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Knowledge gaps in potato technology adoption: The case of central highlands of Ethiopia

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The paper intends to identify knowledge gaps in potato technology adoption among farm households in Welmera, Ethiopia. Within the district, four administrative peasant associations were selected based on their potato production potential. From these peasant associations, a total of 112 farm households were selected using a simple random sampling method proportional to population size. The sampled households were interviewed by using a structured interview schedule. Group discussions were undertaken with selected households, development agents and researchers to gather qualitative data. For data analysis, statistical tests like t-tests, chi-squares and one way analysis of variance (ANOVAs) were used to test the variation of means and associations among the sampled households. About 79.5% of households were male headed, whereas the remaining 20.5% of households were female headed. ANOVA results indicated that there was significant variation in the adoption index score in sampled households. Non adopters, low adopters and high adopters account 46.4, 27 and 27% with the mean adoption indices of 0.0000, 0.5233 and 0.74. Moreover, all recommended potato production packages were not implemented by all adopter farmers. Low adopters used seed rates, fertilizer rates, diffused light stores (DLS) and chemical applications below the recommended packages. On the other hand, high adopters used seed rates and DLS below recommended quality and spacing and fertilizer application above the recommended rate. The overall finding of the study underlined the high importance of institutional support in improving seed rate, DLS construction, spacing, fertilizer rate and chemical application. Therefore, research center, development agents and other stakeholders should provide on farm extension training, strengthening cooperative societies, and improving market condition to fill knowledge gaps in adoption of improved potato production packages.

Key words: Potato technology, production, knowledge, market condition.

INTRODUCTION

For household food security, vegetable crops have been contributing highly for small land holder farmers. Horticultural production is usually money spinning as compared to staple crops. The production of fruits and vegetables has a comparative advantage to cereals particularly under conditions where arable land is scarce, labor is abundant and markets are accessible (Lumpkin et al., 2005). Some studies show that horticultural

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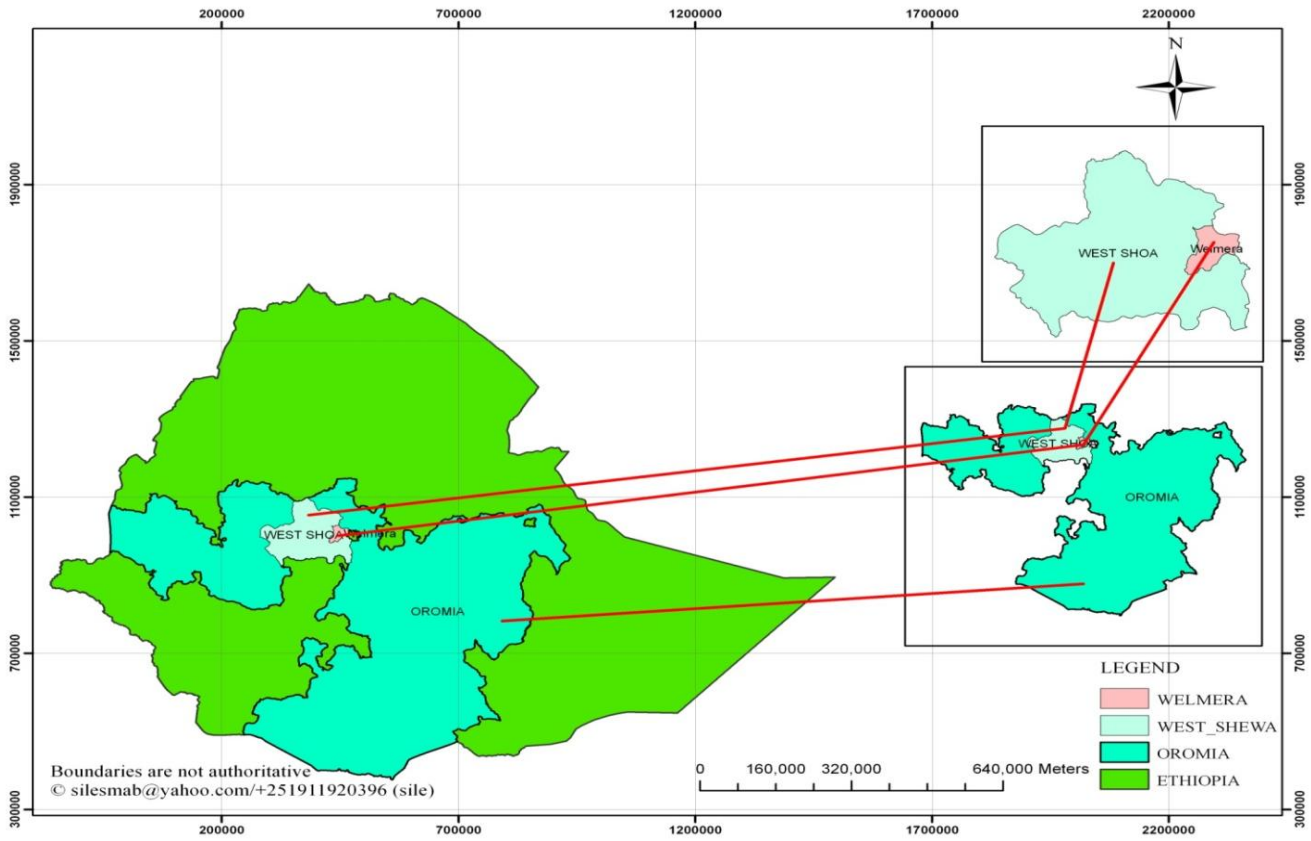

Figure 1. Map of Welmera district.

production needs twice labor forces as compared to stable crops. Increasing horticultural production contributes to commercialization of the rural economy and creates many off-farm jobs (Lumpkin et al., 2005). Potato is one of the horticultural crops, in general, and vegetable crops, in particular, that plays a key role as source of food and cash income for small-land holder producers. As a food crop, it has a great potential to supply high quality food within a relatively short period and is one of the cheapest sources of energy. Potato produce 54% more protein per unit of land area than wheat and 78% more than rice (Stevenson et al., 2001).

Ethiopia has many places where horticultural crops are produced in small scale and commercial scales. The potential attainable average yields of the crop on research and farmers' fields are 45 and 25 tons/ha, while the current national average production is limited to about 10 tons/ha (CSA, 2007). In sub-Saharan African countries the yield is around 8 tons/ha on the continent compared to a world average of 16 tons/ha (FAOSTAT, 2008). Today, more than 160,000 ha are planted. With a population of 93 million and a land size almost double that of Texas, Ethiopia can accommodate growing 3 million hectares of potatoes (Cornell, 2014).

Because of this, Ethiopian Institute of Agricultural Research (EIAR) under its different research centers has been introducing different kinds of improved potato varieties. The released potato varieties along with improved package of technologies have been disseminated through Ministry of Agriculture (MOA) and its regional and grassroots structures. For this reason most farmers in West Shewa zone are able to produce thousands of quintals of potato tuber. However, some potato growing farmers do not apply all the recommended technology packages. Identifying the knowledge gaps on potato technology adoption is critical for professionals engaged in agricultural development, researchers, policy makers and institutions. This study aimed to identify the knowledge gaps in adoption of improved potato technology packages. This was conducted in one of potato grown region of Oromia Special Zone in Welmera district.

METHODOLOGY

The study site

Welmera district (Figure 1) is one of the eight districts in the Oromia Special Zone, covering a total area of 755 km. It is found 40 km east of Addis Ababa and has 24 rural peasant associations. According to 2007 Census data, the district had a total population of

Table 1. Recommended package of improved potato production.

S/N	Name of packages	Abbreviation	Recommended rate
1	Land preparation	LP	Fine seed bed preparation (3-4times)
2	Varieties	VA	Gudena and Jalene
3	Seed rate	SR	20 q/ha
4	Fertilizer rate	FR	60 kg of urea and 60 kg of DAP
5	Chemical application	CA	2 times sprayed 50 - 55, 70 - 75 days
6	Spacing	SP	30 × 75 cm - 30 cm between plant -75 cm between row
7	Seed size	SS	Medium
8	Planting method	PM	Row
9	Weeding /hoeing and hilling frequency	WF	2 hand weeding at 35-40, 60-70 days
10	Seed storage	ST	Diffused light store (DLS)

Source: Holetta Research Center (2011).

83,784. The altitude of the district ranges between 2060 to 3380 m above sea level. Temperature ranges from 0.1 up to 26.9°C, and the mean annual rainfall ranges from 1000 to 1100 mm. The rainfall pattern is usually bimodal from January to June for summer and from June to October for off season time. Livestock is used for meat and milk in addition to that supports crop production as draught power.

Sampling techniques

In this study, two types of sampling techniques were applied. These are purposive and simple random sampling techniques. The district and four administrative peasant associations were selected purposively by reviewing secondary data about potato production experience and area coverage under potato production. After preparing up-to-date list of the sampling frame, households were selected based on probability proportional to size of total potato growing farmers in each peasant associations. Following that 112 sampled farmers were selected by using simple random sampling techniques.

Data type, source, data collection and analysis methods

Individual interviews and four group discussions from each peasant association were conducted to gather qualitative and quantitative data types. Relevant secondary data were collected from annual reports, journals, articles, book in chapters, and manuals. Descriptive statistics were applied for quantitative data type. In addition to that analytical techniques like t-tests, chi-square tests and one way analysis of variance (ANOVA) analyses were carried out.

The Adoption index (AI_i) in this study indicates the extent of adoption of improved potato recommended packages. The farmers who meet the recommended rate in the packages were given 1 and 0 for those who did not. The formula was calculated as follows:

$$AI_i = \frac{LP_i + VA_i + SR_i + FR_i + CA_i + SP_i + SS_i + PM_i + WF_i + ST_i \times 100}{10}$$

Where LP_i, Land preparation of *i* farmer; VA_i, varieties land coverage by *i* farmer farm; SR_i, seed rate usage by *i* farmer; FR_i, fertilizer rate usage by *i* farmer; CA_i, chemical application by *i* farmer; SP_i, spacing usage by *i* farmer; SS_i, seed size usage by *i* farmer; PM_i, planting method by *i* farmer; WF_i, weeding /hoeing and hilling frequency applied by *i* farmer; ST_i, seed storage method by *i* farmer.

This equation includes all of these variables due to the fact that not all sampled households use the entire recommended potato package. On the basis of adoption index respondent farmers were classified in to two categories; that is, low and high adopters.

The above method was applied because of variation in potato production packages. The recommended packages (Table 1) are put in terms of number and word. During group discussion with farmers, development agent, and researchers gave equal weights for each package. The reason was that every package has equal contribution to the production of improved potato varieties.

RESULTS AND DISCUSSION

Extent of adoption of improved potato production package

In order to know the level of adoption of each respondent, the Adoption index score was calculated. Before the calculation the technology packages were listed and weighted. Equal weights were given to all technology packages through discussion with districts experts, development agents and researchers in the study area. The sampled households' Adoption index scores were categorized into three adopter groups; namely non-adopter, low and high adopter. The actual Adoption index score ranges from 0 to 1. An Adoption index score of 0 point implies non-adoption of the overall improved potato production package. Statistical analysis of ANOVA indicated that there was significant variation ($F = 50.796$, $P = 0.000$) among the Adoption index score among the three categories at 1% level of significant which indicates difference of adoption of potato technology packages among sampled households (Table 2).

As indicated in Table 2, non-adopter accounts for 46.4% with the mean adoption index of 0.0000. This indicated that non-adopters were not practicing any of the recommended package and the technologies in the production year of 2010. Next to non-adopters, low and high adopters constituted about 27% each. Low adopters

Table 2. Distribution of respondents by adoption category of improved potato technologies

Adoption category	N	Percent	Adoption index score	Mean	SD	F-value	P-value
Non-adopter	52	46.4	0.00	0.000	0.00000		
Low	30	26.8	0.01 - 0.60	0.5233	0.09353		
High	30	26.8	0.61 - 1	0.7467	0.05713		
Total	112	100	0.00 - 1	0.3482	0.32604	50.79***	0.000

Source: Own survey data (2011). *** = significant at 1% level.

Table 3. Distribution of adopter households by the area coverage under improved potato variety.

Adoption category	N	Mean	SD	t	P-value
Low	30	0.3047	0.24237		
High	30	0.6858	0.41552		
Total	60	0.4952	0.38817	30.85***	0.0000

Source: Own survey data (2011); *** = the mean difference is significant at 1% level.

Table 4. Average seeding rate applied by sample adopter households in quintal/ha.

Adoption category	N	Mean	SD	t-value	P-value
Low	30	18.2667	2.93		
High	30	19.83	2.46		
Total	60	19.05	2.8008	2.575**	0.029

Source: Own survey data (2011); ** = the mean difference is significant at 95 % level.

have mean adoption index of 0.5233, while high adopters mean adoption index were 0.74.

Current practices of improved potato production package

Farmers' current practice of technologies components consists of varieties, seed rate, seed size, methods of planting, spacing, fertilizer rate, chemical spraying, weeding/hoeing and hilling frequency, number of seed in a hole, and seed storage type are discussed as follows:

Improved potato varieties

Gudena and Jalene improved potato varieties are widely grown in the study area. These varieties were released from Holetta Research Center located near by the study area, and so most farmers have been growing these varieties. The extent of varietal adoption was measured by the area covered by improved potato varieties by each farmer.

As shown in Table 3, the total household's average area coverage under improved potato varieties was 0.49 ha. The minimum and maximum area covered by improved potato varieties were 0.13 and 1.50 ha. The statistical analysis of t-test revealed that the existence of significant difference between the two groups at 1% significant level (Table 3).

Seed rate

Using disease free seed and appropriate seed rate are the most critical component of improved potato production. Using over and lower seed rate will cause excessive plant population or less plant population both leading to lower production. Research recommends a specified level of seed rate, however depending on availability of quality seed and farmers interest the recommended seed rate may or not applied as recommended. In the study area farmers were used a minimum of 12 quintal and maximum of 28 quintal seed rate per hectare, whereas the recommended rate of potato production is 20 quintal/ha.

According to Table 4, low and high adopters were using on average 18.29 and 19.86 qt/ha, respectively. However, both categories have used the seed rate below the recommended rate but the seed rate used by high adopter category is close to the recommended rate. From group discussion farmers were explained that increasing

Table 5. Sources of potato seed for sample households in 2010/2011 production year.

Source of seed	Frequency	Percent
Local market	5	8.3
Own /home	6	10.0
MOA	3	5.0
Research center	30	50.0
Cooperative	5	8.3
NGO	2	3.3
Individual producer	9	15.0
Total	60	100

MOA, Ministry of Agriculture Source: own survey data (2011).

Table 6. Fertilizer rate applied by sample households in 2010/2011 production year.

Adoption category	N	Mean	SD	t	P-value
Low	30	95.9333	37.74591		
High	30	125.0667	37.75322		
Total	60	110.50	40.2077	2.328***	0.004

Source: Own survey (2011), ***the mean difference at 1% significant level.

the space between rows was minimized the quantity of the average seed rates. In 2010/2011 production year potato grower's farmers average seed cost incurred in one production season was 4560 birr. In the same year the seed purchasing price was ranged between 600 to 800 birr per quintal. Most recently, most farmers became seed producers and mostly used their own seed source. On the other hand, Holetta Agricultural Research Center delivered good quality seed for scaling up the technologies.

As shown in Table 5, half of adopters obtained seed from Holetta Research Center. From group discussion farmers said that "Holetta Research Center gave them clear seed without cash and they will repay next year in kind (potato itself)". On the other hand, the current seed price is expensive so it minimized the amount of credit farmers took for seed. Few numbers of sample households purchased improved seeds from cooperatives and local markets (Table 5).

Fertilizer application

In the study area farmers have good knowledge on fertilizer application. However, some farmers did not apply the recommended rate of fertilizer of 120 kg (urea and DAP) per hectare. The maximum and minimum fertilizers applied by respondent farmers were 50 and 200 kg/ha.

According to Table 6, the average fertilizer rates applied by the respondent farmers were 110.50 kg/ha. However, the rate of fertilizer application across adopter categories has showed high variation. This was also revealed by statistical analysis of independent t-test (t = 2.328, P = 0.004); it shows that there is significant mean difference between the two groups. In the group discussion some farmers said that a "few years back fertilizer price became expensive because of that they could not apply the recommended fertilizer rate as needed."

Weeding/hoeing and hilling

The recommended number of weeding operations per cropping season is two times. The first weeding and hilling operation should be after 40 and 60 days of planting (HARC, 2008).

The sampled respondent farmers practice weeding and hilling on average 2.27 times (Table 7). And independent t-test also revealed that there is no weeding and hilling practice difference between the two groups (t = 1.161, P = 0.250). On the other hand, all sampled farmers practiced more than the recommended rates. From group discussion, farmers were said that they have good knowledge on the advantage of timely weeding and hilling the plant. Depending on the incidence of the weed and the amount of the rain could increase frequency of weeding and hilling practice. Moreover, the area is highland and the farmers are enforced to hill the plant more than the recommended number of weeding and hilling frequency.

Number of seed in a hole

After the rows are prepared farmers put the seed with an

Table 7. Weeding frequency by sample households in 2010/2011 production year.

Adoption category	N	Mean	SD	t	P-value
Low	30	2.20	0.407		
High	30	2.33	0.479		
Total	60	2.27	0.446	5.458	0.250

Source: Own survey (2011). NS = Not significant.

Table 8. Number of seed put in a hole by sample households in 2010/2011 production year.

Adoption category	N	Mean	SD	t	P-value
Low	30	1.17	0.379		
High	30	1.03	0.183		
Total	60	1.10	0.303	1.736	0.880

Source: Own survey (2011). NS = Not significant.

Table 9. Planting method by sample households in 2010/2011 production year.

Adopter category	Planting method		Total	χ^2
	Broadcasting	Row		
Low	2	28	30	
High	0	30	30	
Total	2	58	60	2.069

Source: own survey, (2011), (χ^2 = 2.069, p = 0.150) = Not significant

appropriate spacing. The recommended number of seed in each hole is one. The respondent farmers put on average 1.10 seeds in each hole. As shown in Table 8, the low and high adopters were putting on average 1.17 and 1.03 seeds in each hole, respectively. This implies that there are no statistical differences between the two groups. This was also revealed by independent t-test (t = 1.736, P = 0.880).

Planting method

Before plantation, farmers prepared rows to prevent water logging and to manage the farm very easily. Majority of potato producer farmers use row planting method.

As shown in Table 9, all high adopters used row planting method and all except two of the low adopters also used the same method. There is no difference between the two groups on method of planting. This was also revealed by statistical analysis of Chi-square (χ^2 = 2.069, P = 0.150) which showed insignificant difference between the two groups. On the study area farmers have enough knowledge on row planting methods and almost all respondent farmers prefer row planting method rather than broadcasting method.

Chemical application

“Late blight” and “Bacteria wilt” are the common diseases that occurred during production period. Both affect potato production very seriously and minimize the quantity and quality of the product. To prevent the Late blight disease, two times spray of redomile chemical at after 50 and 70 days of plantation is recommended. The incidence of the disease is common in all farmers farm. So, farmers are enforced to spray the chemical before the incidence of potato blight goes worse. All high adopters and 19 low adopter’s farmers used radomile chemical to prevent “Late blight” disease (Table 10). The chi-square test also revealed the existence of strong correlation between the two groups (χ^2 = 13.469, P = 0.000) at 1% significant level.

From group discussion farmers said that radomile chemical is expensive so it is very difficult to buy at the beginning of technology adoption. Even after having few years of potato production experience some famers do not need to buy chemical sprayer because they use one by borrowing or renting.

Seed storage

In the study area, a few years ago most farmers reserved

Table 10. Chemical use by sample households in 2010/2011 production year.

Adoption category	used chemicals/Radomile		Total	χ^2
	"yes"	"No"		
Low	19	11	30	
High	30	0	30	
Total	49	11	60	13.5***

Source: own survey (2011), *** (χ^2 =13.469, p = 0.000) significant 1% level.

Table 11. Number of DLS constructer by sample households in 2010/2011 production year.

Category		Storage type		Total	χ^2
		Floor	DLS		
Adopter and non-adopter	low	12	18	30	
	high	5	25	30	
Total		17	43	60	9.17***

Source: Own survey (2011), (χ^2 = 9.170, p = 0.010) = significant at 1% significant level.

Table 12. Seed size selection by sample households in 2010/2011 production year.

Category	Seed size		Total	χ^2
	Large	Medium		
Low	1	29	30	
High	0	30	30	3.018
Total	1	59	60	

Source: Own Survey (2011), (χ^2 = 3.018, p = 0.221) = Not significant.

their seed in the hole. However, at present time most potato producer farmers use the diffused light store (DLS) for seed reservation. It helps the seed tuber to have enough sun light, ventilation and is easy for management.

Farmers who used DLS for seed reservation can have disease free and good quality seeds for the next season. Twenty-five (25) and 18 high and low adopters, respectively used DLS for seed reservation (Table 11). The statistical analysis of Chi-square also shows positive correlation between the two groups (χ^2 = 9.170, p = 0.010) at 1% significant level.

Seed size

The major seed tuber selection criteria employed by farmers were by healthiness and size of tuber (Gebermedihn, 2005). Medium sized tubers are recommended for seed purpose. Before the product is supplied to market, farmers commonly sort the potato tuber by three types of size. They use most of the time small sized tuber for home consumption, whereas medium and big sized tubers for seed and marketing purpose. Almost all respondents used medium sized potato tubers for seed purpose. As shown in Table 12, there is no significant difference between the two groups by statistical analysis of Chi-square (χ^2 = 3.018, p = 0.221).

Spacing

Spacing is one of the management practices that help to minimize mineral competition and have sufficient spacing between plants. The recommended spacing for potato production is 30 cm between plant and 75 cm between rows. From sampled households, high adopters used more than the recommended spacing (30 × 80), and more than low adopters. As shown in Table 13 and 19 of low and high adopters used (30 × 80) spacing practices. However, statistical analysis of Chi-square (χ^2 = 4.519, P = 0.477) showed that there was no significant difference between the two groups.

From group discussion farmers said that increasing the space between rows would help for management like hoeing and hilling, and chemical spraying. Beyond that the tuber grows bigger in size, and is highly preferred for market.

Table 13. Spacing by sample households in 2010/2011 production year.

Adoption category	spacing		Total	χ^2
	30 × 75	30 × 80		
Low	17	13	30	
High	11	19	30	4.519
Total	28	32	60	

Source: Own Survey (2011), (χ^2 = 4.519, p = 0.477) = Not significant.

CONCLUSION AND RECOMMENDATIONS

1) Non adopters, low adopter and high adopters account 46.4, 27 and 27% with the mean adoption index of 0.0000, 0.5233 and 0.74. Moreover, all recommended potato production packages were not implemented by all adopter farmers. Low adopters used seed rate, fertilizer rate, DLS and chemical application below the recommended packages. On the other hand, high adopters used seed rate and DLS below recommended quality and spacing and fertilizer application above recommended rate. The overall finding of the study underlined the high importance of institutional support in improving seed rate, DLS construction, spacing fertilizer rate and chemical application. Therefore, the research center, development agents and other stakeholders should provide on farm extension training to fill knowledge gaps in adoption of improved potato production packages. Because, horticultural crops like potatoes demand skill in the production process.

2) From the study, half of adopters obtained potato seeds from the Holetta Research Center. Few numbers of sample households purchased improved seeds from cooperatives and local markets. So, the district administrative and related offices should increase number of cooperatives and improve the services provided by the existing cooperatives.

3) It is reported that the potato seed quality has gradually decreased in terms of yield performance and resistance to diseases. To keep the seed quality to the regained standard, there should be monitoring mechanisms and training facilities to seed producers. So, the district agricultural office and Holetta Research Center should strengthen the training and seed monitoring system.

4) Producers and extension agents need adequate skills in production management practices starting from seed selection to post harvest technology suitable at their level. Marketing principles, bargaining skills, business planning, quality management and post harvest handling of horticultural products are some of the interventions needed in study area. Thus, the district agricultural office and Holetta Agricultural Research Center should take the responsibilities to meet the above requirements.

Conflict of Interest

The authors have not declared any conflict of interest.

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