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Determination of Technical and Allocative Efficiency of Seed Replaced and Non-Seed Replace Smallholder Maize Farmers in North-West, Nigeria

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Abstract
The study examined technical and allocative efficiency of seed replaced and non-seed replace smallholder maize enterprises in north-west, Nigeria. Multi-stage sampling was used to select 374 smallholder maize farmers who replaced seed and those not in Kaduna, Kano and Katsina. Cross-sectional data was collected using structured questionnaires and the data was analysed using SPSS version 20 and stochastic frontier 4.1 for the following: descriptive statistics and technical, allocative and economic efficiencies. The mean age of the farmers was 46 years; 48.7% had 10 – 19 years of experience and 74.1% had formal education with the mean household size of 12 people. From the findings, majority of the farmers 55.1% belongs to farmers associations with a minimum household income of ₦60,000 per annum. The coefficients of seed and labour were positive and significant for both groups but seed replaced farmers group had higher coefficient for seed. From the result 53.47% of the seed replaced farmers fall within the technical efficiency range of 0.01 – 0.50. Inadequate seed management information was ranked 1st constraints to the seed replaced farmers while non-seed replace farmers

ranked low fodder yield as their 1st constraints to seed replacement. The study concluded that seed replacement had significant influence on the smallholder maize farmers' productivity and resource efficiency and also recommended encouraging other farmers to join cooperatives societies; resource adjustment by the farmers to improve efficiency; seed system monitoring by the National Agricultural Seed Council (NASC) be strengthen; and seminars/campaign to build capacity of the downstream seed marketers and farmers by the government, researchers and Non-Governmental Organizations (NGOs).

INTRODUCTION

Background of the Study

Maize (Zea mays L.) is a cereal crop that is grown widely throughout the world in a range of agro -ecological environments. Specifically, maize is a hot season crop and is grown principally in areas with temperatures ranging from 21 - 30ºC (70 - 86 F), though seeds germinate best at a lower temperature range of 18 - 21ºC (Sowunmi and Akintola, 2010). Currently, nearly 1147.7 million MT of maize is being produced by over 170 countries from an area of 193.7 million ha with average productivity of 5.75 t/ha (FAOSTAT, 2020). Farmers' current maize yields are 50 to 75% lower than attainable yields and the persisting yield gaps has been attributed to many biophysical and socioeconomic factors, and are exacerbated by the extant weak support systems for wide technology adoption among farmers (IITA, 2016). In 2019, Nigeria was Africa's second largest maize producer after South Africa and the 14th largest producer globally. Yet, its local maize demand continues to surpass supply thus creating an annual demand gap of million metric tonnes (USDA, 2022). Data from FAO put Nigeria's total maize production in 2019 at about 11 MMT harvested from over 6.8 million hectares of land (PWC, 2021). The country has a demand of 15 million metric tons, leaving a supply-demand gap of 4 million metric tons per annum (FMARD, 2021). In Nigeria, the top ten maize producing states Borno, Niger, Plateau, Katsina, Gombe, Bauchi, Kogi, Kaduna, Oyo and Taraba accounts for nearly two-third (64%) of maize produced in the country (PWC, 2021).

Use of quality seed alone can increase productivity by 15-20% and as the use of traditional varieties coupled with farm saved seed whose quality is not guaranteed, resulted in drastic reduction in productivity (Ambika, Manonmani & Samasundaram, 2014). Seed supply system is broadly divided into formal and informal sector. Public institutions and private seed companies involved in breeding, variety selection, seed production, dissemination and quality control constitute the formal seeds sector (Biemond *et al.,* 2012). The informal Seed System (SS) consists of all farmers involved in on-farm selection, seed production and dissemination of seed. According to the National Agricultural Seeds Council (NASC) 2019, there are 157 registered seed companies in Nigeria, with the majority producing fewer than 1,000 metric tons of seeds annually. The Seed Entrepreneurs Association of Nigeria is the country's main private seed trading body, with approximately 67 registered members.

Overall, smallholder farmers are characterized by marginalization, in terms of accessibility, resources, information, technology, capital and assets, but there is great variation in the degree to which each of these applies (Murphy, 2010). The Food and Agriculture Organization of the United Nations (2008) adopted a 2-hectare (ha) threshold as a broad measure of a small farm. With these, Akinsuyi (2011) reported that more than 80% of the total farmers in Nigeria are smallholder farmers and they are the backbone of the Nigerian agricultural sector and deserve every support to produce more food and accounting for 90 percent of the total farm output in the country. However, the slow turnover of maize varieties and hybrids on farm coupled with limited availability of good quality improved seed, fertilizer and other inputs have minimized the potential yield gains recorded on farm in Nigeria.

Objectives of the Study

The broad objective was to analyse the effect of seed replacement on resource use efficiency among smallholder maize producers in North-Western Nigeria. The specific objectives were to:

i. determine the socio-economic characteristics of smallholder maize producers influencing seeds replacement in the study area;

ii. determine the technical, allocative and economic efficiencies among seed replaced and non-seed replace maize enterprises;
iii. examine the socio-economic factors influencing inefficiency among seed replaced and non-seed replace maize enterprises; and
iv. describe the constraints of smallholder maize producers on seed replacement in the study area.

METHODOLOGY

Study Area

North-West is one of the biggest and highly populated regions in Nigeria; it is made up of seven (7) states which include Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara. The zone embraces the old Hausa states of Daura, Gobir, Kano, Katsina, Kebbi, Zamfara and Zazzau (Ibrahim, 2012). The zone has a landmass of 216,065 sq km and it covers about 25.75% of the Nigerian population which is 35,786,944 (NPC, 2006) and the projected population at 2022 was 60,150, 400 (NPC and NBS, 2022). The Great savannah belt of the Great Plains of Hausa land dominates the region, this region experiences rainfall between 508 and 1,524 mm per year (Ibrahim, 2012). The savannah in the region zoned into two categories of Guinea and Sudan savannas, and these savannas are the most suitable ecological zones for maize production in Nigeria. According to the study of maize production in Nigeria from 1980 to 2020 revealed that majority (56.33%) of maize produced in the country comes from North-West region (Gerald *et al.,* 2022) with the mean annual production of 2,863.4 million metric tonnes (NAERLS, 2021).

Sampling Procedure

Multistage sampling technique was used to draw the sample of the research. Stage I involved selection of three states in the North-Western Nigeria purposively; Kaduna, Kano and Katsina States were selected because they are among the major maize producers in Nigeria with established clusters of smallholder maize farmers across the LGAs in the states and been dispersed into the two major Savannas dominated region. Stage II involved purposive selection of four (4) Local Government Areas (LGAs) from each of the selected State based on the intensity of maize production and agro-ecological variation; Lere, Ikara, Soba and Giwa

LGAs were selected in Kaduna state; Bunkure, Garin-Malam, Doguwa and Tudun-wada LGAs were selected in Kano State; Bakori, Dandume, Faskari and Funtua LGAs were selected in Katsina State. Stage III involved purposive selection of four communities in each selected LGA based on the smallholder maize farmers' cluster. Stage IV involved a random selection of smallholder maize farmers in each of the selected communities, respectively.

The registered small scale maize farmers from north-western Nigeria on the Agricultural Transformation Agenda (ATA) database 969,774 (FMARD, 2014). Thus, the selected states had representation of small-scale maize farmers as 245,170 for Kano, 220,806 for Kaduna and 91,988 for Katsina. The total sample drawn from the population of smallholder maize producers in the selected states was determined using IFPRI sample sizes approach (IFPRI, 1999). Based on parameters ***P*** and ***M***, 95% confidence level and % prevalence of maize producers in the states, three hundred and seventy-four (374) maize producers were selected from the three states. According to IFPRI (1999) the approach was described below:

$$n = \frac{pt^2(1-p)}{m^2} \qquad (15)$$

Where:

n = required sample size;

t = confidence level at 95% (standard value of 1.96);

p = estimated prevalence of maize producers in the study area (%);

m = margin of error at 5% (standard value of 0.05).

Table 1: Registered Maize Farmers in the three (3) selected states & Sample Drawn per State

S/no	State	Registered maize farmers	Prevalence (%)	Sample drawn
1	Kano	245,170	44	164
2	Kaduna	220,806	40	150
3	Katsina	91,988	16	60
	Total	**557,964**	**100**	**374**

Thus, the number of samples drawn from each of the selected LGA was proportionate to the registered maize farmers in the LGA and drawn using the formula described below:

$$n_i = \frac{Y_i}{N}(n) \qquad (16)$$

Where:

n_i = number of samples required from i-th area {for i = 1, 2, 3……….12 representing the selected LGAs in the north-western Nigeria}

Y_i = population of maize farmers in ith LGA

N = total population of maize farmers in the study area

n = total number of samples to be drawn from the entire study area

Table 2: LGAs Selected from the three States (3) & samples drawn

State	LGAs Selected	Number of selected communities	Ecological Zone	Estimated Maize Farmers	Sample Size
Kano	Doguwa	4	NGS	27,860	54
	Tudun Wada	4	NGS	22,288	44
	Bunkure	4	SDS	22,288	44
	Garin-Malam	4	SDS	11,144	22
	Total	16		83,580	164
Kaduna	Lere	4	NGS	28,000	53
	Soba	4	NGS	19,000	37
	Giwa	4	NGS	17,800	33
	Ikara	4	NGS	14,400	27
	Total	16		80,000	150
Katsina	Dandume	4	NGS	13,525	19
	Bakori	4	NGS	10,820	15
	Faskari	4	NGS	10,820	15
	Funtua	4	NGS	8,115	11
	Total	16		43,280	60

	Grand total	**48**		**206,860**	**374**

**NGS= Northern Guinea Savannah ***SDS= Sudan Savannah

Data Collection

Primary data was gathered using 374 structured questionnaires which were administered to the selected smallholder maize farmers in the selected communities using trained enumerators and all the 374 questionnaires were retrieved and used. Data of maize production for three production seasons: 2016, 2017 and 2018 was collected and analysed.

MODELS SPECIFICATION

Descriptive Statistics

Mainly arithmetic mean, frequency and percentages were used to achieve objectives I & IV.

Stochastic Frontier Analysis

Stochastic Frontier analysis was used to achieve objective IV of the research, using Stochastic Frontier Production Function and Stochastic Frontier Cost Function:

Stochastic Frontier Production Function

Comprises production function of the usual regression type with a composite disturbance term equal to the sum of two error components (Aigner *et al.,* (1977); Meeusen and Van den Broeck, (1977); Xu and Jeffrey, (1998); Amodu et al, (2011)). The use of stochastic frontier analysis in agriculture would enable optimal resource allocation and utilization study by researchers and used by farmers as well. The model was defined below as:

$Y_i = f(X_i\,;\,\beta)e\mathcal{E}$ for $i = 1,2,\ldots\ldots\ldots N$……………………………....(22)

and $\mathcal{E} = V_i - U_i$ for $i = 1, 2,\ldots\ldots\ldots N$……………………………....(23)

Where:

Y_i = output of the ith farms

$f(x_i)$ = function of the vector, Xi for vector of input quantities used by the ith farms

β = vector of unknown parameters to be estimated

$\mathcal{E}$ = composite error term

The stochastic production frontier model was used to establish the effect of variable inputs and socio-economic factors to determine the technical efficiency of the resources use in maize production in the study area. If the coefficient of an input is positive and significant, then the resource is under-utilized but if negative, it is over-utilized and when the coefficient is one (1) then the input is optimally utilize that is when MVP is equals to MFC. The model is specified below:

$$\ln Y_i = \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + e \ldots.(24)$$

Where:

Y_i = Output of maize (kg);

X_1 = Quantity of maize seeds (kg);

X_2= Quantity of NPK (kg);

X_3= Quantity of Urea (Kg)

X_4 = Farm size (ha);

X_5 = Labour used (man-days);

β_0 = Constant

$\beta_1 – \beta_5$ = Regression Parameters

Ln = Natural logarithms

e = Composite error term and defined as $v_i – u_i$.

The stochastic frontier model for the socio-economic factors is specified as:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (25)$$

Where:

U_i = Technical inefficiency of the maize farmers

Z_1 = Age of farmers (years)

Z_2 = Household size (numbers)

Z_3 = Farming experience (years)

Z_4 = Membership of farmer-based organization (dummy){member = 1; non-member = 0) δ_i = Parameters estimated

Stochastic Frontier Cost Function

The corresponding cost frontier as used by Ogundari *et al.* (2006) can be derived analytically as:

$C = y\,(P\ Yi: \gamma) + (V_i + U_i)$……………………………………………(26)

Where:

C = total production cost (₦);

P = vector variable of input prices;

y = suitable functional form;

Yi = value of output in Kg;

γ = parameter to be estimated and

(vi + ui) = Composite error term

The stochastic frontier cost function was used to analyze the allocative (cost) efficiency of maize production in the study area. The model was computed below as:

$\ln C = \beta 0 + \beta 1 \ln P1 + \beta 2 \ln P2 + \beta 3 \ln P3 + \beta 4 \ln P4 + \beta 5 \ln P5 + (vi + ui)$...(27)

Where:

C =Total production cost (₦)

P1 = Cost of land (₦)

P2 = Cost of maize seed (₦)

P3 = Cost of NPK fertilizer (₦)

P4= Cost of urea fertilizer (₦)

P5 = Cost of labour (₦)

Yi = Output of maize (Kg)

Ln = Natural logarithm

βi = Parameters to be estimated (i = 1, 2, ….., 5)

(vi + ui) = Composite error term

Economic Efficiency Measurement

Economic Efficiency (EE) is an overall performance measure and is equal to the product of Technical Efficiency (TE) and Allocative efficiency (AE) i.e EE = TE*AE. The economic efficiency of maize production will be the basis for estimation of technical and allocative efficiencies. The research obtained the economic efficiency of maize production in the study area by taking the product of technical and allocative efficiency scores obtained from the Stochastic Production Frontier analysis and Stochastic Frontier Cost Function. Therefore, the economic efficiency of maize production was analyzed using given function below:

$$EEj = TEj*AEj \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (28)$$

Where:

EEj = Economic Efficiency of j-th farm

TEj = Technical Efficiency of j-th farm

AEj = Allocativ Efficiency of j-th farm

RESULTS AND DISCUSSION

This chapter presents the findings of the analysed data collected from the study area relating to smallholder maize farmers and seed replacement. The chapter presents analysis and discussion of the results on household socio-economic characteristics influencing seed replacement; seed replacement rate and its effect on the smallholder maize farmers' yield; profitability analysis of seed replaced and non-seed replaced smallholder maize enterprises. Moreover, the chapter analysed the production efficiencies and inefficiency of the smallholder maize farmers based on categories of seed replaced and non-replaced enterprise; marketable surplus and effect of seed replacement on it, then, constraints of smallholder maize producers on seed replacement in the study area.

Socio-Economic Characteristics of Smallholder Maize Farmers

Socio-economic characteristics are individuals or family's economic and social position in relations to others based on their attributes assessment of the smallholder maize farmers. Socio-economic characteristics of smallholder maize farmers refer to a combination of social, economic and demographic variables or features and how directly or indirectly influence seed replacement in maize production. They are usually not direct inputs but go a long way in influencing the production efficiency of the maize farmers (Olayiwola, 2013; IITA, 2009). The socio-economic characteristics in this context are categorized into two: (a) Qualitative socio-economic characteristics which includes gender, marital status, education, cooperative membership and extension contact. (b) Quantitative socio-economic characteristics which include age, farming experience, household size and annual income were presented on tables 3(a) and 3(b).

Table 3(a): Socioeconomic Characteristics of Respondents

Variables	Frequency	Percentage	Ranking
Gender			
Male	355	94.5	
Female	19	5.5	
Total	**374**	**100**	
Marital Status			
Married	368	98.4	
Single	06	1.6	
Total	**374**	**100**	
Education			
Qur'anic education only	97	25.9	
Primary	38	10.2	
Secondary	160	42.8	
Tertiary	79	21.1	
Total	**374**	**100**	
Cooperative membership			
Member	206	55.1	
Non member	168	44.9	
Total	**374**	**100**	
Cooperative membership benefits			
***Trainings**	125	60.6	1st
***Access to improved maize seed**	95	46.2	2nd
***Access to fertilizer**	88	42.7	3rd
Extension contacts			
Contact	366	97.9	
No contact	08	2.1	
Total	**374**	**100**	

Source: Field survey, 2018; *Multiple responses

Gender of the Respondents

Gender is a socially constructed definition of women or men and it enables us to ascertain gender involvement and role they play in agricultural production. The farmer's gender is an important factor in agricultural production because it influences farm organization and income earning opportunities of a farmer which in turn determines smallholder farmers' income generation and food security. Table 3(a), revealed that 94.5% of the respondents were male while only 5.5% were females. This implies under representation of female population in small-scale maize farming despite their population in the study area and also implies low sensitization for women to actively engage in small-scale maize production activities. This could be due to socio-cultural and religious factors playing crucial role in the livelihood of people in the study area were male participated more in agricultural production aspect than females who mostly participated in processing. This conformed to the findings of Halliru (2017), in econometric analysis of food security and poverty status of smallholder maize farmers in the savannahs of Northern Nigeria where 94.8% of the household heads were male.

Marital Status of the Respondents

Marriage is a legal union of male and female individuals who are believed to have attained maturity and take responsibilities of their actions and it also confers on individuals some degree of responsibility and respect in the society. Marital status described individual as married or not and it also signifies the level of responsibility shouldered on the household head. From the result in Table 3(a) 98.4% of the respondents were married with 55.9% being married polygamous and 42.5% being married monogamous while the least 1.6% being single among the respondents. This implies married individual participated more in small-scale maize production in the study area than un-married and this may be because they are responsible for supporting their households with daily needs and food demanded for a better living. Also being polygamous by majority implies that the respondents were male household heads and had means of livelihood to sustain more than one wife coupled with tradition and prestige in the study area. This disagrees with the findings of Umar, Musa and Kamsang (2014) in their study of determinants of Adoption of Improved Maize Varieties among Resource-Poor Households in Kano and Katsina States, Nigeria where majority of the respondents were married with 58% being in monogamous marriages, 35.5% being in polygamous marriages and only small proportion 5.7 were single.

Education of the Respondents

Education is the process of facilitating learning, or acquisition of knowledge, skills, values, beliefs and habits. Low level of formal education may limit adoption of improved farming techniques including seed replacement. From Table 3(a) it was revealed that majority 74.1% have formal education which may impacted on their output due to their ability to practice seed replacement with better agronomic practice; 21.1% reaching tertiary level, 42.8% secondary school level and 10.2 primary level respectively while 25.9% had qur'anic education only as highest level of education. This agrees with the findings of Halliru (2017) in the econometric analysis of food security and poverty status of smallholder maize farmers in the savannahs of Northern Nigeria where majority of the farmers attained one form of formal education or the other with 22.7% primary school, 23.1 secondary and 25.4% tertiary education. This implies majority of the respondents had attained some levels of formal education in the study area with knowledge of improved farming techniques and possibility to accepts innovations in their farming practices. According to Abdullahi and Abdullahi (2012), formal education facilitates adoption of modern technologies and improved farm practices.

Cooperative Membership and Membership Benefit to the Respondents

Cooperative membership enables farmers to interact with other farmers, share experience and assist themselves (Yanguba, 2004). From the result in Table 3a majority of the farmers 55.1% belongs to farmers associations in the study area while 44.9% which may be because of their inability to meet up with associations requirements or certain financial obligations after joining the association. Also, from the result the 206 smallholder farmers who registered with farmers' cooperative societies reported the major benefits gained for being members of the cooperative bodies. The multiple responses result revealed that majority 60.6% of farmers registered with cooperative societies reported benefiting from trainings and 46.2% reported gaining access to improved maize seed while 42.7% reported gaining access to fertilizer through the cooperative bodies. This implies that among smallholder farmers in the area some did not participate in farmer cooperative organizations despite the benefit derived for enhancing agricultural productivity through knowledge sharing and exchange of idea from fellow farmers which may be because of their level of formal education and low experience in farming enterprises which made it difficult for them to comprehend the benefits of joining farmer's cooperative societies. Also, Ekong (2003) and Ajayi and Ogunlola (2005), observed that membership of cooperative societies has advantages of accessibility to micro-credit and input subsidy. Also serve as an avenue of availing ideas and information that could help them in pooling of resources together in order to expand production efficiency and profit maximization.

Extension Contact of the Respondents

Extension contacts exposes farmers to information; new ideas and technology and has been widely reported to positively influence adoption and continued use of agricultural technologies. Contact with extension agents relates to individual meeting between the farmer and an extension worker or an interactive session between a group of farmers and an extension worker in which the extension worker educates the farmers on recommended practices. Based on the findings 97.9% of the respondents had extension contact within three years in the study area which may impacted on their maize output due to their ability to embrace seed replacement with better agronomic practice within the period; while the least 2.1% did not have extension contact within three years. This implies that majority of the farmers in the study had extension contact and possibly awareness of new farming techniques and innovation for enhancing agricultural productivity. This is in-line with the findings of Umar *et. al.* (2014) in determinants of Adoption of Improved Maize Varieties among Resource-Poor Households in Kano and Katsina States, Nigeria where 79.7% of the respondents had extension contacts.

Table 3(b): Socioeconomic Characteristics Continued

Variables	Frequency	Percentage	Minimum	Maximum	Mean	SD
Age						
22 -31	40	10.7	22	71	46	10.354
32-41	113	30.2				
42-51	116	31.0				
52-61	88	23.5				

62-71	17	4.5				
Farming Experience						
1-9	22	5.9	01	47	21	8.293
10-19	182	48.7				
20-29	98	26.2				
30-39	60	16.0				
40-47	3.2	3.2				
Household Size						
1-8	99	26.5	01	39	12	7.274
9-16	157	42.0				
17-24	83	22.2				
25-32	26	7.0				
33-39	09	2.4				
Annual Income (Maize enterprise)						
60,000 – 240,00	87	23.3	60,000	960,000	435,331.93	5.353
241,000 – 420,000	93	24.9				
421,000 – 600,000	79	21.1				
601,000 – 780,000	98	26.2				
781,000 – 960,000	17	4.5				

Source: Field survey, 2018

Age of the Respondents

Age is a measure in number of years from the day farmer was born. Age among other things has implication on decision making on farm and may indicate the future scope for changes in agriculture. The age distribution is expected to have positive influence on the farmers' participation in maize production and also determine how active and productive a household head would be. From the findings in Table 7b, the mean age of the farmers was 46 years and majority (71.9%) of the respondents were in their active age; 10.7% had age range of 22 – 31 years; 30.2% had age range of 32 – 41 years and 31.0% had age range of 42 – 51 years respectively while 23.5% had age range of 52 – 61 years, and the least

4.5% had age range of 62 – 71 years. This implies that over 70% of the respondents are in their active age which may have impacted on the farming operations and signifies prospect for maize farming as the farmers have strength to carry-out farming operations and good decision making. This in-line with findings of Buba, (2005), in Economic Analysis of Maize Production in Kaduna State, Nigeria, who reported that 44% of the maize farmers fell within the age range of 41-50 years and the average age of the farmers, was 46 years. This finding is similar to that of Adegboye (2011), in which he observed that youth constitute the majority of the maize farmers.

Farming Experience of the Respondents

Farming experience is the active years spent by a farmer in maize production. The longer the years of farming experience, the better the expected performance on maize production. It is expected that output will increase as the years of experience of farmers' increases and this signifies prospect for maize production the study area. From the findings majority 48.7% had 10 – 19 years of experience then followed by 26.2% with 20 – 29 years of farming experience and 16.0% had 30 – 39 years of experience while 5.9% had 1 – 9 years and the least 3.2% had 40 – 47 years in maize production and mean age of 21 years' experience in maize farming. This implies that over 70% of the respondents had more than 10 years farming experience and it may be the reason why they were willing to accept innovations and know about seed replacement and practice it based on the count experience. This is closed to the findings of Yakubu (2016) in the Analysis of Productivity among Maize Farmers in Doguwa Local Government Area of Kano State, Nigeria where the mean years of farming experience was 24 years.

Household Size of the Respondents

Household consist of one or more people who live in the same dwelling and also meals or having same source of livelihood. It may also consist of a single family or some other grouping of people. Household size influences the availability of family labour for agricultural operations, since the main source of labour for a typical smallholder farmer is his immediate dependents, it is therefore expected that, household size if grown up to matured stage would influence the adoption of agricultural technologies, especially where joint labour is needed, implying that they have enough unpaid labour for farm activities (Okoedo-Okojie and Onemolease, 2009). From the findings it shows that the minimum household size was 1 person while the maximum was 39 peoples and mean of 12 people. Also from the result on Table 7b 42.0% of the respondents had 9–14 family members while the least 2.4% had 32–39 family members. This implies that majority of farmers in the study area were having large household size and signifies family labour which influence maize production of smallholder farmer and also shows more responsibility to feed a number of individuals within the household. This is close to the findings of Buba, (2005), in the study on Economic Analysis of Maize Production in Kaduna State, Nigeria, among the maize farmers, 49% had more than 12 people in the household, the average household size was 10 persons, this could mean that there was a reasonable supply of family labour for farm operations in the study area considering matured persons among household size.

Annual Income of the Respondents

The level of Annual income is a key determinant of a household's ability to spend on food and other goods and services which also measures household's welfare and also determines purchasing power of smallholder farmer ability to purchase farming inputs. From the result the minimum annual income was 60,000 naira while the maximum annual income was 960,000 naira and the mean annual income was 435,331naira. Also from the findings, majority of the respondents 69.3% belong household income earners between 60,000 – 600,000 naira per annum. This implies that over 70% of the respondents had over 240,000 naira annual income from sale of their surpluses and signifies their ability to purchase agricultural inputs and also support local economy for purchase of other assets and consumables. This agrees with findings of Abdullahi, Hassan and Audu (2015) in Analysis of Farm Households' Food Security Situation and Level of Per Capita Income in Kaduna State, Nigeria where majority (52.2%) of the respondents reported per capita income greater than ₦400,000.

Production Efficiency of Smallholder Maize Production

Over the time production units can become inefficient to catch up with the frontier. It is possible that the frontier shifts, indicating technical progress. In addition, production unit can move along the frontier by changing inputs quantity. Finally, there can be some combinations of these three effects. The stochastic frontier method allows decomposing growth effect into changes in input use, change in technology and changes in efficiency thus extending the widely used growth accounting method.

Technical Efficiencies of Smallholder Maize Enterprises with and Without Seed Replacement

The maximum likelihood estimates of stochastic production frontier function for the seed replaced and non-seed replaced enterprise were presented in Table 14. The variables included in the model were farm size, quantity of seed, quantity of NPK fertilizer, quantity urea fertilizer and labour for the technical efficiency model and age, household size, farming experience and cooperative membership for the inefficiency model.

Table 5: Maximum Likelihood of Stochastic Frontier Production Function for the Seed Replaced and Non-Sees Replace Maize Enterprise

Variables	Seed Replaced Enterprise			Non-Seed Replaced Enterprise		
	Parameters	**Coefficient**	**T-value**	**Parameters**	**Coefficient**	**T-value**
Constant	β_0	8.972	17.138***	β_0	7.221	9.112***
Farm size	B_1	-0.954	-26.367***	B_1	-0.777	-3.972***
Seed	β_2	0.087	1.970*	β_2	0.009	0.979*
NPK	β_3	-0.091	-1.844*	β_3	0.231	1.848*
Urea	β_4	0.108	2.869***	β_4	-0.039	-0.112
Labour	β_5	0.180	1.949*	β_5	0.080	2.178**
Inefficiency Effects						
Delta	δ_0	-0.242	-0.342	δ_0	0.038	0.038
Age	δ_1	-0.020	-2.075**	δ_1	-0.029	-0.557
Household size	δ_2	-0.016	-1.181	δ_2	-0.084	1.064*
Farming experience	δ_3	-0.018	-1.649*	δ_3	-0.006	-0.215

Cooperative membership	δ_4	-0.065	-0.400	δ_4	-0.271	-0.331*
Sigma square	δ^2	89.609		δ^2	70.961	
Gamma	Γ	99.500		Γ	100.00	
Log likelihood		78.525			41.158	
Lr-test of the one sided erro r		10.007			19.812	

Source: Field survey, 2018 *** = significant at1%, (P<0.01), ** = significant at 5 % (P<0.05) * = significant at 10% (P<0.1)

From the result in Table 14, the efficiency estimates for the seed replaced enterprise revealed gamma value of (0.995). This implies that 99.5% of the variation in the maize output for the farmers can be attributed to the technical efficiency of the farmers. The log likelihood was (78.525) which shows that the functional form specified and used in the estimation is adequate representation of the data. Other estimated parameters that further proved fitness, validity and accuracy of the estimated model were sigma square (89.6) and LR test (10.0), respectively. The constant of specified model is positive and significant at 1% level which indicates that the constant directly related to the efficiency in maize production.

From the findings it was revealed that the coefficients of seeds, urea and labour were the significant variables that positively influence maize output. This implies that a unit increase in seeds, urea, and labour will increase the output of maize by 8.7%, 10.8% and 18.0%, respectively. Farm size was negative and significant at 1% level; this implies that farm size was inversely related to maize production efficiency and was over-utilized and this may be because of continues cultivation of the land each production season and other cultural and poor land management practices which exhausted natural vigour of the soil and destroy soil structure to make it less productive. The findings further revealed under-utilization of seeds, urea and labour by the seed replaced farmers in the study area. This may be because the average seeds used per hectare by the seed replaced farmers were 20 kg/ha which was less than the recommended rate of 25kg/ha and may also be due to the farmers' status as smallholders and lack adequate capital of production of which made them use inputs below optimum level or used seeds contaminated due to handling. The negative coefficient for NPK fertilizer is surprising and indicating that NPK fertilizer was over-utilized. This may be attributed to poor extension service to guide the farmers on modern methods of fertilizer application for optimum fertilizer use in maize production. The findings agreed with Idris, Raheem and Shakirat (2015) who reported that significant variables affecting maize production were seeds, herbicides, labour and farm size while farm size inversely related to maize technical efficiency at significant level which indicated that farm size was not part of the factors influencing maize production technical efficiency and implies that efficiency in maize production is not by size of land.

While the result of efficiency estimates for the non-seed replace enterprise revealed gamma value of (1.000). This implies that 100% variation in the maize output for the farmers who did not replace seeds can be attributed to the technical efficiency of the farmers. The log likelihood was (41.15) which shows that the functional form specified and used in the estimation is adequate representation of the data. Other estimated parameters that further proved fitness, validity and accuracy of the estimated model were sigma square (70.96) and LR test (19.81), respectively. The constant of specified model is positive and significant at 1% level which indicates that the constant is directly related to the efficiency in maize production. From the findings it was revealed that the coefficient of seeds, NPK and labour were the positive and significant variables that positively influence maize output. This implies that a unit increase in seeds, NPK, and labour will increase the output of maize by 0.9%, 23.1% and 8%, respectively. The result further implies that the seed used related directly to the maize production efficiency but with very low coefficient 0.9% when compared with 8.7% for those farmers who replaced seed in the same production season. Farm size is negative and significant at 1% level, this implies that farm size was over-utilized and inversely related to maize production efficiency.

The inefficiency parameters shown in Table 15 for the seed replaced enterprise relate to farm-specific characteristics and the farmer's socio-economic position. The coefficient of age was negative and significant at 5% level and this implies that increase in age decreases inefficiency as indicated by the farmers socio-economic characteristic that the mean age of the farmers was 46 year and 22 years minimum and also implies that the more age gain by the farmers the higher the ability to make informed decisions on the farming business. The coefficient of farming experience was negative and significant at 10% level and this implies that increase in farming experience decreases inefficiency in maize production; a farmers' with more year of experience are more likely to adopt modern production technologies and this is in line with findings of Abu *et. al* (2012) which revealed farming experience as one the major drivers of agricultural efficiency levels.

The coefficient of cooperative membership was negative and significant at 10% level, this implies that cooperative participation increases maize production efficiency and this may because farmers interact with other experienced farmers to share ideas and gain more access to extension services as buttress in the socio-economics characteristic were all cooperative members accessed extension services. This goes in-line with findings of Abate *et al.* (2014) that cooperative membership exerts a positive and significant impact on technical efficiency. Also Gedara *et al.* (2012) found that farmers belonging to a farmer organization have higher level of technical efficiency.

While the inefficiency parameters of the non-seed replaced enterprise in the Table 15 indicated that the coefficient of household size was negative and statistically significant at 10% level. This implies that larger household size increases maize production efficiency which may be because non-replace seed smallholder farmers use crude production techniques which involved more manual, larger households with matured members who can provide labour to support the maize production enterprise can reduce inefficiency. The coefficient of cooperative membership was negative and significant at 10% level, this implies that cooperative participation increases maize production efficiency and this may because farmers interact with other experienced farmers and share ideas.

Allocative Efficiency of Smallholder Maize Enterprises with and without Seed Replacement

The maximum likelihood estimates of stochastic frontier cost function for the seed replaced and non-seed replace enterprise were presented in Table 15. The variables included in the model were land rent, cost of seed, cost of NPK fertilizer, cost of urea fertilizer and cost of labour for the efficiency model and age, household size, farming experience and cooperative membership for the inefficiency model.

Table 6: Maximum Likelihood of Stochastic Cost Function for the Seed Replaced and Non-Sees Replace Maize Enterprise

Variables	Seed Replaced Enterprise			Non-Seed Replaced Enterprise		
	Parameters	Coefficient	T-value	Parameters	Coefficient	T-value
Constant	β_0	9.294	12.422***	β_0	7.240	2.917***
land rent	B_1	0.261	6.369***	B_1	0.084	1.394*
Cost of Seed	β_2	0.022	1.846*	β_2	-0.152	-0.499
Cost of NPK	β_3	0.046	1.450*	β_3	0.308	1.888*
Cost of Urea	β_4	0.019	1.083	β_4	-0.137	-1.336
Cost of Labour	β_5	-0.120	-2.241***	β_5	0.271	1.650*
Inefficiency Effects						
Delta	δ_0	-1.741	-0.810*	δ_0	0.385	0.627
Age	δ_1	0.049	1.430*	δ_1	-0.014	-0.434
Household size	δ_2	-0.113	-1.584*	δ_2	0.015	0.389
Farming experience	δ_3	-0.052	-1.427*	δ_3	-0.018	-0.932*
Cooperative membership	δ_4	0.023	0.112	δ_4	-0.253	-1.875*
Sigma square	δ^2	96.861		δ^2	21.039	
Gamma	Γ	98.200		Γ	197.000	
Log likelihood		51.648			77.119	
Lr-test of the one-sided error		91.644			12.424	

Source: Field survey, 2018 *** = significant at1%, (P<0.01), ** = significant at 5 % (P<0.05) * = significant at 10% (P<0.1)

The model statistics for the seed replaced enterprise revealed gamma value of 0.982 and this implies that 98.2% of the variation in replaced seed maize production cost can be attributed to allocative efficiency of the smallholder maize farmers who replaced seed. The log likelihood was 51.6% which implied that the functional form specified and used was adequate representation of the data. Other estimated variables to prove fitness, validity and accuracy of the model were sigma square (96.86) and LR test (91.64) respectively. The results of the estimated cost function revealed a positive constant and significant at 1% level. This implies that the constant relates directly to maize production allocative efficiency. The cost of land rent was positive and significant at 1% level and this implies that a unit increase in cost of land rent will increase maize production allocative efficiency by 26.1%. The coefficient of cost of labour was negative and significant at 1% level. This implies that cost labour was over utilized in the production process and inversely related to maize production allocative efficiency. This conformed to the findings of the study in Table 12 where variable costs of production were computed with 93 days average man-days for labour for the seed replaced farmers which was more than the days required for the production of early maturing maize varieties which was most likely the type used by the group. The coefficients of cost of seed and cost of NPK fertilizer were positive and significant at 10% level. This implies that an increase in the cost of seed and NPK by 10% will increase maize allocative efficiency of the seed replaced farmers by 2.2% and 4.6%. This goes in line with findings of Abdul *et al.* (2017) reported that cost of seed, agrochemicals and labour as statistically variable that determines allocative efficiency of smallholder maize farmers. Also, Halliru (2017) found that cost of seed, Fertilizer, organic manure, herbicides and labour were positive statistically significant variables that influence maize production.

While the model statistics for the non-seed replaced enterprise revealed gamma value of 1.97 and this implies that 197% of the variation in maize production of non-seed replaced can be attributed to allocative efficiency of the smallholder maize farmers not replaced seed. The log likelihood was 77.11% which implied that the functional specified and used is adequate representation of the data. Other estimated variables to prove fitness, validity and accuracy of the model were sigma square (21.03) and LR test (12.42), respectively. The results of the estimated cost function revealed a positive constant and significant at 1% level. This implies that the constant related directly with maize production allocative efficiency. The cost of land rent, NPK and labour were significant at 10% level and this implies that a unit increase in cost of land rent, cost of NPK and cost of labour will influence maize production output by 8.4%, 30.8% and 27.1% for non-seed replaced farmers. This may be because of the result of farm saved used which was in efficient, cost land expansion contributes significantly to maize production output; cost of NPK fertilizer also which enhanced vegetative growth and cost of labour especially for matured household members where family labour supplied were the key variable increased maize production output for the non-seed replaced farmers. This is in-line with findings of Abu *et al.* (2012) who reported labour as a positive significant variable that influence total farm production cost.

The inefficiency model revealed that household size and farming experience were the significant variables decreasing allocative inefficiency in maize production of the seed replaced farmers. This may be because labour supply for the matured household members and ability in taking risks and better decision from the farmer previous experiences in maize production. The positive coefficients of age revealed that increase in age has decreasing effect on allocative efficiency of smallholder maize enterprise who replaced seed. This implies that younger farmers were more active and inquisitive in allocative decisions than older ones who had other critical family and community issues distracting them. This conformed to the findings of the study where the respondents had a mean of 12 persons household size and 21 years mean farming experience and also affirmed to the findings of Sadiq and Sigh (2015) who reported age as negative significant variable contributing to farmers' inefficiency while education, farming experience and extension contact contribute to the increase farmers efficiency level.

While the negative and significant coefficients of farming experience and cooperative membership revealed that increase farming experience and cooperative membership have decreasing effect on allocative inefficiency of smallholder maize farmers not-replaced seed. This may be because of the ability to make good allocative decisions based on the farmers' previous experiences on maize production and also improved allocative decisions based on the knowledge acquired through cooperative societies on improving maize production productivity trainings and discussions. This conformed to the findings of the study where the mean farming experience of the respondents was 21 years and 55.1% of them were registered members farmers' cooperative societies.

Deciles Range of Technical, Allocative and Economic Efficiencies for Seed Replaced and Non-seed Replace Smallholder Maize Enterprises

The Table 16 presented the frequency distribution for the technical, allocative and economic efficiencies of smallholder maize production that replaced seed and those not.

Table 7: Deciles Range for Efficiency Estimates of Seed Replaced and Non-Seed Replace Enterprises

Seed Replaced Enterprise							Non Seed Replace Enterprise					
Efficiency Level	**Technical**		**Allocative**		**Economic**		**Technical**		**Allocative**		**Economic**	
%	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
0.01-0.50	171	53.47	0	0	115	36.36	25	45.45			13	23.63
0.50-1.0	148	46.52	0	0	101	31.55	30	54.54			18	32.72
1.01-1.50			207	66.04	58	18.18			27	49.09	14	25.45
1.51-2.0			69	19.25	25	7.75			14	25.45	2	3.63
2.01-2.50			19	6.68	11	3.47			7	12.72	4	7.27
2.51-3.0			9	4.01	4	1.33			4	7.27	2	3.63
3.01-3.50			6	1.60	3	0.80			1	1.81		
3.51-4.0			4	1.06	1	0.26						

4.01-4.50			3	0.80	0	0			2	0.36	2	3.63
4.51-5.0			0	0	1	0.26						
5.01-5.50			2	0.53	0							
Total	**319**	**100.00**	**319**	**100.00**	**319**	**100.00**	**55**	**100.00**	**55**	**100.00**	**55**	**100.00**
Average	0.52		1.55		0.86		0.57		1.74		1.06	
Minimum	0.04		1.04		0.04		0.10		1		0.12	
Maximum	0.97		5.50		4.86		1.00		4.15		4.15	

Source: Field survey, 2018

From the result in Table 16 revealed that 53.47% of smallholder maize producers who replaced seed fall within the technical efficiency range of 0.01 – 0.50. The minimum technical efficiency was 0.04 while the maximum was 0.97 and an average of 0.52. This implies that in the short run there is chance for increasing technical efficiency of maize production for smallholder farmers who replaced seed by 48.0% using existing resources and technology. Also, from the result 66.04% of seed replaced farmers fall within the allocative efficiency range of 1.0 – 1.50. The minimum was 1.04 while the maximum was 5.50 and an average of 1.55. The result further revealed that the economic efficiency which is the product of technical and allocative efficiency had 36.36% within the range of 0.1 – 0.50. The minimum was 0.04 while the maximum was 4.86 and an average of 0.86. This implies that 14% is the shortfall for smallholder maize farmer who replaced seed to be economically efficient. The overall analysis of the stochastic frontier result showed that there is chance for improvement through better use of the existing resources and technology improvement except for resource allocation for the seed replaced farmers.

While for non-seed replace farmers the result revealed that 54.54% of smallholder maize producers fall within the technical efficiency range of 0.50 – 1.0. The minimum technical efficiency was 0.10 while the maximum was 1.00 and an average of 0.57. This implies that in the short run there is chance for increasing technical efficiency of maize production for smallholder farmers who do not replaced seed by 43.0% using existing resources and technology. Also, from the result 49.09% fall within the allocative efficiency range of 1.01 – 1.50. The minimum was 1.00 while the maximum was 4.15 and an average of 1.74. The result further revealed that the economic efficiency which is the product of technical and allocative efficiency had 56.35% within the range of 0.1 – 1.0. The minimum was 0.12 while the maximum was 4.15 and an average of 1.06. The overall analysis of the stochastic frontier result showed that there is no much chance for improvement through use of the existing resources and technology by the non-seed replace farmers in the study area.

Constraints of Maize Seed Replacement in the Study Area

Despite the importance of seed replacement on maize production which enhances income generation and household food security, maize producing households were faced with some constraints in replacing seeds stock in the study area. The results on Table 21 revealed that the constraints were ranked by both groups of replaced seeds and non-replace seeds farmers on a scale of 1 – 11 as degree of challenge severity.

Table 8: Constraints Associated with Seed Replacement on Maize Production

Constraints	Replaceed Seed		Seed not Replace	
	F (%)	**Ranking**	**F (%)**	**Ranking**
***Inadequate seed information management**	299(93.7)	1st	46(83.6)	4th
***Seed not available/too expensive**	253(79.3)	2nd	41(74.5)	5th
***Not good in intercropping**	200(51.1)	3rd	48(87.3)	3rd
***Requires much fertilizers**	159(49.8)	4th	38(69.1)	7th
***Variety sensitive to pests & diseases**	151(47.3)	5th	37(67.3)	8th
***Variety sensitive to drought**	121(37.9)	6th	34(61.8)	9th
***Low market value**	118(37.0)	7th	32(58.2)	10th
***Produce small grain size**	99(31.0)	8th	39(70.9)	6th
***Low yielding variety**	86(27.0)	9th	50(90.1)	2nd

***Low fodder yield**	45(14.1)	10th	52(94.5)	1st
***Unacceptable seed color**	11(3.4)	11th	07(12.7)	11th

Source: Field Survey, 2018*Multiple responses; figures inside parenthesis are percentages

From Table 21, the results revealed that the constraints smallholder maize farmers had in seed replacement were inadequate seed information management ranked 1st by the seed replaced farmers while non-seed replace farmers ranked low fodder yield as first constraint. This implies the seed replacers accepted the replacement practice which was attributed to their higher socio-economic status and social interactions while the non-seed replacers it was constraint to the due to their socio-economic status and demand of the crop residue for feeding their livestock to augment their means of livelihood.

From the result also seed replaced farmers' ranked seed not available and too expensive as second constraint while non-replace seed farmers ranked low yielding variety as their 2nd constraint. This may be because of their difference in experience and believe where the seed replacers considered the maize grains measure as yield maize yield obtained and access to the quality seed was constrain to them while non-seed replacers considered both grains and other crop residue which was important to them in feeding their livestock. This agrees with findings of Yakubu (2016), in the Analysis of Productivity among Maize Farmers in Doguwa Local Government area of Kano State, Nigeria that high cost of inputs like fertilizer, improved seeds and labour was the most severe constraint in maize production with about 34% of maize farmers attesting to this fact. This finding is also in line with Ekong (2003), who reported that most farmers have little or no access to improved seeds and continue to recycle seeds obtained from previous harvest. Other ranking were 3rd seed not good for intercropping and the least ranking 14th was unacceptable colour of seed by both the seed replaced and non-seed replace farmers, seed required much fertilizer for seed replacers and ranked 4th while non-seed replacers ranked inadequate seed information management as 4th. The 5th constraints were seed sensitive pest and diseases for seed replacers while seed not available/expensive for non-seed replacers then 6th were variety sensitive to drought for seed replacers and small grain size for non-seed replacers and 7th low market value for seed replacers and require much fertilizer for non-replacers respectively. Also from the findings the 8th constraints were seed produce small grains for seed replacers while variety sensitive to pests and diseases for non-seed replacers than 9th low yielding variety for seed replacers while very sensitive to draught for non-seed replacers and 10th were low fodder yield for seed replacers while low market value for non-seed replacers respectively. The least constraints both groups was unacceptable seed colour. This implies the presence of weak extension system to enlighten the non-seed replacers of the advantage seed replacement and accept the innovation which even though had constraints but proved to be profitable.

CONCLUSION AND RECOMMENDATIONS

Conclusion

From the findings of the study, small-scale maize production in the study area was more popular among the male smallholder farmers; significant numbers of smallholder farmers were not registered cooperative members. Majority of the selected smallholder farmers were aware of seed replacement and practice it, the average seed replacement rate among the farmers who practice it was good and seed replacement has significant and positive effect on the smallholder maize farmers' productivity, profitability, resource efficiency and market surplus though with chances of improving both technical and overall economic efficiency. Farming experience and cooperative membership were the socio-economic variables influence smallholder maize producers to practice seed replacement. Both groups were constrained with the seed replacement practice majorly inadequate seed management information for the seed replaced farmers and low crop residues for the non-seed replaced farmers.

Recommendations

Based on the findings of the study, the following recommendations were made:

(i) It is recommended for the need of interventions to bring more women into small-scale maize production to bridge the huge gap for improved livelihood; income generation and enhanced food security in the study area;

(ii) Need for capacity building to farmers on variable production cost management and profit analysis to ascertain gains and loses per season and make comparison between farm enterprises;

(iii) Resource adjustment by the farmers to improve efficiency using the available resources to avoid over and under-utilization of production inputs;

(iv) Rigorous seed system monitoring and supervision by the National Agricultural Seed Council be established/strengthen to guarantee farmers on the certified seed they purchase and also to guaranty potential yield and efficiency in maize production in the study area;

(v) Seminars and enlightenment campaign be conducted to build capacity of downstream seed marketers and farmers on seed handling, storage and seed information management by government, NGOs and major seed marketers; and

(vi) Making certified seeds that are more suitable to the farmers' environment more accessible by governments, researchers, seed marketers and NGOs in the study area.

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