Annual Report

2067/68

Government of Nepal

Nepal Agricultural Research Council

National Citrus Research Program

Paripatle, Dhankuta

2068

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Correct citation: NCRP. 2012. Annual Report 2067/68 (2010/11). National Citrus Research Programme, Paripatle, Dhankuta.

Foreword

Citrus fruit crops have special significance in mid hill farming system of Nepal. Despite wider adoptability of the species, mid hill agro-ecology is very congenial for mandarin, sweet orange, acid lime and hill lemon cultivation. With the extension of agricultural roads across the country and technological advancements, commercial citrus cultivation is becoming more popular in mid hills and lime and lemon cultivation is also expanding in terai region of the nation. The greater expansion of cultivation areas and agro-zones along with more economic focus have simultaneously demanded the appropriate technologies suitable for commercial as well as subsistence growers, who have been maintaining trees in home gardens from generations. In the context of low production and productivity of citrus in Nepal, focuses have to be paid on varities, quality sapling production, production technologies for higher productivity, soil fertility management, technologies for insect pest management and post-harvest technologies.

For the overall improvement of citrus farming in the country, National Citrus Research Programme has been putting its efforts to generate technologies for nursery management, variety selection for extended production period, orchard management and insect pest management. This report highlights the progress made in technology generation during the fiscal year 2067/68 (2010/11). I would like to appreciate commendable tasks undertaken by former coordinators, scientists and technical officers, which made possible continuation of research projects and publish this report in this form. More precisely, I would like to thank Mr. Kishor Bhandari, Scientist for his dedication to compile the information. Special thanks go to technicians, farmers and different stakeholders who are directly or indirectly involved in the process of technology generation, verification and dissemination of citrus technologies.

It is my privilege to be a part of this report, which encompasses the annual progress of National Citrus Research Programme for FY 2067/68. Fortunately, the year happens be to the 50th anniversary of the establishment of National Citrus Research Programme (then Citrus Research Station) in Nepal. I believe that the information portrayed in the report will be useful to the institutions and personnel related with citrus fruits research and development in Nepal. I would appreciate to have suggestions in the report from the valued readers.

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ACRONYMS

ARS	**=**	**Agriculture Research Station**
BS	**=**	**Bikram Sambat**
BRT	**=**	**Biratnagar**
CABI	**=**	**Centre for Agricultural Bioscience International**
CD	**=**	**Critical differences**
CIRAD	**=**	**Agriculture Research for Development**
cm	**=**	**Centimeter**
CV	**=**	**Coefficient of variation**
^{0}C	**=**	**Degree Celsius**
DADO	**=**	**District Agriculture Development Office**
DAG	**=**	**Days after grafting**
DAS	**=**	**Days after sowing**
FY	**=**	**Fiscal year**
gm	**=**	**Gram**
GA	**=**	**Gibberellic acid**
GREAT	**=**	**Green Research Private Limited**
ha	**=**	**Hectare**
IAAS	**=**	**Institute of Agriculture and Animal Sciences**
ICAR	**=**	**Indian Council of Agriculture Research**
ICIMOD	**=**	**International Centre for Integrated Mountain Development**
INRA	**=**	**French National Institute for Agriculture Research**
JICA	**=**	**Japan International Cooperation Agency**
OM	**=**	**Organic manure**
Kg	**=**	**Kilogram**
Km	**=**	**Kilometer**
L	**=**	**Litre**
LSD	**=**	**Least Significant Difference**
M	**=**	**Meter**
m asl	**=**	**Meter above sea level**
MoAC	**=**	**Ministry of Agriculture and Cooperatives**
mt	**=**	**Metric ton**
P	**=**	**Probability**
ppm	**=**	**parts per million**
NARC	**=**	**Nepal Agricultural Research Council**
NCRP	**=**	**National Citrus Research Programme**
NS	**=**	**Not significant**
NPK	**=**	**Nitrogen, Phosphorus and Potash**
RARS	**=**	**Regional Agriculture Research Station**
RCBD	**=**	**Randomized Complete Block Design**
Rs	**=**	**Rupees in Nepali currency**
s.e.d.	**=**	**Standard error of differences**
SEm	**=**	**Standard Error of mean difference**
TA	**=**	**Titratable Acid**
T/ha	**=**	**Ton (metric) per hectare**
TSS	**=**	**Total Soluble Solid**
VDC	**=**	**Village Development Committee**

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1. INTRODUCTION

1.1 Background and History

National Citrus Research Programme (NCRP) is only the fruit commodity research programme under Nepal Agricultural Research Council (NARC). Initially it was established as 'Citrus Research Station' in 1961 (2018 BS) with the objectives to generate appropriate technologies and promote commercial citrus cultivation in mid-hills of Nepal. In 1966 (2022 BS), the name of this station was changed to 'Horticulture Research Station' and its mandate was broadened to work on other horticultural crops including vegetable crops continuing major emphasis on citrus fruits. Chungbang farm was established in 1967 as an independent entity to conduct research on cereal crops. After two years of existence, it was merged with Horticulture Research Station, Paripatle had led to abandoning cereal research programme and inception of citrus research and development from Chungbang as well. After the establishment of NARC in 1990, Government of Nepal handed over both Chungbang and Paripatle stations to Nepal Agricultural Research Council and the research stations were named as Agriculture Research Station (Horticulture), Dhankuta. Officially, the station was recognized as National Citrus Research Programme from July 2000 (Shrawan 2057) and national mandate was given for generation of technologies on citrus fruit crops. Presently, all citrus growing areas of the country are the command areas of the station. In 2011, Chungbang farm was formally handed over to Agriculture Research Station, Pakhribas from NCRP, Paripatle acknowledging the decision made by NARC.

1.2 Location

The research station, commonly known as Paripatle Farm, is located at Belahara VDC Ward No.1, Paripatle village of Dhankuta district. Geographically, it is situated at 27^0 1' North latitude and 87^0 18' East longitude. The altitude of the station ranges from 900 to 1390 meter above sea level (m asl) with south-east aspect. It is situated at a distance of 3.85 km west of Kagate (a point at Koshi highway) and 7.85 km from Dhankuta district headquarters in north-west direction.

1.3 Climate and soil

The farm is situated at southern slope of hill. It receives average annual precipitation of 1826.8 mm along with average minimum and maximum temperature of 12.17^0C and 20.72^0C respectively (Appendix 1). The soil texture of Paripatle research farm varies from sandy loam to clay along with gravel in different terraces. The pH of soil is acidic ranging from 4.5 to 6.2 with low (0.04%) to medium (3.33%) organic matter. Phosphorus and potash content of the soil vary from 15 to 50 kg/ha and 2.14 to 3.50 kg/ha respectively.

1.4 Land Utilization

National Citrus Research Programme has a total of 20 ha of land. Out of it, eight hectare is covered by orchards and three hectare by nursery (including mother stocks). About two hectare is occupied by building, canals and road; and remaining seven hectare is occupied by forest. Most of the farm area has been covered by citrus fruit crops namely mandarin, sweet orange, lime, pummelo and grapefruits. Old plantations are mostly dominated by local variety 'Khoku' of mandarin and 'Dhankuta selection' of sweet orange. These old blocks were established to demonstrate farmers that citrus production is commercially viable in Nepal. In recent years, more emphasis has been placed on collection, evaluation, maintenance and utilization of citrus diversities in terms of genus, species, varieties and landraces. Number of collections and recommended genotypes (indigenous and exotic) are increasing every year and data are gathered to initiate the variety release process.

1.5 Goal of NCRP

Contribute to increase productivity and quality of citrus fruit crops in Nepal through technological support.

1.6 Objectives of NCRP

Develop and disseminate demand driven technologies on citrus fruit crops needed for the country.

1.7 Functions of NCRP

To achieve the above mentioned objectives, NCRP performs the following activities on citrus fruit crops:

- **Identify production and post-production problems faced by clients such as citrus growers, traders and processing industries,**
- **Develop appropriate technologies to solve the problems faced by the clients,**
- **Disseminate proven technologies to the clients through out-reach research, demonstration and publication of research findings,**
- **Coordinate with other national and international organizations in order to develop and disseminate citrus technologies efficiently,**
- **Compilation and publication of research findings and other information related to citrus fruit crops from national and international sources and made available to target groups,**
- **Serve as the repository for technical know-how and genetic resources of citrus species, and**
- **Production and supply of healthy mother plants to nursery owners and farmers.**

1.8 Working Strategies

- **Identification of researchable problems faced by extension agents, farmers, traders and processing industries through formal and informal discussion, survey, meetings and secondary sources.**
- **Prioritization of problems based on their severity and formulation of research proposals on priority areas.**
- **Presentation of research proposals to Nepal Agricultural Research Council and other potential donors.**
- **Implementation of approved research projects in research stations and farmerfield conditions.**
- **Verification of newly developed technologies in farmers' fields through outreach research.**
- **Dissemination of the technologies that are accepted by farmers to extension agents and/or action leader farmers for scaling-up.**

NCRP has been adopting aforementioned strategies and trying best to deliver the anticipated outputs based on the available human (Appendices 2 and 3) and financial (Appendix 4) resources. However, there should be a serious consideration for fulfilling the professional staff so as to meet the technological demand of the important commodity for import substitution and export promotion.

1.9 Present status of citrus fruit crops in Nepal

Citrus fruits are cultivated all over the world in tropical and sub-tropical regions having suitable soil and climatic conditions. Mid hills of Nepal ranging from 800 to 1400 m asl altitude all across the country are considered favorable for all types of citrus fruits cultivation. However pumelo, acid lime and lemon can also be cultivated successfully in up-land areas of terai, inner terai, foothills and river basin areas of Nepal. Citrus crops cover about 30% of the total area under fruit cultivation. Citrus crops are potential exportable commodities particularly to India, Bangladesh and China. The history of citrus fruit cultivation in Nepal is not well documented. However, description of the fruits in old scriptures in religious ceremonies and medicinal values indicate that citrus farming has association with early days of civilization. But commercial cultivation of citrus fruits in Nepal started only after 1970. At present, major citrus producing districts of Nepal having more than 1000 ha area are Taplejung, Tehrathum, Dhankuta, Ramechhap, Sindhuli, Kavrepalanchowk, Lamjung, Syangja, Salyan and Dailekh. Table 1 shows the pattern of changes in area coverage, production and productivity of citrus fruits in Nepal during recent decade.

Table 1. Total area, production and productivity of citrus fruits in Nepal from 2000/01 to 2010/11

Year	Total area (ha)	Productive area (ha)	Production (mt)	Productivity (mt/ha)
2000/01	20,673	11,892	121,665	10.23
2001/02	22,423	12,615	130,928	10.38
2002/03	23,663	13,312	139,110	10.45
2003/04	24,799	13,931	148,010	10.62
2004/05	25,910	14,606	156,956	10.75
2005/06	26,681	15,206	164,075	10.79
2006/07	27,980	15,832	171,875	10.86
2007/08	30,790	19,915	226,404	11.37
2008/09	32,322	22,482	253,766	11.29
2009/10	33,898	22,903	259,191	11.30
2010/11	35,578	23,609	263,710	11.17

Source: Ministry of Agriculture and Co-operatives, 2011

Production of citrus fruits has increased by more than two folds whereas increase in productivity is very slow during last 10 years. The productivity of citrus fruits in Nepal is very low (11.17 t/ha) but which is higher than the world average (Appendix 5). However other leading citrus producing countries (Appendices 5 and 6) have productivity more than double than that of ours. Despite the facts, statistics shows the more or less stagnation of the productivity in Nepal in the recent years. Even in the case of cease in productivity uplift, annual production is gradually increasing and it is primarily attributed by the increase in area under citrus cultivation. Therefore there is tremendous potential for productivity increment of citrus fruit crops in Nepal, which can be achieved by utilizing better varieties along with improved orchard management systems. The region-wise disintegrated data of area and productivity of citrus fruits shows that far-west has the lowest area coverage along with the low productivity in 2010/11 (Table 2). However, central region has the highest productivity. More or less similar rate of productivity over the years clearly indicate the poor orchard management situation.

Table 2. Region-wise total area, production and productivity of citrus fruits in 2010/11

Development region	Total area (ha)	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
Eastern	9,008	5,546	61,265	11.05
Central	7,324	5,214	63,083	13.00
Western	10,816	7,387	83,610	11.32
Mid-western	4,899	3,059	33,893	11.08
Far-western	3,532	2,403	21,859	9.09
Nepal	35,578	23,609	263,710	11.17

Source: Ministry of Agriculture and Co-operatives, 2011

The cumulative figures area and production of citrus fruits don't elucidate the contribution made by each species. Area and production of citrus fruits is primarily dominated by mandarin (Table 3).

Table 3. Area coverage (ha) of different citrus species in 2010/11

Development region	Citrus species					
	Mandarin	Sweet orange	Acid lime	Lemon	Other	Total
Eastern	3510	720	1141	112	697	5546
Central	2330	2131	468	134	151	5214
Western	5452	373	530	633	399	7387
Mid-western	2374	280	252	102	51	3059
Far-western	1247	585	340	106	125	2403
Nepal	14913	4089	2731	1087	789	23609

Source: Ministry of Agriculture and Co-operatives, 2011

The three most important species on citriculture in Nepal are mandarin (*Citrus reticulata* Blanco), sweet orange (*Citrus sinensis* Osbeck) and acid lime (*Citrus aurantifolia* Swingle). Mandarin is the most important species all across the regionwhich contributes more than 60% of the total citrus growing areas. The second ost important species is the sweet orange and its main coverage is concentrated (about 50%) in Central development region. Acid lime appeared to be in the third position particularly concentrated in the Eastern Nepal.

2. Nursery management and plant propagation

Nursery is a place where seedlings, saplings or any other planting materials are raised and sold out for planting in gardens and orchards. The prerequisites of a successful and remunerative fruit production are the availability of true-to–type, healthy and good quality planting materials. Setting up a citrus fruit nursery is a long term venture and requires careful planning and expertise, because mistakes committed initially cannot be rectified easily and may adversely affect the return from the investment. Thus one should pay due attention on every aspects of nursery to be established. The young seedlings require special attention during the first few weeks after germination. It is easier and economical to look after the young and tender seedlings growing in nursery bed in small area than in the large permanent site. Demand of seedlings was higher in early days and now farmers are inclined towards grafted saplings. Citrus fruit crops are propagated by grafting and budding. The propagules require special care and management before transferring them in the main field. Planting materials are the main foundation of orchard establishment. Hence, many research works have been conducted in National Citrus Research Programme to generate improved nursery management techniques. Reports of the achievements and progresses are mentioned hereunder.

2.1 Development of integrated citrus nursery and orchard management technologies

2.1.1 Study on growth rate of trifoliate seedlings growing in different media under different environmental conditions

Background

Slow growth rate of trifoliate orange is one of the serious problems of citrus nursery owners. It takes more than two years to attain the size suitable for grafting. To address this problem an experiment was conducted on trifoliate orange to accelerate the growth rate of the seedlings.

Methodology

The seedlings were grown in different media under three different environmental conditions i.e. poly-house, plastic tunnel and open field condition at NCRP, Dhankuta. Seeds were grown in five different media as per the treatments and replicated four times.

Results

The highest seedling height (83.7 cm) and diameter (7.1 mm) was observed in poly-house condition with vermicompost + soil mixture (1:1) treatment whereas the lowest height (28.2 cm) and diameter (3.6 mm) was observed in open field condition in the same media within a year. The result showed highly significant effect of environmental condition on seedlings growth. Seedlings height of trifoliate orange was almost three times and diameter was two times greater in poly-house as compared to open field. Based on the experiment results it has been recommended to grow the trifoliate orange seedling in the poly-house condition with soil and vermicompost mixed media (1:1) to accelerate growth of the seedlings and to get standard height and diameter within one-year period.

2.1.2 Study on effect of different doses of GA_3 and nitrogen on trifoliate orange seedlings growth under open and plastic tunnel condition

Background

Trifoliate orange is the most commonly and widely used rootstock for citrus fruits in Nepal. Different cultivars of trifoliate orange exhibit a great cold hardiness (up to -15^{0}C). This cold hardiness is partially conferred to the scion. Therefore, this rootstock is recommended for areas with cold winters. In addition to cold hardiness, it is also tolerant to gummosis, cachexia-xyloporosis and nematodes. Furthermore, it is also resistant to the citrus tristeza virus (Aubert and Vullin, 1998). Nevertheless, it takes

more than two years to reach the appropriate size suitable for grafting. Hence, the experimental trial was conducted to produce appropriate size of trifoliate orange seedlings suitable for grafting within a year.

Methodology

The experiment was conducted at National Citrus Research Programme, Paripatle. Seeds of trifoliate orange were sown at a spacing of (7×5) cm in well prepared seedbed applying organic manure at a rate of five kg per m^2. After sowing, seeds were covered with white transparent plastic sheet and irrigated at seven days intervals. The treatments were allotted to the seedlings at 2 months after the germination. The spacing was maintained by uprooting and planting the seedling at the same bed. The seedlings were planted at (15×10) cm spacing in (90×80) cm sized experimental plots. The experiment was laid out in two factorial split plot design consisting three replications for each treatment. Each experimental unit consisted of 48 plants. The open field and plastic tunnel was considered as the main plot factors (Factor A) and the combination of different doses of GA_3 and nitrogen as sub plot factors (Factor B). White transparent plastic sheets were used for covering the plant in the form of tunnel having 50 cm height at the centre of the bed. GA_3 was applied as foliar spray at one month intervals while nitrogen was applied through urea as soil application at two split doses one in Chaitra and the next in Baisakh. Ten sample seedlings were selected randomly for the study from each plot.

Results

For seedling growth, the effect of growing condition *i.e.* open and plastic condition was found significant at 180, 240 and 300 days after sowing (DAS), where taller seedlings were found under poly-tunnel. Seedlings height was 25.48 cm, 44.34 cm and 47.75 cm at 180, 240 and 300 days after sowing respectively (Table 4). Since there were no significant different between 120 ppm GA_3 with 300 kg N and 400 kg N/ha, 120 ppm GA_3 + 300 Kg N/ha is found the best economic treatment for taller seedlings at final count.

Table 4. Effect of different doses of GA_3 and nitrogen under open and plastic tunnel condition on growth of trifoliate orange seedling height at NCRP, Paripatle

Treatments	Seedling height (cm)		
	180 DAS	240 DAS	300 DAS
Growing conditions			
Open	19.62^{b}	34.06^{b}	41.84^{b}
Plastic tunnel	25.48^{a}	44.34^{a}	47.75^{a}
CV (%)	8.45	4.04	6.57
F value	141.78**	631.36**	60.38*
CD (P≤0.05)	2.11	1.76	3.27
SEm±	0.348	0.28	0.53
Doses of GA_3 and nitrogen			
0 ppm GA_3+200 Kg N/ha	23.83^{bc}	40.05^{cd}	43.27^{bc}
0 ppm GA_3+300 Kg N/ha	21.67^{d}	38.58^{de}	45.20^{b}
0 ppm GA_3+400 Kg N/ha	20.38^{ef}	36.21^{ef}	40.20^{d}
80 ppm GA_3+200 Kg N/ha	23.15^{c}	36.14^{ef}	44.83^{bc}
80 ppm GA_3+300 Kg N/ha	21.75^{d}	35.46^{f}	42.35^{cd}
80 ppm GA_3+400 Kg N/ha	24.38^{ab}	39.72^{cd}	45.43^{b}
120 ppm GA_3+200 Kg N/ha	21.13^{de}	41.53^{bc}	44.72^{bc}
120 ppm GA_3+300 Kg N/ha	24.08^{bc}	45.28^{a}	48.29^{a}
120 ppm GA_3+400 Kg N/ha	25.05^{a}	42.98^{ab}	48.81^{a}
Control	20.08^{f}	36.07^{ef}	44.88^{bc}
CV (%)	3.46	5.30	4.39
F value	30.81**	15.49**	10.04**
CD (P≤0.05)	0.91	2.43	2.30
SEm±	0.31	0.84	0.80

SEm± = Standard error of mean difference, CV = Coefficient of variation, CD (P≤0.05) = Critical difference at probability value 0.05, Treatment means followed by common letter(s) within a column are not significantly different at 5% by DMRT, DAS=Days after sowing

While considering the collar diameter of seedling, the significant influence of plastic tunnel was recorded over open condition on size of seedling diameter at 180, 240 and 300 DAS. At 180 DAS seedlings grown under plastic tunnel exhibit greater diameter (2.73 mm) as compared to open condition. At 240 days after sowing seedling grown under plastic tunnel gave 4.00 mm diameter and the collar diameter increased to 5.19 mm at 300 days after sowing under the tunnel (Table 5).

Table 5. Effect of different doses of GA_3 and nitrogen under open and plastic tunnel condition on trifoliate orange diameter growth at NCRP, Paripatle

Treatments	Seedling diameter (mm)		
	180 DAS	240 DAS	300 DAS
Growing condition			
Open	**2.58^{b}**	**3.52^{b}**	**4.64^{b}**
Plastic tunnel	**2.73^{a}**	**4.00^{a}**	**5.19^{a}**
CV (%)	**2.88**	**3.94**	**4.16**
F value	**59.70***	**160.27****	**108.03****
CD (P≤0.05)	**0.06**	**0.16**	**0.22**
SEm±	**0.04**	**0.03**	**0.04**
Doses of GA_3 and nitrogen			
0 ppm GA_3+200 Kg N/ha	**2.65^{bc}**	**3.97^{a}**	**5.00^{c}**
0 ppm GA_3+300 Kg N/ha	**2.58^{bc}**	**3.85^{abc}**	**5.22^{b}**
0 ppm GA_3+400 Kg N/ha	**2.58^{bc}**	**3.58^{d}**	**4.75^{de}**
80 ppm GA_3+200 Kg N/ha	**2.70^{ab}**	**3.72^{bcd}**	**4.53^{f}**
80 ppm GA_3+300 Kg N/ha	**2.53^{c}**	**3.65^{cd}**	**4.73^{e}**
80 ppm GA_3+400 Kg N/ha	**2.55^{c}**	**3.68^{bcd}**	**4.70^{e}**
120 ppm GA_3+200 Kg N/ha	**2.65^{bc}**	**3.75^{bcd}**	**4.92^{c}**
120 ppm GA_3+300 Kg N/ha	**2.82^{a}**	**3.87^{ab}**	**5.05^{c}**
120 ppm GA_3+400 Kg N/ha	**2.80^{a}**	**3.87^{ab}**	**5.38^{a}**
Control	**2.72^{ab}**	**3.67^{bcd}**	**4.90^{cd}**
CV (%)	**3.93**	**4.10**	**2.73**
F value	**5.45****	**3.74****	**21.68****
CD (P≤0.05)	**0.12**	**0.18**	**0.15**
SEm±	**0.04**	**0.06**	**0.05**

SEm± = Standard error of mean difference, CV = Coefficient of variation, CD (P≤0.05) = Critical difference at probability value 0.05, Treatment means followed by common letter(s) within a column are not significantly different at 5% by DMRT, DAS=Days after sowing

The effect of combination of different doses of GA_3 and nitrogen on size of seedling diameter was found highly significant at 180, 240 and 300 days after sowing. Highest size of seedling diameter (5.38 mm) was recorded by 120 ppm GA_3 + 400 kg N/ha while recording at 300 DAS as final count.

2.1.3 Effect of grafting dates and methods on success and growth of mandarin saplings

Background

Government of Nepal has targeted to increase citrus areas 35,000 ha by 2015. To meet the target, the area under citrus is to be increased with a rate of more than 1,000 ha per year (Regmi and Shrestha, 2001). It creates the demand of citrus saplings at a rate of around 300,000 per annum in Nepal. To meet the demand of the saplings, nursery person should adopt the suitable method of grafting at right time. Identifying the suitable time of grafting is a vital for successful and profitable propagation business. High graft success not only saves the time but also increases per unit production by minimizing the cost of production. Therefore, this study was undertaken to standardize the time and method of grafting along with assess of the subsequent growth of mandarin saplings at nursery stage.

Methodology

The experiment was conducted at Paripatle during winter season. Scions collected from the mother plant of 'Khoku Local' mandarin were grafted onto one-year-old trifoliate orange seedling rootstocks by shoot tip and veneer methods in eight different dates from 29th October, 2009 to 12th February, 2010 at fortnight intervals. The grafts were planted inside the closed tunnel made from bamboo splits, jute and plastic sheet at (10×10) cm spacing in (60×50) cm experimental plots laid out in two factor split-plot designs with three replications containing 30 grafts per plot. The methods of grafting were allotted on the main plots and the dates on sub-plots randomly. At final digging, vermicompost (nitrogen 1.25-2.5%, phosphorus 0.75-1.6% and potash 0.5-1.1%) was mixed with soil. Each (60×50) cm^2 sized experimental plot received 5 kg vermicompost (4 kg per plot at final bed preparation and 1 kg per plot as top dressing, 4 months after grafting). The tunnel was made by bamboo splits and jute sheet cover from inside and the plastic cover from outside. Bamboo splits were used for construction of tunnel by bending and fixing them in a semi-circle shape in the ground. Irrigation, de-suckering, weeding, hoeing, topdressing, plant protection, opening and closing of tunnel and removal of plastic laces were done as intercultural operations.

Results

Graft success was recorded based on the sprouted scions. The graft success was not influenced significantly by the grafting methods from initial to final observations. However, the effect of grafting dates on success and growth of mandarin was found highly significant. At final observation, the highest graft success was recorded in saplings grafted on 13th January (96.1%) which was followed by 28th January (91.1%) and the success percent of these dates are statistically at par (Table 6).

Table 6. Effect of dates and methods of grafting on graft success of mandarin in Paripatle

Treatments	Sprouted scion (%)				
	15 DAG	30 DAG	45 DAG	60 DAG	12th August
Methods of grafting					
Shoot tip	8.194	28.61	67.78	73.89	77.78
Veneer	9.583	32.36	70.97	78.19	82.08
F value	5.24^{ns}	2.07^{ns}	3.36^{ns}	10.53^{ns}	14.31^{ns}
CD (P≤0.05)	2.610	11.20	7.487	5.706	4.896
SEm±	0.4290	1.840	1.230	0.9377	0.8047
Dates of grafting					
29th October	21.11^{a}	42.22^{a}	51.11^{c}	51.67^{d}	51.67^{f}
14th November	11.67^{b}	34.44^{bc}	67.78^{b}	71.11^{c}	72.22^{e}
29th November	5.000^{c}	28.89^{cd}	66.11^{b}	72.22^{c}	73.33^{e}
14th December	3.330^{c}	26.67^{de}	68.33^{b}	76.11^{bc}	81.67^{d}
29th December	3.330^{c}	22.78^{de}	78.33^{a}	84.44^{a}	88.89^{bc}
13th January	5.000^{c}	21.67^{e}	77.22^{a}	86.67^{a}	96.11^{a}
28th January	6.670^{c}	26.67^{de}	75.00^{ab}	86.11^{a}	91.11^{ab}
12th February	15.00^{b}	40.56^{ab}	71.11^{ab}	80.00^{ab}	84.44^{cd}
CV (%)	37.50	17.22	9.96	6.99	6.36
F value	22.48**	13.18**	9.41**	28.34**	46.19**
CD (P≤0.05)	3.942	6.207	8.172	6.284	6.011
SEm±	1.361	2.143	2.821	2.169	2.075

SEm± = Standard error of mean difference, CV = Coefficient of variation, CD (P≤0.05) = Critical difference at probability value 0.05, Treatment means followed by common letter(s) within a column are not significantly different at 5% by DMRT, DAG=Days after grafting

The maximum success of grafting (96.1%) was recorded on 13th January at Paripatle in the condition of 25.69°C average tunnel temperature and 90±5% relative humidity. During the same time the average air temperature and relative humidity were recorded as 12.52°C and 63.1% respectively. The temperature and relative humidity inside the tunnel was observed about two times and 1.5 times higher respectively as compared to air temperature and relative humidity which was achieved by closing all the edges of plastic sheet immediately after the irrigation of grafts and soaking of jute sheet.

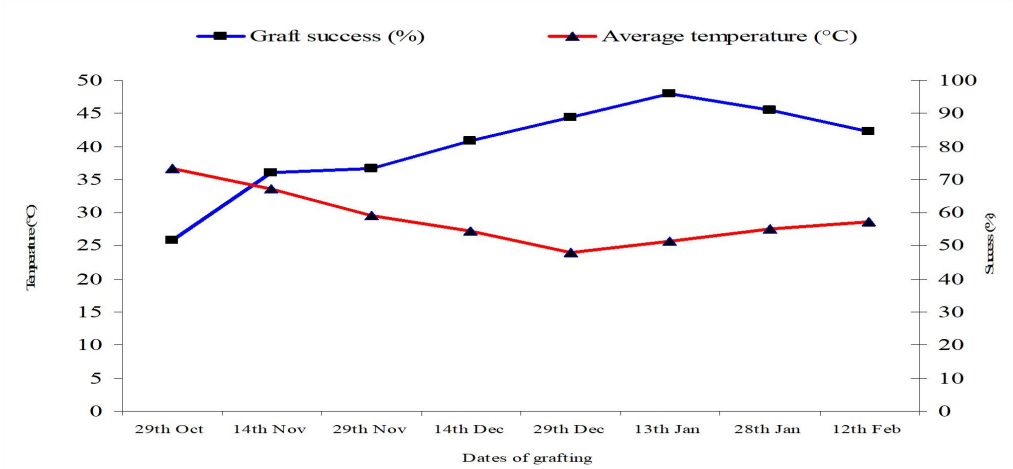

Figure 1. Relation of average tunnel temperature with graft success in different dates of grafting at Paripatle

Figure 1 shows the effect of graft success because of exposed temperature. The percentage of success of grafting was observed minimum (51.7%) on 29th October at 36.76°C, then started rising up to the 13th January (96.1%) at 25.69°C and declining started from 28th January (91.1%) at 27.6°C and onwards.

Mortality of sprouted grafts

Up to the final observation on 12th August, the number of plants died after sprouting was found to be relatively affected by the dates and methods of grafting (Figure 2). Higher percentage of mortality was found in shoot tip method as compared to veneer method of grafting. The highest graft mortality at final observation was recorded in the grafts prepared on 12th February, 4.5% in shoot tip and 2.9% in veneer method respectively. The minimum mortality of sprouted grafts, 0.2% in shoot tip and 0.1% in veneer method was recorded on 29th December grafting.

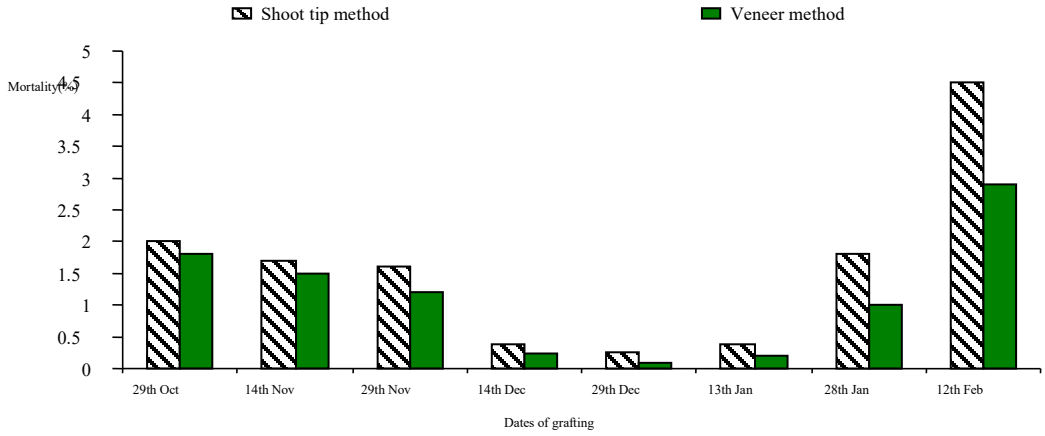

Figure 2. Mortality of sprouted grafts of mandarin in different dates and methods of grafting at Paripatle

The higher mortality of sprouted graft prepared on 12th February was thus due to the lack of moisture needed to meet transpiration loss from the newly expanded leaves. Because union formation completed only at the end of March when there was higher temperature. Thus lack of sufficient water was the principal cause of the death of early sprouted scion of the graft.

Table 7. Effect of dates and methods of grafting on growth different parameters of mandarin sapling at 180 days after grafting at Paripatle

Treatments	Number of leaves/sapling	Sapling growth Sapling height (cm)	Number of primary branches/sapling	Number of secondary branches/sapling	Canopy volume (cm^3)
Methods of grafting					
Shoot tip	29.89	31.00	1.950	1.793	1162.0
Veneer	29.71	31.88	1.892	1.903	1263.0
F value	0.08^{ns}	2.05^{ns}	2.15^{ns}	12.2726^{ns}	1.55^{ns}
CD (P≤0.05)	2.776	2.650	0.1712	0.1361	350.7
SEm±	0.4562	0.4355	0.02814	0.02236	57.64
Dates of grafting					
29th Oct	34.38^{b}	29.03^{b}	2.200^{a}	2.338^{ab}	973.3
14th Nov	48.47^{a}	31.91^{a}	2.150^{ab}	2.505^{a}	1536.0
29th Nov	33.23^{b}	31.97^{a}	2.017^{ab}	2.153^{ab}	1446.0
14th Dec	24.73^{c}	30.39^{ab}	1.883^{ab}	1.808^{bcd}	1094.0
29th Dec	26.93^{bc}	32.86^{a}	1.800^{bc}	2.035^{abc}	1204.0
13th Jan	21.93^{c}	30.43^{ab}	1.867^{abc}	1.333^{de}	1077.0
28th Jan	24.19^{c}	32.74^{a}	1.533^{c}	1.172^{e}	1179.0
12th Feb	24.53^{c}	32.17^{a}	1.917^{ab}	1.442^{cde}	1192.0
CV (%)	20.31	6.79	14.08	26.15	31.15
F value	12.55**	2.38*	3.61**	6.19**	1.51^{ns}
CD (P≤0.05)	7.15	2.52	0.31	0.57	446.8
SEm±	2.47	0.872	0.11	0.19	154.2

SEm± = Standard error of mean difference, CV = Coefficient of variation, CD (P≤0.05) = Critical difference at probability value 0.05, Treatment means followed by common letter(s) within a column are not significantly different at 5% by DMRT, DAG=Days after grafting

Sapling height

The effect of methods of grafting on sapling height was found non significant from 60 days to 180 days after grafting. But the effect of dates on sapling height was found highly significant at 60 days to 150 days after grafting while significant at 180 days after grafting (Table 7). Higher number of leaves per sapling produced more photosynthetic and plant growth regulators, especially gibberellins, causing the faster elongation of internodes of main stem and branches as well. Similarly, accelerated growth of shoot also produced more new roots producing excess auxins, causing the dominance of main shoot over the side branches resulting into increased sapling height.

2.1.4 Effect of grafting height on success and growth of acid lime saplings

Background

Acid lime is the third important citrus crop of Nepal after mandarin and sweet orange in terms of area coverage, production and productivity (MOAC, 2010). Unlike mandarin and sweet orange, acid lime can successfully be cultivated from terai to mid-hill region of Nepal. Nevertheless, production and productivity of acid lime is very low in Nepal due to use of low quality planting materials and poor orchard management. Moreover, the seedling trees are susceptible to *Phytophthora* root rot disease as compared to the grafted ones. Saplings of acid lime prepared by grafting acid lime onto trifoliate orange [*Poncirus trifoliata* (L.) Raf.] are tolerant to *Phytophthora* gummosis, cachexia-xyloporosis and nematodes, especially *Tylenchulus semipenetrans*. The rootstock is also resistant to the citrus tristeza viruses. Considering the benefits of trifoliate orange as rootstock for acid line, a field experiment was carried out to find the suitable height of grafting for maximum success and optimum growth of the saplings at nursery.

Methodology

About eight months old scions were taken from the mother plant of acid lime 'NCRP 49' accession grown inside the screen house at Paripatle. Scions were grafted onto one-year-old trifoliate orange seedling rootstocks by shoot-tip method at five different heights (4 cm, 8 cm, 12 cm, 16 cm and 20 cm) from the collar region of the rootstock as the treatments. The grafts were planted inside the closed tunnel made from bamboo splits, jute sheet cover from inside and plastic sheet cover from outside at (10×8) cm spacing in experimental plots laid out in randomized complete block design (RCBD) with four replications. Each (100×64) cm sized experimental plots were supplied with a total of 10 kg vermicompost (nitrogen 1.2-2.5%, phosphorus 0.75-1.6% and potash 0.5-1.1%) containing 80 grafts. Ten plants were selected from each experimental plot for the study. The regular de-suckering, irrigation, plant protection, weeding, hoeing and top-dressing, removal of plastic laces, removal of jute and plastic sheet were done timely in each experimental plot for better growth of the saplings.

Results

Graft success

The experiment revealed that the success of grafting was not significantly influenced by the height of grafting. , Success rate was more than 95% in all treatments, while taking final observation of success at 180 days after grafting (Figure 3).

Figure 3. Effect of grafting height on success of acid lime grafting at 180 days after grafting at Paripatle

Growth of scion height

The growth of scion height was significantly effected by the grafting height at 180 and 300 days after grafting while non significant at rest of the observations. At 180 days after grafting, the maximum growth of scion height (27.83 cm) was given by 16 cm grafting height which was followed by grafting at 20 cm height. Similarly, at 300 days after grafting, the highest growth of scion height (39.75 cm) was produced by sapling grafted at 16 cm height followed by 20 cm grafted sapling and the lowest by 4 cm grafted sapling. At 360 days after grafting the highest growth (42.13 cm) was again produced by 16 cm height grafted sapling and the lowest scion height by 4 cm height grafted sapling (Table 8).

Table 8. Effect of grafting height on growth of scion height of acid lime saplings at Paripatle

Treatments (Grafting height)	Scion height (cm)					
	60 DAG	120 DAG	180 DAG	240 DAG	300 DAG	360 DAG
Grafting at 4 cm	7.23	15.61	17.76^{c}	24.13	30.35^{b}	32.07
Grafting at 8 cm	8.12	17.30	20.51^{bc}	25.66	30.39^{b}	33.64
Grafting at 12 cm	8.60	18.44	22.94^{abc}	27.01	32.90^{ab}	35.09
Grafting at 16 cm	7.40	19.18	27.83^{a}	31.24	39.75^{a}	42.13
Grafting at 20 cm	6.93	17.56	23.69^{ab}	28.35	35.45^{ab}	38.11
F value	0.86^{ns}	1.31^{ns}	5.08*	2.49^{ns}	3.35*	3.17^{ns}
CV (%)	19.28	13.36	14.77	12.60	12.78	12.37
CD (P≤0.05)	2.27	3.62	5.13	5.29	6.64	6.903
SEm±	0.73	1.17	1.66	1.71	2.15	2.240

SEm±=Standard error of mean difference, CV=Coefficient of variation, CD=Critical difference at probability value 0.05, Treatment means followed by common letter(s) are not significantly different at 5% by DMRT, DAG=Days after grafting

Length of primary branches

The length of primary branches was found significant at 180, 300 and 360 days after grafting while non significant at the rest of the observations. At 180 days after grafting the highest length of primary branches (18.51 cm) was recorded in 16 cm height grafted saplings which were statistically at par with 12 cm and 20 cm grafting height. The lowest length (11.70 cm) was recorded from 4 cm grafting height. At 300 days after grafting, maximum height (27.92 cm) was again given by 16 cm and the lowest (20.55 cm) by 4 cm height of grafting. At 360 days after grafting, the highest length (31.19 cm) was recorded in 16 cm height of grafting and the lowest (21.86 cm) in 4 cm grafting height (Table 9).

Table 9. Effect of grafting height on length of primary branches of acid lime sapling at Paripatle

Treatments (Grafting height)	Length of primary branches (cm)					
	60 DAG	120 DAG	180 DAG	240 DAG	300 DAG	360 DAG
Grafting at 4 cm	4.545	10.20	11.70^{b}	16.54	20.55^{b}	21.86^{b}
Grafting at 8 cm	5.242	10.93	13.85^{b}	18.06	22.21^{b}	23.02^{b}
Grafting at 12 cm	5.773	11.49	14.65^{ab}	17.09	22.08^{b}	23.74^{b}
Grafting at 16 cm	4.975	12.37	18.51^{a}	22.83	27.92^{a}	31.19^{a}
Grafting at 20 cm	4.863	11.27	14.75^{ab}	19.07	25.20^{ab}	27.40$^{a\ b}$
F value	0.66^{ns}	0.81^{ns}	3.39*	2.41^{ns}	3.61*	4.28*
CV (%)	22.32	15.70	18.19	17.13	13.16	14.54
CD (P≤0.05)	1.74	2.72	4.11	4.94	4.78	5.69
SEm±	0.56	0.88	1.3	1.6	1.5	1.8

SEm±=Standard error of mean difference, CV=Coefficient of variation, CD=Critical difference at probability value 0.05, DAG=Days after grafting

2.1.5 Rootstock evaluation for commercial varieties

Background

Trifoliate orange is the only rootstock used in Nepal for propagating citrus fruits. Sole dependency on a species or variety is not a wise approach for long term sustainability. Taking this into account, many varieties of rootstocks are being used in other countries. In the same line, need of identifying other rootstocks which are equally or better than trifoliate orange has been realized and attempt was made to introduce and evaluate the different rootstock species/varieties.

Methodology

Seeds (25 gm of each variety) of seven different types of rootstocks were introduced from INRA_CIRAD France in 2062 BS. Seedlings from the imported seeds were raised for the grafting of elite genotypes available at NCRP so as to evaluate these rootstocks.

More specifically, superior varieties of mandarin, sweet orange and acid lime were grafted on seven (Table 8) newly introduced rootstocks during f/y 2063/64. A total of 192 saplings were planted (4 varieties in 8 rootstock species, 6 plant each varieties) at Sirise block of NCRP. Rootstocks used for evaluation were NCRP-36 (old trifoliate), NCRP-65 (citrange, C-35), NCRP-66 (citrange, Carrido), NCRP-67 (trifoliate, Pomeroy), NCRP-68 (trifoliate, Flying Dragon), NCRP-69 (Citrumello, 04475), NCRP-70 (Volkameriana), NCRP-71 (Rangpur lime) and NCRP-116 (Naite Jyamir). Saplings were planted in factorial RCBD where a total of 32 treatments were replicated five times.

Results

The tested rootstocks have positive traits relating with biotic and abiotic problems associated with citrus cultivation and their characteristics are presented in Table 10.

Table 10. Characteristics of different rootstocks varieties introduced from France

Name	Variety	Response to				
		Phytophthora	Tristeza	Drought	Excess water	Dwarfing
Poncirus	Pomeroy	Resistant	Tolerant	Not adopted	Adapted	Semi Dwarf
Poncirus	Flying Dragon	Resistant	Tolerant	Not adopted	Adapted	Dwarf
Citrange	C-35	Resistant	Tolerant	Acceptable	Not adapted	Vigorous
Citrange	Carrizo	Resistant	Tolerant	Acceptable	Not adapted	Vigorous
Citrumelo	4475	Resistant	Tolerant	Acceptable	Adapted	Vigorous
Volka-meriana		Susceptible in very wet condition	Tolerant	Well adapted	Adapted	Very vigorous
Rangapur lime	Red	Susceptible in very wet condition	Tolerant	Well adapted	Not adapted	Very vigorous

Based on preliminary data on plant height, trunk diameter and spreading, Volkameriana rootstock was observed to increase plant height and trunk diameter of the grafted plants. No complication is observed in graft union till time of reporting. The data are being recorded and will take few more years for conclusive results.

3. Varietal evaluation and citrus orchard management

Citrus is predominantly cultivated in mid hills of Nepal and expanding as an important livelihood option of farmers. Though citrus being considered as a cash crop, significant number of farmers have been growing seedling plants and practicing traditional cultivation methods. It has led to poor fruit quality, irregular bearing/alternate bearing, poor production and finally very low productivity. Poor orchard management is rampant all across the country and it is believed to be a cause of citrus decline in Nepal. For the better production and higher productivity in extended period of time, there is a need for use of new varieties, planting of grafted saplings and appropriate husbandry practices along with better plant protection approaches. Taking this into account National Citrus Research Programme has been putting its efforts to introduce new genotypes and develop appropriate husbandry technologies. This section of the report encompasses the progress made during the reporting period on varietal and orchard management research.

3.1 Diversity study, maintenance of genetic material, production and maintenance program

3.1.1 Germplasm collection and maintenance

Several germplasms (varieties/genotypes/landrace) of different citrus species (mandarin, sweet orange, grapefruit, tangor and tangelo) have been collected from local and exotic sources since the establishment of the research station. Collected germplasms have been preserved in field gene bank of NCRP Paripatle. In 2061/62, thirty-two different species of citrus varieties (mandarin 22 varieties, sweet orange 14 varieties, grapefruit five varieties, tangor three varieties and tangelo three varieties) were introduced from Corsica, France with the support from Prof. Joseph Bove of French National Institute for Agriculture Research (INRA) - CIRAD. These introduced germplasms from exotic sources and locally collected germplasms of different citrus species have also been maintained in the field gene bank of NCRP Paripatle which is presented in Table 11.

Table 11. Different citrus germplasms collected and maintained in a field gene bank

Crop	Accession No.	Variety	Type of collection	Source	Year of introduction
Mandarin	NCRP 01	Khoku Selection	Seeds	Khoku, Dhankuta	
	NCRP 02	Kinnow	Saplings	Govt. of Pakistan	
	NCRP 03	Frutrel early	Saplings	Unknown	
	NCRP 04	Unshu	Saplings	JICA, Japan	
	NCRP 05	Miyagawawase	Grafting	Hort. Cen, Kirtipur	2001 (2058)
	NCRP 06	Okitsuwase	Grafting	Hort. Cen, Kirtipur	2001 (2058)
	NCRP 08	Pongan, Tangarin	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 09	Kamala	Scions	Dhankuta (farmer)	2002 (2059)
	NCRP10	Bashkharka local	Scions	RARS, Lumle	2003 (2060)
	NCRP11	Sikkim	Layering	Tehrathum	2004 (2061)
	NCRP 12	Kalamandarin	Scions	Unknown	
	NCRP 80	Satsumawase	Scions	INRA, France	2005 (2062)
	NCRP 81	Satsuma Miho	Scions	INRA, France	2005 (2062)
	NCRP 82	Satsuma URSS	Scions	INRA, France	2005 (2062)
	NCRP 95	Satsuma Okitsu	Scions	INRA, France	2005 (2062)
	NCRP 88	Fortune	Scions	INRA, France	2005 (2062)
	NCRP 89	Kara	Scions	INRA, France	2005 (2062)
	NCRP 90	Nova	Scions	INRA, France	2005 (2062)
	NCRP 91	Pixie	Scions	INRA, France	2005 (2062)

	NCRP 92	Dancy	Scions	INRA, France	2005 (2062)
	NCRP 93	Avana	Scions	INRA, France	2005 (2062)
	NCRP 94	Page	Scions	INRA France	2005 (2062)
	NCRP 97	Hernandina	Scions	INRA, France	2005 (2062)
	NCRP 98	Oroval	Scions	INRA, France	2005 (2062)
	NCRP 99	Commune	Scions	INRA, France	2005 (2062)
	NCRP 100	Marisol	Scions	INRA, France	2005 (2062)
	NCRP 101	Nules	Scions	INRA, France	2005 (2062)
	NCRP112	Gorkhali Suntala	Scions	Nareshor, Gorkha	

Crop	Accession No.	Variety	Type of collection	Source	Year of introduction
Sweet orange	NCRP 13	Valencia late		ICAR, India	
	NCRP 14	Sevelle Common		ICAR, India	
	NCRP 15	Navalancia		ICAR, India	
	NCRP 16	Malta blood red		ICAR, India	
	NCRP 17	Samauti		ICAR, India	
	NCRP 18	Mosambi		ICAR, India	
	NCRP 19	Vanelle		ICAR, India	
	NCRP 20	Ruby		ICAR, India	
	NCRP 21	White taker		ICAR, India	
	NCRP 22	Washington Navel		ICAR, India	
	NCRP 23	Hamlin		ICAR, India	
	NCRP 24	Pineapple		ICAR, India	
	NCRP 25	Yoshida Navel	Grafted plant	Hort Cen, Kirtipur	2001 (2058)
	NCRP 27	Delicious seedless	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 28	Skage Binanza	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 29	Blood Red	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 30	Newhall Navel	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 31	Succari	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 32	Meisheu-9	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 26	Madam Venous	Tissue culture	GREAT, Nepal	2002 (2059)
	NCRP 83	Cara Cara	Scions	INRA, France	2005 (2062)
	NCRP 84	Lane Late	Scions	INRA, France	2005 (2062)
	NCRP 85	Pineapple	Scions	INRA, France	2005 (2062)
	NCRP 86	Valencia late	Scions	INRA, France	2005 (2062)
	NCRP 87	Salustiana	Scions	INRA, France	2005 (2062)
	NCRP 96	Tomango	Scions	INRA, France	2005 (2062)

Crop	Accession No.	Variety	Type of collection	Source	Year of introduction
Grapefruit	NCRP 45	Shamber	Scions	ICIMOD, Lalitpur	2002 (2059)
	NCRP 76	Henderson	Scions	INRA, France	2005 (2062)
	NCRP 77	Star Ruby	Scions	INRA, France	2005 (2062)
	NCRP 78	Reed	Scions	INRA, France	2005 (2062)
	NCRP 79	Pink Rubi	Scions	INRA, France	2005 (2062)
Tangore	NCRP 102	Ellendale	Scions	INRA, France	2005 (2062)
	NCRP 07	Murkotte (old)	Scions		
	NCRP 103	Murkotte	Scions	INRA, France	2005 (2062)
	NCRP 72	Ortanique	Scions	INRA, France	2005 (2062)
Tangelo	NCRP 73	Minneola	Scions	INRA, France	2005 (2062)
	NCRP 74	Oriando	Scions	INRA, France	2005 (2062)
	NCRP 75	Seminole	Scions	INRA, France	2005 (2062)
Rootstocks	NCRP 65	Citrange C-35	Seeds	INRA, France	2005 (2062)
	NCRP 66	Citrange – Carrizo	Seeds	INRA, France	2005 (2062)
	NCRP 67	Poncirus – Pomeroy	Seeds	INRA, France	2005 (2062)
	NCRP 68	Flying Dragon	Seeds	INRA, France	2005 (2062)
	NCRP 69	Citrumelo 4475	Seeds	INRA, France	2005 (2062)
	NCRP 70	Volkameriana	Seeds	INRA, France	2005 (2062)
	NCRP 71	Rangapur lime Red	Seeds	INRA, France	2005 (2062)
	NCRP 36	Trifoliate orange	Seeds	Unknown	Unknown
	NCRP 37	Rangapur lime	Seeds	Unknown	Unknown
	NCRP 38	Citrange	Seeds	Unknown	Unknown
	NCRP 39	Boxifolia	Seedlings	Unknown	Unknown
	NCRP 40	Rough lemon	Seeds	Unknown	Unknown
	NCRP 116	Rough lemon	Seeds	Belahara-1, Dhankuta	2007(2064)

Crop	Accession No.	Variety	Type of collection	Source	Year of introduction
Acid lime	NCRP 46	01 (25)	Scions	IAAS, Rampur	
	NCRP 47	01 (17)	Scions	IAAS, Rampur	
	NCRP 48	101 (2)	Scions	IAAS, Rampur	
	NCRP 49	101 (3)	Scions	IAAS, Rampur	
	NCRP 50	71 (5)	Scions	IAAS, Rampur	
	NCRP 51	Sundar pur lime	Scions	Sundarpur Morang	
	NCRP 52	Belapur lime	Scions	Belepur Morang	
	NCRP 53	Panta -1	Scions	IAAS Rampur	
	NCRP 55	Madrasi lime	Scions	Himali Nursery Biratnager	
	NCRP 56	Vanarasi lime	Seedlings	Himali Nursery Biratnager	
	NCRP 57	Krishnapur Kagati	Seedlings	Bharatpur Chitwan	
	NCRP 59	Kaptanganj golo lime	Scions	Kaptanganja, Sunsari	
	NCRP 60	Kaptanganj lamo lime	Scions	Kaptanganja, Sunsari	
	NCRP 107	Tehrathum lime	Scions	Fakchamara, Tehrathum	
	NCRP 108	Khursani bari lime	Scions	Saptagandaki Farm Chitwan	
	NCRP 117	Durgabhabani lime	Saplings	Durgabhabani- 7, Baitadi	
	NCRP 118	Sejwal takura lime	Seeds	Sejwal Takura, Salyan	
	NCRP 119	Takshar lime	Seeds	Takshar, Bhojpur	
	NCRP 120	Lekphant Kagati	Seeds	Mallaj Lekphant, Parbat	

Crop	Accession No.	Variety	Type of collection	Source	Year of introduction
Pummelo	NCRP 42	Phultrac	Scions	Vietnam	
	NCRP 43	Nam Roi	Scions	Vietnam	
	NCRP 44	Phodiem	Scions	Vietnam	
Lemon	NCRP 61	Eureka lemon	Unknown	Unknown	
	NCRP 63	Hill lemon	Scions	Sundar pur, Morang	
	NCRP 109	Thimura local	Saplings	Saptagandaki Farm, Chitwan	
	NCRP 110	BRT Nibuwa	Saplings	Saptagandaki Farm, Chitwan	
	NCRP 111	Prembasti local	Saplings	Saptagandaki Farm, Chitwan	
Kumquat	NCRP 105	Oblong type	Unknown	Unknown	
	NCRP 106	Round type	Scions	Dhankuta Bazaar	
Bud Muted	NCRP 114	Khoku, muted	Scions	Sanche block, NCRP	
Citron	NCRP 62	Local Bemire	Scions	Belahara, Dhankuta	
Hokse	NCRP 41	Local Hokse	Scions	Dhankuta Bazaar	

3. 2 Variety evaluation and selection of superior genotypes

3.2.1 On-farm and on-station variety evaluation of mandarin, sweet orange, tangor and acid lime for off-season variety selection for mid-hills region

3.2.1.1 Establishment of on-farm variety evaluation plots of mandarin, sweet orange, acid lime, tangor and tangelo

Background

Despite having all the year round demand of citrus fruits, its production period within the country is confined between Kartik and Poush. Low production, narrow production period and poor infrastructural facilities for storage have led insufficient supply of national produces to fulfill the national requirement. Because of that significant amount of citrus fruits are being imported from India since many years. To address the problem of narrow production season, an effort has been made to evaluate different varieties of citrus crops to select superior varieties for out of season production so that production period of citrus fruits can be prolonged and made available to market for longer period.

Methodology

Variety evaluation research plots, two sites in each district, have been established in five districts namely Tehrathum, Sindhuli, Makawanpur, Shyanja and Kailali in 066/67 (Table 12).

Table 12. Name and address of the participatory farmer in on-farm variety evaluation of mandarin, sweet orange, acid lime, tangore and tangelo

Name of participatory farmer	Address	District	Crops included
Harka Dhoj Limbu	Sabla -1	Terhatnum	Complete set
Trilochan Luitel	Fakchamara -7	Terhathum	Mandarin and tangor
Suresh Dahal	Fakchamara -7	Terhathum	Acid lime set
Narendra Khatiwada	Fakchamara -7	Terhathum	Sweet orange set
Bishnu Prasad Shrestha	Ratanchura -2	Sindhuli	Complete set
Hasta Bahadur Masrangi	Baseswar – 6	Sindhuli	Complete set
Chakra Bahadur Magar	Baseswar – 6	Sindhuli	Tangor and mandarin
Hari Bahadur Magar	Baseswar – 6	Sindhuli	Acid lime set
Thakur singh Bloon	Namtar -9	Makawanpur	Complete set
Bhim Bahadur Thokar	Bhaise -5	Makawanpur	Complete set
Khadananda Paudyal	Rapakot -7	Shyanja	Complete set
Shiva Chapagai	Aladi -9	Shyanja	Complete set
Maya Devi Basyal	Malunga -1	Shyanja	Acid lime set
Bishnu Kala Adhikari	Malunga -1	Shyanja	Acid lime set
Khadak Bahadur Saha	Sahajpur -9	Kailali	Complete set
Durgadatta Kandel	Nigali -2	Kailali	Complete set

One experimental site comprised of three promising varieties of mandarin (Okitsuwase, Nova and Khoku Local), sweet orange (Washington Navel, Valencia Late and Dhankuta Local), acid lime (NCRP 49, NCRP 55 and Tehrathum Local), and tangor (Ortanique, Ellendale and Murkotte). A total of 72 saplings of each species have been planted in the five districts.

Data on plant characteristics such as plant height, spread, trunk diameter, incidence of major diseases and insect pest will be recorded from the second year of plantation.

3.2.1.2 Establishment of on-station variety evaluation plots of mandarin, sweet orange, acid lime, tangore and tangelo

A total of 24 varieties/genotype of mandarin, 23 varieties/ genotype of sweet orange, 20 genotype of acid lime, 5 varieties of grape fruit, 4 varieties of pumelo, 3 varieties of tangor and 3 varieties of tangelo have been planted at research plot of NCRP, paripatle during the fiscal year 2064/65 for on-station variety evaluation. Data recording on qualitative and quantitative parameters is being continued. Likewise total 15 varieties/genotype of mandarin, 6 varieties/genotype of sweet orange, 5 varieties of grape fruit, 3 varieties of tangor and 3 varieties of tangelo have been planted at research plot of ARS, Dailekh for on station variety evaluation during the fiscal 2063/64.

3.2.1.3 On-station variety evaluation of mandarin

Altogether twenty two germplasms (varieties/genotype) collected from different sources (local and exotic) at NCRP Paripatle from its establishment to 063/064 are maintained for on station variety evaluation at different research plots of NCRP Paripatle. Similarly, germplasms collected from France have been planted at research plot of ARS (Hort) Dailekh for on station variety evaluation in 2063/64.

3.2.1.4 On-farm variety evaluation of mandarin

Four varieties of mandarin (Miyagawawase, Okitsuwase, Frutrel Early and Murkotte) for off-season production were identified for participatory on farm variety evaluation and were planted in three different sites of Dhankuta district at Goth Gaun, Karmitar and Seule during 2063/064 (Table 13).

Table 13. Name and address of the participatory farmer in on-farm variety evaluation of mandarin

Farmer name	Address	Altitude (m asl)	Variety included
Sushil Mishra	Dhankuta 4, Gothgaun	850	Okitsuwase, Murkotte
Denesh Shrestha	Dhankuta 6, Karmitar	1050	Okitsuwase, Miyagawawase , Murkotte and Frutrel Early
Bhuval Guragain	Dhankuta 2, Seule	1300	Okitswase, Miyagawawase , Murkotte and Frutrel Early

Data on plant characteristics such as plant height, spread, trunk diameter, incidence of diseases and insect pests are recorded from the second year after plantation. Based on recorded preliminary data, variation on plant height was observed across altitude and among varieties. Murkotte showed the fast growing behavior but Okitsuwase was found very slow in growth. It is noted that scale and leaf minor insects were main problem in all locations. Leaf minor problem was higher during new flush stage i.e. during Falgun and Asar. Powdery mildew was the only disease noted during rainy season in all locations. Powdery mildew disease was noted severe in higher altitude than in lower altitude.

3.2.1.5 On station variety evaluation of sweet orange

Sweet orange (*Citrus sinensis* Osbeck) occupies first position among citrus fruit crops in terms of area under coverage in world scenario and it contributes nearly 60% of the total citrus production. The crop is being cultivated in most citrus growing countries of the world. Brazil, Mexico, United States of America and China are the leading sweet orange producers in the globe. In Nepal, sweet orange ranks second after mandarin in terms of area and production. It is cultivated in more than two dozen of districts but two districts Ramechhap and Sindhuli account more than 50 percent of total sweet orange production of Nepal.

Twenty three sweet orange germplasms were collected from different sources (local and exotic) at NCRP Dhankuta from its establishment period 063/64 and planted at research plots of NCRP. Germplasms collected from France have been planted at research plot of ARS (Hort) Dailekh for on-farm variety evaluation for western Nepal in 2063/64. Data on plant characteristics such as plant height, spread, trunk diameter, incidence of major diseases and insect pest are being recorded from the next year of plantation.

3.2.2 Front line study on off- season acid lime production technology through farmers' participatory approaches in terai region

Background

Acid lime ranks third after mandarin and sweet orange in terms of area under coverage. It is traditionally considered as a crop of mid hills and the production from the main growing areas is regarded as normal season crop. The normal season production is very short and limited between Kartik and Poush. Even in the main production season, more than 50 percent market demand of acid lime fruits in Kathmandu valley is fulfilled by the import from India. Imported acid lime meets nearly 90% national and 95% of Kalimati wholesale market demanded quantity (Dhakal and Bhattarai, 2060). The situation has not much changed yet and it clearly indicates the need of production and productivity increment of acid lime through expanding coverage area to move towards self sufficiency in Nepal. Based on the recent on-farm research outcomes, acid lime can be successfully cultivated under up-land condition of terai, inner terai, foot hills and river basin areas for out of normal season production. It shows the high potential of expanding areas of acid lime in up-land condition of almost all terai, inner terai, foot hills and river basin ecological conditions of Nepal. To verify and demonstrate the results of acid lime production in different agro-climatic conditions in wider locations, this project is developed for verification cum demonstration of acid lime orchard in terai region through farmers' participatory approach for its commercialization.

Methodology

Farmers' participatory acid lime front line study plots are established in Morang, Sarlahi, Chitwan, Dang and Kailali. Total 105 saplings of acid lime were planted including genotypes NCRP-55, NCRP-49 and NCRP-107 in spacing of (4x4) m.

Table 14. Name and address of the participatory farmer in frontline study of acid lime

S.N.	Name	Address	District	Remarks
1	Hari Prasad Koirala	Bayarban-9, Bargachhi	Morang	
2	Jugal Prasad Singh	Katahari-5, Tohal Gaun	Morang	
3	Bhagawan Mainali	Hariwon-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	Cooperatives land
7	Prem Lal Chaudhary	Sishaniya-9, Bagarapur	Dang	
8	Vishnu P. Chaudhary	Musuriya-3, Matkana	Kailali	
9	Gagan Singh Thaguna	Malakheti-4, Khamaura	Kailali	

Results

Shoot borer, leaf minor and scale insects were recorded as the major insect pests in almost all genotypes of acid lime. Similarly, *Phytophthora* gummosis (root rot) and citrus canker diseases were identified as limiting factors for acid lime cultivation under terai condition of Nepal, which can be managed effectively by the use of Antiriot (10 ml/l) and Kasugamycin (1ml/l) respectively. Data on plant characteristics such as plant height, spread, trunk diameter, diseases and insects incidence will be recorded from second year after plantation.

NCRP-55, NCRP-49 and NCRP-53 genotypes are also doing good in terai and inner terai demonstration sites. NCRP-53 (lemon type genotype) is extra earlier than other genotypes, which can be harvested from the first week of Jestha to mid Shrawan as the main harvesting period and showed potential for processing where as rest genotypes were found suitable for table purpose. Genotypes NCRP-49 and NCRP-55 are harvested from 1st week of Asar to end of Bhadra.

3.2.3 On-station variety evaluation of acid lime *(Citrus aurantifolia* Swingle*)*

NCRP Paripatle has collected twenty different germplasms of acid lime from different local sources for on-station variety evaluation. The collected germplasms are planted in the research plot of NCRP during 2063/64 to 2064/65 for varietal evaluation. The main parameter of varietal selection was out of main season maturity period of the mid hills. Data on plant characteristics such as plant height, spread, trunk diameter, diseases and insects incidences have been recorded from second year after plantation. Shoot borers, leaf minors and scale insects were the major insect pests observed in all genotypes of acid lime in mid hills condition. Similarly, Gummosis and citrus canker diseases were noted in all genotypes except NCRP-49, NCRP-53, NCRP-55 and NCRP-56.

Moisture stress during Falgun-Chaitra is found as main culprit for flowers dropping before fruit set. Subsequent flower and fruit initiation can be observed in the case of moisture availability either through irrigation or rainfall. Tendency of off season flowering and fruiting (Jestha-Asar, Bhadra-Aswin and Mangsir-Poush) was observed in all genotypes resulting availability of small amount of lime fruits throughout the year. Off season fruits can be harvested from Aswin to Baishak. Based on the result of this experiment, genotypes of acid lime namely NCRP-49, NCRP-53 and NCRP-55 were found to be superior because of early maturity (Ashar to Bhadra), high yielder having excellent fruit shape and size and high juice content. Based on the research results, three elite genotypes of acid lime are recommended for commercial cultivation under up-land condition of terai, inner terai, foot hills and river basin region of Nepal.

3.2.4 On-station variety evaluation of Grapefruit (*Citrus paradise* Mac.*)*

Grapefruit covers nearly seven percent of world citrus production. United States of America, Cuba, Greece and Israel are the major grapefruit producing countries of the world. The production of red-fleshed varieties has increased dramatically in the last 15 years in Texas, Florida and Israel. Therefore, five grapefruit varieties (Shamber, Henderson, Star Rubi, Reed and Pink Rubi) were introduced from France for on station variety evaluation and were planted on research plot of NCRP Paripatle, during 2064/065. Data on plant characteristics are being taken from the second year after plantation and the varieties have not yet started fruiting but their growth and vigour are satisfactory.

3.2.5. Varietal recommendation for commercial cultivation

On-station varietal trials followed by participatory varietal selection studies on acid lime in farmers' fields of Jhapa, Morang, Sunsari and Chitwan were carried out by NCRP, Dhankuta during 2062/63 to 2066/67. Similarly, farmers' participatory variety selection study on mandarin and sweet orange was also carried out in different locations of Dhankuta district and at paripatle station during 2062/063 to 2066/067. Based on the experimental results recorded so far, different varieties of citrus species is recommended (Table 15) for higher production along with extended period of time.

Table 15. Recommended varieties of mandarin, sweet orange and acid lime

Crop	Variety	Harvesting season
1. Mandarin	1. Okitsuwase (Unshu mandarin)	Early (Bhadra- Kartik) for mid hills
	2. Khoku (Common mandarin)	Mid-season (Mangsir-Magh) for mid hills
2. Sweet orange	1. Washington Navel	Early (Kartik-Mangsir) for mid hills
	2. Valencia late	Late season (Chaitra-Baisakh) for mid hills
3. Acid lime	1. Tehrathum local	Kartik to Poush in mid hills
	2. NCRP- 55	Asar to Bhadra in terai
	3. NCRP- 49	Asar to Bhadra in terai
	4. NCRP- 53	Jestha to Shrawan in terai

3.2.6 Storage of mandarin in cellar store

Research work indicates that matured mandarin and sweet orange fruits with fruit stalk can be stored for two to three months after harvest in the month of Poush at 10^0C and 95% humidity under cellar store in mid hills condition.

4. Citrus pest management

Citrus cultivation in Nepal is facing both biotic and abiotic problems. Insects and diseases problem are the main challenges of many commercial citrus growing areas and these have led to yield reduction and production cost increment. Among them citrus psylla, fruit flies, green stink bug, scale insects, citrus greening and root rot are more common insects and diseases. Citrus psylla (*Diaphorina citri* Kuwayama) (Hemiptera: Psyllidae) is the number one pest of citrus because it vectors the bacterium responsible for huanglongbing disease (citrus greening), considered to be one of the world's most devastating diseases of citrus. Fruit fly is another devastating insect that causes up to 97% loss by the end of harvesting season in the eastern hills of Nepal. Similarly, citrus green stink bug (*Rhynchocoris humeralis*) is another major insect responsible for premature fruit drop in citrus. In totality natural fruit drop is 20% where as green stink bug is responsible for 50% of loss. Scale insects are also serious pest in the citrus plantation particularly in the eastern region of Nepal. It sucks plant cell thereby causing growth retardation and further promotes shooty mould development. In this scenario, research on plant protection is pivotal to minimize the loss caused by insects and diseases. Realizing the fact, researches have been conducted both at on-station and at various outreach sites. Major plant protection researches carried out during the reporting period is elucidated under this section.

4.1 Identification of new species of fruit fly

Citrus fruit flies are the most serious insect pest of sweet orange and hill lemon in the eastern hills of Nepal. Despite several years of effort to control fruit flies through male annihilation using methyl eugenol and affected fruits sanitation tactics, fruit losses of sweet orange did not decrease at the farm of NCRP Dhankuta and farmers' fields of eastern region of Nepal. Since last five years even mandarin fruits are being damaged (about 15%) by the fruit flies. It forced to think the researchers that the flies which is affecting citrus fruits in the eastern hills could be other than oriental fruit fly (*Bactrocera dorsalis*). On this ground, an attempt was made rearing adult flies from the maggots of affected fruits for identification. Affected fruits of sweet orange, mandarin and hill lemon were collected on first week of Kartik. Fruits were kept under appropriate soil moisture on the plastic trays and covered by plastic net in NCRP Paripatle. The flies started to emerge from first week of Baisakh. The emerged live flies were sent to Entomology Division, Khumaltar for further rearing and identification of species. The reared flies were compared with flies captured inside the pheromone and cue lure traps. An attempt was also made to identify the reared species by comparing it with reference photographs published in Fruit Flies of Economic Significance, their Identification and Bionomics by Ian M. White and Marlene M. Elson-Herris, CAB International in association with ACIAR.

All the adult flies reared from affected fruits of sweet orange at NCRP Dhankuta and Entomology Division Khumaltar was similar types. The body size and body and wing patterns were very similar to that of reference picture of Chinese citrus fly (*Bactrocera minax*). They were much bigger than those captured in methyl eugenol (oriental fruit fly) and cue lure (melon fly). Those emerged adults were sent to UK for identification of the species for final confirmation. Hence, the identification strongly confirmed that Chinese citrus fly (*Bactrocera minax*) is the species affecting the citrus fruits of NCRP, Dhankuta and vicinity areas but not the oriental fruit fly (NCRP, 2006).

4.2 Integrated management of Chinese citrus fly in Citrus crops

Background

Fruit flies is the most devastating insect of citrus crops. Fruit drop caused by Chinese citrus fly (*Bactrocera minax*) is very serious causing up to 97% loss by the end of harvesting season (Bajracharya, 2008). Chinese citrus fly has been recognized as a serious pest of commercial sweet orange, especially in the eastern regions of Nepal and is considered one of the major limiters of production. The earlier efforts to minimize fruit flies problem in sweet orange and hill lemon through male annihilation using methyl eugenol and affected fruits sanitation tactics did not give any positive result in the farm of NCRP and farmers' fields in the eastern region of Nepal. Therefore, an effort has been initiated for its management study by using protein bait.

Methodology

An extensive survey was undertaken to know the economically important fruit fly species infesting citrus fruits, especially in two districts of the eastern region i.e. Dhankuta and Tehrathum and three districts from the western region, i.e. Gorkha, Lamjung and Syanja. The samples comprising infested fruits were collected during the peak activities of fruit flies and the emerging fruit fly adults were identified. Since the identified species is new to Nepalese context, different treatment combinations are designed to find the more appropriate method of management. The first treatment is Proteinax at a rate of 50 gm per litre, the second one is orange-ammonia solution (750 ml orange juice, 25 gm ammonium carbonate, 1 litre water, 0.2% potassium sorbate preservatives), the third one is Australian fruit fly lure at a rate of 50 ml per litre and the last one is control (spraying of plain water). These four treatments were replicated 10 times and all the treated and control sweet orange trees were selected for yield loss assessment.

Results

An extensive survey of the fruit flies infesting citrus orchards were undertaken especially in five districts i.e. Dhankuta, Tehrathum, Gorkha, Lamjung and Syanja and studied its biology to identify the species. The adult fruit flies emerged from the samples taken from Tehrathum were found *Bactrocera minax* but no adults emerged from the samples taken from Gorkha, Lamjung and Syanja.

Similarly, the above mentioned treatments were applied on sweet orange and trees were selected for yield loss assessment. Fruits showing pre-matured yellow colour collected in weekly interval from first week of Aswin to third week of Mangsir. These fruits were cut and fruit fly maggots inspected. Proteinax and Orange-ammonia solution treated sweet oranges were found equally damaged as control but Australian fruit fly lure showed slightly positive result but its efficacy is yet to be studied. Likewise, fruit fly lure was used as the insect trap to evaluate its efficacy which was found slightly effective in attracting adult *B. minax*. But its conclusive result is yet to come.

4.3 Control of scale insects

Various types of scale insects such as red scale, arrowhead scale, soft scale, cottony-cushion scale damage citrus fruits. It has been found that spray of mineral oil Servo Agro spray (M) at a rate of 20 ml + 2 ml Rogor per liter of water during Falgun and Asar is more effective to control the scale insects.

4.4 Control of green stinkbug

Research work showed that foliar application of contact + systemic insecticide (Rogor at a rate of 1 ml + Doom 1 ml/l of water) at the nymph stage of bugs (white to yellow colour) in the month of Jestha to Bhadra in 15 days of interval is more effective than that of spraying in adult stage.

4.5 Control of root rot and gummosis diseases

Exposure of affected roots during dry season and drenching with Bordeaux mixture in Falgun and Jestha along with approach grafting with trifoliate rootstocks during Jestha-Asar and application of Bordeaux paste on the main trunk above the ground surface after pruning in winter season is very effective to improve the root health of the declining trees. Proper drainage system and well sanitation around the basin area of the tree play important role to control root rot, foot rot and gummosis diseases. Foliar application of systemic fungicide *i.e.* Anti-rot at a rate of 10 ml per liter of water at 15 days interval during Magh to Falgun and Jesth to Bhadra has been found more effective to control gummosis and root rot/foot rot disease caused by *Phytophthora* species.

4.6 Control of powdery mildew

Powdery mildew is one of the serious fungus diseases of citrus crops. It affects on new flush of the plant during rainy season especially during Asar to Bhadra. High temperature and high humidity condition are the favorable for its spreading. In severe cases, young fruits are also affected resulting in twigs die, pre-mature fruit drop and deterioration of the fruit quality. Foliar application of Karathion at a rate of 1 ml/l of water was very effective control measure and recommended previously. However, farmers did not adopt this fungicide due to its expensive cost (Rs 400 per 100 ml). For that, a study was conducted by NCRP during 2062/063 to 2065/066 for evaluating effective and cheap fungicides for farmers. The study result indicated that foliar applications of sulfur-containing fungicide (i. e. Insuf or Sulfex) at a rate of 2- 2.5 gm per liter of water in 15 days intervals during rainy season (Jestha to Shrawan) found very effective and five times cheaper (Rs. 50 per 100 gm pack) than Karathion to manage this disease.

4.7 Monitoring of Huanglongbing (HLB) disease

Huanglongbing disease (citrus greening) is most devastating bacterial disease of citrus species and caused by *Liberobacter asiaticum*. It is believed to be introduced 40 years ago in Nepal from Saharanpur, India with planting materials. Survey reports indicate that citrus greening disease has spread in many citrus growing areas of Nepal. A survey was carried out on citrus production pocket areas of Dhankuta, Gorkha, Lamjung, Tanahu, Kaski and Syanja districts. Visual observation of symptomatic trees and leaf sample analysis by PCR technique at NAST laboratory and in France confirmed that the disease was prevalent in all surveyed districts except Syanja. The pace of disease spreading has not yet stopped and the disease is spreading day by day due to unscientific handling of planting materials. As a result of that, established commercial mandarin orchards in Gorkha, Tanahu and Lamjung districts are gradually declining. Likewise, orchards of many districts of the mid and the far western regions have the same fate due to citrus greening disease and lack of integrated orchard management techniques adopting by the growers. NCRP Dhankuta has carried out the monitoring of citrus greening disease in different citrus growing pocket areas of the country since 2062/63. Management tactics found appropriate so far have been suggested to the growers upon monitoring the seriousness of the disease.

5. Production and support

Technology development and recommendation merely carry any meaning until it reaches to the end users and utilized by them. Citrus cultivation in Nepal is not yet reached at the industry level but current trend of interest of primary and secondary stakeholders has widen avenues towards rapid development of the enterprise and ultimately become an industry in near future. On this ground, NCRP has been putting its efforts to disseminate the technologies developed by the programme to extension officers and leader farmers so as to spread it within short span of time. Likewise handing over of quality mother stocks of new genotypes particularly to nursery owners is another approach for widening the genetic base so as to expand the production season in Nepal. However, not only restricting to nursery growers, the programme has been distributing saplings to progressive farmers and District Agriculture Development Offices for the establishment of commercial orchard for demonstration. This section of the report shed light on the production and technology dissemination through training during the reporting fiscal year.

5.1. Sapling production and distribution

To discourage the seedling use and promote the sapling (grafted plants) plantation, NCRP has a regular activity of grafted saplings production and distribution. The programme has sold saplings of different species in the reporting year as per the following Table 16.

Table 16. Saplings of different species sold during 2067/68

Crop	Production and sale (no.)	Revenue (Rs.)
1. Mandarin	5,781	143,626
2. Sweet Orange	2,259	56,475
3. Acid Lime	5,720	135,234
4. Kumquat	54	2,160
5. Rose	403	10,075
6. Sweet lime	20	500
7. Tangor	180	4,500
Total	14,417	352,570

Since mandarin is the main crop among citrus crops, major demand comes along with the species. Demand of acid lime is sharply increasing because of its commercial cultivation in terai and foot hills of Nepal.

5.2. Technology dissemination through training

Handing over of the developed technologies is not a straightforward undertaking in Nepalese context as mandate of technology generation rests with NARC but dissemination is in the shoulders of Department of Agriculture. In this situation, NCRP has organized training to subject matter specialists to disseminate the technology through the formal system. However, to hasten the technology handover to end user, NCRP has also planned training to leader farmers.

5.2.1. Subject Matter Specialist (SMS) training:

NCRP has identified "Extension Service Provider" as one of the important source of technology disseminator among the needy farmers and thus organizing SMS training every year to disseminate generated technologies. Therefore, to disseminate newly introduced technologies, NCRP has organized 2 day SMS training on "Scientific cultivation technology of citrus crops" successfully from 19-20 Baishak 2068 at Dhankuta involving 19 SMSs from different District Agriculture Development Offices of mid hills and terai districts. The list of participants of different districts is presented in Appendix 8.

5.2.2. Farmers' Training:

NCRP has organized farmers' training on "Scientific cultivation technology on Citrus crops" and "Scientific cultivation technology on acid lime in terai region" which was prerequisite of "Integrated nursery and orchard management technology" and "Frontline study on off- season acid lime production technology through farmers" participatory approaches in terai region of Nepal" projects, respectively. The training date and place was finalized on the basis of feasibility and accessibility of farmers. Farmers involved in outreach research activities of NCRP and commercial citrus cultivation were selected for these training programmes. A total 82 farmers of different VDCs and districts have participated in three training slots at Pokhara of Kaski, Khajura of Banke and Tarahara of Sunsari. The name list of participants of Pokhara, Khajura and Tarahara are presented in Appendices 9, 10 and 11.

5.2.3. Calendar of operation for citrus orchard

Based on research findings and field experiences, NCRP has developed a calendar (Table 16) of operation for its orchard management. This calendar has been shared with all stakeholders who have been directly or indirectly involved in citrus orchard management.

Table 16. Calendar of operation adopted at NCRP Paripatle for orchard management

Month	Operation
Baishakh	• Irrigate the orchards and nursery beds
	• Uproot the diseased and very old unproductive trees
	• Prepare pits for new plantation
Jestha	• Make a drainage system in the orchard
	• Prepare the nursery bed for rootstock transplanting
	• Prepare compost for next year
	• Apply chemical fertilizers
Asar	• Spray with sulfur containing fungicide to control powdery mildew
	• Transplant rootstocks for next year sapling production
	• Distribute healthy saplings for plantation
Shrawan	• Weed citrus orchard
	• Transplant rootstock seedlings (trifoliate) in main nursery block
	• Remove diseased, new suckers and dry branches
	• Spray Insuf at a rate of 2g/L of water for the control of powdery mildew
	• Maintain Pheromone traps
Bhadra	• Weed in citrus orchards and nurseries
	• Apply Servo agro spray mineral oil at a rate of 15ml/l of water to control scale insects
	• Apply systemic insecticides for the control of green stinkbug
	• Drench the root with 1% Bordeaux mixture infected by root rot disease
Aswin	• Collect trifoliate seeds for rootstock production
	• Apply insecticides for the control of green stinkbug
	• Weed and mulch in the orchards
	• Stack the heavily fruited branches
	• Collect fruit fly infected sweet orange fruit and burry into pits

Month	Operation
Kartik	• **Collect fruit fly infected sweet orange fruits and burry in pits**
	• **Prepare new nursery bed and sow trifoliate seeds for next year production**
	• **Harvest early maturing varieties**
Mangsir	• **Harvest mid-season varieties**
	• **Graft for sapling production**
Poush	• **Harvest mid-season varieties**
	• **Graft for sapling production**
Magh	• **Harvest late season varieties, prune and train, apply fertilizer and manure and spray Servo agro spray to control scale insects**
Falgun	• **Spray Servo agro spray to control scale insects; apply fertilizer and manure**
	• **spray foliar micronutrients**
	• **Spray Insecticide in nursery plants to control leaf minor**
	• **Irrigate the orchards and nursery**
Chaitra	• **Irrigate the orchard and nursery bed**
	• **Uproot the diseased and very old unproductive trees and prepare pits for new plantation**

APPENDICES

Appendix 1. Meteorological data of NCRP, Paripatle (1300 m asl)

Month	Temperature (^{0}C)		Total
	Maximum	Minimum	Rainfall (mm)
July	22.8	17.93	409.2
August	23.23	17.82	449.4
September	22.64	16.18	266.8
October	22.57	13.74	70.2
November	18.58	9.57	-
December	16.13	6.07	-
January	13.55	3.94	11.7
February	17.29	6.76	23.9
March	21.65	10.35	29.0
April	23.09	12.43	93.0
May	22.89	14.35	168.7
June	24.31	17.00	304.9
Mean/Total	20.72	12.17	1826.5

Appendix 2. Manpower situation of National Citrus Research Program in FY 2067/68

S. N.	Post	Approved number	Fulfilled	Vacant	Remark
1	Chief Scientist (S5) -Soil.	1	1	-	
2	Senior Scientist (S4)-Horticulture	1	-	1	
3	Senior Scientist (S3)-Horticulture	2	-	2	
4	Senior Scientist (S3)-Plant Pathology	1	-	1	
5	Scientist (S1) – Soil	1	-	1	
6	Scientist (S1) – Plant. Breeding (Tissue culture)	1	-	1	
7	Scientist (S1) – Entomology	1	1	-	
8	Scientist (S1) – Plant Pathology	1	-	1	
9	Senior Technical Officer (T8) – Pomology	1	1	-	
10	Senior Technical Officer (T7) – Pomology	1	-	1	
11	Technical Officer (T6) – Pomology	3	1	2	
12	Senior Technician (T5)	2	1	1	
13	Technician (T4)	5	2	3	
14	L. Technician (5^{th}.level)	13	12	1	
15	L. 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	24	19	

Appendix 3. List of staff at NCRP, Dhankuta in FY 2067/68

S.N.	Name	Designation	Qualification	Remark
1	Mr. Surendra P. Srivastava	Coordinator (S4)	MSc (Soil Sc.)	
2	Mr. Manish K. Thakur	Scientist (S-1)	MSc (Hort.)	Deputed from ARS Dailekh
3	Mr. Kishor Bhandari	Scientist (S-1)	MSc (Ento.)	
4	Mr. Hari P. Subedi	Senior Technical Officer (T-7)	BSc Ag.	
5	Mr. Basant Chalise	Technical Officer (T-6)	MSc Ag.	
6	Mr. Parsuram Yadav	Technical Officer (T-6)	B.L.	Deputed to RARS Tarahara
7	Mr. Khagandra P. Niraula	Account Officer (A-6)	M. B. S.	
8	Mr. Kumar P. Koirala	Admin. Officer (A-6)	B.A.	
9	Mr. Yagya B. Karki	Technician (T-4)	Literate	
10	Mr. Nara B. Tamang	Technician (T4)	Literate	
11	Mr. Amar B. Shrestha	L. Technician (5thLevel)	Literate	
12	Mr. Ser B. Tamang	L. Technician (5thLevel)	Literate	
13	Mr. Singh. B. Tamang	L. Technician (5thLevel)	Literate	
14	Mr. Jagat B. Karki	L. Technician (5thLevel)	Literate	
15	Mr. Buddhi Man Darji	L. Technician (5thLevel)	Literate	
16	Mr. Purna B. Darji	L. Technician (5thLevel)	Literate	
17	Mr. Ram P. Timilsina	L. Technician (5thLevel)	Literate	
18	Mr. Tanka P. Timilsina	L. Technician (5thLevel)	Literate	
19	Mr. Bhabani P. Phuyal	L. Technician (5thLevel)	Literate	
20	Mr. Thir B. Ale	L. Technician (5thLevel)	Literate	
21	Mr. Man B. Tamang	L. Technician (5thLevel)	Literate	
22	Mr. Hem B. Dahal	L. Technician (4thLevel)	Literate	
23	Mr. Tej B. Darji	L. Technician (4thLevel)	Literate	
25	Mr. Tara B. Khatri	Heavy driver (4thLevel)	SLC	

Appendix 4. Budget expenditure statement of NCRP in F. Y. 2067/68

Budget code	Budget Heading	Budget allocated	Released	Expenditure	Balance
40 JK	Staff Expenses	5031000.00	4925407.00	4924912.00	495.00
4000	Staff Basic Salary	3750000.00	3556900.00	3556770.00	130.00
4010	Staff Allowances	501000.00	481900.00	481830.00	70.00
4020	Provident Fund	375000.00	355900.00	355677.00	223.00
4030	Medical	0.00	0.00	0.00	0.00
4040	Uniform	350000.00	172507.00	172500.00	7.00
4050	Dasain Kharcha	310000.00	301800.00	301735.00	65.00
4080	Insurance Fund	60000.00	56400.00	56400.00	0.00
41 JK	Operational Expenses	7045000.00	7045000.00	7024398.01	20601.99
4100	Travel expenses	603600.00	603600.00	603528.00	72.00
4110	Vehicle fuel, lubrication	370000.00	370000.00	360907.39	9092.61
4120	Wages to labor	1360400.00	1360400.00	1352690.00	7710.00
4130	Laboratory research supply	340000.00	340000.00	339575.87	424.13
4140	Farm supplies	850000.00	850000.00	849463.82	536.18
4150	Books, newspaper, periodicals	268000.00	268000.00	267565.00	435.00
4160	Training and Seminar	633000.00	633000.00	632758.00	242.00
4180	Repair	2620000.00	2620000.00	2617909.93	2090.07
42 JK	Administrative Expenses	1785000.00	1785000.00	1783892.58	1107.42
4200	Rent, utilities and other services	153600.00	153600.00	153551.30	48.70
4210	Communication expenses	85900.00	85900.00	85883.56	16.44
4220	Repair and maintenance	1395500.00	1395500.00	1395231.72	268.28
4230	Stationary, printing & office supplies	81500.00	81500.00	81110.00	390.00
4240	Board and panel meeting	0.00	0.00	0.00	0.00
4260	Contingency expenses	68500.00	68500.00	68116.00	384.00
4280	Other administrative budget	0.00	0.00	0.00	0.00
43 JK	Capital expenses	600000.00	600000.00	598579.66	1420.34
4310	Land	0.00	0.00	0.00	0.00
4320	Building and other construction	0.00	0.00	0.00	0.00
4330	Furniture and fixture	196000.00	196000.00	195829.00	171.00
4340	Equipment, machinery and tools	87000.00	87000.00	86432.50	567.50
4350	Vehicle	0.00	0.00	0.00	0.00
4360	Computer and computer software	115000.00	115000.00	114810.00	190.00
4370	Other fixed assets	202000.00	202000.00	201508.16	491.84
	Grand Total	14461000.0	14355407.0	14331782.25	23624.75

Appendix 5. Top five citrus producing countries of the world with their production and productivity, 2010

Country	Productive area (ha)	Total production (mt)	Productivity (mt/ha)
China	1,74,750	48,86,900	27.96
India	55,500	7,64,300	13.77
Mexico	21,200	1,03,600	4.86
Iran	6,400	87,000	13.59
USA	2,100	43,700	20.80
World	12,45,710	1,17,63,628	9.44

Source: FAO, 2010

Appendix 6. Major countries of the world producing different types of citrus fruits

Types of citrus fruit	Major producing countries
Oranges	Brazil, United States, Mexico, India, Spain, China, Iran, Italy, Egypt, Indonesia
Small citrus	Nigeria, China, Syria, Guinea, Japan, Saudi Arabia, India, Sierra Leone, Angola, Tunisia
Lemons and limes	Mexico, India, Iran, Spain, Argentina, Brazil, United States, China, Italy, Turkey
Grapefruit	United States, China, South Africa, Mexico, Israel, Cuba, Argentina, India, Turkey, Tunisia

Source: FAO, 2010

Appendix 7. Revenue collection at National Citrus Research Program in FY 2067/68

S.N.	Source of Revenue	Total revenue (Rs.)
1.	Horticultural commodity (Fresh fruit & saplings)	603545.00
2.	Miscellaneous (Wood, grass, broom grass etc)	39742
	Total	643327

Appendix 8. List of SMS's involved in "Scientific Cultivation Technology of Citrus crop" at Dhankuta

S.N.	Name	Institution	Position
1.	Birendra Dhital	DADO Tanahun	
2.	Surya Narayan Yadav	DADO Jhapa	Horticulturist
3.	Satya Narayan Sah	DADO Panchthar	P P Officer
4.	Mitralal Paudel	RATC Jhumka Sunsari	Training Officer
5.	Govinda Raj Joshi	DADO Kailali	Horticulturist
6.	Padam Nath Aatrya	DADO Parwat	Horticulturist
7.	Subodh Shakya	DADO Tehrathum	Horticulturist
8.	Yam Kumar Shrestha	DADO Sankhuwasava	P P Officer
9.	Sitaram Chaudhari	DADO Dang	Horticulturist
10.	Rabendra Partap Yadav	DADO Palpa	Horticulturist
11.	Gyanandra Raj Adhikari	DADO Lamjung	Horticulturist
12.	Ramchandra Bhattarai	DADO Kavre	Junior Technician
13.	Tirpit Narayan Mishra	DADO Sunsari	Horticulturist
14.	Bishnu Kanta Jha	DADO Udayapur	Horticulturist
15.	Durga prasad Pokhral	DADO Dhankuta	P P Officer
16.	Kasi Kumar Chaudhari	DADO Sunsari	Horticulturist
17.	Sita Lama	DADO Khotang	Junior Technicean
18.	Uma Devi Shrestha	DADO Dhankuta	Junior Technicean
19.	Narshingha P Chaudhari	DADO Nawalparasi	Extension officer

Appendix 9. Training on "Scientific cultivation technology on acid lime in terai region" organized at ARS Malepatan, Pokhara (13-Jestha 2068)

S. N.	Name	Address	District
1	Khadananda Paudyal	Rapakot VDC-7	Shyanja
2	Shiva Chapagin	Aaladi VDC-9	Shyanja
3	Narayan Prasad Marasini	Putalibazar municipality-3	Shyanja
4	Maya Devi Basyal	Malunga VDC-1	Shyanja
5	Yaga Prasad Pathak	Tin Dobate VDC-5	Shyanja
6	Bishnukala Adhikari	Malunga VDC-1	Shyanja
7	Mina Paudyal	Kristi VDC-2	Kaski
8	Sarada Adhikari	Kristi VDC-2	Kaski
9	Krishna Prasad Subedi	Kristi VDC-2	Kaski
10	Uma Nath Subedi	Kristi VDC-2	Kaski
11	Narayan Prasad Subedi	Kristi VDC-2	Kaski
12	Khim Lal Subedi	Kristi VDC-2	Kaski
13	Dhaneshor Subedi	Kristi VDC-2	Kaski
14	Sasidhar Subedi	Kristi VDC-2	Kaski
15	Gobinda Paudyal	Nirmal Pokhari VDC-9	Kaski
16	Rupa Paudyal	Nirmal Pokhari VDC-9	Kaski
17	Chitra Prasad Baral	ARS, Malepatan	Kaski
18	Tek Bahadur BK	ARS, Malepatan	Kaski
19	Arjun Pokhrel	APF, Malepatan	Kaski

Appendix 10. Training on "Scientific cultivation technology on acid lime in terai region" organized at RARS, Khajura, Banke (16-Jestha2068)

S.N.	Name	Address	District
1	Kamala Kumari Chaudhari	Musuriya VDC-3, Matkauna	Kailali
2	Khadak Bahadur Saha	Sahajpur VDC-9, Sahajpur	Kailali
3	Dabal Bahadur Saha	Sahajpur VDC-9, Sahajpur	Kailali
4	Bishnu Prasad Chaudhari	Musuriya VDC-3, Matkauna	Kailali
5	Prem Lal Chaudhari	Sishaniya VDC-9, Bagarpur	Dang
6	Jaliram Chaudhari	Sishaniya VDC-9, Bagarpur	Dang
7	Gobinda Prasad Sharma	Laxmipur VDC-2	Dang
8	Gobinda Prasad Chaudhari	Saundiyar VDC-7, Dabar Gaun	Dang
9	Thaman Budha Magar	Tari Gaun VDC-2, Tarigai	Dang
10	Buddhiram Chaudhari	Tari Gaun VDC-3, Haripur	Dang
11	Jhaggu Prasad Oli	Khaskusma VDC-8	Banke
12	Salik Bhandari	Khaskusma VDC-8	Banke
13	Khemraj K.C.	Khaskusma VDC-1	Banke
14	Jamalal Pun	Duruba VDC-9	Dang
15	Bhedlal Oli	Khaskusma VDC-2	Banke
16	Dhanshingh Khadak	Khaskusma VDC-3	Banke
17	Gaganshingh Thagunna	Malakheti VDC-4	Kailali
18	Durga Prasad Kandel	Nigali VDC-2	Kailali
19	Ashis Boom	Udashipur-2	Kailali

Appendix 11. Training on "Scientific cultivation technology on acid lime in terai region" organized at RARS, Tarahara (24-25 Jestha 2068)

S. N.	Name	Address	District
1	Mahesh Timsina	Mechinagar municipality- 4 Dhulabari	Jhapa
2	Jugal Prasad Shingh	Katahari VDC- 5	Morang
3	Durga Niraula	Dulari VDC-2	Morang
4	Hari Prasad Koirala	Bayarban VDC- 9	Morang
5	Raju Subedi	Parkashpur VDC- 7	Sunsari
6	Netra Bahadur Khadak	Dumrha VDC- 2	Sunsari
7	Som Prasad Bhattarai	Bayarban VDC- 8	Morang
8	Bishnu Kattel	Lakhanpur VDC- 9	Jhapa
9	Thunga Tamang	Chaudandi VDC-	Udayapur
10	Dipendra Hamal	Belahara VDC- 2, Paripatle	Dhankuta
11	Om Nath Nepal	Patheri VDC-2, Devigang	Morang
12	Anil Kumar Yadav	Shreepur VDC- 5	Sunsari
13	Manoj Shingh	Chandragadhi Municipality-2	Jhapa
14	Dambar Bahadur Magar	Rauta VDC- 9	Udayapur
15	Santa Kumar Shrestha	Madan Bhandari Memorial Academy, Uralbari	Morang
16	Sulochana Pariyar	Madan Bhandari Memorial Academy, Uralbari	Morang
17	Kebal Budhathoki	Madan Bhandari Memorial Academy, Uralbari	Morang
18	Nawaraj Ojha	Beltar VDC-7	Udayapur
19	Ramila khadaka	Lafagaun VDC-2	Udayapur
20	Indira Rai	Baklauri VDC-2	Sunsari
21	Madn Mishra	Lakhanpur VDC- 3	Jhapa
22	Kul Prasad Bhattarai	Maharani VDC- 3	Jhapa
23	Sattya Narayan Yadav	Babiya VDC-4	Sunsari
24	Mahananda Mehata	Kaptanganj VDC-2	Sunsari
25	Rishidev Goyal	Dadarkairiya VDC-2	Morang