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2075/76 (2018/19)

GOVERNMENT OF NEPAL

NEPAL AGRICULTURE RESEARCH COUNCIL

NATIONAL CITRUS RESEARCH PROGRAMME

PARIPATLE, DHANKUTA

2019

Nepal Agriculture Research Council (NARC)

National Citrus Research Programme (NCRP)

Paripatle, Dhankuta, Nepal

Postal code: 56800, Dhankuta, Nepal

Contact No.: 026-620232; 9852050752 (Cell phone)

Email address: ncrpdhankuta@gmail.com

URL: http://www.narc.gov.np

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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 five thousand quality acid lime saplings at the cheapest price last year.

It is a matter of great satisfaction that we are working on exploring potential of mandarin and sweet orange production with introduction breeding. These mandarin germplasms from abroad has potential for commercial production in terai plains, where a great demand for suitable mandarin variety persists. In the last fiscal year, NCRP had been able to endorsed one local variety of acid lime (Terhthum) and one local variety of mandarin (Khoku) for registration. With better management of fruit orchard within NCRP, Paripatle, we had a record high fruit 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 in citrus. Lab facilities, mainly of tissue culture lab had not properly utilized in absence of expert technical person. Positions of soil scientist, entomologist and plant breeder have been vacant for a long period.

I hope this report with citrus research related findings 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 thank to Dr. Hari Krishna Shrestha, former Citrus Coordinator for research support and Mr. Roshan Pakka, Scientist 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	Agriculture Research for Development
Cm	Centimeter
CV	Coefficient of Variation
Cv	Cultivar
CVT	Coordinated Varietal Trial
DADO	District Agriculture Development Office
DAP	Di-ammonium phosphate
DAS	Days after sowing
DBH	Days before harvest
DFTQC	Department of Food Technology and Quality Control
DGR	Dry Ginger Recovery
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
PMAMP	Prime Minister Agriculture Modernization Project
ppm	Parts per million
RARS	Regional Agricultural Research Station
RATWG	Regional Agricultural Technical Working Group
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
viz.	Videlicet
Wt	Weight

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

प्रमुख सार संक्षेप

सुन्तलाजात फलफुल खेती मध्य पहाड र तराईका नेपाली कृषकहरुको आर्थिक स्तर वृद्धिमा टेवा पुर्‍याउने 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. ०७५/७६ अवधिमा जम्मा ७ वटा परियोजना अन्तर्गत ४० वटा अनुसन्धान क्रियाकलापहरु सम्पन्न गरेको थियो । यी कार्यक्रमहरु विशेष रुपमा जातीय अनुसन्धान, बालि 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. ०७५/७६ सम्म पुरा गरिएका क्रियाकलापहरुको उपलब्धिहरु संक्षिप्त रुपमा तल उल्लेख गरिएको छ ।

- जातीय संकलन र सम्बर्द्धन अन्तर्गत १३२ 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 समस्यालाइ र्‍हल 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 । यसै आर्थिक बर्षमा कागतीको तेर्हथुम सुन्तलाको खोकु स्थानीय जात पुर्वी पहाडमा खेती गर्न सिफारिस गरिएको छ । आउने बर्षमा सुन्तलाको एक जात ओकित्सुवासेलाई उन्मोचनको लागि प्रस्ताव गर्न तयारी गरीएको छ ।

- वासिगंटन नेभल जातको जुनारले राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको छ । यो जात बेमौसमी जुनार उत्पादनको लागि राम्रो 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.२०७०/७१ मा कागतिका दुई जातहरु क्रमस: सुनकागति -१ र सुनकागति -२ को नामवाट तराई, भित्रिमधेस, र बेशि क्षेत्रको लागि उन्मोचन गरीएको छ । यसै आर्थिक बर्षमा कागतीको तेर्हथुम स्थानीय जात पुर्वी पहाडमा खेती गर्न सिफारिस गरिएको छ ।
- सन्तला बगैचा ह्रास व्यवस्थापन गर्नु सुन्तला उत्पादन व्यवसायको एउटा चुनौतिपूर्ण कार्य हो । यस अन्तर्गत एकिकृत खाद्यतत्व व्यवस्थापन, रोग तथा किरा व्यवस्थापन र बगैचा व्यवस्थापनमा अध्ययन भैरहेको छ । अनुसन्धानको लागि धनकुटा, भोजपुर र ताप्लेजुङ जिल्ला बाट ह्रास भएका दुई-दुई वटा बगैचाहरु छनोट गरीयो । धनकुटाको खोकुको बगैचा वाहेक अरु ह्रास भएर गएका बगैचाहरुमा सन्तोषजनक प्रगति भएको पाईयो । तसर्थ, थप प्रमाणिकरण र केही परिमार्जन गरी परीक्षण गरियो जसमा मलखादको पूर्णमात्राको साथै सूक्ष्म तत्वको प्रयोग गर्दा ज्यादै प्रभावकारी पाइयो ।
- सुन्तलाको पोष्टहार्भेष्ट भन्डारण अवधि वढाउने सम्बन्धि अध्ययन गरियो । फ्लुड़ीक्सोनिल ३०० पिपिएम र अदुवाको १० प्रतिशतको झोलमा डुवाएर भण्डारण गरेको सुन्तला सेलार स्टोरमा ३ महिना सम्म निलो ढुसि रोग कम लागेको पाईयो । यसरी परिक्षण गर्दा ९० दिनको भन्डारणबाट थोरै मात्र तौल घटेको, राम्रो स्वाद भएको र हेडोनिक मुल्याङकन कर्ताले मन पराएको पाईयो ।
- फल कुहाउने औंसा किराको प्रजाति पत्ता लगाउन तीन जिल्लाहरु जस्तै धनकुटा (मौनबुधुक र पारिपाल्ले) र सिन्धुली (खनियाखर्क) मा गरिएको अध्ययनबाट

सुन्तलामा लाग्ने औंसा फर्सी बालीमा लाग्ने ओरियन्टल औंसा B. Dorsalis नभई सिन्धुलीमा चाइनिज फ्रुट फ्लाई (Bactrocera minax) भएको र अन्य जिल्लाहरुमा B. zonata, B. scutellaris र B. tau प्रजातिको भएको पाईयो । सोहि अध्ययनमा मे देखि जुलाई महिना सम्म B. minax बाहेक अन्य प्रजातिहरु अधिकतम रुपमा Methyl eugenol को पासोमा परेको पाईयो । सिन्धुलीमा अप्रिल देखि जुलाई महिना सम्म B. minax प्रजाति प्रोटिन पासो (protein bait) मा परेको पाईयो । सिन्धुली र धनकुटामा गरिएको परिक्षणमा ग्रेट फ्रुट फ्लाई बेटको चारो बनाई स्प्रे र सेरानोकको पासो प्रयोग गर्दा जुनारको फलमा कम किरा लागेको र कम फल झरी बढी उत्पादन भएको पाईएको थियो ।

- गत आ.व.२०७५/७६ मा करिव २५०० जना कृषक र सरोकारवालाहरुलाई अनुसन्धान कार्यक्रम वारे जानकारी र प्रविधिहरु वारे सल्लाह दिईयो ।
- कलमीको लागि सुन्तला र कागतिको माउ बोटबाट स्वस्थ सायन धनकुटा जिल्लाका नर्सरी व्यवसायीहरुलाई उपलव्ध गराईयो । त्यस्तै गरी खोकु लोकल सुन्तला ओकित्सुवासे र कागतिका तीन जातहरु जस्तै सुनकागति -१, सुनकागति - २ र तेह्रथुम लोकलका कलमी बिरुवाहरु विभिन्न जिल्लाका कृषकहरुलाई वितरण गरियो ।
- गत आ.व. २०७५/७६ मा कृषकहरुलाई वितरण गरिएका जम्मा कलमी विरुवा ३५००० मध्ये सुन्तलाको २५००, जुनारको १५००, कागतिको २३०००० र अन्य १००० बिरुवाहरु थिए ।
- यस कार्यक्रमको आ.व. २०७५/७६ को लागि विनियोजित वजेट रु दुई करोड बत्तिस लाख थियो जस मध्ये अनुसन्धान कार्यक्रमको लागि जम्मा एक करोड दस लाख विनियोजन गरिएको थियो । बार्षिक आम्दानी रु बाइस 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 2075/76 (2018/19), a total of 40 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 132 different citrus germplasms which were collected from local and exotic sources in past periods. These conserved germplasm includes mandarin orange, sweet orange, acid lime, lemon, grapefruit, tangor, tangelo and different rootstock species. A distinct variation with respect to flowering, fruiting behavior, fruit traits and morphological characteristics has been observed. Further selection is necessary to screen the best variety based on economic characters.
- As the existing cultivars of mandarin, sweet orange, acid lime and tangor had low yield, the exotic cultivars inclusive of elite local cultivars have been introduced and evaluated since 2063/64. The preliminary performances of varietal evaluation of mandarin revealed some exotic genotypes such as Miyagawase, Okitsuwase, Oraval, Page and Marisol were promising with early maturity and high fruit yield. Khoku local mandarin genotype has been registered for cultivation in eastern hills in this fiscal year. One genotype of mandarin viz., Okitsuwase is in process of being proposed for variety release based on its performance for yield and yield attributes.
- Washington navel, a variety of sweet orange had been performing more excellent in terms of higher fruit yield than those of other varieties. This genotype was noted to be suitable for off season production. This genotype is in the process of being proposed for variety release. Similarly, other

genotypes viz., Malta blood red, Delicious seedless, Succari and Dhankuta local had shown good fruit yield characteristics.

- Ten elite acid lime genotypes collected locally have been evaluated since 2063/64 in terai districts. Two acid lime varieties: Sunkagati-1 and Sunkagati-2 were released in 2014 for upland condition of terai, inner terai, foothills and river basin areas. Moreover, NCRP 107 (Terhathum local) has been registered by Variety Release Sub-committee as suitable for eastern mid-hill condition recently.
- Citrus decline management is the crucial aspect of citrus industry in Nepal. To address this problem, NCRP has worked on integrated plant nutrient management, pest & disease management, and orchard management based on the previous achievements in these regards. The experiment for decline management has been conducted since past 2 years in two declined mandarin orchards each in Dhankuta, Bhojpur and Terhthum. The results were found satisfactory except from Khoku, Dhankuta. Henceforth, verification and modification of previous experiment was carried out and a complete fertilizer dose including micro nutrients was found very effective in reviving old orchards with excellent production.
- The result of postharvest storage study showed that dipping Fludioxonil @ 300 ppm and ginger extract (10%) before storage effective in controlling blue mold disease in cellar storage for three month. There was lower weight loss and good taste and also preferred by hedonic raters after 90 days of storage.
- The result of rootstock trial for mandarin and sweet orange showed that three types of rootstocks viz., Citrange, C-35 and Citrumelo 4475 showed better performance for different morphological and yield traits.
- An investigation to identify the fruit fly species in three districts: Dhankuta (Maunabudhuk and Paripatle), Sindhuli (Khaniyakhark) and Bhojpur (Danwa) during fruit fly infestation time of the year 2074/75 confirmed that the infested fruits with fruit fly were detected to be the Chinese fruit fly (*Bactroceraminax*, Elderlein) in Sindhuli while B. zonata, B. scutellaris and B. tau in other districts but no Oriental fruit fly (*B. dorsalis*). In the same study, maximum fruit flies were entrapped into methyl Eugenol trap during May to July months except B. minax which was entrapped into protein bait trap starting from April till July in Sindhuli district.
- During the fiscal year 2075/76, 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 2075/76, total of 35000 grafted saplings constituting 2500 mandarin orange, 1500 sweet orange, 30000 acid lime and 1000 other saplings were made available to farmers.
- The total annual budget approved for the program was Rs. 23.2 million, while operational budget consisted of Rs. 11.0 million to carry out research projects. The revenue was 2.26 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 15 years. The current area is recorded to be 44,424 ha producing 2,45,176 metric tons with productivity of 9.94 mt/ha (Table 1), which is very low compared to the most citrus growing countries in the world. The productivity is in declining trend and some studies revealed that such productivity deteriorated situation is mostly linked to poor orchard management and declining soil fertility in Nepal. Thus, there has been a huge scope of increasing the production and productivity through the use of improved technologies.

Table 1: Area, production and productivity of citrus fruits during 2003/04 to 2017/18

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2003/04	24,799	13,931	1,48,010	10.62
2004/05	25,910	14,606	1,56,956	10.75
2005/06	26,681	15,206	1,64,075	10.79
2006/07	27,980	15,832	1,71,875	10.86
2007/08	30,790	19,915	2,26,404	11.37
2008/09	32,322	22,482	2,53,766	11.29
2009/10	33,898	22,903	2,59,191	11.30
2010/11	35,578	23,609	2,63,710	11.20
2011/12	37,565	24,089	2,40,793	10.00
2012/13	36,975	23,645	2,16,188	9.14
2013/14	38,988	25,497	2,24,357	8.80
2014/15	39,035	25,261	2,22,790	8.82
2015/16	40,554	24,854	2,18,447	8.82
2016/17	46,328	26,759	2,39,773	8.96
2017/18	44,424	25,946	2,45,176	9.44

Source: MoAD, Nepal, 2019

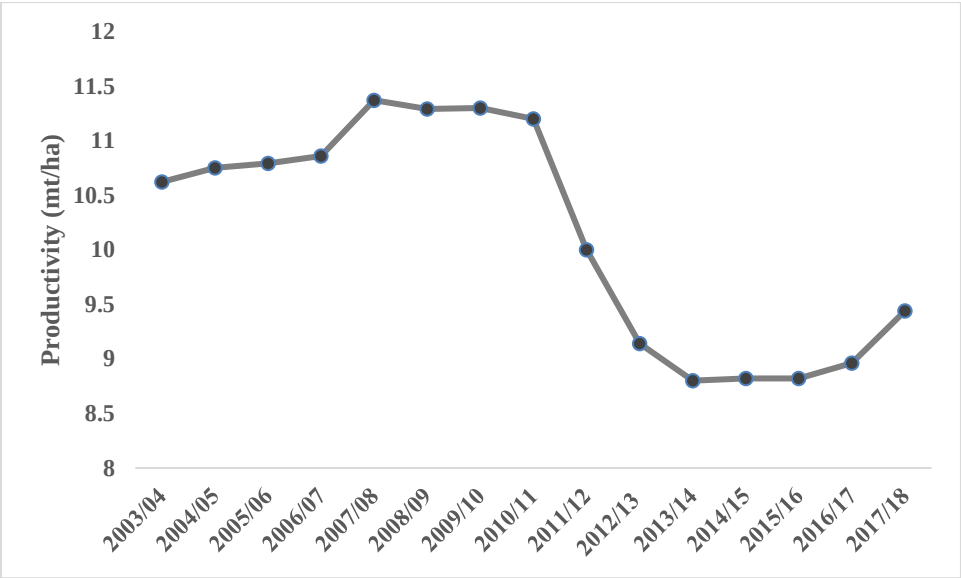

Figure 1: Productivity of citrus crops during 15 years period

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 area, productive area and production; mandarin has acquired the first position with 44,424 ha, 25,964 ha, 2,45,176 mt respectively, but sweet orange has the highest productivity (10.8 mt/ha). On the other hand, lemon fruit acquired the lowest area (1002 ha), productive area (662 ha), and production (5,431 mt). The lowest productivity of 6.7 mt/ha was recorded with acid lime.

Table 2: Total area, productive area, production and productivity of major citrus fruits in Nepal (2017/18)

Major citrus fruits	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
Mandarin orange	27150.4	16155.5	161434.4	10.0
Sweet orange	6276.8	3864.7	41556.3	10.8
Acid lime	8875.7	4611.6	31002.7	6.7
Lemon	1002.0	662.0	5431.0	8.2
Other citrus species	1119.8	670.8	5752.2	8.6
Grand Total	44424.3	25964.1	245176.2	9.4

Source: MoAD, Nepal, 2019

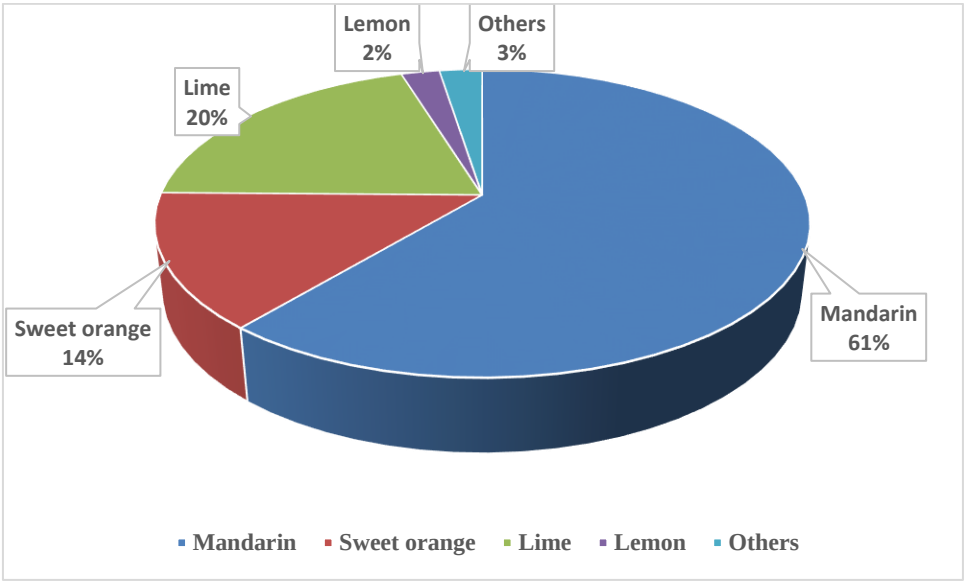

Figure 2: Total area (in percentage) of major citrus fruits in Nepal during 2017/18

The result shown in above pie-chart reveals that mandarin orange covers the maximum production area among citrus fruit. Mandarin orange covers 61.0% area among the citrus cultivated area. Similarly, acid lime, sweet orange, lemon and other citrus covers 20.0%, 14.0%, 2.0% and 3.0% respectively.

Table 3 shows the total orchard area, productive area, production and productivity of five groups of citrus based on provinces of the country. In terms of total cultivated area, productive area and production of citrus crops, regardless of respective group Province 1 has occupied the first position with 11,773 ha, 7848 ha and 65,313 mt respectively, but Province 3 has stood the first position for productivity (11.2 mt/ha) followed by Gandaki Province with 9.8 mt/ha and Province 5 with 9.6 mt/ha. Although, area, productive area and production of mandarin orange is the highest in Gandaki Province with 7,795 ha, 4,627 ha and 47,925 mt; productivity is noted to be the highest in Province 3 (11.0 mt /ha) followed by Gandaki (10.4 mt/ha) and Province 5 (10.2 mt/ha) while the lowest productivity of mandarin is in Sudur-Paschim Province (9.2 mt/ha). As for sweet orange, Province 3 has had considerably the highest area (2862 ha), productive area (1754 ha), production (22,580 mt) and productivity (12.9 mt/ha) whereas Karnali Pradesh showed the lowest productive area (108 ha) and production (916 ha). The lowest productivity was found in Gandaki Province (8.4 mt/ha). Province 1 showed considerably the maximum acid lime area (3,588 ha), productive area (2,249 ha) and production (23,808 mt). However, highest productivity for lime was recorded from Province 2 (6.0 mt/ha). The Province 2 reflected the lowest for acid lime in respect of area (38 ha), productive area (22 ha) and production (134 mt). In regards with lemon fruit crop, its' total area

(443 ha), productive area (237 ha), production (1,822 mt) and productivity (7.7 mt/ha) are recorded to be highest in eastern region. In contrast, the lowest production area, productive area and production was found in Province 5 with 45 ha, 31 ha and 255 mt respectively. As for other citrus fruit crop, cropped area (578 ha), productive area (326 ha), production (2,781 mt) and productivity (8.5 mt/ha) have been noted the highest in Province 1. The highest productivity was noted from Province 5 (9.1mt/ha), whereas the lowest productivity (8.4 mt/ha) was recorded from Province 3.

Table 3: Total area, total productive area, total production and productivity of different citrus species in different province of Nepal (2017/18)

Province	Crop	Area (ha)	Productive Area (ha)	Production (ton)	Yield (t/ha)
Province No.1	Mandarin	6304.0	4390.4	41286.2	9.4
Province No.2	Mandarin	0.0	0.0	0.0	0.0
Province No.3	Mandarin	4565.8	2450.6	26988.3	11.0
Gandaki Pradesh	Mandarin	7795.0	4627.4	47925.5	10.4
Province No.5	Mandarin	3222.6	1793.9	18312.9	10.2
Karnali Pradesh	Mandarin	3702.6	2023.9	18884.8	9.3
Sudurpashchim Pradesh	Mandarin	1560.5	869.2	8036.7	9.2
Nepal	**Mandarin**	**27150.4**	**16155.5**	**161434.4**	**10.0**
Province No.1	Sweet orange	860.1	646.2	5616.2	8.7
Province No.2	Sweet orange	0.0	0.0	0.0	0.0
Province No.3	Sweet orange	2862.0	1753.5	22579.5	12.9
Gandaki Pradesh	Sweet orange	840.7	558.3	4667.0	8.4
Province No.5	Sweet orange	583.6	340.4	3060.3	9.0
Karnali Pradesh	Sweet orange	264.9	107.6	916.1	8.5
Sudurpashchim Pradesh	Sweet orange	865.6	458.8	4717.0	10.3
Nepal	**Sweet orange**	**6276.8**	**3864.7**	**41556.3**	**10.8**
Province No.1	Lime	3588.2	2249.3	13807.9	6.1
Province No.2	Lime	37.7	22.3	133.9	6.0
Province No.3	Lime	1571.8	709.8	5818.8	8.2
Gandaki Pradesh	Lime	748.5	443.6	2914.5	6.6
Province No.5	Lime	1481.9	509.5	3937.8	7.7
Karnali Pradesh	Lime	783.7	322.6	1987.0	6.2
Sudurpashchim Pradesh	Lime	663.8	354.4	2402.9	6.8
Nepal	**Lime**	**8875.7**	**4611.6**	**31002.7**	**6.7**
Province No.1	Lemon	442.9	236.9	1821.6	7.7
Province No.2	Lemon	0.0	0.0	0.0	0.0
Province No.3	Lemon	122.6	101.0	1103.9	10.9
Gandaki Pradesh	Lemon	119.6	85.4	757.9	8.9
Province No.5	Lemon	45.0	31.0	255.3	8.2

Karnali Pradesh	Lemon	111.8	82.6	539.8	6.5
Sudurpashchim Pradesh	Lemon	159.8	124.6	952.2	7.6
Nepal	**Lemon**	**1001.6**	**661.5**	**5430.6**	**8.2**
Province No.1	Others	578.3	325.6	2780.9	8.5
Province No.2	Others	0.0	0.0	0.0	0.0
Province No.3	Others	155.1	119.2	997.6	8.4
Gandaki Pradesh	Others	188.7	129.6	1155.1	8.9
Province No.5	Others	81.2	40.5	368.4	9.1
Karnali Pradesh	Others	14.1	6.6	59.5	9.0
Sudurpashchim Pradesh	Others	102.5	49.2	390.7	7.9
Nepal	**Others**	**1119.8**	**670.8**	**5752.2**	**8.6**

Source: MoAD, Nepal, 2019

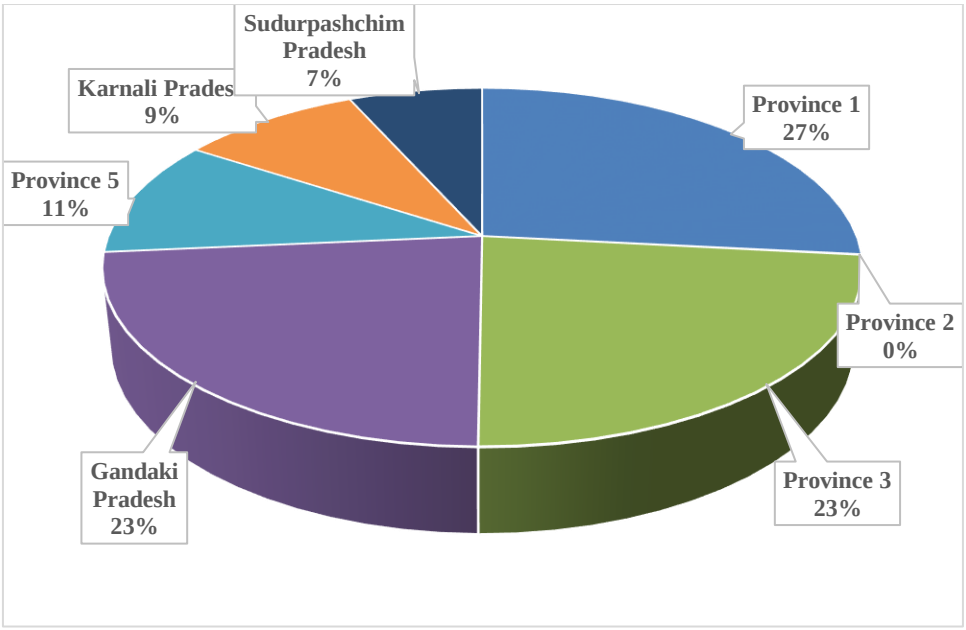

Figure 3: Total production of citrus in seven province during 2017/18

The pie-chart shows the status of citrus fruit production of the seven provinces of Nepal. Out of total citrus production; i.e. 245176 mt, Province 1 contributes maximum (27%) citrus production with total production of 65313 mt followed by Gandaki region (57488 mt) and Province 3 (57420 mt). There is very negligible production from citrus crops in Province 2 (134 mt). Citrus crops share about 28% of the total fruit area in Nepal. The government of Nepal has recognized mandarin and sweet orange as the potential export commodities, taking place of an initiative for exporting sweet orange in Tibet. Nevertheless, citrus industry is still facing several problems, some important are: traditional practices for crop management, short production season of existing varieties,

declined soil fertility and water resources, citrus greening and fruit fly, poor quality and small production scale, poor infrastructures and legal and institutional mechanism for marketing and lack of entrepreneurship for this crop.

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

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

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

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

2. INTRODUCTION

2.1 Background

Citrus is an important subsector of Horticulture for raising economy of Nepalese farmers. Because of appropriate geography and climate, citrus is grown throughout the mid-hills (800-1400 masl) from east to west across the country. Moreover, the government of Nepal has recognized it as potential crop for income and employment generation through import substitution and export promotion.

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

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

2.2 Goal

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

2.3 Purpose

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

2.4 Objectives

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

5. To document and maintain information on citrus research and development
6. To provide technical supports and services to citrus stakeholders

2.5 Strategies

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

2.6 Responsibilities

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

2.7 Prioritized Research for upcoming years

- Integrated approach to combat citrus decline
- Postharvest processing and value addition
- Marketing and export business
- Cost effective and eco-friendly production technologies
- Integrated nutrient management
- Breeding new varieties for extended harvest period
- Biological pest and disease control
- Water use efficiency
- *In-vitro* technology for healthy propagation

- Citrus based farming system
- Socio-economic studies

2.8 Infrastructure and resources

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

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

For nursery propagation and research, the farm has an isolated nursery segment expanding in two hectare area accommodating five screen houses (two iron-framed and three bamboo-made screen houses) 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 two senior scientist (1 Agri-economics and 1 Horticulture), one scientists, one technician, seven 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 2075/76 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 132 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. 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. Beside these, 8 new varieties comprising of 3 mandarin orange, 4 sweet orange and 1 rootstock was introduced from Australia in FY 2017/18.

3.1.2. VARIETAL EVALUATION

3.1.2.1 MANDARIN ORANGE

Mandarin (*Citrus reticulate* Blanco) is a high potential fruit crop in Nepal. It is widely grown throughout the mid-hills across the country. In Nepal, almost all mandarin varieties are of local origin that are specific to the location and vary each other. These varieties are characterized as declining yield potential and short production period within the same season. Therefore, mandarin production is confined to three to four months

leading to shortage during other period of the year. A huge amount is being imported to meet the national demand during other period of the year.

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

Fruit physical parameters and yield attributing characteristics of mandarin orange

Table 4 reveals that fruit weight, fruit diameter, fruit rind weight, number of segments per fruit, number of seeds per fruit were significant between genotypes whereas fruit rind thickness was found non-significant.

Fruit weight

Fruit weight was found varying from 54.84 g to 168.08 g with mean value of 102.80 g. The highest fruit weight was found in Kara (168.08 g) followed by Pongan (159.41 g) and Murkotte (147.64 g). The lowest fruit weight was found in Okitsu (54.84 g) followed by Avana (55.58 g) Dancy (66.30 g) (table 4).

Fruit diameter

Fruit diameter was found significant varying range from 49.00 mm to 72.52 mm with mean value of 61.43 mm. The highest fruit diameter was found in Murkotte (75.52 mm) followed by Kara (72.51 mm) and Pongan (71.02 mm). The lowest fruit diameter was found in Okitsu (49.00 mm) followed by Avana (49.71 mm) and Dancy (52.45 mm) (table 4).

Fruit rind thickness

Fruit rind thickness was found ranging from 1.55 mm to 5.25 mm with mean value of 2.47 mm. The highest fruit rind thickness was found in Fortune (5.25 mm) followed by Kamal (3.58 mm) and Kinnow (3.23 mm). The lowest fruit rind thickness was found in Okitsu (1.55 mm) followed by Miyagawawase (1.57 mm) (table 4).

Fruit rind weight

Fruit rind weight was found varying from 10.91 g to 45.23 g with mean value of 25.89 g. The highest fruit rind weight was found in Pongan (45.23 g) followed by Kara (42.85 g) and Murkotte (39.97 g). The lowest fruit rind weight was found in Okitsu (10.91 g) followed by Avana (13.10 g) and Dancy (15.60 g) (table 4).

Number of segments

The number of segments per fruit was found highly significant ranging from 8.57 to 11.7 with mean value of 10.26. The maximum number of segments per fruit was found in Satsuma Okitsu (11.77) followed by Kara (11.60) and Satsuma URSS (11.37). The minimum number of segments per fruit was found in Oroval (8.57) followed by Marisol (8.73) (table 4).

Number of seeds per fruit

Number of seeds per fruit was found varying from 0.07 to 21.02 with mean value of 8.02. The maximum number of seeds per fruit was found in Page (21.02) followed by Kinnow (18.30) and Commune (16.13). The number of seeds per fruit was found minimum in Miyagawawase (0.07) followed by Satsuma Mino (0.17) and Okitsuwase (0.30) (table 4).

Table 4: Fruit physical parameters and yield attributing characteristics of mandarin orange at NCRP in 2018/19

Genotypes	Fruit weight (g)	Fruit diameter (mm)	Fruit rind thickness (mm)	Fruit rind weight (g)	No of segments	No of seeds per fruit
Khoku local	106.12	61.46	2.26	28.83	9.97	6.27
Kinnow	85.63	59.01	3.23	30.54	10.80	18.20
Frutrel early	86.95	57.30	2.99	29.04	10.33	15.53
Okitsu	54.84	49.00	1.55	10.91	11.27	1.33
Miyagawawase	100.22	63.49	1.57	19.24	11.03	0.07
Okitsuwase	98.27	62.42	1.81	18.35	11.00	0.30
Murkotte	147.64	72.52	2.18	39.97	9.73	9.40
Pongan	159.41	71.02	3.00	45.23	9.73	7.47
Kamala	85.02	58.67	3.58	29.80	9.80	15.87
Banskharka local	83.32	56.63	2.18	21.45	9.40	11.53
Sikkime	72.31	54.16	2.28	19.35	9.10	5.93
Satsumawase	110.64	65.44	2.03	25.63	11.00	3.20

Satsuma Mino	105.98	63.16	1.80	29.69	10.90	0.17
Satsuma URSS	102.88	63.35	1.97	23.44	11.37	1.93
Fortune	106.21	61.06	5.25	19.26	10.10	16.00
Kara	168.08	72.51	2.99	42.85	11.60	7.87
Nova	131.22	65.77	2.97	31.80	10.57	10.97
Dancy	66.30	52.45	2.04	15.60	9.60	2.87
Avana	55.58	49.71	2.19	13.10	11.17	8.98
Page	109.15	62.44	1.81	21.00	10.50	21.02
Satsuma Okitsu	85.64	60.44	1.80	15.27	11.77	1.43
Oroval	119.59	65.21	2.91	36.81	8.57	8.17
Commune	99.16	62.77	2.30	32.39	9.03	16.13
Marisol	131.74	65.34	2.46	31.09	8.73	1.17
Nules	98.03	60.50	2.68	26.68	9.53	8.60
Mean	**102.80**	**61.43**	**2.47**	**25.89**	**10.26**	**8.02**
P-value	**	**	**NS**	**	**	**
CV %	**14.88**	**5.46**	**50.18**	**16.60**	**4.65**	**20.45**

Physio-chemical properties of mandarin orange

Physio-chemical properties (juice volume, TSS % and TA %), total number of fruits per tree and total fruit yield per tree were significantly different as presented in table 5.

Juice volume

Juice volume was found significantly different among test genotypes and ranged between 20.17 ml to 77.73 ml with mean value of 43.48 ml. The highest juice volume was found in Kara (77.73 ml) followed by Miyagawawase (56.87 ml) and Satsuma Mino (56.63 ml). The lowest juice volume was found in Avana (20.17 ml) followed by Kinnow (26.60 ml) and Dancy (26.80 ml) (table 5).

TSS %

TSS % was found significant among the tested genotypes and varied from 7.24 % to 12.55 % with the mean value of 10.18 %. The highest TSS % was found in Pongan (12.55 %) followed by Fortune (12.37 %) and Kinnow (11.98 %). The lowest TSS % was found in genotype Satsuma Mino (7.24 %) and Satsuma URSS (7.61 %) (Table 5).

TA %

Among the tested genotypes TA % was found significant ranging from 0.71 % to 1.76 % with mean value of 1.08 %. The TA % was remarkably high in Kara (1.76 %). Other genotypes with higher percentage of TA were Fortune (1.70 %) and Avana (1.68 %). Khoku local (0.71 %) recorded significantly the lowest TA %. Other genotypes with lower values of TA % were Pongan (0.74 %), Feutrel Early (0.78 %) and Murkotte (0.79 %) (Table 5).

Total number of fruits per tree

The total number of fruits per tree was found significant ranging from 22.67 to 926.67 with the mean value of 231.81. The highest number of fruit was found in Frutrel Early (926.67) followed by Kamala (531.00) and Satsuma Okitsu (384.67). The lowest number of fruit was found in Dancy (22.67) followed by Nova (25.00) (table 5).

Total fruit yield per tree

The total fruit yield per tree was found significant ranging from 1.19 kg to 61.29 kg with the mean value of 16.69 kg. The highest fruit yield was found in Frutrel Early (61.29 kg) followed by Murkotte (39.06 kg) and Kamala (31.59 kg). The lowest fruit yield was found in Dancy (1.19 kg) followed by Khoku local (2.96 kg) and Nova(2.97)(table 5).

Table 5: Physio-chemical properties of mandarin orange genotypes at NCRP in 2018/19

Genotypes	Juice volume (mm)	TSS %	TA %	#fruits/ tree	Yield/ tree (kg)
Khoku local	40.l3	11.52	0.71	37.33	2.96
Kinnow	26.60	11.98	1.08	243.67	13.40
Frutrel early	34.60	9.43	0.78	926.67	61.29
Unshiu	28.80	9.03	1.17	203.33	8.23

Miyagawawase	56.87	7.96	0.90	353.67	17.71
Okitsuwase	53.52	8.06	0.98	224.33	15.54
Murkotte	50.87	11.46	0.79	333.00	39.06
Pongan	51.53	12.55	0.74	84.67	7.99
Kamala	27.93	9.94	0.93	531.00	31.59
Banskharka local	31.17	11.39	1.00	62.33	3.60
Sikkime	28.93	10.68	0.89	113.67	7.91
Satsumawase	50.57	7.75	0.94	365.33	29.25
Satsuma Mino	56.63	7.24	0.80	105.33	29.65
Satsuma URSS	45.83	7.61	0.89	272.33	24.66
Fortune	49.90	12.52	1.70	98.33	7.60
Kara	77.73	10.85	1.76	162.33	19.65
Nova	50.27	8.97	0.96	25.00	2.97
Dancy	26.80	12.37	1.07	22.67	1.19
Avana	20.17	11.90	1.68	83.67	3.81
Page	51.13	11.48	1.57	41.00	3.86
Satsuma Okitsu	47.97	8.81	1.04	384.67	19.93
Oroval	47.53	10.06	0.98	282.67	22.68
Commune	38.23	10.17	1.05	264.67	17.80
Marisol	53.73	8.05	1.06	110.67	12.44
Nules	39.67	10.36	0.90	163.00	13.43
Mean	**43.48**	**10.18**	**1.08**	**231.81**	**16.69**
P-value	**	**	**	**	**
CV %	**15.63**	**8.95**	**9.77**	**73.40**	**76.58**

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: Sindhuli, Ramechap, Baitadi, Doti, Dadeldhura, Palpa, Lamjung and Rukum. The harvesting time of present local varieties remains only two months during December-January and beyond this period, Nepal imports fresh sweet orange fruit as well as processed fruit juice throughout the year.

Thus, NCRP has focused on variety selection of this species, so that there will be varietal diversity for expanding the fruit harvesting period beyond normal season, especially for early and late harvesting seasons. With this objective, varietal evaluation of sweet orange including 23 exotic and local varieties have been continued since 2064/65.

The performance of the sweet orange genotypes being evaluated in NCRP, Paripatle is described as follows.

Fruit characteristics and yield of different genotypes of sweet oranges

Fruit characteristics and yield attributes like individual fruit weight, fruit diameter, rind thickness, number of seeds per fruit were statistically significant due to the effect of different genotypes of sweet orange but number of fruits/tree and fruit yield/tree were found non-significant (Table 6).

Individual fruit weight

The data in table 6 shows that the individual fruit weight was statistically significant among different genotypes. Fruit weight varied from 95.69 g to 186.54 g with the mean value of 133.60 g. Lane late (186.54 g), Washington Navel (171.90 g) and Cara carra Navel(169.40 g) possessed higher individual fruit weight. Lower individual fruit weight were recorded on Tamango (95.69 g) and Sevelle common (96.07 g) (Table 6).

Fruit diameter

Individual fruit diameter was statistically variable and ranged between 55.16 mm and 71.64 mm with the mean value of 63.74 mm. Lane late had the highest fruit diameter (71.64 mm) followed by Cara car Navel (70.51 mm) and Washington Navel (69.76 mm). In contrast, fruit diameter was considerably low in Delicious seedless (55.16 mm), Tamango (55.68 mm) and Sevelle common (57.53 mm) (Table 6).

Rind thickess

The rind thickness differed significantly among genotypes and ranged between 2.05 mm and 4.16 mm with mean value of 3.22 mm. Maximum rind thickness was found in Dhankuta local (4.16 mm) followed by Malt blood red (3.91 mm) and Lane late (3.68 mm). Minimum rind thickness were observed in Vanelle (2.05 mm), Tamango (2.54 mm) and Hamlin (2.61 mm) (Table 6).

Number of seeds per fruit

The number of seeds per fruit differed significantly among genotypes and ranged between 0.47 to 23.73 with mean value of 8.31. The highest number of seeds were recorded in Succari (23.73) followed by Pineapple (22.40) and Malta blood red (16.30). The lowest number of seeds was recorded in Washington Navel (0.47) followed by Lane late (0.53) and Cara Cara Navel (0.63). (Table 6).

Fruit number per tree

The number of fruits/plant ranged 29.00 from 11 to 2.00 with the mean value of 97.27. Tamango recorded the highest number of fruits/plant i.e. 217.00 followed by Malta blood red (212.33) and Delicious seedless (179.67). Lue Gim Gong (29.00), Valencia late (40.00) and White tanker (41.33) were found to produce lower number of fruits per plant (Table 6).

Fruit yield per tree (kg)

Total weight of fruits/plant ranged between 3.31 kg and 27.54 kg with a mean value of 10.91 kg. Malta blood red gave the highest yield/tree (27.54 kg) followed by Tamango (18.89 kg) and Delicious seedless (18.68 kg). The genotype Lue Gim Gong produced the least fruit yield /tree (3.31 kg) followed by Valencia late (4.51 kg) and White tanker (4.64 kg) (Table 6).

Table 6: Fruit characteristics of different sweet orange genotypes at NCRP in 2018/19

Genotypes	Fruit wt (g)	Fruit diameter (mm)	Rind thickness (mm)	No. of Seed per fruit	No. of fruits per tree	Fruit yield per tree (kg)
Valencia Late	137.13	63.21	3.43	2.61	40.00	4.51
Sevelle Common	96.07	57.53	3.34	5.13	73.00	6.87
Lue Gim Gong	122.72	63.53	3.00	9.02	29.00	3.31
White Tanker	145.10	66.32	3.14	10.33	41.33	4.64
Hamlin	114.52	60.92	2.61	7.83	48.67	5.18
Dhankuta Local	141.43	66.16	4.16	16.83	104.67	12.16
Salustiana	124.98	64.13	3.46	1.82	91.33	8.34
Malta Blood Red	157.24	68.48	3.91	16.30	212.33	27.54
Vanelle	100.47	57.61	2.05	7.60	121.00	10.60
Lane Late	186.54	71.64	3.68	0.53	75.33	10.34
Delicious Seedless	112.73	55.16	2.88	3.33	179.67	18.68
Cara Cara Novel	169.40	70.51	3.27	0.63	91.33	13.89
Pineapple	124.21	63.70	3.14	22.40	91.00	10.19
Tamango	95.69	55.68	2.54	4.33	217.00	18.89
Succari	137.42	65.41	3.28	23.73	65.33	8.33
Washington Novel	171.90	69.76	3.54	0.47	75.33	11.08
Mean	**133.60**	**63.74**	**3.22**	**8.31**	**97.27**	**10.91**
P-value	**	**	**	**	**NS**	**NS**
CV%	**15.45**	**6.05**	**11.27**	**26.51**	**74.52**	**73.45**

Physio-chemical properties of different genotypes of sweet orange

Physio-chemical properties like Pulp weight, juice volume and TSS % of sweet orange genotypes/accessions under variety evaluation experiment were significantly different but TA% was found non-significant as presented in table 7.

Pulp weight

The pulp weight was significantly different among test genotypes and ranged between 56.11 g to 141.02 g with mean value of 89.40 g. The highest pulp weight was found in genotype Washington Navel (141.02 g) followed by Lane late (123.69 g) and Cara cara novel (112.57 g). The lowest pulp weight was recorded in Tamango (56.11 g) followed by Sevelle common (64.12 g) and Vanelle (66.96 g) (Table 7)

Fruit juice Volume

The volume of fruit juice was significantly different among test genotypes and ranged between 26.48 ml and 58.13 ml with mean value of 40.46 ml. The genotype Cara Cara Navel was found to give the highest juice volume (58.13 ml) followed by Lane late (54.37 ml) and White tanker (50.5 ml). The genotype Sevelle common gave the least juice volume (26.48 ml). Similarly, Vanelle (30.07 ml), Delicious seedless (32.7 ml) and Washington Navel (33.0 ml) yielded low fruit juice volume (Table 7).

Juice weight

The juice weight was significantly different among test genotypes and ranged between 26.07 g and 59.07 g with mean value of 39.87 g. The genotype Cara Cara Navel was found to give the highest juice weight (59.07 g) followed by Lane late (55.03g) and White tanker (51.28g). The genotype Sevelle common gave the least juice weight (26.07 ml). Similarly, Vanelle (30.31 g), Delicious seedless (31.60 g) and Washington Navel (32.60 g) yielded low fruit juice weight (Table 7).

Total Soluble Solids % (TSS %)

Among the tested genotypes the percent TSS varied from 9.52 % to 12.31 % with the mean value of 10.54 %. TSS % was found significantly higher in Valencia late (12.31 %) and Pineapple (12.01 %). Lower TSS % values were observed in Cara Cara Navel (9.52 %) and White tanker (9.59 %) (Table 7).

Titratable acid % (TA %)

Among the tested genotypes percent of TA ranged from 0.57 % to 2.61 % with mean value of 1.44 %. The TA percent was remarkably high in White tanker (2.61 %) followed by Washington Navel (1.90 %) and Malta blood red (1.75 %). Succari recorded lowest TA (0.57%). Other genotypes with lower values of TA % were Salustiana (0.97 %), Cara Cara Navel (1.13 %) (Table 7).

Table 7: Physio-chemical properties of different sweet orange genotypes at NCRP in 2018/19

Genotypes	Pulp Wt (g)	Juice vol (ml)	Juice wt (g)	TSS	TA

Valencia Late	96.46	34.77	35.06	12.31	1.70
Sevelle Common	64.12	26.48	26.07	10.45	1.52
Lue Gim Gong	72.22	45.88	45.74	9.94	1.47
White Tanker	90.62	50.50	51.28	9.59	2.61
Hamlin	78.22	33.07	33.25	10.56	1.09
Dhankuta Local	91.38	46.13	46.55	10.17	1.57
Salustiana	85.71	35.70	36.22	9.70	0.97
Malta Blood Red	109.32	44.97	45.44	10.28	1.75
Vanelle	66.96	30.07	30.31	10.32	1.60
Lane Late	123.69	54.37	55.03	10.83	1.08
Delicious Seedless	75.64	32.70	31.60	10.69	1.30
Cara Cara Novel	112.57	58.13	59.05	9.52	1.13
Pineapple	81.58	38.27	28.14	12.01	1.28
Tamango	56.11	36.17	36.83	11.00	1.45
Succari	84.73	47.13	44.76	10.75	0.57
Washington Novel	141.02	33.00	32.60	10.48	1.90
Mean	**89.40**	**40.46**	**39.87**	**10.54**	**1.44**
P-value	**	**	**	**	**NS**
CV%	**16.00**	**17.64**	**20.85**	**6.71**	**59.11**

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 is limited to range of 800 m to 1400 masl in mid hill districts, producing a very small volume during September to November. The current production is far below to meet the domestic demand that Nepal imports more than 90 % of fresh lime fruit demand 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 masl 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.

Result and discussion

Fruit weight (g)

Fruit weight was found to vary between 30.60 g to 81.05 g with mean value of 47.11 g. The highest fruit weight was recorded with genotype NCRP-53 (81.05 g) followed by NCRP-57 (70.60 g) and NCRP-60 (64.63 g). Lower fruit weight was found in genotype NCRP-50 (30.60 g) followed by NCRP-52 (31.10 g) and NCRP-46 (36.35 g) (Table 8).

Juice percent

Juice percent varied from 17.00 % to 43.70 % with mean value of 33.67%. The maximum juice % was found in genotype NCRP-52 (43.70 %) followed by NCRP-50

(42.40 %) and NCRP-56 (41.70 %). Lowest juice % was recorded in genotype NCRP-57 (17 %) followed by NCRP-53 (20.75 %) NCRP-60 (25.65 %) (Table 8).

Rind thickness (mm)

Rind thickness was found significantly different varying from 1.40 mm to 3.94 mm with average value of 2.32 mm. The highest rind thickness was found in genotype NCRP-60 (3.96 mm) followed by NCRP-57 (3.66 mm) and NCRP-53 (3.59 mm). Lowest rind thickness was found in genotype NCRP-59 (1.40 mm) followed by NCRP-48 (1.60 mm) and NCRP-49 (1.66 mm) (Table 8).

Fruit diameter (mm)

Fruit diameter was found significant varying from 37.10 mm to 54.40 mm with average value of 41.98 mm. The maximum fruit diameter was found in genotype NCRP-53 (54.40 mm) followed by NCRP-57 (48.90 mm) and NCRP-60 (46.00 mm). The minimum fruit diameter was found in genotype NCRP-50 (37.10 mm) followed by genotype NCRP-52 (37.90 mm) and NCRP-46 (37.90 mm) (Table 8).

Average TSS %

TSS was found significantly different ranging from 7.23 % to 9.25 % with mean value of 8.14 %. The maximum TSS % was found in genotype NCRP-60 (9.25 %) followed by NCRP-50 (8.80 %) and NCRP-48 (8.50 %). The minimum TSS % was found in genotype NCRP-55 (7.23 %) followed by NCRP- 51 (7.70 %) and NCRP-46 (7.75 %) (Table 8).

Average TA %

TA % was found varying from 6.78 % to 8.90 % with mean value of 7.95 %. The maximum TA % was found in genotype NCRP-48 (8.90 %) followed by NCRP-51 (8.70%), NCRP-52 (8.70%) and NCRP-50 (8.70%). The minimum TA % was found in NCRP-60 (6.78 %) followed by NCRP-57 (6.90 %) and NCRP-53 (7.20 %) (Table 8).

Number of fruits per tree

The number of fruits per tree was found varying from 5.00 to 395.75 with mean value of 210.70. The maximum number of fruits per tree was found highest with genotype NCRP-51 (395.75) followed by NCRP-52 (350.00) and NCRP-60 (299.50). The minimum number of fruits per tree was found in genotype NCRP-57 (5.00) followed by NCRP-59 (50.00) and NCRP-50 (58.00) (table 8).

Tree yield

Tree yield was found varying from 0.40 kg to 20.80 kg with mean value of 9.34 kg. The

maximum yield was found in genotype NCRP-60 (20.80 kg) followed by NCRP-51 (13.96 kg) and NCRP- 52 (11.05 kg). The minimum yield was recorded from NCRP-57 (0.40 kg) followed by NCRP-50 (1.80 kg) and NCRP-59 (1.95 kg) (Table 8).

Productivity

Productivity was found ranging from 0.39 t/ha to 23.14 t/ha with mean value of 10.38 t/ha. The maximum productivity was found in genotypes NCRP-60 (23.14 t/ha) followed by NCRP-51 (13.96 t/ha) and NCRP-52 (12.31 t/ha). The minimum productivity was found in genotype NCRP-57 (0.39 t/ha) followed by NCRP-50 (1.97 t/ha) and NCRP-59 (2.17 t/ha) (Table 8).

Table 8: Fruit quality and yield of different acid lime accessions grown at NCRP Dhankuta in year 2018 (FY2075/76)

Genotype	Fruit Wt (g)	Juice %	Rind thickness (mm)	Fruit Diameter (mm)	Av TSS (%)	Av TA (%)	# Fruit / tree	Tree Yield (kg)	Productivity (t/ha)
NCRP 51	38.15	40.18	1.71	40.23	7.70	8.70	395.75	13.96	15.52
NCRP 52	31.10	43.70	1.74	37.90	8.35	8.70	350.00	11.05	12.31
NCRP 60	64.63	25.65	3.94	46.00	9.25	6.78	299.50	20.80	23.14
NCRP 49	40.80	36.17	1.66	38.53	7.97	7.33	249.33	8.37	9.26
NCRP 46	36.35	36.20	1.68	37.90	7.75	7.30	210.50	7.65	8.52
NCRP 48	44.90	35.70	1.60	40.90	8.50	8.90	190.00	8.50	9.47
NCRP 53	81.05	20.75	3.59	54.40	7.95	7.20	107.50	7.85	8.70
NCRP 55	44.90	30.10	2.14	39.90	7.23	8.33	95.00	4.27	4.72
NCRP 56	41.05	41.70	2.44	41.50	8.10	8.35	92.50	3.80	4.23
NCRP 50	30.60	42.40	1.84	37.10	8.80	8.70	58.00	1.80	1.97
NCRP 59	39.30	33.60	1.40	41.35	8.45	8.55	50.00	1.95	2.17
NCRP 57	70.60	17.00	3.66	48.90	7.80	6.90	5.00	0.40	0.39
Mean	**47.11**	**33.67**	**2.32**	**41.98**	**8.14**	**7.95**	**210.70**	**9.34**	**10.38**
P value	**	**	***	*	**	Ns	Ns	Ns	Ns
LSD (0.05%)	**19.62**	**8.31**	**8.31**	**7.23**	**0.76**	-	-	-	-
CV	**23.78**	**14.10**	**11.93**	**9.84**	**5.32**	**10.29**	**97.54**	**92.07**	**91.96**

3.1.2.4 GRAPEFRUIT AND TANGELO

The tangelo are hybrid between true species of citrus while grape fruit is true citrus crop from mother nature. Among these two crops grape fruit is mostly used for making juice while tangelo are eaten fresh as well as juice. In Nepal juice consumption from citrus fruits are not common and hence cultivation of grapefruit is limited to backyard garden. At NCRP farm, three tangelo, four tangor and four grape fruits are planted in RCB design with five replication. However, due to limited replication producing fruit proper ANOVA analysis and mean comparison was not possible for this year. The table below present the physical and chemical parameters of grapefruits and tangelos.

Even though all cultivars of grapefruits, tangor and tangelos were high yielder the low level of TSS below 10^{o}brix coupled with >2.5 % TA at an altitude of 1200 meter is limiting out-scaling of the grapefruits . Simlarly, the greater number of seed/ fruit and

higher TA values of Tangor and Tangelo could not help much to attract farmers eventhough these cultivars have higher level of TSS. The low productivity of these cultivars are also hindering the out-scaling. It would be advisable to test these crops at lower altitude for better yield and fruit quality in future.

Table 9: Fruit quality and yield of different grapefruits, tangors and tangeelo accessions grown at NCRP Dhankuta in year 2018

Cultivars	Fruit wt. (g)	Fruit Diameter (mm)	Fruit rind thickness (mm)	Plume weight (g)	# Seeds/ fruit	Juice (%)
Grapefruit (Henderson)	191.1	75.3	3.9	125.4	3.9	29.1
Grapefruit (Pink Rubi)	178.2	74.6	5.0	112.2	5.0	32.0
Grapefruit (Shamber)	200.9	76.7	4.3	130.7	4.8	29.8
Grapefruit (Star Ruby)	222.0	78.5	4.8	137.0	4.2	33.3
Tangelo (Minneola)	117.9	60.4	3.1	87.2	15.3	43.3
Tangelo (Oriando)	85.6	56.5	2.8	63.0	15.3	36.9
Tangelo (Seminole)	87.3	56.7	2.9	67.0	14.6	42.5
Tangor (Murkott)	80.0	55.2	1.8	66.6	19.6	41.0

Cultivars	TSS (%)	TA (%)	Brim A	# fruit/tree	Yield/tree (kg)	Yield (t/ha)
Grapefruit (Henderson)	8.7	2.6	-4.1	92.7	18.5	20.6
Grapefruit (Pink Rubi)	9.3	2.5	-3.3	30.0	5.2	5.7
Grapefruit (Shamber)	9.3	2.6	-3.7	44.0	8.9	9.8
Grapefruit (Star Ruby)	9.8	2.6	-3.2	53.0	11.8	13.1
Tangelo (Minneola)	10.8	1.6	3.0	30.5	3.4	3.7
Tangelo (Oriando)	8.9	1.2	3.0	32.5	2.8	3.1
Tangelo (Seminole)	10.5	2.7	-2.8	27.0	2.4	2.6
Tangor (Murkott)	11.7	2.5	-1.0	37.0	3.0	3.3

3.2 POST-HARVEST RESEARCH

3.2.1 Effect of different chemicals on enhancing storage life of mandarin (var. Khoku) in cellar store

Citrus fruits are cultivated all over the world in tropical and sub-tropical regions having suitable soil and climatic conditions. Mid hills of Nepal ranging from 800 to1400 masl altitude all across the country are considered favorable for all types of citrus fruits cultivation. However pumelo, acid lime and lemon can also be cultivated successfully in up-land condition of terai, inner terai, foothills and river basin areas of Nepal. Citrus crops cover about 30% of the total area under fruit cultivation. Citrus crops are potential exportable commodities particularly to India, Bangladesh and China. At present, major citrus producing districts of Nepal having more than 1000 ha area are Taplejung, Tehrathum, Dhankuta, Ramechhap, Sindhuli, Kavrepalanchowk, Lamjung, Syangja, Salyan and Dailekh.

Citrus production and international trade in fresh citrus fruit has increased manifold during the last decade. World citrus production is around 73.3 million metric tons, with Brazil being largest producer, while European Union being the largest importer of citrus (Anonymous, 2004; FAO, 2003). Although citrus production in many citrus growing countries has increased, however, the overall profitability of the industry in developing countries has been limited by high postharvest losses due to the lack and/or use of proper postharvest handling system of fresh fruit. From sustainability and economic perspectives, there will be less investment needed to improve the situation through better postharvest management of the existing produce, the production area to compensate for these losses (Kader, 2002).

Based on secondary data source (HARP, 2002) there are remarkable losses in case of fresh fruit and vegetable in post-production stage. The loss reported 20-30% and this figure could exceed 50% under adverse condition. Losses reported in case of citrus fruits have been estimated between 15-20% (HARP, 2002). In Nepal, post-harvest loss observed in oranges is up to 29% (DFTQC, 2002). Bastakoti and Gotame (2013) reported that the fruit harvested at 26-50% yellow stage had minimum weight loss and rotting percentage accompanied by good taste, freshness, firmness and higher degree of overall acceptability after the storage of 90 days in a modified cellar store. The storage losses of mandarin fruits were found to be 5% during 2 to 4 days in Dharan Krishi Bazaar while 40.1% during 21 days of storage in room condition (Bhattarai *et al*, 2013). Therefore, this research was carried out to fulfill the following objectives:

- To extend storage life of mandarin fruits in cellar store with minimum fruit loss.

Methodology

The experiment was carried out to identify suitable chemicals that enhance storage life of mandarin at NCRP, Paripatle, Dhankuta begining from the fiscal year 2075/76. Cellar store constructed at NCRP was used for the experiment. The experiment was carried out by completely randomized block design and were given six treatments and replicated thrice. The treatments given are stated below:

T1: Fruit dipped in Fludioxonil @ 600 ppm solution
T2: Fruit dipped in Fludioxonil @ 300 ppm solution
T3: Fruit dipped in 10% garlic solution
T4: Fruit dipped in 10% ginger solution
T5: Fruit dipped in Bavistin solution @ 2 g per liter water
T6: Control

The observation was taken at 15 days interval for 6 times on physical and chemical parameters like physiological weight loss percentage, decay loss percentage and juice recovery percentage.

Result and discussion

The experiment was carried out to identify suitable chemical that enhance storage life of mandarin at NCRP, Paripatle, Dhankuta beginning from the fiscal year 2075/76. All the treated fruits were stored in cellar store for 90 days and observations on different parameters were taken six times at 15, 30, 45, 60, 75 and 90 days at 15 days interval. Five kilograms of fruits were initially taken for each treatment and subjected to observations at 15 days interval for all parameters.

Table 10 illustrates that there was no significant difference in physiological loss in weight of mandarin fruit in any storage duration except at 30 days of storage. At 30 days of storage duration, lowest physiological loss in weight was found in bavistin treatment (0.42) followed by Fludioxonil @ 300 ppm (7.58) and 10% ginger solution (8.65).

Table 10: Effect of postharvest treatments on physiological loss in weight of mandarin fruit during storage at cellar store during year 2075/76

Treatments	Physiological loss in weight on days indicated (%)					
	15	30	45	60	75	90
Fludioxonil @ 600 ppm	10.80	11.94	7.07	15.31	15.34	23.41
Fludioxonil @ 300 ppm	8.80	7.58	11.33	9.12	6.52	17.90
10% garlic solution	13.13	17.37	23.07	8.73	8.12	29.01
10% ginger solution	13.00	8.65	9.38	8.16	21.71	34.31
Bavistin	0.40	0.42	1.87	3.53	2.68	11.99
Control	12.00	9.55	9.87	12.98	25.41	35.58

Mean	9.69	9.11	10.43	9.64	13.30	25.37
P-value	**NS**	*****	**NS**	**NS**	**NS**	**NS**
CV	**51.16**	**46.24**	**107.90**	**60.87**	**82.67**	**48.23**

Table 11 illustrates that there was no any significant difference in decay loss percentage beyond 30 days of storage. Minimum decay loss percentage was found in bavistin (0.00) followed by Fludioxonil (8.21) up to 15 days. Similarly, minimum decay loss percentage was found in bavistin (0.68) followed by Fludioxonil (3.82) up to 30 days of storage.

Table 11: Effect of postharvest treatments on decay loss percentage of mandarin fruit during storage at cellar store during year 2075/76

Treatments	Decay loss on days indicated (%)					
	15	30	45	60	75	90
Fludioxonil @ 600 ppm	10.91	11.10	6.78	14.34	15.14	5.26
Fludioxonil @ 300 ppm	8.21	3.82	10.10	7.55	7.08	10.00
10% garlic solution	11.62	15.61	22.76	11.20	2.43	16.35
10% ginger solution	14.36	5.40	9.06	4.18	15.08	9.86
Bavistin	0.00	0.68	4.31	2.39	2.38	8.56
Control	12.68	7.50	7.34	11.62	11.74	19.05
Mean	**9.63**	**7.35**	**10.06**	**8.55**	**8.98**	**11.51**
P-value	*****	*****	**NS**	**NS**	**NS**	**NS**
CV	**34.94**	**41.14**	**114.90**	**71.73**	**76.29**	**91.60**

Tables 12 illustrates that there was no significant difference in juice recovery percentage among various treatments in any storage duration.

Table 12: Effect of postharvest treatments on juice recovery percentage of mandarin fruit during storage at cellar store during year 2075/76

Treatments	Juice recovery (%)					
	15	30	45	60	75	90
Fludioxonil @ 600 ppm	40.69	43.80	42.58	39.47	40.42	38.96
Fludioxonil @ 300 ppm	42.69	48.09	42.03	36.75	40.10	40.02
10% garlic solution	42.74	44.36	42.44	41.33	40.17	34.76
10% ginger solution	41.62	46.04	41.09	39.07	39.50	41.12
Bavistin	39.81	43.12	43.18	39.08	38.70	39.31
Control	40.58	46.94	44.62	38.82	40.16	40.43
Mean	**41.36**	**45.39**	**42.66**	**39.09**	**39.84**	**39.10**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV	**7.87**	**6.63**	**8.56**	**4.88**	**4.83**	**9.28**

Organoleptic taste

For outlook of fruit, preferential ranking index (PRI) was found highest with treatment control (0.56) followed by 10% ginger solution (0.50). For taste, PRI was the highest with treatment 10% ginger solution (0.63) followed by fludioxonil @ 600 ppm and control (0.60). Similarly, for aroma, PRI was the highest with fludioxonil @ 600 ppm (0.65) followed by fludioxonil @ 300 ppm (0.57). Similarly for acceptance of fruit, PRI was found highest with treatment control (0.68) followed by (10 % ginger solution (0.57). Likewise, for readiness to purchase, PRI was the highest with treatment 10 % garlic solution (0.67) followed by fludioxonil and control (0.65) (Table 13).

Table 13: Preferential ranking index for different traits of mandarin fruit during year 2074/75

Treatment	Preferential ranking index of mandarin fruit				
	Outlook	Taste	Aroma	Acceptability	Purchase
Fludioxonil @ 600 ppm	0.50	0.60	0.65	0.38	0.65
Fludioxonil @ 300 ppm	0.52	0.58	0.62	0.47	0.55
10% garlic solution	0.50	0.52	0.57	0.57	0.67
10% ginger solution	0.55	0.63	0.55	0.45	0.63
Bavistin	0.53	0.55	0.53	0.38	0.52
Control	0.56	0.60	0.50	0.68	0.65

3.3 Plant Husbandry

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

The fruit physical parameters: rind thickness and rind weight were found non-significant due to rootstock, while the rootstock effect was significant on fruit wt, fruit diameter (mm) and number of seeds/fruit. The heaviest fruit was produced from plants grafted on to Carizzo Citrange (97 g) while the smallest fruit (57.2 g) was from Rangpur rootstock. Similary, the fruit with biggest diameter was from plants grafted onto Carizzo Citruage (59.5 mm), while the smallest was from Rangpur (49.3 mm). However, the thickest fruit skin (2.8 mm) was from plants grafted onto Trifoliate, while the thinnest was from Carizzo Citrange (2.0 mm) (Table 14).

Table 14: Fruit quality of Mandarin cultivar Khoku Local grafted on six different rootstocks (FY 2075/76)

Rootstock	No of Fruit/tree	Fruit wt (g)	Fruit Diameter (mm)	Rind Thickness (mm)	Rind wt (g)	# Seed/fruit
Citrange (C-35)	49.4	83.3	56.3	2.2	24.5	15.0
Citrange-Carizzo	21.0	97.6	59.5	2.0	26.0	12.1
Citrumelo-4475	43.8	90.5	58.0	2.1	24.5	13.8
Flying dragon	23.0	83.1	55.3	2.1	22.7	16.6
Poncirus-Pomroy	69.0	80.6	54.3	2.4	22.9	16.2
Rangpur	23.0	57.2	49.3	2.2	21.7	10.2
Trifoliate	58.5	80.1	54.0	2.8	24.0	17.0

Grand Mean	**44.17**	**84.18**	**55.91**	**2.24**	**23.89**	**14.93**
P value	**ns**	*****	*****	**ns**	**ns**	*****
LSD (0.05%)	**-**	**14.5**	**3.6**	**-**	**-**	**3.2**
CV %	**80.3**	**11.5**	**4.3**	**13.2**	**13.9**	**14.3**

Among fruit quality parameters titratable acidity (TA), TSS and ratio of TSS and TA were found significantly different due to rootstock effect, while juice percent was found non-significant. The sweetest fruits were from plants grafted onto Citrange (C35) rootstock while the least sweet was from Rangpur lime (6.5%) grafted plants. The least sour fruits were from the mandarin plants grafted onto Carrozo Citrange rootstock (0.96%) while the most acidic fruits were from Rangpur lime (1.48%) rootstock. However, the sweetness to sourness value (BrimA) was very highest from Citrange (C-35) grafted plants (Table 15).

All the yield parameters were found non-significantly affected by the rootstocks. However, the highest number of fruit/tree was obtained from Poncirous Pomeroy grafted plants (69) while the least from Carrizo Citrange (21) grafted ones (Table 14). Similarly, the highest yield/tree and productivity was also obtained from Poncirous Pomeroy grafted plants with least from Rangpur lime grafted plants (Table 15).

Table 15: Fruit physio-chemical properties and yield characteristics of mandarin cv Khoku local grafted on different rootstock (FY 2075/76)

Rootstock	Juice (%)	TA (%)	TSS (Brix%)	Brim A	TSS/TA	Tree Yld (kg)	Yield (t/ha)
Citrange (C-35)	39.24	1.22	12.06	5.97	10.15	4.29	4.76
Citrange-Carizzo	42.04	0.96	10.79	6.01	11.46	2.06	2.29
Citrumelo-4475	54.21	1.05	10.75	5.51	10.99	3.91	4.34
Flying dragon	40.35	1.21	12.00	5.95	10.26	1.93	2.15
Poncirus-Pomeroy	38.79	1.06	10.84	5.53	10.54	5.48	6.08
Rangpur	33.57	1.48	6.47	-0.90	4.48	1.32	1.46
Trifoliate	36.74	1.33	11.01	4.36	8.42	4.69	5.21
Grand Mean	**42.39**	**1.15**	**11.11**	**5.35**	**10.14**	**3.71**	**4.13**
P value	**ns**	*****	*******	*******	*****	**ns**	**ns**
LSD (0.05%)	**-**	**0.22**	**0.78**	**1.14**	**2.11**	**-**	**-**
CV %	**32.08**	**12.54**	**4.68**	**14.18**	**13.79**	**81.68**	**81.65**

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

The fruit physical parameters: fruit weight and fruit diameter were found non-significantly different due to rootstocks, while rind thickness and number of seed per fruit were found significantly affected. The thinnest skinned fruit (1.6 mm) with highest juice percent (52%) was obtained with lime plants grafted onto Poncerous pomroy, while the thickest skin (2.2 mm) and the least juiciest (26.2%) fruit was from Citrumelo 4475 (35.5%) grafted plants (Table 16).

The fruit quality parameters, total soluble solids was found highly significant while titratable acidity (TA %) was significant due to rootstock effect. The highest level of TSS was obtained from fruits of flying dragon (9.16%) grafted plants while the least was from Volkamerina grafted plants. The highest TA was obtained from fruits of Carizzo citrange grafted plants (11.7%) while the least (10.1%) was from Citron grafted plants (Table 17)

All the yield related parameters (yield/tree, productivity) were found non-significantly affected by the rootstocks. The highest yield per tree (2.6 kg) and productivity (2.9 t/ha) was from Flying Drangon and trifoliate orange grafted plants and the least yield per tree (0.7 kg) with productivity (0.8 t/ha) was from the plants grafted on to Carrozo Citrrange (Table 17).

Table 16: Fruit quality and yield parameter of acid lime cv. Tehrathum local grafted on different rootstocks (FY 2074/75)

Rootstock	Fruit wt (g)	Fruit Dia (mm)	Rind Thickness	# Fruit /tree	# Seed /fruit	Juice (%)
Citrange-C-35	32.4	39.2	2.0	68.8	4.7	52.0
Citrange-Carizzo	32.2	39.5	1.8	25.5	6.0	49.4
Citrumelo-4475	33.1	38.8	2.2	56.8	5.8	35.5
Flying-Dragon	34.4	38.9	1.7	77.0	8.1	43.1
Poncirus-Pomeroy	37.5	40.1	1.6	39.5	6.8	52.0
Rangapur lime	37.6	39.6	2.2	46.0	5.2	36.9
Trifoliate orange	39.2	40.7	1.7	66.3	8.2	41.0
Volkamerina	35.4	39.6	1.7	40.5	6.2	41.0
Grand Mean	**35.21**	**39.52**	**1.90**	**53.22**	**6.33**	**43.56**
P value	ns	ns	*	ns	*	ns
LSD (0.05)	-	-	**0.4**		2.0	-
CV (%)	**17.36**	**5.78**	**14.19**	**64.45**	**23.8**	**26.1**

Table 17: Fruit physico-chemical and yield parameter of acid lime cv. Tehrathum local grafted on different rootstocks (FY 2074/75)

Rootstock	TSS (Brix)	TA (%)	Brim A	TSS /TA	Tree Yld (kg)	Yield (t/ha)
Citrange-C-35	8.1	3.9	-11.3	2.1	2.3	2.6
Citrange-Carizzo	7.0	4.6	-16.1	1.5	0.7	0.8
Citrumelo-4475	7.6	4.7	-15.6	1.6	1.9	2.1
Flying-Dragon	8.4	4.6	-14.6	1.9	2.6	2.9
Poncirus-Pom	7.7	6.0	-22.2	1.3	1.6	1.7
Rangapur lime	6.9	5.4	-20.2	1.3	1.8	2.0
Trifoliate orange	7.5	5.3	-19.2	1.4	2.6	2.9
Volkamerina	12.2	2.8	-1.6	4.4	1.5	1.6
Grand Mean	**7.9**	**4.8**	**-16.1**	**1.8**	**1.9**	**2.1**
P value	***	***	***	***	ns	ns
LSD (0.05)	**0.6**	**0.6**	**2.9**	**0.2**	**-**	**-**
CV (%)	**5.01**	**8.06**	**12.13**	**8.55**	**71.63**	**71.63**

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 was not possible due to lack of replications caused by limited fruiting 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

The preliminary study found that the hybrid rootstocks Flying Dragaon and Citrange (C-35) were performing well in terms of fruit weight (>133gm) and fruit diameter (>66 mm). Further, those fruits were juicier than other root stock grafted plants (>40%). All the rootstocks has produced less acidic fruit (1%). The Citrumelo 4475 and Poncerous Pomeroy rootstocks were found producing more fruit per tree (>10 kg) with better productivity (>11.0 t/ha) as compared to other three rootstocks used in the study (Table 18).

Table 18: Fruit quality and yield of sweet orange cv Washington Navel grafted on eight rootstocks grown at NCRP Dhankuta (FY2075/76)

Rootstock	Fruit Dia (mm)	Peel Thickness (mm)	Plume Wt (g)	Fruit Wt (g)	Juice (%)
Carrizo Citrange	68.1	4.4	121.7	110.0	27.0
Citrange-C-35	66.3	3.6	103.3	133.2	41.4
Citrumelo-4475	66.4	3.8	102.8	118.1	39.5
Flying Dragon	71.9	3.8	128.8	150.0	40.0
Poncirous Pomeroy	70.0	4.1	128.4	126.4	24.5
Rangapur lime	66.1	4.3	107.4	122.4	32.6
Trifoliate	66.1	3.9	110.6	120.3	24.3
Volkamerina	67.9	4.4	104.0	109.8	37.0
Grand mean	**67.3**	**7.9**	**111.1**	**122.6**	**32.1**
P value	**ns**	**ns**	**ns**	**ns**	**ns**

LSD	-	-	-	-	-	
CV (%)	**13.27**	**24.55**	**30.01**	**32.72**	**102.54**	

Rootstock	Av. TA	Av. TSS	TSS/ TA	BrimA	Tree Yld (kg)	Yield (t/ha)
Carrizo Citrange	0.9	11.3	12.6	7.9	2.5	2.8
Citrange-C-35	1.0	10.0	10.5	6.2	2.5	2.8
Citrumelo-4475	0.9	10.6	11.5	7.0	10.0	11.2
Flying Dragon	0.9	9.2	10.0	5.5	3.5	3.8
Poncirous Pomeroy	0.9	9.8	11.0	6.2	11.6	12.9
Rangapur lime	0.9	9.9	11.5	6.4	1.6	1.8
Trifoliate	0.9	10.0	10.7	6.3	6.7	7.4
Volkamerina	0.9	10.1	11.3	6.5	7.7	8.6
Grand mean	**0.9**	**10.1**	**11.0**	**6.9**	**5.9**	**6.6**
P value	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
LSD	-	-	-	-	-	-
CV (%)	**12.7**	**24.7**	**24.3**	**37.3**	**284.8**	**284.6**

3.3.3 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 20. 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 above.

Result and discussion

This year was off-year for Khoku mandarin in high density trail with some treatment having yield on single replications. Therefore, the fruit physical and quality data on table 20 was presented as mean without further ANOVA analysis. Due to seasonality on bearing we were not able to see a definite trend on observed parameters. On an average there was 1.59 to 7.49 ton/ha productivity from different planting densities which are quite below than last year's highest productivity of 27 t/ha.

Table 19: Effect of different planting densities on fruit quality and yield of mandarin cv. Khoku local grafted onto trifoliate rootstock (FY 2074/75)

Spacing	Fruit wt (g)	Fruit Dia (mm)	Fruit Thickness (mm)	# Segment	Juice %	TSS (Brix)	TA (%)	BrimA	Tree yield (Kg)	Productivity (ton.ha)
1.5 X 3.0 m	92.8	60.00	2.93	10.93	35.10	9.76	0.83	5.60	0.71	1.59
1.75X3.0 m	88.7	58.44	3.09	10.70	36.72	9.49	1.16	3.68	3.93	7.49
2.25X3.0 m	93.4	59.88	3.06	10.57	36.51	10.13	0.96	5.34	4.84	7.17

2.50X3.0 m	79.3	55.91	2.89	10.30	33.88	9.98	0.85	5.71	1.98	2.64

3.4 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.

3.4.1 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 * 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.

Result

In the 1st 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. Similarly in 2nd year 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.

3.4.2 Study on efficacy of different bio-chemical agents and fungicides for management of citrus root rot

Root rot is the most serious root disease of citrus. The disease is caused by fungi (Fusarium and Phytophthora) which can survive in soil. The disease is more likely to develop in water-logged conditions and when roots are wounded by insect pests. The disease cause slow decline and death of citrus trees.

NCRP has generated several innovative technologies on integrated plant nutrient management, insect, pest and disease management, orchard management, etc. to revive declined orchard to healthy and productive one. Thus, this study was carried out on fiscal year 2075/76 to meet the following objective:

- To revive the declined acid lime orchard (caused by Phytophthora root rot and Fusarium root rot) to healthy and productive orchard.

Methodology

The declined mandarin orchard was initially identified and pathogen causing the root rot disease and was confirmed to be *Phytophthora* spp and *Fusarium* spp. Eighteen infected trees were selected. Three different orchards one at Dhankuta, one at Sunsari and two at Chitwan. Soil drenching was done with six treatments including two different bio-control agents, three fungicides and one control and was replicated three times. The treatments given to infected plant are listed below:

T1- Drenching with *Trichoderma viride* @ 10 g/lt of water

T2- Drenching with *Pseudomonas fluroscens* @ 10 g/lt of water

T3- Drenching with Copperoxychloride @ 4 g/lt of water

T4- Drenching with 1% Bordeaux mixture

T5- Drenching with Carbendazim @ 2 g/lt of water

T6- Control

The root of infected plant was exposed and infected roots were pruned. Drenching of roots and soil with above listed bio-control agent and fungicide were done and exposed area was filled with soil.

Beside above treatment, manure, fertilizer and micronutrients in soil FYM @ 30 kg + N 250 g + P 125 g + K 250 g + Boric acid 10 g + Zinc sulphate 75 g + Copper sulphate 40 g + manganese sulphate 25 g + agri-lime 75 g per plant was applied. Nitrogen was applied in two equal split doses i.e. first as basal dose after harvest and second dose at the time of flowering.

Result and discussion

Table 20 reveals that fruit weight, fruit diameter, fruit rind thickness, fruit rind weight and juice volume were statistically different.

Fruit weight

Fruit weight was found varying from 0.00 g to 73.95 g with mean weight of 55.90 g. The highest fruit weight was recorded from soil drenching with 1 % Bordeaux mixture (73.95 g) followed by soil drenching with *Pseudomonas fluroscens* @ 10 g/lt (71.92 g). No fruit yield was obtained from treatment control.

Fruit diameter

Fruit diameter was found varying from 0.00 mm to 55.11 mm with mean diameter of 42.09 mm. The highest fruit diameter was recorded from soil drenching with 1 % Bordeaux mixture (55.11 mm) followed by soil drenching with *Pseudomonas fluroscens* @ 10 g/lt (54.96 mm).

Fruit rind thickness

Fruit rind thickness was found varying from 0.00 mm to 2.56 mm with mean thickness of 1.78 mm. The highest fruit rind thickness was recorded from soil drenching with *Pseudomonas fluroscens* @ 10 g/lt (2.56 mm) followed by *Trichoderma viridae* @ 10 g/lt (2.44 mm).

Fruit rind weight

Fruit rind weight was found varying from 0.00 g to 21.80 g with mean weight of 15.88 g. The highest fruit rind weight was recorded from soil drenching with 1 % Bordeaux mixture (21.80 g) followed by soil drenching with *Trichoderma viridae* @ 10 g/lt (20.75 g).

Juice volume

Juice volume was found varying from 0.00 ml to 24.93 ml with mean volume of 18.54 ml. The highest juice volume was recorded from *Pseudomonsa fluroscens* @ 10 g/lt (24.93 ml) followed by 1 % Bordeaux mixture (24.80 ml).

Table 20: Effect of different treatments on fruit physical parameters at Maunabudhuk, Dhankuta during the FY 2075/76

Treatment	Fruit wt (g)	Fruit diameter (mm)	Fruit rind thickness (mm)	Fruit rind weight (g)	Juice volume (ml)
Trichoderma viridae @ 10 g/lt	70.62	54.13	2.44	20.75	21.00
Pseudomonas fluroscens @ 10 g/lt	71.92	54.96	2.56	20.59	24.93
Copper oxychloride @ 4 g/lt	65.92	51.52	2.16	17.72	21.93

1% Boredeaux mixture	73.95	55.11	2.07	21.80	24.80
Carbendazim @ 2 g/lt	53.00	36.89	1.45	14.42	18.60
Control	0.00	0.00	0.00	0.00	0.00
Mean	55.90	42.09	1.78	15.88	18.54
P-value	**	**	**	**	**
CV %	33.39	30.43	36.21	35.56	39.90

Fruit yield (kg)

Fruit yield of grade A was found ranging from 0.00 kg to 3.67 kg with mean value of 2.22 kg. The highest grade A yield was recorded from *Pseudomonas fluroscens* @10 g/lt (3.67 kg) followed by 1 % Bordeaux mixture (3.00 kg). Fruit yield of grade B was found ranging from 0.00 kg to 2.33 kg with mean value of 1.11 kg. The highest grade B yield was recorded from copper oxychloride @ 4 g/lt and 1% Bordeaux mixture (2.33 kg). Fruit yield of grade C was found ranging from 0.00 kg to 1.67 kg with mean value of 1.00 kg. The highest grade C yield was recorded from 1 % Bordeaux mixture (1.67 kg) followed by *Trichoderma viridae* @ 10 g/lt (1.33 kg).

Table 21: Effect of different treatments on fruit yield at Maunabudhuk,, Dhankuta during the FY 2075/76

Treatment	Weight of fruits (Kg)		
	Grade A	Grade B	Grade C
Trichoderma viridae @ 10 g/lt	2.33	1.67	1.33
Pseudomonas fluroscens @ 10 g/lt	3.67	2.00	1.00
Copper oxychloride @ 4 g/lt	2.33	2.33	1.00
1% Boredeaux mixture	3.00	2.33	1.67
Carbendazim @ 2 g/lt	2.00	1.33	1.00

Control	0.00	0.00	0.00
Mean	2.22	1.11	1
P-value	NS	NS	NS
CV %	75.15	67.68	83.67

3.4.3 Sustainable management of citrus orchard through nutrient management

Citrus are perennial. As fruit trees are perennial crops, they take up nutrients year after year from the soil zone around the roots. Supply of adequate quantities of nutrients is very essential for sustainable high yields and for good quality fruits over a long period of time. In the initial 4-5 years of vegetative growth and later during reproduction growth stage of crop, the nutritional requirements are different and must be met with as per their needs. If fertilizers are not applied every year, the soil will be poor in nutrients, and the productivity and quality of the trees will be badly affected. More nutrients are needed as the tree develops in age and size. Weaker trees with less vigor need more nutrients to help them recover. The higher the yield in the previous season, the more nutrients is needed.

3.4.3.1 Sustainable management of 21-40 years old citrus orchard

Methodology

This experiment was carried out to make availability of sustainable mandarin orchard management technology to farmers especially through nutrient management for twenty to forty years old mandarin orchard at NCRP, Paripatle, Dhankuta beginning from the fiscal year 2075/76. The experiment was carried out in completely randomized block design and was given five treatments and replicated four times. The treatments given are stated below:

T1: FYM 100 kg/tree
T2: FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g
T3: FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g
T4: FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g
T5: FYM 100 kg + Micronutrient spray

Result and discussion

Average fruit weight

The average fruit weight varied from 68.12 g to 98.09 g with the mean value of 76.88 g. The highest average fruit weight was obtained from treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (98.09 g) followed by FYM 100 kg + Micronutrient spray (78.20 g). The lowest average fruit weight was obtained from treatment FYM 100 kg/tree (68.12 g) (Table 22).

Fruit diameter

The fruit diameter ranged from 52.22 mm to 60.06 mm with the mean value of 54.98 mm. The highest fruit diameter was recorded from treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (60.06 mm) followed by treatment FYM 100 kg + Micronutrient spray (54.82 mm). The lowest fruit diameter was recorded from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (52.22 mm) (Table 22).

Fruit rind weight

The fruit rind weight was found varying from 16.62 g to 28.12 g with the mean value of 21.10 g. The highest fruit rind weight was obtained from treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (28.12 g) followed by FYM 100 kg + Micronutrient spray (21.05 g). In contrast, lowest fruit rind weight was recorded from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (16.62 g) (Table 22).

Juice volume

The juice volume ranged from 26.60 ml to 41.05 ml with the mean value of 31.88 ml. The highest juice volume was obtained from treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (41.05 ml) followed by treatment FYM 100 kg + Micronutrient spray (32.65 ml). The lowest juice volume was recorded from treatment FYM 100 kg/tree (26.60 ml) (Table 22).

Table 22: Effect of different treatments on average fruit weight, fruit diameter, fruit rind weight and juice volume on the year 2075/76

Treatments	Average Fruit weight (g)	Fruit diameter (mm)	Fruit rind weight (g)	Juice volume (ml)
T1: FYM 100 kg/tree	68.12	53.26	19.59	26.60
T2: FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g	71.32	54.54	20.14	28.70
T3: FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	68.65	52.22	16.62	30.40

T4: FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	98.09	60.06	28.12	41.05
T5: FYM 100 kg + Micronutrient spray	78.20	54.82	21.05	32.65
Mean	**76.88**	**54.98**	**21.10**	**31.88**
P-value	**	**NS**	*	**NS**
CV %	**15.47**	**6.74**	**19.41**	**19.72**

Total fruit weight of grade A

The total fruit weight of grade A ranged from 1.94 kg to 7.22 kg with the average value of 3.91 kg. The maximum fruit weight of grade A was obtained from treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (7.22 kg) followed by treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (6.16 kg). In contrast, minimum fruit weight of grade A was obtained from FYM 100 kg + Micronutrient spray (1.94 kg) (Table 23).

Total fruit weight of grade B

The total fruit weight of grade B ranged from 2.37 kg to 16.29 kg with the mean value of 6.88 kg. The maximum fruit weight of grade B was obtained from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (16.29 kg) followed by treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (6.56 kg). The minimum fruit weight of grade B was obtained from treatment FYM 100 kg/tree (2.37 kg) (Table 23).

Total fruit weight of grade C

The total fruit weight of grade C varied from 3.66 kg to 18.60 kg with the mean value of 7.19 kg. The maximum fruit weight of grade C was obtained from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (18.60 kg) followed FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (5.15 kg). The minimum fruit weight of grade C was obtained from treatment FYM 100 kg + Micronutrient spray (3.66 kg) (Table 23).

Total number of fruits per plant

The total number of fruits per plant ranged from 142.50 to 934.75 with mean value of 346.05. The maximum number of fruits was recorded from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (934.75) followed by treatment FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (314.75). The lowest number of fruits per plant was recorded from treatment FYM 100 kg/tree (142.50) (Table 23).

Total fruit yield per plant

The total fruit yield per plant ranged from 8.43 kg to 41.05 kg with the mean value of 17.99 kg. The highest fruit yield per plant was obtained from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (41.05 kg) followed by FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (18.92 kg). The lowest fruit yield per plant was obtained from treatment FYM 100 kg/tree (8.43 kg) (Table 23).

Table 23: Effect of different treatments on total fruit weight of grade A, grade B, grade C, total number of fruits per plant and total fruit yield per plant on the year 2075/76

Treatments	Total fruit weight of grade A (kg)	Total fruit weight of grade B (kg)	Total fruit weight of grade C (kg)	Total no. of fruits per plant	Total fruit yield (kg)
T1: FYM 100 kg/tree	2.30	2.37	3.76	142.50	8.43
T2: FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g	1.95	4.48	4.80	163.00	11.22
T3: FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	6.16	16.29	18.60	934.75	41.05
T4: FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	7.22	6.56	5.15	314.75	18.92
T5: FYM 100 kg + Micronutrient spray	1.94	4.71	3.66	175.25	10.31
Mean	**3.91**	**6.88**	**7.19**	**346.05**	**17.99**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**
CV %	**93.17**	**99.93**	**138.99**	**123.09**	**103.45**

3.4.3 Sustainable management of 40 years above citrus orchard

Methodology

The experiment was carried out in completely randomized block design and was given five treatments and replicated four times. The treatments given are stated below:

T1: FYM 150 kg/tree

T2: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g

T3: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g

T4: FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g
T5: FYM 150 g + Micro-nutrient spray

Result and discussion

The result projected in Table 24 illustrates that weight of ten fruits, average fruit weight, fruit diameter and juice volume was statistically non-significant, whereas fruit rind weight was statistically significant.

Weight of ten fruits (kg)
The weight of ten fruits ranged from 540.28 g to 862.35 g with mean value of 698.94 g. The maximum weight was obtained from treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (862.35 g) followed by treatment FYM 150 g + Micro-nutrient spray (765.03 g). The minimum weight of ten fruits was obtained from treatment FYM 150 kg/tree (540.28 g) (Table 24).

Average fruit weight (g)
The average fruit weight was found ranging from 56.58 g to 93.60 g with mean value of 76.38 g. The maximum fruit weight was obtained from treatment FYM 150 g + Micro-nutrient spray (93.60 g) followed by treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (90.66 g). In contrast, the minimum fruit weight was found with treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (56.58 g) (Table 24).

Fruit diameter
The fruit diameter was found ranging from 41.29 mm to 59.91 mm with mean value of 51.51 mm. The maximum fruit diameter was obtained from FYM 150 g + Micro-nutrient spray (59.91 mm) followed by treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (58.32 mm). The minimum fruit diameter was recorded from treatment FYM 150 kg/tree (49.21 m) (Table 24).

Fruit rind weight
The fruit rind weight was found significantly varying ranging from 14.99 g to 28.47 g with mean value of 22.28 g. The highest fruit rind weight was obtained from treatment FYM 150 g + Micro-nutrient spray (28.47 g) followed by treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (27.20 g). The minimum fruit rind weight was obtained from treatment FYM 150 kg/tree (14.99 g) (Table 24).

Juice volume

The juice volume was found significant varying range from 23.27 ml to 38.49 ml with the mean value of 31.52 ml. The maximum juice volume was recorded from treatment FYM 150 g + Micro-nutrient spray (38.49 ml) followed by treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (37.46 ml). In contrast, the lowest juice volume was recorded from treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (23.27 ml) (Table 24).

Table 24: Effect of different treatments on fruit weight of ten fruits, average fruit weight, fruit diameter, fruit rind weight and juice volume

Treatments	Weight of ten fruits (g)	Average fruit weight (g)	Fruit diameter (mm)	Fruit rind weight (g)	Juice volume (ml)
T1: FYM 150 kg/tree	540.28	57.25	41.29	14.99	23.65
T2: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g	736.05	83.78	56.60	24.30	34.75
T3: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	590.97	56.58	41.40	16.44	23.27
T4: FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	862.35	90.66	58.32	27.20	37.46
T5: FYM 150 g + Micro-nutrient spray	765.03	93.60	59.91	28.47	38.49
Mean	698.94	76.38	51.51	22.28	31.52
P-value	NS	NS	NS	*	NS
CV %	38.37	32.07	33.79	30.44	33.80

Total fruit weight of grade A

The total fruit weight of grade A ranged from 1.36 kg to 4.31 kg with the average value of 2.23 kg. The maximum fruit weight of grade A was obtained from treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (4.31 kg) followed by treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g y (2.06 kg). In contrast, minimum fruit weight of grade A was obtained from FYM 150 g + Micro-nutrient spray (1.36 kg) (Table 25).

Total fruit weight of grade B

The total fruit weight of grade B ranged from 1.85 kg to 8.69 kg with the mean value of 4.69 kg. The maximum fruit weight of grade B was obtained from treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g (5.61 kg) followed by treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (4.99 kg). The minimum fruit weight of grade B was obtained from treatment FYM 150 g + Micro-nutrient spray (1.85 kg) (Table 25).

Total fruit weight of grade C

The total fruit weight of grade C varied from 3.68 kg to 5.61 kg with the mean value of 4.25 kg. The maximum fruit weight of grade C was obtained from treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g (5.61 kg) followed by FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (4.23 kg). The minimum fruit weight of grade C was obtained from treatment FYM 150 kg + Micronutrient spray (3.68 kg) (Table 25).

Total number of fruits per plant

The total number of fruits per plant ranged from 194.75 to 4193.50 with mean value of 2121.40. The maximum number of fruits was recorded from treatment FYM 150 kg/tree (4193.50) followed by treatment FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (2439.75). The lowest number of fruits per plant was recorded from treatment FYM FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g (194.75) (Table 25).

Total fruit yield per plant

The total fruit yield per plant ranged from 6.89 kg to 16.70 kg with the mean value of 11.17 kg. The highest fruit yield per plant was obtained from treatment FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (16.70 kg) followed by FYM YM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g (12.40 kg). The lowest fruit yield per plant was obtained from treatment FYM 150 g + Micro-nutrient spray (6.89 kg) (Table 25).

Table 25: Effect of different treatments on total fruit weight of grade A, grade B, grade C, total number of fruits per plant and total fruit yield per plant on the year 2075/76

Treatments	Total fruit weight of grade A (kg)	Total fruit weight of grade B (kg)	Total fruit weight of grade C (kg)	Total no. of fruits per plant	Total fruit yield (kg)
T1: FYM 150 kg/tree	1. 94	3.22	4.01	4193.50	9.1
T2: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g	2.06	4.73	5.61	194.75	12.40
T3: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	1.46	4.99	4.23	2439.75	10.68
T4: FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate	4.31	8.69	3.70	2310.00	16.70

75 g + Agri-lime 150 g T5: FYM 150 g + Micro-nutrient spray	1.36	1.85	3.68	969.00	6.89
Mean	2.23	4.69	4.25	2121.40	11.17
P-value	NS	NS	NS	NS	NS
CV %	84.89	90.03	93.64	154.29	69.60

3.4.4.3 Decline management study at farmer's field

Symptoms of nutritional disorder are observed in citrus orchard at Maunabudhuk, Dhankuta. Symptoms such as, interveinal and intraveinal Chlorosis, little leaf etc are seen resulting in flower abortion, poor fruit set, small fruit size and low yield and productivity. So, to overcome these problems NCRP has carried out the nutritional management research during the FY 2075/76 at Munabudhuk, Dhankuta.

Methodology

The nutritional deficient orchard was selected. Twenty different plants were selected. Different macro- and micro-nutrients were given with 5 different nutrient combinations and replicated four times. The treatments given in the orchard are listed below:

T1 : N 500g + P 250g + K 500 g/tree
T2 : N 500g + P 250g + K 500 g + 75 g CuSo4 /tree
T3 : N 500g + P 250g + K 500 g + 150 g ZnSo4 /tree
T4 : N 500g + P 250g + K 500 g + 75 g MnSo4 /tree
T5 : N 500g + P 250g + K 500 g + 0.5 % ZnSo4, MnSo4, CuSo4 + 0.2 % H_3BO_3 /tree

Result and discussion

Table 26 reveals that fruit weight, fruit diameter, fruit rind weight and juice volume were statistically non-significant. Table 27 reveals that yield of Grade A, Grade B and Grade C was found to be statistically non-significant.

Table 26: Effect of different nutrient combination on fruit physical characteristics during FY 2075/76

Treatment	Fruit wt (g)	Fruit diameter (mm)	Fruit rind weight (g)	Juice volume (ml)
N 500g + P 250 g + K 500 g/tree	79.70	55.76	21.40	26.20
N 500g + P 250 g + K 500 g + CuSO4 75 g/tree	76.50	54.91	23.07	23.90
N 500g + P 250 g + K 500 g + ZnSo4 150 g/tree	73.41	53.29	20.62	23.40
N 500g + P 250 g + K 500 g + MnSo4 75 g/tree	87.41	56.60	23.49	29.60
N 500g + P 250 g + K 500 g + 0.5% ZnSo4, CuSo4 + 0.2 % H3BO3 /tree	73.30	54.18	20.03	25.00
Mean	**78.12**	**54.95**	**21.72**	**25.62**
P-value	**NS**	**NS**	**NS**	**NS**

CV %	**15.76**	**7.14**	**20.62**	**16.18**

Table 27: Effect of different nutrient combination on fruit yield during FY 2075/76

Treatment	Weight of fruit (Kg) per tree		
	Grade A	Grade B	Grade C
N 500g + P 250 g + K 500 g/tree	13.50	9.75	4.50
N 500g + P 250 g + K 500 g + CuSO4 75 g/tree	17.00	15.75	7.50
N 500g + P 250 g + K 500 g + ZnSo4 150 g/tree	7.25	6.75	3.25
N 500g + P 250 g + K 500 g + MnSo4 75 g/tree	12.50	16.75	5.50
N 500g + P 250 g + K 500 g + 0.5% ZnSo4, CuSo4 + 0.2 % H3BO3 /tree	10.75	16.75	9.25
Mean	**12.20**	**13.15**	**5.00**
P-value	**NS**	**NS**	**NS**
CV %	**69.88**	**90.49**	**78.60**

3.4 FRUIT FLY MANAGEMENT

Citrus is an important fruit commodity in the mid hill of Nepal. Mandarin (*Citrus reticulata*) holds first position in terms of area and production followed by sweet orange (*Citrus sinensis*) in Nepal (Amgai et al., 2016). Sweet Orange is one of the important citrus fruit of Nepal and contributes for the nutritional supply and income for livelihood of Nepalese people at hilly region. Citrus fruits are generally consumed as fresh fruit and as well its processed products including different forms of juice (Adhikari and Rayamajhi, 2012). Sindhuli and Ramechhap are the two major sweet orange growing districts in Nepal. Fruits of sweet orange are popularly known as junar.

Citrus growers of Sindhuli, Ramechhap and Dhankuta districts are facing problem to manage fruit damage due to Chinese Citrus fly (CCF) since 2014 that has been traveled from China through Bhutan and western hilly part of India to Nepalese citrus orchards (Adhikari and Joshi, 2018). Indeed, fruit fly is one of the most important pests in fruits and fruit vegetables (Adhikari et al., 2016). Nepalese citrus growers became forced to forget the tight skinned oranges such as Sweet Orange and Lemon from eastern hilly region due to heavy fruit damage by the maggots of fruit fly. The tight skinned oranges have been replaced by the Mandarin in the eastern region of Nepal where the problem of CCF was very high up to 100 %.

A field survey by a team of experts from National Citrus Research Program (NCRP) Dhankuta and Junar Super zone, Sindhuli in year 2017 in Sweet orange orchard of

Sindhuli and Ramecchap reported at least 60% fruit drop caused by Bactrocera minax (NCRP, 2018). Farmers have tried a few ways like burring dropped fruit in the orchard, feeding these to livestock, making compost and feeding larvae of CCF to chickens, and very low number of farmer's spraying systemic insecticide during June and July months. These all methods applied as strand alone solution were not able to reduce the CCF related fruit drop and therefore, a set of experiment were trailed at both location to find out the suitable way to control this malady.

Materials and methods

Two set of fruit fly management study were conducted at NCRP, Dhankuta and Junar Superzone, Sindhuli in the year 2018 (FY 2074/75). Protein hydrolyses product (17% from UK), Great fruit fly bait (from China), Ceranock bait, locally made bear waste hydrolyses four times (single tree as a replication) in both locations. The treatments were repeatedly spread on same sweet orange trees at 15 days interval till 15th July starting from 1st May, 2018. All the treatments were imposed in fruiting trees within NCRP farm in Dhankuta while each treatment was applied at different localities in a single farmer's orchard in Sindhuli. Moreover, the Great fruit fly bait was applied to whole Tinkanya area of Sindhuli. A set of protein hydrolyzed trap (17% UK product) was set at three altitude of 1100 masl, 1200 masl and 1300 masl to represent the trail area in Sindhuli and was set at NCRP Dhankuta farm. The data on various types of fruit flies entrapped were also collected at weekly interval starting from fourth week of March to second week of October. Further, the data on fruit drop caused by fruit fly and marketable yield/ tree was collected and later analyzed using R software (v3.3.1). The fruit drop percent and yield/tree data was analyzed after Arc-sin transformation as the data were violating the normality assumption of ANOVA analysis.

Result and discussion

Surveillance of insect

In Dhankuta, Chinese Citrus fly (*Bactrocera minax*) was not entrapped in the hydrolyzed protein trap as well as other traps (data not shown). However, other five species (*B. scutellaris, B. tau, B. zonata, B. dorsalis and B. cucurbitae)* of fruit flies were trapped in methyl eugenol traps and mostly during May to July. This time of fruit fly emergence coincides with initial stage of sweet orange fruit growth and this phase is very favorable for oviposition on smaller fruits by fruit flies. In the past there was report of *B. minax* incidence in Dhankuta area (Bhandari et al. 2017, NCRP 2015) and no incidence in this year could be attributed to cooler temperature in this year 2018. Similar trend of entrapping five fruit fly species were observed in methyl eugenol trap at Sindhuli district (data not shown). In addition to this, there was entrapping of *B. minax* in hydrolyzed protein trap (Fig 4). The time and frequency of CCF entrapping in protein trap was in confirmation with the report of Bhandari et al (2017) and NCRP (2015) in Sindhuli

district. The time of first emergence of CCF was delayed with few days with increasing the altitude which is mearly due to lower temperature at higher altitude. Hence, the preventive baiting spray should be initiated earlier in orchards on lower that higher altitude. Based on these result a combination of methyl eugenol and hydrolyzed protein bait spray is preferable in Dhankuta while hydrolyzed protein bait spray is recommended in May to July months for effective control of citrus fruit fly.

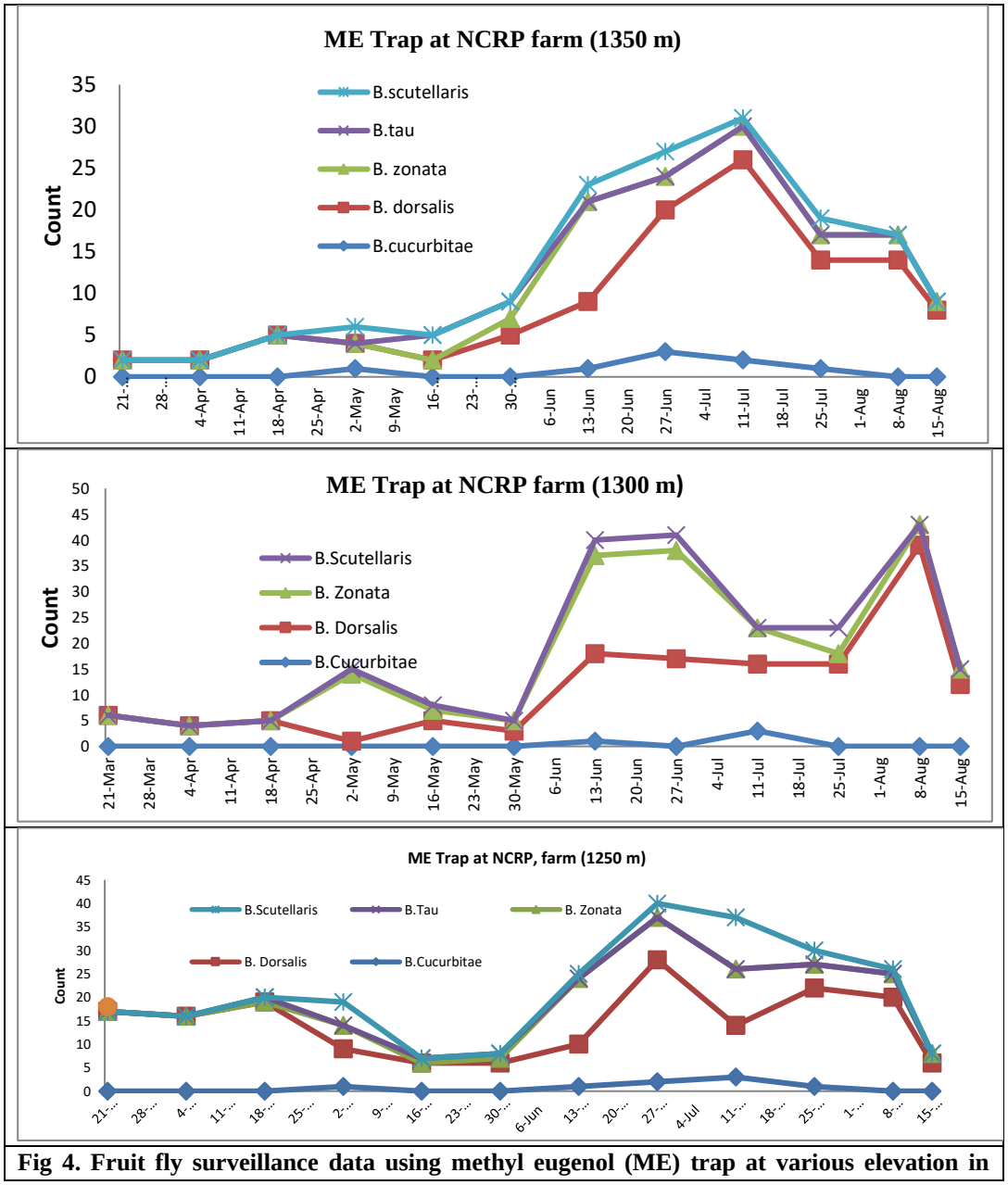

Fig 4. Fruit fly surveillance data using methyl eugenol (ME) trap at various elevation in

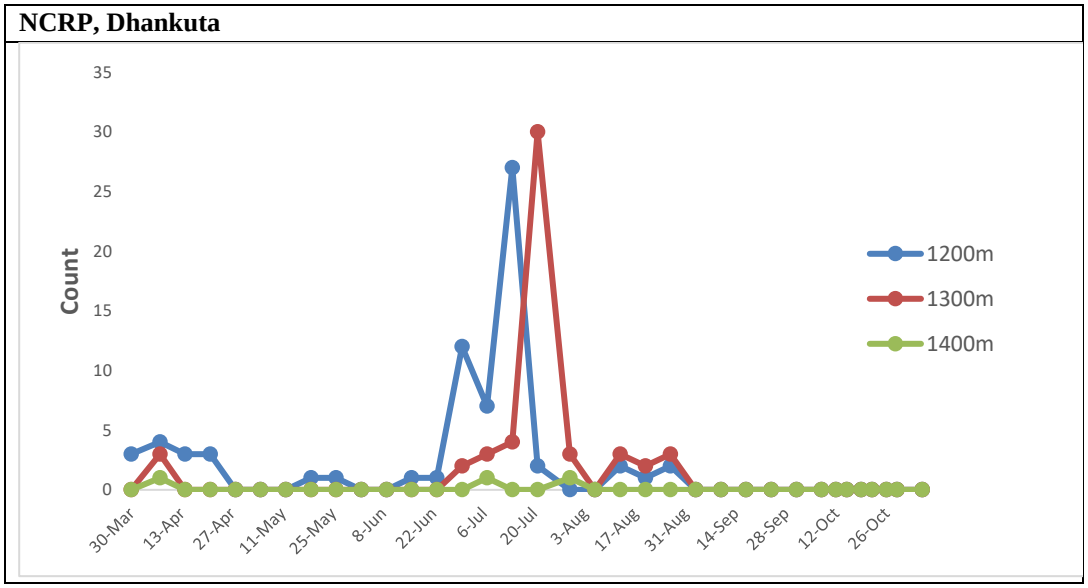

Fig 5. Fruit fly surveillance data using hydrolyzed protein bait at various elevation in Sindhuli

Control of fruit drop

The fruit drop percent recorded in Dhankuta due to various control measure was non-significantly different (Fig. 6). However, there was lower fruit drop in hydrolyzed protein containing treatment including Great fruit fly bait. The bear waste supernatant + slurry in honey spray and Ceranock bait station was as ineffective as negative control treatment. However, there was 100% fruit drop recorded from Beer waste (Supernatant with honey) and Dimethoate treated plants in Sindhuli district (Fig. 7) while Ceranock bait station, hydrolyzed protein and Great fruit fly bait sprayed tree had below 7% fruit drop.

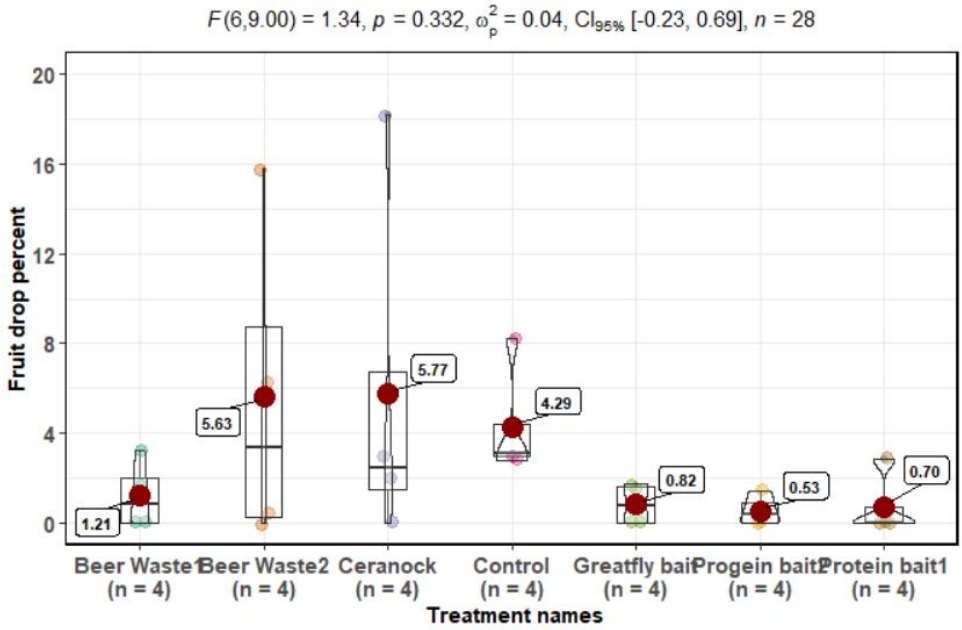

Fig 6. Effect of various treatment on percent sweet orange fruit drop at NCRP Dhankuta in year 2018 (circular area and number corresponding to it represent the mean fruit drop) (Beer Waste1= hydrolyzed supernatant+ water (1:1)+ honey 6 ml/ltr+ 0.25 ml Tracer; Beer Waste 2= hydrolyzed product supernatant +Slurry + Water (1:1:1)+ honey 6 ml/ltr+ 0.25 ml Tracer/ltr; Ceranock= Ceranock bait station; Control= no any application; Greatfly bait= Great fruit fly bait +water (1:2)+ 0.25 ml Tracer/ltr; Protein bait 1= Protein hydrolyzed protein 50 ml/ltr water+ + 0.25 ml Tracer/ltr; and Protein bait 1= Protein hydrolyzed protein 25 ml/ltr water+ + 0.25 ml Tracer/ltr)

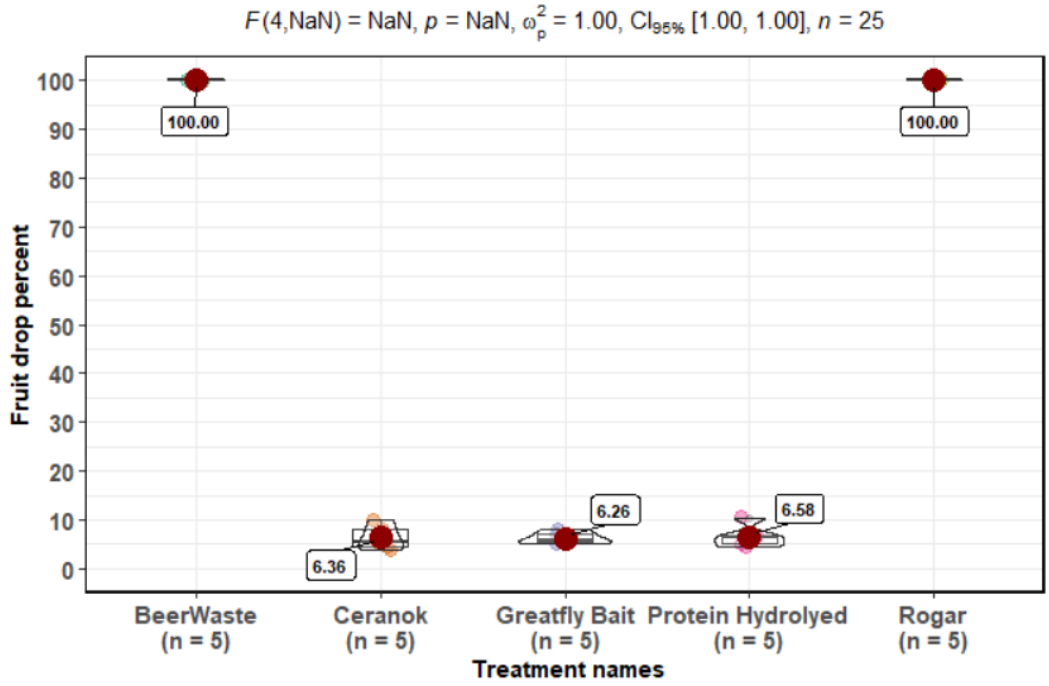

Fig 7. Effect of various treatment on percent sweet orange fruit drop at junar super zone, Sindhuli in year 2018 (circular area and number corresponding to it represent the mean fruit drop percent) (Beer Waste= hydrolyzed supernatant+ water (1:1)+ honey 6 ml/ltr+ 0.25 ml Tracer; Ceranock= Ceranock bait station; Greatfly bait= Great fruit fly bait +water (1:2); Protein bait= Protein hydrolyzed protein 50 ml/ltr water+ 0.25 ml Tracer/ltr; and Rogar= Rogar 1 ml/ltr whole tree application)

Marketable Fruit yield/ tree (kg)

There was non-significant treatment effect on marketable fruit yield/tree in NCRP Dhankuta experiment (Fig 8). However, there was the highest fruit yield from hydrolyzed protein bait spray (50 ml/ lt of water+ spinosad) treated plants. However, there was nil fruit yield from Dimethoate and Beer waste (Suppernatant+ honey + spinosad) treated trees in Sindhuli district (Fig. 9). The maximum yield /tree was obtained from Great fruit fly bait spray treated plants followed by hydrolyzed protein bait sprayed and Ceranock bait station applied orange trees.

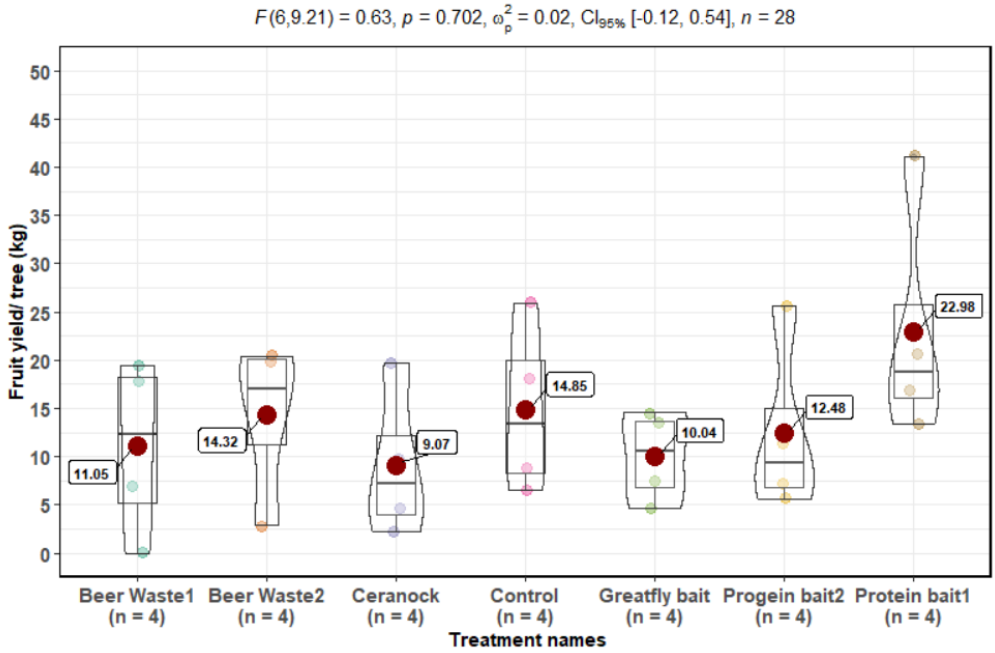

Fig 8. Effect of various treatment on sweet orange fruit yield at NCRP Dhankuta in year 2018 (circular area and number corresponding to it represent the mean fruit yield/ tree (kg)

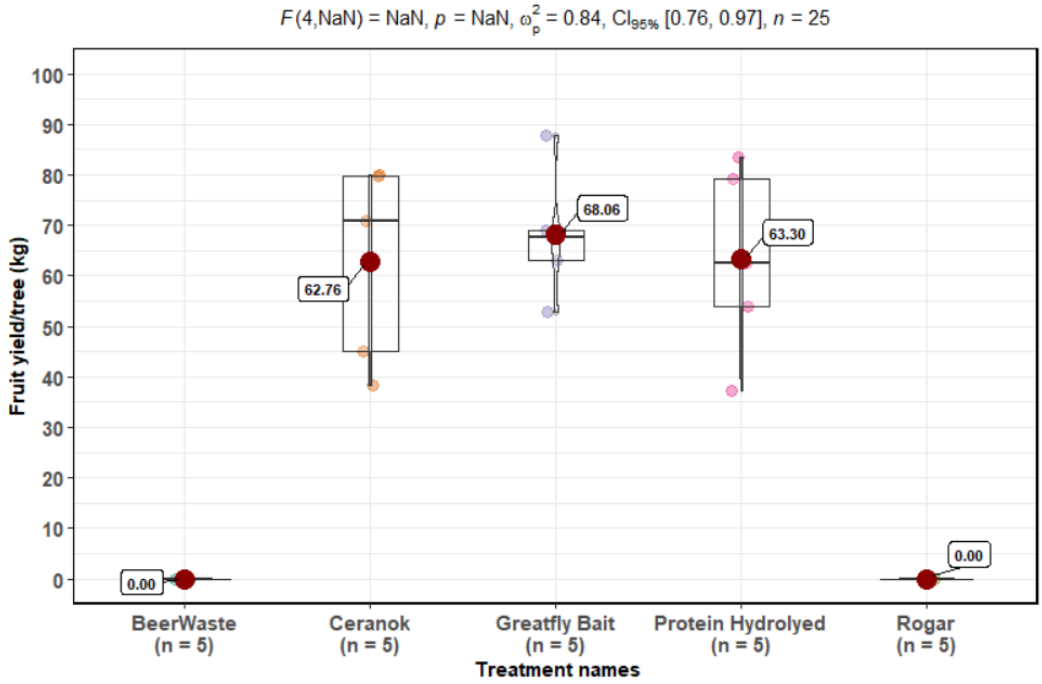

Fig 9. Effect of various treatment on sweet orange fruit production at Junar super zone, Sindhuli in year 2018 (circular area and number corresponding to it represent the mean fruit yield/ tree (kg)

A proper surveillance on the type of fruit fly in each year is needed to identify actual causal agent of sweet orange drop as the insect dynamics changes over time and environment. A selective bait application of protein supplemented pesticide is very effective than blanket application of systemic pesticide to whole tree and orchard. An area wide disease management is the only option which should be followed in managing sweet orange fruit drop caused by fruit fly.

3.5 Multi-locations (Collaborative) Trial

3.5.1 Coordinated Varietal Trial on Ginger

Introduction

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

Methodology

Eight genotypes of ginger including 'Local Check' were obtained from National Ginger Research Program (NGRP), Salyan in 2018. They were included in CVT, and evaluated in the field of NCRP, Dhankuta with three replications in RCBD. Thirty tones of FYM/ha were incorporated into soil in the first week of May, 2018: 70 kg Nitrogen, 50 kg Phosphorus and 50 Kg Potassium/ha were recommended doses of fertilizer/ha. Full dose of phosphorus and half dose of potash were applied as basal dose prior to planting rhizome in the last week of May. Rhizomes were planted in the intra row spacing of 30 cm and inter-row spacing of 30 cm. Immediately after rhizome planting, dry forest leaves @ 16 tones/ha were applied as mulching. The whole recommended nitrogen dose was split into two doses: first at 30 days after planting and remaining half dose of nitrogen and half dose of potash were applied at 60 days after planting. Weeding was done twice: first in 45 days after rhizome planting and second in 70 days after rhizome planting. Earthing up was given in 140 days after rhizome planting. Fresh rhizomes were harvested in 232 days later than planting day. Experimental data *viz.*, plant height, number of tillers per clump, length of primary and secondary fingers, fresh rhizome yield and Dry Ginger Recovery (DGR %) were recorded.

Result and discussion

Plant height

The plant height varied from 81.67 cm to 96.37 cm with mean plant height of 88.77 cm. The highest plant was recorded from genotype KK 1 (96.37 cm) followed by genotype ZI 1302 (94.47 cm). The lowest plant height was recorded from genotype ZI 1027(84.03 cm) (Table 28).

Number of tillers per clump

The number of tillers per clump was found ranging from 5.10 to 7.07 with mean value of 6.20. The highest number of tillers per clump was found in genotype ZI 1007 and ZI 1303 with the value of 7.07 each. The lowest number of tillers per clump was found in genotype ZI 1027 (5.10) and ZI 1302 (5.70) (Table 28).

Length of primary finger

The length of primary finger ranged from 4.07 cm to 4.87 cm with mean value of 4.45 cm. The highest length of primary finger was recorded from genotype ZI 1010 (4.87 cm) followed by genotype ZI 1007 (4.63 cm). The lowest length of primary finger was recorded from genotype ZI 1303 (4.07 m) (Table 28).

Length of secondary finger

The length of secondary finger ranged from 5.43 cm to 6.67 cm with mean value of 6.10 cm. The highest length of secondary finger was recorded from genotype KK 1 (6.67 cm) followed by genotype ZI 1010 (6.30 cm). The lowest length of secondary finger was recorded from genotype ZI 1025 (5.97 cm) (Table 28).

Total rhizome yield

The total rhizome yield per hectare ranged from 21.37 t/ha to 34.04 t/ha with mean total rhizome yield of 26.34 t/ha. The highest fresh rhizome yield was recorded from genotype ZI 1007 (34.04 t/ha) followed by ZI 1302 (30.65 t/ha). The lowest fresh rhizome yield was recorded from local genotype (21.37 t/ha) (Table 28).

Dry ginger weight

The dry ginger weight was found significantly different varying from 150.16 g to 183.04 g with mean value of 166.56 g. The highest dry ginger weight was recorded from genotype ZI 1010 (183.04 g) followed by KK 1 (172.61 g) and local genotype (170.14 g). The lowest dry ginger weight was recorded from genotype ZI 1302 (150.16 g) (Table 28).

Dry ginger recovery %

The dry ginger recovery % was found significantly different varying from 15.02 % to 18.30 % with mean value of 16.66 %. The highest dry ginger recovery % was recorded from genotype ZI 1010 (18.30 %) followed by KK 1 (17.26 %) and local genotype (17.01 %). The lowest dry ginger recovery % was recorded from genotype ZI 1302 (15.02 %) (Table 28).

Table 28: Performance of eight genotypes of ginger tested under Coordinated Varietal Trial in the field of NCRP, Pariptle, Dhankuta in 2017

Genotypes	Plant	No. of	Length of finger	Total	Dry	DGR %

	height (cm)	Tillers per clump	(cm)		rhizome yield (t/ha)	ginger weight (g)	
			Primary	Secondary			
ZI 1010	81.67	6.00	4.87	6.30	28.38	183.04	18.30
KK 1	96.37	6.13	4.60	6.67	25.08	172.61	17.26
ZI 1007	91.23	7.07	4.63	6.03	34.04	169.78	16.98
ZI 1027	84.03	5.10	4.20	5.43	22.70	160.43	16.04
Local	86.07	6.43	4.50	6.03	21.37	170.14	17.01
ZI 1302	94.47	5.70	4.43	6.10	30.65	150.16	15.02
ZI 1303	89.70	7.07	4.07	6.27	25.02	167.98	16.80
ZI 1025	86.63	6.13	4.33	5.97	23.50	158.36	15.84
Mean	**88.77**	**6.20**	**4.45**	**6.10**	**26.34**	**166.56**	**16.66**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	**	**
CV%	**10.93**	**21.90**	**8.36**	**10.82**	**16.83**	**4.35**	**4.35**

3.5.2 Coordinated Varietal Trial on Turmeric

Introduction

The family Zingiberaceae comprises four or five genera that are commercially important, namely *Amomum*, *Curcuma*, *Elattaria* and *Zingeber*. Turmeric belongs to the genus *Curcuma*. In plant the underground stem (rhizome) is commercial product. It is a flowering plant, a perennial herb that measures about 40 inches in height and has white flowers. Zingiberaceous spices are known for their medicinal properties in the traditional systems of medicine in Asia. There are several pharmaceutical applications for these spices. Turmeric is valued for the yellow pigment curcumin (diferulolylmethane) which varies 4-8% in the dried rhizome. Curcumin in turn contains curcumin-1 (almost 94%), curcumin-11 (6%) and curcumin-111 (0.3%). Turmeric is used in cases of biliary disorders, intestinal disorders, anorexia, cough, diabetic wounds, hepatic disorder, pain, rheumatism and sinusitis, cancer, psoriasis and Alzhemer's disease (Anandaraj, 2009).

Methodology

Five genotypes of turmeric were obtained from National Ginger Research Program (NGRP), Salyan in 2018. They were included in CVT, and evaluated in the field of NCRP, Dhankuta as first replication in RCBD. Thirty tones of FYM/ha were incorporated into soil in the first week of May, 2016: 30 Kg of Nitrogen, 30 Kg of Phosphorus and 69 Kg of Potash per hectare were recommended doses of fertilizer/ha. Full dose of phosphorus and half dose of potash were applied as basal dose prior to planting rhizome in the last week of May. Rhizomes were planted in the intra-row spacing of 30 cm and inter-row spacing of 30 cm. Immediately after rhizome planting, dry forest leaves @ 16 tones/ha were used as mulching. The whole recommended nitrogen dose was split into two doses: first at 30 days after planting and remaining half dose of nitrogen and half dose of potash were applied at 60 days after planting. Weeding was done twice: first in 45 days and second in 70 days after rhizome planting. Earthing up was given in 140 days after rhizome planting. Fresh rhizomes were harvested in 240 days later than planting day. Experimental data *viz.*, Plant height, number of tillers per clump, length of primary and secondary fingers, total rhizome weight, weight of dry slice

per kg sample, weight of dry powder per kg sample and Turmeric Powder Recovery (TPR %) were recorded.

Result and discussion

Plant height
Plant height varied from 96.70 cm to 114.50 cm. The highest plant height was recorded from local genotype (114.50 cm) followed by CI 0207 (100.20 cm). The lowest plant height was recorded from genotype CI 0205 (96.70 cm) (Table 29).

Number of tillers per clump
The number of tillers per clump ranged from 1.70 to 2.70. The highest number of tillers per clump was obtained from genotype KK1 (2.70) followed by CI 9102 (2.3). The lowest number of tillers per clump was recorded from genotype CI 0207 (1.70) (Table 29).

Length of primary finger
The length of primary finger ranged from 3.15 cm to 4.85 cm. The highest length of primary finger was recorded from local genotype (4.85 cm) followed by CI 9102 (4.50 cm). The lowest length of primary tillers was recorded from genotype KK1 (3.15 cm) (Table 29).

Length of secondary finger
The length of secondary finger ranged from 7.90 cm to 9.65 cm. The highest length of secondary finger was recorded from local genotype (9.65 cm) followed by CI 9102 (8.65 cm) and KK1 (8.65 cm). The lowest length of secondary tillers was recorded from genotype CI 0205 (7.90 cm) (Table 29).

Total rhizome yield
The total rhizome yield was found ranging from 21.27 t/ha to 28.46 t/ha. The maximum rhizome yield was obtained from genotype KK1 (28.46 t/ha) followed by CI 0205 (25.82 t/ha). The lowest rhizome yield was obtained from genotype CI 0207 (21.27 t/ha) (Table 29).

Table 29: Performance of five genotypes of turmeric tested under coordinated varietal trial in Dhankuta in 2018

Genotype	Plant height (cm)	Tillers per clump	Length of fingers (cm)		Total rhizome yield (t/ha)
			Primary	Secondary	
CI 0207	100.20	1.70	3.75	8.35	21.27
KK 1	104.50	2.70	3.15	8.65	28.46
CI 0205	96.70	1.80	3.50	7.90	25.82
CI 9102	98.00	2.30	4.50	8.65	23.79
Local	114.50	1.90	4.85	9.65	21.62

Weight of dry slice per kg sample

The weight of dry slice per kg sample varied from 0.13 Kg to 0.18 Kg. The maximum weight of dry slice per kg sample was obtained from local genotype (0.18 Kg). The lowest weight of dry slice per kg sample was obtained from genotype CI 0205 (0.13 Kg) (Table 30).

Weight of dry powder per kg sample

The weight of dry powder per kg sample varied from 0.14 g to 0.17 Kg. The maximum weight of dry slice per kg sample was obtained from local genotype (0.17 Kg) followed by CI 9102 (0.15 Kg) and KK1 (0.15 Kg). The lowest weight of dry slice per kg sample was obtained from genotype CI 0207 (0.14 Kg) and CI 0205 (0.14 Kg) (Table 30).

Turmeric powder recovery %

The TPR % was found ranging from 14.30 % to 17.68 %. The maximum TPR % was recorded from local genotype (17.68 %) followed by genotype KK1 (15.08 %). The lowest TPR % was recorded from genotype CI 0205 (14.30 %) (Table 30).

Table 30 : Performance on quality parameters of eight genotypes of turmeric tested under coordinated varietal trial in Dhankuta in 2018

Genotype	Weight of dry slice (kg)	Weight of dry powder (kg)	TPR %
CI 0207	0.15	0.14	14.49
KK 1	0.15	0.15	15.08
CI 0205	0.13	0.14	14.30
CI 9102	0.15	0.15	14.69
Local	0.18	0.17	17.68

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. 2.26 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 2075-76, a total of 35,610 grafted saplings were produced and made available to the farmers. The figure showed the major demand of acid lime followed by sweet orange and mandarin. The demand of acid lime saplings was high from the farmers of terai districts. The detail of fruit and sampling production is given on the Table 45.

Table 31: Production of fruits, saplings and revenue collected during 2075/76

S.N.	Particulars	Unit	Quantity	Revenue (NPR) '000
1	Mandarin saplings	No.	4010	
2	Sweet orange saplings	No.	0	
3	Acid lime saplings	No.	31600	
4	Rose saplings	No.	300	
5	Mandarin fruits	Kg.	2530	
6	Trifoliate orange, Citrange, Rangpur lime, Volkamerina seed	Kg.	102	
7	Scion of different citrus species	No.	1500	
8	Sweet orange fruits	Kg.	16	
9	Acid lime fruits	Kg.	127.5	
	Sub-total			**2257987.00**
10	Other horticultural sources			28945.00
	Sub-total			**2286932.00**
11	Administrative			8460.00
	Grand Total			**2295392.00**

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 46).

Table 32: **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. 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.
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.
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. 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.
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 1,600 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

Five trainings were conducted on various aspects of commercial citrus cultivation practices during fiscal year 2075/76. Thirty two farmers from different districts (Dhankuta, Dailekh, Syanja, Udayapur, Bhojpur, Sindhuli, Jajarkot, Solukhumbu, Gorkha, Tehrathum and Taplejung) were provided training on production of grafted citrus saplings and nursery management at NCRP, Dhankuta. Similarly, training on acid lime orchard management was conducted in Ramdhuni-5, Sunsari. Twenty one farmers from Sunsari and Morang district had participated in training. Similarly, thirty six farmers from Nawalpur, Chitwan, Lamjung and Sarlahi had participated in off-season acid lime production technique organized in Ranitar-8, Nawalpur. Similarly, twenty three farmers from different district (Bhojpur, Tehrathum and Dhankuta) were given training on citrus decline and its management at NCRP, Dhankuta. Similarly, twenty

nine farmers from Sindhuli and Ramechhap district were given training on fruit fly on sweet orange and its management at Khaniyakharka, Sindhuli.

10 SERVICES

In fiscal year 2075/76, NCRP supplied 35,000 grafted saplings of different citrus species to the farmers. The grafted saplings made available to the farmers comprised of Khoku local mandarin, Okitsuwase unshiu, Miyagawase unshiu, two acid lime varieties; Sunkatagi-1 and Sunkagati-2. 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 15 staffs are working in the Program although there are 37 approved positions allocated by the NARC. Among the working staffs, only two scientists are there for research execution.

13 FUTURE STRATEGIES

At present, government of Nepal has recognized citrus sector as the national important and prioritized commodity. Because of appropriate geography and climate, citrus is widely grown throughout the mid hills from east to west across the country. In addition to, acid lime could be grown in upland condition of terai. Moreover, the demand of mandarin and acid lime in the domestic markets is escalating very high in recent years. Thus, it has an enormous potential to generate income and employment including nutrition to rural farmers in the country.

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

Therefore, NCRP has prioritized following research areas for the upcoming years:

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

S.N.	***Accession no***	***Identification/common name***	***Source***
	Tangor		
33	NCRP 102	Ellendale	INRA_CIRAD, France
34	NCRP 103	Murkott	INRA_CIRAD, France
35	NCRP 72	Ortanique	INRA_CIRAD, France
36	NCRP-07	Tangor, Murkotte	JICA, Japan
	Tangelo		
37	NCRP 73	Minneola	INRA_CIRAD, France
38	NCRP 74	Oriando	INRA_CIRAD, France

S.N.	*Accession no*	*Identification/common name*	*Source*
39	NCRP 75	Seminole	INRA_CIRAD, France
	D. Sweet orange (C. sinensis)		
40	NCRP-13	Valencia late	ICAR, India
41	NCRP-14	Sevelle common	ICAR, India
42	NCRP-15	Navelencia	ICAR, India
43	NCRP 16	Malta Blood Red	ICAR, India
44	NCRP 17	Samauti	ICAR, India
45	NCRP 18	Masambi	ICAR, India
46	NCRP-19	Vanelle	ICAR, India
47	NCRP-20	Ruby	ICAR, India
48	NCRP 21	White Tanker	ICAR, India
49	NCRP-22	Washington novel	ICAR, India
50	NCRP 23	Hamlin	ICAR, India
51	NCRP 24	Pine Apple	ICAR, India
52	NCRP-25	Yashida navel	FDC, , Kirtipur
53	NCRP-26	Madam vanous	GRESCO, Kathmandu
54	NCRP-27	Delicious seedless	ICIMOD
55	NCRP-28	Skages Bonanja	ICIMOD
56	NCRP-29	Blood red	ICIMOD
57	NCRP-30	New Hall Navel	ICIMOD
58	NCRP-31	Succari	ICIMOD
59	NCRP-32	Meisheu-9	ICIMOD
60	NCRP 33	Dhankuta Local	Dhankuta

S.N.	*Accession no*	*Identification/common name*	*Source*
61	NCRP 34	LueGim Gong	ICAR, India
62	NCRP 83	Cara Cara Novel	INRACIRAD, France
63	NCRP 84	Lane Late	INRACIRAD, France
64	NCRP 85	Pine Apple	INRACIRAD, France
65	NCRP 86	Valencia Late	INRACIRAD, France
66	NCRP 87	Salustiana	INRACIRAD, France
67	NCRP 96	Tamango	INRACIRAD, France
	Grape Fruit		
68	NCRP 45	Shamber	ICIMOD
69	NCRP 76	Henderson	INRA_CIRAD, France
70	NCRP 77	Star Ruby	INRA_CIRAD, France
71	NCRP 78	Reed	INRA_CIRAD, France
72	NCRP 79	Pink Rubi	INRA_CIRAD, France
73	NCRP-44	Phultrac (Pumelo)	Vietnam
74	NCRP-43	Nam Roi (Pumelo)	Vietnam
75	NCRP-42	Phodiem (Pumelo)	Vietnam
	E. Acid lime (C. aurantifolia)		
76	NCRP-108	Khursanibari local	SHARP, Chitwan
77	NCRP-107	Tehrathum local	Tehrathum
78	NCRP-117	Baitadi local	Baitadi
79	NCRP-118	Salyan local	Rojwal Takura, Salyan
80	NCRP-119	Bhojpur local	Takshor, Bhojpur
81	NCRP-120	Parwat local	Lekhpant, Parwat

S.N.	***Accession no***	***Identification/common name***	***Source***
82	NCRP-60	Kaptangang lamo	Sunsari
83	NCRP-59	Kaptangang golo	Sunsari
84	NCRP 58	Krishnapur kagati	Bharatpur, Chitwan
85	NCRP-57	Krishnapur kagati	Bharatpur, Chitwan
86	NCRP-56	Banarasi Kagati	Biratnagar
87	NCRP-55	Madrasi Kagati	Biratnagar
88	NCRP 54	Banarasi Kagati	Biratnagar
89	NCRP-53	Panta-1	Chitwan
90	NCRP-52	Belepur	Morang
91	NCRP-51	Sundarpur	Morang
92	NCRP-50	IAAS Acc # 71 (5)	IAAS, Rampur
93	NCRP-49	IAAS Acc # 101 (3)	IAAS, Rampur
94	NCRP-48	IAAS Acc # 101 (2)	IAAS, Rampur
95	NCRP-47	IAAS Acc # 01 (17)	IAAS, Rampur
96	NCRP-46	IAAS Acc # 01 (25)	IAAS, Rampur
	E. Lemon		
97	NCRP 61	*Ureka lemon Unkwown*	Unknown
98	*NCRP 63*	*Hill Lemon*	Sunderpur Morang
99	*NCRP 64*	*Ureka lemon Lamcho lemon*	Sunderpur Morang
100	*NCRP 109*	*Thimura local*	SHARP Chitwan
101	*NCRP 110*	*Biratnagar Local*	SHARP Chitwan
102	*NCRP 111*	*Prembasti local*	SHARP Chitwan

S.N.	*Accession no*	*Identification/common name*	*Source*
	Rootstocks		
103	NCRP 65	Citrange C-35	INRA_CIRAD
104	NCRP 66	Citrange – Carrizo	INRA_CIRAD
105	NCRP 67	Poncirus– Pomeroy	INRA_CIRAD
106	NCRP 68	Flying Dragon	INRA_CIRAD
107	NCRP 69	Citrumelo 4475	INRA_CIRAD
108	NCRP 70	Volkameriana	INRA_CIRAD
109	NCRP 71	Rangapur lime Red	INRA_CIRAD
110	NCRP 113	Citrange old	Unknown
111	*NCRP 38*	*citrange*	Unknown
112	*NCRP 35*	*Citron*	Unknown
113	*NCRP 36*	*Trifoliate*	Unknown
114	*NCRP 37*	*Rangapur lime*	Unknown
115	*NCRP 39*	*Boxifolia*	Unknown
116	*NCRP 40*	*Rough lemon*	Unknown
117	*NCRP 116*	*Rough lemon*	Paripatle Dhankuta
118	NCRP-41	Hokse	Dhankuta
119	NCRP-62	Local Bimiro (Citron)	Belahara, Dhankuta
120	NCRP-104	Sweet lime Citrus limetta	Dhankuta

Annex 2: Human Resource Allocation in 2075/76

Designation	Approved	Fulfilled	Vacant
1. Chief Scientist (S.5) – Horticulture	1	-	1
2. Senior Scientist (S.4)- Horticulture	1	1 (Agri-economics)	-
3. Senior Scientist (S.3)- Horticulture	1	1	0
4. Senior Scientist (S.3)- Plant pathology	1	-	1
5. Scientist (S.1) - Soil	1	-	1
6. Scientist (S.1) - Plant breeding (Tissue culture)	1	-	1
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
12. Technical Officer (T.6) - Pomology	3	-	3
13. Senior Technician (T.5)	2	-	2
14. Technician (T.4)	5	1	4
15. Technician	13	8	5
16. Account officer (A6)	1	1	0
17. Administrative Assistant (A5)	1	1	0
18. Driver (Heavy)	1	1	-
Total	37	15	22

Annex 3: Human Resource of NCRP in 2075/76

Name	Position	Qualification	Working area
1. Dr. Hari Krishna Shrestha	Coordinator (S.4)	Ph.D. (Agri-Economics)	Coordinator
2. Dr. Umesh Kumar Acharya	Sr. Scientist (S-3)	Ph.D. (Pomology)	Horticulture
3. Roshan Pakka	Scientist (S. 1)	M. Sc. (Plant Pathology)	Plant Pathology
4. Basupasa Hangsarumba	Account Officer (A.6)	Bachelors' degree	Account section
5. Gopal Raj Shrestha	Admin. Officer (A.6)	I.A.	Administration and store
6. Sita Sharma	Technician (T.4)		Support in research and production
7. Jagat Bahadur Karki	TS- Fifth	Literate	Administration support
8. Man BahadurTamang	TS- Fifth	Literate	Support in research and production
9. Hem Bahadur Dahal	TS- Fifth	Literate	Support in research and production
10. Tara Nath Khatri	Heavy driver-Fifth	S.L.C.	Driver
11. Kashi Nath Subedi	TS-First	Literate	Support in research and production
12. Dhan Kumar Rai	TS-First	Literate	Support in research and production
13. Tetri Devi Shah	TS-First	Literate	Administration support
14. Gopal Silwal	TS-First		Support in research and production
15. Saroj Chaudhary	TS-First		Administration support

Annex 4: Publications in FY 2075/76

Publication	Type	Language	Published number
Annual Reports (2074/75)	Book	English	100
Citrus fruit production technology	Book	Nepali	501
Registered varieties of mandarin and lime- An introduction	Fact sheet	Nepali	1000
Citrus fruit production improved technology	Leaflet	Nepali	2000

Annex 5: Regular Annual Budget and Expenditure in 2075/76

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
	Operational Expenses				
21111	Staff Salary	6293000.00	5787397.20	5787397.20	505605.80
21112	Local Allowances	163000.00	156720.00	156720.00	6280.00
21113	Dearness Allowances	360000.00	350000.00	350000.00	10000.00
21119	Other Allowances	75000.00	58400.00	58400.00	16600.00
21121	Uniform	150000.00	150000.00	150000.00	0.00
22111	Water and Electricity Expenses	684000.00	667935.00	667935.00	16065.00
22112	Communication Expenses	129000.00	119837.00	119837.00	9163.00
22211	Fuel	598000.00	597976.39	597976.39	23.61
22212	Operational and Repair Expenses	732000.00	731946.88	731946.88	53.12

22213	Insurance	60000.00	60000.00	60000.00	0.00
22311	Office related expenses	570000.00	565776.20	565776.20	4223.80
22313	Books expenses	70000.00	68357.50	68357.50	1642.50
22314	Fuel for Other Purposes	190000.00	189994.00	189994.00	6.00
22321	Repair/Maintenance of Public Assets	300000.00	299616.22	299616.22	383.78
22512	Training and seminar expenses	520000.00	504590.00	504590.00	15410.00
22521	Production Material Service	8625000.00	8624603.18	8624603.18	396.82
22611	Monitoring and evaluation expenses	150000.00	149949.00	149949.00	51.00
22612	Travel Expenses	1636000.00	1633731.00	1633731.00	2269.00
22711	Miscellaneous Expenses	111000.00	110913.50	110913.50	86.50
	Capital Expenses				
29221	Building Construction	0.00	0.00	0.00	0.00
29231	Capital Improvement - Building	500000.00	491878.60	491878.60	8121.40
29311	Furniture and Fixtures	0.00	0.00	0.00	0.00
29511	Machinery Equipment	550000.00	549789.07	549789.07	210.93
29611	Public Construction	200000.00	197770.57	197770.57	2229.43
29712	Capital Improvement	550000.00	545967.89	545967.89	4032.11
	Grand Total	**23216000.00**	**22613146.20**	**22613146.20**	**602853.8**

Annex 6: Beruju Status Till Fiscal Year 2075/76

Beruju	Amount	Remarks
Beruju till year (2075/76)	86,080.80	
Beruju in FY 2075/76	0.00	
Beruju cleared in this FY (2075/76)	0.00	
Remaining beruju	86,080.80	

Annex 7: Annual Budget ad Expenditure of KOIKCA UNDP Project in 2075/76

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
	Operational Expenses				
21119	Other Allowances	40000.00	39701.00	39701.00	299.00
22521	Production Material Service	190000.00	176553.05	176553.05	13446.95
22612	Travel Expenses	60000.00	58200.00	58000.00	1800.00
	Grand Total	**290000.00**	**274454.05**	**274454.05**	**15545.95**