



Field Evaluation of the Efficacy of some Plant Oils for the Management of *Aphis craccivora* (Koch)

*¹Ukatu, P.O., ¹Udo, I. A., ¹Nwagwu, F. A., ²Ogban, E. I. and ¹Umoetok, S.B.A.

¹Department of Crop Science, University of Calabar, P.M.B, 1115, Calabar.

²Department of Animal and Environmental Biology, University of Cross River State, Calabar.

Abstract

The Research was conducted to evaluate the efficacy of *Jatropha curcas* (L.) and *Azadirachta indica* (A. Juss) for the management of *Aphis craccivora* (Koch) infesting cowpea. The experiment was laid out in a Randomized Complete Block Design. The result indicated that, of the plant oils, 2 and 3 % concentrations of *J. curcas* and *A. indica* oil gave the highest reduction in *A. craccivora* population and the number of leaf curls per plant. Also, significantly ($P \leq 0.05$) longer vines, a higher number of pods and a higher of 100 seeds weight were obtained from cowpea plants with the application of *J. curcas* and *A. indica* respectively, compared with their respective control. The result also indicated that the application of 1, 2 and 3 % concentrations of *A. indica* oil led to an average of 8.42, 39.63, and 64.31 per cent increase in the total grain yield, respectively when compared with the control, while 1, 2 and 3 % concentrations of *J. curcas* oil resulted in 25.39, 47.27 and 69.66 % increases in the cowpea total grain yield, respectively when compared with the control. The application of Lambda-cyhalothrin led to a 69.74 per cent increase in grain yield. *Jatropha curcas* oil resulted in a higher grain yield than *A. indica* oil and compared favourably with that of Lambda-cyhalothrin. The results suggest that both oil extracts can be used by cowpea farmers for effective management of *A. craccivora* infesting cowpea.

Key words: *Jatropha curcas*, *Azadirachta indica*, *Aphis craccivora*, Cowpea, Leaf curl.

*Correspondence email:

Ukpat6237@gmail.com

ORCID: 0000-0000-1912-9248

INTRODUCTION

Cowpea, (*Vigna unguiculata* L. Walp) commonly called bean is a flowering plant that belongs to the family of Fabaceae, and it is the most economically important indigenous legume crop in Africa (Pitan and Olatunde, 2006; Awodun, 2007; CGIAR, 2011). The grain is used throughout Nigeria and other parts of Africa to provide an

inexpensive source of protein of high quality for humans and animals (Oparaeke *et al.*, 2005; Wakili, 2013). It contains “25 per cent protein and several vitamins and minerals” (IITA, 2009). Cowpea provides cash income to resource-poor farmers (Dugje, *et al.*, 2009). West Africa grows about 75 per cent of the world's cowpea with Nigeria being the world's highest producer and consumer, accounting for 61 per cent of production in Africa and 58 per cent of world production (IITA, 2009). Cowpea is the most important member of the Fabaceae family in Africa because of its nutritive value (IITA,

2009; Haruna and Usman, 2013). The seed of cowpea is the highest contributor to the overall “protein requirement” of rural and urban poor diets (Agbogidi, 2010). It is a deep-rooted and warm-season crop. It is more drought tolerant than soybean, does well in sandy soils and is better adapted to a temperature of 25oC-30oC (Awodun, 2007; Nwofia *et al.*, 2015).

The production capacity of the crop in Nigeria was 2.95 million tonnes, cultivated in 3.8 million hectares of land in 2013, making Nigeria the largest producer of the crop in the World (FAO, 2014). Cowpea is a cover crop with the ability to fix nitrogen to improve marginal lands in a tropical cropping system (Dujge *et al.*, 2008; IITA, 2009). Cowpeas can fix about 240kg/ha of “atmospheric nitrogen for succeeding crops” grown in rotation with it (Nwofia *et al.*, 2015), to make use of 60-70kg/ha of available nitrogen (Nwofia *et al.*, 2015).

However, the cultivation of cowpea is faced with a lot of challenges among which are pest infestation and disease infection. Cowpea is attacked by over 100 species of insects. Out of these insects, only about ten are said to be of real economic importance (Habou *et al.*, 2011). Some of the insect pests include; *Aphis craccivora* Koch, *Maruca vitrata* Fabricius, *Megalurothrips sjostedti* Trybom, *Clavigralla tomentosicollis* Stål, *Nezara viridula* Linnaeus, *Cydia ptychora* Meyrick, *Riptortus dentipes* Fabricius, *Mirperus jaculus* Thunberg, *Anoplocnemis curvipes* Fabricius and *Callosobruchus maculatus* Fabricius (Centre for Overseas Pest Research, 1981).

The problems associated with the use of synthetic pesticides have necessitated the search for user and environment-friendly/ecologically tolerable methods of control which are safe, affordable (relatively

cheap), locally available and provide adequate supply to meet the insecticide shortage (Zhao *et al.*, 2006; Gokce *et al.*, 2010; Uddin II *et al.*, 2016). Jackai and Abdalla (1997) opined that insect pest problems on cowpeas persist at least in part because of a lack of diversity in control measures. The use of botanicals notably, *Jatropha curcas* L. and *Azadirachta indica* A. Juss remains one of the most viable options for the control of crop pests (Dubey *et al.*, 2008; Chaieb, 2010; Devappa *et al.*, 2012; Amit and Das, 2018; Ukatu *et al.*, 2021). The use of *J. curcas* and *A. indica* have been employed to effectively manage pests of several crops (Aumeeruddy-Elalfi & Mahomoodally, 2016; Gahukar, 2016, Roy *et al.*, 2016; Okbatinasae and Haile, 2017; Bayih *et al.*, 2018; Traore *et al.*, 2019; Ugwu and Mokwunye, 2019). *Jatropha curcas* was used to effectively treat honey bees against parasitic mites and as such resulted in a higher amount of brood area and a higher number of combs with bees (Masry *et al.*, 2020). Similarly, *J. curcas* was used by Roy *et al.* (2016) to repel spider mites (*Camellia Sinensis*) and it also caused oviposition deterrence. Ojumoola *et al.* (2018) reported the efficacy of the leaf extracts of *A. indica* against the emergence of *Callosobruchus maculatus* (F.) on legume seeds. Srinivasan *et al.* (2020) also indicated the effectiveness of neem extract in the control of *Aphis craccivora*, *Maruca vitrata* and *Megalurothrips usltatus* Bagnall to be equivalent to conventional insecticides. The potency of *J. curcas* and *A. indica* were also acknowledged for their use in the effective management of Kola weevil, *Balanogastriis kolae* by enhancing the increased mortality of the weevils and reduction in the exit holes as reported by Ugwu and Mokwunye (2019).

Aphis craccivora (Koch) is one of the major pests of cowpeas, affecting the development of the entire plant (Laamari *et*

al., 2008). In order to address these problems of pest infestation and disease infections, there is a need to intensify research on neem (*A. indica*) and physic nut (*J. curcas*) which have been reported to possess great potential as insecticides (Makkar, *et al.*, 1998; Devappa *et al.*, 2012; Nesseim *et al.*, 2012; Ukatu *et al.*, 2021). *A. indica* is reported to contain more than 25 active compounds that combat insects in various ways such as anti-feedant where the insects are repelled from the areas sprayed with neem extracts and insect growth regulator while phorbol esters are noted to be the most active component of *J. curcas* (Orwa *et al.*, 2009; Devappa *et al.*, 2011; Tobih, 2011). Azadirachtin A has been reported to be the most active of all azadirachtin compounds (FAO, 2006). Many researchers have reported, that the seeds of *A. indica* and *J. curcas* contain the highest amount of azadirachtin and phorbol esters respectively (Martinez-Herrera *et al.*, 2006; Devappa *et al.*, 2011; Diabate *et al.*, 2014). If these two plant products are properly harnessed in managing cowpeas, it is anticipated that there could be a great reduction in pest infestation of the crop, thereby bringing about the needed food security in Nigeria.

The objective of this study is to evaluate the efficacy of *A. indica* and *J. curcas* oils for the management of *A. craccivora* using a simple method of plant oil extraction that could be easily carried out by resource-poor farmers for the management of insect pests.

MATERIALS AND METHODS

Plant materials collection and extraction of oil

Mature seeds of neem, *Azadirachta indica* were collected from Calabar, Cross River State. The location lies within Latitude 4°58' 58.3428"N and Longitude 8°20'4.2108"E. The *Jatropha curcas* seeds were obtained

from Ijegu, Cross River State. It lies within Latitude 06° 44' 19"N and Longitude 8°40'30"E.

The seeds were washed thoroughly with tap water and air-dried in a shade for 3 days. *Jatropha curcas* and *A. indica* seeds were cracked manually using mortar and pestle but separately to obtain their kernels into two different containers. The dried kernels of both plants were heated at the temperature of 50°C for 5 minutes in an oven before the extraction period to enhance the quantity of the oils (Warra, 2011). The kernels were packed into 2 clean white muslin clothes and tied with rope. Then the kernels were subjected to a mechanical press to extract the oils.

The sediment in each of the oils was allowed to settle down for 1 week after which, they were separated from the oils to make the oil available for use. These procedures were repeated for use in the second field experiment. Cowpea seeds (Vita 7 variety) used for the experiments were obtained from "The International Institute of Tropical Agriculture (IITA)", Ibadan, Nigeria. Vita 7 variety was used for this experiment due to its susceptibility to *A. craccivora* (Ferreira and Nere, 2020).

Land preparation

The site was cleared, raked and tilled with machet, rake, hoe and spade. It was subsequently demarcated into 3 blocks each of which contained 8 plots of each treatment. Each plot measured 2m x 3m (6m²) and there were a total of 24 plots. The size of each block was 25m x 3m. Boundaries between plots and blocks were 1.0 and 1.5 wide respectively: After clearing, soil samples were taken from 0-15cm depth for physico-chemical analysis. The entire plot size was 375m² (i.e. total plot size = 25m x 15m).

Treatments and experimental design

The treatments consisted of three concentrations of Neem oil (1, 2, 3 per cent V/V), three concentrations of Jatropha oil (1, 2, 3 per cent V/V), Lambda-cyhalothrin (2.5 EC) and control (untreated). Each treatment was replicated 3 times and laid down in a Randomized Complete Block Design.

Planting operation

Two seeds of cowpea (vita 7 variety) were sown per hole on September 2013 and 2014 respectively using spacing of 70cm between rows and 20cm within rows. The plants were thinned to one per stand after two weeks of planting. The same operation was repeated in 2014.

Post planting operation

Weeding was done manually at 2 and 5 weeks after planting (WAP). Fertilizers were applied at the following rates; 40kg/ha of P, 25kg/ha of N and 25kg/ha of K using the Ring method (Finneran, 2012). The *A. indica*, *J. curcas* oils and Lambda-cyhalothrin were applied using a knapsack sprayer starting from 4 weeks after planting (4WAP) to 7 weeks after planting. Jatropha and neem oil spray were done by first adding 1ml of eco-friendly black liquid soap made from palm kernels as a dispersing agent to water and it was properly mixed with the 240mls water used for each dilution. The volume of oil used for the dilution included 2.40mls, 4.8mls and 7.2mls corresponding to 1, 2 and 3 per cent of the oils (V/V) respectively. The measured quantity of neem oil or Jatropha oil in drops was added while stirring/agitating vigorously the solutions to disperse the oil in water before being sprayed. Similarly, 0.4mls of Lambda-cyhalothrin (2.5EC) was diluted in 240mls of water (V/V) which was used per treatment plot. The solution was agitated vigorously before being used.

Data collection

Data for agronomic characters were taken randomly from each net plot measuring 0.4m x 0.7m (0.28m²). Six cowpea plants per plot were sampled randomly from the 2 middle rows of the plot for data collection. The population of *A. craccivora* was taken in the field by visual counting of mature aphids from the sampled plants using a hand lens. Data obtained from the field included the following:

i. Number of *A. craccivora* /plant: The number of *A. craccivora* was determined by counting the number of mature aphids in 6 sampled plants in each of the plots and the average was then recorded.

ii. Number of leaf curls/plant: This was determined by counting curled leaves from the 6 sampled plants in each plot and the average was recorded.

iii. Vine length (m) at 6 WAP: One cowpea vine length was randomly measured from each of the 6 sampled plants using measuring tape and then the average was recorded.

iv. Number of pods/plant: This was determined by counting the pods in 6 plants and the average was then recorded.

v. Pod length/plant (cm): This was determined by measuring the length of 6 randomly selected pods from the 6 sampled plants with measuring tape and the average was recorded.

vi. Number of grains/pod: This parameter was determined by counting the number of seeds in 6 randomly selected mature pods from the 6 sampled plants in each plot and the average was recorded.

vii. Grain yield/plant (g): The pods from 6 sampled plants were shelled and the seeds were weighed using electronic weighing balance and the average weight was determined.

viii. Grain yield (t/ha): The weight of grain obtained from the 6 sampled plants of each

plot and its area of 0.28m² was used to extrapolate the grain yield/hectare.

ix100-grain weight: At random, 100 seeds were picked and weighed from the 6 sampled plants using an electronic weighing balance (Starcraft,MP series, Zhejiang, China) and the average was recorded.

Harvesting and drying

Harvesting was done by hand picking at 3-day intervals when 85-90 per cent of the pods have reached physiological maturity. The pods were threshed and the grains were spread out and left to dry 3 days before weighing.

Data analysis

The data collected from the field were subjected to the analysis of variance (ANOVA) and treatment means were separated using Duncan's New Multiple Range Test at a 5 percent level of probability (Genstat, 2005; Alika, 2010). The data on several *A. craccivora* and leaf curl were subjected to Square Root transformation ($\sqrt{x+0.5}$) before analysis.

RESULTS

Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on *Aphis craccivora* population/plant.

The effect of *A. indica* and *J. curcas* oils on the population of *A. craccivora* on cowpea plants in 2013 at different growth stages is presented in Figure 1. At 4 and 5 weeks after planting (WAP), the application of both plant oils significantly ($p \leq 0.05$) reduced the population of aphids compared with the control (Figure 1). At both growth stages, higher concentrations (2 and 3 per cent) of the plant oils were significantly ($p \leq 0.05$) more effective in reducing aphid population than 1 per cent concentration. At 4 WAP, there was no significant ($P > 0.05$)

difference in the aphid population between 2 and 3 per cent concentration of both plant oils. There was also no significant ($P > 0.05$) difference in the aphid population between the 3 per cent plant oils and the synthetic insecticide (Lambda-cyhalothrin). At 5 WAP, successive increases in the concentration of both plant oils resulted in a significant ($p \leq 0.05$) decrease in aphid population for both plant oils. The highest concentration (i.e. 3 per cent) of oils, had plants with significantly the least number of aphids.

The number of aphids was significantly ($p \leq 0.05$) lower in plants treated with the synthetic insecticide when compared to the 3 per cent oil concentration of both plant materials. At 6 and 7 WAP, there was no significant ($P > 0.05$) difference in aphid population when the cowpea was sprayed at 1 per cent and control but the number of aphids was significantly ($p \leq 0.05$) reduced with the application of 2 and 3 per cent concentrations of the oils when compared with 1 per cent oil and the control. The application of the synthetic insecticide (Lambda-cyhalothrin) showed no significant difference ($P > 0.05$) in the aphid population when compared with a 2 per cent concentration of both plant oils at 6 and 7 WAP.

The effect of *A. indica* and *J. curcas* on the population of *A. craccivora* on cowpea plants in 2014 at different growth stages of the crop is presented in Figure 2. At 4 and 5 Weeks after Planting (WAP), the application of both oils significantly ($p \leq 0.05$) reduced the population of aphids compared with the control. At both growth stages, higher concentrations (2 and 3 %) of the plant oils were significantly ($p \leq 0.05$) more effective in reducing aphid population than 1 % concentration. Similarly, a 1 % concentration of both oils significantly ($p \leq 0.05$) reduced the population of aphids on cowpea plants when compared with the control. A successive (1 to 3 %) increase in

the concentration of both oils resulted in a significant ($p \leq 0.05$) decrease in aphid population for both plant oils at 4 WAP.

Furthermore, there was no significant ($p > 0.05$) difference in the aphid population between the 3 % concentration of plant oils and the synthetic insecticide at 5WAP but existed at 4WAP. There was also no significant ($p > 0.05$) difference in aphid population between 2 % and 3 % concentration of both plant oils.

At 6 and 7WAP, the application of the synthetic insecticide (Lambda-cyhalothrin) showed no significant ($p > 0.05$) difference in aphid population when compared with the 3 % concentration of both plant oils. At 6WAP, the application of a 1 % concentration of both oils significantly ($p \leq 0.05$) reduced the population of aphids when compared with the control but the application of a 1 % concentration of *A. indica* oil did not significantly ($p > 0.05$) reduce the population of aphid at 7 WAP when compared with the control.

Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on number of leaf curl/plant

The effect of *A. indica* and *J. curcas* oils on the number of leaf curls on cowpea plants at different growth stages as obtained from the 2013 experiment is presented in Figure 3. The application of both plant oils on cowpea plants significantly ($p \leq 0.05$) reduced the number of leaf curls when compared with the control (Figure 2). At 4 and 5 WAP, 2 and 3 per cent of the plant oils were more effective in reducing the number of leaf curls when compared with 1 per cent concentration. At 4 WAP, there was no significant ($P > 0.05$) difference in the number of leaf curls between 2 and 3 per cent concentration of the plant oils. Also, no significant ($P \leq 0.05$) difference was observed in the number of leaf curls in cowpea plants

between both plant oils at 3 per cent concentration and the synthetic (Lambda-cyhalothrin) at 4 and 5 WAP. At 5 WAP, the successive increase in concentration from 1 to 3 per cent of both plant oils resulted in a significant ($p \leq 0.05$) decrease in the number of leaf curl. Also, for both *J. curcas* and *A. indica* plants, the highest concentration of the 2 oils (3 per cent) had plants with significantly ($p \leq 0.05$) the least number of leaf curls (Figure 3).

The application of *J. curcas* and *A. indica* oils at 6 and 7 WAP showed significant ($p \leq 0.05$) reduction in the number of leaf curls in cowpea plants between 1 per cent concentration of *J. curcas* and control but not with 1 per cent *A. indica* and the control. At 6 and 7 WAP, the application of both plant oils significantly ($p \leq 0.05$) reduced the number of leaf curls at 2 per cent and 3 per cent oils when compared with the control. There was a successive significant ($p \leq 0.05$) reduction in the number of leaf curls for both plant oils from 1 to 3 per cent. For both plant oils, 3 per cent oil concentration significantly ($p \leq 0.05$) had the least number of leaf curls in the cowpea plant. At 6 WAP, there was no significant ($P > 0.05$) difference in the number of leaf curls in cowpea plants between the highest concentration of both plant oils (3 per cent) but a significant ($p \leq 0.05$) difference existed between 3 per cent *A. indica* and Lambda-cyhalothrin.

However, at 6 WAP, plants treated with the synthetic insecticide had the lowest number of leaf curls, which was significantly ($p \leq 0.05$) less than the plants treated with a 3 per cent concentration of both plant oils.

The effect of *A. indica* and *J. curcas* oils on the number of leaf curls on cowpea plants in 2014 at different growth stages is presented in Figure 4. The application of both plant oils on cowpea plants significantly ($p \leq 0.05$) reduced the number of leaf curl at 4 and 5 WAP when

compared with the control. The increase in the concentration of both plant oils from 1 to 3 % resulted in a significant reduction in the number of leaf curl at both 4 and 5WAP. At both growth stages, the application of lambda-cyhalothrin significantly ($p \leq 0.05$) had the same level of leaf curl reduction when compared with a 3 % concentration of both plant oils. Also, at 4WAP, the application of 1 % of both plant oils had a significant ($p \leq 0.05$) reduction in the number of leaf curl

when compared with the control. At 5WAP, the application of a 3 % concentration of both plant oils had the same level of reduction of leaf curl with a 2 % concentration of both plant oils. Successive increase in concentration of both oils from 1 to 3 % resulted in a significant ($p \leq 0.05$) reduction in the number of leaf curl at 4WAP.

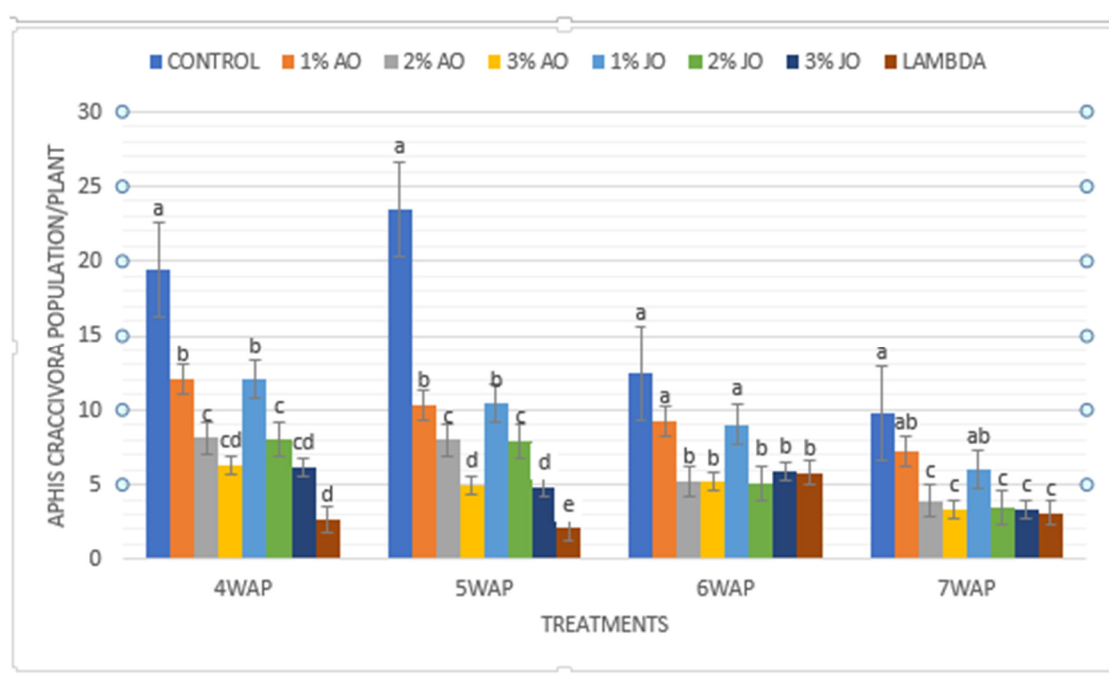


Fig 1: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on *Aphis craccivora* population in 2013.

NOTE:

Means capped with the same letter (s) within the same week are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL= Without insecticide (control)

LAMBDA= Lambda-cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

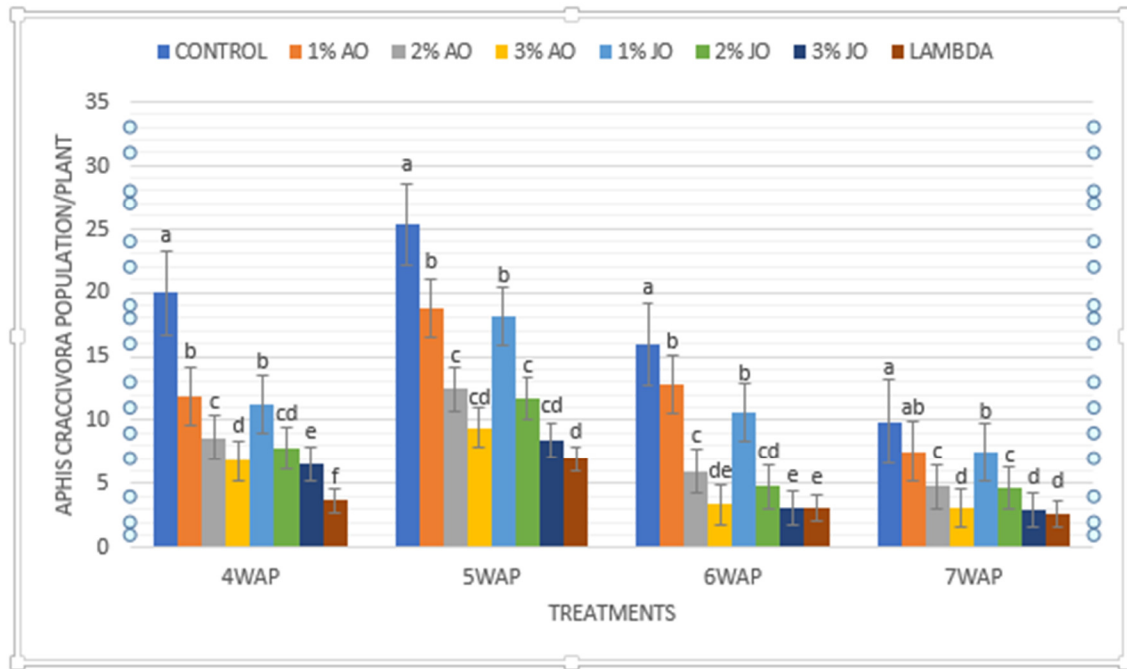


Fig 2: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on *Aphis craccivora* population in 2014.

NOTE:

Means capped with the same letter (s) within the same week are not significantly ($p>0.05$) different from each other according to Duncan’s New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL= Without insecticide (control)

LAMBDA= Lambda cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

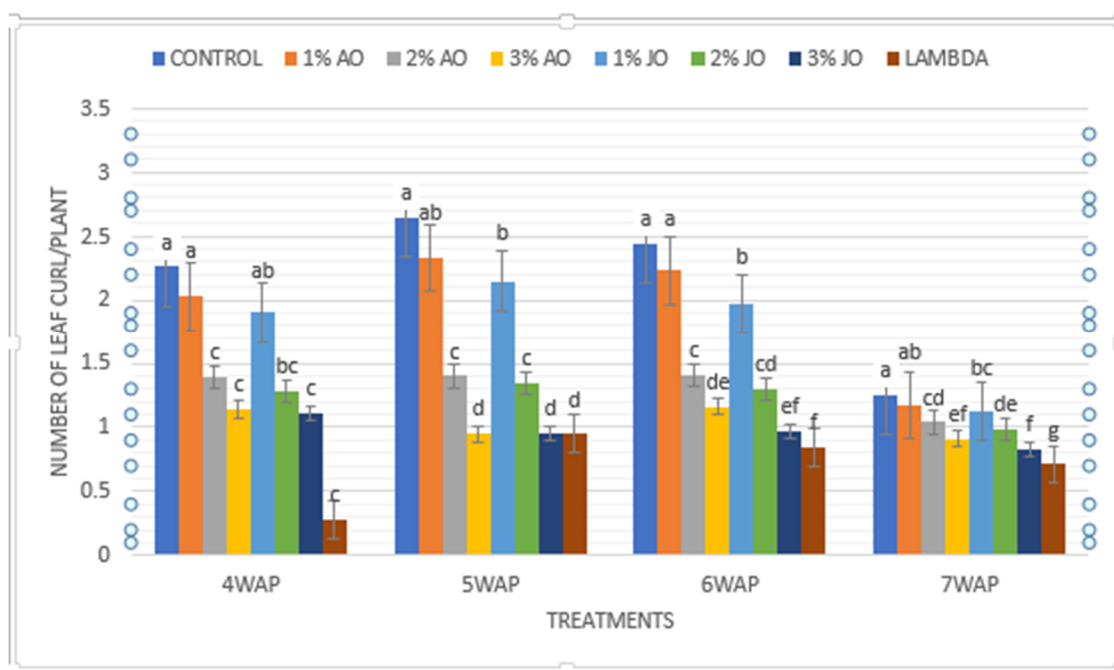


Fig 3: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the number of leaf curls in 2013.

NOTE:

Means capped with the same letter (s) within the same week are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL= Without insecticide (control)

LAMBDA= Lambda cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

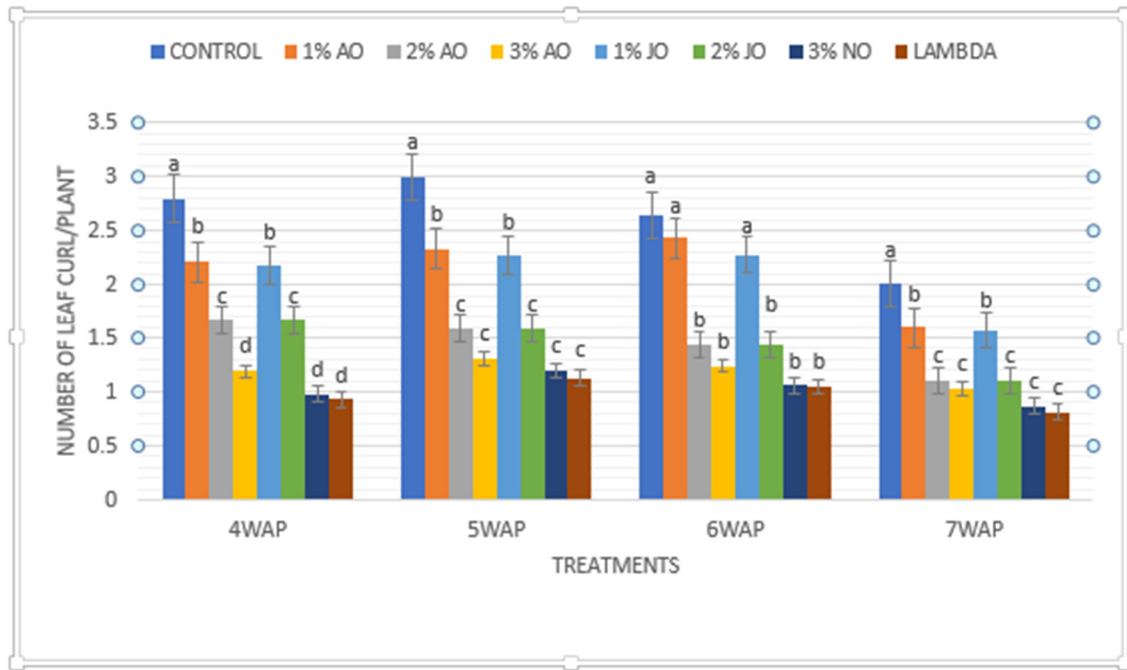


Fig 4: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the number of leaf curls in 2014.

NOTE:

Means capped with the same letter (s) Within the same week are not significantly ($p > 0.05$) different from each other according to Duncan’s New Multiple Range Test (DNMRT).

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL= Without insecticide (control)

LAMBDA= Lambda cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

At 6 and 7WAP, the application of 2 and 3 % concentration of both plant oils resulted in a significant ($p \leq 0.05$) reduction in the number of leaf curl when compared with the control. At both stages of the plant growth, the application of 3 % of the plant oils had statistically ($p \leq 0.05$) the same number of leaf curls when compared with Lambda-cyhalothrin. The number of leaf curls obtained from cowpea plants sprayed with a 1 % concentration of both oils was not significant ($p > 0.05$) from that of control whereas the application of 1 % of both plant

oils at 7WAP had significant ($p \leq 0.05$) reduction in the number of leaf curl when compared with the control.

Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on “Vine length, number of pods/plant, pod length, number of seeds/pod and weight of 100 seeds”.

The effects of *A. indica* and *J. curcas* oils on “vine length, number of pods/plants, pod length, number of seeds/pod

and 100 seed weight” is shown in Figure 5-14. The application of both plant oils significantly ($p \leq 0.05$) increased the vine length of cowpea plants relative to the control (Figure 5) in 2013. However, there was no significant ($P > 0.05$) increase in the vine length between the control and 1 to 2 per cent of both plant oils. Cowpea plants treated with the highest concentration (3 per cent) of the two plant oils had significantly ($P \leq 0.05$) longer vines than 1 per cent *A. indica* oil but not 1 per cent *J. curcas* oil.

The application of both plant oils significantly ($p \leq 0.05$) increased the vine length of cowpea plants in 2014 (Figure 6). The application of 2 and 3 % of both plant oils resulted in a significant ($p \leq 0.05$) increase in the vine length of cowpea, respectively when compared with the control. The vine length obtained from the cowpea plants sprayed with a 3 % concentration of both plant oils was not significantly ($p > 0.05$) different from Lambda-cyhalothrin. The application of a 1 % concentration of *J. curcas* resulted in a significant ($p \leq 0.05$) increase in the vine length when compared with the control but the application of a 1 % concentration of *A. indica* did not show a significant ($p > 0.05$) difference when compared with the control.

The application of both plant oils on cowpea in 2013 did not cause any significant ($P > 0.05$) difference in the number of seeds/pod produced (Figure 7) and the pod length (Figure 8) of cowpea plants as presented in Figures 7 and 8, respectively. However, successive increases in the application rate of 1 to 3 per cent of both plant oils increased the number of seeds/pods when compared to the control. The 3 per cent oil concentration of the two plant oils had the highest number of pods but less than Lambda-cyhalothrin treated plants.

The application of both plant oils on cowpeas also did not cause any significant ($p > 0.05$) difference in the number of

seeds/pod produced and the pod length of cowpea plants in 2014 as presented in Figures 9 and 10 respectively. However, successive increases in the application rate of 1 to 3 % of both plant oils increased the number of seeds/pod when compared with the control (Figure 9). The 3 % oil concentration of the two plant oils had the highest number of pods but less than Lambda-cyhalothrin treated plants. Similarly, the application of both plant oils increased the pod length of the cowpea (Figure 10). The successive increase in the application rate of both plant oils up to 3 % concentration resulted in the production of the corresponding longer pod than the control. The 3 % concentration of both oils had the longest pods/plant but which were not longer than cowpea plants treated with Lambda-cyhalothrin.

The application of both plant oils on cowpea significantly ($p \leq 0.05$) increased the number of cowpea pods/plant (Figure 11) in 2013. The 3 per cent concentration of both plant oils significantly ($p \leq 0.05$) increased the number of cowpea pods/plant compared with 1 per cent. There was no significant ($P > 0.05$) difference in the number of pods/plants between 2 per cent and 3 per cent concentrations.

The application of *A. indica* and *J. curcas* had a significant ($p \leq 0.05$) difference in the number of pods/plants at various concentrations of the plant oils in 2014 as shown in Figure 12. The application of 2 to 3 % concentration of both plant oils resulted in the production of a higher number of pods/plants in cowpeas when compared with control. The application of a 1 % concentration of *J. curcas* oil on cowpea showed a significant ($p \leq 0.05$) increase in the number of pods/plant when compared with the control but the same concentration of *A. indica* did not significantly ($p > 0.05$) differ from the control in terms of number of pods produced per plant. The application of a 3 %

concentration of *J. curcas* on cowpea resulted in the production of the highest number of pods per plant in cowpea which was significantly ($p \leq 0.05$) higher than that produced from cowpea with the application of 3 % *A. indica* but not Lambda-cyhalothrin.

The application of both plant oils on cowpea plants significantly ($p \leq 0.05$) resulted in higher seed weight of cowpea grain compared with the control in 2013 as shown in Figure 13.

The 3 per cent oil concentration of both plant oils resulted in significantly ($p \leq 0.05$) higher weight of cowpea grains than 2 per cent of the 2 oils. However, no significant ($P > 0.05$) difference in the weight of grains was observed at 3 per cent concentration of both plant oils and Lambda-cyhalothrin.

The application of both plant oils on cowpea plants significantly ($p \leq 0.05$) resulted in higher seed weight of cowpea grain compared with the control. However, the application of 3 % of both plant oils produced the highest weight of cowpea grains which

was statistically ($p > 0.05$) the same as that produced from cowpea sprayed with Lambda-cyhalothrin but significantly ($p \leq 0.05$) higher than that produced from the application of 1 % of both plant oils and the control. Also, the application of a 1 % concentration of both plant oils significantly ($p \leq 0.05$) produced a higher weight of cowpea grains than that produced from the cowpea plants.

However, in 2014, the application of both plant oils on cowpea plants significantly ($p \leq 0.05$) resulted in higher seed weight of cowpea grain compared with the control as shown in Figure 14. The application of 3 % of both plant oils produced the highest weight of cowpea grains which was statistically ($p > 0.05$) the same as that produced from cowpea sprayed with Lambda-cyhalothrin but significantly ($p \leq 0.05$) higher than that produced from the application of 1 % of both plant oils and the control. Also, the application of a 1 % concentration of both plant oils significantly ($p \leq 0.05$) produced a higher weight of cowpea grains than that produced from the untreated cowpea plants

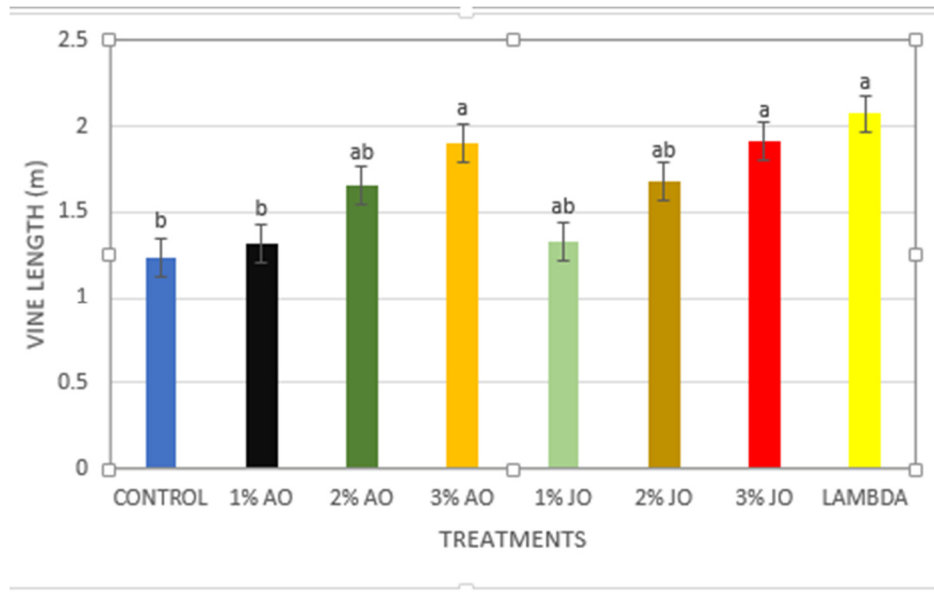


Fig 5: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on Vine length in 2013.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL= Without insecticide (control)

LAMBDA= Lambda-cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

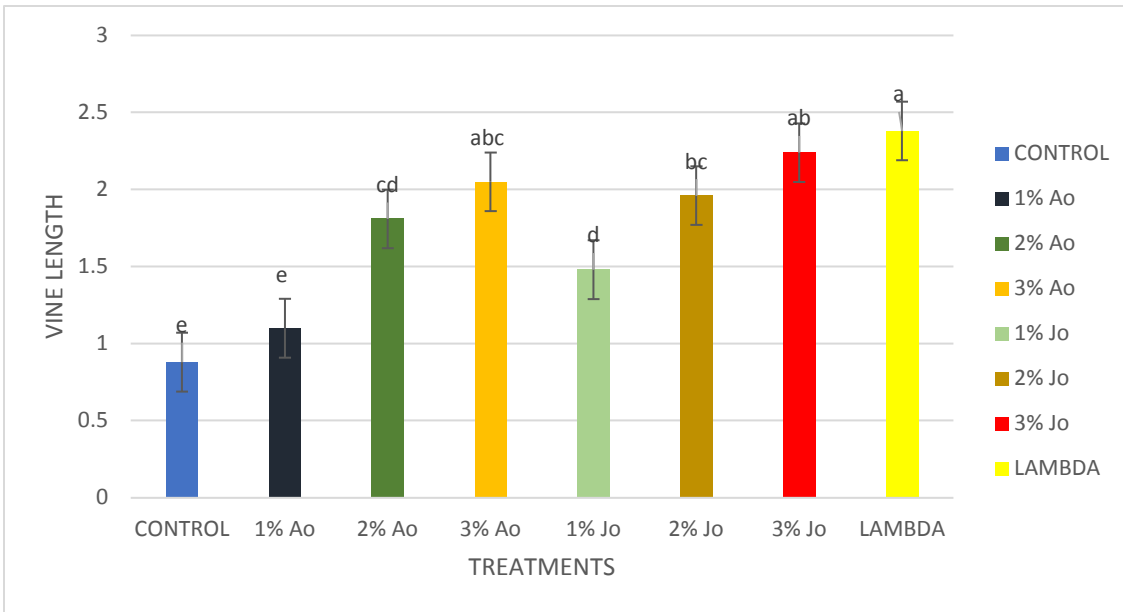


Fig 6: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on Vine length in 2014.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda-cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

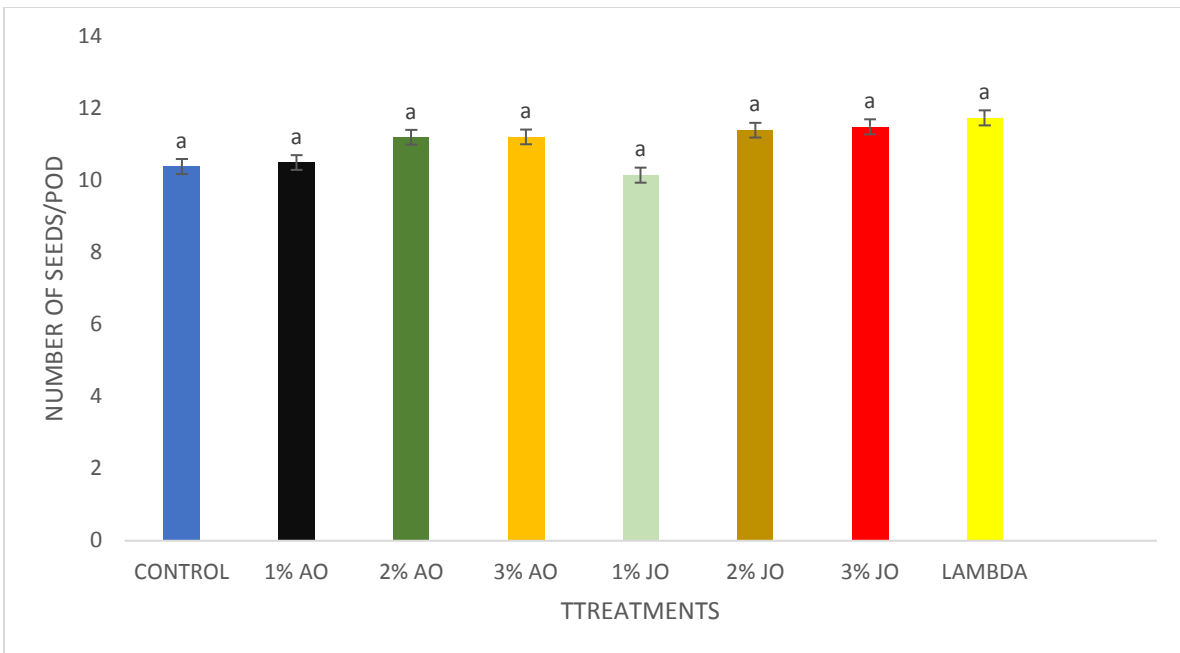


Fig 7: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the Number of seeds/pods in 2013.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA= Lambda cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

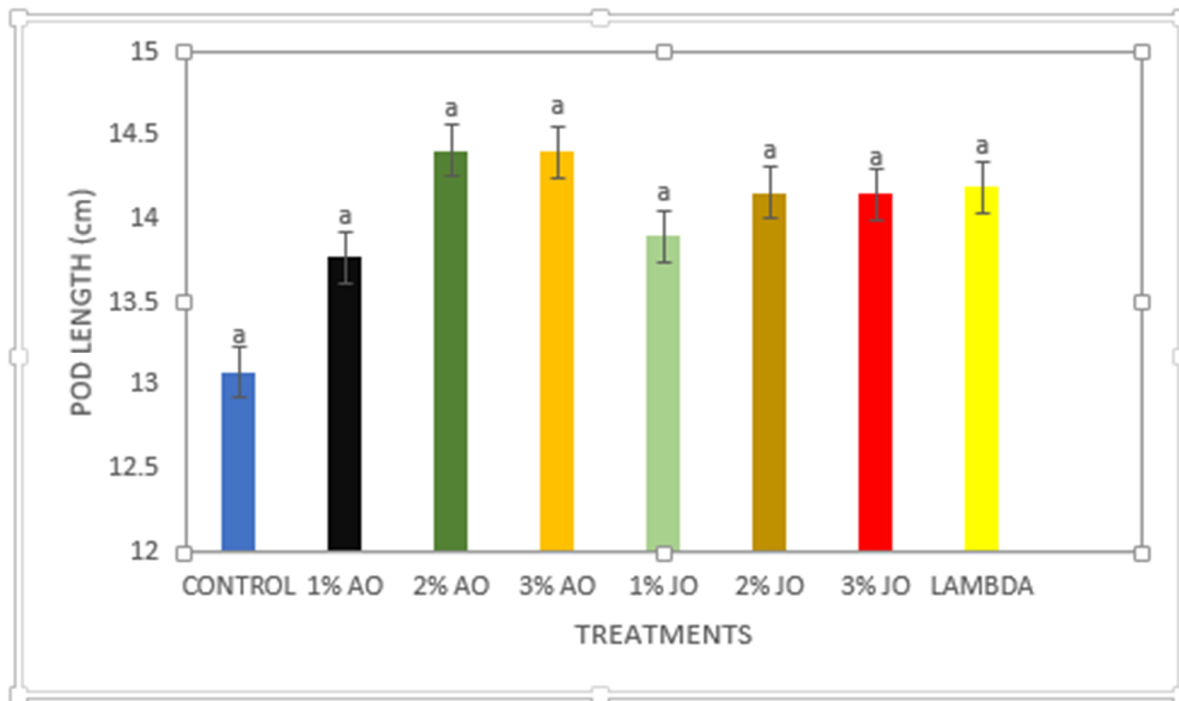


Fig 8: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on pod length in 2013.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan’s New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

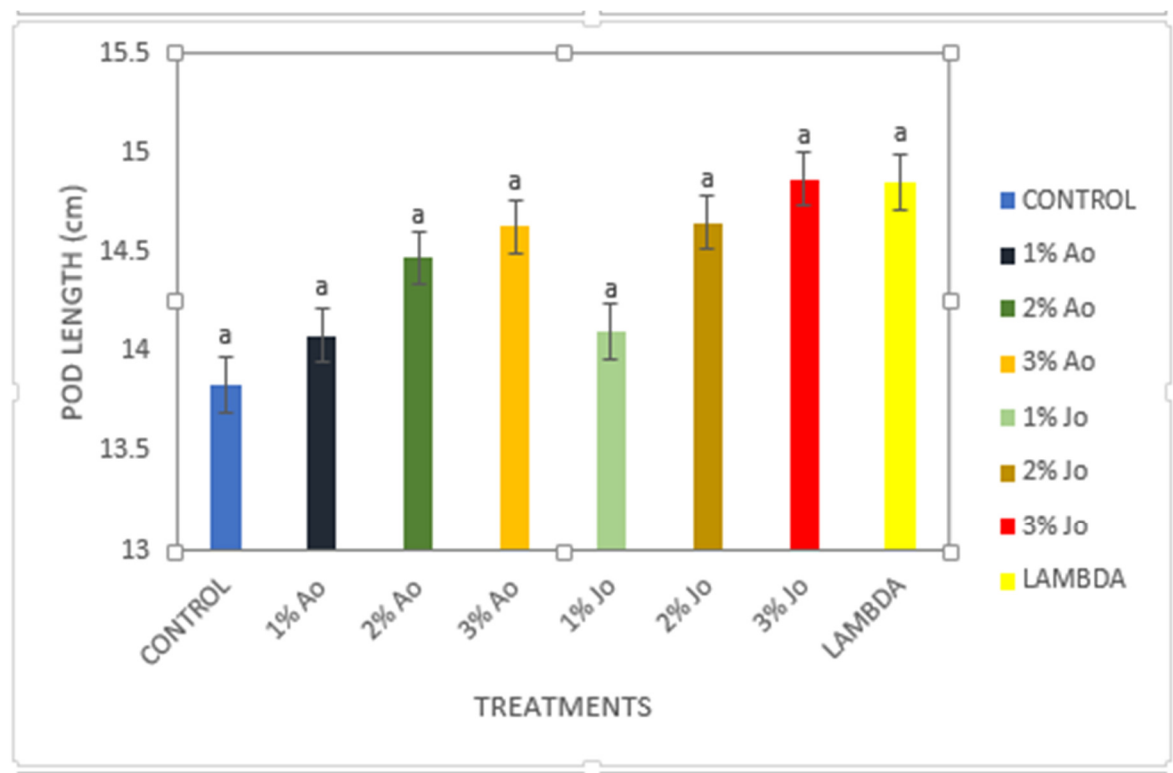


Fig 9: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on Number of seeds/pods in 2014.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

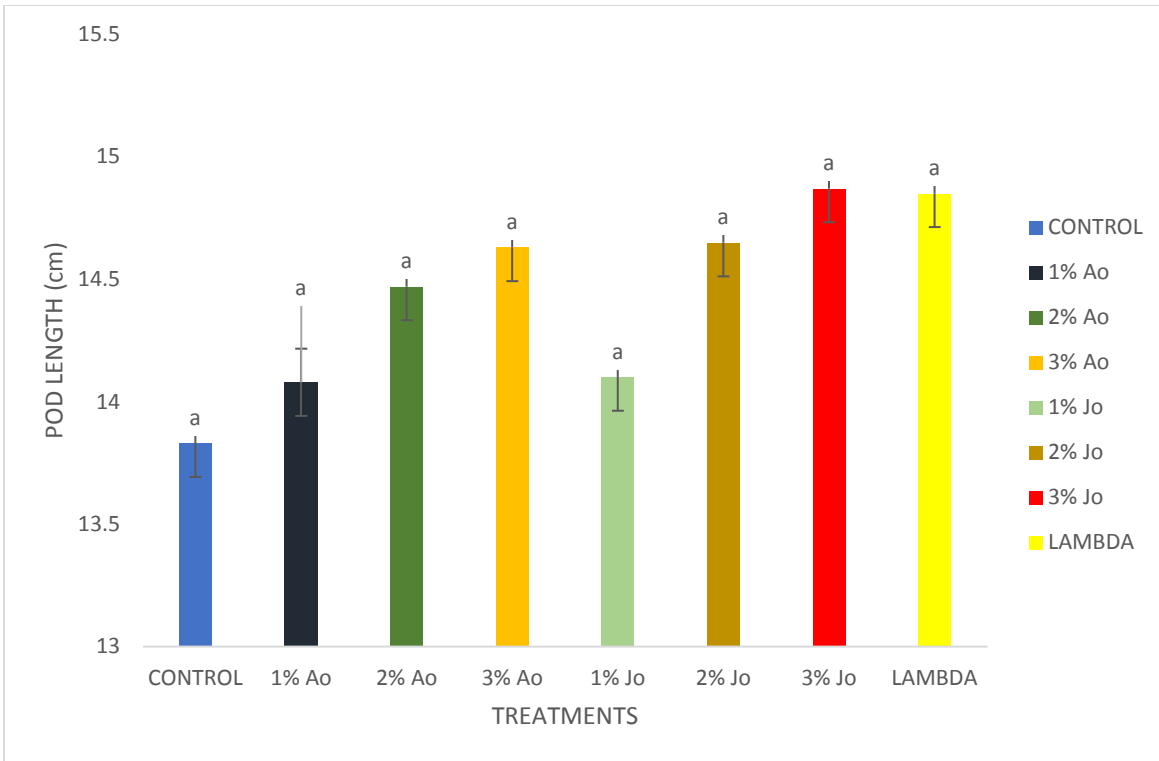


Fig 10: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on pod length in 2014.

NOTE:

Means capped with the same letter (s) are not significantly ($p>0.05$) different from each other according to Duncan’s New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA= Lambda-cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

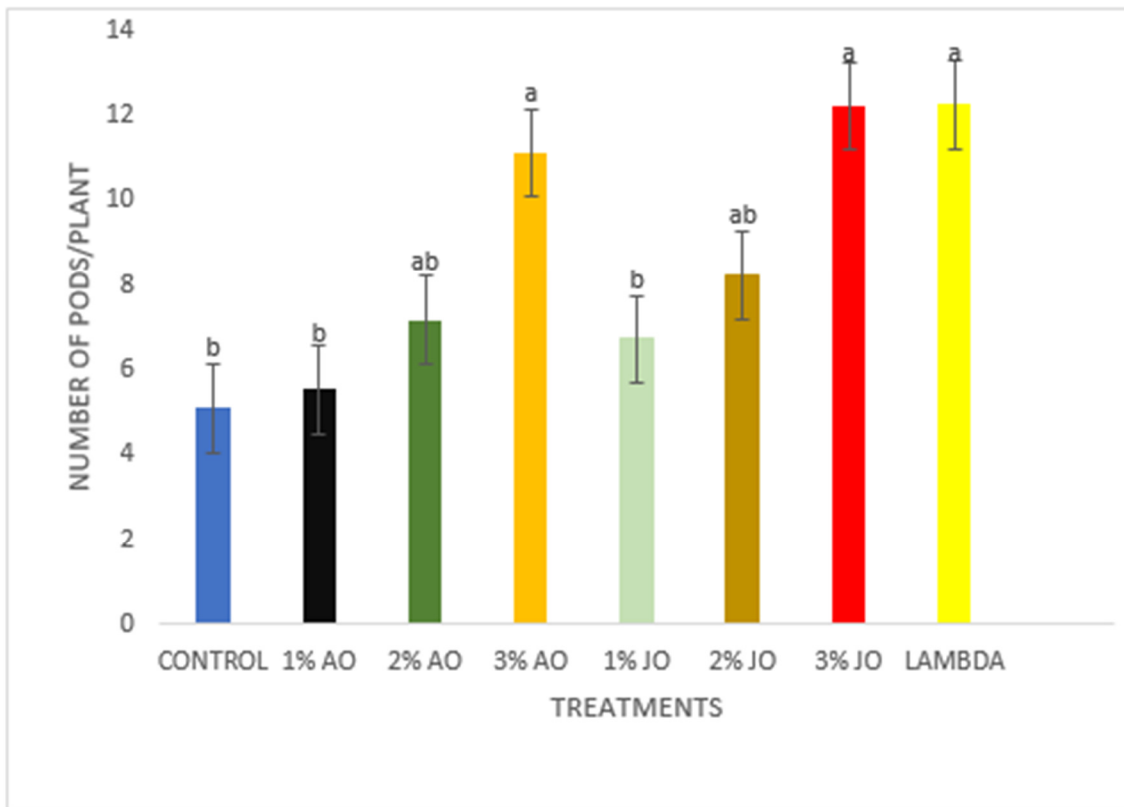


Fig 11: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the number of pods/plants in 2013.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL= Without insecticide (control)

LAMBDA= Lambda-cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

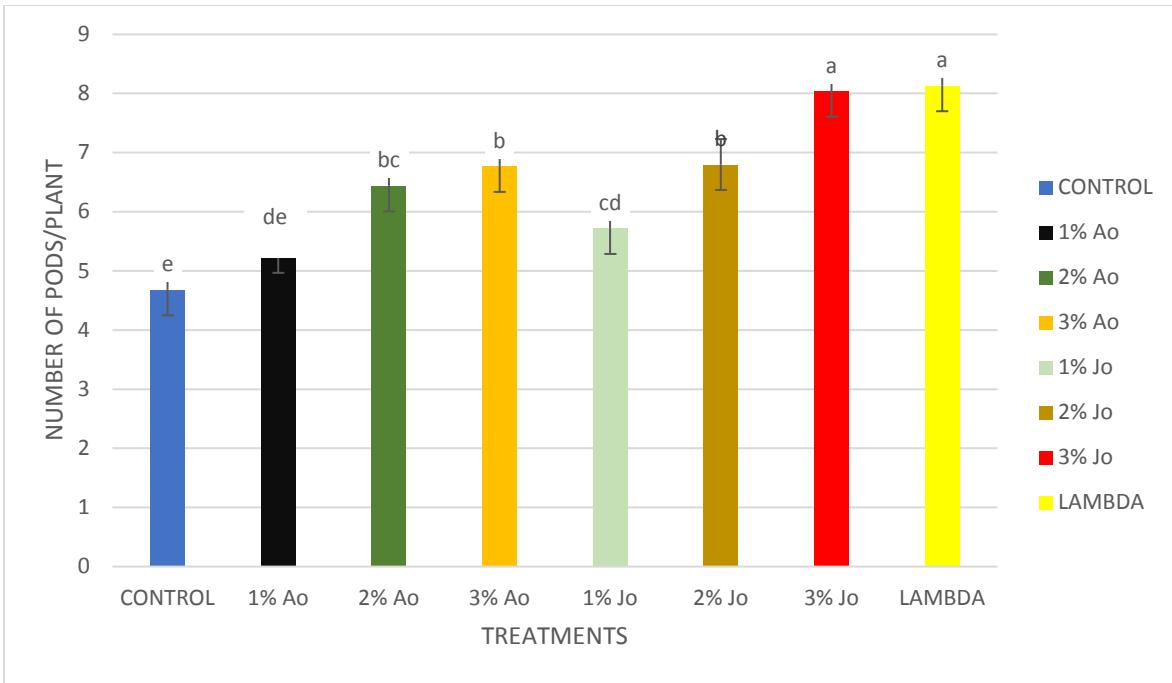


Fig12: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the number of pods/plants in 2014.

NOTE:

Means capped with the same letter (s) are not significantly ($p>0.05$) different from each other according to Duncan’s New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda-cyhalothrin (Synthetic insecticide)

WAP=Weeks after planting

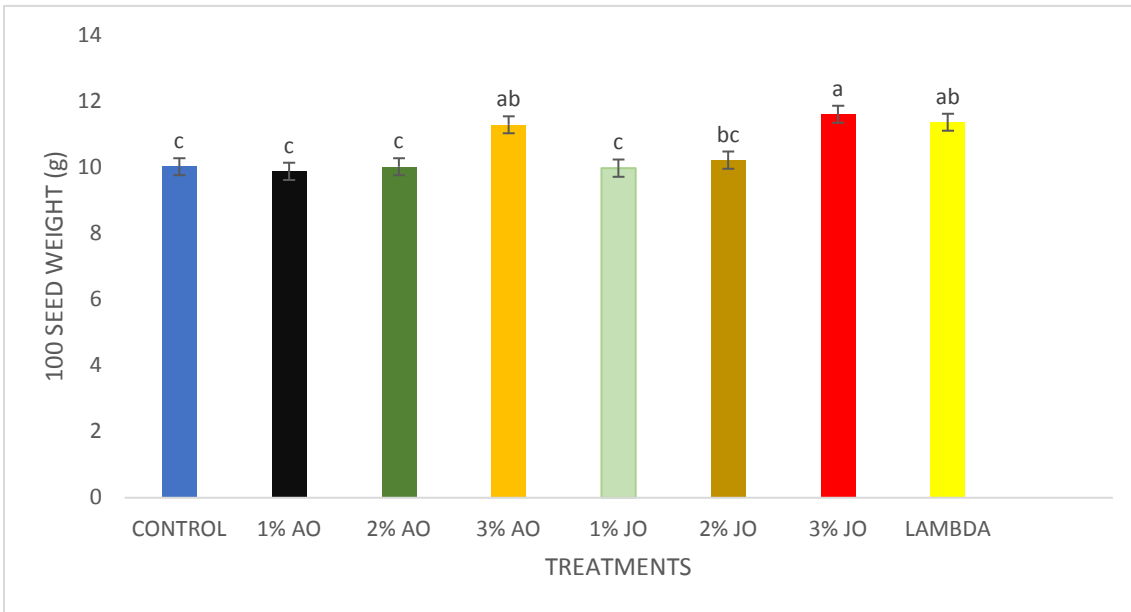


Fig 13: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on 100 seed weight in 2013.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO= *Jatropha curcas* oil

AO= *Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda-cyhalothrin (Synthetic insecticide)

WAP=Weeks after planting

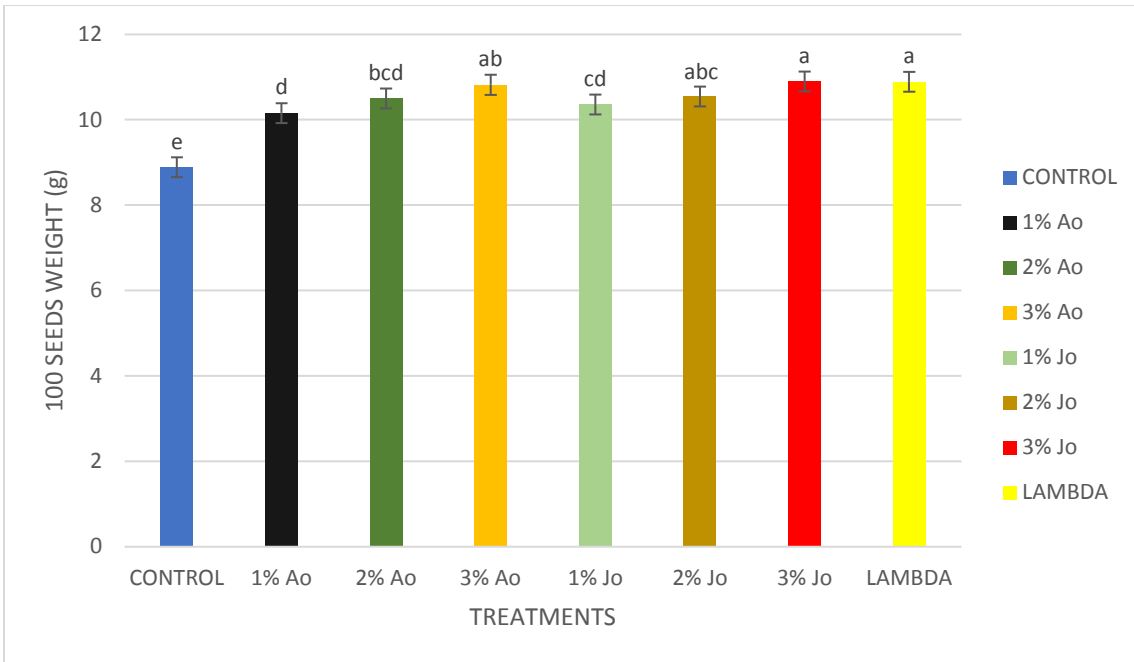


Fig 14: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on 100 seed weight in 2014.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan’s New Multiple Range Test.

JO= *Jatropha curcas* oil

AO=*Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA= Lambda-cyhalothrin (Synthetic insecticide)

WAP= Weeks after planting

Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the yield of cowpea grains.

The effects of *A. indica* and *J. curcas* oils on the yield of cowpea grains as obtained from the 2013 experiment are presented in Figure 15. The application of both oils significantly ($p \leq 0.05$) increased the grain yield of cowpea. A successive increase in the concentration of both plant oils from 1 per cent to 3 per cent resulted in a significant ($p \leq 0.05$) increase in the grain yield of cowpeas (Figure 3). Of the two oils, a 3 per cent concentration of *J. curcas* oil had the

highest grain yield and it significantly ($p \leq 0.05$) differed from the 3 per cent concentration of *A. indica* but not Lambda-cyhalothrin. The application of 1 per cent *J. curcas* resulted in a significant ($p \leq 0.05$) increase in grain yield than the control. No significant ($P > 0.05$) difference was observed in grain obtained with a 3 per cent concentration of *J. curcas* and Lambda-cyhalothrin.

Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on the yield of cowpea grains as obtained in the 2014 experiment are presented

in Figure 16. Similarly, the application of both plant oils significantly ($p \leq 0.05$) increased the grain yield of cowpeas. A successive increase in the concentration of both plant oils from 1 to 3 % resulted in a significant ($p \leq 0.05$) increase in the grain yield of cowpeas. The application of the same rate (1 to 3 %) of *J. curcas* oil resulted in a higher yield of cowpea

grains when compared with the application of an equivalent concentration of *A. indica* (1 to 3 %) and control. The 3 % concentration of *J. curcas* oil had the highest grain yield and it significantly ($p \leq 0.05$) differed from the 3 % concentration of *A. indica* but statistically ($p > 0.05$) the same with Lambda-cyhalothrin

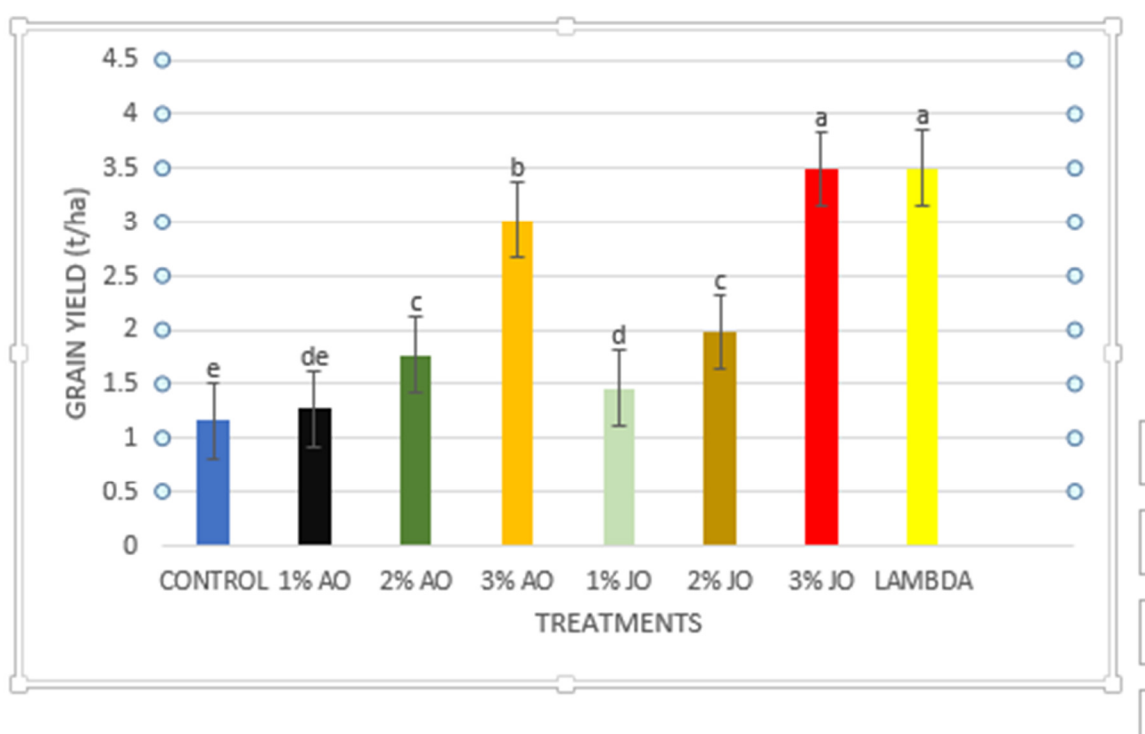


Fig 15: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on yield of cowpea grains in 2013.

NOTE:

Means capped with the same letter (s) are not significantly ($p > 0.05$) different from each other according to Duncan's New Multiple Range Test.

JO=*Jatropha curcas* oil

AO=*Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda-cyhalothrin (Synthetic insecticide)

WAP=Weeks after planting

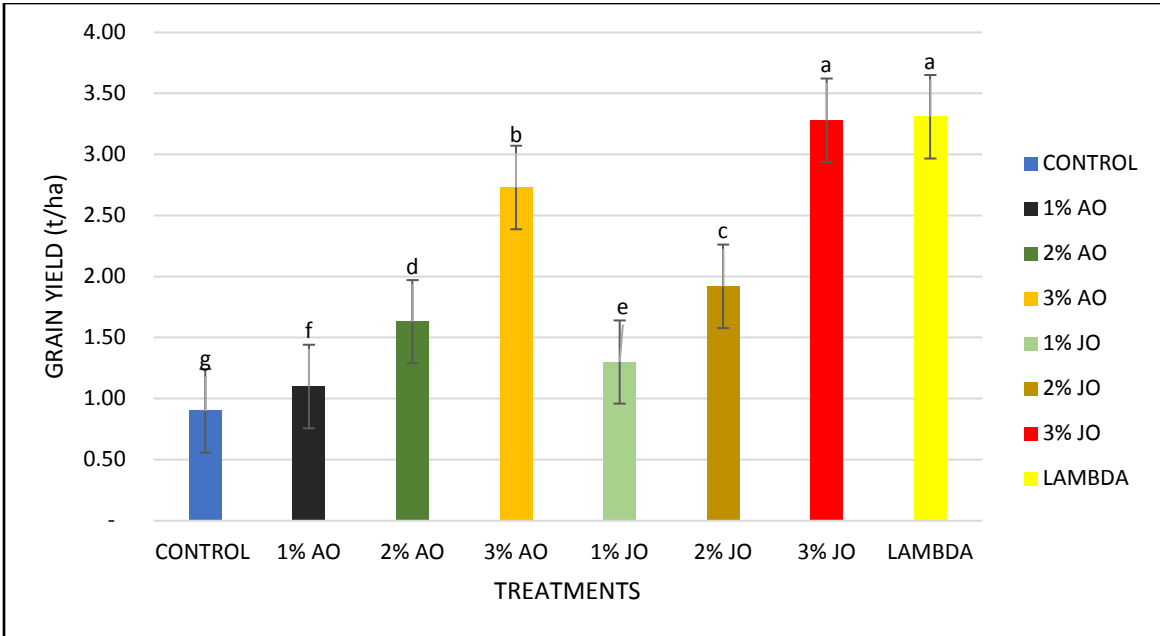


Fig 16: Effect of different concentrations of *Azadirachta indica* and *Jatropha curcas* oils on yield of cowpea grains in 2014.

NOTE:

Means capped with the same letter (s) are not significantly ($p>0.05$) different from each other according to Duncan’s New Multiple Range Test.

JO=*Jatropha curcas* oil

AO=*Azadirachta indica* oil

CONTROL=Without insecticide (control)

LAMBDA=Lambda-cyhalothrin (Synthetic insecticide)

WAP=Weeks after planting

DISCUSSIONS

The result from this study revealed that *A. indica* and *J. curcas* oils possess insecticidal properties that aided in the management of *A. craccivora*. These plant oils significantly reduced the population of *A. craccivora* as well as the number of leaf curls. Application of the plant oils also increased the “-vine length, number of seeds/pod, number

of pods/plant and pod length-”. This observation is supported by the report of Martinez-Herrera *et al.* (2006) on the potency of *J. curcas* on insects due to its content of a toxic compound called phorbol ester. Makkar *et al.*, (2007) reported that the toxicity of *J. curcas* oil in the control of insect pests is due to the presence of several steroids and diterpenes (phorbol ester) which are the

most toxic substances in the plant while that of *A. indica* is Azadirachtin (Okbatinsae and Haile, 2017; Srinivasan *et al.*, 2019). This research has further proved that *A. indica* and *J. curcas* reduced the population of *A. craccivora* associated with cowpea plants treated with a 3 per cent concentration of both plant oils rather than 1 per cent and plants. This is in agreement with Habou *et al.* (2011) who observed that the higher the concentration of *J. curcas* applied, the higher the mortality of the insects. The result may be connected with the report of Jide-Ojo *et al.* (2013) and Roy *et al.* (2016) that, the insecticidal effect of *J. curcas* increased with increased concentration of the extract. This position is also supported by the results of Ojumoola *et al.* (2018) and Traore *et al.* (2019) who indicated that an increase in concentration of *A. indica* resulted in increased mortality of *Maruca vitrata* and *Callosobruchus maculatus*. The observed rapid action of *J. curcas* and *A. indica* could be associated with their property of acting in the vapour phase, hence gaining entry into the internal system of the insect with ease through the spiracles (Wekesa *et al.*, 2011). There were significantly fewer leaf curls resulting from the application of *A. indica* and *J. curcas* oils than the untreated control. The result from the application of the extracts is that the lowest number of leaf curls was obtained from plants treated with a 3 per cent concentration of both oils. The number of leaf curls increased with the population of *A. craccivora*. The higher number of leaf curls may have resulted from a higher aphid population, sucking plant sap thus causing heavily infested leaves to curl, and also spreading cowpea diseases arising from aphids as a vector, with localized heavy infestation leaves curling downward. The reduction in the *A. craccivora* population could lead to a reduction in the number of leaf curls in cowpea plants. This reduction in the

population of *A. craccivora* is in agreement with observations of Diabate *et al.* (2014) who stated that Jatropha and neem oils affected the hatching of insect's eggs adversely, as it decreases with an increase in concentration of the oils. The effectiveness of the oil of *J. curcas* against insect pest of cowpeas under laboratory and field conditions depends on increased concentrations of the oil (Habou, *et al.*, 2011). At 7 WAP, the failure of the oils to reduce the number of leaf curls compared with Lambda-cyhalothrin could be attributed to a decline in potency of the plant oil due to environmental effects on the oils arising from the biodegradable nature of botanicals (oils) over shorter periods than the synthetic insecticide (Orwa, *et al.*, 2009; Wekesa *et al.*, 2011). Treated plants with a 3 per cent concentration of *J. curcas* and *A. indica* significantly ($p \leq 0.05$) had longer vines than the control. The length of the cowpea vines varied according to the concentration of the oils applied, with higher concentrations having longer vine lengths. The plants with a lower population of *A. craccivora* had a reduced number of insects that fed on the cowpea plant. Similarly, this may also have caused lower chances of transmission of diseases to the plants thereby created a healthy condition for the growth and development of crops ultimately culminated into higher number of pods/plant, seed weight and total grain yield. The higher the concentration of the oil applied, the higher the yield obtained from the cowpea plants. The population build-up in the aphids hinders the leaf surface from receiving sunlight, amounting to the reduction in the photosynthetic efficiency of the plants, thereby resulting in lower productivity of seeds (grains). The honey dew builds up on plants when high aphid numbers occur, and acts as a substrate for fungal growth, particularly of sooty mould and this results in decrease in respiration and photosynthetic efficiency (Smith and Boyko, 2007). This

result is similar to that of Uddin II and Abdulazeez (2013) who reported *J. curcas* at 2.5 per cent to be the most effective plant extract, followed by *A. indica* at 2.5 per cent in preventing weight loss of cowpea grains. From the experiment, it was observed that the highest total cowpea grain yield was obtained from the plants treated with a 3 per cent concentration of *J. curcas* oil, with the same concentration of *A. indica*. This indicated the superiority of the application of *J. curcas* oil in the management of insect pests of cowpeas (Lakshhi, 2009; Zewde and Jembere, 2010; Addisu *et al.*, 2014). This result is in agreement with Jaglan (2008) that the potency of *J. curcas* oil on insects decreases with an increase in dilution. The significant increase in the yield of cowpea grains is an indication that both *A. indica* and *J. curcas* oils can be effectively used in the management of *A. craccivora* of cowpea by farmers to increase the productivity of cowpeas in Nigeria.

CONCLUSION

The research showed that seed oil extracts of *J. curcas* and *A. indica* were able to control *A. craccivora* in cowpea fields. The increase in the concentration of the oil extract resulted in a corresponding increase in the yield of cowpeas with a 3 per cent concentration of *J. curcas* and *A. indica* oils resulting in the highest yield. *Jatropha curcas* oil was found to be relatively more effective and can be compared favourably with Lambda-cyhalothrin.

RECOMMENDATIONS

It is hereby recommended that:

- (i) A 3 % concentration of seed oil extracts of *A. indica* and *J. curcas* could be applied to cowpea for maximum cowpea grain yield.
- (ii) *Jatropha curcas* and *A. indica* are effective bio-insecticides in the management of *Aphis craccivora* of cowpea and can serve as replacements for synthetic insecticides that

are currently being used for controlling this pest.

(iii) The application of *Jatropha curcas* oil extract at 3 % concentration is recommended for a higher yield of cowpea grains.

(iv) There is increasing competitive demand for the *J. curcas* plant and as such urgent farmer enlightenment for increased cultivation of this plant because of its enormous potential for agricultural (biopesticides, feeds), biodiesel, and other industrial, medical and environmental purposes.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

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