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Efficacy of Water Soaked Neem (*Azadiarachta indica*) Leaf Filtrate on Three Insect Pests on okra [*Abelmoschus esculentus* (L.) Moench] Plants

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Abstract

This study investigated the efficacy of neem leaf filtrate on three insect pests of okra in a garden at Winneba, Ghana. In this experiment the garden was demarcated into two equal halves where one half was used as the experimental area whereas the other half used as the control area. Filtrate of 500g of neem leaves soaked in 40 litres of pipe born water left for two weeks was used in spraying okra plants in the experimental area while five litres of ordinary water was used to spray the control area. Ten plants from each area were selected and labelled and the number of Aphis (*Aphis gosspii*), Thrips (*Thrips spp.*) and whiteflies (*Bemisia tabaci*) which are common okra insect pests in the area monitored on these plants. Means calculated were compared using t-test and two-way analysis of variance at 0.05 probability. Whiteflies (*Bemisia tabaci*) were the most abundant (48.53%) and the differences among the total numbers for the three insect pests were significant ($P<0.05$). There were significant differences among the means for the control and experimental groups ($F = 110.15$, $df = 1, 36$; $P<0.05$). The findings suggest that neem leaf filtrate was effective in reducing the population of the three insect pests on okra. Therefore, neem leaf filtrate may be useful alternative in controlling *Aphis gosspii*, *Thrips* spp. and whiteflies (*Bemisia tabaci*) on okra.

Keywords: filtrate, okra, neem leaf, garden, insect pests

1. Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] (also known as *Hibiscus esculentus*) commonly known as okro in Ghana belongs to the family Malvaceae (Yohanna, *et al.*, 2022). It is an annual vegetable crop cultivated in tropical and sub-tropical regions of the world (Ajayi *et al.*, 2017; Boateng *et al.*, 2019). It can be grown in a garden or on large commercial farms (Rubatzky & Yamaguchi, 1997). Okra is cultivated in several countries and regions worldwide (Tripathi *et al.*, 2011). The crop is grown on commercial level in some countries but on subsistent level in others.

Different parts of okra are used for different purposes. For example, the fresh leaves, buds, flowers, pods, stems and seeds are used for different purposes (Mihretu *et al.*, 2014). The green immature fruits are consumed as vegetables and used in salads, graves, soups and stews, fresh or dried, fried or boiled (Ndunguru & Rajabu, 2004). According to Tripathi *et al.* (2011) okra fresh fruits are used as a thickening agent in Charleston gumbo whereas breaded, deep fried okra is served in the southern United States. The immature pods can also be pickled, the leaves cooked in a similar manner as greens of beets or dandelions, or the leaves eaten raw in salads (Tripathi *et al*., 2011). Crude fibre used in the paper industry can be obtained from the mature fruits and stems (Tripathi *et al*., 2011; Kumar *et al*., 2013). Edible oil (Tripathi *et al*., 2011; Maduwanthi, & Karunarathna, 2019) and protein (Maduwanthi, & Karunarathna, 2019) are contained in the seeds and the oil is high in unsaturated fats such as oleic acid and linoleic acid (Tripathi *et al*., 2011). Furthermore, okra contains vitamins A, C, and K and minerals such as Calcium, Iron, Magnesium and Potassium (Arapitsas, 2008; Varmudy, 2011; Kumar *et al*., 2013; Rizzo, 2023), vitamin B6, folic acid, riboflavin, zinc, phosphorus, b carotene, carbohydrates, proteins and fats (Varmudy, 2011).

Some potential human health benefits of okra include relieving cardiovascular diseases, type 2 diabetes, digestive diseases and cancers (Dubey & Mishra, 2017). It can also treat digestive problems (Maduwanthi & Karunarathna, 2019) and therefore, eating more keeps the stomach clean and creates an environment that prevents destructive cultures from flourishing (Messing *et al*., 2014, cited by Maduwanthi & Karunarathna, 2019). It promotes healthy skin and aids in the growth and repair of bodily tissues, plays an important role in blood clot formation, promotes healthy pregnancy, the essential vitamin B aids in preventing birth defects, improves heart health, used to stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract (Maduwanthi & Karunarathna, 2019).

Despite the many benefits of okra, the crop suffers a lot of damage from insect pests. Several insect pests have been reported to damage okra plants from vegetative to reproductive stage (Rahman *et al*., 2013). Some of the common insect pests are *Aphis* spp. (e.g. *Aphis gossypii* G.), *Thrips* (e.g. *Thrips tabaci* L.), whiteflies (*Bemisia tabaci* G.), *Earias* spp. (shoot borers) and *Helicoverpa armigera* H.) (Nithish, 2021; Jan *et al*., 2022); fruit borer, shoot weevil, mealy bug, red spider mite, cotton leaf roller, cotton stainer, Epilachna beetles, Blister beetles, Flea beetles, and jassids (Nithish, 2021). The infestation of such insect pests leads to reduction in growth and development as well as transfer of pathogens (Dhaliwal *et al*., 1981; Tripathi *et al*., 2011). This study focused on *Thrips tabaci* L, *Aphis* spp. and whiteflies (*Bemisia tabaci* G.) because they are the dominant okra insect pests in the research area.

The adult whitefly (*Bemisia tabaci*) is yellow in colour with white waxy powder. The adult is between 1.0 -1.5mm long. The females lay single eggs beneath the leaf. Immature and mature ones suck sap from the leaves (Idowu *et al*., 2022). Adult *Aphis gossypii* are small bodied organisms that dwell in colonies in leaves of okra plants. Both immature and mature forms suck cell sap. *A. gossypii* secretes honey dews upon which black shooty molds grow (Idowu *et al*., 2022). In the actual fact *A. gossypii* are considered the most serious insect pests of okra. In times of heavy leaf infestation, the leaves become yellow, deformed, curled and dry up resulting in poor yield. *A. gossypii* infestation can also cause viral diseases to be transmitted onto the plants (Butani and Verma, 1976 cited by Nithish, 2021). Thrips (Melon Thrips - *Thrips palmi* and *Thrips tabaci* L) most often feed on older leaves and flower buds, but satisfied larvae move down into soil litter to form pupae. Mature ones are yellow with dark setae. A common feature is a black line running from the wings down the back of the body. They are about 0.8 -1.0 mm long and have seven segmented antennae and occeli are red. As a result of its feeding activities leaves curl up. Feeding during flowering period causes wilting of flowers (Nithish, 2021; Idowu *et al*., 2022). Thus, activities of these three insect pests cause economic loss of okra.

In many cases the main insect pest control measure used by farmers is synthetic insecticide applications. Despite the fact that these synthetic insecticides are effective they lead to other devastating biological problems. In some cases wrong applications lead to pest resistance, while in other cases useful organisms like predators, parasitoids and pollinators are destroyed. These insecticides can also enter the food chain and cause harm to humans and other organisms. Runoffs can also carry residues into water bodies that are used by humans and other animals. Another thing is that these insecticides are expensive and not readily available to farmers thereby leading to low okra productivity. These suggest that continuous use of such synthetic insecticides will in the long term be deleterious for life and economic progress. Therefore, the need for more biologically friendly alternative insecticide which is more affordable and locally available is needed for insect pest control in okra agro-ecosystems. The alternative that readily comes to mind is organic-herbicides.

Stankovic *et al*. (2020) intimated that botanical pesticides were widely utilized for millennia in both subsistence and commercial farming before the development of synthetic pesticides and they are currently gaining popularity in organic farming due to their safety profile on crop consumption, and consumers are willing to pay a premium price for organic produce (Misra, 2014). According to Bora *et al*. (2012) natural products are excellent alternatives to synthetic chemical pesticides. These submissions are cogent justifications for the use of natural or plant-based insecticides as useful alternatives to synthetic insecticides. This is because they are easily biodegradable, environmentally friendly, safe, more readily available, easy to formulate and affordable (Gogate, 2016).

In general terms natural materials that can be used to eliminate or slow down the growth of damaging pests or organisms that interfere with the growth of plants used by humans are known as natural pesticides (Oguh *et al.*, 2019). Documented organic pesticides include garlic, neem tree, rotenone, pyrethrin, sabadilla (Odum, 2006; Oguh *et al.*, 2019), nicotine, ryania, fluoroacetate, carboxin and *Bacillus thuringiensis* (Oguh *et al.*, 2019).

Among the numerous plants exploited for insect pest control neem (*Azadiarachta indica*) tree in the family Meliaceae which grows in both tropical and semi-tropical regions stands tall. This is because its various parts such as seeds, leaves, flowers, and the bark are known to be used for different purposes (Rahmani *et al*., 2018). It has been established that neem oil negatively affects children. Its ingestion by children leads to vomiting, drowsiness, respiratory difficulty, seizures after one and half hours of last dose, and liver becoming enlarged after 12 hours (Sinniah et al., 1982). It has also been reported that neem seed oil intoxication produces occasional diarrhea, nausea and general discomfort (Chopra *et al*., 1965). Despite these negative effects, neem extracts have been used severally in many positive ways. They have been reported to be good for skin health, ameliorating diabetes, boosting the immune system, and controlling different insect pests (Van, 2023). It has been used in a number of cases in controlling insect pests. For example, extracts of fruits and leaves of neem tree (*Azadiarachta indica*) are known to cause inhibition of feeding and oviposition, growth disruption and sterility in insects. It exhibits repellant activity at the higher concentration and phagostimulatory effect at the lower level (Gangwar, 2011).

Currently, many commercial formulations are used in different agro-ecosystems worldwide. Therefore, in this study the effort was made to determine the influence of filtrates of neem leaves soaked in water on some three important insects pests, *Aphis gossypii* G., *Thrips spp.* and Whiteflies (*Bemisia tabaci* G.) on garden okra plants in Winneba, Central Region of Ghana.

The objectives of the study were to:

- Determine the level of infestation of three insect pests, Aphis (*A. gossypii* G.), *Thrips spp.* and whiteflies (*B. tabaci*) on okra plants.
- Assess the efficacy of filtrate of neem leaf soaked in water on the three pest species.

The null hypotheses tested were that:

H_{01}: there is no statistically significant difference among the levels of infestation of the three pests on okra plants at 0.05 probability.

H_{02}: there is no statistically significant difference in pest densities on the control and experimental plants at 0.05 probability.

The alternate hypotheses were that:

H_{a1}: there is statistically significant difference among the levels of infestation of the three pests on okra plants at 0.05 probability.

H_{a2}: there is statistically significant difference in pest densities on the control and experimental plants at 0.05 probability.

2. Materials and Methods

Study area: The study was conducted in Winneba, a coastal town in Southern Ghana. It is located 56 km (35 miles) west of Accra and 140 km (90 miles) east of Cape Coast. Geographically, Winneba is located between latitude 50 '21' and '50 35' north of the equator and longitude '00 37' and '00 63' west of the Greenwich Meridian (Eze *et al*., 2023).

Okra cultivation and application of neem extract: Seeds of okra cultivar known as Togo (TG) were obtained from seed sellers in Agona Swedru. The seeds were sown on a plot of

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land six meters by eight meters in a backyard garden at Winneba, Ghana. Three seeds were sown about three centimeters deep into the soil. Germinated seeds were left for three weeks. The garden was demarcated into two equal halves. One demarcated area was declared the experimental area whereas the other end declared the control area. Neem plants in the area were identified, leaves harvested and 500g soaked in 40 litres of pipe born water and left for two weeks to dissolve in the water. This process was repeated for eight weeks. Each time the water covering the leaves was sieved off using fine mesh mosquito net. Five litres of the filtrate was used in spraying okra plants in the experimental area while five litres of ordinary water was used to spray plants in the control area.

Data collection: From the control area, ten plants were randomly selected and ten from the experimental area. The selected plants were labelled for sampling purpose. Three dominant insect species visiting the plants [*Aphis gossypii* G., *Thrips spp.* and whiteflies (*B. tabaci*)] were observed and counted four times per week. The observation was done each other day and took place for seven weeks. Thus, eight continuous days was declared as a week.

Data analysis: The percentage number of each pest and the level of infestation on okra during the experiment were calculated and a bar chart drawn for interpretation. Mean number of each of the three insect species per plant as well as per week was calculated. The differences between the abundance of the pests were tested using chi-square (χ^2). For the weeks, t-test and two way-analysis of variance (ANOVA) were used to compare the differences between the means for the control and experimental groups. Excel version 2013 was used for the analysis of the inferential statistics.

3. Results and Discussion

From Figure 1, it is clear that out of the three pests under consideration *B. tabaci* were the most abundant (48.53%) infesting the okra plants, followed by *A. gossypii* (29.49%) and then *Thrips* spp. (21.99%). The differences among the total numbers for the three insect pests (abundance) were significant (χ^2 = 453.67; df = 2; P<0.05). Thus, the null hypothesis was rejected and the alternate hypothesis accepted.

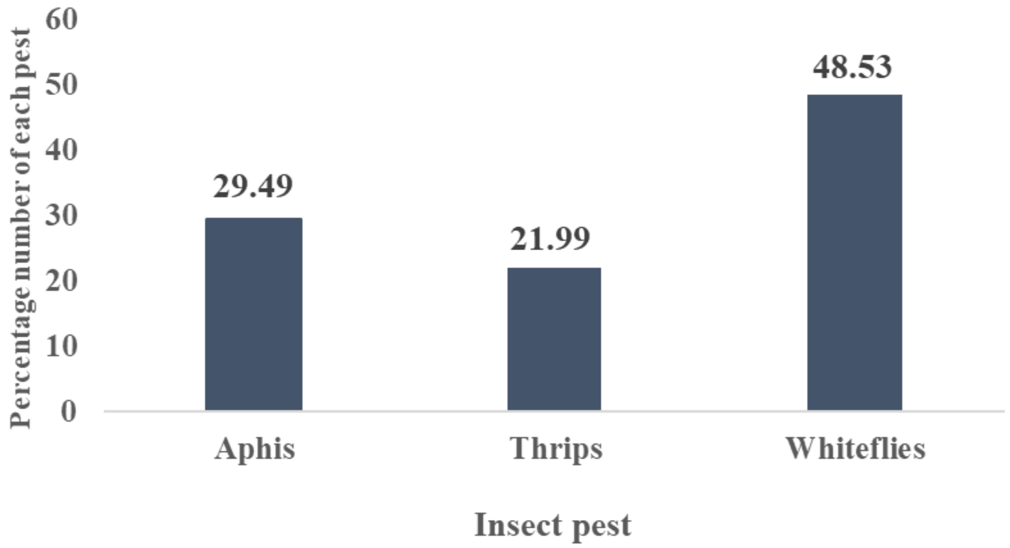

Figure 1. Level of insect pest infestation on okra during the experiment

El-Mewafy (2020) established the fact that okra plant is affected by number of insect pests from sowing to harvesting such as *Aphis* spp., jassid, *B. tabaci*, *Thrips* spp., spotted bollworms and mites. Out of these, *B. tabaci* (Genn.) is the most important insect pest of okra crop because they damage the crop by sucking the sap directly and by transmitting a large number of viral diseases indirectly (Basu, 1995). The above assertions have been proved by the current finding where *B. tabaci* were the most abundant (48.53%) infesting the okra plants, followed by *A. gossypii* (29.49%) and then *Thrips* spp. (21.99%). Meanwhile, Blackman and Eastop (2000) as well as Munthali and Mmapetla (2008) observed that *A. gossypii* is a major pest on a number of crops including okra and worldwide known to be important piercing and sucking pests of okra (Blackman & Eastop, 2000). In another study by Imam *et al*. (2010) involving a survey of some insect pests of cultivated vegetables in three selected irrigation areas along Jakara river, Kano in Nigeria, *Aphis* spp. recorded the highest insect pest density of 66.7/pest/m at Kwakwachi area. They also recorded significant differences between number of insects per site and vegetable types ($P<0.05$) and there was also a significant difference between average frequency of insect pest per site and vegetable types ($P< 0.05$). Similarly, in this study also the differences among the total numbers for the three insect pests were significant ($P<0.05$). Thus, since the Null hypothesis was rejected and the alternate hypothesis accepted then it can be argued that the different levels of infestation by the three pests, *A.gossypii*, *Thrips* spp. and *B. tabaci* were real. This is suggestive that *B. tabaci* were the most important okra insect pests on the research plot.

In an experiment to evaluate pest control strategies on okra, Naseer *et al*. (2023) found out that control plants recorded the highest *B. tabaci* population compared to plants treated with Chrysoperla + Trichogramma, Thiodan and tobacco. In the current study also, the total percentage infestations recorded for the control and experimental plants for the three pests on the okra plants presented in Figure 2 and Table 1 show that control plants recorded more than 60% infestation for each pest whereas experimental plants recorded less than 35% infestation for each pest. The differences among the mean numbers of insects for the experimental and control plants were all statistically significant (P<0.05 in Tables 2, 3 and 4). Therefore, the null hypotheses in all the cases were rejected and the alternate hypotheses were accepted.

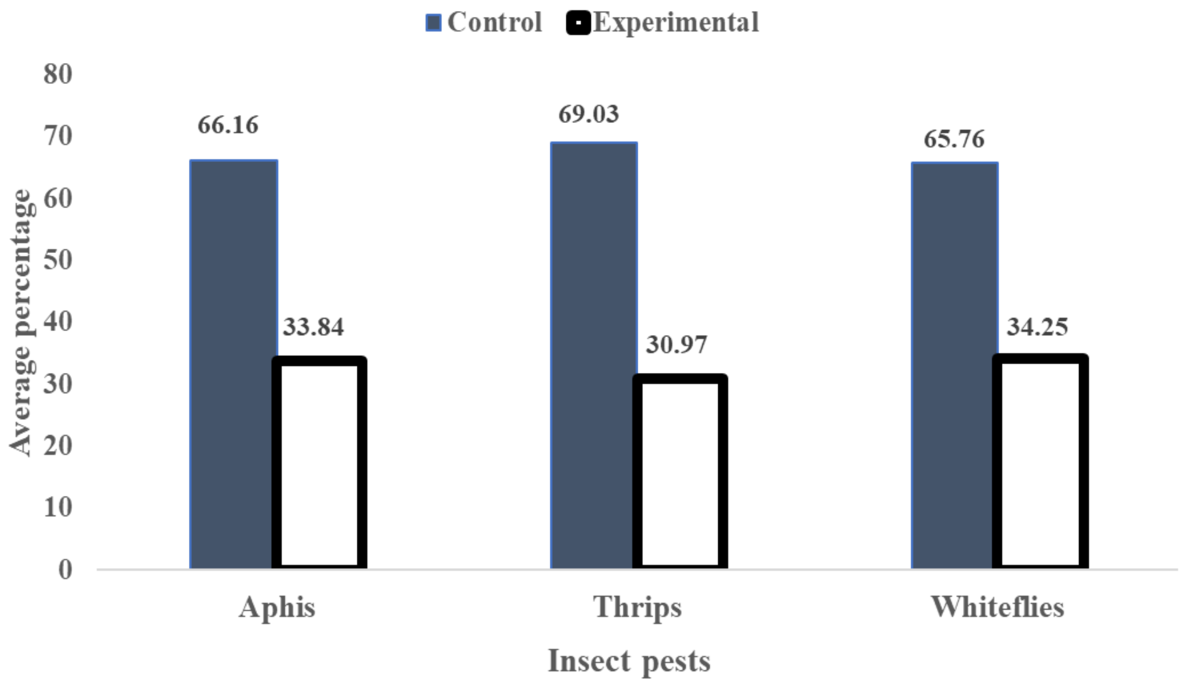

Figure 2. Total percentage number of each insect pest per treatment

Table 1. Mean number of insect pests observed on okra plants

Aphis		*Thrips*		**Whiteflies**	
Control	Experimental	Control	Experimental	Control	Experimental
Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
28.00 ± 1.41	15.25 ± 1.71	22.25 ± 0.75	14.75 ± 1.93	48.25 ± 4.03	33.25 ± 2.40
35.50 ± 1.29	16.75 ± 2.72	27.50 ± 1.56	11.25 ± 1.03	46.00 ± 2.49	27.25 ± 3.43
32.25 ± 1.71	18.00 ± 2.16	24.00 ± 1.08	13.00 ± 1.83	52.50 ± 3.31	28.75 ± 1.8
27.25 ± 1.71	16.00 ± 1.83	22.25 ± 1.65	9.25 ± 1.11	43.25 ± 4.87	21.25 ± 1.11
34.75 ± 2.22	14.00 ± 2.16	23.00 ± 1.23	7.75 ± 1.03	47.75 ± 3.75	26.50 ± 1.71
20.25 ± 1.71	9.50 ± 1.29	21.00 ± 175	6.00 ± 092	39.50 ± 4.03	16.75 ± 1.93
19.00 ± 1.83	11.25 ± 1.89	13.25 ± 1.65	6.75 ± 1.11	45.00 ± 3.5	14.00 ± 1.08

Table 2. t-test results of *Aphis* spp. observed on okra plants

Source of variation	SS	Mean	t-value	df	p- value	No of tails
Control	41.01587	28.1429	10.09	12	5.2455E-14	2
Experimental	11.13624	14.3929				

Table 3. t-test results of *T. tabaci* observed on okra plants

Source of variation	SS	Mean	t-value	df	p- value	No of tails
Control	23.06217	21.89	10.33	12	2.15511E-14	2
Experimental	15.18915	9.82				

Table 4. t-test results of *B. tabaci* observed on okra plants

Source of variation	SS	Mean	t-value	df	p- value	No of tails
Control	59.22	46.03571	13.0677	12	.4337E-14	2
Experimental	20.57	23.96429				

Two-way Analysis of Variance (ANOVA) of the data in Table 1 indicates that there were significant differences among the means for the control and experimental groups ($P<0.05$); differences among the means for the three insects were significant ($P<0.05$) and the differences due to interaction between the treatments and the insects were also significant ($P<0.05$; Table 5). These show that the null hypothesis was rejected and the alternate hypothesis accepted.

Table 5. Two-way ANOVA results of the data

Source of variation	**SS**	**Df**	**MS**	**Calculated F-value**	**Tabulated F-value**
Treatment (T)	2,674.42	1	2,674.42	110.15	4.11
Insects (I)	2,721.91	2	1,360.96	56.05	3.26
T&I interaction	202.19	2	101.10	4.16	3.26
Residual Error	873.98	36	24.28		
TOTAL	**6,472.50**	**41**			

The results of this study pointing to the fact that control plants were the most infested (more than 60% infestation) by each pest compared to the experimental plants that had less than 35% infestation by each pest suggests that the filtrate of neem leaf soaked in water helped in reducing the number of each of the pests on the experimental plants. This may be confirming the fact that neem extracts cause various effects on insects such as antifeedants, growth regulators and sterilants (Sale, *et al*., 2015). In a study by Sale, *et al*., (2015) covering the effect of neem extract preparations and nutrient sources on performance of okra (*Abelmoschus esculentus*) it was reported that the efficacy of the treatments was based on the reduction in number of *B. tabaci*. The results showed that the number of *B. tabaci* and leaf defoliation significantly reduced on the plots that neem extracts were applied compared to the plots that did not receive neem extract application (Sale, *et al*., 2015).The story for this study is the same as that of Sale *et al*. (2015), where neem leaf filtrate treated plants recorded far less number of pests compared to the control plants. This study also confirms results of a study by Mudathir and Basedow (2004) which revealed that neem formulations to high extent reduced the infestation of okra bugs, a common pest. In any case, it is on record that azardirachtin derived from the neem tree (*Azadiracthta indica* L.) is an antifeedant, repellant, oviposition deterrent, and insect growth regulator (Isman, 2008). The efficacy of plant-based pesticides are attributed to the fact that they act specifically in the insect nervous system; affect γ-aminobutyric acid (GABA), gated chloride channels, and sodium channels; and competitively combine acetylcholinesterase, nicotinic acetylcholine receptors (nAChR), octopamine, and tyramine receptors (Pavela & Benelli, 2016). Hence, it is possible that the phytochemicals of neem leaf filtrate might have acted in the nervous system of the various life stages of the three pests and thereby drastically reducing their numbers far below the numbers on the control plants.

In a study where the efficacy of leaf ethanolic extract of *Balanite aegytiaca*, *Ricinus communis*, and *Eucalyptus camaldulensis* were used for the control of *Attractomorpha acutipennis*, *Amarasca biguttula biguttula*, *A. gossypii* and *B. tabaci* of okra fruits in Sudan Savannah agro-ecological zone of Nigeria, all the treatments were significant in reducing the mean population of A. gossypii and B. tabaci in both locations compared to the control. Thus, *B. aegyptiaca* extracts induced a reduction of *A. gossypii* and *B. tabaci* on treated plots (Yohanna *et al*., 2022). Similarly, in the two locations, *E. camaldulensis* and *R. communis* extracts significantly ($p < 0.05$) reduced the population of the insect pests compared to the control. In this study also, the differences among the numbers of insects for the experimental and control plants were statistically significant ($P<0.05$ in Table 5). This suggests that there were differential effects of the neem leaf filtrate on the different insect pests. Similarly, in this study, there were differences in the effects of the control and the neem filtrate on the density of the pests on the okra plants. Not only that, but there was also differential effects of the interactions between the treatments and the insects. This further confirms the findings of Patil *et al*. (2016) in a study of the bio-efficacy of new insecticide molecules in controlling okra *A. gossypii*, and noticed that means recorded on second, seventh and twelve days after application were far better than for the control. Therefore, for this study, it will not be out of place to state that the neem filtrate was very effective in controlling the pests.

4. Conclusions

- The findings suggest that out of the three insect pests of okra focused upon *B. tabaci* were the most important of them because it was the most infesting insect pest.

- Furthermore, indications are that filtrates of neem leaves soaked in water may be useful alternative to inorganic pesticides in controlling *A. gossypii*, *Thrips* spp. and *B. tabaci* on okra plants. This may be very important so far as okra pest control is concerned because neem trees are readily available in the environment, they are less toxic to the environment, humans and other useful organisms and they are more cost effective than inorganic pesticides.

- It can also be said that okra farmers may find the use of the extract less laborious because its preparation does not involve the use of any sophisticated equipment or any special knowledge. All that they need is neem leaf, water and a container into which the soaking will be done and the one into which it will be filtered as well as the equipment for filtering and spraying.

5. Recommendations and Suggestions for Further Studies

- Once the neem leaf filtrate is found to be efficacious against the three okra pests, it is recommended that farmers in the research area can endevour using it to reduce the population of the three pests on their okra farms.

- A further research covering the effects on other pests is recommended. In addition to that a further study covering damage levels of the various pests should be covered in subsequent studies.

- It is also recommended that future studies using neem leaf filtrate should cover larger field and span longer period of time to more effectively monitor the efficacy of the filtrate.

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Authors' contributions

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Competing interests

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

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The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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