ISSN: 2224-0616
Int. J. Agril. Res. Innov. Tech. 9(2): 15-22, December 2019 Available online at http://ijarit.webs.com
DOI: https://doi.org/10.3329/ijarit.v9i2.45405 https://www.banglajol.info/index.php/IJARIT

ADOPTION OF IMPROVED POTATO VARIETIES IN JELDU DISTRICT, OROMIA REGION, ETHIOPIA: A DOUBLE-HURDLE MODEL

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Received 8 August 2019, Revised 27 November 2019, Accepted 24 December 2019, Published online 31 December 2019

Abstract

Smallholder potato producers in Jeldu district produce potato for both home consumption and market. Adoption of improved varieties is suggested to improve and diversify farmers' household income. This study intents to identify factors determining adoption and intensity of adoption of improved potato varieties in Jeldu district of West Shewa zone, Oromia region, Ethiopia. Both primary and secondary data were used. The primary data were collected from 140 sample households' selected using two-stage random sampling techniques. Descriptive statics and double hurdle econometric model were used to analyze the data. Results indicate that sex of the household head, access to extension services, livestock ownership and farmers' perception about the technology positively and significantly determined adoption of improved varieties in the district. In contrast, distance from the nearest market affected adoption of improved potato varieties negatively and significantly. Intensity of adoption is measured by the area of land allocated for improved potato varieties by farmers. The truncated result identified improved varieties yield perception, family size, livestock ownership and membership to agricultural cooperative influenced intensity of improved potato varieties adoption positively and significantly. Strengthening extension services to enhance farmers' awareness about improved potato varieties infrastructure development, family planning, asset ownership and facilitating membership to cooperatives are recommended.

Keywords: Adoption, Intensity of Adoption, Double Hurdle Model, Potato Variety, Ethiopia.

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Cite this article as: Ogeto, M.A., Mohammed, J.H. and Bedada, D.G. 2019. Adoption of improved potato varieties in Jeldu District, Oromia Region, Ethiopia: a double-hurdle model. *Int. J. Agril. Res. Innov. Tech.* 9(2): 15-22. DOI: 10.3329/ijarit.v9i2.45405.

Introduction

Ethiopia with a total population of 112,078,730 ranked 12th in the world and 2nd in Africa after Nigeria that has a population of 200,963,599. Oromia region has the largest population in Ethiopia and the estimated population in 2019 is 38.36 million (World Population Prospects, 2019). Rain-fed mixed-agriculture by smallholders constitutes the dominant share of Ethiopia's economic sectors in foreign exchange earnings and employment opportunities for the growing population. The country achieved, a 10% increase of public investment in agriculture, target set by the African Union Comprehensive Africa Agricultural Development Program (CAADP) and marked as among major successes (The World Fact Book, 2016).

Improving food security, diversifying smallholders' income and reducing poverty are the major development challenges that Ethiopia is recurrently facing. To achieve these targets, potato is identified as a priority policy intervention area due to early maturing and better dietary value attributes. The genotypic variation and short vegetative period of potato also creates an opportunity for smallholders to harvest both in short-rainy season, February-May, and main rainy season, June-October (Devaux *et al.*, 2014). A national average potato productivity of 13.5 t ha^{-1} was recorded during 2015 cropping season. Even if the highest land area (70,132 ha) was allocated for potato, among major root crops, it is third in production and productivity in same group (CSA, 2016).

Despite suitability of climatic condition in Ethiopia, the average potato yield (30-35 t ha^{-1}) in research centers is lower than global average yield of 50.0 t ha^{-1} (Endale *et al.*, 2008). A latter study indicated a lower average productivity of

potato (10.0 t ha^{-1}) by smallholder farmers in Ethiopia (EHDA, 2011). Low productivity of potato in Ethiopia is also indicated by Roger (2014). The limited adoption of improved potato varieties by smallholders, in Ethiopia, is mainly due to lack of adequate quantity and quality of improved potato seed tubers (Hirpa *et al.*, 2010; CIP, 2011; Aregawi, 2014) and high cost of improved varieties (Hirpa *et al.*, 2012). To reverse this scenario, enhancing involvement of smallholder farmers and private sectors in the production of improved potato varieties are suggested.

Walker and Alwang (2015) indicated that the adoption of improved varieties of grains and root and tuber crops is low in Sub-Saharan African countries. Facilitating access for improved crop varieties and effective disseminations are the major challenges that Sub-Saharan African countries are facing. Following rice and wheat, potato is globally labeled as the most import food crop for human consumption. Besides, potato is a highland crop suitable at an altitude of 1500 meters above sea level with annual rainfall of 600 mm (FAO, 2014).

In Ethiopia, farmer-to-farmer approach of adopting improved potato varieties are effective (Tadesse *et al.*, 2016). A latter study in Chencha district of Ethiopia identified lack of skill, cash and availability of labor hindering the adoption of improved potato varieties (Tadesse *et al.*, 2017).

Globally, despite increasing working hours, employment in agriculture sector decreased in the last two decades. In contrast, employment in agriculture sector on average increased by 3% in Sub-Saharan Africa. During the same periods, the highest growth rate (23%) of agricultural employment was achieved in Ethiopia (FAO, 2017).

A study in Ethiopia indicated credit and extension services from NGOs positively and significantly affecting decision to adopt improved potato varieties, while consultation from major buyers was negative and significant. Tuber size, access to credit, stew quality, proportion of land owned and mobile phone services are significant determinants of intensity of adoption. The authors emphasized the need to focus on market-related attributes of improved potato varieties for successful scale up (Gumataw *et al.*, 2013). A latter study in Eastern Ethiopia identified membership to cooperatives, annual farm income and access to irrigation service significantly influencing adoption of improved potato technology package (Mengistu *et al.*, 2016).

Poor fertility of the soil is a major cause for low productivity of potato in Wolaita Zone of Southern Ethiopia (Abay and Tesfaye, 2011). Another study in southern Ethiopia identified major challenges for potato production. These are prevalence of crop diseases, low market price of tubers after harvest, storage problems and poor quality of seed tubers for planting (Hailu *et al.*, 2017).

There is a growing demand for improved potato seed varieties in Ethiopia (Gildemacher *et al.*, 2009; Abebe *et al.*, 2013; Gebremedhin, 2013; Mengistu *et al.*, 2016). The major potato growing areas in Ethiopia are central, eastern, north western and southern highlands constituting 83% of potato growing farmers. West Shewa and North Shewa are the two major potato producing zones in the country (CSA, 2017). Despite efforts made by Ministry of Agriculture in disseminating improved potato varieties in Jeldu district of West Shewa zone, the status of adoption and intensity of adoption are not studied to come up with applicable recommendation. To design effective policy interventions that can enhance utilization of improved agricultural technologies, there is a need to identify location specific factors. Given the high potential of Jeldu district for dissemination of improved potato varieties, this study intends to identify both factors determining adoption decision and intensity of adoption among smallholder potato growers in the district.

Research Methodology

Description of the study area

Jeldu is one of the districts in West Shewa zone of Oromia National Regional State, Ethiopia. The district is located 72 km east of Zonal capital Ambo and 115 km west of the capital Addis Ababa. Of the total 38 kebeles (smallest administrative division in Ethiopia) in Jeldu district, four are rural and the remaining 34 are urban kebeles. The topography is characterized by mountains, plateaus and hills with an average elevation and rainfall of 2800 m above sea-level and 900 mm, respectively. The three dominant soil types are vertisol (42.10%), nitosol (36.83%) and sandy sol (21.07%) (ANRDO, 2016). As indicated by Getachew and Jema (2016) wheat, barley, teff, sorghum, maize, field beans, peas, chickpeas, potato, onion and enset are the major crops grown by farmers in Jeldu district. Majority (93.9%) of Jeldu residents live in rural areas and 6.1% live in urban areas. Moreover, 50.7% of the sampled households are female-headed and 49.3% male-headed.

Data types, sources and methods of data collection

Qualitative and quantitative data were used to achieve the objectives of the study. Both primary and secondary data sources were considered. A semi-structured questionnaire is used to collect primary data from selected potato growing farmers applying a face-to-face interview technique. Secondary data were obtained from official reports, published and unpublished sources to supplement the primary data.

Sampling techniques and sample size determination

A two-stage random sampling technique was used to selected representative sample households. In the first stage, four kebeles were randomly selected from a total of 22 potato producing kebeles in the district. In the second stage, 140 potato producing farmers were selected randomly using probability proportional to size of potato producing households in the selected four kebeles. Cochran (1977) sample size determination technique was used for this study.

$$n = \frac{Z^2 pq}{e^2} \quad (1)$$

Where n represents the sample size, Z is the selected critical value of desired interval (1.81), p is the estimated proportion of an attribute that is present in the population and $q = 1 - p$. The desired level of precision e is 0.07. A total of 140 potato farmers, 98 improved potato varieties adopters and 42 non-adopters, are selected for this study. Distribution of the samples in four selected kebeles is given in Table 1.

Table 1. Distribution of sample potato producer households in the selected kebeles.

Kebeles	No. of Households	Adopters	Non adopters	Selected Sample	Adopters	Non adopters
Osole	725	510	215	44	31	13
Tulu Bultuma	557	393	164	34	24	10
Chilanko	478	335	143	30	21	9
Kilbe	520	358	162	32	22	10
Total	2280	1596	684	140	98	42

Source: Jeldu District Office of Agriculture (2017)

Methods of data analysis

Descriptive statistics and a Double-Hurdle econometric model are used to analyze the survey data.

Descriptive statistics

For descriptive statistics tools such as mean, percentage, frequency and standard deviation were used. To compare adopters and non-adopters of improved potato varieties, with respect to different explanatory variables, t-test and χ^2- test were conducted.

Econometric model specification

Double hurdle model is commonly used in studies that use two stage decisions (Cragg, 1971). For this study, the model is used to assess demographic characteristics, socio-economic and institutional factors that are expected to determine household head's decision to adopt and intensity of adoption of improved potato varieties. In the first stage, probit model is estimated to identify determinants of decision to adopt improved potato varieties. The probit regression is estimated with a dummy value of 1 if the household is adopter and 0 otherwise. The standard probit model used for this study is given by equation 2.

$$Y_i^* = X_i\beta + e_i \quad (2)$$
$$Y_i = \begin{cases} 1 \; if \; Y^* > 0 \\ 0 \; if \; Y^* \leq 0 \end{cases}$$

Where $Y^*$is s a latent variable that takes a value of 1 if the household adopted improved potato varieties and 0 otherwise, the error term e_i is independent from X_i which is a 1 by K vectors of factors that determine improved potato varieties adoption decision for the i^{th} household and $e_i \sim N(0,1)$, and β is a 1 by Kvector of parameters to be estimated.

In the second stage, a truncated regression model is used to identify determinants of intensity of adoption of improved potato varieties among adopters. The truncated regression model is given by equation 3.

$$Z^* = \beta x_i + u_i, \qquad u_i \sim N(0, \delta^2)$$
$$Z_i = \begin{cases} Z_i^* \; if \; Z_i^* > 0 \; and \; Y_i = 1 \\ 0 \; otherwise \end{cases} \quad (3)$$

Where Z_i is the intensity (level) of improved potato varieties adoption which depends on the latent variable (Z_i^*) being greater than 0 and conditional on the decision to adopt improved potato varieties ($Y_i = 1 \; if \; Y^* > 0$).

If each farmer's decision to adopt and intensity of adoption are assumed to independent, the error terms are independently and normally distributed as given in equation 4.

$$v_i \sim N(0,1) and \; u_i \sim N(0,1) \quad (4)$$

Following Cragg (1971), the final analysis is estimated using the log-likelihood function for the double-hurdle model that nests a univariate probit model and a truncated regression model.

The list of explanatory variables, which are hypothesized to affect adoption decision and intensity of adoption of improved potato varieties, with their sign of relationship with dependent variables and respective hypotheses are summarized in Table 2.

Table 2. Description of variables, sign of relationship and Hypotheses.

Variables	Description	Adoption	Intensity
Adopt	Adoption decision (1= yes, 0=no)		
AreaL	Land allocated for improved potato varieties (in %)		
Credit	Access for credit (1=yes ,0=no)	+	+
Educ	Household head formal years schooling (in years)	+	+
TLU	Livestock ownership measured in TLU	+	+
Extension	Extension services access (1=yes ,0=no)	+	+
Sex	Sex of the household head (1=male, 0= female)	+	+
Family	Family size of the household (in adult equivalent)	+	+
Non-farm	Access for non-farm income (1= yes, 0=no)	±	±
Land	Total land owned by the household(in ha)	+	+
Experience	Farming experience of household head (in years)	+	+
Fragment	Number of farm plots owned (in number)	-	-
Cooperative	Membership to cooperatives(1=yes, 0= no)	+	+
MarketD	Distance from the nearest market (in walking hrs)	-	-
Perception	Perception about improved variety (1=good, 0=not)	+	+

Results and Discussion

This chapter presents major results of the study with brief discussion organized into two sub-parts of descriptive analysis and econometric model results.

Descriptive analysis

Descriptive statistics for the demographic and socio-economic characteristics of sampled respondents is given in Table 3. In this section, descriptive statistics results on demographic, socio-economic, and access to institutional services for sampled respondents are presented. Results mainly focus on significant differences between adopters and non-adopters of improved potato varieties in Jeldu district. Significant difference between adopters and non-adopters of improved potato varlets was identified with respect to sex of the household head, farming experience, landholding size, education of the household head, extension contact services, access to credit services, distance from the nearest market, cooperative membership and involvement in non-farm activity.

Sex: Results indicate that most of the respondents are male-headed (79.29%) households and the remaining (20.71%) female-headed. The proportion of male-headed households (89.78%) among adopters of improved potato varieties are higher than the non-adopter counterparts (54.76%). The chi-square test result indicates a significant difference between adopter and non-adopters sex of the household head at 1% significance level.

Potato farming experience: With mean farming experience of 25.17 years for sampled respondents, the adopters have more average farming experience (27.21 years) than non-adopters (20.40 years) and this difference is significant at 1% significance level.

Land size: The mean landholding of sampled respondents is 2.87 ha. The mean landholding size among adopters (2.99 ha) is higher than the non-adopters (1.40 ha) and the difference is significant at 10% significance level.

Education of the household head: Despite prevalence of significant difference between adopters and no-adopters in formal education of the household head, most of the respondents are illiterate in among adopters (47.96%) compared to non-adopters (16.67%). The chi-square test result indicates significant difference at 1% significance level.

Access to extension services: More than half of the sample respondents (56.43%) do not have access to extension services even if frequency of extension service is significantly higher for adopters than non-adopters.

Access to credit: Non-adopters access to credit (66.67%) is higher than adopters (32.65%) and limited access to credit service is prevalent in which only 42.86% sample respondents have access to credit. The chi-square test imply significant difference of access to credit service between adopters and non-adopters at 1% significance level.

Distance from the nearest market: Adopters have a closer average distance (1.35 hours) to nearest market than non-adopters (1.77 hours). The t-test result shows significant difference at 1% significance level.

Membership to cooperative: The survey result depicts very limited membership to cooperative between adopters (16.33%) and non-adopters (2.38%) implying significant difference at 5% significance level. In contrast, non-adopters are not mostly participating in non-farm activities (57.14%) compared to adopters (37.76%) with significant difference at 5% significance level.

Table 3. Characteristics of sampled households by adoption of improved potato varieties.

		Adopters (98)		Non-adopters (42)		
Dummy		N	%	N	%	χ^2 / t-value
Sex						21.9716***
	Male	88	89.78	23	54.76	
	Female	10	10.22	19	45.24	
Education						-2.8213***
	Illiterate	47	47.96	7	17.67	
	Literate	51	52.04	35	83.33	
Extension						-6.6147***
	No	41	41.84	38	90.48	
	Yes	57	58.16	4	9.52	
Credit						13.8889***
	No	66	67.35	14	33.33	
	Yes	32	32.65	28	66.67	
Cooperative membership						5.3595**
	No	82	83.67	41	97.62	
	Yes	16	16.33	1	2.38	
Non-farm activity						4.4947**
	No	37	37.76	24	57.14	
	Yes	61	62.24	18	42.86	
Continuous		Mean	Std. Dev.	Mean	Std. Dev.	
Farming experience		27.21	14.28	20.40	9.77	-2.8213***
Land holding size		2.99	2.56	1.40	1.140	-1.8037*
Distance to market		1.35	0.73	1.77	0.59	3.3614***

**** and ** imply significant at 1% and 5% significance levels, respectively.*

Econometric model results

The probit model result

Probit model was used to identify the determinants of improved potato varieties adoption decision. Among thirteen explanatory variables, five of them significantly influenced respondents' decision to adopt. These are sex of the household head, distance to the nearest market, access to extension services, perception towards improved potato varieties and ownership of livestock (Table 4).

Male-headed households are more likely to adopt improved potato varieties compared to female-headed ones. The difference is significant at 1% significance level. The marginal effect of 0.272 implies that male headed households are 27.200% more likely to adopt improved potato varieties than female headed households. The result is in line with that of Lavison (2013) on adoption of organic fertilizers in Ghana and Tesfaye *et al.* (2014) on adoption of improved wheat varieties in Ethiopia.

In accordance with the hypothesis, distance to the nearest market determined improved potato varieties adoption decision of respondents negatively and significantly. The marginal effect result confirms that as distance from the nearest market increases by one hour, the probability to adopt improved potato varieties decreases by 9.2%. The implication is that farmers who are far from market centers face higher transaction, transport costs, and less likely to adopt the technology. A study on chemical fertilizers adoption in northern highlands of Ethiopia identified negative and significant effect of distance to nearest market on adoption decision (Hassen *et al.*, 2012).

Access to extension service is another factor that determined improved potato varieties adoption decision positively and significantly. Access to extension service increases the probability to adopt improved potato varieties by 19.3%. Positive and significant effect of access to extension service on adoption decisions are found in studies (Degnet and Belay, 2001; Mignouna *et al.*, 2011; Akudugu *et al.*, 2012).

The positive perception towards improved potato varieties influenced farmers' adoption decision positively and significantly at 1% significance level. Marginal effect result indicates 8.3% more probability to adopt improved potato varieties among farmers who perceive the technology positively. This result conforms that of Ermias (2013) and Getahun (2013).

As hypothesized, livestock ownership influenced adoption of improved potato varieties positively and significantly at 10% significance level. For each additional tropical livestock unit, the household would be 3.63% more likely to adopt improved potato varieties, keeping other factors constant. The result is in line with the findings of Ermias (2013) and Beriso (2017).

Table 4. Maximum likelihood estimation of the first-hurdle (probit) model.

Variables	Coefficients	Robust Std. Err	Marginal effect
Sex	1.165	0.419	0.272***
Farming experience	0.019	0.016	0.003
Family size	-0.115	0.089	-0.018
Level of education	-0.052	0.151	-0.008
Distance to the market	-0.593	0.224	-0.092***
Membership to cooperative	0.022	0.813	0.003
Non-farm income	0.130	0.333	0.020
Access to credit	-0.054	0.381	-0.008
Access to extension services	1.249	0.290	0.193***
Fragmentation	-0.185	0.141	-0.029
Perception toward yield	0.538	0.184	0.083***
Livestock ownership	0.235	0.127	0.036*
Land size	0.187	0.115	0.029
Constant	-2.100*	1.153	
Number of observation = 140		Prob>chi^2 = 0.0000***	
Log pseudo likelihood = -40.336919		Pseudo R^2= 0.5283	
Correctly predicted = 91.58%		Wald chi^2(13) = 60.45	

**** and * imply significant at 1% and 10% significance levels, respectively.*

The truncated regression model result

A truncated regression model result that is used to identify the determinants of intensity of improved potato varieties adoption in the study district are presented in Table 5. The result indicates positive and significant effect of family size, membership to cooperatives, perception of improved varieties yield and livestock ownership on intensity of adoption.

Table 5. Maximum likelihood estimation of the second-hurdle (truncated) model.

Variables	Coefficients	Robust Std. Err.
Sex	-0.0120	0.036
Farming experience	-0.0004	0.001
Family size	0.0100*	0.000
Membership to cooperatives	0.1140***	0.041
Non-farm income	-0.0090	0.025
Access to credit	0.0400	0.025
Fragmentation	0.0007	0.010
Perception toward yield	0.0200*	0.012
Livestock ownership	0.0130*	0.008
Land size	-0.0130	0.008
Number of observation = 98		Prob>chi^2= 0.0001***
Log pseudo likelihood = 87.913367		Wald chi^2 (10) = 35.63

**** and * imply significant at 1% and 10% significance levels, respectively.*

Family size positively and significantly determined land area allocated for improved potato varieties at 10% significance level. The possible explanation is labor-intensive nature of growing potatoes. This result is in line with the findings of Tesfaye *et al.* (2014) and Tsegaye (2014).

Farmers' membership to cooperative has a positive and significant effect on area of land allocated for improved potato varieties. It is significant at 1% significance level and in accordance with results of Degnet and Mekibib (2013) and Edward *et al.* (2014). Membership to cooperatives facilitates peer learning, information sharing, and access to various institutional services that enhance intensity of improved technology adoption.

As per the hypothesis made, positive perception towards improved varieties yield attributes influenced land area allocated for improved potato varieties positively and significantly at 10% significance level. This result is consistent with Ermias (2013) and Getahun (2013) that found positive and significant influence of perception on intensity of adoption.

Livestock ownership had a positive and significant effect on the proportion of land area allocated for improved potato varieties at 10% significance level. This is mainly due to supplementary nature of crop-livestock production system in the study district. The result is consistent with that of Ermias (2013) and Beriso (2017).

Conclusion and Policy Implications

Adoption of improved potato varieties by smallholders has major roles of diversifying and increasing their farm income. In the study district, despite some positive progresses, prevalence of limited institutional services for both adopters and non-adopters are identified. These mainly include membership to cooperative, access to credit and access to extension services.

The probit model result indicates positive and significant effect of being male-headed household, access to extension service, perception about improved potato varieties yield and livestock ownership on decision to adopt improved potato varieties. In contrast, distance from the market is negative and significant in determining improved potato varieties adoption decision. Proportion of land area allocated for improved potato varieties is positively and significantly determined by family size, membership to cooperatives, perception of improved varieties yield attribute and livestock ownership. Hence, future interventions have to target aforementioned institutional services to facilitate adoption and use of improved potato varieties.

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