INTEGRATED MANAGEMENT OF ROOT-KNOT NEMATODES USING AGROCHEMICALS, ORGANIC MATTER AND THE ANTAGONISTIC FUNGUS, *PAECILOMYCES LILACINUS* IN NATURAL FIELD SOIL

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Summary. A glasshouse trial was conducted to ascertain the effects of organic amendments, aldicarb and captafol (Orthodifolatan 80% WP) on integrated management and parasitic potential of *Paecilomyces lilacinus* against *Meloidogyne javanica* eggs in the field. Tomato cv. Moneymaker plants were used as the host for the nematode. Chicken manure and organic matter from antagonistic plants *Tagetes minuta, Ricinus communis,* and *Datura stramonium* stimulated the parasitism of *M. javanica* eggs while the fungicide captafol inhibited it. The galling index and the population of juveniles were lower in soils treated with aldicarb or any of the four organic materials. The smallest galling index, number of galls and nematode population were in soils treated with aldicarb in combination with *P. lilacinus.* Soils amended with organic additives supported plants with significantly heavier shoots than untreated controls.

Plants antagonistic to phytonematodes are widespread in Kenya (Kokwaro, 1976) and their potential in the management of root-knot nematodes when used in mixed cropping systems has been documented (Sayre, 1986; Yeates, 1987; Oduor-Owino *et al.,* 1996). Nematode control by organic amendments has also been proposed, and is attributed to the accumulated toxicity of the decomposing products (Sayre *et. al.*, 1986). Organic matter and fungal egg parasites offer prospects for nematode management (Jatala, 1986; Oduor-Owino *et al.,* 1993) but these control measures are relatively slow. In addition, there is little information on factors that affect the efficacy of egg parasites in the soil ecosystem (Kerry *et al.,* 1986). It is not clear if organic matter, agrochemicals and fungal egg parasites can be integrated for the management of nematodes. Therefore, a glasshouse test was conducted to evaluate the effects of different combinations of *Paecilomyces lilacinus,* aldicarb, captafol and organic matter from chicken manure and antagonistic plants on the biological control of a root-knot nematode.

MATERIALS AND METHODS

Leaves of mature *Ricinus communis* L., *Tagetes minuta* L., and *Datura stramonium* L. were oven dried at 60 °C for 72 h, ground into 20 µm particles using Wiley's grinding mill, and incorporated separately in to dry field soil contained in 13 cm diam. plastic pots at the ratio of 1:8 (w/w). The organic matter was sieved through a 2 mm pore sieve to remove large lumps before mixing with soil. Chicken manure was also put in similar pots and mixed with field soil in the ratio of 1:8 (w/w). Pots containing soils without organic matter served as a control. The soil was collected from a field that had been left fallow for three years. It comprised of 60% sand, 39.1% clay, 0.9% silt at pH. 6.0, and was naturally infested with *P. lilacinus* (Samson) Thom. It had low populations of *Pratylenchus* spp. (50-nematodes/300 cm^3 soil) and *Meloidogyne* sp. (30 per 300 cm^3 soil).

Ten-day-old *P. lilacinus,* cultured on PDA and used in previous tests (Oduor-Owino *et al,* 1996), was immediately added to the pots at the rate of eight macerated PDA plugs (7-mm diam.) per pot and mixed thoroughly to boost the soil infestation levels. Other treatments were pots containing uncolonized PDA, pots with captafol (0.5 g/pot) and fungal colonized PDA plugs, but no organic matter; pots with organic matter but no fungus or uncolonized PDA plugs acted as controls. Pots with aldicarb (1 g/pot) and fungus, and those with aldicarb without fungus were also included in the test. All pots were watered. After three-weeks, four-weeks-old seedlings of tomato *Lycopersicon esculentum* Mill, cv. Moneymaker, raised in autoclaved sand, were transplanted singly into each pot. The soil was then inoculated with ca 4000 ± 50 eggs and 200 juveniles of *M. javanica* (Treub) Chitw. suspended in 10 ml of sterile distilled water. The treatments are as shown in Table I. Nematode alone treated pots had PDA plugs added to them but no fungus. Ten pots were left uninoculated. There were 15 treatment combinations in this test, each combination had ten replicates.

All pots were arranged on a glasshouse bench in a randomized block design at 21 ± 2 °C. Plants were watered regularly and sprayed biweekly against insect pests and powdery mildew using 1% diazinon and 2% benomyl, respectively. Fertiliser (N:P:K:20:10:10) was used at the rate of 2 g/pot at planting. The experiment was terminated 50 days after inoculation and root galling index (0-4 scale) and dry shoot weights determined. The number of galls per gram root weight and nematodes per 300 cm^3 soil were also counted. The percentage of

parasitized eggs was determined by plating ca 1000 eggs on water agar (WA), incubating for two days at room temperature and counting the proportion of eggs showing fungal growth (i.e. parasitized eggs) under the microscope at x100 magnification (Kerry and Crump, 1977). The data were analysed using a two-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Aldicarb, chicken manure and organic mater from the three antagonistic plants stimulated egg parasitism, while captafol inhibited it (Table I). The galling indices, number of galls and the population of juveniles were smaller ($p \leq 0.05$) in soils treated with aldicarb or any of the four organic additives (Table I). The lowest galling index and nematode population was obtained from soils treated with aldicarb in combination with *P. lilacinus*. The effects of *Datura, Ricinus* and *Tagetes* on *M. javanica* were similar whether used alone or in combination with *P. lilacinus*. Chicken manure had the greatest ($p \geq 0.05$) inhibitory effect on galling intensity, among the organic amendments. Tomato plants grown in amended soils had greater shoot weights than the non-treated controls. The best plant growth was associated with aldicarb treatments.

Although the highest levels of egg parasitism were associated with organic matter and aldicarb treatments, the percentages of parasitized eggs (1.3 – 37%) were too low to cause significant decreases in the galling index. Thus, organic matter did not stimulate egg parasitism adequately to cause a corresponding decrease in galling index or nematode populations. The lesser galling and better plant growth could therefore be attributed to the nematicidal effects of the products of decomposition. The improved plant performance and low galling in pots treated with *P. lilacinus* in combination with aldicarb or any of the three organic materials demonstrates that these materials have positive attributes which may be utilized in integrated nematode control systems. There is a need to intensify research on the interaction between nematodes, fungal antagonists, agrochemicals and naturally occurring organic matter in order to develop cost effective and environmentally safe nematode control methods which can be used in integrated pest management programmes.

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Table I. Effect of organic soil amendments and chemicals on parasitism (%) of *Meloidogyne javanica* and growth of tomato.

Treatment	Egg parasitism (%)	Gall index[1] (0-4)	Galls (No/g of root)	Juveniles/ 300 cm^3 soil	Shoot dry weight
M. javanica 'alone'untreated	1.5f	3.4b	623.1a	625b	1.4j
Soil 'alone' untreated	1.0f	1.6e	18.1e	30e	4.5c
P. lilacinus + *M. javanica*	21.2f	3.5b	551.4b	638b	1.7i
P. lilacinus + Captafol + *M. javanica*	1.3f	3.6ab	567.8b	700a	2.6h
P. lilacinus + Aldicarb + *M. javanica*	26.2d	0.5f	19.9e	10e	5.1a
P. lilacinus + *Tagetes minuta* + *M. javanica*	30.9b	2.0d	126.5c	400c	3.0g
P. lilacinus + *Datura stramonium* + *M. javanica*	28.4c	2.0d	122.2c	401c	3.2f
P. lilacinus + *Ricinus communis* + *M. javanica*	37.2°	2.5c	102.9cd	387c	3.6e
P. lilacinus + Chicken manure + *M. javanica*	37.3a	1.8d	75.7d	345d	4.2d
Tagetes *minuta* + *M. javanica*	1.5f	2.3c	128.8c	388c	2.8g
Datura stramonium + *M. javanica*	1.7f	2.5c	127.7c	399c	2.9g
Ricinus communis + *M. javanica*	1.2f	2.4c	108.7cd	307c	3.5e
Chicken manure + *M. javanica*	1.0f	1.8d	94.0cd	317c	5.0b
Aldicarb + *M. javanica*	1.8f	1.3e	19.7e	180e	5.4a
Captafol + *M. javanica*	1.0f	3.8a	615.4a	707a	2.9g

Means followed by different letters within a column are significantly different ($P \leq 0.05$) according to Duncan's Multiple Range Test.
[1] Gall index was based on a 0-4 rating scale, where 0 = no galls and 4 = 76-100% of the root system galled.

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