Adoption and Impact of Potato Production Technologies in Oromiya and Amhara Regions

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Introduction

Several potato production technologies, including improved potato varieties with their associated agronomic practices, crop protection measures, and postharvest handling techniques, have been generated and promoted for beneficiaries, especially since the early 1990s. At least nine improved potato varieties, of which most originated at the International Potato Center (CIP), have been released for production since 1991 (Table 1). In addition to high-yielding and disease-resistant potato varieties, associated packages, such as recommended spacing; recommended fertilizer rate; fungicide type, rate, time of application, calibration techniques, and safe use of chemicals; and postharvest handling techniques, have been released for beneficiaries. Released improved varieties provided average yields of 218–467 q/ha under research stations and as high as 250 q/ha at farm levels. The improved varieties provided a two- to sevenfold yield advantage over the local varieties. Special emphasis was also given for the generation of appropriate seed and ware potato storage techniques. Accordingly, diffused light store (DLS) has been generated to store seed potato for longer time than local storage practices. Estimates from on-farm trials have shown that improved potato varieties with improved management practices could yield about 150–250 q/ha (Progress Reports of Horticulture Division, 2000). However, the potential yielding ability of these varieties under good management practices is more than 40 t/ha.

These innovations have been made available to farmers through the outreach activities of Holetta Research Center (HRC) in collaboration with Office of Agriculture and Rural Development and various other governmental and nongovernmental organizations (GOs and NGOs). These include verification and demonstration trials, scaling-up of technologies, farmer and subject matter specialist trainings, farmer field days, and other appropriate measures (Progress Report of Horticulture Division, 2001–2006; Progress Report of Research and Extension, 2004–2006). Informal seed multiplication schemes were also developed to create minimum access to seeds for the beneficiaries. CIP played key role in the

introduction of potato germplasms as well as provision of financial and technical assistance. The Regional Potato and Sweetpotato Improvement Program (PRAPACE) has also contributed financial and technical assistance during technology generation, dissemination, and capacity building.

Table 1: Released potato varieties in Ethiopia

Varieties	Year of release	Average yield (q/ha)	Suitable altitude (m)	Agro-ecology
Awash	1991	254	1,500–2,000	Wide adaptable
Wechecha	1997	218	1,700–2,800	Wide adaptable
Menagesha	1993	270	Above 2,400	Wide adaptable
Zengena	2001	300	2,000–2,800	Northwest Ethiopia
Digemegn	2002	467	1,600–2,800	Wide adaptable
Jalene	2002	448	1,600–2,800	Wide adaptable
Guassa	2002	224	2,240–2,630	Northwest Ethiopia
Gera	2003	259	2,700–3,200	Specific adaptation
Gudene	2006	291	1,600–2,800	

Source: *Potato profile, unpublished report*

In Ethiopia, adoption of improved agricultural technologies has been a long-term concern of agricultural experts, policy makers, agricultural researchers, and many others linked to the sector. However, evidence indicates that adoption rate of modern agricultural technologies in the country is very low (Asfaw et al., 1997; Teressa and Heidhues, 1996). Empirical studies on adoption of agricultural technologies are very few and limited in geographical coverage. It is pertinent to undertake area-specific studies to assess the status of adoption and identify constraints that hamper further adoption of technologies. Therefore, this report presents information on the status of adoption of potato production technologies and some impacts observed by adopters in the major potato production areas where the technology has been introduced and promoted.

Materials and Methods

The study sites

The study was conducted in the major potato-growing areas of Oromiya and Amhara regions. Two zones, where potato production technologies have been widely disseminated, were selected from Oromiya region and one zone from Amhara region. In each of the zones, one representative woreda was selected

based on the extent of dissemination of potato production technologies. Accordingly, Jeldu woreda was selected from West Shewa zone and Degem woreda was selected from North Shewa zone, both from Oromiya region.

Data collection techniques and sample size

The overall data were collected in three stages: secondary data collection, rapid appraisal, and quantitative survey. Each of them is briefly described below.

Secondary data collection. In the first stage, secondary information relevant to the study was collected from various published and unpublished sources. Secondary information available from zonal, woreda, and development station of Office of Agriculture and other partners was reviewed in detail. This stage helped to get the general understanding of the subject matter related to the objectives of the study before the study team goes to the grassroots level. It helped to develop a checklist that was used in the second stage. Review of secondary sources also helped to identify the issues and gaps that need to be addressed adequately with appropriate methodologies and tools.

Rapid appraisal survey. In the second stage, the study team collected a rapid appraisal survey to collect qualitative information and gain an understanding of how potato production technologies are used by the beneficiaries. The approach also allowed a free discussion of farmers and the study team on various issues related to the objectives of the study. This stage was a prerequisite to develop a questionnaire that was used to collect quantitative data in the third stage. A checklist that was developed with some of the predetermined questions based on the objectives of the study and general information obtained from secondary sources was used as a tool in the second stage. Additional relevant questions were also raised during the discussion based upon the observations and responses. The questions were open-ended and the interview system was informal. A rapid appraisal report was generated to help design structured questionnaire.

Quantitative survey. In the third stage, a focused formal survey was conducted following the rapid appraisal survey to quantify some of the most important parameters. Quantification of some parameters helped to verify the qualitative information collected in the second stage and presents the findings with empirical evidence. A structured questionnaire was designed based on the reports of the rapid appraisal survey. The questionnaire was pretested for consistency and time it would take to fill it. Enumerators were recruited and trained both theoretically and practically on how to fill in the questionnaire and interview the selected farmers. During data collection, researchers, experts of the woreda office of Agriculture,

supervised enumerators closely and Development Agents located at village levels. A total sample size of 336 respondents was selected randomly and interviewed from each of the study woredas (Table 2).

Table 2: Sample sizes in the study areas

Woreda	Sex	Participant		Non participant		Total	
		n	%	n	%	n	%
Jeldu	Male	60	98	71	93	131	96
	Female	1	2	5	7	6	4
	Subtotal	61	100	76	100	137	100
Degem	Male	42	84	51	94	93	89
	Female	8	16	3	6	11	11
	Subtotal	50	100	54	100	104	100
Banja	Male	16	100	74	94	90	95
	Female	0	0	5	6	5	5
	Subtotal	16	100	79	100	95	100
Grand Total		127	100	209	100	336	100

Analytical tools

Appropriate analytical tools were used to analyze the data and summarize the information. Information obtained from first and second stages was summarized using maps, tables, descriptions, diagrams, and graphs. To analyze the quantitative data collected from third stage, the questionnaire was coded and the data were cleaned and prepared for analysis. Some of the most important statistical tools were employed to analyze the data and summarize the information.

Results and Discussion

Adoption status of released varieties

Adoption rates of released potato varieties in Jeldu woreda. Farmers of Jeldu woreda have good experience of diversifying potato varieties and grow 23 types of both local and improved varieties. In Jeldu woreda, participant farmers started adopting improved varieties of potato, mainly since 2001; nonparticipant farmers started since 2003. The farmers of Jeldu woreda have adopted six types of officially released varieties. The adoption rates vary from one variety to another and from one year to another. In the 2005 cropping season, the adoption rates of released varieties by participant farmers varied 3–39%,whereas adoption has increased in 2006 and varied 11–66% (Table 3). At an adoption rate of 66%, the most adopted variety in Jeldu was Jalene.

Table 3: Adoption rates of released potato varieties in Jeldu woreda

Variety grown	Year	Participants		Non participants		Overall sample	
		n	Adoption rate (%)	n	Adoption rate (%)	n	Adoption rate (%)
Menagesha	2006	17	28	3	4	20	15
	2005	24	39	2	3	26	19
Wochecha	2006	12	20	--	--	12	9
	2005	18	30	--	--	18	13
Jalene	2006	40	66	2	3	42	31
	2005	11	18	--	--	11	8
Gudene	2006	20	33	--	--	20	15
	2005	5	8	--	--	5	4
Gera	2006	20	33	1	1	21	15
	2005	4	7	--	--	4	3
Digemegn	2006	7	11	--	--	7	5
	2005	2	3	--	--	2	1

The adoption rate increases from one year to another for some varieties, but declines for others. For instance, the adoption rate of old improved varieties, such as Menagesha and Wochecha, shows a declining trend from 2005 to 2006

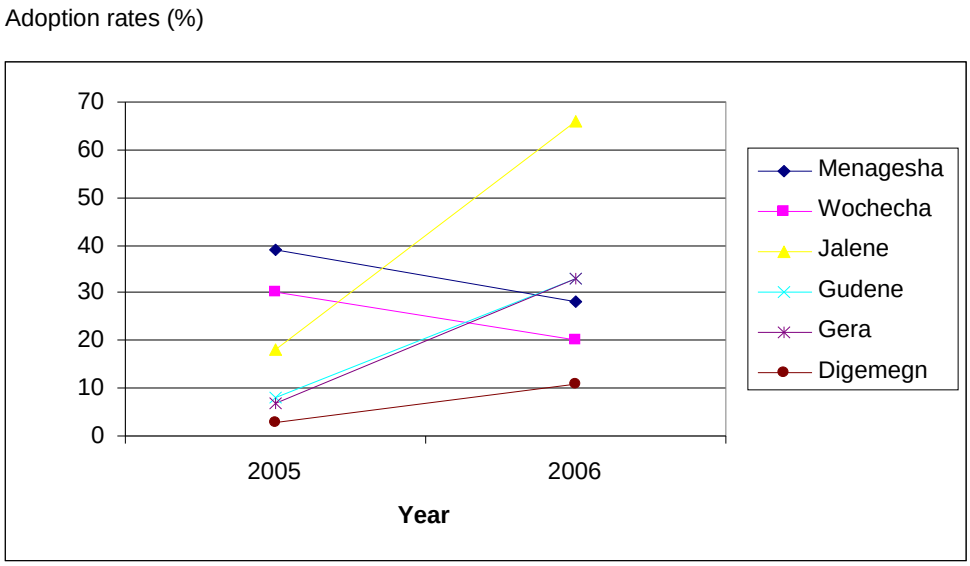


Figure 1: Adoption trend of released potato varieties by participant farmers in Jeldu woreda

cropping season. The adoption rate of the new varieties, such as Jalene and Gudene, shows an increasing trend (Fig. 1). Farmers replace one variety with another depending on the merits of the new variety.

It was also realized that diffusion of improved potato varieties mainly follows road sides, and diffusion off the road was very limited (Fig. 2). This suggests that appropriate mechanisms have to be in place to diffuse the technologies to the beneficiaries located off the road.

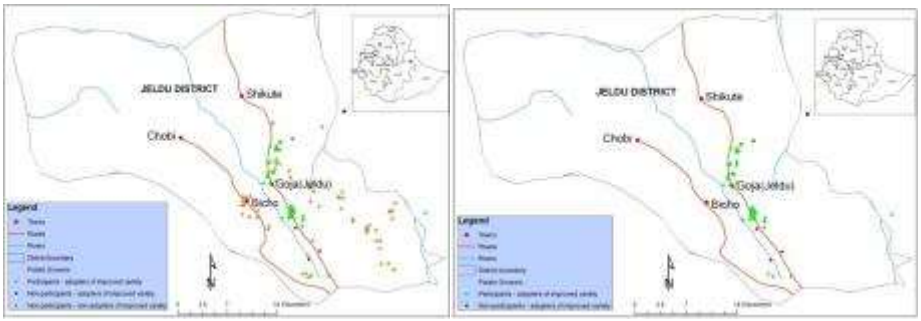


Figure 2: Diffusion status of improved potato varieties in Jeldu woreda

Adoption rates of released potato varieties in Degem woreda. Potato is mainly produced in the meher season than in other seasons in Degem woreda. In the years 2005 and 2006, 38% and 62% of the farmers, respectively, produced potato in the meher season. Farmers of Degem woreda grow 11 types of potato varieties, of which 5 are officially released by the Ethiopian Institute of Agricultural Research (EIAR). Other varieties are clones but not officially released for production. Since potato is a new introduction to the farming systems of Degem woreda, adoption rates of improved varieties is increasing from time to time (Fig. 3).

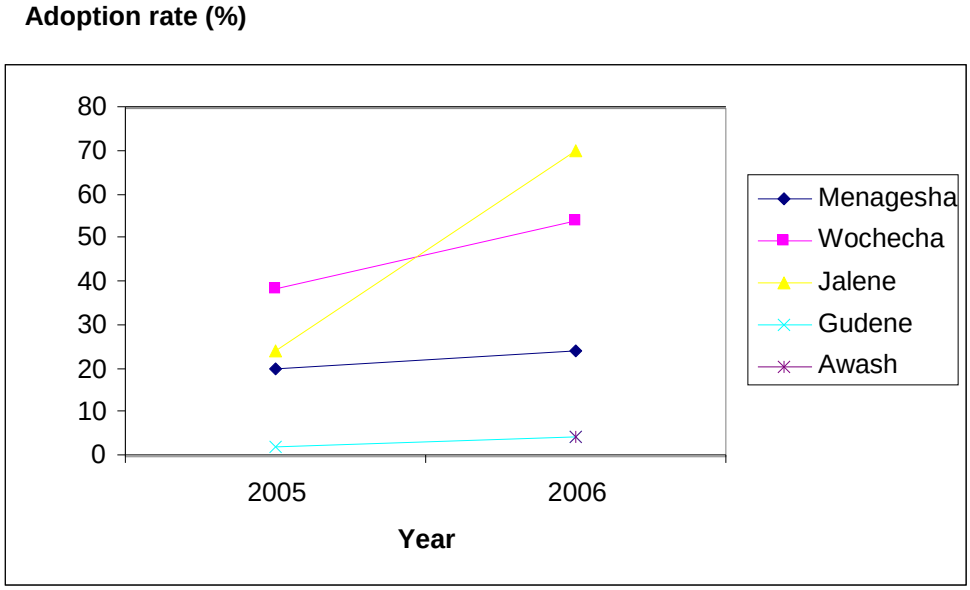


Figure 3: Adoption trend of CIP varieties by participant farmers in Degem woreda

In Degem woreda, participant farmers started adopting improved potato varieties since 1998; nonparticipant farmers started since 2001. In all the cases of released varieties, the adoption rate is higher in the 2006 cropping season than the 2005 cropping season (Table 4). Among the participants, Jalene is relatively the most adopted variety, with adoption rate of 70% by sample farmers in the 2006 cropping season. The nonparticipant farmers have also adopted some released varieties, such as Wochecha (adoption rate of 15%) and Jalene (adoption rate of 6%), especially in the 2006 cropping season.

Diffusion status of released varieties in Degem woreda is relatively better than other woredas and includes not only along the roads but also off the roads (Fig. 4).

Table 4: Adoption rates of released potato varieties in Degem woreda

Variety grown	Year	Participants		Nonparticipants		Overall sample	
		n	Adoption rate (%)	n	Adoption rate (%)	n	Adoption rate (%)
Menagesha	2006	12	24	1	2	13	13
	2005	10	20	1	2	11	11
Wochecha	2006	27	54	8	15	35	34
	2005	19	38	5	9	24	23
Jalene	2006	35	70	3	6	38	37
	2005	12	24	1	2	13	13
Gudene	2006	2	4	0	0	2	2
	2005	1	2	0	0	1	1
Awash	2006	2	4	0	0	2	2
	2005	-	-	-	-	-	-

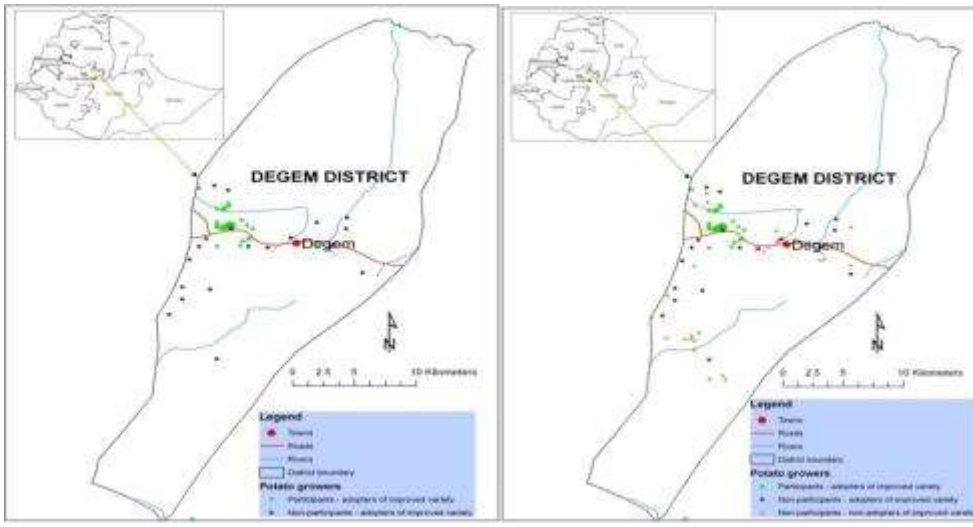


Figure 4: Diffusion status of improved potato varieties in Degem woreda

Adoption rates of released potato varieties in Banja woreda. In Banja woreda, potato production is a common practice three times a year: the Meher season, the belg season, and residual moisture. Farmers grow 18 types of potato varieties, most of which are local ones. They started adopting improved varieties since 2003; nonparticipant farmers started in 2004.

Even though four types of released varieties were identified in the woreda, their adoption rate was still lower than other study sites. In the case of varieties, Guasa is relatively better adopted, with adoption rate of 31%, followed by Jalene with adoption rate of 25% in the 2006 cropping season (Table 5). A few nonparticipant farmers (4%) have adopted Zengena variety. In Banja woreda, adopting improved

varieties is a recent practice and shows an increasing trend (Fig. 5). However, diffusion status indicates along the road (Fig. 6), which suggests that further promotion work on potato production needs to be done in Banja to include areas located off the main roads. In general, the findings indicate that adoption of technologies vary over space and time. This is in line with findings of past research studies (Degnet et al., 2003).

Table 5: Adoption rates of released potato varieties in Banja Shikudad woreda

Variety grown	Year	Participants		Nonparticipants		Overall sample	
		n	Adoption rate (%)	n	Adoption rate (%)	n	Adoption rate (%)
Jalene	2006	4	25	-	-	4	4
	2005	-	-	-	-	-	-
Zengena	2006	2	13	3	4	5	5
	2005	2	13	7	9	9	9
Degemegn	2006	1	6	-	-	1	1
	2005	-	-	-	-	-	-
Guasa	2006	5	31	-	-	5	5
	2005	-	-	-	-	-	-

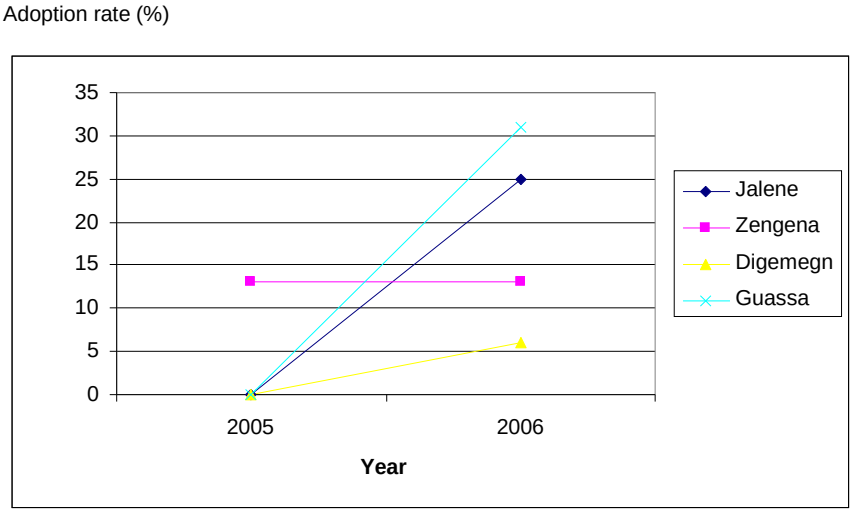


Figure 5: Adoption trend of released potato varieties by participant farmers in Banja woreda

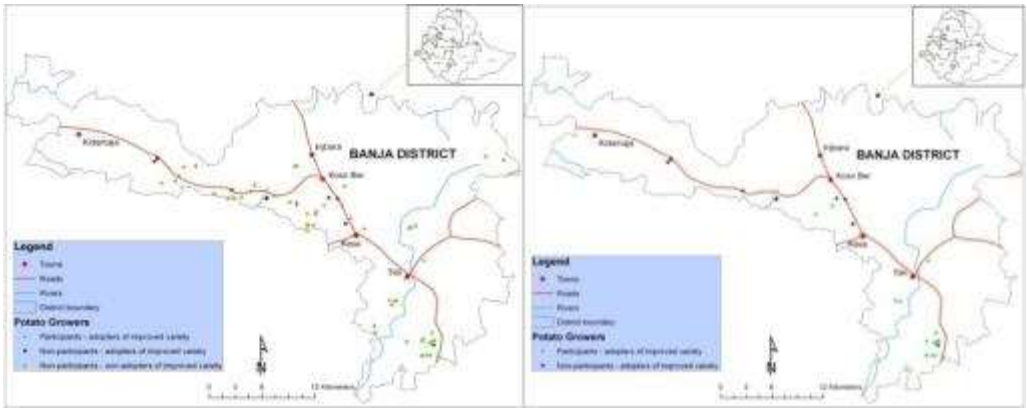


Figure 6: Diffusion status of improved potato varieties in Banja woreda

Intensity of adoption for released potato varieties

Farmers allocated different sizes of land for the different potato varieties. Old improved potato varieties occupy relatively larger area of land than recently released ones.

Size of land occupied by released varieties in Jeldu woreda. In Jeldu woreda, participant farmers allocated 0.1–0.25 ha of land for released potato varieties (Table 6). In the case of participants, improved varieties released earlier, such as Menagesha and Wochecha, occupied higher area of land than recently released varieties, such as Jalene. Menagesha occupied 0.25 ha of land on average ranging 0.0025–0.3 ha, followed by Wochecha, which occupied 0.13 ha of land on average. Recently released and most widely adopted variety, Jalene, occupied 0.1 ha of land on average, ranging 0.0025–0.5 ha. Some farmers have even started allocating as much as 5 ha of land for new varieties, such as Jalene and Gudene. This is because these varieties are in high demand and are sold at premium prices, which are 17–33% higher than other improved varieties.

Table 6: Average size of land (ha) allocated for released potato varieties in Jeldu Woreda

Participation	Varieties	Mean	Minimum	Maximum	SE
Participants	Menagesha	0.25	0.0025	3.0	0.0725
	Wochecha	0.13	0.01	1.0	0.0327
	Jalene	0.10	0.0025	0.5	0.0172
	Gudene	0.11	0.0025	0.5	0.0249
	Gera	0.12	0.0025	1.0	0.0416
	Digemegn	0.10	0.005	0.25	0.0321
Nonparticipants	Menagesha	0.07	0.03	0.13	0.0272
	Jalene	0.15	0.06	0.25	0.0937
Overall sample	Menagesha	0.24	0.0025	3.0	0.0679
	Wochecha	0.14	0.01	1.0	0.03271
	Jalene	0.10	0.0025	0.5	0.0168
	Gudene	0.11	0.0025	0.5	0.0249
	Gera	0.12	0.0025	1.0	0.0403
	Digemegn	0.10	0.005	0.25	0.0321

Size of land occupied by released potato varieties in Degem Woreda. Even if rate of adoption was high in Degem woreda, intensity of adoption (average size of land occupied by improved varieties) was still low. Participant farmers allocated 0.004–0.13 ha of land for released varieties. Wochecha occupied 0.13 ha ranging 0.0075–0.5 ha of land (Table 7). The most widely adopted variety, Jalene, also occupied 0.03 ha of land on average ranging 0.0025–0.14 ha. Nonparticipant farmers allocated 0.16 ha of land for Jalene ranging 0.025–0.5 ha. The average size of land occupied by Awash variety is too small (0.004 ha). This is because farmers replace Awash with other new varieties, due to its susceptibility to LB, and it was on the way to be phased out of production.

Size of land occupied by released potato varieties in Banja Woreda. Even though adoption rate of Guassa is higher than other varieties in Banja woreda, its intensity of adoption is lower. Participant farmers allocated relatively more land for Zengena (0.48 ha ranging 0.06–1.38 ha) than other released varieties (Table 8).Guassa occupied only 0.1 ha of land on average ranging 0.06–0.125 ha. Nonparticipant farmers planted only Zengena variety and allocated 0.045 ha of land on average ranging 0.005–0.125 ha.

Table 7: Average size of land (ha) allocated for released potato varieties in Degem Woreda

Participation	Varieties	Mean	Minimum	Maximum	SE
Participants	Menagesha	0.06	0.005	0.19	0.01059
	Wochecha	0.13	0.0075	0.5	0.01870
	Jalene	0.03	0.0025	0.14	0.00488
	Gudene	0.05	0.03	0.0625	0.01083
	Awash	0.004	0.0025	0.005	0.00125
Nonparticipants	Menagesha	0.0125	0.0125	0.0125	--------
	Wochecha	0.09	0.03	0.25	0.01741
	Jalene	0.16	0.025	0.5	0.11528
Overall sample	Menagesha	0.06	0.005	0.19	0.010146
	Wochecha	0.12	0.0075	0.5	0.01516
	Jalene	0.04	0.0025	0.5	0.01071
	Gudene	0.05	0.03	0.06	0.01083
	Awash	0.004	0.0025	0.005	0.001250

Table 8: Average size of land (ha) allocated for released potato varieties in Banja Woreda

Participation	Varieties	Mean	Minimum	Maximum	SE
Participants	Jalene	0.06	0.03	0.125	0.02180
	Zengena	0.48	0.06	1.38	0.30014
	Digemegn	0.125	0.0125	0.125	……
	Guassa	0.10	0.06	0.125	0.015
Non participants	Zengena	0.045	0.005	0.125	0.01098
Overall sample	Jalene	0.06	0.03	0.125	0.021803
	Zengena	0.17	0.005	1.36	0.09502
	Digemegn	0.125	0.125	0.125	……
	Guassa	0.1	0.06	0.125	0.015309

Adoption rates of potato storage technologies

DLS technology has been widely adopted in Jeldu and Degem woredas. In the case of participants, 90% in Jeldu, 80% in Degem, and 25% in Banja woredas have adopted the use of DLS technology to store potato seeds. Even nonparticipant farmers have become beneficiaries of DLS through spillover effects. For instance, 21% of nonparticipants in Jeldu, 24% in Degem, and 6% in Banja woredas have adopted DLS technologies. Farmers stored potato seed tubers for as long as 6–7 months in DLS. However, some potato growers (among both participants and nonparticipants) in all the study areas did not use DLS mainly because they are not well aware of it. Moreover, small quantities of produce did not encourage them to use DLS.

Adoption rate of recommended seed rates

The recommended seed rate for improved potato varieties is 18–20 q/ha. It was realized that almost all the participant farmers have adopted recommended seed rates ranging from 16.5 to 28.7 q/ha for released varieties (Table 9). Nonparticipant farmers are using seed rates ranging 8.6–23.1 q/ha. In general, seed rate used for released varieties is mostly either recommended or above the recommended rate. According to the farmers, higher seed rate is mostly considered as a compensation for low level of management. However, seed rates considerably higher than the recommended might result in higher cost of production.

Table 9: Average seed rates (q/ha) used for potato in all the study areas

Varieties	**Participants**		**Nonparticipants**		**Overall sample**	
	n	**Mean**	**n**	**Mean**	**n**	**Mean**
Released varieties:						
Menagesha	63	22.1	5	23.1	68	22.2
Wochecha	76	20.9	13	8.6	89	19.1
Jalene	82	24.31	6	10.3	88	23.3
Gudene	26	22.1	-	-	26	22.1
Gera	22	27.3	1	16.0	23	26.8
Zengena	4	16.5	10	18.2	14	17.7
Digemegn	7	28.7	-	-	7	28.6
Guassa	4	28.0	-	-	4	28.0
Tolcha	110	20.9	42	13.6	152	19.0
Awash	1	26.0	-	-	1	26.0
Other varieties:						
Genet	4	18.0	-	-	4	18.0
Diredawa	75	18.4	144	11.4	219	13.8
0.2	6	22.2	2	6.0	8	18.2
0.13	3	18.7	8	16.3	11	17.0
Red flower	5	27.5	2	15.4	7	24.0
Abesha	20	10.3	51	10.5	71	10.4
0.5	36	13.0	8	8.8	44	12.2
Chobe	30	16.3	37	13.0	67	14.5
Shashemene	2	14.6	28	15.0	30	15.0
Mirtzer	18	25.8	190	18.3	208	18.9
Samun	4	15.0	98	19.0	102	18.9
Deme	20	34.7	19	19.2	39	27.1
Aterabeba	11	32.5	28	27.8	39	29.1
0.14	2	9.2			2	9.2
Jiga	-	-	10	23.3	10	23.3
Key dinich	-	-	13	25.3	13	25.2

Adoption rates of spacing mechanisms

The recommended spacing between plants is 20–30cm and between rows is 60–75cm. Participant farmers ranging 52–65% in all the study areas have adopted the recommended spacing between plants (Table 10). The proportion of nonparticipants who adopted the recommended plant-to-plant spacing is also considerable (39–47%). Moreover, participant farmers ranging 48–57% and nonparticipant farmers ranging 27–36% have adopted the recommended spacing between rows (Table 11).

Table 10: Adoption rates of 20– 30cm between plants spacing

Woreda	Participants		Nonparticipants		Overall sample	
	n	Adoption rates (%)	n	Adoption rates (%)	n	Adoption rates (%)
Jeldu	41	64	25	47	66	56
Degem	36	65	22	42	58	54
Banja Shikudad	11	52	31	39	42	42

Table 11: Adoption rates of 60–75cm between rows spacing

Woreda	Participants		Non participants		Overall sample	
	n	Adoption rates (%)	n	Adoption rates (%)	n	Adoption rates (%)
Jeldu	31	51	19	25	50	36
Degem	27	54	14	26	41	39
Banja	12	75	29	37	41	43

Adoption rates and intensity of adoption of soil fertility management practices

In Jeldu woreda, 46% and 39% of the participant farmers have adopted application of DAP and Urea, respectively, on potato crops. Application of DAP is also a common practice among 51% of nonparticipants. Farmers of Degem (42%) and Banja (37%) woredas have also adopted application of DAP on potato. In general, inorganic fertilizer has been more adopted in Jeldu and Degem woredas than in Banja, whereas organic fertilizer has been more adopted in Banja woreda than in other study areas. Moreover, one of the recommended agronomic practices in potato production is application of fertilizers on potato fields, and most of the farmers have adopted this approach. The recommended practice suggests that inorganic fertilizer should be applied at the time of planting. Accordingly, 85% of the participants and 91% of nonparticipants have adopted application of inorganic

fertilizers at planting in all the study areas. The practice is the same for all other types of fertilizers.

The recommended fertilizer rate on potato is 195 kg/ha DAP and 165 kg/ha Urea. However, participant farmers in Jeldu on average applied less rate (119 kg/ha DAP and 97 kg/ha Urea) than the recommended rate (Table 12). Even though the rate of inorganic fertilizer applied is less than the recommended, the farmers maintain the fertility of potato fields with additional application of organic fertilizers (compost and farm yard manure). The use of organic fertilizer has also contributed to reducing costs of inorganic fertilizers. For instance, in the case of participants of Jeldu woreda, 39% of the cost is reduced from DAP and 41% from Urea in reducing the amount of inorganic fertilizers and compensating with organic fertilizers (Table 13).

The rate of DAP applied by participant farmers of Degem woreda is 80.4 kg/ha and for Banja woreda is 175.6 kg/ha. Participant farmers of Jeldu woreda applied 1.8–2.2 t/ha of organic fertilizers. The rate of organic fertilizers applied is even higher in Degem and Banja woredas. In general, farmers in all the study areas have the practice of maintaining the fertility of potato fields through application of both inorganic and organic fertilizers.

Table12: Average rates of fertilizer (kg/ha) adopted

Woreda	Fertilizer type	Participants	Non participants	Overall sample
Jeldu	DAP (kg/ha)	119	47.8	95.1
	Urea (kg/ha)	97	53.0	96.0
	Compost (t/ha)	1.8	--	1.8
	FYM* (t/ha)	2.2	2.7	2.6
Degem	DAP (kg/ha)	80.4	78.9	80.2
	Urea (kg/ha)	66.7	95.6	69.6
	Compost (t/ha)	2.9	8.4	4.3
	FYM (t/ha)	5.6	8.7	7.9
Banja	DAP (kg/ha)	175.6	110.5	143.0
	Urea (kg/ha)	145.0	73.3	105.1
	Compost (t/ha)	4.1	3.2	3.2
	FYM (t/ha)	6.0	2.5	2.8
	Oil extract (t/ha)	2.8	0.8	1.5

** FYM = Farm yard manure*

Table 13: Cost reduction as a result of compensating inorganic with organic fertilizers

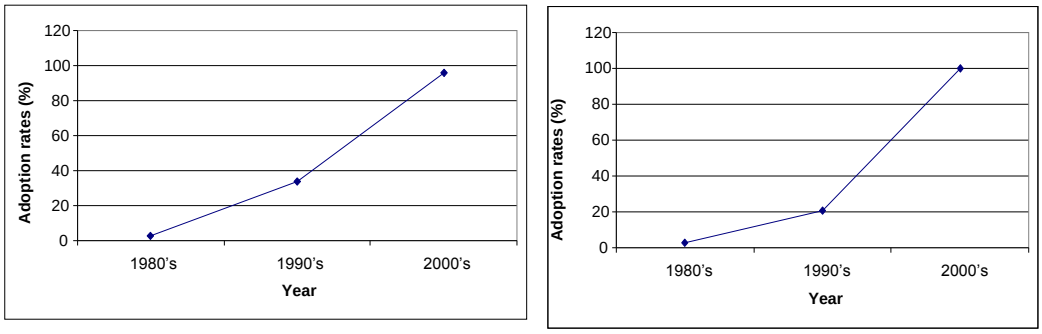
Woreda	Fertilizer type	Reduced rate applied (kg/ha)	Cost reduction (% of total cost of recommended inorganic fertilizer)
Jeldu	DAP (kg/ha)	119.0	39
	Urea (kg/ha)	97.0	41
Degem	DAP (kg/ha)	80.4	59
	Urea (kg/ha)	66.7	60
Banja	DAP (kg/ha)	175.6	10
	Urea (kg/ha)	145.0	12

Adoption of chemical control technologies for late blight

Adoption rates of fungicides increased over time in Jeldu woreda. The use of fungicides has been almost fully adopted by all the potato growers, irrespective of participation in Jeldu woreda. The cumulative adoption rate is 98%for participants and 100% for nonparticipants (Table 14). The nonparticipants learned the technology from their neighbors and through advice of the Office of Agriculture in their woreda. This is because they realized that chemical control of LB is becoming compulsory to produce potato. In the 1980s and 1990s, 34% of the participant farmers adopted chemical control of LB, whereas the proportion was only 21% for nonparticipants. This indicates that participants are adopt earlier than nonparticipants (Fig. 7).

Table 14: Adoption rates of fungicides over years in the study areas

Woreda	Time started using fungicides	Participants		Nonparticipants		Overall sample	
		n	Adoption rates (%)	n	Adoption rates (%)	n	Adoption rates (%)
Jeldu	1980s	2	3	2	3	4	3
	1990s	19	31	14	18	33	24
	2000s	38	62	60	79	98	72
Degem	1980s	--	--	--	--	--	--
	1990s	--	--	--	--	--	--
	2000s	49	98	13	24	62	60
Banja Shikudad	1980s	--	--	--	--	--	--
	1990s	--	--	--	--	--	--
	2000s	1	6	--	--	1	1



(a) **(b)**

Figure 7: Adoption trends of participants (a) and nonparticipants (b) for fungicides in Jeldu woreda

However, the proportion of adopters increased in the 2000s in both cases of sample farmers. Introduction of improved technologies by EIAR in collaboration with CIP and PRAPACE has contributed to creating awareness for the farmers to use fungicides to control LB. Enhanced demand from farmers has encouraged urban businesses to make the chemicals readily available on the local market. Availability of chemicals on local market has contributed the nonparticipant farmers to adopt chemical control even for their local potato variety.

In Degem woreda, almost all of the participants (98%) and 24% of nonparticipants have adopted chemical control technology of LB. They started using fungicides recently in the 2000s.

However, the practice is different in Banja woreda, where there is almost no adoption of chemical control technology for LB. It was realized that the farmers were not aware of fungicides, nor are they available on the local market. Therefore, this calls for promotion of fungicide technology in Banja woreda.

Productivity of potato (q/ha)

The yield obtained from released varieties at farm level ranged 99.3–232.5 quintals per hectare on participant farms (Table 15). The lowest yield is obtained from the variety Zengena (99.3 q/ha), while the highest yield is obtained from the varieties Gera (232.5 q/ha) and Guassa (213.6 q/ha). However, most of the participant farmers obtained yields ranging 150–195 q/ha. The yield obtained by nonparticipant farmers from released varieties ranged 65.6–212.9 q/ha. Even though the potential of improved varieties is more than 400 q/ha, the performance of most released varieties at farmers' level is almost by half less than the potential.

Table 15: Average yields (q/ha) of potato varieties in the study areas

Varieties	Participants		Non participants		Overall sample	
	n	Mean	n	Mean	n	Mean
Released varieties:						
Menagesha	63	162.4	5	212.9	68	166.1
Wochecha	76	151.9	13	126.7	89	148.2
Jalene	94	194.9	5	65.6	99	188.4
Gudene	27	174.8	--	--	27	174.8
Gera	23	232.5	1	80.0	24	226.1
Zengena	4	99.3	9	96.3	13	97.2
Digemegn	8	134.6	--	--	8	134.6
Guassa	5	213.6	--	--	5	213.6
Awash	1	150.0	--	--	1	150.0
Tolcha	109	146.7	42	117.4	151	138.5
Other varieties:						
Genet	4	58.0	--	--	4	58.0
Diredawa	73	130.1	132	81.3	205	98.6
0.2	6	196.2	2	72.0	8	165.1
0.13	3	253.3	8	165.7	11	189.6
Red flower	5	185.3	2	30.7	7	141.1
Abesha	16	81.2	46	73.5	62	75.5
0.5	35	133.2	8	99.2	43	126.9
Chobe	27	139.0	36	165.8	63	154.3
Shashemene	2	129.0	26	116.3	28	117.2
Mirtzer	18	70.8	179	53.0	197	54.6
Samun	4	41.0	92	62.6	96	61.7
Deme	20	89.9	19	49.8	39	70.3
Aterabeba	11	128.5	26	83.0	37	96.5
0.14	2	48.0	--	--	2	48.0
Jiga	--	--	10	66.3	10	66.3
Key dinich	--	--	13	83.5	13	83.5

Impacts observed from the use of improved potato production technologies

In general, the extent of diffusion of improved potato production technologies is limited follows mainly accessible areas and roadsides. There are impacts observed for some of the adopters, and among them, considerable impacts are observed for some elite groups. The impact areas mainly focus on asset creation, better housing, and improvements in other livelihood components. The proportions of adopters that brought impacts on different impact areas are indicated in Tables 16–18.

Table 16: Impact of potato production technology on asset creation

Impact areas	Jeldu		Degem		Overall sample	
	n	%	n	%	n	%
Purchased oxen	22	65	22	49	44	56
Purchased cows	16	49	20	44	36	46
Purchased bulls	13	38	10	22	23	29
Purchased heifers	9	27	5	11	14	18
Purchased sheep and goat	21	62	22	49	43	54
Purchased donkey	7	21	14	31	21	27
Purchased horse	16	47	3	7	19	24
Purchased mule	2	6	0	0	2	3

Table 17: Impact of potato production technologies on housing

Impact areas	**Jeldu**		**Degem**		**Overall sample**	
	n	**%**	**n**	**%**	**n**	**%**
Built new grass-roofed house	6	18	13	29	19	24
Rehabilitated existing grass-roofed house	3	9	6	13	9	12
Built new corrugated-roofed house	25	74	18	40	43	54
Rehabilitated corrugated-roofed house	7	21	6	13	13	17

Table 18: Impact of potato production technologies on other livelihood components

Impact Areas	**Jeldu**		**Degem**		**Overall**	
	n	**%**	**n**	**%**	**n**	**%**
Expanding farm land	21	64	20	44	41	53
Schooling for children	13	39	10	22	23	30
Purchase TV	5	15	0	0	5	6
Purchased mobile phone	7	21	0	0	7	9
Improved household incomes	33	97	44	98	77	98
Ensured food availability	34	100	45	100	79	100
Meet household expenses	34	100	43	96	77	98
Settling debts	34	100	43	96	77	98
Better health care	34	100	40	89	74	94
Use hired labor	24	71	20	44	44	56
Fulfill clothing needs	31	91	39	87	70	89

Major problems that hindered further diffusion of potato production technologies

The most important factors that hindered further diffusion of potato production technologies to more production areas and more beneficiaries include lack of clean seed tubers of improved varieties, problem of sustainable demand for seed and ware potato, unaffordable price of clean potato seed tubers, and deterioration of earlier released varieties due to disease leading to low yields. The findings indicate

that participant farmers in all the study areas ranging 41–69% and nonparticipants ranging 78–83% faced problems of getting high-quality seeds (Table 19). The complaint from participants is that the existing improved varieties are becoming susceptible to LB which has resulted to yield declines. Nonparticipants complained that they could not get quality improved seeds.

Table 19: Proportion of sample respondents that faced problems in getting high quality seed

Woreda	Participants		Non participants		Overall sample	
	n	%	n	%	n	%
Jeldu	25	41	63	83	88	64
Degem	25	50	42	78	67	64
Banja Shikudad	11	69	62	79	73	77

The earlier released varieties, such as Digemegn (33%), Wochecha (25%), and Menagesha (16%), are facing problems of low yield and susceptibility to LB (Table 20).This highlights the continuous need either for generating new improved varieties or cleaning the disease from existing ones using appropriate mechanisms.

Potato is becoming a cash crop, especially since introduction of improved technologies. However, some problems related to marketing are still hampering further diffusion of the released varieties to more potato production areas. The two major problems associated with potato marketing in Jeldu and Degem woredas are lack of buyers and low prices. Participants in Jeldu woreda (47%) complained of lack of buyers for their potato seed, while nonparticipants (47%) complained of low prices (Table 21). In Banjana Shikudad woreda, the major problem related to potato marketing is low prices. In general, ware potato is suffering from low prices and improved potato seed is suffering from luck sustainable demand. There used to be good demand for improved seed potato, and the buyers were mostly GOs and NGOs. However, at the time of this study, the demand from these organizations has declined and thus farmers started complaining. Seed producers have minimized this problem by selling the seeds for neighboring farmers at lower prices.

Table 20: Problems encountered on released potato varieties (% of respondents)

	Low yielding	Susceptible to LB	Susceptible to bacterial wilt	Late maturing	Small tubers	Low marketability	Not tasty	No response
Menagesha	18	16	3	0	5	5	26	27
Wochecha	21	25	4	2	2	4	10	32
Jalene	2	15	0	5	6	0	5	67
Gudene	0	0	5	5	5	0	0	85
Gera	0	16	5	0	0	5	5	69
Zengena	0	20	0	10	0	10	0	60
Digemegn	0	33	17	17	0	0	0	33
Guassa	0	0	0	0	0	0	0	100

Table 21: Problems related to potato marketing in the study areas

Woreda	**Problems selling potato**	**Participant**		**Non participant**		**Total**	
		n	%	n	%	n	%
Jeldu	No problem	6	10	6	8	12	9
	Lack of sustainable demand for seed	24	39	11	15	35	26
	Low prices for ware potato	15	25	21	28	36	26
	Transportation problem	3	5	7	9	10	7
	Theft	1	2	--	--	1	1
	Lack of market information	1	2	--	--	1	1
	Monopolization by organized groups	1	2	--	--	1	1
Degem	No problem	7	14	6	11	13	13
	Lack of sustainable demand for seed	20	40	10	19	30	29
	Low prices for ware potato	20	40	20	37	40	38
	Transportation problem	3	6	14	26	17	16
	Price fluctuation	1	2	--	--	1	1
Banja	No problem	10	63	10	13	20	21
	Lack of sustainable demand for seed	--	--	4	5	4	4
	Low prices for ware potato	2	13	14	18	16	17
	Tubers lost their quality in storage (desiccation, rotting, etc.)	--	--	4	5	4	4
	Transportation problem	--	--	2	3	2	2
	Researchers' delay to pay	1	50	--	--	1	1

Conclusion and Recommendations

In the study areas, adoption rates of potato production technologies varied in time and space. However, adoption of the improved varieties and associated packages, especially in Jeldu and Banja woredas, occurred along the main roads, which the technology did not diffuse further to potato production areas and beneficiaries located off the roads. This was mainly because verification, demonstration, scaling-up, and promotion activities were concentrated along the road sides due to accessibility. Partner institutions, such as Office of Agriculture, did not make adequate efforts to disseminate and promote these technologies in the areas.

The major problems that hindered further diffusion of improved potato production technologies were identified to be lack of clean seed tubers, unaffordable prices of clean seed tubers, lack of sustainable demand for clean seed tubers, and low prices of ware potato. Inadequate awareness about technological packages, such as storage, chemical application, and others, also contributes to less diffusion. Earlier released varieties were also becoming susceptible to LB.

The following recommendations are suggested to enhance diffusion levels of package technologies

- Adoption rates of improved varieties released earlier were showing a declining trend in some areas. This is because of their susceptibility to LB and yield decline. This suggests that replacement of these varieties by new improved varieties should be a regular and continuous process;
- Adoption of technological packages could be sustainable if key stakeholders in the area are accountable and committed to discharge their responsibilities. Office of Agriculture should play key roles in dissemination and promotion of technology packages to wider areas located off road;
- Lack of sustainable markets was reported to be a major problem for participant farmers. This was because potato varieties generated by research so far were not designed for diversified uses. Sustainable markets could be created by generating varieties with processing qualities. Thus potato products, such as chips, are in high demand by the market;
- For nonparticipant farmers, lack of clean seeds of improved varieties was reported to be a major problem. This calls for organizing and strengthening of informal seed producers in the locality to ensure sustainable supply of seeds for the neighboring farmers and other areas;
- The use of a combination of inorganic and organic fertilizers has become a common practice among farmers. This has helped reduce the cost of potato production. However, the optimum recommended rate of inorganic and

organic fertilizer combination was not known, and this calls for the need to determine the rates; and

- In areas such as Banja woreda, adoption of improved potato production technologies is much less, largely because promotion and dissemination of technologies were not conducted intensively. There is lack of improved seeds in the area. This calls for strengthening promotion and dissemination activities. Informal seed production system should also be established to create easy access to improved seeds.

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