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Technology adoption in maize farming: a comparative analysis between improved seed users and local seed users of Argakachi district of Nepal

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Abstract. *Maize is one of the top agricultural commodities that has great share in the Agricultural Government Development Plan of Nepal. Despite being a major crop, productivity of maize is quite lower than global average. In this context, a study was undertaken to determine the extent of technology adoption between improved and local seed users of Arghakhanchi district of Nepal. A pretested semi-structured questionnaire was administered among 120 randomly selected farmers during the month of January 2018. The extent of technology adoption was measured on sowing time, seed replacement, variety change, seed rate, application of fertilizer, weeding and plant protection. The empirical evidence suggested that, extent of technology adoption and benefit cost ratio were magnificently higher for improved seed users than local seed users. So, there is still a gigantic scope to improve maize productivity in the area by adoption of recommended technology of maize farming. The probability of adoption of recommended technology (improved seed) for maize farming was found to be higher for those with access to extensive service. Overall, our study pointed out that extension facility is a key strategy to make famers aware of the new technologies and a crucial factor to increase the chance of adoption.*

Keywords: technology adoption, seed replacement rate, certified seed, improved seed

Introduction

Maize (*Zea mays*), native to Mexico, belongs to family Graminae. Maize is a traditional crop of Nepal; cultivated for food, feed, and fodder on slopping Bari land mostly under rainfed conditions during summer as a single or relay crop with millet and also grown during winter and spring in Terai (low land region of southern Nepal ranging from 67 to 300m above sea level) provided that irrigation is available (Paudyal et al., 2001). Having the highest yield potential, maize, among other cereals is known as ‚the queen of cereals' (Singh, 2002). By the same token, in the world, maize is the second largest crop after sugarcane in terms of quantity of production. Contributing 6.67% in Agricultural GDP, being second important crop after rice, in Nepal, maize is principal food crop of hills, particularly among the poor and disadvantaged group of farmers and a prime source of animal feed for growing livestock industries in Terai (MoAD, 2016). It occupies 78% area out of the total cultivated land in hills. Two thirds of the maize produced in the hills of Nepal is directly consumed by farmers (Sapkota et al., 2017). Maize fodder has low amount of protein (3-3.5%), yet it is preferred by animals because of its palatable and succulent nature (Randhawa et al., 1994). With its multipurpose value, maize, gives us freedom for making *Dhido, roti, chayakhla* – typical food products of Nepal and its flour is utilized in different bakery and fermentation industries.

Looking at the world scenario, the demand of maize is increasing, particularly in developing countries and its requirement is predicted to increase from 282 million tons in 1995 to 504 million tons by 2020 (Haque et al., 2012). In 2016, production and yield of maize in Nepal was 235517 Mt and 2.50 t/ha, respectively (MoAD, 2016). In Nepal, demand of maize has been growing constantly by 5% in the last decade (Sapkota and Pokhrel, 2010). During the year of 2014, in Nepal, total quantity of maize requirement and production for food was about 2.9 million metric ton and 2.35 million metric ton, respectively, resulting in deficit of 0.65 million Mt (Khattrai-Chhetri, 2015). There was 6.46 million metric ton demand of feed to run the existing poultry industries in Nepal while the poultry industries were increasing at an alarming rate (Khattrai-Chhetri, 2015). During the year of 2014/2015, maize had fulfilled 40-50% demand for poultry feed in Nepal (Acharya and Kaphle, 2015). However, the increase in maize productivity during the past decade since 1970 to 2015/16 was only 0.43 Mt/ha (MoAD, 2016).

The present production of maize is quite low to fulfill the country's demand. The gap between maize production and demand was due to various socio-economic and technological factors (Sapkota and Pokhrel, 2010). Lack of organic and chemical fertilizers (JICA, 2016), unavailability of quality seed and farmer's preferred varieties at the right time, in desired quantities and at reasonable price are the major constraint for maize farming in Nepal (Adhikari et al., 2003). Thus, the production of maize can be improved by adopting recent technologies of maize production. The present study was, therefore, undertaken to assess current adoption of maize production technologies and to identify major factors associated with the adoption of improved maize varieties in Arghakhanchi district of Nepal.

Material and methods

Purposefully, a study was carried out in Arghakhanchi district, province No. 5 of Federal Republic of Nepal, 27‘45“ N to

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28‘26“ latitude and 80‘45“ to 83‘23“ E longitude, altitude of 305 to 2515m above the sea level, because it is a major maize producing district with identifiable maize producers using both improved seed and local seed. This beautiful district encompasses in 68% of its total area Mountainous range and the rest are the Siwalik Hills. In addition, climate here ranges from tropical to temperate but dominantly tropical and subtropical.

A total of 120 respondents, 37 using improved seed and 87 respondents using local seed were selected randomly from the population of households cultivating maize for the last two years. By using pretested semi-structured format, face to face interview was scheduled to collect primary data about socio-economic and demographic information, technologies of maize cultivation, cost of production and income in the month of January 2018. Focus group discussion, key informant (long-term maize producers, technical assistants, local leaders) interviews were conducted to validate the information obtained from respondents. Among the two categories of famers: improved seed users and local seed users, analysis and comparisons were made using different descriptive statistics (such as mean, standard deviation), Inferential statistics (such as Chi-square test, t-test) and Analytical statistics (such as probit regression model), with the help of different statistical software such asff Microsoft Excel, SPSS and STATA.

Probit model

Probit model was used to determine the factors affecting the level of technology adoption among maize producers in Arghakhanchi district. This model is a statistical probability model with two categories in the dependent variable (Liao, 1994). Probit model is based on the cumulative normal probability distribution. The binary dependent variable, y< takes on the values of zero (0) and one (1) (Aldrich and Nelson, 1984). When using the binary probit regression model, farmers using improved variety as seed were taken as 1, while those using local seed - as zero. It is assumed that the i^{th} farmer obtains maximum utility, he has improved seed preference rather than local seed. The probability P_i of choosing any alternative over not choosing it can be expressed by the following equation, where φ represents the cumulative distribution of the standard normal random variable (Uzunoz and Akcay, 2012):

$$P_i = \text{prob}\ [Y_i = 1\ \text{Ixl} = \int_{-\infty}^{xi'\beta} = (2\pi^{-1/2}\ \exp(-t^2/2)dt = \varphi(x'_{i\beta}).$$

Summary statistics:
Number of observations =120 (n=120);
Log likelihood: -62.53753;
LR chi^2(8): 23.19;
prob>chi^2: 0.0031;
pseudo R^2 0.1564.

Benefit cost analysis

Benefit cost analysis was done for both categories of farming households using improved seed and local seed for maize production so as to find out which way is more profitable. Benefit Cost Ratio, which defines the benefit per unit cost, in the following format, was used for benefit cost analysis.

B/C = Total income/Total variable cost.

Results and discussion

Socio-economic characters

Average land holding of improved maize users was 10.46ha and that of local seed users was 9.84ha but the difference was statistically non-significant (Table 1). Despite smaller land holding, local seed growers cultivated maize on larger area (on 7.96ha) in comparison to that of improved seed users (on 7.95ha) but the difference was statistically non-significant. Productivity of improved maize in the research area was 2187.96 kg/ha and that of local maize was 1671.54 kg/ha. The difference was statistically significant at 1% level of probability. Furthermore, the overall productivity of maize in the research area was similar to the productivity of Arghakhanchi district (MoAD, 2016).

Table 1. Land holding and productivity of maize

Variables	Overall	Farmers category		Mean difference	t-value	P-value
		Improved seed user	Local seed user			
land under maize	7.954	7.95 (0.63)	7.96 (0.38)	-0.11	-0.17^{ns}	0.987
Total land holding	10.037	10.46 (1.21)	9.84 (0.71)	0.61	0.485^{ns}	0.65
Productivity	1830.77	2187.96 (103.98)	1671.54 (63.52)	516.42	4.39^{***}	0

*Figures in parenthesis indicate standard error of mean; *** indicates significance at 1% level of probability

The returns from maize grains, stubble and cone were added to calculate total returns and total variable cost incurred for maize production was calculated considering different input factors such as seed, nutrients, human and animal labor (bullocks) (Table 2). The profit from maize farming was calculated by deducting total cost from total returns. Although, statistically, the cost of production was found to be similar among local and improved seed users, the average cost of production of maize for improved seed users (Rs. 77257.056 = 681.75 US$ per hectare) was higher than that of the local seed users (Rs. 68746.59 = 606.65 US$ per hectare). Significantly higher return for improved seed users with average return of Rs. 88638.46 (782.19 US$) per hectare and for local seed users, average return of Rs. 68358.43 (603.23 US$) per hectare was observed, probably because improved seed increased productivity of the maize farm was also noted (Tehamou Meughoyi, 2018). The benefit cost ratio (B/C) was computed as the ratio of gross return to the total variable cost incurred in maize production. B/C ratio of improved seed was 1.23 and that of local seed was 1.03. Significantly higher B/C ratio indicates that farmers who use improved seed were making more profit than farmers using local seed. B/C ratio of the study area was 1.08 which was lower than maize farming in the western plain of Nepal (Ghimire et al., 2016). Low B/C ratio in the research area was due to various socio-economic and technological factors (Sapkota and Pokhrel, 2010).

Table 2. Economic status of maize cultivation

Variables	Overall	Farmers' category		Mean difference	t-value	P-value
		Improved seed user	Local seed user			
Total returns, Rs (US$)	74611.45	88638.46 (4188.40)	68358.43 (2556.49)	20280.02	4.27^{***}	0.00
Total cost, Rs(US$)	7137.67	77257.05 (5159.38)	68746.59 (2603.49)	8510.48	1.63^{ns}	0.10
B/C ratio	1.08	1.23 (0.05)	1.03 (0.02)	0.2	3.8^{***}	0.00

*1Rs = 0.0088US$

Technology adoption of maize farming

According to the study, it was found that very few respondents (only three) change seed every year (Table 3). Around 35% of the respondents among improved seed users and 7% of the respondents among local seed users were found to be changing seed within 3 years. Moreover, about, 43% of the improved seed users and 21% among local seed users take at least 5 years to change the seed, whereas 68% of the respondents among local seed users did not replace seed at all. Seed replacement rate (SRR) in the research area is estimated to be 29%, indicating that most of the farmers were beyond the reach of certified seed. Seed replacement rate in the study area was higher than the national average of 2010 (11%). This increasing trend in seed replacement rate could be due to gradual increase in formal supply of quality seed in the country as mentioned in a previous study (Gauchan, 2017). The field study revealed that 14% of the respondents among the improved category change variety every year but none of the respondents among the local seed users changes variety every year. Besides, it is estimated that nearly 54% farmers within the improved category change variety in alternate years but very few respondents (around 1%) among local seed users change variety alternatively. However, most of the local seed users (nearly 99 %) and few (around 32%) improved seed users assessed to be not changing variety at all, as shown in Table 3.

Table 3. Technology adoption among categories of farmers

Variables	Overall	Farmers' category		Chi-square vale	P-value
		Improved seed user	Local seed user		
Seed replacement					
Each year	3 (2.5)	3 (8.1)	0 (0)	36.65^{***}	0.000
Within 3 year	19 (15.8)	13 (35.1)	6 (7.2)		
Within 5 year	37 (30.8)	16 (43.2)	21 (25.3)		
No change	61 (50.8)	5 (13.5)	56 (67.5)		
Variety change					
Each year	5 (4.16)	5 (13.5)	0 (0)	66.49^{***}	0.000
Alternate years	21 (17.5)	20 (54.1)	1 (1.2)		
No change	94 (78.3)	12 (32.4)	82 (98.8)		
Sowing date					
Appropriate	26 (21.70	22 (59.5)	4 (4.8)	47.28^{***}	0.000
Before appropriate	90 (75)	13 (35.1)	77 (92.8)		
After appropriate	4 (3.33)	2 (5.4)	2 (2.4)		
Level of seed rate					
Recommended	29 (24.16)	11 (29.7)	18 (21.7)	2.003^{ns}	0.360
Above recommended	76 (63.33)	20 (54.1)	56 (67.5)		
Below recommended	15 (12.50)	6 (16.2)	9 (10.8)		

*Figures in parenthesis indicate percent; *** indicates 1% level of probability

From the observation made, it was unraveled that all the respondents use a common planting method – sowing behind the plough method, despite the fact that row planting method is the recommended one as this technique maintains optimum plant density (Ebrahim, 2002). Most of the respondents (about 60%) among improved seed users found to be cultivating maize at appropriate time whereas the majority of the local seed users (about 93%) found to be cultivating maize before the appropriate time. Appropriate time of sowing maize in mid-hills is April to May (JICA, 2016). Maize sowing before the appropriate time faces severe water and temperature stress during knee high stage and 2-3 weeks before silking stage. Water stress before 2 weeks of silking reduces the yield of maize (Singh and Singh, 1995). Very few, altogether four, respondents cultivated maize after appropriate period. Around 30% of the respondent among the improved category and 28% among the local seed category used the recommended level of seed rate but the result was statistically non-significant. The recommended seed rate for maize is 20 kg/ha (Lamichhane et al., 2015). Around 54% of the respondents of the improved seed category and 68% of the local seed category applied seed more than the recommended dose, which ultimately increased the cost of production.

As shown in Table 4, around 73% of the respondents among the improved seed category and 26% of the respondents among the local seed category applied the recommended dose of FYM. The recommended dose of FYM for maize farming in Nepal is 1000 *doko* per hectare (5-6t/ha) (JICA, 2016). Most of the improved seed users applied FYM at the accurate time than those of the local seed users and the result was statistically highly significant at 1% level of probability. Around 49% of the respondents among the improved seed users and 5% of the respondents among the local seed users applied FYM two weeks earlier than sowing which was found to be in consistency with the recommended time of FYM application (JICA, 2016). Very few respondents had applied FYM one week earlier than maize sowing. Around 49% of the respondents among the improved seed category and 94% of the respondents among the local seed category applied FYM once every year. Most of the respondents among the improved seed category applied the recommended dose of nitrogen whereas most of the respondents among the local seed users applied lower dose of nitrogen. The recommended dose of nitrogen in the western region of Nepal is 100-150 kg per hectare (Ghimire et al., 2016). None of the respondents applied phosphorous and potassium, which could be a probable reason for low yield because of the nutrient deficiency in soil (Ashraf et al., 2013). All the respondents performed manual method of weeding, threshing and harvesting. They performed weeding two times during the crop period which was consistent with the recommended weeding practice (JICA, 2016).

Table 4. Technology adoption of categories of farmers

Variables	Overall	Farmers' category		Chi-square vale	P-value
		Improved seed user	Local seed user		
FYM dose					
Recommended	49 (40.83)	27 (73.0)	22 (26.5)	22.95***	0.000
Below recommended	46 (38.33)	7 (18.9)	39 (47.0)		
Above recommended	25 (20.83)	3 (8.1)	22 (26.5)		
Time of FYM application					
Prior to 2 weeks	22 (18.33)	18 (48.6)	4 (4.8)	33.733***	0.000
Previous week	2 (1.67)	1 (2.7)	1 (1.2)		
Once a year	96 (80)	18 (48.6)	78 (94.0)		
Nitrogen dose					
Recommended	23 (19.16)	13 (35.1)	10 (12.0)	26.711***	0.000
Below recommended	68 (56.67)	12 (32.4)	56 (67.5)		
Above recommended	16 (13.33)	11 (29.7)	5 (6.0)		
No application	13 (10.83)	1 (2.7)	12 (14.5)		

*Figures in parenthesis indicate percent; *** indicates 1% level of probability

Determinants of adoption of improved maize seed in Arghakhanchi district

Probit model was used to assess the factor influencing the adoption of maize technology (Table 5). Good explanatory power of the model was revealed through likelihood ratio Chi-square (LR chi^2) which was found statistically significant at 1% level of probability. The Pseudo R^2 was 0.1564. Among the eight variables studied under the model, visit of the extension worker was found to be statistically significant. It has been found that farmer's access to extension service was more likely to adopt technologies of maize compared to those without access and the difference was found statistically significant at 1% level of probability. The result was in accordance with the findings of Dahal and Rijal (2019). The probability of adoption was found to be 21.11% higher for those with access to extension service as compared to those without access because visit of the extension workers offers technical guidance to farmers as compared to those lacking such facility. It was previously found that access to extension worker helps to adopt agricultural technology (Feder and Slade, 1986). The other variables such as economically active members, land holding, gender of household head, and age of household head and schooling of household head had positive relation with the adoption of technologies of maize production while none of them were found statically significant. Positive relation of economically active members with adoption of improved maize technology is supported by the fact that greater number of laborers is required for commercial maize farming; commercial farmers with higher number of active members in the family are more likely to adopt recent agricultural technologies. Similarly, farmers with higher schooling have access to agricultural information, are more likely to adopt improved maize technology. Positive relation with gender of household head and age with adoption of improved maize technology is partly attributed by the fact; aged male farmers have more experience in farming and have more chance of adoption of improved maize technology. Some variables such as occupation of household head and family type had negative relation with adoption of technology while none of them were found statistically significant.

Table 5. Determinants of improved maize seed adoption

Variables	Coefficients	Standard error	Z	p>IZI	dy/dx
Active member (number)	0.063924	0.0709839	0.90	0.368	0.0187011
Access to extension (@)	0.7246141***	0.265551	2.73	0.006	0.2119874
Land holding (@)	0.0612057	.2666639	0.23	0.818	0.017905
Gender of HHH (@)	0.6574805	0.510087	1.29	0.197	0.1923473
Age of HHH (years)	0.0104096	0.0130176	0.80	0.424	0.0030454
Schooling of HHH (years)	0.0763606	0.0469335	1.63	0.104	0.0223395
Occupation of HHH (@)	-0.1579343	0.2829435	-0.56	0.577	-0.046204
Family type (@)	-0.3368901	0.3628558	-0.93	0.353	-0.0985579
Constant	-2.539332	1.205196	-2.11	0.035	

*@ indicates dummy variable; *** indicates 1% level of probability

Conclusion

Higher benefit cost ratio in maize production was found for improved seed users, which indicates that improved seed users earn more profit than local seed users. Technology adoption was found to be significantly higher for improved seed users than local seed users but the level of adoption of technology for improved seed was not under satisfactory range. Probability of adoption of improved seed was higher for those farmers who had access to extension. There is huge scope for increasing profit in maize farming by increasing use of improved varieties, application of phosphorous and potassium fertilizer, adopting row method of planting, managing irrigation facility and applying recommended dose of nitrogen, FYM, and seed rate. Maize production in Arghakhanchi district demands further researches on resource use efficiency of maize production, feasibility of mechanization and value addition.

References

Acharya KP and Kaphle K, 2015. Major issues for sustainable poultry sector in Nepal. Global Journal of Animal Scientific Research, 3, 227-239.

Adhikari K, Ransom JK and Paudyal K, 2003. Adoption of improved maize varities in hills of Nepal. Journal of the International Association of Agricultural Economics, 29, 299-305.

Aldrich JH and Nelson FD, 1984**.** Linear probability, logit, and probit models. Newbury park, California: Sage publication.

Ashraf QH, Weil DN and Wilde J, 2013. The effect of fertility reduction on economic growth. Population and Development Review, 39, 97-130.

Dahal BR and Rijal S, 2019. Production economics and determinants of potato production in Nuwakot, Nepal. International Journal of Applied Sciences and Biotechnology, 7, 62-68.

Ebrahim IZ, 2002. Effect of maize planting methods on plant regularity and yield of crop. Journal of Agricultural Science Mansura University, 27, 1833-1839.

Feder G and Slade R, 1986. The impact of agricultural extension: the training and visit system in India. Research Observer, 1, 2.

Gauchan D, 2017. Research and support services in seed production and supply in Nepal. Hariharbhawan, Kathmandu: Seed Quality Control Centre, Ministry of Agricultural Development, Government of Nepal.

Ghimire S, Sherchan D, Andersen P, Pokhrel P, Ghimire S and Khanal D, 2016. Effect of variety and practice of cultivation on yield of spring maize in Terai of Nepal. Agrotechnology, 5, 2.

Haque MA, Moniruzzaman, Rahman MS and Alam QM, 2012. Profitability of hybrid maize (*Zea mays* L.) seed production under contract farming in Bangladesh: a farm level study. Bangladesh Journal of Agricultural Research, 37, 327-334.

JICA, 2016. Maize Farming Techniques Manual. JICA project.

Khatri-Chhetri G, Karki TB, Shrestha J and Achhami BB, 2015. Status and prospects of maize research in Nepal. Journal of Maize Research and Development, 1, 1-9.

Lamichhane J, Timsina KP, RanaBhat DB and Adhilari S, 2015. Technology adoption analysis of improved maize technology in western hills of Nepal. Journal of Maize Research and Development, 1, 146-152.

Liao TF, 1994. Interpreting Probability Models: Logit, Probit, and Other Generalized Linear Models. Thousand oaks, California, USA: Saga publication.

MoAD, 2016. Primeminister Agricultre Modernization Project, Ministry of Agriculture Development. Kathmandu: MoAD.

MoAD, 2016. Statistics information on Nepalese agriculture. Singhadurbar, Kathmandu, Nepal, Ministry of Agriculture Development, Government of Nepal.

Paudyal KR, Ransom JK, Rajbhandari NP, Adhikari K, Gerpacio RV and Pingali PL, 2001. Maize in Nepal: production system, constraints and priorities for research. Kathmandu: NARC and CIMMYT.

Randhawa MA, Jamil K, Yousurf RM, Siddiqui, MZ and Toor MA, 1994. Influence of different nitrogen levels on the yield and quality of maize fodder. Pakistan Journal of Agricultural Science, 31, 27-29.

Sapkota D and Pokhrel S, 2010. Community based maize seed production in the hills and mountains of Nepal: A review. Agronomy Journal of Nepal, 1, 107.

Sapkota M, Joshi NP, Kattel RR and Bajracharya M, 2017. Determinants of maize seed income and adoption of foundation seed production: evidence from Palpa district of Nepal. Agriculture and food security, 6, 41.

Singh BR and Singh DP, 1995. Agronomic and physiological responses of sorghum, maize and pearl millet to irrigation. Field Crops Research, 42, 57-67.

Singh C, 2002. Modern techniques of raising field crops. New Delhi, India, Oxford and IBH Publishing Co. Pvt. Ltd.

Tehamou Meughoyi C, 2018. Improved seeds and agricultural productivity of family farms in Cameroon. In: Building resilent and sustainable agriculture in sub-Saharan Africa (eds. A. Shimele, A. Verdier-Chouchane and A. Boly). Palgrave Macmillan, Cham.

Uzunoz M and Akcay Y, 2012. A case study of probit model analysis of factors affecting consumption of packed and unpacked milk in Turkey. Economics Research International, Vol. 2012, Article ID 732583. doi:10.1155/2012/732583