



Distribution and incidence of viral disease of black pepper (*Piper nigrum* L.) in Karnataka and Kerala, India

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Abstract

Two hundred and seventy six plantations in 96 locations in major black pepper (*Piper nigrum* L.) growing areas of Karnataka and Kerala were surveyed for the distribution and incidence of viral disease. The incidence of the disease was highest in Wyanad District (45.4%) followed by Idukki District (29.4%) in Kerala. In Karnataka, Kodagu District (14.9%) had the highest incidence of the disease followed by Hassan District (5.2%). In general, the incidence and severity of the disease was higher in black pepper plantations situated at higher altitudes of Kerala such as Idukki and Wyanad districts. Mosaic, reduction in leaf size and internode length leading to stunting of the vine, and bright yellow mottling along veins were the two foliar symptoms observed on diseased vines. DAC-ELISA of symptomatic black pepper vines with antisera to different viruses confirmed viral infection either by CMV or BSV or by both. All cultivars and improved varieties including hybrids were susceptible to the disease under natural conditions. Vines of all ages raised on all kinds of standards were also found affected by the disease. Among the several weeds found in and around black pepper plantations, a few of them showed typical viral like symptoms, which might act as potential inoculum source. Though 12 species of insects were collected from diseased vines from different locations, no species was specifically associated with diseased vines.

Key words: Black pepper, *Piper nigrum*, survey, incidence, distribution, viral disease

Introduction

Black pepper (*Piper nigrum* L.) (Piperaceae) known as the 'King of Spices', originated in the tropical evergreen forests of Western Ghats of India (Ravindran, 2000). India has the largest area under black pepper cultivation in the world but its productivity is one of the lowest among major black pepper producing countries. Kerala and Karnataka are important states growing black pepper in the country. Stunted disease of black pepper is one of the important viral diseases affecting the crop in the country. Stunted disease was first reported from a black pepper nursery at Neriamangalam in Idukki District of Kerala during 1975 (Pailey *et al.*, 1981) and in Pulpally of Wyanad District in 1978 (Sarma *et al.*, 1992). A wide range of symptoms is observed on vines affected by viral disease. These include distortion, reduction in size and mottling and mosaic on leaves, along with stunting of the whole plant, reduction in spike length and poor filling of spikes, leading to yield reduction. Similar diseases

have been reported from other black pepper growing countries such as Brazil, Indonesia, Malaysia, Sri Lanka and Thailand (Ranombage and Bandara, 1984; Kueh and Sim, 1991; Sitepu and Kasim, 1991; Eng *et al.*, 1993; Lockhart *et al.*, 1997; de Silva *et al.*, 2001;2002).

The association of two viruses namely, *Cucumber mosaic virus* (CMV) and an uncharacterized badnavirus with the disease was reported from India (Sarma *et al.*, 2001; Bhat *et al.*, 2003). CMV and *Piper yellow mottle badnavirus* (PYMV) were reported to be associated with diseased vines at Brazil (Duarte *et al.*, 2001) and Sri Lanka (de Silva *et al.*, 2001; 2002). However, in rest of the South East Asian countries, the association of PYMV only has been reported (Lockhart *et al.*, 1997). The major means of spread of the viruses is through use of infected stem cuttings. CMV is known to have a wide host range and spreads in nature through aphids while badnaviruses have narrow host range and spread through mealybugs (Lockhart *et al.*, 1997; de Silva *et al.*, 2002; Bhat *et al.*,

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2003). The loss caused by the disease varies depending on the growth stage of the crop. Although death of vine is not reported due to the disease, decline in vigour and productivity are noticed (Sarma *et al.*, 2001). Preliminary surveys conducted in Wyanad District of Kerala indicated that 0.6-46.0% of vines in various gardens were affected by the disease (NRCS, 1993; 1994). However, there are no published reports on the distribution of viral diseases in major black pepper growing areas of Karnataka and Kerala although they are the third important disease affecting black pepper in the country. This paper reports the distribution and incidence of viral disease in major black pepper growing areas of Karnataka and Kerala.

Materials and Methods

A total of 276 black pepper plantations in 96 locations of Karnataka and Kerala were surveyed during 2002-04 for the distribution and incidence of viral diseases on black pepper. A standard proforma was used for collection of data which included, terrain of the plantation, soil type, shade level, standard, cultivar/variety, age of the crop, cropping system, associated insect fauna, weed flora and agro practices followed. For recording the incidence of viral disease, 15 black pepper vines selected randomly in each plantation were observed and the number of infected vines was counted. In each location, either two or three plantations were visited for recording the observations and the mean percent incidence of the disease for each plantation and each location surveyed was determined. Representative isolates of the virus from various locations were brought to the laboratory and maintained under insect proof conditions.

Results and Discussion

In general, the incidence of viral disease was higher in Kerala compared to Karnataka (Table 1). In Kerala, except four locations (Koodathai, Mulleria, Santhapara and Thodupuzha), the incidence of viral disease was noticed in all the locations surveyed. All the locations surveyed in Kannur and Wyanad Districts showed the presence of the disease. The highest incidence of the disease (83%) was noticed in Nadavayal of Wyanad District. No incidence of viral disease was noticed in any of the plantations surveyed in Dakshina Kannada District of Karnataka while only one plantation in Uttara Kannada District of Karnataka showed the presence of the disease. In Hassan District, Belur Taluk had a higher disease incidence compared to the other taluks surveyed. Among the three taluks of Kodagu district, higher incidence was noticed in Somvarpet Taluk while Madikeri recorded the least incidence.

Table 1. Distribution and incidence of viral disease of black pepper in Karnataka and Kerala

State/ District	Taluk	Location	Incidence in different plantations (%)			Mean incidence (%)	
			A	B	C		
Karnataka	Bantwal	Adyanadka	0	0	0	0	
Dakshina Kannada		Alangar	0	0	0	0	
		Peramogaru	0	0	0	0	
	Puttur	Sediyappu	0	0	0	0	
		Shibara	0	0	0	0	
Hassan	Alur	Chennalli	0	0	0	0	
		Rayarakoppalu	0	7	7	5	
	Belur	Ankehalli	0	0	0	0	
		Bantenahalli	33	27	0	20	
		Biccodu	0	0	7	2	
	Sakleshpur	Bagge	0	0	0	0	
		Belagodu	20	13	20	18	
		Fatimapura	7	0	0	2	
		Rajendrapura	0	0	0	0	
Kodagu	Madikeri	Boikeri	33	53	0	29	
		Hakkathur	0	20	0	7	
		Heravanad	0	0	0	0	
		Napokulu	0	0	0	0	
		Siddapur	0	0	0	0	
	Somvarpet	Almatti	0	13	7	7	
		Horoor	0	0	0	0	
		Suntikoppa	100	100	33	78	
		Valagunda	13	27	-	20	
	Virajpet	Balale	0	20	7	9	
		Margoli	0	0	0	0	
		Mayamudi	53	27	13	31	
		Polibetta	7	20	13	13	
UttaraKannada	Sirsi	Balegadde	0	0	0	0	
		Gadakai	0	0	0	0	
		Kambara kattige	0	0	0	0	
		Malenahalli	0	0	0	0	
		Neernahalli	7	0	0	2	
Kerala	Idukki	Devikulam	Adiraali	20	7	27	18
			Vellathooval	13	20	0	11
	Peermade	Chottupara	33	27	13	24	
		Kumily	60	100	73	78	
		Vandiperiyar	20	20	67	36	
	Thodupuzha	Muttom	0	0	0	0	
	Udumbanchola	Chakkupallam	47	47	40	45	
		Kalthoty	20	13	13	15	
		Meppara	0	0	27	9	
		Myladumpara	20	53	7	27	
		Nedumkandani	67	73	53	64	
		Puliyamala	33	20	27	27	
		Rajakkad	53	20	13	29	
		Santhapara	0	0	0	0	
		Thoorkupalam	37	60	67	58	
Kannur	Kannur	Mathamangalam	0	27	20	16	
		Nareekamvalli	13	27	33	24	
		Olayambadi	60	53	13	42	
	Taliparamba	Kalikadavu	53	47	13	38	
		Kuramathur	7	0	7	5	
		Taliparamba	7	27	47	27	

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	Tellicherry	Ayipuzha	27	20	7	15
		Chalodu	0	7	0	2
		Paduvilai	13	0	0	4
Kasaragod	Hosdurg	Balal	33	33	0	22
		Kanhangad	40	60	60	53
		Plachikara	40	0	0	13
		Vellarikundu	7	0	0	2
	Kasaragod	Kuntar	7	7	7	7
		Kundankuzhi	33	27	20	27
		Kuttikole	20	7	0	9
		Mulleria	0	0	0	0
		Poinachi	60	47	-	37
Kozhikode	Kozhikode	Chembukadavu	33	0	13	15
		Kattumunda	7	0	20	9
		Kodenchery	53	20	13	29
		Koodaranji	67	0	33	33
		Koodathai	0	0	0	0
		Maranjathi	20	7	0	9
		Mykavu	0	7	7	5
		Nellipoyil	7	0	20	9
		Pulloorampara	13	0	7	7
		Shanthinagar	7	33	20	20
		Thiruvambadi	20	27	27	25
	Quilandi	Chakkittapara	0	7	0	2
		Cherabanoda	7	0	20	9
		Koorachundu	7	13	7	9
		Narinada	13	13	0	9
		Poozhithode	20	0	0	7
	Vadakara	Kakkat	0	20	0	7
		Mokeri	0	0	7	2
		Naripetta	0	13	7	7
		Thottilpalam	0	0	7	2
Wyanad	Mananthavady	Koileri	67	67	53	62
	Sultan Batheri	Ambalavayal	7	67	-	37
		Areapally	87	13	-	50
		Chainthakunnu	67	53	-	60
		Kenichira	67	60	-	64
		Kuppadi	27	13	-	20
		Nadavayal	73	93	-	83
		Pulpally	13	40	-	27
	Vythiri	Karumannam	33	33	-	33
		Vengapalli	73	27	-	50
		Vythiri	13	13	-	13

-, not surveyed

When the disease incidence data was analysed district wise, higher range of disease incidence (13-83%) and mean incidence (45.4%) was noticed in Wyanad District of Kerala while the least disease range (0-2%) and mean incidence (0.4%) was recorded in Uttara Kannada District of Karnataka (Table 2). In Kerala, highest incidence of the disease was seen at Wyanad District (45.4%) followed by Idukki District (29.4%). In Karnataka, the highest disease incidence was recorded in Kodagu District (14.9%) followed by Hassan District (5.2%).

When the collected isolates were subjected to direct antigen coated enzyme linked immunosorbent

assay (DAC-ELISA) using antisera to different viruses, 46% of the isolates reacted with *Cucumber mosaic virus* (CMV), 39% of the isolates reacted with *Banana streak badnavirus* (BSV) and 15% reacted with both the CMV and BSV indicating dual infection by two viruses (belonging to the genera *Cucumovirus* and *Badnavirus*) in the disease. A majority of isolates from Idukki and Wyanad Districts of Kerala and Kodagu District of Karnataka reacted with CMV antiserum indicating the involvement of CMV with diseased vines, while majority of the samples from remaining locations reacted with BSV antiserum indicating the involvement of a badnavirus with the diseased vines collected from these locations.

Table 2. Incidence of viral disease of black pepper in various districts of Karnataka and Kerala

State/District	Disease incidence	
	Range (%)	Mean (%)
Karnataka Dakshina Kannada	0	0
Hassan	0-20	5.2
Madikeri	0-78	14.9
Uttara Kannada	0-2	0.4
Kerala Idukki	0-78	29.4
Kannur	2-42	19.5
Kasaragod	0-53	18.9
Kozhikode	0-33	10.7
Wyanad	13-83	45.4

Two major kinds of disease symptoms were noticed in the locations surveyed. Typical symptoms of stunting such as mosaic and mottling on leaves, reduced leaf size, brittle leaves and reduced internodal length leading to stunting of the vine were the most prominent symptoms observed in a majority of the black pepper plantations in Idukki and Wyanad Districts of Kerala (Figure 1A, B). The other symptoms, which were observed mainly in black pepper plantations grown in coastal plains, included chlorotic flecking, bright yellow mottling along the veins coupled with characteristic curling of leaves (Figure 1C). Reduction in spike length and poor filling of spikes were observed in most of the diseased vines. Masking of symptoms (especially in older leaves) during monsoon and winter months were also seen in many of the affected vines. The symptoms were prominently exhibited in the affected vines during March to May.

Among the various cultivars/varieties, cv. Wyanadan had the highest incidence of the disease (93%) and cv. Balankotta the least incidence (6%) (Table 3). The results clearly indicate that most of the cultivars (Arakkulam Munda, Chomala, Jeerakamundi, Kalluvally, Karimunda, Karimkotta, Neelamundi, Thevanmudi,



Fig. 1. Symptoms of viral disease affected black pepper vines : (A) Severly affected vine showing shortening of intern nodes and stunting of whole vine (B) Close-up view of a lateral branch of affected vine showing mottling, curling and reduction in leaf size and internode length (C) Close-up view of leaves of affected vine showing bright yellow mottling along the veins.

Vattamundi and Vellanamban) and improved varieties (Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4 and Panniyur-5) are susceptible to the disease (Table 3). Vines of all age groups were also found to be susceptible to the disease.

Table 3. Incidence of viral disease of black pepper in relation to cultivars/varieties

Cultivar/Variety	No. of vines observed	No. of infected vines	% infected vines
Arakkulam Munda	84	29	35
Balankotta	33	2	6
Chomala	8	1	13
Jeerakamundi	27	15	56
Kalluvally	26	16	62
Karimkotta	11	4	36
Karimunda	1306	272	21
Malligesara	50	19	38
Neelamundi	43	14	33
Panniyur-1	1882	206	11
Panniyur-2	14	3	21
Panniyur-3	26	6	23
Panniyur-4	16	4	25
Panniyur-5	20	3	15
Thevanmudi	156	42	27
Vattamundi	13	10	77
Vellanamban	145	58	40
Wyanadan	15	14	93
Unidentified	265	33	12

In the surveyed areas, several standards such as arecanut, coconut, drumstick, erythrina, glyricidia, jack, mango, rubber, silver oak and a few unidentified forest trees were used to raise black pepper vines. However, the incidence of viral disease was noticed on black pepper irrespective of the kind of standard used. Around 40 species of weeds belonging to various families were found to occur in black pepper gardens. Some of the weeds like *Aegeratum conyzoides* L., *Amaranthus viridis* L., *Chromolaena odorata* (L.), *Colocasia esculenta* (L.) Schott, *Euphorbia geniculata* Orteg., *Knoxia corymbosa* Willd., *Leucas aspera* (Willd.) Link, *Oxalis corniculata* L., *Synedrella nodiflora* (L.) Gaertn. and *Sonchus oleraceus* L. showed typical viral like symptoms such as mosaic and curling (Table 4), indicating that they might act as reservoir hosts for the virus. In addition, other cultivated crops like banana, cardamom, chilli, citrus and tapioca grown in and around black pepper plantations also showed typical viral symptoms on them. Weeds and cultivated hosts are known to act as reservoir hosts for many viruses including CMV (Rist and Lorbeer, 1988; Hull, 2002). DAC-ELISA of these symptomatic weeds showed that a few of them reacted with CMV antiserum (*A. conyzoides*, *C. esculenta*, *S. nodiflora* and *Sonchus*

oleraceus) but not with BSV antiserum.

Table 4. Weed flora with viral like symptoms in the black pepper plantations surveyed

Family	Genus / Species	Symptoms observed
Oxalidaceae	<i>Oxalis corniculata</i> L.	Leaf curl
Rubiaceae	<i>Knoxia corymbosa</i> Willd.	Leaf curl
Asteraceae	<i>Ageratm conyzoides</i> L.	Yellow mosaic and leaf curl
	<i>Chromolaena odorata</i> (L.) R.M. King & H.Rob.	Leaf curl
	<i>Sonchus oleraceus</i> L.	Mosaic
	<i>Synedrella nodiflora</i> (L.) Gaertn.	Leaf curl and stunting of plant
Lamiaceae	<i>Leucas aspera</i> (Willd.) Link	Marginal leaf curl
Amaranthaceae	<i>Amaranthus viridis</i> L.	Yellowing, dark pin head size lesions on leaves
Euphorbiaceae	<i>Euphorbia geniculata</i> Orteg.	Leaf curl
Araceae	<i>Colocasia esculenta</i> (L.) Schott	Mosaic

Twelve species of insects belonging to nine families were found to be associated with diseased vines (Table 5). However, no insect species was specifically associated with diseased vines. Among the various species of insects, aphids are known to transmit CMV and mealybugs are known to transmit badnaviruses (Lokhart *et al.*, 1997; Hull, 2002). In India, striped mealybug (*Ferrisia virgata* Cku.) was shown to be the vector of badnavirus (Bhat *et al.*, 2003). Although aphid (*Toxoptera aurantii* (B.deF.) colonies were seen on black pepper vines under natural conditions, its role as a vector in the transmission of CMV is yet to be established.

Table 5: Insects associated with viral disease affected black pepper vines

Family	Genus/Species
Aleyrodidae	<i>Bemisia tabaci</i> (Genn.)
Aphididae	<i>Toxoptera aurantii</i> (B. de F.)
Membracidae	<i>Leptocentrus</i> sp.
Pseudococcidae	<i>Planococcus</i> sp. <i>Pseudococcus</i> sp.
Diaspididae	<i>Aspidiotus destructor</i> Sign.
	<i>Lepidosaphes piperis</i> Green
	<i>Unnaspis</i> sp.
Phlaeothripidae	<i>Liothrips karnyi</i> Baga
Chrysomelidae	<i>Longitarsus nigripemis</i> Mots.
Tortricidae	<i>Cydia hemidom</i> Meyr.
Geometriidae	<i>Synegia</i> sp.

The survey clearly showed that the incidence and severity of viral disease of black pepper was generally higher in black pepper plantations situated at higher altitudes of Kerala (Idukki and Wyanad districts). This is probably due to the high susceptibility of many of the local cultivars grown along with favourable

environmental conditions prevailing in these regions for the multiplication and spread of the viruses. The major means of spread of viral disease is through use of infected cuttings used as planting material. Secondary spread within plantations might take place through aphid and mealybug vectors but this mode of spread may be very slow or negligible in many of the plantations. Thus, the higher incidence of the disease in Kerala (compared to Karnataka) might be due to indiscriminate use of diseased cuttings for planting and non-removal of diseased vines in the plantations. Hence, adequate care should be taken to plant virus-free cuttings especially in new and non-traditional areas where the incidence of the disease is not observed in the field and the primary aim should focus on production of virus-free planting material. In order to check the secondary spread of the disease within a plantation besides eliminating the infected black pepper vines, insect vectors, weed and other hosts, which might act as virus reservoirs, also need to be controlled.

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