International Journal of Research & Review Proceeding & Conference Thesis & Antithesis Novelty & Findings
Sciences; Economics & Business; Social, Politics & Humanities; Law; Engineering & Industry; Biology, Physics & Matematics; Agriculture & Agribusiness; Health, Nursing, & Medicine; Informatics, Technology & Computers; Food & Nutrition
Zambrut

Analysis of Potato Seed Systems In Ethiopia: Review

Beriso Bati Bukul

Beriso Bati Bukul
Department of Agricultural Economics, Adami Tulu Agricultural Research Centre
Adami Tulu, Ethiopia

Abstract: *Potato is one of the tuber crops grown in Ethiopia. This review paper investigated different literatures on potato seed systems in Ethiopia with objective of describing the status and performance of potato seed systems, seed production and storage, seed tuber quality, seed availability and distribution and information flow. As different literature indicate that potato seed systems in Ethiopia classified into informal, alternative and formal. The informal potato seed system supplies 98.7% of the seed tubers required in Ethiopia whereas the remained 1.3% supplied by alternative seed system. There is no public formal seed potato supply system in Ethiopia because Ethiopian Seed Enterprise is not involved in seed potato production and supply because of its limited capacity. Unavailability of quality seeds at the right place and time coupled with poor promotion system is due to inefficiency of the seed systems of the country. In general although, the crop is important food crop, wide ranging factors are hindering seed potato system. Therefore, for the improvement of the potato seed system and thereby the services obtained from the system it should be improved through integrative study.*

Keywords: *Review, Potato seed system, Informal, Alternative and Formal.*

1. INTRODUCTION

1.1 Background and Justifications

Potato (Solanum tuberosum L.) is one of the tuber crops grown in Ethiopia. It is grown by approximately 1 million farmers (CSA, 2008/2009). Recently the price of cereals strongly increased worldwide and in Ethiopia the price subsequently stabilized at a high level, whereas the price of roots and tubers remained relatively low during the entire food crisis. This shows that there is room for added value in the chain of tuber crops. Potato can potentially be grown on about 70% of the 10 Mha of arable land in the country (FAO, 2008)

Ethiopia are suitable for potato production although the national average production is low (that is 13.7 ton/ha) (CSA, 2015). The national average potato yield is low as compared to the potential yield (40 ton/ha) obtained under research condition was due to lack of high-quality seed potatoes is a major factor (Lemaga *et al.*, 1994; Endale *et al.*, 2008a; Gildemacher *et al.*, 2009a; Tewodros, 2014), Lack of quality seed potato (Amede *et al.*, 2006; Hardy *et al.*, 1995; Medhin *et al.*, 2000;Tewodros, 2014), high yielding varieties and storage facilities coupled with poor agronomic practices (Medhin *et al.*, 2000; Adane *et al.*,

2010; Tewodros, 2014) have been found to contribute to the low yield of potato in Ethiopia. The majority of potato growing smallholder farmers uses low yielding and late blight susceptible local varieties due to the limited availability of improved seed potatoes in the country (Getachew and Mela, 2000; Medhin *et al*., 2000). Ethiopia is a landlocked, poor country with a negative trade balance, which makes expensive imports of high-quality seed tubers from Europe or elsewhere unaffordable. Increase in potato acreage and yield calls for improvement of the quality of seed potatoes supplied to the ware potato production systems (Adane *et al*., 2010).

Generation and transfer of improved technologies are critical prerequisites for agricultural development particularly for an agrarian based economy such as of Ethiopian. Despite the release of several technologies, particularly of improved crop varieties, there has been limited use of improved seeds by the majority of farmers (CSA, 2010). According to Adane *et al.* (2010) unavailability of quality seeds at the right place and time coupled with poor promotion system, is one of the key factors accounting for limited use of improved seeds, which further contributing for low agricultural productivity. Poor availability and promotion of improved seeds is due to inefficiency of the seed systems of the country. According to the Abebe and Lijalem, (2010) report the major challenges of the seed system of the country are;- lack of proper linkage between different actors involved in seed systems, inadequate supply of good quality seed at affordable prices, focus on few crops (maize & wheat) in the formal system and other beneficial crops (such as pulses, vegetable especially potato & oilseeds) remain orphan, low level of private sector involvement in the formal system, inefficient seed promotion, distribution and marketing mechanisms, weak variety release and weak seed quality assurance system.

Information and understanding of the seed potato production and storage, seed potato tuber quality, seed availability and distribution and information flow would facilitate increasing production and productivity of potato. This review identifies and provides information on potato seed system in the country which helps different stakeholders to design appropriate technologies and technology transfer system for ware and seed potato production under smallholder farmers based on the idea obtained from this review study. Therefore this review is shed light on required efforts to improve production and productivity of potato at large scale by solving its inefficiency supply system as well the information generated from this review would also help different organization such as research and developmental organization, traders, seed producers (private, cooperative, smallholder farmers and other if any), government and non government to design proper mode of operations which may influence the design and implementation of policies and strategies. The purpose of this investigation was therefore, to describe the potato seed systems, Seed production and storage, seed tuber quality, seed availability and distribution, and information flow. In general this review paper is initiated, aimed at reviewing an overview and assessing the status of potato seed systems operating in the country and reviewing initiatives in the area and documenting best approaches.

1.2 Objectives

- ✓ To review different literatures of potato seed systems in Ethiopia
- ✓ To describe the status and performance of potato seed systems, Seed production and storage, seed tuber quality, seed availability and distribution and information flow.

2. LITERATURE REVIEW

Potato Seed Systems in Ethiopia. Different authors classify seed systems into different types; Struik and Wiersema (1999) classify seed systems into informal and formal, while others classify them into local and formal (World Bank *et al*., 2009), or farmers' and formal (Almekinders and Louwaars 1999) and others classify seed systems into informal, alternative and formal (Lemaga *et al*., 1994; Mulatu *et al*., 2005a; Endale *et al*., 2008a; Gildemacher *et al*., 2009a; Adane *et al*., 2010). The description of each potato seed system presented as follows.

2.1.1. The informal seed potato system

The informal seed potato system is a seed potato system in which tubers to be used for planting are produced and distributed by farmers without any regulation. This seed system exists in all potato growing areas of Ethiopia and it is the major seed potato system which supplies 98.7% of the seed tubers required in Ethiopia (Gildemacher *et al*., 2009a; Adane *et al.,* 2010). The seed tubers supplied by this system are deemed to be poor in health, unsuitable in physiological age, poor in genetic quality, impure (varietal mix-up), physically damaged and inappropriate in size (Lemaga *et al*., 1994; Mulatu *et al*., 2005a; Endale *et al*., 2008a; Gildemacher *et al.,* 2009a; Adane *et al.,* 2010). Besides, in the informal seed potato system, seed tubers are produced usually as part of ware and stored under poor conditions. In this seed system farmers usually use varieties of unknown origin and improved varieties are not available to the majority of the farmers. Lack of awareness about the availability and use of improved technology and practices has also impeded adoption of potato technologies (Adane *et al.,* 2010).

2.1.2. The alternative seed potato system

The alternative seed potato system is a seed potato system that supplies seed tubers produced by local farmers under financial and technical support from NGOs and breeding centers. It supplies only 1.3% which is very low and thus the system still has limited impact on improvement of potato production in Ethiopia (Gildemacher *et al*., 2009a; Adane *et al.,* 2010). In Ethiopia there are community-based seed supply systems which are undertaken by the community with technical and financial assistance of NGOs and breeding centers examples such as Self-help development international (SHDI) and the FAO seed security project, both in the eastern area of Ethiopia (Getachew and Mela 2000; Mulatu *et al*., 2005a), can be mentioned as good examples. These NGOs formed cooperative, community-based seed enterprises (CCBSEs) which produce seed tubers of improved varieties and sell those to other farmers or back to the NGOs for further dissemination. The roles of NGOs have been to provide the financial assistance to CCBSEs and to link the CCBSEs to the breeding centre (Haramaya University in the eastern area) for technical assistance. There are also farmers' research groups (FRG) and farmers' field schools (FFS) in the central and north western areas of Ethiopia which are involved in seed potato production (Bekele *et al*., 2002). They are formed by the Ethiopian Institute of Agricultural Research (EIAR). Some members of FRG and FFS in the central area of Ethiopia became specialized seed potato growers (Gildemacher *et al*., 2009b). These "specialized" commercial seed potato producers are local smallholder farmers. These farmers are producing better quality seed tubers than other farmers but these may still not be of standard quality. From 2002 to 2003, also some efforts were made in the southern area of Ethiopia to multiply seed potatoes by individual farmers with technical and financial assistance from breeding centers and NGOs.

2.1.3. The formal seed potato system

The formal seed potato system is a seed tubers are produced by licensed private sector specialists and cooperatives. There is no public formal seed potato supply system in Ethiopia. The contribution of the formal seed potato system to the overall seed tuber use in Ethiopia is very meager as both the private sector and the cooperatives are at the incipient stage (Gildemacher *et al.,* 2009a; Adane *et al.,* 2010). Very recently, two seed potato producer cooperatives were established and two more are under the process in the central area of Ethiopia as mentioned on report of Adane *et al*. (2010).

The Ethiopian Seed Enterprise (ESE) is not involved in seed potato production and supply because of its limited capacity. There is only one modern seed Potato Company in Ethiopia, i.e. the Sola Grow PLC. It is established in 2006 by group of Dutch investors in collaboration with the Dutch potato breeding company HZPC Holland B.V. with the aim of strengthening the Ethiopian agricultural sector by producing seed potatoes. From 2006 to 2008, the PLC had already a signed agreement with HZPC Holland B.V., established central and local demonstration farms and produced 150 Mg of seed potatoes (EVD, 2009).

Status of Seed Potato Systems. Under this chapter to know the status and performance of potato seed system a modified conceptual framework as suggested by Weltzien and vom Brocke (2001) such as Seed production and storage method, Seed tuber quality, Seed availability and distribution and Information flow

was described in detail as follows. *Seed production and storage;* refers to all activities leading to the production of seed at the time of sowing; it includes all operations of production and storage. Specific issues to address from literature review are how seed potatoes are produced, pre-treated and stored, and whether selection is practiced to identify individual plants that will be used to collect seed tubers for the next season's crop. *Seed tuber quality;* can be defined as the ability of a seed tuber to produce a healthy, vigorous plant that produces a high yield of good quality within the time limits set by the growing season into which the seed is going to be used. Seed tuber quality is affected by seed health, physiological age and status, seed size, seed purity and genetic quality. The appropriateness of the variety or genetic quality of the seed is the adaptability to specific growing conditions and biotic or abiotic stresses and its food and processing quality characteristics. *Seed availability and distribution;* concerns the access of all farmers to appropriate seed at the appropriate time. Timeliness is crucial for obtaining the expected yield. Delays in planting usually result in yield losses and can seriously affect the development of diseases or insect populations, which in turn can affect yield and quality at harvest. Relevant questions relating to this component are: What is the actual origin of seed that farmers are planting? Is their own production or do they get it from other sources? What role does the market play? *Information flow;* covers issues such as: What information is available about new varieties and new seed sources? Where and from whom do farmers search for new information? How is information regarding new varieties of potato and new practices exchanged among farmers? What type of information are farmers searching for? These aspects are especially relevant in the context of change and innovation.

2.1.4 Seed Potato Production and Storage

2.1.4.1 Seed Potato Production Methods

The aim of crop husbandry varies between seed and ware potato production system. High rate of multiplication, maintaining health and optimum physiological quality of seed tuber are the main focus in seed potato production whereas, in ware potato production system, high yield and disease control up to economic level as well as consumption and processing quality of tubers are given priority (Tewodros, 2014). However, the final quality and quantity of potato yield is determined by the quality of the potato seed tuber used at the time of planting (Struik and Wiersema, 1999).

According to Adane *et al.* (2010) study report, in all generally areas of Ethiopia, there is no separate plot and management for ware and seed potato production. Mostly, potato tubers are sorted into ware and seed immediately after harvest. For most potato producers seed potato is usually considered as the by-product of ware potato. Medium sized (egg sized) tuber is recommended to use as a planting material and farmers in Ethiopia who get training on potato production methods use this recommended size of tuber whereas the majority of the farmers in research unaddressed areas traditionally use mostly small sized tuber as a planting material this is because small sized tubers are preferable to cover large more land (Agajie *et al*., 2007). High quality of seed potato tuber could be achieved through the application of appropriate production practices which start from selecting best production site (Struik and Wiersema, 1999).

Only some farmers in the central and north western areas of Ethiopia have recognized the problems of using part of ware potato as planting material, such as disease transmittance and resulting yield loss. In the central and north western areas, some farmers practice positive selection and some also grow seed potatoes on a separate piece of good quality land. In the central and northwestern areas, some farmers practice positive selection and some also grow seed potatoes on a separate piece of good quality land. 13% of the farmers in the district Degem and 15% of the farmers in the district Jeldu in the central area and 8% of the farmers in the district Banja in the northwestern area produced seed potatoes by positive selection, whereas 1% of the farmers in district Degem, 14% of the farmers in the district Jeldu and 6% of the farmers in the district Banja produced seed potato on separate plots (Adane *et al.,* 2010). In another study report in the central and northwestern areas of Ethiopia, 9% of farmers were found to produce seed potatoes through positive selection and 2% of the farmers were found to produce seed potatoes on separate plots (Gildemacher *et al.,* 2009b). Positive selection means selecting only the healthy-looking mother plants, showing good production characteristics, for seed collection (Gildemacher *et al.,* 2007). In the southern

area there is no practice of positive selection or use of separate plots for the production of seed tubers. According to Mulatu *et al.* (2005a) farmers in the eastern area of Ethiopia usually do not produce seed tubers on separate plots. In this area of the country, there is no positive selection either.

2.2.1.2. Seed Potato Storage Methods

Storage is the tool to realize the optimum physiological status of the seed to keep the seed in an optimum condition and to get ready the seed for planting (Struik and Wiersema, 1999). Storage method determines the longevity and the quality of seed during storage. Seed potato storage is a common practice in all potato producing areas of Ethiopia. Farmers store seed potato by leaving the tubers in the soil un-harvested (postponed harvesting); by other traditional storage methods like in a local granary, on bed-like structures or the floor in their house; or by diffused-light storage (DLS) (Adane *et al.*, 2010). Because of storage and other post harvest problems Ethiopia loses 30– 50% of its potato production (Endale *et al.*, 2008b). Under this chapter types of storage are described in more detail below as follows.

A. Postponed harvesting as storage mechanism

Postponed harvesting is the most commonly used storage method for ware potatoes in the highland and northwestern areas of the country to extend piece-meal consumption and also to wait for a better price (Endale *et al.*, 2008b). According to these authors, tubers can be kept up to 4 months without major quality loss in cool highlands. This storage method is also used to store seed potatoes. About 37% of the farmers in Banja in the northwestern area of Ethiopia left the potato tubers for seed un-harvested in the field, whereas only 1% (Jeldu) to 3% (Degem) of the farmers in the central area used this method (Adane et al., 2010). In a study undertaken in the central and northwestern areas of Ethiopia, Gildemacher *et al.* (2009b) found that 47% of the potato farmers leave seed potatoes in the soil un harvested. This storage method was not reported in seed potato studies in the eastern area of Ethiopia. There is also no information on the presence of this storage type in the southern area of Ethiopia. Postponed harvesting as storage mechanism has been creating problems in potato production for it could allow more accumulation of tuber-borne diseases than early harvesting (Endale *et al.*, 2008a). In ground storage of potato is also associated with large losses: in the Gojam and Gonder areas of the northwest losses of up to 50% have been reported caused by tuber moth and ants (Tesfaye *et al.*, 2008).

B. Other traditional storage methods

Farmers also store seed potatoes in bags stacked on the floor in untidy places in the house where there is no ventilation, heaped loosely or put on a bed-like structure (Adane *et al.*, 2010). 47% of the farmers in the district Degem and 46% of the farmers in district Jeldu in the central area of Ethiopia and 73.6% in the eastern area of Ethiopia (Mulatu *et al*., 2005a) used bags to store their seed potatoes. About 45% of the potato farmers of Jeldu district in the central area of Ethiopia and 21% of the farmers of Banja district in the northwestern area of Ethiopia heap their seed potatoes loosely while 33% of the farmers of Banja district in the northwestern area of the country use a bed-like structure Mulatu *et al*. (2005a) also found that about 26.4% of the farmers in the eastern area of Ethiopia piled up their seed potatoes in an open place or in a corner of their house. However, there are also farmers who store their potatoes in a better place. In a study made in the central and northwestern areas of Ethiopia, about 18% of the farmers were found to use light spaces in the house to store their seed potatoes. In the southern area farmers store seed potatoes in their home or in a store constructed for this purpose. Seed and ware potatoes are stored side by side in the same store or home. In the Shashemene district of the southern area, farmers cover stored ware and seed tubers with teff straw to protect the tubers from sun light. They use a thicker cover for the seed than for the ware. The farmers increase the thickness of the seed tuber cover a few weeks before planting. The farmers believe that an increase in the thickness of the cover will help the seed tubers to break dormancy and thereby encourage sprouting (Gildemacher *et al.*, 2009b; Adane *et al.*, 2010).

C. Diffused light storage

Diffused light storage (DLS) is a storage method using a low cost rustic structure to store seed tubers (Adane *et al.*, 2010). It maintains seed tuber quality by allowing diffusion of light and free ventilation which suppress sprout elongation and thereby slow-down aging of the sprout. In an experiment carried out in Holetta to quantify the effects of storage methods, Lemaga *et al*. (1994) found that seed tubers stored in multilayered burlap sacks (similar to farmers' dark storage method) produced significantly taller sprouts and lost significantly more weight than those stored in DLS. This shows that DLS has a better potential to keep quality seed tubers than the traditional storage method. Even though the storage performance differs from variety to variety, seed potatoes can be stored in DLS up to 7 months without considerable depreciation of seed quality (Endale *et al.*, 2008b). The DLS is usually used for the storage of seed potatoes of improved varieties whereas the other storage mechanisms are used for the storage of seed potatoes of local varieties. The reason for this might be that farmers are not aware of the importance of DLS for the storage of local varieties. Diffused Light Stores (DLS), developed by CIP, have proven a capacity to maintain the quality of seed tubers, especially in the Central Highlands region (Medhin *et al.*, 2001). The use of DLS has been strongly encouraged by projects which work with farmers to multiply seed tubers, enabling them to keep their seed longer and thus reduce their dependency on other sources (Getachew and Mela, 2000). However, in spite of apparent success in experimental treatments, the DLS technique remains very rare.

Gildemacher *et al.* (2009) on his studies on seed potato systems in East Africa (Ethiopia, Kenya and Uganda) showed that a potato tuber stored in a diffused light storage gives strong sprout, indicating the importance of appropriate potato seed storage system in stimulating sprouting and getting vigour plant stand of potato crop as well as to ensure the availability of ready seed tuber at time of planting. According to Fuglie (2007), in Sub-Saharan African countries including Ethiopia availability of improved seed potato storage method is one of the main constraints in potato production. In the country like Ethiopia where the majority of the potato seed comes from farm saved or locally exchanged seeds, the knowledge about the effect of local storage and seed quality management systems applied needs to be emphasized. In contrast, the knowledge of farmers in this aspect is very low which shows the demand of improvement options to achieve quality seed supply system in the country.

In the central and northwestern areas of Ethiopia only 5% of potato farmers were found to use DLS (Gildemacher *et al.*, 2009b) but the use of DLS for seed tubers of improved varieties is becoming common in the central area of Ethiopia. About 87% of the farmers in the central area and 25% in the northwestern area were found to use DLS for storage of seed potatoes of improved varieties (Tesfaye *et al.*, 2008). The use of DLS is slowly increasing in the northwest. In the eastern area of Ethiopia, the use of DLS is restricted to the cooperative community based seed enterprises established by the FAO seed security project (Mulatu *et al.*, 2005a). The reason for not using DLS, for about 22% of the farmers in the central area of Ethiopia and about 71% of the farmers in the northwestern area of Ethiopia was lack of awareness (Adane *et al., 2010*).

D. Seed Quality

The yield and quality of table potato production depends on the quality of seed potatoes (Anton *et al.*, 2012). In Ethiopia, quality of seed tubers is a serious problem because of varietal mix-up, poor storage mechanisms, prevalence of diseases and pests and poor knowledge of seed selection (Adane *et al.*, 2010). According to Agajie *et al.* (2007), getting high quality/improved potato seed tuber is the main problem for most potato producing farmers in Ethiopia, especially potato producing farmers who are not involved in potato production technique training faced problem in getting improved seed potato whereas, farmers who participate in potato production technique training complain about the quality level of the improved potato varieties since this varieties are getting susceptible to late blight which resulted in yield decline.

In this section the following aspects of potato seed quality was discussed in details follows: purity, genetic quality, health, size, physical damage and physiological age.

E. Seed potato purity

In all potato growing areas of Ethiopia most farmers use seed potatoes of unknown origin (Adane *et al.*, 2010). As mentioned by the author farmers obtain their seed tubers usually from the local market if they do not set aside tubers from their own previous season production. Different varieties of potato are mixed during harvest or trade and in the southern area, in the district Shashemene, phenotypically different potato plants were observed in the same field which might have occurred due to genetic differences or differences in physiological age of the seed tubers. Planting of mixed seed tubers results in a produce with a within-lot variation in cooking and processing qualities, there are also problems in timing of the harvest because of differences in maturity between plants. Mulatu *et al.* (2005a) studied tuber characteristics of the *improved potato variety Al-624 released in 1987*. The study revealed that only 46–52% of the tubers found in farmers' plots resembled tubers of this variety retained by the breeding institution (Haramaya University). On potato field inspections made in several villages of the districts Alemaya and Kersa in the eastern area an average of 4–5 varieties was found to be grown as a mixture per plot (Mulatu *et al.*, 2005a). It was observed on seed potato markets in the central and northwestern areas that traders mixed seed tubers purchased from different growers (Guenthner, 2006).

F. Seed potato genetic quality

Potato variety improvement research has been undertaken in Ethiopia since 1975 with the objective of developing high-yielding, late-blight resistant and widely adaptable varieties. In the last two decades (from 1987 to 2006) about 18 improved varieties, which are adaptable to altitudes ranging from 1000 to 3200 m and receiving 750–1500 mm rainfall with on farm yielding ability ranging from 19 to 38 Mg ha−1, were released (Gebremedhin *et al.*, 2008). Genetic quality also includes food and processing quality. According to Endale *et al.* (2008b), improved potato varieties, namely Digemegn, Zengena, Jalele, Gorebella, Guassa, Menagesha, Tolcha and Wechecha, had an acceptable dry matter concentration and specific gravity for processing. No processing is currently done in the northwestern area.

G. Seed potato health

Late blight [Phytophthora infestans (Mont.) de Bary] is common in all potato growing areas of Ethiopia (Adane *et al.*, 2010). In many parts of the country it is the cause for the shift of potato production from the long rainy season (meher) to off-season production, despite the high potential yield in the long rainy season. Local varieties do not cope with the disease pressure in the main rainy season and often are wiped out, particularly in the highlands. When seed tubers become infected by Phytophthora infestans they may rot during storage or will fail to produce emerging and surviving plants. Viruses [e.g., Potato leaf roll virus (PLRV) and Potato virus Y (PVY)] and bacterial wilt (Ralstonia solanacearum) are causing potato plant and tuber degeneration in Ethiopia (Bekele and Eshetu, 2008).

The prevalence of these diseases is high in the low to medium altitudes. On a seed degeneration experiment undertaken in Holetta Agricultural Research Centre from 1997 to 2000, percent yield reductions due to viruses (mainly PLRVand PVY) were recorded of 62, 45, 44 and 41 in the varieties Tolcha, Genet, AL-624 and Awash, respectively (Bekele and Eshetu 2008). Because these pathogens attack the foliage, root system and tubers, they are important throughout the crop cycle. Potato tuber moth, PTM (Phthorimaea operculella) is affecting seed potatoes in the field and stored in DLS (Bayeh *et al.*, 2008).

As described by Haverkort *et al.* (2009), the serious damage caused by late blight also continued throughout the potato growing areas of the world and frequent pesticide application is considered the only possible means of late blight control. Furthermore, potato productivity hindered by late blight infestation throughout the developing countries and the problem takes the first rank among the other potato production and productivity limiting factors (Fuglie, 2007). In Ethiopia also, late blight is the main problem in potato production and most of the potato producing farmers in the country faced this problem although the degree of infestation varies area to area (Agajie *et al.*, 2007).

According to Sileshi and Teriessa (2001), field infestation per se causes about 9% potato yield loss out of the total potato tuber yield in Eastern Ethiopia. Moreover, the loss is pronounced in case of delayed harvest. In addition, field infestation increases the severity of potato loss during storage. Similarly, Medhin *et al.* (2000) reported up to 100% yield loss due to late blight. A study by Sileshi and Teriessa (2001) in the Eastern Ethiopia demonstrated that the degree of damage on potato tuber varies from cultivar to cultivar. In field as well as in store tuber infestation, results with multidimensional negative effect on farmers like; price reduction due to damaged tuber, less appropriateness to use as a planting material and increasing the cost spent for handling and tuber discards.

According to study report of Adane *et al.* (2010) there are efforts underway to produce healthy seed potatoes by farmers in some parts of Ethiopia even though they are limited. In the central area of Ethiopia farmers commonly destroy the haulm of the part of their potato field reserved for seed. 39% to 54% of the farmers in the central area of Ethiopia had adopted the recommended haulm destruction date. According to Endale *et al.* (2008a) and Gebremedhin *et al*. (2008), disease and insect pressures in the highlands, especially late-blight pressure, was considerably reduced because of the use of disease-resistant varieties. Farmers also renew their seed stock. According to Gildemacher *et al.* (2009a, b), 44% of farmers in the central and northwestern areas of Ethiopia renew seed on average every three seasons, but only 15% of their seed stock each time. The improvement in the practices to produce better quality seed potato in the central area of Ethiopia is achieved because of the concerted efforts of the Ethiopia Institute of Agricultural Research (EIAR). Holetta Agricultural Research Centre of the EIAR has been assisting farmers in the central area of Ethiopia in providing seed and training through its farmers' research group (FRG) and farmers' field school (FFS). Because of the use of home saved seed, use of seed potatoes of unknown origin from local markets, limited use of resistant varieties, poor storage practices like leaving potato underground un-harvested and only limited adoption of haulm killing and selection practices by farmers, the seed tubers used by most potato producers cannot be healthy. However, according to Endale *et al*. (2008a) and Gebremedhin *et al.* (2008), in the highland areas, disease and insect pressures, especially late-blight pressure, were considerably reduced because of the use of disease-resistant varieties.

H. Seed potato size

Among the Ethiopian smallholder farmers in all areas, it is common practice to save tubers for seed that are too small and inferior to be sold for consumption (Mulatu *et al*., 2005a; Endale *et al.*, 2008a; Gildemacher *et al*., 2007). Small-sized tubers may have two problems. The first one is delayed emergence and low sprout vigour and number because of low food reserve (Lommen 1994; Lommen and Struik 1994). The second is that they might be a progeny of an infected mother plant and thus infected by diseases, because infected mother plants usually give small tubers (Struik and Wiersema 1999).

In Ethiopia, the use of small potato tubers as seed might have contributed to the building up of high level of disease especially in the locally grown varieties. However, there are areas where many farmers use medium-sized tubers for seed. For instance, 72% of farmers in district Degem, 66% of farmers in district Jeldu in central area and 63% of the farmers in district Banja in north western area selected medium-sized tubers from the whole produce immediately after harvest, to save for seed (Adane *et al*., 2010). Also Gildemacher *et al.* (2009b) found that 40% of the potato farmers in the north western area of Ethiopia selected medium-sized tubers for seed.

I. Seed potato physical damage

Physical damage includes cuts, bruises and holes, inflicted on tubers during harvesting, storage, packaging and transportation. In a study undertaken on seed potato tubers stored on farm by using a traditional storage method, in two districts of the eastern area, Kersa and Alemay, 8% of the tubers were found to be damaged during harvest (Mulatu *et al.* 2005a). There is no information on physical damage of seed potatoes for the remaining three major potato growing areas (Adane *et al*., 2010).

In Ethiopia potato tubers are harvested, stored, packaged and transported with little care to prevent physical damage to the tuber, most likely because of the low level of knowledge about the consequence of

physical damage by all parties involved. The tools used by farmers to dig out tubers from the soil might not be appropriate (too sharp or elongated ending). Physical damage in seed tubers may also occur during storage because of piling of one sack upon the other and lack of ventilation. Potatoes are usually packed in sacks which cannot protect tubers from any external pressure causing bruising and stabbing. Potato sacks are usually transported by pack animals and are tied by ropes on their back, which may cause bruising to tubers. Distant transportation takes place by Lorries' in this case loading and unloading is done by throwing up and down the tuber sacks. The tubers may be loaded with other sharp or beneath heavy materials which might cause damage to the tubers (Adane *et al*., 2010).

J. Seed potato physiological age

Effects of physiological age on yield are of paramount importance for a country like Ethiopia where there is more than one potato production cycle per year, very poor seed tuber handling and poor storage conditions (Struik and Wiersema 1999; Endale *et al.,* 2008b). Multiple season production has two physiology related problems, a short time gap (limited time for a seed tuber to break dormancy) between adjacent seasons and a long time gap (resulting in physiologically old seed with reduced vigor) between un-adjacent seasons (Adane *et al*., 2010).

According to Endale *et al.* (2008a) farmers in the district Shashemene, West Arsi zone, in the southern area, abandoned production of the improved variety Genet despite its good yielding ability compared to other varieties, because of the short dormancy period (less than 52 days) whereas the period between the off-season (January to March) and the meher season (June to September) is about 2 months and the period between two successive seasons of the same type is 8 months.

According to Adane *et al.*, (2010) report indicate that in the southern area, farmers use seed tubers saved on farm and/or imported from other, distant places. We observed that the same farmer planted seed tubers from different origins on different plots in the same growing season. There is a difference in the physiological age of the seed tubers saved on farm and those imported. Field observations in Shashemene district in October 2009 indicated that the seed tubers imported from a low temperature area were large in size, sprouted well and gave more stems per seed tuber planted than the local farm-saved seed tubers, which had been stored in this high temperature area. Farmers do not practice de- sprouting before planting. However de-sprouting might increase the number of stems per seed tuber planted. In the current plant stands, the low number of stems per plant contributes to a suboptimal development of the foliage, resulting in incomplete capture of the available incoming radiation. Therefore, increasing the number of stems per seed tuber planted by a de-sprouting treatment might be beneficial for final tuber yield. Seed potatoes produced in high-altitude areas often have a good physiological condition. However, such seed tubers may contain latent bacterial wilt or late blight.

2.2.3. Seed Availability and Distribution

According to Adane *et al.* (2010) there are several sources of seed potato in Ethiopia: own savings, local open markets, village markets, breeding centers, NGOs, vegetable traders, district agricultural bureaus, specialized seed potato growers, relatives and friends. There are also about 18 improved potato varieties grown in Ethiopia. However, according to Gebremedhin et al. (2008) and Mulatu et al. (2005a), not all the 18 varieties have been widely distributed and grown by farmers due to the very limited capacity of the alternative seed supply system in the country.

Nevertheless there is difference in the proportion of tubers of improved and local varieties that are used as seed. The central and northwestern areas of Ethiopia, out of the total amount of tubers of improved varieties produced, 46% was used as seed, 49% was used for consumption and 5% was used as gift (Adane *et al.,* 2010). Without distinguishing between improved and local varieties, 24% and 75% of the total produce of tubers were used as seed and ware, respectively (Gildemacher *et al.,* 2009b).

According to report of Adane *et al.* (2010) seed tubers produced in the central area are sold to farmers in the vicinity as well as to those hundreds of kilometers away. The distribution to distant areas is usually undertaken by traders, agricultural bureaus or NGOs. The main destinations of the seed tubers produced in

the central area are the central area itself and the western and southwestern areas. For instance seed tubers produced in the district Jeldu were used by many farmers within the district, neighboring districts and far distant areas like Nekemte (E. Wellega), Dembidolo (W. Wellega), Metu (Illubabor), and Gimbi (W. Wellega) (Endale *et al.,* 2008a). The seed tubers produced in the cool central areas are most likely at a suitable physiological age and thus give better yield than seed tubers available in the other, warmer areas. In the eastern area of Ethiopia, own savings and local markets are the two major sources (Mulatu *et al*., 2005a; Bezabih and Hadera 2007). Seed potato transactions are usually undertaken by cash because of the bulkiness of tubers and the high amount of seed needed for a field prevents farmer-to-farmer seed exchange and gifts like in other crops (Mulatu *et al.,* 2005a).

In the southern area of Ethiopia, seed tubers flow from place to place depending on season. Seed tubers can be transported from and to highland, mid altitude and irrigated areas. Some authors claim that there is a large volume of seed tubers flowing from irrigated areas to places where potato is produced under rain-fed conditions (Adane *et al.,* 2010). For instance, Endale *et al.* (2008a) revealed that most of the farmers in the Shashemene area use seed tubers produced under irrigation in Wondogenet and Shemena areas. Seed potatoes produced in the southern area are also distributed to the western and southwestern areas of Ethiopia even though it might not be significant. In the Shashemene market seed tubers are sold mainly by men while ware is mainly sold by women. Seed tubers availed to Shashemene market were offered to be sold as seed and ware. The seed potato flows in northwestern and eastern Ethiopia are not documented.

Low quantity of production and lack of buyer are the major reasons for the farmers who did not sell potato (Agajie et al., 2007). As illustrated by Agajie et al. (2007), seed potato marketing in Ethiopia constrained by low market price and lack of buyers. Tuber deterioration during storage is among the factors affecting the quality thereby marketability of potato seed tuber. This shows the importance of post-harvest market quality maintenance since the quality and marketability of potato seed tuber not only determined by pre-harvest agronomic practices.

According to survey of Bezabih and Mengistu (2011) in Tigray and SNNPR seed potato farmers sell 50 to 57% of their seed to other farmers. Potato seed supply has three major chain channels. Channel 1; from producer to producer, channel 2; from producers to traders and from traders to producers again, channel 3; from cooperative to NGOs, and from NGOs to producers again. Shashemene is hub for seed potato supply system.

The study of Gildemacher *et al.* (2009) showed that 44% of the Ethiopian farmers renewed the seed, thus meaning that 56% never renewed the seed. The average renewal intervals was three seasons in Ethiopia, for those who renewed their seed. The dominant source of new seeds was the village market (69%), neighbor (14%) and specialized seed growers (16%) provided the remaining part.

2.2.4. Information Flow

Farmers can obtain information on name, source, yielding ability, marketability and food quality of varieties and production practices from various sources, such as family members, neighboring farmers, extension agents, NGO employees, researchers, and potato traders (Adane *et al.,* 2010). Gildemacher *et al.* (2009a) found that about 58.7% of the farmers in North Shewa and West Shewa zones of the central area and East Hararghe zone of the eastern area of Ethiopia obtain information on the aforementioned characteristics of varieties from farmers in their own community. Tesfaye *et al.* (2008) found that the majority of the farmers (62%) in the central area of Ethiopia obtained information on improved potato technologies from Holetta Research Centre, whereas 33% obtained it from fellow farmers and only 4% from the office of agriculture. Own community and research centers like Holetta Agricultural Research Centre are the major sources of information for seed potato technologies.

In Ethiopia, seed tubers are sold either packed in sacks without any label or loose in open markets (Adane *et al.,* 2010). As discussed by author there is no way by which information about variety and quality is transferred from seller to buyer except trust. There is need for a system that differentiates high quality seed tubers from low quality tubers, given the importance of high-quality seed tubers, the mixing of different varieties and the sanitary condition of the tubers. Guenthner (2006) suggested a three colors tag system to

show high, medium and low quality seed tubers. Colours were used as identification for illiterate farmers and criteria for different qualities were suggested.

3. CONCLUSION

In this study review paper the state of affairs of seed potato systems in Ethiopia was briefly described. With regard to the current status of seed potato systems it can be concluded that in general all three seed potato systems operating in Ethiopia, i.e. the informal, alternative and formal system, have problems in undertaking their functions as a seed system. More specifically it could be concluded as follows:

Seed tubers supplied by the informal seed potato system (supplies 98.7% of seed tubers used in the country) are deemed to be poor in health, unsuitable in physiological age, poor in genetic quality, impure (varietal mix-up), physically damaged and inappropriate in size. Besides, in the informal seed potato system, seed tubers are produced usually as part of ware and stored under poor conditions. In this seed system farmers usually use varieties of unknown origin and improved varieties are not available to the majority of the farmers. Lack of awareness about the availability and use of improved technology and practices has also impeded adoption of potato technologies. Therefore, to improve the informal seed potato system increasing awareness and skills of farmers, improving seed tuber quality, and improving market access are the major one.

The alternative potato system, which co-exists with the informal seed system in the central and eastern areas, supplies better quality seed tubers than the informal seed potato system. However, the amount of seed tubers supplied by the alternative seed potato system is very small (1.3%) and thus the system still has limited impact on improvement of potato production in Ethiopia and finally the formal seed system which is at the incipient stage and its contribution to the overall seed system is negligible. Therefore, to improve alternative and formal seed systems availing new varieties, designing quality control methods and reducing cost of seed production are crucial and finally to improve the overall seed potato supply in the country, the co-existence and a good linkage of the three seed systems and development of self-regulatory and self-certification in the informal, alternative and formal cooperative seed potato systems are important.

In general although, the crop is important food crop, wide ranging factors are hindering seed potato system. Therefore, for the improvement of the potato seed system and thereby the services obtained from the system it should be improved through integrative study.

4. REFERENCES

1. Abebe Atilaw and Lijalem Korbu, 2010. Recent Development in Seed Systems of Ethiopia: Debre Zeit Research Center, Ethiopian Institute of Agricultural Research, Debre Zeit, Ethiopia. pp: 14-21.
2. Adane, Hirpha., Miranda P. M. Meuwissen, A. Tesfaye, Willemien J. M. Lommen , Alfons Oude
3. Lansink , A. Tsegaye and Paul C. Struik (2010), Analysis of Seed Potato Systems in Ethiopia. American Journal of Potato Research. Volume 87; Number 6.
4. Agajie Tesfaye, Lemaga Berga, Mwakasendo, J.A., Nzohabonayoz, Z., Mutware, J., Wanda, K.Y., Kinyae, P.M., Ortiz, O., Crissman, C. and Thiele, G. 2010. Markets for Fresh and Frozen Potato Chips in the ASARECA Region and the Potential for Regional Trade: International Potato Center (CIP), Lima, Peru, Working Paper, 2010-1. pp. 44.
5. Almekinders, C.J.M., and N.P. Louwaars. 1999. Farmers' seed production: New approaches and practices, 291. London: Intermediate Technology Publications.
6. Bayeh, M., A. Refera, B.Wubshet, and B.Asayehegn. 2008. Potato pest management. In Root and tuber crops: The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 97–112. Addis Abeba: Ethiopian Institute of Agricultural Research.
7. Bekele, K., and B. Eshetu. 2008. Potato disease management. In Root and tuber crops: The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 79–96. Addis Abeba: Ethiopian Institute of Agricultural Research.
8. Bekele, K., G. Woldegiogis, F.Kelemework,A.Mela,O.M.Olanya, P.T. Ewell, and R. El-Bedewy. 2002. Integrated potato late blight management: Experience of farmer field school in Dendi district. In Towards farmers' participatory research: Attempt and achievements in the central highlands of Ethiopia. Proceedings of client oriented evaluation workshop, 16–18 October 2001, Holetta, Ethiopia, ed. G. Kenei, Y. Gojjam, K. Bedane, C. Yirga, and A. Dibabe, 56–67. Holetta: Holetta Agricultural Research Centre.
9. Bezabih Emana and Hadera Gebremedhin. 2007. Constraints and Opportunities of Horticulture Production and Marketing in Eastern Ethiopia. Dry Lands Coordination Group Report. Grensen 9b. Norway. pp. 46-90.

10. Bezabih Emana and Mengistu Nigussie, 2011. Potato Value Chain Analysis and Development in Ethiopia; Case of Tigray and SNNP Regions. International Potato Center (CIP-Ethiopia), Addis Ababa Ethiopia; website: www.cipotato.org, PP-26. Access on November 15, 2013.
11. Central Statisical Authority (CSA) (2010). Agricultural Sample Survey 2009/2010 (2002 Ethiopian Calender). Report on Area and Production of Crops (Private Peasant Holdings Main Season). Vol. IV, Addis Ababa.
12. CSA (Central Statistical Agency of Ethiopia). 2008/2009. Agricultural sample survey: Report on area and production of crops, Addis Abeba, Ethiopia, p 126.
13. CSA. 2015. Agricultural sample survey report on area and production of crops (private peasant holding, meher season). Volume 1, Addis Ababa, Ethiopia.
14. Endale, G., W. Gebremedhin, and B. Lemaga. 2008a. Potato seed management. In Root and tuber crops: The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 53–78. Addis Abeba: Ethiopian Institute of Agricultural Research.
15. Endale, G., W. Gebremedhin, K. Bekele, and B. Lemaga. 2008b. Post harvest management. In Root and tuber crops: The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 113– 130. Addis Abeba: Ethiopian Institute of Agricultural Research.
16. EVD (Agency of Ministry of Economic Affairs). 2009. Introduction of a seed potato production system in Ethiopia. Project number 174384. Information available at website: www.evd.nl. Date of accession: 13/9/2009.
17. FAO (Food and Agriculture Organization). 2010. Strengthening Potato Value Chains. Technical and Policy Options for Developing Countries. The Food and Agriculture Organization of the United Nations and the Common Fund for Commodities. Rome, Italy.
18. FAO.2008. Potato World: Africa—International Year of the Potato 2008. http://www.potato2008.org/en/world/africa.html. Date of accession: 1/1/2009.
19. Gebremedhin, W., G. Endale, and B. Lemaga. 2008. Potato variety development. In Root and tuber crops: The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 15–32. Addis Abeba: Ethiopian Institute of Agricultural Research.
20. Getachew, Tesfaye and Awole Mela. 2000. The Role of SHDI in Potato Seed Production in Ethiopia: Experience from Alemaya Integrated Rural Development Project. African Potato Association Conference Proceedings, Vol. 5, pp. 109-112.
21. Gildemacher, P., P. Demo, I. Barker, W. Kaguongo, W. Gebremedhin, W.W. Wagoire, M. Wakahiu, C. Leeuwis, and P.C. Struik. 2009b. A description of seed potato systems in Kenya, Uganda and Ethiopia. American Journal of Potato Research 86: 373–382.
22. Gildemacher, P., P. Demo, P. Kinyae, M. Nyongesa, and P. Mundia. 2007. Selecting the best plants to improve seed potato. LEISA Magazine 23(2): 10–11.
23. Gildemacher, P., W. Kaguongo, O. Ortiz, A. Tesfaye, W. Gebremedhin, W.W. Wagoire, R. Kakuhenzire, P. Kinyae, M. Nyongesa, P.C. Struik, and C. Leewis. 2009a. Improving potato production in Kenya, Uganda and Ethiopia. Potato Research 52: 173–205.
24. Guenthner, J.F. 2006. Development of on-farm potato seed tuber production and marketing scheme. Agricultural economics extension series no. 06-01, July 2006. University of Idaho, Moscow.
25. Haverkort, A., Koesveld, V.F., Schepers, H., Wijnands, J., Wustman R. and Zhang, X. 2012. Potato Prospects for Ethiopia: On the Road to Value Addition. Wageningen UR, Netherland. Available on: www.ppo.wur.nl
26. Lemaga, B., G. Hailemariam, and W. Gebremedhin. 1994. Prospects of seed potato production in Ethiopia. In Proceedings of the second national horticultural workshop of Ethiopia, ed. E. Hareth and D. Lemma, 254–275. Addis Abeba: Institute of Agricultural Research and FAO.
27. Lommen, W.J.M. 1994. Effect of weight of potato mini tubers on sprout growth, emergence and plant characteristics at emergence. Potato Research 27: 315–322.
28. Lommen, W.J.M., and P.C. Struik. 1994. Field performance of potato mini tubers with different fresh weights and conventional tubers: Crop establishment and yield formation. Potato Research 37: 301–313.
29. Louwaars, N. 2007. Seeds of confusion: The impact of policies on seed systems. PhD dissertation, Centre for Genetic Resources, WUR, The Netherlands.
30. Maredia, M., and J. Howard. 1998. Facilitating seed sector transformation in Africa: key findings from the literature. Policy synthesis for USAID—Bureau for Africa, FS II Policy synthesis No. 33.
31. Medhin, G.; W. Giorgis; Bekele Kassa; Endale Gebre; Atsed E. Solomon; Berga Lemaga; Ramzy El-Bedewy; Agaje Tesfaye. Farmer Based Potato Seed Tuber Production (1998-2000). Final Report. PRAPACE (Regional Potato and Sweet potato Improvement Network in Eastern and Central Africa).
32. Medhin, G.; W. Giorgis; Endale Gebre; Kiflu Bedane; Bekele Kassa. 2001. Country Profile on Potato Production and Utilization: Ethiopia. Ethiopian Agricultural Research Organization (EARO), Holetta Agricultural Research Centre, National Potato Research Program.
33. Mulatu, E., E.I. Osman, and B. Etenesh. 2005a. Improving potato seed tuber quality and producers' livelihoods in Hararghe, Eastern Ethiopia. Journal of New Seeds 7(3): 31–56.

34. Mulatu, E., E.I. Osman, and B. Etensh. 2005b. Policy challenges to improve vegetable production and seed supply in Hararghe, Eastern Ethiopia. Journal of Vegetable Science 11(2): 81–106.
35. Sileshi, G. and J, Teriessa. 2001. Tuber Damage by Potato Tuber Moth, Phthorimaeaoperculella Zeller in the Field in Eastern Ethiopia. International Journal of Pest Management (UK). 47(2): 109-113.
36. Sperling, L. and Cooper, H. D. (2003). Understanding seed systems and seed security. In Improving the effectiveness and sustainability of seed relief. In Proceedings of a stakeholders' workshop, 26-28 May 2003. Rome: Food and Agriculture Organization.
37. Struik, P.C., and S.G. Wiersema. 1999. Seed potato technology, 383. Wageningen: Wageningen Pers.
38. Tesfaye, A.B., K. Bedane, C. Yirga, and W. Gebremedhin. 2008. Socioeconomics and technology transfer. In Root and tuber crops: The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 131–152. Addis Abeba: Ethiopian Institute of Agricultural Research.
39. Tewodros Ayalew, 2014. Analysis of Seed Potato (Solanumtuberosum L.) Systems with Special Focus in Ethiopia: Review. Asian Journal of Agricultural Research, 8: 122-135.
40. Weltzien, E., and K. vom Brocke. 2001. Seed systems and their potential for innovation: Conceptual framework for analysis. In Targeted seed aid and seed system interventions: Strengthening small farmer seed systems in East and Central Africa. Proceedings of a workshop held in Kampala, Uganda, 21–24 June 2000, ed. L. Sperling, 9–13. Kampala.
41. World Bank, FAO, and IFAD. 2009. Gender in seed production and distribution. Gender in Agriculture Sourcebook, 764. Washington, DC: World Bank..