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Analysis of the determinants of adoption of bio-herbicide technology for sustainable food production in the North-Eastern Region of Nigeria

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There is a growing concern in many developing countries of sub-Saharan Africa on the harmful effects of synthetic herbicide usage on the agro-ecology, as well as food crop production. Therefore, this study focused on analyzing the factors that influence the adoption of bio-herbicide technology as an alternative to the chemical herbicides used by rural farmers in the North-Eastern region of Nigeria. Multi-stage random sampling technique was used to select 330 small-holder farmers in the study area using structured questionnaires. The data obtained were analyzed using Probit Regression Model. The results of Probit Regression identified the farmers' age, educational status, farm-size, access to extension services, farming experience, and membership in cooperative society as the factors which influenced adoption of the bio-herbicide technology by farmers in the study area. It was recommended that an awareness campaign on the new bio-herbicide technology among farmers in the area should be intensified. The farmers' access to education and extension services should be improved to enhance adoption of bio-herbicides technology which will impact significantly on the food production in the area. Also, farmers should be encouraged to be part of cooperative societies as a way to improving the adoption of Bio-herbicides for increased productivity.

Key words: Adoption, bio-herbicides, sustainable, food, Probit Model.

INTRODUCTION

The need for sustainable food production and elimination of perennial hunger occasioned by the insurgency in the North-eastern states of Nigeria top the priority of government programmes and policies. However, if activities that have the tendency of causing land degradation and environmental hazards are not properly addressed, many laudable efforts of the government would not yield the expected results. Wrong use of synthetic herbicides is one of the major activities that have a potential threat on the environment and

agricultural land. Shashidhara (2017) stressed the need for alternative methods in pest control which essentially include expanding biological agriculture and employing natural enemies to combat pests in order to lower the degree of toxicity accompanying the indiscriminate use of chemical pesticides by rural farmers. The multiplier effects of increasing use of chemical herbicides according to Saskia (2019), which include land degradation, depletion of essential soil-microbes, loss of nutrients, erosion and deposition of toxic elements in the

soil, etc., pose great danger to the efforts at improving food sufficiency in Nigeria, especially the North-Eastern states that have been severally ravaged by insurgent activities and communal crisis.

Many researchers have raised concern on the damaging impacts of chemical herbicides on the environment and human life (Matías et al., 2021; James et al., 2017; Sanzidur and Chidiebere, 2018; Melesse, 2018). The potential of chemical herbicide released into the environment causing harm is measured largely in terms of its toxicity and persistence. Majekodunmi (2014) reported that environmental pollution affects farmlands and water supply, and erodes the people's sources of livelihood, which in turn makes them susceptible to violence resulting from disputes on farmlands. This violence is manifested in the form of insurgency leading to low farm productivity and subsequently contributing to food insecurity especially in the North-Eastern parts of Nigeria. Shashidhara (2017) reported in his study of farmer's perception on ill effects of agro-chemicals in North-Eastern part of Karnataka that environmental pollution affects farmlands and water supply which in turn makes them susceptible to cancer-related ailments commonly observed among most rural farmers due to excessive and indiscriminate use of chemical herbicides. Mercy et al. (2016) further stressed that environmental degradation factors such as climate change effects e.g. shrinking of Lake Chad, erosion, flooding, desert encroachment, etc., are increasingly aiding the fast deterioration of the agriculture production resources.

James et al. (2017) stressed that weed management is essential for agricultural production and management of landscapes. They further observed that proper weed management will play an important role in determining whether we meet future food production requirements. Hence, awareness on bio-herbicides as alternative to chemical herbicides become inevitable to ensure good weed management and preservation of the environment. Ojo (2016) stated that there has been an alarming rate of low level of information and awareness on the dangers associated with the use of pesticides among Nigerian farmers. Mass-production of microbes applied as bio-herbicides to suppress weeds is a promising method of weed control (James et al., 2017). Bio-herbicide technology provides an excellent alternative to the current adverse effects inherent in the application of chemical herbicides with a bid to enhancing environment-friendly agro-ecology and sustainable food production in the North Eastern Nigeria. Joseph et al. (2018) opined that wrong handling of chemical pesticides by rural farmers in Nigeria have the tendency of damaging the natural nutrients regeneration capacity of soil as well as poor water retention efficiency of the farmlands. James et al. (2018) noted that weed management is essential for agricultural production and management of landscapes. They noted that proper weed management which involves mass production of microbes applied as bio-herbicides to suppress weeds is a promising alternative to chemical herbicide for the preservation of the environment.

Improvement in agricultural technologies through researches and the capacities of end users to adopt and utilise these technologies are critical in boosting agricultural productivity in developing countries according to Mapila (2011). The adoption of modern agricultural technologies by rural farmers has been shown to be influenced by some major factors. Melesse (2018) identified farm size as a factor that significantly affects the adoption of different agricultural innovations and technologies by rural farmers in developing countries. Thomas et al. (2017) also noted in adoption of improved rice varieties (Nerica) in the Northern Region, Ghana, that farm size represented a very significant factor. Moreover, membership in farming association such as cooperative societies has been observed to play a major role in the adoption of modern agricultural technologies (Dhraiefa et al., 2018; Ogochukwu and Okafor, 2017). Mamudu et al. (2012) identified age as an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. Furthermore, farm size significantly affects the adoption of different agricultural innovations and technologies by rural farmers in developing countries (Melesse, 2018; Thomas, 2018). According to Dhraiefa et al. (2018) membership of association played a major role in the adoption of modern agricultural technologies. They observed in their findings on the Factors Affecting the Adoption of Innovative Technologies by Livestock Farmers in Arid Area of Tunisia" the farmers' membership in farming association had a significant effect on the adoption status of the farmers. The influence of farmer's education on the adoption of new technologies was corroborated by Mamudu et al. (2012) in their study of Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana. The introduction of new farming technology is desirable for improved productivity and efficiency. Matías et al. (2021) noted that the utmost concern of farmers is usually the increase in the farm yields. However, many rural farmers are generally influenced by an array of certain important factors which critically determine their level of adopting new farming techniques. The harmful effects of synthetic herbicide usage on agro-ecology as well as food crop production cannot be over-emphasized. This has necessitated the increased researches on finding alternative methods of weed management towards sustainable agricultural production. Therefore, this study is focused on analysing the factors that influence the adoption of bio-herbicides by farmers to enhance sustainable food production in the North-east, Nigeria.

METHODOLOGY

Study area

The study was carried out in the North-Eastern Region of Nigeria which comprises Adamawa, Borno, Yobe, Bauchi, Taraba and
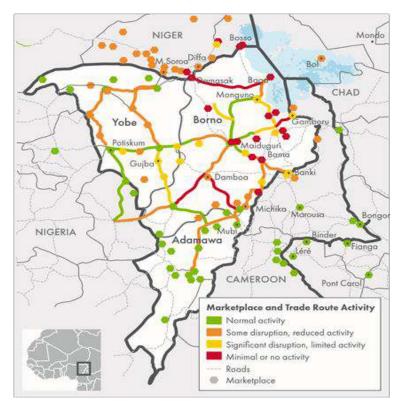
Figure 1. Map showing the study area.
Source: authors 2021

Gombe states (Figure 1). This research is focused only on three states from the region, namely; Adamawa, Borno and Yobe states. These three states have high records of land degradation and desert encroachments coupled with negative impacts of insurgent activities especially by Boko-Haram and Fulani-herds-men/Farmers clashes (Saskia, 2019). These three states are notably agrarian environment with farmers growing cereal crops such as maize, guinea corn, cowpea, groundnuts, millet, etc., animal husbandry is also predominant in Adamawa State mostly among the Fulani dwellers. The Northern states which are substantially rural and having less exposure to education, experiences more poverty than other parts of the country. The inhabitants are predominately peasant farmers, though few are cattle herdsmen. North-East occupies slightly less than one-third of Nigeria's total area and had a projected population for 2011 of 23,558,674 or 13.5% of the country's total population. The inhabitants are mainly Fulani with only Borno State having Kanuri people as majority with more than 100 minority ethnic groups. Adamawa State is located in the northern part of Nigeria. It shares with Taraba State in the south and west, with Gombe State in North-West and Borno State to the North. The state has an international boundary with Cameroon Republic along its eastern side (Federal Office of Statistics, 1996).

Sampling technique

Primary data for this study were collected through the use of structured questionnaires. The questionnaires were distributed by enumerators using a multi-stage sampling survey for the study. The first stage involved random sampling of three Local Government Areas each from Adamawa, Borno and Yobe states within the North-Eastern region of Nigeria. Second stage involved the random sampling of four wards from each of the 9 Local Government Areas

sampled in the three selected states. Thus, a sum of 36 wards was randomly sampled and ten farmers were selected from each of the wards to give a total sample size of three hundred and sixty. At the end of the survey, three hundred and thirty properly filled questionnaires were returned and used for the analysis.

Analytical framework

Probit Regression model was used to evaluate the determinants of adoption of the bio-herbicide technology among farmers in the area. The Probit Regression model has been widely employed by many researchers to evaluate the functional association among the probability of adoption and its determining variables (Mamudu et al., 2012; Agnieszka et al., 2020). The probit model assumes variable Y_i as binary with only two possible outcomes (1 for adoption and 0 for non-adoption). It also considers a vector of explanatory variables x_i which explains Y_i. The empirical specification of the probit model for the study is given as follows:

$$Y_i = \beta_0 + \sum_{n=1}^{0} \beta_n X_{ni} + u_i$$

where X_i represents a vector of explanatory variables, u_i is a random disturbance term, n is the total sample size, and β is a vector of unknown parameters to be estimated by the method of maximum likelihood.

Hence, Y_i = Adoption of bio-herbicides = (1 if farmer adopted, 0 otherwise); X1 =Age; X2 = Marital status (1 if farmer is married, 0 otherwise); Gender (1 for Male farmer, 0 otherwise); X3 = Household Size; X4 = Education; X5 = Farm Size; X6 = Farming Experience (Years); X7= Access to Extension Services (1 for Access to Extension Services, 0 otherwise); X8 = Access to credit (1 if farmer had access to credit, 0 otherwise); X9 = Membership of

Cooperative Society (1 if farmer belong to Cooperative Society, 0 otherwise).

RESULTS AND DISCUSSION

Socio-economic characteristics of the farmers in the study area

The results in Table 1 showed that majority of the farmers (above 50%) were within the active ages of 40 years and below. According to Onu and Adebayo (2010) farming activities usually require able-bodied young and active members of most rural communities in Nigeria and this justifies the outcome of the result of this research. Furthermore, the results revealed that more than 70% of the farmers acquired education beyond primary level. This implies that most of the farmers in the area have access to formal education. Mapila (2011) similarly stressed that access to formal education is a very important factor that influences the farmer's attitude in adopting new technology. The results further showed further that 77% of the farmers were farming on land area of between 1 and 5 ha. This result corroborates the findings of Onu and Adebayo (2010) that most farmers in sub-Saharan Africa generally operate on subsistent level using small plots of farmlands. The results of the study revealed that above 70% of farmers in the area had house-hold size of more than 5. This indicates that many of the farmers in the study area had relatively large family size. According to Ahmadu and Erhabor (2012) majority of farmers in Nigeria have averagely large-sized family which usually justified by the need to cope with high demand for farm family labour. Furthermore, the study also indicated that farmers in the area had limited access to extension services and credit facilities. This would have major effects on the attitude of the farmers towards adopting new agricultural technology. Access to extension services and credit facilities has been observed to have significant effects on the adoption of new technology by farmers according to Mamudu et al. (2012).

Determinants of adoption of bio-herbicide technology by farmers in the area

The results of the Probit regression analysis revealed that the factors which influenced the adoption of bio-herbicide technology among the farmers in the North-Eastern Region of Nigeria include the age of the farmers, educational status, farm size, their access to extension services, farming experience and their membership in cooperative societies. The findings showed that age of the farmers, educational status, farm size and their access to extension services were identified as having statistically significant influence on the adoption of the bio-herbicide technology by the farmers in the study area at 1% level of significance. In addition, at a 5% significance level,

farming experience and their membership in cooperative society also influence the farmers' decision in adopting the new technology.

Age of the farmers was identified from the result of the study as an important determinant of adoption of the bio-herbicide technology in the area. This result supports the similar report obtained by Thomas et al. (2018) that age of farmers is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. The study further showed that the level of farmer's education plays a major role in determining the attitude of the farmers towards adopting the bio-herbicide technology. The result indicates a statistically significant relationship between the farmers' education and the adoption of bio-herbicide technology. This report corroborates the findings of Melesse (2018) who identified the farmers' access to formal education as an important factor that influences the adoption of agricultural new technologies by farmers in Ethiopia. Sanzidur and Chidiebere (2018) also observed that educational level of farmers is critical in decision making process in adopting new farming techniques. Farmers' access to education will enhance efficiency in receiving and interpreting major information on new agricultural practices.

Moreover, the size of the farmland used by the farmers was also shown to have a positive and significant influence on the adoption of the new technology. This implies that farmers with larger farm sizes were ready to adopt the technology more than those with smaller plots. Generally, commercial farmers have greater capacity to take risks than peasant and subsistent farmers. The result agrees with the report of Thomas et al. (2018) who observed that the farm size played a major role in the adoption of Improved Rice varieties (Nerica) in the Northern Region, Ghana. Another factor identified in the study as influencing the adoption of bio-herbicide technology in the area is the access to extension services by the farmers. Extension service is a crucial institutional factor that differentiates adoption status among farmers as equally noted by Melesse (2018). Extension services create a platform for the acquisition of relevant information on the new agricultural technologies. The result revealed that there is a positive and significant relationship between the access to extension services by the farmers and the adoption of the bio-herbicide technology. It implies that the more access the farmers have to extension services, the better the attitude towards adopting the bio-herbicide technology in the study area. Moreover, the study showed farming experience of the farmers as another important factor that determined the adoption of bio-herbicide technology by the farmers in the area. The result showed that the more years of their experience in farming, the higher the probability of adoption of the new technology. Also, their membership of cooperative societies was identified as a significant factor which influenced the decision of the farmers towards adopting the bio-herbicide

Table 1. Determinants of the adoption of bio-herbicides by farmers in the study area.

Variable	Coefficient	Standard error	Z-Statistic	P-Value
Age	-0.201857	0.042283	-4.773945	0.0000*
Marital status	-0.166895	0.109739	-1.520831	0.1283
Household size	-0.007683	0.083502	-0.092008	0.9267
Education level	2.366165	0.840941	2.813712	0.0049*
Farm size	2.998871	0.960444	3.122379	0.0018*
Farming experience	0.760099	0.358506	2.120184	0.0340**
Extension service	2.858395	0.607396	4.705984	0.0000*
Access to credit	0.131725	0.243569	0.540812	0.5886
Membership of cooperatives	1.376817	0.633800	2.172322	0.0298**
McFadden R-squared	0.743352			
Sum squared residue	16.59865			
Log likelihood	-57.47980			

*Significant at 1%; **Significant at 5%. Source: Field Survey (2021).
Source: authors 2021

technology. Consequently, the formation of cooperative societies provides an added advantage to the farmers in taking corporate decisions on issues that would improve their productivity. Similar result was obtained by Dhraiefa et al. (2018) who identified the farmers' membership in association as a critical factor which significantly influenced their adoption of new farming technologies. Ogochukwu and Okafor (2017) also reported that membership in cooperative societies is a significant variable to be considered in determining the decision of farmers to adopt new technologies.

CONCLUSION AND RECOMMENDATIONS

The study has shown the various factors that have significant effects on the readiness of the farmers in the study area to adopt the bio-herbicide technology as alternative method for weed control instead of using the mostly harmful synthetic chemical herbicides. The determinants of the farmers' adoption of the new technology according to the results of the study include age of the farmers, educational status, farm size, their access to extension services, farming experience and their membership in cooperative societies.

Therefore, it is recommended that an awareness campaign on the new bio-herbicide technology among farmers in the area should be intensified. Furthermore, the farmers' access to formal education should be improved, especially through adult literacy programmes as this will positively influence their adoption of new technology thereby enhancing their productivity. Moreover, the need to raise the farmers' access to extension services should also be stressed as it has been shown as a critical factor which influences the rate of the adoption of new technology by the farmers. Also, the need for the farmers

to be part of cooperative societies in their farming communities should be emphasized. This will encourage useful all-inclusive decisions with concerted efforts towards increased food production in the area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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