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Best Fit Practice Manual for Potato Production and Utilization

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Applicable for mid-altitude areas including South Achefer, Burie and Jabitehenan Districts of North-western Ethiopia

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Capacity building for scaling up
of evidence-based best practices
in agricultural production in Ethiopia

The CASCAPE project is designed to assist the activities deployed under the Agricultural Growth Programme (AGP) by further strengthening the capacity of AGP stakeholders in identifying, documenting and disseminating best practices in agricultural production. CASCAPE is jointly executed by Ethiopian researchers from Jimma University, Haramaya University, Bahir Dar University, Hawassa University, Mekelle University, Addis Ababa University and Dutch researchers from Wageningen University and Research Centre. In each site researchers from the universities and from the RARIs from different disciplines work on the CASCAPE project. The CASCAPE project is financed by the Dutch Ministry of Foreign Affairs through the Embassy of the Kingdom of The Netherlands.

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Acronyms/Abbreviations

ACSI	Amhara Credit and Saving Institute
AGP	Agricultural Growth Program
BoA	Bureau of Agriculture
CASCAPE	Capacity building for scaling up of evidence-based best practices in agricultural production in Ethiopia
DAs	Development Agents
DAP	Diammonium Phosphate
DLS	Diffused Light Store
DoA	District office of Agriculture
FAO	Food and Agricultural Organization
FRG	Farmers Research Group
FTC	Farmer Training Centre
kg ha^{-1}	Kilo gram per hectare
NGOs	Non-Governmental Organizations
MoARD	Ministry of Agriculture and Rural Development
MonQI	Monitoring for Quality Improvement
PA	Peasant Association
PRA	Participatory Rural Appraisal
PTM	Potato Tuber Moth
TOT	Training of Trainers
t ha^{-1}	ton per hectare
ZOA	Zone Office of Agriculture

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1.Introduction

Crop production in Ethiopia and Amhara Region is mainly dominated by cereal and other crops. Despite the significant potential contributions of horticultural crops, particularly of root and tuber crops, for food security, income generation, and resource base conservation, they have not yet been fully exploited and utilized (Gebremedhin *et al*., 2008).

Potato is an important food security and a hunger reliever crop in Amhara region and in several other parts of the country by virtue of its ability to mature earlier than most other crops at time of critical food need. In recent years, the production of this crop is expanding rapidly owing to the presence of improved technologies and expansion of irrigation culture.

South Achefer, Jabitehenan and Burie Districts are characterized by different agro ecologies, soil types, high population pressure; cereal based farming system, accessibility to infrastructures and market which is a good opportunity to expand potato technologies. However, due to lack of potato technology innovation, farmers in these areas still use local potato varieties that are susceptible to disease and have low yield potentials. Moreover farmers are following poor agronomic and postharvest practices.

Nowadays many improved potato varieties have been released by research centers and universities for production. These improved potato varieties together with improved management proved to give three to four fold yield advantage as compared to local varieties together with traditional production and management practices. Therefore, introduction and testing of improved potato technologies to specific areas involving farmers' participation will help identify best fit technologies to the existing production system that can ensure sustainable food security.

Before CASCAPE project intervention, potato production technology demonstration was very limited in the project intervene districts. Accordingly, participatory evaluation and demonstration of improved varieties were undertaken in 2011 cropping season at Abchkili Kebele of South Achefer and Woynma Kebele of Burie District. Results of the participatory evaluation activities at both sites of the two districts identified improved potato variety *Belete* as the best adaptable and preferred variety by farmers for its yield, early maturity, disease tolerance (late blight) and taste.

Similarly, results of the demonstration trials indicated *Belete's* superiority over other varieties in South Achefer and Burie Districts. This improved variety with improved management practices gave a tuber yield of 37 ton ha^{-1}. In contrast the local variety with improved management practices produced 13 ton ha^{-1} indicating a 24 ton ha^{-1} tuber yield increase over the local variety. Moreover, comparing to the regional average productivity (8.8 ton ha^{-1}) in the same cropping season (CSA, 2010/2011), in which most of the farmers have been used local variety and traditional management practices, the tuber yield gain improved by 320% (from 8.8 ton to 37 ton ha-1). Subsequently, an on farm seed multiplication of *Belete* variety was conducted in 2012 cropping season on selected farmers' fields with the main objective of distributing its seed tubers for wider community in the target villages and outsiders.

In the third year a scaling out activity is carried on 68 farmers' field of South Achefer, Burie and Jabitehenan Districts. Besides, optimum spacing was validated for seed and ware potato. Accordingly, 60 cm inter row spacing for both while intra row spacing of 20 cm and 30 was found optimal for seed and ware potato, respectively. In 2014 scaling up of *Belete* improved variety was implemented. This best fit practice manual is therefore written for the wider utility of the proven best practices.

The process of identification of these best practices involved execution of an integrated technology validation in South Achefer and Burie Districts by CASCAPE. The innovations included participatory evaluation and demonstration of improved potato varieties with their production packages that included pest management practices, on farm healthy potato seed multiplication, seed storage and demonstration of different potato dishes.

This manual describes the tested and validated innovation and best practices proved for their appropriateness by CASCAPE in Amhara Region. These practices are proven sufficiently to be handed over and scaled out to many farmers. It is written for extension workers and other development actors.

2. Testing of potato production technologies

Participatory evaluation and demonstration of six improved potato varieties and the local variety was conducted on six farmers' field in South Achefer and Burie Districts (Table 1). *Belete* was selected jointly by researchers and farmers based on its yield, disease tolerance, maturity and cooking quality. Subsequently, on-farm seed multiplication and scaling up activity has been carried out on the second and third year including Jabitehenan District. Practical training on improved potato production practice was given to development agents and farmers.

The selected variety *Belete was* planted at a spacing of 60cm x 30cm between rows and plants, respectively. DAP fertilizer was applied at the rate of 150 kg ha^{-1} and urea 117 kg ha^{-1}. All DAP was applied at planting, while urea one third at planting, one third at two weeks after emergence and the remaining one third at the initiation flowering. Depending on the infestation level, one to two times spray of fungicide (Ridomil Gold) against late blight was applied at the rate of 3kg ha^{-1} as soon as late blight disease symptom appeared. Field days were organized at flowering and at harvesting stages. Additional trainings on postharvest management, seed store construction and preparation of different foods from potato has been delivered. Some model farmers have also constructed food and seed potato store through the technical support of CASCAPE.

Table 1: Altitude, mean annual rainfall and temperature of the study districts

Attributes	Districts		
	South Achefer	Burie	Jabitehenan
Altitude(m)	1500-2500	700- 2300	1500- 2300
Rainfall (mm)	1450- 1594	900 - 1400	1250
Temperature (^{o}C)	15 - 23	17- 25	14 - 32

Source: Woreda Office of Agriculture

3. Best fit potato production practices

Best fit practices of potato production are described based on the recommendation domains of improved varieties, agronomic and postharvest management technologies. Each technology for the whole value chain must be done correctly in the intervention areas. This will ensure technologies to bring yield advantage over the existing production practices.

3.1 Development pathways

The promotion of best practices should be designed in the context of the broader development pathway for a selected location and the factors that shape the nature of particular development pathways. What are the comparative advantages for a specific geographic area and its household groups (target groups) and what best practices help develop such opportunities? What are the factors influencing the spread or inhibition of uptake of the best practices in each path? Farmers adopt best practices that help them exploit the comparative advantages provided by the development path and therefore transform their livelihoods. For example, opportunities for development of high value perishable commodities, such as horticultural crops or dairy, are likely to be greatest in areas with relatively high market access and agricultural potential (Pender et al, 2001). Scaling up/out of best practices in horticulture or dairy may be targeted to such areas.

3.1.1 Possible development pathways for potato in South Achefer, Burie and Jabitehnan

Potato technology demonstration and promotion was carried out at South Achefer, Burie and Jabitehenan Districts for the last four consecutive years. Based on data collected from the base line survey and current observation, the innovation development pathway analysis result has been summarised with three main factors namely, agricultural potential, population pressure and market access (Table 2).

Table 2: Development pathway analysis for scaling up of improved potato technologies

Agricultural potential	Market and infrastructure access	Population pressure
• Suitable agro-ecologies (altitude, temperature, rain fall)	• Potential farm gate, local and regional markets	• High population density (land shortage)
• Availability of irrigation	• Access to all weather roads and availability of transport facilities like cart	• Availability of labor for intensive potato culture
• Availability of well drained and suitable soils	• Accessibility of credit for input supply	• Culture of potato consumption and production

As indicated in Table 2, the development pathway analysis of the innovation revealed that the agricultural potential of the intervention areas are characterized by high rain fall, availability of irrigation and well drained and fertile soils. The presence of good road networks in these areas provided opportunities to have access to high local and regional market. The development pathways analysis showed that areas with similar agro-potential, market, and infrastructure should be considered in scaling up of improved potato production. Therefore, in these areas and similar agro-ecologies, the innovation would contribute to achieve sustainable production, productivity and food security in the region and in the country.

3.2. Drivers for adoption

Drivers for adoption are those factors which facilitate or inhibit the rates of adoption of new agricultural technologies. In 2013 and 2014 analysis of drivers for adoption was conducted in Dera, South Achefer, Burie and Jabitehenan Districts. The potato technologies included in the adoption were improved variety, fertilizer use, pesticide application and potato storage structures. The result of the Tobit model measures the average intake level of the above technology groups. According to the result, district difference, sex of head of the household, total land size and membership to cooperatives have significant effect on the level of potato technology adoption.

The levels of potato technologies adoption decreased from Dera to Burie, South Achefer and Jabitehenan Districts, respectively. The reason is most farmers in Dera district have good experience of potato technologies through Tana Beles Project and Adet Agriculture Research Centre and they are eager to accept any technology related to potato. Tana Beles Project, which works in Tata Watershed, has worked in *Shime kebele* of Dera District for more than six years and introduced improved potato varieties such as *Jalene*, *Gudenie*, *Belete* and

Guassa for the farmers. Sex of head of the household also affected positively the levels of potato technologies adoption. That means male headed households adopt more than female headed households. Total land size affects significantly and positively the adoption levels of potato technologies and adoption increases as cultivable land holding size increases. Similarly, the descriptive analysis result indicated that unavailability of quality seed and fungicide in nearby areas and lack of awareness were the major inhibiting factors that limits the wide scale adoption of potato technologies.

3.3. Recommendation domains for potato best fit practices

Recommendation domains are defined as a group of farmers whose circumstances are similar enough that the same recommendation can be given. In other words, places and sets of conditions in which a particular target technology is considered feasible and therefore good to promote. The specific conditions for this practice are presented in Table 3.

Table 3: Recommendation domains for potato technology scaling up

Identifier	**Specific Identifier**	**Descriptions**
Agro-ecology	**Highland to midland**	Altitude ranging from 1600-2800 m asl
	High rainfall	750-1000mm per annum
Resource endowment	**Purchasing power or credit access**	About Birr 20,000/hectare is required for the purchase of improved seed only with cost when other inputs increased
	Transportation facility such as vehicles, donkey or any other (own or pay)	Potato is bulky to transport
	Labour availability	Labour demand for the whole production process
Location proximity	**Input suppliers (*improved seed ,chemicals and fertilizers*)**	Two hours walking distance
	Market for potato	
	Local market	Within 10 km distance
	Sufficient numbers of wholesalers and retailers	Within 50 km distance from producer
	Potato cooperatives	Seed and ware potato supply
Cultural	**Consumption pattern of the community**	Own food consumption(Boiled and stew)

Note: Identifiers in bold/italics are deemed more important

CASCAPE Project intervention districts are within the recommendation domain having mid to highlands and a reliable input supplier organizations within an average of one hour drive. There are markets for potato within a reasonable distance, local processors in not more than 50 km and traders within 10 kms. Farmers have access to capital or credit to purchase improved seed and other inputs and transportation means either by their own or by payment. Generally, recommendation domains are described in terms of suitable agro ecologies, cropping compatibility, resource endowment, proximity, extension service, credit and market access and culture of community for potato innovations. Therefore, any potato innovations should target these recommendation domain indicators.

3.3.1 Suitable agro-ecology

Belete potato variety was released in 2009 by Holeta Agricultural Research Centre and registered by Ministry of Agriculture (MoARD, 2009). It can be grown in areas having an altitude of 1600-2800 m. a. s. l. and annual rainfall of 750-1000 mm. Well drained and fertile soil types are good for *Belete*. High tuber yields were obtained in mid highland areas like South Achefer, Jabitehenane and Burie Districts.

3.3.2 Compatibility to the cropping system

Improved potato variety *Belete* is tolerant to late blight and has erect growth habit that enables it to be intercropped with maize and faba bean in rainy season production. Furthermore, its maturity period (90-110 days) enables *Belete* to be a suitable candidate for double cropping especially where irrigation production is a common practice.

3.3.3 Resource endowment

Potato seed rates per hectare are very high (2.0 - 2.2 ton ha^{-1}). Given the high costs of seeds per unit area and high seed rate, a farmer requires access to capital or credit to afford the relatively high cost per unit area of potato seed. With regard to labour, it requires much labour for row planting, weeding, hilling, harvesting and transportation than other crops. However, it can be handled by family labour, as small holder farmers usually plant limited area of their farm land for potato crop. Potato gives high yield per unit area than any other crop. Hence, a farmer having relatively limited land size can adopt potato.

3.3.4 Location proximity

Proximity to input suppliers: Timely supply of chemical fertilizers, fungicides and certified seed for farmers, input suppliers including cooperatives, private traders and seed enterprises should be present nearby farmers' village.

Extension services: Kebele DAs should be nearby farmers' village for effective and efficient supervision and management of potato production innovation. Moreover, higher level of agricultural experts and other relevant stakeholders should support farmers with frequent supervisions. Particular attention should be given for farmers to construct and store seed potato using improved DLS that can help to extend shelf life and to maintain quality of seed.

Credit service: Since cost of input such as chemical fertilizers, insecticides and seed of improved potato production is high, the presence of credit service at kebele level is very important.

Market access: Market is very crucial for the produced product since potato is among those crops that are easily perishable and difficult to transport for long distance compared to cereal crops. Therefore, availability of local markets nearby farmers' village minimizes the postharvest lose.

3.3.5 Consumption and production culture

Communities knew potato as one of the staple food crops. Therefore, culturally communities produce and consume potato in different forms such as boiled, fried, stewed, salad, etc.

3.4 Improved potato varieties

Selection of appropriate variety to be planted is one of the most important management decisions made by the grower. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability. Several improved potato varieties were released for different agro-ecologies in the country. Among these CASCAPE has selected six improved varieties and evaluated in its intervention areas (Table 4). Host and participant farmers in the three CASCAPE project districts have selected improved potato variety *Belete* for its superior yield, disease and insect tolerance, maturity, cooking quality and adaptability.

Table 4: Tested improved potato varieties against the local check with their recommended altitude and rainfall

Variety	Altitude(meter above sea level)	Rainfall(mm)
Belete	1600-2800	750-1000
Gudenie	1600-2800	750-1000
Jalene	1600-2800	750-1000
Guassa	1600-2800	750-1000
Gorebella	2000-3100	800-925
Zengena	2200-3200	1000-1500
Local	--	--

3.5 Land preparation

The frequency of potato field ploughing depends on the type of the field, precursor crop and soil type. For instance, fields with maize precursor crop can be easily prepared with few number of ploughing or cultivation than tef precursor fields that needs more number of ploughing to make the soil suitable for potato production. According to CASCAPE project host farmers experience, ploughing potato field on average seven times is a common practice.

Farmers usually plough their land eight times if the precursor crop is tef while, for maize and finger millet as precursor crop, they usually plow their land six to seven times. Generally, for high potato yield the land should be prepared well so that it should not hinder root growth and expansion in one hand and ensure the minimization of soil borne diseases, insects and weeds.

3.6 Planting time

Even though planting date is determined by moisture availability, rain fed potato is commonly planted from late May to third week of June. During the rainy season, potato is affected by the leaf disease late blight of potato. Therefore growing tolerant varieties like *Belete* with one to two times Ridomil Gold fungicide spray at the rate of 3 kg ha^{-1} is recommended. Under irrigation production system potato can be planted at any time provided there is enough moisture and no frost.

3.7 Seed rate and planting methods

During planting, potato seed tubers are manually placed 30 cm apart in the rows and at a row to row spacing of 60 cm apart. Soon after planting, a ridge is done to cover the potato tubers by throwing the soil from both the sides. Use of medium sized and well sprouted seed tubers that are not diseased and infected is vital. A hectare of potato field planted with medium sized seed tuber requires a seed rate of 20 quintal.

According to CASCAPE project demonstration results, inter row spacing of 60 cm and intra row spacing of 30 cm was found to be optimum for ware potato production which resulted in 225 g tuber weight, 5.5 cm tuber diameter, 37 t/ha tuber productivity and 173,000 tuber number/ha. However, for seed potato production inter row spacing of 60 cm and intra row spacing of 20 cm resulted in optimum tuber size and greater number of tubers. Which resulted in 144 g tuber weight, 4.8 cm tuber diameter, 35 t/ha tuber productivity and 234,000 tuber number/ha, indicating 61, 000 additional tubers for seed purpose. Thus, for both ware and seed potato inter row spacing should be 60 cm, while intra row spacing for ware and seed potato should be 30 cm and 20 cm, respectively.

3.8 Fertilizer application and ridging

Potato is high nutrient demanding crop. Therefore, 150 kg ha^{-1} DAP and 117 kg ha^{-1} urea should be applied as recommended by researchers and also verified by CASCAPE project. The whole DAP should be applied during planting time while, urea should be applied three times in which one third at the time of planting, the other one third at two weeks after emergence and the remaining one third at the initiation of flowering. Fertilizer must be placed slightly below the seed tubers to avoid contact between the seed and fertilizer.

Earthing (ridging): This is an important agronomic practice carried during potato production. The first earthing up should be done when the potato plant reaches 10-15cm high so that the lower part will be covered with loose soil in which the tubers can develop. This first ridging matches with the first weed control. The second ridging should be done after potato tubers have started to break the soil. The second earthing up will help to avoid greening of tubers, suppress weed and control tuber moth. Earthing up in potato involves drawing mounds of soil up around the plant to prevent new tubers from growing exposed to light and turning green and poisonous. Also many times more potatoes will form from the buried stems. It also helps to prevent tubers from tuber moth and blight infection. Potatoes are a shallow rooted crop; hence care is needed to avoid excessive cultivation. After applying the top dressing, potatoes should be ridged up to 20-30 cm high. Earthing up should be done and completed before the crop canopy is closed.

3.9 Crop protection

3.9.1 Weed management

Weeds compete with the potato crop for light, nutrients and water. If weeds are not controlled, crop yields can be severely reduced. The presence of weeds in a potato field can also increase disease levels on potato serving as host for aphids and other insect pests. The planting time of potatoes, the timing and frequency of cultivation, soil type, weather conditions and crops types grown in rotation with potatoes can adversely affect weed dynamics. Repeated ploughing ensures effective weeds control apart from preparation of fine seedbed for good plant growth and development. In potato, weeds are controlled while hilling is being done.

Farmers in CASCAPE project districts have practiced two times of hilling/earthing up and two to three times of weeding according to the type of field and precursor crop to control weeds in potato fields.

3.9.2 Insect pest management

Insect pests are still the major production limiting factors of potato in the country. The most important insect pests of potato in the project area are aphids and potato tuber moth.

Potato aphids (Myzus persicae)

Aphids infest the leaves, flowers, stems and sprouting tubers. Aphids usually cause physical damage to the crop serving especially as efficient vectors of viral diseases. Aphids suck the hosts' sap, weaken the plant and subsequently transmits or spreads viral diseases. Aphids infect a crop with viruses such as potato leaf roll virus and mosaic virus. Virus-infected seed tubers produce poor stands and few tubers. These insects are low in the highland so seed potatoes should be produced in the high elevation areas.

Potato tuber moth (Phthorimae operculella)

Potato tuber moth affects foliage and tubers in the fields and in storage also it affects tubers. Young larvae mine the leaves. Leaves produce silver blotches. Then it bores in to the tubers. From field it is carried to storage. Potato tuber moth survives in the field throughout the year and 10 -12 generations are observed in one year. It possesses complete metamorphosis (Figure 1 and 2).

Figure1: immature stages of moth(larva and pupa)

Figure2: Adult potato tuber moth

Major damage is caused by caterpillars burrowing in the tubers. Infestations start in the field. The pest is transferred with the harvested tubers to the potato store, where it can reproduce and infest other tubers. This may lead to total destruction of the stored crop (Figure 3).

Figure 3: Potato tuber moth larvae and pupae on potato tuber

Management options to tackle potato tuber moth

- Proper hilling-up to cover the tubers with soil at the field
- Spraying foliage with an insecticide at 7-14 day intervals ensuring that all parts of the plants are wetted.
- Only healthy potatoes should be stored for seed.
- The surface, walls and ceiling of stores should be dusted using recommended insecticides before storage.
- Other control measures include; on time harvest, deep tillage during dry season, destruction of all harvest residues, sorting and discarding infested tubers before storage.
- Spraying potato at storage with appropriate insecticides, like Diazinon and malathion

Experiences from CASCAPE project potato demonstration and promotion intervention revealed that, spraying of 100 ml of Diazinon mixing in 20 litre of water every one to two weeks starting from January to planting (May or June) was found to be effective in controlling potato tuber moth in small scale diffused light store. According to the intensity and occurrence of the insect (potato tuber moth) farmers sprayed every two week to reduce potato tuber moth.

3.9.3 Disease management

Potato is prone to many diseases caused either by bacteria, fungi, and viruses. Late blight is generally the most important disease wherever potatoes are grown in the country. The local varieties do not cope with the disease pressure in the main rainy season and often are wiped out particularly in the highlands. Viruses and bacteria wilt are also very important diseases affecting potato production.

Tuber and plant degeneration due to virus is becoming very important throughout the potato growing areas. Likewise bacterial wilt is nowadays advancing at an alarming rate owing to the unchecked/unregulated seed circulation in the country from the very well known centres of this disease. The prevalence of these diseases is high in the low-to-mid attitude areas. The pathogens attack foliage, root systems and tubers, which makes them important throughout the crop cycle. Many factors contribute to the survival, spread and damage of the pathogens. The major reasons include use of susceptible local varieties, poor management practices in field and storage, conducive environmental conditions for the diseases to build and lack of internal seed certification system.

Potato late blight (Phytophtora infestans)

Late blight is one of the main diseases affecting potato plants and damages leaves, stems and tubers. This disease can wipe out a potato crop in a relatively short period of time. The cause of late blight of potato is the fungus *Phytophtora infestans*.

Late blight spreads fast in cloudy warm weather. First small patches appear on lower leaves. Whitish fungal growth is also seen on under surface of leaves. Disease starts from lower leaves and finally covers the whole plant. Late blight is a plant disease that mainly attacks potatoes and tomatoes, although it can sometimes be found on other crops, weeds and ornamentals in the same botanical family (Solanaceae). The disease can cause the entire potato crops to be rotted in the field or in storage. This pathogen (*Phytophtora infestans*) is well known for its ability to produce millions of spores from infected plants under the wet weather conditions that favour the disease.

On potato, early symptoms of late blight first appear on leaves as small, circular or irregularly shaped, dark necrotic lesions (Figure 4A). On petioles and stems, symptoms appear as dark, water-soaked lesions (Figure 4B). Lesions expand with time as the pathogen colonizes the internal plant tissues. On mature lesions, the pathogen produces glistening white spore-bearing structures called sporangia on the underside of the leaves or surface of stems (Figure 4C). As the disease progresses, the entire infected tissue will decay (Figure 4D). Tubers become infected at any stage of their development and they start to turn brown and rot slowly from the outside (Figure 4E & 4F).

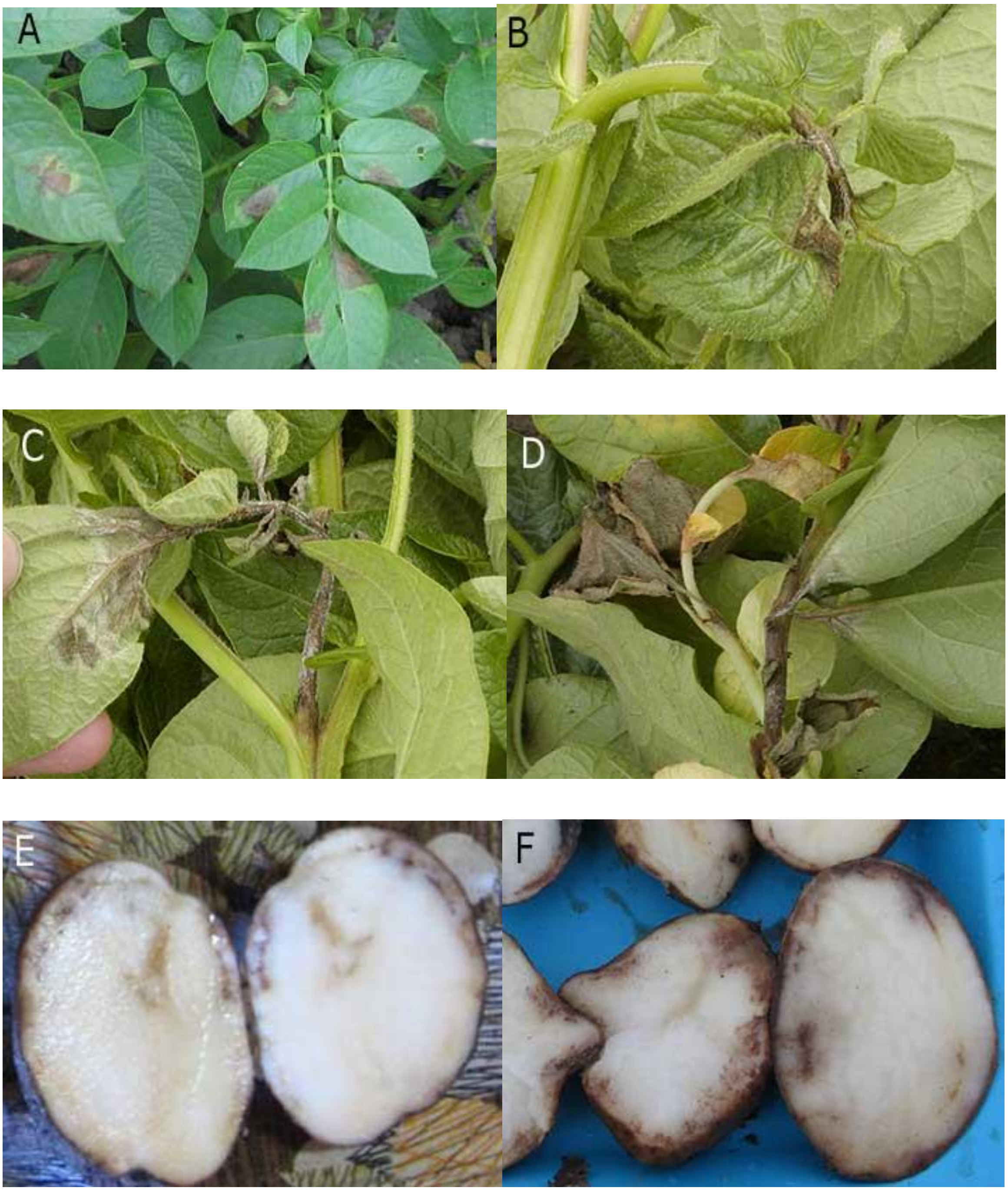

Figure 4: Symptoms of late blight on potato. Early symptoms on young leaves (A) and stems (B). Appearance of white sporangia on the underside of infected leaf and on stem (C). Blight and death of infected tissues (D). Browning and rotting of tubers (E & F).

Management options

- Use of resistant varieties (moderately resistant varieties, like ‘’Belete improved variety
- Protection of potato plants with fungicides, for the control of late blights Ridomil Gold M.Z 64 % W.P at a rate of 3 kg/ha mixing with 400-600 liter of water from 1 to 3 times repetitively.
- Avoid infected tubers during seed storage,
- Avoid replanting fields which had severe late blight the previous year

CASCAPE project experience: Followed integrated pest management approach as follows;

- Use of tolerant Variety (Belete variety)
- Crop rotation and use of disease free planting material
- Application of Redomil fungicide 1-2 times at a rate of 3 kg ha^{-1} with around 360 litre of water beginning from the onset of disease. This translates into approximately 90 g of Redomil (equivalent to around 1 coffee cup) to be mixed into 15 liter of water. Assuming a knapsack sprayer capacity of 15 liter, around 24 knapsack sprayer is sufficient to cover one hectare of potato field.

Bacterial wilt of potato

This disease is caused by the bacterium *Ralstonia solanacearum*. It is one of the most serious diseases affecting potato plants. It develops in high temperatures areas more aggressively than cool areas. The primary sources of bacterial wilt infection are infected seed, soil and irrigation water or infected soil carried with the soles of feet or boots or with farming implements. Actual infections of the roots are facilitated when they are damaged by nematodes or tillage. Bacterial wilt causes wilting to begin on the tips of leaves or where the stems of a plant branch out. Later the whole plant wilts, turns brown and finally dies (Figure 5) and also damage tubers (Figure 6). Poor storage management systems and seed tuber sorting can also cause tubers to become easily infected by bacterial wilt during storage and handling.

Management Options to tackle bacterial wilt

- Use of healthy seed;
- Rotation with crops that do not host bacterial wilt like maize, teff, wheat, barely excluding Solanaceae family crops like pepper and tomato;
- Sanitation, roughing and burring of infected plants to control the disease;

CASCAPE has applied integrated bacterial wilt management through use of healthy seed, crop rotation and sanitation, roughing and burring of infected plants to control the disease.

Figure 5: Bacterial wilt damage at vegetative part

Figure 6: Bacterial wilt damage at tuber part

3.10 Harvesting, sorting, grading and post-harvest handling

Determining the right time to harvest is essential for achieving high quality produce. Ware potato fields should be harvested when tubers are mature, that is when the foliage has dried up and the tuber's skin is firm and cannot be removed when lightly rubbed with fingers. In other words, yellowing of the potato plant's leaves and easy separation of tubers from stolons indicate that the potato crop has reached maturity and can be harvested for immediate consumption. If the potatoes are to be stored rather than consumed immediately, they should be left in the soil for to allow their skin to harden and hard skin also help seed potatoes to resist storage diseases. Consequently, seed potato fields should be harvested after hardening by cutting the foliage of the seed and letting to cure for 10 to 15 days. After the skin of tubers has become stronger it is then possible to dig out tubers using appropriate tools or manually not to damage tubers during harvesting. Tubers should be cleaned and free from soil other inert materials immediately after harvesting (Figure 7).

Then afterwards it will be important to separate the tubers for seed purpose and other purposes (Figure 8). It should be kept safely in appropriate areas not exposed to insect pests attack. But tubers isolated for seed purpose should be kept in diffused light store. But, the tubers should be stored temporarily in a shaded, dry, well- ventilated place for seven to ten days to allow time for the skin to become well suberized, and for any cuts or bruises from digging to heal.

Figure 7: Harvesting and cleaning of potato tubers

Figure 8: Sorting of potato tuber for seed, medium size (left) and for not seed purpose, large size, damaged, and small size tubers(middle and right).

Seed potato storage (Diffused light store)

In Ethiopia, where cold storage is unavailable or too costly, smallholder growers store their potato seeds on the floor, granary or left on farm (unharvested) until next planting season. The efficiency of their simple home storage facilities could be dramatically improved with use of diffused light technology. Diffused light stores (DLS) are most suitable where temperatures are moderate (no frost or extreme high temperatures) and seed has to be stored for more than four months. By using DLS, farmers are able to store their own seed stocks, instead of buying seeds of unknown health state from distant suppliers. However, the storage capacity of DLS is limited since all tubers must be exposed to the diffused light. These stores are suitable generally for small seed units and not for large scale seed production schemes. Seed potatoes stored in diffused light give short and strong sprouts (Figure 10) than seed that has been stored for relatively long periods in the dark at higher temperatures (Figure 11).

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Experiences from CASCAPE project had shown the possibility to having small scale DLS at household level (12-14 corrugated iron sheet) and maintained quality potato seed by using this technology for more than seven months. But, this technology should be integrated with insect management especially potato tuber moth through use of pure seed, cleaning the DLS before storage and after storage, use of chemicals (Diazinon), keeping the DLS cool and dry and finally allowing each potato tuber receive diffused light in the store. Generally, better quality seed tubers can be obtained with storage in DLS than in traditional dark storage, and as a result, productivity of potato can be enhanced through this postharvest management technology (Figure 9 and 10).

Seed constitutes a very important part of potato cultivation as it accounts for higher percent of the total cost and it is the main source of diseases. In addition, unavailability of good quality seed potatoes at the right time is another problem in potato cultivation. Diffused Light Storage (DLS) is an innovation proven by CASCAPE project to enable small holder farmer to maintain their potato seed at higher quality levels. It can also be easy adopted to the existing farming systems and farm house holds cultivating potato. The DLS method is based on the use of natural indirect light and good ventilation or air flow, instead of low temperature, to control excessive sprout growth and associated storage loss. There are two basic elements of the DLS principle: light and ventilation.

Light: It is the major element in DLS principle, should be indirect (no direct sunlight), light checks the excessive white, thin sprout growth. Instead, it induces short, stout, green sprouts. Insufficient light intensity is indicated by the development of long, white sprouts which promote quick shrinkage in the tubers. Shrinkage of the tuber means energy loss. A shriveled tuber is regarded as physiologically old and is not able to produce a good healthy plant. Therefore, potatoes must be arranged in the storage area so that each tuber receives sufficient indirect light.

Ventilation: Since the potato tuber is a living organism it requires sufficient air (especially oxygen) to respire. Respiration of the tubers produces heat inside the storage area. Heat speeds up the growth of sprouts which means the tuber is quickly using more energy, thus quickly becoming physiologically old. Good management of ventilation (air flow) helps to remove the heat generated by the respiration and to provide sufficient air for respiration. Thus, DLS should be constructed in such a wat that;

- Roof must be thatched, not made of tin as a tin roof heats the storage area
- IT shouldn't be sealed that means it should allow diffused light to inter to the DLS
- The longer sides should be situated in sun rise to sun set direction. This helps to protect the potato tuber affected/drying by direct sun light
- The height of the shelf should be 50 to 60 cm.
- If possible, it should be built under the shade
- Spread the tubers thinly on the bed (up to 3 potato). This helps each potato to expose to diffused light

Figure 9: Seed potato storage (DLS) in South Achefer District

Figure 10: quality tubers seed with short and strong sprouts kept under small scale diffused light storage

Figure 11: poor quality potato seed tuber with weak and long sprouts kept under dark storage

Ware potato store

In most parts of potato growing areas, potato is mainly grown under rain-fed production system. As a result excess production supply is evident during the main season leading to low crop price or letting farmers to getting not attractive market prices for their produce.

To avert such unattractive market price for their produce, demonstration and wider scale utilization of zero energy demanding and locally constructed affordable ware potato storage structure is crucial. Hence model ware potato store (Figure 12) is designed to help them avoid this problem. The store is called *Atbianesh*.

Figure 12: Ware Potato Storage (*Atbianesh*) Facility to Farmers

The potato warehouse was adapted from a store made in Kenya from curved bamboos plastered with clay and cement. The basic principle of the store lies on insulating heat coming from the atmosphere and preventing it not to enter to the potato.

This was done by building double walls and ceiling made from wood and mud. The inter wall space was stacked with dry grass that will prevent heat movement. The store has two windows one at the bottom of the stored in the north direction and the other at the top of the store in the south direction. The windows are closed in the day time to avoid warm air entry. No light is allowed to the store during the day time. During the night, the two windows will be opened to ventilate the tubers. Black curtain is also put on the windows to avoid light entry. The roof of the store is made in such a way that the water from the roof drains down in the east and west directions. This will reflect as much light as possible. Between the roof and the ceiling, there will be a space for air circulations (Figure 13a).

The store has layers that will carry the potato tubers. Between the layers, there is 50 cm space left (Figure 13b).

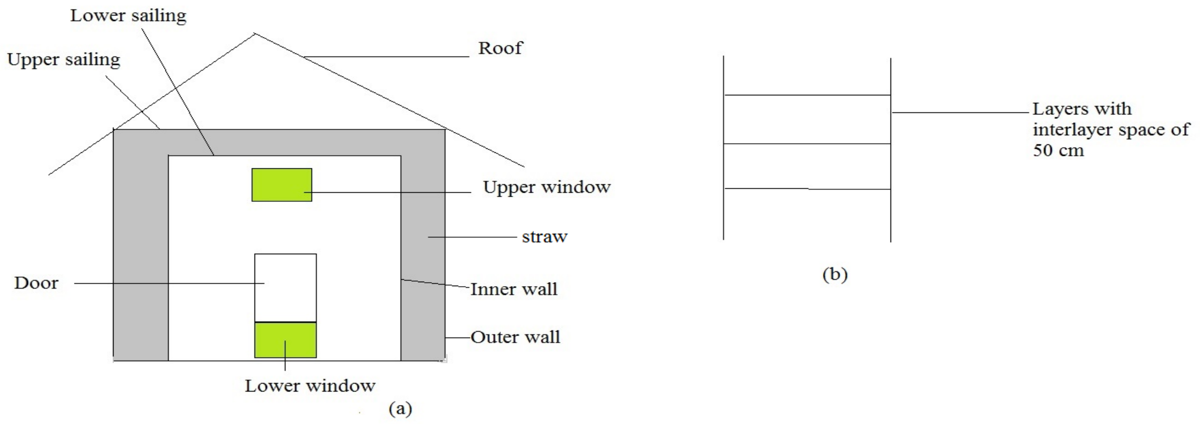

Figure 13: Potato store design (a) and storage layers (b)
Design: Yihenew G.Selassie (2013)

Using the above store, it is possible to store ware potato for over three months. This helps farmers store potato and reduce spoilage. Moreover, they can keep it until the price rises.

3.11 Productivity

CSACAPE demonstration result has indicated that 37 ton ha^{-1} has been produced from improved variety *Belete* as compared to 13 ton ha^{-1} from the local variety at South Achefer and Burie Districts (Table 5). The tuber yield advantage of *Belete* improved variety was found to be 185 % against the local check (with improved management practice) and 320 % as compared to the regional average productivity during the same production season, 2010/2011 cropping season (Table 5).

Table 5: Potato yield advantage (%) of varieties tested by CASCAPE

Varieties	Productivity, ton ha^{-1}	Advantage over the local variety(%)	Advantage over the regional average (%)
Guassa	34	161	286
Jalene	30	131	241
Belete	37	185	320
Gorebela	26	100	195
Zengena	23	77	161
Gudene	24	85	173
Local(variety with improved practice)	13	-	48

Regional average productivity 8.8 ton /ha (CSA, 2010/2011)

3.11 Farmers preferences

Farmers have been active participants starting from the initiation of the innovation. They evaluated the innovation at different levels and cropping seasons (Figure 14). Finally, they preferred *Belete* potato variety based on its superior yield, disease tolerance, maturity and test quality over other varieties.

Figure14: Farmers participation at different levels of potato technology demonstration and promotion activities

3.12 Sustainability assessment

Sustainability of a technology can be favored or constrained by many factors such as economic, social and environmental (profit, people and planet). Thus, it is important to examine the sustainability of a technology by setting indicator for the three parameter and do the analysis to look into the short term and long-term effects of the technology (Table 6 and Figure 15). Once relevant indicators are selected the spider graphs will help to do such type of systemic comparisons. The indicators were selected with the farmers and development agents for the systemic comparison of the benchmark, in this case the conventional potato production that employed the use of local variety with the improved potato technology that included improved variety, improved agronomic practice, seed store, optimal use of fungicide (Redomil) to control late blight and optimal use of insecticide (Diazinon) to suppress potato tuber moth.

Table 6: Summary of sustainability indicators for potato innovation

Sustainability parameters/indicators	Conventional production practice	Improved potato technology	Remarks
People			
Labour	±	-	higher yield that could reach up to 37 ton ha^{-1} has demanded the farmer additional labour to harvest and transport
People safety	±	-	The chemicals that are used to prevent potato moth has effect on people health or safety because working with chemicals has its negative effect
Profit			
Revenue	±	++	Yield has increased by three folds
Resource efficiency	±	++	At farm level, it is in favour of agricultural land use efficiency since it yielded three times as compared to the conventional
Input supply	±	--	Accessibility and affordability of inputs mainly potato plating material has limited its widespread
Market access	±	±	At present it is the local market that serve as the main market outlet
Planet (environment)			
Soil erosion	±	±	The new technology neither trigger nor reduce soil erosion
Soil nutrient	±	-	Soil nutrient depletion is evident with higher amount of harvested crop product or biomass unless it is compensated with external source.
Biodiversity	±	-	The pesticides that would be sprayed at farm level to control the potato blight could potentially affect other micro and macro non-target organisms. Besides, the new potato innovation could potentially erode the landrace.

Once the indicators are set and their relative magnitude is evaluated, then spider graph will simplify the comparison of indicator through visualization (Figure 15)

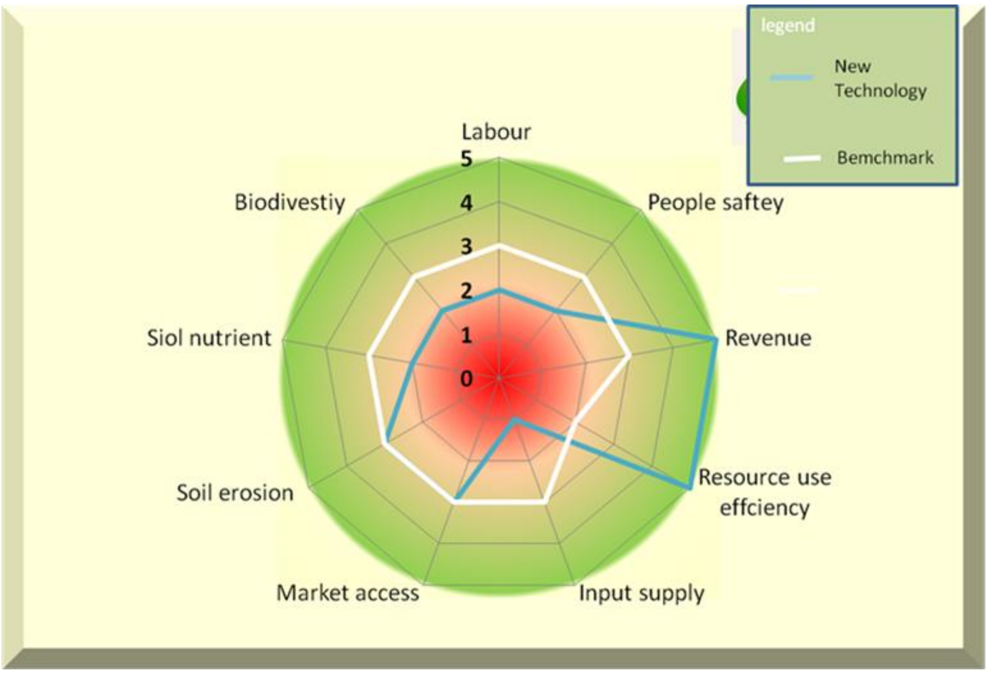

Figure 15: Spider diagram on potato sustainability assessment

The first selected sustainability indicator of the technology from the peoples' aspect was the workload it adds to the farmers because of the higher productivity of the new potato production technology that sometimes reached up to 37 ton ha^{-1}. Definitely, it adds huge workload to the farm enterprise particularly if they cultivate larger potato field. Despite its productivity, farmers didn't allot more land for potato because farmers in the project area rely on a number of crops (diversification) for their livelihoods. Besides, the crop rotation practice to control pest incidence also limited the size of potato fields. Thus, the maximum observed potato field was nearly half a hectare. The produce from this size of potato field could be considered as manageable by average family size in the community.

The second indictor selected from the people perspective was health or safety of people as the technology uses pesticide to control potato moth that are usually sprayed in area where people lived because the DLS are constructed near their home. That could have potential impact on the health or safety of people; however, farmers did not experience series illness because of Diazinon on spray potato store.

The higher revenue from the technology and its resource efficiency has created higher demand for the technology. Particularly the agricultural land use efficiency at farm level is very high because the new potato production technology has helped farmer to produce three times more than the local one.

The market accessibility and affordability of each elements of the package is the other aspect that will have impact on its sustainability. The late blight and moth pesticide are supplied by private supplier and farmers cooperatives that are found within reachable range with reasonable price. While the most constraining input for the sustainability of this technology is getting quality potato seed. So far the only seed source is farm-to-farm exchange. It is very expensive and non-affordable to all farmers. Besides, farmers capacity to produce large quantity of quality potato seed is very limited because it need high initial investment cost for big DLS that have larger storage capacity.

The conventional and the new technology both use the same local market. However, with the increasing number of farmers participating in the new high yielding potato variety the market access will be a challenge due to high supply. Connecting the producer to potential markets will be a priority for the sustainability of the technology.

Since the new technology didn't employ any agronomic conservation measure, it neither triggers nor reduces soil erosion compared with the conventional one. Thus, the two production methods would have the same effect with regard to soil erosion. Soil nutrient depletion seemed to be higher for the new potato innovation because higher K is taken through high product harvest. This was not the case with N because of its judicious application as per the recommendation.

As the new production technology encourage optimal use of pesticide to control potato late blight there would be slightly higher biodiversity loss at farm level since this place is the feeding area for bees. Besides, the new potato innovation could potentially erode the landrace. Thus, relatively higher value for biodiversity loss for the new technology compared to the conventional is shown on the spider graph (Figure 15).

Soil nutrient balance

The soil nutrient balance indicators (NPK balance) are also required to thoroughly examine the farm management of small-scale farmers (Table 7). MonQI toolbox was used to analyze the soil nutrient balance of the potato innovation with the benchmark (conventional ones). The MonQI toolbox calculates the nutrient balance by taking the difference between the amounts of nutrients flowing IN minus the amount flowing OUT.

Table 7: Entries for MonQI nutrient balance calculation

Easy to quantify flows	IN1	Mineral inputs	OUT1	Harvested products
	IN2	Organic inputs	OUT2	Harvested crop residues
Hard to quantify flows	IN3	Atmospheric deposition	OUT3	Leaching
	IN4	Biological N fixation	OUT4	Gaseous losses
			OUT5	Erosion

From table 8 and Figure 16, Nitrogen balance for the new potato innovation showed positive balance (13kg ha^{-1}) because of the judicious application of urea that has compensated the larger amount of nitrogen loss from erosion and harvest of large quantity of potato. Whereas, the N balance for the benchmark showed negative (-7kg ha^{-1}). It is mainly from less amount of urea application that couldn't compensate the larger amount of nitrogen loss from erosion and harvest.

Table 8: Nitrogen balance and flows for the two methods

Method	No	Balance	IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4	OUT5
benchmark	15	-7.3	38.2	23.2	2.6	2.1	9.9	0.0	19.2	5.0	39.4
Potato innovation	16	13.9	73.6	26.2	2.8	2.2	21.0	0.0	27.6	8.7	34.71.

No= Number of observations

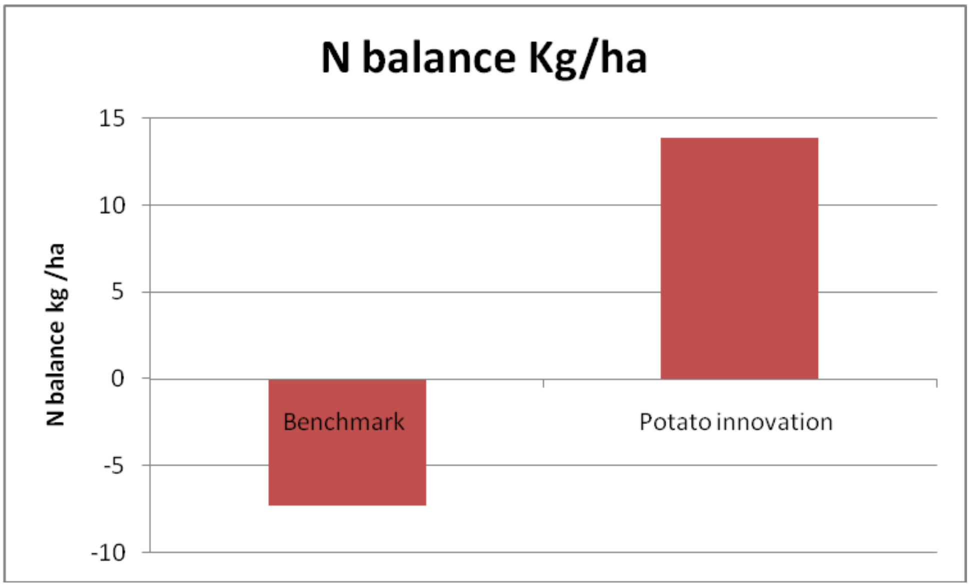

Figure 16: N Balance kg ha^{-1} of potato innovation versus benchmark

Table 9 and figures 17 showed, P the balance for the two practices showed similarity (28 kg ha^{-1}). This was because, farmers used recommended rate of DAP for the two practices and immobile nature of the elements.

Table 9: P balance and flows kg ha^{-1} for the two methods

Method	No	Balance	IN1	IN2	IN3	OUT1	OUT2	OUT5
Benchmark	15	28.0	28.0	2.8	0.4	2.0	0.0	0.25
Potato innovation	16	28.0	30.8	2.8	0.4	5.9	0.0	0.15

No= Number of observations

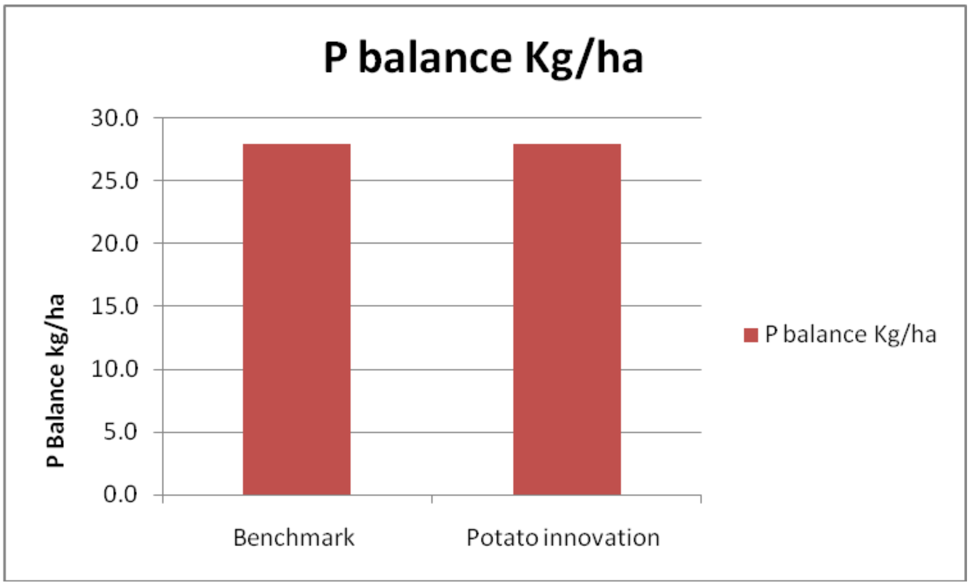

Figure 17: P Balance kg ha^{-1} of potato innovation versus benchmark

Table 10 and figure 18 showed, negative balances for potassium (K) because potato is k miner. Even more negative K (-30 kg ha^{-1}) is shown for the new technology because farmers didn't apply compost and/or farmyard manure which is the only source of K. Besides, the highest harvest product from the new potato innovation also contributed its part. Thus, balancing K either by organic or inorganic source of fertilizer is important. However, further verification need also be required.

Table 10: K balance and flows kg ha^{-1} for the two methods

Planting Methods	No	Balance	IN1	IN2	IN3	OUT1	OUT2	OUT3	OUT5
Benchmark	15	-10.1	0.0	7.0	1.7	15.3	0.0	0.12	3.3
Potato innovation	16	-30.4	0.0	6.0	1.8	31.4	0.0	0.8	6.8

No= Number of observations

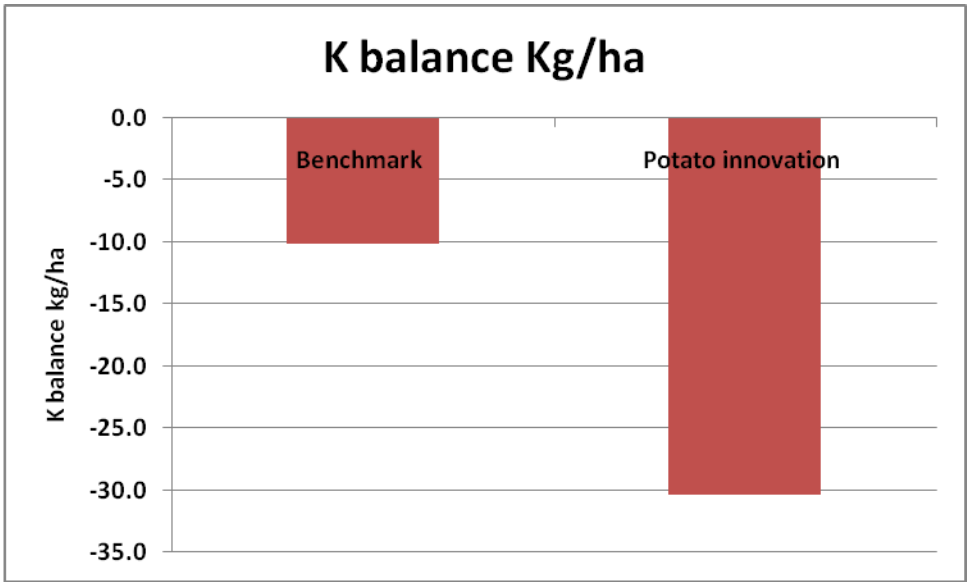

Figure 18: K Balance of potato innovation versus benchmark (conventional)

3.14 Contribution of the best fit practice to nutrition and gender aspects

Processing of perishable fruits and vegetables, post-harvest handling and proper utilization techniques are some of the important areas where CASCAPE is trying to address. As part of this work, training was conducted in different areas for different groups like women; jobless youths and small business entrepreneurs on tomato, potato and onion processing techniques.

Potatoes are rich in several micronutrients. Potato is also a good source of iron and zinc and its high vitamin C content promotes iron absorption. According to FAO (2008) potato is a good source of vitamins B1, B3 and B6 and minerals such as potassium, phosphorus and magnesium, and contains folate, pantothenic acid and riboflavin. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing and dietary fiber that benefits health (FAO, 2008).

Potato can be baked, boiled, roasted, mashed and fried. Potato can be consumed alone or as a side dish with other foods (Figure 19). However, most of the time potato is consumed in the form of boiled and stew. As a result, CASCAPE has demonstrated home level potato processing to produce potato crisp, chips, porridge and *Injera* for famers and youths.

General directions for home level potato processing

Choose potato variety with high dry matter content like *Belete*. Select healthy and firm potato tubers without soft spots, green spots or sprouts. Do not store in the refrigerator rather store in a well-ventilated, dark and cool area until the tubers are needed for cooking. To avoid discoloration, put the peeled potato in water.

Figure 19: Potato, tomato and onion food processing and recipe demonstrations at Bahir Dar University

Figure 20: Potato food recipe demonstrations at South Achefer

Potato chips preparation procedure

- Select potato tubers having oval shaped
- Wash and peel and then slice the tuber along the length in uniform size of 1cm by1cm
- Rinse with clean water and dry
- Finally, fry with oil until it develops golden yellowish color

Potato crisp preparation procedure

- Select potato tubers having round shaped
- Wash and peel and then slice in round shape with uniform size of 1.2 to 1.5 mm thickness sizes
- Rinse with clean water and dry
- Finally, fry with oil until it develops golden yellowish color

Mashed potato preparation procedure

- Select healthy potato, wash and peel it
- Mash the potato with a potato masher or hand-held mixer
- Gradually beat in the warm liquid until the potato is smooth, moist and light
- Season with salt and pepper

Potato porridge preparation procedure

- Select healthy potato tuber and wash and boil it
- Cool after boiling and then peel and mash it
- Boil the water and after adding table salt and mashed potato and then steer it
- Add three coffee cup mashed potato
- Add one and half coffee cup or water and 0.5 tea spoon salt for taste

Potato Injera preparation procedure

The main ingredients includes four coffee cup mashed potato, four coffee cup tef flour, one coffee cup yeast and pure water. Mix 50% of mashed potato with 50 % teff flour and then after one or two days, remove the upper part of dough and dilute it with warm water again and finally, bake it when the dough become raise up. One can use the same procedure for making bread also, except for the bread we have to use 50 % wheat flour, yeast and baking powder.

Production of improved variety *Belete* has increased labor during planting and fertilizer application especially for women. Moreover, it demands more time than the local variety during planting, caused by the differences in planting methods. The improved variety requires a specific planting method, where a ridge needs to be made on specific distances after fertilizer application and subsequent two three ridings are needed. However, the benefit from the new variety is also much higher. Both male and female farmers further stated that the new variety has better food taste, and gets cooked relatively faster than local variety. This has brought a shift in gender role to some male farmers that they are encouraged to cook and serve for the family when they come back from farm activities or in times when the mother is occupied with other tasks.

4. Suggested points for extension workers and other development actors

4.1 Identification and involvement of relevant stakeholders

Identifying and involving key stakeholders is the first task to share responsibility and optimize the effort of each stakeholder for the successful scaling up of improved potato technologies in a wider scale. The key stakeholders and their role are listed in Table 11.

Table 11: Main relevant stakeholders and their involvement, for improved potato production.

Identified stakeholders	Stakeholders' role
Model farmers	• Joint planning and execution of scaling up • Seed multiplication • Share their potato production, handling and utilization best experience to other farmers
Kebele office of agriculture	• Assist farmers in site selection • Provide training and technical backstopping to farmers • Facilitate credit service
Kebele Administration	• Mass mobilization • Facilitate inputs supply to farmers
District office of agriculture	• Participate in joint planning • Provide training and technical backstopping to farmers and DAs • Facilitate timely availability of input • Arranging market availability to farmers
District office of administration	• .Participate in joint planning and mobilizing the community
BoA	• Provide training and technical backstopping to ZoA and DoA • Facilitate timely availability of inputs • Facilitate establishment of platform
Quarantine Agency	• Seed quality inspection, control and certification
Seed enterprises	• Multiply and supply certified seed of potato seed to farmers
Research institution and centers	• Provide training to BoA, DoA, ZoA and DAs • Technology demonstration and evaluation • Supply basic and pre-basic seeds for farmers and seed enterprises
Cooperatives	• Organized local seed producer cooperative and provide training at different levels • Supplying chemical fertilizers and herbicides to farmers
Traders	• Supply insecticides to farmers
Universities	• Provide training and advisory services • Technology demonstration and evaluation
Credit institutions	• Provide credit to farmers for purchasing input
Projects and NGOs	• Support logistics and participating in capacity building • Participate in input supply and technology transfer

4.2. Joint planning

Joint planning, monitoring and evaluation should be done by establishing potato platform.

4.3. Training at different levels

Experts from BoA, research centres, universities and NGOs should provide both theoretical and practical training of trainers (ToT) for ZoA and DoA. Similarly, ZoA and DoA should train development agents. Finally, development agents should provide training to target farmers.

4.4. Availability of inputs

The inputs required are improved seeds, fungicide, insecticide and fertilizers. There is a huge challenge in getting quality potato seeds for all districts. This is because, farmers are not aware of building diffused light store (DLS), very high seed rate, and its perishable nature. In addition, there is no reliable seed supply system in the region. Experience of CASCAPE indicates that building of DLS at individual farmer's level and large DLS at kebele and district level by organized Farmers' Seed Producer Cooperatives ensure seed demand.

The other important inputs are fungicide and insecticide. Experiences of CASCAPE, in this area is selection of important fungicide chemicals and train farmers on how to apply them. After CASCAPE intervention, farmers are aware of where true to type or genuine and effective chemicals are found and on how to apply them. In general CASCAPE's approach in solving the problems of input supply and management was very successful and need to be scaled out/up to other geographical area and to the other farmers.

4.5. Market access

Potato is high yielding and perishable agricultural product. Hence, it has to be sold or stored in appropriate store within short period of time after harvest. For this farmers should use all sorts of markets such as farm gate, local and city markets either in wholesale consumers or retail means. Farmers producing potato for market should be located near good infrastructures such as all weathered roads, main market areas, and should have good storage facilities. In addition, they need to have either own or hired sources means of transportation.

4.6. Joint monitoring and evaluation

Monitoring is a management process that systematically seeks to supply to the stakeholders information on the progress of implementation of a program/project in order to facilitate timely decision making. Monitoring means keeping track of where you are with a project in relation to where you planned to be. Evaluation is a periodical review of the status of implementation and of achievement of a project or program.

Joint monitoring and evaluation is where all stakeholders are involved in the monitoring and evaluation process either alone or together. Each stakeholder has a role to play in the process and need to participate to make the process effective by creating sense of ownership in the whole process of production, harvesting and marketing. Farmers need to follow the day to day events of planting, weeding, harvesting, and marketing because they are the nearest stakeholders for each activity from anyone in the system. They can know what is happening in the planted seedlings, in the status of weeds, in the emergence of diseases, in the process of harvesting and marketing on a daily bases. They can also evaluate the efficiency and effectiveness of the system better periodically. In so doing farmers can deliver correct and fresh information for other stakeholders who are located relatively in far areas from the field, for instance for woreda and regional stakeholders and subject matter specialists.

The other stakeholders can follow up the process as timely as possible and can support technically as well as with resources. For instance, the technical people at woreda or region can advise on the technique of planting, weed and disease control and other processes based on their daily follow up or information obtained from farmers.

Data collection

Qualitative and quantitative data should be collected every time by every stakeholder and should be centrally organized, analysed and communicated again to every stakeholder. The tools used to collect qualitative data are focus group discussion, key informant interview, storytelling and attitude and perception measures. Similarly, there are a number of tools which we can use to collect quantitative data. To mention some, structured formats developed and agreed up on stakeholders, reports, surveys, transect woks, field visits, etc.

All the data collected by different stakeholders should be brought into experts in the Bureau of Agriculture, for reorganization and analysis. Some of the analyses that can be performed include:

1. Summary tables for the different attributes/indicators;
2. Comparison between planned and actual;
3. Comparison between different areas (Villages, Districts, Zones and Region);
4. Comparison between years;
5. Compare the performance of different interventions; and

6. The average performance at kebele, woreda, zone, region and at country level.

In most cases the above analysis relate to the quantitative data. However, if this is complemented with the qualitative data which will be generated by the qualitative surveys it will help to answer why the interventions are performing as observed in the quantitative data. For example, the quantitative data about training can be complemented with the trainee’s feedback result on the same issue. This type of information can explain why things are happening (or not happening) in a particular manner and provide significant insights for decision making purposes.

Communication

Monitoring and evaluation information collected through the established process can only be used for accountability, learning and decision making, as well as input for re-planning of project if there is a clear plan for appropriately communicating it to the stakeholders of the programme. Communication can be done through periodical reports, stakeholders meetings and critical reflections, broachers, leaflets, using electronic means (telephone, e-mail, etc), vocal and in so many other means.

Capacity building

For the joint monitoring and evaluation process to be effective, capacity building need to be given intensively. Farmers should be given appropriate training on how to record information and on how to communicate it. They need also be supported by necessary materials. The other stakeholders in the process need to get the capacities which enable them to discharge the monitoring and evaluation process effectively.

In general, the monitoring and evaluation activities must be done jointly and in participatory ways. Otherwise, lack of sense of ownership and carelessness may appear among some stakeholders and will lead to total failure in implementing the innovation as a whole. This is a common phenomenon or experience and occurrence appearing in most projects and programs.

4.7. Sharing lesson learned and challenges faced

Lessons learned

- Start with identification of problems and potentials intervention areas
- Involving policy makers, development workers and farmers at all stages of development intervention has made technologies to be sustainable
- Following participatory approach has resulted integrated innovations and ensured stakeholder partnership
- Farmers have been convinced not by we tell them but by what we show them by supplying proven technologies and best practices
- Starting demonstration of best practices and technologies with model farmers has been an important approach to be followed for any interventions
- Establishing market linkage is a key for success in agricultural production interventions
- Providing training to farmers, DAs and experts will enhance adoption rate of improved potato technologies easily
- Mainstreaming gender and nutrition in all agricultural development activities will improve sustainability of technology impacts

Challenges faced

- Lack of either governmental or private seed potato producers and seed system which limits quality seed access
- Limited capacity of research centers to supply basic potato seed tubers
- Expectation of farmers for free inputs and seed store construction materials
- Lack of strong coordination among stakeholders involved in the project as stipulated in the role and responsibility of each actors.

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