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Research article

# Evaluation of released sweet potato [*Ipomoea batatas* (L.) Lam] varieties for yield and yield-related attributes in Semen-Bench district of Bench-Sheko-Zone, South-Western Ethiopia

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ABSTRACT

Sweet potato is a significant root crop that can be used for both food and feed. Bench-Sheko zone mid-altitudes, in general, are among the most important sweet potato growing regions in southwest Ethiopia. During the 2017 and 2018 growing seasons, a study was carried out in the Semen-Bench district of the Bench-sheko zone, southwestern Ethiopia, to investigate the adaptability and performance of improved sweet potato varieties and to identify the best performer variety. A randomized complete block design with three replications was used to compare the performance of five improved (viz., Awassa-83, Beletch, Berkume, Kulfo, Tula) and one Local sweet potato variety. The results of both years and over year combined statistical analysis indicated that the varieties significantly varied in terms of all yield and yield-related traits. As a result, the Awassa-83 variety acquired the greatest values of average root diameter in both the 2017 (11.9 cm) and 2018 (10.1 cm) growing seasons, followed by the Berkume variety. In both 2017 and 2018 growing seasons and over year combined analysis, the highest average storage root length (21.5 cm), marketable storage root yield (29.06 ton/ha), total storage root yield (43.22 ton/ha), and storage root dry weight (42%) was recorded from variety Awassa-83. Variety Beletech and Berkume were found to be statistically similar and the next highest in terms of marketable storage root yield, and total storage root yield; moreover, variety Berkume was found to be the next highest in terms of storage root dry weight in two years combined result. On the other hand, the variety Beletech, which was closely followed by Awassa-83, had the highest average number of roots per plant (8.28) and the greatest number of marketable roots per plant (7.04). Therefore, considering overall traits Awassa-83 was found to be superior in overall performance and can be recommended for production in the study area and related agro-ecologies.

## 1. Introduction

The sweet potato [*Ipomoea batatas* (L.) Lam] belongs to the Convolvulaceae family. It was domesticated in Central America more than 5000 years ago. It is currently frequently cultivated between sea level and 2300 m above sea level in tropical and temperate zones that are 40° south and north of the equator. The developing world produces more than 95% of the world's sweet potatoes. China is the top sweet potato producer in the globe, generating 80% of the world supply, followed by Nigeria and Uganda, which each produce approximately 2.5 percent (FAOSTAT, 2017).

In many among the Global low income regions, sweet potatoes are a significant food security crop, predominantly produced by women for home use and as a source of income for their families. It is one of the top six food crops and is cultivated in more than 100 underdeveloped nations after rice, wheat, maize, potato, and cassava (Aritua and Gibson, 2002). Because of its minimal input requirements, simplicity of production, and capacity to yield in harsh weather and inferior soil conditions, it is considered to be a poor man's crop (Aritua and Gibson, 2002). Sweet potatoes' vegetative and storage roots are used by the majority of small-scale farmers in Africa and Asia as a source of protein and vitamins for human meals as well as for animal feed (Scott, 2000).

In Sub-Saharan African countries, sweet potatoes are the third significant root crop after cassava and yam. In East Africa, in 2011, Uganda led in production followed by Rwanda and Kenya with 2554, 845.1 and 759.5 metric tons, respectively (FAOSTAT, 2017). African yields are

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estimated to be 4–5 tons per hectare, which is low and roughly one-third of Asian yields, indicating enormous potential for future sweet potato yield increases in Africa.

Next to potato (*Solanum tuberosum*) and other tuber and root crops planted in Ethiopia, sweet potato [*1. batatas* (L.) Lam] ranks first in overall yield (42.84%) and second in terms of area coverage (25.43%) (CSA, 2014). The root is usually eaten boiled as a food. It is among the most affordable vitamin A sources. It can withstand unfavorable circumstances such as drought. Due to its lower input and care requirements, farmers choose it as a food crop (CIP, 2005). The young vines and leaves of the crop can be eaten as vegetables or given to animals (CTA, 2007). In Ethiopia, it is cultivated as the most important root crop mostly for human consumption.

The cultivation of sweet potatoes in the southern nations, nationalities and people regional states was a recent phenomenon and its area of production in 2007 was only 188 ha. However, recently the regional government has given special attention due to the potential of sweet potato to be used as a food security crop.

Any variety trial program's objective is to get the most accurate evaluation of variety performance while abiding by the limitations of the growing environment (Addis, 2003). Farmers are mainly concerned in varieties that are advanced and specifically suitable to their conditions and have a high degree of long-term stability (Scott and Maldonado, 2008). Plant breeders are particularly interested in sweet potato's potential to function well in a variety of conditions (Moussa et al., 2011). Because of the crop's better productivity and drought tolerance, it has the potential to help the region achieve food self-sufficiency.

Despite its importance and suitability to the agro-ecology of the country including the presence of suitable soil type, temperature and rainfall for the production of sweet potato, Ethiopia's average sweet potato yield is 33.74 tons per hectare (CSA, 2014) which is very low as compared to the crop potential which rises to 50 ton/ha (Gurmu and Mekonen, 2017).

One of the key factors contributing to the area's poor production, among other contributing factors is the shortage of improved cultivars that is appropriate for the environment and then the use of low yielding cultivar. Endale et al. (2004) reported that the lack of better genotypes and inadequate agronomic techniques are the primary causes of the farmer's field's low yield. This is also true in the study area (Bench--Sheko) condition. Furthermore, eventhough there are several studies conducted on yield of sweet potato varieties in southern Ethiopia, their performance varies from place to place due to genotype by environment interaction and this calls for specific area recommendation. Therefore, this study's objective was to evaluate the performance of sweet potato varieties and recommend the best performing variety for production at Semen-Bench, South-western Ethiopia.

## 2. Materials and methods

### 2.1. Description of the study area

The study was carried out at Semen-Bench district of Bench-Sheko Zone, in southwest people's regional state of Ethiopia during the 2017 and 2018 cropping seasons. The location is around 580 km from Addis Abeba to the southwestern part of country. The research location is situated between 35°E latitude and 6°09′N latitude, at an elevation of 1500 m above sea level in the south-western, sub-humid tropical region of Ethiopia. The seasonal pattern of rainfall is unimodal, with the rainy season lasting halfway between March and November. The region's annual rainfall is 2000 mm and the average minimum and highest temperatures each year is 20 °C and 28 °C, respectively. Table 1 describes some of the research area's soil physico-chemical properties. The area was selected due to its suitable agro-ecology and represents sweet potato growing areas of Bench-Sheko Zone, south-western Ethiopia.

**Table 1.** Some Physico-chemical characteristics of soil in North Bench.

| Properties | Value |
|---|---|
| Texture | Clay Loam |
| pH ($H_2O$) | 6.63 |
| Organic matter (%) | 6.24 |
| Total nitrogen (%) | 0.42 |
| Available phosphorus (ppm) | 14.32 |
| CEC (meq/100 g) | 57.22 (meq/100 g) |
| Exchangeable Ca (meq/100 g) | 18.04 |
| Exchangeable K (meq/100 g) | 1.46 |
| Exchangeable Mg (meq/100 g) | 5.56 |
| Exchangeable Na (meq/100 g) | 0.09 |
| Exchangeable acidity (mg kg-1) | 0.29 |

### 2.2. Experimental material and design

Five different types of sweet potatoes varieties were used in the experiment (Awassa 83, Beletech, Kulfu, Tula, and Berkume), which were obtained from Hawassa Agricultural Research Center (HARC) and one indigenous variety gathered from the farmer's field surrounding the experimental site. Table 2 provides thorough information on the varieties. A three-replication randomized complete block design (RCBD) was used for the study.

### 2.3. Experimental techniques

According to farmer practice of surrounding the experimental area, the study site was ploughed with a pair of oxen until fine tilth was achieved, and ridges were manually prepared with traditional hoes. The total field was divided into three blocks of six plots each, each of which included six plots, for a total of eighteen plots. Each plot was 4 m × 3.6 m (14.4 $m^2$) in size, with four rows and twelve plants per row, with a recommended spacing of 30 cm between plants and 100 cm between rows. The treatments were randomly assigned to each plot in each replication, and a distance of 1 m and 1.5 m spaces were maintained between plots and blocks, respectively. The young middle portion of 30 cm length of the vine cuttings was planted with 2/3 of its length covered with soil. In every ridge hole, one vine cutting was inserted. A week after planting, replanting was done to replace the dead vines. Hand hoeing was used to create the experimental plots, and the site was maintained free of weeds during the whole growth phase. To prevent the storage roots from being exposed, earthing-up of soil surrounding the plant was made three times at monthly intervals beginning the second month after planting (Emana 1990). Fertilizers were used in accordance with the region's suggestion of 46 kg N and 44 kg P2O5 $ha^{-1}$ in which Urea was used to provide nitrogen (46% N) 100 kg/ha (split: half at planting with the total dose of phosphorus and the rest is applied at one and a half month after planting) and P2O5 in the form of DAP (46% P205 and 18% N) 95.65 kg/ha side dressing at the time of planting (EARO, 2004; OARI, 2002). Major disease incidence and insect pest occurrence were monitored throughout the growing season to avoid the effect of external factors on the treatments of interest so as to meet the objective of the study. However no disease incidence and insect pest infestation were observed on the crop throughout the study period. When the leaves of the sweet potato became yellow in the field, the vines and leaves were removed (cut off), and the roots were dug out with hoes and pulled by hand with care not to hurt the root.

### 2.4. Data collection

For each variable, data were collected from two net harvestable rows of ten randomly selected plants from each plot.

**Mean vine length (cm):** vine length of 10 sampled plants was measured and the result was averaged per plant for the analysis.

**Table 2.** Descriptions of the five released sweet potato varieties.

| No. | Variety | Year of release | Altitude | Maturity days | Flesh colour | Yield (qt/ha) | Center of release |
|---|---|---|---|---|---|---|---|
| 1 | Kulfo | 2005 | 1200–2200 | 150 | Orange | 270 | Hawassa |
| 2 | Tulla | 2005 | 1200–2200 | 150 | Orange | 285 | Hawassa |
| 3 | Awassa-83 | 1983 | 1200–2200 | 150–180 | White | 366 | Hawassa |
| 4 | Berkume | 2007 | 1650–2000 | 188–195 | White | 195 | Haramaya University |
| 5 | Beletech (192026-II) | 2004 | 1200–2200 | 150 | White | 184 | Hawassa |

*Source:* Crop variety registration bulletin, Ministry of Agriculture (1983–2017).

**Storage root length (cm):** This was calculated by averaging the matured storage root lengths of 10 randomly chosen plants from each plot and using the average as the unit of measurement for data analysis.

**Storage root diameter (cm):** The average size was determined by measuring the width at the centre of the mature storage root of 10 randomly selected plants and the result was averaged for the analysis.

**The average number of storage roots per plant:** was determined by taking the average number of the actual storage roots that were counted from the sampled plants.

**Marketable storage root number per plant:** The marketable storage roots of 10 sampled plants from each net plot were counted and divided by the quantity of sampled plants collected at maturity. Storage roots that are free from any damage, uninfected by insect pests and whose root size was between 100 and 500 g were considered as marketable roots (Yohannes, 2007).

**The number of unmarketable storage roots per plant**: was determined by sorting and counting the unmarketable storage roots of 10 sampled plants from each net plot at maturity, and dividing this by the quantity of the sampled plants. Unmarketable storage roots are those that are harmed, infested with insects, and have roots weighing between 100 and 500 g (Yohannes, 2007).

**Marketable storage root yield (ton/ha):** This was calculated by multiplying the average marketable storage root yield of the plants in the sample by the number of plants per hectare of land.

**Unmarketable storage root yield (ton/ha):** This was calculated by multiplying the average of unmarketable storage root yield of sampled plants with plant populations per hectare.

**Total storage root yield (ton/ha):** This was determined by multiplying the average fresh storage root weight of the sampled plants by the number of plants present per hectare of land.

**Dry matter content (%):** From each plot, 10 g slices of sweet potatoes were taken and weighed right away after slicing them, and then after being left out in the open air for five days, the samples were dried in oven for 24 h at 80 °C in the laboratory. The dry matter content (%) was then estimated using the formula below (Kwach et al., 2010; Yildirim et al., 2011).

Dry matter (%) = weight of sample (g) upon drying/original sample weight (g) multiplied by 100

## 2.5. Statistical analysis

Analysis of variance (ANOVA) was used to test the significant difference between treatments (Montgomery, 2013). According to Gomez and Gomez (1984), the results of average storage root diameter, unmarketable storage root number per plant and unmarketable storage root yield response variables were reported based on individual year analysis (2017 and 2018) due to significant error variances across years; whereas, the results of the rest of the response variables were reported based on combined analyses over years as a result of their non-significant error variances across years. SAS 9.2 software (SAS, 2008) was used for statistical analysis, and the mean of treatments which were found to be significant were compared with the LSD method (Montgomery, 2013) at a significance level of 0.05.

# 3. Results and discussion

Results of individual year analysis of 2017 and 2018 growing season were indicated in Tables 3 and 4, respectively. The two years combined analysis was also carried out for all variables due to their homogeneous error variance (Table 5).

**Vine length:** The result of the individual year and combined analysis revealed that there were significant differences among the varieties at $P < 0.01$. Based on over year combined analysis the highest and statistically similar vine lengths were recorded for Local (143.0 cm) and Berkume (140.8 cm) varieties. Tula variety was found to have the lowest vine length (56.3 cm) (Table 5). A similar difference in vine length amongst sweet potato varieties was reported by Shamil (2021) who discovered vine lengths ranging from 135.2 cm to 175.1 cm in the assessment of six sweet potato varieties, with the longest length being seen from variety Koka-6. On the other hand, Berhanu and Beniam (2015) also reported different vine lengths at different locations in which they found highest vine length from the local cultivar as compared to the released one at the Dilla site whereas the released cultivar (Algetta) was higher in Chichu site. Nazrul (2018) also reported significant variation in sweet potato vine length which ranged from 119 cm to 192.3 cm in his evaluation of five sweet potato varieties. These differences in vine length might be attributed to variation in the genotypes' genetic make-up and their interaction with the environment.

Moreover, in this study, variety with medium vine length (Awassa-83) produced maximum storage root yield but the local variety that produced maximum vine length couldn't gave higher storage root yield (Table 5). This might be due to the growth in vine length up to optimum stage may improve storage root yield up to some point through increased leaf number that photosynthesize and accumulate more dry matter; however excess vine length growth may result in reduced storage root yield which could be attributed to most of the assimilates produced may be used in leaf and vine growth instead of tuber growth as reported by Saddique et al. (1988). Ravi (1997) also demonstrated that sweet potato varieties with higher shoot growth result in lower storage root development as a consequence of higher competition for assimilates. Several findings also showed that the relationship between the vine length characteristic and total root yield was non-significant and/or negative (Birhanu et al., 2018; Tesfaye, 2011).

**Average storage root length:** According to the result of the individual year and two years combined analysis, a significant ($P < 0.01$) variation were observed among tested varieties in average root length (Tables 3, 4, and 5). As a result, averaged over years the highest measured root length (21.5 cm) was recorded in the Awassa-83 variety. However, the Tulla variety had the lowest value (6.8 cm) (Table 5). In line with our results, Shamil (2021) reported that root length varied among the genotypes significantly and ranged from 8.9 to 24.8 cm with maximum and minimum values obtained from Awassa-83 and Beletech varieties, respectively among six tested varieties. Mohammed (2018) also reported the existence of substantial variation among eight tested sweet potato varieties where the maximum root length (12.2 cm) was obtained from Awassa-83 variety, and suggested that such differences could be attributed to genotypic variability between varieties. Uwah et al. (2013) also reported two years of storage root length which ranges from 14.4 to 16.3 cm.

**Table 3.** Mean values of sweet potato varieties at Semen-Bench district in the 2017 growing season.

| Variety | MVL (cm) | ASRL (cm) | ASRD (cm) | RNPP | MRNPP | URNPP | MY (ton/ha) | UMY (ton/ha) | TY (ton/ha) | DW% |
|---|---|---|---|---|---|---|---|---|---|---|
| Tulla | 58.3$^{d}$ | 6.5$^{c}$ | 6.3$^{b}$ | 1.58$^{e}$ | 1.34$^{e}$ | 0.24$^{e}$ | 9.67$^{c}$ | 7.44$^{bc}$ | 17.11$^{c}$ | 33.6$^{c}$ |
| Beletech | 118.0$^{b}$ | 14.4$^{b}$ | 6.6$^{b}$ | 8.28$^{a}$ | 7.04$^{a}$ | 1.24$^{a}$ | 13.11$^{b}$ | 12.67$^{a}$ | 25.78$^{b}$ | 20.0$^{e}$ |
| Kulfo | 71.0$^{c}$ | 7.9$^{C}$ | 5.9$^{b}$ | 0.77$^{f}$ | 0.65$^{f}$ | 0.12$^{f}$ | 4.13$^{d}$ | 2.44$^{d}$ | 6.58$^{d}$ | 24.0$^{d}$ |
| Awassa-83 | 137.0$^{a}$ | 17.7$^{a}$ | 11.9$^{a}$ | 6.38$^{b}$ | 5.42$^{b}$ | 0.96$^{b}$ | 28.78$^{a}$ | 13.78$^{a}$ | 42.56$^{a}$ | 51.0$^{a}$ |
| Berkume | 142.9$^{a}$ | 17.6$^{a}$ | 7.6$^{b}$ | 2.40$^{d}$ | 2.04$^{d}$ | 0.36$^{d}$ | 14.00$^{b}$ | 11.00$^{ab}$ | 25.00$^{b}$ | 40.0$^{b}$ |
| Local | 133.4$^{a}$ | 16.5$^{ab}$ | 7.3$^{b}$ | 4.56$^{c}$ | 3.87$^{c}$ | 0.68$^{c}$ | 8.22$^{c}$ | 6.89$^{c}$ | 15.11$^{c}$ | 31.0$^{c}$ |
| $LSD_{0.05}$ | 10.1 | 2.15 | 1.9058 | 0.5146 | 0.4343 | 0.0805 | 2.3921 | 3.6481 | 3.7475 | 1.78 |
| P-value | <.0001 | <0.0001 | 0.0004 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.0004 | <.0001 | <.0001 |
| CV(%) | 5.03 | 8.8 | 13.77 | 7.08 | 7.03 | 7.38 | 10.13 | 22.20 | 9.35 | 2.96 |

Means within a column with distinct letters vary substantially by LSD at the 5% level of significance.
MVL = mean vine length, ASRL = average storage root length, ASRD = average storage root diameter, RNPP = average storage root number per plant, MRNPP = marketable storage root number per plant, URNNP = unmarketable storage root number per plant, MY = marketable storage root yield, UMY = unmarketable storage root yield, TY = Total storage root yield, DW = storage root dry weight.

**Table 4.** Mean values of sweet potato varieties at Semen-Bench district in the 2018 growing season.

| Variety | MVL (cm) | ASRL (cm) | ASRD (cm) | RNPP | MRNPP | URNPP | MY(ton/ha) | UY(ton/ha) | TY (ton/ha) | DW% |
|---|---|---|---|---|---|---|---|---|---|---|
| Tulla | 54.2$^{f}$ | 6.9$^{e}$ | 4.7$^{e}$ | 2.43$^{e}$ | 1.67$^{e}$ | 0.77$^{c}$ | 2.470$^{e}$ | 6.86$^{c}$ | 9.33$^{d}$ | 12.20$^{e}$ |
| Beletech | 103.1$^{d}$ | 14.8$^{c}$ | 5.3$^{d}$ | 7.61$^{a}$ | 6.27$^{a}$ | 1.64$^{a}$ | 18.33$^{b}$ | 12.00$^{b}$ | 30.33$^{b}$ | 20.00$^{c}$ |
| Kulfo | 65.7e | 10.0$^{d}$ | 5.8$^{c}$ | 1.43$^{f}$ | 1.03$^{f}$ | 0.37$^{d}$ | 5.47$^{d}$ | 2.64$^{d}$ | 8.11$^{d}$ | 13.70$^{d}$ |
| Awassa-83 | 129.4$^{c}$ | 25.2$^{a}$ | 10.1$^{a}$ | 6.54$^{b}$ | 5.30$^{b}$ | 1.24$^{b}$ | 29.33$^{a}$ | 14.56$^{a}$ | 43.89$^{a}$ | 33.00$^{a}$ |
| Berkume | 138.5$^{b}$ | 11.5$^{d}$ | 7.4$^{b}$ | 3.41$^{d}$ | 2.93$^{d}$ | 0.48$^{d}$ | 15.22$^{c}$ | 13.00$^{ab}$ | 28.22$^{b}$ | 22.50$^{b}$ |
| Local | 152.6$^{a}$ | 19.7$^{b}$ | 4.3$^{f}$ | 4.88$^{c}$ | 3.90$^{c}$ | 1.31$^{b}$ | 15.00$^{c}$ | 8.22$^{c}$ | 23.22$^{c}$ | 11.50$^{e}$ |
| $LSD_{0.05}$ | 5.88 | 2.72 | 0.33 | 0.72 | 0.59 | 0.26 | 1.91 | 1.91 | 3.98 | 1.45 |
| P-value | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| CV(%) | 3.01 | 10.15 | 2.87 | 9.06 | 9.27 | 14.63 | 11.19 | 11.01 | 9.17 | 4.25 |

Means inside a column with recognizable letters is noticeably different by LSD at a 5% threshold of significance.
MVL = mean vine length, ASRL = average storage root length, ASRD = average storage root diameter, RNPP = average storage root number per plant, MRNPP = marketable storage root number per plant, URNNP = unmarketable storage root number per plant, MY = marketable storage root yield, UMY = unmarketable storage root yield, TY = Total storage root yield, DW = storage root dry weight.

**Table 5.** Two years combined mean values of sweet potato varieties at Semen-Bench during 2017 and 2018 cropping seasons.

| Variety | MVL (cm) | ASRL (cm) | RNPP | MRNPP | MY(ton/ha) | TY (ton/ha) | DW% |
|---|---|---|---|---|---|---|---|
| Tulla | 56.3$^{e}$ | 6.8$^{e}$ | 2.01$^{e}$ | 1.50$^{e}$ | 6.07$^{d}$ | 13.22$^{d}$ | 22.25$^{c}$ |
| Beletech | 110.6$^{c}$ | 14.6$^{c}$ | 7.94$^{a}$ | 6.65$^{a}$ | 15.72$^{b}$ | 28.05$^{b}$ | 20.00$^{de}$ |
| Kulfo | 68.3$^{d}$ | 8.9$^{d}$ | 1.10$^{f}$ | 0.85$^{f}$ | 4.80$^{d}$ | 7.34$^{e}$ | 18.85$^{e}$ |
| Awassa-83 | 133.3$^{b}$ | 21.5$^{a}$ | 6.46$^{b}$ | 5.36$^{b}$ | 29.06$^{a}$ | 43.22$^{a}$ | 42.00$^{a}$ |
| Berkume | 140.8$^{a}$ | 14.6$^{c}$ | 2.91$^{d}$ | 2.49$^{d}$ | 14.61$^{b}$ | 26.61$^{b}$ | 31.27$^{b}$ |
| Local | 143.0$^{a}$ | 18.2$^{b}$ | 4.72$^{c}$ | 3.89$^{c}$ | 11.61$^{c}$ | 19.17$^{c}$ | 21.27$^{cd}$ |
| $LSD_{0.05}$ | 6.31 | 1.77 | 0.49 | 0.42 | 2.10 | 3.14 | 1.35 |
| P-value | <.0001 | <.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| CV(%) | 3.19 | 6.9 | 6.48 | 6.68 | 8.46 | 7.53 | 2.86 |

When using LSD at the 5% threshold of significance, means within a column with distinct letter combinations are substantially different.
MVL = mean vine length, ASRL = average storage root length, RNPP = average storage root number per plant, MRNPP = marketable storage root number per plant, MY = marketable storage root yield, TY = Total storage root yield, DW = storage root dry weight.

**Average storage root diameter:** The average storage root diameter of sweet potatoes was significantly ($P < 0.01$) influenced by the varieties in both the 2017 and 2018 growing seasons (Tables 3 and 4). Accordingly, the Awassa-83 variety had the largest average root diameter (11.9 cm), followed by Berkume (7.6 cm), even though the value of Berkume was statistically at par with all the rest varieties, including the Kulfo variety, which had the smallest average root diameter (5.9 cm) in the 2017 growing season (Table 3). Similarly, in the 2018 growing season Awassa-83 (10.1 cm) showed the highest value followed by Berkume (7.4 cm); whereas, Local variety showed significantly the lowest of all (4.3 cm) (Table 4). The results of this study are in line with the reports of Shamil (2021) and Mohammed (2018) who found great variation among sweet potato varieties in terms of root diameter, which could be argued to be due to genetic variability. As a result, Shamil (2021) reported average values ranging from 4.7 to 10.4 cm with the maximum and minimum values of Awassa-83 and Kulfo, respectively among the six tested varieties. Similarly, Mohammed (2018) also reported the highest root diameter from the Awassa-83 variety and the lowest and statistically similar values from varieties Guntutea and Kulfo during the evaluation of eight sweet potato varieties. Berhanu and Beniam (2015), Bezawit et al.(2015), and Desalegn et al. (2015) also reported that different varieties had different storage root diameters.

**Average root number per plant and marketable root number per plant:** A significant ($P < 0.01$) varietal difference was also observed in these variables in both growing years (Tables 3 and 4), and in two years combined analysis (Table 5). In over year combined analysis, variety Beletech had the largest mean root number per plant (7.94), followed by Awassa-83 (6.46), while the Kulfo variety had the lowest value (1.10) (Table 4). Similar patterns were seen for marketable root number per plant, where variety Beletech produced the greatest value (6.65) followed by Awassa-83 (5.36), while variety Kulfo produced the lowest value (0.85) (Table 5). Mohammed (2018) observed similar variations in average root number per plot, with local and Beletech varieties having the greatest average root number per plot (which was much higher than the highest mean discovered in this research) and Kulfo varieties having the lowest average root number per plot. Shamil (2021) and Uwah et al. (2013) both also noted a significant variation in the number of roots per plant. The variations observed in terms of these variables might be arised from genetic variability among the varieties. Increased amount of stored roots per plant improves sweet potato total yield.

**Marketable storage root yield:** Mean marketable fresh yield also indicated a significant variation ($P < 0.01$) between varieties in both years and combined analysis (Tables 3, 4, and 5). In two years combined analysis, variety Awassa-83 (29.06 tons/ha) had the highest average marketable storage root yield, followed by Beletech (15.72 tons/ha) and Berkume (14.61 tons/ha), which are statistically similar to one another; while Kulfo (4.8 tons/ha) had the lowest average marketable storage root yield (Table 5). Mohammed (2018) also noted a similar pattern of variance in marketable fresh yield, and of the eight tested sweet potato cultivars, he determined Awassa-83 to have the highest value. The presence of variations in the marketable yield of sweet potato might be caused by the genetic heterogeneity present in the studied cultivars. Yohannes (2007) also noted similar variation in sweet potato genotypes. Additionally, Wonda et al. (2007) reported that genotype, location, and genotype by location interaction had a substantial influence on sweet potatoes' productivity.

**Unmarketable storage root yield:** There was a substantial ($P <$ 0.01) variation in the unmarketable root yield of the varieties in both years (Tables 3 and 4). Accordingly, the highest and statistically similar values of 13.78, 12.67 and 11.00 ton/ha were recorded in varieties Awassa-83, Beletech and Berkume varieties, respectively in 2017 season (Table 3). Similarly, the maximum and statistically similar values of 14.56 and 13.00 2.54 ton/ha were recorded for varieties Awassa-83 and Berkume, respectively in 2018 growing season (Table 4). Whereas, the lowest values of 2.44 and 2.64 ton/ha were observed for Kulfo variety in 2017 and 2018 seasons, respectively (Tables 3 and 4). Similarly, Mohammed (2018) reported a wide variation in unmarketable root yield among eight sweet potato genotypes with the highest value being Awassa-83 variety. Several unfavorable varietal features for sweet potato production or unmarketable yield classes were discovered in the present study, including small-sized (<100 g), long tails, and malformed storage roots (Feliciano, 2004). Oversized (>500g) roots, which were considered as unmarketable, were also noticed in this study in Awassa-83, Berkume and Local varieties eventhough they were less frequently observed. On the otherhand, Tula, Kulfo, and Beletch varieties mostly had unmarketable root classes that arised from small roots (less than 100 g). Despite the fact that the large roots are classified as unmarketable root classifications, their acceptability by consumers is substantially better than that of small-sized unmarketable storage root classes.

**Total storage root yield:** A separate year and over year combined analysis result indicated that the sweet potato total storage root yield was significantly ($P < 0.01$) affected by varieties (Tables 3, 4, and 5). Averaged over years, the highest total storage root yield was recorded from variety Awassa-83 (43.22 ton/ha); whereas, the lowest total storage root yield per hectare was recorded from Kulfo (7.34 ton/ha) (Table 5). These findings support the conclusions of Mohammed (2018) and Shamil (2021) that reported the presence of variation among sweet potato varieties in terms of total storage root yield, and suggested that such differences could be attributed to genotypic variability between varieties. Both Mohammed (2018) and Shamil (2021) found the maximum total storage root yield from the Awassa-83 variety among the tested eight and six varieties, respectively. Tesfaye et al. (2011) also found significant variation in yield and other desirable features between sweet potato genotypes in their adaptation study in diverse agro-ecologies of Ethiopia. Similarly, Nazrul (2018) reported significantly the highest sweet potato yield of 40.63 tons/ha in his five sweet potato variety evaluation studies. The findings of this study was also supported by the results of Rahman et al. (2015) and Yooyongwech et al. (2014) who found that the genetic makeup of the plant affects the yield potential of sweet potatoes. This is also true for other root and tuber crops where yield and quality varied for different varieties as reported by Tilahun (2018), and Tilahun and Bewuketu (2019) for potato and Tewodros and Tilahun (2021) for taro crops. As observed in this study, Rahman et al. (2015) clearly showed that total storage root yields increased when the quantity, diameter, length, and the total amount of dry matter content of sweet potato storage roots increased.

**Root dry matter content (%):** In the two-year study and over-year combined analysis, there was a significant variation ($P < 0.01$) in the root dry weight values of the varieties. The variety Awassa-83 had the highest value (42%), followed by Berkume (31.27%), and the Kulfo variety had the lowest value (18.87%) (Table 5). Differences in dry matter content across different varieties may account for the variation in response of varieties to the specific environmental conditions of the experimental area including climate and soil conditions. Rahman et al. (2015), Teow et al. (2007), and Kathabwalika et al. (2016) observed similar differences in dry matter content. According to Teow et al. (2007), the genotypes of sweet potatoes' root dry matter content ranged from 26.8 to 33.5%.and that of Kathabwalika et al. (2016) varied between 26.8% and 34.4% As stated by Marlize (2010), sweet potato cultivars with root dry matter content ranging from 20% to 26% are acceptable to the taste of both adults and children. In the present study, most tested sweet potato varieties showed acceptable root dry matter contents.

## 4. Conclusion

This study revealed substantial differences among the evaluated of sweet potato varieties considering yield and yield-related characteristics. Accordingly, the Awassa-83 variety was found to be a high yielder and had superior performance in its productivity and yield components, while Kulfo variety had the lowest productivity. Considering the findings of this research, the Awassa-83 variety is suitable for the study area and similar agro-ecologies and can be recommendable to farmers and small-scale farming communities. Furthermore, adopting this variety can alleviate the shortage of sweet potato supply, which in turn will help consumers.

## Declarations

### *Author contribution statement*

Tewoderos Legesse; Melkam Mesenbet; Tilahun Bekele: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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### *Data availability statement*

Data will be made available on request.

## *Declaration of interest's statement*

The authors declare no conflict of interest.

## *Additional information*

No additional information is available for this paper.

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