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FIELD EVALUATION OF NON-SYNTHETIC INSECTICIDES FOR THE MANAGEMENT OF INSECT PESTS OF OKRA *ABELMOSCHUS ESCULENTUS* (L.) MOENCH IN GHANA

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ABSTRACT: In a two-year study, aqueous seed extracts of the neem tree *Azadirachta indica* A. Juss (Meliaceae) and *Bacillus thurigiensis* (Bt) were evaluated in the field for the management of pests of okra, *Abelmoschus esculentus* (L.) Moench. The aqueous neem seed extracts were applied at the rate of 30, 50, 75 and 100 g/l and *B.thurigiensis* was applied at the rate 1.0 g/l of water. Actellic 25 EC, a synthetic insecticide, was applied at the rate of 2 ml/l as standard check. Arthropod fauna on okra were sampled using traps, sweep nets, aspirators and handpicking. The nature of damage caused to the stems, leaves, flowers and fruit was assessed by visual observation. The major insect pests of okra collected were *Podagrica uniformis* Jac, *Aphis gossypii* Glov, *Sylepta derogata* (F.), *Spodoptera litoralis* Boisd, *Prodenia litura* (F.), *Dysdercus superstitiosus* (F.), *Epilachna similis* (F.), *Bemisia tabaci* (Genn.) and *Zonocerus variegatus* (F.). These pests were observed attacking mainly the leaves of okra. Some of the minor pests identified were *Lagria villosa* (F.), *L. cuprina* Thoms, *Mylabris temporalis* Wellni, *M. trifasciata* (Thumb.), *Lapidognatha* sp and *Empoasca devastans* (D.). Actellic, neem seed extract and Bt significantly reduced the population and damage caused by the major insect pests of okra recorded at Legon, Ghana compared to the untreated. Actellic and aqueous neem seed extracts were equally effective against the pests of okra and caused a significant reduction in insect damage to the leaves, flowers and fruit of the crop. There were no significant differences among the different dosages of neem seed extract on all the parameters assessed, with the exception of the final fruit yield. Actellic, neem extracts or Bt produced higher yield of marketable fruit of okra than untreated plants. Neem seed extract applied at the rate of 30 g/l of water to okra plants produced lower fruit yield than those treated with 50 g or more. Aqueous neem seed extracts and Bt can be used effectively by farmers as a component of integrated management of pests of okra in Ghana.

Key words/phrases: *Bacillus thurigiensis* (Bt), insect pests, neem seed extract, non-synthetic insecticides, okra

INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) Moench (Malvaceae) is one of the major vegetable crops grown in West Africa. It is a native of tropical Africa, but now widespread throughout the tropics (Norman, 1992; Sinnadurai, 1992). It is known in various names as okra, okro, bhindee, lady's fingers and quinbambo (Norman, 1992). Okra is mainly cultivated for its green immature fruits, which are used as vegetable. It can be preserved by freezing or canning as is done in the United States of America (Spivey *et al.*, 1957). The fresh leaves can be used as spinach in soups while the seeds are said to be good sources of oil (Oyolu, 1977). Okra fruit have high nutritive value and therefore play very important role in the diet of many Ghanaians (Norman, 1992). Apart from its nutritive value, it is also a major source of income for many vegetable growers in Ghana and other parts of the world.

It was reported that okra may produce up to 3-6 tonnes/ha of green pods with approximately 4-6 fruits/plant, over a harvesting period of 30-40 days (Sinnadurai, 1992). In Ghana, however, the number of fruits per plant are usually more than 20 and the harvesting period extends for over 60 days if there is adequate rainfall (Norman, 1992). The potential yield of okra in the magnitude of 2,559-6,936.8 fruit/ha is not realised due to a number of constraints. Among the major problems that affect okra production in Ghana are leaf curl and okra mosaic diseases caused by viruses, brown leaf mould caused by *Cercospora abelmoschi* and black leaf mould disease caused by *Irenopsis* sp (Norman, 1992).

Between 1910 and 1960 ten important insect pests of okra were recorded in Ghana (Forsyth, 1966), while in the Sudan as many as 36 insect pests were found permanently associated with the crop (Schmutterer, 1969). In India, 16 insect species were recorded attacking okra (Butani and Verms, 1976). These insects cause serious economic loss by boring holes into the leaves and reducing the photosynthetic ability of the leaves. Some of the insects pierce and suck sap from the plants. They may also bore holes into the fruit and reduce their quality. The holes also provide penetration sites for the entry of plant pathogens (Pursglove, 1972).

In the control of insect pests of okra, many farmers rely on the use of synthetic chemicals such as actellic 25 EC (pirimiphos-methyl) and heptachlor (Murthy, 1959), thiometon (David, 1964), which are applied on weekly calendar schedules. More often, farmers use chemicals recommended for cotton and cocoa on vegetables. These synthetic chemicals are harmful to the environment and their chemical residue may be found in the fruit. The chemicals are also dangerous to the health of the users and can kill other non-targeted animals. Indeed, the continued use of high doses of synthetic insecticides, at very high costs, had completely eliminated the indigenous natural enemies and other beneficials that would otherwise normally keep pest populations under control (Youdeowei, 2000). Many insects have also developed resistance to these chemicals (Youdeowei, 2000). Synthetic insecticides are also expensive and many resource-poor farmers cannot afford to buy the recommended chemicals to protect their crops against pest infestation. There is therefore the need to develop alternative methods of control that are relatively cheap and less destructive to environment and the end user.

Several plant species have been reported to have insecticidal properties (Golob and Webley, 1980; Schmutterer, 1985). Much work has been done on the neem tree *Azadirachta indica* A. Juss which has been found to be effective against several species of insect pests of major crops including vegetables (Schmutterer, 1990; Obeng-Ofori and Akuamoah, 1998). The neem tree contains several biologically active compounds but Azadirachtin is the main component (Schmutterer, 1990). Almost every part of the plant contains the compound, however, the seeds are the richest source. Neem products have antifeedant, repellent, growth-inhibiting and toxic properties against insects (Schmutterer, 1985).

Bacillus thuringiensis is a spore-forming bacterium that produces a crystal of toxic protein (delta-endotoxin) (Hall *et al.,* 1977). The toxin is biologically active against the larvae of several species of insects, particularly moths and flies (Garcia and Goldberg, 1977). Two varieties of *B. thuringiensis* are currently widely produced and marketed under different trade names such as Bactospeine, Bactimos, Dipel, Biobit and Thuricide (Hall *et al.,* 1977).

The widespread use of different types of plant materials by medium to small-scale farmers in the developing countries to protect crops against pest infestation and the need to develop bio-rational control strategies have stimulated active research on the efficacy, effective application, economics of control and the suitability of non-synthetic insecticides for pest control. This study evaluated the effectiveness of neem seed extracts and *B. thuringiensis* for the control of insect pests of okra in Ghana.

MATERIALS AND METHODS

Land preparation and planting

The experiments were carried out at the University of Ghana farm, Legon in the major (April-July) and minor (September-December) planting seasons of 1999 and 2000. Thus, two cropping activities with the same treatments were carried out in each year. The area has a mean annual rainfall of 880.75 mm, mean temperature of 28.5 °C and relative humidity of 81%. The local Labadi Dwarf okra variety was used in all the experiments. The seeds were soaked in water overnight to ensure uniform germination before planting them directly into the soil using a dibber to the depth of 1.2-1.5 cm at the rate of four seeds per hill and planting distance of 50 cm x 80 cm. The stands were thinned to two plants after four weeks.

Cultural practices

The plots were fertilized with N.P.K. (15:15:15) by band placement at the rate of 300 kg/ha, three days before planting of okra seeds. Six weeks after planting, sulphate of ammonia was broadcasted at the rate of 200 kg/ha followed by heavy watering. Weeds were controlled manually by hoeing and the plants were watered when necessary.

Extraction of neem seed

Matured neem seeds were collected from neem trees at Legon campus and in the 37 Military Hospital area and dried for few days under shade. The seeds were milled into powder and then soaked in water and left to stand overnight. The solution was filtered using Whatman's. No. 42 filter paper and the filtrate were applied at the rate of 30, 50, 75 and 100 g of neem seed/litre of water.

Application of products

The experiments were laid out in Randomised Complete Block Design with four replications. There were seven treatments namely; water only as check, Actellic 25 EC applied at the rate of 2 ml/litre of water, neem seed extract at 30, 50, 75 and 100 g of neem seed/litre of water and Bt at the rate of 1 g/litre of water. The products were applied using a knapsack sprayer when the plants were two weeks old and then after every fortnight until maturity. In total each treatment was applied five times. Each treatment plot had a size of 11.6 m^2 and the spacing between and within rows were 0.8 m and 0.5 m, respectively.

Sampling of insects on okra

Five tagged okra plants per treatment were observed daily, and insects found on them were collected using aspirators, sweep nets, yellow sticky traps or by hand-picking where appropriate. The yellow sticky traps were placed at both ends of each plot and inspected daily. Sampling of insects started two weeks after planting. This was done a day before spraying, one day after spraying and five days thereafter. All insects collected were sent to the entomology laboratory of the Crop Science Department for identification. Thereafter, the insects were prepared and mounted in insect boxes. Where immature insects were collected they were reared to adult stage in the laboratory with temperature of 26 ± 2 °C and 70–80% relative humidity. The larvae were reared in glass jars and fresh pieces of okra leaves were supplied to them daily. The pupae were kept in Petri dishes containing moist cotton wool until emergence. The feeding activity and the nature of damage caused by the various insects was determined by visual observation. The numbers of insects collected on okra plants treated with the various products at different sampling periods using the different sampling techniques were pooled and the mean per plot was calculated.

Leaf and fruit damage

The feeding on okra leaves and fruit by the various insect pests was quantified to determine the effect of the different products on the feeding activity of the pests. For leaf damage, the number of holes (feeding punctures) with 0.5-1.0 mm diameter on the five tagged okra plants were recorded. All the leaves of the tagged plants were examined and those with and without feeding punctures were recorded and percentage leaf damage was then calculated. On maturity the fruit were harvested at weekly intervals over one month period and separated into damaged and undamaged depending on the presence or absence of feeding punctures on the fruit. The percentage fruit damage was calculated on the total number of fruit harvested.

Fruit yield

On maturity the fruit were harvested from all the plants in the plot at weekly intervals over one month period and were sorted out into marketable and unmarketable fruit. Fruit yield was calculated based on mean yield of marketable fruit per plant, spacing and plot size.

Analysis of data

All count data on the major insect pests and yield were transformed using the square root transformation and data on percentage leaf and fruit damage were transformed using arcsine before analysis of variance was performed. Where significant differences were observed, means were separated using the Least Significance Difference (LSD).

RESULTS

Insect fauna on okra

The species of insects collected on untreated okra plants belonged to five orders namely, Coleoptera, Heteroptera, Homoptera, Lepidoptera and Orthoptera (Table 1). It was observed that the population densities of the various insect pests, particularly the aphids, grasshoppers and caterpillars were higher during the minor season (September-December) than during the major season (April-July). Five species of beetles were found feeding on leaves of okra. The cotton flea beetles, *Podagrica uniforms* (Jac) (Chrysomelidae) were very destructive to the leaves, flowers and fruit, but the damage was severe on the leaves. They fed on both the upper and the undersides of the leaves and bored numerous holes into them. Two species of *Lagria* were found. *Lagria villosa* (F) and *L. cuprina* (Thoms). These were observed feeding on the upper sides of leaves. Their numbers were, however, low and did not cause any appreciable damage.

The blister beetles, *Mylabris abdominalis* Thumb, *M. temporalis* (Wellni), and *M. trifaciata* Thumb occurred mainly during the flowering stage. Their numbers, however, reduced considerably when a lot of fruits had formed. The three species were all observed feeding on the flowers but *M. trif*aciata fed also on the green fruits. Two species of *Chellomonos* occurred regularly depending on the presence of aphids on the leaves. These were *C. lunata* (F.) and *C. vicina* Muls and they fed on aphids. Scolytid beetles, *Labidognatha* species were found in small colonies when the plants were ten weeks old. They fed on the upper sides of leaves but the damage caused was not serious.

The adults and larvae of *Epilachna similis* (L.) were very destructive to the leaves by feeding between the veins, sometimes the leaves were completely eaten. They were observed on the plants when the plants were four weeks old, but their numbers reduced after flowering. Similarly, the adults and nymphs of cotton stainer *Dysdercus superstitious* (F.) pierced and sucked sap from the leaves and fruits causing shriveling of both the leaves and pods. The cotton aphid, *Aphis gossypii* Glover and white fly, *Bemisia tabaci* (Gennadius) caused considerable damage by sucking plant sap from the undersides of leaves. Leafhoppers, *Emposaca devastans* (D.) occurred throughout the sampling period and caused minor damage to plant foliage by sucking sap from the undersides of the leaves.

Table 1. Insect pests attacking okra in Legon, Ghana

Name	Family	Damage	Remarks
Coleoptera			
Flea beetle *Podagrica uniformis* Jac	Chrysomelidae	Feed on leaves	Major
Epilachna beetle *Epilachna similis* (F.)*	Coccinellidae	Defoliator	Major
Lagria beetle *Lagria villosa* (F.)	Lagriidae	Feed on leaves	Minor
L. cuprina (Thoms.)	Lagriidae	Feed on leaves	Minor
Blister beetle *Mylabris temporalis* (W.)	Myloidae	Flower feeder	Minor
M. abdomnalis (Thumb)	Myloidae	Flower feeder	Minor
M. trifasciata (Thumb)	Myloidae	Flower feeder	Minor
Scolytid beetle *Labidognatha* sp.	Scolytidae	Feed on leaves	Minor
The beetle *Chellomonos lunata* (F.)	Coccinellidae	Aphid feeder	Beneficial
C. vicina muls	Coccinellidae	Aphid feeder	Beneficial
Homoptera			
Cotton aphid *Aphis gossypii* Glov.	Aphididae	Suck sap and vector	Major
White fly *Bemisia tabaci* (Genn.)	Aleryrodidae	Suck sap and vector	Major
Heteroptera			
Cotton stainer *Dysdercus superstitious* F.	Pyrrhocoridae	Suck sap	Major
Leafhoppers *Empoasca devastans* (D.)	Cicadellidae	Feed on leaves	Minor
Lepidoptera			
Leaf roller *Sylepta derogata* (F.)	Pyralidae	Defoliator	Major
The moth *Prodenia litura* (F.)	Noctuidae	Defoliator	Major
Leafworm *Spodoptera littoralis* Boisd.	Noctuidae	Defoliator	Major
Orthoptera			
Grasshopper *Zonocerus variegatus* (L.)	Pyrgomorphidae	Defoliator	Major

Insects collected from untreated plots. * New record on okra.

The larvae of several species of moths were observed attacking mainly the foliage of okra plants. Cotton leaf worm, *Spodoptera littoralis* (Boisd.) caused extensive defoliation. Cotton leaf roller, *Sylepta derogata* (F.) was the commonest and the most destructive lepidopteran pest found. The larvae were found congregating within a roll of leaves, which they secured with silken threads as they fed on the undersurface of leaves, sometimes covering them with webbing. The leaves were curled and rolled as they fed on the leaf margins. *Prodenia litura* (F.) appeared late in the growing season on mature plants and fed mainly on the upper surface of the leaves. The nymps and adults of the variegated grasshopper, *Zonocerus variegatus* (L.), caused extensive defoliation to okra plants.

Effect of actellic, Bt and neem seed extract on insect population

Actellic, neem extract and Bt caused a significant ($P<0.05$) reduction in the population of *P. uniformis, A. gossypii, E. similis, S. doragata, P. litura* and *S. littoralis* compared to untreated plants (Tables 2 and 3). For all the insects sampled actellic and neem seed extracts gave similar results.

Insect damage to leaves and fruit of okra

The insect pests of okra caused three main types of damage: leaf, flower and fruit damage. The damage caused to the leaves was, however, the most significant. The feeding activity of the insects, particularly *P. uniformis* resulted in numerous holes bored into the leaves (Table 4). Leaf damage was significantly higher on the untreated plants than Actellic, neem extract or Bt treated plants.

Table 2. Population densities of *P. uniformis*, *E. similis* and *A. gossypii* pests on okra treated with actellic, neem extract and Bt at Legon, Ghana.

Treatment	Mean number of adults (+SE)		
	P. uniformis	*E. similis*	*A. gosypii*
Control	120 ± 10.5^a	45 ± 5.5^a	85 ± 9.5^a
Actellic (2 ml/l)	10 ± 1.5^c	5 ± 2.5^c	10 ± 5.5^c
Bt (1 g/l)	25 ± 4.5^b	15 ± 0.3^b	38 ± 7.5^b
Neem extract (30 g/l)	12 ± 2.5^c	4 ± 0.5^c	14 ± 4.2^c
Neem extract (50 g/l)	12 ± 2.5^c	3 ± 0.4^c	11 ± 3.8^c
Neem extract (75 g/l)	10 ± 2.2^c	3 ± 0.5^c	10 ± 3.5^c
Neem seed extract (100 g/l)	10 ± 2.5^c	3 ± 0.3^c	8 ± 1.5^c

Note: Means for each species followed by different letter (s) are significantly different at $P<0.05$, LSD

Table 3. Effect of actellic, neem extract and Bt on the larval population of Lepidopteran pests recorded on okra at Legon, Ghana.

Treatment	Mean number of larvae (+SE)		
	S. derogata	*P. litura*	*S. littoralis*
Control	50 ± 7.5^a	30 ± 5.5^a	34 ± 9.5^a
Actellic (2 ml/l)	5 ± 1.5^c	3 ± 2.5^c	5 ± 0.6^c
Bt (1 g/l)	15 ± 4.5^b	14 ± 0.3^b	12 ± 5.5^b
Neem extract (30 g/l)	5 ± 0.5^c	4 ± 0.5^c	5 ± 0.5^c
Neem extract (50 g/l)	4 ± 0.5^c	4 ± 0.4^c	4 ± 0.5^c
Neem extract (75 g/l)	3 ± 0.3^c	3 ± 0.5^c	3 ± 0.3^c
Neem seed extract (100 g/l)	3 ± 0.5^c	3 ± 0.3^c	3 ± 0.3^c

Note: The same as in Table 2.

Table 4. Effect of actellic, neem extract and Bt on levels of damage caused by the various insect pests and yield of okra.

Treatment	Mean no. of holes per leaf	Leaf damage (%)	Fruit damage (%)	Fruit weight (kg/ha)
Control	60 ± 6.5[a]	77 ± 8.5[a]	46 ± 5.5[a]	895 ± 13.5[a]
Actellic (2 ml/l)	12 ± 1.5[c]	11 ± 2.5[c]	2 ± 0.2[c]	4317 ± 12.5[d]
Bt (1 g/l)	29 ± 4.5[b]	25 ± 6.3[b]	8 ± 1.5[b]	3886 ± 16.2[b]
Neem extract (30 g/l)	18 ± 2.5[c]	15 ± 2.5[c]	5 ± 0.5[c]	4037 ± 14.5[c]
Neem extract (50 g/l)	15 ± 2.5[c]	13 ± 1.4[c]	3 ± 0.5[c]	4437 ± 12.4[d]
Neem extract (75 g/l)	15 ± 2.2[c]	11 ± 2.5[c]	3 ± 0.6[c]	4492 ± 13.0[d]
Neem seed extract (100 g/l)	13 ± 2.5[c]	11 ± 2.3[c]	2 ± 0.4[c]	4389 ± 14.0[d]

Means for each treatment followed by different letter (s) are significantly different at $P<0.05$, LSD.

Actellic and neem seed extracts were equally effective in reducing insect damage to the leaves (Table 4). The feeding activity of the insects on the fruit significantly reduced their quality and marketability. The fruit of plants treated with Actellic, neem seed extracts or Bt were less damaged compared to those of the untreated plants.

Fruit yield

Actellic, neem extract and Bt had significant effect on the fruit yield of okra compared to the untreated (Table 4). Plants treated with 75 g/1 of neem seed extract produced the highest yield but it was not significantly different from plants treated with neem extracts at the rate of 50 and 100 g/l or actellic.

DISCUSSION

The present study has confirmed that the feeding activities of leaf beetles, caterpillars and aphis cause serious damage to the leaves and fruit of okra plants and reduce yield of marketable fruits. The damage caused to the leaves was, however, the most significant. In particular *P.* u*niformis* bored numerous holes into the leaves and the larvae of *S. derogata*, *P. litura* and *S. littoralis* also caused extensive damage to the leaves of untreated plants. The feeding activity of the larvae and/or the adults of these pests on the leaves might have reduced the photosynthetic capacity of the plants resulting in stunted growth and low yield. *E. similis* is known to be a pest of cabbage and was found to feed on the leaves of the crop (Ankrah, 1998). It also attacks garden egg and other crops such as tomato, cowpea and French beans (Forsyth, 1966). Amuh (1972) recorded *E. similis* as a minor pest of cotton in Southern Ghana. This is the first record of its occurrence on okra in Ghana.

This study has also demonstrated the efficacy of actellic, neem extracts and Bt against major insect pests of okra in Ghana. These products caused significant reduction in the numbers of insect pests collected on treated plants. Leaf and fruit damage was, therefore, significantly higher on the untreated plants than Actellic, neem extract or Bt treated plants. It is significant to note that as much as 46% fruit damage was recorded on fruit harvested from untreated plants compared to less than 3% on neem-treated plants. This suggests promising potential for the use of neem products and Bt to manage pests of okra in Ghana. It is encouraging that many farmers are rapidly adopting the use of crude neem extracts in a variety of crop production systems in Ghana including cereals, legumes and vegetables.

The ability of neem extracts to control economically important pests of okra is of considerable interest. Though the principally active ingredient (Azadirachtin) is known to be present in only small amounts in crude extracts, the neem tree is locally available throughout Ghana. The development of suitable formulations coupled with proper collection and storage techniques might enhance the performance of neem for the control of pests of okra and other economically important crop pests.

Several workers have demonstrated the efficacy of neem products and Bt against pests of major crops in the tropics (Schmutterer, 1985; Cobbina and Osei-Owusu, 1988; Adu-Acheampong, 1997; Ankrah, 1998; Owusu-Ansah, 1999; Youdeowei, 2000; Obeng-Ofori and Kelly, 2000). Neem products have insecticidal, repellent, antifeedant, sterilising and growth inhibition effects against several species of insects (Schmutterer, 1990). Clearly the potential for the use of neem extracts and Bt in crop production is extremely high and farmer education and training on the economic and environmental benefits of these products need to be intensified. Refinement of aqueous neem extracts to standardize the most effective dosage applications for different pests and crop production systems should receive urgent attention.

Furthermore, the accurate evaluation of the use of biopesticides in integrated pest and crop management and the sustainability of their use in smallholder crop production systems need to be further explored.

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