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EFFECT OF *MELOIDOGYNE GRAMINICOLA* ON ROOT GROWTH OF GRAMINACEOUS PLANTS

by
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Summary. The rice root-knot nematode, *Meloidogyne graminicola*, significantly suppressed root growth of the graminaceous plants, rice, wheat, sorghum and a grass, *Echinochloa colonum*. The amount of damage varied with the plant species, the main roots of rice and *E. colonum* were inhibited by the nematode and laterals grew in clusters on or around the galls. The largest number of galls and nematodes occurred on sorghum roots.

Root-knot nematodes (*Meloidogyne* spp.) may impair plant growth by inhibiting new root development, suppressing the rate of root extension and causing degeneration of existing roots (Hussey, 1985; Shane and Barker, 1986). The root growth of four graminaceous hosts, *Oryza sativa* L. (rice), *Triticum aestivum* L. (wheat), *Sorghum bicolor* (L.) Moench (sorghum) and a grass *Echinochloa colonum* L., in relation to invasion by the rice root-knot nematode *M. graminicola* Golden *et* Birchfield was investigated under controlled conditions.

Materials and methods

Seeds of rice, wheat, sorghum and *E. colonum* were germinated for seven days on moist paper in petri dishes. Seedlings with similar root size were transplanted individually into 9 cm plastic pots containing sterile soil (loam + sand 2:1). The pots were randomized in a growth cabinet at 27 °C with 15h artificial daylight. Eight days after transplanting, some of the pots were inoculated with 2,000 second-stage *M. graminicola* juveniles per pot, replicated five times.

After 20 days, all the plants were removed from the pots, roots were washed and root growth measured. The root measurements were done by the "line intersect" method (Newman, 1966, modified by Tennant, 1975), using the grid system devised by Marsh (1971). Roots were spread out under water in a perspex tray with 1.27 cm^2 (0.5 inch) grid markings on it (Spaull, 1981), which gives direct length in centimeters according to the formula: Root length = 11/14 x number of Intercepts x Grid unit. The length of each axis was directly measured on graph paper attached to the tray and the roots were displayed. The number of laterals and the number of intercepts for total root length were counted directly from displayed roots (a magnifying glass was used if necessary) and the length of the laterals was calculated by subtracting axis length from total root length.

After measuring the roots, a representative root system from each treatment was selected to photograph to illustrate the growth patterns of each plant. Roots were dyed black by soaking in "Chlorazole Black E" in 70% alcohol for 12 hours (Soomro, 1987). They were rinsed in water and spread out on a clear perspex sheet on black paper and displayed carefully with dissecting needles. Excess water was blotted dry with paper tissue and sheets of white paper were placed on top of the root. The perspex sheet (with root + papers) was copied on a photocopier, producing a record of the actual root system for illustration (Schuurman and Goedewaagen, 1971; Rawsthorne, 1982).

For quantitative estimation of nematodes, roots were fixed in F. A. (4:1), stained in acid fuchsin in lactoglycerol and cleared for 24 h in 50:50 solution of glycerol and water (Bridge *et al.*, 1982). Cleared roots were cut into 0.5-1 cm pieces, placed in a glass vial with a small amount of water and comminuted in a "Silverson Laboratory Homogeniser" at maximum speed for 30 seconds. The suspension was made up to a suitable volume and nematodes were counted in three 5 ml aliquots.

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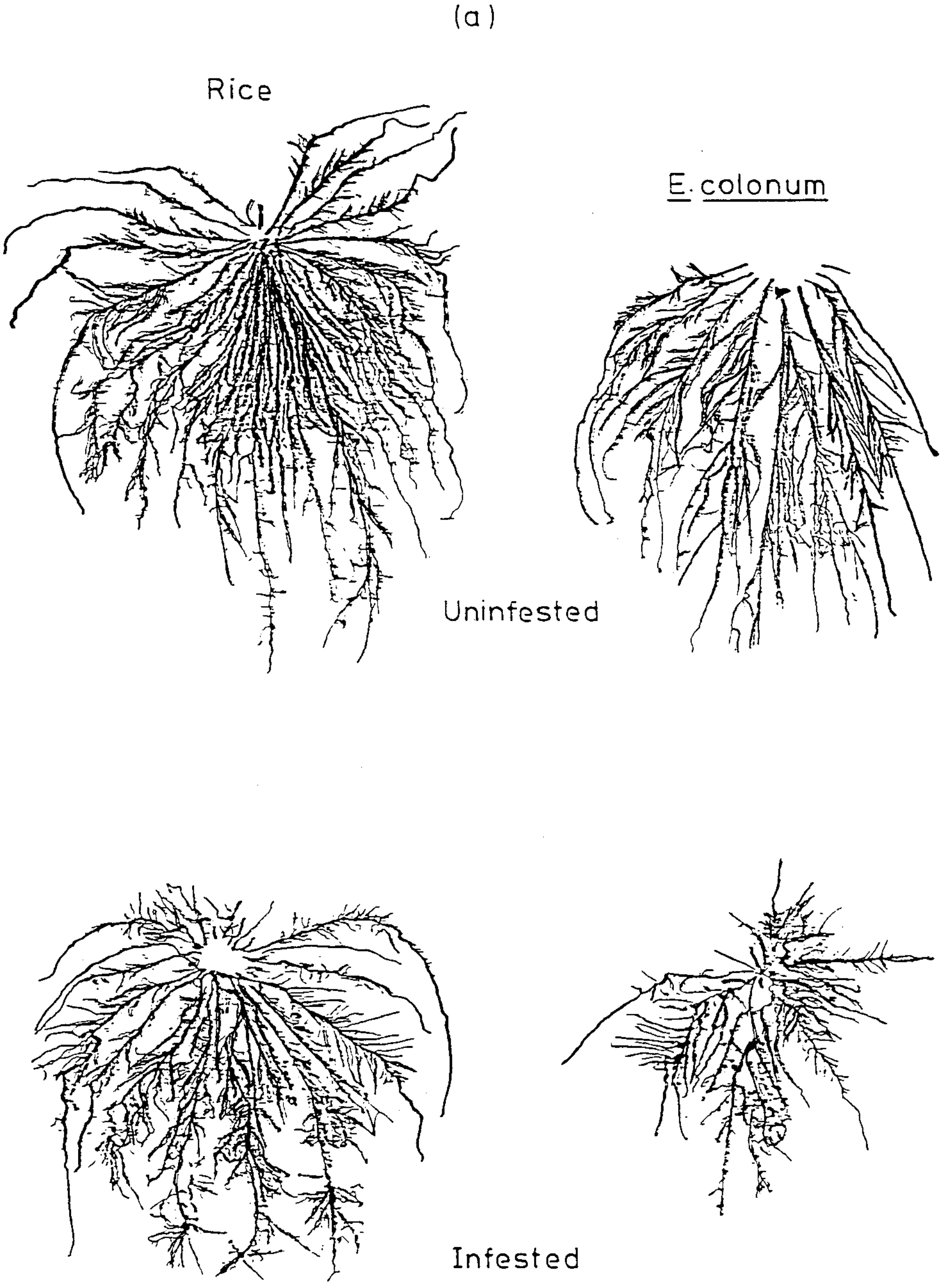
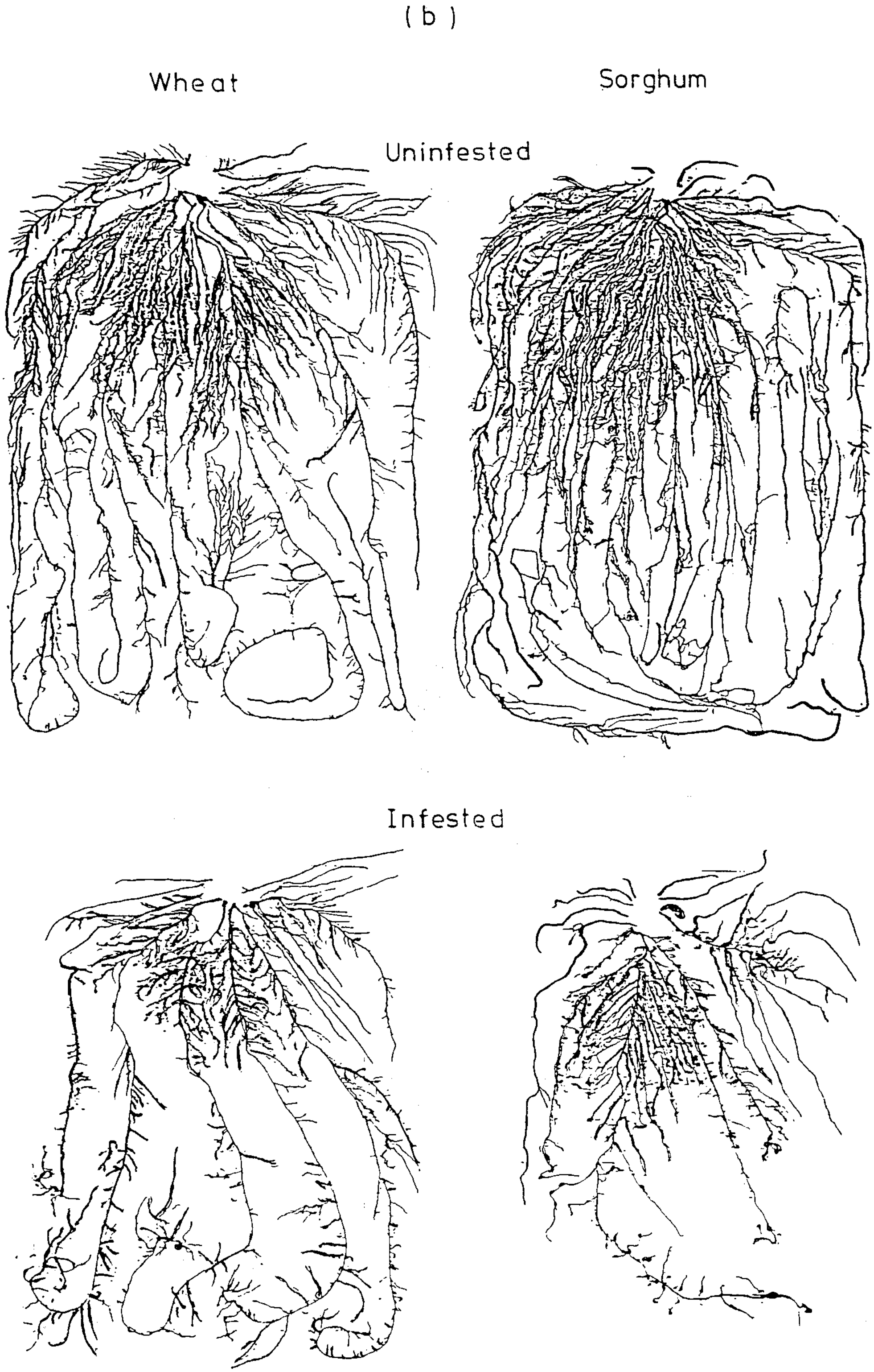


Fig. 1 - The effect of *M. graminicola* on the growth patterns of graminaceous plants (reduced to 41% of original): a) rice and *E. colonum*; b) wheat and sorghum.


(b)
Wheat
Sorghum
Uninfested
Infested

Results

Overall growth of all four hosts was significantly reduced by *M. graminicola* (Table I), the largest reduction of shoot and root weights being in sorghum, followed by *E. colonum*, rice and wheat. The pattern of growth of the four hosts was different: rice, *E. colonum* and sorghum produced one seminal root (radicle), whereas wheat had as many as three.

The root systems of the plant species were of different sizes at the same age (Fig. 1). Sorghum had a large root system because the relatively long laterals enhanced total root length (Table I), whereas rice had more axes and primary laterals, but they were not as long. Wheat had 3-6 long seminal roots which continued to live and support the plants, but *E. colonum* produced a weak radicle which disintegrated after a few weeks and the root system then depended on the newly formed nodal roots (see Figs. 1, a and b). *M. graminicola* significantly suppressed the root length, the total number of root tips and the number of 1° and 2° laterals of all the hosts (Table I). Clumping of laterals on infested roots of rice and *E. colonum* and twisting of root tips in sorghum was noted, but in wheat, infected roots continued to grow after some initial inhibition (Fig. 1). Rice had the largest number of root tips, followed by wheat, sorghum and *E. colonum*. Occasionally some laterals grew from the galls caused by the nematodes.

There were more nematodes in the roots of sorghum (Table II), probably because the root system was larger (Table I), but *E. colonum* supported more nematodes g^{-1} and nematodes cm^{-1} root (Table II).

Discussion

According to Elkins *et al.* (1979) a large-rooted plant is more susceptible, i.e. harbours more nematodes, than a small-rooted plant. In the present study sorghum supported the most nematodes even though it had fewer root tips than rice and wheat. On the other hand, *E. colonum*, which had the fewest root tips and nematodes, was damaged more than rice and wheat. Although Elkins *et al.* (1979) suggested that genetic differences were the cause of susceptibility of large-rooted plants, they emphasised that root length was the most important parameter for measuring nematode invasion, and that plants with large root systems would be more susceptible and suffer more damage. This hypothesis was not confirmed by the present study.

The growth rates of different plants vary during their development, and therefore, the response of a plant may depend on the time of invasion by nematodes and the stage of plant growth. The time at which sampling is done may also affect results, because a plant may not have reached its fastest growth rate, e.g. initially *E. colonum* grows very slowly and has a very small root system composed of only a weak radicle; thus it may be more vulnerable to nematode attack (Fig. 1a). However, *E. colonum* later produces nodal roots that develop into a large root system which is much bigger when infected with nematodes than an uninfected rice root.

Crossett and Campbell (1975) found that ethylene treatment of barley inhibited the growth of axis roots: primary laterals were not affected, but the number and length of secondary laterals was increased. Similar results were found in the present work when rice and *E. colonum* roots were inoculated with *M. graminicola*. Dawkins *et al.* (1983) noted that mechanical impedance increases the levels of ethylene in the root environment and suggested that it could be the result of either elevated endogenous ethylene production by the plant itself or by soil micro-organisms. If the nematode produces certain growth regulators/hormones which can initiate lateral growth, then why does it not have similar root proliferation effect on wheat and sorghum as on rice and *E. colonum*? To answer this question further studies are needed.

TABLE I - *Effect of* Meloidogyne graminicola *on root growth of four graminaceous hosts*

Plants	Nematodes + or -	Total Root Length (cm)	Total Number Root Tips	Number 1° Laterals	Number 2° Laterals
Rice	-	2,995	3,358	2,545	782
	+	1,305***	1,691***	1,201***	430*
E. colonum	-	1,199	978	670	289
	+	443***	497***	192***	273NS
Wheat	-	2,427	2,268	563	1,440
	+	1,053***	1,060***	498NS	504***
Sorghum	-	3,135	1,699	492	984
	+	941***	793**	309NS	457**

*** = significant at 0.1% level using student's t test; ** = significant at 1% level; * = significant at 5% level; NS = non significant at 5% level.

TABLE II - *Nematode populations of graminaceous plants invaded by* M. graminicola *20 days after inoculation*

	Rice	*E. colonum*	Wheat	Sorghum
Total number of galls (Means of 5 reps)	378^{a}	181^{b}	395^{ca}	487^{c}
Total number of nematodes per root (Means of 4 reps)	574^{a}	485^{a}	597^{a}	940^{a}
Number of nematodes g-1 root (Means of 4 reps)	$1,377^{abc}$	$1,942^{b}$	863^{cd}	$1,012^{ad}$
Nematodes cm-1 (Means of 4 reps)	0.47^{a}	1.132^{b}	0.58^{ca}	0.99^{cb}

Numbers followed by the same letter on each line are not significantly different.

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