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Determinants of the probability of adopting quality protein maize (QPM) technology in Tanzania: A logistic regression analysis

T. Gregory [1*], P. Sewando [2]

[1] *Selian Agricultural Research Institute (SARI) Arusha, Tanzania*
[2] *Community Development Training Institute (CDTI) Tengeru, Arusha Tanzania*

Abstract

Adoption of technology is an important factor in economic development. The thrust of this study was to establish factors affecting adoption of QPM technology in Northern zone of Tanzania. Primary data was collected from a random sample of 120 smallholder maize farmers in four villages. Data collected were analysed using descriptive and quantitative methods. Logit model was used to determine factors that influence adoption of QPM technology. The regression results indicated that education of the household head, farmers' participation on demonstration trials, attendance to field days, and numbers of livestock owned have positively influenced the rate of adoption of the technology. Access to credit, and poor QPM marketing problem perception by farmers negatively influenced the rate of adoption. The study recommended government to ensure efficiency input-output linkage for QPM production.

Keywords: Adoption, Quality Protein Maize, Technology, Logit model

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* Corresponding author. *E-mail address:* theresiagregory@yahoo.com

1. Introduction

Maize accounts for 31% of the total food production and constitutes more than 75% of the cereal consumption in the Tanzania (Msuya et al., 2008). Maize represents about 30 per cent of the value of crop production in the country and 10 per cent of total value added in agricultural sector respectively (Ibid). The main maize producing areas are southern highlands and northern regions. Normal maize contains limited contents of lysine and tryptophan that are important, amino acids (FAO, 1992; Bressani, 1991). This reduces its protein quality for humans and monogastric animals like pigs.

Maize breeders have done a series of processes in maize breeding in search for better quality maize. Initial breeding efforts at International Maize and Wheat Improvement Center (CIMMYT), focused on conversion of a range of sub tropical and tropical lowland adopted, normal endosperm populations to *opaque-2* (o2) [a] versions through a backcross- recurrent selection procedure with a focus of accumulating the hard endosperm phenotype, maintaining protein quality and increasing yield and resistance to ear rot.

The improved populations were released for direct use in the field as open pollinated varieties (OPVs) or individual plants were self pollinated to form inbred lines used in hybrid formation. The efforts have resulted into a type of maize known as Quality Protein Maize (QPM). As a result many cultivars (both OPVs' and hybrids) with improved protein quality were developed for temperate, tropical highland, and for subtropical and tropical lowland growing conditions. The resulting genotypes with elevated lysine and tryptophan content relative to normal maize but without the negative soft opaque grain were termed by CIMMMYT as Quality Protein Maize (QPM).

QPM holds superior nutritional and biological value and is essentially interchangeable with normal maize in cultivation and kernel phenotype (Prasanna et al., 2001). This type of maize has twice the amounts of two essential amino acids namely Lysine and Tryptophan than normal maize (Table 1).

Table 1. Lysine and Tryptophan in whole grain flour of normal maize and QPM.

Parameter	Levels in whole grain flour (Normal maize) (%)	QPM (%)	Requirement for Pre school child (2-5 yrs) [c] (Kcal)
Lysine [a]	1.6 - 2.5 (Avg 2.0)	2.7 -4.5 (Avg 4.0)	5.80%
Tryptophan [b]	0.2 – 0.5(Avg 0.4)	0. -1.1 (Avg 0.8)	1.10%

[a]Moro et al. (1996).[b]CIMMYT Report (2005). [c]FAO 1985, Energy and protein requirements. FAO, Rome

QPM looks and performs like normal maize (Figure1). It is produced using normal breeding technique and hence not genetically modified (GMO).Can be reliably differentiated only through laboratory tests. Overall, the QPM is expected to contribute to household's food security, income generation and also reducing malnutrition problems, especially in children, (Ibid). It will also help reducing feed costs in livestock production.

In Tanzania, the National Agricultural Research Systems (NARS) in collaboration with CIMMYT and SG 2000 released three varieties of QPM in 2001, two hybrids Lishe H-1 and H-2, and one Open Pollinated Variety called Lishe K-1. These varieties were officially released after their advanced yield trials data and farmers' assessment data compiled by originating Breeder and tabled for Variety Release Committee (VRC) for discussion before the varieties were released. Later on the committee was satisfied by the merits of the varieties and were released. Tanzania Official Seed Certification Institute (TOSCI) conducts continuous seed certification every year for the released varieties. So far TOSCI has no laboratory facilities for testing QPM protein contents standards. These laboratories are in CIMMYT Mexico and Ethiopia. In Tanzania this exercise is done by the researcher to assure its standard by the use of Light Table Test in the process of variety release.

1.1. Problem statement

Adoption of technology is an important factor for economic development especially in developing countries. In order to attract more investment in agricultural research, there is a need for researchers to produce evidence that research and technology dissemination investments have been competitive compared to other alternatives (Anandajayasekeram, et al., 1996). A study on adoption of improved technology is important because it will generate key indicators for measuring farm level impact so as to improve farming practices.

Bearing in mind the importance of QPM in human diet as nutritional staple food which can be produced and consumed by many households like normal maize there was a need therefore, to understand its status of adoption as well as factors that contribute to its adoption. So far various QPM promotional activities like field demonstrations, field days, leaflets/brochures distribution, various recipes and QMP seeds production have been conducted by Selian Agricultural Research Institute (SARI), in the Northern Zone of Tanzania since the inception of the QPM project in 2003. However, with all these promotion efforts, the adoption status is low. Furthermore there is little or no empirical information, to the researchers' knowledge which can establish the factors behind such situation as far as the status of QPM technology adoption is concerned. Therefore, there was a need of conducting a study on the factors that influence its adoption in the Northern Zone specifically in Hai and Babati districts.

The study is useful in documenting whether the introduced technology (QPM) has been accepted by the targeted group and for researchers, extension officers and policy makers as an input. The Results from this study will help the researchers to refine their technology to suit farmers' and consumers' needs. The findings will facilitate in drawing the implication for stakeholders to design strategies for scaling up adoption of this technology so as to attain sustainable productivity, improved farmers' livelihood, ensured food security, increased rural income and ultimately poverty reduction in the country.

1.2. Methodologies employed in adoption studies

Both probability and purposive samples are used in adoption studies. Large samples are normally used especially when rigorous econometric analyses are involved. Formerly multivariate linear regression analysis was the common analytical tool for determinant of adoption but the linear probability model (LPM) and cumulative distribution function (CDF) are becoming popular (Bisanda et al., 1998; Feder, et al., 1985; Ntege-Naneenya et al., 1997). CDF models take into consideration of non-linear characteristic, which is typical in adoption data. Although LPM is the simplest, it has limitations. Estimated probabilities for LPM may fall outside the 0-1 bounds. It also suffers non-normality and heteroscedasticity problems.(Gujarati, 1995). CDFs include Probit and Logit probability models as suggested by Gujarati (1995).

Probit and Logit models measure the relationship between the strength of stimulus and the proportion of cases exhibiting a certain response to the stimulus. These models are appropriate tools in situation where there is a dichotomous output that is thought to be influenced by levels of some independent variable(s). Moreover, they are useful in estimating the strength of stimulus required to induce a certain proportion of responses, such as the probability of adoption resulting from farming experience. The models are quiet appropriate analysing cross sectional data with binary dependent variable. In some cases they have been used to analyze time- series-cross-section (Beck et al., 1997).

The difference between the two models is that Logistic curve has flatter tails than probit curve. Probit curve approach the axes quickly than Logistic curve. A Logistic estimate of a parameter multiplied by 0.625 gives a fairly good estimate of probit mode, (Ibid.). Choice between the two models is that of mathematical convenience and ready availability of computer soft ware.

Logit model has been widely used in wheat and maize studies. For instance, in southern highlands of Tanzania.a logistic regression model was used to analyse factors affecting adoption of improved wheat (Mwanga et al., 1999). They found that household size; farm size and extension contact had significant influence on adoption of improved wheat varieties. The same model was used in maize study in Uganda and wheat study in Ethiopia by Ntege-Nanyeenya, et al. (1997) and Ensermu et al. (1998) respectively. Using the model, Ibid. found that education, farmers' group and land tenure had statistically significant effect on adoption of improved maize. The logistic model is also applicable in analysis of land conservation technologies. For example logit regression model was used to analyse factors influencing adoption of soil conservation in Tanzania (Kalineza et al., 1999; Senkondo et al., 1998). It was also used in Tennessee by Roberts et al. (2002) to determine factors affecting the location of precision farming technology. Also Heissey et al. (1993) used the logit model to determine adoption of new wheat varieties in Pakistan. Nzomoi et al. (2007) applied the same model to assess determinants of technology adoption in the production of horticultural export produce in Kenya.

2. Material and methods

The study was conducted in Babati and Hai district. Babati district is one of the five districts in Manyara region and Hai district is one of the six (6) districts in Kilimanjaro region. These districts are located in the Northern zone of Tanzania.

2.1. Research design

Non-experimental design was employed whereby cross sectional research design was used. The design allows for descriptive analysis as well as for exploring and verification of relationships between variables. The target population of the study was maize farmers.

2.2. Sample size and sampling procedures

In consultation with the farming systems/socio-economics department of SARI, and DALDOs, multistage purposive sampling techniques were employed to select districts, wards and villages. Two districts were selected purposively one from Kilimanjaro Region (Hai district) and the other one from Manyara region (Babati district) from where by two wards (Mamire and Bonga in Babati; Masama South and Machame North in Hai District) were also purposively selected basing on the fact that these districts, wards and villages were the pilot area for Quality Protein Maize Development (QPMD) project for the Horn and East Africa 2003.

Table 2. Distribution of the sample

District	Ward	Villages	Sampled household head
Babati	Mamire	Endakiso	30
	Bonga	Bonga	30
Hai	Masama South	Mungushi	30
	Machame North	Nshara	30
Total			**120**

Therefore various promotional and dissemination activities like field demonstrations, field days, various recipes production and seeds production have been conducted in these areas since the inception of the project. One village was selected from each ward, making a total of four villages for the study. The villages selected were Endakiso, Bonga (Babati), Mungushi and Nshara (Hai). An entire list of maize farmers' households' heads was prepared during the introductory visit with the help of Village Agricultural Extension officer (VEOs). From this list a total of 30 maize farmers household heads from each village were randomly selected making a total of 120 sampled household heads that were used for the interview (Table 2).

2.3. Data collection

Both secondary and primary data were collected for the study. Secondary data sources included published and unpublished information, research reports, scientific papers, journals, books, and various reports from Sokoine National Agricultural Library (SNAL), District Agricultural and Livestock Development Offices (DALDOs) and different websites on the internet.

Primary data were collected from household head using semi-structured questionnaire. The questionnaire was pre-tested in a pilot survey in the district in order to determine their relevance and the quality. After the pre testing, the questionnaires were revised to obtain the final version. Modified version of the questionnaire was used to solicit information from farmers.

The enumerators who administered the questionnaires underwent a preparatory training before embarking on the field work. This was necessary in order to avoid unnecessary mistakes in data collection. Interviews were done at farmers homestead and where necessary on farmers field.

2.4. Data analysis

The data collected was analysed using SPSS and STATA software version 8 for Logistic regression analysis so as to determine factors affecting adoption of QPM technology. Regression analysis was carried out to establish causal-effect relationship. In this study, Cumulative Distribution Functions (CDF) specifically logit model was used to determine the influence of a number of pre-indicated variables on adoption of QPM technology. Choice of independent variables was based on literature review, and socio-economic theory governing the adoption of innovation.

2.4.1. Model for adoption behaviour

Quite a large number of studies have investigated the influence of various socio-economic, cultural and political factors on the willingness of farmers to use new technologies. According to Adeogun et al. (2008, p.469) "In many of the adoption behaviour, the dependent variable is constrained to lie between 0 and 1 and the models used were exponential functions while univariate and ultivariate logit and probit models including their modified forms have been used extensively to study the adoption behaviour of farmers and consumers". Shekya and Flinn (1995) have recommended probit model for functional forms with limited dependent variables that are continuous between 0 and 1 and logit models for discrete dependent variables.

In this study, the responses recorded are discrete (mutually exclusive and exhaustive) and therefore, a univariate logit model was developed to analysed the adoption behaviour of farmers to hybrid catfish. The logit model, which is based on cumulative logistic probability functions, is computational easier to use than other types of models and it also has the advantage to predict the probability of farmers adopting any technology.

Hence the study aimed at identifying the critical determinants of farmers' adoption to QPM. To attain this, a logistic regression model was estimated against a set of demographic, socio-economic and institutional factors. The logistic regression model is defined by a latent variable y* which is presented by the relationship equation

$$y^* = \beta^I x_{ij} + u_i$$

where x_i and u_i are normally distributed with mean and common variance.

2.4.2. Specification and estimation of the Logit Model

Therefore the present study employed a logistic regression model to determine factors influencing adoption of QPM technology. The model is a probabilistic model that explains the possibility that one will select to adopt new varieties given a combination of factors (socio-economic variables). The model was specified as:

$$\log\left(\frac{p}{1-p}\right) = \alpha + \beta_1 AGEHH + \beta_2 SEHH + \beta_3 FEDYE + \beta_4 HHSIZE + \beta_5 HWON + \beta_6 FARSIZ + \beta_7 FAFFD + \beta_8 FTRAI + \beta_9 DEMTRI + \beta_{10} LIOH + \beta_{11} CREF + \beta_{12} EXTC + \beta_{13} QPMK + \varepsilon$$

2.4.3. Factors influencing adoption of QPM technology

The factors hypothesized to influence the adoption of QPM technology are listed in Table 4. In this study, three aspects were considered in the analysis of factors associated with the adoption of QPM: Farmers' demographic characteristics (e.g., age, gender, education level household size); farmers' socio-economic factors (e.g., farm size, livestock ownership); and institutional support systems available to farmers (including; credit, extension, Research and seed source).

Table 3. The list of factors affecting adoption

Variable	Variable label	Exp. sign	The theory and logic behind
X_1= AGEHH	age of the household head	+ or -	The age of a farmer can generate or erode confidence; in other words, with age, a farmer can become more or less risk-averse to new technology
X_2 = SEHH	sex of the household head	+ or -	Female or male –headed households can have different adoption rates. Female headed households have less access to resources than male head households.
X_3=FEDUYR	Education level of the farmer	+	Level of education is assumed to increase a farmers ability to obtain, process and use information relevant to adoption of technology
X_4= HHSIZE	Number of people in the household	+	Large households will be able to provide the labour that might be required by new technology. Thus household size could be expected to increase the probability of adopting QPM technology

Variable	Variable label	Exp. sign	The theory and logic behind
X_5= HHWON	Number of household working in the farm	+	Household labour is the most dependable source of labor. Thus, large households with more labour supply are expected to adopt labour intensive technologies.
X_6 =FARSIZ	farm size	+	Large scale farmers have more freedom in allocating land to new crops. They also have access to information and credit since land is used as collateral.
X_7=FAFFD	Farmers attendance to farmers field day	+	. Farmers who have attended QPM field days are expected to have positive attitude to the adoption of QPM technology
X_8=FTRAI	Farmers attendance to farmer training	+	Farmers training is a key element in exposing farmers to new information and subsequently adoption
X_9=DEMTRI	Participate in demonstration trials	+	Farmers participation in demonstration trials are expected to recognize the benefit of adopting the technologies demonstrated and hence to be more likely to adopt them.
X_{10} = LIOH	Livestock ownership	+	Livestock stand for wealth in agro-pastoralists society. In general term, rich farmers are better placed in terms of risk bearing
X_{12}=CREFA	Credit facilities availability	+	Access to credit can relax farmers' financial constraints and, in some cases, is tied to a particular technology package
X_{13} =EXTC	Frequency of extension contacts/visit	+	The more visits the farmer get from extension agent the more informed about the innovations the farmer becomes. Contact with extension agents was hypothesized to increase a farmer's likelihood of adopting QPM technology.
X_{15}= QPMK	QPM marketability	+	Farmers' subjective perception on the characteristics of an innovation will influence the decision to adopt. Farmers who are informed on marketability and utilization alternatives of a variety will tend to adopt it faster than non –informed.

3. Results and discussion

3.1. Characteristics of Adopters and non-adopters

In this study the characteristics of households which are known to be associated with adoption are divided into demographic, socio-economic and institutional perspectives. Generally these are as shown in Table 4 below.

Table 4. Household characteristics of the sample

Characteristics of household head	**Adopters (n= 30)**		**Non-adopters (n=90)**	
	Mean	**SD**	**Mean**	**SD**
Age (years)	48	13.8	45.1	11.9
Household size	6.6	2.6	5.9	2.7
Farming experience (years)	22.2	12.9	22.3	22.5
No. of years in schooling	7.1	2.6	6.4	2.2
Farm size (acres)	4.3	3.1	3.5	2.8

3.1.1. Demographic characteristics of the head of the household

The demographic characteristics include age, education level, family size, and sex. The household head characteristics of sampled household, (QPM adopters and non-adopters) are shown in Table 4. The mean age of household head of adopters was 48 and 45 years for non adopters. The age was significantly different at ($p<0.05$). Household heads for adopters were older compared with household heads for non-adopters. No significant difference was found in the number of years in schooling. The mean number of years was 7 and 6 for adopters and non adopters respectively. Farm size and farming experience between adopters and non adopters of QPM technology had no significant differences. The average number of years of farming experience of both adopters and non adopters of QPM technology was 22 years. The study showed that there was significant difference in household size ($P<0.001$) between adopters and non adopters. In the study area, the average households' size for adopters was comparatively higher than the non-adopters. The mean household size of the adopters and non-adopters was approximately 7 and 6 persons respectively. This suggests that adoption of QPM technology was associated with large household sizes. This is because for smallholder farmers, household labour is the most depended source of labour.

The results show that thirty (30) household heads out of 120 randomly selected for the study were adopters of QPM technology while the remained 90 were non adopters. The household head characteristics of adopters and non adopters are presented in Table 4.

The household heads sex become critically important in circumstances where the farming community allocates responsibilities based on sex differences. The results show that there was significant difference in distribution of household heads by sex with the non adopters having large number of male headed households 74.4% and 36.6% female headed households compared to adopters. About 60% of adopters were male- headed while 40% were female headed household.

Table 5. Household heads distribution by sex

Sex	Adopters		Non adopters	
	Frequency	Percent	Frequency	Percent
Male	18	60	67	74.4
Female	12	40	23	25.6
Total	30	100	90	100

3.1.2. Socio-economic characteristics of the household head

The socio economic characteristics (farm size, off farm activities and livestock owned) are among the variables which affect the uptake of technology. The following are the findings concerning the variables.

a) Farm size

The mean farm size for the sampled households was 1 hectare (3.68 acres) of which 51% was under maize in 2007/08 cropping season. Adopters possessed more land than non adopters in terms of total farm size although the difference was not significant. The average area of land allocated by adopters and non-adopters for maize production was 0.5ha and 0.3ha respectively. Maize, beans, pigeon peas and sunflower are the most important crops grown. Maize was the first-ranked crop grown, for both adopters and non-adopters followed by pigeon peas for Babati and beans for Hai district. Sunflower was the third important crop grown in both Districts.

b) Off-farm activities

Off-farm activities are sources of additional income which may encourage or discourage investment in new technologies. In this study the main off-farm activities were casual labour, salary employment, carpentry and petty business. Table 6 shows that 36.7% and 56.7% of the sampled adopters and non adopters involved in off-farm activities respectively. There was significant different ($p<0.01$) in number of adopters and non adopters involved in off-farm activities. The results showed that adopters are less involved in off-farm activities than non-adopters of QPM technology. Casual labour was the type of work mostly reported to be done by adopters (55.6%) and there was significant difference ($P<0.05$) between adopters and non adopters.

This indicates that the availability of labour in local markets would affect technology adoption. When there is local labour market, farmers can hire labour once needed. The household's members may also sell labour to obtain cash when necessary.

Table 6. Off-farm activities

Characteristics	**Adopters**		**Non-adopters**		**χ2 statistic**
	Response	**Percent**	**Response**	**Percent**	
Involvement in off farm					
Yes	19	36.7	51	56.7	3.33*
No	11	63.3	39	43.3	
Total	**30**	**100**	**90**	**100**	
Type of work					
Casual labour	10	55.6	15	30.6	7.95**
Salaried employment	2	5.6	13	24.5	
Carpentry	2	5.6	9	18.4	
Petty business	6	33.2	13	26.5	
Total	**20**	**100**	**50**	**100**	

**=Significant at 10% level, **=Significant at 5% level*

c) Livestock owned

The study shows that, the average number of livestock kept per household for adopters was 3 cows, 2 bull, 5 goats, 2 sheep, 3 pigs and 13 chicken and 2 cows, 2 bulls, 5 goats, 3 sheep, 2 pigs and 9 chickens for non-adopters (Table 7). These results indicate that adopters are more livestock keepers than non-adopters. However, there was no significant difference between adopters and non-adopters with regard to most livestock types.

Table 7. Number and type of livestock owned

Livestock type	Adopters		Non adopters	
	Mean	SD	Mean	SD
Cows	2.96	2.36	2.37	1.34
Bulls	2.37	1.33	2.11	1.04
Goats	5.10	4.02	4.71	6.31
Sheep	2.30	1.02	2.51	2.55
Pigs	2.50	2.50	2.04	0.67
Chicken	13.37	10.56	8.89	10.57

3.1.3. Institutional characteristics

An institution is a set of behavioural rules that govern and shape the interactions of human beings, in part by helping them to form expectations of what other people will do. Such institutions supporting systems include extension services, research, seed/input provisional services (inputs stockists) and credit facilities. Institutions are considered as mechanisms used to structure human interactions in the face of uncertainty, and as they are formed to reduce uncertainty and risk in human exchange. Institutions help human beings to form expectations of what other people will do (Kirsten et al., 2009).

a) Extension services

Extension is known to catalyze awareness, organization, exchange information and technology adoption among farmers. Extension service is crucial in uptake and adoption of improved technologies. The number of extension workers per unit of population influences extension delivery. In the study area, about 54% and 27% of the QPM adopters and non-adopters had access to agricultural extension services respectively. This indicates that most of the sampled household heads did not receive extension visits. This is probably due to lack of appropriate means of transport and wider coverage per extension worker as it has been reported by the respondents that there was only one extension worker per division in the surveyed area. The study by Baidu –Forson (1999) observed that adoption was higher for farmers having contact with extension agents working on agro forestry technologies than farmers who have never experience any extension contacts.

b) Access to credit

About 26.7% of adopters and 54.4% non adopters reported to access credit facilities in their area (Table 9). In the study area there was none formal credit facility for maize production. This demonstrates that credit facilities that exist provide credits for other activities. The major problems that were reported about credit facilities that were available are, long processes in obtaining credits, short repayment period and lack of information. Credit sources in the study area are SACCOS, VICOBA, BRAC Cooperative union and World Vision.

c) Membership to farmers' organization /group

Being a member of farmers group put a farmer in a privileged position in relation to other farmers. Group members have better access to technical information and receive preferential treatment from extension workers and other development agents. In the study area, these groups are organized by researchers and other development agencies in various agricultural aspects. Examples of these are Kware Lishe group, coffee cooperative society and Mkombozi of Hai and organic farming, Dairy goat groups and sunflower production group of Babati. About 70% of adopters and 33% of non-adopters had membership in farmer organizations/groups.

3.2. Farmers preferences on QPM technology attributes

Farmers are consumers of the products of agricultural research and their subjective preferences for characteristics of new agricultural technologies affect their adoption decisions. QPM technology attributes is very important aspect for it to be adopted. Farmers' preferences on QPM technology characteristics were assessed by farmers who had attended either of the QPM field days conducted by researchers in 2004 or 2005 or 2006 or/ and 2007) in QPM promotion and dissemination activities. During field days farmers are exposed to QPM technology and also to various QPM dishes for them to test. During the survey only those farmers (adopters and non-adopters) who reported to have attended one of the field days were asked to answer the preference question. Farmers reported the selected characteristics of QPM as they perceive it. The score as per questionnaire ranged from one to five that is, very good to very poor (1-5). This allowed comparison of QPM and normal maize varieties for a range of agronomic, processing, and cooking characteristics, particularly those considered important by local farmers. The value of scores showed to what extent the farmer is in favor of the attribute of the characteristic involved. Early maturity, pound ability, taste for ugali and porridge and cooking quality attributes were perceived to be good (55%) of the sample farmers. For resistant to drought, field pests, storage pests, and resistant to diseases, QPM was perceived to be good by majority (61%) of sample farmers. For marketability attribute, QPM was ranked poor by the majority adopters who have sold QPM.

3.3. Factors affecting the adoption rate of QPM

Adoption of QPM technology was analysed using logit analysis model. The model predicts the probability of these factors influencing farmers QPM technology adoption.

3.3.1. Logistic model estimates

Estimation of the adoption model included different explanatory variables (regressors) presented in Table 8. The Maximum Likelihood Method was used for estimating the variable coefficients and marginal effects (elasticities) of regressors on the probability of adopting QPM technology. The variables included in the model were as specified in Table 3. All variables included in the model possess the hypothesized direction of influence on the probability for farm household to adopt QPM technology.

Results from Table 8 indicate that number of years in schooling (FEDUYRS) of the household was significant at ($p< 0.1$) and positively influences the adoption of QPM technology. This confirms with the expected sign. Furthermore, it suggests that a unit increase in number of years in schooling increases the probability (likelihood) for a household to adopt the technology by 45% (marginal effect). Nkonya et al., (1997) have found a positive relation between education level of the farmers and the adoption probability of improved maize seed in northern Tanzania. Ersado et al. (2004) in their study on productivity and land enhancing technologies in northern Ethiopia have found that more educated household's heads are well informed and receptive, which translates into a higher likelihood of engaging in new technologies.

Number of livestock owned by the household (LIOHH) was positive and statistically significant at ($p<0.1$). This entails that a unit increase in number of livestock increase the probability of the household to adopt the QPM technology by 6% (marginal effect). Pitt and Sumodiningrat (1991) note that the positive relationship that they identify between adoption of high-yielding varieties and the value of livestock holdings may be related to the effect of the diversity of income sources on a household's willingness to take on a riskier investment.

Participation of farmers on on-farm demonstration trials (DEMTRIA) was statistically significant ($p<0.01$) and positively associated to the rate of adoption of QPM technology (Table 8). The results suggest that participating in on-farm demonstrations increases the probability of adopting the technology by 54% (marginal effect). Zhang et al. (2002) examine the adoption of HYV (high yielding variety) seeds in India, suggested that demonstration fields could be used to speed up the adoption of technology

Table 8 shows that attendance to farmers' field days (FAFFD) was statistically significant at $p<0.05$ level and positively related to the rate of adoption of the technology. This implies that attending farmers' field day increases the farmers' likelihood to adopt the technology by 11% (marginal effect). Farmers' perception on QPM market problem (QPMKTPR) was strongly significant at 0.01 levels but negatively related to rate of adoption of QPM technology. This is contrary to the hypothesized sign.

Unexpectedly access to credit by household head (ACCRED) in the study area was strongly significant ($p<0.01$) but negatively related to rate of adoption of QPM technology (Table 8). This was also contrary to the expected sign and economic theory too. As household access credit in the study area the probability to adopt QPM technology decreased by 16% (marginal effect). This means that the accessed credit was not invested on the technology in question resulting into low (25%) rate of adoption. This is probably due to the fact that there is non credit facility for maize production in the study area as reported by the respondents (Table 8). These results comply with that of Tovignan and Nuppenau (2004) where access to credit was found to be negatively related to organic cotton adoption decision whereby organic farmers had no official credit system reserved for conventional farmers.

Table 8. Logit model results for factors influencing the adoption of QPM technology

variable	Parameter estimate	Marginal effects (dy/dx)	Std error	Probability
AGEHH	0.03	0.00	0.41	0.48
SEHH	0.88	0.36	1.28	0.49
FEDUYRS	0.45	0.02	0.22	0.06*
HHDSIZE	0.07	0.00	0.18	0.69
HHWONF	-0.76	-0.00	0.39	0.85
FARSIZE	0.12	0.00	0.16	0.46
FTRAI	-1.47	0.06	1.25	0.24
FAFFD	2.17	0.11	1.11	0.04**
LIOHH	3.26	0.06	1.85	0.08*
DEMTRIA	4.75	0.54	1.52	0.00***
EXTCO	-0.03	-0.00	0.35	0.93
QPMRKTP	-1.13	-0.05	0.34	0.00***
ACCRED	-3.82	-0.16	1.37	0.03**
Constant	-8.79		4.19	0.04

*Number of observation =120; Pseudo R^2=0.69; LR chi^2=93.39; Log Likelihood=-20.78; Prob. > chi^2=0.00Note: * Indicates significance at 10% level, ** Significance at 5% level and *** Significance at 1%*

4. Conclusion and recommendation

The general objective of this study was to establish the variables which determine adoption of QPM technology. However, in the study area the rate of adoption of the Quality Protein Maize is low. From the results of the logit model, it can be concluded that number of years spent in schooling by the farmer, farmers' field day attendance, number of livestock owned by the farmers and farmers' participation on demonstration trials are significant factors that influenced positively the probability of farmers to adopt the QPM technology. Moreover, access to credit services and perception of farmer on poor QPM marketability are significant factors that negatively influenced the likelihood of farmers to adopt the technology in the study area. This means that there are no credit facilities for maize/QPM production also information on the technology and its marketing.

The following recommendations are suggested towards increasing adoption rate of QPM technology in Babati and Hai districts and Tanzania in general. To make the QPM adoption more successful, efforts to sustain QPM seed sources (public, private and CBOs) at all levels especially at village levels to ensure timely availability is crucial, More farmers' training and seminars need to be conducted by researchers and extensionists to increase knowledge on nutritional value of the new technology, production and marketing among farmers, Promotion and dissemination activities (such as on farm demonstrations and field days) of QPM by researchers and extension officers to create more awareness to diverse groups including advocacy at all levels for support and partnership, and need to improve the variety development for QPM by breeders in order to increase its production potential.

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