

## Adoption of Improved Potato Varieties in Nepal

Samaya Gairhe<sup>1@</sup>, Devendra Gauchan<sup>2</sup> and Krishna Timsina<sup>3</sup>

<sup>1</sup>Scientist, Agricultural Economics, NARC, Singhdurbar Plaza, Kathmandu, @: [samaya43@gmail.com](mailto:samaya43@gmail.com)

<sup>2</sup>National Project Manager/Agricultural Economist, Bioversity International, Nepal; <[dgauchan11@gmail.com](mailto:dgauchan11@gmail.com)>

<sup>3</sup>Senior Scientist, Socioeconomics and Agricultural Research Policy Division, Khumaltar, Lalitpur Nepal;  
<[krishnatimsina2000@gmail.com](mailto:krishnatimsina2000@gmail.com)>

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### ABSTRACT

Nepal is one of the top twenty countries where potato contributes substantially for the human diet. Enhancing adoption of improved potato varieties could impact on farmer's income, household food and nutritional security. As such, using a multistage sampling procedure, a study was conducted to assess the determinants of improved potato varieties adoption in Nepal covering 180 samples in four districts, two in hills and two in Tarai region. The study revealed that; Kavre and Bardiya districts in the hills and Tarai, respectively, were dominated by improved potato varieties adoption. On the other hand, Dhankuta and Jhapa in the hills and Tarai, respectively, were dominated by local potato varieties adoption. The informal seed sources followed by agro-vet and market were the major sources for improved varietal adoption. Farmers' accesses to training and formal seed sources were important factor determining improved potato varietal adoption. However, households with larger farm size were less likely to allocate more area for improved potato varieties as many of farmers were reluctant to take potato cultivation as agri-business and still follow subsistence farming. Potato R&D programs, therefore, need to strengthen formal seed system to enhance access to quality potato seeds and build producer's capacity through regular training and exposer visits in order to improve adoption of improved potato varieties in Nepal.

**Keywords:** Adoption, potato, sources of seed, training, varieties

### सारांश

मानव आहारमा आलुको उच्च योगदान हुने शीर्षस्थ बीस देश मध्ये नेपाल पनि पर्दछ। वढी उत्पादनशील उन्नत आलुका जातहरूको अपनाउदा लाखौं किसानहरूको घरेलु आय, खाद्य तथा पोषण सुरक्षा मा सकारात्मक प्रभाव हुन सक्दछ। नेपालका किसानहरूले खेतीका लागि अपनाएका आलु उन्नत जातहरूको अवस्था अनुसरणका निर्धारक आकलन गर्न मल्टिस्टेज (Multistage) विधिबाट दुई पहाड र दुइ तराई क्षेत्रमा गरि जम्मा ४ जिल्लामा १८० घरधुरीको नमूना संकलन गरिएको थियो। अध्ययन अनुसार काभ्रे र बर्दिया जिल्लाहरूमा आलुका उन्नत जातहरूको प्रभुत्व पाइयो तर धनकुटा र भ्रपा जिल्लाहरूमा आलुका स्थानिय जातहरूको प्रभुत्व पाइयो। आलुको उन्नत जात तथा प्रविधिको मुख्य स्रोतमा अनौपचारिक स्रोत (आफ्नो तथा छिमेकी) त्यसपछि एग्रोभेट र बजार रहेको पाइयो। तालिममा किसानको पहुँच र वीउको औपचारिक स्रोत उन्नत आलुका जातको अनुसरणका लागि महत्वपूर्ण पाइयो। धेरैजसो किसानले अझैपनि निर्बाहमुखी खेति प्रणाली गरिरहेको र आलु उत्पादनलाई कृषि व्यापारको रूपमा लिन अनिच्छुक रहेकोले ठुला घरधुरीले पनि धेरै जग्गा आलु खेतीलाई छुट्याने सम्भावना न्यून देखियो। आलुको अनुसन्धान तथा विकास कार्यक्रमले यस नतिजालाई मध्य नजर राखि अनुसरण तथा उत्पादनमा वृद्धि गर्न वीउको औपचारिक प्रणालीलाई बलियो बनाउन आवश्यक देखिन्छ। यसका साथै गुणात्मक आलु वीउको पहुँच तथा उत्पादकको क्षमता अभिवृद्धि गर्न नियमित तालिम तथा भ्रमण गराई साना तथा उद्यमशिल किसानलाई आलु प्रविधिमा प्रोत्साहन गर्नु पर्ने देखिन्छ।

### INTRODUCTION

Potato (*Solanum tuberosum*) is one of the important food crop for food security and fourth most important staple crop after rice, maize, and wheat in Nepal. It is cultivated in 197,037 ha with production of 258, 6287 t and productivity of 13.13 mt/ha (MoAD 2015). Potato recently accounted for 6.57 percent and 2.17 percent of Agricultural Gross Domestic Product (AGDP) and Gross Domestic Product (GDP) of the country, respectively (MoF 2015). It is one of the major staple food crops and source of income for smallholder farmers in high mountain regions of Nepal (NPRP 2014, Timsina et al 2011, Khatri et al 2004). Seed potato grown in higher elevations in mountains is a major traditional source of seeds for farmers in lower hills and lowland because of their disease free status (Rhoades 1985). This is also an important vegetable crop in kitchen gardens and also a cash crop for smallholder farmers in market accessible part of lower hills and Tarai (lowland).

Nepalese farmers have been cultivating potato over 200 years with its earliest record of its introduction in Nepal in 1793. However, the crop became economically important only in 19<sup>th</sup> century (Rhoades 1985). National Potato Research Program (NPRP) of Nepal Agricultural Research Council (NARC) is involved in developing and testing improved potato varieties in Nepal, while potato development programme of Department of Agriculture is involved in dissemination and production of improved potato varieties and technologies through district agricultural development offices (DADOs) located across 75 districts of the country.

Research on potato varietal development and promotion was initiated in 1980 with the establishment of National Potato Development Program in Khumaltar, Lalitpur (NPRP 2014). Initially, the program was supported by Swiss Development Cooperation (SDC). Since then, different varietal trials were conducted under on-station and on-farm conditions in the country for several years which resulted to release of Kufri Sindhure, Desiree, and Kufri Jyoti in 1992 and Khumal Seto 1, Khumal Rato 2 and Janakdev in 1999, Khumal Laxmi and IPY-8 in 2008, and, Khumal Ujwal and Khumal Upahar in 2014. Similarly NARC has registered TPS 1 (HPS II /67) and TPS 2 (HPS 7/67) varieties developed from true potato seeds in 2014. The Government of Nepal has also recommended Cardinal and NPI-106 which have spread throughout the country but, not officially released. Till date, 12 improved potato varieties have been recommended by NARC along with improved production technology. Most of these improved varieties are high yielding than farmers' local varieties. Moreover, these improved varieties have high yield potential and diffusion of these technologies can greatly enhance national potato production (Tufa et al 2015). However, farmers' choice on improved varieties is one of the most critical factors affecting productivity of a crop which is affected by many socioeconomic and farm-specific characters.

Adoption studies can provide information for setting research priorities, improving efficiency of agricultural research, extension services, and investment in new technologies. These information and insights of adoption studies are essential for drawing implications for government intervention thereby reducing cost of non-adoption and facilitating a rapid technological change (Doss 2006, Adesina and Zinnah 1993). More detail understanding of development and adoption pattern of newer improved varieties in farmer fields is important because it relates the impact of public plant breeding research that continues to develop and release new varieties (Launio et al 2008). Several adoption studies have been conducted in several countries since Griliches (1957) pioneered work on adoption of hybrid corn in United States. These include survey of adoption studies carried out by several researchers in many developing countries (Mwangi and Kariuki 2015, Doss 2006, Adesina and Zinnah 1993, Brush and Taylor 1992). Adoption studies from various countries globally indicate that; availing improved potato varieties, improved storage facility and access to marketing (Ayalew 2014) influenced adoption of improved varieties. In context of Nepal, some earlier studies by Ghimire (2005) and Kafle and Shah (2012) also have provided some information and analysis of adoption of potato varieties focusing on a case of single district in terms of the choice between modern and traditional varieties (TVs). However, limited studies has done to investigate factors influencing the extent of adoption of improved potato varieties covering different agro-ecological (hills and *Tarai*) of Nepal. Therefore, this study aims to analyze a comparative adoption of improved potato varieties in selected agro-ecologies, locations and factors influencing adoption of these improved varieties including farmers' access to sources of seeds from formal and informal system in Nepal.

## **MATERIALS AND METHODS**

### **Study Area, Sampling Process and Data Collection**

This study was derived from a sample field survey from mid hills and *Tarai* agro-ecological regions representing eastern and western parts of Nepal. The current study employed a multistage sampling procedure by selecting four representative districts, Bardiya and Jhapa from *Tarai* and Kavre and Dhankuta from mid hills based on the potato growing potentiality. The survey was carried out selecting potential potato growing village development committees (VDCs) in the districts in consultation with district stakeholders particularly District Agricultural Development Offices (DADOs). The survey was concentrated to Mainapokhar VDC of Bardiya, Gherabari, Haldibari, and Topgachchi VDC's of Jhapa, Kushadevi VDC of Kavrepalanchowk and Pakhribas, Bhirgaun, Hathikharka, and Parewadin VDC's of Dhankuta in the fiscal year 2013-14. Depending upon population of potato growing households, the sample size varied in each VDCs. The survey covered 60 households each from Bardiya and Kavre districts and 30 households from Jhapa and Dhankuta, selected randomly from potato producing villages. The total sample size for the study constitutes 180 farmers from four districts representing mid hills and *Tarai* of two developmental regions of Nepal. The data was collected from face to face interviews of the farmers from study districts.

## Empirical Model

The various regression tools and techniques were reviewed to analyze adoption of crop varieties. Many studies have used both dichotomous choice and continuous data regression models. For instance, dichotomous variable models such as Probit and Logit are commonly used, when the dependent variable is binary in nature (Maddala 1983). In continuous data, Tobit (Censored regression) model is commonly used (Gauchan and Pandey 2012, Timsina et al 2012, McDonald and Moffitt 1980). Considering continuous area adoption data available from survey, we used Tobit model in this study because share of improved potato area to total area is continuous and censored at zero (lower limit). Tobit model was suitable here to assess extent of adoption of improved potato varieties as there were a few numbers of farmers with zero or complete adoption of improved varieties at the limit.

The model is defined as:

$$Y = X\beta + u, \text{ if } \beta' X + u > 0;$$

$$= 0, \text{ Otherwise}$$

$u$  is the residual where,  $u \sim N(0, \sigma^2)$ .

Where  $Y_i$  is the  $(n \times 1)$  vector of dependent variable which is expressed as the percentage of improved potato area to total area of a household;  $\beta$  is the  $(k \times 1)$  vector of unknown parameter; and  $X_i$  is the  $(n \times k)$  vector of exogenous and predetermined variables, which were;

$X_1$ = age,  $X_2$  = gender,  $X_3$ =education,  $X_4$  = Household size,  $X_5$ =Size of holding,  $X_6$ = involvement in organizations (yes or no)  $X_7$  = training (yes or no),  $X_8$ = Source of seed (formal or informal). The STATA 10 Package was used for the data analysis. The descriptive statistics as well as model results are interpreted and presented in Table 2.

## RESULTS

### Potato Production Systems

Potato is grown in different production systems in diverse land types (upland and lowland), and agro-ecological conditions ranging from lowland Tarai (100 msl) to high mountain up-to 4000 msl (Rhoades 1985; SARPOD 2014). In mid hill region of Kavre district, farmers were cultivating potato in both lowland *kheta* (paddy growing land) as well as upland (*bari*) but in Dhankuta district, farmers were cultivating potato only in upland in rain-fed condition. In Kavre district, potato is a commercial crop hence it is grown after paddy harvesting in low land (*kheta*). In mid-western Tarai, such as Bardiya district, farmers were growing potato in lowland (*kheta*) only however; in eastern Tarai such as Jhapa district, farmers were cultivating potato in both lowland as well as upland with availability of irrigation facilities at lowland. Recently potato is becoming a cash crop in many parts of Tarai, mid hills and some parts of mountains, where road connectivity and market services are prevalent. The cropping patterns were different for upland and lowland in the hills. The dominant patterns in hills were (i) rice-potato and (ii) rice-potato-potato in lowland, and (i) maize-potato, (ii) maize-potato-rapeseed (iii) potato-vegetables and (iv) maize-millet-potato in upland. The major potato based cropping patterns in the Tarai were (i) rice- potato-maize/jute/legumes, (ii) rice-potato-rice.

### Household Characteristics of Potato Farmers

Farms and households characteristics of sampled farmers is shown in Table 1. The average age of respondent was 48 years with 6 years of schooling and average family size of 6.38 members. Average size of land holdings was 1.17 ha in which potato occupied 0.25 ha. 25 percent of the respondent were participated on potato production and marketing training and 65 percent of them were involved in one or more organization. Most of sample households were adopting improved varieties even though; the extent of improved variety adoption was higher in Kavre and Bardiya low in Dhankuta and Jhapa. Higher proportion of area under local variety was found in Dhankuta and Jhapa compared to other districts.

**Table 1.** Farm and household characteristics of sample farmers

Particular	Kavre	Dhankuta	Bardiya	Jhapa	Average
Sample size (number)	60	30	60	30	
Average age of respondent (year)	47.42	50.03	42.30	45.13	46.22
Average education (year)	6.43	5.80	7.00	6.20	6.36
Average household size (number)	6.13	6.60	6.92	5.87	6.38
Average land holdings (ha)	0.67	1.04	1.64	1.34	1.17
Average potato area (ha)	0.22	0.42	0.23	0.12	0.25
Participation on training (%)	12.00	23.33	37.00	16.67	22.25
Participation on organization (%)	87.00	26.67	88.00	60.00	65.42

**Sources of Seeds of Potato Varieties**

Farmers obtain potato seeds from various informal and formal sources such as own saving (informal) and, formal sources covering government R&D programs, cooperatives and agro-vet including market centers (Figure 1). The major sources of seed for potato varieties were from farmers own production and their seed preservation as well as agro-vet and market. The sources of potato seed to farmers vary by study location. Farmers own stored seed was very high in Kavre (88 %) and Dhankuta (53%). Potato seed from agro-vet and market was very high in Jhapa (80%) and Dhankuta (47%). The extent of seed use from key sources was government (38 %) and cooperatives (21%) in Bardiya. Seed use from governmental and cooperatives were nil in Dhankuta. In Jhapa, source of seed obtained from governmental programs and cooperatives were very low but it was very high for Agro-vet and market. However, in Kavre, the source of seed obtained from both agro-vets and government R&D programs was very low.

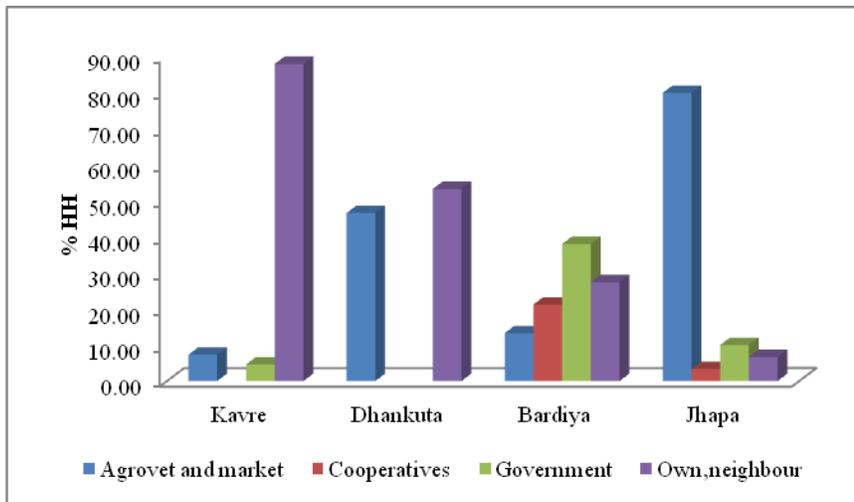


Figure 1. Household sources of potato seed in the study area.

**Comparative Adoption of Potato Varieties**

The extent of adoption of improved potato varieties varied according to the locations (Figure 2). The highest adoption (% area coverage) of improved potato varieties was highest in Bardiya followed by Kavre and Jhapa respectively (Figure 2). The study revealed that about 57 % of the total potato area in Kavre was covered by improved potato variety, whereas 43 % area was covered by local varieties. In case of Dhankuta about 29 % of the area was covered by improved varieties and 71 % area was covered by local varieties. In Bardiya all most all the potato area was dominated by improved varieties. In Jhapa, 40 % of the total area covered by improved varieties and 60 % by local varieties. In total, 79 % of the total area covered by improved varieties and 21 % by local varieties.

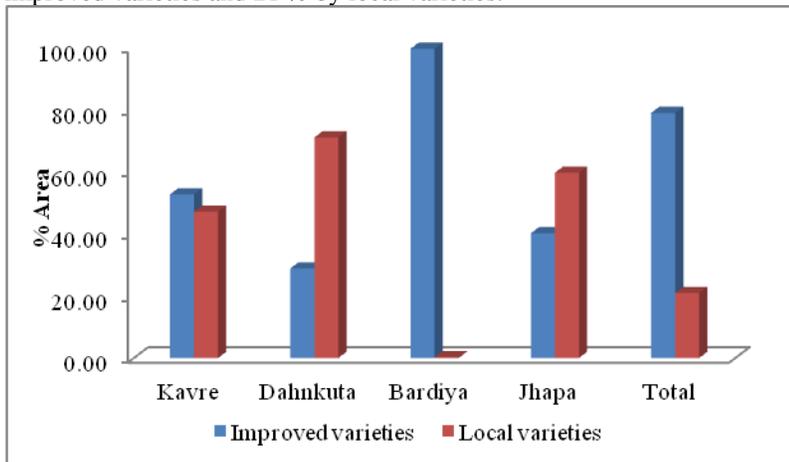


Figure 2 Extent of adoption (% area) of potato varieties.

The higher adoption of improved potato varieties in Bardiya is probably due to higher education level of farmers with their higher participation and involvement in the organization as compared to Dhankuta. This is because higher education level increases the ability of farmers to achieve; process and utilize information germane to adoption of a new technology (Abebe et al 2013, Lavison 2013, Namara et al 2003, Mignouna et al 2011, Nyagaka et al 2010).

### Factor influencing adoption of improved potato varieties

Tobit model was used to analyze the factors influencing adoption of improved potato. Proportion of area allocated by the households for improved potato cultivation was used as dependent variable in this model. The independent variables used in the model were household-specific factors such as age, gender, education, household member, land holdings including farmers' involvement in local organization, training, and source of seeds for farm household cultivation (Table 2). Among various factors, proportion of potato acreage was found to be affected by farm size, farmers' access to training and sources of seed (formal or informal).

**Table 2.** Tobit analysis for adoption of improved potato varieties

Variable	Coefficient	Standard Error	T	P>t
Age of respondent (No of years)	0.282	0.157	1.800	0.074
Gender of respondent (Male=1; Female=0)	-0.748	5.089	-0.150	0.883
Education (No of years)	0.139	0.454	0.310	0.760
Household size (Number)	1.065	0.547	1.950	0.053
Farm size (hectare)	-12.406**	1.890	-6.560	0.000
Involvement in organization (yes=1; Otherwise=0)	7.989	4.110	1.940	0.054
Access to training (Yes=1; Otherwise=0)	13.836**	4.125	3.350	0.001
Source of seed (Formal=1; Informal=0)	10.984**	3.673	2.990	0.003
Constant	42.130*	16.657	2.530	0.012

# No of obs. 180, LR chi (8) =75.14, Prob>chi2=0.0000, Log likelihood=-802.85, and \* means significant at 1 and 5 percent respectively.

Farmers' accesses to training and formal source of seed have positive relation with proportion of area allocated to potato by the households. However, there is a negative relationship between farmers' adoption of improved potato varieties (% area allocated) with an increase in total land holdings which indicates that the larger farmers are less likely to allocate more area in improved potato variety adoption (Table 2). Since, potato is cultivated in smaller area, the proportion of area allocated to improved potato varieties is less for larger farmers. Additionally, the regression results showed that impact of training and formal source of seed was found significant ( $P > 0.001$ ) which are vital for to increase in potato acreage (Table 2). However, age, education, gender, household size and involvement in organization have no significant effect in the adoption of improved potato varieties. This is expected as potato is well accepted in all socio-cultural settings and commonly used and grown by all type of households in Nepal.

## DISCUSSION

The negative relationship between adoptions of improved potato with an increase in total land holdings indicates that probability of decrease in potato area under improved varieties occurs with an increase in farm size. Roy (2015) also found negative relation with farm size and crop diversification. This might be due to farmers' diversification in agriculture. This is because small farm size may provide a reward to adopt a technology especially in case of an input-intensive advancement such as a labor-intensive or land-saving technology. Since, improved potato production is highly productive, and therefore becoming a remunerative cash crop for smallholder farmers. Farmers with small landholder may adopt land saving technologies like as green house technology, zero grazing among other as an option to improve agricultural production (Mwangi and Kariuki 2015).

The impact of training and access to formal sources of seed was positive and significant ( $P > 0.001$ ) for improved potato variety adoption indicating that farmers' easy access to knowledge and information from training and easy and timely access of quality seeds from formal sector agencies (government agencies and agro-vets) have played important role in the adoption. Acquisition of information about a novel technology from education or training is another aspect that determines adoption of technology. It enables farmers to gain knowledge of the existence as well as the efficient use of technology and facilitates its adoption. Farmers will only adopt and use the technology they are aware of or have heard about it (Mwangi and Kariuki

2015, Doss 2006). So, the training is one of the best ways to provide information to farmers and enhance adoption of improved potato varieties (SARPOD 2014).

Adoption of improved potato is positively related to access of quality improved seeds. Ghimire (2005) explained that a vast majority of the farmers were found to be using uncertified potato seed i.e. from the informal source for cultivation, which caused the lower potato yield. So the potato seed from quality declared and formal source are vital for increasing yield. Household specific factors such as age, education and family size has no influence on the technology adoption despite previous research for example Kafle and Shah (2012) has shown some relation of these factors in adoption. This may be due to their small sample size and limiting the study in single site.

## CONCLUSION

Potato was well fit in both rice and maize based cropping system in mid hills of Nepal compared to tarai. Kavre and Bardiya districts were dominated by improved potato varieties, whereas Dhankuta and Jhapa districts were dominated by local potato varieties. The informal source of seed (own and neighbor) were the major sources followed by agro-vet and market of improved varieties, and technology of potato even though there were some involvement of government and cooperatives for supplying seed. Farmers' accesses to training and quality improved seeds from formal sources were important for adoption of improved potato varieties. Households with larger farm size were less likely to allocate more area for improved potato varieties as potato was grown in small area by smallholder farmers. These small farmers were reluctant to take potato cultivation as agri-business and still follow subsistent farming.

Based on the findings of the study some policy recommendations can be made. Training program in modern varieties of potato and its associated technology need to increase through government as well as non-governmental organization to promote the adoption of improved potato varieties for harnessing more benefit from existing cropping systems in both midhills and Tarai where potato is one of the important crops. Similarly provision should be made to provide high quality improved potato seed through formal sector sources (agro-vets, cooperative) to increase productivity of potato which ultimately increase the household income of rural farmers. Moreover, focus should be given to promote potato technology focusing on small innovative farmers that will more likely to impact increase in adoption and productivity of potato compared to large farmers. Future research should focus on the impact of adoption of improved potato varieties on household food security and farm household economy which was not undertaken in this study.

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