NEW DISEASES AFFECTING BLACK PEPPER CROP IN BRAZIL*

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INTRODUCTION

The cropped area with black pepper in Brazil has increased greatly, due to the attractive prices in the international market. From 1999, the area under cultivation increased 15% being the production estimated in 30 to 35 metric tonnes, in 2001 (IPC..2000). The State of Para is the main producer contributing with some 85% of pepper production, which come from Bragantina (Panniyur-1 ecotype), Singapore (Kuching ecotype) and Guajarina (Arkulan Munda ecotype) cultivars. The Kottanadan-1 and Iaçara-1 (originated from open pollination) have been cropped by many pepper growers in order to enhance the genetic variation within black pepper population and to improve the content of essential oil, piperine, oleoresin of the final products.

In the past four years, black pepper plants have been affected by new diseases other than root rot and stem blight (*Nectria haematococca* f. sp. *piperis*). Even minor diseases like anthracnose (*Colletotrichum gloeosporioides* Penz) and black berry disease (*Cephaleuros virescens*) have caused losses of production under special climate conditions. Descriptions of the main symptoms, causal agent and control measures are given.

YELLOW WILT

Since 1992 black pepper vines, cultivar Guajarina growing in the field for more than four years have been affected by a new disease, in the municipality of Tome Açu. After eight years since the first record, this disease has been noticed in the municipalities of Baião, Castanhal, Bujaru, São Francisco, Paragominas, Ipixuna, Mocajuba, Capitão Poço, Santarém Novo, Primavera, Vila da Forquilha, Jamic and Tailândia

Symptoms

The pathogen invades pepper through wounded roots inflicted by nematodes (*Meloidogyne incognita* and *M. javanica*) or during the emergence of new roots. It colonises the vascular bundles causing necrosis and preventing water and nutrients uptake. The vascular necrosis, unilateral initially, extents to the leaf veins of apical twigs resulting in quick wilt and death of plants. Externally, diseased plants shows yellowing, shedding of leaves and internodes and lack of rootlets (Fig. 1). The internodes show triangular and necrotic lesions around the nodes of the main branch, which result in unilateral necrosis of the internode turn them half green half necrotic (Fig. 2). When several roots are infected, the plant collapses getting the foliage adhered to the branches. If branches are cut, necrotic vessels of phloem can be seen immediately below epidermis (Duarte et al., 1999).

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*Research partially supported by JICA suggesting that the pathogen is being spread by infected stem cuttings. In the field this disease has been recorded so on Guajarina cultivar, so far.

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The disease has been observed in pepper plantations that grow Guajarina cultivar, even in properties in the same area where Bragantina and Singapore are planted.

Causal agent

The disease is caused by *Fusarium oxysporum* Schlecht.:Fr. The pathogen was isolated from discoloured tissues of orthotropic branches. It produces floccose and sparse mycelium, ranging in colour from white to light violet. Numerous and hyaline conidia are produced in the central part of the colony. Macroconidia are falcate to almost straight, with thin walls measuring 12 μm – 44 μm x 4 μm – 8 μm, with apical cells like a hook and the basal is foot-shaped and formed from monophialides on hyphae. Septum number varies from 3 to 7, being more frequent 4-septa spores. Microconidia are unicellular, ovoid to elliptic measuring 3.6 μm – 9.6 μm x 2.4 μm – 6.0 μm and formed on false heads on short monophiallids on hyphae. Chlamidospores are formed by the eighth day but after 30 days of age most of mycelium and conidia are turned into globose and brown and thick wall chlamidospores.

The pathogen was identified by Dr. Brayford from International Mycological Institute as *Fusarium oxysporum,* a new pathogenic formae to black pepper, whose origin is still unknown .

Hosts

In the field, the pathogen has been infecting Guajarina, cultivar of black pepper, but under experimental conditions, it has the ability to infect vessel tissues of Bragantina, Iaçará-1 and Singapore. The majority of black pepper genotypes have shown intermediate and resistant responses.

Guajarina is an ecotype of Arkulan Munda introduced in Brazil in 1976 and available to the pepper growers since 1982. It has broad leaves and long spikes. Although susceptible to *Nectria haematococca* Berk & Br. f. sp. *piperis* Albuq., it has been the pepper growers preference due to its high productivity (3.5 ton/ha).

Recommended control measures

In Tomé Açu, some pepper growers have been trying to prevent the disease spread through cultural practices as balanced fertiliser formulation with high content of K_2O, cover crop with leguminous, dolomite lime. However, as a soil-borne pathogen the following control measures are also recommended: a) Collect stem cutting from free-disease pepper plants, only; b) Preventative treatment of stem cutting by immersion in 0.1% benomyl solution for 15 to 20 minutes, before plant; c) Suitable drenching of cultivated area; d) Rouging of infected plants followed by drench of 5 to 10 litres 0.1% benomyl or thiabendazole solution in the pit. Surrounded plants should also to be treated; e) Keep area just cut-weed to restrain disease spread; f) Prevent soil depression ("basins") around the base of pepper plants while cut weed; g) Apply fertiliser formulation with increased K_2O content; h) Replace Guajarina cultivar by Singapore, Bragantina (Panniyur-1 ecotype) and Kottanadan-1 that have shown resistant response to the pathogen colonisation.

BLACK BERRY DISEASE

Pepper plantations have been affected by minor diseases as black berry disease known in Brazil as algae black spot that causes severe damages to berries in the main Asian producer countries. In those areas it has been observed that old and poor growth pepper vines are more susceptible.

From 1998 on, it has been noticed that this disease that for a long time was occurring endemically causing no serious losses to pepper crops, began to cause epidemics in the municipalities of Paragominas, Don Eliseu and Tome Açu, State of Pará resulting in decreases of productivity.

Symptoms

The disease affects leaves, stems, and spikes. Young leaves show minute and numerous spots, which are black brilliant in colour, erumpent, with resinous appearance and irregular margins, surrounded by a yellow halo (Fig. 3). Discoloured veins embedded into yellow halo can be seen. As numerous black spot are formed on young leaves, premature fall of leaves may occur. Lesions are formed in

between or on secondary veins being more common in between veins. Numerous and quite long black depressed stripes are formed on young stems. On old stems, long and depressed lesions showing cracks in the central part reaching 1 to 2 mm depth are noticed (Duarte *et al.*, 2000). Those cracking serve as entry to other fungi like *Colletotrichum gloeosporioides* Penz & *Nectria haematococca* Berk & Br. f. sp. *piperis* Albuq. In the Municipality of Don Eliseu symptoms of die-back and fall of leaves have been observed in poor managed crops. On infected spikes the rotten fruits become light and are of low value for market.

Causal agent

The disease is caused by the alga *Cephaleuros virescens* Kaunze, a plant pathogenic green algae (Chlorophyta) that belongs to the family Trentepholiaceae and occur world-wide in tropical and subtropical regions where the temperature and humidity conditions are suitable (Joubert & Rijkenberg, 1971). *C. virescens* is a phycobiont of two parasitic lichen species, *Strigula camplanata* (Fee) Mont. and *S. elegans* (Fee) Mull. Arg., which also occur commonly but not recognised as parasites (Holcomb, 1986). That alga is the only parasitic alga of superior plants with an ample host range among cultivated and native plants of different botanical families. The pathogen produces endophytic and discoid mycelium formed by articulate hyphae that give rise to erect and aerial bunches containing sporocysts. It has blue and green cytoplasm and reproduces by zoogonides or oogonia (Bicudo & Bicudo, 1970).

Epidemics of alga black spot are related to mist formation that lasts for four to five hour on plants growing near forest, from September to November, as average temperature reaches 27° C and relative humidity is around 77%.

Hosts

C. virescens is the incitant of leaf, stem and fruit diseases of economically important tropical plants such as tea (*Camellia sinensis* (L.) O. Kuntze), coffee (*Coffea arabica* L.), oil palm (*Elaeis guineensis* Jacq.) litchi (*Litchi chinensis* Sonn.), vanilla (*Vanilla planifolia* Andr.), guava (*Psidium guava* L.), cacao (*Theobroma cacao* L.) and citrus (*Citrus* spp.) (Wellman, 1972; Marllat & Alffieri, 1980). Leaf spot damage to the majority of *C. virescens* hosts is of a minor nature and usually limited to death of cells just beneath the algal thallus.

Recommended control measures

Due to the high incidence of the disease, measures of control are recommended mainly in clonal gardens from where vegetative material to produce new plants are taken. Weekly or biweekly sprays of Benomyl at 0.05% active ingredient after spike formation have been effective as well as of Triadimefon or Triadimenol. Sprays with protective fungicides like Mancozeb, Captan or Copper compounds are also recommended to prevent algal resistance and to control other foliar pathogens

PIPER YELLOW MOTTLE VIRUS

Brazilian pepper plantations have been infected by several pathogens including fungi, alga, nematodes and viruses. Pepper mosaic caused by a strain of Cucumber mosaic virus (CMV~Pn) was detected for the first time in 1970 but, a prompt eradication of infected plants prevented pepper production from a collapse. There are still some spots of the disease in some municipalities in the State of Para but, the disease is under control, the incidence being less than 2%.

From October 1998, some black pepper plants showing symptoms of an unknown disease were observed at Embrapa germplasm collection, in Belém, State of Pará. In leaves and branches samples sent to Virology laboratory at São Paulo State University virus particle associated to infected tissues were detected. The origin of this disease is not clear but there is a suspicion that it was introduced in Brazil in pepper accessions introduced from India.

Symptoms

Infected plants show leaves with yellow and brilliant punctuation dispersed in foliar blade or interveinal forming a typical mottle. Severely infected leaves are malformed with waving margins (Fig. 4). Pepper plants show changes in its growth pattern. Foliage become sparse, and decreases in production are observed due to reductions in the size and number of berries per spike. After the branches are cut new shoots show chlorotic and

malformed leaves and delayed growth. Internally, vascular vessels show discoloration and necrotic points.

Causal agent

The disease is caused by Piper yellow mottle virus (PYMV), a non-enveloped bacilliform virus-like particle assemble to badnavirus (Lockhart et al., 1997). The occurrence of PYMV in several black pepper cultivars (Iaçará-1, Karimunda, Guajarina, Bragantina, Apra, Kottanadan-2, accessions 239 and 1558) was detected after ultrafine sections observed under scanning microscope under low frequency, in the mesophyll parenchyma cells, PCR tests confirmed virus identity.

This disease has already been detected in Indonesia, Thailand, Sri Lanka and Malaysia (Lockhart et al., 1997). Pepper plants showing similar symptoms to those caused by PYMV were noticed in India and Indonesia (Holliday, 1959).

Differential symptoms between yellow mottle and mosaic

Two viruses have already been identified infecting black pepper in Brazil: mosaic caused by CMV-Pn and yellow mottle (PYMV). However, those viruses show distinct symptoms which can be identified surely by pepper growers (Duarte et al., 2001). Those differences are observed in roots, stems and branches, foliage, plant growth, transmission and virus-vector insects (Table 1).

Table 1.
Differential symptoms between yellow mottle and mosaic on black pepper plants

Organs	PYMV	CMV-Pn
Roots	Normal root system	Poor root system
Stems	Necrotic points in vessel tissues	Shortening of internodes
Branches	Vascular discoloration, necrotic point	Vascular discoloration, no necrotic points
Leaves	Yellow lemon and brilliant spots dispersed on foliar blade, chlorosis interveinal, waving margins, puckering in several infected leaves.	Diffuse chlorotic spots, malformation, thickening, secondary veins glued, puckering
Inflorescence	Partially sterile flowers	Reduced size, partially sterile flowers
Spike	Reduced number of fruit per spike	Reduced spike size and number of fruit per spike
Vector-insect	*Pseudococcus elisae* (mealy bugs)	*Aphis spiricolae* (aphids)
Transmission	Stem cuttings, vector-insect, seeds, related species, grafting	Stem cuttings, vector-insect, related and cultivated species.

Hosts

Accessions 239 (Perumkodi ecotype) and 1558 (Kaluvally ecotype) selected to be cropped under the shading were first infected. Those plants heavily infested with mealy bugs acted as inoculum source. Within four weeks the disease had spread to Iaçará-1, Karimunda, Guajarina, Bragantina, Apra, Kottanadan-1 and Singapore. All infected plants, more than five hundreds, were eradicated by rouging.

Virus-vector insect

The constant association of mealy bugs with pepper plants exhibiting characteristic symptoms of the disease suggest that PYMV is transmitted plant by plant by *Pseudococcus elisae* Borshsenisius. It feeds in plant collar, branches, adventitious roots, inflorescence and spikes (Fig. 5). Female body shows ovular shape, measuring 1.2 mm to 2.0 mm, with 12 lobules and 15 pairs of appendices. In the anal region two central, short and non waxed appendices can be seen. Eggs are long, orange coloured and involved by a loose and cottonous tissues. In Southern Asia PYMV is transmitted by *Planococccus citri* (Lockhart et al., 1997)

Control

Exclusion measures

In order to prevent the establishment of PYMV in producer areas the following control measures should be taken: a) Prohibition of

free traffic of vegetative material from suspect or contaminated area to free-disease areas; b) For vegetative propagation get stem cuttings from free-disease plants, only; c) Inspect nurseries for new shoots showing disease symptoms, periodically; d) Establish forecast services to keep pepper growers informed on the progress of disease control.

Eradication measures

For many viruses meristem tissue culture has been used to clean virus infected genotypes. There are evidences however, thatbadnavirus can be transmitted by meristem tissues. This will make difficult the genotype cleanness if the pathogen establishes in the main producer areas. So, it is of primordial importance to adopt the following measures if infected plants are detected in clonal gardens, nurseries or plantations: a) Interdict infected clonal garden and nurseries keeping them under narrow vigilance up to complete disease eradication. b) Cut all plants showing initial symptoms of the disease. c) Control virus-vector insects with dimethoate, malathion, methyl parathion or diazinon insecticides. d) Control fire ants with pyretroid, carbamate or organophosphorous insecticides. e) Eradicate infected plants by rouging and keep plants nearby eradicated ones under observation for new shoots exhibiting virus disease symptoms.

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Fig. 1: Black pepper cultivar Guajarina showing generalised yellowish due to vascular invasion caused by *Fusarium oxysporum*.

Fig. 2: Internodes of Guajarina exhibiting unilateral necrosis, characteristic symptoms of yellow wilt (*Fusarium oxysporum*) in the main branch.

Fig. 3: Black brilliant spots with resinous appearance and irregular margins dispersed on pepper leaves caused by the alga *Cephaleuros virescens*.

Fig. 4: Kottanadan-1 leaves showing yellow and brilliant mottle and waving margins, typical symptoms of PYMV on black pepper.

Fig. 5: Mealy bugs (*Pseudococcus elisae*) feeding on black pepper branches.