VOLUME 10 ISSUE 2 2024

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 10, No. 2, 883-891 (2024)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Awareness, Knowledge, and Effects of Fall Armyworm (*Spodoptera frugiperda*) Among Maize Farmers in Imo State, Nigeria

Chikaire J.U.[1]*, Osuji N.M.[2], Ibe M.N.[1], Ugwoke F.O.[1], Ajaero J.O.[1], Godson–Ibeji C.C.[1], Onoh P.A.[1] and Okonya-Chukwu C.R.[1]

[1]Department of Agricultural Extension, Federal University of Technology, Owerri, Imo State, Nigeria.
[2]Department of Agribusiness, Federal University of Technology, Owerri, Imo State, Nigeria

**Corresponding Author*

Received: 6th May, 2024; **Accepted:** 21st September, 2024; **Published online:** 29th September, 2024

https://doi.org/10.33745/ijzi.2024.v10i02.086

Abstract: Armyworm has been a serious nightmare for maize farmers throughout the century, ravaging maize plants from farm to farm. This study therefore, examines maize farmer's awareness of armyworm, their knowledge of armyworm and its effect on maize farmers in Imo State, Nigeria. Purposive sampling technique was used to elicit information from 450 maize farmers selected randomly using structured questionnaire and oral discussion. Data collected were analyzed using descriptive tools such as percentages, mean and standard deviation. Result shows that all the maize farmers (100%) were aware of the armyworm menace. The following sources of information on Fall armyworm exist-- agro-veterinary shops (95.5%), fellow farmers (95.3%), personal experience (100%), town criers (84.4%) and cooperative societies (68.8%). The farmers have knowledge of armyworm as a small crawling worm (M=2.59), that eats large portion of maize leaves (M=3.05), deformed maize grains (M=3.01), fecal deposits on leaves (M=3.05) among others. The effects on maize includes total loss of yield on maize production (100%), stunted growth (96%), leads to death of maize plants (96%) and loss of income (96%), from maize, increase malnutrition (97.5%), reduces quality and quantity of maize crop (98.8%), heighten food security concern (94.8%) among others.

Keywords: Fall Armyworm, Information, Small crawling worm, Maize, Farmers

Citation: Chikaire J.U., Osuji N.M., Ibe M.N., Ugwoke F.O., Ajaero J.O., Godson–Ibeji C.C., Onoh P.A. and Okonya-Chukwu CR.: Awareness, knowledge, and effects of fall armyworm (*Spodoptera frugiperda*) among maize farmers in Imo State, Nigeria. Intern. J. Zool. Invest. 10(2): 883-891, 2024.

https://doi.org/10.33745/ijzi.2024.v10i02.086

Introduction

Fall armyworm (FAW), *Spodoptera frugiperda,* is a native of the tropical and sub-tropical Americas, where it is known to have seriously done great damage to many crop species especially maize (FAO, 2017a, 2020). The FAW was first detected in West Africa in the year 2016 when it invaded countries like Benin, Nigeria, São Tomé and Príncipe; and Togo. Within two years of its

appearance, it has invaded all of sub-Saharan Africa, Imo State, Nigeria inclusive (FAO, 2020).

The FAW is a moth (adult stage) with a damaging photo-phagous stage called larvae or caterpillar, known to feed on several different crop species including maize, sorghum, millet, sugarcane and vegetables. The life cycle of FAW is completed in about 13 days during summer months and can extend to 60-90 days in cooler temperatures (FAO, 2017b). The number of eggs it lays is worrisome from 1500 to over 2000, and the duration of egg to hatchery is 2 to 3 days during the warm/summer months. FAW has six larval instars, which tend to conceal themselves during the brightest time of day and pupates in the soil at a depth of 2 to 8 cm (FAO, 2017a, 2020).

The FAW, a transboundary damaging pest of cereals has become cosmopolitan in distribution. It has the ability to spread fast into new areas, multiply and establish quickly, making it a huge threat to food security and life of many rural dwellers, whose livelihoods depend on agriculture (FAO, 2020), as it primarily attacks maize plants. In Africa, FAW consumes a wide variety of cereal crops, particularly maize which is the major staple grown by most farmers. This makes FAW a current threat to food security and incomes and continues to threaten the livelihoods of millions of people as it has led to increased production costs and hinders trade between countries. The FAW causes especially severe damage to maize, feeding on virtually all parts of the plant, resulting in total crop failure (de Almeida Sarmento *et al*., 2002).

One of the main cereal crops grown worldwide is maize (*Zea mays*). As a grain crop used for trade, food, feed, and industrial purposes, it is the second most significant cereal crop globally, after wheat, and it makes a significant contribution to the total production of cereal grains in the global economy (Pingali, 2001). According to Macauley (2015), maize is the most significant staple cereal crop cultivated by small-scale farmers in sub-Saharan Africa and is a major crop in the majority of other African nations. 90% of maize grown in sub-Saharan Africa is used for food, and 50%, 30%, and 13% of people in southern, eastern, and west and central Africa, respectively, get their calories from it (Pandey, 1998). Maize is the main staple food of more than 500 million people in sub-Sahara Africa. It is mainly cultivated by small scale farmers using low input production system (Macaulay and Ramadjita, 2015; Diro *et al*., 2018). Because FAW is a major pest attacking maize CABI (2017; 2018), it has the potential to cause maize yield losses of 8.3 to 20. 6 million tonnes (capable of feeding 40.8 million to 100 million persons) annually. It is also among Nigeria's most significant crops to be grown. Most people's diets include a significant amount of maize, which is also used as a raw material for agro-based businesses such as the manufacturing of animal feed (Iken and Amusa, 2004; Abdulraham and Kolawole, 2006). The larval stage of a fall armyworm moth is known as the fall armyworm (*Spodoptera frugiperda*), and it belongs to the order Lepidoptera. Because of the species' propensity to ruin crops, its scientific name, *frugiperda,* comes from the Latin for "lost fruit" (Wikipedia, 2017).

In Nigeria, maize farming affects several agroecologies, such as the guinea savannah, derived savannah, and forest ecology (Olaniyan, 2015). In the pharmaceutical industry, maize is utilized as a raw material to produce oil, starch, alcohol, and, more recently, fuel (Ellis *et al*., 1998; Acharya and Young, 2008; Ranum *et al*., 2014). The issue of FAW insect pests is one of the elements working against maize production, despite the crop's potential to reduce hunger and contribute to food security (Sanchez *et al*., 1997). Worldwide, insect pests pose a severe threat to crop productivity. If pest damage to farmed crops is not reduced, the production and quality of food may completely collapse. One major obstacle to the global fulfillment of food security is crop loss due to insect pests. Thus, crop loss due to insect pest damage must be addressed in order to fulfill the growing global population's need for food (Berenbaum, 1995).

The Fall Armyworm (FAW) is so named

because of how quickly and ruthlessly it consumes any plant matter it comes across during its extensive dispersal, resembling an army. Wide-ranging crop damage results from the worms' long list of potential food sources (University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) Extension, 2017). FAW targets a wide range of crops, including but not limited to corn, rice, peanuts, tobacco, grass, and various fruits like oranges and apples. According to Pogue (2002), the FAW is a polyphagous pest that consumes at least 100 different plant species from 27 different families. Some types of sweet corn are partially resistant to armyworms, but not completely (UF/IFAS Extension, 2017). In a study of 12 African nations that produce maize, yield losses from FAW ranged from 8.3 to 20.6 million tons annually, wiping out 21.3% to 53.5% of the average annual production of maize in these nations over a three-year period. The larvae consume a large amount of the plant and have a negative impact on crop yield and survival. In order to consume the kernels during seed filling and maturity, they even burrow into the corn ear (UF/IFAS Extension, 2017).

In Nigeria, the FAW is a major threat to household food security, agro and agro allied industries. In the areas affected by the armyworm, average of 395.05 hectares of land is affected per state. Average crop loss of 68.2% (in maize production) has been reported since 2016, the fall armyworm came to Nigeria (Odeyemi, 2018; Ajiboye, 2019). In Nigeria several farmers have abandoned their maize farms which drastically leads to low yield and productivity (Ajiboye *et al*., 2021).

FAW causes severe damage by feeding on the foliage of crops, leading to heavy skeletonization or defoliation. The leaves of infested maize crops appear ragged, this damage to the leaves disrupts the photosynthetic process, inhibiting food manufacturing (Darby and Lauer, 2000). The fall armyworm therefore becomes a plant pest of great destruction tendencies. Farmers must go to great lengths to deter the larvae hence, it has become a nightmare unimaginable - particularly to maize farmers (Georgen *et al*., 2016). The activity of the pest and its presence is not easily noticed until havoc has been down. It is a nocturnal pest of plants with the peak of its destruction activity happening at late evening or in the night and early morning (Santos, 2003; Clark, *et al*., 2007).

The attack of FAW on maize fields in Nigeria has really been of great concern, due to the threat posed to the food and nutrition security of farm families and the nation at large. Its outbreak in 2006 in Nigeria is a clear evidence that FAW is a great and potential danger to agricultural/ farming communities. This is so because of its strong ability to fly/migrate across several thousand kilometers (Dent, 2000; Early *et al*., 2018).

In the context of research, awareness describes one's degree of knowledge or comprehension of a particular issue or phenomenon. It entails learning about the main elements and problems at hand as well as any viable fixes or approaches that might be used to deal with the problem. Therefore, whether maize farmers are aware of the above information provision remains unknown. There is death of research based studies on farmer's awareness, knowledge and effects of FAW on maize farmers in Imo State, Nigeria. Therefore, the objective of the work was to ascertain maize farmers' awareness of FAW, knowledge and effects on maize farmers in Imo State.

Materials and Methods

The study was conducted in Imo State. It is in the tropical rainforest zone. Imo State has three agricultural zones namely; Owerri, Okigwe and Orlu, subdivided into 27 Local Government Areas (LGAs). Purposive random sampling technique was used in selecting 450 maize farmers from a list of 4500 maize farmers obtained from the Maize Growers Association Zonal Offices, in Imo State. Data were collected using structured questionnaire complimented with oral interviews. Basically, descriptive statistics were used to

Table 1: Awareness of Fall Armyworm by Responded

Sources of Awareness	Frequency	Percentage
Aware	450	100
Not aware	-	**-**
Extension	50	11.1
Agro-vet shop	430	95.5
Fellow farmer	429	95.3
Radio	-	-
Television	-	-
Newspaper	04	02.2
Church	250	55.5
Town criers	380	84.4
Personal expenses	450	100
Cooperative unions	310	68.8

*Multiple response

analyze the data. This involves the use of percentages and frequency counts, for objectives 1 and 3, while objective 2 was analyzed using a 4-point likert type scale of strongly agreed, agreed, disagreed and strongly disagreed to examine maize farmers fall armyworm knowledge. The responses were assigned weight of 4, 3, 2 and 1, respectively and added to give 10 divided by 4 to give a mean of 2.50. A mean score of 2.50 and above indicated good knowledge of fall armyworm. while a mean score lower than 2.50 indicated lack of proper knowledge.

Results and Discussion

Awareness of Fall Armyworm by Farmers:

Awareness signifies knowing, perceiving and being cognizant of an event. It can also mean knowing that something exists when that is directly available to bring to bear in the directions of a wide –range of a behavioral action (Hussain *et al*., 2009). Table 1 shows that the maize farmers are fully aware of fall armyworm menace. All the respondents (100%) have seen it and are aware. They become aware through a variety of means. These means include personal observations (100%) having been in the business of maize growing, they have observed armyworm infestation. Agro – veterinary shop (95.5%) is another fall armyworm information source. Farmers who go to the agro -vet shop get more information and learn more. Fellow farmers (95.37) are invaluable in this information sharing. The respondents, said their fellow farmers provide information on armyworm. Other fall armyworm information sources include the church (55.5%), town crier (84.4%), cooperative society (68.8%) and of course the extension staff (11.1%). During oral discussions with the farmers they said that their town criers beat the metal gong round the village to alert them of any form of emergency, as in the fall armyworm menace. Again, in the church, announcement is also made on farm information. It could be seen from the table that extension staff (11%) who could have been a great source of information, is not reaching the farmers at all. The system need be resuscitated and revived to provide farms information that the farmers need. The respondents did not have fall armyworm information from radio and television because the radio farmer programme of the government has long stopped.

Farmer's Knowledge of Fall Armyworm Infestation:

Knowledge of fall armyworm here has to do with farmers understanding and awareness of its menace. It refers to farmer information, facts, skills, wisdom acquired through learning and expenses. Table 2 reveals that the farmers have adequate knowledge of the fall worm with the high mean score recorded. They said it is a small crawling worm (M=2.59), maize leaves change colour (M = 2.47), big leaf portion eaten away

Table 2: Maize Farmer Knowledge of Fall Armyworm Infestation

Knowledge statement	Mean	S D
Small crawling worm	2.59	0.46
Maize leaves change color	2.47	0.59
Big leaf portion eater away	3.05	0.74
Maize grain become deformed	3.01	0.84
The leaf edges perforation	2.90	0.94
Leaves with focal excrement	3.05	1.10
Fall armyworm attack maize more often	2.85	0.84
Lays mass eggs on maize plant	3.04	0.74
Leaves shows first sign of attack	2.78	0.64
The caterpillar has dark spot on tail	2.80	1.08
Attack maize at different growth stage	3.01	0.97
Can easily eat maize very faster	3.41	0.85

Accept mean = 2.0

(M=3.05), maize grain deformation (M=3.01), perforation of leaf edges (M=2.90), focal excrement on leaves (M=3.05), lays mass egg on leaves (M=3.04), caterpillar has four dark spots (M=2.78), maize attack at different stages of growth (M=3.0). During oral discussion with the farmer it was observed that their adequate knowledge of fall armyworm has helped them to become smarter in managing their farms, make informed decisions, solve farm problems, understand complex concepts, leads to personal growth and makes farm advancement/progress. The above finding agrees with Tiko and Mohamed (2024) who said that in Papua New Guinea, when informed about the fall armyworm larvae, the majority of respondents, according to the survey, had a mediocre understanding of them but no theoretical knowledge of them. When the pest was still in the moth stage, farmers discovered it in their gardens, but they frequently confused it with other pests. Farmers sometimes saw the pest when it was in the egg stage, but not always. Compared to the egg and moth stages, the farmers found it simpler to identify the morphological structure of the larvae. Using the ranking order, they could determine the color of the fall armyworm's body. They thought the pest was a common one that usually survives and reproduces, so they were unable to identify the head and legs. According to the survey, maize plants were more heavily affected by fall armyworm larvae from the time of early development to maturity than rice or sugarcane crops. The farmers were still figuring out what kind of bug targets these crops, though. The symptoms caused by the fall armyworm larvae on the corn plant were first noticed by the farmers as holes in the leaves, then pinholes and significant damage on the stem and leaf sections (Bourke and Sar, 2020). In Benin West Africa, Houngbo *et al.* (2020) reported that majority of farmers (91.8%) were aware of *S. frugiperda*'s harm to maize crops. Most of them (78.9%) could recognize the pest when it was still in its larval stage and the farmers (88.6%) reported seeing *S. frugiperda* activity in their maize fields. Therefore, for pest scouting and early detection, farmers' knowledge and proficiency in identifying organisms that damage crops is essential. Their decision-making, attitude, and behaviors-- such as using pesticides and taking the necessary safety precautions—may be influenced by their knowledge. Due to the diversity of farmer populations, they may be impacted by the demographic profile of farmers (Abdulai *et al*., 2018; Wongnaa and Awunyo-Vitor, 2018; Bariw *et al*., 2020; Tambo *et al*., 2020; Asare-Nuamah, 2022). Therefore, the development of efficient pest control measures as well as farmer resilience and adaptive capabilities are informed by an understanding of farmers' knowledge, management practices, coping mechanisms, and adaption strategies (Abraham *et*

Table 3: Effect of Fall Armyworm on Maize production and Farm

Effect maize production /farmer	*Frequency	Per cent
Causes 100% loss of yield	450	100
Causes stunted/decayed growth of maize	441	98.0
Leads to death of plants	435	96.6
Leads to loss of revenue/income	444	96.6
Cause maize defoliation	407	90.4
Destruction of organs on store or horn	394	87.5
Reduced/delays tassel formation time	384	85.3
Increase maize production cost	423	940
Heighten food security concerns	427	94.8
Loss in both quality and quantity of maize	445	98.8
Increase food insecurity	410	91.1
Increases malnutrition	439	975

*multiple response

al., 2017; Tambo *et al*., 2020; Awudzi *et al*., 2021; Obour *et al*., 2022; Umeh *et al*., 2022).

Effects of fall armyworm menace on maize production:

Table 3 showed the damage done to both maize production and farm families, by fall armyworm. Fall armyworm cause total loss of maize yield (100%), causes staunted/ delayed growth (98%), leads to death of maize plants (96.6%), leads to loss of revenue (96.6%), reduced tassel formation (85.3%), destruction of grains in store (87.5%), leads to poverty (97.5%), heightens food security concerns (94.5%), loss in both quality and quantity of maize (98.8%), increasing food insecurity (91.1%), increase malnutrition (97.5%), increases maize production cost (94%), among other concerns. Supporting the above, Kalyebi *et al.* (2023), on the impact of the FAW in terms of yield losses reported by farmer in Uganda, reported that, 20% of the farmers reported yield losses less than 25% in Kamuli district, numbers were much less at 10% in Namutumba district. In Kamuli, 56% of the farmers experienced yield losses of 25–50% as compared to 57% of the farmers in Namutumba who experienced similar magnitudes of yield loss, and 16% of farmers in Kamuli and 20% of farmers in Namutumba reported yield losses to the magnitude of 51-70%.

In a study by Odeyemi *et al.* (2020) in 3 States in Southwest, Nigeria, it was observed that the severity of damage caused by the pest varied among the surveyed states of Ogun, Oyo and Ondo States which recorded the highest percentage of severely affected fields (high to very high). When plants of between two to eleven weeks were sampled, armyworm was found to be deleterious to all growth stages of the maize crop (including the seedling, vegetative and reproductive stages). Leaf tattering, a symptom associated with armyworms, was observed to be more prominent between two to six weeks after planting. The severity of damage varied from farm location to farm location, while most farms had moderate to very high damage.

Again, the insect hinders the achievement of food security and poverty allocation among smallholder farm families who have limited or restricted access to productive resources (Terblanche *et al*., 2015). It will also lead to reduction in income, depleted savings, market access difficulty and trade interruption in Africa (Vargas, 2009; Amusan, 2018). Again, if the farmer borrows money, repayment will be difficult as household basic needs would not be met, this is because of the rapid change in food consumption (Marenco *et al*., 1992; Bessin, 2010).

Conclusion

The maize farmers are fully aware of FAW as indicated in their responses. They have seen that the armyworms destroy maize plants, they have made attempts at controlling them, and they battle the fall armyworms every maize growing season. They became aware through various avenues such as fellow farmers, Agro-vet shop, town crisis, personal experience and through their cooperative societies. They are very knowledgeable of FAW that eats every parts of maize plants, deform maize leaves, leave fecal excrement on maize leaves. FAW causes loss of yield, delays growth of plant, leads to death of maize plants etc.

References

Abdulraham AA and Kolawole OM. (2006) Traditional preparation and uses of maize in Nigeria. Ethnobotany Leaflets 10: 291-227.

Abdulai S, Nkegbe PK, Donkoh SA and Yildiz F. (2018) Assessing the technical efficiency of maize production in northern Ghana: The data envelopment analysis approach. Cogent Food Agricult. 4(1): 1512390.

Abrahams P, Bateman M, Beale T, Clottey V, Cock M, Colmenarez Y, Corniani N, Day R, Early R, Godwin J, Gomez J, Moreno PG, Murphy ST, Oppong Mensah B, Phiri N, Pratt C, Richards G, Silvestri S and Witt A. (2017) Fall armyworm: Impacts and implications for Africa. Outlooks Pest Managem. 28: 196-201.

Acharya V and Young BR. (2008) A review of the potential of bio-ethanol in New Zealand. Bull Sci Technol Soc. 28: 143.

Ajiboye TO. (2019) Project proposal of integrated management of fall armyworm (*Spodoptera frugiperda*) for sustainable food security in Africa (Nigeria). National centre for Genetic Resources and Biotechnology (NACGRAB).

Ajiboye TO, Aladele SE, Ogunbiyi M, Olubiyi MR, Michael C, Oduoye OT, Olajire O and Oyewole O (2021) Review of fall armyworm (*Spodoptera frugiperda*) invasion in Nigeria and lessons learned for sustainable food production. Greener J Agricult Sci. 11(1): 48-56.

Amusan L and Olawuyi SO. (2018) The menace of the fall armyworm: Food security challenges in Nigeria and South Africa. https://www.researchgate.net/publication/328686210

Asare-Nuamah P. (2022) Smallholder farmers' adaptation strategies for the management of fall armyworm (*Spodoptera frugiperda*) in rural Ghana. Int J Pest Managem. 68(1): 8-18.

Awudzi GK, Adu-Acheampong R, Avicor SW, Bukari Y, Yeboah MA, Boateng EKO and Ahadzi SK. (2021) Farmers' knowledge and perception of cocoa insect pests and damage and the implications for pest management on cocoa in Ghana. J Plant Prot Res. 61(2): 145-155.

Bariw SA, Kudadze S, Adzawla W and Yildiz F. (2020) Prevalence, effects and management of fall armyworm in the Nkoranza south municipality. Cogent Food Agricult. 6(1): 1800239.

Berenbaum MR. (1995) Bugs in the system: Insects and their impact on human affairs. Basic Books, USA, pp. 377.

Bessin R. (2010) Fall Armyworm in Corn. https://entomology.ca.uky.edu/ef110

Bourke M and Sar S. (2020) Fall armyworm in Papua New Guinea: how big is the risk? https://devpolicy.org/potential-impact-of-fall-armyworm-in-papua-new-guinea-20200526-1/?utm_source=rss&utm_medium=rss&utm_campaign=potential-impact-of-fall-armyworm-in-papua-new-guinea-20200526-1

CABI. (2017) Fall armyworm: Impacts and implications for Africa. https://www.cabi.org/isc/FullTextPDF/2018/20187200429.pdf

CABI. (2018) Fall armyworm: Impacts and implications for Africa. https://www.invasive-species.org/wp-content/uploads/sites/2/2019/02/FAW-EvidenceNote-October-2018.

Clark PL, Molina-Ochoa J, Martinelli S, Skoda SR, Isenhour DJ, Lee DJ, Krumm JT and Foster JE. (2007) Population variation of the fall armyworm, *Spodoptera frugiperda*, in the Western Hemisphere. J Insect Sci. 7: 5.

Darby H and Lauer J. (2000) Critical stages in the life of a corn plant. https://corn.aae.wisc.edu/Management/pdfs/CriticalStages.pdf

de Almeida Sarmento R, de Souza Aguia RW, de Souza Almeida Sarmento, Aguiar R, Vieira SMJ, de Oliveira HG and Holtz AM. (2002) Biology review, occurrence and control of *Spodoptera frugiperda* (Lepidoptera, Noctuidae) in corn in Brazil. Biosci J. 18: 41-48.

Dent, D. (2000). Insect Pest Management. 2nd edn., CABI Publishing, UK.

Diiro GM, Seymour G, Kassie M, Muricho G and Murithi BW. (2018) Women's empowerment in agriculture and productivity: Evidence from rural maize farmer households in western Kenya. PLoS One 13: e0197995.

Early R, Gonzalez-Moreno P, Murphy ST and Day R.

(2018) Forecasting the global extent of invasion of the cereal pest *Spodoptera frugiperda*, the fall armyworm. NeoBiota 40: 25-50.

Ellis RP, Cochrane MP, Dale MFB, Duffus CM, Lynn A, Morris IM, Prentice IDM, Swanston JS and Tiller SA. (1998) Starch production and Industrial use. Sci Food Agricult. 77(3): 289-311.

FAO. (2017a) Fall armyworm life cycle (in Latin America). http://www.fao.org/3/a-i7424e.pdf

FAO. (2017b) FAO advisory note on fall armyworm (FAW) in Africa. http://www.fao.org/3/abs914e.pd

FAO. (2020) The global action for fall armyworm control action framework (2020 – 2022) working together to tame the global threat. food and agricultural organization.

Goergen G, Kumar PL, Sankung SB, Togola A and Tamo M. (2016) First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (JE Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in west and central Africa. PLoS One 1(10): e0165632.

Hussain A, Aleksander I, Smith L, Barros A, Chrisley R and Cutsuridis V. (2009) brain inspired cognitive systems 2008. Springer Science, New York, pp. 298.

Iken JE and Amusa NA. (2004) Maize research and production in Nigeria. African J Biotechnol. 3(6): 302-307.

Kalyebi A, Otim MH, Walsh T and TekTay W. (2023) Farmer perception of impacts of fall armyworm (*Spodoptera frugiperda* J.E. Smith) and transferability of its management practices in Uganda. CABI Agricult Biosci. 4: 9.

Macauley H. (2015) Cereal crops: rice, maize, millet, sorghum, wheat: background paper. Conference on Feeding Africa, Dakar, Senegal, October 21-23, 2015.

Macauley H and Ramadjita T. (2015) Cereal crops: Rice, Millet, Sorghum, Wheat. Background paper. Feeding Africa, October 21-23, 2015, https://www.afdb.org.

Marenco RJ, Foster RE and Sanchez CA. (1992) Sweet corn response to fall armyworm (Lepidoptera: Noctuidae) damage during vegetative growth. J Economic Entomol. 85: 1285-1292.

Obour PB, Arthur IK and Owusu K. (2022) The 2020 maize production failure in Ghana: A case study of Ejura-Sekyedumase municipality. Sustainability 14(6): 3514.

Odeyemi O. (2018) Fall Armyworm (Spodoptera frugiperda J.E. Smith) (Lepidotera: Noctuidae): The journey so far in Nigeria. Brief Update on FAO intervention. September 2018.

Odeyemi OO, Lawal BO, Owolade OF, Olasoji JO, Egbetokun OA, Oloyede- Kamiyo QO, Omodele T and Anjorin FB. (2020) Fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae): Threat to maize production In Nigeria. Nigerian Agricult J. 51(1): 101-108.

Olaniyan AB. (2015) Maize: Panacea for hunger in Nigeria. African J Plant Sci. 3: 155-174.

Pandey S. (1998) Varietal development: Conventional plant breeding. In: Maize Seed Industries in Developing Countries, (ed.) Morris M.L., Lynne Rienner Publishers, Boulder, Colorado.

Pingali PL. (2001) CIMMYT 1999–2000 World Maize Facts and Trends. Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector. Mexico, D.F.

Pogue MA. (2002) A world revision of the genus Spodoptera guenée (Lepidoptera: Noctuidae). Memoirs Am. Entomological Society, Philadelphia 43: 1- 201.

Ranum P, Pena-Rosas JP and Garcia-Casal MN. (2014) Global maize production, utilization and consumption. Annals New York Acad Sci. 1312: 105-112.

Sanchez PA, Shepherd KD, Soule MJ, Place FM, Buresh RJ, Izac AMN, Mokwunye AU, Kwesiga FR, Ndiritu CG and Woomer PL. (1997) Replenishment soil fertility in Africa: an investment in natural resource capital. In: Replenishing soil fertiality in Africa, (eds.) Buresh R.J., Sanchez P.A. and Calhoun F., Special Publication No. 51. American Soc Agronomy Soil Sci Soc America, Madison, pp. 1-46.

Santos LM, Redaelli LR, Diefenbach LMG and Efrom CFS. (2003) Larval and pupa stage of *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera:Noctuidae) in sweet and field corn genotypes. Brazilian J Biol. 63 (4): 627-633.

Sidol H, Afio Z, Augustin A, Hervé CS, Antonio S, Rachidatou S, Espérance Z, Henri ST V, Aristide A and Adam A. (2020) Farmers' knowledge and management practices of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in Benin, West Africa. Agriculture 10: 430.

Tambo JA, Day RK, Lamontagne-Godwin J, Silvestri S, Beseh PK, Oppong-Mensah B, Matimelo M and Matimelo M. (2020) Tackling fall armyworm (*Spodoptera frugiperda*) outbreak in Africa: An analysis of farmers' control actions. Int J Pest Managem. 66(4): 298-310.

Terblanche JS, Karsten M, Mitchell KA, Barton MG and Gibert P. (2015) Physiological variation of insects in agriculture landscapes: Potential impacts of climate change. In: Climate Change and Insect Pests, (eds.) Björkman C. and Niemelä P., CAB International, pp,

920-118.

Tika B and Mohammed A. (2014) Evaluating the knowledge and perceptions of local farmers in Tanam Village, Morobe Province regarding Fall armyworm infestation. E3S Web of Conferences 477, 00021.

UF/IFAS Extension (2017) University of Florida's Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu.

Umeh BC, Avicor SW, Dankyi E and Kyerematen R. (2022) Farmers' knowledge and practices on pollination and insecticide use in cocoa farming in Ghana. Int J Agricult Sustainability 20(7): 1294-1306.

Vargas HR. (2009) Using stated preferences and beliefs to identify the impact of risk on poor households. J Develop Stud. 45(2): 151-171.

Wikipedia (2017) Fall armyworm. https://en.wikipedia.org/wiki/Fall_armyworm

Wongnaa CA and Awunyo-Vitor D. (2018) Achieving sustainable development goals on no poverty and zero hunger: Does technical efficiency of Ghana's maize farmers matter? Agricult Food Security 7(1): 71.