Farmer's knowledge and management practices of Fall armyworm, *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera, Noctuidae) in the Central region of Burkina Faso

Pousbila SALO[1*, 2], Wendemanegde Ernest SALOU[1, 2], Kouka Benjamin KOAMA[1], Sami Éric KAM[1], Eliasse ZONGO[1], Rasmané GUIRE[1], Georges Anicet OUEDRAOGO[1] And Nâg-Tiéro Roland MEDA[1]

[1]*Research and Teaching Laboratory in Animal Health and Biotechnology (LARESBA),Université Nazi BONI (UNB), 01 BP 1091.Bobo-Dioulasso, Burkina Faso;*

[2]*Animals and Tropical Health Laboratory (LASANTROP), Université Nazi BONI (UNB), 01 BP 1091.Bobo-Dioulasso, Burkina Faso*

Corresponding Author's email: salopousbila@gmail.com

Key words: maize farmers, *Spodoptera frugiperda*, attack severity, management practices, Burkina Faso.

Submitted 29/02/2024, Published online on 30/04/2024 in the *Journal of Animal and Plant Sciences (J. Anim. Plant Sci.) ISSN 2071 – 7024*

1 ABSTRACT

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) is a crop pest originating from America that has become global. This study aimed to assess the level of knowledge and management practices of fall armyworms among farmers of the Central region of Burkina Faso. A survey of maize growers was carried out between July and November 2022 in this region, using a semi-structured questionnaire. The attacks severity of maize plants and maize fields infestation levels were assessed by the Davis and Williams (1992) scale. The results showed that 100 farmers, including 94 men and 6 women, were involved. They had 23 to 80 years old, were mostly less educated (91%) and were familiar (99.98%) with *S. frugiperda* at all stages of development. The cropping practices in the study area were mono-cropping (54%) and intercropping (46%) with peppers, cowpea, and sorghum. Most farmers (78%) applied organic and mineral fertilizers (NPK, Urea) during maize production; and have used traditional varieties of maize (86%).The severity of leaf attack of maize was medium in all fields surveyed; and the average of their infestation levels was between 89±0.15% and 94±0.09% and 89±0.15%. Farmers mainly use synthetic and botanical pesticides to reduce the intensity of attacks. Nine plant species belonging to 06 families and 08 genera have been used as botanical pesticides. *Azadirachta indica* A. Juss (50.87%) and, *Capsicum annum* L (21.05%), followed by *Allium sativum* L (08.77%) and *Nicotiana tabacum* L (07.02%) were the most identified species. Botanical pesticides could be an alternative to synthetic pesticides. Further studies would be necessary to demonstrate the effectiveness of botanical pesticides.

2 INTRODUCTION

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae), is a polyphagous and highly migratory insect pest (Kasoma *et al*., 2021). This species, originating from tropical and subtropical America, has become an invasive species in West Africa since 2016 (Goergen *et al*., 2016). Due to its high dispersion in sub-Saharan Africa between 2016 and 2018 (FAO, 2018), *Spodoptera frugiperda* was observed for the first time in Burkina Faso in

2016 (Day *et al.,* 2017). Fall armyworm is a devastating pest larva of maize crops (Cokola *et al.,* 2021). In the absence of management methods, the armyworm caused losses of 8.3 to 20.6 tons of maize in 12 African maize-producing countries from 2016 to 2017 (Prasanna *et al.,* 2018). This loss accounts for 21 to 53 % of annual maize production in Africa; and would match betweenUS$2.48 billion or US$6.19 billion economic loss (Makirita, 2020).In Burkina Faso, the fall armyworm caused an overall loss of maize, sorghum, and rice estimated at 477448 tons. This resulted in a 50% reduction in the income of vulnerable farming households during the 2017-2018 cropping season (BAD, 2018). To control the impact of fall armyworm on fields, the farmers of many countries have used synthetic pesticides from the class of organophosphates, carbamates, neonicotinoids and pyrethroids (Kasongo *et al*., 2021). For example, in the 2016-2017 crop year, more than 60% of Zambian farmers used synthetic pesticides in their cereal fields. In the same crop year, the Ethiopian government distributed about 100,000 litres of synthetic pesticides to maize farmers to control fall armyworm (FAO, 2019; Kansiime *et al*., 2019). For the case of Burkina Faso, US$ 1,148,250 were allocated for the purchase of 3803 litres of pesticides sprayed on 1862 ha of infested maize fields during the 2018-2019 cropping season (MAAH,2020). A most recent survey showed that 84.4% of farmers in the Sudanian and Sudano-Sahelian zones of Burkina Faso, applied synthetic pesticides against the Fall armyworm (Ahissou *et al*., 2022).However, this method of controlling fall armyworm has its limits. Indeed, the anarchic use of synthetic pesticides by farmers, and the availability of their counterfeit on the local market, have progressively caused the appearance of resistance to pyrethroids, organophosphates and carbamates, as well as to transgenic maize such as MON89034, TC1507, NK603 (Farias *et al.,* 2014; Bernardi *et al.,* 2017; Zhang *et al., .,* 2021). In addition, synthetic pesticides are air and soil pollutants (Vanderwerf, 1997). Furthermore, surveys on armyworm control conducted in Zambia (Kansiime *et al.,* 2019; Tambo *et al.,* 2020), Ghana (Tambo *et al*., 2020), Benin (Houngbo *et al.,* 2020), and the Democratic Republic of Congo (Kasongo *et al.,* 2021), revealed the existence of endogenous and effective methods of managing of *S. frugiperda* by farmers. These alternative methods are based on knowledge of *S.frugiperda* and the control methods used by farmers and could be essential for the search of effective and sustainable alternatives against this pest. Surveys carried out in Benin (Houngbo *et al.,* 2020), the Democratic Republic of Congo (Kasongo *et al*.,2021), the Sudanian and Sudano-Sahelian zones of Burkina Faso (Ahissou *et al.,* 2022) have shown that farmers use sand, ash and extracts of *Azadirachta indica* A. Juss, *Vernonia amygdalina* Del., *Capsicum annuum* L., and *Khaya senegalensis* (Desr.) A. Juss to control *S. frugiperda*. In Burkina Faso, little information is available on the knowledge of the fall armyworm and the endogenous management methods used by farmers. The objective of this study is to assess the level of knowledge and management practices of fall armyworm among farmers of the Central region of Burkina Faso. This farmer participatory approach will allow the implementation of an innovative, effective, and environmentally friendly technology against the armyworm.

3 MATERIALS AND METHODS

3.1 Study area: The Centre region lies between latitudes 12°30'32.68''N and longitudes 01°35'39.92''W and is bordered to the north and east by the Centre-Plateau region, to the south by the Centre-Sud region and to the west by the Centre-West region (Figure 1). It covers an area of 2826.28 km2 and has a population of around 30,0384 (RGPH, 2022). The survey was conducted among 100 maize growers whose fields had been attacked by *Spodoptera frugiperda* in 12 villages of four rural communes Pabré (Pabré, Pabré Saint-Joseph, Sag-nyonyogo), Koubri (Nambé, Koubri, Noungou), Saaba (Kouidi, Tanguen, Tansobentenga), and Komki-Ipala

(Komki-Ipala, Nabelin and Vipalgo), in the central region of Burkina Faso (Ahissou *et al.,* 2021). The climate is tropical with 2 seasons: a wet season, which lasts 4 to 5 months (from July to October/November), and a dry season, which lasts for 7 to 8 months (November/December to June). Water levels rarely exceed 700 mm per year and the average temperatures oscillate between 17°C and 36 °C. The most dominant vegetation cover in the region is the shrubby savannah with a few large trees and an herbaceous layer. The Central region is composed of tropical ferruginous soils and lateritic-clay soils (Zida, 2009). The percentage of maize plants attacked by fall armyworm was about 80% in some fields surveyed by agricultural officers in this area in 2017 (MAAH, 2018).

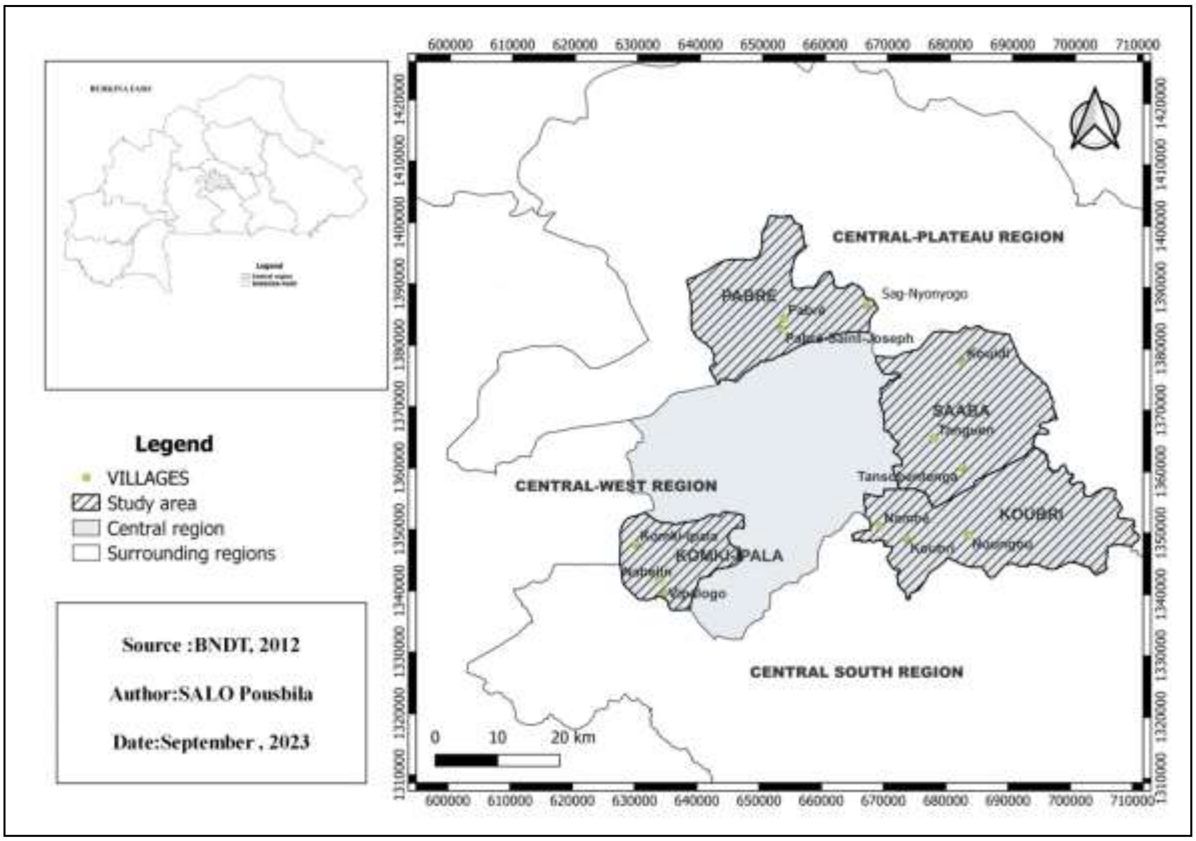

Figure 1: Location of the study area

3.2 Data collection: For data collection during the survey conducted from July to November 2022, the farmers interviewed were required to the following criteria: (i) the farm area was greater than or equal to 0.5 ha and (ii) the presence of *S. frugiperda* was reported in their fields by the agricultural services in 2022.100 maize farmers were interviewed in the local language (Mooré) using a semi-structured questionnaire. The surveys focused on the following information: (i) socio-demographic profile of farmers, (ii) cropping practices, (iii) knowledge of *S. frugiperda* attacks, management practices and farmers' perceptions. Maize yield losses are calculated as the difference between the yields obtained by the farmer before and after the fall armyworm attack.

3.3 Determination of damage caused by *S. frugiperda*: The unharvested maize fields of 75farmers were used to assess the attack severity of maize plants and the infestation levels of fields.

3.4 Attacks severity of maize plant: The Davis scale was used as a method to assess the attacks severity of leaf. This method consists of randomly selecting of 50 maize plants per field. This selection of maize plants should cover the area of the field. Then the observation of the leaves on each maize plant is used to assess the severity of the attack. According to this scale, 0 corresponds to no damage, 1-4tolow damage, 5-7to medium damage and 8 – 9 to high damage (Davis and Williams, 1992).

3.5 Infestation levels of maize fields: Field infestation levels were determined according to the method recommended by FAO, (2018). A total of 50 sample plants in each field were examined to screen a fall armyworm attack either as the presence of eggs, larvae, or damage caused by this pest. Maize plants were randomly selected using the "W"pattern approach, and the attack intensities have been calculated by using the following formula:

$$I=\frac{\sum_{i=1}^{5} Xi}{X} * 100$$

I= Attack intensities
Xi = number of damaged plants
X = number of plants observed

Data analysis: The following indices were calculated:
The Relative Frequency of Citation (RFC)of botanical pesticides:

$$RFC = \frac{Nc}{Nt} x\ 100$$

Nc: number of citations of plants
Nt: total number of interviewees.
The data were processed by the SPHINX Plus [2] (V5) 5.0.0.82.software. Epi info 7.2.4 software version 2021 was used to calculate mean and standard deviations. (P <0.0001).

4 RESULTS

4.1 Socio-demographic profile of Farmers: One hundred farmers were identified for this survey in the central region of Burkina Faso. The male sex was significantly (P <0.0001) more representative (94%) compared to the female sex (6%). Figure 2 shows the socio-democratic profile of famers. Concerning age, the youngest was 23 years old and the oldest famer was 80 years old. The most representative age group was between 25 and 54 years old (75%).Regarding education, less educated famers (Illiterate, Arabic, Alphabetize) showed significantly higher level (91%); P <0.0001.

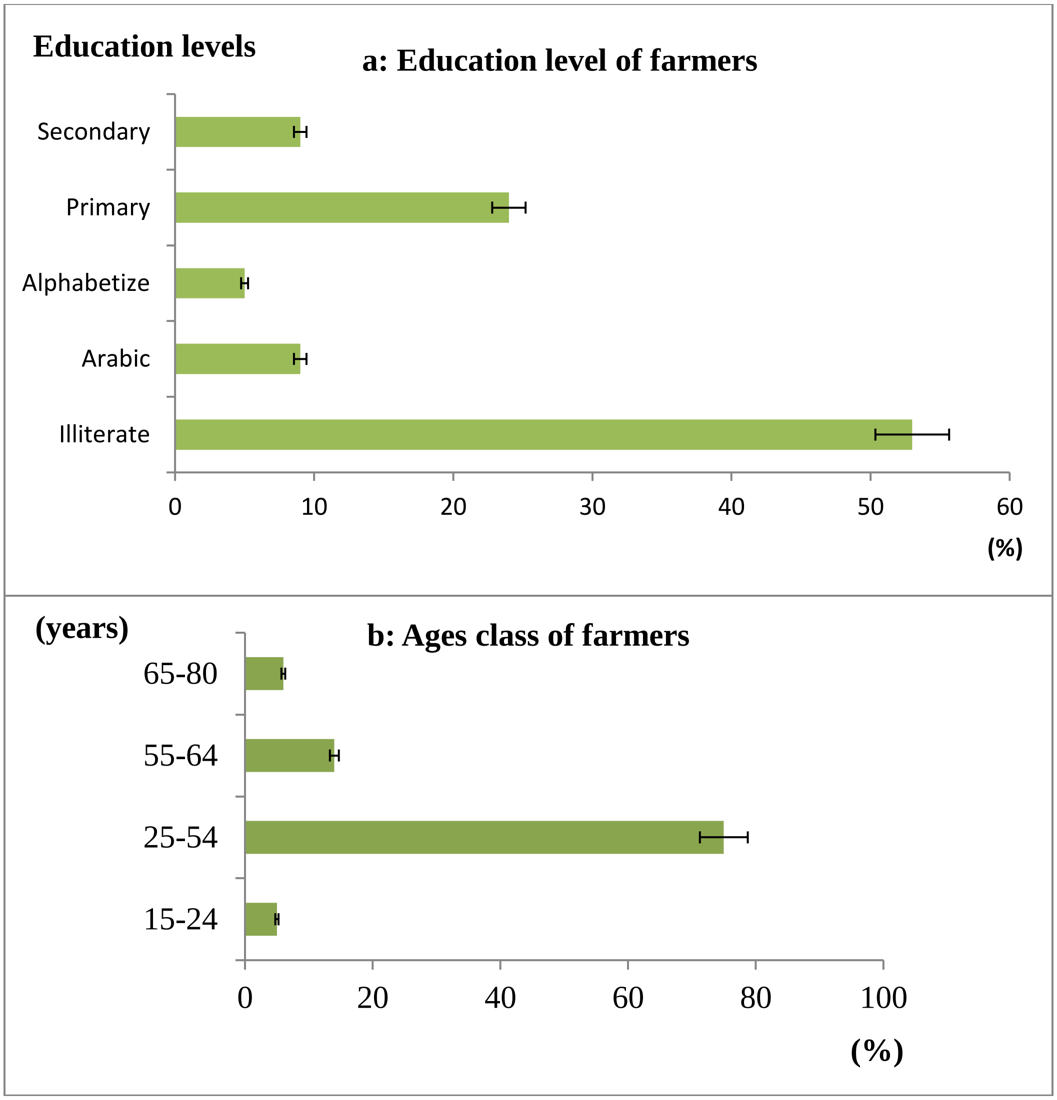

Figure2. Socio-demographic profile of farmers

4.2 Cropping Practices: The cropping practices in the study area are recorded in Table 1. Two main systems were used for maize production, such as mono-cropping (54%) and intercropping (46%) with peppers, cowpea, and sorghum. Most farmers (78%) applied simultaneously organic and mineral fertilizers (NPK, Urea) during maize production. Many farmers (86%) used traditional varieties of maize; and had their maize fields surrounded by sorghum fields (33.15%) Cowpea fields (14.67%) and other maize fields (13.58%). However, fields of market gardening, peanuts, millet, earth weights, sesame, peppers, and soybeans were found in a minority around the fields of the interviewees.

Table 1: Farmers' cropping practices.

Copping Practices		Numbers	Frequency (%)
Maize cropping systems	Intercropping	46	46
	Mono-cropping	54	54
Application of fertilizers	NPK	03	03
	Organic fertilizer	09	09
	NPK+Urea	05	05
	NPK+ Organic fertilizer	05	05
	Mineral fertilizer (NPK, Urea) and Organic fertilizer	78	78
Maize varieties used	Traditional	86	86
	Modern	11	11
	Traditional and modern	03	03

4.3 Farmers' knowledge on *S.frugiperda* attacks: Table 2 summarizes farmers' knowledge and perception on *S.frugiperda* attacks. The majority of farmers could correctly identify *S. Frugiperda* immature stages such as egg (33.57%), larvae (32.49%); and the adults' stage (31.04%). The stage of pupae was less recognized (02.88%). For most farmers (97%), maize plants were more attacked in their mounting stage; and these attacks result in loss of leaves; stem and grains attacked contained insects (25.44%) and were rotten (25.19%).Average yield losses were estimated at 491± 313.25 Kg/ha.

Table2. Farmers' knowledge and perceptions on damages caused by *S. frugiperda*

Variables		Numbers	Frequency (%)
Knowledge of *S.frugiperda* development stages	Egg	93	33.57
	Larva	90	32.49
	Pupae	08	02.88
	Adults	86	31.04
Perception of the vulnerability of maize plants according to their development stages	Emergence and Mounting	03	03
	Mounting	97	97
Damage on vegetative system	Loss of leaves and stem	100	100
Damage on grain quality	Bad smell	97	24.68
	Contains insects	100	25.44
	Bad taste	97	24.68
	Are rotten	99	25.19
Maize yield losses (Kg/ ha)		491 ± 313.25	

4.4 Damage caused by *S.frugiperda*: According to the Davis and Williams, (1992) scale, the severity of leaf attack of maize was medium in all fields surveyed. All the 75 maize fields not yet harvested were infested with fall armyworm. The average of infestation levels in monoculture and intercropping maize fields was estimated respectively, at 94±0.09% and 89±0.15% (Table 3).

Table 3. Damage caused by *S. frugiperda*

Severity of maize leaf attack		Number	Frequency (%)	
Medium		75	100	
Infestation levels of maize fields		**Number**	**Means (%)**	**Standard deviation**
Monoculture		53	94	0.09
Intercropping		22	89	0.15
Associated with	*Capsicum annum* L.	04	81	0.09
	Sorghum bicolor L.	09	90	0.13
	Vigna unguiculata (L.) A. Walp.	09	86	0.19
Maize fields treated with	synthetic pesticides	68	93	0.11
	synthetic pesticides and botanical pesticides	07	90	0.14

4.5 Farmers' management practices: To control the fall armyworm, farmers of the Central region of Burkina Faso, have used methods such as synthetic pesticides (45.87%), cultural methods (36.70%), botanical pesticides (14.68%), and physical technique (2.75%) (Table4).

Table 4: Management practices of *S.frugiperda* used by farmers.

Management practice		**Number**	**Frequency (%)**
Physical methods (02.75%)	Crushing by hand	03	01.38
	Pouring sand on the whorl	02	0.92
	Pouring hot water or embers before planting	01	0.46
Cultural methods (36.70%)	Spreading of fertilizers	71	32.57
	Pouring liquid soap on the whorl	04	01.83
	Pouring ashes on the whorl	05	02.29
Synthetic pesticides (45.87%)		100	45.87
Synthetic pesticides and Botanical pesticides(14.68%)		32	14.68

4.6 Knowledge of botanical pesticides

4.6.1 Plant parts used: The most commonly used plants parts are seeds (40.35%) and fruits (21.05%); followed by leaves (14.04%), bulbs (12.28%), mixtures of leaves and seed (7.02%), rhizomes (3.51%) and skins (1.75%) (Figure 3).

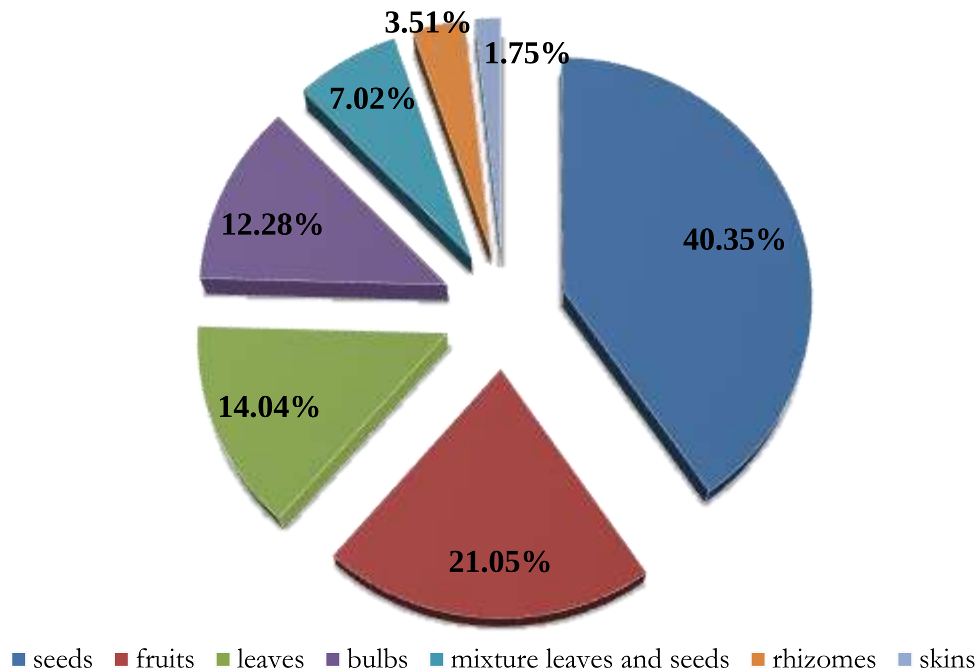

Figure 3: Plant parts used

4.6.2 Method of application and effectiveness of botanical pesticides according to farmers: The timing, daily treatments periods and frequencies of botanical pesticides application are presented in Table 5. Most respondents treated their fields in presence of fall armyworm or maize emergence (68.75%); in the morning or evening (50%) and twice a week (46.88%).Botanical pesticides are mainly prepared by maceration and the spraying is the method of their applying. 65.63% of farmers considers botanical pesticides more effective than other methods of *S. frugiperda*.

Table 5: Applications method and effectiveness of botanical pesticides according to farmers

Methods of application		**Numbers**	**Percentages**
Timing of treatments	in presence of fall armyworm or maize emergence	22	68.75
	In presence of fall armyworm	09	28.13
	Maize emergence	01	03.12
Daily treatment periods	Morning or evening	16	50
	Morning	11	34.38
	Evening	02	06.25
	Morning or Day	02	06.25
	Morning or Night	01	03.12
Treatment frequencies	Once a week	07	21.88
	Twice a week	15	46.88

Journal of Animal & Plant Sciences (J.Anim.Plant Sci. ISSN 2071-7024)
Vol.60(1) : 10990 -11003 https://doi.org/10.35759/JAnmPlSci.v60-1.3

	Three times a week	05	15.63
	Every day	03	09.37
	Once every two weeks	01	03.12
	Once a month	01	03.12
Farmers' appreciation		**Number**	**Frequency (%)**
Effective		21	65.63
Moderately effective		08	25
Not very effective		03	09.37

4.6.3 Plants used as botanical pesticides: The plants used as botanical pesticides by farmers in the study area are recorded in the Table 6. Nine species belonging to 06 families and 08 genera have been identified. The families of plants commonly used are Meliaceae and Solanaceae. The most identified species were *Azadirachta indica* A. Juss (50.87%) and, *Capsicum annum* L (21.05%), followed by *Allium sativum* L (8.77%), *Nicotiana tabacum* L (7.02%), *Allium cepa* L (3.51%), *Zingiber officinale* R (3.51%); *Khaya senegalensis* (Desr) A. Juss, *Carica papaya* L and *Citrus auriantum* L (1.75% for each).

Table 6. Botanical pesticides used against Fall Armyworm by farmers

Species	Family	Parts used	Method of preparation	Method of application	RFC (%)
***Azadirachta indica* A .Juss**	Meliaceae	Leaves and seeds	Maceration	Spraying	05.26
			Decoction	Spraying	01.75
		Seeds	Maceration	Spraying	33.33
			Decoction	Spraying	07.02
		Leaves	Maceration	Spraying	03.51
***Capsicum annuum* L.**	Solanaceae	Fruits	Maceration	Spraying	21.05
***Allium sativum* L**	Liliaceae	Bulbs	Maceration	Spraying	08.77
***Nicotiana tabacum* L.**	Solanaceae	Leaves	Maceration	Spraying	07.02
***Allium cepa* L**	Liliaceae	Bulbs	Maceration	Spraying	03.51
***Zingiber officinale* Roscoe**	Zingiberaceae	Rhizomes	Maceration	Spraying	03.51
***Khaya senegalensis* Desr) A. Juss**	Meliaceae	Leaves	Maceration	Spraying	01.75
***Carica papaya* L.**	Caricaceae	Leaves	Maceration	Spraying	01.75
***Citrus sinensis* (L) Osbeck**	Rutaceae	Skins	Maceration	Spraying	01.75

5 DISCUSSION

The majority of farmers are men, as they are the owners of the family fields. According to the FAO, in 40% of the countries providing data, the proportion of men holding property or guarantee rights to agricultural land is twice that of women (FAO, 2023). In Africa, female farmland owners represent 15% of farmers, and none of them are heads of household farms in Burkina Faso. In fact, patriarchal social norms, religious beliefs, inadequate policies and laws, the lack of financing mechanisms adapted to women's situation are all obstacles to their access to agricultural land (Boly *et al.,* 2022; UEMOA, 2022). Many farmers are between 25 and 54 years old, as they are mostly young and adult in the Central region of Burkina Faso according to a 2019 census by the country's ministry of agriculture (MAAH, 2020). The low level of education among farmers could be explained by the high illiteracy rate in rural areas and the fact that the activity does not require a high level of education (RGPH, 2022). Mono-cropping (50%) and intercropping (46%) are the cropping practices used by farmers. Many authors have reported that intercropping reduces the infestation level of *S. frugiperda*. Midega *et al.* (2018) reported that push-pull and intercropping maize with legume crops are the best methods to protect maize crops against *S. frugiperda* and other pests compared to mono-cropping. Kasongo *and al.* (2021) showed in their survey in Democratic Republic of Congo that intercropping maize with other crops reduces the incidence of the pest. In fact, certain repellent plants or *S. frugiperda* hosts present in the field would reduce attacks on maize plants (Houngbo *et al.,* 2020). Many respondents apply NPK and use the traditional maize variety. NPK is a chemical fertilizer that allows plant to develop rapidly after application (Kumar *et al.,* 2022). Similarly to others studies from Benin (Houngbo *et al.,* 2020), Sudanian and Sudano-Sahelian zones of Burkina Faso (Ahissou *et al.,* 2022), farmers could correctly identify *S. frugiperda* immature stages such as egg (33.57%), larvae (32.49%); and the adults stage (31.04%). The identification of pest development stages can be explained by its presence in the area since 2016 and farmers had better knowledge of its biology (Day *et al.,* 2017). Few of them (02.88%) recognize the insect at the pupa stage. This could be linked to fact that the pupation takes place in a cocoon in the soil at a depth 2-8 cm (Prasanna *et al.,* 2018; Kumar *et al.* 2021; Kasongo *et al.*, 2021). According to the farmers, the maize cobs contain mostly insects (25.44%), are rotten (25.19%) and can cause average yield losses of 491±313.25 Kg/ha. These losses caused by *S.frugiperda* attacks are encountered by farmers in Benin during the 2018-2019 cropping season with decreases in maize production of 797.2 ± 613.6 Kg/ha (Houngbo *et al.,* 2020). In the absence of effective management practices, late-stage *S. frugiperda* larvae consume maize grain (Prasanna *et al.,* 2018) and can lead to a total loss of maize production (Kumar *et al.,* 2022). According to farmers, pests' attacks result in loss of leaves and stem (100%). *S. frugiperda* prefers tender maize leaves and stem Capinera, 2017; Deole and Paul, 2018). The eggs of female *S.frugiperda* are deposited on maize leaves, which are eaten by the larvae after hatching before the stem and other parts (Capinera, 2017; Deole and Paul, 2018; Houngbo *et al.,* 2020; Jamil *et al.,* 2021). The combining of maize with other crops reduces the level of pest infestation (89±0.15%). The same observation was made from survey conducted by Kasongo *et al.* (2021) among maize farmers in the peripheral areas of the University of Kinshasa. Concerning intercropping system, the maize fields associated with *Capsicum annum* L. showed the lowest infestation levels (81±0.09%). Maize fields treated simultaneously with botanical pesticides and synthetic pesticides are less attacked (90±0.14%) than those treated with synthetic pesticides only (93±0.11%). This treatment would reduce pesticides resistance by using several molecules against *S. frugiperda* (Prasanna *et al.,* 2018). The predominance of synthetic pesticides could be explained by their high removal power, low cost (Prasanna *et al.,* 2018) and free distribution to farmers by the Burkina Faso government (MAAH, 2018; Ahissou *et al.,* 2022; FAOSTAT, 2022). With the heavy use of synthetic pesticides, their alternatives, in particular botanical pesticides are little known and could explain their low use (14.68%) (Ahissou *et al*, 2022). In this study, the association of synthetic pesticides with botanical pesticides showed the reduction of maize infestation levels. Because of their effectiveness, ease of use, degradable and protective characteristics of the environment and non-target organisms, botanical pesticides could be an alternative to synthetic pesticides (Prasanna *et al.,* 2018; Kansiime *et al.,* 2019). Surveys carried out by many authors have shown that farmers use ash and sand against pest, or crush its eggs and larvae with their hands (Kansiime *et al.,* 2019; Kasongo *et al.,* 2021; Ahissou *et al.,* 2022). Ashes and sand, in addition to making the maize plants dirty and non-preferable, could cause the larvae to die of desiccation. Most respondents using botanical pesticides treated their fields in presence of fall armyworm or maize emergence (68.75%); in the morning or evening (50%) and twice a week (46.88%). The larvae of *S. frugiperda* feed on the surface of the leaf or stem of the maize plant during the dark periods of the days, and are more to pesticides, which is why many farmers spray in the morning or evening (Prasanna *et al.,* 2018). 65.63% of farmers said that botanical pesticides are effective. This result corroborates those of Houngbo *and al.* (2020) whose farmers (1.9%) found botanical pesticides effective against *S. frugiperda*. Among the 9 plant species identified, other studies conducted in Benin, Togo and in the Sudanian and Sudano-Sahelian, zones of Burkina Faso have also revealed the use of *Capsicum annuum* L, *Azadirachta indica* A. Juss and *Khaya senegalensis* (Desr.) A. Juss as botanical pesticides by farmers (Houngbo *et al.,* 2020; Tchao *et al.,* 2022; Ahissou *et al.,* 2022).*Azadirachta indica* A. Juss extracts have insecticidal properties on *S.frugiperda* and are non-toxic to non-target organisms (Kumar *et al.,* 2022). Studies by Adeye *and al.* (2018) showed that *Azadirachta indica* A. Juss oil at 4.5l/ha reduced the incidence of *S.frugiperda* attack, the severity of damage and maize yield losses.

6 CONCLUSION

This study showed that farmers in the central region of Burkina Faso have a high level of knowledge of the armyworm at all stages of its development. To reduce *S. frugiperda* attacks on crops, they mainly use synthetic pesticides. However, botanical pesticides in combination with synthetic pesticides have also been applied. Nine plant species belonging to 6 families and 8 genera were used as botanical pesticides. *Azadirachta indica* A. Juss and Capsicum annum L were the main species used. Additional laboratory studies would be necessary to demonstrate the effectiveness of botanical pesticides.

7 ACKNOWLEDGEMENTS

The authors thank the farmers of the rural communes of Pabré, Koubri, Saaba and Komki-Ipala for useful information they provided.

Conflicts of interest: The authors declare no conflict of interest

Contributions from authors: Pousbila SALO collected information, assessed caterpillar attacks in maize farmers' fields, drafted the survey sheet and manuscript; Kouka Benjamin Koama, Sami Eric KAM, Eliasse ZONGO and Rasmané GUIRE each corrected the manuscript; Wendemanegde Eernest SALOU, Nâg-Tiéro Roland MEDA and Georges Anicet OUEDRAOGO each corrected the manuscript and supervised the work.

8 REFERENCES

Adeye, A.T.,R. Sikirou, S. Boukari, M. Aboudou, G.Y.G.A. Amagnide, B.S. Idrissou, M. Drissou-Toure and B. Zocli (2018).Protection de la culture de maïs contre *Spodoptera frugiperda* avec les insecticides plantneem, lambdace 25 EC et viper 46 EC et reduction de pertes de rendement au Benin. *J. Rech. Sci. Univ. Lomé, 20*, 53–65

Ahissou, B. R.W. M. Sawadogo, A. H. Bokonon-Gant, I. Somda andF. Verheggen (2022). Farmers' knowledge and management practices of the fall army worm (*Spodoptera frugiperda* Smith) in Burkina Faso. *Biotechnol. Agron. Soc. Environ.* **26**(4), 191-197.

Ahissou, B. R., W. M. Sawadogo, S.Bonzi, H.Baimey, I.Somda, A. H.Bokonon-Ganta and F. J. Verheggen (2021). Natural enemies of the fall armyworm *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) in Burkina Faso.

Tropicultura 39 (2021). DOI: 10.25518/2295-8010.1881

BAD, 2018. Burkina Faso. Aide d'urgence pour la lute intégrée contre l'invasion de la chenille légionnaire d'automne. Banque Africaine de Développement.

Bernardi, D., O. Bernardi, R. J. Horikoshi, E. Salmeron, D. M. Okuma, J . R. Farias, A. R. B. do Nascimento and C. Omoto (2017). Selection and characterization of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) resistance to MON 89034 X TC1507 X NK603 maize technology. Crop. Prot. 94, 64-68. http//dx.doi.org/10.1016/j.cropro.2016.11.026.

Boly, A., A. Wango, A. Kaboré,F. Traoré, M.N.Ba and A. Sanon (2022).Perception des producteurs sur les insects ravageurs du mil au Burkina Faso: place de la mineuse de l'épi de mil, *Heliocheilus albipunctella* De Joannis (Lepidoptera: Noctuidae). J. Appl. Biosci 176 https://doi.org/10.35759/JABs.

Capinera, J.L., 2017. Fall Armyworm, Spodoptera frugiperda (J.E.Smith) (Insecta: Lepidoptera: Noctuidae). Publication#EENY098. Florida (FL): UF/IFAS Extension Service, University of Florida; [accessed 10 October 2017]. http://edis.ifas.ufl.edu/in255. Fall Armyworm.

Cokola, M.C., S.S. Ndjadi, E.B.Bisimwa, L.E. Ahoton and F. Francis (2021). First report of Spodoptera frugiperda (Lepidoptera: Noctuidae) on Onion (*Allium cepa L.*) in South Kivu, Eastern DR Congo.Revista Brasileira de Entomologia. 65 (1).

Davis, F.M.N.G. S.S. and W.P. Williams (1992).Visual rating cales for screening whord-stage corn for resistance to fall armyworm. Mississipi Agricultural and Forestry Experiment Station, Technical Bulletin. Mississipi State University, MS 39762, U.S.A. 186 (1-9).

Day, R., P. Abraham, M. Bateman, T. Beale, V. Clottey, M. Cock, Y. Colmenarez,N. Corniani, R. Early, J. Godwin, J. Gomez, P.G. Moreno, S. T. Murphy, B. Oppong-Mensah, N. Phiri, C. Pratt, S. Silvestri, A. Witt (2017).Fall armyworm: impacts and implications for Africa. Outlooks on Pest Management. 28, DOI: 10.1564 pp.196-201.

Deole, S and N. Paul (2018). First report of fall armyworm, *Spodoptera frugiperda* (J.E. Smith), their nature of damage and biology on maize crop at Raipur, Chattisgarh. Journal of Entomology and Zoology Studies; 6(6): 219-221.

FAO, 2023. Les femmes encore marginalisées dans l'agriculture et l'alimentation. Copyright © africanews. Food and Agriculture Organization of the United Nations, Rome.

FAO, 2019. Emergency Assistance to obtain the spread of fall armyworm outbreak.Reporting@fao.org Pp2 TCP/ETH/3604. Food and Agriculture Organization of the United Nations, Rome.

FAO, 2019. Projet d'appui pour la mise en place d'une stratégie de gestion durable de la chenille légionnaire d'automne au Burkina Faso; FAO-BF@fao.org. Food and Agriculture Organization of the United Nations, Rome.

FAO, 2018. Fall Armyworm Monitoring and Early Warming System (FAMEWS) Platform. Available from: URL:http//www.fao.org/fall-armyworm/en/. Food and Agriculture Organization of the United Nations, Rome.

FAOSTAT, 2022. Pesticides Indicators. In: *FAO*. Rome. Cited October 2022. http://www.fao.org/faostat/en/#data/EP based on UN Geospatial. 2020. Map geo data [shape files]. New York, USA, UN. https://doi.org/10.4060/cc2212en-map10.

Farias, J.R., D.A. Andow, R. J. Horikoshi, R. J. Sorgatto, P. Fresia, A.C. dos Santos andC. Omoto (2014).Field-evolved resistance to Cry1F maize by Spodoptera frugiperda (Lepidoptera: Noctuidae) in Brazil. Crop. Prot. 2014, 64, 150-158. http:// dx.doi.org/10.1016/j.cropro.2014.06.019.

Goergen, G., P.L. Kumar, S.B. Sankung, A. Togola and M. Tamò (2016).First report of outbreak of the fall armyworm *Spodoptera frugiperda* (J.E.Smit)(Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa.PLOS ONE.11:1-9.Available from:https//doi.org/10.1371/journal pone0165632.

Houngbo, S., A. Zannou , A. Aoudji, H. C. Sossou , A. Sinzogan, R. Sikirou, E. Zossou, H. S. T. Vodounon, A.Adomou andA. Ahanchédé (2020). Farmers' Knowledge and Management Practices of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) in Benin, West Africa. *Agriculture, 10*, 430; doi: 10.3390/agriculture10100430.

Jamil, S. Z., Saranum, M.M., L.J.S. Hudin and W.K.A.W. Ali (2021). First incidence of invasive fall armyworm, Spodoptera frugiperda (J.E.Smith, 1797) attacking maize in Malaysia. Bioinvasions Records, 10, 1, 81-90, http://doi:.org/10.3391/bir.2021.10.1.10.

Kansiime, M.K., I. Mugambi, I. Rwomushana, W. Nunda, J. Lamontagne-Godwin, H. Rware, N. A. Phiri, G. Chipabika, M. Ndlovu, and R. Daya (2019).Farmer perception of fall armyworm (Spodoptera *frugiperda* J.E.Smith) and farm-level management practices in Zambia. *Pest Management Science* May**.** DOI: 10.1002/ ps.5504.

Kasoma, C., H. Shimelis and M.D. Laing (2021).Fall armyworm invasion in Africa: implications for maize production and breeding. Journal of crop Improvement. 35 (1), 111-146.

Kasongo, Y. M., R. K. Vumilia, M.Muengula, , K. Fiaboe, J. P.K. Tshiabukole,A. F. Ngoie,H. N. Lumami and A.K.Mbuyi (2021). Détermination de la présence et du mode de gestion de la chenille légionnaire d'automne (*Spodoptera frugiperda* J.E. Smith) par les agriculteurs des zones périphériques de l'Université de Kinshasa, Revue Africaine d'Environnement et d'Agriculture ; 4(3), 38-45.

Kumar, P.,K. Kumari, S.K. Sharma, and S.N. Singh (2021).Efficacy of bio-pesticides against fall armyworm*Spodoptera frugiperda* under laboratory condition.Journal of Entomology and Zoology Studies; 9(2): 1282-1284.

Kumar, R.M., B.-G. Gadratagi, V. Paramesh, P. Kumar, Y. Madivalar, N. Narayanappa andF. Ullah, (2022). Sustainable Management ofInvasive Fall Armyworm, *Spodoptera frugiperda*. *Agronomy*, *12*, 2150. https://doi.org/10.3390/agronomy12092150

MAAH,2020.Gestion durable de la chenille légionnaire d'automne: Le Gouvernement et la FAO mettent les bouchées doubles dans le Centre-Est, le Centre-Sud et le Centre-Ouest. Ministère de l'Agriculture et des Aménagements Hydro-agricoles, Burkina Faso.

MAAH, 2018.Lutte contre la chenille légionnaire d'automne au Burkina Faso (Campagne agricole 2018-2019). Rapport général. 2018. Ministère de l'Agriculture et des Aménagements Hydrauliques, Burkina Faso.

MAAH, 2020. Tableau de bord statistique de l'agriculture 2019. Ministère de l'Agriculture et des Aménagements Hydrauliques, Burkina Faso.

Makirita, W. E. (2020). Development of bio-pesticide for management of *Spodoptera frugiperda* (J E Smith) and other Lepidoptera pests of maize in Tanzania. Doctoral dissertation, NM-AIST.

Journal of nanoscience and nanotechnology, 20 (3), 1434-1439.

Midega, C.A.O., J. O. Pittchar, J.A. Pickett, G.W. Hailu, R.Z. Khan (2018). A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (J E Smith) in maize in East Africa. Crop Prot 105: 10-15.

Prasanna, B.M.,J.E. Huesing, R. Eddy and V.M. Peschke(2018).Fall Armyworm in Africa: A Guide for Integrated Pest Management, 3rd ed.; CIMMYT: Mexico City, Mexico; pp. 11–106.

RGPH, 2022. Synthèse des résultats définitifs.Cinquième Recensement General de la Population et de l'Habitation du Burkina Faso.

Tambo, J.A., R.K. Day, J. Lamontagne-Godwin, S. Silvestri, P.K. , Beseh, B. Oppong-Mensah, N. A. Phiri, M. Matimelo (2020).Tackling fall armyworm (*Spodoptera frugiperda*) outbreak in Africa: an analysis of farmers' control actions. *International Journal of Pest Management*. 66(4), 298-310. DOI: 10.1080/09670874.2019.1646942.

Tchao, M., A. K. Tounou, A. Gnankoulamba, K. Agboka, A. Tchabi, T. Gnon, M. Tchegueni, K. Sanda (2022). Farmers' perceptions of fall armyworm*Spodoptea frugiperda* (J.E.Smith) (Lepidoptera: Noctuidae) and control methods de lute in corn (Zea mays L.) in Togo. *Int. J. Biol. Chem. Sci.*2022, 16(5): 1941-1957. DOI:https://dx.doi.org/10.4314/ijbcs.v16i5.11.

UEMOA, 2022. Accès et contrôle des femmes et jeunes au foncier. Bulletin d'information de l'Observatoire régionaldu Foncier Rural enAfrique de l'Ouest. Numéro 03. Union Economique et Monétaire Ouest Africaine, Ouagadougou.

Van der werf, H.M.G. (1997). Evaluer l'impact des pesticides sur l'environnement. Courrier de l'environnement de l'INRA n°31.

Zhang, D.D., Y.T. Xia, P.J. Xu, X.M. Yang, Q. L. Wu and K.M. Wu (2021). Insecticide resistance monitoring for the invasive populations of fall armyworm, *Spodoptera frugiperda* in China. J. Integr 20, 783-791.

Zida, Y., (2009). Monographie de la région du Centre pp. 19-22.