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S&T REVIEW

INSECT PESTS INFESTATION, DISEASES AND MANAGEMENT PRACTICE OF LARGE CARDAMOM IN NEPAL: A REVIEW

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ABSTRACT

Prolong infestation of Insects Pests and rapid virulence of several diseases on large cardamom causes a drastic reduction in potential production, threatens Nepalese agricultural finance of 48 hilly districts. Unsustainable, unhealthy, and traditional management practices before and after susceptible are major causes of yield reduction. This review will be fruitful to the segregation and management of major pathogenic entities of large cardamom. The entire information is collected through reviewing different published thesis, articles of Research gate, Science direct, pub med, ministry of agriculture in Nepal, and self field study on cardamom orchards of different agro-climatic districts of Nepal. Large cardamom is a commercially cultivated major cash crop of Nepal having large export potential. However, successful cultivation and management practice is a challenging task for every farmer due to monoculture farming support on the infestation of insect Pests and susceptibility of several diseases. This review helps cardamom farmers for identification of structural abnormalities caused by insect pests, bacteria, fungus, virus, nematodes till date and integrated management practice in field level.

KEYWORDS

Diseases, Insects pests, Large Cardamom, Management, Nepal.

1. INTRODUCTION

Large Cardamom (*Amomum subulatum rox.*) is one of the large commercially cultivated spice and medicinal cash crops of Nepal (Baniya et al., 2019; Ravindran & Madhusoodanan, 2002; K. P. Shrestha, 2018). From recent years, the production capacity of large cardamom is gradually decreasing due to insect pests infestation, diseases, environmental factors, soil fertility degradation, fluctuation in market price (Chakraborty & Chakma, 2019; Pun, 2018; K. Shrestha, 2018). The Nepali name of large cardamom is "Alainchi" also renowned as 'black gold' as well as queen of spice crops falls under Zingiberaceae family (Acharya, 2019; Shrestha, 2018). It is partially shade loving, tall, perennial, evergreen, herbaceous, monocot plant generally pollinated by Bumblebees and grow under *Uttis* (*Alnus Nepalensis*) tree in eastern Himalayan of Nepal (Khatiwada et al., 2019; RAO et al., 1993; Sharma et al., 2019). Recently, Nepalese government had registered 5 different varieties of large cardamom which are Ramsai, Golsai, Dambarsai, Jirmale and Bharlyange (Adhikari, 2020). According to the Ministry of Agriculture of Nepal, those farmers who cultivate the registered varieties of large cardamom will get subsidies on fertilizer, quality planting materials, irrigation system management.

In Nepal, generally 14 varieties of large cardamom are being cultivated, whose name and generally cultivated height above sea level is given below on table.

Table 1: Different varieties with their cultivable height (Adhikari, 2020)

| Name of varieties. | Cultivated height above sea level (M) |
|----------------------|---------------------------------------|
| 1) Ramsai | 1500 to 2000 |
| 2) Golsai | 1200 to 1600 |
| 3) Jirmale | 600 to 1200 |
| 4) Dambarsai | 600 to 1200 |
| 5) Bharlyange | 1200 to 2200 |
| 6) Saune | 1000 to 1600 |
| 7) Chibesai | 700 to 1200 |
| 8) Serimna | 1200 to 1800 |
| 9) Madhusai | 1200 to 1600 |
| 10) Sikkim | 1500 to 1700 |
| 11) Ramala | 1000 to 1500 |
| 12) Taplejung golsai | 1500 to 1200 |
| 13) Jangugolsai | 600 to 1200 |
| 14) Dzongu golsai | 975 |

Nearly 50 % of shade is required for the healthy cultivation of large cardamom (Sharma et al., 2008; Thapa & Dhimal, 2018). Cardamom farming is a monoculture practice so there are more chances to complete several life cycles by insects, pests, fungi, bacteria, viruses, and more severity of infestation. There are certain varieties of large cardamom which are seriously affected by under low shade condition which are Bharlyange, Sawney, Jirmale (Pathak, 2008; Srivastava, 1989). It has medicinal properties too but several Insects pests infestation, diseases; the ingredients composition quality is decreasing (Prasad et al., 1984; Yadav et al., 2014). So this review helps both qualitative and quantitative production and management according to international standards as well as sustainable farming.

2. STATEMENT OF PROBLEM

Few previous researchers have done research on particular aspects of large cardamom in Nepal but a not complete review on major insects pests infestation and Diseases of large cardamom that is actually more severe in farmers field level. This present review focus on such topic from 1985 to 2020 A.D. as well as has attempted at healthy cultivation practice.

3. METHODOLOGY

The entire information was obtained from a review of Several published sources such as the thesis of A.F.U library, review papers, several books, journal papers, self-survey of different parts of large Cardamom producing areas of Sankhuwasava, Dhankuta, Illam, Bhojpur districts of Nepal.

4. INSECT PESTS INFESTATION AND SUSTAINABLE MANAGEMENT OF LARGE CARDAMOM

4.1 Leaf eating caterpillar in large cardamom

4.1.1 Causal agent

Artona chorista Jordan (Vijayan, 2020)

4.1.2 Major infested districts of Nepal

(Shrestha, 2018)

- Sankhuwasava
- Dhankuta
- Illam
- Baglung
- Bhojpur

4.1.3 Diseases symptoms

When we see on the lower surface of the leaf, we can see the larvae of butterflies in around 60 to 200 clustering together because they are more voracious and gregarious in nature (Chakraborty & Chakma, 2019; Srivastava, 1989; Tangjang & Sharma, 2018). During the primary stage, they stay underneath of leaf surface and feed the chlorophyll content of leaves resulting papery thin epidermis-like structure is remain also called skeletonization (Mandal et al., 2012; Vijayan, 2020). At advance, stage mechanical damages of leaves and defoliation occur (Prasad et al., 1984). The figure of the susceptible leaf is given here.



Figure 1: Leaf eating caterpillar in large cardamom (Dema, 2021)

4.1.4 Management practice

The management should be the adoption of modified cultural methods, judicious application of chemicals, use of resistant cultivars, and exploitation of biological resources (Yadav et al., 2021).

- **Cultural methods:** Remove the Infested plant and it's parts with larvae of butterflies and burn it distance from the main field (Bentley, 2016; Ravindran & Madhusoodanan, 2002)
- **Chemical method:** At the early stage of infestation, make the solution of Quinalphos 25 EC@ 200ml/100L of water or Endosulfan

35EC @143/100L of water and spray 500 to 600 ml solution per Plant. If the infestation is more severe, make the same solution@400ml/100L of water or 286ml/100L of water (Sharma et al., 2016; Vijayan, 2020).

4.2 Shoot fly infestation in large cardamoms

4.2.1 Causal agent

Merchloropous dinnorophus (Bentley, 2016; Pun, 2018).

4.2.2 Diseases symptoms

When the capsule is harvested, thinning out of unproductive tillers and non-bearer old pseudostem is generally done (Pathak, 2008; Shrestha et al., 2018). After that, the rapid growth of productive tillers occurs. When flies landing on shoots of tiller infestation progress more and a brown coloration pattern is visible and finally necrosis of the shoot and its heart occurs (Vijayan, 2020).



Figure 2: Shoot fly infestation in large cardamoms symptoms (Vijayan, 2015)

4.2.3 Management of Shoot fly infestation in large cardamom

a) Cultural method: inspect the main field then if u see such symptoms, Prune out the bushes and burn them.

b) Chemical method: Spray the Dimethoate 30 EC or Quinalphos 25 EC@1 Liter/500 to 800L of water for 1 ha land (Prasad et al., 1984; Shrestha, 2018; Vijayan, 2020).

4.3 Stem borer in large cardamom

4.3.1 Causal agent

Glyphetera species (Tangjang & Sharma, 2018; Yadav et al., 2014).

4.3.2 Diseases symptoms

The larvae of *Glyphetera species* start to bore the pseudostem above from the collar region and feed the central part is pseudostem causes dead heart (Acharya, 2019; Chakraborty & Chakma, 2019; Ravindran & Madhusoodanan, 2002). Finally, leaf starts to logging and chlorosis to necrosis (Prasad et al., 1984). When we closely observe the tunnel on pseudostem, we can see some worm castings outside (Bentley, 2016; Vijayan, 2020).



Figure 3: Stem borer symptom (Vijayan, 2020)

4.3.3 Management practice

Remove the affected plant parts and burn them (Mandal et al., 2012; Sharma et al., 2016). Chemically drenching of Quinalphos 25 EC@1L per 500 to 800 L of water for 1 ha during March, April, May, August to September give the best result (Pathak, 2008).

4.4 Tea mosquito bug infestation in large cardamom

4.4.1 Causal agent

Helopeltis theivora (Sahoo et al., 2016).



Figure 4: Tea mosquito bug infestation (Sahoo et al., 2016)

4.4.2 Diseases symptoms

In recent years it becomes the major infestable pest for large cardamom in Nepal (Prasad et al., 1984; Sahoo et al., 2016; Srivastava, 1989). It sucks the sap leaves result in the streak stain formation causes a brown color pattern in leaves (Prasad et al., 1984; Sahoo et al., 2016). Sometimes the young shoot appears curling type and causes slow down the growth of the plant and reduces the yield indirectly (Vijayan, 2020). The infestation is more dominant in April to September; spreads rapidly from the micro-level to the whole orchard (Prasad et al., 1984; Srivastava, 1989).

4.4.3 Diseases Management

Remove all the collateral and alternate host plants like Colocasia, ginger, turmeric, Alder tree then maintain the 50 percent shade level (Deka et al., 2016; Sharma et al., 2008). Remove the infested plant part and burn it (Vijayan, 2020). Chemically, Drenching of Malathion 50 EC or Phosalone 35 EC@2 ml/ L of water (Deka et al., 2016; Prasad et al., 1984).

4.5 Leaf folding caterpillar in large cardamom

4.5.1 Causal agent

Brownish yellow moth (Vijayan, 2020).

4.5.2 Diseases symptoms

From July to September, the moth folds the currently mature leaf of large cardamom and gradually feeds the chlorophyll content of leaves (Nair, 2020). Indirectly reduces yield as well as more chances of an infestation of other Diseases (Nair, 2020; Vijayan, 2020).

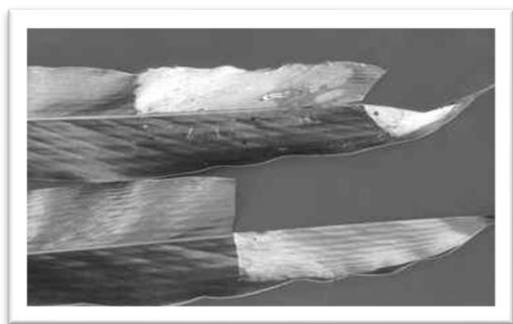


Figure 5: Leaf folding caterpillar symptoms (Leaf Folding Caterpillar - Large Cardamom - Medicinal Plants Archive, 2019)

4.5.3 Management practice

Used pheromones trap to capture the adult male (Chakraborty & Chakma, 2019; Deka et al., 2016). Abamectin can also used@2.5gm/L of water and spray it on folded parts.

4.6 Capsule borer in large cardamom

4.6.1 Causal agent

Dichocrocis punctiferalis (Nair, 2020).

4.6.2 Diseases symptoms

When we closely observe the capsule of large cardamom, we can see the hole on it so the decay of the capsule occurs (Nair, 2020; Shohe & Roy, 2018).



Figure 6: Capsule borer effect symptoms (Cardamom :: Major Pest :: Shoot, Panicle, and Capsule Borer,)

4.6.3 Management practice

Clear all the weeds and leaves of the Alder tree that falls on the capsule that prevents the manifestation of Insects pest (Sharma et al., 2008). Spray the carbaryl 50 WP 1 kg a.i 600 to 800L of water for 1 ha (Ravindran & Madhusoodanan, 2002).

4.7 Leaf beetle in large cardamom

4.7.1 Causal agent

Lema spp (Vijayan, 2020).

4.7.2 Disease symptoms

Beetles make irregular holes on tender leaf surfaces that cause damages to the leaf resulting in indirect yield loss (Vijayan, 2020).

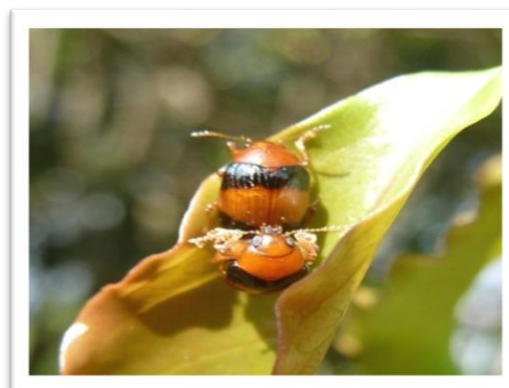


Figure 7: Leaf beetle (JMK, 2012)

4.7.3 Disease Management

Use pheromones trap to capture the adult male (Ravindran & Madhusoodanan, 2002).

4.8 Fruit borer in large cardamom

4.8.1 Causal agent

Scolytid beetle (Vijayan, 2020).

4.8.2 Diseases symptoms

Generally beetles make holes on immature capsules and feed all the seeds of the capsule thus making an empty capsule (Nair, 2020; Vijayan, 2020).

4.8.3 Diseases management

Used Diafenthiuron @200 gm with 800L of water for 1 ha (Nair, 2020).

4.9 White grub in large cardamom

4.9.1 Causal agent

Holotrichia spp (Vijayan, 2020).

4.9.2 Diseases symptoms

Generally, grub damage the base of the pseudostem and rhizome part of the plant resulting in yellowing to final wilting of the whole plant (Chakraborty & Chakma, 2019; Tangjang & Sharma, 2018; Yadav et al., 2014). In Nepal, the infestation is severe during September to December reported in Sankhuwasava district of Dharmadevi municipality (author personal observation).



Figure 8: Showing larvae of white grub in large cardamom. (*What Are Grub Worms | King Green,*)

4.9.3 Management

Collect the beetles using a hand net in the daytime because they are resting on leaves. Apply the chlorpyrifos in soil @ 0.075 % or Phorate 2.4 gm a.i per plant and from September to December. Used entomopathogenic nematode @ 100 million per arc in the white grub-infested field (Devi, 2019).

5. ROOT-KNOT NEMATODE IN LARGE CARDAMOM

5.1 Causal agent

Meloidogyne incognita (Dhakal & Shrestha, 2004; Nair, 2020).

5.2 Diseases dominance

Generally more dominance occurs in the post-monsoon period (Sep to Oct in soil) (Nair, 2020).

5.3 Diseases symptoms

This type of nematode generally affects the seedlings of cardamom in the nursery bed (Mandal et al., 2012). Due to this leaves becomes narrow and the Rosette type consequently reduces in inter-nodal area. When we see the roots, excessive branching with galls (Dhakal & Shrestha, 2004; Nair, 2020). Finally, the plant becomes stunted and can't bear a productive capsule. Flowering starts delay from normal time and premature fruit drooping causes the yield loss on large scale. One study shows that serve infestation can decrease the 80 percent total yield (Dhakal & Shrestha, 2004).



Figure 9: Root affected by *Meloidogyne spp.* (Padilla, 2019)

5.4 Management of Nematode

- Major sources of inoculums are infested seedlings hence avoid the transplanting of infested seedlings (Vijayan, 2020).
- Solarization of nursery beds is recommended (Nair, 2020).
- Replace the site of the nursery bed each year (Nair, 2020).
- Pretreatment of infested nursery bed by methyl bromide @500 to 600 gm per 10 square meters (Nair, 2020). Drenching of a 5 percentage formalin solution is recommended (Dhakal & Shrestha, 2004).
- Application of nematicides in the infested nursery is recommended @ Carbofuran or Phorate @5 gm a.i per bed twice a year (Nair, 2020).
- Biocontrol: Inoculation of *Trichoderma* in seedlings is best for nematode control (Dhakal & Shrestha, 2004).
- Curing of the stock base with meta captain solution before planting also used well-rotted Manure (Dhakal & Shrestha, 2004).

6. FUNGAL DISEASES OF LARGE CARDAMOM

About 70-80% of losses in agricultural production due to microbial disease are caused by fungal pathogens. There are around 8,000 fungal species that cause 100,000 diseases in plants (Bhandari et al., 2021). Similarly, many fungal diseases are found in Large cardamom some common diseases are listed below.

6.1 Blight

6.1.1 Causal agent

Colletotrichum gloeosporioidis (Prasad et al., 1984).

6.1.2 Diseases symptoms

When observing the Cardamom orchard we can see the water-soaked types of lesions on leaf tips or margins (Nair, 2020; Prasad et al., 1984). When infestation is prolonged, the lesions are enlarge and coalesce result covering of entire leaf blade and a burning type or blighted appearance occur (Belbase et al., 2018; Gurung et al., 2020; Pathak, 2008). At the advanced stage, lesions appear blackish brownish color (Ravindran & Madhusoodanan, 2002; Yadav et al., 2014). When infestation is severe, the leaf becomes necrotic and dry soon and the leaf sheath covering to pseudostem shows an alternate patterns of blackish brownish from apex to rhizome parts (Prasad et al., 1984). Finally, the pseudostem brittle and breaks at the middle or collar region and lodging occurs (Belbase et al., 2018). Eventually, the entire clumps dry up completely and the whole bush appears completely burnt type (Belbase et al., 2018; Tangjang & Sharma, 2018).

6.1.3 Nature of fungus

Soil born and able to withstand crop residue (Nair, 2020).

Favorable conditions for fungus inoculation and colonization (Nair, 2020).

- Inadequate shade level
- Lack of field sanitation and nutrient management.

- Generally, cultivation practices of cardamom in monoculture type resulting favorable conditions for the growth and development of fungus.



Figure 10: Showing blighted appearance of the leaf (Author)

6.1.4 Management practice

6.1.4.1 Cultural method

Remove all the plant parts and pruned non-productive bearer from the base of the clumps of cardamom after harvesting the capsule and burn it (Nair, 2020; Prasad et al., 1984), manage the collateral and alternate host.

6.1.4.2 Chemical method

Spray copper oxychloride or Bordeaux mixture@300 gm per 100L of water and spray 500 to 600 ml per plant and repeat the same action every 15 days interval if the infestation is more advanced (Belbase et al., 2018; Gurung et al., 2020; Nair, 2020).

We can treat the propagating sucker with bioagents like *Pseudomonas fluorescens* @5L in 100 L of water from April last week to May first week because the infestation is more dominant (Chakraborty & Chakma, 2019; Shrestha et al., 2018; Vijayan et al., 2013). During soil preparation, we can mix the *Trichoderma* with FYM at the ratio of 1:100@2kg/clump at the soil bed (Rao et al., 1993; Vijayan et al., 2013).

6.2 Seedling rots/ wilts diseases of large cardamom

6.2.1 Causal agent

Fusarium oxysporum (Chakraborty & Chakma, 2019; Shrestha et al., 2018).

6.2.2 Diseases symptoms

When we see the leaf of seedling, we can see a pale and yellow color pattern gradually spreading over leaf sheath and pseudostem resulting in wilt occurs (Shrestha et al., 2018). At the advanced stage, the collar portion of the seedling starts to decay and the whole seedling collapse, and infestation spread over all nursery.



Figure 11: Showing wilting of Cardamom (Kisan suvidha, 2017)

6.2.3 Diseases management

Make nursery in well-draining place and sandy loam soil is best for drainage and nutrient purpose (Ravindran & Madhusoodanan, 2002), spray mycostop fungicide@2 gm to 3.5 gm/100 square feet (Chakraborty & Chakma, 2019; Dhakal & Shrestha, 2004; Shohe & Roy, 2018). Use organic neem oil and complete solarization of nursery bed before establishing the seedlings.

6.3 Leaf blotch Diseases of large cardamom

6.3.1 Causal agent

Phaeodactylum spp (Bentley, 2016).

6.3.2 Infestation season

June to August (Commonly seen in eastern parts of Nepal (P. K. Yadav et al., 2014).

6.3.3 Diseases symptoms

Generally in the Rainy season, we can see the ovoid, rounded, or irregular water-soaked lesions on the middle parts of leaves. These lesions enlarge the size and appear dark brown with a necrotic center (Pathak, 2008; Sharma et al., 2016; Thapa & Dhimal, 2018). In humid weather, when we see beneath the leaf surface, we can see the outgrowth of dense fungal mycelia in blotches area (Nair, 2020).

6.3.4 Diseases management

- Spray Bavistin or Hinoson @1.5 to 2 gm with 1 L of water. Spray copper oxychloride in an infested field@3percentage (Acharya, 2019; Nair, 2020; Thapa & Dhimal, 2018).
- Used the seedlings propagated through tissue culture (Acharya, 2019).

6.4 Leaf rust diseases of large Cardamom

6.4.1 Causal agent

Phakopsora spp (Nair, 2020; SCHIEBER & ZENTMYER, 1985).

Period of Fungal dominance: October to May (SCHIEBER & ZENTMYER, 1985).

6.4.2 Diseases symptoms

When we see beneath the leaf surface of cardamom, we can see the several yellowish rusty-colored pustules distributed. When we touch it we get some yellowish fungal bodies to attach to our fingers. At an advanced stage, the leaf turns into a Reddish-brown color pattern, and a completely dry-off occurs (Nair, 2020).

6.4.2.1 Diseases management

6.4.2.2 Chemical method

Spray the mancozeb 0.2 to 2 gm per liter of water at the rate of 700 to 800 ml per plant or indofil M 45 at the same rate (SCHIEBER & ZENTMYER, 1985).



Figure 12: Leaf rust diseases (ENTOMOLOGY SIKKIM, 2019)

6.5 Sooty Mold fungus in large cardamom

6.5.1 Causal agent

Tricosporiopsis spp (Ravindran & Madhusoodanan, 2002; Vijayan, 2020).

6.5.2 Fungal dominance

December to June (Vijayan, 2020).

6.5.3 Major cause

Generally, Cardamom is grown under the shade of *Uttis* tree in Nepal. In December to June season, certain leaf sac sucker of the Alder tree defoliated and infests the leaf of the Alder tree. During their feeding stage, they generally released the resin-like waxy honeydew substance and fall directly on the leaf of cardamom resulting in the development of Sooty mold fungus (Nair, 2020; Vijayan, 2020).

Diseases symptoms: Due to these waxy substances, fungal thin papery carbon black dark mycelia is spread over the upper leaf surface, and when the infestation is more severe the dense mycelial starts the leaf surface and not allow the light to fall on the chlorophyll content result no food formation occurs and leaf starts to tear off from wind blow on margin along the direction of vein and drying of the leaf at premature stage occurs (Acharya, 2019; Nair, 2020).

Diseases management: Maintain the shade level 50 percent and replace the avocado tree in place of the Alder tree (Acharya, 2019; Shrestha et al., 2018).

- The sprinkler irrigation method is the best for washing out the fungal mycelia in the beginning stage of mycelial development (Nair, 2020).
- Spray copper oxychloride solution on the field after sprinkler irrigation to eradicate the fungus (Acharya, 2019; Belbase et al., 2018).
- Spray the special type of insecticide to kill sapsucker.



Figure 13: Sample infested by sooty mold (Callan & Carris, 2004)

6.6 Damping of/Rhizome rot Diseases of large cardamom

6.6.1 Causal agent

Pythium vexan, *Rhizoctonia solani*, *Fusarium spp* (Belbase et al., 2018; Karkee & Mandal, 2020; Pathak, 2008; Tangjang & Sharma, 2018).

6.6.2 Diseases symptoms

When an infestation of Rhizome rot occurs, bristling and cracking of pseudostem occurs so there is the formation of dense tillers but unable to grow full size. Due to this, rotting starts from the tip of the tiller occurs (Nair, 2020; Vijayan, 2020). The favorable condition for faster rotting of tillers is bright sunlight after heavy rainfall (Ravindran & Madhusoodanan, 2002).

6.6.3 Management of Rhizome rot of Large Cardamom:

- Use disease-free planting material specially produced from tissue culture (Nair, 2020; Shrestha et al., 2018).

- Early sowing of suckers has fewer chances of infestation than is generally in August.
- Avoid stress during a flowering time like water stress (Keshav Prasad Shrestha et al., 2018).
- Used cinnamon oil or Neem oil to prevent the Damping-off to seedling in the winter season (Bentley, 2016).
- Treat the sucker with benzoyl 25 WP or bavistin 50WP @ 2.5 to 3 gm per liter of water and sowed (Karkee & Mandal, 2020; Vijayan, 2020).
- Spray the Dithane Z -78 or Mancozeb @ 2.5 gm per liter of water each 10 to 15 days interval (Mandal et al., 2012; Tangjang & Sharma, 2018).



Figure 14: Damping of/Rhizome rot Diseases (*Rhizome Rot: Large Cardamom*, 2016)

6.7 Phoma leaf spot diseases in large Cardamom

6.7.1 Causal agent

Phoma spp (Saju et al., 2011).

6.7.2 Diseases symptoms

These diseases are more prominent in the seedling of cardamom in nurseries (Bentley, 2016; Saju et al., 2011). When we see the leaf lamina, we can see the numerous water-soaked lesions generally ovoid or round in shape. When infestation more severe the soaked lesions coalesce and increase their diameter causing yellowing of leaf and center portion gradually dry out towards periphery (Belbase et al., 2018; Deka et al., 2016). Infestation is more prominent during the late winter and Rainy season having a humid environment (Saju et al., 2011).

Diseases management: Remove the advance infested plant parts and burn them. Provide a better drainage system in the Rainy period. Remove collateral and alternate host plant and maintain proper shade level (Nair, 2020; Saju et al., 2011). Spray the Bordeaux mixture 1 gm mixed with per liter of water 500 to 600 ml per bush and every 20 to 25 days repeat the same treatment during the rainy period (Belbase et al., 2018; Nair, 2020; Saju et al., 2011).



Figure 15: showing a sample of phoma leaf spot. (*Minor Disease :: Leaf Spot*, 2014)

6.8 Anthracnose in large cardamom

6.8.1 Causal agent

Pythium vexans, *Rhizoctonia solani* (Bentley, 2016).

6.8.2 Diseases symptoms

When we see on the leaf surface, water-soaked lesion appear on the leaf margin or the tip of leaves. These lesions gradually enlarge and coalesce and cover the entire leaf giving a burnt appearance (Bentley, 2016; Yadav et al., 2014). At an advanced stage, lesions are more blackish and brownish in color and the infested leaf starts chlorosis followed by necrosis and dry out (Belbase et al., 2018; Hugouvieux-Cotte-Pattat et al., 1996). The leaf sheath which covers the pseudostem shows blackish brownish coloration and gradually progresses down to rhizome. Finally, the pseudostem becomes brittle and breaks in the middle or at the base of the collar region and the entire bush appears burnt type (Nair, 2020).

6.8.3 Infested plant parts

Roots, clumps (POUDEL et al., 2018).

6.8.4 Mode of disease transmission

Infested planting materials like suckers, clumps, mechanical equipment (POUDEL et al., 2018).

6.8.5 Control and management

(POUDEL et al., 2018; Shohe & Roy, 2018).

- Maintain the proper shade level (Bhattari, 2016).
- Don't make the plant from water and nutrients stress (Khatiwada et al., 2019)
- Remove the alternate and collateral host (Sharma et al., 2008; Shrestha et al., 2018).
- Maintain proper spacing 150 cm apart (Ravindran & Madhusoodanan, 2002).
- Maintain the field and phyto sanitation by removing old cut dense and non-productive tillers (Ravindran & Madhusoodanan, 2002)
- By means of chemicals, the drenching of *bacillus subtilis* mixed with Cow urine diluted with water in a ratio of 1:5:10 can give better results (Nair, 2020; Ravindran & Madhusoodanan, 2002).



Figure 16: Showing Anthracnose in large cardamom (*Anthracnose: Large Cardamom.*)

6.9 Fungal Leaf streaks Diseases of large cardamom

6.9.1 Causal agent

Pestalotiopsis royenae (Gopi et al., 2018).

6.9.2 Diseases symptoms

When we see the young leaf of Cardamom; we can see numerous enlarged translucent streaks appearing on young leaf parallel with the vein (Gopi et al., 2018). In 4 to 5 days, the streaks appears reddish-brown in color

consisting of the central necrotic area surrounded by more prominent dark brown margins (Chakraborty & Chakma, 2019). The infection is more prominent in emerging folded leaves. The severity of this fungus is more prominent in Golai, Jirmale, Serimna, and Madhusai in different eastern Himalayan districts of Nepal (Pathak, 2008).

6.9.3 Diseases management

6.9.3.1 Chemical method

Generally, this disease infestation can be minimized by using copper oxychloride solution or Bordeaux mixture @ 2 gm per Liter of water or 1.5 gm per liter of Water (Chakraborty & Chakma, 2019; Gopi et al., 2018). The composition of the Bordeaux mixture is $\text{Ca(OH)}_2 + \text{CuSO}_4$ mixture.



Figure 17: Leaf streaks Diseases of large cardamom (Gopi et al., 2018)

7. BACTERIAL DISEASES OF LARGE CARDAMOM

7.1 Capsule canker/Spot

7.1.1 Causal agent

Xanthomonas spp (Nair, 2020)

7.1.2 Diseases symptoms

When we see the capsule of Cardamom after 15 days of flowering, we can see their shining blast or eruption which are silvery or papery white in color. Sometimes these eruptions cover the half area of the capsule depending upon the physiological race of bacteria (Nair, 2020; Shrestha et al., 2018).

7.1.3 Diseases management

Maintain the proper drainage system and prune the branches of the Alder tree in such a way that maximum sunlight allows to different parts of cardamom.

Drenching of Blitox -50 with 50 percentage copper oxychloride or Glycerols in soil or pyraclostrobin 0.08 gm per liter of water (Nair, 2020; Ravindran & Madhusoodanan, 2002; Shrestha et al., 2018).

7.2 Erwinia rots in large Cardamom

7.2.1 Causal agent

Gram negative bacterium *Erwinia chrysanthemi* (Hugouvieux-Cotte-Pattat et al., 1996)

7.2.2 Diseases symptoms

Foliage starts to chlorosis. Rotting and collapse of leafy stem on ground level (Hugouvieux-Cotte-Pattat et al., 1996). Inside the ground level, a pale yellow color develops on the rhizome which later leads to decaying of occurs (Nair, 2020; Ravindran & Madhusoodanan, 2002). At an advanced stage, roots start to die leads to the complete collapse of the whole plant occurs (Vijayan, 2020).

7.2.3 Bacterial management

Phyto sanitation is major best practice to control this bacterium (Nair, 2020; A. Vijayan, 2020) cut and separates the susceptible plant from the orchard and burn it (Ravindran & Madhusoodanan, 2002; A. Vijayan,

2020). Used disease-free plant propagated through tissue culture techniques. Chemically we can drench the streptocycline with Blitox 50 W containing 50 percentage copper oxychloride (Nair, 2020; Ravindran & Madhusoodanan, 2002).

8. APHIDS

8.1 Aphids in Large cardamom

Aphids act as the vector for transforming the major viral diseases of large cardamom (Ghosh et al., 2016). Banana aphid (*Pentalonia nigronervosa*), Alder tree aphid like *Moltrichosiphum montanum*) which is the collateral host (Bentley, 2016; Deka et al., 2014; Rao et al., 1993). These aphids are congregated on twigs or leaves of Alder tree respectively (G. Sharma et al., 2008). They feed the leaves sap and phloem tissue of pseudostem (Deka et al., 2014; Sharma et al., 2008). Hence they help to Inoculation of the viral entities on the healthy plants (Deka et al., 2014). To control aphids, phyto sanitization is a major cultural practice and chemically, we can control it by using systemic insecticide to kill the aphids in the collateral host plants (Sharma et al., 2008). Spray the Dimethoate 75 ml/ 100 liter of Water or acephate 1.3 gm/ Liter of water on the colony of aphid (Deka et al., 2014).



Figure 17: showing aphids attack (Vijayan et al., 2014)

9. VIRAL DISEASE

9.1 Chirkey Diseases of large cardamom

Both mechanically and biologically means can help the Inoculation process to the virus in the plant body (Aryal et al., 2018). Pruning tools help Inoculation mechanically and Corn Aphid (*Rhopalosiphum maidis*) is a biological vector. The primarily infected rhizome is a major source for spreading the diseases from one place to another (Aryal et al., 2018; Mandal et al., 2012; Ravindran & Madhusoodanan, 2002).

9.1.1 Diseases symptoms

When we see young emerged just unfolded leaves, we can see the mosaic appearance consisting of discreet pale green to yellow longitudinal stripes running parallel to each other. This result flowering greatly reduces results in yield loss (Aryal et al., 2018; Mandal et al., 2012; Tangjang & Sharma, 2018).

Diseases management:

- Used systemic herbicide to kill the aphids (Aryal et al., 2018).
- Uproot the infected plant parts and burn them (Nair, 2020).
- Plant the seedlings propagated through tissue culture or meristematic culture (Aryal et al., 2018; POUDEL et al., 2018).
- Phyto Sanitization is a major factor and inspection of Aphids during the rainy season and autumn (Deka et al., 2014; Ghosh et al., 2016).
- Maintain the shade level about to 50 Percentage (Deka et al., 2014; Shrestha et al., 2018).
- Make the nursery bed 500M away from the main field (Deka et al., 2014; Sharma et al., 2008). Spray the Neem oil or NSKE@0.3% or 5

ml/ Liter of water to vector colony (Aryal et al., 2018; Mandal et al., 2012).



Figure 18: Chirkey Diseases of large cardamom

9.2 Foorkey Diseases of large cardamom

9.2.1 Vector for Diseases

Only biological vector is responsible for Inoculation of the viral entity in plant cells but not mechanical means. Banana black Aphid (*Pentalonia nigronervosa*) and Uttis tree aphid (*Moltrichosiphum montanum*) is a major entity (Aryal et al., 2018).

9.2.2 Diseases symptoms

Many stunted shoots are seen in the affected bush. Thus leaves become small, curled, and place green color pattern but broader leaves appear to pan like modification which causes the unable to flower because inflorescence is stunted so no flower no fruit (Aryal et al., 2018; Pun, 2018).

9.2.3 Diseases management

- Used systemic herbicide to kill the aphids. Like 0.075 percentage of hydroquinone treatment on rhizome and soil drenching of 0.1 percentage thiourea (Aryal et al., 2018).
- Uproot the infected plant parts and burn it (Nair, 2020).
- Plant the seedlings propagated through tissue culture or meristematic culture (POUDEL et al., 2018; Prasath et al., 2010).
- Phyto Sanitization is a major Factor and inspection of Aphids during the rainy season and autumn (Aryal et al., 2018).
- Maintain the shade level about to 50 Percentage (Ravindran & Madhusoodanan, 2002).
- Make the nursery bed 500M away from the main field (Dhakal & Shrestha, 2004; Ravindran & Madhusoodanan, 2002).
- Spray the Neem oil or NSKE@0.3% or 5 ml/ Liter of water to vector colony (Dhakal & Shrestha, 2004; Ravindran & Madhusoodanan, 2002).



Figure 19: Showing Foorkey disease of cardamom (Suraj Poudel)



Figure 20: Well established healthy orchard of large Cardamom (Picture by Author)

10. CONCLUSION

Large Cardamom is a major export potential cash crop of Nepal. It contributes the major Agriculture GDP and source of income for about 48 hilly districts of Nepal. Large Cardamom is a multipurpose plant so it is used for medicinal, spice and condiments, and fiber purposes. In recent years the production of large Cardamom is decreasing due to Several factors like Insect pests infestation, diseases, environmental change, lack of self-processing techniques and third exporting countries, lack of diseases resistant varieties, etc. Major practical cause of declining large Cardamom production is lacking knowledge and inefficient management practice during infestation and diseased as well as the traditional system of cultivation practices. Efficient insect pests and diseases (fungal, bacterial Nematodes, and viral) management knowledge is necessary for enhancing qualitative as well as quantitative production and marketing. Many further research and review are necessary for identifying the new pathogenic organism and it's integrated control and measures. Experimental study, research, and extension in farmer's level should be prioritize to compete for the international trade and gain high profit in Large cardamom cultivation.

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