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Influence of water management on tolerance of rice cultivars for *Meloidogyne graminicola* (1)

Irma C. TANDINGAN*, Jean-Claude PROT** and Romulo G. DAVIDE***

Division of Entomology and Plant Pathology, International Rice Research Institute, P.O. Box 933, 1099 Manila, Philippines.

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Summary – Among fifteen rice cultivars tested for their susceptibility to *Meloidogyne graminicola* under flooded conditions, IR72 was the most resistant, IR29 was the most susceptible, and others cultivars such as IR36 and IR74 showed an intermediate response. The multiplication of *M. graminicola* on IR29, IR36, IR72 and IR74 and its effect on their yield were tested under simulated rainfed upland and flooded conditions. Greater number of juveniles were recorded from the roots when these cultivars were grown in flooded soil than under rainfed conditions. Yield reductions by more than 20 % were observed under rainfed conditions with IR29 and IR74. The same cultivars were tolerant and their yield was not affected when they were grown in flooded soil. IR36 and IR72 were tolerant under both water management systems. These results suggest that the tolerance level of rice cultivars to *M. graminicola* vary with the water management system under which they are tested.

Résumé – ***Influence du régime hydrique sur la tolérance de cultivars de riz à* Meloidogyne graminicola** – Parmi quinze cultivars de riz testés pour leur sensibilité à *Meloidogyne graminicola* en sol inondé IR72 était le plus résistant alors que IR29 était le plus sensible et IR36 et IR74 avaient une sensibilité intermédiaire. La multiplication de *M. graminicola* sur IR29, IR36, IR72 et IR74 et son effet sur leurs rendements en grains ont été testés lorsque ces cultivars étaient cultivés dans des conditions simulant celles du riz pluvial et en sol inondé. Lorsque ces cultivars étaient cultivés en sol inondé, les nombres de juvéniles de deuxième stade extraits des racines étaient supérieurs à ceux obtenus en conditions pluviales. Des réductions de rendement de plus de 20 % étaient observées avec IR29 et IR74 lorsqu'ils étaient cultivés en conditions pluviales. Les mêmes cultivars étaient tolérants et leurs rendements n'étaient pas réduits par le nématode lorsqu'ils étaient cultivés en sol inondé. Quel que soit le régime hydrique, IR36 et IR72 étaient tolérants et leurs rendements en grain n'étaient pas réduits. La tolérance des cultivars de riz à *M. graminicola* varie d'un cultivar à l'autre et pour un même cultivar elle paraît être influencée par le régime hydrique.

Key-words : Flooding, *Meloidogyne graminicola,* resistance, rice, tolerance, water management.

The rice root-knot nematode, *Meloidogyne graminicola* Golden & Birchfield, 1968, is widely distributed in Asia where it occurs in upland (Manser, 1968), rainfed lowland (Jairajpuri & Baqri, 1991), deepwater (Page *et al.*, 1979; Cuc & Prot, 1992), and irrigated rice (Prot *et al.*, 1994). It has been associated with yield loss under upland, rainfed lowland, and deepwater conditions (Rao *et al.,* 1986; Bridge *et al.,* 1990; Jairajpuri & Baqri, 1991).

Because of the small size of rice farms, the environmental hazards associated with chemical control, and low monetary value of rice, growing of resistant/tolerant cultivars is certainly the most practical method to reduce root-knot damage in tropical rice fields. A number of rice cultivars have been reported resistant to *M. graminicola* (Roy, 1973; Jena & Rao, 1976; Prasad *et al.,* 1979, 1986; Yik & Birchfield, 1979). However, there are discrepancies between results. Rice cv. Ratna, rated resistant by Jena and Rao (1976) and Prasad *et al.*(1979), was later considered susceptible (Prasad *et al.,* 1986). Cultivar TKM6, that showed a resistant reaction in a field experiment (Jena & Rao, 1976), was rated susceptible by Manser (1971) and Swain *et al.* (1986). Cultivar IR36 was reported resistant (Swain *et al.* 1986; Swain & Prasad, 1989) and was used to estimate the yield loss caused by *M. graminicola* under upland conditions (Plowright & Bridge, 1990). Variability among accessions of the same variety, differences in virulence among nematode isolates, and varying inoculum levels used during the different tests may be responsible for these

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* IRRI research scholar, ** ORSTOM nematologist, IRRI visiting scientist, and *** professor, Department of Plant Pathology, University of the Philippines Los Baños.

discrepancies. However, experimental conditions may have also affected the reactions of the different varieties tested.

Water management is one of the abiotic factors that can influence the development of *M. graminicola* and the response of a rice variety to this nematode. Continuous flooding has been reported as highly effective in controlling *M. graminicola* (Kinh *et al.*, 1982) and preventing root invasion by the nematode (Bridge & Page, 1982). Two glasshouse experiments were conducted to test the host status of different rice cultivars for *M. graminicola* and study the influence of water management on their susceptibility.

Materials and methods

Both experiments were conducted using autoclaved (120 °C for 30 min) clay loam soil containing 44 % clay, 37 % silt, 19 % sand, and 0.12 % N. In all experiments, ammonium sulfate was applied at the rate of 100 kg/ha in three splits at planting, and at 46 and 67 days after planting.

The *M. graminicola* population used in both experiments was originally collected from irrigated rice in batangas, Philippines and cultured on IR58 under upland conditions. Second-stage juveniles (J2) were obtained by placing infected roots in a mistifier (Seinhorst, 1950). Only J2 collected during 24 h periods were used as inoculum.

Screening test

Three-day-old pregerminated seeds of IR20, IR29, IR32, IR36, IR42, IR54, IR72, IR74, Farma, Gabura, Hamsa, Ratna, TKM6, TKM7, and TNAU(AD) 103 were planted (one per pot) in 30-cm-diameter clay pots containing 3 kg of soil. Seven days after planting, one-day-old J2 of *M. graminicola* were introduced into the soil around the seedlings. two levels of nematode inocula (*Pi*) were used : 100 and 1000 J2 per plant. Treatments were replicated five times and arranged in split-pot design with cultivars as main plot and *Pi* level as subplots. Two days after inoculation of the nematodes, pots were flooded up to 5 cm above the soil surface and were kept flooded until the varieties matured. At maturity, roots were chopped into pieces of 1-2 cm long and J2 were extracted from 3 g subsamples of roots by placing them in a mistifier for 4 days (Seinhorst, 1950). Data were analyzed using ANOVA and DMRT.

Reaction of four rice cultivars to *M. graminicola* under two methods of water management

The reaction of IR29, IR36, and IR74 to *M. graminicola* was tested under two methods of water management : simulating rainfed upland and irrigated conditions. Three-day-old pregerminated seeds were planted (one per pot) in 20-cm-diam × 35-cm-high polyvinyl pots containing 8.5 kg of dry soil which was then saturated until a thin layer of water covered the soil. Half of the pots were inoculated by introducing 8500 fresh J2 of *M. graminicola* into the soil around the seedlings in a split inoculum applied first at 10 days after planting (DAP) and then at 12, 14, 16, 18, 20, and 22 DAP. Half of the pots were not inoculated. The soil was kept saturated in all pots by daily watering throughout the inoculation process. Upon completion of the inoculation process, the soil was flooded under 5 cm of water in half of the pots to simulate irrigated conditions.Thereafter, water was added biweekly to restore the original water status (saturation and 5 cm of standing water). Treatment combinations were arranged in split-split-pot design with seven replications. Presence/absence of nematodes was considered as main plot, water management as subplot, and cultivar as sub-subplot. At maturity, grain weight and number of juveniles of *M. graminicola* per g of root were recorded. J2 were extracted from the roots using the same procedure as that for varietal testing. Data were analyzed using ANOVA.

Results

Screening test

At both *Pi* levels, IR20 and IR29 produced the highest number of J2 of *M. graminicola* per 3 g of roots while IR72 and Gabura produced the lowest number (Table 1). With *Pi* = 100, significantly lower numbers of J2 of *M. graminicola* were recovered from IR32, IR36, IR42, IR54, IR72, IR74, Gabura, Hamsa, Ratna, TKM6, TKM7, and TNAU(AD) 103 than from IR20 and IR29. However, when *Pi* = 1000, only IR42, IR72, and Gabura produced significantly less J2 per 3 g of roots than the two most susceptibles cultivars.

Reaction of four rice cultivars to *M. graminicola* under two methods of water management

A significant higher number of juveniles were recovered per g of roots of IR29 and IR36 when these cultivars were grown in flooded soil than in nonflooded soil (Table 2). The same trend was observed with IR72 and IR74, but differences were not significant. The presence of *M. graminicola,* water management cultivars, and the interaction between these three variables influenced the grain yield. However, only the yield of IR29 and IR74 was significantly ($P \leq 0.05$) reduced, (by 23 and 28 %, respectively), by *M. graminicola* when these two cultivars were grown under upland conditions (Table 3). When IR29 and IR74 were grown in flooded soil, their yield was not significantly affected by the nematode. In this experiment, yields of IR36 and IR72 were not significantly affected by the nematode. Yields of IR72 and IR74 were significantly higher in flooded soil than in saturated soil while yields of IR29 and IR36 were not influenced by water management.

Table 1. *Average number* of J2 of* Meloidogyne graminicola *recovered at maturity from 3 g of roots of fifteen rice cultivars originally inoculated with 100 and 1000 nematodes.*

Cultivar	Number of J2 inoculated per plant	
	100	1000
IR 29	16 583 *ab***	22 229 *a*
IR 20	8 861 *a*	12 229 *ab*
Ratna	3 880 *c-e*	6 918 *a-d*
Farma	3 766 *b-d*	8 787 *a-c*
IR 32	3 501 *c-e*	4 618 *b-d*
TKm6	3 071 *c-e*	4 709 *b-d*
TNAU (AD) 103	2 692 *a-c*	5 311 *b-d*
IR 54	2 497 *c-e*	8 117 *a-c*
TKm7	2 396 *c-e*	8 029 *a-d*
IR 36	1 912 *c-e*	6 816 *a-d*
Hamsa	1 394 *de*	4 470 *b-d*
IR 74	1 379 *c-e*	3 414 *b-d*
IR 42	927 *c-e*	2 308 *c-e*
Gabura	563 *ef*	1 932 *de*
IR 72	417 *f*	842 *e*

* Average of seven replications. ** In a column, numbers followed by the same letter are not significantly different at the 5 % level by DMRT.

Table 2. *Effect of water management on number* of second-stage juveniles of* Meloidogyne graminicola *recovered at maturity from 1 g of root of four rice cultivars inoculated with 8500 juveniles at transplanting.*

Cultivar	Water management	
	Rainfed upland conditions	Flooded soil
IR 29	1 075 *a***	6 044 *b*
IR 36	400 *a*	5 262 *b*
IR 72	762 *a*	2 627 *a*
IR 74	1 237 *a*	3 693 *a*

* Average of seven replications. ** In a row, numbers followed by the same letter are not significantly different at the 5 % level by ANOVA.

Discussion

None of the fifteen cultivars tested were totally resistant to *M. graminicola.* However, differences in level of susceptibility were observed with IR72, IR42, Gabura being the least susceptible. Degree of susceptibility also appears to be dependent on the inoculum level. Susceptibility seems to increase with increasing levels of inoculum. Our results support earlier reports (Prasad *et al.,* 1986; Swain *et al.,* 1986) showing that Ratna, and TKM6 are susceptible to *M. graminicola.* However, Hamsa was also found susceptible although it was reported as resistant by Jena and Rao (1976).

The tolerance level of rice cultivars, in terms of yield according to Trudgill's (1986) definition, seems to depend on the water management under which they are tested and are independent of their host status. It is possible that high-yielding cultivars IR29 and IR74 (which have been selected for the permanently flooded irrigated rice agroecosystem), lose their tolerance for *M. graminicola* when grown in a less favorable environment. The poor adaptability of IR36 to upland conditions and well-drained soils may be partly responsible for its very high susceptibility to *M. graminicola* as reported by Plowright and Bridge (1990). These results support the hypothesis made by Wallace (1987) that tolerance is influenced by environmental factors.

The results obtained from these experiments suggest that testing rice cultivars for identification of sources of resistance to *M. graminicola* must be performed under maximum effects of parasite and under environmental conditions that are favorable to the expression of the damage it causes. On the other hand, tests for tolerance must be conducted under environmental conditions similar to those existing in the agroecosystem in which the cultivars are intended to be grown.

Table 3. *Effect of* Meloidogyne graminicola *on grain yield* (g) of four rice cultivars grown under two water managements.*

Cultivar	No. of J2 of *M. graminicola*	
	0	8500
	Rainfed upland conditions	
IR 29	19.9 *a***	15.3 *b*
IR 36	22.4 *a*	19.8 *a*
IR 72	26.5 *a*	25.0 *a*
IR 74	25.0 *a*	17.9 *b*
	Flooded soil	
IR 29	20.1 *a*	19.1 *a*
IR 36	25.0 *a*	21.7 *a*
IR 72	32.9 *a*	33.3 *a*
IR 74	32.6 *a*	32.1 *a*

* Average of seven replications. ** In a row, numbers followed by the same letter are not significantly different at the 5 % level by ANOVA.

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