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Understanding the Nature and Effects of Armyworm Infestation in Maize Production in Nigeria: Empirical Evidence from Enugu State, Nigeria

[1]Mgbeodi, C. C. C., [1]Enete, A. A., *[2]Onyekuru, N. A., [1]Ukwuaba, I. C., [1]Onyekwe, C. and [1]Mukaila, R.
[1]Department of Agricultural Economics, University of Nigeria Nsukka
[2]Resource and Environmental Policy Research Centre, Department of Agricultural Economics, University of Nigeria, Nsukka.

*Corresponding author: anthony.onyekuru@unn.edu.ng

Abstract
This study assessed the nature and effects of armyworm infestation in maize production in Nigeria. The objectives of the study were to explore the nature of the outbreak, farmers' understanding and experiences about the effect of the pest invasion and the control measures adopted by the farmers. Data were collected using a structured questionnaire through a face-to-face interview. Descriptive statistics were used in the analysis of the data. Farmers were selected using purposive and multistage random sampling techniques. Results show that the armyworm outbreak has had very serious effects on maize production in the area, manifesting in the form of damage and unusual changes in the colour of the leaves, stems, and cobs. The majority of the respondents (98%) agreed that the outbreak started in 2016, and 85% agreed that the damage caused by the pest was to a great extent. About 53%, 14%, 12%, and 2% of the respondents used pesticides, regular weeding, local herbs and ashes, and removal of affected plants, respectively. Lack of awareness, inadequate pesticides, and low level of extension education were among the constraints identified in the control of the pest. Implementation of an integrated approach is therefore recommended for effective control of the pest.

Keywords: Maize, Armyworm, Disease, Economic loss, Food insecurity.

1.0 Introduction
The mainstay of economic growth of most countries in Sub-Saharan Africa, including Nigeria, is agriculture (Hoang, 2020). However, the performance of Nigeria's agricultural sector has often been described as being far below optimum, leading to declining local food production, food importation, and decreased farmers expected income and welfare (Chiaka *et al*., 2022). Although agriculture has grown in the last few years, the growth has been a result of area expansion, as productivity has been very low (Hemathilake & Gunathilake, 2022). Nigeria consequently had to resort to large importation to cope with the increasing demand for food. The decline in the performance of the sector has been largely attributed to the problems of pests and diseases (Zhang *et al*., 2018). The situation is worsened by the increasing threat due to new outbreaks of pests and diseases in recent times (Schneider *et al*., 2022; Subedi *et al*., 2023), which has affected different crops across the country, particularly maize (*Zea mays*). An unprecedented pest and disease outbreak has badly hit maize crop in the last few years. This situation has been attributed to different causes, including the already changing climatic conditions. Climate change brings about the increased threat of pest, disease, and weed invasion in agriculture (Skendžić *et al*., 2021; Samuel *et al*., 2018). With increasing climate change devastations, new pests and diseases may become present in previously uninhabitable areas or crops. This is due to changes in temperature, changes in precipitation, and water

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shortage (Malhi *et al*., 2021). This is probably the case with the armyworm outbreak in maize production in Nigeria.

Armyworm (*Spodoptera exempta)* is a severe pest of cereal crops and maize, in particular in Sub-Saharan Africa. The name armyworm derives from its behaviour of migrating in large numbers into fields similar to invading armies (Bessin, 2003). Its major features include the migratory moth with high variability in the nature and severity of infestation; the larvae (caterpillars), which occur in large numbers, are important pests that occur in large numbers. Particularly in sub-Saharan Africa, the Western Arabian Peninsula, the Pacific Islands, South East Asia, and Australia (Kalyebi *et al*., 2023; Ibrahim & Mochiah, 2017). When there is an outbreak, armyworms travel in large masses from one field to another in search of food to complete their development, devouring crops as they move. Significant yield losses have been consistently reported from infested areas (Kalyebi *et al*., 2023; Makgoba *et al*., 2021). Armyworm outbreaks can have catastrophic impacts on farmer's crops, their livelihoods, and food security (Makgoba *et al*., 2021). Its outbreaks can have catastrophic impacts on farmer's crops, their livelihoods, and food security (Makgoba *et al*., 2021). In most cases, infestation may cover the entire field, with eggs laid on grasses before planting. The application of herbicides may even aggravate the situation by forcing the pests to feed on maize as the grasses die (Bessin, 2016).

Maize is one of the most important food crops in Africa, providing income and livelihood to most of the communities in the continent and the world at large. Nigeria is the highest maize producer in Africa, followed by South Africa. In the ranking of 162 maize-producing countries, Nigeria ranks 14th, competing with countries such as Canada and Russia (FAO, 2023). Compared with other cereal production generally, maize still tops the table of Nigerian cereal production, with an average annual production of 10,485,000 units, Sorghum 6,124 units, and Rice 6,120 units (GIEWS, 2019). The recent fluctuation in output may not be unconnected with the outbreak of armyworm in 2016, sometimes causing the loss of the entire maize plant and its foliage or reducing its productivity, thereby reducing the output of the farmers. This has led to serious economic hardship among the maize farmers in the country. Regrettably, the production of maize has fallen short of expectations in meeting the food and industrial needs of Nigeria (Wossen *et al.*, 2023). Currently, this has led to a significant volume of maize products being imported annually and the crops' productivity has continued to remain low (Grote *et al.*, 2021). Worse still, armyworm infestation and menace remain unabated (Zhang *et al.*, 2018), leading to an even lower level of output and more erratic production (Makgoba *et al*., 2021).

Due to low capacity, poor knowledge, inadequate income, and poor investment in crop health management in developing economies like Nigeria, it is difficult to cope with crop losses, especially in situations of unfavourable environmental and disease conditions. The challenge of pest and disease infestation triggers adverse ripple effects on poor communities, upsetting food production, which makes them dependent on imported food (Tambo *et al.*, 2023). These have negative effects on the already poor nutrition of the people. Consequently, the farmers are left with no choice but to spend their income on pest and disease management under a situation of even poor technical support, which results in negative outcomes such as poor disease control, harmful results, and environmental pollution (Tambo *et al*., 2023; Zhang *et al*., 2018). In Enugu State particularly, the problem has been so devastating that some farmers even lost their entire fields. This caused serious food security problems in the state since most of the farmers were largely subsistent and relied heavily on their yield for sustenance. Such a situation poses a serious challenge, especially in developing economies like Nigeria, where over 70% of the population is already living under the poverty line. Thus, many will sink deeper into poverty.

The effect of armyworm attacks is not only felt by the farmers but also by the poultry farmers and feed millers, as maize is a major ingredient in the formulation of poultry feed (Fisayo et al., 2016). This

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development has prompted scholars and stakeholders to advocate for industrial substitutes for maize in feed production. As a result, feed millers are folding up gradually due to huge losses in yield (Benson *et al.*, 2020; Bessin, 2016; Senay *et al*., 2022). Poultry farmers who cannot cope with the price increase of feed occasioned by the outbreak have abandoned the business for now, while some are adopting either the 1-0-0 or 1-0-1 feeding formula for their birds to stay afloat (Fisayo *et al.*, 2016). A report by Akinfena (2017) shows that armyworm infestation is a very serious threat to the country's agricultural-dependent economy and threatens Nigeria's annual turnover of US$6b from the maize industry; this is because the disease has already been discovered in 22 states including Enugu state, ravaging several hectares of maize fields across the affected states. This situation has led to the soaring price of maize in the Nigerian market (Ozor *et al*., 2018).

Few studies, such as Amusa and Iken (2004) and Akinbode *et al.* (2014), have been conducted on maize disease conditions and management. However, despite these studies, gaps still exist in the areas of understanding the nature of the armyworm infestation and its effect on maize. In addition, no significant progress has been recorded in understanding the most effective control measure, particularly in Nigeria and, by extension, Enugu State. This situation could present serious limitations on policy formulation and decision-making concerning the prevention and control of pests and improvement in maize production. Thus, this study aims to assess the nature and effects of the outbreak of armyworm on maize production in Enugu State, Nigeria. Specifically, it describes the nature and manifestations of armyworm outbreaks in maize production, assesses control measures used by maize farmers, and identifies constraints faced by the farmers in coping with the pest outbreak in the study area.

2.0 Material and Methods

The study was conducted in Enugu State, Nigeria. The state has an estimated total land area of about 8,022.96 sq. Km (ENADEP, 2009). It lies entirely within the tropical zone between latitudes 5^0 56^0N and 7^0 05^0E of the Equator and longitudes 6^0 53^0N and 7^0 55^0E of the Greenwich Meridian (ENADEP, 2009). The estimated population of the study area was 5,396,098, with a density of 268 persons per sq km, which is high when compared with the average national density of about 96 persons per sq. Km (National Bureau of Statistics, 2023). Generally, Enugu State has fertile soil and favourable weather conditions for agriculture hence. The major crops produced are cassava, maize, cocoyam, plantain, banana, pineapple, yam and so many fruits and vegetables.

The sample for the study was selected using a multistage sampling procedure. In the first stage, three Local Government Areas (LGAs) with high concentrations of maize farmers were purposively selected. In the second stage, two farming communities were randomly selected from each of the LGAs, making a total of six communities. Finally, 20 maize farmers were randomly selected from each of the communities. A list of maize farmers was prepared in each selected area as provided by the All-Farmers Association of Nigeria (AFAN) in the various chapters within the state and with the assistance of the community leaders to make a total of 120 respondents for the study. Data were collected using a pretested structured questionnaire through a face-to-face oral interview.

Data collected were analysed using descriptive statistics, mean, percentages, tables, charts, and a Likert-type scale (mean score). A four-point Likert-type scale was employed to ascertain the level of seriousness of the constraints facing maize farmers in the study area. The scale was specified as follows: $\bar{X} = \frac{\sum fn}{N}$ ……..(1)

Where: X= Mean score, ∑ = Summation, f = frequency, N = Number of respondents, n = Likert nominal value. The following scaling procedure was adopted: strongly agree (SA) = 4, agree (A) =3, disagree (D) =2, and strongly disagree (SD) = 1. The values were added thus, 4 + 3 + 2 + 1 to give a total of 10. Their average was taken to give a mean of 2.50, which was regarded as the mean response level. Based on this,

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any score below 2.50 (MS<2.50) was taken as a weak factor and was not considered, while those with a mean score of above 2.50 (MS≥2.50) were taken as strong factors and considered in the analysis.

3.0 Results and Discussion

Nature and manifestations of armyworm outbreak in maize production

The majority of the respondents (95%**)** asserted that pest and disease attack in the area causes changes in the yield of maize. These findings agree with that of Rashid and Rasul (2011) that the changes are obvious in maize and cause reduced output of the farmers as well as the market value of maize in the area. With respect to damages, the majority of the respondents (85%) agreed that the damage caused by the pest on the yield was to a great extent and very great extent, respectively, of pest and disease attack in the area. This is in line with the findings of Tefera *et al.* (2011) that once there is an attack of pest and disease, the severity is always manifested as the attack ravages the affected area of the maize plant. The unusual changes affecting maize production, the nature of the change, and how the pest manifests in maize production in the area are presented in this section.

Also, the stage of attack, the pest causing the problem, the nature of the pest, changes in maize, and the extent of damage were all considered. The results in Table 1 indicate that almost all the respondents (99.09%) accepted that there is always an unusual change in colour whenever the maize plant comes under attack by armyworm which reduces maize production in the area. The result is in line with that of Tefera *et al* (2011), who found out that there is an overwhelming change in the colour of maize due to attacks by pests and diseases, as it is a noticeable sign of the outcome of such attacks. The recent outbreak of armyworms on maize plants affects the leaves, and as such, photosynthesis is reduced. Some of the maize plants turned yellow. It is also in resonance with the DFID (2017) report, which noted that about 28 countries have confirmed the presence of armyworm attacks in Africa, including Nigeria, within the period of the survey.

Table 1: The nature and manifestation of armyworm outbreak

Items	Frequency	Percentage
Notices unusual changes in maize plant		
Yes	109	99
No	1	0.91
Knowledge of periods of change		
2016 till date	108	98.18
Before 2016	2	1.82
Nature of pest attack on maize		
Damage on leaves	82	74.55
Damage on stems	15	13.64
Damage on cobs and harvested maize	13	11.82
Idea of the pest causing the problem		
Yes	107	97.27
No	3	2.73
Negative changes in maize yield		
Yes	105	95.45
No	5	4.55
The extent of damage caused		
No extent	8	7.27
Less extent	8	7.27
Great extent	48	43.64
Very great extent	46	41.82

Source: Field Survey, 2018

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With respect to the period when the outbreak began, there was a unanimous agreement amongst the respondents that the outbreak started in 2016 (98%). Only 2% of the respondents noticed the outbreak before 2016. The DFID (2017) also attested to this in their report. The majority of the farms visited were drastically affected by the invasion of the armyworm. Describing the attack, 75% of the respondents indicated that armyworm infestation on maize mostly manifests with damages on leaves. This finding conforms with the result of Onuk *et al*. (2010) that the susceptibility of the leaves and their broadness makes them attractive to pest and disease invasion. About 14% of the respondents acknowledged that the stem was equally affected, while the remaining (12%) showed evidence of the damage on cobs, which reduces maize yield in terms of quantity and quality. It was also noted that the pest attacked different parts of the crop depending on the stage it infested the farm. These findings are in line with Olabanji (2017), citing the FAO report (2018), which stated that armyworm causes damage by feeding on both vegetative and reproductive structures. Also, Abrahams *et al*. (2017), in their work noted that the stem of young plants may be cut, serving as proof of damage. By hiding inside the funnel of leaves, older larvae can avoid natural enemies and gain some level of protection from pesticide applications. Larger larvae can reduce the yield quality and quantity in older plants when they bore into developing maize cobs, which are vital reproductive structures.

Regarding the stage of the attack on maize plants (Fig 1), 35% of the respondents agreed that the pest attacked maize after sprouting when the leaves were very succulent. About 17% of the respondents experienced the attack of the armyworm on their maize plant before tasselling, while 2% saw the pest either in the cobs of the maize in the field or on harvested maize. This may be attributed to the period of attack of the Armyworm or the stage in their life formation.

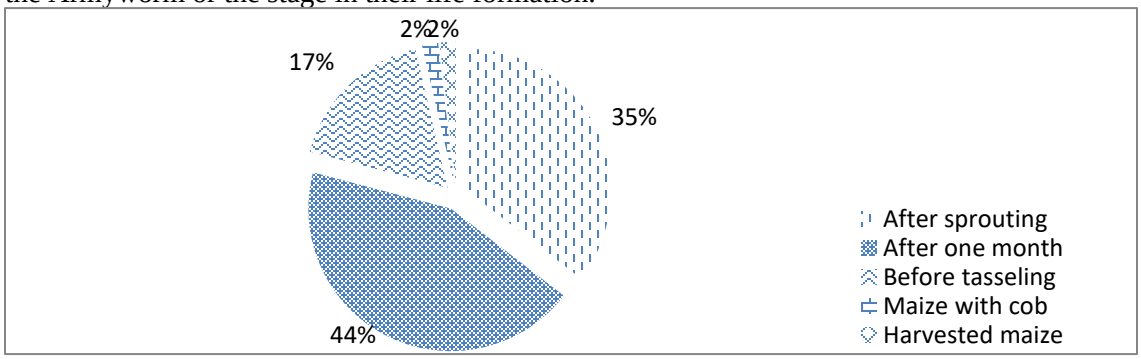

Figure 1: Stage of Attack of Armyworm

The majority of the respondents (55%) agreed that maize infested by armyworms usually has its leaves eaten up by the pest (Fig 2). About 25% of the respondents noted that the most severely attacked crops had stunted growth, while 17%, 2%, and 1% stated that the leaves of the plants turned yellow, some died, and others had their leaves eaten and fell off the plants, depending on the severity of the attack.

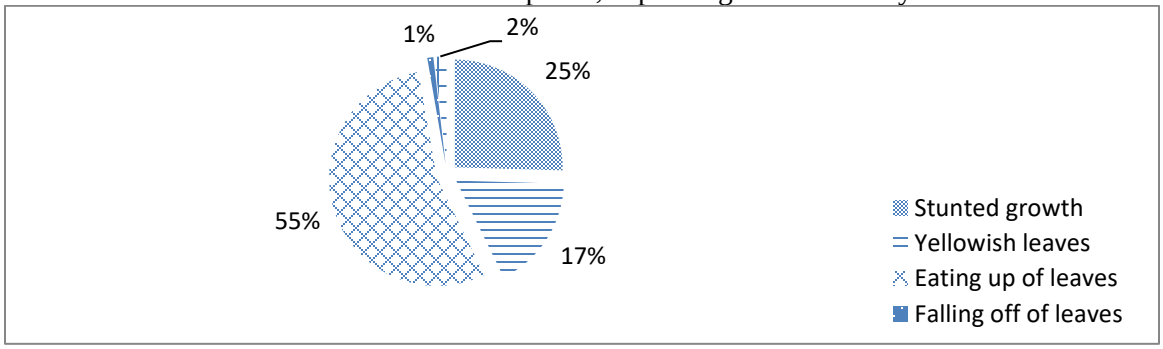

Figure 2: Nature of Change

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On the idea of pests causing the problem, the Majority (97%) answered in affirmation that armyworms were causing the damage at the time of the survey. This confirms the findings of Rashid and Rasul (2011) that the reoccurrence of the problem makes almost every farmer aware of the pest and disease causing the problem of pest outbreaks. About 3% did not know the pest causing the problem.

Regarding the stage in the life cycle of the armyworm (Fig 3), about 53% of the respondents agreed that it is the larvae stage that causes the havoc. This also explains why the attack is mostly on leaves since the early formation of armyworms (larvae) feeds mostly on the leafy parts of a plant. About 33% indicated that the pest is in a beetle form, and 14% added that it is the pupa stage that causes the havoc.

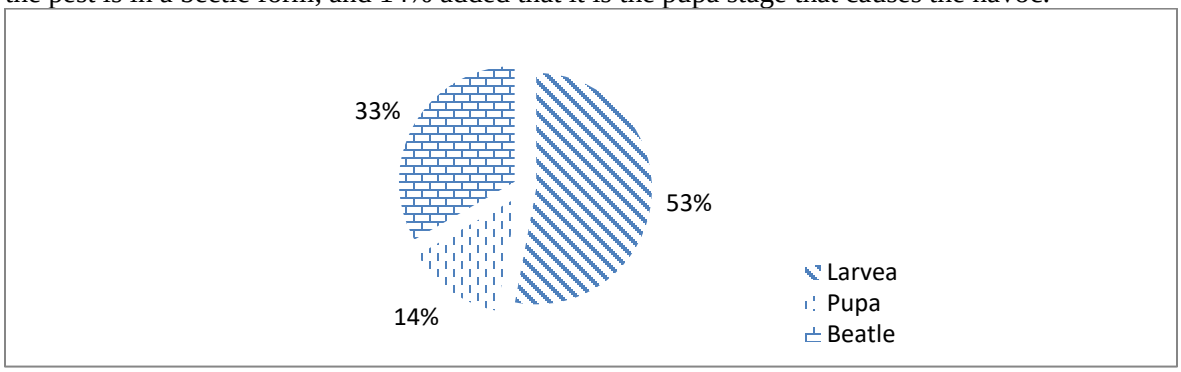

Figure 3: Stages in the life cycle of armyworm that causes the Infestation

Regarding the nature of damage caused by the pest on maize leaves (Fig. 4), 52% of the respondents reported that the pest ate up the leaves of the maize plant, 29% indicated that some of the leaves that were eaten up by the pest fell off the plant, 10% reported that the attacked leaves turned yellow, 5% said that holes are bored on the leaves while 4% indicated that some of the plants die. This is in resonance with the work of Abraham et al. (2017), who noted that young larvae usually feed on leaves, creating a characteristic windowing effect.

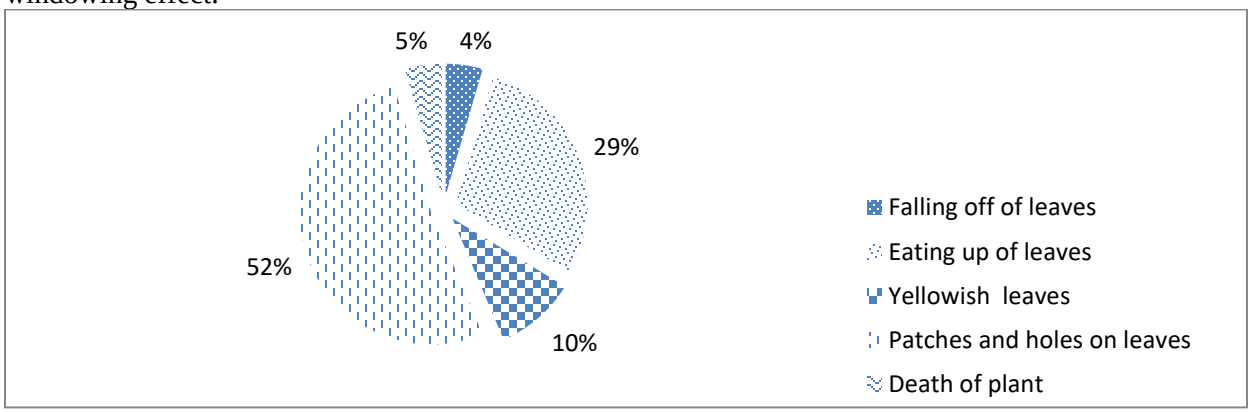

Figure 4: Nature of Damage on Leaves

About 64% of the respondents agreed that the pest damaged the stem by boring holes in the maize plant, 24% attested that the pest ate up some of the stems, 9% noted that the productive structure was affected and the maize plant lodged and 3% submitted that the maize severely affected sometimes die (Fig 5). This is also in agreement with Abraham *et al*. (2017), who noted that early in the season, the feeding of the armyworm can kill the growing point, a symptom called 'dead heart' in maize, which prevents cob formation. A physical visit to some of the farms showed that moist sawdust-like particles were present on the funnels and upper leaves. This can be a sign of larval feeding.

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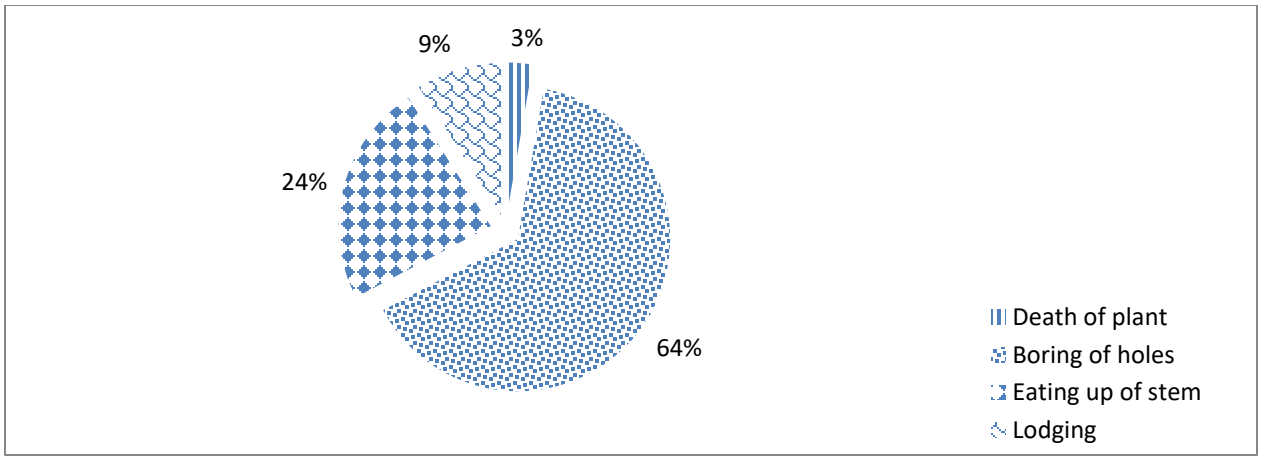

Figure 5: Damage on Stem

Damage also was noticed on the cobs as 25% of the respondents said that the pest bore holes on the cobs, 20% noticed that after the attack, small cobs were produced, 25% stated that the pest ate up the seeds, 16% reported that exudates of their waste were observed in the cobs while 14% said that the pest remained in the cobs after infestation (Fig 6). This implies that when the pest ate the leaves of the maize plant, there was not much photosynthesis, which might have led to the reduction in size of the cobs. This finding is in agreement with the assertion of Abraham *et al*. (2017) that FAW is likely to directly affect productivity due to yield losses resulting from a decrease in the size of cobs produced by the maize after the attack.

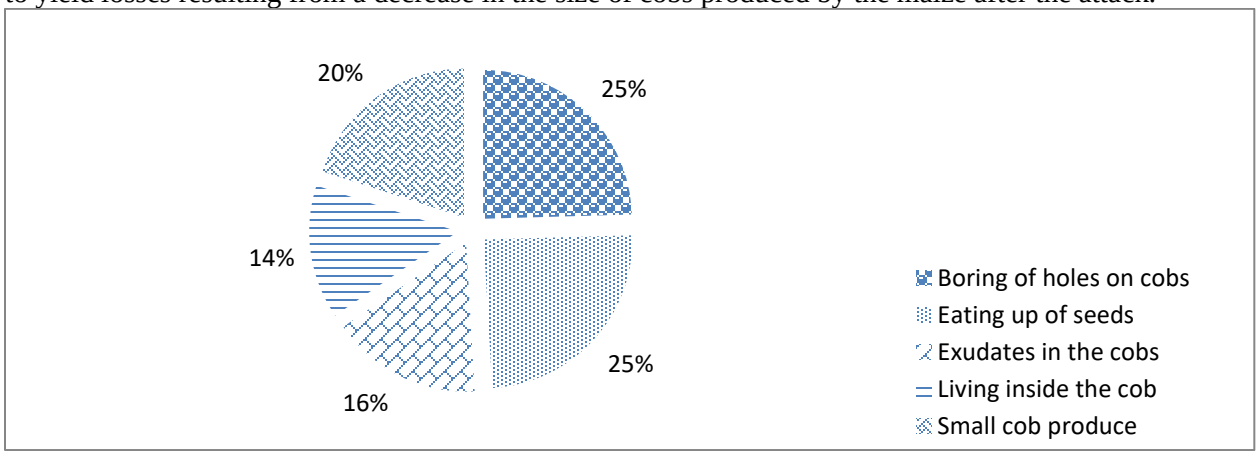

Figure 6: Nature of Damage on Cobs

This, as noted by Abraham et al. (2017), that FAW increases capital costs, as there will be yield losses, an increased need for labour, and specific knowledge required to handle the pest as well as the ability of agricultural lands to respond to shocks; and financially, through its effect on income and increasing the cost of production due to costs of control (defined as the cost of technology and its application). It will also indirectly affect households' social and physical capital. The nation's international trade with other countries will also suffer from this damage as the trade partners begin to fear that the pest will also affect their countries. Not only will the farmer's income suffer but the country's GDP will equally suffer, leading to increased poverty and hunger.

Control Measures

Figure 7 presents the control measures adopted by maize farmers. These are hand picking, the use of ash and local herbs, weeding the farm, uprooting affected plants, and the use of pesticides/insecticides.

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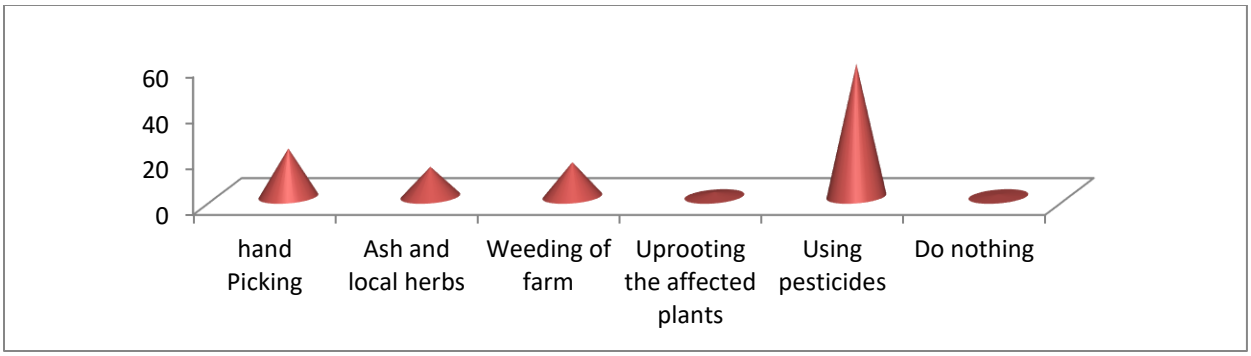

Figure 7: Control Measures

This result indicates that the majority (53%) of the respondents use pesticides as their control measure against armyworms of maize in the area. This development could be because of the current intensified governments' provision and campaign for the use of pesticides in the state. The result conforms with that of Farauta *et al*. (2012) that pesticides are the most convenient and reliable means of preventing and controlling pest and disease infestation on the farm. Furthermore, 19% of the respondents indicated that they handpicked the pest to depopulate the number. About 14% adopted regular weeding as their control measure, while 12% used local herbs and ashes, and 2% uprooted some of the maize plants that were damaged. This is in line with Abraham *et al*. (2017), who noted in their work that the majority of the farmers in the study area who used cultural control techniques, such as hand-picking egg masses and caterpillars and weeding, stated that these measures were 'somewhat successful.' About 1% of the respondents did not do anything on the affected farms; this may be due lack of knowledge on what to do or that they may not have resources to enable them to combat the pest. It may also be that there was total loss of crops so the farmers did not need to waste more resources in controlling the outbreak.

Different kinds of pesticides used in controlling armyworm infestation

Regarding different kinds of pesticides used by the farmers in the control of armyworms, findings show that about 17% of the respondents use a pesticide called a punch, 11% used Red force and 6% used Art Force 55 (Figs. 8). However, these are not some of the recommended pesticides by Standards Organisation of Nigeria (SON) and National Agency for Food and Drug Administration and Control (NAFDAC) who are responsible for setting the standard, controls and enforcement.

About 32% of the respondents used one form of chemical or the other that did not have names nor their chemical components known, which are purchased from the local markets. Most of the pesticides observed during the survey were seen in containers that could not be identified with any known name. These chemicals were available in the local markets, which the farmers were experimenting with. This situation poses a great danger to the crops, the farmers, the maize they produce, and to the environment. This is because the unregulated nature of these applications may increase the pesticide load in the environment, be counterproductive to other useful insects and animals and may even poison the farmers. Furthermore, it may increase the presence of the quantity of chemicals in the food we eat and this is very dangerous.

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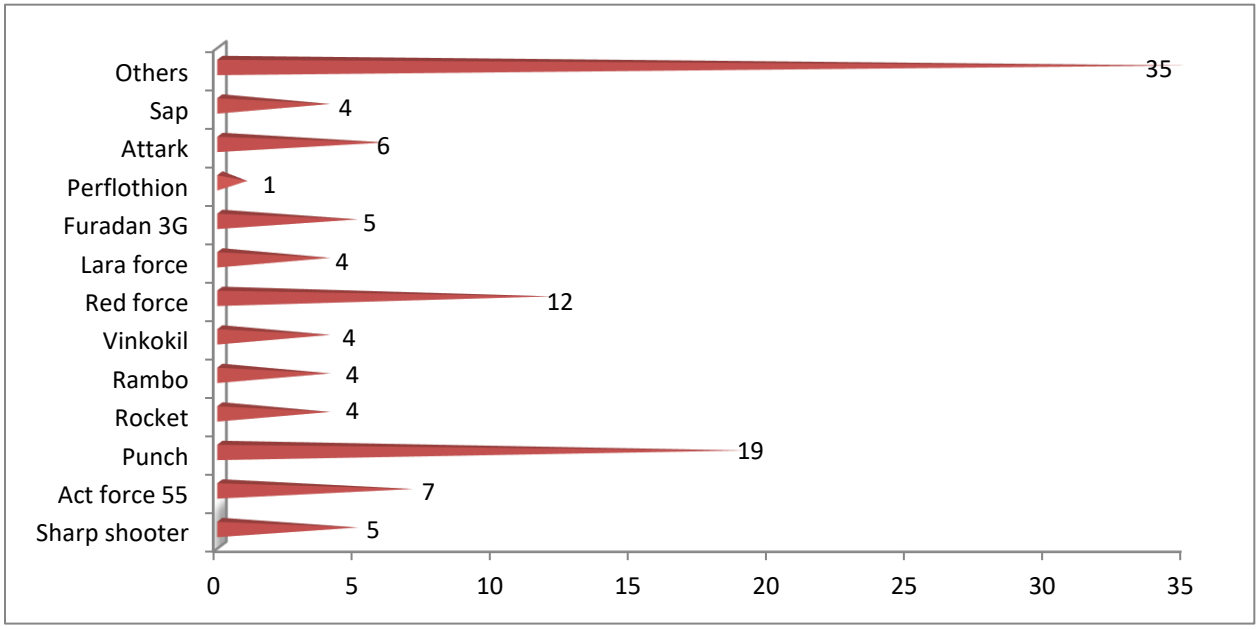

Figure 8: Different kinds of Pesticides used in Controlling Armyworm Infestation

This is in line with Kafkas *et al.* (2018) that, in African countries, there is still unregulated circulation and use of older pesticide molecules which are hazardous and have been banned in industrialized countries. These products put farmers' and consumers' health and their environments at risk. Also, their use may result in high pesticide residue levels that could negatively affect the marketability of crops both domestically and internationally—furthermore, Abraham. (2017) submitted that the selling of fake and adulterated products such as pesticides (and other inputs) is a widespread problem in Africa, which may lead to increased pesticide resistance in crops, making farmers more cautious about buying inputs in the future in order not to waste money.

There are already frequent reports of pesticides 'not working' in Africa due to inappropriate use, substandard pesticides, or the presence of resistance (Corbel et al., 2007; Asogwa & Dongo, 2009). In a survey in Ghana and Zambia by CABI (2017) of the farmers who had used pesticides for FAW control, only 27% reported total success, with 57% and 16% reporting the control as somewhat or not successful, respectively.

Mode of Application of Chemicals by the Farmers

About 67% of the farmers reported that the chemicals were mixed with water and sprayed, 15% claimed they dropped the dry pesticides on the foliage while 17% applied them on the basal areas (Fig.9). These varieties of the mode of application of the chemical could be to take care of the varying modes of operation by the pest. It could also be attributed to some of the activities of the pest which the farmers would want to curb. This finding is in agreement with those of Ibrahim *et al*. (2017) that larvae occur in large numbers when there is an outbreak, which could, therefore, manifest in different forms, attacking different parts of the crop. Also, Durham *al.* (2016) in their work reported that in no-till or reduced tillage systems, the infestation may cover the entire field, thus making it paramount to use different methods to control the infestation if it is to be effective. Furthermore, the farmers submitted that the stage of development of pest attack determines the method of pesticide application. This is also in line with the opinion of the U.S. Environmental Protection Agency (2019) that the application method one chooses to control pests and diseases depends on such factors as the target site characteristics, the nature and habits of the target pest,

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and the pesticide formulation properties. The suitability of the application equipment, cost, and efficiency of alternative methods must also be considered in such application.

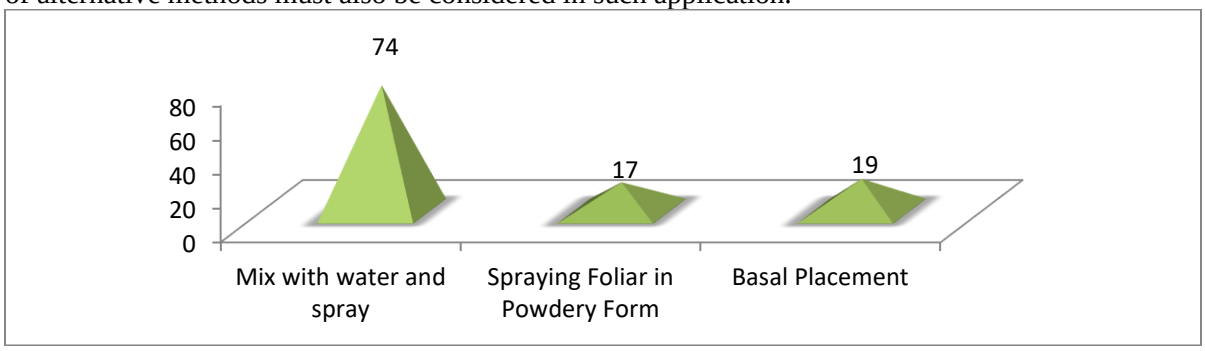

Figure 9: How Pesticides are Applied

Replanting of the affected area

The majority (75%) agreed that replanting the affected plot was their way of controlling maize pests in the area (Fig. 10). This could be attributed to the fact that this method is traditional and devoid of modern farming expertise. It could equally be that when the crops are replanted, they must have eluded the stage of the pest's development when it is most virulent.

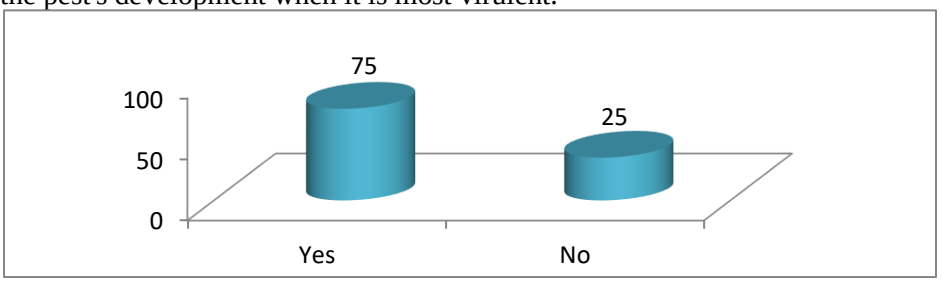

Figure 10: Replanting of affected Plot

Constraints Experienced by farmers in the control of armyworm infestation

The mean score rating of the constraints faced by the farmers in the control of armyworms in the study area indicates that lack of awareness on what to do (M =3.39), inadequate finance to buy insecticides (M=3.25), inadequate labour supply (M=2.90), lack of improved maize varieties (M=3.15), inadequate herbicides and pesticides (M=3.21), inadequate fertilizer(M=3.14), low level of education (M=3.34), and poor extension communication system (M=2.92), are the major constraints limiting the control of pest among farmers. This implies that farmers lack early information on the outbreak and what to do when there is an outbreak, as the farmers face serious challenges in the control of the infestation in the area. These variables were also found to be important in the study by Tefera *et al.* (2011) as posing serious problems to maize production. These challenges have incapacitated the maize farmers to produce efficiently. Inadequate labour supplies and lack of improved maize varieties were both found to be constraints in the study by Ettah (2017) as constituting impediments to maize production and resulting in low output.

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Table 2. Constraints faced by Maize Farmers

Variables	Mean	Rank	Remark
Lack of awareness about what to do	3.39	1st	A
Inadequate finance to buy insecticides	3.25	3rd	A
Inadequate labour supply	2.90	8th	A
Lack of improved maize varieties	3.15	5th	A
High cost of improved maize seeds	2.84	9th	A
Inadequate herbicides and pesticides	3.21	4th	A
Inadequate fertilizer	3.14	6th	A
Low level of education to understand what to do	3.15	5th	A
Poor extension communication system	3.34	2nd	A
Late delivery of farm input	2.92	7th	A
No challenge	1.34	10th	SD

A = Agree, SD = Strongly disagree.
Source: Field Survey, 2018

The problem of the high cost of improved varieties of maize could be attributed to the poor extension communication system maize farmers are experiencing in the study area, which has made them unaware of appropriate areas to get improved varieties of maize at reduced rates. Inadequate herbicides, pesticides and fertilizer were also a problem because of the difficulty in accessing these inputs and the cost.

4.0 Conclusion and Recommendation

The impact of armyworm infestation on maize crops cannot be overemphasized; the outbreak has had very serious effects on maize production in Enugu state, Nigeria, which manifests in the forms of damages, loss in yield, and food insecurity. Farmers and the government have undertaken different measures to control its impact; however, inadequate finance to buy insecticides, lack of improved maize varieties, low level of education, and poor extension services were the major constraints faced by the farmers in implementing effective control strategies. Efforts of the farmers, as well as the government, against the armyworm outbreak, are still very rudimentary and uncoordinated. Given the severity of the issue, urgent collective action among stakeholders is required to mitigate its impact. Therefore, there is a need for coordinated research to bring about effective control strategies for the pest and recommended pesticides with their right specifications should be made available and affordable by the various levels of government for use by maize farmers. Also, stakeholders in the maize value chain should make available to farmers disease and pest-resistant maize varieties. Early planting of maize is also recommended to escape the period of the invasion of pests and diseases in the area. Extension services in the country need to be strengthened because of their importance in farmers' education.

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