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Management of *Meloidogyne incognita* on cowpea (*Vigna unguiculata* L. Walp) with three powdered *Aloe* species leaves

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Abstract: *In vitro nematicidal efficacy of some Aloe species on Meloidogyne incognita are known, but their effectiveness in the management of nematodes of field crops is scant. Pot and field experiments were laid out in completely randomized design and randomized complete block design, respectively, to determine the effects of three powdered Aloe species leaves of Aloe keayi (AKY), Aloe succrotina (AST), and Aloe vera (AVR) compared with carbofuran in the management of M. incognita on cowpea. Two-week old cowpea seedlings were inoculated with 10,000 eggs of M. incognita. A week after inoculation, powdered leaves of AKY, AST, AVR at 20 kg/ha, 40 kg/ha, 60 kg/ha, 80 kg/ha and carbofuran at 1 kg and 2 kg a.i/ha were applied. Data were collected on Vegetative Growth (VG), Grain Yield (GY), Gall Index (GI), Nematode Population (NP), and Reproductive Factor (RF). Data were analyzed using standard procedures. Carbofuran at 2 kg a.i/ha, A. keayi at 80 kg/ha, A. vera at 80 kg/ha, and A. succrotina improved VG by 185.2%, 146.3%, 127%, and 84.5%, respectively. Carbofuran-treated plants at 2 kg a.i/ha, AKY at 80 kg/ha, carbofuran at 1 kg a.i/ha, AVR at 80 kg/ha and AST at 80 kg/ha improved cowpea yield by 317.9%, 296.8%, 253.3% and 235.7%, respectively. All treated plants with carbofuran and powdered Aloe leaves reduced GI, NP and RF, but AKY at 80 kg/ha compared effectively with carbofuran at 2 kg a.i/ha. Powdered AKY, AVR and AST leaves at rates of 40-80 kg/ha can be used to manage M. incognita on cowpea, but best in A. keayi treatments at 80 kg/ha.*

Keywords*: Aloe species, Carbofuran, Meloidogyne incognita, Management, Cowpea*

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I. Introduction

Cowpea, *Vigna unguiculata* (L.) Walp is very important as a source of high quality plant protein in the diets of many individuals in many developing countries [16] [23]. It contributes economically to the livelihood of most farmers of West and Central Africa [21]. Nigeria is one of the major producers of cowpea in the world [10], but with an actual yield between 0.43-0.69 tonnes per hectare against a potential yield of 2-3 tonnes per hectare with good agronomic management [9] [27]. Cowpea yield from cultivation is still low due to many factors which include the devastating effect of pests and phytopathogens with plant-parasitic nematodes being a notable pathogen, amongst others [36] [26].

Plant-parasitic nematodes are important pathogens that cause economic yield losses of crops [18] [4], especially in the tropics where environmental conditions and cropping systems favour their development [22]. Plant-parasitic nematodes are one of the major pests of cowpea in Nigeria and worldwide with root-knot nematodes, *Meloidogyne* species reported as major species found in cowpea [35] [27] [28]. *Meloidogyne incognita,* a notable species of the root-knot nematodes had been identified as a major reason for yield reduction in crops such as cowpea [30] [35] [27]. It is very important to increase cowpea production to meet the plant protein demand for the ever increasing world population through effective management of pests and diseases of cowpea while protecting producers, consumers and the environment.

Nematicides are adjudged to be effective in the management of plant-parasitic nematodes [12] [28], but are expensive, require skilled manpower in their usage, nonspecific and possess high general toxicity to an extent that they have been banned by many governments because of environmental safety [1] [7] [40] [28]. Many farmers do apply more of these chemicals indiscriminately above the recommended application rate with a view to safeguarding their crops for good net returns. However, the use of chemical pesticides in the management of pests and diseases is increasing in the developing countries as farmers intensify production and expand cultivation areas and planting seasons beyond crops traditional range which do increase pests and diseases pressure.

The use of botanicals as an effective alternative for the management of plant-parasitic nematodes have been acknowledged as being more sustainable and environment-friendly compared to synthetic nematicides [6] [12]. There is a gradual shift in the world towards production of food items either without the use or with minimum application of inorganic fertilizers, synthetic growth regulators, and pesticides in what is known as organic agriculture for the safety of man and the environment [20] [13]. These reasons justified the use of botanicals which might reduce or replace the use of synthetic pesticides [37] [6] [28]

Aloe species are of the family Asphodelaceae and commonly found in Africa [3]. Nematicidal efficacy of *Aloe* species on *M. incognita* had earlier reported [29]. Also, [38] reported the *in vitro* nematicidal efficacy of some *Aloe* spp. on *M. incognita* with *Aloe keayi, A. succrotina* and *A. vera* being outstanding. However, these *Aloe* species are yet to be used in the management of crops either in pots or on the field. Therefore, pot and field experiments were conducted to determine the efficacy of three powdered *Aloe* species leaves, *A. keayi, A. succrotina* and *A. vera* at rates of 20-80 kg/ha compared with carbofuran with the view to managing *M. incognita* and increasing cowpea yield.

II. Materials and methods

2.1 Study sites

The pot and field experiments were carried out during rainy seasons in two similar trials per experiment at the Roof-top Garden and Crop Garden, respectively of the Department of Crop Protection and Environmental Biology, University of Ibadan between 2009 and 2011 growing seasons. So, there was no need for supplementary irrigation in the field trials. University of Ibadan is located within Ibadan in Southwest Nigeria on latitude N 07^{o} 27.029^{1} and longitude E 003^{o} 53.827^{1} with an elevation of 218 metres above sea level. The climate is tropical, where the annual rainfall ranges from an average of 1,500 mm to 2,500 mm while the annual temperature ranges from an average minimum of 22.6 ^{o}C to an average of 34.5 ^{o}C [25]. Three *Aloe* species used in this study were selected based on *in vitro* reports on their nematicidal activities and phytochemical characterization [38].

2.2 Pot experiment

The experiment was laid out in a completely randomized design. The treatments were made up of powdered three *Aloe* species leaves of *A. keayi*, *A. vera* and *A. succotrina* applied at four rates of 20 kg/ha, 40 kg/ha, 60 kg/ha or 80 kg/ha; carbofuran 5G at the rates of 2 and 1 kg active ingredient per hectare (kg. a.i./ha) and the controls (inoculated-untreated and uninoculated).

Sixty-four 10-litre pots of diameter 30 cm and depth of 24 cm were filled with 10 kg of sterilized sandy-loam soil per pot. Cowpea (Ife Brown) was sown at the rate of two seeds per pot and later thinned to one stand per pot one week after sowing (WAS). *Meloidogyne incognita* eggs used were extracted from *Celosia argentea* roots using the method of [15]. At 2 WAS, two milliliter of *M. incognita* egg suspension containing 10,000 eggs was pipetted into four holes each at a depth of 4 cm made at the rhizosphere of the cowpea seedlings thereby facilitated inoculation. After inoculation, the holes were covered with sterilized sandy-loam soil. Cowpea stands assigned the uninoculated control treatment status were not inoculated. Each treatment was replicated four times. The air-dried milled leaves of *Aloe* species and carbofuran at varying application rates were applied as a band of 3 cm around roots of each seedling at 3 WAS, excluding inoculated and uninoculated cowpea stands. The plants were watered twice everyday and hand-weeded throughout the period of study in the pot trials. Insect pests were managed by the application of Lambdacyhalothrin (Attacke produced by Bretmont Limited, England) at 2 ml/litre.

2.3 Data collection in pot trial

Growth parameters, leaf area (cm^2), plant height (cm), stem diameter (mm) and number of leaves were taken immediately after inoculation at 2 WAS and subsequently weekly till termination of experiment. Plant height was taken by measuring the plant from the base of the plant at soil level to the tip with a metre rule. Stem diameter was taken with the aid of Vernier caliper and number of leaves taken by visually counting the leaves per plant. Length and width of leaf was measured using a metre rule and then multiplied with Ife Brown leaf area factor and this gave the leaf area. Growth data were taken weekly for eight weeks after which the experiment was terminated. Number of pods, 100 seed weight (g) and grain yield per plant were determined at harvest. At harvest, each plant fresh weights (shoot and root) were determined using a Mettler balance (Model P1210). The plant roots were assessed after each harvest for nematode damage with gall index using the scale of [39]; 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 and 5 = more than 100 galls or egg masses.

Eggs of *M. incognita* were extracted from each root system [15]. Subsequently, the plants' fresh shoots were oven-dried at 80 ^{o}C for 48 hours and had their shoot dry weight determined using Mettler balance (Model P1210). Second-stage juveniles (J_2) of *M. incognita* were extracted from properly mixed 200 ml soil samples obtained from each pot using the pie-pan method [41]. Final nematode population (Pf) was calculated by the summation of *M. incognita* eggs and J_2 population. Reproductive factor (RF) was calculated using the formula

Pf/Pi; where Pf =final nematode population and Pi= initial nematode population of 10,000 eggs. The second trial was repeated in the same manner as first trial.

2.4 Field experiment

A piece of land in the Crop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan was used for this study. The experimental field covered an area of 249.9 m^2 (25.5 m x 9.8 m). The experiment was laid out in a randomized complete block design with 16 treatments and replicated in four blocks. The piece of land was cleared manually. The field was divided into four blocks of 25.5 m x 1 m each. Each block was sub-divided into 16 plots of 1.2 m x 1 m each with an alley of 0.5 m between plots and 1m between blocks. Soil samples of 200 ml each were randomly collected from top 1-15 cm soil from each plot using a soil auger. The soil samples were collected into polythene bags and appropriately labeled. Nematodes were extracted from the soil samples (200 ml/plot) in the laboratory using the pie pan method [41] with a view to determining the initial population of *M. incognita* in the field. *Meloidogyne incognita* second-stage juveniles were identified and counted under a stereomicroscope with the aid of Doncaster counting dish [8]. The field was not richly infested with *M. incognita* to cause significant infection of cowpea to be cultivated. This necessitated the inoculation of cowpea seedlings with eggs of *M. incognita* in similar manner as in pot.

The treatments in the field experiment were similar to those in pot experiment and each block had 16 treatments in the field layout. Plots in each block assigned uninoculated/uninfected control status were denematized using carbofuran at 3 kg. a.i./ha three weeks prior to sowing of cowpea seeds. Each plot was sown with cowpea cv. Ife Brown at the rate of two seeds per hole, spacing of 50 cm within and 60 cm between rows and later thinned to one stand of cowpea plant per hole after a week.

Eggs of *M. incognita* were extracted from roots of *Celosia argentea* using the method of [15]. Each cowpea plant were inoculated with 10,000 eggs of *M. incognita* at 2 WAS except plants in uninoculated/uninfected plot. A week after inoculation, air-dried milled leaves of the selected three *Aloe* species at the rates of 20 kg/ha, 40 kg/ha, 60 kg/ha or 80 kg/ha were applied in a band of 3 cm around roots of each of the inoculated plants; and carbofuran at 2 rates of 1 kg a.i./ha and 2 kg/a.i./ha, whereas the control plots were neither treated with the *Aloe* botanicals nor carbofuran. All necessary agronomic practices such as weeding and control of insect pests (Lambdacyhalothrin was used at the recommended dosage) were carried out when necessary. The field trial was repeated in similar manner as in first trial with no modifications.

2.5 Data collection in field trial

Data in the field trials were collected in similar manner to that in pot experiment. Growth parameters; plant height (cm), leaf area, stem diameter and number of leaves were taken immediately after inoculation in both pot and field studies. The grain yield per hectare was also determined in the field trials at harvest besides other yield data taken in pot trials. Nematode population data were also taken in similar manner to that in pot trials.

2.6 Data analysis

The average of data collected from the two trials of both pot and field experiments were used for analysis since there was no marked difference in their values and trends. Data were statistically analyzed using analysis of variance with SAS (2009) statistical package for all the treatments tested and means separated using Fisher's Least Significant Differences (LSD) at 5% level of probability.

III. Results

3.1 Effects of three powdered *Aloe* species leaves and carbofuran on growth of *Meloidogyne incognita*-infected cowpea

The effects of air dried-milled leaves of *Aloe succotrina*, *A. vera* and *A. keayi* and carbofuran on mean leaf area (cm^2)**,** number of leaves, plant height and stem diameter of cowpea infected with *M. incognita* are presented in Tables 1, 2, 3 and 4, respectively.

3.1.1 Effects of treatments on mean leaf area of *Meloidogyne incognita*-infected cowpea

In the pot experiment, all the plants showed statistically similar leaf area at inoculation with 10,000 eggs of *M. incognita* at 2 WAS and at 2 weeks after inoculation (WAI)**.** At 4 WAI, All treated plants with either powdered *Aloe* leaves except *A. succrotina* at 20 kg/ha, 40 kg/ha or carbofuran had higher mean leaf area which were significantly higher than those of inoculated-untreated plants (Table 1). The trend at 6 WAI was similar to that at 4 WAI. At harvest, 8 WAI, all treated plants with either powdered *Aloe* leaves or carbofuran had significantly higher ($P \leq 0.05$) leaf area than inoculated-untreated control plants. There was no significant difference in the mean leaf area of carbofuran at 2 kg a.i/ha and *A. keayi* at 80 kg/ha.

In the field trials, there was significant difference in the effects of carbofuran and dried-milled leaves of three *Aloe* species applied in treating *M. incognita* on cowpea at 8 WAI (Table 1). *Aloe keayi* at 80 kg/ha had the highest mean leaf area which was not significantly higher than those of *A. vera* at 80 kg/ha, *A. succrotina* at 80 kg/ha, *A. succrotina* at 60 kg/ha and uninfected control. The lowest leaf area of 62.8 cm^2 was recorded in infected-untreated cowpea (Table 1).

3.1.2 Effects of treatments on mean number of leaves of *Meloidogyne incognita*-infected cowpea

All plants had statistically similar mean number of leaves at inoculation in pot experiment (Table 2). No significant difference was observed among treatments till after 4 WAI. At 6 WAI, treated plants with either carbofuran or powdered *Aloe* species leaves had significantly more number of leaves than inoculated-untreated plants. At 8 WAI, plants treated with carbofuran at 2 kg a.i/ha produced the highest mean number of leaves, but not significantly higher than number of leaves recorded in cowpea treated with carbofuran at 1 kg a.i/ha, *A. keayi* at 80 kg/ha and uninoculated control. All plants treated with either powdered leaves of the three *Aloe* species or carbofuran produced significantly more ($P \leq 0.05$) leaves than inoculated-untreated plants. The fewest number of leaves was observed in the inoculated-untreated cowpea plants (Table 2).

The trend observed in mean number of leaves on the field was similar to that in the pot experiment till 6 WAI (Table 2). There was no significant difference among all the treated plants with either powdered leaves of *Aloe* species or carbofuran at 6 WAI, but they produced significantly more leaves than inoculated-untreated plants (Table 2). At 8 WAl, carbofuran-treated plants at 2 kg a.i/ha produced the highest number of leaves, followed by *A. keayi* treated plants at 80 kg/ha and the fewest recorded in inoculated-untreated plants. No significant difference was recorded among all the treated plants and uninfected plants, but they produced significantly more ($p \leq 0.05$) leaves than *M. incognita* infected-untreated cowpea (Table 2).

3.1.3 Effects of treatments on mean plant height of *Meloidogyne incognita*-infected cowpea

No significant difference exists among the treatments in mean plant height till 4 WAI in the pot experiment (Table 3). At 4 WAI, uninoculated, *A. succrotina* at 40 kg/ha, *A. vera* at 40 kg/ha, *A. vera* 80 kg/ha, carbofuran at 2 and 1 a.i kg/ha had significantly taller plants than inoculated-untreated cowpea seedlings. At 6 WAI, only *A. succrotina* and *A. keayi* at 20 kg/ha treated plants did not have significantly taller plants than inoculated-untreated plants. At harvest (8 WAI), carbofuran-treated plants at 2 kg a.i/ha had the highest mean plant height, followed by carbofuran-treated plants at 1 kg a.i/ha, uninoculated control plants and *A. keayi* at 80 kg/ha with no significant difference among these four treatments. The least plant height was observed in the inoculated-untreated plants. All the treated plants with either carbofuran or powdered leaves of *Aloe* species had significantly taller plants than inoculated-untreated plants (Table 3) (Plate 1).

The trend in plant height in the field trial was similar to that in pot till 4 WAI. In the field trial, at 4 WAI, uninfected plants had the highest mean plant height that was not significantly higher than height of *A. succrotina* at 80 kg/ha, *A. keayi* at 80 kg/ha, *A. succrotina* at 60 kg/ha and *A. vera* at 80 kg/ha (Table 3). At 6 WAI, *A. keayi* at 80 kg/ha had the highest mean plant height which was not significantly higher ($p \leq 0.05$) than height of cowpea treated with carbofuran at 2 kg a.i/ha, uninfected and *A. succrotina* at 80 kg/ha. The shortest plants were found in the infected-untreated plants. At 8 WAI, the trend observed was similar to that at 6 WAI with highest mean plant height recorded in *A. keayi* treated plants and the shortest in infected-untreated plants. All treated and uninfected cowpea had significantly higher heights than *M. incognita* infected-untreated plants in the field (Table 3).

3.1.4 Effects of treatments on mean stem diameter of *Meloidogyne incognita*-infected cowpea

All plants had averagely the same mean stem diameter at inoculation (Table 4). At 4 WAI, all treated plants with air-dried milled leaves of the three *Aloe* species, carbofuran and uninoculated control plants significantly had higher stem diameter than inoculated-untreated plants. The trend was the same at 6 WAI till termination of experiment at 8 WAI. At 8 WAI, carbofuran-treated plants at 2 kg a.i/ha had the highest mean stem diameter which was not significantly higher than those of *A. keayi* at 80 kg/ha and uninoculated control. The least stem diameter of 0.9 cm was recorded in inoculated-untreated plants (Table 4).

In the field trial at 4 WAI, *A. keayi* at 80 kg/ha had the highest mean stem diameter, but not significantly higher than other treated cowpea except *A. vera* at 20 kg/ha and 40 kg/ha, and *A. succrotina* at 20 kg/ha (Table 4). The least stem diameter was recorded in the infected-untreated cowpea. All treated and uninfected plants significantly ($P \leq 0.05$) had higher stem diameter than infected-untreated cowpea at 6 WAI. At 8 WAI, carbofuran-treated plants at 2 kg a.i/ha had the highest stem diameter which was not significantly higher than the mean stem diameter of the other treated plants. However, all the treated plants with either milled leaves of *Aloe* species and carbofuran had higher mean stem diameter than inoculated-untreated plants (Table 4).

3.1.5 Effects of treatments on the yield parameters of *M. incognita*-infected cowpea

Cowpea treated with carbofuran at 2 kg a.i/ha produced the highest number of pods, but this was not significantly more (P≤0.05) than number of pods produced by uninoculated control, *A. keayi* at 80 kg/ha, *A. vera* at 80 kg/ha, carbofuran at 1 kg a.i/ha and *A. keayi* 60 kg/ha (Table 5). The fewest number of pods was produced from the inoculated-untreated control plants (Table 5). In the field trial, *A. keayi* at 80 kg/ha had the highest number of pods that was significantly more than pods produced from carbofuran-treated plants at 2 kg a.i./ha (20.5) and other treated cowpea plants. All treated cowpea produced more pods than inoculated-untreated plants both in pot and field studies.

Carbofuran at 2 kg a.i/ha, *A. keayi* at 80 kg/ha and *A. vera* at 80 kg/ha had the highest 100-seed weight and this was not significantly higher than seed weights of *A. keayi* at 60 kg/ha, carbofuran at 1 kg a.i/ha, *A. keayi* at 40 kg/ha, *A vera* at 60 kg/ha and *A succotrina* at 80 kg/ha. The lowest seed weight was from inoculated-untreated cowpea plants and this was significantly lower than the 100-seed weights from all other treated cowpea plants (Table 5).

In the pot studies, the uninoculated cowpea plants produced the highest yield (752.3 kg/ha) that was significantly higher (P≤0.05) than those of treated plants with *A. keayi* at 80 kg/ha (679.3 kg/ha), carbofuran at 2 kg. a.i/ha (667.5 kg/ha) and carbofuran at 1 kg a.i/ha (644.3 kg/ha). The lowest yield of 159 kg/ha was produced from the inoculated-untreated plants and this was significantly lower than the yields produced from all the other treated plants (Table 5). The effects of the treatments on cowpea yield in the field are also presented in Table 5. *Aloe keayi*-treated plants at 80 kg/ha produced the highest yield (469.1 kg/ha) which was significantly higher than those of uninfected plants (451.2 kg/ha), carbofuran at 2 kg a.i/ha (445.1 kg/ha), *A. vera* at 80 kg/ha (415 kg/ha) and the lowest yield from infected-untreated plants (180 kg/ha). All treated plants produced better yield than infected-untreated cowpea plants (Table 5). The yield values recorded in the pot studies were higher than those in the field.

3.1.6 Effects of three powdered *Aloe* species leaves and carbofuran on the shoot and root weights (g), and root length (cm) of *M. incognita*-infected cowpea

Table 6 showed the effects of carbofuran and three powdered *Aloe* species leaves on the fresh shoot and root weights (g) and root length (cm) of cowpea infected with *M. incognita*. Carbofuran at 2 kg a.i/ha had the highest mean fresh shoot weight which was not significantly higher than those of uninoculated control plants, *A. keayi* at 80 kg/ha, *A. vera* at 80 kg/ha and carbofuran at 1 kg. a.i./ha in the pot studies (Table 6). The lowest fresh shoot weight was recorded in inoculated-untreated plants and this was significantly lower (P≤0.05) than from the other treated plants. Carbofuran-treated plants at 2 kg a.i/ha had the highest dry shoot weight that was not significantly higher than (P≤0.05) those of *A. keayi*-treated plants at 80 kg/ha, carbofuran at 1 kg a.i/ha and *A. vera*-treated plants at 80 kg/ha. The lowest dry shoot weight was observed in inoculated control plants.

In the field trial at harvest, carbofuran-treated plants at 2 kg a.i/ha had the highest fresh shoot weight which was not significantly higher than the fresh shoot weight of uninfected cowpea plants (Table 6). The least mean fresh shoot weight of 22.6 g was recorded in infected-untreated plants. All treated plants had significantly higher fresh shoot weights than infected-untreated plants. *Aloe keayi*-treated plants had the highest dry shoot weight which was significantly higher than those of uninfected plants, carbofuran at 2 kg ai./ha, *A. vera* at 80 kg/ha and the least dry shoot weight of 5.7 g was recorded in the inoculated-untreated plants (Table 6).

Inoculated-untreated plants had the highest fresh root weight (63.4 g) and this was significantly higher than those of *A. keayi*-treated plants at 80 kg/ha (47.4 g), carbofuran at 1 kg a.i./ha (43.0 g), carbofuran at 2 kg a.i./ha (42.9 g), and the least fresh shoot weight of 26.0 g was recorded in *A. succrotina* at 20 kg/ha (Table 6). At harvest in the field trial, inoculated-untreated plants had the highest fresh root weight which was significantly higher than those of carbofuran-treated at 2 kg a.i./ha, carbofuran at 1 kg a.i./ha, *A. keayi* at 80 kg/ha and *A. vera* at 80 kg/ha (Table 6).

Uninoculated control plants had the longest mean root which was not significantly longer than those of carbofuran at 2 kg a.i./ha, carbofuran at 1 kg a.i./ha, *A. keayi* at 80 kg/ha. The shortest roots were recorded from the inoculated-untreated control plants (16.9 cm) (Table 6).

3.1.7 Effects of treatments on gall index (root damage), nematode population and reproductive factor of *Meloidogyne incognita* on cowpea

Carbofuran-treated cowpea at 2 kg a.i./ha were the least galled at harvest, but not significantly different from those of carbofuran at 1 kg a.i./ha, *A. keayi* at 80 kg/ha and *A. keayi* at 60 kg/ha (Table 7). The highest level of galling was recorded in inoculated-untreated plants which was significantly higher (P≤0.05) than the level of galling recorded in other plants. The trend observed in the field trial was similar to that in pot experiment (Table 7).

The lowest population of nematode eggs of *M. incognita* was recorded in carbofuran-treated plants at 2 kg a.i./ha which was significantly lower than those of carbofuran-treated plants at 1 kg a.i./ha and *A. keayi* at 80

kg/ha. The highest nematode egg population was recorded in inoculated-untreated cowpea plants (Table 7). Similar observations hold for second-stage juveniles and mean final nematode population of *M. incognita*.
Inoculated-untreated plants had the highest reproduction factor of 68.2 which was significantly higher than other treated plants with either dried-milled leaves of *Aloe* or carbofuran (Table 8). The least reproduction factor was recorded in carbofuran at 2 kg a.i./ha which was not significantly lower than those of carbofuran at 1 kg.a.i./ha, and *A. keayi* at 80 kg/ha (Table 8). All the treated plants with either carbofuran or dried-milled leaves of *Aloe* species at all application rates had significantly lower final nematode population than inoculated-untreated plants. Similar trends reported for egg, second-stage juveniles' population, and final nematode populations of *M. incognita* on cowpea in pot experiment were observed in the field trial (Table 8).

IV. Discussion

All cowpea plants infected with *M. incognita* and treated using either air-dried milled leaves of *Aloe keayi*, *A. succrotina*, and *A. vera* or carbofuran improved growth when compared with inoculated-untreated plants. The improvement in the vegetative growth of *Aloe* species treated plants might be due to controlling effects of the treatments on *M. incognita* owing to the active principles within them that might be nematicidal in action. The nematicidal activity observed in the *Aloe* species in the management of *M. incognita* on cowpea might be due to the presence of phytochemicals such as tannins, saponins, alkaloids, amongst others. These phytochemicals confer nematicidal properties in plants [6]. Several toxic compounds such as terpenoids and phenolics are released from plant tissues during decomposition and are reported to reduce plant-parasitic nematode infection for they are known to have nematicidal properties [34] [33] [14]. Also, the decomposition process of the dried *Aloe* species leaves might have been accompanied with heat release that might have killed the nematodes. The *Aloe* species might also have aided growth of the infected cowpea since the dried-milled leaves applied are organic materials capable of decomposition to release nutrients and improve soil structure. These readily made available nutrients might have helped the plants to tolerate better the nematode attack [30]. The application of these dried-milled leaves of *Aloe* species in no doubt might have improved the soil physical conditions, soil biological activity and thereby improved crop performance [5] [30].

The effectiveness of carbofuran as a nematicide against many plant-parasitic nematodes including root-knot nematodes had been reported by many workers to improve growth in treated plants [2] [30]. The better growth and yield observed in terms of values in the pot experiment than in the field might be due to the fact that plants grown in the field were exposed to vagaries of nature, competition from other factors beside nematodes which were not there under the controlled environment of pot experiment. However, the trend in the activity of the powdered *Aloe* leaves and carbofuran were the same in the management of *M. incognita* on cowpea justifying the activity of the treatments.

The application of botanicals in the management of *M. incognita* had been reported by some workers to improve plant growth when compared to inoculated-untreated plants [23] [11]. All treatments with chopped tubers of *Dioscorea floribunda* incorporated at 25, 35, 50 and 100 g into soil planted with tomato significantly increased the vegetative growth than inoculated-untreated control plants where *M. incognita* multiplied freely on tomato plants [23]. Cowpea plants infected with *M. incognita* treated with Siam weed leaves, Siam roots, neem leaves and carbofuran showed higher increase in plant height and number of leaves as compared with control plants [11]. The ability of dried leaves of plants to increase vegetative growth was also reported by [30] where they observed that Chinaberry (*Lantana azedarach*), Oleander (*Nerium oleander* L.), Lantana (*Lantana camara*), Castor (*Ricinus communis*) and Jimson (*Datura stramonium*) applied at 5 and 10 g/kg soil of tomato plants infected with *M. incognita* significantly increased top growth compared to the untreated-inoculated plants.

The efficacy of these treatments either carbofuran or powdered *Aloe* species leaves is however application rate dependent in which the higher application rates of carbofuran performed better than the lower application rates. The relative differences in the efficacy observed from one treatment to another might be due to species' different phytochemical compositions which made higher quantities of phytochemicals to be available with higher application rates and thus higher application rates performed better than lower rates in terms of growth, yield and nematode management. The fact that variation in the efficacy of the *Aloe* species used might be linked qualitatively and quantitatively to the active ingredients present in them was in agreement with findings of [30]. Application of treatments, especially *A. keayi* ensured improvement in cowpea grain yield thereby making the production profitable.

There was better performance of dried-milled leaves of the three *Aloe* species and carbofuran over inoculated-untreated plants in terms of fresh and dry shoot weights, fresh root weight and the root length in both trials. These results were corroborated by the findings of [30] and [17] that the fresh and dry weights of the shoots and roots of *M. incognita* infected plants treated with dried leaves of some botanicals were significantly higher than those of inoculated-untreated plants. The higher dry weights in treated plants than inoculated-untreated plants might be attributed to better physiological functions of various parts of the plants such that assimilates produced during photosynthesis are well utilized and stored by these treated plants than in inoculated-untreated plants.

The higher weight recorded in the fresh root weight of inoculated-untreated plants might be linked to the presence of heavy galls on the roots since the nematodes freely multiplied without check after the inoculation. The reduction in root length observed among the treatments might be due to nematode feeding activities around the roots and root tips of the infected plants [24]. It was however more pronounced in the inoculated-untreated plants when compared with the other treated plants since *M. incognita* were left unchecked in their feeding activities in the roots thereby leading to highly damaged short roots. This in no doubt will affect the ability of the roots to absorb water and other nutrients from the soil necessary for good growth and yield. Assimilates produced via photosynthesis that should have been channeled for growth or pod production might be directed to the infection sites thereby leading to poor growth and yield.

However, root galling, an index of root damage by the nematode, was significantly reduced by all the treatments, but the highest gall reduction was obtained in carbofuran-treated plants and then at *A. keayi* at 80 kg/ha when compared with inoculated-untreated cowpea roots. This observation equally holds for nematode population. The reduction in root damage and nematode population in carbofuran and *Aloe* treated plants showed the prophylactic efficacy of these treatments owing to their active principles. The effectiveness of the powdered *Aloe* leaves might also be due to increase in populations of some other antagonistic microbes to *Meloidogyne incognita* facilitated by these organic amendments and some of these microbes do parasitize the eggs and larvae of *Meloidogyne* species [32]. The fact that carbofuran showed superior nematicidal efficacy than *Aloe* treatments might be due to the presence of more effective nematicidal principles qualitatively and quantitatively than in *Aloe* species. All the yield indices showed that carbofuran-treated plants at 2 kg a.i/ha gave more yield than all the other treatments, but all the treated plants significantly produced more yield than the inoculated-untreated plants. This showed that the treated plants with either the powdered *Aloe* species leaves or carbofuran might have suppressed the adverse effects of the nematode by reducing their population below levels that can cause economic damage; thereby leading to good growth and yield than inoculated-untreated plants.

The results in these studies attested to the efficacy of carbofuran as the most effective in reducing nematode population and root damage amongst all treatments. Many workers reported the effectiveness of carbofuran as a nematicide in the management of plant-parasitic nematodes [2] [30].

V. Conclusion

Meloidogyne incognita-infected cowpea treated with dried leaves of *Aloe* species, especially *Aloe keayi*, significantly improved the plant growth, grain yield of cowpea, reduced root damage and nematode population comparable to carbofuran treatments. The higher application rates of *Aloe* species and carbofuran were more effective in the management of *M. incognita* on cowpea than lower rates, but effective rates are between 40-80 kg/ha.

Application of powdered *Aloe keayi* leaves at 80 kg/ha at 3 WAS to cowpea either infected with *M. incognita* or on *M. incognita* infested soils might help to mitigate the adverse effects of this nematode on growth and yield of cowpea. It is equally another safer management measure that should be adopted in accordance with the concept of organic farming than the use of synthetic nematicides such as carbofuran that had been reported to be hazardous in the environment and equally expensive in the management of plant-parasitic nematodes. The other promising *Aloe* species, *A. vera* and *A. succrotina* can equally be given consideration in lieu of carbofuran in the absence of *Aloe keayi.*

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Table 1: Effects of carbofuran and dried-milled leaves of three *Aloe* species on mean leaf area (cm^2) of cowpea infected with *M. incognita.*

Treatment	Rate	AT I	Weeks after inoculation (Pot trial)				AT I	Weeks after inoculation (Field trial)			
	Kg/ha		2	4	6	8		2	4	6	8
A. succotrina	20	14.6	43.0	55.4	59.6	60.1	16.5	40.7	58.4	61.6	64.7
A. succotrina	40	13.9	49.4	61.4	65.6	66.1	13.2	50.6	62.3	66.2	69.9
A. succotrina	60	13.6	51.7	67.1	70.3	70.8	10.9	44.7	67.3	69.8	72.1
A. succotrina	80	14.6	52.9	66.1	71.3	71.8	14.2	52.3	65.4	67.3	74.3
A. vera	20	14.9	51.5	64.4	68.6	69.1	14.7	42.3	61.7	64.0	66.7
A. vera	40	12.8	49.4	66.9	69.2	69.7	14.6	47.0	64.1	65.9	67.4
A. vera	60	15.3	49.7	65.0	71.1	71.7	15.9	51.4	66.5	66.2	70.1
A. vera	80	14.8	56.4	68.4	72.6	73.1	15.5	53.8	66.2	69.9	76.9
A. keayi	20	13.6	40.6	62.6	66.8	67.3	15.9	48.7	59.8	62.1	66.7
A. keayi	40	15.1	54.9	67.8	65.9	68.6	15.8	43.7	63.9	66.6	67.5
A. keayi	60	15.6	57.0	60.3	68.1	72.5	14.7	43.7	63.2	67.2	70.4
A. keayi	80	14.2	53.5	63.9	72.0	75.4	14.0	56.3	74.8	75.8	80.9
Carbofuran	1 kg a.i/ha	14.5	46.8	68.9	73.7	74.2	15.4	46.2	58.7	63.0	64.7
Carbofuran	2 kg a.i/ha	13.9	30.0	73.5	77.7	78.2	11.8	48.9	62.7	65.2	65.8
Uninocontrol		12.6	40.8	69.7	73.9	74.4	12.2	57.2	68.9	68.8	70.5
Inocontrol		13.1	41.4	50.2	54.4	54.9	15.9	41.4	56.4	62.1	62.8
LSD($p \leq 0.05$)		3.1	18.9	10.9	10.7	10.8	2.0	13.7	11.5	11.3	11.4

Each value is a mean of eight replicates. AT I= At inoculation. Uninocontrol= Uninoculated/Uninfected control, Inocontrol= Inoculated/infected-untreated control

Table 2: Effects of dried-milled leaves of three *Aloe* species and carbofuran on mean number of leaves of cowpea infected with *M. incognita* (first and second trials)

Treatment	Rate	AT I	Weeks after inoculation (Pot trial)				AT I	Weeks after inoculation (Field trial)			
	Kg/ha		2	4	6	8		2	4	6	8
A. succotrina	20	5	14	30	39	40	5.4	12.3	44.4	73.3	91.6
A. succotrina	40	5	14	34	39	41	4.5	12.1	45.5	86.9	96.6
A. succotrina	60	5	14	30	39	41	4.5	11.0	48.5	88.9	101.3
A. succotrina	80	5	14	29	43	46	4.3	9.5	39.5	92.1	108.4
A. vera	20	5	16	37	43	45	5.1	9.5	38.0	87.9	96.0
A. vera	40	5	13	29	41	44	5.0	11.1	44.8	86.5	104.3
A. vera	60	5	15	35	43	46	5.1	9.9	41.8	86.0	102.9
A. vera	80	5	15	34	46	47	4.5	9.9	23.8	105.9	119.1
A. keayi	20	5	14	31	41	43	5.1	10.9	21.1	59.4	92.4
A. keayi	40	5	18	36	44	47	4.8	13.1	39.8	93.9	105.9
A. keayi	60	5	17	34	43	46	5.0	10.6	43.8	91.0	107.1
A. keayi	80	5	18	38	44	49	5.4	11.1	45.1	134.1	154.9
Carbofuran	1 kg a.i/ha	5	18	40	51	53	5.0	9.3	39.9	100.6	122.4
Carbofuran	2 kg a.i/ha	5	10	25	53	55	4.5	10.6	39.8	108.5	127.6
Uninocontrol		5	15	31	46	49	5.0	9.4	33.5	80.5	95.6
Inocontrol		5	14	26	31	33	5.0	10.5	34.5	65.3	73.5
LSD($p \leq 0.05$)		0.9	6.3	12.2	7.3	7.1	0.5	1.5	8.5	13.5	11.4

Each value is a mean of eight replicates. AT I= At inoculation. Uninocontrol= Uninoculated/Uninfected control, Inocontrol = Inoculated/infected-untreated control

Table 3: Effects of carbofuran and dried-milled leaves of three *Aloe* species on mean plant height (cm) of cowpea infected with *M. incognita* (first and second trials)

Treatment	Rate	AT I	Weeks after inoculation (Pot trial)				AT I	Weeks after inoculation (Field trial)			
	Kg/ha		2	4	6	8		2	4	6	8
A. succotrina	20	6.1	11.6	16.1	19.5	20.3	6.4	8.4	12.6	19.8	20.8
A. succotrina	40	6.2	10.9	16.9	21.9	22.6	6.3	9.9	14.1	20.4	22.3
A. succotrina	60	6.2	11.0	19.1	22.9	23.6	6.2	9.2	15.7	19.6	22.2
A. succotrina	80	5.9	10.9	16.6	23.8	24.5	6.3	10.5	15.9	22.3	24.7
A. vera	20	6.3	11.8	18.1	22.2	23.0	6.3	9.4	12.7	18.7	19.7
A. vera	40	6.0	11.1	19.1	24.4	25.2	6.2	9.6	14.3	19.1	20.8
A. vera	60	6.1	11.2	16.8	22.7	23.5	6.5	9.0	14.0	20.1	21.3
A. vera	80	6.2	12.3	19.1	25.1	25.9	5.8	9.1	14.6	20.6	23.6
A. keayi	20	6.3	11.0	16.4	21.0	21.7	6.2	8.6	13.3	18.5	19.6
A. keayi	40	6.3	12.5	18.4	22.3	23.0	6.4	9.6	13.4	19.7	20.9
A. keayi	60	6.0	12.3	17.7	22.5	23.3	6.5	9.1	14.6	19.8	21.2
A. keayi	80	6.5	13.3	19.5	25.9	26.6	6.2	11.4	15.3	24.0	26.2
Carbofuran	1 kg a.i/ha	6.5	11.8	20.1	26.5	27.3	6.0	8.6	13.0	19.5	21.8
Carbofuran	2 kg a.i/ha	6.1	10.1	19.0	28.5	29.3	6.3	9.3	12.8	23.3	24.7
Uninocontrol		6.2	12.5	20.3	26.4	27.2	6.2	11.2	16.6	22.9	24.9
Inocontrol		6.3	12.4	15.7	19.0	19.8	6.3	11.6	14.5	15.8	16.3
LSD($p \leq 0.05$)		0.5	2.7	3.0	2.8	2.8	0.3	1.5	2.3	2.2	2.1

Each value is a mean of eight replicates. AT I= At inoculation. Uninocontrol= Uninoculated/Uninfected control, Inocontrol = Inoculated/infected-untreated control

Table 4: Effects of carbofuran and dried-milled leaves of three *Aloe* species on mean stem diameter (cm) of cowpea infected with *M. incognita* (First and second trials)

Treatment	Rate	AT I	Weeks after inoculation (Pot trial)				AT I	Weeks after inoculation (Field trial)			
	Kg/ha		2	4	6	8		2	4	6	8
A. succotrina	20	0.1	0.4	0.7	1.0	1.1	0.1	0.10	0.42	0.49	0.56
A. succotrina	40	0.1	0.4	0.8	1.1	1.2	0.1	0.12	0.45	0.53	0.61
A. succotrina	60	0.1	0.4	0.7	0.9	1.1	0.1	0.10	0.46	0.60	0.66
A. succotrina	80	0.0	0.4	0.8	1.0	1.3	0.1	0.11	0.51	0.58	0.67
A. vera	20	0.1	0.4	0.8	1.1	1.3	0.1	0.10	0.38	0.46	0.55
A. vera	40	0.1	0.4	0.8	1.0	1.2	0.1	0.10	0.44	0.50	0.60
A. vera	60	0.1	0.5	0.8	1.0	1.2	0.1	0.10	0.43	0.54	0.60
A. vera	80	0.1	0.5	0.8	1.1	1.3	0.1	0.10	0.48	0.58	0.62
A. keayi	20	0.1	0.4	0.8	1.1	1.2	0.1	0.10	0.50	0.57	0.65
A. keayi	40	0.1	0.5	0.8	1.0	1.2	0.1	0.10	0.45	0.55	0.62
A. keayi	60	0.1	0.5	0.9	1.0	1.2	0.1	0.10	0.46	0.50	0.57
A. keayi	80	0.2	0.6	0.9	1.2	1.4	0.1	0.13	0.54	0.61	0.66
Carbofuran	1 kg a.i/ha	0.1	0.5	0.8	1.1	1.3	0.1	0.10	0.44	0.53	0.63
Carbofuran	2 kg a.i/ha	0.1	0.4	0.8	1.2	1.4	0.1	0.10	0.46	0.55	0.68
Uninocontrol		0.1	0.5	0.8	1.2	1.3	0.1	0.11	0.49	0.60	0.65
Inocontrol		0.1	0.3	0.5	0.7	0.9	0.1	0.10	0.26	0.36	0.41
LSD($p \leq 0.05$)		0.1	0.2	0.2	0.1	0.1	0.0	0.04	0.10	0.11	0.14

Each value is a mean of eight replicates. AT I= At inoculation. Uninocontrol= Uninoculated/Uninfected control, Inocontrol = Inoculated/infected-untreated control

Table 5: The effects of three air-dried milled *Aloe* species and carbofuran on the number of pods, 100-seed weight (g) and yield of cowpea (kg/ha) infected with *M. incognita*

Treatments	Rate	Number of pods		100 seed-weight (g)	Yield (Kg/ha)	
	Kg/ha	Pot Trial	Field Trial	Pot Trial	Pot Trial	Field Trial
A. succotrina	20	16.8	10.0	12.6	382.8	332.8
A. succotrina	40	19.3	11.5	12.6	405.8	347.3
A. succotrina	60	19.5	14.0	13.1	529.6	352.6
A. succotrina	80	23.8	13.0	13.6	573.0	361.6
A. vera	20	21.3	11.0	12.3	393.8	333.9
A. vera	40	22.5	15.0	12.8	407.1	346.4
A. vera	60	24.3	14.0	13.6	563.4	360.4
A. vera	80	26.5	17.5	13.8	595.0	415.0
A. keayi	20	21.3	10.0	12.8	447.9	347.9
A. keayi	40	24.0	13.8	13.6	457.5	357.4
A. keayi	60	25.0	16.5	13.7	581.7	381.7
A. keayi	80	27.3	26.0	13.8	679.3	469.1
Carbofuran	1 kg a.i	26.3	18.1	13.6	644.3	440.8
Carbofuran	2 kg a.i	29.0	20.5	13.8	667.5	445.1
Uninocontrol		28.3	17.0	12.7	752.3	451.2
Inocontrol		7.8	6.0	10.7	159.2	180.0
LSD (p≤0.05)		4.5	1.6	0.3	9.3	5.3

Each value is a mean of eight replicates. AT I= At inoculation. Uninocontrol= Uninoculated/Uninfected control, Inocontrol = Inoculated/infected-untreated control

Table 6: Effect of three powdered *Aloe* species leaves and carbofuran on the shoot and root weights (g), and root length (cm) of *M. incognita* - infected cowpea

Treatments	Rate	Fresh shoot weight (g)		Dry shoot weight (g)		Fresh root weight (g)		Root length (cm)
	Kg/ha	Pot Trial	Field Trial	Pot Trial	Field Trial	Pot Trial	Field Trial	Pot Trial
A. succotrina	20	73.9	36.6	10.8	5.8	26.0	11.8	30.6
A. succotrina	40	86.4	52.2	11.1	6.8	28.4	11.8	36.8
A. succotrina	60	102.3	54.0	12.6	7.9	33.3	14.4	3.3
A. succotrina	80	104.4	63.8	15.4	7.8	28.1	23.4	33.6
A. vera	20	109.7	61.0	16.6	8.9	30.1	21.9	35.6
A. vera	40	116.6	62.9	18.5	9.3	32.3	12.2	36.1
A. vera	60	119.9	82.0	18.9	9.7	30.2	18.9	40.2
A. vera	80	127.8	87.6	21.2	19.3	36.2	23.5	42.9
A. keayi	20	90.8	41.3	18.3	9.4	33.7	12.7	44.5
A. keayi	40	106.3	71.2	16.7	11.5	35.9	17.7	38.6
A. keayi	60	118.0	88.9	19.9	17.2	39.4	23.8	43.6
A. keayi	80	131.2	100.2	25.5	27.4	47.4	26.9	48.3
Carbofuran	1 kg a.i	125.1	99.1	24.9	19.0	43.0	26.9	48.6
Carbofuran	2 kg a.i	142.7	118.6	26.6	20.0	42.9	27.7	52.4
Uninocontrol		131.3	112.5	19.9	22.9	39.2	22.3	57.0
Inocontrol		51.2	22.6	7.4	5.7	63.4	62.3	16.9
LSD(p≤0.05)		19.9	9.5	6.1	3.1	11.8	5.1	9.3

Each value is a mean of eight replicates. AT I= At inoculation. Uninocontrol= Uninoculated/Uninfected control, Inocontrol = Inoculated/infected-untreated control.

Table 7: Effects of carbofuran and selected *Aloe* species on gall index and nematode population of cowpea infected with *Meloidogyne incognita*

Treatments	Gall index		Egg population/root system		Juvenile population/ 10 L (pot) and 200ml (field) soil		Final nematode population (Pf)	
	Pot Trial	Field Trial	Pot Trial	Field Trial	Pot Trial	Field Trial	Pot Trial	Field Trial
A. succotrina 20kg/ha	3.3	3.0	175000	34000	8625	1500.0	183625	35143
A. succotrina 40kg/ha	3.0	3.0	153000	20750	6875	700.0	159875	21653
A. succotrina 60kg/ha	2.5	3.0	131750	19250	5475	800.0	137225	20150
A. succotrina 80kg/ha	2.3	2.5	80750	18250	4500	600.0	85250	18575
A. vera 20kg/ha	2.8	3.0	116500	24538	6000	800.0	122500	24963
A. vera 40kg/ha	2.8	3.0	104125	18750	4500	700.0	108625	19738
A. vera 60kg/ha	1.8	2.5	84900	15750	4125	400.0	89025	16113
A. vera 80kg/ha	2.0	2.5	68750	13525	2875	600.0	71625	13475
A. keayi 20kg/ha	2.8	2.5	100125	21000	3425	1000.0	103550	21860
A. keayi 40kg/ha	2.0	2.5	69500	16500	2500	800.0	72000	17345
A. keayi 60kg/ha	1.5	2.0	41750	14163	2250	400.0	44000	14338
A. keayi 80kg/ha	1.3	1.5	25000	13000	1750	500.0	26750	13225
Carbofuran 1kg a.i	1.5	1.5	17300	12825	1775	400.0	19075	12625
Carbofuran 2 kg a.i	1.0	1.0	8775	10500	1250	400.0	10025	10200
Uninocontrol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150.0
Inocontrol	4.5	4.5	656500	657500	25000	5000.0	681500	667738
LSD (p≤0.05)	1.1	0.3	20458	6000.6	1564.6	174.29	19886	8836.3

Each value is a mean of eight replicates. Rating scale: 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. Uninocontrol= Uninoculated/Uninfected control, Inocontrol = Inoculated/infected-untreated control.

Table 8: Effects of dried-milled leaves of *Aloe* species and carbofuran on reproductive factor of *M. incognita* on cowpea

Treatments	Rate (kg/ha)	Reproductive Factor (Pf/Pi) Pot Trial
A. succotrina	20	18.4
A. succotrina	40	15.7
A. succotrina	60	13.7
A. succotrina	80	8.5
A. vera	20	12.3
A. vera	40	10.9
A. vera	60	8.9
A. vera	80	7.2
A. keayi	20	10.4
A. keayi	40	7.2
A. keayi	60	4.4
A. keayi	80	2.8
Carbofuran	1 kg a.i	1.9
Carbofuran	2 kg a.i	1.0
Uninocontrol		0.0
Inocontrol		68.2
(P≤0.05)		1.9

Each value is a mean of eight replicates. Uninocontrol = Uninoculated plants. Inocontrol= Inoculated-untreated plants. Pf= Final nematode population. Pi= Initial nematode population (10,000 eggs).

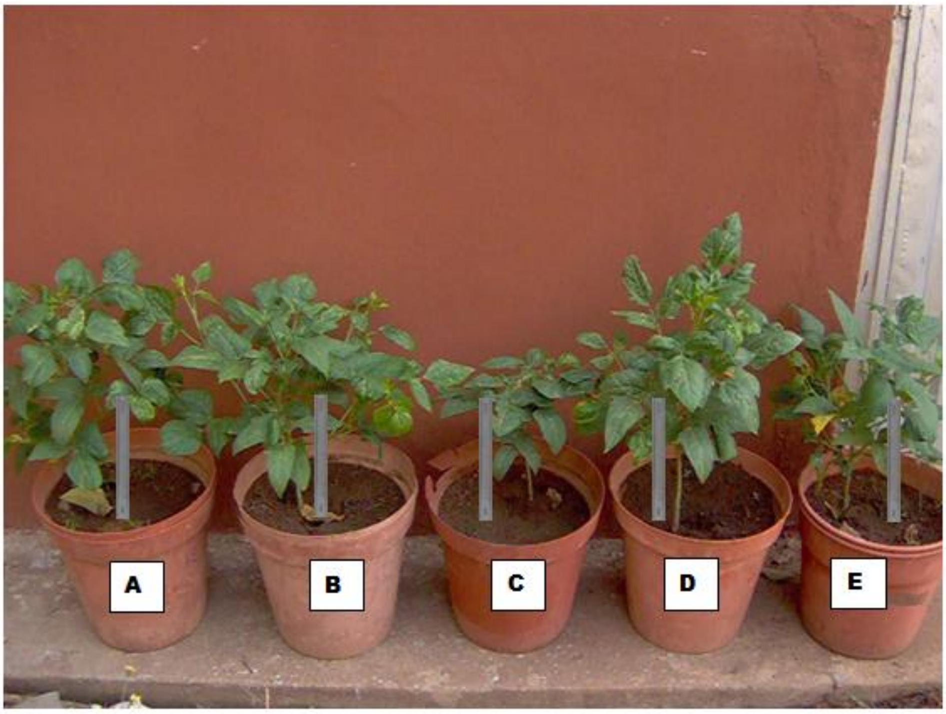

Plate 1: Effects of carbofuran and some *Aloe* species on growth of *M. incognita*-infected cowpea at six weeks after inoculation.

A= Uninoculated plant, B= carbofuran-treated at 2 kg a.i/ha, C= inoculated-untreated plant, D= *A. keayi*-treated plant at 80 kg/ha, E= *A. vera*-treated plant at 80 kg/ha

A. Tanimola "Management of Meloidogyne incognita on cowpea (Vigna unguiculata L. Walp) with three powdered Aloe species leaves. "IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) 11.1 (2018): 01-13.