RESPONSE OF *MELOIDOGYNE INCOGNITA*-INFECTED COWPEA TO SOME AGRO-WASTE SOIL AMENDMENTS

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Accepted:
17.III.1986
Aceptado:

ABSTRACT

Egunjobi, Olufunke A., and J. O. Olaitan 1986. Response of *Meloidogyne incognita*-infected cowpea to some agro-waste soil amendments. Nematropica 16:33-43.

The use of cocoa pod husks (CPH), cassava peelings (CASP), and rice husks (RH) as soil amendments for the control of *Meloidogyne incognita* (Kofoid & White) Chitwood on cowpea cv. Ife Brown were compared with carbofuran pesticide and NPK fertilizer application in field and greenhouse trials. Amending soil with CPH proved virtually as effective as carbofuran application, reducing populations of *M. incognita,* crop damage, and galling index in the field. Improvements in cowpea productivity in CPH- and CASP-amended soil were associated with *M. incognita* population depression as well as other unknown factors that may include some fertilizing properties of CPH. RH significantly reduced *M. incognita* populations, but also was a carrier for *Fusarium semitectum* (Smith), *Colletotrichum lindemuthianum* (Sacc. & Magn.), and *Phoma* spp., three pathogenic fungi that completely (in greenhouse) or nearly (in the field) wiped out the cowpea seedlings within 5 weeks after sowing.

Additional key words: Vigna unguiculata, carbofuran, cocoa pod husks, cassava peelings, rice husks, root-knot nematodes.

RESUMEN

Egunjobi, Olufunke A. y J. O. Olaitan. 1986. Respuesta del chícharo de vaca infestado de *Meloidogyne incognita* a algunos residuos agrícolas enmendadores del suelo. Nematropica 16:33-43.

El uso de la cáscara de la mazorca del cacao (CMC), la cáscara de la casava (CC) y la cáscara del arroz (CA) como enmendadores del suelo para el control del *Meloidogyne incognita* (Kofoid & White) Chitwood en el chícaro de vaca, fueron comparados con el pesticida carbofuran y con aplicaciones de fertilizantes (NPK) en pruebas de invernadero y de campo. El suelo enmendado con CMC probó ser tan efectivo como la aplicación de carbofuran en la reducciân de las poblaciones de *M. incognita,* el índice de nódulos en las raices y el daño a la cosecha en las pruebas de campo. Los aumentos de la productividad del chicharo de vaca enmendados con CMC y CC fueron asociados con la disminución de la población de *M. incognita* así como con otros factores desconocidos que pudieron inducir cietras propiedades fertilizantes de los residuos agrícolas agreados al suelo. CA redujo significativamente la población de *M. incognita* pero también fue portador los de hongos patógenos *Fusarium semitectum* (Smith), *Colletotrichum lindemuthianum* (Sacc. & Magn.) y

Phoma spp. que tanto en el invernadero como en el campo arrasaron las posturas del chícharo de vaca en un periodo de 5 semanas después de la siembra.
Palabras claves adicionales: Vigna unguiculata, carbofuran, cáscara de la mazorca del cacao, cáscara de la casava, cáscara del arroz, nematodo nodulador de las raices.

INTRODUCTION

Cowpea, *Vigna unguiculata* Walp. cv Ife Brown, is the most important grain legume crop in Nigeria (1) as it is in other parts of Africa (2,24,28) where 84% of the world's output is produced (3). The average yield of 250 kg/ha for West Africa is considered the lowest in the world (23). Nematodes, especially *Meloidogyne* spp. constitute one of the major factors limiting cowpea production in this area (4,6,17,19).

Constraints in the use of chemical nematicides in reducing nematode-induced losses of crops in these areas have been discussed (5,11,14,16). Studies on alternative measures for *Meloidogyne* control had taken little cognizance of the possible use of soil amendments. Apart from work by Caveness (6) and Egunjobi (10), no documented soil amendment trials for the control of *Meloidogyne* spp. in Nigeria are known.

This study was initiated to evaluate the effectiveness of cocoa pod husks (CPH), cassava peelings (CASP), and rice husks (RH) when used as soil amendments in the control of *Meloidogyne incognita* (Kofoid & White) Chitwood on cowpea, in comparison with the use of a nematicide (carbofuran), and NPK fertilizer.

MATERIALS AND METHODS

The studies involved both a field and a greenhouse trial. Materials used included: (i) partially decayed cassava (*Manihot utilissima* Pohl) peelings; (ii) decayed and dry husks of cocoa (*Theobroma cacao* L.); (iii) husks of rice (*Oryza sativa* L.); (iv) carbofuran (granules), a broad-spectrum carbamate insecticide/nematicide; (v) NPK (30:30:30) fertilizer; and (vi) an untreated check.

In both the field and the greenhouse trials, the organic amendments were applied at the rate of 10 metric tons/ha; carbofuran granules at 2 kg(ai)/ha, and NPK at 30 kg/ha. Cowpea cv Ife Brown was the test crop. The statistical design was a randomized complete block with 6 replications.

The CPH, CASP, and RH used originated respectively from the Cocoa Research Institute of Nigeria at Onigambari, Ibadan; the Cereals Research Institute of Nigeria in Moor Plantation, Ibadan; and the Abadina village of the University of Ibadan, Ibadan.

The CPH was pounded into flakes before use. Each amendment was thoroughly mixed with the soil, and the soil was watered prior to planting cowpea seeds. NPK fertilizer and carbofuran granules were incorporated into the soil in appropriate plots or pots at planting.

The field experiment was located in the Rockefeller experimental plot of the University of Ibadan (7.23 degrees N by 3.54 degrees E). An area 20 m × 24 m was ploughed and mixed thoroughly, and layed out into 36 subplots. Each subplot measuring 2 m × 1 m was separated from the others by a 1-m path. Two cowpea seeds were sown into each hole, and spaced 15 cm apart within rows that were 60 cm apart.

Each of the 36 plastic pots used in the greenhouse trial was 21 cm in diameter and 9 cm deep. The pots were filled with soil collected from the Rockefeller plot that was naturally infested with 15 *M. incognita* juveniles/10 g soil. Appropriate pots received the amendments a day before planting. Each pot was planted to 2 cowpea seeds. Seven days after sowing, seedlings were reduced to one per pot. Three weeks after sowing, cowpea seedlings in all but the carbofuran treatment were inoculated with 2500 viable eggs plus larvae of *M. incognita* that were recovered from previously infested roots of *Celosia* sp. extracted in 10% chlorox (25). All plants were protected with the insecticide Ambush® 25, applied weekly at 2 cm^3/L of water.

In the field, cowpea response to the treatments were monitored in terms of dry grain yields, fresh pod and top weights, time of flowering, leaf numbers/plant, and plant heights. The nematode populations were assessed at harvest, 9 weeks after sowing. Two-hundred-gram soil samples were also collected from around the roots of each of 6 randomly selected cowpea plants from each subplot and the soil was thoroughly mixed into a 1200-g composite sample. Of this, two 500-g subsamples were extracted for nematodes. All cowpea roots were similarly harvested together per subplot and rated for galling (25). Two 20-g subsamples were extracted for *Meloidogyne* population determination.

In the greenhouse trial, 100-g soil and 5-g root samples were collected from each pot. Eggs and larvae were recovered from roots in 10% chlorox (25). The soil was extracted by the method of Whitehead and Hemming (27).

M. incognita was re-confirmed by the perineal pattern method (13). Data were compared using the analysis of variance and Duncan's multiple range test. An analysis of the economics of the treatments in the field was attempted based on current market values of labor and materials in Nigeria and excluding labor expended in weeding and in preplant field preparations.

Because all plants exposed to RH and carbofuran died within the first 4 to 5 weeks in the greenhouse, yield, growth indices, and *M. incog-*

Table 1. Cowpea yield and population of *Meloidogyne incognita* under selected treatments in the field.

Treatment	Grain yield (g/plant)[z]	Fresh pod wt (g/plant)[z]	Fresh top wt (g/plant)[z]	Plant heights (cm at 8 wk)[z]	*M. incognita*/ 20 g cowpea roots[z]	*M. incognita*/ 500 g soil[z]	Gall index[z]
Rice husks (RH)	138 b	265 b	1550 a	55.0 b	35,400 bc	841 c	3.2 b
Cocoa pod husks (CPH)	248 a	770 a	3630 d	67.0 a	20,750 d	856 c	2.2 c
Cassava peelings (CASP)	223 a	728 a	3430 cd	61.3 ab	28,480 cd	1458 b	2.8 c
NPK fertilizer	178 ab	575 ab	2790 ab	56.7 b	42,780 b	1560 b	3.2 b
Carbofuran	185 ab	530 ab	2940 bc	66.3 a	17,180 d	467 c	2.0 c
Check	160 b	538 ab	2450 ab	55.8 b	59,350 a	3489 a	4.0 a

[z]Means of 6 observations. Means followed by the same letters are not significantly different ($P = 0.05$, Duncan's multiple range test).

nita populations were compared between CPH, CASP, NPK, and check treatments only. Infected, dying seedlings from the RH-treated plots were incubated on sterile filter paper in closed petri dishes in the laboratory and examined for fungi. Pathogenic fungi identified included *Fusarium semitectum* (Smith), *Colletotrichum lindemuthianum* (Sacc. & Magn.), and *Phoma* spp.

RESULTS

Field Trial

Plants in check plots were selectively stunted and chlorotic 4 weeks after planting. Within the same period, the RH-treated plants suffered from premature die-back. Some plants actually died, but plants that survived grew rather vigorously thereafter. The healthiest looking crops were generally associated with the carbofuran treatment, although this treatment did not actually produce the best grain yields. Best yields were usually harvested from CPH- and CASP-amended soils, and these were occasionally significantly higher than yields in the carbofuran or NPK treatments (Table 1). Plant performance in the RH and check treatments was usually very poor.

With respect to the vegetative production, increases of 48%, 40%, 20%, and 14% were associated respectively with CPH, CASP, carbofuran, and NPK treatments (Table 1). Differences in heights became significant in the 8th week when the carbofuran, CPH, and CASP treatments supported the tallest plants (Table 1).

The least and the highest populations of *M. incognita* were recovered from roots of plants in carbofuran and check treatments respectively (Table 1). Populations were significantly ($P = 0.05$) reduced in CPH (65%), CASP (52%), and NPK (28%) treatments compared to the check (Table 1). Populations recovered from plants in the NPK treatment were significantly higher than those from any of the other treatments, except the check. *Meloidogyne incognita* populations in the soil were similarly significantly reduced, the most drastic reduction (87%) occurring in the carbofuran treated soil, while NPK and CASP treatments were associated with nematode population reductions of 55% and 28% respectively (Table 1). The actual cowpea productivity in terms of grain yield, top weight, and other measured growth parameters was negatively related to these nematode values (Table 1). However, while the lowest yields were often harvested from the RH and check treatments where comparatively high populations of *M. incognita* occurred, the highest yields often were not associated with the carbofuran treatment, which usually gave the most effective nematode control (Table 1).

Table 2. The economics of the soil amendment treatments relative to the application of carbofuran and NPK fertilizer on cowpea.

Rice husk amendment at 10 mt/ha[y]	
Cowpea grain yield per hectare	704 kg
Total revenue at #3.00/kg[z]	#2112
Cost of application at 2 man days	# 14
Transportation cost of amendment	# 20
Total expenditure	# 34
Net returns/ha	#2078
Cocoa pod husk amendment at 10 mt/ha	
Cowpea grain yield per hectare	1250 kg
Total revenue at #3.00/kg	#3750
Cost of application at 2 man days	# 14
Transportation cost of amendment	# 20
Total expenditure	# 34
Net returns/ha	#3716
Cassava peelings amendment at 10 mt/ha	
Cowpea grain yield per hectare	1134 kg
Total revenue at #3.00/kg	#3402
Cost of application at 2 man days	# 14
Transportation costs of amendment	# 20
Total expenditure	# 34
Net returns/ha	#3368
NPK fertilizer treatment at 30 kg/ha	
Cowpea grain yield per hectare	882 kg
Total revenue at #3.00/kg	#2644
Cost of application at 1 man day	# 7
Cost of fertilizer at #6.50/kg	# 195
Transportation cost of fertilizer	# 5
Total expenditure	# 207
Net returns/ha	#2438
Carbofuran treatment at 2 kg (ai)/ha	
Cowpea grain yield per hectare	930 kg
Total revenue at #3.00/kg	#2790
Cost of application at 1 man day	# 7
Cost of 2 kg (ai)/ha of carbofuran	# 123
Transportation cost of carbofuran	# 5
Total expenditure	# 135
Net returns/ha	#2655
Check	
Cowpea grain yield per hectare	800 kg
Total revenue at #3.00/kg	#2400
Total returns/ha	#2400

[y]10 mt = 10,000 kg.

[z]1984 market values; Nigerian currency: one naira (#) = one U.S.A. dollar.

Gross returns per hectare

Although based on limited data, projected economic returns show that the use of CPH and CASP generated the highest returns per hectare in monetary values when compared with the other treatments. The use of carbofuran generated #1061 and #713 less than the use of CPH and CASP per cultivated hectare of land (Table 2).

Greenhouse trial

Significant improvement in grain yield and top weights were associated with the use of CPH under greenhouse conditions where NPK depressed these parameters (Table 3). Populations of *M. incognita* in soil and within cowpea roots were significantly less where CPH, CASP, and NPK fertilizer were applied as compared with the check (Table 4).

Table 3. Grain yield and growth indices of cowpea as influenced by CPH, CASP, and NPK fertilizer under greenhouse conditions.

Treatment	Grain yield (g/plant)[z]	Top wt (g/plant)[z]	Days to 50% flowering[z]
Cocoa pod husks	11.2 a	75 a	39.8 a
Cassava peelings	7.0 b	64 a	40.3 a
NPK fertilizer	5.3 b	31 b	39.7 a
Check	6.6 b	49 ab	41.3 a

[z]Means of 6 observations. Means followed by the same letters do not differ significantly (P = 0.05, Duncan's multiple range test).

Table 4. *Meloidogyne incognita* populations in soil and within cowpea roots as affected by CPH, CASP, and NPK fertilizer under greenhouse conditions.

Treatment	*M. incognita*/ 5 g root[z]	*M. incognita*/ 100 g soil[z]	Galling index[z]
Cocoa pod husks	92 b	58 b	1.3 b
Cassava peelings	146 b	98 b	1.3 b
NPK fertilizer	123 b	90 b	1.5 b
Check	271 a	152 a	2.3 a

[z]Means of 6 observations. Means followed by the same letters do not differ significiantly (P=0.05, Duncan's multiple range test).

DISCUSSION

Our results suggest that CPH and CASP may compare favorably with standard pesticides like carbofuran in protecting the cowpea plant against *M. incognita*. Of the three amendments used, CPH was the most effective. The galling incidence was not different statistically whether the crop received CPH or carbofuran.

Cowpea productivity was enhanced more by CPH and CASP treatments than by the inorganic fertilizer (NPK) and the carbofuran treatments. These improvements, however may not have been exclusively due to the observed nematode population reductions. Plots treated with carbofuran showed a 16% increase in grain yield. When compared with carbofuran treatment, cowpea grown in CPH and CASP amended soil had yield increases of 34% and 22%. Thus, these amendments improved cowpea health and productivity in ways other than nematode population suppression alone. This point is supported by our findings that the RH amendment significantly suppressed *M. incognita* populations as well as cowpea productivity, apparently because it also harbored fungi that were pathogenic to the cowpea seedlings. Similarly, plants in CPH and CASP amended plots also yielded 39% and 25% more than plants receiving NPK fertilizer, also indicating that their role was somewhat more than a simple fertilizing effect.

These results confirm earlier findings. Egunjobi (9) concluded that CPH enhanced maize yield both by suppressing populations of *Pratylenchus brachyurus* and by acting as a probable source of fertilizer. It is feasible that soil texture modifications by the added amendments to favor root growth (21) or their influence on rhizobial microbes or other soil fauna (26) indirectly also affected cowpea productivity in this study. Egunjobi (10) also found substantial reductions in the incidence of root galling on cowpea plants grown in CPH-amended soil both in the greenhouse and in field conditions. Similar also to our current results, CPH and CASP increased leaf numbers/maize plant and accelerated flower production rate in maize subsequent to reducing soil populations of *P. brachyurus* (9,11).

Furthermore, in agreement with Egunjobi and Ekundare (12), our current findings also indicate that CPH and CASP were superior to either carbofuran or NPK fertilizer in terms of economic returns. If integrated with groundnut hay, intermittent soil ridging (5,7), and selective systems of cropping (10), an effective cultural method could evolve for alleviating *Meloidogyne*-induced problems of cowpea in tropical Nigeria.

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ACKNOWLEDGMENT

The authors acknowledge with gratitude the assistance of Dr. V. Ayeni of the Department of Agronomy, University of Ibadan, Ibadan, Nigeria.

Received for publication:
1.XI.1985
Recibido para publicar: