**Original Research Article**

**Screening of potato Germplasms for Heat Stress at lowland, Fafen, Somali Region, Ethiopia**

**Abstract**

*Potato is an important food security crop and a major source of household income for smallholder farmers in Ethiopia. Potato (Solanum tuberosum L.) produces more nutritious food on limited land with time, but the production in lowland areas is low due to the temperature constraints. The production of potatoes at lowland areas requires thedevelopment of heat-tolerant cultivars specific to high temperatures. Thus, it is very important to evaluate such genotypes, which have high yield potential and are suitable for local environmental conditions of Ethopia. A field experiment was conducted at Fafen Research Station, during 2021 and 2022, to evaluate the performance of fifty different potato plant genotypes for tuber yield characters. The experiment was laid out in a randomized complete block design with three replications. The genotypes and year showed highly significant difference for all the traits except flowering and days to maturity. The interaction between genotypes and years revealed significant differences in all the studied parameters except days to flowering, maturity, plant vigor and plant height. Genotype CIP312923.522 and CIP312906.575 produced more marketable tubers for category I and II (>80g and >30g tuber1) and total tuber yield than all other genotypes respectively. Thus, the genotypes are recommended to be promoted to variety verification trial in the coming year for further evaluation at on-farm and on-station in the study area and similar agro ecologies.*

***Keywords:*** *screening, heat tolerance, germplasm, potato, yield*

**Introduction**

Potatoes are a precious source of food for many low-income people in both urban and rural areas. Potato is the world’s third most important food crop in overall production after rice and wheat, and is a food security crop in Ethiopia (Devaux *et al*., 2014). It is mainly used as vegetable and available in the market throughout the year with reasonable price and has great importance in rural economy of the country as compared to other vegetables crops in Ethiopia. It can be consumed in different forms, such as boiled, roasted, fried and chipped (Kibar, 2012). Potatoes provide different types of nutrients and vitamins (Kärenlampi and White, 2009). They are source of different minerals like iodine (I), copper (Cu), iron (Fe), potassium (K), manganese (Mn), phosphorous (P), zinc (Zn), magnesium (Mg) and calcium, (Ca) (USDA, 2014). It is also an important food security crop in eastern Ethiopia in particular and in Ethiopia in general (Tewodros and Belay, 2015).

In Ethiopia, potatoes are mostly cultivated in the central, north western, southern, and eastern parts of the country (Semagn *et al*., 2016). The crop has potential for improving the livelihoods of millions of smallholder farmers in the high lands area of the country. The potential for higher yield per unit area, early maturity, and excellent food value give the potato crop greater potential for improving food security, increasing household income, and reducing poverty than other crops (Semahagn Asredie *et al*., 2015).

It is an important crop in the Somali region also however, there is no potato production in the region, any were all potatoes consumed in the region come from the neighbouring region. The absence of potato production in the region could be due to the unavailability of potato variants suitable for the Somali region. A variety adaptability trial will be able to determine the different varieties that are suitable for each location, in which farmers will be able to choose which of the introduced varieties are suited for their needs. Therefore, to introduce potato technology in the region a variety adaptability trial project was required that which would help the selection of suitable varieties. Therefore, the objective of this study was to evaluate the performance of potato genotypes for their tuber yield and yield-related traits at Fafen research centre, Somali regional state.

**Materials and Methods**

**Experimental Materials, Design and Procedure**

A total of 15 potato genotypes were used (CIP312921.550, CIP312926.502, CIP312923.522, CIP312923.562, CIP312920.538, CIP312927.550, CIP312916.591, CIP312897.548, CIP312898.640, CIP312911.508, CIP312906.575, CIP312896.509, CIP312905.530, CIP312901.638 and Belete (St.ck). The genotypes were arranged in Randomized Complete Block Design with two replications due to seed shortage and each gross plot were 3 m x 3 m = 9 m2 consisting of four rows, which accommodated 10 plants per row and thus 40 plants per plot. The spacing between rows and plants were 0.75 m and 0.30 m, respectively. The spacing between plots and adjacent replications were 1 m and 1.5 m, respectively. The two middle rows were used for data collection. The experimental field was cultivated to a depth of 25-30 cm by a tractor and ridges were made manually after leveling. The planting depth was maintained at 10-15 cm. All other agronomic practices such as weeding, cultivation and spraying Redomil chemical were kept uniform for all treatments in each plot.

**Data collection and Statistical Analysis**

Days to 50% flowering: The number of days from planting to flowering of 50% of plants in each plot was recorded. Days to 50% maturity: This was registered by counting the number of days taken from planting to 50% of plants in each central two row per plot showed yellowish haulms. Plant height: The height of the plants recorded from at least eight plants in the central two rows by measuring from the ground surface to the tip of the main stem in centimetre and averaged to get the mean plant height in centimetre. Number of plants harvested: This was recorded by counting the number of plants harvested from the central two rows. Number marketable tubers category I/plot: Recorded by counting the number of marketable tubers for category I with weighing between >80 g or tubers of 40-60 mm from the central two rows. Number marketable tubers category II/plot: Count the number of marketable tubers category II weighing between 30-80 g or tubers between 20-40 mm from the central two rows. Number of non-marketable tubers/plot: Count the number of non-marketable tubers with weighing less of 30 g or less of 20 mm from the central two rows. Marketable tuber weight category I/plot was recorded by Weighing marketable tuber category I/plot. The unit of measure is in Kilograms. Marketable tuber weight category II/plot was recorded by Weighing the marketable tuber category II/plot. The unit of measure is in Kilograms. Non-marketable tuber weight/plot was recorded by Weighing the non-marketable tuber/plot. The unit of measure is Kilograms. Total tuber yield (kg ha -1): the total tuber yield was obtained by adding marketable and unmarketable tuber yields. Collected data was subjected to analysis of variance (ANOVA) for RCBD using GenStat 18th edition software. Means that are significantly different were compared using Least Significant Difference (LSD) at 5% level of significance.

**Results and discussions**

Genotypes and year had significantly affected all measured plant characters except days to flowering and maturity (Table 1). The presence of significant differences between varieties indicates the presence of genetic variation for each of the genotypes tested**.** The interaction between genotypes and year exhibited a significant variation on the studied parameters except days flowering, maturity, plant vigor and plant height. this may be due to the genetic trait of the genotypes as well as the changing weather pattern in the experimental location.

**Table 1**: Combined Mean square values of plant characters and yield components of potato genotypes for combined analysis of variance over two years (2021 and 2022) at Fafen, research stations

|  |  |  |
| --- | --- | --- |
| **Source of variation**  | **DF** | **Mean square** |
|  | DsF | PU | PV | DM | PH | AvSN | NMTCI | NMTCII | NNoMTP | MTWCI | MTWCII | NoMTWP | TTY |
| **Rep** | 1 | 112.07 | 0.2667 | 0.267 | 0.267 | 228.74 | 14.2009 | 3.267 | 36.817 | 12.15 | 0.998 | 0.299 | 0.5419 | 1.412 |
| **Genotype** | 14 | 21.59ns | 6.2571\*\* | 5.429\* | 4.245ns | 151.48\*\* | 0.7671ns | 413.874\*\* | 529.493\*\* | 322.62\*\* | 157.888\*\* | 19.314\*\* | 0.7590\*\* | 227.671\*\* |
| **Year** | 1 | 4.27ns | 41.6667\*\* | 17.067\*\* | 8.067ns | 218.62\* | 1.2760ns | 1401.667\*\* | 13053.750\*\* | 5208.02\*\* | 1136.897\*\* | 798.766\*\* | 2.6014\*\* | 4044.100\*\* |
| **G\*Y** | 14 | 21.80ns | 6.2381\*\* | 2.781ns | 2.602ns | 78.24ns | 0.6426ns | 237.774\*\* | 138.036\*\* | 318.98\*\* | 111.525\*\* | 5.312\*\* | 0.8960\*\* | 125.962\*\* |
| **Error** | 29 | 14.51 | 0.4046 | 2.198 | 9.749 | 45.73 | 0.5150 | 9.336 | 9.093 | 12.63 | 6.404 | 1.436 | 0.1056 | 7.891 |
| **Total**  | 59 |  |  |  |  |  |  |  |  |  |  |  |  |  |

Keys: \*, \*\*: significant at 5% and 1% respectively, Rep= replication, Y= year, V \* Y=variety verses year, DF=degree of freedom DsF=days to flowering, DM=days to maturity, PH=plant height, PU- plant uniformity, PV= plant vigor, NMCTI=Number marketable tubers category I, NMCTII= Number marketable tubers category II, MNoMTP= Number of non-marketable tubers/plot, MTWCI= Marketable tuber weight category I, MTWCII= Marketable tuber weight category II, NoMTWP= Non-marketable tuber weight, TTY(kg/ha)=total tuber yield

**Growth and Phonological Parameters**

**Plant uniformity:** The analysis of variance showed that genotypes had a highly significant effect at (p<0.01) on the number of plant uniformity (Table 1)**.** The best/optimumplant uniformity was recorded from CIP312921.550 (7.500); which was significantly at par with CIP312911.508 (7.500) genotype and the lowest plant uniformity was recorded from CIP312920.538 (3.500) genotype followed by CIP312898.640 (4.000) genotype (Table 2). The variation in plant uniformity of the potato genotypes was reported by previous researchers too Luitel *et al*. (2016) and Tessema *et al*. (2020) that Genotypes differ genetically in their growth habit.

**Plant vigor:** The result of statistical analysis showed that genotypes had highly significantly (p<0.01) effect on plant vigor (Table 1)**.** The best plant vigor was obtained from CIP312901.638 (3.500) genotype while the lowest plant vigor was from CIP312923.562 (7.500) genotype (Table 2).

**Days to 50% Maturity:** The effect of different potato genotypes on days to maturity was in-significant (Table 1). genotype CIP312901.638 matured early (111.8 days) while genotypes CIP312923.562 matured lately the other tested genotypes (109.0 days) and the grand mean being 109.87days (Table 2).

**Plant height (cm):** The result of analysis of variance showed the effect of different genotypes on plant height was found highly significantly (p<0.01) (Table 1). Plant height ranged from 65.50 cm to 43.95 cm with an over mean of 58.41cm. Genotypes CIP312923.562 produced longer stem (65.73 cm) genotype; at par with CIP312923.522 genotype, while genotype CIP312901.638 produced shorter stem (43.95 cm) (Table 2). Differences in plant height between genotypes may be related to genetic differences, which can lead to variable growth and development performance. also, many authors in different part of the world have found that potato genotypes had significant variation of plant height Aweka *et al*. (2021); Abebe Chindi *et al*. (2021) Abebe Chindi *et al*. (2020); Binod *et al.* (2020), Arifa *et al*. (2018), Eaton *et al*. (2017) and Getachew *et al*. (2016).

**Yield component**

**Number of marketable tubers for category I (>80g** tuber1**)**: The result of analysis of variance revealed that genotypes highly significant (p < 0.01) difference on the number of marketable tubers for category I (>80g **tuber1**) in both of the cropping seasons (Table 1). CIP312923.522 genotype produced maximum numbermarketable tubers category I (>80g **tuber1**) **(**64.00g **tuber1)** followed by CIP312897.548 (53.00 tuber) while the minimum was recorded from CIP312901.638 (26.00g **tuber1**) genotype, which was statistically at par withCIP312927.550 (27.75g **tuber1**) (Table 2)**.** a study byBinod *et al*. (2020)described highly significant differences among potato genotypes formarketable tubers.

**Number of marketable tubers for category II (>30g** tuber1**)**: The result of analysis of variance revealed that genotypes highly significant (p < 0.01) difference on the number of marketable tubers for category II (>30g **tuber1**) in both of the cropping seasons (Table 1). the maximum Number of marketable tuber category II (>30g **tuber1**) was from CIP312911.508 (51.75g **tuber1**) genotype followed by CIP312923.522 (47.75g **tuber1**) and the minimum was from CIP312901.638 (12.50g **tuber1**) genotype, which was statistically at par withCIP312926.502 **(16.00**g **tuber1)** (Table 2). Similarly, other researchers also investigated that marketable yield was significantly varied by genotypes Abebe (2020); Binod *et al*., (2020) and Raphael (2022)

**Number of non-marketable tuber category (<30g tuber1)**. There was a highly significant (P< 0.01) variation among the tested genotypes with respect to number of non-marketable tuber category (<30g **tuber1**) (Table 1). The maximum Number of non-marketable tuber category (<30g **tuber1**) of tested genotype was obtained in CIP312898.640 (51.75g **tuber1**) genotype followed by CIP312923.522 (47.75g **tuber1**) and the minimum was in CIP312901.638 (18.00g **tuber1**) genotype (Table 2). The variation of number of tubers per plant is due to genetic traits of genotypes, canopy development and study area conditions. Our results are in line with Aweko *et al*. (2021); Binod *et al*. (2020); Abebe Chindi *et al*. (2021) Abebe Chindi *et al*. (2020); Getachew *et al*. (2016); Getie *et al*. (2018) and Ebrahim *et al*. (2018); Eaton *et al*. (2017); Kena (2018); Abebe *et al*. (2020) who reported high variation among potato genotypes with respect to tuber number.

**Marketable tuber weight category I, II (>80 and 30 kg/ha).** In potatoes, weight of tubers has an important role in tuber yield. The result of analysis of variance revealed that genotypes highly significant (p < 0.01) difference on the marketable tubers weight category I and II (>80g and 30 **kg/ha**) in both of the cropping seasons (Table 1). In the present study, maximum Marketable tuber weight category I (>80 g) of tested genotype was produced by CIP312923.522 (35.25 kg/ha) genotype followed by CIP312906.575 (32.90 kg/ha) and the minimum was obtained from **CIP312927.550** (13.98 kg/ha) genotype (Table 2). Moreover, the maximum Marketable tuber weight category II (>30 g) of tested genotype was obtained from CIP312911.508 (10.133 kg/ha) genotype followed by CIP312923.562 (9.582 kg/ha) and the minimum was recorded from CIP312901.638 (2.706 kg/ha) genotype. This is in agreement with Binod *et al*. (2020) and Raphael (2022)

**Non-marketable tuber weight (<30 kg/ha):** The result of analysis of variance revealed that genotypes highly significant (p < 0.01) difference on the non-marketable tuber weight (<30 kg/ha) in both of the cropping seasons (Table 1). the maximum non-marketable tuber weight (<30 kg/ha) of tested genotype was from CIP312897.548 (3.25 kg/ha) genotype followed by CIP312911.508 (3.144 kg/ha) and the minimum was from CIP312901.638 (1.83 kg/ha) genotype. The variation in tubers weight may be attributed to inheritability of genotypes and season.

**Total tuber yield (kg/ha).** The result of analysis of variance revealed that genotypes highly significant (p < 0.01) difference on Total tuber yield in both of the cropping seasons (Table 1). Regarding of Total tuber yield, the yield performance of genotype (CIP312923.522) showed the highest (41/51 kg/ha) total tuber yield followed by CIP312906.575 (42.83 kg/ha) and CIP312897.548 (41.51 kg/ha) while the lowest total tuber yield was recorded from CIP312901.638 (19.99 kg/ha) genotype (Table 2). **Yield** differences **among** these **genotypes** may **therefore** be related to genetic makeup in efficient **use** of inputs **such** **as** **nutrients**. Accordingly, Raphael (2022), Abebe Chindi *et a*l. (2021) Abebe Chindi *et al*. (2020); Awoke *et al*. (2021), Binod *et al*. 2020, Getachew *et al*. (2016), Getie *et al*. (2018) and Ebrahim *et al*. (2018) reported a significant variation of potato genotypes for their total tuber yield.

**Table 2.** Combined mean of potato genotypes on agronomic traits and tuber yield of over two years.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | PU | PV | DM | PH | NMTC1 | NMTCII | NNoMTP | MTWCI | MTWCII | NoMTWP | TTW |
| CIP312921.550 | 7.500il | 6.500c | 110.5a | 63.56cde | 47.00c | 39.25de | 45.25bc | 20.68fg | 8.228bcd | 2.568c-f | 31.48ef |
| CIP312926.502 | 4.500bc | 5.000abc | 110.2a | 52.42abc | 33.50f | 16.00h | 26.50f | 23.18def | 3.377hi | 1.884hi | 28.44f |
| CIP312923.522 | 6.500hi | 7.000c | 110.0a | 65.66e | 64.00a | 44.50bc | 47.75ab | 35.25a | 9.196abc | 2.969abc | 47.41a |
| CIP312923.562 | 5.000cde | 7.500c | 109.0a | 65.73e | 34.50ef | 48.25ab | 39.50de | 19.76fg | 9.582ab | 2.011ghi | 31.35ef |
| CIP312920.538 | 3.500a | 5.500abc | 109.5a | 55.13b-e | 39.75d | 28.00fg | 39.50de | 29.65bc | 6.002fg | 2.531c-f | 38.19cd |
| **CIP312927.550** | 6.000gh | 5.000abc | 111.0a | 62.53b-e | 27.75g | 37.25e | 40.75cd | 13.98i | 7.276def | 2.796a-e | 24.05g |
| CIP312916.591 | 6.500g-j | 6.500c | 110.0a | 60.32b-e | 41.25d | 25.25g | 36.00de | 24.93de | 5.388g | 2.260f-i | 32.58ef |
| CIP312897.548 | 5.500c-g | 7.000c | 108.8a | 64.05de | 53.00b | 41.00cde | 37.50de | 29.58bc | 8.678a-d | 3.258a | 41.51bc |
| CIP312898.640 | 4.000ab | 6.500c | 108.0a | 60.22b-e | 40.75d | 42.25cd | 51.75a | 17.93gh | 7.784cde | 2.924a-d | 28.64f |
| CIP312911.508 | 7.500ijl | 7.000c | 111.2a | 58.05b-e | 52.25b | 51.75a | 45.50bc | 26.66cd | 10.133a | 3.144ab | 39.93bc |
| CIP312906.575 | 4.500bcd | 6.500c | 109.8a | 54.18a-d | 46.50c | 31.75f | 35.25de | 32.90ab | 7.466c-f | 2.467d-g | 42.83b |
| CIP312896.509 | 6.500g-k | 4.000ab | 110.0a | 51.63ab | 37.75def | 24.00g | 34.75e | 25.55de | 6.098efg | 2.759b-e | 34.41de |
| CIP312905.530 | 7.000h-l | 6.500bc | 108.5a | 56.18b-e | 50.50bc | 36.75e | 37.00de | 30.00bc | 8.044bcd | 2.517c-f | 40.56bc |
| CIP312901.638 | 5.000b-f | 3.500a | 111.8a | 43.95a | 26.00g | 12.50h | 18.00g | 15.45hi | 2.706i | 1.831i | 19.99h |
| Belete (St.ck | 6.000e-h | 6.000bc | 109.8a | 62.56b-e | 39.00de | 26.25g | 24.75f | 22.59ef | 5.002gh | 2.351e-h | 29.94ef |
| **Mean** | 5.700 | 6.00 | 109.87 | 58.41 | 42.23 | 33.65 | 37.32 | 24.54 | 7.00 | 2.55 | 34.09 |
| **CV%** | 11.2 | 24.7 | 2.8 | 11.6 | 7.2 | 9.0 | 9.5 | 10.3 | 17.1 | 12.7 | 8.2 |
| **LSD** | 0.9199 | 3.032 | 4.516 | 9.780 | 4.419 | 4.361 | 5.140 | 3.660 | 1.733 | 0.470 | 4.062 |

*Keys: DM=days to maturity, PH=plant height, PU- plant uniformity, PV= plant vigor, NMCTI=Number marketable tubers category I, NMCTII= Number marketable tubers category II, MNoMTP= Number of non-marketable tubers/plot, MTWCI= Marketable tuber weight category I, MTWCII= Marketable tuber weight category II, NoMTWP= non-marketable tuber weight*

**Conclusion and Recommendation**s

Screening helps in ongoing efforts to select the best genotypes**.** In order to increase the productivity of potatoes in research and similar agroecological fields**,** it is recommended to consider the characteristics of the best varieties with high yields and market dominance. In this study, genotypes showed a significant difference in most of the studied parameters. the yield performance of genotype (CIP312923.522) showed the highest (47.41 kg/ha) tuber yield followed by CIP312906.575 (42.83 kg/ha) and CIP312897.548 (41.51 kg/ha). Hence this implied that, both genotypes were recommended to be promoted to variety verification trial in the coming year for further evaluation at on-farm and on-station in the study area and similar agro ecologies.

**References**

Abebe Chindi, Gebremehin Wgiorgis, Egata Shunka, Kasaye Negash, Tesfaye Abebe, Alemu Worku and Fikadu Gebretensay. (2021). Evaluation of Advanced Potato (Solanum tuberosum L.) Clones for High Tuber yield and Processing Quality in Central Highlands of Ethiopia. International Journal of Horticulture, Agriculture and Food Science (IJHAF). 5(3). DOI: <https://dx.doi.org/10.22161/ijhaf.5.3.5>

Arifa Khan, Shazia Erum, Abdul Ghafoor and Naveeda Riaz. (2018). Evaluation of potato (Solanum tuberosum L.) genotypes for yield and phenotypic quality traits under subtropical climate. Academia Journal of Agricultural Research 6(4): 079-085.

Awoke Ali, Dasta Tsagaye and Demis Fikirie. (2021). Performance Evaluation of Potato Genotypes for Tuber Yield at Bekoji, Southeastern Ethiopia. International Journal of Research in Agricultural Sciences, 18(1): 2348 – 3997

Binod Prasad Luitel , Bishnu Bahadur Bhandari and Bihani Thapa. (2020). Evaluation of Potato Genotypes for Plant and Yield Characters in field at Dailekh. *Nepal journal of science and technology*. 19(2): 2382-5359

CSA (Central Statistical Agency). (2018/19). Agricultural Sample Survey Report on Area and Production (Private Peasant Holdings Meher Season. Central Statistical Agency of Ethiopia, Statistical Bulletin.

Devaux, A., Kromann, P. and Ortiz, O. 2014. Potatoes for sustainable global food security. Potato Research, 57: 185–199.

Eaton TE, Kalam A, Humayun K, Siddiq AB (2017). Evaluation of six modern varieties of potatoes for ield, plant growth parameters and resistance to insects and diseases. Agric. Sci. 8:1315-1326.

Ebrahim S., Wasu, M. and Tesfaye, A. (2018). Genetic Variability in Potato (Solanum tuberosum L. Genotypes for Tuber Quality, Yield and Yield Related Traits at Holetta, Central Highlands of Ethiopia. (MSc.Thesis, Haramaya University).

Gebremedhin Woldegiorgis, Endale Gebre and Berga Lemaga. (2008). Potato variety development. Pp. 15-32. In: Gebremedhin Woldegiorgis, Endale Gebre and Berga Lemaga (eds.), Root and Tuber Crops: The Untapped Resources. Ethiopian Institute of Agricultural Research, Ethiopia. Addis Ababa, Ethiopia

Getachew Asefa, Wassu Mohammed and Tesfaye Abebe. (2016). Genetic variability studies in potato (Solanum tuberosum L.) genotypes in Bale highlands, South Eastern Ethiopia. Journal of Biology, Agriculture and Healthcare, 6(3): 117- 119.

Getie, A.T., Madebo, M.P. and Seid, S.A. (2018). Evaluation of Growth, Yield and Quality of Potato (Solanum tuberosum L.) Varieties at Bule, Southern Ethiopia. African Journal of Plant Science, 12(11), pp.277-283

International Potato Center. 2016. Potato facts and figures. http://cipotato.org/potato/facts/ Accessed July 21, 2016

Kärenlampi, S. and P.J. White. 2009. Potato proteins, lipids and minerals. In: Singh J, editor. Advances in potato chemistry and technology. Oxford: Elsevier; 2009. pp. 99–126.

Kena Kena (2018) Adaptability and Performance Evaluation of Potato (Solanum tuberosum L) Varieties under Irrigation in West and Kellem Wollega Zones. J Advan Plant Sci 1: 213.

Lung’aho, C., B. Lemaga, M. Nyongesa, P. Gildermacher, P. Kinyale, P. Demo, and J. Kabira. (2007). Commercial seed potato production in Eastern and Central Africa. Kenya Agricultural Institute, 140p.

Punkhurst, R. (1964). Notes on history of Ethiopian agriculture. Ethiopian observer, 7:210-240.

Raphael Butler Chepken. (2022). Evaluation of Acceptable Yield for Potato Tuber Genotypes Based on Specific Processing Traits. JOURNAL OF AGRICULTURE AND ENVIRONMENTAL SCIENCE. 2(1).

Semagn Asredie Kolech, Halseth, D., Perry, K., Wolfe, D. and Fentahun Mengistu. 2015. Potato variety diversity, determinants, and implications for potato breeding strategy in Ethiopia. American Journal of Potato Research, 5(92): 551–566.

Semagn Asredie Kolech, Halseth, D., Perry, K., Wolfe, D., Douches, D.S., Coombs, J. and De Jong, W. 2016. Genetic diversity and relationship of Ethiopian potato varieties to germplasm from North America, Europe, and the International Potato Center. American Journal of Potato Research, 6(93): 609–619.

Tesfaye Abebe and Yigzaw, D. (2008). Review of crop improvement research achievements and future focus in parts of Western Amhara Region: The case of Adet. Tesfaye Abebe, (ed.). In Proceedings of the 1st Amhara Region Regional Workshop on Potato Research and Development Achievements and Transfer Experiences and Future Directions. Bahir Dar, Ethiopia, pp. 85-101.

Tewodros M, and Belay Y. 2015. Review on integrated soil fertility management for better crop production in Ethiopia. Sky Journal of Agricultural Research, 4(1): 021- 032.

Tewodros, A., Paul, C. Struik and Adane, H. (2014). Characterization of seed potato (Solanum tuberosum L.) Storage, pre-planting treatment and marketing systems in Ethiopia: The case of West-Arsi Zone. African journal of agricultural research, 9 (15): pp.1218-1226.

USDA, 2014. United States Potato Board. 2014 <https://www.usda.gov/nass/pubs/todayrpt/uscapo15>

Zhang, H.F. Y. Xu, H. Wu, Hu and X.F. Dai. 2017. Progress of potato staple food research and industry development in China. J. Integ. Agric. 16: 2924-2932. [https://doi.org/10.1016/S2095-3119(17)61736-2](https://doi.org/10.1016/S2095-3119%2817%2961736-2).