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Evaluation of Synthetic and Neem-Based Insecticides for Managing Aphids on Okra (Malvaceae) in Eastern Kenya

[1]J.H. Nderitu, [2]J.M. Kasina, [1]J.W. Kimenju and [1]F. Malenge
[1]Department of Plant Science and Crop Protection, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya
[2]Center for Development Research (ZEF), University of Bonn, Postfasch, Walter-Flex-Str. 3, 53113 Bonn, Germany

Abstract: This field study was conducted to evaluate the efficacy of two synthetic insecticides (Imidacloprid 350 g L^{-1} (Gaucho FS[R]) and Lambda-cyhalothrin 17.5 g L^{-1} (Karate 1.75 EC[R]), two neem products (Azadirachtin 0.15%w/w (Achook[R]) and Azadirachtin 0.6% w/w (Neem extractive[R]) and a spray alternation of Azadirachtin 0.6% w/w and Lambda-cyhalothrin, in the management of aphids (*Aphis gossypii* Glover) infesting okra (*Abelmoschus esculentus* L. Moench). The crop was established in two seasons, December 2003-March 2004 and February-May 2004 at Kibwezi, Eastern Kenya. Imidacloprid was applied as a seed dresser while the other insecticides were foliar applied. The population of live and parasitized aphids was monitored on the leaves and pods of the plants for 9 and 7 weeks, respectively. The number of live and parasitized aphids was significantly ($p<0.05$) lower in plots treated with Imidacloprid, causing more than 95% aphid reduction. Plots treated with spray alternation of Lambda-cyhalothrin and Azadirachtin 0.6% had higher pest infestation than the other treated plots. Plants in Imidacloprid-treated plots had slightly higher yields than in other treatments. The results of this present study show that neem products are as effective as the synthetic insecticides in the management of aphids infesting okra. The study provides the best alternative of managing aphids' pests in okra that can reduce both the cost of production and chemical residue levels in the produce.

Key words: *Aphis gossypii*, MRLs, neem-based insecticides, okra, synthetic insecticides

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is the third major export vegetable and the leading Asian vegetable in Kenya. In 2005, it accounted for 37% of the value of all Asian vegetables and 4.1% by value of all export vegetables (MOA, 2006). It is mainly grown by smallholder farmers through out the year, a practice that ensures permanent source of pests. Aphids (*Aphis gossypii* Glover) are the most economically important insect pests (Seif, 2002) of okra in Kenya and infest the crop in all stages of development, as adult and/or nymphs. Its feeding behaviour (sap sucking) causes leaf distortion and curling. This debilitates the plant especially when the attack is severe in its early growth stage. The aphids' excreta (honeydew) encourage growth of black sooty moulds. The moulds interfere with photosynthesis in leaves while pods appear blemished, which lowers their quality and renders them un-saleable. Various control methods; biological, cultural, chemical insecticides and host plant resistance have been evaluated against this pest. Chemicals are the most widely used strategy due to their quick action (Chinniah and Ali, 2000; Godfrey and Fuson, 2001). However, *A. gossypii* has

Corresponding Author: J.M. Kasina, Center for Development Research (ZEF), University of Bonn, Postfasch, Walter-Flex-Str. 3, 53113 Bonn, Germany Tel: +49-228-73-1715 Fax: +49-228-73-1889

developed resistance to most insecticides due to high exposure and hence limiting their use (Kerns and Gaylor, 1992; Varela and Seif, 2004). Furthermore, there is now evidence suggesting that in areas where insecticide-resistant aphids occur, use of some insecticides may result in increased population densities (Fuson *et al*., 1995). Leaves and seeds of neem (*Azadirachtin indica* A. Juss) have traditionally been used in India to treat human ailments and control plant pests (Chopra *et al*., 1956; Gahukar, 2005). Azadirachtin (a major active ingredient from neem) has anti-feedant action and insect-growth regulatory properties (Yamasaki and Klocke, 1987; Isman *et al*., 1990). It is rated as the most potent natural insect feeding deterrent and has been used in management of pests of many crops (Lowery *et al*., 1993). In Kenya, neem is mainly exploited for medicinal purposes but little has been done to tap its potential for crop pest management. The high susceptibility of crops to pests and diseases in Kenya has necessitated frequent use of chemical pesticides. This has led to increased cost of production, as well as a looming chemical residue accumulation in the pods. Farmers are currently faced with the challenge of meeting the permitted maximum residue levels of pesticides in their produce and, keeping the cost of production low enough so as to make profits (MOA, 2006). This study evaluated effectiveness of synthetic insecticides and neem based extracts in managing *A. gossypii* infesting okra in Eastern Kenya. The study sought to provide farmers with cheap option for managing the pest that would guarantee lower residue accumulation in their produce.

MATERIALS AND METHODS

The study was carried out at Kibwezi, Eastern Kenya (2° 21.5′ S 38° 2.5′ E). The area is semi-arid and receives an average annual bi-modal rainfall of about 600 mm with short rains from October and long rains from March. Usually rainfall in the area is unreliable and farmers use irrigation as a supplement. The area is situated at 700 m above sea level and experiences temperatures ranging from 25-30°C (Jaetzold and Schmidt, 1983). Land was prepared to fine tilth using disc harrow plough and plots demarcated manually. Okra seeds (var. Pusa Sawani) were hand-sown in plots of 6.4×6.3 m on 6 December 2003 and 22 February 2004 (first and second season, respectively). An inter-row spacing of 40 cm and intra-row spacing of 30 cm was used. Treatments were laid in Randomised Complete Block Design (RCBD) and replicated four times. A path of 3.8 m was maintained between blocks while an alley of 1.5 m was left between plots. The treatments were: Lambda (L)-cyhalothrin 17.5 g L^{-1} EC (Karate^R 17.5 g a.i.ha^{-1}), Azadirachtin 0.15% w/w (Achook ^{R} EC 3 g a.i.ha^{-1}), Azadirachtin 0.6% w/w (Neem extractive^R 27.9 g a.i.ha^{-1}), Imidacloprid 350 FS (Gaucho ^{R} 43.7 g a.i.ha^{-1}), an alternating spray schedule of L-cyhalothrin and Azadirachtin 0.6% and untreated plots (control). All locally recommended agronomic practices were adhered to. At the time of planting, Diammonium Phosphate fertilizer was mixed well with the soil at the rate of 125 kg ha^{-1}. Calcium ammonium nitrate was applied as a top dresser 4 week after sowing at a rate of 70 kg ha^{-1} and repeated again after 4 week. Drip irrigation was used to supplement rains and plots were kept weed-free through out the season. Treatments were applied on 6, 7 and 8 week after sowing except Imidacloprid, which was used as a seed dressing. In the alternating spray schedule treatment, L-cyhalothrin and Azadirachtin 0.6% were applied on alternate weeks starting with L-cyhalothrin. During insecticide spraying, polythene sheeting was placed around the target plot to prevent spray drift to other non-target plots. Two outer rows of each plot were kept as guard rows and were not sampled. The number of live and parasitized (mummified) aphids were counted *in situ* on leaves from fifth week after sowing and continued weekly for 9 week. This was on ten plants randomly selected from each plot in every sampling period. From each plant, a leaf was randomly sampled from the top, middle and bottom section. On the pods, aphids were also counted *in situ* weekly from seventh week after sowing for seven weeks. Ten pods per plot were randomly selected on 10 plants at every sampling period. When the pods reached commercial maturity, they were harvested four times weekly for seven consecutive weeks. The harvested pods were categorized to grades for export market, local market and unmarketable pods. Export market-graded pods were 10-15 cm long, dark green, unblemished or bruised and had no pimples. The pods graded for local market had some defects, somehow overgrown but could be accepted for local consumption, while unmarketable pods were highly damaged such that they could not be sold. The unmarketable grade was further classified to; aphid-contaminated grade (pods with honeydew, sooty moulds, aphids or their cast skins) and non-aphid contaminated grade (pods with damage caused by non aphids).

All data were subjected to Analysis of Variance (ANOVA) using GENSTAT statistical package vers. 8. The data were transformed prior to analysis to satisfy the assumption of normality of ANOVA in case this was not so. Least Significant Difference (LSD) was used to separate means at 95% level of significance only when ANOVA showed significance.

RESULTS

The number of live aphids counted on Okra leaves during the two seasons was significantly different ($p<0.05$). In both seasons, plants in the untreated plots (control) had the highest mean number of live aphids whereas those in the Imidacloprid-treated plots had the lowest mean count (Table 1). Plants spayed with Azadirachtin 0.15% had relatively lower aphid infestation compared with plants sprayed with Azadirachtin 0.6% though not significant. There were no significant differences ($p>0.05$) in the number of live aphids counted in plants sprayed with L-cyhalothrin and L-cyhalothrin/Azadirachtin 0.6% alternation sprays although L-cyhalothrin-treated plots had slightly lower aphid population than plots treated with the latter. Likewise, the number of parasitized aphids was significantly ($p<0.05$) different among the treatments in the two seasons (Table 1). Plants in the untreated plots recorded the highest number of parasitized aphids while plants in Imidacloprid-treated plots recorded the lowest. Aphid parasitization was higher in the second season of the untreated plants but this was opposite in the other treatments.

The number of aphids recorded on the pods were significantly ($p<0.05$) different among the treatments. Pods in the untreated plots had the highest aphid population while those in the Imidacloprid-treated plots had the lowest (Table 1). Plots treated with L-cyhalothrin/ Azadirachtin 0.6% spray alternation had higher counts than those treated with only L-cyhalothrin though not significant using the LSD value at 95% level. The number of aphids recorded on pods in the second season was lower than those recorded in the first season in all treatments except the Azadirachtin 0.6% treated plots.

In the first season, plots treated with different insecticides produced higher yield than untreated plots (Table 2). There was significant difference ($p<0.05$) among treatments in the pod weight of

Table 1: Mean number of live and parasitized *A. gossypii* counted on okra leaves and pods under different treatments in two seasons, 2003 and 2004 at Kibwezi, Eastern Kenya

	Season 1			Season 2		
Treatments	Leaves	Pods	Parasitized aphids	Leaves	Pods	Parasitized aphids
Imidacloprid	59.0a	6.9a	1.0a	98.0a	3.3a	0.8a
Azadirachtin 0.6%	462.0b	15.0a	2.3ab	461.0b	18.0a	1.7a
Azadirachtin 0.15%	468.0b	21.1a	2.4ab	294.0c	9.5a	1.5a
L-cyhalothrin	687.0c	20.5a	3.3b	617.0d	16.3a	2.2a
L-cyhalothrin/ Azadirachtin 0.6%	755.0c	25.2a	3.3b	619.0d	18.0a	2.5a
Control	3291.0d	371.6b	5.0bc	2709.0e	271.3b	16.9b
LSD (p = 0.05)	168.0	23.4	2.3	131.0	23.0	3.5

Means with similar letter(s) in the same column are not significantly different at 95% level; N is 270 leaves, 70 pods

Table 2: Mean weight (kg) of okra pods harvested from plants under different treatments in the two seasons, December 2003-May 2004 at Kibwezi, Eastern Kenya

	Season 1				Season 2			
	Marketable grades		Unmarketable grades		Marketable grades		Unmarketable grades	
Treatments	Export	Local	Aphids contaminated	Non aphids contaminated	Export	Local	Aphids contaminated	Non aphids contaminated
Imidacloprid	18.9a	1.5a	0.0a	1.5a	17.6a	1.0a	0.0a	0.6a
Azadirachtin 0.15%	17.6b	1.6a	0.0a	2.0a	15.8b	1.0a	0.0a	1.4b
Azadirachtin 0.6%	17.3b	1.7a	0.0a	1.9a	16.0b	0.6a	0.0a	1.3b
L-cyhalothrin/ Azadirachtin 0.6%	17.2b	1.9a	0.0a	1.4a	15.8b	0.6a	0.0a	1.4b
L-cyhalothrin	16.6b	1.9a	0.0a	1.5a	16.1b	1.3a	0.0a	1.1b
Control	9.3c	1.7a	3.0b	2.5b	8.3c	1.8b	2.2b	2.3c
LSD (p = 0.05)	1.06	0.42	0.16	0.62	1.23	0.82	0.06	0.49

Means with similar letter(s) in the same column are not significantly different at 95% level

different grades except the grade that can only be targeted for the local market. Plants in the Imidacloprid-treated plots produced the highest marketable pod yield while untreated-plots recorded the lowest yield.

The yield recorded in the second season was lower than in the first season (Table 2). However, the insecticide-treated plots had more than 80% of the production suitable for export market. Contamination was high in untreated plots in both seasons. This was mainly caused by non aphids, especially in the insecticide-treated plots.

DISCUSSION

This present study shows that both synthetic insecticides and neem based products are capable of reducing aphids' population on okra crop. However, their effectiveness was variable. The results revealed that Imidacloprid was significantly superior to the other treatments in controlling aphids. This is in agreement with studies by Misra (2002) and could be due to its systemic nature of assimilation into a plant compared to the other treatments. Imidacloprid, which is applied as a seed dresser, has several advantages over the foliar insecticides. Its exposure to the applicant during application is highly reduced compared with foliar sprays and there is no repeated application. It offers protection from infestation from early crop development and it is cost effective. Indeed even earlier studies done in 1970s show that aphids can effectively be controlled by systemic insecticides. For example, Uthamasamy and Balasubramanian (1976) reported effective controlled aphids on okra by side application of aldicarb granules 10 days after sowing. The three applications of L-cyhalothrin at a 7 day interval from 42 days after sowing adopted in this study gave good control of aphids similar to findings by Khaire and Naik (1986).

It was also very interesting that the two Neem based insecticides, Azadirachtin 0.15% and Azadirachtin 0.6%, were as effective as the synthetic insecticides in reducing aphids' infestation in okra. Azadirachtin 0.15% was the second superior insecticide after Imidacloprid, providing farmers with cheap means of controlling aphids. In Africa, as well as other parts of the world, neem extracts containing azadirachtin (3 g a.i ha^{-1}) have been reported to be effective against aphids of okra (Ahmed, 2000; Praveen and Dhandapani, 2002; Obeng-Ofori and Sackey, 2003).

The significant differences in the yield recorded among the treatments suggest that without pesticides, aphids can result to high yield losses. Imidacloprid-treated plots had relatively more yield than other treatments, which is consistent with Bhargava *et al*. (2001) and Latha and Divakar (1997) findings that use of Imidacloprid results to better yields in okra production due to its effectiveness in controlling the aphids. The higher yields in Imidacloprid treated plots could also be attributed to its early protection of the crop.

Since Azadirachtin 0.15% and Azadirachtin 0.6% have a pre-harvest interval of eight hours and twelve hours, respectively, they are suitable for application at the harvesting period as okra pods are picked every 2-3 days. The use of these neem products in okra production has added advantages of conserving natural enemies and does not pollute the environment. It was shown that these products had higher aphid parasitization than Imidacloprid. The results suggest that neem-based insecticides can be used alone in the management of aphids. Farmers who still insist on the synthetic insecticides could be advised to alternate them with the neem products. This would prevent or delay development of resistance by the pest.

Because neem based products have no knock down effects, farmers should be clearly taught on their mode of action as they may expect quick action while using the product. Neem products have relatively short residual life, which is good for the ecology. The neem derivatives could be suitable in an elaborate Integrated Pest Management system in okra production. They have been used elsewhere primarily as feeding poisons for nymphs and larvae of different phytophagous insects, due to their considerable selectivity toward natural enemies especially parasitoids and many predators (Schmutterer, 1990). This current study recommends use of the neem products as a first priority in management of aphids in okra fields. This is because they are cheap and can be accessed by most small holder farmers, who are low input users. There is evidence that farmers can invest in seed treatment (using Imidacloprid) without incurring other costs of aphids control later in the season. This can only be constraint by the high cost of this insecticide. The problem of insecticide residues can be highly reduced by using the seed dresser and neem products. Use of foliar sprays of synthetic insecticides should be restricted to avoid resistance build-up as well as reducing cost of pest management.

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