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Effectiveness of *Tephrosia vogelii* on Armyworms Control in Maize (*Zea mays*) Crops: A Case Study of Small-Scale Farmers in Mkushi District (Farmers Training Centre Area)

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ABSTRACT- *The purpose of inducing Tephrosia vogelii on the control of Armyworms in Maize crops was to assess its effectiveness by determining the Armyworm mortality rate and the leaf/stem damage caused by armyworms. The Tephrosia vogelii is found in many parts of savanna region and it is planted by the farmers as windbreak and as a nitrogen fixation plant. The main problem that is faced by the small local farmers in Mkushi District, during the farming season is the attack of armyworms in the fields and the damage they cause is very severe to the extent of loss on the farmer. The farmers therefore, are finding challenges to buy the synthetic pesticides to control the armyworms that occur seasonally. Hence, cheaper and possible means to control the armyworms were discovered by the researcher by simply the use of the common plant (Tephrosia vogelii). The leaf extracts of the Tephrosia vogelii were very effective in the control of the armyworms. Analysis of Variation (ANOVA) showed the F critical value to be less the F value which signified a mean significant difference at 99% confidence interval (18 F crit < F 2117.1285). The highest stage of mortality of the armyworms was at larval with the approximate of 8000 dead larval armyworms. The chemical analysis of the T. vogelii leaf extracts confirmed the presence of the rotenoid deguelin which is the toxic compound found in the leaf, it causes the respiratory system of the armyworms of be compromised hence dies in the processes.*

Keywords: *Tephrosia vogelii, Rotenoid, Tephrosin, Armyworms, small scale farmers.*

1. INTRODUCTION

1.1 Background

Armyworms are green stripped caterpillar larvae of the adult armyworm moth and they got their name because of their mode of travelling in armies and eating everything in their paths. A common pest of grass armyworms also eats corn, beets, beans, millet and other grains. The African armyworm is a migratory moth, the larvae (caterpillars) of which are important pests of pastures and cereal crops, predominantly in Africa south of the Sahara, Yemen, and certain countries of the Pacific region. Generally, only small numbers of this pest occur, usually on pastures. However, periodically the populations increase dramatically and mass migration of moths occur, covering many thousands of square kilometers and traversing international boundaries and they travel from field to field in great numbers (Ngegba et al, 2007). Outbreaks follow the onset of wet seasons when dry grasslands produce new growth and cereal crops are planted. The severity and extent of outbreaks are increased by extended drought followed by early season rainstorms, which concentrate egg-laying moths and provide flushes of new grass as food for newly hatched caterpillars, and dry and sunny periods during the caterpillar development, which promote survival and rapid development. Therefore, major upsurges occur in seasons of sporadic rainstorms and long sunny periods throughout the outbreak period.

Caterpillars are major pests in outbreak years, causing significant losses on a local, national and regional scale. During outbreaks, caterpillars occur in such high numbers that they have to travel in masses from one field to another in search of food to complete their development, devastating crops as they move. Significant losses are most consistently reported from eastern and southern Africa and Zambia is one of the Countries in the Southern Africa that is greatly affected. However, in recent decades, the frequency of reports from West Africa has increased, possibly due to the extension of suitable grassland habitats following forest and bush clearance for agriculture. The economic importance of the African armyworm is due to its rapid development (short life cycle), high reproductive capacity, and mobility by migration. Moreover, there is little time to react as infestations frequently go unnoticed, since young caterpillars are difficult to detect. When caterpillars become noticeable, they cause a lot of damage in a very short time, (Diario, 2017).

The degree of Damage of the Armyworms usually depends of many stages such as the stage of development of the crop, prevailing weather conditions, Density of caterpillars present and area affected. In areas with high and localized rainfall during armyworm seasons, plants can regenerate provided the growing tips are not damaged, with little or no yield reduction. In contrast, in areas of erratic rainfall, farmers may lose their crop completely, (Maund, 2002). The degree of damage by armyworms varies from year to year. In East Africa, a severe outbreak can cover several square kilometers at very high densities, while in non-outbreak years, caterpillar density is often low, and the size of attacked areas is negligible. The first armyworm outbreaks appear in Tanzania and Kenya, and are serious in nine years out of ten, causing up to 90% losses of crops and pasture in bad years and they covered 157,000 hectares of crops and pasture in 2001, (Maund, 2002). In major outbreak years, the moths subsequently migrate to cause extensive damage in Uganda, Ethiopia, Somalia and Eritrea and may travel as far as Yemen or south to Malawi, Mozambique and Zambia.

In Grasslands, even maturing crops can be totally destroyed and if drought conditions follow an outbreak, plants may not recover from defoliation and replanting may fail to produce a crop. Damage to cereal crops results principally from attack on young plants by young caterpillars hatching or dispersing into the crop from adjacent wild grasses. Weed-free maize crops taller than 50 cm are unlikely to become infested by newly hatched caterpillars because the leaves are too tough to allow them to establish (Maund, 2002). However, when older caterpillars moving from heavily infested grasslands invade fields, even maturing crops can be destroyed. Reported yield losses caused by defoliation in maize range from nine percent in plants attacked at the early whorl (four leaves) stage to 100% in those damaged at the pre-tassel stage. The ability of young maize plants to recover from armyworm

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damage depends on the position of the growing point at the time of attack and the amount of root development when the caterpillars stop feeding. Damage is always serious if the growing point is affected but, as it remains at the base of the plant until near to the pre-tassel stage, it may be below ground during the outbreak and remain undamaged. Replanting maize after armyworms have destroyed the first-sown plants is frequently unsatisfactory, as the optimum planting dates will have been missed. Yield losses of 6% have been estimated for each day's delay after the optimum planting date in high-rainfall areas in Kenya. Late planting may result in much higher losses in areas with less rainfall; yield losses of up to 92% have been recorded in such areas in Malawi and Kenya. If drought conditions follow an outbreak, plants may not recover from defoliation and replanting may fail to produce a crop, (Diario, 2017).

1.1.1. Tephrosia vogelii

Tephrosia vogelii is a soft, woody herb with dense foliage. It stands 0.5 to 4 m tall and contains stems and branches with short and long white or rusty brown hairs. Long, narrow leaves branch out from stems, as well as sack like shapes that contain the seeds of the plant for reproduction. Tephrosia can be used for various purposes besides human and livestock consumption, which makes it a diverse and helpful plant. Its most common use is for organic tick control. First, leaves from the Tephrosia plant are ground up and a juice is extracted which is then used on the animal. The green liquid from the plant is mixed with water and is then applied to the animal's skin with a piece of cloth or a sponge. A little bit of soap can be added to the liquid to make it stick to the skin. Usually it is left on the animal for a week after which results appear. It is only effective against ticks that still have soft skin and are immature. This is a great practice for farmers that do not have access to veterinary medicine (Chebet et al, 2013).

Tephrosia can also be used as a fish poison, because chemicals in the plant react to chemicals in the fish and surprise them so they can be easily caught. *Tephrosia vogelii* is not used for human or livestock consumption, although another great use is for a natural, organic pesticide on farmer's crops. Its leaves contain high amounts of nutrients, including nitrogen, which is important for good plant development. When Tephrosia trees are cut down, the leaves are worked into the soil, the nutrients can then be used by the plants that are grown in the field after the leaves of the *Tephrosia vogelii* have decomposed entirely in the soil, and then the plant can use it. The befits that the Tephrosia leaves gives to plants is usually Nitrogen that helps the plant in it enzymatic processes and its vegetation, (Chebet et al, 2013).

Though *Tephrosia vogelii* is not consumed directly, it can be used to increase the yield of various crops. For instance, leaf extracts of *Tephrosia vogelii* are used as chemical pesticides. Crops that have had this extract applied show significant decreases in insect and another pest activity.

1.2 Statement of the Problem

The armyworms have been irresistibly destroying the crops around many parts of Africa. Zambia is among the countries that has experienced this damage of crop at early stages for the past four (4) years now (ZARI, 2016). The category of famers that are at much of a loss are peasant and small-scale famers. The researcher found an opportunity to establish a help for the small-scale farmers because some of them are unable to access and later alone buy the pesticide to control the armyworms because of their low-income base (Rose & Dewhurst, 1996).

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The armyworms seem to be challenging the farmers in Mkushi District. The possible and cheaper means to treating the armyworms if established, will enable the peasants and small-scale farmers to produce their garden and field maize effectively with affordable income. In the recent years when Zambia received the other type of armyworms from the western parts of Africa, the government helped the farmers that experienced the armyworm attacks with synthetic insecticides. The insecticides were offered at no cost and as time grew, the government could not continue to help the farmers hence they started to find solutions to themselves buying either the recommended chemicals or face a loss. With the advent of the various types of army worms across Africa and Zambia' Mkushi area, seriously causing damage to maize crop at early stage, the researcher was prompted to conduct a study towards the use of the cheapest and possible ways of controlling army worms among peasants and small-scale farmers of Mkushi Farmers Training Centre area with the use of *Tephrosia vogelii* is a soft, woody herb locally accessible.

1.3 General Objective

The main objective of this study was to assess the effectiveness of the *Tephrosia vogelii* on the armyworm control in the maize crop in Mkushi, Farmers Training Center.

1.3.1 Specific Objectives

- ✓ To determine the mortality rate of the Armyworms.
- ✓ To assess the most effective treatment concentration on the armyworm's mortality.
- ✓ To evaluate the stage with highest mortality in the life cycle of the Armyworms.
- ✓ To determine the rate of damage caused by armyworms on maize crops.

1.3.2 Research Questions

1. How is the mortality rate of Armyworms when treated with *Tephrosia vogelii*?
2. What is the most effective treatment on the Armyworms mortality?
3. What stage in armyworms lifecycle has the highest mortality?
4. How much damage will the armyworms cause on the maize crops?

1.3.3 Research Hypothesis

1. H_0: $\mu_1 = \mu_2 = \mu_3$ (the means are equal, hence no significant difference)
2. H_1: At least there is one difference among the means, hence there is a significant difference.

1.4 Establishment of Gap

Literature reviewed many uses of the *Tephrosia vogelii* plant on the control of pests and insects which do not include the current armyworms. Hence the study to assess the effectiveness of *Tephrosia vogelii* on armyworm control.

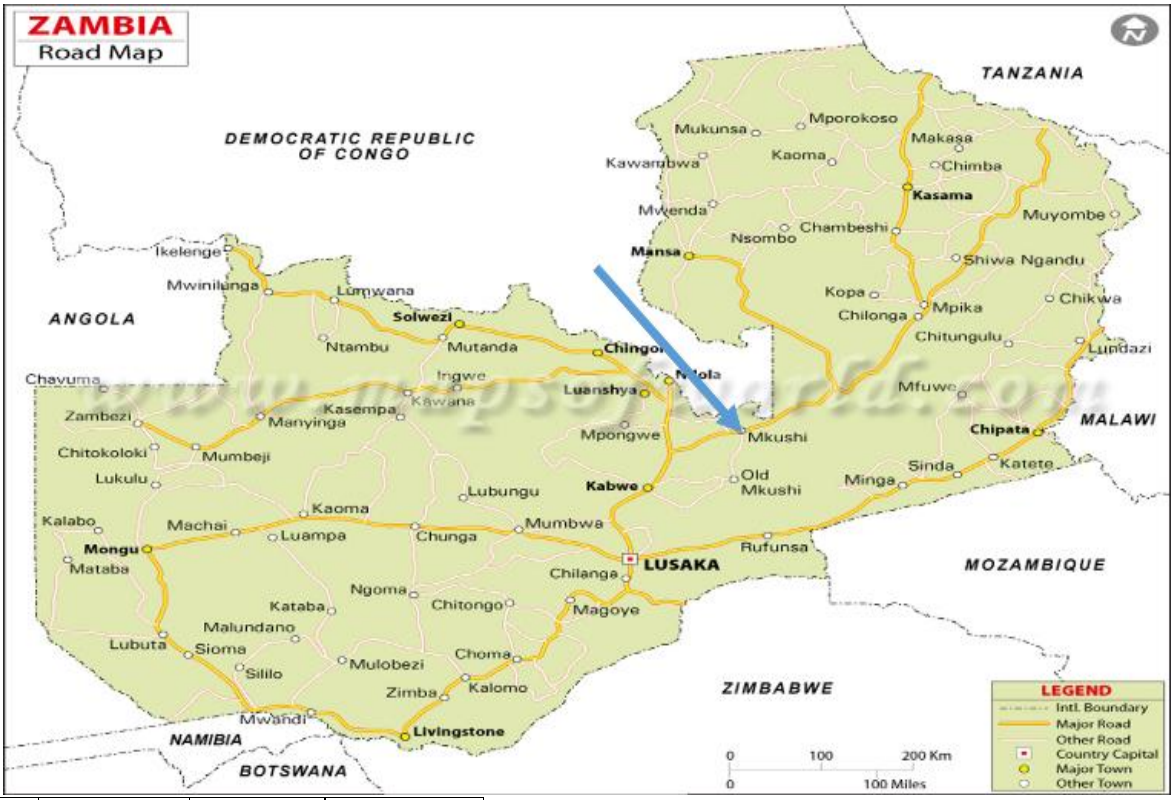
1.5 RESEARCH STRATEGY

1.5.1 Site of study

The study was undertaken at Farmers Training Centre in the Mkushi District in the Central Province of Zambia. Mkushi is about 270 km from Lusaka the Capital city of Zambia. (weather statistical, 2015), records the rainfall patterns zone II of Zambia where Mkushi District is found about 900mm to 1200mm and has average temperatures of about 32.1 degrees during the rain seasons.

***Figure 1** shows the blue arrow pointing at the District where he research was conducted.*

- ✓ Measuring tap



Block A	**T 1** 60m x 5 m	**T 2** 60m x 5 m	**Control** 60m x 5 m
Block B	**Control** 60m x 5 m	**T 1** 60m x 5 m	**T 2** 60m x 5 m
Block C	**T 2** 60m x 5 m	**Control** 60m x 5 m	**T 1** 60m x 5 m

1.5.3 Materials

The variety of maize that was used in the research was Pannar 53. The fertilizers applied as Basal (Compound D) and Top dressing

Table 1: treatments and controls per block

(Urea). The other materials include;

- ✓ *Tephrosia vogelii* leaves
- ✓ Motor and pounding stick
- ✓ Protective and Tags
- ✓ Hoes, Pens and Papers

1.5.3 Materials

The total land size was 20 m x 60 m, which was 1,200m^2 of land. The three blocks which the treatments had consisted of equal measurements of 60m x 15m. The maize spacing was 75cm x 25cm, the plants per lines was about 80 plants and each treatment had three lines. The treatments and controls per block had the same land size in the as shown in the table below;

1.5.5 Research design

The research design that was used in this research was Randomized Block Design where the researcher assigned the treatment at Random within blocks of adjacent subjects, each treatment once per block.

1.5.6 Treatment measurements

The two treatments varied in the chemical concentration because the measurements were also different which included;

1. The first treatment had 160g/L
2. The second treatment has 320g/L
3. The third treatment was the control

1.5.7 Preparation of *Tephrosia vogelii*

Crude leaf plant extract evaluated were obtained from *Tephrosia vogelii* collected from the nearest site where they are located and were weighed to get 160 g and 320 g respectively and were separately crushed using a mortar and a pestle then put in separate containers. 1 liter of water was added in each container and sealed tightly. *T. vogelii* soaked for 48 hours under ambient condition. At the end of soaking period, the extracts were filtered using a sieve to remove the large pieces of leaf material according to (Viglianco *et al*., 2008). The filtrates were then put separately into a plastic hand sprayer and used immediately on the pests.

1.5.8 Application of *Tephrosia vogelii*

The pesticide was applied after two days for a period of one months and two weeks. The two days between the times of chemical application was for the checkup of the response on the Armyworms in mortality rate. The attack of Armyworms was seen when the Maize crop reached almost the Knee high and applications of the chemicals began the same period.

1.5.9 Data collection

The data was collected after 2-4 hours after application of the *Tephrosia vogelii* chemical extract. The collection was to continue for 2 days before the next application. The sampling procedure, which was used to identify and collect the dead Armyworms, was Random Sampling Technique. In each treatment of about 240 plants, a sample of 120 random plants were checked to see the number of dead army worms per plant and the mean was found for the entire population in each treatment.

1.6 Data Analysis

The data, which was collected, was subjected to excel for Analysis of Graphical presentations and the Analysis of Variance (ANOVA).

1.7. RESULTS

The armyworms that attacked the crops (maize) were checked at random in 120 plants per treatment and the mean mortality that was found per treatment was used to the entire plant population in each of the three blocks.

1.7.1 Mortality of Armyworms

The probability of the Armyworms per plant was $P \geq 5$ at the time of attack and in the period of one month and two weeks the three blocks where sprayed 10 times and the below table shows the morality record after two, 3, 4, 5, and 48hrs of spray.

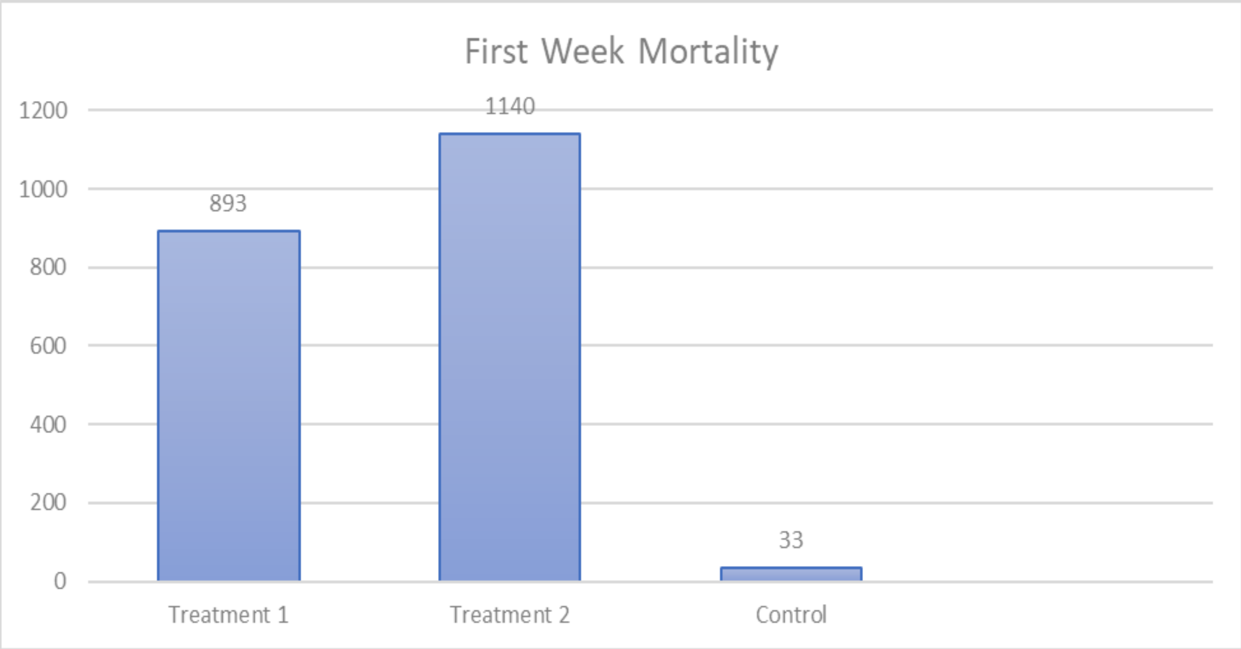


***Figure 2** shows the average mortality of the armyworms in the first week*

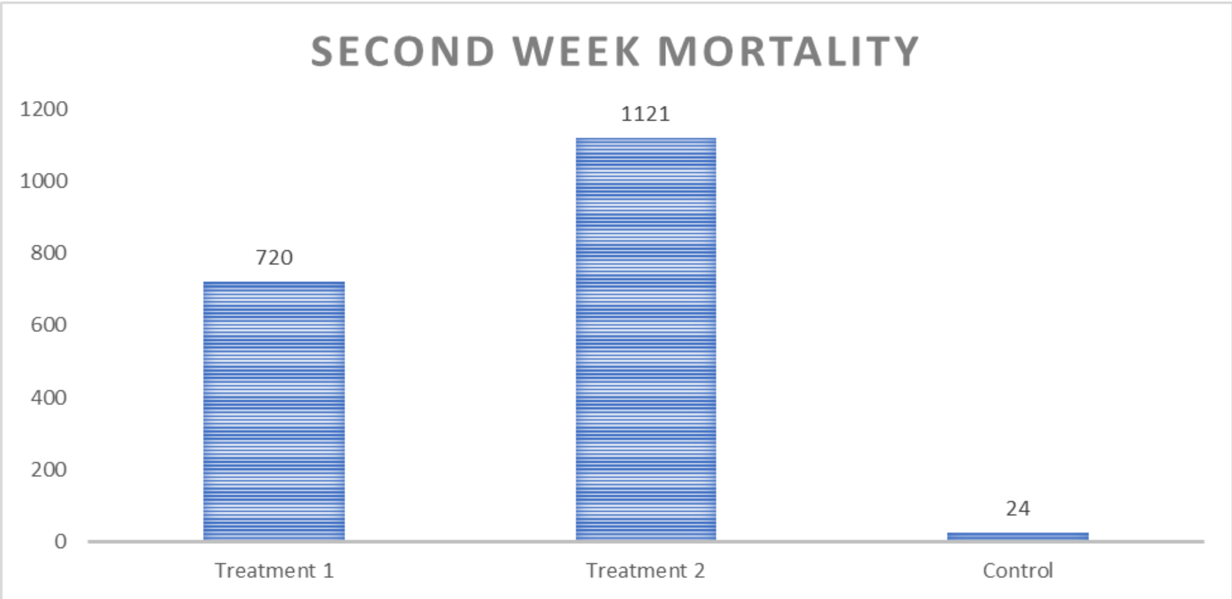


***Figure 3** illustrates the mortality of Armyworms in the second week*

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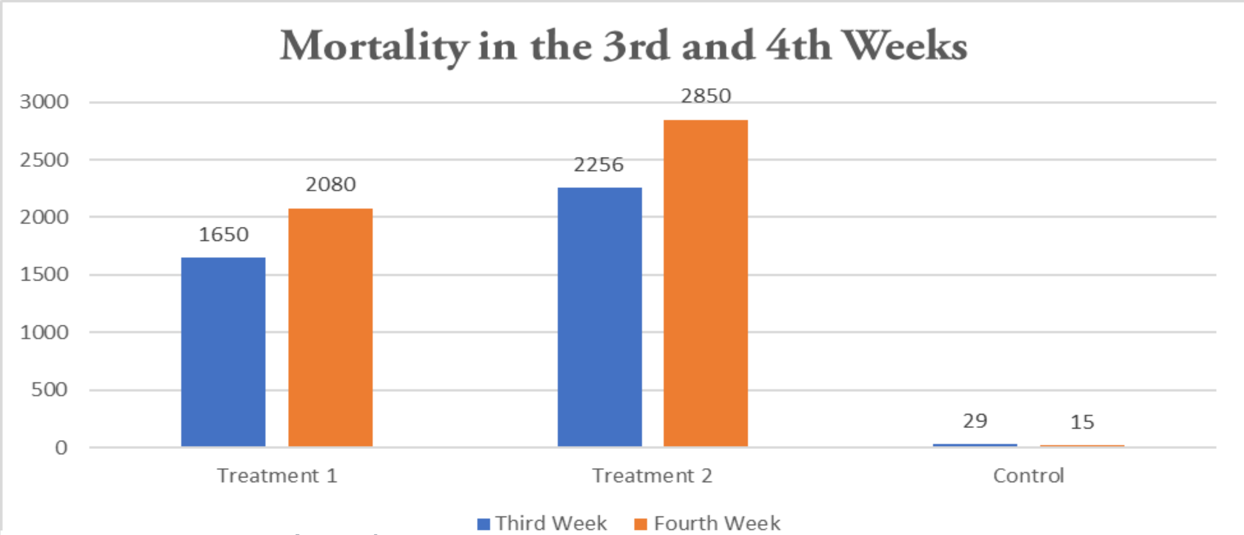

Figure 6 above shows the 3rd and 4th week mortality

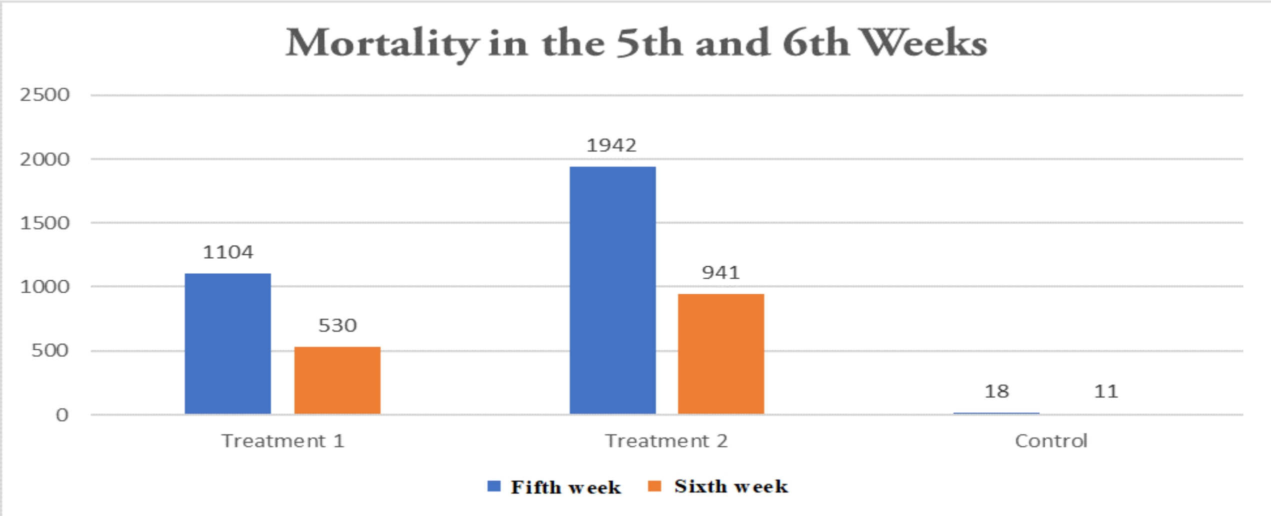

Figure 5: shows the fifth and sixth weeks armyworm mortality

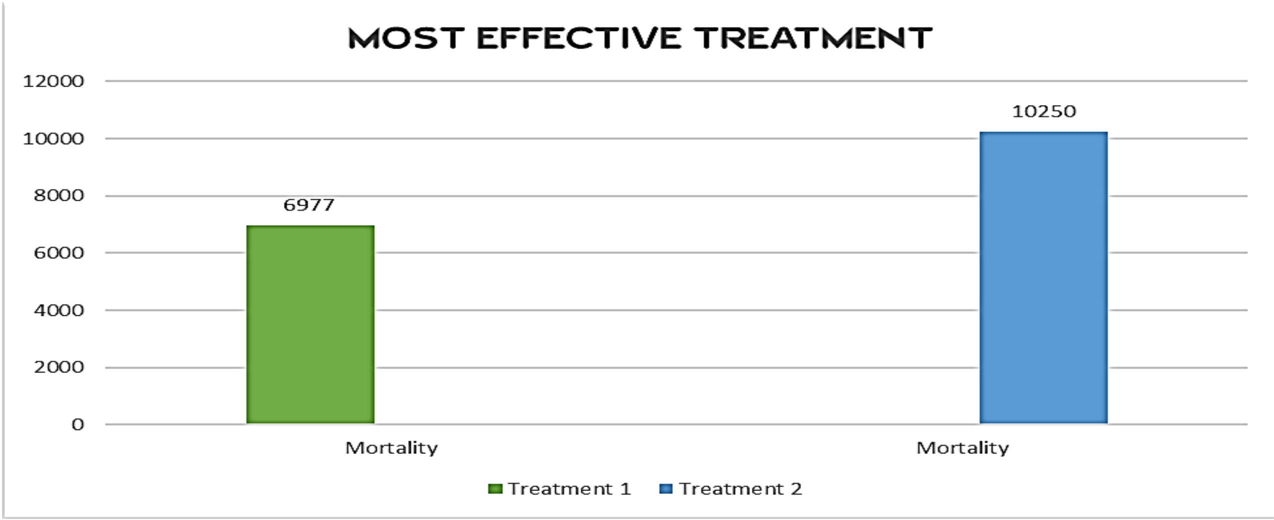

Figure 4: The most effective treatment

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1.7.2 Hypothesis Results

SUMMARY	Count	Sum	Average	Variance
A	3	5767	1922.333333	2945650.33
B	3	5890	1963.333333	3122766.33
C	3	5700	1900	2829333
T1	3	6977	2325.666667	552.333333
T2	3	10250	3416.666667	10920.3333
Non	3	130	43.33333333	20.3333333

Table 2: shows the analysis at average mortality

ANOVA						
Source of Variatioı	SS	df	MS	F	P-value	F crit
Rows	6190.888889	2	3095.444444	0.73722512	0.53387423	18
Columns	17778704.22	2	8889352.111	2117.1285	8.90729E-07	18
Error	16795.11111	4	4198.777778			
Total	17801690.22	8				

Table 3: ANOVA at 99% Confidence Interval

1.8 STAGE OF HIGHEST MORTALITY

TREATMENT	Treatment 1	Treatment 2	Control
Larval	**6110**	**8956**	**105**
Adult	**867**	**1294**	**16**

Table 4: Stage of Highest Mortality

1.8.1 Larval stage

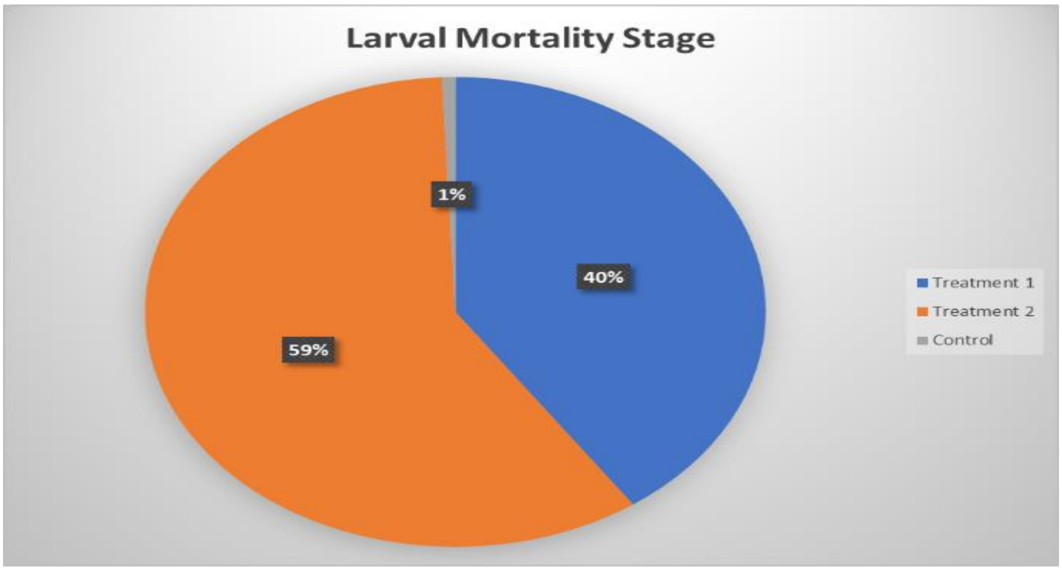

Figure 7: Larval Mortality Stage

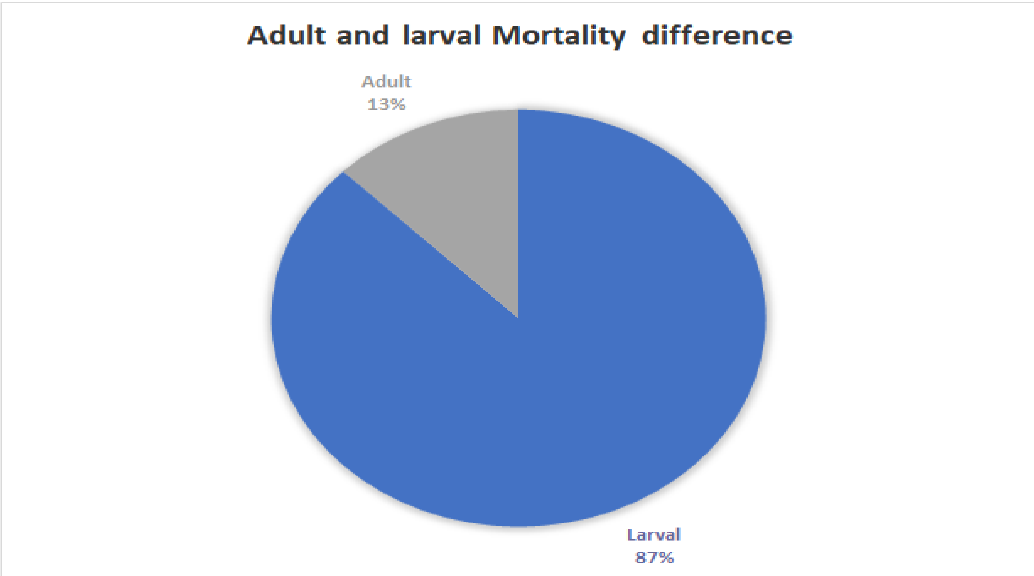

Figure 8: shows the Mortality difference on Larval and Adult stage

1.9 MAIZE LEAF DAMAGE

TREATMENTS	Treatment 1	Treatment 2	Control
Plants	Mean sample X= 2.5 x 720	Mean sample X= 1.75 x 720	Mean sample X= 4.45 x 720

Table 5: mean leaf damage (selected 120 plants at random)

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TREATMENTS	Treatment 1	Treatment 2	Control
Damaged Leaves	1800	1260	3204

Table 6: Average total leaf damage

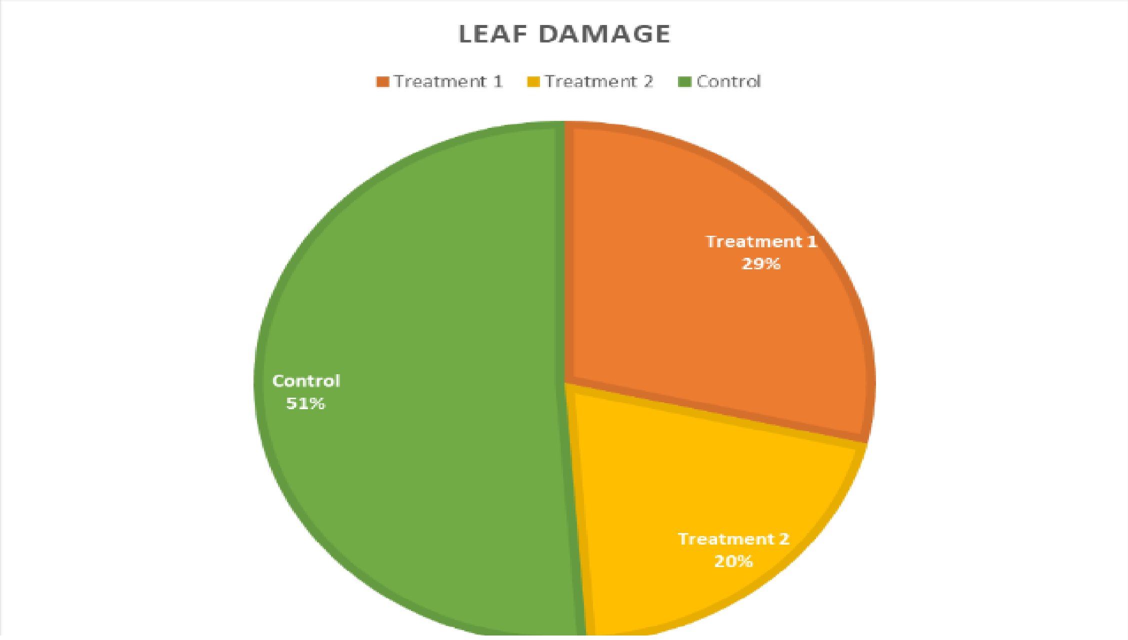

Figure 9: Leaf damage in the Treatments and Control

2.0 DISCUSSION

Figure 2 shows the average mortality of the of the armyworms in the first week and the mortality recorded in treatment one was 43.2%, treatment 2 was 55.2% and control with 1.6%. The treatment with the highest mortality in the first week was treatment 2, which had 320g/L chemical concentration. The researcher also noticed that the dead armyworms which were which were found near the control came from other treatments and they are suspected that they were migrating from the unfavorable conditions. The second week (figure 3) had almost similar rate of mortality as observed by the researcher. The researcher also observed that the temperatures during the two weeks period was cool as the sun was not intensive at all times. According to (Pond, 1960) reported that the lower temperatures decreases the rate of the armyworms to finish their life cycle within it stipulated time and the mortality was observed to be similar. The mortality that was recorded in the control was suspected that some armyworms migrated from the treatments, which had toxicities of the *Tephrosia vogelii* to the control where they died. There was found no dead armyworm in the middle raw of the portions of control, instead near, or in the first raw on the control.

The third and fourth weeks (figure 4) had recorded the highest mortality in the entire duration of the research and during the last two days of the second week, the temperatures were higher than the previous two recorded weeks. The armyworm mortality recorded was very high because the high weather makes their life cycle processes to be hastened; hence, there was more production of the larval in the third and fourth week. It was also observed that the egg stage in the life cycle of the armyworms hatched very effective and young

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larval stage was multiplied and they were more vulnerable to *Tephrosia vogelii* treatment and it was at its highest effective because, the young larval have a very soft morphological skin which allows the easy penetration of the chemical, hence suffocate the to death. Figure 5 shows the reduction of Armyworm mortality from the firth week and the sixth week. The researcher observed that there was an eradication of armyworms while others migrated to the control and other areas because the treatments were no longer good habitat of the armyworms while the two doses treatments recorded the average small numbers of the dead armyworms as compared to week three and four. The temperatures during the last two weeks were moderate.

The second objective was to assess the most effective treatment concentration on the armyworm mortality, and is mapped to figure 6. The most effective treatment as illustrated in the figure 13 is the second treatment that had the concentration of 320g/L. There was a difference of about 3273 dead armyworms between treatment 2 and treatment 1. Hence, the use of the 320g/L treatment is the most effective to the main damaging stages of the armyworm lifecycle because it also recorded the highest mortality in both larval and adult stage. The hypothesis therefore as shown in the table 6, states that there is a significant difference in the means presented above and therefore, the Null Hypothesis is hence rejected.

The third objective was to evaluate the stage with highest mortality in the life cycle of the armyworms. The stage of highest mortality was seen that the larval stage is most dangerous and it damages the leaf and stem of the maize crop severely. The same stage is more vulnerable to treatments as shown in figure 7. The two doses of *T. vogelii*, however, inhibition and disruption of moulting was observed and larval-pupal abnormal pupae were commonly found. This was therefore, similar with the research that was conducted by (Paul, 1990) on the treatment of armyworms with the use of the Neem seeds extracts, which showed the abnormal pupal stage of the armyworms when it passes through the stage of larval. The *T. vogelii* in both treatments of 160g/L and 320g/L concentration recorded the mortality to the adult armyworms since even that stage was sprayed to observe if its life would be affected. The rate of mortality at larval stage of the armyworms was high as compared to the adult stage. The researcher observed that the difference could be on the morphology of the two stages. The adult is able to migrate so easy by ways of flying while the larval stage is more stationary till it grows to pupal stage.

The fourth and final objective was to determine the rate of damage caused by armyworms in maize crops and this objective is mapped to figure 9. The damage caused on the leaf of the maize plant according to (Georg G, 2004) explains that, it is at larval stage where they feed to complete their lifecycle, this is due to the limitations that are faced when it reached the pupal stage. Therefore, Treatment 2 (Figure 9) has less damage on the leaves of all the plants because the 320g/L concentration terminated most of the larval stage of the armyworms where the armyworms are at most dangerous. The other stages failed to survive the environments in Treatment 2 as observed because they could not withstand the toxicity of the leaves that had the chemicals. It was also discovered that, the Control had more of the armyworms every week and this was concluded that some of the armyworms at adult stage-managed to migrate to Control where they continued their life cycle and full development.

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2.1 Chemical Analysis

This study examined the leaves of the *T. vogelii* contains the chemotypes such as; rotenoids, including deguelin, rotenone, sarcolobine, tephrosin, obovatin 3-methylether and a-toxicarol. With the presence of the obovatin 3-methylether and rotenone, it causes the respiratory system of the insect of be compromised hence dies in the processes. The contact of deguelin and rotenone also causes harm of the skin of the various pest including the armyworms at larval stage respectively.

2.2 Conclusion

The research therefore, shows that *T. vogelii* has the chemical components that are harmful to the armyworms in maize crops. It showed no negative effect to the normal growth of the maize crop and the yields when using *Tephrosia vogelii* as a treatment. The maize growth rate was entirely different from the treatment that had 160g/L and 320g/L and also the control. The marginal difference was determined by the number of damaged leaves and the stems to the maize plant, hence, treatment two (320g/L) had the highest maize growth and the yield. The researcher also observed that the early of the larval is the best to control the armyworms from the massive attacks on the leaves and stems of the maize plants.

Most of the plants in Control, failed to grow because their stems and plumules were cut, and by the end of the season they failed to recover their growth. The armyworms mostly eat the fresh leaves from the plants that newly develop and they eat plants in order to complete their lifecycle. The research hypothesis therefore shows that the treatments were effective with mean differences and about 51% of the plants in Control recorded the highest damage of plant's leaves. The higher temperatures increase the armyworm lifecycle developments and the damage of the larval stage is very high. In a cool weather, the development of armyworms is delayed hence; it is a better time to expose them to treatments.

2.3 Recommendations

The research that was carried out was successfully positive undertaken on the analysis of *T. vogelii* on armyworms in Maize crops and the researcher recommends the following;

1. A further research to be conducted to compare the effectiveness of the *Tephrosia vogelii* botanical pesticide and any synthetic pesticide that is recommended to be used on the treatment on armyworms.

2.5 ACKNOWLEDGEMENT

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