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Utilization of Organic Wastes for the Management of Phyto-Parasitic Nematodes in Developing Economies

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1. Introduction

The agricultural system in Nigeria and most developing countries has been dominated by the use of inorganic fertilizers as nutrient sources and synthetic pesticides for the management of pests and diseases. However the prices of these agro-chemicals have been skyrocketing beyond the reach of the rural poor farmer. Associated with this is their availability which is very highly unpredictable, thereby exposing the farmers to undue hardships in the crop production chain. Due to the high prices and unpredictable nature of the availability of these inputs, the rural poor farmers have resorted to utilizing organic materials /wastes principally as nutrient sources. These wastes however, have been shown to control a number of pests and diseases.

The term' waste' can be loosely defined as any material that is no longer of use, useless, of no further use to the owner and is, hence discarded or unwanted after use or a manufacturing process. These materials include agricultural wastes in the form of farm yard manure and dry-crop residues, sewage sludge, municipal refuse, industrial by-products, such as oilcakes, sawdust and cellulosic waste. Others are animal wastes such as feathers, bone meal, horn meal, and livestock wastes. Most discarded wastes, however, can be reused or recycled. This is the basis of the rag picking trade, the rifting through refuse dumps for recovery and resale of some materials. Today, heaps of refuse dump sites are disappearing in Nigeria because farmers evacuate them for use on their farms as organic fertilizers. Fortunately, these have been found to control phyto-parasitic nematodes among other diseases (Abubakar and Adamu, 2004; Abubakar and Majeed, 2000; Akhtar and Alam, 1993; Chindo and Khan, 1990; Hassan *et al.*, 2010). This is becoming an unconscious but well organized economically important waste management practice in Nigeria and many West African countries with attendant environmental benefits.

In recent years, there has been tremendous increase in public awareness on environmental pollution and climate change associated with pesticide toxicity and residues. This resulted in the shift in pest control strategies from chemical to the environmental era in the late 1980s. Since then several workers have reported that waste materials either of animal, plant or industrial origin have nematicidal and plant growth promoting properties (Akhtar and Alam, 1993; Chindo & Khan, 1990; Kimpinski *et al*., 2003. This has been exploited as an alternative means of nematode control (Abubakar and Adamu, 2004; Abubakar and Majeed, 2000; Hassan *et al*., 2010; Nico *et al*., 2004; Nwanguma and Awoderu, 2002;). The beneficial effects of organic incorporation have been generally considered to be due to increase in soil nutrients, improvement in soil physical and chemical properties (Huang and Huang, 1993; Hungalle, *et al*., 1986; Kang *et al*, 1981), direct or indirect stimulation of predators and parasites of phyto-parasitic nematodes (Kumar, 2007; Kumar et al, 2005; Kumar and Singh, 2011), and release of chemicals that act as nematicides (Akhtar and Alam, 1993; Sukul, 1992). Very often, when there was a decrease in the soil-pathogen population, there was a consequent increase in crop yield. (Akhtar, 1993; Akhtar and Alam 1993; Chindo and Khan, 1990).

Given the high cost and unpredictable supply of inorganic fertilizers and synthetic nematicdes, the best way to overcome such condition in the developing economies is to utilize waste resources for sustainable crop production and plant disease management. Given the importance of organic wastes highlighted above, this chapter intends to:

i. put together the research works published on the utilization of organic wastes for the management of plant disease with special reference to phyto-parasitic nematodes,
ii. examine the prospects of their usage in modern day agriculture,
iii. look at the challenges posed in the utilization of these wastes particularly in large scale agriculture, and
iv. attempt to proffer suggestions towards addressing these challenges.

2. Deployment of organic wastes for the management of phyto-parasitic nematodes

The food and agricultural organization (FAO) of the United Nations defines sustainable agriculture as a practice that involves the successful management of resources for agriculture to satisfy human needs while, maintaining or enhancing the quality of the environment and conserving natural resources (FAO, 1989). The system does not unduly deplete the resource as it makes best use of energy and materials, ensure good and reliable yields, and benefit the health and wealth of the local population at competitive production costs (Wood, 1996). Organic wastes perfectly fit into this definition. Being products of crop farms, domestic use, animal or industrial wastes, they are often recycled from the soil to farm produce thereby ensuring conservation of resources and environmental cleanliness. In addition, indirect benefits of pest and disease management are achieved. Numerous examples of these benefits on the management of phyto-parasitic nematodes have been reported by several workers.

2.1 Wastes from plants and plant origin

Compost made of agricultural and industrial wastes have been widely used as amendment in soil for the management of soil-borne diseases (Hoitink and Boehm, 1999;

Shiau et. al., 1999). In particular, several authors have reported suppression of diseases caused by root-knot nematodes with composted agricultural wastes (McSorely and Gallaher, 1995; Oka and Yerumiyahu, 2002). McSorely and Gallaher (1996) reported reductions in populations of the nematodes Paratrichodorus minor, M.incognita, Criconemella spp and Pratylenchus spp following applications of yard waste compost on maize (Zea mays) in Florida, USA. Forage yield of maize was increased by 10 to 212% when compared with the control.

In Spain, Andres, *et al*. (2004) using different composted materials at different rates in potting mixtures for the management of *Meloidogyne* species, found that root galling and final nematode populations of *M. incognita* race1 and *M. javanica* in tomato and olive plants were reduced. Increasing the rate of the test materials exponentially reduced galling and final population density of *M.incognita* by 40.8 and 81.9%, respectively (Table 1). Similar results were obtained for *M. javanica.* In south western Nigeria, Olabiyi *et al*. (2007) found that both decomposed and un-decomposed manure applied as organic amendment caused significant reduction in the soil population of *Meloidogyne* spp. *Helicotylenchus* sp. and *Xiphinema* sp. on cowpea. The organic manure resulted in a significant reduction of root galls on the cowpea (Table 2).

Composted amendment		Tomato				Olive
		M. incognita race I		*M. javanica*		*M. incognita* race I
Material	Rate (%)	RGS[b]	Final population[c]	RGS	Final population	Final population
Dry cork		Experiment I				
	0	3.3[d] a	114,612 a	4.0 a	73,777 a	8379 a
	25	2.4 b	39,752 b	2.9 b	25,470 b	1565 b
	50	1.8 c	17,396 bc	2.1 c	16,138 c	573 c
	75	1.5 c	8435 c	1.1 d	3483 d	248 c
	100	1.5 c	1737 c	1.0 d	215 d	132 c
Dry-grape marc		Experiment II				
	0	4.1 a	59,480 a	4.3 a	61,490 a	
	25	3.1 b	42,926 b	3.2 b	43,946 b	
	50	3.2 b	39,144 b	3.3 b	40,164 b	
	75	3.3 b	41,144 b	3.3 b	42,164 b	
	100	3.2 b	44,296 b	3.3 b	45,316 b	
Dry-olive marc + dry-rice husk (1:1)						
	0	3.7 a	69,499 a	3.8 a	65,609 a	
	25	3.4 a	64,914 a	3.5 a	60,750 a	
	50	3.4 a	72,931 a	3.5 a	68,249 a	
	75	3.6 a	71,208 a	3.4 a	68,654 a	
	100	3.4 a	64,078 a	3.4 a	63,561 a	

[a] Plants were inoculated with 10,000 eggs + second-stage juveniles (J2s) (tomato) or 5000 eggs + J2s (olive) at the time of transplanting into the amended potting mixture. Plants were incubated in a growth chamber under conditions favorable for nematode development for 2 months.

[b] Severity of root galling (*RGS*) was rated on a 0–5 scale according to the percentage of galled tissue, in which 0 = 0–10% of galled roots; 1 = 11–20%; 2 = 21–50%; 3 = 51–80%; 4 = 81–90%; and 5 = 91–100%.

[c] Final nematode population determined by extracting nematodes from 100-cm^3 samples of infested soil mixtures and from 5-g root samples of each plant 2 months after inoculation.

[d] Data are the average of two trials each with seven replicated plants per treatment combination. Means followed by the same letter do not differ significantly ($P > 0.05$) according to Fisher's protected LSD test.

Source; Andres, *et al*. (2004).

Table 1. Effects of composited amendments of potting mixtures on the root galling and finl population of *Meloidogyne incognita* race I and *M. javanica* on tomato and olive planting stock.

	Meloidgogyne spp.			*Helicotylenchus* sp.			*Xiphinema* sp.			
Treatment	Initial population	Final population	% reduction	Initial population	Final population	% reduction	Initial population	Final population	% reduction	Gall index
Decomposed wild sunflower leaf	546	341b	62.45	113	38a	33.63	69	41a	59.42	1.2a
Decomposed maize stover	569	308a	54.13	108	47a	43.52	72	38a	52.78	1.0a
Decomposed cassava peel	581	311a	53.53	119	31a	26.05	75	35a	46.67	1.0a
Undecomposed wild sunflower leaf	552	361b	65.40	115	48a	41.74	64	31a	48.44	1.3a
Undecomposed maize stover	568	307a	54.05	109	29a	26.61	67	33a	49.25	1.0a
Undecomposed cassava peel.	580	402b	69.31	107	35a	32.71	62	40a	64.52	1.5a
Control	577	2641c	457.71	114	188b	164.91	70	227b	324.29	4.7a
	NS		NS	NS						

NS = Not Significant

Means followed by the different letter(s) along the same column are not statistically different at 5% probability level

Source; Olabiyi, *et al.,* 2007

Table 2. Soil Nematode Population in 200 ml soil sample at planting (initial population) and harvest (final population), percentage reduction of nematodes and root gall index.

2.2 Use of plant parts

Numerous plant parts used as organic amendments have been shown to control phyto-parasitic nematodes. Neem (*Azadirachta indica*) is the best known example that act by releasing pre-formed nematicidal constituents into soil. Neem products, including leaf, seed kernel, seed powders, seed extracts, oil, saw dust and particularly oil cake, have been reported as effective for the control of several nematode species (Egunjobi and Afolami, 1976, Akhtar, 1998). Neem constituents, such as nimbin, salanin, thionemone, azadirachtin and various flavonoids, have nematidal effects; triterpene compounds in neem oil cake inhibit the nitrification process and increase available nitrogen for the same amount of fertilizer (Akhtar and Alam, 1993).

Akhtar (1998) reported the effect of two neem-based granular products, Achook and Sunneem G, urea and compost manure incorporated in the soil. These treatments were found to decrease the number of phyto-parasitic nematodes with increasing doses of plant products. Combination of both neem with urea were reported to be the most effective in suppressing this pathogen.

2.3 Use of animal and industrial wastes

Several animal and industrial wastes have been found to be very efficacious in the management of phyto-parasitic nematodes when applied to the soil. For instance steer and chicken manures reduced number of cyst and citrus nematodes and resulted in increased yields of potato and citrus (Gonzalez and Canto-Saenz, 1993). Chindo and Khan (1990) reported a significant reduction of root-knot nematode populations and root gall index following application of poultry manure on tomato (Table 3).

Hassan *et al*. (2010) reported the use of refuse dump (RD), saw dust (SD) and rice husk (RH) for nematode control with attendant increases in crop yield in tomato in northern Nigeria.

Levels of poultry manure (g/pot)	Population of *M. incognita*/kg of soil at:		Root gall index†	Root weight (g)†	Plant height at midseason (cm)†	Fruit number at harvest†	Fruit weight at harvest (g)†	Mean weight/fruit (g)‡
	Mid-season	Harvest						
7·5	1 600	8 300	5·0	54·6	34·6	6·2	235·0	37·9
15·0	600	3 100	3·1	48·2	42·4	9·0	406	45·1
30·0	540	2 800	1·0	39·1	47·8	9·6	464·0	48·3
0 (control)	12 500	17 900	6·0	62·0	31·8	5·6	202·0	36·0
C.D.	—	—	—	—	7·3	1·7	105	—

†Each value is a mean of five replicates.
‡Mean of total number of fruits.

Source; Chindo and Khan, 1990

Table 3. Effect of soil amendment with four levels of poultry manure on the development of *M. incognita* and growth of tomato cv. Enterpriser in the greenhouse.

Refuse dump was found to perform best compared to rice husk (RH) and sawdust (SD) and this was attributed to the lower C: N ratio of the RD compared to SD and RH (Table 4&5).

Treatment	Rates of application (t/ha)	Nematode populations per 500 cm^3			Nematode populations per 10 g root	Number of galls per 10 g root	Egg-masses per 10 g root	Root galls indices
		initial (Pi)	mid-season (Pm)	final (Pf)				
	15	40.0^{a}	34.3^{b}	26.0^{b}	18.0^{b}	14.3^{b}	28.0^{a}	2.3^{b}
Rice husk	30	38.5^{a}	27.3^{bc}	17.8^{bc}	9.7^{d}	8.0^{cd}	14.0^{b}	1.3^{c}
	45	37.0a	22.3^{bc}	13.2^{de}	5.3e	3.3^{de}	8.0^{b}	1.0^{c}
	15	38.8^{a}	31.0^{bc}	24.5^{b}	14.3^{bc}	12.0^{bc}	19.0^{ab}	2.0^{b}
Sawdust	30	32.3^{a}	23.2^{bc}	18.8^{bc}	8.3^{de}	6.3^{de}	11.7^{b}	1.0^{c}
	45	30.3^{a}	20.7^{bc}	13.0^{ef}	3.7^{ef}	2.3^{e}	5.3^{b}	1.0^{c}
	15	43.2^{a}	31.3^{bc}	20.3^{b}	11.0^{cd}	10.0^{bcd}	16.0^{ab}	2.0^{b}
Refuse dump	30	35.2^{a}	24.3^{bc}	14.7^{cd}	4.3^{ef}	3.0^{de}	6.7^{b}	1.0^{c}
	45	35.7^{a}	21.5^{bc}	8.3^{fg}	2.3^{f}	1.0^{e}	2.7^{b}	1.0^{c}
	0.01	42.5^{a}	18.5^{bc}	9.8^{ef}	5.0^{ef}	3.0^{de}	7.7^{b}	1.0^{c}
Furadan	0.032	44.5^{a}	15.3^{bc}	6.0^{g}	2.3^{f}	1.0^{e}	3.0^{b}	1.0^{c}
	0.064	36.2^{a}	11.5^{c}	2.8^{g}	1.0^{f}	1.0^{e}	1.7^{b}	1.0^{c}
Non-amended (Control)	–	37.0^{a}	53.0^{a}	66.8^{a}	45.3^{a}	39.7^{a}	38.3^{a}	4.3^{a}

Means followed by the same letter within each column are not significantly different ($P = 0.05$) as indicated by Student-Newman-Kuel's (SNK) test

Table 4. Effect of soil amendment with three organic wastes on the number of galls, egg masses and populations of *Meloidogyne* spp. on tomato in the villages of Arewaci and Kurmi Bomo of Zaria, Nigeria

This is in conformity with the report of Miller *et al*., (1973) that availability of more nitrogen enhances the ability of the organic amendment to control nematodes. Similar achievements of nematode control through the use of several organic amendments have been reported by other workers (Abubakar and Adamu, 2004; Abubakar and Majeed, 2000; Khan and Shaukat 2002; Nwanguma and Awoderu, 2002; Nico *et al*., 2004). The abundance of refuse dump, industrial sawdust and rice husk all over Nigeria and most developing countries makes them very suitable candidates for deployment as soil organic amendments for the management of phyto-parasitic nematodes.

Treatment	Rates of application (t/ha)	Tomato (fruit) yield (t/ha)	Plant dry weight (g)		Plant shoot height	Plant root length
			shoot	root		
Rice husk	15	4.7^{gh}	139.8^{j}	44.2^{i}	29.0^{e}	10.4^{fg}
	30	5.8^{fg}	144.4^{ij}	46.5^{gh}	29.1^{e}	11.2^{de}
	45	7.8^{d}	149.8^{hi}	48.1^{g}	33.7^{cd}	11.8^{de}
Sawdust	15	5.4^{fg}	159.7^{g}	42.4^{j}	29.9^{e}	10.3^{fg}
	30	6.6^{e}	164.4^{fg}	46.2^{hi}	31.3^{de}	10.8^{ef}
	45	8.9^{c}	171.3^{f}	47.6^{f}	36.2^{c}	11.6^{de}
Refuse dump	15	5.6^{fg}	209.4^{e}	55.4^{c}	30.0^{de}	13.1^{b}
	30	7.9^{dc}	215.6^{de}	57.9^{b}	32.7^{de}	14.2^{a}
	45	9.9^{b}	221.6^{cd}	60.3^{a}	40.9^{b}	14.8^{a}
Furadan	0.01	6.2^{ef}	227.3^{bc}	50.9^{e}	39.1^{b}	11.6^{de}
	0.032	8.0^{cd}	233.2^{ab}	53.2^{d}	42.0^{b}	12.0^{cd}
	0.064	11.8^{a}	239.7^{a}	55.5^{c}	51.5^{a}	12.6^{bc}
Non- amended (Control)	–	4.8^{gh}	127.7^{k}	45.8^{h}	28.9^{e}	9.9^{g}

Means followed by the same letter within each column are not significantly different ($P = 0.05$) as indicated by Student-Newman-Kuel's (SNK) test

Source; Hassan, *et. al.*, 2010

Table 5. Effect of soil amendment with three organic wastes on the yield and growth of tomato in the villages of Arewaci and Kurmi Bomo of Zaria, Nigeria

The beneficial effects of organic wastes are both direct and indirect. They affect the nematodes directly by releasing toxic products (after decomposition) that kill or inactivate the nematodes (Bello *et al*., 2006). They indirectly control nematode effects by increasing soil fertility to the advantage of the crop (Boehm *et al*., 1993). In addition to soil fertility, soil amendment with organic matter may also alter soil physical and chemical properties, and thereby affecting soil microflora (Huang and Huang, 1993).

Nematodes are important participants in the underground energy transfer system. They consume living plant material, fungi, bacteria, mites, insects and each other and are themselves consumed in turn. Some fungi do capture nematodes with traps, sticky knobs and other specialized structures (Dropkin, 1980; Jaffe *et al*., 1998; Kumar *et al*., 2011) (Table 6 &7).

There is substantial evidence that the addition of organic matter in the form of compost or manure will decrease nematode populations and associated damage to crops (Akhtar and Alam, 1993; Oka and Yerumiyahu, 2002; Stirling and Smith, 1991; Walker, 2004).

The fungus, *Arthrobotrys* species is a nematode-trapping fungus, which produces constricting rings for capturing and killing nematodes. The biocontrol efficiency of this fungus in reducing the population of *Meliodogyne javanica* was described by Galper *et al*. (1995). However, excellent control of root knot nematodes of vegetables following the application of granular formulations of *A. dactyloides* in pot and field was obtained by Sterling *et al*. (1998) and Sterling and Smith (1998). Hoffmann –Hergarten and Sikora (1993) also reported that the efficacy of *A. dactyloides* and some other *Arthrobotrys spp*. was enhanced with mustard as green manure and barley straw as soil amendment against early penetration of rape roots by *Heterodera schachtii.* Kumar and Singh (2005) reported that *A.*

dactyloides with cow dung manure reduced infection of plants for 10 weeks due to well developed roots that protected the initial stage of infection by capturing and killing of nematodes by this fungus. These findings are in consonance with similar reports by Sterling *et al*., (1998), and Stirling and Smith (1998) where formulation of *A. dactyloides* caused 57 - 96% reduction in number of root-knots and 75- 80% reduction in number of nematodes per plant in tomato in pot and field experiments, respectively.

	Isolate				
	Trapping (%)				
Nematode	A	B	C	D	E
Meloidogyne incognita (J_2)	87.0 a 1	83.3 a 1	86.7 a 1	92.3 a 1	84.3 a 1
M. graminicola (J_2)	82.3 a 2	79.0 a 1	80.7 a 2	88.7 a 2	80.3 a 1
Hoplolaimus indicus	0.0 a 3	0.0 a 2	0.0 a 3	0.0 a 3	0.0 a 2
Helicotylenchus dihystera	18.7 a 4	16.3 a 3	19.0 a 4	24.7 a 4	20.7 a 3
Xiphinema basiri	0.0 a 3	0.0 a 2	0.0 a 3	0.0 a 3	0.0 a 2
Tylenchorynchus brassicae	5.3 a 5	4.0 a 4	5.7 a 5	9.0 a 5	4.7 a 5

J_2 = second-stage juvenile.
Data with same letter (a) show non-significant difference of row data among isolates by completely randomised design (CRD) test at $p \leq 0.05$.
Data with different digits (1, 2, 3, 4 and 5) show significant difference of column data among temperatures by completely randomised design (CRD) test at $p \leq 0.05$.

Source; Kumar *et.al*., 2011

Table 6. *In vitro* trapping of plant parasitic nematodes by direct formed rings of five isolates of *Dactylaria brochopaga* after 12 h of inoculation.

Stage of development	*Helicotylenchus dihystera*	*Tylenchorynchus brassicae*	*Meloidogyne incognita*	*Meloidogyne graminicola*
Numbering of constricting ring per nematode (pre-capturing)	1–2	1–3	1–4	1–4
Inflation of ring cells	0.3 to1.5 h	0.2 to 1.3 h	10–32 min	15–45 min
Killing	2.2 to 6.3 h	2.5 to 8 h	1–4 h	1.3–5 h
Mycelial growth outside of nematode body	13–15 h	11–14 h	7–10 h	8.2–11 h
Numbering of rings formed (after mycelial growth out side nematode body)	60–110	36–64	28–52	22–43
Mycelium visible within nematode body	3–5 days	3–5 days	3–4 days	3–4 days

Source; Kumar *et.al*., 2011

Table 7. Development of *Dactylaria brochopaga* in some important phytonematodes.

Generally, refuse dump, composts and some industrial wastes are abundant all over the major cities in the developing world. With support from governments and some private organizations, the abundance of these wastes can be channeled into our agricultural systems for the management of plant parasitic nematodes and other plant diseases.

2.4 Deployment of allelopatic plants in the management of phyto-parasitic nematodes

Production of allelopathic chemicals that function as nematode antagonistic compounds has been demonstrated in many plants such as castor bean, chrysanthemum, velvet bean, sesame, jack bean, crotalaria, sorghum-sudan, indigo, tephrosia, neem, *Tamarindus indica*, flame of the forest. These chemicals include saponins, tannins, polythienyls, glucosiniolates, cyanogenic glucosides, alkaloids, lipids, terpenoids, triterpenoids and phenolics, among others. When grown as allelopathic cover crops, bioactive compounds are exuded during the growing season or released during green manure decomposition. Sunn hemp, a typical legume, and sorghum-Sudan, a prolific grass plant grown for its biomass, are popular nematode-suppressive cover crops that produce the allelochemicals known as monocrotaline and dhurrin, respectively (Chitwood, 2002, Grossman, 1988, Hackney and Dickerson, 1975. Ball-Coelho *et al*., 2003) found that using forage pearl millet (Canadian Hybrid 101) and marigold (rakerjack) as rotation crops with potatoes resulted in fewer root lesion nematodes and increased potato yield than rotation with rye.

2.5 Deployment of plant extracts in the management of phyto–parasitic nematodes

The use of plant extracts is one of the promising tools being investigated for the management of nematode diseases. They are relatively cheap, easy to apply, with minimal environmental hazards and have the capacity to structurally and nutritionally improve the soil health. Several parts of neem tree and their extracts are known to exhibit nematicidal activities (Bello *et al*., 2006 ((Fig.1&2), Mojundar, 1995, Raguraman *et. al*., 2004, Suresh *et al*., 2004), and many neem based pesticidal formulations have been developed and marketed.

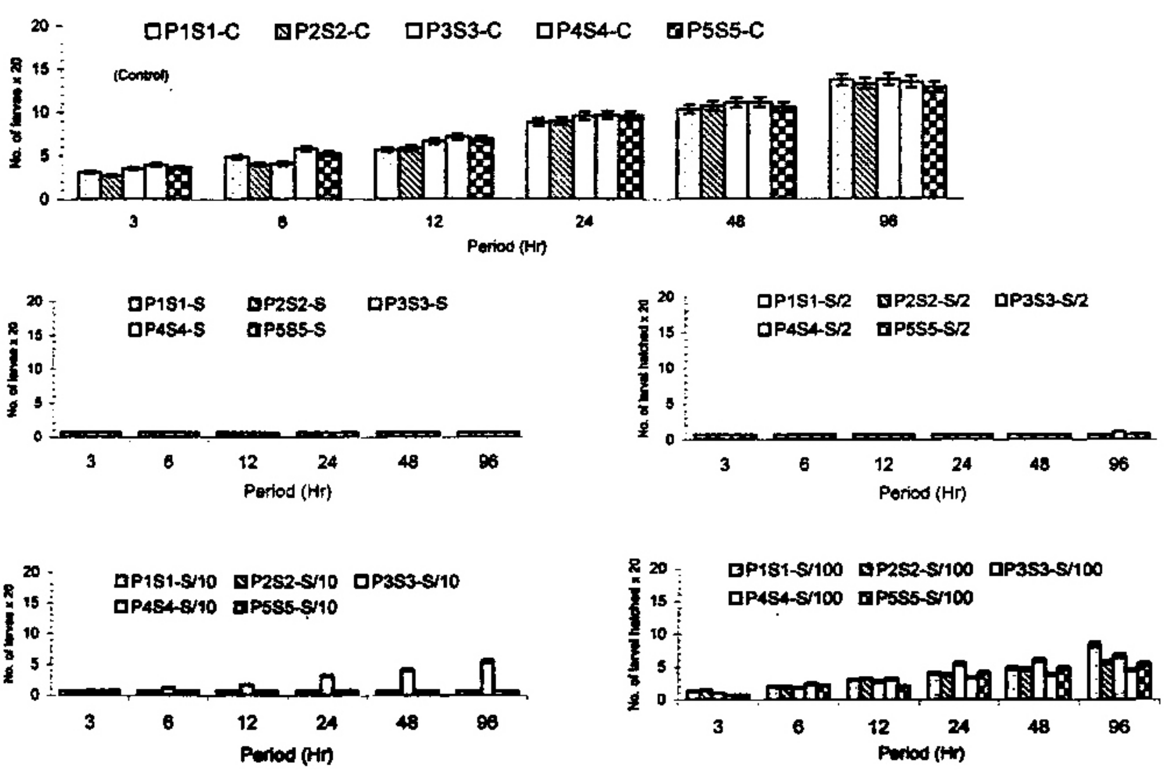
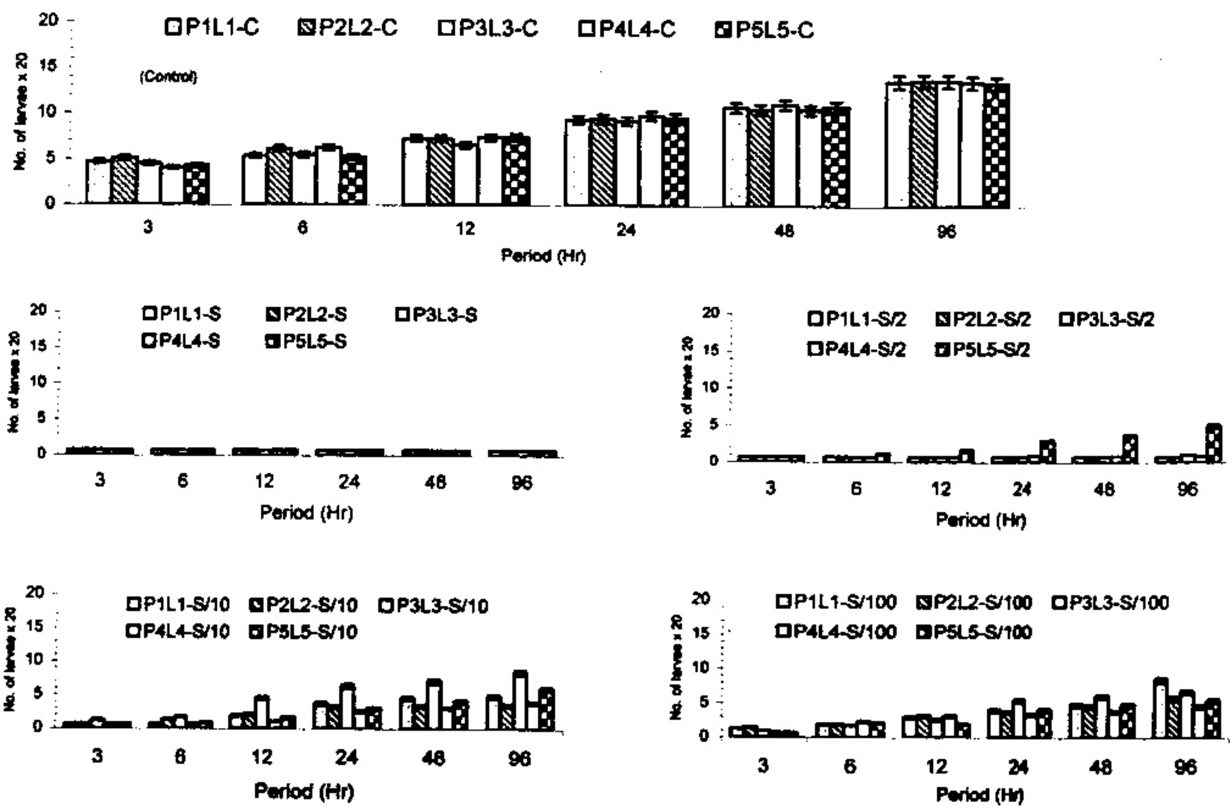


Fig. 1. Effect of water-soluble fraction of seed (S) extracts of *Tamarindus indica* (P1), *Cassia siamea* (P2), *Isoberlinia doka* (P3), *Delonix regia* (P4) and *Cassia sieberiana* (P5) on egg hatch of *Meloidogyne incognita* at different concentrations and time



Source; Bello *et. al.*, 2006

Fig. 2. Effect of water-soluble fraction of the leaf (L) extracts of Tamarindus indica (P1), Cassia siamea (P2), Isoberlinia doka (P3), Delonix regia (P4) and Cassia sieberiana (P5) on egg hatch of Meloidognye incognita at different concentrations and time

The extracts of five organic waste of citrus (cv. Late Valencia), cocoa bean testa, rice husk, poultry manure and oil palm bunch were reported to have inhibitory effect in the egg masses of *M. incognita* (Osei *et al*., 2011). Adegbite *and Adesiyan (*2005) reported that the root extracts of Siam weed, neem, lemon grass and castor bean were found to have nematicidal properties. Rakesh *et al*. (2000) determined the efficacy of essential oils in *Cymbopogon martinii*, *Mentha aivensis* and *Ociumum basilicum* on the production potential of root-knot nematode, *M. incognita* and growth of black henbane, *Hyoscyamus niger*. Reduction of population of *M.incognita* by all the oils was achieved. The effect of aqueous leaf extracts of seven plants species on hatching and mortality of second stage juneniles of *M. incognita* were tested. There was a great reduction in hatching and an increase in nematode mortality with *Murraya koenigii* (curry leaf), *Jasminum sambac* (Jasmine), *Citrus aurantifolis (*sour orange*), Zizyphus jujuba (ber), Hibiscus rarasieusis (*China rose*),* and *Justicia gandurosa (J. gendaussa*) leaf extracts (Padhi *et al*., 2000). Bello *et al*. (2006) and Bello (2010) reported mortality of *M. incognita* following the use of water extracts *of A. indica, Tamarmdus indica, Cassia sieberiana, Cassia siamea, and Delonix regia*

Bharadwaj and Sharma (2007) observed that higher concentration levels of *Carica papaya* inhibited hatching of *M. incognita.* Similarly. The plant extract of stored pulpified peels of lemon, orange and grape fruit demonstrated significant nematicidal activity against *M. incognita* second stage juveniles after 48 hours of exposure (Tsai, 2008). Also, root exudates of *Gaillardia pulchella* were reported to be lethal to J2 of *M. incognita* and inhibitory to egg hatch at the concentration of 250 ppm or higher (Tsay, *et al*., 2004).

Chemical based conventional systems of agricultural production have created many sources of pollution that either directly or in indirectly contribute to degradation of the environment and destruction of our natural resource - base. In this situation organic waste could be utilized both for the control of plant parasitic nematodes and other plants pathogenic diseases and improvement of soils and maintenance of a productive environment. For sustainability of agriculture in the developing economies, farmers should divorce themselves from the synthetic pesticides strategy for phyto-parasitic nematode management and marry the phytochemical option which is non-toxic to man and its environment. Most of these plants are richly available, biodegradable and affordable to the peasant farmers in the developing world.

3. Challenges and prospects in the utilization of organic wastes for the management of phyto-parasitic nematodes

The deployment of organic materials for the management of phyto-parasitic nematodes in modern day agriculture is pregnant with several challenges. These include among others initial fear of the unknown, dosage labour requirement and financial constraints

3.1 Fear of the unknown

The adoption of any new farming technology is often received by farmers with a lot of skeptism because of fear of the implications of the new technology on the productivity of their crops. Thus, adoption of such technologies is often slow until when fully convinced of its advantages over the traditional systems. Experience has shown that the transition from conventional agriculture to nature farming or organic farming can involve certain risks, such as initial lower yields and increased pest problems (James, 1994). However, once the transition period is over, which might take several years, most farmers find their new farming systems to be stable, productive, manageable, and profitable. In this case, the use of organic wastes will be beneficial through abundance of beneficial micro-organisms (characteristic of organically amended soils) which can fix atmospheric nitrogen, decompose organic wastes and residues, detoxify pesticides, suppress plant diseases and soil-borne pathogens, enhance nutrient cycling and produce bioactive compounds such as vitamins hormones and enzymes that stimulate plant growth (Higa, 1995). Besides, amendments may increase soil populations of micro-organisms antagonistic to nematodes, but are also known to release several toxic compounds during their decomposition in soil that act directly by poisoning the phyto-parasitic nematodes (Oka and Pivonia, 2002).

3.2 Dosage/Application rate

The quantities of organic wastes usually required per unit area are large.This poses problems of acquisition transportation and application particularly in large scale farms. Fortunately, in Nigeria and other developing countries, these wastes are in abundance. Large quantities of refuse dump sites, rice and other cereal straws, industrial wastes such as saw dust, rice husk, by-products of breweries, agro-processing plants etc abound. Concerted efforts by governments, organizations, non-governmental organizations (NGOs), research centers etc. are needed to mobilize these resources for use either directly or transformed into other products that can be utilized more easily by the farmers. In Taiwan for instance, fertilizers and organic wastes have been transformed into different products that are used to control plant diseases including nematodes (Huang and Huang, 1993; Huang and Kuhlman, 1991; Huang *et al*., 2003).

3.3 Labor requirement

Traditionally organic farming is labor and knowledge – intensive whereas conventional farming is capital intensive, requiring more energy and manufactured inputs (Halberg, 2006). This, however, is not a serious drawback in most developing economies .There is abundance of idle labour which can be readily deployed to the movement and application of these wastes to work in farms thereby mitigating the myriad of social ills that is often associated with such idle minds.

3.4 Financial constraints

Research and development in organic farming is normally constrained by scarce funding from government and large commercial stakeholders, and smaller commercial players are generally unable to allocate funds for research and development. In order to have a breakthrough, research organizations such as the Colloquium of Organic Research in the United Kingdom (UK) and the Scientific Committee for Organic Agriculture Research in the USA should be formed in the developing countries such as Nigeria to boost agriculture and provide employment for the increasing population.

Organic agriculture in developing economy can be improved upon with adequate funding, removal of production subsidies that have adverse economic, social and environmental effects, investment in agricultural science and technology that can sustain the necessary increase of food supply without harmful tradeoffs involving excessive use of water, nutrients or pesticides.

4. Conclussion

In view of the foregoing, it is clear that synthetic pesticide-based conventional system of agricultural production which has created many sources of pollution either directly or indirectly, contributed to degradation of the environment and destruction of our natural resource needs to be critically examined. This is with the view to minimizing usage of these compounds and deploying much more effective, cost effective and environmentally friendly strategies that will ensure good health of our people and enhance the stability of our agricultural soils. An area that appears to hold the greatest promise for technological advances in crop production, crop protection and natural resource conservation is that of organic wastes and organic materials. The generation of solid waste has been increasing steadily after the past ten years due to rising population, urbanization and industrialization in Nigeria and most developing countries. In the early 1970s, prior to the discovery of oil in Nigeria, municipal wastes were managed as compost manure and used as organic amendments. The onset of oil wealth changed lifestyle patterns leading to increased generation of varied components of municipal solid wastes which can be channeled towards improvement in crop production.

5. References

Abubakar, U., Adamu, T. (2004). Control of *Meloidogyne incognita* (kofoid and White) Chitwood of tomato (*Lycopersicon lycopersicum* Karst) using camel dung. *Journal of Tropical Biosciences*, Vol. 47, (2004), pp.1–3. ISSN: 1007-3515

Abubakar, U., Majeed, Q. (2000). Use of animal manure for the control of root-knot nematodes of tomato. *Journal of Agriculture and Environment* Vol. 1, No. 12, (2000), pp. 29-33. ISSN 1573-322X

Adegbite, A.A and Adesiyan S.O. (2005). Root extracts of plants to control root-knot nematode on edible soybean. *World Journal of Agricultural Science* Vol.1, No.1(January, 2005), pp. 18-20, ISSN1817-3047

Akhtar, M. (1993). Utilization of plant-origin waste materials for the control of parasitic nematodes. *Bioresource Technology* Vol.46 (1993), pp. 255-257,

Akhtar,M and Alam, M. M. (1993). Control of plant-parasitic nematodes by 'Nimin'-an urea-coating agent and some Splant oils. *Zetschrift fur Planzenkrankhei ten und Pflanzenschutz* Vol. 100 (1993), pp.337-342,

Akhtar, M., and Malik, A. (2000). Role of organic soil amendments and soil organisms in the biological control of plant-parasitic nematodes. A review. *Bioresources Technology*, Vol. 74 (2000), pp. 35-47

Akhtar, M, (1998). Biological control of plant parasitic nematodes by neem products in agricultural soil. *Applied Soil Ecology*, Vol.7, (1998), pp. 219-223. ISSN 0105-8568

Andres, I. N. Rafael, M. J. and Pablo, C. (2004). Control of root-knot nematodes by composted agro-industrial wastes in potting mixtures, *Crop Protection* Vol. 23 (2004), pp. 581-587, ISSN 0306-3941

Ball-Coelho, B., Bruin, A.J., Roy, R.C and Riga, E. (2003). Forage pearl millet and marigold as rotation crops for biological control of root-lesion nematodes in potato. *Agronomy Journal*, Vol. 95, No, 2. (2003), pp. 282- 292. ISSN 0002- 1962.

Bello, L.Y., P.S Chindo.,P. S Marley, and M.D. Alegbejo. (2006). Effects of some plants extracts on larval hatch on the root-Knot nematode *Meloidogyne incognita. Archives of Phytopathology and Plant Protection, Vol.* 39 (2006), No.4, pp. 253-257. ISSN 007-2425

Bello, L.Y and M.O. Abogunde (2010). Effect of *Delonix regia* leaf extract on egg hatch and larva mortality of root- knot nematodes *Meloidogyne incognita. Journal of applied Agricultural Research*, Agricultural Research Control of Nigeria (ARIN) Vol. 2: pp. 113-117.

Bharadway A, and Sharma, S. (2007). Effects of some plant extracts on hatch of *Melodogyne incognita* eggs. *Int. J. Bot.* Vol.3 (2007), pp. 312-316, ISSN18119700

Boehm, M.J., Madden, L.V., and Hoiting, H.A.J. (1993). Effect of organic matter decomposition level on bacterial species diversity and composition in relationship to Pythium damping-off severity. *Applied Environmental Microbiology*, Vol.59, (1993), pp.4171-4179. ISSN: 0717-3458.

Chindo, P.S. and Khan, F.A. (1990). Control of root-knot nematodes (Meloidogyne spp.) on omato (*Lycopersicon esculentum* Mill.) with poultry manure. *Tropical Pest Mangement*, Vol.36, (1990), No. 4, pp. 332-335,

Chitwood, D. J. (2002). Phytochemical based strategies for nematode control. *Annual Review of Phytopathology* Vol. 40 (2002), pp. 221-249. ISSN: 1392-3196

Dropkin, V. H. (1980). Introduction to plant nemathology. John Wiley and Sons. New York. NY. pp. 38-44, 242-246, 256.

Egonjobi, O.A, Afolami, S.O., (1976). Effect of Neem (*Azadirachta indica)* leaf extract on population of *Pratylenchus brachyurus* on the growth and yield of maize. *Nematolologia*, Vol.22 (1976), pp. 125-132. ISSN 0391-9749

FAO. (1989). Sustainable agricultural production: Implications for International Agricultural Research. *Technical Advisory Committee, CGIAR, FAO Research and Technical Paper* No. 4 Rome, Italy.

Galper, S. Eden L.M, Stirling G. R, Smith, L.J. (1995). Simple Screening methods for assessing the predacious activity of nematodes trapping fungi. *Nematologica* Vol.41, (2995), pp. 130-140, ISSN 0103-8478.

Gonzalez, A., Canto-Sanenz, M. (1993). Comparism of five organic amendments for the control of *Globodera pallida* in microplots in Peru. *Nematropica, Vol.* 23 (2993), pp. 133-139, ISSN: 0717-3458

Grossman, J. (1988). Research Notes: New directions in nematodes control. *The IPM Practitioner*. February (1998). pp. 1-4.

Hackney, R.W. and Dickerson, O.J. (1975). Marigold, castor bean, and chrysanthemum as controls of *Meloidogyne incognita* and *Pratylenchus alleni, Journal of Nematology*, Vol. 7, No 1, (1975), pp. 84-90, ISSN: 1388-66-45

Halberg, N. (2006). *Global development of organic agricultural challenges and prospects*. CABI pp 297.

Hassan, M.A., Chindo, P.S., Marley, P.S, Alegbejo, M.D. (2010). Management of root-knot nematodes (*Meloidogyne spp*.) on tomato (*Lycopersicon lycopersicum*) using organic wastes in Zaria, Nigeria. *Plant Protect. Science*, Vol.46, (2010), pp.34-39, ISSN 1212-2580.

Higa, T. (1995). Effective microorganisms: their role in Kyusei nature farming and sustainable agriculture. In J.F. Parr, S.B. Hornick and M.E. Simpson (ed.) *Proceedings of the Third International Conference on Kyusei Nature Farming*. U.S. Department of Agriculture, Washington, D.C, USA. (In Press).

Hoffman- Hergartan, S, Sikora R.A. (1993). Studies on increasing the activities of nematodes trapping fungi against early attack by *Heterodera sehachtii* using organic fertilizer. *Z. Pfikr pfish*. 100:170-175.

Hoiting, H.A.J.,and Boehm, M.J. (1999). Biocontrol within the context of soil microbial communities: a substrate- dependent phenomenon, *Annual Review of Phytopathology*, Vol. 37, (1999), pp.427-446, ISSN 0021-8596.

Huang H.C. and Huang, J.W. (1993). Prospects for control of soil-borne plant pathogens by soil amendments. *Current Topics in Bot. Research, vol.* 1 (1993), pp. 223-235.

Hungalle, N., Lal, R, Terkule., C. H. H. (1986). Amelioration of physical properties by Mucuna after mechanized land clearing of tropical rain forest. *Soil Science, vol.* 141 (1986), pp. 219-224. ISSN 0973-9424.

Huang, J.W, Hsieh, T.F and Sun, S.K. (2003a). Sustainable management of soil-borne vegetable crop disease . In: *Advances in Plant Disease Management*, H.C. Huang and S.N. Acharya (Ed.), 107-119, ISSN 1230- 0462, Research Signpost, Kerala, India.

Huang, J.W. and Kuhlman, E.G. (1991). Mechanisms inhibiting damping-off pathogens of slash pine seedlings with a formulated soil amendment. *Phytopathology* Vol. 81(1991), pp.171-177. ISSN 0191-2917

Jaffe, B.A., Ferris, H. and Scow, K.M. (1998). Nematode trapping fungi in organic and conventional cropping systems. *Phytopathology*, vol.88 (1998), pp. 344-350, ISSN 1553-7374.

James, F.P. 1994. Beneficial and Effective Microorganisms. In: *Preservation of Natural Resources and the Environment*, T. Higa and F.P. James (Ed.), International Nature Farming Research Center, Afami, Japan.

Kang, B.T., Sipkens, C., Wilson, G.F., Nangju, D. (1981). Leucaena (Leuc*eaena leucocephala* (Lal) de wit) prunings as nitrogen sources for maize. (*Zea mays L*). *Fertelizer Research, Vol.* 2(1981), pp.279-287, ISSN 0564- 3295

Khan A., Shaukat, S.S. (2002): Effect of some organic amendment and carbofuran on population density of four nematodes and growth and yield parameters of rice (*Oryzae sativa*). *Pakistan Journal of Zoology*. Vol. 32 (2002), pp.145-150, ISSN 1536-2442.

Kimpinski, J, Gallant, C.E, Henry, R, Macleod, J.A, Sanderson, J.B, Sturz, A.V. (2003). Effect of compost and manure soil amendments on nematodes and on yields of potato and barley: a 7-year study. *J. Nematology*, Vol.35 No. 3 (2003), pp. 289-293, ISSN 0303-6960.

Kumar, D, Singh, K.P. and Jaiswal R.K. (2005). Effect of fertilizers and neem cake amendments in soil on spore germination of *Arthrobotrys dactyloides*. *Mycobiology*, Vol. 33 No. 4, (2005), pp. 194-199.ISSN 1229-8093

Kumar, N. (2007). Studies on predacity and biocontrol potential of *Dactylaria brochopaga.* Ph.d Thesis, Banaras Hindu University, Varanasi-India.

Kumar, N., Singh, R.K. and Singh K.P. (2011). Occurrence and colonization of nematophagous fungi in different substrates, agricultural soils and root-knots. *Archives of Phytopathology and Plant Protection, Vol.* 44 (2011)s, No.12, pp.1182-1195. ISSN 1229-8093

Kumar, N., Chindo, P.S. and Singh, K.P. (2011). The trapping fungus *Dactylaria brochopaga*: induction of trap formation, attraction, trapping and the development in some phytonematodes. *Archives of Phytopathology and Plant Protection, Vol.* 44 (2011), NO.13, pp.1322-13334.

McSorley, R.., and Gallaher, R.N. (1995a). Effect of yard waste compost on plant-parasitic nematode densities in vegetable crops. *Journal of Nematology*, Vol. 27 (1995), pp.545-549, ISSN 0919-6765.

McSorley, R. and Gallaher, R.N. (1995b). Effect of yard waste compost on nematode densities and maize yield, *Journal of Nematology*, VOl.28, 4S, (Dec.1996), 655-660.ISSN 0303-6960

Miller, P.M., Sands, D.C., Rich, S, 1973. Effects of industrial residues, wood fiber wastes and chitin on plant parasitic nematodes and some soil borne disease. *Plant Disease Reporter* 57 (1973), pp.438-442, ISSN 1450-216X

Mojumdar, V. (1995). Effect on nematodes. The neem tree, *Azardirachta indica* A. Juss. and other miscellaneous plants: Source of unique natural products for integrated pest management, industry, and other purposes. In: Schmutterer H, editor. Weinheim, Germany: VCH, Pp 129-150.

Nico, A.I., Jimenez-Diaz, R.M., Castilla, P. (2004). Control of root-knot nematodes by composed agro-industrial wastes in potting mixtures, *Crop Protection*, Vol.23 (2004), pp.581-587, ISSN 1023-1072.

Nwanguma, E.I., Awoderu J.B 2002. The relevance of poultry and pig droppings as nematode suppressants of okra and tomato in Ibadan, Southern Western Nigeria. *Nigerian Journal of Horticultural Sciences*, Vol.6(2002), pp.67-69, ISSN118-2733ss

Oka, Y. and Pivionia, S. (2003). Effect of a nitrification inhibitor on nematicidal activity of organic and inorganic ammonia-releasing compounds against the root-knot nematode *Meloidogyne javanica*. Nematology, Vol. 5, (2003), pp.505-513.

Oka, Y. and Yerumiyahu, U. (2002). Suppressive effects of composts against the root-knot nematode *Meloidogyne javanica* on tomato. *Journal of Nematology*, Vol.4, No 8, (2002), pp.891-898, ISSN 1072- 2852.

Osei, K., Addico, R, Nafeo,A., Edu-Kwarteng, A., Agyemang, A., Danso, Y., and Sackey-Asante,J. (2011). Effect of some organic wastes on hatching of *Meloidogyne incognita* eggs. *African Journal of Agricultural Research* Vol.6(10); pp. 2255-2259. ISSN 1991-637X

Padhi, N.N., Gunanidhi, B. and Behera, G. (2000). Evaluation of nematicidal potential in ten indigenous plant species against *Melodogyne incognita*. *India Phytopathology* Vol. 53(2000), No.1, pp.28-31, ISSN1982- 5676

Raguraman, S., Ganapathy, N. and Venkatesan, T. (2004). Neem versus entomopathogens and natural enemies of crop pests: the potential impact and strategies. In: *Neem:Today and in the new millennium* , O. Koul and S. Wahab, (Ed), 125-182, ISSN 0889-9746, Dodrecht, The Netherlands,

Rakesh, P.A.K., S. Kumar, S. and Randy, R. (2000). Efficacy of various essential oils on the management of root- knot diseases in black henbane and aromatic plants. Challenges opportunities in New Century, Contributory Papers Centennial Conference on Species and aromatic plants. Calicut, kara, India. 20th-23rd September 2000, ISSN 0971-3328

Shiau, F.L., W.C. Chung, J.W. Huang and H.C. Huang (1999). Organic amendment of commercial culture media for improving control of *Rhizoctonia* damping-off of cabbage.*Can .J. Plant Pathol*. Vol. 2(1999), pp.368- 374, ISSN 0706-0661.

Stirling G.R, Smith, L.J. (1991). Conservation and enhancement of naturally occurring antagonistics and the role of organic matter, In: *Biological control of plant parasitic nematodes, Progress, Problems and Prospects*. CAB International, Wallingford, U.K,ISSN 0717-3458.

Stirling G R, Smith L.J. (1998). Field test of formulated products containing either *Verticillin chlamydosporium* or *Arthrobotrys dactyloides* for biological control of root-knot nematodes. *Bio control,* VOl.11(1998), pp.231- 239, ISSN 0717-3458.

Stirling, G.R, Smith, L.J. Licastro, K.A., Edem, L.U. (1998). Control of root-knot nematode with formulation of nematode trapping fungus *Arthrobotrys dactyloides*. *Biol control,* Vol.11(1998), pp. 224-230, ISSN0717- 3458.

Sukul, N.C., (1992). Plant antagonistic to plant-parasitic nematodes, *Indi*an *Review of Life Science,* Vol.12(1992), pp.23-52, ISSN 0002-9440

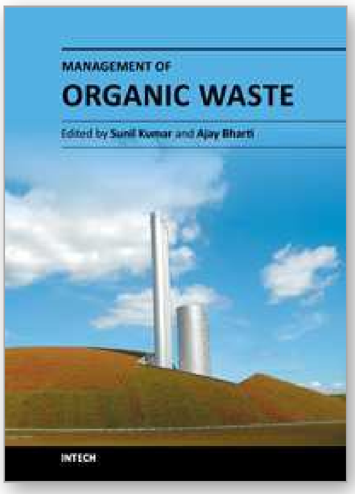
Suresh, G, Gopalakrishnan, G, Masilamani, S. (2004). Neem for plant pathogenic fungal control: the outlook in the new millennium, 183-208, In; Koul, O, Wahab, S, (Ed.), *Neem: Today and in the new millennium,* Dordrecht, ISSN 0889-9746, Dodrecht, The Netherlands.

Tsay, T.T, WUST, Lin, Y.Y. (2004). Evaluation of Asteraceae plants for control of *Meloidogyne incognita*, *J. Nematology,* Vol. 36(2004), pp.36-41, ISSN0022-3004

Tsai, B.Y. (2008). Effect of peels of lemon, orange and grape fruit against *Meloidogyne incognita*. *Plant Patholog Bull*, Vol.17(2004), pp.195-201, ISSN1725-5813

Walker, G..E. (2004). Effects of *Meloidogyne javanica* and organic amendments, inorganic fertizers and nematicides on carrot growth and nematodes abundance. *Nematologia Mediterranea*, Vol. Vol.32, No. 2(2004), pp.181- 188, ISSN 0718- 1620.

Wood, R.K.S. (1996). Sustainable Agriculture: the role of Plant Pathology. *Candian Journal Journal of Plant Pathology*, Vol.18 (1996), pp.141-144, ISSN 1715-2992.



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This book reports research on the utilization of organic waste through composting and vermicomposting, biogas production, recovery of waste materials, and the chemistry involved in the processing of organic waste under various processing aspects. A few chapters on collection systems and disposal of wastes have also been included.

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