International Journal of AgriScience Vol. 3(4):298-307, April 2013 *www.inacj.com*
ISSN: 2228-6322© International Academic Journals

Effects of poultry manure and carbofuran soil amendments on soil nematode population and yield of pineapple

Daramola F.Y.[1*], Afolami S.O.[2], Idowu A.A.[3], Odeyemi I.S.[2]
[1] *Department of Crop Science, Landmark University, P.M.B 1001, Omu-Aran. * Author for correspondence (email: fisayodara@yahoo.com)*
[2] *Department of Crop Protection, Federal University of Agriculture, Abeokuta.*
[3] *National Horticultural Research Institute, Ibadan.*

Received January 2013; accepted in revised form March 2013

ABSTRACT
Two field experiments were conducted at the National Horticultural Research Institute, Ibadan and the Federal University of Agriculture, Abeokuta to assess the efficacy of poultry manure and carbofuran in suppressing nematode populations and promoting pineapple yield. Three rates of poultry manure (0, 20 and 25 tonnes per hectare) and carbofuran (0, 3.0 kg a.i/ha and 3.4 kg a.i/ha) were applied to pineapple plants in a Randomized Complete Block Design replicated three times in each of the two locations. Soil samples were collected from the rhizosphere of plants at 0, 3, 6, 9, 12, 15 and 18 months after planting to monitor soil nematode populations. Plant growth data were obtained by measuring the length and breadth of 'D' leaves for five randomly selected plants per plot. Flowering was induced at the 18th month by spraying with 0.5 kg ethephon in 2000L of water/ha. Results showed that Poultry manure and carbofuran treatments significantly ($P < 0.05$) suppressed plant-parasitic nematode populations in both locations. At harvest, significantly bigger fruit sizes, higher fruiting percentage and number of fruits were recorded on both poultry manure- and carbofuran-treated plots. It was concluded that appropriate management of plant-parasitic nematodes will promote higher fruit yields in pineapple farms in Nigeria.

***Keywords*:** *Carbofuran, Nigeria, pineapple, plant-parasitic nematodes, poultry manure, soil amendment*

INTRODUCTION
For decades, the control of plant-parasitic nematodes has been achieved mainly through the use of chemical nematicides (Afolami 1993). Synthetic pesticides are efficient and fast yielding and have been found to increase the yield of agricultural products over tenfold (IITA 2000). Fumigants and non-fumigant nematicides including methyl bromide, ethylene di-bromide (EDB), 1,2 di-bromo-3-chloropropane (DBCP), ethoprop, fenamiphos and carbofuran have been variously employed in combating nematode problem of agricultural crops (Sipes et al. 2005). The use of these chemicals is however currently re-appraised with respect to the environmental hazards associated with them.

Indiscriminate and misuse of synthetic chemicals for pest control has led to

problems such as pest resistance, adverse effect on non-target organisms and health hazards to the users. Unsafe use of pesticides may also result in poisoning of humans which is a problem especially in developing countries (Yudelman et al. 1998). In addition, the pesticides are relatively unaffordable to many small scale farmers. Hassan et al. (2001) reported that owing to environmental pollution and costliness of synthetic pesticides, chemical control no longer holds sway in sustainable agricultural production.

The employment of various sources of organic materials has been promoted as one of the principal sustainable management options for improving soil quality and productivity (Widmer et al. 2002). Organic amendments such as green manure, crop residues, cow dung and poultry manure used in improving soil fertility, have also been found to control root diseases including nematodes (Poswal and Akpal 1991). The application of organic amendment to the soil as an alternative strategy for the management of plant-parasitic nematodes, have been proved to substantially increase soil health (Neher 2001), environmental wellness (Adegbite and Adesiyan 2005) and sustainable crop production with no documented negative effect of organic soil amendment on non-target organisms (Agyarko and Asante 2005).

Oka et al. (2000) indicated that organic addition have constantly produced beneficial effects on soil nutrients, soil physical conditions, and soil biological activities thereby improving the health of plants and reducing populations of plant-parasitic nematodes. On the other hand, population of free-living nematodes have increased rapidly following the addition of organic substrates (Aktar and Malik 2000). Kimenju et al. (2004) reported that application of organic amendment stimulated the activity of natural antagonists of plant-parasitic nematodes by stimulating the occurrence of nematode destroying fungi in the soil.

In Nigeria, initial reports on the use of plant extracts in nematode control were those of Egunjobi and Afolami (1976). The control of plant-parasitic nematodes has been successful with poultry manure, cow dung and sawdust (Egunjobi and Larinde 1975, Babatola 1982 and Chindo et al. 1991). On cowpea, Olabiyi et al. (2007) reported a significant reduction in root galls and improved growth yield on soil amended with organic manure. Orisajo et al. (2008) also suppressed populations of *Meloidogyne incognita* and stimulated growth of cacao seedlings with the addition of poultry litter in a cacao establishment. Agu (2008a) evaluated different organic manures (municipal garbage, swine, compost, poultry and farmyard manure application) for effective control of root-gall nematode disease on African yam bean and indicated that plants treated with poultry and farmyard manures gave significantly higher yields than those of other organic manures. He also showed that root-gall nematode damage on pineapple was best controlled with poultry manure application (Agu 2008b).

The continuing environmental problems associated with the use of nematicides have introduced a sense of urgency and a persistent pressure on farmers worldwide to adopt other management strategies that do not contribute to environmental pollution. Therefore the focus of this research is to compare the suppressive effects of poultry manure and carbofuran on plant-parasitic nematodes and subsequently, on pineapple yield.

MATERIAL AND METHODS

The field experiments to determine the effects of poultry manure and carbofuran on nematode suppression and the yield of pineapple was conducted at National Horticultural Research Institute, Idi-isin,

Ibadan (Longitude 3º 50' E and Latitude 7º 23'N) and the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta (Longitude 3º 21'E and Latitude 7ºN).

The experiment consisted of three rates of poultry manure (0, 20, and 25 tonnes/ha) and three rates of 3G carbofuran (0, 3.0 and 3.4 kg a.i/ha) which were replicated three times in a Randomized Complete Block Design. Pineapple suckers (cv. Smooth cayenne) were planted at a spacing of 60 cm between lines and 30 cm between rows using a double row spacing method of 1m. The experimental plot size was 2.4m x 2.1m. There were 40 plants per plot and 15 plots at each location. Carbofuran was applied at 3 weeks after planting (WAP) and at every three-month interval while poultry manure were incorporated into the soil at 3 WAP and at 6 months interval. The data was subjected to analysis of variance and the means partitioned by Duncan's multiple range tests.

Soil samples for nematode analysis were collected from each experimental plot prior to planting, and at 3, 6, 9, 12, 15 and 18 months after planting. Twenty core samples of soil collected with a soil auger to a depth of 15cm and within a 25 cm radius from the base of the pineapple plants were taken from each plot for bulking, thorough mixing and extraction of nematode. Nematodes were extracted from two sub-samples of 250ml from the bulk, using the modified Baermann tray extraction method of Whitehead and Hemming (1965).

At 18 months after planting (MAP), the plant maturity indices (Plant height, number of leaves, 'D' leaf length, and 'D' leaf width) were determined per plot. The pineapple plants were also induced to flower by spraying with 0.5 kg ethephon and 5% urea in 2000L of water/ha (Barthrolomew et al. 2003). At harvest, the fresh fruit weights, the number of fruits and percentage fruiting were recorded for each plot.

RESULT

The result showed that plots amended with Poultry Manure (PM) and carbofuran treatments suppressed the population of plant-parasitic nematodes that were associated with pineapple in the two experimental fields (Table 1).

Table 1: Suppressive Effects of Poultry manure and Carbofuran treatments on Nematode Population at 18 MAP

Treatment	Abeokuta			Ibadan		
	Plant-parasitic nematodes/250ml soil	Non- parasitic nematodes/250 ml soil	Total nematode population/250ml soil	Plant-parasitic nematodes/250ml soil	Non-parasitic nematode/250ml soil	Total nematode population/250ml soil
T1=20 metric tonnes PM	154.67 [b]	1611.70 [b]	1766.30 [b]	259.33 [b]	821.67 [ab]	1081.00 [a]
T2=25 metric tonnes PM	119.00 [c]	1709.70 [b]	1828.70 [b]	229.00 [c]	872.00 [a]	1101.00 [a]
T3=3.0 kga.i/ha C	50.33 [d]	1091.00 [c]	1141.30 [c]	104.67 [d]	761.67 [bc]	866.33 [b]
T4=3.4 kga.i/ha C	40.67 [e]	1092.30 [c]	1131.70 [c]	90.00 [d]	682.67 [d]	772.67 [c]
T5=control	868.67 [a]	2623.00 [a]	3491.30 [a]	386.67 [a]	721.67 [cd]	1108.33 [a]

PM=Poultry manure; C=Carbofuran; MAP= Months after Planting

*Means followed by the same letter in the same column do not differ significantly according to Duncan's Multiple Range Test ($P < 0.05$)

Soil treatment with 3.4 kg a.i/ha of carbofuran gave the most effective nematode control when compared with poultry manure-ammended and the untreated plots in the two fields. Population of the non-parasitic nematodes was more abundant in PM-treated plots while high numbers of plant-parasitic nematodes and non-parasitic ones were recorded from the untreated plots in both locations (Table 1).

In Abeokuta field, the population of plant-parasitic nematodes was significantly higher ($p<0.05$) in the untreated plots than those recovered from plots treated to different rates of carbofuran and poultry manure. Carbofuran at 3.4 kg a.i/ha gave the highest nematode suppression, which was significantly higher than the effects of carbofuran at 3.0 kg a.i/ha, PM at 20 and 25 metric tonnes/ha. A similar trend was observed in the Ibadan field where highest nematode population was recorded on untreated plots and the greatest nematode suppression recorded on plots with 3.4 kg a.i/ha of carbofuran. There was however no significant difference in the effects of carbofuran at 3.4 kg a.i/ha and 3.0 kg a.i./ha on the nematode population in the soil.

Pineapple plots amended with poultry manure and carbofuran treatments supported good vegetative growth and fruit yield of pineapple in both Abeokuta and Ibadan fields. Uniform fruiting was also enhanced in pineapple plots with carbofuran treatments while low percentage fruiting and small fruit sizes characterized the untreated pineapple plots (Fig 3).

In Ibadan field, significantly higher values ($P<0.001$) of the vegetative growth parameters in form of plant height, number of leaves, 'D' leaf length and 'D' leaf width, were recorded on plots amended with PM at 25 and 20 metric tonnes/ha at 18 MAP. The lowest vegetative growth and number of leaves were recorded on the untreated plots (Table 2). A similar trend was observed on Abeokuta field. However, there was no significant treatment effect on the vegetative growth of pineapple in the field.

At harvest, plots amended with 25 t/ha of PM in Ibadan field had greater fruit yield in terms of fruiting percentage, number of fruits harvested and the total fruit weights per plot (Fig 1). This was significantly higher than the yield recorded on the carbofuran and the untreated plots. There was however no significant treatment effect on the total fruit weights of pineapple from plots with PM at 20 t/ha and those treated with carbofuran at 3.4 kg a.i/ha. Greater yield and more uniform fruiting of pineapple characterized the 3.4 kg a.i/ha carbofuran-treated plots at Abeokuta field (Fig 2). This was significantly higher than those from the PM and untreated plots. Very small fruit sizes and poor fruiting percentage were also recorded on the untreated plots.

DISCUSSION

The result of this study showed that carbofuran and poultry manure amendments significantly reduced the population of plant-parasitic nematodes that were found in the pineapple fields. The use of chemical nematicides has been described as the quickest and most effective control of plant-parasitic nematodes especially when crop failure is eminent (Rohrbach and Apt 1986, Afolami 1993, Aktar and Malik 2000). The nematostatic action of carbofuran in nematode control could be responsible for the significantly low population recorded in the pineapple fields (Bunt 1987).Whereas fumigant nematicides cause a high degree of nematode mortality in the soil, carbamates, at concentrations presently used in the field, do not actually cause direct mortality (Hartwig and Sikora 1991) but inhibit acetyl-cholinesterase at the nerve synapse, causing malfunction of the muscular and

other organic systems in the nematode. Carbofuran, due to their cholinesterase inhibiting activity, may disrupt juvenile orientation and host recognition, which subsequently, could greatly affect nematode movement and behaviour and ultimately alter the infection process and root penetration by the infective juveniles.

***Table 2*:** Effects of Poultry manure and Carbofuran on the vegetative growth of Pineapple at 18 MAP

Treatment	Abeokuta				Ibadan			
	Plant Height[1] (cm)	Leaf Number[1] (cm)	'D' Leaf Length[1] (cm)	'D' Leaf width[1] (cm)	Plant Height[1] (cm)	Leaf Number[1] (cm)	'D' Leaf Lenght[1] (cm)	'D' Leaf width[1] (cm)
T1=20 tonnes PM	55.74 [a]	19.28 [ab]	49.96 [a]	3.92 [a]	58.64 [bc]	20.87 [bc]	50.77 [bc]	4.26 [ab]
T2=25 tonnes PM	52.675 [ab]	17.99 [b]	47.77 [ab]	3.86 [a]	74.42 [a]	28.48 [a]	62.92 [a]	4.64 [a]
T3=3.0 kg a.i/ha C	52.725 [ab]	20.42 [a]	46.55 [ab]	3.82 [a]	62.40 [b]	24.07 [ab]	54.17 [b]	4.24 [ab]
T4=3.4 kg a.i/ha C	51.075 [b]	18.83 [ab]	45.81 [b]	3.81 [a]	61.57 [b]	22.47 [b]	52.90 [b]	4.25 [ab]
T5=control	51.10 [b]	18.65 [ab]	46.86 [ab]	3.73 [a]	53.56 [c]	18.43 [c]	46.12 [c]	3.76 [b]

PM=Poultry manure; C= Carbofuran; 'D' Leaf = the biggest leaf of the plant
[1]Means followed by the same letter in the same column do not differ significantly according to Duncan's Multiple Range Test ($P < 0.05$)
MAP= Months after planting

Effects of carbofuran on nematodes have been described as reversible, therefore nematode activity is restored after degradation or dilution of the carbamates in the plant rhizosphere (Sikora and Hartwig 1991, EXTOXNET 2001). Since carbofuran is systemic in plants, and is quickly metabolized and degraded in the soil, chances remain that the reduction in nematode population recorded on the carbofuran-treated plots in the experiment was due to starvation resulting from the inability of the nematodes to penetrate and initiate feeding sites on the pineapple roots and not necessarily due to the acute toxicity of the nematicide.

Significant increase in the vegetative growth and yield of pineapple following the application of carbofuran to the pineapple plots were also recorded. The carbofuran-treated plants had good plant heights with large 'D' leaf area and more uniform fruiting. This level of vegetative growth implies higher rate of photosynthesis and fruit production of the plants. It was observed that 3.4 kg a.i/ha of carbofuran gave the highest pineapple yield in Abeokuta field. This could be partly due to the fact that the Abeokuta field had more population of plant-parasitic nematodes which was effectively controlled by the quick action of the chemical treatment, thereby resulting in a better yield than the more gradual effect of the poultry manure amendment. This conforms to the findings of Tanimola (2008) who reported the best plant growth, highest yield and nematode control on carbofuran treatment at 2kg a.i/ha, as compared with poultry manure treated ones in nematode-infected cowpea. Thus, in nematode-infested soils, as in the case of Abeokuta field, soil treatment with carbofuran gave an effective control for plant-parasitic nematodes and at the same time promoted yield of pineapple.

The result of this study also showed that poultry manure significantly suppressed the population of plant-parasitic nematodes.

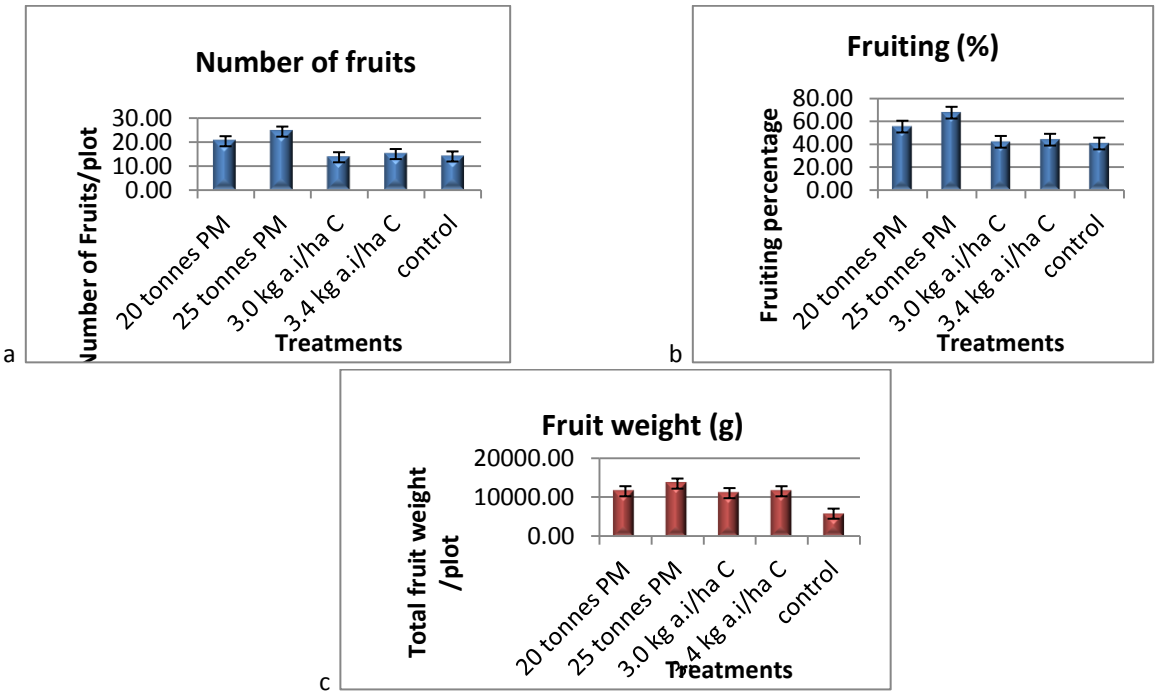

Fig.1: Effects of poultry manure and carbofuran treatments on the yield of pineapple in Ibadan field at harvest. PM=Poultry Manure; C=Carbofuran;

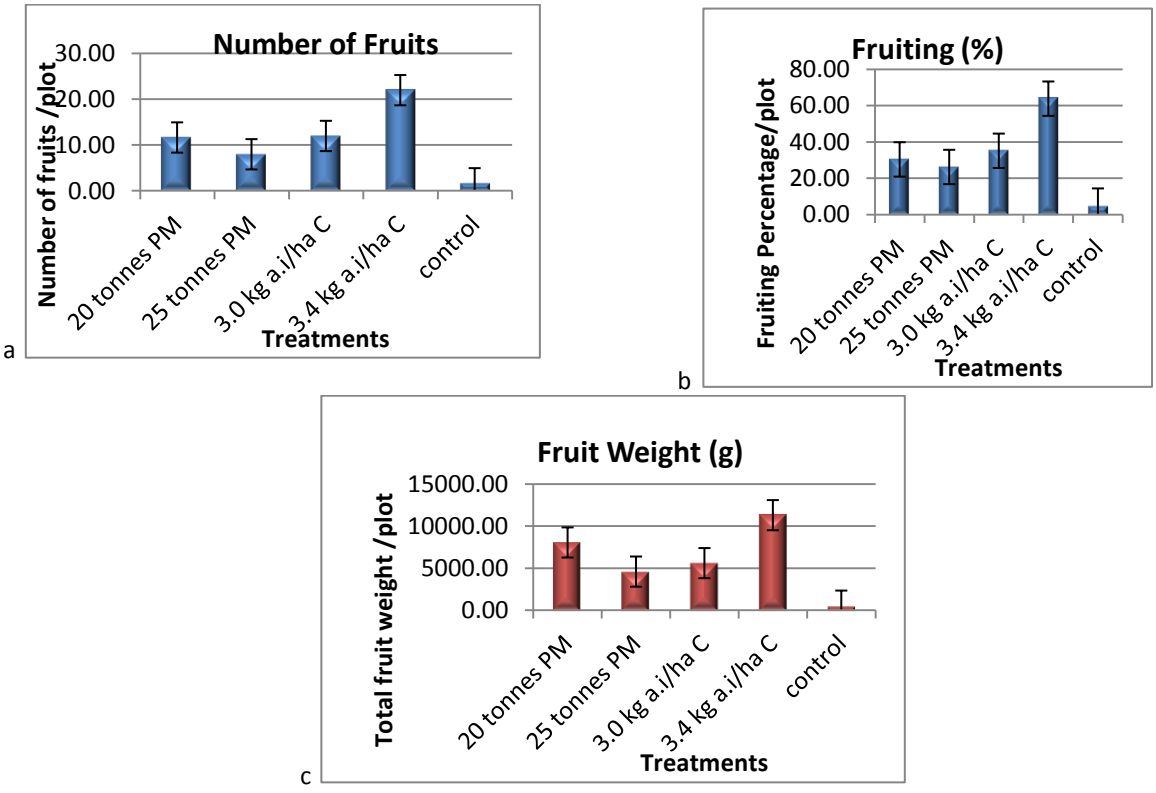

Fig.2: Effects of poultry manure and carbofuran treatments on the yield of pineapple in Abeokuta field at harvest. PM=Poultry manure; C=Carbofuran

a b

Fig. 3: Carbofuran treated plot showing big and uniform-sized fruiting at 24 MAP (a) and an untreated plot with poor fruiting percentage at 24 MAP (b)

This observation agrees with that of Agu (2008) which reported significant control of root-gall disease of pineapple with poultry manure. Poultry manure contains a significant amount of nitrogen, the majority of which is in the form of uric acid that can be easily converted to ammonia, which is lethal to plant-parasitic nematodes. According to Riegel and Noe (2000), suppression of nematodes by poultry litter is probably a combination of enhanced microbial activity and constituent toxicity to crops. Nematode population densities have also been negatively correlated with fruit weight of pineapple (Schenck 1990). Rohrbach and Apt (1986) had proposed that plant-parasitic nematodes could cause significant yield losses and in some cases lead to complete devastation of the crop due to their feeding activities on pineapple roots. Therefore suppressive effect of poultry manure on the nematode population in the pineapple fields could have resulted in the improved yield recorded on the poultry manure-amended plots.

The present study recorded significantly higher vegetative growth, number of fruits and fruit sizes on poultry manure-treated plot. Soil amendment with poultry manure has been shown to consistently improve the health of plants while reducing the populations of plant-parasitic nematodes (Oka et al. 2000 and Orisajo et al. 2008). Poultry manure contains significant quantities of N, P, K, Ca, Mg and micronutrients. The Nitrogen content of poultry manure also contains significant amounts of uric acid, which is readily decomposable and available to plants (Hue and Silvia 2000) for enhanced plant growth and yield. The application of poultry manure to the pineapple plots could have contributed to the concentration of nutrients within and below the root zone of the pineapple plants. The resultant effect of which is increased yield recorded.

CONCLUSION

Many alternatives to the use of chemical pesticides have been evaluated for their effectiveness in suppressing nematode population and environmental friendliness. Unfortunately, many of the more environmentally benign chemical products that have recently come on the market are ineffective in controlling nematode damage to pineapple. Soil amendment with poultry manure could therefore serve as an alternative to chemical nematicides in

controlling plant-parasitic nematodes of pineapple.

REFERENCES

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

Adekunle OK (2006) Evaluation of Weathered Poultry Manure, Cow Dung and Sawdust in the management of *Meloidogyne incognita* Race 2 in okra: In Nigerian Society for Plant Protection, 33rd Annual Conference (Book of abstracts) pg 16.

Afolami SO (1993) The Effect of Basamid Granular (Dazomet) on nematodes parasitic on cacao seedlings in the nursery. In: Proceedings, 11th International Cocoa Research Conference, Bahia, Brazil. pp. 237-240.

Agu CM (2008a) Effects of Organic Manure Types on Root-Gall Nematode Disease and African Yam Bean Yield. The Journal of American Science, 4(1), 2008, ISSN 1545-1003,

Agu CM (2008b) Root-Gall Disease of Pineapple as Affected by Seed Material, Amount and type of Organic Soil Amendment. Plant Sci. Res., 1 (2):36-39, ISSN: 1995-476X. © Medwell Journals.

Agyarko K, Asante JS (2005) Nematode Dynamics in Soils Amendment with Neem Leaves and Poultry Manure. Asian J. Plant Sci., 4:425-424.

Ahmad AA, Fares F, Abbas J, Deenik L (2009) Nutrient concentrations within and below root zones from applied chicken manure in selected Hawaiian soils. J. of Environ. Sci. and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes, 1532-4109, 44: 828–843.

Aktah A, Malik A (2000) Roles of organic soil amendment and soil organisms in the biological control of plant-parasitc nematodes: A reviw. Bioresource Tech. pp74-34.

Babatola JO (1982) Effects of soil amendments in tomato cultivation. In: Proc. 5th Annual Conf. Horticultural Society of Nigeria, Ahmadu Bello University, Zaria, 21–25.

Bartholomew DP, Paul RE, Rohrbach KG (2003) The Pineapple: Botany, production and uses. Bartholomew, D.P, Paul, R.E., Rohrback, K.G (eds.). CABI Publishing, Wallingford, UK. Pp 1 – 301.

Bunt JA (1987) Mode of action of nematicides, In: Veech, J and Dickson, D. (eds.),Vistas on Nematology, Society of Nematologist Inc, Hyattsville, Maryland, pp. 461-468.

Chen J, Abawi GS, Zuckerman BM (2000) Efficacy of *Bacillus thuringiensis*, *Paecilomyces marquandii*, and *Streptomyces costaricanus* with and without organic amendment against *Meloidogyne hapla* infecting lettuce. J. of Nematology 32: 70-77.

Chindo PS, Khan FA, Erinle ID (1991) Reaction of three tomato cultivars to two vascular diseases in presence of the root-knot nematode *Meloidogyne incognita* Race I. Crop Protect., 10: 62–64.

Chitwood DJ (2003) Nematicide Review. USDA-ARS, Beltsville, Maryland. Pp1104-1114.

Egunjobi OA, Afolami SO (1976) Effect of neem leaf extracts on populations of *Pratylenchus brachyurus* and on the growth and yield of maize. Nematologca. 22:125-132.

Egunjobi OA, Larinde MA (1975) Nematodes and maize growth in Nigeria. II. Effects of some amendments on populations of *Pratylenchus brachyurus* and on the yield of maize (*Zea mays*) in Nigeria. Nematol. Medit., 3: 65–73.

EXTOXNET (1996) Carbofuran. Available on line ttp://.extoxnet.orst.edu/pips/carbofur.htm

EXTOXNET (2001) Carbofuran. Available online http://ace.ace.orst.edu/info/extoxnet/pips/carbofur.htm

Hartwig J, Sikora RA (1991) Mode-of-action of the carbamate nematicides cloethocarb, aldicarb and carbofuran on Heterodera schachtii - : 1. Contact activity. Revue de Nématologie, Vol. 14, Num. 4, p. 525-530

Hassan NM, Ismail AB, Zulkifli M (2006) Nematode infestation on commercial pineapple cultivation on infested Peatland. Horticultural Research Center, MARDI. Malaysia.

Hassan SME, Rahman M Sq, Amin MR, Hoque ATMR, Islam SMS (2001). Effect of some organic substances on the root-knot disease of Brinjal. Online Journal of Biological Sciences 1:791 – 792.

Hue NV, Silvia JA (2000). Organic soil Ammendments for Sustainable Agriculture: Organic sources of Nitrogen, Phosphorus and Pottassium.In: Plant Nutrient Management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture.J. A. Silva and R. Uchida (eds.) College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Pp 133-144.

Iqbal MF, Maqbool U, Asi MR, Aslam S (2007) Determination of pesticide residues in brinjal fruit at supervised trial. J. Anim. Pl. Sci. 17(1-2): 2007. Pp 21-22.

Kimenju JW, Muiru DM, Karanja NK, Nyongesa MY, Miano DN (2004) Assessing the role of organic amendment in the management of Root-knot nematodes on common bean Phaseolus vulgaris L. Trop.Micobiol. Biotechnol. 3:14-23.

Neher DA (2001) Role of nematodes in soil health and their use as bioindicators. Journal of Nematology 33:161 – 168.

Oka Y, Nacar S, Putieusky E, Ravid U, Zohara Y, Spiegal Y (2000) Nematicidal activity of essential oils and their components against the root knot nematode. Phytopathology 90 (7). p. 710—715.

Olabiyi TI, Akanbi WB, Adepoju IO (2007) Control of certain nematode pests with different organic manure on cowpea. American-Eurasian J. Agric and Environ. Sci., 2(5):523-527.

Orisajo SB, Afolami SO, Fademi O, Atungwu JJ (2008) Effects of poultry litter and carbofuran soil amendments on Meloidogyne incognita attacks on cacao. Journal of Applied Biosciences (2008), Vol. 7: 214 – 221. ISSN 1997 – 5902: www.biosciences.elewa.org.

Otieno PO, Lalah JO, Virani M, Jondiko IO, Schramm K (2010) Carbofuran and its toxic metabolites provide forensic evidence for Furadan exposure in vultures (Gyps africanus) in Kenya. Bulletin of Environmental Contamination and Toxicology 84: 536-544.

Poswal MAT, Akpal AD (1991) Current trends in the use of traditional and organic methods for the control of crop pests and diseases in Nigeria. Trop. Pest Mgmt. 37:329-333.

Riegel C, Noe JP (2000) Chicken litter soil amendment effects on soil borne microbes and *Meloidogyne incognita* on cotton. Plant Dis. 84:1275-1281.

Rohrbach KG, Apt WJ (1986) Nematode and disease problems of Pineapple. Plant Disease 70:81-87.

Schenck S, Holtzmann O (1990) Evaluation of Potential Problems in a changing

Agricultural systems: Nematodes control in Hawaiian crops. Plant Diseases 1990.
Sikora RA, Hartwig J (1991) Mode-of-action of the Carbamate Nematicides Cloethocarb, Aldicarb, and Carbofuran on H. Schachtii. 2. Systemic Activity. Revue de Nématoie. 14(4): 531–536.
Sims JT, Wolf DC (1994) Poultry waste management and environmental issues. Adv. Agron.52:1-83.
Sipes BS, Caswell Chen, Sarah J, Apt W (2005) Nematodes Parasites of Pineapple In: Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 2nd Edition (eds) M. Luc, R.A. Sikora, J. Bridge. Pg 709 – 731.
Tanimola AA (2008) Comparison of the Effects of Carbofuran and Poultry Manure in the Management o*f Meloidogyne incognita* Race 2 on the growth and yield of Root-knot infected Cowpea (*Vigna unguiculata* (L., walps). Journal of Agriculture and Social Research (JASR) Vol. 8, No.1, 2008.
Whitehead AF, Hemming JR (1965) A comparison of some quantitative methods of extracting small vermiform nematodes from soil. Annals of Applied Biology. 55:25-28.
Widmer TL, Mitkowski NA, GS Abawi (2002) Soil Organic Matter and Management of Plant-Parasitic Nematodes. Journal of Nematology 34(4):289–295. 2002.
Yudelman M, Ratta A, Nygaard D (1998) Pest Management and Food Production: Looking to the future. Food, Agriculture and the Environment. Discussion paper 25, International Food Policy Research Institute, USA. pp. 50.