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Research Article

# Lambda Cyhalothrin Application Time and Weeding Regime on the Control of Fall Army Worm (*Spodoptera frugiperda* J.E. Smith) on Maize (*Zea mays* L.)

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**Abstract**

The effect of lambda cyhalothrin 2.5 EC application time and weeding regime on the control of fall army worm (*Spodoptera frugiperda* J.E. SMITH) in maize (*Zea mays* L.) was conducted at Agricultural Research Farm, University of Port Harcourt. The study consists of 4 treatments with 3 replicates laid out in a completely randomized design (CRD). Insecticide lambda cyhalothrin 2.5 EC treatment was applied at the rate of 2 ml to 5L of water at different weeks after planting (WAP) and weeded once to thrice. The control experiment received insecticide treatment and no weeding. Data were collected on number of leaves, plant height, Fall Army Worm (FAW) infestation count per plot, weed density/m$^2$, fresh and dry weight of maize cob, fresh and dry weight of grains, grain weight, moisture content and maize yield. Results indicated that there was no significant difference ($p$>0.05) between the treatments for plant height and number of leaves. Weed density was significantly lower at 5 WAP and weeded thrice while moisture content was significantly higher in the control ($p$<0.05). Highest maize yield components such as cob weight (1520.0 g) per plot, grain weight (476.1 g) per plot and maize yield (4273.4 kg/ha) was higher at plots sprayed at 5 WAP and weeded thrice. Application of lambda cyhalothrin 2.5 EC at 5-WAP and weeding at 3, 5 and 7 WAP increased maize yield with the effective control of fall army worm and weeds in maize.

**Keywords:** *Fall army worm, Insecticide, Weeding regime, Yield components, Zea mays.*

## Introduction

Maize is a crop highly susceptible to weed competition particularly at its early stage of growth. It is sensitive to weed interference as it reduces grain yield at maturity. Thus, to minimize effect of grain yield reduction associated with weed competition, weeding regime is usually planned in such a way to coincide with the critical stage of weed impact on the growth stages and consequently yield of maize. Despite the importance of the crop to man as source of food, the yield of maize obtained in Nigeria is far below expectation due to numerous factors which include weed infestation, poor soil fertility and availability of labour (FAO, 2011). Yield losses of between 60–80% have been attributed to uncontrolled weed infestation in maize (Lagoke. *et al*., 1998). In addition, continued cultivation of maize as a staple food is however threatened by a number of problems, including diseases such as downy mildew disease, maize rust, leaf blight, maize streak, maize mottle/chronic stunt, curvularia leaf spot, stalk and ear rots (Iken. *et al*., 2004) and pests attacks of stem borers, fall army worms, silkworms, grasshoppers, termites, weevils, birds, rodents and weeds. Effective control of these pests and diseases require the use of chemical agents called pesticides (Rasheed. *et al*., 2003).

Furthermore, weed applies to any plant that grows or reproduces aggressively, or is invasive outside its native habitat. Weeds are recognized as major constraints that seriously lower growth and yield of maize. In Nigeria, yield losses as high as 51-100% has been recorded on maize due to weed competition

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(Akobundu and Ekeleme, 2000). It is important to increase the yield of maize because it provides the greatest potential among food crops for attaining food security in West and Central Africa (Kamara and Senginga, 2001). Weed control is an important management practice in maize production in order to ensure optimum grain yield.

Fall army worm (FAW) is an emerging menace that severely damages crop such as maize, sorghum, rice, millet, cotton and sugarcane (FAO, 2018). FAW belongs to cutworm family and was first reported in Africa in 2016. It can cause significant yield losses if not properly managed (Georgen. *et al.*, 2016). The larval stage of FAW feeds on maize leaves thereby reducing crop photosynthetic production. The worm is a trans-boundary pest as the adult moth can fly long distance up to 100 km per night to cause devastation in maize fields. This pest continues to spread due to its biological characteristics and also with high volume of trade between African countries (FAO, 2018). Damage from the FAW has severe consequences on both large and small hold farmers in terms of reduction of income as result of crop yield losses or even total crop failure. The pest is very difficult to control but, chemical control remains the main option in use (Togola. *et al.*, 2018). Like other pests of crops, FAW may use weeds as temporary hosts thereby sustaining their presence and destructive activities on crop field.

The favourite spot of the larval stage of FAW is curled up in tender young leaves in the whorl of a maize plant, where it feels protected. As they chew, the leaves continue to grow out leaving ragged, half-chewed leaves that are typical of FAW infested maize plants. At very high population levels, FAW can also penetrate maize ears, causing direct damage to harvest. At the early vegetative stage of maize plant, severe damage may occur, especially when the growing points of young plants are eaten by the larvae at 14 days after sowing (Tomquelski and Martins, 2007). Infestation of FAW at the early vegetative stage can cause more leaf damage and yield losses than late vegetative stage when the adult larvae might occasionally move to the tassel and the ears of the maize as the FAW population increased on plant, thus, reducing the quality of produce at harvest (FAO, 2018). The larvae migrate easily from crop to weeds as its alternative hosts. There is scanty information on effective control of FAW on crops. Therefore, this work was carried out with the aim to determine which insecticide application period in the life of the crop will effectively control the worm. It was also designed to determine the effective weeding regime for the control of the pest.

## Materials and Methods

### Sources of Maize and Pesticides

Materials were obtained from Agricultural Development Programme (ADP), Rumuodumaya, Port Harcourt. These include hybrid maize (Oba super 2), herbicides glyphosate (N-phosphonomethyl glycine and herbicide Parae-force also known as Gramoxone (1, 1–dimethyl-4, 4-bipiridinium dichloride). Insecticide Lambda cyhalothrin(Cyano-3-phenoxyphenylmethy-l-3-(2-chloro-3,3,3-trifluoro-1-propenyl-2,2dimethyl cyclopropanecarboxylate) was also used.

### Pre-Germination Test

The pre-germination test used was the method employed by Som (2007). Ten (10) seeds/dish of maize were placed in 10 Petri dishes lined with filter paper (Whatman® No.1) moistened with distilled water and placed on the laboratory bench at room temperature (25$^{o}$C). Germination was indicated by the emergence of the radicle and plumule which were observed daily for three days thereafter, germinated seeds were counted and percentage seed viability computed as:

$$\text{Seed viability (\%)} = \frac{\text{Total no of germinated seed}}{\text{Total number of seed sown}} \times \frac{100}{1}$$

Pre-germination test was 100% because all the seeds in the Petri dishes produced radicle and plumule.

**Land Preparation and Experimental Design**
Plot area for the study was cleared of its vegetation and allowed for two (2) weeks and after which, plant debris on the area were gathered and removed. Glyphosate herbicide was sprayed using knapsack sprayer at the rate of 100 ml in 8 litres of water to kill germinated stems of *Panicum maximum* observed 12 hours before planting was done. Plots were mapped-out using measuring tape, twines and pegs. The size of the area was 72 $m^2$ with 4 split plots of 2 × 3m per plot. The plots were separated from each other by 1 m alley pathway. Completely Randomized Design (CRD) was used to allocate treatments and replications to plots and split-plots. Four (4) treatments with 3replications per treatment were used in the study.

**Planting and Experimental Procedure**
Planting and experimental procedure used was the method employed by Aguoru. *et al.,* (2014). Three (3) seeds of maize were planted per hole at 5 cm of soil depth and thinned to one (1) seedling per hole two weeks after planting (2-WAP). The crop was spaced at 25 × 75 cm apart to give a plant population of 288 in the 12 plots of three ridges each of 8 stands maize/ridge. Twelve (12) hours after planting, the plots were treated with Gramoxone (concentration of 70 ml in 5 litre of water) to eliminate any other weed present. NPK fertilizer (20:10:10) was applied at 2-WAP at the rate of 68 kg/hectare rate. Urea was also applied at 4 WAP at the rate of 48 kg/hectare.

Details of the experimental setups are given and described below:
Plot $T_1$: weeded at 3-WAP and sprayed with Lambda Cyhalothrin at the rate of 0.16 L/hectare.
Plot $T_2$: weeded twice at 3- and 5-weeks after planting and sprayed with Lambda Cyhalothrin 4-WAP.
Plot $T_3$: weeded thrice at weeks 3-, 5- and 7-weeks after planting and sprayed Lambda Cyhalothrin at 5-WAP.
Plot $T_4$: Control (no weeding and insecticide treatment).

**Soil Analysis**
Soil samples were collected using soil auger at depth of 0-30cm from 3 random plots and bulked together to form a composite sample. The sample was air-dried, crushed and sieved before use for physico-chemical analyses following standard methods (Gundu. *et al.,* 2020).

## Data Collection
Data were collected on fall army worm infestation, weed species/population, plant height, number of leaves and weed density as assessment parameters. Other parameters used include cob fresh and dry weights, cob moisture content and grain yield. Population of fall army worm (infestation) was counted per stand of plant, weed species were identified by a Plant Taxonomist from University of University of Port Harcourt Herbarium while weed density was obtained through quadrat method by counting the total number of the different weed species present within 25 cm x 25 cm quadrat area placed at three points within each plot. Plant height was measured by means of metre rule while number of leaves per stand of maize was counted and recorded, Cobs were harvested and its fresh weights were immediately determined by means of scientific weighing balance (model: Scout™ Pro OHAUS™) and recorded. The fresh cobs were dried in the greenhouse for 21 days, weighed to obtain cob dry weight. Cob moisture content was determined and expressed in percentage using the formula below.

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times \frac{100}{1}$$

The dried cob was dehusked and grain yield obtained by means of the weighing balance and recorded.

## Data Analysis
Data collected were used to calculate totals, means and subjected to Analysis of Variance

(ANOVA) to determine difference between plot (treatment) means at 95% confidence limit. Standard errors were also calculated and used as error bars. Fall army worm infestation, weed species and weed density results are presented in composite tables; number of leaves and plant height results are presented in line graphs while cob fresh and dry weights, cob moisture content, grain yield results are presented in charts.

## Results

### Soil Property

Table 1 describes the physicochemical parameters of soil samples analyzed. It was largely sandy (74%) and acidic (4.06) with high manganese content (55.61mg/g) and cation exchange capacity (6.32 Cmol/kg) but low organic matter (2.1%) and nitrogen (0.22%) contents.

**Table 1:** Soil Physico-chemical properties

| Parameter | Value |
|---|---|
| Sand (%) | 74.00 |
| Silt (%) | 17.40 |
| Clay (%) | 8.60 |
| pH | 4.06 |
| Ca (Cmol/kg) | 3.89 |
| Mg (Cmol/kg) | 1.16 |
| Na (Cmol/kg) | 0.61 |
| Mn (mg/g) | 55.61 |
| Fe (mg/kg) | 19.82 |
| Cu (mg/g) | 1.29 |
| Zn (mg/g) | 3.04 |
| K (Cmol/kg) | 0.26 |
| CEC (Cmol/kg) | 6.32 |
| Organic Matter (%) | 2.078 |
| N (%) | 0.216 |

### Fall Army Worm Infestation

There was no significant difference in the number of FAW at the 3-WAP between treatments and the control (Figure 1). From 4-WAP, there were differences and increase in infestation of the worms in all treatments including control with the highest infestation observed on the twice-weeded; insecticide sprayed treatment at 6-WAP setup ($T_2$). From 6-WAP, there were general reduction in infestation in all treatments and the control with the least infestation value recorded on the thrice-weeded; insecticide sprayed at 5-WAP treatment ($T_3$).

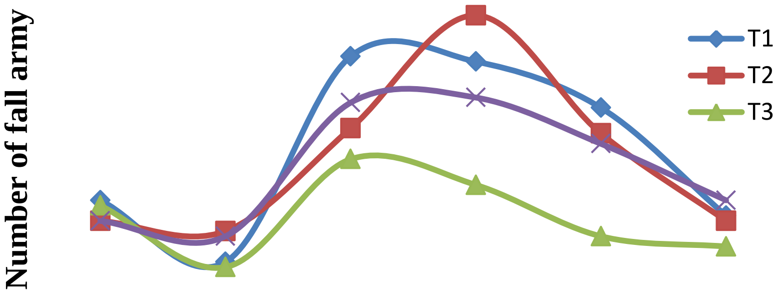


Figure 1: Number of Fall Armyworm at intervals after planting

**Weed Species/Populations**

There were differences in weed population in the different plots of treatment, the plot sprayed at 5-WAP and weeded thrice ($T_3$) recorded the lowest weed population of 54 weeds. The highest number of weeds (116) was recorded in control ($T_4$) while the plot weeded once and sprayed at 3-WAP ($T_1$) had 70 and the one sprayed at 5-WAP and weeded twice ($T_2$) had 87 weed species (Table 2).

**Table 2:** Weed Species and their Populations

| Species Name | $T_1$ | $T_2$ | $T_3$ | $T_4$ | Total |
|---|---|---|---|---|---|
| *Acalypha prostrata* | 1 | 0 | 0 | 0 | 1 |
| *Ageratum conyzoides* | 14 | 3 | 2 | 5 | 24 |
| *Axonopus compressus* | 10 | 3 | 17 | 12 | 42 |
| *Borreria* sp. | 0 | 2 | 1 | 1 | 4 |
| *Brachiaria* sp. | 0 | 0 | 1 | 0 | 1 |
| *Centrosema pubescens* | 1 | 0 | 1 | 3 | 5 |
| *Chromolaena odorata* | 0 | 0 | 1 | 1 | 2 |
| *Cleome rutidosperma* | 0 | 2 | 2 | 0 | 4 |
| *Commelina* sp. | 2 | 2 | 3 | 3 | 10 |
| *Croton* sp. | 3 | 0 | 0 | 0 | 3 |
| *Cyathula prostrata* | 13 | 36 | 0 | 23 | 72 |
| *Dipharia horizontalis* | 0 | 0 | 0 | 1 | 1 |
| *Eleusine indica* | 0 | 0 | 2 | 6 | 8 |
| *Eleutheranthera ruderalis* | 7 | 8 | 3 | 5 | 23 |
| *Euphorbia hirta* | 0 | 0 | 0 | 1 | 1 |
| *Mimosa pudica* | 12 | 2 | 1 | 5 | 20 |
| *Mitracon jusillospora* | 0 | 0 | 0 | 2 | 2 |
| *Oldenlandia corymbosa* | 1 | 0 | 0 | 24 | 25 |
| *Oplismenus burmannii* | 1 | 0 | 0 | 0 | 1 |
| *Panicum maximum* | 0 | 0 | 0 | 7 | 7 |
| *Panicum laxum* | 12 | 7 | 3 | 0 | 22 |
| *Paspalum sendiculata* | 0 | 3 | 1 | 0 | 4 |
| *Passiflora foetida* | 1 | 0 | 0 | 0 | 1 |
| *Peperomia pellucid* | 0 | 1 | 0 | 0 | 1 |
| *Phyllantus amarus* | 3 | 1 | 1 | 0 | 5 |
| *Pueraria phaseoloides* | 1 | 2 | 4 | 0 | 7 |
| *Sedges* | 3 | 10 | 6 | 16 | 35 |
| *Sida* sp. | 0 | 2 | 4 | 0 | 6 |
| *Spigelia anthelma* | 0 | 1 | 0 | 0 | 1 |
| *Talinum triangulare* | 0 | 0 | 1 | 0 | 1 |
| *Triumefetta* sp. | 0 | 1 | 0 | 0 | 1 |
| **TOTAL** | **70** | **87** | **54** | **116** | |

**Plant Height (cm)**

There was no significant difference in growth performance of maize planted in the different plots. There was increase in plant height from 2-WAP to 4-WAP for all the treatments. However, growth was observed to decrease in the treatment sprayed at 5-WAP and weeded thrice (Figure 2). This may be as a result of the insecticide sprayed at 4-WAP. However, the $T_3$ plot recovered at 6-WAP. The highest growth (i.e. height) was recorded in the plot sprayed at 4-WAP and weeded twice ($T_2$) (76.68±41.505).

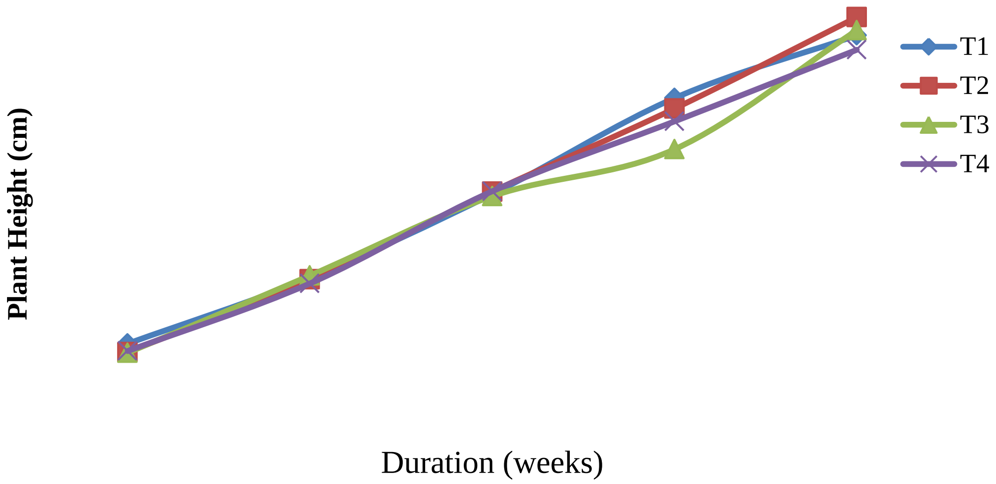


Figure 2: Effect of lambda cyhalothrin application time and weeding regime on plant height

**Number of Leaves**

Number of leaves increased from 2- to 6-WAP in all the plots (Figure 3). The highest leaf number (8.51±2.8) was recorded $T_2$ (i.e. the plot weeded twice). There was slight reduction in the control ($T_4$) at 5-WAP. Overall, the highest number of leaves was found at 6-WAP. There was no significant difference in the number of leaves for the different treatments studied. Details of foliage production result are as shown in Figure 3.

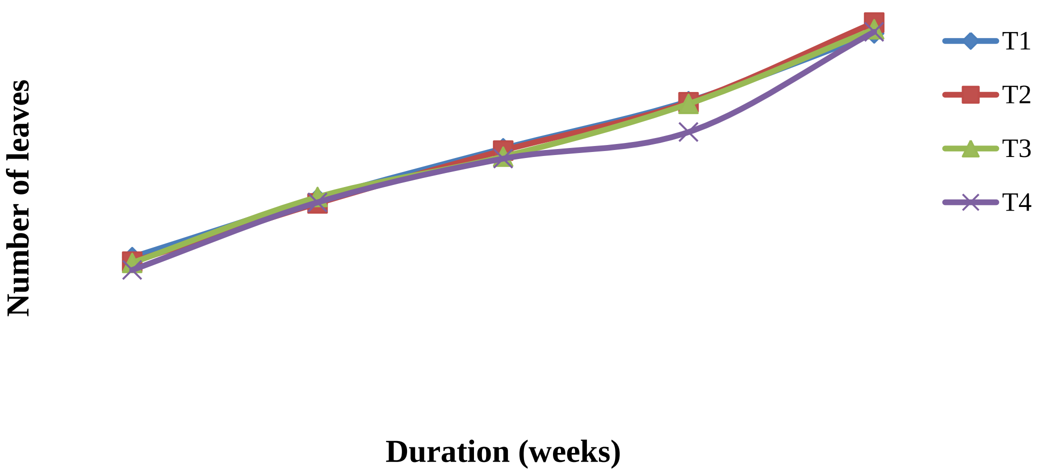


Figure 3: Effect of lambda cyhalothrin application time and weeding regime on number of leaves of maize

**Weed Density (g)**

There is significant difference in weed density results between treatments as result obtained is separated into two categories: low weed density results ($T_1$ – $T_3$) and high weed density results, $T_4$ (Figure 4). Weed density is high in $T_4$ (control: no weeding) compared with the other treatments (Figure 4). There was significant difference in weed density between $T_3$ and $T_4$. However, there is no significant difference in weed density between $T_1$ and $T_2$.

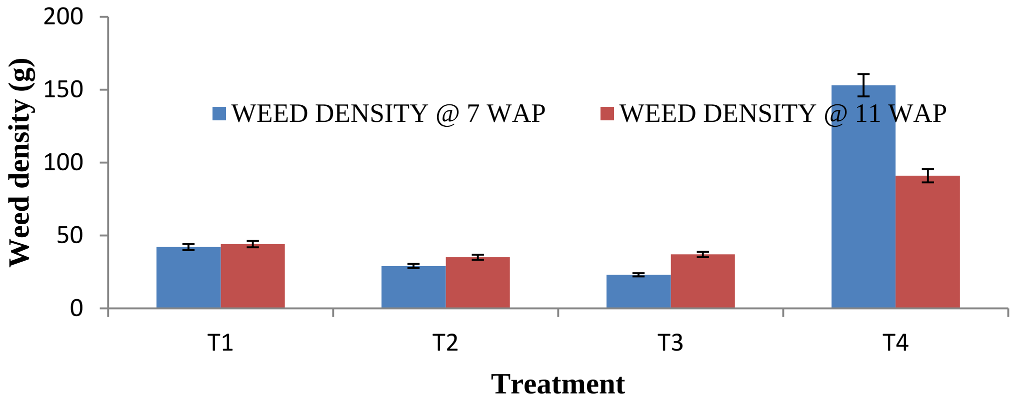


Figure 4: Effect of Lambda cyhalothrin and weeding regime on weed density

**Cob Fresh and Dry Weight (g)**

The result for the cob fresh and dry weights showed that the plot sprayed at 5-WAP and weeded thrice had the highest cob fresh/dry weight per plot (1520.0 g and 1111.8g) compared to the control which had the lowest cob fresh and dry of 613.3 g and 394.1 g (Figure 5). There was increase in fresh and dry weights from plots weeded once (i.e. $T_1$) and plots weeded twice ($T_2$) with the maximum recorded in plots weeded thrice ($T_1$) (Figure 5).

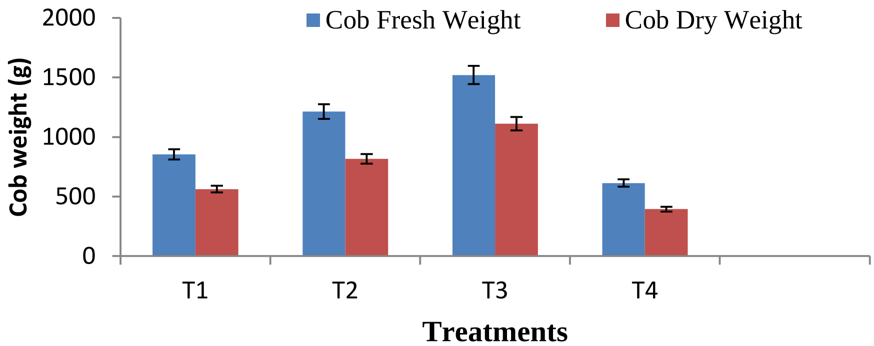


Figure 5: Cob Weight (Fresh and Dry) of various treatments

**Grain Dry Weight (g)**

Grain dry weight showed variation in results between the plots. There was increase from the plot sprayed once and weeded once ($T_1$) to the plot sprayed at 4-WAP and weeded twice ($T_2$). The highest value (376.4 g, 476.1 g, and 380.6 g) was found in plot sprayed at 5 WAP and weeded thrice compared to $T_4$ with the lowest value (362.8 g, 245.1 g and 273.7 g (Figure 6).

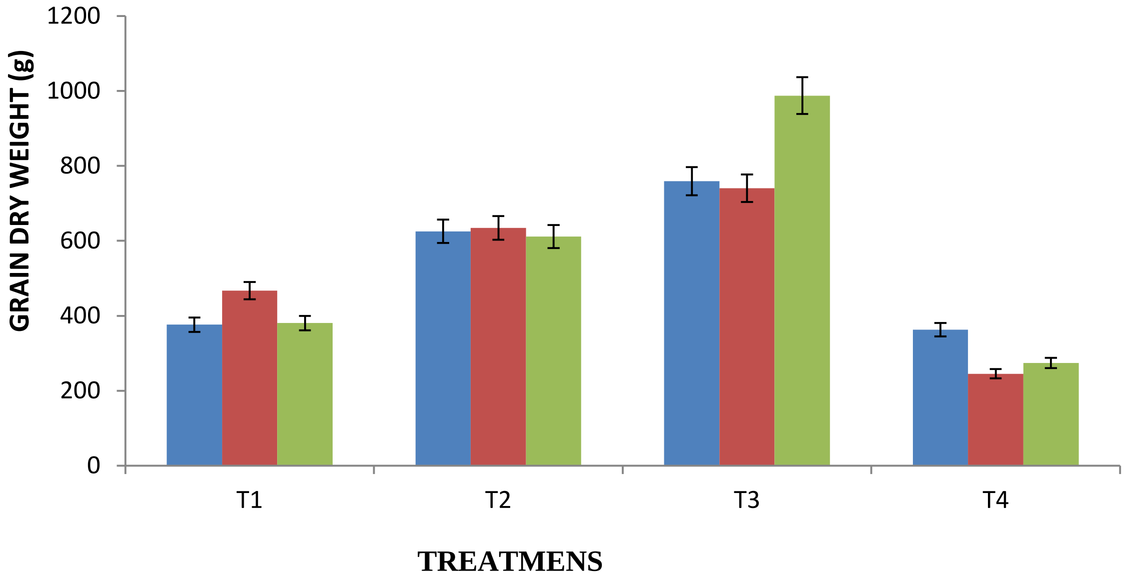


Figure 6: Grain Dry Weight (g) of the different treatments

**Cob Moisture Content (%)**
Details of cob moisture content results are displayed in Figure 7. There was significant difference in moisture content of the various treatments. The highest moisture content was found in the ($T_4$) control (10.8%), this was closely followed by the plot sprayed at 3-WAP (9.9%) and weeded once ($T_1$) while the lowest moisture content (7.6%) was found in the plot sprayed at 5-WAP and weeded thrice (i.e. $T_3$) (Figure 7).

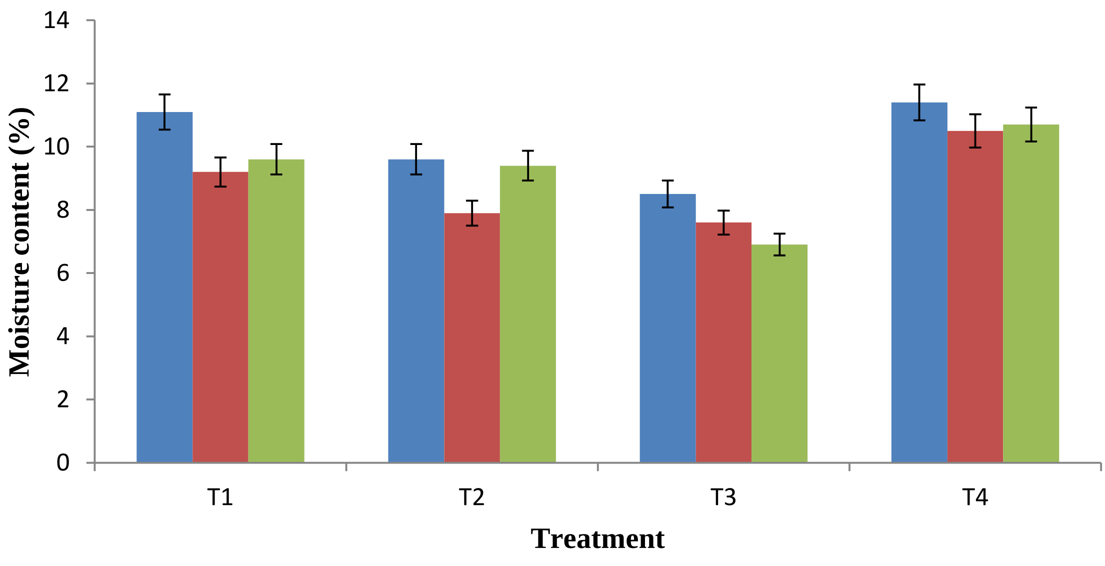


Figure 7: Moisture Content (%) of various treatment levels

**Grain Yield**
Grain yield result increased in the order: $T_3$ was greater than $T_2$ which was higher than $T_1$ but reduced significantly in $T_4$. The highest yield was found in $T_3$ (Figure 8) which was weeded thrice and sprayed at 5-WAP while the least was found in control ($T_4$). The low yield result of the control could be due to no weeding regime and consequent nutrient and light factor competition faced by the crop on this treatments.

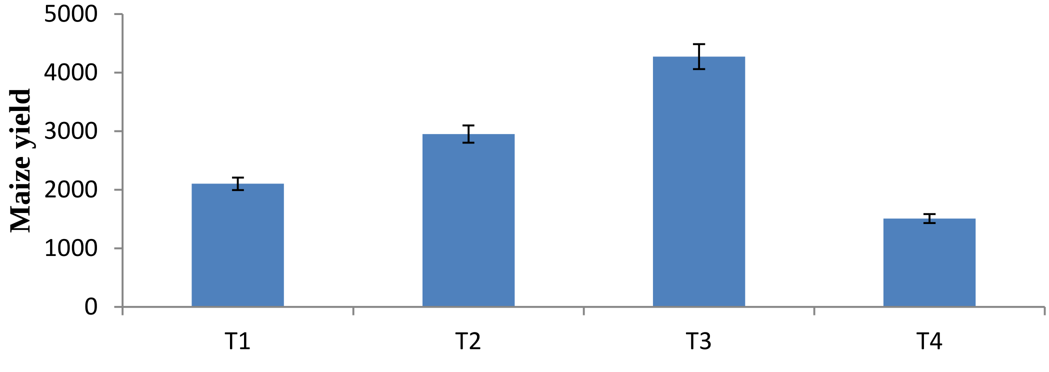

Figure 8: Grain Yield at various treatment levels at harvest (13 WAP)

## Discussion

Fifty-four (54) weed species found on the thrice weeded treatment plot ($T_3$) is the least compared with 70, 87 and 116 species for the once, twice weeded treatment setups and the control respectively. This low weed species content observation could have resulted from the effect of the weeding regime on the plots. Hand-hoeing as a weed control method was repeated thrice on the plots. This could have exterminated species that could not withstand repeated mechanical damage of the hand-hoeing weed control method adopted for the plot. Highest grain yield record in $T_4$ could be attributed to the weed-free condition maintained where the plants did not compete with the weeds for nutrients and other environmental factors that are necessary for growth. Spraying at 5-WAP was very effective in checking the economic threshold of the insects. This competition can influence the growth of the maize plant thereby reducing the growth. This was explained by Hall. *et al.,* (1992) who reported that maize is easily affected by competition from weeds especially at its early stage of growth and thus the reduced growth. Maintaining the minimum interference level possibly favours crop growth and ensures productivity in weed management, thus, Pitelli (2014) stated that establishing crop management strategies is necessary for the growth of plants.

The results of FAW infestation show that insecticide treatment with three times weeding regime had the least FAW infestation at harvest over the other treatments. This could be due to the application of the insecticide (lambda cyhalothrin) at the best time to rid it of the FAW larvae which cause leaf damage by primarily feeding on leaves thereby reducing photosynthetic area and yield loses. This agrees with FAO (2018) report that severe damage of maize plant by FAW is caused by larvae infestation during the early vegetative stage of the maize growth. Weeding regimes of $T_1$, $T_2$ and $T_3$ produced significant reduction in weed density compared to $T_4$ (control, no weeding). Weeding once and spraying at 3-WAP ($T_1$) had highest number of leaves and cob moisture content but grain yield was only higher than $T_4$. Lambda cyhalothrin sprayed at 5-WAP and weeding at 3-, 5- and 7-WAP ($T_3$) had the highest plant height and grain yield. The performance of $T_3$ may be due to the weeding regime (i.e. thrice) to which it was subjected to. This agrees with Liebman and David (2000) who indicated that increase in weeding regime results in a significant decrease in weed population and species and vice versa. This may be due to the destruction of weeds during weeding operation at the early stage of the maize growth.

The maize yield components (cob fresh weight, cob dry weight and grains yield) showed a trend of the order $T_3 > T_2 > T_1$. This could be due to the number of weeding regime for each treatment as $T_1$ was weeded once, $T_2$ twice while $T_3$ was weeded thrice. The highest maize yield component values were recorded in $T_3$ compared to $T_4$ which had the lowest yield values. This could be due to spraying at the early (i.e. larval) stage of the fall army worm which is the most destructive stage of the FAW and application of proper weeding regime (i.e. at 3-, 5- and 7-WAP) to minimize competition. The result of the maize yield indicated that $T_3$ had the highest yield of 4273.43 kg/ha (i.e. 4.3 T/ha) compared to $T_4$ which had the least yield of 1508.09 kg/ha (1.5 T/ha). This can be attributed to the combined effects of the insecticide and weeding as soon as is necessary to be weeded. These measures helped in the control of the FAW at the early infestation before they cause severe damage to the maize plant. Spraying lambda cyhalothrin insecticide, a pyrethroid (Niu. *et al*., 2009) at 5-WAP on $T_3$ also gave a boost to the performance of the maize. This is because despite the weeding that had been done, the weed and pest population were further reduced by spraying which gave the plant the conditions to grow and flourish. Vanbijon. *et al*., (2007) reported a significantly lower weed biomass due to the removal of weeds at the early stage of crop and similar results were reported by James. *et al*., (2006) that all control practices decreased weed density.

Low weed incidence improves growth and increases yield which invariably leads to increased crop production in this case more maize. This is in line with the findings of Jones and Thornton (2003) who reported that the average maize production globally is put at 4.3 T/ha and yield can be as high as 8.6 T/ha in developed countries. $T_4$ had the lowest maize yield because it was not weeded and not sprayed, therefore the maize plants were allowed to grow with weeds and there was no insecticide spray to reduce the infestation of FAW, hence lower maize yield was recorded.

## Conclusion

This study of the effects of insecticide application time and weeding regime on the control of fall army worm on maize has shown that weeding at 3-, 5- and 7-WAP effectively controlled FAW infestation and promoted higher maize yield. Spraying lambda cyhalothrin at 5-WAP also reduced infestation and increased crop yield. It therefore can be concluded that effective control of Fall Army worm for good crop yield can be achieved by weeding at 3-, 5- and 7-WAP and followed with spraying lambda cyhalothrin at 5-WAP.

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