QUALITY POTATO SEED A CHALLENGE FOR SMALLHOLDER FARMERS IN NORTH, WEST AND SOUTHWEST SHEWA ZONES OF CENTRAL HIGHLANDS OF ETHIOPIA

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Abstract: Participatory on-farm seed production has been carried out the year 2004 to 2006 at Jeldu, Dendi, Wolmera and Degem districts of central Ethiopia. The on-station seed production was under taken at Holetta and Jeldu experimental sites. To produce quality potato seed various rapid multiplication techniques (RMTs) were used. Thus, potato technologies were demonstrated and popularized using different methodologies such as the farmers’ field schools (FFS), the farmers research group (FRG) and filed days. To supply clean tubers about 30,719 high quality mini-tubers of improved varieties of Menagesha, Awash and Tolcha were produced. Moreover, a total of 257.08 tons of seed tubers of 15 released potato varieties were produced and disseminated in different parts of the country for research and demonstration. The participant farmers produce 204.6 tons of relatively clean seed tubers and sold to different parts of the country. During, this activity positive selection technique was demonstrated and participant farmers applied the techniques that helped them to improve the yield and quality of seed potato. Farmers obtained a 40% yield increase and a 33% vigor improvement when positive selection techniques were applied. Trainings on improved potato production and postharvest handling technologies and selection of vigorous healthy looking potato plants have also been given to farmers, development agents, agricultural experts and home agents in Oromia, regional states. A total of 1712 farmers from Oromia were trained. Training of farmers on the use of healthy seed tubers and other aspects of integrated disease management was found to be crucial in sustaining the availability of healthy seed tubers. Therefore, decentralized the production of quality potato seed improves the wealth of the producer and the producer farmers got an opportunity to be engaged in potato seed business and create creates awareness on various management techniques for disease and insect pests. Moreover, it reduces the movement of dangerous diseases like bacterial wilt and viruses from invading areas with high potential for seed production due to purchase of seed only from within one’s same region..

Key words: Potato, Informal Seed Production, Mini-tubers, Positive Selection, RMT
1. Introduction:

Potato (*Solanum tuberosum* L.) is among the major food crops grown in more than 100 countries in the world (Nyunza and Mwakaje, 2012), Ethiopia inclusive. Potatoes production in Ethiopia is more concentrated in Northwest, Central highlands, South & South east and Eastern parts of the country with rural districts but production is as low as 10 t ha\(^{-1}\) (Haverkort *et al*., 2010). Studies conducted by Gebremedhin *et al*. (2008) and Hirpa (2010) revealed that the potential average potato tuber yield in Ethiopia is 25-45 t ha\(^{-1}\) under optimal agronomic practices. Moreover, shortage or lack of high yielding, sufficient quantity of good quality seed potatoes is one of the most important constraints that limit both production and productivity of potatoes. In most areas of Ethiopia, among local farmers, it is a common practice to save the small and inferior tubers as seed that they cannot normally sell for consumption. It is believed that this practice has contributed to the build-up of high level of virus diseases in the locally grown potato cultivars in Ethiopia (Gebremedhin *et al*., 2008). In vegetatively propagated crops, reusing planting material over successive generations causes build-up of seed pathogens resulting in losses due to seed degeneration (Rahman *et al*., 2010).

In Ethiopia, potato production increased considerably through the 20th century. In 1975, the area of cultivation was estimated at 30,000 ha, with an average yield of approximately 5 tons/ha. By 2001, Ethiopia's potato area had grown to 160,000 ha, with average yields of around 8 tons/ha (Gebremedhin *et al*., 2001) and by 2014 the potato area had grown to 179,159 ha with average yields of around 10 tons/ha (CSA, 2014). Potato can still grow on 70% of the 10 million ha of arable land in the country (FAOSTAT, 2008). Low yields of potato in the tropics are attributed to a multitude of factors including, late blight (*Phytophthora infestans*), bacterial wilt (*Ralstonia solanacearum* E. M. smith) and limited availability of improved seed are the major constraints to successful potato cultivation (Sengooba *et al*., 2001). It was also reported that, repeated use of the same seed stock infested with different diseases has resulted in devastating disease epidemics, drastically reducing yields (Low, 1997). Shortage or lack of healthy, high yielding planting materials and the common practice among farmers of planting undersized potato tubers are some of the major limiting factors to production of potatoes in Ethiopia. Consequently, yields have remained persistently below 8 t/ha in comparison to over 35 t/ha attainable under research condition and over 25 t/ha on farmers fields using the improved potato technologies (Gebrmedhin *et al*., 2008), despite the area under potato cultivation having expanded almost four-fold from 30,000 ha in to 160,000 ha in 2001(Gebremdhin *et al*., 2001).

Quality seed of an improved potato variety is a key to increase the productivity of a potato crop. The genetic potential and other traits of a potato variety are determined or manifested by the use of healthy
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Seed (Endale et al., 2008). Unavailability of healthy seed tubers in the required quantity and quality is probably the most important in contributing to the low yield in Ethiopia (Berga and Gebremedhin, 1994). Absence of seed certification system and certified seed tubers is a major constraint to potato production in Ethiopia. As a factor of seed shortage farmers commonly plant tubers obtained by saving from a previous seasons’ crop or by purchasing from neighbors or market places. However, such tubers have a high potential of harboring tuber-borne diseases such as bacterial wilt and those caused by viruses. Thus, planting of disease free seed tubers has been recognized as a very important aspect in boosting potato yields and controlling diseases, other components of integrated management can then be applied more reliably and effectively. Holetta Agricultural Research Center (HARC) has the national mandate to produce basic seed tubers (Breeder’s seed) but can only supply few starter seed for the national requirements due to several reasons. In many African countries including Ethiopia efforts are under going to strengthening seed production programs. The use of informal or participatory seed tuber production has been implemented in the last few years in collaboration with the international potato center (CIP) and Regional Potato and Sweet Potato Improvement Program in Eastern and Central Africa (PRAPACE). Therefore, this system has been seen as best alternative in developing countries where there are no formal seed systems.

To minimize this challenge, from 2004-2006 Holetta Agricultural Research center (HARC) began promoting improved potato technologies and the adoption of positive selection (PS) and farmers practices (FP) in the central highlands of Ethiopia where potato production is a major food security and cash crop in the country. The potato team of HARC has been offering technical support and encouraging smallholder farmers who can produce seed on their own to adopt and demonstrate quality seed in potato production through FFS using PS. In a participatory approach with farmers, trials comparing seed generated from positive selection and seed obtained through farmers’ practices were demonstrated.

Potato is the major food and cash crop after barley in West Shewa and North Shewa Zones. The farmers in this area are the source of seed potatoes for most parts of the country. Moreover due to mono-cropping of the potato crop, the local variety that has been used as a source of seed for years has been degenerated. Thus, improved and late blight tolerant potato varieties are introduced to the farmers in these areas via participatory on-farm seed production to popularize improved potato technologies and mitigate the shortage of quality potato seed. In addition lack of storage facilities, farmers usually use sacks or pile potatoes in dark/shade. The farmers also use a piece meal harvest in extended harvesting system where the tubers are left for months until the next harvesting. In the process, the tubers become infested with potato tuber moth, red ants and other soil born potato diseases as well as wild animals. As a result the tubers will not be in their optimum health & physiological stage for planting. This results into
poor establishment and eventually very poor growth and yield; thus, the use of improved varieties, improved production technologies and diffused light store should be demonstrated to the farmers.

The main challenge of the informal seed potato production system in most African countries is suggested to be lack of rigorous seed health testing and certification (Sengooba et al., 2001). This makes it difficult to sustain distribution of healthy seed tubers to farmers. As a way of increasing the availability of satisfactory healthy seed tubers to resource poor small-scale farmers, a participatory seed potato tuber production was started in the central highlands of Ethiopia (Wolmera, Jeldu, Kersana Malima, Dendi and Degem) districts.

Objectives:

- To evaluate the improved potato seed production package on farmers field.
- To integrate the use of diffused light store (DLS) in the seed system.
- To determine the efficiency of positive selection technique against farmers practice in improving the quality of potato planting material.
- To train farmers on the production of clean and healthy seed potatoes in a sustainable manner.
- To gain experience on farmer-based seed potato production system in the intervention districts.

2. Materials and Methods:

2.1. On station seed production

2.1.1 Tissue culture:

Even though the technique is at its early stage, there has been an attempt to improve production of healthy/high quality planting materials. Different rapid multiplication techniques (RMT) have been in use for bulking up of selected materials for distribution to growers.

2.1.2. Multiplication and Distribution of Healthy Potato Planting Materials:

The supply of healthy planting material is of prime importance in promoting potato production in Ethiopia. The ultimate availability of adequate planting material of desired varieties has been one major drawback in production. As potato is fast becoming of high value for household consumption and income generation, its cultivation is gaining more attention. Dissemination of information and technologies is a critical aspect in the promotion of potato. Technology transfer has therefore become the key component of the potato project at Holetta research center in the last six to eight years.

The Holetta research center aims at increasing and improving production of potato in Ethiopia through promoting the use of planting material of superior performance. Pathogen free planting material of selected varieties is multiplied at Holetta and Jeldu centers and distributed to growers in selected districts of the country. The selection of the districts is based mainly due to their potential to grow healthy seed tubers and proximity to the research center.
2.2. Participatory informal seed production

The farmer based seed production was carried out at Wolmera, Dendi, Jeldu, Degem and Kersana Malima districts. To disseminate the improved technologies of potato seed tuber production, Farmer Field Schools /FFS/ and Farmer Research Groups /FRG/ organized for the activities on Integrated Disease Management (IDM), Integrated Nutrient Management (INM) and Post harvest handling (PHH) were used for the implementation of the activity. Each FFS is constituted from an average of twenty five members and each FRG had five members. On the other hand, follow ups have been made to other potato producing farmers in the respective districts to monitor their field for cleanness from pests, diseases and off-types. Improved potato varieties released by HARC have been used for the activity. Apart from the ones delivered by the center other farmers have managed to obtain the seeds from neighboring farmers through sales and seed exchange. All the agronomic practices have been carried out as per the recommendation of HARC for potato production. Planting was conducted during the early of June during all the three years for the demonstration activities. Recommended rates of inorganic fertilizer was used at 195 kg ha\(^{-1}\) and 165 kg ha\(^{-1}\) of DAP and Urea, respectively, and side dressed at time of planting. A supplementary single spray of Ridomil Gold against late blight was practiced in each location at a rate of 2 kg per ha\(^{-1}\).

2.2.1. Positive selection

Positive selection (PS) involves identification and marking of healthy looking plants for seed generation. The positive selection activity was implemented on formerly established six FFSs at Jeldu and Dendi districts. The experiment has been implemented from 2004 to 2006 at three locations in Jeldu district using improved varieties which are being multiplied by farmers. In 2004 initial stock has been selected from the farmer stock and was stored separately to be used for the experiment for the next season. The experiment has been laid out in RCB design in three replications at each site. A plot size of 3.75m x 4.8 m was used to accommodate 80 plants per plot. All the agronomic practices were conducted as per the recommendation. Positive selection was conducted using wooden pegs to mark vigorous and healthy looking plants just before flowering, and these plants were harvested and stored separately to be used again for the next season.

Management of the potato field was carried out by participant farmers, and they have cultivated the crop twice during the growing period (20 days after emergence and just before canopy closure). Two field sessions have been organized in a growing season; one on importance of the activity and selection procedures and the second on harvest considerations in implementing the activity. Training was given on selection techniques of elite materials at field level for disease free seed, optimum tuber size and construction and the use of Diffused Light Store (DLS) to ensure improved and quality seed tuber production at farmer’s level. Participant farmers were advised to retain the potato
seed tubers for the next planting season in the DLS they constructed. Therefore, Geldmacher et al. (2011) reported that the practice of positive selection can easily improve the quality of seed in farmers’ field. The technique and procedure is simple and can easily be transferred to subsistence potato farmers through farmer field school. The relative efficiency of this technique in improving seed quality has not been evaluated in the study areas before 2004.

2.2.2. Training

Intensive and extensive trainings have been organized to potato producer farmers, development agents (DA), agricultural extension experts of MoARD and NGO in Oromia, Amhara, Tigray, and SNNP regional states which focused on clean seed potato production and handling, post harvest management of ware and seed potatoes and different recipe preparation from potato. These trainings have also been given to FFS participants on integrated disease management (IDM), integrated nutrient management (INM) and post harvest handling. The basic methods used for the training were both on-station and hands-on on-farm approached based on the situation and convenience. Rigorous discussions have also been made with the trainees regarding the subject in question. To effectively convey the information various demonstrations and visiting have been organized in all the three years.

3. Results:

3.1. The Multiplication and Distribution Scheme:

In this program high quality planting materials which are either imported from CIP regional coordination center at Nairobi or multiplied at Holetta tissue culture laboratory are distributed to growers and different research centers for seed production or research purposes. A total of 257.08 tons of seed potatoes of fifteen released potato varieties have been produced on-station at Holetta and Jeldu from 2004 – 2006. The distribution of the materials to farmers was practiced using farmer groups organized in to farmer field schools or farmer research groups. This had led the foundation of reaching more farmers at a place and time.

The healthy planting materials/stocks multiplied using rapid multiplication technique /RMTs are of the selected varieties which are maintained under strict hygienic conditions in an insect proof screen house. Subsequent propagation is carried out using rooted cuttings in the screen house to obtain enough planting material before they are planted in open field. By using this technique it was possible to produce 30319 mini-tubers during the three years (Table 1). These materials have been induced to the center’s seed production program and have played a paramount role in regenerating the materials at hand.

<table>
<thead>
<tr>
<th>No</th>
<th>Name of Varieties</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tolcha</td>
<td>12300</td>
<td>8335</td>
<td>4707</td>
<td>25342</td>
</tr>
<tr>
<td>2</td>
<td>Menagesha</td>
<td>2768</td>
<td>2609</td>
<td>-</td>
<td>5377</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15068</td>
<td>10944</td>
<td>4707</td>
<td>30719</td>
</tr>
</tbody>
</table>

Table 1: Yield of mini tubers obtained from two potato varieties using RMT

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3.1.2. Participatory seed production

For participatory seed potato production FFS and FRG were organized based on request from districts BoA to access quality planting materials and technology popularization. Thus, only farmers who were willing to be involved in the Farmers’ Field School (FFS) and Farmer Research Group (FRG) were selected. Farmers were encouraged to allocate their plots necessary for the trials and conduct seed production. Member farmers fully participated in the management of the trials: planting, fertilization, weeding, and cultivation, which were done according to research recommendations. Both farmers and researchers followed up the trials and researchers made periodic observations. In general, selection was made using the earlier set criteria, including willingness of the farmer to be a potato seed grower, willingness to work in a group, and capacity to build DLS for seed storage. Based on these criteria, 20–25 farmers were selected per site in the first season (2004) for FFS and 12-15 farmers for FRG where five them are female house head. Selection and organization of FFS and FRG continued in the following seasons using the same procedure, but more than one group of FFS per site. Many farmers were willing to participate in such activities after observing the performance of the improved potato varieties under rainfed conditions and the benefits of participant farmers. A total of 1712 farmers participated from both FFS and FRG from Oromia regional states were trained on clean potato seed production and post-harvest management. In general, organized farmers got additional training on potato late blight (LB) management, seed and ware potato production, and storage technologies in workshops and discussions. These groups were getting strong technical backup of researchers and extension agents of Bureau of Agriculture at local level throughout the project period. Therefore, about six different improved potato varieties were demonstrated and popularized in three districts and a total of 442.9 tons of relatively quality seed potato produced over period of three years.

3.2.3. Positive selection activity

A total of six FFS were selected to undertake the positive selection training and the experiment was undertaken on three FFS fields. A total of 140 farmers have been trained on the practice from the six farmer field schools. Therefore, the practice of positive selection was implemented using framers’ seed stock, which was retained from previous year’s potato harvest. In order to implement the training effectively, two field sessions were organized by facilitators and their guides were prepared. Thus, the first session was on positive selection procedures and was given when the crop was at its early flowering stage. The second session was on considerations during harvesting management of tubers and this session was given during harvesting. In the sessions given participant farmers were taught on the importance of positive selection activity and its benefits in improving the seed stock quality. In addition to the 140 participant farmers, the district office of MoARD has invited more than 200 farmers to participate on the field day, which was organized by HARC at Jeldu district.
In the experiment conducted, significant differences have been observed in yield, Average Tuber Weight (ATW) and plant vigor between positive selection and farmers practices. A yield advantage of 39.5% has been obtained in adopting positive selection technique and a 22.6% increment has been obtained in ATW in the positively selected treatment over the farmer practice. Plant height was not significant, but plant vigor was significant and a 33% advantage was obtained in adopting positive selection practice (Table 2).

Table 2: Summary results of the positive selection experiment conducted at Jeldu district (2005 – 2006)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (t/ha)</th>
<th>ATW (g)</th>
<th>Plant height (cm)</th>
<th>Plant Vigor (1-5*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive selection</td>
<td>60.09 A</td>
<td>95.47 A</td>
<td>60.98 A</td>
<td>4 A</td>
</tr>
<tr>
<td>Farmers practice</td>
<td>43.06 B</td>
<td>77.88 B</td>
<td>60.88 A</td>
<td>3 B</td>
</tr>
<tr>
<td>CV (%)</td>
<td>27.6</td>
<td>24.54</td>
<td>33.9</td>
<td>26.6</td>
</tr>
</tbody>
</table>

* 1 least vigor and 5 vigorous

3.2.4. Training and Demonstrations

Since 2004 training has been offered to 1712 farmers in Oromia regional states which emphasize on potato production and post harvest management techniques. The main aims of the training workshops were to increase and improve potato production through capacity building by imparting appropriate knowledge and skills. Trainees for this activity include farmers, development agents from extension department of MoARD, technicians and extension workers from NGOs. Trainings are conducted through lectures, discussions, field sessions and field days. Participants are provided with important production guides and notes to complement the training. In most cases farmers were organized in to groups either farmer filed schools (FFS) or farmers research group (FRG) in order to be effective and address more farmers.

Demonstrations of improved agronomic practices are organized on field days for the selection and evaluations of new varieties. This will facilitate information exchange and distribution of materials among the end users. Scientific results and recommendations on the production of potato are relayed to non-institutional members through local publications viz. pamphlets, leaflets, fliers and production guide. Through these approaches a vast number of farmers have benefited from the information provided. Training of farmers on the use of healthy seed tubers and other aspects of integrated disease management, to incorporate field sanitation/hygiene, is an important consideration if the informal potato seed production is to realize its potential impact of increasing the availability of disease-free seed tubers.

4. Discussion and Conclusions:

The dissemination of potato production technologies through demonstration started in the early 1990s in Wolmera district of West Shewa Zone. Since then, demonstration program has continued and expanded to cover other major potato growing areas in the zone and beyond. Lack of sustainable seed potato production system has been a major problem in the diffusion of improved potato varieties and expansion of potato production in Ethiopia. There is no government or private agency,
which produces and distributes seed potatoes in the country. Therefore, farmers resort to the available local varieties which are susceptible to late blight and produce very low yield as the degeneration, modified planting time, etc. Potato seed transported from long distance is very expensive, requires intensive management and it may not reach at an optimum physiological condition at the destination. In the absence of seed potatoes producing agency, an informal and farmer-based seed potato production system is an alternative. The system enables farmers get appropriate improved varieties, relatively healthier & sound seed potatoes than the local varieties and seed at an appropriate physiological age for planting. Moreover, it enables farmers build diffused light store (DLS) for the storage of seed potato tubers. The system could also serve as a means of disseminating improved potato technologies to farmers.

Beside demonstration efforts, dissemination of information using different outlets has created some level of awareness on the side of potato growers on available improved production technologies. These include farmers’ field days, distribution of pamphlets, trainings of farmers and subject matter specialists, and use of different mass media. The creation of awareness has been demonstrated by the multitude of growers and development agents, both from GOs & NGOs, who have been coming from far away from places to West Shewa seeking for seed tubers of improved potato varieties from successful potato tuber seed growers. Specific joint projects namely CIP, PRAPACE, IFAD-FFS-Ethiopia and AHI coordinated by EIAR have also contributed considerably for potato technologies transfer efforts to farmers. Moreover, farmer-to-farmer improved potato tuber seed and information exchange has played key role in the dissemination of improved potato production technologies.

From this activity it can be concluded that informal seed production in the farmers’ field contributed in producing healthy and sufficient seed tuber. Thus, in addition to seed tuber production going on in the research stations, informal seed production in the farmers fields has now become a major practice which helps farmers to get relatively clean and sufficient seed for the next cropping season and also benefit from selling to other users. The system enabled farmers to get improved varieties, relatively healthier and sound seed potatoes than the local varieties and seed at an appropriate physiological age of planting.

5. Recommendations:
The following recommendations could be drown which have a pivotal role in the clean seed production effort.

- Strengthening and expanding the capacity of the HARC in multiplication and distribution of high quality planting material.
- Establishment of more farmer owned potato seed producing FFS and FRG that will be promoted to more functional seed producers’ cooperatives.
• Introduction and dissemination of new suitable improved potato varieties for the specific localities.

• Strengthening the post harvest technologies of potato for sustainable production of the crop.

• Strengthening the training program for farmers, development agents, subject matter specialists and regular periodic technical backstopping to producers.

• Establishing seed certification scheme for sustainable seed potato tuber in the country.

To satisfy the increasing need for potato seed tubers in the country, finally, it is highly recommended that the informal seed sector should be highly strengthened and its potential built until there is a well established formal seed production system.

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