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OCCURRENCE AND DISTRIBUTION OF *RADOPHOLUS SIMILIS* (COBB, 1893) THORNE, 1949 IN SOUTH INDIA

BY

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The burrowing nematode, *Radopholus similis* is widely distributed in South India associated with coconut, arecanut, banana and pepper. In coconut and arecanut plantations *R. similis* occurred maximum in sandy-loam soil. Banana as an intercrop was found to favour multiplication of *R. similis* in arecanut gardens. A range of 10–20°C was the optimum temperature for extraction of active *R. similis* population from banana and pepper roots. The introduction of *R. similis* to a new area through infested coconut seedlings recorded here, warrants the need for immediate intra and interstate regulatory measures against distribution of nematode infested planting materials.

In India, *Radopholus similis* (Cobb, 1893) Thorne, 1949 was reported from banana (Nair *et al.*, 1966 and coconut (Weischer, 1967). Setty (pers. comm.) observed this nematode around banana roots in Bangalore and Muthukrishnan (pers. comm.) part from Coimbatore, Madurai, Tirunelveli, Salem, Dharmapuri and North Arcot districts of Tamil Nadu State. This paper presents the results of surveys conducted during 1972-78 in relation to the incidence of root (wilt) disease of coconut and yellow leaf disease of arecanut.

MATERIALS AND METHODS

The route of survey was mostly along the main roads and samples were collected from nearby gardens every 10 km. The survey covered Chirayinkeezh, Nedumangad, Neyyattinkara and Trivandrum taluks of Trivandrum district ; Karunagappally, Kottarakara, Kunnathur, Pathanamthitta, Pathanapuram and Quilon taluks of Quilon district, Ambalabuzha, Chengannur, Karthigappally, Kuttanad, Mavelikara, Shertalai and Thiruvalla taluks of Alleppey district, Changanacherry, Meenachil, Vaikom and Kottayam taluks of Kottayam district, Thodupuzha taluk of Idikki district, Alwaye, Cochin, Muvattupuzha, Parur and Kanayannur taluks of Ernakulam district, Chowghat, Kodungallur, Mukundapuram, Talappilly and Trichur taluks of Trichur district,

Alathur, Ottapalam and Palghat taluks of Palghat district, Eranadu, Perinthalmanna and Ponnani taluks of Malapuram district, Kozhikode taluk of Calicut district, Kasaragod and Taliparamba taluks of Cannanore district in Kerala State ; Agastiswaram, Kalkulam, Thovala and Vilavankode taluks of Kanyakumari district, Nanguneri, Radhapuram, Sankarankovil, Shencottah, Sri Yaikuntam and Tiruchendur taluks of Tirunelveli district, Rajapalayam taluk of Ramanathapuram district, Avanashi, Erode, and Coimbatore taluks of Coimbatore district, Sankagiri, Tiruchengode and Salem taluks of Salem district, Coonoor and Gudalur taluks of Nilgiris district in Tamil Nadu State ; Chickmagalur, Moodigere, Koppa, Sringeri and Kadur taluks of Chickmagalur district, Bantwal, Belthangady, Karkala, Sullia and Puttur taluks of South Kanara district in Karnataka State ; Car Nicobar and South Andamans in Andaman islands, Minicoy island in Lakshadweep and Razole taluk of East Godavari district in Andhra Pradesh. For coconut, soil and root samples were collected one metre away from the bole of the palm from a depth of 10–50 cm with a 75 mm diam. soil auger. Three such samples were taken within the basin at 120° to each other, mixed well and 250 cc samples drawn. In addition to the root bits collected through auger, 50–60 g tender, white to orange coloured semi-hard portion of the main roots was also collected whereever possible from the base of the palm. Arecanut samples were collected 75 cm away from the bole of the palm to a depth of 10–50 cm as in the case of coconut. Banana and pepper root samples were mostly from coconut and arecanut gardens whereever it was convenient. Number of samples collected from these crops are not large because the survey was mainly meant for coconut and arecanut. Soil samples were processed by Cobb's sieving and shifting method. Root populations were extracted by the method reported by Koshy *et al.* (1975) and counts made under a stereoscopic microscope. The results reported herein on *R. similis* are based only on the population recovered from roots.

RESULTS

From Table I it is seen that 213/877 (24.3%) root samples collected from coconut ; 233/766 (30.4%) from arecanut ; 116/240 (48.3%) from banana and 24/85 (28.2%) from pepper yielded *R. similis*.

The samples covered 41 taluks/tehsils in eleven districts of Kerala, 20 taluks in six districts of Tamil Nadu, ten taluks in two districts of Karnataka, two samples from Andhra Pradesh (Fig. 1), five samples from South Andaman and Car Nicobar islands in the Bay of Bengal and three samples from Minicoy island of Lakshadweep.

TABLE I

Distribution of R. similis *in South India*

Host

Area	Arecanut Y/T*	Banana Y/T	Coconut Y/T	Pepper Y/T
1	2	3	4	5
	I. *Kerala State*			
1. Trivandrum District	95/308	9/28	4/66	3/11
2. Quilon ,,	32/141	12/22	20/128	3/23
3. Alleppey ,,	3/8	48/72	135/264	0/5
4. Kottayam ,,	0/5	3/7	1/14	0/3
5. Idikki ,,	—	—	0/1	1/4
6. Ernakulam ,,	4/19	3/9	3/24	2/6
7. Trichur ,,	28/110	15/34	18/144	0/4
8. Palghat ,,	2/8	2/8	1/13	1/3
9. Malapuram ,,	0/5	1/5	0/7	0/2
10. Calicut ,,	—	1/1	—	6/7
11. Cannanore ,,	—	6/6	19/84	6/15
Total	164/604	100/192	201/745	22/83
	II. *Tamil Nadu State*			
1. Kanyakumari District	4/19	2/6	5/30	—
2. Tirunelveli ,,	0/7	0/10	1/54	—
3. Ramanathapuram ,,	—	0/1	0/2	—
4. Coimbatore ,,	2/7	6/15	1/17	—
5. Salem ,,	0/1	2/7	0/8	—
6. Nilgiris ,,	1/2	1/2	0/1	—
Total	7/36	11/41	7/112	—
	III. *Karnataka State*			
1. Chickmagalur District	17/23	—	—	—
2. South Kanara ,,	45/102	4/5	5/13	2/2
Total	62/125	4/5	5/13	2/2

TABLE I (contd.)

1	2	3	4	5
		Andaman Islands		
South Andamans	0/1	—	0/2	—
Car Nicobar	—	—	0/2	—
		Lakshadweep		
Minicoy	—	1/2	0/1	—
		Andhra Pradesh		
East Godavari District				
1. Razole	—	—	0/2	—
Grand total	233/766	116/240	213/877	24/85

*Y/T = $\frac{\text{Number of samples yielded } \textit{R. similis}}{\text{Total number of samples collected}}$

— Location not sampled.

In coconut, of 213 samples yielding *R. similis*, 115 yielded at least one or more than one nematode per gram of root weight ; (Table II) 57 of such samples yielded ten and above. Ninety three of them were in sandy loam soil. The percentage occurrence of *R. similis* in sandy loam, laterite, alluvial, clayey and red loam soils was 9.8, 13.0, 10.5, 3.0 and 17.8 in the healthy tract whereas in the apparently healthy it was 53.0, 0.0, 0.0, 31.0 and 0.0 and in the diseased it was 28.0, 12.0, 9.5, 15.6 and 0.0 respectively (Table II). The maximum number was 745 per gram of root from sandy loam soil in Karthigappally taluk of Alleppey district, Kerala. The percentage occurrence in healthy, apparently healthy and diseased palms was 12.3, 41.8 and 20.5 respectively which again varied between soil types. The samples collected from apparently healthy trees yielded more nematodes compared to the diseased in the diseased tract and the healthy of the healthy tract. This could also be due to the fact that more number of samples were collected in sandy loam soil.

In the case of arecanut also the percentage of occurrence was more in sandy loam soil (42.3) followed by laterite (29.6) and alluvial (28.0). The percentage occurrence was equal in diseased and healthy (32.0) compared to apparently healthy (30.0). The maximum number recorded was 139 per gram of root (Table III).

TABLE II

Occurrence of R. similis *in different soil types with reference to health of the coconut palm*

Soil types	Healthy Y/T	Apparently healthy Y/T	Diseased Y/T	Total Y/T	Samples yielded > 1/g			
					Healthy	Apparently healthy	Diseased	Total
1. Sandy loam	5/51 (9.8)*	107/202 (53.0)	47/167 (28.0)	159/420 (37.8)	0	80	13	93
2. Laterite	11/84 (13.0)	0/28 (0.0)	9/74 (12.0)	20/186 (10.7)	3	0	4	7
3. Alluvial	4/38 (10.5)	0/18 (0.0)	4/42 (9.5)	8/98 (8.2)	2	1	1	4
4. Clayey	1/34 (3.0)	5/16 (31.0)	5/32 (15.6)	11/82 (13.4)	0	1	0	1
5. Red loam	15/85 (17.8)	0/4 (0.0)	0/2 (0.0)	15/91 (16.5)	10	0	0	10
	36/292 (12.3)	112/266 (41.8)	65/317 (20.5)	213/877 (24.3)	15	82	18	115

$$Y/T = \frac{\text{Number of samples yielded } \textit{R. similis}}{\text{Total number of samples collected}}$$

*=Figures in parentheses are the percentages.

TABLE III

Occurrence of R. similis *in different soil types with reference to health of the Arecanut palm*

Soil types	Healthy Y/T	Apparently healthy Y/T	Diseased Y/T	Total Y/T	Samples yielded > 1/g			
					Healthy	Apparently healthy	Diseased	Total
1. Sandy loam	6/19	14/36	19/37	39/92	3	4	9	16
	(31.6)*	(39.0)	(51.3)	(42.3)				
2. Laterite	38/102	37/112	74/290	149/504	4	1	17	22
	(37.2)	(33.0)	(25.5)	(29.5)				
3. Alluvial	7/27	11/35	11/42	29/104	0	8	7	15
	(25.9)	(31.4)	(26.2)	(28.0)				
4. Clayey	1/10	3/36	5/18	9/64	1	1	1	1
	(10.0)	(8.3)	(27.7)	(14.0)				
5. Red loam	2/11	2/5	0/3	4/19	0	0	0	0
	(18.0)	(40.0)	(0.0)	(21.5)				
Total	54/169	67/224	109/390	233/766	8	14	34	56
	(32.0)	(30.0)	(32.0)	(30.4)				

$$Y/T = \frac{\text{Number of samples yielded } R.\ similis}{\text{Total number of samples collected}}$$

* =Figures in parentheses are the percentages.

In pepper the percentage occurrence was maximum in red loam soil (36.3) followed by laterite soil (33.3) (Table IV) and the maximum population recorded was 94 per gram of root.

TABLE IV

Occurrence of R. similis *in different soil types on Banana and Pepper*

Soil types	Banana		Pepper	
	Y/T	More than 1/g	Y/T	More than 1/g
1. Sandy loam	50/87 (57.5)*	6	1/12 (8.3)	0
2. Laterite	30/64 (46.8)	17	16/48 (33.3)	7
3. Alluvial	12/36 (33.3)	6	3/10 (30.0)	0
4. Clayey	11/34 (32.3)	6	0/4 (0.0)	0
5. Red loam	11/19 (57.9)	7	4/11 (36.3)	0

$$Y/T = \frac{\text{Number of samples yielded } \textit{R. similis}}{\text{Total number of samples collected}}$$

*=Figures in parentheses are the percentages.

In the case of banana *R. similis* was recorded maximum from red loam soil (57.9%) and sandy loam soil (57.5%) (Table IV). Between the four crops the highest percentage (48.3) occurrence was in banana which shows that banana is more susceptible to *R. similis* than the other three crops. The per gram population recorded was 150.

R. similis was not obtained from Radhapuram, Rajapalayam, Nanguneri, Sankarankovil, Shencottah, Srivaikuntam, Tiruchengode, Tirunelveli, and Vilavancode taluks of Tamil Nadu ; Belthangady taluk of Karnataka ; Changanacherry, Eranadu and Meenachil taluks of Kerala ; Razole taluk in East Godavari district of Andhra Pradesh and from Andaman islands. This could be due to the very low number of samples collected from these areas. At the same time *R. similis* was recorded from all the four crops from Nedumangad, Neyyattinkara and Ottapalam taluks of Kerala and Puttur taluk of Karnataka. Recovery of 1600 *R. similis* per gram from the rotting roots of a dead coconut seedling at Central Plantation Crops Research Institute (CPCRI) Kidu is a typical case of establishment at a fresh area of cultivation through infested transplants raised at CPCRI, Kasaragod.

During these studies it was observed that banana and pepper roots when sliced and left submerged in water for extraction at room temperature (27°C and above) yielded only very few active nematodes and the water always turned black in colour. In the case of coconut and arecanut the colour changed to brown. Another difficulty was the tannin rich suspension blocking the pores of finer sieves. Both these difficulties were overcome by extracting the nematodes at lower temperature (10-20°C) in a refrigerator or B.O.D. incubator.

DISCUSSION

The widespread occurrence of *R. similis* in most of the areas surveyed and recorvery of their high numbers from coconut, arecanut, banana and pepper suggests that the nematode might have been introduced long time ago or even indigenous to Kerala as these crops are known to be cultivated in the State since vedic times. The delay in their detection must have been because of the lack of awareness of nematode problems and the absence of nematological centres and trained nematologists.

The problems encountered in the present survey in detection of *R. similis* in roots of coconut and arecanut are difficulty in sampling, need for frequent sampling, its abundance in a particular type and portion of the root (Koshy *et al.* 1975) confined to a certain season, (Koshy and Sosamma, 1977) delay in transport to the laboratory and problems in their extraction etc. Studies on the standardisation of sampling zone of coconut have shown that only 30% (av. of 3 palms) samples yielded *R. similis* for known infested palms (unpublished). Such difficulties were also met with by other workers in citrus and banana (Suit & DuCharme, 1953 ; Vilardebo, 1976).

R. similis was found to occur maximum, in sandy loam soil on coconut and arecanut and in red loam soil in the case of banana and pepper (Table II, III & IV). Obviously *R. similis* prefers loose well drained soil and the situation is in agreement with the findings of O'Bannon & Tomerlin ; 1970, Tomerlin & O'Bannon, 1974 who reported that spreading decline symptoms on citrus was more severe in well drained deep sandy soils compared to moderate to slight symptoms of infection in other soil types.

Regarding association of the nematode with root (wilt) disease of coconut, it is seen that 41.8% samples from apparently healthy palms followed by 20.5% from diseased palms of diseased tracts and 12.3% from the healthy of disease free tracts yielded *R. similis*. Thus in total 30.2% of the samples from the diseased area yielded *R. similis* against 12.3% from the healthy tracts.

The percentage occurrence of *R. similis* was 30.0 in the yellow leaf disease affected tracts against 32.0 in the healthy arecanut tracts. Again the incidence was 25.3% and 37.5% respectively in pure planting of arecanut and in intercultivated with banana. Banana as an intercrop is already known to favour the incidence of *R. similis* in arecanut (Koshy *et al.* 1976). Hence growing banana, an usual intercrop in coconut and arecanut needs to be discouraged.

It may not be desirable at this stage to correlate the results with the incidence of root (wilt) disease of coconut and yellow leaf disease of arecanut because of the failure to find the burrowing nematode always in association with the diseases. Considering the vast healthy and diseased tracts, the number of samples collected was not only inadequate but also did not represent all the soil types. Moreover, all the samples could not be collected during the peak season (October-November). However, the informations obtained from this survey do indicate the need for an extensive as well as intensive survey to correlate the nematode populations in respect of the two diseases.

The most important means by which *R. similis* gets introduced into new geographical areas is through infested planting materials. Establisment of a new infestation at Kidu from coconut seedling taken from CPCRI Kasaragod and report of *R. similis* on banana in Lakshadweep probably are examples of spread through planting materials through several shipments of banana suckers taken from Kerala and Tamil Nadu since, 1957. These above cases warrants stringent intra and interstate regulatorymeasures against the supply of infested coconut (Koshy & Sosamma, 1976b) arecanut, banana and pepper planting materials in India to minimise indiscriminate introduction specially in the absence of report of *R. similis* from states other than Kerala, Karnataka and Tamil Nadu.

In view of the loss this nematode can cause to Indian agriculture, detailed studies are warranted to map out the infested areas in relation to various economically important crops recorded as hosts such as coconut, arecanut, banana, pepper, sweet potato, groundnut, sugarcane, cardamom, turmeric and ginger.

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