Research article

Evaluation of improved taro (Colocasia esculenta (L.) Schott) genotypes on growth and yield performance in North-Bench woreda of Bench-Sheko zone, South-Western Ethiopia

Tewodros Legesse a,*, Tilahun Bekele b

a Mizan-Tepi University, College of Agriculture and Natural Resources, Department of Plant Science, P.O. Box 260, Mizan Teferi, Ethiopia
b Mizan-Tepi University, College of Agriculture and Natural Resources, Department of Horticulture, P.O. Box 260, Mizan Teferi, Ethiopia

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ABSTRACT

Taro is the world's fourth most important root crop in terms of production by weight, behind cassava, potato, and sweet potato, and the second most significant staple root crop in terms of consumption, after sweet potato. However, a shortage of well-adapted cultivars is one of the production problems that contribute to low yields and small planted areas across the country. As a result, genotypes with high production potential and adaptability for local environmental circumstances must be evaluated. During the 2018 and 2019 main cropping seasons, field experiments were done in the North-Bench woreda in the Bench-Sheko zone, south-western Ethiopia, to improve taro production and productivity by evaluating and selecting high yielding taro cultivars. Three improved and one local taro variety were used in the trial, which was laid out in a randomized complete block design (RCBD) with three replications at the North bench location. The data were collected and analyzed by using SAS 9.2 Version statistical software. The study's findings revealed that variety had a significant (P < 0.01) impact on all of the variables considered. Accordingly, combined analysis over years indicated that the highest leaf number per plant (7.76), plant diameter (40.82cm), corm diameter (8.28cm), cormel number per plant (6.10), and total yield (22.34 t/ha) were observed for Boloso-1 variety. The highest value of the number of suckers per plant was also observed for the Boloso-1 variety in both years (8.2 in 2018 and 6.2 in the 2019 growing season). However, combined analysis over years indicated the highest corm length in local variety (12.15cm) followed by Boloso-1 variety (10.34cm). Therefore, based on the overall results of this study, the Boloso-1 variety performed best and was more adapted to the area as compared to other varieties. This variety should be popularized and disseminated to users to boost the production and productivity of taro in the testing location and similar agro-ecologies of the region.

1. Introduction

Taro (Colocasia esculenta (L.) Schott) is a perennial root crop that is erect herbaceous, monocotyledonous, and belongs to the Araceae family (Manner and Taylor, 2010; Amadi et al., 2011; Prajapati et al., 2011). It is native to tropical areas of South and Southeast Asia, as well as the Pacific Islands (Jianchu et al., 2001), and has since spread to other parts of the world. However, the largest area of cultivation is in West Africa, which accounts for the majority of output (Onwueme, 1999; Kuswara and Prana, 2003). The crop is widely cultivated in tropical and subtropical regions of the world. It is now grown in almost every area of the humid tropics. The corm and cormels are the major economic part of the crop. Depending on the cultivars and culture, the leaves, blossoms, and petioles are occasionally utilized for food (Fred and Makeati, 2001). Both taro and sweet potato are consumed in three ways: human food, animal feed, and the production of alcohol and starch (Yared and Tewodros, 2014).

With an estimated annual production of around 229,088 tones, taro is the second most important staple root crop in terms of consumption after sweet potato (Singh et al., 2006), and the fourth most important root crop concerning production by weight after cassava, potato, and sweet potato (Bourke and Vlassak, 2004). The crop is grown all over the world, primarily by resource-poor farmers, in different ecological conditions ranging from 1,300 to 2,300 m above sea level. Its compatibility with various types of limited input farming methods, as well as its reliability under conditions such as drought, excessive rainfall, and low soil fertility, have made it an appealing crop to farmers, according to Yared et al.

* Corresponding author.
E-mail address: ledutew@gmail.com (T. Legesse).

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2405-8440/© 2021 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
The most essential characteristics of taro are its flexibility, disease resistance, and ability to generate a high yield in a variety of conditions, particularly in tropical environments (Tewodros, 2013). Taro is grown and used extensively as a food and a source of revenue in the South, West, and South Western parts of Ethiopia. Reported data of agricultural sample survey of the central statistical agency (CSA) indicated that area coverage, production, and productivity of taro are increasing from time to time. According to the CSA report area coverage, production, and productivity of taro were increased from 30,251.07ha to 45,995.28ha; 228,242.78ton to 11,797, 769.33 ton and 7.545 ton/ha to 25.650 ton/ha respectively during 2008/2009 (2001 E.C) and 2017/2018 (2010 E.C) growing seasons. It ranked 3rd followed by potato and sweet potato in terms of area coverage and 2nd in terms of production and productivity next to Sweet potato among the major root crops grown in major growing regions of the country (CSA, 2018).

However, under intensive management, the productivity of the crop may reach up to 73 t/ha (Goenaga and Chardon, 1995; Silva et al., 1992). So far three improved varieties were released by Jimma and Areka agricultural research centers in Ethiopia (MOANR, 2015). Under experimental field conditions, one of these cultivars (Boloso-1) produced an average fresh yield of almost 67 t/ha, well exceeding the national average (Asfaw and Waga, 2004, unpublished). This demonstrates that taro yield obtained by farmers including the study area is by far below the crop potential (Belachew and Aklilu, 2017). This is due to little information on the use of well-adapted cultivars for the maximum yields of taro and there are currently no research recommendations for adaptable cultivars that take into account the study area’s environmental conditions. The present study was, therefore designed to improve the production and productivity of Taro at Bench-sheko Zone through evaluation and selection of high yielding taro variety.

2. Materials and methods

2.1. Description of study area

The field experiment was conducted at North-Bench (Boseka kebele) woreda of Bench-Sheko zone, during the 2018 and 2019 cropping seasons. The area is found in South Nations, Nationalities, and Peoples Regional State, in the sub-humid tropic of South-Western Ethiopia. Geographically, the study site is located at 6°09’N latitude and 35°E longitude at an altitude of 1400m above sea level. The area receives annual rainfall ranging from 1801 to 2000 mm with mean minimum and maximum temperature 15.01°C and 25°C, respectively.

2.2. Experimental material

Three released varieties of taro, namely: Boloso-1, Kiyaq, and Denu obtained from Jimma and Areka agricultural research center; and one local variety collected from farmers surrounding the testing site was used for the study. Morphological and agronomic characteristics of the three released varieties and the nutritional and anti-nutritional composition of the Boloso-1 variety are indicated in Table 1.

2.3. Treatments and experimental design

The study used a Randomized Complete Block Design with three replications and included four treatments (three commercially released and one local Taro variety).

2.4. Experimental procedures

The experimental land was cleared and plowed by oxen plow according to farmers’ practice. The entire field was divided into three blocks, each of which included four (4) plots, for a total of twelve (12) plots. The sizes of each unit plot were 3 m × 6 m (18 m²) with each plot subdivided into four rows and ten plants per row, having inter-row and intra-spacing of 0.75 m and 0.60 m, respectively. Between the unit plot and the blocks, a 1 m space was maintained. Suckers or main plants, which comprise the top 3 cm of the corm with the petiole, were used to make planting material. This was carried out after the dormancy periods when the shoot (sprouts) come out of the shoot tips and was planted on the ridge at the depth of 10cm in the ground during the onset of the rainy season (early March). All management practices were practiced uniformly as per the recommendation for root and tuber crops. Harvest was undertaken by hand when the leaves of 50% of the plants in the plot turned yellowish. Similar procedures were used in both years to repeat the experiment for the comprehensive recommendation.

2.5. Data collection

Both pre-harvest and post-harvest data from the two net harvestable rows on randomly selected ten plants from each plot for each response variable were recorded.

2.5.1. Stand count

Plant population per plot after 4 weeks of first planting was counted and recorded. In the same manner, the stand count of the crop just immediately before harvesting was counted and recorded.

2.5.2. Plant height(cm)

Plant height (cm): The height of ten (10) randomly selected plants were measured in centimeters from the ground level to the tip of the leaf at the time of final harvesting and the average was worked out.

2.5.3. The number of leaves per plant

A total of ten (10) plants’ leaves were counted, and the number of leaves per plant was calculated.

2.5.4. The number of suckers per plant

The total number of suckers were counted from ten randomly selected plants and suckers per plant were worked out.

2.5.5. Plant diameter(cm)

The plant canopy diameter of ten selected plants was measured and worked out.

2.5.6. Corm length and corm diameter(cm)

For ten selected plants corm length and corm diameter were measured and worked out.

2.5.7. Cormel number per plant

The randomly selected ten plants were uprooted carefully at harvest and the portion below the ground was separated. Then the fresh cormels were counted.

2.5.8. Total yield(ton/ha)

was calculated from the harvestable plot and converted into yield/ha and expressed as t/ha.

2.6. Data analysis

The collected data were subjected to analysis of variance (ANOVA) following the standard procedure given by Montgomery (2013). Combined analyses over years were performed for response variables that showed non-significant error variances across years according to Gomez and Gomez (1984); whereas for response variables that showed significant error variance across years, the results were reported based on individual year analysis. After fitting the ANOVA model, for those response variables significantly affected by variety, multiple mean separations were carried out using the LSD method (Montgomery, 2013) at a 5 percent level of significance. The SAS-9.2 statistical software was used for all statistical analyses (SAS, 2008).
3. Results and discussion

3.1. Stand count

Highly significant ($P < 0.01$) variation was observed among taro varieties concerning stand count in both years (Tables 2, 3 & 4). Accordingly, combined analysis over years indicated that the highest stand count was recorded for variety Kiyaq (30.43), which was statistically at par with Denu (28.9); while, the lowest (23.33) was observed in Local cultivar (Table 4). This variation in stand count could be due to variation in the genetic make-up of varieties in response to specific environmental conditions. Tewodros et al. (2013) indicated the existence of variability among taro accessions including Denu and Kiyaq varieties.

3.2. Plant height

The effect of taro varieties on plant height was also significant ($P < 0.05$) in the 2018 growing season (Table 2) and highly significant ($P < 0.01$) in the 2019 growing season (Table 3). The highest plant height was recorded for Boloso-1 in both years (44.20 cm in 2018 and 44.70 cm in 2019); while the lowest was observed in Denu (34.23 in 2018) and Kiyaq (33.4 cm in 2019) (Tables 2 & 3). The variation in plant height among varieties might be attributed to differences in their genetic expression or response under a given environment. This result agrees with the works of Gerrano et al. (2018) and Angami et al. (2015) in which they found highly significant variation among taro varieties in terms of plant height. A similar variation in plant height among taro genotypes was also reported by Singh et al. (2006). Whereas, non-significant variation among taro varieties in terms of plant height was reported by Desta and Merga (2020).

The number of leaves per plant: The analysis of variance showed that the number of leaves per plant was highly significant ($p < 0.001$) among varieties in both cropping seasons (Table 2, 3 & 4). In this study, based on the combined analysis of two years data the highest numbers of leaves per plant (7.755) was observed for the Boloso-1 variety as compared to other varieties; The least number of leaves per plant was seen in the Kiaq variety (5.488) even though it was statistically at par with Denu and Local variety (Table 4). A similar variation in the number of leaves per plant among taro cultivars was reported by Angami et al. (2015), Desta and Merga (2020) also reported that a significantly lower number of leaves per plant was observed in the Kiyaq variety as compared to Denu and Boloso-1. Great variation in the number of leaves per plant among taro accessions including Denu and Kiyaq was also reported by Tewodros et al. (2013) in their taro genetic variability study.

3.3. The number of suckers per plant

In both years, the number of suckers per plant exhibited a highly significant ($p < 0.001$) difference related to variety, as shown in Tables 2 & 3. The highest numbers of suckers per plant were recorded for variety Boloso-1 in both years where 8.2 and 6.2 were recorded in 2018 and 2019 growing seasons respectively as compared to other varieties. This might result from variation in the genetic make-up of the different taro varieties used in the study as indicated in the genetic variability study of taro accessions by Tewodros et al. (2013).

### Table 1. Summary of the descriptions of the studied three released taro varieties.

| No. | Morphological and Agronomic characteristics of varieties | Nutritional and anti-nutritional Composition |
|-----|--------------------------------------------------------|--------------------------------------------|
|     | Characters                                             | Varietal Composition                       |
| 1   | Altitude (m.a.s.l.)                                    | Protein 6.43%                              |
| 2   | Year of release                                       | Fat 0.47%                                  |
| 3   | Breeder/maintainer                                    | Fiber 2.63%                                |
| 4   | Plant height (cm)                                      | Total ash 4.82%                            |
| 5   | Growth habit                                          | Carbohydrates 85.65%                       |
| 6   | Leaf color                                            | Moisture content - 67.64%                  |
| 7   | Pseudostem color                                      | P (mg/100g) - 60.63                        |
| 8   | Corm cortex color                                     | Na “ - 37.61                               |
| 9   | Number of suckers                                     | K “ - 710                                  |
|     |                                                        | Ca “ - 186                                 |
|     |                                                        | Cu “ - 0.76                                |
|     |                                                        | Fe “ - 10.57                               |
|     |                                                        | Zn “ - 14.27                               |
|     |                                                        | Mg “ -                                     |
|     |                                                        | Ca “ - 45.23                               |
|     |                                                        | Na “ - 13.81                               |
|     |                                                        | P “ - 7.77                                 |
|     |                                                        | Mn “ - 3.61                                |
|     |                                                        | Phytate “ - 78.11                          |
|     |                                                        | Oxalate “ - 187                            |
|     |                                                        | Tannin “ - 67.07                           |
|     |                                                        | Cyanide “ -                                |

Source: MARD (2004), MARD (2005), Adane et al. (2013), Habitamu and Tesfahun (2017)

JARC-Jimma Agricultural Research Centre, ARARC-Areka Agricultural Research Centre, SARI-South Agricultural Research Institute, EIAR-Ethiopian Institute of Agricultural Research.

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3.4. Average plant diameter (cm)

Data also indicated a highly significant \( (p < 0.001) \) difference in average plant diameter (cm) among varieties in both cropping seasons (Tables 2, 3 & 4). According to two years combined analyses, the highest average plant diameter was recorded for variety Boloso-1 (40.82). The lowest value was recorded in the local variety (25.40) (Table 4). Similar results were reported by Angami et al. (2015) in which they obtained variation between taro genotypes in terms of leaf area index. Gerrano et al. (2018) also reported significant variation between varieties in canopy diameter. Higher plant diameter in the ‘Boloso-1’ variety observed in this study might be due to the genetic make-up of the variety or its spreading growth habit as compared to Denu and Kiyaq varieties which were erect (Table 1 variety description). This indicates that canopy development in taro is subject more to internal plant control, and suggests that the capacity of a variety at attaining a certain leaf area index depends on its ability to express its potential leaf area (Pardales, 1986).

3.5. The average corm length

The result revealed that the average corm length was highly significantly \( (P < 0.01) \) affected by variety in both growing seasons (Tables 2, 3 & 4). According to two years combined analyses, the highest average corm length was recorded from local variety (12.15 cm) followed by Boloso-1 variety (10.34 cm). The lowest value was recorded in the Kiyaq variety (8.05 cm) (Table 4). This result is in agreement with the findings of Angami et al. (2015) where they reported significant variation among taro varieties in terms of corm length. On the other hand, Desta and Merga (2020) reported nonsignificant variation among taro varieties concerning corm length. This variation could be attributed to the inherent variation of taro varieties in response to specific environmental conditions.

3.6. The average corm diameter

As indicated in Tables 2, 3 & 4; the effect of variety revealed a highly significant \( (P < 0.01) \) difference on average corm diameter in both
growing seasons. According to two years combined analyses, the highest average corm diameter was recorded for Boloso-1 variety (8.28); while, the lowest value was recorded in local variety (5.20) (Table 4). This variation in corm diameter among varieties could be due to differences in the genetic make-up of the germplasms used. The maximum value observed in the Boloso-1 variety might be due to its highest growth variables in plant height, leaf number, number of suckers, and plant diameter which helped in better utilization of photosynthates resulting in better-sized corm diameter. Angami et al. (2015) also found a significant variation on the average corm diameter of taro due to variety. Whereas, nonsignificant variation of corm diameter was reported by Desta and Merga (2020).

3.7. The average cormel number per plant

Variety indicated a highly significant ($P < 0.01$) difference on average cormel number per plant in both cropping seasons (Tables 2, 3 & 4). Based on two years combined analysis, among the varieties; Boloso-1 showed the highest (6.099) average cormel number per plant; however, the lowest value was recorded in local variety (2.74) (Table 4). A similar variation in cormel number was also reported by Desta and Merga (2020) in which they found maximum value for Boloso-1 and Denu as compared to Kiyaq variety. This variation could be related to the fact that taro cultivars have inherent diversity (Tewodros et al., 2013).

3.8. Total yield (ton/ha)

In both cropping seasons, the experiment revealed a highly significant ($P < 0.0001$) difference in total yield between varieties (Table 2, 3 & 4). According to two years combined analyses, the highest average yield was recorded for the Boloso-1 variety (22.34); while, the lowest value was recorded in the local variety (8.36) (Table 4). This result is in agreement with the findings of Desta and Merga (2020) and Yared et al. (2014) in which they found maximum yield from ‘Boloso-1’ as compared to other varieties. High yield in ‘Boloso-1’ may be attributed to better utilization of photosynthates (due to maximum growth variables like plant height, leaf number, number of suckers, and plant diameter), resulting in better-sized corm diameter; it could also be due to a higher number of cormels per plant which in turn, maybe due to accumulated storage foods, which have a direct bearing on crop yield (Bhuiyan and Quadir, 1989).

Cormel weight and the number of cormels per plant, according to Eze and Nwoifa (2016), are the most important predictors of taro yield, accounting for around 72 percent of the overall variation in yield and thus serving as important selection indices for taro yield improvement. Similar variations in yield among taro varieties were also reported by Angami et al. (2015) and Sarmah (1997). It has also been noted that genotypes tested in different locations or years often have significant fluctuations in yield due to the response of genotypes to environmental factors such as climate, soil fertility, pests, and disease pathogens (Kang 2004). This report was also supported by Miyasaka et al. (2003). A similar yield difference among taro genotypes and locations was also recorded by Singh et al. (2006). In addition, Singh et al. (1995) also indicated that the yield of taro was affected significantly by genotype, location, and interaction of genotype by location.

4. Conclusion

Root and tuber crops in general, and Taro in particular, are the crops that must be produced for food security in nations like Ethiopia, particularly in the southwestern region of the country, where the population is rapidly increasing. Therefore, it is paramount important to increase the production and productivity of the crop by adopting different agronomic practices out of which working for variety development is the major. In the present experiment, the Boloso-1 variety showed superior performance in the number of leaves per plant, plant diameter, corm diameter, cormel number per plant and total yield per hectare as compared to the tested varieties in two years combined analysis. This variety also exhibited maximum value in plant height and number of suckers per plant in the study made in both 2018 and 2019 growing seasons. Boloso-1 variety should be popularized and disseminated to users to boost the production and productivity of taro in the testing location and similar agro-ecologies of the region. However, this finding should be supplemented with other agronomic management researches including fertilizer rates and type, plant spacing that have a direct effect on yield and quality attributes. Nutritional and antinutritional content and other quality parameter analysis and also suitable post-harvest management practices need to be done to improve the quality and longtime use of the crop in the study area.

Declarations

Author contribution statement

Tewoderos Legesse; 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

The authors do not have permission to share data.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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