencia Late (India) (3.54) followed by Dhankuta Local (3.68) and Pineapple (3.76)

DA (chlorophyll) reading

The decline in chlorophyll content of the fruit skin, measured on the tree by DA meter (Table 7), showed significantly different among the genotypes at harvest time. The value ranges from 0 to 0.748 with a mean of 0.1. Minimum of DA reading was recorded in Delicious Seedless (0) and Vanelle (0.003) whereas the Navalencia (0.748) followed by Sevelle Common (0.454) were recorded with maximum DA value among the genotypes.

Citrus Color Index (CCI)

The CCI value for tested mandarin genotypes were significantly different with each other. Higher the CCI value means no uniform orange color development. The CCI value of fruit ranged from 6.28 to 11.5 with a mean value of 8.78. Minimum CCI was recorded in LueGim Gong (6.28) followed by Navalencia (6.69) and maximum CCI was in Dhankuta Local (11.5) and Pineapple (11.5) followed by Tamango (10.5)

Table 7: Physio-chemical properties of different sweet orange genotypes at NCRP in 2022/23

Genotypes	Juice Wt (%)	TSS	TA	pH	DA meter reading	CCI
Valencia Late (India)	33.4	1.23	11.6	3.54	0.011	9.65
Sevelle Common	29.2	1.11	10.5	5.51	0.454	7.1
Navalencia	28.9	1.16	10.6	5.56	0.748	6.69
Malta Blood Red	35.6	0.82	10.8	4.59	0.009	8.3
Vanelle	37	0.71	10.9	5.55	0.0027	8.29
Washington Navel	19.1	0.74	12	4.34	0.74	9.62
Hamlin	34.5	0.79	11	4.46	0.009	7.82
Delicious Seedless	34.3	0.81	10.9	4.41	0	7.91
Blood Red	29.4	1.14	10.8	4.92	0.08	8.35
Succari	32.7	0.52	11.9	4.41	0.101	8.66
Dhankuta Local	30.1	1.63	11	3.68	0.022	11.5
LueGim Gong	28.8	1.29	10.4	3.77	0.194	6.28
Cara Cara Navel	35.4	3.55	11	4.12	0.015	8.94
Lane Late	31.8	1.13	11.1	3.82	0.19	8.83
Pineapple	34.2	1.19	11.7	3.76	0.019	11.5
Valencia Late (France)	29.8	1.32	10.3	4.14	0.2	6.34
Salustiana	31.9	1.37	10.6	4.55	0.046	7.95
Tamango	36.2	0.94	11.4	4.88	0.038	10.1
Grand Mean	21.75	1.22	11.07	4.35	0.1	8.78
P Value	***	NS	***	***	***	***
C.V %	1.27	18.27	0.51	0.37	6.74	1.83
LSD	3.93		0.55	0.39	0.069	1.57

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 2022/23

Accession no.	Fruit weight (g)	Fruit diamater (mm)	Peel thickness (mm)	Peel weight (g)	No. of seed
NCRP-47	34.5	38.8	2.65	21.8	5.07
NCRP-48	32.3	37.5	1.61	17.2	5.8
Sunkagati-2	46.1	43	1.68	33.1	4.85
NCRP-50	36.5	39.5	2.06	21	7.4
NCRP-51	36.5	39.2	2.2	20.5	5.93
NCRP-52	35.3	38.5	2.1	21.8	6.2
NCRP-53	101	57.5	3.5	75.9	0.8
Sunkagati-1	40.4	42.1	2.07	27.6	4.9
NCRP-56	40.2	40.9	2.41	24.7	8.07
NCRP-57	104	55.3	3.7	86.6	11
NCRP-59	36.6	39.6	2.04	21.2	4.73
NCRP-60	42.7	38.3	3.07	33.9	4.9
Terhathum Local	43.6	41.7	1.75	22.7	7.4
NCRP-108	37	39.1	2.1	21.5	7.2
Grand mean	47.74	42.45	2.39	32.51	5.38
P value	NS	NS	***	NS	***
C.V. %	1.85	0.76	3.98	2.04	5.76
LSD	-	-	0.67	-	2.17

Fruit characteristics and yield of different genotypes of sweet oranges

Fruit characteristics and yield attributes like individual peel thickness, number of seeds/fruit, number of fruits/tree, yield/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 individual fruit weight was statistically not different among the tested genotypes. Fruit weight was varied from 32.3g to 104g with the mean value of 47.74g. NCRP-57 (104g) had the biggest individual fruit sizes. The smallest individual fruit sizes were recorded in NCRP-48 (32.3) followed by NCRP-47 (34.5)

Fruit diameter (mm)

Individual fruit diameter was non-significantly different and ranged between 37.5mm to 57.5mm with the mean diameter of 42.45mm. The smallest fruit diameter was observed in NCRP-48 (37.5mm) followed by NCRP-60 (38.3mm) and NCRP-52 (38.5mm). The biggest fruit diameter was observed in NCRP-53 (57.5mm) followed by NCRP-57 (55.3).

Fruit peel thickness (mm)

Fruit peel thickness differed highly significant among tested genotypes and ranged between 1.61mm to 3.7mm with the mean thickness of 2.39mm. The thinnest peel was

found in NCRP-48 (1.61mm) followed by Sunkagati-2 (1.68mm). The thickest peel was found in NCRP-57 (3.7mm) followed by NCRP-53 (3.5mm).

Fruit peel weight (g)

The peel weight differed non-significantly among the tested genotypes and ranged between 17.2g to 86.6g with the mean value of 32.51g. NCRP-57 (86.6) gave the most fruit peel weight followed by NCRP-53 (75.9g). Lowest fruit peel weight was observed in NCRP-48 (17.2g) followed by NCRP-51 (20.5g).

Number of seeds per fruit

The number of seeds per fruit differed highly significant and ranged from 0.8 to 11 with the mean value of 5.38. NCRp-57 (11.0) had the highest number of seeds per fruit followed by NCRP-56 (8.07). In contrast, number of seeds per fruit was found minimum with NCRP-53 (0.8) followed by NCRP-59 (4.73)

Fruit number per tree

Among the tested genotypes, the number of fruits per tree was found significantly different and ranged from 58.2 to 110 with the mean value of 91.19. Sunkagati-1 (110) recorded the highest number of fruits/tree followed by NCRP-50 (104) and NCRP-56 (104). Genotype like NCRP-53 (58.2) and NCRP-108 (74) were found to produce lower number of fruits per tree.

Fruit yield per tree

The fruit yield per tree was found varying from 2.18kg to 7.21kg with mean value of 4kg. The highest yield per tree, among the tested genotypes, was recorded in NCRP-57 (7.21kg) followed by NCRP-53 (5.8kg). Similarly, the lowest yield per tree was recorded in NCRP-52 (2.18kg) followed by NCRP-108 (2.66).

Fruit yield per hectare

The fruit yield per hectare was significant among the tested genotypes and ranged between 2.42 ton and 8.01 ton with an average of 4.43 ton. NCRP-57 (8.01 ton) gave the highest yield per hectare followed by NCRP-53 (6.44 ton) and Sunkagati-1 (4.98 ton). NCRP-52 (2.42 ton) produced the least fruit yield per hectare followed by NCRP-108 (2.96ton) and NCRP-47 (3.14 ton).

Table 9: Physio-chemical properties of different acid lime genotypes at NCRP in 2022/23

Accession no.	Juice Volume %	TA%	TSS	pH	DA meter	Fruit/tree	Yield/tree	Yield/ha
NCRP-47	29.7	7.01	7.6	3.02	0.699	85.7	2.82	3.14
NCRP-48	38.5	8.1	8.1	2.92	0.918	94	3.57	3.97
Sunkagati-2	25.7	6.78	5.43	7.76	1.03	97.8	4.25	4.73
NCRP-50	31.6	7.23	7.8	2.87	1.35	104	3.06	3.4
NCRP-51	37.8	7.72	8.1	2.78	1.08	95	3.28	3.64
NCRP-52	52.5	6.8	7.65	2.72	1.12	69.5	2.18	2.42
NCRP-53	21	5.49	11.8	2.7	0.316	58.2	5.8	6.44
Sunkagati-1	28.2	6.56	5.35	8.08	1.03	110	4.48	4.98
NCRP-56	31.8	6.43	7.32	3.15	0.818	104	4.03	4.47
NCRP-57	12.8	6.5	4.76	6.24	0.19	89	7.21	8.01
NCRP-59	33.7	7.36	7.85	2.99	0.918	91.7	3.08	3.42
NCRP-60	16.1	6.41	5.87	8.2	0.757	99.2	4.34	4.82
Terhathum Local	38.2	6.78	7.82	2.9	0.779	96	4.31	4.79
NCRP-108	33.1	7.28	7.95	2.88	1.69	74	2.66	2.96
GM	29.52	6.76	7.39	4.64	0.87	91.19	4	4.43
P value	**	NS	NS	NS	***	*	**	**
C.V. %	5.32	0.79	3.42	1.03	5.07	3.66	5.53	5.54
LSD	11.01	-	-	-	0.32	22.95	1.52	1.68

Juice %

The juice percentage was found varying from 16.1% to 52.5% with the mean value of 29.52%. The highest juice percentage was found in NCRP-52 (52.5%) followed by NCRP-48 (38.5%). The lowest juice percentage was found in NCRP-57 (12.8%) followed by NCRP-60 (16.1%).

Titrable acid (TA %)

Among the tested genotypes, percent of TA ranged from 5.49% to 8.1% with mean value of 6.76%. The TA percentage was highest in NCRP-48 (8.1%) followed by NCRP-51 (7.72%) and NCRP-39 (7.36). NCRP-53 (5.49%) recorded the lowest TA percent followed by NCRP-60 (6.41%) and NCRP-56 (6.43%).

Total Soluble Solid (Brix%)

Among the tested genotypes the percent TSS varied from 4.76% to 11.8% with an average of 7.39%. TSS% was found highest in NCRP-53 (11.8%) followed by NCRP-51 (8.1%) and NCRP-48 (8.1%). Lower TSS % values were observed in NCRP-57 (4.76%) and Sunkaagati-1 (5.35%).

pH

The pH was found varying from 8.2 to 2.72 with average of 4.64. The highest pH wwas recorded from NCRP-60 (8.2) followed by Sunkagari-1 (8.08) and Sunkagati-2 (7.6). The least pH was recorded from the fuit of NCRP-53 (2.7).

DA (chlorophyll) reading

The decline in chlorophyll content of the fruit skin, measured on the trees by DA meter, showed significantly different among the genotypes at harvest time. The value ranges from 0.19 to 1.69 with a mean value of 0.87. Minimum of DA reading was recorded in NCRP-57 (0.19) followed by NCRP-53 (0.316) whereas the NCRp-108 (1.69) followed by NCRP-50 (1.35) 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 and 11, respectively.

Table 10: Fruit physical parameters and yield attributing characteristics of grapefruit, Tangor and Tangelo genotypes at NCRP in 2022/23

Variety	Fruit wt. (g)	Fruit diameter (mm)	Fruit rind thickness (mm)	Fruit rind weight (g)	Seeds/ fruit	Juice (%)
Grapefruit (Shamber)	197.53	73.97	4	123.39	3.1	36.27
Grapefruit (Henderson)	204.24	74.99	4.37	125.75	3.8	35.17
Grapefruit (Pink Ruby)	199.46	76.23	4.04	125.86	4	33.80
Tangelo (Seminole)	139.11	64.29	1.54	30.73	7	51.18
Tangelo (Minneola)	133.21	60.23	2.01	36.01	14.10	48.76
Tangor (Ortanique)	72.58	52.27	1.59	14.91	7.9	35.05
Tangor (Murkott)	76.38	53.56	1.26	14.26	7	48.28

Table 11: Physico-chemical properties of grapefruit, tangor, and tengelo genotypes at NCRP in 2022/23

Variety	TSS%	TA%	BrimA	CCI	DA meter reading
Grapefruit (Shamber)	9.52	1.43	2.38	2.04	0.03
Grapefruit (Henderson)	9.67	1.3	3.18	2.78	0.03
Grapefruit (Pink Ruby)	10.8	1.46	3.52	2.87	0.06
Tangelo (Seminole)	12.43	1.43	5.29	14.35	0
Tangelo (Minneola)	12.51	1.21	6.46	17.98	0.04
Tangor (Ortanique)	10.41	1.42	3.29	11.27	0.21
Tangor (Murkott)	12.95	1.37	6.13	11.64	0.22

3.2 DISEASE MANAGEMENT RESEARCH

3.2.1 Effect of different chemicals pesticide on Citrus canker management of acid lime

Citrus fruits cultivated all over the world in tropical and sub-tropical regions having suitable soil and climatic conditions. Mid hills of Nepal ranging from 800 to 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, Lamjhung, Syangja, Salyan and Dailekh. However, there are some biotic factor hindering the production of citrus and canker is one of them.

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

Methodology

The effectiveness of six antibiotics for controlling citrus canker was studied in acid lime (Sunkagati-2) at orchard of NCRP in 2023. The trial was set-up in randomized complete block design (RCBD) with three replications. The plots were sprayed with antibiotics for four times at fifteen days interval. Disease score and lesion diameter (LD) was measured fifteen days after every spray. Disease severity (DS) and area under disease progress curve (AUDPC) were calculated based on disease score rating. The treatments were:

T1: Plantomycin (Streptomycin Sulphate 9% + Tetracycline Hydrochloride 1% WP) @ 0.2 g/lt
T2: MU-REUM TAN (Validamycin A 10% SP) @ 1.5 g/lt
T3: KASU-B (Kasugamycin 3% SL) @ 2ml/lt
T4: 1 % Bordeaux mixture (1 lit water: 10 gm lime: 10 gm copper sulphate)
T5: Curex (Copper oxychloride 50% WP) @ 2gm/lit
T6: Zinkicide @ 3.51ml/lit (200 ppm)
T7: Control

Disease severity (DS) and Area under disease progress curve (AUDPC) was calculated using following formula:

$$\text{Disease severity (DS)} = \frac{\text{Sum of all disease score rating } \mathbf{X} \text{ 100}}{\text{No. of leaves observed } \mathbf{X} \text{ Maximum rating scale}}$$

$$AUDPC = \sum_{i=1}^{n} [(X_{i+1} + X_i)/2][T_{i+1} + T_i]$$

Where,
X_i = disease severity on the i^{th} date
T_i = date on which disease was scored
n = number of dates on which disease was scored

Result and discussion

Disease severity for each observation and mean disease severity (DS) was found varying significantly among tested antibiotics (Table 12). The mean disease severity ranged from 11.75% to 35.42%. The highest disease severity was found in copper oxychloride 50% WP while lowest in Bordeaux mixture 1 %. The second highest DS was seen in control (34.25%) followed by Zinkicide (32.46%). The second lowest DS was seen in Streptomycin Sulphate 9% + Tetracycline Hydrochloride 1% WP (14.96%) followed by Validamycin A (21.54%) and Kasugamycin (21.75%).

The total AUDPC between various antibiotics was found differing significantly. The total AUDPC value was found from 528.75 to 1668.7 with the mean value of 1135.71. The highest AUDPC was seen Copper oxychloride 50% WP (1668.7) followed by control (1627.5) and Zinkicide (1495). The lowest AUDPC value was found in Bordeaux mixture (528.75) followed by Streptomycin Sulphate 9% + Tetracycline Hydrochloride 1% WP (703.75) and Kasugamycin 3% SL (917.5).

The diameter of lesion was not found varying significantly among the tested pesticides. The lesion diameter (LD) ranged from 3.09 mm to 4.32 mm with an average of 3.55 mm. The highest LD was measured in Copper oxychloride 50% WP (4.32 mm) followed by control (4.15mm). The lowest LD was measured in Plantomycin (3.09 mm) followed by 1% Bordeaux mixture (3.11 mm) as shown in the table below:

Table 12. Disease severity (%) for each observation, mean disease severity (%) and total AUDPC value for seven different pesticides during July to September, 2023 at NCRP, Paripatle

Treatment	DS after 1st spray (15 days) (%)	DS after 2nd spray (30 days)	DS after 3rd spray (45 days) (%)	DS after 4th spray (60 days) (%)	Mean DS (%)	Total AUDPC	Lesion Diameter (mm)
Plantomycin	12.7d	13.67	20.33	13.67	14.96	703.75	3.09
MU-REUM TAN	20.33	24.17	24.16	17.5cd	21.54	1008.75	3.46
KASU-B	15.00	18.83	16.50	36.67	21.75	917.5	3.28
Bordeaux mixture	13.67	9.83	13.67	9.83	11.75	528.75	3.11
Curex	43.33	50.0	30.83	17.50	35.42	1668.75	4.32
Zinkicide	27.50	32.83	36.67	32.83	32.46	1495.0	3.45
Control	32.83	36.67	43.33	24.17	34.25	1627.5	4.15
Grand mean	23.55	26.57	26.5	21.74	24.59	1135.71	3.55
P value	***	***	*	**	**	**	NS
C.V. %	25.31	23.36	36.98	28.32	25.58	26.38	21.6
LSD	10.6	11.04	17.43	10.95	11.19	533.09	-

3.2.2 Effect of different chemicals pesticide on Powedery mildew management of mandarin orange

Powdery mildew is the fungal disease caused by *Acrosporium tingitaninum.* Powdery mildew is one of common disease found in citrus nurseries and orchard. This disease is generally seen in new flushes of plants. White ash like powder can be observed on leaves, twigs and fruits especially during rainy season when temperature and relative humidity (RH) is high in the environment. In case of heavy infestation, falling of leaves and fruit drops is seen followed by wilting of young twigs and dieback.

Methodology

The efficacy of four fungicides was studied for controlling powdery mildew in mandarin (Khoku Local) at orchard of NCRP. RCBD design was used to assign four replications of each five treatments. Four spraying was done during July to September 2023 at the interval of 15 days. Disease score rating was recorded from selected branch in all four direction of tree fifteen days after every spray of fungicide. Disease severity (DS) and AUDPC was calculated based on disease score.

Disease severity (DS) and Area under disease progress curve (AUDPC) was calculated using following formula:

Disease severity (DS) = $\frac{\text{Sum of all disease score rating } \mathbf{X} \text{ 100}}{\text{No. of leaves observed } \mathbf{X} \text{ Maximum rating scale}}$

$$AUDPC = \sum_{i=1}^{n} [(X_{i+1} + X_i)/2][T_{i+1} + T_i]$$

Where,

X_i = disease severity on the i^{th} date
T_i = date on which disease was scored
n = number of dates on which disease was scored
The treatments are enlisted below:
T1: Spraying of Tendex (Azoxystrobin 23% SC) @ 1ml/lt
T2: Spraying of 3 view (Hexaconazole 2 % DC) @ 0.5 ml/lt
T3: Spraying of Consac plus (Hexaconazole 5% SC) @ 2ml/lt
T4: Spraying of Sulfex (Sulphur 80% WP) @ 3g/lt
T5: Control (Spraying of water)

Result and Discussion

Total AUDPC and mean disease severity % were calculated as per equation above. The efficacy of fungicides varied significantly in all 4 observation dates except for third observation. The mean disease severity varied from 14.06% to 30.94%. The highest disease severity was observed in plants sprayed with only water i.e., control (30.94 %) followed by Hexaconazole 5 % SC (30.63%). On the other hand, the lowest mean disease severity was seen in Azoxystrobin 23% SC (14.06%) followed by Sulphur 80% wp (19.53%).

There was highly significant difference among the tested fungicides in terms of AUDPC value. The total AUDPC value was found varying from 732.88 to 1682.91. The highest AUDPC was seen in Control whereas the lowest in Azoxystrobin. Similarly, Sulphur 80% WP had the second lowest AUDPC value (1112.62). Hexaconazole 2% DC (1534.88) and Hexaconazole 5% SC (1550.84) did not vary significantly for total AUDPC as shown in table below:

Table 13. Disease severity (%) for each observation, mean disease severity (%) and total AUDPC value for 5 different fungicides at NCRP, Paripatle in 2022/23

Fungicides	DS after 1st spray (15 days) (%)	DS after 2nd spray (30 days) (%)	DS after 3rd spray	DS after 4th spray (60	Mean DS (%)	AUDPC
Tendex (Azoxystrobin 23% SC)	11.25	15	15	15	14.06	732.88
3 View (Hexaconazole 2% DC)	33.75	33.75	33.13	14.4b	28.75	1534.88
Consac plus (Hexaconazole 5 % SC	28.75	37.5	33.13	23.1	30.63	1550.84
Sulfex (Sulphur 80% WP)	19.38	26.88	20.63	11.25	19.53	1112.62
Control	48.75	33.13	30	11.88	30.94	1682.91
Grand mean	28.38	29.25	26.38	15.13	24.78	1322.83
P value	***	*	NS	*	***	***
C.V. %	28.84	26.11	35.45	27.5	19.62	18.02
LSD	12.61	11.77	14.4	6.41	7.49	367.16

3.3 Plant Husbandry

3.3.1 High density planting trial of mandarin orange

Methodology

Mandarin cv. Khoku local saplings (grafted onto trifoliate) at the age of two years were transplanted at NCRP, Paripatle orchard at 1300 m altitude. The saplings were planted at six different spacing as shown in Table 14. 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, except individual fruit diameter, showed that the individual fruit weight, fruit rind thickness, fruit rind weight, number of segments per fruit, number of seeds per fruit, number of fruit/tree and yield/hectare were non-significant for different planting spacing (Table 14).

Fruit weight (g)

Fruit weight was found varying from 68.4 g to 86 g with mean value of 74.91. The highest fruit weight was found in 3.5 x 3 m spacing (86g) followed by 2.5 x 3 (75.5 g). The lowest fruit weight was found in 1.15 x 3 (68.4g) followed 1.8 x 3 spacing by (72.9g).

Fruit diameter (mm)

Fruit diameter among the tested genotypes of mandarin varied significantly and ranged from 50.3 mm to 56.9 mm with the mean value of 51.96 mm. The highest fruit diameter was found in 3.5 x 3 m spacing (56.9 mm) followed by 2.25 x 3 m spacing (52.2 mm). The lowest fruit diameter was found in 1.14 x 3 m spacing (50.3 mm) followed by 3 x 3 m spacing (50.8 mm).

Fruit rind thickness (mm)

Fruit rind thickness was ranged from 2.85 mm to 2.37 mm with the mean value of 2.59 mm. The highest fruit rind thickness was found in 1.15 x 3 m spacing (2.85 mm) followed by 3.5 x 3 m spacing (2.79 mm). The lowest fruit rind thickness was found in 3 x 3 m spacing (2.37 mm) followed by 1.8 x 3 m spacing (2.45 mm).

Fruit rind weight (g)

Fruit rind weight was ranged from 20.3 g to 42.4 g with the mean value of 25.41 g. The highest fruit rind weight was found in 1.5 x 3 m spacing (42.4 g) followed by 3.5 x 3 m spacing (26.8 g). The lowest fruit rind weight was found in 1.15 x 3 m spacing (20.3 g) followed by 1.8 x 3 m spacing (20.7 g).

Number of segments per fruit

The number of segments per fruit was found non-significantly different ranging from 9.4 to 10.2 with the mean value of 9.69. The maximum number of segments per fruit was found in 3.5 x 3 m spacing (10.2) followed by 1.75 x 3 m spacing (9.82). The minimum number of segments per fruit was found in 1.15 x 3 m spacing (9.4) followed by 1.8 x 3 m spacing (9.5).

Number of seeds per fruit

The number of seeds per fruit was found varying from 10 to 10.9 with an average of 10.54. The highest number of seeds was found in 3 x3 m spacing (10.9) followed by 1.8 x 3 m spacing (10.7). The lowest number of seeds was found in 1.15 x 3 m spacing (10) followed by 3.5 x 3 m spacing (10.3).

Total number of fruits per tree

The total number of fruits per tree was ranged from 53.5 to 221 with the mean value of 99.28. The highest number of fruits was found in 3.5 x 3 m spacing (221) followed by 3 x 3 m spacing (117). The lowest number of fruits was found in 1.15 x 3 m spacing (53.5) followed by 1.8 x 3 m spacing (69.8).

Fruit yield per hectare (ton)

The fruit yield per hectare ranged from 8.16 t/ha to 18.1 t/ha with the mean value of 11.75 t/ha. The highest fruit yield was found in 3.5 x 3 m spacing (18.1 t/ha) followed by 1.5 x 3 m spacing (16.1 t/ha). The lowest yield was found in 2.25 x 3 m spacing (8.16 t/ha) followed by 1.8 x 3 m spacing (9.2 t/ha).

Table 14: Different yield and quality parameters of Khoku Local mandarin under various planting densities at NCRP Dhankuta in 2022/23.

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	68.4	50.3	2.85	20.3	9.4	53.5	9.34
1.5 x 3	75	52.2	2.51	42.4	9.67	97	16.1
1.75 x 3	74.1	51.5	2.61	22.1	9.82	100	13.3
1.8 x 3	72.9	51.1	2.45	20.7	9.5	69.8	9.2
2.25 x 3	75.4	52.2	2.68	23	9.6	72.4	8.16
2.5 x 3	75.5	51.8	2.54	22.3	9.69	111	11.2
3 x 3	73.6	50.8	2.37	22.2	9.8	117	9.44
3.5 x 3	86	56.9	2.79	26.8	10.2	221	18.1
Grand mean	74.91	51.96	2.59	25.41	9.69	99.28	11.75
P Value	NS	*	NS	NS	NS	NS	NS
C.V%	1.48	0.82	2.35	14.13	0.84	13.67	13.18
LSD		2.69					

Physicochemical properties of mandarin orange

The difference in physiological properties viz. BrimA, pH, TSS%, TA%, DA reading and CCI were non-significant among the treatments. However, juice volume was found significantly different among the treatments (Table 15).

BrimA

The BrimA value was varied from 7.71 to 8.34 with an average of 7.99. The highest BrimA value was recorded in 1.75 x 3 m spacing (8.34) followed by 3x 3 m spacing (8.28). On the other hand, the lowest BrimA value was recorded in 2.5 x 3 m spacing (7.71) followed by 1.5 x 3 (10.5).

Juice volume (ml)

The juice volume was differed statistically significantly among various spacing. The juice volume was ranged from 24.5 ml to 30.3 ml with an average of 26.6 ml. The highest juice volume was found in 3.5 x 3 m spacing (30.3 ml) followed by 2.25 x 3 m spacing (27.2 ml). The lowest juice volume was found in 3 x 3 m spacing (24.5 ml) followed by 1.15 x 3 (24.6 ml).

Total soluble solids (TSS %)

TSS % was found varying from 11.2 % to 11.8 % with the mean value of 11.42 %. The highest TSS % was found in 1.75 x 3 m spacing (11.8 %) followed by 3 x3 m spacing (11.7 %). The lowest TSS % was found in 1.15 x 3 m spacing (11.2 %) followed by 1.5 x 3 m spacing (11.3 %).

Titrable acid (TA %)

Among the tested spacing of same genotype, TA % was found non-significantly ranging from 0.63 % to 0.74 % with the mean value of 0.69 %. The TA % was highest in 1.5 x 3 m spacing (0.74 %) and 2.5 x 3 m spacing (0.74 %), whereas it was lowest in 1.8 x 3 m spacing (0.63 %) followed by 3.5 x 3 m spacing (0.64 %).

pH

The pH was found varying from 3.14 to 4.38 with an average of 3.35. The highest pH was observed in 1.75 x 3 m spacing (4.38) followed by 1.5 x 3 m spacing (3.2). The lowest pH was found in 2.25 x 3 m spacing (3.14) and 2.5 x 3 m spacing (3.14).

DA (chlorophyll) reading

The DA reading value was varied from 0.068 to 0.257 with the mean value of 0.16. The highest DA reading was found in 3.5 x 3 m spacing (0.257) followed by 1.5 x 3 m spacing (0.203). The lowest DA reading was found in 1.15 x 3 m spacing (0.068) followed by 2.5 x 3 m spacing (0.143).

Citrus color index (CCI)

The CCI value was ranged from 9.7 to 12.4 with an average of 10.77. The highest CCI was recorded in 1.5 x 3 m spacing (12.4) followed by 3 x 3 m spacing (11.2). The lowest CCI was recorded in 1.15 x 3 m spacing (9.7) followed by 1.8 x 3 m spacing (10.1).

Table 15: Physio–chemical properties of Khoku Local mandarin under various planting densities at NCRP Dhankuta in 2022/23.

Spacing (m)	#Seed/fruit	BrimA	pH	TSS	TA%	Juice volume (ml)	DA meter reading	CCI
1.15 x 3	10	8.12	3.18	11.2	0.63	24.6	0.068	9.7
1.5 x 3	10.5	7.72	3.2	11.3	0.74	26.8	0.203	12.4
1.75 x 3	10.6	8.34	4.38	11.8	0.71	26.5	0.15	10.7
1.8 x 3	10.7	8.06	3.16	11.2	0.63	26.1	0.154	10.1
2.25 x 3	10.6	7.8	3.14	11.3	0.72	27.2	0.166	10.4
2.5 x 3	10.6	7.71	3.14	11.4	0.74	26.6	0.143	10.6
3 x 3	10.9	8.28	3.16	11.7	0.7	24.5	0.155	11.2
3.5 x 3	10.3	8.05	3.18	11.4	0.64	30.3	0.257	10.9
Grand mean	10.54	7.99	3.35	11.42	0.69	26.6	0.16	10.77
P Value	NS	NS	NS	NS	NS	*	NS	NS
C.V%	2.7	2.35	2.7	1.12	0.45	1.44	17.64	2.36
LSD	-	-	-	-	-	2.43	-	-

3.3.2 Alternate bearing management study in mandarin orange

Khoku mandarin (Citrus reticulata Blanco) shows bieniality on its production. To over come this various treatment were applied to 6 years old trifoliate orange grafted saplings in the month of March 2023. There are ten treatments (as below in the table) replicated three times. Single tree is taken as replicatin. This is first year of the experiment and there was non significant effect of all the treatment on fruit and yield attributing parameters.

Table 16: Different yield and quality pameters of Khoku local mandarin uner various biennial bearing management treatment at NCRP Dhankuta in 2022/23.

Treatment	Fruit wt (g)	Fruit Dia (mm)	# segment/ fuit	Juice percent	No fruit/ tree	Yield (t/ha)
Thiourea-1.5g/L (Foliar)	80.1	52.7	9.67	37.8	71	5.4
Thiourea-2.5g/L (Foliar)	89.2	56.7	10.1	42.9	138	12.9
KNO3-1.5 g/L (Foliar)	72.7	52	8.83	36.9	67	5.04
KNO3-2.5 g/L (Foliar)	81.7	55.3	9.44	36	81.3	7.2
Niraculan-0.5 ml/L (Foliar)	76.9	53.9	8.83	30.5	185	12.9
Niraculan-1 ml/L (Foliar)	81.8	54.9	9.11	36.5	88.7	7.46
Paclobutrazol-10 ml/tree (Foliar)	57.5	47.6	8.11	33.9	86	5.85
Paclobutrazol-10 ml/tree (Drenching)	77.9	53.6	9.33	38.1	128	9.95
Combo treatment*	76.9	52.8	8.67	36.5	81	5.88
Control (Water spray)	88	55.2	9.22	35	77	6.81

Treatment	Fruit wt (g)	Fruit Dia (mm)	# segment/ fuit	Juice percent	No fruit/ tree	Yield (t/ha)
Grand mean	78.52	53.5	9.15	36.6	98.43	7.86
P Value	NS	NS	NS	NS	NS	NS
C.V%	3.8	1.47	1.65	4.24	14.96	16.14
LSD	-	-	-	-	-	-

***** Thiourea (1.5 g/L) + KNO3 (1.5 g/L) + Niraculan (0.5 ml/L) + Paclobutrazol (10 ml/tree) (Foliar)

Results

The fruit parameters were found non-significantly different due to application of various treatments as shown on Table 16. The highest yield (12.9 t/ha) was obtained with spray of Thiourea (2.5 g/l) while the lowest (5.4 t/ha) was from same thiourea spray (1.5 g/l). The fruit physio-chemical paramegters were also found non-significantly different due to treatment (Table 17).

Table 17: Different fruit quality pameters of Khoku local mandarin under various biennial bearing management treatment at NCRP Dhankuta in 2022/23.

Spacing (m)	TSS	TA%	DA meter reading	pH	CCI	BrimA
Thiourea-1.5g/L (Foliar)	10.8	1.04	0.35	4.33	12.5	6.60
Thiourea-2.5g/L (Foliar)	10.4	0.87	0.11	4.42	11.0	6.94
KNO3-1.5 g/L (Foliar)	10.4	1.00	0.28	4.15	12.5	6.38
KNO3-2.5 g/L (Foliar)	10.7	1.14	0.14	4.28	10.0	6.14
Niraculan-0.5 ml/L (Foliar)	11	0.91	0.26	4.3	9.87	7.42
Niraculan-1 ml/L (Foliar)	10.5	0.93	0.21	4.3	9.89	6.77
Paclobutrazol-10 ml/tree (Foliar)	10.5	1.44	0.16	4.17	9.39	4.78
Paclobutrazol-10 ml/tree (Drenching)	11.0	1.13	0.11	4.31	10.3	6.51
Combo treatment*	10.4	0.91	0.36	4.31	9.17	6.77
Control (Water spray)	10.9	1.04	0.99	4.37	9.32	6.79
Grand mean	10.67	1.05	0.2	4.3	10.34	6.48
P Value	NS	NS	NS	NS	NS	NS
C.V%	1.09	9.02	17.35	0.98	4.74	6.04
LSD	-	-	-	-	-	-

***** Thiourea (1.5 g/L) + KNO3 (1.5 g/L) + Niraculan (0.5 ml/L) + Paclobutrazol (10 ml/tree) (Foliar)

3.3.1 Effect of different rootstocks on growth and yield components in Mandarin (Khoku local), Sweet orange (Valencia late) and Acid lime (Tehrathum local).

Rootstocks and scions are the foundation of many tree fruit industries of the world. Together, those components establish profitability, but it can be argued that the rootstock is the critical component; otherwise, scions would be grown on their own roots everywhere. There is no precedent for the failure of a citrus industry because of an inadequate scion variety, but serious problems have occurred because of a less than satisfactory rootstock. A rootstock primarily provides a reduction in juvenility (time to bearing) and tree vigor when compared with seedling trees; thus, citrus trees propagated

with a rootstock combined with a pathogen-free scion bring a much improved degree of uniformity and consistency to an orchard. They influence various horticultural traits and provide tolerance to pests and diseases and certain soil and site conditions that contribute significantly to orchard profitability. Also important are rootstock nursery traits such as the degree of nucellar embryony that is related to the ease, expense, and consistency of propagation.

3.3.1.1 Mandarin orange (var. Khoku local) rootstock trial at NCRP, Dhankuta

Methodology

The trial was established with planting two years old Mandarin cv. Khoku local grafted saplings in FY 2063/64 in NCRP orchard at an altitude of 1250 m. Six species of rootstocks were used while preparing saplings as shown below. The saplings were planted at the spacing of 3m x 3 m with six replications.

Rootstock	Scion
Carrizo Citrange	Mandarin cv Khoku local
Citrange C-35	Mandarin cv Khoku local
Citrumelo 4475	Mandarin cv Khoku local
Flying Dragon	Mandarin cv Khoku local
Poncerous-Pomeroy	Mandarin cv Khoku local
Trifoliate	Mandarin cv Khoku local
Rangapur lime	Mandarin cv Khoku local

Result and discussion

Fruit physical parameters

Fruit physical parameters like individual fruit weight, fruit diameter, fruit rind thickness and number of seeds per fruit were found varying significantly. The heaviest fruit (146 g) and the widest fruit (67.2 mm) was produced from plants grafted on Poncirus Pomeroy, while the lightest (87 g) and narrowest fruit (57.3 mm) was from the Rough lemon. The thickest fruit skin (3.02 mm) was from plants grafted onto Citrange-carrizo, while the thinnest (2.31 mm) was from Rough lemon. Khoku grafted on Citrumelo-4475 had the highest number of seeds per fruit (18.11), while Citrange-carrizo had the lowest number of seeds per fruit (13) (Table 18).

Physio-chemical parameters

Among the fruit physio-chemical parameters BrimA, DA reading value and TSS were found significantly different due to rootstock effect, while Juice %, TA % and pH were found non-significant (Table 18). The highest juice percent (56.1 %) was found on the plant grafted on Volkamerina, while the lowest juice % (33.3%) was from Rangapur lime red. The highest DA value (0.93) and sweetest fruit (11.4 %) was from the plant grafted

on Citrange C-35 and the lowest DA value (0.16) was from Volkamerina and least sweet (8.59 %) was from Rough lemon. Fruits from the plants grafted on Citrange-carrizo was found mostly sour (1.19 %) while the least sour (0.66 %) fruits were from Volkamerina. The highest BrimA value (7.21) was calculated in the fruits of the plant grafted on Trifoliate. Similarly the highest pH value (4.81) was from the fruits of plant grafted on Flying Dragon (Table 18).

Table 18: Fruit quality of Mandarin cultivar Khoku Local grafted on six different rootstocks in year 2022/23

Rootstock	**Fruit wt (g)**	**Fruit diameter (mm)**	**Peel thickness (mm)**	**Juice %**	**BrimA**	**No. of seeds**
Rough lemon	34.2	39	1.70	41.6	-32.3	4.00
Trifoliate	30.2	37.4	1.79	40.7	-26.9	4.65
Citrange C-35	32.5	37.8	1.44	44.7	-27.6	5.99
Citrange-carrizo	32.8	38.3	2.31	28.0	-26.4	2.35
Poncirus Pomeroy	36.4	40.0	2.34	33.8	-26.5	3.78
Flying Dragon	34.7	38.5	1.70	44.2	-29.4	7.70
Citrumelo-4475	35.3	39.7	1.79	39.0	-30.5	3.72
Volkamerina	33.8	40.3	2.37	28.3	-26.7	3.20
Rangapur lime	33.1	38.6	1.77	39.9	-27.2	6.07
Grand mean	33.63	38.84	1.91	37.74	-27.97	4.69
P value	NS	NS	***	***	**	***
C.V. %	1.8	0.68	2.49	2.88	-1.24	5.38
LSD			0.37	8.34	2.66	1.93

Yield related parameters

All the yield related parameters like number of fruits per tree, fruit yield per tree and total fruit yield per hectare was found non-significantly different due to the effect of different rootstocks (Table 19). The highest number of fruits per tree (496) was obtained from Citrumelo-4475 followed by Citrange-carrizo (289). Further, the highest yield per tree (56.6 kg) and the highest yield per hectare (62.9 tons) was seen in the plants grafted on Citrumelo-4475.

Table 19: Fruit physio-chemical properties and yield characteristics of mandarin cv Khoku local grafted on different rootstock in year 2022/23

Rootstock	DA	TSS (%)	TA (%)	pH	# Fruit/ tree	Tree Yld (kg)	Yield (t/ha)
Rough lemon	0.78	8.59	0.69	4.68	100	8.2	9.11
Trifoliate	0.71	10.6	0.72	4.56	161	18.9	21.
Citrange C-35	0.93	11.4	0.85	4.41	127	13.5	14.9
Citrange-carrizo	0.55	10.1	1.19	4.52	289	36.1	40.1
Poncirus -Pomeroy	0.78	9.8	0.84	4.72	138	18.7	20.8
Flying Dragon	0.41	10.6	0.75	4.81	85	10.8	12
Citrumelo-4475	0.62	10.4	0.84	4.67	496	56.6	62.9
Volkamerina	0.16	8.82	0.66	4.66	104	11	12.2
Rangapur lime	0.27	8.74	0.71	4.59	97	8.95	9.95
Grand mean	0.58	10.1	0.82	4.62	189.05	22.01	24.46
P value	*	***	NS	NS	NS	NS	NS
C.V. %	9.79	0.54	8	0.79	15.59	15.8	15.8
LSD	0.4	0.38	-	0.26	-	-	-

3.3.1.2 Acid lime (Terhthum local) rootstock trial at NCRP, Dhankuta

Methodology

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

Rootstock	Scion
Citrange-C35	Tehrathum local
Citrange-Carizzo	Tehrathum local
Citron	Tehrathum local
Citrumelo 4475	Tehrathum local
Flying Dragon	Tehrathum local
Poncerous-Pomeroy	Tehrathum local
Rangapur lime	Tehrathum local
Volkamerina	Tehrathum local

Result and discussion

Fruit quality and physical parameters

The fruit weight and fruit diameter were found non-significantly different due to rootstocks, while rind thickness and no of seeds per fruit were varied highly significant

(Table 19). The highest fruit weight (36.4 g) was found in acid lime grafted with Poncirus Pomeroy. Similarly, the highest fruit diameter (40.3 mm) and the thickest rind (2.37 mm) was found in acid lime grafted with Volkamerina. Acid lime grafted with Citrange C-35 had the highest juice percentage (44.7%), whereas Citrange-carrizo had the lowest juice percentage (28%). The highest number of seeds per fruit (7.7) was obtained from fruits of Flying dragon grafted plants while the least was obtained from Citrange-carrizo (2.35) plants.

Physio-chemical parameters

Physio-chemical parameters like Titrable acidity (TA %) and DA meter reading value was found significantly different while Total soluble solid (TSS %), pH and BrimA were found differing non-significantly due to rootstock effect. The highest DA reading value (1.22) and pH (3.23) was found in Rangapur lime grafted plant. Further, the highest TSS (8.32 %) and TA (8.01 %) was found in plants grafted with Citrange C-35 and Rough lemon respectively. The lowest DA reading value (0.74), TSS (7.72 %), pH (2.8) was found in acid lime grafted with Volkamerina, Rough lemon, Citrange C-35 respectively. The lowest TA (6.85) was seen in Citrange-carrizo and Poncirus Pomeroy.

Table 20: Fruit quality and yield parameter of acid lime cv. Tehrathum local grafted on different rootstocks in year 2022/23

Rootstock	Fruit wt (g)	Fruit Dia (mm)	Rind Thickness	Juice (%)	BrimA	# Seed /fruit
Rough lemon	34.2	39	1.7	41.6	-32.3	4
Trifoliate	30.2	37.4	1.79	40.7	-26.9	4.65
Citrange C-35	32.5	37.8	1.44	44.7	-27.6	5.99
Citrange-carrizo	32.8	38.3	2.31	28	-26.4	2.35
Poncirus Pomeroy	36.4	40	2.34	33.8	-26.5	3.78
Flying Dragon	34.7	38.5	1.7	44.2	-29.4	7.7
Citrumelo-4475	35.3	39.7	1.79	39	-30.5	3.72
Volkamerina	33.8	40.3	2.37	28.3	-26.7	3.2
Rangapur lime	33.1	38.6	1.77	39.9	-27.2	6.07
Grand mean	33.63	38.84	1.91	37.74	-27.97	4.69
P value	NS	NS	***	***	**	***
C.V. %	1.8	0.68	2.49	2.88	-1.24	5.38
LSD (0.05)			0.37	8.34	2.66	1.93

Table 21: Fruit physico-chemical and yield parameter of acid lime cv. Tehrathum local grafted on different rootstocks in year 2022/23

Rootstock	DA	TSS (Brix)	TA (%)	pH	#Fruit/ tree	Tree Yld (kg)	Yield (t/ha)
Rough lemon	0.88	7.72	8.01	3.04	80	2.5	2.78
Trifoliate	1.08	8.07	6.99	3.03	119	3.67	4.08
Citrange C-35	1.06	8.32	7.18	2.8	112	3.82	4.24
Citrange-carrizo	0.86	7.82	6.85	2.95	119	3.67	4.08
Poncirus Pomeroy	0.82	7.74	6.85	2.88	118	4.07	4.52
Flying Dragon	0.99	8.11	7.5	3.06	115	3.71	4.12
Citrumelo-4475	0.94	7.99	7.71	3.09	108	3.64	4.05
Volkamerina	0.74	7.97	6.93	3.01	124	3.92	4.36
Rangapur lime	1.22	7.94	7.04	3.23	103	3.39	3.76
Grand mean	0.97	7.98	7.19	3.02	112	3.65	4.05
P value	*	NS	***	NS	NS	NS	NS
C.V. %	3.67	0.71	0.91	1.16	3.31	3.67	3.67
LSD (0.05)	0.27	-	0.5	-	-	-	-

Yield related parameters

All the yield related parameters (no. of fruit/tree, yield/tree and yield/ha) were found non-significantly affected by the rootstocks (Table 20). The highest number of fruit per tree (124) was observed in acid lime grafted with Volkamerina while the lowest number of fruit was observed in Rough lemon grafted acid lime. The highest yield per tree (4.07 kg) and yield per hectare (4.52) was found in Poncirus Pomeroy grafted pant whereas the lowest yield/tree (2.5) and yield/ha (2.78) was found in Rough Lemon grafted plants.

3.3.1.3 Sweet orange (Washington Navel) root stock trial at NCRP Dhankuta

Methodology

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

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

Result and discussion

All the fruit physical parameters were statistically non-significant (Table 22). It was found that the rootstocks trifoliate and Citrange C-35 performed well in terms of fruit weight (>160 g). Similarly, Citrange C-35 and Flying Dragon were best in terms of fruit diameter (>65mm). Further, Juice % was highest in Citrange C-35 grafted sweet orange i.e. 31.4 % followed by Trifoliate grafted sweet orange i.e. 30.8 %. All the rootstocks have produced less acidic fruit (<1 %). The trifoliate and Poncirus Pomeroy rootstocks were found producing more fruit per tree (>40 kg). The difference in fruit yield per tree and yield per hectare was found statistically significant (Table 22). The trifoliate rootstock produced highest yield/tree (7.39 kg) and yield/ha (8.21 ton) among other rootstocks.

Table 22: Fruit quality and yield of sweet orange cv Washington Navel grafted on five rootstocks grown at NCRP Dhankuta in year 2022/23

Rootstock	Fruit wt (g)	Fruit Dia (mm)	Peel Thickness (mm)	Plume Wt (g)	Juice %	Brim A	No of seeds
Trifoliate	166	59.1	3.9	135	30.8	6.32	0.2
Citrange C-35	162	67.8	3.89	134	31.4	7.7	0.33
Poncirus Pomeroy	141	63.2	4.09	116	20.8	7.35	1.7
Flying Dragon	157	66	4.35	123	30.2	6.48	0
Rangapur lime	147	64.9	4.62	96.9	24.2	6.59	0
Grand mean	158.29	63.24	4.05	126.72	28.78	6.84	0.42
P value	NS	NS	NS	NS	NS	NS	NS
C.V. %	2.56	5.81	2.27	2.88	5.42	2.75	45.63
LSD (0.05)	-	-	-	-	-	-	-

Table 23: Fruit physico-chemical and yield parameter of acid lime cv. Tehrathum local grafted on different rootstocks in year 2022/23

Rootstock	DA	TSS	TA	pH	CCI	#Fruit/ tree	Tree Yld (kg)	Yield (t/ha)
Trifoliate	0.14	10.3	0.79	4.54	6.84	45	7.39	8.21
Citrange C-35	0.11	11.5	0.77	4.51	8.04	20.3	3.52	3.91
Poncirus Pomeroy	0.20	11.7	0.86	4.45	7.33	41	5.03	5.58
Flying Dragon	0.23	10.2	0.75	4.59	7.1	17.5	2.49	2.76
Rangapur lime	0.13	10.2	0.71	4.5	6.76	18	2.14	2.38
Grand mean	0.15	10.8	0.79	4.53	7.23	32.38	4.98	5.53
P value	NS	NS	NS	NS	NS	NS	*	*
C.V. %	12.5	2.28	2.47	0.4	4.94	16.3	15.22	15.23
LSD (0.05)	-	-	-	-	-	-	3.91	4.35

3.4 CITRUS INSECT MANAGEMENT

3.4.1 Management of Chinese fruit fly (Bactrocera minax) on mandarin orchard

Citrus fruit drop caused by at least 3 species of fruit flies are becoming treat to sweet orange, acid lime and mandarin orange production in mid hills of Nepal. To identify these pest activities in eastern hills a surveillance study was carried out setting 3 kinds pheromone (methyl eugenol, Cue lure and protein bait) traps in four districts (Dhankuta, Terhthum Bhojpur and Sindhuli) in the farmer's orchards at different altitudes. The surveillance data on Dhankuta and Sindhuli showed that there were severe infestation of *B. minax* (Chinese fruit fly) in both districts in the protein bait trap. Later in year 2018-20 protein bait spraying as Area Wide Control Program (AWCP) initiated in Sinduli, Ramechhap and Dhankuta distrits. There was loss reduction from 35 percent to less than 5 percent due to protein bait spray under AWCP. It compariase of bait spraying of hydrolysed protein at the ration of 1:2 (protein:water) underneath the tree leaves at @17 ml/tree covering 50 cm^2 area starting from Jesth to Sharawan month. The spray is done each week (10-12 spray) on one tree per three fruiting trees. The bait spray time coincides with monsoon and spraying is also troublesome hence an alternative trapping method using DYI trap 12-cm diameter and 8 cm in depth with sponge soaked with protein bait liquied as proposed in AWCP method was used. Six traps per 500 m^2 was set up and the number of fruit drop and yield of mandarin fruit was recorded from five trees from each of two farmers orchard in Dhankuta District. The result is encouranging and need to be continued in coming years.

Table 24: Effect of protein bait trap on control of Chinese fruit fly at farmer's field of Dhankuta District in year 2022/23

Farmer's name	Address	No of fruit/tree	No. of fruit drop/tree	Fruit drop %	Yield/tree (kg)
Arjun Tamang	Dhankuta-10	378	0.6	0.09	86.2
Bhakta Thapa	Dhankuta-3	848	48.6	5.72	107.2

3.6 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 been widespread serious threat for mandarin production in almost 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.

3.6.1 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 erytreae*, 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. Similary 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 5st 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 2-3 years of planting and in this case also greening disease may appear after 2-3 years of plantation.

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.4.508 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 2079-80, a total of 36,500 grafted saplings were produced and 16679 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 25.

Table 25: Production of fruits, saplings and revenue collected during 2079-80

S.N.	Particulars	Unit	Quantity	Revenue (NPR) '000
1	Mandarin saplings	No.	3045	
2	Sweet orange saplings	No.	1168	
3	Acid lime saplings	No.	12406	
4	Mandarin fruits	Kg.	20000	
5	Sweet orange	Kg.	150	
5	Trifoliate orange, Citrange, Rangpur lime, Volkamerina seed	Kg.	8.5	
	Sub-total			**4375979.50**
6	Other horticultural sources			-
	Sub-total			**4375979.50**
7	Administrative			**132400.00**
	Grand Total			**4508379.50**

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 26).

Table 26: Calendar of operations adopted at NCRP, Paripatle for orchard management

Month	Operations
Baishak	New flush attracts insects like psylla, white black fly and leaf miner Irrigate the orchard and nursery bed at 8-12 days interval. Budding has to be done at the height of 9"-12" above the ground level. Integrated disease and insect management strategies should be adopted considering environmental protection and biodiversity conservation. Uproot the diseased and very old trees and prepare pits for new plantation. Start protein trap (4/ropani) to monitor fruit fly (*Bactrocera minax*) on sweet orange orchard. Note: spraying any sort of fungicide, antibiotic and insecticide must be discontinued during flowering period.
Jestha	Increase the frequency of irrigation from earlier schedule of 8-12 days to 5-7 days interval in case of absence of pre-monsoon showers. The most critical period is during heat spells. To be more accurate, check to moisture level 12" deep under trees to determine dryness and water accordingly. Keep water away from the trunk. Grafted/budded rootstock in winter months requires checking, thereafter, the tops of successfully intake grafting/budding are to be cut. Any fertilizer should be applied if there is sufficient moisture in soil. Recommended prophylactic measures need to be followed to the plants infected with *Phytophthora.* Make a drainage system in the orchard. Prepare the nursery bed for rootstock transplant. Prepare compost for next year. Continue protein trap (4/ropani) to monitor fruit fly (*Bactrocera minax*) on sweet orange orchard. Initiate area wide fruit fly control program with bait of protein at weekly interval (Great fruit fly bait) to control fruit drop caused by Chinese fruit fly in afffected area in consultation with Agricultural Knowledge Center and or Zone and super zone of prime minister agriculture modernization program.
Ashad	The trunk of citrus trees that are infected with fungal diseases need to be applied with Bordeaux paste as prophylactic measure against the collar rot and gummosis caused by *Phytophthora*. In case of water stagnation near the trunk of tree, 'V' shaped furrows are to dug in between the rows across the slope to drain out excess of water on the orchard. Incidence of citrus *Psylla* and leaf miner is common on new flushes. Recommended measures are to be followed by spraying insecticides at bud burst stage. Spray is to be repeated after 15 days in the event of noticeable infestation. Cankerous leaves and branches should be pruned and brunt and copper oxychloride should be sprayed before the onset of rainy season. Later than the onset of rainfall, copper oxychloride mixed with Streptocycline ought to be sprayed at monthly intervals. Spraying with sulfur containing fungicide to control powdery mildew. Transplant rootstocks for next year sapling. Distribution of healthy saplings to farmers. Continue the area wide fruit fly bait spray as suggested in Jestha month.
Shrawan	Stagnated water should be disposed by providing trenches along with the slope. Weeding in citrus orchard. Doses of N, P and K fertilizers have to be applied depending upon the age of the trees in the later period of rainy season. If fruit drop is observed due to pathological and hormonal factors NAA or 2,4-D @ 8-15 ppm with urea @ 5 g and bavistin @1.5 g/ LW should be sprayed to reduce the intensity of fruit drop. Transplanting of rootstock seedling (Trifoliate) in main nursery block.

Month	Operations
	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.
Bhadra	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 trifoliate fruit should be taken up at right stage of maturity. Sow the trifoliate rootstock seed in primary nursery for better growth of seedlings. Earthing up of basins to break the crust formed that facilitates aeration in root zone.
Ashoj	Basins should be kept ready for irrigation. New flush should be sprayed with insecticides against citrus psylla and leaf miner. Likewise, recommended dose of insecticide should be sprayed to control green stink bug. Weeding and mulching in the orchards. Stacking of heavily fruiting branches. Harvesting of citrange fruit should be taken up at right stage of maturity. Sow the citrange rootstock seed in primary nursery for better growth of seedlings. Apply Bordeaux paste after the withdrawal of monsoon. Collect fruit fly infected sweet orange fruits, and immerse them into big bucket full of water.
Kartik	Collect fruit fly infected sweet orange fruits and bury them into deep pits. Prepare new nursery bed and sow trifoliate seed for next year production. Excess leaf fall could be an indication of disease infestation. Suitable control measures are to be taken up. Harvesting of early maturing species of citrus fruits for rootstock should be taken up at right stage of maturity. Harvesting of early maturing varieties.
Mangsir	Harvesting of mid-season varieties. Grafting for sapling production.
Poush	Harvesting of mid-season varieties. Grafting for sapling production. Farm yard manure should be applied to facilitate decomposition. Its mobilization starts after 3-4 months.
Magh	Irrigate the orchard at 7-10 days intervals. Harvesting of late season varieties. Pruning and training should be carried out. Fertilizer application and Servo agro spray to control scale insects. If zinc deficiency symptoms are notices, apply zinc sulphate.
Falgun	Servo agro spray to control scale insects; fertilizer application. Foliar spray of micronutrients. Insecticides spray in nursery plants to control leaf miner. Irrigation in orchards and nursery. In the case of zinc deficiency symptoms, zinc sulphate is to be mixed with adequate quantity of farm yard manure, and then applied to the plants by spreading uniformly on the entire root zone.
Chaitra	Irrigate the orchard and nursery bed. Uproot the diseased and very old unproductive trees and prepare pits for new plantation.

8 INFORMATION DISSEMINATION

Information regarding citrus research programs and technologies was shared with the visitors that altogether 2,500 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

This fiscal year there was no training event due to budget cut under this heading.

10 SERVICES

In fiscal year 2079/80, NCRP supplied 16679 grafted saplings of different citrus species to the farmers. The grafted saplings made available to the farmers comprised of Khoku local mandarin, Okitsuwase unshiu, Banskharka, 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 2500 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.

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 (Citrus japonica):		
1	NCRP-105	Fortunella (oval)	Unknown
2	NCRP-106	Fortunella (rounded)	Unknown
3	NCRP-115	Fortunella (Indian Muntala)	Unknown
	B. Mandarin (C. reticulata)		
4	NCRP-01	Khoku Suntala	Khoku, Dhankuta
5	NCRP-02	Kinnow	Pakistan
6	NCRP-03	Frutrel early	Unknown
	C. ***Mandarin (C. unshiu)***		
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	GRESCO, 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
	E. Acid lime (C. aurantifolia)		
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
	E. Lemon		
115	NCRP 61	Ureka lemon Unkwown	Unknown
116	*NCRP 63*	Hill Lemon	Sunderpur Morang
117	*NCRP 64*	Ureka lemon Lamcho lemon	Sunderpur Morang
118	*NCRP 109*	Thimura local	SHARP Chitwan
119	*NCRP 110*	Biratnagar Local	SHARP Chitwan
120	*NCRP 111*	Prembasti local	SHARP Chitwan
	Rootstocks		
121	NCRP 65	Citrange C-35	INRA_CIRAD
122	NCRP 66	Citrange – Carrizo	INRA_CIRAD
123	NCRP 67	Poncirus– Pomeroy	INRA_CIRAD
124	NCRP 68	Flying Dragon	INRA_CIRAD
125	NCRP 69	Citrumelo 4475	INRA_CIRAD
126	NCRP 70	Volkameriana	INRA_CIRAD
127	NCRP 71	Rangapur lime Red	INRA_CIRAD
128	NCRP 113	Citrange old	Unknown
129	*NCRP 38*	Citrange	Unknown
130	*NCRP 35*	Citron	Unknown
131	*NCRP 36*	Trifoliate	Unknown
132	*NCRP 37*	Rangapur lime	Unknown
133	*NCRP 39*	Boxifolia	Unknown
134	*NCRP 40*	Rough lemon	Unknown
135	*NCRP 116*	Rough lemon	Paripatle Dhankuta
136	NCRP-41	Hokse	Dhankuta
137	NCRP-62	Local Bimiro (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 2079/80

Designation	Approved	Fulfilled	Vacant
1. Chief Scientist (S.5) – Horticulture	1	-	1
2. Senior Scientist (S.4)- Horticulture	1	1	0
3. Senior Scientist (S.3)- Horticulture	1	0	1
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 2079/80

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

Annex 4: Publications in FY 2078/79

Publication	Type	Language	Published number
Annual Report (2079/80)	Book	English	70
Early season mandarin Paripatle Aguate -1 production technology	Leaflet	Nepali	1000
Citrus Production annual calendar	Leaflet	Nepali	1000

Annex 5: Regular Annual Budget and Expenditure in 2079/80

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
21111	Staff Salary	6139303	5217275.23	5217275.23	922027.77
21121	Uniform	110000	80000	80000	30000
21131	Local Allowance	157000	89560	89560	67440
21132	Dearness Allowance	288000	206000	206000	82000
21134	Meeting Allowance	45000	15800	15800	29200
21213	Insurance Fund Expenses based on Contribution	60000	41200	41200	18800
22111	Water and Electricity	228000	228000	228000	0
22112	Communication Expenses	189000	184999	184999	4001
22212	Fuel(Office Purpose)	828000	718294	718294	109706
22213	Vehicle Repair Cost	340000	287817	287817	52183
22214	Insurance and Renewal Expenses	66000	66000	66000	0
22221	Repair and Maintenance of Machinery and Equipments	223000	193942	193942	29058
22231	Repair/Maintenance of Public Assets	100000	94249	94249	5751
22291	Repair and Maintenance of other Assets	95000	76000	76000	19000
22311	Office related expenses	111000	102920	102920	8080
22314	Fuel for other pueposes	268000	149498	149498	118502
22315	Newspaper,Printing and News Publication Cost	270000	247122	247122	22878

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
22413	Contract Service Cost	1476000	1472869	1472869	3131
22512	Training and seminar expenses	1120000	0	0	1120000
22521	Production Material Service	10554000	9107628	9107628	1446372
22522	Operational Expenses	200000	0	0	200000
22611	Monitoring and evaluation expenses	272000	131595	131595	140405
22612	Travel Expenses	1718000	1460254	1460254	257746
22711	Miscellaneous Expenses	118000	99583	99583	18417
28143	Vehicle&Machinery Equipment Rent Cost	100000	98547	98547	1453
	Capital Expenses				
31113	Renovation expenses for Constructed Building	700000	696467	696467	3533
31121	Vehicle	300000	298900	298900	1100
31122	Machinery Equipment	3150000	3143980	3143980	6020
31123	Furniture and Fixture	30000	29999	29999	1
31159	Other Public Construction	5000000	4967829	4967829	32171
31171	Maintenance of other public assets	500000	496593	496593	3407
	Grand total	34755303	30002920	30002920	4752383

Annex 6: Beruju Status till Fiscal Year 2079/80

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)	31,61,000.00	
Remaining beruju	6,43,000.00	