ORGANIC SOIL AMENDMENTS IN NEMATODE MANAGEMENT IN YAM PRODUCTION

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ABSTRACT

Osei, K, E. Otoo, Y, Danso, J. Adomako, A. Agyeman and J. S. Asante. 2013 Organic soil amendments in nematode management in yam production. Nematropica 43:78-82.

The potentials of organic soil amendments (OSA) to control plant parasitic nematodes (PPN) infection in yam production were evaluated in Ghana. The ability of organic soil amendments; neem (*Azadirachta indica* A. Juss) seed powder, cocoa (*Theobroma cacao* L.) bean testa powder and cowitch (*Mucuna pruriens* L.) seed powder to suppress PPN in yam were compared to Fulan (a synthetic pesticide) and a non-treated control. The organic soil amendments suppressed *Pratylenchus* and *Rotylenchulus* soil population densities compared to the control. *M. pruriens* also reduced soil populations of *Meloidogyne* and *Scutellonema* with reductions similar to nematicide application. Only *M. pruriens* reduced population densities of plant parasitic nematodes in yam tubers compared to the control. There were no differences in yield. *Mucuna pruriens* treated plots yielded 32.1 t/ha while the control yielded 17.4 t/ha. In terms of relative yield, *M. pruriens* treated plots were 1.84 times higher than the control. The application of organic materials may be sufficient to keep some nematode populations below the economic threshold level.

Key words: Dioscorea rotundata, Ghana, nematodes, organic soil amendments.

RESUMEN

Osei, K, E. Otoo, Y, Danso, J. Adomako, A. Agyeman and J. S. Asante. 2013. Enmiendas orgánicas para el manejo de nematodos en la producción de ñame. Nematropica 43:78-82.

Se evaluó el potencial del uso de enmiendas orgánicas para el control de nematodos fitoparásitos en la producción de ñame en Ghana. Se comparó la eficacia de enmiendas orgánicas; polvo de semilla de neem (*Azadirachta indica* A. Juss), polvo de testa de granos de cacao (*Theobroma cacao* L.), y polvo de semilla de mucuna (*Mucuna pruriens* L.) en el control de nematodos fitoparásitos en ñame, comparados con Fulan (un pesticida sintético) y un control negativo. Las enmiendas orgánicas controlaron las densidades de población de *Pratylenchus* y *Rotylenchulus* en el suelo de manera similar al control positivo. El polvo de mucuna también redujo las poblaciones de *Meloidogyne* y *Scutellonema* en el suelo de manera similar al nematicida. Sólamente *M. pruriens* redujo las poblaciones de nematodos fitoparásitos en los tubérculos de ñame. No se observaron diferencias en la productividad. Los lotes tratados con *M. pruriens* produjeron 32.1 t/ha mientras que los lotes no tratados produjeron 17.4 t/ha, loc ual corresponde a un aumento relativo de 1.84 veces en la producción. La aplicación de estas enmiendas puede ser sufiente para mantener las poblaciones de algunos nematodos fitoparásitos por debajo de niveles de umbral económico.

Palabras clave: Dioscorea rotundata, enmiendas orgánicas, Ghana, nematodos.

INTRODUCTION

Plant parasitic nematodes are a major constraint to agricultural production worldwide (Rubino *et al*., 2008). Tropical conditions mediated by high temperatures as found in Ghana, favour high reproduction rates of nematodes (Luc *et al*., 2005) and correspondingly high yield losses may be incurred. Therefore, for sustainable food production these poikilothermic pests must be managed. Yam, *Dioscorea* spp. is the second most important root and tuber crop in the world and contributes more than 200 dietary calories everyday for over 60 million people (Nweke *et al*., 1991). In Ghana, yams are used in the preparation of local dishes. The two most cherished dishes are "fufu" (yam pounded into a thick paste after boiling) and eaten with soup and "ampesi" (boiled yam) eaten with sauce. Besides nutritional significance, yam has pharmaceutical properties. For instance, diosgenin, a steroidal saponin is extracted from the root of wild yam, *D. villosa* L. with the potential to minimize post-menopausal symptoms (Benghuzzi *et al*., 2003). Yam is extensively produced in West Africa where they are steeped in cultural history and revered as a cultural symbol of fertility (Bridge *et al.*, 2005). In the West African country of Ghana, large-scale cultivation of the crop is in the Afram plains, the three northern, Brong Ahafo and Ashanti regions (Osei *et al*., 2004). Production of the crop offers employment for people. There is ready market for the crop as there is a high demand on both the local and export markets. In Ghana, yams can be mono-cropped but are more often intercropped. Selection of intercrops might influence the diversity and density of pests. Inter-cropping yam with crops highly susceptible to *Meloidogyne* spp. such as okra, *Abelmoscus esculentus* (L.) Moench. and pumpkin, *Cucurbita pepo* L. increases the damage to yam tubers by *M.incognita* (Kofoid & White) Chitwood (Atu and Ogbuji, 1986).

Yams are generally susceptible to plant-parasitic nematodes. The most economically important nematode pests include: the yam nematode, *Scutellonema bradys* (Steiner& Le Hew) Andrássy; the lesion nematode, *Pratylenchus coffeae* Zimmermann; the root-knot nematode, *M. incognita,* and; the reniform nematode, *Rotylenchulus reniformis* Linford & Oliveira. Generally, these nematode pests cause dry rot in yam tubers, flaking off of epidermis, galls and cracks on tubers, a corky appearance, unsightly tubers and general loss in yield (Bridge *et al*., 2005; Moura, 1997). Thus, nematode infection affects productivity, quality and commercial value of yam (Moura, 1997; Garrido *et al*., 2003). Synthetic chemicals remain the most effective management strategy but they are expensive and more importantly can impact the environment negatively (Bell, 2000; Bakker, 1993). Crop rotation will always be a difficult strategy to implement because of the wide host range of nematode species (Sikora and Fernandez, 2005). Organic soil amendments (OSA) have been reported to possess nematicidal properties *in vitro* and *in vivo* (Hassan *et al*., 2010), and also have the potential to increase the yields of crops significantly (Parr *et al.*, 1989). A field trial was therefore conducted at Ejura (forest-savanna transitional zone of Ghana) to evaluate some organic amendments for their ability to suppress nematodes and to improve yield of yam.

Neem is a fast-growing tropical evergreen tree in the family Meliaceae and native to India. It can reach a height of 15-20 metres. Oil extracted from the seed has insecticidal and medicinal properties. *Theobroma cacao* is a small evergreen tree in the family Malvaceae which can reach a height of 4-8 metres. Its seeds are used for cocoa powder and chocolate. Cowitch is a tropical climbing legume found in Africa, India and the Caribbean. The plant is infamous for the extreme itchiness it produces on contact, particularly with the seed pods. It is used as a cover crop in some farming systems. *Theobroma cacao* is an economic crop cultivated in Ghana while neem and cowitch grow in the wild. The organic amendments of these three plants were used because they are readily available and have other benefits to mankind.

MATERIALS AND METHODS

Field trials were conducted in the major rainy seasons at Ejura, Ejura Sekyedumasi District of the Ashanti Region, Ghana. Ejura is located on (07º 24′N 01º 21′W) in the forest-savanna transitional zone. Yam is extensively cultivated at the location which experiences a bimodal rainfall pattern. The soil type at this site is a "Amantin series" Chromic Lixisol (Adu, 1992).

Five treatments were evaluated: neem, *Azadirachta indica* A. Juss seed powder, cocoa, *Theobroma cacao* L. bean testa powder and cowitch, *Mucuna pruriens* (L.) DC. seed powder; Fulan (2,5-Dimethoxytetrahydrofuran distributed by Sigma-Aldrich), a synthetic pesticide and a non-treated control were replicated three times in a randomized complete block design (RCBD) and the experiment was conducted twice (2010 and 2011). Yam setts cv. Leelee each averaging 350 g were planted in mounds with 20 mounds in a 20 x 20 m plot area. Yam setts were tested for presence of plant-parasitic nematodes prior to planting. The OSA were applied at the rate of 30g/mound and Fulan was applied at 10g/mound. Treatments were placed in the hole in the mound and covered with a little soil before placing the yam sett which was properly covered with soil. Fertilizers were not applied. The trial was manually weeded three times before harvesting. Harvest of tubers was eight months after planting and accomplished with the aid of hoe and cutlass (machete). Yield of yam was expressed as weight of produce per plot area and later converted to tons/ha.

Soil samples were collected twice, at the beginning were uprooted; roots were carefully washed with water and observed under a stereoscopic microscope for the of the trial before planting and at harvest. Soil samples (200 cm^3/mound) were randomly collected with a 2.5 cm diam soil probe to a depth of 20 cm from the mounds. Three soil cores were collected from each mound. Five gram tuber peel samples were also collected and processed for nematodes from the setts at planting and at harvest. Three tubers per plot were peeled for extraction. Nematodes were extracted from soil and peel samples using the modified Baermann funnel method. After 24 h of extraction, samples were fixed with TAF (Formalin-37% Formaldehyde 7.6 ml, ri-ethylamine 2 ml and distilled water 90.4 ml) and second, third and fourth stage nematodes were mounted on aluminium double-coverglass slides and specimens were identified (CIH, 1978) by morphology. Plant parasitic nematode population data are xpressed as number of nematodes/200 cm3 soil and number of endo-parasitic nematodes population/5 g of tuber peel.

The two years data (2010 and 2011) was analyzed using the mixed model (REML) approach. Yield (kg) of yam being continuous data was not transformed. Nematode count data however was log transformed (ln (x +1)) to improve homogeneity of variance before analysis using GenStat 8.1 (Lawes Agricultural Trust, VSN International). Means were separated using Fisher's Least Significant Difference (LSD) at $\alpha = 0.05$.

RESULTS

From initial soil samples, four parasitic nematode taxa all of them belonging to the Order Tylenchida were identified. The nematodes in order of abundance were: *Pratylenchus coffeae* > *Meloidogyne* spp. (juveniles) > *Rotylenchulus reniformis* > *Scutellonema bradys*. Yam setts used for planting were not infested with endoparasitic nematodes as yam tuber peel samples did not contain nematodes (data not presented).

Plant parasitic nematodes were differentially affected by the treatments. *Meloidogyne* and *Scutellonema* were reduced by *M. pruriens* and Fulan compared to the control (Table 1). This reduction was also significant compared to Neem and cocoa bean for *Meloidogyne*. All of the OSA and Fulan reduced soil population densities of *Pratylenchus* and *Rotylenchulus* compared to the control, however, for *Rotylenchulus* the reduction by Neem was less than that of *M. pruriens*, cocoa and Fulan.

None of the treatments reduced *Scutellonema* population densities in tubers compared to the control. There was a significant reduction in *Meloidogyne* population densities in tubers by *M. pruriens* and Fulan compared to the other treatments; this reduction was greater by Fulan compared to *M. pruriens*. *Mucuna pruriens* and Fulan also reduced population densities of *Pratylenchus* in tubers compared to the control and cocoa, but not to Neem. While the yields of yam were higher in all treatments compared to the control, this difference was not significant.

DISCUSSION

The results of the present study were in consonance with previous workers as OSA suppressed nematode populations both in soil and tuber samples. For instance, *M. pruriens* resulted in significant population reduction of 62, 75, 71 and 72% over the control in *Meloidogyne* spp., *P. coffeae*, *S. bradys* and *R. reniformis* respectively. In a related experiment in Nigeria, *M. pruriens* used as cover crop significantly suppressed *S. bradys* populations in yam tubers and plots compared with plots without cover crops (Claudius-Cole *et al.*, 2003). Similarly, cocoa bean testa and neem resulted in population reductions (67, 54 and 65) and (59, 58 and 55%) over the control in P. *coffeae, S. bradys* and *R. reniformis* respectively. In an in vitro experiment, cocoa bean testa aqueous extract inhibited hatching of *M. incognita* eggs (Osei *et al*., 2011). Neem on the

Table 1. Plant parasitic nematode population/200 cm^3 soil at harvest in yam.

Treatment	*Meloidognye spp.*	*Pratylenchus coffeae*	*Scutellonema bradys*	*Rotylenchulus reniformis*
Mucuna pruriens	133 (2.1)*c	128 (2.1) b	88 (1.9) b	74 (1.8) c
Fulan	115 (1.9) d	136 (2.1) b	92 (1.9) b	91 (1.9) c
Neem	243 (2.3) a	210 (2.3) b	128 (2.1) ab	118 (2.0) b
Cocoa bean testa	163 (2.2) ab	167 (2.2) b	141 (2.1) ab	92 (1.9) c
Control	346 (2.5) a	508 (2.7) a	305 (2.5) a	261 (2.3) a
P value	(0.003)	(<0.001)	(<0.001)	(0.002)
Lsd	(0.3)	(0.2)	(0.2)	(0.2)
Cv (%)	(4.1)	(6.6)	(3.1)	(1.6)

*Log transformed ln (x + 1) data used in analysis in parenthesis. The values are means of three replicates. The values followed by the same letter (s) in a column are not different according to the Fisher's Least Significance Difference (LSD) test.

Table 2. Endo-parasitic nematodes population/5 g yam peel at harvest.

Treatment	*Meloidognye spp.*	*Pratylenchus coffeae*	*Scutellonema bradys*
Mucuna pruriens	21 (1.2)*c	30 (1.4) b	34 (1.5) a
Fulan	13 (1.0) d	20 (1.3) b	13 (1.0) ab
Neem	34 (1.0) a	39 (1.5) ab	29 (1.4) a
Cocoa bean testa	45 (1.6) ab	51 (1.7) a	32 (1.4) a
Control	78 (1.8) a	93 (1.9) a	47 (1.6) a
P value	(<0.001)	(0.003)	(0.003)
Lsd	(0.2)	(0.3)	(0.2)
Cv (%)	(1.7)	(2.5)	(1.4)

*Log transformed log10 (x + 1) data used in analysis in parenthesis. The values are means of three replicates. The values followed by the same letter (s) in a column are not different according to the Fisher's Least Significance Difference (LSD) test.

Table 3. Effect of organic soil amendments on the yield (t/ha) of yam.

Treatment	Mean yield	Relative yield
Mucuna pruriens	32.1	1.84
Fulan	27.8	1.60
Neem	23.3	1.34
Cocoa bean testa	29.5	1.70
Control	17.4	1.00
P value	0.62	
Lsd	31.3	
Cv (%)	10.3	

Un-transformed data. The values are means of three replicates. The relative yield equals the ratio of a particular treatment on the least yielding in this case, the control.

other hand has been reported to possess nematicidal properties (Akhtar and Mahmood, 1996). Mulching has been reported to generally reduce nematode populations compared with preplanting levels in soil (IITA, 1976). *Mucuna pruriens* performance was not different from the synthetic pesticide, Fulan which resulted in pest reduction of (68, 73, 70 and 65%, respectively, over the control. In Nigeria, granular oxamyl at rates of 3 or 6 kg a.i./ha applied at planting controlled *M. javanica* on *D. rotundata* (Badra *et al*., 1980).

Nematode populations recovered from tuber peels followed a similar trend. *Mucuna pruriens* treated samples resulted in significant population reduction of (73, 68 and 28%) respectively over the control. All three OSA possessed different concentrations of nematotoxic properties with M. pruriens being the most efficient candidate which was not different from the synthetic pesticide, Fulan. Nogueira *et al.* (1996) reported that triacontanol and tricontanyl tetracosanoate in *M. pruriens* might be responsible for the nematode suppression activity, while the nematicidal potential of neem might be due to the presence of Azadirachtin (Akhtar and Mahmood, 1996). Perhaps, cacao the active ingredient in cocoa bean might possess nematicidal potential which conferred suppressive activity on nematode populations compared with untreated samples.

The OSA reduced nematode population densities but did not increase the yield of yam. The highest yield of 32.1 t/ha observed in *M. pruriens* treated samples was not significantly different from 17.4 t/ha observed in the control treatment. However, in terms of relative yield, *M. pruriens* treated samples were 1.84 times better than the control treatment.

The study would introduce the scientific community to the nematicidal potential of the organic amendments employed while yam growers on the other hand would have a cheaper and environmentally safe option of managing plant parasitic nematodes.

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