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# Evaluation of potato (*Solanum tuberosum* L.) varieties for yield and yield components

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**Lack of well adapted potato (*Solanum tuberosum* L.) varieties is a production problem accounting for low yield. Farmers grow local landraces. A field experiment was conducted to investigate the performance of potato varieties for yield and yield components from 2013 to 2015 under rain fed condition using improved varieties and a local landrace. There were differences among varieties for all traits. Year had little effect on most traits except for days to emergence, days to flowering and days to maturity. Only days to emergence and average number of stems per plant were affected by the variety by year interaction. The improved varieties outperformed than the local landrace for the majority of traits studied except that the local landrace emerges, flowers and matures earlier than the others. The varieties Belete and Guassa were superior for tuber weight, tuber yield and average number of stems per plant. 'Belete' and 'Guassa' had tuber yields that were 155 and 136.6% greater than the local landrace. Moreover, these two varieties have larger tuber size which may be good means to get market value better return for the farmer and are comparably good in all other studied traits. Hence, they are recommended for the area and similar agro-ecologies**.

**Key words:** *Solanum tuberosum*, correlation, Ethiopia, traits, varieties.

## INTRODUCTION

Potato (*Solanum tuberosum* L.) has potential for adaptation to diverse growing conditions of the tropics. The shorter growing period makes it possible for a small-scale farmer to fit this crop into intensive cropping systems and have more than one crop on the same land in a year (Gebremedhin et al., 2008). The crop has great yield potential per unit area which is a key for attaining food security especially for developing countries.

Potato produces more energy and protein per unit area and unit of time than most other major food crops, and it is fat-free (Lutaladio and Castaldi, 2009). Potato is also rich in several micronutrients and vitamin C (FAO, 2008), is a source of iron, vitamins $B_1$, $B_3$ and $B_6$ and minerals. It is a source of dietary antioxidants, which may play a part in preventing diseases related to ageing, and a source of dietary fiber (Mulatu et al., 2005).

Potato average yield is low (7.2 $Mt \cdot ha^{-1}$), far below the crop potential. Lack of well adapted varieties, inappropriate rate and application of fertilizer, unavailability and high cost of seed tubers, improper planting

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**Table 1.** Characteristics of varieties used.

| S/N | Genotype name | Year of release | Released by | Favorable environment | | Time to maturity | Yield performance (t/ha) | |
|---|---|---|---|---|---|---|---|---|
| | | | | Altitude (m) | Rainfall (mm) | | Farmer field | Research site |
| 1 | Guasa (CIP-384321.9) | 2002 | ADARC | 2000-2800 | 1000-1500 | 110-115 | 22-25 | 24.4-33 |
| 2 | Belete (CIP-393371.58) | 2009 | HARC | 1600-2800 | 750-1000 | 110-120 | 28-33.8 | 47 |
| 3 | Jalenie (CIP-37792-5) | 2002 | HARC | 1600-2800 | 750-1000 | 100-110 | 29.1 | 40.3 |
| 4 | Gera (KP-90134.2) | 2003 | ShARC | 2200-3200 | 800-950 | 120-157 | 27.2 | 31.2 |
| 5 | Gudenie (CIP-386423.13) | 2006 | HARC | 1600-2800 | 750-1000 | 120 | 21 | 29.2 |
| 6 | Local | - | - | 1600-3100 | 980-1398 | - | - | - |

ADARC = Adet Agricultural Research Center, HARC = Holetta Agricultural Research Center, and ShARC = Sheno Agricultural Research Center. Source: Anonymous (2010, 2012).

density, diseases, insect, inadequate storage, transportation and marketing facilities are major problems in potato production (Gebremedhin et al., 2008; Adane et al., 2010).

None of the currently used varieties or cultivars has potential for production in all environments and for all uses (Bradshaw, 2007), since agro-ecologies vary with respect to soil type, moisture and temperature regimes, fertility condition and the onset, intensity and duration of rain as well as availability of irrigation facilities (Gebremedhin et al., 2008). Farmers grow local landraces in traditional production systems, even though improved varieties have been released. This is due to lack of awareness of farmers of improved varieties and lack of research to select well adaptive potato varieties. The objective of the study was to evaluate varieties for yield and yield components.

## MATERIALS AND METHODS

The study was conducted on farmers' field in Dara Kebele, Dabat district of North Gondar Zone, Ethiopia, from 2013 to 2015. The area is located at 12°59'3"N and 37°45'54"E, 814 km from Addis Ababa. The altitude ranges from 1500 to 3200 m.a.s.l. Mean annual rainfall ranges from 800 to 1100 mm with the main rainy season extending from June to October. Average annual maximum and minimum temperatures are 19.9 and 8.58°C, respectively (Tafere, 2012). The major soil types are clay, sandy loam and clay loam.

Five improved varieties of potato (Table 1) and one local landrace were arranged in a randomized complete block design with 3 replications. The soil was tilled 3 times and compost from the university site was applied a month before planting with a rate of 15 $Mt \cdot ha^{-1}$ (13.5 kg/plot) to provide nutrients (Edwards et al., 2007). Medium sized potato tubers (35-45 mm diameter) were planted by hand in rows with 75 cm between rows and 30 cm between plants within rows and each experimental plot was 9 $m^2$ in size. Blocks were separated by 1.5 and 1 m between blocks and within a block, respectively. There were 4 rows/plot for each treatment. Data were collected from the middle two rows; the 2 outermost rows and terminal plants were considered as guards. Other cultural practices like earthening up and weeding were carried out 3 times each during the growing period.

### Data collected

Data on days to emergence, plant heights (cm), days to 50% flowering, days to maturity, average number of stem per plant, average number of tuber per plant, weight of tuber per plant (g/plant) and tuber yield (t/plant) were recorded from the middle two rows. On each middle two rows, the two outer most rows and terminal plants were considered as guard rows and plants, respectively.

### Data analysis

Analysis of variance and correlation of traits were performed using Statistical Analysis Software (SAS, ver. 9.2, SAS, Cary, NC). Least Significant Difference (LSD) test at 5% probability level was used for mean comparison when the ANOVA showed significant difference. Before performing ANOVA, normality and constant of variance test was performed using Minitab (ver. 16 Minitab Inc., State college, PA).

## RESULTS AND DISCUSSION

Variety affected all measured traits (Table 2), indicating there was sufficient variability for selection of varieties (Habtamu et al., 2016). Year affected plant height, tuber weight, number of stems/plant and yield indicating annual environmental fluctuation mediated responses. The interaction of variety and year was significant for days to emergence and number of stems/plant indicating that genetic makeup could be affected by environmental conditions.

**Table 2.** Mean square values of yield and yield components of potato varieties for combined analysis of variance over three years (2013 to 2015).

| Source of variation | df | DEM | DFL | PH | DTM | ANSt | ATWt | ANTu | AL |
|---|---|---|---|---|---|---|---|---|---|
| Variety (V) | 5 | 15.84** | 201.75** | 89.18* | 216.31** | 21.67** | 1419.35** | 14.79* | 268.23** |
| Year (Y) | 2 | 0.13ns | 6.12ns | 345.91** | 20.06ns | 8.09* | 816.49** | 88.73** | 582.37** |
| V×Y | 10 | 4.57* | 5.06ns | 48.34ns | 7.63ns | 3.46* | 82.38ns | 10.47ns | 22.17ns |
| Error | 34 | 1.68 | 4.82 | 29.40 | 14.40 | 1.68 | 58.96 | 5.26 | 11.05 |

ns, **, * not significant or significant at 0.01% and 0.05%, respectively. df = Degrees of freedom, DEM = Days to emergence, DFL = Days to flowering, PH = Plant height, DTM = Days to maturity, ANSt = Average numbers of stems, ATWt = Average tuber weight, ANTu = Average numbers of tubers, AL = Average yield.

**Table 3.** Means of variety over yield and yield characters of potato varieties combined over years (2013 to 2015).

| Variety | DEM | DFL | PH | DTM | ANSt | ATWt | ANTu | YIL |
|---|---|---|---|---|---|---|---|---|
| Gudene | 15.44[c] | 54.89[c] | 57.06[a] | 108.45[c] | 5.93[bc] | 33.13[c] | 13.71[a] | 20.02[c] |
| Belete | 16.77[b] | 63.55[ab] | 51.84[b] | 121.67[a] | 8.37[a] | 52.05[a] | 11.29[b] | 25.93[a] |
| Jalene | 16.77[b] | 65.22[a] | 50.93[b] | 116.44[b] | 6.93[b] | 34.26[bc] | 13.75[a] | 21.01[bc] |
| Gera | 17.22[b] | 55.22[c] | 57.51[a] | 113.78[b] | 6.37[b] | 41.54[b] | 11.24[b] | 20.13[c] |
| Guassa | 17.77[b] | 62[b] | 53.2[ab] | 115.89[b] | 8.88[a] | 50.75[a] | 11.09[b] | 24.04[ab] |
| Local | 19.44[a] | 65[a] | 50.13[b] | 121.11[a] | 4.73[c] | 18.53[d] | 13.02[ab] | 10.16[d] |
| $R^2$ | 69.82 | 86.76 | 62.44 | 71.12 | 73.53 | 83.21 | 67.23 | 87.98 |
| CV | 7.5 | 3.6 | 10.15 | 3.26 | 18.89 | 20 | 18.57 | 16.43 |
| Gm | 17.24 | 60.98 | 53.44 | 116.22 | 6.87 | 38.38 | 12.35 | 20.21 |
| LSD | 1.24 | 2.1 | 5.19 | 3.63 | 1.24 | 7.35 | 2.19 | 3.18 |
| P value | <.0001 | <.0001 | 0.0228 | <.0001 | <.0001 | <.0001 | 0.0314 | <.0001 |

DEM = Days to emergence, DFL = Days to flowering, PH = plant height (cm), DTM = Days to Maturity, ANSt = Average numbers of stems, ATWt = Average tuber weight (g), ANTu = Average numbers of tubers, AL = Average yield ($Mt{\cdot}ha^{-1}$), Gm = Grand mean; LSD = Least significant difference. Means in columns followed by the same letters are not significantly different, $p < 0.05$.

Numbers of days to emergence, flowering and maturity are important for potato producers because they enable growers to forecast and develop a suitable production scheme and marketing plan (Khalafalla, 2001). In this study, variety affected number of days to 50% emergence, flowering and maturity (Table 3). 'Gudene' emerged earlier than the others and the local landrace emerged late. It is possible to select early, or late, emerging varieties based on duration of rainfall, temperature, labor availability and maturation period based on the number of days for maturation. The variety Jalene exhibited late flowering while 'Gudene' and 'Gera' flowered earlier than other varieties. Early flowering of these varieties may indicate the beginning of tuberization at an early stage (Carrie et al., 2014). Differences in emergence and flowering between varieties may be due to genetic differences (Bradshaw, 2007).

Variety also affected numbers of days to maturity. 'Gudene' matured early while 'Belete' and the local landrace was late (Table 3). Varieties Gera, Guassa and Gudene matured in fewer days than the grand mean which allow farmers to increase land vs. time use efficiency, that is, possible to intensify production on unit of land. The difference between varieties in length of growing period might be due to differences in genetic makeup (Girma, 2012), since flowering and maturity are heritable traits (Getachew et al., 2016).

Variety affected plant height (Table 3). The variety Jalene produced shorter stems; 'Gera' produced longer stems. 'Gudene', 'Gera' and 'Guassa' were the tallest and different from 'Belete', 'Jalene', and the local landrace. Many authors in different part of the world have observed that potato germplasm had different response of plant height (Regassa and Basavaraj, 2005; Getachew et al., 2016).

Variety affected the number of stems/plant. The number of stems relate to numbers of branches and numbers of leaves which contributes to photosynthesis potential. An increase in absorption of solar radiation can ensure a higher photosynthesis potential and promote synthesis and accumulation of reserve carbohydrates in the potato tuber which has a positive effect on the final tuber yield (White et al., 2007). More stems/plant were obtained from varieties Guassa and Belete (Table 3)

**Table 4.** Correlation matrix of the measured traits.

| Correlation | DTF | Ph | DTM | ANSt | ATWt | ANTPt | Yield |
|---|---|---|---|---|---|---|---|
| DEM | 0.41079<br>0.0020 | -0.12016<br>0.3868 | 0.31477<br>0.0204 | 0.00413<br>0.9764 | -0.21296<br>0.1221 | 0.01064<br>0.9391 | -0.25486<br>0.0629 |
| DTF | | -0.40029<br>0.0027 | 0.66197<br><0.0001 | 0.13023<br>0.3479 | -0.04709<br>0.7353 | 0.04006<br>0.7737 | -0.03073<br>0.8254 |
| Ph | | | -0.50106<br>0.0001 | 0.15496<br>0.2632 | 0.28358<br>0.0377 | 0.12184<br>0.3801 | 0.41997<br>0.0016 |
| DTM | | | | -0.02910<br>0.8345 | -0.12457<br>0.3695 | 0.01013<br>0.9420 | -0.13424<br>0.3332 |
| ANSt | | | | | 0.70793<br><0.0001 | -0.14955<br>0.2804 | 0.59254<br><0.0001 |
| ATWt | | | | | | -0.39769<br>0.0029 | 0.72767<br><0.0001 |
| ANTPt | | | | | | | 0.29652<br>0.0295 |

DEM = Days to emergence, DFL = days to flowering, Ph = plant height (cm), DTM = days to maturity, ANSt = average number of stems, ATWt = average tuber weight (g), ANTPt = average number of tubers, Yield = average yield ($Mt{\cdot}ha^{-1}$).

while fewer stems were produced on the local landrace. According to Paul (2007) the number of initially available (first order) stems have a role in increase in leaf number and position on the plant which is important for rate of leaf area increase. Stem density, which is influenced by genetic makeup, increase tuber yield as stem density increases numbers of tubers, or size of tubers, or both (Tsegaw, 2005; Zelalem et al., 2009).

Variety affected average tuber weight (Table 2). Average tuber weight is an important yield component of potato contributing to total tuber yield (Morena et al., 1994). Higher tuber weights were produced by 'Belete' and 'Guassa' and the lowest tuber weight was for the local landrace (Table 3). According to Kirkman (2007), number and size of potato tubers are an economically important characteristic in processing, marketing demand, human consumption, and for seed for planting. Gray and Hughes (1978) stated that tuber size required by consumers depends upon ease of handling for household purposes and upon acceptable level of peeling loss. Varieties Belete and Guassa were better in tuber size and weight.

Variety affected number of tubers/plant (Table 3). The highest number of tubers was from 'Jalene' followed by 'Gudene'. Fewer tubers were produced on 'Guassa', 'Belete' and 'Gera'. The variety with more tubers had lower average tuber weight. Getachew et al. (2016) reported significant differences among 24 potato genotypes in their number of tubers per plant due to genetic variation.

Variety affected tuber yield (Table 3). The highest tuber yield was from 'Belete' followed by 'Guassa', and the lowest yield was from the local landrace. 'Belete' and 'Guassa' produced yields that were 155 and 136% over the local landrace, respectively. Improving traditional production and management practices will increase yield even for the local variety from 7.2 $Mt{\cdot}ha^{-1}$ of national production to 10.16 $Mt{\cdot}ha^{-1}$ as in Table 3.

'Belete' and 'Guassa' had an intermediate number of days to emergence and flowering but late maturity as compared to other varieties. The two highest yielding varieties had the most stems and longest stems which could result in high photo-assimilate production. Even though 'Belete' and 'Guassa' had fewer tubers/plant they produced larger/heavier tubers which increased yield (Table 4). This result agrees with Ahmed et al. (2000), Endale and Woldegiorgis (2001), Girma (2012), and Getachew et al. (2016) which were done in different locations and with different germplasm.

There was a significant, positive, correlation with average tuber weight, average number of stems, and plant height with average number of tubers (Table 4). Tuber yield may be increased by using varieties which have higher average tuber size/weight, taller plants, and which produce more stems and tubers. According to Girma (2012) increased number of stem/plant leads to increased plant height due to light availability and its effect on increased length and number of node. The traits having positive correlation with yield can be used to improve yield by making simultaneous improvement of those traits (Solomon et al., 2014). Khayatnezhad et al. (2011) indicated strong positive correlations between tuber yield and stems/plant, tuber weight and plant height. Similarly, Girma (2012) reported that tuber yield was significantly, and positively, correlated with average tuber weight, plant height, and total tuber number. Increasing numbers of stems and plant height allowed more light interception and likely an increase of production, and accumulation of, more carbon assimilation resulting in increased individual tuber size, weight and total tuber yield.

Days to emergence was positively, and significantly, correlated with days to maturity and with days to flowering (Table 4). Delaying tuber initiation prolongs the growth period and days to flowering. The period of tuber initiation and emergence is a determinant factor in length of time to maturity. The result disagrees with Gebeyehu (2011) who reported that a day to emergence was significantly, and positively, correlated with days to flowering and days to maturity.

Generally, “Belete” and “Guassa” varieties offered better performance over the other varieties regarding their tuber yield. Also they have tuber size which has direct relationship with market acceptance for consumption purpose and are comparably good in all other studied traits. In order to boost productivity of potato in the study and similar agro-ecological area, it is better to consider the characters of the best variety having high yield and market advantage. Therefore, these two varieties are recommended for future use in the study area and similar environments. The local landrace is out performed by all the improved varieties tested for the traits studied.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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