REGULAR ARTICLE

FACTORS INFLUENCING FARMERS' WILLINGNESS-TO-PAY FOR BIOFORTIFIED MAIZE IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

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ABSTRACT

Research background: Biofortified maize are products of modern biotechnology and genetic engineering, which produce crops with special traits of interest resistance to pests and diseases, tolerance to the herbicide, high yield, salt tolerance, submergence, nitrogen efficiency, etc. It is not just about technological advances and the development of a new product, ascertaining the factors that could stimulate demand, and creating awareness about the benefits of biofortified crops are crucial for this new enhanced variety of maize to make an impact.
Purpose of the article: The research was conducted to determine the factors influencing farmers' willingness-to-pay for biofortified maize in Gwagwalada Area Council, of the Federal Capital Territory (FCT), Nigeria, to identify the stimulating factors and challenges confronting farmers' willingness-to-pay for biofortified maize.
Methods: The multistage sampling technique was adopted for the study and used to select a total of 100 maize farmers for this study. Primary data were collected from the respondents using a well-structured questionnaire. The data were analyzed using descriptive statistics and the Two-limit Tobit Model, which was used to identify the factors influencing farmers' willingness-to pay for biofortified maize.
Findings, value-added & novelty: The study found that the majority of the maize farmers in FCT, Nigeria were willing-to-pay for biofortified maize, while the result from the Two-limit Tobit analysis revealed that sex, extension contact, access to land, the number of literate in the farmers' households, and maize farming training were the factors that influenced the maize farmers' willingness-to-pay for biofortified maize, while non-availability of credit facilities was a major constraint militating against their willingness to pay for biofortified maize. The study recommends that stakeholders should ensure to make credit facilities more accessible to maize farmers to enhance the adoption of biofortified crops, especially maize, and advocated for regulatory land-use acts that will make maize farmers participate more inland ownership systems that are more secured should be put in place for land tenants to benefit so that they can be able to invest and use sustainable maize production strategies to maximize benefits.

Keywords: *biofortification; Two-limit Tobit; maize; willingness-to-pay.*
JEL Codes: R52; R58; D1.

INTRODUCTION

Maize (Zea mays) is one of Nigeria's most important cereals, both in terms of the number of farmers that cultivate it and in terms of its economic importance. Maize, which began as a subsistence crop in Nigeria, has evolved into a commercial crop on which many agro-based industries rely for their raw materials, owing largely to the fact that maize is a versatile crop that allows it to grow across a range of agro-ecological zones of the country, costing less than other cereals, high yielding and easy to process **(Iken & Amusa, 2004)**. The animal feed sector consumes about half of the total maize produced in Nigeria, with poultry accounting for up to 98% of the total feed. There are nearly 870 million people who are chronically undernourished **(Food and Agriculture Organization [FAO], 2012)**, and according to **United Nations Children's Fund** [**UNICEF] (2017)**, 22.9% of underage five children worldwide are stunted, with one-third of these stunted children living in Sub-Saharan Africa, with West and Central Africa accounting for 33.5%.
Maize's richness lies in its enormous genetic diversity, which has allowed breeders to improve it using traditional breeding methods. Maize is the most extensively consumed staple food in Africa, providing over 30% of total calories to over 4.5 billion people in developing countries. Poor-quality diets dominated by dietary staples are typically lacking in minerals and vitamins, but maize can supply enough amounts of Provitamin A (proVA), which the body converts to Vitamin A. According to **Nilupa *et al.*, (2019)** the first commercial biofortified crop was Quality Protein Maize (QPM), which is a group of maize varieties established by traditional plant breeding methods to produce grains with higher protein quality. The maize breeding target was set at 15 g/g beta-carotene, to provide an additional 50% of the estimated average Vitamin A requirements in maize-eating regions. Maize containing these quantities of beta-carotene would be an effective contributor to reducing Vitamin A deficiency.

Biofortification is the process of biologically enriching food crops with macro or micronutrients by agronomic methods, traditional plant breeding, or genetic engineering **(Bouis & Saltzman, 2017)**. Biofortification tries to boost nutrient levels in crops while they're still growing, rather than after they've been harvested. According to the World Health Organization (WHO), vitamin A deficiency affects 5.2 million preschool-age children worldwide. The International Maize and Wheat Improvement Center have partnered with several agencies in recent years to develop provitamin A maize to reduce vitamin A deficiency in children. The first zinc-enriched maize varieties were launched in Honduras and Colombia in 2017 and 2018, respectively, as a result of the collaborative efforts. Biofortified maize consumption has been shown to boost total body Vitamin A deposits as effectively as supplementation **(Gannon *et al.*, 2014)**, as well as considerably improve visual performance in children who are Vitamin A deficient **(Palmer *et al.,* 2016)**.
The International Institute for Tropical Agriculture (IITA), the Institute of Agricultural Research (IAR), and the Nigerian university's agriculture faculties are also involved in breeding initiatives that assist maize stack nutrients. For biofortified maize to have an impact, research institutes must collaborate with maize farmers, this entails much more than simply technology advancements and generating new products; it's also about enabling legislation, encouraging demand, and raising knowledge about the advantages of various kinds.
Despite the fact that biofortified maize has been identified as one of the key staple crops that can be used to reduce hunger and combat malnutrition in Africa, it is yet to be fully accepted by farmers in Nigeria and this can be attributed to numerous factors. Farmers' willingness-to pay (a measure of their acceptance) for biofortified maize depends largely on the farmer's attributes and agronomic traits' including its nutritional values. Currently, the perceived agronomic traits of biofortified maize by smaller holder farmers in Gwagwalada Area Council of the FCT, have not been explored. This and many more drawbacks necessitated this study to assess the factors influencing farmers' willingness-to-pay for biofortified maize in the FCT, Nigeria. Specifically, the study would assess the willingness-to pay for biofortified maize by the respondents in the study area, identify the factors influencing farmers' willingness-to pay for biofortified maize in the study area, and assess the perceived constraints facing farmers in acceptance of biofortified maize in the study area.
The null hypotheses that aided the study to achieve the specific objective of identifying factors influencing farmers' willingness-to-pay for biofortified maize in Gwagwalada Area Council, FCT were: (i) H_{01}: There is no significant relationship between socio-economic characteristics of the farmers and their willingness-to-pay for biofortified maize in the study area; (ii) H_{02}: There is no significant relationship between the willingness-to-pay for biofortified maize and the farm and institutional factors in the study area.

LITERATURE REVIEW

Biofortification is derived from the Greek word "bios" which means "life" and the Latin word "fortificare" which means "making strong". It's the process of improving the nutritional quality of food crops through agronomic practices, traditional plant breeding, or modern biotechnology **(Meena *et al.,* 2017)**. Biofortification is defined as "the enhancement of micronutrient levels of staple crops through biological processes such as plant breeding and genetic engineering". Biofortification of staple crops, according to **Meenakshi *et al.,* (2010)**, is a major technique to combat micronutrient insufficiency and increase the availability of vitamins and minerals for individuals whose diets are dominated by low-nutrient foods.
Biofortification employs advanced technology (breeding and genetic engineering) alone or in combination with crop selection to increase the nutritional value by increasing micronutrient content, the bioavailability of nutrients, and cost-effectiveness. Because of its long-term cost-effectiveness in delivering micronutrients once incorporated into plant food varieties, biofortification has been identified as an advantageous approach. It has the potential to make micronutrients available to underserved rural populations who cannot afford other forms of fortification and micronutrient sources and rely more on staples **(Bovis, 2003)**. Biofortification is aimed at the rural poor, who produce and consume staple food crops in large quantities and may lack access to other nutrition interventions such as fortification, which are primarily aimed at urban populations who consume processed foods **(Birol et al., 2015**). If fully adopted and accepted, genetically modified crops could provide food-based interventions to remote populations with micronutrient deficient diets **(Onyeneke *et al.,*2019)**. According to **Mwiti *et al.,* (2015**), biofortification, particularly in staples, can help to reduce the prevalence of vitamin A deficiency and food insecurity. Creating new products from these biofortified crops can help to increase acceptability and utilization, and thus increase dietary intake of provitamin A carotenoids **(Nkhata*, et al.,* 2020)**. Biofortification may thus provide a means of reaching populations where supplementation and traditional fortification activities may be difficult to implement and/or limited **(World Health Organization [WHO], 2019)**.
Maize (Zea mays) belongs to the grass family (gramineae). It originated in South and Central America and was introduced to West Africa in the 10th century by the Portuguese. Maize is a major cereal and one of Nigeria's most important food crops. Dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn are the six major types of maize **(Franklin, 2013)**. Sweet corn varieties are typically grown for human consumption as kernels, whereas field corn varieties are used for animal feed, and various corn-based human food uses (such as grinding into cornmeal or masa, pressing into corn oil, and fermentation and distillation into alcoholic beverages such as bourbon whiskey), and as chemical feedstocks. Maize is also used in the production of ethanol.
Maize has grown in importance over the years, displacing traditional crops such as millet and sorghum. In 2018, Nigeria produced 10.2 million tons of maize from 4.8 million hectares, making it Africa's largest producer **(FAO, 2018)**. Because

of its genetic plasticity, it has become the most widely cultivated crop in the country, ranging from the wet evergreen climate of the forest zone to the dry ecology of the Sudan savanna. Maize has become a staple food in many parts of the world, with total maize production exceeding wheat or rice. Maize is used for corn ethanol, animal feed, and other maize products in addition to being consumed directly by humans (often in the form of masa).

Willingness to pay (WTP) is the highest price a consumer is willing to pay for a commodity, product, or service. The concept of WTP assists economists in determining aggregate consumer demand. Businesses set the price points for their products based on information about consumer demand. According to **Vernazza *et al.,* (2015)**, "willingness-to-pay" (WTP) is a systematic and reliable monetary method. WTP attempts to quantify an individual's preference strength for any desired intervention by calculating the maximum amount of money they would be willing to sacrifice **(Matthews *et al.,* 2002)**. **Donaldson (2011)** saw this as an example of "direct democracy" in public policymaking.

WTP can be measured in two ways, according to **Carson & Hanemann (2005)**: first, the "revealed preferences" approach, which focuses on farmer behaviour in the market and can be measured based on information obtained from actual real market purchases of individuals, and second, "stated preferences," an indirect technique in which farmers are asked to explicitly state their WTP. WTP can be elicited through an interview or a questionnaire, but **Calder (2004)** recommended a face-to-face interview method for a more valid result.

The two-limit Tobit model can be used to isolate factors that influence willingness-to-pay for biofortified maize. The two-limit Tobit model is a special case of the censored model; this model class is known as limited dependent variable models or latent variable models. Censoring occurs when the values of the dependent variable are restricted to a narrow range of values, i.e., we see $Yi=0$ and $Yi>0$. When data is censored, the distribution that applies to the sample data is a hybrid of the discrete and continuous distributions. The total probability is 1, as expected, but instead of scaling the second part, we simply assign the full probability in the censored region, in this case, 0, to the censoring point.

Tobit models are a type of censored regression model in which a model captures variation in a specific direction where variables are only observable under certain set conditions. When it assumes a value greater than zero, it is frequently defined as equal to the latent variable; otherwise, it is defined as zero. The relationship between a non-negative dependent variable and independent variables is statistically described by Tobit models. Heckman's two-step, or correction method, is a popular alternative to the maximum likelihood estimation of the Tobit model.

Zhou and Li (2015) used the Tobit model to examine the factors that influence residents' willingness to pay for watershed services, and the results show that residents' heterogeneity is significantly related to residents' willingness to pay. **Zheng et al. (2010)** used the Probit model to investigate the factors that influence residents' willingness to pay for the Jinhua River Basin, and the empirical results show that education levels and income levels have a significant correlation with residents' WTP. Literature has shown that previous studies primarily used Tobit **Zhou and Li (2015)**, Probit **Zheng *et al.,* (2010)**, logistic **(Ge *et al.,* 2009)**, or structural equation models **(Li *et al*., 2012)** to analyze the factors influencing willingness to pay. But none specifically used the two-limit Tobit model that is characterized by censoring from the two extremes. This study adopted a two-limit Tobit model to examine the factors that influence the willingness-to-pay for biofortified maize.

DATA AND METHODS

Study Area

The study was carried out in Gwagwalada Area Council of Federal Capital Territory Abuja, Nigeria. It is located at the extreme South-west near the flood plain of River Gurara which transverses the territory from North to South at an elevation of 70m above sea level. The area lies between latitude $07^0.57$̀N and longitude $07^0.7$̀E. There are ten (10) wards within the Gwagwalada Area Council, they are Dobi, Ikwa, Tungan Maje, Gwagwalada center, Kutunku, Zuba, Paiko, Gwako, Ibwa, and Staff quarters. The vegetation in the area combines the best features of the southern tropical rain forest and guinea savanna of the North. This reflects the full transitional nature of the area between the Southern-forest and Northern grassland which have the woods and shrubs respectively. The soil is reddish with isolated hills filled with plains and well-drained sandy clay loams which support the farming of the major crops such as sorghum, millet, melon, yam, soybean, benniseed, cassava, and rice cultivation **(Federal Capital Territory Agricultural Development Programme [FCTADP], 2004)**.

Sampling Technique and Sample Size

This study made use of the multistage sampling technique that includes the purposive and simple random sampling techniques for sample size selection. In the first stage, the purposive sampling technique was adopted and employed in choosing Gwagwalada Area Council as the study area. The criteria for the selection of Gwagwalada Area Council as the study area was based on the high maize production activities in the council areas. In the second stage, simple random sampling techniques were employed for the selection of five (5) wards out of the ten (10) wards within the Gwagwalada Area Council. The third stage involves the random selection of two (2) villages per ward to give a total of 10 villages in all. The fifth and final stage involves the random selection of ten (10) smallholder maize farmers from each selected village, thus giving a total of 100 respondents, but 94 were finally used after data cleaning and removal of questionnaires that were not filled.

Method of Data Collection

The primary data used for this study were collected using a well-structured questionnaire. The questionnaires were administered to selected farmers in the selected areas through personal interviews.

Econometric Model Specification: Two-limit Tobit Model

Two-limit Tobit Model was adopted for this study and used to identify the factors influencing farmers' willingness-to pay for biofortified maize in the study area. This was purposely chosen because the objective being investigated involves two limits of zero and any positive categorical value of the respondent on willingness-to-pay for bio-fortified.

$$Y^* = \beta_0 + \beta_i X_i + \varepsilon_i \quad (1)$$

Where = Y^* is a continuous latent variable, X is a matrix of explanatory variables, β is a vector coefficient to be estimated, and ε_i is a vector of normally distributed error terms with variance σ^2, if we denote the observed dependent variable as Y, then

$$Y = 0 \; if \; Y^* \leq= 0 \quad (2)$$

$$Y = Y^* if \; 0 < Y^* < \infty \quad (3)$$

The model is one of the censored dependent variables because observations at the limits are observed. If the observations at the limits are not observed, the model is known as truncated. In this case, the dependent variable is the amount the farmer is able to pay above ₦3000.00 Nigerian Naira for the conventional maize.

Where: X_i factors that influence pest management decisions (socio-economic, farm-specific, and institutional factors) and include: X_1 = Sex, X_2 = Age of household head (Years); X_3 Membership Cooperative Society (Dummy, 1 if yes, 0 otherwise), X_4 Education level (years of schooling), X_5 Annual income (naira), X_6 Maize farming experience (Years), X_7 Farm Size (hectares), X_8 Access to credit (Dummy, 1 if yes, 0 otherwise), X_9 Extension contact (Dummy, 1 if yes, 0 otherwise), X_{10} Access to land (Dummy, 1 if yes, 0 otherwise), X_{11} Number of dependent in the household, X_{12} Number of Literates in the household, X_{13} Maize farming training (Dummy, 1 if yes, 0 otherwise), and ε_j error terms.

Hypotheses Testing

The null hypotheses (i) and (ii) were tested using t-test statistics embedded in the Two-limit Tobit model at various levels of significance (1%, 5%, and 10%).

$$t_i = \frac{Coefficient(\beta_i)}{Standard\ Error\ (\beta_i)} \quad (4)$$

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Maize Farming Households in the Study Area

Table 1 shows the relevant socio-economic characteristics of the maize farmers in the study area. The result revealed the mean marital status of the maize farming household heads as 77.7%, implying that 77.7% were mainly married with a mean age of approximately 41years. This implies that the maize farmers in the study area are within the economically productive age. According to **Adeola (2010)**, people of this age are more resilient to stress and devote more time to agricultural operations, which can lead to increased output. Farmers' risk aversion, adoption of improved agricultural technologies, and other production-related decisions are all influenced by their age.

The Table further revealed that 90.4% of the maize farmers had formal education. Educational attainment is very important because it could lead to awareness of the possible advantages of modern farming techniques thereby increasing their level of willingness-to-pay for biofortified maize. **Ahmadu (2011)** found a positive correlation between education and the adoption of new innovations.

The mean year of maize farming experience is approximately 10years, implying that a majority of the maize farmers had been in the business for a long time. According to **Nwaobiala (2014)**, with more experience, a farmer can become less fearful of the risks associated with adopting new technology. The mean farm size is 1.73hectares. The maize farmers' average farm size is in agreement with the findings of **Orisakwe & Agumuo (2011)**, who found that most agroforestry farmers in Nigeria own farmlands of no more than two hectares (2ha). 58.9% of the maize farmers are members of one cooperative society or the other. Through collective bargaining, cooperative membership assists farmers in obtaining credit, information, and inputs. According to the literature, intra-community bonds of trust and cooperation may lead to inward-looking behaviour, making individuals less likely to seek out new agricultural innovations **(Van Rijn *et al.* 2012)**.

Table 1 Socio-economic characteristics of the maize farming households in the study area

Socio-economic variable	Measurement	Mean distribution
Sex	Dummy (1, "Male"; 0, otherwise)	0.862
Age	Years	40.67
Marital status	Dummy (1, "Married"; 0 otherwise)	0.777

Maize Farming Experience	Years	9.80
Farm size	Hectares	1.73
Annual Income	Naira (₦)	₦1,530,136.53
Level of Education	Dummy (1, "Formal Education"; 0, otherwise)	0.904
Membership in Cooperative Society	Dummy (1, "Membership"; 0, otherwise)	0.589

Farmers' willingness-to-pay for biofortified maize in the study area

Table 2 below revealed the information obtained from the farmers on their willingness-to-pay for biofortified maize in Gwagwalada Area Council of the Federal Capital Territory. The result shows that 33.0% of the respondents are not willing-to-pay for biofortified maize while a majority (67.0%) were willing-to-pay for biofortified maize in the study area.

Table 2 Farmers' Willingness-to-Pay for Biofortified Maize in the Study Area

Willingness to Pay for Biofortified Maize	Frequency	Percentage (%)
Not WTP for BiofortifiedMaize	31	33.0
WTP for Biofortified Maize	63	67.0
Total	**94**	**100.0**

Factors that influence the willingness-to-pay for biofortified maize in the study area

Two-limit Tobit model analysis was carried out to determine the factors influencing the maize farmers' willingness-to-pay for biofortified maize in the study area, some factors such as socio-economic characteristics (sex of the farmer, and number of literates in the household), and farm-specific and institutional factors (extension contact, access to land and maize farming training) were regressed against the maize farmers' willingness-to-pay for biofortified maize and the result is presented in table 3 below. The goodness of fit measured by the moderate Pseudo R-square of 0.0507 showed that the choice of explanatory variables included in the two-limit Tobit regression model fairly explained the variation in the maize farmers' willingness-to-pay for biofortified maize. Of the twelve (12) variables included in the model, only 5 variables were statistically significant out of the 12 variables used in the model and thus led to the rejection of the null hypotheses.

The coefficient of sex of the farmers (4681.10) was positive and significantly influenced the maize farmers' willingness-to-pay (WTP) for biofortified maize at a 5% level. This implied that male maize farmers in the area were more likely to show willingness-to-pay (WTP) for biofortified maize than their female counterparts within the study area. In the study by **Michalscheck *et al.,* (2018**), sex was also found to significantly affect the adoption of new agricultural technologies by smallholder farmers in Africa.

Extension contact (-5964.74) is negatively related and statistically significant to willingness-to-pay for biofortified maize at a 5% level of probability, implying that the more extension contacts the maize farmers in the area have, the less willing they become to pay for biofortified maize. This result went against the a priori expectation. But the reason could be that the village extension workers/agents have not really understood the benefits of biofortification of crops. This finding is consistent with the findings of **Emmanuel *et al.,* (2016)** and **FAO, (2014)** that agricultural development is heavily reliant on access to new technologies and information, which extension services can greatly facilitate.

The result further revealed that access to land (6773.12) is positively influenced the maize farmers' willingness to pay for biofortified maize and statistically significant at a 1% level of probability. The implication of this is that the maize farmers' willingness-to-pay for biofortified maize in the study area, increases with their increasing access to agricultural land. This means that maize farmers who own a large area of land are more likely to show willingness-to-pay for biofortified maize than those who are tenants with relatively fewer farm sizes. It is widely assumed that owning land encourages the adoption of new technologies **(Daberkow & McBride, 2003)**. Tenants can be assumed less likely than landowners to adopt new technological innovations, as the benefits may not necessarily flow to them, while land ownership is likely to influence the adoption decision. This is consistent with the result of **Oni (2014) Otitoju & Oni (2017)** on farmers' willingness to plant agroforestry trees.

The number of literates in the farmers' households (-1680.81) is contrary to the a priori expectation related and statistically significant to willingness-to-pay for biofortified maize at a 1% level of probability. This implies that maize farmers with fewer educated persons in their households were more willing to pay for biofortified maize in the study area. This is in contrast to the observation made by **Olumba & Rahji (2014)** that the educational status of farmers positively influences their adoption of improved technologies. The reason could be that those that could read and write were not really involved in the decision-making in the households.

Maize farming training (4279.56) was positive and statistically influenced maize farmers' willingness-to-pay for biofortified maize at a 10% level of significance. This implies that an increase in the maize farming training would increase WTP for biofortified maize by its coefficient, ceteris paribus. Farmers' training is essential in the adoption of agricultural technologies. According to **Tey *et al.,* (2017)**; **Jha *et al.,* (2019)** the adoption of new technology by smallholder farmers in Africa is influenced by a variety of factors. According to **Salami *et al.,* (2017)**, smallholder farmers need to learn how to apply new technologies and processes, as well as how to integrate these new technologies and processes into existing systems, through training.

Table 3 Determinants of Willingness-to-pay for Biofortified Maize in the Study Area

Explanatory Variable	Coefficient	Robust Standard Error	t-value	P>|t|
Sex (Dummy, 1 if male, 0 otherwise)	4681.10	2271.87	2.06**	0.04
Age of the farmer (Years)	-107.77	112.52	-0.96	0.34
Membership Cooperative Society (Dummy, 1 if yes, 0 otherwise)	1073.69	2188.25	0.49	0.61
Education level (years of schooling)	-195.81	213.74	-0.92	0.36
Annual income (naira)	-0.00063	0.00064	-0.98	0.33
Maize farming experience (Years)	-262.97	194.30	-1.35	0.18
Farm Size (hectares)	-890.12	805.47	-1.11	0.27
Access to credit (Dummy, 1 if yes, 0 otherwise)	-252.21	2381.06	-0.11	0.92
Extension contacts (Dummy, 1 if yes, 0 otherwise)	-5964.74	2462.40	-2.42**	0.02
Access to land (Dummy, 1 if yes, 0 otherwise)	6773.12	2412.74	2.81***	0.01
Number of dependent in the household	484.96	595.39	0.81	0.42
Number of Literates in the household	-1680.81	668.69	-2.51***	0.04
Maize farming training (Dummy, 1 if yes, 0 otherwise)	4279.561	2148.96	1.99*	0.05
Constant	12463.66	6560.22	1.90	0.06

Diagnostic statistics: Number of Observation = 94; F (13, 81) = 1.78; Prob > F = 0.0608; Log Pseudo likelihood = -6664.55; Pseudo R-square = 0.0507. Triple asterisk (***), double asterisk and asterisk denote variables significant at 1%, 5% and 10% respectively.
Source: Computed from field data, 2021.

Constraint militating against the willingness of farmers to pay for biofortified maize in the study area

Table 4 showed the constraints militating against the willingness of farmers to pay for biofortified maize in Gwagwalada Area Council. Non-availability of credit facilities was a major constraint with 53.2% of the maize farmers attested to it as a very serious challenge, 28.7% of them attested to it as a serious constraint, 11.7% of them confirmed it as a less serious problem and 6.4% of the sampled farmers believed it not to be a serious problem. Also, 42.6% of the respondents agreed that the non-availability of storage facilities was a very serious constraint, 21.3%ot them believed it was not a serious problem, 19.1% of them believed it was a serious problem, while 17% of them agreed that it's a less serious problem. These constraints posed by credit access and agricultural technology have been linked by **Abdul-Hanan *et al.* (2014)** and **Abdallah (2016)** to credit market imperfections that prevent farmers from obtaining adequate credit.

Again, 47.9% of the maize farmers agreed that inadequate/lack of extension programmes directed to meet the need of farmers was a serious problem, 27.2% of them believed it was a very serious problem, 17% of them believed it was not a serious problem, while 7.4% of them agreed that it was a less serious problem. More so, 31.9% of the maize farmers believed that poor access to and control of land was a serious problem, 28.7% of them agreed that it was a less serious problem, 20.2% of them agreed that it was a very serious problem, while 19.1% of them believed it was not a serious problem. In the same vein, 36.2% of the maize farmers believed that lack of/or inadequate access to supporting institutional facilities was a very serious problem, 33% of them agreed that it was a very serious constraint, 17% believed it was a less serious problem, while 13.8% of them believed it not a serious problem. Also, 39.4% of the maize farmers believed that inadequate facilities to facilitate biofortified maize production was a very serious problem, 35.1% of them believed it was a serious problem, 13.8% of them believed it was a less serious problem, while 11.7% of them believed it was not a serious problem. Investment in structural infrastructures such as roads and the formation of farmer cooperatives has been shown by **Padula et al. (2012)**, and **Andri *et al.,* (2011)** to increase farm incomes.

Again, 33% of the maize farmers believed that the technical know-how of farmers in handling mechanized and technical duties in biofortified maize was a very serious problem, 22.3% of them agreed that it was not a serious problem. So, this confirms the hypothesis of **Alene & Manyong (2007)** that technological know-how has a strong threshold effect on the probability of adoption of modern technology.

Table 4 Frequency and Mean Distribution of Constraints Militating Against the Willingness of Farmers to Pay for Biofortified Maize

Constraints	Very Serious	Serious	Less serious	Not serious	Mean Score
Non-availability of credit facilities	50(53.2)	27(28.7)	11(11.7)	6(6.4)	3.11
Illiteracy of the farmer	25(26.6)	24(25.5)	25(26.6)	20(21.3)	2.10
Non-availability of storage facilities	40(42.6)	18(19.1)	16(17.0)	20(21.3)	2.45
Inadequate/lack of extension programmes directed to meet the need of farmer	26(27.2)	45(47.9)	7(7.4)	16(17.0)	2.62
Non-availability of Labour	21(22.3)	43(45.7)	13(13.8)	17(18.1)	2.40

Insufficient knowledge of credit sources to support paying for biofortified maize	28(29.8)	35(37.2)	16(17.0)	15(16.0)	2.48
Inadequate/lack of government policies to empower paying for biofortification actors	26(27.7)	28(29.8)	19(20.2)	21(22.3)	2.20
Lack of/ or inadequate collateral security required to secure a loan to support paying for biofortification operations	19(20.2)	37(39.4)	18(19.1)	20(21.3)	2.18
Neighbourhood norms, customs, culture and traditional beliefs about maize	15(16.0)	34(36.2)	22(23.4)	23(24.5)	1.96
Poor access to and control of land	19(20.2)	30(31.9)	27(28.7)	18(19.1)	2.05
High cost of resources and services	21(22.3)	32(34.0)	19(20.2)	22(23.4)	2.12
Lack of/or inadequate awareness of and inadequate access to NGOs programmes in biofortification	18(19.1)	34(36.2)	21(22.3)	21(22.3)	2.07
Lack of/or inadequate support systems	28(29.8)	33(35.1)	18(19.1)	15(16.0)	2.43
Lack of/inadequate access to information on biofortified maize	31(33.0)	36(38.3)	11(11.7)	16(17.0)	2.59
Low income of farmers	27(28.7)	32(34.0)	15(16.0)	20(21.3)	2.33
The low technical know-how of farmers in handling mechanized and technical duties in biofortified maize	31(33.0)	31(33.0)	11(11.7)	21(22.3)	2.43
The unwillingness of farmers to take risks in biofortified maize	22(23.4)	32(34.0)	20(21.3)	20(21.3)	2.17
Lack of/or inadequate access to supporting institutional facilities	34(36.2)	31(33.0)	16(17.0)	13(13.8)	2.61
Inadequate facilities to facilitate biofortified maize production	37(39.4)	33(35.1)	13(13.8)	11(11.7)	2.77
Strict government policies in input sector of biofortified maize	28(29.8)	36(38.3)	16(17.0)	14(14.9)	2.51

Source: Computed from field data, 2021.

CONCLUSION AND RECOMMENDATIONS

The study examined the factors influencing farmers' willingness-to-pay for biofortified maize in Gwagwalada Area Council of Federal Capital Territory, Nigeria. The result shows that majority of the maize farmers in the study area were willing-to-pay for biofortified maize. while sex, farming experience, extension contact, access to land, literacy ratio, and training in maize farming were the factors that influenced the maize farmers' willingness-to-pay for biofortified maize in the study area. For the constraints militating against the willingness of farmers to pay for biofortified maize in the study area; non-availability of credit facilities was a major constraint, non-availability of storage facilities was also a very serious constraint, and inadequate/lack of extension programmes directed to meet the need of farmer was a serious problem, lack of/or inadequate access to supporting institutional facilities and inadequate facilities to facilitate biofortified maize production were also a very serious problem. Therefore, agricultural extension and advisory services/programmes have to develop with a viable component of agricultural biotechnology by the Federal Capital Territory Agricultural Development Programme (FCT-ADP) and the Ministry of Agriculture. Also, stakeholders should ensure to make credit facilities more accessible to maize farmers to enhance the adoption of biofortified crops, especially maize. There is also a need for government and development partners to train farmers more in good agronomic practices with a focus on bio-fortified crops and cropping systems. Regulatory land use acts that will make maize farmers participate more inland ownership systems that are more secure should be put in place for land tenants to benefit so that they can be able to invest and use sustainable maize production strategies to maximize benefits.

This study was limited to the primary data obtained from the respondents in Gwagwalada Area Council in the Federal Capital Territory of Nigeria. There is a need for further research on factors influencing farmers' willingness-to-pay for biofortified maize in other agro-ecological zones of Nigeria and possibly a comparative analysis of factors influencing farmers' willingness-to-pay for biofortified maize across all the agro-ecological zones of Nigeria.

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