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Assessment of Damage of the Fall Armyworm, *Spodoptera frugiperda* J. E. Smith., 1797 (Lepidoptera, Noctuidae) on Maize and Millet in Maradi, Niger

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Abstract

Millet and maize play an important role in food and nutrition security in Niger. Despite their importance both in terms of food and economics, these cereal crops continue to face insect pests including the Fall armyworm, *S. frugiperda* (Smith., 1797). This caterpillar appeared for the first time in 2016 in sub-Saharan Africa (Nigeria, Sao Tome, Benin and Togo) and the same year in Torodi in Niger. The Fall armyworm is present in all regions of Niger from where it attacks the main cereals. The damage caused by this pest poses a significant threat to the productivity of these crops. The objective of this study is to assess the incidence and severity of Fall armyworm damage on maize and millet in the Maradi region. The study was conducted at the station (INRAN) and in Djirataoua. Four (4) fields were chosen, population dynamics monitoring through Delta Traps for captures of adult males of *S. frugiperda* and larval scouting in the field. The "N" sampling technique was used to determine the natural *S. frugiperda* infestation rate on corn (71.7% on maize produce in INRAN and 31.5% on maize produce in Djirataoua) and millet (17.4% on millet produce in Djirataoua and 7.8% on millet produce in INRAN). And the level of leaf damage recorded only scores 2 and 3 on millet and maize recorded up to score 7, measured using a method of the Davis *et al.*, (1992) Leaf Damage Assessment Scale/Score. These results will contribute to the development of an integrated management program for Fall armyworm. The main objective is to assess the impact of the fall armyworm, *Spodoptera frugiperda* (J. E.

Smith), on maize and millet crops in the Maradi region. More specifically, the aim is to: 1) Monitor fall armyworm population dynamics in the fields; 2) Determine the infestation rate of *S. frugiperda* on maize and millet; 3) Assess the level of CLA leaf damage also on maize and millet.

Keywords

Assessment, Damage, Fall Armyworm, *Spodoptera frugiperda*, Infestation, Niger

1. Introduction

In Niger, agriculture employs 80% of the working population, for which it is the main activity and source of income to meet food and economic needs. Agriculture contributes more than 40% to the Gross Domestic Product (GDP) [1]. Among the cultivated plants, cereals (millet, maize, sorghum, rice) not only occupy an important place in national agricultural production but also constitute the food base of the population and are therefore the most consumed by the population [2]. Millet (Pennisetum glaucum (Leek) R. Br.), is the most widely grown cereal in Niger, with a planted area of more than 65% and; it constitutes 75% of the country's total cereal production [3] [4]. Millet is produced in all regions of the country, with an estimated average annual production of 2,146,706 tons [5] [6]. As for maize (*Zea mays* L.), it is ranked as the fourth largest cereal grown in Niger with an average annual production at the national level of 5681 tonnes after millet, sorghum and rice [5]. Despite their importance, both in terms of food and economics, millet and maize crops continue to face many biotic constraints, including insect pests. In 2016, a new species called Fall armyworm, *Spodoptera frugiperda*, appeared in Sub-Saharan Africa [7], a brand-new pest. This pest colonized almost all the countries of the African continent only two (2) years after its appearance [8]. Fall armyworm (CLA) is a voracious and polyphagous insect that forms large populations at a very high rate of spread [9] [10]. This species is considered an extremely dangerous pest; one of the most destructive on the American continent [10]. Severe infestations, especially early ones, lead to significant reductions in yield, the consequences of which are disastrous on the economic, social, and ecological levels [11]. In Niger, this pest has been present since 2016 and is currently found in all regions of the country [12]. Given its rapid spread and the number of crops on which Fall armyworm is present, it is important to monitor the population dynamics of this pest through monitoring tools and larval detection in the field. These tools usually come in the form of the various traps such as simple glue traps, light traps, chromatic traps, and pheromone traps. The latter has particular characteristics of specificity to insects [13]. This sex pheromone trap is a better way to monitor Fall armyworm population dynamics [14]-[16]. The objective of this study is to assess the incidence and severity of damage caused by the Fall armyworm, *Spodoptera frugiperda* (J. E. Smith) on maize and millet crops in the

Maradi region. More specifically, it is a question of monitoring the population dynamics of Fall armyworm in the fields.

2. Presentation of the Study Area

This study was conducted in Niger in the Maradi region. The Maradi region is located at 13˚27' and 15˚26' north latitude and 6˚16' and 8˚36' east longitude; it is located in the southern strip of Niger with an area of 41,796 km^2 (**Figure 1**), bordered by the region of Tahoua to the west, Zinder to the east, Agadez to the north and the Federal Republic of Nigeria to the south (PDR, 2015).

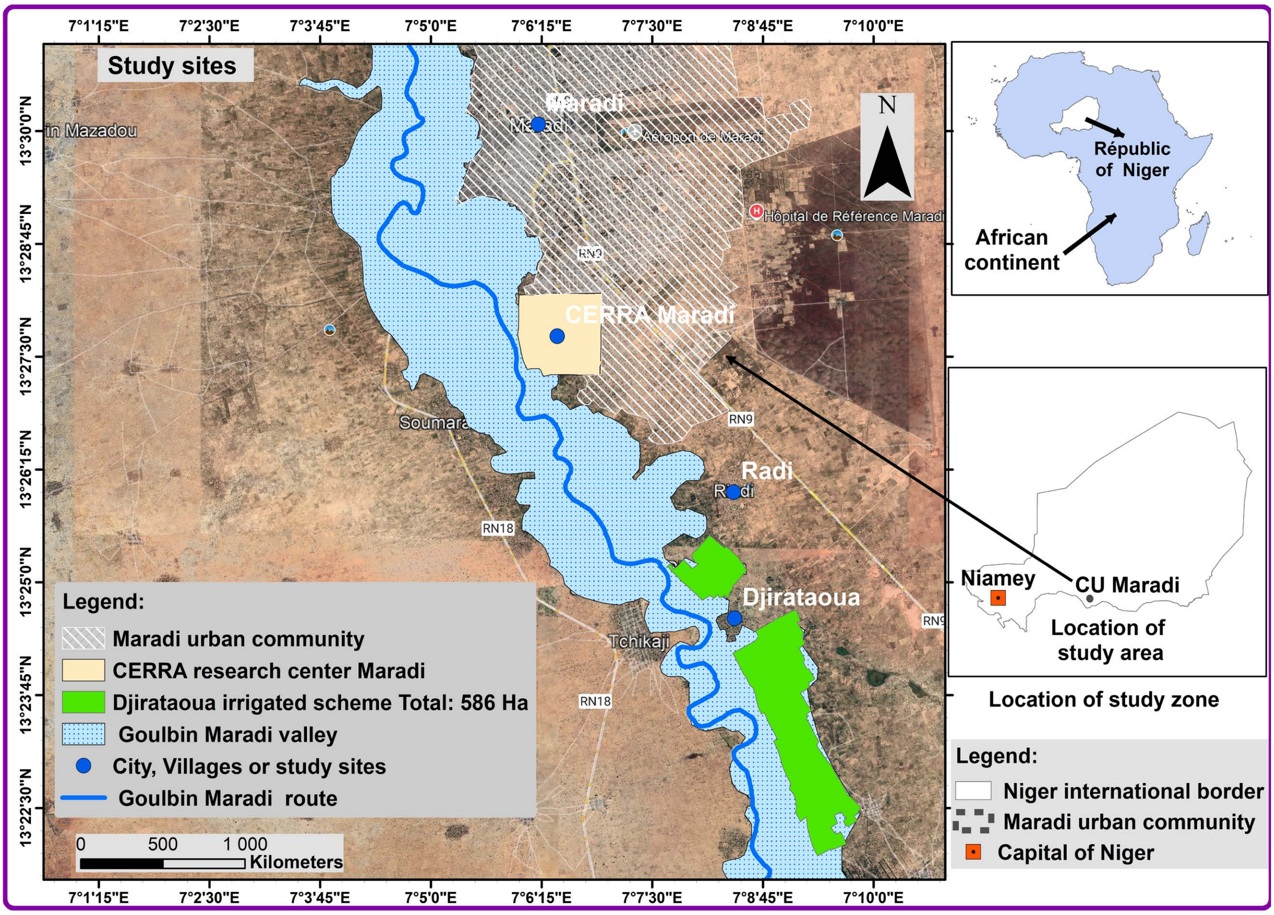


Figure 1. Map showing the study area in the urban commune of Maradi (Shapfile/IGNN) (Farouk *et al.*, 2025 authors of this current paper created this figure).

2.1. Rainfall

Annual rainfall over the last ten years (2012-2022) has ranged from 435.1 mm to 755.2 mm.

2.2. Sols

- Valley soils: relatively undeveloped, black in color, generally flooded soils suitable for cultivation;

- Plateau soils: are yellowish-red tropical ferruginous soils with little organic matter (SRAT, 2008).

3. Materials and Methods

3.1. Materials

Technical Equipment

- Delta Traps" pheromone traps were used to trap CLA males. Geographical coordinates were recorded using a GPS, and photos were taken using a Redmi Note 12 S cell phone.

3.2. Trapping

Pheromone traps were used to capture adult males of *S. frugiperda*.

Six (6) traps were installed, three (3) in the maize field and three (3) in the millet field at Djiratoua (Figure 2). Four (4) traps were installed on station, including two (2) in the maize field and two (2) in the millet field.

Figure 2. Trap installed in the millet field and (b) trap installed in the maize field.

A total of (10) traps at the Djirataoua and INRAN sites.

The traps were suspended from the millet and maize stalks at approximately 1 m above ground level.

The pheromone capsule was placed in the center of the "Delta Traps" with a sticky film. The pheromone contained an active ingredient of 97% (Z)-9-tetradecenyl acetate (Z9 - 14: Ac), 2% (Z)-7-dodecenyl acetate (Z7 - 12: Ac) and 1% (Z)-9-dodecenyl acetate (Z9 - 12: Ac), prepared by Russell IPM and marketed under the trade name *S. frugiperda* PH-869-1PR.

3.3. Sampling of Observation Patches

With a view to studying the impact of *S. frugiperda* on maize and millet crops at the observation sites, 30 random patches were selected using the "N" pattern method (Figure 3). From A to B, 10 consecutive patches were marked, as well as from B to C and from C to D.

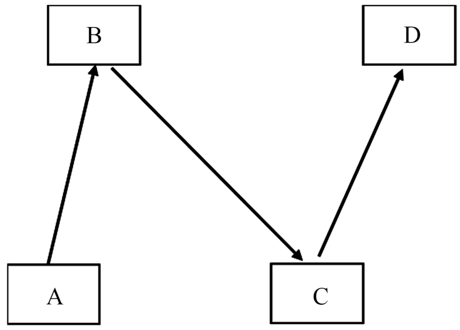


Figure 3. N sampling diagram.

3.4. Data Collected

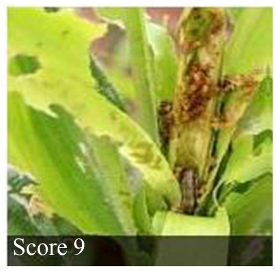
Weekly observations were made on the 30 planting beds in each field. The following parameters were noted at each observation:

- The number of *S. frugiperda* imagos captured;
- The number of batches of eggs on 30 bins;
- The number of larvae observed in the observation poquets;
- Level of leaf damage: *S. frugiperda* damage to maize leaves takes the form of holes or perforations. These are measured using a leaf damage assessment scale/score from [17] (**Table 1**);

Table 1. Damage assessment scores.

Score	Description	
1	No visible damage to the leaves	
2	A few pinholes on 1 - 2 old sheets	
3	Several holes on a few leaves (<5 leaves) and small circular holes of damage on the leaves	

Continued

4	Multiple multi-leaf hole lesions ranging from 6 to 8 leaves or small lesions with pinholes, circular and elongated lesions 1.3 cm long on the leaf set	
5	8 to 10 leaves with elongated lesions less than 2.5 cm long, plus a few small to medium size holes uniform to irregular (basement membrane consumed) consumed by whorl and/or full leaves	
6	Presence of several lesions on several whorled and curled leaves and/or presence of several large irregularly shaped holes eaten from the whorled and curled leaves	
8	Presence of numerous elongated lesions of all sizes on most whorled leaves and curled leaves, as well as numerous holes of the same or irregular shape, of medium to large size, consumption on whorled and curled leaves	
9	The whorl-shaped, curled leaves are almost completely destroyed and the plants die as a result of extensive leaf damage	

3.5. Data Processing and Analysis

3.5.1. Data Processing

The infestation rate is calculated with the following formula:

$$\text{Infestation rate} = \frac{\text{Number of infested pockets}}{\text{Total number of pockets}} \times 100$$

The severity of the damage was calculated according to the following formula:

$$\text{Severity of damage} = \frac{\text{Number of scores}}{\text{Number of observations}} \times 100$$

3.5.2. Data Analysis

The data collected were subjected to analysis of variance (ANOVA) at the 5% significance level ($P \le 0.05$). When a significant difference between treatments was revealed, the Tukey HSD test of separation of means was applied at the 5% significance level ($P \le 0.05$). R software version 4.2.2 was used for statistical analysis and the figures were made on excel.

4. Results

4.1. Infestation Rate of *S. frugiperda* at Study Sites

The CLA infestation rate was determined based on maize and millet production. It should be noted that there is a significant variability in the infestation rate in the maize ($P < 0.001$; Figure 4) depending on the sites of production. Maize produced in INRAN has the highest infestation rate (71.7%), while the maize produced in Djirataoua has a low infestation rate of 31.5% (Figure 4).

Figure 4. Infestation rate of *S. frugiperda* on the maize.

For millet, a significant variation in the rate of *S. frugiperda* infestation was also observed depending on the production site ($P < 0.001$; Figure 5). Millet produced in Djirataoua has the highest infestation rate (17.33%), while millet produced in INRAN has a low infestation rate of 7.78% ($P < 0.001$; Figure 5).

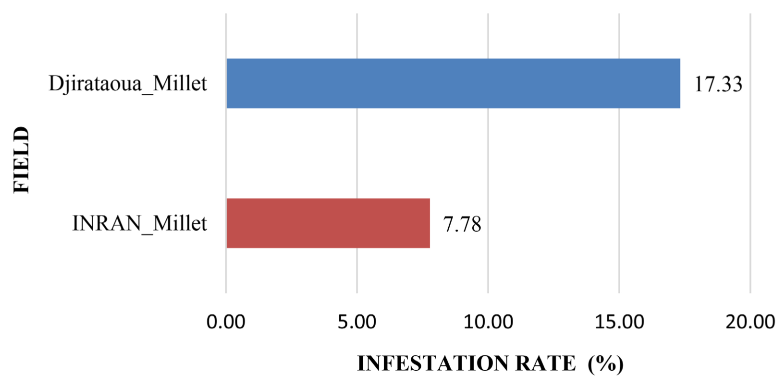


Figure 5. Infestation rate of *S. frugiperda* on the millet.

4.2. CLA Damage Severity Rate

The evaluation of the damage severity rate based on the Davis and William method shows that the maize produced in both Djirataoua and INRAN has a low damage severity score (score 2) characterized by one or two holes on the leaves (Figure 6). At this score, the severity rate is 92%, 98% and 75.97% respectively in Djirataoua and INRAN.

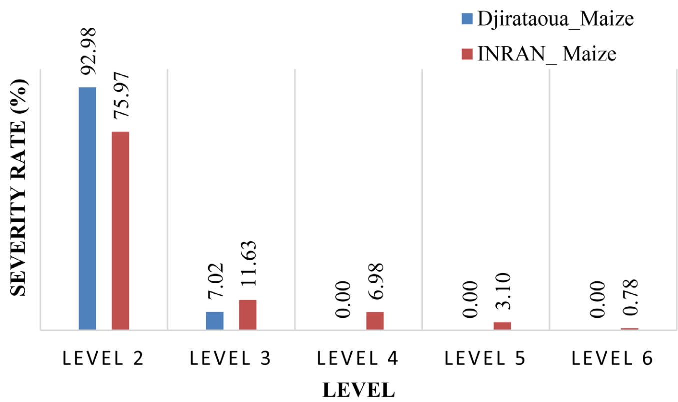


Figure 6. Severity rating of *S. frugiperda* on the maize.

Similarly, millet produced in both Djirataoua and INRAN has a low and unique damage severity score (score 2) characterized by one or two holes on the leaves (Figure 7). The severity rate is 66.67% and 33.33% respectively in Djirataoua and INRAN (Figure 7).

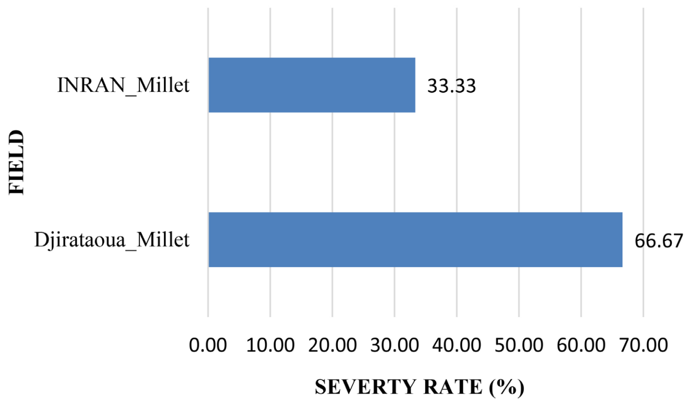


Figure 7. Severity rating of *S. frugiperda* on the millet.

4.3. Population Dynamics of *S. frugiperda*

4.3.1. CLA Adults Caught in Pheromone Traps

The figure below shows the captures of Fall armyworm adults at sex pheromone traps in corn and millet fields (Figure 8). The catch period is spread over a period of approximately eleven (11) weeks. There is variability in the number of adults captured with time and field. The average number of adults captured in traps is higher with the maize produced in (Djirataoua_Maize) on September 25 with 32 adults compared to the other fields where the number of adults observed is not considerable during the observations, *i.e.* 6 adults captured with the maize produced in INRAN (INRAN_ Maize), 3 adults on the millet produced in Djirataoua (Djirataoua_Millet) and 3 adults captured on the millet produced in INRAN (INRAN_Millet) during the month of August.

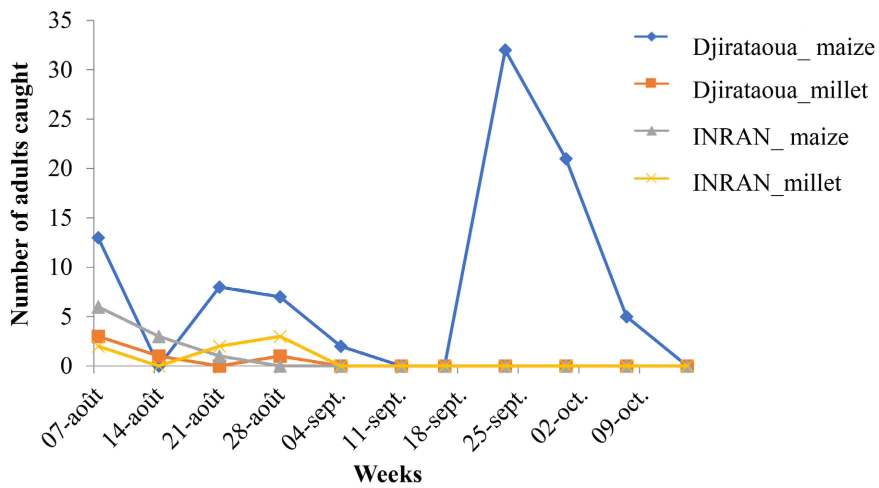


Figure 8. Capture of adults in pheromone traps.

4.3.2. Eggs Collected

The eggs collected from the *S. frugiperda* in the different fields were used to establish the dynamics curves (**Figure 9**). Fluctuations in *S. frugiperda* spawning on maize fields have been observed at the Djirataoua and INRAN sites depending on the observation periods. The largest peak in egg batches (14 batches) was observed on 18 September at the level on the maize produced in Djirataoua (Djirataoua_Maize), while the maximum number of egg batches observed with the maize produced in INRAN (INRAN_Maize) is 9 egg batches on 21 August. However, no batches of eggs were recorded on the millet fields at the two (2) sites.

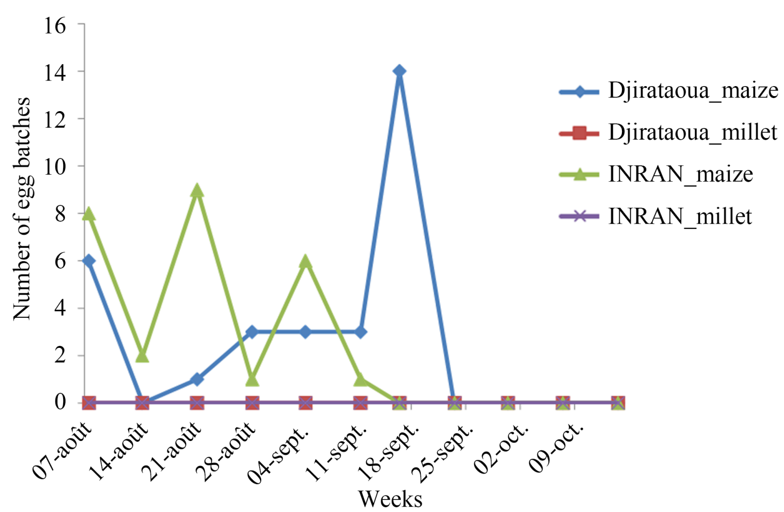


Figure 9. Average number of *S. frugiperda* egg batches.

4.3.3. CLA Larva

The evolution of *S. frugiperda* larvae during field monitoring is shown in the Figure 10. The maize fields of Djirataoua saw the highest number of larvae on August 28, with an average of 20 larvae. The other fields do not have a large number of larvae, 3 *S. frugiperda* larvae were recorded with the maize produced in INRAN (INRAN_Maize) and 2 larvae with the millet produced in INRAN (INRAN_Millet) during the month of August.

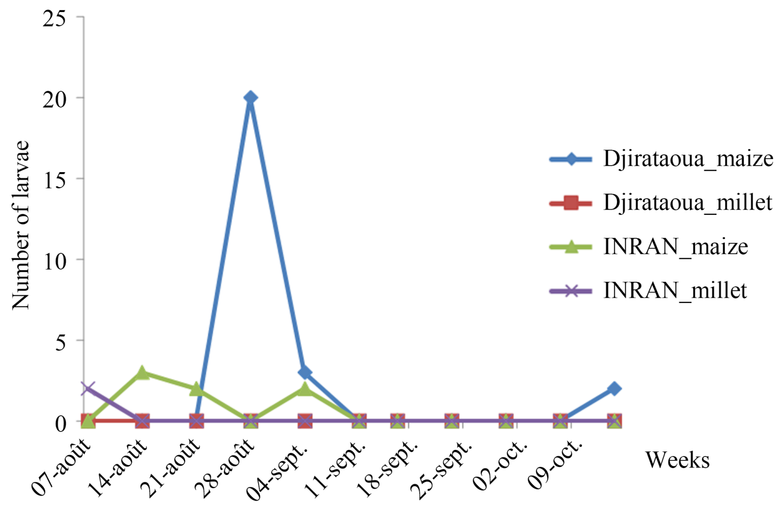


Figure 10. Evolution of *S. frugiperda* larvae.

5. Discussion

The results of this study show that the Fall armyworm, *S. frugiperda*, is present in the Maradi region where all the fields of sites concerned by the study were attacked. This study is one of the first of its kind to address the extent of *S. frugiperda* damage to maize and millet. The infestation rate of 71.7% recorded as the highest in the present study appears low in view of the literature in many of the studies. This rate is lower than those reported by [18] in a similar study in East African countries, 90.83% in Kenya and 96.5% in Tanzania. [19] noted a 100% infestation rate in Maputo province in Mozambique. This low infestation rate could be explained by the misuse of chemical pesticides on the main pest. These pesticide applications significantly affect *S. frugiperda* populations at production sites. Other factors such as temperature, relative humidity and photoperiod may also explain the low infestation in the Maradi region. [20] pointed out that longevity and fecundity in Fall armyworm are highest between 21˚C and 25˚C, while in the Maradi region, at least an average temperature of 35˚C is recorded. This rate is comparatively higher than 37.31% obtained by [21] in the rural commune of Djirataoua in a similar study in the Maradi region and 42.81% *S. frugiperda* infestation rate obtained on maize by [22] in the same commune. However, an increase of about 35% was observed in the same region. It also proves a gradual adaptation in the region since its introduction in 2016 in the country, despite the use of synthetic pesticides. However, the millet treatments of INRAN and Djirataoua recorded an average rate respectively. These low *S. frugiperda* infestations on millet could be explained by cultural practice, and natural enemies, especially predators present in the environment. The most common predators of millet belong to the Formicidae, Forficulidae and Vespidae families. Species of the family Vespidae and Formicidae are formidable predators of *S. frugiperda* larvae, while insects of the family Forficulidae are known as egg predators according to [11] [23].

All fields at the sites were attacked by armyworm but the rate is not as high compared to other countries on the continent, as it was reported in a similar study that about 80% to 100%, 93% to 100% and 100% of maize fields infested with the pest in Ethiopia, Tanzania and Kenya respectively, [18]. The total average of the level of leaf damage of the two (2) sites Djirataoua and INRAN on the Davis and William rating scale shows a higher level of severity of score 2. Despite the evolution of the pest infestation rate in the fields, the low level of foliar damage observed could be due to the misuse of pesticides against the pest, which could then reduce the damage to the leaves by killing the larvae of *S. frugiperda*. This low degree of attack could be linked to the abundant rainfall in the Maradi region. According to [24], heavy precipitation causes mortality of *S. frugiperda* larvae by filling whorled leaves with water, especially young larvae, and can fall from larvae to the ground where possible contact is established with predators or entomopathogenic microorganisms. [25] have developed other parameters that influence the incidence and severity of *S. frugiperda*, among which the use of chemicals, cultural practices, varieties, are important parameters.

The average number of 32 *S. frugiperda* adults captured in Djirataoua_Maïs appears to be higher in this study. This number of adults is comparatively higher than that noted by [26] of 6 adult male butterflies of *S. frugiperda* captured in 2019 in a study in the Centre-West region of Burkina Faso. This number could be explained by the duration of the captures about three (3) months to Djirataoua_Maïs and the favorable conditions for the survival of the armyworm in the irrigated perimeter of Djirataoua. It could also be related to the phenomenal quality and the necessary time of activity of the substance during monitoring. According to [27], the number of adult *S. frugiperda* in a given area is influenced by factors such as climate, cultivated hosts and cropping system. [28] pointed out that adult catches are relative to temperature, humidity and wind; and vary from one moment to another or from one site to another. [29] also reported that the number of males captured in traps varies by geographic area.

The average number of *S. frugiperda* eggs (14 lots) and 20 larvae recorded in Djirataoua_Maïs has the highest number for this survey. These results are similar to that of [30] which obtained in 2019 an average of 174.8 eggs per egg mass and 280.5 larvae in the conditions of temperature of 24˚C ± 1˚C, relative humidity of 50 in 2019 in a similar study in the Democratic Republic of Congo. This low number could be due to the application of pesticides for phytosanitary treatment and the large number of *telenomus remus* in the area.

6. Conclusion

This study has shown that the armyworm attacks the main cereals grown in Niger. Since its introduction, this caterpillar has posed a major threat to the country's food security, as millet, being the most widely grown cereal, is not spared from its attacks, although the level of damage observed is not worrying. Natural infestation and the severity of damage caused by armyworms are higher on maize than on millet. In addition, the sex pheromone traps used to monitor population dynamics captured large numbers of adult male *S. frugiperda* in the fields at the study sites. FAW poses a threat to cereal production, the observed damage levels are not alarming, possibly due to pesticide use by farmers and natural enemies. This study confirms the presence and attacks of armyworm on millet, the main cereal crop in Niger, already undermined by attacks from the ear leaf miner. This pest pressure on millet could further complicate millet production in Niger. This situation could further complicate also the biological control efforts against millet earworm in Niger.

Conflicts of Interest

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

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