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Factors Influencing Adoption of Improved Maize Varieties in Nepal: A Case Study of Chitwan District

[1]Pashupati Paudel and [2]Atsushi Matsuoka

[1]The United Graduate School of Agricultural Sciences, Ehime University, Tarumi 3-5 -7, Matsuyama, Ehime 79 0 -8 5 6 6, Japan

[2]Faculty of Agriculture, Ehime University, Tarumi 3-5 -7, Matsuyama, Ehime 790-8566, Japan.

Abstract: Maize (*Zea mays* L.) is the most important cereal crop in the Nepalese agriculture. This crop occupies a momentous position than other cereal crops since it is used as food, feed, fodder and other industrial raw material. The aim of this study was to identify the socio-economic as well as demographic factors that influence the farmer's decision to adopt improved maize varieties in the Chitwan district of Nepal, using the farm household survey data collected from 180 maize farming households in May-June 2005 for the cropping year 2004-05. The impact of winter maize cultivation, age, family size and education of household head, land type, access to credit, access to extension services and farm yard manure on the adoption of maize varieties were analyzed using the logit regression model. The results from the study indicated that the adoption of improved maize varieties is significantly influenced by winter maize cultivation, education of the household head, lowland area, upland area as well as access to credit and extension services. This study suggests the need to bring more area under maize cultivation during winter season especially in the low lying area. Further, there is the need for special training, seminars, field demonstrations and technical support for the maize farmers. As majority of the households had no formal education, the extension program should be intended to the less educated people. In addition, the credit facility especially the procedure for loan should be made simple to improve the adoption rate of improved maize varieties in the study area.

Key words: Zea mays L., Adoption, Improved maize varieties, Logit regression model, Chitwan district

INTRODUCTION

Agriculture is the leading sector of the Nepalese economy as it contributes about 40% to the Gross Domestic Product (GDP) engaging more than 80% of the labor force (Paudyal and Poudel, 2001). According to the Ministry of Agriculture and Co-operatives, Nepal (2005), cereal crops contribute a large share of the output of the agricultural sector. Maize is a popular cereal crop cultivated for food, feed and fodder in both irrigated and non-irrigated land (Paudyal and Poudel, 2001). This is the second major cereal crop with respect to area and production after paddy and as a consequence, it has great socio-economic importance in Nepalese agriculture. During 2003-04, this crop was cultivated in 0.834 million hectares with an average productivity of 1.90 t ha^{-1} accounting for about 25% of the total cropped area and 21% of the total cereal production in Nepal (MOAC, 2005).

Rising income in much of the developing country and the consequent growth in meat and poultry consumption resulted in a rapid increase in the demand for maize as livestock feed (Pingali *et al.,* 2001). The demand for maize is ever on the rise with an increasing population, its increasing use in animal and poultry feed as well as in other industrial raw materials like production of corn flakes. In Nepal, the future demand for maize is expected to grow by 4-6% per year over the next 20 years (Paudyal *et al.,* 2001; Pathik, 2002). Considering the agroclimatic suitability, road access for product supply and expansion of poultry enterprise, maize production is one of the important constituents of the farming system in Chitwan district, Nepal. This district is considered as one of the most potential poultry district in Nepal as it contributes a

Corresponding Author: Pashupati Paudel, The United Graduate School of Agricultural Sciences, Ehime University, Tarumi 3-5 -7, Matsuyama, Ehime 79 0 -8 5 6 6, Japan
Tel: (+ 81)-89-946-9833 Fax: (+ 81)-89-946-9830 Email: paudelp@agr.ehime-u.ac.jp

significant proportion to the Nepalese poultry industry (Dhakal, 2001). Among maize growing districts in Nepal, Chitwan enjoys the second position regarding the area and production of maize (MOAC, 2005). It has been reported that the production of cereal is two times more than the quantity required for fulfilling the demand of its population (Anonymous, 2002). Due to the easy road access, maize produced in this district can be easily distributed to other parts of the country that are deficient in food availability. The mountainous and hilly regions are comparatively food deficient areas in Nepal and the demand in these areas is partly met from the plains or from other countries (Sherchan, 2004). This scenario points out the need for intensification in current maize production systems that should bring more land area under this crop particularly in the plains such as inner Terai regions of Nepal since enough irrigation facilities exist in this region for the spring and winter maize production. In these areas maize is grown in spring (March-June) and winter (October–February) in irrigated land in rotation with rice, as well as in unirrigated and/or upland fields. During summer (April–August) maize is cultivated especially in rain fed land/ upland part of field that isn't under submerged and hence not suitable for paddy growing. Therefore, keeping in view the possibility of bringing more land area under irrigation facility than in hill regions, maize farming has greater potential for growth to contribute greatly to the food supply for the growing people and industries in the country (Paudyal *et al.,* 2001). Rapid improvement in production and productivity is important to ascertain the central role of agriculture in Nepalese economy. It is widely recognized that the sustainable flow and use of improved agricultural technology is key to increased growth and agricultural productivity (Ouma *et al.,* 2002). Therefore, a better alternative is to improve and sustain the production system by providing strong support for a greater contribution to national economic growth (Anonymous, 2000).

Maize research in Nepal was first undertaken in an organized way in 1965 (Paudyal *et al.,* 2001). Since then, 9 out of 15 open pollinated varieties (OPVs) and one hybrid variety named as Gaurav have been released, disseminated and adopted for Terai and *Inner* Terai regions in different years. The adoption of improved maize varieties[1)] in Nepal is about 64% and about 40% of all maize area in Nepal was cultivated with fresh seed of improved varieties (i.e. varieties that farmers have recycled for no more than one to three years) and the rest were renewal, local / traditional varieties (Paudyal *et al.*, 2001). If we compare the adoption rate of improved maize varieties across the ecological regions of Nepal, the rate is higher in *Terai* region than the mountainous and hilly maize growing areas of the country (ASD, 1998) because of easy access, availability of inputs and other facilities for production. Research conducted in hilly regions of Nepal and also in other countries indicated that adoption of improved maize varieties depends on socio-economic as well as demographic factors (Ransom *et al.,* 2003; Okuro *et al.,* 2000). However, in the extensive reviews of studies on socio-economic as well as demographic factors influencing adoption of improved maize varieties, no systematic study has been conducted so far to assess the factors influencing the farmer's decision on adoption of improved technology in Chitwan district of Nepal.

Therefore, the objective of this study was to assess the factors that influence the adoption of improved maize varieties in the Chitwan district of Nepal. More specifically, it examines current adoption level of maize production technologies and identifies major socio-economic and demographic factors that influence the adoption of improved maize varieties. This information can be used by policy makers, researchers and extension workers to design a strategy for improving productivity and increasing agricultural production in the country.

MATERIALS AND METHODS

Both primary and secondary source of information were used in this study. For the primary source of information an interview was conducted to obtain necessary information from the farmers while secondary information was obtained from reports of government and non- governmental organizations. The information related to socio-economic, demographic and input-output data was collected from the respondent farmers.

Overview of the Study Area:

The present study was conducted in the Chitwan district of Nepal which is the major maize producing area in the country. This district covers an area of 2,205.90 square kilometers and has a population of 472,048 which was 2.03% of the total population of Nepal. Administratively, this district is divided into 36 Village Development Committees (VDCs) and 2 municipalities. The climate of Chitwan valley is subtropical monsoon type with hot and humid summer and cool and dry winters. Over 75 percent of annual rainfall occurs during the monsoon from June through September and very low rainfall occurs from January to April with an annual average rainfall of 2,318 mm (Anonymous**,** 2002). People are predominantly peasant farmers cultivating mainly food and cash crops such as rice, maize, wheat, beans, lentils, mustard and vegetables. In this district maize is cultivated on irrigated /seasonal irrigated land in winter and spring while summer in the rain fed land. In the year 2003-04, the area under maize cultivation was 27,170 ha with an average productivity of 2.23 t ha^{-1} (MOAC, 2005). The area for spring maize comprises about 51% of total maize area while summer and winter shares about 29% and 20% respectively (Anonymous, 2004).

Sampling Technique:

This study was conducted in May-June 2005 for the cropping year 2004-05 covering 11 VDCs and one municipality having easy access to market, near to the poultry and animal feed industries and also within the easy reach of technology providing institutes. Therefore, the major maize producing areas i.e. VDCs and municipality[2)] in the Chitwan district were purposively selected for this study. Fifteen maize growing households in each VDCs / Municipality were randomly selected for interview and thus the total sample size consisting 180 maize farming household was used for the collection of data. Farmers from each sampled households were interviewed by administrating a pre-structured questionnaire.

Logit Model:

In the model the dependent variable was dichotomous in nature, taking the value 1 or 0, i.e., a qualitative variable which is incorporated into the regression model as dummy variable. In this case the value 1 indicated as a farmer who adopted the improved maize varieties while the value 0 indicated the farmer who did not adopt. Adopters of improved maize variety were defined as farmers who planted improved and certified seed from the market and non-adopters were defined as farmers who planted local or recycled OPVs seed. Although Ordinary Least Squares (OLS) can be used to compute the estimates for the binary choice models, certain assumptions of the classical regression model are violated. These include non-normality of the disturbances, heteroscedastic variances of the disturbances and questionable value of R^2 as the measure of goodness of fit (Gujarati, 2004).

To fix ideas, consider the following simple regression model:

$$Y_i = \beta_0 + \beta_1 X_i + u_i \qquad (1)$$

Where, Y_i if a farmer who adopts improved maize varieties and 0 if a farmer does not.

X_i = value of attribute e.g. age of household head for the ith individual person
u_i = error term which is an independently distributed random variable with a mean of zero.

Model (1) looks like a typical linear regression model but because the regressand is binary or dichotomous, it is called a linear probability model (LPM). However in the regression model, when the dependent variable is dichotomous in nature taking the value 1 or 0 the use of linear probability models is a major problem: the predicted value can fall outside the relevant range of zero to one probability value. Thus many models used in adoption studies failed to meet the statistical assumptions necessary to validate the conclusions based on the hypothesis tested (Feder *et al.,* 1985). Therefore, to overcome the problem associated with the linear probability model, logit or probit models have been recommended (Gujarati, 2004). The model uses Maximum Likelihood Estimation (MLE) procedures. The advantage of these models is that the probabilities are bound between 0 and 1. Both logit and probit transformations estimate cumulative distribution, thereby eliminating the interval 0, 1 problem associated with LPM. The logistic cumulative probability function can be represented by

$$P_i = E\left(Y = 1 \,{}^{1}\!/_{X_i} \right) = 1/1 + e^{-(\beta_0 + \beta_1 X)} \qquad (2)$$

For ease of exposition, we can write equation (2) as

$$P_i = \frac{1}{1+e^{-z_i}} = , \frac{e^z}{1+e^z} \qquad (3)$$

Where P_i is the probability that the ith person will be in the first category, $Z_i = \beta_0 + \beta_1 X_i + \ldots + \beta_n X_n$ and e represents the base of natural logarithms. It is easy to verify as Z_i ranges from $-\infty$ to $+\infty$, P_i ranges between 0 and 1 and that P_i is nonlinearly related to Z_i (i.e. X_i).

If P_i, the probability of adoption of improved maize varieties, is given by the equation (3), then ($1-P_i$), the probability of non-adoption of improved maize varieties can be presented as

$$1 - P_i = \frac{1}{1+e^{Z_i}} \qquad (4)$$

Therefore, we can write

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i} \qquad (5)$$

Now if we take the natural log of equation (5), we obtain

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n \qquad (6)$$

Where, *L* is the log of the odds ratio, not only in X, but also linear in the parameters. *L* is called the logit, and hence it is the logit probability model. It can thus be noted that the logistic model defined in the equation is based on the logits of $Z_{i,}$ which is the stimulus index. We selected the logit model for this study because the dependent variable is dichotomous and the model is computationally easier.

As mentioned earlier, the adoption or non-adoption of Improved Maize Varieties (IMV) was treated as a decision involving a dichotomous response variable. The variables representing farmer and farm attributes are likely to affect farmers' decision about adoption of IMV. These include winter maize cultivation, family size, age of the respondents, education, land type, access to credit, extension contact and use of manure in the farm. Different studies on the subject have used different sets of explanatory variables and, to some extent, with various definitions as well as measurements of these variables. Since maize crop is cultivated globally in different seasons and productivity may also differ according to seasons even though different farms use the same package of technologies. In this context we have included the winter maize cultivation as an additional and more relevant variable that decides the farmer's attributes for the adoption decision. Moreover, cultivation of maize in different seasons itself may also play a role in affecting the adoption decisions due to the difference in the climatic factors and/or availability of irrigation facility in different seasons. In addition, the laborers play significant attributes for the productivity, most of the studies consider the hired labor as an important factor affecting farm-level adoption of technology. However, we consider the family size of the households rather than the farm hired labor to be the more appropriate variable. Further, family size may also play significant role of labor supply for the improved technologies as supplement of hired labor, because major proportion of the farmers of the present study were either poor and small scale. Timely unavailability of hired labor may also play a role in affecting the adoption decisions. Considering the above mentioned facts, this study uses the winter maize cultivation as well as family size along with other explanatory variables. In this study we focused on farmer's decisions to use improved maize varieties and we sought to quantify the probabilities of significant factors influencing the decision to adopt improved maize varieties by the sample farmers in the Chitwan district of Nepal.

Specification of the Model:

The empirical model of the effect of a set of explanatory variables on the adoption of improved maize varieties is specified using the following linear relationship:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + ... + B_9X_9 + u \qquad (7)$$

Where:

Y = adoption of improved maize varieties over the year
X_1 = winter maize cultivation (dummy; 1: cultivation; 0: no cultivation)
X_2 = family size (number)
X_3 = age of the household head (year)
X_4 = education of the household head (schooling year)
X_5 = lowland area (hectare)
X_6 = upland area (hectare)
X_7 = farmers access to credit (dummy; 1: have access; 0: no access)
X_8 = farmers access to extension services (dummy; 1: have access; 0: no access)
X_9 = farm use of farm yard manure (t ha^{-1})
u = disturbance term; B_0 is the constant and $B_1, B_2...B_9$ are the coefficients of the independent variables.

The coefficients of the regression model were estimated by applying the maximum likelihood estimation of factors influencing adoption of improved maize varieties using the Statistical Package for the Social Sciences (SPSS).

The working hypotheses of this paper are:

- Winter maize cultivation: It is hypothesized that during winter season farmers adopt improved cultivars of maize more than in other seasons. This is mainly because the productivity of maize is comparatively more when cultivated during winter season in Terai environment due to climatic suitability (Sherchan, 2004).
- Family size: Only the able bodied and working age members of the household are considered in determining the family size. It is expected that farmers with larger number of able members will adopt improved maize varieties more than those with smaller family size**.** Adoption of improved varieties requires more labor per unit area than the local varieties (Ransom *et al.,* 2003). Farmers with large number of able bodied family members can rely on their own family labor for the field operation. It is therefore hypothesized that family size would have positive influence on the adoption of improved maize varieties.
- Age of household head: It is hypothesized that younger farmer may adopt improved maize varieties more than older farmers. This is because younger farmers are open to new ideas. It is expected that farmers of older age are less likely to adopt the improved maize varieties (Ransom *et al.,* 2003).
- Education of the household head: Education status of the household head is considered to have influence in understanding new technologies. If farmers are educated, they will be able to understand new information and open to novel ideas. Education is thought to be most important for higher farm production in a rapidly changing technological or economic environment (Shultz, 1964; 1975).Thus education increases the probability of adopting improved maize varieties (Ouma *et al.,* 2002).
- Land size: In the study area, there are basically 2 types of land on the basis of topography, viz. lowland and upland. Lowland refers to the irrigated/ seasonally irrigated type of land which is topographically low lying than the upland area. As a consequence, the low land is more suitable for rice cultivation especially in summer season. Higher extent of operational land holding leads to application of modern technologies in the farms. Further, the lowland area is more productive than the upland area. It is hypothesized that the farmer with more lowland area is expected to be positively associated with adoption of improved cultivar. It is assumed that farmers with more lowland area tend to be better connected to markets, use more inputs, and therefore may have better access to information and seed (Ransom *et al.,* 2003).
- Access to credit: It is hypothesized that access to credit increases the probability of adopting improved maize varieties. It is of interest often know whether the farmers have access to cash or credit, because the lack of such access may constrain farmers from adopting technologies that require higher initial investments, such as outlays for seed and other technologies at the start of the growing season or large cash expenditures for machinery. The farmer who received the credit is expected to be positively

associated with adoption of improved maize varieties as hypothesized and observed by Ouma *et al.* (2002).

- Access to extension services: It is hypothesized that availability of extension service has positive and significant effect on the probability of adoption of improved maize varieties as farmers are known to gain access to new information provided through extension (Ransom *et al.,* 2003).
- Use of manure: It is hypothesized that the farmers who use more farm yard manure (FYM) are aware of soil fertility management and therefore more likely to adopt improved maize varieties (Okuro *et al.,* 2000). Further, the respondents are applying FYM complementary with chemical fertilizers to maintain and improve the fertility status of soil as improved varieties are more fertilizer-responsive than the local varieties.

RESULTS AND DISCUSSION

Current Adoption Level of Maize Production Technologies:

Of the total respondent farmers, 11.85% cultivated maize in summer, 18.96% cultivated in winter and 69.19% cultivated in spring season (Table 1). Besides, 83.89% of the households planted maize only in one season in a year, mainly in spring. Likewise 15% of them planted the crop in two seasons and 1.11% farmers planted it in three seasons a year. Respondent farmers used their irrigated land for rice production in the summer season and hence very few farmers cultivated maize in this season. Application of farmyard manure (FYM) is the traditional and dominant method for maintaining soil fertility in the study area. All farmers used FYM for summer maize cultivation but slightly lower percentage of farmers used FYM in winter and spring maize cultivation. The average use of FYM was 9.90, 15.99 and 9.26 t ha^{-1} in summer, winter and spring seasons, respectively. The rate of FYM did not differ significantly between summer and spring season but was higher in winter. The average use of chemical fertilizer in summer was 24.96 kg ha^{-1} (DAP: 10.35; Urea: 11.33; MOP: 3.28 kg ha^{-1}). Similarly, the average use of chemical fertilizer was 155.83 kg ha^{-1}(DAP: 64.57; Urea: 67.90; MOP: 23.36 kg ha^{-1}) in winter, whereas 26.95 kg ha^{-1} (DAP: 11.67; Urea: 11.97; MOP: 3.31 kg ha^{-1}) fertilizer was used in spring. The certified amount of chemical fertilizer was 90 kg ha^{-1} (60:30 kg N, P) for the summer maize cultivation and 190 kg ha^{-1} (90:60:40 kg N, P, K) for winter and spring seasons (Adhikari, 2002). The result from our study shows that the use of chemical fertilizer in winter was quite adequate but a very low amount of fertilizer was used in summer and spring.

Table 1: Adoption level of maize production technologies by season in Chitwan district, Nepal, 2005

Technologies	Seasons		
	Summer	Winter	Spring
Total maize farmers (%)	11.85	18.96	69.19
Total IMV adopters (% of maize farmers)	48.00	85.00	46.00
Area planted to IMV (% of total maize planted)	47.65	87.04	48.76
FYM adopters (% of farmers)	100.00	85.00	97.95
Rate of FYM use (t ha^{-1})	9.90	15.99	9.26
Fertilizer adopters (% of farmers)	24.00	92.50	32.19
Rate of fertilizer use (Kg ha^{-1})	24.96	155.83	26.95
DAP (Kg ha^{-1})	10.35	64.57	11.67
Urea (Kg ha^{-1})	11.33	67.90	11.97
MOP (Kg ha^{-1})	3.28	23.360	3.31
Yield of IMV (Kg ha^{-1})	2,461.00	3,548.00	2,018.00
Yield of local varieties (Kg ha^{-1})	1,925.00	1,983.30	1,460.00
Yield of all maize (Kg ha^{-1})	2,234.00	3,472.00	1,899.00

Note: FYM: farm yard manure; IMV: improved maize varieties; MOP: muriate of potash

The main improved open pollinated varieties of maize that are cultivated in the study area are Rampur Composite, Arun-2 although Hetauda Composite and Rampur Yellow are also grown to a small extent especially during spring season only (Table 2). These varieties are among the nine improved OPV maize varieties that have been recommended by the National Maize Research Program for cultivation in the Terai, Inner Terai and foothills of Nepal. In the study area, almost all cultivated land is suitable for growing improved varieties of maize and significant proportion of the production is meant for market sale. Although the number of farmers growing winter maize is lower, the adoption rate of improved maize varieties in this season was recorded as 85%.The rate of adoption of IMV was comparatively lower in summer (48%) and spring seasons (46%). Further, the farmers who adopt improved varieties in winter season cultivate the improved varieties in other seasons also. Out of the total improved maize varieties in winter, 20% farmers cultivated hybrids and the remaining 65% farmers cultivated open pollinated maize varieties (OPVs). Similarly, in spring only 3.42% of farmers cultivated hybrid maize and the remaining 42.58%, cultivated OPVs. Since the hybrid maize has been recommended only for the winter and spring seasons, there was no adoption of hybrid maize in summer (Table 2). This implies that adoption of hybrid maize is very low compared to OPVs maize in all seasons of maize production. Of the total land used for maize cultivation, 47.65% of land was used for improved maize varieties in the summer season, 87.04% in winter and 48.76% in spring. Yield of

Table 2: Adoption level of maize varieties by season in Chitwan district, Nepal, 2005

Maize varieties	Summer Adopters (%)	Winter Adopters (%)	Spring Adopters (%)
Rampur Composite (OPV)	34.50	52.50	30.61
Arun -2	13.50	12.50	9.23
Hetauda Composite	0.00	0.00	0.69
Rampur Yellow	0.00	0.00	2.05
Hybrid	0.00	20.00	3.42
Renewal OPVs/ Local	52.00	15.00	54.00

improved maize varieties was higher in all seasons compared to the yield of all maize varieties. Generally, yields were higher in the winter season compared to the summer and spring seasons. This is due to the adoption of more improved maize varieties and use of higher dose of FYM and chemical fertilizers and also lower pest and disease incidence (Paudyal *et al.,* 2001). Furthermore, winter maize farmers were motivated to produce maize meant for seed which has a higher price than other commercial maize meant for consumption. Hence the adoption rate of improved maize varieties was higher in winter than in summer and spring. This suggests that the farmers who adopt improved maize varieties were more active and aware of obtaining benefits from the maize cultivation. However, the price for maize produced for consumption isn't significantly different among varieties and the price is mainly influenced by various factors governing the demand and supply. The price has been found to fluctuate slightly in different months/season ranging from NRs. 8.20 Kg^{-1} in July-August to NRs. 11.50 Kg^{-1} in January-February (Anonymous, 2004).

Logit Analysis on Factors Influencing Adoption of Improved Maize Varieties:

The collected data were analyzed using the maximum likelihood estimation of a logistic regression model to assess the factors influencing the adoption of improved maize varieties. The logistic regression coefficients that influenced adoption of improved maize varieties are presented in Table 3. Results from the model show that it has a correct prediction rate of 76.70%. Since the main purpose of the model is to identify the main factors that influence the adoption of improved maize varieties, the model is appropriate for the purpose of considering its significant model chi-square ($p<0.001$) as well as -2 Log Likelihood, which shows the soaring predictive ability (Table 3).

Table 3: Logit estimates of coefficients of various determinants affecting adoption of improved maize varieties in Chitwan district, Nepal, 2005

Variables	Coefficient estimate (β)	Standard error	P-value
Constant	1.19	0.176	0.00
Winter maize cultivation (dummy)	2.276	1.055	0.031**
Age of household head (years)	-0.016	0.019	0.398
Family size (no.)	0.096	0.097	0.321
Education (schooling years)	0.073	0.037	0.050**
Lowland area (ha)	0.717	0.351	0.041**
Upland area (ha)	-1.476	0.814	0.070*
Access to credit (dummy)	1.411	0.594	0.018**
Access to extension (dummy)	1.16	0.434	0.008**
Farm uses manure (t ha-1)	0.018	0.043	0.676
Model χ^2		44.493	0.000***
-2 Log likelihood		151.085	
Overall cases correctly predicted (%)		76.7	
Sample size		180	

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level

The results show that winter maize cultivation, education of the household head, lowland area, upland area, access to credit and access to extension services were the significant factors that influenced the adoption of improved maize varieties. The variables such as age of household head, family size and use of farm yard manure, which were expected to influence the adoption of improved maize varieties and were included in the model, were found to be non significant regarding their influence on the adoption of improved maize varieties.

The Influence of Winter Maize Cultivation:

Of the factors that significantly influenced the adoption of improved maize varieties, winter maize cultivation had the most dramatic influence on adoption of improved maize varieties (Table 3). It had the highest positive coefficient that was significant at p= 0.05. As shown in Table 1, about 85% of the total maize farmers adopted improved maize varieties. Sherchan (2004) while analyzing food security and improvement of the livelihood of the Nepalese people reported that the productivity of maize is more during winter season than in summer planting and productivity is exclusively determined by the planting season. The higher productivity in winter season is associated with the lower risk of production resulting from favorable climatic condition, availability of irrigation facility as well as the lower incidence of pests and diseases. Therefore, in the study area the adoption of improved maize varieties in winter cultivation was found to be significantly higher than the other season.

The Influence of Age of Household Head:

The result shows that younger farmers would likely adopt improved maize compared to the older farmers as it is shown by the negative coefficient in the Table 3. However, this was not significant probably due to inadequate extension services delivered to the study area by the service providing agencies for diffusion of the new technology. Ransom *et al.* (2003) also reported the negative and insignificant influence of the age of household head on the adoption of improved maize varieties in Nepal.

The Influence of Family Size:

The results of the model as depicted in Table 3 suggest that the household comprising larger number of able bodied family members adopt improved variety of maize more than those with a smaller family size as witnessed by the positive coefficient. However this is an insignificant factor influencing adoption of improved maize varieties. This suggests that large family size provides more labor for farm operation and an increased incentive to produce more output on farm. In the study area the average number of family size of households adopting improved varieties was comparatively higher than the non-adopters (Table 4). Most farmers in the study area were holding small-scale farm size, did not have enough capital to hire labor and relied on family labor for most of the operations. It should also be noted that more labor is required per unit of land area for cultivating improved maize due to systematic cultivation methods compared to the local variety (Ransom *et al.,* 2003). This implies that the farmer who has a larger family size and as a consequence uses more family labor including the labor needed for barter system was likely to adopt improved maize varieties.

Table 4: Socio-economic Characteristics of the farmers associated with the Adoption of IMV in Chitwan district, Nepal, 2005

Characteristics	Adopters	Non-adopters
Family size (No.)	6.44	4.48
Education (Schooling Year)	5.46	2.98
Lowland area (ha)	0.87	0.53
Upland area (ha)	0.06	0.15
Access to credit (% of households)	36.23	16.67
Access to extension (% of households)	60.14	26.19

The Influence of Education:

The results suggest that a farmer who has more years of education is more likely to adopt improved maize varieties than those who have never been to school. 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. This is shown by the positive coefficient of the years of schooling of the respondent farmers. Education was found to be a significant factor (p= 0.05) in influencing people to adopt new technologies. This finding is in harmony with the report of Mafuru *et al.* (1999), Asfaw *et al.* (2004) and Feleke and Zegeye (2006). This implies that education increases the probability for the adoption of improved maize varieties.

The result from the descriptive statistics shows that the adopters had an average of 5.46 schooling years, whereas non-adopters had 2.98 (Table 4). It implies that adopter farmers were relatively more educated as compared to the non-adopters. In the study area about 56% of all the respondent household heads did not have formal education (Table 5). In the study area, education may enhance farm productivity directly by improving the quality of labor, to help farmers' master new information and develop new skills by increasing the ability to adjust to instability of situations, and through this increases the propensity to successfully adopt innovations. One can therefore conclude that adoption of improved technology is directly influenced by the level of education of the farmers.

The Influence of Lowland Area:

The results from the logit regression Table 3 showed that lowland area is positively related to the adoption of improved cultivars. This is shown by the positive coefficient and is significant at p=0.05. Similar positive and significant effect of lowland area on the adoption of improved maize varieties was reported by Ransom *et al.* (2003). 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 5: Proportion of the farmers based on different characteristics in Chitwan district, Nepal, 2005

Characteristics	Have access (%)	No access (%)
Formal education (literacy)	43.89	56.11
Credit services	31.67	68.33
Extension services	47.78	52.22

In the study area lowland area is used for rice cultivation especially in the summer season and these farmers tend to be more connected to the market as more crops are sequentially cultivated in the same field in a year and regularly sold in the market. Furthermore, rice being the cereal and staple food crop in Nepal is the main competitor crop of maize. In the study area, more than 90% of the farmers cultivate rice during summer season while maize is cultivated during winter and spring seasons in the same lowland. In addition, significant proportion of the lowland area is seasonally irrigated especially during summer and winter than in spring. This implies that maize cultivation in lowland area may effect the adoption of improved maize varieties depending on available irrigation facility. Further, as reported by Paudyal and Ransom (2001), the price of maize is comparatively higher than rice in the domestic market of Nepal and hence farmers holding more lowland are motivated to adopt new technology and take benefit from maize production. The descriptive statistics also shows that on an average the adopters hold 0.87 ha of lowland while non adopters hold 0.53 ha of low land (Table 4).

The Influence of Upland Area:

The result shows that the farmers with smaller proportion of upland area would adopt improved cultivar of maize compared to the farmers with larger proportion of upland area as it is witnessed by the negative and significant effect (p=0.10) shown in Table 3. Ransom *et al.* (2003) 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.

The Influence of Access to Credit:

The logit result for the adoption of improved maize varieties suggests that use of credit will result in more adoption of improved maize varieties. It has a positive coefficient and is significant at p= 0.05. Significant positive effects of access to credit on the adoption of improved maize varieties was reported by Feleke and Zegeye (2006) and similar effects on adoption of fish enterprise was observed by Matiya *et al.* (2005). Farmers having access to credit can buy improved maize seed as well as other inputs and hence higher adoption was seen than those with no access to credit. Table 4 shows about 36% of the adopters had access to credit whereas only about 17% of the non-adopters were accessing the credit facility suggesting higher chances of adopting improved maize varieties with the higher access to credit.

Of the total respondent farmers, about 68% did not use credit in their operations (Table 5) although the physical distance between farms and credit centers such as bank, finance company and cooperatives are not more than 5-7 kilometers. This is due to the reasons that credit provided by financial institutions as well as credit cooperative groups was not so encouraging due to unfavorable policies, delay in timely transactions, higher interest rate which may cause high cultivation cost and period of repayment. This indicates that easy access to credit may possibly influence the farmer's decision to adopt improved maize varieties.

The Influence of Access to Extension:

The results of the model as depicted in table 3 suggest that access to extension is positively related to adoption of improved maize varieties. It was found to be a significant factor (p= 0.05) in influencing farmers to adopt improved maize varieties. This finding is in harmony with the observation of Ouma *et al.* (2002) and Igodan *et al.* (1988) who also reported positive and significant influence of access to extension on the adoption of improved maize varieties. The results suggest that farmers who have access to extension services may more likely adopt improved maize varieties. In the study area, about 60% of the IMV adopters had access to extension services whereas only 26% of the IMV non-adopters had access to such services (Table 4). This implies that the lack of extension visits to farmers would lead to non-adoption of the new technologies.

Agricultural extension services are the major source of information in the study area and contact with extension agents increases a farmer's likelihood of adopting improved maize technologies. Extension visits will help to reinforce the message and enhance the accuracy of implementation of the technology packages. Of the total respondent households about 52% did not use the extension services (Table 5). This was mainly due to lack of adequate skill among extension staff as well as the lack of available services on time due to poor management of government extension service providers and hence farmers were not interested to consult extension agents. This indicates that the lack of information about the improved maize varieties is the main constraint in the adoption of improved maize varieties.

The Influence of Manure:

The result shows that use of more manure would increase the adoption of improved maize. This is shown by the positive coefficient in Table 3 although this was not significant. The positive effect with the use of manure was earlier reported from Kenya by Ouma *et al.* (2002) and Okuro *et al.* (2000).

Conclusion:

This study has provided information on maize production in the Chitwan district with respect to the adoption of improved maize varieties for cultivation. The rates of input as well as productivity of maize variety and seasonal maize production were also analyzed. The study revealed that the maize farmers were using low amount of improved seed and fertilizer in summer and spring seasons compared to winter which had resulted in low productivity. Most of the farmers adopted improved maize varieties and applied higher dose of fertilizer in winter and consequently had a higher productivity in this season. Further, the adoption of hybrid maize in all seasons was found much lower compared to improved OPVs. A wide range of socio-economic characteristics as well as demographic factors affecting the adoption of improved maize varieties has been described. The study has conceded that adoption of improved maize varieties are influenced by the socio-economic as well as demographic characteristics. The results of logit analysis has shown that winter maize cultivation, education of the household head, land type, access to credit and access to extension services are the main factors that influence farmers decision to cultivate improved maize varieties.

In the study area farmers should be motivated to bring more land area especially the lowland mainly in winter season under maize cultivation as such adoption of improved maize varieties was found to be significantly profitable in such cases. Alternatively, upland area can be facilitated with irrigation facility like shallow tube wells to make those areas more suitable for improved maize cultivation. Further, it is apparent from the study that if the farmers get credit more easily at lower interest rate, they would use improved seed for maize cultivation. Thus, the credit facility should target poor farmers especially those who were not adopting the technologies due to lack of operating capital, assuring them loans at reasonable rates of interest so that they can afford it. This will encourage the farmers to do commercial farming and to implement innovative practices in their farms. The other significant factor that affects adoption is the limited exposure to new technologies of production. It has been reported that there is less frequent contact between farmers and the extension service providers. This may be due to the fact that extension staff are not well equipped with adequate skills and do not deliver their services on time. Since significant proportion of farmers had no formal education, the extension program should be targeted to the less educated people for its effective delivery. Therefore, the study suggests that better extension services should be well equipped with special training, seminars, field demonstrations and technical support to improve the adoption rate of improved maize varieties to increase the productivity.

Notes

- Improved varieties mean other than local cultivars, i.e. both the open pollinated and hybrid cultivars. In Nepal, the seed of such open pollinated maize varieties constitute the major share of improved maize varieties although few farmers are also using the hybrid cultivars. But majority of hybrid cultivars being used by the farmers are mainly imported from other countries because only one hybrid cultivar is developed in Nepal. The seeds of such improved (open pollinated) cultivars are categorized as (1) Breeder seed (2). Foundation seed (3). Certified seed and (4). Improved seed according to the stage of production of seed. Only the improved and certified seed categories of the open pollinated cultivars are distributed to the farmers for production.

- The selected VDCs for study were: Padampur, Chainpur, Jutepani, Bachhauli, Pithuwa, Phulbari, Parbatipur, Saradanagar, Gunjanagar, Shivanagar and Sukranagar while the Municipality was Bharatpur.

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