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Adaptation of recently released improved orange flesh sweet potato *(Ipomoea batatas* L.*)* varieties in Southwestern Ethiopia

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ABSTRACT

Most sweet potato varieties currently grown by farmers are poorly adapted, have low root yields, less nutritive and white fleshed which have no beta carotene, a precursor to vitamin "A". However, among the cheapest and richest sources of vitamin A; orange fleshed sweet potato varieties were rich in beta carotene are well accepted by young children. Hence the aim of this research project was conducted to evaluate the adaptability and performance of improved orange-fleshed sweet potato varieties on yield and other yield related traits during the 2020 main cropping season in southwest Ethiopia. The varieties used were Tulla, Kulfo, Guntutie, Vita, Kabode, Alamura and Dilla. The experiment was carried out using a randomized block design with three replications. The analysis of variance over locations depicted significant differences ($p \leq 0.05$) among varieties for most of the studied traits. In this study, Alamura (31.42 t ha^{-1}) and Dilla (27.8 t ha^{-1}) varieties give a high yield among seven evaluated orange-fleshed sweet potato varieties. Based on farmer test preference, the first and second rank of test preference was recorded from Alamura and Dilla variety. Therefore, by considering both farmer's test preference and the yield potential of the variety, Alamura and Dilla were selected as high yields and have the best test preference. Therefore, to fill the gap vitamin "A" deficiency at the community level Alamura and Dilla were selected as the best orange fleshed variety that has the best test preference with the highest yield in the humid tropics of Southwestern Ethiopia and these two varieties were recommended for production. Finally, since the result of this finding was based on data gathered from two locations and only one cropping season to test adaptability. So, one more additional season evaluation is necessary and also further studies are required to generate more reliable information on performance, nutrition and resistance to disease.

Keywords: Adaptation, Orange fleshed, Sweet potato, Variety

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Introduction

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant belonging to the family Convolvulaceae (Tortoe *et al.,* 2010). It is the third most important crop after potato and cassava in the world and one of the root and tuber crops largely grown in East Africa as staple for rural communities (Laban *et al.,* 2015). It is one of the most important sources of carbohydrates for small holder farmers in Ethiopia (Amare *et al.,* 2014). It is grown around the world in diverse environments, often by small farmers in marginal soils, using low inputs (Amare *et al.,* 2014). In some of the world's poorest nations, taro and sweet potato are important part of food security packages (Dagne *et al.,* 2014). In Ethiopia, sweet potato is widely grown in south, southwestern and eastern parts by small-scale farmers with limited land, labor and capital. According to the Central Statistical Authority (Cochrane and Bekele, 2018) reports, sweet potato occupied about 53,499 hectares of land with a total annual production of 1.85 million tons during the main growing season only. However, the productivity of the crop remained low (8 t ha-1) for a long time and the production of the crop is also declining due to many factors including recurrent drought, lack of planting materials, shortage of farmer preferred varieties, poor extension system that doesn't encourage production of root crops, market and post-harvest related problems (Fekadu *et al.,* 2015).

Due to the low level of agricultural input requirement, high productivity per unit area, good nutritional value and increasing food demand owing to high population growth of the country, sweet potato is one of the ideal starch staples for food security of the country (Laban *et al.,* 2015). Although the majority of sweet potato varieties are high in carbohydrates, orange fleshed sweet potato (OFSP) varieties also provide vitamins A and C (Labanet *al.,* 2015). Vitamin A is an essential micro nutrient for human health and vitamin A deficiency (VAD) can limit growth, weaken immunity and cause xeropthalmia leading to blindness, and increase mortality (Sommer and West, 1996). Despite this remarkable potential of the crop, vitamin A deficiency (VAD) is widespread and the most common cause for young children blindness in the developing world (Low *et al.,* 2007). Most sweet potato varieties currently grown by farmers are poorly adapted, have low root yields, less nutritive and white fleshed which have no beta carotene, a precursor to vitamin A (Wariboko and Ogidi, 2014). But among the cheapest and richest sources of vitamin A, OFSP varieties, rich in beta carotene are well accepted by young children (Low *et al.,* 2007). The intensity of orange colored flesh in sweet potatoes root indicates the level of beta carotene (Low *et al.,* 2001). Therefore, these OFSP varieties could be useful to combat the widespread VAD that results in blindness and death of 250,000-500,000 African children yearly (Wariboko and Ogidi, 2014). Hence, evaluation of improved OFSP varieties is timely. So, the objective of this experiment was to identify promising and adaptable orange fleshed sweet potato variety in terms of yield and yield contributing parameters and hence could combat vitamin A deficiency (VAD) at community level in agroecology of Southwestern Ethiopia.

Materials and Methods

Description of study area

The study was conducted at south western region of Ethiopia in two districts Gimbo and Guraferda for one season. The site is located at elevation range from 1233-1732 masl N 06044.817' E 035^{o} 51.765'. The soil at the site is characterized as sandy clay and sandy loam with pH of 5.21-5.78 and temperature rage low 24^{o}C high 43^{o}C. The livelihood of the people of the zones bares mostly agriculture and agro-pastoral.

Planting materials and experiment methodology

Six (Dilla, Kulfo, Alamura, Vita, Guntutie, Tulla) and one standard check (Kabode) varieties of sweet potato were brought from Awassa research center for their adaptation with standard check variety. The experiment was carried out by using RCBD with three replications in 2020 main cropping season. Six rows with recommended spacing of 30 cm between plant and 60 cm between rows were followed. Fertilizer and other chemicals were not applied to this experiment.

Data collection and statistical analysis

Data were collected on parameters like average root number per plot, root length, root diameter, vine length, total fresh weight per hectare, marketable fresh weight per hectare, unmarketable fresh weight per hectare. Analysis of variance for the collected parameters was performed as per the methods described by Gomez and Gomez (1984) using R computer software for randomized complete block design (Table 1) and treatment mean comparison was done by using list significance difference (LSD) at 5% level.

Preference test

Preference test for the seven varieties was conducted by using ten panelists and ten observers. Parameters used for preference test included; flesh color, sugariness, taste, powerlessness and flesh texture.

Objectives

To identify orange fleshed sweet potato varieties that is better in yield, test preference and other agronomic characteristics for the south west Ethiopia.

Results and Discussion

Effect of variety on yield and yield related traits

The result of combined ANOVA showed that there is significant variation between orange fleshed sweet potatoes (OFSPs) varieties for yield and yield contributing parameters collected (Table 1). This variation was generated due to environmental effect and genetic variability among each variety. The current finding is supported by the finding of Mekonnen *et al.* (2015), who indicated that varietal effect had a significant influence on the marketable tuberous root yield as well as total tuberous root yield of sweet potato. Similarly, Kathabwalika *et al.* (2013) also observed significant differences in total tuberous root yield among sweet potato varieties. So, based on this combined analysis of variance result over the studied location variety that have better yield performance in different agroecology was selected for production.

Table 1. Mean square values for vine length and yield of the tested varieties combined over location.

Source of variation	DF	Vine length	Marketable yield in tone ha^{-1}	Unmarketable yield in tone ha^{-1}	Total yield in tone ha^{-1}
Varieties	6	6115.2**	49.110**	2.5286	52.08**
LOC	1	9147.9**	59.045**	15.6405**	13.91*
REP	2	2658.9	47.864	0.4791	57.85
Varieties X LoC	6	39819.0	85.787	0.8173	82.15*
Error	21	2480.5	35.429	0.8173	42.76
Total	42				

DF= degree of freedom, LOC=location, Rep= replication
***=indicates level of Significance difference (P<0.001), * =indicates level of Significance difference (P<0.01)*

Table 2. Average values for yield related traits and tuber yield per hectare of seven orange flesh sweet potato varieties evaluated at two districts, Gimbo and Gura-ferda districts in SNNPRS.

Varieties	VL	NR	RL	RD	MY in ton ha^{-1}	UNY in ton ha^{-1}	TY in ton ha^{-1}
Guntute	123.43c	2.3c	11.2d	4.6cd	15.22877c	2.5000	17.734d
Alamura	183.70ab	4.3a	18.3a	9.5a	28.7800a	2.6279	31.416a
Dilla	197.43a	3.5ab	18.0a	8.3ab	26.2000ab	1.5610	27.770ab
Tulla	108.50c	2.5	12.0cd	4.5cd	16.7200c	1.2130	17.937cd
Kabode	148.00abc	3.1b	16.0b	7.0b	20.1100b c	1.6250	22.740abc
Kulfo	141.00abc	2.4c	13.3c	5.0c	17.2200c	1.4470	18.670bcd
Vita	134.70bc	2.8bc	14.0c	6.0c	19.9390abc	0.8670	20.800bc
Mean	148.11	3.0	14.5	6.4	19.17	1.6920	20.860
CV (%)	33.62	2.3	3.2	2.5	31.04	60.8280	31.330
LSD	59.106	1.5	2.4	3.0	7.06	NS	8.76

LSD=least significance difference, CV=coefficient of variation, NR=Number of roots per plant, RL=root length, RD=root diameter, VL= Vine length, MY=Marketable yield, UNY=Unmarketable yield, TY=Total yield
Mean value indicated by the same letters show there is no significance difference among each variety.
Mean value indicated by the different letters show there is significance difference among each variety.

Marketable tuberous root yield

Significant ($p<0.05$) differences occurred in marketable tuberous root yield among the orange fleshed sweet potatoes (OFSPs) varieties evaluated in this research (Table 2). The highest mean value of marketable tuberous root yield (28.78 ton ha^{-1}) was recorded from Alamura variety, followed by Dilla variety (26.2 ton ha^{-1}). However, the lowest mean value of marketable tuberous root yield (15.23 ton ha^{-1}) was recorded from Guntutie variety compared to the remaining four orange fleshed sweet potatoes (OFSPs) varieties Vita, Kabode, Kulfo and Tulla (Table 2). The differences in marketable tuberous root yield could be attributed to the genetic variations among the OFSP varieties in partitioning photosynthesis (Nedunchezhiyan *et al.,* 2007). The result of the current study is in agreed with the finding of Omiat *et al.* (2005), who obtained the highest marketable tuberous root yield from variety Ejumula but the lowest marketable tuberous root yield from variety Arivumaku. Based on the current result we can suggest that variety Alamura was the best variety followed by variety Dilla for marketing purposes but the five newly introduced OFSP varieties Vita, Kabode, Kulfo, Tulla and Guntutie were considered the poorest varieties for marketing purposes.

Unmarketable tuberous root yield

Unmarketable tuberous root yield was none significantly ($p<0.05$) different among the orange fleshed sweet potatoes (OFSPs) varieties (Table 2). Similarly, Mekonnen *et al.* (2015) and Nwankwo *et al.* (2012) also observed none significant differences in unmarketable tuberous root yield among sweet potato varieties. Even though unmarketable tuberous root yield was none significantly different among the orange fleshed sweet potatoes (OFSPs) varieties, the highest unmarketable tuberous root yield (2.623 t ha^{-1}) was recorded from variety Alamura, and the lowest unmarketable tuberous root yield (0.867 t ha^{-1}) was recorded from variety Vita. Amare *et al.* (2014) had observed wide variation among sweet potato varieties in most of the parameters (number of branches per plant, vine length, fresh fodder weight, and useable root yield) studied and attributed such differences to genetic composition.

Total tuberous root yield

Combined ANOVA indicated that, variety has significant effect on total tuberous root yield (Table 2). The highest mean value of total tuberous root yield (31.416 ton ha^{-1}) was recorded from Alamura variety, followed by Dilla variety (27.77 ton ha^{-1}). However, the lowest mean value of total tuberous root yield (17.73 ton ha^{-1}) was recorded from Guntute variety. The differences in total tuberous root yield could be attributed to varietal differences among the OFSP varieties (Antiaobong, 2007). This result is in line with the finding of Amare *et al.* (2014), who also found significant differences in total tuberous root yield among OFSP varieties in their trial. Totally, the evidence obtained from this study indicated that from the seven evaluated OFSP variety Alamura, and Dilla were identified as the highest total tuberous root yielding variety in the study area and can be beneficial to growers aimed at producing sweet potatoes for tuber production, since yield is an important factor which determines choice of sweet potato varieties for cultivation (Njoku *et al.*, 2009).

Vine length

Vine length was highly significantly ($p<0.01$) affected by variety and showed significant differences among the seven-orange fleshed sweet potato varieties evaluated (Table 2). The highest mean value in vine length (197.43 cm) was recorded from Dilla variety. While the lowest mean value (108.50 cm) was recorded from Tulla variety. The difference observed in vine length among the OFSP varieties is attributed to their genotypic difference.

Yield related traits

The highest number of roots per plant (4.3), root length (18.3 cm) and root diameter (9.3 cm) were recorded from Alamura variety. Where as lowest number of roots per plant (2.3), root length (11.2) and root diameter (4.6) were obtained from Guntutie variety.

Effect of variety on test preference of orange fleshed sweet potato varieties

Test preference

Test preference of these seven varieties is conducted by using ten panelists and ten others with observing their testing and smelling the sample of seven orange flesh sweet potato varieties (Table 3).

Depend on these methods, the mean value of test preference obtained from ten panelists and ten others showed that, from selected seven samples Alamura and Dilla are ranked first and second whereas Guntutie and Kulffo are 6th & 7th rank. Hence, Alamura and Dilla varieties have best test preference and higher yield performance at both location, Alamura and Dilla varieties were recommended for production in studied agro ecology.

Table 3. Shows test preference rank value of seven released orange flesh sweet potato varieties.

Variety	Color	Sugariness	Test	Powerness	Texture	Overall acceptance	Average	rank
Dilla	4.51	4.01	3.91	4.40	2.10	4.99a	3.8820a	1
Alamura	4.40	4.08	4.00	3.23	3.20	4.22ab	3.770ab	2
Kabode	3.75	3.34	3.86	4.21	3.67	3.10b	3.6360b	3
Vita	3.10	2.88	3.02	4.10	3.01	3.20bc	3.2975bc	4
Guntutie	2.30	3.10	2.21	2.20	2.70	3.02c	2.6460c	6
Kulfu	3.60	1.20	1.30	1.40	3.20	2.23cd	1.8660d	7
Tulla	1.30	2.10	2.20	2.07	4.10	3.30	2.7540	5

Discussion

In this study, seven sweet potato varieties were evaluated across two locations in one year based on their yield performance and test preference. The findings of this study clearly showed significant differences in yield and yield contributing parameters of studied orange-fleshed sweet potato varieties (Table 1). The significant difference among evaluated varieties for yield and yield-related traits was generated due to environmental effect and genetic variability among each variety. The current finding is supported by the finding of Mekonnen *et al.* (2015), who indicated that varietal effect had a significant influence on the marketable tuberous root yield as well as total tuberous root yield of sweet potato.

G X E interaction is an important technique in the identification and selection of promising varieties that perform better in terms of yield potential to specific environmental situations or over different agro ecological conditions. Highly significant differences were recorded between the varieties, environment, and their interaction for root tuber yield (Table 1). The presence of a highly significant difference between the two test locations for all traits indicated that the genotypes performed differently across the test environments. The significant genotype by environment interaction showed that the genotypes performed differently across the different environments revealing the complication of selecting a single genotype for all environments.

According to test preference evaluation, there were significant differences among seven white-fleshed sweet potato varieties with respect to their selection criteria for test preference parameters such as; root cortex color, flesh texture, sugariness, taste, and powerlessness (Table 3). So, based on the mean value of five test preference parameters recorded by ten panelists and ten observers; Dilla and alamura variety gives the best test preference value (4.99) and it ranked first and 2nd among seven varieties while very low-test preference was recorded by Kulfu variety (2.23) and it ranked seven from seven evaluated varieties (Table 3).

Therefore, based on the present study Alamura and Dilla variety, that gives a high yield and ranked 1st and 2nd by test preference value, could be used instated of currently using varieties to increase production and productivity of the crop in the studied area for better enhancement of food security and livelihood income.

Conclusion and Recommendation

Orange flesh sweet potato need to be cultivated as source of carbohydrate and β-carotene (Vitamin A). Due to that this research project was initiated with aim of evaluation of OFSP in agro climatic condition of south west Ethiopia. The current results showed that the most important yield and yield contributing parameters: vine length, root length, number of root per plant, root diameter, marketable tuberous root yield and total tuberous root yield were significantly varied among the OFSP varieties evaluated. Accordingly, based on yield performance and test preference Alamura, and Dilla selected as best orange fleshed sweet potato variety both for yield and test preference. Therefore, Alamura, and Dilla orange fleshed sweet potato varieties are important for food security and to fill the gap nutrient deficiency at community level in south west Ethiopia. Therefore, for popularization and promotion of these two varieties at the south west Ethiopia demonstration should be done at farming level. Therefore, Alamura, and Dilla can be used as the best orange fleshed sweet potato varieties with optimum yield and highest adaptability in the humid tropics of Southwestern Ethiopia and potentially combat VAD at community level.

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