Factors Affecting Adoption of Improved Maize Varieties in Western Hills of Nepal - A Tobit Model Analysis

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ABSTRACT

Maize is the most important cereal crop of hills of Nepal which is used as food for consumption and fodder for animals. A survey was carried out in Baglung and Palpa districts of western hills of Nepal to find out the determining factors of the adoption of improved maize varieties. The number of households sampled from each of the district was 90. Semi structured questionnaire was administered to 180 households chosen using simple random sampling. The most popular improved varieties in the study sites were Manakamana-6, Rampur composite and Arun-2. There seems to be a gap between the recommended practice and current level of practice at the farmers' level in some of the factors like nitrogenous, phosphorus and potassium fertilizers, method of planting. The factors affecting the adoption of improved maize varieties were measured using the Tobit Regression model. Eight socioeconomic variables were taken into consideration for the study. The major socioeconomic variables taken in the study were age, gender, educational status, membership of the farmers' group, extension contact, family size, farm size, farming experience and access to credit. Educational status, extension contact, farm size and access to credit were found statistically significant. Each unit increase in these variables, increases the intensity of adoption of improved maize varieties by 7.14, 12.47, 1.9, 5.2 and 1.6 percentage respectively. Policy that enhances farmers' access to credit, well equipped extension workers, education will facilitate adoption through increased access to seeds of improved maize varieties and will enhance the intensity and rate of adoption.

KEYWORDS*:* Adoption, Maize, Tobit

Introduction

Maize is the second most important crop in Nepal. It is cultivated in 882,395 hectares of land. Its total production is about 2,145,291 metric tons. Its average productivity is 2,431 kilograms per hectare (MoAD, 2016). The hill area that extends from east to west is the most important maize growing area. Eastern, central and western hills are the highest maize growing areas of the country. Maize is the most important cereal crop in the hills of Nepal, where the grain is used for human consumption and the stover for animal fodder. It is usually used for food, feed, fodder, and fuel and is significant source of energy (Adhikari, 2008). Seed replacement rate in maize is about 11.3% (Pokharel, 2013). More than two thirds of the maize produced in the mid hills and high hills is used for direct human consumption at the farm level and the ratio of human consumption to total production is higher in less accessible areas (Paudel, 2008). Only about 16% of Nepal's total land area is cultivated. Of this, the terrain, where 38% of the land area is cultivated, is the most important. Maize is the third most important crop here after paddy and wheat. The second most important agricultural land area is the mid hills where 15% of land is cultivated. Out of the total maize area about 78% falls in the hills area (mid hills 70%, and high hills 8%). Maize is generally grown under rain-fed conditions in Nepal with basal application of low quantity of farm yard manure. Unavailability of quality seeds of farmer's preferred varieties at right time, in desired quantities and at reasonable price is the major constraint for increasing the production (Adhikari *et al*., 2003). Most of the farmers keep their own seeds year after year. More than 88% of farmers used farm saved seeds (Gurung, 2011). Maize yield fluctuates seasonally and annually, especially in the hills. Although maize yields increased slightly over the past five years, there has been very little yield improvement when compared to nationwide yield 30 years ago. This is probably due to the expansion of maize cultivation into less suitable terrain, declining soil fertility, and the adoption of improved management practices. While productivity in the country is almost stagnant, the overall demand for maize driven by increased demand for human consumption and livestock feed is expected to grow by 4% to 6 % per year over the next 20 years. Thus, Nepal will have to resort maize imports in the future, if productivity is not increased substantially. National average yield of maize is 2.5 t/ha. Where maize is grown, farmers often do not apply adequate amounts of fertilizer. Even when applied, the basal application, which is crucial from the production point of view, is missed. Application of fertilizer is very important for increasing the productivity (Tiffen, 2003). The maize yield of different maize varieties respond positively to seed rate (Pinter *et al*., 1994). Recommended seed rates usually result in increments in maize yield (Lucas, 1986). Generally, the presence of weeds for the first six, nine and twelve weeks after sowing and for the entire growing season of maize resulted in estimated yield losses of 36, 61, 80, and 85%, respectively (Assefa, 1999). The technology adoption index is a catch-all measure of technology practices of the farmers (Timsina *et al.,* 2012). Technology adoption index measures the adoption level of the number of practices of any technology. The technology adoption index in the western hills of Nepal is calculated to be 63%. Rampur composite, Manakamana-6 and Arun-2 are the popular varieties in the hilly areas whereas the varieties Manakamana-1 and Manakamana-5 are being disadopted by the farmers (Lamichhane *et al*, 2015).

The decision of whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, institutional and socio-economic factors (Feder *et al*, 1985). Depending on the context, these can include demographic characteristics of the household (size, age of household head and gender composition, wealth, education level of the household head). Large amount of theoretical work has focused on adoption in general, only few cases have explained the factors affecting farm-level decision to adopt improved maize (Byerlee, 1994; Heisey, 1993).

Understanding the factors which affect the maize technologies adoption in the study area is vital in promoting use of the maize technologies in order to enhance its production. This current paper therefore seeks to identify and describe the major variables (factors) that underlie adoption of improved maize varieties in western hills of Nepal.

Methodology

Study Sites and Sampling

The study was based on the farm level data of maize farmers in western hills of Nepal. Two districts from western mid hills; Baglung and Palpa were purposively selected, because maize is prominently produced due to its suitable environmental conditions. Malika Village Development Committee (V.D.C) and Deurali V.D.C were selected from Baglung and Palpa districts respectively based on the accessibility. The study used mainly the primary data. Hundred and Eighty farm household heads were selected from the study area using simple random sampling technique taking into account proportional to size (number) of maize growers in each of three selected areas. Data collected include maize area under cultivation (ha) and the socioeconomic variables such as: age, gender, farming experience, level of education, contacts with extension agents, farm size, family size and access to credit.

Tools for Determining the Factors

Tobit model was used to measure the intensity of adoption (McDonald and, Moffit 1980; Kristjason *et al.*, 2005; James *et al.*, 2006) and marginal effect. This model was chosen because; it has an advantage over other analytical models in that, it reveals both the probability of adoption and intensity of use of the technology (Maddala, 1992; Johnston and Dandiro, 1997). Strictly dichotomous variable often is not sufficient for examining intensity of adoption (Feder *et al*, 1985). In such cases, Tobit model, which has both discrete and continuous part, is appropriate. The Tobit model is a censored normal regression model. Its estimation is related to the estimation of a censored and truncated normal distribution. The function is estimated from a censored sample where the sample population consists of both adopters and non-adopters of improved maize varieties. The intensity of the adoption of Improved Maize Varieties (IMV) is defined as the proportion of total area planted with IMV to the total maize land area. Let Y be the intensity of the use of an improved technology, Y* is equal to an index reflecting the combined effect of the explanatory variables hindering or promoting the use of an improved technology, Y* is not observable and is recorded as zero for not having area under high yielding variety.

The empirical Tobit model is expressed as:

$$Y = X\beta + \mu_i \ \text{ if } X\beta > \mu_{i,} 0 \text{ if } X\beta = \mu_i \tag{1}$$

$$Y = Y^*, \text{ if } Y^* > 0$$

$$= 0 \text{ if } Y^* \leq 0$$

Where,
X_I = vector of the explanatory variable
β = vector of the Tobit maximum likelihood estimates
μ = random error term (independently distributed with mean 0 and variance)

To examine the intensity of use of improved maize varieties, the number of hectares of land planted to improved maize is specified as a function of socio-economic and institutional factors as follows:

$$Y = \beta_0 + \beta_1 AGE + \beta_2 GENDER + \beta_3 EDU + \beta_4 MEMG + \beta_5 EXT\ CONTCT + \beta_6\ FAMILY\ SZ + \beta_7\ FSZ + \beta_8\ CREDIT + \mu_i$$

Where Y= percentage of farmers' total maize area planted to improved open pollinated varieties, β_0 = constant and μ_i = the random error term.
Table 1 describes the variables used in the Tobit model. Variables included controlling for social factors are age of the household head (AGE), Sex of the household head (GENDER), education level of the head of the household (EDU) and household membership in the group (MEMG), contact with the extension visit (EXT CONTCT), no of family members (FAMILY SZ), farm size (FSZ) and access to credit, that is if farmers had borrowed credit or not (CREDIT).

Table 1: Description of the Variables Used in the Tobit Model

Variables	Description	Unit	Expected sign
Age	Age of the household head	Years	+/-
Gender	Gender of the household head	1=male & 0= female	+/-
Education	Educational level of the household head	No of years of education	+
Membership in the group	Whether the farmers belong to any group or not	1= Yes & 0= No	+
Contact with the extension agent	Whether the farmer had contact with extension agent or not	1=Yes & 0= No	+
Family size	Number of family members in the family	No	+/-
Farm size	Total land owned by farmers	ha	+/-
Access to credit	Whether the farmers had access to credit or not	1= Yes & 0=No	+

Likewise Technology Adoption Index (TAI) was calculated and farmers were divided into different categories of adopter.

The Technology Adoption Index was calculated by using formulae:

$$TAI_i = 1/7(Ah_i/Ca_i + Sa_i/Sr_i + Na_i/Nr_i + Pa_i/Pr_i + Ka_i/Kr_i + Wa_i/Wr_i + Ra_i/Rr_i)$$

Where i= Numbers of farmers say 1, 2, 3,……………., n, TAI_i = Technology Aoption Index of i^{th} farmer, Ah_i= Area under improved maize varieties (ha), Ca_i= Total area under improved maize varieties , Sa_i=Quantity of seed per hectare , Sr_i= Recommended seed rate, Na_i= Quantitiy of Nitrogen applied per ha, Nr_i= Recommended dose of Nitrogen per ha, Pa_i = Quantitiy of Phosphorus applied per ha, Pr_i = Recommended dose of Nitrogen per ha, Ka_i= Quantitiy of Potassium applied per ha, Kr_i= Recommended dose of Potassium per ha, Wa_i=Number of weeding applied Wr_i= Recommended number of weeding, Ra_i= Method of sowing, Rr_i= Recommended method of sowing.

Depending upon the extent of adoption of improved technologies the respondents will be categorized as: Low Adopters (LA) from 0-33 percent, Partial Adopters (PA) from 34 – 66 percent, and High Adopters (HA) from 67 – 100 percent.

Results and Discussion

Demographic Characteristics

Table 2 summarizes demographic characteristics of sampled farmers in the study area. The mean age of household head in Baglung and Palpa was 55 and 48 years respectively. The average size of the family in Baglung and Palpa was 5 and 4 respectively. Majority of the households were male headed households. Most of the households belong to Brahmin and Kshetri ethnicity. The average size of the lowland was 4.54 ropani in Baglung, 4.25 ropani in Palpa. Likewise the average size of upland was found to be 4.35 ropani in Baglung, 4.53 ropani in Palpa. The educational experience of the household heads in Baglung and Palpa districts were about 4.3 and 3.4 years respectively.

Table 2: Demographic Characteristics of the Study Sites

Socioeconomic Characters	Baglung	Palpa
Age of the household head	55	48
Family size	5	4
Male headed household	42	32
Female headed household	18	28
Ethnicity (number)		
Brahmin/Kshetri	51	50
Janjati	9	1
Dalit	0	9
Lowland (ropani)	4.54	4.25
Upland (ropani)	4.35	4.53
Education (yrs)	4.3	3.4

Note: 1ha = 20 ropani

Pattern and Extent of Adoption

The nature and extent of the modern variety adoption is a good measure of the crop research program. Adoption of crop varieties is measured generally by two indicators; the proportion of farmers growing modern varieties and the proportion of area under improved varieties. In overall 62.5% farmers were adopting improved maize varieties in the sampled households. Likewise out of the total maize growing area in the study sites, 62% of the area is covered by improved maize varieties. The most popular improved varieties mainly adopted by the farmers in the study sites are Rampur composite (40%), Manakamana-6 (40%) and Arun-2 (20%). The main reasons for adopting these varieties were being less prone to lodging, having good taste and having higher yield compared to the local ones. Despite of the adoption of the variety there were some varieties that were disadopted. The varieties disadopted were Manakamana-1 and Manakamana-5. These varieties were disadopted because they were prone to lodging and susceptible to diseases and pests.

Adoption Analysis of Improved Maize Technology

The responses received from the respondents were categorized as low (up to 33.33 %), medium (33.34 to 66.66 %) and high adoption (above 66.66 %). Table 3 presents the current level of practice of the different factors at the study sites taken into consideration. Average seed rate in Palpa is 40 kg/ha whereas in Baglung it is 49 kg/ha. Average use of Nitrogenous, Phosphorus and Potassium fertilizer in Palpa is 45, 11 and 10 kg/ha respectively whereas in Baglung it is found to be 75, 10 and 12 kg/ha respectively. Both districts were following the recommended number of weeding. Row planting is not followed by any farmers in both districts. Practice wise category of adoption of improved maize production technology is presented in Table 4.

With regards to recommended seed rate, all respondents in both districts were observed to be high adoption category. Suwar (1981) also found respondents to be in high adoption category regarding adoption of seed rate. With regards to Nitrogenous fertilizers, majority of the farmers in Palpa were from low adoption category whereas in Baglung majority of the respondents were from high adoption category. With regards to Phosphorus and Potassium fertilizers, all the respondents were from low adoption category. Govereh *et al.*, (2003) in Zambia also found the adoption of Nitrogenous fertilizers to be in high adoption category compared to other chemical fertilizers. None of the farmers were found to practice row planting in both districts. Ephraim and Featherstone (2001) also found that only 1% of the total sampled respondents followed the row planting in Tanzania. Data presented in Table 4 indicates that majority of respondents were found in high adoption category followed by medium adoption category and low adoption category. Etoundi and Dia (2008) report also found 70% of the respondents to be in high adoption category in adopting Maize improved technology in Cameroon. Low adoption of improved technology is due to non-availability of improved varieties' seed at proper time and lack of knowledge. The technology adoption index in Palpa and Baglung is 61% and 65% respectively.

Table 3: Recommended and Current Level of Practice of Different Factors Taken into Consideration at the Study Sites

Practices	Palpa		Baglung	
	Recommended Practice	Current Practice	Recommended Practice	Current Practice
Seed rate	20 kg/ha	40 kg /ha	20 kg/ha	49 kg/ha
Nitrogenous fertilizer	104.9kg/ha	45kg/ha	104.9kg/ha	75kg/ha
Phosphorus fertilizer	65.22kg/ha	11kg/ha	65.22kg/ha	10 kg /ha
Potassium fertilizer	50kg/ha	10kg/ha	50 kg/ha	12 kg/ha
Number of weeding	2	2	2	2
Planting method	row planting	sowing after plough	row planting	sowing after plough

Table 4: Frequency and Percentage of Farmers with Different Cultivation Practices

Cultivation Practices	Palpa			Baglung		
	Low Adopter	Medium Adopter	High Adopter	Low Adopter	Medium Adopter	High Adopter
Improved varieties	10(17)	20(33)	30(50)	6(10)	24(40)	30(50)
Seed rate	0	0	60(100)	9(15)	0	51(85)
Nitrogen	38(62)	5(8)	17(30)	6(10)	12(20)	42(70)
Phosphorus	60(100)	0	0	60(100)	0	0
Potassium	60(100)	0	0	60(100)	0	0
Weeding	0	5(8)	55(92)	3(5)	0	57(95)
Row planting	60(100)	0	0	60(100)	0	0

Note: figures within parenthesis indicate percentage

Analysis of the Factors Affecting the Adoption of the Improved Maize Varieties

The Tobit result shows the relationship between socio-economic factors of the respondents and the intensity of adoption of improved maize varieties in the study area. R^2 was calculated to be 0.737. The column, dy/dx in the table shows the marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable. The estimated coefficients and t-ratios are presented in Table 3.

The coefficient of educational status is positive and significant at 10%. The positive coefficient of educational status means that there is a direct relationship between adoption of IMV and educational status, whereby as educational status increases, adoption level also increases among farmers. Per year increase in the schooling years increases the intensity of adoption by 7.1%. Similar type of findings were reported by Alao (1971).

Table 5: Tobit Model Analyzing the Factors Affecting the Adoption of Improved Maize Varieties in Western Hills of Nepal

Explanatory Variables	Maximum Likelihood Estimate	Standard Error	Marginal Effect (dy/dx)	p-Value
Constant	-0.057	0.227		0.753
Age	0.000	0.003	0.003	0.675
Gender	0.020	0.039	0.004	0.933
Educational status	0.005	0.002	0.071	0.079
Membership of farmers groups	0.003	0.003	0.167	0.864
Extension contact	0.383	0.035	0.124	0.000
Family size	-0.006	0.005	0.006	0.058
Farm size	-0.341	0.029	0.019	0.000
Farming experience	0.007	0.002	0.052	0.034
Access to credit	0.000	0.000	0.016	0.000
Log likelihood		-33.521		
R^2		73.722		
F- value		38.373		

The coefficient of contact with extension agents is positive and significant at 1% level. This agrees with the expectation that, there is a positive significant relationship between extension contact and adoption of IMV in the study area. Similar findings are reported by Kaliba *et al.*, 2000. The positive relationship suggests that, adoption of IMV increases as extension contact between the extension agents and farmers become more frequent. Contact with the extension personnel, intensity of adoption of the IMV by 12.4%.

Family size coefficient was negative and significant at 10% level of significance. The negative coefficient indicates that, the greater the family size the lower the intensity of adoption of IMV. It is likely that, farmers with relatively larger family sizes were attracted to other non-farm activities than relatively smaller households. Shakya and Flinn (1985) also found similar result.

The coefficient of farming experience was also positive and significant at 5% level and was in line with our expectation. This explains that more farming experience, higher the intensity of adoption of IMV. This result was also supported by the findings of Amaza *et al.*, 2007. Per year increase in the experience of the farmers increases the intensity of adoption by 5.2%.

The coefficient of farm size was negative and significant at 1% level. The negative coefficient shows an inverse relationship between farm size adoptions of IMV. In other words, the larger the farm size, the lower the potential of the intensity of adoption. Etoundi and Dia (2008) also pointed out that increasing the area diminishes the probability of adopting the improved variety. Increase in each unit of land increases the intensity of adoption by 1.9 %

Access to credit also had a positive coefficient and significant at 1% level. The positive coefficient indicates that adoption of IMV increase as farmers have adequate capital for the purchasing of inputs such as fertilizer and seeds. These findings were in line with that of Lawal *et al*., (2004). With the access of credit to the farmers' intensity of adoption of the improved maize varieties by 1.6 %.

Conclusions

The study was conceived with the objectives of finding the factors affecting the adoption of IMV in western hills of Nepal. Age, gender, educational status, membership of the farmers' group, extension contact, family size, farm size, farming experience and access to credit were the major socioeconomic variables taken into consideration. Educational status, extension contact, farm size and access to credit were found statistically significant. Policy should target at strengthening maize farmers to have improved access to credit. In addition, policy that provides adequately trained and equipped extension workers, higher level of education for disseminating technology information has the potential to increase the intensity and rate of adoption of the improved maize technology.

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