ISSN : 2350-0743

www.ijramr.com

International Journal of Recent Advances in Multidisciplinary Research

Vol. 09, Issue 09, pp.7945-7948, September, 2022

RESEARCH ARTICLE

EFFECTS OF MINERAL FERTILIZATION OF MAIZE ON THE INFESTATION AND DAMAGE OF *SPODOPTERA FRUGIPERDA* J.E. SMITH, 1797 (LEPIDOPTERA: NOCTUDAE) IN THE KARA REGION OF NORTHERN TOGO

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ARTICLE INFO

Article History:

Received 18th June, 2022
Received in revised form
19th July, 2022
Accepted 27th August, 2022
Published online 16th September, 2022

Keywords:

Fall Armyworm,
Mineral Fertilization,
Infestation, Yield.

ABSTRACT

Aim: Find alternatives for the control of the fall armyworm, *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae), in Togo, through mineral fertilization of maize. ***Methods:*** A completely random block design of four treatments repeated four times was used at the agronomic station of Tchitchao. Three doses of fertilizer, NPK15-15-15 at 200 kg/ha, NPK20-10-10 at 200 kg/ha and the combination 100 kg/ha NPK15-15-15 +100 kg/ha NPK20-10-10; were tested in comparison with the absolute control from November 2019 to March 2020. ***Results:*** The results show that the mean number of egg clusters is significantly higher (P=0.0220) between 16th and 22nd DAS on the treatment combination than on the rest of the treatments (NPK15-15-15 at 200 kg/ha, NPK20-10-10 at 200 kg/ha and the absolute control. Also, between the 16th and 19th DAS, the infestation rates remain significantly higher between the combination of treatment and treatment with NPK20-10-10 at 200 kg/ha (0.0182). ***Conclusion:*** Fertilization has an influence on the incidence of the fall armyworm and can then be used as an option in integrated pest management.

INTRODUCTION

Spodoptera frugiperda J.E. Smith, 1797 (Lepidoptera: Noctudae) is an insect pest native to Latin America. This insect in the larval stage feeds on more than 186 cultivated and wild plants distributed in more than 42 botanical families Casmuz Augusto et al (2010). In January 2016, the invasion of this insect was reported in Nigeria, Ghana, Benin, Togo and Sao Tomé Goergen et al (2016). This invasion was followed by a rapid expansion of the pest, especially in sub-Saharan Africa. Thus, its presence was reported in 28 countries in 2017 Abrahams et al (2017), 44 countries in 2018Rwomushana et al (2018). It is also reported in the territory of Karnataka in India Ganiger et al (2018). This invasion in Africa is associated with significant damage to maize, the pest's preferred crop and which is the main staple cereal for the populations. Yield losses associated with damage caused by this pest in 12 major maize producing countries are required between 8.5 and 21 million tonnes or a financial loss of US$250-630 million when no control measures are taken Abrahams et al (2017). The threat reached by this pest is likely to cause hunger and dangerously compromises the achievement of objective 2 of the SDGs. Faced with this situation, the immediate control method implemented to manage this pest is chemical control Kumela et al (2019). However, the Fall Armyworm has developed resistance against several synthetic chemical families such as organophosphates, carbamates and pyrethroids Abrahams et al (2017), as well as Bt maize Tabashnik et al (2013).

The decision-making aid method based on the use of pheromone traps has been tested in Togo Meagher et al (2019). It made it possible to identify the different strains created by the pest. Thus, the integrated pest management method is the most suitable for an effective, efficient and sustainable management of the armyworm in Africa. It is in this context that this research project comes to test the influence of mineral fertilization on the dynamics of *S. frugiperda* populations in stations in the Kara region in northern Togo.

MATERIALS AND METHODS

Trial site: The agronomic experimentation station of Tchitchao of the Higher School of Agronomy of the University of Lomé (ESA/UL) served as a study framework for our trial. It is located in the Kara region with a unimodal rainfall distribution, at an altitude of 270 m and at coordinates 9°27 North and 1°02 East. Characterized by a tropical climate of the Sudanian type, this zone is marked by a single major rainy season from April to October and a single major dry season from November to March. The soils are of relatively poor skeletal types. The average temperature is around 27.2°C.

Test setup: The study was conducted from November 2019 to March 2020. Before the installation of the trial, the preparation of the experimental site was done manually through the following operations: clearing, plowing, leveling, delimitation of blocks and plots. A completely random block design of four treatments, T0 (Absolute control without NPK intake); T1 (treatment with fertilizer: NPK 15 -15 -15); T2 (treatment with fertilizer: NPK 20 -10 -10) and T3 (treatment with mixed fertilizer: ½ NPK 15 -15 -15 and ½ NPK 20 -10 -10), repeated four times each. The total area is 1008 m2 or 28m* 36m with plot units of 40 m2 or 8m * 5m. The cropping pattern used is 80cm * 25cm, 8 rows of 5m long per elementary plot. The blocks are separated by 1m while the elementary plots are separated by 0.5m. Sowing was carried out at the rate of 3 seeds per pocket, thinning out at one plant per pocket was carried out 8 days after sowing giving rise to a population density of 50,000 plants/ha. Each plot benefited from two manual weedings every 15 and 40 days after sowing and one ridging every 51 days after sowing. Complex fertilizers were buried the day before sowing at a dose of 200 kg/ha and urea at 45 DAS at a dose of 100 kg/ha.

Data Collection: Data such as the number of larvae per plant, the number of egg clusters per plant were collected on a sample of 50 plants following the W approach FAO (2018) described by the following a frequency of 3 days up to when the male flowers appear FAO (2017). The level of damage was evaluated from a destructive sampling of 10 plants on the 15th, 30th and 45th DAS following the scale of Davis et al (1989). To evaluate the average yield, a random sampling of 20 feet was carried out at full maturity of the grains on each elementary plot. The harvested cobs were dried and then shelled. The grains obtained are weighed on the Practum balance with a precision of 10-3 g. the average of the grain weight per treatment was calculated by the sum of the production of ears sampled on each repetition. The value found was multiplied by the 50,000 plants, population density according to the scheme adopted per hectare divided by the 20 plants sampled.

Thus, the yield was calculated according to the formula:

Where:

$$R(t/ha) = \frac{(P \times Dp)}{Npe \times 1000}$$

R(t/ha) = Yield per hectare of dry maize grains expressed in Ton t/ha
P = Production in Kg of maize grain per plot unit
Dp= Population density: 50,000 plants per hectare.
Npe = number of plants harvested per plot unit (yield square)
To determine the mass of 1000 grains, 1000 grains were counted from the ears from each elementary plot. They are then weighed on the scale. The average of the different repetitions was then performed.

Data analysis: The data collected was entered and processed using the Excel 2013 spreadsheet. They were then statistically analyzed using SAS software version 9.2 (SAS Institute 2005). Before their use for the analysis, the data relating to the number of larvae and egg masses were transformed by the function log (x +1), and those relating to the percentages by the function, with p=x/ 100 in order to homogenize their variances. The PROC MIXED syntax made it possible to evaluate the effect of treatment and time on the various parameters studied. The comparison between the different treatments at each collection date (JAS) was carried out using the analysis of variance (Proc GLM). For all parameters, when the analysis of variance reveals significant differences between the means, these were separated using the Student-Newman-Keuls (SNK) multiple comparison test at the 5% level.

RESULTS

Effect of different mineral fertilization formulas on mean number of FAW egg clusters: The evolution of the average number of egg clusters per plant is shown in Figure 3. We note the presence of egg clusters on all treatments from the 13th to the 49th DAS. This average number is higher between the 13th and 22nd DAS for all treatments. As for the lowest average number of egg clusters, it is observed between the 37th DAS until the appearance of male flowers. The laying peaks were observed on the fertilized plots and correspond to 0.45 ± 0.06; 0.39 ± 0.05; and 0.47 ± 0.05 egg clusters/plant for T1, T2 and T3 respectively, whereas it is only 0.37 ± 0.06 on the control plot (T0). The mean number of egg clusters is significantly higher (P=0.0220) between 16th and 22nd DAS on T3 than the rest of the treatments and between the 13th and 22nd DAS than the rest of the trial period for T3. set of treatments.

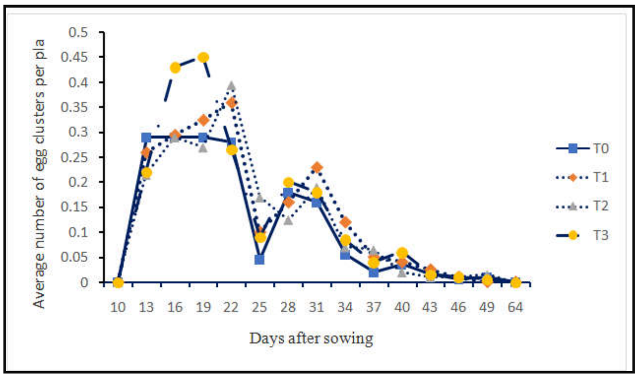

Figure 1 .Variation in the average number of egg clusters per plant over time under the effect of different treatments

Effect of different mineral fertilization formulas on the larval population of the fall armyworm : The average number of larvae per plant is represented by figure 4. On the 10th DAS, no larvae were observed on all the treatments. The first larvae are observed from the 13th DAS on all treatments. The treatments had a significant effect on the mean number of egg clusters (0.0220). The average number of larvae increased gradually with peaks observed between the 16th and 31st DAS. The highest average number of larvae was observed on the fertilized plots compared to the control.

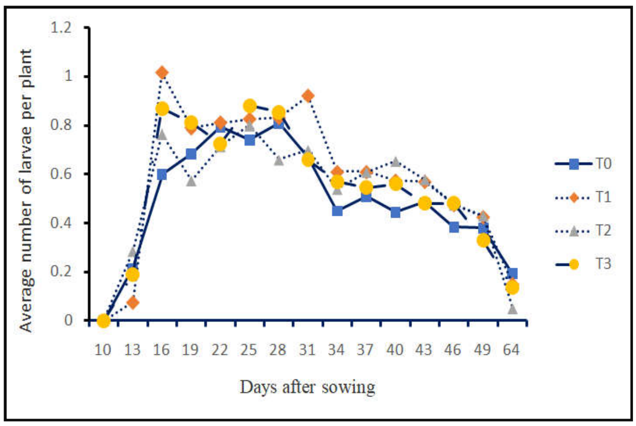

Figure 2. Evolution of the average number of larvae per variety

The T1 treatment recorded the highest average number of larvae per plant (1.01± 0.14) at the 16th DAS. As for Treatment T2 and the combination, the peaks were observed at the 25th DAS, 0.80±0.06 and 0.88±0.08 respectively, whereas it was only observed at the 28th DAS for the control (0.81±0.08). On the 64th DAS, the average number of larvae per plant was higher on the control plot than on the fertilized plots. 0.19 ±0.03 versus 0.15 ±0.03; 0.05 ± 0.02 and 0.13 ± 0.04 respectively for T1, T2 and T3.

Effect of varieties on plant infestation rate Effects of different mineral fertilization formulas on the average armyworm infestation rate : Caterpillar infestation rates per treatment are shown in Figure 5. Armyworm infestations evolved parabolically. Indeed, the infestation is weak at the survey, increasing between the 13th and 16th DAS with the peak reached between the 16th and 22nd DAS before starting to decrease until the 64th DAS. These infestations were significantly higher on T3 than on T2 between the 16th and 22nd DAS (P = 0.0182). Thus, at the 19th DAS, the T3 treatment recorded a higher rate of infestation (72.5% against 56.00; 62.00 and 68.5% respectively for T2, T1 and T0) on the other hand at the 22nd DAS this rate is lower (61.5%) compared to the other three treatments 72.50 ± 2.88; 70.00 ± 3.49; 72.50 ± 3.21; and 71.50 ± 4.10 corresponding respectively to T1, T2 and T0.

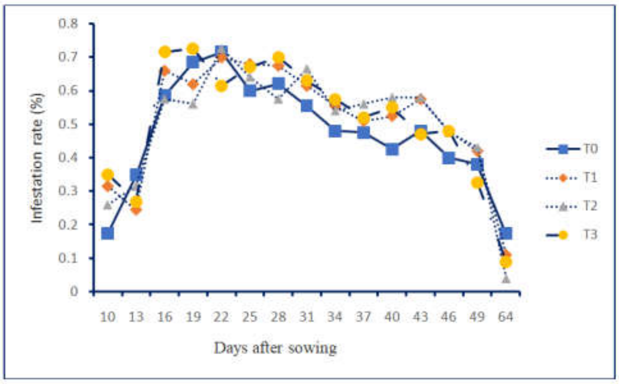

Figure 3 . Effect of different mineral fertilization formulas on armyworm infestation rate

Tableau 1. Effect of different doses of mineral fertilization on the level of leaf damage

Treatment	Domage		
	15ème JAS	30ème JAS	45ème JAS
Without contribution of NPK	1,26 ± 0,06 a A	1,48 ± 0,08 ab B	1,18 ± 0,04 aA
$NPK_{15-15-15}$	1,24 ± 0,06 a A	1,22 ± 0,05 b A	1,22 ± 0,05 aA
$NPK_{20-10-10}$	1,30 ± 0,07 a A	1,42 ± 0,06 ab B	1,20 ± 0,04 aA
½ $NPK_{15-15-15}$ + ½ $NPK_{20-10-10}$	1,41 ± 0,09 a B	1,66 ± 0,08 a C	1,22 ± 0,04 a A
TRAIT EMENTS	*F = 5,53*	*DF = 3*	*p = 0,0012*
JAS	*F = 17,66*	*DF = 3*	*p< 0,0001*
*TRAIT*JAS*	*F =,64*	*DF = 6*	*p = 0,0182*

Means followed by the same lowercase letters in the same column and uppercase letters on the same row are not significantly different p=0.05

Effect of different mineral fertilization formulas on the level of leaf damage : The evolution of the leaf damage level is shown in Table 1. The highest level of leaf damage was observed on the plants fertilized with the combination and the lowest on those having received treatment 1 (NPK 15 -15 - 15). Mineral fertilization had a significant effect on the level of leaf damage (P= 0.0012). Like fertilization, the level of leaf damage changed significantly over time (p<0.0001). With the exception of plots that received T1, the level of leaf damage changed between the 15th and 45th DAS for all treatments. The highest level of leaf damage on the control plots was observed on the 30th DAS.

DISCUSSION

Insects interact with the composition of nutrients contained in plants while the latter depend on the nutrients contained in the soil and especially their concentration of soluble elements in the soil solution. Mineral fertilization had a significant effect on the infestation rate over time. As well as the infestation rate, the highest average number of egg clusters and larvae per plant is obtained on plots that received mineral fertilization, compared to untreated plots. Our results are consistent with those of Jahn (2004) who state that adding nutrients to soils helps the plant to produce enough lush, succulent plant material that provides a suitable environment for egg laying by a variety of pests. The highest average number of egg clusters was obtained with the combination between NPK15-15-15 and NPK20-10-10. This Combination has resulted in a synergy of the proportion of the fertilizing element nitrogen; element which would have increased the concentration of soluble sugar, proteins and amino acids, thus attracting adults to spawn and promoting the development of larvae.

Thus, the richness of plants in low molecular weight nutrients positively affects the reproduction, lifespan and health of certain pests. According to Jansson et Ekbomb (2002) excessive nitrogen supply or low potassium fertilization leads to the accumulation of free amino acids and contributes to an increase in the pest population. According to Rostami et al (2016) nitrogen is the major element needed by insects and in many cases the main limiting factor for their optimal growth. Work by Cisneros and Godfrey (1999) reported that female whiteflies aggregate and lay enough eggs on plants and leaves with high nitrogen concentration. Increasing the nitrogen content of plant tissues changes the nutritional quality of the plant while reducing its resistance against aphids on cotton. Arshad et al. (2013) by evaluating the effect of different doses of nitrogen fertilization on the development of *chilopartellus* showed that larval development and survival was lower in control plots.

On the other hand, for the maximum dose of 150Kg/ha they were optimal. A similar conclusion was also drawn by Setamou et al (1993) on *S. calamistis*. Mineral fertilization had an effect on the level of leaf damage. The combination of treatments (T3) recorded the highest level of foliar damage compared to the other treatments. The synergy of action of the different proportions would have made the plants very succulent for feeding the larvae. However, the corresponding level of damage on the Davis scale indicates very low damage and this is attributable to the composition of fertilizing elements which enabled the plant to compensate for larval removals and therefore to be more resistant than to unfertilized plants. This result is in line with that of Chabi-Olaye et al (2005) who reported that increasing the doses of fertilizers leads to increased damage at the active growth stage of young plants, but this improves the vigor of the plant ultimately leading to a net benefit resulting in increased grain yield. The right mineral fertilization can then be used in the sustainable management of FAW as a control option.

CONCLUSION

The study demonstrated that variation in mineral fertilization influences the incidence of the fall armyworm Spodoptera frugiperda J.E. Smith (Lepidoptera: Noctudae) in maize crops. Infestations are low at emergence but remain severe during the vegetative growth phase of the plant. The combination of NPK15-15-15 and NPK20-10-10 recorded higher infestation rates even though yields remain less influenced by this observed damage. Mineral fertilization can then be used as one of the control options to take into account in the integrated fight against the fall armyworm in maize crops. An additional study on the dates of application as well as the different doses of each fertilizer applied will make it possible to better formulate recommendations for producers for sustainable management of the fall armyworm.

Acknowledgements

This work was the result of the sacrifice of several people for whom we thank. Our thanks go to the Food and Agriculture Organization of the United Nations (FAO) for its support. We would like to thank Professor TOUNOU K. Agbéko from the Graduate School of Agronomy for his support in the completion of this work. Mr. FAMAH SOURASSOU Nazer for his support throughout the internship. Mr. TCHABI Atti, director of the higher institute of agricultural professions at the University of Kara for his management.

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