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Incidence and Intensity of Root Disease Complex due to Nematode and Soilborne Fungal Pathogens in Mulberry (*Morus alba* L.)

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A preliminary survey on the incidence and intensity of root disease complex (association of *Meloidogyne incognita* and root rot pathogens) was carried out in the sericultural areas of Karnataka. A total of 280 mulberry gardens were surveyed in 14 districts of Karnataka belonging to different types of soil (red sandy, red loamy and black cotton), farming systems (irrigated and rainfed), varieties (V-1, K-2, Local and S-13) and age of the plants (0-5, 5-10 and 10-15 years). It was observed that the association of *M. incognita* with *Botryodiplodia theobromae* and *Fusarium solani* causes the root disease complex in mulberry. Of the 280 gardens visited, 94 were infested with the disease complex and incidence was recorded as 33.6%. The higher intensity of root disease complex was observed when the root system had more than 100 galls/plant with infection of mixed population of *B. theobromae* and *F. solani* in sandy soil under irrigated farming. The 5-10 years old mulberry plantation with V-1 variety was found to be most susceptible to root disease complex. Districts like Mysore, Kolar, Mandya, Tumkur, Chitradurga and Bangalore were observed as sensitive areas. Further, the wounds caused by *M. incognita* in mulberry roots favour the easy entry of root rot pathogens, which increased the severity of the disease very fast.

Key words: Mulberry, Survey, Root disease complex, Root knot nematode, Root rot pathogens

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Introduction

Mulberry (*Morus alba* L.), the sole food plant of silkworm (*Bombyx mori* L.) is a perennial crop and intensively cultivated for its leaves. Various soilborne diseases affect the crop. Among them, root knot (*Meloidogyne incognita*) and root rot (*Fusarium solani*, *F. oxysporum* and *Botryodiplodia theobromae*) diseases pose a serious threat in well-established gardens causing loss of 20% leaf production besides altering the quality of leaf especially the protein, which is essential for silkworms to obtain good quality cocoons and silk. Various methods such as physical, cultural, chemical and biological are being used individually for the control of root knot and root rot diseases (Sharma *et al.*, 2003; Sharma and Gupta, 2005 a). But sometimes these control measures do not come up to the desired level due to the interaction of the nematode with other soilborne pathogens that cause a disease complex. It has been reported that nematode causes wounds in the roots, which make the plants susceptible to attack by root rot pathogens and increase the disease severity, which results in considerable damage to the crop. The disease complex has been very well studied in certain agricultural and horticultural crops (Khan, 1993; Rao and Krishnappa, 1996 a; 1996 b; Singh and Goswami, 2001; Chaitali *et al.*, 2003; Pathak and Keshari, 2004; Siddiqui *et al.*, 2005). In India, Bhagyarathy *et al.*, (2000) reported that the interaction between *M. incognita* and *Rhizoctonia bataticola* causes disease complex in mulberry and *M. incognita* provided added entry points for the pathogen.

In any crop, survey of disease is very essential to know the geographical distribution, the extent of its incidence and intensity, magnitude of the problem and the economic impact in the area concerned, which helps to identify the epidemic/endemic localities and hot spot areas of the concerned disease. Not much information is available on survey of root disease complex in mulberry. Hence, the

present study was undertaken to know the association of soilborne fungal pathogens causing root rot disease with plant parasitic nematode (*M. incognita*) on its incidence and intensity in mulberry gardens of Karnataka as this state alone occupies an area of 77,998 hectares of mulberry for food of silkworm (Roongta and Parker, 2005).

Materials and methods

A preliminary survey (2001-2002) on incidence and intensity of root disease complex (association of *Meloidogyne incognita* and soilborne fungal pathogens) was carried out and 280 mulberry gardens were surveyed in 14 districts of Karnataka belonging to different types of soil (red sandy, red loamy and black cotton), farming systems (irrigated and rainfed), varieties (V-1, K-2, Local and S-13) and age of the plants (0-5, 5-10 and 10-15 years) (Tables 1 & 2). In each district, 20 gardens, infected with root knot disease, were selected randomly from 5 villages at a distance of 4-5 km. In each garden, root and soil samples were collected from plants having the disease complex symptoms (yellowing of foliage with stunted plant growth) covering the entire mulberry garden from 50 spots to a depth of 10-15 cm in sterile polythene bags for isolation of nematode and soilborne pathogenic fungi associated with the samples.

Observations on incidence and intensity of root disease complex

Root samples collected during survey were washed with water for counting the number of galls/plant and egg masses/25 g root. Incidence of root disease complex under different soil types, farming systems, varieties and age of the plants was calculated as follows:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infested gardens}}{\text{Total number of gardens surveyed}} \times 100$$

Further, infection of soilborne fungal propagules on the foliage (wilting of leaves due to rotting of roots) was determined using following formulae (Sharma and Gupta, 2005 b).

$$\text{Foliar infection (\%)} = \frac{\text{Number of wilted leaves}}{\text{Total number of leaves}} \times 100$$

$$\text{Root infection (\%)} = \frac{\text{Wt. of whole root system} - \text{Wt of healthy root system}}{\text{Wt of whole root system}} \times 100$$

Based on gall/egg masses (for nematode) and root rot (for soilborne pathogens) indices; the severity of root disease complex was assessed using 1-5 grading scale and infested mulberry gardens were categorized into different levels of disease severity (Sharma and Gupta, 2005 b).

Isolation, pathogenicity and identification of nematode and fungal cultures

Nematode population was estimated from the samples by Cobb's sieving and Baermann funnel method (Southey, 1986) while fungal population by dilution plate technique (Waksman, 1927) using Potato Dextrose Agar (PDA) medium. The fungi were also isolated from the infected root samples by keeping root bits on Petri plate earlier seeded with PDA medium. Later, nematode culture was purified by inoculating single egg mass in potted mulberry variety (V-1) susceptible to nematode and root rot pathogens (Naik and Sharma, 2003) having 3 kg sterile soil mixture (soil, sand and FYM; 2 : 1 : 1) and fungal cultures by mono hyphal tip method (Waksman, 1927).

Pathogenicity test for root knot nematode was conducted by inoculating the egg masses from purified cultures to 3 months old potted mulberry plant (V-1) containing 3 kg sterile soil mixture in the root zone. The soil without inoculum of nematode served as a check for comparison and 15 replications of each treatment was maintained. After 90 days of inoculation, the number of galls/plant and egg masses/25 g root were counted for confirming the pathogenicity. However, to know the pathogenicity of the fungal isolates, they were mass - multiplied on boiled maize (*Zea mays* L.)+gram (*Phaseolus mungo* L.) husk+wheat (*Triticum vulgare* L.) straw (3 : 1 : 1 w/w) separately. The biomass of each fungus (2.6×10^7 spores/g) was inoculated @ 500 g/pot near root zone of 3 months old potted mulberry plants (V-1) con-

Disease Index	Root rot index		Root knot index		Severity of garden
	Foliar infection (%)	Root infection (%)	Galls/plant	Egg masses/25 g root	
1	No wilting	No root rotting	Nil	Nil	Disease free
2	0 - 25 wilting	0 - 25 rotting	0 - 10	0 - 10	Mild
3	25.1 - 50 wilting	25.1 - 50 rotting	10.1 - 30	10.1 - 30	Moderate
4	50.1 - 75 wilting	50.1 - 75 rotting	30.1 - 100	30.1 - 100	Severe
5	> 75 wilting	> 75 rotting	> 100	> 100	Very severe

Table 1. Incidence and intensity of root disease complex in mulberry gardens

Districts	Disease Incidence		Disease intensity											*Grade for disease complex	Severity of gardens with disease complex
			Nematode infection				Root rot infection								
	Infected gardens out of 20	Infected gardens (%)	Galls/ plant (no.)	Egg masses/ 25 g root	Grade	N. popu./ 250 cc soil	Population $\times 10^6$	Bt	Fs	Bt + Fs	Foliar infection (%)	Rotting of root (%)	Grade		
Bangalore	12	60.0	270	147	5	326	5.2	-	-	+++	51.6	53.9	4	4.5	Severe
Kolar	13	65.0	302	176	5	368	6.6	-	-	+++	59.5	57.0	4	4.5	Severe
Mysore	15	75.0	310	188	5	405	7.8	-	-	+++	60.7	59.9	4	4.5	Severe
Mandya	8	40.0	193	119	5	266	5.9	-	-	+++	58.5	55.5	4	4.5	Severe
Hassan	6	30.0	95	71	4	208	3.6	++	-	-	40.0	32.6	3	3.5	Moderate
Chitradurga	9	45.0	167	103	5	236	5.5	-	-	+++	54.0	51.9	4	4.5	Severe
Tumkur	14	70.0	180	109	5	214	5.7	-	-	+++	56.8	52.0	4	4.5	Severe
Chamarajanagar	5	25.0	87	58	4	160	2.2	-	++	-	28.5	26.2	3	3.5	Moderate
Kodagu	0	0.0	9	3	2	26	-	-	-	-	-	-	1	1.5	Nil
Chikmagalur	4	20.0	75	55	4	149	2.1	++	-	-	38.0	32.0	3	3.5	Moderate
Davangere	2	10.0	91	62	4	134	2.4	++	-	-	32.8	28.8	3	3.5	Moderate
Dakshina Kannada	0	0.0	7	2	2	18	-	-	-	-	-	-	1	1.5	Nil
Udupi	0	0.0	10	5	2	23	-	-	-	-	-	-	1	1.5	Nil
Shimoga	6	30.0	58	38	4	134	2.9	-	++	-	33.0	30.5	3	3.5	Moderate
Total/Average	94	33.8													

Very high (++++)	$> 8 \times 10^6$ Population of root rot pathogen/g soil	High (+++)	$5.1 - 8.0 \times 10^6$ Population of root rot pathogen/g soil
Moderate (++)	$2.1 - 5.0 \times 10^6$ Population of root rot pathogen/g soil	Mild (+)	$0 - 2.0 \times 10^6$ Population of root rot pathogen/g soil
Absent (-)	Nil Population of root rot pathogen/g soil		

Mi: *Meloidogyne incognita*; Bt: *Botryodiplodia theobromae*; Fs: *Fusarium solani*

*Based on an average of galls/egg masses and root rot indices

Table 2. Incidence and intensity of root disease complex under different soil types, farming systems, varieties and age of the plant

Parameters	Total no. of gardens and infested gardens according to											
	Soil types			Farming system		Variety				Plant age (years)		
	Red sandy	Black cotton	Red loamy	Irrigated	Rainfed	V-1	K-2	Local	S-13	0-5	5-10	10-15
Total gardens surveyed (no.)	146	40	94	227	53	89	90	65	36	83	120	77
Infected gardens (no.)	65	3	26	91	3	40	29	21	4	26	57	11
% Infected gardens (Incidence)	44.5	7.5	27.6	40.0	5.6	44.9	32.2	32.3	11.1	31.3	47.5	14.3
Intensity of root disease complex												
No. of galls/plant	293	28	76	310	21	166	207	214	16	83	234	69
No. of egg masses/ 25 g root	179	17	42	188	11	118	143	159	11	56	175	38
Nematode population 250 cc soil	460	48	176	389	38	415	342	382	31	216	399	175
Disease intensity grade for root knot (RK)	5.0	3.0	4.0	5.0	3.0	5.0	5.0	5.0	3.0	4.0	5.0	4.0
Population of fungal pathogens 10^6/g soil	7.8 ● *	5.2 * ●	3.6 ●	6.7 ● *	4.7 *	8.9 ● *	3.5 ●	3.3 ●	1.6 *	4.6 ●	6.3 ● *	3.8 *
Foliar infection (%)	64.5	52.5	33.5	60.5	30.0	79.8	36.0	38.0	8.5	34.9	57.5	27.8
Root infection (%)	59.8	50.9	29.8	56.0	27.5	76.5	27.5	28.0	7.0	30.0	53.0	21.5
Disease intensity grade for root rot (RR)	4.0	4.0	3.0	4.0	3.0	5.0	2.0	2.0	2.0	3.0	4.0	3.0
Intensity grade for disease complex (Av. grades of RK & RR)	4.5	3.5	3.5	4.5	3.0	5.0	3.5	3.5	2.5	3.5	4.5	3.5
Severity of gardens with disease complex	Severe	Mode-rate	Moderate	Severe	Moderate	Very severe	Mode-rate	Mode-rate	Mild	Mode-rate	Severe	Mode-rate

● : Population of *B. theobromae* only; ● * : Mixed population of *B. theobromae* and *F. solani*;
* : Population of *F. solani* only; * ● : Mixed population of *F. solani* and *B. theobromae*

taining 3 kg sterile soil mixture. Fifteen replications of each fungal isolate and control were maintained. After, 90 days, observations on number of wilted leaves/plant and rotting of roots were noted. After artificial inoculation, the pathogens were re-isolated from the infected roots to ascertain the association of fungus for fulfilling Koch's postulates. After pathogenicity, the nematode was identified on the basis of North Carolina differential host plants like cotton (Deltapine-61), tobacco (NC-95), pepper (California wonder), watermelon (Chareston grey), peanut (Florunner) and tomato (Rutgers) [Hartman and Sasser, 1985] and perineal patterns of the female (Eisenback, 1985). The pathogenic fungi were identified on the basis of their morphological characters (Sutton, 1980; Ellis and Ellis, 1985; Agrios, 2000).

Results

Incidence and intensity of root disease complex

The disease symptoms appeared as wilting/withering of foliage with reduced leaf size and stunted plant growth. The root system of severely infected plants showed more than 100 galls/plant along with rotting of roots (due to fungal attack) and due to this complete death of the plants in patches was occurred. Out of the 280 gardens surveyed, 94 were infested by the disease complex with 33.6% of disease incidence. Among the districts, the maximum incidence of disease complex was recorded in Mysore (75.0%) followed by Tumkur (70.0%), Kolar (65.0%) and Bangalore (60.0%). Whereas, districts like Chitradurga, Mandya, Hassan and Shimoga recorded the disease incidence up to 30-45.0%. The minimum disease incidence (10.0-25.0%) was noticed in Davangere, Chikmagalur and Chamarajanagar. However, the disease incidence was not observed in districts like Kodagu, Dakshina Kannada and Udupi (Table 1).

Similarly, the higher intensity of disease complex was observed in Mysore, Kolar, Mandya, Tumkur, Chitradurga and Bangalore where nematode infection was very high (grade: 5.0) with severe wilt intensity (grade: 4.0 *i.e.* >50 to less than 75.0%) by the mixed infection of *B. theobromae* (F-1) and *F. solani* (F-2) ($5.2-7.8\times10^6$ CFU/g soil). Based on an average of nematode and root rot indices, these gardens were considered as severely infested by disease complex with an intensity grade of 4.5. The moderate intensity of disease complex (grade: 3.5) was recorded in Hassan, Davangere, Chamarajanagar, Chikmagalur and Shimoga where nematode infection was severe (38-95 galls and egg masses) with moderate infection of mixed population of *B. theobromae* and *F. solani* (wilting of leaves and rotting of roots by >25 to below 50.0%). However, the disease intensity was not observed in districts like Kodagu, Dakshina Kannada and Udupi and the gardens had a mild infection of nematode (below 10 galls/egg masses) (Table 1).

In all the 280 gardens surveyed, the mulberry plantations were found growing in three types of soil *viz.*, red sandy, red loamy and black cotton under irrigated and rainfed farming systems with four popular varieties (V-1, K-2, Local and S-13) having 0-15 years old plantations (0-5, 5-10 and 10-15 years). Results revealed that higher intensity of disease complex was observed in sandy soil under irrigated farming between 5-10 years old plantation with V-1 variety. Such types of gardens were having very severe intensity of nematode (>100 galls/egg masses) with severe intensity of wilt/rotting (>50 to below 75.0%) by the highest mixed population of *B. theobromae* and *F. solani* ($6.3-8.9\times10^6$ CFU/g soil). In these gardens, the intensity grade of disease complex was rated as 4.5 (Table 2).

Isolation, pathogenicity and identification of nematode and fungal cultures

During the survey, a single species of root knot nematode was isolated from soil samples collected from 14 districts of Karnataka and five fungal isolates (F-1 to F-5) were also found to be associated with root knot disease except in Kodagu, Dakshina Kannada and Udupi districts. During pathogenicity, nematode and 2 fungal isolates (F-1 and F-3) caused severe infection in mulberry (53.0-66.9%). However, three fungal isolates like F-2, F-4 and F-5 did not show any symptoms on mulberry (Tables 3-4). On the basis of parasitism on differential host plants, the isolated nematode was unable to reproduce on peanut and cotton whereas it successfully reproduced on tobacco, pepper, watermelon and tomato. However, perineal pattern of female showed features like high squarish dorsal arch, absence of lateral ridges and tail terminus contained within a distinct whorl. With regard to morphology of pathogenic fungal isolates (F-1 and F-3), the mycelium of F-1 is septate having numerous greyish-black hypha. The formation of conidiophores and conidia was observed inside the fruiting bodies (pycinidia). At first, the fungus produces immature conidia, which are hyaline and unicellular with ellipsoidal shape. On maturity, they became bi-celled and cinnamon to light brown measuring $10-15\times18-30$ μm. The mycelium of fungal isolate, F-3 is septate and produced 3 types of the spores *i.e.* microconidia, macroconidia and chlamydospores. Microconidia are born on long phialides, small in size, oval to ellipsoidal, non-septate measuring $4-6\times10-19$ μm. The macroconidia are born on nonphilides, inside the sporodochium. They are linear, slightly curved, two septate,

Table 3. Pathogenicity of nematode on mulberry (V-1) after 90 days

Parameters	Control (without nematode)	Nematode inoculated
Plant height (cm)	77.7	66.6 (14.3%)
Leaf yield/plant (g)	79.0	60.5 (23.4%)
Weight of shoot/plant (g)	80.8	62.8 (22.2%)
No. of galls/plant	0.0	269.2
No. of egg masses/25 g root	0.0	204.0
N. population/250 cc soil	0.0	1180.5
SE±	0.39	0.73
CD at 5%	1.12	2.08
CV %	3.15	0.75

Figures in parentheses denote extent of reduction over control

Table 4. Pathogenicity of different fungal isolates on mulberry after 90 days of soil inoculation (in pots)

Fungal isolate	Survival of the plants (%)	Wilted leaves (%)	Rotted roots (%)
F-1	61.8 (38.2)	66.9	60.8
F-2	100.0 (0.0)	0.0	0.0
F-3	66.5 (33.5)	58.5	53.0
F-4	100.0 (0.0)	0.0	0.0
F-5	100.0 (0.0)	0.0	0.0
Control	100.0 (0.0)	0.0	0.0
SE±	0.22	0.21	0.26
CD at 5%	0.65	0.62	0.70
CV %	0.82	3.32	4.45

Figures in parentheses indicate the percent plant mortality

wider at the center, rounded at the tips and notched at the base, measuring 6-9×37-45 µm. Chlamydospores are thick walled, oval to spherical, golden in colour and occur intercalary, singly/chains of two.

Discussion

Incident and intensity of root disease complex

In the present study, the severe incidence and intensity of disease complex in districts like Mysore, Kolar, Mandya, Tumkur, Chitradurga and Bangalore could have occurred due to the cultivation of nematode-fungal susceptible crops like tomato, brinjal, cowpea, chick pea, *etc.* along with mulberry in these areas. These crops are highly susceptible to the nematode and various wilt/root rot causing pathogens (Khan, 1993; Singh and Goswami, 2001). In these districts, the number of galls/plant recorded was more than 100 and as a result, the higher infection of *B. theobromae* (F-1) and *F. solani* (F-3) occurred together; since higher the number of nematode population, wounding to the root system and subsequent provision of infection, court for the easy entry of soilborne pathogens (Khan, 1993; Bhagyarathy *et al.*, 2000; Chaitali *et al.*, 2003; Pathak and Keshari, 2004). Intensity of the disease complex was not observed when the number of galls/plant was below 10. This was confirmed by the apparent absence of the disease in districts like Kodagu, Dakshina Kannada and Udupi. Consequently, the soilborne fungal pathogens were unable to get any entry points to infect the plants. Therefore, in these gardens the symptoms of disease complex were not observable. Similar observations were also noticed during the survey conducted by Haseeb and Shukla (2005) on maximum severity of disease complex caused by *M. incognita* and *F. udum* due to higher nematode population.

The occurrence of higher intensity of disease complex in sandy soil under irrigated farming might be due to the favourable micro climate created for the fast movement and multiplication of the nematode, *M. incognita* (Sharma and Gupta, 2005 a). Nematode mobility decreases as the percentage of clay and silt increases in the soil (Dhangar *et al.*, 1995). Consequently, a higher intensity of soilborne fungal pathogens was recorded, because the high and low soil moisture and all types of soils, have been reported to favour the fast multiplication and establishment of root rot pathogens like *B. theobromae* and *F. solani* in mulberry (Sharma *et al.*, 2003; Sharma and Gupta, 2005 a). The

present findings are also in agreement with the view of Rao and Krishnappa (1996 a; 1996 b) who reported that the maximum severity of the disease complex caused by the association of *M. incognita* and wilt causing pathogens (*F. oxysporum* f. sp. *ciceri*) in chickpea was observed in sandy soil under irrigated farming. Among the varieties, V-1 recorded a higher intensity of root disease complex. This suggests that V-1 variety is highly susceptible thereby supporting high population of *M. incognita, B. theobromae* and *F. solani* (Table 2). High populations of nematode and fungal pathogens in susceptible varieties could be due to the result of root exudation pattern as documented by Rao and Krishnappa (1996 a). However, in varieties like K-2 and Local, though the nematode infection was observed to be very severe, the intensity of wilting of leaves and rotting of roots was recorded to be moderate, which might be due to the infection only by *B. theobromae*, while *F. solani* was not encountered in such types of root and soil samples. The mild intensity of S-13 variety is might be, due to its evolution, exclusively for rainfed areas (Dandin *et al.*, 2003) and as a result mild infection of nematode (more than 10 and less than 30 galls/plant) was recorded. Secondly, from among the soil-borne fungal pathogen, only *F. solani* was noticed. In respect to the age of the mulberry plantations (0-5; 5-10 and 10-15 years old), the minimum incidence and intensity of disease complex was recorded in 10-15 years old mulberry gardens, which may be attributed to the inability of the nematode to penetrate into older tissues of roots (Christie, 1949; Rao and Krishnappa, 1996 a).

Isolation, pathogenicity and identification of nematode and fungal cultures

On pathogenicity, isolated nematode and 2 fungal isolates such as F-1 and F-3 from 14 districts of Karnataka have proved their pathogenicity on mulberry by ful-filling Koch's Postulates and caused infection (53.0 - 66.9%) in mulberry. However, 3 fungal isolates like F-2, F-4 and F-5 failed to full-fill the Koch's Postulates, suggesting that they are non-pathogenic to mulberry. Further, these observations suggest that fungal isolates like F-1 and F-3 are found to be associated with root knot disease (*M. incognita*) causing root disease complex in mulberry. These observations are supported to a great extent by the reports of Govindaiah *et al.* (1991) who has proved that *M. incognita* is highly pathogenic to mulberry, causing root knot disease. However, pathogens such as *B. theobromae* and *F. solani* are potent pathogens, which cause root rot in mulberry (Sharma *et al.*, 2003).

Based on the parasitism on differential host plants, the root knot nematode was identified as *Meloidogyne incognita* (Kofoid & White) Chitwood in all the samples because it was unable to reproduce on peanut, while *M. hapla* can be separated by its inability to reproduce on watermelon, *M. arenaria* on cotton and *M. javanica* on pepper and peanut (Hartman and Sasser, 1985). This was also confirmed by the perineal pattern of female by showing high, squarish dorsal arch, absence of lateral ridges and tail terminus contained with distinct whorl, which are the most characteristic features of *M. incognita* (Eisenback, 1985). Regarding the identification of pathogenic fungal isolates (F-1 and F-3), by comparing all the morphological characters with available literatures, the fungal isolate, F-1 was identified as *Botryodiplodia theobromae* Pat. based on asexual reproductive structures, conidial shape, size and striation, which are the characteristics of this genus and species while on the basis of types of conidial formation, measurement, shape, number of septa/conidium, *etc.* isolate, F-3 was identified as *Fusarium solani* (Mart.) Sacc. as these characters are considered as an important taxonomic criteria of this genus and species (Booth, 1971; Sutton, 1980; Ellis and Ellis, 1985; Agrios, 2000). Later, Prof. H. Shekhar Shetty, Department of Applied Botany, University of Mysore, India confirmed the identity of both the fungal isolates.

Conclusion

The present survey indicates that higher intensity of root disease complex was observed when the root system had more than 100 galls/plant with infection of *B. theobromae* and *F. solani* in sandy soil under irrigated farming. The 5-10 years old mulberry plantation with V-1 variety was found to be most susceptible to disease complex and districts like Mysore, Kolar, Mandya, Tumkur, Chitradurga and Bangalore were observed as sensitive areas. *M. incognita* provides a good site for easy entry of developing hyphae of *B. theobromae* and *F. solani* in the roots of mulberry, which increased the severity of the disease and causes the root disease complex.

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