Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.9, No.22, 2019

# Performance of Potato (Solanum tuberosum L.) varieties Using True Potato Seed (TPS) at Gerado, Northeastern Ethiopia

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**Abstract**
Potato is one of economically important crop in Ethiopia. However, the average yield is far below the potential due to many challenges like lack of improved variety and quality seed potatoes. True potato seed is alternative seed source for potato production with many advantages, particularly where seed tubers is hampered by diseases. TPS used in Ethiopia, is negligible but it is likely to gain thrust in future particularly where quality seed tubers are either not available or expensive. Therefore, this study was conducted to evaluate the performance of potato varieties established by open-pollinated TPS seedling for yield and yield components. Eight potato varieties (Local, Bulle, Challa, Dagim, Gudanie, Jalenie, Shonkolla and Zengena) were established by open-pollinated TPS seedling for yield and yield components. The experiment laid in Randomized Complete Block Design with three replications. The results revealed that a significant variation in most traits was observed. The highest plant height (118.87cm) was recorded from Zengena. Bulle scored the highest marketable, unmarketable, total tuber number and marketable tuber yield per hill was 25.31, 26.03, 51.34 and 1.1117kg respectively. Local scored the highest tuber weight (1.2949 kg hill$^{-1}$) and tuber yield (54.44 ton ha$^{-1}$) but not significant different with Bulle, Gudanie, Dagim and Challa varieties due to its highest unmarketable tuber yield (0.3296 kg hill$^{-1}$). The result of the study reviled that the open-pollinated potato varieties established through TPS have a great influence on yield and yield components of potato. Bulle variety has been recommended in all yield and yield components than others.
**Keywords**: Potato, variety, Tuber number, Tuber yield, Tuber weight, True Potato Seed (TPS)
**DOI**: 10.7176/JNSR/9-22-02
**Publication date:** November 30th 2019

**Background**

Potato (*Solanum tuberosum* L.) is the most important vegetable crops of Solanacea family in the world (Abubaker *et al*., 2011). Currently, potato is grown in worldwide especially in temperate climate though the production increases rapidly in tropics. Worldwide more than 320 million tonne of potatoes are being produced annually on 20 million hectares of land (FAO, 2010). Potato is regarded as a high-potential food security crop because the crop produces large quantities of dietary energy (30-35 t ha$^{-1}$ starch based produce within 3 to 4 months) and has relatively stable yields under conditions in which other crops may fall (Gebremedhin *et al*., 2008; FAO, 2010).

In Ethiopia, potato is one among the most economically important crops as a source of food and cash in the country (Adane *et al*., 2010). Potato production in Ethiopia has increased from 349,000 tons in 1993 to around 932,701 tons in 2017 (FAOSTAT. 2019) and can potentially be grown on about 70% of arable land in the country (CSA, 2008/2009). However, the current area cropped with potato (about 160,000 ha) is small and the average yield (less than 10 tons ha$^{-1}$) which is far below the potential of the crop (Adane *et al*., 2010). The low acreage and yield of potato in Ethiopia are attributed to many factors, such as lack of improved crop variety to specific environment and high-quality seed potatoes, degenerative diseases associated with the tuber, inappropriate agronomic practices, late blight and absence of proper pest management practices, unavailability of proper transport, storage and marketing facilities are the prominent ones (Tekalign and Hammes, 2005; Kefelegn, *et al*., 2012)

Potato is mainly propagated through seed tubers (Malagamba *et al*., 1983; Struik and Lommen, 1999). However, tubers are usually bulky and expensive accounting for more than half the total production cost (Mahmood, 2005; Woods and Martin, 1987). However, low yield could easily be doubled or tripled through using quality seed (Schulz *et al*., 2013). Moreover, tubers are often the main carrier of diseases and pests (Simmonds, 1997; Zitter and Gallenberg, 1984) that attributed to seed degeneration (Gildemacher *et al*., 2007) which leads to lower yields and tuber quality considerably. Poor quality seed potato is believed to be one of the major factors contributing to low potato yield in Sub-Sahara Africa (Fuglie, 2007). This has been accelerated by the informal seed distribution system prevailing in most developing countries accounting for more than 90% of the seed tuber used by smallholder farmers (Hidalgo *et al*., 2009; Lung'aho *et al*., 2010).

True potato seed (TPS) has been suggested as an alternative seed source for potato production, particularly in countries where the use of conventional seed tubers is hampered by large storage losses (Hoang *et al*., 1988) or infestation with tuber transmitted diseases (Bofu *et al*., 1987; Fernandez *et al*., 1988), because TPS carries few pathogens especially viruses from season to season (Malagamba *et al*., 1983; Burrows and Zitter, 2005). About 2 tonnes of seed tubers which also represent food is required to plant in one hectare which can be replaced by 100-150 gms TPS (Rowell *et al*., 1986; Mahmood, 2005). TPS appears today as a viable and promising alternative method of potato propagation in the tropics (Cioloca *et al*., 2012; Golmirzaie and Ortiz, 2004; Kidane-Mariam *et al*., 1985; Malagamba, 1988) which can reduce the cost of production.

The use of true potato seed (TPS) had many advantages over the use of seed tubers and attractive for small-scale farmers in developing countries **(**Almekinders *et al*., 2009 and Cioloca *et al*., 2012**).** It includes the small mass of seed required to sow, transportation and storage of TPS are safe, easy and inexpensive, long-term TPS seed storage, low seed costs and most seed-borne diseases are not transmitted through the true seed (Rowell *et al*., 1986) and reduces production cost (Accatino and Malagamba, 1982). In spite of the fact that TPS provides the above mentioned importance its production and use in Ethiopia, in particular in northeaster Ethiopia is negligible but it is likely to gain thrust in future particularly in the area where quality seed tubers are either not available or are too expensive. Hence, this research was conducted to check the performance of potato varieties for yield and yield components through TPS at Gerado, northeastern Ethiopia.

## MATERIALS AND METHODS

### Site description

The study was conducted during 2017 dry season on Gerado farmers training center, Dessie, Northeaster, Ethiopia. It is located at 11°07′59″N and 39°37′59″E at an elevation of 2300 m.a.s.l. The average annual minimum and maximum temperatures of the district is about 6ºC and 26ºC, respectively. The annual average rainfall of the district ranges 900-1000mm with bimodal distribution. The soil type of the site is heavy clay soil.

### Experimental materials, procedures and design

Eight open-pollinated (OP) TPS varieties (Local, Challa, Dagim, Zengena, Gudanie, Bulle, Shonkolla and Jalenie) were produced during rainy season of 2015 at Gerado farmers training center, Northeaster Ethiopia. Seed dormancy breakage was done through soaking of seeds for 24 hours and air dried. Then seed germination test was done for each variety and scored above 80%. The true potato seedlings were raised from these eight open pollinated (Local, Challa, Dagim, Zengena, Gudanie, Bulle, Shonkolla and Jalenie) varieties in 1 $m^2$ nursery beds at at the same area during dry season of 2016. To do so, seeds were drilled in 2 cm deep in rows spaced with 10 cm. After sowing, seed beds were mulched with dried grass till 50% of seeds emerged and the mulch was removed and shades were constructed. The shade was thinned down gradually and removed about one month after emergence. The nursery beds were watered daily and gradually reduced near to transplanting time.

Seedlings were transplanted on wet soil after 2 months of sowing. The urea fertilizer was split applied during transplanting and one month later at the rate of 165 kg $ha^{-1}$ and Diammonium phosphate (DAP) during transplanting at 195 kg $ha^{-1}$ (Shunka *et al*., 2016). First Irrigation was given just after transplanting and subsequent irrigations were given as and when required. Weeding was done manually whenever needed. Earthing-up was done twice at the first and second months after transplanting which promotes stolon production that develops in to tubers.

The experimental plots were laid out as a randomized complete block design with three replications. Each plot was 3 meter wide and 3 meter long with 1 m and 1.5 m spacing between plots and blocks respectively. Each plot contained 4 rows with 10 plants per row. Vigor and healthy potato seedlings were planted at 30 cm and 75 cm of intra row and inter row spacing respectively.

### Data collection and analysis

Both the growth and yield parameters were collected from the central rows. The parameters collected were plant height (cm)**,** number of stems per hill, marketable and unmarketable tuber numbers per hill, marketable and unmarketable tuber weight per hill (kg), average tuber yield per hill (kg) and total tuber yield (t $ha^{-1}$). The collected data was subjected to the analysis of variance (ANOVA) by using SAS (Statistical Analysis System) version 9.2 (SAS, 2008). Least significant difference (LSD) test at 5% probability was used for mean comparison of the treatments.

## RESULT

### Plant height and Stem number per hill

The analysis of variance revealed that the effect of varieties was highly significant difference ($P<0.01$) on plant height. Zengena had highest plant height (118.87cm) than any of the varieties established through TPS seedlings. The lowest plant height (83.27) was recorded from Challa variety but did not show significance difference with Local, Bulle, Shonkola and Jalenie varieties (Table 1). Also, the difference in mean of stem number per hill ($p > 0.05$) showed non-significant variation. Despite the fact that stem density is one of the most important yield components in potato, the results showed that the influences of varieties on stem number were non-significant (Table 1).

### Marketable and unmarketable Tuber Number per hill

Differences in mean marketable tuber number between varieties were significant ($P \leq 0.05$) difference. Bulle scored the highest marketable tuber number (25.31) while the lowest number of marketable tuber of 11.47 was recorded for Zengena variety, however it was not significant different with Chala, Dagim, Shonkolla and Jalenie varieties (Table 1). Similarly, there was significant ($P \leq 0.05$) difference amongst varieties in number of unmarketable tuber number. Bulle variety scored the highest number of unmarketable tuber (26.03) which was not significantly different from the number of unmarketable tuber of Local variety (19.65). The lowest number of unmarketable tuber (8.98) was recorded for Dagim variety but not significant different with Chala, Gudanie, Shonkolla and Jalenie varieties (Table 1).
Table 1:-

### Total tuber number per hill

Varieties showed significant difference ($P \leq 0.05$) on total tuber number per hill. The highest (51.34) total tuber number per hill was recorded from Bulle variety. The lowest number of total tuber (23.13) was recorded for Shonkolla variety but not significant different with Chala, Dagim, Zengena, Gudanie and Jalenie varieties (Table 1).

### Marketable and unmarketable tuber weight per hill

Varieties had significant ($P \leq 0.05$) effect on weight of marketable tuber. The highest weight (1.1117kg) of marketable tuber yield per hill was obtained from Bulle variety but not significant different with Local, Dagim and Gudanie varieties. The lowest weight (0.4907kg) of marketable tuber yield per hill was recorded from Zengena variety but not significant different with Challa, Shonkolla and Jalenie varieties (Table 2). Similarly, variety showed significant ($P \leq 0.05$) effect on weight of unmarketable potato tuber (Table 2). The highest weight of unmarketable tuber yield per hill (0.3296 kg) was obtained from Local variety but not significant different with Zengena variety. Whereas, the lowest weight (0.1219kg) of unmarketable tuber yield per hill was obtained from Dagim variety but not significant different with all varieties except Local and Zengena (Table 2).

### Tuber weight per hill

Variety showed significant ($P \leq 0.05$) difference on total weight of tuber (Table 2). The highest tuber weight per hill (1.2949 kg) was recorded from Local variety however, it was not significant different with Bulle, Gudanie, Dagim and Challa varieties. The lowest tuber weight (0.6810 kg) was recorded from Shonkolla variety but not significant difference with all varieties except Local, Gudanie and Bulle.
Table 2:-

### Tuber yield

Varieties showed significant ($P \leq 0.05$) effect on tuber yield (ton $ha^{-1}$). The highest tuber yield (54.44 ton $ha^{-1}$) was recorded from Local variety but not significant difference with all except Zengena, Shonkolla and Jalenie varieties. However, the lowest tuber yield (27.16 ton $ha^{-1}$) was recorded from Shonkolla but not significant different with all varieties except Local, Gudanie and Bulle varieties (Table 2).

## DISCUSSION

### Plant height and Stem number per hill

The effect of varieties produced via TPS was highly significant difference on plant height.. Similarly, Bilate and Mulualem, (2016) and Stephen *et al*., (1997), reported that TPS hybrids grown from tubers showed significant difference on plant height. But, Sikka and Kanzikwera (1993), reported that varieties produced through TPS transplants grown at both highland and mid-elevation did not show significance difference on plant height. This might be due to gene by environment interaction.

While, the difference in mean of stem number per hill did not show significant variation among varieties. Despite the fact that stem density is one of the most important yield components in potato, the results showed that the influences of varieties on stem number were non-significant this could be the effect of the environment. This result is contradicting with that of Bilate and Mulualem (2016), Nizamuddin, *et al*., (2010) and Morena *et al*., (1994) who showed that the number of stems per plant is influenced by variety produced through TPS transplants and seed tubers.

**Marketable and Unmarketable Tuber Number per hill**

The marketable tuber number per hill were significant difference among varieties. Similarly, potato varieties grown from seed tubers showed significant difference on marketable tuber number per hill (Bilate and Mulualem, 2016; Gebreselassie *et al*., 2016). The difference in marketable tuber number might be due to varietal characters.

Similarly, significant difference on unmarketable tuber number per hill was recorded amongst varieties. Also Gebreselassie *et al*., (2016), reports that potato varieties grown from seed tubers showed significant difference on unmarketable tuber number per hill. This variation observed for unmarketable tuber yield could be varietal differences (Bilate and Mulualem, 2016). Moreover, unmarketable tuber yield might be controlled more importantly by manipulating other factors such as disease incidence, harvesting practice, etc. (Berga *et al*., 1994).

**Total tuber number per hill**

Varieties showed significant difference on total tuber number per hill with highest (51.34) total tuber number per hill from Bulle variety. Similarly, the seedling tubers from true potato seed (TPS) showed a significant difference in tuber numbers among varieties (Cioloca *et al*., 2012; Nizamuddin, *et al*., 2010; Okonkwo and Chibuzo, 2002; Tuku *et al*., 1994). But, Sikka and Kanzikwera, (1993) reported that varieties produced through TPS transplants grown at high land and mid-elevation show non-significance and significance difference on tuber number per hill respectively. This might be due to gene by environment interaction.

**Marketable and unmarketable tuber weight per hill**

Varieties had significant difference on weight of marketable tuber and unmarketable tuber weight per hill. Stephen *et al*., (1997), also, reported that TPS hybrids grown from tubers showed significant difference on marketable tuber yield per hectare. Similarly, other researchers also investigated that marketable yield was significantly varied by variety (Bilate and Mulualem, 2016**;** Gebreselassie *et al*., 2016; Elfinesh, 2008; Kumar *et al*., 2007; Pandey *et al*., 2004) which correlated with this finding. Also, potato varieties grown from seed tubers showed significant difference on unmarketable tuber weight per hill (Bilate and Mulualem, 2016). The variation in non-marketable yield of the genotypes may be due to adaptability, crop maturity and inherent ability of potato genotypes in producing unmarketable tubers per plant (Gebreselassie *et al*., 2016).

**Tuber weight per hill**

Variety showed significant difference on total tuber weight per hill. Similarly, the seedling tubers from true potato seed (TPS) showed a significant difference in tuber weight per plant among varieties (Cioloca *et al*., 2012). The variation in weight of tubers may be due heredity and adaptability or establishment effect of other growth attributes which influences differently on different varieties (Gebreselassie *et al*., 2016; Patel *et al*., 2008; Kumar *et al*., 2007; Muthuraj *et al.,* 2005; Azad *et al*., 1997).

**Tuber yield**

Varieties showed significant effect on tuber yield (ton ha$^{-1}$). The highest tuber yield (54.44 ton ha$^{-1}$) was recorded from Local variety but not significant difference with all except Zengena, Shonkolla and Jalenie varieties. However, the lowest tuber yield (27.16 ton ha$^{-1}$) was recorded from Shonkolla but not significant different with all varieties except Local, Gudanie and Bulle varieties (Table 2). Similarly, potato varieties established in TPS seedling transplants and seed tubers showed significant difference among varieties (Stephen *et al*., 1997; Nizamuddin, *et al*., 2010; Okonkwo and Chibuzo, 2002; Tuku *et al*., 1994). This suggestion is in agreement with other authors who reported that yield differences among genotypes were attributed by the inherent yield potential of genotypes (Bilate and Mulualem, 2016; Gebreselassie *et al*., 2016; Elfinesh, 2008; Asmamawu, 2007). But, potato varieties produced through TPS transplants grown at both highland and mid-elevation did not show significance difference on tuber yield (Sikka and Kanzikwera, 1993). This might be due to gene by environment interaction.

**CONCLUSION**

The growth and yield parameters studied in this paper indicated that varieties had significant differences in plant height, marketable tuber number per hill, unmarketable tuber number per hill, total tuber number per hill, marketable tuber weight (kg hill$^{-1}$), unmarketable tuber weight (kg hill$^{-1}$), total tuber weight (kg hill$^{-1}$) and tuber yield (ton ha$^{-1}$).This justifies that different varieties had different genetic potential for yield and yield components. The research findings indicate that; Zengena variety had highest plant height than any of the varieties. Generally, amongst varieties Bulle performed best by the marketable tuber number per hill, unmarketable tuber number per hill, total tuber number per hill and marketable tuber yield per hill. While, Local variety recorded the highest unmarketable tuber yield per hill; total tuber weight per hill and tuber yield per hectare but, it was not significant different with Bulle, Gudanie, Dagim and Challa varieties. Despite of these, the lowest plant height was recorded from Challa variety. Zengena variety recorded the lowest marketable tuber number per hill and marketable tuber yield per hill. While, the lowest unmarketable tuber number per hill and unmarketable tuber yield per hill was recorded for Dagim variety. In the same way, Shonkolla variety recorded the lowest total tuber number per hill, total tuber weight per hill and tuber yield per hectare. Hence, this study showed that, it is possible to produce potato from true potato seed under Gerado, Dessie, Ethiopia condition. Amongst the varieties tested through TPS transplants, Bulle variety is recommended because of its marketable tuber number per hill, total tuber number per hill, marketable tuber weight per hill, tuber weight per hill and tuber yield.

**Acknowledgement**
We would like to acknowledge Wollo University for the financial support.

## REFERENCES

Abubaker, S., A. Aburayyan, A. Amre, Y. Alzu'bil, and N. Hadidi. 2011. Impact of Cultivar and Growing Season on Potato under Center Pivot Irrigation System. *World Journal of Agricultural Sciences* 7:718-721.

Accatino, P., and P., Malagamba. 1982. Potato production from true seed, Centro Internacional de la Papa, Lima, Peru.

Adane, H., P.M. Miranda, A.T. Meuwissen, J.M. Willemien, A.O.L. Lommen, T. Admasu, and C.S. Paul. 2010. Analysis of Seed Potato Systems in Ethiopia. *American Journal of Potato Research* 87:537–552.

Almekinders, C.J.M., E. Chujoy, and G. Thiele. 2009. The Use of True Potato Seed as Pro-poor Technology. *Potato Research* 52(4):275-293.

Asmamaw, Y. 2007. Postharvest quality of potato (*Solanum tuberosum L.*) cultivars as influenced by growing environment and storage period. An M. Sc. Thesis submitted to the school of graduate studies of Haramaya University, P: 41-44.

Azad, S., B.K. Nehra, S.C. Khurana and N. Singh. 1997. Influence of plant density and geometry on growth and yield in seed crop of potato. *Journal of Indian Potato Association* 24:1-2, P: 17.

Berga L., G. Hailemariam and G. Woldegiorgis, 1994. Prospects of seed potato production in Ethiopia. pp. 254-275. In: E. Hareth, D. Lemma (ed.). Proceedings of the Second National Horticultural Workshop of Ethiopia. EARO-FAO, Addis Ababa, Ethiopia

Bilate, B., and T. Mulualem. 2016. Performance evaluation of released and farmers' potato (*Solanum tuberosum* L.) varieties in eastern Ethiopia. *Sky Journal of Agricultural Research* 5(2):34-41.

Bofu, S., Q.D. Yu, and P.V. Zaag. 1987. True potato seed in China: Past, present and future. American Journal of Potato Research. 64: 321-327.

Burrows, M.E., and T.A. Zitter. 2005. Virus Problems of Potatoes. In M. Cioloca, A. Baciu, A. Nistor and, M. Popa. 2012. Production of seedling tubers from true potato seed (TPS) in protected area.

Cioloca, M., A. Baciu, A. Nistor and M. Popa. 2012. Production of seedling tubers from true potato seed (TPS) in protected area. *Journal of Horticulture, Forestry and Biotechnology* 16(4):136- 141.

CSA (Central Statistical Agency of Ethiopia). 2008/2009. Agricultural sample survey: Report on area and production of crops, Addis Abeba, Ethiopia. P:126.

Elfnesh, F., T. Tekalign, and W. Solomon, 2011. Processing quality of improved potato (*Solanum tuberosum* L.) cultivars as influenced by growing environment and blanching. *African Journal of Food Science* 5:6, P: 324.

FAO (Food and Agriculture Organization of the United Nations), 2010. Quality declared planting material. Protocols and standards for vegetatively propagated crops. FAO plant production and protection paper, 195.

FAOSTAT (Food and Agriculture Organization Statistical Database). 2019. *Statistical database*. Rome: Food and Agricultural Organization of United Nations.

Fernandez, B. B., A. S. Tumapon, L. V. Duna, N. M. Balanay, J. P. Kloos, P. Vander Zaag. 1988. On-farm evaluation of true potato seed in the Philippines. *American Potato Journal* 65:8, P: 457-461.

Fuglie, K.O. 2007. Priorities for potato research in developing countries: results of a survey. *Potato Research* 84:353-365.

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.

Gebreselassie, H., W. Mohamed, and B. Shimelis. 2016. Evaluation of Potato (*Solanum tuberosum* L.) Varieties for Yield and Yield Components in Eastern Ethiopia. *Journal of Biology, Agriculture and Healthcare* 6:5, P:146-154.

Gildemacher, P., P. Demo, P. Kinya, M. Nyongesa, P. Mundia. 2007. Selecting the best plants to improve seed potato. LEISA 23:10-11.

Golmirzaie, A. M., and R. Ortiz. 2004. Diversity in Reproductive Characteristic of Potato Landraces and Cultivars for Producing True Seeds. *Journal of Genetic Resources and Crops Evolution* 51(7):759-763.

Hidalgo, O., Manrique, K., Velasco, C., Devaux, A., Andrade, J.L. 2009. Diagnostic of seed potato systems in Bolivia, Ecuador and Peru focusing on native varieties. In: 15th International Symposium of the International Society for Tropical Root Crops (ISTRC), Lima, Peru, 2-7, November 2009.

Hoang, V.T., P.X. Liem, N.D. Dam, N.X. Linh, N.V. Viet, P.X. Tung, and P. Vander Zaag. 1988. True potato seed Research and Development in Vietnam. American Potato Journal 65: 295–300.

Kefelegn, H., A. Chala, B. Kassa, and P. K. Tiwari. 2012. Evaluation of different potato variety and fungicide combinations for the management of potato late blight (*Phytophthora infestans*) in Southern Ethiopia. *International Journal of Life Sciences* 1:1, P:8-15.

Kidane-Mariam, H. M., H. A. Mendoza, R.O. Wissar. 1985. Performance of True Potato Seed Families Derived from Intermating Tetraploid Lines. *American Journal on Potato Research* 62(12): 643-652.

Kumar, S., H.D. Khade, V.S. Dhokane, A.G. Bethere, and A. Sharma, 2007. Irradiation in Combination With Higher Storage Temperatures Maintains Chip-Making Quality of Potato. *Journal of Food science,* 72.

Lung'aho, C., M. Nyongesa, M.W., Mbiyu, N.M., Ng'ang'a, D.N., Kipkoech, P., Pwaipwai, J., Karinga. 2010. Potato (*Solanum tuberosum* L.) minituber production using aeroponics: Another arrow in the quiver? Paper presented at the 12th KARI Scientific Conference, KARI Headquarters, Kenya, 8-12 November 2010.

Mahmood, 2005. Comparison of hydroponic culture and culture in a peat/sand mixture and the influence of nutrient solution and plant density on potato yields. *Potato Research* 40:431-438.

Malagamba, P. 1988. Potato production from true seed in tropical climates. *HortScience* 23:495-500.

Malagamba, P., J. White, S. Wiersema, P. Accatino, S. Sadik, A. Monares. 1983. True potato seed: An alternative method for potato production. Potato International Center (CIP) series, Training publication, Lima, Peru, September, 1983.

Morena, D.L., I.A. Guillen, and L.F. Garcia. 1994. Yield development in potato as influenced by cultivars and the timing and level of nitrogen fertilizer. American Potato Journal 71:165-171.

Muthuraj, R., G. Ravichandran, K.S. Krishna, and S. Singh. 2005. Effect of planting date on seed size tuber yield of potato in Nilgiris. *Potato Journal* 32:3-4, P:239.

Nizamuddin, Q. Maqsood, M. Bushra, Shakirullah, A. Mehmood, A. Sher, D. Muhammad, H. Iqbal, and B. Daulat. 2010. Yield Performance of True Potato Seeds (TPS) Hybrids under climatic conditions of Northern areas. *Sarhad journal of Agriculture* 26:2.

Okonkwo, J.C., and A.C. Chibuzo. 2002. Performance of potato varieties raised from True potato Seed in Jos Plateau, Nigeria. *Nigeria Agricultural Journal* 33:60-67.

Pandey, S.K., S.V. Sing, P. Kumar, and P. Manivel. 2004. Sustaining potato chipping Industry from western and central Uttar Pardesh: Adoption of suitable varieties. *Potato Journal* 31:3-4, P:119-127.

Patel, C.K., P.T. Patel, and S.M. Chaudhari. 2008. Effect of physiological age and seed size on seed production of potato in North Gujarat, Potato Journal 35: 85-87.

Rowell, A.B., E.E. Ewing, R.R. Plaisted. 1986. General combining ability of neo-tuberosum for potato production from true potato seed. American Journal of Potato Research. 63:143-153.

SAS (Statistical Analysis Software). SAS/STAT version 9.2 user's guide. Cary: SAS Institute Inc.; 2008.

Schulz, H., D. Gerald, and G. Bruno. 2013. Positive effects of composted biochar on plant growth and soil fertility. *Agronomy for Sustainable Development* 33:817–827.

Shunka, E., A. Chindi, G. W/giorgis, E. Seid, and L. Tessema. 2016. Response of Potato (*Solanum tuberosum* L.) Varieties to Nitrogen and Potassium Fertilizer Rates in Central Highlands of Ethiopia. *Advances in Crop Science and Technology* 4:250.

Sikka, L., and R. Kanzikwera, 1993. Recent Advances in Solanum Potato Improvement in Uganda. *Uganda Journal of Agricultural Science* 1:29-35.

Simmonds, N.W. 1997. A Review of Potato Propagation by Means of Seeds as Distinct from Clonal Propagation by Tubers. *Potato Research* 40:2.

Stephen, L.L., K.W. Bruce, I.G. Horia, and T.J. Asunta. 1997. Performance of commercially available True Potato Seed Hybrids grown from tubers. *Hortscience* 32:4, p:728-732.

Struik, P.C. and W.J.M. Lommen. 1999. Production, storage and use of micro and mini-tubers. Proceedings of the 11th triennial conference of the European Association of Potato Research (EAPR), Edinburg, UK, 122-133.

Tekalign, T., and P.S. Hammes. 2005. Growth and productivity of potato as influenced by cultivar and reproductive growth I, stomatal conductance, rate of transpiration, net photosynthesis and dry matter production and allocation. *Scientia Horticulture Journal* 105:13-27.

Tuku, B.T., G. Woldegiorgis, B. Lemaga and Y. Hiskias. 1994. The Utilization of True Potato Seed (TPS), as an alternative Method of potato production. A thesis Wageningen, The Netherlands.

Woods, M., and M. Martin. 1987. Potato from true seed. A major advance in propagating this genetically complex and disease prone vegetable promises improved nutrition for many of the world's people. *World and I Journal*

2:176.
Zitter, T.A., and D.J. Gallenberg. 1984. Virus and Viroid Diseases of Potato. Vegetable crops. Department of Plant Pathology, Cornell University. Fact Sheet. Pp. 725.

Table 1:- The effect of varieties on plant height, stem number per hill, marketable tuber number per hill and unmarketable tuber number per hill at Gerado, northeastern, Ethiopia.

| Variety | Plant height | Stem number | Marketable Tuber Number | Unmarketable Tuber Number | Total Tuber Number |
|---|---|---|---|---|---|
| Local | 83.58$^{c}$ | 3.11 | 18.38$^{b}$ | 19.65$^{ab}$ | 38.03$^{b}$ |
| Chala | 83.27$^{c}$ | 3.15 | 14.27$^{bc}$ | 15.90$^{bcd}$ | 30.17$^{bc}$ |
| Dagim | 102.49$^{b}$ | 2.88 | 17.54$^{bc}$ | 8.98$^{d}$ | 26.51$^{bc}$ |
| Zengena | 118.87$^{a}$ | 4.53 | 11.47$^{c}$ | 17.00$^{bc}$ | 28.47$^{bc}$ |
| Gudanie | 101.80$^{b}$ | 3.60 | 18.40$^{b}$ | 15.93$^{bcd}$ | 34.33$^{bc}$ |
| Bulle | 96.34$^{bc}$ | 3.65 | 25.31$^{a}$ | 26.03$^{a}$ | 51.34$^{a}$ |
| Shonkolla | 94.93$^{bc}$ | 3.00 | 14.07$^{bc}$ | 9.07$^{cd}$ | 23.13$^{c}$ |
| Jalenie | 85.73$^{c}$ | 4.33 | 16.40$^{bc}$ | 11.27$^{cd}$ | 27.67$^{bc}$ |
| LSD (5%) | 15.28 | ns | 6.85 | 7.96 | 11.72 |
| CV (%) | 9.1 | 24.3 | 23.0 | 29.4 | 20.6 |

Means in columns with the same letter are not significantly different from each other at P≤ 0.05.

Table 2:- The effect of varieties on Marketable tuber weight (kg hill$^{-1}$), Unmarketable tuber weight (kg hill$^{-1}$), Tuber weight (kg hill$^{-1}$) and Tuber yield (ton ha$^{-1}$) at Gerado, northeastern Ethiopia.

| Variety | Marketable tuber weight | Unmarketable tuber weight | Tuber weight | Tuber yield |
|---|---|---|---|---|
| Local | 0.9653$^{ab}$ | 0.3296$^{a}$ | 1.2949$^{a}$ | 54.44$^{a}$ |
| Challa | 0.6677$^{bc}$ | 0.2118$^{bc}$ | 0.8795$^{abc}$ | 35.98$^{abc}$ |
| Dagim | 0.9337$^{ab}$ | 0.1219$^{c}$ | 1.0556$^{abc}$ | 43.80$^{abc}$ |
| Zengena | 0.4907$^{c}$ | 0.2367$^{ab}$ | 0.7273$^{c}$ | 29.21$^{c}$ |
| Gudanie | 1.0273$^{ab}$ | 0.1673$^{bc}$ | 1.1947$^{ab}$ | 49.98$^{ab}$ |
| Bulle | 1.1117$^{a}$ | 0.1744$^{bc}$ | 1.2861$^{a}$ | 54.05$^{a}$ |
| Shonkolla | 0.5377$^{c}$ | 0.1433$^{bc}$ | 0.6810$^{c}$ | 27.16$^{c}$ |
| Jalenie | 0.7147$^{bc}$ | 0.1247$^{c}$ | 0.8393$^{bc}$ | 34.19$^{bc}$ |
| LSD (5%) | 0.388 | 0.0982 | 0.420 | 18.66 |
| CV (%) | 20.0 | 25.6 | 18.1 | 18.1 |

Means in columns with the same letter are not significantly different from each other at P≤ 0.05.