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INFLUENCE OF 2,3-DIHYDRO-2, 2-DIMETHYL BENZOFURAN RATES AND OKRA VARIETIES ON THE INCIDENCE OF FLEA BEETLE

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ABSTRACT

Okra, *Abelmoschus esculentus* L. (Syn. Hibiscus esculentus) is an important vegetable crop cultivated mainly for its immature edible green fruits that are known for their high levels of vitamins A, C and some minerals. Unfortunately, insect pests are a major setback for commercial production of the crop in many countries in Africa. Among the insect pests that cause economic damage on the crop, the flea beetle, *Podagrica uniformis* JAC. (Coleoptera: Chrysomelidae) is the most serious in the recent times. The most efficacious rate of 2, 3-dihydro-2, 2-dimethyl benzofuran or carbofuran, one of the systemic pesticides, for Okra varieties. This study was conducted to determine the most efficacious rate of carbofuran 3G, one of the systemic pesticides, for Okra varieties. Treatments included carbofuran 3G rates (0.0, 0.75, 1.5, and 2.25 kg a.i. ha^{-1}) and three Okra varieties (Tae-38, NHae-47 and cv 'Awgu early'). The incidences of *P. uniformis* were significantly affected by the carbofuran rates and Okra varieties. Carbofuran at 1.5 kg a.i. ha^{-1} was superior in reducing the incidence and increasing pod yield. The effect of the insecticide also decreased with increase in plant age, especially from 6 weeks after planting. All the varieties planted differed significantly in the incidence of *P. uniformis*. NHae-47 was the most resistant, while ''Awgu early'' had the highest beetle infestation. All the varieties had higher pod yields under higher carbofuran application than the control; with Nhae-47 producing the highest and ''Awgu early'' the least pods yield.

Key Words: Carbofuran, *Podagrica uniformis*

RÉSUMÉ

Okra, *Abelmoschus esculentus* L. (Syn. Hibiscus esculentus) est une importante légume cultivée principalement pour ses fruits verts, immatures comestibles connus pour leurs niveaux élevés en vitamins A, C et quelques minéraux. Malheureusement, les pestes d'insectes constituent une contrainte majeur à la production commerciale de la culture dans beaucoup de pays africains. Parmi les pestes d'insectes qui causent des dommages économique à la culture, se trouve l'altise, *Podagrica uniformis* JAC. (Coleoptera: Chrysomelidae) est le plus recemment important. Une dose le plus efficace de 2, 3-dihydro-2, 2-dimethyl benzofuran ou carbofuran, un des pesticides systémiques, pour les variétés d'Okra. Cette étude était conduite pour déterminer la dose la plus efficace du carbofuran 3G, un des pesticides systémiques, pour les variétés d'Okra. Les traitements consistaient en doses de carbofuran 3G (0.0, 0.75, 1.5, et 2.25 kg a.i. ha^{-1}) et trois variétés d'Okra (Tae-38, NHae-47 et cv 'Awgu précoce). Les incidences de *P. uniformis* étaient significativement affectées par la dose de carbofuran et les variétés d'Okra. Le Carbofuran à 1.5 kg a.i. ha^{-1} était supérieur en terme de réduction de l' incidence et augmentation du rendement en gousses. L'effet de l'insecticide a aussi diminué avec l'augmentation de l'age du plant, spécialement à partir de 6 semaines après plantation. Toutes les variétés plantées étaient significativement différents fâce a' l'incidence de *P. uniformis*. NHae-47 était le plus résistant, alors que ''Awgu précoce'' avait enregistré le niveau le plus élevé d'infestation. Toutes les variétés avaient des rendements plus élevés sous application de la dose la plus élevée du carbofurant par rapport au témoins; avec Nhae-47 enregistrant le rendement le plus élevé et "Awgu précoce" produisant le plus bas rendement en gousses.

Mots Clés: Carbofuran, *Podagrica uniformis*

INTRODUCTION

The flea beetle (*Podagrica uniformis)* appears to be the most serious insect pest of Okra in Nigeria (Fasunwon and Banjo, 2010; Alao *et al.,* 2011). Two species of *Podagrica* are recognised in Nigeria: *Podagrica sjostedti and Podagrica uniformis. Podagrica sjostedti* has bluish - black elytra; while *P. uniformis* has shiny brown elytra (Osisanya and Tayor, 1981). These species have constantly been observed as major pests of Okra, infesting leaves leading to considerable economic yield losses.

Defoliation due to infestations has been reported to be up to 80%, and severity of damage varies in different places (Egwuatu, 1982; Clementine *et al*., 2009). They commence infestation from germination throughout all stages of growth. They are mainly leaf eaters, and have biting and chewing mouth parts (Youdewel, 1988). The activity of *P. uniformis* drastically reduces the photosynthetic capacity of the leaf resulting in low dry matter production and consequently, low yield. It has also been reported that *Podagrica* species are responsible for the transmission of Okra mosaic virus (OMV) observed in Côte d' Ivories, Kenya, Nigeria and Sierra Leone in Africa (Egwuatu, 1982; Fajinmi and Fajinmi, 2010).

In view of the aforementioned destructive activities of these insects, their control becomes imperative in order to achieve and maintain high yields. In the past, various control measures have been adopted, such as use of insecticides. Generally, synthetic insecticides are the most effective means due to their quick action and long lasting effects. Similarly, chemical methods are important in the case of insect pests of economic importance, with frequent outbreaks like *P. unformis*.

Research reports showed that spraying Okra plants with insecticides could be a profitable, especially for the dry season cropping (Adenuga, 1971). Thus, the use of different concentrations of carbanyl insecticides on the plants, resulted in great improvement of crop yield. Unfortunately, the yearly increase in the cost of pesticides has gone out of reach of common farmers, and for the fact that most Okra farmers are poor, illiterate and cannot adopt application of most insecticides.

There is thus need to assess some measures that are environmentally friendly for handling such economically important pests. Among the environment friendly pest management approach, host plant resistance (HPR) is one of the self perpetuating and cost effective methods of pest management and has been used for the management of many insect pests of crops. Plants contain a large number of substances, which are primarily used as a means of defense against natural enemies. A resistant variety can provide a base on which to construct an integrated control system and may be most fruitful when used in connection with other methods of control (Iqbal *et al.,* 2008).

Host plant resistance is seen to be a sustainable approach to pest management and varietals trials of different Okra plants to *Podagrica* are essential. Varietal resistance has often been used for the management of *Earias* spp. on Okra (Memon *et al*., 2004).

Although use of insecticides for the management of *P. uniformis* has been reported in Nigeria, no study on the varietal resistance of Okra against *Podagrica* spp has been reported. Evaluating available varieties to exploit the benefit of resistance inherent in it would serve as a source of materials for hybridisation for improved crop protection and yield. In addition, following the fact that *P. uniformis* is one of the economic and stubborn pests of Okra, knowledge of the mechanism that is involved in Okra resistance to the pest becomes quite eminent. There is also paucity of information on the effect of combined application of carbofuran and varieties on crop development, pest and disease incidence of Okra in Nigeria.

The objective of this study was to evaluate the response of different available Okra varieties and carbofuran rates to *Podagrica* infestation in Nigeria.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki in Nigeria during the 2009 and 2010 farming seasons. Abakaliki lies within 7o 30'E, 5o 45'N, with an average annual rainfall of 2000 mm. The fields were laid out in split-plots in a randomised complete block design. The four levels of carbofuran 3G (0.0, 0.75, 1.5 and 2.25 kg a.i. ha^{-1}) formed the main plots treatments; while Okra varieties (Tae-38, NHae-47 and cv 'Awgu early'), collected from National Institute for Horticultural Research, Ibadan, Nigeria, were treated as sub-plots. All the treatments were replicated thrice. Plot size was 4 x 5 m, with 0.5 m pathways between the plots and 1.0m between blocks.

The seeds were sown on raised beds (30 cm height) in parallel lines through a hand drill, two seeds per hole at about 3 cm depth. Each variety occupied a single row. Plant spacing was 60 cm by 50 cm inter- and intra- spacing, respectively. Thinning was done after full emergence, to one plant per hill.

Carbofuran was placed in the drilled holes of the seeds at planting. Blanket applications of NPK 15:15:15 fertiliser was done at 50 kg ha^{-1}, 21 days after planting. Manual weeding was done at three weeks interval throughout the experiment starting from 3 weeks after planting.

Observations on *P. uniformis* infestation started three weeks after sowing, and continued till harvest. The population of *Podagrica* species was assessed during the two planting seasons. Sampling was done weekly until crop maturity. Sampling was based on five plants that were randomly selected from each variety.

The population of the insect was determined by hand picking and direct counting on Okra plants. Counting was done early in the mornings between 7.00 and 8.00 am when the flea beetles were less active. Damage on leaves from the selected plants was also estimated by scoring (using a scale of 0 to 10) the percentage number of leaf infestation and leaf defoliation/severity.

Yield and yield components were assessed by determining the total number of pods per plant, weight per pod and the total pod yield. Harvesting was done twice a week.

All the data collected were subjected to analysis of variance (ANOVA) using SAS computer package (SAS, 2003). Data on percentage infestation were subjected to Arcsine transformations before analysis of variance using SAS. Detection of differences among treatment means was carried out by Fisher's protected LSD test at 5% probability level.

RESULTS

Variety resistance. The results revealed that carbofuran rates and host plant resistance have significant effect on the incidence of *P. uniformis* (Table 1). Infestation varied significantly ($P<0.05$) among the different varieties of Okra. Of all the varieties assessed, NHae-47 variety showed the highest level of resistant with minimum percentage leaf infestation throughout the experimental period; and differed significantly ($P<0.05$) from other varieties. Tae-38 variety and ''Awgu early'' were comparatively more susceptible varieties and did not show significant difference from each another; though ''Awgu early'' had the highest number of leaves infested.

Among the insect pests of economic importance observed were the two flea beetle species, *Podagrica* species (*Podagrica sjostedti and Podagrica uniformis)* feeding on Okra leaves; however, only results from *P. uniformis* were recorded because of its dominant nature in the field. Infestation of *P. uniformis* on the different varieties started from day 21 to 35 after planting, before carbofuran was applied. Treated plots did not show infestation until 5 weeks after planting. The level of *P. uniformis* infestation varied with carbofuran rate, with least infestation recorded with 1.5 kg a.i. ha^{-1} rates. This rate differed significantly from other doses across the varieties, while the control plots had the highest level of number of leaf infestation by *P. uniformis* throughout the experimental period.

The effect of the insecticide decreased with increase in plants' age (Table 2). Its depressing

TABLE 1. Effect of carbofuran rates and Okra varieties on percentage number of leave damage by *P. unformis*

Carbofuran rates (kg ha^{-1})	Okra varieties		
	NHae-47	Awgu early	Tae-38
0	84.8	90.2	89.3
0.75	80.9	86.2	86.7
1.5	66.6	83.5	81.2
2.25	73.8	78.1	79.3

LSD (P< 0.05) for comparing two carbofuran or variety means = 5.1; LSD (P< 0.05) for comparing two carbofuran x variety means = 1.5

TABLE 2. Flea beetle populations at different growth stages of the plant as influenced by carbofuran and variety

Weeks after planting	Carbofuran rates (kg ha^{-1})	Varieties		
		Tae-38	NHae-47	'Awgu early'
3	0.0	0.4	0.0	0.5
	0.75	0.3	0.0	0.2
	1.5	0.0	0.0	0.0
	2.25	0.0	0.0	0.0
5	0.0	7.7	3.7	8.1
	0.75	7.2	3.3	7.9
	1.5	3.7	1.7	4.3
	2.25	3.9	1.5	4.4
7	0.0	25.8	19.7	27.1
	0.75	25.1	16.3	25.5
	1.5	20.9	12.3	23.3
	2.25	22.3	13.4	23.7
9	0.0	33.5	25.1	35.2
	0.75	32.4	22.3	33.1
	1.5	27.1	20.2	29.2
	2.25	27.9	22.1	28.9

	Weeks after planting			
	3	5	7	9
LSD (P< 0.05) for comparing two carbofuran or variety means =	NS	2.1	NS	NS
LSD (P< 0.05) for comparing two carbofuran x variety means =	NS	NS	NS	NS

NS = Not significant

effect on insect pest infestation peaked at 5 weeks after planting, and subsequently declined gradually. From 7 weeks after planting, the incidences of *P. uniformis* had increased in the field dominating the incidences of other insect pests of the crop. At this stage, differences in the pest incidence among the varieties and carbofuran doses were not significant (P>0.05).

Flea beetle population. The population of *P. uniformis* also varied with the varieties, with the least population recorded in NHae-47; which differed significantly from the other two varieties (Table 2). "Agwu early" recorded the highest number of *P. uniformis* population across the varieties and years. Plots treated with carbofuran showed a significant (P<0.05) decrease in flea beetle population over the untreated plots in both years, regardless of doses. Similarly, the beetle population was relatively low at the vegetative stage of Okra, but increased progressively through the flower, pod set and pod harvest stages.

The severity of defoliation by *P. uniformis* took a similar trend with infestation level (Fig. 1). Plots treated with 1.5 kg a.i. ha^{-1} had the least leaf defoliation by the pest and differed significantly from other dosages. Similarly, variety NHae-47 that had the least level of infestation, recorded the least leaf defoliation and differed significantly (P< 0.05) from other varieties. Throughout the period of the experiments, variety NHae-47 and carbofuran at 1.5 kg a.i. ha^{-1} had the least proportions of number of infested leaves, *P. uniformis* population and percentage leaf defoliation severity.

Yield components. Plots that received the highest doses of carbofuran were superior to those with other rates (Table 3). Plots treated with 1.5 kg a.i. ha^{-1} gave more pod yield across the varieties, with NHae-47 variety recording the highest number of pods. The trend was similar to the pod weight and total pod yields across the varieties and carbofuran rates. Weight per pod and per total pod yield appeared highest with a

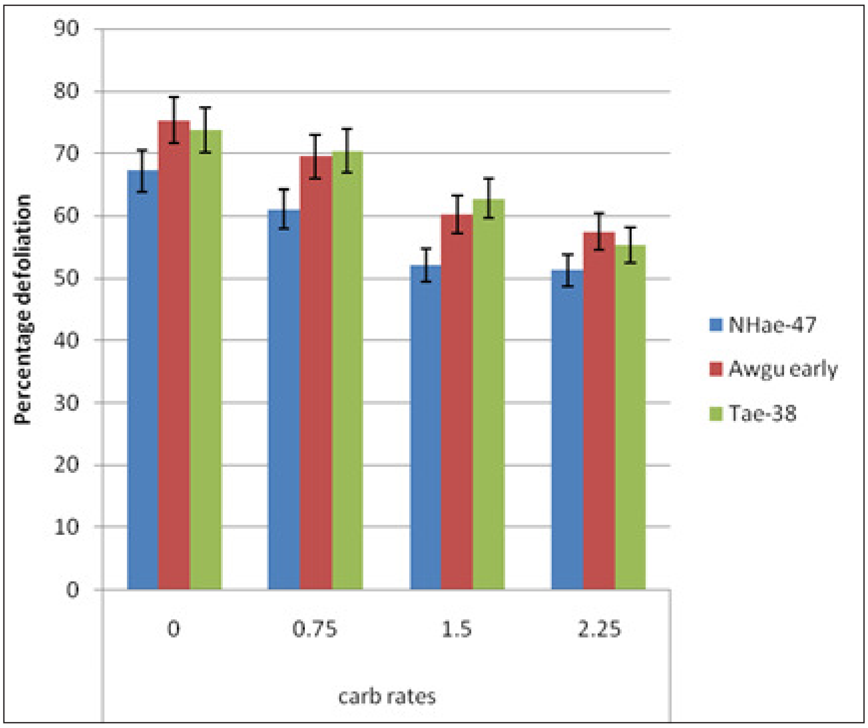

Figure 1. Effect of carbofuran rates and Okra varieties on percentage defoliation of Okra leaves by *P. uniformis.*

TABLE 3. Effect of carbofuran rates and okra varieties on the yield components

Paarameters	Varieties	Carbofuran rates (kg ha^{-1})			
		0	0.75	1.5	2.25
Number of pods per plant	NHae-47	6.1	6.2	16.6	12.6
	Awgu early	4.2	5.0	12.3	9.8
	Tae-38	4.1	4.6	12.6	10.4
Weight of pod (g)	NHae-47	27.6	27.6	31.9	28.9
	Awgu early	22.3	25.3	39.2	23.1
	Tae-38	18.6	18.0	23.4	20.7
Total pod yield (t ha^{-1})	NHae-47	11.0	13.4	16.3	14.7
	Awgu early	9.5	11.3	13.5	13.1
	Tae-38	10.3	10.7	12.4	12.9

	Pods/plant	Weight of dry pod (g)	Total dry pod yield (t ha^{-1})
LSD (P< 0.05) for comparing two carbofuran or variety means =	2.4	5.3	1.7
LSD (P< 0.05) for comparing two carbofuran x variety means =	3.3	6.7	NS

NS = Not significant

combination of 1.5 kg a. i. ha^{-1} of carbofuran and NHae-47 variety; while the least pod was recorded with the combination of 0 kg a.i. ha^{-1} of carbofuran with the ''Awgu early'' variety.

DISCUSSION

The relative low incidence of *P. uniformis* with significantly higher pod yield observed in Nhae-47 variety, even without insecticide compared to the other varieties (Table 1) may be attributed to the innate ability of this variety to withstand pests attack. It has been reported that different crop varieties respond differently to biotic and abiotic stresses. This is in line with the report of Lokesh and Singh (2005), which states that Okra plants respond differently to different insect pests. Similarly, Singh and Brar (1994) studied the resistance of 14 varieties of Okra to *E. vittella* and reported that while some were resistant; others were susceptible to the pest.

Though the modes of resistance of these varieties were not clear, it could be attributed to the inherent characteristics of these varieties that made them to be resistance to attack.

The low incidences of flea beetles/population observed during the vegetative stage, which rapidly increased during the reproductive phase of the plant, could be attributed to the increasing abundance of food sources (flower buds, flowers and pods) that were more at the reproductive stage of the plant compared with the vegetative phase. This is in line with the results reported by Egwuatu and Taylor (1976) and Echezon *et al.* (2010), which stated that insect aggregations increase with increase in food supply sources. The significant differences observed in severity across the varieties could also be attributed to continuous feeding of beetles on susceptible Okra leaves. Similar leaf damages were reported by Obeng-Ofori and Sackey (2003).

Results of the effect of carbofuran rates indicated differential efficacies of carbofuran rates on *P. uniformis* control till 5 weeks after planting. Carbofuran is one of the systemic insecticides that have high potential for the management of various insect pests of crops. Efficacy of carbofuran against *P. uniformis* has also been reported in Nigeria (Anaso and Lale, 2002; Anaso, 2003). Similarly, high reduction of flea beetles with different insecticide molecules has been reported by various studies in Nigeria (Emosairue and Uguru, 1999; Mohamed-Ahmed, 2000; Ahmed *et al*., 2007).

The reduction in the efficiency of the insecticide with the increase in the age of the plant (Table 2) may be attributed to the loss of efficacy of the insecticide at the shelf life limit of the chemical.

The increase in pod yield observed with increase in rate of carbofuran applied across the varieties may be attributed to the ability of some chemicals to promote plant growth parameters. According to Ceccon *et al.* (2004) and Van Hezewijk *et al.* (2008), carbofuran and other systemic are known to promote growth and enhance yield of the affected crops to varying extents.

Although there was a progressive trend of higher number of pods, heavier pods and total pod yield with increasing combined doses of carbofuran and varieties, significant differences were only detected among higher carbofuran rates with NHae-47 variety.

CONCLUSION

Podagrica uniformis attacks on Okra varies from different growth stages of the plant and from variety to variety. While the population/ infestations is low at the vegetative stage, it increases with plant age, a peaking at the reproductive phase. Application of carbofuran has significant effect in the management of *P. uniformis* especially when applied at the rate of 1.0 kg ha^{-1} and above for up to 5 weeks after planting. However, increase in carbofuran application above 1.5 kg ha^{-1} does not result in a continuous increase in effect. Of all the varieties tested NHae-47 is the most resistance variety to *P. uniformis*. Therefore, application of carbofuran at the rate of 1.5 kg ha^{-1} together with NHae-47 Okra variety have high potential in the management of *P. uniformis* in Nigeria.

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REFERENCES

Adenuga, A. O. 1971. Field insecticide trial for the control of insect pest of Okra. *Hibiscus esculentus*. *Tropical Science*. pp. 175 - 185.

Ahmed, B. I., Yusuf, S.R., Yusuf, A. U., Aliyu, M. 2007. Comparative efficacy of different concentrations of some promising insecticides for the control of *Podagrica* spp. (Coleoptera: Chrysomelidae) on Okra (*Abelmoschus esculentus* (L.) Moench). *Global Journal Agricultual Science* 6:31- 34.

Alao, F.O., Adebayo, T.A., Olaniran, O.A. and Akanbi, W. B. 2011. Preliminary evaluation of the insecticidal potential of organic compost extracts against insect pests of Okra (*Abemoschus esculentus* (L.) Moench). *Asian Journal of Plant Science and Research* 1(3):123-130.

Anaso, C. E. 2003. Cost-benefits of spraying sole and intercropped Okra with neem seed extracts and deltamethrin in the Nigerian Sudan Savanna. *Agricultural Environment* 3:171-177.

Anaso, C. E. and Lale, N.E.S. 2002. Spraying intervals and cost-benefit of using aqueous neem kernel extract and deltamethrin against some foliage and fruit pests of Okra in Sudan savanna of Nigeria. *Journal of Sustainable Agricultural Environment* 4:122-128.

Anonymous, 1972. Pesticide Manual. Basic information on the chemicals used as Active Compounds of Pesticides. 3rd Ed. Hubert, M. (Ed.). Issued by British Crop Protection Council, Clacks Farm, Worcester England, UK. 701pp.

Ceccon, G., Ragga, A., Duarte, A.P. and Siloto, R. C. 2004. Effects of Insecticides at sowing on seedling pests and yield of off-season maize crop under no-tillage system. *Bragantia, Campinas* 63 (2):227-237.

Clementine, L., Dabiré-Binso, L., Malick, N., Ba-Koussao, S. and Antoine, S. 2009. Preliminary studies on incidence of insect pest on Okra, *Abelmoschus esculentus* (L.) Moench in central Burkina Faso. *African Journal of Agricultural Research* 4 (12):1488-1492.

Egwuatu, R. I. and Taylor, T. A. 1976. Aspects of the spatial distribution *of Acanthomia* *tomentosicollis* stal (*Heteroptera, Coreidae*) in *Cajanus cajan* (Pigeon pea). *Journal of Economic Entomology* 69 (5):591-594.

Egwuatu, R.I. 1982. Field trials with systemic and contact insecticide for the control of *Podagrica uniforma* and *P. sjostedti* (*Coleoptera: Chrysomelidae*) on Okra. *Tropical Pest Management* 28 (2):115-121.

Emosairue, S. O. and Uguru, E. I. 1999. Field trial of aqueous and petroleum ether extracts of *Monodora myristica* (Gaertn) Dunal and *Jatropha curcas* L. for the control of Okra flea beetles, *Podagrica* spp. *Journal of Applied Chemistry and Agricultural Research* 6:100-104.

Fajinmi, A. A. and Fajinmi, O. B. 2010. Incidence of Okra mosaic virus at different growth stages of Okra plants (*Abelmoschus esculentus* L. Moench) under tropical condition. *Journal of General and Molecular Virology* 2 (1):028- 031.

Fasunwon, B.T. and Banjo, A.D. 2010. Seasonal population fluctuations of *Podagrica Species* on Okra plant (*Abelmoschus Esculentus*). *Research Journal of Agriculture and Biological Sciences* 6(3): 283-288.

Iqbal, J., Mansoor, H., Muhammad, A., Shahbaz, T. and Amjad, A. 2008. Screening of Okra genotypes against Jassid, *amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae). *Pakistan Journal Agricultural Science* 45(4):448 - 451.

Lokesh, S. and Singh, R. 2005. Influence of leaf vein morphology in Okra genotypes (Malvaceae) on the oviposition of the leafhopper species *Amrasca biguttula* (Hemiptera cicadellidae). *Entomological General* 28(2):103-114.

Memon, A.J., Abro, G.H. and Syed, T.S. 2004. Varietal resistance of Okra against *Earias* spp. *Journal of Entomology* 1:1-5.

Mohamed-Ahmed, M.M. 2000. Studies on the control of insect pests in vegetables (Okra, tomato, and onion) in Sudan with special reference to neem preparations. PhD. dissertation, University of Giessen, Germany.

Obeng-Ofori, D. and Sackey, J. 2003. Field evaluation of non-synthetic insecticides for the management of insect pests of Okra *Abelmoschus Esculentus* (L.) Moench in Ghana. *Ethiopian Journal Science* 26:145-150.

Osisanya, E.O. and Tayor, T.O. 1981. Assessment of damages caused by the leaf eating beetle *Podagrica* spp. on Okra in Southern Western Nigeria. *African Journal Agricultural Science* 1:123-141.

SAS Institute 2003. SAS systems for Windows, Version 9.1 Edition. SAS Institute Inc., Cary, NC., USA.

Singh, G. and Brar, K. S. 1994. Effect of dates of sowing on the incidence of *Amrasca biguttula* (Ishida) and *Earias* spp on Okra. *Indian Journal Ecology* 21:140-144.

Van Hezewijk, B. H., De Clerck-Floate, R. A. and Moyer, J. R. 2008. Effect of nitrogen on the preference and performance of a biological control agent for an invasive plant. *Biological Control* 46:332-340.