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DETERMINANTS OF ADOPTION OF IMPROVED MAIZE VARIETIES IN DEVELOPING COUNTRIES: A REVIEW

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Abstract: This paper provides a synopsis on various studies conducted on adoption of improved maize varieties in developing countries, particularly Africa and South Asia, during last fifteen years. The studies have pointed out a number of socio-economic characteristics, agro-ecological variables, and farmers' perception as important determinants of improved maize varieties in different countries. Among these variables, extension contact, education, farm size, credit availability, use of fertilizer, low land area, yield and profitability are found to be major determinants which have strong positive influences. The adoption studies are found more focused to socio-economic variables in comparison to agro-ecological variables and farmers' perception. Researchers are suggested to consider these variables as important as the socio-economic variables in any adoption studies of agricultural innovations.

Key words: adoption, socio-economic variables, agro-ecological zone, perception

INTRODUCTION

Maize is the third most important cereal crop after wheat and rice. Improving maize production is considered to be one of the most important strategies for food security in the developing countries. The diffusion of the improved maize variety (IMV), i.e. hybrids and open pollinated varieties (OPV) can greatly increase maize yield per unit of land. However, farmers' choice on improved varieties is one of the most crucial factors affecting the productivity of a crop. This is influenced by many factors that affect the farmers' varietal adoption decision (Iqbal et al. 1999; Rogers, 2003).

A large number of adoption studies on maize have pointed out the influences of socio-economic and agro-ecological variables, sources of farm information, and farmers' attitude towards the improved maize varieties on adoption of improved maize varieties. As the studies are scattered, an attempt was, therefore, made to accumulate the findings and overview the most important determinants of adoption of IMV at different agro-ecological domains and socio-economic environments.

Glimpse on statistical methods used

A total of 21 studies on adoption of IMV published on various journals and proceedings were reviewed. Most of the studies were from developing countries of Africa (19) and South Asia (2) which have covered following countries: Nigeria (4), Tanzania (3), Mozambique (3), Kenya (2), Uganda (2), Malawi (1), Cameroon (1), Ghana (1), Zimbabwe (1), Ethiopia (1), Pakistan (1) and Nepal (1). Different forms of regression models, namely logistic model, tobit regression, logit, probit, and spatial and standard tobit model, were found used to analyse farmers' choice between improved and local varieties. The model chi-square was significant in all the studied reviewed and the value was between 18.54 and 87.0. The correct prediction of the models studied was high, i.e. 72.0 to 84.7%. The R^2 was observed within the range of 0.12 (Mc Fadden's R^2) to 0.70 (count R^2). The low R^2 is attributed to the dummy dependent variable. Gujarati (2004) argues that R^2 in the dichotomous response model is much lower compared to the linear model because of dummy or binary dependent variable. The variables taken for the study were found very low, 4 (Iqual et al. 1999) to very high, 41 (Sserunkuuma, 2005). Interestingly enough,

Ephraim and Featherstone (2001) found no significant factor to influence adoption of cross pollinated maize variety in Tanzania. The reason was that more than 90% of sample maize farmers had used improved seeds. This implies that it becomes difficult to identify the significant factors of adoption, if one of the two categories, adopters or non-adopters, is too high.

Socioeconomic variables and adoption of improved maize varieties

Eighteen socio-economic variables were found significant from 21 different studies. Table 1 reveals the fact that age, education, family size, farm size, extension contact and credit availability are the most studied factors. Similarly, gender, group membership, farming experience, livestock holding, land tenancy, use of fertilizer and use of labor are the moderately studied variables. Researchers are seemed to be less interested in studying the influence of off-farm income, marketing distance, use of FYM, ethnicity and farm tools on adoption of IMV.

Table 1: Socio-economic variables studied (N=21)

Variable	Studied	Significant		Effect (Sign)
		Positive	Negative	
Age/age group	15	1	4	+/-
Education	17	8	1	+ (mostly)/-
Family size (Adult equivalent)	14	1	2	+/-
Land holding size	16	9	2	+ (mostly)/-
Off-farm income	3	1	0	+ (*IS)
Group membership	7	3	0	+
Extension contact	13	9	0	+
Access to credit	10	5	0	+
Farming experience on maize	5	2	0	+ (mostly)
Livestock size	6	3	1	+/-
Land tenancy (rented)	4	2	1	+/-
Use of farm yard manure	3	1	1	+/-
Quantity of fertilizer use	4	4	0	+
Gender	7	1	0	+ (IS)
Marketing distance	3	1	2	+/-
Farm hires labor/experience in labor hiring	5	3	0	+
Ethnicity-western people	1	1	0	+ (IS)
Farm tools	1	1	0	+ (IS)

Note: *IS = Insufficient studies

Positive influence of extension contact and access to credit on adoption of IMV has been reported in several studies (Kaliba et al. 2000; Amaza et al. 2007; Langyintuo and Mekuria, 2008; Paudel and Matsuoka, 2008; and Tura et al. 2010). Regular contact with extension agents make farmers being aware of new technologies and how they can be applied, and access to credits enable them to buy inputs required by improved technologies.

Age happens to be one of the human capital characteristics that have been frequently associated with non-adoption of IMV in many adoption studies (Simtowe et al. 2007; Etoundi and Dia, 2008; Langyintuo and Mekuria, 2008; and Cavane and Subedi, 2009). Among the several reasons that could explain the negative effect of age on adoption is the fact that older farmers tend to stick to their old production techniques and are usually less willing to accept change. In addition young people are associated with a higher risk-taking behavior than the elderly as stated by Simtowe et al. (2007). However, Etoundi and Dia (2008) report positive and significant relation between age group and improved maize variety, *CMS 870* in Cameroon. Early adopters of *CMS 8704* were mostly adults. The highest adoption rate was that of farmers aged between 46 and 60 years (58.18%).

Education was found positive and significant in a large number of adoption studies (Nkonya et al. 1997; Ntege-Nanyeena et al. 1997; Iqual et al. 1999; Morris et al. 1999; Paudel and Matsuoka, 2008; and Kudi et al. 2011). It indicates that the more educated household head is expected to be more efficient to understand and obtain new technologies in a shorter period of time than uneducated people. The negative influence of education was also observed in some studies which are very typical to the study area. Tura et al. (2010) justifies his

finding that households headed by literates were relatively less likely to adopt improved maize varieties in Central Ethiopia. Given the fact that the relatively more educated household heads are youngsters and that land ownership among the youth is minimal, hence are land constrained. It was similarly reported in Ethiopia that education influences timing of adoption but not whether to adopt an agricultural innovation (Weir and Knight, 2000). Etoundi and Dia (2008) also observed that farmers having secondary education were less likely to adopt the improved maize seeds, *CMS 8704*. The reason was that most farmers have not reached secondary school and those who have opted for non-agricultural activities. However, having a primary level of education has a positive though not significant effect on the adoption of *CMS 8704* improved maize seeds.

The land holding size returned a positive and significant in several studies (Nkonya et al. 1997; Iqual et al., 1999; Morris et al. 1999; Simtowe et al. 2007; Langyintuo and Mekuria, 2008; and Tura et al. 2010) indicating that households with larger land holdings allocated more land to improved maize. Inconsistent with this finding, Etoundi and Dia (2008) point out that increasing the area diminishes the probability of adopting the improved variety, *CMS 8704*. The reason was that a big sown area with maize requires much manpower and huge resources. Since subsistence farming is essentially the prerogative of woman, as compared to cash crop farming in production systems, it is difficult for a woman early adopter without external or family labor to work on a large area: difficult work like the felling of trees and clearing of farms is reserved for men while ploughing, hoeing, sowing, harvesting and selling are reserved for women.

It is difficult to generalize the influence of family size as compared to access to extension contact because both positive and negative influences have been noticed in case of family size. The family members may be supportive or non-supportive towards adoption of a new technology. Adoption of new technology requires more labour inputs (Feder et al., 1985). If this requirement is fulfilled by the family member, adoption of IMV is likely to be positive. However, Amaza et al. (2007) states that it is likely that farmer with larger families attach greater importance to nonfarm activities than smaller households. Consistent with the notion of Feder et al. (1985), use of hired labor was found positive in most studies (Ntege-Nanyeena et al. 1997; Amaza et al. 2007; and Etoundi and Dia, 2008).

Membership in a group, farming experience and use of fertilizer have generally positive influences (Amaza et al., 2007) while livestock, land tenancy, marketing distance and use of organic manure were found to have both influences. Livestock is generally supposed to be supportive for adoption of new maize varieties as it provides organic manure. If it has significant negative influence on adoption, the reason will be very typical to the study area. Alumira and Rusike (2005) observed negative influence of livestock in adoption of new hybrid seed in Zimbabwe. In justifying this finding, they mention that draft cattle-owning households have more staggered and spatially dispersed cultivation and use proportionately more recycled hybrids because they lack cash and credit to purchase sufficient hybrid seeds to plant all their maize plots.

It is generally perceived that the shorter the distance from the household to the nearest market, the higher the probability of adoption which was also reported by Sserunkuuma (2005) and Langyintuo and Mekuria (2008). Salasya et al. (2007) found a positive correlation between distance to the market and adoption of stress-tolerant maize hybrid, *WH 502,* in western Kenya that implies that farmers do not necessarily purchase inputs from the nearest stockists. Distance may thus be proxying the quality of seeds bought at distant sources, or the reliability of supply.

Ntege-Nanyeenya et al. (1997) mentioned that the odds of adopting the improved maize technology decrease by a factor of 0.24 if a farmer/family owns land compared to farmers who rent land. Farmers who rent their land are more likely to use improved variety to maximize profits. Similarly, Sserunkuuma (2005) reports that maize plots held under the freehold tenure system are more likely to be planted with improved seeds than plots held under leasehold, while plots rented for fixed payment are more likely to be planted with improved seeds than purchased plots, likely because those who rent land tend to be more commercial oriented and are, thus, more likely to use improved seeds to increase yield. Households that use inorganic fertilizers and mulching are more likely to adopt improved maize seeds, while animal manure use and crop rotation are associated with lower adoption of improved seeds.

The role of off-farm income, gender, ethnicity, marketing and farm tool on adoption seems positive but not sufficient to explain as only a

few studies have taken these variables into consideration.

One premise of adoption studies is that factors for adoption of improved agricultural technologies should not be generalized. Adoption study needs contextual specific (type of technology and location) study. For example, 4 different adoption studies conducted in Nigeria have pointed out different significant variables. The socio-economic and agro-ecological variables and farmers' perception on improved technology vary largely even within a country. Consistent with this fact, Amaza et al. (2007) found significant negative influence of farm size on adoption of improved maize varieties in the Guinea Savannas of Nigeria while it was observed positive and significant in the study of adoption of downy mildew resistant maize by small-scale farmers in Kwara State of Nigeria, as reported by Ayinde et al. (2010).

Influence of agro-ecological zones on adoption of IMV

Though the agro-ecological variables have been identified as important variables in some adoption studies (Table 2), they appear less in comparison to the socio-economic variables.

Positive relation between low land area and adoption of IMV was reported by Kaliba et al. (2000), Ransom et al. (2003), and Paudel and Matsuoka (2008). This suggests that those farmers who owned more lowland area had a higher probability to adopt improved maize varieties than those with smaller proportion of lowland area.

Table 2: Agro-ecological variables studied (N=21)

Variable	Studied	Significant	
		Positive	Negative
Upland/highland	4	3	1
Lowland	2	2	0
Low rainfall area	1	0	1
Soil type-clay	1	1	0
Bimodal-low	1	1	0
Bimodal-medium	1	1	0
Unimodal	1	1	0
Low population density	1	0	1
District (Butere/Mumias, W. Kenya)	1	1	0

Ransom et al. (2003), and Paudel and Matsuoka (2008) reported negative effect of upland area on the adoption of improved maize varieties in the hills of Nepal. It is noted that more irrigation is needed for improved maize varieties compared to local/traditional varieties resulting in lower adoption of improved maize varieties in upland area.

However, Cavane and Subedi (2009), and Sserunkuuma (2005) reported positive relation between highlands and adoption of IMV. Cavane and Subedi (2009) mention that farmers in the highlands of Mozambique were slightly more supportive than farmers in the lowlands, of the drought tolerance and maize meal quality of hybrid maize, *SC513*. Similarly, the adopters of IMV were mostly located in the eastern highlands of Uganda. Compared to the bimodal-high agro-climatic zone, the adoption of improved maize seeds is significantly higher in all other zones except the southwestern highlands (Sserunkuuma, 2005). Kaliba et al. (2000) reported that the probability of adopting improved maize seeds for farmers in the lowlands was higher by 25 percent. The lowlands generally receive lower rainfall than the intermediate altitude areas. However, the adoption is higher in lowlands than the intermediate zone. The result can be related to the effect of research and extension activities. Most research and extension activities are conducted in the lowlands to reduce the risk of production associated with low rainfall. Ilonga Research Station (Eastern Zone), a lead center for maize research in Tanzania, is in the lowlands and so are the other outreach research stations, i.e., Hombolo in the Central Zone and Mubondo and Tumbi in the Western Zone. The presence of these research stations may affect adoption positively as most of the on-farm evaluation and demonstration trials are conducted within the vicinity of the research stations.

High levels of adoption of improved maize varieties and chemical fertilizers are more likely to be found among farmers located in regions with high rainfall (Kaliba et al., 2000; Hintze et al., 2003). Alumira and Rusike (2005) reported that that farmers are more likely to invest in hybrid maize seeds for cultivating clay

soil in Zimbabwe, because they perceive it as having higher inherent fertility, which gives a better payoff than sandy loams if the rainfall is good.

Based on the studies, it seems that lowland area, high rainfall and clay soil are likely to favour the adoption of IMV.

Farmers' attitude and adoption of IMV

Though the importance of studying farmers' attitudes on innovation characteristics has been focused in several studies (Feder et al. 1985; Neupane et al. 2002; Rogers, 2003), they are less common in adoption studies alike to the agro-ecological variables. Table 3 reveals that generally the farmers perceive IMV as higher yielding, profitable and market oriented than the local varieties (Kaliba et al., 2000; Akpoko and Yiljep, 2001; and Cavane and Subedi, 2009, Cavane, 2011). Farmer's perception on an innovation largely depends upon their knowledge and information about the innovation, socio-economic conditions and agro-ecological variables. Farmers' knowledge on improved agricultural technology can be accelerated with the help of extension agents and farm information sources. Preference of short maturing or intermediate or long maturing varieties depends upon farmers' evaluation on yield and total benefit accrued from the variety within one year. So, sometimes farmers can prefer intermediate and even long maturing varieties as reported in the studies of Kaliba et al. (2000).

Table 3: Perceived attributes of IMV studied (N=21)

Variable	Studied	Significant	
		Positive	Negative
Knowledge of advantages and disadvantages of IMV	2	2	0
Yield	4	4	0
Maturity			
Long	1	1	0
Intermediate	1	1	0
Winter maize cultivation	1	1	0
Number of maize season in a year	1	1	0
Marketability	3	3	0
Traits	1	1	0
Cost (local variety less costly)	1	0	1
Availability (local variety more available)	1	0	1
Profit	2	2	0
Ability to purchase required amount of fertilizer	1	1	0
Timely availability of fertilizers	1	1	0

CONCLUSION

The essence of the review is that adoption studies should not be generalized since it needs location and technology specific study. However, it should not be ignored that extension contact, education, farm size, credit availability, use of fertilizer and low land area the major determinants of adoption of improved maize varieties in these area which have strong positive influences. Similarly, farmers' perception of higher yield and profitability in IMV should be highlighted through extension agents and information sources to enhance the adoption rate of IMV. Researchers are also suggested to study the influences of agro-ecological variables, farm information sources or communication channels and farmers' perception on adoption of agricultural innovation which are equally important to the socio-economic variables.

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