



Distribution and ecology of root mealybugs associated with black pepper (*Piper nigrum* Linnaeus) in Karnataka and Kerala, India

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ABSTRACT: Surveys conducted in 297 gardens in 99 locations in Kerala and Karnataka in India showed that five species of mealybugs (*Planococcus* sp., *P. citri*, *P. lilacinus*, *Dysmicoccus brevipes* and *Ferrisia virgata*) infested the roots and basal region of stem (under the soil) of black pepper vines (*Piper nigrum*). Infestation was observed in all the taluks surveyed in Wayanad (Kerala) and Kodagu (Karnataka) districts and also in Udumbanchola, Kozhikode, Taliparamba (Kerala), Alur and Saklespur (Karnataka) taluks. The infestation was positively and significantly correlated with altitude and was observed in all cultivars/varieties, and on vines trailed on all standards (support trees), resulting in defoliation, yellowing and wilting of leaves and mortality of vines. *Phytophthora capsici*, *Meloidogyne incognita* and *Radopholus similis* were associated with root mealybug infested vines. Colonies of root mealybugs were also observed on 18 species of crop/weed plants especially during summer in black pepper gardens infested with the pest. *Anaplolepis* sp., *Crematogaster* sp., *Technomyrmex* sp. and two unidentified species of ants were associated with root mealybug colonies. © 2010 Association for Advancement of Entomology

KEYWORDS: black pepper, *Piper nigrum*, root mealybug, distribution, damage

INTRODUCTION

Dried mature berries of the perennial climber, *Piper nigrum* Linnaeus (Piperaceae), known as black pepper, is a widely used spice. The crop is grown in about 2,45,970 ha in India, mainly in Kerala and Karnataka (over 98% of total area), with a production of about 69,000 tonnes annually (DASD, 2008). Mealybugs are important pests of the crop, with nine species reported, viz., *Ferrisia virgata* Ckll., *Icerya* sp., *I. aegyptiaca* (Dgl.), *Planococcus* sp., *P. citri* (Risso), *P. minor* (Mask.), *Pseudococcus*

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sp., *P. longispinus* (Targioni) and *P. orchidicola* Takahashi (Pseudococcidae). All these species except *Planococcus* sp. infest the leaf, shoot and berry (Koya *et al.*, 1996). Increasing reports on damage caused by mealybugs to the roots of black pepper, especially from Wayanad District of Kerala in recent years prompted this investigation on the distribution and ecology of root mealybugs in various major black pepper areas

MATERIALS AND METHODS

The surveys were conducted in 15 taluks in 5 districts (Idukki, Kozhikode, Wayanad, Kannur and Kasaragod) in Kerala and 9 taluks in 4 districts (Dakshina Kannada, Uttara Kannada, Kodagu and Hasan) in Karnataka during 2002–04. These districts account for over 75% of the area under black pepper in the country. The total number of locations and black pepper gardens covered during the survey included 67 and 201 in Kerala and 32 and 96, in Karnataka, respectively (Table 1). The black pepper gardens in various taluks were selected at random based on the information obtained from the Department of Agriculture/Horticulture. From each garden, 15 vines were selected at random and the number of vines with symptoms of damage and incidence of root mealybugs was recorded. Other details of the garden such as altitude, intercrops grown, standards used and cultivars/varieties grown were collected through a standard proforma. The nature of damage caused by root mealybugs and the organisms associated with the pest were studied in the field. Samples of mealybug infested roots were brought to the laboratory and examined for the presence of nematodes and plated for *Phytophthora* sp. and also placed in natural enemy emergence cages to record the predators and parasitoids occurring on them. The ants associated with root mealybug colonies were also recorded in the field. Collections of root mealybugs were also made and preserved in the laboratory for identification. The percentage of vines infested was calculated for each garden/location/taluk. The incidence of root mealybugs in relation to altitude, intercrops grown, standards used and cultivars/varieties grown was also determined.

RESULTS AND DISCUSSION

Distribution of root mealybugs

Root mealybug infestations on black pepper was observed in all the taluks surveyed in Wayanad and Kodagu districts in Kerala and Karnataka and also in Udumbanchola (Idukki District), Kozhikode (Kozhikode District) and Taliparamba (Kannur District) taluks in Kerala and Alur and Saklespur (Hasan District) taluks in Karnataka. The pest infestation was higher in Wayanad (8.0–21.1%) and Kodagu (1.7–15.1%) districts and lower in Idukki (0–3%) and Hasan (0–4.4%) districts; stray infestations of the pest were also observed in Kozhikode and Kannur districts. No infestation was observed in Kasaragod, Dakshina Kannada and Uttara Kannada districts. Among the taluks, the percentage of vines infested by root mealybugs was higher in Vythiri (21.1%) and Virajpet (15.1%) in Kerala and Karnataka, respectively (Table 1). Analysis of the pest infestation in relation to altitude of the location indicated a highly significant and

TABLE 1. Incidence of root mealybugs on black pepper in Kerala and Karnataka

State	District	Taluk	No of locations surveyed	% infested vines (range)	% infested vines (mean)	
Kerala	Idukki	Thodupuzha	1	0	0	
		Devikulam	2	0	0	
		Peerumedu	3	0	0	
	Kozhikode	Udumbanchola	9	0–6.7	3.0	
		Kozhikode	11	0–2.3	0.4	
		Koyilandy	5	0	0	
		Vadakara	4	0	0	
		Wayanad	Manathavady	3	0–15.5	8.9
	Wayanad	Sultan's Battery	6	0–22.3	8.0	
		Vythiri	4	0–33.3	21.1	
		Kannur	Thalassery	3	0	0
			Taliparamba	4	0–2.3	0.6
	Kasaragod	Kannur	3	0	0	
		Kasaragod	5	0	0	
		Hosdrug	4	0	0	
Karnataka	Dakshina Kannada	Bantwal	3	0	0	
		Puttur	2	0	0	
	Uttara Kananda	Sirsi	5	0	0	
		Kodagu	Madikeri	4	0–20.0	5.0
	Kodagu	Somwarpet	4	0–6.7	1.7	
		Virajpet	5	4.5–24.5	15.1	
		Hasan	Alur	2	0–6.7	3.3
			Belur	3	0	0
		Saklespur	4	0–17.8	4.4	

TABLE 2. Incidence of root mealybugs on black pepper in relation to altitude in Kerala and Karnataka

Altitude (m above MSL)	No. of locations	% infestation (range)	% infestation (mean)
0–250	47	0–2.3	0.1
251–500	0	0	0
501–750	16	0–17.8	1.5
751–1000	36	0–33.3	8.9

Correlation: % Infestation vs Altitude ($r = 0.451$).

positive correlation ($r = 0.451$) between pest infestation and altitude. A mean of 0.1% of vines were infested at lower altitudes (0–250 m above MSL) when compared to 8.9% at higher altitudes (751–1000 m above MSL) (Table 2).

Root mealybug infestations were observed on black pepper vines trailed on all standards. The infestation percentage was higher in vines trailed on silver oak (*Grevillia robusta* A. Cunn. ex R. Br.) (18.2%) compared to those on *Erythrina*

TABLE 3. Incidence of root mealybugs on black pepper in relation to standards

District	Standard	No. observed	% Infested
Wayanad,	<i>Erythrina</i> spp.	290	13.1
Kerala	Silver oak (<i>Grevillia robusta</i>)	115	18.3
	Jack (<i>Artocarpus</i> spp.)	82	13.4
	Arecanut (<i>Areca catechu</i>)	36	30.6
	Others (including unidentified forest trees)	62	4.8
Kodagu,	Silver oak	310	9.6
Karnataka	<i>Erythrina</i> spp.	90	13.3
	Others (including unidentified forest trees)	185	7.0

TABLE 4. Incidence of root mealybugs on black pepper in relation to cultivars/varieties in Wayanad and Kodagu districts in Kerala and Karnataka

District	Cultivar	No. observed	% infested
Wayanad,	Panniyur 1	295	13.2
Kerala	Karimunda	140	15.7
	Balankotta	46	19.6
	Others (including unidentified cultivars)	100	10.0
Kodagu,	Panniyur 1	535	8.2
Karnataka	Karimunda	24	20.8
	Others (including unidentified cultivars)	26	15.3

spp. (13.1%) and jack (*Artocarpus* spp.) (13.4%), in Wayanad District. In Kodagu District, the infestation percentage was higher (13.3%) in vines trailed on *Erythrina* spp. compared to silver oak (9.6%) and miscellaneous forest trees (7.6%) (Table 3). With regard to cultivars/varieties used, the infestation percentage was higher (19.6%) on Balankotta compared to Karimunda (15.7%) and Panniyur 1 (13.2%), in Wayanad District whereas in Kodagu District it was higher (29.1%) in vines trailed on Karimunda compared to Panniyur 1 (8.2%) (Table 4). With regard to intercrops, 92.1% of locations intercropped with coffee were infested compared to only 7.9% of locations without coffee. At lower altitudes (up to 250 m above MSL) in Kozhikode District where the pest infestation was observed only at two locations out of 11 surveyed, one had coffee as intercrop.

In general, every species is limited in its distribution by biotic and abiotic factors. Among the abiotic factors, climate, especially temperature, rainfall and relative humidity and their interactions between physical and chemical attributes of the host plant, competition among herbivores and natural enemies define the geographic distribution of species (Price, 1984). Climate also determines the physiological tolerances of the insect and host plant and influences insect distribution. The mean maximum and minimum temperatures are lower at higher altitudes and is probably an important factor responsible for the higher incidence of root mealybugs at higher

altitudes. In addition, the availability of other suitable host plants is an important factor.

Five species of mealybugs, namely, *Planococcus* sp., *P. citri* (Risso), *P. lilacinus* (Ckll.), *Dysmicoccus brevipes* (Ckll.) and *Ferrisia virgata* (Ckll.) (Pseudococcidae) were recorded infesting roots and basal portions of stems (under the soil) of black pepper vines. Among them *P. lilacinus* and *D. brevipes* (Ckll.) are being recorded for the first time from black pepper. *P. citri* and *F. virgata* are recorded from the roots/basal regions of stems for the first time. In India, *P. citri* and *P. lilacinus* are known to have a wide host range including many horticultural crops and the hypogeic forms of these species also infest coffee (*Coffea* spp.) in Wayanad and Kodagu districts and are known to cause wilting and mortality especially in younger plants (Sekhar, 1964). *D. brevipes* is a polyphagous species and mainly infests pineapple (*Ananas comosus*) L. (Merr.). In India the hypogeic form has also been recorded on potato (*Solanum tuberosum* L.), groundnut (*Arachis hypogaea* L.), red gram (*Cajanus cajan* (L.) Millsp.), and soybean (*Glycine max*) L. (Merr.) apart from pineapple (Rajagopal *et al.*, 1982; Khan, 1984; Thippaiah and Kumar, 1999). *F. virgata* mainly affects the aerial parts of many horticultural crops in India and has also been recorded to feed on the roots of the weed plant, *Parthenium hysterophorus* L. (Char *et al.*, 1975).

Colonies of root mealybugs were distributed on the main, secondary and tertiary roots and basal region of stems on rooted cuttings in the nursery and also on vines of all age groups in the field. The colonies were observed even up to a depth of two feet below the soil in severely affected vines. The infestation on the basal regions of the stem was seen under the soil and also when they were covered with mulch. Severe infestation resulted in defoliation, yellowing and wilting of leaves and lateral branches and also mortality of vines.

Alternative host plants

In black pepper gardens severely infested with the pest, colonies of root mealybugs were found also on banana (*Musa* sp.) (Musaceae) corm, colocasia (*Colocasia* sp.) (Araceae), turmeric (*Curcuma* sp.) and cardamom (*Elettaria cardamomum* Maton) (Zingiberaceae) rhizome and base of stems of coffee (*Coffea* spp.) (Rubiaceae) and *Erythrina* spp. (Fabaceae) and roots of 11 weed plants (belonging to 10 families including Nephrolepidae) (Table 5). On the weed hosts the insect was generally seen during the post monsoon and summer months. At Wayanad, various intercrops were grown in black pepper gardens among which coconut (*Cocos nucifera* L.), arecanut (*Areca catechu* L.), coffee and banana were the most common and root mealybug infestations were observed in coffee and banana also. In addition, infestation was seen on colocasia, cardamom and turmeric that are grown as intercrops. At Kodagu where coffee was the most common intercrop, followed by *Citrus* sp. and cardamom (*Elettaria cardamomum* Maton) root mealybug infestation was also observed on coffee and cardamom. Six weed species, *Amaranthus gracilis* Desf., *Ludwigia lyssoipifolia* Exell., *Solanum nigrum* L., *Mirabilis jalapa* L., *Sonchus arvensis* L. and *Spilanthes acmella* L. were reported to harbour *P. lilacinus* at Saklespur, Karnataka (Bhat and

TABLE 5. Alternative host plants of root mealybugs in black pepper gardens

Genus/Species	Family
<i>Nephrolepis</i> sp. Schott	Nephrolepidaceae
<i>Sida acuta</i> Burm.	Malvaceae
<i>Senna tora</i> (L.) Roxb.	Fabaceae
<i>Erythrina</i> sp. L.	Fabaceae
<i>Coffea</i> sp. L.	Rubiaceae
<i>Ageratum conyzoides</i> L.	Asteraceae
<i>Vernonia cinerea</i> (L.) Less.	Asteraceae
<i>Scoparia dulcis</i> L.	Scrophulariaceae
<i>Clerodendron infortunatum</i> L.	Verbenaceae
<i>Achyranthus aspera</i> L.	Amaranthaceae
<i>Phyllanthus niruri</i> L.	Euphorbiaceae
<i>Musa paradisiaca</i> L.	Musaceae
<i>Colocasia</i> sp. Schott	Araceae
<i>Cyperus rotundus</i> L.	Cyperaceae
<i>Heteropogon condortus</i> Beauv. ex Roem. et. Schult	Gramineae
<i>Curcuma longa</i> Roscoe	Zingiberaceae
<i>Eleteria cardamomum</i> Maton	Zingiberaceae
<i>Zingiber officinale</i> Rose.	Zingiberaceae

Shamanna, 1972). At Hawaii, *D. brevipes* was observed colonizing two species of weeds namely, *Chloris gayana* Kunth. and *Eleusine indica* (L.) Gaertn. (Poaceae) adjacent to pineapple plantations (Pandey and Johnson, 2006). The authors suggest that weed management could play a significant role in reducing pink mealybug movement into pineapple plantings.

Associated organisms

The fungal pathogen, *Phytophthora capsici* and the nematodes, *Meloidogyne incognita* and *Radopholus similis* were commonly associated with root mealybug infested vines. At Wayanad and Kozhikode districts, all the root mealybug infested vines examined ($n = 104$) were also infested with either *P. capsici* and nematodes or both. The infested vines exhibited symptoms such as root rotting, absence of feeder roots, yellowing and wilting of leaves, defoliation and mortality of vines that are characteristically associated with *P. capsici* and nematode infections. At a few locations in Wayanad District the root mealybug colonies (an undetermined species of *Planococcus*) were covered with a fungal colony (unidentified) which formed a soil-encrusted covering lined with mycelia around them. The fungus, *Diacanthodes philippinensis* is reported to be associated with *P. lilacinus* on coffee in India and whenever both occurred together, the plants wilted and died. Infestation by the mealybug alone did not cause the death of coffee plants (Sekhar, 1964; Chacko and Sreedharan, 1981). In Africa, the coffee root mealybug earlier identified as *P. citri* and associated with the fungus *D. novoguineensis* (Hennings) Fidalgo has been later described as a new

species, *P. fungicola* (Watson and Cox, 1990). According to Fidalgo (1962) the fungus is a symbiont providing protected cavities on the root surface in which the mealybugs live in return for the sugars in the honeydew excreted by the insects and in the sap that escapes from the insects' feeding punctures in the roots.

Five species of ants including *Anaplolepis* sp., *Crematogaster* sp., *Technomyrmex* sp. and two unidentified species were associated with root mealybug colonies and in many cases it was easier to identify infested vines based on the activity of ants. Many species of ants are associated with root mealybugs across the world. Le Pelley (1968) has given a detailed account of the relationship of various species of ants with mealybugs infesting coffee. In India, nine species of ants are reported to be associated with mealybugs on coffee in Kodagu and Wayanad districts (Venkataramaiah and Rehman, 1989).

Among the natural enemies, only larvae of *Spalgis* sp. (Spaligidae) were observed to predate on root mealybug colonies especially those at the base of the stems. *Spalgis* sp. is a well-known predator of mealybugs in many parts of the world and in India *S. epius* Westwood has been identified as a potential predator of the mealybug complex of *P. citri*, *P. lilacinus* and *F. virgata*, occurring on shoots of coffee. Though numerous natural enemies have been recorded on mealybug species occurring on the aerial parts of the plant, the hypogeic habit of the root mealybugs probably render them difficult for predation and parasitisation by natural enemies.

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