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EFFECT OF *RADOPHOLUS SIMILIS* ON GROWTH, FLOWERING AND YIELD OF COCONUT

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ABSTRACT

The burrowing nematode, *Radopholus similis* is the most important nematode infecting coconut in South India. The pathogenic effects of *R. similis* on growth, flowering and yield of coconut cv. West Coast Tall was established under field conditions. Decrease in growth parameters of inoculated palms was corresponding to the increase in inoculum level and differed significantly from control. All the uninoculated palms came to flowering during 65-83 months after planting compared to 67-132 months in inoculated palms. However, the palms that received an initial inoculum of 1000 nematodes and above did not yield any nuts even after 11 years of planting. The control palms produced a total of 624 nuts compared to 186 nuts by palms that were inoculated initially with 100 nematodes. Final populations of nematodes did not differ significantly between treatments. The economic threshold level of *R. similis* on coconut (WCT) is 100 nematodes per seedling in loamy sand under the experimental conditions.

INTRODUCTION

The most important nematode problem on coconut (*Cocos nucifera* L.) in South India is the root rotting caused by the burrowing nematode, *Radopholus similis* (Cobb, 1893; Thorne, 1949). The spread occurrence of *R.similis* on coconut, arecanut, banana and black pepper has been reported (Koshy *et. al.*, 1978). The nematode population has been reported to be maximum during September to November and minimum during March to June (Koshy and Sosamma, 1978). Though the pathogenic potential of the nematode on coconut seedling in pot culture has been established (Koshy and Sosamma, 1987), the role of the nematode on growth, flowering and yield could not be established as the plants got pot bound. A detailed pathogenicity experiment was initiated in August 1982 in field simulated microplots so that the coconut seedlings are able to grow, flower and yield and exhibit the adverse effects of the nematode under natural conditions.

MATERIALS AND METHODS

Field tanks (microplots) were built in a levelled area of 1600 sq.m. This area was condoned off with barbed wire fencing with a single entrance. Tanks of 180 x 180 x 120 cm (L x B x D) were made. The bottom (240 x 240 cm) of the tank was concreted to a thickness of 10 cm. The tanks were built with two layers of bricks which were cement plastered both externally and internally (wall thickness 25 cm). Of the 120 cm depth, 30 cm was above the ground level. Individual tanks were given drainage connections with 10 cm diameter asbestos pipes. All the pipes were laid out at 30° angle for easy flow of water. These pipes opened into a 100 cm wide cement plastered channel which had a slope (150 cm depth at one end and 250 cm at the distal end). The channel at the distal (deeper) end was connected to a reinforced cement plastered well (120 cm dia) that had an outlet at 240 cm, so that the water collected in the well or in the channel will not flow back to the tanks. The tanks were separated from one another by 240 cm leaving an interplant distance of 470 cm sufficient to prevent any contact between plants. Further, to avoid contamination through soil splashes during heavy rains granite chips (5 cm) were heaped to a width of 25-30 cm and to a height of 15 cm around each tank. All the tanks were filled with sandy loam soil from a nearby paddy field. Cowdung (141584 cu.cm.) was mixed with the soil (35,64,000 cc) in each tank before fumigation with methyl bromide @ 1 kg per tank with an exposure period of 48 hours. *Mucuna bracteata and Pueraria phaseoloides* were grown as cover crops in the interspace to avoid heating up of the tanks as well as to prevent soil movement in the area. Excessive growth of the cover crop was removed periodically. The tanks were kept weed free. All the implements used were washed and dipped in 2% formalin before using them in tanks. Water supply was ensured by an extension from the main water tank of the institute and a tap each was made available amidst four experimental tanks for irrigation during summer months.

One year old uniform West Coast Tall (WCT) seedlings were selected from 200 seedlings raised in fumigated soil (June 1981) in 30 cm earthen pots in the greenhouse. Uniform seedlings of 127 cm height, 11-12 cm girth and with five leaves were planted in tanks in August 1982. At the time of planting, PVC pipes (2.5 cm. dia) of 30, 45 and 60 cm length were placed at three different depths near the root system. This helped in introducing the nematode inoculum to three depths without damaging roots.

There were six treatments with five replications each in CRD design. The treatments were T_1-uninoculated control (0), T_2- *R. similis* 100 nematodes per seedling/tank (one nematode in 35640 ccc soil), T_3-*R. similis* 1000 (one nematode in 3564 ccc soil), T_4-*R. similis* 10,000 (one nematode in 356 ccc soil), and T_5-*R. similis* 1 lakh (one nematode in 35 ccc soil) and T_6-*R. similis* 10 lakhs (one nematode in 3.5 ccc soil). Coconut isolate of *R. similis* axenically multiplied on carrot discs was used for inoculation. On establishment of seedlings, inoculations were carried out in October, 1982 by pouring the respective inoculum viz., 100 to 10 lakhs per seedling through the pipes fixed at the time of planting. Growth parameters such as girth, height and number of leaves were recorded at the time of planting and at six monthly intervals. The data were computed annually. Data on flowering such as leaf axil number in which the inflorescence was produced, number of inflorescences and nuts produced were also recorded.

Eleven years after inoculation final observations were recorded in December, 1993. Soil samples were collected 50 cm away from the base at 120° at three points. The soil from top to bottom was collected by using G.I. pipes (5 cm OD) and mixed thoroughly. Three aliquots of 250 ccc soil was drawn and analysed by Cobb's sieving and sifting method followed by the modified Baermann's funnel method. Root samples were collected from the base as well as from the roots collected from ¼ th sector of the palm in the tank. Roots were cut into small pieces mixed well and three 10 g samples were drawn for population assessment. The roots were stained in boiling acid fuchsin-lactophenol for three minutes, cleared and churned for 40 seconds in a waring blender. The total root population was computed with the average per gram population. Growth parameters were recorded. The total number of main roots and total weight of roots were calculated by counting/ weighing the main roots collected by cutting the roots from ¼ th sector of the tank. The palms were felled and stems were cut into pieces for recording the shoot weight with the help of a platform balance. As there was no clearcut differentiating line between the stem base and the bole region from where the roots emerge, this portion was weighed along with the shoot. In addition, nut characters such as weight of whole nut, dehusked nut, weight and volume of water, meat weight and shell weight were also recorded (Table V).

RESULTS AND DISCUSSION

The growth parameters recorded at six monthly intervals showed reduced growth of palms corresponding to the initial inoculum levels one year after inoculation. The progressive production of number of leaves in various treatments is shown in Table I. The seedlings that received the highest initial inoculum (T_6) had put out three leaves compared to four leaves in all the other treatments after one year. The seedlings that received 10,000 nematodes (T_4) and above had put out on an average six leaves from third year onwards compared to eight to nine leaves by seedlings that received 100 and 1000 nematodes and nine to ten leaves in uninoculated seedlings. Similar decreasing trend was seen with regard to height as well as girth at the base with increase in inoculum levels.

After eleven years, an initial inoculum level of 100, 1000, 10000, 1 lakh and 10 lakhs nematodes per seedling caused reductions of 14, 21, 32, 31 and 41 per cent in height; 10, 15, 23, 36 and 41 per cent in girth at base; 36, 47, 68, 72 and 79 per cent in shoot weight; 10, 11, 67, 62 and 82 per cent in root weight; 11, +12 (increase), 38, 61 and 67 per cent in number of main roots; 15, 15, 25, 30 and 36 per cent in total number of leaves; 2, 13, 15, 22 and 17 per cent in lamina length and 5, 11, 14, 26 and 20 per cent in lamina breadth over control respectively. The reduction in height, total number of leaves, shoot weight, girth at base, breadth of leaflets, root weight and number of main roots was highly significant compared to control (Table I) after eleven years of inoculation, whereas decrease in lamina length, number of leaflets per leaf and length of middle leaflet were not significant. Maximum reduction in growth was seen in the case of shoot weight, root weight and number of main roots ranging from 36 to 79, 10 to 82 and 11 to 67 per cent respectively. The decrease in height, girth at base and total number of leaves produced varied from 10 to 41 per cent (Table I). The data in Table I show that irrespective of the initial inoculum levels the reduction in retention of leaves was always more compared to the reduction in the number of leaves produced. The results clearly brought out that nematode infestation reduces the life span of leaves, causes early senescence and defoliation, thereby reducing the photosynthetic area of the infested palm. The effect of different levels of inoculum on lamina length, number of leaflets per leaf and length of leaflets was nonsignificant but the differences were highly significant in the case of breadth of leaflets. With increase in inoculum levels there was corresponding decrease in the breadth of leaflets which means that nematode infestation causes narrowing of leafblades in coconut.

The effect of *R. similis* was most pronounced on the root system especially with respect to weight, number and mass of feeder roots. Heavy matting of lateral roots was seen in control palms compared to very few in palms that received one or 10 lakh nematodes. The root system of all incoulated palms showed lesions, rotting and reduction in number of lateral roots of various intensities. The infestation of the nematodes caused heavy root rotting, yellowing, loss of vigour, stunting, delay in flowering and reduction in yield. The plants that received 10 lakhs, 1 lakh and 10,000 nematodes would have succumbed to drought, if they were not given irrigation during summer months.

One of the control palms put out the first inflorescence in the 31st leaf axil after 65 months of planting. All the uninoculated palms came to flowering during 65 to 83 months after planting between 31st to 49th leaf axils whereas four out of the five palms that received an initial inoculum level of 100 nematodes flowered during 67 to 130 months in the leaf axils from 39 to 56. Two palms each that received an initial inoculum level of 1000 and 10,000 nematodes came to flowering after 108 months and one out of five palms that received an initial inoculum level of 1 lakh nematodes also came to flowering after 132 months. None of the palms that received

Table I. Effect of different initial inoculum levels of *R. similis* on growth parameters of coconut

Treatment	Initial inoculum level (cm)	Height (cm)	Girth at base (cm)	Shoot weight (kg)	Total no. of leaves produced	No. of leaves retained	Av. lamina length	Av. no. of leaflets	Middle leaflet		No. of main roots	Root weight (kg)
									length	breadth		
T_1	0	958	146	514	100	20	364	233	108	6.5	4577	84.8
T_2	100	784 (14)	131 (10)	329 (36)	84 (16)	14 (28)	362 (1)	229 (2)	106 (2)	6.2 (5)	4091 (11)	76.4 (10)
T_3	1,000	761 (21)	124 (15)	273 (47)	85 (15)	16 (20)	331 (9)	211 (10)	94 (13)	5.8 (11)	4611 (+12)	75.8 (11)
T_4	10,000	649 (32)	112 (23)	165 (68)	75 (25)	11 (45)	336 (8)	207 (11)	91 (15)	5.5 (14)	2834 (38)	28.4 (67)
T_5	1,00,000	658 (31)	94 (36)	145 (72)	70 (30)	10 (50)	291 (20)	194 (17)	83 (22)	4.8 (26)	1529 (61)	15.4 (62)
T_6	10,00,000	564 (41)	87 (41)	109 (79)	63 (37)	9 (54)	289 (21)	208 (11)	89 (17)	4.6 (29)	1529 (67)	15.4 (82)
	G. Mean	729	116	256	79	13	329	213	95	5.5	3239	52.0
	CV%	16.11	18.1	45.6	13.6	36.0	15.3	12.3	14.5	13.5	43.21	47.8
	F. ratio	6.89**	5.76**	8.43**	7.12**	3.70*	2.11	1.55	2.4	4.98**	4.89**	7.33**
	CD (P=0.05)	153.0	27.4	151.9	14.1	6.34	NS	NS	NS	0.99	1823	32.47

Figures in parentheses are per cent reduction over control.

Table II. Effect of different initial inoculum levels of *R. similis* on its multiplication on coconut

Treatment	Initial inoculum level	Nematode population (in thousands)		
		Root	Soil	Total
T_1	0	0	0	0
T_2	100	26728	890	27618
T_3	1,000	33940	1300	35240
T_4	10,000	57831	1693	59525
T5	1,00,000	49575	1488	51064
T6	10,00,000	19957	1691	21647
	G. mean	31339	1177	32516
	CV (%)	109.4	81.8	105.7
	F. ratio	1.85	2.28	1.93
	CD	NS	NS	NS

10 lakhs came to flowering (Table III). The control palms produced a total of 155 inflorescences compared to 67 inflorescences in palms inoculated with 100 nematodes as initial inoculum level (Table IV). However, the palms that received an initial inoculum of 1000 nematodes and above did not yield any nut even after eleven years of planting (Table III). The control palms produced an average of 125 nuts compared to 37 nuts by palms that were inoculated initially with 100 nematodes (Table IV). This clearly brought that even one nematode in 35,640 ccc of soil or 100 nematode per seedling reduced the yield by 70 per cent under the present experimental conditions. The need for application of nematicides to infested seedlings at planting and later in July and October for proper growth has been clearly brought out in this experiment. This further supports the finding of 30 per cent increase in yield on application of nematicides to infested palms (Koshy, 1986). The burrowing nematode is known to cause considerable yield reduction in banana, citrus, black pepper, ginger etc. An increase of 17,000 lbs of fruit production/acre/ year in the *R. similis* free banana plots was recorded, compared to the nematode infested plots in Central America (Wehunt and Edward, 1968). In Surinam, 100 per cent infestation of banana reduced the yield to 30 tons/ha/year whereas plantations with three per cent infestation yielded 73 tons/ha/year (Maas, 1969). Yield increases of 30 to 60 per cent in banana have been reported following the control of *R. similis* over a range of conditions (Blake, 1972). Spreading decline of citrus caused by *R. similis* reduced yield from 50 to 80 per cent for grapefruits and from 40 to 70 per cent for oranges (Ducharme, 1954; Suit *et. al.*, 1954). Similarly, in a comparison of two citrus groves of four hectares each, one planted with healthy seedlings and the other with burrowing nematode infested seedlings, the healthy grove produced 1,322 boxes of citrus per ha and the infested grove only 62 boxes at the end of nine years (O'Bannon, 1977). Yield reduction of 60 per cent in vines inoculated with *R.similis* @ 1000 nematodes per vine over a period of three years has been reported in black pepper (Mohandas and Ramana, 1991).

The nuts produced on palms that received 100 nematodes as initial inoculum were inferior in all characters viz., weight of whole nut, husked nut, meat weight and nut water (Table V). However, the sample size used being very small, further studies are required.

The final nematode population given in Table II showed that maximum nematode population was recorded in root as well as in soil of palms that received 10,000 nematodes as initial inoculum level whereas the minimum population was recorded in palms that received the maximum initial inoculum as expected. However, there was no significant difference between treatments because of the long duration (11 years) of experiment. The average field population is 26 nematodes per 35,640 ccc of soil which falls between 1000 and 10,000 nematodes per plant. The economic threshold level of *R.similis* on coconut (West Coast Tall) is 100 nematodes per seedling in 3,564,000 ccc loamy sand under the present experimental conditions.

The results of this experiment is in agreement with the pathogenic potential of the nematode in other crops such as pepper (Venkitesan and Setty, 1977; Mustika, 1978; Mohandas and Ramana, 1991), arecanut (Koshy and Sundararaju, 1983), turmeric (Sosamma *et. al.*, 1979) and ginger (Sundararaju *et. al.*, 1979).

Though the pathogenicity experiments in pots under field condition over a period of five years have clearly established the pathogenic potential of the nematode on coconut, the role of the nematode in delaying flowering and reducing yield could not be established previously since the plants got pot bound (Koshy and Sosamma, 1987). The present pathogenicity experiment, first of its kind, on a perennial crops has clearly brought out the damage potential of the burrowing nematode on growth, flowering and yield of coconut under field conditions over a period of eleven years from planting.

Table III. Effect of different levels of *R. similis* on flowering

Treatment	Initial inoculum level	No. of palms flowered	Production of inflorescences in leaf axil	Time taken for flowering in months	Delay in initiation of flowering in months	No. of yielding palms
T_1	0	5/5	41.8 (31-49)	73.8	—	4/5
T_2	100	4/5	47 (39-36)	84.8	11	2/5
T_3	1,000	2/5	55 (42-68)	116	42	0/5
T_4	10,000	2/5	58.5 (54-63)	125	51	0/5
T_5	1,00,000	1/5	68	132	58	0/5
T_6	10,00,000	0/5	0	0	0	0/5

Table IV. Effect of different levels of *R. similis* on yield

Treatment	Control							*R. similis* - (100)						
Replication	1	2	3	4	5	Total	Average	1	2	3	4	5	Total	Average
No. of inflo-rescences produced	61	39	26	25	4	155	31	7	32	26	2	0	67	13.4
No. of nuts produced	396	137	38	53	0	624	125	0	99	87	0	0	186	37.0

Table V. Effect of *R. similis* on nut characters of coconut

Initial inoculum level	Whole nut weight (g)	Dehusked nut weight (g)	Nut weight without water (g)	Coconut water (ml)	Meat weight (g)	Shell weight (g)
Control	1370	559	430	108	246	184
R. similis (100)	1040	487	396	83	220	172

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