ISSN 1819-1894

Asian Journal of Agricultural Research

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

Asian Journal of Agricultural Research 8 (3): 122-135, 2014
ISSN 1819-1894 / DOI: 10.3923/ajar.2014.122.135

Analysis of Seed Potato (*Solanum tuberosum* L.) Systems with Special Focus in Ethiopia: Review

Tewodros Ayalew
Department of Plant Sciences, College of Agriculture and Natural Resources, Dilla University Ethiopia, P.O. Box 419, Dilla, Ethiopia

ABSTRACT

Potato (*Solanum tuberosum* L.) is the most consumed food crop world-wide next to wheat and rice and potato production is rapidly increasing in Africa. Potato is a high potential food security crop in Ethiopia due to its high yield potential and nutritional quality tuber, short growing period and wider adaptability. Potato potentially grows in different corners of the country. In some parts of the country, potato is grown as a field crop whereas, in some other part, it is still grown as a garden crop. Despite the suitability of the agro-ecology for high quantity and quality potato production in the country, there are several constraints which drastically affect to the low production and productivity of potato crop under smallholder farmers condition. Therefore, the objective of this review study was to evaluate the current state of seed potato systems, seed potato husbandry, seed potato quality, seed potato storage and sourcing and marketing systems used by seed potato producers and potato utilization. The result of this review study showed that a number of factors are constraining the system. These consists lack of wide adaptive improved potato varieties, unavailability of improved storage facilities, the high cost of improved seed tuber, low price of produced tuber especially immediately during harvest are the major one. Based on the review information, it can be concluded that availing improved potato varieties, improved storage facility and creating better marketing opportunity are crucial to improve the seed potato systems.

Key words: Seed potato system, seed potato husbandry, seed potato quality

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most consumed food crop world-wide next to wheat and rice (Champouret, 2010; Verzaux, 2010; Visser *et al*., 2009). Although, the total per capita consumption is low, potato production is rapidly increasing in Africa as well (Fuglie, 2007; Haverkort *et al*., 2009). This increase in potato production is pronounced from the 1990's since potato is significantly used as a stable food as resource by poor farmers and contributes to the livelihood of millions of people worldwide (Verzaux, 2010). Similarly, interest on potato crop is increasing both as a food and cash crop in Southern Africa (Scott *et al*., 2013).

In Ethiopia, potato is a high potential food security crop due to its high yield potential per hectare and nutritious tubers. Potato production in Ethiopia is possible on about 70% of the arable land (FAO, 2008; Medhin *et al*., 2000; Yilma, 1989). Potato is a leading vegetable crop in Ethiopia and smallholder farmers cultivate about 50,000 ha each season (Getachew and Mela, 2000). Moreover, in Ethiopia potato production serves as mean to overcome food shortage periods 'hungry months', since it matures before the harvest of other food crops such as cereals (Sanginga *et al*., 2009). Although, the edaphic and climatic conditions are suitable for production

of high quality potato in Ethiopia, the national average production is as low as 8 t ha^{-1} (Medhin *et al*., 2000). This national average yield is very low as compared to the potential yield (40 mg ha^{-1}) obtained under research conditions (Getachew and Mela, 2000). Lack of quality seed potato (Amede *et al*., 2006; Hardy *et al*., 1995; Medhin *et al*., 2000), high yielding varieties and storage facilities coupled with poor agronomic practices (Medhin *et al*., 2000) 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).

At present, chemical treatment and biotechnological techniques are widely applied throughout the world to manage sprout at desired level (Farre *et al*., 2001) which is not a common practice in Ethiopia. Pre-planting seed dormancy breaking is another important issue in seed potato production (Struik and Wiersema, 1999), this specially contributes to the low yield in countries like Ethiopia, where potato is produced twice per year. In addition to the shortage of improved potato varieties, the lack of appropriate seed potato storage contributes to the low production of potato in Ethiopia. For instance, about 30-50% yield loss is recorded due to the lack of appropriate potato storage and other post-harvest management related problems of the total production of potato in Ethiopia (Hirpa *et al*., 2010).

Potato seeds obtained from the local markets are not uniform, mixed and susceptible to diseases. In addition to seed quality, poor agronomic practices and lack of proper storage systems are the main factors contributing to the low yield of potato in the country. Information and understanding of the seed potato production, storage and pre-planting treatment methods would facilitate for the increased production and productivity of potato seed and helps different stakeholders to design appropriate technologies and technology transfer systems for potato seed production under smallholder farmer based on the idea obtained from this review study. The purpose of this investigation was therefore, to describe the current state of seed potato sytems, seed potato husbandry, potato yield, seed potato quality and sourcing, seed potato storage system, potato utilization and seed potato production constraining factors.

SEED POTATO HUSBANDRY

The aims 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 upto economic level as well as consumption and processing quality of tubers are given priority. 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 Fuglie (2007), availability of quality seed potato received higher priority by farmers in East Africa (Ethiopia, Kenya and Uganda). 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). Potato needs intensive management and production of better quality potato tuber demands timely application of the appropriate production inputs such as nutrients, water and crop protection measures. These packages of seed potato production are responsible to increase the developmental process throughout the life span of the potato crop (Pehrson *et al*., 2010).

Soil preparation in seed potato production: Potato crop production demands well prepared soil even than other crops, since expansion of tuber needs enough amount and optimum textured soil and also for ease of harvesting. Moreover, ploughing regulates soil temperature and the moisture level of the soil and the growth of sprout influenced positively as the soil temperature is warmer as far as the soil has adequate moisture level (Pavek and Thornton, 2009). According to Pavek and Thornton (2009), soil moisture content and temperature differences are the most common factors followed by volume and mechanical resistance of soils in affecting sprout growth. This is because, the emergence of potato crop limited by differences in temperature and moisture level of soil which shows the importance of this factors in potato production.

Planting time and depth in seed potato production: Once the soil preparation done, planning of appropriate planting time is crucial since the growing condition, which the crop faces afterwards, determined by the time of planting used (Struik and Wiersema, 1999). According to Struik and Wiersema (1999), earlier planting is preferable since this practice helps the crop to use all conducive environmental conditions of the production season potentially. Moreover, potato crop emergence impeded if planting is done when the soil environment is hot and cold and planting during the occurrence of these soil conditions (hot and cold) resulted with poor crop stand (Struik and Wiersema, 1999).

Appropriate planting depth is one of the main agronomic practices required for potato production, this is because, the potato tuber is produced under ground which is the economical part of the crop. Early development below ground morphology, tuber expansion, yield and tuber quality are among the aspects affected by planting depth (Pavek and Thornton, 2009). Moreover, planting depth determines the time and energy the sprout requires to emerge, thereby early establishment and vigour are affected which are vital in seed potato production (Struik and Wiersema, 1999). For instance, deep planting may result in delayed ground cover. On the contrary, deeper planting help to overcome tuber greening, exposure of tuber to external environments, water shortage and to reach the expected yield (Pavek and Thornton, 2009). According to Pavek and Thornton (2009), planting potato in shallow depth results with declined marketable yield and gross income from potato crop production. This is because, in case of shallow planting depth, rapid sprout emergence restricted by less soil moisture content. As investigated by this same study, soil temperature also has its contribution towards hastening sprout emergence. Accordingly, warmer soil temperature positively affects the emergence as far as the moisture content of the soil is in adequate level. As explained by Pavek and Thornton (2009), more stem can be produced from pieces of seed which planted shallower, since shallower planting allows the pieces of seed to be exposed to warmer soil temperatures than deeper planted seed pieces.

A study by Pavek and Thornton (2009) illustrated that rapid sprouting used as a means against potato shoot and stem diseases resistance during the early stage of the potato crop and increases radiation capture efficiency early in the growing season thereby resulted in higher final tuber yield since higher radiation capturing efficiency in the early stage advance the vigour of the plant onwards and also contribute to the quantity and quality yield advantages. According to Pavek and Thornton (2009), increased planting depth resulted with delayed emergence, higher number of nodes, stolon and tuber number whereas, shallow planting hastened potato plant emergence. But this early emergence not always results in increased number of tubers or higher final yield per entire plant. Although, the differences in the planting depth resulted with differences in rate of emergence, it doesn't affect the total yield of the potato crop.

Plant population/spacing in seed potato production: Potato crop needs to get enough intra and inter row spacing to allow maximum tillering of the plant as well as an optimum number and better quality tuber formation. In most of study, addressed potato producing areas of Ethiopia spacing of 20-30 and 60-75 cm are recommended between plants and between rows, respectively (Agajie *et al*., 2007). As indicated by Pavek and Thornton (2009), tuber expansion is one of the tuber development characteristics most affected by spacing among the other tuber development characteristics. This is because, the surrounding soil volume becomes insufficient to hold the expanding masses of tubers in addition to competitions imposed by having crops planted near each other. Gebre and Giorgis (2001) illustrated that, having optimum number of plants per unit area and spatial arrangements have a great potential in securing high potato tuber yield. This warrant the importance of practicing appropriate spacing in potato production and this becomes more important in seed potato production since to secure quality and quantity of the next season potato crop quality and healthy seed tuber is the most determinant in potato production. However, potato producing farmers in Ethiopia have less knowledge about the use of optimum spacing. This results from lack of awareness of farmers about the importance of using appropriate agronomic practices in potato production including-spacing. According to Gebre and Giorgis (2001), practicing improper spacing in potato production system may be caused by using irregular planting system or broadcasting method of planting which the farmer experienced from their cereal cultivation. As reported by Gebre and Giorgis (2001), average tuber weight increased when wider spacing practiced while small sized tuber number increased in the case of narrower spacing. According to Agajie *et al*. (2007), appropriate seed rate is crucial as far as potato productivity is considered, since low seed rate results in less yields, whereas seed rate more than research approved one result in more production cost since it hinders the application and ease of appropriate agronomic practices, demands more water, chemicals and fertilizer than the rate used in normal plant spacing per planted area. Moreover, more seed rate exposes each plant for inter and intra-row nutrient and radiation competition thereby result in less tuber formation per plant and small sized tuber production. Narrower spacing also contributes for easy dissemination of diseases (Agajie *et al*., 2007).

Soil fertility management in seed potato production: Maintaining the fertility of the soil is one of the most important agronomic practices needed to be followed in potato production (Agajie *et al*., 2007; LeMonte *et al*., 2009). According to LeMonte *et al*. (2009), reliable supply of recommended amount of fertilizer helps to optimize economics of crop production and minimizes environmental losses. Potato is particularly sensitive to a steady supply of nitrogen fertilizer (LeMonte *et al*., 2009). According to these studies, although potato needs appropriate supply of nitrogen for increased yield, production of tubers of bigger size and minimum internal-external tuber defect, excessive supply of nitrogen has its own negative effect. According to Westermann and Kleinkopf (1985), to increase the nitrogen use efficiencies and also final tuber yield of potato plant within the limitations of climatic conditions, disease occurrence and variety related problems developing appropriate recommendations and also application of recommended rates based on the dry matter production and nitrogen uptake rates of the crop at each specific development stage of the crop is the crucial issue concerning nutrient management in potato crop production. This study indicates that practicing the recommendation hasten early growth rate and sustain maximum growth rate which thereby result in potential yield while higher application resulted in delayed potato tuber growth. Especially, nitrogen fertilizer not only hasten the growth rates of

potato tuber, it also plays a major role in the production and maintenance of plant canopy which result in continued tuber growth for a long growing period (LeMonte *et al*., 2009) and the nitrogen fertilizer demands of the potato crop varies between different growing stages which is relatively high during the periods of high tuber growth rates which warrants the importance of split application of nitrogen.

As demonstrated on a study of Agajie *et al*. (2007), about 94% of potato farmers in most potato producing areas of Ethiopia practice application of fertilizer of organic or inorganic sources. As indicated in the same study to get better tuber yield from potato crop, application of inorganic fertilizer during planting is recommended. Fertilizer application rate of 195 kg ha^{-1} DAP and 165 kg ha^{-1} urea are recommended by research for major potato producing area of Ethiopia and application of DAP is largely practiced by most potato producing farmers in the country (Agajie *et al*., 2007). According to Agajie *et al*. (2007), farmers who do not able to get the recommended amount of inorganic fertilizer, additionally apply organic fertilizer (compost and Farm Yard Manure (FYM)) to compensate the fertilizer demand of the potato crop and application of organic fertilizer also contributed to the reduction of production cost. But the knowledge on preparation and use of compost are in infant stage. While, application of manure is limited based on the distance of the farm from the village and its less availability, since this-days the number of cattle reared by individual farmer is dropping down due to scarcity of grazing land. Crop rotation is also an alternative means on which potato producing farmers depend to maintain and improve soil fertility. According to Agajie *et al*. (2007), potato producing farmers in Ethiopia practice crop rotation to maintain and improve the fertility of the soil in addition to the use of organic and inorganic fertilizer sources.

Water management in seed potato production: A potato crop is sensitive to water shortage. Hence, to meet the water requirement and reach with high quality and quantity of final potato tuber yield, efficient and effective water management is crucial (Pehrson *et al*., 2010). Potato production needs intensive management practices among which appropriate water management is the crucial one (Pehrson *et al*., 2010). According to Pehrson *et al*. (2010), most potato cultivars are characterised by their shallow rooting system and grown on soil type having low water holding capacity, since this kind of soil is preferable for the ease of potato tuber harvesting. This makes potato crop more susceptible to water stress than a lot of other crop species. Regular monitoring of soil moisture content, scheduled watering and having water resource and/or irrigation system capable of providing the required amount of water are the most important factors to address effective water management in potato production and thereby to achieve the desired quantity and quality potato tuber production (Pehrson *et al*., 2010). As indicated in this study, applying the amount of water which exceed the potato crop demand as well as providing the amount of water which is lower than the crop requirement resulted with quantity and quality loss of potato tuber. Moreover, maximum water application results in loss of nutrient and water to the environment. This indicates the importance of effective water management as far as yield with high quality and quantity of potato tuber, reduction of environmental impacts and maintaining the overall profit from potato crop is concerned. Although, most potato producing farmers in Ethiopia are dependent on rain water, some farmers produce potato by using irrigation as a water source based on accessibility of irrigation water as well as irrigable lands. Furthermore, the farmers who practice irrigation are able to produce three times per year.

Crop protection in seed potato production: Practicing appropriate crop protection methods are also the other important component of potato production packages to achieve a desired potato seed tuber yield and the overall benefit from the potato production. According to Haverkort *et al.* (2009), potato crop is affected by different diseases and pests of which late blight is the most damaging disease in the world. 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). 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. 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 Agajie *et al.* (2007), the incidence of late blight aggravated by presence of high rain fall, moisture and mist during the production season. The use of fungicide is a common and compulsory practice for potato producing farmers in Ethiopia to overcome late blight problem and secure attainable yield (Agajie *et al.*, 2007) but still some farmers are not aware of the importance of fungicide application to control late blight and the chemicals also not available in their local market and the price of the chemicals are expensive. In some potato producing areas of Ethiopia the farmers had forced to stop potato production due to late blight problems and since introduction of new late blight resistance varieties, these farmers re-started producing potato crop (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 upto 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.

Weed control is one of the crucial agronomic practices in potato production. Weed control practiced by chemical application and recently cultivation is becoming a sustainable way of weed control method in potato crop production (Eberlein *et al.*, 1997). According to Eberlein *et al.* (1997), using cultivation has economic and tuber health related advantages since chemical weed control needs more investment than the cost of cultivation practiced for weed control and also related to sunlight exposure because during cultivation the soil hilled and protects, the tuber from direct sunlight attack which has an effect on tuber greening. As illustrated by Eberlein *et al.* (1997), cultivation also contributes to the improvement on the structure of the soil thereby improves the soil aeration. But it needs timely application since cultivation during wet period may result in soil compaction thereby inhibits soil aeration and water infiltration. Moreover, efficient mechanical (cultivation/hilling) weed control method needs repeated application of the practices which demands more human labour, time and implements. According to Eberlein *et al.* (1997), a combined practice of timely hilling and herbicide application is efficient way of weed control method.

POTATO YIELD ANALYSIS

The yield gap between attainable and potential yield of potato in Ethiopia is very high. Different factors contributed to the low national average yield of potato in Ethiopia Gebre and Giorgis (2001). A study by Aliye *et al.* (2008) in Ethiopia on bacterial wilt finds out that disease

are one of the most important factors that contributes to this high yield gap in the country. According to Aliye *et al.* (2008), the contribution of diseases to the gap between the production potential and the current average national production takes a large part since potato crop is susceptible to a number of diseases including late blight, viruses and bacterial wilt. This same study indicated that mid-altitude areas of the country around Shashamene, Bako, Jima and Rift Valley are most affected by bacterial wilt. According to Gebre and Giorgis (2001), sub-optimal agronomic practices are also the other most important factor contributing to this potato yield gap. Furthermore, the use of local varieties is one and the most important factors which contribute to the low yield of potato in Ethiopia. This is because, the local varieties are susceptible to late blight and of course low yield potential (Getachew and Mela, 2000).

HARVESTING AND SEED POTATO QUALITY

Deciding appropriate date of harvest and practicing proper harvesting are among the most important practices to secure the quality and quantity of potato tuber yield. This is because post-harvest tuber quality of potato and progress in natural development of potato tuber affected by harvesting date (Bethke and Busse, 2010) sine most of the tuber physiological parameters affected by maturity level of potato tuber at harvest. According to Bethke and Busse (2010), aspects of tuber physiology such as mature periderm formation, respiration rate and reducing sugar accumulation are among the important aspects for long term storage of high quality tubers. This is because, well-developed periderm helps to minimize water loss and resist entrance of disease causing pathogens into the tuber during storage life of potato tuber (Bethke and Busse, 2010). Harvesting may done by hand or through ploughing the soil by oxen (developing country including Ethiopia) or tractor operated system. During hand harvesting, it needs to practice harvesting carefully since the hand tools or digger nick potato tubers and it affects the shelf life of the tuber (Yangta and Tong, 1993). Additionally external tuber damage increases the susceptibility of the tuber for entrance of diseases causing vectors. Moreover, tuber physical damage during harvesting affects the market quality of the potato tuber as well as the quality of the tuber to use as a planting material. Maintenance of post-harvest market quality is of prime importance for producers and processors. Tuber deterioration during storage can result from both disease related and physiological processes which shows the importance of pre-storage management of potato tuber.

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). According to Wiltshire and Cobb (1996), in potato crop production sector storage adds a great value to the seed tuber and need to be maintained at optimum temperature level to avoid undesirable changes on the tuber. Storage method determines the longevity and the quality of seed during storage (Thijssen, 2008). The state of potato tuber during the start of storage determines the quality of the tuber after storage period. Seed potato tuber differs in storage condition requirements from the processing potatoes (Pringle *et al.*, 2009), since seed tuber is a living entity, it is exceptionally sensitive to storage conditions. According to Davidson (1958), storage conditions determine soundness, viability and cooking quality. Moreover, the level of potato seed quality loss depends on the status of the tuber before storage, length of the storage period and conditions of the storage facilities (Rastovski and Van Es, 1987).

Respiration, sprouting, change in chemical composition, disease spread, damage by extreme temperatures and evaporation are the main processes causing storage losses (Hesen and Rastovski, 1985). Therefore, maintaining these processes at optimum level result in reduction of losses and thus appropriate storage conditions are necessary in potato seed production (Rastovski and Van Es, 1987). Wiersema and Booth (1985) reported that appropriate storage of seed is potato could reduce the difference in yield potential of seed potato tuber originated from different sources. As reported in the study of Muthoni *et al.* (2010), dormancy and sprout of potato seed is highly affected by storage conditions of which light and temperature contributes the larger share. Good storage is therefore, that which reduces the cost of potato seed storage and yield loss thereby secure the quality of the tuber by maintaining the above mentioned conditions at optimum level. When the potato seed tuber from inappropriate storage conditions is used as a planting material, it results with low tuber yield. This is because, the seed gives uneven emergence, uneven crop development and growth, suboptimal stem density and the plant becomes weak and susceptible to different devastating potato diseases in the early growth stage (Mulatu *et al.*, 2005). According to Fuglie (2007), in Sub-Saharan African countries including Ethiopia availability of improved seed potato storage method is one of the main constraint in potato production. Moreover, small-scale farmers affected most by unavailability of appropriate storage methods (Fuglie, 2007). In addition to storage type used, appropriate in store management is crucial. Of course, the management applied depends on the intended end use, storage facilities available and the type of varieties stored (Wiltshire and Cobb, 1996).

According to Acasio *et al.* (1986), some traditional farmers store seed potato tuber in any place available in their house or farm whereas, most of them store in dark area in the house. These kind of storage results in shrivelled seed tuber and produces long etiolated sprout which is not easy to handle during transportation and planting, whereas, seeds stored in diffused light storage produces short sprout which are easier to handle during transportation and planting. As described by Acasio *et al.* (1986), seed tubers stored in diffused light storage resulted in higher economic benefits because of improved emergence, higher tillering and increased final yield. This is due to better quality seed obtained from diffused light storage, since diffused light storage reduce weight loss, advance more sprout production per tuber which are short and robust. Moreover, diffused light storage increases the possibility of keeping seeds for long (upto eight months) without seed tuber deterioration (Acasio *et al.*, 1986). For processing potato tuber, chemical means of sprout growth control is used mainly, unless, otherwise refrigeration is available whereas, cold storage is the possible means for seed potato storage without seed tuber damage but this kind of storage is expensive (Wiltshire and Cobb, 1996).

A study in Ethiopia on "Improving Potato Seed Tuber Quality" by Mulatu *et al.* (2005), showed that good storage conditions of potato seed tubers has resulted in long shelf-life of the seed potato (six to eight months) whereas, seed tubers stored for two months under inappropriate storage conditions resulted in weight loss, withering and depletion of reserved food leading to rotting and diseases build-up. This warrants the need for an appropriate storage conditions for increased net returns from potato cultivation. Farmers can sell their potato product as seed if they have appropriate storage facilities and benefited from premium market price (Mulatu *et al.*, 2005). The same study indicates that the farmers has discouraged from storing potato as seed for subsequent planting and market because of the high potato crop loss during storage. This calls for development and use of appropriate storage system in the country. Moreover, the inter-seasonal gap is about eight months and this makes using own saved seed tuber for the next production season more

difficult and farmers forced to purchase seed tuber for every growing season due to unavailability of appropriate storage methods under farmer conditions. The lack of appropriate storage condition causes inadequate supply of quality seed tuber at the time of planting which in turn constrains the overall potato production. Additionally, farmers are not aware of the cheapest but modern storage methods like DLS which reported to store potato tuber without loss for about six to eight months.

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 Thijssen (2008), 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.

According to Sileshi and Teriessa (2001) on their study about tuber damage by potato tuber moth in eastern Ethiopia, the quantity of potato which become available in the market is high during the harvest and the supply become very less in the later season. This is because farmers forced to bring their potato produce to market immediately after harvest due to fear of tuber deterioration since appropriate storage systems are not available, this call for development of improved potato storage facilities as far as quality and quantity of seed potato production as well as the profitability of potato producing farmers in the country are concerned.

PRE-PLANT TREATMENT PRACTICES AND SEED POTATO QUALITY

Treating the seed tuber used for planting with different pre-planting treatment inputs have paramount advantage in seed potato production since it enhance rapid development and vigour plant stand thereby help the crop to suppress weed in the early stage of the crop (Struik and Wiersema, 1999). Potato tuber is dormant immediately during harvest (Suttle, 2004; Yangta and Tong, 1993; Wiltshire and Cobb, 1996). The dormancy period stretch six to eight months depending on the storage temperature and variety (Yangta and Tong, 1993) and as potato tuber stored for long it starts sprouting (Suttle, 2004; Yangta and Tong, 1993). Timely sprout enhancing management is important (Wiltshire and Cobb, 1996) as far as quality of seed potato is concerned while sprouting results in quality loss for processing potato tuber (Suttle, 2004; Yangta and Tong, 1993). One of the most important factors which need emphasis in potato production is sprout management. Sprouting has a different effect on processing and seed potato production (Farre *et al.*, 2001; Suttle, 2004). For industrial processing, potato sprouting may cause economical loss whereas, stimulation of sprouting is advantageous in minimizing the period of seed dormancy in case of potato tubers used as a planting material (Farre *et al.*, 2001). In the case of processing potato tuber, sprouting inhibited by different synthetic chemicals whereas, seed potato growers threat the tuber with sprout enhancing synthetic chemicals (Suttle, 2004). According to Wiltshire and Cobb (1996), in addition to chemical treatment, temperature control system is also used to control potato tuber sprout formation in case of processing potatoes, whereas, exposing tuber to sunlight practiced in the case of seed tuber (Wiltshire and Cobb, 1996). In case of the processing tuber the demand of sprout inhibiting chemicals pronounced since innate tuber dormancy not able to keep the tuber dormant for long as required for better market price in the later season (Wiltshire and Cobb, 1996).

According to Suttle (2004), regulating potato tuber sprouting is the most important mean to keep the quality of seed potato tuber. Supply of quality seed tuber requires better control of dormancy and sprouting, since application of appropriate seed dormancy management technology allows wider cross country marketability, easy diseases management and to run potato breeding programme easily (Wiltshire and Cobb, 1996). Potato tuber sprouting process related with different physiological processes such as respiration, reduction of tuber sugar content and water loss (Suttle, 2004).

Sprout emerge early during the growing season enhance disease resistance ability of the potato crop which thereby contribute in increasing radiation capturing efficiency of the crop in the early stage (Pavek and Thornton, 2009). A study by Hartmans *et al.* (1995) showed that the loss of water increases due to the formation of sprout and decrease the shelf life of the tuber. To overcome this problem, different chemicals and other treatment methods are used. The seed dormancy needs to be broken in order to get an optimal performance of potato crop. The problem of potato seed dormancy is pronounced when two growing season practiced within one year. Under this situation, it needs manipulation of techniques to shorten dormancy period so as to increase early establishment and vigour of the sprout (Struik and Wiersema, 1999), thereby quality and productivity of the potato production system increased. According to Struik and Wiersema (1999), potato seed dormancy breaking using chemicals, seed tuber cutting and chitting as well as pre-sprouting are recommended to advance growth vigour of potato crop.

A study on assessment of the effect of whole seed and cut seed tuber size and pre-plant seed storage conditions on yield of potato by Arsenault and Christie (2004) indicated that the cut seed resulted in higher yield of potato tubers than the whole seeded seed tuber. Moreover, exposing the seed tuber to warmer condition and green sprouting before planting mentioned as a mean of pre-plant treatment so as to advance early ground cover and vigour of the potato crop stand (Arsenault and Christie, 2004). And also pre-plant application of phosphorus is recommended in potato crop to increase the crop yield (Hopkins *et al.*, 2010). According to Bethke and Busse (2010), application of herbicides on the stand of potato crop used to enhance potato crop maturity since the application of this herbicides result in leaf desiccation, which help to go fore on time harvesting thereby increase the quality of the tuber to use as a planting material forwards.

Farmers in Ethiopia apply different traditional techniques to sprout seed potato tuber on time (Agajie *et al.*, 2007). As illustrated by Agajie *et al.* (2007), putting in bags, putting in the warm place in the house, covering the tubers with crop residues, spreading on the sun, putting on the shelves of the Diffused Light Storage (DLS), mixing with ash and putting in bags and spreading on the ground are the methods of potato producing that farmers practiced to let the tuber to sprout early. According to Agajie *et al.* (2007) about 43% of the farmers simply waits until it sprouts by itself without applying any treatments to enhance sprouting before planting. Diseases occurrence and potato tuber physiological processes are the causes of tuber deterioration during the storage period of potato tuber and unregulated sprouting of tuber is one of the most important factors among physiological processes result in potato tuber deterioration (Suttle, 2004).

SEED POTATO QUALITY AND SOURCING

The quality of potato tubers used as a planting material determines the quantity and quality of final product in potato production (Struik and Wiersema, 1999). According to Almekinders *et al.* (1994), farmers can get seed tuber from different sources such as own previous harvest, neighbour farmers, local market and formal seed sectors. A study by Fuglie (2007) on the priorities for potato

research in developing countries including Ethiopia described that quality seed tuber availability gate higher priority rank by potato producing farmers in these countries. Furthermore, the problem of improved potato seed tuber availability and appropriate potato seed tuber management methods are severe for resource poor small-scale farmers. Majority of potato farmers in east Africa use local seed tuber as a sources of seed due to unavailability of improved seed (Fuglie, 2007). According to Gildemacher *et al.* (2009) and Getachew and Mela (2000), about 50% of the potato farmers in this region including Ethiopia use farm saved potato seed tuber during planting. Moreover, the farmers in Ethiopia use a potato tuber of inferior quality as a planting material which is less accepted by market to sell as a ware potato (Getachew and Mela, 2000). This is because of scarcity of potato seed tuber produced by specialized seed growers and also lack of awareness of the farmer about the appropriate size of tubers which result with vigor plant stand as well as better final yield.

According to Agajie *et al.* (2007), getting high quality/improved potato seed tuber is the main problem for most potato producing farmers in Ethiopia. As illustrated by Agajie *et al.* (2007), 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 (Agajie *et al.*, 2007).

Among the techniques that potato producing farmers apply to secure the quality of the seed tuber used for planting is sorting. Potato tuber sorting might done immediately after harvesting or during seed tuber preparation for planting based on the health condition and size of the tuber. According to Agajie *et al.* (2007), sorting is among the methods that potato farmers in Ethiopia use to prepare their seed potato for planting as well. As indicated in this same study farmers' sort-out the tuber of preferred size out of the mass harvest. 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 (Agajie *et al.*, 2007). This is because small sized tubers are preferable to cover large more land.

Renewing the seed lot have a paramount importance in seed potato production since continuous use of the tuber resulted in yield and quality decline due to accumulation of seed borne diseases over time (Gildemacher *et al.*, 2009). And also the tubers harvested from the same land not give good yield when it used for the next time in the same production environment, this forces the farmer to look for seed from other areas each season. According to Agajie *et al.* (2007), potato producing farmers in major potato producing areas of Ethiopia practice seed renewal, although the length of the season in which they practice renewal varies among farmers. Additionally, physiological age plays a great role in determining the quality of seed tuber. This is because physiological age of the potato tuber used as a seed modifies the morphological, physiological and agronomic characteristics of the crop (Caldiz *et al.*, 2001).

SEED POTATO MARKETING

These days potato is becoming a cash crop in Ethiopia and the introduction of improved varieties hasten the broadening of potato marketing, since seed potato create a better market price for the farmers than ware potato. 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 (Suttle, 2004).

POTATO UTILIZATION IN ETHIOPIA

Potato is one of the most important garden and cash crop in Ethiopia (Kassa, 2004). The crop able to grow on about 70% of the arable land in the country (Yilma, 1989). In some parts of the country potato grown as a garden crop for the purpose of household consumption in small plots, whereas it grown as a cash crop in major potato producing areas of Ethiopia. According to Aliye *et al.* (2008), a potato crop is among the most important income generating commodity for farmers in mid to high land parts of Ethiopia. Potato crop used for different purposes by the society across the country. Among these; household consumption, seed, income source and social purposes are the main one (Agajie *et al.*, 2007). As described by Getachew and Mela (2000), the level of potato production also varies based on the production objective, production for consumption and market. The production and use of potato crop as a household consumption is stretching rapidly in Ethiopia more than any other major food crops which is also true in developing country as a whole (Yilma, 1989).

CONCLUSION

Potato is among the most consumed crops worldwise. Although, the crop is important food crop, a wide ranging factors are hindering seed potato system such as; uses of traditional production technology, poor market demand, low price, lack of improved storage technologies and absence of improved pre-plant treatment techniques. On the other hand, the crop, adopts in wide range of agro-ecology and the crop also uses for different purposes. Therefore, as the improvement of the potato system and thereby the services obtained from the system is concerned the production system, transportation, storage, marketing and treatment methods should be improved through integrative study.

REFERENCES

Acasio, R.F., A. de los Santos and P. Vander Zaag, 1986. Acceptance of diffused light storage technology by potato farmers in the Benguet and mountain provinces of the Philippines. Am. Potato J., 63: 162-170.

Agajie, T., K. Wachira, M. Gebre, G. Wolde, L. Berga and N. Demeke, 2007. Adoption and impact of potato production technologies in selected districts of Oromiya and Amhara Regions of Ethiopia. Ethiopian Institute of Agricultural Research, Research Report.

Aliye, N., C. Fininsa and Y. Hiskias, 2008. Evaluation of rhizosphere bacterial antagonists for their potential to bioprotect potato (*Solanum tuberosum*) against bacterial wilt (*Ralstonia solanacearum*). Biol. Control, 47: 282-288.

Almekinders, C.J.M., N.P. Louwaars and G.H. De Bruijn, 1994. Local seed systems and their importance for an improved seed supply in developing countries. Euphytica, 78: 207-216.

Amede, T., L. German, S. Rao, C. Opondo and A. Stroud, 2006. Integrated natural resource management in practice: Enabling communities to improve mountain livelihoods and landscapes. Proceedings of the African Highlands Initiative Conference, October 12-15, 2004, Nairobi, Kenya, pp: 12-15.

Arsenault, W.J. and B.R. Christie, 2004. Effect of whole seed tuber size and pre-plant storage conditions on yield and tuber size distribution of Russet Burbank. Am. J. Potato Res., 81: 371-376.

Bethke, P.C. and J.S. Busse, 2010. Vine-kill treatment and harvest date have persistent effects on tuber physiology. Am. J. Potato Res., 87: 299-309.

Caldiz, D.O., L.V. Fernandez and P.C. Struik, 2001. Physiological age index: A new, simple and reliable index to assess the physiological age of seed potato tubers based on haulm killing date and length of the incubation period. Field Crops Res., 69: 69-79.

Champouret, N., 2010. Functional genomics of phytophthora infestans effectors and solanum resistance genes. Ph.D. Thesis, Wageningen University, Wageningen, Netherlands.

Davidson, T.M.W., 1958. Dormancy in the potato tuber and the effects of storage conditions on initial sprouting and on subsequent sprout growth. Am. Potato J., 35: 451-465.

Eberlein, C.V., P.E. Patterson, M.J. Guttieri and J.C. Stark, 1997. Efficacy and economics of cultivation for weed control in potato (*Solanum tuberosum*). Weed Technol., 11: 257-264.

FAO, 2008. Potato world Africa: International year of the potato 2008. Food and Agriculture Organization (FAO), Rome, Italy. http://www.fao.org/potato-2008/en/world/africa.html.

Farre, E.M., A. Bachmann, L. Willmitzer and R.N. Trethewey, 2001. Acceleration of potato tuber sprouting by the expression of a bacterial pyrophosphatase. Nat. Biotechnol., 19: 268-272.

Fuglie, K.O., 2007. Priorities for potato research in developing countries: Results of a survey. Am. J. Potato Res., 84: 353-365.

Gebre, E. and G.W. Giorgis, 2001. Effects of spatial arrangement on tuber yields of some potato cultivars. Afr. Crop Sci. J., 9: 67-76.

Getachew, T. and A. Mela, 2000. The role of SHDI in potato seed production in Ethiopia: Experience from Alemaya integrated rural development project. Proceedings of the 5th African Potato Association Conference, Volume 5, May 29-June 2, 2000, Kampala, Uganda, pp: 109-112.

Gildemacher, P.R., P. Demo, I. Barker, W. Kaguongo and G. Woldegiorgis *et al.*, 2009. A description of seed potato systems in Kenya, Uganda and Ethiopia. Am. J. Potato Res., 86: 373-382.

Hardy, B., P. Malagamba and C. Martin, 1995. True Potato Seed in the Middle East and Africa: Proceedings of an International Workshop Held in Cairo, Egypt, April 9-15, 1994. International Potato Center, Egypt, ISBN-13: 9789290601753, Pages: 97.

Hartmans, K.J., P. Diepenhorst, W. Bakker and L.G.M. Gorris, 1995. The use of carvone in agriculture: Sprout suppression of potatoes and antifungal activity against potato tuber and other plant diseases. Ind. Crop Prod., 4: 3-13.

Haverkort, A.J., P.C. Struik, R.G.F. Visser and E. Jacobsen, 2009. Applied biotechnology to combat late blight in potato caused by *Phytophthora infestans*. Potato Res., 52: 249-264.

Hesen, J. and A. Rastovski, 1985. Potato storage requirements and recommendations in the Netherlands and Belgium. Proceedings of the International Symposium on Potato Storage: Technology and Practice, June 27-29, 1985, Lansing, MI., USA.

Hirpa, A., M.P.M. Meuwissen, A. Tesfaye, W.J.M. Lommen and A.O. Lansink *et al.*, 2010. Analysis of seed potato systems in Ethiopia. Am. J. Potato Res., 87: 537-552.

Hopkins, B.G., J.W. Ellsworth, A.K. Shiffler, T.R. Bowen and A.G. Cook, 2010. Pre-plant versus in-season application of phosphorus fertilizer for Russet Burbank potato grown in calcareous soil. J. Plant Nutr., 33: 1026-1039.

Kassa, B., 2004. Ethiopia late blight profile: Diseases impact on the industry, consumers and country. Ethiopian Agricultural Research Organization, Holetta Agricultural Research Center, Addis Ababa, Ethiopia.

LeMonte, J.L., T.W. Taysom, B.G. Hopkins, V.D. Jolley and B.L. Webb, 2009. Residual soil nitrate and potato yield with polymer coated urea. Western Nutr. Manage. Conf., 8: 77-81.

Medhin, G., A. Solomon, E. Gebre and B. Kassa, 2000. Multi location testing of clones in Ethiopia. Progress Report, Ethiopian Agricultural Research Organization (EARO), Ethiopia.

Mulatu, E., O.E. Ibrahim and E. Bekele, 2005. Improving potato seed tuber quality and producers' livelihoods in hararghe, Eastern Ethiopia. J. New Seeds, 7: 31-56.

Muthoni, J., M.W. Mbiyu and D.O. Nyamongo, 2010. A review of potato seed systems and germplasm conservation in Kenya. J. Agric. Food Inform., 11: 157-167.

Pavek, M.J. and R.E. Thornton, 2009. Planting depth influences potato plant morphology and economic value. Am. J. Potato Res., 86: 56-67.

Pehrson, L., R.L. Mahler, E.J. Bechinski and C. Williams, 2010. Water management practices used in potato production in Idaho. Am. J. Potato Res., 87: 253-260.

Pringle, B., C. Bishop and R. Clayton, 2009. Potato Post-Harvest. CAB International, Cambridge, UK.

Rastovski, A. and A. Van Es, 1987. Storage of Potato: Post-Harvest Behaviour, Storage Design, Storage Practice, Handling. Institute for Storage and Processing of Agricultural Produce, Wageningen, USA., Pages: 468.

Sanginga, P., A. Waters-Bayer, S. Kaaria, J. Njuki, C. Wettasinha, 2009. Innovation Africa: Enriching Farmers Livelihoods. Earthscan, UK., ISBN-13: 9781844076710, Pages: 405.

Scott, G.J., R. Labarta and V. Suarez, 2013. Benchmarking food crop markets in Southern Africa: The case of potatoes and potato products 1961-2010. Am. J. Potato Res., 90: 497-515.

Sileshi, G. and J. Teriessa, 2001. Tuber damage by potato tuber moth, *Phthorimae operculella* Zeller (Lepidoptera: Gelechiidae), in the field in Eastern Ethiopia. Int. J. Pest Manage., 47: 109-113.

Struik, P.C. and S.G. Wiersema, 1999. Seed Potato Technology. Wageningen University Press, Wageningen, Netherlands, ISBN-13: 9789074134651, Pages: 383.

Suttle, J.C., 2004. Physiological regulation of potato tuber dormancy. Am. J. Potato Res., 81: 253-262.

Thijssen, M., 2008. Farmers, Seeds and Varieties: Supporting Informal Seed Supply in Ethiopia. Wageningen International, Wageningen, Netherlands, ISBN-13: 9789085852155, Pages: 347.

Verzaux, E., 2010. Resistance and susceptibility to late blight in Solanum: Gene mapping, cloning and stacking. Ph.D. Thesis, Wageningen University, Wageningen, Netherlands.

Visser, R.G., C.W. Bachem, J.M. de Boer, G.J. Bryan and S.K. Chakrabati *et al*., 2009. Sequencing the potato genome: Outline and first results to come from the elucidation of the sequence of the world's third most important food crop. Am. J. Potato Res., 86: 417-429.

Westermann, D.T. and G.E. Kleinkopf, 1985. Nitrogen requirements of potatoes. Agron. J., 77: 616-621.

Wiersema, S.G. and R.H. Booth, 1985. Influence of growing and storage conditions on the subsequent performance of seed potatoes under short-day conditions. Potato Res., 28: 15-25.

Wiltshire, J.J.J. and A.H. Cobb, 1996. A review of the physiology of potato tuber dormancy. Ann. Applied Biol., 129: 553-569.

Yangta, J.P. and C.B. Tong, 1993. Commercial postharvest handling of potatoes (*Solanum tuberosum*). FS-06239, University of Minnesota Extension Service, USA.

Yilma, S., 1989. The potential of true potato seeds in potato production in Ethiopia. Acta Hort., 270: 389-394.