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Analysis of Drought-Tolerant Maize Adoption and its Effect on Food Security among Farmers in the Sudan Savanna of Northeastern Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author YLI designed the study, wrote the protocol and wrote the first draft of the manuscript. Author YLI also managed the literature searches and performed the analyses. Author TA reviewed the draft of the work. He made valuable contributions especially on the review of literature and on the statistical tools used. Author STM also went through the draft of the work and made some suggestions. Author AAI assisted in the data collection and editorial work. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

This article examined the factors influencing the adoption of the drought-tolerant Maize (DT) varieties and their effect on food security among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria. Data for the study were collected from 200 farmers who were selected through a multi-stage sampling procedure. Factors influencing the adoption of DT maize varieties were determined through the use of censored regression (the Tobit model) while the effect of adoption of DT maize on food security was determined through the use of the chi-square test. The results from the chi-square test were further converted to a contingency coefficient in order to obtain the extent of the association between the adoption of DT maize and food security. The study revealed that income ($\rho \leq 0.01$) and access to extension services ($\rho \leq 0.01$) were significant in influencing the adoption of DT maize among farmers. The study also found a strong

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association (χ^2 – cal = 15.53; χ^2 – tab = 13.28) between the adoption of DT maize and food security among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria with a contingency coefficient of 0.25. The study thus concluded that maize farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria are generally small-scale farmers that produce for subsistence. It was also concluded that the adoption of DT maize significantly reduced the level of food insecurity among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria. It was therefore recommended that farmers should be linked to source of market for their produce in order to boost their income and that extension services should be strengthened so as to give farmers access to improved technologies.

Keywords: Drought-tolerant maize; adoption; food security; Sudan savanna; Nigeria.

1. INTRODUCTION

Agricultural research and technological improvement are crucial to improving agricultural productivity. Improved agricultural productivity is a very important method through which to solve the problems of poverty and food security which are rampant in rural communities [1]. This is especially necessary in developing countries where economies are dependent on climate-sensitive sectors such as agriculture. Singha and Baruah [2] as well as Muzari et al. [3] are of the opinion that the adoption of high-yielding crop varieties is a solution to food insecurity among farmers. However, the adoption rate and subsequent impact of adoption on food security among farmers, especially in sub-Saharan Africa have not been desirable. This could be due to the fact that the intended end users of the technologies are not adopting these technologies as expected or because the technologies are not suited to their situations. Adoption decisions among farmers are influenced by a number of factors, some of which are beyond the control of the farmers.

Maize is a dominant crop in Nigeria in general, and in northeastern Nigeria in particular. Most of the small-scale farming households in the region are engaged in maize production. The annual per capita maize output for the years spanning 2000 – 2005 was 85kg [4] while the per capita maize consumption was 175kg [5]. This results in a deficit in maize production which is primarily attributed to low productivity. As a result, maize production received substantial research attention, especially from the International Institute for Tropical Agriculture (IITA) and the International Maize and Wheat Improvement Center (CIMMYT).

Given the increased evidence FOR climate change, it has been established that drought is a major challenge to maize production in the drier regions of the world, including northeastern Nigeria [6]. As part of the effort to ensure productivity of maize in the drier regions of the world, scientists from CYMMIT, IITA and other development partners have developed and disseminated some varieties of maize, which have been tagged as drought-tolerant maize (DT maize). Several varieties of this crop are being promoted in some parts of Nigeria, including the northeastern states through the Drought Tolerant Maize for Africa (DTMA) project. The aim behind introducing the DT maize varieties to the farming communities was to convince farmers to adopt this technology. This is because the DT maize varieties are characterized by their early maturation, high yield and they also contain more protein and vitamins than most of the local varieties of maize. The DTMA project has been in operation in northeastern Nigeria since 2007 and its level of acceptance and how it has impacted the welfare of the farmers must be determined. It is against this backdrop that this study was conceived to assess the level and determinants of adoption of the improved DT maize

varieties among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria as well as to examine the effect of the adoption of DT maize on food security in this area. The specific objectives of the study were to:

i. Examine the socio-economic characteristics of maize farmers in the study area;
ii. Determine the factors that influenced the adoption of improved DT maize by farmers in the study area; and
iii. Establish the effects of adoption of improved DT maize on food security among maize farmers in the study area.

2. METHODOLOGY

The study was conducted in the Sudan Savanna agro-ecological zone of northeastern Nigeria. Two states (Bauchi State and Borno State) where the DTMA project is being implemented were selected for the study. From each of the states, one local government, where the DTMA project is currently being implemented was selected for the study and in each of the selected local government areas, ten communities were randomly selected. This meant that a total of 20 communities were used for the study. Ten farming households that were engaged in maize production were selected from each of the 20 communities, resulting in a total of 200 farming households used for the study. These 200 farming households were administered questionnaires/interview schedules to collect data for the study. Both descriptive and inferential statistics were used to analyze the collected data. Descriptive statistics (mainly frequencies and percentages) were used to categorize the respondents, while inferential statistics were used to establish relationship between the variables. The Tobit model was used to determine the factors that influenced the adoption of improved DT maize varieties by farmers in the study area. The model was also used to analyze the extent of use of DT maize seed by farmers. This model is appropriate in explaining relationships involving a continuous dependent variable and a set of independent variables [7,8,9]. The advantage of the Tobit model over the dichotomous choice models such as the Probit model [10] and the Logit model [11] is that it can determine the intensity of technology use once adoption has taken place. It also uses the observed values of the dependent variable. The model assumes that the intensity of use of the improved technology by farmers is a function of explanatory variables, x_{is} and unknown parameter vector, e. For the Tobit model, the equation for the relationship between the socio-economic characteristics of the respondents and the adoption of DT maize is specified as:

$$\mu^*_i = B_{xi} + \mu \quad (1)$$

which is algebraically expressed for the i_{th} farmer as:-

$$\mu_i = B_0 + B_1X_1 + \text{----------} B_nX_n \qquad i = 1\ldots\ldots\ldots n\ldots\ldots\ldots\ldots \quad (2)$$

$\mu i =$ 0, if $\mu^*_i \leq T$

$\mu i =$ 1, if $\mu^*_i > T$

μ_i is the observed dependent variable *i.e.* the total land area under DT maize cultivation measured in hectares;

μ^*_i is the non-observable latent variable representing the use of DT maize;

T is the critical (cut-off) value that translates into $\mu^*_i > T$ as a farmer adopts and $\mu^*_i < T$ as a farmer rejects the DT maize technology; and n is the number of observations.

The chi-square test was used to determine whether any relationships exist between the adoption of improved DT maize varieties and food security status of farmers in the study area. The results of the chi-square test was converted into contingency coefficient in order to examine the extent to which the adoption of improved DT maize reduced the incidence of food insecurity in the study area.

The χ^2 distribution is given as:

$$\chi^2 = \sum \frac{(Fo-Fe)2}{Fe}$$

where;

F_0 = observed frequency
F_e = expected frequency
$\sum$ = summation sign
The contingency coefficient (C) was calculated as:

$$C = \sqrt{\frac{\chi^2}{\chi^2+N}}$$

where;

N= sample size

To obtain the frequencies, food security status and adoption levels were categorized as low, medium and high. This study categorized the food security status of a household as low when that household had a maize shortage of two months until the next harvest or less. It was regarded as medium when that household has maize shortage of three to five months before the next harvest. Finally, a household was considered as having a high food insecurity status when it had maize shortage of six months or more before the next harvest. The adoption level was regarded as low when a farmer devoted 40% or less of his or her total land area to DT maize production. A medium adoption level was characterized by a farmer who devoted between 41% and 65% of his or her total land to DT maize technology. High adopters were those whose adoption rates were 66% and above. This categorization was based on the observed minimum and maximum levels of food security status and adoption as determined from the collected data.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

Table 1 shows that 38.00% of the respondents were 40 years of age or younger, with 31.50% of the respondents aged between 41 and 50 years. It is also evident from the results that 30.5.00% of the respondents were above the age of 50 years while 4.00% were 71 years or older. The average age among the farmers in the study area was 46 years. This suggests that a large proportion of the respondents were strong enough to vigorously engage in farming activities. Young and middle-aged people are more likely to adopt technologies [12] and also to engage in farming activities, given that farming in developing countries is not mechanized [13]. Table 1 further reveals that about half (48.50%) of the respondents had fewer than 7 years of schooling, with the average number of years in

school being 7 years among the respondents. This further brings to the light the low level of education among the farmers in developing countries. Table 1 also reveals a low level of commercialization among the respondents.

The results in Table 1 show that 47.50% of the respondents sold 20% or less of their total maize harvest for the 2012 farming season, while the average level of commercialization among the respondents was 30%. This shows that farmers in the study area mostly produce for subsistence, with only a little products remaining for the market. This corroborates the finding that small-scale farmers in developing countries mostly produce at a subsistence level [14]. Table 1 also reveals that more than half (57%) of the respondents had access to extension services.

Table 1. Distribution of the respondents based on their socio-economic characteristics

Variable	Frequency (n=200)	Percentage
Age (years)		
≤ 30 years	20	10.00
31 – 40 years	56	28.00
41 – 50 years	63	31.50
51 – 60 years	35	17.50
61 – 70 years	18	09.00
≥ 71 years	08	04.00
Years of schooling		
≤ 6 years	97	48.50
7 – 9 years	20	10.00
9-12 years	41	20.50
13 – 15 years	39	19.50
≥ 16 years	03	1.50
Household members engaged in farming activities		
≤ 3	94	47.00
4 – 6	67	33.50
7 – 9	24	12.00
10 – 12	10	05.00
≥ 13	05	02.50
Level of commercialization (%)		
≤ 20%	95	47.50
21% - 40%	35	17.50
41% - 60%	38	19.00
61%-80%	21	10.50
≥ 81%	10	05.00
Access to extension services		
Has access	114	57.00
Has no access	86	43.00

Source: Field Survey, 2013

3.2 Determinants of the Adoption of Improved (DT) Maize Varieties

Table 2 shows the factors that influenced the adoption of improved maize varieties among farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria. The entries

show that age was significant in influencing the adoption of DT maize among farmers in the study area (ρ ≤ 0.05). The variable was positive, indicating that the older a farmer is, the more his or her tendency to adopt improved DT maize. This could be the result of the level of experience of the older farmers as the older farmers have more experience in farming and they possess better knowledge of the climate when compare to younger (or less experienced) farmers.

Table 2. Tobit estimate of factors influencing the adoption of DT maize among farmers Sudan savanna of northeastern Nigeria

Adoption of DT Maize	Coefficient	Std. Error	t	P> |z|	(95% Conf. Interval)	
Age	1.294812	.5234867	2.47	0.015**	.2549701	2.334654
Education	-.3889828	1.202163	-0.32	0.747	-2.77693	1.998966
Farming members of household	-5.33068	2.257688	-2.36	0.020**	-9.81530	-.846060
Income	.0093132	.0021484	4.34	0.000***	.0050458	.0135807
Extent of commercialization	.125551	.2325554	0.54	0.591	-.336392	.5874936
Access to Extension service	28.28738	10.67397	2.65	0.009***	7.08484	49.48992
Constant	-17.68694	30.67289	-0.58	0.566	-78.61488	43.24099

***= Significant at 5%*
****= Significant at 1%*

This puts them ahead of the younger farmers in terms of knowing that the duration of rainfall will continue to decrease. This is probably why the older farmers adopt DT maize varieties more readily than their younger counterparts. The study also revealed that the number of household members engaged in farming activities was significant (ρ ≤ 0.05) and negative in influencing the respondents to adopt DT maize. The possible reason for the negative coefficient is that, farmers who use more family members in farming activities are mostly small-scale/peasant farmers. On the other hand, farmers that use less of their family members in farming activities mainly use hired laborer or machines. Such farmers are mostly large-scale and/or commercial farmers. They are therefore, in a better position to adopt improved technologies such as DT maize varieties. An earlier study [15] found that expenditure associated with hired labour significantly influenced the adoption of improved soybean seeds among small-scale farmer in Borno State, Nigeria. This could be explained by the fact that hired labour is generally used by medium-scale and large-scale farmers in Nigerian agriculture where labor-saving technologies are not always readily available. Income was also highly significant and positive (ρ ≤ 0.01) in influencing the adoption of DT maize among the respondents. Farmers that have higher income levels are in a better position to afford inputs in the form of seeds, fertilizers, herbicides or machinery. This can place them above other farmers in terms of the ability to purchase the main technology and the associated/complementary inputs. Part of the reasons for this is that inputs, such as improved seeds are costly. Cash is needed to purchase the seeds and the complementary inputs. In a study of climate change and agricultural technology adoption in rural Nigeria [16], it was found that income was statistically significant in influencing farmers' adoption of DT maize technology. This explains why access to credit is often observed as an important determinant in the adoption of improved technologies. One possible reason is that most of the farmers in developing countries are resource-poor and cash-trap [17,18]. Access to extension services positively and significantly (ρ ≤ 0.01) influenced the extent to which the

respondents adopted DT maize. Access to extension services determines the type of information that farmers obtain regarding production activities and the application of innovations; this is through counseling and demonstrations by extension agents. The effect of exposure to extension programs is enormous. For instance, an earlier study [19] found that farmers who had access to extension services were 72% more likely to adopt alley farming technologies than were farmers who had no access to extension services. This could be because farmers' interactions with extension personnel as well as technical support offered to farmers greatly increases farmers' knowledge of the available technologies and their potential benefits, hence acting as a trigger mechanism for intensive adoption.

3.3 Test of the Association between the Adoption of DT Maize Varieties and Food Security among the Respondents

A chi-square test was carried out to determine whether there was any association between the adoption of the DT maize varieties by farmers and the food security status of the farmers. The results in Table 3 revealed a calculated chi-square (χ^2 – cal) value of 15.53. When this value was compared with the tabulated chi-square (χ^2 – tab) value of 13.28, and given the degree of freedom of 4, it was found that the χ^2 – cal (15.53) value was greater than the χ^2 – tab (13.28) value. This shows that the adoption of DT maize varieties affected the food security status of the respondents. The adoption of improved varieties of maize is one of the surest ways of increasing farming output thereby reducing the level of food insecurity among small-scale farmers. This is in view of the fact that yield is a direct measure of seed performance and that high-yield seeds have a high likelihood of being adopted by farmers.

Table 3. Results of chi-square test between the adoption of DT maize varieties and food insecurity among the farmers

Tabulated χ^2	Calculated χ^2	DF	Level of significance	Decision	Contingency coefficient
13.28	15.53	4	0.01	Significant	0.25

This means that there was an association between the adoption of DT maize by farmers and the food security status of the farmers. This is in agreement with the findings from an earlier study [12] where it was determined that DT maize adoption significantly improved the food security status among small scale farmers in Gwoza Local Government Area of Borno State, Nigeria. Furthermore, the chi-square value was converted to a contingency coefficient (C) so as to find out the extent to which adoption of DT maize was able to reduce the level of food insecurity among farmers in the study area. The result of the analysis revealed a contingency coefficient of 0.25. This suggests that a 1% level of adoption of DT maize varieties by the respondents can lead to a 0.25% reduction of food insecurity status. In other words, the introduction of DT maize into the communities has enhanced food security in those communities by at least 25%.

4. CONCLUSION AND RECOMMENDATION

From the findings of this study, it was concluded that the average land area devoted to DT maize production in the study area was 63.55%. This implies that most of the farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria are interested in adopting the DT maize varieties. It was also determined that most of the farmers in the Sudan Savanna

agro – ecological zone of northeastern Nigeria are small-scale farmers who mainly produce for subsistence. Furthermore, it was found that the adoption of DT maize varieties by the farmers in the Sudan Savanna agro-ecological zone of northeastern Nigeria significantly reduced the level of food insecurity among farmers in the area.

Based on the findings of this study, it was recommended that:

i. Farmers should be linked to market sources for their produce so as to enhance their incomes; and
ii. Extension services should be strengthened so as to give farmers access to improved technologies and better ways of managing their farms. This can also boost the educational status of the farmers through the provision of informal educational programmes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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