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DETERMINANTS OF ADOPTION OF INTEGRATED PEST MANAGEMENT PRACTICES AMONG MAIZE FARMERS IN SOUTHWEST NIGERIA

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SUMMARY

The purpose of this study is to examine the determinants of integrated pest management (IPM) adoption among maize farmers in Southwest Nigeria. A multistage sampling technique was used to collect information from 360 respondents (namely 180 adopters and 180 non-adopters of IPM) from Osun and Ekiti States, Nigeria. The data collected were analyzed using descriptive statistics and probit regression models. The descriptive statistics results obtained on the respondents' awareness of IPM practices indicate that a majority (74.2%) of the respondents are aware of IPM practices. Most of the respondents (98.9%) were categorized as adopters of IPM. The probit regression analysis results revealed that the respondent's gender, farm size, access to enough credit, land ownership and the environmental impact of IPM were significant coefficients, potentially increasing the adoption of IPM at various levels. The findings obtained suggest that the government and financial institutions should assist farmers by offering readily available loans at a low or no interest rate and by making essential inputs available to farmers at a subsidize rate.

Key words: *adoption, integrated pest management (IPM), probit regression model, land ownership, Nigeria*

Abbreviations: ADP - Agriculture Development Programme; AEZs - Agro-Ecological Zones; EU - European Union; FMA&RD - Federal Ministry of Agriculture and Rural Development; GAP - Good Agricultural Practices; IITA - International Institute of Tropical Agriculture; IPM - Integrated Pest Management; LGA - Local Government Areas; MRLs - Maximum Residue Levels; NBS - National Bureau of Statistics; NGO - Non-Governmental Organization; RUDEP - Rural Development Programme; WB World Bank

INTRODUCTION

Pests and diseases are the major cause of low maize yield and productivity, thus exacerbating poverty and food insecurity among maize farmers (Tounou et al., 2013). Insect pests have been defined by Manoharan et al. (2017) as any insect in the wrong place. Cereals (especially maize) are vulnerable to pests and diseases (Iken & Amusa, 2004). The major insect pests in the maize field are stem borers (*Busseola fusca* and *Sesemia calamistis*), shoot flies (*Atherigona spp.*), grasshoppers (*Zonocerus variegatus*) and army worms (*Spodoptera exempta* and *Helicoverpa armigera*). According to the International Institute of Tropical Agriculture (IITA, 2010), the harmful activities of insects have direct impacts on crop cultivation through a cascade of events linking injuries they inflict on crop stands. The losses in crop quantity and quality often affect the livelihood of maize farmers.

The effective control of pests and diseases require the use of chemical agents called pesticides. The use of chemicals (insecticides) is presently the most popular control measure in Nigeria (Tijani & Sofoluwe, 2012). Pesticides are the quickest and most pragmatic means of combating pest infestation. However, the use of pesticides has been restricted in many parts of Africa because of their cost and the ability to contaminate the environment, leaving harmful residues in products and inducing resistance in pest species. The effective control of pests and diseases requires the use of pesticides, which depends on their price, application risk, credit availability and cropping pattern. The Nigerian experience reported in the literature confirms that the use of pesticides is implicated in the contamination of air, soil and water (Dahiru et al., 2014). These chemicals are very expensive and are not easily available. Moreover, if used incorrectly, synthetic insecticides possess the capacity to leave harmful residues in food commodities and facilitate a rapid emergence of resistant pest strains (Tijani & Sofoluwe, 2012).

Maize farmers need to boost their yield and food security while fighting insect pests and yield-limiting crop pathogens. This has led to the farmers' adoption of synthetic pesticides. Farmers in Nigeria have strongly relied on the use of chemical pesticides (IITA, 2010). It has been estimated that about 125,000 - 130,000 metric tons of pesticides are applied every year in Nigeria. The emergence of new weeds and increasing numbers of insect pests and diseases have made traditional Nigerian farmers greatly dependent on the use of pesticides for controlling various weeds, insect pests and diseases, which has resulted in a significant import of these products. However, their prices have become so steep that it is becoming impossible for local farmers to afford pesticides (Oruonye & Okrikata, 2010). Moreover, the application of synthetic chemicals for pest control has increased the costs of production, contaminated products, threatened the ecosystem, impaired human health, and reduced farmers net returns with attendant poverty (Ofuoku et al., 2008).

The adverse effects of synthetic pesticides prompted the passing of the European Union (EU) Legislation on Maximum Residue Levels (MRLs), which came into effect in Nigeria on September 1, 2008. The maximum residue levels (MRLs) are part of good agricultural practices (GAP) and are meant to reflect the highest amount of pesticide residues allowed in food substance treated with correctly applied pesticides. MRLs are primarily trading standards, which are applied to ensure that residue levels do not pose unacceptable risks for consumers of such food. The failure of Nigerians to comply with this legislation resulted in banning some Nigerian agricultural export products such as beans, sesame seeds, melon seeds, dried fish and meat, peanut chips, and palm oil by the European Union (EU).

Responding to these scenarios, the Federal Ministry of Agriculture and Rural Development (FMA&RD, 2011), in collaboration with the World Bank (WB), organized a project entitled "Integrated Pest Management Plan (IPMP), Nigeria Agro-Processing, Productivity Enhancement and Livelihood Improvement Support Project (APPELISP)" to increase awareness and educate farmers on the use of IPM to control pests on agricultural crops such as cocoa, maize, rice vegetables etc. IPM is a pest management technology that emphasizes the reduced or total non-use of synthetic chemicals in the control of pests and diseases for the purposes of enhancing the yield and profit of farms while aspiring to preserve the environment (Rahman & Hamid, 2012). The Integrated Pest Management (IPM) approach combines chemical control (when necessary) with cultural, biological and/or indigenous practices to form a comprehensive program for managing pests. IPM emphasizes maintaining pests below the economic threshold while applying the minimum amount of chemical necessary for control. Therefore, this study aims at determining the level of awareness of IPM practices among maize farmers in Southwest Nigeria, the preferable IPM practices used by the farmers considered, and the factors influencing the adoption of IPM in the study area.

MATERIAL AND METHODS

Study area, data sources and sample techniques

The study was conducted in the States of Ekiti and Osun, Southwest Nigeria, which were purposively selected because of their high maize production (National Bureau of Statistics - NBS, 2018) and the presence of the Catholic Rural Development Programme (RUDEP), which is an NGO that promotes the use of IPM among farmers in the two states. The states are made up of 46 local government areas (LGA) (i.e. Ekiti State has 16 and Ondo State 30 LGAs). The total population of the both states combined is 5,801,171 (Ekiti has a population of 2,384,212, whereas Osun has a population of 3,416,959). The primary data for this study were collected using a well-structured questionnaire on the socio-economic characteristics of respondents such as their age, level of education, farm size, credit access, off-farm income, and institutional factors such as association membership, extension contact and cooperative membership. The data were also collected on the pest control methods, awareness and compliance level of IPM practices, IPM adoption, and perceived effectiveness of IPM practices.

A multi-stage sampling technique was used to collect information from 360 respondents (namely 180 adopters and 180 non-adopters of IPM). The first stage involved the selection of Osun and Ekiti States out of six states in Southwest Nigeria. Both Osun and Ekiti States have three agro-ecological zones (AEZs) each: the agro-ecological zones of Osun State are Rainforest (Ife/Ijesa), Derived Savannah (Osogbo), and Savannah (Iwo), whereas the AEZs of Ekiti State are Rainforest (Aramoko), Derive Savannah (Ikere) and Savanna (Ikole). One LGA was selected from each AEZ, totaling six LGAs (three from Ekiti State and three from Osun State). In each LGA, three villages participating in the Catholic Rural Development Programme (RUDEP) were selected for the study. From each village, a total of ten maize farmers who adopted IPM and ten maize farmers who did not adopt IPM were randomly selected on the basis of the RUDEP list of registered maize farmers. In total, 360 maize farmers (namely 180 IPM adopters and 180 IPM non-adopters) were interviewed for the study.

Methods of data analysis

Descriptive statistics and probit regression models were used for analyzing the data collected. The collection of data was carried out with the assistance of trained enumerators from the Agriculture Development Programme (ADP) and RUDEP. The probit model was used to explain the behaviour of the dichotomous dependent variable, i.e. the factor influencing the adoption of IPM practices among the maize farmers in the study area. Equation 1 shows the general form of the probit model used:

$$P_i^* = f\left(\beta' X\right) = 1/\left[\exp(-\beta' X)\right] \quad 1$$

The original functional relationship is specified in Equation 2:

$$Y_i^* = \beta_0 + \sum \beta_i X_{ij} + u_i \quad 2$$

In this study, the dependent variable will be dichotomous, taking a value of 1(one) if a farmer has adopted IPM practices and 0 (zero) if not. The social and economic factors considered were hypothesized to influence the adoption decision. Most of these hypothesized factors were motivated by previous adoption studies. A dummy variable was observed (Y_i), i.e., whether the respondent is adopting the technology or not, and defined as follows:

$Y_i = 1$ if $Y_i^* > 0 = 0$ otherwise 3

The marginal effects were computed using Equation 3. The IPM adoption model is specified as follows

$$P_i = f(b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 ... b_{12} X_{12}) \quad 4$$

(1= Adoption, 0 = Non adoption)
b_0……b_{15} = parameters to be estimated
X_1 - gender (measured in binary; 1 for male and 0 for female)
X_2 - education (measured as the number of years of formal education)
X_3 - age (in years)
X_4 - family size (the number of individuals in the household)
X_5 - total farm size (measures in hectares)
X_6 - access to credit (1 for access, 0 otherwise)
X_7 - extension visit (the number of visits by extension agent in the cropping season)
X_8 - association Membership (1 if yes, 0 otherwise)
X_9 - distance to input market (km)
X_{10} - IPM materials adequacy (1 if adequate, 0 otherwise)
X_{11} - farming experience (measured in years)
X_{12} - off-farm income (the actual amount in Naira)
X_{13} - labor adequacy (1 if adequate, 0 otherwise)
X_{14} - land ownership type (personal =1; if otherwise = 0)
X_{15} - environmental impact (i.e. air contamination, water contamination, animal death) (1 if yes, 0 otherwise)

RESULTS AND DISCUSSION

IPM awareness and source of information

The result of IPM awareness and source of information on IPM practice is presented in Table 1. Most (74.2%) of the respondents in the study area were aware of IPM practice. 98.9 percent of these categories are adopters of IPM. Previous studies (Kaliba et al., 2000; Shiferaw et al., 2008) have emphasized the significant of awareness in improving agricultural technology adoption. The improved technology diffusion theory assumes that innovations are well developed but improper communication can cause individual's inability to adopt it (Shampine, 1998). On the sources of information about IPM practice in the study area, 36.9% of respondents got their information from extension officer, while low percentage of respondents (3.6%) have other farmers as the source of information on IPM. Furthermore, 39.4% of adopters have NGO as the source of the information, while 32.2% of non-adopter has no source of information about IPM practice. Agricultural information and its sources create awareness among farmers about agricultural technologies for adoption. A proven source of information could convince the farmers about the effectiveness of new technology, thus, increase its adoption (Agbamu, 2006)

Table 1. IPM awareness and source of information (Source: Field survey, 2019)

	Adopter	Non-adopter	Pool
IPM Awareness			
Yes	178 (98.9%)	89 (49.4%)	267 (74.2%)
No	2 (1.1%)	91 (50.6%)	93 (25.8%)
Total	180(100%)	180 (100.0%)	360 (100.0%)
IPM Awareness sources			
Farmers association	42 (23.3%)	24 (13.3%)	66 (18.3%)
Extension officer	59 (32.8%)	74 (41.1%)	133 (36.9%)
NGO	71 (39.4%)	10 (5.6%)	81 (22.5%)
Friends	4 (2.2%)	5 (2.8%)	9 (2.5%)
Other farmers	4 (2.2%)	9 (5.0%)	13 (3.6%)
None	0	58 (32.2%)	58 (16.1%)
Total	180 (100.0%)	180 (100.0%)	360 (100.0%)

Note: The values outside and inside brackets are frequencies and percentages, respectively.

Various IPM combination practices among the farmers in the study area

Table 2. shows various IPM combination practices adopted by the farmers considered in the study area. The identified IPM practices are biological, cultural, mechanical, sanitary, indigenous, and chemical control measures. The biological control involves the use of species that are natural enemies of pests we wish to control, as well as pheromones, resistant plant varieties, and autocidal techniques such as sterile insects. The cultural measures are practices that suppress pest issues by minimizing the conditions that favour their existence (namely water, shelter, food, crop rotation, tilling, different planting time, crop residue disposal, pruning, thinning, and fertilization). The mechanical control is the use of machinery and other tools to control pests (namely traps, hand destruction and mechanical exclusion such as screen, net and fences). The sanitary control refers to cleaning field equipment (tillage equipment, haying equipment, etc.), planting certified seeds, and the quarantine of infested crops or farmlands. The indigenous control is a combination of botanical and natural components to manage pests and crop diseases. Botanicals such as the neem tree (*Azadiracta indica*), the Siam weed (*Eupatorium odorata*) and tobacco *(Nicotiana tabacum*) are used with other materials such as ashes. The chemical control refers to a therapeutic approach to killing pest organisms with toxic chemicals such as DD force.

The results obtained indicate that a majority (23.5%) of the farmers considered combine the indigenous pest control method with other IPM practices, followed by the cultural pest control (22.3%). However, the chemical pest control method was found least preferable (3.9%). This shows that the adopters of IPM virtually avoided the use of chemical for pest control in the study area.

Table 2. Various integrated pest management (IPM) practices adopted by the maize farmers in the study area (Source: Data Analysis, 2019)

IPM Combination	N^{o} of respondents*	Percentage	Rank
Indigenous pest Control	161	23.5	1st
Cultural pest control	153	22.3	2nd
Sanitary pest control	131	19.1	3rd
Biological pest control	119	17.3	4th
Mechanical pest control	95	13.8	5th

Chemical pest control	27	3.9	6th
* Multiple responses recorded			

Factors influencing the adoption of IPM

Table 3. shows the factors influencing the adoption of IPM among the farmers considered. The probit model employed was estimated (Tab. 3) with the marginal effect (Tab. 4). The results of the likelihood ratio, log likelihood and their probability values show that the specification is appropriate to determine the factors influencing the adoption of IPM among the farmers considered. The factors such as gender, farm size, credit accessibility, frequency of extension visit, organization membership, and land ownership were found to be significant to IPM adoption decisions. The coefficient of gender is positive and significant (10%) indicating that male farmers are more disposed to adopting IPM in maize production. The marginal effect of gender (Tab. 4) shows that an increase in the number of male farmers would increase the probability of IPM adoption by 0.133. The results obtained lend credence to the capacity of male farmers to seek new innovations more than female farmers. The male-headed households were also found more likely to adopt IPM practices as they are more likely to get information about new technologies and undertake risky businesses than female-headed households. This confirmed the findings from previous studies that the female farmers' awareness of new technology in Nigeria is limited by factors such as women mobility and access to the relevant information, emphasizing the need for extension services which would help them learn what technologies are available, how to acquire them, and how to use them (Ragasa et al., 2015). Obisesan (2014) also found that the farmer's gender had a significant positive influence on the adoption of improved cassava production in Nigeria.

The coefficient of total farm size is positive and significant (5%), showing that an increase in size of farm holdings of maize farmers would likely increase the adoption of IPM. The marginal effect estimate (Tab. 4) shows that the probability of IPM adoption would increase by 0.044 if there is an increase in total farm size. This finding suggests the need for expansion of farm area to allow for the effective risk management. The farm size is very important in the process of adopting new technology. Many researchers have analyzed the size of farms as one of the most important determinants of technology adoption. The size of a farm can affect and, in turn, be affected by other factors influencing the IPM adoption (Lavison, 2013). Farmers with large farms are likely to adopt new technology, as they can afford to devote part of their land to test new technology (Uaiene et al., 2009). These results are consistent with the finding of Mignouna et al. *(*2011), who also reported a positive relation between the farm size and adoption of agricultural technology.

The parameter of credit accessibility was found positive and significant (5%), indicating that an increase in credit accessibility could increase the probability of IPM adoption. The magnitude of effect is 0.125. Increasing credit accessibility could provide financial support for the adoption of IPM. Credit accessibility has been reported to stimulate technology adoption (Mohamed & Temu, 2008). Simtowe & Zeller (2006) asserted that credit accessibility promotes the adoption of risky technologies through the relaxation of liquidity constraints, as well as through the improving of household's risk-bearing ability. The coefficient of extension visit was found negative, but significant (5%). The results obtained show that the probability of IPM adoption is less associated with the extension visit. Although contrary to the a-priori expectation, IPM practices could be closely associated with the indigenous knowledge of farmers, which is clearly different from modern innovations that require a totally new set of information. It might be due to the fact that farmers in the study area have confidence in the RUDEP officials (the NGO was promoting the use of IPM in the study area) and rely on them as a source of information and facts more than on extension officers.

The coefficient of association membership was significant (10%) and positively influenced the adoption of IPM. It was hypothesized that association membership such as cooperative membership enhanced interaction, cross-fertilization of ideas, and greater chance of getting credit and farm inputs by its members. This finding was congruent with the discovery of Taha (2007), who found that being a member of farmers' association had a positive and significant relationship with the adoption of new technologies. The coefficient of land ownership is positive and significant (5%), suggesting that the more maize farmers gain access to land ownership, the higher the probability of adopting IPM. The magnitude of adoption (Tab. 4) indicates that the probability of adopting IPM would increase by 0.046. The access to land ownership implied that farmers receive the exclusive rights to manage their farmlands, which favored the adoption of innovations compared to land tenancy. The results obtained confirmed the finding of Hornbeck (2014), who discovered that land property rights such as land ownership increase the adoption of new technology in agriculture.

The coefficient of perception of the IPM impact on the environment is significant and positively influences the adoption of IPM (at 1%). This means that an increase in the positive IPM impact on the environment would increase the adoption of new technology by the farmers in the study area. The marginal effect (Tab. 4) shows that the

perception of positive IPM impacts on the environment would increase its adoption by 0.345. This result is consistent with that of Alam et al. (2015), who argued that a successful IPM plan must account for the protection of beneficial insects, secondary pest outbreaks, spread of disease, contamination of air, water, and soil resources, and pest resurgence.

Table 3. Factors influencing the adoption of IPM (Source: Field survey, 2019)

Factors	**Coeff**	**Std. Err.**	**Z**	**P>|z|**
Gender	0.3347	0.1796	1.86	0.062*
Education	-0.06516	0.0482	-1.35	0.177
Age	-0.01084	0.0091	-1.19	0.234
Family size	0.01947	0.0217	0.90	0.369
Total farm size	0.11216	0.0460	2.44	0.015**
Access to credit	0.31586	0.1272	2.48	0.013***
Extension visit	-0.03514	0.0147	-2.38	0.017**
Membership	0.21437	0.1127	1.90	0.057*
Distance to input market	-0.02784	0.02865	-0.97	0.331
IPM materials adequacy	-0.1475	0.1314	-1.12	0.262
Farming experience	-0.00254	0.0094	-0.27	0.787
Labour adequacy	0.02640	0.1403	0.19	0.851
Land ownership	0.1162	0.0522	2.23	0.026**
Environmental impact	0.8707	0.1410	6.17	0.000***
Constant	-1.135	0.66969	-1.70	0.090
N = 360				
LR $chi^2(14)$ = 109.12				
Prob > chi^2 = 0.0000				
Pseudo R^2 = 0.2186				
Log likelihood = -194.9736				
Legend: *,**,*** - represent significant at 10%, 5% and 1%, respectively				

Table 4. Marginal effects after probit model regression (Source: Field survey, 2019)

Factors	**dy/dx**	**Z**	**P>|z|**	**X**
Gender	0.13276	1.86	0.062*	1.23333
Education	-0.0258	-1.35	0.177	5.26111
Age	-0.0043	-1.19	0.234	42.3667
Family size	0.00772	0.90	0.369	6.33333
Total farm size	0.0444	2.43	0.015**	2.97306
Access to credit	0.12527	2.49	0.013***	1.53611
Extension visit	-0.01393	-2.39	0.017	4.21389
Membership	0.0850	1.91	0.057*	1.27778
Distance to input market	-0.0110	-0.97	0.331	3.56292
IPM materials adequacy	-0.0585	-1.12	0.262	1.28333
Farming experience	-0.0010	-0.27	0.787	12.65
Labour adequacy	0.01047	0.19	0.851	1.54167
Land ownership	0.0461	2.23	0.026**	2.56389
Environmental impact	0.34534	6.28	0.000***	1.69444

CONCLUSION

The results obtained in the present study indicate that factors such as the farmer's gender, credit accessibility, land ownership and environmental impact of integrated pest management (IPM) exert significant effects on the adoption of IPM practices among maize farmers in Osun and Ekiti, Southwest Nigeria. Therefore, the study recommends that increasing credit accessibility could provide financial support to maize farmers for the adoption of IPM. The access to sufficient credit has been reported to stimulate technology adoption in agriculture by reducing the risk-increasing effect of a larger-size farm and increasing the purchasing power of farmers required for essential inputs on a larger-size farm. Therefore, effort should be made by the government, financial institutions and non-governmental organizations (NGOs) to provide readily available funds to farmers at a low or no-interest rate and essential inputs at a subsidized rate. The access to land ownership means that farmers have the exclusive rights to manage their farmlands, which favors the adoption of innovations compared to land tenancy. The government should intensify land acquisition ensuring that the practicing farmers are the beneficiaries. Therefore, one of the key policy

implications of this study is the need to review the land tenure system in Nigeria to facilitate the farmers' access to land for agricultural purposes.

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REFERENCES

Agbamu J.U. (2006): Essentials of Agricultural Communication in Nigeria. Malthouse Press Limited, Lagos.

Alam M..Z., Haque Islam M.M., Hossain M.S., Hasan E., Hasan S.B., Hossain M.S (2015): Comparative Study of Integrated Pest Management and Farmers Practices on Sustainable Environment in the Rice Ecosystem. *International Journal of Zoology,* Volume 2016, Article ID 7286040, 12 pages, https://doi.org/10.1155/2016/7286040

Dahiru B., Abdullah G., Bukar N. (2014): Pesticides use among grain merchants in Mubi grain markets of Adamawa state, Nigeria. *Agrosearch,* 14(1): 1-13.

Federal Ministry of Agriculture and Rural Development Abuja, Nigeria (2011): Agricultural Transformation Agenda (ATA): we will grow Nigeria's agricultural sector (Draft for Discussion) 9th September, 2011.

Hornbeck R. & Naidu S. (2014): When the Levee Breaks: Black Migration and Economic Development in the American South. *American Economic Review*, 104(3): 963-990.

Iken J.E. & Amusa N.A. (2004): Maize research and production in Nigeria. *African Journal of Biotechnology,* 3(6): 302-307.

IITA (2010): International Institute of Tropical Agriculture - Integrated Pest Management and Crop Health - bringing together sustainable agro-ecosystems and people's health. White Paper. SP-IPM Secretariat, Ibadan, Nigeria. pp. 17.

Kaliba A.R.M., Verkuijl H., Mwangi W. (2000): Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania. *Journal of Agriculture and Applied Economics*, 32(1): 35-47.

Lavison R. (2013): Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra, MSc Thesis, Accra Ghana.

Manoharan M., Bhuvaneshwari V., Latha R. (2017): Impact of Insects and Pests in loss of Crop Production: In: A Review, Sustainable Agriculture towards Food Security, pp. 57-67. doi: 10.1007/978-981-10-6647-4_4

Mignouna B., Manyong M., Rusike J., Mutabazi S., Senkondo M. (2011): Determinants of Adopting Imazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya: *AgBioforum*, 14(3): 158-163.

Mohamed K. & Temu A. (2008): Access to credit and its effect on the adoption of Agricultural Technologies: The case of Zanzibar. *African Review of Money Finance and Banking*, 45-89.

National Bureau of Statistics - NBS (2018): Version 01: Edited, anonymized dataset for public distribution. NGA-NBS-NLSS-2018-v01

Obisesan A. (2014): Gender Differences in Technology Adoption and Welfare Impact among Nigerian Farming Households, *MPRA Paper,* No. 58920

Ofuoku A.N., Emah G.N., Itedjere B.E. (2008): Information utilization among rural fish farmers in central agricultural zone of Delta State, Nigeria. *World Journal of Agricultural Science,* 4(5): 558-564.

Oruonye E.D. & Okrikata E. (2010): Sustainable use of plant protection products in Nigeria and challenges. *Journal of Plant Breeding and Crop Science,* 2(9): 267-272.

Ragasa C., Sengupta D.M., Osorio M., Ourabah N.H., Mathieson K. (2015): Gender- specific approaches, rural institutions and technical innovations. Available at: https://gender.ifpri.info/2015/02/19/publication-gender-specific-approaches-rural-institutions-and-technological-innovations/(accessed 2. 1 2020).

Rahman A.M.A. & Hamid M. E. (2012): Impact of FFS on farmer's adoption of IPM options for tomato: A case study from the Gezira State, Sudan. *International Journal of Development and Sustainability,* 1(2): 338-349.

Shampine A. (1998): Compensating for information externalities in technology diffusion models. *American Journal of Agricultural Economics*, 80(3): 337-346.

Shiferaw B., Kebede T.A., You L. (2008): Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. *Agricultural Economics*, 39(3): 309-323.

Simtowe F. &Zeller M. (2006): The Impact of Access to Credit on the Adoption of hybrid maize in Malawi: An Empirical test of an Agricultural Household Model under credit market failure. *MPRA Paper*, No. 45.

Taha M. (2007): Determinants of the adoption of improved onion production package in Dugda Bora District, East Shoa, Ethiopia. Unpublished MSc. Thesis presented to School of Graduate of Alemaya University.Technology adoption in a changing agricultural Sector. In: Handbook of Agricultural and Resource Economics, (ed). B.L. Gardner, G.C, Rausser, Amsterdam: North, pp. 85-88.

Tijani A.A. & Sofoluwe N.A. (2012): Factors determining the extent of pesticide use in Nigerian farms. *Journal of Agricultural Economics and Development*, 1(1): 1-9.

Tounou A.K, Agboka K., Agbodzavu K.M., Wegbe K. (2013): Maize stemborers distribution, their natural enemies and farmers' perception on climate change and stemborers in southern Togo. *Journal of Applied Biosciences*, 64: 4773-4786.

Uaiene R., Arndt C., Masters W. (2009): Determinants of Agricultural Technology Adoption in Mozambique. *Discussion papers*, No. 67E.

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