Annual Report

2070-71 (2013-14)

Government of Nepal

Nepal Agricultural Research Council

National Citrus Research Programme

Paripatle, Dhankuta, Nepal

2014

National Citrus Research Programme (NCRP)

Nepal Agricultural Research Council (NARC)

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Cover Page Photo:

Mandarin cultivar Frutel early at field gene bank, NCRP, Paripatle, Dhankuta

FOREWARD

Citrus sector has a great prospect of economic development in Nepal since the country is noted for having appropriate geography and climate for quality citrus production. Recently, the sector has received national priority as the high value commodity. Nation has trust on this sector for rising farmers' economy in mid hills across the country. In particular, mandarin, sweet orange and acid lime have commercial importance following the increasing domestic as well as external market demand of Nepalese products.

The adequate quality and quantity production are two important aspects for commercialization of this sector. The area and volume of production are both increasing; however there is additional thousand hectare of land yet to be covered by this crop in the country. Furthermore, the sector is still sustaining by adopting the traditional farming practices that needs to be transformed. As being the perennial fruit crop, the sector demands a large initial investment, but the equally important is to be adopting improved technologies appropriate in specific local context. The major problems in the sector include declining soil fertility and moisture, poor orchard management, increasing disease problems such as greening and root rot, and inadequate supply of healthy planting materials. Similarly, the short harvesting period of existing local cultivars illustrates the need of variety research 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 among others. This annual report encompasses the highlights of research outcomes accomplished during 2070-71 (2013-14).

I thank to Mr. Amar Bahadur Pun, Mr. Manish Kumar Thakur and Mr. Kishor Bhandary, scientists of NCRP for their valuable contribution and endeavor in research accomplishment and role in the preparation of this report. The equal appreciation goes to technicians, administrative and account staffs since the valuable research execution and findings could not be expected without their support and contribution. I hope this annual report will be an important asset for all stakeholders of citrus sector.

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ABBREVIATIONS

ARS	Agriculture Research Station
DADO	District Agriculture Development Office
FY	Fiscal year
FYM	Farm yard manure
g	Gram
ha	Hectare
K	Potassium
LSD	Least significant difference
m asl	meter above sea level
m	Meter
mm	Millimeter
N	Nitrogen
NARC	Nepal Agricultural Research Council
NCRP	National Citrus Research Programme
P	Phosphorus
ppm	Part per million
RARS	Regional Agricultural Research Station
RCBD	Randomized complete block design
Rs.	Rupees
t	Metric ton
t/ha	Ton per hectare
TA	Titrable acid
TSS	Total soluble solid
VDC	Village Development Committee

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प्रमुख सार संक्षेप

नेपालमा सुन्तला खेती, देशको आर्थिक विकास र रोजगार सृजनाको लागि उच्च महत्वको रुपमा अगाडि आएको छ । सुन्तलाको बढ्दो आन्तरिक तथा बाह्य बजार भएको कारणले यसलाई एउटा उच्च मुल्य भएको क्षेत्रको रुपमा पहिचान गरिएको छ । यसर्थ नेपाल सरकारले विगत केही वर्षदेखि सुन्तला क्षेत्रको प्रवर्दन र विकासको लागि उच्च प्राथमिकता दिदैआएको 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 बिकासका विद्यमान प्रमुख चुनौतीहरु हुन् ।

यस परिपेक्ष्यमा राष्ट्रिय सुन्तला अनुसन्धान कार्यकमले राष्ट्रिय जिम्मेवारीको रूपमा यस क्षेत्रको प्रवंदन र विकास गर्न उपयुक्त प्रविधि विकासको लागि अनुसन्धान कार्यक्रम संचालन गर्दै आएको छ । यो कार्यक्रमले आ.व. २०७०/७१ अवधिमा जम्मा ७ ओटा परियोजना अन्तर्गत २६ ओटा अनुसन्धान क्रियाकलापहरु सम्पन्न गरेको थियो । यी कार्यक्रमहरु विशेष रुपमा जातीय अनुसन्धान, नर्सरी व्यवस्थापन, बाली उपरान्त व्यवस्थापन, बगैचा व्यवस्थापन र सुन्तलाको झिंगा/औषा व्यवस्थापनसंग सम्बन्धित थिए । फलफूल अनुसन्धान सम्पन्न गर्न लामो समय लाग्ने भएकोले धेरैजसो कार्यक्रम नियमित संचालनमा छन् भने केही सम्पन्न भई अपेक्षीत उपलब्धीहरु हासिल भएका छन । यसरी आ.व. २०७१ सम्म पुरा गरिएका क्रियाकलापका उपलब्धीहरु संक्षिप्त रुपमा तल उल्लेख गरिएको छ ।

- जातीय संकलन र सम्वंद्धन अन्तर्गत १२० वटा स्थानीय र बाह्य स्रोतबाट सुन्तलाका विभिन्न जातहरु संकलन गरि कार्यक्रमको फारमभित्र (field gene-bank) सम्वर्द्धन गरी राखिएको छ । यी संकलित जातहरु सुन्तला, जुनार, भोगटे, कागती, निबुवा, सुन्तला वर्णशंकर र रुटस्टक वर्ग अन्तर्गत पर्दछन । प्रारम्भिक अध्ययन अनुसार यी संकलित जातहरु फल लाग्ने समय, फलको गुण र बोटको वृद्धिविकास आदिको विशेषतामा निकै विविधता देखिएको छ । त्यसर्थ उपयुक्त जातको छनौट तथा विकासको लागि अझ केही वर्षसम्म अध्ययन गर्न आवश्यक देखिन्छ ।
- सुन्तला, जुनार र कागतीका प्रचलनमा रहेका जातहरुको उत्पादन क्षमता र उत्पादन अवधी क्रमश कम र छोटो रहेका छन । यस समस्यालाई हल गर्ने उदेश्यले विदेशबाट भित्राइएका र उपयुक्त स्थानीय जातहरुको खोजगरी उत्पादन र उत्पादन समयको मुल्यांकन गर्दै आएको छ । प्रारम्भिक नतिजा अनुसार बाह्य सुन्तलाका जातहरु जस्तै ओकित्सुवासे, नोभा, मियावागासे, मिनु र स्थानीय खोकुले क्रमशः अगौटे र राम्रो उत्पादनको लागि उत्साहजनक परिणाम दिएको पाइएको छ । त्यसर्थ आउने वर्षमा सुन्तलाको दुई जातहरु ओकित्सुवासे र खोकु स्थानीय उन्मोचनको लागि प्रस्तावको लागि सिफारिस गरिन्छ ।
- त्यसै गरि मौसम सुन्तलाका दुईजात भ्यालेन्सीया लेट र वासिङ्गटन नेभलले क्रमशः पछौटे र आगौटे बालीको रुपमा राम्रो देखाएको छ । त्यसर्थ आउदो वर्षमा यी जातहरु उत्मोचनका लागि प्रस्ताव गर्ने योजना छ ।
- पूर्वी र मध्यमाञ्चलका तराईका जिल्लाहरुमा विभिन्न स्थानीय कागती जातहरुको खेती सम्भाव्यता अध्ययनको निचोडबाट जातीय गुणको आधारमा आ.व. २०७०/७१ मा दुई जातहरु सुनकागती-१ र सुनकागती-२ को नामबाट उत्मोचन गरिएको छ ।
- सुन्तलाको पोष्टहार्भेष्ट मण्डारण अवधि बढाउने सम्बन्धी अध्ययन गरियो । जसमा फलको भेटनो सहित टिपिएको फललाई १००० पिपिएम कार्वनडाजीम, १० प्रतिशत लसुनको झोल र

१० प्रतिशत अदुवाको झोलले उपचार गरिएकोबाट ३६ दिनसम्म थोरैमात्र तौल घटने र रोग लाग्नबाट बचाएको पाइयो ।

- सुन्तलामा तिनपाते रुटस्टकसंग विभिन्न उचाइमा कलमी गर्ने अध्ययन गरियो । जसमा १२ सेमी उचाईमा गरिएको कलमीबाट सफलतापूर्वक विरुवाको उचाई वृद्धि भएको पाईयो । तर ३६० दिनमा नापेको रेकर्डमा २० सेमी उचाईमा गरिएको कलमीको उच्च वृद्धि भएको पाइयो ।
- पश्चिमाञ्चलका तीन जिल्लाहरु पर्वत, गुल्मी र म्याग्दीमा फल कुहाउने औषाको यथार्थ पहिचान गर्ने अध्ययनबाट सुन्तलामा लाग्ने औषा/झिंगा फर्सी वालीमा लाग्ने ओरियन्टल झिंगा नभई चाइनिज फ्रुट फ्लाई (*Bactorocea minax*) भएको ठहर गरियो । सोही अध्ययनबाट उक्त प्रजातिको झिंगा सुन्तलामा जेष्ठको दोस्रो हप्तादेखि असार १५ सम्म उच्चतम आक्रमण गर्ने गरेको पाइयो । त्यसर्थ उक्त अवधिमा विभिन्न प्रोटीन पासो बनाई झिंगा नियन्त्रण गरेमा उचित हुने देखिन्छ ।
- झिंगा आकर्षण गरि मार्ने विभिन्न प्रोटिन पदार्थहरुको अध्ययनबाट अष्ट्रेलियन प्रोटिन ल्युर सवैभन्दा उपयुक्त भएको ठहर गरियो । त्यसै गरि औषाले फुललाई आक्रमण गरी फल झरेको दिन देखि ६/७ दिनको अवधिमा औषाबाट प्युपा बनि माटोभित्र प्रवेश गर्ने गरेको पाइयो । यसबाट झिंगाको अर्कोवर्ष वगैचामा जनसंख्या कम तथा नियन्त्रण गर्नको लागि फल झरेको ६/७ दिन अगावै सबै झरेका फलहरु संकलन गरी नष्टगर्ने वा खाल्डो खनी पुर्ने काम गरेमा उचित नियन्त्रण हुने निष्कर्ष निकालियो ।
- यस आ.व.मा सुन्तला बगौचा व्यवस्थापन, नर्सरी, रोगकिरा नियन्त्रण र जातीय विकासमा गरिएको प्रविधि र ज्ञान हस्तान्त्रण गर्ने उदेश्यले पूर्वाञ्चलका १३ जिल्लाका प्रतिनिधि कृषकलाई संलग्न गरि तालिम संम्पन गरियो ।
- कागतीको उन्नत खेती प्रविधि नामक किताव प्रकाशन गरियो ।
- यस वर्ष कार्यक्रममा सुन्तला अनुसन्धान कार्यक्रम अवलोकन गर्न करीव १५०० कृषक समुह, सरोकारवालाहरुको भ्रमण भयो ।
- कलमीको लागि सुन्तला र कागतीको माउबोटबाट स्वस्थ साइन धनकुटा जिल्ला नर्सरी व्यवसायीहरुलाई उपलब्ध गराइयो । यसैगरी यस आ.व. मा सुन्तला, मौसम र कागतीका करीव ४००० कलमी विरुवा कृषकहरुलाई उपलब्ध गराईयो ।
- यस कार्यक्रमको आ.व. २०७०/७१ को लागि विनियोजित वजेट रु १ करोड अस्सी लाख बाउन्न हजार थियो । जसमध्ये अनुसन्धान कार्यक्रमको लागि जम्मा ७३ लाख अस्सी हजार विनियोजन गरिएको थियो ।

EXECUTIVE SUMMARY

Citrus has been as a high prospect sector for raising economy and employment of the farmers in Nepal. The sector has been recognized as the high value commodity following the increasing demand for domestic as well as external markets. Thus, the government of Nepal has put high priority recently for its growth and development in the country. However, lower productivity and quality due to the increasing invasion of various diseases and pests including declining soil fertility and moisture besides limited variety option and lack of healthy planting materials are the main challenges. In these contexts, National Citrus Research Programme (NCRP) with the national mandate of developing appropriate technologies has been conducting research programs for promoting the citrus industry in the country. During fiscal year 2070/71 (2013/14), a total of 26 activities under 7 research projects were executed by the programme. Particularly, these were comprised of varietal research, nursery management, post harvest, citrus decline management and fruit fly. Most of the research activities are ongoing, while some concluded with worthwhile outputs that are summarized as follow:

- Under collection and maintenance of citrus genotypes activity, of total, 120 citrus genotypes have been collected from local and exotic sources during different periods and maintained at field genebank at NCRP, Dhankuta. These species include: mandarin, sweet orange, grapefruit, acid lime, lemon, tangor, tangelo, and rootstock species. A distinct variation with respect to fruiting behavior, fruit traits and morphological characteristics has been observed. Further selection is necessary to screen the best variety based on economic characters.
- Given the circumstances of poor yield and short production season of existing cultivars of mandarin, sweet orange and acid lime, the introduced exotic cultivars including elite local varieties have been evaluating by NCRP since 2063/64. The preliminary results of varietal evaluation of mandarin showed some exotic genotypes such as Okitsuwase, Nova, Miyagawase, Mino, URSS including Khoku local being promising for early crop maturity and fruit yield. Two genotypes of mandarin viz. NCRP 06 and NCRP 01 have been under pipeline for variety releasing based on their performance for yield and yield attributes that were evaluated during 2060/61 to 2069/70.
- Similarly, two sweet orange genotypes: Valencia late and Washington Novel have been performing excellent for higher fruit yield and off-season production. These genotypes are also under pipeline for releasing.
- 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 riverbasin 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.
- The result of postharvest storage study revealed that the fruit harvested with spike and treated with 1000 ppm carbendazim, 10% garlic extract, and 10% ginger extract were found better to enhance the storage life up to 36 days along with the minimum weight loss and pathological damages.
- 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 at those saplings grafted at 12 cm height during first two initial period viz. 90th and 180th days after planting, while the final maximum growth was noticed at those saplings grafted at 20 cm height.
- 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 and disease management, and orchard management based on the previous achievements in these regards. The experiment for decline management has been conducted since last year in two declined mandarin orchards each in Dhankuta, Bhojpur and Taplejung. The results were found encouraging and a complete data will be present next year.

- An investigation to identify the fruit fly species in three districts: Parbat, Gulmi and Myagdi confirmed that the infested fruits with fruit fly were detected to be the Chinese fruit fly (*Bactrocera minax*, Enderlein) 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 occured between 15th Jestha to 15th Asad. As a result, it could be suggested that the control measure during this period would be effective for minimizing the population of this pest.
- The Australian fruit fly lure (autolysed protein) @ 50 ml/L was resulted as the effective trap for fruit fly among different lure substances such as hydrolyzed protein (soyabean based) @ 50gm/L, orange-ammonia solution @ 750 ml + ammonium carbonate @ 25 gm/L + potassium sorbate preservatives @ 2 gm, and proteinax @ 50 gm/L.
- The study illustrated that the maximum pupal emergence from infested fruits was occurred on 7th day onward after fruit drop out. Thus, this indicates that orchard sanitation through collection and destruction of dropped fruits should be carried out before first six days of fruit drop. As result, fruit fly population into the soil could be minimized controlling this pest for next year in the orchard.
- A farmer training was carried out involving 14 citrus farmers from 13 districts in the eastern region. The participating farmers deserved the knowledge and experience of the technologies in regard to agro-husbandry, disease and pest management and nursery management of citrus.
- A booklet, Kagati Kheti published in this fiscal year.
- During this fiscal year, technical counseling was given to the 1500 farmers and other stakeholders regarding to 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 six nursery entrepreneurs. Likewise, grafted saplings of Khoku local mandarin, Okitsuwase mandarin, two acid lime varieties Sunkagati-1 and Sunkagati-2 were provided to the farmers in the region.
- The total annual budget approved for the programme was Rs. 18.052 million, while the operational budget comprised of Rs. 7.38 million (40.88 %) 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 to1400 m asl 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 36, 975 ha producing 216,188 metric tons annually with 9.14 t/ha productivity which are 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 2002/03 to 2012/13

Year	Total area (ha)	Productive area (ha)	Production (mt)
2002/03	23,663	13,312	139,110
2003/04	24,799	13,931	148,010
2004/05	25,910	14,606	156,956
2005/06	26,681	15,206	164,075
2006/07	27,980	15,832	171,875
2007/08	30,790	19,915	226,404
2008/09	32,322	22,482	253,766
2009/10	33,898	22,903	259,191
2010/11	35,578	23,609	263,710
2011/12	37,565	24,089	240,793
2012/13	36,975	23,645	216,188

Source: MoAD, Nepal, 2013

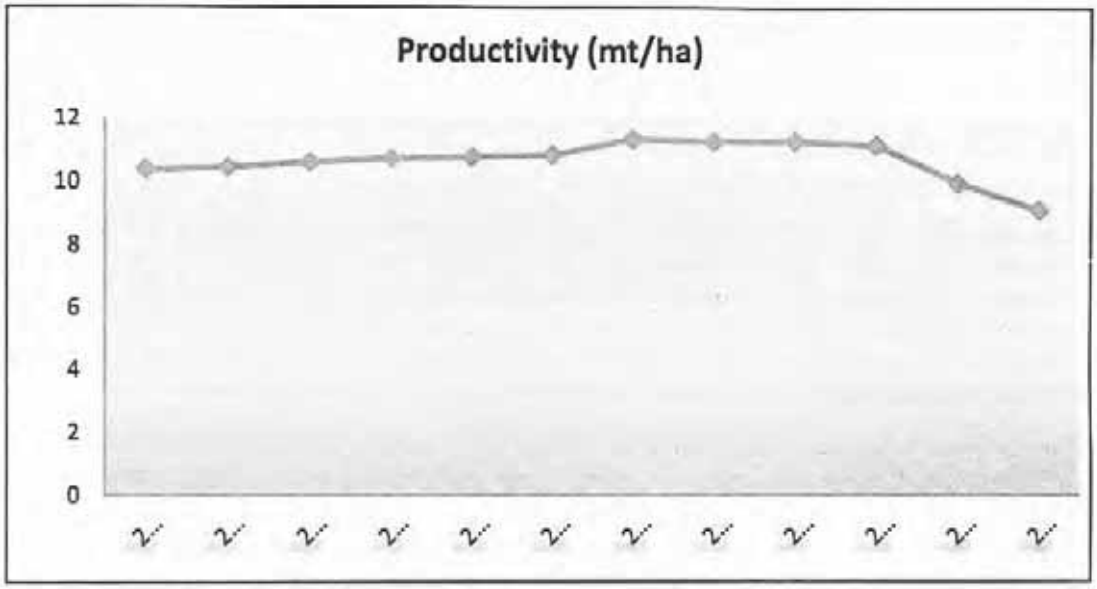

Figure 1. Productivity of citrus fruit crops during different period

The major citrus fruit crops are mandarin, sweet orange, acid lime, lemon, and pummelo, while mandarin stands first position among citrus fruit crops followed by sweet orange and acid lime, respectively constituting 60%, 20 % and 8 % of the total citrus growing areas. Mandarin as mostly grown in western region are important fruit crop for most mid hill districts across the country, while sweet orange is primarily concentrated in the central development region and acid lime in the eastern region (Figure.2).

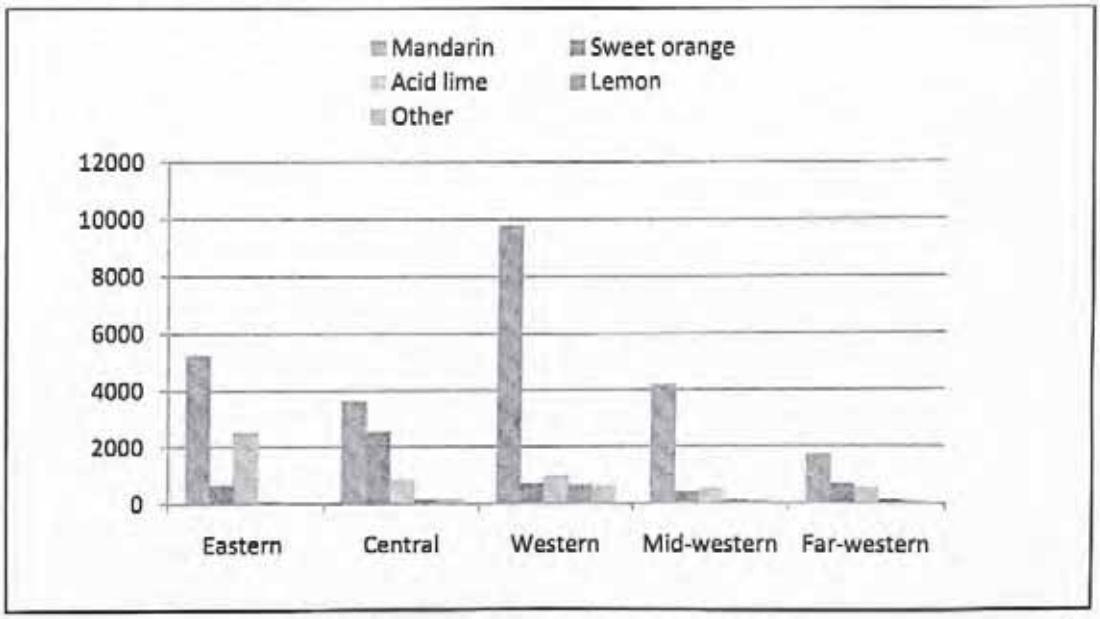

Figure 2. Area under citrus (ha) during 2012/13

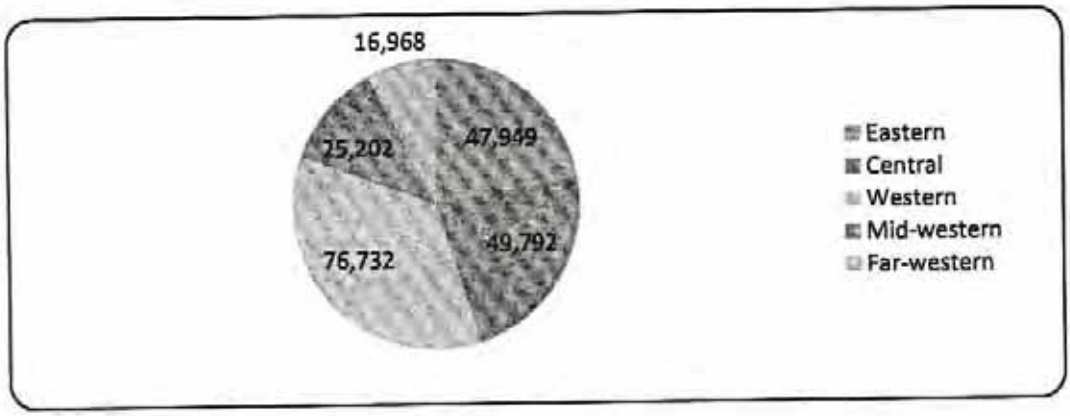

Figure 3. Production of citrus in five development regions during 2012/13

Citrus crops share about 26.84% of the total fruit area in Nepal. Recently, the government of Nepal has been recognized mandarin and sweet orange as the potential export commodities, taking place of an initiative for exporting sweet orange in Tibet from last year. 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 sort 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 are not 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 midhills (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 has 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. Located at Belhara VDC, Paripatle of Dhankuta district between 27°1' north latitude and 87°18' east longitudes with the elevation of 900-1390 m asl, 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 genebank 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

Increased 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 priorities 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 National Agricultural Research Council (NARC) since 2000 (2057 B.S) with mandate of technology generation on citrus fruit crops at national level. Located at Belhara VDC, Paripatle of Dhankuta district between 27°1' north latitude and 87°18' east longitudes with the elevation of 900-1390 m asl, 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 genotypes. Furthermore, a block is also established for demonstrating the released acid lime varieties including other promising lines.

For nursery propagation and research, the farm has an isolated nursery segment expanding in two hectare area accommodating five screen houses (two iron-framed and three bamboo-made screen houses) and more than 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 has just established for irrigation.

2.9 Organization structure and human resource

NCRP is moving about with a shortage of human resources for many years. Currently, the national mandated programme is working with a small team of human resources 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 2070/71 is depicted in Annex 4.

3. RESEARCH HIGHLIGHTS

3.1 Varietal Research

3.1.1 Field Gene Bank

Collection and maintenance of citrus genotypes is an important thrust of National Citrus Research Programme. Of total, 120 citrus genotypes have been collected from local and exotic sources during different periods since 2001. These are preserved at field genebank of NCRP, Paripatle, Dhankuta. These species include: mandarin, sweet orange, grapefruit, acid lime, lemon, tangor, tangelo, and rootstock species. The exotic genotypes were introduced mainly from India, France, India, Japan, and Vietnam, while local species 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 Prof. Joseph Bove of French National Institute for Agriculture Research (INRA), CIRAD.

Similarly, three dwarf varieties of Unshiu mandarin were introduced from JICA, Japan in 2001. Likewise, promising 12 varieties of sweet orange were introduced from ICAR, India during 2006. Several varieties of sweet orange, grapefruit and acid lime were collected with the support of ICIMOD, Vietnam and IAAS, Rampur during different period. Similarly, 21 promising acid lime cultivars were collected from different districts and other local sources during different periods (Annex). These cultivars are to be screened based on fruit yield and fruiting characteristics. Preliminary characterizations of each variety were carried out while a distinct variation with respect to fruiting behavior, fruit traits and morphological characteristics has been observed. Further selection is necessary to screen the best variety based on economic characters.

3.1.2 Varietal Evaluation

Poor yield and short production season are the main concern to the citrus industry in Nepal. Most of the existing varieties are local origin and differ to regions. NCRP, Dhankuta has introduced several exotic varieties including elite local cultivars. These need to evaluate in specific agroclimates and socio-economic condition at different region of Nepal. Since last eight years, selection and improvement of citrus varieties is underway in farmers' fields as well as in NCRP, Paripatle. Major citrus crops include mandarin, sweet orange, acid lime and lemon.

3.1.2.1 Mandarin

Mandarin (*Citrus reticulata* Blanco) ranks first position among citrus fruit crops in Nepal. Because of congenial geography and agro-climatic condition, mandarin is widely grown throughout the mid hills (800 – 1400 m asl) from east to west across the country. Most of the mandarin varieties are local origin that some popular local varieties comprised of Khoku Local, Pokhara Local, Gorkha Local and Dailekh Local are specific to location and vary each other. However, production and productivity of these varieties are declining over time. Likewise, production period of existing cultivars is confined to very short season from Kartik and Poush leading to low supply to meet the national demand that huge amount being imported from India. Hence, effort to introduce new genotypes and varietal improvement programs has put forward. The 22 varieties introduced from abroad and locally collected have been evaluated from 2063/64 in order to select variety suitable for off-season production. So far, some exotic genotypes are identified as promising for early crop maturity and fruit yield. These include: Okitsuwase, Nova, Miyagawase, Mino, URSS including Khoku local (Table 2).

Table 2. Fruit yield attributes and physiochemical characteristics of promising genotypes of mandarin evaluated during 2069/70

SN	Genotypes	Fruit weight (g)	Pulp %	Juice %	TSS	Total Acid %	Maturity period
	Khoku local	77.4	26.8	70.2	13.0	0.98	Mangsir- Push
	Okitsuwase	128.5	25.1	65	7.4	0.90	Asoj- Kartik
	Nova	98.7	29.79	66	9.0	0.95	Kartik- Mangsir
	Miyagawase	125.0	27.1	62	8.1	0.98	Asoj- Kartik
	Mino	105.6	31.3	66	7.4	0.88	Kartik-Mangsir
	URSS	101.2	29.6	60	7.7	0.92	Kartik-Mangsir

3.1.2.1.1 Pipeline Varieties

Two genotypes of mandarin viz. NCRP 06 and NCRP 01 have been under pipeline for variety releasing based on their performance for yield and yield attributes that were evaluated during 2060/61 to 2069/70. The specific characteristics of these genotypes are presented in Table 3 and Table 4.

Table 3. Agronomic and fruit characteristics of mandarin genotype NCRP 06

1.	Recommended domain (m asl)	: 800-1500
2.	Fruit maturity and seed content	: Early harvesting seedless
3.	TSS (%)	: 7.4
4.	Total acidity (%)	: 0.9
5.	Juice (%)	: 50
6.	Fruit weight (g)	: 128
7.	Fruit harvest season	: Asoj-Kartik

Table 4. Agronomic and fruit characteristics of mandarin genotypes NCRP 01

1.	Recommended domain (m asl)	: 800-1500
2.	Fruit appearance	: Golden red and attractive shape
3.	TSS (%)	: 13
4.	Acidity (%)	: 0.98
5.	Juice (%)	: 70.2
6.	Fruit weight (g)	: 77.4
7.	Fruit harvest season	: Mangsir-Push

3.1.2.2 Sweet orange

Sweet orange (*Citrus sinensis* Osbeck) is the second most important among citrus fruits in Nepal. The statistic of 2012/13 shows that this fruit occupies 5000 ha area producing of 34,765 mt with 9.62 t/ha productivity in the country. Presently, it is cultivated in about 30 districts, but major districts occupying more than 100 ha area under this fruit include: Sindhuli, Ramechap, Baitadi, Doti, Dadeldhura, Palpa, Lamjung and Rukum. However, former two districts, Sindhuli and Ramechap grow this fruit in 1476 ha and 871 ha respectively that account about 50 percent of total sweet orange acreage in Nepal. Recently, Tibet has expressed interest for importing Nepalese sweet orange including mandarin and a sort of agreement has made for.

Nevertheless, 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 varietal evaluation has been carried out in NCRP farm including ARS, Dailekh and ARS, Malepatan as well as in the farmers' fields across the country in collaboration with the concerned stakeholders.

Table 5. Fruit yield attributes and physiochemical characteristics of promising genotypes of sweet orange evaluated during 2069/70

SN	Genotypes	Fruit weight	Pulp %	Juice %	TSS	Total Acid %	Maturity period
1.	Washington Navel	148	52	45	11	1.04	December-January
2.	Valencia Late	119	36	56	9	1.25	February-March
3.	Dhankuta Local	137	48	52	10	1.20	December-January

3.1.2.2.1 Pipeline Varieties

Two sweet orange genotypes viz. NCRP 32 and NCRP 86 have been under pipeline for variety releasing based on their promising performance for yield and yield attributes that were evaluated during 2060/61 to 2069/70. The specific characteristics of these genotypes are presented in Table 6 and Table 7.

Table 6. Agronomic and fruit characteristics of sweet orange genotype NCRP 32

1.	Recommended domain (m asl)	: 800-1500
2.	Varietal character	: Mid season seedless
3.	TSS (%)	: 11
4.	Acidity (%)	: 1.04
5.	Juice (%)	: 45
6.	Fruit weight (g)	: 148
7.	Fruit harvest season	: Mangsir - Push

Table 7. Agronomic and fruit characteristics of sweet orange genotype NCRP 86

1.	Recommended domain	: 800-1500 m mid hills
2.	Varietal character	: Late season and seedless
3.	TSS (%)	: 9
4.	Acidity (%)	: 1.25
5.	Juice (%)	: 56
6.	Fruit weight (g)	: 119
7.	Fruit harvest season	: Falgun-Baisakh

3.1.2.3 Acid Lime

Acid lime (*Citrus aurantifolia* Swingle) is an important fruit crop of commercial value, ranking third after mandarin and sweet orange in Nepal. The current production of this crop is reported to 22,271 metric tons under 2891 ha acreage with productivity of 7.7 metric tons per ha (MoAD, 2012). Traditionally, acid lime cultivation is limited to a range of 800 m to 1400 m asl in mid hill districts, 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 percent 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 m asl to 1400 m asl in Nepal. Thus, Nepal has enormous scope of increasing production and productivity to make import substitution by adopting better varieties along with improved management husbandry in midhills and terai.

In these contexts, NCRP, Paripatle has been conducted a study on participatory variety selection and evaluation of acid lime in four terai districts: Jhapa, Morang Sunsari and Chitwan during 2008-2014. Altogether 10 acid lime genotypes collected locally were evaluated for their morphological and agronomic characteristics.

3.1.2.3.1 Tree height and canopy spread

The tree height and canopy spread was significantly (P >0.001) differed among the tested genotypes (Table 8). The genotype NCRP-55 had the highest tree height (360 cm) followed by NCRP-53 (294.75cm) while the lowest tree height was measured at NCRP-52 (168.0 cm). The result revealed that the genotypes NCRP-55 was significantly tallest among tested genotypes while intermediate tree height was found at par among NCRP- 46, NCRP- 47, NCRP- 48, NCRP- 49, NCRP- 50, and NCRP-53. The canopy spread of the tested genotypes ranged from 212.0 cm to 337.0 cm. The genotype NCRP-53 had the extensive canopy spread (320.0 cm) followed by NCRP-55 (320 cm) while the least spread was of NCRP-52 (212.0 cm). The intermediate tree spread ranging from 283.25 cm to 308.25 cm was found at six genotypes. The result showed that the tree height and canopy spread were correlated as higher tree height corresponded to the wider canopy spread.

Table 8. Tree height and canopy spread of 4-years old acid lime genotypes

SN	Genotypes	Tree height (cm)	Canopy spread (cm)
1.	NCRP-46	281.00 b	294.50 b
2.	NCRP-47	289.50 b	308.25 ab
3.	NCRP-48	272.75 b	283.25 bc
4.	NCRP-49	265.00 b	304.25 ab
5.	NCRP-50	288.75 b	306.25 ab
6.	NCRP-51	183.50 c	247.25 c
7.	NCRP-52	168.00 c	212.00 c
8.	NCRP-53	294.75 b	337.00 a
9.	NCRP-55	360.00 a	320.00 ab
10.	NCRP-56	269.00 b	236.00 c
	P value	***	***
	LSD (0.05)	58.025	41.6

3.1.2.3.2 Fruit characters and yield

The data indicated a significant variation of fruit characters (viz. fruit weight, fruit number and fruit yield) among the tested genotypes (Table 9). The genotype NCRP-53 produced the weightiest fruit (92.75 m) followed by genotypes: NCRP-55 (55.0 g) and NCRP 49 (53.0 gm), while genotype NCRP-52 gave the lightest fruit (45.0 g) among tested genotypes.

Table 9. Fruit characteristics of acid lime genotypes tested at different locations during 2065-67

SN	Treatment	Fruit weight (g)	Fruit no/plant	Fruit yield (kg/plant)
1.	NCRP-46	50.25	527	25.75
2.	NCRP-47	46.00	692	32.25
3.	NCRP-48	45.25	673	28.00
4.	NCRP-49	53.00	813	41.75
5.	NCRP-50	50.50	651	32.00
6.	NCRP-51	47.25	273	13.25
7.	NCRP-52	45.00	115	5.00
8.	NCRP-53	92.75	553	52.50
9.	NCRP-55	55.00	1025	56.00
10.	NCRP-56	50.00	669	33.00
	P value	***	***	***
	LSD (0.05)	1.075	193.875	9.125
	CV %	1.35	21.225	20.075

The numbers of fruits per tree of the tested genotypes were observed a large variation ranging from 115 to 1025. The maximum number was found at genotype NCRP-55 (1025 nos) followed by NCRP- 49 (813 nos) while genotype NCRP-52 produced the lowest number of fruit (115 nos). The results showed that genotype NCRP-55 produced the highest fruit yield (56.0 kg/plant) among the tested genotypes. Similarly, the second higher yielder was testified by genotype NCRP-53, however genotype NCRP-49 showed equally good yield potential. Therefore, two acid lime genotypes: NCRP-55 and NCRP-49 were found promising for bearing higher fruit weight and number of fruits, and corresponding higher fruit yield. Moreover, these two genotypes also were reported to have higher juice and acid content among the tested genotypes (Figure 4).

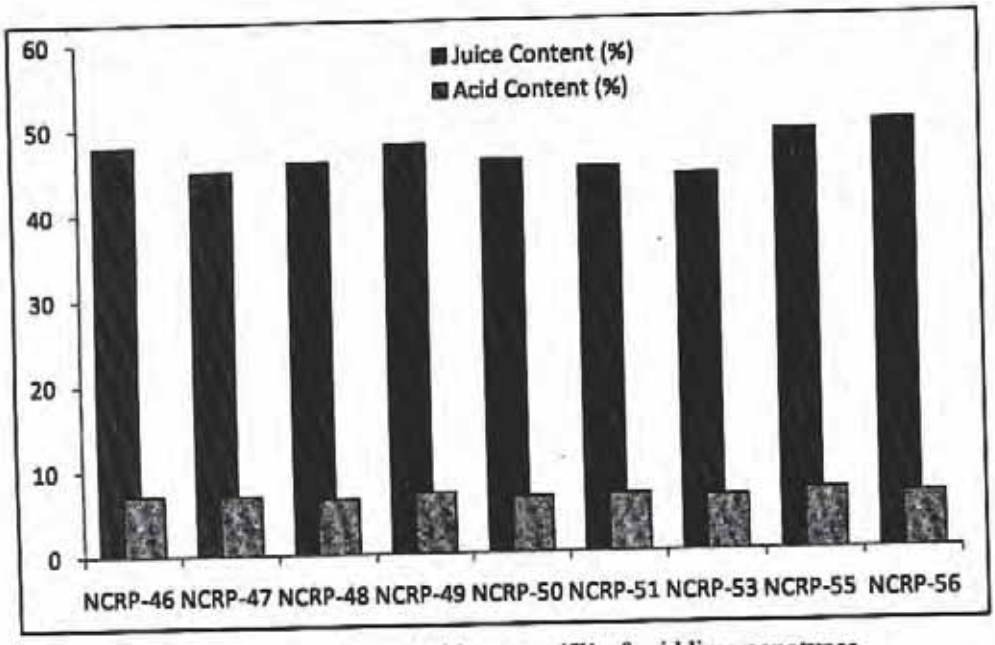

Figure 4. Juice (%) and acid content (%) of acid lime genotypes

3.1.2.3.3 An Economic Analysis

An economic analysis indicated that when calculated the total return from 4-years old tree, the highest return of Rs. 10,606.0 was observed at genotype NCRP-55 followed by NCRP-49 (Rs. 8023.0) from five plants (Table 10). It showed that a promising income could be incurred from growing acid lime adopting these genotypes in terai region that about Rs. 40,000.0 can be achieved from one ropani.

Table 10. An income (Rs/5 trees) from 4-years old of acid lime genotypes

Genotype	Jhapa	Morang	Sunsari	Chitawan	Mean
NCRP-46	3,340	2,887	12,310	2,638	5,293
NCRP-47	3,890	6,138	14,810	3,484	7,080
NCRP-48	3,780	4,870	13,120	3,180	6,237
NCRP-49	4,662	5,995	16,920	4,518	8,023
NCRP-50	4,040	5,895	15,320	3,236	7,122
NCRP-51	3,010	2,323	4,520	1,038	2,722
NCRP-53	3,750	4,146	9,250	1,725	4,717
NCRP-55				10,606	10,606
NCRP-56				6,756	6,756

Two genotypes of acid lime: NCRP-49 and NCRP-55 were found superior for producing high yield having excellent fruit shape and size, high juice content and other attributes of tolerating to gummosis and canker diseases. Moreover, these two genotypes were found potential for early production (June-September) in upland condition of terai compared to normal season in mid hills. Thus, based on the data and farmers feedback, these genotypes would be suitable for commercial cultivation in upland condition of terai, inner terai, river basin areas and foothills of Nepal for off-season production.

3.1.2.3.4 Release of two acid lime varieties

Two acid lime varieties: Sunkagati-1 and Sunkagati-2 have been released in 2014. The recommended domains for these two varieties include upland condition of terai, inner terai, foothills and riverbasin areas. The main characteristic features are attractive fruit size and shape, higher yield, and early fruit harvest. Both varieties are local origin collected from Biratnagar and Rampur, Chitwan (Table 11).

Table 11. Distinctness characters of two released varieties of acid lime

SN	Characteristics	NCRP-55 (Sunkagati-1)	NCRP-49 (Sunkagati-2)
1.	Origin	Nepal, Biratnagar	IAAS
2.	Plant height (cm)	360	230
3.	Canopy spread (cm)	340	300
4.	Fruit/plant	1025	813
5.	Fruit weight (gm)	54	53
6.	Fruit diameter (mm)	44.5	43.3
7.	Juice content (%)	49	48
8.	Acid content (%)	7	7.1
9.	Yield (t/ha)	34.5	26.9
10.	Economic yield (Rs per tree per annum)	2100	1600
11.	Age of flowering	3 years	
12.	Time of flowering	January-February	
13.	Harvesting season	July- September	July- September
14.	Growth habit	Spreading type	Spreading type
15.	Stem's Bark colour	Grey with white streaks	Green with white streaks
16.	Branch/Twigs	Hard	Tender
17.	Leaf lamina shape	Elliptic	Ovate
18.	Width of leaf	4.3 cm	3.9 cm
19.	Length of leaf	7.5	6.8
20.	Leaf lamina margin	Dentate	Dentate
21.	Fruit apex shape	Mammiform	Round
22.	Fruit shape	Spheroid	Spheroid
23.	Fruit skin color	Green	Green

The reasons behind the release of these varieties are as followings: 1) appropriate for off-season production (July to September) in Terai region, ii) high yielding along with superior agronomic traits, iii) Similar Qualitative Traits with Indian Acid Lime, iv) potential opportunity of commercialization in Terai, v) prospect of Import Substitution, and vi) Increasing demand of about 80,000 saplings every year. An economic analysis indicated that when calculated the total return from 4-years old trees of NCRP 55 (Sunkagati-1) and NCRP 49 (Sunkagati-2), NRS 10,606.0 and NCRP 8,023.0 per five trees were reported that a promising income could be incurred from growing acid lime adopting these varieties in terai region. The growing of acid lime in Terai and inner terai is getting popular among commercial farmers since last couple of years in Nepal that demanding about 80 thousand saplings every year.

Table 12. Farmers' preferred traits of released acid lime varieties

	NCRP-55	NCRP-49
1.	Appropriate for off-season production	Appropriateness for off-season production
2.	High yielding	High yielding
3.	Attractive color and size	Attractive color and size
4.	Aromatic fruit flavor	Aromatic fruit flavor
5.	High juice content	High juice content
6.	Citrus canker tracery tolerant	Citrus canker tolerant
7.	Good market price	Good market price

3.1.2.3.5 Front line demonstration of acid lime for off-season production

The normal production season of acid lime is very short, limiting to Kartik-Paush period, and production volume is also very low to meet the internal demand. Therefore, Nepal imports fresh acid lime fruit from India throughout the year that the report shows about 50 percent market demand of Kathmandu valley being met by import. Moreover, the statistic revealed an alarming figure of the import volume that about 90% of national and 95% of Kalimati wholesale market demand are being fulfilled by import from India worth hundred million annually.

In this context, there is much prospect of increasing the production and productivity through expanding area and variety selection for off-season production beyond normal season. To achieve this objective, farmer's participatory frontline demonstration for off-season acid line production has been continued since 2067/68 in six terai districts: Morang, Sarlahi, Chitwan, Dang, Surkhet and Kailali, including RARS, Nepalgunj and ARS, Malepatan (Table 13). The performance of four promising genotypes viz. NCRP-55, NCRP-49, NCRP-53 and NCRP-107 have been studied by establishing the demonstration blocks in the farmers' field in each district.

The result revealed that fruit yield of each genotype was found promising on up-land condition of Terai. Similarly, fruiting season of each genotype was found earlier during Asar-Asoj. Therefore, the findings of the study illustrates that there would be potential for expanding areas

of acid lime cultivation throughout the terai region and similar agro-ecological domains such as river basin, inner terai, and foot hills.

Table 13. A list of participatory farmers for acid lime demonstration program

Name		Address
1.	Nagendra Koirala	Bayarban-9, Bargachhi, Morang
2.	Jugal Prasad Singh	SishaniJahada-7, Morang
3.	Bhagawan Mainali	Dhunge Khola VDC-2, Sarlahi
4.	Narayan Datta Paudyal	Birendranagar-7, Bhrma Nagar, Chitwan
5.	Hasta Bahadur Gurung	Dev Ghat-2, Saune, Tanahu
6.	Sana Kisan Krishi Sahakari Sanstha Ltd.	Laxmipur-4, Golgi, Dang
7.	Prem Lal Chaudhary	Sishaniya-9, Bagarapur, Dang
8.	Vishnu Prasad Chaudhary	Musuriya-3, Matkana, Kailali
9.	Gagan Singh Thaguna	Malakheti-4, Khamaura, Kailali
10.	Man Bahadur Subedi	Kunathari-5, Surkhet
11.	ARS, Malepatan, Kaski	
12.	RARS, Khajura, Banke	

3.2 Postharvest Research

The production and trade of fresh citrus fruit has increased manifold during the last decade in Nepal. However, the postharvest losses due to improper postharvest practices and handling need to be addressed adequately for making this sector profitable. In general, the losses during postharvest storage occur due to fungal infection by *Lasiodiplodia theobromae*, *Phomopsis citri*, and *Penicillium digitatum*. The statistics showed that the postharvest losses of citrus fruits have been estimated between 15-20% (HARP, 2002). From sustainability and economic perspectives, the investment required for postharvest management is much lower than required for increasing the production area to compensate these losses.

3.2.1 Application of plant extracts and chemicals to enhance storage life of mandarin orange

To address these problems, an experiment on minimization of postharvest loss during storage was carried out at NCRP, Paripatle, Dhankuta in two consecutive years, 2069/70 and 2070/71. The experiment aimed two objectives: i) to enhance storage life and ii) to minimize postharvest losses during storage of mandarin.

The experiment was designed under completely randomized design with three replications. The fruits were harvested with spike and without spike separately, and treated with different compounds such as neem extract, garlic extract, ginger extract, carbendazim and rice starch. The detail of the experiment design is given below. The mature fruits were harvested without any physical injury. Then, fruits were treated with the each substance solution by dipping them for 10 minutes. After treatment, the fruits were air-dried and finally kept in the plastic crates under ambient room temperature. The observation on fruit weight, TSS, TA and organoleptic taste was taken at 12-day interval for three times. The TSS and TA were determined respectively by hand refracto-meter and method of titrating 2 ml juice with 0.1 N NaOH using phenolphthalein as an indicator.

Detail of experimental design:

- Treatments: 12
- Fruit harvested with and without spike
  i) Fruits with spike and
  ii) Fruits without spike
- Fruit treated with plant extracts and chemical
  i) Fruit treated with 15% neem extract
  ii) Fruits treated with 10% garlic extract
  iii) Fruits treated with 10% ginger extract
  iv) Fruits treated with 1000 ppm carbendazim
  v) Fruits treated with 6% rice starch, and
  vi) Fruit untreated (control)
- Design: Completely randomized design
- Replication: 3
- Fruit condition: Fully matured and healthy fruits
- Mandarin genotype: Khoku Local
- Total quantity of fruit per treatment: 5 kg
- Storage condition: room temperature

The results revealed that both fruit weight and T.A. were found decreased, while TSS was found increased over the time in all the treatments in both years. However, TSS was non-significantly different, while fruit weight was significantly different among the treatments in both years.

On 12th day observation, the spiked fruit treated with 10% garlic extract retained the highest weight (4.93 kg) during 2069/70 but there was maximum fruit weight (4.7 kg) at spiked fruit treated with 1000 ppm carbendazim during 2070/71. Similarly, total acidity (TA) was found significantly highest at spikeless fruit treated with 10% garlic extract and lowest at spiked fruits treated with 1000 ppm carbendazim (Table 14).

On 24th day of storage, the maximum fruit weight (4.5 kg) was observed at spiked fruits treated with 10% ginger extract in 2069/70 while the maximum fruit weight (4.23 kg) was observed at spiked fruits treated with 1000 ppm carbendazim that was at par with spiked fruit treated with 10% ginger extract (4.18 kg) and spiked fruits treated with 10% garlic extract (4.09 kg) (Table 15).

The result observed on 36th day showed the maximum fruit weight (3.52 kg) at spiked fruits treated with 10% ginger extract in 2069/70, which was at par with spiked fruits treated with 10% garlic extract (3.5 kg), spiked fruits treated with 1000 ppm carbendazim (3.49 kg) and spiked fruit untreated (3.4 kg) (Table 16).

In 2070/71, the treatment of spiked fruits treated with 1000 ppm carbendazim gave the highest fruit weight (3.52 kg) followed by spiked fruits treated with 1000 ppm carbendazim (3.23kg), spiked fruits treated with 10% ginger extract (3.12kg), and spiked fruits treated with 10% garlic extract (3.09kg). The two year's results revealed that spiked fruits treated with 1000 ppm carbendazim, 10% garlic extract, and 10% ginger extract were found better to enhance the storage life up to 36 days along with the minimum weight loss and pathological damages.

Table 14. Effect of plant extracts and chemicals on fruit weight and physio-chemical properties of mandarin fruits during postharvest period at 12th day after harvest

Treatments	Fruit Weight (kg)		Total Soluble Solid		Total Acidity (%)	
	2069	2070	2069	2070	2069	2070
1. Spiked fruit treated with 15% neem extract	4.62c	4.62abc	11.53ab	11.33ab	2cde	3.33a
2. Spiked fruit treated with 10% garlic extract	4.93a	4.68ab	11.9ab	11.66ab	2.79abcd	3.47a
3. Spiked fruit treated with 10% ginger extract	4.76abc	4.68ab	11.23ab	11.66ab	2.37cde	3.56a
4. Spiked fruit treated with 1000ppm carbendazim	4.77abc	4.7a	11.26ab	12.5a	1.51e	3.90a
5. Spiked fruit treated with 6% rice starch	4.86ab	4.6abc	11.13ab	11.33abs	2cde	3.47a
6. Spiked fruit untreated	4.88ab	4.68ab	10.4b	11.33ab	1.82 de	4.05a
7. Spikeless fruit treated with 15% neem extract	4.72bc	4.39d	12.43a	10.5b	2.94abcd	3.36a
8. Spikeless fruit treated with 10% garlic extract	4.59c	4.5cd	11.93ab	11ab	3.96a	3.73a
9. Spikeless fruit treated with 10% ginger extract	4.89ab	4.58abc	11.77ab	11.16ab	3.66ab	3.07a
10. Spikeless fruit treated with 1000 ppm carbendazim	4.85ab	4.6abc	11.3ab	10.5b	3.09 abc	3.85a
11. Spikeless fruit treated with 6% rice starch	4.81ab	4.62abc	10.77ab	11.83ab	2.5 bcde	3.24a
12. Spikeless fruit untreated(control)	4.87ab	4.56bc	11.77ab	11.5ab	2.32 cde	3.36a
Grand mean	4.79	4.6033	11.45	11.361	2.59	3.53
P (≤0.05)	s	s	ns	Ns	S	ns
F – value	2.63	3.67	0.71	1.07	3.15	0.59
CV (%)	2.42	1.7	9.97	8.17	27.83	18.92
Sem±	0.0669	0.045	0.66	0.536	0.5877	0.386

Table 15. Effect of plant extracts and chemicals on fruit weight and physio-chemical properties of mandarin fruits during postharvest period at 24th days after harvest

Treatments	Fruit Weight (kg)		Total Soluble Solid		Total Acidity (%)	
	2069	2070	2069	2070	2069	2070
1. Spiked fruit treated with 15% neem extract	3.86^{cd}	4^{abc}	12.8^{ab}	11.67^{ab}	1.77^{ab}	3.38^{abc}
2. Spiked fruit treated with 10% garlic extract	4.2^{abc}	4.09a	12.4^{b}	12^{ab}	2.11^{ab}	3.76^{a}
3. Spiked fruit treated with 10% ginger extract	4.5^{a}	4.18a	12.86^{ab}	12^{ab}	1.53^{b}	3.7^{ab}
4. Spiked fruit treated with 1000ppm carbendazim	4.2^{abc}	4.23a	13.33^{ab}	12^{ab}	1.47^{b}	3.24^{abc}
5. Spiked fruit treated with 6% rice starch	4.13^{bc}	4.04^{ab}	13.7^{a}	11.33^{b}	1.47^{b}	3.4^{abc}
6. Spiked fruit untreated	4.16^{abc}	4.04^{ab}	12.7^{ab}	11.33^{b}	1.76^{ab}	3.39^{abc}
7. Spikeless fruit treated with 15% neem extract	3.53^{d}	3.37^{abcd}	13^{ab}	11.5^{ab}	1.7^{b}	3.57^{ab}
8. Spikeless fruit treated with 10% garlic extract	4.1^{bc}	3.18^{bcd}	13.66^{a}	12.33^{ab}	2.47^{a}	2.65^{c}
9. Spikeless fruit treated with 10% ginger extract	4.1^{bc}	3.12^{cd}	13.6^{a}	11.67^{ab}	1.98^{ab}	2.92^{abc}
10. Spikeless fruit treated with 1000 ppm carbendazim	4.26^{ab}	3.9^{abc}	13.23^{ab}	11.33^{b}	2.15^{ab}	3.1^{abc}
11. Spikeless fruit treated with 6% rice starch	4.2^{abc}	2.92^{d}	12.56^{ab}	12.5^{ab}	2.13^{ab}	2.89^{abc}
12. Spikeless fruit untreated(control)	4.1^{bc}	3.14^{bcd}	12.4^{b}	12.83^{a}	1.7^{b}	2.81^{bc}
Grand mean	4.1083	3.6868	13.013	11.87	1.85	3.2367
P (≤0.05)	s	s	ns	ns	Ns	Ns
F – value	3.75	2.51	1.38	1.02	1.63	1.36
Cv (%)	5.08	14.59	5.44	7.12	22.97	16.53
.Sem±	0.1206	0.311	0.4092	0.488	.2459	0.309

Table 16. Effect of plant extracts and chemicals on fruit weight and physio-chemical properties of mandarin fruits during postharvest period at 36th days after harvest

Treatments	Fruit Weight (kg)		Total Soluble Solid		Total Acidity (%)	
	2069	2070	2069	2070	2069	2070
1. Spiked fruit treated with 15% neem extract	2.89^{abc}	3.02^{a}	14.13^{a}	11.16^{ab}	1.55^{b}	3.43^{a}
2. Spiked fruit treated with 10% garlic extract	3.5^{a}	3.09^{a}	13.83^{a}	12.16^{a}	1.5^{b}	3.25^{a}
3. Spiked fruit treated with 10% ginger extract	3.52^{a}	3.12^{a}	13.4^{a}	12^{ab}	2.48^{a}	3.14^{a}
4. Spiked fruit treated with 1000ppm carbendazim	3.49^{a}	3.52^{a}	14.33^{a}	11.33^{ab}	1.62^{b}	2.47^{a}
5. Spiked fruit treated with 6% rice starch	3.33^{ab}	3.23^{a}	13.66^{a}	12.16^{a}	1.21^{b}	3.04^{a}
6. Spiked fruit untreated	3.4^{a}	3^{a}	13.33^{a}	11.33^{ab}	1.17^{b}	3.02^{a}
7. Spikeless fruit treated with 15% neem extract	2.1^{d}	1.89^{b}	13.4^{a}	10.5^{b}	1.51^{b}	2.82^{a}
8. Spikeless fruit treated with 10% garlic extract	2.42^{cd}	1.76^{b}	13.66^{a}	11.5^{ab}	1.74^{ab}	2.4^{a}
9. Spikeless fruit treated with 10% ginger extract	3.06^{abc}	1.73^{b}	13.66^{a}	11.33^{ab}	1.48^{b}	2.47^{a}
10. Spikeless fruit treated with 1000 ppm carbendazim	2.98^{abc}	3.01^{a}	12.66^{a}	11.5^{ab}	1.71^{ab}	2.85^{a}
11. Spikeless fruit treated with 6% rice starch	2.7^{bcd}	1.52^{b}	13.66^{a}	11.83^{ab}	1.78^{ab}	2.89^{a}
12. Spikeless fruit untreated(control)	2.7^{bcd}	1.53^{b}	14.33^{a}	11.83^{ab}	1.36^{b}	2.34^{a}
Grand mean	3.0092	2.54	13.675	11.56	1.5947	2.845
P (≤0.05)	s	s	ns	ns	Ns	Ns
F – value	4.4	8.62	0.57	0.74	1.64	0.87
Cv (%)	12.75	17.83	7.82	8.35	28.71	23.23
Sem±	0.2216	0.261	0.612	0.557	0.2644	0.382

3.3 Nursery Management

Khoku is the popular local genotype of mandarin in the eastern region of Nepal. The excellent yield attributes including sweet taste and fruit size of this genotype maintain its prospect for developing as a commercial variety. The old orchards in most areas are raised from seedlings. Now, Phytophthora root rot is a major problem in the seedling-raised orchards because seedling plants are more susceptible to this pathogen. Thus, thrust should be given to the adoption of

grafted-plants in new orchard in the future, while trifoliate rootstock is the important rootstock tolerating to root rot for mandarin.

3.3.1 Effect of graft height on graft success and growth of mandarin cv. Khoku

With this objective, this study was carried out to determine an appropriate grafting height under shoot tip grafting method for getting higher percentage of graft success of the trifoliate rootstock on mandarin. The experiment was carried out at NCRP, Dhankuta in 2069/70. Eight to ten-month old healthy scions from Khoku mother plant and one-year old trifoliate rootstock were grafted by shoot tip method at five different heights: 8 cm, 12 cm, 16 cm, 20 cm, and 25 cm on 5th Push.

Fifty grafted saplings of each treatment was prepared and planted in the nursery bed. The nursery bed was manured with vermin-compost @ of 10 kg per square meter. After planting, the nursery bed was covered by plastic-jute tunnel above the 1m height and irrigated regularly. The experiment was designed at randomized complete block design (RCBD) and replicated thrice. Observation on scion height, scion diameter, collar diameter and graft union diameter was taken at 90 day interval for four times. The experiment was carried out with an aim to identify suitable grafting height of mandarin on Trifoliate rootstock. Observation on physical parameters such as scion height, scion diameter, collar diameter and graft union diameter was taken on four times viz. 90th day, 180th day, 270th day and 360th day.

Effect of graft height on the scion growth

The scion growth in terms of height during 90, 180 and 360 day after planting was found significantly differed among all treatments. Under scion growth during 90th days, the maximum scion height (32.27 cm) was observed at those saplings grafted at 12 cm height followed by saplings grafted at 8 cm height (31.87 cm) and saplings grafted at 16 cm height (31.3 cm). Similar trend of scion growth for the height was observed on 180th day period that the maximum height was observed at saplings grafted at 12 cm height (51.53 cm) followed by saplings grafted at 8 cm height (49.27 cm). But scion height on 360th day was maximum at those saplings grafted at 20 cm height (77.53 cm) followed by those saplings grafted at 16 cm height (77.01 cm). The results revealed that scion height at those saplings grafted at 25 cm height was found minimal on all growth periods (Table 17).

Table 17. Effect of graft height on the scion height growth

Treatments	Growth on scion height (cm)			
	90th Day	180th Day	270th Day	360th Day
1. Sapling grafted at 8 cm height	31.87a	49.27a	59.91ab	70.63ab
2. Sapling grafted at 12 cm height	32.27a	51.53a	60.66a	64.29bc
3. Sapling grafted at 16 cm height	31.3a	45.38ab	57.01abc	77.01a
4. Sapling grafted at 20 cm height	19.83b	35.8bc	49.89bc	77.53a
5. Sapling grafted at 25 cm height	21.7b	32.92c	48.02c	60.34c
Mean	27.39	42.98	55.09	69.96
P value	s	S	ns	S
F value	5.26	6.87	3.18	6.51
CV %	16.81	12.66	10.25	7.39
Sem	2.66	3.14	3.25	2.98

Effect of graft height on the Scion diameter: Observation on 90th day for scion diameter propounded significant result i.e. mandarin sapling grafted at 12 cm height exhibited highest scion diameter (5.57 cm). But later days of showed non-significant result (Table 18).

Table 18. Effect of graft height on the growth of scion diameter

Treatments	Growth of scion diameter (cm)			
	90th Day	180th Day	270th Day	360th Day
Sapling grafted at 8 cm height	5.35ab	8.25a	10.15a	8.92a
Sapling grafted at 12 cm height	5.57a	8.10ab	9.48ab	9.41a
Sapling grafted at 16 cm height	4.53c	6.98bc	7.65c	8.92a
Sapling grafted at 20 cm height	4.73bc	7.12abc	8.45bc	8.87a
Sapling grafted at 25 cm height	4.56c	6.55c	7.65c	8.48a
Mean	4.94	7.4	8.78	8.92
P value	s	Ns	ns	ns
F value	4	4.31	3.77	0.55
CV %	8.44	8.36	10.25	8.76
Sem	0.24	0.357	0.52	0.45

Effect of graft height on the collar and graft union diameter

The experiment revealed that all the treatments and at different level of observation showed non-significant result with respect to collar and graft union diameter as stated in table 19 and 20 respectively.

Table 19. Effect of graft height on the collar diameter

Treatments	Growth of collar diameter (cm)			
	90th Day	180th Day	270th Day	360th Day
Sapling grafted at 8 cm height	11a	13.72a	8.92a	8.92a
Sapling grafted at 12 cm height	11.08a	14.49a	9.41a	9.41a
Sapling grafted at 16 cm height	9.68a	13.22a	8.92a	8.92a
Sapling grafted at 20 cm height	10.07a	13.14a	8.86a	8.86a
Sapling grafted at 25 cm height	10.16a	12.91a	8.47a	8.47a
Mean	10.4	13.49	8.92	8.92
P value	ns	Ns	ns	ns
F value	1.86	1.29	0.55	0.55
CV %	7.49	7.15	8.76	8.76
Sem	0.45	0.55	0.45	0.45

Table 22. Effect of graft height on the growth of graft union diameter

Treatments	Growth of graft union diameter (cm)			
	90th Day	180th Day	270th Day	360th Day
Sapling grafted at 8 cm height	90th Day	180th Day	270th Day	360th Day
Sapling grafted at 12 cm height	6.2ab	7.39a	8.34a	11.39a
Sapling grafted at 16 cm height	6.7a	7025a	8.81ab	10.92ab
Sapling grafted at 20 cm height	5.7b	6.39a	7.8ab	9.97ab
Sapling grafted at 25 cm height	5.5b	6.4a	7.31ab	9.96ab
Mean	5.6b	6.4a	6.99 b	9.46b
F value	5.9	6.7	7.7	10.34
P value	ns	Ns	ns	ns
Cv %	2.88	2.32	2.08	1.97
Sem	8.45	8.57	8.45	9.44
	0.29		0.37	0.56

3.4 Citrus Decline Management

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

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

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

Likewise, NCRP has technologies for integrated plant nutrient management, pest and disease management, and orchard management to revive declined orchard. Thus, this activity was carried out to transfer these technologies to address the decline problem in mandarin orchard. The experiment was conducted in two declined mandarin orchards each in Dhankuta, Bhojpur and Taplejung. The DADO from each district has cooperated while selecting the sites for the study. The treatments applied to the 20 selected declined trees for the rejuvenation were as following:

i) all overcrowded, dead and diseased branches were pruned appropriately and pasted with Bordeaux paste mixture and paste
ii) root rot infected roots were treated by exposing, pruning and drenching with 1 % Bordeaux mixture
iii) those trees of severely damaged roots were approach grafted with trifoliate rootstock
iv) manure and fertilizer @ FYM 50 kg + N 500g + P 250g + K 500g + Boric acid 20g + Zinc sulphate 150g + Cupper sulphate 75g + Manganese sulphate 75 g per tree were applied to the selected trees beneath the root zone in the ring around the tree canopy, while nitrogen was applied in two equal split doses. Then, mulching and irrigation were carried out.
v) Fungicides and insecticides provided to the farmers to manage insect pest and diseases as stated below:
    - Lime and copper sulphate was given to prepare 1% Bordeaux mixture and paste to manage gummosis and root rot disease.
    - For the management of gummosis and root rot disease, Antirot (10 ml per litre of water) was provided.
    - Rogor and servo agro-spray was given to manage scale insect, aphid and green stink bug which should be applied at the rate 1 ml rogor + 5 ml. agro-spray per litre of water.

- Imidachlopride to manage leaf miner which should be applied at the rate 1to 1.5 ml per litre of water.
- Sulphex, a sulphur based fungicide to manage powdery mildew disease which should be applied at the rate 2 to 3 gm per litre of water.

Observation will be taken once in each trimester to see the impact of treatments and collect feedback from farmers.

3.5 Citrus Fruit Fly Management

3.5.1 Introduction

The Chinese Citrus Fruit Fly (*Bactrocera minax*, Enderlein) is the most devastating insect of citrus crops in Nepal including China, Bhutan and India. Since last few years, it has been recognized as a serious pest of sweet orange in the eastern regions of Nepal causing a serious hindrance of its production (NCRP, 2011). Mandarin and sweet orange are the primary cash crops in mid-hills of Nepal. Unfortunately, yield losses between 15 and 97 % due to the *B. minax* infestation are common in eastern mid-hill orchards (Bajracharya, 2008). Since the Chinese citrus fruit fly had been wrongly identified as Oriental fruit fly earlier for long-decade, the former efforts to control the fruit fly in sweet orange through male annihilation using methyl eugenol and sanitation tactics did not give any positive result. Therefore, NCRP has embarked on a research study to identify fruit fly species infesting the citrus crops in order to develop a control measure against this pest since 2069/70.

3.5.2 Identification of fruit fly species

An investigation to identify the fruit fly species was carried out in three districts: Parbat, Gulmi and Myagdi. Samples of the infested fruits with fruit fly were collected from the citrus orchards in each district. Then, a complete biology of the pest was studied by rearing in the laboratory at NCRP, Dhankuta. The characteristic feature of the adult fruit flies emerged from the samples was examined thoroughly with the help of the verified sample of *B. minax* that had been confirmed in UK (2006, NCRP). The feature of all samples taken from the three districts was found identical to that of *B. minax*.

The general characteristic of *B. minax* is having a predominant orange-brown body color and comparatively double in size than *B. dorsalis*. It has medial and lateral yellow vittae (stripes) on the scutum and the scutum has brown base color. In contrast, B. dorsalis has black base color and lacks medial yellow vittae. Similarly, B. minax has elongated abdomen but *B. dorsalis* has oval abdomen. Thus, the result has confirmed that the fruit infestation in these three districts is due to the *B. minax*; as before it was deemed to be due to B. dorsalis.

Table 21. Detail address of the sample collection locations

District	Place	Farmers Name
1. Parbat	Lekaphanta VDC	Bishnu Prasad Subedi
2. Myagdi	Piple VDC Word No 9, Mauwa Phant	Om Kumari Khatri
3. Gulmi	Pipaldhara VDC Word No 7, Katauje	Bishnu Khanal

3.5.3 Measurement of Oviposition Period

Fruit fly is oviparous insect, which lays eggs with little embryonic development within the mother. Thus, identification of egg-laying period is crucial that helps to determine the appropriate time for employing of the control measures such as cover sprays, protein bait sprays and other forms of baiting substances to manipulate pest population. A study on the identification of oviposition period of fruit fly was carried at NCRP, Paripatle in 2070/71. The observations of egg lying were taken at eleven fortnight intervals beginning from 20th Baisakh to 18th Asoj. Five branches containing of five fruits from each tree of sweet orange were selected for the study. Initially the selected fruited branches of eleven trees were bagged with pollinating net. Then, after exposing for two week, the branches were again enclosed at fortnight intervals.

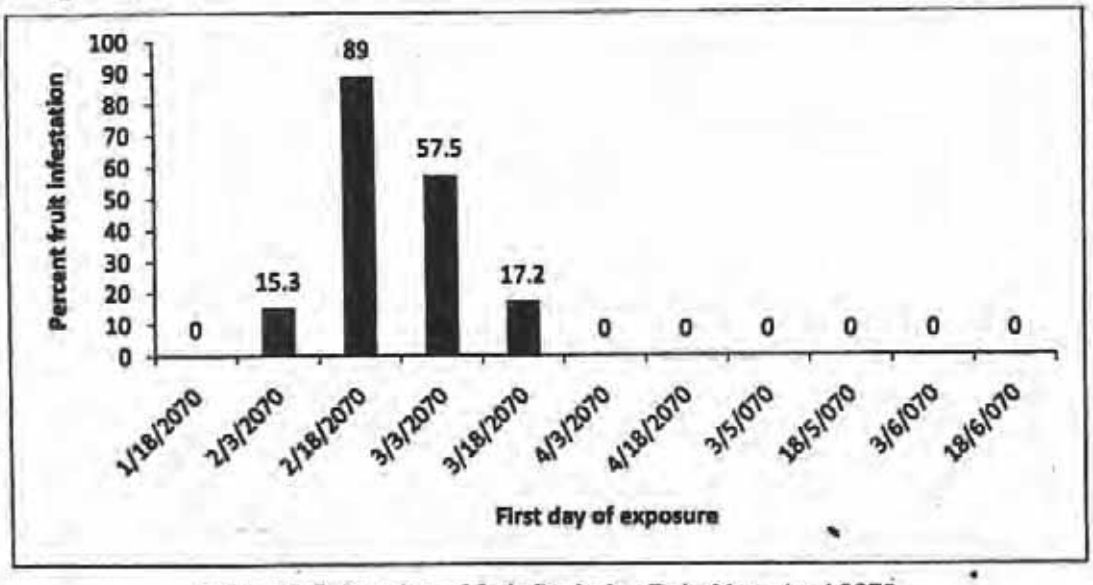

Figure 5. Infestation of fruit fly during Baisakh to Asoj 2070

The maximum infestation (89%) with fruit fly was observed on second weeks of Jestha followed by next two consecutive fortnight intervals. The first oviposition was commenced from first week of Jestha and ended after first week of Shrawan. Hence, the result revealed that the oviposition period occurs between 15th Jestha to 15th Asad, reaching maximum on second week of Jestha. As a result, it could be suggested that the control measure during this period would be effective for minimizing the population of this pest.

3.5.4 Assessment of attractiveness of lures for fruit fly

The traps and attractant lures are more common practice for suppression of the fruit fly. But the pheromone trap has been proved to be ineffective for Chinese Citrus Fruit Fly. Thus, several substances including protein lures have been found being used in many countries for suppression and management of the insect. Hence, the effectiveness of different protein lures to trap the fruit fly was assessed in sweet orange orchard at NCRP, Paripatle during 2069/70 and 2070/71. The study aimed at determining the effective attractant substances to trap the fruit fly so as to develop an appropriate control measure against this pest.

Four different lure substances viz. Australlian fruit fly lure (Autolysed Protein) @ 50 ml/L, Hydrolyzed Protein (Soyabean based) @ 50gm/L, Orange-ammonia solution @ 750 ml + ammonium carbonate @ 25 gm/L + potassium sorbate preservatives @ 2 gm, and Proteinax @

50 gm/L were evaluated during 15th Baisakh to 15th Asoj, 2070. The trapping was carried out once a week until 18th Ashoj 2070. The traps were baited with 250 ml aqueous solution and attached to the tree branches at 1.5 m height. The number of fruit flies trapped into the traps was checked weekly that all adult flies into the trap were recognized for their sex and then removed. After that, traps were washed with water and renewed with fresh lure in every week.

The results revealed that the traps with the Australian fruit fly lure trapped maximum flies (246 nos) than traps with other lures during the study period. The number of flies trapped during different months was significantly varied that the maximum number (55) was observed on 10 Asadh followed by 17 Asadh in all lures. Similarly, hydrolyzed protein trap and orange-ammonia solution ensnared little number of fruit flies. Hence, Australian fruit fly lure was found effective among other lures for suppression of the insect.

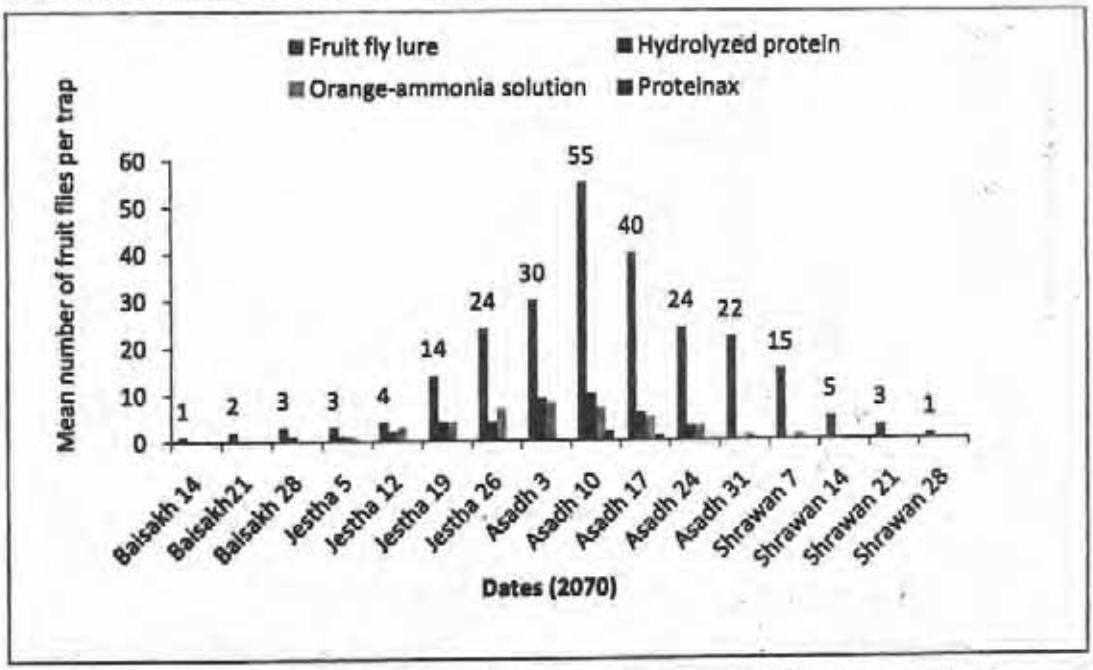

Figure 6. Mean number of B. minax flies captured per trap weekly using lures in experimental orchard in Dhankuta

3.5.5 Measurement of period between larval stages to puparia development of fruit fly after fruit drop

Orchard sanitation is one of the most important practices for the management of Chinese citrus fruit fly. In general, the 3rd instars larvae enters into the soil from the infected fruits and remains overwintering pupae for 150-160 days, thus it is very crucial to destroy the larvae before entering into the soil in order to eradicate this pest from the orchard.

Thus, an experiment was conducted to know the exact period from the fruit-drop to puparia stage of fruit fly, so that larvae within the infected fruits can be destroyed within this period successfully before entering into the soil. The experiment was initiated on first week of Kartik. Forty fruits freshly dropped on the ground in previous 24 hours were collected and kept on clean and heat-sterilized sand in the Laboratory. The sand was sieved daily and any puparia developed in preceding 24 hour were counted.

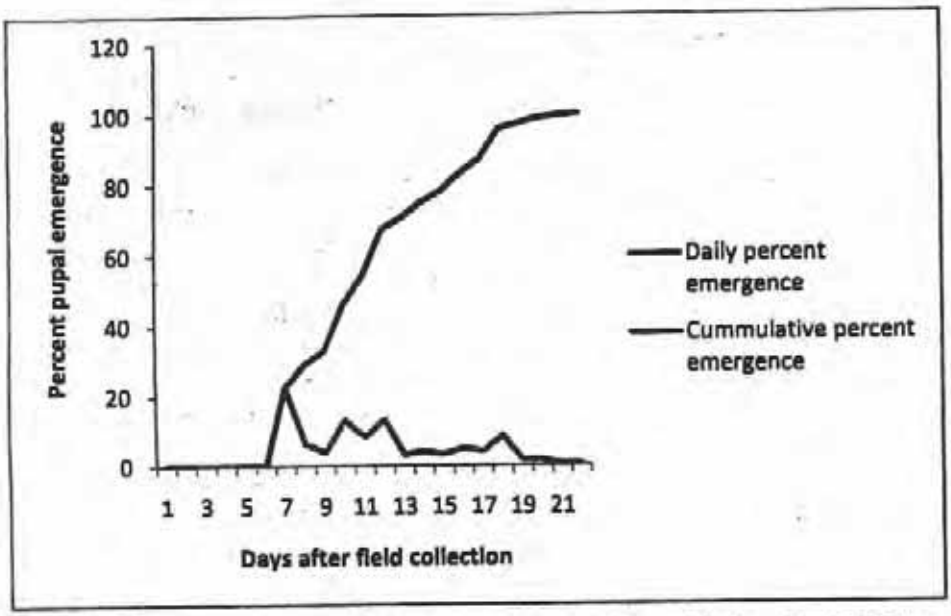

Figure 7. Percentage of pupae emergence from the infected fruits after fruit drop

The results showed that from the 1st to 6th day after field collection of fallen fruits, no puparia were observed to emerge. The first and maximum percent pupal emergence (22.6%) was found on 7th day after collection and the last and least pupae (0.4%) were observed on 22nd day onward. It means the larva surviving period on the fruits is up to the first six days after fruit drop. Thus, it is suggested that the orchard sanitation through collection and destruction of dropped fruits due to fruit fly should be carried out before first six days of fruit drop.

Thus, the following cultural practices are advised to manage fruit fly: i) clean up the orchard by collecting the freshly dropped fruits as earlier as possible that would prevent the third instar larvae from entering into the soil, thereby reducing of fly population for the next year; ii) spray systemic insecticide in early Jestha followed by second spray in late Asadh that would result in egg mortality within the fruits; and iii) weekly protein bait spray as well as traps from mid Baisakh to early Shrawan that would reduce the fly population.

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 322, 000.00 revenue was collected from fruit production.

Besides, NCRP has a regular activity of sapling production of major varieties of mandarin, sweet orange and acid lime. In 2070-71, a total of 6883 grafted samplings were produced and made available to the farmers. The figure showed the major demand of mandarin followed by acid lime. 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 22 below.

Table 22. Production of fruits and saplings during 2070/71

S.N.	Particulars	Quantity	Revenue (NPR) '000
1.	Mandarin saplings	2654	94.19
2.	Sweet orange saplings	232	8.12
3.	Acid lime saplings	3934	137.69
4.	Kumquat saplings	63	2.52
5.	Rose saplings	328	11.48
6.	Mandarin fruits		322.29
7.	Others		8.73
	TOTAL		585.03

5. TECHNOLOGY TRANSFER AND SERVICES

1.1 Farmers Training

A farmer training on citrus orchard and nursery management was held on 6-7 Jestha 2071 involving 14 farmers from 13 districts of eastern region. The objective of the training was to deliver the technologies in regard to agro-husbandry, disease and pest management and nursery management of citrus. The list of participant farmers of the training is presented in annex 2.

5.2 Calendar of Operation

Based on research findings and field experiences, NCRP has developed a calendar of operation for orchard management (Table 23).

Table 23 Calendar of operation adopted at NCRP Paripatle for orchard management

Month	Operation
Baishak	Irrigate the orchard and nursery bed
	Uproot the diseased and very old unproductive trees and prepare pits for new plantation
Jestha	Make a drainage system in the orchard
	Prepared the nursery bed for rootstock transplanting
	Prepare compost for next year
	Application of chemical fertilizers
Asar	Spraying with sulfur containing fungicide to control powdery mildew
	Transplant rootstocks for next year sapling
	Distribution of healthy saplings to farmers
Shrawan	Weeding in citrus orchard
	Transplanting of rootstock seedling (Trifoliate) in main nursery block
	Removed diseased, new suckers and dry branches
	Spray Insuf @ 2g/L of water for the control of powdery mildew
Bhadra	Weeding in citrus orchards and nurseries
	Application of Servo agro spray mineral oil @ 15ml/L of water to control scale insects
	Application of systemic insecticides for the control of green stinkbug
	Drenching of the root with 1% Bordeaux mixture infected by root rot disease
Aswin	Collect trifoliate seeds for root stock production
	Application of insecticides for the control of green stinkbug
	Weeding and mulching in the orchards
	Stacking of heavily fruiting branches
	Collect fruit fly infected sweet orange fruit and burry into pits
Kartik	Collect fruit fly infected sweet orange fruit and burry in pits
	Prepared new nursery bed and sow trifoliate seed for next year production
	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
Magh	Harvesting of late season varieties, pruning and training, Fertilizer and manure application and Servo agro spray to control scale insects
Falgun	Servo agro spray to control scale insects; fertilizer and manure application
	Foliar spray micronutrient
	Insecticide spray in nursery plants to control leaf minor
	Irrigation application in orchards and nursery
Chaitra	Irrigate the orchard and nursery bed
	Uproot the diseased and very old unproductive trees and prepare pits for new plantation

5.3 Publications

A booklet, Kagati Kheti has been produced during this fiscal year.

5.4 Information Dissemination

Information regarding citrus research programs and technologies was shared with the visitors that altogether 1500 visitors made their presence in the NCRP. The visitors were mainly from farmers groups, cooperatives, extension officials, entrepreneurs, NGOs/CBOs officials among others. They were acquainted with the field knowledge and experience of citrus cultivation.

5.5 Services

In this fiscal year, NCRP supplied 6883 grafted saplings of different citrus species to the farmers. The grafted saplings made available to the farmers were comprised of Khoku local mandarin, Okitsuwase mandarin, two acid lime varieties Sunkagati-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.

6 BUDGET STATEMENT

The total annual budget approved for the Programme was Rs. 18.052 million. The operational budget comprised of Rs. 7.38 million (40.88 %) to carry out research projects, while the budget under staff expense and administrative heading were Rs. 5.64 million (27.83 %) and Rs. 5.02 million (31.28 %) respectively.

7 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) efficient irrigation,

e) fruit drop due to fruit fly,

f) root rot and greening,

g) poor institutional mechanisms and coordination for marketing, and

h) lack of entrepreneurship

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

8 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 midhills 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) Postharvest processing and value addition,

ii) Marketing and export business,

iii) Cost effective and eco-friendly production technologies,

iv) Integrated nutrient management,

v) Breeding new varieties for extended harvest period,

vi) Biological pest and disease management,

vii) Water use efficiency,

viii) In-vitro technology for healthy propagation,

ix) Citrus based farming system, and

x) Socio-economic studies

9. 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	Miyagawa wase- Unshiu	JICA, Japan
9	NCRP-06	Okitsu wase- 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	Lue Gim Gong	ICAR, India
62	NCRP 83	Cara Cara Novel	INRA CIRAD, France
63	NCRP 84	Lane Late	INRA CIRAD, France
64	NCRP 85	Pine Apple	INRA CIRAD, France
65	NCRP 86	Valencia Late	INRA CIRAD, France
66	NCRP 87	Salustiana	INRA CIRAD, France
67	NCRP 96	Tamango	INRA CIRAD, 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	Khursani bari local	SHARP, Chitwan
77	NCRP-107	Tehrathum local	Tehrathum
78	NCRP-117	Baitadi local	Baitadi
79	NCRP-118	Salyan local	Rojwal Takura, Salyan
80	NCRP-119	Bhojpur local	Takshor, Bhojpur
81	NCRP-120	Parwat local	Lekhpant, Parwat
82	NCRP-60	Kaptangang lamo	Sunsari
83	NCRP-59	Kaptangang golo	Sunsari
84	NCRP 58	Krishnapur kagati	Bharatpur, Chitwan
85	NCRP-57	Krishnapur kagati	Bharatpur, Chitwan
86	NCRP-56	Banarasi Kagati	Biratnagar
87	NCRP-55	Madrasi Kagati	Biratnagar
88	NCRP 54	Banarasi Kagati	Biratnagar
89	NCRP-53	Panta-1	Chitwan
90	NCRP-52	Belepur	Morang
91	NCRP-51	Sundarpur	Morang
92	NCRP-50	IAAS Acc # 71 (5)	IAAS, Rampur
93	NCRP-49	IAAS Acc # 101 (3)	IAAS, Rampur
94	NCRP-48	IAAS Acc # 101 (2)	IAAS, Rampur
95	NCRP-47	IAAS Acc # 01 (17)	IAAS, Rampur
96	NCRP-46	IAAS Acc # 01 (25)	IAAS, Rampur
	E. Lemon		
97	NCRP 61	*Ureka lemon Unkwown*	Unknown
98	*NCRP 63*	*Hill Lemon*	Sunderpur Morang
99	*NCRP 64*	*Ureka lemon Lamcho lemon*	Sunderpur Morang
100	*NCRP 109*	*Thimura local*	SHARP Chitwan
101	*NCRP 110*	*Biratnagar Local*	SHARP Chitwan
102	*NCRP 111*	*Prembasti local*	SHARP Chitwan

S.N0	*Accession no*	*Identification/common name*	*Source*
	Rootstocks		
103	NCRP 65	Citrange C-35	INRA_CIRAD
104	NCRP 66	Citrange – Carrizo	INRA_CIRAD
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 List of participant famers in the training

Farmers' Name	Address
1. Krishna Prasad Baral	Dolhu-3, Taplejung
2. Jagdish Rajbashi	Patharia-1, Jhapa
3. Udhab Hamaal	Okhre-7, Udaipur
4. Kubir Gurung	Rumjatar-8, Okhaldhunga
5. Ramesh Rai	Sittalpati-6, Sankhuwasabha
6. Rajkumar Thegim Limbu	Aamchok-2, Ilam
7. Janardan Panta	Thelia-5, Saptari
8. Dammar Sigdel	Naagi-9, Paanchthar
9. Dhalu Ram Majhi	Dangraha-3, Morang
10. Kanak Bahadur Rai	Khoku-9, Dhankuta
11. Dhan Bahadur Limbu	Maunabuduk-2, Dhankuta
12. Balkrishna Rasaili	Sabla-5, Tehrathum
13. Chedilal Majhi	Aurabani -3, Sunsari
14. Chandrakala Shrestha	Dawa-5, Bhojpur

Annex 3 Human Resource Allocations

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	2	3
14. Technician (5^{th}.level)	13	6	7
15. Technician (4^{th}. level)	2	2	-
16. Technician (3^{rd}. level)	2	-	2
17. Admin officer (A6)	1	1	-
18. Account officer (A6)	1	-	1
19. Computer operator (T5)	1	-	1
20. Administrative Assistant (A5)	1	-	1
21. Driver (4^{th}. level)	1	1	-
Total	43	16	27

Annex 4 Human Resources of NCRP in 2070/71

Name	Position	Qualification	Working area & remarks
1. Deo Kant Chaudhary	Coordinator (S.4)	M. Sc (Hort.)	Fruits and vegetables, going to be retired from coming Magh
2. Amar Bahadur Pun Magar	Senior Scientist (S.3)	M. Sc (Hort.)	Horticulture, joined from Chaitra 2070
3. Manish Kumar Thakur	Scientist (S.1)	M. Sc (Hort.)	Pomology
4. Kishor Bhandari	Scientist (S.1)	M. Sc (Entomology)	Horticulture pests
5. Parsuram Yadav	Tech. Officer (T.6)	Bachelor degree	
6. Tilak Rajbanshi	Acc. Officer (A.6)	I.Com	
7. Gopal Raj Shrestha	Admin. Officer (A.6)		Joined in Falgun 2070
8. Yagya Bahadur Karki	Technician (T.4)	Literate	Retired from Jestha 2071
9. Nar Bahadur Tamang	Technician (T.4)	Literate	
10. Prem NarayanYadav	Technician (T.4)	B.Sc. Ag.	Joined in Falgun 2070
11. Amar Bahadur Shrestha	Technician		
12. Sher Bahadur Tamang	Technician		Retired from Jestha 2071
13. Singha Bahadur Tamang	Technician		
14. Jagat Bahadur Karki	Technician		
15. Tanka Prasad Timilsina	Technician		Deputed to ARS, Pakhriwas
16. Bhabani Prasad Phuyal	Technician		Deputed to ARS, Pakhriwas
17. Thir Bahadur Ale	Technician		
18. Man Bahadur Tamang	Technician		
19. Hem Bahadur Dahal	Technician		
20. Tara Nath Khatri	Heavy driver		

Annex 5 Regular Annual Budgets and Expenditure in 2070/71

(In '000 Nepalese rupees

Budget code	Budget Heads	Budget allocated	Released	Expenditure	Balance
40*	Staff Expenses	5647.00	5647.00	5250.81	396.18
4000	Staff Basic Salary	4032.00	4116.00	4115.09	0.90
4010	Staff Allowances	321.00	321.00	287.57	33.42
4020	Provident Fund	404.00	379.30	379.30	24.69
4030	Medical				
4040	Uniform	130.00	135.50	135.00	0.50
4050	Dasain Kharcha	340.00	340.00	295.52	44.47
4080	Insurance Fund	420.00	330.50	38.31	292.18
41**	Operational Expenses	7380.00	7380.00	7376.36	3.63
4100	Travel expenses	958.00	799.00	798.63	0.366
4110	Vehicle fuel, lubrication	609.00	639.00	638.58	0.412
4120	Wages to labor	2880.00	2880.00	2878.85	1.150
4130	Laboratory research supply	595.00	512.00	511.37	0.628
4140	Farm supplies	1233.00	1355.00	1354.59	0.409
4150	Books, newspaper, periodicals	115.00	115.70	115.67	0.021
4160	Training and Seminar	300.00	288.30	288.15	0.148
4180	Repair	690.00	791.00	790.50	0.499
42***	Administrative Expenses				
4200	Rent, utilities and other services	240.00	262.00	261.42	0.571
4210	Communication expenses	90.00	90.00	89.23	0.762
4220	Repair and maintenance	3540.00	3507.50	3506.78	0.711
4230	Stationary, printing & office supplies	100.00	100.00	99.84	0.153
4240	Board and panel meeting				
4260	Contingency expenses	75.00	85.50	85.08	0.416
4280	Other administrative budget				
43 JK	Capital expenses				
4310	Land				
4320	Building and other construction	500.00	499.00	496.95	2.045
4330	Furniture and fixture				
4340	Equipment, machinery and tools	305.00	296.00	295.10	0.896
4350	Vehicle				
4360	Computer and computer software	125.00	134.00	133.82	0.180
4370	Other fixed assets	50.00	51.00	50.95	0.050
Grand Total		18052.00	18052.00	17646.38	40.561

NR- 5843

Major Achievements of NCRP

1. Two acid lime varieties released:

Sunkagati-1 and Sunkagati-2 have been released as the promising varieties of acid lime for upland condition of terai, river basin and foot hills of Nepal. The both varieties are developed by the selection of local elite genotypes. The variety Sunkagati-1 is featured of higher fruit yield (1025 fruits/plant & 34.5 t/ha) and earlier fruit harvesting period. The fruit size is measured at 44.5 mm diameter and green-yellowish is fruit color. Similarly, the variety Sunkagati-2 has potential for higher fruit yield (813 fruits /plant & 26.9 t/ha) and earlier harvest period (July-August) including higher fruit juice content (48 %).

2. Pipeline genotypes for mandarin, sweet orange, and acid lime recommended:

Two mandarin genotypes: NCRP 06 and NCRP 01 have been recommended as the pipeline cultivars for releasing. The genotypes NCRP 06 has potential for early harvesting, dwarf and seedless characteristics, appropriate for mid hills. The genotypes NCRP 01 is the local selection, known as Khoku local. This is very popular in eastern region for sweet and juicy fruits in addition to its higher fruit yield (1708 fruits/plant & 128 g fruit weight).
Similarly, two promising genotypes of sweet orange: NCRP 32 and NCRP 86 have been recommended for variety release based on their performance for yield and yield attributes. The genotype NCRP 32 has fruit weight of 148 g/fruit, juice content of 45 %, recommended as midseason and seedless cultivar for midhill domain. Second genotype NCRP 86 is promising for late season harvest (March-April), potential for higher fruit weight (119 g/fruit) and juice content (56 %).
Two elite local genotypes of acid lime are under pipeline for variety release, these include NCRP 53 and NCRP 107. These are promising for off-season production in upland condition of terai and inner terai.

3. Postharvest technology developed:

The mandarin fruits harvested with spike have resulted in minimum fruit weight loss during postharvest storage period when fruits are treated with 10 % ginger.

4. Grafting technology developed:

The mandarin scion grafted with trifoliate rootstock at 12 cm height was resulted in higher graft success and higher percentage of scion growth.

5. Fruit Fly Management Study

Fruit fly infestation in sweet orange in eastern, central and western regions has been recognized as being the Chinese Fruit Fly (Bactocera minax Enderlein). The maximum egg-laying period of the Chinese Fruit Fly was found in between Baisak to Jestha. The results of the assessment of protein lure have revealed the Australian Fruit Fly Lure (autolysed protein) to be effective for trapping fruit flies. In the same study, the mature larva was found to enter into the soil for pupation from 6-7 days after fruit dropped due to this pest infestation. As a result, disposal of the dropped fruit due to the fruit fly should be carried out before this period in order to minimize its population for next near.

Pipeline acid lime genotype NCRP 051

Participant farmers at the farmers' Training

Grafted saplings growing under screen house

President Dr. Ram Baran Yadav visited the NCRP Stall demonstrated at the Mahotsav

NCRP participation at Dhankuta Mahotsav, 2071

NARC Day 2070-71 celebration