Annual Report

2063/64

Government of Nepal

Nepal Agricultural Research Council

National Citrus Research Program

Paripatle, Dhankuta

2064

4. NTRODUCTION

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 27^0 1' North latitude and 87^0 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 12.4^0 C and 26.78^0 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, Dhanding, 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, trifoliate 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. Trifoliate 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 Feromin 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 eugenal 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 trifoliate 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 10^0 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 veriety 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)
Rootstocks	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 (*Citrus reticulata)*	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 *(Citrus clementina* 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 (*Citrus unshiu*)	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 (*Citrus sinensis)*	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 (*Citrus paradisi*	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. On of such example 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. Trifoliate orange is the only rootstock used in Nepal for propagating citrus fruit trees. Obviously, selection of rootstock(s), which is better than trifoliate orange, has been

realized. Therefore, seeds (25 gm of each variety) of seven different types of rootstocks was 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
Citrange	C-35	Resistant	Tolerant	Acceptable	?	Vigorous
Citrage	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, Unites States of America and China are the leading sweet orange producers of the world. About 30 thousands tons of sweet orange fruits was produced in Nepal in 2006 from 3015 hectare 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 season and production environment. 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 Phenophthalein 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, Sevelle 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 anthocynin 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 (^{0} 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 (±14.9)	31.7 (±2.6)	67.2 (±2.7)	4.8 (±1.4)	39.6 (±3.3)	9.6 (±1.0)	1.3 (±0.2)	7.5 (±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.
Nevelencia	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

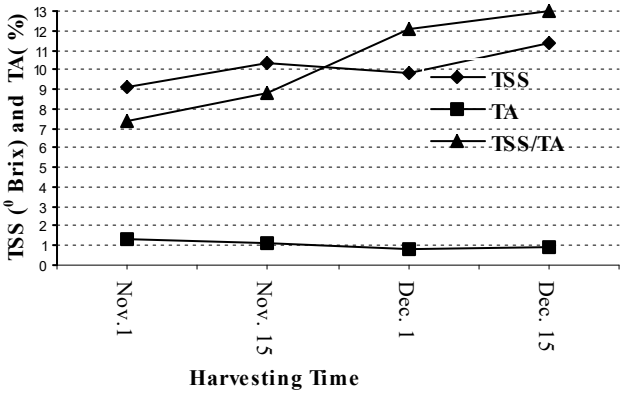
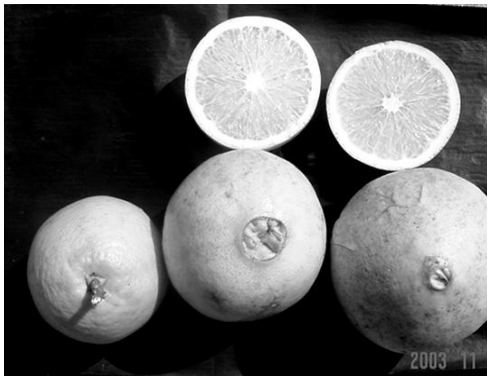


Fig. 2 Seedless fruits of W. Navel sweet orange



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, Sevelle 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

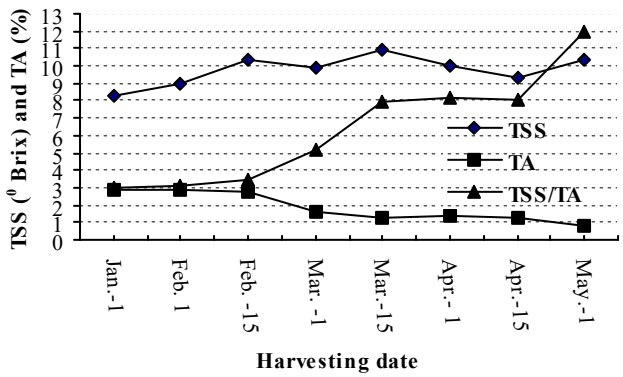


Fig. 4 Overlapping of new bloom and fruit maturity in Valencia sweet orange

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 to11. 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			
60-1	450	357	342	349.5			

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 fist 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 trifoliate 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 'Madrasi 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/fruiting 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 trifoliate 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 have 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 applies 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 Jhapa**	**Pathari Morang**	**Narasingh Sunsari**	**Prembasti Chitawan**	**Thimura 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 c*itrus* 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 23^0 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 20-24^0C with 16-hour light condition for 6 weeks. Grafting was performed on the 4^{th} 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 24^0 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.

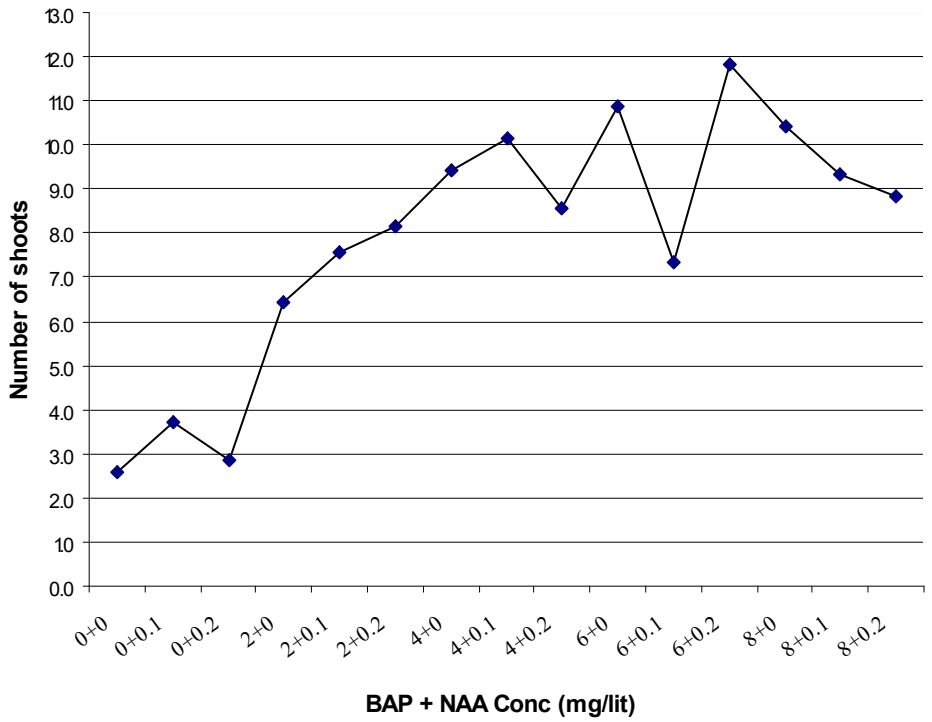


Fig 5. Effect of different concentration of BAP and NAA on shoot multiplication rate of large cardamom

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 garmplasm 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 (*Citrus reticulata*)	1. Khoku collection	30	1700
	2. Collection from 10 districts		
	3. Kinnow	20	400
	4. Unshu	15	250
	5. Murkott	3	10
Sweet orange (*Citrus sinensis*)	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 (*Citrus aurantifolia*)	1. Terathum local	20	200
	2. Collection from different district	2	100
Lemon (*Citrus lemon*)	1. Hilll-lemon (Nibuwa)	20	5
	2. Ureka	2	50
Citron (*Citrus medica*)	1. Local	20	2
Calamondin (*Citrus mitis*)	-	3	3
Trifoliate orange (*Poncirus trifoliata)*	-	10	250
Rangapur lime (*Citrus limonia*)		11	1
Rough lemon (*Citrus jambhiri)*	Local	20-25	10
Citrange (Carizo and Tryor)		10	5
Boxifolia (*Severiana boxifolia*)		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.

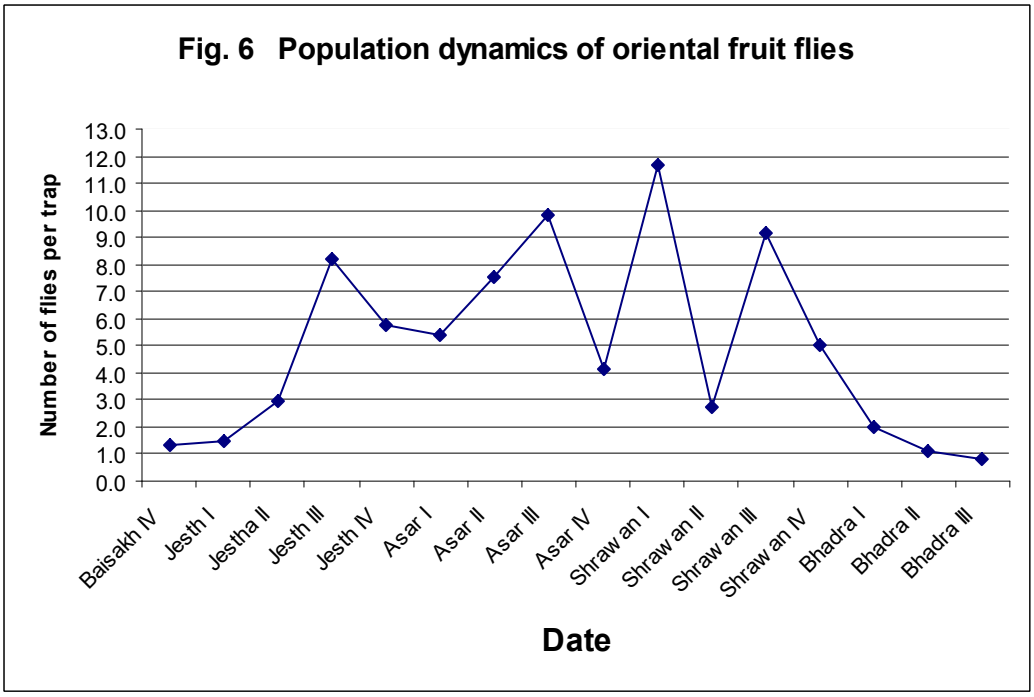
Table 30. Flies of citrus fruit crops and their geographical distribution.

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

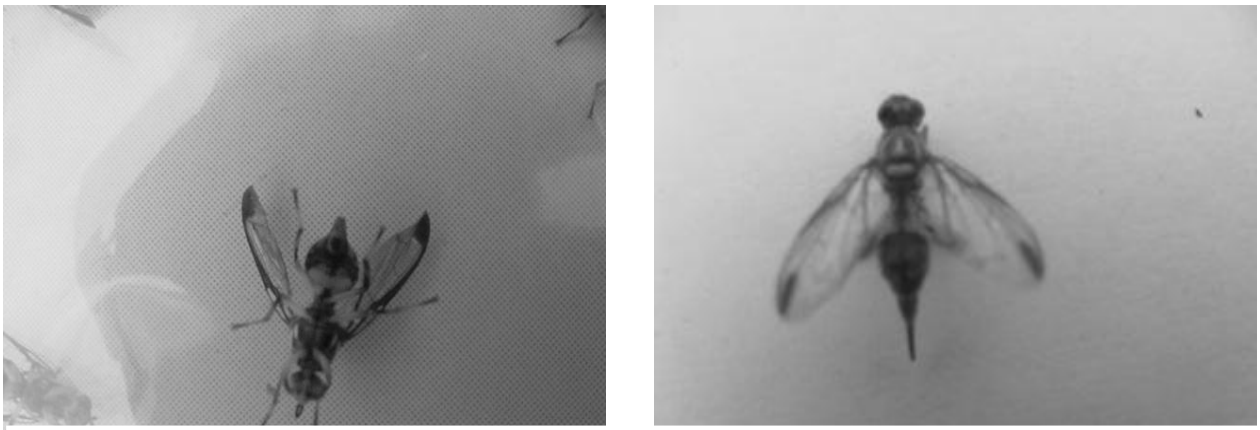
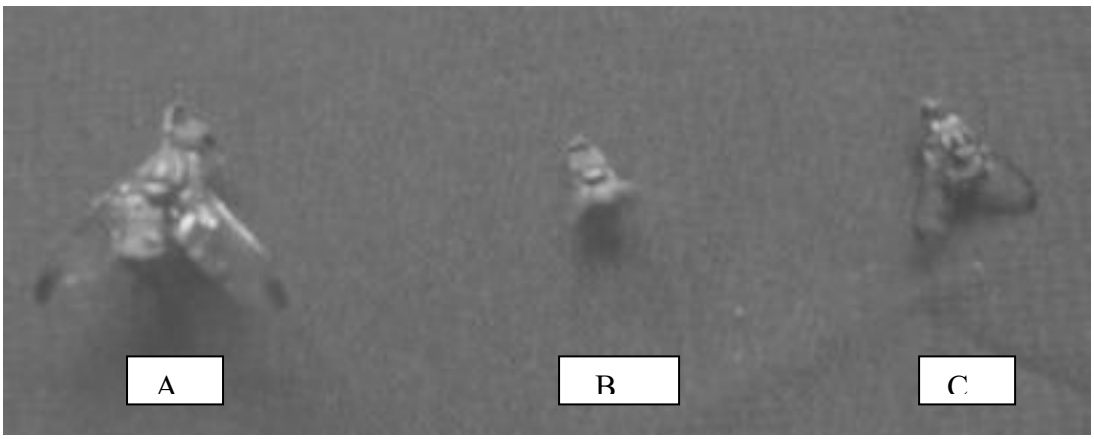


Fig 7. Fruit flies reared from affected sweet orange and mandarin fruits (*Bactrocera minax* ?



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, trifoliate 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 (Trifoliate) 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 trifoliate 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 trifoliate seed for next year production. Harvesting of early maturing varieties.
Mangsir	Harvesting of mid-season varieties Grafting for sapling production
Poush	Harvesting of mid-season varieties Grafting for sapling production
Magh	Harvesting of late season varieties; pruning and training; Fertilizer and manure application.; 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.)	Dept. NARC
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 (^{0} 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