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Assessment of the damage of the fall armyworm *Spodoptera frugiperda*, J.E. Smith (1797)

(Lepidoptera: Noctuidae) on three varieties of maizein agroecological zones I and II of Togo

Hodabalo Kpemoua*[1]; Naser Famah Sourassou[1], Oyétoundé Djiwa[2,3], Hodabalo Dheoulaba Solitoke[2], Atti Tchabi [1],

1- *Institut Supérieur des Métiers de l'Agriculture (ISMA), Université de Kara (UK-Togo).*

2 -Faculté des sciences, Université de Lomé (UL-Togo).

3- *Organisation des nations unies pour l'agriculture et l'alimentation (FAO-Togo).*

***For Correspondence**

Hodabalo Kpemoua
Institut Supérieur des Métiers de l'Agriculture(ISMA), Université de Kara (UK).

kpemouah@gmail.com

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Abstract: *In order to demonstrate a certain resistance / varietal tolerance against the fall armyworm, Spodoptera frugiperda, J.E. Smith (1797) (Lepidoptera: Noctuidae), three varieties of maize were tested under agro-ecological conditions I and II of Togo. From October 2019 to January 2020 at the Tchitchao agronomic experiment site the Ikenné, Obatanpa and Sotubaka varieties were tested using a complete random block device with four replicates. The infestation of the plants by the pest occurs naturally and the data (number of egg clusters, fresh droppings, larvae, leaf damage) were collected from the 10th to the 59th day after sowing (DAS). The results showed that the three varieties are already infested on the 10th DAS with peak rates of infestation between the 17th and 24th DAS but the Ikenne variety remains significantly more infested than the other two from the 24th to 59th DAS. Also, the leaf damage observed on the Ikenné variety was significantly higher than on the other two varieties Obatanpa and Sotubaka (P <0.0001) themselves. The different varieties tested have an influence on the incidence of the fall armyworm. The varieties could be used in integrated pest managementprograms against the fall armyworm.*

I. INTRODUCTION

The Fall Armyworm (FAW), *Spodoptera frugiperda*, J.E. Smith (1797) (Lepidoptera: Noctuidae), which appeared in Africa in 2016, was a new invasion of maize cultivation. It is a polyphagia's pest, particularly virulent on maize crops. It caused yield losses in maize which could range from 15 to 73% when 55 to 100% of the plants were infested **[1].** Native to the Americas, it was detected for the first time simultaneously in several West African countries (Benin, Nigeria, Sao Tome and Togo) and was a real regional scourge **[2].** In response to this caterpillar (CLA) which caused significant damage to the maize crop, chemical control has remained the main alternative to combat it. However, according to **[3],** inappropriate use of pesticides could lead to adverse effects on agricultural production, human health and the environment. It could also result in pesticide residue levels in treated products posing a risk to consumers and limiting the marketing of the products in national and international markets. Also the risk of developing resistance to certain molecules used remains high, as already reported for *Spodoptera litura* **[4-5-6]; *Spodoptera exigua*** **[7]**. In addition, the growing awareness of the harmful impact of these products on the environment [8-9] leads to favor the intensive organic management of pests which recommends minimal use of synthetic chemical insecticides **[10].** This justifies the adoption of sustainable agricultural systems based on integrated pest management and which emphasizes preventive measures and devoting particular attention to agronomic practices, the use of tolerant / resistant varieties adapted and tested, to comprehensive biological control programs. In Guadeloupe, for example, studies had shown that the local maize variety (Fondor) was less sensitive to attacks by *Spodoptera frugiperda* than the imported variety (I.N.R.A 400). Also, in Virginia, varieties from the northern United States were much more susceptible to attack by this moth than lines with southern origins **[11].** In Togo, more than seven (7) varieties of maize are cultivated throughout the territory. In order to study the dynamics of *Spodoptera frugiperda* and highlight a certain resistance or varietal tolerance, an experiment was carried out on three varieties of maize, the most cultivated in agroecological zones I and II of Togo.

II. Materials and methods

Trial site

The test was set up in Zone II precisely at the Tchitchao experiment site. The site was located in the Kara region about 400Km from Lomé, precisely between 9°38"N and 01°08"E. Agroecological zones I and II extend between 8°30" North to the west and 9°00" North to East to the Burkina Faso border. They benefit from two-season Sudanese subtropical climate. A great rainy season (June - October) and a great dry season (November - May). The average temperature varies between 26 to 28°C in the plains and drops to 24°C in altitude. But the aridity was very marked there: 4 to 5 ecologically dry months in zone I against 3 to 4 months in zone II. The area was marked by strong evaporation and a strong Harmattan influence. The average relative humidity varies from 70 to 90% in the Guinean zone and from 50 to 70% in the Sudanian zone **[12].**

Test setup

The full random block device was used with three treatments (Ikenne, Obatanpa, Sotubaka varieties) repeated four times. The sowing was carried out in October 2019, on elementary plots of 5mx5m. The scheme used is 80cm × 25cm for 120 pockets per elementary plot at the rate of six (06) rows and 20 pockets per row, ie a stocking density of 50,000 plants per hectare after stripping. Two weeding were done, on the 14th day followed by thinning and on the 30th day after sowing and ridging between the 45th days after sowing. Mineral manure (NPK 15-15-15) at the conventional dose of 200kg / ha was added on the 15th day after sowing and urea between the 43rd day after sowing at the dose of 100kg / ha.

As the test was conducted in the off-season, watering was done regularly to maintain humidity on the plot and ensure the development of the plants.

Data Collection

The following data: egg mass, fresh excretion, number of larvae per plant; were collected from the 10th to the 59th day after sowing. For each collection, a sample of 50 plants are inspected using the W method **[13]** which consists of walking by drawing a W and at each point of the W, 10 plants are randomly selected for data collection. Data collection was done once a week and in the morning. Each plant was carefully inspected down to the whorl to observe and record parameters. For the assessment of leaf damage, four samples, three of which were destructive, corresponding respectively to 04 phenological stages of maize cultivation were carried out.

Stage 1: 5-6 leaves, on average 35 cm high at 21 DAS;
Stage 2: 8-10 leaves (on average 90 cm high) at 35 DAS;Stage 3: panicle draft at 49 DAS;
Stage 4: ripe flowering-heading at 63 DAS.
For each sample, 10 plants are selected at random, ie a total of 40 plants per treatment. Selected plants were cut and screened in the laboratory to assess leaf damage using the method of **[13].**

Data analysis
The data collected has been organized in Excel table and the averages were calculated and ordered in this same spreadsheet. This Excel spreadsheet was then exported to SAS 2009 software which served as a basis for statistical analysis. The effects of the different treatments (varieties) on the parameters studied were determined using analysis of variance (Proc GLM). Before being used for analysis, raw data relating to the number (number of egg clusters, number of larvae, level of damage) were transformed into log (x +1), and those relating to percentages (rate of infestation) were transformed into square root (arsin (sqrt (Proportion)) in order to homogenize their variances. The infestation rate (Ir) is calculated by the formula (1):

(1)

(Ir = Infestation rate)

The level of damage (Ld) was calculated by this equation (2):

(2)

Where (xi = score attributed to the attacked leaf, ni = number of leaves having received the score xi, n = total number of plant leaves). For all parameters, when the analysis of variance revealed significant differences, they averages were separated using the Student-Newman-Keuls (SNK) multiple comparison test (SNK) at the 5% level

III. Results Assessment of the average number of egg clusters per variety

The change in the average number of egg clusters observed per plant of each variety over the entire data collection period is shown in figure 1. There is presence of egg clusters on all varieties of the 10th DAS. Until the 39th JAS. At 39 DAS egg clusters are still found on Ikenne and Obatanpa while the Sotubaka variety no longer contains egg clusters. These egg masses for all varieties gradually diminished with the development of the plants. The egg clusters observed on all varieties are significantly higher (P <0.0001) between the 10th and 17th DAS than during the rest of the development period of the plants. However, the Ikenne variety remains the most suitable for laying (0.25 and 0.28 eggs / plant), followed by the Obatanpa variety (0.14 and 0.16 eggs / plant) between the 10th and 17th DAS.

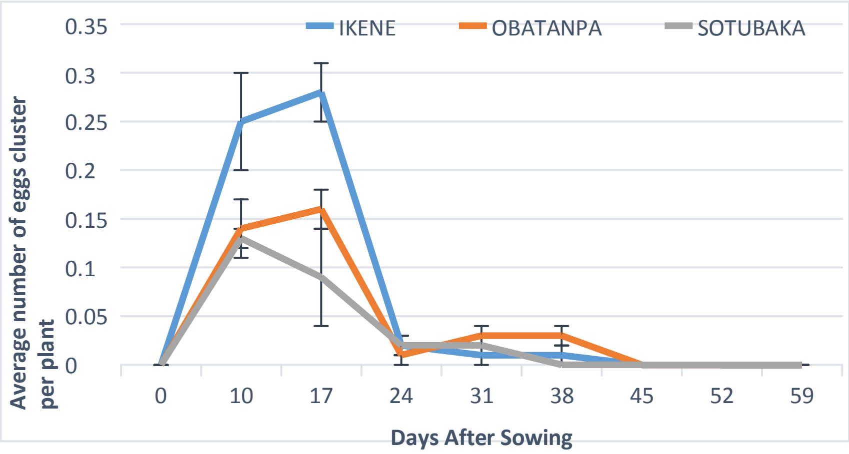

Figure 1: Evolution of the average number of egg clusters per plant.

Assessment of the average number of larvae per variety

The number of larvae per plant is shown in Figure 2. The figure shows that until the 24th DAS, at least one larva is found per plant on all varieties. From the 24th DAS only one larva per plant was found. The average number of larvae per plant gradually decreased with the development of the plants. Over the entire collection period, the greatest number of larvae was found on the variety Ikenne. From 10th to 17th DAS the number of larvae on the Ikenne variety was significantly higher than that on Sotubaka and Obatanpa (P <0.0001).

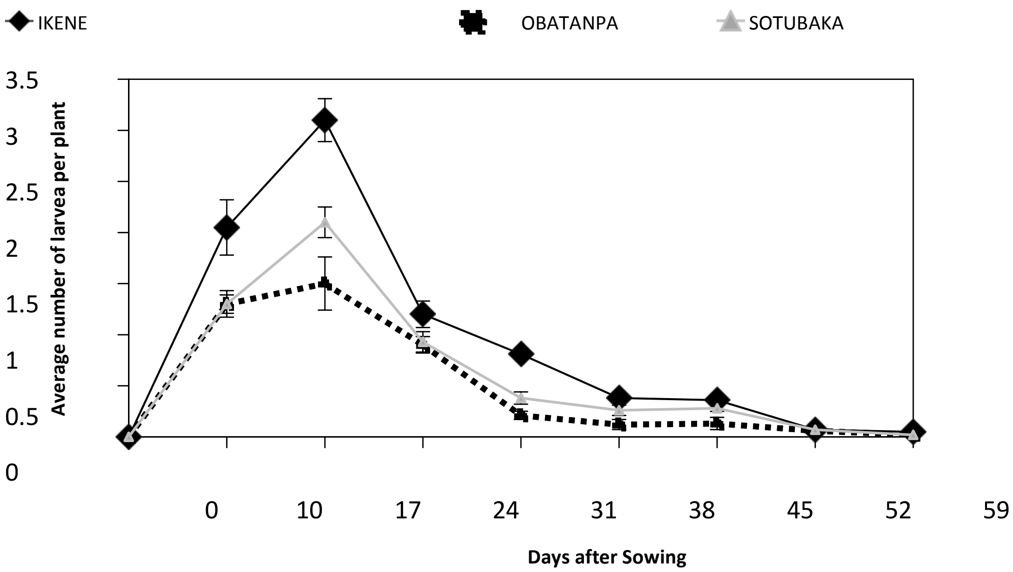

Figure 2: Evolution of the average number of larvae per variety

Effect of varieties on plant infestation rate

The evolution of the infestation rates by variety from the 10th to the 59th DAS is illustrated in Figure 3 and Table 1 summarizes the statistical analyzes for the infestation rate. The varieties have an effect on the infestation rate of the Fall Armyworm. In general, the infestation rate increased from the 10th to the 25th DAS, then gradually declined thereafter. This rate is close to 100% at the 17th DAS for the three varieties. However, the Ikenne variety was found to be more infested during the period and has the highest infestation rates over the entire collection period. At the 24th DAS, the Ikenne variety already shows a significantly higher infestation rate (Table 1, P <0.000) than the other two varieties. These differences were observed until the 45th DAS, Ikenne remaining much more infested followed by Sotubaka and Obatanpa (Table 1). From the 45th DAS no difference was observed between the infestation rates between the three varieties. Analysis of variance also

indicates that there is a significant difference between the observed infestation rates (P <0.0001) as a function of time for each variety. This rate with a peak between the 17th and 24th DAS 94.5; 97.5 and 98% respectively for Ikenne, Obatanpa and Sotubaka, gradually regresses and becomes almost zero from the 59th DAS.

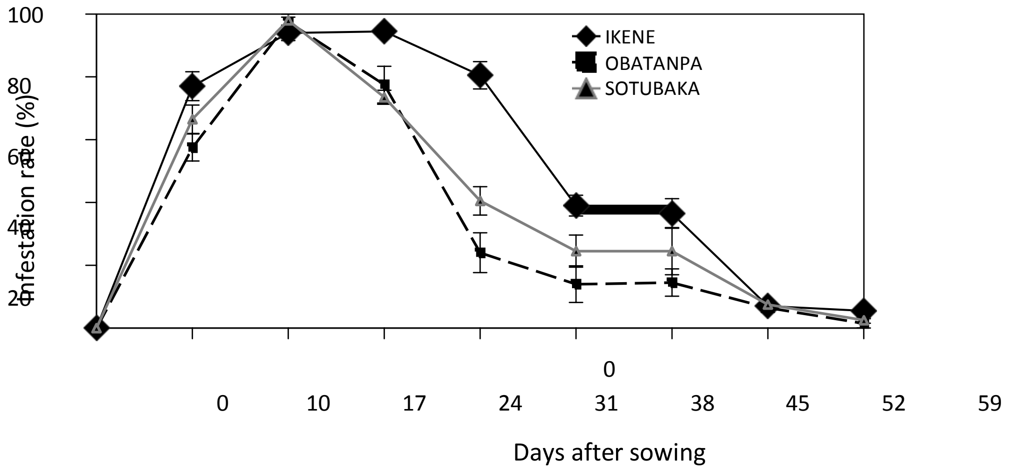

Figure 3: Evolution of the infestation rate by variety.

Tableau 1: Statistical analysis of infestation rates

Days after sowing Source of variation 10		17 24	31 38	45	52	59
Ikenne vs Obatanpa	***	ns***	******	***	ns	ns
Ikenne vs Sotubaka	ns	ns***	***ns	ns	***	ns
Obatanpa vs Sotubaka	ns	nsns	***ns	ns	ns	ns

***** significatif ; ns = no significatif**

Assessment of the level of damage to plants per variety

The damage level was relatively low (<3) for all varieties with the exception of Ikenne which is 3.23 ± 0.11 at the 23rd DAS. Analysis of variance indicates that there was highly significant variability in the level of damage between Ikenne and the other two varieties (Obatanpa and Sotubaka) as a function of time (P <0.0001). For the Obatanpa and Sotubaka varieties the analysis does not reveal any significant difference between the means as shown in figure 4.

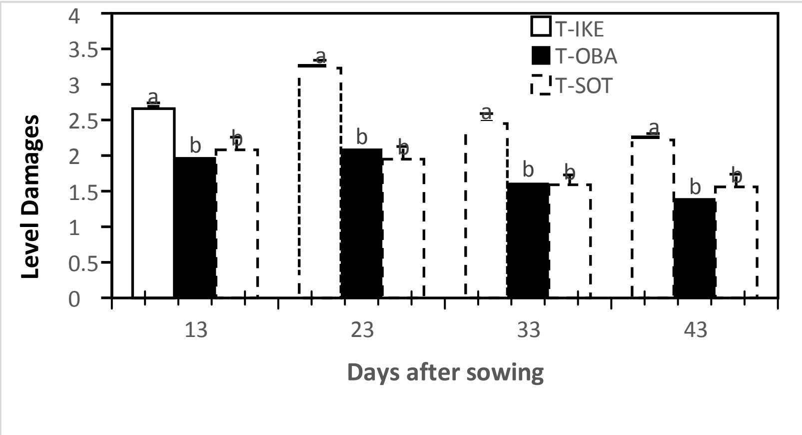

Figure 4: Evolution of the level of damage observed on each variet

Evaluation of yields by variety

The yields obtained by variety were illustrated in figure 5. The yield of the Obatanpa variety (3.70 t / ha) is slightly higher than that of Sotubaka (3.60 t / ha) and IKENNE (3.05 t / ha). However, the comparison of the averages showed that there is no significant difference between these obtained yields.

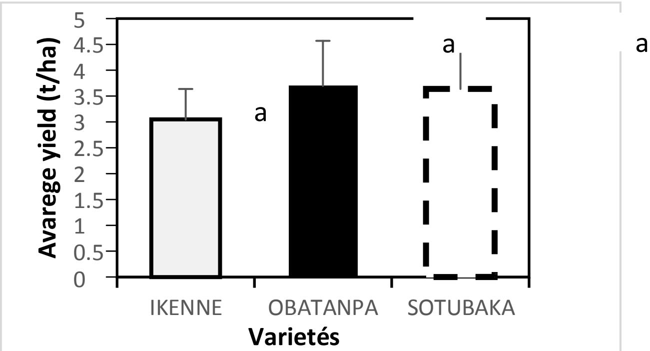

Figure 5: Average yields obtained per variety

IV. Discussion

Varietal resistance was an important practice in crop pest control options. The results of the trials showed that the damage of *S. frugiperda* differs from variety to variety with greater sensitivity observed between the 10th and 24th DAS. The sensitivity of all varieties between the 10th and 24th DAS is thought to be due to the tenderness of the leaves which at this stage were easier to eat than the leaves in the later stages which were more leathery. This observation is similar to that of **[15]** on two varieties of maize tested in Guadeloupe and which notes a greater sensitivity of maize at the 6-8 leaf stage. The largest number of caterpillars is found in these stages of development, which was explained by the fact that the eggs were deposited on the young plants and the greatest damage occurs in the following stages by feeding the larvae after hatching. The number of egg clusters and larvae observed on each variety between the 10th and 24th DAS remains significantly higher than in the rest of the development stages. These results were in line with the work of **[16]** whom state that in the vegetative phase, maize plants were more attractive to female layers of *S. frugiperda*. Regarding the larvae, the high number per plant in the early stages of development was correlated with the hatching of egg clusters and their low number in the advanced stages was explained by the cannibalistic behavior of these larvae from their 3rd stage of development. The same observations were made by **[17]** stating that larval abundance was highest during the early stages of crop development from the second to the fourth vegetative stage. In terms of damage, the Ikenne variety was shown to be more susceptible with a higher damage level than the other two varieties (Obatanpa and Sotubaka). These differences in susceptibility to leaf damage would probably be due to the tenacity of the leaves through the thickness of the epidermis which differs from one variety to another, which confirms the second hypothesis. This result confirms those of **[18]** who also found significant differences between attack levels by *S. frugiperda* in different "resistant" and "susceptible" maize cultivars. **[11]** also noted that in Virginia, varieties from the northern United States were much more susceptible to attack by this moth than lines with southern origins. **[19]** reported that a thicker epidermis of corn leaves appears to function as a resistance mechanism of the plant against insect damage. According to Davis' classification, a variety that registers a damage level <3 was a resistant variety. On the basis of this scale, the three varieties can be considered as tolerant although significant differences were observed between the level of damage of the Ikenné variety compared to the other two. Crossing these damage levels with observed yields suggests that leaf damage did not really have an effect on yield. Our results agree with those obtained by **[20]** on the damage caused by *S. frugiperda* on the vegetative growth of sweet corn in Florida. They found that severe leaf damage does not directly lead to significant yield losses, as the reduction depends on the stage of development of the affected plant. The varieties then have an influence on the feeding of the larvae of *S. frugiperda*. They could therefore be used as an alternative in the strategy of fight or sustainable management of this pest.

V. Conclusion

From this study, it emerges that the Ikenne variety has been shown to be more conducive to egg laying and therefore the larval density is higher on this variety than the other two. This variety remains more sensitive to infestations and leaf damage caused by *S. frugiperda* compared to the other two varieties. These varieties can then be used as an option in the integrated fall armyworm pest management program. It should be noted that during the study, the infestation was natural which would have influenced the comparison in terms of assessment of leaf damage. It is important to repeat this study under controlled conditions while inoculating the same numbers of larvae and of the same age on these different varieties in order to objectively assess the leaf damage caused by these caterpillars as well as their impact on yields.

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