A comparative evaluation of effect of carbofuran 5G, chlorpyrifos 20Ec and chilli pepper aqueous extract on the growth, fruit yield and control of *Podagrica uniformis* of okra (*Abelmoschus esculentus* L. moench) in Enugu, Southeastern Nigeria

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ABSTRACT: A field experiment to comparatively evaluate the effect of carbofuran 5G, chlorpyrifos 20Ec and chilli pepper aqueous extract on the growth, yield and control of insect pest of okra (*Abelmoschus esculentus* L. Moench) 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 during the 2017 rainy season between the months of April and October. The experimental design was randomized complete block (RCB) with four (4) treatments replicated five (5) times. Parameters assessed were plant height(cm), number of feeding holes created by leaf beetles (*Podagrica uniformis*) per plant, number of flowers per plant, number of fruits per plant, leaf area index and fruit yield (t ha⁻¹). The result of the experiment showed a significant ($p \leq 0.05$) treatment effect on all the parameters measured/assessed except leaf area index. Plots treated with carbofuran 5G recorded highest on all the parameters assessed except number of feeding holes created by *P. uniformis* per plant as follows; mean plant height of 45.45 cm, mean number of 4.20 fruits per plant, mean leaf area index of 4.18, mean number of 48.60 feeding holes created by *Podagrica* per plant and mean fruit yield of 1.79 t ha⁻¹. The efficacy of Chilli pepper aqueous extract (bio-insecticide) in the control of a major insect pest (*Podagrica uniformis*), growth and yield of okra did not significantly differ from that of chlorpyrifos 20Ec (Synthetic insecticide), the use of Chilli pepper aqueous extract to okra producers in Enugu area is therefore recommend as a better substitute to synthetic insecticide.

Keywords: Bio-pesticide, insecticides, leaf beetles (*Podagrica uniformis*), non-bio-pesticides, okra.

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., 2002). There are three domesticated species of okra; *Abelmoschus esculentus*, *Abelmoschus hibiscus* and *Abelmoschus caillei*. In many English-speaking countries, it is known as "lady's finger or gumbo". It belongs to the

Malvaceae family and originated from tropical Africa. It is cultivated both in the tropical, subtropical and warm temperate regions around the world. It is widely grown in Nigeria primarily for its mucilaginous content (Tindall, 2000).

Okra is a fruit vegetable crop found in abundance in the rainy season and is commonly used as food in different homes. Usually fruit picking is done because the fruit

reaches maturity at various times and it mainly depends on the vegetative cycle which varies according to varieties (Schipper, 2000). Okra is eaten in various ways; the leaves are eaten as raw salads, 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 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 contains 2.1 g protein, 0.2 g fat, 8 g carbohydrate, 36 g calories, 1.7 g fibre, 175.2 mg minerals, 232.7 mg vitamin and 88 ml 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 to 6.8. Okra is moderately tolerant to soil salinity and can germinate in well-drained sandy-loam (Tindall, 2000). With increasing population, okra yield per unit area increases till a certain limit beyond which resources for plant become limited and yield decrease (Weiner, 1990). That is increasing plant population, okra yield per unit area increases till a certain point where resources for plants become limited and yield decrease. Plant spacing determines the available area for plant growth to source for resources such as water, light and nutrients. Therefore, optimal plant population size is required for high yield in okra (Awere and Njoku, 2018).

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 (Ekamuay, 2007). The most destructive insect pests are flea beetle species (*Podagrica uniformis* and *Podagrica sjostedti*) which are responsible for heavy defoliation of which yield losses are reported in Nigeria and Ghana (Obeng-Ofori and Sachery, 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 insecticides 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, infecting the leaves of the plant and have a great economic significance on the yield of the crop (Odebiyi et al., 1981). Conventional insecticides like endosulfan, dimethoate and monocrotophos 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). There is need for more researches to find out more chemicals that are proven to be effective against the pest. Therefore, the objective of this research work was to comparatively evaluate the effect of carbofuran 5G, chlorpyrifos 20Ec and chilli pepper aqueous extract on the growth, fruit yield and control of *P. uniformis* of okra (*Abelmoschus esculentus* L Moench) in Enugu, Southeastern Nigeria.

MATERIALS AND METHODS

Study area

The experiment was carried out at the Teaching and Research Farm, Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Enugu, Southeastern Nigeria during the 2017 rainy season between the months of April and October. The University lies between latitude 06° 50'N and longitude 07°15' E, with a mean elevation of 450 m above sea level and an annual rainfall of 1800 to 2100 mm. The soil is of shale parent material and is classified as typic paleudult and is sandy clay textural class (Anikwe et al., 2005).

Land preparation

The land area for the experiment was mapped out with ropes, pegs, measuring tape and cleared with cutlass. Twenty (20) flat beds were made with a traditional hoe.

Experimental design

The experiment was carried out in a randomized complete block design with four (4) treatments replicated five (5) times. The experimental area measured 10.20 × 13.0 m, whereas the experimental unit/plots measured 1.8 × 1.8 m with 1 m pathway. Plant spacing was 50 × 50 cm. Each plot contained four (4) rows of four (4) plants each. Two seeds were planted per hole and latter thinned to one plant per hole.

Preparation of chilli pepper aqueous extract

Twenty-five grams (25 g) of ground chilli pepper and one hundred and twenty grams (120 g) of common salt (NaCl) were mixed together and left for twelve hours (12 hours) before filtering the emulsion. The filtered emulsion was made up to sixteen (16) liters with water, kept in the refrigerator and used within fourteen (14) days (Gabriele 2000).

Treatments

Experimental treatments involved; (i) 100 kg ha⁻¹ of Furadan 5G (Carbofuran 5G), (ii) 1 L ha⁻¹ of Termicot 20Ec (chlorpyrifos 20Ec), (iii) 500 L ha⁻¹ of plant extract (chilli pepper aqueous extract) and (iv) control. NPK 20: 10: 10 at the rate of 200 kg ha⁻¹ was applied by ring method around each plant as basal treatment two weeks after planting. The experiment was kept weed free during the experiment with traditional hoe.

Carbofuran was applied once by ring method around each plant whereas chlorpyrifos 20 Ec and chilli pepper aqueous extract were sprayed four (4) times at fourteen (14) days interval starting from twenty-one (21) days after planting.

Variety and source of okra seed

Clemson spineless variety was sourced from Molon Agro-Shop, Bank Avenue Enugu, Enugu State Nigeria.

Data Collection

Data were collected on plant height (cm), number of feeding holes created by leaf beetles (*P. uniformis*) per plant, number of flowers per plant, number of fruits per plant, leaf area index and fruit yield (t ha⁻¹). Four (4) plants were sampled from the two (2) middle rows of each plot for data 60 days after planting. A measuring tape was used to measure plant height.

Data analysis

Data collected were subjected to analysis of variance for Randomize Complete Block Designs (RCBD) experiment as outline by Obi (2001) using Genstat Release 10.3DE (PC window 2012 software). Differences between treatment means were detected using fisher's least significant difference (F-LSD) as outlined by steel and Torrie (1980).

RESULTS

Effects of carbofuran 5G, chlorpyrifos 20Ec and chilli pepper aqueous extract on plant height (cm), number of feeding holes created by *P. uniformis* per plant and number of flowers per plant

The result of the experiment showed a significant treatment effect on plant height, number of feeding holes created by *P. uniformis* per plant and number of flowers per plant. On plant height, plots treated with carbofuran 5G

recorded the highest plant height of 45.45 cm, followed by plots treated with chlorpyrifos 20Ec that recorded plant height of 39.20 cm, plots treated with chilli pepper with plant height of 30.70 cm and lastly, control plots recorded plant height of 30.70 cm respectively (Table 1). Less mean number of 48.60 feeding holes created by *P. uniformis* per plant was recorded on plots treated with chlorpyrifos 20Ec that recorded a mean of 106.40 feeding holes per plant, whereas plots treated with no insecticide recorded the highest mean number of 396.33 feeding holes per plant (Table 1). On the number of flowers per plant, plots treated with carbofuran recorded the highest mean number of 7.05 flowers per plant, followed by plots treated with chlorpyrifos 20Ec which recorded mean number of 5.20 flowers per plants, chilli pepper aqueous extract that recorded a mean of 4.40 flowers per plant and no insecticides with a mean of 3.40 flowers per plant respectively.

Effects of carbofuran 5G, chlorpyrifos 20Ec and chilli pepper aqueous extract on mean number of fruits per plant, leaf area index and fruit yield (t ha⁻¹)

The result of the experiment showed a significant ($p \leq 0.05$) treatment effect of carbofuran 5G, chlorpyrifos 20Ec and chilli pepper aqueous extract on the mean number of fruits per plant, fruit yield (t ha⁻¹) whereas there was no significant treatment effect on leaf area index. On the mean number of fruits per plant, carbofuran recorded the highest mean number of 4.20 fruits per plant, followed by chilli pepper aqueous extract that had a mean of 3.25 fruits per plant, chlorpyrifos 20Ec with a mean of 2.95 fruits per plant and control with a mean of 1.50 fruits per plant respectively.

On leaf area index, carbofuran had the highest leaf area index of 4.18, followed by chlorpyrifos 20 Ec. with a mean leaf area index of 3.24, chilli pepper aqueous extract with a mean of 3.08 and control with a mean of 3.01 (Table 2). On fruit yield, carbofuran recorded significantly ($p \leq 0.05$) a higher yield of 1.79 t ha⁻¹, followed by chilli pepper aqueous extract that had a mean fruit yield of 1.44 t ha⁻¹, chlorpyrifos with a mean fruit yield of 1.16 t ha⁻¹ and control with a mean fruit yield of 0.66 t ha⁻¹ (Table 2).

DISCUSSION

In this research work, carbofuran 5G and chlorpyrifos 20Ec as conventional synthetic insecticides served as standard that helped to comparatively evaluate the efficacy of chilli pepper aqueous extract as bio-insecticide in the production of okra. The result of the experiment showed that chlorpyrifos 20Ec. recorded a mean plant height of 39.20 cm that did not significantly differ from that of chilli pepper aqueous extract which had a mean plant height of

Table 1. Effect of Carbofuran 5G, Chlorpyrifos 20Ec and Chilli pepper aqueous extract on plant height, mean number of feeding holes per plant and mean number of flowers per plant.

Treatments	Mean plant height (cm)	Mean number of feeding holes	Mean number of flowers/plant
Carbofuran 5G	45.45	48.60	7.05
Chlorpyrifos 20Ec	39.20	106.40	5.20
Chilli pepper aqueous extract	34.30	235.07	4.40
No insecticide	30.70	396.33	3.40
F-LSD _{0.05}	9.10*	156.00*	1.33*

Table 2. Effect of Carbofuran 5G, Chlorpyrifos 20Ec and chilli pepper aqueous extract on the number of fruits per plant, leaf area index and fruit yield (ton ha⁻¹).

Treatments	Mean number of fruits/ plant	Mean leaf area index	Mean fruit yield (t ha ⁻¹)
carbofuran 5G	4.20	4.18	1.79
chlorpyrifos 20Ec	2.95	3.25	1.16
Chilli pepper aqueous extract	3.25	3.08	1.44
no insecticide	1.50	3.01	0.66
F-LSD _{0.05}	0.29*	N.S	0.31*

34.30 cm. Again, on the control of *P. uniformis*, chlorpyrifos 20Ec recorded a mean of 106.40 feeding holes created by the insect pest per plant which did not significantly ($p \leq 0.05$) differ from that of chilli pepper aqueous extract that recorded a mean of 235.07 feeding holes per plant. Furthermore, chlorpyrifos 20Ec recorded a mean of 5.20 flowers per plant that did not significantly ($p \leq 0.05$) differ from that of aqueous chilli pepper which recorded a mean of 4.40 flowers per plant.

The result of this experiment may therefore suggest that okra farmers in Enugu whose emphasis are on reduction of plant height for easy harvest, control *P. odagrica* attack and increase flower production as a component of yield may use chilli pepper aqueous extract instead of synthetic insecticides to comply with the present demand for the use of more bio-pesticides that are more eco-friendly than synthetic ones.

The result of the experiment further showed that chilli pepper aqueous extract recorded significant ($p \leq 0.05$) higher fruits yield than chlorpyrifos 20Ec. A similar result was reported by Awere and Omeje, (2019) when a higher dose of 550 L ha⁻¹ of chilli pepper aqueous extract (bio – pesticide) was used to promote yield of watermelon (*Citrulus lunatus*).

A non-significant difference between chlorpyrifos 20Ec and chilli pepper aqueous extract revealed that chilli pepper aqueous extract was as effective as chlorpyrifos 20Ec and carbofuran (non-biopesticides) in the control of okra leaf beetle (*Podagrica uniformis*). The findings are in conformity with that of Suraj et al. (2015) who reported that some bio-pesticides tested such as Imidacloprid 17.8 SL,

Azadirachtin, Spinosad, Bacillus (B.t) and Beauveria bassiana, increased marketable fruit yield and control red cotton bugs (*Dysdercus Koenigii* F) and fruit borers (*Helicoverpa armigera*) of okra effectively. In the same way, Pandey and Tiwari (2011) and Fakhri and Murad (2002) reported that neem based formulations are highly effective against both nymphs and adults of red cotton bug which is also regarded as insect pest of okra. Also, Kodandaram et al. (2008) reported that annonin 1% Ec was found to be very toxic against red cotton bug.

Again, the same chilli pepper aqueous extract recorded a leaf area index that did not significantly differ from that of chlorpyrifos 20Ec (Table 2). This result may also suggest that okra producers/farmers who aim at increasing fruit yield and also produce okra plants that can form enough canopy to protect soil surface from the impact of rain drops that may cause soil erosion should apply chilli pepper aqueous extract, since this bio-insecticide does not pollute environment or produce residues that may harm okra consumers.

Conclusion and recommendation

Since the result of this research work revealed that the efficacy of chilli pepper aqueous extract (bio-insecticide) in the control of a major insect pest (*P. uniformis*), growth and yield of okra did not significantly differ from that of chlorpyrifos 20Ec (Synthetic insecticide), the use of chilli pepper aqueous extract to okra produces in Enugu area is therefore recommend as a better substitute to synthetic

insecticide. This bio-insecticide (chilli pepper aqueous extract), apart from being effective in the control of insect pests and improving growth and yield of okra plants, it is eco-friendly. That is, it does not pollute the environment or have residual effect on the consumers of the crop.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

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