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**Original Research**

# Evaluation of underutilized cultivated Anchote (*Coccinia abyssinica* (Lam.) Cogn.) accessions in West Shewa Zone, Oromia Regional State, Central Ethiopia

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## Abstract

Anchote (*Coccinia abyssinica*) is an endemic root and tuber crop species of Ethiopia, which belongs to the Cucurbitaceae family. The aim of this study was to assess *C. abyssinica* accessions to identify better physical adaptability potential and high-yielding in the West Shewa zone, central highland of Ethiopia. Sixteen (16) promising Anchote accessions were planted in a 2m x 2m plot area by using a randomized complete block design, with three replications for three consecutive main rain-fed cropping seasons from 2018-2020 years. In the present study, the statistically analyzed outputs of the measured agronomic parameters of individual accession mean values were varied in the range of seedlings emergency percentage (77-96.13%), vine number per plant (2.34-3.54), vine length per plant (1.99-6.35m), vine internodes length (7.70-11.57cm), number of leaves per plant (116.66-129), Leaf area per plant (92.27-162.8 $cm^2$); storage root diameter (62.35–136.26 cm), storage root dry matter content (5.55-25.14%), total storage root weight per plant (0.41-1.15kg), total storage root yield per hectare (52.25-143.79 tonne/ha), marketable storage root yield per hectare (50.63-143.7 tonne/ha) and unmarketable storage root yields per hectare (0.05–1.62 tonne/ha) were recorded. From this study, six (6) accessions: 223090, 223113, 223086, 223100, 223105, and 223104 were identified as those that produced the highest storage root yield (> 101 tonne/ha), highest marketable storage root yield (> 101 tonne/ha), and highest dry matter content (> 21 %) which indicating a good performance and adaptation in west Shewa central highland of Ethiopia. Therefore, these accessions are suggested to produce and scale up by farmers in the central highland of a country, and other areas of similar agroecological zones.

**Keywords:** Accessions, Anchote, *Coccinia abyssinica,* root crops, underutilized crop

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## 1. INTRODUCTION

The Ethiopian economy is mainly based on agriculture, which accounts for half of the gross domestic product, 90% of the exports, and 85% of the total population employment (NMSA, 2001). Smallholders are the spine of the agrarian sector. Ethiopia has diverse agro-ecological and climatic conditions suitable for the production of various crops including root and tuber crops (IBC 2005). Root and Tuber are defined as plants yielding starchy roots, tubers, rhizomes, corms, and stems (FAO 2000). Root and tuber crops such as potato, sweet potato, yam, cassava, enset, Anchote, and *Plectranthus edulis* are also grown in several places in Ethiopia. The major indigenous root and tuber crops of the country include Enset, Anchote, Ethiopian potato, and Yams (Amsalu et al. 2008).

Among the roots and tubers crops that are commonly grown in Ethiopia, *C. abyssinica* is an annual trailing vine belonging to the Cucurbitaceae family. *C. abyssinica* is an endemic crop species of Ethiopian origin mainly cultivated for its nutritious tuberous roots and tender leaves. The vernacular name of *C. abyssinica* is 'Anchote' and is spoken in Oromia in western and south-western parts of Ethiopia. It is also known by different vernacular names in different places by different tribes, and its cultivation as a root crop is common in Wollega, Iluababor, Jimma, Kaffa, and Sidama Zones of Ethiopia (Amsalu et al. 2008). The crop is widely grown and utilized in western, southern, and southwestern parts of Ethiopia (Desta 2011). Farmers prepare seeds by gathering mature and healthy fruit from the mother plants because it is propagated by seed.

*Coccinia abyssinica* is grown for its edible root tuber and leafy vegetables in western and south-western parts of Ethiopia. Anchote is an important nourishment source with numerous medicinal values for human curative qualities. It contains high quantities of nutrients like crude fiber, protein, calcium, iron, zinc, and magnesium, which are rare in other tuber crops (Abera, 1995). Anchote is a subsistence crop widely grown to fill food security during hunger months.

Unlike many other crops, Anchote can be grown with minimal inputs and it can produce reasonably well under unfavorable conditions such as low soil fertility, acidic soils or drought, and under intercropping with cereals. Anchote has been grown over a wide range of environments (1300-2800 meters above sea level), with sporadic distribution (Abera and Gudeta, 2007). It occurs in many parts of Ethiopia including the western, southern, and northern parts (Yambo and Feyissa, 2013). Anchote is a drought-resistant tuber crop indigenous to Ethiopia, originating particularly in the Oromia region. There are about ten species of genus *Coccinia* in Ethiopia; nonetheless, one *C. abyssinica* is grown for human consumption. The crop plays an important role in the local diet of rural and peri-urban communities mainly in Western and South Western Ethiopia (Abera, 1995,

Abera and Gudeta, 2007). Anchote contains high quantities of nutrients like crude fiber, protein, calcium, iron, zinc, and magnesium, which are rare in other tuber crops (Desta 2011).

Underutilized species are defined as species with underexploited potential for contributing to food security, health and nutrition, income generation, and environmental protection (GFU 2007). Underutilized species may have different terms or names such as neglected, underutilized, minor, orphan, underexploited, underdeveloped, lost, new, novel, promising, alternative, local, traditional, and niche crops. If underutilized crop species are continuing forgotten by research and development, the genetic diversities due to lack of attention; might be lost. Among the underutilized species of root tuber crops, *C. abyssinica* is widely grown and utilized in western, southern, and south-western parts of Ethiopia with limited research coverage and lower attention given to this crop species at national and regional levels (Abera, 1995, Desta, 2011, Yambo and Feyissa, 2013).

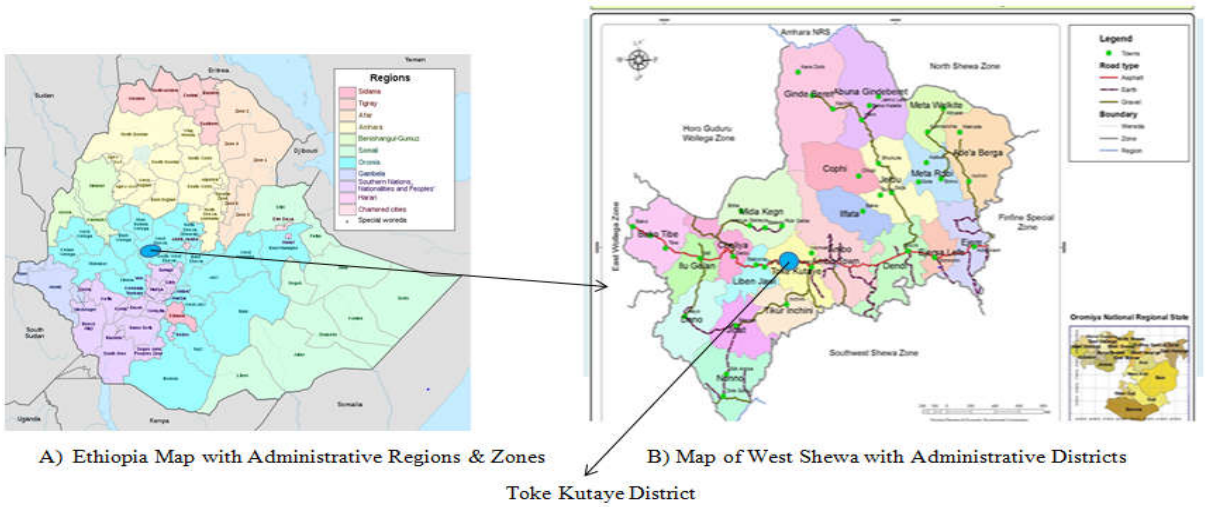
Practices of cultivation and utilization of *C. abyssinica* have been passed from generation to generation through oral tradition with very little recorded information. The production of the indigenous root tuber crop of *C. abyssinica* is still dependent on local varieties maintained by farmers. However, there is inadequate documentation of *C. abyssinica* breeding and agronomic characteristics, and little chance of exposure to research and development in the past in the study area, particularly in the West Shewa zone, central highland Ethiopia. The current study attempted to collect and evaluated the underutilized crop species of *C. abyssinica* accessions to identify better phenological adaptability potential in terms of growth, development, and high root-yielding performance accession (s) in the west Shewa zone, central highland of Ethiopia.

## 2. MATERIALS AND METHODS

### 2.1. Description of the study area

#### 2.1.1. Location

The field experiment was conducted in the west Shoa zone, Oromia regional state, central Ethiopia. West Shoa zone is located at 8°57′N latitude and 38°07′E longitude and with elevation ranges between 1380-3300 m.a.s.l. The study was conducted at Ambo University Guder Mammo Mezemir Campus research site, in the Toke Kutaye District of West Shewa zone. The district is located about 126 km away from Addis Ababa to the western and 12 km away from the Zonal Town of Ambo (WSHZORS Road Authority, 2020). Specifically, Toke Kutaye district is located at 37 $^{0}$ 26‟ 0‟‟ to 37$^{0}$ 57‟30‟ E longitude and 8$^{0}$ 49‟0‟ to 9$^{0}$5’30‟ N latitude with an elevation of 1580 to 3190 m. a.s.l. (TKWAO, 2020) (Figure 1).




A) Ethiopia Map with Administrative Regions & Zones B) Map of West Shewa with Administrative Districts

**Figure 1** Images represent: (A) a Map of Ethiopia with Administrative Regions & Zones and (B) a Map of West Shewa with Administrative Districts

### 2.1.2. Climate

The Agroecology of the district covers 23% high land, 60% mid-highland, and 17% low land. The area obtains the maximum rainfall during the rainy season between June September and followed by March and April Months. Generally, the area has bimodal rainfall patterns, but it has one separate crop growing season (main season). The annual mean maximum and minimum rainfall are 1900mm and 600mm, respectively. The mean minimum and maximum air temperatures of the area are 11.7°C and 27.4°, respectively (Ethiopia Meteorological Agency 2020).

### 2.2. Experimental materials used

In the present study, the experimental materials used include a total of 16 different *C. abyssinica* accessions collected from different provenance sites in the country by the Institute of Biodiversity Conservation. The collected 16 *C. abyssinica* accessions from different sites were taken from Instituted of Biodiversity (IBC) which were collected from different Ethiopian provenances of Anchote crop growing areas of a country (Table 1). The field experimental research was conducted for three consecutive main rain-fed cropping seasons 2018-2020 between April and October Months, at Ambo University Guder Mamo Mezemir Campus on-farm research site.

### 2.3. Treatment and Experimental Design

This single-factor experiment was conducted by using sixteen (16) *C. abyssinica* accessions treatments (207984, 223085, 223086, 223087, 223088, 223089, 223090, 223096, 223097, 223098, 223100, 223104, 223108, 223109, 223112, 223113), in randomized complete block design (RCBD) with three replications.

**Table 1:** Sixteen (16) Anchote (*Coccinia abyssinica)* accessions materials used and their area of collections

| S/ No | Species | Accession Number | Accession collection provenance | | |
|---|---|---|---|---|---|
| | | | Region | Zone | Woreda/ District |
| **1** | *C. abyssinica* | 207984 | Benishangul Gumuz | Asosa | Asosa |
| **2** | *C. abyssinica* | 223085 | Oromiya | East Wellega | Diga Leka |
| **3** | *C. abyssinica* | 223086 | Oromiya | East Wellega | Diga Leka |
| **4** | *C. abyssinica* | 223087 | Oromiya | West Wellega | Gimbi |
| **5** | *C. abyssinica* | 223088 | Oromiya | West Wellega | Gimbi |
| **6** | *C. abyssinica* | 223090 | Oromiya | West Wellega | Gimbi |
| **7** | *C. abyssinica* | 223096 | Oromiya | East Wellega | Guto Wayu |
| **8** | *C. abyssinica* | 223097 | Oromiya | East Wellega | Guto Wayu |
| **9** | *C. abyssinica* | 223098 | Oromiya | East Wellega | Guto Wayu |
| **10** | *C. abyssinica* | 223100 | Oromiya | East Wellega | Jimma Arjo |
| **11** | *C. abyssinica* | 223104 | Oromiya | Jimma | Dedo |
| **12** | *C. abyssinica* | 223105 | Oromia | Jimma | Dedo |
| **13** | *C. abyssinica* | 223108 | Oromiya | Illubabor | Ale |
| **14** | *C. abyssinica* | 223109 | Oromiya | Illubabor | Ale |
| **15** | *C. abyssinica* | 223112 | Oromiya | Illubabor | Bedele |
| **16** | *C. abyssinica* | 223113 | Oromiya | Jimma | Mana |

## 2.4. Experimental procedures

The experimental site area was cleared and plowed by oxen plow according to farmers' practice. The entire field was divided into three blocks, each of which included sixteen (16) different accession plots, for a total of 48 (16 accessions x 3 replications) plots. The plot size was fixed at two meters long and two-meter in width and each plot was having five rows with 10 plants each and with a spacing of 40 cm between rows and 20 cm between plants. The plots were 1m apart from each other and 1.5m between blocks. Three seeds per hill were sown in the plots as they were intended. Seeds were planted on well-prepared five rows per plot bed at 5 cm depth in the soil. For individual accession, totally of 150 good-performance seedlings from direct sowing were grown for this field of experimental research to evaluate accession adaptability and better yields in a study area. The seeds were sown at the beginning of the rainy season (April) in well-drained, loose soil on flat ground. The appropriate recommended intercultural agronomic activities such as field planning, land clearing, land preparation, planting, weeding, and fertilizer were used during the cropping season for *C. abyssinica* production as recommended by Bako Agricultural Research Center (2004).

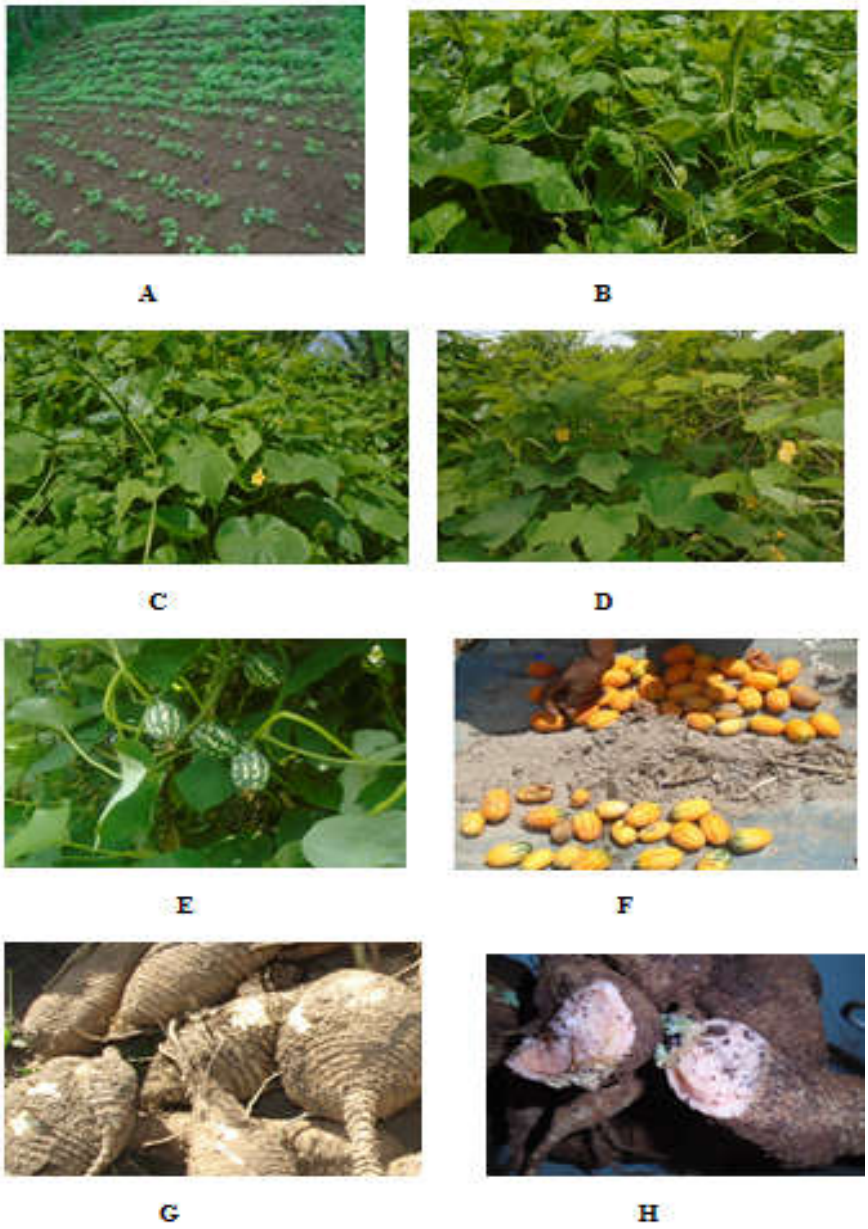



**Figure 2** Images represent: Anchote (*C. abyssinica*) indicates (A) seedlings stage, (B) young stage, (C) flower initiation stage, (D) fully flowering stage, (E) fruiting stage, (F) ripen harvested fruit, (G) harvested storage root and (H) internal storage root part

## 2.5. **Data Collection**

### 2.5.1. Data collection procedure

Quantitative variables were recorded on a total of 15 randomly selected plants per plot (3 plants randomly at the center or middle of each accession planting row x 5 rows per plot) of Anchote accessions. For sampling techniques, the International Plant Genetic Resources Institute descriptor list for potato (Huaman, 2002) and cucurbit species (ECPGR, 2008) was adopted with some modifications to suit the Anchote crop performance to record the quantitative morphological

growth, yield components, and yield. Both pre-harvest and post-harvest data were recorded from randomly selected fifty (15) plants per plot at different growth stages (Figure 2).

In the present study, the Anchote plant vegetative growth, yield components, and yield data were collected. The pre-harvest and post-harvest plant data variables include seedlings emergency percentage, stand count, vine numbers per plant, vine length, vine internode length, leaf number per plant, leaf area, number of roots per plant, root diameter per plant, root weight per plant and root yield per plant. These plant data were collected according to the following procedure:

2.5.2. Vegetative growth parameters

**Seedlings emergency percentage (% SE)**: The seedlings emergency percentage was calculated after 20 days of sowing by counting the number of seeds that emerged from each plot and dividing by the total sown and then the plots average was taken.

**Vine numbers (VN)**: The number of vines per single hill was counted after the maturity of the plant or at four months of sowing from fifteen (15) randomly selected plant samples per plot, and then the average number of vines per hill was taken.

**Vine length (VL)**: The Vine length was measured after the maturity of the plant or at four months of sowing in centimeters from base to tip of the plant by randomly taking 15 plants from each plot and then the average was worked out.

**Vine internodes length (VIL)**: Vine internodes' length was measured after the maturity of the plant or at four months of sowing in centimeters by taking the representative part or the middle portion of vines from fifteen (15) randomly selected plant samples per plot.

**The number of leaves (NL)**: The total number of leaves was counted three times on two months, three months, and four months of sowing from fifteen (15) randomly selected plant samples per plot, and then the average of the samples was calculated.

**Leaf area (LA)**: The leaf area was recorded by measuring the length and width. i.e., Leaf area ($cm^2$) = Leaf length (cm) x leaf width (cm). Leaf area was measured from the middle parts of the plant by selecting 15 leaves at random from each plot and then the average was done at the full maturity stage from 15 sampled plants.

2.5.3. Yield and yield component parameters

**Number of storage roots (NR)**: The average number of storage roots per single hill was determined by counting from sample plants of each of the fifteen (15) randomly selected plant samples per plot and then the average was worked out.

**Storage root diameter (SRD)**: The diameter of roots was measured at the middle of the root in centimeters from 15 randomly selected sample storage roots and then the average was taken from each plot during the harvested period.

**Storage root dry matter content** (kg): the dry matter was done using the method described by Behera et al. (2010) using the oven and a sensitive balance (BP 16000-S) with an accuracy of 0.1g. To avoid post-harvest changes in dry matter content before dry matter analysis, initial steps were carried out within 24hr after harvest. For the root samples, medium-sized five undamaged market-size roots were chopped into small flakes and mixed thoroughly, and a 400 g sample was taken for the next step. The samples, which weighed 400g when fresh, were put in paper bags and dried for 24 hours at 105°C to achieve a consistent weight.

The dried samples were weighed and the resulting figure was used for calculating dry matter content as DM % i.e. (Dry weight/Fresh weight) x 100.

**Total storage root weight (TRW):** The weight of storage roots per plant was measured using a sensitive balance (BP 1600-S) in kilogram (kg) and the average was recorded per plant during the harvested period.

**The total storage root yield or TRY**: Total root yield from the sampled plants to the entire plots, and converted to hectare, then it expressed in tonnes per hectare. The total storage root yield (tonne/ha) was calculated from the storage root yield weight per hill.

**Marketable storage root yield (MRY):** Marketable storage root yield was measured in kilograms from the total yield, which was not affected by the disease, not oversized, not undersized, and not damaged storage roots from each plot. The roots that affected damaged, under, or oversized from each plot were measured by the kilogram and converted to the hectare.

**Unmarketable storage root yields (UMRY)**: That measured in kilograms from the total storage root yield that affected, damaged, under, or oversized storage root from each plot.

### 2.6. Data Analysis

The data were subjected to analysis of variance (ANOVA) in single factor RCBD for the random effects model for the factorial experiment (Montgomery, 2009). Based on the Significant difference in ANOVA, mean separation was employed at alpha=5% and 1% probability levels using statistical software (SAS) package Version 9.4**.** The relationship among vegetative growth parameters, yields, and yield components was tested by correlation coefficients analyzed.

## 3. RESULTS AND DISCUSSION

### 3.1. The analysis of *C. abyssinica* accessions with different growth parameters

The growth parameters of *C. abyssinica* were determined from 16 different accessions taken from the Institute of Biodiversity Conservation of Ethiopia that was collected from different provenance sites in the country. In this study, the measurement growth parameters of Anchote accessions including seedlings emergency percentage vine number, vine internodes length, number of vine length per plant, and Leave area were revealed that very highly significantly different at ($P<0.001$), except for leave number per plant was significantly different at ($P<0.01$) among all accessions (Table 2). In the study area, the overall highest mean values of all plant growth parameters were recorded in accession 223090 (which was collected from East Wellega, Guto Wayu district) which varied between 3.54 (Vine number per plant) and 162.80 (leaf area/plant). However, the least mean values of Vine number per plant, Vine length per plant, and Leaf number per plant were observed in the accession of 223098 (East Wellega, Guto Wayu district). Similarly, the wide mean values of Anchote accession growth characters were observed by Desta (2011) and Daba et al. (2012).

**Germination Percentage**: analysis of variance reveals that there is a very highly significant difference ($p < 0.001$) in germination percentage among accession. The mean germination percentage ranged from 77% to 96.13% (Table 2). The maximum mean germination percentage of 96.13 % was obtained from accession no. 223090 which was collected from the West Wellega zone, Gimbi district, followed by accession no. 223096 (95.33%) that was brought from East Wellega, Guto Wayu district. While the lowest germination percentage was recorded from 223097 (77%), 223098 (77.5%), and 223085 (77.67%) which were collected from the East Wellega zone of Guto Wayu and Diga Leka districts. This variation may be due to the genetic variation among accession and also due to the environmental condition (soil temperature) difference in the growing area. This result is in agreement with the previous research on yam genotypes (Zanklan, 2003), and Anchote accessions (Daba et al. 2012).

**Vine number, vine internodes length, and vine length per plant:**

**Vine number:** There was a very highly significant ($p<0.001$) difference in terms of vine number among Anchote accession (Table 2). The highest average vine number (3.54) was recorded from accession no. 223090 (West Wellega zone, Gimbi district) and no. 223112 (Illubabor zone, Bedele district ), which was statistically non-significant variation with accessions no. 223108 (3.48) that was collected from the Illubabor zone, Ale district, while the lowest vine number (2.34) was no. recorded from accession no. 223098, and followed by accession no. 223087 (2.62) which was

brought from the East Wellega zone of Guto Wayu and West Wellega Gimbi districts, respectively. This result shows that the Anchote accession numbers of 223090, 223112, and 223108 were performed very well and show an optimum number of vine numbers per plant in the study area of agroecology. This is attributed due to well suitable environmental conditions (soils, temperature, and moisture) of the study area to these accessions. General the mean values of vine number per plant show variation among accession between 2.34 and 3.54. The variation of vine number per plant among Anchote accessions was probably happening due to genetic variation among accessions, and local environmental conditions (soils, climate, water) influence individual accessions. Similar findings were reported by Daba et. al. (2012). According to (Gichimu et al., 2009), long and highly branching main vine directly translated to high fruit yields in cucurbits. This also occurred in Anchote accessions having long main vines that are directly translated to internodes length.

**Table 2:** Growth variables of Anchote root as influenced by accessions from different provenances

| Accession Code | Seedlings emergency (%) | Vine number per plant | Vine length per plant | Vine internode length per plant | Leaf number per plant | Leaf Area/plant |
|---|---|---|---|---|---|---|
| 207984 | 85.27dce | 3.13bc | 3.40d | 8.87dfge | 122.52bac | 92.267j |
| 223085 | 77.67f | 2.96dc | 2.26e | 8.77hdfge | 121.95bac | 107.23ji |
| 223086 | 85.40dce | 2.80de | 5.60b | 8.57hfge | 128.77a | 148.00bac |
| 223087 | 86.00dce | 2.62fe | 4.48c | 8.17hg | 127.90a | 124.80fgeih |
| 223088 | 83.97de | 2.79de | 3.39d | 11.07ba | 122.29bac | 128.20fgdeh |
| 223105 | 88.33dc | 3.34ba | 4.68c | 10.34bc | 128.30a | 123.56fgih |
| 223090 | 96.133a | 3.54 a | 6.35a | 11.57a | 129.00a | 162.80a |
| 223096 | 93.33ba | 3.40ba | 4.40c | 11.00ba | 127.13ba | 154.70ba |
| 223097 | 77.00f | 3.26ba | 2.24e | 10.33bc | 116.8bc | 132.20fgdec |
| 223098 | 77.50f | 2.34f | 1.99e | 7.70 h | 116.66c | 143.00bdac |
| 223100 | 89.33bc | 2.80de | 5.43b | 8.50hfg | 128.40a | 139.97fbdec |
| 223104 | 87.47dce | 3.27ba | 4.53c | 9.67dc | 128.20a | 113.55ih |
| 223108 | 82.67e | 3.48 a | 3.39d | 9.49dfce | 122.10bac | 130.00.fgdech |
| 223109 | 87.17dce | 3.27ba | 4.53c | 9.70dc | 128.03a | 113.70gih |
| 223112 | 86.67dce | 3.54a | 4.50c | 9.60dce | 127.79a | 144.77bdac |
| 223113 | 95.33a | 3.37ba | 5.67b | 11.33a | 128.80a | 151.66ba |
| Mean | **86.20** | **2.80** | **3.50** | **9.67** | **125.30** | **101.92** |
| LSD | 3.43 | 0.282 | 0.3482 | 0.76 | 10.449 | 18.461 |
| CV (%) | 3.44 | 10.28 | 10.7 | 6.8 | 5 | 10.86 |
| Sign | *** | *** | *** | *** | ** | *** |

Note: Means for Anchote accessions within a column followed by the same letter are not significantly different from each other at $p < 0.05$. Keys: *, **, ***, and ns = significant at $P < 0.05$, high significant at $P < 0.01$, very high significant at $P < 0.001$, and non-significant at $P > 0.05$, respectively.

**Vine internodes length:** There was a very highly significant ($p \leq 0.001$) difference among accession for vine internodes length (Table 2). The longest Vine internodes length (11.57cm) was recorded from accession no. 223090, while the shortest (7.7cm) vine internode length was recorded from accession no. 223098 which was collected from the West Wellega zone of Gimbi, and East Wellega zone of Guto Wayu districts, respectively. The variability in internode length among accessions could be due to the effect of genetic differences among accession. This also occurred in Anchote accessions having long main vines that are directly translated to internodes length. Additionally, the study area's local environmental conditions (soils, climate, moisture) may influence the adaptability performance of each Anchote accession in relation to their original environmental adapted. This result is in line with the finding of Desta (2011), and Daba et. al. (2012), who reported the existence of high genetic variation in vine internode length per plant among the accession of Anchote.

**Vine length per plant**: in terms of vine length, there is a very highly significant difference ($p<0.001$) among accessions for vine length per plant (Table 2). The longest vine length (6.35 m) was recorded from accession no. 223090, followed by accession no. 223113 (5.67) those collected from the West Wellega zone of Gimbi district, and Jimma zone Mana districts, respectively. However, the shortest vine length (1.9 m) was recorded in accession no. 223098 that was brought from the East Wellega zone of the Guto Wayu district. The variability in internode length among accessions could be due to the genetic difference among accessions, and the environmental effects of the growing area. Similar to the present finding Desta (2011), and Daba et. al. (2012) reported the variation of mean values of vine length per plant among accessions. Elameen et al., (2010) reported that there is a significant variation observed in different accessions of sweet potato collected from Tanzania in vine characters.

**Leave number per plant:** The data obtained on the number of leaves revealed that accessions had highly significant differences ($p<0.001$) within the accessions (Table 2). The largest number (129) was recorded from accession no. 223090 followed by accession no. 223113 (128.80), 223086 (128.77), 223100 (128.40), 223105 (128.30), 223104 (128.20), 223109 (128.03), 223087 (127.90), and 223112 (127.79), however, it was not statistically significant difference among these accessions. This shows that the majority of the accessions responded more positively to the study site by producing a large number of leaves per plant. While the lowest leave number was recorded from accession no. 223098 (116.66). This shows the presence of genetic variability among the accessions evaluated. This may be attributed due to the conducive environmental conditions (soil

suitability, climate, moisture) of the study site than their original provenance environmental conditions. The present study result agreed with the results reported by Huh et al., (2008), Desta et. al. (2011), and Daba et. al. (2012.

**Leave area:** There is a very highly significant ($p<0.001$) difference among the accessions for the leaf area. The range of the leaf area among the 16 different accessions varied between 92.27 $cm^2$and 162.8$cm^2$ (Table 2). From the present study result, the significantly higher average leaf area (162.8$cm^2$) was produced by accession no. 223090, followed by accession no. 223096 (154.7 $cm^2$). However, the minimum leaf area (92.27 $cm^2$) was produced by accession no. 207984. The variation attributed in leaf area variation among Anchote accessions may be due to the genetic make-up variation, and the capacity of adaptability of the collected accessions to the local environmental conditions (soils, climate, moisture), which contribute to the physiological process difference among the accessions, that resulting in differential genotypic response. The significant accession by the local environment indicated that the response of accessions to change in the original provenance environment was not the same for all accessions evaluated in the left area. Similar to the present finding, other workers reported the variation in leaf area in yam (Belford et al. 2001), and in potatoes (Showemimo, 2007), in different varieties (Ahmad et al. 2008).

### 3.2. Yield and yield components analysis of Anchote (*Coccinia abyssinica*) Accessions

Under yield and yield components of Anchote, number of storage roots per plant, storage root diameter, storage root yield per plant, storage root yield per hectare, storage root dry matter content, marketable storage root yield, and unmarketable storage root yield data were measured. Analysis of variance shows highly significant ($p<0.001$) differences among Anchote accessions.

**Number of storage roots per plant:** analyses of variance on number of storage root per plant reveals highly significant differences ($p < 0.001$) among Anchote accessions used for the field trial experiment. The maximum storage root number (4.5) was observed in accession no. 223087, which was statistically on par with accession no. 223090 (4.1), 207984 (3.85), 223098 (3.85), and 223108 (3.85). These accessions had above the overall average (3.42), the majority of which were under the West Wellega zone of Gimbi, and the East Wellega zone of Guto Wayu districts. However, the minimum number of storage roots per plant was recorded (2.40) in accession no. 223097. The recorded mean value of the number of storage roots per plant (2.40) at accession no. 223097 was lower than the overall mean value of the number of storage roots per plant (3.42) of all 16 accessions. These results indicate that the performance of Anchote accessions varies among accession between 2.40 and 4.50 mean value of the number of storage roots per plant. This variation could be related to the genetic variability of accessions, and because the environmental

conditions (water, soil, climate change) of the study area contributes to the adaptability capacity of different accessions. Similar to the present finding Desta et al. (2011), and Daba et al. (2012) reported the variation mean values of the number of storage roots per plant among different Anchote accessions in Ethiopia.

**Storage Root Diameter:** There was a highly significant ($p < 0.001$) difference among accessions for storage root diameter in the study area. The highest storage root diameter (136.26) was recorded in accession no. 223096, followed by accession no. 223090 (125.52) with a statistically significant difference. However, the lowest storage root diameter (62.35) was recorded from accession no. 207984 followed by accession no. 223097 (65.20) (Table 3). This shows the presence of genetic variability among accessions evaluated and/or because of the environmental condition of the study area to the accessions. This finding agrees with (Manrique and Hermann, 2000) who showed significant differences among genotypes for the root diameter of sweet potatoes.

**Storage root yield weight per plant (kg)**: There was a very highly significant ($p<0.001$) difference among the accessions storage root yield per plant. In the present study result, the overall mean value of total storage root yield weight per plant under different Anchote accessions varied between 0.41 kg and 1.15 kg. Significantly the highest total storage root yield weight per plant (1.15 kg) was obtained from accession no. 223090 which was collected from the West Wellega zone, Gimbi district, followed by accession no. 223113 (0.94kg) from Jimma zone, Mana district, and 223086 (0.92 kg) from East Wellega zone, Diga Leka district, with a statistically significant difference. While the lowest storage root yield weight per plant was recorded from accession no. 223097 (0.41 kg) brought from East Wellega zone, Guto Wayu district, followed by accession no. 223108 (0.64kg) from the Illubabor zone, Ale district, with a statistically significant difference. This shows the presence of genetic variability among accessions evaluated and that the accessions interact with environments from which they were collected resulting in differential genotypic responses to the variation mean values of storage root yield weight per plant. The present finding agrees with other workers reported in yam (Belford et al. 2001) and potato (Showemimo, 2007); as different accessions significantly produce various values of storage root yield weight per plant due to accession genotypic behavior in the environments.

**Storage root yield per hectare (tonne)**: The analysis of variance (ANOVA) for storage root weight per hectare indicated that there was a highly significant ($p <0001$) difference among accession. The overall mean value of storage root yield per hectare varied from 52.25 tonne /ha to 143.79 tonne/ha. The largest storage root yield per hectare was recorded from accession no.223090

(143.79 tonne/ha), followed by accession no. 223113 (117.00) which was collected from the West Wellega zone, Gimbi district, and Jimma zone, Mana district, respectively with a statistically significant difference. The root yield of Anchote is higher as compared to other root and tuber crops found in Ethiopia. The highest yield obtained from this crop encourages the cultivation of Anchote plants in the country for securing food security. Similarly, Desta (2011) stated that Anchote storage root yields are much stickier and/or dense than other root and tuber crops.

However, the smallest storage root yield per hectare was recorded from accession no. 223097 (52.25 tonne/ha), followed by accession no. 223098 (70.00 tonne/ha) those collected from the East Wellega zone, Guto Wayu district. Wider variability in storage root yield per hectare among different Anchote accessions could happen due to high genetic variability and the study area (Guder) local environmental conditions (soils, climate, moisture) adaptation capacity as compared to their original province agro-ecologies. The storage root yield per hectare obtained in the current study lies within the range of storage root yield reported by Desta (2011). The other worker, Gebremedhin et al. (2008) also reported that the tuber yield of released potato varieties ranges from 22-47 tonne /ha in Ethiopia. As compared the Anchote storage root yield per hectare is the highest-yielding root crop and it has a prospect to develop a better variety from the presently tested accessions by testing their yields per hectare in the study area.

**Storage root dry matter content per plant (%):** the analysis of variance on storage root dry matter content revealed that accessions had highly significant differences ($p<0.001$). The dry matter content (percentage) of accession no. 223090 (25.14%) and 223086 (24.69%) were higher than the others, those collected from the West Wellega zone, Gimbi, and East Wellega zone, Diga Leka districts, respectively. Accession no.223090 was the highest storage root dry matter content (25.14%), this is due to the highest storage roots yielder per plant and per hectare in the study area. Whereas the lowest storage root dry matter content (5.55%) was recorded under accession no. 223097 that was brought from East Wellega zone, Guto Wayu district, this may be attributed due to the lowest storage roots yielder per plant and per hectare in the area among other accessions. There was also a wider variability in dry matter content among the accessions which ranges between 5.55 % and 25.14 % root dry matter content. This indicates that most of the high root-yielding accessions have higher dry matter content (%) than the low root-yielding ones. The higher dry matter content in high-storage root-yielding accessions could be due to the higher assimilate accumulation due to their higher photosynthetic efficiency than the low-storage root-yielding accessions. The present finding agrees with Terefe (2003) had reported the higher root-yielding

sweet potato cultivars to divert a larger fraction of assimilates to the root during the growing period. Similarly, Thaina et al. (2010) stated that the nutrient composition of root crops is affected by genetics, environment (soil conditions, moisture availability, etc), cultural practices, and processing methods.

**Table 3:** Yield and yield components of *C. abyssinica* root as influenced by accessions from different provenances

| Accession Code | Root number per plant | Root dry matter content per plant (%) | Root diameter per plant (cm) | Root weight per plant (kg) | Root weight per hectare (tonne) | Marketable Root weight per hectare (tonne) | Unmarketable Root weight per hectare (tonne) |
|---|---|---|---|---|---|---|---|
| 207984 | 3.85bac | 17.90feg | 62.35j | 0.69fed | 86.25gf | 85.98gf | 0.27fed |
| 223085 | 2.70ef | 15.97g | 100.77gef | 0.637f | 79.63hi | 79.12hi | 0.51f |
| 223086 | 3.27edc | 24.69ba | 112.50c | 0.92cb | 115.00cbd | 114.70cbd | 0.30 cb |
| 223087 | 4.50a | 18.889fe | 95.79ghef | 0.73fcebd | 91.25gf | 90.70gf | 0.55fcebd |
| 223088 | 3.27edc | 16.84fg | 95.00ghf | 0.66fe | 82.50gh | 82.05gh | 0.45fe |
| 223105 | 3.27edc | 22.14dc | 93.90ghi | 0.86cbd | 107.50cebd | 107.20cebd | 0.30cebd |
| 223090 | 4.10ba | 25.14a | 125.52b | 1.15a | 143.79a | 143.70a | 0.09a |
| 223096 | 3.56bdc | 18.00feg | 136.26a | 0.72fced | 90.00gf | 89.50gf | 0.05fced |
| 223097 | 2.40f | 5.55i | 65.20j | 0.41g | 52.25j | 50.63j | 1.62a |
| 223098 | 3.85bac | 10.70h | 102.56de | 0.56fg | 70.00ji | 69.16ji | 0.84fg |
| 223100 | 3.56bdc | 22.59bc | 101.98def | 0.89cbd | 111.25cb | 110.86cb | 0.39cb |
| 223104 | 3.00edf | 21.80dc | 87.44i | 0.81fcebd | 101.25cefd | 101.13cefd | 0.12fcebd |
| 223108 | 3.85bac | 16.40g | 98.84ghef | 0.64fe | 80.00gh | 79.10ghi | 0.90fe |
| 223109 | 3.56bdc | 20.10de | 114.72c | 0.76 fcebd | 95.00gefd | 94.40gefd | 0.60fcebd |
| 223112 | 2.99edf | 19.785de | 108.92dc | 0.76 fcebd | 95.00gef | 94.80gef | 0.20 fcebd |
| 223113 | 2.99edf | 24.74bc | 92.60hi | 0.94b | 117.00b | 116.48b | 0.52b |
| Mean | 3.41745 | 18.84 | 99.65 | 0.7715 | 96.4372 | 93.5238 | 48.8843 |
| LSD | 0.84 | 2.4 | 7.335 | 0.2194 | 27.425 | 15.92 | 17.539 |
| CV (%) | 16.6436 | 7.65259 |  | 21.52 | 21.5168 | 12.98942 | 21.5168 |
| Sign | ** | ** | ** | ** | ** | ** | ** |

Note: Means for Anchote accessions within a column followed by the same letter are not significantly different from each other at $p < 0.05$. Keys: *, **, ***, and ns = significant at $P < 0.05$, high significant at $P < 0.01$, very high significant at $P < 0.001$, and non-significant at $P > 0.05$, respectively.

**Marketable storage root yield (MSRY)**

Analysis of variance revealed that the existed of highly significant ($P < .001$) difference among accessions (Table 3). A high marketable storage root yield is at the end, the goal of priority yields

to obtain by producers for higher yielders accession selection. From the present study, the overall mean values of marketable storage root yields varied from the minimum (50.63 tonne/ha) to the maximum (143.70 tonne/ha). In the study area, the maximum marketable storage root yield (143.70 tonne/ha) was recorded from accession no. 223090, followed by accession no. 223100 (110.86 tonne/ha), 223086 (114. 70 tonne/ha), 223105 (107.20 tonne/ha), and 223104 (101.30 tonne/ha) with the statistically significant difference among accessions. The possible reasons for the higher marketable storage root yield (> 100 tonne/ha) produced by these accessions in the study area may be attributed due to the produced storage root yields were not damaged physically and affected by disease and insects, and also there were no over and undersized storage root yields, which means all these accessions had average root diameter size ranging from 87.44 cm to 125.52 cm, and root weight ranging between 0.81 and 1.32 kg. Generally, these accessions produced a more marketable storage root yield (> 100 tonne/ha) than Desta, (2011) recommended the average storage root yields of Anchote 70.0 tonne/ha on a vertisol. From this study, all the storage root yield produced were highly marketable (Table 3) this was because there no damaged and affected roots, and also there were no over and under-sized roots (all had average size ranging from 62.35 mm to 125.5 mm), which is in the range of the average size for Anchote (Desta, 2011). As a result, the majority of total yields were marketable even though there were slight variations among accessions.

**Unmarketable storage root yields (UMSRY)**

The data obtained on unmarketable storage root yields revealed that accessions had significant differences ($p < 0.05$) within the accessions. The overall unmarketable storage root yields of all Anchote accessions were varied between 0.05 to 1.62 tonne/ha which observed at accession no. 223096, and 223097, respectively. The largest unmarketable storage root yields (1.62 tonne/ha) were produced from accession no. 223097 which was collected from the East Wellega zone, Guto Wayu district. This indicates that the storage root yields per plant and hectare from accession no. 223097 were affected by disease and insects, and some produced storage roots were under normal weight due to genetically susceptible to disease and insects, and local environmental conditions and adaptability problems are among the factors that contributed to these results. The range of root diameter obtained from this field trial experiment was in the range of marketable yield, so the storage root grouped with unmarketable roots under this study is the lowest. However, the smallest unmarketable storage root yields (0.05 tonne/ha) were produced from accession no. 223096 which was brought from the East Wellega zone, Guto Wayu district. This is attributed due to the produced

storage roots were laid in the normal root diameter and weight per plant distribution, free from diseases, insects, and deformed by genetic makeup, and local environmental adaptability. Similarly, other workers Desta et al. (2011), and Daba et al. (2012) observed the variation of mean values of unmarketable storage root yields under different Anchote accessions in different areas.

**Table 4.** Combined Pearson correlation coefficients among vegetative growth, yield, and yield components of Anchote accessions evaluated at Ambo University, Guder Mammo Mezemir Campus research site

| | SE | VNPP | VLPP | VIL | LNPP | LA | RNPP | RDMC | RD | RYWPP | RYWPH | MRYPH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE | 1 | | | | | | | | | | | |
| VNPP | 0.27ns | 1 | | | | | | | | | | |
| VLPP | 0.28ns | 0.34** | 1 | | | | | | | | | |
| VIL | 0.7*** | 0.09* | 0.32** | 1 | | | | | | | | |
| LNPP | 0.08ns | 0.21* | 0.47** | 0.33** | 1 | | | | | | | |
| LA | 0.71*** | 0.13* | 0.44** | 0.48*** | 0.54** | 1 | | | | | | |
| RNPP | 0.36** | 0.22* | -0.12 | 0.27* | 0.14* | 0.28* | 1 | | | | | |
| RDMC | -0.02 | 0.29* | -0.33 | 0.36* | 0.36** | 0.34* | 0.31 | 1 | | | | |
| RD | 0.75*** | -0.19* | -0.26* | 0.59** | 0.69*** | 0.83** | -0.23ns | 0.24ns | 1 | | | |
| RYWPP | 0.29*** | -0.15* | -0.33** | 0.63** | 0.79*** | 0.55** | 0.68** | 0.53* | 0.65** | 1 | | |
| RYWPH | 0.29* | -0.15* | -0.33** | 0.63** | 0.79*** | 0.55** | 0.68** | 0.53* | 0.65** | 1*** | 1 | |
| MRYPH | 0.2ns | -0.16* | -0.21* | 0.55** | 0.66** | 0.42** | 0.41** | 0.67** | 0.51** | 0.92*** | 0.95*** | 1 |

Keys: *, **, ***, and ns = significant at P < 0.05, high significant at P < 0.01, very high significant at P < 0.001, and non-significant at P > 0.05, respectively. SE = Seedlings emergency (%), VNPP = Vine number per plant, VLPP = Vine length per plant, VIL= Vine internode length per plant, LNPP = Leaf number per plant, LA = Leaf Area/plant, RNPP = Root number per plant, RDMC= Root dry matter content per plant (%), RD = Root diameter (cm), RYWPP = Root weight per plant (kg), RYWPH = Root weight per hectare (tonne), MRYPH = Marketable Root weight per hectare (tonne), and UMRYPH = Unmarketable Root weight per hectare (tonne)

### 3.3.Correlation analysis among variables

Correlation analysis was used to express the associations between variables of vegetative growth parameters, yields, and yield components of Anchote accessions. The Pearson correlation coefficient provides a numerical summarization of the degree to which a linear relationship exists between two quantitative variables of Anchote accessions. The correlation analyzed of Anchote accession characters of germination (%), vine number per plant, vine length per plant, vine

internode length per plant, leaf number per plant, and leaf area/plant showed a significant positive correlation among them, which means the existence and increment of one character positively contributing to the existence and increasing of the others and vise-verse.

Among the majority analyzed of Anchote accession characters: vine internodes length (cm), leave number per plant, leave area per plant ($cm^2$); root diameter (cm), root dry matter content (%), and total root yield weight per plant (kg) were revealed positive significant correlation with the target of total root yield weight per hectare (tonne/ha), and marketable root yield per hectare (tonne/ha) (Table 4). This indicates that the existence and physical performance of these characters contributes/ influence directly the increment of total root yield weight per hectare (tonne/ ha) productivity. Similar findings were reported by Desta et al. (2011) in Anchote accession, Weyessa et al. (2009) in 36 *P. edulis* accessions, and Meaza (2015), in 25 potato genotypes. Generally, the correlation coefficients compute was important to understanding the magnitude and the interrelationship of the accession characters among themselves and with the target total root yield weight per hectare (tonne/ha), and marketable root yield per hectare (tonne/ha).

## 4. CONCLUSION

Ethiopia has diverse agroecological and climatic conditions suitable for the production of various root and tuber crops. Among the roots and tubers crops commonly grown in Ethiopia, *C. abyssinica* is an annual trailing vine belonging to the Cucurbitaceae family that is cultivated in the western and southern parts of a country. The present study was initiated to evaluate, the agronomic performance of *C.abyssinica* accessions by analyzing data of growth, yield, and yield component parameters. Accordingly, the Anchote accession tested results showed a differential response to the west Shewa zone, central highland environmental conditions. The variation response in growth, yield, and yield component parameters among the selected 16 Anchote accessions could be attributed due to the genetic variability, and potential of adaptation to the local environmental conditions (soil, water, and climate) of the study area. From this study, we conclude that six (6) accessions no.: 223090, 223113, 223086, 223100, 223105, and 223104 were identified for higher storage root yield (> 101 tonne/ha), higher marketable storage root yield (tonne/ha), and higher dry matter content production, which indicates good performance and adaptation in west Shewa central highland of Ethiopia. Therefore, these accessions are suggested to produce and scaling up by local producers/farmers in the central highland of Ethiopia, particularly in the West Shewa zone, and other areas of similar agroecological zones of a country.

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