NPSN: 00721-535/2018/19

ANNUAL REPORT

2074/75 (2017/18)

Government of Nepal
Nepal Agricultural Research Council

National Citrus Research Programme

Paripatle, Dhankuta, Nepal
2018

ANNUAL REPORT

2074/75 (2017/18)

GOVERNMENT OF NEPAL

NEPAL AGRICULTURE RESEARCH COUNCIL

NATIONAL CITRUS RESEARCH PROGRAMME

PARIPATLE, DHANKUTA

2018

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

Citation:

NCRP, 2018. Annual report 2074/75 (2017/18). NARC Publication Serial No.00721-535/2018/19.,National Citrus Research Programme, Paripatle, Dhankuta, Nepal.

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 for citrus fruits. A large number of potential citrus growers from mid hills and terai plains have contacted us for technical counseling. 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 pipeline variety of acid lime for mid hills has also seen increased demand. This could be backed up by the fact that NCRP, apart from private nurseries, had distributed around twenty three thousand acid lime saplings at cost price last year, a record sale in its history.

Last year, NCRP had carried out a research program on sweet orange (junar) under Prime Minister Agriculture Modernization Project (PMAMP) in Sindhuli. Unfortunately, NCRP could not continue the program this year since the program budget was not allocated by PMAMP. However, some important research activities will be continued with NARC's regular budget. Research is focused to address fruit fly problem in sweet orange in coordination with Junar Super Zone Program Implementation Unit of PMAMP.

It is a matter of great satisfaction that we have endorsed a number of seedless mandarin germplasms from Australia last year. These mandarin germplasms 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 submit one local variety of acid lime and one local variety of mandarin for registration in variety release sub-committee. With better management of fruit orchard within NCRP, Paripatle, we had a record high fruit production and sale. 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 been 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 important research findings and citrus related information 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. Umesh Kumar Acharya, Senior Scientist and Mr. Roshan Pakka, Scientist for their conscientious work while preparing this annual report.

Hari Krishna Shrestha, 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. ०७४/७५ अवधिमा जम्मा ७ वटा परियोजना अन्तर्गत ३६ वटा अनुसन्धान क्रियाकलापहरु सम्पन्न गरेको थियो । यी कार्यक्रमहरु विशेष रुपमा जातीय अनुसन्धान, नर्सरी व्यवस्थापन, 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. ०७४/७५ सम्म पुरा गरिएका क्रियाकलापहरुको उपलब्धिहरु संक्षिप्त रुपमा तल उल्लेख गरिएको छ ।

- जातीय संकलन र सम्बर्द्धन अन्तर्गत १२९ 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 ंहल गर्ने उदेश्यले विदेशबाट भित्राईएका र उपयुक्त स्थानिय जातहरुको खोजीगरी बिगत २०६३/६४ देखि उत्पादन र उत्पादन समयको मुल्यांकन गर्दै आएको छ । प्रारम्भिक नतिजा अनुसार वाह्य सुन्तलाका

जातहरु जस्तै ओकित्सुवासे, मियागावासे, नोभा, ओरोभल, पेज र सत्सुमा मिनो र स्थानीय जातमा खोकु स्थानीयले अगौटे र राम्रो उत्पादनको लागि उत्साहजनक परिणम दिएको पाईएको छ । तसर्थ,आउने बर्षमा सुन्तलाका दुई जातहरु ओकित्सुवासे र खोकु स्थानीयलाई 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 नाम वाट तराई, भित्रिमधेस, र बेशि क्षेत्रको लागि उन्मोचन गरीएको छ । हालसालै NCRP 107 (तेह्रथुम लोकल) जातको कागतिलाई जातिय उन्मोचन उपसमितिबाट स्वीकार 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 सम्वन्धि अध्ययन गरियो । सोडियम बाईकार्बोनेट प्रति लिटर पानी ६.३ ग्राम फल टिप्नु भन्दा ३० दिन, ४५ दिन र ६० दिन अगावै रुखमा छर्दा सेलार स्टोरमा ३ महिना सम्म निलो ढुसि रोग नलागेको पाईयो । यसरी परिक्षण गर्दा ९० दिनको भन्डारणबाट थोरै मात्र तौल घटेको, राम्रो स्वाद भएको र हेडोनिक मुल्याङकन कर्ताले मन पराएको पाईयो ।
- कागतिको लागि बिभिन्न प्रकारका रुटस्टकहरुको अनुसन्धानमा तीन प्रकारका जस्तै Citrange , C-35 र Citrumelo 4475 ले राम्रो परिणाम देखायो ।

- कागतिको कलमी बिरुवा उत्पादनमा जंगली माटो, बालुवा र गड्यौली मलको मिश्रण (१:१:१) ले बिरुवाको राम्रो वृध्दि देखायो ।
- तिनपातेको विउ उमार शक्ति परिक्षणमा कृषकको खुला खेतमा उमार्ने तरिका पनि प्लास्टीक टनेलको दुवै तिर खुला गरेर लगाए जस्तै प्रभावकारी पाईयो । यसमा बिउको पाक्ने अवस्था र बिउ रोप्ने समयको प्रभाव देखिएन ।
- फल कुहाउने औंसा किराको प्रजाति पत्ता लगाउन तीन जिल्लाहरु जस्तै धनकुटा (मौनबुधुक र पारिपात्ले), सिन्धुली (खनियाखर्क) र भोजपुर (दांवा) 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 ।
- गत आ.व. २०७४/७५ 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. २०७४/७५ मा कृषकहरुलाई वितरण गरिएका जम्मा कलमी विरुवा २९२०० मध्ये सुन्तलाको ३०००, जुनारको ३१००, कागतिको २२८०० र अन्य ३०० बिरुवाहरु थिए ।
- यस कार्यक्रमको आ.व. २०७४/७५ को लागि विनियोजित वजेट रु दुई करोड सोह्र लाख थियो जस मध्ये अनुसन्धान कार्यक्रमको लागि जम्मा एक करोड छ लाख विनियोजन गरिएको थियो । बार्षिक आम्दानी रु एकचालिस 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 2074/75 (2017/18), a total of 36 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 129 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, Satsuma Mino including Khoku local were promising with early maturity and high fruit yield. 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 accepted by Variety Release Sub-committee as suitable for 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 tree spray of sodium bicarbonate @6.3g/lt 30, 45 and 60 days before harvesting was 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.
- The study of effect of potting mixture on grafted acid lime sapling production showed forest soil + sand + vermi-compost (1:1:1) as a good media with better sapling growth.
- The study on effect on trifoliate seed germination under different raising structures as influenced by maturity of fruit and seed sowing date revealed that farmers practice of open field seed sowing is as effective as keeping both sides of tunnel open on percentage of seed germination irrespective of maturity stages and seed sowing dates.
- 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 2074/75, 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 2074/75, total of 29200 grafted saplings constituting 3000 mandarin orange, 3100 sweet orange, 22800 acid lime and 300 other saplings were made available to farmers.
- The total annual budget approved for the program was Rs. 21.6 million, while operational budget consisted of Rs. 10.6 million to carry out research projects. The revenue was 4.1 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 edaphic condition across the country are considered quite suitable for growing citrus fruits. Moreover, the pocket areas with deep sandy loam soil and soil pH range of 5.0 to 6.5 are most suitable for the cultivation of citrus. In recent years, citrus is grown commercially in 50 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 46,328 ha producing 2,39,773 metric tons with productivity of 8.96 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 2016/17

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

Source: MoAD, Nepal, 2018

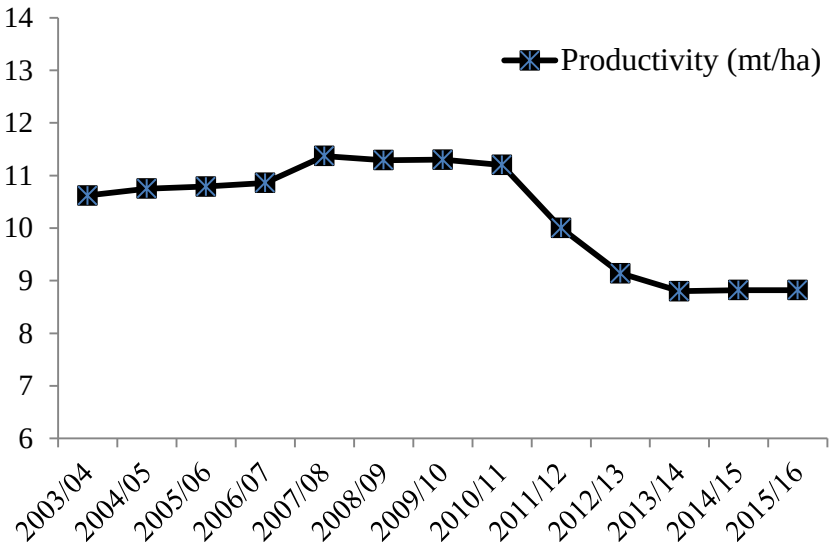

Figure 1: Productivity of citrus crops during different period

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 26,282 ha, 16,248 ha, 1,46,690 mt respectively, but sweet orange has the highest productivity (9.7 mt/ha). On the other hand, lemon fruit acquired the lowest area (837 ha), productive area (595 ha), and production (4,941 mt). The lowest productivity of 7.0 mt/ha was recorded with acid lime.

Table 2: Total area, productive area, production and productivity of major citrus fruits in Nepal (2015/16)

Major citrus fruits	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
Mandarin orange	26,282 (64.81)	16,248	146,690	9
Sweet orange	5,131 (12.65)	3,443	33,558	9.7
Acid lime	7,296 (17.99)	3,858	27,017	7
Lemon	837 (2.06)	595	4,941	8.3
Other citrus species	1,008 (2.49)	741	6,242	7.1
Grand Total	40,554	24,885	218,448	8.79

Source: MoAD, Nepal, 2017

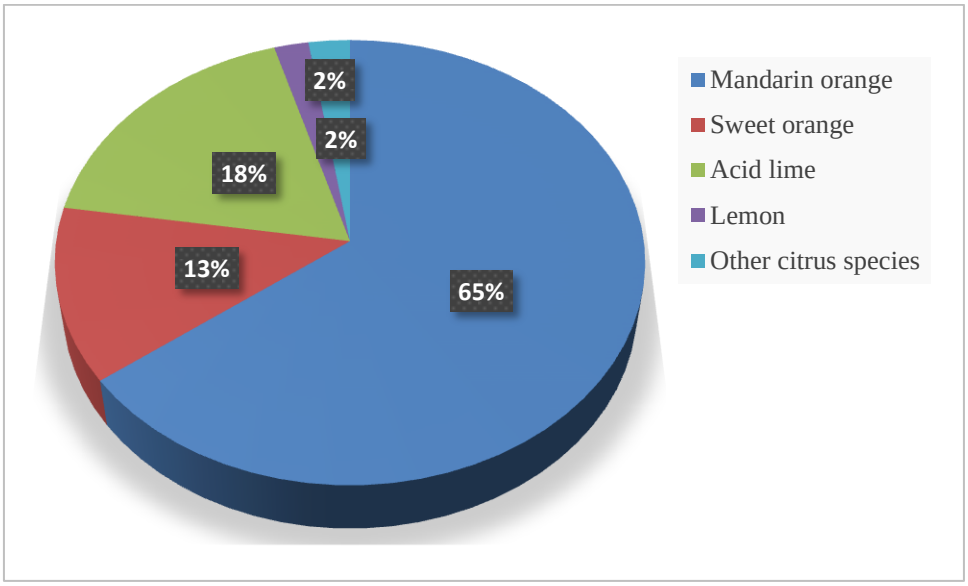

Figure 2: Total area (in percentage) of major citrus fruits in Nepal during 2015/16

The result shown in above pie-chart reveals that mandarin orange covers the maximum production area among citrus fruit. Mandarin orange covers 65.0% area among the citrus cultivated area. Similarly, acid lime, sweet orange, lemon and other citrus covers 18.0%, 13.0%, 2.0% and 2.0% respectively.

Table 3 shows the total orchard area, productive area, production and productivity of four groups of citrus based on development region of the country. In terms of total cultivated area, productive area and production of citrus crops, regardless of respective group, western region has occupied the first position with 13,213 ha, 8,352 ha and 79,509 mt respectively, but central region has stood the first position for productivity (8.90 mt/ha) followed by western region with 7.96 mt/ha and far-western region with 7.62 mt/ha. Although, area, productive area and production of mandarin orange is highest in western region with 10,094 ha, 6,571 ha and 65,221 mt; productivity is noted to be the highest in central region (9.7 mt /ha) followed by western region (9.1 mt/ha) and western eastern (8.7 mt/ha) while the lowest productivity of mandarin is in mid-western region (7.8 mt/ha). As for sweet orange, central region has had considerably highest area (2,275 ha), productive area (1,431 ha), production (16,572 mt) and productivity (10.7 mt/ha) whereas mid-western region showed the lowest productive area (310 ha) and production (3,425 ha). The lowest productivity was found in Eastern region (7.4 mt/ha). Eastern region showed considerably the maximum acid lime area (2,706 ha), productive area (1,481 ha) and production (96,428 mt). However, highest productivity for lemon was recorded from central region (7.7 mt/ha). Far-western region reflected minimally lowest for acid lime in respect of area (584 ha), productive area (371

ha) and production (2,628 mt). Mid-western region had lowest productivity (6.9 mt/ha). In regards with lemon fruit crop, its' total area (328 ha), productive area (197 ha), production (1,578 mt) and productivity (7.9 mt/ha) are recorded to be highest in eastern region. In contrast, the lowest production area, productive area and production was found in western region with 92 ha, 58 ha and 459 mt respectively. As for other citrus fruit crop, cropped area (458 ha), productive area (364 ha), production (3258 mt) and productivity (7.7 mt/ha) have been noted the highest in western region. The lowest production was noted from mid-western region (74 mt), whereas the lowest productivity (6.8 mt/ha) was recorded from central and far-western region.

Table 3: Total area, total productive area, total production and productivity of different citrus species in different regions of Nepal (2015/16)

Major Citrus species	Regions	Area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
Mandarin orange	Eastern	5,439	3,756	35,574	8.7
Sweet Orange	"	748	581	4,310	7.4
Acid Lime	"	2,706	1,481	9,628	6.1
Lemon	"	328	197	1,578	7.9
Other Citrus species	"	222	143	1,213	6.8
Sub-total		**9,443**	**6,158**	**52,303**	**7.38**
Mandarin orange	Central	3,768	2,726	28,506	9.7
Sweet Orange	"	2,275	1,431	16,572	10.7
Acid Lime	"	1,529	704	5,478	7.7
Lemon	"	134	115	1151	9.4
Other Citrus species	"	224	184	1,374	7
Sub-total		**7,930**	**5,160**	**53,081**	**8.9**
Mandarin orange	Western	10,094	6,571	65,221	9.1
Sweet Orange	"	1032	673	5,656	7.9
Acid Lime	"	1,537	686	4,920	7.5
Lemon	"	92	58	459	7.6
Other Citrus species	"	458	364	3,253	7.7
Sub-total		**13,213**	**8,352**	**79,509**	**7.96**
Mandarin orange	Mid-western	4,973	2,401	17,999	7.8
Sweet Orange	"	552	310	2,534	8
Acid Lime	"	1067	667	4,510	6.6
Lemon	"	145	116	837	6.9
Other Citrus species	"	25	12	74	7.3
Sub-total		**6,762**	**3,506**	**25,954**	**7.32**
Mandarin orange	Far-western	1,200	820	6,912.00	8.3
Sweet Orange	"	528	440	4,487	9.3
Acid Lime	"	457	326	2,213	5.7
Lemon	"	139	111	920	8
Other Citrus species	"	80	40	328	6.8
Sub-total		**2,404**	**1,737**	**14,860**	**7.62**

Source: MoAD, Nepal, 2017

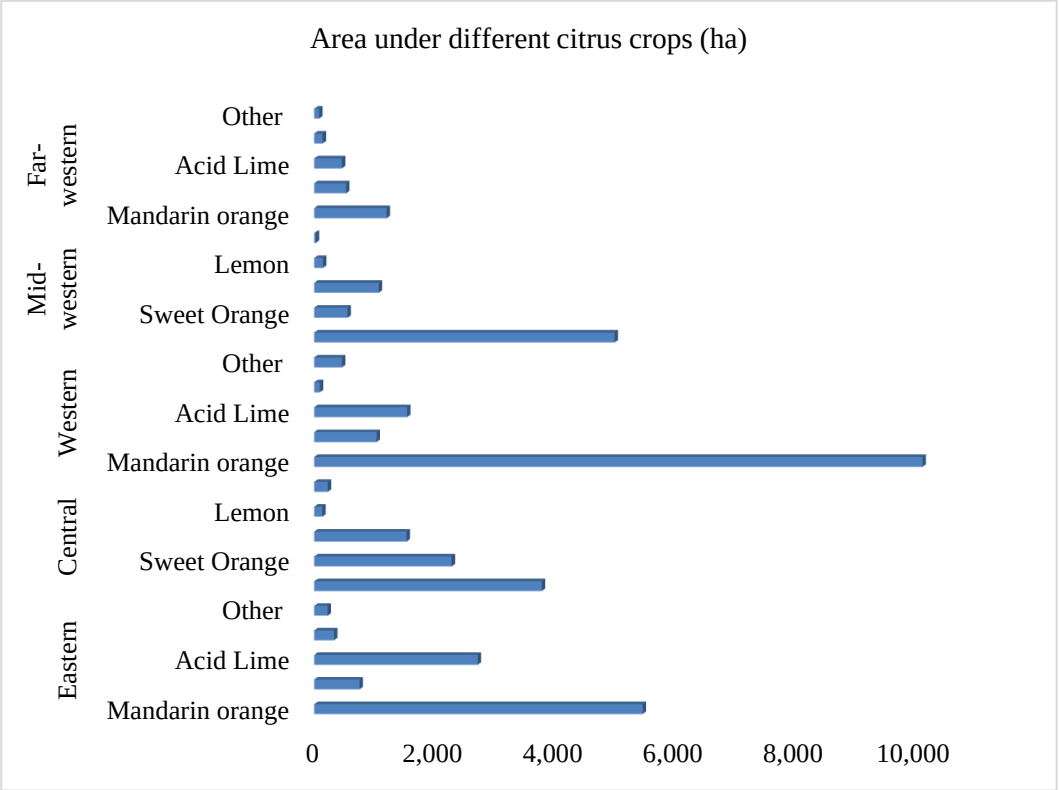

Figure 3: Total areas of major citrus fruits in different regions of Nepal in 2015/16

The result presented in bar diagram reveals the five different regions on Y-axis and area (ha) on X-axis. There is the highest area for mandarin orange production among different citrus fruits in each of the regions in the country. Of all regions, western region has possessed the largest area of citrus (13,213 ha). Western region has highest area for mandarin orange cultivation with the total area of 10,094 ha. The central region has largest area for sweet orange production (2,275 ha) as comparing against all the regions. In respect of area for acid lime and lemon, eastern region stands first with area of 2,706 ha and 328 ha respectively.

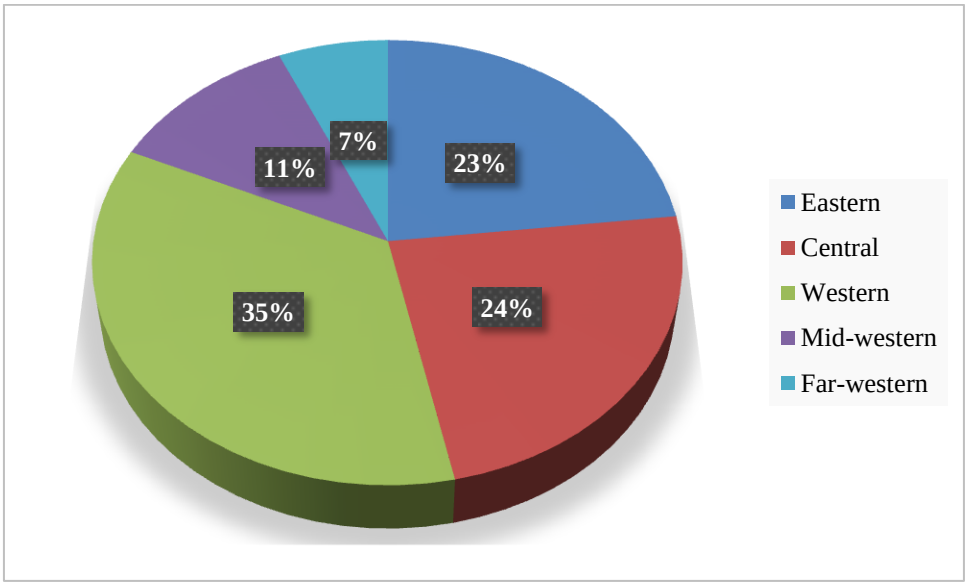

Figure 4: Total production of citrus in five development regions during 2015/16

The pie-chart shows the status of citrus fruit production of five regions of Nepal. Out of total citrus production; i.e. 2,2,705 mt, western region contributes maximum (35%) citrus production with total production of 79,509 mt followed by central region (53,081 mt) and eastern region (52,303 mt). Citrus crops share about 25.96% 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 hundred million annually. 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 2074/75 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 120 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 diameter, fruit rind thickness, number of fruits per tree, yield per tree and yield ton/ha were significant between genotypes.

Fruit weight

Fruit weight was found varying from 71.11 g to 175.30 g with mean value of 112.58 g. The highest fruit weight was found in Kara (175.76 g) followed by Satsuma Okitsu

(136.00 g) and Pongan (135.77 g). The lowest fruit weight was found in Nules (71.11 g) followed by Commune (76.40 g) and Marisol (92.87 g) (Table 4).

Fruit diameter

Fruit diameter was found significant varying range from 54.14 mm to 73.27 mm with mean value of 64.64 mm. The highest fruit diameter was found in Kara (73.27 mm) followed by Satsuma URSS (72.59 mm) and Satsumawase (69.71 mm). The lowest fruit diameter was found in Nules (54.14 mm) followed by Banskharka local (59.64 mm) and Sikkime local (58.91 mm) (Table 4).

Fruit rind thickness

Fruit rind thickness was found varying from 1.68 mm to 3.03 mm with mean value of 2.33 mm. The highest fruit rind thickness was found n Oraval (3.03 mm) followed by Miyagawawase (2.89 mm) and Okitsuwase (2.62 mm). The lowest fruit rind thickness was found in Sikkime local (1.68 mm) followed by Nules (1.92 mm) and Fortune (1.93 mm) (Table 4).

Number of fruits per tree

The number of fruits per tree was found highly significant ranging from 28.30 to 485.70 with mean value of 193.24. The maximum number of fruits per tree was found in Commune 485.70 followed by Oraval (354.00) and Sikkime local (336.30). The minimum number of fruits per tree was found in Nova (28.30) followed by Kara (38.00) and Okitsuwase (56.70) (Table 4).

Yield per tree

Yield per tree was found ranging from 1.97 kg to 37.94 kg with mean value of 9.02 kg. The maximum yield per tree was found in Commune (37.94 kg) followed by Oraval (34.90 kg) and Satsuma Mino (33.96 kg) (Table 4). Yield per tree was found minimum in Nova (197 kg) followed by Kara (5.91 kg) and Okitsuwase (6.25 kg).

Yield per hectare

The yield per hectare was found ranging from 2.19 t/ha t 42.15 t/ha with mean value of 21.13 t/ha. The maximum yield per hectare was found in Commune (42.15 t/ha) followed by Satsuma Mino (37.73 t/ha) and Sikkime local (32.82 t/ha). The minimum yield per hectare was found in Nova (2.19 t/ha) followed by Kara (6.57 t/ha) and Okitsuwase (6.94 t/ha) (Table 4).

Table 4: Fruit physical parameters and yield attributing characteristics of mandarin orange at NCRP in 2017/18

Genotype	Fruit wt (g)	Fruit Diameter (mm)	Rind thickness (mm)	# fruit / tree	Yield/tree (kg)	Yield/ha (t/ha)
Banskharka Local	92.81	58.64	2.23	291.70	26.38	29.31
Commune	76.40	59.17	2.34	485.70	37.94	42.15
Fortune	127.30	65.87	1.93	101.30	11.53	12.81
Kara	175.86	73.27	2.71	38.00	5.91	6.57
Khoku Local	121.18	66.33	2.29	115.70	12.52	13.91
Marisol	92.87	62.81	2.03	223.00	18.91	21.01
Miyagawawase	117.74	65.84	2.89	127.00	15.71	17.45
Nova	110.36	62.57	2.21	28.30	1.97	2.19
Nules	71.11	54.14	1.92	132.00	9.46	10.50
Okitsuwase	128.56	68.63	2.62	56.70	6.25	6.94
Oraval	94.1	59.92	3.03	354.00	34.90	38.78
Pongan	135.77	65.44	2.51	163.70	-	18.28
Satsuma Mino	114.46	65.94	2.26	305.30	33.96	37.73
Satsuma Okitsu	136.00	68.95	2.14	147.00	19.02	21.13
Satsuma URSS	126.49	72.59	2.56	142.70	17.61	19.56
Satsumawase	120.93	69.91	2.38	185.00	20.93	23.25
Sikkime Local	92.97	58.91	1.68	336.30	29.54	32.82
Mean	**112.58**	**64.64**	**2.33**	**193.24**	**19.02**	**21.13**
P value	**Ns**	*****	******	*******	******	******
LSD	**-**	**9.91**	**0.57**	**115.33**	**17.61**	**19.57**
CV%	**26.19**	**9.24**	**14.66**	**48.34**	**55.68**	**55.68**

Physio-chemical properties of mandarin orange

Physio-chemical properties (juice %, TSS %, TA %, TSS/TA ratio and brimA) of mandarin orange genotypes/accessions under variety evaluation experiment were significantly different as presented in Table 5.

Juice percent

Juice % was found significantly different among test genotypes and ranged between 28.02 % to 52.29 % with mean value of 43.74 %. The highest juice % was found in Satsuma Mino (52.29 %) followed by Kara (51.00 %) and Marisol (50.84 %). The lowest juice % was found in Banskharka local (28.02 %) followed by Pongan (35.33 %) and Oraval (36.98 %) (Table 5).

TSS %

TSS % was found significant among the tested genotypes and varied from 9.63 % to 13.05 % with the mean value of 11.17 %. The highest TSS % was found in Kara (13.05 %) followed by Fortune (12.87 %) and Pongan (12.50 %). The lowest TSS % was found in genotype Satsumawase 9.63 % and Satsuma URSS (9.87 %) (Table 5).

TA %

Among the tested genotypes TA % was found significant ranging from 0.56 % to 2.17 % with mean value of 1.07 %. The TA % was remarkably high in Fortune (2.17 %). Other genotypes with higher percentage of TA were Oroval (1.40 %) and Kara (1.36 %). Marisol (0.56 %) recorded significantly the lowest TA %. Other genotypes with lower values of TA % were Satsuma Mino (0.61 %), Okitsuwase (0.69 %) and Miyagawawase (0.77 %) (Table 5).

TSS/TA ratio

TSS/TA ratio was significantly different varying range from 5.95 to 18.29 with mean value of 11.45. The highest TSS/TA ratio was recorded from Marisol (18.29) followed by Satsuma Mino (17.68) and Okitsuwase (14.63). The lowest TSS/TA ratio was recorded from genotype Fortune (5.95). Other genotypes with lower TSS/TA ratio were Oroval (83.71), Satsuma Okitsu (8.93) and Satsumawase (9.17) (Table 5).

BrimA

The brimA was found significantly different varying range from 4.17 to 8.61 with mean value of 6.90. The highest brimA was found in Pongan (8.61) followed by Satsuma Mino (8.33) and Marisol (8.01). The lowest brimA was found in Fortune (4.17) followed by Satsumawase (5.40), Satsuma URSS (5.60) and Satsuma Okitsu (5.93) (Table 5).

Table 5: Physio-chemical properties of mandarin orange genotypes at NCRP in 2017/18

Genotypes	Juice %	TSS %	TA %	TSS/TA ratio	BrimA
Banskharka Local	28.02	11.72	1.13	10.42	7.18
Commune	38.14	11.60	1.13	10.22	7.06
Fortune	45.07	12.87	2.17	5.95	4.17
Kara	51.00	13.05	1.36	9.65	7.61
Khoku Local	47.33	10.85	1.04	10.47	6.71
Marisol	50.84	10.27	0.56	18.29	8.01
Miyagawawase	46.68	10.35	0.77	13.39	7.26
Nova	45.61	11.07	0.99	11.97	7.12
Nules	41.73	11.20	1.06	10.59	6.96
Okitsuwase	45.92	10.13	0.69	14.63	7.36
Oroval	36.98	12.10	1.40	8.71	6.49
Pongan	35.33	12.50	0.98	13.06	8.61
Satsuma Mino	52.29	10.78	0.61	17.68	8.33
Satsuma Okitsu	48.67	10.80	1.22	8.93	5.93
Satsuma URSS	47.60	9.87	1.06	9.27	5.60
Satsumawase	45.78	9.63	1.06	9.17	5.40
Sikkime Local	39.16	11.73	1.01	11.72	7.71
Mean	**43.74**	**11.17**	**1.07**	**11.45**	**6.90**
P value	**	***	***	***	***
LSD	**10.61**	**1.08**	**0.21**	**2.40**	**1.24**
CV%	**14.59**	**5.80**	**11.69**	**12.61**	**10.83**

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, pulp weight, number of fruits/tree and fruit yield/tree were statistically significant due to the effect of different genotypes of sweet orange (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 87.70 g to 210.19 g with the mean value of 138.99 g. Genotypes NCRP-22 (210.19 g), NCRP-84 (194.14 g) and NCRP-83 (168.07 g) possessed higher individual fruit weight. Lower individual fruit weight were recorded on genotypes NCRP-26 (87.70 g) followed by NCRp-15 (104.74 g) and NCRP-27 (116.44 g) (Table 6).

Fruit diameter(mm)

Individual fruit diameter was statistically variable and ranged between 56.54 mm and 75.41 mm with the mean value of 64.79 mm. Genotype NCRP-22 had the bigger fruit diameter (75.41 mm) followed by NCRP-84 (73.93 mm) and NCRP-83 (70.25 mm). In contrast, fruit diameter was considerably smaller of genotype NCRP-26 (56.54 mm), NCRP-15 (57.78 mm) and NCRP-27 (61.07 mm) (Table 6).

Pulp weight (g)

The pulp weight differed significantly among tested genotypes and ranged between 61.01 g and 167.67 g with mean value of 91.86 gm. The genotype NCRP-22 (167.67 g) gave the most pulp weight followed by NCRP-84 (124.89 g) and NCRP-83 (113.20 g). Lower pulp weights were observed in genotypes NCRP-26 (61.01 g) and NCRP-14 (63.22 g) (Table 6).

Fruit number per tree

The number of fruits/plant was highly variable from 11.67 to 134.67 with the mean value of 54.01. NCRP -86 recorded the highest number of fruits/plant i.e. 134.67 followed by NCRP-27 (124.50) and NCRP-84 (91.33). Genotypes like NCRP-83 (11.67), NCRP-14 (19.68) and NCRP-26 (22.33) were found to produce significantly lower number of fruits per plant (Table 6).

Fruit yield per tree

Total weight of fruits/plant was highly variable and ranged between 1.37 kg and 13.96 kg with a mean value of 5.69 kg. The genotype NCRP-84 gave the highest yield/tree

(13.96 kg) followed by NCRP-27 (11.61 kg) and NCRP-86 (10.49 kg). The genotype NCRP-26 produced the least fruit /tree (1.37 kg) per tree. NCRP-83 (1.73 kg), NCRP-14 (1.84 kg), NCRP-15 (2.29 kg) and NCRP-19 (2.54 kg) were other low yielding genotypes/accessions (Table 6).

Table 6: Fruit characteristics of different sweet orange genotypes at NCRP in 2017/18

Genotype	Fruit weight (g)	Fruit diameter (mm)	Pulp weight (g)	Fruits number / tree	Fruit yield / tree (kg)
NCRP-14	120.05	61.28	63.22	19.68	1.84
NCRP-15	104.74	59.78	75.62	24.33	2.29
NCRP-16	156.18	68.02	82.97	69.17	8.72
NCRP-19	149.99	64.90	87.10	20.00	2.54
NCRP-22	210.19	75.41	167.67	43.17	8.06
NCRP-26	87.70	56.54	61.01	22.33	1.37
NCRP-27	116.44	61.07	86.19	124.50	11.61
NCRP-31	139.84	62.20	97.11	52.33	5.64
NCRP-33	135.64	64.63	97.69	46.50	3.01
NCRP-34	134.82	65.03	89.06	36.00	3.15
NCRP-83	168.07	70.25	113.20	11.67	1.73
NCRP-84	194.14	73.93	124.89	91.33	13.96
NCRP-85	123.20	63.42	79.10	30.50	3.33
NCRP-86	119.57	62.29	78.13	134.67	10.49
NCRP-87	135.00	65.64	88.01	47.17	4.35
NCRP-96	128.40	62.30	78.83	90.83	8.96
Mean	138.99	64.79	91.86	54.01	5.69
P-value	**	**	**	**	**
CV%	18.09	5.80	19.91	69.45	69.64
$LSD_{(0.05)}$	41.92	6.27	30.49	62.55	6.61

Physio-chemical properties of different genotypes of sweet orange

Physio-chemical properties (juice volume, TA% and TSS %) of sweet orange genotypes/accessions under variety evaluation experiment were significantly different as presented in table 7.

Fruit juice Volume

The volume of fruit juice was significantly different among test genotypes and ranged between 24.33 ml to 68.16 ml with average value of 42.44 ml. The genotype NCRP-84 was found to give the highest juice volume (68.16 ml) followed by NCRP-19 (57.73 ml), and NCRP-16 (54.90 ml). The genotype NCRP-26 gave the least juice volume (24.33

ml). Similarly, NCRP-15 (24.81 ml), NCRP-33 (30.97 ml) produced low fruit juice volume (Table 7).

Total Soluble Solids % (TSS %)

Among the tested genotypes the percent TSS varied from 10.93 % to 15.30 % with the mean value of 12.20 %. TSS % was found significantly higher in genotypes such as NCRP-84 (15.30 %) and NCRP-31 (13.80 %). Lower TSS % values were observed in genotypes NCRP-27 (10.93 %) and NCRP-87 (10.97 %) (Table 7).

Titratable acid % (TA %)

Among the tested genotypes percent of TA ranged from 0.52 % to 3.83 % with mean value of 1.71 %. The TA percent was remarkably high in NCRP-15 (3.83 %) followed by NCRP-86 (2.35 %) and NCRP-34 (2.08 %). NCRP-31 recorded significantly the lowest TA (0.52%). Other genotypes with lower values of TA were NCRP-19 (1.04 %), NCRP-22 (1.09 %) and NCRP-87 (1.21%) (Table 7).

Table 7: Physio-chemical properties of different sweet orange genotypes at NCRP in 2017/18

Genotype	Juice volume (ml)	TSS %	TA%
NCRP-14	41.36	11.96	1.85
NCRP-15	24.81	11.81	3.83
NCRP-16	54.90	12.20	1.41
NCRP-19	57.73	11.87	1.04
NCRP-22	40.00	13.37	1.09
NCRP-26	24.33	11.79	1.92
NCRP-27	38.60	10.93	1.92
NCRP-31	36.47	13.80	0.52
NCRP-33	30.97	11.58	1.97
NCRP-34	40.40	11.60	2.08
NCRP-83	50.99	11.74	1.56
NCRP-84	68.16	15.30	1.50
NCRP-85	38.77	12.65	1.87
NCRP-86	39.07	11.97	2.35
NCRP-87	45.03	10.97	1.21
NCRP-96	47.50	11.60	1.78
Mean	42.44	12.20	1.71
P-value	**	**	**
CV%	15.01	13.04	18.98
$LSD_{(0.05)}$	10.62	2.65	0.54

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 2017 (FY2074/75)

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**

3.2 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 beginning from the fiscal year 2074/75. Cellar store constructed at NCRP was used for the experiment. The experiment was carried out by completely randomized block design and were given seven treatments and replicated thrice. The treatments given are stated below:

T1: Bavistin spray @ 2gm/lt of water 45 days before harvest
T2: Sodium bicarbonate spray @ 6.33gm/lt of water 45 days before harvest
T3: Bavistin spray @ 2gm/lt of water 45 and 30 days before harvest
T4: Sodium bicarbonate spray @ 6.33gm/lt of water 45 and 30 days before harvest
T5: Bavistin spray @ 2gm/lt of water 45, 30 and 15 days before harvest
T6: Sodium bicarbonate spray @ 6.33gm/lt of water 45, 30 and 15 days before harvest
T7: 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, juice recovery percentage, TSS% and TA %.

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 2074/75. 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.

Tables 9, 10, 11, 12 and 13 illustrates that there was no significant difference in physiological loss in weight, decay loss percentage, juice recovery percentage, TSS % and TA % among various treatments in any storage duration.

Table 9: Effect of postharvest treatments on physiological loss in weight of mandarin fruit during storage at cellar store during year 2074/75

Treatments	Physiological loss in weight on days indicated (%)						
	15	30	45	60	75	90	Cummulative
Bavistin 45 DBH	1.40	4.34	2.91	5.62	3.92	11.86	30.04
Bavistin 45 and 30 DBH	1.60	2.98	3.65	5.52	4.27	12.54	30.56
Bavistin 45, 30 and 15 DBH	2.47	2.48	2.79	5.89	6.83	5.77	26.22
Sodium Bicarbonate 45 DBH	2.53	3.26	3.20	2.90	9.30	4.56	25.76
Sodium Bicarbonate 45 and 30 DBH	4.07	6.96	3.20	3.76	2.15	7.76	27.88
Sodium Bicarbonate 45, 30 and 15 DBH	3.33	1.69	1.65	4.60	8.56	19.94	39.77
Control	3.00	3.30	2.33	7.15	3.62	10.04	29.44
Mean	**2.63**	**3.57**	**2.82**	**5.06**	**5.52**	**10.35**	**29.95**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$LSD_{(0.05)}$							
CV%	**55.00**	**62.30**	**94.55**	**66.11**	**108.01**	**53.05**	**31.28**

Table 10: Effect of postharvest treatments on decay loss percentage of mandarin fruit during storage at cellar store during year 2074/75

Treatments	Decay loss on days indicated (%)						
	15	30	45	60	75	90	Cummulative
Bavistin 45 DBH	0.00	1.75	1.82	4.55	4.94	10.99	24.06
Bavistin 45 and 30 DBH	0.00	0.63	2.83	3.95	3.55	10.76	21.73
Bavistin 45, 30 and 15 DBH	1.15	0.00	1.92	4.72	6.10	5.18	19..07
Sodium Bicarbonate 45 DBH	1.17	1.69	2.29	3.03	5.29	6.21	19.68
Sodium Bicarbonate 45 and 30 DBH	2.43	3.39	2.34	3.05	9.17	5.90	26.28
Sodium Bicarbonate 45, 30 and 15 DBH	1.02	0.52	0.56	0.55	1.26	8.10	12.00
Control	1.06	1.10	0.56	6.03	3.52	3.22	15.49
Mean	**0.98**	**1.29**	**1.76**	**3.69**	**4.83**	**7.19**	**19.76**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$LSD_{(0.05)}$							
CV%	**144.82**	**154.71**	**142.42**	**72.43**	**139.09**	**43.57**	**42.65**

Table 11: Effect of postharvest treatments on juice recovery percentage of mandarin fruit during storage at cellar store during year 2074/75

Treatments	Juice recovery on days indicated (%)					
	15	30	45	60	75	90
Bavistin 45 DBH	47.26	43.35	41.64	41.55	45.25	41.20
Bavistin 45 and 30 DBH	43.69	41.19	42.67	37.63	39.96	39.58
Bavistin 45, 30 and 15 DBH	39.71	37.22	37.11	39.00	39.60	40.11
Sodium Bicarbonate 45 DBH	42.62	40.89	45.63	39.55	41.56	43.58
Sodium Bicarbonate 45 and 30 DBH	40.16	41.59	38.47	38.38	45.11	39.39
Sodium Bicarbonate 45, 30 and 15 DBH	43.55	42.91	40.71	40.53	44.28	39.43
Control	47.76	44.57	47.76	44.13	43.29	43.00
Mean	**43.54**	**41.67**	**41.99**	**40.11**	**42.72**	**40.90**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$LSD_{(0.05)}$						
CV%	**14.18**	**9.38**	**11.53**	**8.46**	**9.27**	**10.23**

Table 12: Effect of postharvest treatments on total soluble solids of mandarin fruit during storage at cellar store during year 2074/75

Treatments	Total soluble solids on days indicated (^{o} Brix)					
	15	30	45	60	75	90
Bavistin 45 DBH	14.00	13.39	14.33	14.11	13.08	13.00
Bavistin 45 and 30 DBH	14.33	13.50	13.84	14.03	12.39	13.17
Bavistin 45, 30 and 15 DBH	14.00	13.28	13.78	14.28	12.31	14.00
Sodium Bicarbonate 45 DBH	14.50	13.78	14.11	14.58	13.05	14.23
Sodium Bicarbonate 45 and 30 DBH	14.43	13.16	14.33	14.36	12.85	13.78
Sodium Bicarbonate 45, 30 and 15 DBH	13.87	13.23	14.67	14.61	13.48	14.00
Control	14.00	13.72	14	14.19	13.28	14.39
Mean	**14.16**	**13.45**	**14.15**	**14.31**	**12.92**	**13.79**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	******
$LSD_{(0.05)}$						**0.77**
CV%	**4.18**	**3.16**	**3.17**	**2.01**	**4.08**	**3.12**

Table 13: Effect of postharvest treatments on titratable acid (%) of mandarin fruit during storage at cellar store during year 2074/75

Treatments	Titratable acid on days indicated (%)					
	15	30	45	60	75	90
Bavistin 45 DBH	1.11	1.01	0.86	0.58	0.67	0.60
Bavistin 45 and 30 DBH	1.06	0.99	0.75	0.53	0.45	0.55
Bavistin 45, 30 and 15 DBH	0.97	1.00	0.65	0.55	0.40	0.65
Sodium Bicarbonate 45 DBH	1.04	0.88	0.71	0.58	0.45	0.66
Sodium Bicarbonate 45 and 30 DBH	1.33	1.11	0.99	0.80	0.82	0.77
Sodium Bicarbonate 45, 30 and 15 DBH	0.97	1.04	0.95	0.78	0.73	0.65
Control	**1.00**	**1.24**	**0.88**	**0.79**	**1.56**	**0.88**
Mean	**1.07**	**1.04**	**0.83**	**0.66**	**0.72**	**0.68**
P-value	**NS**	**NS**	**NS**	******	**NS**	**NS**
$LSD_{(0.05)}$				**0.20**		
CV%	**25.23**	**11.42**	**15.49**	**17.11**	**71.64**	**16.47**

Organoleptic taste

For outlook of fruit, preferential ranking index (PRI) was found highest with treatment sodium bicarbonate 45 DBH (0.61) followed by Bavistin 45 DBH (0.60). For taste, PRI was the highest with treatment sodium bicarbonate 45, 30 and 15 DBH (0.50) followed by sodium bicarbonate 45 DBH and bavistin 45 DBH (0.47). Similarly, for aroma, PRI was the highest with sodium bicarbonate 45 and 30 DBH (0.59) followed by sodium bicarbonate 45 DBH (0.57) and sodium bicarbonate 45, 30 and 15 DBH (0.54). Likewise, for readiness to purchase, PRI was the highest with bavistin 45 DBH (0.59) followed by sodium bicarbonate 45 and 30 DBH (0.57) and sodium bicarbonate 45,30 and 15 DBH (0.51) (table 14).

Table 14: 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
Sodium Bicarbonate 45 DBH	0.61	0.47	0.50	0.57	0.49
Bavistin 45 DBH	0.60	0.47	0.49	0.51	0.59
Control	0.49	0.40	0.43	0.47	0.41
Sodium Bicarbonate 45 and 30 DBH	0.57	0.41	0.47	0.59	0.57
Sodium Bicarbonate 45, 30 and 15 DBH	0.46	0.50	0.49	0.54	0.51
Bavistin 45, 30 and 15 DBH	0.51	0.44	0.44	0.46	0.50
Bavistin 45 and 30 DBH	0.39	0.43	0.47	0.40	0.47

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

Result and discussion

The fruit physical parameters: average fruit weight, rind weight, number of fruit segments were found non-significant due to rootstock, while the rootstock effect was significant on fruit diameter (mm) and rind (peel) thickness (mm). The heaviest fruit was produced from plants grafted on to Citrange (112 g) while the smallest fruit (99.6 g) was from trifoliate rootstock. However, the fruit with biggest diameter was from plants grafted onto Citrumelo 4475 (64.5 mm), while the smallest was from trifoliate (57 mm). Similar to this, the thickest fruit skin (2.8 mm) was from plants grafted onto Citrumelo 4475, while the thinnest was from trifoliate (1.68 mm) (Table 15).

Table 15: Fruit quality of Mandarin cultivar Khoku Local grafted on six different rootstocks (FY 2074/75)

Rootstock	*# fruit/tree*	Av Fruit Wt (g)	Fruit Diameter (mm)	Rind thickness (mm)	Rind Wt (g)	# of segment
Carrizo Citrange	33.00	105.78	60.65	2.30	23.60	9.65
Citrange C-35	69.20	112.18	62.14	2.18	26.86	9.72
Citrumelo 4475	70.20	106.78	64.56	2.82	26.20	10.00
Flying Dragon	39.33	103.50	61.63	2.10	24.90	10.27
Poncerous-Pomeroy	24.60	99.56	60.02	2.26	24.12	9.68
Trifoliate	39.25	95.58	56.95	1.68	22.15	9.80
Mean	**47.19**	**104.17**	**61.11**	**2.25**	**24.75**	**9.83**
P value	**Ns**	**Ns**	*****	*******	**Ns**	**Ns**
LSD (0.5)	**55.22**	**17.00**	**4.58**	**0.34**	**4.84**	**0.55**
CV (%)	**79.16**	**11.04**	**5.07**	**10.27**	**13.24**	**3.77**

Among fruit quality parameters juice percent and titratable acidity (TA) were found significantly different due to rootstock effect, while total soluble solid (TSS) and BrimA values were found non-significant. The juiciest fruits were from plants grafted onto citrange (C35) rootstock while the least juicy was from Poncerous-Pomroy grafted plants. The least sour fruits were from the mandarin plants grafted onto Flying dragon rootstock (1.1%) while the most acidic fruits were from Citrange (1.32%) rootstock. However, the total soluble solids was very highest from same Citrange grafted plants (Table 16).

All the yield parameters were found non-significantly affected by the rootstocks. However, the highest number of fruit/tree was obtained from Citrumelo 4475 grafted plants (70) while the least from Poncerous-Pomroy (25) grafted ones. Similarly, the highest yield/tree and productivity was also obtained from Citrumelo 4475 grafted plants with least from Poncerous-Pomroy grafted plants (Table 16).

Table 16 : Fruit physio-chemical properties and yield characteristics of mandarin cv Khoku local grafted on six different rootstock (FY 2074/75)

Rootstock	Juice %	Av TA	Av TSS	BrimA	Tree Yield (kg)	Productivity
Carrizo Citrange	42.38	1.10	10.03	4.45	3.75	4.15
Citrange C-35	44.74	1.32	11.13	4.44	7.48	8.32
Citrumelo 4475	37.94	1.18	10.29	4.38	7.54	8.36
Flying Dragon	40.10	1.07	10.21	4.90	4.07	4.50
Poncerous-Pomeroy	36.74	1.20	10.07	4.06	2.44	2.72
Trifoliate	41.45	1.23	10.13	4.03	3.92	4.35
Mean	**40.49**	**1.19**	**10.34**	**4.35**	**5.01**	**5.56**
P value	**	**	**Ns**	**Ns**	**Ns**	**Ns**
LSD (0.5)	**4.01**	**0.13**	**0.92**	**1.04**	**5.86**	**5.82**
CV (%)	**6.70**	**7.12**	**6.03**	**16.11**	**79.15**	**79.42**

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 juice percent were found significantly affected. The thinnest skinned fruit (1.42 mm) with highest juice percent (42.4%) was obtained with lime plants grafted onto Rangpur lime, while the thickest skin (2.33mm) fruit was from Citrumelo 4475 and least juiciest (26.2%) from Carizzo citrange grafted plants (Table 17).

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 (no. fruit/tree, yield/tree, productivity) were found significantly affected by the rootstocks. The highest number of fruits (115) was produced by plants grafted onto Citrumelo 4475 while the least number of fruit (30) was from Rangpur lime grafted plants. Similarly the highest yield per tree (447 kg) and productivity (4.97 t/ha) was from Citrumelo 4475 grafted plants and the least yield per tree (1.27 kg) with productivity (1.4 t/ha) was from the plants grafted on to Rangpur lime (Table 17).

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

Rootstock	Fruit Wt (g)	Rind thickness (mm)	Fruit Diameter (mm)	Juice %	Av TSS	Av TA	*#Fruit*	Yield/ tree (kg)	Productivity (t/ha)
Citrange-C35	34.00	2.57	37.70	18.83	8.33	9.43	72.67	2.43	2.73
Citrange-Carizzo	30.20	2.07	36.83	26.20	9.00	11.70	44.67	1.30	1.47
Citron	32.45	2.10	37.62	34.30	8.84	10.10	49.50	1.73	1.92
Citrumelo 4475	39.38	2.33	43.52	26.82	8.13	11.38	114.50	4.47	4.97
Flying Dragon	34.65	1.90	39.67	35.10	9.16	10.88	39.00	1.30	1.42
Poncerous-Pomeroy	33.25	1.85	38.75	41.75	8.37	10.35	37.50	1.30	1.50
Rangpur lime	41.60	1.42	43.33	42.40	7.75	10.45	29.50	1.27	1.40
Volkamerina	37.43	1.93	39.57	38.03	7.47	10.70	55.67	1.97	2.20
Mean	**35.69**	**2.01**	**39.87**	**32.86**	**8.39**	**10.64**	**56.44**	**2.03**	**2.26**
P value	**Ns**	******	**Ns**	******	*******	*****	*****	*****	*****
LSD (0.05%)	**9.89**	**0.45**	**4.64**	**8.35**	**0.61**	**1.15**	**46.38**	**1.70**	**1.91**
CV %	**18.02**	**15.08**	**7.83**	**18.33**	**4.88**	**7.25**	**55.31**	**57.25**	**56.85**

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. Five 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	Washington Navel
Poncerous-Pomeroy	Washington Navel
Volkamerina	Washington Navel

Result and discussion

The preliminary study found that the hybrid rootstocks Citrumelo 4475 and Volkamerina were performing well in terms of fruit weight (150gm) and fruit diameter (>65 mm), however, those fruits were not juicier than trifoliate grafted plants and less sweet as well. But the Volkamerina rootstock has produced less acidic fruit (1%) compared to others. The Citrumelo 4475 and Volkamerina rootstocks were found producing more fruit per tree (1.80 kg) with better productivity (>2.0 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 five rootstocks grown at NCRP Dhankuta (FY2074/75)

Rootstock	Av fruit wt (g)	Fruit Diameter (mm)	Rag Percent	Juice percent	Av TSS (%)	Av TA (%)	Brim A value	Tree Yield (kg)	Productivity (t/ha)
Citrumelo 4475	153	67	79.4	19.7	12.9	1.2	6.9	1.98	2.2
Rangapur lime	104	58	81.2	17.1	13.9	1.4	7.1	0.73	0.81
Trifoliate	115	61	79.8	20.1	14.3	1.2	8.2	0.88	0.98
Poncerous-Pomeroy	108	59	79.4	21	14.1	1.2	7.9	1.35	1.5
Volkamerina	150	66	86.4	13.9	12.1	1	7.2	1.82	2.03

3.3.2 On-farm rootstock evaluation of acid lime recommended for terai region of Nepal

Acid lime is one of the important citrus crops of Nepal. Traditionally, acid lime cultivation is limited to a range of 800 m to 1400 masl in the mid hills producing a very small volume during normal season on 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 terai to 1800 masl high hills in Nepal (Shrestha *et al*, 2012). Thus, Nepal has enormous scope of increasing production and productivity by adopting better varieties along with improved management. Thus, variety selection and evaluation of acid lime was carried out in different terai regions during 2062-2067 and two varieties of acid lime (NCRP-49 and NCRP-55) were identified ideal for terai region of Nepal. These varieties are found very popular among farmers in recent years and most of the farmers are commercially cultivating these two varieties. Similarly, according to DADO Sunsari and Morang, most of the kinnow mandarin grafted on trifoliate orange died within 6-7 years. According to DADO Morang (RATWG, 2013), these varieties suffer from canker disease when grafted on trifoliate orange but found traces when grafted on pumelo. Thus, this experiment was conducted at RARS, Tarahara to fulfill the following objectives:

- To identify compatible rootstock for acid lime.
- To enhance productive life of acid lime in terai region

Methodology:

To conduct this experiment, seedlings of trifoliate orange, citrange, rangpur lime, pumelo, sour orange and rough lemon were raised as a rootstock in a nursery of NCRP, Dhankuta. Healthy scion of NCRP-49 and NCRP-55 were grafted on those seedlings by shoot tip method and raised in nursery. These grafted saplings were planted by

Randomized Complete Block Design. Individual seedling was considered as a single treatment as stated below:

Treatment (rootstock)		Scion	Scion
T1 – Pumelo	+	NCRP-49	NCRP-55
T2 – Rangpur lime	+	NCRP-49	NCRP-55
T3 – Seti jyamire	+	NCRP-49	NCRP-55
T4 – Kali jyamire	+	NCRP-49	NCRP-55
T5 – Citrange	+	NCRP-49	NCRP-55
T6 – Trifoliate orange	+	NCRP-49	NCRP-55

Result and discussion

The result projected in table 19 illustrates that plant canopy, plant height, rootstock diameter, graft union diameter and scion diameter were statistically significant.

Plant canopy

a) East-west plant canopy

East-west plant canopy was statistically significant varying range from 108.33 to 306.67 with mean value of 211.26. The maximum value was found in treatment Pumelo*NCRP-55 (306.67) followed by Seti jyamir*NCRP-49 (273.33). In contrast, minimum value was recorded from treatment trifoliate orange*NCRP-55 (108.33) (table 19).

b) North-south plant canopy

North-south plant canopy was found statistically significant varying range from 110.00 to 316.67 with the mean value of 209.94. The maximum value was recorded from treatment citrange*NCRP-49 (616.67) followed by pumelo*NCRP-49 (282.00). The minimum value was recorded from treatment trifoliate orange*NCRP-55 (110.00) (Table 19).

Plant height

The plant height was highly significant varying the range from 106.67 cm to 233.33 cm with mean plant height of 175.30 cm. The maximum plant height was observed from treatment seti jyamir*NCRP-49 (233.33 cm) followed by treatment pumelo*NCRP-49 (210.00 cm). The minimum plant height was recorded from treatment rangpur lime*NCRP-55 (106.67 cm) (table 19).

Number of branches

The number of branches ranged from 7.00 to 36.00 with mean value of 19.03. The highest number of branches was found in treatment pumelo*NCRP-49 (36.00) followed

by rangpur lime*NCRP-49 (26). The lowest number of branches was found in treatment trifoliate orange*NCRP-55 (7.00) (Table 19).

Rootstock diameter

The rootstock diameter varied from 37.76 mm to 73.92 mm with the mean value of 56.02 mm. The maximum rootstock diameter was recorded from pumelo*NCRP-55 (73.92 mm) followed by seti jyamir*NCRP-55 (65.47 mm). In contrast, the minimum rootstock diameter was recorded from rangpur lime*NCRP-55 (37.76 mm) (Table 19).

Graft union diameter

The graft union diameter was found varying from 36.28 mm to 69.66 mm with mean value of 55.63 mm. The maximum graft union diameter was found from pumelo*NCRP-55 (69.66 mm) followed by pumelo*NCRP-49 (69.39 mm). The minimum graft union diameter was found from kali jyamir*NCRP-55 (36.28 mm) (Table 19).

Scion diameter

Scion diameter was found statistically significant varying from 28.25 mm to 64.75 mm with mean value of 49.60 mm. The maximum scion diameter was found with pumelo*NCRP-55 (64.75 mm) followed by pumelo*NCRP-49 (62.66 mm). The minimum scion diameter was found with trifoliate orange*NCRP-55 (28.25 mm) (Table 19).

Table 19: Performance of six different rootstocks on acid lime in Tarahara, Morang in 2017

Treatment	Plant canopy		Plant height (cm)	Number of branches	Rootstock diameter (mm)	Graft union diameter (mm)	Scion diameter (mm)
	East-West	North-south					
Seti jyamire*NCRP-49	273.33	233.33	233.33	25.33	60.72	62.22	56.43
Pumelo*NCRP-49	243.33	282.00	210.00	36.00	61.04	69.39	62.66
Rangpur lime*NCRP-49	243.33	260.00	203.33	26.00	57.91	67.09	58.59
Trifoliate orange*NCRP-49	203.33	200.00	186.67	17.33	61.87	58.49	49.06
Citrange*NCRP-49	223.33	316.67	190.00	22.33	56.47	56.11	53.07
Seti jyamire*NCRP-55	256.67	235.00	186.67	12.00	65.47	66.54	52.57
Pumelo*NCRP-55	306.67	263.33	196.67	25.67	73.92	69.66	64.75
Rangpur lime*NCRP-55	125.00	120.00	106.67	10.00	37.76	36.30	35.33
Trifoliate orange*NCRP-55	108.33	110.00	113.33	7.00	42.95	36.36	28.25
Citrange*NCRP-55	193.33	166.67	150.00	20.33	54.48	53.49	52.01
Kali jyamire*NCRP-55	146.68	123.33	151.67	7.33	43.67	36.28	32.83
Mean	**211.26**	**209.94**	**175.30**	**19.03**	**56.02**	**55.63**	**49.60**
P-value	**	**	**	NS	NS	**	**
CV%	**27.79**	**25.48**	**27.61**	**41.74**	**32.90**	**23.11**	**20.07**
LSD(0.05)	**95.71**	**83.48**	**78.92**	**12.95**	**30.06**	**20.97**	**16.24**

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

Among fruit physical parameter fruit weight, fruit diameter and juice percentage were significant due to planting densities, whereas skin thickness was found non-significant. The juice percent was found increasing with widening the spacing and so the fruit weight and fruit diameter. Among fruit quality parameters titratable acidity (TA) was found significantly different while total soluble solids (TSS) and BrimA values were found non-significant due to plant spacing. The yield and yield attributing parameter like number of fruits/tree, tree yield/ tree and productivity was found non-significant among plant spacing. However, the recommended spacing for hills (3m x 3m) is giving the highest number of fruits/ tree (33) as well as tree yield (2.64 kg) and productivity (27 t/ha) (Table 20).

Table 20: Effect of different planting densities on fruit quality and yield of mandarin cv. Khoku local grafted onto trifoliate rootstock (FY 2074/75)

Spacing	*Juice %*	Av TSS (%)	Av TA (%)	Brim A	Fruit wt (g)	Fruit Dia (mm)	Rind Thickness (mm)	# Fruit/ tree	Tree Yield (kg)	Productivity (t/ha)
1.50X3.0 m	31.32	12.26	1.20	6.12	73.10	55.36	1.92	7.20	0.38	7.52
1.75X3.0 m	37.90	11.90	1.20	5.90	73.44	52.54	2.08	10.20	0.75	12.82
2.25X3.0 m	36.98	12.46	1.30	5.92	82.40	56.36	1.76	13.80	0.96	12.85
2.50X3.0 m	41.88	12.08	1.02	7.00	98.40	62.54	1.98	21.00	1.87	22.42
3.00X3.0 m	44.00	12.43	0.95	7.72	86.30	57.98	1.85	33.25	2.64	27.00
3.50X3.0 m	44.26	11.54	1.10	6.08	98.34	62.14	2.28	21.60	1.89	16.24
Mean	**39.23**	**12.1**	**1.13**	**6.41**	**85.30**	**57.81**	**1.98**	**17.31**	**1.37**	**16.11**
P value	*****	**Ns**	******	**Ns**	******	******	**Ns**	**Ns**	**Ns**	**Ns**
LSD $_{(0.05\%)}$	**8.02**	**1.11**	**0.17**	**1.33**	**14.85**	**5.58**	**0.38**	**18.85**	**1.55**	**15.40**
CV%	**15.59**	**6.97**	**11.24**	**15.78**	**13.27**	**7.36**	**14.52**	**83.02**	**86.18**	**72.88**

3.4 NURSERY MANAGEMENT

For a sustainable and profitable commercial citrus industry, trees should be propagated from citrus root stocks and bud wood that are true to type genetically and tested to be free from potentially harmful viruses and other pathogens. Nurseries are to be adopted in the propagation of those trees. An orchard that was established from sub-standard nursery stock will never be as vigorous, productive and profitable as those established

from high quality and disease free materials. Citrus have a high rate of natural mutation so; care must be taken to ensure bud wood which is only taken from superior trees. In addition, citrus trees may be infected with diseases that show no symptoms in young plants, but they will have serious implications over the life of the tree (Pyle, 2012). In order to use certified propagation materials five different but closely related programs are needed in any citrus industry:

- A quarantine program to ensure the safe introduction of new germplasms introduced in to the country.
- A clean stock program to produce sources of pathogen free propagating stock of new and existing commercial varieties.
- A parent tree program in which parent trees of each cultivar needs to be virus indexed and certified.
- A program of horticultural evaluation to ensure that parent trees reflect the genetics attributes of a variety, without any disadvantageous mutation.
- A quality assurance program whether a range of best practices have been adopted during the nursery propagation cycle to growers the assurance that the end product is of high quality and is free of diseases and pest.

3.4.1 Identification of appropriate harvesting stage of trifoliate orange under different raising environments in relation to sowing dates for maximum seed germination

Methodology

There is an issue of poor germination (around fifty percent) under NCRP farm condition. To mitigate poor germination problem an experiment was laid out in RCB design with four replications. Trifoliate seed extracted from three maturity type fruit (Full green, Half yellow and full green) were sown on three dates (1st week of Sept, 3rd week of Sept and 1st week of Oct) in three type of nursery beds (Farmer's method, Dailekh method and NCRP method). In farmers; method raised bed was prepared, seed were sown without using plastic cover, where as in other two methods: 50 cm high arched plastic tunnel was established using bamboo with both sides open in Dailekh and closed in NCRP method. Seeds were sown in 10-m x 0.75-m dimension bed at 10-cm line distance with 3-cm seed to seed distance. In each plot, 100 seeds were dropped two cm deep into soil and mulched with herbs. The seeds used in this experiment were extracted 6 days before first sowing date, shade dried, treated with 2 g/kg Bavistin fungicide and kept refrigerated at 4^{o}C until sown. The germination percentage was recorded at 35, 50, 65, 90 and 210 days after sowing (DAS).

Result and discussion

There was no difference on seed germination percent due to maturity stage of fruit on all observation days. However, date of sowing seed has shown significantly different germination percent at 35 DAS and 65 DAS with no difference in result at final count. Moreover, types of nursery bed showed significantly different germination percentage on all observation dates except 90 DAS. Famers could use seed from any maturity stage fruit from 1st September to 1st week of October provided the seeds are kept in 4-8^{0}C condition treating with Bavistin (2g /Kg) if not used immediately after extraction. In case of nursery bed, there was earlier and more germination with NCRP method (tunnel side closed) but seedlings were died due to heat stress within one month of sowing and that was not the problem with Dailekh method (tunnel sides open). There was cold injury symptom with farmer's method three months after sowing seed and plastic tunnels were raised to protect the seedlings during the winter season. The more percentage germination on Farmers' method is due to this reason otherwise Dailekh method is hassle free way of seed sowing. Therefore there is still hope of more than 80% germination with closing tunnel sides for 30 DAS and opening the sides till 90 DAS and closing it until winter ceases (Table 21).

Table 21: Trifoliate seed germination percentage affected by maturity stage, sowing date and nursery bed structure at NCRP Dhankuta in year FY2074/75

Fruit Maturity	*35 DAS*	50 DAS	65 DAS	90 DAS	Final
Full green	25.89	33.92	32.39	38.42	64.81
Full yellow	22.89	32.17	35.03	32.12	67.28
Half yellow	23.19	31.81	35.47	31.33	70.72
Date of Sowing					
1st wk of Oct	28.78	32.78	30.31	34.78	66.36
1st wk of Sept	19.86	29.78	32.36	33.14	67.69
3rd wk of Sept	23.33	35.33	40.22	-	68.75
Nursery Method					
Dailekh	16.36	37.58	40.86	38.92	75.83
Farmer	20.61	31.75	33.00	33.33	80.00
NCRP	35.00	28.56	29.03	29.62	46.97
Mean	**23.99**	**32.63**	**34.30**	**33.96**	**67.60**
P value (Maturity)	**Ns**	**Ns**	**Ns**	**Ns**	**Ns**
(Sowing date)	*****	**Ns**	*****	**Ns**	**Ns**
(Nursery bed)	*******	*****	******	**Ns**	*******
LSD (0.05%)	**6.71**	**7.08**	**7.47**	**9.12**	**7.72**
CV%	**57.81**	**46.37**	**46.58**	**46.62**	**24.41**

3.4.2 Effect of different soil potting mixture on growth and development of grafted saplings of acid lime

The selection of the growing media is one of the most important decisions in growing of seedlings and saplings. The physical, chemical and biological characteristics of the growing media affect seedlings growth and other aspects of nursery operations as well, the purposes of media are to physically support the plant and to supply adequate oxygen, water and nutrient for proper root functions The ideal medium should have the following properties: it must be porous, sterile, light weight, holds sufficient water, consistent in quality and supplies of necessary mineral nutrients, and it should be free of disease organisms, insects, weed seeds and poisonous products. Soil mixtures with different organic residues and compost are used recently as potting mixture.

Methodology

The study was carried out to determine the best suitable soil mixture for growing grafted saplings of acid lime for good growth and development. The experiment was carried out in screen house on NCRP, Dhankuta in 2073/74. Eight to ten months old healthy scions from healthy mother plant were grafted on one year old trifoliate rootstock by splice method and transferred to poly bags (6''x8'') containing different types of soil mixture. Eight different soil mixtures were prepared which are stated below. Ten grafted saplings each for eight different soil mixtures were planted on poly bags. The experiment was designed at completely randomized block design and replicated ten times. Observations on plant height and scion height on different dates were taken. The composition of different soil mixtures are listed below:

T1- Surface soil + Sand + FYM (1:1:1)
T2- Surface soil + Sand (1:1)
T3- Surface soil + Sand + Vermicompost (1:1:1)
T4- Surface soil + Vermicompost (1:1)
T5- Forest soil + Sand (1:1)
T6- Forest soil + Sand + FYM (1:1:1)
T7- Forest soil + Sand + Vermicompost (1:1:1)
T8- Forest soil + Vermicompost (1:1)

Result and discussion

The result revealed that plant height and scion height were statistically significant on different dates.

Plant height

The result revealed that maximum plant height and increase in plant height was obtained from composition of growing of forest soil + sand + FYM (56.50 cm and 35.30 cm

respectively) followed by forest soil + sand + vermicompost (51.70 cm and 32.00 cm respectively). The minimum plant height and increase in plant height was obtained from composition of growing of surface soil + sand (38.50 cm and 17.85 cm respectively) (table 22).

Table 22: Effect of different growing media on plant height of grafted saplings raised at NCRP, Dhankuta in fiscal year 2017/18

Treatment	Initial plant height (cm)	Plant Height (increase in plant height) (cm)				
		12th Baishak	12th Jestha	12th Ashad	12th Shrawan	12th Bhadra
Surface soil + Sand + FMY	23.60	26.80 (3.20)	31.70 (8.10)	40.50 (16.90)	45.30 (21.70)	49.10 (25.50)
Surface soil + Sand	20.65	25.30 (4.65)	27.90 (7.25)	30.00 (9.35)	36.10 (15.45)	38.50 (17.85)
Surface Soil + Sand + Vermicompost	19.80	24.30 (4.50)	27.20 (7.40)	36.00 (16.20)	44.90 (25.10)	48.20 (28.40)
Surface Soil + Vermicompost	20.80	24.60 (3.80)	28.60 (7.80)	39.70 (8.90)	44.00 (23.20)	51.30 (31.00)
Forest Soil + Sand	16.60	23.60 (7.00)	25.80 (9.20)	35.90 (19.20)	42.70 (26.10)	47.00 (30.40)
Forest Soil + Sand + FYM	21.20	27.50 (6.30)	29.10 (7.90)	41.90 (20.70)	47.50 (26.30)	56.50 (35.30)
Forest + Sand + vermicompost	19.70	25.80 (6.10)	27.60 (7.90)	40.50 (20.80)	27.50 (27.80)	51.70 (32.00)
Forest soil + Vermicompost	20.30	25.50 (5.20)	29.70 (9.40)	38.70 (18.40)	44.90 (24.60)	48.80 (28.50)
Mean	20.33	25.43	28.45	37.90	44.11	48.89
P-value		**	**	**	**	**
CV %		14.76	14.27	18.03	21.78	20.12
$LSD_{(0.05)}$		3.35	3.62	6.10	8.58	8.79

Scion height

The result revealed that maximum scion height was obtained from composition of growing of forest soil + sand + FYM (46.60 cm) followed by forest soil + sand + vermicompost (43.30 cm). The minimum plant height and increase in plant height was obtained from composition of growing of surface soil + sand (27.60 cm) (table 23).

Table 23: Effect of different growing media on scion height of grafted saplings raised at NCRP, Dhankuta in fiscal year 2017/18

Treatment	Initial scion height (cm)	Scion Height (cm)				
		Baishak 12	Jestha 12	Asar 12	Shrawan 12	Bhadra 12
Surface soil + Sand + FMY	12.65	15.85	20.75	29.55	34.35	38.15
Surface soil + Sand	9.75	14.40	17.00	18.90	25.20	27.60
Surface Soil + Sand + Vermicompost	9.25	13.75	16.65	25.45	34.35	37.35
Surface Soil + Vermicompost	9.90	13.70	17.70	28.80	33.50	40.40
Forest Soil + Sand	8.00	14.20	16.40	26.50	33.40	37.40
Forest Soil + Sand + FYM	11.30	17.60	19.20	32.00	39.40	46.60
Forest +Sand + vermicompost	11.30	17.40	19.20	32.90	38.10	43.30
Forest soil + Vermicompost	10.00	15.20	19.40	28.40	34.50	38.50
Mean	10.269	15.26	18.29	27.81	34.10	38.66
P-value		**	**	**	**	**
CV %		24.46	22.28	24.67	29.22	26.22
$LSD_{(0.05)}$		3.34	3.64	6.13	8.91	9.06

3.5 CITRUS DECLINE MANAGEMENT

Citrus decline is the foremost threat to the future of citrus industry in Nepal. Unless this problem is managed, citrus will be declined (Roistacher, 1996). It has now been widespread serious threat for mandarin production in almost citrus growing regions of 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.

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

3.5.1 Assessment of citrus decline with rapid method (Scratch method)

Citrus decline caused by Huanglungbing disease is one of the major devastating disease of citrus caused by gram negative, fastidious phloem-restricted bacteria (*Candidatus Liberibacter spp*). The disease was first described in 1929 and first reported in China in 1943. Diseased trees produces bitter, misshapen fruit and the infected plant die within few years of infection. There is reduction in leaf size, presence of interveinal chlorosis that is generally confused with mineral deficiency of zinc, iron and magnesium.

There are many techniques like polymerase chain reaction (PCR), use of monoclonal antibodies, scratch test method to detect greening disease. PCR method is time-consuming and expensive but can detect very low concentration of bacteria in plant tissue. Using monoclonal antibodies are laborious and can take months to screen thousands of trees in citrus orchard. Scratch method is quick, cheap and easy method to detect presence of disease in field level. Scratch method is also called iodine-starch reaction. This method gave 89% accuracy over PCR test (Onuki, et al., 2002). Similarly, a report showed the result varied in between iodine and PCR test by 8.9% and 3% for negative and positive reactions respectively (Hong and Truc, 2003).

Methodology

In total of twenty six different HLB suspected leaves samples were collected in paper envelop from different district such as Sindhuli, Kaski, Bhojpur, Tehrathum, Dhankuta, Ilam, Syanja, Lamjung and Dhading. The collected leaves were tested using the scratch test with a formulation of iodine solution. 120 mesh size sand paper was cut in small rectangles of 1*1/2 inch each. Then it was used to scratch the upper surface of an infected leaf for at least 20 times. Then it was put into small polythene bag (about 3*2 inch) containing 1 ml of distilled water and a drop of iodine solution and left for 2-3 minutes. Then the change in color of solution was noticed to confirm the presence/absence of greening disease. It there is presence of disease the color of solution changed to dark brown-black, whereas in case of absence of disease the color of solution remained yellow-orange. Many of these samples were also sent to NAST lab Khumaltar, Lalitpur for PCR analysis as confirmation test after scratch method test. We are thankful to NCDP, Kritipur for financial assistance to PCR analysis of the samples

Table 24: List of farmers for scratch test for citrus greening disease on the year 2074/75

S.N.	Name of farmer	Address	Result
1	Chuda Raj Sharma	Golonjor-5, Sindhuli	Negative
2	Narayan Kunwar	Golonjor-4, Sindhuli	Negative
3	Krishna Bahadur Thapamagar	Golonjor-4, Sindhuli	Negative
4	Padam Bahadur Thadamagar	Golonjor-4, Sindhuli	Negative
5	Harka Dhoj LImbu	Sabla-1, Tehrathum	Negative
6	Trilochan Luitel	Fachhamara-7, Tehrathum	Negative
7	Sudesh Shrestha	Bhojpur	Negative
8	Bishwo Bandhu Pokhrel	Kristi-11, Kaski	Positive
9	Mitralal Subedi	Kristi-11, Kaski	Negative
10	Loknath Subedi	Kristi-11, Kaski	Negative
11	Thakur Prasad Subedi	Kristi-11, Kaski	Negative
12	Iswori Subedi	Kristi-11, Kaski	Negative
13	Ghanashyam Poudel	Nirmal pokhari, Kaski	Positive

S.N.	Name of farmer	Address	Result
14	Kul Prasad Parajuli	Nirmal pokhari, Kaski	Positive
15	Om Prasad Poudel	Nirmal pokhari, Kaski	Positive
16	Ashok Basnet	Godak, Ilam	Positive
17	Dhana Bahadur Limbu	Maunabudhuk, Dhankuta	Negative
18	Kausila Limbu	Maunabudhuk, Dhankuta	Negative
19	Goma Panta	Syaut-11, Lamjung	Negative
20	Tilak Panta	Besisahar-1, Lamjung	Negative
21	Fani Prasad Aryal	Bhirkot-7, Syajna	Negative
22	Tara Prasad Aryal	Bhirkot-7, Syajna	Negative
23	Bodhraj Aryal	Mayatari-11, Syanja	Negative
24	Nil Kantha Poudel	Syardul-6, Dhading	Positive
25	Kiran Baral	Syardul-6, Dhading	Positive
26	Bhakta Bahadur Baral	Syardul-6, Dhading	Positive

3.5.2 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 2 years to control spreading of 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.
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.

3.5.3 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 2074/75 to meet the following objective:

- To revive the declined mandarin 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. 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 Copper-oxychloride @ 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.

Data on disease incidence and yield attributing characteristics will be taken and analyzed.

3.5.4 Sustainable management of citrus orchard through nutrient management

Citrus are perennial commodities. 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 yield 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.

3.5.4.1 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 2074/75. 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

Fruit weight of ten fruits

Fruit weight of ten fruits varied from 831.30 g to 1008.00 g with mean value of 942.85 g. The highest fruit weight of ten fruits was obtained from treatment FYM 75 kg + Urea 400 g + DAP 200 g + Potash 400 g (1008.00 g) 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 (995 g). In contrast, lowest fruit weight of ten fruits was obtained from treatment FYM 100 kg/tree (831.30 g) (Table 25).

Average fruit weight

The average fruit weight varied from 79.08 g to 98.34 g with the mean value of 90.60 g. The highest average fruit weight was obtained from treatment FYM 100 kg + Micronutrient spray (98.34 g) followed by 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 (92.16 g). The lowest average fruit weight was obtained from treatment FYM 100 kg/tree (79.08 g) (table 25).

Fruit diameter

The fruit diameter ranged from 57.31 mm to 60.79 mm with the mean value of 58.96 mm. The highest fruit diameter was recorded from treatment FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g (60.79 mm) 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 (59.51 mm). The lowest fruit diameter was recorded from treatment FYM 100 kg + Micronutrient spray (57.31 mm) (table 25).

Fruit rind weight

The fruit rind weight was found varying from 17.51 g to 21.47 g with the mean value of 20.43 g. The highest fruit rind weight was obtained from treatment FYM 100 kg + Micronutrient spray (21.47 g) followed by 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 (21.31 g). In contrast, lowest fruit weight was recorded from treatment FYM 100 kg/tree (17.51 g) (table 25).

Juice volume

The juice volume ranged from 35.55 ml to 47.60 ml with the mean value of 42.39 ml. The highest juice volume was obtained from treatment FYM 100 kg + Micronutrient spray (47.60 ml) 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 (45.65 ml). The lowest juice volume was recorded from treatment FYM 100 kg/tree (35.55 ml) (table 25).

Table 25: Effect of different treatments on fruit weight of ten fruits, average fruit weight, fruit diameter, fruit rind weight and juice volume on the year 2074/75

Treatments	Fruit weight (10 fruits) (g)	Average Fruit weight (g)	Fruit diameter (mm)	Fruit rind weight (g)	Juice volume (ml)
T1: FYM 100 kg/tree	831.30	79.08	59.10	17.51	35.55
T2: FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g	1008.00	91.70	60.79	20.89	43.95
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	940.00	92.16	58.10	21.31	39.20
T4: FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	995.00	91.52	59.51	20.99	45.65
T5: FYM 100 kg + Micronutrient spray	940.50	98.34	57.31	21.47	47.60
Mean	942.85	90.60	58.96	20.43	42.39
P-value	**	NS	NS	NS	NS
CV %	10.47	20.72	11.04	19.74	24.46
LSD(0.05)	152.10	28.83	10.03	6.21	15.97

Total fruit weight of grade A

The total fruit weight of grade A ranged from 7.75 kg to 25.75 kg with the average value of 16.40 kg. The maximum fruit weight of grade A 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 (25.75 kg) followed by treatment FYM 100 kg + Micronutrient spray (21.00 kg). In contrast, minimum fruit weight of grade A was obtained from FYM 100 kg/tree (7.75 kg) (Table 26).

Total fruit weight of grade B

The total fruit weight of grade B ranged from 16.00 kg to 22.50 kg with the mean value of 19.70 kg. The maximum fruit weight of grade B was obtained from treatment FYM 100 kg + Micronutrient spray (22.50 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 (21.25 kg). The minimum fruit weight of grade B was obtained from treatment FYM 100 kg/tree (16.00 kg) (Table 26).

Total fruit weight of grade C

The total fruit weight of grade C varied from 18.92 kg to 20.51 kg with the mean value of 19.60 kg. The maximum fruit weight of grade C 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 (20.51 kg) followed by 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 (19.82 kg). The minimum fruit weight of grade C was obtained from treatment FYM 100 kg + Micronutrient spray (18.92 kg) (Table 26).

Total number of fruits per plant

The total number of fruits per plant ranged from 898.75 to 1288.75 with mean value of 1052.95. 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 (1288.75) 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 (1119.75). The lowest number of fruits per plant was recorded from treatment FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g (898.75) (table 26).

Total fruit yield per plant

The total fruit yield per plant ranged from 43.55 kg to 66.82 kg with the mean value of 55.75 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 (66.82 kg) followed by FYM 100 kg + Micronutrient spray (62.42 kg). The lowest fruit yield per plant was obtained from treatment FYM 100 kg/tree (43.55 kg) (table 26).

Table 26: 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 2074/75

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	7.75	16.00	19.80	942.50	43.55
T2: FYM 75 Kg + Urea 400 g + DAP 200 g + Potash 400 g	14.25	20.00	18.97	898.75	53.22
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	25.75	21.25	19.82	1288.75	66.82
T4: FYM 75 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	13.25	18.75	20.51	1119.75	52.51
T5: FYM 100 kg + Micronutrient spray	21.00	22.50	18.92	1015.00	62.42
Mean	16.40	19.70	19.60	1052.95	55.75
P-value	NS	NS	NS	NS	NS
CV %	78.25	59.18	60.70	58.05	50.09
LSD(0.05)	19.77	17.96	18.33	941.70	43.02

3.5.4.2 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 27 illustrates that average fruit weight, fruit diameter, fruit rind weight and juice volume were statistically significant.

Weight of ten fruits

The weight of ten fruits ranged from 775.00 g to 995.00 g with mean value of 833.50 g. The maximum weight was obtained from treatment Potash 500 g + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (995.00 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 (802.50 g) and FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g (802.50 g). The minimum weight of ten fruits was obtained from treatment FYM 150 g + Micro-nutrient spray (775.00 g) (Table 27).

Average fruit weight

The average fruit weight was found statistically significant varying range from 69.63 g to 96.00 g with mean value of 78.72 g. The maximum fruit weight was obtained 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 (96.00 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 (80.80 g). In contrast, the minimum fruit weight was found with treatment FYM 150 kg/tree (69.63 g) (Table 27).

Fruit diameter

The fruit diameter was found significant varying range from 53.49 mm to 59.36 mm with mean value of 56.30 mm. The maximum fruit diameter was obtained 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 (59.36 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 (57.09 mm). The minimum fruit diameter was recorded from treatment FYM 150 kg/tree (53.49 m) (Table 27).

Fruit rind weight

The fruit rind weight was found significant varying range from 16.98 g to 24.89 g with mean value of 19.84 g. The highest fruit rind weight was obtained 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 (24.89 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 (19.77 g). The minimum fruit rind weight was obtained from treatment FYM 150 kg/tree (16.98 g) (Table 27).

Juice volume

The juice volume was found significant varying range from 30.15 ml to 39.65 ml with the mean value of 34.25 ml. The maximum 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 (39.65 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 (36.35 ml). In contrast, the lowest juice volume was recorded from treatment FYM 150 kg/tree (30.15 ml) (Table 27).

Table 27: 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	792.50	69.63	53.49	16.98	30.15
T2: FYM 100 kg + Urea 500 g + DAP 250 g + Potash 500 g	802.50	74.92	55.77	18.85	33.50
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	995.00	96.00	59.36	24.89	39.65
T4: FYM 100 kg + Boric acid 20 g + Zinc sulphate 150 g + Copper sulphate 75 g + Manganese sulphate 75 g + Agri-lime 150 g	802.50	80.80	57.09	19.77	36.35
T5: FYM 150 g + Micro-nutrient spray	775.00	72.26	55.78	18.73	31.60
Mean	833.50	78.72	56.30	19.84	34.25
P-value	NS	**	**	**	**
CV %	16.03	14.62	3.76	14.57	16.08
LSD(0.05)	205.90	17.73	4.34	4.45	8.49

3.6 FRUIT FLY MANAGEMENT

Citrus fruit drop caused by at least 3 species of fruit flies are becoming treat to sweet orange, acid lime and mandarin orange production in mid hills of Nepal. To identify these pest activities in eastern hills a surveillance study was carried out setting 3 kinds pheromone (methyl eugenol, Cue lure and protein bait) traps in four districts (Dhankuta, Terhthum Bhojpur and Sindhuli) in the farmer's orchards at different altitudes. The surveillance data on Bhojpur and Sindhuli are not available due to some technical issues. This study found that there were no severe infestation of *B. minax* (Chinese fruit fly) in

both districts in the protein bait trap. However, *B. tau*, *B. zonata* and *B. scutellaris* were found as predominant insects causing fruit drop in citrus orchards in those two orchards. Heavy trapping of the three B. tau, B. zonata and B. scutellaris species were recorded in Dhankuta district.

The results are shown in graphs below:

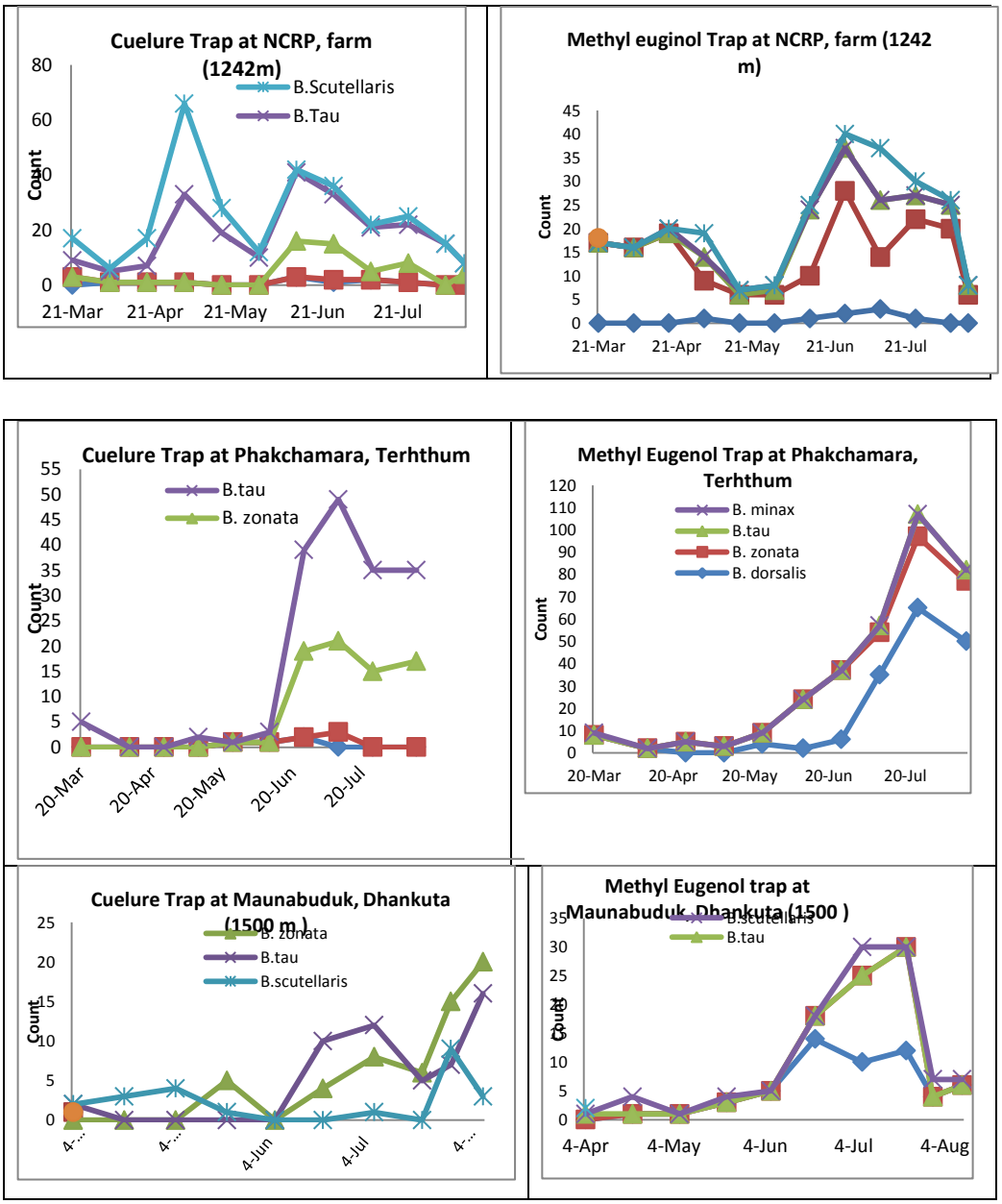

Fig 6. Surveillance of fruit flies causing citrus fruit drop in eastern hills in 2017/18

3.7. Program on Prime Minister Agricultural Modernization Program at Junar Super zone Sindhuli

3.7.1. Status of Sweet Orange Production in Sindhuli and Ramechhap District

3.7.1.1. Focus Group Discussion in Sindhuli

Focus group discussion was held in Khaniya Kharka, Sindhuli on 2074-7-29 in a group of 15 farmers who had their own orchards of sweet orange (Junar) and actively involved in the farming. A multidisciplinary team of scientists comprising a socio-economist, a pomologist and a plant pathologist interacted with the farmers by using a checklist.The team also visited different villages including Ratanchura and Jalkanya to observe orchards having fruit drop problem caused by fruit fly. In Sindhuli district, the total area of sweet orange was reported as 1381 hectare whereas that of mandarin was reported as 619 hectares. Total estimated production of sweet orange in the district was 8200 ton per annum which showed low average yield of fruits i.e. 5.94 ton per hectare. The estimated annual revenue from sweet orange was Rs. 28 crore during last fiscal year i.e. 2073/74. Market promotion activities were carried out by an organization having 34 members from Sindhuli district and 13 members from Ramechhap district. In a query on the area under sweet orange, whether it was increasing or decreasing for last five years, farmers responded that the area was increasing.

Farmers had practical options to sell their fruit produce either directly to the consumers in local market or sell to the traders or intermediaries. The marketing practice of individual farmer depends upon various factors like availability of family labor, market distance, road access etc. About 10 percent farmers used to sell their produce in nearby market whereas 60 percent farmers used to sell through contractual arrangement with local traders. Rest 30 percent farmers used to sell their produce to local cooperatives engaged in juice production and packaging. Although the area under sweet orange was increasing for last five years, farmers reported that the fruit yield per tree was declining mainly due to fruit fly problem. The fruit production was also affected by other insects like scale, and bug. Harmful diseases in sweet orange were reported as sooty mold, powdery mildew, foot rot, gummosis and citrus canker. Prime Minister Agriculture Modernization Project (PMAMP) was supporting the sweet orange farmers through research and development programs since the start of fiscal year 2074/75 by declaring the area as sweet orange super zone. However, different projects were launched from time to time in the past to support the sweet orange production in Sindhuli and Ramechhap. Farmers were still receiving some technical support from concerned District Agriculture Development Office (DADO).

Most of the sweet orange area in Sindhuli had mild acidic soil having pH 6 whereas a few areas (in Basheswor) had acidic soil having pH 5. Bhubaneswori area had mild alkaline soil having pH 7. Sweet orange farmers were facing a short of expert human resources to facilitate them in the context of shifting agricultural technicians from DADO to local government bodies although a few local resource persons at junior level were working in the villages. In a query on probable marketing problem of sweet orange if its area and production would be enhanced in the future, farmers responded that there would be no marketing problem since the consumer demand was rising every year. There were four processing centers of sweet orange with rural road network in the district. The processing centers used to produce juice, squash, jam, marmalade, and candy and mostly sell in local market. Some farmers used to store their fruit produces in cold storages like Himalayan Bikri Sheet Bhandar and Sindhuli Junar Utpadak Bikri Sheet Bhandar. The later cold storage was established with the financial contribution of JICA (60%) and local farmers (40%). Its storage capacity was 500 m ton however, only 250 m ton sweet orange was used to store. Farmers used to pay Rs 3.0 per kg fruits per season for cold storage.

There were merely 1-2% farmers who used to take loan from bank for sweet orange farming and its related enterprises. Farmers had made effort for insurance to safeguard their investment in orchard but did not get success due to differences of interest with insurance company. The insurance company was interested to insure the whole trees and orchards whereas farmers' interest was to insure only the fruit produce.

Farmers were also facing some problems related to existing government policies. The policy related problems were (1) transfer of experienced technical staff of government in short time (2) relatively low priority of government towards sweet orange as compared to the priority towards rice wheat even in the altitude of 800-1400 meter (3) less priority of government towards enhancing irrigation facility in the hills (4) inadequate road network in farm villages (5) lack of policy to use community forest for sweet orange farming by private farmers

Farmers' major expectations from research sector were (1) effective control measures of fruit fly (minax) (2) verification of suitability of sweet orange production in altitude of 800- 1400 meter (3) quality test of local sweet orange in different storage conditions (4) studies on post harvest processing and technology development (5) studies on off season flowering in sweet orange

3.7.1.2. Focus Group Discussion in Ramechhap

Focused Group Discussion was held in Bhalukhop, Okhreni in a group of 12 farmers in presence of DADO, Ramechhap on 2074-7-30. A multidisciplinary team of scientists comprising a socio-economist, a pomologist and a plant pathologist interacted with the

farmers by using a checklist. The team visited several villages including Bhangeri, Golmatar and Okhreni to observe the fruit drop problem caused by fruit fly. Major locations of sweet orange production were Ramechhap, Manthali, Sunapati, Likhu, Horamba, and Fulapi. The total area of sweet orange orchard in the district was reported as 1100 hectares. The marketing network was fairly efficient within the district however, about 25-30% of total fruit produce used to export to Kathmandu, Birgunj and Janakpur. Three processing centers for squash making were established under cooperatives, one of them had financial support from MEDEP (Micro Enterprise Development Project). The area under sweet orange was found increasing in last five years with the increase in production and productivity. However, fruit loss was a serious problem caused by fruit fly. The other insects like scale, leaf minor, bug, and aphid also affect the fruit production. The major stakeholders in sweet orange production, marketing and post harvest business were Poverty Alleviation Project (PAF), PMAMP and MEDEP. The existing support from technical staff of government was reported less as compared to past.

Farmers did not have knowledge on soil status of their orchard although the sample was taken away for testing. Farmers had expectation for more support from technical staff when they would shift to local government body. Farmers responded that market demand would rise with increase in area and production of sweet orange in future. There was a functional cold storage established with the support of APPSP in the past. Farmers had not taken loan for the purpose of commercial production of sweet orange. There was no insurance practice for safeguarding their investment in fruit orchard. Farmers demanded for stringent policy to ban selling of immature fruit in the market rather these fruits could be used for production of wine, vinegar etc.

Farmers' expectations from research sector were (1) control measures of fruit drop caused by fruit fly (2) technology for healthy sapling production (2) system development for bud wood certification in order to have healthy saplings.

3.7.1.3. Household survey in Sindhuli and Ramechhap

Sample households

One hundred twenty-two households were surveyed in two districts using a semi structured questionnaire. Randomly selected 60 respondents from Sindhuli and 62 respondents from Ramechhap were interviewed. Out of 122 respondents, 81.97% were male and 18.03% were female. Among them 85.25% had studied below class 10 level, 12.2% had studied college level and 2.46% had higher degree. The age of junar growing farmers ranged from 21 to 72 years. The junar farming had not attracted new generation as the average age of farmers in Sindhuli and Ramechhap was 47 and 51 years, respectively.

Orchard situation

Most of the sweet orange orchards in survey area (54.1%) was east facing followed by north facing (27.87%). The situation was similar in Sindhuli district (66.7%) facing east, while in Ramechhap district the most orchards were facing north (45.2%) followed by east (41.9%). Ramechhap district, being in rainshadow area, north facing orchards were obvious due to less sun shine on that face which helps retain more moisture required for junar cultivation. The average age of orchard in Sindhuli was 17.5 years while that was 23 in Ramechhap with a range 1-45 years old in both districts.

Table 28 . Aspect of orchards in survey area (%)

Aspect	Sindhuli	Ramechhap	Total
East	66.7	41.9	54.1
West	16.7	11.3	13.93
North	10	45.2	27.87
South	1.7	-	0.82
Mixed	5	-	3.28

Most of the orchard area had loamy type soil in Sindhuli (56.67%) and Ramechhap (87.1%). A significant area in Sindhuli had sandy type (15%) and clay type (13.3%).

Table 29. Soil type in survey area (%)

Soil type	Sindhuli	Ramechhap	Total
Loamy	56.67	87.1	72.13
Sandy	15	1.61	8.2
Clay	13.3	8.84	9.02
Others	15	6.45	10.66

Planting material

There was issue with quality planting materials in survey area as most of them were from nearby nurseries (Table 30). Mostly the planting materials were of seedling type rather than grafted ones resulting old age orchard of nearly 50 years in the surveyed area. Further, all of these seedlings were from local cultivar with only a few exceptional cases.

Table 30. Source of planting material used (%)

Type	Sindhuli	Ramechhap	Total
Own source	15	1.6	8.2
Nearby nursery	81.7	83.9	82.79
Nursery form another district	0	1.6	0.82
Government farm	1.7	6.4	4.1
No idea	1.7	6.4	4.1

In Ramechhap, about one-fourth orchards were established with purely seedlings whereas in Ramechhap, very few orchards were established with purely grafted saplings. Most of the orchards had both type saplings in Sindhuli and Ramechhap (Table 31).

Table 31 .Planting materials used in surveyed area (%)

Type	Sindhuli	Rammechhap	Both
Seedlings	0	24	12.3
Grafted	5	0	2.5
Both	85	76	80.3
Don't know	10	0	4.9

Cultivation practice

Most of the citrus orchards were grown in rainfed condition especially in Ramechhap district (Table 32). Sindhuli district was more resourceful in terms of irrigation facilty than Ramechhap. Farmers in Sindhuli used to irrigate up to six times during the required season. Small farm canal and polythene pipes were the most common irrigating methods in Sindhuli.

Junar farmers were well aware about the importance of training and pruning of citrus tree for healthy management of their orchards. Eighty nine percent farmers from both disticts were found following pruning practice during December-January (Table).

In both districts, farmers used to apply FYM as main source of fertilizer, which was mostly taken up by intercrops rather than main junar crop. Most of the faremrs had followed intercropping prcatice in their orchard (Fig 7). Negligible amount of chemical fertilizers (urea, DAP and Potash) used to applied by farmers in both districts. The amount of applied chemical fertilizer was far below national recommendation. Farmers in both districts were cultivating a number of crops as intercrops irrespective of the age

of orchards. Mostly cereal crops were used as intercrops (50%, Fig.7) which could not be recommended to cultivate in the citrus orchard.

More than ninety percent orchards had irrigation facility in Sindhuli whereas only one-fifth orchards had such faciltiy in Ramechhap (Table 32).

Table 32. Irrigagion facility in surveyed households (%)

Facility	Sindhuli	Ramechhap	Total
Yes	91.7	22.6	56.56
No	8.3	77.4	43.44

In Sindhuli, about half of the households use to irrigate only one time whereas one-fourth households use to irrigate two times per season. A few households use to irrigate their orchards up to six times per season. In Ramechhap, only a few households had irrigation facility and they use to irrigate their orchards up to two times per season (Table 33). Less number of irrigation is attributed by water shortage in the area. Rainwater harvest could be a best way for irrigation in such area.

Table 33. Irrigation frequency (%) provided in sweet orange orchards in survey area

Time	Sindhuli	Ramechhap	Total
0	8.3	77.4	43.44
1	51.7	6.4	28.69
2	26.7	11.3	18.85
3	1.7	-	0.82
4	5	-	2.46
6	5	-	2.46
When needed	1.7	4.8	0.82

In Sindhuli, one-third households were using farm canal and a similar percentage was using polypipes for irrigation (Table 34). Some of them had plastic ponds for water storage to irrigate as and when needed. In Ramechhap, some households were using polypipes whereas a few households had plastic ponds.

Table 34. Methods of irrigation (%) used for sweet orange orchard in survey area

Method	Sindhuli	Ramechhap	Total
Rainfed	8.3	77.4	42.6
Farm canal	33.3	-	16.4
Polypipes	30.3	14.5	22.1
Plastic ponds	15	8.1	11.5
Mix method	5	-	2.5

Others	8.1	-	4.9

For manuring in orchard, about ninety percent households used to apply sole FYM in both districts. Application of sole FYM could not fulfill the nutritional requirement of fruit trees. Very few percent households used to apply both FYM and chemical fertilizer (Table 35). It showed that farmers were not aware about proper nutritional management which was most important for healthy orchard.

Table 35. Type of fertilizer use (%) in sweet orange in survey area

Type	Sindhuli	Ramechhap	Total
FYM only	91.7	87	89.34
Chemical only	1.7	-	9.84
Both	6.7	13	0.82

About ninety five percent farmers in both districts had followed intercropping prcatice in their orchard (Table 36). Most common intercrop was cereal crop which had obviously negative impact on the junar trees.

Table 36. Intercropping practices in survey area

Intercropping	Sindhuli	Ramechhap	Both
Yes	98.3	93.5	95.9
No	1.7	6.4	4.1

Application of FYM was very less in quantity as compared to the age of fruit trees which were more than 10 years old. Similarly, use of chemical fertilizer was negligible as compared to the requirement. The recommended dose of FYM, urea, DAP, Potash was 100 kg, 0.883 kg, 0.521 kg, and 0.583 kg respectively for a ten year old tree. The table.. shows that FYM application amount was about one-fourth of the requirement whereas the chemical fertilizer application amount was negligible.

Table 37. Amount of fertilzer used in survey area (Kg/tree/year)

Particular	FYM	Urea	DAP	Potash
Sindhuli	34.8	0.07	0.12	0.07
Ramechhap	22.6	0.03	0.05	0.01
Average	28.6	0.05	0.08	0.04

Most of the orchards had cereal crops as intercrop resulting negative effects on fruit trees. Some orchards had vegetables as intercrop and some other orchards had a crop

rotation of cereal – legume. A few orchards had cereal – legume and other few had cereal – vegetables as intercrops. Very few orchards had sole fruit trees without intercrop (Fig. 7).

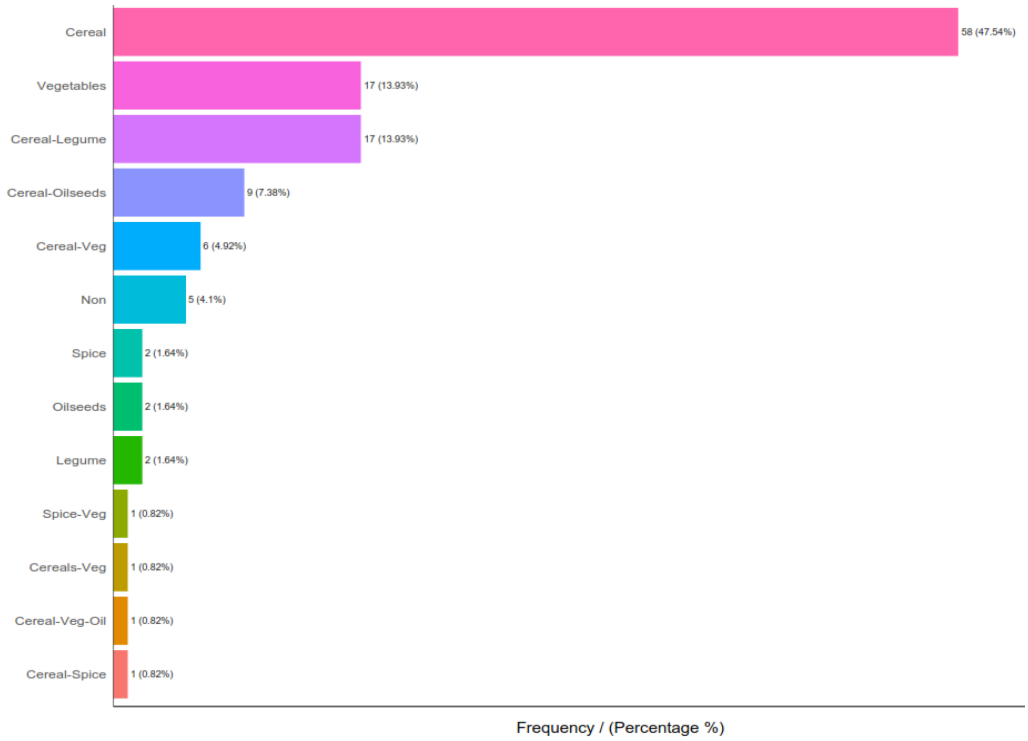

Fig 7: Percentage household intercropping various crops in sweet orange orchard

Post-harvest practice

Farmers used to start harvesting fruit as early from Kartik month and the harvesting lasts untill late Paush. Mostly fruits were hand picked leaving fruit stalk intact (Table 38). About one-fifth farmers were using clipper to pick the fruit. The fruits were then carried to the nearby collection center or storage facilty using traditional bamboo basket (doko) followed by jute or plastic sacks (Table 39). These doko and sacks are the post harvest loss inducing means of transportation as there would be more physical damage caused by bruising and compaction of fruits.

Table 38 Harvesting way in survey area(%)

Harvesting	Sindhuli	Ramechhap	Both
With stalk	91.7	90.3	91
Without stalk	8.3	9.7	9

More than ninety percent farmers in Sindhuli had practice of hand picking whereas thirty nine percent farmers in Ramechhap were using clippers for fruit harvesting (Table 39).

Table 39. Harvesting means used in survey area (%)

Harvesting	Sindhuli	Ramechhap	Both
By hand	93.4	61	77.05
By clipper	5	39	22.13
Both	1.6	0	0.82

Although there was a substantial loss of fruits while using bamboo basket (doko) or other sacks, farmers were using the same for transportation. Only five percent farmers in Sindhuli were using plastic crates which could make minimum loss of fruits (Table 40).

Table 40. Methods of transporting fruit to market at survey area (%)

Means	Sindhuli	Ramechhap	Both
Bamboo basket (Doko)	88.3	34	60.66
Jute Sacks	1.7	66	34.43
Plastic crates	5	0	2.46
Doko and Sacks	3.4	0	1.64
Other	1.7	0	0.82

Production and marketing

The survey results showed that the productivity of Ramechhap district was higer (5952 kg/ha) than Sindhuli district (4942 kg/ha) (Fig 8). In Ramechhap, the productivity of sweet orange ranged from 445 – 20040 kg/ha, while that ranged from 41-17985 kg/ha in Sindhuli district. Farmers were earning from as low as NRs 500 to as high as 170000/- per year in both districts. Farmers get as low as NRs.35/kg of sweet orange at farm gate and 60/kg at the market while the consumer price ranges around 80-150/kg in retail shop. About two third of the farmers sell their produce to the local traders at farm gate, while one third do contract selling and negligible number of farmers go for retail selling at the market. About 3% farmers had stored fruit produce for late season sale. However, only one farmer at Sindhuli had his own cellar storage facility accomodating one ton quantity of fruit. Only 4% (5) farmers from both districts had idea about post-harvest processing products of junar and they used to prepare jam, squash, jelly and wine from the junar fruit.

Table 41. Fruit selling ways in surveyed area (%)

Method	Sindhuli	Ramechhap	Average
Self-selling at farm	72.4	54.1	63.03
Contractor selling	13.8	42.6	28.57
Middle man selling	6.9	1.6	4.2
Self-selling at Market	5.2	1.6	3.36
Storage	1.7	0	0.84

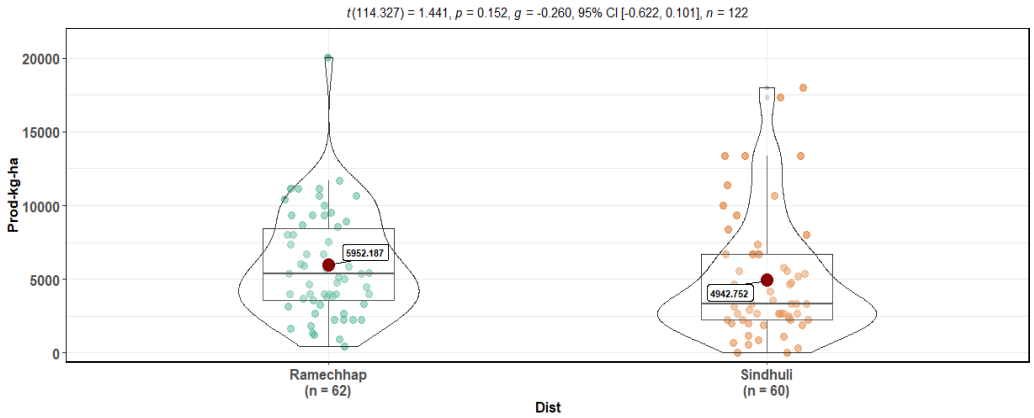

Fig 8: Sweet orange yield (Kg/ha) differences in two surveyed districts

Preference ranking of production issues and farmers need

Preferencial index ranking was carried out (using formula below) to find out important diseases, insects and production issues by assigning scale value of 1-5 based on priorities set by the 122 respondents.

Preferencial ranking index, $I_{imp} = \Sigma (S_i \times f_i/N)$

Where, I_{imp} = Index of importance
S_i= scale value
N= No. of respondents
f_i= Frequency of importance given by respondents

Regarding the diseases, powdery mildew accorded the highest index value of 0.93 followed by Sooty mold (0.30) and root rot (0.18). In case of insects, fruit fly was the number one trouble with index value of 0.73 followed by green stink bug (0.71), scale

insect (0.23) and leaf minor (0.01). When the respondents were asked for their need to improve the junar production in the surveyed area, the preferencial index ranking for irrigation system obtained the highest value (0.83) followed by quality sapling (0.42), availability of qualified technician (0.29), access to market (0.08), subsidy (0.07), availability of pesticide (0.06), technical knowhow/training (0.06), road (0.01) and storage facility (0.01).

Recommendations

Based on existing problems and constraints of sweet orange production in Sindhuli and Ramechhap, major recommendations are listed as follows:

1) As most of the orchards did not have irrigation facility, rainwater harvest could be a best way for assured irrigation. Prime Minister Agriculture Modernization Project (PMAMP) for Junar Super Zone could take initiative in this regard.
2) Most of the orchards had deficiency of nutrition. Much awareness is needed to apply recommended dose of both organic and chemical fertilizer based on the age of fruit trees.
3) Fruit drop caused by fruit fly was a common problem that resulted great loss in fruit production. To cope with this insect area wide pest management approach is essential in order to follow control measures such as using protein baits in orchards, collection and burying of infected fruits in mass scale.
4) Farmers had temptation for early harvest and quick sale in the market to escape from fruit drop and rot in the field. This practice was not a solution but it would further aggravate the fruit fly problem in next season since the larvae would easily hibernate in the field. There should be mass commitment among farmers that no one would sale his or her fruit produce until it would get maturity.
5) Awareness about suitable crops for intercropping is needed. Most of the orchards had cereal crops as intercrop which had negeative effect on junar trees.
6) Healthy sapling production and distribution of early, mid and late season cultivars need to be promoted.

3.8. Multi-locations (Collaborative) Trial

3.8.1 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 2017. 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, 2016: 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 and applied first at 30 days after planting and remaining half dose of nitrogen and half dose of potash at 60 days after planting. Weeding was done twice: first at 45 days after rhizome planting and second at 70 days after rhizome planting. Earthing up was given at 140 days after rhizome planting. Fresh rhizomes were harvested at 232 days after 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 64.03 cm to 77.08 cm with mean plant height of 70.86 cm. The highest plant was recorded from genotype Kapurkot-1 (77.08 cm) followed by genotype ZI 1007 (75.26 cm). The lowest plant height was recorded from genotype ZI 1302 (64.03 cm) (Table 42).

Number of tillers per clump

The number of tillers per clump was found varying from 6.53 to 12.93 with mean value of 8.95. The highest number of tillers per clump was found in genotype Kapurkot-1 (12.93) followed by genotype ZI 13.03 (11.89). The lowest number of tillers per clump was found in genotype ZI 1302 (6.53) (Table 42).

Length of primary finger

The length of primary finger ranged from 3.68 cm to 5.42 cm with mean value of 4.23 cm. The highest length of primary finger was recorded from genotype ZI 1303 (5.42 cm)

followed by genotype ZI 1027 (4.58 cm). The lowest length of primary finger was recorded from genotype ZI 1025 (3.68 m) (Table 42).

Length of secondary finger

The length of secondary finger ranged from 6.68 cm to 9.03 cm with mean value of 7.69 cm. The highest length of secondary finger was recorded from genotype ZI 1027 (3.03 cm) followed by genotype ZI 1303 (8.22 cm). The lowest length of secondary finger was recorded from genotype ZI 1010 (6.68 cm) (Table 42).

Fresh rhizome yield

The yield of fresh rhizome ranged from 17.16 t/ha to 25.18 t/ha with mean fresh rhizome yield of 21.47 t/ha. The highest fresh rhizome yield was recorded from genotype ZI 1303 (25.18 t/ha) followed by Kapurkot-1 (24.20 t/ha). The lowest fresh rhizome yield was recorded from genotype ZI 1302 (17.16 t/ha) (Table 42).

Dry ginger recovery %

The dry ginger recovery % ranged from 21.17 % to 22.00 % with mean DGR % of 21.61 %. The maximum DGR % was recorded from genotype ZI 1010 (22.00 %) followed by genotypes ZI 1303 (21.83 %) and Kapurkot-1 (21.83 %). The lowest DGR % was recorded from genotype ZI 1025 (21.17 %) (Table 42).

Table 42: Performance of eight genotypes of ginger tested under Coordinated Varietal Trial in the field of NCRP, Pariptle, Dhankuta in 2017

Genotypes	Plant height (cm)	No. of Tillers per clump	Length of finger (cm)		Fresh rhizome yield (t/ha)	DGR %
			Primary	Secondary		
ZI 1010	68.00	7.87	3.90	6.68	20.90	22.00
ZI 1303	73.82	11.89	5.42	8.22	25.18	21.83
ZI 1302	64.03	6.53	4.00	7.59	17.16	21.50
Local	74.07	7.42	4.27	7.65	17.30	21.23
ZI 1007	75.26	8.60	4.23	7.30	22.69	21.77
Kapurkot-1	77.08	12.93	3.75	7.67	24.27	21.83
ZI 1025	65.42	7.00	3.68	7.36	19.89	21.17
ZI 1027	69.19	9.33	4.58	9.03	24.20	21.50
Mean	**70.86**	**8.95**	**4.23**	**7.69**	**21.47**	**21.61**
P-value	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV%	**14.16**	**67.41**	**17.67**	**12.27**	**37.37**	**4.24**
LSD	**17.57**	**11.74**	**1.31**	**1.65**	**14.05**	**1.61**

3.8.2 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

Eight genotypes of turmeric were obtained from National Ginger Research Program (NGRP), Salyan in 2017. 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, 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 after planting day. Experimental data *viz.*, Plant height, number of tillers per clump, length of primary and secondary fingers, fresh 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 number

The plant number varied from 26.00 to 28.00 with mean final plant number of 27.00. The highest final plant number was recorded from genotype CI 0210 (28.00) followed by genotype CI 0507 (27.67). The lowest final plant number was recorded from genotypes CI 0205 and CI 9102 (26.00) (Table 43).

Plant height

Plant height varied from 67.96 cm to 79.53 cm with mean plant height of 74.44 cm. The highest plan height was recorded from genotype CI 9102 (79.53 cm) followed by CI 0210 (75.80 cm). The lowest plant height was recorded from genotype CI 0503 (67.96 cm) (Table 43).

Number of tillers per clump

The number of tillers per clump ranged from 2.19 to 2.63 with mean value of 2.39. The highest number of tillers per clump was obtained from genotype CI 0205 (2.63) followed by CI 9102 (2.46). The lowest number of tillers per clump was recorded from genotype CI 0210 (2.19) (Table 43).

Length of primary finger

The length of primary finger ranged from 4.23 cm to 4.84cm with mean value of 4.60 cm. The highest length of primary finger was recorded from genotype KK1 (4.84 cm) followed by CI 9102 (4.82 cm). The lowest length of primary tillers was recorded from genotype CI 0205 (4.23 cm).

Length of secondary finger

The length of secondary finger ranged from 7.36 cm to 9.42 cm with mean value of 8.10 cm. The highest length of secondary finger was recorded from genotype CI 0207 (9.42 cm) followed by CI 0507 (8.85 cm). The lowest length of secondary tillers was recorded from genotype CI 9102 (7.36 cm).

Table 43: Performance of eight genotypes of turmeric tested under coordinated varietal trial in Dhankuta in 2017

Genotypes	Plant number		Plant height (cm)	No. of Tillers per clump	Length of finger (cm)	
	Initial	Final			Primary	Secondary
CI 0207	30	27.33	72.16	2.37	4.63	9.42
KK1	30	27.33	75.49	2.31	4.84	7.53
CI 0205	30	26.00	73.57	2.63	4.23	7.37
CI 9102	30	26.00	79.53	2.46	4.82	7.36
CI 1312	30	26.67	74.56	2.32	4.55	7.43
CI 0503	30	27.00	67.96	2.40	4.52	8.38
CI 0507	30	27.67	76.42	2.40	4.69	8.85
CI 0210	30	28.00	75.80	2.19	4.53	8.42
Mean		**27.00**	**74.44**	**2.39**	**4.60**	**8.10**
P-value		**NS**	**NS**	**NS**	**NS**	**NS**
CV%		**7.79**	**11.24**	**19.40**	**13.88**	**13.94**
LSD		**3.68**	**16.65**	**0.81**	**1.12**	**1.98**

Fresh rhizome yield/ha

The fresh rhizome yield was found significantly different varying range from 5.61 t/ha to 14.73 t/ha with average yield of 9.68 t/ha. The maximum fresh rhizome yield was obtained from genotype CI 0507 (14.73 t/ha) followed by CI 0210 (11.54 t/ha). The minimum fresh rhizome yield was obtained from genotype CI 0503 (5.61 t/ha) (Table 44).

Weight of dry slice per kg sample

The weight of dry slice per kg sample varied from 108.61 g to 129.28 g with mean value of 118.65 g. The maximum weight of dry slice per kg sample was obtained from genotype KK1(129.28 g) followed by CI 0507 (122.11 g). The loe=west weight of dry slice per kg sample was obtained from genotype CI 1312 (108.61 g) (Table 44).

Weight of dry powder per kg sample

The weight of dry powder per kg sample varied from 108.20 g to 128.53 g with mean value of 118.39 g. The maximum weight of dry slice per kg sample was obtained from genotype KK1 (128.53 g) followed by CI 0507 (121.89 g). The lowest weight of dry slice per kg sample was obtained from genotype CI 1312 (108.20 g) (Table 44).

Turmeric powder recovery %

The TPR % was found ranging from 10.82 % to 13.15 % with average value of 11.87 %. The maximum TPR % was recorded from genotype KK1 (13.15 %) followed by genotype CI 0507 (12.19 %). The lowest TPR % was recorded from genotype CI 1312 (10.82 %) (Table 44).

Table 44: Performance of eight genotypes of turmeric tested under coordinated varietal trial in Dhankuta in 2017

Genotype	Fresh rhizome yield (t/ha)	Weight of dry slice (g)/ 1 kg sample	Weight of dry powder (g)/1 kg sample	TPR%
CI 0207	10.02	121.63	121.16	12.12
KK1	11.33	129.28	128.53	13.15
CI 0205	9.06	120.81	120.51	12.03
CI 9102	9.16	118.48	117.67	11.77
CI 1312	5.98	108.61	108.20	10.82
CI 0503	5.61	110.70	110.46	11.04
CI 0507	14.73	122.11	121.89	12.19
CI 0210	11.54	117.54	118.71	11.87
Mean	**9.68**	**118.65**	**118.39**	**11.87**
P-value	**	**NS**	**NS**	**NS**
CV%	**39.04**	**13.15**	**13.52**	**14.49**
LSD	**6.62**	**27.31**	**28.03**	**3.01**

4. PRODUCTION PROGRAM

NCRP has maintained production orchards of mandarin, sweet orange and acid lime for different research purposes. It spreads out in about 7 ha area. The popular local variety, which is known as Khoku local has occupied major portion of the production orchard followed by sweet orange variety Dhankuta local and different local genotypes of acid lime. This year, Rs.4.0 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 2074-75, a total of 28,900 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 45: Production of fruits, saplings and revenue collected during 2074/75

S.N.	Particulars	Unit	Quantity	Revenue (NPR) '000
1.	Mandarin saplings	No.	3000	
2.	Sweet orange saplings	No.	3100	
3.	Acid lime saplings	No.	22800	
4.	Rose saplings	No.	300	
5.	Mandarin fruits	Kg.	4164	
6.	Trifoliate orange seed	Kg.	5.80	
7.	Scion of different citrus species	No.	1510	
8	Sweet orange fruits	Kg.	89	
9	Acid lime fruits	Kg.	47	
	Sub-total			**4011.45**
10	Other horticultural sources			34.23
	Sub-total			**4045.68**
11	Administrative			50.60
	Grand Total			**4096.28**

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 46: **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 1,550 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

Three trainings were conducted on various aspects of commercial citrus cultivation practices during fiscal year 2074/75. Thirty-five farmers from different district (Dhankuta, Sindhuli, Bhojpur, Myanglung, Tehrathum, Syanja, Solukhumbu, Udayapur and Taplejung) were provided training on commercial mandarin cultivation practices. Similarly, training on citrus decline management was conducted in Dawa, Bhojpur

district. Twenty five farmers had participated in training. Similarly, training on fruit fly management of sweet orange was conducted in Khaniyakharka, Sindhuli district. Twenty eight farmers had participated in the training.

10 SERVICES

In fiscal year 2073/74, NCRP supplied 29,400 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, 6 and 7, 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 16 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

ANNEX

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

S.No	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.N0	*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
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
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

S.N0	***Accession no***	***Identification/common name***	***Source***
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
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.N0	***Accession no***	***Identification/common name***	***Source***
	Rootstocks		
103	NCRP 65	Citrange C-35	INRA_CIRAD
104	NCRP 66	Citrange – Carrizo	INRA_CIRAD

S.N0	*Accession no*	*Identification/common name*	*Source*
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

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	2	3
15. Technician	13	11	2
16. Account officer (A6)	1	1	0
17. Administrative Assistant (A5)	1	-	1
18. Driver (Heavy)	1	1	-
Total	37	18	19

Annex 3: Human Resource of NCRP in 2074/75

Name	Position	Qualification	Working area & remarks
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. Ram Awatar Maharo	Technician (T.4)	JTA	Support in research and production

7. Sita Sharma	Technician (T.4)		Support in research and production
8. Jagat Bahadur Karki	TS- Fifth	Literate	Support in administration
9. Thir Bahadur Ale	TS- Fifth	Literate	Support in research and production
10. Tej Bahadur Darji	TS- Fifth	Literate	Support in research and production
11. Man BahadurTamang	TS- Fifth	Literate	Support in research and production
12. Hem BahadurDahal	TS- Fifth	Literate	Support in research and production
13. Tara Nath Khatri	Heavy driver-Fifth	S.L.C.	Driver
14. Laxmi Bhattarai	TS-First	Literate	Support in research and production
15. Kashi Nath Subedi	TS-First	Literate	Support in research and production
16. Dhan Kumar Rai	TS-First	Literate	Support in research and production
17. Tetri Devi Shah	TS-First	Literate	Support in administration
18. Gopal Silwal	TS-First		Support in research and production
19. Saroj Chaudhary	TS-First		Support in research and production

Annex 4: Publications in FY 2074/75

Publication	**Type**	**Language**	**Published number**
नेपालमा जुनारको व्यवसायिक खेति प्रविधि	किताव	नेपाली	**700**
सुन्तलाजात फलफूलको उन्नत खेती प्रविधि	लीफलेट	नेपाली	**2000**
वार्षिक प्रतिवेदन	किताव	अंग्रेजी	**100**

Annex 5: Regular Annual Budget and Expenditure in 2074/75

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
	Operational Expenses				
21111	Staff Salary	6,487,000.00	6,044,972.40	6,044,972.40	442,027.60
21112	Local Allowances	169,000.00	162,320.00	162,320.00	6,680.00
21113	Dearness Allowances	216,000.00	190,000.00	190,000.00	26,000.00
21119	Other Allowances	100,000.00	40,200.00	40,200.00	59,800.00
21121	Uniform	135,000.00	127,500.00	127,500.00	7,500.00
22111	Water and Electricity Expenses	522,000.00	465,056.00	465,056.00	56,944.00
22112	Communication Expenses	116,000.00	115,906.50	115,906.50	93.50
22211	Fuel	278,000.00	272,260.76	272,260.76	5,739.24
22212	Operational and Repair Expenses	665,000.00	663,217.84	663,217.84	1,782.16
22213	Insurance	50,000.00	50,000.00	50,000.00	0.00
22311	Office related expenses	551,000.00	509,226.65	509,226.65	41,773.35
22313	Books expenses	50,000.00	21,245.00	21,245.00	28,755.00
22314	Fuel for Other Purposes	190,000.00	187,810.90	187,810.90	2,189.10
22321	Repair/Maintenance of Public Assets	450,000.00	449,239.43	449,239.43	760.57
22512	Training and seminar expenses	150,000.00	143,480.00	143,480.00	6,520.00
22521	Production Material Service	9,169,000.00	8,628,608.48	8,628,608.48	540,391.52
22611	Monitoring and evaluation expenses	170,000.00	170,000.00	170,000.00	0
22612	Travel Expenses	1,700,000.00	1,556,266.00	1,556,266.00	143,734.00
22711	Miscellaneous Expenses	100,000.00	98,840.00	98,840.00	1,160.00
	Capital Expenses	**21,268,000.00**	**19,896,149.96**	**19,896,149.96**	**1,371,850.04**
29221	Building Construction	0.00	0.00	0.00	0.00
29231	Capital Improvement - Building	2,300,000.00	2,298,386.51	2,298,386.51	1,613.49
29311	Furniture and Fixtures	220,000.00	218,542.00	2185,42.00	1,458.00
29511	Machinery Equipment	144,000.00	143,995.38	143,995.38	4.62
29611	Public Construction	200,000.00	196,953.00	196,953.00	3,247.00
	Grand Total				

Annex 6: Beruju Status Till Fiscal Year 2074/75

Beruju	Amount	Remarks
Beruju till year (2073/74)	86,080.80	
Beruju in FY 2074/75	0.00	
Beruju cleared in this FY (2074/75)	0.00	
Remaining beruju	86,080.80	

Annex 7: Annual Budget and Expenditure of PMAMP in 2074/75

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
	Operational Expenses				
22111	Water and Electricity Expenses	522,000.00	465,056.00	465,056.00	56,944.00
22121	House Rent	150,000.00	111,375.00	111,375.00	38,625.00
22122	Other Rent	100,000.00	61,788.40	61,788.40	38,211.60
22212	Operational and Repair Expenses	665,000.00	663,217.84	663,217.84	1,782.16
22311	Office related expenses	551,000.00	509,226.65	509,226.65	41,773.35
22522	Program expenses	1,250,000	1,174,295.14	1,174,295.14	75,704.86
22711	Miscellaneous Expenses	100,000.00	98,840.00	98,840.00	1,160.00
	Grand Total	**1,630,000.00**	**1,444,671.39**	**1,444,671.39**	**185,328.61**