academicJournals

Vol. 9(17), pp. 1334-1343, 24 April, 2014
DOI: 10.5897/AJAR2013.8336
Article Number: 33AAD6444132
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Determinants of smallholder farmers' hybrid maize adoption in the drought prone Central Rift Valley of Ethiopia

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Received 5 February, 2013; Accepted 7 April, 2014

This paper examines the factors influencing smallholder farmers' adoption decision of hybrid maize in drought prone Central Rift Valley (CRV) of Ethiopia. The analysis is based on data collected through a questionnaire survey of 277 randomly selected maize grower farm household heads. Binary response Logit model was employed in the data analysis. Hybrid maize adoption in the CRV was found to be influenced by age, years of formal education, farmland size, the proportion of farmland allocated to maize, frequency of extension visit, grain market distance and altitude. Extension visit was negatively associated with hybrid maize adoption contrary to the prevailing beliefs and the earlier findings. Extension workers have been promoting open pollinated varieties (OPVs) maize since the OPVs have been more common in drought prone area though the farmers in the CRV also producing hybrids. Even though the prevailing maize hybrids have essentially been released for high potential areas, the production of these hybrids is currently expanding in the CRV where it is grown by 30% of the farmers. Likewise, hybrid maize adoption in this area offers better opportunity for private seed companies' involvement in the seed provision of adapted hybrids. A paradigm shift in the maize breeding efforts and extension service on hybrid for drought prone areas is commendable in order to enhance the food security of smallholder farmers in the CRV.

Key words: adoption, Central Rift Valley, hybrid maize, drought prone.

INTRODUCTION

Maize is one of the most important food crops produced and consumed in Ethiopia. Among cereal crops, it stands first both in production and productivity and second after teff in area coverage. It is grown by slightly more than nine million farm households (CSA, 2012). It contributes about a quarter of the daily calorie requirements of the Ethiopians. Increasing and sustaining maize productivity is a vital concern in Sub-Saharan African countries in enhancing a household food security principally in drought induced risk prone areas such as Central Rift Valley (CRV) of Ethiopia. Ethiopia has been pursuing agricultural production intensification approach to boost crop productivity through the application of modern agricultural inputs primarily improved varieties fertilizers

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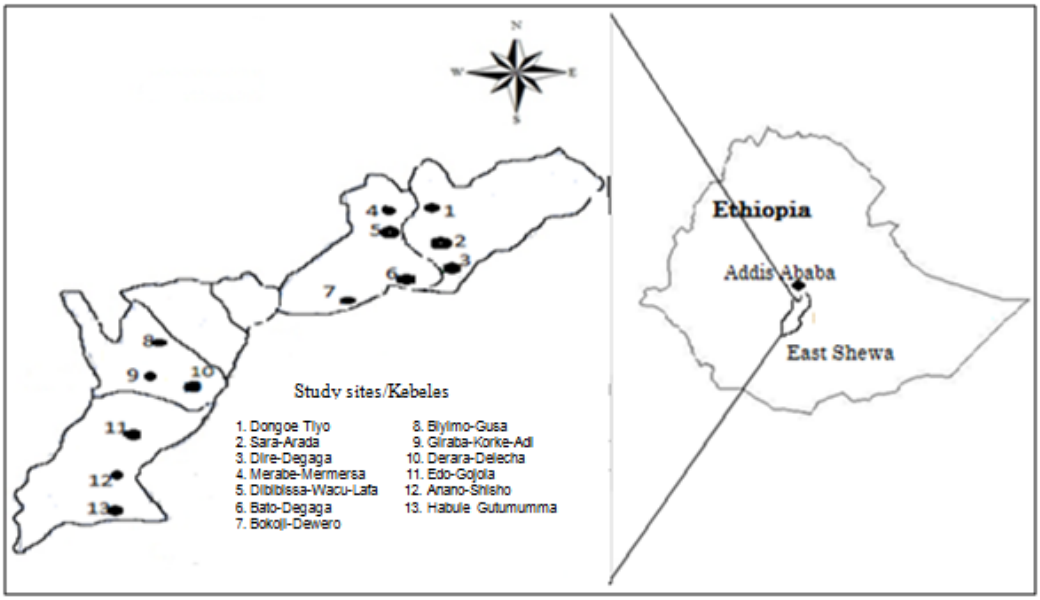

Figure 1. Map of the study area.

and improved agronomic practices focusing on high potential areas. Accordingly substantial amount of resources were devoted to the development and dissemination of improved maize varieties (Alemu et al., 2008). So far, about 43 improved maize varieties including the hybrids and open pollinated varieties (OPVs) have been released and disseminated though farmers adopted a few. Limited information has been documented aboutthe factors influencing adoption decision of maize growing farmers particularly in drought prone areas.

In Ethiopia, about 40% of area of maize production is located in moisture stress environments and contributes to less than 20% of maize production. Low maize production in drought stressed areas in relation to its land area is partly attributed to low research attention given to this agro-ecology since the beginning of maize research and afterwards. There have been substantial progresses made under African Maize Stress (AMS), Drought Tolerant Maize for Africa (DTMA) and Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) projects in research and dissemination of improved open pollinated maize varieties for drought prone areas of the country.

Adoption of technological innovations in agriculture has attracted a considerable attention of socio-economic researchers and policy makers in developing countries since its population drive most of their livelihood from agriculture (Feder and Umali, 1993). Moreover, a new technology is believed to offer an opportunity to boost production and income substantially. However, the introduction of technological innovations have met with only partial successes, as measured in observed rates of adoption.

Several studies have been devoted to analyzing the factors influencing the adoption of agricultural technologies such as improved varieties and documented different results. Those studies considered human and physical resource endowments in the analysis. There are no, however, conclusive evidences from the factors considered in adoption study where some essential factors such agro-ecological conditions were barely considered which are critical in crop production decision in the study area. Moreover, the studies conducted focused on high potential areas for crop production. This paper tries to capture agro-ecology by considering altitude since altitude is a salient feature influencing both temperature and precipitation in Ethiopia. In general, identifying factors that hinder or facilitate the adoption of improved maize varieties such as hybrids in stress environments provide valuable information in improving the efficiency of maize research, extension services, and food security concerns to smoothen enhanced technological changes. The objective of this paper is, therefore, to analyze factors influencing the adoption of hybrid maize in the drought prone CRV of Ethiopia. It takes into account hybrid maize in the analysis based on a cross-sectional data obtained from farm household survey.

METHODOLOGY

The study area and methodological considerations

The study was conducted in East Shewa Zone, CRV of Ethiopia (Figure 1). The area is characterized by drought prone agro-

ecology where effective crop growing period lasts for three months per annum. Moreover, there is a significant crop harvest stress once every 3 to 4 years. In most of the months, the precipitation is in short of evapotranspiration. The rainfall of the area by low and erratic rainfall, averaging between 600 and 800 mm per year. The minimum temperature ranges from 8 to 17°C and the maximum from 24 to 32°C.The major cereal crops produced in the study areas include maize, teff, wheat and barley while common bean is the main pulse crop produced under rainfed condition.

Sampling and data collection method

Data were obtained from farm household survey conducted in 2011, using multi-stage sampling approach. East Shewa Zone of Oromia Regional State of Ethiopia was purposively selected for its importance in drought prone maize producing area, presence of well-organized maize research and extension services. Accordingly, four districts: Adama, Boset, Dugda and Adami-Tulu-Jido-Kombolcha (ATJK) were selected based on their importance in maize production. From those districts, thirteen maize producing *Kebeles* were randomly selected (Figure 1). *Kebele* is the lowest administrative entity in the Ethiopian administrative tiers and also known as Peasant Association (PA). Finally, 277 maize farmers were randomly selected from agricultural land use taxpayers lists obtained from the respective district offices of the revenue. Structured and pretested questionnaires were administered to the farmers to solicit information through face-to-face interview.

Data management and analysis

Data collected from maize grower farm household heads on selected factors were coded, entered, cleaned then analyzed using descriptive statistics and Logit model. SPSS 17.0 was used in the data management while both the SPSS and StataIC 10 Softwares were used in the data analysis.

Conceptual framework and analytical considerations

The conceptual framework for the analysis is based on partial adoption of agricultural innovation (Feder et al., 1985). Adoption of agricultural innovation was hypothesized to be a result of an elaborate set of inter-technology choice made by a farm household head among available alternative production inputs. Many of the adoption studies were preoccupied with analysis of the impact of factors such as credit, information availability, risk, and farm size.

The factors explaining adoption of improved technology can be estimated using Logit, Probit or Tobit models. The choice of improved technology adoption can be assumed as a dichotomous outcome of adoption or non-adoption. Hence, a farmer's choice was represented by a dichotomous dependent variable measured in nominal dummy variables1 (adoption) or 0 (absence of adoption). Selection between Logit and Probit models is sticky since both models provide equally efficient parameter (Demaris, 1992). However, when continuous independent variables are included in the model, Logit model is well suited for explaining and testing the hypotheses about the relationships between a categorical outcome variable and one or more categorical or continuous variables (Peng et al., 2002). Thus, in this study, Logit model chosen since the explanatory variables are constructed from both categorical and continuous variables while the dependent variable is categorical.

Model specification and description of the variables

Logit model of binary response (Menard, 2002) was employed to test the factors influencing the adoption of hybrid maize. The model is specified as:

$$\text{Log}\left(\frac{P_i}{1-P_i}\right) = \sum \beta_j X_{ij} + \varepsilon_i$$

The probability that a farmer adopts the technology is denoted as $P= P[y_i = 1]$ while the probability for adopters is 1 and $P = P[y_i = 0]$ for non-adopters. This binary adoption variable has a probability function $f(y) = P^y(-P)^{1-y}$ where y = 0 or 1. Thus, P_i stands for the conditional probability that a farmer adopts hybrid maize while $(1-P_i)$ represents the conditional probability that a farmer does not adopt hybrid maize; β_js are coefficients to be estimated about an explanatory variable; X_js are the explanatory variables and ε_i is the error term. The explanatory variables of hybrid maize adopter (HYMA) in the CRV is specified and explained as follows.

$$\text{HYMA} = \beta_0 + \beta_1\text{GND} + \beta_2\text{AGE} + \beta_3\text{HHSIZ} + \beta_4\text{EDC} + \beta_5\text{FRMSZ} + \beta_6\text{MZAP} + \beta_7\text{OX} + \beta_8\text{EXTN} + \beta_9\text{FLD} + \beta_{10}\text{TMKT} + \beta_{11}\text{DRGHT} + \beta_{12}\text{ALTI}.$$

A number of working hypotheses were employed and literatures were consulted in constructing the model since there is no firm econometric theory that dictates the choice of independent variables in adoption studies. The factors influencing the adoption of hybrid maize were roughly categorized into three: human and physical resource endowments, institutional and agro-ecologic factors. The human and physical resource includes gender (GND), age (AGE), household size (HHSIZ), formal education of the household head (EDC), farmland size (FRMSZ), percent of farmland allocated to maize (MZAP) and number of oxen owned (OX) were captured.

In agricultural technology adoption, behavioral differences between genders is presumed since female-headed households are usually poorer in developing countries and their access to information and innovation limited that may negatively affect their improved technology adoption. Age is a proxy for farming experience of a farmer that can erode or generate confidence to try a new technology. Accordingly, younger farmers are expected to be adventurous or risk takers; and thus, test an improved technology and adopt it. Likewise, household size accounts for household farm labor since an intensive field management for optimum production usually accompanies the adoption of improved varieties. Hence, larger household size is presumed to provide ample labor for the intensive field management in improved variety such as hybrid maize cultivation. Year of formal education is expected to enhance farm household likelihood of the adoption of improved technology since education boosts the capacity of a farmer in acquiring, processing and utilizing new information.

Farmland and livestock (particularly oxen) are the major farm household assets in pursuing crop production. A farmer's possession of those resources is anticipated to enhance a farmer's hybrid maize adoption. Hence, a well-off farmer is supposed to allocate part of his or her farmland to improved varieties, and be able to purchase inputs that are accompanying them. Likewise, farmers who own sufficient numbers of oxen are expected to perform land preparation on time hence adopt hybrid maize to enhance their maize production.

The second set of explanatory variables of hybrid maize adoption comprise extension visit (EXTN), field day participation(FLD), time taken to the nearest grain market (TMKT) which are related to institutional factors. Extension visit is presumed to be a major means for a farmer's access to reliable agricultural information. Hence, it is expected to influence the adoption of improved variety. A farm household head participation on field days of improved maize variety demonstration is presumed to develop farmers'

Table 1. Definition of explanatory variables and their expected signs in hybrid maize adoption in the CRV.

Variable	Definition/unit	Expected sign
Gender of the household head	1 if the farmer is male; 0 otherwise	+
Age of the household head	Years completed since birth	+/-
Household size	Number of household members	+
Years of formal education	Number of years formal education completed by household head	+
Farmland size	Total farmland area in hectare owned by household	+
Proportion of maize area	Per cent area of the household planted to maize	+
Oxen owned	Number of oxen owned by household	+
Extension visit	Frequency of extension contact per month	+
Field day participation	1 if the farmer participated on improved maize demonstration field day; 0 otherwise	+
Time to the nearest grain market	Walking time (minutes) to the nearest grain market	+
Drought encounter frequency	Frequency of drought that caused substantial maize yield stress	_
Altitude	Altitude of the area in meters above sea level (masl)	+

confidence and facilitate improved variety adoption. Distance to the nearest grain market is a proximity to market accessibility. A farmer residing close to a grain market place is expected to have up-to-date information about agriculture inputs and outputs availability and their prices then the farmer is expected to use improved variety in order to enhance grain production.

In the third category of explanatory variables of hybrid maize adoption, agro-ecological characteristics were included. Environment, namely altitude (ALT) and drought (DRGHT) are expected to shape crop production thereby influence improved variety adoption. In Ethiopia altitude is the outstanding feature that alter both temperature and rainfall consequently crop production. Hence, raise in altitude is expected to positively influence hybrid maize adoption in the CVR of Ethiopia. Recurrent drought is a major challenge of crop production in Ethiopia particularly in drought prone areas. Once every ten years a severe drought occurs in the country (Nigussie et al., 2002) and it recurs once in three to four years in the CRV of Ethiopia. Therefore, to incorporate the risk associated with maize production, the number of severe drought encountered (drought caused a significant maize harvest stress) was included to examine farmers' behavior in such circumstances (Table 1).

RESULTS

Description of hybrid maize producing farm households

Female-headed households constituted 14.5% of the 277 respondents. On average, a household was composed of seven persons headed by 41 years-old adult with a low level of formal education (about two years). Farmers had long experience (about 24 years) in maize production with mixed crop and livestock production systems. The land holding was 2.36 ha per household. The major livestock were found to be cattle, goat, sheep and donkey. Maize receives 46% of farm area allocated to crops and covered 60% of the total production of the area. Oxen were the critical source of draught power for crop production. On average basis, farmers in the study area had slightly less than a pair (1.8) of oxen.

Maize varieties produced in the Central Rift Valley of Ethiopia

A number of different maturity groups of maize varieties were found to be cultivated in the CRV of Ethiopia. Medium maturing improved OPVs and hybrid were dominantly grown. OPVs have been recommended for commercial production in the area. Among the OPVs, the varieties released by MARC were the dominant ones. OPVs are preferred because the seed can be recycled, and their seeds production cost is cheaper than that of hybrid. The popular OPVs in the study area showed variable maturity dates. Some varieties were very early and can escape peak season and terminal drought stresses.

The OPVs had disadvantages of lower yield than that of the hybrids; and showed non-uniform performances among individual plants in the population. Using high inputs for the production of OPV maize can reduce farmers' profit margin due to its lower yielding potential. On the other hand, hybrids were found to be high yielders than OPVs. Under suitable conditions, hybrids show uniform grain color, maturity, and other plant characteristics. Hence, hybrids usually have better market advantage when sold with recommended quality standards. The empirical studies showed that there is a significant yield differences between hybrids and OPVs under farmers' condition. The current study showed highly significant yield differences ($P < 0.001$) between OPVs and hybrids. Average yield obtained from OPV was 2.3 tons per hectare while that of hybrid was 3.7 tons per hectare, indicating that hybrids had more than 50% yield advantage over the OPVs. Over the last ten years, an average of 2 to 3 varieties (minimum 1 and maximum 7) were grown by individual farmer while a total of 37

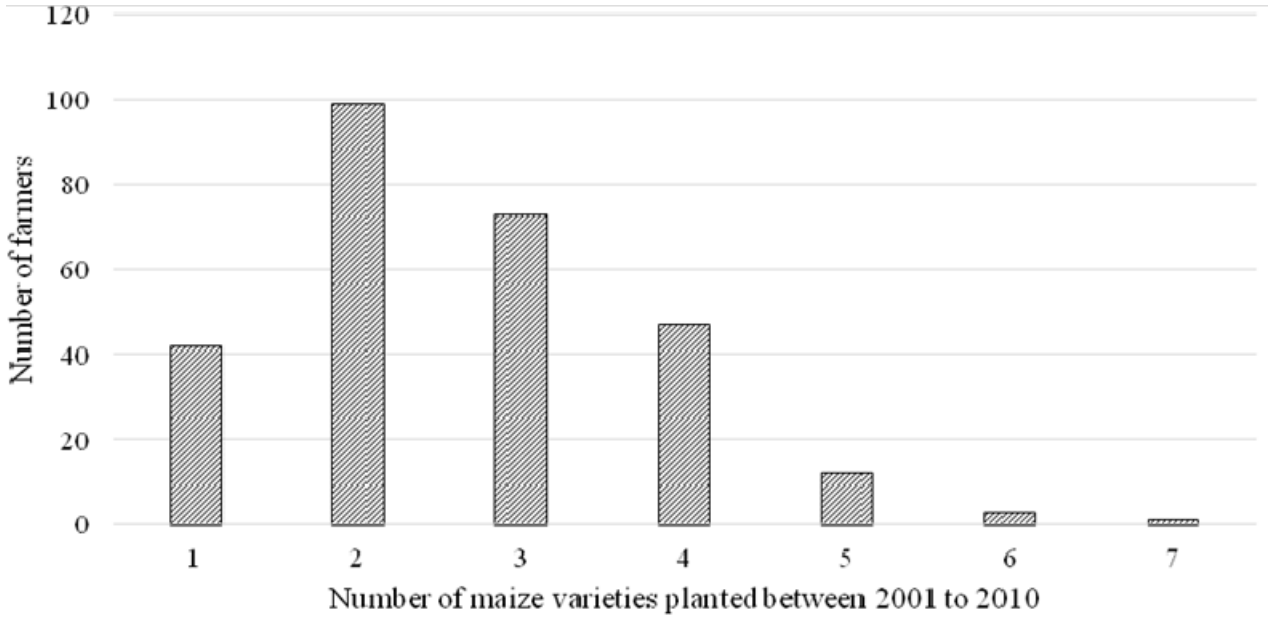

Figure 2. Number of maize varieties grown by farm households in the Central Rift Valley of Ethiopia between 2001 and 2010

Table 2. Characteristics of maize varieties grown in the Central Rift Valley of Ethiopia.

Variety	Release Year	Altitude (m)('00)	Rainfall (mm)('00)	Days to maturity	Average yield on research station (t/ha)	Per cent of farmer who has grown the variety in past 10 years ‡
Hybrids						
BH-540	1995	10-20	10-20	145	9.0	25
BH-543	2005	10-20	10-12	151	9.8	7
BH-660	1993	16-23	10-15	160	10.5	1
Zama	2009	6-17	4.5-12	135	11.0	3
Wolel (Phb30v53)	2006	10-20	8-12	163	9.0	3
Open pollinated varieties						
Awassa-511	1973	10-19	6–9	142	5.6	31
Bukuri	na	na	na	135	3.2	1
Ghibe	2001	10-17	9-12.5	145	7.4	3
Guto	1988	10-17	8-12	126	4.0	2
Hararghe	na	na	na	150	3.7	7
Hizbawi nuro	na	na	na	150	3.5	3
Katumani	1974	12-17	5-7	110	3.1	27
Limat	na	na	na	150	3.4	14
Marid	na	na	na	150	4.0	6
Melkassa-1	2001	5-16	4.5-7.5	85	4.5	7
Melkassa-2	2004	12-17	6-8	130	5.0	25
Melkassa-4	2006	10-16	5-7	105	4.0	2
Melkassa-6Q	2008	10-17.5	5-8	120	5.0	3
Milisha	na	na	na	150	3.6	21
Shaye	na	na	na	150	3.6	27
Sinde	na	na	na	120	3.0	5

na= data not available; ‡ the figure in the column do not add up to 100% since one farmer plant more than variety over this period.

Table 3. Descriptive summary of explanatory variables included in hybrid maize adopters and non-adopters.

Variables	All respondents (n=277)	Non-adopters (n=193)	Adopters (n=84)	F	p-value
Gender of the household head (% male)	0.84(0.36)[a]	0.81(0.39)	0.92(0.28)	4.80	0.03
Age of the household head (year)	41.1(12.7)	42.6(12.6)	37.8(12.2)	8.56	0.00
House hold size (persons)	6.7(3.2)	6.3(2.8)	7.6(3.7)	9.49	0.00
Formal education (year)	1.9(3)	1.1(2.3)	3.6(3.5)	45.90	0.00
Farmland size (ha)	9.4(5.8)	8.9(5)	10.7(7.3)	5.97	0.02
Maize area proportion (%)	0.46(0.22)	0.44(0.2)	0.57(0.25)	39.41	0.00
Oxen owned (number)	1.8(1.3)	1.5(1.2)	2.3(1.5)	17.43	0.00
Extension visit (number per month)	2.4(1.6)	2.7(1.6)	1.8(1.2)	19.73	0.00
Field day participation (% yes)	0.2(0.4)	0.2(0.4)	0.3(0.4)	3.86	0.05
Time to the nearest grain market (minute)	94(51)	100(53)	82(44)	7.46	0.01
Drought encounter (frequency in 10 years)	2.7(1.4)	2.9(1.4)	2.3(1.3)	9.34	0.00
Altitude (masl)	1561(118)	1530(127)	1631(38)	51.79	0.00

[a]Figures in the bracket indicate standard deviations.

varieties including both improved varieties and land races were grown over the past ten years. About 85% of the farmers grew more than one variety (Figure 2). At the time of this study, the majority of the farmers were producing improved varieties and the total number of varieties grown by the farmers' were 26. Table 2 shows major maize varieties grown in the CRV of Ethiopia during the study period.

Explanatory variables of hybrid maize adoption in CRV

Table 3 presents the explanatory variables in hybrid maize adoption. Variables that showed a significant difference in the descriptive statistics included in the Logit model in the estimation of hybrid maize adoption. The rate of hybrid maize adopters was 30%. Significant differences were found between hybrid maize adopters and non-adopters by gender, age, year of formal education completed by the household heads when human resource endowments were considered. Households headed by male, younger and the more literate person were found to be more adopters than households headed by female, older and illiterate counterparts.

Hybrid maize adopters leave close to grain market center as compared to non-adopters. There was also a significant difference in extension visit between adopters and non-adopters that the frequency of visit was considerably less among adopters as compared to non-adopters. Moreover, hybrid maize adopters were clearly distinguishable by higher proportion of farmland allocated to maize production. Adopters tend to live in relatively higher altitude areas as compared to non-adopters; and hence, altitude was strongly associated with hybrid adoption. Multicollinearity analysis among the independent variables using the Variance Inflation Factor (VIF) showed absence of multicollinearity problem as the highest VIF value was 1.7, which was far less than the threshold level of 10 (Table 3).

Logit model estimate of hybrid maize adoption in the CRV of Ethiopia

The variables included in the Logit model showed the expected signs, except for the frequency of extension visit (Table 4). Six variables found to be statistically highly significant (at 5% or less) while two variables were marginally significant (at 10% or less) in explaining farmer adoption of hybrid maize variety.

The model was highly significant as indicated by likelihood ratio χ^2 statistics of 144.08 (P <0.001). The likelihood ratio χ^2statistic test signifies the dependence of adoption of hybrid maize on the explanatory variables captured in the model. The Logit model estimation has shown that the independent variables were simultaneously associated with the log odds of hybrid maize adoption. The null-hypothesis that all the variables can be dropped from the model is rejected at less than 1% level of significance since the Wald'sχ^2statistic is 62.38 (P<0.01).

Regarding human and physical resource endowment, gender did not show significant association with the adoption of hybrid maize. Age had the expected negative association with log odds of hybrid maize adoption and it had significant influence on hybrid maize adoption (Table 4). Hybrid maize adopters were distinguishable by their age since the adopters found to be significantly younger than non-adopters.

The size of farmland owned and percent of farm area

Table 4. Logit model estimates for hybrid maize adoption in drought prone areas of CRV of Ethiopia (N=277).

Variables	β	Wald's χ^2	Exp (β)	Δ% adoption
Constant	20.52***	21.18	0.000	
Gender	0.05	0.01	1.05	
Age	-0.03*	3.63	0.97	-3.3
Household size	0.06	0.82	1.06	
Formal Education	0.13*	3.26	1.14	13.6
Farmland size	0.08*	3.64	1.08	7.9
Maize area percent	0.04***	22.20	1.05	4.5
Oxen owned	0.22	1.76	1.25	
Extension visit	-0.39***	7.23	0.68	-32.3
Field day participation	0.50	1.12	1.64	
Time to the nearest grain market	-0.01**	6.37	0.99	-1.0
Drought encounter frequency (in 10 years)	-0.13	0.80	0.88	-12.2
Altitude	0.01***	20.01	1.01	1.2
Likelihood ratio χ^2 (12)		144.08	Cox and Snell R^2	0.40
Wald's χ^2 (12)		62.38	Nagelkerke R^2	0.57
Overall Percentage prediction		83.8		

***, **, * indicate statistical significance at 1%, 5% and 10%, respectively.

allocated to maize production were positively associated with log odds of hybrid maize adoption. The likelihood of adoption of hybrid maize increase with the proportion of farmland allocated to maize that was statistically highly significant (P<0.001). Accordingly, the log odds was in favor of adopting hybrid maize increase by 4.5% for every 1.0% increase in the farmland allocated to maize among non-adopters. The average walking time required to get to the nearest grain market was negatively associated with log odds of hybrid maize adoption. In this aspect, improving rural road and transportation means can help in enhancing hybrid maize adoption. Extension visit showed negative association with log odds of hybrid maize adoption which was statistically highly significant (P =0.04). Altitude found to be highly influential in hybrid maize adoption. Every one-meter raise in altitude is associated with 2% increase in log odds of hybrid adoption.

DISCUSSION

Adoption of an improved crop variety is a dynamic process of a farmers 'decision to include an innovation in the existing farming system (Feder and Umali, 1993). The decision process considers a number of factors. Several studies were devoted to analyzing the factors influencing the adoption of agricultural innovation such as improved crop varieties and production information. The studies considered human and physical resource endowments, institutional and environmental factors in their analysis. Beginning with gender, Tura (2010) from Ethiopia and Ouma (2002) from Kenya pointed out a negative association between a female headed household and improved maize variety adoption in high potential areas (area with more than 900 mm rainfall). On the other hand, Morris (1999b) and others (Morris et al., 1999a; De Groote et al., 2002) did not observe a significant influence of gender on improved maize variety adoption.

Although age is an important factor in the adoption of improved varieties, previous studies showed inconsistent results of its effects. Some investigators reported non-significant influence of age on adoption of improved variety (Paudel and Matsuoka, 2008; Cavane, 2009; Alene et al., 2000) while Ensermu et al. (1998) and Kaliba (1998) found strong positive association between age and improved variety adoption. In line with the current study, Morris et al. (1999a) and Fufa and Hassan (2006) report found negative influence of age on adoption. A year increase in age of a farmer from average was accompanied by a 3.3% decrease in the log-odds of hybrid maize adoption. Hybrid adopters tend to be younger, and have longer year of formal education suggesting that the young and literate farmers have a tendency to take more risk, seek and utilize innovations than the older farmers. This indicates that younger farmers try to maximize their harvest by growing high yielding varieties such as hybrids. Moreover, in the near future, demand for hybrid is expected to increase in Ethiopia, as more number of young and educated people will join crop farming while the land holding size is squeezing per head as the population is growing at an alarming rate (2.6% per year).

Education of the farm household head tends to significantly influence hybrid maize adoption. This result is in line with the finding of Tura et al. (2010), Paudel and

Matsuoka (2008) and Feleke and Zegeye (2005), who reported that there was significant influence on improved maize variety and related innovation adoption. The result, however, in contrast with the finding of Fufa and Hassan (2006) and Kaliba et al. (1998) who find no meaningful influence of years of formal education on improved crop variety adoption. According to the present study, every single year of additional formal schooling increased hybrid maize adoption by 13.6% keeping other variables constant at their means.

Likewise, hybrid maize adoption found to be influenced by the distance of a farmer's residence from local grain market center. For every 10 min increase in walking time to the nearest grain marketplace, the log odds of hybrid maize adoption decreased by 10%. The result supported the theoretical hypothesis and the findings of Feleke and Zegeye (2005). The present study is in contrast with empirical results of Tura et al. (2010) and Cavatassi et al. (2010).

Hybrid maize adopters were clearly distinguishable by the proportion of farmland they allocate to maize suggesting that the adopters tendency of specialization in maize production, particularly the hybrid varieties. The adopters allocated 57% of their farmland to maize as compared to only 44% by the non-adopters. Likewise, every 1.0% increase in the land allocated to maize was associated with a 4.5% increase in the hybrid maize adoption. This suggested production specialization and market orientation of hybrid maize adopters. Landholding size is a wealth indicator of a farm household among physical resources; and supposed to have a positive influence on improved variety adoption. However, the exiting evidences provide mixed results from those which show absence of considerable influence of landholding (Fufa and Hassan, 2006; Gemeda et al., 2001; Degu et al., 2000; Ntege-Nanyeenya et al., 1997) to those who substantiated positive and meaningful influence on improved variety adoption (Alene et al., 2000; Tura et al., 2010).

Ox is an essential farm household asset and draught power source in Ethiopia. The influence of oxen ownership on improved variety adoption is mixed. Like many previous studies (Gemeda et al., 2001; Tura et al., 2010; De Groote et al., 2002; Feleke and Zegeye, 2005), the present work found no meaningful influence of oxen on improved maize variety adoption. On the other hand, Degu et al. (2000) on the other hand established a positive and significant influence of oxen ownership on hybrid maize adoption. The apparent reason for the absence of meaningful influence of oxen on adoption might be attribute to availability of nearly a pair of oxen that is sufficient to plough the average farmland size of about two and a half hectares owned by a farm household.

Extension visit believed to provide direct and meaningful influence on crop technology adoption. The result of extension visit provides contrasting results from negative result though absence of significant influence to positive influences. A number of studies (Paudel and Matsuoka, 2008; Feleke and Zegeye, 2005; De Groote et al., 2002; Alene et al., 2000) proved a positive and meaningful influence of extension visit on crop variety adoption.

Some investigators, for instance, Gemeda et al. (2001) found that extension visit had positive influence on adoption of hybrid maize variety but negative effect on OPV adoption in Western Ethiopia. Ntege-Nanyeenya et al. (1997) find no significant association between extension visit and adoption of agricultural innovations.

The present study also in support of the group those who reported negative association but with no significant association. Differing from the widely held beliefs and empirical literature, extension visits had negative and statistically significant influence on hybrid maize adoption.

The plausible explanation is that extension workers in the study area do not provide advice on hybrid maize production as the hybrids were mainly recommended for high moisture areas. For drought prone areas of the CRV, OPVs were recommended; and hence, extension workers have been focusing on the promotion of those varieties. This is further confirmed by the fact that most varieties released by Melkassa Agricultural Research Center, the main maize breeding center for drought prone areas, are OPVs.

In the current study, field day participation did not have influence on hybrid maize adoption. This result is in agreement with the work of Ouma et al. (2002) who reported effective influence of field day participation on improved variety demonstration enhances variety adoption. This result is in contrast with the findings Gemeda et al. (2001) which established direct and strong relationship between maize adoption and field day participation.

Hybrid maize adopters were found to reside in mid to high altitude areas as compared to non-adopters. This attributes to the increase in moisture availability in higher altitudes as compared to the lowland areas. The available hybrids require higher moisture to express the potential productivity.

Likewise, every meter rise in an altitude is associated with 0.9% increase in the log odds of adoption of hybrid maize. This result agrees with the findings of Kaliba et al. (1998) who reported a negative association between hybrid maize adoption and low altitude and low rainfall areas in Tanzania. Contrary to the current findings, Cavatassi et al. (2010) reported that agro-ecology does not show any influence on the adoption of modern sorghum varieties.

The adoption rate of hybrid maize in the study area was substantial (30%), suggesting that maize breeding and extension works for drought prone areas should give a due attention to the development and dissemination of high yielding and well adapted hybrid maize varieties to

benefit smallholder maize producers in the drought prone areas of CRV of Ethiopia.

CONCLUSION AND IMPLICATIONS

This paper examined the factors influencing farmers' hybrid maize adoption in CRV of Ethiopia. The study was conducted in drought prone areas where improved variety adoption study is rarely exist and hybrid maize variety development received little attention. The factors influencing adoption of hybrid maize varieties were discussed considering farmers' resource endowment, institutional and environmental factors.

Different factors found influencing the adoption of hybrid maize. Age of farm household head, year of formal education of household head and distance from the local grain market substantially influenced adoption of hybrid maize. Contrary to the commonly held beliefs and many empirical results, extension visit found to have negative influence on adoption of hybrid maize. This could be because extension workers in the study area were promoting the production of OPVs rather than hybrids. A reasonable proportion –about one-third of the farm household grew hybrid maize in drought prone environments of the CRV of Ethiopia though research and extension services tend to be reluctant in the development and promotion of hybrid maize in the area lest of drought influences. However, a range of maize varieties are produced including the hybrids and farmers who produce hybrids tend to specialize in maize farming as they allocate larger proportion of their farm plots to maize. Likewise, hybrid production will give an opportunity for private seed sector involvement in seed supply system in the drought prone areas, who had been reluctant to get involved in seed provision of OPVs. Similarly, farmer research group approach that has been used and found effective for promotion of OPV maize and other crops can be employed to enhance the dissemination and adoption of hybrid maize in the CRV of Ethiopia. Considering the level of acceptance and of the factors affecting the adoption of improved maize varieties, maize research, maize seed production and maize extension need to react and pursue proactive measures in providing hybrid maize varieties to smallholders' farmers.

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