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Drought Tolerant Maize Adoption and its Determinants in West Africa

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Abstract

Drought tolerant maize (DTM) was developed to reduce farmers' food insecurity due to drought effect caused by climate change. This study examined the adoption of DTM variety among maize farmers in savannah area of West Africa. It described the socioeconomic characteristics of the adopters and non-adopters of DTM variety and analysed factors influencing the adoption of DTM using Logit model on cross-sectional data of 2343 farmers from Benin, Ghana, Mali and Nigeria. The results show that the study area experienced drought on an average of 3 years in a decade which affected 94 % (0.94) of the farm households. Awareness rate of DTM was low (37%), and currently only 15% adopted due majorly to non-availability of its seeds (64%). Running t-test on the differences in the socioeconomic variables between adopters and non-adopters suggested that adopters fared significantly better on variables considered; they had higher years of education, better contact with extension personnel, better access to credit, higher use of chemical fertilizer with more closeness to agro dealers; in addition, they had more small ruminants to access liquid cash in times of emergency with resultant significant higher maize yield over non-adopters. The decision to adopt DTM seeds, was positively and significantly influenced by awareness of DTM ($P < 0.01$), male as household head ($P < 0.01$), number of years of education of household head ($P < 0.01$), household size ($P < 0.05$), use of chemical fertilizer ($P < 0.01$), credit access ($P < 0.1$), and advice from extension agent ($P < 0.01$); while factors that negatively influenced adoption of DTM included maize farm size ($P < 0.05$) among others. The study concluded that DTM would likely be adopted if maize farmers are made aware of it since one of the preferred maize characteristics by household was DTM and in addition, availability of the its seeds would encourage farmers to plant.

Keywords: Drought Tolerant Maize; Awareness; Adoption; Logit Model

Introduction

Maize is the most important cereal food crop in Sub-Sahara Africa (SSA) with more than 50% of all countries assigning over 50% of their cereal crop production area to maize [1]. In Nigeria, for instance, maize is one of the two major crops that occupy about 40% of the land area under agricultural production, and accounts for about 43% of the maize grown in West Africa [2,3]. There is also growing utilization by food processing industries and livestock feed mills [4].

However, recurring droughts are a continuous challenge to the production of this important crop in Africa by drastically reducing yields and livelihoods [5,6]. It has been estimated that drought reduces global maize yields by as much as 15% annually, representing crop loss of more than 20 million tonnes of grain [7].

Drought is peculiar to the savannah region of sub-Saharan Africa; the region is a grassland ecosystem characterised by trees that are sufficiently widely spaced so that the canopy does not close [8]. Savannas are also characterised by seasonal water availability, with the majority of rainfall confined to one season. There are different types based on severity of sun and rainfall, first is the derived guinea savannah (DS) which is sun stressed with less water; followed by the guinea savannah which consists of northern guinea savannah (NGS) and southern guinea savannah (SGS), and the Sudan savannah (SS) which is the most stressed with water and sun (http://agriculturenigeria.com/research/introduction/agro-ecological-zone).

As part of a worldwide effort to curb these losses, scientists from two Consultative Group on International Agricultural Research (CGIAR) centers; International Maize and Wheat Improvement Center (CIMMYT) and International Institute of Tropical Agriculture (IITA) worked together with national partners in sub-Saharan Africa to develop drought tolerant maize varieties and so far several varieties have resulted from this work [8]. A project in Africa titled 'Drought Tolerant Maize for Africa (DTMA)' is helping in the development and promotion of drought tolerant maize (DTM) in Sub Sahara Africa, a region very vulnerable to climate change. Many farmers in the region are still yet to adopt these varieties and little is known about the determinants and constraints to adoption of the innovation in the face of a changing climate. The development, deployment, and cultivation of drought tolerant maize (DTM) varieties, therefore, have the potential of reducing vulnerability and food insecurity, and improving farmers' livelihoods. This project proposes to reach a greater number of poor farmers in specified countries (Benin, Ghana, Mali and Nigeria) in SSA with drought tolerance maize to reduce farmers' vulnerability, increase their food security, and improve their livelihoods in drought period as more than 35 million hectares of cultivated maize in Sub-Saharan Africa rely on the rain, thus making environmental shocks such as drought have major impact on smallholder farmers whose livelihoods depend on the crop (http://www.scidev.net/sub-saharan-africa/food-security/news/african-smallholders-stress-tolerant-maize.html) [9].

Methodology

The study area, sampling technique and data collection

The survey was conducted in areas with high levels of maize production in each country, and in regions where Bamire., *et al.* [5] stated to have drought probability risk of between 40 - 60%. The regions/states were purposefully selected based on the regions/states where DTM had been introduced earlier before the survey. Data was collected from 4 countries, 18 enumeration areas and 235 villages. Total number of respondents from different countries was 2343: 400 from Benin, 600 from Ghana, 397 from Mali and 946 from Nigeria. In Benin, the respondents were selected from four regions, with ten villages selected from each region and each region provided 100 respondents to make 400 respondents. In Mali, the 397 respondents were selected from 2 regions – Koulikoro and Sikassa, 300 respondents came from Koulikoro region, while 97 came from Sikassa region. In Ghana, 3 regions were selected, and in each region 200 respondents were chosen to make 600 in total. In Nigeria, 10 states were surveyed, each was to produce 100 respondents to make up a total of 1000 respondents from selected states; however, only 946 responses were suitable for the analysis.

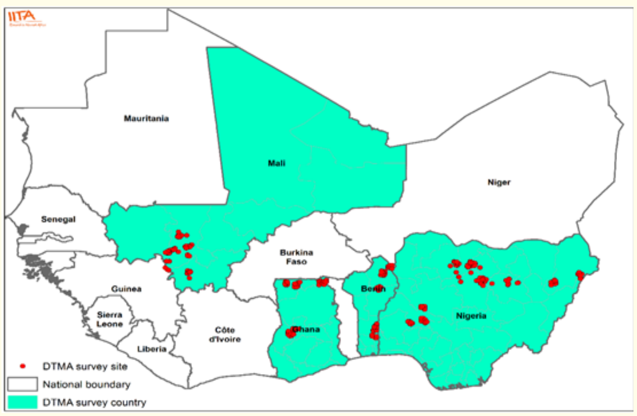

Figure 1: Map of the study areas.

Analytical techniques

Descriptive statistics such as mean, standard deviation and frequency distributions were computed and used for household characterization. In addition, Logit model was used to determine factors influencing adoption and non-adoption of drought tolerant maize varieties among maize farmers. The model is specified below.

Model specification - Logit model (LM)

LM is given in its estimable form as

$$LM = Ln\,(P_i\,/1-P_i) = Z_i = b_i + b\Sigma_k X_{ik} + \varepsilon \qquad (1)$$

Where: $Ln\,(P_i\,/1-P_i)$ = log odd ratio

P_i = probability that a household adopted or did not adopt DTM variety; it ranges from 0 to 1, and is non-linearly related to Z_i ;b_i = constant term/intercept; b_k = coefficients of explanatory variables; from X_{ik} , k= 1, 2, ……n , indicating number of independent variables X (with ith observation); ε = error term with zero mean' as Z_i ranges from -∞ to ∞, P_i ranges from 0 to 1; thus the dependent variable 'P' is 1 if adopted DT maize and is '0' if not adopted using maximum likelihood estimation method, X a vector of adoption's determinants is specified under 'empirical model below.

Empirical model – Logit model

The empirical model employed for the probability of adoption of drought tolerant maize varieties by maizes farmers was Logit model and is as stated below:

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 GENDER\_HHD + \beta_2 AGE\_HHD + \beta_3 SCHYRS\_HHD + \beta_4 HOUSEHOLD\_SIZE + \\ & \beta_5 SUFFICIENT\_INCOME + \beta_6 SMALL\_RUMINANTS + \beta_7 FERTILIZER + \beta_8 IRRIGATION \\ & + \beta_9 SELF-SUFFICIENT\_FOOD + \beta_{10} DISTANCE + \beta_{11} EXTENSION\_CONTACT + \beta_{12} CREDIT \\ & + \beta_{13} DROUGHT + \beta_{14} DROUGHT\_SQUARED + \beta_{15} AWARENESS + \beta_{16} SFARM + \beta_{17} NGS\_DUMMY \\ & + \beta_{18} SGS\_DUMMY + \beta_{19} SS\_DUMMY + \mu \end{aligned}$$

The dependent variable is the adoption status of drought tolerant maize (DTM) variety. The explanatory/independent variables included farmer, farm and institutional factors postulated to influence adoption of technologies and they are shown in Table 1. The variables included gender of household head (GENDER _HHD), age of the household head in years (AGE_HHD), years of education of the household head (SCHYRS_HHD), number of people in the household (HOUSEHOLD_SIZE), livestock ownership in form of small ruminants (SMALL RUMINANT) measured in number, access to credit (CREDIT), maize farm size of the respondents in hectare (S FARM) farm families income sufficiency throughout the year (SUFFICIENT_INCOME), number of month maize produced by farmer last for home (SELF-SUFFICIENT_FOOD), drought experience of the farmer (DROUGHT), income and regional dummies such as Northern Guinea Savannah (NGSDUMMY), awareness of DTM varieties by farmers (AWARENESS), farmer use of irrigation (IRRIGATION), distance to agro dealers (DISTANCE), Southern Guinea Savannah (SGS_DUMMY), and Sudan Savannah (SS_DUMMY) and Northern Guinea Savannah (NGS_DUMMY), use of fertilizer by farmer (FERTILIZER), and receive advice from extension agent (EXTENSION_CONTACT). The rationale for inclusion of these factors was based on previous agricultural technology adoption literature and the analysis of these systems.

Variable	Description of variables for maize farmers	Unit	Apriori signs
GENDER_HHD	Sex of maize farmer: 1 = male, 0 = female	Dummy	±
AGE_HHD	Age of the household head in years	Years	±
SCHYRS_HHD	Educated = 1, 0 = Otherwise	Dummy	+
HOUSEHOLD_SIZE	Family size of the house head	Number	±
SUFFICIENT_INCOME	Farmer has sufficient income = 1, otherwise = 0	Number	+
SMALL_RUMINANT	Ownership of small ruminant (goat,sheep)	Dummy	+
FERTILIZER	Use of fertilizer = 1, otherwise = 0	Dummy	+
IRRIGATION	Use of irrigation = 1, Otherwise = 0	Dummy	-
SELF-SUFFICIENT_FOOD	Number of month maize stocks lasted at home	Month	±
DISTANCE	Distance to the maize seed seller in minutes	Minutes	-
EXTENSION_CONTACT	Receive advice from extension agent = 1, otherwise = 0	Dummy	+
CREDIT	Access to credit = 1, Otherwise = 0	Dummy	+
DROUGHT	Years of drought	Dummy	+
DROUGHT_SQUARED	Square of year of drought		+
AWARENESS	Awareness of DTM = 1, Otherwise = 0	Dummy	+
SFARM	Farm size	Number	+
NGS_DUMMY	NGS = 1, SS, SGS and DS = 0	Dummy	±
SGS_DUMMY	SGS = 1, SS, NGS and DS = 0	Dummy	±
SS_DUMMY	SS = 1, NGS and DS = 0	Dummy	±

Table 1: Description of key variables on DTM adoption.

Results and Discussion

The result on the socio-economic characteristics of the sampled households in Benin, Ghana, Mali and Nigeria are presented in section 1; information on varietal yield across the countries is presented in section 2; awareness and other information on DTM variety is discussed in section 3; information about maize and its preferred characteristics that farmers wanted are discussed in section 4. Finally, an econometric result of the determinants of adoption of maize seed is presented in section 5.

Socio-economic characteristics of respondents

Data analysis was segregated into groups: first is the 'Pooled' representing all data from countries (Benin, Ghana, Mali, and Nigeria) and savannahs (DS, SGS, NGS and SS) under study and secondly into countries in Table 2 and into savannahs in appendix 1. Running t-test in Table 3 on the differences in the socioeconomic variables between adopters and non-adopters suggests that adopters differ significantly in some proxies of human, social and physical capital and this might affect determinants of adoption of DTM in the counties and savannahs under study. In the pooled data, the differences favour adopters of DTM in terms of gender which was mainly male headed type ($P < 0.01$), better education level ($P < 0.01$), higher years of education ($P < 0.01$), better ownership of small ruminants ($P < 0.05$), better use of chemical fertilizer ($P < 0.01$), more self-sufficiency in maize grain ($P < 0.05$), better contact to extension agents on new technologies ($P < 0.01$), better access to credit ($P < 0.05$), and higher maize yield from the farm ($P < 0.01$). Less than 10% in both groups have access to irrigation; more than 90% experience drought with a minimum of about 3 years of their experience within the last 10 year; this confirmed that the study area was drought prone.

The fact that the area cultivated to maize was statistically greater for NDTM ($P < 0.01$), but its yield being statistically lower ($P < 0.01$) than DTM varieties showed that DTM was superior to NDTM in a drought prone area. Variations across countries are shown in Table 2.

Variable	Pooled				Benin			Ghana				Mali			Nigeria		
	All	DTM	NDTM	t-value	DTM	NDTM	t-value	DTM	NDTM	t-value	t>|P|	DTM	NDTM	t-value	DTM	NDTM	t-value
Gender (Male = 1, Female = 0)	0.15	0.39	0.12	10.15***	0.00	0.01	-2.248**	0.11	0.08	0.950	0.344	0.02	0.01	0.653	0.66	0.25	10.909***
Age	47.84	46.79	48.03	-1.63*	47.00	45.01	0.747	49.36	49.82	-0.295	0.769	55.45	55.44	0.005	43.02	45.07	-2.173**
Schooling years	4.96	7.76	4.45	10.15***	4.18	3.24	0.830	6.92	3.04	6.108***	0.000	4.65	1.98	2.330**	9.04	7.84	3.077***
Literacy (Educated = 1, Non-Educated = 0)	0.45	0.67	0.41	9.66***	0.55	0.39	1.003	0.64	0.31	6.017***	0.000	0.23	0.16	1.215	0.83	0.60	7.063***
Household size	10.88	10.44	10.96	-1.32	13.18	12.68	0.269	9.78	11.04	-1.713*	0.089	7.94	7.92	0.024	11.35	11.40	-0.092
Poultry ownership	0.62		0.62	-1.84*	0.91	0.63	2.993**	0.85	0.81	0.970	0.334	0.00	0.00		0.59	0.78	-4.905***
Ruminant ownership (small)	0.75	0.79	0.75	2.05**	0.64	0.56	0.509	0.78	0.78	-0.036	0.971	0.75	0.67	1.378	0.82	0.85	-1.013
Fertilizer usage	0.79	0.90	0.77	6.65***	0.82	0.71	0.855	0.98	0.95	1.392	0.166	0.56	0.58	-0.293	0.96	0.77	9.585***
Irrigation usage	0.08	0.07	0.08	-0.83	0.09	0.06	0.375	0.00	0.01	-2.662***	0.008	0.05	0.06	-0.253	0.11	0.15	-1.720*
Self-sufficiency in maize (Yes = 1)	0.50	0.55	0.49	2.12**	0.91	0.77	1.504	0.00	0.00			0.16	0.27	-2.125**	0.92	0.78	5.319***
Running out of maize (Months)	2.62	2.20	2.56	-1.99**	0.55	1.24	-1.241	4.44	4.64	-0.762	0.448	4.55	3.80	1.316	0.52	1.27	-4.579***
Distance to agro-dealers minutes)	36.10	29.53	37.29	-3.85***	13.18	22.54	-3.603***	35.91	51.41	-3.518***	0.001	31.35	36.74	-0.708	26.79	35.03	-3.682***
Extension contact	0.46	0.64	0.47	5.95***	0.73	0.43	2.047*	0.85	0.53	7.262***	0.000	0.52	0.46	0.766	0.56	0.45	2.740
Credit access	0.38	0.44	0.37	2.25**	0.64	0.48	1.009	0.57	0.31	4.584***	0.000	0.42	0.37	0.545	0.37	0.36	0.251
Years of drought	3.35	3.19	3.39	-1.52	4.73	3.60	1.671	2.97	2.98	-0.081	0.935	4.11	4.27	-.221	2.98	3.20	-1.773*
Affected by drought	0.94	0.93	0.94	-0.35	1.00	0.98	2.854***	1.00	0.99	1.735*	0.083	0.77	0.83	-1.013	0.95	0.93	0.957
Area cultivated (Ha)	2.67	2.06	2.77	-5.36***	5.12	4.46	0.359	2.45	2.26	0.948	0.345	2.04	1.80	0.676	1.71	2.68	-6.792***
Maize yield (Kg/Ha)	1487.64	1682.93	1453.48	2.58***	1281.67	1423.93	-0.625	1354.09	1156.61	2.077**	0.040	1275.40	1149.61	.448	1975.80	1802.25	1.300

Table 2: Difference in Socio-economic characteristics of adopters and Non-Adopters (sample means) of drought tolerant maize variety.

NB: *, **, *** = the estimate is significant @ 10 percent, 5 percent and 1 percent respectively. Data are not available for empty cells.

Varietal yield across the countries

By considering yield across countries in Table 2, it was only in Ghana that yield from DTM was significantly higher ($P < 0.05$) than that of NDTM – non drought tolerant maize; while across savannahs in appendix 1, it was only in Northern Guinea savannah that yield from DTM was significantly higher ($P < 0.01$) than that of NDTM. In Table 3, the NDTM was disaggregated into other improved varieties and local variety and compared with DTM variety on yield output basis. The ANOVA result in table 3 showed that DTM variety had the highest yield among the 3 categories of maize varieties and that the result was statistically significant ($P < 0.05$). The LSD in table 4 confirmed that yield difference between DTM and other varietal groups was greater than other improved ones at 5% level of probability, while it was 1% level of significance over local variety. Across countries, the significance was only in Ghana ($P < 0.01$) and Nigeria ($P < 0.10$).

Variables	POOLED				DS				SGS				NGS				SS			
	DTM	NDTM	t-value	t>|P|	DTM	NDTM	t-val-ue	t>|P|	DTM	NDTM	t-value	t>|P|	DTM	NDTM	t-value	t>|P|	DTM	NDTM	t-value	t>|P|
Gender	0.39	0.12	10.15	0.00	0.13	0.06	1.49	0.14	0.00	0.03	-3.51	0.00	0.92	0.21	22.09	0.00	0.03	0.14	-5.19	0.00
Age	46.79	48.03	-1.63	0.1	48.36	50.16	-0.99	0.33	50.56	48.44	0.76	0.45	43.82	48.65	-3.98	0.00	48.39	47.01	1.01	0.32
Schooling Years	7.76	4.45	10.15	0.00	9.53	5.77	5.59	0.00	3.16	4.12	-1.08	0.29	9	5.15	7.73	0.00	6.15	3.99	3.48	0.00
EDU	0.67	0.41	9.66	0.00	0.87	0.47	7.35	0.00	0.34	0.39	-0.53	0.6	0.85	0.52	8.25	0.00	0.45	0.35	2.09	0.04
HH Members	10.44	10.96	-1.32	0.19	6.87	8.53	-3.42	0.00	14.01	10.08	2.94	0.01	9.98	9.53	0.72	0.47	11.83	12.61	-1.09	0.28
Cattle, Donkey, Horses	0.57	0.59	-0.59	0.56	0.1	0.08	0.43	0.67	0.77	0.63	1.82	0.08	0.5	0.47	0.62	0.53	0.84	0.76	2.21	0.03
Poultry	0.57	0.62	-1.84	0.07	0.82	0.78	0.67	0.5	0.78	0.59	2.47	0.02	0.47	0.37	2.12	0.04	0.5	0.7	-4.09	0.00
Goats, sheep	0.79	0.75	2.05	0.04	0.75	0.72	0.55	0.58	0.69	0.64	0.57	0.57	0.82	0.62	4.66	0.00	0.82	0.85	-0.96	0.34
Livestock	0.91	0.91	-0.07	0.95	0.84	0.9	-1.3	0.2	0.97	0.93	1.28	0.21	0.9	0.75	4.3	0.00	0.94	0.97	-1.12	0.27
CHEM Fertilizer	0.9	0.77	6.65	0.00	0.97	0.58	9.98	0.00	0.94	0.85	1.79	0.08	0.94	0.63	9.71	0.00	0.8	0.84	-1.07	0.28
Irrigation	0.07	0.08	-0.83	0.41	0.00	0.04	-3.22	0.00	0.03	0.07	-1.03	0.31	0.07	0.05	0.93	0.35	0.11	0.11	-0.12	0.91
Self sufficiency	0.55	0.49	2.12	0.04	0.02	0.33	-9.24	0.00	0.28	0.39	-1.31	0.2	0.95	0.67	9.06	0.00	0.45	0.52	-1.45	0.15
Running Out of Maize	2.2	2.56	-1.99	0.05	4.79	3.84	2.38	0.02	3.16	2.72	0.91	0.37	0.3	1.78	-7.16	0.00	2.79	2.43	1.08	0.28
DIST. to place to buy maize	29.53	37.29	-3.85	0.00	26.7	41.11	-3.46	0.00	38.6	45.15	-0.76	0.45	24.63	30.24	-2.47	0.01	33.79	35.4	-0.41	0.69
RCV ADV on new VAR of MZ SD (Extension agent)	0.64	0.47	5.95	0.00	0.82	0.54	4.78	0.00	0.81	0.44	4.87	0.00	0.6	0.38	4.32	0.00	0.53	0.49	0.75	0.45
Credit	0.44	0.37	2.25	0.03	0.59	0.45	1.96	0.05	0.55	0.47	0.86	0.4	0.46	0.37	1.85	0.07	0.29	0.31	-0.49	0.62
AFF NEG by drought (years)	3.19	3.39	-1.52	0.13	2.85	3.36	-2.52	0.01	3.62	3.06	1.71	0.1	3.27	3.7	-2.68	0.01	3.16	3.42	-0.8	0.43
Drought1/0	0.93	0.94	-0.35	0.73	0.98	0.92	2.62	0.01	0.91	0.9	0.14	0.89	0.96	0.94	1.06	0.29	0.88	0.96	-2.62	0.01
QTY MZ SD	30.23	41.84	-4.01	0.00	28.05	26.36	0.2	0.84	76.55		1.91	0.06	20.85	36.91	-5.38	0.00	30.08	48.05	-4.51	0.00
COMB. Area	2.06	2.77	-5.36	0.00	2.21	2.3	-0.43	0.66	3.86	3.01	1.72	0.09	1.36	1.92	-4.54	0.00	2.31	3.12	-2.87	0.00
COMB. Yield	1682.93	1453.48	2.58	0.01	1490.97	1432.07	0.35	0.73	1008.58	1267.5	-2.25	0.03	2208.09	1512.96	3.43	0.00	1349.67	1525.45	-2.45	0.02

Appendix 1: Socioeconomic characteristics of farmers across savannahs.

NB: DTM= Drought Tolerant Maize; NDTM= Non- Drought Tolerant Maize. DS=Derieved Savannah; SGS=Southern Guinea Savannah; NGS=Northern Guinea Savannah and SS=Sudan Savannah;Data are not available for empty cells

Variable	Pooled	Benin	Ghana	Mali	Nigeria
DTM	1682.93	1281.66	1354.09	1275.40	1975.79
IMV	1502.10	1467.30	1243.78	1217.60	1857.90
LV	1454.23	1285.96	1016.96	1045.29	1755.06
F-Value	0.000	0.953	6.119	0.637	1.371
P>|F|	0.032	0.387	0.002	0.53	0.254

Table 3: ANOVA analysis showing average yield of maize from different varietal groups.

NB: Drought Tolerant Maize (DTM), Improved Maize Variety (IMV), Local Variety (LV)

Variable		Pooled	Benin	Ghana	Mali	Nigeria
Maize Type (I)	Maize Type (J)	Mean Difference (I-J)	Mean Difference (I-J)	Mean Difference (I-J)	Mean Difference (I-J)	Mean Difference (I-J)
DTM	IMV	180.82** (0.032)	-185.64 (0.606)	110.31 (0.270)	57.80 (0.79)	117.90 (0.40)
	LV	228.70*** (0.010)	-4.30 (0.991)	337.12951*** (0.001)	230.11 (0.339)	220.73* (0.10)

Table 4: LSD on the yield mean differences of different maize varietal groups.

NB: Least Significant Different=LSD; *, **, *** = the estimate is significant @ 10 percent, 5 percent and 1 percent respectively

Awareness and other information on DTM variety

Table 5 revealed that on the average only 37% of the respondents had a good knowledge of DTM while 15% were using DTM on the average at the time of the survey. The percentage varied across countries under study.

Variables	Pooled	Benin	Ghana	Mali	Nigeria
Awareness	37	39	32	48	35
Ever adopted	24	32	13	13	31
Adoption	15	3	15	14	20
Sources of awareness					
Extension Agents	43.4	35.1	49.5	10.3	61.4
Farmer field day	4.5	0.00	13.7	0.00	2.6
Cooperative	1.8	0.00	1.1	14.4	1.3
Other farmers	29.7	60	21	33.9	23.1
Media	13.3	1	10.5	33.4	7.8
Agro dealer	0.7	0.00	1.1	0.00	2.7
Other	2.6	4.1	3.2	0.00	1.3

Table 5: Awareness and its related information %.

Sources of information on awareness included among others extension agents (43.4%), other farmers (29.7%) and media (13.3%). Reasons for non-adoption of drought tolerant maize in Table 6 included non-availability of DTM variety in the farmers' vicinity (64%) and inadequate capital to acquire it (11%) among others. There is the need for awareness creation among the farmers to understand what DTM stands for and the benefits that can be accrued through adopting it.

Variables	Pooled	Benin	Ghana	Mali	Nigeria
Seed unavailable locally	64.0	80.9	69.8	NA	50.4
Lack of money to buy the seed	11.0	4.3	15.4	NA	8.3
Satisfied with the varieties on ground	7.9	2.1	2.7	NA	16.5
Not interested in new varieties	2.8	2.1	2.7	NA	3.3
Too Risky	2.5	4.3	1.3	NA	3.3
No demonstrations to show its superiority	8.2	6.4	7.4	NA	9.9
Others	3.5	0.0	0.7	NA	8.3

Table 6: Reason for non-adopting DTM variety %.

Source: Field Survey, 2013/2014; NA, 'Not Applicable' information

Maize characteristics and information

Preferred characteristics from maize were assessed. Table 7 throws light on this; the characteristics that were mainly preferred in maize by maize farmers based on ranking was high yield (64.4%), early maturity (24.6%), food taste/quality (21.2%) and drought tolerance (11.1%) among others; drought tolerant maize was ranked fourth. Since one of the preferred characteristics was drought tolerant, it meant that DTM would be adopted if maize farmers were aware of it and it was available to farmers. Appendix 2 throws light on disaggregation based on maize variety and savannah types.

Variable	Pooled	Benin	Ghana	Mali	Nigeria
Grain yield	64.4	77.2	67.3	56.7	60.3
Early maturity	24.6	31.3	17.2	35.7	21.9
Food taste and quality	21.2	23.8	0.0	33.1	28.5
Drought tolerance	11.1	9.5	9.9	14.2	11.3
Marketability	9.0	2.8	9.3	1.6	14.4
Grain colour	6.6	3.0	6.4	3.4	9.6
Flour-to-grain ratio	6.4	20.3	2.0	10.0	1.9
Cob per plant	5.5	8.0	5.4	2.6	5.7
Field pest and disease resistance	5.2	7.8	2.2	5.5	5.7

Table 7: Major maize characteristics that interest maize farmers by countries %**.

Source: Field Survey, 2013/2014 NB: ** a case of multiple responses

Variable	Pooled	DTM	NDTM	DS	SGS	NGS	SS
Grain yield	64.4	66.2	64.1	62.4	67.4	61.9	64.8
Grain and cob size	42.2	43.3	42.0	47.3	48.1	41.3	38.3
Early maturity	24.6	31.2	23.4	16.1	28.8	31.7	21.8
Food taste and quality	21.2	14.7	22.2	13.5	14.3	22.2	26.1
Drought tolerance	11.1	24.4	8.8	11.3	7.1	20.6	8.3
Marketability	9.0	5.6	9.6	11.9	17.4	3.8	6.7
Grain color	6.6	2.4	7.4	8.4	4.4	4.0	8.4
Flour-to-grain ratio	6.4	2.1	7.2	0.6	5.5	6.6	8.5
Cob per plant	5.5	2.9	6.0	5.5	4.4	7.0	5.3
Field pest and disease resistance	5.2	8.0	4.6	1.9	1.2	7.4	6.7

Appendix 2: Maize characteristics preferences by varietal types and savannahs.

NB: DTM: Drought Tolerant Maize; NDTM: Non- Drought Tolerant Maize ;DS=Derieved Savannah; SGS=Southern Guinea Savannah; NGS=Northern Guinea Savannah and SS=Sudan Savannah

Determinants of adoption

The result of analysis using Logit model to determine factors influencing adoption of DTM varieties is shown in Tables 8. The dependent variable was the adoption (dummy value = 1) or non-adoption (dummy value = 0) of DTM varieties by maize farmers. The Logit model estimation gave a Pseudo R^2 of 0.2499 (Table 8) which implied that the variables included in the model were able to explain roughly about 25% of the probability of farm households' decision to adopt or not to adopt DTM variety. The Log-likelihood Ratio (LR) and the Chi^2 were also found to be significant at the 1% level. This means that all the explanatory variables included in the model jointly influence farmers' probability of adoption of the variety. Given the foregoing goodness of fit measures, it is concluded that the Logit model employed had integrity and hence was appropriate.

Variables	COEF.	STD. ERR.	Z	P>|Z|	DY/DX
GENDER_HHD	1.175	0.221	5.310***	0.000	0.140
AGE_HHD	-0.001	0.007	-0.090	0.928	-0.0001
SCHYRS_HHD	0.087	0.017	5.090***	0.000	0.008
HOUSEHOLD_SIZE	0.031	0.014	2.300**	0.022	0.003
SUFFICIENT_INCOME	0.034	0.187	0.180	0.856	0.003
SMALL_RUMINANTS	0.071	0.204	0.350	0.728	0.006
FERTILIZER	0.782	0.286	2.730***	0.006	0.057
IRRIGATION	0.034	0.325	0.100	0.917	0.003
SELF-SUFFICIENT_FOOD	-0.241	0.223	-1.080	0.280	-0.021
DISTANCE	-0.004	0.003	-1.260	0.208	-0.0003
EXTENSION_CONTACT	0.588	0.171	3.440***	0.001	0.053
CREDIT	0.282	0.166	1.700*	0.090	0.026
DROUGHT	-0.038	0.168	-0.220	0.822	-0.003
DROUGHT_SQUARED	-0.005	0.020	-0.270	0.790	-0.0005
AWARENESS	1.219	0.169	7.210***	0.000	0.124
SFARM	-0.079	0.040	-1.980**	0.048	-0.007
NGS_DUMMY	-0.294	0.294	-1.000	0.318	-0.024
SGS_DUMMY	-0.844	0.291	-2.900***	0.004	-0.062
SS_DUMMY	-1.311	0.266	-4.940***	0.000	-0.112
Constant	-3.278	0.623	-5.260***	0.000	
Test Statistic					
Log likelihood	-525.716				
LR chi^2	350.24				
Prob > chi^2	0.0000				
Pseudo R^2	0.2499				

Table 8: Determinants of adoption of DTMA.

NB: *, **, *** = the estimate is significant @ 10 percent, 5 percent and 1 percent respectively. Source: Field Survey, 2013/2014

Results showed that some factors were significant at 1%, 5% and 10% respectively. The decision to adopt DTM seeds was positively and significantly influenced by gender of the household head (GENDER_HHD), number of years of education of household head (SCHYRS_HHD), household size (HSIZE), use of chemical fertilizer (FERTILIZER), credit access (CREDIT), contact with extension agent (EXTENSION_CONTACT), and awareness on DTM (AWARENESS); while factors that negatively influenced adoption of DTM included maize farm size (SFARM) and agro ecological locations of the responding farm families (SGS and SS).

The gender of farmers showed that men farmers were more prone to adopting DTM than their women counterparts (P < 0.01), this might be due to resources ownership criterion with men more empowered than women. This is in support of several authors that posited that males have more access to, and control of resources such as land, labour and capital which are critical for the adoption of new technologies [10-14] and in addition according to Mamudu., *et al.* [14], males make production decisions. Male farmers therefore might likely have more access to different maize varieties, and as a result make choices favouring DTM variety. Number of years of education of an household head led to higher adoption of the technology (P < 0.10), a unit in the years of education of an household increased the probability of using DTM seeds by 0.8 percent. This is supported by Mamudu., *et al.* [14] who found out that education had a positive relationship with the probability of adoption and was significant at 1% in the work titled 'Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions?' The implication of this is that farm household heads with well-educated members are more likely to adopt modern agricultural production technologies than those without it. This is consistent with the literature that education creates a favourable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices [15,16].

Contact of farmers with extension personnel was positive and significant to adoption decision of DTM (P < 0.01), it increased probability of DTM's adoption by 5.3%; this is in line with many authors who are of the opinion that contact with extension agents is expected to have a positive effect on adoption based on the innovation-diffusion theory. Such contacts, by exposing farmers to availability of information can be expected to stimulate adoption by reducing the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time thereby facilitating adoption [14,17-22]. According to Yaron., *et al.* [23], extension contact can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies therefore creating the platform for acquisition of the relevant information that promotes technology adoption. Access to credit was found to have a positive relationship with the probability of adoption. This was found to be significant at the 10% probability level. This means that credit is an important facilitating factor of DTM varietal adoption. This is consistent with the view that high poverty levels among farmers and lack of access to credit make it almost impossible for them to afford technologies [14,24,25], the access has the probability of enabling farmers to acquire credit and utilize it for technology adoption; in this study, use of credit increased probability of adoption by 2.6%.

Access and use of fertilizer facilitated probability of adoption of DTM variety positively and significantly (P < 0.01). Butzer., *et al.* [26] used a choice of technique framework to characterize the decision to adopt HYVs maize in India and found that maize required use of fertilizer to realize its yield potential. In addition, its introduction corresponded with a large jump in the demand for fertilizer. McGuirk and Mundlak [27] also used a choice of technique framework in a study of the transformation of Punjab agriculture during the Green Revolution and found that the short period of transition from the use of traditional varieties to the adoption of HYVs was largely determined by the availability of fertilizer among others; this was confirmed by Chadha [28] who reported that use of fertilizer increased adoption of DTM variety by 5.7%.

Household size was positively and significantly related to adoption (P < 0.05). According to Simonyan., *et al.* [29] and Ezeh., *et al.* [30], an increase in family size implies an increase in family labour. The additional labour can be channelled into production of different maize varieties; hence, family size could have a positive influence on the decision to choose between different maize varieties. This paper showed that a unit increase in household size increased probability of adoption by 0.3%.

Awareness of DTM variety was significant at 1% probability level and it increased probability of adoption by 12.4%. According to past literature, awareness promotes demand and demand is a force for rapid adoption and spread of agricultural innovations [31,32]. In addition, Diagne and Demont [33] also stated that awareness is an important precondition for adoption to occur. Farm size (SFARM) was negatively and significantly (P < 0.05) related to adoption decision on DTM variety. Based on literature, the effect of farm size on adoption could be positive, negative or neutral. For instance, McNamara., *et al.* [34]; Abara and Singh [35]; Feder., *et al.* [36]; Fernandez-Cornejo [37] and Kasenge [38] found farm size to be positively related to adoption. On the other hand, Yaron., *et al.* [23] and Harper., *et al.* [39] found a negative relationship between adoption and farm size. Interestingly, Mugisa-Mutetikka., *et al.* [40] found that the relationship between farm size and adoption is a neutral one. In this paper, it was revealed that farm families with small farm sizes for maize, adopted DTM than those with larger farms, and a unit decrease in farm size had the probability of increasing adoption of DTM variety by 0.7%; this might be because small farm size farmers did not wish to risk planting other varieties of maize as a result of drought than those that are drought resistant (DTM). In consideration of ecological location and based on the result in table 8, moving to Derived Savannah from Sudan Savannah (SS_DUMMY) would lead to higher adoption of DTM (P < 0.01) by farmers compared to being in SS; this increased adoption by 11.2%. In the same vein, moving to Derived Savannah from Southern Guinea Savannah (SGS_DUMMY) would lead to higher adoption of DTM (P < 0.01) by farmers compared to being in SGS; this increased adoption by 6.2%. According to Prince., *et al.* [41], farmers in different agro ecologies would probably have to adopt different adaptation technologies in response to climate change and variability. Mensah-Bonsu., *et al.* [42] reported a positive and significant relationship between agro ecology and a farmer's uptake of improved technologies. Morris., *et al.* [43] also observed that the level of adoption of improved technologies varied across agro ecologies, opining that improved technologies may be better suited in some agro ecologies than others.

Conclusion

Simple comparison of the adopters and non-adopters of drought tolerant maize (DTM) groups of farmers suggests that adopters differ significantly in some proxies of human, social and physical capital and this might affect determinants of adoption of DTM in the countries and savannah areas under study. By using ANOVA test to compare yield of DTM, other improved varieties and local variety, the result shows that DTM variety had better yield as attested by LSD at 1% level of significant over local variety and at 5% level of significant over other improved varieties in the study areas.

Awareness of DTM was 37% and only 15% of farmers were currently using it; this is low, but varied across countries. There is therefore the need for awareness creation among the farmers to understand what DTM stands for and the benefits that can be accrued through adopting it. Sixty four percent (64%) of the respondents claimed that non-availability of DTM variety was the main reason for not planting it. One of the preferred characteristics by maize farmers was 'drought tolerance' (11.1 %), it means that DTM would likely be adopted if maize farmers are made aware of it and if it is made available to farmers.

The decision to adopt DTM seeds based on the result from Logit model analysis was positively and significantly influenced by gender of the household head, number of years of education of household head, household size, use of chemical fertilizer, credit access, contact with extension agents, agro-ecological location and awareness of DTM. The significance of 'awareness' variable further confirmed result of the descriptive statistics, thus call for awareness creation among farmers is recommended.

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Volume 2 Issue 1 January 2018