TECHNICAL REPORT

OF NARDF-401

"PRODUCTIVITY IMPROVEMENT OF CITRUS FRUITS THROUGH EFFECTIVE FRUIT DROP MANAGEMENT TECHNIQUE IN THE MID AND FAR WESTERN DEVELOPMENT REGION OF NEPAL"

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FROM 15 JEST 2064 TO 14 JEST 2067

National Citrus Research Program

Paripatle, Dhankuta, 2067

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Prepared By

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Project leader

Project Location: ***Salyan, Dailekh, Kailali and Baitadi districts***

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Productivity improvement of citrus fruits through effective fruit drop management techniques in the mid and far-western development region of Nepal (PP No 401/2006/07)

Abstract

Citrus especially mandarin is one of most important and highly commercial fruits crops grown in the mid hills range from east to west of Nepal. Productivity of citrus fruits in Nepal is very low as compared to western countries. Fruit drops are one of the most important factors, to reduce the productivity of citrus fruits in Nepal. Therefore, to mitigate the dropping of citrus fruits, a project was implemented in the mid and far western development region of Nepal funded by NARDF for three years. In the first year, site selection, survey and identification of the existing situation of citrus orchards was carried out. In thee second and third year, research and development activities was implemented in the project sites. The project was implemented in the major citrus production areas of four districts (Salyan, Kailali, Baitadi and Dailekh) with coordination of District Agriculture Development Offie. Thirty bearing trees were selected and tagged from each site for implementation of activities. Plastic sheets were placed around the tree canopy for recording the dropped fruits. Dropping intensity of mandarin fruits were recorded every 15 days interval during Baisakh to Aswin month from the selected trees of project implemented sites.

On the basis of survey report citrus growing areas ranges on 1150-1550 m als and located 1 to 8 hour distance from the road. The existing situation of citrus orchard in the project implemented sites was, the orchards were planted in marginal land at the edge of the terrace, no plant protection measured, all the orchards in the mid and far western region were seedlings oriented, no manuring and irrigation, nitrogen and organic matter in the soil and plant leaf was very poor. Green string bug is the serious problem in most of the survey sites and major factor of citrus fruit drop. Powdery mildew and root rot were two major fungal disease found in all districts. These diseases will assess to fruit drop. The intensity of fruit drop is 35 to 180 kg depending on the size of the tree and orchard and economic losses was 39.3%. The average percentage of losses due to the fruit dropped in the farmers practices was observed 16.9% whereas in the improved practices was observed 15.5% per tree. Spraying insecticides Roger or Phoskill @ 2ml / L of water in 1st and 2nd nymph stage (June-July) at 15 days interval is effective for the control of green string bug.

Keyword

Fruit drop intensity, organic matter, orchard, economic losses, marginal land, green string bug.

1. Introduction

Citrus is the most important and popular fruits crops of Nepal. It is grown commercially in the mid-hill region of the country stretching from east to west. Mainly three citrus species are grown commercially in Nepal, i.e. Mandarin (*Citrus reticulala*), Sweet Orange (*Citrus sinensis*) and Llime (*Citrus aurantifolia*). These species are widely grown in 49 districts at wide altitudinal range from 600-1400 meter (asl). The total cultivated area under citrus in Nepal is 26,681 ha and the production is around 171,875 tons with an average productivity is 10.4 ton /ha (MOAC, 2008). The productivity of citrus fruits in Nepal is three times lower as compared to 35 tons per ha, in USA and Brazil 20.4 ton /ha. (FAO, 2004). The western part of the country has less productivity 10.1 t/ha than east 11.35 t/ha. Western hills (Mid and Far-western region) shares about 20.1 % (3,082 ha) of total citrus area of the country but due to low productivity, its share on total citrus production is only 18.3% (300,037 mt). According to MOAC (2006) citrus fruit crops (bearing trees) are cultivated in 1,717 and 1,365 hectares of area in mid and far-western region respectively. It is estimated that presently 515,000 trees in mid-western and 410,000 trees in far-western region (300 trees/ha) are at bearing stage. On this basis it can be estimated that nearly 18,000 households of these regions earn their cash income from citrus cultivation. Among three species Mandarin is covered about 60% area of the country. It is a priority cash generating commodity in mid-hill farmers of Nepal and its area and production are increasing trend. High qualities of citrus fruits are produced in Nepal (Roistacher, 1996) and have great potential for

export (Gurung, 2003). In the context of WTO, interring into the international market needs very high quality products with low production costs owing to tough competition among the producers. Therefore, improvement of productivity through proper technological intervention can help to increase the family income of citrus growers of western Nepal. Western Nepal has tremendous scope for increase the commercial citrus cultivation due to congenial climate, close to big Indian markets like Lucknow, Delhi, Deharadun etc. and opening of south-north feeder roads. To exploit this opportunity and meet the main goal of 10^{th} Plan – poverty reduction, productivity of citrus fruit should be improved in the regions. High level of pre-harvest fruit drops has been reported as one of the factors causing low productivity of citrus in Nepal (CDS, 2060 ; Pradhan and Miya, 2004). Adhikari (2001) reported about 50% fruit drops in Salya, Dailekh and Dadeldhura districts. Yield losses due to fruit drop has also been reported by farmers of western Nepal through Regional Technical Working Group meeting at Nepalgunj (organized by NARC) and Dhangadi (organized by Crop Diversification Project). Hence, this project will address the fruit drop problem faced by the farmers of mid and far-western regions through identification of location specific fruits drop reason(s) and demonstration of appropriate mitigation technologies together with technological empowerment of citrus growers on these aspects.

Table 1. Area and Production of Citrus fruits in Nepal.

SN	Description	Mandarin	Sweet orange	Lime	Lemon	Others	Total
1.	Total area covered (Ha)	17494 (60.8%)	5524 (20.6%)	4183 (15.2%)	600 (2.5%)	179 (0.7%)	26681
2.	Productive area (Ha)	9641 (58.4%)	3072 (20.5%)	2439 (16.5%)	551 (3.5%)	129 (0.9%)	15823
3.	Production (Ton)	109277 (61.6%)	36736 (22.9%)	20492 (12.3%)	4343 (2.4%)	1027 (0.72%)	171875
4.	Productivity (Ton/ha)	11.3	11.9	8.4	7.8	8.3	10.8

Source: MOAC Report, 2008.

Note: Other include sweet lime, citron, Pommelo, rough lemon. Productive area includes area of bearing trees only.

FRUITS DROP

Fruits drop is a complex problem caused by several factors and it is one of the major problems of citrus industries in all over the world. Citrus species has bisexual flower and heavy flowering. All the flowers could not set the fruits up to harvesting stage. According to the species degree of fruit setting is varies. Generally citrus species takes 8-9 month for maturity. Dropping of flowers and fruits are starts from flowering up to harvesting. Dropping will be continuing but degree of dropping may vary according to development stage. Sometimes farmers are facing high economic losses.

1. Natural fruit drop

Profuse flowering was observed in most of the fruit trees but the trees retain the load only it can support and rest of the flower and fruits are dropped. Dropping will be starts from flowering up to harvesting. In the early stages the size of fruit is very small and farmers do not considered it. This type of drop in fruit let stage is natural and self-thinning mechanism. Tree will adjust the number fruits as their bearing capacity. Second type of fruit drop is shedding of fully ripened fruits from the tree. It is a part of natural seed dispersal program. Both type of naturally occurring fruit drops are influenced by abiotic factor and not much important in economic point of view also could not control by management practices. Literature revels that, dropping of fruits is higher in seedless cultivars than seeded. In sweet orange, Erickson and Brannaman (1960) found that 48.5% of flower buds in Valencia and 35.5% in Navel dropped before they opened and the developing fruits. It is continued shedding in fast speed, lastly only 0.2% of flower bud in Navels and 1.1% in Valencia reached full maturity stage. Fruit drop in seedless varieties like Washington Navel was higher as compared to seeded varieties of sweet orange.

Table 2. Percentage of fruit set in different species.

SNo.	Species	Dropping %	
		Flowering to fruit setting time	Fruit development stage
1	Lemon	51	22
2	Sweet orange (Young stage)	42	33
3	,, (Valencia late)	48.5	1.1
4	,, (Washington Navel)	35.5	0.2

Source: Erickson et al 1960.

2. Un-natural Fruits drop

Un-natural fruits drop is induced by biotic factors and imparts heavy economic loss to the growers. Dropping of fruit due to external factor is very common in citrus species. This type of fruit drop is mainly attributed by physiological, pathological and entomological factors. Singh et al. (2002) reported that, in citrus species dropping of fruits 70-60 % is physiological, 8-17% entomological and 8-10% is pathological in central and south India. However, rate of dropping vary depending upon species, location, intensity of disease and pest.

2.1 Physiological fruits drop

Sudden changes in temperature and humidity, poor nutritional management, improper soil moisture are very critical in orchard management aspects that change the physiological system of the trees and cause fruit drop in citrus. This type of fruits drop can be mitigated by following appropriate orchard management techniques. Fruit drop due to hormonal imbalance, especially auxin that may occur any time from flowering to pre-harvest period may cause more economic losses in citrus fruit crops. The abscission layer of mature fruits, (often called 'pre-harvest drop') may occurs in various cultivars especially during cool in the winter. It is due to low concentration of naturally synthesis of auxin in the fruit base and increase the concentration of abscises acid, result is dropping the fruits. It can be reduced by the application of synthetic auxins (Spiengel et al, 1996). In Nepal very limited studies are available in this subject.

2.2 Hormones

Two types of symptoms can be observed in shaded fruits. Either it is completely green or it has yellow at the stem end and rest of the fruit may be green. When completely firm and green fruits are dropped, it may be the causes of hormonal imbalance. Plenty of research works have been carried out in the western countries in this aspect. They are practices many plant growth regulators (PGR) to control physiological fruit drops in citrus species. Bhullar (1981) was able to control fruit drop from 33–90% with use of 2,4-D (30 ppm), NAA (25 ppm) and GA_3 (750 ppm). Allurwer et al. (1999) found foliar application of GA_3 (25 ppm) and silver nitrate (10 ppm) was more effective chemicals to control the pre-mature fruit drops in citrus species. At present several studies were carried out on the effect of PGR and/or mineral nutrients in fruit setting, size and quality in USA and California. These studies include: PGR (Coggins, 2002) and use of urea to improve the fruit setting, fruits size and quality (Lovatt, 2002), but in Nepal, no reliable literatures are available in the use of hormone for control of fruit drop.

2.3 Nutrients

Naturally citrus plants are heavy feeder and require balance nutrition for good bearing. If any elements are lacking that affect physiological systems of plant and fruits drop will be occur. Status of microelements in the plant system is prime importance to determine the proportion of fruits that will reach in final maturity. Especially nitrogen, calcium and zinc deficiencies have been critically related with fruit drops (Saini et al, 1999). Farmers are used only the compost in their orchard but not considered the balance nutrition. Few studies have been carried out to determine the nutritional status of citrus orchards in Nepal and its relation with fruits drop. Leaf analysis report of the western districts shows that the nitrogen level of healthy plant

was 0.57 - 0.72%, which is much deficient level (Shrestha et al, 2007). Smith (1964) reported that the level of N, P and K in the plant tissue should be at least 2.6%, 0.14% and 1.5% respectively for good quality fruit production. Tripathi et al. (2004) carried out a survey in ten potential pockets of Gorkha and Lamjung districts to determine the status of micro-nutrients in mandarin orchards. They observed most of the orchards were deficient in nitrogen, zinc, boron and manganese and suggest applying micronutrient from external sources. Most of the citrus orchards of Salyan, Dadeldhura and Dailakh districts were found poor in nitrogen and organic matter (Regmi and Gurung, 2001). Gupta et al, (1988) also reported a wide spread deficiency of zinc, nitrogen, magnesium, boron, copper and calcium in mandarin trees of Dhankuta district. Fruit drop due to mineral deficiency can be corrected by supplying the deficient mineral element preferably by foliar sprays. For example, two sprays of 10 ppm 2,4-D and 0.5% zinc sulphate given in the month of May and September were very effective in reducing the June and pre-harvest fruits drop (Varma, 1969). The flower and pre-mature fruit drop in lemon is due to irregular watering. Any stress or excess watering may lead to it. So, only the light water should be given to the extent of wetting the soil surface and also good amount of farm-yard manure should be applied which besides adding nutrition, also conserves soil moisture.

2.4 Pathological fruit drop

Various types of diseases attract citrus fruit crops from nursery to harvesting period. Among the citrus diseases post–bloom fruit drop, stem end rot and powdery mildew are the major diseases responsible for fruits drop in citrus.

2.4.1 Stem end rot (*Colletotrichum acutatum*)

Post bloom fruit drop (PFD) especially those orchards established in humid areas of Americas is caused by Colletotrichum acutatum (Timmer et al. 1994). In Brazil, PFD was first reported in 1979 (Theodoro et al., 2003). The first occurrence of PFD in Florida was in 1983 and outbreak occurred in many subsequent years, especially in 1993 and 1998 (Timmer, et al. 2001). The disease has not yet been reported from south Asian countries.

The first symptoms of PFD are light red brown necrotic spots on open petals. Pin head to half grown flowers may also be attacked if inoculums level is high. Senescent petals of healthy flowers usually are light in colour or dry from the tip downward but diseased petals are dark brown to orange colour and dry first in the affected areas. Petals become hard and dry, persisting for several days after the healthy flowers have fallen. After petal fall young fruits show a slight yellowish discoloration and usually abscise leaving the calyx and flower disc. These structures are commonly known as 'bottoms' (Timmer, et al. 2001). PFD affects all species and cultivars of citrus but severity may vary according to time of bloom in relation to rainfall. Losses were observed higher in Florida on Navel oranges and Thahiti limes and to a lesser extent on Valencia oranges. Hamlin and Pineapple oranges and Tangarins have experienced less damage than other cultivars. Grapefruit is rarely affected by PFD. Increase the incidence of PFD is very high under favorable environmental condition and disease difficult to control at that time. Overhead irrigation should be avoided during blooming time, if possible or trees should be irrigated at night and allowed to dry at day. Declining stage of trees perform flowering out of season, thus these trees will be the good sources of inoculums for next season. Such trees should be removed prior to bloom in PFD affected areas. The number of bottoms remaining from previous year and presence of disease on early bloom should be used as early indications of potential PFD problems. Fungicide application should be initiated on the onset of the first bloom if the condition warrant. The incidence of PFD is highly dependent on amount of available inoculums as well as on rainfall. Application of benzimidazole fungicide (Topsin) has been recommended in USA (Timmer, et al. 2006).

2.4.2 Powdery mildew (*Agrosporium tingitaninum*)

Powdery mildew is a fungal disease caused by Agrosporium tingitaninum, and develops whitish powdery growth on young leaves and twigs. Chlorophyll of the affected leaves will be distorted and in severe

conditions drop down. Similarly affected twigs exhibit characteristics die back symptoms. Young fruits are also covered by whitish powdery mass of the fungus and dropped prematurely, resulting in lower yield (Rajput and Haribabu, 1993). Comparatively cool and moist regions are prone to disease development. Cloudy days with few hours of sunshine are most favourable conditions for the on-set of the disease. During winter the fungus survives on infected plant parts and debris such as fallen leaves. The new infection begins by the spores released from the resting structures which are spread by wind to other trees. Fungicide application such as Sulfex or Insuf 0.2 percent (2 gram in one litre of water) or Carbendazim 0.1 percent should be spray when the first white patch symptoms are noticed. Second round of application should be given after 20 days. Early detection and adoption of proper management practices provide good control over the disease (Sahayarani et al, 2008)

2.4.3 Anthracnose (*Colletotrichum gloeosporioides*)

Anthracnose is another disease that causes fruits drop reported from many countries of the world (Brown, 2003). In India, occurrence of anthracnose has been reported from hilly areas of Punjab, Madhyapradesh, Assam, south India and Uttar Pradesh (Rajput and Haribau, 1993). The main symptoms of the disease are shedding of leaves, fruits and die back of twigs. Infected buds and fruit lets are dropped. When this disease attacks in fruit that develop black-brown areas at stem-end, turn yellowish pre-maturely and dropped. Reduced vigour of the plant is one of the contributing factors of this disease; therefore it is evidently necessary to maintain health of the plant by proper manuring, irrigation and other cultural practices. The dead tissues should be pruned and destroyed and the cut ends should be protected by Bordeaux paste particularly in winter followed by spraying with 1% Bordeaux mixture in February, March, and September.

2.5 Entomological fruit drop

More than 250 species of insects and mites are known to damage on citrus through - out the world. Among citrus insect pests fruit sucking bugs and fruit flies are very serious pests as they cause massive fruit drop in citrus species and farmers are facing heavy economic loss. Green stink bug was observed in most of the citrus orchard and loss around 20% in the western region (Shrestha et al 2008) where as fruit fly is serious in the eastern development region and estimated loss is 90% (NCRP 2006).

2.5.1 Citrus green stink bug (*Rhynchocoris humeralis*)

Citrus green stink bug is one of the major insects responsible for premature fruit drop in citrus. Occurrence of adult bugs commences in May and both adults and nymphs are sucks the juice of developing fruits and infected fruits turn yellow colour and dropping down. Fruits drop is more severe during June to August but continue their attack thereafter (Pandey and Rana, 1993). The extent of fruit drop ranged from 92 – 100% under force feeding condition until middle of August and then decreased about 50% and 25% in the first and second half of September respectively. In totality, natural fruit drop was observed 20% where as green sink bug to be responsible for 50% of loss (Pandey and Rana, 1993). The life cycle of citrus green stink bug (CGSB) has five nymph stages prior to mature. They noted that the first instar started feeding on the fruit that induced fruit drop. The adult of CGSB remained alive for more than 50 days in the winter to build population for next season.

Spraying of contact insecticides is common practices to control CGSB. Insecticides will be effective when bugs are at first and second nymph stage (NCRP, 2004). In recent year, biological control methods are also practices in Nepal. Wasp insects i.e. *Anastatus* sp, *Trissolcus letisculus* and *Ooencyrtus utitheisee* were parasitized CGSB eggs and reduced the population of bug. Increasing of wasp population and distribution of parasitized egg would be the effective measure for the control of CGSB (Manandhar et al 2002). Parasitiosed egg of these insects were widely distributed in Tanahu, Syanja and Kaski districts for studies on control of green stinkbug using naturally occurring egg parasitoids are also being carried out. Rearing, conservation and augmentative release of these parasitiosed can be useful for biological control of citrus green stink bug (Pandey and Rana, 1993; Manandhar, et al., 2002). Control of southern green stink bug of macadamia nut

using egg parasitoid: *Trissolcus basalis* has been recommended in Hawaii (Wright et al., 2003).

2.5.2 Fruit fly

Fruit flies are the most destructive insect pests of many crops including citrus species. Several species of fruit flies are known to attack citrus fruits. The major citrus pest fruit fly species and their distribution region is presented in Table 3.

Two species namely Mediterranean fruit fly (Ceratitus capitata) and Oriental fruit fly (Bactocera dorsalis) have been found very serious insects of citrus causing huge economic loss in most citrus growing countries of the world. Mediterranean fruit fly is distributed mainly in European, African and North and South American countries where as oriental fruit flies have been found in most Asian countries including Nepal (Thomos, 1999). It attacks more than 150 kinds of fruits and vegetables including citrus, guava, mango, papaya and avocado (DOACS, 1999). In a fruit loss assessment study about 90% sweet orange fruits were found damaged by fruit flies in Dhankuta (NCRP, 2006). Recently it has been confirmed that Chinese fruit fly (Bactrocera minax) is the main species that causes massive fruit drop in eastern Nepal.

Table 3. Citrus fruit flies and their distribution in the world.

SN	Common name	Scientific name	Distribution
1	Oriental fruit fly	*Bactrocera dorsalis*	China, Myanmar, Thailand, India, Bhutan, Nepal, Guam, Hawaii
2	Chinese citrus fly	*Bactrocera minax*	China, Bhutan, 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

In the past 'male annihilation' was used to control fruit flies. In this technique male flies are attracted to species-specific pheromone traps and killed by poisoning. In addition to this spraying with very toxic chemicals (cover spray) was also practiced. This technique is not very effective, expensive and also has negative effect on environment (Kaplan, 2004). Therefore, many research works were carried out on to determine the environmentally friendly and effective techniques in several countries of the world. Recently, an integrated fruit fly management technique has been recommended and successfully applied at farmers' field in Hawaii, USA (USDA, 2004). This technique consist four components namely identification, male annihilation, sanitation and protein bait spray. Commercial protein baits such as Nulure and GF-120 (Fruit Fly Bait Concentrate) have been developed in USA (USDA, 2004. However, commercially available hydrolyzed proteins can be used to make the bait. Waste yeast of brewery can be converted into inexpensive protein bait used for fruit fly control. Royal Tongalure, Mauri's Pinnacle Protein Insect lure, Van lure are the protein lure converted from brewery waste yeast (Lloyd and Drew, 1997). Chen et al. (2001) found that the percentage of flies trapped by Chenghong protein hydrolyzed was significantly higher than Wufeng and Hsingya ones. The percentage of trapping increased as the concentration of protein hydrolyzed increased. Sterile insect technique (SIT) is the other biological method to control fruit flies. This method requires mass rearing and release of large number of sterile males into target areas that cause infertility in females with which they mate (Handler, 2000, Liu, 1982).

3. Climate:

Intensity of fruit drops is increasing when the weather condition is very dry and cold (Sinha et al 1950). High temperature couple with low humidity is considered as the main causes of premature fruit drops in citrus. Low abscission rate under the low temperature condition and increase with raise in temperature. Higher rate of fruit drops in citrus is mainly due to the high temperature and dry atmosphere. In Nepal, higher rate of fruit drops was observed in March and April due to high speed of dry wind.

4. Irrigation:

Water is most important and readily available in the plant cell. If water is shortage in the plant cell that affect to observe the nutrient elements and increased the rate of fruit drop. Most of the citrus orchards were established where the source of irrigation is lacking. Citrus industries of Nepal are fully dependent on monsoon rain. The flower, fruit lets and mature fruits are dropped in both high moisture or soppy land and water stress condition.

2. Materials and methods (conceptual framework, data, model, methodology)

Survey was conducted in a citrus production pocket of Kailali (Nigale), Baitadi (Nagarjung), Salyan (Khalanga) and Dailekh (Dullu) from August 12 to 25, 2007. Before selecting the sites detailed discussion was held in the DADO offices with senior staffs. Main basis of selection the sites for survey from those pockets having known history of low productivity including fruit drop problem. Information on orchard management practices was collected using semi-structured questioner from twenty randomly selected citrus growers of each pocket. The survey team members composed of citrus expert and socio-economist also noted down the remarkable aspects of citrus cultivation that existed in farmers' orchards. Secondary data and other necessary information were also collected from District Agriculture Offices.

2.1 Soil sample collection:

Select 3 farmers / orchard in the selected pocket areas of each district. Collect soil sample between the tree canopies in zigzag way from 3 orchards in each site. Take soil sample at the top layers (0-30 cm depth) by using soil agar. Collect all samples separately and divide it until 0.5 kg remains. Avoid all unwanted materials from the soil and about 0.5 kg composite soil sample are kept in plastic bag with detailed information (Name and address of farmers, depth, intercrop, sample size/ areas, date etc). Fifteen sample of each district will collected and send for analyzing NPK, OM, and pH in the laboratory of ARS Pakhribas by using standard soil testing technique.

2.2 Leaf sample collection:

Leaves samples are collected form the same orchards where the soil samples are collected. Leaf samples are collected randomly in zigzag way from healthy and deficient plant separately. Samples are collected from fully developed current year spring flush (4-7 month matured leaf), un shaded non fruiting wood, at four dimension of tree and uniform age and height (1.5m). Collect composite sample about 100 leaves from one orchard. About 100 representative leaf samples are collecting from 10% orchard plants and wash it in clean water. Samples are kept in percolated Nepali envelope with full descriptions (Name and address of farmers, Date, types of rootstock, age of tree, bearing year) and send it to laboratory immediately for major nutrients i.e N, P, K. analysis.

Table 4. Rating scale of nutrients in 4 -7 months old mandarin leaves

S.N.	Nutrients	Much deficient	Deficient	Medium	High	Excess
1	Nitrogen (%)	<2.1	2.2-2.4	2.5-2.7	2.8-3.0	> 3.1
2	Phosphorus (%)	<0.08	0.090-0.110	0.12-0.16	0.17-0.29	> 0.3
3	Potassium (%)	<0.7	0.7-1.1	1.2-1.7	1.8-2.3	> 2.4

Source: Smith (1966)

Table 5. Rating Scale of Soil Nutrients for citrus orchards

S.N	Nutrients	Very low	Low	Medium	High	Excess
1.	Nitrogen (%)	<0.050	0.051-0.099	0.100-0.199	0.200-0.500	>0.501
2.	Phosphorus (Kg/ha)	<10	11-30	31-55	56-110	>111
3,	Potassium (Kg/ha)	-	0-110	111-280	281-500	>501

4.	Organic Matter (%)	<1.0	1.1-2.0	2.1-4.9	>5.0	-

Soil pH: <4.5 = Extremely acidic, 4.6-5.2 = Acidic, 5.3-5.9 = Moderately acidic, **6.0-6.5 = Slightly acidic**, 6.6-7.0 = Nearly neutral. Source: Smith (1966).

2.3 Fruit Drop intensity:

The study was conducted in the four districts (Salyan, Kailali, Baitadi and Dailekh) of mid and far western development region of Nepal. Three farmers/ orchards were selected from each district. Fruits dropping records was recorded from the farmers interview as will as field research. Ten bearing trees were selected from each orchard for experiments. Improved management practices i.e application of fertilizer (600g Nitrogen, 250g Phosphorus, and 500g Potash/ tree) with compost (50 kg), Spraying of insecticide (Roger and Foskil three times), fungicide (Diathioun M 45/ Sulphex), Servo agro spray and micronutrients were applied in the selected trees. Ten fruit trees were selected from farmer's practices. Plastic sheets were placed around the tree canopy for recording the dropped fruits. Dropping intensity of mandarin fruits were recorded every 15 days interval during Baisakh to Aswin month from the selected trees of project implemented sites. Yield of the fruits was recorded from the same trees at harvesting time. All the data was analyses in simple statistical tools.

3. Results and Discussion

3.1 Agro-ecology of citrus cultivation

Citrus orchards in the survey areas were established in a wide range of altitude from 1150-1500 m asl with typical mid hill climate in up-land terraces under rain fed condition. The lowest altitude where citrus orchards were established was 1150 m in Nigale, Kailali whereas orchards in Nagarjung of Baitadi were established relatively in high altitude 1450-1550 m. The soil type of citrus orchards in all sites was found loam to clay loam, which is suitable for citrus cultivation.

Most of the surveyed sites were north or northwest facing which is positive aspect for citrus cultivation since moisture is conserved for longer duration during summer season in north facing side of the hill. Citrus production pocket of Dullu in Dailekh district is 8.0 hour far from pich road (Surkhet) where as in Salyan around 1 hour far from the district head quarter. Vehicle facilities are available only in winter season from Surkhet to Dullu.

Table 6. Agro ecological characteristics of sites

S No	District	Location of pocket	Altitude (M)	Aspect	Distance from road
1.	Baitadi	Nagarjung VDC -6	1400-1550	South west	3 hour walking
2.	Kailali	Nigale -6	1150-1350	North facing	5 hour walking
3.	Dailekh	Dullu - 5	1250-1350	North East	8 hour walking
4.	Salyan	Khalanga VDC-5,6	1250-1450	North East	1 hour ,,

3.2 Orchard management system

Most of the sampled farmers had more than 50 bearing mandarin trees. Existing orchards were found predominantly seedling origin. Farmers were not adopting any training and pruning practices. Citrus, maize, upland rice, wheat and millet were the major crop of upland (Bari land) in the surveyed areas. Intercropping of cereals (Maize and wheat) under young citrus trees was also common practice in all districts. In recent years, few farmers have also started planting soybean, mustard, vegetables or potato under citrus orchards. None of the citrus growers of the surveyed areas were found using any fertilizer to citrus trees due to higher cost and lack of awareness about the nutrient requirement of citrus trees. Compost was the main source of nutrient for citrus and other crops. But cereal crops get first priority while applying compost. Livestock like cattle and goats are the major source of compost and manure. The compost making technique was found very traditional resulting to poor in quality compost. Hoeing and weeding is done for cereals but not especially to the citrus trees. In summary, very poor orchard management practices are being adopted in all survey sites. Among the cultivated fruits mandarin has covered maximum areas (82.2%) in the selected districts followed by Lemon and Sweet orange.

Table 7: Number of citrus trees (mean of 80 farmers) in the selected sites of the districts.

District	Location of pocket	Mandarin	Sweet orange	Lemon	Lime	Total
Baitadi	Nagarjung VDC -6	96.1 (71.45)	24.2 (18.0)	5.9 (4.4)	8.3 (6.2)	134.5 (100)
Kailali	Nigale -6	245.6 (78.9)	9.4 (3.0)	50.2 (16.1)	5.9 (1.9)	311.1 (100)
Dailekh	Dullu - 5	161.4 (88.4)	8.2 (4.2)	7.0 (3.8)	6.4 (3.6)	182.6 (100)
Salyan	Khalanga VDC-5, 6	196.4 (88.1)	18.6 (8.4)	4.6 (2.1)	3.2 (1.4)	222.8 (100)
	Average	174.9 (82.2)	15.1 (7.0)	16.9 (7.9)	5.9 (2.7)	212.7 (100)

Note: Figure enclosed the parenthesis indicates the percentage of trees out of total number. Mean figure of 20 farmers of each district.

3.3 Intensity of Fruit drop:

Intensity of citrus fruits drop governed by several factors and dropped in various stages. Fruit drop was taken by interviewing the farmers. According to the farmers view dropping of fruits in the selected sites was found 34.6% in Salyan and 44.7% in Kailali district (Table 8). Average dropping of citrus fruits in four districts is 35 to 180 kg and economic losses due to dropping are 39.3%. Dropping starts during post bloom stage to before harvest. In the selected pocket dropping starts from Ashard to Bhadra (fruit development stage) and mainly infection by green string bug and farmers are facing high economic loss. However recording of fruit drop intensity will continue in next year.

Table 8: Intensity of fruit drop and economic losses:

Districts	General yield (Kg)			Dropped (Kg)			Dropped Percent	Dropping time	Reasons
	Min.	Max.	Mean	Min.	Max.	Mean			
1. Baitadi	80	400	195	30	200	80.5	41.7	Shrawan-Bhadra	Unknown
2. Kailali	50	400	188.2	30	220	85.2	44.7	Ashard-Bhadra	Bug
3. Dailekh	50	300	175	30	200	155	36.2	Ashard-Bhadra	Bug
4. Salyan	80	300	173.3	30	100	58.3	34.6	Ashard-Bhadra	Bug
Mean	65	350	182.8	35	180	94.7	39.3		

3.4 Intensity of fruit drops in the improved practices:

Intensity of fruit drops was lower in the beginning (Baisakh month) due to small size of fruit lets and farmers / recorders did not consider the small fruits. Higher rate of fruit drops was observed in the 1st and 2nd week of Shrawn month (83.2) that may be causes of green string bug insect than reduced during Shrawan last. Average number of fruit drops is higher in Saylan districts (50.2) followed by the Dailekh (48.5) where as Baitadi and Kailali was observed similar (Table 9). The average number of fruit dropped in the improved management practices was observed 44.9 in the mid and far western development region.

Table 9. Number of fruit drops in the improved practices at different location during Baisakh to Aswin month (Average of 10 trees/ farmer).

S.No	Treatm.	Baisakh		Jestha		Ashard		Shrawan		Bhadra		Aswin		Average
		1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	
1.	Kailali	12.6	10	20.3	33	25	46	55	14	16	12	4	1	40.4
2.	Saylan	17	23.3	24.3	40	30	36	61.6	35	19	14.3	5	4	50.2
3.	Dailekh	18.3	18	27	43	31	58	42	31	12	10	7	3	48.5
4.	Baitadi	16.5	10	20	25.5	44	36	49.5	25	10	9	4	3	40.7
Total		64.4	61.3	91.6	141.5	130	176	208.1	105	57	45.3	20	11	179.8
Average		16.1	24.5	36.64	56.6	52	70.4	83.2	42	22.8	18.1	8	4.4	44.9

3.5 Intensity of fruit drops in the farmers practices:

Fruits drop record was taken from the farmer's management practices in all sites. Intensity of fruit drops

was observed low in the beginning (Baisakh month) due to small size of fruit lets and farmers / recorders did not consider the small fruits. Higher rate of fruit drops was observed in the Ashard month (79) that may be causes of green string bug insect than reduced during Shrawan. Average number of fruit drops is higher in Kailali districts (75.6) followed by the Dailekh (71.1) where as in Baitadi was observed lower (53.0). The average number of fruit dropped in the farmers practices was observed 67.2 in the mid and far western development region (Table 10).

Table 10. Number of fruit drops in the farmers practices at different location during Baisakh to Aswin month (Average of 10 trees/ farmer).

S. No	District.	Baisakh		Jestha		Ashard		Shrawan		Bhadra		Aswin		Average
		1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	1-15	16-30	
1.	Kailali	29	25	42	55	99	67	70	22	32	20	5	2	75.6
2.	Saylan	24.6	25.6	29.3	47	84	51.6	59	48	37	14	4	4	69.3
3.	Dailekh	23	22	36	62	79	69	41	42	23	27	10	4	71.1
4.	Baitadi	24.6	12.5	22.3	29	54	82	46	25.5	13.5	9.6	8	3	53.0
Total		101.2	85.1	129.6	193	316	269.6	216	137.5	105.5	70.6	27	13	268.9
Average		25.3	21.2	32.4	48.2	79	67.4	54	34.3	26.3	17.6	6.7	3.5	67.2

The average number of fruit dropped in the farmers practices was observed higher (67.2) than the improved management practices (44.9) in the mid and far western development region. Higher rate of fruit drops in the farmers practices due to the nutritional deficiency. Green sting bug insect is the primary factor for fruit drops in both practices. The results indicate that dropping intensity of fruits can be reduced by the appropriate management practices in the citrus orchard. Generally dropping intensity is increased when dry weather and stressed condition.

3.6 Estimation of economic losses in improved practices

Number of fruit losses due to the dropped was estimated at different location. Higher percentage of fruit drops was observed in the Salyan district (31.3%) and lower was observed in Kailali (6%) district. The fruit yield losses also observed in the same pattern. The average percentage of losses due to the fruit dropped in the improved practices was observed 15.5% per tree in the mid and far western development region.

Table 11. Number of fruits drop and economic losses in improved practices (Average of 10 trees/ farmer).

		Number of fruit/ tree			
S.No	Location	Harvest	Dropped	Total	Loss%
1	Kailali	630	40.4	670.4	6
2	Saylan	110	50.2	160.2	31.3
3	dailekh	409	48.5	457.5	10.2
4	Baitadi	239	40.7	279.7	14.6
Total		1388	179.8	1567.8	-
Average		347	44.95	391.95	15.525

3.7 Estimation of economic losses in farmers practices

Number of fruit losses due to the dropped was estimated at different location. Higher percentage of fruit drops was observed in the Salyan district (21.7%) and lower was observed in Kailali (12.7%) district but the fruit yield losses was observed higher in the Kailali (6.2 kg) districts and lower in the Baitadi (3.6kg) district. The average percentage of losses due to the fruit dropped in the farmers practices was observed 16.9% in the mid and far western development region (Table 12).

Table 12. Number of fruit drops and economic losses in farmers practices (Average of 10 trees/ farmer).

S.No	Location	Number of fruit

		Harvest	Dropped	Total	Loss%
1	Kailali	520	75.6	595.6	12.7
2	Saylan	707	69.3	776.3	21.7
3	dailekh	396	71.1	467.1	15.2
4	Baitadi	240	53	293	18.1
Total		1863	269	2132	-
Average		465.75	67.25	533	16.92

3.8 Disease

Many diseases are observed in the citrus pocket areas of the selected districts. Among them Powdery mildew (*Oidium tingitanium*) is the most common disease of citrus species found in all selected sites of the districts. According to farmers the disease is more serious during July- August when new flushes develop in the trees and weather is fuggy. Tender flush and fruits are also affected from this disease. Farmers were not practices any control mechanism for prevention of the disease. Timmer et al. (1994) reported that, Postbloom fruit drop (PFD) caused by Anthracnose (*Colletotrichum acutatum)*, is an important disease of citrus especially those orchards planted in humid areas. Pathogens are attacted in floering stage and produced orange brown leison on the petal of flower and induce abscission on fruitlets. Suspected symptoms of *Collectrorichum acutatum* is also observed in Kailali and Baitadi district but farmers are not considered on these disease. Root/ foot rot (*Phytophthora spp*) and Melanose disease were also found in survey sites. Two diseases namely anthracnose *(Collectrotrichum acutum)* and root rot *(Phytophthora spp)* are major agents for citrus fruit drop in this region.

3.9 Insect

Various types insects i.e. green stinkbug, mites and leaf minor are observed in the citrus orchards of selected sites. Among them green string bug is one of the serious that dropped the fruits more than 25% in all sites. Farmers are not practice any control measures to control of these insects due to poor technical knowledge and resources.

Entomological fruit drop especially fruit fly can be reduced by bating with 20 g malathioun WP with vinigor or fruit juice in 2l of water (2 bottle containing poison bait per 25-30 trees) has been used with little sucrose for fruit fly 0.05% Malathioun+ 1% crude sugar. About 2 month before ripening followed by 10 days interval bait containing.

4. Nutrient status of the orchard:

Soil sample are collected from selected sites of the districts and analysed major nutrients, result of the report are given in the table. On the basis of analysis report level of pH is 6.7 nearly neutral which is suitable for citrus. Major nutrient i.e Nitrogen, Phosphorus Potash and Organic matter in the soil was found satisfactory level in all sites.

Table 13: Soil sample analysis report of the selected sites

S.No.	Name	Address	pH	OC%	OM%	N%	P (Kg/ha)	K (Kg/ha)
1.	Buddhi Raj Bista	Khalanga-6	6.75	3.44	5.93	0.21	181	1208
2.	,,	,,	6.79	3.73	6.42	0.23	99.26	1198
3.	Sufal Bikram Shah	Dullu 5	6.60	2.5	4.31	0.16	184.6	385
4.	Praytna Shah	Dullu 5	5.89	2.77	4.78	0.18	296.4	1107
5.	Jaya Singh Bhandari	Nagarjung-5	7.5	4.5	7.76	0.26	57.0	1751
6.	Share Sing Bhandari	Nagarjung-5	7.6	6.48	11.17	0.36	115.4	1830
7.	Mani Ram Bhandari	Nigali-5	6.6	6.41	11.05	0.36	97	1588
8.	Gangaram Bhandari	Nigali-5	6.5	3.13	5.4	0.20	59	1572
		Mean	**6.77**	**4.12**	**7.1**	**0.24**	**136.2**	**1329.8**
		SD	0.58	1.63	2.8	0.08	80.3	493.3

Note: N= Nitrogen, P= Phosphorus, K= Potash, OM= Organic matter, OC= Organic carbon, CGD= Citrus Greening Disease.

Leaf analysis is a reliable tool of determining the nutritional level for citrus. Leaf nutrient indices (critical level) different elements responsible for growth and productivity (Srivastave et al 1998). Leaf sample are collected from selected sites of the districts and analysed major nutrients, result of the report are given in the table. On the basis of analysis report level of Nitrogen in the healthy plant is 0.57% to 0.72%, which is much deficient level, but level of P and K is in satisfactory in deficient trees leaf. Smith (1996) reported that the level of N, P and in the plant tissue should be 2.6%, 0.14% and 1.5% respectively for good quality of furit production. Kohli et al (1997) reported that 180 kg of Nitrogen required every year for 40 kg sweet orange fruit production. Therefore on the basis of leaf analysis result it indicated that the additional nitrogen should be applied for optimum yield and better growth in all sites.

Table 14: Leaf sample analysis report of the selected sites

S No.	Name	Address	Healthy trees leaf			Deficient trees leaf		
			N%	P%	K%	N%	P%	K%
1.	Buddhi Raj Bista	Khalanga 5	0.62	0.34	1.96	0.58	0.31	1.53
2.	Indra Bdr. Devkota	,,	0.57	0.37	1.53	0.52	0.29	1.61
3.	Bishnu P. Basnet	Khalanga 6	0.65	0.31	1.46	0.53	0.40	1.73
4.	Bishnu Shah	Dullu 5	0.62	0.25	1.26	0.73	0.30	0.90
5.	Lasxmi Shah	Dullu 5	0.64	0.59	1.52	0.52	0.29	1.61
6.	Binod K C	Dullu 5	0.72	0.21	1.68	0.65	0.30	1.81
7.	Ganesh S.Bhandari	Nagjung-5	0.57	0.26	1.69	0.71	0.19	1.88
8.	Jaya Sing Bhandari	Nagjung-5	0.71	0.16	1.32	0.57	0.29	1.49
9.	Laxman Chand	Nagjung-5	0.58	0.30	1.59	0.53	0.30	1.43
10.	Maniram Bhandari	Nigali-5	0.59	0.36	1.98	0.58	0.31	1.53
11.	Chhatra Saud	Nigali-5	0.63	0.21	1.59	0.52	0.29	1.61
12	Gauri lal saud	Nigali-5	0.64	0.31	2.46	0.53	0.60	1.73
Mean			**0.62**	**0.32**	**1.67**	**0.58**	**0.31**	**1.57**
	SD		0.04	0.11	0.32	0.07	0.09	0.250

5. Conclusion and implication

- Generally the intensity of fruit drop is 35 to 180 kg per tree depending on the volume and age of the tree. Yield losses was 39.3% , but actual economic losses from dropping was found 15-17% in the mid and far western development region of Nepal.
- Main causes of fruit drops are nutritional deficiency and Green stink bug insects (about 20% yield losses) were observed in the project implement region.
- Nutrient stress especially nitrogen and zinc in the plant, is the secondary factor of fruit drop in the mid and far western development region of Nepal.
- Powdery mildew, stem end rot and anthracnose are the main diseases responsible for dropping of citrus fruit.
- High temperature and strong wind velocity especially in March/ April is also responsible factor for fruit dropping.
- Stress condition especially moisture and poor nutrition is also the causes of fruit drop in citrus species.

Suggestion/ Implementation

- Suggest to the farmers group to improve the quality of the compost and make vermin compost using suitable species of earthworm and contact to the AD office of related districts for technical

information.

- Level of Nitrogen in the plant is very poor and suggests to foliar application of nitrogenous fertilizer (urea 2%) and increases the efficiency of irrigation especially in spring season (Falgun - Baisakh). Also suggest to spray the zinc sulphate with urea.
- Application of quality compost at the rate of 80-120 kg per bearing tree around the tree canopy every year is recommend for the improvement of tree health and increase the quality and quantity of fruits. At least one kg of DAP in March and one kg of urea top dress in July should be apply per year.
- Application of Bordeaux mixture after pruning (before flowering) and at the time of fruit setting is preferred to prevent from the fungal disease.
- Established the orchard with grafted seedling in the centre of the terrace and intercropped with legume crop in the orchard.

Table 15. Causes and solution of fruit drops.

S.No	Causes	Time	Solution Techniques
1.	Natural drop	March-April	-Auxin (spray 2,4-D @ 15-20ppm at flowering time.
2.	Irrigation	February-June	Irrigation and mulching
3.	Disease: Powdery mildew	February-August	-Apply sulphur containing fungicides like Insuf or Sufos @ 2.5 gm / L of water at 15 days interval.
	Stem end rot Anthracnose		-Apply 1% Bordeaux mixture at 15 days interval.
4.	Insects: Green stink bug	March-August	-Spray insecticides Roger or Phoskill @ 2ml / L of water in 1st and 2nd nymph stage (June-July) at 15 days interval.
	Fruit fly		-Collect damaged fruit and buried in the pit 2 ft below. -Follows integrated pest management techniques i.e. identification, male annihilation, sanitation and protein bait spray.
5.	Nutrition	April-June	Apply sufficient amount of compost and follow foliar application of micro nutrients regularly.

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