Preliminary evaluation of the potency of crop rotation scheme in the management of plant-parasitic nematodes in organic farm in Abeokuta

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ABSTRACT

Phytonematodes constitute serious crop production constraints especially in newly established organic farms. A field experiment was conducted at the University of Agriculture in 2010 to determine the effectiveness of sesame-soybean-maize-sunflower rotation in the management of phytophagous nematodes. Seeds of sesame were sown at a spacing of 60 x 5 cm where sunflower were previously grown, *Meloidogyne incognita* (Mi)-resistant soybean variety, TGx 1448-2E, was sown at a spacing of 60 x 5 cm where sesame were previously grown, maize was sown at a spacing of 75 x 25 cm where soybean were previously planted and harvested, each replicated twice. Nematodes in soil were isolated and censured at pre-plant (0 day), 45 and 90 days after planting. Gall and root-knot nematode eggs were extracted and counted at 60 days after planting (DAP). Results showed that sesame and soybean significantly ($p = 0.05$) reduced *Meloidogyne* population (15.24 % at 45 DAP and further to 22.86 % at 90 DAP with no observable root gall on the Mi-resistant soybean variety utilized. While maize enhanced *Pratylenchus* spp. population by 63.53 % sunflower known for allellophatic effect reduced *Pratylenchus* spp. significantly ($p = 0.05$) by 58.33 % but increased *Meloidogyne* spp. population in the soil. These preliminary results attested to the efficaciousness of resistant cultivar in the management of root-knot nematodes in organic farms where reliability on chemical nematicide is disallowed.

Keywords: *Crop husbandry, Nematode control, Organic farming, Rotation*

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INTRODUCTION

Plant- parasitic nematodes constitute a major threat to both organic and conventional crop grown throughout Nigeria. Adesiyan e*t al*. (1990) documented that the ultimate effect phytonematodes on crops was reduction in quality and quantity of crop yield. Although pests and diseases have long been recognized as important constraint affecting crop production, extensive research linking of crop damage to plant parasitic nematodes infestation in the soil, probably remain one of the most difficult problems to identify, demonstrate and control (Stirling, 1988). Farmers, agronomists and Pest Management Consultants commonly underestimate the effect of plant- parasitic nematode due to its hidden habit. However, it has been estimated that 10% of the world crop production is lost as a result of plant-parasitic nematodes damage (Whitehead, 1998). This may be higher in newly established farms. A survey report in Nigeria however, showed that 70% of farmers are aware of nematode disease symptoms but does not necessarily recognize it as a problem requiring intensive control measure (Green and Florini, 1996).

Adesiyan *et al.,* (1990) reported that plant-parasitic nematodes can be managed using various control strategies such as chemical, biological, physical and cultural measures (which include crop rotation, intercropping, and mixed cropping). Crop rotation is a planned order of specific crops planted on the same field either in space or over time. Crop rotation requires that succeeding crops should be of a different genus, species, subspecies, or variety than the previous crop. The planned rotation sequence may be for a two- or three-year or longer period. Some of the general purposes of rotations are to improve or maintain soil fertility, reduce erosion, reduce the build-up of pests, reduce risk of weather damage, reduce reliance on agricultural chemicals, and increase net profits.

Crop rotation is a cultural measure used to control nematodes. It involves the use of non-host or resistant varieties (Kratochvil *et al*., 2004). It is the oldest proven method of nematodes control and management (Egunjobi, 1992). Crop rotation has been successfully used to control *Meloidogyne hapla* and *Meloidogyne arenaria* race 1 on tomato when rotated with groundnut

(Taylor and Sasser, 1978). The ultimate objective of plant–parasitic nematodes control is the reduction of nematodes population in the soil. However, the degree of success depends on the particular crop sequence and the relative level of susceptibility and resistance involved and the pathogenic characteristics of the nematodes (Rodriguez – Kabana *et al*., 1992). Use of synthetic nematicides for management of outbreaks of plant-parasitic nematodes have become increasing costly for resource-poor farmers who produce the bulk food in sub-Saharan Africa, so there is need to shift to other alternative method like crop rotation which is cheap , efficient and also help to increase farmers income. Therefore, this study was designed to determine the effectiveness of sesame-soybean-maize-sunflower rotation in the reduction of plant- parasitic nematode population in the soil.

Sesanum indicum L. belongs to the family *Pedaliaceae* and well acknowledged to have dual advantage of high nutritional importance (Oplinger *et al.,* 1990, Dudley *et al*., 2000) and *Meloidogyne* – resistance making (Araya and Caswell-Chen 1994, Atungwu *et al*., 2003) to recommend *Sesamum indicum* as an economic crop rotation component that would inhibit or restrict penetration and reproduction of *Meloidogyne incognita* thereby reducing their population in agricultural soil due to the presence of aspartic acid, glutamic and leucine, proline, serine and valine in root exudates or extracts (Tanda *et al*., 1988, 1989).

Sunflower (*Helianthus annus* L.) belongs to the family, *Compositae*. Sunflower is generally susceptible to root knot nematode (*Meloidogyne* spp) which (Rehman *et al.,* 2006) reported to have caused 16.44% yield loss. Maize (*Zea mays* L.) belongs to the family *Poaceae*. Plant-parasitic nematodes are known to cause up to 50% yield loss on maize with lesion nematodes *Pratytlenchus* spp being rated as the most important (Hollis,1962; Adeniji *et al*.,1979, Bridge,1994). Soybean {*Glycine max* (L). Merril} belongs to the family *Fabaceae.* Maize farmers found that rotating maize with soybean reduce the need for nitrogen fertilizer (Sauer 1993).

Several management options are available for the control of plant-parasitic nematodes this include chemical control, use of resistant varieties, biological control, physical control and cultural control which include crop rotation, mixed cropping, and intercropping(Adesiyan *et al*., 1990). Atungwu (2004) reported that soybean TGx 1448-2E was resistance to *Meloidogyne incognita* which he suggested that when used for rotation may help to reduce plant parasitic nematode significantly in the soil. Crop rotation is a cultural control method used to control pest and disease. The principal objective of crop rotation is to alternate a non host with a susceptible main crop with the assumption that the non - host will suppress a build up to nematodes (Adesiyan *et al*., 1990). Idowu and Fawole (1989, 1992) investigated the efficiency of intercropping cereals (poor host) and cowpea (good host) in the control of the root-knot nematodes (*Meloidogyne* spp) as well as improving crop yield. Significant effort to utilize crop rotation scheme as alternatives to synthetic nematicides in the control of nematodes are promising. However, specialized schemes that incorporate resistant varieties appear scarcely reported in literature. Therefore, the need for evaluation of TG_X 1448-2E recommended previously as resistant to *Meloidogyne* in rotation scheme prompted this research work.

MATERIALS AND METHOD

Nematode extraction from soil.

Soil samples were collected from the experimental site located at UNAAB.where sunflower, sesame, soybean and maize were rotated with the aid of a soil auger at a depth of 20cm, eight core samples were taken on each crop, mixed together homogenously to get a composite sample. Extraction of nematodes from the soil was carried out using Whitehead and Hemming (1965) modified tray method of Baerman techniques.

Two hundred and fifty grams (250g) of the composite soil sample was weighed and placed in two plastic sieves sandwiched with double-ply nematode extractor tissue paper and placed in a plastic bowl containing 250ml of water. The sample was left for 18 hours after which the sieves were removed from the plastic bowl. Excess supernatant was poured into a nalgene bottle, water was added to the fill level, left for 5 hours for nematodes to settle at the bottom.

The supernatant was siphoned out with the aid of 3-cm inside diameter rubber tubing inserted to the sprout, until the siphon automatically breaks up at a factory- fixed level just above the concentrated nematode suspension. Nematode was picked with the aid of a broom and identified under the binocular microscope. The suspension was observed under a stereomicroscope and counted. Extraction of nematodes from the soil was carried out again using Whitehead and Hemming (1965) modified tray method at 45 and 90 days after planting.

Design of experiment

The experiment consists of 4 treatments made up of the rotational crop namely sunflower (Funtua), sesame (E8), soybean (TGx1448-2E), and maize (TZSR-Y). The experiment was laid out in a randomized complete block design (RCBD) with two replications. The rotation is as shown below:

Rotation	2008	2009
1	sunflower	sesame
2	sesame	soybean
3	soybean	maize
4	maize	sunflower

Sowing of sesame, sunflower, maize, and soybean was done on the 2nd and 3rd of July 2009. Planting space for sunflower is 60 x30cm, sesame 60x 5cm, soybean 60x 5cm, and maize 75 x 25cm.After two weeks of planting weeding operation commenced.

The plants were observed daily for the appearance of plant-parasitic disease symptoms. At 45 days after planting (DAP) and 90 days after planting (DAP), destructive sampling was done on six plants selected randomly on the field and soil samples collected; galls were counted and recorded on the uprooted plant. Eggs of root-knot nematode were extracted from the roots and estimated using Hussey and Barker (1973) sodium hypochlorite method using 1.5% a.i NaOCl instead of 0.52% a.i NaOCl for maximum recovery of the nematode from the roots.

After the preparation of sodium hypochlorite solution, the roots of the plant were washed under a gentle stream of cool tap water to remove adhering soil. Washed roots was chopped into 1-2 cm pieces and placed into a conical flask containing 200ml of 1.5% a.i NaOCl solution, corked tightly after which it was manually but vigorously shaken for three minutes to dissolve the gelatinous egg matrices. The suspension was quickly poured over a 200- mesh sieve nested upon 500- mesh sieves. The 500 mesh sieve containing nematodes was quickly placed under gentle streams of cool tap water for 5 minutes to rinse off residual NaOCl solution before rinsing the nematodes into the beaker. The nematodes were identify under a binocular microscope, and counted with the aid of Doncaster (1962) ringed counting dish under a stereomicroscope using a multiple tally counter. Nematodes count was recorded for pre-plant, 45 days and 90 days.

Data analysis

Galls, root-knot nematodes eggs counted at 45 and 90 days after planting and plant parasitic nematodes counted in the soil after extraction at pre-plant, 45 and 90 days after planting were subjected to analysis of variance using the generalized linear model procedure (GLM), and means of treatments were separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Table 1 shows the effect of crop rotation on nematode population in the soil. Non-parasitic nematodes varied significantly at ($p < 0.05$). Highest population (73.0) was observed on soybean and lowest population (39.3) on sunflower. *Meloidogyne* spp. did not vary significantly to ($p < 0.05$) under crop rotation scheme. Sunflower had the highest population (116.7) and the lowest population (103.2) was observed on soybean, *Helicotylenchus* spp. was not significantly different ($p < 0.05$) irrespective of the crop in rotation highest population (72.0) was observed on sesame and lowest population (52.7) on soybean, *Pratylenchus* spp. was significant at ($p < 0.05$) on the treatment, highest population (87.2) was observed on maize and lowest population (18.3) was observed on sesame.

Table 1: Effect of crop rotation on nematode population in the soil

Treatment	non-parasitic spp nematode	*Meloidogyne* spp.	*Helicotylenchus*	*Pratylenchus* spp.
Soybean	73.8	103.2	52.7	27.3
Sesame	56.0	103.3	72.0	18.3
Maize	46.0	106.7	57.0	87.2
Sunflower	39.3	116.7	52.8	34.2
LSD (0.05)	10.5	13.5	23.2	6.3

LSD (0.05) – least significant difference at 5% probability level.

Table 2 shows the effect of time of sampling on nematode population in the soil. Non-parasitic nematode varied significantly with days of planting, highest population (61.6) was observed at 45 days after planting; however, non-parasitic nematode mean did not differ significantly at 45 and 90 days after planting though it recorded a lower population (48.0) at pre- plant. The population mean of *Meloidogyne* varied significantly with days of planting at ($p < 0.05$), *Meloidogyne* had the highest population (123.5) at 45 days after planting and lowest population (99.1) at 90 days after planting though there was no significant difference at pre-plant and 90 days after planting. *Helicotylenchus* did not varied significantly with days of planting at ($p < 0.05$), highest population (69.1) was observed at 45 days after planting and lowest population (49.5) at 90 days after planting, The population mean of *Pratylenchus* also varied significantly with days of planting at ($p < 0.05$), highest population (48.6) was observed at 45 days after planting and lowest population (37.8) at pre-plant, though there was no significant difference at pre-plant and 90 days after planting.

Table 2: Effect of time of sampling on nematode population in the soil.

Days	non-parasitic nematode	*Meloidogyne* spp.	*Helicotylenchus* spp.	*Pratylenchus* spp.
Pre-plant	48.0	99.8	59.3	37.8
45 DAP	61.6	123.5	69.1	48.6
90 DAP	51.8	99.1	49.5	38.9
LSD (0.05)	9.1	11.8	20.1	5.5

LSD (0.05) – least significant difference at 5% probability level.

Table 3 shows the mean number of galls and root-knot nematode eggs found in the root of treatment after extraction, *Meloidogyne* eggs count varied significant at ($p < 0.05$) in the root of treatments after extraction at 45 and 90 days after planting. Highest population mean was observed on sunflower (24.8) and (24.7) at 45 and 90 days after planting while lowest population (0.0) and (0.0) was observed on soybean and sesame at 45 days after planting and on soybean (0.0) at 90 days after planting. No eggs was found in the root of soybean and sesame after extraction at 45 days after planting ,at 90 days after planting no eggs were found in the root of soybean after extraction.

Similarly, number of galls counted in the root of treatments at 45 and 90 days after planting varied significantly at ($p<0.05$).highest population (7.5) and (23.0)was observed on sunflower at 45 and 90 days after planting while the lowest population (0.0) and (0.0) was observed on soybean and sesame at 45 days after planting and only on soybean(0.0) at 90 days after planting, at 45 days after planting no gall was observed on the root of sesame and soybean while at 90 days after planting no gall was observed on soybean.

Table 3: Mean number of galls and root-knot nematode) egg per roots of test crops at 45 and 90 days after planting.

Treatment	45DAP		90DAP	
	No. of Galls/root	No. of Mi eggs/root	No. of Galls/root	No. of Mi eggs/root
Sunflower	7.5	24.8	23.0	24.7
Maize	5.3	23.7	19.3	16.8
Soybean	0.0	0.0	0.0	0.0
Sesame	0.0	0.0	5.5	8.2
LSD (0.05)	3.0	5.2	5.2	6.2

DAP- days after planting. LSD (0.05) – least significant difference at 5% probability level.

Crop rotation involves planting different types of crop in a sequence. Sunflower shows a level of susceptibility to *Meloidogyne* , it increase *Meloidogyne* population and reduce *Pratylenchus* population in the soil when rotated with maize, galls and *Meloidogyne* eggs were also observed on the root, affirming the report of Rehman *et al*., 2006 that *Meloidogyne* is a threat to sunflower. Maize supported the increase of *Meloidogyne* and *Pratylenchus* in the soil when rotated with soybean, the level at which *Pratylenchus* increased in the soil was high, this shows that maize is susceptible to *Pratylenchus,*susceptibility of maize cultivars to Pratylenchus is widely reported (Egunjobi, 1974). Sesame (E8) reduced *Meloidogyne* population in the soil when planted as a succeeding crop to sunflower, at 45 days after planting no galls and *Meloidogyne* eggs was observed on the root of treatment but at 90 days after planting, galls and *Meloidogyne* eggs was observed but at a low population, this study partially agree with report of Atungwu *et al.,* (2003) that breeding line E8 was tolerant to *Meloidogyne incognita*. Soybean (TGx1448-2E) greatly reduced *Meloidogyne* in the soil, no gall and *Meloidogyne* eggs was found in the root of soybean at 45 days and 90 days after planting, different cultivars of soybean was screened by Atungwu (2004) and confirmed that TGx 1448 – 2E was resistant to *Meloidogyne incognita*. The performance of soybean (TGx 1448-2E) in the reduction of *Meloidogyne incognita* shows the significance of rotating susceptible crops with resistant cultivars in the management of plant parasitic nematode. Periodic data taken on nematode population at different time of sampling elucidated information on the trend of nematode population dynamics during cropping period. Highest population mean was observed on all the nematode at 45 days after planting on all the nematodes and lowest population on *Meloidogyne* and *Helicotylenchus* at 90 days after planting while *Pratylenchus* and non parasitic nematode population had it lowest population at pre-plant.

CONCLUSION

This study shows that sesame (E8) is a poor host of *Meloidogyne*, soybean (TGx 1448-2E) is also a poor host of *Meloidogyne,* maize (TZSR-Y) is a good host of *Pratylenchus*, sunflower (Funtua) is a poor host of *Pratylenchus* but a good host of *Meloidogyne*,. Crop rotation should be encouraged among farmers because most of the plant-parasitic nematodes are becoming more resistant to chemicals, this chemical also cause environmental hazard when mis-used or frequently used.

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