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Root Yield and Growth Performance of Orange Fleshed Sweet Potato Varieties at Dera and Libokemkem Districts, North West Ethiopia

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Abstract

Sweet potato (Ipomoea batatas L.) is one of an important root crop produced in Dera and Libokemkem districts with cereal-based diets predominate. White fleshed sweet potato varieties are commonly produced in the districts; however, orange fleshed sweet potato varieties were not yet produced due to non-existence of adapted varieties and lack of vine or planting materials. With this problem, a study was carried out to evaluate and identify the best performing orange fleshed sweet potato varieties for their storage root yield and its attributes. The five orange fleshed sweet potato varieties were planted at two locations from Dera and Libokemkem districts using randomized complete block design in three replications with 40 plants per plot. The data were scored for storage root yield and agronomic traits for each variety across locations. The analysis of variances for each location and across locations showed significant varieties differences for most traits considered in this study. Varieties Kulfo, Kabode and Dilla were found to be in good performances. It is therefore; the current negligible production of orange fleshed sweet potato in these areas can be easily increasing through the use of these superior performed varieties. Thus, it is strongly recommended that seed productions and dissemination program for these varieties have to initiate in the study and similar agro-ecological areas.

Keywords: Adaptation; Evaluation; Orange fleshed; Storage root yield; Varieties

Introduction

Sweet potato (Ipomoea batatas L.) is a dicotyledonous plant belongs to the family of Convolvulaceae [1]. It is one of the most important source of carbohydrate for small farmers in Ethiopia [2], and the third root and tuber crop after Irish potato and cassava in quantity of consumption in tropical Africa [3], which is mostly produced (over 95%) in developed countries. The total world sweet potato production was 86,410,354.75 metric tons. Sweet potato is an important root crop that is mainly cultivated in tropical and subtropical region [4]. In Ethiopia, more than 1.5 million small holder farmers engaged in sweet potato production that are grown primarily for human consumption. The total area allocated for sweet potato was 39,939.10ha, with a total production of 913,785.252 tons and its average yield of 22.88tons. It is mainly produced in the south, southwestern, and eastern regions with a trend of expansion of other parts of the country.

With this trend of expansion, sweet potato can be produced in a wide range of agro-ecologies with a high yield potential and adaptability in the country [5]. Based on Gurumu (2019) description sweet potato is largely produced in mid and low altitude of Ethiopia with warm weather growing condition for high yielding. Thus, Dera and Libokemkem districts in Northwest Ethiopia have suitable environmental conditions for sweet potato production since majority of their areas lies in mid altitudes with warmest temperature. Because of this farmers in these districts have long experiences for sweet potato production with cereal-based diets predominates. For long time, white fleshed sweet potato varieties are commonly produced in Dera and Libokemkem district. However, orange fleshed sweet potato varieties were not yet produced in the districts due to nonexistence of adapted varieties and lack of planting materials. There is an increasing demand by farmers for production and consumption of orange fleshed sweet potato in the districts of Dera and Libokemkem. Increasing population growth and food insecurity in Ethiopia is also inciting extensive production of food security crops like sweet potato. According to World Food Program (2022) report 14 to 15 million Ethiopians (13% - 14% of the country population) are experiencing severe food insecurity. Accordingly, sweet potato is one of the ideal starch staple food security crop due to low level of agricultural input requirement and high productivity per unit area. Besides, orange fleshed sweet potato is crucial for improving nutrition of vitamin A deficient in community especially for children and infants since it has high content of carotenoids and pleasant sensory characteristics with color [6,7] described that both the tubers and leaves of orange fleshed sweet potato are rich sources of vitamin, mineral and antioxidants, which is needed to combat food insecurity and malnutrition. Orange-fleshed sweet potato is a bio-fortified crop that is a rich source of beta-carotene (pro-vitamin A) which is necessary for combating the problems related to vitamin A deficiency [8]. It is therefore; this study was proposed to evaluate and identify the best performing and adaptable orange fleshed sweet potato varieties for their storage root yield and its attributes in Dera and Libokemkem districts.

Materials and Methods

Description of the study sites

A study was carried out to evaluate different orange fleshed sweet potato varieties in 2020 main rain fed growing season at Dera and Libokemkem districts in Northwest Ethiopia. Dera district is about 602km and 42km far from Addis Ababa and Bahir Dar respectively.

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It is located at 37o25'45"-37o54'10"E longitude and 11o23'11"-11o53"30"N latitude with the average altitude of 1788 meter above sea level. The annual rainfall and temperature of the area ranges from 1000mm-1500mm and 13oc -30oc, respectively [9].

Libokemkem is 645km far from Addis Ababa which is located between 11o58'15"to 12o22'67" N latitude and 37o33'25.4" to 37o58'16.5"E longitude. The altitude of Libokemkem ranges from 1560m to 2200m meter above sea level. Libokemkem district received average annual rain fall and temperature of 900-1200mm and 13-28oc, respectively. Hence, the majority part of these districts is characterized as mid-altitude in the Ethiopian agro-ecological classifications [11].

Planting materials and experimental design

The five improved orange fleshed sweet potato varieties namely Dilla, Kabode, Alamura, Kulfo and Vita were planted on 28 June 2020 using randomized complete block design in three replications with 40 plants per plot. Initial planting materials/vines were brought from Hawassa Agricultural Research Center which is the national sweet potato research program coordinator in Ethiopia. Then, cutting materials or vines were planted and multiplied in Fogera research site in open field from April to June 2020. Main field planting was done in rows with spacing of 60cm between rows and 30cm between plants. Furthermore, field operations like three times hoeing and weeding were applied properly and timely.

Data Collections

Data were collected from the 20 plants in the middle of two rows for all plots. The data were scored on plot based for storage root yield, above ground fresh weight and days to maturity. Whereas, root diameter, root length, root weight, number of roots per plant, vine length, vine inter-nodal length, vine girth, leaf length and leaf diameter were measured from five plants randomly taken from each net plots and averaged over the plants.

Dry matter content was calculated as a ratio of sample dry root weight to root fresh weight and was expressed in %.

$$\text{Dry matter content} = \frac{sample\ dry\ root\ weigtht}{root\ fresh\ weight} \times 100 \quad (1)$$

In addition, harvest index (HI) was calculated as a ratio of fresh root weight to total weight (above ground fresh weight + fresh root weight) on fresh weight basis times by 100%.

$$HI = \frac{fresh\ root\ weight}{total\ weight} \times 100 \quad (2)$$

Results and Discussion

The mean square from the combined analysis of variance over two locations (Table 1) showed that differences due to varieties were significant (P <0.01) for traits of total and marketable storage root yield and above ground fresh weight. The varieties also exhibited significant (P <0.05) variation for number of storage root per plant and non-significant variation for harvest index. The effect due to location were significant (P <0.01) for above ground fresh weight and harvest index, but it was not significant for number of roots per plant and the total and marketable root yield. The variances due to variety * location interaction were not significant for the root yield, number of roots per plant, above ground fresh weight, harvest index, root diameter, days to maturity and dry matter content (Table 1 and Table 2).

The significant (P <0.01) varieties differences were also observed for root length, width and root weight, days to maturity and dry matter content (Table 2). Similarly, location effects were observed for root diameter and individual root weight. The variances due to varieties * location interaction were also significant (P<0.01) for root length, a single root weight and dry matter content (Table 2). The mean square in Table 2 showed significant (P <0.01) difference in vine length and leaf diameter and significant (P<0.05) difference in vine girth and vine internode length among tested varieties. However, leaf length was not significant difference among varieties. Location and location by varieties interaction was significantly influenced on the growth of vine length and internode length. Different authors from related researches described significance difference between OFSP varieties for their storage root yield and yield related traits across [12,13].

Table 1: Mean squares from the analyses of variance for five orange fleshed sweet potato varieties over two locations.

Source of variation	DF	Mean Squares							
		TRY	MRY	NRPP	AGFWt	HI	RL	RD	RWt
Replication	2	225.019	195.584	1.65	0.96	23.988	70.08	28.92	0.002
Location	1	6.532ns	17.709ns	0.71ns	67.8**	568.89**	201.66ns	368.76*	0.020 **
Variety	4	26.339 **	23.25**	3.72 *	21.6**	67.326ns	2523.2**	641.64**	0.060 **
Var * Location	4	21.111 ns	22.366ns	0.48 ns	7.06ns	80.543ns	1183.9*	74.69ns	0.010**
Residual	16	22.4	20.781	0.8	3.06	38.516	311.59	50.19	0.002

Where, **TRY-** total root yield t ha^{-1}, **MRY-** marketable root yield t ha^{-1}, **NRPP-** number of roots per plant, **AGFWt**-above ground fresh weight in kg, **HI**-harvesting index, **RL**-Root length in mm, **RD**-Root diameter in mm, **RWt**-Root weight in kg, * indicate Significant at 0.05 and ** significant at 0.01 probability levels, **NS** = non- significant at 0.05 and 0.01 probability level, **DF**-Degree of freedom

Table 2: Mean squares from the analyses of variance for five orange fleshed sweet potato varieties over two locations.

Source of variation	DF	Mean Squares						
		DMC	DM	VL	VG	IL	LL	LD
Replication	2	7.233	26.13	472.07	2.58	6.20 **	1.99	1.71
Location	1	50.70ns	21.641ns	1869.1**	0.17ns	43.34**	2.17ns	0.84ns
Variety	4	144.95**	62.2897**	2366.8**	7.43*	3.74 *	3.19ns	9.68**
Var * Location	4	8.617ns	17.8951ns	663.6 *	9.02**	3.15 *	6.64*	0.77ns
Residual	16	19.752	12.89	202.8	1.64	0.93	1.98	1.39

Where, **DMC**-dry matter content(%), **DM**-days to maturity, **VL**- vine length in cm, **VG**- vine girth in mm, IL internode length in cm, **LL**-leaf length in cm, **LD**-leaf diameter in cm,* indicate Significant at 0.05 and ** significant at 0.01 probability levels, **NS** = non- significant at 0.05 and 0.01 probability levels, **DF**-degree of freedom

Mean performance of OFSP varieties for tuberous root yield

In this study, the mean value of marketable root yield over two locations was 13.2 t ha^{-1}. The mean values of storage root yield at individual location ranged from 2.82 to 20.78 t ha^{-1} at Dera and 4.57 to 17.49 t ha^{-1} at Libokemkem (Table 3). The highest total storage root yield were recorded from variety Kulfo (20.7 t ha^{-1}) followed by Kabode (17.0 t ha^{-1}) and Dilla (16. t ha^{-1}). The least yielding variety was obtained from variety Alamura (3.7 t ha^{-1}). Considering the locations mean, Dera location was found to be suitable than Libokemkem environment for orange fleshed sweet potato production with average yield of 14.08 t ha^{-1}. Similary, Assefa et al. (2020) reported that high marketable and total tuber root yield was recorded from variety Kulfo (15.20 and 15.54 t ha^{-1} respectively). This result is in line with Amare et al (2014) and Mekonnen et al (2015) who found significant difference in marketable and total tuberous root yield among the studied orange fleshed sweet potato varieties. Additionally Mekonnen, 2021 reported that significance difference was observed between OFSP varieties for tuber root yield. The differences in marketable and total tuberous root yield would be to the genetic variations among the orange fleshed sweet potato varieties in partitioning photosynthates [14].

In case of storage root number per plant, the mean values were ranged from 2-5 which obtained from variety Alamura and Dilla, respectively. The higher mean value of average root number per plant was obtained from variety Dila (5) and Kulfo (4) while the lowest mean value were recorded from variety Alamura (2). This result is closely related to Assefa et al. (2020) reports that the number of roots per plant ranges from 6.67 to 3.67 which is obtained from variety Kulfo and Tula respectively. The difference perceived among the orange fleshed sweet potato varieties in number of tuberous roots per plant could be attributed to the differences in their genotypic composition [15].

Mean performance of OFSP varieties for vegetative growth and tuberous root quality parameters

The highest root length was recorded from variety Dilla (202.7mm) and Vita (174.7mm) at both locations while the smallest root length was from variety Kulfo (127.4mm) at Dera location and from variety Alamura (125.4mm) at Libokemkem location. Similarly, for over location analysis the highest root length were recorded from variety Dilla (193.1mm) and Vita (172.4mm) followed by variety Kabode (154.4 mm). The average root length performance over two locations was 162.1mm (Table 3). Namo O.J et al. (2017) were found the range values of 224mm to 119mm for root length which were almost similar to this finding. Additionally, Kuddus et al. (2020) also reported the average root length values of 104.5mm to 128.2mm while studied different orange fleshed sweet potato varieties performance.

Likewise, the study showed that the highest root diameter was obtained from variety Kulfo (58.8mm) and Dilla (58.2mm) followed by variety Kabode (47.8mm). Whereas the lowest root diameter was scored from variety Alamura (33.5mm). The average root diameter performance over two locations was 49.0mm (Table 3). This result was in line with the finding of Mekonnon et al. (2015) who reported the mean range values of 33.9mm to 49.0 mm storage root diameter. Similarly, Assefa et al. (2020) reported that highest root diameter was recorded from variety Kulfo (66mm) and the lowest from variety Beletech (43.5mm).The difference between OFSP varieties in terms of root length and diameter due to genetic and environmental factors [16]. Regards to root weight variety Dilla (0.34kg) had the maximum value next to Kulfo (0.27kg) and Vita (0.22kg) and variety Alamura (0.07kg) had the minimum value. The mean storage root weight over two locations was 0.22kg (Table 4).

Table 3:

Variety	MRY			TRY			NRPP			RL			RD		
	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean
Alamura	2.82	4.57	3.7	3.8	5.43	4.6	3	2	2	163.5	125.4	144.4	34.1	32.9	33.5
Dilla	13.17	15.11	14.1	16.07	17.54	16.8	4	5	5	202.7	183.4	193.1	66.2	50.2	58.2
Vita	14.91	13.06	14	17.57	15.5	16.6	4	4	4	174.7	170.1	172.4	47.4	46.1	46.8
Kabode	18.71	11.35	15	20.83	13.27	17	3	4	4	155.4	153.4	154.4	49.5	46.2	47.8
Kulfo	20.78	17.49	19.1	22.07	19.3	20.7	4	4	4	127.4	165.4	146.4	65.4	52.2	58.8
Mean	14.08	12.32	13.2	16.07	14.21	15.1	3.5	3.8	3.6	164.7	159.5	162.1	52.3	45.5	49
CV	29.9	43.8	34.5	27.96	38.6	31.3	23.1	25.6	24.5	12.6	8.7	10.9	15.7	12.5	14.5
$LSD_{0.05}$	7.87	10.1	7.8	8.45	10.3	8.1	1.519	1.83	1.6	39.04	26.2	30.55	15.55	10.7	12.26
	**	Ns	**	**	**	**	Ns	Ns	*	*	**	**	**	*	**

Where, **TRY**- total root yield t ha-1, **MRY**- marketable root yield t ha-1, **NRPP**- number of roots per plant, **AGFWt**-above ground fresh weight in kg, **HI**-harvesting index, **RL**-root length in mm, **RD**-root diameter in mm, **RWt**-root weight in kg, **DMC**-dry matter content (%), **DM**-days to maturity, **VL**- vine length in cm, **VG**-vine girth in mm, **IL**-internode length in cm, **LL**-leaf length in cm, **LD**-leaf diameter in cm

Table 4: Mean values of storage roots yield and yield related traits of five OFSP varieties over two locations.

Variety	RWt			VL			IL			VG			AGFWt		
	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean
Alamura	0.09	0.06	0.07	86.6	63.3	74.9	34.1	32.9	33.5	5.5	6.7	6.1	1.7	2.58	2.13
Dilla	0.46	0.23	0.34	111.2	61.7	86.5	66.2	50.2	58.2	8.2	8.8	8.5	22.5	7.11	14.81
Vita	0.23	0.21	0.22	43.8	41.2	42.9	47.4	46.1	46.8	10	6.9	8.5	16.7	8.94	12.81
Kabode	0.19	0.2	0.2	43.2	42.8	43	49.5	46.2	47.8	9.5	7.2	8.3	20	8.22	14.11
Kulfo	0.28	0.26	0.27	72.8	69.7	71	65.4	52.2	58.8	7.5	10.3	8.9	17.8	9.83	13.81
Mean	0.25	0.19	0.22	71.5	55.7	63.6	52.3	45.5	49	8.1	8	8.1	15.7	7.33	11.53
CV	24	10.8	20.2	26.2	11.8	22.3	15.7	12.5	14.5	15.3	16.5	15.8	31.5	65	42.2
$LSD_{0.05}$	0.11	0.04	0.77	35.85	12.37	24.7	15.55	10.7	12.26	2.35	1.47	2.2	3.3	3.23	3
	**	**	**	*	**	**	**	*	**	*	*	**	**	Ns	**

Where, **TRY**- total root yield t ha-1, **MRY**- marketable root yield t ha-1, **NRPP**- number of roots per plant, **AGFWt**-above ground fresh weight in kg, **HI**-harvesting index, RL-root length in mm, **RD**-root diameter in mm, **RWt**-root weight in kg, **DMC**-dry matter content(%), **DM**-days to maturity, **VL**- vine length in cm, **Vg**-vine girth in mm, **IL**-internode length in cm, **LL**-leaf length in cm, **LD**-leaf diameter in cm

Table 5: Mean values of storage roots yield and yield related traits of five OFSP varieties over two locations.

Variety	LL			LD			DMC			HI			DM		
	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean
Alamura	6.63	9.37	8	4.55	4.16	4.35	16.9	14.42	15.66	86.16	85.07	85.62	155	155	155
Dilla	10.2	7.34	8.77	7.73	6.68	7.2	26.09	19.72	22.91	66.91	86.42	76.67	157	158	158
Vita	10.13	9.07	9.6	5.3	6.16	5.73	23.31	24.76	24.04	75.37	84.4	79.89	150	153	151
Kabode	9.75	9.77	9.76	5.66	5.22	5.44	21.98	18.9	20.44	74.22	82.92	78.57	142	148	145
Kulfo	9.39	7.86	8.62	4.31	3.65	3.98	20.02	22	21.01	77.12	84.52	80.82	148	151	150
Mean	9.22	8.68	8.95	5.51	5.17	5.34	21.66	19.96	20.81	75.96	84.67	80.31	150	153	151.63
CV	8.28	21.19	15.7	27.89	12.67	22.1	7.12	24.43	17.25	6.05	9.43	7.73	2.7	3	2.93
$LSD_{0.05}$	1.44	3.46	2.44	2.89	1.23	2.04	2.9	9.18	4.35	8.65	15.04	7.52	8	9	5.39
	**	ns	ns	Ns	**	*	**	Ns	**	*	ns	ns	*	ns	**

Where, **TRY**- total root yield t ha-1, **MRY**- marketable root yield t ha-1, **NRPP**- number of roots per plant, **AGFWt**-above ground fresh weight in kg, **HI**- harvesting index, **RL**-root length in mm, **RD**-root diameter in mm, **RWt**-root weight in kg, **DMC**-dry matter content(%),DM-days to maturity, **VL**- vine length in cm, **Vg**-vine girth in mm, **IL**-internode length in cm, **LL**-leaf length in cm, **LD**-leaf diameter in cm

The mean location values in vine length, internode vine length and vine girth showed that the tested varieties were better performed at Dera district than Libokemkem district. The maximum vine length was obtained from variety Dilla (112.2cm) at Dera district while the minimum vine length was obtained from variety Vita (42.9 cm) at Libokemkem district. From the combined analysis the highest vine length was recorded from variety Dilla (86.5cm) next to variety Alamura (74.9cm) and Kulfo (71.0cm). Similarly, variety Dilla and Kulfo were scored the higher internode vine length at individual tested location and over two locations analysis. Variety Kulfo (8.9mm) was recorded the highest vine girth followed by variety Dilla and Vita with the similar value of 8.5 mm (Table 4). Similar to the result found in the current research, a significant variation between OFSP varieties was observed in terms of vine length [17,18]. Mekonnen et al. (2015) stated that varieties with good vine length can be used as a good vine source/ planting materials especially where production is aimed at producing sweet potato vines.

The mean value of the above ground fresh weight over two locations was 11.53kg. The maximum and minimum values were obtained from varieties Alamura (2.13 t ha^{-1}) and Dilla (14.81 t ha^{-1}), respectively. The mean of above ground fresh weight performances at Dera (15.7 t ha^{-1}) was found to be better than at Libokemkem 7.33 t ha^{-1} (Table 4). The location means of leaf length and width performances were ranged from 8.0 cm to 9.76 cm and 3.98 cm to 7.20 cm, respectively. Varieties Vita and Kabode were found be superior in leaf length followed by Dilla whereas varieties Dilla and Vita showed superior performance in leaf width followed by Kabode. The shortest leaf length was recorded from variety Alamura and the thinnest was obtained from variety Kulfo (Table 5).

Based on the results of this research, varieties Vita (24.04%) and Dilla (22.91%) were showed better performance in dry matter content followed by Kulfo (21.01%). The maximum and the minimum values of dry matter content were recorded from variety Vita (24.76) and Alamura (14.42%) at Libokemkem testing site, respectively. The mean of dry matter content over two locations was 20.81% (Table 5). The mean value of dry matter content in this study was slightly lower than the result of Mbusa et al. (2018) which was 24.84%, but it is slightly similar to the reports of Carey E.E et al. (2020) that was 22%. The Dry matter content is one of the important factors for selection of sweet potato and serves as an indicator of adaptability of the crop to the local growing conditions [19].The variation observed in dry matter content is expected since the varieties had different origins and genetic variation [20].

The result of this finding also indicated that the least harvest index was obtained from variety Dilla (76.67%) meanwhile the largest harvest index was obtained from variety Alamura (80.82%). Kabode variety (145 days) was obtained the shortest days to maturity from the five orange fleshed tested varieties. On the other hand, Dilla variety (158 days) was attained the longest days to maturity (Table 5).

Conclusions and Recommendation

In conclusion, varieties Kulfo, Kabode and Dilla were found to be in good performances at both tested locations; Dera and Libokemkem districts for most measured traits counting storage root yield. To improve nutrition and diversifying food habit of end users, it is strongly recommended that vine or cutting material productions and dissemination program for these varieties have to initiate in the study and similar agro-ecological areas. Besides, the current low production of orange fleshed sweet potato can be easily increasing and expanding with the use of these superior performed varieties in study.

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Conflict of Interest

The Authors declared that they have no conflict of interest

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