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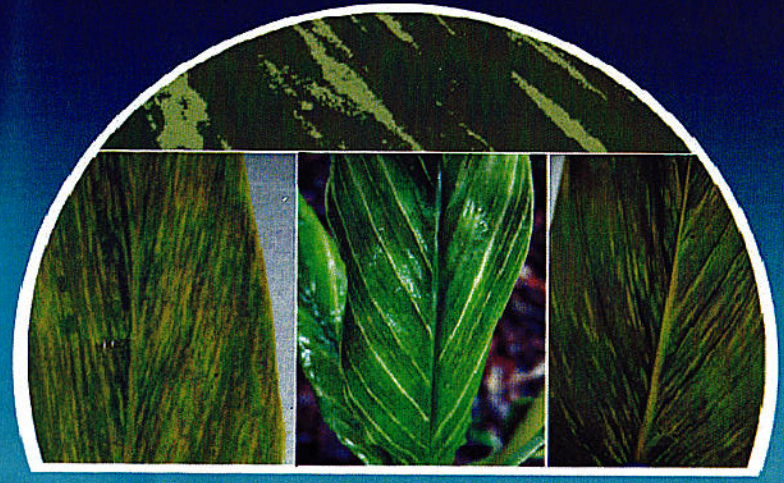
VIRAL DISEASES OF CARDAMOM AND THEIR MANAGEMENT



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Small cardamom (*Elettaria cardamomum* Maton) is a perennial, herbaceous monocot that belongs to the family, Zingiberaceae. This spice has its origin in the evergreen forests of the Western Ghats of South India and known as 'Queen of spices'. It is mainly cultivated in the states of Kerala, Karnataka, and Tamil Nadu, spanning an area of 82,150 ha with a production of 28,250 tonnes. Besides insects and fungal diseases, cardamom is affected by three important viral diseases namely, mosaic, chlorotic streak, and vein clearing (*kokke kandu*) the details of which are given below.

1. MOSAIC (*KATTE* OR MARBLE) DISEASE

Occurrence and yield loss

Katte or mosaic or marble disease incited by the cardamom mosaic virus (CdMV) is one of the important production constraints of cardamom in Guatemala, India, and Sri Lanka. In India, disease incidence ranged from 0 to 85% with a higher incidence and severity in Karnataka. Yield loss due to the disease invariably depends on the time of infection. If the plant is infected at the young stage, the loss will be almost 100%. However, delayed infection leads to a gradual decline in productivity. Higher crop losses (10-60%, 26-91%, and 82-92% during the first, second, and third year) was reported in cardamom-areca mixed cropping system compared to mono-crop conditions (38, 62 and 68.7% for the first, second and third year of infection). In general, the complete decline of the plants occurs within 3 to 5 years of infection.

Symptoms

The symptoms induced by CdMV include; prominent, discontinuous yellowish stripes radiating from the midrib to the margin on young leaves. The size of leaves gets reduced progressively and the plant remains stunted. Later, mottling develops on leaf sheaths. Immature plants when infected rarely produce panicles and set fruits. Whereas, older plants may produce a few lean crops. Variations in symptoms manifested could be attributed to variations in virus strains involved and prevailing environmental conditions in a particular geographical location. Being systemic, the disease consequently invades all the tillers in the clump and eventually the plants produce short, slender tillers with few short panicles in the advanced stages of disease development.

Causal virus

The disease is caused by the cardamom mosaic virus (CdMV) belonging to the genus, *Macluravirus* in the family, *Potyviridae*. CdMV is a flexuous rod-shaped virus with 650 nm x 12 nm in size. The various isolates of the virus are grouped into three: all isolates originating from Karnataka (except for the Sirsi isolate) were clustered into one group whereas Kerala isolates represented the other group.

2. CHLOROTIC STREAK

Occurrence and Symptoms

Chlorotic streak, initially reported from Sirsi taluk of Karnataka, is now widespread in all major cardamom cultivating tracts of both Karnataka and Kerala. The disease is characterized by the formation of spindle-shaped intravenous streaks along the veins and midribs. The streaks subsequently join together imparting yellow or light green colour to the veins. The petiole and pseudostem of infected plants also show spindle-shaped mottling. As disease advances, the number of tillers produced in the infected plants is reduced.

Causal virus

The disease is caused by a strain of banana bract mosaic virus (BBrMV) belonging to the genus, *Potyvirus* in the family, *Potyviridae*. Like CdMV, BBrMV also has a flexuous rod-shaped particle with about 700 nm x 13 nm in size. Genetically the BBrMV strain causing chlorotic streak in cardamom is 97% similar to the BBrMV strain causing bract mosaic disease in bananas.

3. VEIN CLEARING (*KOKKE KANDU*) DISEASE

Occurrence and yield loss

The vein-clearing disease, also known as *kokke kandu*, poses a severe threat to cardamom cultivation in India since 1993. The disease is reported from the Kodagu, Hassan, Chikkamagaluru, Shimoga, and Uttara Kannada districts of Karnataka. Among the three viral diseases, *kokke kandu* is the most devastating as the affected plants decline rapidly with yield reduction up to 62-84% in the first year of peak crop. The affected plants become stunted and perish within 1-2 years of infection. The disease occurs either singly or in mixed infection with the mosaic disease. Several thousands of hectares of cardamom plantations in the Hongadahalla zone of Hassan and Uttara Kannada districts of Karnataka have become uneconomical due to this disease.

Symptoms

The first visible symptoms of the *kokke kandu* disease include chlorosis of the veins followed by rosetting, loosening of the leaf sheath, and shredding of leaves. The newly emerging leaves get entangled in the older leaves and form a hook-like tiller hence the disease is locally known by the name *kokke kandu* (hook-like tiller). Leaf-sheaths of the infected

plants exhibit mottling symptoms. Light green patches with shallow grooves are seen on the immature capsules. Cracking of fruits and partial sterility of seeds are other associated deformities.

Causal virus

The disease is caused by the cardamom vein clearing virus (CdVCV) belonging to the genus, *Betanucleorhabdovirus* in the family *Rhabdoviridae*. CdVCV is a bacilliform (bullet) shaped enveloped virus with 45-100 nm in diameter and 130-300 nm in length.

Transmission of CdMV, BBrMV, and CdVCV

The major spread of all three viruses infecting cardamom (CdMV, BBrMV, and CdVCV) occurs vegetatively through suckers from infected plants used for fresh planting. None of the viruses are transmitted either through the seeds of infected plants or through the soil. The potential source of virus inoculum that facilitates disease spread includes nearby affected plantations, seedlings, nurseries raised in the vicinity of virus sources, and sprouted discards of infected suckers. The spread of viruses within the plantations occurs through winged alate forms of the aphid, *Pentalonia caladii.*

The aphid breeds on cardamom, *Colocasia,* and *Caladium*. Both the nymphal and adult stages of the aphid are able to transmit the virus. In plantations, the aphids are prevalent throughout the year, although a decline occurs during monsoon. The migrating population was found to be the maximum during January-February, while the populations of alate vectors were found higher from November to May.

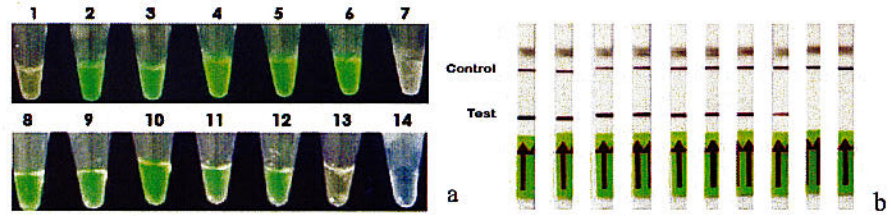
The incubation period of the virus within the plant ranges from 20-114 days depending upon the age of the plant and environmental conditions. Symptom expression is quicker from May to November, while the expression is delayed from December to March. Similarly, the symptoms develop within 15-20 days of virus inoculation in young plants compared to adult plants that require 30-40 days.

DETECTION AND DIAGNOSIS OF VIRUSES

Nucleic acid-based diagnostics such as reverse transcription polymerase chain reaction (RT-PCR) and real-time RT-PCR for quick and sensitive detection of the virus that will help in identifying virus-free mother plants for the production of virus-free plants.

Though symptoms are a good criterion for detection, many times depending on the season, and other factors, the disease can be difficult to identify or detect visually. Hence symptoms cannot be used as the criterion to identify virus-free plants. Viruses can be best detected using diagnostic assays such as enzyme-linked immunosorbent assay (ELISA), reverse transcription-polymerase

chain reaction (RT-PCR), real-time RT-PCR, RT-loop-mediated isothermal amplification (RT-LAMP) and recombinase polymerase amplification-lateral flow assay (RPA-LFA). Among them RT-LAMP and RPA-LFA are on site diagnostic tools that can be used at the field. Any of the above assays can be used to identify virus-free plants for vegetative propagation and virus-infected plants can be avoided for vegetative multiplication.



Detection of the virus through (a) Reverse transcription - loop mediated isothermal amplification (RT-LAMP), Green fluorescence indicates that the plant is infected and (b) RT - recombinase polymerase amplification - lateral flow assay (RT-RPA-LFA), Presence of coloured lines both at the test and control indicates that the plant is infected

MANAGEMENT

The major strategy to manage the disease should include developing/evolving virus-resistant varieties. IISR-Vijetha, a resistant variety of cardamom against CdMV is recommended for cultivation in endemic areas of *katte* disease. No resistant variety is available against the other two viruses infecting cardamom. Hence, the present focus for the management should be on the integrated approach that includes removal of sources of virus

reservoirs/inoculum, identification, and production of virus-free plants, early detection of the virus in the plants at the incubation stage, and management of the aphid vector. Large-scale multiplication and planting of virus-free planting material play a vital role in eliminating viral diseases of small cardamom even from endemic regions. Several strategies have been developed and recommended to ward off the disease from nurseries as well as plantations. The nurseries should be established in isolated locations and the nucleus planting material should be obtained from disease-free plantations.

Early detection of the viruses using reliable and sensitive nucleic acid-based techniques such as RT-PCR, real-time RT-PCR, and RT-LAMP would enable to the identification of disease-free healthy mother genotypes for subsequent propagation. Volunteers grown out from the remnants of infected plants could serve as potential primary sources of the viruses and could facilitate the subsequent spread of disease in the plantations. Rouging and destruction of volunteers and their complete elimination in the vicinity of nurseries, particularly in the endemic areas are imperative for the production of virus-free planting materials. Regular monitoring, tracing out, and destruction of infected plants and collateral hosts (like *Colocasia* and *Caladium*), which may act as breeding sites of vectors are indispensable in managing viral diseases of cardamom. Whenever insects such as aphids are seen in the plantations, they should be managed by spraying with recommended insecticides such as imidacloprid (0.5 ml per litre) or

thiometon (0.5 g per litre) after trashing old and senile leaves that increases the efficacy of vector control.

Extracts from plant species including neem, *Acorus calamus*, *Annona squamosa* and *Lawsonia inermis* were found to adversely affect the breeding potential of aphids. Entomopathogens like *Beauveria bassiana*, *Verticillium chlamydosporium* and *Paecilomyces lilacinus* would also help in suppressing the aphid population.