

Annual Report

2062/63



Government of Nepal
Nepal Agricultural Research Council
National Citrus Research Program
Paripatle, Dhankuta
2063

1. INTRODUCTION

1.1 Background and History

National Citrus Research Programme (NCRP) is one of the commodity research programs under Nepal Agricultural Research Council (NARC). Firstly, it was established in 1961 (2018 B.S.) in the name of '**Citrus Research Station**' with the objectives to generate technologies and promote commercial citrus cultivation in mid-hills of Nepal. In 1966 (2022 B.S.), the name of this station was changed to '**Horticulture Research Station**' and its mandate was broadened to work on other horticultural crops including vegetables although the major emphasis was on citrus fruits. Chungbang farm, established in 1967, as an independent farm to conduct research on cereal crops was also later annexed to Horticulture Research Station, Paripatle and consequently programs on cereal crops were abandoned and horticultural activities mainly on citrus fruits were initiated. This satellite farm is situated at a distance of 10 km from main research station at Paripatle, Dhankuta. After the establishment of NARC in 1990, HMG/N handed over both Chungbang and Paripatle stations to Nepal Agricultural Research Council and the research station was named as **Agriculture Research Station (Hort.)**, Dhankuta. Officially the station was recognized as **National Citrus Research Program (NCRP)** from July 2000 (Shrawan 2057) and national mandate was given for technologies generation on citrus fruit crops.

1.2 Location

The main 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° 1' North latitude and 87° 18' East longitude. The altitude of the station ranges from 1250 to 1390 meter and facing south-east aspect. It is situated at a distance of 3.85 km west of Kagate (a point at Dharan-Dhankuta-Hile highway). Chungbang farm is located at Chungbang VDC at a distance of 10 km from Paripatle farm and is faced towards northern side of hill.

1.3 Soil and Climate

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 (0.044%) 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. The Paripatle farm situated in southern slope hill whereas Chungbang farm is faced to northern aspect with sub-tropical type of climate. Paripatle farm receives average annual minimum and maximum temperature of 12.4° C and 26.78° C respectively. Monthly average meteorological data are presented in Appendix 5.

1.4 Land Utilization

National Citrus Research Program has a total of 26 hectare of land. Out of this, Paripatle farm has 20.0 hectares and rest is in Chungbang farm. Land utilization pattern of both the stations has been presented in Table 1. Most of the farm area has been covered by citrus fruit crops namely mandarin, sweet orange and lime. Old plantations are mostly dominated by local variety: Khoku of mandarin and Dhankuta selection of sweet orange. It is due to the reason that at the time of establishment of station major emphasis was to demonstrate to the farmers that citrus production is commercially viable in Nepal. In recent years, more emphasis has been given on collection, evaluation, maintenance and utilization of citrus diversities in terms of genus, species, varieties and land races. Number of collections and recommended genotypes (indigenous and exotic) are increasing every year. Nearly 30% of the land is still

covered by forest or is fallow, which can be utilized for cardamom, coffee or for other non-timber forest product.

Table 1: Land utilization pattern of National Citrus Research Program

| S.N. | Utilization pattern | Area (ha) | | |
|------|--------------------------|----------------|----------------|-------|
| | | Paripatle Farm | Chungbang Farm | Total |
| 1. | Orchard | 8.0 | 3.0 | 11.0 |
| 2. | Fruit nursery | 3.0 | 0.0 | 3.0 |
| 3. | Building, canal and road | 2.0 | 1.5 | 3.5 |
| 4. | Forest and fallow | 7.0 | 1.5 | 8.5 |
| | Total | 20.0 | 6.0 | 26.0 |

1.5 Goal of NCRP

The goal of NCRP is to contribute in increasing productivity and quality of citrus fruit crops in Nepal with especial emphasis in mid-hill region of the country.

1.6 Objectives of NCRP

The short-term goal or objective of this program is to develop and disseminate demand driven technologies on citrus fruit crops needed for the country.

1.7 Functions of NCRP

To achieve above mentioned goal and objective 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 (farmers, traders and processing industries) through out-reach research, extension 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.
- Production and supply of healthy mother plants to nursery owner and farmers.

1.8 Working Strategy

- Identification of researchable problems faced by extension agents, farmers, traders and processing industries through formal and informal discussion, survey, meetings, reports etc.
- Prioritization of problems based on their severity and formulation of research proposals on priority areas.
- Presentation of research proposals to Nepal Agricultural Council and other potential donors.

- Implementation of approved research projects in research stations and farmers' fields.
- Verification of newly developed technology in farmers' fields through outreach research.
- Transfer of the technologies that are accepted by farmers to extension agents for scaling-up.

Status of Citrus Fruit Crops in Nepal

Citrus fruits are cultivated all over the world in tropical and sub-tropical region where there are suitable soil and climatic condition. In Nepal, the climatic condition of mid-hill regions having altitude range of 900 to 1300 m from east to far west of the country are considered very favorable for all types of citrus fruit cultivation. Pummelo, lime and lemon can also be cultivated in Terai regions (< 500 m). Citrus is the number one fruit crop of Nepal covering about 25% of total area under fruit cultivation. The three most important species on which citriculture of Nepal is based are mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and lime (*Citrus aurantifolia*). Mandarin is a potential exportable commodity particularly to India and Bangladesh.

The history of citrus fruit cultivation in Nepal is not well documented, but the description of fruits in old scriptures about their importance in religious ceremonies and medicinal values indicates that citrus farming must have been a traditional practice since ancient period. But commercial cultivation of citrus fruits in Nepal started only after seventies. Table 2 presents pattern of changes in area, production and productivity of citrus fruit crops in Nepal. At present, major citrus producing districts of Nepal are Ilam, Panchthar, Terathum, Dhankuta, Bhojpur, Sindhuli, Ramechhap, Kabre, Dhading, Gorkha, Lamjung, Tanahu, Kaski, Syanja, Gulmi, Argakhachhi, Dailekh, Dadeldhura, Baitadi and Darchula.

Table 2. Area and production of citrus fruit crops in Nepal from 1975 to 2002.

| Year | Total area (Ha) | Productive area (Ha) | Production (T) | Productivity (T/Ha) |
|-------------------|-----------------|----------------------|----------------|---------------------|
| 1974/75 (2031/32) | 2,600 | 1,690 | 15,000 | 8.9 |
| 1979/80 (2036/37) | 5,200 | 3,300 | 30,000 | 9.1 |
| 1984/85 (2041/42) | 8,448 | 5,000 | 45,000 | 9.0 |
| 1989/90 (2046/47) | 13,515 | 7,136 | 78,639 | 11.0 |
| 1993/94 (2050/51) | 13,544 | 7,899 | 76471 | 9.68 |
| 1994/95 (2051/52) | 14,628 | 8,448 | 83,375 | 9.82 |
| 1995/96 (2052/52) | 15,243 | 8,977 | 88,635 | 9.87 |
| 1996/97 (2053/54) | 15,924 | 9,330 | 92,994 | 9.97 |
| 1997/98 (2054/55) | 17026 | 10034 | 100,352 | 10.00 |
| 1998/99 (2055/56) | 18,007 | 10,592 | 107,250 | 10.13 |
| 1999/00 (2056/57) | 19,017 | 11,277 | 115,062 | 10.20 |
| 2000/01 (2057/58) | 20,672 | 11,892 | 121,665 | 10.23 |
| 2001/02 (2058/59) | 22,423 | 12,615 | 130,928 | 10.38 |

| | | | | |
|-------------------|--------|--------|---------|-------|
| 2002/03 (2059/60) | 23,663 | 13,312 | 139,110 | 10.45 |
| 2003/04 (2060/61) | 24,800 | 13,930 | 148,010 | 10.62 |
| 2004/05 (2061/62) | 25,909 | 14,606 | 156,956 | 10.75 |
| 2005/06 (2062/63) | 26,680 | 15,206 | 164,075 | 10.79 |

Source: Ministry of Agriculture and Cooperatives.

Since last 30 years area and production has been increased by more than 10 folds whereas increase in productivity is very slow. The productivity of citrus fruits in Nepal is very low (10.8 t/ha) as compared to 20 - 50 t/ha in most citrus growing countries of the world. Thus, increase in total production in Nepal is primarily attributed to the increase in area under citrus cultivation. So, there is enormous scope of increasing productivity of citrus fruit crops in Nepal, which can be achieved by utilizing better varieties along with improved orchard management system. Production statistics of citrus fruit crops of Nepal for the year 2005/06 has been presented in Table 3.

Table 3. Area and production of citrus fruit crops in Nepal in 2005/06 (2062/63)

| Region | Mandarin | | Sweet orange | | Lime | | Lemon | | Other | | Total | |
|---------|-----------------|------------|----------------|------------|----------------|------------|--------------|------------|--------------|------------|------------------|------------|
| | Area (Ha) | Prod. (Mt) | Area (Ha) | Prod. (Mt) | Area (Ha) | Prod. (Mt) | Area (Ha) | Prod. (Mt) | Area (Ha) | Prod. (Mt) | Area (Ha) | Prod. (Mt) |
| Eastern | 3998 (2421) | 28525 | 842 (536) | 6480 | 1518 (920) | 7606 | 174 (151) | 1244 | 33 (18) | 158 | 6565 (4072) | 44013 |
| Mid | 2678 (1645) | 18848 | 2880 (1691) | 21898 | 732 (494) | 4089 | 73 (75) | 627 | 31 (23) | 217 | 6394 (3929) | 45679 |
| Western | 5821 (3157) | 36325 | 636 (253) | 2609 | 878 (524) | 3989 | 189 (144) | 1083 | 58 (45) | 399 | 7582 (4123) | 44345 |
| M. W. | 2563 (1193) | 12228 | 335 (164) | 1617 | 484 (272) | 2149 | 76 (62) | 467 | 33 (27) | 202 | 3492 (1717) | 16663 |
| F. W | 1325 (761) | 8010 | 647 (345) | 3420 | 337 (185) | 1397 | 70 (55) | 412 | 23 (18) | 135 | 2402 (1365) | 13374 |
| Nepal | 16626 (9177) | 103937 | 5582 (3015) | 36024 | 4193 (2395) | 19230 | 826 (488) | 3833 | 421 (131) | 1052 | 26681 (15206) | 164075 |

Source: Ministry of Agriculture.

** Figure inside parenthesis are productive area i.e. area under fruit bearing trees.

2. TECHNOLOGIES DEVELOPED

Since its establishment NCRP has been involved in on-station and on-farm technology generation, dissemination, farmers' training and production of foundation mother trees and quality planting materials of citrus species. Following paragraphs present some of the major achievements (technologies) of the past:

2.1 *Germplasm collection*

NCRP had collected various varieties and land-races of citrus germplasm from local and exotic sources in the past. These germplasm are being established in the field gene bank of Paripatle farm for evaluation. Collected germplasm include local mandarins (land races from different districts of Nepal), Kamala, exotic mandarin varieties (Unshiu, Murkott, Kinnow and Fruetrel early, Kalamondin, Ponkan Mandarin, Sikkime), sweet orange (22 varieties) lime (28 accessions), grapefruit (5 varieties), pummelo (4 accession), hill lemon (24 accessions) and citrus rootstocks (rough lemon, trifoliolate orange, citrange, Rangpur lime). A farmers' participatory survey was also carried out in Terai region to identify early maturing acid lime genotypes. A total of 26 trees (genotypes) were evaluated and 11 were selected for further on-farm evaluation. Presently selected genotypes are being evaluated at farmers' fields in Jhapa, Morang, Sunsari and Chitawan district. List of recently introduced germplasm has been presented in Table 5.

2.2 *Variety Selection*

A number of varieties have been recommended for commercial cultivation to the farmers as a result of variety evaluation works carried out for last four years. Recommended varieties for early, mid and late season production are presented in Table 4.

Table 4 Recommended varieties of mandarin, sweet orange and lime in Nepal.

| Crop | Variety | Harvesting season |
|-----------------|--------------------------------------|---------------------------------|
| 1. Mandarin | 1. Okitsuwase (Unshu mandarin) | Early (Aswin - Kartik) |
| | 2. Khoku (Common mandarin) | Mid-season (Mangsir - Magh) |
| | 3. Murkott (Mandarin x Sweet orange) | Late (Falgun - Chaitra) |
| 2. Sweet orange | 1. Washington Navel | Early (Kartik - Mangsir) |
| | 2. Pineapple | Mid season (Poush – Falgun) |
| | 3. Valencia late | Late season (Chaitra-Baisakh) |
| 3. Lime | 2. Terathum | Aswin - Poush) |

2.3 *Standardization of nursery system*

Studies were carried out to standardize the vegetative propagation of mandarin and sweet orange. It was recommended that veneer method of grafting should be performed in the months of November and December in mid-hill climate. Maintenance of grafted plants under plastic tunnel for three months produces up to 95 percent success. Trifoliolate orange is suitable rootstocks for mandarin and sweet orange. Grafted saplings packed in moistened moss and jute sheet can survive up to 12 days during transportation.

Hunglungbin (greening) and Citrus tristeza virus (CTV) are major graft transmissible diseases causing citrus decline worldwide. These diseases have been found present in many

citrus orchards of Nepal including in government farms. Collection and use of scions from unprotected mother plants could serve the source of such diseases resulting in introduction and spread these diseases to disease-free areas with planting materials. So, a new approach for establishment and maintenance of foundation mother plants has been adopted in NCRP, Dhankuta. Under this approach mother plants of selected varieties are indexed for Hunglungbin by PCR technique and for CTV using lime as indicator plants. The mother plants that confirmed to be free from these diseases are maintained inside insect proof screen houses. Scions are obtained from these protected mother plants for sapling production. Mother plants are indexed in every five years and replaced in every 7 years. Low cost screen house suitable for Nepal has been designed.

2.4 Control of fruit fly

Fruit flies are the most serious insect pest of sweet orange and lemon in the eastern hills of Nepal. Its population dynamics has been studied using Feromon traps in Dhankuta area since five years. Study showed that population of citrus fruit flies starts increasing from Baisakh (April), reaches in its peak point in Sawan and Bhadra (September) and becomes almost nil in Aswin (October). Therefore, protein bait spray for fruit fly control should be carried out during Shrawan and Bhadra when sweet orange fruits start to attain physiological maturity. On the basis of past research findings recommendations for the control of citrus fruit flies are (i) collection and destruction (burying into soil or boiling in water) of infected fruits within half an hour of their drop from the tree (iii) spraying (one sq. meter per tree) with sugar + hydrolysed protein + malathion solution during July - August (iv) use of Pheromone trap from March to September (5 ml malathion + 5 ml methyl eugenol per trap; one trap per 10 trees).

2.5 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 - ATSO @ 5 ml + 1 ml Rogor/liter of water during February - March (just after the harvest) and June-July is very effective for controlling most scale insects.

2.6 Control of green stink bug

For the effective control of green sting bugs spraying of insecticide when bugs are at nymph stage (yellow color) is more effective than at adult stage because adults may fly away and escape from insecticide treatment.

2.7 Control of root-rot and gummosis diseases

Exposure of affected roots during dry season and drenching with Bordeaux mixture in February and May and approach grafting with trifoliolate rootstocks during May - June can improve the health of the declining trees. Proper drainage system in the basin area of the tree is also very important. Spray of Anti-rot @ 10 ml per litre of water at active growth stage has been found effective to control gummosis and root rot caused by phytophthora spp.

2.8 Storage of mandarin in cellar store

Matured mandarin fruits with fruit stalk can be stored for two months and sweet orange for three months at room temperature of 10⁰ C. and nearly 95% relative humidity inside cellar store.

2.9 Control of Powdery Mildew

Powdery mildew is one of the serious diseases of citrus species. It affects second flush developed during May-June and young fruits. Affected twigs die and fruits drop pre-maturely

or quality deteriorates. Spraying of Karathion @ 1 ml/liter of water was recommended previously. However, farmers were found reluctant to use this fungicide, as this is an expensive chemical (Rs 250 per 100 ml). A study carried out at NCRP showed that another fungicide- ' Insuf ' which contains sulfur is five times cheaper and as effective as Karathion.

2.10 Monitoring of Huanglongbing (HLB) disease

Huanglongbing (Greening) is most devastating disease of citrus species. It is believed to be introduced into Nepal from Saharanpur, India with planting materials some 40 years back. Some survey works have indicated that at present this disease has already spread in many citrus growing areas of Nepal. A survey was carried out in Dhankuta, Lamjung, Tanahu, Kaski and Syanja districts to identify the affected trees and citrus production pockets. Visual observation of symptomatic trees and leaf sample analysis by PCR technique at NAST laboratory and in France revealed that the disease has already spread in all surveyed districts except Syanja. If the disease is not managed quickly the orchards of affected districts will decline rapidly due to this disease.

3. RESEARCH REPORTS (2062/63)

All the research projects implemented during FY 2062/63 were continuation of previous years. These projects were in mid-way of implementation and therefore, all the envisaged activities are not yet completed. Thus the results and the conclusion drawn in the following sections are based on the activities that have been completed or are at the final stage of completion. Following research projects were carried out during this year:

1. Variety Improvement in Citrus
2. Off-season lime production technology in Terai and inner Terai of Nepal
3. Use of Tissue Culture for Standardization of Bud-wood Sanitation Program in Nepal
4. Germplasm Maintenance and Production of Horticultural Commodities.

Implementation status and major findings of each of these projects is presented in the following sections.

3.1 VARIETY IMPROVEMENT IN CITRUS

Citrus fruit crops mainly mandarin, sweet orange and lime are important commodities for mid-hill farmers as a source of income and family nutrition. However, there is only seasonal production mainly from November to January resulting in glut during this period in the market. Moreover, quality of fruit in the market is very heterogeneous due to the use of unselected genotypes and seed propagated planting materials. With the objective of increasing production period and quality by selecting early, mid and late varieties from local gene pool as well as new introductions, the project was initiated in 2001 and it will be completed in 2010. The project intends to carry out two main activities namely (i) collection of different citrus varieties from local and exotic sources (ii) multi-location evaluation and selection of elite genotypes.

3.2.1 *Germplasm Collection*

During reporting period (first, second and third year of the project) several scion varieties/genotypes of mandarin, sweet orange, grapefruit, tangor and tangelo were collected. In the first year of the project collection were made from indigenous sources such as farmers' fields and other Horticulture Stations. The collected genotypes include both local and exotic materials. In 2061/62 (2005), a total of 32 additional varieties of different scion varieties were introduced from Corsica, France with the support of Prof. Joseph Bove of INRA-CIRAD. The new germplasm collected from 2001 to 2005 are presented in Table 5. Newly collected scion varieties include mandarin 22 varieties, sweet orange 14 varieties, grapefruit 5 varieties, tangor 3 varieties and tangelo 3 varieties. In addition to this a total of seven rootstock varieties were also collected. Planting materials of elite genotypes that were collected during first year of the project were multiplied in second year.

The varieties introduced from France are proved to be elite types in one or other parts of the world. Table 6 presents the characteristics of these varieties at Corsica condition of France. The characteristics of the new accessions were provided by the donor. Most of these introduced germplasm are seedless. The maturity period of common mandarin varieties ranges from December to March. The variety Kara which is late maturing (March) type could be very valuable genetic material to expand harvesting season. The seedless early (October) maturing clementine variety: Marisol and Satsuma variety Okitsuwase are potential for early season production. Most introduced sweet orange varieties are seedless and have very wide range of maturity period (December to May). The production possibility and market acceptability of tangor, tangelo and grapefruit has not yet explored in Nepal. So, presently

introduced varieties of these species/hybrids will be evaluated in coming years to develop production technologies

Table 5: Citrus germplasm collected during 2058/59 - 2061/62 (2001/02 - 2004/05)

| Species | Accession # | Variety | Type of collection | Source | Year of introduction | |
|--------------|-------------|--------------------|--------------------|---------------------------|----------------------|-------------|
| Mandarin | NCRP 05 | Miyagawawase | Graftling | Hort. Centre, Kirtiput | 2001 (2058) | |
| | NCRP 06 | Okitsuwase | Graftling | Hort. Centre, Kirtiput | 2001 (2058) | |
| | NCRP 08 | Pongan, Tangarin | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 09 | Kamala | Scion | Farmer's field ' Dhankuta | 2002 (2059) | |
| | NCRP10 | Baskharka local | Scion | ARS, Lumle | 2003 (2060) | |
| | NCRP11 | Sikkime | Layer | Farmer orchard (Terathum) | 2004 (2061) | |
| | NCRP 80 | Satsuma wase | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 81 | Satsuma Miho | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 82 | Satsuma URSS | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 95 | Satsuma Okitsu | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 88 | Fortune | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 89 | Kara | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 90 | Nova | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 91 | Pixie | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 92 | Dancy | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 93 | Avana | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 94 | Page | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 97 | Hernandina | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 98 | Oroval | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 99 | Commune | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 100 | Marisol | Scion | INRA_CIRAD, France | 2005 (2062) | |
| NCRP 101 | Nules | Scion | INRA_CIRAD, France | 2005 (2062) | | |
| Sweet orange | NCRP 25 | Yoshida Navel | Grafted plant | Hort. Centre, Kirtipur | 2001 (2058) | |
| | NCRP 27 | Delicious seedless | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 28 | Skage Binanza | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 29 | Blood Red | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 30 | Newhall Navel | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 31 | Succari | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 32 | Meisheu-9 | Scion | ICIMOD | 2002 (2059) | |
| | NCRP 26 | Madam Venous | Tissue culture | GREAT, Nepal Pvt. Ltd | 2002 (2059) | |
| | NCRP 83 | Cara Cara | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 84 | Lane Late | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 85 | Pineapple | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 86 | Valencia late | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 87 | Salustiana | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 96 | Tomango | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | Grapefruit | NCRP 45 | Shamber | Scion | ICIMOD | 2002 (2059) |
| | | NCRP 76 | Henderson | Scion | INRA_CIRAD, France | 2005 (2062) |
| NCRP 77 | | Star Ruby | Scion | INRA_CIRAD, France | 2005 (2062) | |
| NCRP 78 | | Reed | Scion | INRA_CIRAD, France | 2005 (2062) | |
| NCRP 79 | | Pink Rubi | Scion | INRA_CIRAD, France | 2005 (2062) | |
| Tangor | NCRP 102 | Ellendale | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 103 | Murkott | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 72 | Ortanique | Scion | INRA_CIRAD, France | 2005 (2062) | |
| Tangelo | NCRP 73 | Minneola | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 74 | Oriando | Scion | INRA_CIRAD, France | 2005 (2062) | |
| | NCRP 75 | Seminole | Scion | INRA_CIRAD, France | 2005 (2062) | |
| Rootstock | NCRP 65 | Citrange C-35 | Seed | INRA_CIRAD | 2005 (2062) | |
| | NCRP 66 | Citrange – Carrizo | Seed | INRA_CIRAD | 2005 (2062) | |
| | NCRP 67 | Poncirus - Pomeroy | Seed | INRA_CIRAD | 2005 (2062) | |
| | NCRP 68 | Flying Dragon | Seed | INRA_CIRAD | 2005 (2062) | |

| | | | | |
|---------|-------------------|------|------------|-------------|
| NCRP 69 | Citrumelo 4475 | Seed | INRA_CIRAD | 2005 (2062) |
| NCRP 70 | Volkameriana | Seed | INRA_CIRAD | 2005 (2062) |
| NCRP 71 | Rangapur lime Red | Seed | INRA_CIRAD | 2005 (2062) |

In this year, all new introductions were propagated on trifoliate orange rootstocks for further on station variety evaluation. Next year, variety evaluation plots will be established at NCRP, Dhankuta for detailed evaluation of these varieties.

Table 6. Characteristics of scion varieties (introduced from France) on Poncirus rootstock in Corsica condition as reported by donor.

| Species | Variety | Maturity period | Seeds per fruit | Yield (adult tree) | Fruit weight (g) |
|--|----------------|-----------------|-----------------|--------------------|------------------|
| Common Mandarin (<i>Citrus reticulata</i>) | Fortune | February | 5-10 | Medium | 70-100 |
| | Kara | March | 2-6 | High | 80-120 |
| | Nova | Dec.-Jan | 0-3 | Medium | 80-120 |
| | Pixie | December | 0-3 | Medium | 60-80 |
| | Dancy | February | 4-8 | High | 70-100 |
| | Avena Tardivo | February | 10-15 | Medium | 60-80 |
| | Page | January | 0-3 | Medium | 60-80 |
| Clementine mandarin (<i>Citrus clementina</i> ex Tanaka) | Hernandina | January | 0* | Medium | 50-80 |
| | Oroval | November | 0* | High | 80-120 |
| | Commune 92 | Nov.-Dec | 0* | High | 60-100 |
| | Marisol | October | 0* | High | 70-110 |
| | Nules | January | 0* | High | 70-110 |
| Satsuma mandarin (<i>Citrus unshiu</i>) | Satsumawase | October | 0 | High | 80-120 |
| | Satsuma Miho | October | 0 | High | 80-120 |
| | Satsuma URSS | November | 0 | High | 80-120 |
| | Satsuma Okitsu | October | 0 | High | 80-120 |
| Tangor (Tangarin x orange) | Ellendale | April | 4-8 | Medium | 100-150 |
| | Murkott** | May | 4-8 | Medium | 80-130 |
| | Ortanique | February | 2-6 | High | 120-180 |
| Tangelo (Tangarin x Grapefruit) | Minneola | February | 0-5 | High | 120-150 |
| | Orlando | January | 4-8 | High | 100-140 |
| | Seminole | March | 4-8 | Medium | 120-180 |
| Sweet orange (<i>Citrus sinensis</i>) | Cara Cara | Feb | 0 | Medium | 180-250 |
| | Lane late | March | 0 | High | 180-250 |
| | Pineapple | January | 2-5 | High | 150-200 |
| | Valencia late | May | 0-3 | High | 150-200 |
| | Salustiana | December | 0-3 | High | 130-180 |
| | Tomango | March | 0-5 | Medium | 130-180 |
| Grapefruit (<i>Citrus paradisi</i>) | Henderson | Mar.-Apr. | 0 | High | 180-300 |
| | Star Ruby | Mar.-Apr | 0 | High | 180-300 |
| | Reed | April | 0 | High | 180-300 |
| | Pink Ruby | Apr.-May | 0 | High | 180-300 |

* No seed only in monospecies orchard ** Not compatible with Poncirus

In recent years, various problems related to rootstock/scion combination have been reported from different countries. One of such examples is the Sudden Citrus Decline (SCD) in Brazil possibly caused by certain strain of tristeza virus. This disease has caused huge loss of sweet orange trees on Rangpur lime rootstocks. Trifoliolate orange is the only rootstock used in Nepal for propagating citrus fruit trees. Obviously, selection of rootstock(s), which is better than trifoliolate orange, has been realized. Therefore, seeds (25 gm of each variety) of seven different types of rootstocks were introduced from France and seedlings were produced. Recommended varieties of mandarin, sweet orange and lime will be propagated on these rootstocks next year and performance of rootstock/scion combination will be evaluated. The mother plants of these rootstocks will also be established at NCRP farm for seed source. The characteristics of these rootstocks have been presented in Table 7.

Table 7. Characteristics of rootstocks varieties introduced from France as reported by donor.

| Name | Variety | Response to | | | | |
|---------------------|---------------|-----------------------------------|----------|--------------|--------------|---------------|
| | | Phytophthora | Tristeza | Drought | Excess water | Dwarfing |
| Poncirus | Pomeroy | Resistant | Tolerant | Not adapted | Acceptable | Semi-dwarf |
| Poncirus | Flying Dragon | Resistant | Tolerant | Not adapted | Acceptable | Dwarf |
| Citrango | C-35 | Resistant | Tolerant | Acceptable | ? | Vigorous |
| Citrango | Carrizo | Resistant | Tolerant | Acceptable | Not adapted | Vigorous |
| Citrumelo | 4475 | Resistant | Tolerant | Acceptable | Acceptable | Vigorous |
| Citrus volkameriana | | Susceptible in very wet condition | Tolerant | Well adapted | Acceptable | Very vigorous |
| Rangapur lime | Red | Susceptible in very wet condition | Tolerant | Well adapted | Not accepted | Very vigorous |

3.2.2 Variety evaluation

Sweet Orange (Citrus sinensis)

Sweet orange (*Citrus sinensis* (L.) Osbeck) occupies first position among citrus fruit crops in area coverage and contributes nearly 60% of the total citrus production of the world. This crop has been grown in most citrus growing countries but Brazil, Mexico, United States of America and China are the leading sweet orange producers of the world. About 30 thousand tons of sweet orange fruits were produced in Nepal in 2006 from 3015 hectares of orchards. It is the second important citrus species of Nepal after mandarin sharing about 20 and 23 % of total citrus area and production respectively. The two districts: Ramechhap and Sindhuli account nearly 56 percent of total sweet orange production of Nepal.

Genetic base of sweet orange cultivation in Nepal is very narrow since almost all plantations are composed of single variety: 'Junar' which is the selection from local land races. Junar is a mid-season variety having harvesting season during January-February, a normal season for sweet orange production in Nepal. In the other months, sweet orange fruits are imported from India to meet market demands. Limited studies carried out in the past were mainly focused on evaluation of 'Junar' trees for mother plant selection, rootstock selection and propagation techniques. Most citrus growing countries have developed several varieties suitable for different harvesting seasons and production environments. However, varieties for different harvesting seasons are completely lacking in the citriculture industry of Nepal, which has

resulted to a very narrow harvesting season. Therefore, a variety evaluation study was carried out to select superior sweet orange varieties especially early and late maturing type for mid-hill region of Nepal.

A total of 14 sweet orange varieties (Table 8) established at research orchard of National Citrus Research Programme, Dhankuta (1350 m altitude) were evaluated for horticultural characters in 2002 to 2004. Of the 14 varieties evaluated Junar was a local selection whereas rest of the 13 were exotic varieties introduced from India. All varieties were grafted on rough lemon (*Citrus jambhiri*) rootstocks and age ranged from 20 to 30 years. The fruit characters which are important for market acceptance and least affected by external environment like fruit, apex and base shape, rind texture, skin colour, fruit weight, seed number, rind, pulp and juice percent, total soluble solids (TSS), total acids (TA) and TSS/TA ratio were recorded. Most of the quantitative characters vary depending on maturity period. It is important to compare the fruit quality of varieties at similar maturity stage. So, first of all initiation of maturity period was determined. For this, in the first year of evaluation, fruits of selected trees of each variety were observed for color development from mid October (beginning of Kartik). When most fruits started to turn yellow color, fruit samples (two fruits/tree) were evaluated for TSS, TA and their ratio in weekly interval. Same fruit samples were also used for organoleptic test. The fruits were found sweet enough for fresh consumption when ratio of TSS and TA crossed 7:1 level. So, the time at which this ratio was recorded was considered as initiation of maturity period for that variety. Fifteen days after the date when TSS/TA ratio crossed 7 all fruit characters as mentioned above were evaluated in detailed. Therefore, unless otherwise mentioned all data presented are those recorded at this time. For detailed evaluation, fruit samples (10 fruits/tree) were randomly collected from all directions of the tree. Fruit shape, apex shape, base shape and rind texture were determined following the Citrus Descriptors (IPGRI, 1999). TSS was recorded by hand refractometer. Two ml fruit juice was titrated with 0.1 N sodium hydroxide (NaOH) solution to Phenolphthalein end point and percentage of TA was calculated using formula of Rangana (1995). Rind, pulp and juice percent was calculated based on fruit weight. Means of two years data with standard deviations within variety were used for comparison.

Table 8 presents the quantitative fruit characteristics, which are important on horticultural point of view and were evaluated 15 days after TSS/TA ratio crossed 7 (initiation of maturity). Average fruit size ranged from 101.8 to 157.7 gm among varieties. Shamauti produced biggest fruits (157.7 ± 22.1 gm) whereas Dhankuta Junar (101.8 ± 8.6 gm), Lue Gim Gong (104.4 ± 14.9 gm) had smallest fruits. Navelencia (30.2%), Hamlin (31.1%), Lue Gim Gong (31.7%) and W. Navel (32.6%) recorded the lowest rind percentage. On the other hand the percentage of pulp in the fruit was highest in these varieties. The varieties with highest rind percentage (thick rind) such as Mosambi and Malta Blood Red had lowest pulp content in the fruits.

Washington Navel and Nevelencia were seedless (Fig. 2); Pineapple, Shamauti, Seville Common, Vanelle, Lue Gim Gong and Hamling had very less seeds (3-5 seeds per fruit). Valencia, Rubi and White Taker were medium seeded (5-9 seeds/fruit). Dhankuta Junar and Malta Blood Red had 7-14 seeds in a fruit whereas Mosambi was very seeded (20.3 ± 4.2 seeds/fruit). Juice content in fruit was lowest in Mosambi (26.2%) and in Malta Blood Red (28.5%). But fruits of Gue Gims Gung (39.6%), Hamblin (38.6%) and Nevelencia (35.7 %) were more juicy. Evaluation of varieties at similar stage of maturity (but at different time could have resulted to relatively less variation on TSS and TA.

External fruit characters such as fruit shape and texture are important factors for market acceptance. Table 9 shows the variation on such qualitative traits among the varieties. Fruits with three types of shape namely spheroid (height and diameter nearly equal) oblate (height less than diameter) and ellipsoid (height greater than diameter) were recorded. Fruits of W. Navel were oblate; Shamauti and Vanelle had ellipsoid fruits while other 11 varieties produced spheroid fruits. Citrus traders were found to prefer spheroid and oblate type of fruits as such fruits are easy in packaging (personnel communication with local traders). Varieties with two types (truncate or convex) of fruit bases and apices were found. Rind surface in all the varieties except in Mosambi was smooth. Fruit rind in Mosambi was grooved which was very prominent at basal end. On horticultural point of view sweet oranges are classified into four groups namely navel, common, pigmented and acidless. Except acidless, other three types of sweet oranges were identified in this study. W. Navel and Nevelencia were navel type with small secondary fruit embedded in the apex of the main fruit. Malta Blood Red was pigmented or blood type since at full maturity fruit pulp of this variety was pink in color due to the development of anthocyanin in the juice. All other varieties were common or blond oranges. Acidless or sugar oranges have very less acid in the fruit juice generally less than 0.2%. Fruit juice analysis (Table 8) showed that all the 14 varieties had more than 1% acid confirming that none of these varieties were acidless type.

Table 8. Quantitative fruit characters of 14 sweet orange varieties

| Variety | Fruit Weight (gm) | Rind (%) | Pulp (%) | Seed No. | Juice (%) | TSS (^o Brix) | TA (%) | TSS/TA |
|-----------------|-------------------|----------------|----------------|----------------|-----------------|--------------------------|----------------|---------------|
| Pineapple | 136.2 (±13.6) | 39.6 (±2.7) | 62.0 (±1.6) | 2.6 (±1.5) | 36.7 (±2.7) | 10.3 (±0.3) | 1.3 (±0.1) | 8.2 (±0.6) |
| W. Navel | 144.1 (±28.7) | 32.6 (±1.4) | 67.2 (1.4) | 0.8 (±0.8) | 35.3 (±1.6) | 11.4 (±0.6) | 1.4 (±0.1) | 8.4 (±0.8) |
| Malta Blood Red | 130.0 (±25.9) | 44.4 (±6.2) | 53.9 (±6.0) | 10.5 (±4.0) | 28.5 (±7.5) | 10.3 (±1.0) | 1.6 (± 0.3) | 7.5 (±0.9) |
| Shamauti | 157.7 (±22.1) | 35.6 (±3.2) | 64.0 (±3.3) | 3.7 (±2.1) | 30.6 (±3.0) | 10.8 (±0.6) | 1.4 (±0.1) | 7.9 (±1.0) |
| Mosambi | 120.8 (±16.4) | 46.0 (±5.4) | 51.1 (±5.1) | 20.3 (±4.2) | 26.2 (±5.6) | 9.0 (±0.7) | 1.2 (±0.2) | 7.6 (±1.3) |
| Sevelle Common | 111.0 (±10.1) | 34.0 (±5.1) | 65.0 (±5.0) | 4.8 (±2.3) | 34.6 (±4.7) | 9.9 (±0.6) | 1.3 (±0.2) | 7.5 (±1.1) |
| Valencia | 124.5 (±20.7) | 34.2 (±2.1) | 64.7 (±2.2) | 5.3 (±1.9) | 35.3 (±2.6) | 10.0 (±0.8) | 1.2 (±0.2) | 8.4 (±0.9) |
| Nevelencia | 148.0 (±40.7) | 30.2 (±3.7) | 69.7 (±3.6) | 0.6 (±0.9) | 38.4 (±3.6) | 10.2 (±0.5) | 1.1 (±0.2) | 9.1 (±1.3) |
| Vanelle | 124.5 (±20.7) | 34.3 (±8.4) | 65.0 (±8.4) | 4.5 (±2.0) | 36.3 (±8.1) | 10.6 (±1.0) | 1.3 (±0.1) | 8.7 (±0.7) |
| Dhankuta Junar | 101.8 (±8.6) | 37.2 (±4.0) | 60.1 (±3.9) | 10.2 (±3.4) | 34.0 (±3.2) | 9.9 (±1.2) | 1.2 (±0.6) | 8.2 (±2.2) |
| Rubi | 113.9 (±24.6) | 36.8 (±8.1) | 62.0 (±7.7) | 7.7 (±4.1) | 32.8 (±11.1) | 11.1 (±2.0) | 1.4 (±0.2) | 8.3 (±1.8) |
| Lue Gim Gong | 104.4 | 31.7 | 67.2 | 4.8 | 39.6 | 9.6 | 1.3 | 7.5 |

| | | | | | | | | |
|-------------|------------------|----------------|----------------|---------------|----------------|---------------|---------------|---------------|
| | (±14.9) | (±2.6) | (±2.7) | (±1.4) | (±3.3) | (±1.0) | (±0.2) | (±1.3) |
| White Taker | 132.9 (±18.2) | 34.1 (±6.0) | 64.7 (±6.4) | 8.5 (±3.0) | 37.5 (±4.4) | 9.0 (±0.8) | 1.2 (±0.3) | 7.9 (±1.8) |
| Hamlin | 151.5 (±21.2) | 31.1 (±4.6) | 68.3 (±4.7) | 4.4 (±2.5) | 38.6 (±4.5) | 9.1 (±0.2) | 1.3 (±0.1) | 7.2 (±0.8) |

As mentioned above, fruit samples (when rind stated to develop yellow color) were used for organoleptic taste and same samples were also used for TSS and TA analysis. It was found that when TSS/TA ratio crossed 7:1, sweet orange fruits were sweet enough in organoleptic taste. So, TSS/TA ratio of 7 has been considered as indicator of initiation of maturity and harvesting time in sweet orange in mid-hill condition of Nepal.

Table 9 presents the maturity periods of all 14 varieties evaluated. Based on maturity period the varieties were classified into three groups: early (maturing from November), mid-season (maturing from January) and late (maturing from March). Washington Navel and Nevelecia were early varieties; Valencia, Seville Common and Lue Gim Gong were late maturing varieties and rests of the varieties were found mid-season maturing type. The TSS/TA ratio in mid and late season varieties was less than 5 and fruits were sour in taste even after one month of full yellow color development on rind surface. On the other hand, in early maturing varieties like W. Navel fruits were sweet and TSS/TA ratio crossed 7 even when only about 50% of the fruit rind had turned to yellow color. Differences in maturation between early and late cultivars are believed to reflect differences in heat unit requirements- late cultivars require a larger sum of heat units. In California, Valencia orange matures in 12 months after bloom and harvesting can be continued about three months, which is very close to the results obtained in this study.

Table 9. Qualitative fruit characteristics of sweet orange varieties

| Variety | Fruit Shape | Base shape | Apex shape | Stylar end | Maturity period |
|-----------------|-------------|------------|------------|---------------|-----------------|
| Pineapple | sheroid | tuncate | convex | closed | Jan.-Feb. |
| W. Navel | obate | convex | truncate | open-navel | Nov.-Dec. |
| Malta Blood Red | sheroid | tuncate | truncate | closed | Jan.- Feb. |
| Shamauti | elipsoid | tuncate | convex | closed | Jan.- Feb. |
| Mosambi | sheroid | convex | convex | closed | Jan.- Feb. |
| Sevelle common | sheroid | truncate | convex | closed | Mar.-Apr. |
| Valencia | sheroid | truncate | convex | closed | Mar.-Apr. |
| Nevelecia | sheroid | convex | truncate | open- navel | Nov.- Dec. |
| Vanelle | elipsoid | tuncate | convex | closed | Jan.- Feb. |
| Dhankuta Junar | sheroid | convex | truncate | closed | Jan.- Feb. |
| Ruby | sheroid | convex | truncate | closed | Jan.- Feb. |
| Lue Gim Gong | sheroid | tuncate | convex | Slightly open | Mar.-Apr. |
| White taker | sheroid | convex | convex | closed | Jan.- Feb. |
| Hamlin | sheroid | truncate | convex | closed | Jan.- Feb. |

Citrus fruits are non-climacteric in nature meaning that changes in fruit texture and composition during maturation takes place in a slow and gradual manner. Maturation of citrus fruit is characterized by gradual changes in juice content and some of its constituents. On one hand there is a decline in total acidity (TA) brought about by decomposition of citric acid, a principal organic acid of citrus juice. On the other hand, there is an increase in sugars, usually expressed as total soluble solids (TSS). With acidity declining and sugars increasing towards maturation, the

TSS/TA ratio starts to increase and is commonly used as 'maturity index' in most countries. But in Nepal, development of yellow color in rind surface is a commonly used indicator of maturity in sweet orange. The results of present study also revealed that color development might not be the true indicator of maturity since it may depend on several factors like variety, climate and season. TSS/TA ratio of 8 has been used as maturity and harvesting index of sweet orange in USA but considering the production climate of Nepal and taste preferences of consumers TSS/TA ratio of 7 has been suggested as the indicator of harvesting time of sweet orange for Nepal.

As mentioned earlier, there was diversity (from November to April) among varieties on maturity period and these varieties were broadly grouped into early, mid and late maturing types. So, an attempt was also made to select superior varieties for each maturity group. For selection, varieties within each maturity group were compared on fruit size, rind, pulp and juice percent, seed number, TSS, TA, TSS/TA ratio and other observation made during evaluation.

W. Navel and Nevelencia were early maturing varieties. Both varieties were very similar in most fruit characters but in Nevelencia very high rate of post bloom fruit drop was observed in comparison to W. Navel. So, W. Navel was selected for early season production. On first week of November (second week of Kartik) TSS/TA ratio in W. Navel was 7.37:1 (Fig. 1) and taste was adequately sweet for fresh consumption. It confirms that this variety started to mature from the beginning of November at 1350 elevation. It is likely that this variety may mature 1-2 weeks earlier at lower (1000-1200 m) altitude because higher amount of heat unit and sunshine are received at lower altitude.

Fig. 1 Change in TSS, TA and TSS/TA ratio over time in early variety: W. Navel

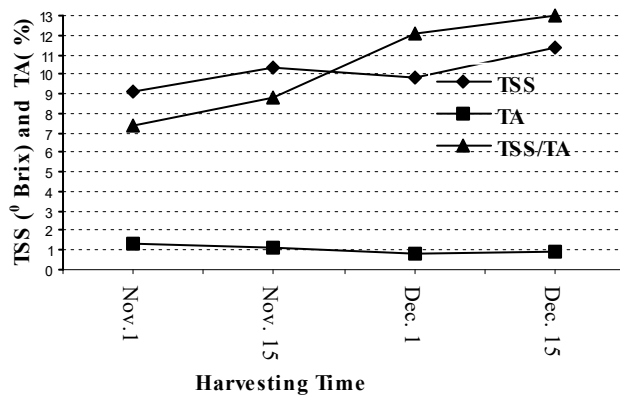


Fig. 2 Seedless fruits of W. Navel sweet orange



Of the 14 varieties evaluated 9 were found maturing during January – February, which is considered as mid or normal season in Nepal. The TSS/TA ratio of these varieties crossed 7 in the beginning of January (mid Paush). Junar, a predominantly cultivated local variety of Nepal, was a mid-season variety. However, present study showed (Table 8) that Hamlin and Pineapple are superior to Junar in most of the fruit characters such as high pulp and juice and low rind and seed content. So, in addition to Junar, Hamlin and Pineapple were also recommended for mid-season production. The fruit quality of Mosambi, a popular commercial variety of India was found very poor (low pulp and juice percent, highly seeded and thick rind) in mid-hill condition of Nepal. It suggests the need of location specific varieties for quality fruit production. .

Three late maturing varieties: Valencia, Seville Common and Lue Gim Gong were very similar in all characters except that fruits of Valencia were biggest possibly due to better tree health of this variety. It is likely that these varieties could have been originated as clonal progenies of same variety but given different names in different countries. The acid content was high (>2.8%) and taste was sour in late varieties until mid-February. After this, acid content started to decrease with slightly increase in TSS

which resulted to sharp increase in TSS/TA ratio. The fruits of Valencia variety started to mature (TSS/TA crossed 7) from second week of March (Fig. 3) and can be harvested until the end of April. It was observed that in this variety, maturity of fruits overlaps with new shoot development (Fig. 4) and fruits store remarkably well on the trees without much dropping and little loss in quality.

Fig. 3 Change in TSS, TA, TSS/TA ratio over time in late variety: Valencia

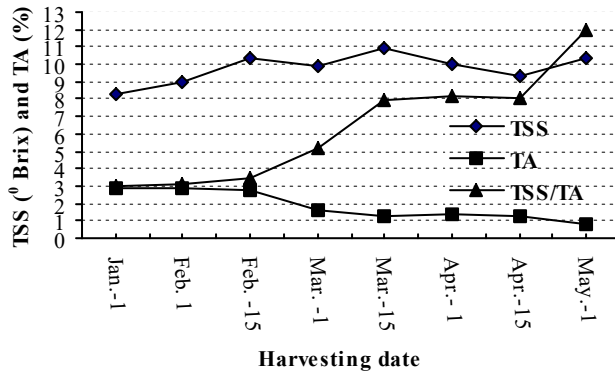


Fig. 4 Overlapping of new bloom and fruit maturity in Valencia sweet orange



Narrow genetic base resulting by the use of single variety could be very vulnerable for biotic and abiotic stresses. To reduce such vulnerability and provide choices on quality to consumers most countries use more than one variety. For example, in India varieties like Mosambi, Sathguti, Jaffa, Valencia and Malta in India and in USA Pineapple, Cara Cara, Lane Late, Washington Navel, Autumn Gold and Summer Gold in USA are recommended and being cultivated in commercial level. Commercial cultivation of presently selected early, mid and late season varieties can broaden the genetic base of sweet orange and is also appropriate technique for expanding harvesting season in Nepal where storage facilities are inadequate and expensive.

Following conclusions have been drawn from this study:

- Narrow harvesting season of sweet orange in Nepal is due to the use of single variety
- Variation on fruit shape, size, seed number, pulp percent, juice, TSS and TA content, TSS/TA ratio and maturity season was noted among 14 varieties evaluated.
- Navelencia and Washington Navel were early maturing and seedless.
- Pineapple, Shamauti, Rubi, White Taker, Hamlin, Dhankuta Junar, Vanelle, Mosambi and Malta Blood Red were mid-season varieties
- Sevelle Common, Lue Gim Gong and Valencia were late season varieties.
- Based on Maturity period and other desirable fruit characters following varieties are selected and recommended:

Washington Navel for early season production.

Pineapple and Hamlin for mid-season production

Valencia for late season production.

- Commercialization of early and late maturing varieties can extend harvesting period of sweet orange at least for six months (November-April) in comparison to about two months (January-February) at present.

Mandarin (*Citrus reticulata*)

Evaluation of Khoku genotypes:

Most of mandarin trees at Paripatle farm are seedlings of Khoku cultivar. Being cross-pollinated species, such seedling trees could have different genetic composition. Therefore, fruit characters and quality of 26 accessions (trees) of Khoku mandarin were evaluated from 2058 to 2062 to select superior tree for the source of mother plant and for variety registration. Table 10 presents fruit quality parameters (average of 2058 and 2059) of the 26 mandarin accessions. Average fruit weight ranged from 66.5 gram to 87.8 gram. Proportion of pulp (percentage by fruit weight) ranged from 64.3% to 69.80%. Percentage of juice in the fruit (based on fruit weight) ranged from 36.7 – 46.5%. Most of the accessions had more than 10 seeds per fruit. Number of seeds per fruit was maximum (16.3) in J-9 and was minimum (8.6) in J-41. There was very less variation in number of segments per fruit. It ranged from 8 to 11. Total soluble solids (TSS) content in the juice was minimum (10.7) in accession J-23 and it was maximum (12.9) in J-4 and J-72. Variation in total acids (TA) content ranged from 0.8 to 1.2%. In most cases TSS and TA ratio was higher than 11. The maturity period of all the Khoku genotypes (accessions) was from Mangsir to Magh at 1300 m altitude of Paripatle farm, a normal season for mandarin production in Nepal.

Table 10: Fruit characteristics of local (Khoku) mandarin genotypes (2-years' mean)

| Acc. No. | Fruit wt. (gm) | Pulp (%) | Juice (%) | Seeds/Fruit | TSS | Total Acid (%) | TSS/TA | Maturity Period |
|----------|----------------|----------|-----------|-------------|------|----------------|--------|-----------------|
| J-4 | 74.7 | 65.2 | 41.2 | 11.6 | 12.9 | 1.2 | 11.5 | Mangsir -Magh |
| J-9 | 84.5 | 68.5 | 44.5 | 16.3 | 11.4 | 1.0 | 12.5 | Mangsir -Magh |
| J-13 | 84.7 | 69.7 | 43.8 | 15.4 | 11.7 | 0.9 | 13.5 | Mangsir -Magh |
| J-16 | 73.9 | 69.8 | 42.6 | 8.9 | 12.8 | 0.9 | 15.5 | Mangsir -Magh |
| J-21 | 83.3 | 65.3 | 39.3 | 14.4 | 12.2 | 0.8 | 15.7 | Mangsir -Magh |
| J-23 | 78.5 | 66.8 | 41.4 | 14.7 | 10.7 | 0.8 | 14.9 | Mangsir -Magh |
| J-24 | 82.9 | 69.3 | 44.5 | 14.8 | 11.0 | 0.9 | 13.5 | Mangsir -Magh |
| J-26 | 87.4 | 68.5 | 41.3 | 15.5 | 11.0 | 0.8 | 13.3 | Mangsir -Magh |
| J-34 | 79.4 | 65.4 | 38.3 | 8.8 | 11.0 | 0.8 | 14.1 | Mangsir -Magh |
| J-35 | 87.8 | 65.6 | 39.9 | 10.6 | 11.4 | 1.0 | 12.5 | Mangsir -Magh |
| J-40 | 76.0 | 64.3 | 41.1 | 12.8 | 10.9 | 0.8 | 14.5 | Mangsir -Magh |
| J-41 | 72.0 | 69.4 | 41.7 | 8.6 | 11.5 | 0.9 | 13.8 | Mangsir -Magh |
| J-42 | 72.4 | 65.5 | 36.7 | 8.9 | 11.0 | 1.4 | 8.7 | Mangsir -Magh |
| J-48 | 79.5 | 68.9 | 46.5 | 8.7 | 11.2 | 1.2 | 11.1 | Mangsir -Magh |
| J-50 | 72.4 | 66.3 | 40.0 | 14.3 | 11.5 | 1.2 | 11.2 | Mangsir -Magh |
| J-52 | 83.2 | 66.0 | 41.6 | 14.0 | 11.4 | 1.0 | 12.6 | Mangsir -Magh |
| J-58 | 73.6 | 66.9 | 41.0 | 12.5 | 11.6 | 1.0 | 13.6 | Mangsir -Magh |
| J-68 | 82.9 | 65.2 | 39.3 | 12.3 | 11.6 | 0.8 | 13.8 | Mangsir -Magh |
| J-70 | 68.8 | 68.3 | 43.7 | 12.0 | 11.1 | 0.9 | 12.8 | Mangsir -Magh |
| J-71 | 66.5 | 67.1 | 39.7 | 9.6 | 12.8 | 0.9 | 13.6 | Mangsir -Magh |
| J-72 | 73.5 | 66.8 | 41.6 | 12.7 | 12.9 | 1.1 | 13.0 | Mangsir -Magh |
| J-75 | 76.5 | 66.3 | 42.5 | 12.6 | 11.5 | 1.1 | 11.1 | Mangsir -Magh |
| J-82 | 75.2 | 65.3 | 39.9 | 11.6 | 11.5 | 1.1 | 12.4 | Mangsir -Magh |
| J-84 | 67.6 | 64.8 | 37.8 | 10.8 | 11.5 | 1.1 | 12.7 | Mangsir -Magh |

| | | | | | | | | |
|-------------|------|------|------|------|------|------|------|---------------|
| J-90 | 82.3 | 65.8 | 41.0 | 12.7 | 11.2 | 0.9 | 13.0 | Mangsir -Magh |
| J-91 | 72.9 | 65.2 | 39.5 | 10.3 | 12.0 | 1.1 | 12.0 | Mangsir -Magh |
| Mean | 77.4 | 66.8 | 41.2 | 12.1 | 11.6 | 0.98 | 13.0 | Mangsir -Magh |
| SD | 6.08 | 1.7 | 2.2 | 2.4 | 0.6 | 0.16 | 1.5 | |

Although all trees were about 30 years old, there was wide range of variation in fruit yield (total fruit weight and number of fruits per tree). In 2058, yield ranged from 1 kg to 101.5 kg per tree and average yield of 26 trees was 55.5 ± 25.4 kg. Likewise number of marketable fruits per tree ranged from 17 to 1355 with an average of 686 ± 312 fruits per tree in 26 accessions. In 2059, fruit yield in most of the trees increased in comparison to previous year. In this year average yield per tree was 91.1 ± 61.5 kg which was 64% higher than 2058. J-75, J-82, J-90 and J-91 were the highest yielder trees. In 2060, average fruit yield was 81.2 ± 36.7 kg which was 10.9% less than that recorded in 2059. But fruit size was increased by 3.6% in 2060 in comparison to 2059. It shows that in Khoku mandarin, the year of heavy bearing is followed by a shy bearing year. In the present context, 2058 was shy bearing year followed by heavy bearing year 2059. Again 2060 was a shy bearing year. Researches on reducing yield gap between heavy and shy bearing years should be carried in future. In 2061 average fruit yield was 910 ± 383 fruits per tree which was equivalent to 62 ± 26 kg in term of weight. In 2062 averaged fruit yield increased to 1370 ± 670 fruits or 95.4 ± 50.3 kg per tree. Four years' average fruit yield of 26 accessions was 76.9 kg or 1055 marketable fruits. Four years average data showed that J-90 and J-70 had the highest marketable fruit yield. Average annual yield of J-90 was 126.3 kg (1544 fruits) while second highest yielder: J-70 produced on an average 125.6 kg (1983 fruits) per year. Average yield of 26 accessions was 76.9 ± 28.3 kg per tree, which gives about 20 Mt/ ha productivity considering that 300 trees can be accommodated in a hectare of land. J-82 was the highest yielder (131.5 kg) followed by J-90 (126.5 kg) and J-70 (125.6 kg). But size of fruits was smaller in J-82 compared to J-90. Among the 26 accessions of Khoku mandarin evaluated during 2058 to 2062, accession number J-90 has been selected for mother plant based on yield and fruit quality (pulp content, juice content, TSS, TA and TSS/TA ratio).

Table 11 Marketable yield of Khoku mandarin trees from 2058 to 2062

| Acc No. | Kg | | | | | Mean | Fruit Number | | | | | Mean |
|---------|-------|-------|-------|------|------|-------|--------------|------|------|------|------|--------|
| | 2058 | 2059 | 2060 | 2061 | 2062 | | 2058 | 2059 | 2060 | 2061 | 2062 | |
| J-4 | 39.9 | 89.0 | 32.0 | 30 | 80 | 54.2 | 490 | 1311 | 450 | 361 | 1253 | 773.0 |
| J-9 | 81.9 | 101.0 | 40.5 | 62 | 108 | 78.7 | 850 | 1389 | 448 | 801 | 1409 | 979.4 |
| J-13 | 101.5 | 143.0 | 72.9 | 26 | 52 | 79.1 | 1050 | 1964 | 898 | 353 | 718 | 996.6 |
| J-16 | 63.4 | 66.2 | 91.2 | 51 | 69 | 68.2 | 740 | 1067 | 1275 | 673 | 1025 | 956.0 |
| J-21 | 46.5 | 67.0 | 58.5 | 67 | 53 | 58.4 | 531 | 847 | 711 | 1035 | 804 | 785.6 |
| J-23 | 55.7 | 47.0 | 85.2 | 102 | 39 | 65.8 | 632 | 683 | 1111 | 1581 | 797 | 960.8 |
| J-24 | 49.7 | 20.0 | 75.2 | 78 | 105 | 65.6 | 600 | 241 | 817 | 987 | 1323 | 793.6 |
| J-26 | 20.3 | 75.0 | 58.8 | - | 70 | 56.0 | 200 | 1022 | 761 | - | 905 | 722.0 |
| J-34 | 91.7 | 15.0 | 97.5 | 50 | 41 | 59.0 | 1050 | 210 | 1241 | 909 | 784 | 838.8 |
| J-35 | 66.2 | 114.0 | 124.5 | 94 | 77 | 95.1 | 926 | 1096 | 1625 | 1588 | 1381 | 1323.2 |
| J-40 | 62.0 | 82.0 | 122.0 | 88 | 136 | 98.0 | 880 | 1006 | 1437 | 1215 | 1700 | 1247.6 |
| J-41 | 59.3 | 30.0 | 94.0 | 30 | 92 | 61.1 | 813 | 422 | 1422 | 497 | 1620 | 954.8 |
| J-42 | 1.0 | 11.0 | 8.5 | 61 | 45 | 25.3 | 17 | 128 | 111 | 975 | 725 | 391.2 |
| J-48 | 27.1 | 62.0 | 72.0 | 69 | 117 | 69.4 | 361 | 739 | 921 | 1047 | 1648 | 943.2 |
| J-50 | 15.9 | 34.0 | 38.5 | 22 | 20 | 26.1 | 237 | 438 | 539 | 433 | 384 | 406.2 |
| J-52 | 60.2 | 76.0 | 81.0 | 53 | 122 | 78.4 | 695 | 952 | 995 | 726 | 1507 | 975.0 |
| J-58 | 70.7 | 126.0 | 94.0 | 94 | 160 | 108.9 | 960 | 1711 | 1224 | 1356 | 2089 | 1468.0 |

| | | | | | | | | | | | | |
|-------------|------|-------|-------|----|------|-------|------|------|------|-------|------|--------|
| J-68 | 36.9 | 94.0 | 69.5 | 21 | 76 | 59.5 | 429 | 1177 | 836 | 343 | 1104 | 777.8 |
| J-70 | 76.8 | 137.0 | 115.0 | 96 | 203 | 125.6 | 904 | 2598 | 1591 | 1426 | 3399 | 1983.6 |
| J-71 | 95.5 | 28.0 | 93.8 | 51 | 84 | 70.5 | 1355 | 448 | 1307 | 932 | 1319 | 1072.2 |
| J-72 | 45.7 | 31.0 | 28.5 | 98 | 32 | 47.1 | 597 | 440 | 385 | 1408 | 477 | 661.4 |
| J-75 | 50.3 | 258.0 | 95.0 | 41 | 112 | 111.3 | 617 | 3608 | 1216 | 640 | 1926 | 1601.4 |
| J-82 | 83.5 | 172.0 | 151.0 | 57 | 194 | 131.5 | 1064 | 2394 | 2160 | 713 | 2504 | 1767.0 |
| J-84 | 63.6 | 135.0 | 48.0 | 69 | 107 | 84.5 | 857 | 2217 | 633 | 1036 | 1501 | 1248.8 |
| J-90 | 56.3 | 181.0 | 106.0 | 95 | 194 | 126.5 | 675 | 2227 | 1476 | 1179 | 2166 | 1544.6 |
| J-91 | 20.2 | 175.0 | 158.5 | 37 | 91 | 96.3 | 300 | 2230 | 2039 | 541 | 1171 | 1256.2 |
| Mean | 55.5 | 91.1 | 81.2 | 62 | 95.4 | 76.9 | 685 | 1252 | 1162 | 910.6 | 1370 | 1054.9 |
| SD | 25.4 | 61.5 | 36.7 | 26 | 50.3 | 28.3 | 312 | 878 | 503 | 383 | 670 | 389.5 |

In 2061 and 2062, fruits of 26 Khoku mandarin trees were also evaluated for their grades on the basis of size (Table 12). Based on size, fruits were categorized into 4 groups: big (≥ 100 gm), medium (70-99 gm), small (50-69 gm) and unmarketable (< 50 gm).

In 2061, percentage of big fruits (by weight) ranged from 5.1 (J-34) to 44.1 (J-90); percentage of medium fruits ranged from 10.2 (J-34) to 47.2 (J-40) and percentage of small fruits ranged from 10.9 (J-82) to 69.5 (J-34). In this year, average unmarketable yield of 26 trees was 12.6 percent of total fruit yield (in terms of weight) and it ranged from 6.1 to 33 percent among the trees (Table 12).

Table 12. Yield and grades of fruits in Khoku mandarin genotypes (harvest year 2061)

| Acc. # | Big | | Medium | | Small | | Unmarketable Yield | | Marketable yield | | Fruit size (gm) |
|--------|-------|-------------|--------|-------------|-------|-------------|--------------------|-------------|------------------|---------|-----------------|
| | No. | Wt (Kg) | No. | Wt (Kg) | No. | Wt (Kg) | No. | Wt (Kg) | No. | Wt (Kg) | |
| J-4 | 80 | 9 (26.5) | 137 | 12 (35.3) | 144 | 9 (26.5) | 88 | 4 (11.8) | 361 | 30 | 83.1 |
| J-9 | 249 | 24 (36.4) | 365 | 27 (40.9) | 187 | 11 (16.7) | 102 | 4 (6.1) | 801 | 62 | 77.4 |
| J-13 | 94 | 9 (31.5) | 127 | 9 (31.5) | 132 | 8 (28.0) | 73 | 2.6 (9.1) | 353 | 26 | 73.7 |
| J-16 | 93 | 10 (17.4) | 245 | 21 (36.5) | 335 | 20 (34.8) | 183 | 6.5 (11.3) | 673 | 51 | 75.8 |
| J-21 | 117 | 12 (16.6) | 191 | 15 (20.7) | 727 | 40 (55.2) | 210 | 5.5 (7.6) | 1035 | 67 | 64.7 |
| J-23 | 229 | 24 (21.8) | 397 | 30 (27.3) | 955 | 48 (43.6) | 288 | 8 (7.3) | 1581 | 102 | 64.5 |
| J-24 | 272 | 30 (35.3) | 434 | 33 (38.8) | 281 | 15 (17.6) | 200 | 7 (8.2) | 987 | 78 | 79.0 |
| J-34 | 30 | 3 (5.1) | 80 | 6 (10.2) | 799 | 41 (69.5) | 311 | 9 (15.3) | 909 | 50 | 55.0 |
| J-35 | 129 | 13 (10.5) | 286 | 20 (16.1) | 1173 | 61 (49.2) | 975 | 30 (24.2) | 1588 | 94 | 59.2 |
| J-40 | 171 | 18 (18.9) | 596 | 45 (47.2) | 448 | 25 (26.2) | 136 | 7.4 (7.8) | 1215 | 88 | 72.4 |
| J-41 | 32 | 3 (6.7) | 126 | 9 (20.0) | 339 | 18 (40.0) | 477 | 15 (33.3) | 497 | 30 | 60.4 |
| J-42 | 88 | 9 (12.9) | 233 | 18 (25.9) | 654 | 34 (48.9) | 302 | 8.5 (12.2) | 975 | 61 | 62.6 |
| J-48 | 134 | 13 (16.5) | 283 | 21 (26.6) | 630 | 35 (44.3) | 280 | 10 (12.7) | 1047 | 69 | 65.9 |
| J-50 | 23 | 2 (7.9) | 169 | 10 (39.5) | 251 | 10 (39.5) | 139 | 3.3 (13.0) | 443 | 22 | 49.7 |
| J-52 | 121 | 12 (20.5) | 298 | 23 (39.3) | 307 | 18 (30.8) | 130 | 5.5 (9.4) | 726 | 53 | 73.0 |
| J-58 | 185 | 18 (17.1) | 522 | 39 (37.1) | 649 | 37 (35.2) | 269 | 11 (10.5) | 1356 | 94 | 69.3 |
| J-68 | 30 | 3 (12.7) | 82 | 6 (25.3) | 231 | 12 (50.6) | 74 | 2.7 (11.4) | 343 | 21 | 61.2 |
| J-70 | 117 | 12 (10.9) | 647 | 48 (43.7) | 662 | 36 (32.8) | 371 | 13.8 (12.6) | 1426 | 96 | 67.3 |
| J-71 | 64 | 6 (10.1) | 203 | 15 (25.2) | 665 | 30 (50.4) | 307 | 8.5 (14.3) | 932 | 51 | 54.7 |
| J-72 | 222 | 23 (21.9) | 546 | 41 (39.0) | 640 | 34 (32.4) | 215 | 7 (6.7) | 1408 | 98 | 69.5 |
| J-75 | 57 | 6 (12.3) | 188 | 14 (28.7) | 395 | 21 (43.1) | 288 | 7.7 (15.8) | 640 | 41 | 64.1 |
| J-82 | 164 | 18 (21.8) | 405 | 30 (36.3) | 144 | 9 (10.9) | 530 | 25.7 (31.1) | 713 | 57 | 79.9 |
| J-84 | 110 | 12 (13.2) | 190 | 15 (16.5) | 736 | 42 (46.2) | 625 | 22 (24.2) | 1036 | 69 | 66.6 |
| J-90 | 400 | 45 (44.1) | 355 | 27 (26.4) | 424 | 23 (22.5) | 198 | 7.1 (7.0) | 1179 | 95 | 80.6 |
| J-91 | 79 | 8 (15.4) | 241 | 17 (32.6) | 211 | 12 (23.0) | 415 | 15.1 (29.0) | 541 | 37 | 68.4 |
| Mean | 131.6 | 13.7 (18.5) | 293.8 | 22.1 (30.7) | 485.2 | 26 (36.7) | 287.4 | 12.6 (14.1) | 910.6 | 61.7 | 67.9 |
| SD | 89.53 | 9.8 (9.8) | 160.7 | 12.1 (9.5) | 277.2 | 14.3 (13.8) | 202.0 | 15.1(7.9) | 383 | 26.2 | 8.7 |

Figures inside parenthesis are percent of total yield by weight

Table 13 presents different grades of fruits in terms of percentage of total fruit yield recorded in 2062. Two accessions (J-34 and J-50) did not produce any fruit of big category but J-52 (39.4 %) and J-90 (38.4 %) produced highest proportion of big fruits. Accession: J-90 produced 194 kg marketable yield of which 89 kg was of big size category. Proportion big sized fruits of 26 trees used for evaluation was 18.5 percent of total fruits (by weight). Like wise proportion of medium sized fruits ranged from 11.3 to 58.2 percent and proportion of small sized fruits ranged from 10.4 to 60.7 percent. Mean unmarketable yield of 26 trees was 13.8 percent in 2062 harvesting. Highest marketable yield was recorded in three accessions namely J-70 (203 kg), J-82 (194 kg) and J-90 (194 kg). Mean marketable yield of 26 accessions was 95.4 ± 50.3 kg which is equivalent to 28.5 metric tons of per hectare productivity considering plant densities of 300 trees/ha. As at present average productivity of mandarin in Nepal is about 11 tons per hectare, there is tremendous scope of improving mandarin productivity by disseminating improved production technologies to farmers' fields. In harvesting year 2062, fruit size ranges from 51.4 gm to 89.6 gm. Accession: J-90 produced the biggest sized fruits. Based on yield and fruit quality parameters recorded for 4

consecutive years, accession; J-90 has been found best genotype and therefore, selected for mother plant of Khoku genotypes. It has been found free from greening disease (tested in France using PCR technique).

Table 13 Yield and grades of fruits in different accessions of Khoku mandarin (2062 harvest)

| Acc. # | Big | | Medium | | Small | | Unmarketable Yield | | Marketable yield | | Fruit size (gm) |
|--------|-------|-------------|--------|-------------|-------|-------------|--------------------|------------|------------------|---------|-----------------|
| | No. | Wt (Kg) | No. | Wt (Kg) | No. | Wt (Kg) | No. | Wt (Kg) | No. | Wt (Kg) | |
| J-4 | 120 | 12 (15.0) | 574 | 42 (52.5) | 559 | 26 (32.5) | 0 | 0 (0.0) | 1253 | 80 | 63.8 |
| J-9 | 293 | 31 (27.7) | 630 | 53 (47.3) | 446 | 24 (21.4) | 120 | 4 (3.6) | 1409 | 108 | 76.6 |
| J-13 | 69 | 7 (12.7) | 396 | 32 (58.2) | 253 | 13 (23.6) | 80 | 3 (5.5) | 718 | 52 | 72.4 |
| J-16 | 85 | 9 (11.5) | 439 | 36 (46.1) | 501 | 24 (30.8) | 308 | 9 (11.5) | 1025 | 69 | 67.3 |
| J-21 | 123 | 14 (25.0) | 248 | 18 (32.1) | 433 | 21 (37.5) | 53 | 3 (5.4) | 804 | 53 | 65.9 |
| J-23 | 28 | 3 (6.5) | 126 | 9 (19.0) | 643 | 27 (58.7) | 262 | 7 (15.2) | 797 | 39 | 51.4 |
| J-24 | 371 | 39 (34.8) | 574 | 45 (40.2) | 378 | 21 (18.8) | 127 | 7 (6.3) | 1323 | 105 | 79.4 |
| J-26 | 216 | 22 (28.9) | 385 | 30 (39.4) | 304 | 18 (23.6) | 172 | 6 (8.1) | 905 | 70 | 77.3 |
| J-34 | 0 | 0 (0.0) | 161 | 12 (19.7) | 623 | 29 (47.5) | 718 | 20 (32.8) | 784 | 41 | 52.3 |
| J-35 | 65 | 6 (5.8) | 284 | 21 (20.1) | 1032 | 50 (47.9) | 888 | 27 (26.3) | 1381 | 77 | 55.8 |
| J-40 | 520 | 54 (34.4) | 815 | 61 (38.9) | 365 | 21(13.4) | 542 | 21(13.4) | 1700 | 136 | 80.0 |
| J-41 | 30 | 3 (2.4) | 193 | 14 (11.3) | 1397 | 75 (60.7) | 1039 | 32 (25.5) | 1620 | 92 | 56.8 |
| J-42 | 62 | 6 (11.7) | 247 | 18 (35.0) | 416 | 21(40.8) | 203 | 6.5 (12.6) | 725 | 45 | 62.1 |
| J-48 | 319 | 33 (25.2) | 702 | 51(38.9) | 627 | 33 (25.2) | 460 | 14 (10.7) | 1648 | 117 | 71.0 |
| J-50 | 0 | 0 (0.0) | 86 | 6 (22.6) | 298 | 14 (52.8) | 203 | 6.5 (24.5) | 384 | 20 | 52.1 |
| J-52 | 450 | 50 (39.4) | 577 | 45 (35.4) | 480 | 27 (21.3) | 145 | 5 (3.9) | 1507 | 122 | 81.0 |
| J-58 | 393 | 48 (28.1) | 1070 | 78 (45.6) | 626 | 34 (19.9) | 186 | 11 (6.4) | 2089 | 160 | 76.6 |
| J-68 | 230 | 24 (27.1) | 241 | 18 (20.3) | 633 | 34 (20.3) | 367 | 13 (14.1) | 1104 | 76 | 68.8 |
| J-70 | 218 | 22 (10.1) | 1483 | 97 (44.5) | 1698 | 84 (44.5) | 423 | 15 (6.9) | 3399 | 203 | 59.7 |
| J-71 | 108 | 11 (10.3) | 371 | 28 (26.3) | 840 | 45 (26.3) | 754 | 23 (21.1) | 1319 | 84 | 63.7 |
| J-72 | 49 | 5 (13.9) | 197 | 15 (41.7) | 231 | 12 (41.7) | 130 | 4 (22.4) | 477 | 32 | 67.2 |
| J-75 | 161 | 16 (11.1) | 561 | 39 (27.0) | 1204 | 57 (27.0) | 792 | 32 (16.0) | 1926 | 112 | 58.1 |
| J-82 | 246 | 25 (10.8) | 1128 | 106 (45.9) | 1132 | 63 (27.3) | 973 | 37 (17.4) | 2504 | 194 | 77.5 |
| J-84 | 182 | 20 (15.4) | 624 | 48 (37.1) | 695 | 39 (30.1) | 660 | 23 (30.1) | 1501 | 107 | 71.3 |
| J-90 | 777 | 89 (38.4) | 1019 | 81 (35.0) | 370 | 24 (10.4) | 850 | 38 (16.2) | 2166 | 194 | 89.6 |
| J-91 | 261 | 27 (23.4) | 448 | 37 (32.3) | 162 | 27 (23.4) | 672 | 24 (20.8) | 1171 | 91 | 77.7 |
| Mean | 206.8 | 22.2 (18.1) | 524 | 40.0 (35.1) | 640 | 33.2 (33.1) | 428 | 15 (13.8) | 1370.7 | 95.4 | 67.9 |
| SD | 183.8 | 20.7 (11.8) | 349 | 26.8 (11.6) | 370 | 18.7 (13.3) | 321 | 11(8.3) | 669.8 | 50.3 | 10.4 |

Note: figures inside parenthesis are percentage of total yield (marketable + unmarketable yield)

Lime (*Citrus aurantifolia*)

Different accessions of acid lime collected through HARP project in 2058 are being maintained at NCRP, Dhankuta. Some of these seedling trees started fruiting this year. They were evaluated for their growth, insects and disease incidence and fruit characters.

The height and spreading (East-west and North-south) was measured prior to pruning. The diseases and insects were recorded in each tree in Bhadra, Poush and Baisakh. Like wise flower bud initiation was recorded in third week of Phalgun. Table 14 presents the growth, insects and diseases evaluation data of acid lime trees. Plant height ranged from 100 - 260 cm and mean canopy diameter ranged from 65-238 cm. Some of the plants were showing die

back syndrome possibly due to root rot. Borer and scales were the major insects recorded in this trimester in lime trees. Most of the lime genotypes started to produce flower buds by second week of Phalgun. Canker was noted in some accessions. Kasu-B (Kasugamycin) was sprayed to control canker and found very effective to reduce disease infestation.

Table 14. *Plant growth, insects and diseases recorded on acid lime germplasm*

| Acc # | Plant ht (cm) | Spreading (cm) | | | Disease | Insect | Remark |
|-------|------------------|----------------|-----|-------|----------|--------|--------------------|
| | | E-W | N-S | Mean | | | |
| 001-2 | 250 | 167 | 157 | 162 | die back | No | |
| 001-3 | 210 | 164 | 177 | 170.5 | | | Flowering |
| 001-4 | 190 | 192 | 184 | 188 | | | Flowering |
| 102-1 | 180 | 174 | 127 | 150.5 | | scale | Flowering |
| 102-2 | 150 | 76 | 55 | 65.5 | | | Stunted, flowering |
| 102-3 | 165 | 145 | 150 | 147.5 | | | Flowering |
| 102-4 | 140 | 192 | 159 | 175.5 | | borer | Flowering |
| 83-3 | 125 | 130 | 135 | 132.5 | die back | borer | Stunted, flowering |
| 83-4 | 210 | 170 | 175 | 172.5 | | | Flowering |
| 81-1 | 223 | 195 | 250 | 222.5 | | scale | Flowering |
| 81-2 | 212 | 219 | 200 | 209.5 | die back | | Flowering |
| 81-3 | 190 | 280 | 160 | 220 | | | Flowering |
| 75-3 | 200 | 175 | 160 | 167.5 | | | Flowering |
| 78-1 | 200 | 160 | 190 | 175 | | | Flowering |
| 78-2 | 195 | 170 | 200 | 185 | | | Flowering |
| 78-3 | 145 | 115 | 113 | 114 | | | Stunted, flowering |
| 82-2 | 250 | 245 | 232 | 238.5 | | | Flowering |
| 82-3 | 260 | 155 | 213 | 184 | | | Flowering |
| 82-4 | 243 | 220 | 254 | 237 | | | Flowering |
| 85-1 | 218 | 216 | 158 | 187 | | scale | Flowering |
| 85-2 | 225 | 194 | 245 | 219.5 | | | Flowering |
| 85-4 | 175 | 70 | 110 | 90 | | | stunted |
| 94-3 | 140 | 95 | 125 | 110 | | | Flowering |
| 94-4 | 135 | 80 | 110 | 95 | | | Stunted, flowering |
| 96-1 | 170 | 110 | 113 | 111.5 | | scale | Flowering |
| 76-1 | 207 | 198 | 210 | 204 | | | Flowering |
| 76-2 | 200 | 170 | 155 | 162.5 | | | Flowering |
| 76-3 | 190 | 165 | 210 | 187.5 | | | Flowering |
| 76-4 | 200 | 180 | 200 | 190 | | | Flowering |
| 74-1 | 150 | 175 | 145 | 160 | | scale | Flowering |
| 74-2 | 145 | 140 | 150 | 145 | | | |
| 71-1 | 235 | 155 | 190 | 172.5 | | | flowering |
| 71-3 | 190 | 125 | 135 | 130 | | | flowering |
| 70-4 | 200 | 190 | 180 | 185 | | | flowering |
| 39-1 | 155 | 110 | 105 | 107.5 | die back | | stunted |
| 39-2 | 160 | 190 | 180 | 185 | | | |
| 39-3 | 155 | 115 | 130 | 122.5 | | | flowering |
| 39-4 | 140 | 130 | 110 | 120 | | | |
| 66-1 | 155 | 135 | 130 | 132.5 | | | |
| 66-3 | 190 | 105 | 155 | 130 | | | |
| 101-2 | 205 | 175 | 204 | 189.5 | | | flowering |
| 101-4 | 160 | 194 | 120 | 157 | gumosis | scale | flowering |
| 94-1 | 120 | 100 | 105 | 102.5 | | | |

| | | | | | | |
|------|-----|-----|-----|-------|------------|-----------|
| 96-3 | 100 | 120 | 105 | 112.5 | scale | flowering |
| 66-4 | 110 | 80 | 75 | 77.5 | | stunted |
| 8-1 | 175 | 180 | 155 | 167.5 | leaf minor | flowering |

Table 14 cont...

| Acc # | Plant ht (cm) | Spreading (cm) | | | Disease | Insect | Remark |
|-------|---------------|----------------|-----|-------|---------|--------|-----------|
| 35-1 | 100 | 90 | 115 | 102.5 | dieback | | stunted |
| 35-2 | 155 | 185 | 135 | 160 | | | flowering |
| 35-3 | 195 | 180 | 190 | 185 | | | flowering |
| 30-1 | 200 | 180 | 200 | 190 | canker | | flowering |
| 30-2 | 190 | 233 | 172 | 202.5 | | | flowering |
| 30-3 | 300 | 175 | 165 | 170 | | | flowering |
| 28-1 | 110 | 120 | 135 | 127.5 | canker | | flowering |
| 28-2 | 252 | 215 | 262 | 238.5 | | | flowering |
| 28-3 | 110 | 90 | 95 | 92.5 | | | flowering |
| 7-1 | 130 | 190 | 270 | 230 | | | flowering |
| 29-1 | 180 | 150 | 140 | 145 | | | |
| 29-3 | 200 | 190 | 185 | 187.5 | | | flowering |
| 29-4 | 200 | 185 | 190 | 187.5 | | | flowering |
| 37-1 | 110 | 115 | 90 | 102.5 | | | stunted |
| 37-3 | 110 | 70 | 100 | 85 | | scale | stunted |
| 35-4 | 180 | 50 | 130 | 90 | | | flowering |
| Max | 260 | 280 | 254 | 238 | | | |
| Min | 100 | 50 | 55 | 65 | | | |

A total of 8 accessions (acc. # 28-2, 29-3, 29-4, 30-1, 71-1, 81-2, 82-3, 85-2) produced fruits in this year in which two accessions (28-2 and 82-3) showed the tendencies of off-season flowering and fruiting. Five fruits of each tree were evaluated for their external and internal characters. The fruit characters are presented in Table 15.

Table 15 Fruit characters of acid lime.

| Acc. # | Fruit shape. | Apex shape | Base shape | Fruit wt (gm) | Seed # | Segment # | Juice (gm) | Juice % | TSS | TA (%) |
|--------|--------------------|-------------------|------------|---------------|--------|-----------|------------|---------|------|--------|
| 28-2 | Spheroid | Mammiform | Convex | 32.6 | 5.6 | 10.2 | 14.5 | 43.8 | 5.9 | 3.81 |
| 29-3 | Ellipsoid | Mammiform | Convex | 40.9 | 6.3 | 9.3 | 13.3 | 32.7 | 7.17 | 6.29 |
| 29-4 | Ellipsoid/spheroid | Mammiform | Convex | 29.8 | 6.6 | 10.2 | 13.8 | 46.4 | 7.2 | 6.74 |
| 30-1 | Spheroid | Mammiform | Convex | 28.0 | 10.0 | 9.0 | 11.6 | 40.8 | 7.1 | 6.38 |
| 71-1 | Spheroid | Mammiform/rounded | Convex | 31.3 | 9.6 | 9.2 | 13.6 | 43.2 | 7.5 | 7.07 |
| 81-2 | Spheroid | Mammiform | Convex | 23.5 | 5.0 | 9.6 | 8.4 | 35.8 | 7.65 | 7.42 |
| 82-3 | Spheroid | Mammiform | Convex | 40.9 | 11.4 | 9.8 | 16.8 | 41.1 | 7.65 | 7.0 |
| 85-2 | Spheroid | Mammiform | Convex | 37.3 | 8.0 | 9.2 | 14.4 | 38.5 | 8.15 | 7.71 |

Hill lemon (*Citrus psedolemon*)

Different accessions of hill lemon (Nibuwa) collected through HARP project in 2058 and maintained at NCRP were evaluated for their growth and incidence of insects and diseases. The height and spreading (East-west and North-south) was measured prior to pruning. The diseases and insects were recorded in each tree in second week of Phalgun. Like wise flower bud initiation was recorded in third week of Phalgun. Table 16 presents the germplasm evaluation data of lemon.

Plant height of hill lemon ranged from 200-450 cm among the accessions. Wide range of variation (156-393 cm) in canopy diameter was also noted. Powdery mildew was the major foliar disease noted in most accessions. Also, there was heavy leaf drops in some of the accessions due to root rot caused by *Phytophthora*. Therefore, Bordeaux mixture drenching and anti-rot spraying was done to control this disease. Scale insects and borer were most common insects in hill lemon.

Table . 16 Plant growth, insects and diseases recording of hill lemon germplasm

| Acc # | Plant ht(cm) | Spreading (cm) | | | Disease | Insect | Remark |
|-------|--------------|----------------|-----|-------|----------------|--------|-----------|
| | | E-W | N-S | Mean | | | |
| 19-4 | 235 | 260 | 250 | 255 | | | |
| 20-2 | 430 | 250 | 210 | 230 | | | |
| 20-4 | 245 | 200 | 205 | 202.5 | | borer | |
| 31-1 | 252 | 200 | 180 | 190 | | | |
| 31-2 | 325 | 172 | 161 | 166.5 | | | |
| 61-1 | 345 | 200 | 198 | 199 | | borer | flowering |
| 61-4 | 280 | 204 | 230 | 217 | | | flowering |
| 45-1 | 277 | 170 | 158 | 164 | | scale | |
| 45-2 | 280 | 223 | 200 | 211.5 | | scale | |
| 45-3 | 288 | 215 | 275 | 245 | | scale | |
| 45-4 | 218 | 165 | 240 | 202.5 | | | |
| 36-1 | 384 | 293 | 241 | 267 | | | |
| 36-2 | 363 | 230 | 200 | 215 | | | |
| 36-3 | 365 | 320 | 235 | 277.5 | | | |
| 36-4 | 332 | 280 | 193 | 236.5 | | | |
| 104-1 | 427 | 325 | 310 | 317.5 | | | |
| 104-2 | 365 | 216 | 253 | 234.5 | | borer | |
| 56-3 | 393 | 377 | 409 | 393 | | | flowering |
| 80-1 | 290 | 246 | 217 | 231.5 | | | flowering |
| 80-2 | 264 | 210 | 279 | 244.5 | | | |
| 86-3 | 298 | 243 | 239 | 241 | | | |
| 67-1 | 280 | 197 | 208 | 202.5 | | | |
| 67-3 | 332 | 226 | 243 | 234.5 | | | |
| 005-1 | 390 | 247 | 245 | 246 | powdery mildew | scale | |
| 005-2 | 398 | 306 | 348 | 327 | powdery mildew | | |
| 84-1 | 387 | 256 | 219 | 237.5 | | | |
| 84-2 | 200 | 150 | 162 | 156 | | | |
| 88-1 | 298 | 175 | 217 | 196 | | borer | |
| 88-2 | 385 | 258 | 252 | 255 | | | vigorous |
| 88-3 | 415 | 200 | 270 | 235 | | | |

Table 16 cont...

| Acc # | Plant ht(cm) | Spreading (cm) | | | Disease | Insect | Remark |
|-------|--------------|----------------|-----|-------|---------|--------|-----------|
| | | E-W | N-S | Mean | | | |
| 60-2 | 440 | 203 | 183 | 193 | | | |
| 003-1 | 376 | 209 | 227 | 218 | | | |
| 003-3 | 310 | 198 | 165 | 181.5 | | | |
| 003-4 | 355 | 232 | 246 | 239 | | | |
| 100-1 | 284 | 182 | 286 | 234 | | | |
| 100-3 | 253 | 190 | 180 | 185 | | | |
| 105-2 | 326 | 174 | 187 | 180.5 | | | |
| 105-3 | 296 | 245 | 193 | 219 | | | |
| 84-3 | 295 | 192 | 183 | 187.5 | | | |
| 100-4 | 292 | 162 | 184 | 173 | | | |
| 54-2 | 325 | 199 | 204 | 201.5 | | | flowering |
| 77-3 | 270 | 202 | 175 | 188.5 | | | |
| 77-4 | 285 | 176 | 322 | 249 | | | |
| 008-1 | 305 | 186 | 190 | 188 | | | |
| 002-2 | 410 | 292 | 283 | 287.5 | | | |
| 002-3 | 335 | 181 | 249 | 215 | | | |
| Max | 450 | 377 | 409 | 393 | | | |
| Min | 200 | 150 | 158 | 156 | | | |

Of the 48 hill lemon accessions (trees) evaluated, only 15 had started flowering by third week of Phalgun. A total of 11 accessions of hill lemon produced fruits in this year. This is the first year of fruiting. Number of fruits per tree ranged from 1-15. However, most of the fruits were damaged by fruit flies despite the control measures applied. Fruit samples from 6 accessions were analysed for fruit characters in second week of Kartik. Table 17 presents the fruit characters of hill-lemon.

Table 17 Fruit characters of hill lemon.

| Acc. # | Fruit shape | Apex shape | Base shape | Fruit wt (gm) | Seed # | Segment # | Juice (gm) | Juice % | TSS | TA (%) |
|--------|-------------|------------|-----------------|---------------|--------|-----------|------------|---------|------|--------|
| 002-2 | Ellipsoid | Mammiform | Concave Collard | 230 | 21 | 7.5 | 45.0 | 19.7 | 6.0 | 5.36 |
| 008-3 | Ellipsoid | Mammiform | Convex | 423 | 7 | 9 | 93.8 | 22.2 | 5.5 | 4.8 |
| 36-1 | Ellipsoid | Mammiform | Concave | 273 | 19 | 8.5 | 56.2 | 20.6 | 6.13 | 6.06 |
| 36-2 | Ellipsoid | Mammiform | Convex | 423 | 20 | 11 | 93.8 | 33.3 | 6.25 | 5.92 |
| 56-3 | Ellipsoid | Rounded | Concave Collard | 382 | 17 | 7 | 80.0 | 20.9 | 6 | 5.6 |
| 104-4 | Ellipsoid | Mammiform | Convex | 108 | 46 | 7 | 11.8 | 10.9 | 6.25 | 4.8 |

On-farm variety evaluation of mandarin

Five varieties of mandarin were planted in farmers' fields of Dhankuta district at 700, 850, 1050 and 1200 m altitude in 2061, Asar. The name of the farmers and their address is presented in Table 18. Miyagawa Wase, Okitsuwase, Unshiu (unknown variety), Frutrel early and Murkotte were the varieties included for on-farm evaluation. The objective of this activity is to obtain the reaction of farmers and consumers on early and late maturing mandarin varieties. The experimental plants were maintained following the recommended practices and plant height, insects and diseases were recorded in this year.

There was variation on plant height across altitude and among varieties. Murkotte was fast growing (95 cm) and Okitsuwase was found growing very slow (48 cm) in growth behavior when recorded after one and half year of transplanting.

Scale and leaf minor were the main insects noted in all locations. Scale was possibly transmitted with planting materials. Leaf minor was maximum during new flush stage i.e. during February – March and June – July. Powdery mildew was the only disease noted during rainy season. This disease was more in higher altitude and there were no diseases in 700 m. It was likely that these plants will start fruiting next year and then fruit evaluation will be started.

Table 18 Address of the farmers participating in on-farm variety evaluation of mandarin

| Name of the farmer | Address | Altitude (m) | Variety included |
|--------------------|----------------------|--------------|--|
| Hari Bastola | Balahara-7, Guthitar | 700 | Okitsuwase, Miyagawa Wase |
| Sushil Mishra | Dhankuta-4, Gothgaun | 850 | Okitsuwase, Murkott |
| Denesh Shrestha | Dhankuta, Karmitar | 1050 | Okitsu Wase, Miyagawa Wase , Murkotte, Unshu, Frutrel early |
| Bhuban Guragain | Dhankuta-2, Seule | 1200 | Okitsu Wase, Miyagawa Wase , Murkotte, Unshui, Frutrel early |

Table 19 Plant height (cm) of different mandarin varieties at different locations (age: 1.5 yrs).

| Variety | Location | | | Mean |
|---------------|-----------|----------|-------|------|
| | Goathgaun | Karmitar | Seule | |
| Miyagawa Wase | - | 68 | 56 | 62.0 |
| Okitsuwase | 37 | 52 | 55 | 48.0 |
| Unshiu | - | 85 | 47 | 65.5 |
| Frutrel early | - | 90 | 82 | 86.0 |
| Murkotte | 47 | 143 | 95 | 95.0 |

Table 20 Insects pests recorded in mandarin varieties at different locations in 2062.

| Variety | Location | | |
|---------------|-----------|------------|-------|
| | Goathgaun | Karmitar | Seule |
| Miyagawa Wase | - | Leaf minor | Scale |
| Okitsuwase | Scale | Leaf minor | Scale |
| Unshiu | - | Leaf minor | Scale |

| | | | |
|---------------|-------|-------------------|-------------------|
| Frutrel early | - | Leaf minor, aphid | Leaf minor |
| Murkotte | Scale | Leaf minor | Scale, leaf minor |

Table 21 Diseases recorded in mandarin varieties at different locations in 2062.

| Variety | Location | | |
|---------------|-----------|----------------|----------------|
| | Goathgaun | Karmitar | Seule |
| Miyagawa Wase | - | Powdery mildew | Powdery mildew |
| Okitsuwase | No | No | Powdery mildew |
| Unshiu | - | Powdery mildew | Powdery mildew |
| Frutrel early | - | No | No |
| Murkotte | No | No | No |

Grapefruit (*Citrus paradisi*)

Grapefruit make up nearly 7 percent of worldwide citrus production. United States of America, Cuba, Greece and Israel are the major grapefruit producing countries of the world. For grapefruit to become fully flavored and sweet it needs to be grown in semi tropical climate with high humidity and warm nights. Such locations exist in Nepal but no research work was carried out in the past to explore the commercial production possibility of grapefruit in Nepal. The production of red-fleshed varieties has increased dramatically in the last 15 years in Texas, Florida and Israel. Therefore, 5 grapefruit varieties (Shamber, Henderson, Star Rubi, Reed and Pink Rubi) that were introduced recently from France were multiplied on trifoliolate rootstock. In the month of Asar (July) of 2063 saplings (1.5 years old) of each these varieties were planted at farmers field in Mulghat (350 m), Guthitar (700 m), Pansing (1100 m) and at NCRP, Paripatle (1350 m). Suitable varieties and climate of grapefruit will be identified in the future through farmers' participatory variety evaluation technique. All the varieties used for evaluation are seedless and pink-fleshed type.

On-farm evaluation lime (Citrus aurantifolia) genotypes in Terai condition

Lime (Kagati), which has been traditionally cultivated in about 60 hilly districts of the country ranks third after mandarin and sweet orange in terms of area and production among the citrus fruit crops. Nearly 16.6 percent of productive area of citrus and 12.3 percent of production is shared by lime. Among development region Eastern Development Region and among districts Terathum is the highest producer of lime in Nepal. Except four months from Kartik to Poush (Nov. - Jan.) almost 100% of the lime fruits supplied in major commercial markets are imported from India. Lime fruits produced in hill from November to January is considered as 'normal season' lime in Nepal. Normal season lime production technology is available in the country and fruits produced during this period are supplied in the market although local demand of big markets like Kathmandu is not met by local produce even in normal (winter) season. There is fairly good demand of fresh lime fruits year round. But production in other months does not exist in Nepal due to lack of off-season production technology and varieties. In other months except November to January all lime fruits supplied in Nepalese markets are imported from India mainly from Andra Pradesh commonly known as 'Madras Kagati'. It indicates the need of generating and disseminating technology to expand production period within country in order to substitute import of fresh lime fruits from India and increase income of growers. Therefore, with the objective to identify lime genotypes that can be harvested during off-season (rainy season) a survey and germplasm

evaluation was carried out using the fruiting trees grown in farmers' fields and IAAS Rampur during first year (Shrawan, 2061) of the project: Off-season lime production technology in terai and inner terai of Nepal.

Germplasm survey and *in situ* evaluation of lime trees was carried out in Jhapa , Morang, Sunsari and Chitawan (research orchard of IAAS Rampur). Lime cultivation in Terai is not a common practice. Therefore, the lime growers and fruiting trees in Jhapa, Morang, Sunsari were identified based on information from extension workers, farmers and traders. Selected lime genotypes from a variety collection block of IAAS, Rampur were also evaluated in this study. A total of 11 lime trees were evaluated for tree and fruit characteristics. Each of the evaluated trees was given an accession number for future identification. In the beginning growers were asked to identify superior trees of their orchard and/or in their neighborhood based on fruit quality and off-season flowering/fruitlet tendency. Only those trees that were selected by the growers were purposively sampled for further fruit quality evaluation. The traits such as tree age, flowering period, maturity period, market value, frequency of flowering was determined based growers' information as well as visual observation. The qualitative traits such as fruit shape, base shape, apex shape, surface texture, skin color, pulp color, rind, seed, juice were recorded. The accession number, source of selected trees and maturity period as informed by growers has been presented in Table 22. Accession number NCRP-55 and 56 were collected from Himalayan Nursery, Biratnagar and has not yet evaluated for their fruit characters. Among these accessions, NCRP-53 and NCRP-57 are lemon type. NCRP-53 is Panta-1, a recommended variety by Panta Nagar Univesity, India. NCRP-60 is commercially grown in Kaptanganj VDC of Sunsari district and seems to be a natural hybrid between lime and lemon. Rest of the accessions are pure acid limes (*Citrus aurantifolia*). Maturity period ranged from Asar to Kartik. The accessions which matured prior to Asoj could be valuable genetic materials for off-season production in Terai of Nepal.

Table 22. Source of mother plants selected for on-farm evaluation.

| Acc No. | Name of the grower | Address of the grower | Tree age | Harvesting period | Remark |
|---------|--------------------|-----------------------|----------|-------------------|-------------|
| NCRP-51 | Narendra Sitaula | Sundarpur-2, Morang | 15 | Shrawan-Kartik | Acid lime |
| NCRP-52 | Bhola Bajgai | Belepur, Morang | 20 | Shrawan-Kartik | Acid lime |
| NCRP-59 | Abad Lal Mehata | Kaptanganj, Sunsari | 8 | Shrawan-Kartik | Acid lime |
| NCRP-53 | Phul P. Subedi | Bharatpur, Chitawan | 6 | Asar-Bhadra | Var. Pant-1 |
| NCRP-49 | IAAS | Rampur, Chitawan | 3 | Asar-Asoj | Acid lime |
| NCRP-48 | IAAS | Rampur, Chitawan | 3 | Bhadra-Kartik | Acid lime |
| NCRP-50 | IAAS | Rampur, Chitawan | 3 | Asar-Asoj | Acid lime |
| NCRP-47 | IAAS | Rampur, Chitawan | 3 | Bhadra-Kartik | Acid lime |
| NCRP-46 | IAAS | Rampur, Chitawan | 3 | Asar-Asoj | Acid lime |
| NCRP-57 | Hari Subedi | Bharatpur, Chitawan | 5 | Asar-Bhadra | Lemon |
| NCRP-60 | Mugala Mehata | Kaptanganj, Sunsari | 20 | Asar-Mangsir | Hybrid |
| NCRP-55 | Himalayan Nursery | Biratnagar, Morang | 3 | ?? | Madrasi |
| NCRP-56 | Himalayan Nursery | Biratnagar, Morang | 3 | ?? | Banarasi |

| | | | | | |
|----------|----------------|--------------------------|----|--------------------|----------|
| NCRP-107 | Farmer's field | Phakchamara, Terathum | 15 | Asoj-Kartik | Terathum |
| NCRP-108 | Farmer's field | Khorsane, Morang | 10 | Shrawan- Bhadau | Lime |

Fruit characteristics of these trees were also evaluated during first year of the project Shrawan – Kartik, 2061). Table 23 presents the internal and external fruit characters of selected trees as exhibited in *in situ* evaluation. Fruit weight ranges from 17.3 gm (NCRP-50) to 60gm (NCRP-60). Fruit weight of NCRP-52, 53 and 59 was about 38 gm which is considered suitable for commercial market. Lemon type genotypes (NCRP-53 & 57) and hybrid type (NCRP-60) had bigger fruits in comparison to pure lime genotypes. Pure lime fruits have better market value and acceptability in Nepal compare to lemon types. Since fruit samples were evaluated from the trees of different ages and grown in diverse management conditions variation in fruit size (weight) was expected to be contributed by environmental factors in a considerable degree in addition to genetic composition of the accessions. Skin (peel) percent of the fruit was calculated based on fruit weight. Peel percent was highest (32.3%) in accession: NCRP-60 and it was lowest (13.8%) in lemon type (NCRP-53 & 57). NCRP-53 (Pant-1), 57 and 60 were very seeded while NCRP-59 had very less seeds. Juice content is one of the important criteria for variety selection in lime. NCRP-51, 52, 59 and 57 had more than 40% juice in their fruits. *In situ* evaluation also revealed a wide range of variation in percentage of acid content among the genotypes. This variation could be associated with the genetic nature of the genotypes as well as differences in maturity period of sampled fruits. The acid content was lowest in NCRP-53 and highest in NCRP-46.

Table 23. Fruit characteristics of lime germplasm recorded in *in situ* evaluation.

| Acc No | Fruit weight (gm) | Skin (%) | Seed Number | Seed weight (%) | Juice weight (%) | TSS | TA | TSS/TA |
|---------|----------------------|-------------|----------------|-----------------------|------------------------|------------|-------------|--------------|
| NCRP-51 | 49.6(±10.5) | 24.4(±3.7) | 13.4(±5.3) | 3.1(±0.8) | 40.7(±6.8) | 6.2(±0.2) | 5.8(±0.33) | 1.08(±0.06) |
| NCRP-52 | 38.5(±10.9) | 24.4(±3.1) | 11.3(±7.7) | 4.1(±1.9) | 40.0(±9.4) | 6. (±0.23) | 5.7(±0.27) | 1.09(±0.07) |
| NCRP-59 | 38.1(±17.9) | 15.1(±2.1) | 5.4(±4.1) | 1.4(±1.0) | 42.7(±5.7) | 5.8(±0.6) | 5.6(±0.66) | 1.03(±0.05) |
| NCRP-53 | 50.2 (±1.9) | 15.2 (±3.3) | 24.5(±11.4) | 2.8 (±1.4) | 38.0 (±7.0) | 5.0 (±0.0) | 4.4 (±0.25) | 1.14 (±0.06) |
| NCRP-49 | 38.5(±8.2) | 13.8(±5.6) | 7.0(±2.6) | 1.9(±0.9) | 42.1(±4.2) | 6.2(±0.5) | 6.0(±0.62) | 1.03(±0.07) |
| NCRP-48 | 28.5(±5.4) | 25.6(±3.2) | 10.0(4.1) | 3.5(±0.8) | 36.5(±5.6) | 6.5(±0.2) | 5.1(±0.43) | 1.27(±0.15) |
| NCRP-50 | 17.3(±5.2) | 19.1(±3.2) | 8.0(±1.6) | 5.8(±0.9) | 27.0(±3.6) | 6.5(±0.2) | 6.1(±0.41) | 1.05(±0.02) |
| NCRP-47 | 23.3(±4.9) | 14.2(±4.8) | 9.0(±2.1) | 3.6(±0.9) | 18.2(±5.6) | 6.0(±0.2) | 5.0(±0.27) | 1.20(±0.09) |
| NCRP-46 | 24.9(±6.8) | 20.1(±5.2) | 11.0(±2.4) | 4.3(±0.4) | 34.1(±4.6) | 6.5(±0.6) | 6.5(±0.18) | 1.00(±0.03) |
| NCRP-57 | 51.2(±4.8) | 13.8(±0.74) | 18.4(±9.8) | 2.7 (±1.5) | 44.2 (±3.0) | 5.2 (±0.5) | 5.07 (±0.5) | 1.02 (±0.02) |
| NCRP-60 | 60.0(±10.3) | 32.3(±4.6) | 15.5(±5.3) | 2.6(±0.7) | 36.0(±4.9) | 6.6(±0.4) | 5.9(±0.74) | 1.13(±0.13) |

Figures in parenthesis are standard deviations.

In Mangsir of 2061 scions of 11 accessions were collected to NCRP, Dhankuta and grafted on trifoliolate rootstocks. A total of 50 grafted plants of each accession were produced. These plants were transplanted to farmers' fields in Asar 2062 for farmers' participatory variety selection. Rest of the 4 accessions were multiplied in Mangsir, 2062 and transplanted in farmers' field in Asar, 2063. The participating farmers and their address has been presented in Table 24. One set of all the above mentioned accessions (Table 22) were also planted at NCRP, Dhankuta for on-station evaluation in Asar, 2062.

Height of the plants were recorded in the month of Magh 2063 when plants were either 1.5 years or 6 months old depending upon the accessions; plants of accessions: NCRP-60, 56, 107 and 108 were 6 months old while others were 1.5 years old in Magh 2063. There was variation on plant height among the genotypes. The accessions: NCRP-51, 52 and 59 were dwarf in all locations. NCRP-53 and 57 were tallest (Table 25). Since the plants were very young (1.5 years), present data cannot represent the real growth pattern of the genotypes. The growth data will be recorded every year until plants attain some stability in their growth.

Some of the accessions started to flowering after 1.5 years of transplanting (Table 26). Accessions: NCRP-52, 57, 53 and 59 produced flowers in all locations while NCRP-51 produced flowers only in 3 locations (Morang and Chitawan). Rest of the genotypes has not started flowering in second year of transplanting.

Table 24. Name and address of participatory farmers

| Name of farmer | Address of farmer | Nos. of acc. | Planting distance | Plants /acc | Area (m ²) | Remark |
|---------------------------|-----------------------------------|--------------|-------------------|-------------|------------------------|---------------------------------|
| Himali Farm Pvt. Ltd. | Buttabari, Jhapa | 10 | 4x3 m | 7 | 840 | Acc. 60,55,56, 107, 108 missing |
| Khum Nath Timilsina | Pathari -2, Devigau, Morang | 10 | 4x3 m | 7 | 840 | Acc. 60,55,56, 107, 108 missing |
| Arbinda P. Mehata | Narasingh-2, Sunsari | 11 | 4x3 m | 8 | 1056 | Acc. 55,56, 107, 108 missing |
| Shiva Shrestha | Bharatpur-7, Prem Basti, Chitawan | 14 | 3x3 m | 5 | 1050 | Acc. 46 missing |
| Saptagandaki Hort. Centre | Bharatpur-1, Thimura | 13 | 4x4 m | 8 | 1200 | Acc.60, 107, 108 missing |

Table 25. Plant height (cm) of different accessions of lime (recorded in Magh 2063)

| Acc No | Buttabari Jhapa | Pathari Morang | Narasingh Sunsari | Prem Basti Chitawan | Thimura Chitawan | Mean |
|---------|-----------------|----------------|-------------------|---------------------|------------------|-------|
| NCRP-51 | 76.4 (±30.3) | 102.4 (±31.3) | 96.2 (±24.0) | 64.0 (±16.2) | 63.6 (20.4) | 80.5 |
| NCRP-52 | 90.7 (±8.8) | 81.7 (±28.9) | 120.6 (±36.1) | 56.2 (±21.3) | 73.2 (5.1) | 84.5 |
| NCRP-59 | 67.8 (±12.2) | 82.1 (±13.6) | 84.5 (±25.9) | 51.5 (±11.0) | 67.0 (14.9) | 70.5 |
| NCRP-53 | 186.4 (±23.5) | 247.7 (±25.5) | 210.0 (±62.9) | 125.0 (±56.1) | 161.3 (39.0) | 186.1 |
| NCRP-49 | 131.4 (±50.1) | 217.7 (±51.4) | 184.5 (±23.7) | 69.5 (±34.2) | 113.8 (37.0) | 143.4 |
| NCRP-48 | 140.0 (±46.8) | 213.0 (±38.1) | 212.5 (±37.0) | 112.2 (±24.7) | 161.3 (50.0) | 167.8 |
| NCRP-50 | 115.8 (±23.1) | 127.4 (±54.9) | 158.2 (±82.1) | 19.0 (±6.7) | 128.2 (32.3) | 111.7 |
| NCRP-47 | 158.5 (±36.2) | 167.4 (±77.1) | 200.0 (±50.0) | 42.5 (±2.5) | 102.4 (19.8) | 134.2 |
| NCRP-46 | 167.1 (±24.1) | 129.1 (±67.0) | 209.5 (±36.7) | - | 122.8 (40.8) | 157.1 |
| NCRP-57 | 197.1 (±42.3) | 155.2 (±57.4) | 195.4 (±52.9) | 142.3 (±12.5) | 216.6 (22.4) | 181.3 |

| | | | | | | |
|----------|--------------|---|--------------|--------------|-------------|-------|
| NCRP-60 | - | - | 167.1(±83.7) | 35.5(±13.0) | - | 101.3 |
| NCRP-55 | - | - | - | 39.2(±8.0) | 143.2(35.3) | 91.2 |
| NCRP-56 | - | - | - | 39.7(±8.3) | 76.7(24.0) | 58.2 |
| NCRP-107 | - | - | - | 26.2(±7.7) | - | 26.2 |
| NCRP-108 | - | - | - | 29.0(±8.4) | - | 29.0 |
| Seedling | 127.8(±33.8) | - | - | 119.9(±58.6) | - | 123.9 |

Interaction of lime genotypes with different insects and diseases was also recorded. Brown aphid was the most common insect in Jhapa and Morang. Lemon dog was also noticed in NCRP-51 and 46 in Jahapa during new flush development season (Feb.- Mar.) In other location no insect pest was recorded in first and second year of evaluation. Rogor @ 1 ml/lit of water was applied to control the aphids.

Canker was the most common disease recorded in all genotypes and in all locations although the severity of this disease was less in lemon type accessions (NCRP-53 and 57). All accessions were affected by gummosis in two sites of Chitawan. It is likely that the saplings were already contaminated with gummosis at nursery stage prior to transplanting. For the control of Canker Kasugamycin (Kasu-B) 2 ml/lit of water was applied before and after rainy season and was found effective to reduce the spread of the disease. For the control of gummosis, Bordeaux paste was applied on the trunk of the plants and Anti-rot was sprayed @ 10ml/lit of water at new flush initiation stage (mid January). The treatments produced remarkable positive effect to control gummosis.

Table 26. Flowering status of different lime accessions at different location recorded in 2062/2063.

| Acc No | Buttabari | Pathari | Narasingh | Prembasti | Thimura |
|---------|-----------|-----------|-----------|-----------|-----------|
| | Jhapa | Morang | Sunsari | Chitawan | Chitawan |
| NCRP-51 | No | Yes (1.5) | No (1.5) | Yes (1.5) | Yes (1.5) |
| NCRP-52 | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) |
| NCRP-59 | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) |
| NCRP-53 | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) |
| NCRP-49 | No (1.5) | No (1.5) | No (1.5) | No (1.5) | No (1.5) |
| NCRP-48 | No (1.5) | No (1.5) | No (1.5) | No (1.5) | No (1.5) |
| NCRP-50 | No (1.5) | No (1.5) | Yes (1.5) | No (0.5) | No (1.5) |
| NCRP-47 | No (1.5) | No (1.5) | No (1.5) | No (0.5) | No (1.5) |
| NCRP-46 | No (1.5) | No (1.5) | No (1.5) | - | No (1.5) |
| NCRP-57 | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) | Yes (1.5) |
| NCRP-60 | - | - | No (1.5) | No (0.5) | - |

| | | | | | |
|----------|----------|---|---|----------|----------|
| NCRP-55 | - | - | - | No (0.5) | No (1.5) |
| NCRP-56 | - | - | - | No (0.5) | No (1.5) |
| NCRP-107 | - | - | - | No (0.5) | - |
| NCRP-108 | - | - | - | No (0.5) | - |
| Seedling | No (1.5) | - | - | No (1.5) | - |

Figure in parenthesis are age of the plants in years.

Table 27. Lime genotypes and insect pests interaction in different locations (recorded in 2062/63)

| Acc No | Buttabari Jhapa | Pathari Morang | Narasingh Sunsari | Prem Basti Chitawan | Thimura Chitawan |
|----------|------------------|----------------|-------------------|---------------------|------------------|
| NCRP-51 | Lemon dog | Aphid | No | No | No |
| NCRP-52 | Aphid | No | No | No | No |
| NCRP-59 | Aphid | No | No | No | No |
| NCRP-53 | Aphid | Aphid | No | No | No |
| NCRP-49 | Aphid | No | No | No | No |
| NCRP-48 | Aphid | Aphid | No | No | No |
| NCRP-50 | Aphid | Aphid | No | No | No |
| NCRP-47 | Aphid | Aphid | No | No | Aphid |
| NCRP-46 | Lemon dog, Aphid | No | No | - | No |
| NCRP-57 | No | No | No | No | No |
| NCRP-60 | - | - | No | No | - |
| NCRP-55 | - | - | - | No | No |
| NCRP-56 | - | - | - | No | No |
| NCRP-107 | - | - | - | No | - |
| NCRP-108 | - | - | - | No | - |
| Seedling | No | - | - | No | - |

Table 28. Lime genotypes and diseases interaction at different location during 2062/63

| Acc No | Buttabari Jhapa | Pathari Morang | Narasingh Sunsari | Prem Basti Chitawan | Thimura Chitawan |
|----------|-----------------|------------------|-------------------|---------------------|------------------|
| NCRP-51 | Canker | Canker | Canker | Gummosis, Canker | Gummosis, Canker |
| NCRP-52 | Canker | Canker | Canker | Gummosis , Canker | Gummosis, Canker |
| NCRP-59 | Canker | Canker | No | Gummosis, Canker | Gummosis, Canker |
| NCRP-53 | Shooty mould | No | Canker | Gummosis | No |
| NCRP-49 | Canker | Canker | Canker | Gummosis , Canker | Gummosis, Canker |
| NCRP-48 | Canker | Canker, gummosis | Canker | Gummosis , Canker | Gummosis, Canker |
| NCRP-50 | Canker | Canker | Canker | Gummosis , Canker | Gummosis, Canker |
| NCRP-47 | Canker | Canker | Canker | Gummosis , Canker | No |
| NCRP-46 | Canker | Canker | Canker | - | Gummosis, Canker |
| NCRP-57 | No | Canker | NO | Gummosis | No |
| NCRP-60 | - | - | Canker | Gummosis , Canker | - |
| NCRP-55 | - | - | - | Gummosis , Canker | Gummosis, Canker |
| NCRP-56 | - | - | - | Gummosis , Canker | Gummosis, Canker |
| NCRP-107 | - | - | - | Gummosis , Canker | - |
| NCRP-108 | - | - | - | Gummosis , Canker | - |
| Seedling | Canker | - | - | Gummosis , Canker | - |

3.2 *IN VITRO* SHOOT TIP GRAFTING

Eradication of systemic pathogens from mother plants is necessary to produce healthy planting materials and also to facilitate the movement of plant materials across international boundaries. The therapeutic chemicals capable of eradicating virus from infected citrus plants are not readily available. One of the methods to recover virus free *Citrus* plants is the use of nucellar seedlings from polyembryonic cultivars. The limitation of this method is that nucellar plants have juvenile characters. The apical meristems in the infected plants may generally either be virus free or carry a very low concentration of the viruses. However, in woody species especially in citrus, meristem culture is often impossible. Micro grafting is the best available technique to recover pathogen-free *Citrus* plants. In this technique, the shoot tips are grafted onto a virus free seedling rootstock maintained and propagated *in vitro*.

Seeds of rough lemon (*Citrus jambhiri*) were sterilized by immersion with 70% ethanol for one minute followed by 4% sodium hypochlorite solution for three minutes. The seeds were rinsed with sterile distilled water for three times. The sterilized seeds were individually cultured in test tubes containing 20 ml of MS medium solidified with 7 gram plant agar. The tubes were wrapped with black cloth and incubated about 23^o C for 4 weeks. The shoot tips were excised from *in vivo* germinated green house grown nucellar seedlings of mandarin. The shoot tips were sterilized by detergent for 1 minute followed by 5% sodium hypochlorite solution for five minute. The shoot tips were rinsed with sterile distilled water for three times. *In vitro* germinated seedlings were removed from the test tube under aseptic conditions and decapitated, leaving about 3 cm of the epicotyl. Cotyledons and axillary buds were removed and the root was cut to a length of 5-6 cm. Then, apical meristem of about 0.5mm was excised with a razor blade under binocular microscope and the shoot tip was placed at the top of the decapitated seedling rootstock. Filter paper bridge perforated in its center for insertion of root portion of the rootstock was inserted into test tubes. 25 ml liquid MS medium containing 40 g sucrose was distributed into test tubes and sterilized in autoclave. The grafted plants were cultured in a liquid medium and kept at 20-24^oC with 16-hour light condition for 6 weeks. Grafting was performed on the 4th week of Baisakh. Successful grafted plants were transferred into sterile soil after seven weeks. The plants were covered with polyethylene bags and the size of ventilation was enlarged 2 weeks for acclimatization.

Bud initiation was observed 2 weeks after grafting. Three to four expanded leaves arose four to 6 weeks after grafting. Successful grafting percentage and acclimatization percentage was calculated. Out of 80 grafted seedlings, 30 (37%) grafted plants were recovered and 17 (45%) grafted plants were successfully acclimatized. The acclimatized plants were kept under green house.

3.3 *IN VITRO* MULTIPLICATION OF LARGE CARDAMOM

Decline of large cardamom due to infestation of virus, introduction and spread of such diseases through saplings to new production areas has been identified as major constraints for large cardamom cultivation. Chhirke and Phurke diseases of cardamom are also spreading to cardamom production pockets of eastern hills. Seedlings of large cardamom are not true to type due to cross pollination behavior of the crop. Despite this disadvantage development agencies are advocating for seedling plants as they are considered free of viral diseases like Phurke and Chirke. Saplings produced from micro-propagation will be true to type and free from diseases. Hence, laboratory experiment was carried out at NCRP, Dhankuta to develop economically viable protocol for micro-propagation of large cardamom.

In vitro multiplication of large cardamom were initiated by using new suckers in third week of Baisakh. The outer leaves were removed and washed in tap water for 10 minutes. The suckers were treated with Tween 20 for 20 minutes. The shoots were sterilized by 70% alcohol for 1 minute followed by 0.05 % mercury chloride solution for 20 minutes and rinsed 3 times with sterile distilled water. The explants were prepared removing the basal portion and outer skin. The prepared explants were cultured individually in culture jars containing sterile MS medium supplemented with 30 gram sucrose, 7 gram plant agar. The cultures were incubated in 24^o C at 16 hours light period for 4 weeks. Successfully established (uncontaminated) cultures were used for further experiments.

Above mentioned explants were cultured in solid MS media supplemented with different concentrations of 6-benzyle amino purine (BAP) and naphthalene acetic acid (NAA) as given in Fig 5. There were 7 replications and a jar containing single explant served as a replication. Sub-culture was done in every 4 weeks and final count of axillary shoot was done after 25 days of fourth sub-culture. The best proliferation rate (12 shoots/explant) was produced in the culture containing BAP 6 mg + NAA 0.2 mg per litre of medium (Fig 5). BAP @ 6 mg/lit of medium without NAA produced second best proliferation rate (11 shoots/explant).

A number of experiments like effect of type of sucrose, water, media strength, media type and acclimatization and nursery establishment will be carried out next year for final recommendation of economically viable micro-propagation protocol.

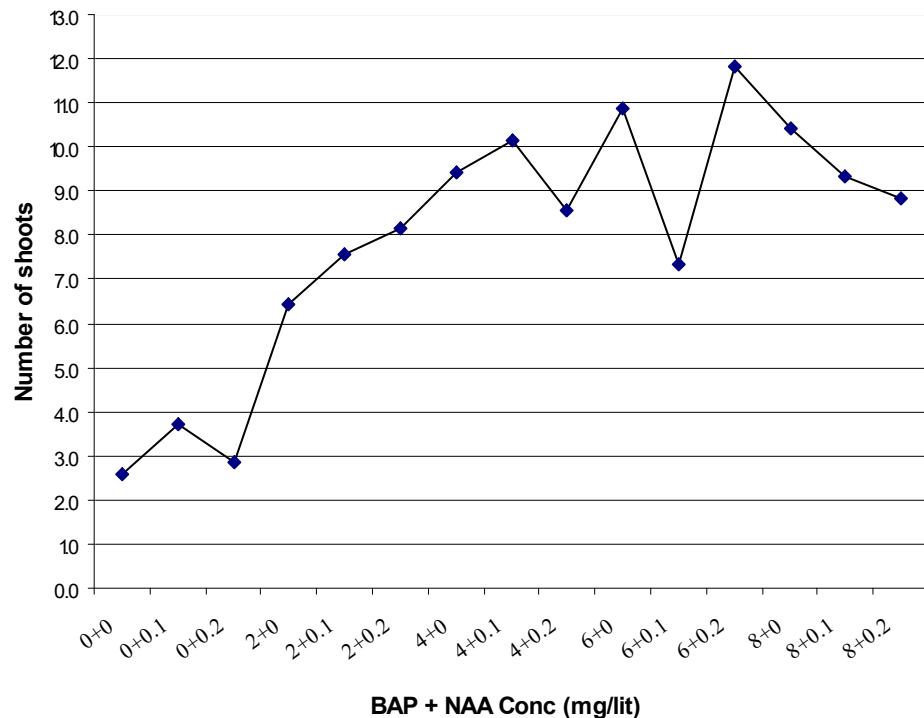


Fig 5. Effect of different concentration of BAP and NAA on shoot multiplication rate of large cardamom

3.4 GERmplasm MAINTAINANCE AND PRODUCTION

3.4.1 Germplasm Maintenance

Germplasm of several types of citrus and other fruit tree were collected locally and from abroad in the past. These germplasm were maintained with recommended practices at Paripatle and Chungbang farm during reporting period. A total of 3700 trees are being maintained at Paripatle and 500 trees at Chungbang. These germplasm are utilized for (i) as mother stock for sapling production (ii) as research materials for superimposed study (iii) source of rootstocks and (iv) *in situ* conservation (field gene bank). List of germplasm maintained at NCRP are presented in Table 29.

Table 29. Citrus and other fruit germplasm maintained at NCRP

| Name of species | Variety/type | Age | No. |
|--|---------------------------------------|-------|------|
| Mandarin (<i>Citrus reticulata</i>) | 1. Khoku collection | 30 | 1700 |
| | 2. Collection from 10 districts | | |
| | 3. Kinnow | 20 | 400 |
| | 4. Unshu | 15 | 250 |
| | 5. Murkott | 3 | 10 |
| Sweet orange (<i>Citrus sinensis</i>) | 1. Dhankuta local | 10-25 | 1135 |
| | 2. Washington Navel | 15-25 | 70 |
| | 3. Mosambi | 25 | 5 |
| | 4. Pineapple | 25 | 5 |
| | 5. Samauti | 25 | 2 |
| | 6. Valencia late | 25 | 3 |
| | 7. Malta Blood Red | 25 | 3 |
| | 8. Ruby | 25 | 3 |
| | 9. Jaffa | 25 | 2 |
| | 10. Hamling | 25 | 2 |
| | 11. Navelencia | 25 | 1 |
| | 12. Seville Common | 25 | 3 |
| | 13. Vanelle | 25 | 1 |
| | 14. Lue Gim Gung | 20 | 1 |
| | 15. White Taker | 20 | 1 |
| Lime (<i>Citrus aurantifolia</i>) | 1. Terathum local | 20 | 200 |
| | 2. Collection from different district | 2 | 100 |
| Lemon (<i>Citrus lemon</i>) | 1. Hill-lemon (Nibuwa) | 20 | 5 |
| | 2. Ureka | 2 | 50 |
| Citron (<i>Citrus medica</i>) | 1. Local | 20 | 2 |
| Calamondin (<i>Citrus mitis</i>) | - | 3 | 3 |
| Trifoliate orange (<i>Poncirus trifoliata</i>) | - | 10 | 250 |
| Rangapur lime (<i>Citrus limonia</i>) | | 11 | 1 |
| Rough lemon (<i>Citrus jambhiri</i>) | Local | 20-25 | 10 |
| Citrangle (Carizo and Tryor) | | 10 | 5 |
| Boxifolia (<i>Severiana boxifolia</i>) | | 5-10 | 5 |
| Rose | Different | 20 | 12 |

3.4.2 Fruit Fly Management

Fruit flies are the most serious citrus insect pest of eastern hills. The insect was first reported from Bhojpur district about 25 years ago. Presently, it is distributed in most hill districts of eastern development region. Integrated techniques of control which include use of methyl euginol for male annihilation, cover spray of insecticide and soil treatment with malathion dust was used in the past. This technique has been used by this research station inside the research farm and also by extension people in farmers' field since many years. But the yield losses due to fruit flies has not decreased rather intensity of losses and fruit flies affected area is increasing every year. In recent years, fruit losses due to fruit flies has also been reported

from Syanja and Bangung. Several species of fruit flies are known to attract citrus fruits. The major citrus pest fruit fly species and their distribution region is presented in Table 30.

Population monitoring

Since oriental fruit fly is one of the pest of citrus crops commonly found in this region (Table 30) it's population was monitored using Feromin traps at research farm of NCRP, Dhankuta (1300 m altitudes). In each trap 5 ml malathion and 5 ml methyl euginol was used and there was one trap per 10 trees. Every week the number of male flies entrapped inside the trap were counted and removed. Fresh methyl eugenol and malthion were added at every 15 days interval.

The data on monitoring of fruit flies at NCRP (1350 m) farm and months of the year are presented in Fig 6. It is clearly observed that number of male flies entrapped tended to increase gradually from Baisakh to Bhadra and then dropped down.

Table 30. Flies of citrus fruit crops and their geographical distribution.

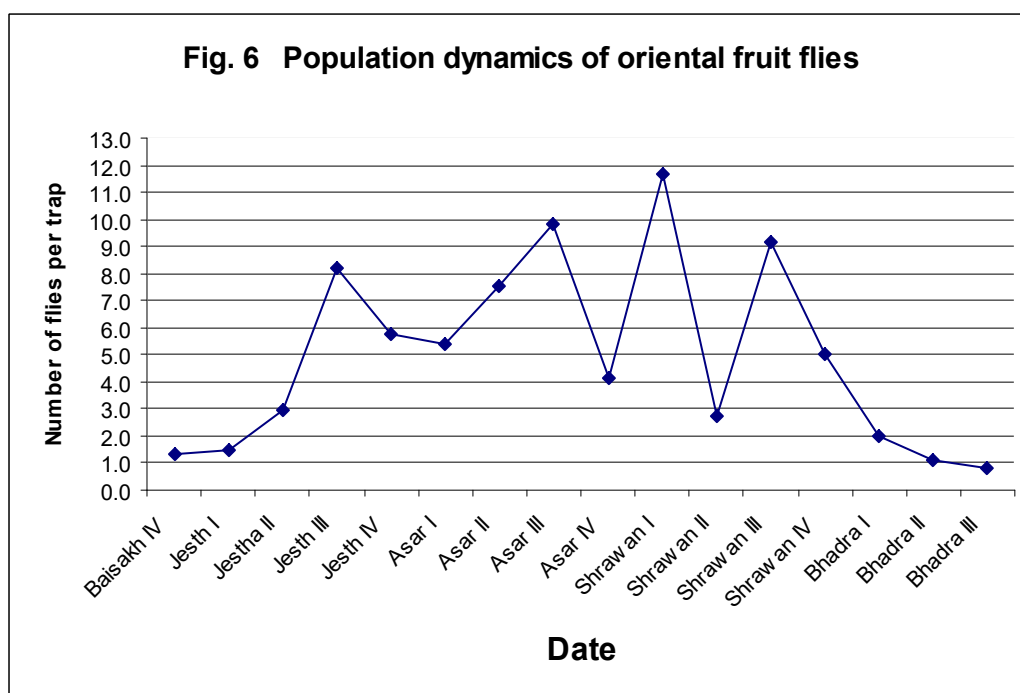
| SN | Common name | Scientific name | Distribution |
|----|---------------------|-----------------------------|---|
| 1 | Oriental fruit fly | <i>Bactrocera dorsalis</i> | Bhutan, China, India, Myanmar, Thailand, Hawaii, Guam, Nepal |
| 2 | Chinese citrus fly | <i>Bactrocera minax</i> | Bhutan, China, India (Sikkim & W. Bengal), Nepal (?) |
| 3 | Japanese orange fly | <i>Bactrocera tsuneosis</i> | China, Japan, Taiwan, Vietnam |
| 4 | Mediterranean fly | <i>Ceratis capitata</i> | Africa, Mediterranean countries, Hawaii, Australia, Central and South America |
| 5 | Mexican fly | <i>Anastrepha ludens</i> | Central America, North America (Texas) |

Yield loss assessment

A total of 30 sweet orange trees were randomly selected for yield loss assessment. Fruits affected by fruit flies started to turn yellow color from third week of Bhadra. Fruits showing pre-matured yellow color were collected in weekly interval from second week of Aswin to third week of Mangsir. These fruits were cut and fruit fly maggots were inspected. Percentage of fruits affected by fruit flies was calculated. Nearly 90 percent of the sweet orange fruits were affected by fruit flies and were unmarketable (Table 31)

A survey was also carried out at Dhankuta municipality areas to assess the fruit losses caused by fruit flies and to collect other information related to this insect. From direct observation and interview with the farmers it was found that citrus growers are not educated properly about the integrated control measure of fruit fly. Most farmers do not understand the life cycle of fruit fly, which is very necessary to manage it. Sanitation of fruit fly affected fruits (regular collection of affected fruits and burying them in pit) was completely lacking in farmers' orchards. Farmers were selling affected fruits in the market, which could cause further spreading of this pest in new areas. There was also lack of coordination among the growers of close vicinity in fruit fly control activity. For example all the growers of a locality were not applying control measures. Among the Citrus species grown in Dhankuta district hill lemon (Nibuwa), sweet orange and Bhale Junar (sweet orange x pummelo?) were found most severely affected by fruit flies. Farmers also informed that fruit flies have also started to infest mandarin fruits in recent years. According to farmers more than 90% of sweet orange

fruits are affected by fruit flies. Therefore, farmers started to cut down sweet orange trees for replacing them by mandarin.



Identification of species

Despite several years of effort to control fruit flies through male annihilation using methyl euginol and affected fruits sanitation tactics, fruit losses of sweet orange did not decrease at NCRP farm. Since last three years even mandarin fruits are being damaged (about 15%) by the flies. It indicated that the fly that is affecting citrus fruits in eastern hills could be other than oriental fruit fly (*Bactrocera dorsalis*). Therefore, an attempt was made rearing adult flies from the maggots of affected fruits for identification. Affected fruits of sweet orange, mandarin and lemon were collected on 6th of Kartik. These fruits were put separately in plastic trays filled with soil. The trays were then covered by insect net and kept inside glass house. Light watering was done from time to time to keep the soil slightly moist. The flies started to emerge from first week of Baisakh. The flies were collected, killed with ethyl acetate vapor and dry mounted specimen were prepared. Some of the live flies were sent to Entomology Division for further rearing and identification. The reared flies were compared with those captured inside methyl euginol and cue lure traps. 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 flies reared from affected fruits of sweet orange, mandarin or lemon were similar types (Fig 7). The body size and body and wing patterns were very similar to that of reference picture of Chinese citrus fly (*Bactrocera minax*). It was much bigger than those captured in methyl euginol (oriental fruit fly ?) and cue lure (melon fly ?) (Fig 8).

As mentioned earlier several species of fruit flies are known to attack citrus fruits. Among them, according to literature oriental fruit fly and Chinese citrus fly are the major citrus pests of this geographical region (south east China, Myanmar, north east India, Bhutan).

Identification of species is the major component of fruit fly management programme. However, research based information about the types of fruit flies that are affecting citrus fruits in eastern hills of Nepal is lacking both in national and international literatures. The present study strongly indicates that Chinese citrus fly (*Bactrocera minax*) is the fruit fly species affecting the citrus fruits of NCRP, Dhankuta and vicinity areas but not the oriental fruit fly.

Table 31. Weekly record of fruit fly affected sweet orange fruits (number) in 2062 (2006)

| Tre # | A-II | A-III | A-IV | K-I | K-II | K-III | K-IV | M-I | M-II | M-III | Tot aff | Tot unaff | Total | % affected |
|-------|-------|-------|------|------|------|-------|-------|-------|------|-------|---------|-----------|---------|------------|
| 1 | 3.0 | 6 | 28 | 109 | 47 | 46 | 19 | 45 | 57 | 217 | 577 | 122 | 699 | 82.5 |
| 2 | 2.0 | 5 | 10 | 43 | 24 | 23 | 17 | 18 | 47 | 101 | 290 | 35 | 325 | 89.2 |
| 3 | 0.0 | 4 | 12 | 22 | 28 | 34 | 15 | 25 | 40 | 92 | 272 | 55 | 327 | 83.2 |
| 4 | 2.0 | 2 | 11 | 21 | 28 | 17 | 10 | 20 | 33 | 103 | 247 | 63 | 310 | 79.7 |
| 5 | 2.0 | 3 | 19 | 2 | 14 | 22 | 18 | 17 | 30 | 72 | 199 | 24 | 223 | 89.2 |
| 6 | 0.0 | 1 | 24 | 33 | 11 | 17 | 19 | 21 | 14 | 111 | 251 | 59 | 310 | 81.0 |
| 7 | 1.0 | 11 | 23 | 25 | 32 | 20 | 14 | 13 | 20 | 95 | 254 | 39 | 293 | 86.7 |
| 8 | 7.0 | 2 | 10 | 14 | 42 | 16 | 10 | 24 | 22 | 56 | 203 | 39 | 242 | 83.9 |
| 9 | 2.0 | 6 | 39 | 28 | 31 | 8 | 13 | 10 | 21 | 68 | 226 | 126 | 352 | 64.2 |
| 10 | 1.0 | 7 | 21 | 35 | 8 | 14 | 12 | 20 | 19 | 57 | 194 | 123 | 317 | 61.2 |
| 11 | 0.0 | 7 | 40 | 22 | 20 | 14 | 9 | 11 | 26 | 0 | 149 | 10 | 159 | 93.7 |
| 12 | 6.0 | 10 | 71 | 53 | 25 | 29 | 27 | 25 | 72 | 0 | 318 | 23 | 341 | 93.3 |
| 13 | 8.0 | 11 | 70 | 52 | 26 | 25 | 25 | 19 | 49 | 0 | 285 | 24 | 309 | 92.2 |
| 14 | 2.0 | 17 | 183 | 66 | 25 | 27 | 19 | 30 | 67 | 0 | 436 | 29 | 465 | 93.8 |
| 15 | 0.0 | 3 | 125 | 35 | 13 | 26 | 10 | 29 | 29 | 0 | 270 | 9 | 279 | 96.8 |
| 16 | 13.0 | 4 | 214 | 22 | 17 | 21 | 10 | 21 | 31 | 0 | 353 | 18 | 371 | 95.1 |
| 17 | 1.0 | 7 | 81 | 71 | 28 | 19 | 18 | 26 | 24 | 0 | 275 | 12 | 287 | 95.8 |
| 18 | 3.0 | 6 | 85 | 42 | 49 | 21 | 19 | 17 | 32 | 0 | 274 | 19 | 293 | 93.5 |
| 19 | 3.0 | 17 | 71 | 26 | 30 | 17 | 14 | 33 | 28 | 0 | 239 | 19 | 258 | 92.6 |
| 20 | 2.0 | 11 | 76 | 32 | 13 | 22 | 16 | 15 | 59 | 0 | 246 | 47 | 293 | 84.0 |
| 21 | 1.0 | 21 | 196 | 49 | 31 | 16 | 13 | 18 | 17 | 0 | 362 | 5 | 367 | 98.6 |
| 22 | 7.0 | 22 | 210 | 35 | 18 | 21 | 32 | 19 | 17 | 0 | 381 | 7 | 388 | 98.2 |
| 23 | 2.0 | 25 | 180 | 25 | 25 | 22 | 12 | 14 | 7 | 0 | 312 | 19 | 331 | 94.3 |
| 24 | 4.0 | 10 | 200 | 32 | 30 | 17 | 22 | 22 | 37 | 0 | 374 | 6 | 380 | 98.4 |
| 25 | 30.0 | 23 | 413 | 64 | 20 | 19 | 19 | 12 | 0 | 0 | 600 | 27 | 627 | 95.7 |
| 26 | 2.0 | 2 | 188 | 11 | 10 | 7 | 15 | 14 | 5 | 0 | 254 | 12 | 266 | 95.5 |
| 27 | 5.0 | 17 | 179 | 21 | 22 | 8 | 18 | 11 | 27 | 0 | 308 | 10 | 318 | 96.9 |
| 28 | 4.0 | 17 | 99 | 21 | 13 | 18 | 11 | 14 | 28 | 0 | 225 | 18 | 243 | 92.6 |
| 29 | 5.0 | 24 | 78 | 6 | 7 | 2 | 1 | 6 | 0 | 0 | 129 | 25 | 154 | 83.8 |
| 30 | 1.0 | 6 | 58 | 1 | 9 | 6 | 0 | 0 | 0 | 0 | 81 | 17 | 98 | 82.7 |
| Total | 119.0 | 307 | 3014 | 1018 | 696 | 574 | 457 | 569 | 858 | 972 | 8584 | 1041 | 9625.00 | 2668.20 |
| Mean | 4.0 | 10.2 | 100 | 33.9 | 23.2 | 19.1 | 15.23 | 18.97 | 28.6 | 32.4 | 286.1 | 34.7 | 320.83 | 88.94 |

Note:

A = Aswin; K= Kartik , M= Mangsir

I, II, III = weeks of the months

Tot aff = total affected fruits

Tot unaff = Total unaffected fruits

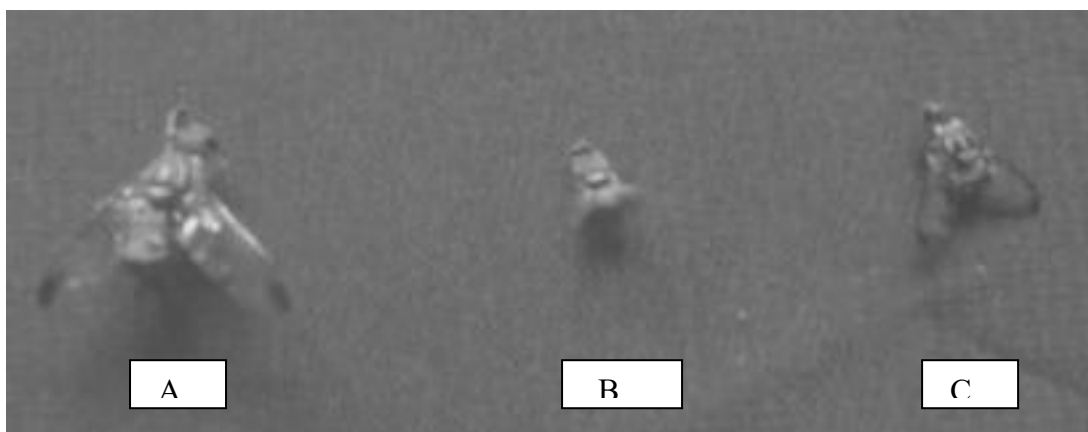
Recently concluded research project in Bhutan (supported by ACIAR, Australia) confirmed that the Chinese citrus fly is the devastating pest of the mandarin industry in Bhutan, with estimated losses up to 80 percent and averaging around 20 percent every year. This research carried out in Bhutan revealed some of the aspects of this insect as given below:

- Although the Chinese citrus fly is a member of the family of fruit flies, its biology is quite peculiar in few aspects
- The fly has one generation per year and employs two rest periods (rather than only one in most other tephritid species): both as pupa in soil and as egg in fruit.

- The female's long ovipositor enables it to lay eggs in the pulp rather than in the peel of citrus fruits (where most other tephrotid flies oviposit), thus avoiding contact of eggs with toxins in the skin.
- The fly oviposits early in the fruit development season i.e. mid June to mid July (rather than during physiological fruit ripening period in case of other species).
- The development of eggs into active maggots took one to four months, in October and November maggots started feeding and induced early ripening and pre-matured fruit drop.
- The use of early to mid-season protein bait sprays and/or targeted use of systemic insecticides during the month of oviposition period, plus the removal of fallen fruits once every 10 days, are recommended as control measures in Bhutan.



Fig 7. Fruit flies reared from affected sweet orange and mandarin fruits (*Bactrocera minax* ?)



4.4.3 Monitoring of citrus diseases and insects

Major insects pests and diseases of citrus fruit crops were monitored and recorded round the year (Table 32) Among the insects noted fruit fly, scales, aphids were causing more economic loss to citrus fruits. Similarly, Foot and root rot, powdery mildew, shooty mould and nutrient deficiency were major diseases noted.

Table 32. Major citrus insect pests found at NCRP in 2062/63

Fig 8 Comparative size and body pattern of fruit flies (A) reared from affected fruit (B) collected from methyl euginol trap and (C) collected from cue lure trap

| Name of insects | Time of occurrence | Crop affected | Damage |
|-------------------------------------|--|---|---------------|
| 1. Fruit fly | Baisakh to Bhadra | Sweet orange, lemon, Bhale Junar | High |
| 2 Scales (red, purple, brown, soft) | Whole year | Sweet orange, mandarin, trifoliolate orange | High |
| 3. Green stink bug | Shrawan – Bhadra | All citrus | Medium |
| 4. Aphids | Phalgun -Asar. Also causing shooty mould | All citrus mainly in nursery and small plants | High |
| 5. Leaf minor | Jestha-Shrawan. In third flush growth | All citrus | Medium |
| 6. Stem Borer | Whole year | Seedling/saplings of lemon and lime and mature plants of eureka lemon | Medium |
| 7. Lemon butter fly | Chaitra – Asar | Seedlings/saplings of all citrus plants | Medium |
| 8. Shoot borer | Chaitra – Asar | Lime and lemon seedlings | High |
| 9. Rose beetle | Baisakh-Jestha | Sweet orange and small plants of all species | High |

Table 33. Calendar of operation adopted at NCRP, Dhankuta for germplasm maintenance.

| Months | Operation |
|----------------|---|
| Shrawan | Weeding in citrus orchard. Transplanting of rootstock seedling (Trifoliolate) in the main nursery block. Removed diseased, new suckers and dry branches. Spray Insuf @ 2g/L of water for the control of powdery mildew Maintenance of Feromin traps |
| Bhadra | Weeding in citrus orchards and nurseries Application of ATSO mineral oil @ 5ml/L of water to control scale insects. Application of insecticides for the control of green stinkbug. Drenching off the plant affected with root rot by Bordeaux mixture |
| Aswin | Collect trifoliolate seeds for root stock production. Cover spray with malathion + molasses in sweet orange orchards for fruit fly control. Application of insecticides for the control of green stinkbug Weeding and mulching in the orchards Stacking of heavily fruiting branches Collect fruit fly infected sweet orange fruit and burry into pits |
| Kartik | Collect fruit fly infected sweet orange fruit and burry in pits Prepared new nursery bed and sow trifoliolate seed for next year production. Harvesting of early maturing varieties. |
| Mangsir | Harvesting of mid-season varieties Grafting for sapling production |
| Poush | Harvesting of mid-season varieties Grafting for sapling production |
| Magh | Harvesting of late season varieties; pruning and training; Fertilizer and manure application.; ATSO spray to control scale insects |
| Phalgun | ATSO spray to control scale insects; fertilizer and manure application. Foliar spray micronutrient. Insecticide spray in nursery plants to control leaf minor Irrigation application in orchards and nursery |
| Chaitra | Irrigate the orchard and nursery bed Uproot the diseased and very old unproductive trees and prepare pits for new plantation |
| Baisakh | Irrigate the orchard and nursery bed Uproot the diseased and very old unproductive trees and prepare pits for new plantation |
| Jestha | Make a drainage system in the orchard. Prepared the nursery bed for rootstock transplanting. Prepare compost for next year Application of chemical fertilizers |
| Asar | Spraying with sulfur containing fungicide to control powdery mildew. Transplant rootstocks for next year sapling. Distribution of healthy saplings to farmers. |

4.4.4 Production of horticultural commodities

Table 34. Production of saplings and vegetable seeds (2062/63)

| Commodity | Unit | Variety | Target | Production |
|--------------------------|------|-------------------|--------------|---------------|
| A. Vegetable seed | | | | |
| 1. Radish | Kg | Mino early 40days | 50.0 | 27.25 |
| | Kg. | 40-days | 30.0 | 32.00 |
| 2. Bean | Kg | Trisuli | 0.0 | 17.00 |
| 3. BL Mustard | Kg. | Tankhuwa | 30.0 | 13.00 |
| 4.. Cauliflower | Kg | KTM Local | 0.0 | 4.00 |
| | Kg | Kibogiant | 0.0 | 2.60 |
| Total | | | 130.0 | 108.85 |

Table 35 Sapling production and sale in 2062/63

| Crop | Variety | Target (no) | Production (no) | Sale (no) |
|-----------------|---------------|----------------|--------------------|--------------|
| 1. Mandarin | Khoku | 1200 | 4050 | 5435 |
| | Murkotte | 400 | 300 | 300 |
| | Okitsu Wase | 500 | 300 | 300 |
| | Kinnow | 1000 | 1100 | 1066 |
| 2. Sweet Orange | W. Navel | 200 | 200 | 400 |
| | Valencia late | 200 | 250 | 409 |
| 3. Acid Lime | Tarathum | 1000 | 3734 | 3734 |
| 4. Muntala | Round | 100 | 150 | 22 |
| 5. Rose | Different | 500 | 500 | 577 |
| Total | | 5100 | 10584 | 12243 |

4. APPENDICES

Appendix 1. List of staff at NCRP, Dhankuta in FY 2062/63

| S.N. | Name | Designation | Qualification | Remark |
|------|------------------------------|---------------------------|----------------|-----------|
| 1. | Dr. Krishna Prasad Paudyal | Coordinator (S4) | Ph.D. (Hort.) | |
| 2. | Mr. Ram Lal Shrestha | Senior Tech. Officer (T7) | M. Sc. (Hort.) | |
| 3. | Mr. Hari Prasad Subedi | Technical Officer (T7) | B. Sc. Ag. | |
| 4. | Mr. Basant Chalise | Technical Officer (T6) | B. Sc. Ag. | |
| 5. | Mr. Rit Raj Bhattarai | Technical Officer (T6) | JTA Training | |
| 6. | Mr. Khagandra Prasad Niraula | Accountant (A5) | B. Com. | |
| 7. | Mr. Tara Bahadur Khatri | Heavy driver (A5) | SLC | |
| 8. | Mr. Bishnu Prasad Adhikari | Technician (T4) | Literate | Chungbang |
| 9. | Mr. Ganga Ram Guragain | Technician (T4) | Literate | Chungbang |
| 10. | Mr. Shyam Ghimire | Administration (A4) | I.A. | |
| 11. | Mr. Man Bahadur Biswakarma | Technician (T3) | Literate | |
| 12. | Mr. Yagya Bahadur Karki | Technician (T3) | Literate | |
| 13. | Mr. Nara Bahadur Tamang | Technician (T3) | Literate | |
| 14. | Mr. Ram Bahadur Darji | Technician (T2) | Literate | |
| 15. | Mr. Amar Bahadur Shrestha | Technician(T2) | Literate | |
| 16. | Mr. Purna Bahadur. Darji | Technician(T2) | Literate | |
| 17. | Mr. Tanka Prasad Timilsina | Technician(T2) | Literate | Chungbang |
| 18. | Mr. Ser Bahadur Tamang | Technician(T2) | Literate | |
| 19. | Mr. Bhabani Prasad Phuyal | Technician(T2) | Literate | |
| 20. | Mr. Jagat Bahadur Karki | Technician(T2) | Literate | |
| 21. | Mr. Buddhi. Man Darji | Technician(T2) | Literate | |
| 22. | Mr. Thir Bahadur Ale | Technician(T2) | Literate | |
| 23. | Mr. Tej Bahadur Darji | Technician(T2) | Literate | |
| 24. | Mr. Hem Bahadur Dahal | Technician(T2) | Literate | |
| 25. | Mr. Man Bahadur Tamang | Technician(T2) | Literate | |
| 26. | Mr. Singh. Bahadur Tamang | Technician(T2) | Literate | |
| 27. | Mr. Ram Prasad Timilsina | Technician(T2) | Literate | Chungbang |
| 28. | Mrs. Suntali Ghising | Technician (T1) | Literate | |

Appendix 2. Manpower situation of National Citrus Research Program in FY 2060/61

| SN | Name of the post | Approved # | Fulfilled # | Vacant # | Remark |
|-------|---|------------|-------------|----------|-------------------------|
| 1. | Chief Scientist (S5) -Soil. | 1 | 0 | 1 | |
| 2. | Senior Scientist (S4)-Horticulture | 1 | 1 | 0 | |
| 2. | Senior Scientist (S3)-Horticulture | 3 | 0 | 3 | |
| 2. | Senior Scientist (S3)-Plant Pathology | 1 | 1 | 0 | Deputation to Belachapi |
| 3. | Scientist (S1) - Soil | 1 | 0 | 1 | |
| 4. | Scientist (S1) – Plt. Breeding (Tissue culture) | 1 | 0 | 1 | |
| 5. | Scientist (S1) - Entomology | 1 | 0 | 1 | |
| 6. | Scientist (S1) – Plant Pathology | 1 | 0 | 1 | |
| 7. | Senior Technical Officer (T7) - Pomology | 1 | 1 | 0 | |
| 8. | Senior Technical Officer (T7) - Olericulture | 1 | 0 | 1 | |
| 9. | Technical Officer (T6) –Pomology | 2 | 2 | 0 | |
| 10. | Technical Officer (T6) - Horticulture | 1 | 1 | 0 | |
| 11. | Senior Technician (T5) | 2 | 0 | 2 | |
| 12. | Technician (T4) | 3 | 3 | 0 | |
| 13. | Technician (T3) | 0 | 0 | 0 | |
| 14. | Technician (T2) | 15 | 14 | 1 | |
| 15. | Technician (T1) | 2 | 2 | 0 | |
| 16. | Typist (A5) | 1 | 1 | 0 | |
| 17. | Accountant (A5) | 1 | 1 | 0 | |
| 18. | Administration Assistant (A4) | 1 | 1 | 0 | |
| 19. | Driver (A5) | 1 | 1 | 0 | |
| Total | | 42 | 34 | 8 | |

Appendix 3: Budget expenditure statement of NCRP in F. Y. 2062/63

| Budget code | Budget Heading | Budget allocated | Released | Expenditure | Balance |
|--------------------|--|-------------------------|------------------|--------------------|------------------|
| 40 JK | Staff Expenses | 2647500.0 | 2647500.0 | 2647174.43 | 352.57.00 |
| 4000 | Staff Basic Salary | 2136000.0 | 2136000.0 | 2135832.00 | 168.00 |
| 4010 | Staff Allowances | 1118000.0 | 111800.0 | 111719.83 | 80.17 |
| 4020 | Provident Fund | 208200.0 | 208200.0 | 208157.60 | 42.40 |
| 4030 | Medical | 0.0 | 0.0 | 0.00 | 0.00 |
| 4040 | Uniform | 15300.0 | 15300.0 | 15300.00 | 0.00 |
| 4050 | Dasain Kharcha | 176200.0 | 176200.0 | 176138.00 | 0.62 |
| 41 JK | Operational Expenses | 782359.0 | 782359.0 | 781128.65 | 1230.35 |
| 4100 | Travel expenses | 115500.0 | 115500.0 | 115416.50 | 83.50 |
| 4110 | Vehicle fuel, lubrication | 66000.0 | 66000.0 | 65999.30 | 0.70 |
| 4120 | Wages to labor | 309900.0 | 309900.0 | 309900.00 | 0.00 |
| 4130 | Laboratory research supply | 41759.0 | 41759.0 | 41758.70 | 0.30 |
| 4140 | Farm supplies | 194000.0 | 194000.0 | 193053.15 | 946.85 |
| 4150 | Books, newspaper, periodicals | 14700.0 | 14700.0 | 14665.00 | 35.00 |
| 4160 | Training and Seminar | 0.0 | 0.0 | 0.00 | 0.00 |
| 4180 | Repair | 40500.0 | 40500.0 | 40336.00 | 164.00 |
| 42 JK | Administrative Expenses | 280200.0 | 280200.0 | 277273.49 | 2926.41 |
| 4200 | Rent, utilities and other services | 116200.0 | 116200.0 | 116171.41 | 28.59 |
| 4210 | Communication expenses | 46000.0 | 46000.0 | 43486.68 | 2513.32 |
| 4220 | Repair and maintenance | 65500.0 | 65500.0 | 65302.50 | 197.50 |
| 4230 | Stationary, printing and office supplies | 27000.0 | 27000.0 | 26864.00 | 116.00 |
| 4240 | Board and panel meeting | 0.0 | 0.0 | 0.00 | 0.00 |
| 4260 | Contingency expenses | 25500.0 | 25500.0 | 25429.00 | 71.00 |
| 4280 | Other administrative budget | 0.0 | 0.0 | 0.00 | 0.00 |
| 43 JK | Capital expenses | 0.0 | 0.0 | 0.00 | 0.00 |
| 4310 | Land | 0.0 | 0.0 | 0.00 | 0.00 |
| 4320 | Building and other construction | 0.0 | 0.0 | 0.00 | 0.00 |
| 4330 | Furniture and fixture | 0.0 | 0.0 | 0.00 | 0.00 |
| 4340 | Equipment, machinery and tools | 0.0 | 0.0 | 0.00 | 0.00 |
| 4350 | Vehicle | 0.0 | 0.0 | 0.00 | 0.00 |
| 4360 | Computer and computer software | 0.0 | 0.0 | 0.00 | 0.00 |
| 4370 | Other fixed assets | 0.0 | 0.0 | 0.00 | 0.00 |
| Grand Total | | 3710059.0 | 3710059.0 | 3705549.67 | 4509.33 |

Appendix 4: Revenue collection at National Citrus Research Program in FY 2062/63

| S.N. | Source of Revenue | Total revenue (Rs.) |
|-------------|--|----------------------------|
| 1. | Horticultural commodity (Fresh fruit, sapling, Veg. seeds etc) | 611530.80 |
| 2. | Miscellaneous (Wood, grass, Amliso etc) | 4860.00 |
| | Total | 616390.8 |

Appendix 5. Top 10 citrus producing countries of the world (2003)

| SN | Name of the country | Production area (Ha) | Production (Mt) | Production share in world (%) | Productivity |
|----|---------------------|----------------------|-----------------|-------------------------------|--------------|
| 1 | Brazil | 9,39,341 | 1,92,15,512 | 18.18 | 20.45 |
| 2 | USA | 4,19,416 | 1,37,71,120 | 13.13 | 30.44 |
| 3 | China | 14,09,700 | 1,25,44,695 | 11.87 | 8.90 |
| 4 | Mexico | 5,23,505 | 64,75,411 | 6.12 | 12.36 |
| 5 | Spain | 3,03,948 | 62,84,153 | 5.94 | 20.67 |
| 6 | India | 2,64,500 | 45,80,000 | 4.33 | 17.31 |
| 7 | Iran | 2,24,600 | 37,03,000 | 3.50 | 19.48 |
| 8 | Italy | 1,75,432 | 31,03,670 | 2.93 | 17.69 |
| 9 | Egypt | 1,43,231 | 25,27,276 | 2.39 | 17.64 |
| 10 | Argentina | 1,46,000 | 24,70,000 | 2.33 | 16.91 |
| | World | 73,12,706 | 10,56,77,706 | - | 14.45 |

Source: FAO, 2004. In: www.faostat.fao.org/faostat. Website of Food and Agriculture Organization on production statistics.

Appendix 6. Meteorological data of NCRP, Paripatle (1300 m)

| Months | Temperature (° C) | | Rainfall (mm) |
|-----------|-------------------|---------|---------------|
| | Maximum | Minimum | |
| January | 19.5 | 6.9 | 1.4 |
| February | 23.2 | 11.6 | 0.0 |
| March | 25.4 | 13.3 | 0.0 |
| April | 28.5 | 18.3 | 4.2 |
| May | 26.5 | 18.6 | 150.4 |
| June | 27.2 | 20.3 | 299.5 |
| July | 26.9 | 21.1 | 321.6 |
| August | 26.7 | 20.9 | 192.3 |
| September | 27.4 | 19.6 | 132.2 |
| October | 26.5 | 17.7 | 1.8 |
| November | 23.7 | 12.0 | 35.6 |
| December | 20.9 | 8.8 | 0.0 |
| | | | 1139 |

