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Adoption of improved maize varieties in the hills of Nepal

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Abstract

Maize (*Zea mays* L.) 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. Maize farms are small, and population pressure necessitates the intensification of existing farming systems. Maize research directed at developing technologies for maize production began in Nepal in 1965. In 2000, a survey was carried out in two districts to determine the current level of adoption of improved maize production practices. In each of these districts, remote and accessible village development committees (VDCs) were surveyed. Questionnaires were administered to 54 randomly selected households in each VDC. A Tobit analysis was used to determine socio-economic, physical and technology factors that influence the use of improved varieties by farmers. All households use composted farmyard manure, and in the more accessible areas, urea as part of their soil fertility management strategy. Use of improved varieties was less than 60% for all VDCs and only 15% in the most remote VDC. In three of the four VDCs, adoption of improved varieties primarily occurred during the past 5 years. Based on a Tobit analysis, Khet land area, ethnic group, years of fertiliser use, off-farm income, and contact with extension significantly and positively affected adoption of improved varieties. Farmers in VDCs in central Nepal reported lack of seed to be the major constraint to the adoption of improved varieties, while lack of knowledge of new varieties was the major constraint for farmers in the western VDCs. The results from this survey suggest that the strategy for improving the adoption of new varieties will differ depending on infrastructure and the socio-economic conditions of the farmers in a given area.

Keywords: Improved varieties; Input access; Information access; Technology adoption; Maize; Nepal

1. Introduction

Agriculture dominates the economy of Nepal, accounting for 80% of the work force and 40% of the GDP. Although Nepal is most famous for its high mountains, there are some 3.2 million ha of cereals grown in the lowlands in the south of the country (the Terai), on the valley floors, and on the terraced hillsides below 3000 m elevation. Agriculture is more commercialised in the Terai, where the road system and markets are fairly well developed compared to the hill region. The Terai provides most of the food needed in the urban centres of the country. Though the agriculture systems in the hills have been less dynamic than those in the Terai, they are of critical importance to Nepal's food security. Approximately 50% of Nepal's population lives in the hills. Due to the limited road networks, combined with the remoteness of most villages from established urban centres, the difficulties of transporting food, and the lack of other

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cash-generating enterprises, food security in these regions is largely dependent on farm produce. Maize is the most important cereal grown in the hills, where about 75% of the country's 800,000 ha of maize are located (Paudyal and Poudel, 2001).

In the hills, maize is cultivated on sloping terraced fields called Bari land. It is generally planted during pre-monsoon rains and harvested prior to the end of the monsoons. In the eastern two-thirds of the country, finger millet is often relayed onto the maturing maize crop, while in the western third, maize is rotated with a winter wheat crop. The rate of growth in maize production has been less than 1% per year over the past 20 years. Average maize yields during 1970–1984 declined from 1900 to 1400 kg/ha, probably due to the expansion of maize into marginal land. Since 1984, however, yields have improved to around 1800 kg/ha (Adhikary et al., 2001). There is currently little scope for the expansion of maize area in the hills, as most non-cropped land is either too steep for sustainable production or is protected forest. In order to just keep pace with the population growth rate of 2.3% (CIMMYT, 1999), a significant increase in the productivity and production of maize is needed. This increase will be dependent upon the development and adoption of new varieties and crop management practices.

Maize research in Nepal was first undertaken in an organised way in 1965 (Paudyal and Poudel, 2001). Since then, 15 improved open-pollinated varieties (OPVs) have been released by the national research system for the various ecologies of the country, however, farmers commonly grow only five of these (Adhikary et al., 2001). Movement of improved OPVs has been constrained by the lack of active seed enterprise in the country. The National Maize Research Program produces about 200,000 kg of foundation seed, which is distributed to farmers, the Department of Agriculture, and small seed producers (Adhikary et al., 2001). There are no formal enterprises producing certified seed. The actual amount of certified seed that enters the market is not known, but the area sown with improved seed, including hybrids from India that are grown mainly in the Terai and seed of improved varieties that have been recycled for one or more seasons, is estimated to be between 54 and 58% (Adhikary et al., 2001; Aquino et al., 2001).

Most farmers in the hills do not have ready access to inputs or information. Villages tend to be isolated from one another by forests, steep ridges, or rivers and streams, and there are few roads suitable for vehicles, only paths between villages. Purchased goods must be carried by a porter or, on a more limited scale, by mules. Due to the remoteness of most hill villages from established urban centres, and the distance between villages in terms of travelling time, the logistics of running an effective extension program are formidable. For these reasons, the movement of technology is much slower in the hills than in the Terai.

The objectives of this study were to determine the rate of adoption of improved OPVs in two hill districts of Nepal and to investigate factors affecting their adoption.

2. Methodology

The data reported here were collected as part of a large survey carried out with support from the Hill Maize Research Project (HMRP) to establish a baseline for quantifying the project's impact in the future. The survey was conducted within two Village Development Committees (VDCs) of Dailekh district in the mid-Western development region and in two VDCs of Dolakha district in the central development region. Dailekh and Dolakha were selected because they contain agricultural research stations that are active in the HMRP. Furthermore, there is relatively little published information on the adoption of improved technologies in these two districts. The two districts differ in their level of development. Dailekh lies within the mid-Western development region which is considered to be less developed and have more poverty than other regions within Nepal (Paudyal et al., 2001). Based on discussions with district officers, one accessible and one remote VDC was selected from within each district surveyed.

A random sample of farmers within each VDC was selected from a voter's list that had been updated with the help of VDC officials, or when this list was not available from a list of farmers within a ward provided by the ward chairman. Fifty-four households were interviewed in each VDC and the total sample size was 216. The survey consisted of a questionnaire administered by trained research staff. Only 206 of the questionnaires were completed and used in the analysis. Means for various physical and socio-economic features were calculated for each VDC. For quantitative data, analyses of variance using a completely random model with VDC as the dependent variable were performed.

To estimate the effects of various quantitative and qualitative factors on the extent of improved OPV use, a Tobit model was used on the combined data. The Tobit model is a censored normal regression model. Its estimation is related to the estimation of a censored and truncated normal distribution (Amemiya, 1973; McDonald and Moffit, 1980). In this study, the Tobit model was used to estimate the parameters of the adoption of improved OPV maize by farmers in Dolakha and Dailekh districts in the mid-hills of Nepal. The function is estimated from a censored sample where the sample population consists of both adopters and non-adopters of improved maize varieties.

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:

$$\begin{aligned} A = {} & \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \\ & + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} \\ & + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + e, \end{aligned}$$

where A is the percentage of farmer's total maize area planted to improved OPVs, β_0 the constant, X_1 the area of Khet land owned by farmer (ha), X_2 the area of Bari land owned by farmer (ha), X_3 the average size of plots farmed (ha), X_4 the off-farm income (Rs. 1000 per year), X_5 the literate head of household (dummy; 1: literate; 0: illiterate), X_6 the age of household head (years), X_7 the district (dummy; 1: Dolakha; 0: Dailekh), X_8 the contact with extension (dummy; 1: yes; 0: no), X_9 the hired farm labour for maize production (dummy; 1: yes; 0: no), X_{10} the distance to market (dummy; 1: $\geq$5 km; 0: $\leq$5 km), X_{11} the caste (dummy; 1: Brahman, Chetri and Thakari; 0: others), X_{12} the years of fertiliser use, and e the error term.

The coefficients of the regression model were estimated by applying the maximum likelihood estimation (MLE) technique.

Khet land is used for rice cultivation. This variable was included in the model because farmers with more Khet land tend to be better connected to markets, use more inputs, and therefore may have better access to information and seed. Variables Bari area and average plot size were included because farmers with less area for maize production are under more pressure to intensify, and therefore potentially have more incentive to adopt new technology. Income from grain sales indicates a connection with markets and an increased incentive to produce more cereals on farm. Age of household head, literacy and caste are all important because they are socio-economic factors thought to influence access to information. The variable years of fertiliser use was included because of the assumption that the adoption of one technology may predispose the farmer to adopt other technologies. District, contact with extension, and distance from markets were included because infrastructure and availability of information were thought to likely affect the availability of and demand for seed.

3. Results and discussion

Namdu and Kalbhairab VDCs were selected for the survey from Dolakha and Dailekh districts, respectively, based on their relative accessibility. Maga Pauwa and Chauratha were selected because they were considered to be relatively remote. Based on the survey results, however, market access was significantly lower in Dailekh than in Dolakha, and the average distance to markets where inputs are purchased was considerably greater for both categories of VDCs (Table 1). Overall, farmers in Chauratha were the furthest from input markets, averaging 19 km. Since this distance was based on farmers' responses and not on a direct measurement, it may not be very accurate, however, it is still useful for comparing relative distances between VDCs. The distance to the input market in the relatively remote VDC of Dolakha was similar to that of the relatively accessible VDC in Dailekh, indicating that the road infrastructure in Dailekh is far inferior to that of Dolakha. Contact with extension was inversely related to the distance to market, though it was poor even in the most accessible VDC (Table 1). Literacy rates tended to be higher in the VDCs in Dolakha than those in Dailekh, while farm and household sizes tended to be smaller (Table 1). The maize area was similar across VDCs and averaged only about 0.3 ha. Farmers in Dailekh sold substantially more maize than farmers in Dolakha, though the highest maize grain sales reported in Chauratha, was only 29 kg per year.

Table 1
Selected characteristics of farming households in four VDCs in Nepal, 2001

Characteristic[a]	Dolakha district		Dailekh district	
	Namdu	Maga Pauwa	Kalbhairab	Chauratha
Farm size (ha)*	0.86	0.50	1.05	0.91
Maize area (ha)	0.33	0.27	0.35	0.39
Bari area (ha)*	0.30	0.28	0.49	0.53
Household size (no.)*	6.0	5.7	7.9	7.2
Age of HH (years)	47	47	49	45
Literacy rate of HH (%)	52	38	19	24
Income from grain sales (Rs.)**	2136	715	550	920
Income from other sources (Rs.)	11411	5896	12376	8412
Maize sold (kg)**	4.0	0.3	13.4	29.1
Distance to input market (km)*	5.1	13.7	13.7	19.1
Transport cost (Rs./kg fertiliser)*	0.87	2.06	2.14	2.73
Contact with extension (%)	18	14	10	4

[a] Bari: sloping terraced fields; HH: household head; Rs.: Nepali rupees.
* Significant F-test for VDC in the ANOVA at the 5% level. An ANOVA was performed on quantitative variables only.
** Significant F-test for VDC in the ANOVA at the 1% level. An ANOVA was performed on quantitative variables only.

This suggests that very little of the maize produced leaves the farm for commercial purposes.

The application of farmyard manure (FYM) is the traditional and dominant method for maintaining soil fertility used by farmers in the hills. All farmers surveyed in all VDCs applied FYM (Table 2). Average rates varied between 7000 and 8000 kg/ha and did not differ significantly between VDCs. The percentage of farmers using fertiliser was high in all VDCs except Chauratha. The amount applied was generally low relative to the recommended rate (Pandey, 2000), particularly in Chauratha, where only 6 kg/ha N was applied on average (Table 2). There was almost no application of P fertilisers in all four VDCs.

With the exception of Namdu, where 59% of farmers used improved OPVs, less than 30% of farmers used improved varieties (Table 2). Except for Namdu, adoption rates were much lower than the national rate estimated by Adhikary et al. (2001) and Aquino et al. (2001). This suggests that adoption rates are much higher in districts not surveyed or that the national estimates are higher than actual rates. The higher adoption rates in Namdu may have been related to the dissemination of information and seed from the

Table 2
Adoption level of yield-enhancing maize technologies in four VDCs in Nepal, 2001

Technology[a]	Dolakha district		Dailekh district	
	Namdu	Maga Pauwa	Kalbhairab	Chauratha
Use of FYM (%)	100	100	100	100
Rate of FYM (kg/ha)	7600	7270	8280	7010
Use of fertiliser (%)	96	100	84	32
Rate of N fertiliser (kg/ha)**	39	34	28	6
Rate of P fertiliser (kg/ha)	1	<1	<1	<1
Use of improved OPVs (% of farmers)**	59	29	22	15
Maize area planted to improved OPVs (%)**	62	13	23	27
Yield of improved OPVs (kg/ha)	1400	1490	1700	1620
Yield of all maize grown (kg/ha)**	1300	1090	1380	1560

[a] FYM: farmyard manure; OPV: open-pollinated variety.
** Significant F-test for VDC in the ANOVA at the 1% level. An ANOVA was performed on quantitative variables only.

Table 3
Proportion of farmers that first adopted improved maize varieties during various periods prior to the study in four VDCs in Nepal, 2001

Time of adoption	Dolakha district (% of those surveyed)		Dailekh district (% of those surveyed)	
	Namdu	Maga Pauwa	Kalbhairab	Chauratha
Never adopted	41	75	87	79
<5 years previous to study	7	19	7	19
5–10 years previous to study	28	6	2	2
>10 years previous to study	24	0	4	0

Kabre agricultural research station which is located nearby and has been active for more than 20 years.

The rate of adoption of improved OPVs was significantly less than the rate of fertiliser adoption. This is somewhat surprising given the relatively higher cost of fertiliser compared to seed, and the additional difficulty of transporting bulky fertiliser. Improved open-pollinated yields were higher (on average by 17%), which clearly indicates the advantage of growing improved varieties. Generally yields were higher in Dailekh than in Dolakha (Table 2).

The time of initial adoption of improved OPVs differed between Namdu, which had the highest adoption level, and the other VDCs. In Namdu, most adoption occurred 5 or more years previous to the study, with almost half of the adoption occurring more than 10 years previously (Table 3). In the remaining VDCs, however, the limited adoption that had occurred took place 5 or fewer years previous to the study.

Based on the Tobit analysis, which combined data from all of the VDCs, the variables that significantly increased the adoption of improved OPVs were area of Khet land, ethnic group, years of fertiliser use, off-farm income, and contact with extension (Table 4). Hired labour was the only variable that had a significantly negative influence on the use of improved

Table 4
Tobit model estimates of index function and marginal effects for determinants of the percentage of total maize area planted to improve OPVs in four VDCs of Nepal, 2001

Variable[a]	Index function		Mean of X	Marginal effects	
	Coefficient	S.E.		Coefficient	S.E.
Constant	−91.1*	40.7		−33.9*	14.3
Khet area (ha)	36.4*	18.7	0.4	13.5*	7.0
Bari area (ha)	−39.6	31.4	0.4	−14.7	11.7
Plot size (ha per HH)	73.3	87.2	0.2	27.2	32.4
Off-farm income × 1000 (Rs.)	0.6**	0.3	9.5	0.2**	0.1
Literacy of HH (dummy)	−24.5	18.2	0.7	−9.1	6.7
HH age (years)	−0.1	0.6	47.0	0.0	0.2
District (dummy)	3.7	19.2	0.5	1.4	7.2
Extension contact (dummy)	61.9**	22.2	0.1	23.0**	8.2
Hired farm labour (dummy)	−50.4**	20.0	0.2	−18.8**	7.3
Distance to market (km)	17.1	18.1	0.3	6.4	6.7
Ethnic group (dummy)	66.1**	17.5	0.6	24.6**	6.2
Fertiliser use (years)	2.8*	1.3	8.2	1.0*	0.5
log likelihood function (unrestricted)		−506.3			
log likelihood function (restricted)		−530.4			
Likelihood ratio		48.2**			
No. of observations		206			

[a] Khet: land important for rice cultivation; Bari: sloping terraced fields; HH: household head; Rs.: Nepali rupees.
* Significance at 5%.
** Significance at 1%.

Table 5
Reasons given by farmers for not adopting improved open-pollinated maize varieties, Nepal, 2001

	Dolakha district (% of those surveyed)		Dailekh district (% of those surveyed)	
	Namdu	Maga Pauwa	Kalbhairab	Chauratha
Lack of knowledge	35	36	62	77
Lack of sufficient manure	5	0	2	0
Stover too hard	0	0	2	3
Not available	55	64	24	3
Undesirable taste	5	0	10	17

OPVs. Of the factors that significantly impacted on the adoption of improved OPVs, Khet area and ethnic group were determined to be important, but also unable to be managed or externally influenced. Farmers with more Khet land tend to be better connected to markets because rice is more often sold or traded than maize. The negative effect of hired labour was determined to be quite large. The use of non-household labour in maize production is dependent on a number of factors, e.g. the distance of the maize field from the homestead or the amount of labour required relative to available labour. Farmers who do not hire labour for maize production (i.e., those who have sufficient family labour) are more likely to adopt improved OPV maize than those who hire labour. This is probably because more labour is used per unit of land for cultivating improved OPV maize compared to local maize.

Of the remaining factors included in the model, contact with extension had the most dramatic influence on adoption (Table 4). This indicates that information, and not just seed availability, currently constrains the use of improved OPVs. Years of fertiliser use had a minor positive impact on the rate of adoption. This may indicate that farmers who have more experience with technologies in general are more likely to test and adopt new OPVs. Off-farm income had a positive effect on adoption, but the data suggest that large changes in off-farm income are needed to create significant increases in adoption of improved OPVs. It is likely that farmers with large off-farm income have one or more family members working outside of the village. Not only would the increased cash allow the family to purchase inputs, but also the individuals working outside the village would have the opportunity to acquire seed and information on new varieties from other areas.

To evaluate the effects of each independent variable on the adoption of improved maize varieties, marginal effects were estimated (Table 4). It can be seen that the same set of independent variables used in the primary index function show a significant effect on the adoption of improved maize.

The marginal effect of 13.5 for Khet land area implies that overall respondents, every 1 ha increase in Khet land area would increase the adoption of improved maize varieties by 13.5%. Similarly, every 1000 Rs. increase in off-farm income would increase the adoption of improved OPV maize by 0.2%, and every 1 year of experience in fertiliser application would increase adoption of improved OPV maize by 1.0%. Among the dummy variables, the largest change of 24.9% is associated with ethnicity and the second largest of 23.0% is due to contact with extension personnel. The results also suggests that adoption of improved OPV maize will be reduced by 18.76%, if farmers need to hire labour for maize cultivation.

The primary reasons given by farmers for not adopting improved OPVs differed between the two districts. In both VDCs in Dolakha, the lack of seed availability was the primary reason for not growing improved OPVs, while in the VDCs of Dailekh, the lack of knowledge of improved OPVs constrained their adoption (Table 5). These data do not support the commonly repeated notion that farmers do not grow improved OPVs because these varieties are not as good as those they currently grow. In fact, the data suggest that very few farmers have had a chance to evaluate the improved OPVs currently available. The data indicate that improved OPVs have a significant yield advantage over local varieties in all VDCs, though the magnitude varied somewhat between VDCs (Table 2). Perhaps in some cases (i.e., in Chauratha), the lack of adoption could be due to the perceived advantage of improved OPVs being insufficient to motivate change. Since higher yielding, better-adapted varieties could be a significant incentive for farmers to adopt new varieties, a more concerted effort in the development of the varieties is justified.

4. Conclusions

A number of conclusions can be drawn from these data regarding the adoption of improved OPVs in Nepal. Since adoption of fertiliser is higher than the adoption improved seed—the relatively cheaper, more transportable input, the poor adoption of seed cannot be blamed on 'remoteness' per se. Perhaps, the most conspicuous finding of this research is the very limited exposure that farmers have had to new production technologies. This deficiency must be immediately addressed if improvement in production and productivity are to occur. Our analysis clearly indicates that there has been limited contact between farmers and the extension system in its broadest sense (including the non-governmental community active in agricultural development). Greater emphasis on exposing farmers to new improved OPVs is urgently needed as a first step in improving adoption. The data also suggest that the strategy for improving adoption of new technologies in accessible areas may be quite different to that used in remote areas. It appears that information is more constraining in remote districts than in accessible districts—in these areas seed constrains adoption. This would suggest that in the inaccessible areas, a program of more intensive on-farm demonstrations and testing is immediately justifiable. On the other hand, actions in accessible districts should focus on improving the availability of improved seed. Community-based seed production programs should be supported until commercial seed enterprises develop to fill the current void. The reported 17% yield advantage of improved OPVs, averaged overall VDCs, indicate that significant increases in production and productivity can be achieved through the use of improved varieties.

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