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Insecticidal activity of some botanical extracts against legume flower thrips and legume pod borer on cowpea *Vigna unguiculata* L. Walp

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Abstract

Background: Insect pests infestation is one the major constraints to cowpea production in many Sub-Saharan Africa including Nigeria. Control of these pests by farmers has been vastly by use of chemical pesticide which possesses lots of threats to human health and environments. This study is aimed at evaluating insecticidal efficacy of petroleum ether seed extracts of four plants (*Azadirachta indica*, A. Juss, *Piper guineense* Schum and Thonn, *Annona muricata* L., and *Jatropha curcas* L.) against legume flower thrips, *Megalurothrips sjostedti* Tryb., and legume pod borer, *Maruca vitrata* Fab. on cowpea as alternative eco-friendly options for the control of the cowpea field pests.

Methods: The extracts were applied at the rate of 10 ml/l of water at 1 week intervals for 6 weeks starting from 7 weeks after sowing (WAS) and replicate three times. The extracts were compared with lambdacyhalothrin at 5 ml/l of water as a standard check and untreated control.

Results: The results showed that all the treatments significantly ($p < 0.05$) reduced the population of legume bud thrips and legume pod borer compared to control. *A. muricata* followed by *Piper guineense* significantly ($p < 0.01$) reduced the population of legume flower thrips and legume pod borer as well as pod damage compared to other extracts. The percentage reduction of *M. sjostedti* and *M. vitrata* population by the extracts ranged from 52.07–69.28% and 57.78–78.52% respectively compared to control. Cowpea yield was significantly ($p < 0.05$) higher in plots treated with *A. muricata* and *Piper guinense* compared to other extracts. The efficacies of *A. muricata* and *P. guineese* were significantly ($p < 0.05$) higher than lambdacyhalothrin for the control of legume flower thrips and legume pod borer of cowpea.

Conclusion: Petroleum ether seed extracts of *A. muricata* and *P. guineense* were very potent against legume flower thrips and pod borer, and thus they can be effectively used by smallholder farmers for the management of cowpea post flowering pests. These plant products are readily available, environment friendly, and are suitable for low-income agriculture practiced in developing countries.

Keywords: Cowpea, Biopesticides, *Maruca vitrata*, *Megalurothrips sjostedti*, Pest management

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Background

Cowpea (*Vigna unguiculata* L. Walp) is one of the major grain legumes that are widely cultivated in semiarid areas of subtropics and tropics for human and animal consumption (Singh & van Emden, 1979). Cowpea is identified as vegetable meat due to high amount of protein in the grain with better biological value on dry weight basis (Owolabi, Ndidi, James, & Amune, 2012).

World production of cowpea was estimated to be 2.27 million tons of which Nigeria produces about 850,000 tons (Adaji, Olufala, & Aliyu, 2007; FAO, 2002). Cowpea production in Sub-Saharan Africa accounts for more than 94% of the world production (FAOSTAT, 2011). About 90% of the world cowpea is produced in West Africa with 4,525, 891 tons of dried grains harvested within an annual area up to 12 million hectares (FAOSTAT, 2014). Cowpea is highly significance to the livelihoods of millions of relatively poor people in less developed and developing countries of the tropics (FAO, 2002).

Insect pests contribute up to 70% grain yield reduction in cowpea (Alghali, 1992; Edema, R.& Adipala, E., 1996), the most vital field insects among them being *Aphis craccivora* Koch., *Megalurothrips sjostedti* Trybom, *Maruca vitrata* Fabricius, and a complex of pod-sucking bugs especially *Clavigralla tomentoscollis* Stat. and *Riptortus dentipes* Fab. (Karungi, Adipala, Nampala, Ogenga-Latigo, & Kyamanywa, 2000b). According to Malgwi and Onu (2004), the most important and prevalent field insect pests of cowpea in Nigeria are aphids (*Aphis craccivora* Koch.), legume flower thrips (*Megalurothrips sjostedti* Trybom), legume pod borer (*Maruca vitrata* Fab), spiny brown bug (*Clavigralla tomentosicollis* Stal.), flower beetle (*Mylabris* species), leaf-footed plant bug (*Leptoglossus australis* F.), and foliage beetle (*Ootheca mutabilis* Sahib).

Maruca vitrata (Lepidoptera, Pyralidae) and *Megalurothrips sjostedti* (Thysanoptera, Thripidae) are among the most damaging pests of legumes (Tanzubil, Tanzubil, 1991, Tanzubil, 2000).

Infestation rate of *Maruca vitrata* can get to 80%, and they causes seed damage of up to 50% if no control measures are administered (Dreyer, Baumgartner, & Tamo, 1994). *M. vitrata* and *M. sjostedti* are significant reproductive pests of cowpea that causes flower abortions and pod setting problems (Tamo, Bottenberg, & Arodekoum, D.& Adeoti R., 1997).

The feeding activities of *M. sjostedti* cause necrosis that subsequently leads to shading of cowpea flowers and buds. The cowpea yield losses due to *M. sjostedti* infestation are estimated at between 20–70% (Edema, R.& Adipala, E., 1996; Rusoke & Rubaihayo, 1994; Singh & Allen, 1980).

Management of insect pests of cowpea is mainly by used chemical insecticides for a very long period of which it has been reported to be very effective by several authors (Jackai, Singh, & Raheja, A.K.& Wiedijk, K., 1985). Control of legume pod borer damage is mainly by timely application insecticides, but their effectiveness is hindered by the tight larval webbing that reduces pesticide exposure (Grigolli, Lourenção, & Avila, 2015). In Nigeria, two applications of lambdacyhalothrin or cypermethrin in combination with dimethoate were reported to be very cost effective for controlling legume pod borer and improving cowpea yield (Amatobi, 1995). Similarly, control of legume flower thrips is mainly by use of chemical insecticides like deltamethrin, malathion, monocrophos, pirimiphos-methyl cypermethrin, dimethoate, and lambdacyhalothrin which mostly reduces infestation and distinctly increase crop yields (Ekesi, Maniania, Onu, & Löhr, 1998).

However, these chemical insecticides have several detrimental effects to non-target organisms, human health, and the environment (Soomro, Seehar, Bhangar, & Channa, 2008). These detrimental effects of chemical pesticides include pesticide residues in the agricultural products, increase of human and livestock poisoning incidents, pesticide resistance of pests, reduction of natural enemy, and disruption of ecological balance.

Mindfulness about the food safety and consequences of the toxic effects of synthetic pesticides in food production have increased the demand for organically produced food, which demands evaluating the concert of biopesticides as safer alternatives to synthetic insecticides (Akbar, Haq, Parveen, Yasmin, & Sayeed, 2010). Plant extracts present a vast practically untapped reservoir of chemical compounds with many potential uses.

Many plant parts have been screened for their insecticidal and antimicrobial properties (Anyaele, Amusan, Okorie, & Oke, 2002; Musa, Dike, Amatobi, & Onu, 2007). The idea of replacing synthetic insecticides with biopesticides is now a collective acceptable and realistic approach in pest management worldwide (Logan, Cowie, & Wood, 1990). Several plants have been found effective for control of crop pests in various trials worldwide (Saxena, 1989; Schmuttere, 1990), and most them were found effective on stored pests (Ivbijaro, 1983; Oparaeke, Dike, & Onu, 1998; Sowunmi & Akinnusi, 1983; Ugwu, 2016; Ugwu, Omoloye, & Obasaju, 2012) and in some field insect pests (Oparaeke, 2006). The use of botanicals pesticides for pest management is being advocated due to several advantages they have over chemical pesticides. These include the following: they possesses less pollution to the environment; have many insecticidal properties with special modes of action which makes it difficult for the pests to develop pesticide resistance; have low toxicity to human, livestock, and natural enemies; and have relatively low-cost production and use.

Thus, this study investigated the efficacy of extracts from four plant seeds in Nigeria against of cowpea flowers thrips and legume pod borer on cowpea under rain fed conditions.

Materials and methods

Experimental site

The study was carried out at the experimental farm of Federal College of Forestry, Jericho, Ibadan, Oyo State, during the 2017 planting season. Ibadan is located within latitude 7° and 9° N longitude 3° and 58° E of Greenwich Meridian Time (GMT) with annual rainfall of about 1300 to 1500 mm and average relative humidity of about 80 to 85% (FRIN, 2014).

Collection of the plant materials for extraction

Plant seeds of *Azadirachta indica*, *Annona muricata*, *and Jatropha curcas* were collected from the Forestry Research Institute of Nigeria, Jericho-Ibadan, while *Piper guineense* seed was purchased from a local market in Ibadan. The samples were air-dried on side benches in the laboratory for 2 weeks and pulverized with a high-speed mill for subsequent use for the extraction. The pulverized plant seeds were weighed out in 100 g each, and Soxhlet extracted separately using petroleum ether for minimum of 8 h according to the methods by (Ofuya et al. 1992).

Land preparation and planting/sowing

The experimental plot measuring 24 m × 12 m was manually cleared with cutlass and hoe and allowed to stand for 14 days before rigging in 1 m apart. Poultry manure was applied at rate of 2.5 t/ha as a basal treatment. Six plots measuring 3 m × 1 m were marked out in three replicates using randomized block design. Each plot consisting of three ridges of 1 m × 0.5 m was separated by 1 m wide border along the ridge. Cowpea variety "Ife brown" collected from Institute of Agricultural Research and Training (IAR&T) were sown at the spacing of 50 cm × 50 m at planting rate of 3 seeds per holes. The seedlings were thinned to 2 plants per planting hole 2 to 3 weeks after sowing (WAS).

Application of treatments

Spraying of extracts and synthetic insecticides commenced 7 weeks after sowing (WAS) at (the initiation of cowpea flowering) weekly interval. The seed extracts were applied at the rate of 10 ml per liter of water using hand sprayer and synthetic insecticide (lambdacyhalothrin) which was used as a standard check was applied at the rate of 2.5 ml/l of water. A liquid soap (2.5 ml) was added to the mixed extracts to enhance the adhesion of insect before spraying while control plot was left unsprayed. The sprayer was rinsed with profuse amount of water after each treatment application to avoid contamination. Manual weeding was done at five to six WAS to ensure a weed free condition.

Data collection and analysis

Legume pod borer, *M. vitrata* larvae, was sampled before each spray early in the morning between 7:00 and 8:00 a.m. by randomly picking of 20 flowers from plants within the three ridges per each plot. The flowers were placed in 25-ml vial containing 30% ethanol and taken to the laboratory where they were dissected the next day, and the number of *M. vitrata* was counted. Legume flower thrips, *M. sjostedti*, were also determined by counting the number of adults and larvae in open flowers collected at 7-day intervals before application of the extracts. A total of 20 randomly selected flowers were sampled between 8:00 a.m. and 10:00 a.m. on the two-edge rows of each replicate plot to avoid disturbance of thrips and placed together into a 25-ml plastic vial in 30% alcohol as described by Oparaeke (2006).

The number of flowers used was a realistic sample size for statistical analysis according to (Tamo et al. 1993). Cowpea pod damages were also assessed at 10 WAS when the pods have attained 75–85% physiological maturity by observing the constricted pods.

Cowpea pods were harvested dry per plot and weighed. Data collected were subjected to analysis of variance, and significant means were separated using Duncan multiple range test (DMRT).

Results

Effect of treatments on the population of legume flower thrips

Extracts from the different plant seeds tested excreted different level of efficacy on legume flower thrips. *Annona muricata* seed extracts were the most effective in reducing the population of legume flower thrips with mean value of 10.90/20 flowers in 1 year of investigation (Fig. 1).

A. muricata significantly ($p < 0.01$) reduced the thrips infestation more than other treatments. This was followed by *P. guineense* with mean value of 14.30/20 flowers. There was no significant difference between *A. muricata* and *P. guineense* in reducing the population of legume flower thrips. *A. muricata* and *P. guineense* significantly reduced higher population of flower thrips on cowpea than lambdacyhalothrin while the efficacy of *A. indica* and *J. curcas* was not significantly different ($p > 0.05$) from lambdacyhalothrin in reducing the infestation of flower thrips on cowpea. All the extracts significantly ($p < 0.01$) reduced the cowpea flower thrips infestation compared with the untreated control.

Effect of treatments on the population of legume pod borer on cowpea

The insecticidal efficacy of the tested seed extracts against cowpea pod borer followed similar trend with that of legume flower thrips (Fig. 2). *A. muricata* was the most effective in reducing the population of legume

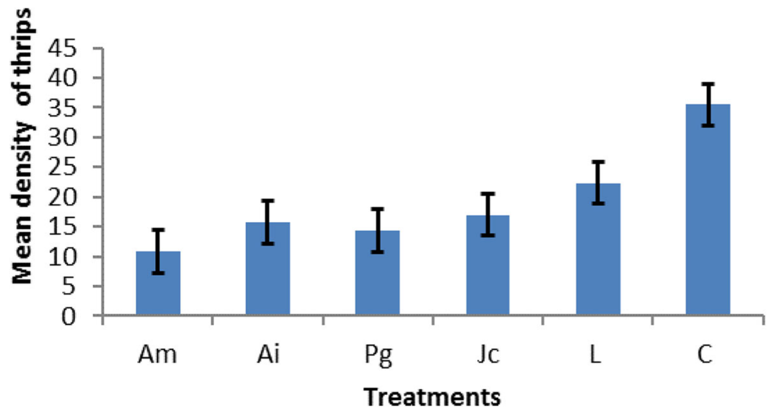

Fig. 1 Effect of treatments on the population of legume flower thrips. Mean values are the number of adult and larvae of flower thrips observed in 20 flowers sampled per plot per week during the flowering period of the cowpea from different plots treated with different botanicals. Am, plot treated with *Annona muricata*; Ai, plot treated with *Azadirachta indica*; Pg, plot treated with *Piper guineense*; Jc, plot treated with *Jatropha curcas*; L, lambdacyhalothrin; C, control (no treatment)

flower thrips, followed by *P. guineense.* There were significantly ($p < 0.05$) lower population of legume pod borer in plots treated with *A. muricata* and *P. guineense* extracts than plots treated with other extracts. *A. muricata* and *P. guineense* extracts significantly ($p < 0.01$) lowered the population of legume pod borer more than other extracts and lambdacyhalothrin. All the extracts significantly ($p < 0.05$) reduced the population of legume pod borer compared with untreated control.

Effect of treatments in reducing legume flower thrips and pod borer population

The mean population and percentage reduction of legume flower thrips and pod borer is shown in Table 1.

A. muricata reduced infestation of legume pod borer and flower thrips by 69.24% and 78.52 % respectively when compared to control. All the extracts were more effective than lambdacyhalothrin in reducing pod borer and flower thrips population. The populations of the legume pod borer and legume flower thrips were minimized by the extracts by more than 50% when compared with control.

Effect of treatments on the number of cowpea pod damage

The result reveals that extracts evaluated were effective in reducing cowpea pod damage due to insect pests infestation (Fig. 3). Plots sprayed with *A. muricata* recorded lower number of damaged cowpea pods, followed by plots sprayed with *P. guineense* extracts. The efficacy of *A.*

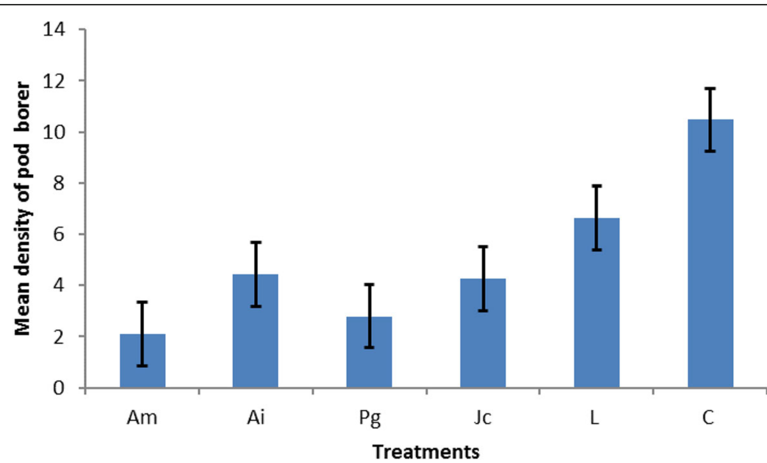

Fig. 2 Effect of treatments on the population of legume pod borer on cowpea. Mean values are the number of legume pod borer larvae observed in 20 flowers sampled per plot per week during the flowering period of the cowpea from different plots treated with different botanicals. Am, plot treated with *Annona muricata*; Ai, plot treated with *Azadirachta indica*; Pg, plot treated with *Piper guineense*; Jc, plot treated with *Jatropha curcas*; L, lambdacyhalothrin; C, control (no treatment)

Table 1 Mean population and percentage reduction of legume flower thrips and pod borer

Treatments	Mean population of legume flower thrips	Mean population of legume pod borer	Percentage (%) reduction of population of flower thrips compared to control	Percentage (%) reduction of population of pod borer compared to control
Annona muricata	10.90c	2.09e	69.28	78.52
Azadirachta indica	15.80bc	4.42c	55.48	57.78
Piper guineense	14.30c	2.80de	59.70	73.26
Jatropha curcas	17.01bc	4.28cd	52.07	59.12
Lambdacyhalothrin	22.36b	6.63b	37.00	36.68
Control	35.49a	10.47a	100	100

Means values followed by the same letter within the column are not significantly different by DMRT

muricata and *P. guineense* in reducing the cowpea pod damage was significantly ($p > 0.05$) higher than all the extracts and lambdacyhalothrin. All the extracts significantly ($p > 0.01$) reduced the cowpea pod damage compared with untreated control.

Effect of treatments on the dry weights of cowpea pod

The effect of the treatments on cowpea yield is shown in Fig. 4.

The number of pods produced per plant was significantly greater ($p < 0.05$) in plots sprayed with *A. muricata*, followed by *P. guineense* with mean values of 173.8 g and 168.2 g, respectively. Plots treated by these two extracts also gave higher grain yields than those of *A. indica* and *J. curcas*. The untreated check gave the lowest yield during the study, although the plots treated with synthetic insecticide (lambdacyhalothrin) recorded lower pod yield than the extracts used.

Discussion

The results of this study have ascertained the potential of the four plant extracts tested in controlling *M. vitrata and M. sjostedti* on cowpea plants. *A. muricata* proved higher efficacy over other extracts against *M. vitrata* and *M. sjostedti* indicating its high potential as biopesticides. This finding is in line with Lala et al. (2014) who reported that the aqueous and oil extracts of *Annona squamosa* and *Annona muricata* were effective against *Aedes albopictus* and *Culex quinquefasciatus* at varying levels of application. Riser (1996) also confirmed the efficacy of *Annona muricata* plant extracts for the control of field insect pests of cowpea .Similarly, Jaramilloa, Arangoa, and Gonzalezb (2000) reported that *A. muricata* exhibited significant antifeedant, pesticidal, anticancerous, anti-tumorous, and anti-viral properties in their studies. Ishuwa, N. Elkanah, and Wahedi (2016) also reported that *A. muricata* was very effective against *Callosobruchus maculatus* on stored cowpea.

The efficacy of *Annona muricata* extract was higher than lambdacyhalothrin for the protecting cowpea against *M. vitrata* and *M. sjostedti* in this study. This result supports the findings of Padma, Pramod, Thyogarajan, and Khosa (1998) who stated that *Annona muricata*-based products were more effective than synthetic insecticides in the control of different order of insect pests. The bioactivity of *Annona muricata* has been attributed to various

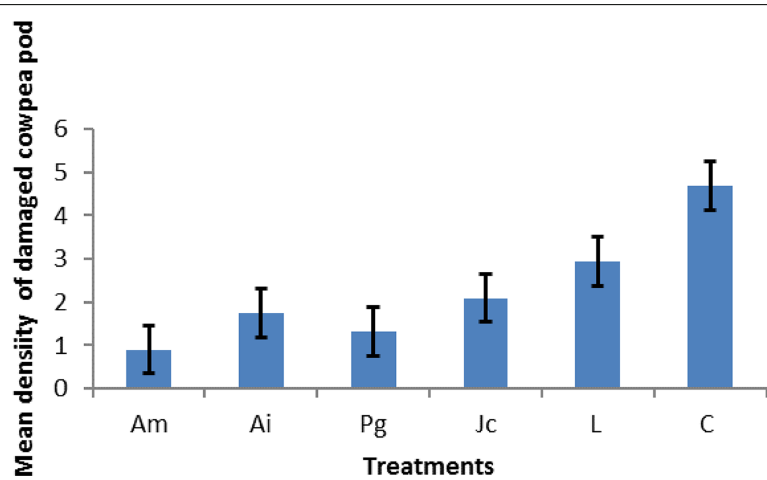

Fig. 3 Effect of treatments on the number of damaged cowpea pod. Mean values are the number damage cowpea pod observed from different plots treated with different botanicals. Am, plot treated with *Annona muricata*; Ai, plot treated with *Azadirachta indica*; Pg, plot treated with *Piper guineense*; Jc, plot treated with *Jatropha curcas*; L, lambdacyhalothrin; C, control (no treatment)

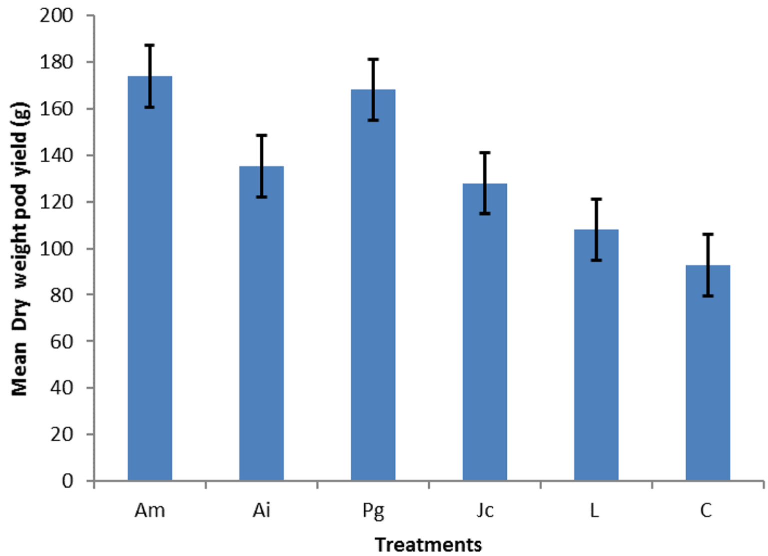

Fig. 4 Effect of treatments on the dry weights (gram) of cowpea pod. Mean values are the dry weight of cowpea pod harvested from different plots treated with different botanicals. Am, plot treated with *Annona muricata*; Ai, plot treated with *Azadirachta indica*; Pg, plot treated with *Piper guineense*; Jc, plot treated with *Jatropha curcas*; L, lambdacyhalothrin; C, control (no treatment)

chemical compounds which include Annonaceous acetogins, muri-catenol, annomuricatin, javoricin, montanacin, monte-cristin, coronin, and donhexocin numbering over 50 which prevents development of insect pests (Jaramilloa et al., 2000). According to Lala et al. (2014), extracts of *A. muricata* and *A. squamosa* contain alkaloids and flavonoids compounds that perhaps confer their biological insecticidal proprieties.

The efficacy of *P. guineense* was very close to *A. muricata* against *M. vitrata* and *M. sjostedti* showing no significant difference between the two. This corroborate the finding by Oparaeke, M. Dike, and Amatobi (2005) who informed that direct spraying of *P. guineense* extracts against *Clavigralla tomentosicollis* and *Maruca* larvae on cowpea plants caused illusion on them at first and followed by killing them within 10–15 min of contact with the extracts. Several past workers have reported the efficacy of *P. guineense* extracts on stored insect pests. Idoko and Adesina (2012) conveyed that sole plant powders application of *P. guineense* caused adults mortality, suppressed oviposition by female beetles on cowpea grains, and F1 progeny emergence of *Callosobruchus maculatus*. Fasaki and Aberejo (2002) also reported that pulverized plant material from *P. guineense* inhibited egg hatchability and adult emergence of *Dermestes maculatus* Degeer in smoked catfish (*Clarias gariepinus*) during storage. A similar report was given by Golob, Moss, Males, Fidgen, and Evans (1999) that *P. guineense* powder, oil and hexane, and acetone extracts are effective in causing mortality and reducing oviposition of various insects when applied to cowpea and maize crops.

A. indica was also found very effective in reducing legume pod borer and legume flower thrips infestation in this study. This finding is also in line with several reports on the insecticidal properties of *A. indica*. Ivbijaro and Bolaji (1990) reported that *A. indica*-based products were more effective than synthetic insecticides for the control of aphids and white flies. Schmutterer (1995) established the potential of products from *A. indica* for the control of field insect pests of eggplant and okra. Adedire and Lajide (2000) reported that *A. indica* plant has developed highly intricate chemical fortifications against insect attack, and they have therefore provided a rich source of biologically active chemical compounds which are highly potent in protecting crops against pests. According to Ascher (1993), *A. indica* (neem) derivatives provide broad spectrum control of over 200 species of phytophagous insects. Ojo and Ugwu (2012) also reported that ethanol seed extracts of *A. indica* were very effective in controlling insect pests of *Adansonia digitata* L. (Baobab) seedlings.

Jatropha curcas was also found effective in reducing the infestation of legume pod borer and flower thrips population in this study. This supports the earlier report on the insecticidal properties of *J. curcas*. Salimond and Abdullah (2008) reported *Jatropha curcas* possess insecticide or antifeedant properties that affect various insects families. Ugwu, Umeh, and Omoloye (2017) reported that *J. curcas* seed extracts proved effective in reducing the population of *M. vitrata* on cowpea under rain fed condition. Several authors reported the insecticidal properties of *J. curcas* extracts against stored insect pest. Sabbour and Abd-El-Raheem (2013) informed that *Jatropha curcas* oil deterred oviposition and adversely influence fecundity of *Callosobruchus maculatus* (F.) and *Callosobruchus chinensis* (L.).

Similarly Habou et al. (2014) reported that *J. curcas* seeds' oil was toxic to the adults of *C. maculatus* and *Bruchidius atrolineatus* and reduced adult survival and oviposition by 85 to 90% in the females of both species.

The plant extracts evaluated in this study were observed to be more effective than lambdacyhalothrin (synthetic chemical) in this study. This confirmed the report of Basedow, Obiewatsch, Bernal Vega, Kollmann, and Nicol (2002) which stated that *A. indica*-based products were more effective than synthetic insecticides for the control of aphids and white flies. Similarly, Ojo and Ugwu (2012) reported that *A. indica* seed extracts were more effective than synthetic insecticides in controlling the insect pests of *Adansonia digitata* seedling in the field.

Conclusion

Extracts from *A. muricata*, *P .guineense*, *A. indica*, and *J. curcas* were found to be effective in controlling legume pod borer and flower thrips on cowpea. However, *A. muricata and P. guineense* extracts were more effective than other extracts and lambdacyhalothrin for the control of *M. vitrata and M. sjostedti.* All the extracts significantly reduced legume pod borer and flower thrips infestation and enhanced cowpea yield compared to untreated control. These extracts at 10 ml/1 l were more efficacious than lambdacyhalothrin at 5 ml/10 l in controlling legume pod borer and flower thrips on cowpea. These plants are widely available, cheap, and easy to extract in crude forms; consequently, farmers should adopt their uses for the management of insect pests in order to curtail human and environmental hazards associated with the use of synthetic insecticides and to reduce cost of purchase.

Abbreviations

FAO: Food and Agricultural Organization; FAOSTAT: The Food and Agriculture Organization Corporate Statistical Database; FRIN: Forestry Research Institute of Nigeria; GMT: Greenwich meridian time; IAR&T: Institute of Agricultural Research and Training; WAS: Weeks after sowing

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Author's contribution

Ugwu Juliana Amaka conceptualized and designed the work; collected, analyzed, and interpreted the data; and drafted and edited the manuscript. The author read and approved the final manuscript.

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Competing interest

The author declares no competing interests.

Ethics approval and consent to participate

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Consent for publication

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