



Research Article

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ADOPTION OF IMPROVED POTATO VARIETIES IN NEPAL

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Abstract


Potato is crop of major significance food sources in Nepal. Purpose of the study was to examine current adoption level of potato production and identify major factors associated with adoption. Study was carried out in five districts namely Bara, Jhapa, Kailali, Kavre and Solukhumbu covering 503 samples. Districts were selected on basis of highest area of potato cultivated. In the district sample was randomly selected. Tobit regression was used to find out factor affecting adoption. Study revealed that variety recommended by Nepal agricultural research council covered 42.56 percent of total potato cultivated area and 51 percent of total production. Farmers found to adopt improved varieties Janakdev 16 percent followed by Cardinal 9.4 percent. Local variety like Namcheli 9.58 percent, Bhotange 10.94 percent and Lal Gulab 5.44 percent and Indian varieties like Arungold 8.87% of potato area. The results showed training and seed source was major significant factor affecting proportion of area allocated for improved potato. The probability of adoption increases by 9% if source of seed were formal and by 8% if farmers get training.


Keywords: Adoption, Improved, Potato, Intensity, Tobit


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1. Introduction

Potato (*Solanum tuberosum* L.), a staple vegetable crop cultivated in most areas of the globe, is a major food crops of high mountains and cash crops of Hills and Terai belts of Nepal (NPDP, 2019). It was originated in western South America and distributed in other parts of world in 15th and 17th century (Reddy et al., 2018). It has been emerged as major commercial crops among the vegetables. As a staple crop, it enhances the livelihood

and food security of poor farmers and is also a way out of poverty (Devaux, 2014). It is a nutritious food that contains carbohydrates (17%), proteins (2%), adequate vitamins B and C and high quality nutritional fiber (Chakrabarti et al., 2018). It is used as vegetable and in industries for manufacturing starch, alcoholic beverages and other processed products like French fries, chips etc (IPC, 2019).

In Nepal it is sixth important crop in terms of area, third in terms of production and second in terms of

productivity (AITC, 2019). This cash crop is popular crop in Nepal due to its wider adoptability, high yield potential and high demand and contributing about 6.57 and 2.17 percent respectively in AGDP and GDP (Bajracharya and Sapkota, 2017). It is grown in all 75 districts of Nepal and its production is increasing rapidly in recent years due to quality researches, effective dissemination and climatic diversity permits year round cropping from terai (plains) to high hills (4400m asl) (MoALD, 2017). Its yield varies from and yield varies from 6.5 tons/ ha to 21.6 tons/ ha. It is also prioritized crop in agriculture perspective plan and national seed vision 2013. Per capita consumption has almost tripled since 1990 to 80.56 a year (FAO, 2008). From 1990/91 to 2016/17 area of potato has been increased by 132%, production is almost tripled and yield was increased by 68%. By ecological region mid hill area occupies most i.e. 40% of total area coverage and production in the country. In deed yield of the potato is remarkably low i.e. 1.5 times less than developed countries. This fact suggests that there is immense potential for improvement of potato yield if we are able to enhance adoption rate of improved variety. Enhancing adoption of improved potato varieties could impact on farmer's income, household food and nutritional security (Gairhe et al., 2017). Till date, Nepal agricultural Research council has released 12 improved varieties of potato along with improved production technologies. The varieties have large yield potential and the diffusion of these varieties can greatly enhance national potato production (Kafle and Shah, 2012). The adoption rate depends upon information, effective extension systems, farmer's risk attitude, socio-cultural resistance and farmer's preference for different product attributes like disease resistance, yield, cooking quality, tuber size and tuber shape (Lancaster, 1966). While research, extension, cooperatives, and NGOs can all play an important role in the development and diffusion of new varieties (Ortiz et al., 2013), buyers' preferences also play a crucial role in farmers' decisions to choose particular varieties (Asfaw et al., 2012).

In context of Nepal there are few research studies which have determined factors influencing the adoption of improved varieties. Strengthening formal seed system and capacity building of producer through training, exposure to visit, higher land tenancy, large number of cattle rearing, availability of extension services, household head education age and found to have positive effect on the adoption (Gairhe et al., 2017; Shrestha and Yadav, 2018). But family size adversely affect (Shrestha and Yadav, 2018). In the same research it has been found that production of potato has been boost up by 21% simply by adopting improved potato varieties. Also training and membership in organization like cooperative and farmers group enhanced production by 33% and 34% respectively. Similarly the research pointed out that diseases attack, weak availability of seed, high cost of

production, labor scarcity, lack of market integration were major constraints of production and research suggested dissemination of new variety, quality seed production and adoption of IPM techniques, development of market infrastructure like cold store, rustic store and collection centers could boost up the production. In some literature education, training, organization membership and family income were found as a significant factor for adoption of improved variety (Panta et al., 2019). These studies were limited to small area therefore it is difficult to draw a valid conclusion. The present study was, undertaken to assess current adoption level of potato production technology and identify major factor associated with adoption of improved potato variety by analyzing farmers' attributes and impeding factors for adoption taking large sample representing Nepal.

2. Materials and Methods

2.1 Sample Size and Sampling Techniques

The study was performed in five districts of Nepal Bara, Kailali, Jhapa, Kavre and Solukhumbu districts. The districts, Municipalities and Ward were purposively selected on the basis of the area under potato, famous for potato production. Among the ward 503 sample were collected by applying simple random techniques.

2.2. Methods of Data Collection

Primary data were collected using semi-structured interview schedule developed by panel of agricultural economist and agronomist. To increase validity and reliability, farmers were interviewed by researchers and experience extension officers. The information gathered were verified by the data collected through Focus Group Discussion (FGD) and Key Informant Interview (KII). Secondary data were obtained from DADO annual reports, newsletters, bulletins and relevant articles, Department of Agriculture, Ministry of Agriculture and Cooperatives (MOAC). The survey was conducted between Januarys to June 2017.

2.3. Data Analytical Techniques

The information collected was arranged systematically. Before entering the data codes were designed and units were standardized. Different analytical software like STATA, SPSS, MS-EXCEL has used to analyze acquired information. Tobit regression analysis was done to determine that factor affecting adoption of improved varieties. In this regression model, the proportion of potato area allocated to improved variety is used as dependent variable. The adoption of new agricultural technology is influenced by three factors like i) farm and farmers' associated attributes like farmer's education, age, family size and farm size.ii) attributes associated with the technology (Adesina & Zinnah, 1993) and the farming objectives (CIMMYT, 1988)

Econometric model used:

$$Y_{ij} = \beta_{ij} X_{ij} + \varepsilon_i$$

i = 1 if farmers grows improved potato variety; j = 0 otherwise.

where,

Y_{ij} = the proportion of potato area allocated to improved potato variety.

β_{ij} = parameter to be estimated.

ε_i = error term.

3. Results and Discussion

3.1 Farmer's Socio-Economic Profile

The survey results showed that the mean age of smallholder farmers was 47.28 years, suggesting that most households were engaged in potato growing in the active age group. The household size affects the productivity as high family labor availability for timely operation of farm activity. The research region appears to be mildly populated since the average size of the family was 5.6 peoples per household. This family size is more as compared to national average as indicated by annual household survey 2015/16 Nepal. Nepalese farmers are mostly illiterate; education helps to build good and confident relationship with development agents thus maximizing production. Major animals owned by the

sampled smallholder are cows, oxen, buffalo, sheep and goat, and poultry keeping. Livestock provide farm yard manure, draft power, source of income for investments. In sampled area average livestock standard unit was found to be 1.49 LSU.

The major caste in the survey location was brahmin/chhettri (45%), culturally household were male headed (68%), lack other non-farm income (36%) and have some family members migrated (36%). Availability and accessibility of extension services and farmers training helps to speed up technology adoption process. Out of 503 respondents, majority of households (25%) have access to extension services like expert advice, training and field days and 28% has got training related to potato production. About 72% of the farmers involved in farmers' groups and cooperatives which will increase their bargaining strengths and enjoy the benefits of large scale production. Access to credit is important for smallholder since loan derived from credit institution would help smallholder to purchase inputs for farm production. Most rural smallholders were characterized by the lack of access to credit (39%).

Table 1. Socio-economic profile of potato farmers*

Socio-demographics	Mean	Std. Dev.	Min	Max
Average Age (Year)	47.28	13.14	19.00	84.00
Gender (Male =1 otherwise=0)	0.68	0.47	0.00	1.00
Education (Year)	5.63	4.47	0.00	16.00
Ethnicity (Brahmin/Chhettri =1, Otherwise=0)	0.45	0.50	0.00	1.00
Household Size (Number)	5.64	2.49	2.00	20.00
Migration Status (Number)	0.35	0.48	0.00	1.00
Membership in organization(Yes=1, otherwise=0)	0.72	0.45	0.00	1.00
Off-Farm Income (Yes=1, otherwise=0)	0.26	0.44	0.00	1.00
Credit Access (Yes=1, otherwise=0)	0.39	0.49	0.00	1.00
Training (Yes=1, otherwise=0)	0.28	0.45	0.00	1.00
Extension Visit (Yes=1, otherwise=0)	0.25	0.44	0.00	1.00
Livestock Standard Unit	1.49	3.17	0.00	53.00
Farm size (Ha)	0.79	1.01	0.05	13.52
Potato Area (Ha)	0.20	0.24	0.01	2.03

*Source= household survey 2017

3.2. General Feature of Production Systems

The basic feature of production in sampled districts area is presented in Table 2. Land is a key resource for production. In the study area, fragmentation of the land from generation to generation led to the transformation of large holding farmers into small holder. The average farm size was found to be 0.79 ha out of which potato was cultivated in 25.40% of area. Most of the potato grower was small holder 40.6% and marginal 34.6% Table 3.

Table 2. General feature of production systems*

Description	Area (ha)	Share (%)
Average farm size (ha)	0.79	
Average size of potato cropped area	0.20	25.40%

*Source= household survey 2017

Table 3. Category of the farmers on the basis of land ownership*

Farmer Classes	Owner Number	Owner Percentage
Marginal (<0.4 Ha)	174	34.6
Small (0.4- 1 Ha)	204	40.6
Medium (1-2 Ha)	81	16.1
Large (> 2 Ha)	44	8.7
Total	503	100

*Source= household survey 2017

The table 4 shows farmer's choice on number of varieties to be adopted. The results showed most of the farmers (82.5%) prefer cultivation of only one variety. Only few i.e. 12.9% like to grow two variety and 4.6 % prefer cultivating more than two varieties.

3.3. Extent of Adoption

For the study purpose the cultivated variety were classified into three categories like Local, Indian and

Improved on the basis literature review. The study revealed that in an average household cultivated local variety in 0.066 ha, improved variety in 0.083 ha and Indian variety in 0.053 ha of land. Therefore we can say that 41.56% of potato cultivated area was occupied by improved variety released by Nepal agricultural research council. Local varieties occupy 32.68% of potato cultivated area and Indian variety occupies 26.32% (Table 5).

Table 4. Farmer's preference on number of variety to be cultivated*

Number of Varieties grown	Total
Single variety choice	415 (82.5)
Two variety choice	65 (12.9)
More than Two variety choice	23 (4.6)
Total	503 (100)

*Source= household survey 2017

Table 5. Extent of Adoption of potato*

Description	Area (ha)	Share (%)
Local variety	0.066	32.68
Improved variety	0.083	42.56
Indian variety	0.053	26.32

*Source= household survey 2017

3.4 Productivity of Potato by Category

Average productivity of potato was found to be 12.40 t/ha. The productivity of improved variety was found to be highest 15.68 tons/ha as compared to Indian variety 13.68 ton/ha and local 7.11 ton/ha and Table 6. In terms of production improved variety share 52.33% of total potato production, Indian variety and local variety share 29.92% and 28.92% of total potato production as shown in Table 6.

Table 7. Potato Variety Adopted in Nepal*

SN	Row Labels	Type	% of Area	SN	Row Labels	Type	% of Area
1	Janak Dev	Improved	16.06	22	Bunga	Local	0.40
2	Bhotange	Local	10.94	23	Khumal seto	Improved	0.40
3	Cardinal	Improved	9.64	24	Local var of kathmandu	Local	0.33
4	Namcheli	Local	9.58	25	Lamcho	Local	0.33
5	Arungold	Indian	8.87	26	Khumal upahar	Improved	0.32
6	C 40	Indian	8.33	27	White Hybrid	Indian	0.32
7	Khumal Rato	Improved	5.66	28	Ilame aalu	Local	0.28
8	Lal Gulab	Indian	5.44	29	Kufri Jyoti	Improved	0.25
9	TPS	Improved	4.36	30	CIP	Improved	0.20
10	Rato golo	Local	2.99	31	Khumal Luxmi	Improved	0.20
11	Dalle local Red	Local	2.89	32	MH-42.3	Indian	0.20
12	Desire	Improved	2.58	33	Seto aalu	Local	0.18
13	Golo Aalu	Local	1.50	34	Hollen	Indian	0.08
14	Local rato	Local	1.35	35	Khumal Ujwal	Improved	0.07
15	Kufri sindri	Improved	1.20	36	Satha	Indian	0.07
16	Kanpure	Indian	1.12	37	Bikashey Seto	Local	0.05
17	BTIS	Indian	1.06	38	Ekar Anta Hybrid	Indian	0.05
18	Seto Morang	Local	0.98	39	Black potato	Local	0.03
19	Tharu Aalu	Local	0.60	40	Laliguras	Local	0.03
20	Rajendra1	Indian	0.53	41	Indian variety	Indian	0.033
21	Rato Dallo	Local	0.46	42	Karnal	Indian	0.033

* Source: Household survey 2017

3.5. Variety Wise Adoption

Based on household survey 42 unique potato variety were reported by sampled farmers, which indicates considerable diversity of potato varieties within five districts. The most popular varieties are shown in Table 7. Among them Janak Dev ranked number one followed by Bhotange in terms of area coverage. Farmers also cultivated Indian varieties such as Arun gold, C 40 mostly in Terai. Similarly main local varieties adopted in Nepal were Bhotange 10.94%, Namcheli 9.64 % was also popular in hilly areas.

Table 6. Average area, production and productivity of potato*

Description	Production (Mt)	Area (Ha)	Productivity (Mt/Ha)
Potato overall	2.49	0.20	12.40
Local variety	0.47	0.066	7.11
Improved Variety	1.30	0.083	15.68
Indian Variety	0.72	0.053	13.68

*Source= field survey, 2017

3.6. Adoption of Improved Potato Production Technology

Table 8 shows adoption status of improved potato production technologies among the household. The result shows that 45 percent of the household adopted improved variety of potato, more than 50% of household used chemical fertilizers such as DAP, Urea and Potash, but use of micro-nutrient is restricted to only 11.73% household. The access to storage in cold store was found very fewer i.e. 10% of household and training taken related to potato farming is limited only to 19.48%. Whether application of insecticide and pesticide is 68% and irrigation facilities were reached to 60% weeding operation was performed by 83 % of household.

Table 8. Adoption of improved potato production technology*

SN	Potato production practices	Adopter household	Percentage
1	Improved varieties Use	227	45.13
2	FYM Use	330	65.61
3	DAP Use	340	67.59
4	Urea Use	290	57.65
5	Potash Use	320	63.62
6	Micro-nutrient use	59	11.73
7	Insecticide and Pesticide Use	344	68.39
8	Irrigation facilities Available	303	60.24
9	Storage facilities Used	50	9.94
10	Weeding operation	419	83.30
11	Training taken related to potato farming	98	19.48

*Source= household survey 2017

3.7 Factors Affecting Adoption of Improved Potato Varieties

The proportion of land allocated to improved potato is a continuous variable but truncated between zero and one therefore the use of ordinary least squares will result in biased estimates (Moffitt and Mcdonald, 1980). The tobit model was used to estimate factor affecting adoption of improved potato varieties (Table 9). The results were shown in table where $\delta EY/\delta xi$ shows the marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable. $\delta EY^*/\delta xi$ shows changes in the intensity of adoption with respect to a unit change of an independent variable among adopters, and $\delta F(Z)/\delta xi$ is the probability of change among non-adopters (e.g., the probability of adopting improved potato varieties) with a unit change of independent

variable xi. The loglikelihood ratio test was significant at the 1% level. The socioeconomic characteristics like gender, education, ethnicity, and training related to potato, seed source and livestock number were found significant variables. The source of seed, gender, and ethnicity has positive influence on proportion of land allocated to improved potato. Similarly Education and livestock number expressed in numbers have negative influence on adoption. The household head who were male likely to allocate more land for improved variety of potato. The marginal effect of male gender on mean proportion of land allocated to improved potato varieties was 13%, and as male household increases the probability of adoption by 3%. Similarly, year of schooling contribute less proportion of land for improved potato.

Table 9. Tobit model estimates for land allocated to improved potato varieties, Nepal*

IM	Coef.	T value	$\delta EY/\delta xi$	$\delta EY^*/\delta xi$	$\delta F(Z)/\delta xi$
Age (Years)	-0.05	-1.12	0.00	-0.01	0.00
Gender (Male =1 otherwise = 0)	3.12	2.39**	0.13	0.41	0.03
Education (Years)	-0.27	-2.00**	-0.01	-0.04	0.00
Ethnicity (Brahamin/Chhettri=1, Otherwise=0)	4.10	3.02***	0.17	0.54	0.05
Household Size (Number)	0.11	0.54	0.00	0.01	0.00
Migration Status (Migrated=1, otherwise=0)	-0.86	-0.77	-0.04	-0.11	-0.01
Membership in organization (Yes=1, otherwise=0)	1.71	1.35	0.23	0.02	0.02
Off-farm income (Yes=1, otherwise=0)	-0.58	-0.52	-0.02	-0.08	-0.01
Credit accessibility (Yes=1, otherwise=0)	0.83	0.74	0.03	0.11	0.01
Training related to potato (yes=1, otherwise=0)	7.02	3.69***	0.29	0.92	0.08
Extension Visit (Yes=1, otherwise = 0)	0.87	0.76	0.04	0.11	0.01
Livestock standard Unit	-0.48	-1.53*	-0.02	-0.06	-0.01
Farm Size (ha)	-0.65	-0.99	-0.03	-0.09	-0.01
Source of seed	7.89	2.63***	0.33	1.04	0.09
_cons	-11.57	-2.66			

Sample Size = 503, $\chi^2(14) = 89.45$, Prob > $\chi^2 = 0.0000$, Log likelihood = -371.22071, pseudo R² = 0.1075

The year of schooling has marginal effect of 1% and the probability that farmers would allocate land to improved potato was less by 1% for more educated farmers. Also if household is Brahmin/chhettri data households likely allocate more land for improved potatoes. The marginal effect of higher caste was 17% on mean proportion of land allocated to improved potato and higher caste has probability of adoption by 5%. The seed source also plays

important role in adoption of improved potato variety. If the farmers getting seed from formal sector like agrovet, district agriculture development office and Nepal agricultural research council and get training on potato production would likely to allocate more land. The marginal effect was found to be 33% and 22% respectively. The probability of adoption increases by 9% if source of seed were formal and 8% if farmers get training.

3.8. Reason for and Factor Influencing Dis-Adoption of Variety

The research identified major 7 cause of dis adoption of varieties out of which lower production was reported by higher percentage of farmers i.e. 29.76% as a major problems fallowed by disease and pest related problems like susceptibility blight, rot and other fungus disease. Bitter taste, tastelessness and lower consumer preferences are also third most reported problems in

potato growing areas. Seed un availability, introduction of new, suitable and better variety, adoption by nearby farmers, problems in maize intercropping , existing variety un suitable for available soil condition are some of the technical problems encountered in potato farming this problems was reported by 13.10% of farmers. The major problems of dis adopted varieties are listed below in Table 10.

Table 10. Information about problems encounter by dis-adopted varieties*

SN	Problem Identified	Farmers	Percent	Rank	Variety dis-adopted due to mentioned cause
1	Disease, Pest Problems	42	25.00	2	Kufri Jyoti, Simla,,Dejeere, Kalo, hybrid seto,, Seto Aalu, Cardinal, Janak Dev, Golo Local , Local (round) White local
2	Storage Problems	5	2.98	8	TPS, Hollen, C-40, Dalle red
3	Taste and consumer choice related problems	26	15.48	3	Khumal Laxmi, Kufri Jyoti, Kanpure Lal gulab, C-40,Djeere, Kufri Sindhuri, Belauti aalu,Khumal Rato
4	Marketing problem	11	6.55	5	C-40, Ekar Anta, Kufri Jyoti, Seto Aalu, Janakdev,
5	Low production	50	29.76	1	Kanpure, Lal Gulab, PBS, Khumal Laxmi, Hollen, Kal ankhe, Ilame lupe Hollen, C-40, Chandramukhi Black potato, Pehelo aalu,Kufri Jyoti Rato Aalu,Janak Dev,Dallo Rato Seto,Dallo Rato Local, Cardinal Local,jhapadi, seto dallo, local TPS, cardinal, Seto, jhapadi, Nilo
6	Technical problems	22	13.10	4	TPS, Kanpure, C-40,Kufri sindure Kufri jyoti,Namcheli ,TPS,Rato Golo Deejire, Khumal Laxmi, BITIS, Seto dallo aalu/golo seto, janakdev, Local Nilo
7	Color factor (white Flesh)	5	2.98	7	Kufri Jyoti, Disiree and laliguras
8	Other cause	7	4.17	6	
		168	100		

*Source= household survey 2017

4. Conclusion

Results show that improved potato variety was adopted in 45% of household and the area coverage was found to be 43% of total potato cultivated area. The area coverage of local variety was 33% of land where as Indian variety was found to be covers 26%. The productivity of improved variety found superior (15.68 ton/ha) among Indian (13.68 ton/ha) and local variety (7.11 ton/ha). Based on above finding we can conclude that there is still scope for expanding improved variety of potato in Nepal. Also seed distribution through formal source such as district agricultural development office, Nepal agricultural research council and cooperative and training of potato grower was significant factor for determining adoption therefore government Research and extension efforts need to be linked and strengthened to strengthen the development of formal seed sector and training of farmer on improved cultivation practices. The variety wise adoption result shows that farmers were still adopting old variety like Janakdev and Cardinal. Therefore the extension agent should make aware of the new technologies. Training should be focused mainly to male farmers and Brahmin Chettri. The research

identified that access to cold store among Nepalese farmer was poor i.e. 10 percent so one of the key approaches could be to help the farmers to construct cold store so that they could warehouse their produce in flush and send it to the market in lean period. Micro-nutrient use should be promoted along with IPM technique control Insect and pest. The potato researcher should focus on productivity, Color (Red flesh), disease pest resistant, and taste while developing the new variety.

Conflict of interest

The authors declare that there is no conflict of interest.

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