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Performance Evaluation of Sweet Potato Varieties for Root Yield and Related Traits in South Gondar Zone, North West Ethiopia

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Abstract: A sweet potato production is not practiced in most parts of North Western Ethiopia mainly due to gap of knowledge and awareness about its production system and benefits; and shortage of improved varieties in the area. So that a study was conducted to overcome such challenges during 2019 main growing season at Dera and Libokemkem districts in North Western Ethiopia. The experiment included five white fleshed sweet potato improved varieties (Hawassa-09, Berkuma, Adu, Tola and Awassa-83). It was established in a randomized complete block design in three replications with the objective of testing the performance of the varieties for their adaptability and to recommend the superior ones for demonstrations on farmers' plots. The results of analysis of root yield and most traits considered shown significant variation among varieties at both locations. The results further revealed that the interaction effects of genotypes by location were significant for most traits except root length, above ground fresh weight and number of roots per plant indicating the differential response of varieties for those traits at each location. Varieties Hawassa-09 and Burkuma gave superior storage root yield than the others at each location. Hence, these varieties need to be multiplication of seed/vines cutting materials and further demonstration for sustainable sweet potato production in the study areas.

Keywords: Adaptability, Root Yield, Selection, Varieties, White Fleshed

1. Introduction

Africa is the second largest producer of sweet potatoes, accounting for 10.6 percent of total production following Asia, which accounts for 86.5 percent of the world's production [8]. About 9.9 million tons of storage roots were produced on an estimated 2.1 million ha in Sub-Sahara Africa [6]. According to [8] it is an important food, feed and vegetable crop in most developing countries including Sub-Sahara African countries. In general, sweet potato is the seventh most important food crop in the world after wheat, rice, maize, potato, barley and cassava [13].

In Ethiopia, about 1,939,761.19 tons of sweet potato were produced on 54, 016.67 ha of land [3]. However, the major growing areas of sweet potato in Ethiopia are limited in South, Southwestern and Eastern parts of the country [10], whereas, the crop can be grown within a wider range of altitude from 1200 to 2000 m.a.s.l in the country [10]. Accordingly, North Western Ethiopia especially Fogera, Dera and Libokemkem districts have a considerable suitable growing conditions for sweet potato production which lies in altitude of 1819 m.a.s.l with the average annual rainfall of 1230mm. However, farmers in these districts do not have sufficient knowledge and awareness on improved varieties, its production practices and benefit of the crop.

High yielding sweet potato varieties for different agro-ecologies in the country have been released by different research centers. Adaptability and performance of these varieties were not, to date, evaluated in south Gondar zone. Hence, it is very important to assess adaptability and yielding potential of sweet potato varieties. Thus, this study was conducted to assess the performance of those varieties for their adaptability and to recommend a suitable ones for sweet potato growers in the study areas. Furthermore, the experiment is important with for farmers to change eating habits, promoting crop cultivation diversity with reducing climatic risk and enhancement of crop rotation

with other compatible crops in the area.

2. Materials and Methods

2.1. Experimental Sites

The experiment was conducted during 2019 main growing season in North West Ethiopia: Dera and Libokemkem districts. Libokemkem is located at 12°07′N latitude and 37°47′N longitude at an altitude of 1975 m.a.s.l [7]. The minimum and maximum temperatures of the area are 11.6°C and 29.4°C, respectively. Libokemkem received the average annual rainfall of 1300mm.

Geographically, Dera district is lies between 37°25′45′E - 37°54′10′ E longitude and 11°23′15′ -11°53′30′N latitude with an altitude ranges between 1,560 to 2,600 m.a.s.l. The district received the average rainfall ranging from 1000-1500 mm and its annual temperature is between 13 and 30°C [2].

2.2. Experimental Materials

The experimental materials consist of five white fleshed sweet potato varieties namely Hawassa-09, Berkuma, Adu, Tola and Awassa-83. The vines/starting materials of those varieties were obtained from Hawassa Agricultural Research Center and then multiplied in Fogera Agricultural Research site for three months before planting them in the experimental field.

2.3. Experimental Design and Trial Managements

The experiment was arranged in randomized complete block design with three replications. Planting was done at the end of June 2019 with spacing of 30cm between plants and 60cm between rows. The plot size was 3mx2.4m ($7.2m^2$) and the varieties were randomized on prepared plots across blocks to avoid biasedness. Fertilizer was not applied at all stage of the crop, but three times weeding and hoeing was done uniformly and timely to the entire plots in each locations.

2.4. Data Collections

Data recorded for a single root weight, root length, root diameter, leaf length, leaf diameter, number of roots per plant, vine girth, internode vine length; and storage root dry matter content were made on five randomly selected sample plants from the internal two rows. Marketable storage root yield (root tubers with free from disease and weight of greater than 100gram) and above ground fresh weight data were recorded on plot basis.

2.5. Statistical Analysis

Data generated was subjected to analysis of variance (ANOVA) using SAS [12] version 9.1 Software. Firstly, separate analysis of variance for each trait measured for each location were performed and then combined analysis was carried out after confirmed homogenous error variances at each location. Means comparison was done using the least significant difference (LSD) according to [14].

3. Results and Discussion

The results of analysis of marketable root yield, a single root weight, root length and diameter at the specific location and combined over two locations are presented in table 1. Differences among varieties were significant ($P<0.05$) for marketable root yield, root diameter and average single root weight. The highest mean values for marketable root yield was exhibited from Hawasa-9 (44.3t/ha) and Tola (26.2t/ha) in Dera and Libokemkem, respectively while the lowest was from Adu variety. Marketable root yield among varieties ranged from 2.67 to 44.3t/ha in Dera where as in Libokemkem it ranged from 2.77 to 26.2t/ha. The combined mean of marketable root yield depicted that the highest was recorded from variety Hawasa-9 followed by Berkuma with values of 34.2 and 30.0t/ha, respectively. According to [1] results sweet potato varieties differed statistically in marketable yield with range values of 7.78- 30.9t/ha. Similarly, [5] reported significance difference in marketable root storage yield among sweet potato varieties tested. They further indicated that minimum and the maximum yield was 3.06 t/ha and 45.28t/ha, respectively.

Table 1. *Mean values for marketable root yield, average root weight, root length and width of five white fleshed sweet potato varieties evaluated at two different locations during 2019/20.*

Variety	Marketable Root Yield (ton/ha)			Root Length (mm)			Root Diameter (mm)			Average Root Weight (kg)		
	Dear	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean
Hawassa -09	44.3	24.1	34.2	202.6	193.0	197.8	62.9	62.6	62.8	0.38	0.28	0.33
Adu	2.67	2.77	2.72	158.8	164.7	161.8	32.2	24.7	28.4	0.10	0.14	0.12
Berkuma	41.2	18.7	30.0	209.1	186.4	197.7	75.5	54.1	64.8	0.43	0.29	0.36
Tula	31.7	26.2	29.0	210.2	183.5	196.8	69.7	70.1	69.9	0.33	0.35	0.34
Awassa-83	16.4	10.7	13.6	184.3	186.3	185.3	52.6	53.5	53.1	0.27	0.17	0.22
Grand Mean	27.3	16.5	21.9	193.0	182.8	187.9	58.6	53.0	55.8	0.30	0.24	0.27
CV (%)	38.0	31.8	39.1	10.90	8.800	9.900	8.60	7.50	7.80	24.3	27.2	27.3
$LSD_{0.05}$	19.54	9.87	5.54	39.65	30.21	7.600	9.47	7.44	7.60	0.14	0.13	0.13
F-test	**	*	**	NS	NS	NS	**	**	**	**	*	**

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, respectively. Libo= Libokemkem, CV= Coefficient of Variation, LSD= Least Significant Difference.

Maximum storage root length was recorded by variety Tola (21.02cm) at Dera district and Hawasa-09 (19.3cm) at

Libokemkem district while the lowest was observed by variety Adu at both locations. The range for overall mean storage root length was 16.18 to 19.78cm, the lowest and the highest was observed by variety Adu and Hawassa-09.

The highest mean storage root diameters were exhibited by variety Burkuma (7.55cm) and Tola (7.01cm) at Dera and Libokemkem districts, respectively. On the other hand, the lowest mean value was observed at Adu variety for storage root diameter.

Over all mean single storage root fresh weight ranged between 0.12 to 0.36 kg from Adu and Berkuma varieties, respectively. It was clear that the highest average single root weight was recorded from variety Berkuma at Dera (0.43kg) and variety Tola (0.35kg) at Libokemkem districts while the lowest from variety Adu.

Leaf length and diameter revealed significant ($p<0.05$) difference among varieties at specific location and combined over locations (table 2), but insignificant for root numbers per plant and above ground fresh weight. The highest over locations mean for leaf length and width was recorded by variety Adu. However, the lowest leaf length and width was by variety Hawassa-09. Cultivar Hawassa-83 scored the highest over location mean value for above ground fresh weight with lowest number of roots per plant. The highest over locations mean for number of roots per plant was recorded by variety Hawassa-09.

Table 2. *Mean values for number of roots per plant, above ground fresh weight, leaf length and diameter of five white fleshed sweet potato varieties evaluated at two different locations during 2019/20.*

Variety	Number of Roots/plant			Above ground fresh weight (kg)			Leaf Length (cm)			Leaf Diameter (cm)		
	Dera	Libo	Mean	Dear	Libo	Mean	Dear	Libo	Mean	Dera	Libo	Mean
Hawassa -09	4.3	5.3	4.8	9.9	3.2	6.5	9.1	5.3	7.2	6.7	4.2	5.5
Adu	3.7	4.1	3.9	9.9	4.7	7.3	12.1	8.6	10.4	9.3	6.7	8.0
Berkuma	3.9	4.2	4.1	8.5	2.7	5.7	8.9	9.8	9.4	7.2	6.2	6.7
Tula	3.4	3.9	3.7	7.4	2.7	5.0	8.6	9.1	8.9	6.3	5.2	5.8
Awassa-83	3.1	3.4	3.3	9.5	3.6	6.6	9.5	10.4	10.0	9.2	3.7	6.4
Grand Mean	3.7	4.2	3.9	9.1	3.4	6.2	9.6	8.6	9.1	5.5	5.2	6.5
CV (%)	23.1	28	22	15.9	36.2	21.6	8.8	7.2	8.1	27.8	13	13.5
$LSD_{0.05}$	1.5	2.2	2.3	2`.7	2.29	2.2	1.6	1.2	1.3	2.0	1.2	1.5
F-test	NS	NS	NS	NS	NS	NS	**	**	**	*	**	**

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, respectively. Libo= Libokemkem, CV= Coefficient of Variation, LSD= Least Significant Difference.

The analysis of variance at specific location and over two locations indicated that the difference in vine girth and internode vine length were significant ($p<0.05$) for tested varieties (table 3). The analysis of vine length revealed highly significant variation among varieties at Libokemkem location. The longest vine and internode interval was scored in variety Hawassa -09 with mean values of 76.9cm and 5.38cm, respectively. The vine length value ranged from 61.5 to 76.9cm and mean of vine internode length varied from 3.06 to 5.38cm. Among the varieties tested, variety Adu had the highest overall mean of vine girth (9.87mm) while Tola had the lowest mean with the value of 6.26mm.

Table 3. *Mean values for vine length, girth and internode length, and root dry matter content of five white fleshed sweet potato varieties evaluated at two different locations during 2019/20.*

Variety	Vine Girth (mm)			Vine Length (cm)			Vine Internode Length (cm)			Root dry matter content (%)		
	Dear	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean	Dera	Libo	Mean
Hawassa -09	5.93	6.67	6.30	90.6	63.3	76.9	3.43	7.34	5.38	19.1	21.4	20.2
Adu	9.40	10.3	9.87	61.4	61.7	61.5	2.28	4.71	3.50	17.7	30.3	24.0
Berkuma	6.67	6.93	6.80	89.6	41.2	65.4	3.96	4.12	4.04	17.7	25.6	21.7
Tula	5.33	7.18	6.26	88.4	42.8	65.6	3.48	4.93	4.21	21.3	18.5	20.0
Awassa-83	9.13	10.3	9.70	69.5	69.7	69.6	2.20	3.92	3.06	34.0	27.7	30.9
Grand Mean	7.29	8.28	7.78	79.9	55.7	67.8	3.07	5.01	4.04	22.0	24.8	23.3
CV (%)	18.7	9.10	14.1	22.1	11.8	23.1	10.5	21.5	19.6	20.5	17.0	18.6
$LSD_{0.05}$	2.40	1.40	1.90	33.2	12.4	1.7	0.61	2.03	1.37	8.50	7.89	5.32
F-test	*	**	**	NS	**	NS	**	*	**	**	*	*

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, respectively. Libo= Libokemkem, CV= Coefficient of Variation, LSD= Least Significant Difference.

After pooled analysis, significant location effect was found for all traits except number of roots per plant, root length and root dry matter content. Genotype effect were highly significant ($p<0.05$) for marketable root yield, root length and diameter, average single root weight, internode vine length, vine girth, leaf length, leaf width and storage root dry matter content. This finding was in agreement with [15] who reported that variety effects significantly affected root yield, root length and vine length. Research results in [9] have also revealed that a significant difference in root yield among pre-released varieties in multi-location trials at Kenya. The mean square due to genotypes by location interaction was also significant for root diameter, average ingle root weight, vine length, internode vine length, leaf length and width indicating

the differential response of varieties for these traits at each location. Similar results of [4] found that genotype by location interactions was significantly different for trait of storage root yield in their study.

Table 4. *Combined analysis of variance (mean square) for 11 traits of five white fleshed sweet potato varieties evaluated at two different locations during 2019/20.*

Source of variation	DF	MRY (t/ha)	RL (mm)	RD (mm)	ARW (kg)	BM (kg)	NR /plant
Loc	1	868.3 **	780.3 NS	233.6 **	0.03 **	242.6*	1.54 NS
Rep	2	89.85 NS	169.4 NS	46.43NS	0.02 NS	9.95 *	0.67 NS
Var	4	1056.2 **	1447.2 *	1625.3 **	0.06 **	4.7NS	1.96 NS
Var*Loc	4	148.8 NS	314.1 NS	134.5 **	0.01 **	0.9 NS	0.12 NS
Residual	16	67.58	5606.8	19.32	0.01	1.81	0.97

Table 4. *Continued.*

Source of variation	VL (cm)	IL (cm)	VG (mm)	LL (cm)	LD (cm)	DMC (%)
Loc	4377.8 **	28.1**	7.3 *	7.7 **	49.9 **	55.2 NS
Rep	170.2 NS	4.7 **	4.1*	0.2 NS	1.5 NS	18.1 NS
Var	204.8 NS	4.6 **	20.3 **	8.8 **	6.0 **	122.0**
Var*Loc	842.5 *	2.9 **	0.51NS	9.1 **	5.1 **	89.4 *
Residual	177.4	0.6	1.21	0.55	0.77	18.9

Where, *, ** and NS indicates significant, highly significant and insignificant difference at 0.05 probability level among varieties and/or varieties by location interactions, respectively. Libo= Libokemkem, CV= Coefficient of Variation, LSD= Least Significant Difference, Loc= location, Rep= replication, Var= variety, MRY= marketable root yield, RL=root length, RD=root diameter, ARW= average single root weight, BM= biomass weight, NR=number of roots per plant, VL= vine length, IV= internode vine length.

4. Conclusions and Recommendations

The results revealed that significant differences were observed among tested varieties in storage root yield and most related traits of sweet potato. In addition, genotypes/varieties by location interactions had shown significant difference for most traits considered. In this regard, two varieties: Hawassa-09 and Burkuma gave admirable storage root yield with good desirable traits than the others at each location. Accordingly, those varieties needs to be multiplication of seed/vines cutting materials and further demonstrated for sustainable sweet potato production in the study areas. In general, the storage root yield was higher at Dera than at Libokemkem areas that was presumably a result from differences in the environment.

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