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ASSESSING THE IMPACT OF CARBOFURAN RATES AND OKRA VARIETIES ON THE INCIDENCE OF *Podagrica uniformis*, JAC. (COLEOPTERA: CHRYSOMELIDAE)

Name: **Dr. E. O. Ogah**
Designation: Ph.D. Department of Crop Production and Landscape Management, Ebonyi State University PMB 053 Abakaliki, Nigeria; emmamarg2005@yahoo.com

Name: Dr. E. N. ogbodo
Designation: Ph.D. Department of Soil Science and Environmental Management, Ebonyi State University PMB 053 Abakaliki, Nigeria; emmanwaogbodo4sem@yahoo.com

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 have been a major setback for the commercial production of Okra in many countries in Africa. Amongst the insect pests that cause economic damage on Okra plants, the flea beetle, *Podagrica uniformis* has been recorded as the most serious pest in the recent time. In the present study, the impact of carbofuran 3G rates (0.0, 0.75, 1.5, and 2.25 kg a.i. ha^{-1}) and Okra varieties (Tae-38, NHae-47 and cv 'Awgu early') in the management of *P. uniformis* was assessed during the 2009/10 farming seasons in Nigeria. The results indicated that the incidences of *P. uniformis* were significantly affected by the carbofuran rates and Okra varieties. Carbofuran at 1.5 kg a.i. ha^{-1} significantly ($P<0.05$) reduced the incidence of *P. uniformis* and differed from other doses with resultant increase in pod yield. The effect of the insecticide was also observed to decrease with increase in plants' age especially from 6 weeks after planting. The results also indicated that all the varieties planted differed significantly on the incidence of *P. uniformis*. Amongst the varieties assessed, NHae-47 was the most resistant and differed significantly from the rest of the varieties with ''Awgu early'' having the highest level of infestation of the beetle. The results of the pod yields showed that all the varieties performed better with higher pod yields under higher carbofuran application than the control with Nhae-47 producing the highest number of pods and ''Awgu early'' having the least pods yield. It could therefore be concluded that a combination of planting resistant variety of Okra with carbofuran application has significant effect on *P. uniformis* incidences and pod yield.

Keywords - Carbofuran, varieties, *Podagrica uniformis,* yield.

INTRODUCTION

Okra, *Abelmoschus esculentus* L. (Syn. Hibiscus esculentus) belongs to the genus *Abelmoschu*s, family *Malvaceae* and is a tropics and subtropics vegetable crop cultivated for its immature edible green fruits, which are used as vegetable both in green and dried state [1]. It serves as a source of carbohydrate, dietary fibre, fat and protein [2]. Okra consumption among other fruit vegetables were found beneficial in management of blood pressure, fibrinogen concentration and plasma viscosity in Nigerian hypertensive [3], [4]. Since okra is a very common and widely consumed vegetable in Nigeria, it is grown almost throughout the year in southern parts due to climatic conditions favorable for okra cultivation. Unfortunately, despite the importance of okra and favorable environments, its yield has been far below national demand. One of the limiting factors to the profitable production of okra is the incidence of insect pests [5, 6]. It has been reported that the major insect pests of okra 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.) [7].

Amongst the insect pests of okra, the flea beetle, *Podagrica uniformis* appears to be the most serious insect pest [6], [8]. In the documentation of insect pests of primary importance in the cultivation of okra crop, it has been noted that *Podagrica uniformis*, Jacoby and *Nisotra sjostedti*, Jacoby (Col.: Chrysomelidae) were the most destructive insect species at Nsukka, Nigeria [9]. Two species of *Podagrica* are recognized in Nigeria: *Podagrica sjostedti and Podagrica uniformis. P. sjostedti* has bluish – black elytra while *P. uniformis* has shiny brown elytra [10]. These two species of *Podagrica* pests have constantly been observed as major pests of okra, infesting the leaves of the okra plants and have had a great economic significance on the yield of the crop. Defoliation of the leaf surface due to their infestations has been reported to be up to 80%, and severity of damage varies in different places [9, 11]. They have been observed to commence their infestation on okra plants from the stage of germination throughout all stages of its growth. They are mainly leaf eaters, and have biting and chewing mouthparts [12]. The activity of *P. uniformis* reduces drastically the photosynthetic capacity of the leaf, resulting in low dry matter production and consequently the yield. It have 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 [9], [13].

In order to improve the okra yield and maintain good quality, the insect pests and diseases of okra must be properly managed. And in view of the aforementioned destructive activities of these insects, their control becomes imperative in order to have a high yield. In the past, various control measures have been adopted in the management of Okra pests such as the use of insecticides. Generally, synthetic insecticides are the most effective means of controlling insect pests due to their quick action and long lasting effect. Similarly, chemical methods are very important in case of insect pest of economic importance with frequent outbreak like *P. unformis*. Research reports showed that spraying Okra plant with insecticide could be a profitable proposition especially for the dry season cropping [14]. Thus, the use of different concentration of carbanyl insecticides on these plants resulted in great improvement of crop yield. Unfortunately, the yearly increase in the cost of pesticides has gone out of reach of common farmer, and for the fact that most okra farmers are poor, illiterate and could not adopt the application of most insecticides, in addition to the side effect of insecticides both to the farmer and his environments, there is need to assess some measures that are environmentally friendly for handling such economically important pests. With the environmental friendly pest management approach invoke, host plant resistance (HPR) is one of the self perpetuating and cost effective methods of pest management and has often been used for the management of many insect pests of crops. Plants contain a large number of substances, which have their primary use as a means of defense against natural enemies. A resistance 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 [5]. Host plant resistant is seen to be a sustainable approach to pest management and varietals trials of different okra plants to *Podagrica* is essential. Varietal resistance has often been used for the management of *Earias* spp. on okra [15].

Although the uses of insecticides for the management of *P. uniformis* have 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 hybridization 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.

Therefore, the present investigation was under-taken to identify the response of different available okra varieties and carbofuran rates to *Podagrica* infestation in Nigeria for the benefit of farmers and consumer communities.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki during the 2009 and 2010 farming seasons under rain fed conditions. Abakaliki lies within 7^{o} 30'E, 5^{o} 45'N with an average annual rainfall of 2000 mm. The fields were laid out as split-plot experiments in randomized complete block design. The four levels of carbofuran 3G (0.0, 0.75, 1.5, and 2.25 kg ha^{-1}) forms the main plots treatments while the three okra varieties (Tae-38, NHae-47 and cv 'Awgu early') collected from National Institute for Horticultural Research, Ibadan, Nigeria used for the experiment were treated as sub-plots. All the treatments were replicated thrice.

The sowing of different varieties of okra was done on June 25, 2009 and 2010 respectively. Prior to the sowing, the seeds were soaked in water for 24 hr to facilitate field germination after planting. The seeds were sown on raised beds in parallel lines through a hand drill, two seeds per hole at about 3 cm depth with each variety occupying a row at the planting spacing of 60 cm by 50 cm inter and intra spacing, and later thinned after full emergence to one plant per hill. The plot size for each treatment was 4 x 5 m with 0.5 m pathways between the plots and 1.0m between blocks. Carbofuran was weighed out at the appropriate rates and placed in the drilling holes of the seeds at planting. Blanket applications of NPK 15:15:15 fertilizer was made at the rates of 50 kg a. i. ha^{-1} 21 days after planting. Manual weeding was done at three weeks interval throughout the periods of the experiment.

The observations on *P. uniformis* infestation started three weeks after sowing and continued till harvest of the crop. The population of *Podagrica species* was assessed during the two seasons of planting. The sampling was done on a weekly basis until crop maturity. Sampling was based on five plants that were randomly selected from each variety, and population of the insect was determined by hand picking and direct counting of insect on the okra plant. Counting was done early in the morning between 7.00 and 8.00 am when the flea beetles were less active and the number collected was recorded. Damages on the leaves from the selected plants were also estimated by scoring the percentage number of leaf infestation and percentage leaf defoliation/severity.

Observations on yield and yield components were based on pod number, weight per pod and total pod yield per hectare. Harvesting was done twice a week. All the data collected were subjected to analysis of variance (ANOVA). Collected data on percentage infestation were subjected to arcsine transformations before analysis of variance using SAS [16]. Detection of differences among treatment means was carried out using the Student Newman Keuls test at 5% significance level.

RESULTS

The results revealed that carbofuran rates and host plant resistance have significance effect on the incidence of *P. uniformis*. Infestation varied significantly ($P< 0.05$) among the different varieties of okra planted. Table 1, indicated the overall varietal resistance of okra against flea beetle spp based on two-year data. Of all the varieties assessed, NHae-47 variety showed the highest level of resistant against *P. uniformis* with a minimum percentage leaf infestation throughout the experimental period and differed significantly (P<0.05) from other varieties. Tae-38 variety and ‘‘Awgu early’’ were found comparatively more susceptible varieties and did not show significant difference from each another with ‘‘Awgu early’’ having the highest number of leaves infested. Amongst 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. Infestations of *P. uniformis* on the different varieties started from day 21 to 35 after planting where carbofuran was not 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 level recorded at 1.5 kg a.i. ha^{-1} rates which differed significantly from other doses across the varieties, while the control plots had the highest level of percentage number of leaf infestation by *P. uniformis* throughout the period of the experiments. The effect of the insecticide was also observed to decrease with increase in the plants’ age. Its effect got to its peak of depressing insect pest infestation at 5 weeks after planting, and subsequently started to decline gradually with the age of the plant. From 7 weeks after planting, the incidences of *P. uniformis* had reasonably increased in the field dominating the incidences of other insect pest of the crop than at the earlier stages of plant development. At this stage, differences in the pest incidence among the varieties and carbofuran doses were not significant.

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

The percentage of defoliation/severity of *P. uniformis* is as presented in (Fig.1). The percentage of defoliation/severity took the same trend with the infestation level. Plots treated with 1.5 kg a.i. ha^{-1} rates had the least level of leaf severity of the pest and differed significantly from other dosage rates, with the control plots recording the highest level of leaf defoliation/severity. Similarly, the variety that had the least level of infestation recorded the least level of leaf defoliation/severity and differed significantly (P< 0.05) from other varieties. The incidence of *P. uniformis* was higher in 2009 than in 2010 across the varieties and carbofuran rates. Throughout the period of the experiments, varieties 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 than did other varieties and dosage rates.

The results of the yield components indicated that plots that received higher doses of carbofuran rates had higher number of pods than the control plots or when 0.75 kh a. i. ha^{-1} rate was applied (Table 3). Plots treated with 1.5 kg a. i. ha^{-1} gave higher number of pods yield across all the varieties than those treated with the other doses with NHae-47 variety recording the highest number of pods, which differed significantly (P< 0.05) from other varieties and doses across the experimental periods. The trend was the same for the pod weight and total pod yields across the varieties and carbofuran rates. Weight per pod/total pod yields appeared highest with a combination of 1.5 kg a. i. ha^{-1} of carbofuran and NHae-47 variety while the least pod weight/yield was recorded with the combination of 0 kg a. i. ha^{-1} of carbofuran with the Awgu early variety.

DISCUSSION

The infestation of okra by *P. uniformis* was observed to vary between different okra varieties, carbofuran rates and years in this study. 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 may be attributed to the genetic makeup of this variety to resist *P. uniformis.* The present findings can partially be compared with those of Lokesh and Singh who reported that okra plant respond differently to different insect pests [17]. Similar results have been reported earlier on other pests of okra to support the results of present study. For example Singh and Brar studied the resistance of 14 varieties of okra to *E. vittella* and reported that while some were resistant; others were susceptible to the pest [18]. Though the modes of resistance of these varieties were not clear, it could be attributed to their genetic makeup. The incidences of flea beetles were observed to change with the growing stages of the plant across the varieties and seasons. The incidence was low during the vegetative stage of the plant, but rapidly increased during the reproductive phase of the plant. This could be attributed to the increasing abundance of food sources (flower buds, flowers and pods) that were more in abundance at the reproductive stage of the plant compared with the vegetative phase. This is in line the results reported by Egwuatu and Taylor, which stated that insect aggregations increase with the increase in food supply sources [19]. The significant differences observed in the severity across the varieties could be attributed to the continuous feeding of beetles on susceptible okra leaves. Similar leaf damages have been reported by Obeng-Ofori and Sackey [7].

The 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 [20, 21]. Similarly high reduction of flea beetles with different insecticides molecules have been reported [22 - 24]. The reduction on the efficiency of the insecticide with the age of the plant may be attributed to the shelf life limit of the chemical. Anonymous has reported that the shelf life of carbofuran in tropical soil is between 30 to 60 days [25]. Despite its shelf life duration, the non repeated application of carbofuran during planting used in this study was to avoid the possible residual effect of the chemical on the products. Similar recommendation has been given by Egwuatu in Nigeria [9]. Similarly, the differential efficiency of the chemical in the management of *P. uniformis* observed across the varieties of okra may be attributed to the genetic make of the plant. Equally, its effect on the yield components observed in this study could account for the significant yield differences and improvement achieved. According to Ceccon *et al.* and Van Hezewijk et al., carbofuran and other systemic are known to promote growth and enhance the yield of the affected crops to varying extents [26, 27].
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

The results of the experiment revealed that carbofuran application in combination with certain okra varieties have the potential for adequate management of *P.uniformis* of okra. This suggests that the adoption of these varieties for further breeding could bring about the management of some of these recalcitrant insect pests of okra for improved pod yields. From these results it was concluded that Tae-38 variety and local ‘‘Awgu early’’ showed susceptible response whereas NHae-47 was comparatively resistant. In conclusion, these methods have significant effect in the management of *P.uniformis* and if adopted as a component of IPM package for *P. uniformis* control, will result in an enhanced okra production, utilization and food security in Nigeria.

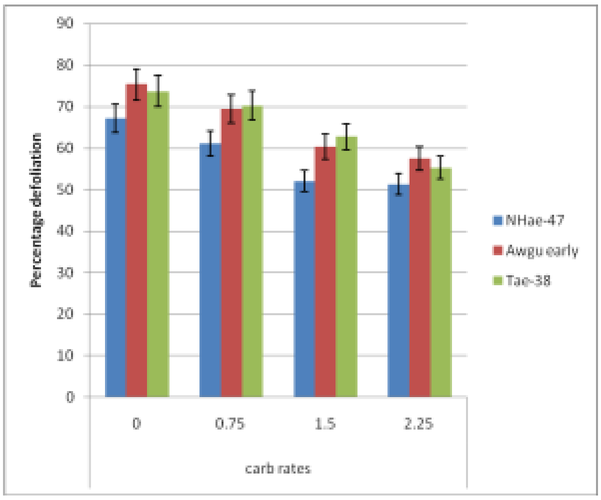

Fig. 1. Effect of carbofuran rates and okra varieties on percentage defoliation of okra leaves by *P. uniformis*

Table 1. Effect of carbofuran rates and okra varieties on *P. unformis* damages to okra plant

		2009	2010
Okra varieties	**Carbofuran rates (kg ha^{-1})**	**% No. leaves infestation by *P. uniformis***	**% No. of leaves infestation by *P. uniformis***
NHae-47	0	95.2^{c}	74.3^{c}
	0.75	92.7^{c}	69.1^{bc}
	1.5	71.8^{a}	61.0^{a}
	2.25	81.2^{b}	66.3^{b}
Awgu early	0	96.2^{c}	84.2^{c}
	0.75	95.0^{c}	77.3^{b}
	1.5	91.8^{b}	75.1^{a}
	2.25	81.5^{a}	74.7^{a}
Tae-38	0	96.1^{c}	82.5^{d}
	0.75	92.0^{b}	81.4^{c}
	1.5	89.4^{b}	73.0^{a}
	2.25	82.2^{a}	76.3^{b}

Values within the same column followed by the same letter(s) do not significantly differ (Student Newman Keuls test, $P < 0.05$)

Table 2. The population densities of *P. uniformis* as influenced by carbofuran rates and okra varieties.

	2009			
	Carbofuran rates (kg ha^{-1})			
Okra varieites	0	0.75	1.5	2.25
NHae-47	17.4^{c}	16.1^{b}	9.5^{a}	9.6^{a}
Awgu early	28.7^{d}	23.1^{c}	16.5^{a}	17.9^{b}
Tae-38	22.2^{c}	18.6^{b}	10.5^{a}	10.7^{a}
	2010			
NHae-47	17.4^{c}	16.1^{b}	9.5^{a}	9.6^{a}
Awgu early	28.7^{d}	23.1^{c}	16.5^{a}	17.9^{b}
Tae-38	22.2^{c}	18.6^{b}	10.5^{a}	10.7^{a}

Means within the same column followed by the same letter(s) do not significantly differ (Student Newman Keuls test, $P < 0.05$)

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Table 3. Effect of carbofuran rates and the incidences of *P. uniformis* on the yield components of okra varieties

Okra varieties	Carbofuran rates (kg h^{a-1})							
	2009				2010			
	0	0.75	1.5	2.25	0	0.75	1.5	2.25
No. of pods per plant								
NHae-47	6.6^{b}	6.7^{b}	18.0^{c}	13.3^{b}	5.5^{b}	5.6^{a}	15.2^{c}	11.9^{b}
Awgu early	3.3^{a}	4.7^{a}	15.7^{b}	12.6^{ab}	5.0^{b}	5.2^{a}	8.8^{a}	7.0^{a}
Tae-38	3.7^{a}	4.0^{a}	14.6^{a}	10.3^{a}	4.4^{a}	5.2^{a}	10.6^{b}	10.5^{b}
Wt of pod (g)								
NHae-47	30.7^{b}	28.7^{c}	35.1^{c}	32.6^{b}	24.5^{c}	26.5^{b}	28.7^{c}	25.2^{b}
Awgu early	23.3^{a}	24.9^{b}	32.2^{b}	21.9^{a}	21.3^{b}	25.6^{b}	26.1^{b}	24.3^{b}
Tae-38	18.7^{a}	18.9^{a}	25.4^{a}	22.1^{a}	18.5^{a}	17.1^{a}	21.3^{a}	19.2^{a}
Total pod yield t ha^{-1}								
NHae-47	11.8^{b}	14.3^{b}	18.0^{c}	16.1^{b}	10.1^{b}	12.4^{a}	14.5^{b}	13.2^{b}
Awgu early	9.4^{a}	10.8^{a}	13.3^{b}	12.7^{a}	9.5^{a}	11.8^{a}	13.7^{ab}	13.9^{b}
Tae-38	9.8^{a}	10.3^{a}	11.9^{a}	13.1^{a}	10.7^{b}	11.1^{a}	12.9^{a}	12.7^{a}

Values within the same column followed by the same letter(s) do not significantly differ (Student Newman Keuls test, $P < 0.05$).

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