ANNUAL REPORT

2072-73 (2015-16)

Government of Nepal
Nepal Agricultural Research Council
National Citrus Research Programme
Paripatle, Dhankuta, Nepal
2016

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(2015/16)

NEPAL AGRICULTURAL RESEARCH COUNCIL

NATIONAL CITRUS RESEARCH PROGRAMME

PARIPATLE, DHANKUTA

2016

Nepal Agricultural Research Council (NARC)

National Citrus Research Programme (NCRP)

Paripatle, Dhankuta, Nepal

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FOREWORD

Citrus sector has emerged as a great prospect of economic development in Nepal since the country is bestowed upon having appropriate geographic and climatic condition for quality citrus production. Recently, this sector has received national priority as the high value commodity. Nation has trust in this sector for raising farmers' economic status in mid hills across the country. Genus 'Citrus' constitutes a large group of fruits that comprises particularly mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*). These three major groups are commercially important citrus fruits owing to the increasing domestic as well as external market. In recent years more farmers are interested to grow acid lime in uplands of terai, inner terai and foot-hills. Although, a large potential to increase total production and productivity of citrus fruit crops exists in the country our efforts are not enough to substitute import of citrus fruits from other countries.

The adequate quantity and quality production are two important aspects for commercialization of this sector. The area and volume of production are both increasing; however, additional thousands hectares of land have yet to be enveloped with these citrus fruit crops in the country. Furthermore, the sector is still sustaining by adopting the traditional farming practices that needs to be transformed. Being perennial fruit crops, citrus orchard establishment demands for a large initial investment, however adoption of appropriate improved technologies in specific local context is equally important. The major problems in the sector include declining soil fertility and moisture, poor orchard management, increasing incidence of diseases (citrus canker, greening and root rot) and insects- pests (leaf miner, citrus psylla, scale insect, fruit fly and aphid) and inadequate supply of healthy planting materials. Similarly, the short harvesting period of existing local cultivars illustrates the need of hour for varietal investigation in Nepal. To address these concerns, National Citrus Research Programme has been undertaking various researches on variety selection, crop husbandry, disease and pest management, nursery propagation, postharvest technology among others. Acute shortage of research scientists and technical officers in the research program has largely affected quality of research. This annual report encompasses the highlights of research outcomes accomplished during 2072-73 (2015-16).

I am thankful to all the researchers, administrative, account and other support staffs of NCRP for their valuable contribution and endeavor in research accomplishment, and role in the preparation of this report. I specially thank Mr. Roshan Pakka, Scientist (S1), for his painstaking efforts to bring this annual report in this form. Support from NARC headquarters is duly acknowledged. I hope this annual report will be an informative asset for all stakeholders involved in citrus research and development.

(Dhana Bahadur Gharti)

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ABBREVIATIONS

@	at the rate
2,4-D	2,4-Dichlorophenoxyacetic acid
B.S.	Bikram Sambat
CFFT	Coordinated Farmers Field Trial
cm	Centimeter
CV	Coefficient of Variation
CVT	Coordinated Varietal Trial
DADO	District Agriculture Development Office
DFTQC	Department of Food Technology and Quality Control
DGR	Dry Ginger Recovery
Ento.	Entomology
etc.	et cetera
FAO	Food and Agriculture Organization
FY	Fiscal Year
FYM	Farm yard manure
g	Gram
ha	Hectare
HLB	Huanglongbing
Hort.	Horticulture
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
JICA	Japan International Cooperation Agency
K	Potassium
Kg	Kilogram
LSD	Least Significant Different
lt	Liter
masl	metre above sea level
ml	Millimeter
MoAD	Ministry of Agriculture Development
mt	Metric ton
N	Nitrogen
NAA	Napththalene Acetic Acid
NAST	Nepal Academy of Science and Technology
NCRP	National Citrus Research Program
NGO	Non-Governmental Organization
NGRP	National Ginger Research Program
NPR	Nepalese Rupee
NS	Non-significant
°	Degree
P	Phosphorus
Patho.	Pathology
PCR	Polymerase Chain Reaction

p^H	Potential of Hydrogen
RARS	Regional Agriculture Research Station
RATWG	Regional Agricultural Technical Working Group
t	Ton
TA	Titratable Acid
TPR	Turmeric Powder Recovery
TSS	Total Soluble Solid
var.	Variety
VDC	Village Development Committee
viz.	Videlicet
wt	Weight

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प्रमुख सार संक्षेप

नेपालमा सुन्तला खेती, देशको आर्थिक विकास र रोजगार सिर्जनाको लागि उच्च महत्वको रुपमा अगाडि आएको छ। सुन्तलाको बढ्दो आन्तरिक तथा वाह्य बजार भएको कारणले यसलाई एउटा उच्च मुल्य भएको क्षेत्रको रुपमा पहिचान गरिएको छ। यसर्थ, नेपाल सरकारले बिगत केहि वर्षदेखि सुन्तला क्षेत्रको प्रवर्द्धन र विकासको लागि उच्च प्राथमिकता दिदै आएको छ। यद्यपी न्यून उत्पादकत्व र गुणस्तर उत्पादन, रोग र किराको बढ्दो आक्रमण, खस्कदो माटोको उर्वराशक्ति र सिंचाईको अभाव, सिमित जातीय विविधता तथा स्वस्थ बिरुवाको अभाव सुन्तला विकासका विद्यमान प्रमुख चुनौती हुन्।

यस परिपेक्ष्यमा राष्ट्रिय सुन्तला जात अनुसन्धान कार्यक्रमले राष्ट्रिय जिम्मेवारीको रूपमा यस क्षेत्रको प्रवर्दन र विकास गर्न उपयुक्त प्रविधि विकासको लागि अनुसन्धानका कार्यक्रमहरु संचालन गर्दै आएको छ। यस कार्यक्रमले आ.ब. ०७२/७३ अवधिमा जम्मा ७ वटा परियोजना अन्तर्गत ३९ वटा अनुसन्धान क्रियाकलापहरु सम्पन गरेको थियो। यी कार्यक्रमहरु विशेष रुपमा जातीय अनुसन्धान, नर्सरी व्यवस्थापन, बाली उत्पादनोपरान्त भण्डारण, बगैंचा 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 अपेक्षीत उपलब्धिहरु हासिल भएका छन्। यसरी आ.व. २०७२/७३ सम्म पुरा गरिएका क्रियाकलापहरुको उपलब्धिहरु संक्षिप्त रुपमा तल उल्लेख गरिएको छ।

- जातीय संकलन र सम्वर्द्धन अन्तर्गत १२० वटा स्थानीय र वाह्य श्रोतबाट सुन्तलाका विभिन्न जातहरु संकलन गरि कार्यक्रमको फार्म भित्र (field gene bank) सम्वर्द्धन 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। त्यसर्थ, उपयुक्त जातको छनौट तथा विकासको लागि अझ केहि वर्ष अध्ययन गर्न आवश्यक देखिन्छ।
- सुन्तला, जुनार, कागती र ट्यांङ्गोरका प्रचलनमा रहेका जातहरुको उत्पादन क्षमता र उत्पादन अवधि क्रमशः कम र छोटो रहेका छन्। यस समस्यालाई हल गर्ने उदेश्यले विदेशबाट भित्राइएका र उपयुक्त स्थानीय जातहरुको खोजीगरी उत्पादन र उत्पादन समयको मुल्यांकन गदै आएको छ। प्रारम्भिक नतिजा अनुसार वाह्य सुन्तलाका जातहरु जस्तै ओकित्सुवासे, मियागावासे, नोभा, ओरोभल, पेज, सत्सुमा मिनो र स्थानीय जातमा खोकु स्थानीयले अगौटे र राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको पाइएको छ। तसर्थ, आउने वर्षमा सुन्तलाका दुई जातहरु ओकित्सुवासे र खोकु स्थानीयलाई उन्मोचनको लागि प्रस्ताव गर्न सिफारिस गरिन्छ।
- जुनारको जात - वासिंटन नेभलले राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको छ। आउँदो वर्षमा यस जातलाई उन्मोचनका लागि प्रस्ताव गर्न सिफारिस गरिन्छ। अन्य जातहरुमा माल्टा ब्लड रेड, डेलेसीओस सिडलेस, सुकारी र धनकुटा स्थानीयको उत्पादन उत्साहजनक देखिन्छ।
- पूर्वी र मध्यमाञ्चलका जिल्लाहरुमा विभिन्न स्थानीय जातहरुको खेती सम्भाव्यता अध्ययनको निचोडबाट जातीय गुणको आधारमा आ.व. २०७०/७१ मा कागतीका दुई जातहरु क्रमशः सुनकागती-१ र सुनकागती-२ को नामबाट उन्मोचन गरिएको छ। यी दुवै जातहरु पश्चिमाञ्चलमा समेत व्यवसायिक रुपमा विस्तार भैरहेको छ। अन्य कागतिका जातहरुमा पन्त-१, बनारसी कागती र तेह्रथुम स्थानीयको उत्पादन राम्रो देखिएको छ।
- त्यसैगरी ट्यांङ्गोरको ओर्टानीक्यु, ट्यान्जेलोको सेमिनोल र ग्रेपफ्रुटको पिंक रुवी र रिडले राम्रो उत्पादनका साथै उत्साहजक परिणाम दिएको छ।

- सुन्तला बगैंचा ह्रास व्यवस्थापन अन्तर्गत एकिकृत खाद्यतत्व व्यवस्थापन, रोग तथा किरा व्यवस्थापन र बगैंचा व्यवस्थापनमा अनुसन्धान संचालन भैरहेको छ । अनुसन्धानको लागि धनकुटा, भोजपुर र ताप्लेजुङ जिल्लाबाट ह्रास भएका दुई-दुई वटा बगैंचाहरु छनोट गरियो । धनकुटा-खोकुको बगैंचाबाहेक अरु ह्रास भएर गएका बगैंचाहरुमा उल्लेखनिय रुपमा प्रगति भएको पाइयो । तसर्थ, थप प्रमाणीकरण र केहि परिमार्जन गरी कृषकहरुको बगैंचा तथा फार्म भित्र अनुसन्धान गर्न आवश्यक देखिन्छ ।
- सुन्तलाको पोष्ट-हार्भेष्ट भण्डारण अवधि बढाउने सम्बन्धि अध्ययन गरियो । जसमा फलको भेट्नो सहित टिपिएको फललाई १०% अदुवाको झोल र १५% नीमको झोलले उपचार गरिएकोबाट ६० दिनसम्म थोरैमात्र तौल घटेको र रोगबाट बचाउन सफल भएको पाइयो ।
- कागतीको लागि गरिएको विभिन्न रुटस्टकहरुको अनुसन्धानमा रंगपुर लाइम, काली ज्यामीर र तीनपाते सुन्तलाको रुटस्टकको परिणाम उत्साहजनक रुपमा राम्रो भएको पाइयो ।
- सुन्तलामा तीनपाते रुटस्टकसंग विभिन्न उचाइमा कलमी गर्ने अध्ययन गरियो । जसमा १२ से.मी. उचाइमा गरिएको कलमीबाट सफलतापूर्वक विरुवाको उचाई वृद्धि भएको पाईयो । तर ३६० दिनमा नापेको रेकर्डमा २० से.मी. उचाइमा गरिएको कलमीको उच्च वृद्धि भएको पाइयो ।
- मध्यमाञ्चलका तीन जिल्लाहरु रामेछाप (ओखेरेनी-२), सिन्धुली (रतनचुरा) र सोलुखुम्बु (देउसा-३) मा फल कुहाउने औंसा किराको यथार्थ पहिचान गर्ने अध्ययनबाट सुन्तलामा लाग्ने औंसा, फर्सी बालीमा लाग्ने ओरियन्टल फल कुहाउने औंसा किरा नभई चाइनिज फ्रुट फ्लाई *(Bactrocera minax*, Elderlein*)* भएको ठहर गरियो । सोहि अध्ययनबाट उक्त प्रजातिको झिंगा सुन्तलामा जेष्ठको दोश्रो हप्तादेखि असार १५ सम्म उच्चतम आक्रमण गर्ने गरेको बिगत दुई वर्षको अनुसन्धानबाट थाहा पाइयो । त्यसर्थ, उक्त अवधिमा विभिन्न प्रोटिन पासो (protein bait) बनाई फल कुहाउने औंसा किरा व्यवस्थापन गरेमा उचित हुने देखिन्छ ।
- फल कुहाउने औंसा किरा आकर्षण गरि मार्ने विभिन्न प्रोटिन पदार्थहरुको अध्ययनबाट अष्ट्रेलियन प्रोटिन ल्युर सबैभन्दा उपयुक्त भएको ठहर गरियो । त्यसैगरि औंसाको फूललाई आक्रमण गरी फल झरेको दिनदेखि ६/७ दिनको अवधिमा औंसाबाट प्युपा बनि माटोभित्र प्रवेश गर्ने गरेको पाइयो । यसबाट फल कुहाउने औंसा किराको अर्को वर्ष बगैंचामा जनसंख्या कम तथा नियन्त्रण गर्नको लागि फल झरेको ६/७ दिन भित्रमा सबै झरेका फलहरु संकलन गरी प्लास्टिकको ठूलो भाडामा पानीमा डुबाएर अथवा बिषादी राखेर नष्ट गर्ने वा खाल्डो खनी बिषादी राखेर पुर्ने काम गरेमा उचित नियन्त्रण हुने बारे बिगत दुई बर्षको अनुसन्धानबाट निष्कर्ष निकालियो ।
- यस आ.व. को कार्यक्रममा सुन्तला अनुसन्धान कार्यक्रम अवलोकन गर्न १५०० कृषक तथा अन्य सरोकारवालाहरुको भ्रमण भयो ।
- कलमीको लागि सुन्तला र कागतीको माउ बोटबाट स्वस्थ साइन धनकुटा जिल्लाका नर्सरी व्यवसायीहरुलाई उपलब्ध गराइयो ।
- सुन्तलाको ३५००, जुनारको ५००, कागतीको ६००० र अन्य सुन्तला जातका १०० गरी जम्मा १०१०० कलमी बिरुवा कृषकहरुलाई उपलब्ध गराइयो ।
- यस कार्यक्रमको आ.व. २०७२/७३ को लागि विनियोजित बजेट रु. तीन करोड बाह्र लाख दश हजार चार सय एकतीस (रु. ३,१२,१०,४३१.०२) थियो जसमध्ये अनुसन्धान कार्यक्रमको लागि जम्मा एक करोड चार लाख तेईस हजार असी (.रु १,०४,२३,०८०.६) विनियोजन गरिएको थियो ।

Executive summary

Citrus has been as a high prospect sector for raising the economic standard and employment to the farmers of Nepal. This sector has been recognized as the high value commodity following the increasing demand for 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 and quality due to increasing invasion of various insects, diseases, nutritional deficiency, moisture stress, limited variety and inadequate sources for healthy planting materials are the main challenges for citrus industry. In these, context, National Citrus Research Program (NCRP) with the national mandate of developing appropriate technologies has been conducting research programs for promoting the citrus industry in Nepal. During the fiscal year 2072/73 (2015/16), a total of 39 activities under 7 research /projects were accomplished by NCRP, Dhankuta. Particularly, these research projects comprised of varietal research, nursery management, post-harvest storage, management of citrus decline and fruit fly. Most of activities are under continuation; while some of them were concluded with worthwhile outputs that are summarized below:

- The total of 120 different citrus germplasms have been collected from local and exotic sources during different periods which are conserved and maintained in field gene bank of National Citrus Research Program, Dhankuta. 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 are resulting poor yield and short production period, the exotic cultivars inclusive of elite local cultivars have been introduced, and they have been being evaluated by NCRP since 2063/64. The preliminary performances of varietal evaluation of mandarin revealed some exotic genotypes such as Miyagawase, Nova, Oroval, Page, Satsuma Mino including Khoku local resulted in promisingly early for crop maturity and fruit yield. Two genotypes of mandarin viz., Khoku local and Okitsu wase are in process of being proposed for variety released based on their performance for yield and yield attributes that were evaluated during 2060/61 to 2072/73.
- Washington navel, a variety of sweet orange has 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 have shown good fruit yield characteristics.
- The 10 elite acid lime genotypes collected locally have been evaluated since 2063/64 in terai districts. Two acid lime varieties: Sunkagati-1 and Sunkagati-2 have been released in 2014 for upland condition of terai, inner terai, foothills and river basin areas. Moreover, there are still some other genotypes performing better for fruit yield and early harvest. These include NCRP 53, NCRP 56 and NCRP 107.
- Similarly, Ortanique, a variety of tangor; Seminole, variety of tangelo; Pink ruby and Reed, varieties of grapefruit have shown their good performance in terms of yield contributing characteristics and yield.

- 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 Taplejung. The results were found satisfactory except from Khoku, Dhankuta. Henceforth, verification and modification of previous experiment is a must in station and on farm condition.
- The result of postharvest storage study showed that the spiked fruits treated with 10% ginger extract and spiked fruits treated with 15% neem extract were found better to enhance the storage life up to 60 days along with the minimum fruit weight loss and pathological damages.
- The result of rootstock trial for acid lime showed that three rootstocks viz., rangpur lime, kali jyamire and trifoliate orange showed better performance in different morphological traits.
- The study of effect of grafting height on graft success and scion growth of mandarin showed a steady result. The maximum graft success and growth in scion height were found in those saplings grafted at 12 cm height during two initial period viz., 90th and 180th days after planting, but the final maximum growth was noticed in those saplings grafted at 20 cm height in 360 days subsequent to planting.
- An investigation to identify the fruit fly species in three districts: Ramechhap (Okhareni-2), Sindhuli (Ratanchura) and Solukhumbu (Deusa-3) during two consecutive years confirmed that the infested fruits with fruit fly were detected to be the Chinese fruit fly (*Bactrocera minax*, Elderlein) other than the Oriental fruit fly (*B. dorsalis*). In the same study, the maximum infestation (89%) with fruit fly was observed on second weeks of Jestha followed by next two consecutive fortnight intervals. The results revealed that the oviposition period occurred between 15th Jestha to 15th Ashad. As a result, it could be suggested that the control measure during this period would be effective for minimizing the population of this pest.
- Continuous two years' study revealed that the Australian fruit fly lure (autolysed protein) @ 50 ml/l was found to be the most efficacious trap for fruit fly among different lure substances such as hydrolyzed protein (soya bean based) @ 50 ml/l, orange-ammonia solution @750 ml + ammonium carbonate @ 25 gm/l + potassium sorbate preservatives @ 2 gm, and proteinax @ 50 gm/l.
- Continuous two years' study illustrated that the maximum pupal emergence from infested fruits occurred on 7th day onward after fruit drop out. Thus, this indicated that orchard sanitation through collection and destruction of dropped fruits should be carried out before the first six days of fruit drop. As a result, fruit fly population into the soil could be minimized controlling this pest for next year in the orchard.
- During the fiscal year 2072/73, technical counseling was given to 1500 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, two varieties of Sunkagati-1 and Sunkagati-2 were provided to the farmers in different locations.

- In the fiscal year 2072/73, total of 10,100 grafted saplings constituting 3500 mandarin orange, 500 sweet orange, 6000 acid lime and 50 kumquat saplings were made available to farmers.
- The total annual budget approved for the program was Rs.31 million, while operational budget consisted of Rs. 10 million to carry out research projects.

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 statistic shows that the area and production under citrus fruit crops are increasing during last 10 years. The current area is recorded to be 39,035 ha producing 2,22,790 metric tons annually with 8.82 mt/ha productivity which is very low compared to the most citrus growing countries in the world (Table.1). The productivity is in declining trend that the studies revealed that such alarming 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 technology.

Table 1: Area, production and productivity of citrus fruits during 2003/04 to 2014/15

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

Source: MoAD, Nepal, 2015

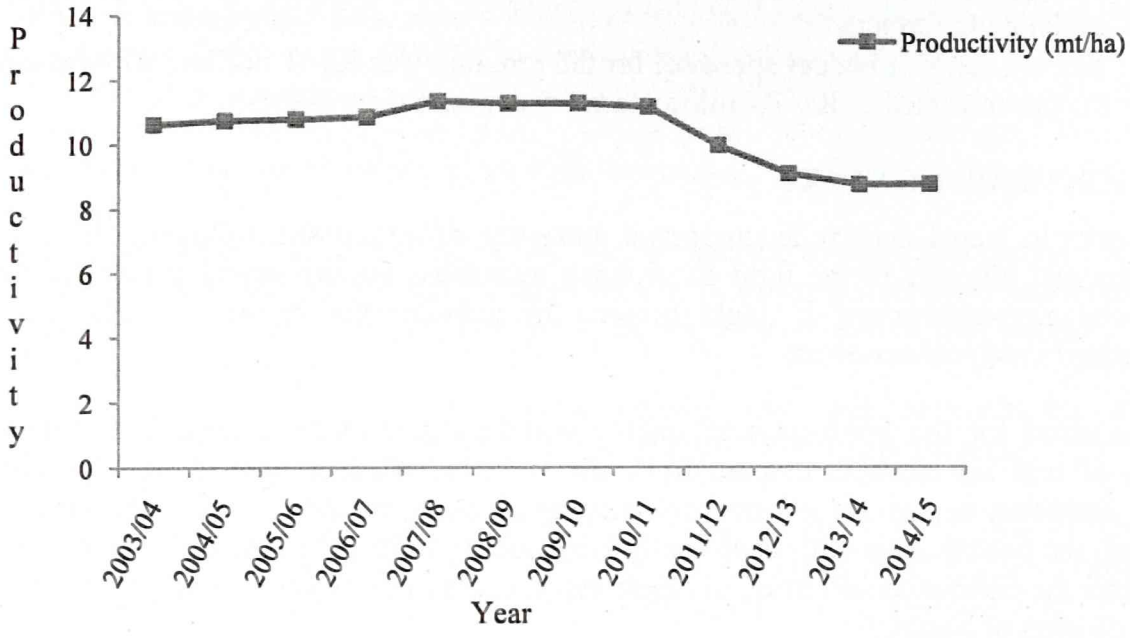

Figure 1: Productivity of citrus crops during different period

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 posed the first position with 25,123 ha, 16,224 ha, 1,49,212 mt respectively, but sweet orange revealed the highest productivity (10.1 mt/ha). On the other hand, lemon fruit revealed the lowest area (907 ha), productive area (625.8 ha), and production (5,285 mt). Lowest productivity with yield of 6.66 mt/ha was recorded in acid lime.

Table 2: Total area, productive area, production and productivity of major citrus fruits in Nepal (2014/15).

Major citrus fruits	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
Mandarin orange	25,123 (64.36)	16,224	1,49,212	9.2
Sweet orange	4,834 (12.38)	3,440	34,675	10.1
Acid lime	6,864 (17.58)	4,046	26,953	6.66
Lemon	907 (2.32)	625.8	5,285	8.45
Other citrus species	1,307 (3.35)	925.5	6,665	7.20
Grand Total	39,035	25,261	2,22,790	8.82

Source: MoAD, Nepal, 2015

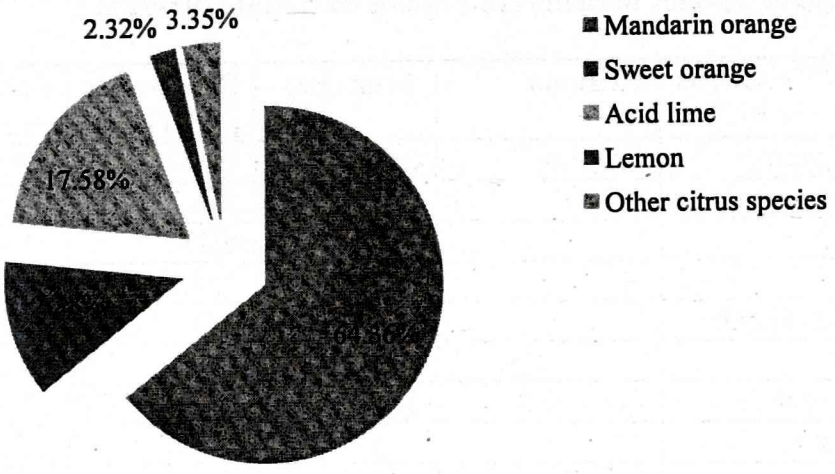

Figure 2: Total area (in percentage) of major citrus fruits in Nepal during 2014/15

The result shown in above pie-chart reveals that mandarin orange covers the maximum production area among citrus. Mandarin orange covers 64.36% area among the citrus cultivated area. Similarly, acid lime, sweet orange, lemon and other citrus covers 17.58%, 12.38%, 2.32% and 3.35% respectively.

Table 3 reveals the area, productive area, production and productivity of four groups of citrus as per region wise 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 11,853 ha, 7,864 ha and 70,519 mt respectively, but central region has stood the first position for productivity (10.84 mt/ha) followed by western region with 8.97 mt/ha and far-western region with 8.84 mt/ha. Although, area, productive area and production of mandarin orange is highest in western region with 9,737 ha, 6,443 ha and 59,940 mt; productivity is noted to be the highest in central region (10.6 mt /ha) followed by eastern region (9.9 mt/ha) and western region (9.3 mt/ha) while the lowest productivity of mandarin is in mid-western region (6.8 mt/ha). As for sweet orange, central region has had considerably highest area (2,294 ha), productive area (1,566 ha), production (18,242 mt) and productivity (11.7 mt/ha) whereas mid-western region showed minimally lowest area (550 ha), productive area (382 ha) and production (3,375 ha). The lowest productivity was found in Eastern region (7.3 mt/ha). Eastern region showed considerably the maximum acid lime area (3,209 ha), productive area (1,856 ha) and production (11,417 mt). However, highest productivity for lemon was recorded from central region (8.14 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 (5.76 mt/ha). In regards with lemon fruit crop, its area (378 ha), productive area (238.5 ha), production (2,137 mt) and productivity (8.96 mt/ha) are recorded to be highest in eastern region. In contrast, lowest area, productive area and production was found in western region with 102 ha, 62 ha and 553 mt respectively. The lowest productivity was found in mid-western region with productivity of 6.95 mt/ha. As for other citrus fruit crop, area (458 ha) and productive area (374 ha) have been noted highest in western region. However, production was noted highest from eastern region (2,206 mt) despite the highest productivity (9.12 mt/ha) in mid-western region.

Table 3: Total area, total productive area, total production and productivity of different citrus species in different regions of Nepal (2014/15).

Major Citrus species	Regions	Area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
Mandarin orange	Eastern	6,142	3,950	37,548	9.9
Sweet Orange	"	750	576	4,192	7.3
Acid Lime	"	3,209	1,856	11,417	6.15
Lemon	"	3,78	238.5	2,137	8.96
Other Citrus species	"	415	243.5	2,206	9.06
Sub-total		**10,894**	**6,864**	**57,501**	**8.38**
Mandarin orange	Central	3,803	2,662	28,217	10.6
Sweet Orange	"	2,294	1,566	18,242	11.7
Acid Lime	"	1,129	587.5	4,785	8.14
Lemon	"	131	114.5	990	8.64
Other Citrus species	"	215	183.1	1,347	7.36
Sub-total		**7,570**	**5,112**	**53,581**	**10.48**
Mandarin orange	Western	9,737	6,443	59,940	9.3
Sweet Orange	"	550	382	3,375	8.8
Acid Lime	"	1,006	603.5	4,508	7.47
Lemon	"	102	62	553	8.92
Other Citrus species	"	458	374	2,144	5.73
Sub-total		**11,853**	**7,864**	**70,519**	**8.97**
Mandarin orange	Mid-western	3,798	2,111	14,297	6.8
Sweet Orange	"	478	301.5	2,437	8.1
Acid Lime	"	938	627.5	3,616	5.76
Lemon	"	146	113.8	791	6.95
Other Citrus species	"	43	17.9	163	9.12
Sub-total		**5,402**	**3,172**	**21,304**	**6.72**
Mandarin orange	Far-western	1,643	1,059	9,209.5	8.7
Sweet Orange	"	762	614.5	6,429	10.5
Acid Lime	"	584	371	2,628	7.08
Lemon	"	151	97	814	8.39
Other Citrus species	"	176	107	804	7.51
Sub-total		**3,316**	**2,249**	**19,885**	**8.84**

Source: MoAD, Nepal, 2015

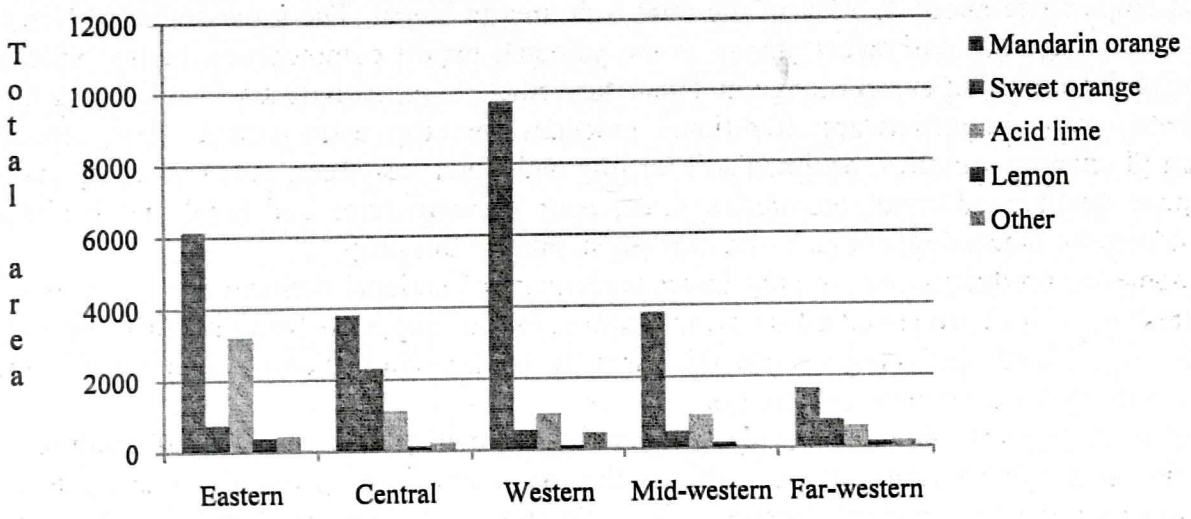

Figure 3: Total areas of major citrus fruits in different regions of Nepal in 2014/15

The result projected in bar diagram reveals five different regions on X-axis and area (ha) on Y-axis. There is 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 (11,853 ha). Western region has highest area for mandarin orange cultivation with the total area of 9,737 ha. The central region has largest area for sweet orange production (2,294 ha) as comparing against all the regions. In respect of area for acid lime and lemon, eastern region stands first with area of 1,856 ha and 378 ha respectively.

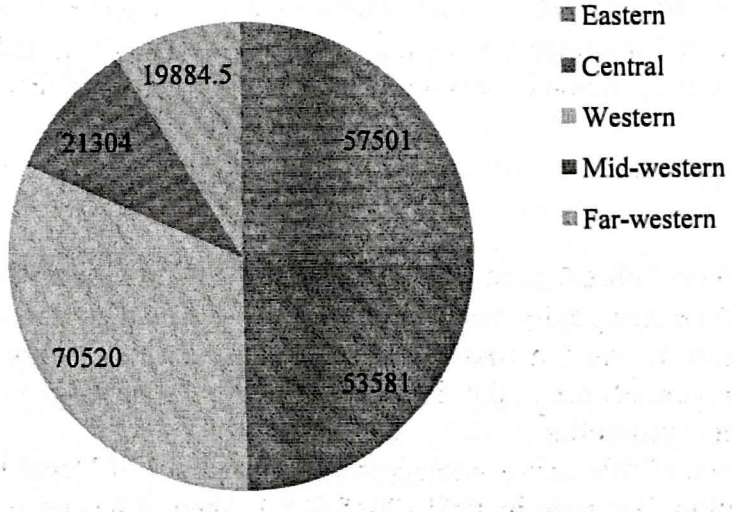

Figure 4: Total production of citrus in five development regions during 2014/15

The pie-chart shows the status of citrus fruit production of five regions of Nepal. Out of total citrus production; i.e. 2,22,790 mt, western region contributes maximum citrus production with total production of 70,520 mt followed by eastern region (57,501 mt) and central region (53,581 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, 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, which are not within the capacity of most farmers. There is serious short of crop husbandry practices in most citrus orchards like manuring, training/pruning, disease and pest control among others. As a result, many orchards are declining.

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 variety diversity for extending the production season that 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-13, 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 far-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. Up-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 variety 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 four screen houses (two iron-framed and two bamboo-made screen houses) and more than twenty 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 long pipe-fitted canal was established for irrigation.

2.9 Organization structure and human resource

NCRP is mainly constrained with a shortage of human resources for many years. Currently, the national mandated programme is working with a small team of human resource comprised of one senior scientist (Horticulture), two scientists, one technical officer and ten support staffs including administrative and account staffs. 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 2072/73 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 diversity is found in the existing varieties 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.

3.1.2 Varietal Evaluation

3.1.2.1 Mandarin

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.

Physical characteristics of fruits of different genotypes of Mandarin

Table 4 reveals that all three fruit characteristics (fruit weight, fruit diameter and number of segments/fruit) were highly significant between genotypes.

Fruit weight:

Individual fruit weight differed significantly between test genotypes ranging between 55.25 g and 128.4 g with mean value of 95.99 g. NCRP-90 produced the heaviest fruits (128.4 g) followed by NCRP-95 (122.7 g), NCRP-98 (111.5 g), NCRP-8 (106.7 g), and NCRP-1 (106.1 g). NCRP-93 had the lightest fruit weight (55.25 g). Other lighter fruits were observed in NCRP-94 (71.81g), NCRP-10 (82.01 g), and NCRP-6 (83.33 g) (table 4).

Fruit Diameter:

Fruit diameter was significantly different between genotypes and ranged between 39.62 cm and 69.69 cm with mean value of 53.65 cm. NCRP-5 had the highest fruit diameter (69.69 cm) followed by NCRP-90 (61.56 cm), NCRP-98 (59.24 cm), and NCRP-99 (58.07 cm) and so on. The least fruit diameter (39.62 cm) was observed in NCRP-93. NCRP-92 (43.02 cm), NCRP-89 (44.44 cm), NCRP-1 (46.62 cm) and so on. No definite correlation was observed between fruit weight and fruit diameter (Table 4)

Number of Segments/fruit

The data in Table 4 shows that the number of segment varied from 8.07 (NCRP-100) to 11.43 (NCRP-82) with significant differences between genotypes, the mean value being 10.20. The highest number of segments (11.43) was found in NCRP-82 followed by NCRP-81 (11.33), NCRP-90 (11.15) and NCRP-93 (11.15). Lowest number of segments/fruit (8.07) was observed in NCRP-100. Similarly, NCRP-94 (8.53), NCRP-99 (8.93), and NCRP-98 (9.27) had lower number of segments/fruit.

Table 4: Fruit physical parameters of mandarin genotypes at NCRP in 2015/16 (2072/73)

Genotypes	Fruit Weight (g)	Fruit Diameter(cm)	No. of Segments/Fruit
NCRP-1	106.10	46.62	9.80
NCRP-5	99.00	69.69	10.51
NCRP-6	83.33	51.72	10.78
NCRP-8	106.70	47.60	11.27
NCRP-10	82.01	51.11	10.53
NCRP-11	86.61	53.19	10.20
NCRP-80	96.76	54.42	10.33
NCRP-81	110.60	56.67	11.33
NCRP-82	102.90	57.09	11.43
NCRP-89	97.09	44.44	9.66
NCRP-90	128.40	61.56	11.15
NCRP-92	83.58	43.02	10.67
NCRP-93	55.25	39.62	11.15
NCRP-94	71.81	53.22	8.53
NCRP-95	122.70	57.83	10.77
NCRP-98	111.50	59.24	9.27
NCRP-99	93.93	58.07	8.93
NCRP-100	95.80	56.88	8.07
NCRP-101	90.51	57.43	9.40
Mean	95.99	53.65	10.20
P Value	**	**	**
LSD $_{(0.05)}$	20.17	5.51	0.87
CV%	12.69	6.20	5.14

Chemical Properties of Mandarin Genotypes

Fruit Juice Volume

Fruit juice volume was found to vary between 24.9 ml and 62.8 ml with a mean value of 41.44 ml among test genotypes. Difference in fruit juice volume was statistically significant. It is evident from Table 5 that fruit juice volume was highest (62.8 ml) in NCRP-95 followed by NCRP-81 (60.77 ml), NCRP-5 (57.3 ml) and NCRP-90 (52.40 ml), respectively. NCRP-94 was observed to give the least (24.9 ml) juice volume. Other genotypes giving lower fruit juice volume were; NCRP-101 (27.1ml), NCRP-100 (31.22 ml) and NCRP-8 (32.45ml), respectively.

Fruit Juice Weight

Fruit juice weight varied between 24.11 g and 65.91 g with a mean value of 40.17g. NCRP-89 had the highest juice weight (65.91g) followed by NCRP-95 (59.71g), NCRP-5 (53.35g) and NCRP-90 (53.13g), respectively. NCRP-94 produced the least fruit juice weight (24.11g) among the entries under evaluation. NCRP-101 (27.19g), NCRP-100 (30.66g) and NCRP-8 (31.91g) were other genotypes with lesser fruit juice weight (Table 5).

Total Soluble Solid (TSS %)

The data in Table 5 shows that TSS varied significantly between 6.65 % and 12.85% with the mean value of 8.89%. The highest TSS was recorded in NCRP-90 (12.85%) followed by NCRP-93 (11.77%), NCRP-94 (10.47%) and NCRP-11 (9.96%).NCRP-82 had the least TSS % (6.65%). Similarly, NCRP-80 (6.89%), NCRP-81 (6.89%), NCRP-5 (7.13%) and NCRP-6 (7.34%) were other genotypes with lower TSS.

Titratable acid (TA %)

Table 5 reveals that TA% was highly variable ranging between 3.92% and 9.33% with the mean value of 5.59%. NCRP- 89 recorded the highest TA (9.33%) followed by NCRP-90 (8.09%), NCRP-94 (6.93%) and NCRP-80 (6.1%). NCRP-11 had the least TA (3.92%) among the test genotypes.

Table 5: Fruit chemical properties of mandarin genotypes at NCRP in 2015/16 (2072/73)

Genotypes	Juice Volume (ml)	Juice wt (g)	TSS %	TA%
NCRP-1	40.56	39.55	9.47	4.50
NCRP-5	57.30	53.35	7.13	5.47
NCRP-6	44.77	40.21	7.34	5.34
NCRP-8	32.45	31.91	9.59	4.41
NCRP-10	33.90	33.59	9.83	4.04
NCRP-11	35.72	33.44	9.96	3.92
NCRP-80	43.37	39.67	6.89	6.1
NCRP-81	60.77	40.75	6.89	3.96
NCRP-82	46.07	45.86	6.65	4.64
NCRP-89	49.13	65.91	9.77	9.33
NCRP-90	52.40	53.13	12.85	8.09
NCRP-92	33.83	33.13	8.85	5.98
NCRP-93	35.40	34.79	11.77	5.82
NCRP-94	24.90	24.11	10.47	6.93
NCRP-95	62.80	59.71	7.39	4.49
NCRP-98	38.77	37.49	7.53	6.00
NCRP-99	37.40	38.69	8.97	5.73
NCRP-100	31.22	30.66	9.13	5.96
NCRP-101	27.10	27.19	8.44	5.63
Mean	41.44	40.17	8.89	5.59
P Value	**	**	**	**
$LSD_{(0.05)}$	9.09	14.50	2.34	0.94
CV%	13.25	21.81	15.90	10.16

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 production season of present local varieties

remains only two months during December-January and beyond this period, Nepal imports fresh 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 variety 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/plant and weight of fruits/plant 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 48.75 g (NCRP-28) to 139.5 g (NCRP-22) with the mean value of 98.9 g. NCRP-22 (139.5 g), NCRP-83 (125.2 g), NCRP-16 (120.7 g) possessed higher individual fruit weight. Lower individual fruit weights were recorded in NCRP-28, NCRP-29 (71.75 g) and NCRP-34 (75.25 g).

Individual Fruit Diameter

Individual fruit diameter was statistically variable and ranged between 43.88 mm (NCRP-28) and 60.71 mm (NCRP-83) with the mean value of 52.86 mm. NCRP-83 had the highest fruit diameter (60.71 mm) followed by NCRP-16 (60.58 mm) and NCRP-22 (59.62 mm). In contrast, individual fruit diameter was considerably low in NCRP-28(43.88 mm), NCRP-17(46.74 mm) and NCRP-31(47.40 mm) (table 6).

Pulp Weight

The pulp weight differed significantly between genotypes and ranged between 33.96 g (NCRP-28) and 100.4 g (NCRP-22) with mean value of 65.87g. NCRP-22 (100.4 g) gave highest pulp weight followed by NCRP-83 (91.19 g) and NCRP-16 (81.85 g). Lower pulp weights were observed in genotypes like NCRP-28 (33.96 g), NCRP-29 (46.65 g), NCRP-34 (47.29 g) and so on (Table 6).

Number of Fruits/tree

The number of fruits/plant was highly variable from 2.67 to 126.3 with the mean value of 45.18. NCRP -87 recorded the highest number of fruits/ plant i.e. 126.3 followed by NCRP-16 (93.67) and NCRP-13 (85.33). Genotypes like NCRP-34 (2.67), NCRP-96 (5.0), NCRP-29 (7.33) and NCRP-21 (7.67) were found to produce significantly lower number of fruits per plant (table 6).

Fruit Weight /tree

Total weight of fruits/plant was highly variable and ranged between 0.77 kg and 10.40 kg with a mean value of 4.92 kg. NCRP-87 produced the highest fruit weight/ tree (10.40 kg) followed by NCRP-23 (9.73 kg) and NCRP-13 (8.75 kg). NCRP-29 produced the least fruit weight (0.77 kg)

per tree. NCRP-21 (1.63 kg), NCRP-22 (1.77 kg) and NCRP-28 (1.93 kg) were other low yielding genotypes/accessions (table 6).

Table 6: Fruit characteristics of sweet orange genotypes at NCRP in 2015/16 (2072/73)

Genotypes	Fruit Weight (g)	Fruit Diameter (mm)	Pulp Weight (g)	No of Fruits / Plant	Fruit weight / Plant (kg)
NCRP-13	89.57	53.59	59.84	85.33	8.75
NCRP-14	88.30	51.06	52.12	25.67	2.30
NCRP-16	120.7	60.58	81.85	93.67	8.09
NCRP-17	89.95	46.74	75.31	39.00	3.70
NCRP-19	96.11	56.79	61.18	26.00	3.00
NCRP-21	84.85	55.10	54.28	7.67	1.63
NCRP-22	139.5	59.62	100.4	17.00	1.77
NCRP-23	110.9	51.11	75.95	84.00	9.73
NCRP-27	106.3	59.59	57.99	36.33	4.05
NCRP-28	48.75	43.88	33.96	18.33	1.93
NCRP-29	71.75	49.92	46.65	7.33	0.77
NCRP-31	122.1	47.40	77.66	81.67	7.53
NCRP-33	92.19	56.41	61.61	34.67	3.87
NCRP-34	75.25	55.36	47.29	2.67	2.97
NCRP-83	125.2	60.71	91.19	59.00	6.50
NCRP-84	110.9	58.76	80.06	30.33	3.23
NCRP-85	108.4	58.00	62.64	47.67	4.87
NCRP-86	100.5	49.73	66.37	76.33	7.87
NCRP-87	110.4	58.42	71.79	126.3	10.40
NCRP-96	87.28	54.46	60.27	5.00	5.33
Mean	98.91	52.86	65.87	45.18	4.92
P-value	**	**	**	**	**
$LSD_{(0.05)}$	18.02	9.13	13.57	47.35	6.21
CV %	11.02	10.45	12.46	63.41	76.41

Physio-chemical properties of different genotypes of sweet orange

Physio-chemical properties (juice volume, juice weight, TA% and TSS %) of sweet orange genotypes/accessions tested 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 13.10 ml and 57.34 ml with mean value of 29.69 ml. NCRP-22 was found to give the highest juice volume (57.34 ml) followed by NCRP-27 (45 ml), and NCRP-85 (37.23 ml). NCRP-28 gave the least juice volume (13.1 ml). Similarly, NCRP-17 (14.27 ml), NCRP-29 (22.8 ml) yielded low fruit juice volume (Table 7).

Fruit Juice Weight

It is obvious from Table 7 that difference in juice weight among test genotypes was statistically significant and ranged between 12.63 g and 39.36 g with mean value of 27.74 g. Highest fruit juice weight (39.36 g) was observed in NCRP-27 followed by NCRP-85 (36.56 g), NCRP-22 (34.70 g) and NCRP-31 (33.58 g) and NCRP-86 (33.58 g). Least juice weight was recorded in NCRP-28 (12.63 g). Other genotypes with lower juice weight were NCRP-17 (13.22 g), NCRP-34 (20.89 g) and so on.

Titratable Acid (TA %)

Per cent of TA varied from 2.29% to 13.20% with mean value of 5.87%. TA per cent was remarkably high in NCRP-19 (13.20%). Other genotypes with higher percentage of TA were NCRP-16 (7.39%) and NCRP-34 (7.36%) whereas NCRP-31 recorded significantly the lowest per cent of TA (2.29%). Other genotypes with lower values of TA were NCRP-22 (2.90%), NCRP-87 (4.05%) and NCRP-84 (4.23%) (table 7).

Total Soluble Solids (TSS %)

Percent TSS varied from 7.78% to 14.45% with the mean value of 11.18%. TSS% was found significantly higher in genotypes such as NCRP-22 (14.45%), NCRP-33 (12.85%), NCRP-31 (12.68%), NCRP-84 (12.48%) and NCRP-85 (12.26%). Lower TSS% values were observed in NCRP-87 (7.78%), NCRP-18 (8.13%), NCRP-27 (8.48%) and so on (table 7).

Table 7: Physio-chemical Properties of Sweet Orange Genotypes at NCRP in 2015/16 (2072/73)

Genotypes	Juice vol(ml)	Juice wt (g)	TSS%	TA%
NCRP-13	26.07	25.34	10.87	5.78
NCRP-14	25.73	24.29	8.13	6.10
NCRP-16	32.67	32.39	10.38	7.39
NCRP-17	14.27	13.22	11.60	6.29
NCRP-19	30.53	29.75	10.96	13.20
NCRP-21	27.33	26.62	9.54	6.50
NCRP-22	57.34	34.70	14.45	2.90
NCRP-23	31.53	31.05	9.72	6.72
NCRP-27	45.00	39.36	8.48	6.07
NCRP-28	13.10	12.63	12.15	5.12
NCRP-29	22.80	21.51	11.09	5.40
NCRP-31	34.40	33.58	12.68	2.29
NCRP-33	23.07	22.21	12.85	6.26
NCRP-34	23.47	20.89	9.24	7.36
NCRP-83	28.83	29.24	9.91	5.45
NCRP-84	27.80	26.08	12.48	4.23
NCRP-85	37.23	36.56	12.26	4.97
NCRP-86	29.50	33.58	10.80	7.21
NCRP-87	30.60	30.15	7.78	4.05

NCRP-96	32.53	31.09	11.79	5.03
Mean	29.69	27.74	11.18	5.87
P-value	**	**	**	**
$LSD_{(0.05)}$	15.13	7.16	1.20	2.96
CV %	30.84	15.61	22.68	30.56

3.1.2.3 Tangor

The tangor is a citrus fruit that is deliberate or accidental hybrid of the mandarin orange (*C. reticulata*) and sweet orange (*C. sinensis*). The fruit has thick rind that is easy to peel and its bright orange pulp is sour-sweet and full-flavored.

Fruit Characteristics and Physio-Chemical Properties of Tangor

Fruit weight, fruit diameter, pulp weight, juice volume, juice weight, total soluble solid and TA% were recorded to be highly significant (Table 8).

Fruit weight

The individual fruit weight of 8 genotypes was found highly significant from 97.29 g to 218.3 g with the mean fruit weight of 155.22 g. The highest fruit weight was found with genotypes NCRP-79 (218.30 g), NCRP-76 (203.00 g) and NCRP-72 (194.70 g). In contrast, the lowest individual fruit weight was recorded from two genotypes NCRP-7 (95.42 g) and NCRP-74 (97.29 g) (table 8).

Fruit diameter

The fruit diameter was found to be highly significant varying from 47.67 mm to 73.89 mm with the average fruit diameter of 60.12 mm. The highest fruit diameter was recorded with two genotypes NCRP-79 (73.89 mm) and NCRP-72 (72.83 mm). The lowest fruit diameter was recorded with two genotypes NCRP-73 (47.67 mm) and NCRP-7 (49.98 mm) (table 8).

Pulp weight

The individual pulp weight ranged from 67.10 g to 174.80 g with mean individual pulp weight of 110.61 g. The pulp weight was found to be highest from genotype NCRP-79 (174.80 g) followed by NCRP-72 (136.20 g) and NCRP-76 (130.10 g). The lowest pulp weight was recorded from genotype NCRP-7 (67.10 g) and NCRP-75 (70.76 m) (table 8).

Juice volume

The juice volume was found to be highly significant varying juice volume from 26.07 ml to 60.13 ml with mean juice volume of 42.83 ml. The highest juice volume was recorded form genotypes NCRP-79 (60.13 ml), NCRP-72 (57.47 ml) and NCRP-54.67 ml. The lowest juice volume was found in genotype NCRP-7 (26.07 ml) followed by NCRP-78 (32.07 ml) and NCRP-74 (32.27 ml) (table 8).

Juice weight

The juice weight was found highly significant varying juice weight from 25.86 g to 60.33 g with average juice weight of 42.45 g. The highest juice weight was found with genotype NCRP-79 (60.33 g) followed by NCRP-72 (56.41g) and NCRP-76 (54.76 g). In contrast, lowest juice weight was recorded with NCRP-7 (25.86 g) and NCRP-78 (31.13 g) (table 8).

Total soluble solid (TSS %)

TSS % was found highly significant varying from 6.33% to 8.67% with average value of 7.40%. TSS % was recorded highest with genotype NCRP-7 (8.67%) followed by genotype NCRP-75 (8.65%). The lowest TSS was recorded with genotypes viz., NCRP-72 (6.33%), NCRP-79 (6.53%), NCRP-73 (6.77%) and NCRP-74 (7.05%) (table 8).

Titratable acid (TA %)

TA % was found highly significant varying the range from 2.68% to 9.51% with the average value of 7.03%. TA% was recorded highest with genotypes NCRP-78 (9.51%) and NCRP-75 (9.12%). On contrary, NCRP-7 (2.68%) imparted lowest TA% followed by NCRP-74 (4.31%) (table 8).

Table 8: Fruit characteristics and physio-chemical properties of tangor genotypes at NCRP in fiscal year 2072/73.

Genotype	Fruit Weight (g)	Fruit Diameter (mm)	Pulp Weight (g)	Juice Volume (ml)	juice Weight (g)	TSS%	TA %
NCRP-7	95.42d	49.98d	67.10c	26.07c	25.86c	8.67a	2.687e
NCRP-72	194.70a	72.83a	136.20b	57.47a	56.41a	6.33b	8.50ab
NCRP-73	160.00b	47.67d	112.00b	39.47b	39.27b	6.77b	7.65bc
NCRP-74	97.29d	56.33c	78.11c	32.27bc	33.19bc	7.05b	4.31d
NCRP-75	120.70cd	57.13c	70.76c	40.47b	38.65b	8.65a	9.12a
NCRP-76	203.00a	57.98c	130.10b	54.67a	54.76a	7.87ab	7.68bc
NCRP-78	152.30bc	65.16b	115.80b	32.07bc	31.13bc	7.36ab	9.51a
NCRP-79	218.30a	73.89a	174.80a	60.13a	60.33a	6.53b	6.80c
Mean	155.22	60.12	110.61	42.83	42.45	7.40	7.03
P-value	**	**	**	**	**	**	**
CV %	12.12	5.11	15.50	15.36	15.87	11.05	9.41
$LSD_{(0.05)}$	32.96	5.38	28.08	11.52	11.80	1.43	1.16

3.2 Postharvest Research

Effect of plant extracts and chemical on enhancing storage life of mandarin (var. Khoku) in a 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.
- To indentify the best alternative to chemicals for the management of pathogenic losses caused during storage.

Methodology

The experiment was carried out to identify suitable botanicals that enhance storage life of mandarin at NCRP, Paripatle, Dhankuta beginning from the fiscal year 2070/71. Cellar store constructed at NCRP was used for the experiment. The experiment was carried out by Completely Randomized Block Design and were given six treatments and replicated thrice. The treatments given are stated below:

T1 : spiked fruits treated with 15% Neem extract

T2 : Spiked fruits treated with 10% Garlic extract

T3: Spiked fruits treated with 10% Ginger extract

T4: Spiked fruits treated with 1000 ppm Carbendazim (check)

T5: Spiked fruits treated with 6% Rice Starch

T6: Spiked fruit untreated

T7: Spikeless fruits treated with 15% Neem extract

T8: Spikeless fruits treated with 10% Garlic extract

T9: Spikeless fruits treated with 10% Ginger extract

T10: Spikeless fruits treated with 1000 ppm Carbendazim (check)

T11: Spikeless fruits treated with 6% Rice Starch

T12: Spikeless fruit untreated

Ripened spiked and spike less fruits were harvested separately without any physical injury from the orchard of NCRP. Neem leaf, fresh garlic and ginger were grinded mechanically in a mixture

grinder and juice was extracted separately. Similarly, rice was boiled for 15 minutes and when starch attained thick consistency was collected. All these extracts were sieved with muslin clothes in a clean flask separately. Now, required amount of concentrated extracts was taken to make 10 lt of above stated solution separately in a plastic bucket. The harvested fruits with spike and spike less were then weighed 5kg for individual treatment separately and then treated with above stated substances by dipping for 10 minutes, air dried and then placed on a bamboo rack made inside a cellar store. Among all treatments, fruit treated with carbendazim (T6 & T10) is considered as check to identify suitable botanicals that have similar effect.

The observation was taken at 15 day interval for three times on physical and chemical parameters like fruit weight, TSS, TA, Juice % and organoleptic taste.

Result and disscussion

The experiment was carried out to identify suitable botanicals that enhance storage life of mandarin at NCRP, Paripatle, Dhankuta in the fiscal year 2071/72. All the treated fruits were stored in cellar store for 60 days and observations on different parameters were taken four times at 15, 30, 45 and 60 days at 15 days' interval. Five kilograms of fruits were initially taken for each treatment and subjected to observations at 15 days' interval for fruit weight only. Fruit Juice volume, TSS and TA were observed at the end of the storage duration i.e 60 days.

Table 9 illustrates that there was no significant difference in weights of fruits among various treatments in any storage duration. This result is in contrary to findings of 2069/070 as stated in annual report of 2071/72 where the storage duration was 90 days with 30 days' interval between observations with significant difference in fruit weight among various treatments.

Table 9: Effects of chemicals and botanicals on fruit weight and juice content of mandarin during storage in cellar store at NCRP, 2015/016

Treatments	Initial Fruit Wt (kg)	Fruit Weight (g)				Juice Volume (ml)	TSS %	TA %
		15 days	30 days	45 days	60 days			
T1: Spiked fruits treated with 15% neem extract	5	5.0	4.86	4.68	4.33	36.33	11.83	2.33
T2: Spiked fruits treated with 10% garlic extract	5	5	4.93	4.37	3.91	30.33	12.00	3.00
T3: Spiked fruits treated with 10% ginger extract	5	5	4.94	4.84	4.41	24.67	12.17	2.93
T4: Spiked fruits treated with 1000 ppm carbendazim	5	5	5	4.75	4.31	25.67	11.67	2.95
T5: Spiked fruits treated with 6%	5	4.9	4.87	4.77	4.19	28.00	11.5	2.5

rice starch								
T6: Spiked fruits untreated	5	4.97	4.89	4.78	4.29	25.00	11.83	3.00
T7: Spikeless fruits treated with 15% neem extract	5	4.93	4.8	4.71	4.24	30.67	10.83	3.67
T8: Spikeless fruits treated with 10% garlic extract	5	4.84	4.72	4.3	3.97	32.5	10.5	2.73
T9: Spikeless fruits treated with 10% ginger extract	5	4.77	4.55	4.28	3.93	31.67	11.33	3.2
T10: Spikeless fruits treated with 1000 ppm carbendazim	5	4.98	4.9	4.78	4.26	36.67	11.67	3.00
T11: Spikeless fruits treated with 6% rice starch	5	4.9	4.71	4.49	4.13	34.67	11.5	2.8
T12: Spikeless fruits untreated	5	4.93	4.67	4.39	4.18	29.33	12.17	2.83
Mean value		4.94	4.82	4.59	4.18	30.49	11.58	2.97
P value		NS	NS	NS	NS	NS	NS	NS
$LSD_{(0.05)}$		0.19	0.29	0.45	0.59	12.6	1.41	2.01
CV%		2.29	3.6	5.81	8.34	24.44	7.2	39.84

3.3 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 or profitable as those established from high quality, 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.

3.3.1 ON FARM ROOTSTOCK EVALUATION OF KINNOW MANDARIN AND 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. At the same time, kinnow mandarin is becoming popular in Jhapa district and more than 100 saplings of kinnow have been planted. Presently, these two varieties are grafted on trifoliate orange. 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 to fulfill the following objectives:

- To identify compatible rootstock for acid lime and kinnow mandarin.
- To enhance productive life of kinnow mandarin and 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, NCRP-55 and Kinnow mandarin were grafted on those seedlings by shoot tip grafting and raised in nursery. Individual seedling was considered as a single treatment as stated below:

Treatment	+	NCRP-49	NCRP-55	Kinnow
T1 – Trifoliate orange	+	NCRP-49	NCRP-55	Kinnow
T2– Citrange var. C35	+	NCRP-49	NCRP-55	Kinnow
T3 – Rangpur lime	+	NCRP-49	NCRP-55	Kinnow
T4 – Pumelo	+	NCRP-49	NCRP-55	Kinnow
T5 –Sour orange	+	NCRP-49	NCRP-55	Kinnow
T6 – Rough lemon	+	NCRP-49	NCRP-55	Kinnow

These grafted saplings were planted by Randomized Complete Block Design in four different location viz. RARS, Tarahara; Itahara, Morang (Madan Bhandari Bhawan); Rupkanchanpur, Saptari (Sahjaadi Begum); and RARS, Parwanipur.

Result and discussion

The results projected in table 10 illustrates that plant height, number of branches, rootstock diameter, graft union diameter and scion diameter were significantly different.

Plant height

Plant height was varied from 44.67 cm to 190.30 cm with mean value of 135.75 cm. The highest plant height was noted from Kali jyamire × NCRP-55 (190.30 cm) followed by Rangpur lime × NCRP-49 (178.30 cm) and Rangpur lime × NCRP-55 (175.00 cm). In contrast, lowest plant height was recorded from pumelo × NCRP-49 (44.67 cm) followed by trifoliate × NCRP-55 (91.00 cm) and seti jyamire × NCRP-55 (92.67 cm) (table 10).

Number of branches

The total number of branches varied from range 6.00 to 40.00 with mean value of 24.31. The highest number of branches was noted form rangpur lime × NCRP-55 (40.00), citrange × NCRP-55 (36.33) and kali jyamire × NCRP-49 (30.33). In contrast, lowest number of branches was recorded from pumelo × NCRP-49 (6.00), followed by seti jyamire × NCRP-55 (17.67) and trifoliate × NCRP-55 (19.33) (table 10).

Rootstock diameter

Rootstock diameter was found highly significant varying range from 0.97cm to 4.60 cm with average value of 3.40 cm. Highest rootstock diameter was recorded from rangpur lime × NCRP-55 (4.60 cm), kali jyamire × NCRP-55 (4.40 cm), Rangpur lime × NCRP-49 (4.37 cm) and pumelo × NCRP-55 (4.30 cm). Lowest rootstock diameter was recorded from pumelo × NCRP-49 (0.97 cm) and trifoliate × NCRP-55 (1.93 cm) (table 10).

Graft union diameter

Graft union diameter was noted highly significant ranging from 0.90 cm to 4.73 cm with mean value of 3.41 cm. Highest graft union diameter was recorded from rangpur lime × NCRP-49 (4.73 cm), rangpur lime × NCRP-55 (4.50cm), citrange × NCRP-55 (4.47 cm) and kali jyamire × NCRP-55 (4.37 cm). Pumelo × NCRP-49 (0.90 cm) recorded the lowest graft union diameter (table 10).

Scion diameter

Scion diameter was highly significant varying range from 0.77 cm to 4.37 cm with mean value of 2.90 cm. Highest scion diameter was noted from rangpur lime × NCRP-49 (4.37 cm) and citrange × NCRP-55 (4.33 cm). Lowest scion diameter Pumelo × NCRP-49 (0.77 cm) trifoliate × NCRP-55 (1.47 cm) and citrange × NCRP-49 (1.77 cm) (table 10).

Table 10: Performance of six different rootstocks on acid lime in Tarahara, Morang in 2015

Treatment	Plant Height (cm)	No. of Branch	Rootstock Diameter (cm)	Graft Union Diameter (cm)	Scion Diameter (cm)
Pumelo * NCRP-55	129.00abc	26.67ab	4.30a	4.23ab	3.70ab
Rangpur lime * NCRP-55	175.00ab	40.00a	4.60a	4.504	3.67ab
Seti jyamire * NCRP-55	92.67bc	17.67bc	2.67bc	2.77bcd	2.40bc
Kali jymaire * NCRP-55	190.30a	25.67ab	4.40a	4.37a	3.97ab
Citrange * NCRP-55	154.00ab	36.33ab	3.93ab	4.47a	4.33a
Trifoliate * NCRP-55	91.00bc	19.33bc	1.93cd	2.13de	1.47cd
Pumelo * NCRP-49	44.67c	6.00c	0.97d	0.90e	0.77d
Rangpur lime * NCRP-49	178.30ab	22.00abc	4.37a	4.73a	4.37a
Seti jyamire* NCRP-49	150.00ab	23.33abc	3.57ab	3.63abc	3.07abc
Kali jymaire* NCRP-49	161.30ab	30.33ab	3.37abc	3.33abcd	2.40bc
Citrange * NCRP-49	98.33bc	22.67abc	2.60bc	2.17cde	1.77cd
Trifoliate * NCRP-49	164.30ab	21.67abc	4.10ab	3.67ab	2.90abc
Grand Mean	135.75	24.31	3.40	3.41	2.90
P-value	*	*	**	**	**
$LSD_{(0.05)}$	76.58	16.34	1.45	1.36	1.430
CV%	33.32	39.71	25.24	23.51	29.12

3.4 CITRUS DECLINE MANAGEMENT

3.4.1 Demonstration of Integrated Nutrient Management Techniques in Farmers' Ochards to Minimize Citrus Decline

Citrus decline is the number one threat to the citrus industry in Nepal and unless this problem is understood and managed, citrus will slowly decline (Roistacher, 1996). It has now been suspected that these diseases are widespread throughout major citrus growing belts in the country and has become a serious threat for mandarin production. Most of the citrus nurseries in the country are located below 1000 masl altitude. In lower altitude areas, insect vector of many diseases are considered active because of the favorable environment.

Ingle, H. V. *et al* (1990) stated that citrus decline tree responded well to pruning treatment with adequate scientific management, irrigation and plant protection measures.

According to the field survey, the possible cause contributing to the decline syndrome are Huanglongbing, Citrus Tristeza virus, insect pest, root rot, poor orchard management, unfavorable soil and climate and low quality planting material. It is stated that application of 300-500 g nitrogen, 200-250 g phosphorus and 250-350 g potassium per tree of bearing stage produce optimum yield and helps to minimize decline gradually (FAO, 2011).

Since its establishment, NCRP has generated several innovative technologies on integrated plant nutrient management, insect pest and disease management, orchard management etc. to revive even declined orchard to healthy and productive. Thus, this activity was carried out on fiscal year 2071 to obtain the following objectives:

- To transfer generated innovative technology to citrus growers.
- To revive declined mandarin orchard to healthy and productive.

Methodology:

In Dhankuta, Bhojpur and Taplejung districts two different sites of declined mandarin orchard were identified with the help of DADO's of concerned districts. Following activities were performed to obtain the proposed objectives:

Identified declined orchards of proposed districts as stated. Selected 20 declined trees in each site of all three districts.

Pruned damaged and overcrowded branches.

Prepared Bordeaux mixture and paste.

Smeared paste on pruned area.

Exposed damaged roots by root rot disease.

Pruned damaged roots.

Drenched Bordeaux mixture on pruned roots and again fill exposed area with soil.

Severely pruned roots of a tree were given approach grafting or nechugi with trifoliate orange.

Prepared ring sized 15 cm * 15 cm * 15 cm around the tree canopy.

Demonstrated application of manure and fertilizer in soil @ FYM 50 kg + N 500 gm + P 250 gm + K 500 gm + Boric acid 20 gm + Zinc sulphate 75 g + Cupper sulphate 75 g + Manganese sulphate 75 g.

In addition 5 gm of agri-lime was also applied.

Nitrogen was applied in two equal split doses i.e. first as a basal after harvest and second half at the time of flowering.

Then the soil around the canopy was mulched and irrigated.

Annual calendar of operation was provided to the farmers to carry out all the cultural operation including plant protection measures. For this, required fungicide and insecticide was given to the farmers to mange insect pest and diseases when observed.

Achievement

All the selected mandarin orchard except from Khoku are reviving to healthy condition due to the treatments provided. Farmers are satisfied with the activity performed and adopting the innovative orchard management practices provided by NCRP.

3.5 Multi-locations (Collaborative) Trial

3.5.1 Coordinated Varietal Trial on Ginger

Introduction

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

Methodology

Seven genotypes of ginger including 'Local Check' were obtained from National Ginger Research Program (NGRP), Salyan in 2015. 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, 2015: 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, forest dry leaves @ 16 tones/ha were used as mulching. The whole recommended nitrogen dose was split into two doses: first at 30 days after germination and remaining half dose of nitrogen and half dose of potash were applied at 60 days after germination. Weeding was done twice: first in 45 days after rhizome planting and second in 70 days after rhizome planting. Earthing up was given in 140 days after rhizome planting. Fresh rhizomes were harvested in 232 days later than planting day. Experimental data viz., plant height, number of tillers per clump, fresh rhizome yield and Dry Ginger Recovery (DGR %) were recorded.

Result and Discussion

Fresh rhizome yield was found to be significant whereas plant height, number of tillers per clump and DGR % were found to be insignificant (table 11). Genotype KK1 recorded the highest plant height (100.10 cm) followed by local genotype (99.80 cm) and genotype ZI 1302 (97.87 cm). The lowest plant height was recorded from genotype ZI 1027 (86.13 cm). The highest number of tillers per clump was found in genotype ZI 1027 (9.33) followed by genotypes ZI 1007 (8.40) and ZI 1025 (8.27). The lowest number of tillers per clump was recorded from genotype ZI 1902 (7.00). Fresh rhizome yield was found significantly varied ranging from 16.89 t/ha to 35.68 t/ha with mean rhizome yield of 27.23 t/ha. Fresh rhizome yield was recorded significantly highest with local genotype (35.68 t/ha) followed by genotypes KKI (31.20 t/ha) and ZI 1027 (30.78 t/ha). The lowest fresh rhizome yield was noted with genotype ZI 8502 (16.89 t/ha). DGR % varied from range of 19.83% to 24.00% with mean DGR % of 22.29%. Highest DGR% was recorded from local genotype (24.00%) followed by ZI 1027 (23.67 %) and ZI 1007 (23.17%). Lowest DGR% was recorded from genotype ZI 8502 (19.83%) and ZI 1025 (21.33%) (table 11).

Table 11: Performance of seven genotypes of ginger tested under Coordinated Varietal Trial in the field of NCRP, Paripatle, Dhankuta in 2015.

Genotype	Plant Height (cm)	No. of Tillers /Clump	Fresh Rhizome Yield (t/ha)	DGR%
Local	99.80a	7.467a	35.68a	24.00a
ZI 1007	92.27a	8.40a	24.58ab	23.17a
ZI 1025	87.13a	8.27a	25.90ab	21.33a
ZI 8502	96.40a	7.60a	16.89b	19.83a
ZI 1027	86.13a	9.33a	30.78a	23.67a
KK1	100.10a	7.00a	31.20a	22.50a
ZI 1302	97.87a	7.00a	25.56ab	21.50a
Mean	94.25	7.87	27.23	22.29
P-value	NS	NS	*	NS
$LSD_{(0.05)}$	14.22	3.22	10.69	5.86
CV %	8.48	23.00	22.07	14.78

3.5.2 Coordinated Farmers Field Trial on Turmeric

Introduction

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

Methodology

Five genotypes of turmeric were obtained from National Ginger Research Program (NGRP), Salyan in 2015. They were included in CFFT, and evaluated in three farmers' field nearby NCRP, Dhankuta, considering one farmer as one replication. Thirty tones of FYM/ha were incorporated into soil in the first week of May, 2015: 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, forest dry leaves @ 16 tones/ha were used as mulching. The whole recommended nitrogen dose was split into two doses: first at 30 days after germination and remaining half dose of nitrogen and half dose of potash were applied at 60 days after germination. Weeding was done twice: first in 45 days and second in 70 days after rhizome planting. Earthing up was given in 140 days after rhizome planting. Fresh rhizomes were harvested in 240 days later than planting day. Experimental data viz., number of tillers per clump, plant height, fresh rhizome weight, dry powder weight and Turmeric Powder Recovery (TPR %) were recorded.

Result and discussion

Plant height, number of tillers per clump, rhizome yield, weight of dry slice/1 Kg sample and TPR% were found to be insignificant (table 12). Plant height varied from 84.50 cm to 110.70 cm with mean height of 99.46 cm. The highest plant height was found in genotype CI 312 (110.70 cm) followed by genotype KKI (108.70 cm). The lowest plant height was noted from genotype CI 0210 (84.50 cm). The number of tillers per clump varied from 1.90 to 3.10 with mean 2.54. The highest number of tillers per clump was recorded from genotype CI 0210 (3.10) that was not significant with genotype CI 1213 (2.80). The lowest number of tiller per clump was noted from local genotype (1.90). The fresh rhizome weight varied from 12.25 t/ha to 25.0 t/ha with the average weight of 16.91 t/ha. The highest fresh rhizome yield was found in genotype KKI (25.033 t/ha) followed by CI 0210 (18.50 t/ha). In contrast, the lowest yield was recorded from genotype CI 0205 (12.25 t/ha). The weight of dry slice per 1 kg sample varied from 0.16 kg to 0.17 kg with average of 0.16 kg. The highest weight of dry powder was found in CI 0205 (0.17 kg) followed by CI 0210 (0.16 kg). Lowest weight of dry powder was recorded from local genotypes (0.155 kg), CI 1312 (0.155 kg) and KKI (0.155 kg). The TPR% was found varied

from 15.25% to 17% with mean TPR% of 15.85%. The highest TPR% was obtained from genotype CI 0205 (17%) followed by CI 0210 (16%). Lowest TPR% was noted from local genotype (15.25%) followed by CI 1312 (15.50%) and KKI (15.50%) (table 12).

Table 12: Performance of five genotypes of turmeric tested under Coordinated Farmers Field Trial in Dhankuta in 2015

Genotype	Plant Height (cm)	No. of Tillers /Clump	Rhizome Yield (t/ha)	Weight of Dry Slice (Kg) / 1 Kg sample	Weight of Dry Powder (Kg) / 1 Kg sample	TPR %
CI 0205	100.00	2.40	12.25	0.178	0.170	17.00
CI 0210	84.50	3.10	18.50	0.165	0.160	16.00
CI 1312	110.70	2.80	16.00	0.165	0.155	15.50
KKI	108.70	2.50	25.03	0.165	0.155	15.50
Local	93.40	1.90	12.75	0.160	0.155	15.25
Mean	99.46	2.54	16.91	0.166	0.159	15.85
P-value	NS	NS	NS	NS	NS	NS
$LSD_{(0.05)}$	23	0.73	42.76	0.12	0.09	9.86
CV %	8.33	10.42	23.29	24.69	22.55	22.40

4 Production Program

NCRP has maintained production orchards of mandarin, sweet orange and acid lime for different research purposes. It spreads out in about 7 ha area. The popular local variety, which is known as Khoku local has occupied major portion of the production orchard followed by sweet orange variety Dhankuta local and different local genotypes of acid lime. This year, Rs.1.086 million revenue was collected from saplings and fruit production.

Besides, NCRP has a regular activity of sapling production of major varieties of mandarin, sweet orange and acid lime. In 2072-73, a total of 10,100 grafted samplings were produced and made available to the farmers. The figure showed the major demand of acid lime followed by mandarin. The demand of acid lime saplings was high from the farmers of terai districts. The detail of fruit and sampling production is given in the table 13.

Table 13: Production of fruits and saplings during 2072/73

S.N.	Particulars	Quantity	Revenue (NPR) '000
1.	Mandarin saplings	2161	111.94
2.	Sweet orange saplings	153	7.65
3.	Acid lime saplings	3806	190.30
4.	Kumquat saplings	29	1.74
5.	Rose saplings	35	1.75
6.	Mandarin fruits		560.00
7.	Others		13.15
	TOTAL		1,086.000

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 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 14).

Table 14: Calendar of operations adopted at NCRP, paripatle for orchard management

Month	Operations
Baishak	New flush attracts insects like psylla, whiteblack 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 1400 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 Services

In fiscal year 2072/73, NCRP supplied 6149 grafted saplings of different citrus species to the farmers. The grafted saplings made available to the farmers comprised of Khoku local mandarin, Okitsuwase mandarin, two acid lime varieties; Sunkatagi-1 and Sunkagati-2. In addition, the scion source from the mother plant of mandarin and acid lime varieties was provided to the nearby six nursery entrepreneurs in Dhankuta district.

10 BUDGET STATEMENT

Budget and expenditure of regular program as well as beruju of the program has been presented in Annex 4 and 5 respectively

11 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 (fruit fly, green stink bug and fruit sucking moths), pathological and hormonal factors.
f) Incidence of insect pests such as citrus psylla, white fly, leaf miner and scale insects.
g) Incidence of Greening, Tristeza, Phytophthora root rot, canker and other diseases.
h) Rainfed cultivation of most of citrus orchards.
i) Presence of hard pan.
j) Non-availability of disease free planting materials.
k) Acidic soil condition including zinc, calcium and magnesium deficiency in most of the citrus orchards particularly in mid-hills of west Nepal.
l) Macro and micro-nutrient deficiency.
m) No information about the nutrient content of citrus orchard.
n) Poor institutional mechanisms and coordination for marketing, and
o) Lack of entrepreneurship

Regarding management aspect, NCRP is lacking human resources for several years. Currently, a total of 18 staffs are working in the Program although there are 43 approved positions allocated by the NARC. Among the working staffs, only three scientists are there for research execution.

12 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 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

ANNEXES

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

S.N0	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

S.N0	Accession no	Identification/common name	Source
	Grape Fruit		
68	NCRP 45	Shamber	ICIMOD

69	NCRP 76	Henderson	INRA_CIRAD, France
70	NCRP 77	Star Ruby	INRA_CIRAD, France
71	NCRP 78	Reed	INRA_CIRAD, France
72	NCRP 79	Pink Rubi	INRA_CIRAD, France
73	NCRP-44	Phultrac (Pumelo)	Vietnam
74	NCRP-43	Nam Roi (Pumelo)	Vietnam
75	NCRP-42	Phodiem (Pumelo)	Vietnam
	E. Acid lime (C. aurantifolia):		
76	NCRP-108	Khursanibari local	SHARP, Chitwan
77	NCRP-107	Tehrathum local	Tehrathum
78	NCRP-117	Baitadi local	Baitadi
79	NCRP-118	Salyan local	Rojwal Takura, Salyan
80	NCRP-119	Bhojpur local	Takshor, Bhojpur
81	NCRP-120	Parwat local	Lekhpant, Parwat
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	IAASAcc # 71 (5)	IAAS, Rampur
93	NGRP-49	IAASAcc # 101 (3)	IAAS, Rampur
94	NCRP-48	IAASAcc # 101 (2)	IAAS, Rampur
95	NCRP-47	IAASAcc # 01 (17)	IAAS, Rampur
96	NCRP-46	IAASAcc # 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

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) – Soil	1	-	1
2. Senior Scientist (S.4)- Horticulture	1	1	-
3. Senior Scientist (S.3)- Horticulture	2	1	1
4. Senior Scientist (S.3)- Plant pathology	1	-	1
5. Scientist (S.1) - Soil	1	-	1
6. Scientist (S.1) - Plant breeding (Tissue culture)	1	1	-
7. Scientist (S.1) - Entomology	1	1	-
8. Scientist (S.1) - Plant Pathology	1	1	-
9. Senior Technical Officer (T.8) – Pomology	1	1	-
10. Senior Technical Officer (T.7) – Pomology	1	1	-
11. Technical Officer (T.6) - Pomology	3	1	2
12. Senior Technician (T.5)	2	-	2
13. Technician (T.4)	5	3	2
14. Technician (5th.level)	17	11	6
15. Admin officer (A6)	1	1	-
16. Account officer (A6)	1	-	1
17. Computer operator (T5)	1	-	1
18. Administrative Assistant (A5)	1	1	-
19. Driver (4th. level)	1	1	-
Total	43	25	18

Annex 3: Human Resource of NCRP in 2072/73

Name	Position	Qualification	Working area & remarks
1. Tul Bahadur Pun	Coordinator (S.4)	M. Sc (Hort.)	Coordinator and Fruits and vegetables
2. Amar Bahadur Pun Magar	Senior Scientist (S.3)	M. Sc (Hort.)	Horticulture
3. Roshan Pakka	Scientist (S. 1)	M. Sc.(Plant Patho.)	Plant Pathology
4. Manish Kumar Thakur	Scientist (S.1)	M. Sc (Hort.)	Pomology
5. Sudeep Kumar Upadhaya	Scientist (S.1)	M. Sc (Ento)	Entomology
6. Kishor Bhandari	Scientist (S.1)	M. Sc (Ento.)	Horticulture pests
7. Pradeep Karki	Tech. Officer (T.7)	M. Sc. (Hort.)	Support in research and production
8. ParsuramYadav	Tech. Officer (T.6)	Bachelor degree	Support in research and production
9. Gopal Raj Shrestha	Admin. Officer (A.6)	I.A.	Administration and store
10. Nar Bahadur Tamang	Technician (T.4)	Literate	Support in research and production
11. Prem Narayan Yadav	Technician (T.4)	B.Sc. Ag.	Support in research and production
12. Damali Sherpa	Technician (T.4)	JTA training	Support in research and production
13. Min Kumari	Technician (T.4)	JTA training	Support in research and production
14. Amar Bahadur Shrestha	TS- Fifth	Literate	Support in research and production
15. Jagat Bahadur Karki	TS- Fifth	Literate	Support in administration
16. Thir Bahadur Ale	TS- Fifth	Literate	Support in research and production
17. Man BahadurTamang	TS- Fifth	Literate	Support in research and production
18. Hem BahadurDahal	TS- Fifth	Literate	Support in research and

			production
19. Tara Nath Khatri	Heavy driver-Fifth	S.L.C.	Driver
20. Sita Devi Dahal Pokhrel	TS-First	Literate	Support in research and production
21. Laxmi Bhattarai	TS-First	Literate	Support in research and production
22. Kashi Nath Subedi	TS-First	Literate	Support in research and production
23. Dhan Kumar Rai	TS-First	Literate	Support in research and production
24. Tetri Devi Shah	TS-First	Literate	Support in administration
25. Tek Bahadur Magar	TS-First	Literate	Support in research and production

Annex 4: Regular Annual Budget and Expenditure in 2072/73

Budget Code	Budget Heads	Annual Budget	Budget Released	Budget Expenditure	Balance
	Operational Expenses	**19584800.00**	**19471334.60**	**19471334.60**	**0.00**
21111	Staff Salary	5495200.00	5434885.00	5434885.00	0.00
21112	Local Allowances	190300.00	187714.00	187714.00	0.00
21113	Dearness Allowances	216800.00	214800.00	214800.00	0.00
21119	Other Allowances	103000.00	102700.00	102700.00	0.00
21121	Uniform	157500.00	157500.00	157500.00	0.00
22111	Water and Electricity Expenses	418000.00	417000.00	417000.00	0.00
22112	Communication Expenses	114000.00	113711.00	113711.00	0.00
22211	Fuel	550000.00	549436.00	549436.00	0.00
22212	Operational and Repair Expenses	700000.00	700000.00	700000.00	0.00
22213	Insurance	35000.00	3118.00	3118.00	0.00
22311	Contingency Expenses	500000.00	499987.10	499987.10	0.00
22314	Fuel for Other Purposes	202000.00	201139.00	201139.00	0.00
22321	Repair/Maintenance of Public Assets	960000.00	955704.90	955704.90	0.00
22521	Production Material Service	8457000.00	8447720.10	8447720.10	0.00
22612	Travel Expenses	1426000.00	1425924.50	1425924.50	0.00
22711	Miscellaneous Expenses	60000.00	59995.00	59995.00	0.00

	Capital Expenses	**11770000.00**	**11739096.42**	**11739096.42**	**0.00**
29221	Building Construction	5000000.00	4992791.92	4992791.93	0.00
29231	Capital Improvement - Building	1570000.00	1547143.74	1547143.74	0.00
29311	Furniture and Fixtures	200000.00	199730.00	199730.00	0.00
29511	Machinery Equipment	2000000.00	1999754.00	1999754.00	0.00
29611	Public Construction	3000000.00	2999676.76	2999676.76	0.00
	Grand Total	**31354800.00**	**31210431.02**	**31210431.02**	**0.00**

Annex 5: Beruju Status of Fiscal Year 2072/73

Beruju	Amount	Remarks
Beruju till last year (2071/72)	0.00	
Beruju cleared in this FY (2072/73)	0.00	
Remaining beruju	0.00	

Powdery Mildew disease in Mandarin

Green Stink Bug insect

Grafted saplings planted in nursery bed

Trifoliate orange seedlings raised in plastic tunnel

Pipeline mandarin genotype - Khoku local

Citrus Field Gene Bank