Management of *Meloidogyne incognita* on Okra Using Three Weeds in Nigeria

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**Abstract**

Efficacy of three weeds in Nigeria; *Costus afer*, *Commelina benghalensis* and *Luffa aegyptiaca* were compared with carbofuran in the management of *Meloidogyne incognita* on okra. The pot experiment was laid out in completely randomized design. Two-week old okra seedlings were inoculated with 5,000 eggs of *M. incognita*. Air-dried milled leaves of weeds were applied at the rate of 100 kg/ha and carbofuran at 2 kg a.i/ha at one week after inoculation (WAI). Qualitative analysis of phytochemicals in the botanicals was also carried out. Data were collected on plant height, number of leaves, fruit weight (FW), gall index, reproductive factor and nematode population at 10 WAI. Carbofuran, *L. aegyptiaca*, *C. benghalensis* and *C. afer* improved vegetative growth by 59.3, 67.5, 36.5 and 34.9%, respectively than the inoculated control okra. *Luffa aegyptiaca* and *C. benghalensis* compared favourably with carbofuran in reduction of galls and nematode population. Carbofuran, *L. aegyptiaca*, and *C. benghalensis* reduced reproductive rate of *M. incognita* in okra by 93.9, 88.8 and 86%, respectively. *Luffa aegyptiaca* improved FW by 75% and was comparable to carbofuran. Phytochemicals present in the plants are tannins, saponins, anthraquinones, cardenolides and alkaloids. *Luffa aegyptiaca* compared effectively with carbofuran in the management of *M. incognita* on okra.

**Keywords:** Root-knot nematode, *Costus afer*, *Commelina benghalensis*, *Luffa aegyptiaca*, management

**INTRODUCTION**

Okra, *Abelmoschus esculentus* (L.) Moench ranks high amongst the economic important vegetables of the world (Agwu *et al.*, 2005). It is widely distributed in the tropics, sub-tropics and warmer portions in the temperate regions (Adenipekun *et al.*, 2009). It has found relevance in human diets and can also be fed to livestock (Fairinde *et al.*, 2007). Okra is one of the most important vegetables in Nigeria (Enokpa *et al.*, 1996; Adenipekun *et al.*, 2009).

A notable bio-constraint in the production of okra is the plant-parasitic nematodes (Saffiuddin *et al.*, 2011). Plant-parasitic nematodes (PPNs) cause loss of yield and quality of okra which indirectly reduces the economic value of the crop (Saffiuddin *et al.*, 2011). Root-knot nematodes (*Meloidogyne* species) have been reported as the major plant-parasitic nematodes on okra (Saffiuddin *et al.*, 2011). *Meloidogyne* species are responsible for about 70-90% yield losses in okra (Adesiyun and Akinlade, 1982; Saffiuddin *et al.*, 2011). *Meloidogyne incognita* is the most widespread and commonly encountered species of root-knot nematodes on okra (Siji *et al.*, 2010).

The management of root-knot nematodes with synthetic nematicides is the predominant strategy for many years (Siji *et al.*, 2010), but studies have shown that high cost of synthetic nematicides and their hazardous effects on the environment, non-target organisms are banes to their use by most peasant farmers in Africa (Adekunle and Fawole, 2003; Fawole, 2009). Many measures are being explored in the management of root-knot nematodes such as crop rotation, planting of resistant varieties, use of botanicals, amongst others (Siji *et al.*, 2010). The use of botanicals in the management *M. incognita* is being promoted due to its reported effectiveness and environment-friendliness (Adegbile and Agbaje, 2007; Fawole, 2009; Claudius-Cole *et al.*, 2010).

*Commelina benghalensis* (tropical spiderwort) is an important weed species in Africa and Asia, especially in irrigated fields (Chivinge and Kawisi, 1989). *Commelina benghalensis* (L.) were ranked as the 39th most troublesome weeds across all crops (Webster and MacDonald, 2001). *Luffa aegyptiaca* (Mill) is a pan-tropical weed of cultivation, waste places, roadsides and widespread in Nigeria (Akobundu and Agyakwa, 1987). *Luffa*
is not well known in the vegetable community, but the unique nature of the fruits, which are used both for food and industrial purposes, promotes interest in the plant. *Costus afer* is a tropical plant of the family Zingiberaceae found in moist or shady forest of West Africa and it is common in Nigeria with over 70 species (Aweke, 2007; Omokhua, 2011). Some phytochemicals such as saponins, flavonoids, amongst others have been reported present in *C. afer*. The world flora is a rich source of botanicals that have been reported to show pesticidal effects based on their phytochemical constituents (Lale, 2009; Siji et al., 2010), but many of them have not yet been profitably screened to ascertain their pesticidal properties (Ofuya, 2009). Basic phytochemicals such as alkaloids, saponins, tannins, amongst others had been reported to confer nematicidal activity in plants (Chitwood, 2002). These plants if explored for nematicidal activity might be alternatives to synthentic nematicides (Siji et al., 2010). The study was carried out to compare the nematicidal potentials of three plants considered as weeds (*C. afer, C. benghalensis, L. aegyptiaca*) in Nigeria with a synthetic nematicide (carbofuran) in the management of *M. incognita* on okra and to screen these weeds for their phytochemical constituents.

**MATERIALS AND METHODS**

**Collection and preparation of weeds:**

*Commelina benghalensis, Costus afer* and *Luffa aegyptiaca* were collected in Choba, Rivers State, Nigeria. They were authenticated after collection by a botanist in the Department of Forestry and Wildlife Management, University of Port Harcourt. The leaves of the weeds were air-dried on the laboratory bench for six weeks. The air-dried leaves were milled into powder using Kenwood® warring blender and kept in labeled bottles.

**Culture and extraction of *M. incognita***:

Pure culture of *M. incognita* obtained from Nematology Research Laboratory of the International Institute for Tropical Agriculture (IITA), Ibadan, were maintained on okra cv V35 grown in pots at the Research Farm in the Department of Crop and Soil science, University of Port Harcourt. Eggs of *M. incognita* were extracted from infected okra roots using the method of Hussey and Baker (1973).

**Experimental design:**

Two separate, but identical trials in pots were conducted at the Research Farm in the Department of Crop and Soil science, University of Port Harcourt. The experiment was laid out in a completely randomized design with six treatments and eight replicates. Forty-eight pots (diameter 20 cm and depth 30 cm) were filled each with 5 kg steam-sterilized sandy-loam top soil.

**Sowing, inoculation of *M. incognita*, application of botanicals and carbofuran:**

Two seeds of okra (Clemson spineless) were sown into each pot. Okra seedlings were later thinned to one per pot at one week after sowing (WAS). *M. incognita* eggs were extracted from infected okra roots using the method of Hussey and Barker (1973). Each okra seedling was inoculated with 5,000 eggs of *M. incognita* at 2 WAS, except uninoculated control. Milled leaves of *C. benghalensis, C. afer* and *L. aegyptiaca* at 100 kg/ha and carbofuran at 2 kg a.i./ha were applied one week after inoculation (WAI) to potted okra seedlings, except okra assigned inoculated-untreated and uninoculated treatments. Soil around roots of each okra seedling was scooped to a depth of 5 cm, appropriate quantities of botanicals and carbofuran were applied around the roots and then roots were covered with soil. The experiment was terminated at 10 WAI.

**Data Collection:**

At 10 WAI, data were collected on number of leaves, plant height (cm), weight of fruits per plant (g), fresh shoot and root weights (g) using Mettler balance (P1210). The plant roots were assessed after each harvest for nematode damage using gall index using the scale of Taylor and Sasser (1978):

where, 0=No galls or egg masses; 1=1-2 galls or egg masses; 2=3-10 galls or egg masses; 3=11-30 galls or egg masses; 4=31-100 galls or egg masses; 5=more than 100 galls or egg masses. Nematode eggs were extracted from okra roots using the method of Hussey and Baker (1973) and estimated under compound microscope using Doncaster counting dish (Doncaster, 1962). The root length (cm) was measured using metre rule. The fresh shoots and roots were oven-dried at 80° C for 48 hours to constant weight. They were later weighed using Mettler balance. Soil from each of the pots was thoroughly mixed and 200 ml soil sample was collected. Second-stage juveniles of *M. incognita* were extracted from the soil using the pie-pan method (Whitehead and Hemming, 1965). The extracted nematode population was later estimated under compound microscope. Subsequently, the nematode reproductive factor was determined [RF= Pf/Pi; Pf is the final nematode population and Pi is the initial nematode population (5,000)].
Qualitative analysis of phytochemicals in the leaves of C. benghalensis, C. afer and L. aegyptiaca:

Milled leaves of C. benghalensis, C. afer and L. aegyptiaca were screened for their phytochemical constituents. The phytochemicals screened for were tannins, saponins, cardenolides, anthraquinones and alkaloids.

Test for tannins:
The leaves of the three weeds were spread on laboratory benches separately for six weeks and air-dried. Air-dried leaves were milled into powder using a warring blender. Each powdered leaf material of a weed (0.5 g) was weighed on Mettler balance into test tubes and shaken in 5 ml of distilled water. The test tube was heated in water bath to 100° C after which it was left to cool and then filtered with Whatman No. 1 filter paper. Ferric chloride was added to the filtrate as a reagent to indicate the presence of tannins. The presence of tannin was acknowledged when the solution turned dark blue (Trease and Evans, 1989).

Test for saponins:
Air-dried milled leaves of each weed (0.5 g) was weighed into test tube. The material was shaken together with 5 ml of distilled water and heated over bath at 100° C. Saponins presence was acknowledged by the evidence of frothing (Trease and Evans, 1989).

Test for alkaloids:
Alkaloids test was carried out by weighing 0.5 g milled leaves of the weeds in 10 ml of distilled water. The set up was heated at 70° C for two minutes and filtered. Aqueous extracts of filtrate was spotted as thin Layer chromatography (TLC) plates and later sprayed with Dragendorff’s reagent. The presence of alkaloids was confirmed when there was orange-red colour (Trease and Evans, 1989).

Test for anthraquinones:
The Borntrager test was used for this experiment, in which 2 ml of layer test sample was shaken with 4 ml of hexane. The upper layer was separated and treated with 4 ml dilute ammonia. When the lower layer changed from violet to pink it indicated the presence of anthraquinones (Chhabra et al., 1984; Orech et al., 2005).

Test for cardenolides:
The powdered leaves were thoroughly mixed with 20 ml distilled water and kept at room temperature for two hours. The suspension was filtered into separate test tubes (Acid B). To A, four drops of reagent was added. The appearance of a blue violet colour indicated the presence of cardenolides. Test tube B was used to monitor and compare colour changes (Chhabra et al., 1984).

Data Analysis:
Data were analyzed using analysis of variance with Statistical Analysis Systems (2009) and means were partitioned using Fisher’s Least Significant Difference (LSD) at 5% of level of significance.

Results:
Effects of milled leaves of Commelina benghalensis, Costus afer, Luffa aegyptiaca and carbofuran on growth of Meloidogyne incognita infested okra:

At 10 weeks after inoculation (WAI), M. incognita infected okra treated with L. aegyptiaca had the highest mean plant height (25.5 cm) which was not significantly higher than plants treated with carbofuran (24.5 cm) (Table 1). All the treated plants with the milled leaves of the three weeds, carbofuran and untreated plants showed significantly higher mean plant height than inoculated-untreated control plants (15.4 cm).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height at 10 WAI (cm)</th>
<th>Number leaves at 10 WAI</th>
<th>Root length (cm)</th>
<th>Fresh shoot weight (g)</th>
<th>Fresh root weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninoccontrol</td>
<td>21.2</td>
<td>8.0</td>
<td>26.3</td>
<td>5.1</td>
<td>3.0</td>
</tr>
<tr>
<td>C. afer</td>
<td>20.8</td>
<td>8.0</td>
<td>16.4</td>
<td>4.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>24.5</td>
<td>9.5</td>
<td>44.0</td>
<td>8.5</td>
<td>3.3</td>
</tr>
<tr>
<td>C. benghalensis</td>
<td>21.0</td>
<td>8.0</td>
<td>17.6</td>
<td>4.5</td>
<td>3.3</td>
</tr>
<tr>
<td>L. aegyptiaca</td>
<td>25.8</td>
<td>8.5</td>
<td>37.3</td>
<td>6.9</td>
<td>3.6</td>
</tr>
<tr>
<td>Inoccontrol</td>
<td>15.4</td>
<td>7.5</td>
<td>12.0</td>
<td>2.4</td>
<td>7.6</td>
</tr>
<tr>
<td>LSD(p&lt;0.05)</td>
<td>4.9</td>
<td>0.7</td>
<td>13.1</td>
<td>2.7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Each value is a mean of eight replicates. Uninoccontrol= uninoculated control plants. Inoccontrol= inoculated-untreated plants. WAI= Weeks after inoculation.
At the end of the experiment (10 WAI), plants treated with carbofuran had the highest number of leaves (9.5) and this was significantly higher than for other treatments. *Luffa aegyptiaca*-treated okra (8.5) had higher number of leaves that were not significantly more than leaves of okra treated with *C. afer* (8.0), *C. benghalensis* (8.0) and uninoculated control (8.0). Inoculated-uninoculated okra had the least number of leaves (7.5) (Table 1).

The result presented in Table 1 shows that plants treated with carbofuran had the highest mean root length (44.0 cm) which was not significantly longer than roots of plants treated with *L. aegyptiaca* (37.3 cm). The shortest roots were recorded in the inoculated-uninoculated control plants (12.0 cm). Carbofuran-treated okra had the highest fresh shoot weigh (8.5 g), followed by plants treated with *L. aegyptiaca* (6.9 g). The lowest fresh shoot weight was observed in inoculated-uninoculated control okra (2.4 g). All the treated okra had better fresh shoot weights than the inoculated control okra. Inoculated-uninoculated okra had the highest fresh root weight (7.6 g) that was significantly higher than fresh root weights of uninoculated and botanical-treated *M. incognita*-infected okra (Table 1).

**Effects of milled leaves of *C. afer, C. benghalensis, L. aegyptiaca* and carbofuran on gall index (GI), second-stage juveniles (J₂), egg population, final nematode population (Pf) and reproductive factor (RF) of *M. incognita*-infected okra:**

The highest level of galling was recorded in inoculated-uninoculated control okra with GI of 5 and this was significantly higher than the level of galling recorded for all other okra (Table 2). The lowest GI was recorded in carbofuran-treated okra (1.8) but this was not significantly lower than GI from *C. afer* (2.3), *C. benghalensis* (2.3) and *L. aegyptiaca* (2.0). The highest population of *M. incognita* eggs was obtained in roots of inoculated-uninoculated okra (54,000) which was significantly higher than the other treatments. The least egg population of *M. incognita* was observed in carbofuran-treated plants (3,500), whereas *Luffa*-treated okra had 6,750 eggs of *M. incognita.*

**Table 2:** Effects of milled leaves of *Costus afer, Commelina benghalensis, Luffa aegyptiaca* and carbofuran on gall index (GI), second-stage juveniles, egg population, final nematode population and reproductive factor of *M. incognita*-infected okra.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>GI</th>
<th>J₂</th>
<th>Egg population</th>
<th>Final nematode popn.</th>
<th>Reproductive Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninoculated</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Costus sp.</td>
<td>2.3</td>
<td>4050</td>
<td>11250</td>
<td>17050</td>
<td>3.1</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>1.8</td>
<td>2000</td>
<td>3500</td>
<td>5500</td>
<td>1.1</td>
</tr>
<tr>
<td>Commelina sp.</td>
<td>2.3</td>
<td>3750</td>
<td>8750</td>
<td>12500</td>
<td>2.5</td>
</tr>
<tr>
<td>Luffa sp.</td>
<td>2.0</td>
<td>3250</td>
<td>6750</td>
<td>10000</td>
<td>2.0</td>
</tr>
<tr>
<td>Inoccontrol</td>
<td>5.0</td>
<td>35300</td>
<td>54000</td>
<td>89300</td>
<td>17.9</td>
</tr>
<tr>
<td>LSD(p≤0.05)</td>
<td>1.0</td>
<td>12709</td>
<td>15967</td>
<td>13519</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Each value is a mean of four replicates. J₂= second-stage juveniles. GI= Gall index. Uninoculated= uninoculated okra. Inoccontrol= inoculated-uninoculated okra.

The highest second-stage juvenile (J₂) population of *M. incognita* was recorded in inoculated-uninoculated control okra (35,300) and this was significantly higher than from all other plants. Carbofuran-treated plants recorded the least J₂ population (2,000), followed by *Luffa* treated okra (3,250). Similar observation holds for the final nematode population of *M. incognita.*

Reproductive factor of *M. incognita* was highest in inoculated-uninoculated okra (17.9) and this was significantly higher than the reproductive factors in other treated okra. The least reproduction of *M. incognita* took place in carbofuran-treated plants (1.1), followed by *Luffa*-treated plants (2.0). However, all the treated plants with milled leaves of botanicals significantly reduced the rate of reproduction of *M. incognita* in okra.

**Effects of milled leaves of *Costus afer, Commelina benghalensis, Luffa aegyptiaca* and carbofuran on weight (g) of fruits of *M. incognita* infected okra:**

*Luffa aegyptiaca* treated plants had the highest fruit weight and this was significantly higher than mean weight of carbofuran-treated plants. Inoculated control plants recorded the least fruit weight and this was significantly lower than fruit weight produced by other plants.

**Table 3:** Effects of milled leaves of *Costus afer, Commelina benghalensis, Luffa aegyptiaca* and carbofuran on fruit weight (g) of *M. incognita*-infected okra.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>6.6</td>
</tr>
<tr>
<td>Costus sp.</td>
<td>3.5</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>5.7</td>
</tr>
<tr>
<td>Commelina sp</td>
<td>3.3</td>
</tr>
<tr>
<td>Luffa sp.</td>
<td>6.9</td>
</tr>
<tr>
<td>Inoccontrol</td>
<td>1.5</td>
</tr>
<tr>
<td>LSD(p≤0.05)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Each value is a mean of four replicates. Uninoculated= uninoculated okra; Inoccontrol= inoculated-uninoculated okra.
Phytochemicals present in C. benghalensis, C. afer, and L. aegyptiaca:

Table 4 shows that alkaloids, saponins and cardenolides are present in the leaves of C. benghalensis, C. afer, and L. aegyptiaca. However, tannins were not detected in C. benghalensis and C. afer. Anthraquinones were absent in C. benghalensis and L. aegyptiaca

Table 4: Phytochemicals present in leaves of C. benghalensis, C. afer, L. aegyptiaca

<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>C. benghalensis</th>
<th>C. afer</th>
<th>L. aegyptiaca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaloids</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Tannins</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Anthraquinones</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Saponins</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cardenolides</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

+ means present. - means absent

Discussion:

Effects of milled leaves of C. afer, L. aegyptiaca, C. benghalensis and carbofuran on growth of okra:

*Meloidogyne incognita*-infected okra treated with air-dried milled leaves of *C. benghalensis*, C. afer, L. aegyptiaca and carbofuran showed better growth than inoculated-untreated okra. Carbofuran-treated okra plants were outstanding in growth than the rest of the treatments. This good vegetative growth observed in treated okra might be due to the therapeutic effect of the milled botanicals and carbofuran on *M. incognita* owing to active principles within them that might be nematicidal (Adekunle and Fawole, 2003). The botanicals might also have aided growth of the infected okra by readily making nutrients available and this might have helped the plants to tolerate better the nematode attack (Radwan et al., 2007). The application of the botanicals in no doubt might have increased the soil physical conditions, soil biological activity and crop performance (Aktar and Alam, 1993; Radwan et al., 2007). The ability of dried leaves of plants to improve vegetative growth had also been corroborated by Radwan et al. (2007) who observed that leaves of china berry (*Melia azedarach*), Oleander (*Nerium oleander* L.), Lantana (*Lantana camara*), Castor (*Ricinus communis*) and Jimson (*Datura stramonium*) applied at 5 and 10 g/10kg soil of tomato plants infected with *M. incognita* significantly increased shoot length compared to the untreated-inoculated plants. The differences observed among the botanicals in growth of plants infected might be due to differences in the composition of active ingredients in suppressing the adverse effects of the nematode (Radwan et al., 2007).

Carbofuran had been confirmed by many workers as an effective nematicide against many plant-parasitic nematodes including *Meloidogyne* species (Radwan et al., 2007; Tanimola and Godwin-Egein, 2009). This opinion agrees with similar observation made by Fakoke (2001) in which he reported that infected cowpea plants with *M. incognita* treated with sian weed leaves, sian roots, neem leaves and carbofuran showed higher increase in plant height and number of leaves as compared to control plants.

Effects of milled leaves of C. afer, L. aegyptiaca, C. benghalensis and carbofuran on galls, eggs, nematode population and reproductive factor:

Treated okra with either carbofuran or milled leaves of weeds had lesser galls, eggs, nematode population and lower rate of reproduction when compared with inoculated-untreated okra. The fact that carbofuran recorded the least gall index followed by *L. aegyptiaca* show that carbofuran showed more nematicidal effect on root-knot nematodes by reducing their population below the economic threshold. It might be that *Luffa* sp. contains more concentrations of nematicidal ingredients than the rest of the botanicals applied for it to show more potency. The view on the potency of carbofuran in reducing nematode population to levels that will not cause economic damage in okra is supported by Akinlade and Adesiyan (1982) and in tobacco by Brodie and Good (1973). They reported low incidence of plant-parasitic nematodes with the application of carbofuran. Adesiyan and Badra (1985) asserted the effectiveness of carbofuran when they evaluated the toxicity of three systemic nematicides (carbofuran, temik and miral) against root knot nematodes attacking tomato plant.

The effectiveness of the air-dried weeds especially *Luffa* sp in reducing adverse effects of the nematode might be due to the nematicidal effects of the active principles in them. Organic amendments have been shown to decrease phytoparasitic nematode population in the soil ecosystem (Sikora, 1992). Microbial activity in the soil is enhanced on incorporation of the organic matter that initiates antibiosis towards the nematode activity. This is due to accumulation of toxic metabolites which are either produced by microbial growth (Djian et al., 1991) or organic matter that releases volatile fatty acids during microbial decomposition (Badra et al., 1979). Vats et al. (1996) reported reduction of galls and egg masses when some *M. javanica*-infected tomato plants were treated with leaf extracts of *Azadirachta indica* and *Eucalyptus tereticornis*.

Effects of milled leaves of C. afer, L. aegyptiaca, C. benghalensis and carbofuran on fruit weight (g):

The improvement in fruit weight observed in the treated okra with carbofuran and botanicals is as a result of the reduction in adverse impact of *M. incognita* due to reduction in their population to a level that cannot have
adverse effect on growth and yield. It means also that the plants when treated were able to perform their basic physiological processes aiding good growth and yield (Adegbite and Agbaje, 2007). Reproductive rate of *M. incognita* was least in carbofuran-treated okra plants obviously because of the efficacy of the nematicide on *M. incognita* either by ensuring mortality or causing dysfunction in the reproductive ability of the nematode (Disanzo, 1977).

The significant reduction in the rate of *M. incognita* reproduction in okra treated with air-dried milled leaves of *L. aegyptiaca*, *C. afer* and *C. benghalensis* when compared with inoculated-uninjected okra implies that the botanicals exerted nematicidal effects that might have affected the development of the nematode, but not as much as carbofuran. The nematicidal effects observed in the management of *M. incognita* on okra in the study might be due to active chemical ingredients (phytochemicals) in them.

Phytochemicals have been confirmed present in the weeds used in this experiment which was in agreement with report of other workers (Aweke, 2007; Anaga et al., 2004). These phytochemicals when present in plants have been reported to confer pesticidal abilities (Chitwood, 2002; Adeniji et al., 2010; Ukpaib et al., 2012).

**Conclusion:**

The study showed that *M. incognita* infected okra treated with milled leaves of *Luffa aegyptiaca*, *Costus afer* and *Commelina benghalensis* at the rate of 100 kg/ha can be applied to okra being grown on *M. incognita* infested soils at planting for effective root-knot nematode control. The *M. incognita*-infected treated okra with botanicals and carbofuran improved growth of okra evident in higher increase in plant height, number of leaves than the inoculated-uninjected okra. The improvement in growth of okra was more observed in infected okra treated with carbofuran. *Luffa aegyptiaca* showed better performance in growth, yield and nematode management among the botanicals applied. *Luffa aegyptiaca* should be given priority among the botanicals in the management of *M. incognita* on okra. The use of synthetic nematicides such as carbofuran should be de-emphasised in view of the cost and hazards caused to man and the environment.

Research is needed in the future to specifically identify the types and concentrations of the phytochemicals present in the botanicals screened. Also, optimum rate at which each botanical might be applied to ensure good growth, yield and management of *M. incognita* on okra should be determined. These botanicals when applied might proffer solution in nematode management as an important component in organic farming.

**REFERENCES**


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