

The Role of Ethanolic Extracts of Leaves and Roots of *Lantana camara* (L.) in the Management of Pests of Okra *Abelmoschus esculentus* (L.) Moench

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How to cite this paper: Baidoo, P.K., Adu, E. and Peprah, S. (2017) The Role of Ethanolic Extracts of Leaves and Roots of *Lantana camara* (L.) in the Management of Pests of Okra *Abelmoschus esculentus* (L.) Moench. *Advances in Entomology*, 5, 99-108. <https://doi.org/10.4236/ae.2017.53010>

Received: March 29, 2017

Accepted: July 18, 2017

Published: July 21, 2017

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Abstract

The cultivation of many crops in Africa is negatively affected by a number of constraints, the most important of which is the incidence of pests and diseases. In many areas of the world, the most preferred option in the management of pests is the application of synthetic chemical pesticides. Due to the negative effects of pesticides on humans and the environment as a whole, efforts are being made to find alternatives for pest management. Ethanolic extracts of the leaves and roots of *Lantana camara* were tested against the major pests of okra, *Abelmoschus esculentus*. The plant extracts were compared with a standard chemical insecticide, Mektin (a.i 18 g/L abamectin) in a randomly complete block design with four treatments and three replications. Parameters studied included the major pests of the plant and the damage caused, leaf area, plant height as well as yield of okra. Cotton aphids, *Aphis gossypii*, the tobacco whitefly *Bemisia tabaci* and the cotton flea beetle, *Podagrica puncticollis* were the major pests encountered on okra plants. *Aphis gossypii* and *B. tabaci* populations were significantly lower on the *L. camara*-sprayed plots compared with the control plots. Similarly, *P. puncticollis* numbers were significantly smaller on the *L. camara*-sprayed plots than the control plots. There were no significant differences between the treatments and the control for plant height, leaf area and yield. The significant reduction in pests numbers on the *L. camara*-sprayed plots indicates its potential as an alternative to chemical insecticides, thereby reducing the reliance on chemical insecticides in the management of insect pests.

Keywords

Abamectin, *Abelmoschus esculentus*, *Bemisia tabaci*, Insecticides, Lantadene

1. Introduction

Okra, *Abelmoschus esculentus* (L.) Moench, is a vegetable crop belonging to the Malvaceae family. The crop is widely cultivated in West Africa for its fresh green pods. It is one of the most cultivated vegetable crops in Ghana where it is mainly used in preparing soups and stews. According to Oppong-Sekyere *et al.* [1] this vegetable is mostly found fresh during the rainy season but in dry and dehydrated form during the dry season. Okra is an important component in the diets of many African countries because it is rich in vitamins A, B and C as well as proteins, carbohydrates and fats [2]. Its antioxidant properties make okra a very important vegetable crop [3].

The high nutritional value and importance of okra in the diets of many Ghanaians has resulted in its widespread cultivation. Several factors, however, limit the increased production of this vegetable crop. These include poor soil quality and low rainfall, but most importantly, the incidence of diseases and pests [4]. These insect pests attack the plant from the seedling stage to fruit formation. Okra plants are subject to attack and damage by the cotton flea beetle, *Podagrica puncticollis*, Weise, cotton aphid, *Aphis gossypii* Glover and tobacco whitefly, *Bemisia tabaci* Gennadius [4] [5]. *Podagrica puncticollis* and *P. uniforma* Jac. infest okra plants at the seedling stage through to the flowering and fruit formation stages, causing damage through their feeding activities. Flowers and maturing pods are attacked by various species of *Earias*, including *E. vetella* Fab. [4] and *E. insulanaa*, Boisd. [6]. Other insect pests such as the gram pod borer, *Heliothis armigera* Hübner prefer the reproductive parts of the plant such as the buds, flowers and fruits.

The destructive effects of insect pests on okra require the application of pest control strategies to limit the effects of these pests below economic damaging levels. Chemical insecticides have been used extensively in the management of insect pests on crops, with varying degrees of success. Continuous use of chemical insecticides can affect the health of humans, contaminate the environment and have negative effects of beneficial animals such as bees, earthworms and termites. According to Lewis *et al.* [7] the major problems associated with the use of conventional pesticides are toxic residues, pest resistance, emergence of secondary pests and pest resurgence. Therefore the use of natural pesticides has become necessary because they are specific and environmentally friendly.

Plant extracts, commonly called botanicals are secondary plant products synthesized by plants to protect them from pests, herbivores and diseases. Extracts from many plants have been used to protect cultivated crops from insect pest attack. Three of the best-known plants with pest control properties are *Azadirachta indica* (A. Juss), *Melia azedarach* (L.) and *Lantana camara* (L.). Extracts from mature fruits of *M. azedarach* showed insecticidal effects against mulberry whiteflies *Tetraleurodes mori* Quaintance [8]. Similarly, extracts from the leaves of *L. camara* have been shown to exhibit antimicrobial, fungicidal, insecticidal and nematocidal activities [9]. Even though *L. camara* contains many chemicals with insecticidal properties, the principal insecticidal agents in *L.*

camara are Lantadene A and Lantadene B. These allelopathic chemicals are present in the leaves, stem, roots and flowers of the plant [10]. According to Dua *et al.* [11] these phytochemicals have negative effects on a variety of living things such as microbes, insects and plants. Even though many plants have been shown to possess pesticidal properties, many of these have not been fully exploited and utilized to manage insect pests. The study therefore evaluated ethanolic extracts of the leaves and roots of *L. camara* in the management of major pests of okra, *Abelmoschus esculentus* and how they affected plant growth parameters and the yield of the plant.

2. Materials and Methods

2.1. Study Area

The study was conducted in the experimental farm of the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, between November 2015 and March 2016. The study area lies within latitude 06°41'N and longitude 01°33'W and in the forest region of Ghana. The area has bimodal rainfall, with peaks in May/June and September/October. Average annual rainfall ranges from 72 cm to 166 cm with annual maximum and minimum temperatures ranging from 31°C to 34°C and 20°C to 23°C respectively [12]. The soil type is sandy loam and the topsoil is about 30 cm deep. The area was previously used for the cultivation of other vegetable crops such as cabbage, lettuce, tomato and eggplant.

2.2. Experimental Design

The experiment was conducted in a randomized complete block design involving 4 treatments, *L. camara* root extract, *L. camara* leaf extract, chemical insecticide, Mektin (a.i 18 g/L abamectin) and a control, each of which was replicated 3 times.

2.3. Preparation of *L. camara* Extracts

Roots and leaves of *L. camara* were harvested and washed with water. They were dried in the shade for 7 days to prevent photo-oxidation of the active ingredients. Dried leaves and roots were milled separately into fine powder. Using the cold extraction method, 2 L of ethanol was added to each plant part in a conical flask and placed on mechanical shaker and shaken for 12 hrs. The extracts were filtered under suction and concentrated in a rotary evaporator. The extracts were stored in a brown bottle in a cupboard, away from light.

2.4. Planting of Okra Seeds

Okra seeds (var. Asontem) were obtained from the Horticulture Section of Crops' Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR), Kwadaso Kumasi. This is a high-yielding variety which is already cultivated by local farmers. Sixteen plots each measuring 6 m × 4 m were raised; each plot had 40 plant stands with 10 rows and 4 columns. Okra seeds were

sown at 2 per hole; the spaces between the columns were 50 cm. Planting spaces within a column were 50 cm. Two weeks after germination, when the seedlings were well established, the seedlings were thinned to one seedling per hill. Three weeks after germination, *L. camara* extracts and the chemical insecticides were applied onto the plants. *Lantana camara* leaves and root extracts were applied at a rate of 50 ml/L; Mektin at the recommended rate of 20 ml/L. Second and 3rd applications were done 3 and 6 weeks after the first one. The control plants were sprayed with water.

2.5. Data Collection

Data collection commenced 1 week after the first spraying. Sampling was done between 6:00 am and 9:00 am when the insects were least active. The simple random sampling was used to sample 10 infested plants from each plot. The leaves and stem were carefully examined for the presence of insect pests. Aphids and whiteflies infestations were assessed by using a visual scoring rating from 0 - 5; 0-no whiteflies or aphids; 1-few individuals; 2-few isolated small colonies; 3-several small colonies; 4-large isolated colonies; 5-large continuous colonies [13].

Other insects were sampled into labelled Kilner jars, the mouths of which were covered by nylon mesh and secured with a rubber band. Each insect species was identified, counted and their numbers were recorded. Data collection continued for 9 weeks after the first spraying.

2.5.1. Growth Parameters

Leaf area was measured by plucking 5 leaves from 5 randomly selected plants, traced on a graph sheet and the leaf area was calculated; boxes on the graph sheet partially covered were counted as half. Mean leaf area for each plot was calculated as well as that for each treatment.

2.5.2. Plant Height

Ten plants were randomly selected from each plot and their heights, from the surface of the soil to the tip were measured using a tape measure. This was done when the plants were 8 weeks old. Mean plant height on each plot was calculated and the mean for each treatment was calculated and recorded.

2.5.3. Yield Assessment

Fresh fruits were harvested 2 times a week continuously for five weeks. Harvested fruits were placed in labelled envelopes and weighed using a top pan balance. The mean weights for each treatment was calculated and recorded.

2.6. Data Analysis

Data obtained were subjected to the GLM procedure of SAS [14]. Analysis of variance was performed on the parameters studied. Where the differences were significant, the means were separated using Tukey's Honest Significant Difference (HSD) test. Significant difference was set at $P \leq 0.05$.

3. Results

During the vegetative and fruit formation stages of okra, a number of insect pests were sampled on the plant, causing varying degrees of damage.

3.1. *Aphis gossypii*

Aphis gossypii was the first to be identified on the plants 2 weeks after germination. This insect was found on all the plots; however, 1 week after the application of the plant extracts and the chemical insecticides, their numbers were significantly reduced, except on the control plots, which recorded a mean score of 3.13. The insecticides-sprayed plots recorded the least score of 1.05 ($P = 0.001$). Infestation by *A. gossypii* on *L. camara* leaf and root extracts-sprayed plants did not differ significantly (Table 1).

3.2. *Bemisia tabaci*

The whitefly, *Bemisia tabaci*, was another major pest encountered on okra plants. It appeared in clusters on the lower surfaces of the leaves, away from the effects of direct sunlight. Infestation of okra plants by *B. tabaci* was observed during the 3rd week of growth, remaining on the plants throughout the period of growth. The control plants recorded the largest score, with the least score recorded on the insecticide-sprayed plots ($P = 0.001$). *Lantana camara* leaves and root-sprayed plots recorded *B. tabaci* scores which were not significantly different from each other (Table 1).

3.3. *Podagrica puncticollis*

The flea beetle *Podagrica puncticollis* was observed on the plants 5 weeks after germination, even though their numbers were low on all the plots. The population of this pest reached its peak in numbers 8 weeks after germination, remaining relatively high throughout the subsequent period of growth. *P. puncticollis* numbers on the insecticide-sprayed plot and *L. camara*-sprayed plots were not significantly different, but all three recorded values that were significantly lower than the control plots.

3.4. Other Insect Pests

Other insects of minor importance were observed on the plants. These include

Table 1. Levels of infestations of okra plants by pests of okra (mean \pm s.e).

Treatment	<i>A. gossypii</i>	<i>B. tabaci</i>	<i>P. puncticollis</i>	<i>Z. variegatus</i>	<i>H. armigera</i>
Abamectin	1.05 \pm 0.20 ^c	1.08 \pm 0.10 ^c	2.14 \pm 0.31 ^b	2.72 \pm 0.24 ^b	0.75 \pm 0.21 ^c
<i>L. camara</i> leaf	1.68 \pm 0.25 ^b	1.42 \pm 0.15 ^b	3.50 \pm 0.44 ^b	3.19 \pm 0.31 ^b	1.44 \pm 0.31 ^b
<i>L. camara</i> root	1.87 \pm 0.30 ^b	1.56 \pm 0.16 ^b	4.03 \pm 0.49 ^a	3.39 \pm 0.36 ^{ab}	1.55 \pm 0.34 ^{ab}
Control	3.13 \pm 0.85 ^a	3.72 \pm 0.85 ^a	6.33 \pm 0.83 ^a	4.75 \pm 0.53 ^a	2.08 \pm 0.45 ^a
<i>P</i> -value	0.001	0.001	0.001	0.001	0.001

Within columns means with same letter are not significantly different $P > 0.05$.

the variegated grasshopper, *Zonocerus variegatus* (L.) and the gram pod borer, *Heliothis armigera*. Even though *Z. variegatus* was found on okra plants they did not cause any significant damage to the plant. The numbers of *Z. variegatus* were largest on the control plots but small on the insecticide-sprayed plots; however, on *L. camara*-sprayed plots and the insecticide-sprayed plots, the numbers were not significantly different (Table 1).

The gram pod borer, *Heliothis armigera* was observed on okra plant at the flowering and fruit formation stages. Feeding activities of this insect resulted in holes on the fruits, making them lose quality and market value. The largest numbers of *H. armigera* were sampled on the control plants while the least was recorded on the insecticide-sprayed plots. Even though significant differences were recorded between the treated plants and the control, no significant differences in the numbers of this insect were recorded between the *L. camara*-root sprayed plots and the control. All three, however, recorded significantly larger numbers than the insecticide-sprayed plots.

3.5. Growth Performance and Yield

Plant height ranged from 1.27 m in the control plants to 1.24 on the insecticide-sprayed plot. The differences were not significant, an indication that application of control measures to manage insect pests' did not have any effect on plant height. Mean leaf area measured was largest in the control plants (60.5 cm²) and least in the insecticide-sprayed plants (58.6 cm²). The differences were not significant. Harvested fruit weight was also not significantly affected by the treatments because no significant differences were observed among the fruit weights (Table 2).

Table 2. Effect of *L. camara* leaves and root extracts on growth parameters and yield of okra. (mean \pm s.e).

Treatment	Plant height (m)	Leaf area (cm ²)	Fruit weight (g)
Mektin	1.24 \pm 0.68 ^a	58.6 \pm 5.00 ^a	313.8 \pm 19.5 ^a
<i>L. camara</i> leaves	1.25 \pm 0.67 ^a	60.1 \pm 5.19 ^a	284.0 \pm 15.5 ^a
<i>L. camara</i> root	1.26 \pm 0.69 ^a	60.2 \pm 5.30 ^a	268.4 \pm 13.8 ^a
Control	1.27 \pm 0.67 ^a	60.5 \pm 5.10 ^a	255.7 \pm 13.7 ^a
<i>P</i> -value	0.991	0.995	0.067

Within columns means with same letter are not significantly different $P > 0.05$.

4. Discussion

Okra and many other vegetable crops are infested and severely damaged by a number of insect pests. The feeding activities of pests significantly reduce the yield and the quality of harvested crops. This has resulted in the application of pesticides to reduce their effects and increase crop yield. Different insect pests were sampled on okra plants at both the vegetative and fruit formation stages. These include foliage feeders such as the whitefly, *B. tabaci* and aphid, *A. gossypii*; these pests have been reported infesting okra plants [15]. The numbers of

both pests were small initially, but increased rapidly due to low rainfall, which favoured their rapid increase. In addition to the negative effects of their feeding on the plants such as denying the plants of manufactured food, *A. gossypii* is the vector for the transmission of the yellow mosaic virus, as reported by Vanlommel *et al.* [16] in their study of the pests of okra. All the plots recorded some levels of infestation throughout the life of the plant, an indication that both the chemical insecticide and *L. camara* extracts could not completely eliminate the pests from the plants. The pests were observed on okra plants at different stages of growth. *Aphis gossypii* infestation was observed 2 weeks after germination. As a result of the feeding activities of this pest some plants, especially those on the control plots had poorly-developed leaves during the early stages of growth, however, it appears that infested plants on the control plots were able to recover from the early infestation resulting in non-significant difference in leaf area among the various sprayed plants and the control. Griffin and Williamson [17] stated that aphid infestation leads to poor leaf development and eventually death of the plant. In our study, however, it appears that the plants were able to tolerate infestation by these pests' because despite the relatively larger *B. tabaci* and *A. gossypii* scores on the control plots, leaf area and yields were not negatively affected. Generally infestation by these sucking pests denies the plants of manufactured food needed for growth and fruit formation leading to reduction in yield.

Like the other insect pests recorded during the study, the control plots recorded the largest *A. gossypii* scores. This pest has been reported as a major pest of okra by several authors [4] [18] [19]. They were found in clusters on the lower side of the leaves where they were shielded from direct sunlight. The small aphid and whitefly scores on *L. camara*-sprayed plots were probably due to the antifeedant property of this plant. This has been reported by Kulkarni *et al.* [20] and Mehta *et al.* [21] as being responsible for its ability to control insect pests on crops. Similar observation was made by Baidoo *et al.* [22] on the management of cowpea pest *Aphis craccivora* using neem, *Azadirachta indica*. The population of *A. gossypii* and *B. tabaci* reduced significantly 8 weeks after germination. The combined effects of the plant extracts and the emergence of natural enemies of such as ladybird beetle resulted in this reduction. In addition, heavy rains that were recorded in the 7th week appeared to have washed them off the leaves.

The cotton flea beetle, *Podagrica puncticollis* has been reported as a pest of many vegetable crops. Infestation by this insect on okra plants caused defoliation of okra leaves as a result of their feeding activities [23]. A related species, *P. uniforma* has also been reported on okra plants [4] [24]. *P. puncticollis* numbers increased rapidly 3 weeks after it was observed on the plant, mainly due to high temperatures and low rainfall during the study period. A study by Fasunnon and Banyo [25] on okra plant revealed that *Podagrica* spp. attacks the lamina of matured okra plant and bore holes in the leaves leading to a reduction in photosynthetic activity and yield. In our study, however, the feeding effects of the various insect pests did not result in significant yield reduction in the control plants compared to the treated plants.

Mean height and mean leaf area on the treated plants and control plants did

not differ significantly. This observation was, however, different from that of Thul *et al.* [26] who reported that application of chemical insecticides increases plant height, leaf area and number of branches of okra plant. It appears that okra plants were able to react positively to the presence of these pests, a case of tolerance which enabled affected plants to produce fruits resulting in non-significant differences in yield among the treated and control plants. Photosynthetic activity is enhanced by larger leaf area; thus defoliation by *P. puncticollis* was expected to reduce photosynthetic activity and yield, as reported by Ahmed *et al.* [27]. This was, however, not the case as yield was not significantly affected by pest infestation and damage. This observation was, however, contrary to that of Obeng-Ofori and Sackey [28] (Ghana) and Ahmed *et al.* [29] (Nigeria), who reported significant yield losses due to heavy defoliation of okra leaves. A similar study conducted by Dabinso-Dabire *et al.* [30] reported that despite heavy infestation of okra plants by *Podagrica* sp. no significant yield loss was recorded in the control plants compared to the treated plants.

5. Conclusion

The use of natural plant products is becoming increasingly popular among many farmers in many developing countries. The consistent and significant reduction in pests' numbers on the *L. camara*-sprayed plots indicated the effectiveness of the plant extracts in reducing pests numbers. In order to minimize the negative effects of synthetic pesticides on crops and the environment, *L. camara* and other plants with pesticidal properties can be considered as alternatives to chemical pesticides. These botanicals will be of importance to the average resource-poor farmer in many areas of developing world where synthetic pesticides and application equipment may not be readily available.

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