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Theme:

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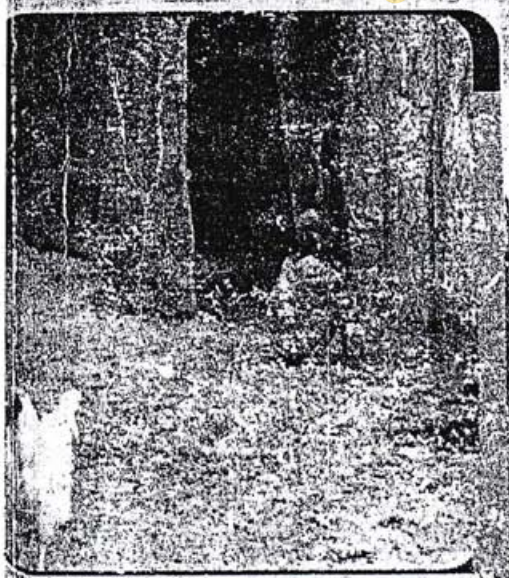

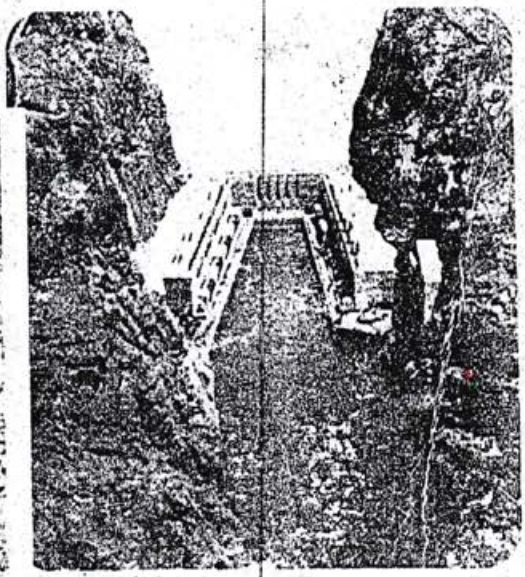

Date:
Monday 3rd to Thursday

Venue:
The College of Agricultural Sciences,
Olabisi Onabanjo University,
Yewa Campus

Efficacy and gross margin analysis of carbofuran on nematode management in three cultivars of cowpea (*Vigna unguiculata* (L) Walp)

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Abstract

Field trials were carried out in 2000, 2001 and 2002 to study the efficacy of applying carbofuran at 0 kg a.i/ha; 2.4 kg a.i/ha; 3.0 kg a.i/ha and 3.6 kg a.i/ha in the management of nematode populations in the production of three cowpea cultivars: Ife Brown, IT90K-277-2 and a local premium 'Oloyin'. The 4x3 field trials were laid out in a randomized complete block design replicated three times at the Institute of Agricultural Research and Training sub-station, Ikenne and University of Agriculture (UNAAB) Teaching and Research Farm Abeokuta. Soil nematode population densities were assayed using the Whitehead and Hemming tray method prior to planting and at the end of each experiment. Data collected on number of days to 50% flowering, number of seeds/pods, 100- seed weight, nematode populations and grain yield were subjected to analysis of variance, correlation, and cost -benefit analysis with means separated using Duncan Multiple Range Test. Results obtained revealed the presence of economically important plant parasitic nematodes in the two locations; *Meloidogyne* juveniles, *Pratylenchus*, *Rotylenchulus reniformis* and *Helicotylenchus* species being the most common. Application of carbofuran significantly reduced number of days to 50% flowering by 2-5 days.The relationship between treatment and nematode population was inversely proportional such that the lower the nematode population density the higher the grain yield and vice versa. Nematode population densities were significantly reduced at the lowest 2.4 kg a.i/ha rate of carbofuran with further significant reduction at 3.0kg a.i/ha. The least nematode infested variety was the IT90K-277-2 which recorded the lowest number of days to 50% flowering, highest number of seeds/pods and consequently yielded more grains than Ife-Brown and Oloyin varieties. Cost- benefit analysis indicated higher monetary returns of N 3,851.00k – N 21,512.50k difference in profit attributable to carbofuran treatments compared to the control at all levels of application.

Key words: *Meloidogyne* juveniles, *Pratylenchus*, *Rotylenchulus reniformis* and *Helicotylenchus* species, cost-benefit.

Introduction

Cowpea, *Vigna unguiculata* (L) Walp is an important legume of the tropics. Importance of cowpea derives from being a relatively affordable and readily available source of protein, which is also low in anti-nutritional factors and forms a complementary mixture with other types of foodstuffs to produce a balanced diet (20). From the production of this crop, rural families variously derive food, animal feed and cash, together with spillover benefits to their farmlands through *in situ* decay of root residues and vegetation cover for farmlands.

The combined effect of plant pathogens ranging from fungi, bacteria, mycoplasma and viruses to nematodes and parasitic angiosperm limit the yield of this important crop. Nematodes have been implicated in the low yields being recorded on the field in cowpea production (5,6,7,13). Although growers have obtained some increased yield with improved varieties that are early maturing and resistant to some diseases and insect pests, the reality however is that cowpea production cannot be economically sustained without the use of pesticides (3,4). Urech (19) noted that chemical control is an indispensable part of integrated control management and that chemical control helps to ensure high yields. Although the efficacy of nematicides in controlling nematodes and soil borne pathogens has been established (14), production estimates are available only in the developed countries (16). In the tropics, they are seldom used because they are considered to be too expensive for profit. Empirical data to justify such statements have however been very scanty. This study was therefore designed to investigate the effectiveness of carbofuran in controlling nematode pests of cowpea and the economic consequences on cowpea production enterprise.

Materials and methods

The field trials were conducted at Ikenne, a rain forest substation of the Institute of Agricultural Research and Training (I.A.R. & T). Ibadan and at Abeokuta within the University of Agriculture Teaching and Research farm, in 2000, 2001 and 2002. Ikenne is located within the humid rain forest ecology on longitude 3^0 43'E and latitude 6^0 50'N. The soil is loamy, grayish brown in colour and classified as Rhodic luxisol (USDA). Abeokuta site is a transition zone of the humid rain forest or transient derived guinea savannah ecology on longitude 3° 25'E and latitude 7° 15'N. The sites were ploughed, harrowed and laid out in a randomised complete block design and replicated three times. Each experimental plot measured 3 m × 3 m with 1m and 2 m alleys between plots and blocks, respectively. In each site, three core soil samples were collected with a soil auger to a depth of between 15 cm – 20 cm in a zigzag pattern from each experimental unit. The core samples were thoroughly mixed together and a 250 g soil sample was taken from the bulked sample thus making a total of 12 samples /replicate. Each sample taken was labelled and put in a polythene bag and thereafter taken to the laboratory where they were stored at 10°C in a refrigerator for 24 hours until processed for nematode extraction. The collection was made twice, one before treatments were applied and the other at near harvest. The soil samples were processed using a

modification of the tray extraction method known as the WhiteHead and Hemming (21) tray method. Identification of the different nematode genera was done using the nematode key of Mai and Lyon (12) and the work of Dropkin (8), under the compound light microscope. Three cowpea varieties namely, Ife Brown, IT90K–277–2 and 'Oloyin' were evaluated in three planting seasons. Two cowpea seeds were planted per hole and later thinned to one per stand at a spacing of 60 cm inter- row and 30 cm within the rows to give 10 plants per row. There were five rows per plot, giving an estimated plant population of 55,555plants/hectare. In 2000, planting was done in September, July in 2001, March and August in 2002. Carbofuran 3G was applied to the soil five days after planting close to the base of the seedlings at the rate of 0 kg a.i/ha as control, 2.4 kg a.i/ha, 3.0 kg a.i/ha and 3.6 kga.i/ha. Five untagged plants per plot were selected at random from each row and carefully uprooted at eight weeks after planting and at harvest to assess the extent of galling on the root. The roots were washed with tap jet spray water and the number of galls observed counted and rated according to the rating scale of Taylor and Sasser (18) as follows:

Number of galls/root system	Index rating
0	0
1 – 2	1
3 – 10	2
11 – 30	3
31 – 100	4
> 100	5

The following data on yield parameters were collected: days to 50% flowering, numbers of seeds/pods, 100 seed weight and grain yield [from the two central rows of the plot measuring 1.8 m^2 (0.6 m × 3 m)]. Harvested pods were dried, threshed and the grains weighed plot by plot were weighed. Data collected on nematode population were subjected to natural log transformation (log n) before analysis. The gross margin analysis of the field trials was carried out using the partial budget analysis technique (11) for on-farm research. It involved the analysis of variable input costs and yield benefits of the various treatment rates applied (Appendix 1).

Results

The most prevalent nematodes found were *Pratylenchus*, *Meloidogyne*, *Helicotylenchus* spp and *Rotylenchulus reniformis* in that order at Ikenne; and *Meloidogyne spp*, *Rotylenchulus reniformis*, *Pratylenchus* and *Helicotylenchus* species in Abeokuta (Table 1). Carbofuran suppressed populations of all identified nematodes in both locations, in all trials and at all levels of nematicide application. The percent reduction of nematode numbers at the lowest rate of 2.4 kg a.i/ha in year 2000 trial was 33.2% for *Meloidogyne* juveniles, 29% for *Pratylenchus*, 31% for *Helicotylenchus*, 20% for *Rotylenchulus reniformis* and 25% for free living nematodes categorized in this study as **'Others'** (*Rhabditis, Eutylenchus*). At 3.0 kg a.i/ha, the percent reduction in population of all the nematodes ranged between 39% and 51% while at the highest rate of 3.6 kg a.i/ha percent reduction was between 40% and 49%. In subsequent trials (2001 and 2002), percent reduction in numbers ranged between 13% and 49% at all levels of carbofuran in both locations (Table 2).

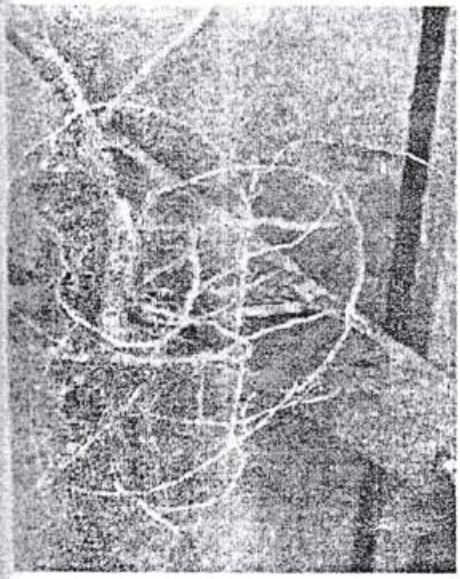
Table 1. Mean population density and frequency of nematode genera identified from soil samples obtained from Ikenne and Abeokuta sites cropped with three cowpea varieties

Nematode Genera	Ikenne		Abeokuta	
	*Population density/250g soil	Frequency of occurrence (%)	*Population density/250g soil	Frequency of occurrence (%)
Pratylenchus	7.3±0.2 (1426)	100	6.9±0.3 (1001)	50.6
Meloidogyne	7.1±0.2 (1214)	98.5	7.1±0.2 (1194)	98.6
Helicotylenchus	6.9±0.3 (985)	93	6.5±0.1 (681)	40
Rotylenchulus reniformis	6.8±0.2 (856)	89.5	6.6±0.1 (769)	53.5
Trichodorus	3.2 ±0.3 (25)	0.6	2.4±0.1 (11)	8.3
Xiphinema	1.8±0.1 (6)	1.4	0.0	0
Scutellonema	4.5±0.1 (86)	21	0.0	0
Dorylaimus	7.2±0.3 (1302)	98	6.9±0.2 (983)	45
Rhabditis	7.2±0.3 (1299)	98	6.7±0.2 (799)	34
Eutylenchus	2.5±0.0 (12)	13	2.7±0.1 (15)	18

*Each figure is the mean nematode counts from ten 250 g soil assayed for nematode populations and the natural Log transformed value with actual count in parenthesis

The effect of carbofuran on galling of cowpea roots (Plate 1) at Ikenne is presented in Table 3. The results show that carbofuran significantly ($P \leq 0.05$) suppressed galling of the plant roots at all levels and in all the seasons of the trial. Carbofuran at the recommended rate (3.0 kg a.i/ha) for nematode control and higher rate of 3.6 kg a.i/ha however significantly suppressed galling compared to the lowest rate (2.4 kg a.i/ha) while there was no significant difference in the effectiveness between these (3.0 kg & 3.6 kg a.i/ha) former rates in suppressing galling. All rates of carbofuran treatment applied at Ikenne significantly ($P \leq 0.05$) affected number of days to 50 % flowering in the first, second and third seasons, respectively. The numbers of days to 50% flowering were 2-4

days shorter in each of the three seasons. At Abeokuta, contrastingly only the 3.0 kg a.i/ha of carbofuran rates applied, significantly ($P<0.05$) affected the number of days to 50% flowering in 2002 late season experiment (Table 4).



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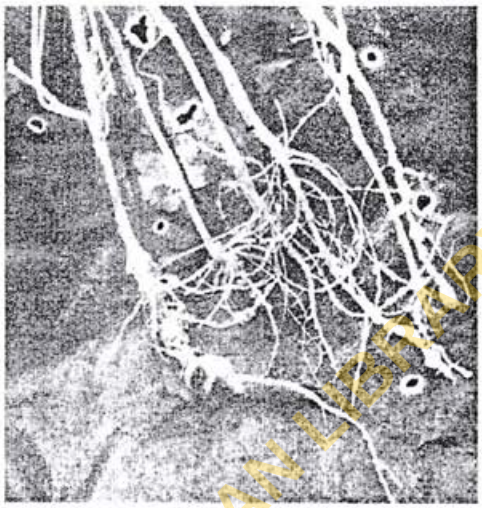


(a)

Plate 1 (a) Healthy cowpea roots (b) Galled cowpea roots.

Carbofuran treatment at 2.4 kg a.i/ha, 3.0 kg a.i/ha and 3.6 kg a.i/ha, resulted in higher percentage increase in yields for all the cowpea varieties compared with those of control plots in Ikenne and also at Abeokuta with the exception of IT90k-277-2 (Table 5). However further significant yield differences were observed among the varieties at the recommended and higher rates of 3.0 kg a.i/ha and 3.6 kg a.i/ha carbofuran, respectively, compared with the least rate of 2.4 kg a.i/ha at Ikenne and Abeokuta, respectively (Figures 1&2). Percentage yield increase brought about by carbofuran treatment ranged from 83 to 183% for Ife-brown; 1 to 13.3% for IT90K-277-2 and between 78.3 to 147% for Oloyin variety compared with the control at Abeokuta (Table 5). In Ikenne, it ranged between 57 to 154.3%, 3 to 78% and 88.4 to 233% for Ife-brown, IT90K-277-2 and Oloyin varieties respectively.The cost-benefits of treatment of carbofuran applied alone at 2.4 kg a.i, 3.0 kg a.i and 3.6 kg a.i/ha were ₦90,994.50k, ₦89,240.00k and ₦91,676.00k respectively in Abeokuta. Table 6 shows the cost-benefits assessment of carbofuran treatment rates applied at both locations (Abeokuta and Ikenne respectively) and for each cropping season. For the 2001 and 2002 late seasons' trials at Abeokuta, higher monetary profits were recorded at all the levels, while in 2002 early season no profit was recorded. However, at Ikenne in all the season, (2000-2002late), carbofuran rate applied at 3.0kg a.i/ha returned the highest monetary profits of ₦15,906.00k, ₦24,512.50k and ₦51,976.00k for 2000, 2001 and 2002, respectively (Table 6). A further cost- benefits analysis carried out on the performance of the three varieties showed that for carbofuran treatment rates applied, the monetary profit was highest at 3.0kg a.i/ha for both Ifebrown and Oloyin varieties compared with IT90K-277-2 variety (Table 7).

Table 2: Effect of different levels of carbofuran on soil population of identified nematodes in Abeokuta and Ikenne (2000-2002).

Carbofuran		*Meloidogyne* juveniles			*Pratylenchus spp*			*Helicotylechus spp*			*Rotylenchulus reniformis*			Others		
Rate/ ha	Year	P_i	P_f	% change	P_i	P_f	% change	P_i	P_f	% change	P_i	P_f	% change	P_i	P_f	% change
0kg	2000 L	305.9	344.4	+12.6	337.8	384.8	+13.9	147.8	157.8	+6.8	72.6	75.4	+3.9	467.1	549.2	**+17.6**
	2001 L	238.6	253.7	+6.3	228.5	271.2	+18.7	113.7	120.4	+5.8	86.4	88.9	+2.9	308.5	320.1	**+3.8**
	2002 L	175.6	177.5	+1.1	161.7	179.1	+10.8	84.4	90.6	+7.4	63.3	77.5	+22.4	190.9	221.9	**+16.2**
	2002 E	174.5	190.8	+9.3	91.2	92.3	+1.2	61.2	61.3	+0.1	71.3	73.9	+3.5	325.4	370.1	**+13.7**
2.4kg	2000 L	178.6	119.4	-33.2	273.3	194.5	-28.9	89.1	61.9	-30.5	60.0	48.1	-19.8	316.3	236.8	**-25.1**
	2001 L	114.9	97.4	-15.3	112.3	90.1	-19.8	56.1	44.9	-19.9	37.9	28.9	-23.8	163.5	133.5	**-18.4**
	2002 L	76.8	67.0	-12.7	69.1	56.7	-18.0	42.1	30.6	-27.3	21.2	16.3	-25.9	104.1	81.3	**-21.9**
	2002 E	136.0	108.3	-20.4	68.7	56.1	-18.3	49.4	38.7	-21.7	36.7	29.8	-18.7	179.8	139.5	**-22.4**
3.0kg	2000 L	104.9	64.7	-38.7	151.9	79.7	-47.6	46.6	22.9	-50.9	28.9	14.9	-48.7	181.6	89.3	**-50.8**
	2001 L	67.6	41.1	-39.3	55.9	32.6	-41.8	26.9	14.2	-47.5	19.2	10.0	-47.5	92.4	57.9	**-37.3**
	2002 L	45.7	30.5	-33.1	32.5	21.4	-34.1	15.4	10.0	-34.9	10.0	5.13	-48.7	57.0	35.4	**-37.9**
	2002 E	87.8	65.6	-25.3	49.1	31.6	-35.7	36.7	22.9	-37.7	18.7	14.6	-21.6	103.7	70.1	**-32.4**
3.6kg	2000 L	100.1	57.1	-42.9	107.5	64.1	-40.3	51.3	26.4	-48.5	35.6	20.7	-41.7	197.3	102.0	**-48.3**
	2001 L	69.3	43.5	-37.2	33.9	32.4	-39.9	25.9	15.0	-42.2	20.5	12.0	-41.4	90.3	62.5	**-30.8**
	2002 L	47.2	32.1	-31.9	32.1	20.6	-35.8	14.8	9.4	-36.4	9.9	5.7	-42.9	52.4	34.7	**-33.6**
	2002 E	90.4	66.2	-26.8	50.1	40.8	-18.5	41.5	27.8	-32.9	26.9	16.8	-37.6	99.5	73.0	-26.6

+ = increase, - = decrease, L = Late season, E = Early season.
P_i = Initial population/250g soil
P_f = Final population/250g soil
'Others'= *Rhabditis; Eutylenchus*

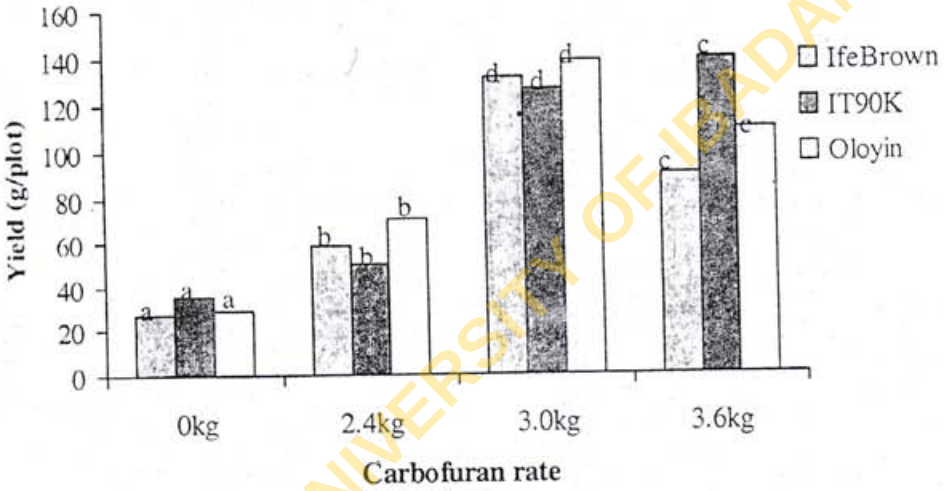
Table 3: Effect of carbofuran on number of galls per root system of three cowpea varieties in three field experiments at Ikenne and Abeokuta

Carbofuran rate		IKENNE			ABEOKUTA		
	N	2000 Late	2001Late	2002 Late	2001Late	2002 Late	2002Early
0kg a.i/ha.	36	2.2 ± 0.2^{d}	2.1 ± 0.2^{c}	2.4 ± 0.3^{c}	2.6 ± 0.2^{d}	2.8 ± 0.3^{d}	2.4 ± 0.2^{c}
2.4kg a.i /ha	36	1.3 ± 0.2^{bc}	1.0 ± 0.1^{b}	0.8 ± 0.1^{b}	1.4 ± 0.1^{c}	1.4 ± 0.2^{b}	1.0 ± 0.1^{b}
3kg a.i /ha	36	0.6 ± 0.1^{a}	0.5 ± 0.1^{a}	0.3 ± 0^{a}	0.6 ± 0.1^{a}	0.6 ± 0.2^{a}	0.4 ± 0^{a}
3.6kg a.i /ha	36	0.6 ± 0.1^{a}	0.5 ± 0.1^{a}	0.3 ± 0^{a}	0.8 ± 0.1^{a}	0.8 ± 0.2^{a}	0.3 ± 0^{a}

a.i = Active ingredient.

Means in the same column with the same letters are not significantly ($P<0.05$) different.

Gall index= 0 – 0 gall; 1 – 1-2 galls; 2 – 3-10 galls; 3 – 11- 30; 4 – 31 –100; 5 -> 100.



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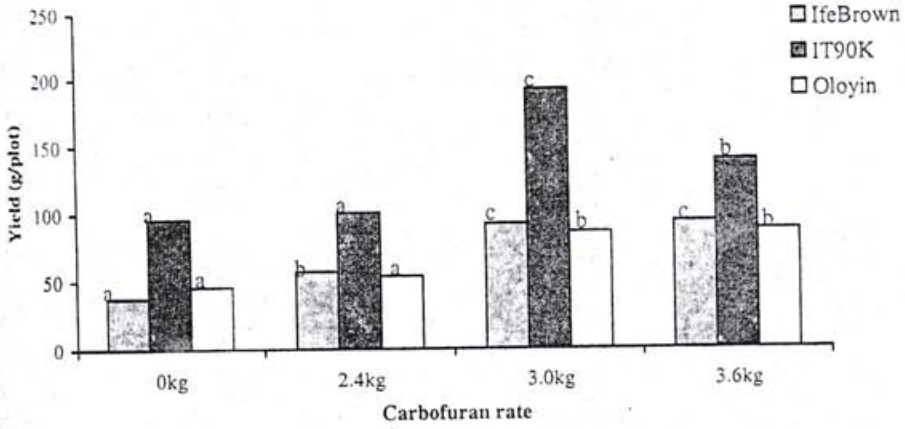

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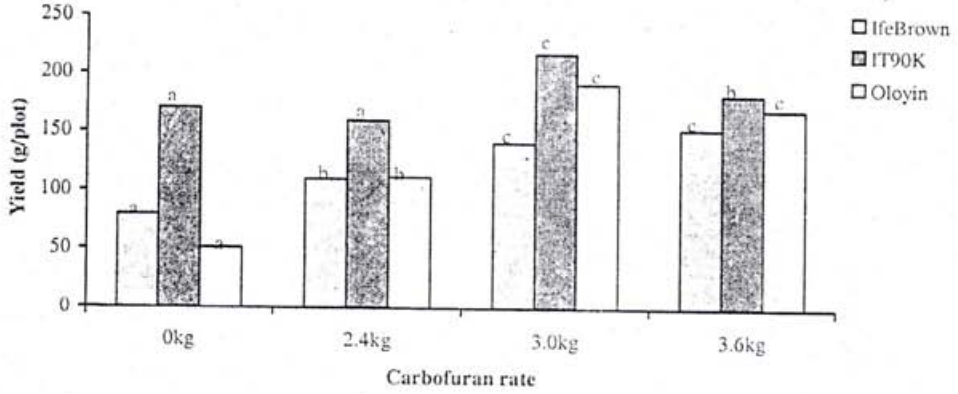
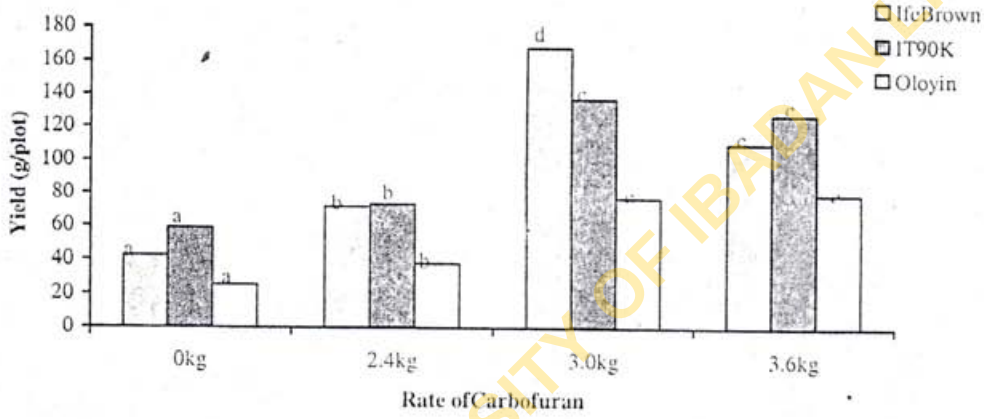


(c)

Figure 1: Mean Grain Yield (g/plot) of three cowpea varieties as influenced by carbofuran in (a) 2000, (b) 2001 and (c) 2002 late seasons at Ikenne.

Means with the same letter of each variety are not significantly different



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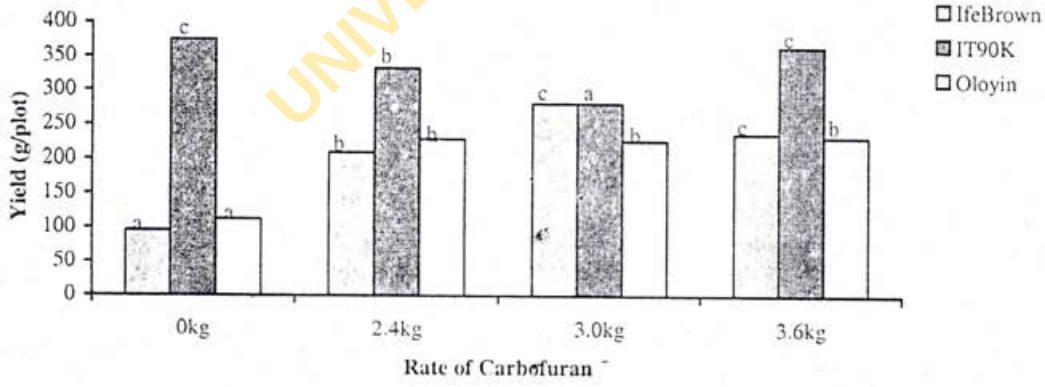

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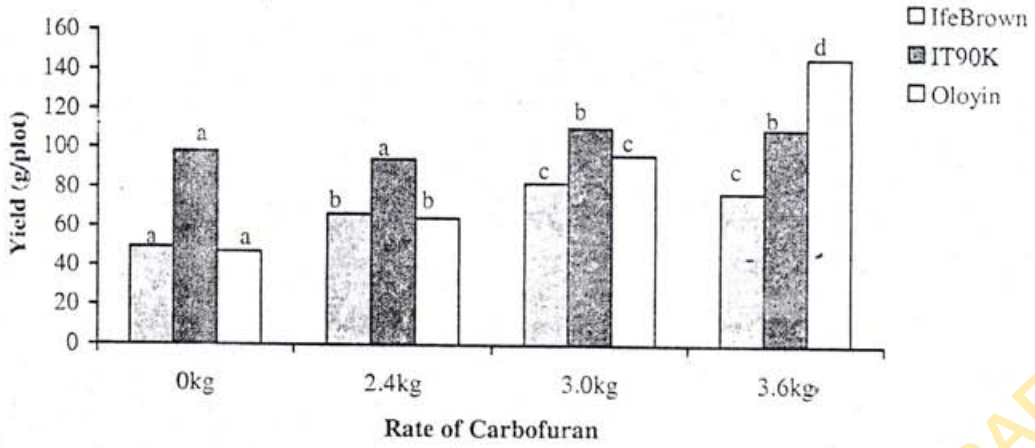

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Figure 2: Grain Yield (g/plot) of three cowpea varieties as influenced by carbofuran in (a) 2001, (b) 2002 late and (c) 2002 early seasons at Abeokuta.

Table 4: Cost-benefit analysis of cowpea grain yield (kg/ha) as influenced by carbofuran in three field experiments at Abeokuta and Ikenne.

		ABEOKUTA					IKENNE			
Season/Year	Carbofuran kg a.i/ha	Grain yield kg/ha	Value of output/ha	Total variable cost	Gross margin/ha	Year	Grain yield kg/ha	Value of output/ha	Total variable cost	Gross margin/ha
2001L	0	235.5	17662.50	9680	7982.50	2000	331.1	19866.00	9760	10106.00
2002E	0	360.0	27000.00	10860	16140.00	2001	168.0	12600.00	9680	2920.00
2002L	0	1082.2	91987.00	10860	81127.00	2002	556.0	47260.00	10860	36400.00
2001L	2.4	341.1	25582.50	22940	2642.50	2000	391.1	23466.00	22460	1006.00
2002E	2.4	415.0	31125.00	30360	765.00	2001	330.5	24787.50	22940	1847.50
2002L	2.4	1427.7	121354.50	30360	90994.50	2002	707.7	60154.50	30360	29794.50
2001L	3.0	713.3	53497.50	30440	23057.50	2000	686.1	41166.00	25260	15906.00
2002E	3.0	535.0	40125.00	34860	5265.00	2001	732.7	54952.50	30440	24512.50
2002L	3.0	1460.0	124100.00	34860	89240.00	2002	1021.6	86836.00	34860	51976.00
2001L	3.6	592.2	44415.00	33940	10475.00	2000	595.0	35700.00	28060	7640.00
2002E	3.6	616.0	46200.00	39360	6840.00	2001	625.5	46912.50	33940	12972.50
2002L	3.6	1541.6	131036.00	39360	91676.00	2002	936.6	79611.00	39360	40251.00

Kg a.i = Active ingredient in kilograms/ha
L = Late season
E = Early season

Table 5: Cost-benefit of carbofuran treatment rates on grain yield of three cowpea varieties.

Carbofuran rate	Variety	Grain yield kg/ha	Value of output/ha	Total variable cost	Gross margin/ha (₦/ha)
0kg a.i/ha	Ife Brown	307.77	23082.75	10100.00	12982.75
	IT90K-277-2	772.22	57916.50	10100.00	47816.50
	Oloyin	287.77	21582.75	10100.00	11482.75
2.4kg a.i/ha	Ife Brown	531.11	39833.25	25253.33	14579.92
	IT90K-277-2	751.66	56374.50	25253.33	31121.17
	Oloyin	525.00	39375.00	25253.33	14121.67
3.0kg a.i/ha	Ife Brown	831.66	62374.50	30186.66	32187.84
	IT90K-277-2	987.22	74041.50	30186.66	43854.84
	Oloyin	756.66	56749.50	30186.66	26562.84
3.6kg a.i/ha	Ife Brown	705.00	52875.00	33786.66	19088.34
	IT90K-277-2	985.55	73916.25	33786.66	40129.59
	Oloyin	763.88	57291.00	33786.66	23504.34

kg a.i/ha=active ingredient in kilograms per hectare

Discussion

Plant parasitic nematodes of economic importance on cowpea worldwide were present in soils of both locations. Among these were *Meloidogyne*, *Pratylenchus*, *Helicotylenchus* species, *Rotylenchulus reniformis*, *Xiphinema* and *Trichodorus* species. Effective control of these nematodes with the attendant yield increases achieved in this study conforms with the findings of VanBerkum and Hoestra (22); Parvatha (14) and Hague and Gowen (10).

Application of different rates of carbofuran in this study significantly reduced populations of identified nematode pests over the years and at both locations. This agrees with Gowen (9); Adegbite and Adesiyan (1) findings who reported the effectiveness of carbofuran in suppressing nematode populations. Population densities of nematode pests were significantly reduced at the lowest application rate (2.4kg a.i/ha) of carbofuran with attendant yield increase. The differences recorded on data reported at the two sites were as a result of the contrast in the physical and chemical properties of the soils as well as the different micro agro-ecologies of the study sites. Profitable grain yield increases in Southwest of Nigeria may not be possible without controlling the activities of both nematode and insect pests. Hence plots intended for cowpea production should be sampled for plant parasitic nematodes and judicious use of pesticides adopted where these pests are a serious threat to cowpea production. Galling of roots attributable to *Meloidogyne* activities occurred in the roots of all the cowpea varieties used in the study with the roots of IT90k-277-2 variety being the least galled. Galling index showed that the least number of galls were obtained on roots of plants from treated plots. Ife Brown was the most affected while IT90K-277-2 was the least affected. This corroborated the findings of Singh *et al.*, (17) that IT90K-277-2 is tolerant or has a measure of resistance to nematode attack. With the hindsight that ovicidal effect of carbofuran is more effective in preventing penetration of nematodes into the roots or in reducing nematode activities within the soil, this suggests that carbofuran acts directly on the nematodes in the soil thereby preventing or limiting hatching of eggs and the movement of larvae into the roots as reported by Qusdia *et al.* (15).Cowpea plants treated with carbofuran started flowering earlier than those of control plants. This early flowering may be due to the effect of the applied chemical, which stimulates early flower production as compared to the control plots. This agrees with the findings of Ajith and Sheela (2). Early flowering is important because it affects the time of maturity and harvesting of cowpea plant. Higher number of seeds and weights of 100 seeds obtained from treated plants could be expected because the better the growth of the plants the more the yield to be expected thereof. The gross margin analyses show that higher monetary returns obtained for all the varieties ranged between ₦3,851 and ₦21,592.50k/ha attributable to carbofuran application. Hence the inclusion of carbofuran for nematode pest management is profitable.

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