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Full Length Research Paper

Managing nematode pests and improving yield of pineapple with *Mucuna pruriens* in Ghana

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We investigated the potentials of a non-traditional legume crop, *Mucuna pruriens* and fallow treatments in managing plant parasitic nematodes population and improving the yield of pineapple in 2008 to 2009 at Asamankese in the Eastern region of Ghana. Nematode population density/200 cm^3 soil at 6 months of application of treatments and at harvest, population/g^{-1} of pineapple root and yield of pineapple were analysed. *M. pruriens* reduced nematodes population and improved the yield of pineapple considerably. At harvest, rhizosphere soil from pineapple cultivated on bush fallow treated plots recorded significantly P = 0.05) higher populations: 76, 211, 100 and 68 for *Helicotylenchus multicintus, Meloidogyne* (juveniles) spp., *Pratylenchus brachyurus* and *Rotylenchulus reniformis,* respectively while soil from pineapple on weed free-*M. pruriens* treated plots recorded lower populations: 39, 50, 64 and 31 representing population reduction of 95, 322, 56 and 119%, respectively. Three nematode species: *Meloidogyne* spp., *P. brachyurus* and *H. multicintus* were recovered from pineapple roots at harvest in which the nematicidal potential of *M. pruriens* was further demonstrated. While significantly (P < 0.01) higher populations (165, 89 and 61) of *Meloidogyne* spp., *P. brachyurus* and *H. multicintus* were recovered from the bush fallow treated pineapple roots, lower populations (39, 35 and 24) of the pests were recovered from weed free-*M. pruriens* treated pineapple roots, respectively. Thus, *M. pruriens* reduced populations by 323, 154 and 154%, respectively. The yield improvement potential of *M. pruriens* was manifested when the main pineapple crop from weed free-*Mucuna* plots recorded 51 t/ha, whilst a bush fallow treatment recorded 34 t/ha out-yielding the bush fallow treatment by 50%. The use of higher plants in managing nematodes and improving yield of crops is environmentally acceptable and sustainable.

Key words: *Ananas comosus*, horticultural crop, plant parasitic nematodes, sustainable agriculture.

INTRODUCTION

Pineapple (*Ananas comosus* L. (Merr.) is an important horticultural crop cultivated for export in the southern part of Ghana. The smooth cayenne cultivar is the most largely cultivated in the Eastern and Greater Accra regions, while the sugar loaf dominates the Central region (Trienekens, 2003). Major production of the crop, especially for the export market is done in the Eastern, Central, Greater Accra and Volta regions. The role of fruits and fruit juices in nutrition and health cannot be overemphasised (Wardy et al., 2009). The pineapple fruit supplies significant amount of vitamins and minerals necessary for healthy growth. In Ghana, local industries process pineapple into fruit juice, oven-dried, salad and jam. The pineapple industry is a source of income and offers employment to a majority of people in southern Ghana (HEII, 2006). It is among the top-five non-traditional export commodities in terms of foreign earnings in Ghana (Wardy et al., 2009). Current Ghana's export earnings of pineapple hovers around 32 million dollars a year. Two of the major constraints to the production of pineapple are infertile soils and the menace of plant parasitic nematodes. Three species of nematodes: the root–knot nematodes, *Meloidogyne* spp., the reniform nematode, *Rotylenchulus reniformis* and the root lesion nematode, *Pratylenchus brachyurus* are of the greatest economic importance (Spies et al., 2005). These pests delay leaf emergence and reduce leaf

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weight (Sarah, 1986), cause stunted growth and generally reduce pineapple yield significantly (Spies et al., 2005). In Ghana, management of nematode pests has relied extensively on the use of agro-chemicals (nematicides). Similarly, the improvement of soil fertility has been largely through chemical fertilizer usage. De-greening of pineapple is done with chemicals such as ethrel which is the most commonly used ethephone product in Ghana. Ethephon is an organophosphate and placed in the US EPA's top toxicity category. Indiscriminate use of agro-chemicals is an abuse of the environment and the price associated with this system of farming is really high. More importantly, the future of the pineapple industry is bleak because the new legislation on Minimum Residue Levels (MRLs) in the European Union (EU) will reject imports of produce with residue of pesticides not approved under its regulations (Gogoe et al., 2001). The purpose of this paper was to find a sustainable system of pineapple production by divorcing the over reliance on synthetic chemicals method of production and marrying the organic system of production. The improper use of synthetic products constitutes an assault on the environment and the practice should be discontinued. An experiment was therefore conducted at Asamankese in the Eastern region of Ghana, to evaluate *Mucuna pruriens* and fallow treatments for their nematode suppression and yield increasing potentials in pineapple production.

MATERIALS AND METHODS

Treatments and experimental design

A two factor experiment mounted on randomized complete block design was conducted to assess the potential of treatments at reducing plant parasitic nematodes population and their effect on yield of pineapple. The factors were four land preparation methods which were the main plot treatments and seed bed preparation methods (the sub plots). The main plot treatments were: weed free-*M. pruriens* (*M. pruriens* was cultivated and weeds controlled), clean fallow (plots were weeded whenever the weed free-*Mucuna* plots were weeded), unweeded-*M. pruriens* (*Mucuna* was cultivated but weeds were not controlled) and bush fallow (plots were not weeded at all). The sub plot treatments were, planting on ridges with plastic mulch, planting on ridges without plastic mulch and planting on the flat. The land preparation methods and the main plots, lasted for five months (April to September, 2008) before the seed bed preparation methods, the sub plots were superimposed. The treatments were replicated three times. A plot measured 5 x 4 m.

Experimental site

The experiment was conducted at Asamankese in the Eastern region of Ghana. The prominent weed on the experimental site was *Setaria* spp. The experimental plot had previously been cultivated with pineapple cv. smooth cayenne in 2005 and the current study started in April 2008. The cultivar used in the current study was smooth cayenne which was planted at a double row spacing of 30 x 30 cm. Hand weeding was done six times before harvesting the main crop.

Sampling and extraction

Soil samples were collected at three time periods; at the start of the trial before the planting of *M. pruriens*, six months of application of treatments and at harvest of the main crop with a 5 cm soil auger to a dept of 20 cm. The samples (200 cm^3) per treatment were extracted using the modified Baermann funnel method. Nematodes were also extracted from one gram pineapple roots per treatment at harvest. After 24 h of extraction, samples were fixed with TAF and nematodes were identified under a stereo microscope at magnification 100x. Yield data was not transformed but nematode based data was log transformed (ln (x+1)) to conform to the assumption of normal distribution before analysis using Genstat 8.1. Means were separated using Duncan's multiple range test (DMRT).

RESULTS

From the initial soil samples assayed, nematodes were found on all the plots. In all, eight species were encountered. The nematodes in order of abundance were; *Meloidogyne* (juveniles) spp. > *H. multicintus* > *P. brachyurus* > *R. reniformis* > *Tylenchulus semipenetrans* > *Hoplolaimus* spp. > *Xiphinema* spp. > *Paratrichodorus minor.* The last two nematodes transmit plant viruses. Of the eight nematodes extracted from the soil samples, *Meloidogyne* spp., *P. brachyurus* and *R. reniformis* are the most pathogenic on pineapple.

Five plant parasitic nematodes namely; *H. multicintus, Meloidogyne* spp., *P. brachyurus, R. reniformis* and *T. semipenetrans* reacted differently to the treatments six months after application (Table 1). There was no interaction between weed free- *Mucuna pruriens* and planting on ridges with plastic mulch regarding the management of the five plant parasitic nematodes. However, weed free-*M. pruriens* treatment significantly ($P < 0.01$) reduced population of *H. multicintus* and *T. semipenetrans* than the clean and bush fallow treatments. Weed free-*M. pruriens* treatment was also different from the unweeded- *Mucuna pruriens* treatment. Similarly, unweeded-*Mucuna pruriens* treatment was not different from the fallow treatments in reducing the population of *H. multicintus* and *T. semipenetrans*.

Weed free-*M. pruriens* treatment was significantly effective in reducing the population of *Meloidogyne* spp., *P. brachyurus* and *R. reniformis* than the other treatments, except unweeded-*M. pruriens* treatment. Unweeded-*M. pruriens* treatment was also different from the two fallow treatments.

No interactions were observed between the main plots and the sub plots treatments at harvest. *T. semipenetrans* encountered six months of application of treatments was never found in soil samples. In root samples, three species *Meloidogyne* spp., *P. brachyurus* and *H. multicintus* were recovered. In both soil and root

Table 1. Nematode population density/200 cm^3 of soil six months after application of treatments.

Treatments	Nematodes				
	Heli	***Meloi*** ^{z}	***Praty***	***Roty***	***Tyl***
Weed-free *Mucuna*	52(3.3) ^{y}a	34(3.0)a	49(4.2)a	51(4.2)a	57(4.0)a
Unweeded *Mucuna*	66(4.5)b	63(4.4)a	64(4.4)a	67(4.2)a	80(4.5)b
Clean fallow	108(4.4)b	143(4.7)b	129(4.6)a	162(4.4)b	100(4.6)b
Bush fallow	222(4.6)b	283(4.7)b	216(4.9)b	365(4.7)b	168(4.6)b
Grand mean	4.1	4.2	4.4	4.6	4.4
Lsd at P <0.01	0.4	0.4	0.5	0.3	0.2

Values following different letters in a column are significant at P < 0.01.z, Juveniles; ^{y}ln (x + 1) transformed data used in ANOVA in parenthesis. *Heli: H. multicintus.; Meloi: Meloidogyne* spp.; *Praty: P. brachyurus; Roty: R. reniformis; Tyl: T. semipenetrans.*

Table 2. Nematode population density/200 cm^3 of soil at harvest.

Treatments	Nematodes			
	Heli	***Meloi*** ^{z}	***Praty***	***Roty***
Weed-free *Mucuna*	39(4.7)^{y}a	50(5.5)a	64(7.0)a	31(4.2)a
Unweeded *Mucuna*	53(6.2)ab	91(8.7)ab	74(7.7)a	42(5.0)ab
Clean fallow	59(7.1)ab	92(9.1)b	84(8.4)a	37(5.0)ab
Bush fallow	76(8.1)c	211(12.8)c	100(9.4)a	68(7.4)bc
Grand mean	6.5	9.0	8.1	5.4
Lsd at P = 0.05	0.8	1.7	2.0	0.9

Values following different letters in a column are significant at P = 0.05. ^{z}, Juveniles; ^{y}, ln (x + 1) transformed data used in ANOVA in parenthesis; *Heli: H. multicintus; Meloi: Meloidogyne* spp.; *Praty: P. brachyurus; Roty: R. reniformis.*

samples, results followed the same trend observed during six months of application of treatments (Tables 2 and 3). Weed free-*Mucuna* treatment significantly (P = 0.05 and P < 0.01) reduced the population density of *H. multicintus* and *Meloidogyne* spp., respectively than did in the two fallow treatments. However, the weed free-*Mucuna* was not different from the unweeded *Mucuna* treatment in soil samples at harvest. The clean fallow and the bush fallow treatments were different with many more *H. multicintus*, *Meloidogyne* spp. and *R. reniformis* found on bush fallow plots than the clean fallow plots (Table 2). In root samples, weed free-*Mucuna* treatment significantly (P < 0.01) reduced the population of *Meloidogyne* spp., *H. multicintus* and *P. brachyurus* than the fallow treatments (Table 3). Pineapple yield from weed free-*Mucuna* treated plots was a high of 51 t/ha, while the yield from bush fallow plots was a low of 34 t/ha (Table 4).

DISCUSSION

To prevent an assault on the environment, a sustainable agriculture should be promoted. The components of sustainable agriculture include integrated pest management (IPM) and integrated crop management (ICM). IPM emphasizes the growth of a healthy crop with the least possible disruption to the agro-ecosystems and encourages natural pest control mechanism. ICM on the other hand, involves managing crops profitably with respect for the environment, in ways which suit local soil, climatic and economic conditions. The conventional crop production system with the attendant indiscriminate use of agro chemicals is not sustainable. Not only would the environment be destroyed to the disadvantage of posterity, crops produced through this system would not be competitive on the world market. Nematicidal properties have been reported in many higher plants (Chitwood, 2002). *Tagetes erecta* cv. Crackerjack reduced the population of root-lesion nematodes, *P. penetrans* in carrots field (Kimpinski and Sanderson, 2004). The high yielding soybean cultivar “Padre” suppressed the population of reniform nematode, *R. reniformis* (Westphal and Scott, 2005). Also, *Arachis pintoi* reduced the galling of *Meloidogyne incognita* on tomato (Marban-Mendoza et al., 1992) and decreased *R. reniformis* numbers on coffee (Herrera and Marban-Mendoza, 1999). Castor bean, *Ricinus communis* has been successful in managing nematode populations (Hagan et al., 1998) and American joint-vetch,

Table 3. Nematode population density / g^{-1} root at harvest.

Treatments	Nematodes		
	Heli	***Meloi*** [z]	***Praty***
Weed-free *Mucuna*	24(4.6)[y]a	39(5.8)a	35(5.5)a
Unweeded *Mucuna*	35(5.6)ab	68(6.1)b	56(7.4)b
Clean fallow	58(7.2)b	97(9.7)c	83(8.7)bc
Bush fallow	61(7.2)b	165(12.7)d	89(9.2)c
Grand mean	6.2	8.6	7.7
Lsd at P < 0.01	1.0	0.1	1.3

Values following different letters in a column are significant at P < 0.01. [z]Juveniles; [y]ln (x + 1) transformed data used in ANOVA in parenthesis. *Heli: H. Multicintus; Meloi: Meloidogyne* spp.; *Praty: P. brachyurus.*

Table 4. Yield of pineapple.

Treatments	Yield (t/ha)
Weed free *Mucuna*	51a
Unweeded *Mucuna*	48a
Clean fallow	36b
Bush fallow	34b
Grand mean	42.1
Lsd at P <0.01	15

Values following different letters in a column are significant at P < 0.01.

Aeschynomene virginica and partridge pea; *Cassia fasciculata* significantly suppressed nematode population densities (Rodríguez-Kábana et al., 1991). Plants with the potential to suppress nematode populations by producing anti-helminthic compounds have been designated "antagonistic plants" (Pandey et al., 2003).

In the current study, *M. pruriens* established itself as an effective candidate in controlling nematode population build up and improving the yield of pineapple. At harvest, the weed free-*Mucuna* treatment reduced the populations of *H. multicintus, Meloidogyne* spp., *P. brachyurus* and *R. reniformis* by 95, 322, 56 and 119% over the bush fallow treatment, respectively**.** The effectiveness of *M. pruriens* was greatest at six months after the application of treatments as weed free-*Mucuna* treatment reduced the populations of the four nematode pests by 327, 732, 341 and 616% over the bush fallow treatment, respectively. Nematode population extracted from pineapple roots at harvest further demonstrated the nematicidal potential of *M. pruriens*. Populations of *Meloidogyne* spp., *P. brachyurus* and *H. multicintus* recovered from roots from weed free-*Mucuna* plots represented significant reduction of 323, 154 and 154% over the bush fallow treatment, respectively. Results were consistent with the findings of Quénéhervé et al. (1998) who used *M. pruriens* to effectively control *M. incognita* and *R. reniformis* in vegetables in France. It was observed from the results that, the effectiveness of *M. pruriens* on soil samples populations reduced with time. A probable explanation might be that, the active ingredients in *M. pruriens* diluted with time. It has also been reported that, the antagonistic activity of *Mucuna* might be due to the production of phytoalexins by the roots (Vargas et al., 1996). Some tropical legumes have demonstrated their ability to increase crop yields (Kumbhar et al., 2007) perhaps due to their potential to positively enhance the nitrogen economy of soils (Giller, 2001). Becker and Johnson (1998) reported that, *Mucuna* spp. *Canavalia ensiformis* and *Crotalaria anagyroides* significantly increased upland rice yield in the Ivory Coast. Also, the growth and yield of okra following *M. pruriens* resulted in a significant 48% yield increase over the control and *Phaseolus vulgaris* treatments in Ghana (Osei et al., 2010). In addition to nematode suppression and yield improvement, some legumes have the potential to control insect pests. Rotenone extracted from the roots of tropical legumes, *Lonchocarpus* and *Derris* control insect pests such as aphids, beetles, fleas and lice by inhibiting cellular respiration (Buss and Park-Brown, 2009) . In the current study, *M. pruriens* not only suppressed populations of plant parasitic nematodes but also increased the yield of pineapple significantly. Weed free-*Mucuna* treatment out yielded the bush fallow treatment by 50%.

Conclusions

Antagonistic plants have a significant role in integrated pest management. Where the antagonistic plant is a leguminous crop, capable of replenishing the fertility status of the soil, then the results of the biotrophic system (host plant–nematode interaction) becomes more rewarding. The fast growing *M. pruriens* is capable of controlling soil erosion, suppressing weed growth and providing hay for livestock.

More importantly, *Mucuna* is used for food in some African countries (Rachie and Roberts, 1974) . The Ghanaian farmer should consider the incorporation of the versatile *M. pruriens* in his farming system. The cost effectiveness, environmental friendliness and product acceptability especially in the international trade render the system sustainable.

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