



Management of plant parasitic nematodes with antagonistic plants in the forest-savanna transitional zone of Ghana

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ABSTRACT

Objective: Usage of synthetic agro-chemicals continues to threaten the environment and mankind. This study was done to offer the peasant farmer with a sustainable nematode management option.

Methodology and results: *Mucuna pruriens* L., *Tithonia diversifolia* (Hemsl.) Gray, *Solanum lycopersicum* L. (control) and a clean fallow treatment were established in a randomized complete block design (RCBD). To evaluate their reaction to *Meloidogyne* spp., *Pratylenchus brachyurus*, *Helicotylenchus multicinctus*, *Rotylenchulus reniformis*, *Paratrichodorus minor* and *Tylenchulus semipenetrans*: root gall index (RGI), population per 200 ml rhizosphere soil and one gram of root samples were analyzed. *M. pruriens* and *T. diversifolia* were antagonistic to *Meloidogyne* spp., *P. brachyurus*, *H. multicinctus* and *R. reniformis*, but *S. lycopersicum* was a favorable host to the four nematode species. *M. pruriens* reduced populations of *Meloidogyne* spp. and *P. brachyurus* in root samples by 93 and 95% while *T. diversifolia* reduced populations by 86 and 87% respectively, compared to the control treatment. Their nematicidal potential was further demonstrated by lower root gall indices (*M. pruriens* recorded 0.5 compared with tomato which recorded 8.8), and population per 200 ml rhizosphere soil (*M. pruriens* recorded 49 and 42 for *Meloidogyne* spp., and *Pratylenchus brachyurus* respectively, compared with tomato which recorded (166 and 227) respectively.

Conclusion and application of findings: The spreading leguminous crop *M. pruriens* and the erect Asteraceae *T. diversifolia* were antagonistic to plant parasitic nematodes under the conditions of this study. *Mucuna pruriens* is a more favorable management candidate because of its potential to fix atmospheric nitrogen, smother noxious weed species and reduce the adverse effects of soil erosion. The use of antagonistic plants is environmentally acceptable. The two candidates are readily available in Ghana and could fit in the farming systems of peasant farmers. They could be included in a rotation system where they would be cultivated first and harvested before the cultivation of the economic crop.

Key words: Nematodes, antagonistic plants, *Mucuna pruriens*, phytochemicals, *Tithonia diversifolia*, *Solanum lycopersicum*

INTRODUCTION

Plant parasitic nematodes are a major constraint to agricultural production worldwide (Luc *et al.*, 2005). General symptoms of nematode infection include chlorosis, wilting, galling of roots and tubers, stunted growth, root lesion and yield loss. For sustainable food

production, effective management of plant parasitic nematodes is essential. The assault on the environment through the use of synthetic agro-chemicals (Bell, 2000) and unreliable results from crop rotation systems (Sikora & Fernandez, 2005) has

necessitated the search for sustainable, effective and environmentally acceptable nematode management options.

Organic soil amendments have been reported to possess nematicidal properties *in vitro* and *in vivo* (Sitarmaiah & Singh, 1978), and also increase crop yields significantly (Parr *et al.*, 1989). Organic amendments are environmentally acceptable but the large quantities required per unit area renders the strategy largely inapplicable in large scale farming enterprises.

The employment of phytochemicals in food production could offer another sustainable management option due to the presence of nematicidal properties in many higher plants (Chitwood, 2002). Plants antagonistic to nematodes are those considered to produce anti-helminthic compounds with different modes of action (Pandey *et al.*, 2003). Marigolds, *Tagetes* species which exude polythienyls have been proven to be nematicidal. *T. erecta* is capable of suppressing a wide range (up to 14 genera) of nematode pests (Wang *et al.*, 2007). *T. erecta* lowered levels of burrowing (*Radopholus similis*) Cobb, spiral (*Helicotylenchus*

multicintus) Cobb and lance (*Hoplolaimus indicus*) Sher nematodes when intercropped with a highly susceptible banana crop (Wang *et al.*, 2007). Ploeg (1999) demonstrated that the efficacy of marigold-based nematode control was a function of the marigold cultivar used and the biological and environmental parameters in a given agro-ecosystem. *Mucuna pruriens* has been used as an antagonistic plant with varying degrees of successes (McSorley & Gallaher, 1992; Rodríguez-Kábana *et al.*, 1992; Quénéhervé *et al.*, 1998). *Tithonia diversifolia* on the other hand has been used *in vitro* experiments to manage plant parasitic nematodes (Akinyemi *et al.*, 2009) and to boost maize production in Papua New Guinea (Igua & Huasi, 2009).

In Ghana, information on plants antagonistic to nematodes is scanty (Osei *et al.*, 2010) compelling farmers to rely on synthetic chemicals which are effective but pose an environmental threat (Thomas, 1996). The purpose of this study was to identify a sustainable nematode management system as an alternative to the synthetic agro-chemical option

MATERIALS AND METHODS

Study site: The field trial was conducted at Ejura in the Ejura Sekyedumasi district of the Ashanti region. Ejura is located on (07° 24'N 01° 21'W) in the forest-savanna transitional zone of Ghana. It experiences a bimodal rainfall system. The soil type belongs to the "Amantin series" Chromic Lixisol (Adu, 1992). The site had previously been cultivated with tomato. Lack of adequate cropping land compels farmers in the area to continuously crop one piece of land and in some cases with the same crop, a practice which favors the buildup of plant parasitic nematodes populations.

Experimental set up: A field trial involving four treatments was conducted to evaluate the nematicidal potential of the treatments (*Mucuna pruriens*, *Tithonia diversifolia*, *Solanum lycopersicum* and a clean fallow) in reducing plant parasitic nematodes populations. It was established in a randomized complete block design (RCBD) and replicated four times resulting in 16 plots. Tomato, *Solanum lycopersicum* (cv. Tiny Tim) a known susceptible crop to *Meloidogyne* species was the control treatment. Stem cuttings of *T. diversifolia* (collected from Aburi botanical gardens in the Eastern region of Ghana) were planted on 30 May 2009. After the *T. diversifolia* had sprouted, *M. pruriens* and tomato were planted at stake at three seeds / hill on 26 June 2009. All treatments were planted at a spacing of 100 x

100 cm and each plot measured 10 x 8 m. After germination *M. pruriens* and tomato were thinned to one seedling / hill. Weeding of the field trial was done three times and each time, the clean fallow plot was also weeded. The selection of antagonistic plants was based on availability.

Nematode sampling and assay: Soil samples were randomly taken with a 5 cm soil augur to a depth of 20 cm. Plastic pots each measuring (27 x 21 x 15 cm) were filled with 7 kg of infested soil from each plot. Two week-old tomato seedlings germinated on tissue paper in 9-cm Petri dish were used for tomato bioassay to determine root-knot nematode situation of the individual plots. Part of the soil samples, 200 ml / plot was extracted using the modified Baermann funnel method for plant parasitic nematodes.

Data recording and analysis: At eight weeks of growth of the tomato plants, root gall index (RGI) on a scale of 0-10 (Netscher & Sikora, 1990) was determined. The treatments were cultivated until 30 September 2009 after which another 200 ml of soil was sampled from the rhizosphere of the plants for extraction of plant parasitic nematodes. One gram of root from each treatment was also extracted for nematodes as described above. At 24 h after extraction, samples were fixed with TAF and

nematodes were identified (CIH, 1978) under stereo microscope at magnification 100x. Count data was log transformed ($\ln(x+1)$) while indices based data were square root transformed $\sqrt{x + 0.5}$ to conform to the

assumption of normal distribution before analysis using Genstat 8.1. The Least significance Difference (LSD) was used to separate means at 95% confidence level.

RESULTS

Six different species of plant parasitic nematodes were recovered from the sixteen plots sampled at the start of the experiment. The nematodes in order of abundance were: *Rotylenchulus reniformis* Linford and Oliveira > *Pratylenchus brachyurus* Godfrey > *Helicotylenchus multicintus* Cobb > *Meloidogyne* (Goeldi) spp. > *Tylenchulus semipenetrans* Cobb > *Hoplolaimus* (von Daday) spp. The root system of tomato plants in the bioassay test conducted at the start of the experiment with soil from all 16 plots galled, implicating root-knot nematodes (Table 1). At harvest, the six genera of nematodes encountered reacted differently to the treatments. While *M. pruriens* and *T. diversifolia* recorded significantly low ($P < 0.05$) population (49, 42, 8, 20, 27 and 13) and (68, 42, 18, 65, 15 and 15) respectively, tomato (the control treatment), recorded significantly high population (166, 227, 21, 125, 54 and

17) in *Meloidogyne* spp. (juveniles), *Pratylenchus brachyurus*, *Helicotylenchus multicintus*, *Rotylenchulus reniformis*, *Paratrichodorus minor* and *Tylenchulus semipenetrans*, respectively (Table 2).

Similarly, nematode population (*Meloidogyne* spp. and *Pratylenchus brachyurus*) recovered from one gram root samples was low in *M. pruriens* and *T. diversifolia* (8 and 5) and (16 and 12) respectively, but high for the control treatment (117 and 92), respectively (Table 3). From the tomato bioassay test conducted at harvest, significantly low ($P = 0.05$) gall index of 0.5 was recorded for both *M. pruriens* and *T. diversifolia* while a high of 8.8 was recorded for the control treatment (Table 1). The performance of *M. pruriens* was not significantly different from *T. diversifolia* but was different from the clean fallow and the control treatments.

Table 1: Root gall index (0-10) of tomato bioassay at start and end of experiment.

Treatment	Indices	
	Start	End
<i>Tithonia diversifolia</i>	6.8 (2.6) ‡	0.5 (0.4)
<i>Mucuna pruriens</i>	7.3 (2.7)	0.5 (0.4)
<i>Solanum lycopersicum</i> (control)	7.0 (2.6)	8.8 (3.0)
Clean fallow	5.5 (2.4)	5.5 (2.40)
Mean	5.7	3.8
Lsd	(0.2)	(0.9)

Data are means of four replications, ‡ $\sqrt{x + 0.5}$ transformed data used in ANOVA in parenthesis

Table 2: Mean nematode population density / 200 ml soil at harvest.

Treatment	Meloi	Praty	Heli	Roty	P'tri	Tyl
<i>Tithonia diversifolia</i>	68 (1.7)*	42 (1.6)	18 (1.4)	65 (1.9)	15 (1.6)	15 (1.6)
<i>Mucuna pruriens</i>	49 (1.6)	42 (1.6)	8 (0.8)	20 (1.3)	27 (1.6)	13 (1.6)
<i>Solanum lycopersicum</i>	166(2.2)	227(2.3)	21 (1.4)	125(2.0)	54 (1.6)	17 (1.6)
Clean fallow	143(2.1)	138(2.1)	30 (1.6)	200(2.3)	5 (0.6)	13 (1.6)
Mean	106.5	112.3	19.1	102.5	25.1	14.5
Lsd	(0.5)	(0.4)	(0.3)	(0.4)	(0.4)	(0.4)

Data are means of four replications

* $\ln(x + 1)$ transformed data used in ANOVA in parenthesis

Meloi = *Meloidogyne* spp. Praty = *Pratylenchus brachyurus* Heli = *Helicotylenchus multicintus*

Roty = *Rotylenchulus reniformis* P'tri = *Paratrichodorus minor* Tyl = *Tylenchulus semipenetrans*

Table 3: Mean nematode population density / g root at harvest.

Treatment	<i>Meloidogyne</i> spp.	<i>Pratylenchus brachyurus</i>
<i>Tithonia diversifolia</i>	16 (1.2)*	12 (1.2)
<i>Mucuna pruriens</i>	8 (0.8)	5 (0.8)
<i>Solanum lycopersicum</i>	117 (2.1)	92 (1.9)
Mean	47	36
Lsd	(0.5)	(0.4)

Data are means of four replications

* $\ln(x + 1)$ transformed data used in ANOVA in parenthesis

DISCUSSION

In the absence of decision guidelines based on damage functions, economic thresholds and bio monitoring, growers of many crops are unwilling to face the risk of not using chemical treatments (UNEP, 1994). However, environmental degradation and risk to human lives among other factors negate the merits of chemical nematicides. Isothiocyanates and glucosinolates from Brassicaceae have been reported to be nematicidal (Halbrendt, 1996). The production and active release of toxic substances while an antagonistic plant is growing is usually responsible for control (Sikora *et al.*, 2005).

In the current study, *M. pruriens* and *T. diversifolia* were antagonistic while tomato was a favorable host to nematode pests. The potential of *M. pruriens* and *T. diversifolia* in controlling plant parasitic nematodes was demonstrated by recording significant population reduction over the control treatment. A similar trend was observed in nematode populations recovered from the root samples. Of the two endoparasitic nematodes recovered, *Meloidogyne* spp. and *Pratylenchus brachyurus*, *M. pruriens* reduced populations by 93 and 95% while *T. diversifolia* reduced populations by 86 and 87% over the control treatment respectively. The efficacy of *M. pruriens* and *T. diversifolia* was further demonstrated in the tomato bioassay test conducted at harvest. The antagonistic activity of *Mucuna* might be due to the production of phytoalexins by the roots

(Vargas *et al.*, 1996). On the other hand, the nematotoxic potential of *T. diversifolia* might be attributed to the presence of terpenoids in the plant (Ragasa *et al.*, 2007). Soil samples from plots grown with *M. pruriens* and *T. diversifolia* recorded 94% gall reduction over the control treatment at harvest. Mulching suckers with 5.0 kg of *T. diversifolia* leaves caused significant nematode reduction in plantains (Akinyemi *et al.*, 2009).

To realize the benefits of the antagonistic plants, a rotation system is recommended. *M. pruriens* and *T. diversifolia* could be cultivated first and harvested before the cultivation of an economic crop. This strategy would reduce the incidence of plant parasitic nematodes infection on fields. The strategy is cost effective and more importantly, environmentally friendly. Being a legume, *M. pruriens* has the potential of fixing atmospheric nitrogen into the soil system and as a trailing plant, has an added advantage of smothering weeds and checking the effects of soil erosion. The employment of antagonistic plants in the management of plant parasitic nematodes in Ghanaian farming systems would circumvent the dangers of environmental degradation. The prospect of adoption of the strategy is high as the plants are readily available and no special skill is needed for its implementation.

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