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ANALYSIS OF FACTORS INFLUENCING ADOPTION OF IMPROVED MILLET PRODUCTION TEHNOLOGIES IN CENTRAL ZONE OF BORNO STATE, NIGERIA

[1]Alkali, K., [2]Sani, M. H. and [3]Ibrahim, A. A.
[1]Department of Agricultural Extension and Rural Development, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, Nigeria
[2]Department of Agricultural Economics, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, Nigeria
[3]Department of Agricultural Extension Services, Faculty of Agriculture, University of Maiduguri
Corresponding Author's E-mail: kyarialkali@gmail.com **Tel.:** 08030818460

ABSTRACT
The study analyzed the adoption of improved millet production technologies among farmers in central zone of Borno State, Nigeria. A multi-stage sampling procedure was employed and total of 178 millet farmers were randomly sampled and proportionately drawn at 5% across each of the eight (8) selected villages. Primary data were collected through structured questionnaire and analyzed using frequency count, percentage, adoption index, and ordered logistic regression. The results revealed that higher percentage (85.6%) of respondents were male, 57% were married and had age range of 31-40 with mean of 43 years. Similarly, household size had a mean of 11 people, about 52% of farmers had a non-formal education, 46.1% had a farm size of 1-2 ha, and about 47% of the farmers had been involved in millet farming with an average of 10 years farming experience. The adoption index result of 57.2% indicated that the study as a whole recorded medium adoption. The results of the ordered logistic regression disclosed that farm size, and household size; and level of education were negatively significant at $P \leq 0.01$ and $P \leq 0.10$, respectively. Access to credit and extension contact were positively significant ($P \leq 0.10$) and also farming experience had positively significant ($P \leq 0.01$) relationship with the adoption of improved millet packages. The major constraint to adoption of improved millet package in the study area was inaccessibility of credit facilities. The study concluded that the adoption of improved millet package as a whole was influenced by socio-economic and institutional factors. The study therefore, recommended that cooperative societies should be strengthened and expanded to accommodate more farmers with a view to having easy access to new agricultural technologies as well as credit facilities.

Keywords: Adoption, Factors, Influencing, Millet, Technologies.

INTRODUCTION
Pearl millet (*Pennisetum glaucum*) is an important grain crop grown in the Guinea and Sudan savannah and the Sahel agro-ecological zones of Nigeria. Three major types of millet are cultivated by the farmers: *gero, maiwa, and dauro*. For each type there are several varieties. A number of improved technologies have been developed to enhance the production of pearl millet in the country. These range from improved varieties (with specific attributes, such as early maturity, drought resistance, and multiple resistances to diseases and insect pests), improved spacing, seed rate, fertilizer rate to improved harvesting, and storage techniques.

Pearl millet is well adapted to production systems characterized by low rainfall (200-250 mm), low soil fertility, and high temperature up to 42°C, and thus can be grown in areas where other cereal crops, such as sorghum and maize, fail to produce assured yields (Chisi and

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Peterson, 2019).Millions of people in semi-arid regions of Africa and Asia use pearl millet as the most important staple food and serving as major sources of food and income for millions of subsistence farmers living in the most marginal agricultural lands of Northern Nigeria (Champion and Fuller, 2018).

Pearl millet is one of the most drought resistant crops among cereals. The crop is also one of the four most important cereals crop after rice, maize and sorghum grown in the tropics regions. Pearl millet is the sixth cereal crop in terms of world's agricultural production, next to wheat, rice, maize, barley and sorghum (Kimeera and Sucharitha, 2019). As the conditions become drier, pearl millet is the only crop that is grown where normal rainfall does not permit the reliable production of sorghum and maize (Negi *et al.*, 2017). Pearl millet is also is used in making a popular fried cake known as *masa*. *Masa* is a popular staple food consumed by million people in Northern Nigerian. Pearl millet is also used in making *Sinasir*. This is a thin pancake made from ground pearl millet (Egwin *et al.*, 2013; and Ukwuru *et al.*, 2018). With respect to its nutritional value, Pearl millet grain is more nutritious than wheat, rice, maize, and sorghum (Muthamilarasan *et al.*, 2016). Kodkany *et al.* (2013) stated that pearl millet bread contains more iron which can provide young children with full daily iron needs. Millet is the third major crop in Sub-Saharan Africa, with the major producing countries being Nigeria, Niger, Burkina Faso, Chad, Mali, Mauritania and Senegal in the west; Sudan and Uganda in the east (Izge and Song, 2013). It is a staple cereal for over 40% of the populace in northern Nigeria especially in areas with 300-700 mm of annual rainfall such as the northern part of Borno State, Nigeria (Angarawai *et al.*, 2013). It is a staple diet for the vast majority of poor farmers and also forms an important fodder crop for livestock production in the arid and semi-arid regions of the World (Lake Chad Research Institute [LCRI], 2019).

Adoption is a decision made by an individual or group to use an innovation in a continuous manner (Orisakwe and Agomuo, 2011). Technology is the systematic application of scientific or other organized body of knowledge to practical purposes (Orisakwe and Agomuo, 2011). This includes new ideas, inventions, innovations, techniques, methods and materials. The importance of technology to agricultural development especially in less developed countries is widely recognized. This is predicted on the observed impact of technology and its potential and actual contribution to the development of agriculture. In developing countries like Nigeria where a greater proportion of the population live in rural areas, agricultural technology could provide a potential means of increasing production and subsequently raising income of the farmers as well as their standard of living (Ani, 2002) cited in Yindau (2014).

There are tremendous factors which influence the adoption of improved millet production technologies. These Improved production technologies are usually introduced in packages that include several components. These include new seed varieties, fertilizers and corresponding cultural practices. While the components of a package may complement each other, some of them can be adopted independently (Munyua *et al.*, 2002). It is assumed that there are some factors influencing the farmers' decision to adopt the millet production package which vary from situation to situation and person to person.

Therefore, if farmers become aware of improved millet production technologies that are relevant to their farm circumstances and can improve their farm production and thus their welfare, they would most likely adopt such technologies. At this point, the importance of adopting a technology to suit local conditions must be stressed if extension services are to be worthwhile. Agriculture is the mainstay of the Borno State's economy and millet is a major food grain in the State. Borno is one of the important millet producing states in Nigeria and the largest millet producer in the North-Eastern sub-region. However, a significant proportion of the farming population in the state still depends almost entirely on the use of primitive implements, local varieties and inadequate cultural practices despite the various improved crop production technologies that are becoming available from research institutes such as the Lake Chad Research Institute (LCRI) and other related organizations. This scenario is a challenge for extensionists and researchers to identify the inhibiting and facilitating factors to these technologies in the study area.

In order to redress these constraints, the Lake Chad Research institute, Maiduguri which has the national mandate for research on millet improvement among other cereal crops, developed a package of technologies to improve and increase millet production. The main components of the package are seeds of improved varieties (SUPER SOSAT), plant/stand, and date of sowing, seed rate, plant spacing and depth of sowing, fertilizer recommendation, cultural practices and crop protection.

These technologies have been tested in on-farm adaptive trials across locations in the Sudan savannah but very little seems to be known about the level of farmers' awareness and adoption of these packages. Efforts have been made to disseminate these technologies to farmers through the Agricultural Development Projects (ADPs) and the mass media. The aim of the study is therefore to assess the extent to which farmers adopted this technology and identify the major problem(s) limiting the usage of these recommendations, and to bridge the gap in existing literature on Analysis of factors influencing adoption of improved millet production technologies among farmers in Central zone of Borno State. The study was aimed to examine the level of adoption of farmers on improve millet production technologies in the study area; describe the socio-economic characteristics of the millet farmers; determine the factors influencing the adoption on improved millet production technologies' and ascertain the constraint militating on improved millet production packages.

MATERIALS AND METHODS

The study Area

The study area is located in Central zone of Borno State, Nigeria, Sudan Savannah zone with approximately between latitudes $10^{0}02^{1}$N and $13^{0}04^{1}$N and between longitudes $11^{0}04^{1}$E and $14^{0}04^{1}$E. As presented in Figure 3, the State shares international boundaries with the Republic of Niger to the north, Chad to the north-east and Cameroon to the east. Within the country, it shares boundaries with Adamawa to the south and Yobe to the west. It has the land mass 31,260 km^2 (Borno State Ministry of Land and Survey, 2018). The study area has a projected population of 1,666,541 (National Population Commission [NPC], 2018).

The study area which is predominantly agrarian is characterized by dry Sub-Humid Gumel-Nguru-Maiduguri plain in the central zone. The climate of the area is characterized by dry and wet seasons. The wet season is normally from June to September and the annual temperature is about 30^{0}C with a maximum of 45^{0}C in March and a minimum of 15^{0}C during the dry hammatan season.

The annual rainfall ranges from 400 mm to 700 mm (Folorunsho, 2006). Agriculture is the mainstay of the State's economy. In the central zone, major crops grown are millet, sorghum, and cowpea, livestock and fisheries are also important agricultural activities in the study are (Amaza *et al*, 2009). The State is pluralistic in ethnic composition with a rich and diverse historical and cultural heritage. The principal ethnic groups are Kanuri, Shuwa Arab, Babur/Bura, Marghi and Gwoza. Others include Fulani, and Hausa.

Sampling Procedure

For this study, central agricultural zone were purposively selected because of intensity of millet production in the area. (4) Local Government Areas (LGAs) were purposively

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selected based on the predominance of millet production. These are Jere, Konduga, Mafa and Maiduguri metropolitan council. four (4) districts were randomly selected, one (1) from each Local Government area (LGA) which were Old Maiduri District from Jere LGA; Dalori District from Konduga LGA; Zannari District from Mafa LGA and Maisandari District from Maiduguri Metro Politan Council LGA, two (2) villages were randomly selected from each District giving a total of eight (8) villages. Finally, 182 farmers were randomly selected using a proportionate sampling of 5%. The list was obtained from Borno State Agricultural Development Project (BOSADP) Headquarters Maiduguri which served as the sampling frame. A total of 178 respondents made the sample size for the study as presented in Table 1.

Table 1: Sample size determination and selection plan for the study

Agricultural zone	LGA	District	Villages	Population	Sample size 5% population
	Jere	Old Maiduri	Fariya	741	37
			Mashamari	514	26
	Konduga	Dalori	Ngomari	640	32
			Kofa	502	25
Central Zone	Mafa	Zannafri	Kaleri	300	15
			Koshebe	200	10
	MMC	Maisandari	Sulumri	350	17
			Bulabulin	400	20
Total				3,647	182

Source: Field survey (2020)

The data collected were analyzed using Adoption Index Formula adapted from Tedese (2008) and Sani *et al.* (2018). Simple descriptive statistics (frequency count and percentage) was used to determine the farmers' distribution across adoption categories). In order to identify the level of adoption of improved millet production package, adoption index of individual farmers was calculated as follows:

$$AI_i = \frac{1}{N_p}\sum_{i=1}^{n}\left[\frac{PSA_i}{PR}+\frac{SRA_i}{SR}+\frac{FA_i}{FR}+\frac{HBA_i}{HBR}+\frac{SDA_i}{SDR}+\frac{DSA_i}{DR}+\frac{DSU_i}{DSR}+\frac{MPU_i}{MPR}\right] \quad \ldots(1)$$

where;
i -1, 2, 3…n, and n = total number of farmers
Np = Number of practices -8
AI_i = Adoption index of i^{th} farmer
PSA_i = Plant spacing used by i^{th} farmer (cm)
PR = Plant spacing recommended for the crop (cm)
SRA_i = Seeding rate used by ith farmer (kg/ha)
SR = Amount of seed rate recommended per hectare (kg/ha)
FA_i = Amount of fertilizer applied per hectare of area in the cultivation of improved millet Variety (kg/ha)
FR = Amount of fertilizer recommended for application per unit of area for improved millet production (kg/ha)
SDA_i = Seed dressing used by i^{th} farmer (g/kg of seed)
SDR = Seed dressing recommended for the crop (g/kg of seed)

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HBAi = Amount of herbicide applied per hectare of area in the cultivation of improved millet variety (liter/ha)
HBA = Amount of herbicide recommended for application per hectare of area for improved Millet production (liter/ha)
DSA = Date of sowing for the i^{th} farmer (months)
DSR = Date of sowing recommended for the improved millet variety (months)
DSU_i = Depth of sowing used by i^{th} farmer (cm)
DPR = Depth of sowing recommended for the crop (cm)
MPUi = Maturity periods used for harvesting millet by ith farmer (days)
MPR = Maturity periods used for harvesting the crop (days)

The adoption index varies from 0-100% depending upon farmer's degree of adoption of the technology. On the basis of adoption index, farmers were classified into three categories: low, medium and high adopter. To know the level of adoption of each sample farmer, adoption index score was calculated by adding the adoption quotient of each practice of improved millet production package. The adoption quotient of each practice was also calculated by taking the ratio of actual rate applied to the recommended rate, which indicates the extent to which an individual farmer has adopted the package practices.

The overall adoption index of all sample farmers were categorized into three distinct categories, that is low, medium and high adoption level. The actual adoption index score ranges from 0-1. The adoption index scores 0 point implies non adoption of improved millet production package and the adoption index score greater than 0 - 1 grouped among different categories. The adoption index score of 1 implies the farmers adopted all practices according to the recommendation. If the adoption index score become above the value of 1, it indicates the farmers used some of the practices above the recommended rate.

Adoption decisions was analyzed with different binary choice models. Regression models, which include a yes or no type dependent variable, are called dichotomous or dummy variable regression model. Such models was and used in this study for the analysis of dichotomous outcome variable. These include the linear probability function, logistic distribution function, and normal distribution function (Ameniya, 1981). Results of earlier studies showed that models of aggregate adoption follow pattern of S-shape curve. Models that generate S-shape curve include logistic function and cumulative normal distribution function (Feder *et al.,* 1985). These functions were used to approximate the mathematical relationships between explanatory variables and the adoption decision that is always assigned qualitative response variables (Gujarati, 1995).

The use of probit and logit models, which give maximum likelihood estimates, overcome most of the problems associated with linear probability models and provide parameter estimators which are asymptotically consistent, efficient and Gaussian so that the analogue of the regression t-test can be applied. The linear probability model has a defect in that f of this model is not a property distributed function, as it is not constrained to lie between 0 and 1. However, the probit model, like many other models using the normal distribution, may be justified by appealing to a central limit theorem. A major justification for the Logit model is that the logistic distribution functions is similar to a normal distribution function but with a much simpler form (Al-Karablieh *et al.,* 2009).

Ordinal outcomes take on three or more values that can be rank ordered. In addition, an assumption of equal-sized intervals between the response options of ordinal outcomes is usually not warranted. An example is employed parents' importance ratings for various workplace family-supportive programs (e.g., flextime, job sharing), where; 1 = not at all important, 2 = somewhat important, 3 = quite important, and 4 = extremely important. Ordinal outcomes can be analyzed via ordered probit regression or ordered logistic regression (Frone, 1997).

For the purpose of this study, the ordered logistic regression was used to achieve the objective of the socio-economic, institutional and psychological factors influencing the probability of adoption of improved millet production technologies by farmers in Central Zone of Borno State, Nigeria. If the coefficient of a particular variable is positive, it means that higher values of that variable result in a higher probability of adoption, while a lower value of a particular variable implies a lower probability of adoption (Sarap and Vahist, 1994). The model is implicitly expressed as:

$Y = (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, \ldots U)$ …(2)

Y = Adoption index score for improved millet technologies for i^{th} farmer.
X_1 = Age of farmers (years)
X_2 = Annual income (naira)
X_3 = Farm size (hectares)
X_4 = Level of education (years)
X_5 = Farming experience (years)
X_6 = Household size (numbers)
X_7 = Extension contact (number of contacts with extension agents in a year)
X_8 = Amount of credit accessed (Naira)
X_9 = Cooperative membership (number of cooperative societies a farmer belong)
X_{10} = Sex (dummy); 1 = male; 0 = female

RESULTS AND DISCUSSION

Adoption Level of Millet Farmers

Improved millet production package was released with nine (9) components production technologies. The objective was to determine the level of adoption of the package by the adopters, and the extent of use of each of the components. As depicted in Table 2, the average proportion (57.3%) of the adopters lies in the medium adoption category. This signifies the proportion of adopters that were at the medium adoption level, meaning a medium degree of compliance with the recommendations. The reason could be traceable to the limited access to improved millet seed, low availability of the recommended inputs and moderate financial status. In the same vein, it can be deduced that an average financial status of the adopters, training participation and their average number of contacts with extension agents were the possible socioeconomic and institutional factors that could be accounted for their medium adoption level of the package.

More so, some (20.2%) of the adopters were discovered to be a high adoption level. Obviously, the reasons that could be adduced for their being in the high category include: high technical ability, high level of formal education and farming experience, better financial position, training and frequent contacts with the extension agent. That is, the high level adopters had years of formal schooling above the mean average, and also their level of income, farm land, households size, training and extension contact all above the mean average. However, 22.5% at low level adoption was as a result of inadequate training, relatively low extension contact, limited access to improved millet seed and low financial resources. In a study on agricultural technologies and adoption efficiency in Western agricultural zone of Bauchi State, Nigeria, Sani *et al.* (2018) corroborates with this results that 80% of owners of large farms and medium farms were high adopters (65%) and about 48% of the owners of small farms were medium adopters. The findings were also in agreement with Ojohomon *et al.* (2006) who reported that some farmers in Ndaloke village of Niger State partially (fairly moderate) adopted

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the recommended technologies. The implication of this finding is that improved millet production package was practiced at varying degree of adoption among the farmers in the study area. This was defined by their respective adoption index. Similarly, it implies that adopters were not static and permanent at a single level of technology adoption; they tend to progress and sometime regress from one level to another which is an indication of farmers' behavior in term of technology adoption. This remark is in consonance with Adekoya and Tologbonse (2005) who observed that the position of an individual in an adoption category is not permanent and will vary with time, type of innovation and other variations in some factors capable of influencing adoption. So, a low adopter may jump into high adopter category if time is slightly extended.

Table 2: Millet farmers according to adoption level (n = 178)

Adoption category	Adoption index range	Frequency	Percentage
Low adopters	0.01- 0.33 (1 - 33%)	40	22.5
Medium adopters	0.34 - 0.66 (34 - 66%)	102	57.3
High adopters	0.67 - 1.0 (67 - 100%)	36	20.2
Total		178	100

Source: Field survey (2020)

Socio-economic Characteristics of the Respondents

The results from Table 3 shows that, 11.2% of the adopters of improved millet farmers fell within the age bracket of 21-30 years, 37.6% were between 31-40 years, 21.3% were within the age of 41-50, while 20.8% of the respondent were between 51-60 years and only 9.0% were above 60 years old. The 37.6% of the respondents were between the ages brackets of 31-40 years old with mean age of 43 years old. This implies that most of the adopters are younger and depicting the risk averse nature of the older and aged farmers who are usually more conservative than the younger ones to adopt new technologies. This agrees with Issa *et al.* (2016) that younger farmers are much more receptive to new ideas than older ones. They may have much wider contact outside farming, alternative employment opportunities and are therefore, much more willing to take risk in adopting new practices than older farmers. The results from Table 3 revealed that, about 42% of adopters had 6 and 10 members in their respective households, while 25.3% had family size of 11 and 15 members, 21.3% had more than 16-20 members, and only 11.5% had 1-5 members in their household, with mean of 11 people. This suggests that overall majority of farmers in the study area have adequate family. This corroborates Anne *et al.* (2012) who did not find a clear relationship between household size and the use of improved varieties. Table 3 also shows that about 47.2% of the adopters had farming experience between 11-15 years, 20.8% had between 6-10 years farming experience, 20.8% had less than 5 years, and only 11.2% had above 16 years of farming experience, with mean of 10 years. Mahdi *et al.* (2012) reported that most (61%) of the adopters had farming experience ranging from 11 to 30 years, while most (64%) of the non-adopters had farming experience that ranged from 20 to 45 years.

The findings presented in Table 3 also shows that some (46.1%) proportion of adopters used 1-2 hectares of land for millet production, while 24.7% used between 3.2 and 4.1 hectares. Also, 14.6% used between 2.1-3.1 1hectares, and only 10.1% of the adopters used less than 1 hectares of land. This implies that there was a limited land for millet production in the study area. The results aligns with the findings of Oriole (2009) who reported that most of the soya bean farmers in Nigeria were small-scale who cultivated less than 3 hectares of land. The results from Table 3 further reveals that about 57% of the respondents were married in the study area.

This result implies that married people have higher responsibilities and therefore would adopt new technologies introduced to them especially those that would improve their living standard. Results in Table 3 shows that 51.76% of adopters had quranic education, 38.8 % had primary education, 5.6% had secondary education and only 3.9 % had tertiary education. Majority of the respondents had Qur'anic education which was the highest owing to the fact that the study area is a predominant Muslim community where Islamic knowledge is given a high priority. This result agrees with the finding of Umar *et al.* (2014) who noted that the low level of formal education may limit adoption of improved technologies including the improved maize varieties.

Table 3 on annual income of the millet adopters in the study area revealed that 29.8% of millet adopters earn between ₦151,000 - ₦200,000, 23.6% earn between ₦50,000 - ₦100,000, 23.6% earn between ₦101,000 - ₦150,000%, 15.7% earn between ₦201,000 - ₦250,000 and 7.3% earn above ₦251,000 - ₦300,000 with average income of ₦197,000 per annum. This shows that most of the adopters fall within the annual income of ₦151, 000 - ₦200, 000 which implies that most of them are middle income earners. This result agrees with the finding of Tijjani *et al.* (2018) that the highest (59.1%) proportion of the adopters earned about₦201,000 - ₦400,000 in the last cropping season, while only 4.5% earned ₦801,000 and above. Table 3 revealed 86.5% of the respondents were males, while only 13.5% were females. This implies that the millet farmer in the study area was predominantly dominated by male. The higher proportion of male farmers compared to female farmers may be due to the energy demanding nature of agriculture. This result agrees with the finding of Vaughan *et al.* (2012) in a study of economic analyses of cassava production in Ogun State that 75.8% of farmers were males who dominated farming operations due to the drudgery nature of farming which limits female farmers' involvement in production.

The results of Table 3 also indicates that 69.7% of the sampled farmers accessed credit whereas 30.3% did not accessed credit. This suggests that inaccessibly to credit hinders the adoption of new technologies as farmers without cash and no access to credit will find it difficult to cope with the cost of seed, high labour requirement and technical skills needed for management of improved millet production. This agrees with Sisay *et al.* (2013) which reported a positive relationship between amount of credit received and adoption of modern beehives technology in Ethiopia. The result from Table 3 also indicates that 73% of the adopters had no access to extension visit and only 27% had access to extension; 7.9% of the adopters had extension visit on weekly basis, 15.7% had extension visits on fortnight basis, and 16.9% had extension visits on monthly basis, while about 60% had extension visits on quarterly basis. This study shows that the rate of visit of extension workers was low indicating unavailability of the extension agents in the study area. This implies that farmers in the study area might lack most vital information with regard to improved technologies used in improved millet production. This result is in contrast to the findings of Ogundele and Okoruwa (2006) who found that there's a significant difference in the number of contacts with extension agents among rice farmers adopting improved technology and those using traditional system.

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Table 3: Socio-economic characteristics of the respondents

Variable	Frequency	Percentage	Mean
Sex			
Male	154	86.5	
Female	24	13.5	
Marital status			
Single	10	5.6	
Married	147	82.6	
Divorce	8	4.5	
Widow	13	7.3	
Age			
18-35	20	11.2	43
36-45	67	37.6	
46-55	38	21.3	
56-65	37	20.8	
>65	16	9.0	
Household size			
<5	20	11.2	10
6-10	75	42.1	
11-15	45	25.3	
>16	38	21.3	
Education level			
Non-formal	92	51.7	
Primary	69	38.8	
Secondary	10	5.6	
Tertiary	7	3.9	
Farming experience			
<5	37	20.8	
6-10	37	20.8	10
11-15	84	47.2	
>16	20	11.2	
Farm size			
<1	18	10.1	1.5
1-2	82	46.1	
2.1-3.1	26	14.6	
3.2-4.1	44	24.7	
>4.1	8	4.5	

Source: Field survey (2020)

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Table 3: Socio-economic characteristics of the respondents **Cont'd.**

Variable	Frequency	Percentage	Mean
Land acquisition			
Inheritance	124	69.7	
Purchase	33	18.5	
Lease	12	6.7	
Gift	9	5.1	
Annual income			
₦50,000-100,000	42	23.6	₦197,000
₦101,000-150,000	42	23.6	
₦151,000-200,000	53	29.8	
₦201,000-250,000	28	15.7	
₦251,000-300,000	13	7.3	
Source of credit			
Personal saving	52	29.2	
Commercial bank	28	15.7	
Agricultural bank	5	2.8	
Money lender	7	3.9	
Cooperative society	55	30.9	
Friends and family	8	4.5	
Ngo	6	3.4	
Thrift	17	9.6	
Access to credit			
No	54	30.3	
Yes	124	69.7	
Extension contact			
Weekly	14	7.9	
Fortnightly	28	15.7	
Monthly	30	16.9	
Quarterly	106	59.6	

Source: Field survey (2020)

Factors Influencing Likelihood of Adoption of Improved Millet Production Technologies

Table 4 shows the results of ordered logistic regression. It was revealed that annual income, farm size, educational level, farming experience, credit access and contact with extension agent level significantly influenced the likelihood of adoption of improved millet production technologies. Of all the 10 variables included in the model, six (6) indicated significant influence on the extent of adoption of improved millet packages. The pseudo R^2 value of 0.698 implies that the variable included in the model accounted for 69% of variation in adoption of millet production technologies. Each coefficient shows the extent to which the variable exerts influence on the adoption of such technologies. The log123WC likelihood function indicates a Chi-2 squared value -711.49683 significant at 1% level. This means the model as a whole fits significantly ($P \leq 0.01$). On the other hand, it implies that all explanatory variables included in the model jointly influence the intensity of use of improved millet production technologies by the farmers in the study area. Sani *et al.* (2018) supported this results that household size, farming experience, attending agricultural exhibition and consulting newspaper were all significant ($P<0.05$), farm size ($P<0.10$) and extension contact ($P<0.01$) in farmers' adoption of the E-wallet agricultural technology.

The results (Table 4) revealed that annual income variable had a positive and significant ($P \leq 0.01$) influence on the level of adoption of improved millet technologies in the study area.

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It was hypothesized that annual income as a socio-economic factor has no significant relationship with the adoption of improved millet package. Thus, by this finding the hypothesis is hereby rejected. This implies that income of the farmer significantly influenced the adoption of improved millet packages in the study area. As income increases, adoption also increases. This result contradicts the findings of Tijjani *et al.* (2018) which reported that income level of adopters negatively influenced the adoption of improved millet (SOSSAT C88) packages in Borno State.

The Table 4 results further indicate that the contact with extension agent had a positive and significant ($P \leq 0.10$) relationship with adoption of millet production packages. It was hypothesized that contact with as a socio-economic factor has no significant relationship with the adoption of improved millet package. Thus, by this finding the hypothesis is hereby rejected. This suggest that adopting improved millet technologies increases with increase in the frequency of extension visit amongst farmers in the study area. This agrees with the findings of Abdoulaye *et al.* (2014) which reported a positive relationship between extension and adoption of improved cotton production practices in Katsina State.

Farm size as reported in Table 4 was found negative and significant ($P \leq 0.01$) in determining factor influencing the level of adoption of improved millet production technologies. The negative impacts suggest that small farmers may be trying to utilize their limited resources (inputs like improved seed and fertilizer) more efficiently to increase millet production in the study area. It was hypothesized that farm size as a socio-economic factor has no significant relationship with the adoption of improved millet package. Thus, by this finding the hypothesis is hereby rejected. The study results is in line with Hailu (2008) provided a negative relationship between farm size and adoption of improved tiff and wheat varieties. Table 4 results further reveals that educational level variable has negative and significant ($P \leq 0.10$) influence on the level of adoption of improved millet production technologies in the study area. The negative coefficient suggests a negative influence on the adoption of the package in the study areas. It was hypothesized that education level as a socio-economic factors has no significant relationship with the adoption of improved millet package. Thus, by this finding the hypothesis is hereby rejected. This agrees with Sani *et al.* (2018) that adoption level of agricultural technologies was positively related with age, level of education and farm size.

The results (Table 4) revealed that farming experience variable had a positive and significant ($P \leq 0.01$) influence on the level of adoption of improved millet technologies in the study area. This suggests that the likelihood of adopting improved millet production technologies increases with increase in farming experience of the farmer. Experience will improve the farmers' skill at production. A more experienced farmer may have a lower level of uncertainty about the innovations performance and also be able to evaluate the advantage of the technology considered. Similarly, the years of experience of farmers in farming to a large extent affects the farmer's managerial ability and decision in many farm operations. More so, adoption influences perception and understanding of climate and factors that affect farming. This coincides with the findings of Tijjani *et al.* (2018) suggests that the likelihood of adoption increases with increase in farming experience of a farmer. As reported in Table 8, there is a positive relationship between credit access and adoption of improved millet production technologies in the study area. The coefficient is significant at 10% level. The positive coefficient suggests those farmers who have access to credit are more likely to adopt improved millet technologies than those with no access. Therefore strengthening and expansion of credit institutions in the study area is of paramount importance to address credit needs of the farming communities. This agrees with Sisay *et al.* (2013) which reported a positive relationship between amount of credit received and adoption of modern beehives technology in Ethiopia.

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Table 4: Factors that influenced adoption of improved millet production technologies

Variable	Coefficient	Std. Err	Z	P>|z|
Age of farmers(X_1)	-0.0620	0.0728	-0.85	0.395
Annual income (X_2)	0.2057	0.0771	2.67	0.008***
Farm size (X_3)	-0.2136	0.0789	-2.71	0.007***
Education level (X_4)	-0.2037	0.1103	-1.85	0.065*
Farming experience (X_5)	0.0915	0.0342	2.68	0.007***
Household size (X_6)	-0.1078	0.0862	-1.25	0.211
Access to credit (X_7)	0.0285	0.0147	1.94	0.053*
Cooperative membership (X_8)	0.0625	0.1179	0.53	0.596
Sex (X_9)	-0.1389	0.2758	-0.50	0.615
Extension contact (X_{10})	0.5722	0.3136	1.82	0.068*
Pseudo R^2	0.0698			
LR chi ^{2}(11)	43.75			
Prob> chi2	0.0000			

Note: *significant at 10%, **significant at 5% and ***significant at 1%
Source: Field survey (2020)

Constraints in Adoption of Improved Millet Production Technologies

Adopting the technologies used in millet production in the study area. The results from (Table 5) revealed that inaccessibility of credit facilities (35.7%) was main the challenge faced by the respondent followed by inaccessibility of improved seeds (25.2%), inadequate extension visit (15.9%), pest and disease (12.0%), inadequate experience (4.7%), low selling price (3.5%), and high cost of production is the least problem faced by the respondent in the study area which constituent for (3.1%).

Poor access to credit (capital availability) was also a problem facing millet farmers in the study area. This may account for the reason that most of the respondents are small scale farmers and have limited access to credit. (35.6.2%) of the farmers were not having access to credit facilities to boost up their millet production. This implies that capital availability contributes significantly to technology adoption, because credit is necessary for the purchase and use of new technologies by low capital based farmers.

Inaccessibility to improved seeds was one of the major constraints to adoption of improved millet production technologies in the study area. This suggests that insufficiency of improved seeds could stifle the uptake of improved millet production technologies. In other words, it has a negative influence on the adoption of improved millet production technologies. This agrees with the findings of Yapi *et al.* (2006) that lack of improved seeds ranked second with 67% in Mali, indicating that improved seeds are not always available when needed and in the required quantity.

Limited extension visit to the farmers was one of the constraints to adoption of improved millet production technologies in the study area. This suggests that limited extension visits in the study area was attributed limited extension personal. The find is in line with the findings of Ibrahim *et al.* (2016) that poor extension services limit the adoption of improve crop production packages.

Pests and diseases were responsible for the pre-harvest and post-harvest losses suffered by crop producers. The damage cause by pest and diseases makes it difficult for farmers to preserve their produce; hence it forces them to sell their produce at the point of harvest. This problem contributes to the lack of good market because millet producers are mostly scarce during the planting time. Pests and diseases control are considered to be too expensive by farmers in Northern Region of Ghana; hence the low levels of adoption of such technologies

(Mbanya, 2012).This is supportive of the findings of Amaza *et al.* (2007) that the constraints or problems identified with adoption of improved crop technologies in Borno State indicated 16% had problems sourcing seed, 64% fertilizer, 36% pesticide, 70% obtaining credit, and 51% selling produce.

Several adoption studies highlight some constraints faced by farmers that are engaged in production of various crops. Tijjani *et al.* (2018) attempted assessing the socio-economic determinants of adoption of improved millet production practices by farmers in Borno State, Nigeria. The result of the findings revealed that the 42.2% of the adopters and 21.0% of the non-adopters of improved pearl millet practices posited that inaccessibility to improved seeds was one of the major constraints to the adoption of the practices in the study area.

Table 5: Constraints associated with adoption of improved millet production

Constraints	Frequency*	Percentage
Inaccessibility of credit facilities	92	35.7
Inaccessibility to improved seeds	65	25.2
Inadequacy of enough extension support	41	15.9
Lack of technical skills	12	4.7
Low selling price	9	3.5
High cost of production	8	3.1
Pest and disease	31	12.0
Total	258	100.0

*Multiple responses exist
Source: Field survey (2020)

The results of Table 5 agrees with Sani et al. (2018) who reported the major constraints to E-wallet agricultural input distribution method in western agricultural zone of Bauchi State, Nigeria to include inadequate registration point (27.24%), network problem (23.16%) and registration of non-farmers (20.43%) and therefore, recommends that agricultural technologies of E-wallet inputs distribution in the study area should be sustained; promotion of virile extension services through private extension services, and farmers to farmers' extension approach should be encouraged. Singh and Jay (2010) also reported constraints faced by rice farmers in Jabalpur, India include high cost of technology, low availability of the required inputs, lack of training and lack of conviction in the technology. Umar *et al.* (2014) observed that inadequacy of seed (75.6%) was the major constraint followed by inadequacy of fertilizer with 69.0% and cost of seed (57.8%) being the third constraint faced by farmers in Kano and Katsina States, Nigeria. Also, Ibrahim *et al.* (2016) mentioned that 48.32% of the respondents indicated that they had input constraints, 39.26% reported financial constraint and 42.79% revealed poor storage facilities to store cowpea after harvest. Other constraints reported by respondents include lack of implement (32.72%) and poor extension services (27.69%). In Askira Uba Local Government Area of Borno State. Similarly, Abubakar *et al.* (2016) studied the adoption of production technologies by lowland rice farmers in Lavun local government areas of Niger State, and reveals that 31.3% of the adopters were constrained by the high cost of inputs (chemical fertilizers, agro-chemicals and tractor hiring to carry out tillage operations) and ranked first in the order of magnitude. In addition, low availability of inputs (20.2%) was a constraint to the adopters to optimally comply with the recommendations.

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CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, it can be concluded that socio economic variables such as farming experience, annual income, credit access and contact with extension agent were found to positively influence adoption. However, the variables education level household size and farm size, negatively influenced adoption of improved millet production technologies in the study area. The package as a whole recorded 57.3% medium level adoption. The relatively complex recommended practices had recorded low level adoption. In addition, drought resistance ranked first, compatibility and diseases resistant ranked second and third, respectively as attributes suitable for the adoption of improved millet production technologies in the study area. It was recommended that:

1. Cooperative societies should be strengthened and expanded to accommodate more farmers with a view to having easy access to new agricultural technologies as well as credit facilities.
2. Extension services should be improved through the provision of transportation facilities for extension agents to make farmers aware of and have a better understanding of improved agricultural technologies, which can facilitate change in the behavior of farmers and ultimately lead to technology adoption.
3. In addition, to overcome the problem of high cost of the recommended inputs.
4. Taxes and charges on agricultural inputs should be reduced such that the prices of the inputs could be affordable to resource-poor farmers.
5. Disease infestation constraint can be overcome through the services of specialist (plant protectionists) who should be responsible for proactive measures against disease outbreak. The specialist should train the millet farmers on various techniques of remedy, the disease problems as well as protective measures against future occurrence.

REFERENCES

Abdoulaye, T., Abbas, A., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V. and Ayedun, B. (2014). Awareness and Adoption of Improved Cassava Varieties and Processing Technologies in Nigeria. *Journal of Development and Agricultural Economics,* **6**(2): 67 – 75.

Abubakar, H. N., Kolo, I. N., Yabagi, A. A. and Garba, Y. (2016). Adoption of production technologies by lowland rice farmers in Lavun local government areas of Niger State, Nigeria. *International Journal of Agricultural Extension,* **4**(1): 49-56.

Adekoya, A. E. and Tologbonse, A. B. (2005).Adoption and diffusion of innovation. In: Adedoyin S. F. (ed.) Agricultural Extension. *Nigeria Agricultural Society of Nigeria,* **8**(6): 68-79.

Al-karablieh, E., Ahmad, K. and Hunati, D. A. (2009).Logit Models for Identifying the Factors that Influence the Adoption of Barley Production Technologies in Low Rainfall Areas. *Jordan Journal of Agricultural Sciences,* 5: 3. DAR Publishers/University of Jordan.

Amaza, P., Ellis-Johns, J., Kamara, A.Y., Helsen, J. and Gaya, H. I. (2007). *A Participatory Adoption of Improved Crop Technologies in the Savannahs of West Africa: Empirical Study from Borno, Nigeria.* African Crop Science Conference Proceedings. Olujide, M. G. (2011). *Assessment of Rural Children in Agricultural Activities in Ogbomosho Zone of Oyo State, Nigeria*. *A vocational concept. http:/www.readperiodical.com.*

Ameniya, T. (1981). Qualitative Response Models: A Survey.*Journal of Economic Literature,* **19**(4): 1483-1536.

Angarawai, J. J. (2013). *Multilocational Evaluation of Pearl Millet*. INTSOEMIL Sorghum Millet Collaboration Research Support Programme (CRSP). LAG-G-96 90009-00; Pp.41.

Ani, A. O. (2002). *Factors Inhibiting Agricultural Production among Rural Women in Southern Ebonyi State, Nigeria.* Ph.D. Thesis, (Unpublished) University of Maiduguri, Nigeria.

Anne, G. T., Mulwa, R. M., Okello, J. and Kamau, M. (2012). *The Role of Varietal Attributes on Adoption of Improved Seed Varieties. The Case of Sorghum in Kenya.* Paper Presented at the Agricultural and Applied Economics Association's Annual Meeting, Seattle, Washington; August 12 - 14, 2012.

Borno State Ministry of Land and Survey (2018). *Borno State at a glance.*

Champion, L. and Fuller, D. Q. (2018). New Evidence on the Development of Millet and Rice Economies in the Niger River Basin: Archaeobotanical Results from Benin. In Plants and People in the African Past. Springer, Cham; Pp. 529-547.

Chisi, M. and Peterson, G. (2019).*Breeding and Agronomy.In Sorghum and Millets.*AACC International Press; Pp. 23-50.

Egwin, C. E., Amanabo, M., Yahaya, A. and Bello, M. (2013*). Nigeria Indigenous Fermented Foods, Process and Prospects.* Biochemistry Department Federal University of Technology Minna, Niger State, Nigeria.

Feder, G., Just, R. and Zilberman, D. (1985) Adoption of Agricultural Innovations in Developing Countries: a Survey. *Economic Development and Cultural Change*, **33**: 255-298.

Folorunsho, O. A. (2006). *Agricultural Development in Borno State: Problems and Prospects.* An Invited Paper Delivered at the First Borno State Economic Summit held at International Conference Centre, Musa Usman Secretariat, Maiduguri, Nigeria. 6th – 11th May 2006. 17Pp.

Frone, M. R. (1997).*Regression Models for Descrete and Limited Dependent Variables.* Research Institute on Addictions, Buffalo, New York.1997 Research Methods Forum No. 2.

Gujarati, D. N. (1995). *Basic Econometrics;* 3rdEdition.McGraw-Hill, Inc., Pp.568.

Hailu, B. A. (2008). *Adoption of Improved Tef and Wheat Production Technologies in Crop-Livestock Mixed System in Northern And Western Shewa Zones of Ethiopia.* Unpublished PhD Thesis Submitted to the School of Post Graduate Studies, University of Pretoria.

Ibrahim, A. A., Wabab, S. Y., Mohammed, N. and Mustaphaa, S. B. (2016). Factors Influencing the Level of Adoption of Cowpea Production Technologies in Askira/Uba Local Government Area of Borno State, Nigeria. *International Academic Journal of Innovative Research*, **3**(9): 15-23.

Issa, F. O., Kagbu, J. H. and Abdulkadir, S. A. (2016). Analysis of socio-economic factors influencing farmers' adoption of improved maize production practices in Ikara Local Government Area of Kaduna State, Nigeria. *Agrosearch*, **16**(2): 15-24.

Izge, A. U. and Song I. M., (2013). Pearl millet breeding and production in Nigeria: Problems and prospects. *Journal of Environmental Issues and Agriculture in Developing Countries*, **5**(9): 25-33.

Kimeera, A. and Sucharitha, K. V. (2019). Millets-Review on Nutritional Profiles and Health Benefits. *International Journal of Recent Scientific Research,* **07**(10): 33943-33948.

Kodkany, B. S., Bellad, R.M., Mahantshetti, N. S., Westcott, J. E., Krebs, N. F., Kemp, J. F. and Hambidge, K. M. (2013). Biofortification of Pearl Millet with Iron and Zinc in a

Randomized Controlled Trial Increases Absorption of these Minerals above Physiologic Requirements in Young Children.*The Journal of Nutrition*, **143**(9): 1489-1493.

LCRI (2019). *Lake Chad Research Institute (LCRI): Review of Activities 2019.* Gaza Press, Maiduguri, Borno State, Nigeria.

Mahdi, E., Pichai, T., Savitree, R. and Sayan, T. (2012).Factors Affecting the Adoption of Improved Sorghum Varieties in Awbare District of Somali Regional State, Ethiopia. *Kasetsart Journal of Social Sciences*, 33: 152 – 160.

Mbanya, W. (2012). Assessment of the constraints in Soya beans production. A case of Northern Region, Ghana. *Journal of Development in Sustainable Agriculture,* **6**(2): 199-214.

Munyua, C., Adams, P. F and Thomson, J. (2002). Designing Effective Linkages for Sustainable Agricultural Extension Information Systems among Developing Countries in Sub-Saharan Africa. Proceeding of the 18tth Annual Conference of Association of International Agricultural and Extension Education. *Journal of Agricultural and Extension Education,* **9**(2): (Pp. 301-307).

Muthamilarasan, M., Dhaka A., Yadav, R. and Prasad, M. (2016). Exploration of millet models for Developing Nutrient Rich Graminaceous Crops. *Plant Science*, **242**: 89–97.

NPC (2018). *National Population Census figure of Nigeria.*

Negi, S., Kumar, V. and Bhatt, A. (2017).Genetic diversity among Finger Millet [*Eleusinecoracana* (L.) Gaertn] genotypes for yield and its contributing traits. *International Journal of Current Microbiology and Applied Sciences*, **6**(8): 3332-3337.

Ogundele, O. O. and Okoruwa, V. O. (2006). *Technical Efficiency differentials in Rice Production Technologies in Nigeria. AERC Research Paper* 154.African Economic Research Consortium, Nairobi, Kenya.

Ojohomon, V. E. T., Abo, M. E., Ojohomon, O. and Ukwungwu, M. N. (2006). Adoption of Recommended Management Practices in the Lowland Rice Ecology of Niger State, Nigeria. *Journal of Tropical Agriculture*, **24**(2): 82-89.

Oriole, E. C. (2009). A framework for food security and poverty reduction in Nigeria. *European Journal of Social Sciences*, **8**(1): Pp. 37-43.

Orisakwe, L. and Agomuo, F. O. (2011). "*Adoption of Improved Agro-forestry Technologies among Contact Farmers in Imo State, Nigeria*" Vol. **2**, No. 1, Pp. 1-9.

Sani, M. H., Kushwaha, S. and Madaki, M. Y. (2018). Analysis of agricultural technologies and adoption efficiency in western agricultural zone of Bauchi State, Nigeria. *Journal of Agripreneurship and Sustainable Development (JASD*), **1**(1): 1-10.

Sarap, K. and Vahist, D. C. (1994). Adoption of Modern Varieties of Rice in Orissa: Farm Level Analyses. In: Al-karablieh, E. K., S. A. Ahmad and D. A. Hunati (eds) Logit Models for Identifying the Factors that Influence the Adoption of Barley Production Technologies in Low Rainfall Areas. *Jordan Journal of Agricultural Science,* **9**(3): 251-265. DA Publishers/University of Jordan.

Singh, P. K. and Jay, V. G. (2010). Adoption of modern varieties and fertilizer use on rice in eastern Tarai of Nepal. *Journal of agricultural economy,* **36**: 409-419.

Sisay,Y., Birham, M. and Melak, D. (2013). Perception of Farmers Towards the use of Modern Beehives Technology in Ambara Region, Ethiopia. *European Journal of Biological Sciences,* **5**(1): 01 – 08.

Tadesse, A. M. (2008). *Farmers's evaluation and adoption of improve Onion production package in Fogera District, South Gonder, Ethiopia.* M. Sc. Thesis presented to the school of Graduate studies of Harmaya University, Ethiopia. 189 Pp.

Journal of Agripreneurship and Sustainable Development (JASD)
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ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Tijjani, H., Tijjani, B. A. and Audu, A. (2018). Socio-economic Determinants of Vegetable Farmers' Awareness of Safety Measures in Pesticide use in Jere Local Government Area, Borno State, Nigeria. *Agrosearch,* **18**(1): 66 - 76.

Ukwuru, M. U., Muritala, A. and Iheofor, A. O. (2018). Cereal Utilization in Nigeria. *Research Journal of Food and Nutrition,* **2**(3): 01-12.

Umar, S., Musa, M. W. and Kamsang, L. (2014). Determinants of adoption of improved maize varieties among resource-poor households in Kano and Katsina States, Nigeria. *Journal of Agricultural Extension*, **18**(2): 196-205.

Vaughan, I. O., Oladeinde, K., Afolabi, O. I. and Olarenwaju, T. O. (2012).Economic Analysis of Cassava Production in Abeokuta North Local Government Area of Ogun State, Nigeria. *Journal of Agricultural Sciences and Policy Research*, **2**(1): 109-120.

Yapi, A. M., Kergna, A. O. Debrah, S. K., Sidibe, A. and Sango, O. (2006). *Analysis of the Economic Impact of Sorghum and Millet Research in Mali.* Impact Series No 8. Patancheru 502324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 60pp. ISBN 92-9066-419-3. Order code ISE 008.

Yindau, J. J. (2014). *Factors influencing the adoption of improved agricultural technology among women farmers in Mayo-Belwa Zone, Adamawa State Nigeria*. Unpublished M. Sc. Thesis.