Original Research Article

Assessment of production constraints of large cardamom in the eastern hills of Nepal

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ABSTRACT

Aims: Identify the status of different factors associated with the Large Cardamom decline in the major cardamom growing districts so as to recommend the control measures for the management of this problem.

Study design: Household survey was conducted in five districts of eastern Nepal.

Place and Duration of Study: Taplejung, Panchthar, Ilam, Dhankuta, and Tehrathum distric of Nepal between January and July 2016.

Methodology: Household survey was carried out with 150 respondent farmers, 30 from each district. Five focus group discussion and one stakeholders meeting were conducted for the triangulation of household outcomes.

Results: Lack of disease resistant/tolerant varietal option and inadequate management practices are reported to be the major problems for promoting disease spread in the eastern region. The public sectors have been unable to fulfil the high demand of disease free saplings. Rhizome rot remains the most prevalent disease in studied districts followed by wilting.

Conclusion: The study suggest plan of actions to implement for the good orchard management to address the problem of biotic factors in short run; technology development and adoption to mitigate biotic problems in large cardamom in long run.

Keywords: Chhirkey, Compound Annual Growth Rate, Foorkey, Rhizome rot, Large Cardamom decline

1. INTRODUCTION

Large Cardamom (*Amomum subulatum* Roxb.) is a high potential crop of Nepal for the export markets in the world. The annual export value of Large Cardamom (LC) was estimated at NPR 4.85 billion in 2017[1]. Particularly, it has been the major farm income of majority farmers in the eastern hill region of Nepal. Moreover, Nepal is the largest producer of LC in the world, supplying over 50% of the world's market demand [2, 3]. Currently, it is grown in 17,002 ha, producing of 6,521 t, with 522 kg ha^{-1} productivity [4, 5]. Currently, LC is grown in 51 hill districts [6]. The LC has been known to be originated in Nepal as many wild races are reported in the eastern Himalayan region of Nepal [7]. The area under LC plantation is growing slowly and steadily. It is a low volume, high value crop with medicinal properties. It was introduced in Nepal from Sikkim long time back [8].

However, in the recent years, its' production has been severely affected by the cardamom decline. There are multiple factors associated with the decline; however the major factors are comprised of rhizome/clump rot; and viral disease like Foorkey and Chhirkey. This problem has become widespread across the cardamom growing districts. As a result, the problem has received national priority that carries important for the assessment of associated factors of this problem in the respective districts.

In this context, the study was conducted to identify the status of different factors associated with the cardamom decline in the major cardamom growing districts so as to recommend the control measures for the management of this problem.

2. MATERIAL AND METHODS

The study was conducted in Taplejung, Panchthar, Ilam, Dhankuta, and Tehrathum during January to July, 2016. The following approaches were adapted to conduct the study:

i. Focus Group Discussions (FGD),

ii. Key Informants Interviews,

iii. Stakeholders meeting,

iv. Literature review, and

v. Household survey.

Literatures published by the public institutions: District Agriculture Development Offices (DADOs), Cardamom Development Office (CDC), Nepal Agriculture Research Council (NARC) and other related stakeholders were reviewed to get the secondary information on various aspects of cardamom decline. Household survey was carried out with an objectively designed household survey questionnaire. Altogether 30 households from the representing VDC of each five districts: Ilam, Panchthar, Taplejung, Dhankuta and Tehrathum were selected as the sample size and sampling for the household survey. Stakeholder meeting was organized among the stakeholders of cardamom to identify the associated factors of cardamom decline in Ilam during 2016 The information was edited by following the procedure of random checking, triangulation, and thorough discussion with the key informants. The data was analyzed with Statistical Package for Social Science (SPSS), while the qualitative information was analyzed and presented in paragraphs, charts and diagrams. Information on perception, behavior, and attitude and other variables for above indicators was processed by Content Analysis. Such information was systematically organized and presented in a logical sequence and smooth flow so as to answer to indicators already Defined. The preference data for disease were categorized into rank based on the percentage of ranking for all the diseases and the disease ranking coefficient value for the districts was calculated with the help of following formula:

$$Rd_1 = \frac{Dr_1 + Dr_2 + Dr_3 \ldots\ldots\ldots Dr_n}{N}$$

Where, Rd_1 = disease ranking coefficient value of district d1,

N = total number of disease taken into consideration,

Dr = rank occupied by the district d1 for disease $r_1, r_2, r_3 \ldots\ldots\ldots\ldots r_n$

This rank coefficient value were delineated into disease intensity and categorized into three groups: high, moderate and low disease intensity. Lower the value of rank coefficient, higher is the disease intensity.

Farmers' perception was ranked based on likert scale based on 1-5 point scale for disease based on symptom asked with respondents with formula:

$$I = \sum \frac{s_i f_i}{N}$$

Where,

I = Index of importance

si = scale value

fi = frequency of perception on satisfaction given

N = Number of observation

3. RESULTS AND DISCUSSION

3.1 Overview of Large Cardamom Decline

In Nepal, currently the LC is cultivated in 51 districts under 17,002 ha area producing of 6,526 t in 2016/17 with productivity 522 kg ha^{-1}[4]. The cardamom decline has become havoc across the country. There are multiple factors associated with the cardamom decline. However, particularly two viral diseases: Chhirkey and Foorkey have been identified as the root causal factors of cardamom decline in Nepal. Besides these, declining soil fertility and moisture, poor orchard management, invasion of rhizome rot disease and various insects and low manuring and fertilization are among the other major factors of the decline.

The current production of cardamom is reported to be two folds higher than that of 1994s. However, the productivity has been declining. The major factors of the productivity shrinkage as reported in the various areas are the invasion of Chhirkey and Foorkey, rhizome rot and blight, and caterpillar.

3.1.1 Area of Large Cardamom in Study Districts

The area of LC in the study districts is decreasing over 10 year's period in almost all districts. In total, the area in 2005/06 was 8646 ha, which decreases each year thereafter and reach to 6786 ha in 2013/14. However, it again slightly increased in the last year and reach to 7645 ha in 2014/15. It is due to increase in awareness in the farmers and government intervention (Figure 1).

While calculating Compound annual growth rate (CAGR) of area with regression analysis on total area of the study districts from 2005/6 to 2014/15, the CAGR significantly decreasing with (minus) -1.743 percent annually with p value 0.0003. It also depict that the area of LC in the study districts are decreasing significantly.

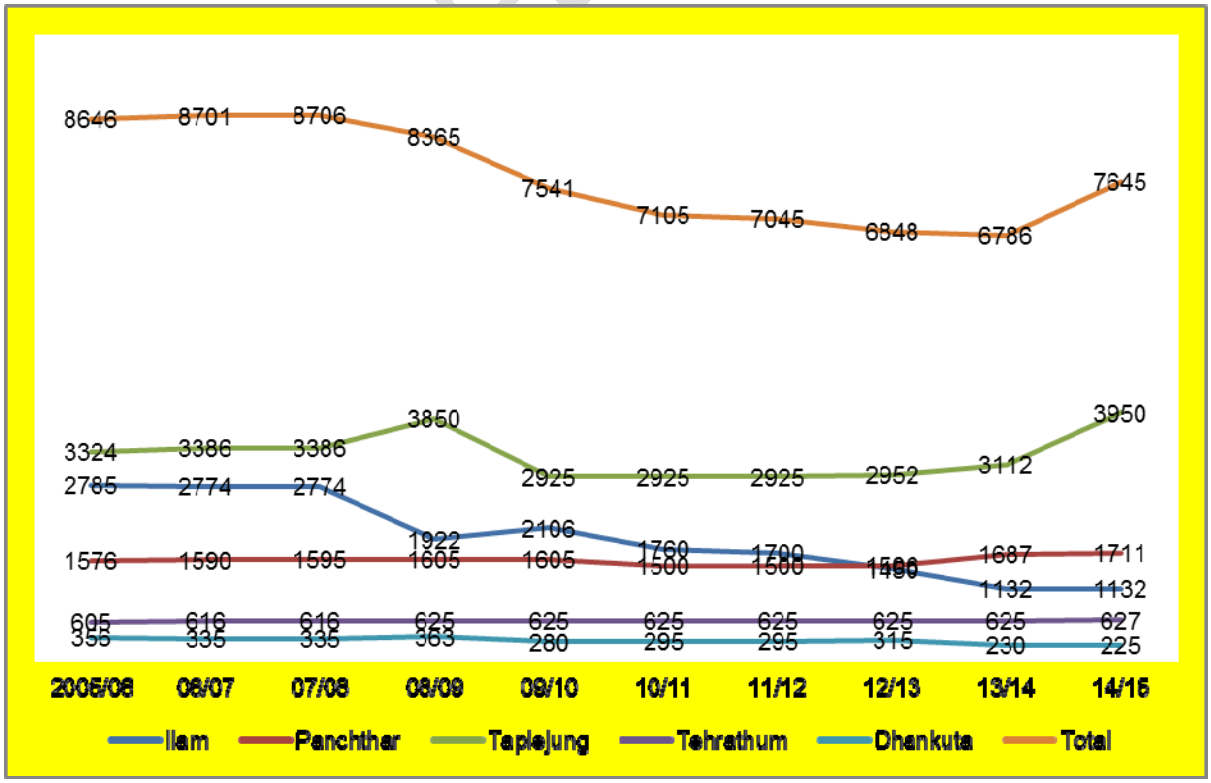

Figure 1: Trend of area (ha) of LC in the study district

3.1.2 Production of Large Cardamom in Study Districts

Production trend of LC in the study districts is also decreasing from fiscal year 2005/06 to 2014/15. In total, the production was 5262 tons in year 2005/06 which decreases each year and reach down to 2956 tons in year 2014/15. The main reason of decline is the very old plantation orchard in the district affected by diseases like foorkey, chhirkey and clump rot/rhizome rot which causes destroying of several plantation orchards in the districts (Figure 2).

We also calculated CAGR with regression analysis of total production of LC of the study districts from 2005/6 to 2014/15, the CAGR of production also significantly decreasing with (minus) -0.284 percent annually with p value 0.0002. It also reveals that the area of LC in the study districts is also decreasing significantly.

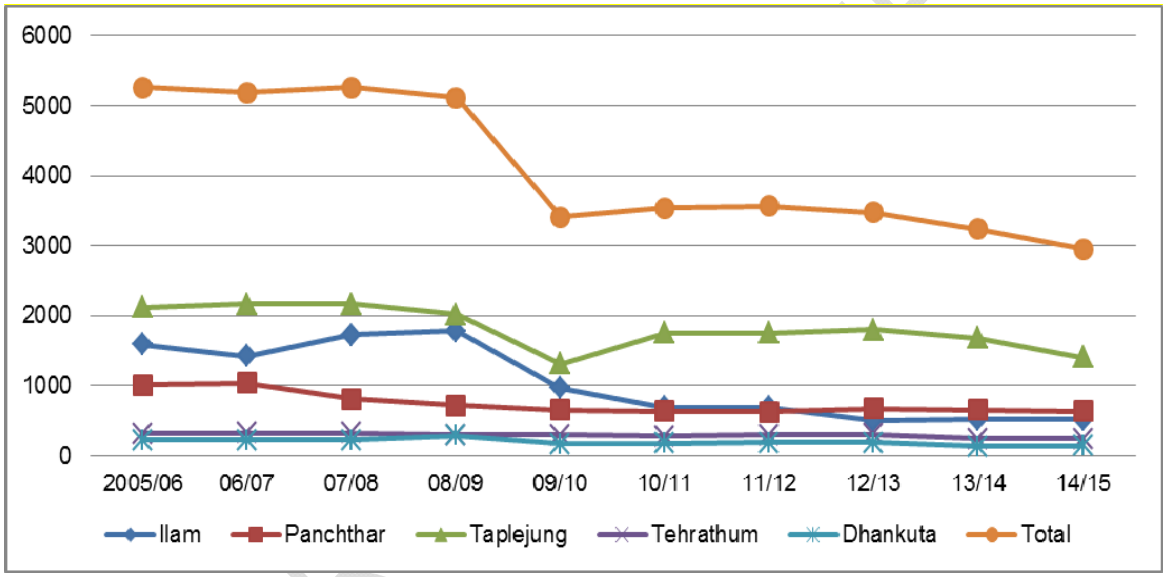

Figure 2: Production (tons) trend of LC in the study districts

3.2 Assessment of farmers practices for the management of Large Cardamom decline

3.2.1 Cultivars and Propagation

There are many cultivars with varied yield potentials and morphological characteristics, which are specific to different climates and altitudes. The popular cultivars, commonly adopted in the region are Ramsai, Golsai, Ramla, Chibesai, Sawane, Varlange, Damarsai, Jirmale, Salakpure, and Pakhe [9]. The study found that cultivars: Golsai and Chibesai had lower productivity compared to Ramsai in Panchthar, while it was found similar among these cultivars in Taplejung and Terhrathum.

Most of the farmers (96.32%) prefer rhizome over seed as a source of propagation material. In Tehrathum, all the farmers use suckers for propagation (Figure 3). Among them, 70% farmers buy suckers from neighbors and 30% farmers use own orchards suckers for multiplication.

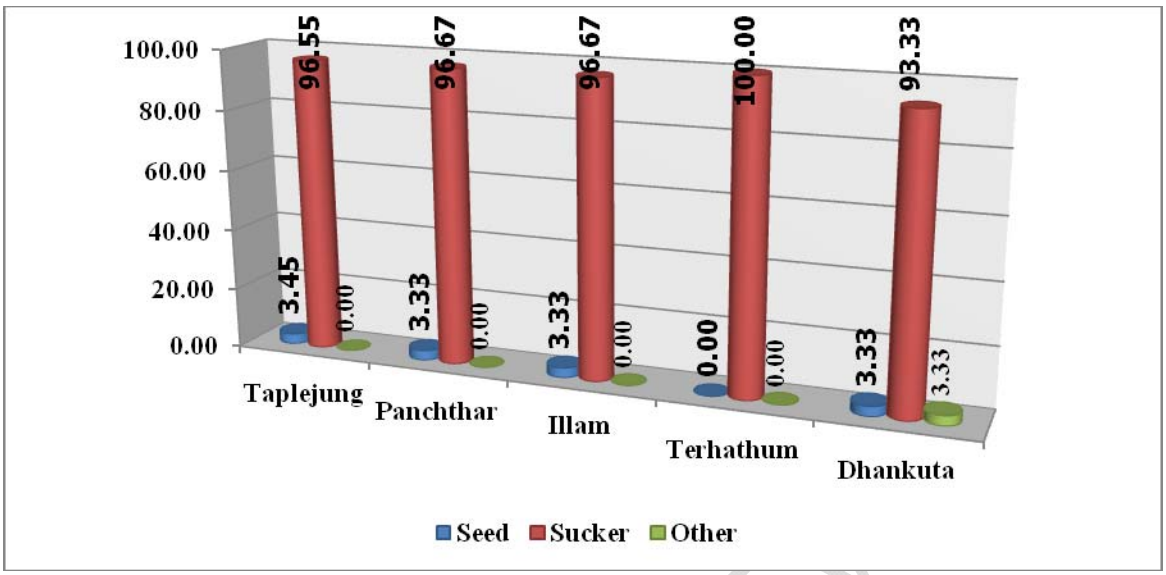

Figure 3: Method of Propagation of LC adopted by respondent in percentage (Source: Field Survey, 2016)

Overall, farmer buy suckers from other's orchard (58.82%) and some transfer suckers from own field (41.18%). Less than 1% farmers adopt other means of propagation such as tissue culture nursery plants (Figure 4). This may be due to ease of sucker transplantation and lack of knowledge about healthy plant establishment.

LC seedling deamand is very high throughout Nepal. The farmers from Province 1, whose orhchards have been collapsed for last few years are willing to replant with healthy seedlings. Due to high suckering nature of some cultivars; and high demand and price, farmers from Kolbung, Ilam are more interested towards sapling production than capsules.

Every year 20,000 saplings were supplied through Haspokhari LC Production Cooperative, Kolbung, Ilam. CDC, Ilam produces around 4.7 lakh saplings annually [10]. Similarly, NARC, Dhankuta also produces 50 thousand seedlings through seed and tissue culture but this is not sufficient to fullfill the high demand of farmers.

The study revealed that twenty seven nurseries are in place in Ilam, mostly concentrated in Jirmale, Kolbung, Fikkal and Mabu. There is nearly 10 lakh seedlings demand per annum, but the supply is only 1.5 lakh. Likewise seedling production internally in Taplejung is also insufficient.

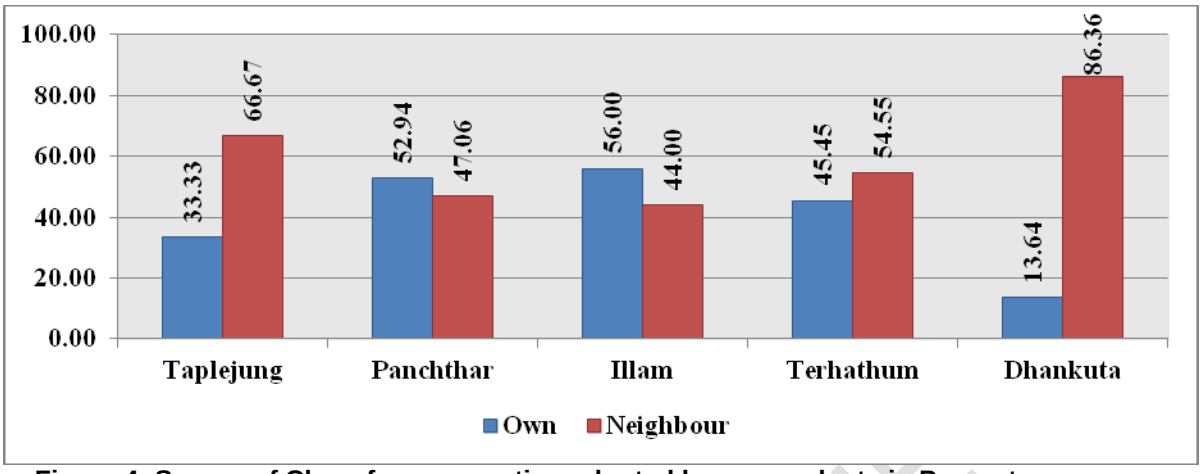

Figure 4: Source of Clone for propagation adopted by respondents in Percentage (Source: Field Survey, 2016)

3.2.2 Manure and fertilizer management

The study revealed that almost all cardamom growers do not apply manure and fertilizer. The general perception is that natural source of plant nutrient derived from the decaying leaf litter of the shading trees is sufficient for the crop. The cardamom orchards without additional manuring and fertilizing look poor growth and yield. The soil fertility in most of the areas has been declining over time. The possible reason for declining the soil fertility is because of exhausting the plant nutrients from the continuous cultivation for long time.

3.2.3 Irrigation

Ninety percent of respondents were irrigating orchards by different techniques such as canal/surface irrigation (39.9%), Sprinkler (15%) both canal and sprinkler (32.7%). The canal irrigation system could be the potential source of transmission of various fungal diseases as these crops grown mainly in terrain. The knowledge of disease transmission process through water found to be known by 29.33% of the respondents but they did not adopt any precaution measures to check the disease spread.

3.2.4 Current status of LC Decline

LC production is declining in most of the growing districts in Nepal. There are many reasons of this problem. In the study areas, Rhizome/Clump rot, Chhirkey, and Foorkey diseases are reported as the major factors of cardamom decline. The fruits remaining unripe due to unknown reason and declining in subsequent year has been reported as the new problem in Taplejung. The inadequate irrigation, use of disease infected seed materials, lack of knowledge about the mode of disease spread and continuous deforestation of shade trees from the cardamom orchards are observed as the major causal factors of the decline in the study areas. The diseases appeared most severe in older orchards in Ilam. Seed abortion and unripening has also become a threat to LC growing areas in Ilam. However, newer plantations are also poor due to the plantation of unhealthy planting materials. The plantations have almost collapsed in Ilam. However, some plantations of those farmers, who have given good care of management and sanitation, are still performing well for good yield.

Inappropriate plantation of cultivar as per the altitude and climate are also being major problem among the farmers, for instance *Ramsai* cultivar performs better in high altitude but it was also cultivated in lower belts. Although number of diseases has been diagnosed, the remedial pace for the control of these diseases is very slow. Farmers reported that over 40% of loss is associated with diseased orchards and will be collapsed completely by next 2-3 years. Comparatively lower incidence of diseases as reported in Taplejung could be the

reason for higher production, but there were many reports that showed a trend of gradual increase in the diseases incidence. All these curtailed the income of growers, forcing them to look to alternate farming enterprises.

3.2.5 Harvesting techniques as a source of disease spread

Use of single knives to harvest spikes of all plants in an orchard was found as main causal factor of spreading viral as well as fungal diseases in LC the plantation.

3.3 Pattern of disease distribution in studied districts

Distributions of diseases were mapped into three categories viz. places with low incidence (1-15%), moderate incidence (15-30%) and high incidence (>30%) based on disease incidence data as a perception of farmers and FGD with the concerned stakeholder.

As a whole, there was decline in LC production due to disease problems in Ilam, Panchthar, Terhathum and Dhankuta. There was no evidence of decline in production in Taplejung in spite of increasing infection of diseases. The decline was highest in Ilam because of higher incidence of Chhirkey, wilt, rhizome rot, and leaf blight, whereas severity of Foorkey and others were low to moderate (Table 1).

Table 1: Severity of different diseases in the study districts

District	Disease Severity				
	Rhizome rot	**Wilting**	**Chhirkey**	**Foorkey**	**Immature capsule**
1. Ilam	High	high	Moderate	Low	Low
2. Panchthar	High	Moderate	High	Low	Moderate
3. Tehrathum	High	Low	Low	Moderate	Moderate
4. Dhankuta	Moderate	High	Low	Low	Low
5. Taplejung	High	Low	Moderate	Low	Moderate

Source: Field survey, 2016

Similarly, Panchthar reported greater decline due to higher incidence of diseases like wilt, leaf blight and medium incidence of Chhirkey, Foorkey and low incidence of rhizome rot. Dhankuta and Tehrathum also reported some decline due to low/moderate incidence of disease and pests. Thus, Ilam and Panchthar can be grouped in one category with higher decline due to severe incidence. Taplejung, Terhathum and Dhankuta can be classified into second group with moderate decline with medium incidence of diseases.

3.3.1 Distributions of rhizome rot disease

Rhizome rot is a fungal disease in LC caused by *Rhizoctonia solani* Kuhn. Teleoporph stadium *Thanatephorus cucumeris* Donk. It is characterized by foul smell and red pink color of rhizome subsequently wilting symptoms and death of plants. It is transmitted by fungal movement from infected plant to healthy plants. It is most damaging disease of LC wherever this is grown but the intensity is high in higher altitude (1550 m) and during heavy raining months and under deep shade [11]. This disease ranked top priority by the farmers of eastern hill districts [12, 13].

This disease is prevalent in most of the LC growing region throughout Eastern hills during November to February. Dhankuta and Ilam are more prone to this disease. Other districts are less affected. Good orchard management with adequate irrigation system was reported to be very effective in controlling this disease.

3.3.2 Distribution of Wilting

Wilting is not serious in case if it is due to abiotic factors and there is chance of recovery. It has ranked second most important disease in the study districts. It was also supported by the Yadav *et.al. (*2014) [13]. Lack of appropriate drainage was reported to be major cause of wilting. This disease was seen during February and March. In Godak and Panchkanya of Ilam and Subang, Bharappa and Ranitar of Panchthar were reported to have this disease. Wilt disease caused by *Fusarium oxysporum Schlecht* shows symptoms of chlorosis of the older leaves at the junction of petiole with pseudo stem or their collapse while still green.

Wilting due to stem borer and rhizome borer are also reported in Dokhu, and Hangdeva of Taplejung. But this disease is not much serious in comparison to others.

3.3.3 Distribution of Leaf Blight Disease

Leaf blight is complex diseases seen in LC. It has hot third rank of the disease in the study district. It was also supported by Yadav *et.al. (*2014) [13]. It mainly occurs due to bacteria and fungi (*Pestalotiopsis versicolor* (Sepg.). It is characterized by minute grey spots with chlorotic holes on the leaves mostly from the tip and margin. This disease is seen during January to May. It is often confusing with the wilting symptoms produced by fungal from wilting due to borer. Leaf blight was reported in all the districts, especially in Taplejung, Panchthar and Ilam. Farmers reported that leaf blight is also a major cause of decline of LC production.

3.3.4 Distribution of Foorkey Disease

Foorkey is also a viral disease belonging to the genus Nanovirus and family Nanoviridae [14] and causal agent is Cardamom bushy dwarf virus (CBDV). This disease is characterized by dwarf tillers with small slightly curled pale green leaves; and mainly reported in lower altitude. The tillers do not grow beyond a few inches in height and appear bushy. The virus induces reduction in size of leafy and leaf shoots of the infected plants. The diseased plants remain unproductive and gradually degenerated. Foorkey symptoms appear both on seedlings and grown up plants [15]. It is also called as stunt mosaic virus of LC. Locally, this disease is called *Jurjure*. This disease is observed mainly during rainy season. It is also sap transmissible disease and is mainly transmitted by aphids (*Mollitrichosiphum sp.*). Clonal propagation from diseased plants is main reason of spread of this disease. So, regular rouging, uprooting and burying the infected samples in an isolated region were mentioned to minimize the spread of these two viral diseases in the affected plantations [16].

Its' severity is found to be low in high hills. Earlier Ilam was found to be affected by this disease but nowadays its severity is low. A total of 10% clumps were infected by this disease [11]. In Kolbung, Panchkanya and Godak of Ilam losses due to this disease was found to be more than 50%. Low incidence of this disease was found in Taplejung district but in some part of Khejunum showed more incidence of this disease. Medium severity exists in Dhankuta and Panchthar. Similarly, low severity is found in Terhthum district.

3.3.5 Distribution of Chhirkey Disease

Chhirkeyy is an important viral disease of LC and is also called as Streak Mosaic Virus. The causal agent of Chhirkey disease is Large Cardamom Chhirkey Virus (LCCV), genus *Macluravirus*, family *Potyviridae*. It was reported since last 50 years in most of the growing areas with significant losses in production. This disease is characterized by light and dark green streaks on leaves. This disease is transmitted by aphids (*Rhopalosiphum maidis* and *Brachycaudus helichrysi*) in a non-persistent manner [17]. The yield loss due to this disease was reported at ranging from 33.97% to 52.84% in the affected plants but Raychoudhuri experiment showed up to 85.2% loss [18].

Chhirkey was initially seen in Ilam district with high severity and later transmitted to other districts. It is the second priority disease of Ilam after Rhizome rot [12]. Low severity of this disease is seen in Taplejung and Terhathum. This disease is not transmitted through seed

so propagation from seed or from sucker is recommended. Treatment of disease by 0.075% of hydroquinone and soil drenching with 0.1% of thiouracil showed virus inhibition [18, 19].

3.3.6 Distribution of Immature Capsule Problem

Immature capsule refers to unripening of capsule that means at the time of harvesting seeds are still white in color. This problem is new in LC orchard. Since last few years, this disease is affecting quality parameter as well as weight of capsule. Etiology of this problem is unknown. During this study it was reported that the severity of this disease in more than 50% in all the districts and nearly 80% in Panchthar district.

Most problematic disease was reported to be Foorkey followed by rhizome rot, leaf blight and Chhirkey in descending order during 1998 [20]. Whereas at present severity of Foorkey disease has found low. Chhirkey affected leaves shows streak mosaic which after drying causes degeneration of clumps resulting in reduction in yield and production. Foorkey causes dwarf tillers and small leaves and stunted growth of suckers which results in whole plant drying. Rhizome rot shows wilting symptoms and death of plants. All these effects of diseases result in decline in production and productivity. It is general perception that LC cultivation is being severely suffered by the disease problems. Majority of farmers estimated the loss to be more than 30%. Foorkey was the burning problem with rhizome rot in second position as problematic disease.

4. CONCLUSION AND RECOMMENDATIONS

The study identified the cardamom decline due to disease complex and its' spread to new areas are main problem of decreasing production and productivity of LC. The complete collapse of the cardamom plants from old orchards in Ilam is havoc among farmers. The farmers are hesitating to replant due to fear of disease complex. In this context, following plan of actions has been suggested for the management of cardamom decline:

1. The NARC should focus on developing technologies in the following areas: :
    a. Management of disease complex
    b. Location specific varietal development
    c. Nutrient and water management
    d. Insect management
    e. Orchard husbandry including shade tree management, mulching, intercultural operation, sanitation
    f. Effect of climate change on cardamom.
2. Capacity building of all actors of cardamom value chain
3. Production and supply of virus-free nursery plants
4. Nurserymen/owners, firms and commercial farmers should be trained on appropriate nursery management techniques for the production and multiplication of saplings.
5. Develop and enforce effective quarantine system within the country to control disease spread within cardamom growing district
6. Carry out awareness campaign and empower the stakeholders with technical and technology knowledge and skill for the overall decline management
7. Destroy diseased orchards and replant with assured healthy planting materials.

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