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Factors influencing adoption of improved maize seed varieties among smallholder farmers in Kaduna State, Nigeria

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This study ascertained factors influencing adoption of improved maize seed varieties in three local government areas of Kaduna State, North-central Nigeria. It collected cross-sectional data for a sample of 180 randomly selected farming households across three local government areas of the State in 2015/16. Both descriptive and inferential analyses were performed on the data. The descriptive statistics differentiated adopters from non-adopters, while the inferential analysis involved estimation of a logit model to determine factors driving adoption of improved maize seed varieties in the study areas. The results of the descriptive analysis show significant mean differences between adopters and non-adopters regarding several farm households' characteristics. The model results reveal that adoption of improved maize seed varieties among the households was positively influenced by age, household size, level of education, farming experience, labour availability, contacts with extension agents, farm size, off-farm income and membership of associations. Thus, the study concluded that improving farmers' education, expanding coverage and depth of extension services and strengthening farmer associations are useful policy actions for promoting adoption of improved maize varieties. It is also important to address availability, accessibility and affordability issues constraining adoption, enhance credit access and mitigate risk perceptions. The link between researchers and innovators and the farmers who are the off-takers of their outputs should be reinforced to increase maize productivity in order to satisfy national demand and promote food security.

Key words: Adoption, determinants, Kaduna State, smallholder farmers, maize.

INTRODUCTION

Maize is a staple food crop in Nigeria widely grown across agro-ecological zones as both subsistence crop and commercially, as raw materials for agro-based industries (Iken and Amusa, 2004). Maize production in Nigeria was estimated at 10.5 million tonnes in 2016/2017 (FAO, 2017). While consumption matched production in that cropping season, up to 200,000 tonnes were exported to Chad, Cameroon, Benin and Niger (as obtained from the Grain and Feed Annual Report of the United States Department of Agriculture, Foreign Agricultural Service, 2017). Nigeria is currently implementing an Anchor Borrowers Programme in many maize-growing states in Northern Nigeria, designed to link anchor companies engaged in processing activities

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with small holder farmers.

This has the prospect of raising domestic production and minimizing importation of maize by processing companies and the poultry industry. Maize yield has fluctuated historically, and especially in recent years, but stood at 15,850 hg per ha in 2014.

The adoption of new technology in the form of improved seed varieties has been shown to increase productivity and reduce poverty especially in rural communities (Becerril and Abdulai, 2010; World Bank, 2008). Indeed, rapid diffusion of improved maize varieties, which expands maize yield per unit of land, can profoundly improve livelihoods (Elkhalil et al., 2013). The poverty reducing effect of new technologies can be direct or indirect (Becerril and Abdulahi, 2010; Moyo et al., 2007). Directly, it fosters productivity and lowers cost and raise income of adopters and indirectly, it boosts supply and reduces prices of food. Similarly, adoption of improved agricultural technology facilitates food security and enhances welfare (Langyintuo et al., 2008; Mendola, 2007).

There is a plethora of reasons why farmers might not adopt improved seeds including negative attitudes, insufficient know-how, absence of information or awareness of the benefits of such technologies and inclement agro-ecological conditions (Suhane et al., 2008). Farmers would be confident to adopt improved seed varieties when they have positive perceptions of them (Rogers, 2003; Sall et al., 2000). Similarly, farmers would be inclined to adopt improved seeds where they have sufficient and informed knowledge about them (Chilonda and Van Huylenbroeck, 2001). Farmers also consider the marginal benefits in terms of earnings from adopting a new technology relative to the accompanying risks (Doss, 2003). According to Uaiene et al. (2009) and Becerril and Abdulai (2010), adoption decisions rest on risk, uncertainty, input rationing, information imperfection, human capital and social networks. Deep-seated traditional beliefs and customary practices may impede adoption of new technology in certain societies (Meinzen et al., 2004). Specific interventions to stimulate adoption of new technologies typically include subsidizing inputs costs including fertiliser and improved seeds and augmenting product prices (Nkonya et al., 2004).

The adoption of new technology is influenced by a broad range of factors such as social, economic, institutional, environmental and attitudinal factors (Neupane et al., 2002; Rogers, 2003). Young farmers would likely be more receptive to fresh ideas and novel production processes compared to older farmers who are firmly rooted in orthodox practices. Education provides basic knowledge and understanding of technical details which could promote adoption (Kafle and Shah, 2012). The male gender and married household heads are predisposed to embracing improved technologies since women often have less access to such technologies (Namwata et al., 2010; Wekesa et al., 2003). Family size matters for supplying incremental labour if the new crop variety requires more hands to cultivate or harvest as a result of higher yield (Abadi et al., 2015; Ojiako et al., 2007). If adoption of new varieties requires more labour inputs, large families provide the labour required for improved maize production practices. Substantial farm income including off-farm income can stimulate procurement or investment in new technologies (Ghazdani, 2013). Lack of access to credit may constrain the adoption of improved maize seeds. Where farmers are unable to put aside enough savings from on-farm and off-farm income, access to credit from social associations or institutional sources will empower them to adopt new maize varieties (Okuthe et al., 2013). Farmers who are exposed to extension information incorporating messages and practical sessions on improved seeds varieties are likely to adopt them (Kakle and Shah, 2012; Adeola, 2010). Similarly, farmers with market access that guarantees higher prices and superior profits for the new technology will be encouraged to adopt them (Bonabana, 2002; Nguthi, 2007). There is also a role for agro-ecological conditions as farmers operating in regions with high rainfall are prone to adopting improved maize varieties (Kaliba et al., 2000; Hintze et al., 2003). Adoption rates are also influenced by cost outlay on improved seeds, availability and knowledge about them (Sugri et al., 2013).

There have been aggressive efforts to develop high-yielding, disease and drought-resistant seed varieties by universities, research institutes and private organizations in Nigeria; however, adoption rates remain abysmal, estimated at 5% compared to 25% for East Africa and 60% for Asia (according to former National Project Coordinator of the West Africa Productivity Programme, (WAAPP), at a workshop on Seed Production Planning in Minna, Niger State in March, 2014). The consequences of the low adoption of improved varieties are low yields and increased hunger. In response, the government established community-based seed producers to facilitate access to improved seeds by smallholder farmers and also inaugurated private seed firms to supply certified maize and other crop seeds to farmers.

Maize cultivation is a way of life in Igabi, Birnin Gwari and Kubau Local Government Areas of Kaduna State in Northern Nigeria, grown mainly under rain-fed conditions, predominantly for human consumption. However, dearth of quality seed at the right price and preferred quantities constrains production. Moreover, heavy dependence on own-farm saved seeds from year to year, coupled with declining soil fertility also diminishes maize yields (Gurung, 2011). This study is motivated by the need to gather systematic information on the adoption of improved maize varieties among smallholder farmers in these local government areas and to locate the factors hindering or promoting their adoption. This understanding would enhance the adoption of improved maize varieties, raise farm productivity and incomes and generally impact

on livelihoods in the area.

MATERIALS AND METHODS

Description of the study area

Kaduna State on coordinates 10°20′N, 7°45′E is located in Northern Nigeria. The vegetation cover is Sudan Savannah type, characterized by scattered short trees, shrubs and grasses. The dominant soil type is loamy and sandy soil with some clay soil as well. It occupies an area of 46,053 km^2 (17,781 sq mi) with a population of 6,113,503 (2016 census). Igabi local Government Area (LGA) with geographical coordinates 10°47′0″N, 7°46′0″E occupies an area of 3,727 km^2 and has a projected population from Nigeria's 1991 census of 581,500 in 2016. Birnin Gwari LGA with headquarters in Birnin Gwari is on coordinates 10° 40′0″N, 6°33′0″E, occupies an area of 6,185 km^2 and has a projected population from Nigeria's 1991 census of 349,000 in 2016. Kubau LGA with headquarters in Anchau is on coordinates 10° 47′0″N, 8°11′0″E occupies an area of 2,505 km^2 and has a projected population from the Nigeria's 1991 census of 378,900 in 2016.

Sampling procedure

The household was the sampling unit, and 180 farming households comprising male-headed (34.7%) and female headed (65.3%) were selected across the three local government areas of *Igabi, Birnin Gwari* and *Kubau* in Kaduna State. The three Local Government Areas (LGAs) were purposively chosen because of high-intensity maize production in these areas. Adopters and non-adopters of improved maize seeds were selected through a multistage sampling procedure. Given the heterogeneity of the population, stratified sampling design was used to create strata which were obtained from respective LGAs. Finally, simple random sampling was used to select a total of 180 households in proportion to the population size of the LGAs. Quantitative and qualitative approaches were employed in collecting data for this study. These involved administering structured questionnaires on the households and conducting key informant interviews with agricultural officers at the LGAs. The data gathered were analyzed by generating descriptive statistics while inferential analysis was accomplished using a binary logistic regression model to ascertain the effects of the various covariates on the probability of farmers adopting improved maize seeds in the study areas. The logit model and the relevant variables are as follows:

$$\frac{P_i}{(1-P_i)} = \frac{1+\exp(Z_i)}{1+\exp(-Z_i)} \quad (1)$$

The logit model can be linearized by taking the natural log as follows:

$$Li = ln\left[\frac{P_i}{(1-P_i)}\right] = Z_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_{11} X_{11} + e \quad (2)$$

Where $\left[\frac{P_i}{(1-P_i)}\right]$ is the ratio of the probability that the farmer would adopt improved maize variety to the probability that he will not. Thus the dependent variable is dichotomous that is, 1 for adopters and 0 for non-adopters. Adopters are defined as farmers who cultivated at least one of the improved maize varieties in the 2015/16 cropping season and non-adopters refers to farmers that did not grow the improved varieties in that season. Z_i is a linear function of explanatory variables as follows:

X_1 = age (age of respondent in years)
X_2 = sex (1= if respondent is male)
X_3= household head (1 = if male headed household)
X_4 = household size (number of persons)
X_5 = experience (number of years of farming)
X_6 = off-farm income (naira per month)
X_7 = education (number of years of formal education)
X_8 = extension contact (1= if exposed to improved seed by extension agent)
X_9 = farm credit (1= if farmer accessed credit)
X_{10} = farm size (in acres)
X_{11} = market (1= if farmers have market access)
X_{12} = association (1= if member belongs to a farmers' association)
X_{13} = seed (1 = if seed is available)
X_{14} = labour (1= if labour is available)
X_{15} = practical effect (1= if farmer has been to experimental trials)
X_{16} = knowledge effect (1= if farmer has attended workshops/conferences on improved maize varieties)

RESULTS AND DISCUSSION

The results of the descriptive analysis reported in Table 1 show that the mean male non-adopters (0.66) exceeded adopters (0.60), suggesting that less males and more females adopted improved maize varieties. Similarly, the male household head non-adopters of new maize varieties (0.85) exceeded male household heads that are adopters (0.62), indicating that less male-headed households adopted the new varieties relative to female-headed households. This contrasts with the findings of Tesfaye et al. (2016) that male headed households' adopters outstripped female-headed households adopters of wheat varieties in Ethiopia, due to disparities in economic endowment and social conditions.

The average age of adopters (44.84 years) was less than non-adopters (49.02 years). Although this difference is marginal, it is indicative of the predilection for younger farmers to embrace improved practices. Danso-Abbeam et al. (2017) agree that older farmers find it difficult to abandon traditional practices while Sánchez-Toledano et al (2018) concur that younger farmers are more inclined to taking risks which predisposes them to adopting improved seeds. However, Etoundi and Dia (2008) contradicted this finding, returning a positive and significant correlation between age group and improved maize varieties in a study on the determinants of the adoption of improved maize in Cameroon.

Adopters have greater average mean years of schooling (8.42 years) compared to non-adopters (7.67 years). Again, this mean difference is rather small as farming is experiencing influx of educated persons as a result of dearth of white collar jobs; still it signifies that the skills and learning obtained through education is a driving force for adopting new maize seed varieties. Danso-Abbeam et al. (2017) and Gebresilassie and Bekele (2015) posited that educated farmers are imbued with basic learning to appraise new technologies and also to adopt and apply them relative to uneducated farmers. This submission was countered by Tesfaye et al. (2016) who found that non-adopters of improved wheat varieties

Table 1. Farm-household characteristics of respondents.

Variable	Non- adopters		Adopters		t-test (chi square)
	Mean	Standard deviation	Mean	Standard deviation	
Sex	0.66257	0.553639	0.60357	0.504339	0.76
Household head	0.85904	0.717808	0.62304	0.520608	19.38***
Age of household head	49.09532	12.17268	44.84832	11.11968	26.37***
Education	7.67634	5.812821	8.42234	6.377721	17.62***
household size	6.306576	4.3684	8.659776	5.9984	3.45**
Experience	23.46108	13.627344	21.43508	12.450544	2.98**
Seed	0.970926	0.247126	0.983133	0.250233	1.89*
Labour	0.76701	0.34188	0.778066	0.346808	2.93**
Extension contact	0.76782	0.36672	0.75978	0.36288	34.28***
Farm credit	0.493608	0.248688	0.473958	0.238788	(1.82)*
Practical	0.564	0.6	0.6486	0.69	9.35**
Knowledge	0.43659	0.552258	0.446215	0.564433	16.72***
Farm size	6.968449	6.792945	7.933448	7.73364	5.2***
Off-farm income	5187.03	3709.73433	5668.349	4053.970939	10.93***
Association	0.6851	0.49725	0.7409	0.53775	1.4

Note: significant at 1% (***), 5% (**) and 10% (*) levels.

in Ethiopia were considerably more educated than adopters. Farmers who were members of farmers' associations were more likely to adopt new maize varieties. This assertion is corroborated by Johannes et al. (2010); Langyintuo and Mekuria (2008) and Abunga et al. (2012). The average household size of adopters (8.69 persons) was more than that of non-adopters (6.30 persons), suggesting that the availability of household labour may provide a motivation to adopt new approaches. For instance, Sodjinou et al. (2015) found that families with substantial members adopted organic cotton than those with smaller number of persons. By contrast, Sánchez-Toledano et al. (2018) found that farmers with small family size were more likely to adopt improved seeds in Southern Mexico.

Non-adopters had slightly higher average years of farming experience (23.46 years) than adopters (21.43 years). Both adopters and non-adopters had similar access to the maize seeds and have comparable labour availability. Mean extension contact by both categories of respondents was also similar. Curiously, non-adopters (0.49) had marginally more access to farm credit than adopters (0.47). Chekene and Chancellor (2015) confirmed that majority of those that had access to credit and extension services were *fast adopters* of improved rice varieties in Borno State, Nigeria. More adopters (0.64) had attended or participated in experimental trial sessions than non-adopters (0.56). Similarly, marginally more adopters (0.45) had been to workshops/seminars where knowledge about the new maize varieties was propagated than non-adopters (0.44). Average farm size of adopters (0.79 acres) exceeded that of non-adopters (0.69 acres), reinforcing the notion that the size of farms was consequential in adopting new crop varieties. Kinuthia and Mabaya (2017) observed that the average size of the farm for adopters was larger than that of non-adopters in their study relating agricultural technology adoption with farmers' welfare in Uganda and Tanzania.

Off-farm monthly income of adopters (N5668.35) outstripped those of non-adopters (N5187.03), substantiating the view that access to supplementary income from off-farm activities provided incentive for adopting new systems. In addition**,** farmers who engaged in off-farm activities invariably had more financial resources to purchase improved maize varieties. Finally, more adopters (0.74) belonged to farm associations than non-adopters (0.68), signifying that knowledge exchanges at such meetings and peer support had a bearing on decisions to adopt new maize varieties (Table 1).

The maximum likelihood estimates of the logit regression presented in Table 2 indicate an indirect and significant relationship between age and probability of adopting improved maize varieties which is consistent with the postulate that older farmers are steeped in their old ways and averse to innovating (Islam et al., 2012). The level of education influences positively and significantly the probability of adopting the new maize varieties, suggesting that education endues respondents with greater intellectual capacity and know-how to dissect and assimilate the strengths and drawbacks of new technologies and in deciding to adopt or not (Kudi et al., 2011; Abadi et al., 2015). Curiously, Tesfaye et al. (2016) found a counter-intuitive negative effect of education on adoption of improved seeds in Ethiopia.

Household size is significant and positively related to the probability of adoption. This suggests that farmers with larger households have a higher probability of embracing innovation especially if it is labour-intensive,

Table 2. Logistic regression results of factors influencing adoption of improved maize varieties.

Variable	Coefficient	Standard Error	P-value
Sex	0.481634*	0.3283204	0.0682
Household head	-0.0738684	0.3376676	-0.4571
Age of household head	-0.1402806**	0.031212	-0.0222
Education	0.0767634**	0.027783	0.0362
Household size	0.0724224**	0.0409216	0.0565
Experience	0.0464958*	0.0349712	0.0752
Seed	0.00927546	0.022547	0.2431
Labour	0.052463**	0.0284655	0.0543
Extension contact	0.0553427**	0.02954364	0.0534
Credit	-0.0449512	0.0270824	-0.0602
Practicals	0.1051008	0.4820248	0.4586
Knowledge	0.03156437*	0.01957393	0.0620
Farm size	2.6299346**	1.35749	0.0516
Off-farm income	0.2016203**	0.077763	0.0386
Association	1.2551112**	0.3599316	0.0287
Constant	-0.0001213	0.9705213	-0.00012
Model χ^2	32.56**		

Note: ** = significant at 5% level; * = significant at 10% level.

as they could harness labour from household members at little or no cost. This finding is buttressed by Sodjinou et al. (2015). However, Elsheikh et al. (2018) found positive but insignificant effects of number of males in the household on adoption of improved millet variety in North Kordofan State of Sudan. The significance of the odd ratio of labour availability variable reinforces the importance of labour supply to the adoption of new methods. There is a significant positive relation between farming experience and probability of adoption of new maize varieties albeit at 10% level, indicating that farmers with longer experience in crop production have a higher probability of embracing change. Ojo and Ogunyemi (2014) confirmed this finding for adoption of agricultural technology in Ekiti State, Nigeria while Baruwa et al. (2015) found farming experience as the only predictor of probability of intensity of adoption of improved maize variety in Osun State, Nigeria.

Seed availability and observation of experimental trials respond positively to the probability of adopting new maize variety although insignificant. The probability of adoption is sensitive to contact with extension personnel, corroborating Feleke and Zegeye (2006) and Kedir (2018); and to farm size, consistent with the result of Mariano et al. (2012) and Chandio and Jiang (2018), who found positive association between farm size and adoption of new technology in Pakistan. Similarly, the odds of adopting improved maize seeds is positively correlated with access to off-farm income and membership of farm associations as affirmed by Manu et al. (2015) and Wekesa et al. (2003), respectively. Access to credit has a perverse negative effect on adoption, negating the finding of Fisher and Carr (2015), which probably reflects the fact that respondents had practically no access to institutional credit. However, Chandlo and Jiang (2018) established that credit availability was a significant factor influencing the adoption of improved wheat varieties in their study areas in Pakistan. Finally, attendance of conferences or seminars on improved maize varieties increases the odds of adopting them. The model chi square result shows that the parameters in the model are significantly different from zero at 5% level.

The major reasons advanced by the farmers for adopting improved maize varieties reported in Table 3 were early maturity (55.7%), high yield (28.5%), disease resistance (10.8%) and drought resistance (5.0%). Conversely, reasons for discontinuing old varieties were given as late maturity (50.2%), poor yield (39.1%), poor sales (7.4%) and storage concerns (3.3%). Tinu et al. (2014) discovered that early maturity did not influence adoption decision for improved sorghum seed varieties in Kenya. Rather, adoption was driven by factors such as yield, drought tolerance, taste, ease of cooking and price. Kalinda et al. (2014) confirmed that yield and price prospects are crucial determinants of adoption of improved maize seed varieties in Southern Zambia. Table 4 shows that constraints to adoption of improved varieties in the study areas included lack of capital (44.3%), high cost of improved varieties (26.3%), lack of market for produce (22.8%), lack of access to the improved varieties (3.4%) and high cost of labour (3.2%). Chandio et al. (2016) and Fatima and Khan (2015) identified paucity of improved seeds varieties, inaccessibility, high prices and lack of credit as constraints to adoption of improved seeds varieties in Pakistan.

Table 3. Reasons for adopting improved maize seeds or discontinuing old maize seeds varieties.

Reasons for adopting improved seeds varieties			Reasons for discontinuing old seeds varieties		
Variable	**Frequency n=171**	**%**	**Variable**	**Frequency n=178**	**%**
Early maturity	95	55.7	Storage problems	6	3.3
Disease resistance	18	10.8	Poor yield	70	39.1
Drought resistance	9	5	Late maturity	89	50.2
High yield	49	28.5	Poor sales	13	7.4

Source: Field Survey (2016).

Table 4. Constraints to adoption of improved maize varieties.

Type of constraint	Frequency n=162	% response
Lack of capital	72	44.3
Lack of access to improved maize varieties	6	3.4
High cost of labour	5	3.2
High cost of improved varieties	43	26.3
Lack of market for produce	36	22.8

Source: Field Survey (2016).

Conclusion

This study has shown that the determinants of adoption of improved maize seed varieties in Kaduna, North-central Nigeria include age, household size, level of education, farming experience, labour availability, contacts with extension agents, farm size, off-farm income and membership of associations. Some key policy messages from these results are the need to deepen formal education among farmers, expand coverage and improve delivery of extension services and strengthen farmers' associations and cooperatives to foster the adoption of improved maize seed varieties. It is also important to address availability, accessibility and affordability issues constraining adoption of improved maize seeds varieties, enhance credit access and mitigate risk perceptions. The link between researchers and innovators and the farmers who are the off-takers of their outputs should be reinforced to increase maize productivity in order to satisfy national demand and promote food security.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abadi T, Damas, P, Moti J (2015). Factors that affect the adoption of improved maize varieties by smallholder farmers in Central Oromia, Ethiopia. Developing Country Studies 5(15).

Abunga AM, Guo E, Dadzie KS (2012). Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions? Journal of Biology and Agricultural Health 2:1-13.

Adeola R (2010). Influence of Socio-Economic Factors on the Adoption of Soil Conservation Measures in Ibadan/Ibarapa Agricultural Zone of Oyo State. Report and Opinion Journal 2(7):42-47.

Baruwa O, Kassali R, Aremu F (2015). Adoption of Improved Maize Varieties Among Farming Households In Osun State, Nigeria. PAT December, 2015. 11(2):1-9.

Becerril J, Abdulai A (2010). The impact of improved maize varieties on poverty in Mexico: A propensity score matching approach. World Development 38(7):1024-1035.

Bonabana JW (2002). Assessing Factors Affecting Adoption of Agricultural Technologies: The Case of Integrated Pest Management (IPM) in Kumi District, Eastern Uganda. Blacksburg, Virginia: Unpublished Masters thesis

Chandio AA, Jiang Y, Magsi H (2016). Agricultural sub-sectors performance: An analysis of sector-wise share in agriculture GDP of Pakistan. International Journal of Economy and Finance 8:156.

Chandio AA, Jiang Y (2018). Factors influencing the adoption of improved wheat varieties by rural households in Sindh Pakistan**.** AIMS Agriculture and Food 3(3):216-228.

Chekene MB, Chancellor TS (2015). Factors Affecting the Adoption of Improved Rice Varieties in Borno State, Nigeria. Journal of Agricultural Extension Abstracted by: EBSCO host. Electronic Journals Service 19(2):21-33.

Chilonda P, Van Huylenbroeck G (2001). Attitude towards and uptake of veterinary services by small-scale cattle farmers in Eastern province Zambia. Outlook on Agriculture 30(3):231-218.

Danso-Abbeam G, Antwi B, Ehiakpo D, Mabe, F. (2017) Adoption of improved maize variety among farm households in the northern region of Ghana. Cogent Economics and Finance 5:1416896. https://doi.org/10.1080/23322039.2017.1416896

Doss CR, Mwangi W, Verkuli H, De Groote H (2003). Adoption of maize and wheat technologies in eastern Africa: A synthesis of the findings of 22 case studies. CIMMYT Economics Working Paper 03-06. Maize and Wheat Improvement Centre (CIMMYT), Mexico, DF.

Elkhalil EBA, Maruod EM, Elrashied EE (2013). Impact of Improved Seeds on Small Farmers' Productivity, Income and Livelihood in Bara Locality of North Kordofan State, Sudan. American International Journal of Contemporary Research 3(11).

Elsheikh, SE, Abdallaziz AH, Hamid HF, Eltighani ME (2018). Factors affecting adoption of improved varieties of sorghum, millet, groundnut and sesame in North Kordofan State, Sudan. Agricultural Research and Technology: Open Access Journal Review Article 13(4)001-008 January DOI:10.19080/ARTOAJ.2018.13.555889

Etoundi SMN, Dia BK (2008). Determinants of the adoption of improved varieties of Maize in Cameroon: case of CMS 8704. Proceedings of the African Economic Conference 2008. pp. 97-413.

Fatima H, Khan MA (2015) Influence of wheat varieties on technical efficiency and production of wheat crop in Pakistan (in selected area of Punjab). Sarhad Journal of Agriculture 31:114-122.

Food and Agriculture Organization (FAO) (2017). GIEWS - Global Information and Early Warning System: Country briefs, Nigeria. http://www.fao.org/giews/countrybrief/country.jsp?code=NGA

Feleke S, Zegeye T (2006). Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. Food Policy 31(5):442-445.

Fisher M, Carr ER (2015). The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: The case of drought-tolerant maize seed in eastern Uganda. Global Environmental Change 35:82-92. https://doi.org/10.1016/j.gloenvcha.2015.08.009

Gebresilassie L, Bekele A. (2015). Factors determining allocation of land for improved wheat variety by smallholder farmers of Northern Ethiopia. Journal of Development and Agricultural Economics 7(3):105-112.

Ghazdani D (2013). An Analysis of factors affecting the adoption of resource conserving Agricultural technologies in Al Prespa Park. Natura Montenegrina Podgorica 12(2):431-443.

Gurung K (2011). Impact Assessment of HMRP J.Agril.Eco.30:308-312 Income Growth. World Development 31(8):1343-1366.

Hintze LH, Renkow M, Sain G (2003). Variety characteristics and maize adoption in Honduras. Journal of Agricultural Economics 29:307-317.

Iken JE, Amusa NA (2004). Maize research and production in Nigeria. African Journal of Biotechnology 3(6):302-307.

Islam KZ, Sumelius J, Backman S (2012). Do differences in technical efficiency explain the adoption rate of HYV rice: Evidence from Bangladesh. Agricultural Economics Review 13(1):93-104.

Johannes TA, Vabi MB, Malaa DK (2010). Adoption of Maize and Cassava Production Technologies in the Forest-Savannah Zone of Cameroon: Implications for Poverty Reduction. World Applied. Science Journal11(2):196-209.

Kafle B, Shah P (2012). Adoption of Improved Potatoe varieties in Neopal: A case of Bara District. Journal of Agricultural Sciences Sri Lanka 7(1).

Kaliba A, Verkuijl H, Mwangi W (2000). Factors Affecting Adoption of Improved Maize Seed and Use of Inorganic Fertilizer for Maize Production in Intermediate and Lowland Zones of Tanzania. Journal of Agriculture and Applied Economics 32(1):35-47.

Kalinda T, Tembo G, Kuntashula E (2014). Adoption of Improved Maize Seed Varieties in Southern Zambia. Asian Journal of Agricultural Sciences 6(1):33-39.

Kedir M. (2018). Adoption and determinants of improved maize in Ethiopia. Agricultural Journal 13(1):1-8.

Kinuthia BK, Mabaya E (2017).The impact of agricultural technology adoption on farmer welfare in Uganda and Tanzania, pep policy brief. Partnership for economic policy. https://www.africaportal.org/publications/impact-agricultural-technology-adoption-farmer-welfare-uganda-and-tanzania/

Kudi TM, Bolaji M, Akinola MO, Nasa IDH (2011). Analysis of adoption of improved maize varieties among farmers in Kwara State, Nigeria. International Journal of Peace and Development Studies. 1(3):8-12.

Langyintuo A, Mekuria, M (2008). Assessing the influence of neighborhood effects on the adoption of improved agricultural technologies in developing agriculture. African Journal of Agricultural and Resource Economics 2(2):151-169.

Langyintuo AS, Mwangi W, Dialo AO, MacRobert J, Dixon J, Banziger M. (2008). An analysis of bottlenecks affecting the production and deployment of maize seed in eastern and southern Africa. Harare, Zimbabwe, CIMMYT.

Manu II, Tarla DN, Chefor GF, Ndeh EE, Chia I (2015). Socio-economic Analysis and Adoption of Improved Maize (*Zea mays* L.) Varieties by Farmers in the North West Region of Cameroon. Asian Journal of Agricultural Extension, Economics and Sociology 4(1):58-66.

Meinzen-Dick R, Adato M, Haddad L, Hazell P (2004). Science and Poverty: An Interdisciplinary Assessment of the Impact of Agricultural Research. https://books.google.com.ng/books?hl=en&lr=&id=f7YequgBbnIC&oi=fnd&pg=PR4&dq=Science+and+Poverty:+An+Interdisciplinary+Assessment+of+the+Impact+of+Agricultural+Research&ots=NAhNo7kAhW&sig=bK5eVHhLoNzyle3caJwj5fw9kco&redir_esc=y#v=onepage&q=Science%20and%20Poverty%3A%20An%20Interdisciplinary%20Assessment%20of%20the%20Impact%20of%20Agricultural%20Research&f=false

Mendola M. (2007). Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. Food Policy 32(3):372-393.

Mariano MJ, Villano R, Fleming E (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. Agricultural System 110:41-53.

Moyo S, Norton GW, Alwang J, Rhinehart I, Demo MC (2007). Peanut research and Poverty Reduction: Impacts of variety improvement to control peanut viruses in Uganda. American Journal Agricultural Economics 89(2): 448-460.

Namwata BML, Lwelamira J, Mzirai OB (2010). Adoption of improved agricultural technologies for Irish potatoes (Solanum tuberosum) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. Journal of Animal and Plant Sciences 8(1):927- 935.

Neupane RP, Sharma KR, Thapa GB (2002). Adoption of agroforestry in the hills of Nepal: a logistic regression analysis. Journal of Agricultural Systems 72:177-196.

Nguthi FN (2007). Adoption of agricultural innovations by smallholder farmers in the context of HIV/AIDS: The case of tissue-cultured banana in Kenya. Wageningen University: Unpublished PHD Thesis.

Nkonya E, Pender J, Jagger P, Sserunkumo D, Kaizzi C, Ssali H (2004). Strategies for Sustainable Land Management and Poverty Reduction in Uganda. https://books.google.com.ng/books?hl=en&lr=&id=TRn0g95omQMC&oi=fnd&pg=PR7&dq=Strategies+for+Sustainable+Land+Management+and+Poverty+Reduction+in+Uganda&ots=FKzqbjDAqD&sig=QuLYUCG5GZ1OsTyIJuSIdMpOUQ8&redir_esc=y#v=onepage&q=Strategies%20for%20Sustainable%20Land%20Management%20and%20Poverty%20Reduction%20in%20Uganda&f=false

Okuthe IK, Ngesa FU, Ochola WW (2013). The Influence of Institutional Factors on the Adoption of Improved Sorghum Varieties and Technologies by Smallholder Farmers in Western Kenya. International Journal of Humanities and Social Science 3(16):196-207.

Ojiako IA, Manyong VM, Ikpi AE (2007). Determinants of rural farmers' improved Soybean adoption decision in northern Nigeria. Journal of Food, Agriculture and Environment 5(2):215-223.

Ojo SO, Ogunyemi AI (2014). Analysis of factors influencing the adoption of improved cassava production technology in Ekiti State, Nigeria. International Journal of Agricultural Sciences and Natural Resources 1(3):40-44.

Rogers EM (2003). Diffusion of Innovations (Fourth Edition). New York: Free Press.

Sall S, Norman D, Featherstone AM (2000.) Quantitative assessment of improved rice variety adoption: The farmer's perspective. Agricultural System 66(2):129-144.

Sánchez-Toledano IB, Kallas Z, Rojas O, Gil J (2018). Determinant factors of the adoption of improved maize seeds in Southern Mexico: A survival analysis approach. Sustainability 10:3543; doi:10.3390/su10103543.

Sodjinou E, Glin CL, Nicolay G, Tovignan L, Hinvi J (2015). Socioeconomic determinants of organic cotton adoption in Benin, West Africa. Agricultural and Food Economics 3(1):12.

Sugri RAL, Kanton F, Kusi SK, Nutsugah SSJ, Buah Zakara M (2013). Influence of current seed programme of Ghana on maize (zea mays) seed security. Research Journal of Seed Science 6(2):29-39.

Suhane RK, Sinha RK, Singh PK (2008). Vermicompost, cattle-dung compost and chemical fertilizers: Impacts on yield of wheat crops. Communication of Rajendra Agriculture University, Pusa, Bihar, India. 88 p.

Tesfaye S, Bedada B, Mesay Y (2016). Impact of improved wheat technology adoption on productivity and income in Ethiopia. African Crop Science Journal 24(s1):127-135.

Tinu A, Mulwa R, Okello J, Kamau M (2014). The role of varietal attributes on adoption of improved seed varieties: the case of sorghum in Kenya. Agriculture and Food Security 3:9.

Uaiene RN, Arndt C, Masters WA (2009). Determinants of Agricultural Technology Adoption in Mozambique. Discussion papers (67E). National Directorate of Studies and Policy Analysis, Ministry of Planning and Development, Republic of Mozambique 1–31.

Wekesa EW, Mwangi H, Verkuijl K, Danda H, De Groote (2003). Adoption of maize production technologies in the coastal lowlands of Kenya. Mexico, D.F.: CIMMYT.

World Bank (2008). World Development Report 2008, Agriculture for Development. The World Bank. Washington, DC.