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Perception and Level of Knowledge of the Fall Armyworm (*Spodoptera frugiperda* J.E. Smith) by Maize Farmers in the Southern Agricultural Zone of Niger

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Abstract

Maize is one of the cereals most consumed by households in Niger. Its production remains marginal despite the efforts made in hydro-agricultural development both around the Niger River and in the interior of the country. The detection of the fall armyworm (Spodoptera frugiperda J.E. Smith) in 2016 in Niger, followed by its rapid spread where in less than a year it has spread over almost the entire national territory is not without consequence on the yields of the but already very low in the main production areas. As a result, maize production is increasingly being abandoned in the southern agricultural zone of Niger. In fact, this caterpillar has become a major pest of maize because of the significant damage observed on this crop during its growth and development cycle. This situation calls for research to be conducted to help maize producers better manage this pest. The objective of this study is to assess the level of knowledge and management of FAW by maize farmers in the southern agricultural zone of Niger. A survey was conducted in July and August 2020 on a sample of 408 farmers in this zone using an individual questionnaire designed and integrated into the ODK data collection software. The results obtained showed that 93% of the producers recognize FAW through its morphology and the aspects of its damage; 53.25% estimate that the attack rate is very high and 60.75% of the producers use pesticides in the management of this pest against only 1.5% who use biopesticides. These results clearly indicate the severity of FAW attacks on corn and the massive use of pesti-

cides by producers.

Keywords

Fall Armyworm, Perception, Producer, Incidence, Niger

1. Introduction

Cereal production, including millet, sorghum, maize, and rice, is the basis of diets in the savannah zones of West and Central Africa. These cereals are grown on a surface area of 98.6 million ha and produce 162 million tons [1]. Among these cereals, *Zea mays* (L) maize ranks third after rice and wheat in terms of cereal crops (142.7 million/ha) in Africa [2].

In Niger, maize is produced in an area of 18,928.75 ha, with an estimated overall production of 41,852.73 tons [3].

However, maize production is faced with pedoclimatic, socioeconomic and biotic constraints [4] [5]. Since 2016, the maize crop has been subject to significant damage from the attack of a new pest *Spodoptera frugiperda* J.E. Smith [6] [7]. Indeed, this bio-pest was detected for the first time in Niger in the Department of Torodi region of Tillabery in 2016. *Spodoptera frugiperda* J.E. Smith attacks leaves, flowers before they emerge, and on the cobs of irrigated maize. It is an extremely polyphagous pest observed on more than 80 plant species, with a clear preference for young maize and rice plants [8] [9] [10]. When the wind direction is favorable, the moths can travel longer distances: for example, a flight of 1600 km from the state of Mississippi [10] [11]. Surveys of maize farmers in Kenya and Ethiopia [12] have revealed that FAW is responsible for yield reductions of up to 47%. Similarly, according to [13] results of farm household surveys, maize yield losses caused by FAW are estimated at 27% and 35%, resulting in annual income losses of US$177 million and US$159 million in Ghana and Zambia, respectively. In Zimbabwe [14] [15], these yield losses range from 12% to 58%. Given the primary importance of maize in the diets of many African households and the conditions in sub-Saharan [16] and the year-round conditions in sub-Saharan Africa being highly conducive to the armyworm [17], the pest poses a significant threat to food security and the achievement of the sustainable development goal of eliminating hunger by 2030 [18].

Since the dawn of time, farmers have had various forms of endogenous knowledge to know and control crop pests. However, this knowledge is often neglected by researchers and extension workers [19]. It is in this context that the studies carried out to know the perception of the producers find their essence because they can highlight the need to train these producers in pest identification [20] [21].

According to [22], the results of the survey conducted among maize producers in Benin on the level of knowledge and incidence of FAW, showed that 91.8% of

the respondents recognized *Spodoptera Frugiperda* and the characteristics of its damage.

In this study, the objective was to assess the perception and knowledge level of corn farmers on this new corn pest detected in 2016.

2. Methods

2.1. Study Setting and Sampling

The survey was conducted in 2020 in 4 regions (Dosso, Maradi, Tahoua and Zinder) located in the southern agricultural belt of Niger. Twenty-eight villages in 12 departments were selected through systematic sampling (Table 1) (Figure 1).

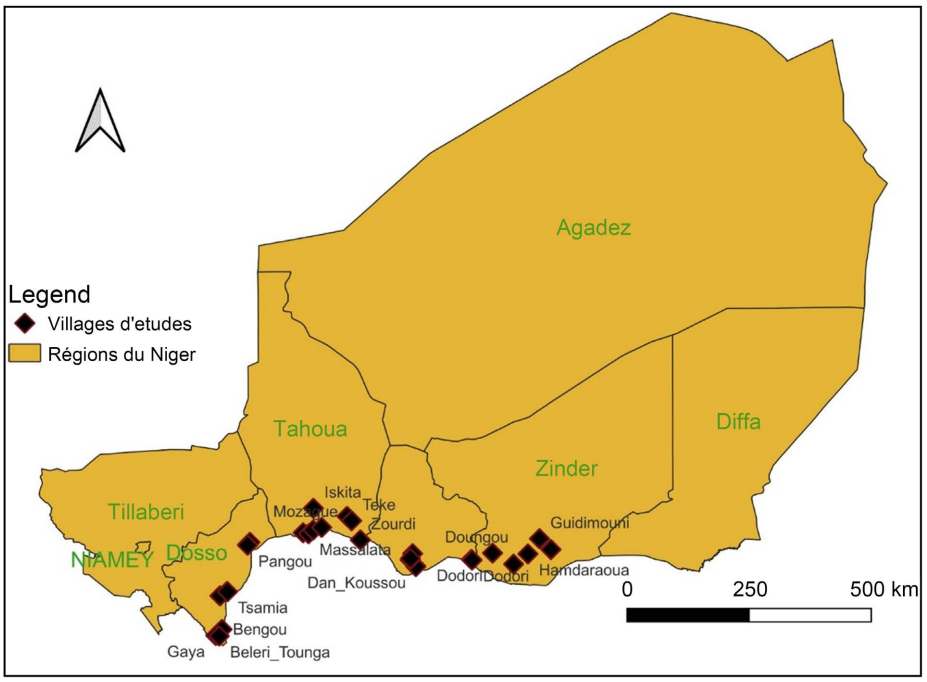

Figure 1. Map of the location of the study villages.

Table 1. Number of respondents by region.

Region	Number of departments	Number of municipalities	Number of villages	Number surveyed	Study villages
Zinder	4	5	5	103	Angoual Manda, Hamdaraoua, Guidimouni, Gassafa, Doungou
Dosso	3	4	8	100	Baléri Tounga, Bengou, Pangou, Liguido, Tsamia, Dioundiou, Gaya, Kouka, Bakoye
Tahoua	3	8	8	103	Bazaga, Cerasa, Mozagué, Massallata, Iskita, Nakoni, Téké, Zourdi
Maradi	2	3	7	102	Djirataoua, Keguel, Dan Koussou, Kabobi, Kormazaoua, Bargaja, Dodori
Total	12	20	28	408	

The sites were chosen according to the importance of maize or sorghum production and, secondly, the availability of irrigated facilities. Indeed, maize is produced in Niger in most cases in lowland areas that often have an irrigation system [3]. 408 maize growers were surveyed in the 4 regions using a simple randomized sample design (SAS) (**Table 1**).

2.2. Data Collection

Data were collected using ODK software from July 18 to 27 in the Dosso and Tahoua regions and then from August 19 to 24 in the Maradi and Zinder regions. Individual questionnaires were used to collect data on the identity of the respondent, maize production and army worm. It should be noted that producers are surveyed in their farm plots to verify certain aspects related to pest infestation. For example, if the producer states that he knows about FAW or that it also attacks other crops in his field, he provides some samples to be used for verification.

2.3. Statistical Processing and Analysis

The yield loss rate for the crop was calculated using the following formula:

$$\text{Rate} = \frac{\text{Estimated production without FAW damage} - \text{Production of the previous season}}{\text{Estimated production without FAW damage}}$$

The level of attack was assessed by the number of FAW-infested bunches out of 100 bunches observed by the producer in his cornfield, using the following scale:

- 1% - 20%: low infestation;
- 21% - 55%: medium infestation;
- More than 55%: strong infestation.

SPSSv20 software was used to calculate the frequency of categorical variables and the mean of quantitative variables. Categorical variables were compared using the Chi-square test.

3. Results

3.1. Characterization of Respondents

The results of the structural analysis of the samples from the four regions covered by the study revealed that the average age of the 408 producers surveyed was 43 ± 14 years. The level of education of the latter is as follows: 55% attended Koranic school; 3% university level; 18% primary level and 14% secondary level and 6% are illiterate. With regard to agricultural activities, 47% ± 23% of respondents practice market gardening, with a particular interest in producers in the Zinder region (54% ± 18%) ($P < 0.001$ in Chi-square test).

3.2. Maize Production

Maize producers' farm areas ranged from 0.7 ± 1.1 ha in Maradi to 1.6 ± 1.9 ha

in Tahoua ($P < 0.001$ Kruskal test) (Figure 1). Maize is produced three times a year in three seasons: February-May, June-September and November-January. The vast majority of producers (65%) cultivate it in a single season, from June to September, corresponding to the winter season. The other seasons are used for fodder production. According to the results of our survey, maize is cultivated by 48% ± 0.15% of respondents, and as a combined crop by (47% ± 0.1%). The survey also showed that maize is cultivated in pure culture much more in the Zinder region (68%), in associated culture (56%) and in borders (11%) in the Tahoua region, and in strip culture in the Dosso region (6%). It should be noted that 95 to 99% of respondents in the southern agricultural zone of Niger, except for Maradi, produce maize for its seeds. The season of choice for intense maize production is the winter season for producers in the Maradi and Zinder regions (Table 2), the dry season for the Tahoua region. The particularity of the Dosso region is that 52% of respondents produce maize during both seasons. Grain maize is used for family consumption by more than 85% of respondents. The majority of producers (81%) produce fodder maize to feed their livestock (Table 2).

3.3. Producers' Knowledge and Year of Occurrence of FAW

About 93% of the producers surveyed knew about FAW through its damage, size and color (Figure 2). The difference in rates between regions was not significant

Table 2. Summary of some results on maize production.

Question	Answers	Dosso	Maradi	Tahoua	Zinder	Average	Chi-square
Rain campaign number	1	57.0	67.0	77.0	65.0	66.5 ± 0.1	**ns**
	2	34.0	30.0	17.0	30.0	27.75 ±7.4	*
	3	5.0	5.0	4.0	7.0	5.25 ± 1.2	**ns**
Season	Winter (%)	29	52.0	31.1	42.7	39 ± 0.1	**
	Dryer (%)	19	4.9	53.4	15.5	23 ± 0.2	***
	Dry and winter (%)	52	43.1	15.5	41.7	38 ± 0.16	***
Type of crop	As an associate (%)	47.0	52.9	56.3	31.1	47 ± 0.1	**
	On the edge (%)		1.0	10.7	1.0	4 ± 0.06	***
	In a band (%)	6.0		1.0		4 ± 0.04	**
	In pure (%)	47.0	46.1	32.0	68.0	48 ± 0.15	***
Purpose Grain	Livestock (%)	3.0		7.0		5 ± 0.03	**
	Marketing (%)	13.0	18.6	8.0	10.7	13 ± 0.04	**ns**
	Family (%)	84.0	81.4	85.5	89.3	85 ± 0.03	**ns**
Forage purpose	Livestock (%)	75.0	86.3	82.5	79.6	81 ± 0.05	**ns**
	Marketing (%)	5.0	6.9	16.5	5.8	9 ± 0.05	*
	Family (%)	20.0	6.9	1.0	14.6	11 ± 0.1	***

***: significant at 1%; **: significant at 5%; *: significant at 10%; ns: not significant.

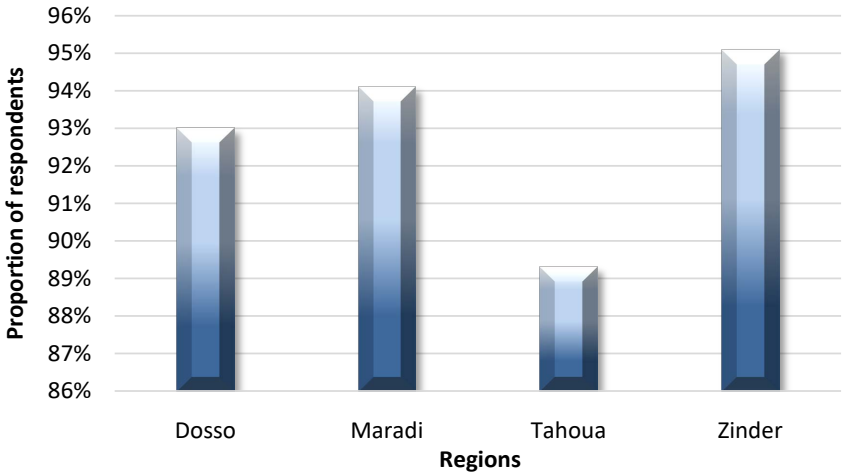

Figure 2. Proportion of respondents who are aware of FAW.

(Chi-square = 0.402). Sixty percent (60%) of the respondents thought that FAW appeared in their field between 1 and 5 years ago (Table 3). A rate of 22% of producers was found to think that FAW appeared in the 6 to 10 year interval. A very low rate of 0% to 6% of respondents thought that FAW appeared more than 20 years ago (Table 3). Maize was the first crop to be attacked by FAW in their maize plots, with 86.5% of respondents believing it was the first crop to be attacked by FAW, followed by sorghum at 3.4%.

3.4. FAW Infestation Level

Analysis of the data on the level of knowledge of FAW and its infestation on maize showed that 53% ± 0.1% of the producers think that FAW is responsible for the considerable damage observed on the maize crop. This percentage was higher in the Zinder region, where 69% of respondents thought that the level of FAW infestation was very high compared to only 12% who thought that the incidence was low on the crop (Table 4).

3.5. Inventory of FAW Infested Crops in the Southern Agricultural Zone of Niger

The results of the survey conducted among producers in our study area confirmed the presence of FAW and identified the different crops that are affected by it. It emerged from the exploitation of the data that, according to the respondents, *Spodoptera frugiperda* is most prevalent on cereals (maize, sorghum and millet) with an infestation rate of about 44%, and on vegetable crops (tomato, cabbage, onion, pepper, sugar cane and lettuce) with 6.3% of infestations. On the other hand, some legumes, such as cowpea and peanut were less infested with only 3.4% of attack rate (Figure 3).

3.6. Loss in Efficiency

Producers estimate that FAW can reduce maize yields by 48.2% ± 29% (Table 5).

Table 3. Proportion of respondents on the number of years of FAW occurrence.

Regions	Range of				
	1 to 5 years	6 to 10 years old	11 to 15 years old	16 to 20 years old	More than 20 years
Dosso	61	18	1	7	1
Maradi	67	20	4	5	0
Tahoua	44	28	3	5	6
Zinder	69	23	2	3	1
Average	60 ± 0.1	22 ± 0.04	3 ± 0.01	5 ± 0.02	3 ± 0.03
Chi-square	*	ns	ns	ns	**

Table 4. Perceived level of FAW attack.

		Dosso	Maradi	Tahoua	Zinder	Average	Chi-square
Attack level	Low	13	8	16.5	10	12 ± 0.04	ns
	Fort	47	50	47	69	53 ± 0.1	**
	Medium	40	42	37	21	35 ± 0.1	**

Table 5. Methods of controlling FAW used by maize farmers in the southern agricultural zone of Niger.

		Dosso	Maradi	Tahoua	Zinder	%Average	Chi-square
Control measures	Chemical pesticide	66	58	63	56	61 ± 0.04	ns
	Nothing	29	42	35	43	37 ± 0.06	ns
	Biopesticide, traditional and mechanical	5	0	2	1	2 ± 0.02	ns

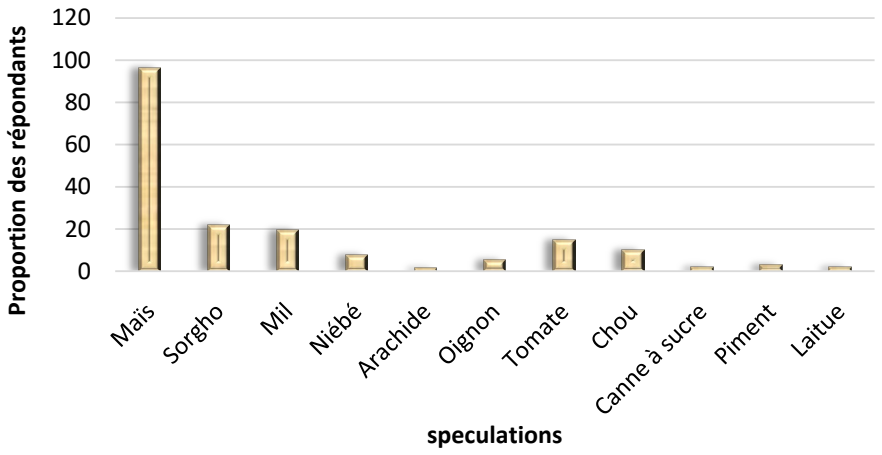

Figure 3. Species under attack by FAW.

In the southern agricultural zone of Niger, the estimate of losses varied by region: in Tahoua it was 44.5% ± 31%, in Dosso 50.5% ± 30%, in Zinder 49.2% ± 27.3%, and 48.2% ± 28.4% in Maradi.

Methods of controlling FAW.

Interviews with growers did not reveal a diversity of control methods for FAW. More than half of the respondents (61% ± 0.04) used chemical pesticides, while 2% ± 0.02 used more ecological methods to control FAW. It should be noted that 37% ± 0.06 of the respondents stated that they do not use any method to control FAW (Table 5).

3.7. Pesticides Used in the Control of FAW

It was found that 27 different types of synthetic chemicals are used by farmers to control FAW. Among them, 2 products are registered by the Sahelian Committee of Pesticides (CSP): Karate and Emacot. This is the case with the other two products, Karate and Emacot. Producers in the Zinder and Tahoua regions use the product Caiman B, known locally as "Gamlo", more often (Table 6). The term "Gamlo" is used by some pesticide sellers to refer to chemicals with Dimethoate as the active ingredient. For others, it refers to all the relatively cheaper EC products on the market. Caiman B is used extensively in the Dosso (40%) and Maradi (22%) regions (Table 6).

4. Discussion

The surveys and observations conducted in this study confirmed the presence of the fall armyworm *Spodoptera frugiperda* J.E. Smith in the southern agricultural zone of Niger. The results obtained also demonstrate that FAW is a major pest of maize in Niger, and despite its relatively recent establishment (2016), it is known to maize farmers. In our study area, 93% of respondents recognized FAW through morphological characteristics and signs of its damage, which they considered very important. These results are similar to those of [22], who reported in

Table 6. Most used chemical by region.

Region	Number of products	More used	Usage rate
Zinder	12	Gamlo	17
		Caiman B	15
		Piapia	10
Dosso	08	Caiman B	40
		Karate	8
		Piapia	6
Tahoua	12	Gamlo	23
		Caiman B	19
		Sharp shooter	9
Maradi	17	Caiman B	22
		Lara force	8
		Piapia	7

a survey on the perception of producers in Benin that 91.8% of maize producers knew about FAW and [23] in Kenya, 82% of respondents among maize farmers who can correctly identify it from images and state that in 2016 already more than 50% of farmers have observed it in their plot. In most countries where FAW was reported, growers were the first to report its presence and the level of knowledge of the pest ranged from 50% to 100% of respondents [12] [21] [24]. According to [24], in Côte d'Ivoire, the first suspicions about the presence of this insect appeared when maize producers reported the invasion of their respective crop sites by a certain caterpillar of which they had no knowledge.

According to [25]-[30] According to the producers surveyed, *Spodoptera frugiperda* J.E. Smith is very polyphagous and attacks a variety of crops including cereals, legumes and vegetables. The incidence of this pest is higher in corn and sorghum compared to other crops. This result is similar to that of [31], who obtained with field collections that the incidence is high in maize and second in sorghum.

In the southern agricultural band of Niger, 47% - 69% of growers rated FAW as having a very high impact on maize production, to the point where some growers have abandoned the crop altogether. These results are also supported by [12] In Ethiopia and Kenya, respectively, 67% and 98% of the farmers surveyed thought that the impact of FAW was very high.

FAW is a relatively new pest whose rapid distribution, polyphagy, and impact on crops surprised growers and policy makers. The results on control methods emphasize the use of synthetic pesticides by the majority of respondents (58% - 66%). Slightly higher results than ours were obtained in Benin with 91.4% of respondents also using pesticides [22]. The use of pesticides is explained by the fact that FAW is a new pest in most sub-Saharan countries and applied studies have not been conducted to develop management methods based on the insect's bio-ecology. For most farmers, as is customary, chemical control is the most appropriate. Unlike maize farmers in Niger and Benin, those in Kenya and Ethiopia use fewer pesticides, with 48 and 48.4% of respondents, respectively [12]. In these countries, the support of research and training institutions such as the International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Insect Physiology and Ecology (ICIPE), which have developed alternative methods to chemical control, especially Push-Pull technology, explains the low rate of pesticide use. It should be noted that a significant 37% of the respondents said they did not apply any control measures against FAW. This percentage varies from country to country, with 11% to 12% of producers in Ethiopia and Kenya, respectively [12].

In contrast, most farmers in the districts surveyed in Mozambique do not use any method to control FAW (from 60.8% in Macate to 88.0% in Manica and Sussundenga, respectively) [21].

However, FAW has developed numerous resistances as a result of the use of synthetic pesticides in North America [8]. This resistance to insecticides may be

widespread in some areas and control may therefore be difficult [31]. In Kenya, 60% of growers considered synthetic pesticides to be ineffective in controlling fall armyworm, given the resistance developed by this caterpillar [23]. The scientific community has been informed about the works carried out in the subtropical zone of China on the degree of development of resistance against synthetic products, whose results show that the ratio of resistance was from 1 to 1068 times by different types of active material tested [32].

To contribute to a considerable reduction in the population of these pests as a result of the problem of resistance development, much more effective insecticides will have to be used and rational application of pesticides will have to be carried out while changing them regularly. But while repeated application of highly toxic pesticides can reduce crop pest populations, it is far from environmentally and socially sound and is done at great expense. Also, these products are at the origin of several cases of intoxication and make according to the estimates of the UNO, each year, 40,000 victims, and causing after-effects to approximately 2,000,000 people [32] [33].

This economically important pest is becoming a new challenge for agricultural production in Niger, especially since 85% of the population depends on it [34]. More efficient ecological control methods against this bio-aggressor must be developed to save the production of maize in the world and particularly in Africa.

5. Conclusion

This study reports on farmers' knowledge, perceptions and management practices they use in managing against *Spodoptera frugiperda*. The study showed that the level of knowledge of FAW by the farmers is very high. The majority of farmers use synthetic pesticides that do not always satisfy them in managing *S. frugiperda*. A very small minority use local practices that they perceive to be more effective. These essentially ecological practices deserve to be studied and expanded.

Conflicts of Interest

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

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