Pathogenicity of Hirschmanniella oryzae, H. spinicaudata, and H. imamuri on Rice[1]

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Abstract: In greenhouse experiments *Hirschmanniella oryzae, H. imamuri,* and *H. spinicaudata* depressed and delayed the tillering and flowering of rice, and suppressed root and shoot growth and grain yield. *Key Words: Oryza sativa,* rice nematodes, yield.

Rice (*Oryza sativa* L.) is a preferred host of most species of the genus *Hirschmanniella.* Breda de Haan (3) and Goodey (5) established that *H. oryzae* was injurious to rice plants. The pathogenicity of this nematode has been investigated by direct nematode inoculations on rice in pot experiments. Yield reductions of 56% and 87% have been associated with *H. oryzae* on rice in Indonesia and India, respectively (12, 17). Panda and Rao (13) also recorded up to 70% yield reduction associated with *H. mucronata* on rice. *H. oryzae* causes general unthriftiness and yellowing of rice plants (8, 17), and Lavabre (10) observed yellowing and etiolation of rice plants attacked by *H. spinicaudata.*

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Despite the sympatric occurrences of *Hirschmanniella* species in most rice-growing areas of the world, no attempt has been made to compare their relative pathogenicity on rice.

This paper reports on the damage caused by three species of *Hirschmanniella* (*H. oryzae, H. spinicaudata,* and *H. imamuri*) and their reproductive potentials in rice culture.

MATERIALS AND METHODS

The source of nematode inoculum was infected fresh rice roots from pure cultures of each species. All roots were chopped into approximately 0.5-cm pieces and mixed, and nematode populations per g of root were estimated by extracting with the maceration-filtration technique (15).

Three nematode inoculum levels (low, 100; medium, 1,000; and high, 5,000) were used in the experiment. Each inoculum was thoroughly mixed with 2 litres of steam-

sterilised clay-loam soil in plastic pots lined with polythene (polyethylene) sheets to provide a water-tight environment for flooding. A 20-day-old rice seedling, cultivar IR 8, was transplanted into each pot. Each treatment and the control (no nematodes) were replicated five times in a heated greenhouse at ambient temperatures (19.4–31.3 C). Fertiliser (N.P.K:1-1-1) applications were made 2 weeks after transplanting and at flowering according to Inter-National Rice Research Institute recommendations (1). Pots were flooded with water at the onset of tillering and maintained this way throughout the remainder of the experiments.

Tiller counts were taken at 30, 60, 90, and 120 days after transplanting. Time of flowering and above-ground symptoms of damage were recorded. At termination of the experiment, 120 days after transplanting, grain yield, fresh root weight, and dry top weight were recorded. Root lesion scoring was: 0 = no lesions, 1 = few scattered lesions, 2 = up to 50% of root system necrosed, 3 = severe necrosis of about 75% of the root system, and 4 = complete necrosis of the root system accompanied by root-rot symptoms. Nematode populations per pot were estimated for 200 cm^3 of soil and 10 g of fresh root, respectively extracted by the flotation, sedimentation, and sieving techniques and the maceration-filtration technique (15). Numbers of empty seeds per 100 grains were noted, and the dry weight of tops was recorded after drying at 60 C to constant weight.

RESULTS

With all three species, general chlorosis was observed sixty days after transplanting of plants inoculated with 1,000 and 5,000 nematodes. No marked differences in number of tillers were apparent at 30 days. At 60, 90, and 120 days after transplanting, however, tillering was depressed by 1,000- and 5,000-nematode inoculum levels of all species (Fig. 1). The high inoculum levels with all species produced peak tiller counts 90 days after transplanting, compared with 60 days with lower inoculum levels.

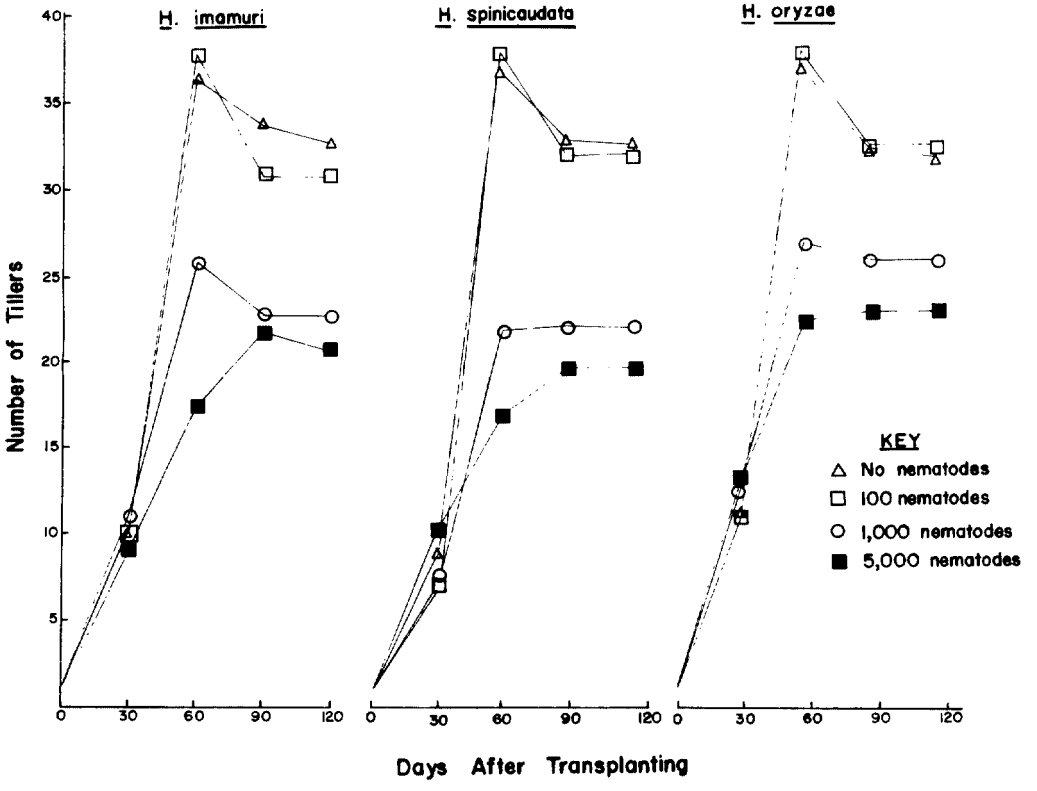

FIG. 1. Influence of *Hirschmanniella imamuri, H. spinicaudata* and *H. oryzae* on tillering of rice.

Flowering was later with medium and high inoculum levels of all three species than in the control. Delays ranged from 3.2 days, in plants with medium inoculum levels of *H. imamuri*, to 9 days, in plants with high levels of *H. imamuri* and *H. spinicaudata* (Table 1).

All three species at medium and high inoculum levels significantly reduced the fresh weight of roots, dry weight of shoots, and grain yield by 31 to 37% (Table 2). At 1,000- and 5,000-nematode inoculum levels, the number of empty grains in panicles was significantly higher for *H. spinicaudata*-inoculated plants than for *H. imamuri* and *H. oryzae* (Table 2). Root-lesion scores for all species were also higher at medium and high inoculum levels than at the low levels or in the controls.

Final populations of nematodes/200 cm^3 of soil were higher in pots inoculated with 1,000 and 5,000 nematodes than pots inoculated with 100 nematodes of all three species (Table 2), and root populations of nematodes showed similar trends. When the experiment was terminated there were negative correlations between final nematode populations and dry weight of shoots, fresh weight of roots, and grain yield (Table 2).

DISCUSSION

The observation of chlorotic symptoms on plants two months after transplanting differs from that of Mathur and Prasad (12), who observed symptoms only 4 weeks after transplanting rice seedlings inoculated with *H. oryzae*. Since the same rice variety was used in both studies, the differences in methods of inoculation may account for this. Chopped infected rice roots were used in this study, whereas Mathur and Prasad used *H. oryzae*-infested soil. Our results, however, agree with those of Vecht and Bergman (17), who found that general yellowing and reduced tillering of cv Gendjah infested by *H. oryzae* occurred 60 days after transplanting even though distinct differences in plant height occurred 30 days after transplanting.

The significant increase in root lesions at medium and high inoculum levels confirmed the important role played by all three species in rice root damage and deterioration (2).

The delay in flowering of plants inoculated with 5,000 nematodes of all the three species agrees with flowering delays of 12–14 days in *H. oryzae*-infected rice plants in India (12) and 1–3 days in Senegal (4).

The suppression and delay in tillering associated with medium and high nematode inoculum levels of all three species is similar to that found previously on *H. oryzae*- and *H. mucronata*-infected rice plants (13, 17).

Plant growth was considerably reduced in plants with medium and high inoculum levels of all three species. Similar results have been obtained with *H. oryzae* (4, 12, 17) and *H. mucronata* (13) on rice cv IR 8.

All three species of *Hirschmanniella* used in this study seem capable of significantly depressing plant growth and yield of rice at populations of 1,000 nematodes per plant (500 nematodes/liter of soil). Such populations are not unusual in rice fields; numbers of 3,140 *H. oryzae* in 250 g soil and 1,152 in 5 g of root have been reported for South India (11), and 900 *H. oryzae* per g of root in Central Java (17). Mathur and Prasad (12) observed that even 100 *H. oryzae* significantly depressed plant growth, although that was not the case in the present study.

The three species appear to have similar pathogenic potentials, although *H. spinicaudata* induced higher percentages of empty grains at medium and high inoculum levels than did *H. imamuri* or *H. oryzae*. Significantly fewer *H. spinicaudata* were endoparasitic at all inoculum levels than the other two species, and the final populations and the corresponding multiplication

TABLE 1. Time (days) required for flowering of 50% of I.R. 8 rice tillers after inoculation with three *Hirschmanniella* species.

Number of nematodes	*H. imamuri*	*H. spinicaudata*	*H. oryzae*
0	92±2.0	92 ± 2.0	92 ± 2.0
100 nematodes	92.4 ± 1.52	93.8 ± 1.30	93.0 ± 0.71
1,000 nematodes	95.2 ± 1.92	95.4 ± 1.67	96.2 ± 2.68
5,000 nematodes	101.0 ± 4.3	101.0 ± 3.4	99.8 ± 3.97

LSD, 5% 2.24 days
0.1% 3.67 days

TABLE 2. *Hirschmanniella* populations, growth of I.R. 8 rice, and root-lesion formation 120 days after inoculation with three *Hirschmanniella* species.

Hirschmanniella species	Inoculum level	Grain Yield			Roots			Shoots		Final nematode populations per pot
		Dry wt. (g)	% empty grains	Coeff. corr. for wt. vs. final nema. population	Fresh wt. (g)	Root lesion scores	Coeff. corr. for wt. vs. final nema. population	Dry wt. (g)	Coeff. corr. for wt. vs. final nema. population	
H. imamuri	100	98.2	4.8		160.7	1.0		60.1		949
	1,000	65.1	16.4	−0.96	96.4	2.8	−0.94	42.4	−0.98	6032
	5,000	64.8	16.8		57.1	3.6		37.7		6219
H. spinicaudata	100	97.7	5.2		155.0	1.2		59.5		756
	1,000	65.1	21.2	−1.00	85.7	3.6	−0.97	43.9	−0.98	4948
	5,000	61.9	24.2		56.1	4.0		41.6		4810
H. oryzae	100	98.8	4.8		156.3	1.2		60.0		992
	1,000	68.0	16.0	−1.00	83.7	2.8	−0.97	37.7	−0.99	6455
	5,000	64.5	17.0		59.0	3.4		30.4		6346
No nematodes		99.0	4.8		162.0	0.8		61.5		0
L.S.D. 5%		6.5	1.9		22.6	0.4		5.1		455
0.1%		10.9	3.1		37.0	0.6		8.3		746

rates at harvest were also significantly lower. The lower multiplication rates observed at higher inoculum levels in all three species probably resulted from competition within the populations. *H. oryzae* had the highest values in the three parameters, followed by *H. imamuri*. Kuwahara and Iyatomi (9) observed only one generation a year of *H. imamuri*, but two of *H. oryzae*. This advantage in population increase of *H. oryzae* over the other species could account for its biological success as the predominant species in all observed cases of sympatric occurrences of *Hirschmanniella* species (6).

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