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Monitoring and Assessment of the Damage of the Fall Armyworm *Spodoptera frugiperda*, J.E. Smith (1797) on Rainfed Crops (Maize, Sorghum and Millet) in Niger

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Abstract

Fall armyworm, *Spodoptera frugiperda* Smith, 1797, is a polyphagous insect reported on more than 350 host plants. In Niger, *Spodoptera frugiperda* was first reported in 2016 and 2 years later, it was able to establish itself in all agricultural areas of the country posing a threat to crops. Surveys carried out in the various agricultural areas of Niger have revealed the presence of *Spodoptera frugiperda* on maize, sorghum, millet, onions and okra. Fall armyworm is an extremely voracious caterpillar on cereal crops with a preference over maize where it is considered a major pest. Its presence on sorghum and millet is a concern because these two cereals are part of the basic diet in Niger. The objective of this work is to contribute to the development of strategies for the sustainable management of Fall armyworm in Niger. To do this, trapping and damage assessment of Fall armyworm was carried out in the fields (millet, sorghum and maize) of the experimental site of the Faculty of Agronomy. Captures of adults were possible thanks to the Delta trap and the PH-869-1PR Para pheromone *Spodoptera frugiperda*. The largest number of male *Spodoptera frugiperda* was captured in field 3 with an average of 5615 individuals and the lowest in fields 2 and 4 with 1538 and 0.769 individuals, respectively. The greatest damage was obtained in field 4 (maize), but statistical analysis showed that there are no significant differences between fields. The *in vitro* consumption test showed that Fall armyworm consumes more maize leaves than sorghum and millet leaves. The study shows that *Spodoptera frugiperda* is present at the experimental site, and the autumn caterpillar causes damage to maize, sorghum and millet. The perspective is that the knowledge of the bio-ecology of the insect will allow a

better effectiveness of control strategies.

Keywords

Monitoring, Damage, Fall Armyworm, *Spodoptera frugiperda*, Niger

1. Introduction

In Niger, millet and sorghum are the main cereals produced and consumed by the majority of the population. Maize and wheat have an important place in production systems and represent a real basis for food security [1]. Despite the importance of cultivated cereals, they have been experiencing difficulties for several decades. Erratic rainfall and the appearance of pests generate and aggravate a set of unfavorable factors such as soil impoverishment, stagnation or even a decline in agricultural production at a time when population growth is increasingly high [2]. It is in this context that the new pest called Fall armyworm (*Spodoptera frugiperda*) was reported in Niger in 2016 and 2 years after its appearance, this caterpillar has invaded the entire national territory [3]. Surveys conducted in these areas have shown that it is present in a number of crops, including maize, sorghum, millet, onions, cabbage and okra.

The Fall armyworm (*Spodoptera frugiperda*) is an insect pest that attacks more than 350 plants, causing damage to cereal crops such as maize and sorghum as well as to vegetable crops [4]-[6]. This caterpillar attacked millet in Torodi, but also in Maradi during the rainy season (several thousand hectares). It is therefore a real danger for cereal crops and it is necessary to know it in order to be able to fight against it [7].

The caterpillar has caused significant damage to maize crops throughout almost the entire national territory. However, the fear that hangs over experts today is that this highly polyphagous insect (which feeds on several plants) will attack key cereals such as millet and sorghum. It has already been known for a long time that some of the species of the same genus, namely *Spodoptera exempta* and *Spodoptera littoralis*, attack the crops of millet and sorghum, the main cereals consumed by rural Nigerien households [8]. It is true that this butterfly has excellent flight abilities, but the spread of infestations is also favored by transboundary transport from one country to another [8].

Fall armyworms appear to be much more damaging to maize in West and Central Africa than most other Spodoptera species in Africa [9] [10].

Indeed, pests are a major constraint in maintaining and improving the productivity of agricultural plots around the world. Their control is, to date, based on chemical control, which would have harmful consequences on the environment. To remedy this, several authors recommend the use of an integrated pest management approach [11]-[13]. This is the case for the management of the Fall armyworm (*Spodoptera frugiperda*) [13]. This caterpillar is particularly fond of cereals, includ-

ing maize, sorghum and millet.

The need to study Fall armyworm in Niger is imperative because of its devastating effects on essential crops. The large-scale damage caused underlines the urgency of understanding its feeding behaviour, its ecology and its life cycle in order to identify effective control methods. In addition, the potential threat of this caterpillar to key cereals such as millet and sorghum requires special attention, as these crops are fundamental to Nigerien rural households.

There is therefore a need to further explore methods of controlling this pest to better protect already vulnerable smallholder farms.

2. Presentation of the Study Area

The study was carried out on the experimental site of the Faculty of Agronomy of the Abdou Moumouni University of Niamey, itself located in Niamey District V on the right bank of the Niger River. The geographical coordinates of this experimental site are 13˚30'0" north latitude and 2˚5'35" east longitude. Figure 1 gives us the graphic transcription of this location.

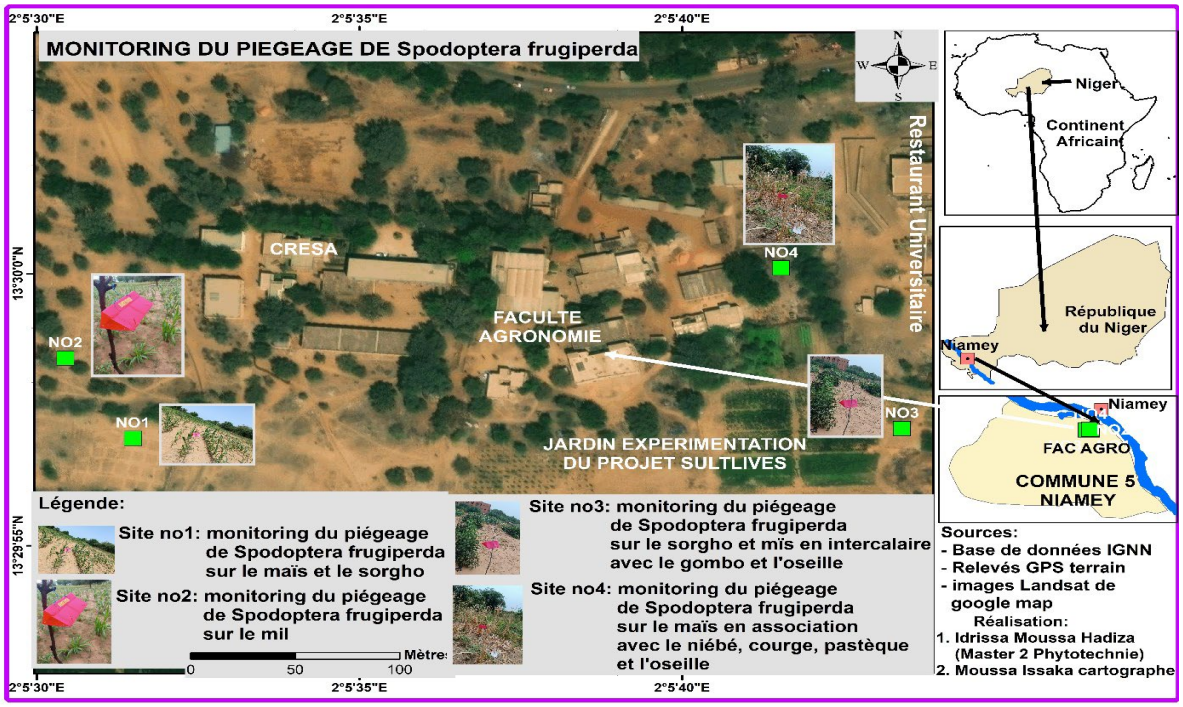

Figure 1. Experimental site location.

The climate is Sahelian, characterized by low rainfall, poorly distributed in time and space, and high temperatures (with an average of 45˚C in April).

The soil is of the leached tropical ferruginous type with a sandy-clay texture. The soil is progressively enriched in organic and mineral matter, thanks to organic and mineral fertilizers and previous cultivation.

Vegetation is average, with woody species poorly distributed in space. The species encountered are: *Ferdherbia albida*, *Balanites aegyptiaca*, *Prosopis julifora*,

Calotropis procera and *Acacia senegalensis*.

3. Materials and Methods

3.1. Monitoring the Trapping of *Spodoptera frugiperda*

Delta trap pheromone traps were installed in the fields. A total of eight traps were used.

Two traps were set in the maize and sorghum fields, covering areas of 330 m^2 and 500 m^2 respectively, with a distance of 1m between the two crops; two traps were set in the millet field, covering an area of 500 m^2, two traps in the sorghum and maize intercrops and borders, covering areas of 540 m^2 and 198 m^2 respectively, with a distance of 1m between the two areas, and two traps in the maize field in association, covering an area of 600 m^2. The traps were suspended on wooden stakes or iron bars 1.5 m from the ground.

The distance between the two traps in the fields is 25 m. Fall armyworm, *Spodoptera frugiperda* was captured using the PH-869-1PR *Spodoptera frugiperda* pheromone capsule (Russell IPM, above, Flintshire, UK), which was prepared in rubber septa and contains (Z)-9-tetradecenyl acetate (Z-9-14: OAca) common to Trichoplusia ni, *Spodoptera exigua* and *Agrotis ipsilon exigua*, and also with proprietary FAW synthetic female sex pheromone blends.

The pheromone capsule works for a month, so even if the sticky film has been changed, the same pheromone capsule is reused. The sticky film is changed when it is full of insects, dirty or sometimes wet from rain. Data collection was carried out on a weekly basis, with trapped insects discarded after counting and photographing, and other types of trapped insects that came in accidentally were not of interest to us for counting.

3.2. Incidence, Prevalence and Severity of FAW on Rained Crops

This incidence includes observations of field damage and Fall armyworm attacks on rainfed crops (maize, sorghum and millet).

3.3. Field Observation of Fall Armyworm Infestation

Every three days, the incidence of armyworm was assessed on the leaves of randomly selected plants. Four fields were involved (**Figure 2**). The assessment was carried out on maize, sorghum and millet. On each attacked crop, the FAO W method was applied, the observation concerned ten plants; these are inspected thoroughly [14]. The percentage of infestation was assessed by applying the following formula:

$$\%\ \text{Infestation} = \frac{\text{Number of leaves attacked}}{\text{Total number of leaves}} * 100$$

3.4. Data Processing

The data collected were subjected to analysis of variance (ANOVA) at the 5% significance level ($p \leq 0.05$). When a significant difference between treatments was

revealed, the Tukey HSD test of separation of means was applied at the 5% significance level ($p \leq 0.05$) and presented as a boxplot. R software version 4.2.2 was used for statistical analysis.

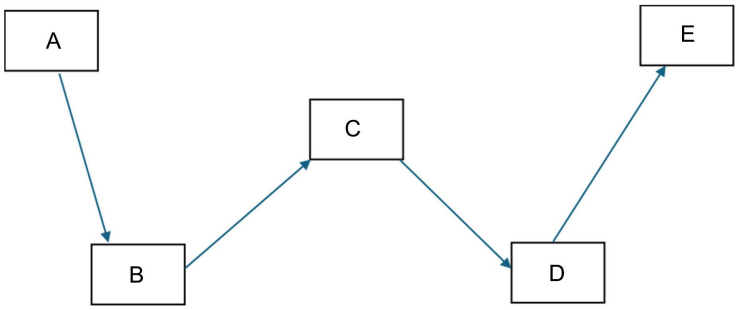

Figure 2. Flow chart for impact assessment. Source: [15].

4. Results

4.1. Monitoring of *Spodoptera frugiperda*

The presence of the male Fall armyworm, *Spodoptera frugiperda* in the fields shows that the female is present at the experimental site (**Figure 3**). The number of *S. frugiperda* captured significantly depending on the field (p-value = 0.00914). Catch in field 3 is higher with an average of 7.40 individuals and lower in field 2, field 3 and field 4.

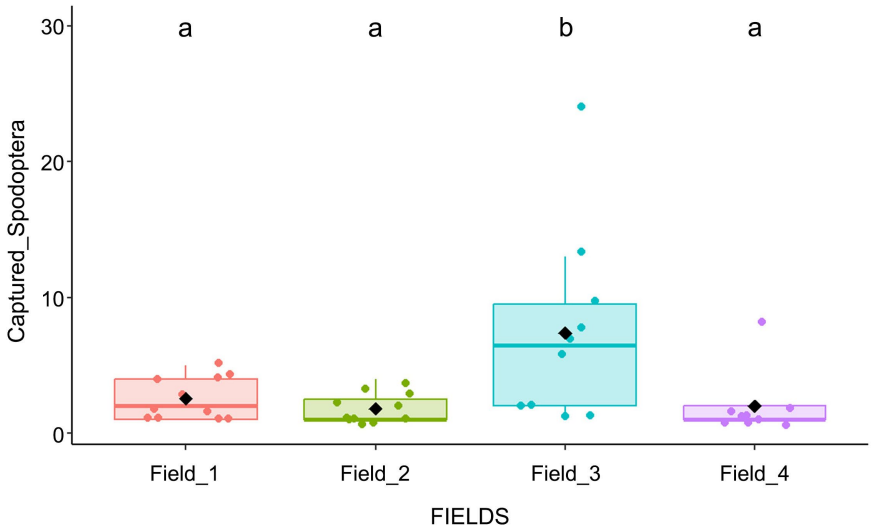

Figure 3. Capture of *S. frugiperda* by fields: *field* 1 (*maize and sorghum*), *field* 2 (*millet*), *field* 3 (*sorghum*), *field* 4 (*maize*).

4.2. Incidence of Fall Armyworm (*Spodoptera frugiperda*)

4.2.1. Observation of Field Damage

The observation of Fall armyworm damage is given in **Figure 4**. Statistical analysis of these results showed that there is no significant difference in the incidence of armyworm damage between fields (p-value = 0.0506).

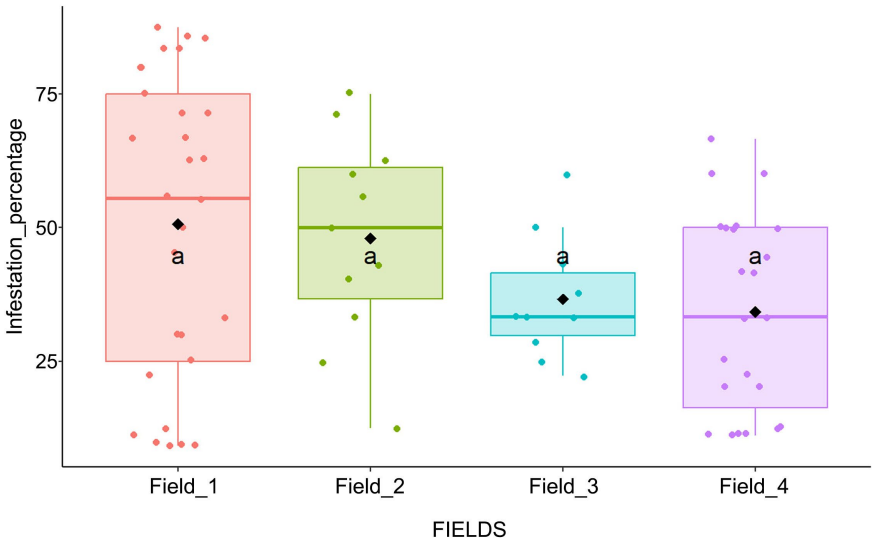

Figure 4. Incidence of damage to fields: *field* 1 (*maize and sorghum*), *field* 2 (*millet*), *field* 3 (*sorghum*), *field* 4 (*maize*).

4.2.2. Fall Armyworm Attack on Rainfed Crops (Maize, Sorghum and Millet)

The results of this study showed that the fall caterpillar nibbled on the cones of the plants and continued to shred the leaves until they were destroyed, as well as attacking the stem and tassel. The Fall armyworm has also attacked the ears, it enters the ears through the bristles (**Figure 5**).

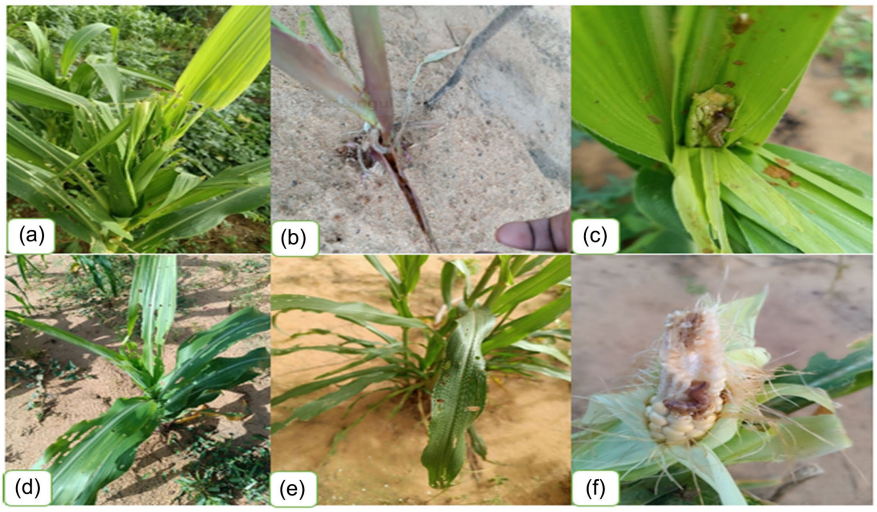

Figure 5. Maize leaves shredded (a); Maize stalk destroyed by *S. frugiperda* (b); Maize cone destroyed (c); Shredded sorghum leaves (d); Caterpillar holes on millet leaves (e); Destroyed cob, deterioration from top to base (f).

4.2.3. Fall Armyworm Attack per Field

Figure 6 shows the number of plants attacked by Fall armyworm. The number of plants attacked in field 4 (maize) is higher than in field 1 (maize and sorghum) followed by field 3 (sorghum) and then field 2 (millet), but the analysis of variance

showed that there is no statistical difference (p-value = 0.81) in the number of plants attacked by the caterpillar depending on the field.

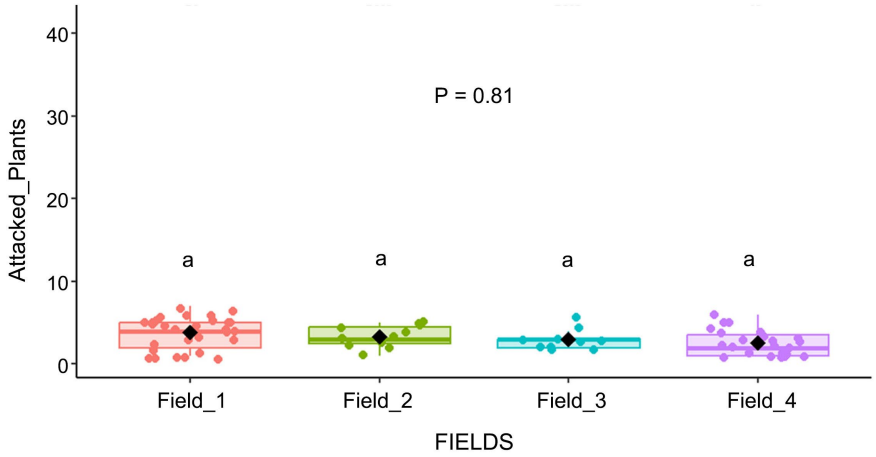

Figure 6. Fall armyworm attack per fields: *field* 1 (*maize and sorghum*), *field* 2 (*millet*), *field* 3 (*sorghum*), *field* 4 (*maize*).

5. Discussion

The trapping device installed at the experimental site made it possible during the winter season to capture one hundred and forty *Spodoptera frugiperda*, so the 1st hypothesis is verified. This follow-up lasted thirteen weeks and involved four fields in the Faculty of Agronomy of the Abdou Moumouni University of Niamey. The highest number of trapped species was obtained in the week of 16.10.2023 with a peak of thirty-one male *S. frugiperda* captured in the traps after crop harvest. Our results do not corroborate those found by [16], who showed that the capture rate decreases at the end of the winter season. In the present study, more male *Spodoptera frugiperda* were observed in field 3 with an average of 5.615 individuals, which is less attacked than in field 4 with an average of 0.769 individuals, which is more attacked. The results obtained show that there is no significant difference in the infestation rate between crops, hypothesis 2 is verified. These results are contrary to those found by [17] who showed that the infestation rate of maize, sorghum and millet is 78.32%, 3.31% and 1.75%, respectively. The results of this study showed that the number of plants attacked in field 4 (maize) is greater than in field 1 (maize and sorghum) followed by field 3 (sorghum) and then field 2 (millet), but the analysis of variance showed that there is no statistical difference in the number of plants attacked by the caterpillar depending on the field. During our observations, the maize in field 4, which is intercropped, is more attacked than the maize in field 1, which is in pure cultivation, and no attack on maize, which is intercropped with okra and sorrel in field 3. These results are contrary to those found by [15] who showed that in pure culture. Fall armyworm attacked leaves, stems, panicles and spikes. But the damage is greater at the flowering and heading stage. These results corroborate those of [18] who showed that the highest average attack rates were observed for the 3 varieties at flowering before stabilizing at heading. This could

be explained by the fact that the caterpillars of *S. frugiperda* have a wide variety of food (leaf, stem and panicle) at their disposal, and also corroborate those of [19] who showed that Fall armyworm causes more damage at the flowering stage. [7] has shown that all ears can be attacked, thus causing a very significant loss of production, and the extent of the damage is due to the insect's spectacular reproductive capacity. [8] has shown that Fall armyworm mainly eats maize leaves. Occasionally, it also attacks the ears. Generally, these ears are not eaten by humans. While direct damage from *S. frugiperda* does not affect the safety of maize, it may make it more conducive to the presence of aflatoxin. In addition, the results obtained in our experiment show that Fall armyworm attacks maize more than sorghum and millet. These results confirm those of the [7], which showed that *S. frugiperda* causes damage to cultivated cereals such as maize and sorghum. The damage to maize is severe, even very severe. This is sufficient evidence that the caterpillar of this butterfly, called the "Fall armyworm", has a particularly devastating impact [15]. [14] showed that due to its spread and distinctive ability to cause damage to multiple crops (this speed is thought to be due to the armyworm's ability to attack a very diverse range of species, especially grasses).

6. Conclusion

This study monitored and assessed the damage caused by the Fall armyworm, *Spodoptera frugiperda*, to maize, sorghum and millet crops. The results showed that *Spodoptera frugiperda* is present on the site where these three crops (maize, sorghum and millet) are grown. The number of *Spodoptera frugiperda* captured was highest in field 3. Weekly monitoring of the *S. frugiperda* population in the fields showed that there were three generations on the experimental site. The results of the incidence assessment showed that there was no significant difference between the fields. The number of plants attacked in field 4 (maize) was greater than in the other fields, but analysis of variance showed that there was no statistical difference in the number of plants attacked by the caterpillar depending on the field. The results of the *in vitro* consumption test showed that the armyworm consumed more corn leaves. Farming conditions were not optimal for the complete cycle of *Spodoptera frugiperda*. This study shows that the armyworm causes damage to maize, sorghum and millet under our experimental conditions. The study concludes that while FAW poses a threat to cereal production, the observed damage levels are not alarming, possibly due to pesticide use by farmers and natural enemies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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