EVALUATION OF EFFECT OF INSECTICIDE (3 G/L OF ABAMECTINE + 15 G/L OF ACETAMPRID EC) AND PLANT SPACING ON THE CONTROL OF *PODAGRICA SPP.*, GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus)* IN ENUGU AREA OF SOUTHEASTERN NIGERIA.

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Abstract
A field experiment to evaluate effect of insecticide (3G/L of Abamectin + 15 G/L of Acetamprid EC.) and plant spacing on the control of *Podagrica spp.*, growth and yield of Okra (*Abelmoschus esculentus*) was carried out at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Enugu, Southeastern Nigeria, using 3 x 2 factorial in a randomized complete block design (R C B D) replicated three times. Parameters assessed were number of days to 50% flowering, plant height (cm), leaf area index, number of fruits per plant, number of feeding holes created by *Podagrica spp.* per leaf and fruit yield (ton ha^{-1}). The result of the experiment showed a significant (P = 0.05) interaction effect of insecticide and plant spacing on all the parameters measured/assessed except plant height. The result of the experiment showed a significant (P = 0.05) interaction effect of insecticide and plant spacing on days to 50% flowering, leaf area index, number of fruits per plant, number of feeding holes created by *podagrica spp.* and fruit yield (ton ha^{-1}). There was no significant (P = 0.05) interaction effect of insecticide and plant spacing on plant height (cm). Plots treated with 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm recorded the highest mean number of 47.70 days to 50% flowering. Plots treated with 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm recorded the highest mean plant height of 77.80 cm, whereas the highest leaf area index of 41.10 was recorded on plots treated with 1L ha^{-1} insecticide and plant spacing of 50 cm x 30 cm. More leaf damage of 35.30 feeding holes by *Podagrica spp.* was obtained from plots treated with 0L ha^{-1} of insecticide andplant spacing of 50 cm x 50 cm. The highest yield of 2.07 ton ha^{-1} was obtained from plots treated with 1L ha ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm.

Keywords: Okra (*Abelmoschus esculentus*), insecticide, plant spacing, interaction.

Introduction

Okra (*Abelmoschus esculentus*, L. Moench) is a fruit vegetable produced and consumed in many ecological zones of the world mainly for its pod yield (Sajjan *et al*., 2000). There are three domesticated species of Okra; *Abelmoschus esculentus, Abelmoschus hibiscus* and *Abelmoschus calillei.* However, *Abelmoschus esculentus*, (L) is the most widely spread and very important mucilaginous crop. It belongs to the malvaceae family and originated from tropical Africa. It is widely grown in Nigeria primarily for its mucilaginous content, (Tindall, 2000). Okra crop is found in abundance during the rainy season and is commonly used as food in the home, and a component of mixed cropping system and often has the subsistent need in home garden. Usually picking is done because the fruits do not reach maturity at the same time. Schipper (2000) observed that vegetative cycle of okra usually varies according to varieties. Okra is eaten in various ways; the leaves are eaten as salad, the seeds may also be roasted and ground to form non-caffeinated substitute for coffee. The immature fruits are also used as vegetable, sliced and ground and used for thickening soups. It contains a lot of fibre and is required for people who want to reduce their weight because it is low in calories. The fruit is an important source of vitamin and mineral elements needed for development and maintenance of healthy human body (Schipper, 2000). Fresh Okra contain 2.1g protein, 0.2g fat, 8g carbohydrate, 36g calories, 1.7g fibre, 175.2mg minerals, 232.7mg vitamin and 88ml of water per 100g edible portion (Siemonsma and Kouame, 2004).

Okra thrives well on wide range of soil but performs optimally in well drained sandy loamy soil with a pH of 6-6.8. Okra is moderately tolerant to soil salinity and can germinate in well-drained sandy-loam (Tindall, 2000). Plant spacing exerts significant effect on crop performance. With increasing population, okra yield per unit area increases till a certain limit beyond which resources for plant become limited and yield decreases (Weiner, 1990). Plant spacing determines the available area for a plant growth to source for resources such as water, light, and nutrients. Therefore optimal plant population size is required for high yields in okra.

The infestation of insect pests is one of the most limiting factors for accelerating yield potential of okra. The crop is prone to damage by various insect pests because various growth stages of the crop are susceptible to different insect pests and diseases (Ek-amuay, 2007). The most destructive insect pests are flea beetle species *Podagrica uniformis* (Jac.) and *Podagrica sjostedti* which are responsible for heavy defoliation of which yield losses are reported in Nigeria and Ghana (Obeng-Ofori and Sackery 2003). As a result, this important vegetable, which is becoming a major crop especially in Eastern Nigeria is however neglected. Insect pests must be controlled to ensure good yield and marketable quality (Palada and Chang, 2003). Many commercial growers now spray insecticide regularly, up to twice a week instead of using traditional control method of spreading wood ash to dispel insects (Adeniyi, 2008). Considering the seriousness of insect pests, a wide range of chemicals with various spray formulations have been used in controlling *Podagrica spp*. in okra (Nazrussalam *et al*., 2008). *Podagrica spp*. have constantly been observed as major insect pest of Okra, infesting the leaves of the plants and had a great economic significance on the yield of the crop (Osisanya and Tayo, 1981). Conventional insecticides like endosulfan, dimethoate, monocrotivos at recommended doses have been used to bring down leaf beetle population, but none of them have been proved effective to reduce the insect pest infestation significantly.

Recently many researchers have reported that imiforce which has imidacloprid 200G/L SL as the active ingredient (ai.), which is found in different formulations in the market as Gauchu 70Ws, Admire 200SL etc are very effective to combat this insect pest (Parveen et al; 2007, Solangi and Lohar 2007). There is need for researchers to find out more chemicals that are proven to be effective against the pest. Therefore the objective of this research work was to evaluate the effect of insecticide (3g/l of Abamectin + 15g/l of Acetamprid EC.) and plant spacing on the control of P*odagrica spp*, growth and yield of Okra (*Abelmoschus esculentus*) in Enugu, southeastern Nigeria.

Materials and Methods

The experiment was carried out at the Enugu State University of Science and Technology. The University lies between latitude 06^0 $50^/$ N, and longitude 07^0 $15^/$ E, with a mean elevation of 450 m above sea level and an annual rainfall of 1800 mm to 2100 mm. The soil is of shale parent material and is classified as typic paleudult and is of sandy clay textural class (Anikwe *et al.,* 2005).

Experimental Design

The experiment was carried out in 3 x 2 factorial in a randomized complete block design (RCBD) replicated three (3) times. The experimental area measured 14.6 m x 6.8 m whereas the experimental units/plots measured 1.6 m x 1.6 m with 1m pathway.

Treatments

A. Three (3) rates of insecticide viz;
(i) 0L ha^{-1} (A1) (ii) 1L ha^{-1} (A2) (iii)1.5L ha^{-1} (A3) …….. (**Factor A**)

(ii) Two (2) plant spacing viz;
i. 50 cm x 30 cm (BI)
ii. 50 cm x 50 cm (B2)
……… (Factor B)

Treatment Combinations

0L ha^{-1} insecticide in 50 cm x 30 cm plots ……....A_1B_1
0L ha^{-1} insecticide in 50 cm x 50 cm plots …..…..A_1B_2
1L ha^{-1} insecticide in 50 cm x 30 cm plots……….A_2B_1
1L ha^{-1} insecticide in 50 cm x 50 cm plots……….A_2B_2
1.5L ha^{-1} insecticide in 50 cm x 30 cm plots….…A_3B_1
1.5L ha-1 insecticide in 50 cm x 50 cm plots…….A_3B_2

Data Collection

Data were collected on number of days to 50% flowering, plant height (cm), leaf area index, number of fruit per plant, number of feeding holes created by (***Podagrica Spp.)*** and fruit yield (ton ha^{-1}).

Data Analysis

Data collected were analyzed using analysis of variance for factorial experiment as outlined by Obi (2001). "Differences between treatment means were detected using Fisher's least significant difference (F-LSD) as outlined by Steel and Torrie (1980).

Results

Effect of insecticide and plant spacing on the number of days to 50% flowering, plant height and leaf area index.

The result of the experiment showed a significant (P = 0.05) interaction effect of insecticide and fungicide combinations on the number of days to 50% flowering and leaf area index, whereas there was non significant (P = 0.05) interaction effect of insecticide and fungicide combinations on plant height. On the number of days to 50% following, plots treated with 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm recorded the highest mean number of 47.70 days to 50% flowering followed by the plots treated with 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm that recorded 45.00 days to 50% flowering, whereas plots treated with 1L ha^{-1} of insecticide and plant spacing of 50 cm x 300 cm recorded the lowest mean number of 42.00 days to 50% flowering (Table 1). On plant height (cm) 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm recorded the highest mean plant height of 97.80 cm, followed by 1L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm, whereas the least mean plant height of 65.20 cm was obtained from 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm (Table 1). On the leaf area index, plots treated with 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm recorded the highest mean leaf area index of 41.10 followed by plots treated with no insecticide and plant spacing of 50 cm x 30 cm that had mean leaf area index of 40.20, whereas the least mean leaf area index of 22.10 was obtained from plots treated with 1.5L ha^{-1} of insecticide and 50 cm x 50 cm plant spacing (Table 1).

Table 1. Effect of insecticide and plant spacing on the number of days to 50% flowering, plant height and leaf area index.

Insecticide (L ha^{-1}) + Plant spacing (cm)	Mean number of days to 50% flowering	Mean plant height (cm)	Leaf area index
0 insecticide + 50 x 30	43.10	67.30	40.20
0 insecticide + 50 x 50	44.30	65.60	40.00
1 insecticide + 50 x 30	42.00	77.80	41.10
1 insecticide + 50 x 50	44.30	76.60	34.10
1.5 insecticide + 50 x 30	47.70	68.70	26.80
1.5 insecticide + 50 x 50	45.00	65.20	22.10
F –L $SD_{0.05}$	5.61	N.S	12.63

Effect of insecticide and plant spacing on the number of fruits per plant, number of feeding holes created by *Podagrica spp* and fruit yield (Ton ha^{-1}).

The result of the experiment showed a significant (P = 0.05) interaction effect of insecticide and fungicide combinations on the number of fruits per plant, number of feeding holes created by *Podagrica spp.* and fruit yield (ton ha^{-1}). On the mean number of fruits per plants, plots treated with 1L ha^{-1} of insecticides and plant spacing of 50 cm x 30 cm recorded the highest mean number of 4.87 fruits per plant, followed by 1L ha^{-1} of insecticides and plant spacing of 50 cm x 50 cm that recorded 3.67fruits per plant, whereas 0L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm recorded the lowest mean number of 2.73 fruits per plant (Table 2). Less mean number of 10.30 feeding holes of *Podagrica spp.* per plant was obtained from plots treated with 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm followed by plots treated with 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm that recorded 18.30 mean number of feeding holes per plant whereas plots treated with 0L ha^{-1} of insecticides and plant spacing of 50 cm x 50 cm had the highest means number of 35.30 feeding holes per leaf (Table 2). On fruit yield plots treated with 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm had a significant (P = 0.05) higher yield of 2.07 tons ha^{-1}, followed by plots treated with 1L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm that recorded 1.60ton ha^{-1} whereas a lower yield of 1.07 was recorded on plots treated with 0L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm (Table 2).

Table 2. Effect of insecticide and plant spacing on the number of fruits per plant, number of feeding holes created by *podagrica spp*. per leaf and fruit yield (ton ha^{-1})

Insecticide (L ha^{-1}) + Plant spacing (cm)	Mean number of fruits per plant	Mean Number of feeding holes created by *Podagrica spp.* per plant	Fruit yield (ton ha^{-1})
0 insecticide + 50 x 30	3.00	30.30	1.27
0 insecticide + 50 x 50	2.73	35.30	1.07
1 insecticide + 50 x 30	4.87	19.30	2.07
1 insecticide + 50 x 50	3.67	29.70	1.60
1.5 insecticide + 50 x 30	3.17	10.30	1.40
1.5 insecticide + 50 x 50	3.17	18.30	1.20
F –L $SD_{0.05}$	1.94	13.87	0.92

Discussion

A rate of 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm that recorded significantly (P = 0.05) higher mean number of 47.70 days to 50% flowering and 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30cm that recorded significantly (P=0.05) lower mean number of 42.0 days to 50% flowering may therefore suggest that farmers in Enugu area who want to help their Okra plants attain early maturity should apply not more than 1L ha^{-1} of insecticide with plant spacing of not more than 50 cm x 30 cm, as a higher mean of 44.30 days to 50% flowering was obtained when 1L ha^{-1} of insecticide and plant spacing of 50 cm x 50 cm was used in the experiment. The same observation was made by Awere and Gbadamosi (2010). Although, there was non significant interaction effect of insecticide and plant spacing on the plant height, the experiment showed that more populated Okra plants were taller than less populated ones. This observation however disagreed with the findings of Agyekum(1999) who reported that the widest spread plants had the widest canopy, produced the tallest plants with more leaves and nodes as well as producing more fruits per plant. I therefore advice Okra farmers in Enugu area who aim at reducing plant height for easy harvest to use the standard recommended plant spacing of 50 cm x 50 cm. Furthermore, Okra farmer in Enugu area, Southeastern Nigeria who aim at reducing the impact of rain drops on the soil particles to prevent soil surface erosion by the rain should apply 1L ha^{-1} of insecticides and plant spacing of 50 cm x 30 cm as this treatment combination recorded a significant (P= 0.05) higher leaf area index of 41.10 than any other treatment combination. 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm that recorded significant (P = 0.05) less leaf damage of 10.30 feeding holes per leaf by *Podagrica spp*, was an indication that an application of a higher rate of insecticide to a more populated Okra plants may reduce the severity of the insect pest attacks better than that of a less populated ones. This observation however agreed with the findings of Adhikary (2007), who pointed out that after six sprays at weekly intervals, the number of feeding holes caused by flea beetles were distinctly reduced. I therefore advice that Okra farmers in Enugu area who aim at reducing leaf damage by the leaf beetle should use not more than plant spacing of 50 cm x 30 cm either with or without insecticide as this plant spacing always recorded a lower leaf damage than a higher plant spacing (Table 2).

A significant (P = 0.05) interaction effect of insecticide and plant spacing on the fruit yield indicated the importance of using a recommended rate of insecticide and plant spacing for increased fruit yield of Okra in Enugu area. As a result of this experiment, I therefore recommend that Okra farmers in Enugu Southeastern Nigeria should adopt the application of 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm, as this treatment combination performed significantly better than others on all the agronomic parameters assessed except plant height.

Conclusion and Recommendation

Okra producers in Enugu area who want their okra plants attain early maturity should apply not more than 1L ha^{-1} of insecticide with plant spacing of not more than 50 cm x 30 cm. again, I advice okra producers in Enugu area who aim at reducing plant height for easy harvest to use the standard recommended plant spacing of 50 cm x 50 cm. furthermore, okra producers in Enugu area, Southeastern Nigeria who aim at reducing the impact of rain drops on the soil particles to prevent soil surface erosion by the rain should apply 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm. To significantly (P = 0.05) reduce leaf damage by *Podagrica spp*. Okra farmers in Enugu area should apply 1.5L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm. To increase fruit yield, I advice okra farmers in Enugu area to adopt the application of 1L ha^{-1} of insecticide and plant spacing of 50 cm x 30 cm.

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