■ CHAPTER 14

MAJOR DISEASES OF BLACK PEPPER AND CARDAMOM AND THEIR MANAGEMENT

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CONTENTS

1. INTRODUCTION

Black pepper (*Piper nigrum* L.), the 'King of Spices' and cardamom (*Elettaria cardamomum* Maton), the "Queen of Spices' are the two most important spices, which have their centre of origin in Western *Ghats* of India. These two spices contribute to the export earnings of 80% and 15% respectively of the total spices marketed from India. However, the productivity of these two crops is low compared to other producing countries in the world. Poor genetic stock, non-adoption of scientific management and severe crop losses due to pests and diseases have been identified as major production constraints. Thus, pest and disease management in these crops assumes greater significance.

Pathological Problems of Economic Crop Plants and their Management
Edited by S.M. Paul Khurana
Published by Scientific Publishers, Jodhpur (India), 1998, pp. 281-293

2. BLACK PEPPER (*Piper nigrum* L.)

In India, black pepper cultivation is mainly confined to three southern states, viz. Kerala, Karnataka and Tamil Nadu, contributing 95% of the production in India. It is grown mainly as pure crop on live supports such as *Erythrina indica* or *Garuga pinnata* and also as a mixed crop in coconut, arecanut, coffee and cardamom plantations. The disease problems of black pepper in India, Indonesia, Malaysia and Brazil have been reviewed recently (Sarma *et al.*, 1991, Kueh & Liang, 1991, and Duarte & Albuqueque, 1991). In general, the major diseases in all the pepper growing countries are *Phytophthroa* foot rot, and slow decline disease. Anthracnose and Stunted disease caused by CMV are on the rise in recent years.

2.1. Phytophthora foot rot

The disease was first reported from Indonesia (Muller, 1936) and later in Malaysia, Brazil, Jamaica, Thailand (Sarma & Nambiar, 1982). In India though it was reported in 1902, its correct Phytophthora etiology was reported only in 1966 (Sam Raj & Jose, 1966). On global scale crop losses due to this disease have been estimated to be US $4.5-7.5 million per annum (de Waard, 1979). In general about 20 - 30% vine death was reported (Nambiar & Sarma, 1977). In Calicut and Cannanore districts of Kerala, vine death of 3.7 and 9.4% was noticed amounting to an annual loss of 119 MT and 905 MT respectively (Balakrishnan *et al.*, 1986; Anandaraj *et al.*, 1988). The understanding of its etiology and epidemiology leads to development of effective disease management strategies.

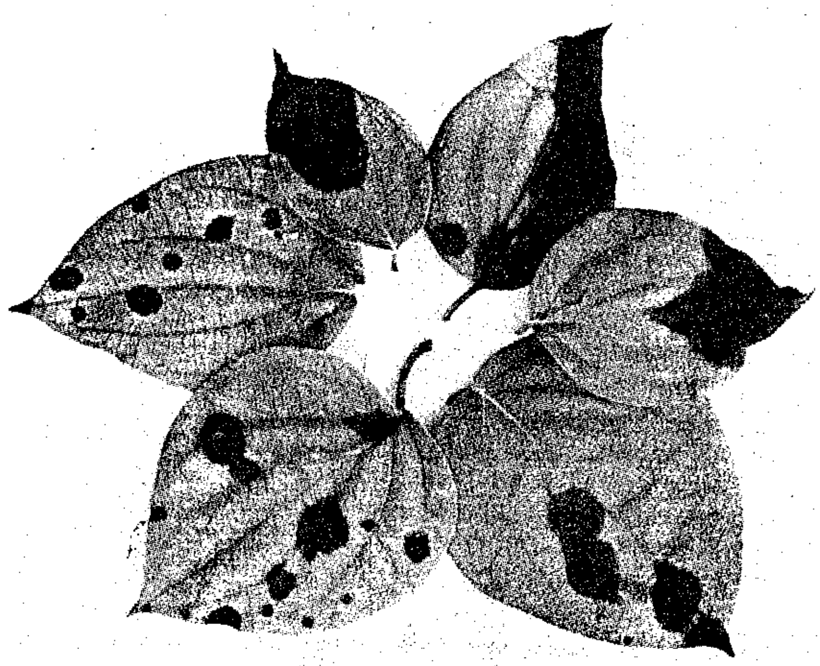

Figure 1. Leaf infection of black pepper caused by *Phytophthora capsici*

2.1.1. Etiology and epidemiology The identity of *Phytophthora* causing foot rot received considerable attention in recent years and is now correctly identified as *P. capsici* Leonian. (Emend A. Alizadeh and P.H. Tsao) (Tsao, 1991). The disease is soil borne and all parts of the black pepper vines are prone to the infection. The disease has got two important phases, viz. the foliar phase and soil phase. The nature of infection varies according to the microclimate prevalent in a locality, since black pepper is grown as a pure crop and also as a mixed crop in arecanut, coconut, coffee and cardamom plantations. The primary source of inoculum has been identified as infected plant bebris in the soil and also infected plants left unattended to in the plantations (Anandaraj *et al.*, 1991b). The disease is prevalent during June-August (South-West monsoon period) and continues upto November- December because of North-East monsoon which ensures high soil moisture.

2.1.2. Symptoms

(a) Foliar phase — Premonsoon showers initiate development of new flush in the vines which continues up to August. With build up of soil moisture and reduction in soil temperature, *Phytophthora* becomes active with rapid phase of multiplication. The infection starts as dark water soaked spots on tender leaves which enlarge rapidly to 1-3cm with a typical fimbriate margin. Disease starts at the base of the vine on tender runner shoots and leaves, due to soil splash. The pathogen sporulates abundantly. With the progress of the monsoon with intermittent rainfall, the disease spreads upwards in the bush due to rain splashes, causing infection of leaves, aerial branches and spikes leading to varying degrees of defoliation. Foliar infection would weaken the vine causing reduction in bush size due to defoliation and in rare cases causes death. Lower temperature (22-29°C), shorter duration of sunshine hours (2.8-3.5 hrs/day), high rainfall (15.8- 23 mm/day) and high relative humidity (81-99%) were found to favour foliar infection, and rapid disease spread (Ramachandran *et al.*, 1988).

(b) Soil phase — With the onset of South-West monsoon from June, soil moisture builds up and simultaneously *Phytophthora* population also builds up. Disease spreads through soil, water and root contact. Extensive root regeneration also takes place during this period. The coincidence of high pathogen propagules and highly susceptible feeder root system leads to an extensive root rot. Feeder root rot spreads to the large roots which ultimately reaches the collar or foot region, resulting in death of the vine. However, independant foot/collar infections are also noticed, when infection reaches foot region through infected runner shoots or stolons spreading on the ground. Root loss to root regeneration ratio would be the deciding factor in the health or death of the vine. Flaccidity, drooping of leaves, foliar yellowing, breaking of the aerial branches at nodal region, extensive defoliation and reduction in the canopy size are the main symptoms of root and foot infections.

2.1.3. Disease management Susceptibility of all parts of the black pepper plant renders disease management programmes rather complicated. In view of the soil-borne nature of the pathogen, an integrated disease management involving cultural, chemical and biological methods coupled with host resistance would be the ideal strategy to combat this disease (Sarma, *et al.*, 1988; Ramachandran *et al.*, 1991).

(a) Cultural practices — The importance of plant hygiene, specially the removal of

infected plant & their parts from the plantations, reduces the population build up of pathogen and use of disease free nursery stock have been stressed (Sarma *et al.*, 1988, 1991). In a pure plantation, lopping off of the branches of standards ensure better light penetration, resulting in a microclimatic condition i.e. less congenial for the disease development.

Pruning of runner shoots or tying them back to the main bush reduces the chances of initial foliar infection and subsequent spread. Maintenance of green or grass cover reduces the chances of soil splash and spread of foliar and root infections (Ramachandran *et al.*, 1991).

Minimum tillage reduces root rot. Provision of good drainage, discouraging movement of farm labourers from diseased to healthy gardens and use of farm implements, used in diseased garden, after disinfection are some of the recommended cultural practices (Sarma *et al.* 1988).

(b) Chemical control — Several contact fungicides were tried both as foliar spray and soil drench. Efficacy of copper fungicides to check this disease was reported from Malaysia and Indonesia (Holliday & Mowat, 1963, and Harper, 1974). Spraying vines with 1% Bordeaux mixture and soil drench, with the same or copperoxychloride as a prophylatic treatment once during pre-monsoon (May-June) and again during July-August or August-September as a post-monsoon treatment has been recommended (Sasikumaran *et al.* 1981; Sarma *et al.* 1988). Besides, application of Bordeaux paste to collar region was also suggested. However the efficacy of the treatment depends on timely application. The timing of treatment should coincide with maximum foliage emergence and root regeneration (Ramachandran *et al.*, 1991). The efficacy of metalaxyl in checking *Phytophthora* infection in black pepper both *in vitro* and *in vivo* was amply established (Ramachandran & Sarma, 1985, 1992). Besides, metalaxyl was found to be compatible with Quinolphos and endosulfan, the two insecticides used against control of flea beetle thus reducing the overall cost of plant protection operation (Ramachandran & Sarma, 1988). Fosetyl Al was the next best in checking the disease (Ramachandran *et al.*, 1991). The efficacy of potassium phosphonate (Akomin) was also reported (Anon, 1991). Though these systemic fungicides are effective, they are not cost effective.

(c) Biocontrol — The *in vitro* inhibitory effects of *Trichoderma* spp. and *Gliocladium virens* on *P. capsici* and their *in vivo* effects in pot culture were reported (Anon., 1992). The field efficacy of *T. viride* and *T. harzianum* in checking foot rot of black pepper has been reported (Subramanyam, 1993). Suppressive effects of Vesicular Arbuscular Mycorrhizae (VAM) *Glomus fasciculatum* on *P. capsici* has been reported (Anon., 1992, Sarma *et al.*, 1992). Incorporation of *Glomus* propagules into nursery mixture ensured better growth of cuttings and also suppressed the root infection by the fungus. Plant products like garlic and mustard extracts were found inhibitory to the growth of *P. capsici*, and when applied to soil, stimulated multiplication of *Trichoderma*. The aqueous leaf extracts *of Piper colubrinum* also were found inhibitory to *P. capsici* (Anandaraj & Leela, 1996). Further, botanical pesticide need to be explored in the disease management programmes of *Phytophthora* foot rot.

(d) Disease resistance — Efforts on locating disease resistance in black pepper to *Phytophthora* did not so far indicate presence of high degree of resistance in the available germplasm (Turner, 1971; Sarma

et al., 1982). However high degree of resistance was reported in *Piper colubrinum*. The efforts of using it as a root stock met with little success (Albuquerque, 1968; Sarma *et al.*, 1991). Biotechnological avenues should be exploited to develop resistant/tolerant genotypes through *in vitro* screening and incorporation of high degree of resistance in *P. colubrinum* to *P. nigrum* through gene transfer (Sarma & Ramadasan, 1990). However, breeding efforts to isolate tolerant/resistant lines should be continued. The likelihood of obtaining resistance through transgressive segregation and recombination do exist in black pepper (Sarma *et al.*, 1991). Monoculture of high yielding but susceptible cultures like Karimunda in India and Kuching in Malaysia needs to be discouraged and cultivation of varietal mixture of tolerant lines should receive priority. Thus an integrated approach is called for an effective disease management to check crop losses due to foot rot.

2.2. Slow decline disease

This disease, commonly known as pepper yellows or slow decline or slow wilt disease, was first reported in Bangka island of Indonesia (Christie, 1957). In India the root knot nematode (*Meloidogyne* sp.) infection was reported as early as 1906 (Butler, 1906) and later infestation by *Radopholus similis* in black pepper was also reported (D'souza *et al.*, 1970). The nematode problems of black pepper have been recently reviewed (Koshy & Bridge, 1990; Ramana, 1991).

2.2.1. Symptoms This disease is considered as a fungal and nematode complex coupled with moisture stress and malnutrition. Infected vines show foliar yellowing, defoliation and die-back symptoms. The root systems of the affected vines show varying degrees of root degeneration. The expression of severe foliar yellowing during March-April period might be due to depletion of soil moisture as the degenerating root system is unable to absorb required water from soil (Nambiar & Sarma, 1977).

2.2.2. Etiology and epidemiology Plant parasitic nematodes belonging to 29 genera and 48 species were reported to be associated with black pepper (Sundararaju, *et al.*, 1979). Out of these *R. similis* and *M. incognita* showed consistent association with diseased black pepper vines both in Kerala and Karnataka (Ramana & Mohandas, 1987). A comprehensive survey carried out in Kerala and Karnataka showed a positive role of plant parasitic nematodes in the etiology of slow decline (Ramana *et al.*, 1987a). The pathogenic effects of these nematodes under simulated field conditions were studied which clearly showed that *R. similis* alone and or in combination with *M. incognita* resulted in greater reduction in root mass leading to severe foliar yellowing, defoliation and die back, typical of slow decline (Mohandas & Ramana, 1991).

2.2.3. Disease management The importance of cultural practices like use of organic amendments like neem cake @ 1kg/vine to soil and use of plant species resistant to nematodes like jack, *Ailanthus malabarica* as supporting standards to reduce the nematode population are also suggested (Ramana *et al.*, 1992). In mixed cropping systems, specially coconut-pepper and Areca- pepper, where both the crops are susceptible to these nematodes, disease management becomes more complicated because of high population build up of the nematodes.

(a) Chemical control — Soil application of Phenamiphos @ 20g/vine (Nambiar & Sarma, 1979) and Aldicarb @ 8 kg ai/ha (Venkitesan & Setty, 1979) were reported to be effective. Soil application of phorate 10G

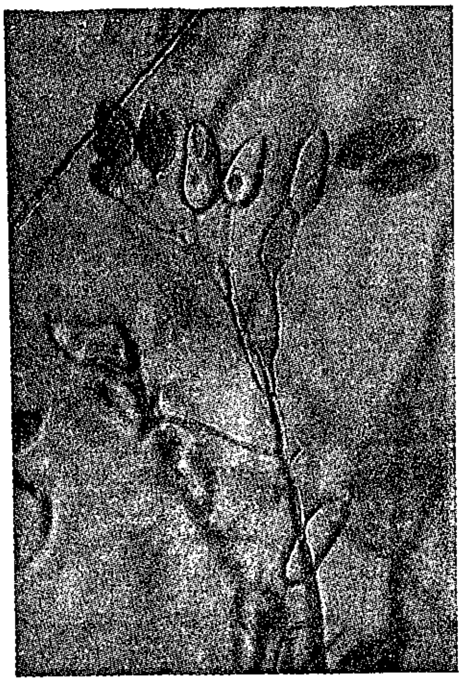

Figure 2. Sporangiophore of *P. capsici* from black pepper

or carbofuran 3G @ 3g a.i./vine as pre-monsoon and post-monsoon treatments was found effective in reducing the nematode infection and to boost up the productivity and vigour of the vines (Mohandas & Ramana, 1988).

(b) Bio-control — The suppressive effects of VAM like *Glomus fasciculatum, G. mossea, Gigaspora margarita* and *Acaulospora laevis* on root knot infestation in black pepper has been reported (Anandaraj *et al.*, 1991a). Besides, these VAM fungi also suppress *Phytophthora capsici* (Sarma *et al.*, 1997). The importance of VAM in suppressing not only plant parasitic nematodes, but also *Phytophthora capsici* has opened new avenues in the integrated disease management of this disease complex. *Paecilomyces lilacinus* a nematophagous fungus was also found effective for the control of both the nematode species infesting black pepper. However, use of *P. lilacinus* has been discouraged since it has been reported to be a human pathogen recently. There is a necessity to exploit predatory nematodes and other microbes for biocontrol to check nematode infestation.

(c) Disease resistance — Locating resistance/tolerance in black pepper to plant parasitic nematodes was initiated in recent years. A cultivar found resistant to root knot nematode, *M. incognita* was identified (Ramana & Mohandas, 1986). However screening of the available germplasm in India showed no reasonable degree of resistance to *R. similis* (Ramana *et al.*, 1987b). The screening programmes are being continued to isolate resistant and productive cultivars of black pepper. However, *P. colubrinum* a wild *Piper* sp. was found resistant to *P. capsici, M. incognita* and *R. similis*. Incorporation of resistance in this wild species to *Piper nigrum* should be resorted to, through biotechnological means.

Since *P. capsici* and plant parasitic nematodes cannot be spatially separated under field situation and these mainly infect the root system, the importance of a holistic approach to check all the above three pathogens has been stressed to boost up the vigour and productivity of the vine (Ramana, 1991; Sarma, *et al.*, 1992).

3. CARDAMOM (*Elettaria cardamomum* Maton)

Eventhough 22 diseases have been reported in cardamom, Mosaic or 'Katte' a viral disease and capsule rot, a fungal disease, are severe causing heavy crop losses. Besides these, other viral diseases, viz. Nilgiri necrosis, vein clearing disease ('Kokke Kandu' in Kannada vernacular) and clump rot a fungal disease are on the increase. Cardamom diseases and their management has been reviewed recently. (Agnihothrudu, 1987; Naidu & Thomas, 1992).

3.1. Capsule rot (*Azhukal*)

Capsule rot ('Azhukal' in Malayalam vernacular) occurs during July-September period coinciding with South-West monsoon in India. The disease was first reported in Idukki district of Kerala (Menon *et al.*, 1972). Crop loss to the extent of 30 per cent has been recorded (Nambiar & Sarma, 1976).

3.1.1. Symptoms The disease starts as water soaked spots on rachis and immature capsules which later spreads resulting in complete or partial rotting of the capsule. The affected capsules are shed. Infection gradually spreads to adjacent mature capsules also, resulting in varying degrees of capsule shedding. Infected panicles dry up. Though capsule rot is the major symptom, foliar infections are also noticed. Infection on leaves appears as water soaked areas which later enlarge rapidly. The affected leaves during November- December period exhibit leaf shredding symptoms (Naidu & Thomas, 1992).

3.1.2. Etiology and epidemiology The disease has been reported to be caused by *Phytophthora nicotianae* var *nicotianae* (Thankamma & Pillai, 1973), *P. palmivora* and *P. meadii* A^2 mating type (Anon., 1986). Infected plant debris in soil serves as the primary source of inoculum. With the onset of South-West monsoon during June, the soil moisture builds up resulting in population build up of *Phytophthora*. The population reaches its peak during August-September (Nair & Menon, 1982). Since the panicles spread on the soil, they are highly prone to infection. Soil splash and movement of inoculum through soil water are the major modes of disease spread. Maximum disease incidence was noticed during August when the atmospheric humidity was 90.6% coupled with heavy rainfall (400mm). Soil pH ranging from 6-7 favours high disease incidence (Nair & Menon, 1982). Combination of factors such as heavy shade, waterlogging and high density of planting favoured the disease severity.

3.1.3. Disease management

(a) Cultural practices — Lopping off the branches of the shade trees during May, which ensure better light penetration and aeration, removal of infected panicles and plants in the garden and provision of good drainage reduced the disease incidence.

(b) Chemical control — The efficacy of the pre- and post- monsoon spraying and soil drenching with Bordeaux mixture (1%) was found to be highly effective in reducing the disease incidence (Nambiar & Sarma, 1976). Spraying with 0.2% Dexon was reported to check the disease.

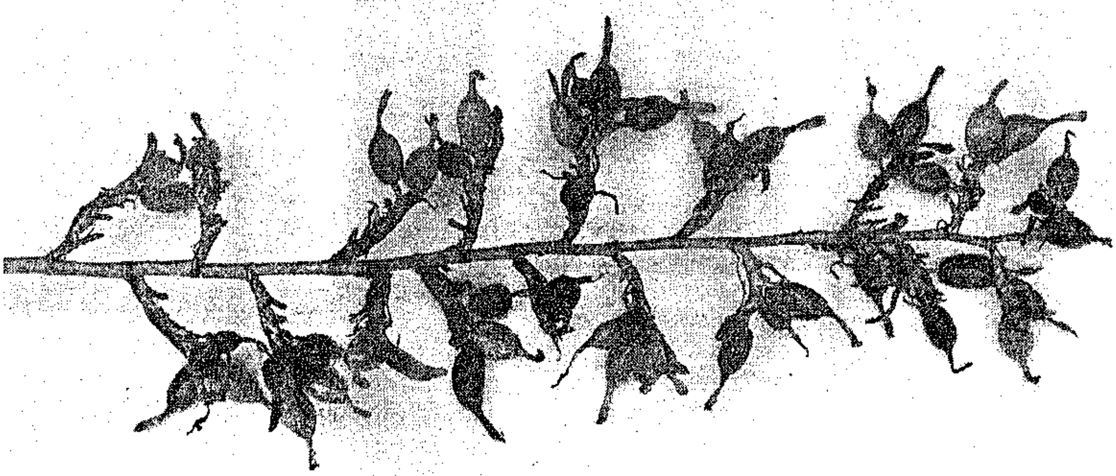

Figure 3. Capsule rot of cardamom caused by *P. meadii* (= *Azhukal*)

(Alagianagalingam & Kandasamy, 1981). Field evaluation of both systemic and contact fungicides over six years clearly established that three rounds of spraying Bordeaux mixture (1%) or Fosetyl Al (0.3%) was highly effective in checking the disease. Further, the importance of timely plant protection operations and phytosanitary measures were also stressed.

(c) Bio-control — Soil amendments with neem-cake reduced the disease and increased *Trichoderma* spp., *Aspergillus* spp. and actinomycetes. Soil inoculation with *T. viride*, *T. harzianum* and *Bacillus subtilis* resulted in reduced disease incidence (Suseela Bhai *et al.*, 1992a).

(d) Disease resistance — High degree of resistance to the disease has not been found so far. Moderate tolerance to this disease was noticed in two cultivars of Mysore and Malabar types (Suseela Bhai *et al.*, 1992b). This being a soil borne disease, a multipronged approach involving cultural, chemical and biological control measures form the practical approach to check capsule rot.

3.2. Cardamom mosaic ('Katte')

Cardamom mosaic is one of the major diseases of cardamom prevalent in all cardamom growing tracts in India and has also been reported from Guatemala recently. It is locally known as 'Katte' disease. The disease was first reported in India during 1945 (Uppal *et al.*, 1945), eventhough the disease was known much earlier (Mollison, 1900). It was reported from Guatemala (Flores, 1980). In arecanut - cardamom mixed cropping system the crop losses due to 'Katte' were 10-68, 26-91 and 82-92 per cent, during first, second and third year after infection respectively (Varma, 1962b). In pure crop of cardamom, crop losses of 38, 62 and 68% during first, second and third year of infection were reported (Venugopal & Naidu, 1984).

Figure 4. 'Katte' or Cardamom mosaic disease symptoms

3.2.1. Symptoms The disease generally appears as chlorotic specks on tender leaves, which later develop into discontinuous stripes running parallel to the midrib. Later typical mosaic symptoms appear on mature leaves. However symptoms are more conspicous on younger leaves. Mottling is often noticed in young leaves and pseudostems (Uppal *et al.*, 1945). Considerable variations in symptoms like necrotic mosaic, vein enation, necrotic and chlorotic ring spots and moderate to severe foliar yellowing are noticed. The affected plants gradually show decline symptoms producing shorter and slender tillers with few short panicles.

3.2.2. Virus-vector relationship The viral nature of the disease was established as early as 1945 (Uppal *et al.*, 1945). Recently in India the virus has been identified as 'poty virus' with flexuous virus particles measuring 650 nm long, 10 - 12nm in diameter (Naidu *et al.*, 1985) and also in Guatemala (Gonsalves *et al.*, 1986). *Pentalonia nigronervosa* the banana aphid was identified as the vector (Uppal *et al.*, 1945). Although experimental transmission was reported with 13 aphid spp. (Rao & Naidu, 1973), it was later found that *P. nigronervosa* f sp. *caladii* is the major vector in India (Siddappaji & Reddy, 1972). In Guatemala *P. nigronervosa* and *Toxoptera* were found as insect vectors. Earlier it was reported as semi persistent virus (Varma, 1962) but later studies confirmed non-persistant nature of the virus (Rao & Naidu, 1973) where the aphid acquired the virus within few minutes and transmitted immediately without any incubation period. Aphid population is noticed throughout the year with peaks in November - May period. Aphid population gets drastically reduced during monsoon period. Aphid colonies are noticed in the old loose leaf sheaths and also on the young suckers, spindle leaves and panicles. Nymphs of all instars were found transmitting the virus but alatae and apterae were found as potent transmitters (Rajan, 1981). A positive correlation was obtained between vector population and disease incidence (Naidu & Venugopal, 1984).

The virus is not transmitted through seed, sap and root contact. However, it spreads through infected suckers when vegetative propagation is adopted. Seed germination from the affected plants was as low as 38% compared to 92% in healthy (Rao, 1977). Though the disease was successfully transmitted to about 10 zingiberaceous hosts, natural infection was recorded only on *Amomum cannecarpum, A. microstephanum, A. nutans, Maranta arundanacea* and *Curcuma nilgherrensis*. These might serve as alternate hosts (Naidu *et al.*, 1985; Varma & Capoor, 1958; Yarraguntaiah, 1979; Siddaramaiah *et al.*, 1986). Actively growing young infected leaves served as good source of inoculum (Naidu & Venugopal, 1984). The virus was also considered as complex in nature (Rao, 1977) and presence of strainal variation was reported (Rao, 1977; Naidu *et al.*, 1985). Disease spreads through clonal propagation and also through volunteer seedlings from infected garden used as planting materials. Disease spread is contiguous and is mainly internal and centrifugal in nature from the source of primary infection and the rate of spread is low. In areca - cardamom cropping system, the infection may reach as high as 83% within six months in fresh plantation (Naidu *et al.*, 1985).

3.2.3. Disease management The etiological and epidemiological information available so far clearly indicated that phytosanitation involving phased eradication of disease affected clumps followed by replanting programmes with disease free seedling would be the ideal strategy of disease management.

Vector control through contact and systemic insecticides proved counter productive since these treatments resulted in increased disease incidence. The hyperactivity of the vector due to the insecticidal treatment and non-persistent nature of the virus might have contributed to the poor disease control (Rajan *et al.*, 1989).

The virus being not seed transmissible, the importance of using disease free seedlings raised through seed is advocated. Raising of fresh nurseries near infected plants be discouraged (Naidu & Joseph, 1992). The use of voluntary but apparently healthy seedling, from the infected plantations has been discouraged, for the possible contamination since incubation period of the virus for expression of symptoms in the host may vary from 1-3 months (Naidu & Venugopal, 1984; Naidu & Josepth, 1982). Eventhough use of seedling progenies is advocated, clonal propagation is preferred for the genetic uniformity specially for high yielding clones. The efficacy of macropropagation through rhizomes (Korikanthimath, 1992) and micropropagation through tissue culture has been reported (Nadogouda *et al.*, 1983). However planting materials from these sources need be checked for virus contamination. ELISA technique for an early detection of 'Katte' virus has also been recently standardised. There is a need for popularisation of this, in a high value crop like cardamom.

In plantations, rate of spread of the disease is internal and slow (Deshpande *et al.*, 1972). Roguing of infected clumps at short intervals (weekly) appeared more advantageous in reducing the chances of secondary spread (Naidu & Venugopal, 1982). Extensive eradication programmes were undertaken in the past. However a community effort has been advocated to eradicate this since many small and marginal farmers may not adopt the phytosanitary measures and chances of reintroduction of infected clumps are high (Varma, 1962 a). Host resistance to this has not been identified so far. Screening of large scale seedlings from open pollinated progenies of different cultivars did not yield any resistance. However, disease free clumps from the hot spot areas of disease have been obtained and screened. Such clumps have been found to be field tolerant/resistant (Anon., 1992). However there is a need to induce host resistance through biotechnological measures.

Apart from 'Katte' two new viral diseases viz. Nilgiri necrosis and 'Kokke Kandu' or vein clearing, have been recorded recently (Naidu & Joseph, 1992). The former is confined to few pockets in Nilgiri hills and infected plants exhibit chlortic streaks on leaves which later turn necrotic. This leads to leaf shredding and stunting of the clumps. The 'Kokke Kandu' or vein clearing virus has been reported to result in quick decline and death of the clumps. The infected plants show continuous and discontinuous vein clearing, which later turn necrotic and finally lead to leaf shredding. Mottling of the pseudostems and loosening of the leaf sheath are the other symptom. New shoots become yellow and stunted and new tillers fail to emerge fully, form hook like structure and hence the name 'Kokke Kandu' in local vernacular. *P. nigronervosa f. caladii* has been found as the potent vector. These diseases being recent and viral in nature, phased eradication programmes alone appear to be a •ideal strategy of disease management.

Spices being export oriented, use of heavy doses of pesticides has been discouraged for the possible residues and cultural and biocontrol measures coupled with host resistance would be the major strategies of disease management.

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