Original Research Article

# Nematicidal Properties of *Moringa Oleifera, 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 of yam 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-year old, 5-year old and 7-year 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 types identified. However, *Scutellonema spp.* was found to be the most pathogenic nematode affecting yam tuber yield and physical quality. *Chromolaena* and *Moringa* mulches suppressed *Scutellonema spp.* populations by 80.7% and 76.2% respectively as compared to the *Panicum maximum* mulch. The suppressed *Scutellonema spp.* 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 sixty million 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 USA are the three 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 *Pratylenchus coffeae* [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] and [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 study was carried out at Atonsu village which had a good representation of all the three natural fallow ages viz: three- year old (3-year), five years (5-year) and seven years (7-year) that would be used. The 3-year and 5-year 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-

year, 5-year 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 *Scutellonema spp*. 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 *Scutellonema spp*. For the 7-year fallow system, the highest population was found in *Rotylenchus spp.,* and the least in *Scutellonema spp.* 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. The population increases in comparison to the initial were 223.2 %, 421.5% and 270.0 % for *P. maximum, C. odorata and M. 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 *Scutellonema spp* 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 were however 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 types and fallow aged systems on Total yam tuber yield over 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* either as 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 two years 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*cutellonema spp*. through their use as mulch.

## REFERENCES


1. FAO. Corporate document repository. Factors affecting storability of roots and tuber. Accessed 20 February, 2017. www.fao.org/docrep.

2. Nahanga, V. and Becvarova, V. An Analysis of Yam Production in Nigeria. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 2015, 63(2): 659–665

3. FAO, Analysis of incentives and disincentives for yam in Ghana. Technical notes series, MAFAP, by Anaadumba P. 2013

4. Ennin, SA., Otoo, E. and Tetteh, F. M. Ridging, a Mechanized Alternative to Mounding for Yam and Cassava Production. West African Journal of Applied Ecology, 2009. vol. 15, No. 1 8pp.

5. Norman, PE. Cytological diversity of some yams Dioscorea spp. University of Kwazulu-Natal, assessed www.slideshare.net, January 10, 2017 MSc. Thesis, 2010

6. UN COMTRADE. Yam sector development strategy, United Nations Comtrade Database-International Trade Statistics. Ghana. Ministry of trade and Industry. *moti.gov.gh/sites/default/files,* 2012.

7. Nyadanu, D., Dapaah, H. and Agyekum, AD. Resistance to Post harvest Microbial

Rot in Yam: Integration of Genotype and Storage methods. African Crops Science Journal, 2014, Vol. 22 No.2 pp 89-95.

8. Baimey, H., Coyne, D. and Labuschagne, N. Effect of fertilizer application on yam nematode (*Scutellonema bradys*) multiplication and consequent damage to yam (*Dioscorea spp.*) under field and storage conditions in Benin. International Journal of Pest Management 2006. 52(1), pp. 63–70.

9. Plowright, RA and Kwoseh, CK. Farmer's perceptions of nematode disease in yams in Ghana and the prevalence of endoparasitic nematodes in stored tubers. Nematologica 1998, 44: 558-559.

10. Plowright, R. and Kwoseh, C. Identification of resistance to major nematode pests of yams (Dioscorea spp.) in West Africa. Crop Protection Programme, CABI. Bioscience. 2000

11. Bridge J., Coyne DL. and Kwoseh, C. Nematode parasites of tropical root and tuber crops. In: "Plant parasitic nematodes in subtropical and tropical agriculture" (Second edition). M. Luc, R. A. Sikora, J. Bridge (eds), CABI Wallingford, UK, pp. 221-258. 2011.

12. Caveness, F. E. Nematological Research at IITA 1969-1988: A summary of investigations. In. Plant Health Management Research Monograph 2. Lowe, ed. Ibadan, Nigeria, p. 52. 1992.

13. Baimey, HK. Scutellonema bradys as a pathogen of yam in Benin PhD dissertation. 2006 http://repository.up.ac.za/bitstream/handle /2263/29022 (Date accessed: 25/02/18)

14. Coyne, DL., Williamson, VM. and Banna, AB. Analysis of the pathogenic, morphological and genetic variability of Scutellonema bradys on yam in West Africa. Afr. Plant Prot. 12 (1). 2006.

15. Nwauzor, EC. and Fawole, B. Root knot nematodes on yams (Dioscorea spp.) in eastern Nigeria. Proceeding of the 3rd Research Planning Conference on Root-knot nematodes, Meloidogyne spp., Region IV and V, Ibadan, Nigeria, 1981. pp. 161-167.

16. Kwoseh, CK. Identification of resistance to major nematode pest of yams (Dioscorea spp.) in West Africa. PhD dissertation. 2000. Dept of Agriculture,

University of Reading, UK.196 pp

17. Bridge, J., Hunt, DJ. and Hunt, P. Plant parasitic nematodes of crops in Belize.*Nematropica* 1996. 26, 111-119.

18. Murslain, M., Javed, N., Khan, SA., Khan, HA., Huma Abbas, H. and Kamran, M. Combined Efficacy of *Moringa oleifera* Leaves and a Fungus, *Trichoderma harzianum* Against *Meloidogyne javanica* on Eggplant. *Pakistan J. Zool.,* 2014 *vol. 46(3), pp. 827-832,*

19. Claudius-Cole, AO., Aminu, AE. and Fawole, B. Evaluation of plant extracts in the management of root-knot nematode *Meloidogyne incognita* on cowpea [*Vigna unguiculata* (L) Walp]. *Mycopath*, 2010. 8: 53-60.

20. Agbede, TM., Adekiya, AO. and Ogeh, JS. Effects of Chromolaena and Tithonia Mulches on Soil Properties, Leaf Nutrient Composition, Growth and Yam Yield. West 2013. frican Journal of Applied Ecology, 21(1).

21. Ajith, K and Sheela, S. Utilization of green leaves of neem and *upatorium* for the management of soil organisms in bhindi and cowpea *Indian Journal of Nematology.* 1996 26, 139-143

22. Adekunle, OK and Fawole, B. Chemical and non-chemical control of *Meloidogyneincognita* under field conditions. *Indian Journal of Nematology* 2002. 32, 1-8.

23. Adekunle, OK. and Fawole, B. Chemical and non-chemical control of Meloidogyne incognita infecting cowpea under field conditions. Moor Journal of Agricultural Research, 2003. 4 (1): pp. 94 -99.

24. Adediran, JA., Adegbite, AA., Akinlosotu, T., Agbaje, GO., Taiwo, LB., Owolade, OF and Oluwatosin, GA. Evaluation of fallow and cover crops for nematode suppression in three agroecologies of south western Nigeria. *African Journal of Biotechnology* 2005 1034-1039

25. Thoden, TC., Oppre, MB and Allmann, JH. Pyrrolizidine alkaloids of *Chromolaena odorata* act as nematicidal agents and reduced infections of lettuce roots by *Meloidogyne incognita*, Nematology, 2007, Vol. 9 (3) 343-349.

26. Akpheokhai, IL., Cole, AOC. and Fawole, B. Evaluation of some plant extracts for the management of Meloidogyne *incognita* on soybeans *(Glycine max)* World J. Agric. Sci. 2012. 8 (4): 429-435.

27. Goswami, B. K. and Vijayalakshmi, V. Nematicidal properties of some indigenous plant materials against root-knot nematode Meloidogyne. (Incognita on tomato). Ind. J. Nematol., 1986. 16, pp. 65-68.

28. Adegbite, AA. Comparative effects of Carbofuran and water extract of Chromolaena odorata on growth, yield and food components of root-knot nematode-infested soybean [Glycine max (L.) Merrill]. Ph. D Thesis. University of Ibadan, Nigeria, p. 219. 2003.

29. Adegbite, AA and Adesiyan, SO). Root extracts of plants to control root-knot nematodes on edible soybean. *World Journal of Agricultural Sciences*, 1(1):18-21. 2005

30. Umar, I. and Mamman, A. Nematicidal potential of Faidherbia albida fruit against Meloidogyne javanica on cowpea. Pakistan Journal of Nematology 2014. 32(1), pp. 77-83.

31. Pavaraj, M., Bakavathiappan, G. and Baskaran, S. Evaluation of some plant extracts for their nematicidal properties against root-knot nematode, Meloidogyne incognita. Journal of Biopesticides. 2012. 5(Supplementary), pp. 106-110.

32. Adeniyan, BO., Ojeniyi, SO. and Awodun, MA. Relative Effect of Weed Mulch Types on Soil Properties and Yield of Yam in Southwest Nigeria. J .Soil. Nature. 2008. 2(3), pp. 01-05.

196