Original Research Article

Nematicidal Properties of *MoringaOleifera, Chromolaena Odorata*and *Panicum maximum* and their Control Effects on Pathogenic Nematodes of Yam

ABSTRACT

A field study was conducted at Atonsu, Sekyere Central District, Ghana from 2013 to 2014, to (i) determine the effects of *Moringa oleifera,Chromolaena odorata* and *Panicum maximum*as ex-situ mulches,on soil nematodes population after two years ofyam cropping and (ii) assess the effects of the soil nematodes on the yield and physical tuber quality of yam. The field experiment was a 3x3 factorial arrangement in a randomized complete block design (RCBD) with three replications. The first factor was ex-situ mulch types at three levels; *Panicum maximum* (farmers' choice), *Chromolaena odorata* and *Moringa oleifera*. The second factor was natural fallow aged systems at three levels:i.e.3, 5 and 7 years old. Data collected included nematode population changes, total tuber yield of yam and tuber physical quality assessment. Generally,*Meloidogyne spp., Pratylenchus spp.,* and *Scutellonema spp.* were the nematode typesidentified. However, *Scutellonema spp.* was found to be the most pathogenic nematode affecting yam tuber yield and physical quality. *Chromolaena* and *Moringa* mulches suppressed *Scutellonemaspp.*populations by 80.7% and 76.2% respectively as compared to the *Panicum maximum* mulch. The suppressed *Scutellonemaspp.* population significantly contributed to higher tuber yields and good tuber physical quality under the *M. oleifera* and *C. odorata* mulches in comparison to the *P. maximum* mulch.

Keywords: nematodes populations, yam, tuber physical quality, ex-situ mulches, tuber yield

INTRODUCTION

Across West and Central Africa, yam plays key roles in the economy, food and livelihoods[1]. For instance in Nigeria, yam contributes 12% to the AGDP [2]with about sixtymillion people depending on it for food and livelihood. In Ghana, yam's contribution to the AGDP is 16 percent [3, 4] and serves as a famine reserve- and cash-crop for resource poor farmers [5].

In world export trade, Ghana,Costa Rica and USAare thethree largest exporters of yam accounting for about 70% of global trade [6]. It has been estimated that an average of over 25% of the yield of yam is lost annually due to diseases and pest, particularly nematodes[7]. These nematodes cause not only a reduction in yam yields but also a profound physical damage to yam tubers thereby rendering them unappealing to consumers and subsequently commanding a very low market value [8]. Earlier reports indicate that yam tubers are significantly damaged by three major nematode species, namely, *Scutellonema spp.Meloidogyne* spp. and *Pratylenchuscoffeae*[9, 10, 11, 12, 13]. These nematode genera are predominant in West and Central Africa and therefore have profound influence on yam tuber yields and physical quality[14]. For instance, *Scutellonema spp.*damage is characterized by the rotting of the tuber to depths of about 2 cm into the tuber[15, 16].[17] reported that *Scutellonema spp.*is very difficult to control because a wide range of other crops and some weeds support its populations. In spite of this drawback, the control of *Scutellonema spp.* is essential to the improvement of yam yields and its subsequent tuber physical quality. There are reports to suggest that the leaves of *M. oleifera* and *C. odorata* possess nematicidal properties for the control of *M. incognita* and *M. javanica* in eggplant and cowpea production resulting in their increased yields[18, 19]. However there is a dearth of such information on other pathogenic nematodes and on other crops.

The objectives of the present study therefore were to (i) determine the effects of *Moringa oleifera,Chromolaena odorata* and *Panicum maximum* as ex-situ mulches, on soil nematodes population after two years of yam cropping and (ii) assess the effects of the soil nematodes on the yield and physical tuber quality of the yam.

MATERIALS AND METHODS

Experimental locations, design and procedure

The studywas carried out at Atonsu villagewhich had a good representation of all the three natural fallow ages ~~viz~~: 3, 5 and 7 year that would be used. The 3 and 5 years old natural fallows were previously cropped to cowpea and cassava, respectively, whiles the 7-year old natural fallow was previously cropped to cocoyam.

The experimental design was a 3 x 3 factorial arrangement in randomized complete block with three replications. The first factor was natural fallow age at three levels, namely, 3, 5 and 7 year. The second factor was mulch type at three levels comprising, *Chromolaena* *odorata* mulch, *Moringa oleifera* mulch and *Panicum maximum* mulch (control -farmer practice). The plot size within each natural fallow age system was 5 m x 4 m with an experimental area of 2,000 m^2 (50 m x 40 m).

Preparation of ridges, plots demarcation and all other cultural practices were done in accordance with the methodology of [4]. The inter-ridge spacing was 1 m whiles the inter-plot spacing was 3 m.

Yam (*Dioscorea rotundata* var. Puna) setts with uniform size and a mean weight of 250 g were planted on the ridges at a spacing of 1 m x 0.5 m. There were 36 plants per plot (18,000 plants ha^{-1}). Two croppings were done over the study period, namely, in 2013 and in 2014.

All three mulch types were applied at a rate of 0.5 kg $plant^{-1}$ (10 t ha^{-1}) in both years of cropping. There were two applications of each mulch type during each cropping period. The first application was done 28 days after planting of yam whiles the second was done 75 days after planting[20].

Data collected included, nutrient content of mulches, soil nematodes populations, yam tuber yield and tuber physical quality.

Data Analysis

Data were subjected to analysis of variance using Genstat version 10. Treatment means were separated using Tukeys Honestly Significant Difference (HSD) at 5% level of probability.

RESULTS

Nutrient content of leaves and stems of the three mulches

Among the three mulches, *M. oleifera* leaf residues contained significantly ($p<0.05$) greater concentrations of nitrogen, phosphorus, potassium, calcium and magnesium than *C. odorata* and *P. maximum* (Table 1)*C. odorata* leaves also had significantly higher contents of all the nutrients studied than *P. maximum*. The nutrient composition of the leaf residues were therefore found to be in the order: *M. oleifera* > *C. odorata* > *P. maximum.* Generally, there were higher contents of nitrogen and calcium in the leaves than in the stems except for potassium, which had higher content in the stems than in the leaves for all the mulches (Table 1). The C/N ratios of the leaf residues of C. *odorata, M. oleifera and* P. *maximum* were 18.73, 8.38 and 43.12, respectively. For the stems, the C/N ratios ranged from 59.54 to 80.52.

Table 1 Nutrient content of leaves and stems of *P. maximum, C. odorata* and *M. oleifera* used in the study

Mulch type	%N	%P	%K	%Ca	%Mg	C/N
Leaves						
P. maximum	0.90c	0.13c	2.00c	0.29c	0.26c	43.12
C. odorata	1.60b	0.24b	2.52b	0.44b	0.50b	18.73
M. oleifera	3.87a	0.29a	2.88a	0.50a	0.59a	8.38
HSD (0.05)	0.039	0.023	0.138	0.054	0.068	
Stems						
P. maximum	0.56a	0.18ab	3.87a	0.18b	0.26b	69.46
C. odorata	0.50a	0.14b	3.05c	0.23ab	0.24b	80.52
M. oleifera	0.57a	0.22a	3.36b	0.29a	0.31a	59.54
HSD (0.05)	0.087	0.041	0.096	0.076	0.043	

Means with the same subscript within a column are not significantly different at $p > 0.05$.

Effects of three mulches on soil nematodes populations

Initial soil nematodes populations

Soil nematode types initially found in the soil were *Meloidogyne spp., Scutellonema spp., Pratylenchus spp., Rotylenchus spp., Helicotylenchus spp., and Tylenchus spp.* Significant differences were observed between the fallow ages for populations of *Meloidogyne spp*., *Scutellonema spp*., and *Rotylenchus spp*. (Table 2). The 3-year fallow system recorded the highest population for *Scutellonemaspp*. and the least for *Meloidogyne*spp and *Rotylenchus spp*. Contrarily, the 5-year fallow system recorded the highest population for *Meloidogyne spp.,*and the least for *Scutellonemaspp*. For the 7- yearfallow system, the highest population was found in *Rotylenchus spp.,* and the least in *Scutellonemaspp.* There were no significant differences in the populations of *Pratylenchus spp. Helicotylenchus spp. and Tylenchus spp.* for all three fallow aged systems.

Table 2. Initial soil nematode population in the three natural fallow aged systems

Fallow aged system	*Meloidogyne* spp.	*Scutellonema* spp.	*Rotylenchus* spp.
3-year	19.67b	14.33a	2.00b
5-year	40.33a	1.33b	14.00b

7-year	29.00a	9.33a	68.00a
HSD	19.72	7.29	30.10

Means with the same subscript within a column do not differ significantly at p>0.05

Changes in soil nematode population after mulching

There were significant increases in the population of *Meloidogyne spp.* under all three mulches, two years after application and cropping. Thepopulation increases in comparison to the initial were 223.2 %, 421.5% and 270.0 % for *P. maximum, C. odorata andM. oleifera*, respectively (Table 3). As regards, *Scutellonema spp*., population increase was only found under P. *maximum,* about 406.0%. Under both C. *odorata* and *M. oleifera*mulches, however, no significant differences were found in the population of *Scutellonemaspp*when the population after two years was compared to the initial. There were no significant differences between the initial and two years populations of *Pratylenchus spp.* and *Rotylenchus spp.*

Table 3. Effects of application of three mulch types on the populations of Meloidogyne spp. and Scutellonema spp. across the fallow aged systems

Sampling period	*Meloidogyne* spp.			*Scutellonema* spp.		
	Population (per 100 g soil)			Population (per 100g soil)		
	P. maximum	*C. odorata*	*M. oleifera*	*P. maximum*	*C. odorata*	*M. oleifera*
Initial	29.67b	29.67b	29.67b	8.33b	8.33a	8.33a
After two years of mulching	96.00a	154.89a	109.89a	42.00a	8.11a	10.00a
HSD (0.05)	58.14	88.77	78.45	23.38	6.55	12.02

Tuber physical damage due to by nematodes

There were no significant fallow ages x mulch type interactions for tuber physical damage due to nematodes.Similarly, there were no significant differences between the mulches for nematode-related tuber physical damage. Furthermore, there were no significant differences between the fallow aged systems for nematode-related tuber physical damage. Generally,tuber damage ranged between 0.29 % and 1.38 %.

Tuber yield of yam

There were no significant fallow aged systems x mulch type interactions for any of the yield components over the two years of cropping.There werehowever significant differences between the mulches for tuber weight and subsequently tuber yield for both years of cropping. Tuber yield of yam under *M. oleifera* was significantly and consistently greater than those under *C. odorata* and*P. maximum*, (Table 4). The least tuber weight of yam was produced under *P. maximum.*In terms of the fallow aged systems, yam tuber yield was greatest under the 7-year fallow system, significantly heavier than those under 5-year and 3-year fallow systems after the first year of cropping. The least tuber weight was produced by yam under 5-year fallow. However, after the second year of cropping, no significant differences were observed between the fallow aged systems for all the measured yield components.

Table 4. Effects of mulch typesand fallow aged systems on Total yam tuber yieldover two years

Mulch type	Mean Tuber wt. (kg)	Total Tuber yield (t/ha)
P. maximum	1.10b	51.3b
C. odorata	1.25b	56.1b
M. oleifera	1.50a	70.5a
HSD (0.05)	0.24	6.62
Fallow age		
3-year	1.25b	31.38b
5-year	1.02b	30.35b
7-year	1.83a	43.16a
HSD (0.05)	0.45	10.48

Means with the same subscript within a column do not differ significantly (p>0.05)

DISCUSSION

Scutellonema spp. population under *P. maximum* significantly increased by 5 fold after two years of mulch application and cropping. Conversely, populations under *M. oleifera and C. odorata* mulches, did not change over the same period of application and cropping. The implication was that, in spite of the yam cropping, the *M. oleifera and C. odorata* mulches were able to prevent the multiplication of the *Scutellonema* spp., one of the most devastating species which causes considerable damage to yam tubers. These two mulches could therefore be considered as good agents for the biological control of the *Scutellonema spp.* nematode. This is the first report of the nematicidal properties of *M. oleifera* in the control of *Scutellonema* spp. For *C. odorata*, the present study corroborates the findings of earlier studies which indicated that the direct application of *C. odorata*eitheras mulch or as in natural fallows, reduced the population of *Scutellonema spp*. [21]; [22];[23]; [24]. The mechanism of control has been explained by the single or combined action of alkaloids, flavonoids, saponins, amides and ketones which are produced during decomposition of the candidate mulch material[25]; [26]; [27]; [28].[23] and[29]have in separate reports indicated that *C. odorata* possessed alkaloids, flavonoids and the other phytochemicals that conferred nematicidal properties on it.In addition, [30] and [31]had indicated that the saponins and tannins in *C. odorata*were responsible for the inhibition of the egg hatching ability of such nematodes. These positive nematicidal attributes of M. *oleifera* and *C. odorata* could partly be responsible for the heavier weighted yam tubers under them as compared to the *P. maximum* mulch. Also contributing to the good yields observed under *M. oleifera* and *C. odorata* were the high nutrient status of the leaves which most probably were released through decomposition, in synchrony with tuberization of the yam. The findings of the present study supports the report of [32] who indicated that tuber yield of yam under *C. odorata* mulch was significantly greater than that under *P. maximum.*

CONCLUSION

After twoyears of application and cropping, the ex-situ mulches, *C. odorata*and *M. oleifera* suppressed *Scutellonema* populations by 80.7% and 76.2% respectively as compared to the control mulch (*Panicum*). The suppressive effects of these mulches on *Scutellonema spp*. partly contributed to the significantly higher tuber yield sustenance of

M. oleifera and *C. odorata* mulches as compared to *P. maximum*as well as to the very minimal (less than 2%) tuber physical damage observed.Both *Moringa* and *Chromolaena* could therefore be exploited for cultural management and suppression of the S*cutellonemaspp*. through their use as mulch.

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