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Economic Implication of the Fall Armyworm in Ekiti State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author AA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AAO initiated the study, wrote the introduction and methodology and interpreted the results. Author OOJ administered the questionnaires and did the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study was conducted to investigate the economic implication years after an outbreak of armyworm among the smallholding farmers in Ekiti State, Nigeria.
Methodology: A combination of purposive and snowball sampling techniques were used to select 60 respondents in four communities of the State. Thematic information from the semi-structured questionnaire related to the socio-economic characteristics of respondents, their enterprise characteristics, farmers' perception of significant constraints militating against maize production in the study area, as well as the efficacy of management strategies adopted by the respondents. Data was analyzed with descriptive statistics and Tobit regression.
Results: The study revealed that maize farming was mostly on smallholdings owned by males within the active age of 35 years. These farmers practised mixed cropping system whereby maize is planted with other crops in a shifting cultivation pattern. Also, the respondents identified lack of inputs, lack of fund and credit facilities, climate change, disease and pest outbreak, inadequate storage and processing facilities, and imperfect information dissemination as significant constraints

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militating against self-sufficiency in maize production. The most debilitating of these constraints was the outbreak of the Fall armyworm, which ravaged maize farms. Information gathered revealed that higher percentages of the respondents combated this notorious pest with the use of synthetic chemicals alongside other management approaches. The result of the gross margin revealed that net return per hectare to maize production was N27, 510. The Tobit results revealed that only pests' infestation in the previous year and age were significant with maize output loss.
Conclusion: The Fall armyworm outbreak resulted in an economic downturn for maize farmers in Ekiti State.

Keywords: Armyworm; maize; economy; smallholders; gross margin; tobit analysis.

1. INTRODUCTION

Maize (*Zea mais* L.) is one of the oldest cultivated and most productive grains in Africa serving as a vital staple diet for more than 300 million people on the continent [1]. In Nigeria, maize is the fourth most consumed cereal after sorghum, millet and rice [2]. Maize consists of 73% starch, 9% protein, 4% oil and 14% other components such as fibre, and supplies an energy density of 365 Kcal/100 [3]. Maize can be processed into a variety of food and industrial products, including sweeteners, oil, beverages, starch, industrial ethanol and fuel ethanol [3]. Thus, maize is also used as filler for plastics, paper, yarn, cigarette papers, insulation and adhesives, and for making explosives, dyes, synthetic rubber, and nylons [4]. Maize is used either alone or in combination with other food materials in several products such as bread, porridges, cakes, gruels, tortillas, cornbread, and couscous [5]. The demand for maize increases with population growth, especially with its inherent versatile characteristics [6]. Maize is the basis for food security in the southwestern part of Nigeria, dominated by smallholding farmers where at least 30% of their farmlands are devoted to maize production under various cropping systems [7,8].

The recurrent invasion of trans-boundary pest, the fall armyworm (*Spodoptera frugiperda*), has been a significant challenge to maize farmers. The fall armyworm is a voracious pest with a vast host range from economically important plant species with graminaceous plants as its preferred hosts [9]. The potential impact of fall armyworm on Africa's continent-wide maize production was estimated between 8.3 and 20.6 million tonnes annually, out of the total expected production of 39.3 million tonnes [10].

FAO [11] reported that about six states, one of which was Ekiti, were severely hit by the armyworm attack. This pest negatively affected the food production and incomes of farming households in Ekiti State Nigeria, resulting in a million dollars' worth of losses in earnings [11]. The highly invasive, aggressive and adaptable nature of this pest is an indication that it could be a potential pest to other economically significant crops [12]. Farmers respond to pest invasion either by neglecting infested fields while switching to other crops or rely heavily on chemical pesticides for its control [13]. The implication of farmers abandoning their maize farms is a reduction in maize production, leading to reduced household income, poverty and food insecurity. Also, the indiscriminate use of chemical pesticides poses a significant risk to human health and the environment. Hence, this study was aimed at assessing the implications of fall armyworm invasion on farmers' economic stability in Ekiti State. This was done by looking specifically at the socio-economic and enterprise characteristics of the farmers, their perception of the armyworm outbreak and maize output loss due to the outbreak.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out during maize planting season (2019) in Ekiti State, Nigeria. The State is located at latitude 7.667^0 N and longitudes 5.250^0 E, with a population estimate of 2.4 million people [14]. It is generally a hilly part of the country with a characteristic landscape that consists of old plains broken step-sided-out-crops that may occur singularly or in ridges. Ekiti land is buoyant in agricultural and forest resources with favourable climatic conditions to support its luxuriant vegetation. Seventy per cent of the people that reside in Ekiti State are farmers, and this attests to the agrarian nature. The State has abundant resources of different species of timber and food crops such as maize,

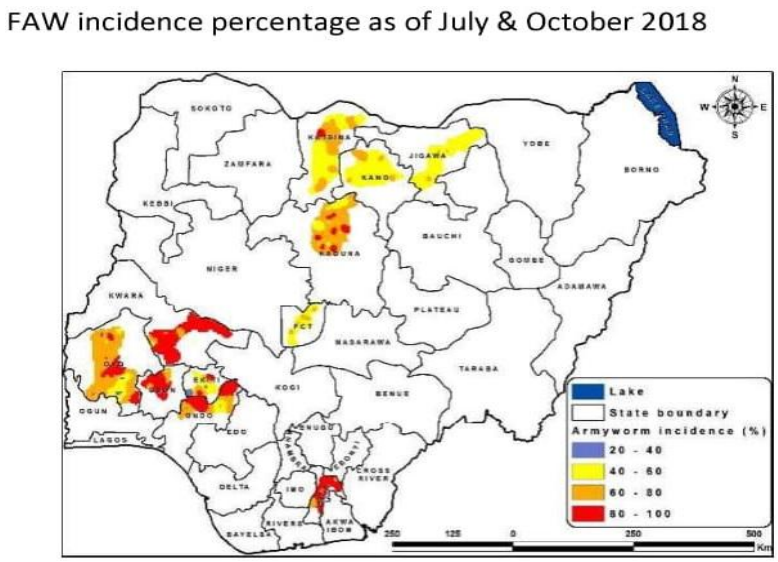

Fig. 1. Fall armyworm in Nigeria (FAO, 2018)

rice, yam, cocoyam, cassava and vegetables. Other notable cash crops like cocoa, citrus, kola nut and oil palm and varieties of fruits are also cultivated in commercial quantities.

2.2 Sampling Technique and Data Analysis

Four communities were purposively chosen out of which 15 respondents each were selected through the snowball method [15]. Sixty respondents were thus interviewed. The enumerator read the questionnaires to any of the farmers that were illiterates while those that could read and write filled the questionnaire under the enumerator's supervision in their respective residences. The four communities were selected because they were among the primary producers of maize. The respondents assisted in locating members of communities whose farms were ravaged by the outbreak. The semi-structured questionnaire had the following themes: socio-economic characteristics of the respondents, their enterprise characteristics, farmers' perceptions of significant constraints militating against maize production in the study area, as well as the efficacy of cultural practices and the use of chemical control. The categories of the socio-economic and enterprise characteristics of respondents are listed in Tables 1 and 2. The categories used for constraints to maize production in the study area is presented in Table 3, while the categories for the level of adoption of the control measure against armyworm are given in Table 4. Data obtained from the respondents were subjected to descriptive statistical analysis of frequency counts. At the same time, Tobit regression was used to analyze the output loss due to Fall armyworm infestation.

2.3 Variable Definitions and Model

Tobit analysis [16] was employed to study the determinants of maize output loss because the dependent variable is censored (indices having values between 0 and 1). The study used Stata software for the analysis. The standard Tobit model is defined as

$$y_i^* = x_i\beta + \varepsilon_i \quad (1)$$

$$y_i = y_i^* \quad \text{if} \quad y_i > 0$$

$$y_i = 0 \text{ if } y_i \leq 0$$

Where y_i^* is the latent dependent variable, y_i is the observed dependent variable, which is maize output loss in this case. x_i is the vector of the independent

variables, β is the vector of coefficients, and the ε_i's are assumed to be independently normally distributed: $\varepsilon_i \sim N(0, \sigma^2)$ (and therefore $y_i \sim N(x_i\beta, \sigma^2)$).

Maximum-likelihood estimation of the Tobit model can therefore, be calculated.

DPR= dummy). Whether there was an outbreak on the same plot last year
DAD= dummy). Whether there was an outbreak in an adjacent plot
CHM= Use of chemicals, (dummy). Whether farmers used chemical or not
AGE= Farmers' age (years).
EXT= (dummy). Whether farmers had extension contacts in the last one year
CRE= (dummy). Whether farmers had access to credits,
ELT= dummy). Whether farmers planted early or late maize,
FERT = dummy). Whether or not farmers used organic fertilizer,
EXP= Experience (years)
LAB= (dummy). Whether farmer used hired labour or otherwise
Y was obtained as the ratio of the area affected by armyworm and the total land area.

$$Y = \beta_0 + \beta_1 DPR + \beta_2 DAD + \beta_3 CHM + \beta_4 AGE + \beta_5 EXT + \beta_6 CRE + \beta_7 ELT + \beta_8 FERT + \beta_9 EXP + \beta_{10} LAB$$

3. RESULTS

3.1 Socio-economic Characteristics of the Respondents

Maize production was dominated by males (63.3%) who were still in their active years (65%) with a tertiary level of education (55%). The majority of these respondents had household sizes ranging between 4 and 6. Most of the respondents had farming experience ranging between 1and 5 years (50%) (Table 1).

3.2 Farmers' Enterprise Characteristics

The respondents' enterprise characteristics (Table 2) showed that maize is majorly cultivated in smallholdings of less than 2 hectares (41.7%) and 2-4 hectares (38.3%). The mixed-cropping system was more prevalent (75%) than the mono-cropping system (25%) among the respondents. The source of labour by the respondents was a distribution among their family members (35%), hired labourers (33.3%) and a combination of family and hired labourers (31.7%). The majority of the respondents reported that the farming enterprise was driven by personal savings (56.7%). Over a quarter (26.7%) of the respondents' sourced their capital through family bail-outs; only 16.7% of the respondents had access to soft loans.

3.3 Farmers' Perception of Significant Constraints Militating Against Maize Production

Table 3 shows respondents' perception of significant constraints militating against maize production in the study area. Lack of inputs was accepted by 66.7% respondents and disagreed by 33.3%, lack of funds/ credit facilities and

Table 1. Distribution of the respondents according to their social characteristics

Characteristics		Frequency	Percentage
Gender	Male	38	63.3
	Female	22	36.7
Age	15-24	13	21.7
	25-34	20	33.3
	35-44	19	31.7
	45-54	4	6.7
	55-64	4	6.7
Marital status	Single	30	50
	Married	30	50
Household size	1-3	13	21.7
	4-6	21	35
	7-9	13	21.7
	None	17	28.3
Educational status	Non-formal	2	3.3
	Primary	3	5
	Secondary	14	23.3
	Adult literacy	8	13.3
	Tertiary	33	55
Farming Experience (Years)	1-5	30	50
	6-10	21	35
	>10	9	15

Source: Field survey, 2019

Table 2. The respondents' farming history

Farming history		Frequencies	Percentages
Type of cropping system	Mono-cropping	15	25
	Mixed-cropping	45	75
Farm size (Ha)	<2	25	41.7
	2-4	23	38.3
	5-7	7	11.7
	8-10	5	8.3
Source of farm labour	Family	21	35
	Hired	20	33.3
	Both	19	31.7
Source of capital	Savings	34	56.7
	Family	16	26.7
	loan	10	16.7
Access to information	Monthly	3	5
	Bimonthly	7	11.7
	Once in 6 month	6	10
	Yearly	8	13.3
	None	36	60

Source: Field survey 2019

Table 3. Constraints to maize production in the study area

Characteristics		Frequency	Percentages	Rank
Lack of inputs	Agreed	40	66.7	4th
	Disagreed	20	33.3	
Lack of funds/ credit facilities	Agreed	52	86.7	2nd
	Disagreed	8	13.3	
Inadequate storage &processing facilities	Agreed	52	86.7	2nd
	Disagreed	8	13.3	
Climate change	Agreed	28	46.7	5th
	Disagreed	32	53.3	
Pest outbreak	Agreed	54	90	1st
	Disagreed	6	10	
Poor information dissemination	Agreed	45	75	3rd
	Disagreed	15	25	

Source: Field survey, 2019

inadequate storage and processing facilities as significant constraints had equal percentages of agreements (86.7%) and disagreements (13.3%) by the respondents. Nearly half (46.7%) of the respondents agreed to climate change as a significant constraint while 53.3 disagreed. Infestation by pest had 90% agreement by the respondents with 10% disagreement, and lack of adequate information by extension officers was attested by 75% of the respondents with a 25% disagreement.

3.4 Efficacy of the Cultural Practices

The suggestion of regular weeding as an effective control measure was attested by 43.3% but disagreed by 56.7%. The efficacy of cultural practices was also attested by 18.3%, while 81.7% of the respondents disagreed. Eight point three of the respondents agreed that the use of natural enemies effectively controlled the armyworm, whereas 91.7% disagreed (Table 4).

3.5 The Use of Chemical Control

The use of chemical control was most popular with agreement from 78.3% of the respondents and disagreement by 21.7% respondents (Table 4).

3.6 Gross Margin Analysis

The result of the Gross Margin analysis (Table 5a and b) revealed that maize farmers earned an average net return of N27, 510 per hectare in the year of armyworm invasion.

Table 4. Level of adoption of the control measure against armyworm

Control measures		Frequency	Percentage	Rank
Weeding	Agreed	26	43.3	2nd
	Disagreed	34	56.7	
Cultural practices	Agreed	11	18.3	3rd
	Disagreed	49	81.7	
Natural enemies	Agreed	5	8.3	4th
	Disagreed	55	91.7	
Chemical control	Agreed	47	78.3	1st
	Disagreed	13	21.7	

Source: Field survey, 2019

Table 5a. Gross margin analysis for of maize production during armyworm invasion

S\N	Items	Costs
1	fertilizers (litres)	13475
2	chemicals (litres)	9901.67
3	seeds (kg)	9615
4	labour (man-days)	15668.33
	Total Variable Cost	48660

Table 5b.

Variables	Values
Total variable cost (TVC)	48660
Total revenue (TR)	76170
Gross margin (GM)	27510

Source: Field survey 2019

3.7 Tobit Regression Parameter Estimates of Maize Output Loss

From the Tobit regression parameter result (Table 6), only two of the included variables, namely age and pest attack in the previous year were found to be significant. Pest attack in the previous year was significant with output loss at 1% level while age was significant with output loss at 5% level. Coefficient of variables such as pest attack in the adjacent plot, early or late maize, and use of chemical, use of fertilizer and years of experience were inversely related to output loss though not significant. Contact with extension agents; assess to credits, and labour source was directly proportional to maize output loss though not significant too.

4. DISCUSSION

4.1 Socio-economic Characteristics of the Respondents

Majority of the respondents were in the active age between 25 and 45 years. This implies that the maize farmers in the study area are young and full of innovation and vigour to practice agriculture. This corroborates the reports of Girei et al., [17] who reported that age influences the amount of physical effort being put to economic activity. A large number of respondents with five years of farming experience and exposure to tertiary education are indications of a gradual shift in the mindsets of the youths from white collar-jobs. This is a positive trend towards agricultural transformation because a high level of literacy tends to significantly improve agricultural productivity [18].

4.2 Farmers' Enterprise Characteristics

More significant percentages of the respondents were smallholder farmers with farm sizes between 2 and 4 hectares. This corroborates Mgbenka and Mbah [19], who stated that small-holders farmers in Nigeria make-up 80% farming population and are responsible for higher percentages of her food production. Land tenure system, one of the determinant factors of farm size is still very much entrenched in all the farming communities of Ekiti State. This system does not give an opportunity for a farmer to expand hectarage without encroaching another family's land. Mechanization is also very difficult to practice due to the nature of their fragmented holdings. Ibitola et al., [20] asserted that about half of the sampled maize farmers in Lagelu local government area of Oyo State-operated less than 1 ha while their average farm size was 1.2 hectares. Most of the respondents cultivated maize in a mixed cropping pattern. Jerumeh and Omonona [21] conducted a Markov analysis on cassava-based farmers in Nigeria and found that 95.5% of the farmers produced on a small-scale. Most of the farmers resorted to mixed cropping systems in order to maximize plot usage, though this has its own attendant problem of rapidly depleting the soil nutrients. Amos et al. [22] observed that food crop farmers in the savanna zone of Nigeria devoted a large proportion of

their farm size (as high as 60%) to mixed farming. Choice of labour source all dependent on the family size and composition, ability to pay for hired labour and the types of farm activities to be carried out. Despite government interjections through the provision of subsidies and soft loans aimed at ensuring that farming looks lucrative, it is noteworthy to say that many peasants in Nigeria don't have access to credit facilities from financial institutions and those who manage to get loans do it at a very high cost.

Extension workers who were supposed to be vehicles of disseminating information were also not visible on the farms.

4.3 Farmers' Perception of Significant Constraints Militating Against Maize Production

The majority (90%) of respondents agreed that armyworm amongst other factors such as lack of inputs, lack of credit facilities, climate change, inadequate storage and processing facilities and poor dissemination of information is a significant constraint militating against maize production in the study area. The appearance of armyworm in Nigeria in 2016 was the beginning of a big concern to maize farmers' livelihood. The armyworm invasion was estimated to pose threats of $3 to 6 billion in annual damage of maize and other crops on the African continent [23].

4.4 The Efficacy of Cultural Practices

Cultural practices such as shifting cultivation, apart from the fact that they allow the soil to replenish, also reduce the spread of pest and diseases. However, from the result of the descriptive analysis, about 87% of the respondents did not agree that a cultural practice was an effective method of curtailing the armyworm disaster. This view might be as a result of respondents' inexperience to tackle the invasion. Besides, the pest was first reported in 2016. The result also indicated that the older the farmer, the more the likelihood of output loss by about 4%. Older farmers were expected to possess the managerial acumen to handle pest emergencies than younger ones. The age distribution, however, revealed that over 86% of them were below 45 years old and more than half were under 35years. Hence that is the likelihood that many of them are youths who were new entrants.

4.5 The Use of Chemical Control

The fact that 78.3% of the respondents attested to the efficacy of chemical pesticides in combatting the menace of armyworm is an indication of its extensive use among the maize farmers. Alalade et al. [24] reported on the wide-usage of chemical pesticides among farmers in Kwara state. The result was not unexpected because chemical use has been a common practice to combat pest infestations before the advent of Fall armyworm in the State. The only issue the farmers were faced with was the choice of appropriate chemical to apply, which is a pointer to the need for advisory officers.

4.6 Gross Margin Analysis

The net revenue, as revealed by the gross margin analysis, would probably have been higher than this in standard years when there was no outbreak. Unfortunately, the poor recollection of the farmers and lack of record keeping on their sides did not allow us to investigate beyond the latest production season. This low revenue during the armyworm invasion must be due to the additional cost incurred for controlling the invasion and the value of the output that was lost on the farm. Comparatively, Sadiq et al. [25] examined the profitability and production efficiency of small-scale maize production in Niger State and found that maize production was profitable with an average net farm income of N48, 109 /hectare. Similarly, a net income of ₦ 102,300/ha was realized in 2018, by maize farmers in Cross River State, Ettah et al. [26]. Peradventure, armyworm outbreak was very mild in Cross River State, or the farmers had better management strategies of cushioning the effects of the decease. In another study conducted Nasarawa State, Girei et al., [17] found that a gross margin of N170, 594.50 was earned from one hectare of maize farm in 2018. Thus, all things being equal, the findings indicated that maize production was still profitable despite the armyworm invasion but relative to what obtained in the previous year higher revenue could have been realized by the farmers. This showed that the armyworm outbreak was more chronic and probably poorly managed in Ekiti State than many other states where the outbreak was reported. This boils down to the responsive nature of each State government to rapidly come to the rescue of peasants during emergency periods such as crop failure, flood, and drought, pest and disease outbreak. This can be deduced from the dearth

Table 6. Tobit regression result

Y (output loss)	Coefficient	Std. Error.	T	p>|t|
Diseases in previous year	0.6393003	0.3620086	1.74*	0.088
Armyworm in adjacent plot	-0.3612997	0.3553186	-1.02	0.314
Use of chemicals	-0.236059	0.4110491	-0.57	0.568
Ext	0.0910626	0.3652049	0.25	0.804
Age	0.036115	0.0131507	2.75**	0.008
CRE	0.328803	0.4005834	0.82	0.416
Early or late maize	-0.0430424	0.3820256	-0.11	0.911
Use of fertilizer	-0.3108873	0.4018941	-0.77	0.443
Experience	-0.0367635	0.0366586	-1.00	0.321
Labour source	0.0114403	0.3418489	0.03	0.973
Constant	0.0899311	0.717267	0.13	0.901
No of obs	60			
LR $chi^2(11)$	12.61			
Prob > chi^2	0.25			
pseudo R^2	0.06			
log-likelihood	-96.06			

*Source: Field survey (2019) *, ** represent significance at 1 % & 5% respectively*

of extension workers, who were supposed to be the channels of service delivery from the government to farmers, during this period of the outbreak.

4.7 Tobit Regression Parameter Estimates of Maize Output Loss

The result of the Tobit analysis was a rather bizarre one as it indicated that majority of the factors responsible for maize output loss were not within the model as it were, conceivably because the pest was a new one in south-west Nigeria. The results showed that a unit increase in the number of plots with armyworm outbreak in the previous year would increase the likelihood of maize output loss by 63%. This corroborates the fact that armyworms are likely to be rampant in a plot where they infested in previous years if such plots were cultivated continuously.

5. CONCLUSION

Fall armyworm outbreak in Nigeria met the farmers unprepared with the technical know-how for its management. The paucity of information dissemination by extension workers, lack of accessibility to financial assistance from credit institutions were significant challenges confronting farmers. We propose that the government should put in place a formidable agricultural support system to cushion the impact on farmers' livelihoods in case of any other future pest resurgence emergency. Farmers, on their parts, should be more careful in their selection of pesticides to tackle any strange development that threatens their productiveness and primary means of survival. Criteria such as accessibility, performance and effectiveness of pesticides, as well as impacts of such pesticides on human health, other non-target organisms and environment safety, should be adequately considered.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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