ENHANCING FOOD SECURITY THROUGH FARMER BASED SEED SYSTEM, THE CASE OF IMPROVED POTATO PRODUCTION TECHNOLOGY TRANSFER IN WESTERN ETHIOPIA

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RESEARCH REPORT

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OARI was established in 2001 with the objectives: to generate, develop and adapt agricultural technologies, and to coordinate research activities of agricultural research centers, higher learning institutes and others in Oromiya National Regional State.

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FOREWORD

Seed (including propagating plant parts that are used for sowing or planting purposes) is a fundamental input to enhance agricultural productivity. Indeed, ensuring food security first necessitates seed security. In here, seed security includes activities undertaken to secure access to adequate quantities of good quality seeds of improved and adapted crop varieties at all times by farming households. More often, the use of quality seed also stimulates the use of other agricultural inputs such as fertilizers, crop protection chemicals, irrigation, and farm implements as well as improved agronomic practices. The combined out come would be increased agricultural productivity and hence more net benefits from overall production costs.

Despite the decisive role of improved seed in boosting agricultural productivity and thereby ensuring food security, the extent of improved seed production and distribution through formal seed system is very small, covering less than 10% of the total land, in Ethiopia. Unfortunately, it is even much smaller than this estimated percentage for horticultural, pulse, oil seed and forage crops. The Ethiopian Seed Enterprise, the only public enterprise, predominantly multiplies and distributes only seeds of selected crops, such as those of maize and wheat. Most smallholder crops remain unserved by the formal seed system and farmer-based informal seed systems supply the bulk of seeds. Some 90-95% of seed used by smallholders is saved on –farm, borrowed or purchased from neighbors, relatives, friends and other local sources. As a result, the majority of the smallholder framers are using local seeds, contributing, to a greater extent, to the low agricultural productivity of the country.

Agricultural research centers are producing and distributing improved seeds to some extent, even though such commitment is not part of their formal mandates. It is as part of this commitment that the Horticulture Division together with the Research Extension Division of Bako Agricultural Research Center, Oromiya Agricultural Research Institute has taken a successful part in initiating farmer based potato (*Solanum tuberosum* L.) seed system project in western Oromiya. The project, specifically referred to as "Potato Seed Technology Transfer" operated for four years, during the period 1999 to 2002. The participatory project package included farmers' training, provision of initial planting materials and other inputs such as fertilizers, demonstration of packages of cultural practices, technical advice and construction and use of diffused light potato store as well as farmer-to-farmer technology transfer mechanisms. During the project period, a total of 153 households in three districts directly benefited from the project. Yield increase from the adoption of improved potato seed variety has been very large, 3-5 times yield advantage over local varieties. It is interesting to note that the multiplicative effect is over 11 folds in that the final evaluation of the project showed a total of 1684 farm households have been reached indirectly through farmer-to-farmer seed dissemination within and outside the target districts. For a rural household of Ethiopia, with an average of over 6 household members, the benefit achieved from the project is quite enormous. This also shows how effective is the informal seed system to reach smallholders for seeds that do not profitably attract the public and private sectors, such as potato.

Many groups have significantly contributed to the success of the project. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the International Potato Center (CIP) generously funded the project. The initial potato seed tuber was provided by the Holetta Agricultural Research Center. The research team of Bako Agricultural Research Center competently implemented the project. The financial support and professional competence and commitment have been coupled with the enthusiastic adoption by the target farmers, and dedicated backup from the extension agents of agricultural development desk serving in the project districts.

I gratefully acknowledge all these groups whose combined efforts have considerably contributed to these commendable achievements. It is also my strong conviction that such project continues not only with potato but also with crops that would significantly contribute to the attainment of food security among Ethiopian smallholder farmers.

At the end, I am confident to say that this book will be useful for practitioners in agricultural research, extension and development sectors as well as policy makers and technological package formulators.

Farmers and private sectors who intended to establish potato farm at small or large-scale may also find this book quite useful.

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ACRONYMS

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AISCO	Agricultural Input Supply Corporation
BARC	Bako Agricultural Research Center
CADU	Chilalo Agricultural Development Unit
CBOs	Community Based Organizations
CEC	Cation exchange capacity
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CIMMTY	International Maize and Wheat Improvement
CIP	International Potato Center
CTA	Technical Center for Agriculture and Rural Cooperation
DAs	Development Agents
DAP	Diammonium Phosphate
DEMO	Demonstration
DLS	Diffused Light Store
EARO	Ethiopian Agricultural Research Organization
ESC	Ethiopian Seed Corporation
ESE	Ethiopian Seed Enterprise
EXH	Exhibition
FAO	Food and Agricultural Organization
FC	Farmer Contact
FD	Field Day
FSRA	Farming Systems Research Approach
GA	Group Approach
GD	Group Discussion
GDP	Gross Domestic Product
IA	Individual Approach
IAR	Institute of Agricultural Research
IARCs	International Agricultural Research Centers
MoA	Ministry of Agriculture
NAISA	National Agricultural Input Supply Authority
NARIs	National Agricultural Research Institutes
NAROs	National Agricultural Research Organizations

NARSs	National Agricultural Research Systems
NGOs	Non-Governmental Organizations
NPIP	National Potato Improvement Program
NSIA	National Seed Industry Agency
ODI	Overseas Development Institute
OARI	Oromiya Agricultural Research Institute
PE	Promotional Effort
PFRs	Potato Farmers Groups
PA	Package Approach
PRA	Participatory Rural Appraisal
PTM	Potato Tuber Moth
TA	Technical Assistant
T&V	Training and Visit

EXECUTIVE SUMMARY

Potato (*Solanum tuberosum* L.) has vital importance in western parts of Ethiopia. It is mainly produced to overcome the transitory food shortage that occurs during rainy season. It is considered as a transitional crop as it enables farmers survive the hunger months. Nonetheless, farmers have been restricted to produce local potato varieties that are low in yield potential and susceptible to major potato diseases and pests. On top of this, unavailability of seeds of improved potato varieties to the farming communities stands as the most important constraints to increasing productivity. Because of this, the majority of smallholder farmers in the project areas were unable to utilize the results of potato improvement. However, the merits of new cultivars could only be realized when they can be accessed and used by smallholder farmers in a sustainable manner.

Accordingly, a project was developed for potato seed increase and distribution activities with a financial assistance of ASARECA. The project became operational for four consecutive years (1999 to 2002) at Jimma Arjo, Jimma Horro, and Jimma Rare Districts, East Wollega Zone of Oromiya National Regional State, Ethiopia. The objectives of the project were: (1) to teach farmers about improved potato seed production techniques and thereby multiply with their active participation; (2) to hasten improved seed adoption and diffusion rate among farmers; (3) to introduce diffused light store and teach farmers about its use; (4) to demonstrate farmer-to-farmer technology dissemination mechanisms; (5) to initiate and enhance farmers participatory technology evaluation process and (6) to draw useful lessons on informal seed system.

Improved seeds of a potato variety known as *Menagesha* were distributed to host farmers along with its full production package, being facilitated by village level extension workers. On-farm multiplication and demonstration of the improved seeds were undertaken with the active participation of host farmers.

The project provided well sprout improved quality seeds, fertilizer, technical advice and training during different project implementation phases. Host farmers provided land, labor and undertook every seed production management practiced; including post harvest handling.

Farmers were able to construct diffused light store (DLS) structures using local materials as per training offered. They were also the nucleus and active members of participatory Potato Seed Technology Transfer evaluating group. Farmers distributed the on-farm multiplied improved seeds using indigenous seed transfer channels such as barter, free gift and sales. This system has a number of advantages for farmers over formal seed exchange because it uses indigenous means for information flow and exchange of goods, and its informal nature makes it less rigid than the formal seed sector. So farmers have easy access to seed and often know from whom they obtain the seed.

From the significant changes observed in the production trends of farmers it was realized that potato is the potential food security crop. It was based on farmers' felt need and preference for the crop that efforts were made to increase and disseminate the selected variety through their active participation. The achievements recorded in this project also revealed that improved potato production could significantly contribute to the national food security goal, if dealt with at macro level. In general, it is significant to note that sustainable community-based seed multiplication and dissemination system is developed for the project areas that could serve as a model for enhancing informal seed system to reach the resource poor farmers. In fact, scaling up of the project to reach more and more potato growers surrounding the project areas need due considerations.

PART I

ETHIOPIAN SEED SYSTEM ANALYSIS WITH EMPERICAL REFERENCE TO POTATO

1. INTRODUCTION

Sub-Saharan Africa countries continue to suffer from food deficits and poverty, despite a wealth of natural resources, such as large areas of arable land, abundant water for irrigation and availability of productive labor. Nearly 70% of the population live in rural areas and is engaged in agriculture. Therefore, major efforts to alleviate poverty and achieve food security must be concentrated on the agricultural sector (CTA, 1999).

Ethiopia is the third highly populated country in Sub-Saharan Africa, with a population of close to 70 million. Agriculture is the base of its national economy, contributing over 48% of the national gross domestic product (GDP), 90% of the national foreign exchange earnings and engaging 85% of the national labor force. It provides raw materials for more than 70% of the domestic industries (Franzel and Houten, 1992). Production coming from the small-scale peasant holdings account for about 97% of the total agricultural output of the nation, using traditional production practices and local cultivars.

Ethiopia is endowed with suitable agro-ecologies favoring the cultivation of a wide range of crops including potato (*Solanum tuberosum* L.). It is one of the most widely grown root and tuber crops and stands second next to enset (*Ensete ventircosum* L.) in area coverage. It is widely grown in the highland and mid-altitude areas of western Ethiopia. Its high yield per unit area and best maturity period are double advantages to be a food security crop. The fact that potato matures during the time when there is a food shortage and its short life cycle to mature enables it to deserve appreciation by farmers. It is not only preferred for filling food shortage period but also favors double/multiple cropping systems. It serves as food and source of cash income for farmers, especially when grains deplete from stores.

It was reported that more than 95% of the farmers residing in the project areas depend on the food that made from potato during early June to late September; commonly known as 'hunger months'. Farmers consider it as a transitional crop that helps survive the severe food shortage that occurs during rainy season.

In spite of its remarkable importance, the productivity of potato has been low and the national average yield record is 8 t ha^{-1}. The possible causes, among others are, lack of seed of improved varieties, use of sub-optimal management practices, poor storage facilities and inadequate technology transfer efforts (Girma, 2001).

Therefore, the supply of high yielding and disease resistant/tolerant healthy seed tubers along with appropriate agronomic practices and storage mechanism to farmers is very crucial for promoting potato production in the region. In recent years, three improved potato varieties *viz.*, *Menagesha*, *Tolcha* and *Wechecha* are found to be superior in adaptation and agronomic performance in the project areas. Nonetheless, until this project has became operational in the area, there had been neither government nor private organization was engaged in the production and dissemination of improved potato seed tubers. As a result, farmers were using inferior quality tubers of local cultivars with traditional production practices. Hence the project was executed to narrow down the existing seed shortage and help ameliorating the production and productivity of potato in the western parts of Ethiopia.

2. BACKGROUND

Unavailability of improved seeds in required quantity and quality is one of the constraints to increasing crop productivity. Because of this majority of the Sub-Saharan African countries are unable to utilize the results of crop improvement works at the national and international agricultural centers. Similarly in Ethiopia, in spite of considerable investments in research programs, majority of the smallholder farmers are using age old local cultivars that hardly respond to improved agricultural practices. The cultivars are also extremely prone to diseases and insect pests. In addition, there exists weak linkage in the overall process of technology generation, multiplication and dissemination activities. This scenario led to initiate the development of a functional community-based seed system, besides the improvement program.

It has been widely recognized that improved seed, more than any other input, holds the key to enhanced farm productivity and increased income generation (CTA, 1999). As the base of production for any crop, seed is probably the single most important input in all crop based farming systems, determining the upper limit on yield and the ultimate productivity of all other inputs (Abdissa *et al.*, 2001). The effectiveness of research results emanating from experiment stations are considered by the strength and efficiency of support services such as extension services, credits and input supply (Regassa *et al.*, 1998). It is frequently considered as an important source of innovation; a lead technology, particularly in resource constrained small farm environment (ODI, 1990).

Quality seed of improved variety is the key to agricultural productivity. The genetic potential and other desirable characteristics of seed are the detrimental factors to limit production. Farmers' entire crop depends on the quality of the seed. If the seed is a low yielding, of unadaptable variety, it is less likely to get good yields in spite of the best management the farmer could make. A start with seed of minor quality leads to low productivity. So seed is not just some thing planted by farmers but it is the carrier of the genetic potential for higher crop production. Recently, farmers are becoming seed conscious and are willing to pay higher prices for quality seeds of improved varieties. To ensure sufficient production, however, the seed supply channel should be accessible to farmers.

Potato seed is high in moisture content. Besides, it is prone to diseases and pests, resulting in high rate of genetic deterioration. Potato seed requires optimum physiological age and sufficient start of sprout (germination) in store for successful establishment and good stand. Therefore, seed handling, storage, and transportation require maximum care to keep storage losses at minimum and provide good seed establishment and high yield. However, proper potato seed storage facilities are lacking in Ethiopia. The phenomena have forced farmers to sell their entire produce during harvesting at lower prices. On the contrary, they purchase seed tubers at a very high price during planting.

Over decades, the national potato improvement program of Ethiopia has identified and developed several high yielding, and disease/pest resistant/tolerant potato varieties. Among them, *Menagesha, Tolcha* and *Wechacha* are found to be widely adapted to western parts of Ethiopia. However, lack of seeds of these varieties in required quantity and quality is often limiting adoption of the varieties. As a result, farmers remained with traditional potato production, using the local varieties that are low in yield potential and prone to diseases and pests. Table 1 presented the different varieties recommended for the various agro-ecologies with different potentials.

Table 1. Recommended and released potato varieties for different agro-ecologies

Variety	Center of release	Year of release	Yield[1] (t/ha)	Altitude (m asl.)	Rain fall (mm)
Al-1	Alemaya	nd	8-10	1500-2500	700-900
Al-100	Alemaya	nd	30-40	1500-2500	700-900
Al-148	Aelmaya	nd	25-30	1500-2500	700-900
Al-560	Alemaya	nd	30-40	1500-2500	700-900
Al-624	Alemaya	1987	30-40	1500-2500	700-900
Bedasa	Alemaya	2001	40.59	1700-2000	700-800
Chiro	Alemaya	1997	32-40	1600-2000	700-800
Digemegn	Holetta	2002	46.70	1600-2800	nd
Gorebela	Adet	nd	30.10	2700-3200	nd
Guwassa	Sheno	nd	24.40	2240-2630	nd
Jallene	Holetta	2002	44.80	1600-2800	nd
Menagesha	Holetta	1993	27.00	nd	nd
Tolcha	Holetta	1993	33.10	nd	nd
Wechecha	Holetta	1997	21.80	nd	nd
Zemen	Alemaya	2001	37.18	1700-2000	700-800
Zengena	Adet	2001	30-35	2000-2800	1000-1500

***Key**: nd=no data.*

***Source**: Holetta (2002); NSIA (1998, 1999, 2000 and 2001) and NAISA (2003).*

The production potentials of new cultivars can only be realized if the ultimate users access them and sustain their production in their farming systems. To this end, on-farm improved potato seed multiplication, demonstration and dissemination project has been undertaken for four consecutive years (1999 to 2002) in the major potato producing districts: *viz.*, Jimma Arjo, Jimma Horro and Jimma Rare Districts of western Ethiopia, with strong participation of smallholder farmers.

[1] Fresh tuber yield recorded on research center

The goal and purpose of the project

The ultimate goal of the project was to contribute towards food self-sufficiency, the country's current agricultural policy concern in general and that of the project areas in particular. The purpose of the project was to increase production and productivity of potato through developing a farmer-based sustainable potato seed production and dissemination system.

The objectives of the project were:

- To teach farmers about improved potato seed production techniques and multiply with their active participation;
- To enhance improved seed adoption and diffusion rate among farmers;
- To introduce diffused light store and teach farmers about its use;
- To demonstrate farmer-to-farmer technology dissemination mechanisms;
- To initiate and enhance farmers participatory technology evaluation process; and
- To draw useful lessons on informal seed system, this will be a base line for future improvement in research and development.

3. ANALYSIS OF ETHIOPIAN SEED INDUSTRY

Despite the importance of improved seed for improving the welfare of small-scale farmers, access to this invaluable technology can be constrained by many factors, including poorly developed seed industry. A seed industry essentially consists of all enterprises that produce or distribute seed (Pray and Romaswami, 1991). At a minimum, the industry has four components: (1) plant breeding research, (2) seed production and multiplication, (3) processing and storage, and (4) marketing and distribution. The industry's overall performance depends on the efficiency of each component, and each component possesses different economic and technical characteristics that determine the roles that public and private organizations play within the industry.

Although there have been efforts to encourage the use of improved seeds in Ethiopia since 1967 through Chilalo Agricultural Development Unit (CADU), it was after the establishment of the Ethiopian Seed Corporation (ESC) in 1978 that one observes significant breakthrough in the production and distribution of improved seed (Wolday, 1999). In 1979, ESC was incorporated to produce, process and market seed. Initially, ESC only supplied improved varieties to state farms and producer cooperatives. Now it is governed by inter ministerial seed board and has been given autonomous status to function as a profit-making enterprise. This organization was the only seed enterprise in Ethiopia until December 1990, when it entered into partnership with Pioneer Hi-Breed International (Hailu, 1992).

It was noted that as a result of the market liberalization and the implementation of the new extension system the role of the Ethiopian Seed Corporation radically redefined and renamed as Ethiopian Seed Enterprise (ESE). In recent years, ESE has made comprehensive and rapid progress in seed production technology. It started seed production in contractual agreements with private enterprises, Ethiopian Agricultural Research Organization (EARO), regional agricultural research centers, farmers and state farms. The contractual agreement is signed between ESE and the contractor with the following obligations: all production costs are borne by the seed producer; the inspection cost and cost of the jute bag and processing is borne by ESE; and ESE pay for raw seed

(Abdissa *et al.*, 2001). This is due to high seed demand resulting from the government agriculture development led industrialization policy. The policy is designed to ensure food self-sufficiency and rapid economic development via the new aggressive extension package program. In this respect, there is an effort to provide farmers with improved seeds, fertilizers, chemical inputs and credit along with improved agronomic management activities. This marked the beginning of an intensive, integrated and multidisciplinary approach to crop improvement in Ethiopia.

Table 2. Seed distribution in ('000 quintal[2]) by Ethiopian Seed Enterprise, 1980-2002

Year	Wheat	Barely	Maize	Tef	Sorghum
1980	19.08	0.26	1.16	0.02	0.20
1981	18.85	0.74	2.35	0.13	0.17
1982	16.43	0.29	1.42	0.27	0.15
1983	16.57	0.87	2.50	0.22	0.05
1984	12.25	1.65	1.30	0.13	0.26
1985	21.77	1.72	12.58	0.77	0.07
1986	25.54	1.83	11.87	0.56	1.12
1987	19.91	2.16	8.28	0.53	1.44
1988	18.81	4.12	4.51	0.57	2.15
1989	9.19	1.39	3.16	0.22	0.94
1990	8.81	0.71	3.87	0.74	0.61
1991	7.10	1.24	1.14	0.03	0.10
1992	6.96	1.23	1.53	1.89	0.19
1993	11.09	0.31	2.38	1.42	2.06
1994	12.06	0.17	3.61	2.24	0.29
1995	10.13	0.15	2.63	0.04	0.58
1996	12.37	0.27	1.89	0.36	0.16
1997	8.18	0.37	1.67	0.28	0.01
1998	11.08	0.14	4.25	0.05	0.01

Source: Abdissa et al. (2001).

[2] A quintal is equivalent to 100 kg.

The National Seed Industry Agency (NSIA) was established in 1993 to strengthen the seed industry in Ethiopia. Its overall objective is to improve farmers' access to quality seeds. Hence, the Ethiopian Seed Enterprise has made some adjustment to its original structure and targets in such a way that enable to meet the seed demand of much more farmers. Nonetheless, improved seed use in Ethiopia is extremely very low. First, this may be because most of the smallholder farmers are unable to pay for the improved seed and the fertilizer required along with due to their low purchasing power. Secondly, seeds produced and distributed by ESE may be insufficient or untimely. For instance, only about 7% of the total seed requirement for maize and wheat has been supplied by ESE (Table 3). Further, the production and distribution of vegetables seeds, and root and tuber crops in general and that of potato in particular have been and are virtually nil (Table 4).

Table 3. Seed usage by type

Crop type	Total land area (ha)	Seed used (tones)	Estimated % by seed type	
			Improved	Indigenous
Tef	2,036,310	61,089.30	1.18	98.92
Barely	800,790	100,098.80	0.34	99.66
Wheat	807,890	121,183.50	7.24	92.76
Maize	1,234,090	37,022.70	7.50	92.50
Sorghum	1,179,460	11,794.60	2.20	97.80
Haricot beans	94,250	7,540.00	0.90	99.10
Pulses and oil seed	1,499,260	129,414.20	0.04	99.96
Potato[3]	50,000	100,000	0.01	99.99

Source: CTA, 1999.

[3] Estimated from field observation.

Table 4. Seed usage by source

Crop type	Public	On-farm saved seed %
Tef	1.18	98.92
Barely	0.34	99.66
Wheat	7.50	92.76
Maize	2.20	92.50
Sorghum	0.90	97.80
Haricot beans	0.04	99.10
Pulses and oil seed	0.04	99.96
Potato	0.01	99.90

Source: CTA, 1999.

Apparently, due to lack of improved seeds of horticultural crops and the production area coverage to the crops have remained extremely low as compared to other major food crops (Table 5). Therefore, this document is to bring to the attention of stakeholders that there is an urgent need to engage in seed production of horticultural crops, if the country is to benefit from the suitable agro-ecologies for horticultural crops production. It is also believed that horticultural crops production is one of the key alternatives for improving agricultural productivity and encouraging specialized farming so as to improve food supply situation and alleviate malnutrition particularly in the rural areas.

Table 5. Area, production and yield of temporary crops, for private peasant holding, 2001/2002

Crop	Area ('000 ha)		Production ('000 quintal)	
	Number	Percent	Number	Percent
Cereals	6,370.11	79.64	87,068.28	76.64
Pulses	1,016.79	12.71	10,212.15	8.29
Oil seeds	426.13	5.33	2,081.36	1.83
Vegetables	74.99	0.94	2,886.10	2.54
Root crops	110.63	1.38	11,361.37	10.00

It is significant to note that since 1995, dictated by the new extension system and development direction of the country, plant-breeding research has become more applied, and as a result several species of crop varieties have been released or a dopted. I ncluded some p otato varieties released for production under different agro-ecologies in the country (refer to Table 1).

The Ethiopian Seed Industry is composed of formal and informal sectors as well as public and private organizations. The formal sector includes federal and regional agricultural research establishments, universities, the National Seed Industry Agency, the Ethiopian Seed Enterprise, and a few private companies like the Agricultural Input Supply Corporation (AISCO). The informal sector encompasses millions of farmers who continue to practice seed selection and conservation. Today, the bulk of national seed demand is met through this informal system of local seed maintenance and exchange (Abdissa *et al.*, 2001).

3.1 Formal Seed System

The formal seed system in Ethiopia is composed of both public and private sectors. It involves the production and distribution of improved seeds and exhibiting most of the conventional characteristics of a modern seed program. Under this system a variety release committee and a seed quality control and certification agency are in place to some extent. Other participating agencies include seed multiplication agencies, seed marketing agencies, agricultural extension agents, donors and non-governmental organizations (NGOs). Research in the country is largely public funded, although there is one private research institute, Pioneer Hi-Bred International, involving in maize and sorghum seed production system. The formal seed system mainly produces and supplies seeds of maize and wheat, and to a very less extent tef, sorghum, barley, and pulses and oil crops (refer to Table 4). On the other hand, its role is conceivably nil in horticultural crops seed production and supply including that of potato.

3.2 Informal Seed System

Our ancestors began identifying and domesticating food plants thousands of years ago, with the simple act of selecting seeds (Ashworth, 2002). The author further pointed that grand parents and their ancestors were seed savers by necessity. Their best plants were carefully selected to produce seeds for the subsequent cropping, which were traded over the back garden fence with neighbors and faithfully passed down to each new generation of gardeners. This type of seed selection and transfer from generation to generation is the informal seed system that is widely practiced in Ethiopia until today.

The informal seed system is made up of unregulated and uncontrolled seed operations. These operations consist largely of on-farm seed selection and multiplication efforts by the farmer himself, seed exchanges among farmers, and the use of planting material saved from previous harvests and set aside as seed to be sown in the succeeding cropping cycle. The system is characterized by the absence of government interventions. It has no links with research and seed quality control. It is confined to the seeds of crops generally considered un-profitable by the formal sector and depends mainly on indigenous cultivars lacking any sophisticated infrastructure. For decades, the system has been neglected by national seed program in spite of its record of providing nearly 90% of the total seed requirement in Africa as a whole (CTA, 1999).

Under this system, variety development and release, seed processing, seed storage, seed quality control, seed marketing, extension and seed promotion are often neglected. These are primarily because of lack of formal link between the informal seed system and research. As a result of the requirements of seed production legislation, the informal seed system is largely cut off from official seed quality control arrangements. Nevertheless, through the activities of NGOs and smallholder seed projects like that of our improved potato seed technology transfer project, seed quality in the informal system continues to improve. Yet, much needs to be done if this system is to be benefited from such modern quality control practices. For example, cultivars selection criteria, isolation and rouging, stacking and monitoring of seeds in field and store all need to be improved through training and collaborating with relevant agencies.

Despite several limitations, informal seed system is the most common form of seed exchange in most African countries. Abdissa *et al.* (2001) reported that the informal seed system has a number of advantages for farmers over the formal seed system. It uses indigenous channels for information flow and exchange of seeds, and its informal nature makes it less rigid than the formal sector. Further more, it operates at the community level between households, so farmers have easy access to seed and often know from whom they obtain their seeds. Availability is further enhanced by the many mechanisms of exchange that are used to transfer seed between individuals and households, on cash base, exchange in kind and transfers based on social obligations[4]. This is especially important for households that have limited resources to purchase seed. Additional benefit of this exchange system is that farmers are able to acquire seed in adequate quantities and whenever they need (Cromwell, 1996).

Major constraints of the informal seed sector

The study identified several constraints that have been impeding the smooth functioning of the informal seed system among smallholders seed production and dissemination mechanisms. The experience gained in this project is in conformity with the report of CTA (1999) for Eastern and Southern Africa. The constraints can broadly be categorized into institutional and technical imperfection and need to be addressed very urgently to exploit the potential of the informal seed system in enhancing smallholder farmers' access to quality seed. The institutional dimension of the problem includes policy and market related issues while technical part is comprised of such factors as seed multiplication, handling and utilization.

[4] In most cases seeds are not sold as a seed because of social taboos rather be given free of charge as opposed to this modern society.

Policy

It is widely recognized that correct policy and institutional conditions are required for the successful implementation of any change in program. Likewise, policy forces play key role in shaping the conditions of seed production and supply in Ethiopia. However, the formal seed system in Ethiopia is much more inclined to the production and supply of limited crops *viz*., maize and wheat. But at the local level there is highly variable and complex seed demand which could not be met through the formal system that is polarized to few crops. This tendency was ruled by the recent market liberalization program in Ethiopia. As a result, the dominant seed supplier in the country, ESE, produces seed in response to and/or based on price or profit and market conditions.

On the other hand, most farmers cannot afford to pay for seeds produced and supplied on profit basis, i.e., they lack the capacity to pay for expensive seeds from ESE. This implies, currently, ESE is not working for the benefit of the majority of smallholder farmers for it has not taken into account the full picture of farmers' condition. Further, it lacks the capacity to meet even the seed demand of a well to do farmers. The other is the inaccessibility of most farmers to formal seed sources due to poor infrastructural development. This also makes the costs of seeds too high to be affordable by smallholder farmers. Because of the difference in the resource possession of farmers, the level of infrastructure development and distance from the formal seed sector, the inequality in terms of access to seed among farmers is often wide. Most smallholder farmers are not seed secured, as they meet their seed demand by their own saved and using the informal seed exchange channels. However, informal seed production and supply in Ethiopia is highly haphazard and with little emphases on quality standards. After all, the informal seed system is the most sustainable seed source for smallholder farmers. As an alternative option, it seems important to encourage the private and semiprivate entrepreneurs to deal with commodity based seed system. This could be possible through creating enabling environments for the sectors. However, the existing realities in the country depicts that this mechanism takes time, yet this condition implies that the smallholders will keep on using their own saved seeds or go for informal sources. It seems better to encourage public sector to create conducive environment such that the formal private and public sectors can adequately respond to farmers' highly variable and complex seed demand.

Evidence from some African countries indicated that, informal seed production activities at the grass root level supplement seed supply efforts of the government and meet seed requirement of smallholder farmers. Some countries have also provided policy support for parallel approaches such as informal seed production in order to hasten the availability of good quality seeds to farmers. In general reviews indicated that Ethiopian experience in seed system lacks sufficient institutional and policy guidelines to integrate traditional and modern practices and strategies in seed production and supply to support the local farmer-to-farmer seed exchange.

Though some initiatives are under taken by the National Seed Industry Agency of Ethiopia and Ethiopian Seed Enterprise to incorporate the role of smallholder farmers in improved seed production, existing legislation and policies need to be reviewed towards fostering the participation of smallholder farmers in the system and strengthening the collaboration and links necessary to develop the informal sector.

Technical constraints

There is a need to develop adequate and appropriate methodologies for on-farm seed multiplication, dissemination, handling and storage for enhancing the contribution of the informal seed sector and facilitate quality seed supply to farming community. Concomitantly, training of farmers and front line workers (village level extensionists) in the use of these methodologies would lead to sustainable seed supply and easy access of the resource poor farmers.

Marketing

Production of seed *per se* is not a means to increase farmers' income, but marketing of the produces as a seed is complementary. Marketing arrangements for both seeds and crops need to be strengthened to ensure the sustained patronage of seed and enhance income generation among producers. If the framers could not find sustainable and dependable market for the improved seeds produced, they never engage in the activities and perhaps obliged to restrain from the activities. These would lead farmers to be suspicious and reluctant to adopt any technology offered to them. Hence market information; on where and when to sale is quite essential, if informal seed production is to be sustainable.

Utilization

After all, raised demand for any commodity is the function of knowledge on utility of the commodity. Demonstrating the utilization of the crop in various forms is mandatory for creating domestic markets and increases the commercial value of the crop. As complementary to this, improving the supply in quantity as well as quality is to be thought of. This realizes that utilization of is detrimental to raise the market demand for the seeds.

4. DESCRIPTION OF THE PROJECT AREA

The project area includes three districts of East Wollega Zone of Oromiya National Regional State namely Jimma Arjo, Jimma Horro and Jimma Rare Districts. These districts are the principal potato producing districts in the zone based on secondary data and previous field experiences

The districts were selected based on their potential resources for potato production and farmers experience in potato production. The districts are and have relatively similar agro climatic conditions and as well receive similar amount of rainfall, 85% of which is recorded in the months of June to September, indicating that potato is grown as rain fed crop.

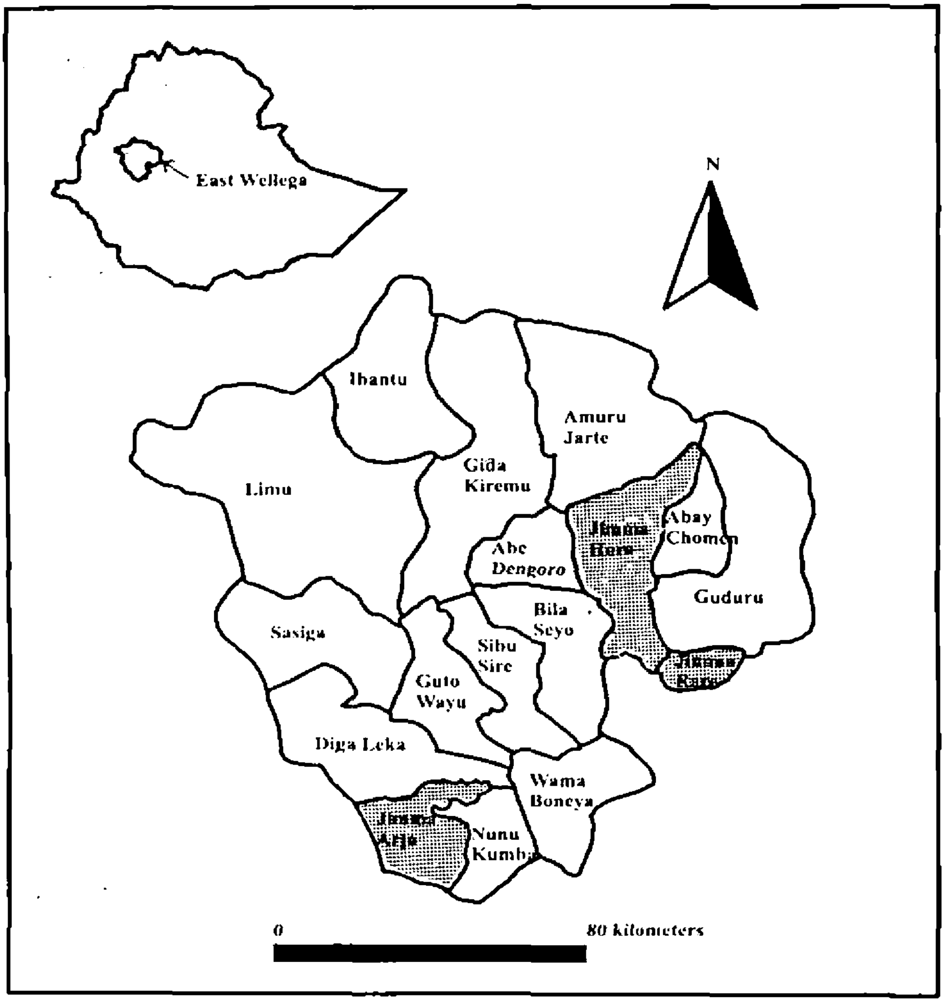


Figure 1. Study area.

4.1 Socio-economic Profile

Almost all farmers of the project area derive their livelihoods from subsistence agriculture. Nonetheless, it was reported that socio-economic differences result from the number of livestock owned, farm and family size. Farmers with large livestock and farm size, and smaller family size are in a better wealth condition. Farm size varies from 0.94 to 3.04 ha, while family size ranges from 5 to 10 and livestock size ranges from 8 to 16 over all the districts. An average household livestock holding was 5, 7 and 10, respectively, in Jimma Arjo, Jimma Horro and Jimma Rare. This indicates that Jimma Rare farmers are in a better economic status followed by Jimma Horro. Farmers of Jimma Arjo district reported that oxen power is the most critical problem that hampered agricultural activities in the district. Besides, farmers of the three districts reported that most villages have no access to market due to poor infrastructure facilities. As a result, they pay high cost for inputs purchase such as seed and fertilizer, and receive low price for their produce. Thus lack of market stability is a serious concern that affects farm income in the project area.

4.2 Population Size and Density

Jimma Arjo district comprises 15 peasant associations. The population of Jimma Arjo district is estimated to be 75,309, out of which 92% are rural population and the rest 8% are urban dwellers who derive their livelihoods both from agriculture and non-agriculture activities. Females accounted for 50.4, 49.3 and 49.4% of the urban, the rural and of total population, respectively. The crude population density of the district is 103.3 persons per km^2 (MoA, 2002).

Jimma Horro district is decomposed into 22 peasant associations. The population of the district was 125,346 in 1997; its rural population was 63.5% of the total. Females accounted for 52.2% of the urban, 47.4% of the rural and 49.1% of the total population in the district. The crude population density of the district was 109 persons per km^2 (Anon, 2000).

Based on the population and housing census, Jimma Rare district had a total population of 59,044, of which 92.3 and 7.7% were rural and urban residents, respectively. Female were 54.3% of the urban, 46.2% of the rural and 46.8% of the total populations in the district. The crude population density of the district was 140.9 persons per km^2 (Anon, 2000). It is the most highly populated districts of East Wollega Zone.

Table 6. Population size by sex both for rural and urban, 2002

District	Sex	Rural		Urban	
		Household	Family	Household	Family
Jimma Arjo	Male	10040	25033	798	2261
	Female	1166	32885	348	2778
	Total	11206	57980	1146	5039
Jimma Horro	Male	10876	31032	5215	16630
	Female	1376	36359	1011	22845
	Total	12252	67391	6226	39475
Jimma Rare	Male	5900	23421	450	1636
	Female	701	24456	211	2269
	Total	6601	47877	661	3905

4.3 Agro-climatic and Soil Types

There are three major agro-climatic zones in the districts, namely: highland, mid-altitude and lowland. Jimma Arjo district (682.4 Km^2) bordered by Nunnu Kumba and Diga Leka districts, and West Wollega and Illuababor Zones (Figure 1). The altitude varies from 1260 m asl at Didessa river to 2500 m asl of Hindhe ridge. Large proportion (59%) of Jimma Arjo district is within the altitude ranges of 1500-2300 m asl that is mid-altitude covering the total area of 44,795 hectares. Areas with an altitude range below 1500 m asl, the lowland covers 29% of the total area. The rest 12% of the total land lies between 2300-2500 m asl. In this area, the traditional off season crop production "bonne" is the most common practice (Anon, 2000; MoA, 2002).

Jimma Horro district is located in the northeast central part of the Zone with an area of 998.7 Km^2. The district is bordered with Abay Chomen and Guduru in the east, Billa Sayo and Abe Dongoro in the west, Amuru Jarte in the north and West Shewa Zone in the south. Most part of the district is characterized by undulating surface, dominated by mountain ridge and hilly landforms. The district experiences widely a temperate type of climate (Anon, 2000; MoA, 2002).

Jimma Rare district (205.8 Km^2), covers a total land area of 34,078 hectares, out of which 30% is highland, 52% is mid-altitude and 18% is lowland. The district borders Guduru in the north, Chaliya district in the south east, Bako Tibe in the southwest and Jimma Genet in the west. The altitude of the district ranges from 1540 to 3047 meters. Tullu Biyyo (3047m) is the highest peak in the district. "Dhangaggoo" and Wangele are the two important rivers of the district. In the district, off season production using residual moisture is widely practiced (Anon, 2000; MoA, 2002).

The project Districts Agricultural Development Office annual metrological data shows that the districts receive an annual rainfall of 1565mm, 1345mm, and 1150mm for Jimma Arjo, Jimma Horro and Jimma Rare, respectively. This data depicts that the districts receive higher amount of rainfall, of which 85% registered during June to September. The average temperature of Jimma Arjo district ranges from 7 to $24^{O}C$, the highest being in the months of February and March and lowest in the months of July and August. While Jimma Rare district experiences narrow ranges of temperature varying from 18 to $25^{O}C$. However, highest peak and lowest limit recorded within similar months as that of Jimma Arjo.

Dystric Nitisols and Orthic Acrisols are the two types of identified soils in Jimma Arjo district. Dystric Nitisols, which have good agricultural potential, cover most part of the district. The dominant soil types of Jimma Horro are Rendzinas, Haplic and Luvic Phaeozems. Chromic and Orthic Luvisols are the widely distributed soils types of Jimma Rare with good agricultural potential (Anon, 2000).

4.4 Farming System

Like most agricultural areas in the country, the project districts practice subsistence mixed farming system, raising livestock and cultivate crops. Horticultural crops such as potato (*Solanum tuberosum* L.), "anchote" (*Coccinia abyssinica*), sweet potato (*Ipomoea batatas* Lam.), onion (Allium Spp.), tomato (*Lycopersicon esculentum* L), "Mose Oromo" (*Coles edulis*), carrot (*Daucus carota*), beetroot (Beta vulgaris), cabbage (*Brassica oleracea*) and hot pepper (*Capsicum annum*) are produced in Jimma Arjo. Tef (*Eragirostis tef* Trotter Zucc.), wheat (*Triticum Spp.*), barley (*Hordeum vulgare* L.), faba bean (*Vicia faba.*), field pea (*Pisum sativum* L.) in the highland and mid-altitude, and maize (*Zea mays* L.), sorghum (*Sorghum bicolor* Monch), and millet (*Eleusine coracana*) in the lowland and mid-altitude are the major crops grown at Jimma Arjo district. The low land area around Didessa is covered with natural forests, while in the highland area different patches of natural and man-made forests with different tree species exists.

The important crops grown in Jimma Horro district are tef, wheat, barley, maize, millet, oats (*Avena sativa*) and sorghum from cereals; faba bean and field pea from pulses, and flax (*Linum usitatissum*), niger seed (*Gyzotia abyssinica*) and rapeseeds (*Brassica napus*) from oil crops. Jimma Horro district is a surplus producing district for cereals. Likewise, the most important crops grown in Jimma Rare are maize, wheat, tef, oats and barely from cereals; faba bean, field pea and lentils (*Lentilla lens*) from pulses; and nigger seed, flax, and rapeseeds from oil crops. The district is one of the surplus producing districts of East Wollega Zone. There are community forests as well as patches of forests in different parts of the district (Anon, 2000).

In summary, about 59.8, 9.6 and 8.4% of Jimma Arjo district were proportionate to arable land, pasture land, and forests and shrubs respectively. Cultivable land, grazing land and forest and shrubs covered 61.6, 8.0 and 11.1% of the Jimma Horro district, respectively, while others covered 19.3% of the district. Regarding land use pattern of Jimma Rare district, about 73.8% of the district was cultivable land, 16% was pasture land, 4.6% was land under forests and shrubs, and others covered 5.6% (Anon, 2000).

Table 7. Estimated production area and yield of potato over the three project districts during 2002

Districts	Rain fed		Irrigation		Bonne[5]	
	Area (ha)	Yield (t)	Area (ha)	Yield (t)	Area (ha)	Yield (t)
Jimma Arjo	281.50	19877.10	46.50	286.7	19.90	94.16
Jimma Horro	134.00	1365.00	-	-	-	-
Jimma Rare	146.00	1314.00	106.25	637.5		

4.5 Food Security

Food security is conventionally defined as access by all people at all times to enough food for an active and healthy life (World Bank, 1986). It is generally accepted as entailing not only food availability but also food access through home production, purchase in the market and transfer. Recent definitions of the concept introduce a third dimension, that is, utilization which refers to the appropriate biophysical conditions (good health) required to adequately utilize food to meet specific dietary needs.

Ethiopia is a country with diverse climatic condition and soil types, which can grow diversified food crops for home consumption and foreign markets. On top of this, there are plenty of rivers and small streams; large bodies of fresh water and vast store of under ground water, which could be used for irrigation. Thus, there exists a great biodiversity related to differences of climate, altitude, hydrological characteristics and relief. To the contrary, as is true in most Sub-Saharan African countries, Ethiopia is currently facing challenging problems ranging from those induced by environmental crises to demographic and socio-economic constraints, which adversely affect farm production. The country is characterized by extreme poverty, high population growth rate, severe environmental degradation and recurrent drought (World Bank, 1992; Getachew, 1995; Markos, 1992). These have resulted in poor agricultural productivity for several years, to the extent that the country could not adequately feed its population from domestic production. This has been manifested in the

[5] Residual moisture

prevailing food insecurity, both chronic and transitory, that has become a structural phenomenon and a way of life for a significant proportion of the population in the country (Degefa, 2002).

Much of the Sub-Saharan Africa population, particularly in rural areas, experiences some degree of hunger over the rainy, or "hunger season", when food stocks dwindle and roads become muddy and impassable (Bonnard, 1999); this is manifestation of food insecurity.

In Ethiopia, the seriousness of the food shortage varies from one area to another depending on the state of the natural resources and the extent of development of these resources. According to various sources, some 42 periods of food shortages (including the years 1999 and 2000 food shortages) have been recorded in Ethiopia (Degefa, 2002).

As common to the whole parts of the country, the study areas were also prone to unpredictable rainfall and crop failure, besides low productivity of crops and livestock, resulting in food insecurity. In addition, transitory food shortage is the commonly occurring phenomena in both mid-altitude and highland areas of the project districts. It is at this juncture that potato is taken up as a transitory food security crop and income generation. Many regions of the country produce less than they consume, and so are in an almost permanent state of regular food insecurity. Drought, declining soil fertility and poor quality seeds are often cited among the root cause of food insecurity and lack of political stability and inefficient agricultural and population policies have also contributed to the countries food insecurity. According CTA (1999) report like other east and southern Africa countries, Ethiopia lacks comprehensive and permanent food security arrangements.

The government extension system tends much to promote improved commodity crops such as maize and wheat. This has forced farmers to abandon traditionally diverse production systems. The loss of these systems reduces farmers' potential for food security. Besides, dependence on a narrow range of crop varieties has been aggravating food insecurity in the project areas. Increased dependence on maize and wheat has also made farmers vulnerable to market price fluctuation and cash shortage. Less focus has been made on diversity and crops that are more appropriate for ensuring food security. On the other hand, famine during the severely food insecure months arises from the decline in output from the other major crops in the project area. On contrary, root and tuber crops have been found to be the most selected horticultural crops identified to attain food security. This is because, root and tuber crops could grow successfully better than other food crops and mature early in the years of even short and erratic rainfall, helping to overcome transitory food shortage. Despite their merits, they were not paid due attention. As a result, the country is not exploiting the existing crop diversities and agricultural potentials that could be a remedy for the wide existing food insecurity at household level.

PART II

TECHNOLOGY TRANSFER: APPROACHES, METHODOLOGIES AND WAYS FORWARD

5. TECHNOLOGY TRANSFER APPROACH AND METHODOLOGIES

5.1 Approaches

Technology transfer approaches are broad techniques used in dissemination and evaluation process. The approaches followed in this project implementation were analogous to those of most ASARECA/CIP Technology Transfer Projects reported by Muturi *et al.* (2001). These are individual approach (IA) as individual farmer was contacted and selected for participating in this project implementation; group approach (GA) due to the fact that farmer were grouped and organized for the project monitoring and evaluation activities; package approach (PA) since the project provided all potato recommendation packages like use of improved variety, fertilizer, spacing, use of compost and farm yard manure, storage structure and disease and pest control strategies; it is also composed of training and visit (T&V) as a compound of the approach in the project sites formal and informal trainings have been offered; farming system research approach (FSRA) and participatory rural appraisal approach (PRA) were used during the problem analysis phase of the project and final evaluation of the impact of the project, respectively, as long as on-farm participatory technology promotion and evaluation process were included into the project implementation and evaluation process.

Group approach is gaining prominence in technology transfer because of its efficiency in resources use. It makes use of group dynamics and stimulates more discussion and presents a formal mechanism of discussing issues related to technology transfer (Merril *et al.*, 1989). Nevertheless, the dynamism of groups can diminish in time and it becomes difficult to keep groups together. Individual and PRA approaches were the next in preponderance of use. Compared to group approach, individual approach is more expensive but it is effective in communicating messages to the intended beneficiaries because of its interpersonal nature. PRA and farming system research approaches are gaining prominence in many agricultural research institutes because of the shift from on-station to on-farm research. In general, approaches that enhance farmer participation in identifying and solving their problems are increasingly used. These two approaches in particular are found to be efficient in identifying and prioritizing problems.

5.2 Methodologies

To achieve the anticipated goal, combinations of methods were used. These are: conventional methods; print media; beneficiary skill development and provisional effort. Each of these methods has sub-categories. These includes farmer contact (FC), demonstrations (DEMO), field days (FD), group discussions (GD), and exhibitions (EXH); beneficiary skill development in turn includes training, seminars, workshops and farmers field schools. Provisional effort (PE) entails the supply of technological inputs such as improved seeds and fertilizer. Print media includes use of pamphlets, posters, newsletters and bulletins. The advantages of the various methods used during the project implementation are given in table 8.

Table 8. Advantages and limitations of the various technology transfer methodologies

Methodology	Advantage	Limitation
Conventional Methods		
- Demonstration - Farmer contact - Field days	- Interpersonal touch as both the presenter and the receiver are physically present - Hands-on observational and trial experience - Effective in reaching late adopters - Direct exchange between individuals	- Methodologies tend to be relatively demanding in terms of time and human resources requirement
Electronic/ print media		
- Radio, television, video - Posters, pamphlets, newsletters	- Spreads information quickly - Reaches many people rapidly - Reach early adopters - Need for knowledge building	- Lack of opportunity for clarification - Not affordable by resource poor clientele
User capacity building		
- Beneficiary training - Seminars - Workshops - Meetings for planning	- Empowerment and building of the clientele knowledge base (skill) - Interpersonal interactions - Leads to sustainability and self reliance	- Limitations include spatial and logistical considerations

Source: Murti et al. (2001).

6. THE ROLES AND CONTRIBUTIONS OF PARTNERS

The success of this project is not an effort of a single individual or institution. Several actors had a stake though their roles and contributions vary with the theoretical and practical knowledge of actors, the goal of institutions and the nature of the technology.

6.1 Bako Agricultural Research Center

The primary objectives of Bako Agricultural Research Center are technology generation and supply of foundation or breeder seeds. It also engages itself in capacity building through offering training to farmers, extension personnel and subject matter specialists regarding emerging research outcomes. Besides, it has been influencing technology adoption through its out reach program such as pre extension demonstration, community based seed multiplication and supply of publications. To this effect, the center has implemented the Potato Seed Technology Transfer Project. It has generously been providing every support needed for the implementation of the project such as logistics, personnel and support services for fund administration. The effort the center out reach research and extension team has been making is a recordable contribution to the success of this project.

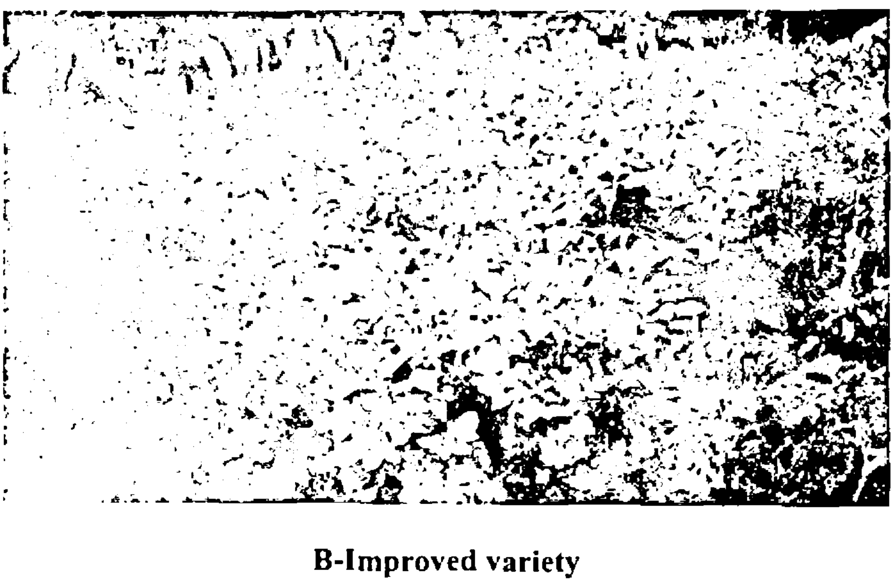
As the project is multidisciplinary in nature, various researchers drawn from Horticulture, Research Extension, Crop Protection, Agricultural Economics, and Soil and Water Management Research Divisions of the center have been participating in training, implementation, monitoring and evaluation of the project. The various training sessions ever arranged for the host farmers on production techniques, compost preparation, farmer-to-farmer transfer mechanisms (extension approaches), principles of effective marketing all these were the technical and scientific supply from the concerned researchers. On top of these, the frequent task force visits have strengthened the contribution of stakeholders to the success of the project.

6.2 Farmers' Groups

It is the first of its kind in the country's extension and research system that farmer groups have been organized and coordinated with facilitation from extension experts. To this effect, a host farmer was able to organize 20-25 other none host farmers as a group. This was to make media suitable to demonstrate the technology on grouped farmers and practically show the procedures to be followed in multiplying improved seeds and DLS construction, and their merits as compared to the local system. Starting from land preparation, farmer groups used to come together, discussed about the field performance of the improved potato variety, its establishment, vigor and reaction to diseases, especially to late blight (*Phythopthora infestanse*) locally called 'tortorsa' or rotten, and rouging techniques of the diseased plant. Farmers had fortnightly meeting on technology evaluation at the field condition; they were curiously following what would happen on the new variety as of July 21 since the local variety is completely damaged at this time, especially at Jimma Arjo. According to their evaluations, the new variety was very tolerant to the disease and it becomes the hope and remedy for successful potato production and expansion in the project area. By evaluating the potato technology, farmers were nitpicked and created pressure on research for further modification of some agronomic management practices like spacing, and nitrogen and phosphorous requirements for successful production under their conditions.

As the host farmers are in the same social and agro-ecological circumstances with none host farmers, it is hopped that farmer-to-farmer information exchange and technology transfer could be more vigorous and easy to disseminate. As a result of farmer-to-farmer exchange, the number of farmers owing improved potato seeds tripled after three years. As already indicated, this was possible because of the fact that the host farmers served as extension workers and trainers. As well they were acting as the chairmen of the farmer groups.

A-Local variety



B-Improved variety

Figure 2. The distinctive difference between local (A) and improved (B) varieties observed on field day.

6.3 Agricultural Development Departments

The major mandate of the departments is technology transfer, popularization, and the management and administration of input supplies like improved seed, fertilizer, herbicides, insecticides, fungicides and credit.

Extension department and horticulture section heads of the zone and respective district agricultural development departments were the principal complements, and contact officers for the project. They have been core members of the project implementation, monitoring and evaluation team. In addition, development agents were the key project representatives at village level and played a major role in mobilizing and assisting farmers in technical advice, and therefore it was hardly possible to achieve the commendable success with out their painstaking efforts.

Close supervision of the on-farm seed multiplication site was also possible through the committed and cooperative extension staff working at district and village levels. Nevertheless, the absence of favorable infrastructure facilities such as telecommunication service and logistics (vehicle and budget) are the major constraints of these partners. As a result, there had been difficulty of communication with the prime project-coordinating organization, Bako Agricultural Research Center, as and when need arises.

The specific contributions made to the technology transfer process by the aforementioned partners described as follows:

- Involved primarily in mobilizing grass root participant farmers;
- Assisted in selection of host farmers and appropriate seed multiplication sites;
- Disseminated the potato seed technology to villages and districts out of the target of the project. This was effected through farmer-to-farmer system;
- Assisted farmers in finding markets for the extra seeds produced;
- Played a role in facilitating farmer-to-farmer seed dissemination with the objective to reach more number of potato growers;

- Closely worked with the research staff, extension officers, development agents and horticulture specialists were efficient in disseminating information on the package of recommendation;
- Assisted in the establishment of farmers' groups at the respective project sites so called potato farmers groups (P-FRGs);
- Collaborated in organizing field day and study visits;
- Assisted in facilitating farmers' periodic meetings for participatory monitoring and evaluation process and
- Supervised close farmers' seed multiplication sites.

6.4 Holetta Agricultural Research Center

The National Potato Research Project Coordinating Center, Holetta has been the major source of basic seed and technology packages for the project. It was also the initial sources of the seeds for starting the on-station and on-farm potato seed production/multiplication schemes.

In addition, the National Potato Research Project Coordinator was closely evaluating and technically backstopping the project activities, besides the responsibility of following up the progress of the project on behave of ASARECA.

6.5 Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)

It was the major source of fund for the project along with Oromiya Agricultural Research Institute, the then Oromiya Agricultural Research Coordination Office. The organization screened competitive projects for grant based on the preset criteria and selected the project for funding. Since the start of fund release ASARECA/CIP controls and monitors the project activities and appropriate utilization of the project fund through technical and financial reports. The ASARECA/CIP also evaluated the project performance in the field condition by sending the external evaluator/expert during the first year of the project implementation period. As to the evaluator's report, the project was successful in achieving its target, and a testimony letter was written indicating that the project met the anticipated goal and impressive results have been registered. Narrating the whole history and success of this project, it could have hardly been possible if it was not based on the fund secured from ASARECA/CIP, and in part the Oromiya Agricultural Research Institute. The funding organization selected the project for grant based on the relevance to the current development issues of the country. Since then, the organization has been in close control and monitoring the implementation of the project, which is, of course, the best tool for improving the pace of our activities. The analysis of the ASARECA on the technical and financial reports periodically submitted and timely release of budget based on the work plan contributed greatly to the success. The testimonial letter written by the evaluator from the ASARECA group had been encouraging as it indicates that the project was successfully implemented and met the anticipated goals.

PART III

ACHIEVEMENTS AND RECOMMENDATIONS

7. MAJOR ACHIVEMENTS

For successful technology transfer process, the issue of proper coordination and multi disciplinary approach often plays an important role. Usually combined methods that are well coordinated tend to be more effective in technology transfer than in situations where a single methodology is used. Integrated use of methods and communication channels however require the coordinated support from suitably trained and committed staff working for clearly defined and explicitly set objective.

7.1 Seed Multiplication at Research Sites

Basic seed of the improved potato variety, *Menagesha,* was collected from the National Potato Research Project Coordinating Center, Holeta in early April 1999. During June to September 1999, 2000 and 2001 this variety has been multiplied at Shambu and Arjo sub-sites of Bako Agricultural Research Center. The seeds were then harvested and stored in DLS structure, pending their distribution to host farmers. In addition to the main season, during 2001/2002 off-season the seeds were multiplied using irrigation to reach much more potato farmers of the project area. Frequent supervision/inspection of seeds has been made at the multiplication sites and in stores.

Figure 3. A technical assistant recording and evaluating on-station improved potato seed.

7.2 Selection of Farmers

After seeds were multiplied at research sites, host farmers were selected for training on the potato seed technologies. This includes techniques of seed multiplication, DLS construction, soil fertility management, diseases and pests control and farmer-to-farmer information and seed transfer mechanisms. The selection of host farmers were made by a team composing of researchers, research technicians, development agents, extension staff and horticulture experts of each district. This was to create innovative farmer-to-farmer technology transfer and thereby facilitate the dissemination and diffusion of improved potato varieties in the western parts of Ethiopia within a short period of time. The selection was made based on the prescribed criteria with special emphasis to:

- Their farm experience on potato;
- Their interest in growing improved potato variety;
- Their ownership of the potential land for potato cultivation;

- Their ability and willingness to perform all cultural practices as per the recommendation, and
- Their ability and willingness to disseminate the seeds to the neighboring farmers in any means possible.

7.3 Training of Farmers

After selecting host farmers, training has been organized each year, just before the beginning of production season. Farmers (men and women), development agents and district experts of horticultural crops were the target clienteles of the training. In addition, responsible research technical assistants and front line workers, field worker of Bako Agricultural Research Center and some other private participants were included. Before starting the training the participants were sub-divided into two groups for the ease of teaching/lecturing based on their level of understanding. Accordingly, the training was offered using two languages: Afaan Oromo and English.

During the introductory section, the representative of East Wollega Zonal Department of Agriculture had made explicit explanation regarding the over all status/conditions of potato production of the zone, whilst district representatives highlighted the specific situations in their areas. This enabled the participants to have good understanding and realize the potentials and constraints of potato production in the zone. More specifically, the reports revealed that inadequate state support for potato technology transfer and wide spread potato diseases and susceptibility of the local land races to these diseases were the chronic problems in potato production. Further, participants had realized the intensity of the problems and the need of improved seeds of potato with its improved production package to boost up production and productivity.

A combination of training methods that have a reinforcing effect in building trainees capacity were employed during the training. In the first session, a theoretical class lecture was offered. The thematic areas addressed in the lecture session, among other things, included environmental requirements of potato, agronomic practices, and disease and pest management, storage/post harvest handling, farmer-to-farmer seed transfer mechanisms and soil fertility management practices. This was followed by a visit to on-station seed multiplication site, diffused light store structure and compost preparation site. The visit was supplemented by additional explanations by expertise with respect to the over all procedures one has to follow in seed production, compost preparation, DLS structure construction and storage. Farmers' technical capacity was further enhanced through informal training such as cross visits and method demonstration during land preparation, at planting, and throughout the crops vegetative and reproductive stage. A similar mix of training techniques was applied for the second and third cycle training phases.

Over all the technical and management capacities of farmers, horticulture experts, extension experts, village level extension workers, and farmers coming from the respective districts and villages were built through regular formal training organized at Bako Agricultural Research Center, via informal training, visit and method demonstration and the production and circulation of reference materials *viz.*, leaflets and extension manuals. Through this pragmatic approach of training extension workers were able to have thorough ground in the knowledge and skills required to assist farmers in their day-to-day seed production undertakings. It was also possible to raise the level of farmers' awareness and skills needed for self-reliant potato seed production and post harvest handling, laying the foundation for sustainable potato seed system in the area.

This method of technology transfer is called users capacity building as it initiates and enhances farmer active involvement in the process. It has the following advantages (i) empowers and builds the clientele knowledge base, (ii) enhances interpersonal interactions and (iii) leads to sustainability and self-reliance. The site visit on the station during the initial year training was noted as in figure 4 below.

Figure 4. Trainees observing on-station improved potato seed multiplication site.

During the second year training each district horticultural crops expert were reported the status of the project in their respective districts with its impact and future hopes, while the project leader presented the overall project activities of the three districts. From the report it was possible to recognize that during the two years training, the technical and management capacities of the horticulture experts, development agents, extension experts and the farmers were built through the formal training. Major themes addressed during both training years were briefly described here under.

7.3.1 Environmental Requirements

The optimum temperature for good potato tuber growth lies between 15 and $18^{O}C$. Temperatures from 20 to $29^{O}C$ lead to small tubers. Temperatures above $29^{O}C$ prevent tuber development. Potato can grow under rain fed as well as irrigated conditions. The amount of rainfall for the rain fed production must be more than 800 mm during the growing period. The optimum altitude for potato production is between 1800 and 2600 m above sea level (m asl.).

Potato is susceptible to frost damage and should be grown after the frost period is over. However, it is still possible to produce potato at lower and higher elevation than the optimum environmental conditions mentioned as it is modified based on vegetation cover, climate, soil of the specific localities and genotypic adaptation.

Sandy loam soils containing ample organic matter with good aeration is preferred for potato production. The crop is supposed to be tolerant of wide pH range but grows best on slight soil acidity (FAO, 1979).

7.3.2 Agronomic practices

Land preparation and ridging

Land preparation is required during the dry season while the soil has sufficient moisture. It is required to avoid weeds through repeated ploughing and exposing to direct sun light. The land should be ploughed to a depth of 25 to 30 cm to facilitate easy root growth. After ploughing, it should be harrowed twice diagonally to the direction of ploughing.

Ridging refers to hilling or earthing up of the soil around the potato plant. It is a common practice in potato production. Tuber should be covered with sufficient layer of soil to avoid exposure to direct sun light. Twice ridging, as compared to non ridged increases tuber yield by 10-15%. It further reduces soil erosion particularly on steep slopes. The first round hilling should be done 10-15 days after emergence, which can be synchronized with the first nitrogen application. At a fortnight interval, the second and the third hilling can be done. Hilling the crop after complete flowering may damage the stolons and the developing tubers. Hence, at a later stage only light cultivation can be applied just to control weeds and cover tubers with soil. This practice reduces damage by potato tuber moth and avoids greening of tubers.

Rotation

Crop rotation is essential in controlling many serious insects, diseases and nematodes besides soil fertility replenishment with legume crop rotation. In growing potato it should not be preceded or followed by solanaceous crops like tomato, pepper, egg plant, etc. Cereals like maize, tef, barley, wheat, sorghum can be commendably used in rotation with potato.

Soil fertility maintenance

Soil is a base for the crop growth; the fertility status of soil determines the growth of crops and yield. The economical use of soil for good achievement necessitates the conservation of soil for its sustainable use. Now days, poor soil fertility is among the many constraints limiting the production of different species of crops including potato in western Ethiopia. In order to mitigate these problems soil fertility maintenance and replenishment through the use of different artificial and organic fertilizers is of paramount importance.

On the other hand, nutrition of potato crop is dominated by its shallow rooting habit and rapid growth rate, so that good supply of nutrients throughout the growth period necessitates high yield.

Nitrogen results in early development of foliage, and hence builds the photosynthetic capacity, for active photosynthesis during the growth period. However, excess nitrogen may delay tuber initiation and, therefore, reduces yield. Nitrogen requirement depends on many factors, including soil type and previous cropping history. A preceding legume or other crop with high residual effects, or an application of organic manure, can reduce 40 to 50 kg ha^{-1} nutrient requirement of potato (FAO, 1979).

Potato needs a good supply of readily available phosphorous, since its root system is none extensive and do not utilize less available forms. Also many tropical potato growing soils are rather acid and immobilize phosphorous fertilizer rapidly.

Because of low efficiency of uptake by potato, phosphorous fertilizer applications need to be considerably higher than 30 to 50 kg ha^{-1} P_2O_5 taken up by the crop. Potato uses phosphorous fertilizer more efficiently if sideband placed and this is especially so at low or moderate application rates. To this end, a fertilizer study with *Menagaeha* potato variety recommended 69/20 kg ha^{-1}, N/P for profitable and high quality potato production in the highland and mid-altitude areas of western Ethiopia.

Compost preparation

At present, fertilizer cost is escalating and its timely availability is not granted. Owing to this, the use of locally available materials like compost, crop residue and farmyard manure are the most strategic option for smallholder farmers to sustain crop production and productivity.

Compost is a natural product, which consists partially decomposed mixture of organic residues. It is artificial manure. Compost technology is an old soil fertility management system in Asian and European countries particularly for horticultural crops production. Nonetheless, it is a recent technology to Africa and particularly to Ethiopian farmers. However, there are considerable amounts of decomposable materials at the farmers' disposal that could be used for composting. Compost has enormous merits such as fertilizer, erosion prevention, potting soil, mushroom growing and fish feeding.

Purpose of composting

Composting helps fast decomposition of organic materials and facilitates fast release of nutrient to the soil, maximizes the locally available waste materials and increases soil organic matter. Composting process takes place in moist, warm and aerated environment. During the process of composting organic wastes are decomposed into CO_2, H_2O and nutrients are released (mineralization process), and pathogens and weeds are destroyed. Composting could help farmers to continue with potato production even if fertilizer shortage would happen. This further helps sustainable production of potato even after the phasing out of this project.

Material used for compost preparation

- Grass or dry leaves;
- Adequate refuse (decomposing matter such as banana skin, dried blood, cabbage stocks, leaves, weeds, grass cuttings, hay, kitchen waste, bird droppings, potato leaves, straw, urine etc.;
- Dung and hyphen (other types of manure from livestock);
- Adequate water;
- Ashes;
- Inner cover, for example old sacks and mats and
- Outer covers.

The techniques and methods of compost preparation from locally existing materials were exhaustively addressed to the trainees. These are heap and pit methods of composting. On the training sessions, the comparison was made between the heap and pit types of composting (Table 9).

Table 9. Comparison of heap and pit method composting

Heap method	Pit method
• Can be done in the field • Ease to control aeration, temperature and moisture • It freely drains excess water • Easy to turn and mix for aeration	• Requires pit digging • Difficult to control aeration and temperature • Water logging can occur in case of excess water • Difficult to turn and mix for aeration

Steps to be followed in heap method composting

- Select the most appropriate sites like under natural shelter and near to the water supply;
- Bring the organic wastes such as animal manure, ash and other materials to the site;
- Demarcate the boundaries of future heaps, on selected sites, preferably using wooden stakes and within the boundary demarcated above the first organic residues is spread on the surface of the soil;
- Cover the bases of the heap (10-20 cm) with none easily decomposable material;
- Cover about 10 cm layer with easily decomposed plant material;
- Set a layer of about 2 cm animal manure (dung);
- Sprinkle about 2 cm ash over the layer. It contains calcium and potassium required by plants and helping the decomposition process by regulating the pH in the heap;
- Spread a thin layer of 2 cm soil which comes from topsoil or arable land. This layer is used to give the right kinds of microorganisms to the compost heap, prevent the ammonia produced in the lower layers from escaping to the atmosphere and prevents lose of temperature and humidity from heap. This step will be repeated till the heap reaches the height of 1.5 m. Figure 5 illustrates the compost structure made by heap method.

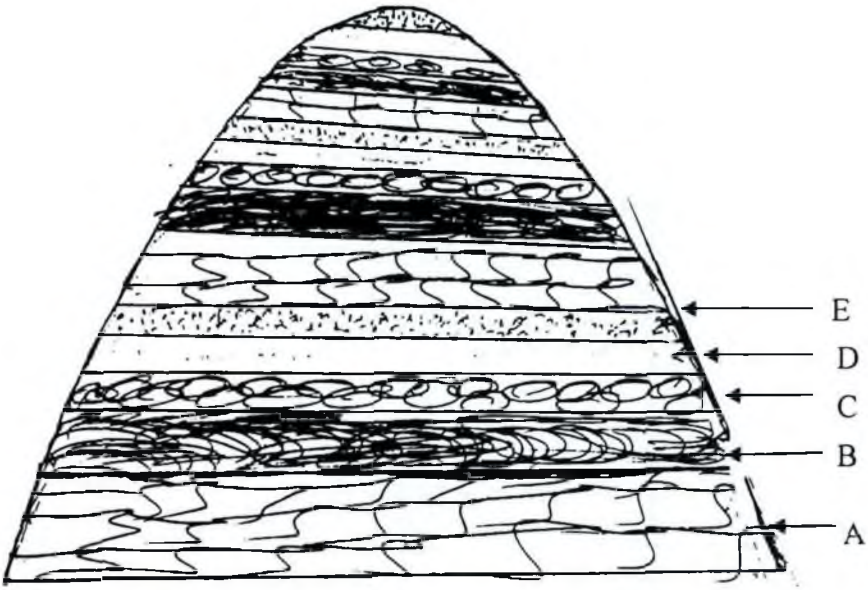


Figure 5. Structure of the compost (heap method).

Key:

A. Materials not easily decomposable (dead leaves, maize cobs and straw);
B. Easily decomposable materials (young and leaving material i.e., green plant parts);
C. Farmyard manure (animal manure);
D. Ash
E. Soil.

Farmyard manure

The beneficial role of farmyard manure in crop production has long been recognized. The capacity of farmyard manure to provide nutrients, especially N, P, K and micro nutrients is one of such benefits. Other benefits of farm yard manure that have been demonstrated include an increase in cation exchange capacity (CEC), pH, water holding capacity, hydraulic conductivity and infiltration rate, and decrease bulk density (Lekasi, *et al.*, 1999; Lekasi, *et al.*, 2001). Utilization of cattle manure as soil amendment is an integral part of the smallholder crop livestock mixed farming system of Ethiopia in particular and Eastern Africa in general. In line with this, application of 10 t ha^{-1} well decomposed farmyard manure or half rate of the recommended inorganic fertilizer plus 5 t ha^{-1} well decomposed farmyard manure was recommended for potato production in this condition. Farmyard manure is usually applied prior to planting and incorporated into the soil for field crops production such as maize, potatoes, and tef etc. Nevertheless, the chemical composition of cattle manure is influenced by the diet of the animal and by the way the nutrient is collected, stored and handled before utilization (Mugwira and Murwira, 1997). Therefore, in order to optimize and maintain manure quality, proper knowledge is required for manure collection, storage and utilization that would minimize nutrient lose and yet allow the nutrients to be readily available to the plants.

Spacing

Spacing for potato depends on the intended end use. If the deliberation is for seed, narrow spacing is advisable to harvest more number of seed with small size tubers. On the contrary, if marketable or large size tuber is envisaged wider spacing between plants is recommendable. To this effect, appropriate spacing for seed and ware potato production are 70 x 20 cm and 70-80 x 30-40 cm, respectively. These spacings are found to be optimum in highland and mid-altitude areas of western Ethiopia and similar agro-ecologies to enable sufficient soil cover and space for any field management. Accordingly, the amount of seed tubers required to plant a hectare of land varies from 12-22 quintals depending on seed size and recommended spacing.

Harvesting

Potato matures within 3 to 4 months after planting based on the variety and agro-ecologies. Dehaulming of the above ground parts or haulm should be undertaken 7-15 days before harvesting. This is to harden the tuber, avoid disease transmission and to dig tubers more easily during harvesting.

Potato harvesting is commonly done manually. Use of local hoes is preferred over that of spade and fork to reduce mechanical damage. Great care must be taken while digging tubers to avoid mechanical damage. After harvesting curing of tubers is required. This can be achieved by displaying the harvested tubers just in an open field without shade for at least two to three days. It avoids disease and pest transmission from field to store, hardens tubers and reduces moisture content of tubers for successful storage.

Storage mechanisms

One of the crucial problems challenging the smallholder potato-producing farmers is lack of appropriate technology to reserve seeds for the forthcoming cropping season. Potato tuber seeds are living organs with high moisture content as compared to seeds of cereals. Hence, there should be a proper storage system, which can keep storage losses at minimum and carry products over months.

Proper storage facilities were lacking in Ethiopia. As a result, farmers were forced to sell the entire harvest at lower prices during and in few weeks after harvest. On contrary, seed tubers are purchased at a very high price during planting. Some farmers store potato seed in burlap sacks or in dark rooms by simply spreading the tubers over floors. Others store the inferior quality and smaller size tubers simply in the soil. In addition to high risk of rotting and tuber attack by the potato tuber moth, potato tubers stored under such conditions significantly lose their weight and hence seed quality (Teriessa, 1997).

Cold store is found the most appropriate storage structure; however, it is costly for small-scale potato producers. Hence, CIP scientists have developed a low cost storage structure called Diffused Light Store (DLS). This structure has been tested at Alemaya University as well as Holetta Agricultural Research Center, Ethiopia, and recommended for wider use in the country. At Bako Agricultural Research Center as well the DLS has proved to be efficient in tuber seed storage. Host farmers of this project were trained and demonstrated on the design and construction methods of the store. At the end of the sessions, farmers were found constructing the store from locally available materials, and this mechanism was found vital for sustainable potato production. As a result, some potato farmers have successfully adopted the DLS structure technology for potato storage. Using the DLS, it is possible to store seed tubers for about 8-10 months depending on the variety and the agro-ecology. The structure can be constructed from locally available materials such as trees or mesh wire for the wall and grasses or iron sheets for the roof. The floor can be made of concrete/cemented or simply soiled depending on the ability of the farmer to afford. The size of the store to be constructed is, however, determined by the amount of tubers intended to be stored. This improved storage for potato production has the following advantages:

- It provided ease treatments to be given in the store;
- It provides good aeration and sun light for proper sprout of tubers;
- It helps for storing of ware potatoes for few weeks;
- It provides good environments for longer time storage of seed tubers.

7.3.3 Diseases and insect pests of potato

Major diseases and insect pests of potato have been explicitly presented during the formal training. Of them, late blight and potato tuber moth are the most threatening disease and insect pest of potato in the project areas.

Late blight (*Phytophthora infestans*)

Late blight caused by *Phytophthora infestans* is one of the major diseases in the major potato production areas of the country. Potato leaves, which were infected with late blight, have a water soaked appearance. In wet weather, white fungus growth or 'mildew' develops on the water soaked areas, particularly on the under side of the leaves. In dry weather, the water soaked areas turn brown and dry up, resulting in death of infected leaves. In Ethiopia, late blight was observed to inflict 50 -70% yield reduction on local potato varieties. Especially, in high infestation years about 100% yield loss could be recorded on local varieties. Hence, integrated control of late blight is the most effective rather than use of single control option.

Control methods

Cultural

Among the many cultural practices used for control of diseases and pests use of clean seeds and health varieties is one. Cleaning the residues from the main and the neighboring fields of potato and other crops of solanaceae family is the other option. The other most recommended cultural practices are use of crop rotation, early planting at time of expected long rain season, destroying dump piles and killing potato tops before harvest; and controlling other diseases to reduce susceptibility of tubers to late blight infection.

Using resistant varieties

Potato varieties. *Menagesha, Tolcha* and *Wechecha* are relatively tolerant varieties recommended for production in western Oromiya highlands. During adaptability study these varieties produced 2-3 fold higher yield over the local varieties at Shambu. The status of the local versus the improved (*Menagesha*) planted the same time and observed at the same day at Arjo is shown in Figure 2 above.

Chemical

Spray the systematic fungicides, Ridomil MZ63.5 WP (metalaxyl mancozeb) at the rate of 3 kg ha^{-1} at an interval of 8 days, beginning from the onset of the disease. Use Captafol 0.4% for reasonable late blight control. Among protective fungicides, Bresthan 10 (Chlorothalonil), Dithane M-45 (mancozeb) and Polyrm M (maneb) could be used for better control of the disease.

Potato tuber moth (PTM) (*Gnorimoschema operculella)*

It is the larvae of the PTM that cause a serious damage by mining the foliage and the stem. The larvae pupate in the leaf already mined and gradually reach the soil. Through the soil cracks the larvae find a way to the tubers. The larvae bore into the tuber and create tunnels on the tuber. PTM incurs a serious crop loss by moving into the store with infected tubers. Different levels of damage have been reported due to PTM at different localities of the country. For instance at Awassa 70-80% yield loss was rendered by PTM. Hence, it is the most important insect pest that demands careful and well designed control strategies.

Control Measures

Cultural

- Cover the seed tubers completely with soil after planting;
- Clean seed stores from all possible source of PTM;
- Avoid any remnants of the previous season crop residues, which could be the potential transmission of PTM.
- Harvest the crop at the right time / appropriate maturity.

Chemical

Different insecticides have been recommended to control PTM both in the field and in the store. However, field control of PTM is not easy as it affects tubers in the soil. Dizinon 60% EC 20 ml in 10 litters of water should be applied to protect seed potato in the store. Fenitrithion 50% EC (Sumathion), Malathion and Cypermethrin 50% EC (Symbush) could be used in the field until location specific recommendations are made available.

7.4 Seed and Fertilizer Supply

Agricultural input supply and technology transfer/extension are complementary activities. Farmers should not be advised production recommendations involving inputs such as seed and fertilizer unless otherwise these inputs are readily available to them. In view of this, the project did not rely only on the provision of information. It accorded to farmers, a package of technologies such as starter seed and fertilizer. Access to seed was further enhanced through facilitating informal seed exchange mechanisms. Each farmer was supplied with 480 well sprout improved potato seeds on loan basis along with recommended fertilizer rates (300 kg DAP ha^{-1}) that is sufficient to plant 10 x 10 m plot of land (Table 10).

The farmers were agreed and signed to return the amount of supplied seed in kind in the coming cropping season. The seed collected from the first year pilot farmers were passed onto the second cycle pilot farmers and the same trend was repeated during the third year. The first, the second and the third cycle host farmers were also advised to save seeds for themselves and transfer the rest seeds to other none host farmers using the existing indigenous seed transfer channels so as to encourage the informal farmer-to-farmer seed exchange mechanism. Table 10 indicates the direct seed distribution by the project.

Table 10. The amount of seed and fertilizer supplied to host farmers directly by the project during 1999-2001

Particulars	District		
	Jimma Arjo	Jimma Horro	Jimma Rare
Number of host farmers	51	51	51
Number of seeds supplied	20400	20400	20400
Amount of fertilizer (kg)	1530	1530	1530

7.5. Participatory Seed Multiplication and Demonstration

The participatory approach envisaged was collaborative in nature, where farmers provided land, prepared the land and ridges, and planted tuber seeds at a spacing of 75 x 20 cm during their local planting time based on the onset of rain. A recommended rate of fertilizer 300 kg DAP ha^{-1} was applied at planting besides the kraal rotated or fertile homestead field used. On top of this, most of the host farmers prepared compost and applied as per the training offered. During 2000 and 2001, a total of 20,954 kg tuber seeds have been produced from the three seed multiplication sites; whereas the estimated harvest of 2002 cropping season was 24,945 kg over the three project districts as a result of increase of participating farmers. Variations were observed in tuber seeds produced among the districts, though significantly not higher. But relatively better tuber seeds production was recorded at Jimma Arjo than the others (Table 11). The differences in the inherent soil fertility, plot (field) management and other environmental factors were thought to be reasons for the variations in tuber seed yields.

Table 11. On-farm produced seeds (kg) and some other agronomic parameters in project districts (2000 and 2001)

Location	Average No. of tubers/hill	Average tuber weight (gm)	Total tuber yield (kg)	Average tuber yield year^{-1} (kg)
Jimma Arjo	10.02	104.16	7256.67	3628.34
Jimma Horro	11.22	108.25	6978.61	3489.31
Jimma Rare	13.38	97.06	6718.78	3359.39
Total			20954.06	

In summary, farmers undertook every seed production management activities in accordance with research recommendation, and this enabled them exploit the genetic potential of the variety. The project team and other stakeholders like experts from district agricultural development offices had frequently visited, supervised and monitored the seed multiplication plots to inspect weather the standard potato seed plot management techniques were applied or not and provided suggestions for correction.

The host farmers selected each year multiplied improved potato seeds on their own plots of land as per the training offered. They executed all appropriate seed plot management. The produced seeds were saved for the forthcoming season.

The other extra seed were reserved for sell and for returning the seeds offered on loan bases. This was based on the agreement made to return the amount of seeds provided to them in kind. The returned seeds were being distributed to other farmers for the forth-coming cropping season. By observing the field performance of the variety under increase on farmers' fields, none host farmers of the vicinity were stimulated and encouraged to use the seeds. Adoption of the varieties and dissemination of seeds were faster as compared to formal seed system. This has happened as a result of rapid dissemination of information through farmer-to-farmer means. Farmers have been disseminating seeds by local seed supply systems such as sales, free gifts and bartering. Accordingly, each host farmer was able to distribute improved potato seeds on average to 20-30 none host farmers. This result was in conformity with the report of Sperling (1995), which indicates that farmers are innovative at adapting technologies to their own conditions, when they are given opportunities and they are often having a significant impact on research and extensions in the process. It was noted that the income of the host farmers have been raised by sales of seeds i.e. a kilogram of seed tuber was sold to 4.00, 2.50 and 2.00 Birr at Jimma Arjo, Jimma Rare and Jimma Horro, respectively, during the second project year. The sale price was meant for potato as a seed, not for consumption.

Figure 6. Female potato grower explaining the performance of the variety to the technical assistant at Jimma Horro district.

7.6 Diffused Light Store Construction

As the name implies DLS diffuses light and air for the start of successful potato seed sprout (germination) and also provides ease of monitoring of diseases and pests in the store. At the early stage of the project implementation year, one DLS structure was constructed at Bako Agricultural Research Center for training and demonstration purpose. Farmers visited this DLS structure at the end of the theoretical courses offering each year. Latter, another DLS structure was constructed at Shambu Research Sub-site for wide scale demonstration, training and seed storage. Subsequently, host farmers are given a brief training about its advantage, method of construction and materials used to construct DLS. Following the training, the farmers had visited the DLS structures constructed for demonstration. The minimum cost of construction and possibility of constructing the store from local materials are the advantages encouraging farmers to adopt the DLS. Most collaborating farmers were the small scale with cash deficit but have surplus labor for DLS construction.

This low cost of construction coupled with the initial training made farmers receptive and encouraged to construct and adopt the DLS structure easily. Consequently, most of the host farmers with close assistance from extension workers, had successfully constructed DLS structure as per recommendation from locally available materials. While some farmers constructed the DLS with simple modification of either roof or wall.

Great variation was observed in number of DLS constructed among the districts with the highest number of DLS in Jimma Rare (Table 12). This perhaps resulted from differences in availability of construction materials particularly trees.

Figure 7. Diffused light store structure constructed at Shambu, sub-site for demonstration purpose.

Table 12. Diffused light store (DLS) constructed by host farmer during 1999-2001

Particulars	Number of DLS constructed[6]		
	Jimma Arjo	Jimma Horro	Jimma Rare
Number of host farmers	51	51	51
Number of DLS constructed	25	35	45

7.7 Demonstration, Field Day and Study Tour

The main purposes of on-farm demonstrations, field days and cross visits (tours) were to facilitate field training and create awareness on the importance of the technical records and the practices as well. To this end, the field days organized for on-farm potato production technology promotion during 12-18 July 2000 and the study visits made by farmer groups were notable achievements during project period.

The activities of the project primarily concentrated on demonstration, field day and cross visits/exchange visits or study tours as an important promotion and communication tools. Major potato production recommendations[7] and improved storage mechanism were initially implemented on selected pilot farmers' fields, at Bako Agricultural Research Center, Arjo and Shambu Research Sub-sites. This was followed by the efficient extension approaches *viz*., demonstration, field day and cross visits with the objective to create wide spread awareness and to impress farmers' and extension officers at various levels[8] with the value and effects of the newly introduced potato seed technology.

On-station demonstration was arranged as a supplement to the in service training that had been organized at the beginning of every project year

[6] The DLS constructed by farmers at the villages are all made up of local materials.
[7] Potato agronomy, fertilizer management and pest and disease control
[8] Village, district, zone and regional levels

and to support the learning process by farmers, extension workers and horticulture experts. During these, the DLS structure constructed at various sites and compost preparation techniques were exhaustively demonstrated. On-farm periodic results and performances of the technologies have been demonstrated for the host and none host farmers so as to build their capacity and encourage them to undertake wide adoption. This had mostly been facilitated by horticulture experts and extension workers at respective districts and researchers from Bako Agriculture Research Center (Figure 6). Through this approach farmers could see the superior performance of the newly developed potato variety over the local cultivar both in yield and late blight disease reaction. The other method used as a tool for creating awareness and information dissemination was field day. Various field days were organized every year in collaboration with the respective districts Department of Agricultural Development extension staff, on farmers' own fields. This was usually organized during the maturity of the crop, when vegetative and yield performance could be observed in the field. The field days have given an immense opportunity for farmers to discuss amongst themselves and raise question to the project team.

It is bare fact that a farmer could easily believe his neighbor than any outsider. The farmer-to-farmers method has therefore enabled to convince more farmers in order to help them adopt the technology. It was through the field days that high-level extension officials at zone and regional levels were induced to support and get stimulated to recognize the problems and importance of potato production in the area. Besides this, wide spread information dissemination has resulted in remarkable adoption of the technologies by the adjacent zones and districts. There is a general consensus that it is more convincing if farmers see a practice successfully applied by another farmer on own field, using his own resources and have it explained to them. In view of this, cross visits/exchange visits were arranged for farmers so that they can teach each other about the new improved potato production and storage mechanisms.

During the visits, the host farmers and farmers' group evaluation panels established circling around the pilot, and made explanations to the visitors about the success stories of the technology.

Figure 8. Field tour evaluating the participatory on-farm potato seed multiplication and demonstration plots (1999).

Figure 9. Field tour of participatory on-farm potato seed multiplication and demonstration plots (2000).

7.8 Farmers Participatory Seed Dissemination

Due to well coordinated and committed stakeholders, particularly district and zone horticulture experts, development agents and farmers, the technology has been taken up so rapidly and so successfully.

The project has directly distributed improved potato seeds to a total of 30, 33 and 90 host farmers during 2000, 2001 and 2002 cropping seasons, respectively. Thus, the project reached directly a total of 153 host farmers over the three districts during its life years. It is significant to note that during the last project implementation year the number of host farmers had been tripled as compared to the previous years. This was made because of the recommendation during the mid term project evaluation workshop undertaken at Bako Agricultural Research Center. On the other hand, through farmer-to-farmer seed dissemination mechanisms potato seeds were distributed to 507, 680 and 497 farmers at Jimma Arjo, Jimma

Horro and Jimma Rare districts, respectively. It was observed that during final project implementation year, late start and erratic rainfall influenced the production of sufficient seed by most of the host farmers. However, the improved variety, *Menagesha,* was found the most promising even during the short rainfall season. The improved variety was tolerant to moisture stress. As a result of its quality traits, the variety was much liked and it informally reached 1684 non-host farmers within and out side the target areas. The mechanism meant for such aggressive adoption of the variety was the farmer-to-farmer mechanism. This indicated that potato seed technology had been successfully diffused crossing the boarders of the project areas. Perhaps this was due to farmer-to-farmer seed transfer, which is more vigorous than formal seed transfer channels (Table 13).

Table 13. Number of farmers reached through farmer-to-farmer seed dissemination mechanism (2000 and 2001)

Type of farmer	Districts			
	Jimma Arjo	Jimma Horro	Jimma Rare	Total
Host	51	51	51	153
Non-host	507	680	497	1684
Total	558	731	548	1637

7.9 Monitoring and Evaluation

Monitoring is a routine internal activity of the project starting from land preparation to harvesting. Monitoring in this project sense is routine supervision of activities undertaken as per the project plan. It was to investigate whether each activity is undertaken as per the recommendation or not and thereby improve any shortcomings that might happen in the course of time. The monitoring and evaluation have been made on regular base by researchers and extensionists assigned for this purpose.

Record keeping and data collection were mostly done by research technicians and extension workers by regular monitoring. This was because farmers did not record their observation due to lack of knowledge in record keeping. Joint evaluation and monitoring visits have been made to the project site at the different stages of the crop from land preparation through to harvesting and storage. Farmers have been an integral part of the monitoring and evaluation process. In 2000 and 2001 farmers were gathered and held meetings facilitated by extension officers, during which participatory verification, monitoring and evaluation were explained to them. It was based on their interest that joint monitoring and evaluation visits decided to take place on fortnightly. The fortnightly meetings were meant to discuss the status of the project and evaluate the performance of the crop as well as the host farmer. Very specifically, the most important monitoring and evaluation criteria set by the farmer groups were: reaction to late blight, moisture stress and hail storm, yield per plot, size of tubers and number of tubers per plant, plant population, fertilizer requirement, tuber color, taste and vegetative performance. At the end, the farmer groups assured that the variety is high yielder, tolerant to late blight, moisture stress and hail storm, tasty and adaptive to the agro-ecologies of the area. Some of the previous recommendations such as spacing and fertilizer rates were being suggested for modification depending on the outcome of farmers' group monitoring and evaluation exercises.

Evaluation is different from monitoring in the sense that both internal and external evaluators of the project can also undertake the activity. In this project, evaluation program was executed as per the periodic work plan and evaluation schedule: early, mid term and final or at the end of project life time. Delegate from the sponsoring organization, ASARECA/CIP had conducted an early field evaluation of the project by comparing the improved and local potato technology and was impressed by the result achieved and as a result an exciting letter was received, as testimony indicating the successful achievement and appreciation on the best effort made. Later on, mid term project status evaluation workshop was conducted by mobilizing different stakeholders of the project to evaluate whether the anticipated project objectives were met as per the plan or not. In line with this, the participants of the project workshop reached at the consensus and convinced that achievements so far made were commendable and encouraging. And this evaluation workshop had stimulated the participants to scale up the attempts of the project by accommodating more potato farmers in the target area. Finally, a field survey was executed in 2003 to asses the impact of the project, and to what extent and how fast the technology has been promoted in the project districts through farmer-to-farmer technology transfer model.

8. FARMERS' EVALUATION OF POTATO VARIETY

Farmer participatory evaluation is neither a substitute for careful agronomic or economic evaluation of technologies, nor for the on-farm research activities but is an essential complement which provides information on how farmers weigh agronomic, economic and socio-cultural consideration to arrive at their own conclusions about the usefulness of the technology in their particular farming system (Ashby, 1990).

Over the three project districts, participating farmers had critically evaluated the distributed potato variety, *Menagesha,* for its input requirement, vegetative growth, pest and disease reaction, quality, storability, stress tolerance, and yield. On average 40-57% of the farmers reported that the fertilizer requirement of *Menagesha* is low to medium. Each district, however, reported differently due to the difference in the inherent soil fertility status. The relatively high fertilizer requirement of *Menagesha* is attributed to the fact that improved crop variety needs higher inputs to express its genetic potential. Besides, short-lived crops like potato, which bulks high yield in relatively short season require high fertilizer input. Majority of the interviewed farmers responded that the variety is vigorous, produce strong stem, high in tillering capacity and tall in height. Farmers liked the variety because of its medium to high moisture stress tolerance and tolerance to disease reaction. The yield potential was the quality trait much liked by farmers, besides its acceptable color and test quality. Its storage potential, 8-10 months without losing its agronomic/genetic potential under diffused light store condition was also appreciated.

On the other hand, farmers commented the recommended spacing 75 x 20 cm for potato seed production, which is found to be dense during its vegetative stage. This fact was reported to hinder earthing up and better plot management. To this end, farmers suggested that improving the spacing for good quality and better management entails better production and it enables to exploit the genetic potential of the crop. Farmers had also commented the activities of ridging before planting in that it is too tedious to apply on large scale production. It is said because it requires high labor and hence economically not feasible. Participatory mode of on-farm research benefits not only farmers but also researchers as well. It gives an opportunity to researchers to learn a lesson from farmers' traditional working habits. The criteria farmers used during the participatory evaluation strengthen the researchers' idea of developing scientific research results based on farmers' experiences. This necessitates the development of technologies having compatibility with farmers' needs and experiences. This increases the opportunity of farmers for adopting the technologies (Biggs, 1989; Bebbington, 1991).

In addition to farmers' day-to-day observation and farmer groups fortnightly visit, field day was organized up on which 127 farmers visited the trial sites at the time of severe late blight devastation (13 July 2000) at Jimma Arjo. This was the time when farmers could discriminate the genetic potential and tolerance of the improved variety. On top of this, the information gathered through questionnaires strengthened the fact. In this context, the desirable and undesirable features of the variety and its practice were analyzed. In table 13 below a content analysis of open-ended evaluation was performed by tabulating the frequency at which each of the criterion was mentioned spontaneously by ten host farmers of Jimma Arjo (Daniel, 2000).

Table 14. Farmers' evaluation of *Menagesha* against local varieties at Jimma Arjo

Parameters	*Menagesha*			*Wachecha*			*Abashe*		
	H	M	L	H	M	L	H	M	L
Resistant to blight	10	-	-	-	-	10	-	-	10
High yielder	7	3	-	-	-	10	-	-	10
Early maturity	-	3	7	-	10	-	10	-	-
Tuber size	8	2	-	-	-	10	-	-	10
Tolerance to heavy storm	8	2	-	-	-	10	-	-	10
Taste	6	4	-	-	-	10	10	-	-
Durability in storage	6	4	-	-	-	10	-	-	10

***Key**: H-high; M-medium and L-low.*
Source: Daniel (2000).

Table 15. Farmers' preference ranking at Hindhe Peasant Association, Jimma Arjo

Parameters	***Menagesha***	***Wachecha***	***Abashe***
Resistant to blight	1	2	3
Yield	1	2	3
Maturity (earliness)	3	2	1
Tuber size	1	2	3
Tolerance to heavy storm	1	3	3
Taste	2	3	1
Durability in storage	1	3	2
Preference ranking	**1st**	**2nd**	**3rd**

***Key**: 1= Very good, 2= Medium, 3=Poor or least*
Source: Daniel (200.).

Table 16. Farmers' evaluation of improved variety (*Menagesha*) in the project areas

Parameters	Jimma Arjo (n=29)		Jimma Horro (n=31)		Jimma Rare (n=42)		Total (n=102)	
	No	%	No	%	No	%	No	%
Fertilizer requirement								
Low	8	28	9	29	24	57	41	40
Medium	21	72	20	65	17	40	58	57
High	0	0	2	6	1	2	3	3
Vigorosity								
Poor	0	0	0	0	0	0	0	0
Medium	2	7	0	0	0	0	2	2
High	27	93	31	100	42	100	100	98
Tillering capacity								
Poor	0	0	0	0	0	0	0	0
Medium	0	0	13	41	6	14	23	23
High	25	86	18	58	36	86	79	77
Plant height								
Short	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0
Tall	29	100	31	100	42	100	102	100
Tolerance to moisture stress								
Low	3	10	4	13	0	0	7	7
Medium	15	52	10	32	8	19	33	32
High	11	38	17	55	34	81	62	60
Disease reaction								
Susceptible	4	14	3	10	0	0	7	7
Tolerant	25	86	20	65	20	48	65	64
Resistant	0	0	8	26	22	52	30	29
Yield								
Low	12	41	0	0	0	0	12	12
Medium	10	34	13	42	4	10	27	26
High	7	24	18	58	38	90	63	62
Taste								
Poor	0	0	0	0	0	0	0	0
Good	24	83	8	26	31	74	63	62
Very	5	17	23	74	11	26	39	38

Source: Potato field survey (2003).

9. SUCCESS FACTORS FOR THE PROJECT

Several factors could be mentioned for the successful promotion of the improved potato production technology transfer. Among the many are:

- Adequate funding and efficient use of the resources for the project;
- Simplicity of the technology for understanding and promotion, simple to apply and accessible and compatible to resource situation of farmers;
- Assisting and facilitating farmer-to-farmer exchange of technology and information dissemination by the village level extensionists;
- The technologies taken to the farmers particularly variety and DLS structure were found superior in their performance over the local/farmers' varieties and traditional seed storage techniques;
- Development and strengthening of farmers' technical knowledge and skill via continuous and sustainable training and supervision;
- Creation of farmers active participation and awareness about improved potato seed multiplication, distribution and the use of DLS;
- The establishment of strong linkage and interaction among research, extension and farmer;
- Relevance of the project with farmers' priority needs and policy concern;
- Careful selection of the appropriate co-farming communities needing the technology and committed collaborators;
- Good initial training and farmers' exposure to the stories of the new improved potato variety and DLS;
- Constant touch and communication with the grass root farmers and village level extension workers;
- The improved potato production and storage technologies that have been disseminated are of least cost. They are affordable by resource poor farmers;

- The improved potato varieties have clear and observable advantage over the local varieties. The net return or profit margin obtained from improved potato seeds sale is incredibly high over the other commodities produced in the area; like maize, wheat, etc.;
- There is high level of match between the technology being disseminated and locally available inputs. Fertility requirement of the crop can be met by preparing compost from locally available materials and use of farmyard manure. Further more, farmers used to build DLS from locally available resources such as eucalyptus, bamboos, grasses, etc. As a result it was observed that there has been dramatic diffusion and adoption of the technology;
- Package and holistic approach: production technology, storage, acquisition of inputs, facilitating marketing of extra seeds and provision of information in all these regards.

10. MAJOR PROBLEMS/CONSTRAINTS

No success could be recorded without any challenge. This potato project being a season determined activity has achieved sensible promotion in improving the life standard of farmers by narrowing down seasonal food shortage, rising household food security and income generation. Yet the project faced the constraints that have limited its wide scale impact. Mitigating the problems is believed to complement the activities in technology transfer on improved potato towards sustainable improvement. Hence, attempts to solve the problems encountered are a ground for future success on similar activities. Among the constraints are:

- Shortage of improved seeds, i.e. the seed increased through the project was not commensurate with the demand for the same;
- Lack of market: the potential impediment to adoption and sustainability of impacts of the project were lack of market outlet. Some of the farmers who multiplied surplus seeds were not able to get market to sale their produce. With no option, they used to sale the quality tuber seed for consumption with very low price.
- Communication problem between the leading organization and front line stakeholders due to lack of communication facilities like telephone, e-mail, and fax;
- Some farmers were not willing to undertake management activities strictly as advised but they try to modify according to their traditional experiences;
- Some farmers used all their produce for food than reserving for seed;
- Shortage of fund to scale up and replicate the project to other districts and zones, which are highly potential for potato production;
- Lack of adequate policy and institutional support for the informal seed system. Owing to this it is difficult to replicate or share the experiences gained from this pioneer project.
- Some times farmers do not value for the technologies they were being given free. Thus, it is not advisable to give technologies free of charge.

11. EXPERIENCES GAINED AND LESSONS LEARNED

Technology transfer involves a series of complementary functions, such as packaging of information, creating of awareness, mobilizing beneficiaries and facilitating access to inputs. Different institutions have different capabilities and perform some functions more effectively than others, thus establishment of closer links with a variety of partners is crucial for successful transfer and adoption (Muturi *et al.*, 2001).

Even if resource conserving technologies that are productive and sustainable when imposed on farmers without emphasis to their specific needs and conditions, they will not be adopted widely. Extension has long been grounded in the 'diffusion' model of agricultural development, in which technologies are passed from research scientists via extensionists to farmers. In this process, not all farmers adopt at once, but some delay to accept. These types of farmers are often labeled by extensionists as 'laggards' (Pretty, 1995).

Nonetheless, in this project, farmers have been actively involving from the beginning of the project planning. Thus, many lessons were learned and experiences were gained from the implementation of the project. The following are notable ones:

11.1 Linkage and interaction

The possible ways to establish strong linkages, as experienced include, (i) clear identification and appreciation of the capabilities, roles and contribution of partners prior to implementation of transfer process, (ii) ensuring that the core partners and collaborators have shared goals about the project, (iii) establishing formal partnership/ collaborative arrangements, (iv) ensuring clear understanding and acceptance of technology transfer mechanisms to be used.

The establishment of strong linkage with and interaction among research, extension and farmers was the first step taken before the project became operational. Partnership among these institutions has effectively been used to transfer the technology and information to the end users. The achievements recorded here are the result of such effective linkage between stakeholders.

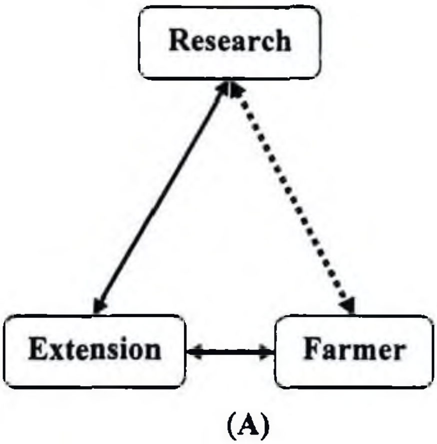


Figure 10. Schematic diagram indicating the conventional (A) and contemporary (B) linkages between research-extension-farmer.

Figure 10-A shows inadequacy of the interaction between the parties in the tripartite system especially between research and farmer; whereas, Figure 10-B shows strong linkage and interaction across the parties. Unlike the conventional system which lacks strong linkage between the research and farmers, this project started with mitigating the wider gap ever existed between the two. Hence, the success of the project is realized by the linkage illustrated under Figure 10-B.

11.2 Farmers' Participation

Improved potato seed multiplication and demonstration have been conducted on farmers' own plots with their keen participation. Furthermore, the construction of diffused light stores and managing the plots was farmers' own responsibility, though there have been some backstopping support by extension workers. In the course of undertaking the activities, individuals as well as farmers, organized into groups have had the chance of evaluating the technology and develop skills. In addition, they played key roles in disseminating information and seeds. As a result, farmers' seed demand has immediately surpassed the capacity of the project. From this experience, one can learn the impact of participating farmers in the project success.

11.3 Training

Extension and horticulture specialists and development agents have attended refresher courses supplemented by practical sessions. Farmers were trained on practical and actual field operations supplemented by field days and study tours. This has helped them to catch the recommendations and implement it accordingly. The main objective of such training was to develop the skill on the improved production practices; besides, to ameliorate the farmer-to-farmer seed dissemination mechanisms and initiate sustainability of the system.

11.4 Physical Availability of the Technology

A technology can be technically feasible, economically payable and socially acceptable. But if it is not physically available in a sufficient quantity it will be impossible to acquire the desired change (Metalign, 2003). Similarly, a lesson was learnt on the execution of this project, as it aims not in transfer of information but also attempted in multiplication and dissemination of seeds as the basic inputs. These were a means for the success achieved in this project.

The access to seeds was promoted through the farmer-to-farmer seed dissemination/exchange mechanisms. Raw materials needed for DLS construction and compost preparation have also been used from locally available resources. Thus the project has been certain that farmers have access to the technology package (improved seeds/inputs, skills and information), all enhancing dissemination of the technology.

11.5 Consistence with Farmers' Priority and Policy Concerns

It has repeatedly been reported that the problem of poverty and food insecurity during rainy season, when grains deplete from store, has been intensified because of poor productivity of agriculture. This is not unique for potato producing areas, where the use of local cultivars, susceptible to diseases, causes low productivity. The relevance of this project to the days of food security concern and farmers demand has created smooth way of adoption. Its compatibility to the local conditions has assisted the rehabilitation of potato production in the area. According to farmers' report, the potato production has come back to their farming system after 15-20 years. It is long years back the potato growers ceased the production mainly due to lack of tolerant seeds.

The goal of the current National Agricultural Extension Program is to attain 'national food-self-sufficiency'. The Regional Extension goal where this project had been initiated and implemented was also on the same line. This was noted at the planning stage of the project. Because of the recognition of the potential contribution of the project to the attainment of this goal in the project areas, the extension institutions have started to take actions that can multiply the impacts and sustain the benefits gained from the project. The experience of farmers together with the initiation of extension personnel confirm the fact that the project implemented was in consistence with farmers' priority needs and the current policy issue.

12. CONCLUSION AND RECOMMENDATIONS

Seed is a very fundamental input in crop production. Indeed, it can hardly be possible to be food secured with out quality seed. Recurrent drought of the recent years devastated large tracts of Ethiopia and resulted in food shortage. In view of the recurring disasters, as well as declining soil fertility and the rapid population growth that place increasing pressure on the local seed sources, there is a need to formulate strategies to secure seed supply for sustainable production and increased productivity of smallholder farmers.

Although informal seed production is an age-old practice in farming, it is only recently that it has begun to receive the attention of policy makers, donors and professionals. But still, it deserves more attention to institutionalize the smallholder seed production program on various horticultural crops.

In Ethiopia over 90 percent of seed supply is through local seed sources. This was because of the low capacity of the Ethiopian Seed Enterprise *vis-a-vis*, the high demand. Through this project it was realized that potato farmers can produce their own improved seed tubers and obtain better quality seeds through a planned process of selection and use of improved storage system. Therefore, there is a need to institutionalize the local seed system by creating favorable policy environment, building technical and management skills of farmers, and field supervisions.

With the implementation of this project it has become possible to stimulate the local extension personnel to recognize the importance of local seed system in the context of potato production as a model to other crops and possibly to replicate to other potential areas. On-farm participatory seed multiplication and demonstration results showed that the improved variety had outsmarted the local varieties with respect to reaction to the severe potato diseases, late blight and bacterial wilt, moisture stress tolerance, storability of tuber seeds, yield potential and market demand for food and seed.

The knowledge and skills of farmers about the improved varieties, agronomic packages, storage mechanisms and disease and pest control strategies have been increased through different promotion efforts via this project. This stimulated farmers to adopt the technology. The vigorous potato seed technology dissemination and adoption efforts under taken by the project resulted in increased seed demand that is beyond the capacity of the project to supply. By the implementation of this project the information was highly diffused to none project zones such as West Wollega and West Shewa. As a result, particularly the Agricultural and Rural Development Desk of West Wollega Zone availed requests to these seeds. This initiated the potato farmers to produce seeds for sale. These farmers are therefore organized into potato farmers groups (PFGs).

For sustainability of quality seed and improved potato production the following suggestions were sensibly recommended.

1. The technical and management capacities of the extension staff should be built through training so that they can effectively provide the required support to farmers;
2. Farmer-to-farmer information exchange and seed dissemination should be encouraged;
3. There should be early involvement/participation of farmers in technology evaluation so that their knowledge and experiences are considered and a wide range of options could be included in the technology package to be formulated;
4. Collaboration between the complementary elements of improved potato technology transfer has been playing a very significant role in the projects drive to the successes achieved so far. This non-bureaucratic and informal partnership aimed at reaching the technology to many farmers should be further strengthened;
5. Strong and sustainable linkage should be established between the potato producers and marketing sectors through organizing farmers into cooperatives and linking them to the marketing sectors.
6. Written materials such as leaflets and manuals that can explain in detail all field operations and DLS construction activities should be produced and provided to literate farmers and extension workers;

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