ALTERNATIVE MANAGEMENT STRATEGIES AGAINST THE RICE ROOT-KNOT NEMATODE, *Meloidogyne graminicola*, IN A RICE-ONION SYSTEM

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ABSTRACT

Studies were conducted to determine alternative management strategies against the rice root-knot nematode, *Meloidogyne graminicola* in a rice-onion system. The cannister experiment, which was conducted to determine the effective soil depth level reached by rice hull burning (RHB) on nematode mortality, showed that nematodes were killed by heat even at 15 cm depth. Several galls in the roots were counted in rice seedlings in the unburned treatments as compared to zero galls in all the burned treatments (0, 5, 10, 15 cm depth). The field experiment using RHB significantly affected the number of galls and in most cases the nematode densities in the soil and roots. Yield of onion increased almost three-fold in the burned treatment. The pot experiment showed that *Tagetes* sp. and two *Crotalaria* species reduced the number of galls and nematode densities in the soil by 73-96% and increased fresh root weight when incorporated in the soil. Rice hull burning and the use of *Tagetes* and *Crotalaria* could be effective alternative management strategies for *M. graminicola* in a rice-onion system.

Key words: Root-knot, nematode, *Meloidogyne graminicola*, Rice Hull Burning, *Tagetes* sp., *Crotalaria* sp., onion, rice, antagonistic plants, non-host

INTRODUCTION

Rice (*Oryza sativa* L.) which is the staple food for most developed and developing countries is considered one of the most important cereal crops. The world population in 1992 was about 5.3 billion and was estimated to increase by almost 100 million people year year. To meet the demand of the increasing population the world must produce 350 million more tons of rice by year 2020. Selection of high yielding cultivars and proper water, nutrient, and pest management are just few requisites in increasing yield of rice. Rice production is beset with pest problems, including nematodes. Many genera of parasitic nematodes are associated with rice, but not all are proven of potential economic importance (Bridge et al., 1990, Villanueva and Prot, 1992; Soriano and Prot, 1992). Among the nematodes associated with rice, the root-knot nematodes, *M. incognita* and *M. graminicola* have been considered the most destructive (Fofie and Raymundo, 1979). *M. graminicola,* which was first found infesting *Echinocloa colona* Link, was discovered to infest rice in Laos, India, Thailand, Japan South Africa, Rio Grande, and the Philippines (Soriano and Prot, 1992).

Symptoms include galling in the roots, swollen and hooked root tips (Diomande, 1984), tip drying, leaf bronzing, chlorosis, growth reduction, unfilled spikelets, reduced tillering and poor yield (Bridge and Page, 1982). The result from these abnormalities is yield reduction in upland rice which was reported to reach about 2.6-32% (Rao et al., 1986; Barsalote and Gapasin, 1995).

Rice is normally grown twice a year where there is continuous irrigation. In Central Luzon, specifically in Nueva Ecija, farmers practice the rice-vegetable cropping pattern. Problems of pests in rice being carried over in vegetables can not be avoided. *M. graminicola* which has become a pest of rice also infests several vegetable crops including weeds (Gapasin et al., 1996; 1997; Roy, 1978a; Zamora and Gapasin, 1996). Most farmers in San Jose and Bongabon, Nueva Ecija grow onion after rice and *M. graminicola* has been reported a potential pest in onion (Gapasin et al., 1996) and therefore management of the nematode is of prime importance. Chemical, cultural, physical, and mechanical methods, use of resistant varieties, and biological control are some management options against the nematode that were found effective (Barsalote and Gapasin, 1995; Johnson et al., 1995; Koening et al., 1995; Hirunsalee et al., 1995; Halbrendt, 1996; Rodriguez-Kabana et al., 1990). Some of these can be integrated but a sound nematode management program should be economical, practical, environmentally safe and friendly, and acceptable.

This study was therefore conducted with the following objectives: a) to determine the effectiveness of rice hull burning (RHB) in controlling root-knot nematode and its effect on yield of onion and b) to determine the effects of *Tagetes* and *Crotalaria* on the population of root-knot nematode.

MATERIALS AND METHODS

Rice Hull Burning Experiment

Small cannisters made of PVC pipe measuring 5 cm long and 3.8 cm diameter were prepared. The cannisters with sterilized soil were first infested with 500 eggs of the root-knot nematode before burying them at specific depths of 0, 5, 10, 15 cm in the farmers field prior to rice hull burning (RHB). The treatments were replicated 4 times. Both ends of the cannister were covered with a wire mesh to protect the soil and eggs from spilling. The cannisters were recovered after 24 hours while the control treatment was incubated in the glasshouse. One-month old rice seedlings (UPLRi 5) were planted in the cannisters with one seedling per cannister for bioassay. Plants were incubated in the glasshouse and uprooted after 35 days. The roots were washed in running water, examined for root galls which later counted.

In the field experiment, farmer cooperators with fields known to have high nematode population were selected. Two 4 x 5 sq m plots were laid out in each farmer cooperator's field, where rice hull about 6 inches thick were dumped. One plot was burned and the other was unburned, with a total of eight plots (4 replications). Prior to RHB, nematode densities were assessed by getting ten 200 g soil samples from each plot. At sampling time (e.g., 4, 8, 12 weeks after transplanting (WAT) onion), ten root systems and ten 200 g soil samples were randomly taken from the plots. All samples were brought to the PhilRice Nematology Laboratory and roots were later examined and galls were counted. The roots were weighed, cut to small pieces, placed in plastic mesh fastened in a 7.5 cm diameter PVC pipe, and placed in a plastic petri dish with water. The suspension was collected after 72 hours and the nematodes were heat-killed, fixed in triethanolamine formalin (TAF), and counted under the stereomicroscope. The soil samples were processed for nematodes using the modified Baermann funnel method and nematode suspensions were taken after 48 hours. The nematodes were heat-killed, fixed in TAF, and later counted under the stereomicroscope. The yield of onion was measured in 6 m^2 plots.

Experiment on the Effect of Antagonistic and Non-host Plants

Pots containing sterilized soil were infested with 750 eggs of *M. graminicola.* Pots were arranged in the screenhouse in CRD manner with the following treatments: Rice, *Crotalaria* 1, *Crotalaria* 2, *Tagetes,* and Fallow (no plants). The treatments were replicated 5 times. Two months after the different treatments, plants were harvested and roots were examined for root galls. Nematode density in the soil was assessed by getting 200 g soil and processed in the Laboratory using the modified Baermann funnel method. The biomass of *Tagetes* and *Crotalaria* was incorporated in the soil. One-month old onion seedlings were then planted in the pots with 3 seedlings per pot. The onions were harvested after 2 months and galls were counted and nematode densities in soil and roots were assessed. The fresh weight of onion was also taken. LSD was used to compare the treatment means.

RESULTS

Rice Hull Burning

In the cannister experiment the heat from the burned rice hull killed nematodes even at 15 cm depths as shown by the absence of galls in the roots of rice seedlings incubated for 35 days. Galled roots were observed in the control plants with a mean of 56.5 (Table 1), an indication of nematode survival and feeding. Table 2 shows the effect of rice hull burning (RHB) on fresh root and top weights, number of galls per root system, nematode densities (L2) in roots and soil and yield of onion (var. Yellow Granex). RHB did not significantly increase root and

Table 1. Number of galls per root system on rice seedlings 35 days after they were grown in cannisters inoculated with 500 eggs of *M. graminicola* and buried at different depths.

Depth (cm)	I	II	III	IV	Total	Mean
Burned						
0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
Unburned (Control)	63	42	66	55	226	56.5

Table 2. Summary of the effect of rice hull burning on fresh root and top weights, number of galls per root system, nematode densities (L2) in roots and soil, and yield of onion (var. Yellow Granex).[1]

Treatment/ sampling	Root Weight (g)	Top Weight (g)	Number of Galls	Nematode Density		Yield ($6\ m^2$)
				Roots	Soil	
Burned						
4 WAT	0.5a	10.4a	6.7b	1.6b	12.6b	
8 WAT	1.3a	130.2	6.8b	6.3a	6.4a	
12 WAT	0.8a	221.6a	2.3b	3.3a	5.5b	35.7a
Unburned						
4 WAT	0.5a	7.0a	20.7a	27.4a	38.0a	
8 WAT	1.2a	86.1a	20.0a	38.4a	30.8a	
12 WAT	0.5a	96.4b	6.5a	15.1a	17.9a	12.7b

[1]Means in a column of the same sampling period having the same letters are not significantly different using DMRT.
WAT – Weeks After Transplanting
Initial population – 3.1

top weights of onion except during the 12 WAT where top weight in the burned plots was significantly higher than in the unburned plots. The number of galls were significantly reduced by RHB. In all cases the nematode density in roots and soil was lower in the burned treatments. Onion yields were almost three-fold higher compared to the unburned treatment.

Effect of Antagonistic and Non-host Plants

No galls were observed when *Tagetes* and 2 species of *Crotalaria* were planted in the infested potted soil (Table 3) while those planted with rice were heavily galled. These plants also reduced the nematode density in soil by 73-96%. When onions were planted to pots grown with *Tagetes* and *Crotalaria* the number of galls was significantly reduced and nematode density in the soil was reduced by as much as 96%. Onions grown after rice were heavily galled with a mean number of 57.5. Fresh weights (g) were significantly higher in the different treatments compared to the treatment where rice was grown.

DISCUSSION

Rice hull burning (RHB) has been shown to effectively reduce galls and nematode densities in roots and soil. While RHB is effective, this may cause environmental pollution because of the smoke emitted especially when widely used. Burning may also alter soil structure and nutrients. This should encourage

Table 3. Effect of *Crotalaria, Tagetes,* and fallow on the number of galls and nematode density in soil and reaction of onion var. Yellow Granex planted to the treatment (Pot experiment).[1]

Treatment	Number of Galls	Nematode Density in Soil		Number of Galls (Onion)	Nematode Density in Soil (Onion)		Fresh Weight (g) (Onion)
Crotalaria 1	0.0b	17.8c	(73.0)	7.4b	16.4b	(67.2)	15.0b
Crotalaria 2	0.0b	12.8cd	(80.6)	3.4b	9.8b	(80.4)	15.0b
Tagetes	0.0b	2.4d	(96.4)	2.3b	1.8b	(96.4)	11.1b
Fallow	-	38.2b	(42.1)	5.6b	12.0b	(76.0)	12.8b
Rice	85.8a	66.0a	(-)	57.5a	50.0a	(-)	4.1a
LSD	14.2	12.5		9.6	14.8		4.5

[1]Means in a column having the same letters are not significantly different using LSD.

nematologists to continuously search alternative management strategies that are environmentally friendly and economical. Yield of onion increased almost three-fold due to RHB. The ashes could have added fertility to the soil. As reported by Khan et al. (1977) fly ash increased the availability of carbonates, bicarbonates, sulfate, chlorides, B, P, K, Ca, Mg, Mn, Cu, and Zn and yield of tomato.

Crotalaria and *Tagetes* effectively reduced nematode densities in soil in a pot experiment. *Crotalaria* was reported to be a non-host of the nematode (Gapasin et al., 1997) and therefore nutrients to complete their life cycle are either limited or absent. *Tagetes* on the other hand has nematicidal properties. Chitwood (1993) reported that naturally occurring phytochemicals with biological activity against plant parasitic nematodes include polythienyls, alkaloids, phenolics, polyacetylenes, fatty acids, terpenoids, and others. The efficacy of *Tagetes* in suppressing nematodes in soil has been reported by several workers. Cultivation of marigolds (*Tagetes* spp.) significantly suppresses the population and build-up of noxious nematodes (Oostenbrink, 1960; Hackney and Dickerson, 1975; Alam et al., 1977). Likewise, McSorley and Frederick (1994) reported little or no galling or egg production from any *Meloidogyne* isolate on *Lageratum houstonianum* cv. Blue Mink, *Lobularia maritima* cv. Rosie O'Day, or *Tagetes patula* cv. Dwarf Primrose. These plants or other plants known to be antagonistic or non-host could be grown in nematode infested fields during the fallow period before onion is planted.

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