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EFFECT OF DIFFERENT CROPPING SEQUENCES ON ROOT-KNOT NEMATODE, *MELOIDOGYNE GRAMINICOLA*, AND YIELD OF DEEPWATER RICE

by
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Summary. The rice root knot nematode, *Meloidogyne graminicola* Golden *et* Birchfield, is an important pest in deepwater rice (DWR) in Bangladesh. Several cropping sequences were followed in an infested field to investigate their effects on *M. graminicola* and yield of DWR. Crops included in the sequences were mustard (*Brassica campestris* subsp. *oleifera* L.), sesame (*Sesamum indicum* L.), millet (*Setaria italica* L.), guzitil (*Guizotia abbysinica* L.F.), khesari (*Lathyrus sativus* L.) and marigold (*Tagetes patula* L.). Numbers of *M. graminicola* juveniles were reduced by 85% when mustard and guzitil were mixed sown in winter followed by mixed sowing of DWR with sesame. There was 65% reduction when mustard was grown alone followed by DWR mixed with millet. Reductions of 18 and 14% were obtained when khesari and mustard respectively preceded DWR. Although different cropping sequences did not affect the yield of deepwater rice, the total economic return in a year was the highest in mustard + guzitil followed by DWR + sesame cropping sequence.

In Bangladesh, deepwater rice (DWR), *Oryza sativa* L. is sown broadcast from March to April in ploughed soil and the crop is harvested in November to December. The monsoon begins in May to June and initiates flooding, reaching a depth of 2-3 m during August to September, and receding in October to November. About 1.35 million/ha of land are planted to deepwater rice, which covers about 13% of the total rice acreage in Bangladesh (Bangladesh Bureau of Statistics, 1986). Deepwater rice is also grown in India, Burma, Thailand, Kampuchea, Vietnam and Indonesia.

The rice root-knot nematode, *Meloidogyne graminicola* Golden *et* Birchfield, is an important pest in seedbeds and in upland or irrigated rice in rice growing countries (Manser, 1968; Golden and Birchfield, 1968; Rao *et al.*, 1970; Buangusuwon *et al.*, 1971; Hoque and Talukder, 1971). It was first reported in DWR in Bangladesh (Page and Bridge, 1978) and later in Vietnam (Kinh *et al.*, 1982) and in semi deepwater rice in India (Prasad *et al.*, 1985). Infested plants are usually stunted, fail to elongate during flooding and remain submerged as the water rises, resulting in a poor yield (Bridge and Page, 1982; Kinh *et al.*, 1982). There is considerable information on control measures, including crop rotation or cropping sequences, for this nematode both in upland and irrigated rice in India (Rao *et al.*, 1970; Alam *et al.*, 1976; Prasad and Rao, 1978; Haque and Prasad, 1980; Sharma *et al.*, 1980) but none on DWR. This paper describes the results of four cropping sequences to control *M. graminicola* in DWR in Bangladesh.

Materials and methods

The experiment was conducted from March 1983 to December 1985. A field naturally infested with *M. graminicola* was selected and divided into four large plots, 20x15 m, each of which had a different cropping sequence (Table I).

TABLE I - *Cropping sequences tested.*

Year		
1983	1984	1985
A. Fallow - DWR*	Khesari – DWR	Khesari – DWR
B. Mustard - DWR	Mustard – DWR	Mustard – DWR
C. Sesame - DWR	Mustard – DWR + Sesame	Mustard + Guzitil – DWR + Sesame
D. Marigold+Millet-DWR	Mustard – DWR + Millet	Mustard – DWR + Millet

*DWR = deepwater rice

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Twenty soil samples were taken per plot at 15 day intervals throughout the year. Samples were bulked and 3 sub-samples of 1 kg were taken, from each of which 100 ml soil was used to extract nematodes by the tray method (Whitehead and Hemming, 1965). Some of the soil collected at the rice harvest in Nov., 1985 was put into earthenware pots (12x15 cm) and seed of a susceptible rice cv. BR3 was sown for a biossay test. The seedlings were uprooted when one month old and the number of galls per plant and percentage of infestation were recorded. Twenty deepwater rice plants from each plot were also collected randomly at monthly intervals to assess the percent infestation, based on the presence of galls in the roots. Deepwater rice was damaged due to flooding in 1984 and therefore no plant samples were collected after September in this year. Each crop was harvested when ripe and the marketable product weighed.

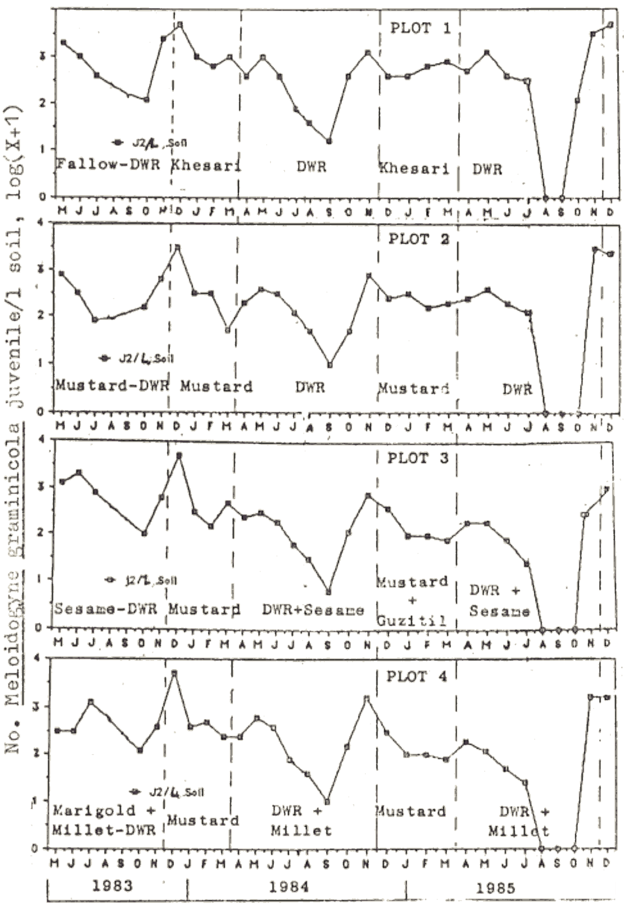

Fig. 1 - Variation of *Meloidogyne graminicola* juveniles under different cropping sequences in a deepwater rice field, Manikganj, 1983-85.

During the winter season, intact DWR roots reamaining in the unploughed plot i.e. cropping sequence 1, and exposed roots in the ploughed plots i.e. cropping sequence 2, 3 and 4, were collected at monthly intervals. Ten galls from these root samples were dissected and teased on to a 90 μm mesh nylon sieve and left overnight at room temperature. Active and inactive juveniles were counted under a stereo-microscope. The rest of the root samples were chopped into pieces, mixed with 4% formalin sterilized soil, put into 12x15 cm earthenware pots and sown with cv. BR3. One month old seedlings were uprooted to record the number of galls/plant root system and per cent infestation.

Results and discussion

Large numbers of *M. graminicola* juveniles were recorded in soil collected at the rice harvest in November or early December (Fig. 1). The population at harvest varied considerably between different cropping sequences. Comparing the population at harvest in December 1983 with that of 1985, the number of juveniles per litre of soil were reduced to 18, 14, 85 and 65% under the 1st, 2nd, 3rd and 4th cropping sequences respectively. These results indicate that it is possible to reduce the numbers of *M. graminicola* in soil if mustard is grown as a single crop or mixed with guzitil in winter followed by DWR mixed with sesame or millet in summer. Sesame and mustard in different cropping sequences have been reported to reduce populations of *M. incognita* and *Pratylenchus indicus* (Prasad and Rao, 1978; Sharma *et al.*, 1980) and millet has been shown to be a poor host to *M. graminicola* (Rao *et al.*, 1970) in India. It was also noted in our study that the numbers of juveniles in soil decreased sharply until the beginning of January in most cases and then slowly and irregularly until March (Fig. 1). Although numbers then increased in April and May, a rapid decrease was again observed from May to August. No *M. graminicola* juveniles were found in flooded soil during August to September or October. Low numbers or complete absence of nematodes in the flooded soil may be due simply to adverse effects of flooding, arrested development and delayed hatching of eggs or rapid killing of nematodes in soil with low pH and large amount of decomposable organic matter as also reported for other nematodes (Linford *et al.*, 1938; Hollis and Kabana, 1966; Guiran, 1979; Trivedi and Barker, 1986). It should be noted here that the basal portion of sesame and millet was left in the field and this decomposed during flooding in this study. The percentage of infested DWR varied from year to year under the different cropping sequences (Fig. 2). It was considerably less (20%) in the sequences where mustard and/or guzitil were grown in winter followed by mixed sowing of DWR with sesame or millet in the summer i.e. 3rd and 4th cropping sequences. A 20% infestation was recorded in the 3rd and 4th sequences and 50 and 60% respectively in the 2nd and 1st sequences at the rice harvest in 1985. On the other hand in spite of a large nematode population present in the soil at harvest in 1985 (Fig. 1), only 4% BR3 seedlings in the 2nd, 3rd and 4th sequences and 14% in the 1st sequence were recorded in the bioassay test. This low infestation under the 3rd and 4th cropping sequences, both in the field and bioassay tests, indicated a reduced infectivity of *M. graminicola* juveniles present in the plots. Rao *et al.* (1970) reported that the progeny of *M. graminicola* from unsuitable hosts, including some other cereals, were less infective to rice plants.

A minimum of 32% and maximum of 42% active *M. graminicola* juveniles were recorded in wet DWR roots collected from the unploughed plots (i.e. sequence 1). Although there were no active juveniles in the dry roots of

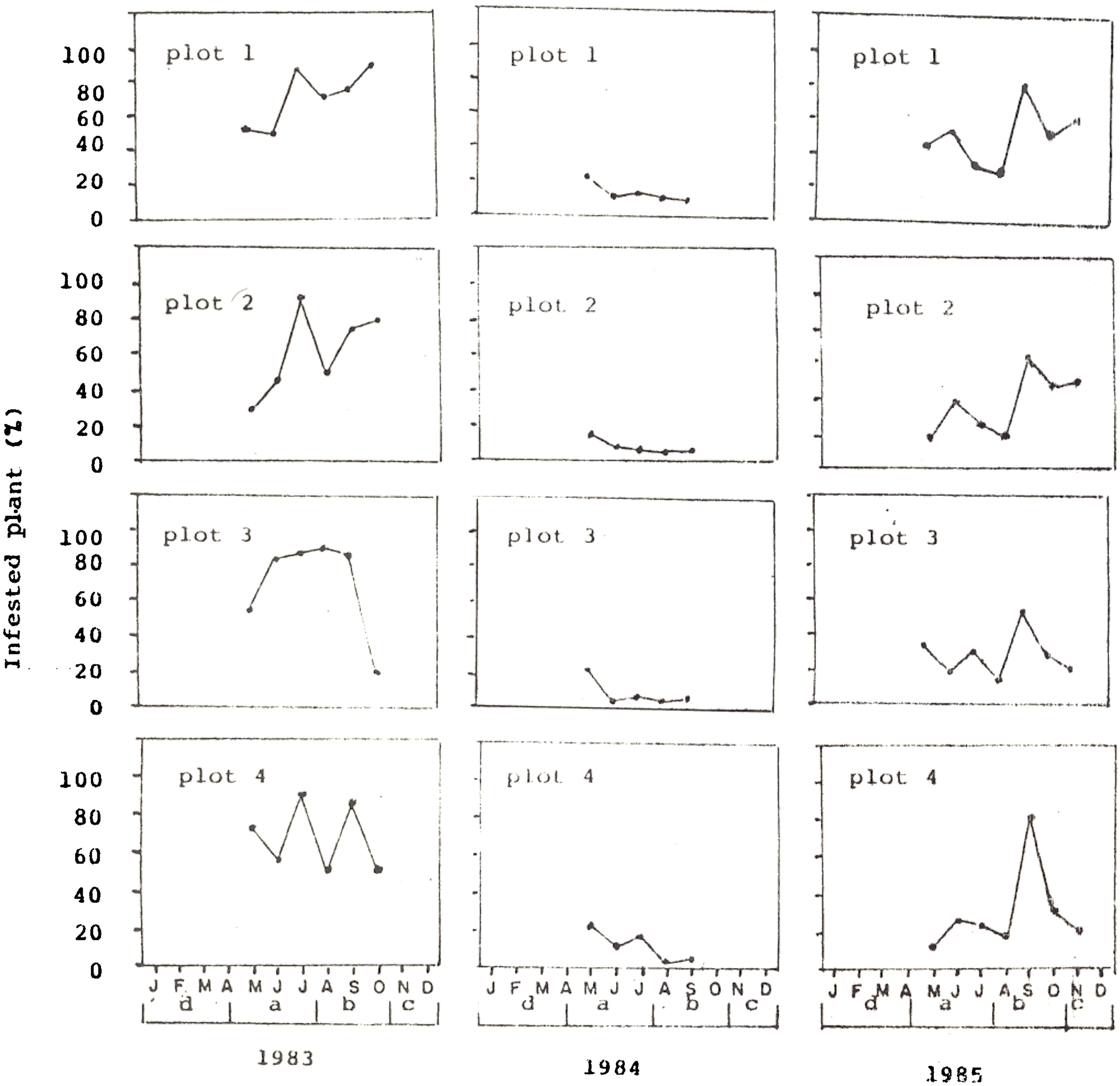

Fig. 2 - Percentage of deepwater rice plants infested in field under different cropping sequences, Manikganj, 1983-85.
Legend: a: April-mid July: Pre-flood season of deepwater rice; b: Mid July-mid Oct.: Flood season of DWR; c: mid. Oct.-December: Post-flood and harvest of DWR; d: January-March: Rabi season for winter crops.

DWR collected from ploughed plots (i.e. sequences 2, 3 and 4) in December and January, 13% active juveniles were recorded at the time of DWR sowing in March (Table III). The higher percentages of active juveniles in the wet roots reflect the higher plant infestation compared with dry roots (Table II). In the bioassay test 16-55% BR3 seedlings were infested with 1-3 galls/plant in wet roots but only 1-3% infestation with a single terminal gall in the case of dry roots (Table II). Such differences could be due to the effect of the poor host plant, degree of soil cultivation and low active nematode population in roots exposed to solar heating as reported for other nematodes (Haque and Prasad, 1980; Trivedi and Barker, 1986; Minton, 1986).

Although the reduced nematode population in the soil and the lower plant infestation in the 3rd and 4th cropping sequences did not result in an increase in the yield of DWR, the total economic return was higher in these sequences (Table III). Thus these cropping sequences may be recommended as being economically superior to the traditional sequence where khesari preceds DWR and beneficial in suppressing or reducing the nematode population and its activity to some extent. Therefore, the results obtained in this study indicate some benefits of growing mustard and/or guzitil before sowing DWR mixed with sesame or millet in root-knot infested fields. It should be mentioned that growing mustard before DWR alone or mixed with sesame are two of the important cropping sequences practiced in DWR areas in Bangladesh. Economically, mustard and sesame are the two major oil seed crops grown in 185,000 ha and 40,000 ha of land which produce 49% and 8% oil seeds respectively in the country (Kaul and Das, 1986).

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TABLE II - *Survival of* Meloidogyne graminicola *(J2) in dry and wet roots of deepwater rice in winter and its infectivity and gall formation on the rice cv. BR3 in bioassay test.*

Character	Type of root	Months			
		December	January	February	March
Percentage active juveniles/gall	Dry	0	0	3	13
	Wet	42	35	32	35
Percentage plants infested	Dry	0	0	1	3
	Wet	55	20	16	17
No. galls/plant	Dry	0	0	1	1
	Wet	3	1	2	3

TABLE III - *Average yield of deepwater rice and different winter crops under four different cropping sequences, Manikganj, Bangladesh.*

Cropping sequences	Yield (t/ha)	Price/kg (US $)	Total return/crop (US $)	Total return/year (US $)
A. Khesari –	1.57	0.12	188.4	
Deepwater rice	1.08	0.15	162.0	
B.Mustard –	0.86	0.37	318.2	
Deepwater rice	1.13	0.15	169.5	
C.Mustard +	0.51	0.37	188.7	
Guzitil –	0.17	0.43	73.1	
Sesame +	0.23	0.43	98.9	
Deepwater rice	1.29	0.15	193.5	
D.Mustard –	0.63	0.37	233.1	
Millet +	0.28	0.24	67.2	
Deepwater rice	1.12	0.15	168.0	

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