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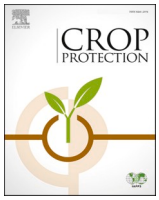

Farmers' knowledge and perceptions of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) damage and factors affecting control method choices in Benin, West Africa

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ABSTRACT

This study examines farmers' knowledge and perceptions of damage caused by fall armyworm (FAW, *Spodoptera frugiperda*), reports their estimated production losses in southern Benin between 2020 and 2022, and investigates the factors that influenced pest management decisions. A semi-structured questionnaire was used to interview 242 farmers across two agroecological zones of southern Benin from September to December 2023. About 93 % of farmers had broad knowledge of FAW, and 95 % believed they had been affected by infestations and considered the pest dangerous. However, 41 % misinterpreted the timing of FAW attacks, believing that the insect emerged and caused damage only at the mature stage of maize. As a result, synthetic insecticides were frequently applied after significant damage had already occurred. Infestation levels varied across zones: farmers in the Guinean zone reported relatively low infestation (20 %), while those in the Sudano-Guinean zone reported higher levels (40 %), especially in 2021. Yield losses were estimated at 20–40 % during this period. In terms of management, 73 % of farmers relied on synthetic insecticides, 2.5 % adopted cultural practices, 11.6 % used no control methods, and only 1.2 % applied botanical extracts. Further analysis revealed that the choice of FAW control measures was significantly influenced by years of maize farming experience ($P < 0.002$), financial means ($P < 0.001$), and to a lesser extent, perceptions of control method effectiveness ($P < 0.068$). These findings showed that although farmers are aware of FAW, misperceptions about its biology and timing of insecticide application remain problematic. To reduce yield losses, extension programs should prioritize training on the biology of FAW, timing of chemical applications, and consider the aforementioned factors when promoting management practices for FAW control in Benin and similar agroecological contexts.

1. Introduction

Maize is important to the economy of Benin and West Africa as a staple food, a source of income for farmers, a key product in agricultural trade, and a major component of animal feed and the food industry (Ba, 2017). However, maize production in Africa, particularly in Benin, is significantly affected by the invasion of *Spodoptera frugiperda* J.E. Smith (Lep.: Noctuidae), commonly known as the fall armyworm (FAW) (Day et al., 2017).

Crop losses due to FAW infestations can result in substantial economic setbacks for farmers, affecting their food security and livelihoods. The pest causes maize yield losses equivalent to 21 %–53 % of annual maize production in 12 of Africa's maize-growing countries (Day et al., 2017), representing US$ 2.5–6.2 billion in financial losses for sub-Saharan Africa (SSA) (Day et al., 2017). Loss estimates at the farm level in Ghana and Zambia showed that FAW infestation reduces yields by 22–67 % (Day et al., 2017), 47 % in Ethiopia and Kenya (Kumela et al., 2019), 9.4 % in Zimbabwe (Baudron et al., 2019), and up to 49 % in Benin (Houngbo et al., 2020).

Farmers have acquired extensive knowledge in dealing with insect pests in the past and have developed ways of perceiving pest damage and how to deal with it (Sinzogan et al., 2004). Studies by Kasoma et al.

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Table 1
Features of the study area spanning south Benin's climate zones with their main climatic characteristics in the two distinct climatic zones.

Climate-related variables	Guinean zone (Agroecological zone of ferruginous, Barre soils)	Sudano-Guinean zone (Agroecological zone of semi-deciduous forests)
Range of annual rainfall (mm)	1100–1400	900–1110
Range of temperatures (°C)	25–29	25–29
Range of relative humidity %	69–97	31–98

Mensah et al. (2014) and Yabi & Afouda (2012).

(2021) in Zambia revealed that farmers adopted FAW management strategies according to their experiences and perceptions with the said methods. According to Kumela et al. (2019), farmers' knowledge and perceptions of FAW significantly influenced their management practices in Ethiopia and Kenya, highlighting the importance of understanding local beliefs and attitudes. Similarly, Koffi et al. (2020a) reported that Ghanaian farmers' perceptions of the severity of FAW were directly linked to the pest management strategies they adopted, with a preference for methods they considered effective. Similarly, Tambo et al. (2020a) observed that African farmers' responses to FAW infestations were shaped by their perceptions of the pest's impacts and their confidence in different management options. In Benin, Houngbo et al. (2020) found that the perceptions and knowledge of farmers were influenced by their educational level, access to information, farming experience, and participation in community networks.

Understanding farmers' perceptions and responses to FAW infestations in Benin, as well as the challenges they face, is essential to guide the development of effective policies and support mechanisms that will enable them to manage pests more effectively. Hence, the present study aims to: (i) analyze Benin farmers' knowledge and perceptions of FAW damage; (ii) estimate farmers' production losses in southern Benin from 2020 to 2022; and (iii) explore factors influencing their pest management choices.

2. Materials and methods

2.1. Study area

The study was conducted in southern Benin, which is characterized by an equatorial climate with high humidity, alternating two dry seasons, i.e., November to March and mid-July to mid-September, and two rainy seasons, April to mid-July and mid-September to October (Tonoukouin et al., 2023), and which is suitable for maize production (see Table 1).

2.2. Sampling and data collection

A multi-stage stratified random sampling procedure was used to select maize-growing households and respondents across southern Benin. The study focused on southern Benin because the majority of the country's maize is produced there (MAEP, 2020), and it offers a favorable climate for FAW. Based on annual maize production data (MAEP, 2020), the main maize-producing villages in southern Benin were identified and chosen for the survey. Considering the severity of FAW damage and the accessibility of locations, a list of 24 villages was established. The selected villages were well distributed within the study area and represented the entire region (Fig. 1).

After presenting the study's objectives to the population in each village, a list of participating households, including household heads, was established and subsequently updated with the support of maize farmers' organizations. This was followed by a systematic sampling of the surveyed households. For this, we first created a list of 30 households per village. From this list, we selected 10 households in each village using a fixed periodic interval of 3, ensuring a consistent and representative sample (see Table 2).

The sample size was determined using Cochran's (1963) formula in Equation (1).

$$n_0 = \frac{Z^2 pq}{e^2} \quad (1)$$

Where $\overset{o}{n}$ was the required sample size (without applying the finite

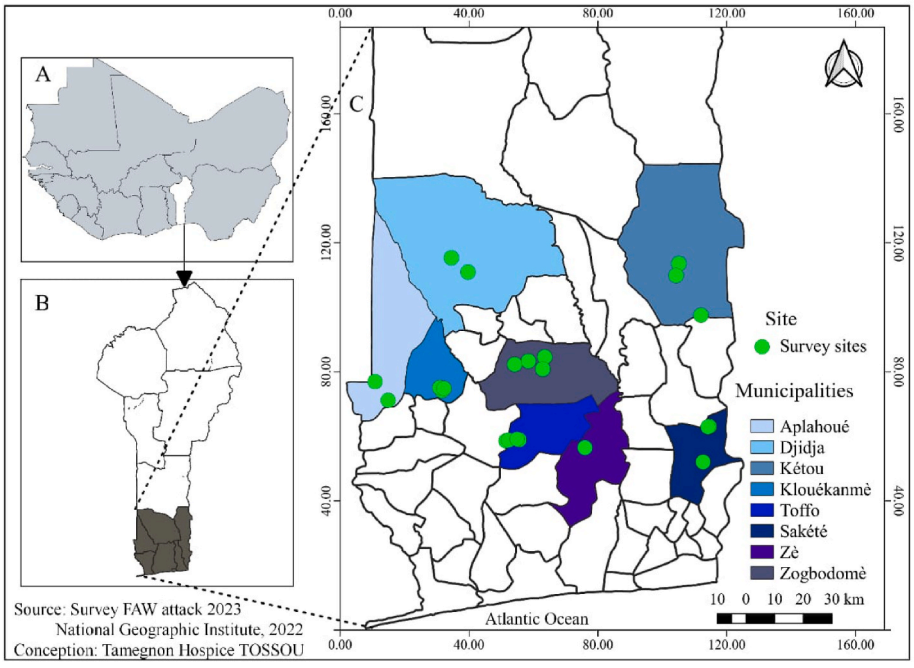

Fig. 1. The geographical distribution of the surveyed villages in southern Benin: (A) West Africa, (B) Republic of Benin, and (C) the southern part of Benin showing the surveyed sites.

population correction), $\frac{Z}{2}$ (3.8416) was the square of the z-score corresponding to a 95 % confidence level (i.e., Z = 1.96, which cuts off an area α = 0.05 in the tails of the standard normal distribution), *e* was the desired level of precision (margin of error), *p* was the estimated proportion of the population with the attribute of interest, and *q* was 1 − *p*, the complement of *p*. The proportion of *p* = 0.8, was used to reflect maximum variability, as most farmers use different methods to control FAW (Houngbo et al., 2020). The corresponding z-value was obtained from standard normal distribution tables.

Applying the finite population correction factor results in the actual sample size *n*, computed as in Equation (2).

$$n = \frac{n_0 N}{n_0 + (N-1)} \quad (2)$$

where *n* was the corrected (actual) sample size, n_0 the initial sample size calculated without correction, and *N*, the population size. According to the last General Population and Housing Census (INStaD, 2013), the total population in the study area is N = 962,446. The calculated sample size was n = 245, with 242 maize farmers subsequently surveyed. In each household, the questionnaire was addressed to the head or another member of the household (e.g., the spouse of the household head or another household member capable of responding to the questions).

In the survey, we collected data on farmers' socio-economic profile and farm characteristics, knowledge and perceptions of FAW, recognition of FAW damage, yield losses, variety of maize grown, and pest management practices. Farmers estimated yield loss as the proportion of production losses, expressed on a scale of 1–10, with 10 representing complete loss.

A pre-test was conducted with 10 farmers from a village, who were subsequently excluded from the study sample. This helped prevent any inconsistencies before the survey. The questionnaires were then administered to maize farmers at their homes. An interpreter was used when needed.

2.3. Data analysis

Descriptive statistics (means, standard deviations, and frequencies) were used to analyze the socio-economic characteristics of the respondents. To characterize farmers' perceptions and knowledge of FAW damage, Principal Component Analysis (PCA) and the distribution of response proportions were applied. PCA was used to identify patterns and reduce redundancy in farmers' responses, allowing for a clearer typology of farmers' views on FAW damage. Logistic regression (Logit model) was employed to predict factors influencing the choice and adoption of FAW control methods. The Logit model was appropriate as the dependent variables were binary. Detailed analyses on the modeling approach, its quality, predictive power, and specification can be found in the supplementary material section.

3. Results

3.1. Socio-economic characteristics of farmers

Agriculture is the main livelihood in southern Benin, with 93.39 % of respondents engaged in it as their primary occupation (Table 3). This activity is predominantly carried out by men (74.38 %) (MAEP, 2021). Secondary activities included food processing, trade, livestock (such as poultry, goats, sheep, cattle, or pigs), and Crafts. The average age within the sample was 43 years. Most farmers (98.3 %) owned their farms and financed their farming activities independently (93.4 %). The majority had no formal education (54.1 %). About 67.8 % were members of a farmer organization and maintained contact with research or extension services. Additionally, 26.4 % of farmers had received training in crop pest management.

Table 2
Distribution of study sites across two agroecological zones in southern Benin.

Study sites across two agroecological zones	Number of villages	Total number of households
Guinean zone		
Toffo (Atlantique Department)	3	30
Zè (Atlantique Department)	3	30
Zogbodomey (Zou Department)	3	30
Djidja (Zou Department)	3	30
Sudano-Guinean zone		
Sakété (Plateau Department)	3	30
Kétou (Plateau Department)	3	30
Aplahoué (Couffo Department)	3	30
Klouekanme (Couffo Department)	3	30

Table 3
Descriptive statistics on the socio-economic profiles of the surveyed farmers in southern Benin.

	Quantitative Variables	Mean	Standard Deviation
	Age of farmers	43.18	11.34
	Years of experience	24.91	11.84
	Qualitative Variables	**Number**	**Frequency (%)**
Gender	Female	62	25.62 %
	Male	180	74.38 %
Education level	None	131	54.13 %
	Primary	59	24.38 %
	Secondary	43	17.77 %
	University	9	3.72 %
Main activities	Agriculture	226	93.39 %
	Food processing	10	4.13 %
	Trading	3	1.24 %
	Handcraft	2	0.83 %
	Livestock	1	0.41 %
Means of farming	Own funds (yes)	219	90.50 %
	Loan (yes)	23	9.50 %
Owner of the field (yes)		238	98.35 %
Contact with research or extension services (yes)		164	67.77 %
Membership in a farmer organization (yes)		164	67.77 %
Participation in pest management training (yes)		64	26.45 %

3.2. Farmers' perceptions of FAW and its impact on maize farms

Approximately 96 % of farmers regarded FAW as a very dangerous pest, while only 0.4 % considered its damage negligible. The perceived damage was consistent across both agroecological zones, with 96.7 % of farmers in the Guinean zone and 95.6 % in the Sudano-Guinean zone reporting considerable damage by FAW. However, the likelihood of being affected by FAW varied with the farmers' primary area of activity: crop production (96.4 %), food processing (100 %), trade (50 %), crafts (50 %), and other activities (100 %).

3.2.1. Characterization of maize farmers' perceptions of FAW

Farmers' perceptions of FAW were explored by means of PCA. The eigenvalue table indicated that the first three axes, explaining 70 % of the observed variations, were sufficient for interpretation. Analysis of variable correlations (Fig. 2A) showed that the first component positively correlated with the development stage variable and negatively with research institution contact, pest management training, and total available (farming) area. The second component positively correlated with total (farming) area and experience as a victim of FAW attacks, but

Table 4
Logistic regression analysis performed to evaluate the factors influencing the choice of methods to control fall armyworm (FAW).

Logistic regression				Number of observations		232
				LR chi2 (10)		135.18
				Prob > chi2		0
Log Likelihood		−15.85		Pseudo R^2		0.81
UMCFAW[a]	Coef.	Std. Err.	z	$P > \|z\|$	[95 % Coef. Interval]	
Efficacy of the control option	1.865631	1.020871	1.83	0.068ns	−0.13524	3.866501
Perception of FAW damage	−1.77416	3.685533	−0.48	0.63ns	−8.99767	5.449357
Varieties grown by farmers	−0.4593	1.339645	−0.34	0.732ns	−3.08496	2.166353
Proportion of fields attacked	0.022678	0.027924	0.81	0.417ns	−0.03205	0.077408
Training on pest management	2.873639	1.772876	1.62	0.105ns	−0.60114	6.348412
Financial resources used for farming	−10.7162	3.187281	−3.36	0.001[a]	−16.9631	−4.4692
Experience in farming	0.36095	0.114552	3.15	0.002[a]	0.136394	0.585507
Level of education (Instruction)	0.349448	1.011679	0.35	0.73ns	−1.63341	2.332302
Marital status	−1.75484	1.427636	−1.23	0.219ns	−4.55295	1.043279
Gender	1.863062	1.449735	1.29	0.199ns	−0.97837	4.70449
Cons_	8.598617	12.2403	0.7	0.482ns	−15.3919	32.58917

[a] UMCFAW: Use of Methods to Control FAW; Coef: Coefficient; Std. Err.: Standard Error; z: Z-value; *P*: Probability; *: $p < 0.05$, ns: not significant.

negatively with pest management training, FAW knowledge, opinions, and affected plant parts. The third component positively correlated with FAW knowledge and victim experiences but negatively with total area, affected plant parts, and control methods. Of the nine perception criteria, seven effectively differentiated three farmers' groups: group 1 (41 %) included farmers with pest management training and research contact, associating FAW damage with plant maturity (Fig. 2 B); group 2 (21 %): trained farmers with extensive FAW knowledge, viewing attacks as highly dangerous to all plant parts (Fig. 2 B); and group 3 (17 %): farmers managing over 3 ha, experiencing FAW damages, and using chemical control methods (Fig. 2 C).

3.3. Farmers' knowledge of FAW

On average, 93 % of farmers were aware of FAW, with 95 % reporting infestations in their fields. Awareness levels varied across the two agroecological zones, with 99.2 % of farmers in the Guinean zone and 86.5 % in the Sudano-Guinean zone, demonstrating knowledge of the pest. Most respondents (95 %) could identify FAW caterpillars and recognized their impacts on maize plants. Farmers observed that the larvae initially create holes in young leaves, then bore into stems, damaging the plant's core and cobs. However, the most commonly noted symptoms of FAW damage included, respectively, the shredded leaves (88.8 %), destruction of the plant's inner tissue (80.5 %), cob damage (59.8 %), and the presence of moist, brownish-red frass (59.8 %). Maize was the most affected crop, with 96 % of farmers reporting infestations. Other affected crops included cowpeas (7 %), vegetables (6 %), groundnuts (5 %), and tomatoes (3 %), while rice was rarely attacked, with only 0.8 % of farmers noting infestations.

3.4. Type of maize variety grown by farmers and reasons of use

Most farmers in southern Benin prefer local maize varieties, with 67 % cultivating landraces and only 33 % opting for improved varieties. Farmers select the variety of maize planted based on specific criteria: 40 % prioritize yield, 46 % value processing qualities, and only 14 % consider pest resistance.

3.5. Estimated proportion of fields infested by FAW across two agroecological zones (2020–2022)

The severity of infestations was different from 2020 to 2022 across the two studied agroecological zones of southern Benin. Consistently lower infestations occurred in the Guinean zone (Fig. 3), where a higher proportion of low-damage cases were reported. For example, 69 % of farmers reported low infestation levels in 2022. By contrast, the Sudano-Guinean zone faced more severe infestations with higher proportions of heavy damage, particularly in 2021 when 42 % of farmers reported severe infestations (80–100 % of attacks). Even in years with lower levels of damage, like 2022, a considerable proportion of farmers (20 %) still faced moderate levels of FAW infestation in the Sudano-Guinean zone. The same trend was observed in 2020, where 48 % of farmers reported moderate damage (20–40 %) in the Sudano-Guinean zone, whereas only 23 % experienced the same level of damage in the Guinean zone. In both agroecological zones, farmers experienced a reduction in infestation levels in 2022, with a higher percentage of farmers reporting lower damage compared to 2021.

3.6. Perceived maize losses due to FAW infestations across two agroecological zones in southern Benin (2020–2022)

Yield losses attributed to FAW infestations varied from year to year. For instance, 47 % and 66 % of farmers reported production losses of up to 20 %, in 2021 and 2022, respectively. In 2021, 38 % of farmers in the Sudano-Guinean zone and 32 % in the Guinean zone suffered substantial losses (40 %), with the Sudano-Guinean zone being more severely affected. (Fig. 4).

3.7. Management options for FAW

Farmers have adopted different methods to control FAW attacks. About 73 % of respondents used synthetic insecticides. Approximately 11.6 % of farmers did not implement any control measures, while 2.5 % used agricultural practices, and only 1.2 % relied on biological pesticides such as botanical extracts to manage FAW infestations.

3.8. Analysis of the factors influencing the choice of FAW control measures

About 88.4 % of farmers have adopted a method (synthetic insecticide, biological insecticide, cultural practice) to control FAW, while 11.6 % have not. The variables that determined the use of a control method against FAW (UMCFAW) by farmers were (1) the years of experience in maize production ($P < 0.002$), (2) the availability of financial means ($P < 0.001$), (3) and to some extent, the effectiveness of the control method ($P < 0.068$) (see Table 4). The propensity for each farmer to use a control method against FAW increased with experience in maize production, availability of financial resources, and when they felt that the method was effective.

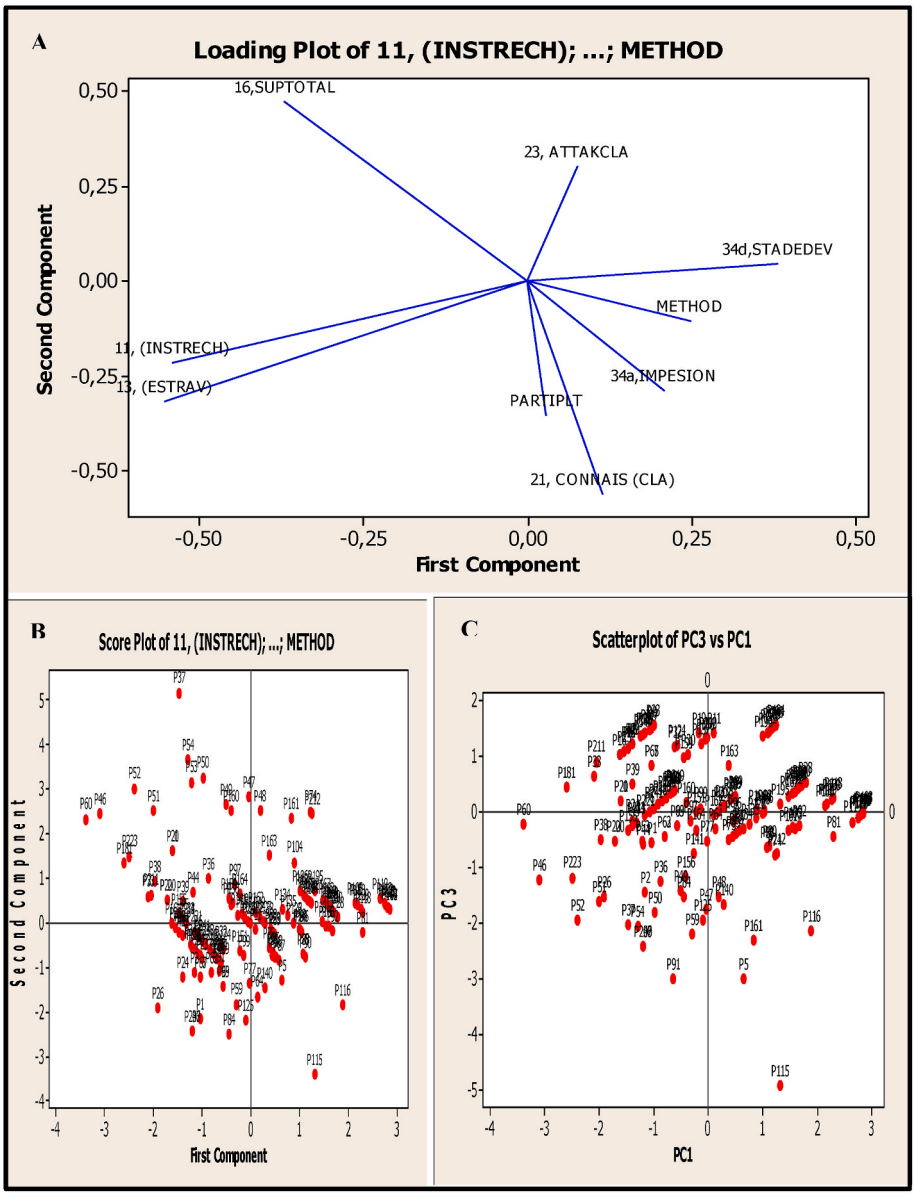

Fig. 2. Farmers' perceptions of fall armyworm (FAW). (2A) Correlations among 11 variables related to farmers' perceptions of FAW; (2B) Projection of farmers in axis 1 and 2 systems; (2C) Projection in axis 1 and 3 systems. STADEV (maize development stage), INSTRECH (research institution contact), ESTRAV (pest management training), SUPTOTAL (total maize area), VICTIM (FAW infestation experience), CONNAIS (knowledge of FAW), IMPESION (farmers' opinions), PARTIPLT (affected maize parts), and METHOD (control methods).

4. Discussions

Our study indicates a significant gap in farmers' understanding of FAW infestations. Farmers often misinterpret the timing of FAW attacks, believing that the insect invades the fields and causes damage only once the maize plant reaches maturity. However, the pest is known to typically attack maize 2–3 weeks after germination, targeting young vegetative stages (FAO, 2018). This implies that control measures might be most effective during the early larval stages of FAW (Hruska, A. J. 2019). The incorrect perception of the FAW appearance leads farmers to apply treatments, typically synthetic insecticides, after the damage has already occurred as by then the larvae have grown larger and have burrowed into the maize stem, where they are less exposed to insecticide applications, thereby greatly reducing the effectiveness of chemical control (FAO, 2018). Hence, the insecticide-based control strategy most of the farmers currently employ in southern Benin is very likely to fail to control the pest effectively. The fact that most of these farmers stated that they had received prior pest management training and were in contact with research and extension services underscores the critical need for appropriate and factual advice to farmers to improve their understanding of FAW biology, diagnostics and appropriate and efficient control practices (Houngbo et al., 2020). Increased awareness and training could enable timely and more effective pest management practices, reducing crop losses and improving the overall effectiveness of FAW control measures (Odong et al., 2024). Kumela et al. (2019) also reported that farmers in Ethiopia, Kenya, and Tanzania often detected FAW infestations only after significant crop damage, resulting in delayed and less effective insecticide applications. Likewise in Ghana, Tambo et al. (2020b) showed that farmers lack of knowledge of the biology of FAW and appropriate control methods resulted in ineffective management practices, including delayed insecticide applications. These and other studies highlight the importance of improving farmers' understanding of FAW for more effective and timely control.

While the Guinean zone had comparatively experienced lower

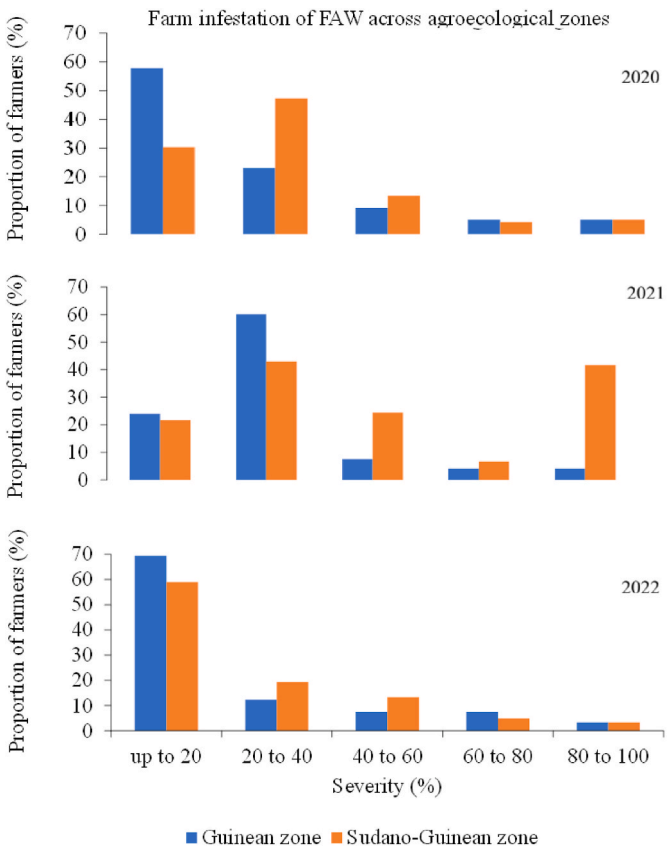

Fig. 3. Level of infestation of maize farms by fall armyworm (FAW) across two agroecological zones of southern Benin.

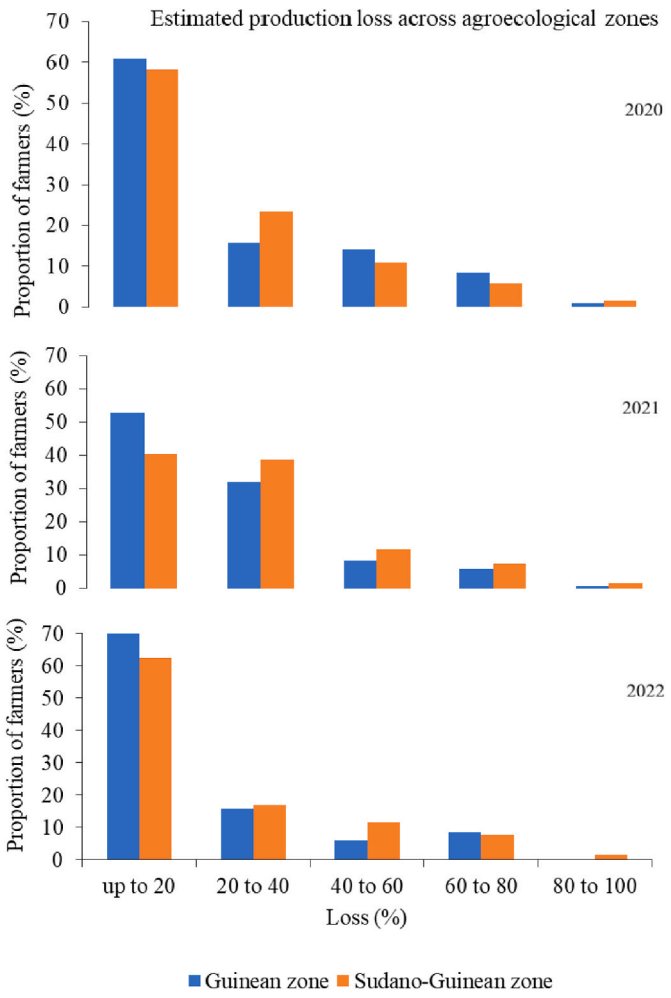

Fig. 4. Estimated production losses from 2020 to 2022 reported by maize farmers due to fall armyworm (FAW) infestations across two agroecological zones of southern Benin.

infestations (20 %), the Sudano-Guinean zone showed greater vulnerability and higher levels of FAW damage (40 %), particularly in 2021, resulting in yield losses of about 20–40 %. Similar figures were reported in maize in Burkina Faso with FAW infestation rates of up to 50 % and yield losses of 22 % (Yaméogo et al., 2024). Similarly, Ghana and Zambia recorded yield losses of 26 %–50 % (Matova et al., 2020). Considering the often observed inappropriately applied insecticide applications, we believe that the reported low levels of FAW infestation in maize fields, particularly in 2020 and 2022, were probably due to additional factors. These could include complex interactions with beneficial organisms, such as natural enemies, and environmental factors, like rainfall, as also reported by Varella et al. (2015). Possibly, indigenous generalist natural enemies of lepidopteran pests, i.e., parasitoids and predators, adapted with time to the new host and prey, thereby exerting more natural control on FAW. The complex of natural enemies associated with cereal-feeding lepidopteran pests in Africa could thus remain a potential strategy for integrated pest management (IPM) of FAW in Benin (Agboyi et al., 2020). Several studies have documented the natural enemies of the FAW in Benin and African countries. Agboyi et al. (2020) reported a diverse parasitoid complex in Ghana and Benin, including egg and larval parasitoids such as *Cotesia icipe* Fernandez-Triana & Fiaboe (Hymenoptera: Braconidae: Microgastrinae), *Chelonus bifoveolatus* Szépligeti (Hymenoptera: Braconidae: Cheloninae), *Coccygidium luteum* Brullé (Hymenoptera: Braconidae: Agathidinae), *Telenomus remus* Nixon (Hymenoptera: Scelionidae), and *Trichogramma* spp. Westwood (Hymenoptera: Trichogrammatidae). Similar parasitoid associations have been recorded in East Africa, where *Chelonus* spp. and *Coccygidium* spp. were widespread. In Uganda, Otim et al. (2021) reported several parasitoids, with *C. icipe* dominant in Ethiopia, *Palexorista zonata* Curran (Diptera: Tachinidae) the primary species in Kenya, and *Charops ater* Szépligeti (Hymenoptera: Ichneumonidae: Campopleginae) together with *C. luteum* common in both Kenya and Tanzania, representing key natural enemy associations with FAW in the region. However, parasitism rates were generally low to moderate (Otim et al., 2021), and fluctuate with host plant availability and FAW population dynamics, suggesting seasonal variations in the parasitoid complex (Winsou et al., 2022). Predators such as ants, particularly *Pheidole megacephala* Fabricius (Hymenoptera: Formicidae), spiders, and predatory beetles were observed preying on FAW eggs and larvae (Koffi et al., 2020b). While these generalist predators contribute to mortality, their effect is often inconsistent across fields and seasons. Entomopathogenic fungi, including *Beauveria bassiana* Balsamo-Crivelli (Ascomycota: Cordycipitaceae) and *Metarhizium anisopliae* Metschnikoff (Ascomycota: Clavicipitaceae), have also been identified in FAW populations, suggesting natural epizootics could contribute to pest suppression under favorable conditions (Ahissou et al., 2021; Otim et al., 2021). Environmental factors such as temperature and rainfall further influence FAW population dynamics and the diversity and abundance of its natural enemies (Tepa-Yotto et al., 2022).

The findings of this study indicate that synthetic insecticides are the predominant method employed by maize farmers in southern Benin to manage FAW infestations. Approximately 73 % of respondents reported using synthetic insecticides, while only 1.2 % utilized biological pesticides, such as botanical extracts, and 2.5 % relied on agricultural practices like crop rotation and intercropping. These observations were consistent with practices observed in other African countries, including Ghana, Zambia, Nigeria, Kenya, and Ethiopia (Day et al., 2017; Kumela et al., 2019; Togola et al., 2018). Yet, prior to the accidental introduction

of FAW into the country, Benin farmers were not using insecticides in maize production (Ahissou et al., 2022; Vodouhe et al., 2019). Based on our results, we believe two main factors might have triggered this switch to chemical pest control in maize: first, the catastrophic nature and magnitude of damage initially inflicted on maize crops by FAW, which created a sense of urgency among farmers to protect their livelihoods; secondly, the availability and subsidies to the use of synthetic insecticides in many FAW affected countries in Africa. This was accompanied and facilitated by many national and international organizations and national extension services providing subsidies and promoting the use of synthetic insecticides for FAW control (FAO, 2018). The prime reason for these actions was the widespread perception of FAW as an agricultural crisis of continental dimension, prompting many organizations and national governments to prioritize immediate access of farmers to chemical control as the presumed only available rapid control measure.

Several factors significantly influenced farmers' selection of FAW control methods. Experience in maize production was a determining factor, with more experienced farmers often favoring use of synthetic insecticides due to their perceived immediate effectiveness and familiarity. However, experience could also play a transformative role, as evidence from Ghana and Zambia indicates that farmers, when exposed to extension training, tend to diversify their pest management approaches and gradually adopt more sustainable practices (Tambo et al., 2023; Kumela et al., 2019). The availability of financial resources also played a crucial role, as the cost of synthetic insecticides can be prohibitive. Wealthier farmers may be able to afford them, potentially leading to over-reliance, while resource-constrained farmers might resort to less expensive methods, such as cultural practices or botanical pesticides, though the latter are often less effective and thus underutilized. This economic disparity underscores the need for affordable and accessible alternatives. Similar findings have been reported in Ghana, Nigeria, and Kenya, where economic limitations restrict farmers' capacity to adopt recommended pest control practices (Day et al., 2017; Tambo et al., 2023). Farmers' perceptions of a method's effectiveness affect its adoption. While synthetic insecticides are viewed as highly effective, their environmental and health risks may be significant. Studies suggest that with proper education and extension services, farmers can be guided towards adopting safer and more sustainable alternatives. For example, research in Ghana showed that with enhanced knowledge and access to information, farmers' reliance on synthetic pesticides decreased, and adoption of IPM practices increased (Tambo et al., 2023).

Despite the limited adoption of alternatives FAW control strategies, these approaches hold significant potential. Biological control methods, particularly the use of natural enemies such as *Trichogramma* spp. in augmentative releases, can effectively suppress FAW populations. In neighboring countries, such as Ghana and Burkina Faso, these practices have been integrated into FAW management strategies with positive outcomes. For instance, research in Ghana highlighted the effectiveness of cultural practices in managing FAW infestations, leading to reduced pesticide use and improved maize productivity (Tefera et al., 2019). Similarly, studies have found that cultural practices such as crop rotation, intercropping, and early planting can disrupt FAW life cycle and reduce infestations. In Burkina Faso, while farmers could identify natural enemies of FAW, they were generally unaware of their beneficial role (Ganou et al., 2024). The low adoption of these methods in Benin may reflect barriers such as limited awareness, inadequate access to biological control agents, and perceptions of low efficacy compared to chemicals.

5. Conclusion

This study examines farmers' perceptions and knowledge of FAW in southern Benin and determines the factors influencing the choice of control options against the pest. The study reveals a need to improve farmer and extension agents training, particularly in the recognition of early signs of attacks in conjunction with improved understanding of the pest biology, to prevent ill-timed and ineffective insecticide applications. The reported reduction in damage of FAW to maize can presumably be attributed to factors other than insecticide applications, which may include indigenous natural enemies that helps manage FAW populations. In addition, it is essential to take into account the economic viability of any control strategy, farmers' experience, and their perception of effectiveness when promoting pest management practices.

CRediT authorship contribution statement

Tamegnon Hospice Tossou: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jan-Henning Sommer:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Cyriaque Agboton:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **Razack Adeoti:** Writing – review & editing, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Manuele Tamò:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Conceptualization. **Florian M.W. Grundler:** Writing – review & editing, Validation, Supervision, Methodology. **Christian Borgemeister:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

Ethical approval

This study focused on the knowledge and perceptions of farmers on FAW damage and involved human participants. The study was conducted under ethical clearance approval after full review by the IITA (IRB) Ref No: IRB/007/2023 and ZEF ID 30c_Tamegnon Hospice Tossou.

Declaration of competing interest

The authors declare that they have no competing or conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cropro.2025.107509.

Data availability

Data will be made available on request.

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