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Orange Fleshed Sweet Potato (*Ipomoea batatas* L.) Varieties Evaluated with Respect to Growth Parameters at Jimma in Southwestern Ethiopia

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ABSTRACT
Field experiment was conducted to identify the most promising and adaptable sweet potato (*Ipomoea batatas* L.) variety. Five Orange Fleshed Sweet Potato (OFSP) varieties: variety Beletech (192026 II), Birtukanie (Saluboro), Kulfo (Lo-323), Tulla (CIP 420027) and one local variety were used as experimental treatments and arranged in randomized block design with three replications. Data collected on growth parameters were analyzed using the GLM procedure of SAS Version 9.2. Variety had highly significantly affected the growth parameters; number of branches per plant, number of leaves per plant and vine length and also significantly affected fresh weight and dry matter content of sweet potato roots. For the majority of growth parameters variety, Tulla was preferably the best variety compared to the other three improved OFSP varieties as, well as the local variety and significantly the highest number of branches per plant (41.41), vine length (99 cm), fresh weight (1.56 kg) and dry matter content (54.40%) were recorded from variety Tulla. The result of the correlation analysis also indicated that fresh weight and dry matter content of sweet potato roots were negatively and significantly correlated with number of branches per plant. This indicated that sweet potato producers targeting above ground biomass production should use number of branches and leaves per plant as selection criteria, where as those targeting sweet potato root tubers production, should use the fresh weight and dry matter content of sweep potato roots as selection criteria. Likewise, these growth parameters are important factors for selection of sweet potato and can serve as indicators of adaptability of the crop to the growing conditions of the study area. Therefore, OFSP variety Tulla (CIP 420027) can be used as the most promising and adaptable variety for optimum growth and productivity at the study area, Jimma in the Southwestern part of Ethiopia and combat VAD at community level.

Key words: Orange fleshed sweet potato, growth parameters, sweet potato variety Tulla, varieties (genotypes), vitamin A deficiency (VAD)

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) belongs to family Convolvulaceae and order Polemoniales (Oggema *et al*., 2007). It is grown around the world in diverse environments, often by small farmers in marginal soils, using low inputs (Amare *et al.*, 2014). 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). In Ethiopia it is mostly cultivated in the southern, southwestern and eastern parts of the country and recognized as the third important crop next to Enset and Potato (Amare *et al.*, 2014). The area covered and the quantity of sweet potato production is increasing from time

to time (Amare *et al.*, 2014) and currently the total area under sweet potato in the country is 75,000 ha with an average productivity of 8 t ha^{-1} (Assefa *et al*., 2007). Over the past few decades, its production increased from 5.7 in 1998 to 7.1 million metric t in 2002, showing a growth rate of nearly 5% per annum. 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 staple 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 (Laban *et al*., 2015). 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 growers are resource poor, therefore consume imbalanced diets. Most sweet potatoes 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.

Therefore, the objectives of this study was to identify promising orange fleshed sweet potato variety in terms of its growth parameters and adaptability in Southwestern Ethiopia and hence used to combat VAD at community level.

MATERIALS AND METHODS

Description of the study site: The experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) experimental site during the main cropping season of 2013/14, from June to October. Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) is located at about 7°, 41' N latitude and 36°, 50' E longitude and at an altitude of 1710 m above sea level (m.a.s.l.). The JUCAVM is situated in the Southwestern part of the country at about 350 km away from Addis Ababa, the capital city of Ethiopia. The experimental site is with the mean maximum and minimum temperature of 26.8 and 11.4°C, respectively and is receiving a mean annual rainfall of 1500 mm (BPEDORS., 2000). The site is characterized with well-drained and loam soil texture, gentle slope and dominated by Nitisols soil type (World Reference Base, 2006).

Experimental treatments and design: Five different Orange Fleshed Sweet Potato (OFSP) varieties of which four were collected from Adama Tulu Agricultural Research Center and one local variety with orange flesh were used as treatments in this experiment (Table 1). These five OFSP varieties (treatments) were laid out in Randomized Complete Block Design (RCBD) with three replications (Wariboko and Ogidi, 2014).

Experimental procedures: The experimental land was ploughed, harrowed, ridged and well decomposed cattle manure was incorporated into the soil at a rate of 20 t ha^{-1} before planting. Vine cuttings of 30 cm length with six nodes were prepared from the healthy stem of each OFSP varieties (Nwankwo *et al*., 2014). Cuttings were planted on the ridges (Anyaegbunam *et al*., 2008) with about three nodes buried in the soil uniformly for all treatments at the spacing of 60 cm between rows and 30cm between plants (Nwankwo *et al*., 2012) on plots with the size of 2.4×2.4 m containing 4 rows and 8 plants per row resulting in 32 plants per plot. Weeding was done two times using manual method. Earthing up and other cultural practices were done according to the standard recommendation.

Data collection and analysis: To evaluate the growth performance and adaptability of Orange Fleshed Sweet Potato (OFSP) varieties all the data on growth parameters were recorded. Data on Number of Branches per Plant (NBP), number of leaves per plant (NLP), Vine Length (VL), root Fresh Weight (FW) and root Dry Matter Content (DMC) were collected. The DMC was determined within 24 h after harvesting. Representative sub samples were taken from the middle part of the fresh root tubers of each variety and sliced into pieces, put on open strays and 100 g was dried in an oven at 70°C until a constant dry weight was achieved.

Table 1: Description of the five orange fleshed sweet potato varieties used as experimental

	Treatments		
Name of varieties	Year of release	Breeder/maintainer	Remark
Local variety	Not well known	Local farmers	Orange fleshed
Beletech (192026 II)	2004	AwARC/SARI	Orange fleshed
Birtukanie (Saluboro)	2008	Sirinka ARC/ARARI	Orange fleshed
Kulfo (Lo 323)	2005	AwARC/SARI	Orange fleshed
Tulla (CIP 420027)	2005	AwARC/SARI	Orange fleshed

AwARC: Aawassa Agricultural Research Center, SARI: South Agricultural Research Institute, Sirinka ARC: Sirinka Agricultural Research Center, ARARI: Amara Agricultural Research Institute

Then the dry weight was recorded and divided by the initial fresh weight to give percentage dry matter content (Nwankwo *et al*., 2012). Finally, data were analyzed using the GLM procedure of SAS Version 9.2 statistical software (SAS., 2002) and treatment means were also compared using LSD value at 5% significance level. Correlation analysis among growth parameters was done, using Pearson correlation analysis of SAS version 9.2 statistical software (SAS, 2002).

RESULTS AND DISCUSSION

Effect of variety on growth parameters: The results of the current study showed, all growth parameters of Orange Fleshed Sweet Potatoes (OFSPs) were significantly ($p<0.05$) affected by variety and showed significant differences among the sweet potato types evaluated (Table 2).

Number of branches per plant: The number of branch per plant is highly significantly ($p<0.05$) affected by variety and showed significant differences among the five different sweet potato types evaluated (Table 2). The highest mean value in number of branches per plant (41.41) was recorded in T5 (variety Tulla), while the lowest mean value (29.29) was recorded in T1 (the local variety) compared to the remaining OFSP varieties (Table 3).

The difference observed in number of branches per plant among the evaluated OFSP types is attributed to their genotypic difference. The current result is in conformity with the finding of Egbe *et al*. (2012) who conclude that sweet potato variety, SPK004 gave significantly higher number (4.83) of branches per plant while sweet potato varieties, NASPOT 2 and NASPOT 4 gave the least number (3.83) of branches per plant. In line with the result of the current study, Mukhtar *et al*. (2010) also stated that sweet potato variety, Dan Zaria produced significantly higher number of branches than variety Dan Bakalori and in similar study the highest number (13.67) of branch per plant was observed in variety CIP 441132 compared to the other varieties included in the study of Rahman *et al*. (2013).

Number of leaves per plant: Number of leaves per plant showed highly significant ($p<0.05$) difference among the five sweet potato varieties tested (Table 2). The highest mean number of leaves per plant (266.44) was recorded in T4 (Variety Kulfo) but the lowest mean number of leaves per plant (222.60) was recorded in T1 (the Local Variety) compared to the other OFSP varieties evaluated (Table 4).

The difference perceived among the OFSP types in number of leaves per plant could be attributed to the difference in their genotypic composition. The current result is in agreement with the finding of Wariboko and Ogidi (2014), whose results showed that the treatments (varieties) were significantly different in their growth parameters. Variety Kulfo had the highest number of leaves per plant and this is one of the important factors for selection of sweet potato varieties and serves as an indicator of adaptability of the crop to the growing conditions of the study area (Nwankwo *et al*., 2012).

Vine length: According to the results of ANOVA, highly significant ($p<0.05$) differences were occurred in vine length among the sweet potato varieties (Table 2). The highest mean value of vine length (99 cm) was recorded from T5 (Variety Tulla) however the lowest mean value of vine length (75 cm) was recorded from T1 (the Local Variety) in this experiment compared to the remaining three varieties (Table 5).

This indicates that variety Tulla can be used as a good vine source especially where production is aimed at producing sweet potato vines. The vines can also be used as forage for feeding of ruminants since the vines are rich in their proteins and minerals contents needed in livestock feeds (Ahmed *et al*., 2012; Kebede *et al*., 2008). Similar to the result found in the current research, highly significant differences obtained in vine length among the OFSP varieties evaluated (Rahman *et al*., 2013; Kathabwalika *et al*., 2013).

Fresh weight: Fresh weight was significantly ($p<0.05$) different among the OFSP varieties evaluated for their adaptability in Southwestern Ethiopia at Jimma (Table 2). The highest fresh weight (1.56 kg) was recorded in T5 (Variety Tulla) and this is not significantly different from the fresh weight obtained in T3 (variety Kulfo) and T2 (Variety Beletech). On the other hand, the lowest fresh weight (1.09 kg) was recorded in T3 (Variety Birtukanie), which is also not significantly different from T1 (the local variety), implying that T3 (Variety Birtukanie) was probably the poorest in fresh weight among the newly introduced four improved OFSP varieties tested in the agro ecological zone in the Southwestern Ethiopia (Table 6).

According to the report of Egbe *et al*. (2012), during the growth of sweet potato substantial morphological changes occur which could be different among varieties and these

Table 2: Mean square values for growth parameters of the five types of orange fleshed sweet potatoes as affected by variety

		Growth parameters				
Source of variations	DF	NBP (No.)	NLP (No.)	VL (cm)	FW (kg)	DMC (%)
Treatment (variety)	4	42.620**	641.120**	0.016**	0.122*	124.832*
Error	8	0.002	0.032	0.00001	0.026	34.380
CV		0.131	0.071	0.469	12.708	13.202

DF: Degrees of freedom, NBP: No. of branches per plant, NLP: No. of leaves per plant, VL: Vine length, FW: Fresh weight and DMC: Dry matter content and **: Highly significant at 1%, *: Significant at 5% probability level

Table 3: Effect of variety on number of branches per plant of the five OFSP types

Treatments (varieties)	Means for No. of branches per plant
T1 (Local variety)	29.29[e]
T2 (Beletech (192026 II)	35.54[d]
T3 (Birtukanie (Saluboro)	38.38[c]
T4 (Kulfo (Lo 323)	38.58[b]
T5 (Tulla (CIP 420027)	41.41[a]
LSD	00.0907

Means followed by different letters per column differ significantly (p<5%) as established by LSD test

Table 4: Effect of variety on number of leaves per plant of the five OFSP types

Treatments (Varieties)	Means for No. of leaves per plant
T1 (Local variety)	222.60[e]
T2 (Beletech (192026 II)	263.60[b]
T3 (Birtukanie (Saluboro)	244.02[d]
T4 (Kulfo (Lo 323)	266.44[a]
T5 (Tulla (CIP 420027)	254.52[c]
LSD	0.3362

Means followed by different letters per column differ significantly (p<5%) as established by LSD test

Table 5: Effect of variety on vine length of the five OFSP types

Treatments (varieties)	Means for vine length (cm)
T1 (Local variety)	75[e]
T2 (Beletech (192026 II))	90[b]
T3 (Birtukanie (Saluboro))	81[d]
T4 (Kulfo (Lo 323))	87[c]
T5 (Tulla (CIP 420027))	99[a]
LSD	0.77

Means followed by different letters per column differ significantly (p<5%) as established by LSD test

Table 6: Effect of variety on fresh weight of the five OFSP types

Treatments (varieties)	Means for fresh weight (kg)
T1 (Local Variety)	1.09[c]
T2 (Beletech (192026 II))	1.18[bc]
T3 (Birtukanie (Saluboro))	1.09[c]
T4 (Kulfo (Lo 323))	1.46[ab]
T5 (Tulla (CIP 420027))	1.56[a]
LSD	0.3058

Means followed by different letters per column differ significantly (p<5%) as established by LSD test

influences the accumulation or distribution of the total dry matter among the major plant organs and directly contributing to the difference in fresh weight.

Dry matter content: Significant (p<0.05) difference occurred in Dry Matter Content (DMC) among the OFSP varieties evaluated (Table 2). The highest DMC (54.40%) was recorded in T5 (variety Tulla) followed by T3 (Variety Birtukanie) and T2 (variety Beletech) which were not significantly different from each other. However, the lowest DMC (38.16%) was recorded in T4 (Variety Kulfo), which is also not significantly different from T1 (the Local Variety) already grown by the local farmers, implying that T4 (Variety Kulfo) was probably the poorest in DMC among the newly introduced four improved OFSP varieties (Table 7).

The DMC is one of the important factors for selection of sweet potato and serves as an indicator of adaptability of the

Table 7: Effect of variety on dry matter content of the five OFSP types

Treatments (varieties)	Means for dry matter content (%)
T1 (Local variety)	37.62[b]
T2 (Beletech (192026 II))	45.43[ab]
T3 (Birtukanie (Saluboro))	46.45[ab]
T4 (Kulfo (Lo 323))	38.16[b]
T5 (Tulla (CIP 420027))	54.40[a]
LSD	11.04

Means followed by different letters per column differ significantly (p<5%) as established by LSD test

Table 8: Correlation (Pearson) coefficient among growth parameters in orange fleshed sweet potato varieties

Correlation parameters	FW	DMC	NBP	NLP	VL
FW	1.00	0.12[ns]	-0.55*	0.25[ns]	0.51[ns]
DMC		1.00	-0.65**	0.25[ns]	0.60*
NBP			1.00	-0.46[ns]	-0.94**
NLP				1.00	0.71**
VL					1.00

**, *: Indicate significant correlation at 1 and 5% probability level, respectively, FW: Fresh weight. DMC: Dry matter contents, NBP: No. of branch per plant, NLP: No. of leaves per plant, VL: Vine length

crop to the local growing conditions (Nwankwo *et al*., 2012). The variation observed in dry matter content is expected since the varieties had different origins. The result obtained in the present study is more or less in agreement with the finding of Saraswati *et al*. (2013), who recorded the highest DMC (39.6%) from OFSP variety Bramwamrum and the lowest DMC (18.3%) from variety BB-00105.1 at the same site called Minyambouw. In addition, Woolfe (1992) concluded that DMC depends on variety and Tsegaye *et al*. (2007) also reported significant differences in dry matter content with genetic variation of sweet potatoes.

Correlation among Growth Parameters of OFSP varieties: The correlation analysis revealed that there were positive and negative associations among the studied growth parameters of OFSP varieties (Table 8). Fresh weight of sweet potato roots was negatively and significantly correlated (R = -0.55*) with number of branches per plant. Likewise the dry matter content of sweet potato roots was also negatively and highly significantly correlated (R = -0.65**) with number of branches per plant but positively and significantly correlated (R = 0.60*) with vine length. In agreement with the current result of our study, Egbe *et al*. (2012) also found in their study, fresh weight was negatively and significantly associated (-0.66*) with number of branches per plant. Similarly a number of researches done by different researchers (Morita, 1969; Ravindran and Nambisa, 1987; Onwueme and Shinha, 1991), on different root and tuber crops found more vegetative growth including number of branches and leaves as well as vine length, as the expense of root and tuber initiation and development. On the other hand, number of branches per plant is negatively and highly significantly correlated (R = -0.94**) vine length but number of leaves per plant is positively and highly significantly correlated (R = 0.71**) with vine length.

CONCLUSION

The result of the current investigation showed that the growth parameters recorded: numbers of branches per plant, numbers of leaves per plant and vine lengths were highly significantly and also fresh weight and dry matter content were significantly different among the Orange Fleshed Sweet Potato (OFSP) varieties evaluated in this study. Accordingly, the highest number of branches per plant (41.41), vine length (99 cm), fresh weight (1.56 kg) and dry matter content (54.40%) were recorded from variety Tulla except number of leaves per plant in which the highest record (266.44) was obtained from variety Kulfo and hence in the majority of the growth parameters variety Tulla was preferably the best variety compared to the other three improved and newly introduced OFSP varieties as well as the local variety. The result of the correlation analysis also showed that fresh weight (R = -0.55*) as well as dry matter content (R = -0.65**) of sweet potato roots were negatively and significantly correlated with number of branches per plant. This indicated that sweet potato producers targeting above ground biomass production should use number of branches and leaves per plant as selection criteria. On the other hand, sweet potato producers targeting sweet potato root tubers production should use fresh weight and dry matter content of sweet potato roots as selection criteria. Furthermore, these growth parameters are important factors for selection of sweet potato and can serve as indicators of adaptability of the crop to the study area and hence our current study result indicated that OFSP variety Tulla as the most promising and adaptable variety to the study area under the rain fed condition. Therefore, variety Tulla (CIP 420027) can be used for optimum growth and highest adaptability of OFSP sweet potato at Jimma in the Southwestern Ethiopia and to potentially combat VAD at the community level.

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