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Effect of improved seed technology adoption on small-scale sorghum farmers' productivity in Kebbi State, Nigeria

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Abstract. *The study examined the effect of improved seed technology adoption on small-scale sorghum farmers' productivity in Kebbi State, Nigeria. Multistage sampling technique was employed in determining the sample size from the sample frame, 240 respondents were sampled using proportionate sampling technique. Data for the study were collected using structured questionnaire containing open and closed ended questions. The data collected were analyzed using descriptive statistics and multiple regression analysis. The results indicated that the sorghum farmers adopted Samsorg-5, Samsorg-14 and Samsorg-17 improved seeds with Samsorg-5 accounting for 64.6% level of adoption, thus ranking first. The multinomial logit regression model showed that the probability of adopting one or two improved sorghum varieties increased with the farmers' educational level, sex, farm size and labour usage in the study area. The results further revealed that the average cost of Samsorg seeds was negative and statistically significant at one percent probability level across the groups which implies that the probability of adopting any of the improved sorghum varieties reduced with its cost. The results also indicated that Samsorg-5, Samsorg-14 and Samsorg-17 improved seeds positively affected farmer's production and productivity at 5% levels of probability. This indicated that a percentage increased in the use of these improved seeds led to an increase in the production and productivity of sorghum farmers in the study area. Also, the influence of farm size and fertilizer on output and productivity were positive and statistically significant at 1% levels of probability. The results further revealed that, the topmost constraints faced were inadequate extension services and low level of formal education at 92.1% and 56.7% ranking 1st and 2nd, respectively. Therefore, the study recommended an action-oriented plan to reach the small scale farmers with adequate information on agricultural practices to promote adoption of improved seeds in order to increase their level of productivity. Agricultural policies should be directed at making inputs available at subsidized rate, on time and at the required level. Credit facilities should be made accessible at single digit interest rate to enable them efficiently utilize inputs in order to increase their productivity level.*

Keywords: sorghum farmers, seed technology, adoption, productivity

Introduction

The importance of agriculture to an economy can never be over-emphasized. Nigerian Agriculture contributes over 24% of Gross Domestic Product (GDP) (Aikhionbare, 2016), and accounts for over 70% of the non-oil exports, provides 80% of the food requirement and employs over 68% of the labour force (Adegboye, 2004). The sector provides raw materials for agro-allied industries as well as income to the farmers (Aikhionbare, 2016). Yet, agricultural production capacity is dominated by small scale farmers living in rural areas, growing food crops and raising livestock at subsistence level (Awoke, 2002). In addition, Adegboye (2004) observed that, the advent of petroleum, gave rise to huge neglect of the sector which resulted in declined productivity, low income to farmers, unemployment, rise in food prices and threat to food security among others. To improve productivity in the agricultural sector therefore, will among other things, require a concerted effort in providing the farming community with new agricultural technologies such as high yielding varieties that are drought and pest resistant. This will lead to sustained development of the arable sector and reduce costs per unit of output (Nkonya et al., 2004).

Food production can be increased simply by ensuring the availability of good quality seeds. Seeds are the starting point of agriculture; they are the sources of continuity, change, and restoration. Seeds and other required inputs can be used to rapidly rehabilitate agriculture in the wake of natural disasters, such as flood, drought, or blight from insects or plant diseases (Ajeigbe, 2010).

Sorghum is a singularly viable food grain crop for many food insecure people in sub-Saharan Africa (Getachew et al., 2016). It is the second major crop (after maize) across all agro-ecologies in Africa (Taylor, 2003). Integration of optimal technology packages and marketing could lift the livelihood of subsistence small-scale sorghum farmers and the adaptive capacity of the encompassing community (Ismail et al., 2010). The adoption of the improved seed technology has positive effect on the life of the adopters by improving their productivity, incomes and consumption expenditures, thereby improving their level of food security and poverty lessening (Challa and Tilahun, 2014). Farmers' adoption of improved seed technology is one of the most crucial factors affecting the productivity of the sorghum crop as most seeds are obtained from informal sources which tend to be inconsistent in terms of quality and as such are vulnerable to pests and diseases. Therefore, the focus of this research was to examine productivity of small scale sorghum farmers as a result

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of adopting the use of improved seed technologies. Hence, the objectives of this study are to identify the improved seed technologies adopted by sorghum farmers, determine factors affecting adoption of improved seed technologies among small scale sorghum farmers, determine the effect of improved seed technologies on production and productivity of small scale sorghum farmers and identify problems faced by farmers in adopting improved sorghum seed technologies in the study area.

Material and methods

Study area

The study was carried out in Kebbi State, Nigeria. Kebbi State is located between latitudes 10°8'N and 13°15'N and longitudes 3°30'E and 6°02'E, and is bounded by Sokoto State to the north and east, Niger State to the south and Benin Republic to the west. It has 21 Local Government Areas (LGAs) and a total land area of 36800 km² with an estimated population of 3 238 628 (Nigeria Galleria, 2015). Kebbi State enjoys a tropical continental type of climate characterized by wet and dry seasons. The wet season lasts from April to October in the south and May to September in the north; while the dry season lasts for the remaining period of the year (Lawal, 2013). The State has Sudan and Sahel-savannah. The mean annual rainfall is about 800mm in the north and 1000mm in the south. Temperature is generally high with mean annual temperature of about 26°C in all locations. However, during the harmattan season (December to February) the temperature goes down to about 21°C and up to 40°C during the months of April to June (Lawal, 2013). Agriculture is the main occupation of the people, especially in rural areas. Major food crops in the area are millet, sorghum, maize, cassava, potatoes, rice, beans, onions and vegetables, while cash crops including wheat, soya beans, ginger, sugarcane, groundnuts and tobacco.

Sampling technique and sample size

A multistage sampling technique was employed to determine the sample size from the sample frame. The first stage involved random selection of one Local Government Area from each of the four Agricultural Zones in the State. Stage two involved random selection of eight farming communities from the four selected Local Government Areas in the Agricultural Zones and the third stage involved random selection of sorghum farmers' households from the selected farming communities based on the proportion of each LGA sample frame. A total of 240 farm households were randomly selected for this study.

Method of data collection

Data for the study were obtained through primary source. Structured questionnaire containing open and closed ended questions was used as an instrument in collecting primary data from the sorghum farmers' households with the help of trained enumerators from Kebbi State Agriculture and Rural Development Authority (KARDA) in each selected farming community for the study under the supervision of the researcher. The data elicited covered types of sorghum technologies adopted, adoption factors, production factors, productivity, crop output level and income level of the farmers.

Analytical techniques

Descriptive statistics and multiple regression analysis were used to achieve the objectives of the study.

Model specification. The multinomial logit regression model/analysis was used following Budry et al. (2006), Bandara and Thiruchelvam (2008), and Rahji and Fakayode (2009) to express the probability of a farmer being in a particular category. The farmers were categorized into three based on the number of improved sorghum varieties adopted. The improved sorghum varieties included improved KSV11 (Samsorg-5), KSV8 (Samsorg-14) and KSV3 (SK5912) (Samsorg-17) seed.

The general form of the multinomial Logit model is:

$$\Pr(y_i = j) = \frac{\exp(X_i \beta_j)}{1 + \sum_{j=1}^{J} \exp(X_i \beta_j)} \quad (1)$$

And to ensure identifiability,

$$\Pr(y_i = 0) = \frac{1}{1 + \sum_{j=1}^{J} \exp(X_i \beta_j)} \quad (2)$$

Where for the i^{th} individual, y_i is the observed outcome and X_i is a vector of explanatory variables; β_j is the unknown parameters.

This model for this study was summarized as follows:

$$P_{ij} = \frac{\exp(\gamma_j X_i)}{1 + \sum_{j=1}^{3} \exp(\gamma_j X_i)} \quad (3)$$

For j = 1, 2, 3

P_{ij} is the probability of being in each of the groups 1 and 2.

$$P_{i0} = \frac{1}{1 + \sum_{j=1}^{3} \exp(\gamma_j X_i)} \quad (4)$$

P_{io} is the probability of being in the reference group or group 0.

In practice, when estimating the model, the coefficients of the reference group are normalized to zero (Maddala, 1990; Greene, 1993; Kimhi, 1994; Rahji and Fakayode, 2009). This is because, the probabilities for all the choices must sum up to unity (Greene, 1993). Hence, for 3 choices only (3-1) distinct sets of parameters can be identified and estimated.

The natural logarithms of the odd ratio of equations (1) and (2) give the estimating equation (Greene, 1993) as:

$$\ln \frac{(P_{ij})}{(P_{i0})} = \gamma_j X_i \quad (5)$$

This denotes the relative probability of each of the groups 1 and 2 to the probability of the reference group. The estimated coefficients for each choice therefore reflect the effects of

Xi`s on the likelihood of the farmers choosing that alternative relative to the reference group. Stata 11.2 software was used in estimating the model. However, following Hill (1983) and Rahji and Fakayode (2009), the coefficients of the reference group may be recovered by using the formula:

$$\gamma_3 = -(\gamma_1 + \gamma_2) \quad (6)$$

For each explanatory variable, the negative of the sum of its parameters for groups 1 and 2 is the parameter for the reference group. This model was employed in determining factors affecting the choice of improved seed technologies adopted by sorghum farmers. It is explicitly specified as follows:

$$P_{ij} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + e_i \quad (7)$$

Where:

P_{ij} = is the probability of being in each of the groups; X_1= Age (years); X_2= Educational level (years); X_3= Sex (1= Male, 0= Female); X_4= Marital status (1= Married; 0, otherwise); X_5= Average cost of Samsorg seeds (Naira); X_6= Farm size (ha); X_7= Labour (Man days); X_8= Farming experience (years); X_9= Credit accessibility (1= yes, 0= no); X_{10}= Household size (Number of persons); X_{11}= Off-farm income (Naira); X_{12}= Extension contact (1= yes, 0= no) and e= Error term.

The effects of improved seed technologies on production and productivity of small-scale Sorghum farmers were also achieved using multiple regression The regression equation is implicitly specified as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8 + e), \quad (8)$$

Where:

Y dependent variable= Output (kg); X_1= Quantity of improved KSV11 (Samsorg-5) seed (kg); X_2= Quantity of improved KSV8 (Samsorg-14) seed (kg); X_3= Quantity of improved KSV3 (SK5912) (Samsorg-17) seed (kg); X_4= Farm size (ha); X_5= Fertilizer application (kg); X_6= Labour (Man days); X_7= Capital (Depreciation in Naira); X_8= Agrochemicals (litre) and e= Error term.

Total Factor Productivity (TFP) index was used in determining the productivity of the sorghum farmers. However, this method ignores the role of TFC as it may not affect both the profit match and the resource use efficiency conditions. Besides it is fixed and as such a constant.

$$\text{The Total Factor Productivity (TFP) Index} = \frac{VOO}{VOI}, \quad (9)$$

Where:

Y (TFP index)= Productivity; VOO= Value of Output produced (Naira); VOI= Value of Inputs used (Naira).

The multiple regression analysis equation for the effect of improved seed technologies on productivity is implicitly specified as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12} + e), \quad (10)$$

Where:

Y (TFP index)= Productivity X_1= Quantity of improved KSV11 (SAMSORG-5) seed (kg); X_2= Quantity of improved KSV8 (SAMSORG-14) seed (kg); X_3= Quantity of improved KSV3 (SK5912) (SAMSORG-17) seed (kg); X_4= Farm size (ha); X_5= Fertilizer application (kg); X_6= Labour (man day); X_7= Capital (depreciation in Naira); X_8= Agrochemicals (litre); X_9= Age (years); X_{10}= Educational level (years); X_{11}= Sex (1= Male, 0= Female); X_{12}= Marital status (1= Married, 0= Unmarried) and e = Error term.

Results and discussion

Adopted improved sorghum seed technologies in the study area

The results of improved seed technologies adopted by the Sorghum farmers in the study area are presented in Table1. The results reveal that Samsorg-5 with about 64.6% of the Sorghum farmers' response, had the highest level of adoption ranking 1st among the three improved sorghum seed technologies adopted, Samsorg-14 constituted 37.9% level of adoption ranking 2nd, while Samsorg-17 showed 34.2% level of adoption ranking 3rd adopted in the study area.

Table 1. Improved seed technologies adopted by sorghum farmers in the study area (n=240)

Adopted technologies (Sorghum varieties)	Frequency*	Percentage	Ranking
Samsorg-5 (KSV 11)	155	64.6	1st
Samsorg-14 (KSV 8)	91	37.9	2nd
Samsorg-17 (KSV 3)	82	34.2	3rd

* = Multiple responses were recorded; Source: Field Survey, 2017

Factors influencing the choice of improved sorghum seed technologies adoption in the study area

The results of the multinomial logit analysis showing the factors that affected the adoption of improved sorghum seed in Kebbi State are shown in Table 2. The effect coefficients were estimated with respect to the adoption of the three improved sorghum varieties under consideration (group 3), as the reference group. Therefore, the inference from the estimated coefficients for each adoption group category was made with reference to group 3.

Table 2 shows that, the Wald chi square (χ^2) value was 1635 and this is significant at 1% level of probability. This test confirms that all the slope coefficients are significantly different from zero. The pseudo R^2 value of 0.7314 also con-

Table 2. Results of the estimated multinomial logit model for factors influencing the choice of improved sorghum seed adopted

Variables	One improved seed (Group 1)	Two improved seeds (Group2)	Three improved seeds (Reference group)
Age (years), (X_1)	-0.0601 (-1.82)*	0.0297 (1.20)	0.0304
Educational level (years), (X_2)	0.2240 (2.02)**	0.1615 (1.83)*	-0.3855
Sex, (X_3)	14.0572 (10.07)***	13.2688 (8.09)***	-27.3260
Marital status, (X_4)	-2.0245 (-1.40)	14.6581 (17.42)***	-12.6336
Average cost of Samsorg seeds (Naira), (X_5)	-0.0092 (-2.94)*	-0.0069 (-2.67)*	0.0161
Farm size (ha), (X_6)	11.9481 (2.98)***	9.4051 (2.91)***	21.3532
Labour (mandays), (X_7)	0.0969 (1.84)*	0.1331 (3.61)***	0.2300
Farming experience (years), (X_8)	0.0636 (1.92)*	-0.0353 (-1.45)	-0.0283
Credit accessibility, (X_9)	-0.9205 (-0.79)	-0.0210 (-0.03)	0.9415
Household size, (X_{10})	-0.0618 (-0.59)	-0.0004 (0.01)	0.0622
Off-farm income (Naira), (X_{11})	-0.0005 (-1.27)	-0.0001 (-0.53)	0.0006
Extension contact, (X_{12})	-1.0079 (1.27)	0.1977 (0.29)	0.8102
Constant	12.8929 (5.36)***	7.1147 (3.10)***	20.0076
No of observations	123	80	37

*Number of observation = 240; Figures in parentheses are Z-values; Log likelihood = -64.279; Wald Chi-square = 1635.00; Pro > Chi-square = 0.0000; Pseudo R^2 = 0.7314; Significant: *** = at 1%, ** = at 5% and * = at 10% level of probability. Source: Field Data Analysis, 2017.

firmed that all the slope coefficients are not equal to zero. In other words, the explanatory variables are collectively significant in explaining the number of improved sorghum varieties adopted by farmers in the study area. The results of the estimated equations were discussed in terms of the significance and signs on the parameters. Therefore, evidence from the model as contained in Table 2 shows that the set of significant explanatory variables varies across the groups in terms of the levels of significance and signs. However, educational level, sex, farm size and labour usage by the farmers with respect to choice of the improved sorghum varieties adopted are positive and significantly associated with the classification of the two groups relative to the reference group. The positive sign implies that the probability of adopting one or two improved sorghum varieties tends to increase with the farmers' educational level, sex, farm size and labour usage in Kebbi State. The results further revealed that the average cost of Samsorg seed was negative and statistically significant at 1% probability level across the groups which imply that the probability of adopting any of the improved sorghum varieties tends to reduce with its cost.

Table 3 contains the values of the estimated marginal effects and the quasi – elasticities calculated for the significant variables. The variables across the three groups with partial elasticities less than unit were inelastic while the variables with partial elasticities greater than unit were elastic. For the variables that were elastic, 1% change in these explanatory variables led to a more than proportionate change in the probability of other classified groups relative to the reference group. For the variables that were inelastic, the probability of classifying the farmers into any particular group is not greatly affected by marginal changes in these variables as a one percent change in the variables led to a less than proportionate change in the probability of classification.

Effect of adoption of improved seed technologies on production of small-scale sorghum farmers

The regression results of the effect of adoption of improved sorghum seed technologies in the study area are presented in Table 4 (double-log production function as the lead equation). The results show R^2 of 0.8618, meaning that the explanatory variables included in the model accounted for 86.2% variation in the output of the farmers in the study area. The F-ratio of 207.67 indicated that the whole model was sig-

Table 3. Marginal effects and the quasi – elasticities estimated

Variables	*One improved seeds (Group1)	*Two improved seeds (Group2)	*Three improved seeds (Reference group)
Age	0.0018	-	-
	(0.7724)		
Educational level	0.0043	0.0010	0.0053
	(0.1572)	(0.1471)	(0.9348)
Sex	-0.1251	-0.2875	0.4126
	(-2.4234)	(-1.6875)	(10.6967)
Marital status	-	1.1428	-0.3458
		(9.5669)	(-3.9918)
Average cost of	-0.0002	-0.0001	-0.0002
Samsorg seeds (Naira)	(-4.5933)	(-4.4348)	(-31.6216)
Farm size (ha)	0.1105	0.1105	0.3049
	(0.1944)	(0.1930)	(24.4700)
Labour (mandays)	-0.0011	0.0050	-
	(-0.1959)	(3.7823)	

* = Marginal effects are above while partial elasticities are in parentheses
Source: Field Data Analysis, 2012

Table 4. Effect of adoption of improved seed technologies on production of small-scale sorghum farmers in the study area (Double-log production function as lead equation) (n=240)

Variables	Linear	Semi-log	Double-log	Exponential
Samsorg-5 seeds (kg), (X_1)	17.012	36.052	0.040	0.004
	(0.83)	(0.27)	(2.86)***	(0.61)
Samsorg-14 seeds (kg), (X_2)	40.609	175.000	0.048	0.013
	(1.81)*	(2.01)**	(2.46)**	(1.71)*
Samsorg-17 seeds (kg), (X_3)	109.247	413.591	0.099	0.034
	(4.57) ***	(3.00)***	(2.06)**	(4.24)***
Farm size (ha), (X_4)	595.711	1531.112	0.623	0.152
	(3.08)***	(4.65)***	(6.13)***	(2.28)**
Fertilizer (kg), (X_5)	4.592	649.635	0.195	0.001
	(5.24)***	(6.30)***	(5.33)***	(3.99)***
Labour (Mandays), (X_6)	-1.961	534.215	0.066	-0.003
	(-0.52)	(1.52)	(0.67)	(-0.23)
Capital, (X_7)	0.015	103.556	0.015	7.000
	(1.15)	(0.87)	(0.53)	(1.29)
Agrochemicals (litre), (X_8)	-2.464	96.424	0.025	-0.001
	(-0.15)	(1.14)	(1.22)	(-0.19)
Constant	3.675	41.294	5.966	7.028
	(0.77)	(3.39)***	(12.34)***	(85.40)***
R^2	0.8459	0.7931	0.8618	0.7479
Adjusted R^2	0.8405	0.7859	0.8570	0.7391
F-Ratio	97.40***	108.12***	207.67***	48.34***

*Figures in parenthesis are t-values, *** = significant at 1%, ** = significant at 5% and * = significant at 10% level of probability;

Source: Field Survey, 2017.

nificant at 1% probability level. The results also showed that the quantity of Samsorg-5 seeds (X_1), Samsorg-14 seeds (X_2) and Samsorg-17 seeds (X_3) used by the sorghum farmers in the study area were positive and statistically significant at 5% levels of probability. This indicates that a percentage increase in the quantity of Samsorg-14 seeds and Samsorg-17 seeds used by farmers led to a significant increase in output by 0.0407, 0.0489 and 0.0993 percent, respectively. The results are similar to those of Ede (2011) and Mekonnen (2015) who reported that adoption of improved technologies led to increase in the farmers' output. The results further showed that regression coefficients of farm size (X_4) and fertilizer application (X_5) had positive relationship with the production output of the sorghum farmers in the study area. The coefficients were statistically significant at 1% levels of probability. The findings of the study agree with Saka and Lawal (2009) that farmers can increase their production through increased land area, use of improved seed and fertilizer.

Table 5. Effect of adoption of improved seed technologies on productivity of small-scale sorghum farmers in the study area (Double-log production function as lead equation) (n=240)

Variables	Linear	Semi-log	Double-log	Exponential
Samsorg-5 seeds (kg), (X_1)	-3.8991	-2.6922	0.0484	-0.1320
	(-0.90)	(-0.51)	(2.26)**	(-1.05)
Samsorg-14 seeds (kg), (X_2)	3.8629	6.2486	0.2782	0.1865
	(2.11)**	(2.53)**	(3.02)***	(2.47)**
Samsorg-17 seeds (kg), (X_3)	-5.0900	-5.0494	0.2367	0.0772
	(-1.07)	(-0.89)	(2.34)**	(0.62)
Farm size (ha), (X_4)	1.5519	3.9066	0.3741	0.1521
	(1.48)	(1.45)	(3.03)***	(2.36)**
Fertilizer (kg), (X_5)	0.0430	13.1911	0.8918	0.0030
	(5.68)***	(7.73)***	(10.19)***	(8.34)***
Labour (manday), (X_6)	0.0036	2.7851	0.0337	-0.0006
	(0.11)	(0.85)	(0.22)	(-0.32)
Capital (Dep. Naira) (X_7)	-0.0004	-2.3684	-0.0583	-0.00001
	(-1.89)*	(-1.31)	(-1.15)	(-1.29)
Agrochemicals (litre), (X_8)	0.2141	5.1915	0.2150	0.0087
	(1.21)	(3.20)***	(4.37)***	(1.07)
Age (years), (X_9)	0.02116	1.4188	0.0279	0.0008
	(0.41)	(0.80)	(0.37)	(0.27)
Educational (years), (X_{10})	-0.3031	-1.2368	-0.0374	-0.0084
	(-1.75)*	(-1.51)	(-1.13)	(-1.17)
Sex (X_{11})	1.1327	1.3984	0.0578	0.0540
	(0.38)	(0.39)	(0.37)	(0.40)
Marital status (X_{12})	4.8962	5.7755	0.3375	0.2886
	(2.77)***	(2.47)**	(3.15)***	(2.05)***
Constant	24.2048	94.0789	7.3381	2.3216
	(1.65)*	(4.47)***	(10.32)***	(4.40)***
R^2	0.2487	0.3664	0.6120	0.4771
Adjusted R^2	0.2090	0.3329	0.5915	0.4495
F-Ratio	11.13***	15.79***	47.38***	23.43***

*Figures in parenthesis are t-values, ******* = significant at 1%, **** =** significant at 5% and ***** = significant at 10% level of probability;
Source: Field Survey, 2017.

Effect of adoption of improved seed technologies on productivity of small-scale sorghum farmers.

The results on the effect of adoption of improved seed technologies on productivity of small-scale sorghum farmers are presented in Table 5 with double-log production function as the lead equation. The results show R^2 of 0.6120, meaning that the explanatory variables included in the model accounted for 61.20% variation in the productivity of the farmers in the study area. The F-ratio 47.38 shows that the whole model was significant at 1% level of probability. The results also showed that the quantity of Samsorg-5 seeds (X_1), Samsorg-14 seeds (X_2) and Samsorg-17 seeds (X_3) had positive and statistically significant relationship with productivity of the farmers in the study area. This implies that a percentage increase in these inputs holding others constant led to increase in productivity in the study area. This confirms the findings of Okike et al. (2001) that use of modern inputs could lead to higher productivity resulting from positive interactions among inputs, especially when they are of improved quality. The results further revealed that farm size (X_4), fertilizer (X_5) and agrochemicals (X_8) had direct relationship with productivity of sorghum farmers and they were statistically significant at 1% level of probability. The result agrees with the findings of Mekonnen (2015) who reported that high-yielding cereal crop varieties and chemical fertilizer adoption, had significant impact on smallholders' crop productivity.

Problems faced by farmers in adopting improved sorghum seed.

The constraints faced by sorghum farmers in adopting improved seed technologies in the study area are presented in the Table 6. Constraints were ranked based on their magnitude as stated by the respondents in the study area. The

Table 6. Problems faced by respondents in adopting improved sorghum seed in the study area (n=240)

Constraints	*Frequency	Percentage	Ranking
Inadequate extension services	221	92.1	1st
Low level of formal education	136	56.7	2nd
Limited and untimely supply of fertilizer	132	55.0	3rd
Insufficient credit availability	113	47.1	4th
Limited and untimely supply of improved sorghum seeds	96	40.0	5th
Low level of off-farm income	64	26.7	6th
High cost of improved sorghum seeds	60	25.0	7th
High production and service costs	47	19.6	8th
Unstable market	19	7.92	9th

* = Multiple responses were allowed; Source: Field Survey, 2017

results show that the topmost problems faced by respondents in the study area are inadequate extension services and low level of formal education, which ranked 1st (92.08%) and 2nd (56.67%), respectively. This implies that farmers in the study area had inadequate extension services and low level of formal education which might have affected the way they handle farming practices thereby reducing their productivity.

The results in Table 6 also show that low level of off-farm income ranked 6th (26.7%), which implies that increase in Sorghum farmers off-farm income will facilitate adoption of new innovations because farmers with additional income get more financial resources to invest in the new technologies. High cost of improved sorghum seeds, high production and service cost, unstable market ranked 7th (25.0%), 8th (19.6%) and 9th (7.92%), respectively. This implies that farmers' adoption of improved seed technology and increase in productivity can best be achieved if these problems are solved or reduced to the lowest level possible.

Conclusion

The study examined the effect of improved seed technology adoption on small-scale sorghum farmers' productivity in Kebbi State, Nigeria. The results indicated that the sorghum farmers adopted Samsorg-5, Samsorg-14 and Samsorg-17 improved seeds with Samsorg-5 accounting for 64.6% level of adoption ranking first. The multinomial logit regression model showed that educational level, sex, farm size and labour usage by the farmers with respect to choice of the improved sorghum varieties adopted are positive and significantly associated with the classification of the two groups relative to the reference group. The positive sign implies that the probability of adopting one or two improved sorghum varieties tends to increase with the farmers' educational level, sex, farm size and labour usage in the study area. The average cost of Samsorg seed was negative and statistically significant at 1% probability level across the groups, which implies that the probability of adopting any of the improved sorghum varieties tends to reduce with its cost. The used Samsorg-5, Samsorg-14 and Samsorg-17 improved seeds positively affected farmers' production and productivity at 5% levels of probability, which led to increase in production and productivity of sorghum farmers in the study area. The influence of farm size and fertilizer on output and productivity were positive and statistically significant at 1% levels of probability. The topmost constraints faced by farmers were inadequate extension services and low level of formal education at 92.1% and 56.7% ranking 1st and 2nd, respectively. Based on the results obtained the study recommended an action-oriented plan to reach the small-scale farmers with adequate information on agricultural practices to promote adoption of improved seeds in order to increase their level of productivity. Agricultural policies should be directed at making inputs available at subsidized rate, on time and at the required level. Credit facilities should be made accessible at low/promotional interest rate to enable them efficiently utilize inputs in order to increase their productivity level.

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