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PATHOGENICITY OF *MELOIDOGYNE JAVANICA* ON ASIAN AND AFRICAN RICE

by

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Summary. Pot experiments were designed to investigate the relationship between initial population densities (*Pi*) of *Meloidogyne javanica* (0, 0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 or 1024 eggs and juveniles/cm^3 soil) and growth of the susceptible Asian rice (*Oryza sativa*) cv Manifugabo III and the resistant African rice (*Oryza glaberrima*) cv Hakurt Monton in a glasshouse at 25±3 °C. Height and fresh top weight of each plant were measured 50 days after sowing. The data fitted the Seinhorst model, $y = m + (1-m) z^{P-T}$, which indicates tolerance limits of rice to *M. javanica* of 1 and 8 for height of plants and 0.26 and 2.68 eggs and juveniles/cm^3 soil for fresh top weight of plants of cv Manifugabo III and cv Hakurt Monton, respectively. Minimum relative fresh top weight and height of cv Manifugabo III was 0 and occurred at $Pi \geq 16$ and 64 eggs and juveniles/cm^3 soil, respectively; minimum relative fresh top weight and height of cv Hakurt Monton were 0 and 0.2 and occurred at $Pi \geq 256$ and 512 eggs and juveniles/cm^3 soil, respectively. The maximum reproduction rates of the nematode were 16.2 on cv Manifugabo III and 1.02 on cv Hakurt Monton. Two months after nematode inoculation, infection sites of the resistant cv Hakurt Monton exhibited necrotic tissue and undersized or no giant cell formation with consequent suppression of nematode development. In roots of the susceptible cv Manifugabo III giant cells were large and well developed, allowing feeding and regular nematode development.

Meloidogyne javanica (Treub) Chitw. occurs in various tropical countries where it causes damage to rice (Lamberti *et al.*, 1987; Bridge *et al.*, 1990).

Screening for resistance has shown that cvs of the African rice, *Oriza glaberrima* Steud, are resistant to *M. incognita* (Kofoid *et* White) Chitw. (Diomandé, 1984).

This article reports the results of a pathogenicity test of *M. javanica* carried out in pots in glasshouse on the Asian rice, *Oriza sativa* L. cv Manifugabo III and the African rice, *O. glaberrima* cv Hakurt Monton.

Materials and methods

An Italian population of *M. javanica* host race 1 (Di Vito and Cianciotta, 1991) was reared on tomato (*Lycopersicon esculentum* Mill.) cv Rutgers. Tomato roots infested by the nematode were gently washed, finely chopped, and thoroughly mixed. Ten root samples of 10 g each were processed with 1% aqueous solution of sodium hypochlorite (Hussey and Barker, 1973) to estimate the number of eggs and juveniles of the nematode. The tomato roots were then thoroughly mixed with 5 kg of steam sterilized sandy soil and used as inoculum. Appropriate amounts of this inoculum were thoroughly mixed with a steam sterilized sandy soil in each pot (750 cm^3 volume) to give population densities of 0, 0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 or 1024 eggs and juveniles of *M. javanica*/cm^3 soil. Two pregerminated seeds of the Asian rice cv Manifugabo III or the African rice cv Hakurt Monton were sown in each pot on 4 May 1993 and thinned to one plant per pot a week later. The pots were arranged on benches in a glasshouse at 25±3 °C in a rando-

mized block design, with six replications for each rice cultivar and for each inoculum level.

Plants were harvested two months after sowing and height and fresh top weight measured. Final population densities (*Pf*) of the nematode in the soil of each pot were evaluated by processing 500 cm^3 soil by the modified Coolen's method (Coolen, 1979; Di Vito *et al.*, 1985). The numbers of eggs and juveniles in the egg masses on the roots were evaluated by processing each root of rice in 1% aqueous sodium hypochlorite solution (Hussey and Barker, 1973). The total final population densities (*Pf*) of each pot was the number of eggs and juveniles in the soil plus that on the roots.

For histological studies infected roots (0.5 cm long) were fixed in FAA (Formaldehyde-Acetic acid-Alcohol) solution, dehydrated in a Ter-butyl alcohol series (from 50 to 100%) and embedded in histowax with 55-58 °C melting point. They were then sectioned at 10 μm thickness with a rotary microtome and stained with safranin and fast green (Johansen, 1940). Selected root sections were observed and microphotographed.

Results and discussion

The Italian population of *M. javanica* host race 1 adversely affected the growth of Asian rice. Symptoms (yellowish and stunting) of the nematode attack were clearly evident 15 days after sowing in pots infested with ≥ 32 eggs and juveniles/cm^3 soil. Ten days later, all plants in pots infested with more than 256 eggs and juveniles/cm^3 soil were dead. Nematode infestation also affected the growth of African rice, but symptoms of the attacks occurred only at initial population densities of 128 eggs and juvenile/cm^3 soil and over and none of the plants died at any inoculum level.

Data on fresh top weight and height of the plants were consistent with the model $y=m + (1-m) z^{P-T}$ (Seinhorst, 1965; 1979), where y is the ratio between the yield (fresh top weight and height of plants) at *Pi* and that at $P \leq T$, *m* the minimum relative yield (*y* at very high *Pi*), *z* a constant < 1 with $z^{-T} = 1.05$, T tolerance limit (*Pi* at which no yield is lost), and *P* initial population density. Fitting the data to this model (Fig. 1), tolerance limits were obtained of 0.26 and 2.68 for fresh top weight and 1 and 8 for height of the plants of the susceptible rice cv Manifugabo III and the resistant cv Hakurt Monton, respectively.

Minimum relative fresh top weight and height of cv Manifugabo III was 0 and occurred at $Pi \geq 16$ and 64 eggs and juveniles/cm^3 soil, respectively; minimum relative fresh top weight and height of cv Hakurt Monton were 0 and 0.2 and occurred at $Pi \geq 256$ and 512 eggs and juveniles/cm^3 soil, respectively (Fig. 1).

The highest final population density (*Pf*) of *M. javanica* was obtained at *Pi* = 2 on cv Manifugabo III and decreased with increasing *Pi*, and lowest at all initial population densities (*Pi*) on cv Hakurt Monton (Table I). The maximum nematode reproduction was 16.2 on cv Manifugabo III and occurred at *Pi* = 2 eggs and juveniles/cm^3 soil; on cv Hakurt Monton reproduction was negligible and most *Pf/Pi* were ≤ 1 (Table I).

The histological response of the susceptible cv Manifugabo III and the resistant cv Hakurt Monton is illustrated in Fig. 2. The infective stages of *M. javanica* had penetrated the roots of both, susceptible and resistant cultivars, but a different host reaction occurred after their penetration. Two months after inoculation the nematode had induced the formation of very large giant cells (with granulated cytoplasm, hypertrophied nuclei and nucleoli) in the roots of the susceptible cv Manifugabo III of *O. sativa* while its vascular system was highly altered by giant cell expansion (Fig. 2 c, d). In contrast, the infection sites of the resistant cv Hakurt Monton of *O. glaberrima* often exhibited varying aspects of necrotic reaction of the tissues (Fig. 2 e, f). This hypersensitive host reaction occurred usually adjacent to the feeding sites of nematodes. In the resistant cultivar giant cells were poorly de-
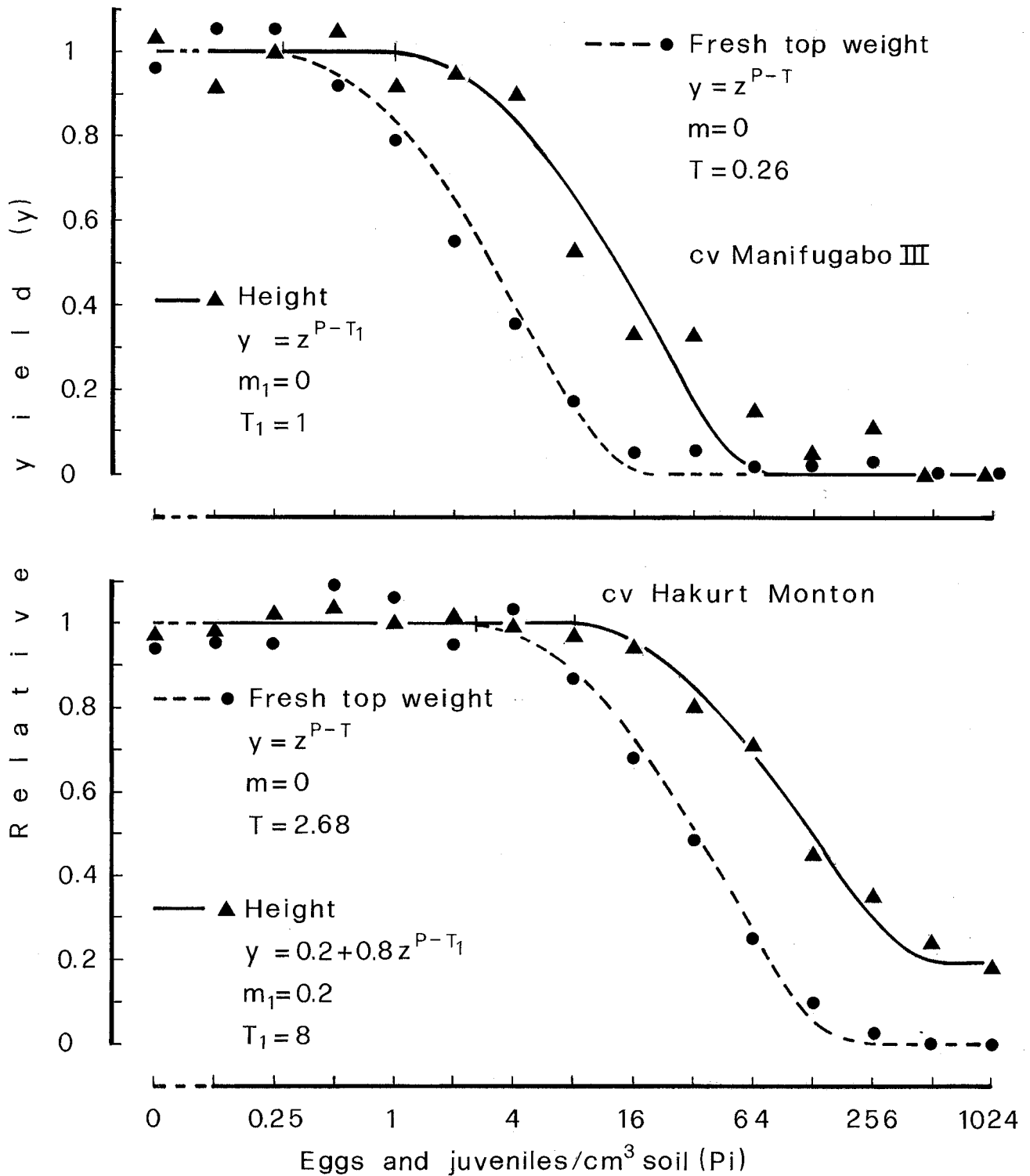
Fig. 1 - Relationship between initial population densities (*Pi*) of *Meloidogyne javanica* at sowing and fresh top weight and height of the susceptible Asian rice (*Oryza sativa*) cv Manifugabo III and the resistant African rice (*O. glaberrima*) cv Hakurt Monton.
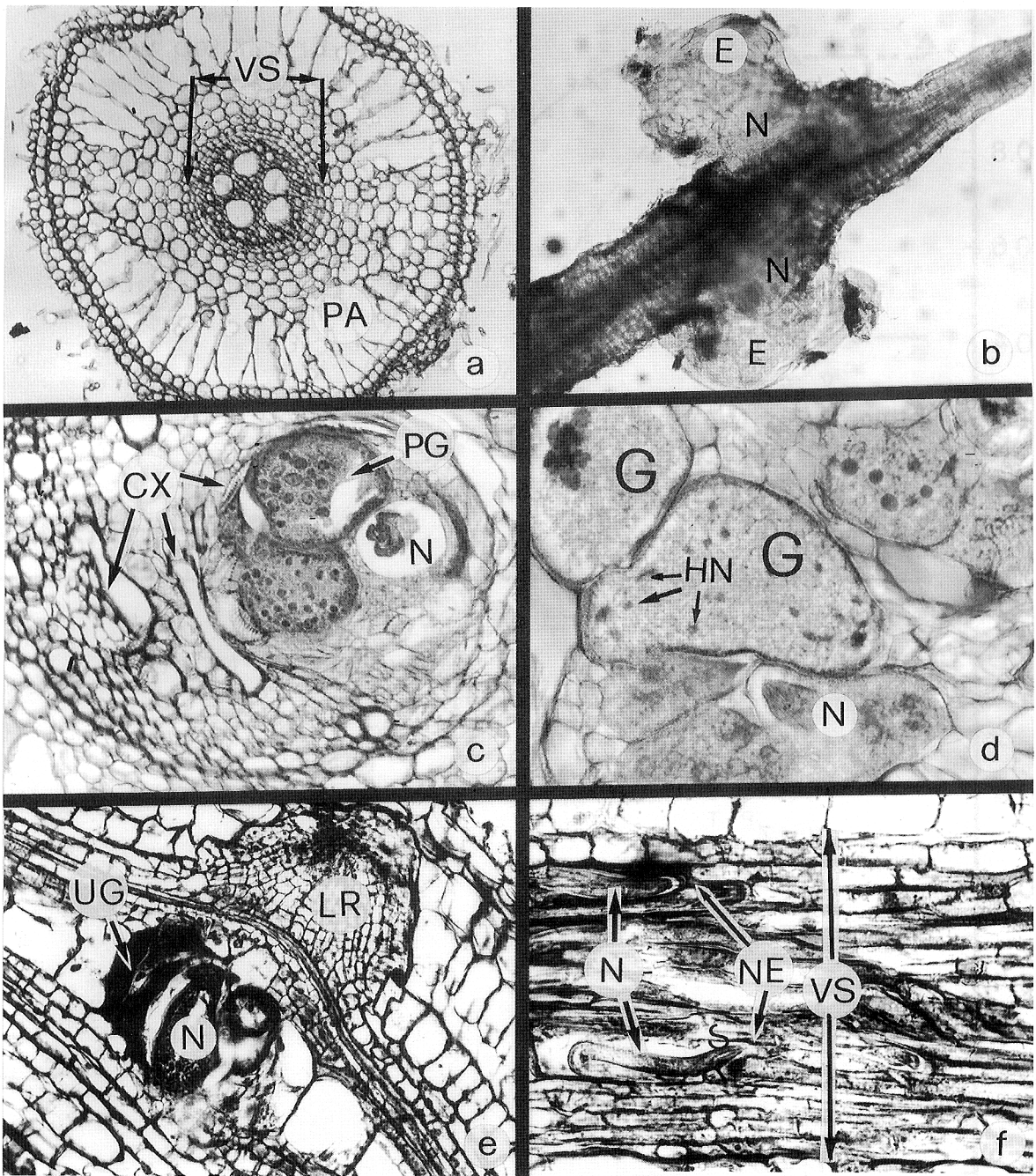
Fig. 2 - Differential histological response of the susceptible cv Manifugabo III (a-d) and the resistant cv Hakurt Monton (e, f) to *M. javanica* infections: a, transverse section of uninfected rice root, for comparison showing healthy vascular system (VS) and parenchymatic cells (PA); b, root gall with protruding large egg masses (E) induced by two nematode females (N); c, d, cross sections of roots with galls showing nematode females (N) feeding on well developed large multinucleate (PG) giant cells (G) with hypertrophied nuclei (HN); note the abnormal and compressed xylem elements (CX) during giant cell expansion; e, disorganized root vascular tissue containing a *M. javanica* young female which failed to form functional feeding cells; note the undersized giant cells near the lateral root induced by the nematode (N); f, hypersensitive reaction into the root vascular system (VS); note the larval stage of nematodes (N) which failed to form functional cells to provide food for their development and reproduction.

TABLE I - *Effect of initial population densities (Pi) of* Meloidogyne javanica *at sowing on final population densities (Pf) and reproduction rates (Pf/Pi), in pots sown with the susceptible Asian rice* (Oryza sativa) *cv Manifugabo III and the resistant African rice* (Oryza glaberrima) *cv Hakurt Monton.*

Initial population densities (Pi)	Eggs and juveniles/cm³ soil		Reproduction rates (Pf/Pi)	
	Final population densities (Pf)		cv Manifugabo III	cv H. Monton
	cv Manifugabo III	cv H. Monton		
0.125	0.24	0.06	1.90	0.48
0.25	0.9	0.4	3.6	1.60
0.5	1.2	0.08	2.4	0.16
1	14.2	1.02	14.20	1.02
2	25.3	0.8	16.20	0.40
4	20.5	3.4	5.1	0.80
8	14.1	4.9	1.8	0.60
16	10.0	6.0	0.62	0.37
32	4.3	4.1	0.13	0.12
64	5	3.2	0.08	0.05
128	3	1.1	0.02	0.008
256	2.1	1.7	0.008	0.007
512	2.5	1.2	0.005	0.002
1024	2.8	2.4	0.003	0.002

veloped with undersized cell unites while nematode development was very poor or absent.

The results obtained in this experiment demonstrate the very high pathogenicity of *M. javanica* on rice and that severe crop losses must be expected in upland cultivations in infested fields. Damage by this root-knot nematode can be reduced by planting resistant cultivars of the African rice *O. glaberrima*. They would produce satisfactory yields and at the same time suppress nematode populations.

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