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EFFECTS OF TWO INSECTICIDAL SPRAYS ON FALL ARMYWORM (*SPODOPTERA FRUGIPERDA* J. E. SMITH) INFESTATION ON MAIZE (*ZEA MAYS* L.) IN CALABAR.

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Abstract

The study aimed to evaluate the effect of different insecticides and spraying schedules on fall armyworm, *Spodopterafrugiperda* (Lepidoptera: Noctuidae) on maize, *Zeamays* L. in Calabar. The experimental design was a factorial experiment laid out in a Randomized Complete Design (RCBD) with eight treatments replicated thrice and with an untreated plot that served as control for each replicate. The treatments were one contact action insecticide (Dichlorvos) and one systemic + contact action (Dichlorvos + Dimethoate) applied following spraying schedules of 2x, 3x and 4 x. The result revealed a significant difference ($p \geq 0.05$) for a number of maize stands infested by armyworm during the late cropping season from the 2nd and 3rd week of spraying. The highest yield (3185kg/ha) was obtained from C_1S_4(Dichlorvos + Dimethoate) at 4x weekly spraying schedule. The result also shows that there was significant difference for undamaged seeds between treated and untreated plots. Results obtained from the trial also indicated that Dichlorvos + Dimethoate mixture spraying at 4x weekly spraying schedule can be used in controlling armyworm in both early and late cropping season.

Keywords: Maize, Insecticides, Armyworm, Spraying schedules.

Introduction

Maize, (*Zeamays* L.) belongs to the family Poaceae, and is one of the oldest and widely grown grain consumed in many countries (Igyuve *et al*., 2018, Garcia Lara and Serna-Saldiva, 2019) Maize is the third most valued cereal in the world next to rice, with global production put at 785 million tons. Nigeria is currently rated the 10th largest maize producer in the world, with a production capacity of 11.6 metric tons, the highest quantity made in the last six decades (USDA, 2021).Maize is a staple food for about 50 percent of sub-Saharan African population and an important source of carbohydrate, protein, iron, vitamin B and minerals (Owoeye, 2017; HLPE, 2017; Loy and Lundy, 2019; FAOSTAT, 2021).This crop is reported to be responsible for 50-70% of feeds for poultry farming in Nigeria (NRC,1988; Klopfenstein *et al*., 2013; FAO, 2015; Mottet *et al*., 2017).Its cultivation provides capacity for income generation, raw materials for industrial products, poverty alleviation, foreign exchange earnings, and accounts for 5.88 percent of

Nigeria's agricultural gross domestic Product, as well as employment of over 50 % labour force (FAOSTAT, 2014; Ayinde *et al*., 2019 Grote *et al*., 2021).

Despite its seeming high production capacity, maize farming in Nigeria yields an average of 1.9 metric tons per hectare which is one of the lowest among the top maize producers in Africa, making it difficult to meet domestic and industrial maize demand (FAOSTAT, 2021.) Local demand is as high as 12 million metric tons excluding exports and leaves a deficit of over 2 million metric tons (FAOSTAT, 2021). This gleam picture, however appears compounded by reports of insect pest complex infestations in both field and storage conditions. One of the most incriminated major insect pest of maize in the field is the fall armyworm *Spodopterafrugiperda* (Lepidoptera: Noctuidae) (Bariwo *et al*., 2020; Bista *et al*., 2020; Bhasal and Chapagain, 2020; Maruthadurai and Ramesh, 2020; Shawn *et al*., 2020). Losses of maize due to the insect attack range from 10-70 % in most affected areas (Balla *et al*., 2029; Assefa *et al*., 2019). At present, several collaborative research efforts show that chemical insecticides with reduced environmental hazards could be very effective in the control of insect pests (Early *et al*., 2018; Kumela *et al*., 2019; Kassie *et al*., 2020 and Minutes not and Ebabuye, 2020). This investigation focuses on the use of one contact action insecticide (Dichlorvos) and one systemic + contact action (Dichlorvos + Dimethoae) applied at 2x, 3x and 4 x spraying schedules weekly intervals in controlling the fall armyworm.

Materials and methods

Study area

The work was conducted at the Teaching and Research Farm of the University of Calabar, Cross River State. The site is located between latitude 5.2^0'N and Longitude 8.3^0 E of the equator with an annual temperature range of 25± 5^{0}C and temperature of 27^{0}C. The area lies within the tropical rainforest zone and has a bimodial rainfall pattern with mean rainfall of 2000mm per annum.

Land preparation and experimental design

The experimental plot of land was ploughed and harrowed using a tractor. Tilling was done using a spade and hole to level the soil and debris. Demarcation of the land was done with the aid of ropes, sticks, measuring tape and a cutlass. The layout of the experimental plot was 27m X 15m while the gross experimental plot for each treatment was 4m X 3m and spacing from one plot to another 90 cm. The design is a factorial experiment laidout in a Randomized Complete Block Design (RCBD) with eight treatments and replicated three times (table 1). The treatments were one contact action (Dichlorvos) and another contact + one systemic (Dichlorvos + Dimethoate). Spraying schedules consisted of 0, 2x, 3x and 4x spraying at weekly intervals, with each plot labelled according to the respective treatment that was applied using a wooden peg and laminated paper.

Maize variety, Hybrid 3550 obtained from Agricultural Development Project (ADP), Atimbo in Akpabuyo Local Government Area of Cross River State were planted, three seeds per hole and three-centimeter-deep into the ground with plant spacing of 25cm apart (interspacing) and with four rows per plot. At emergence of seedlings, they were thinned to one plant after weeks and then compound fertilizer (N.P.K 15:15 and Urea) was applied, first through basal application and then side/spot application. The insecticidal formulations were at the rate of 1 % (100 ml: 10,000 ml water). Insecticide application were carried out during calm, warm and sunny periods using a high volume knapsack sprayer fitted with a hollow core nozzle and using 500 L per ha.

Weeding was carried out manually at 2nd and 5th weeks after planting to remove weeds and regrowth's respectively. Thereafter, insecticidal treatments were applied following schedules of 2, 3 and 4 times weekly intervals.

Field layout showing randomization and treatment allocations

c_{1S_4}	c_{2S_4}	c_{1S_2}
c_{1S_3}	c_{2S_2}	c_{1S_1}
c_{1S_1}	c_{2S_1}	c_{1S_4}
c_{1S_2}	c_{1S_2}	c_2s_2
c_2s_4	c_2s_4	c_1s_2
c_1s_4	c_2s_3	c_1s_3
c_2s_3	c_{1S_1}	c_2s_3
c_2s_2	c_1s_3	c_2s_4
c_2s_1	c_1s_4	c_2s_1

C2S1 = Control (0 spray)

C2S2 = Dichlorvos + Dimethoate (2x)

C2S3 = Dichlorvos + Dimethoate (3x)

C2S4 = Dichlorvos + Dimethoate (4x)

C1S1 = Control (0 spray)

C1S2 = Dichlorvos (2x)

C1S3 = Dichlorvos (3x)

C1S4 = Dichlorvos (4x)

Data collection

Parameters assessed were plant damage, yield (kg/plot) and cobs damage/plot.

- Plant damage. Damage by armyworm larvae were assessed by random sampling of eight plants per plots, showing leaf shredding, whorls distortion with heavy grass and tender leave damage. Damage is expressed as:

$$\% \text{ plant damage/plot} = \frac{\textit{Total no. of plants sampled/plot} - \textit{no of undamaged plant}}{\textit{total no. of plant sampled per plot}} X \frac{100}{1}$$

- Seed yield (kg/plot). This was calculated at harvest. Harvesting was carried out on the 11th week after sowing. Produce was dried, threshed, weighed and recorded
- Percentage clean seed.

$$= \frac{\textit{total weight (kg)of seed/plot} - \textit{weight (kg)of damage seed/plot}}{\textit{total weight (kg)of seed/plot}} \text{X} \frac{100}{1}$$

Data analysis

Data collected were subjected to analysis of variance (ANOVA) and significant mean separated using Duncan's New Multiple Range Test (DNMRT) at 5 % level of probability.

Results

Table 1 shows the effect of different insecticides and spraying schedules on damage caused by armyworm in early cropping season. There were no significant differences amongst the treatments throughout the duration of spraying.

Table 1: Number of maize stands infested by armyworm during early cropping season

Treatment	Before spraying	IWAISP	2WA2SP	3WA3SP	4WA4SP
c_1s_1(control)	1.33a	1.33a	2.33a	2.67a	2.33a
c_1s_2	1.00a	1.00a	1.67a	2.00a	1.67a
c_1s_3	1.33a	0.33a	1.00a	2.00a	1.00a
c_1s_4	2.67a	0.00a	0.33a	2.00a	0.67a
c_2s_1	1.00a	2.00a	1.67a	3.33a	2.67a
c_2s_2	0.67a	1.67a	1.33a	3.00a	1.67a
c_2s_3	0.67a	1.33a	1.33a	2.33a	1.33a
c_2s_4	1.67a	1.33a	0.67a	1.33a	1.00a

C_1 = Dichlorvos, C_2 = Dichlorvos + Dimethoate S_1 = No spraying
S_2 = 2X (times) spraying; S_3 = 3x spraying; S_4 = 4x spraying
IWAISP = One week after first spray; 2WA2SP = One-week after Second spray; 3WA3SP = One week after third spray; 4WA4SP = One week after fourth spray. Numbers with the same letter(s) are not significantly different at 95 % confidence limit using Duncan's New Multiple Range Test.

Table 2: Number of maize stands infested by armyworm during late cropping season

Treatment	Before spraying	IWAISP	2WA2SP	3WA3SP	4WA4SP
c_1s_1(control)	2.00a	1.67a	1.67abc	1.33ab	1.67a
c_1s_2	2.00a	1.33a	1.33abc	0.67ab	1.33a
c_1s_3	1.33a	0.67a	0.67abc	0.67ab	1.33a
c_1s_4	1.67a	0.00a	0.00c	0.33b	1.00a
c_2s_1	1.00a	1.67a	2.33a	2.33a	2.00a
c_2s_2	1.00a	1.67a	2.33a	2.00ab	1.67a
c_2s_3	2.00a	1.00a	2.00ab	1.33ab	1.00a
c_2s_4	1.00a	0.67a	0.33bc	0.67ab	1.00a

Numbers with the same letter(s) are not significantly different at 95% confidence limit using Duncan's New Multiple Range Test.

C_1 = Dichlorvos, C_2 = Dichlorvos + Dimethoate, S_1 = No spraying S_2 = 2 spraying, S_3 = 3x spray, S_4 = 4x spraying.
1WA1SP = one week after first spray, 2WA2SP = one week after second spray, 3WA3SP = one week after third spray, 4WA4SP = one week after fourth spray.

Table 2 shows late season maize cropping. The results revealed significant differences among the treatments at the 2nd and 3rd week of spraying only. At the 2nd week of spraying C_1S_4 (Dichlorvos only with 4 x spraying had significantly ($p< 0.05$), the least maize stand damage compared to C_2S_1, C_2S_2 and C_2S_3. At the 3rd week of spraying, C_1S_4showed the least ($p<0.05$) maize stand damage compared toC_2S_1but was not significantly different ($p>0.05$). In combine analysis of early and later season (table 3), there were no significant differences before spraying but only at the 4th week after spraying among the treatments.

However, significant differences ($P>0.05$) were observed at the 1st, 2nd and 3rd week after spraying damaged maize stands by armyworm.
After the 1st week of spraying, C_1S_4 had significantly reduced maize stand damage compared to C_1S_1 and C_2S_1but not significantly different from the other treatments. At the 2nd week after spraying C_1S_4had significant maize stand damage compared to other treatments except C_1S_3 and C_2S_4. Similarly, at the 3rd week after spraying, C_1S_4 showed significant difference ($P<0.05$) compared to other treatments except C_2S_1.

Table 3: Combined analysis of number of maize stands infested by armyworm during early and late cropping seasons.

Treatment	Before spraying	IWAISP	2WA2SP	3WA3SP	4WA4SP
c_1s_1(control)	1.67a	1.50ab	2.00a	2.00ab	2.00a
c_1s_2	1.50a	1.17abc	1.50ab	1.33ab	1.50a
c_1s_3	1.33a	0.50bc	0.83abc	1.33ab	1.17a
c_1s_1	2.17a	0.00c	0.17c	1.17b	0.83a
c_2s_1	1.00a	1.83a	2.00a	2.83a	2.33a
c_2s_2	0.83a	1.67abc	1.83ab	2.50ab	1.67a
c_2s_3	1.33a	1.17abc	1.67ab	1.83ab	1.17a
c_2s_4	1.33a	1.00abc	0.50bc	1.00b	1.00a

Numbers with the same letter(s) are not significantly different at 95% confidence limit using Duncan's New Multiple Range Test.
C_1 = Dichlorvos; C_2 =Dichlorvos + Dimethoate, S_1 = No spraying, S_2 = 2 x spraying, S_3 = 3x spraying, S_4 = 4x spraying, IWA1SP = One week after first spray, 2WA2SP = One week after second spray 3WA3SP = One week after third spray, 4WA4SP = One week after fourth spray. Table 4 shows the effect of insecticides and spraying schedule on maize yield and clean seeds. Maize yield from the result was significantly higher ($p<0.05$) in C_1S_4 than C_1S_1 but insignificantly different from other treatments. Similarly, C_1S_4 had significantly greater number of clean seeds than that of other treatments except C_1S_3 and C_2S_4.The highest yield (3185 kg/ha) was obtained from C_1S_4 (Diclorvos + Dimethoate) at 4 x weekly spraying schedule.

Table 4. Total seed yield (kg/ha) and clean seeds

Treatment	TSY (kg/ha)	UDS (kg/ha)
c_1s_1(control)	1309b	519c
c_1s_2	2309ab	115bc
c_1s_3	2802ab	1996ab
c_1s_4	3185a	2885a
c_2s_1	1951ab	671c
c_2s_2	2284ab	1243bc
c_2s_3	2409ab	1470bc

Numbers with the same letter(s) are not significantly different at 95% confidence limit using Duncan's New Multiple Range Test. C_1 = Dichlorvos, C_2 = Dichlorvs + Dimethoate, S_1 = No spraying, S_2 = 2 x spraying, S_3 = 3x spraying, S_4 = 4x spraying. TSY = Total seeds yield, UDS = Undamaged seeds.

Discussion

The study indicated that fall armyworm, a major insect pest of maize was found to be economically important in a maize production site where the study was conducted. This observation corroborates the assertion by FAO (2021), that fall army worm is estimated to cause Africa alone nearly US$10 Million in annual maize yield losses. According to Du Plessis *et al*; (2018), fall armyworm caused more damage in maize plant than other species within the same genus in Africa. In this present study, the different treatments at 4x sprays schedules did not show significant differences throughout the first seasons but rather recorded significant (P>0.5) differences among the treatments in the second and third weeks, just six weeks post planting. Treatment C_1S_4 (Dichlorvos) with 4x spraying schedule and C_2S_2 (Dichlorvos+ Dimethoate), with 4x spraying schedule recorded significantly (P>0.5) lower number of army worm infestation on maize. It can be deduced from the result that the combination of two different insecticides and greater frequency in applying them could be responsible for the result obtained. The higher number of plant damage observed in C_1S_1 and C_2S_1 (control for Dichlorvos + Dimethoate with no spraying resulted in higher number of plant damage). Its' been reported that treated plots recorded lower number of damage plants and higher crop yield compared to the untreated (Emosairue and Ukeh, 1996). Similarly, Oparaeke (2007) asserted that the more frequent an insecticidal spray is applied, the lower the insect damage and the greater the yield.

The yield obtained at the late planting season shows that C_1S_4 (Dichlorvos) with 4 x spraying recorded significant (P>0.05) difference compared to C_1S_1 (Control with no spraying, but was not significantly different from the rest of the treatments. The reason for this result is not clear, but it's thought that, environmental changes and adaptability factor may have played a role. The highest yield was however recorded in C_1S_4 (3185kg/ha) but had no significant differences between it and other plots. This result may be attributable to the late planting season variation as reported by Schulthess *et al.,* (1991) and Okweche *et al*., (2010), that higher maize yield is obtained at early than late planting. It's observed that the yield in this present work is higher than that reported by Okoibu (2015), who used bio-insecticide (*Gmelinaarborea*) seed powder to control the effect of insect pests of maize. The yield increase in this present study may be attributed partly to the seed varieties planted as well as the combination of the insecticides used and in addition to the spraying regimes involved. Similarly, the results on the quality of seeds indicated significant difference in sprayed and unsprayed plots. The highest number of clean seeds were obtained in C_1C_4 (2885 Kg/ha) treated compared to C_2S_1 (671kg/ha) which served as control. The reason for this observation is not far fetch. Given the degree of infestation of untreated plots by insect pests, the chances of getting good and healthy seeds became difficult.

Furthermore, the 3 x and 4x spraying schedules of insecticides recorded a significant (P>0.5) and highest yield. It was observed that armyworm population and the number of insecticide sprays applied significantly influenced yield of maize. This is demonstrated from the fact that grains produced in the untreated plots were unhealthy, damaged and unfit for use. Numerous researchers have demonstrated that in designing spray programs, consideration should be given to optimum sprays as it provides better insect control and crop protection.

Conclusion

The result of this study shows that C_1 S_4which is a mixture of Dichlorvos +Dimethoate (contact + system) with spraying schedule of 4x is superior in controlling armyworm in Calabar. Though some of treatments do not show statistical differences than the control, the fact that there was significantly higher yield and quantity of clean seed in the treated plots than the control suggests that insecticidal protection is effective for the cultivation of maize.

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