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Participatory Evaluation, Demonstration and Popularization of Improved Sweet Potato, *Ipomea Batatas L.* Varieties in Middle Awash, Afar Region

Yitages Kuma* and Niguse Chewaka

Department of Agricultural Research, Werer Research Center, Addis Ababa, Ethiopia

Abstract

Storage root and tuber crop like sweet potatoes are the most important crops that need to be cultivated for food security in countries like Ethiopia where population is growing fast, because of the highest potential yield per unit area. However, crop productions especially sweet potato were newly introduced to the irrigated areas of Afar region. Therefore, the experiment was conducted at Bonta kebeles in 2017 cropping season using RCBD with three replications to evaluate and demonstrate five released sweet potato varieties. Results of the experiment indicated that, high significant differences among varieties were observed for all yield and yield parameters: MSRN and MSRY, TSRN and USRY and ABMY. Generally, Me'e was out yielded in MSRY (27.60 t ha^{-1}) but Dubo was the lowest performing variety (16.51 t ha^{-1}) though, it was high yielder in ABMY (16.23 t ha^{-1}). Agronomic parameters were also high significantly differences among varieties. Accordingly, Dubo was significant produced the highest ID (0.58 mm), but Me'e (0.46 mm) was the least. The highest and lowest IL was recorded over Me'e (3.68 mm) and Dubo (3.27 mm), respectively. The result of the correlation analysis revealed that the marketable storage root yield was highly significant and positively correlated with different parameters: TSRN (r=0.89**), TSRY (r=0.95**), ASRY (r=0.89**), IL (r=0.92**) and DPM (r=0.66**). In contrast, negative and significant correlation was also detected between MSRY and other parameters: USRN (r=-0.89**), UMSRY (r=-0.72**) and ABMY (r=-0.89**). Generally, Me'e was out yielded and selected by agro pastorals by marketable storage root number, marketable storage root yield, total storage root number, total storage root yield, high in sweetness, least in days to physiological maturity and cooking time. Therefore, rapid multiplication and delivery of planting material of selected varieties should be needed to sustain the adoption of sweet potato by agro pastorals.

Keywords: Agro pastoral preference; PCDP; PRG; Yield parameters

Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam), a member of convolvulaceae family, is a perennial crop usually grown as an annual and a starchy staple food crop in the tropical, sub-tropical and frost free temperate climatic zones of the world [1]. It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries [2]. In the tropics, it can be planted from vines at any time of the year. It is a low input crop that can almost always yield, and can be harvested at almost any time, four to six months after planting [3]. It is an important food security crop grown in many of the poorest regions of the world mainly by women for food and as a source of food and family cash income [4]. It is tolerant of a wide range of edaphic and climatic conditions [5].

Sweet potato storage roots are used as food by humans whereas the vines are used as supplementary feed for animals [6,7]. The fresh tuberous storage root contains 80 to 90% carbohydrate of the dry matter, 3.6 to 5.4% crude protein, 0.72 to 1.27% fat, 2.5 to 3.25 fiber and 2.5 to 3.2% ash on a dry matter basis [4]. The leave contains, on a dry matter basis about 8% starch, 4% sugar, 27% real protein and 10% ash. Leaf is much reached in protein than the storage root protein, minerals and vitamins and more nutritious [8-10]. Its vines have crude protein contents ranging from 16 to 29% on dry matter basis which is comparable to leguminous forages [11]. Feeding vines to cows as a supplement to a basal diet of other forage increased milk yield [12].

It is cultivated in Ethiopia mostly for human consumption. It ranks third after enset and potato as the most important storage root crops produced in the countries. Sweet potato covers about 81,000 hectares of land in Ethiopia with an average national yield of about <9 t ha^{-1} on farm and 25-36 t ha^{-1}on research centres [13,14]. It is one of the major traditional food crops of Ethiopia [15].

Middle Awash is one of the low land parts of the country which exist in zone 3 of Afar region where crop production does not have a deep storage rooted history similar to other most arid and semi-arid areas of Ethiopia. This is associated with low availability of moisture and higher level of evapo-transpiration due to the high temperature prevalence in such areas. As a result, the major livelihood in this area is pastoralism. However, in recent years, fast transformation of the community to agro-pastoralism is observed by making use of the Awash River. Sweet potato production under irrigated conditions of rift Valley areas of Ethiopia is good for food security, animal feed and nutrition enhancement of the local community. But, its wide cultivation and acceptance by the agro-pastoral community is limited. Therefore, this experiment was initiated to evaluate, demonstrate and popularize

***Corresponding author:** Yitages Kuma, Department of Agricultural Research, Werer Research Center, Addis Ababa, Ethiopia, Tel: +251 910320083; E-mail: yitagesk@gmail.com

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popularize of improved sweet potato production through the approach of pastoral research group.

Material and Methods

Description of the study area

The experiment was conducted at Bonta kebeles in 2017 cropping season. The area is located in the Afar National Regional State, Zone-3, Amibara district, which is 280 km in the north east of Addis Ababa. It is located at 9°60'N latitude and 40°9'E longitude with an altitude of 740 Meter Above Sea Level (MASL). The mean annual temperature is 34°C, while the mean annual rainfall and evapotranspiration are 560 and 2600 mm, respectively. The weather is very long hot and dry and rainfall is very erratic.

Participatory Research Group (PRG) setup

The study was conducted at Amibara district in selected agro pastoralists' in Bonta kebeles. It was done on systematically selected agro-pastoralist. Participatory Research Group (PRG) was formed through the help of development agents and agricultural experts of the kebeles following the appropriate procedures involving innovative agro pastorals. The PRGs was had member of about thirty agro-pastorals that include both men and women. Each pastoral trial was consisted of ten individual. Training was given to the PRG members, developments agents and agricultural experts of the district about sweet potato production techniques, data collection and PRG concepts. All management practices was performed as per the research recommendation as per training. Finally all PRG actors including agro pastoralists, researchers and development agents was let to collected data and made their own evaluation, data analysis and reporting within the time frames.

Field experiment

The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications in which a three group of agro pastorals considered as replication. Five released sweet potato varieties: Ma'e, Kudadi, Koka-6, Fallaha and Dubo were used in this experiment. Each sweet potato varieties were planted on plots size having 4.2 m length and 4.8 m width. Spacing of 60 cm, 30 cm and 2 m between rows, plant and plots were maintained, respectively. Yield and all necessary data was collected from the central six rows excluding the borders, that is from a dimension of 3.6 m length and 3.6 m width of net plot.

Data procedures

Data on yield and yield related traits were collected: planting date, vine length (cm), internodes length (cm), internodes diameter (mm), average storage root weight (g), average storage root number, marketable storage root yield (storage root between 100-500 gm exclusive), unmarketable storage root yield (kg), total storage root yield (kg), above ground biomass yield (kg) and agro pastoral's preference.

Statistical analysis

Collected data were used to carry out Analysis of variance and correlation matrix using SAS software, version 9.0 (SAS Institute Inc., 2002). Mean separations were analyzed using the Least Significant Differences (LSD) test at 5% and 1% level of probability. Correlations between marketable storage root yield and other parameters were computed. Agro-pastorals preference ranking of variety for each criteria was analyzed using number of cards given to each selection criteria. The most preferred variety according to the agro-pastorals selection criteria acquired more number of cards and converted to percentage.

Result and Discussion

Yield and yield parameters of sweet potato varieties

Variations among the five sweet potato varieties were noted for most of the yield and yield parameters assessed (Table 1). However, parameters such as unmarketable storage root number and average storage root yield did not show any variations among the sweet potato varieties under this study.

The analysis of variance revealed that there were high significantly differences ($p<0.01$) among varieties for all yield and yield parameters: marketable storage root yield, total storage root number and yield. In addition significant difference ($p<0.05$) were observed among varieties in parameters: marketable storage root number, unmarketable storage root yield and above ground biomass yield. Generally, variety Me'e was the overall winner and top rank in marketable storage root yield (27.60 t ha^{-1}) but Dubo was the lowest performing variety (16.51 t ha^{-1}). Inversely, variety Dubo was the overall winner in above ground biomass yield (16.23 t ha^{-1}) but Kudadie was the lowest performing variety (13.88 t ha^{-1}). The total tuber yields of the variety Dubo, Koka-5, Kudadie and Fallaha were not significantly different from the tested sweet potato varieties except Me'e which was significantly different from other. This is a suggestion that the sweet potato varieties are well adapted to the Bonta kebeles and its environments and could be well disseminated for its use and food security. The variability of sweet potato varieties for their tuber yield is supported and who reported that Fongsu No.1 and Kafrelzayad genotypes had the highest yield for storage storage roots at Bornova, Izmir [16-19]. Was also gain weight of tubers per plant of the different genotypes ranged from 260 to 1120 g?

Variety	Parameters							
	MRN	MRY	UMRN	UMRY	TRN	TRY	ARY	ABY
Dubo	1243.54^{b}	16.51^{b}	1372.74	13.00^{ab}	2616.28^{b}	29.51^{b}	112.74	16.23^{a}
Me'e	2164.08^{a}	27.60^{a}	2045.65	19.87^{a}	4209.73^{a}	47.47^{a}	114.09	14.46^{bc}
Koka 6	1356.59^{b}	20.75^{b}	1291.99	13.50^{b}	2648.54^{b}	34.26^{b}	130.22	15.52^{ab}
Kudadie	1614.99^{ab}	20.32^{b}	1130.49	10.34^{b}	2745.48^{b}	30.65^{b}	111.88	13.88^{c}
Fallaha	1711.89^{b}	20.43^{b}	968.99	8.88b	2680.88^{b}	29.31^{b}	110.81	14.74^{ab}

Mean	1618.22	21.12	1361.97	13.12	2980.19	34.24	115.95	14.97
LSD	499.03	4.55		6.58	930.23	7.7		1.51
P-Value	*	**	NS	*	**	**	Ns	*
CV	16.43	11.42	28.34	26.64	16.65	11.95	10.71	5.37
R^2	0.74	0.83	0.73	0.75	0.75	0.84	0.49	0.66

Means followed by the same letter within the same column are not significantly different at 5% level of significance, MRN: Marketable Storage Root Number (count ha^{-1}); MRY: Marketable Storage Root Yield (t ha^{-1}), UMRN=Unmarketable Storage Root Number (count $ha^{-1)}$; UMRY: Unmarketable Storage Root Yield (t ha^{-1}); TRN: Total Storage Root Number (count ha^{-1}); TRY: Total Storage Root Yield (t ha^{-1}); ARY: Average Storage Root Yield (g $hill^{-1}$) and ABY: Above Ground Biomass Yield (t ha^{-1}).

Table 1: Yield and yield parameters of sweet potato varieties evaluated at Bonta Kebele.

Agronomic parameters of sweet potato varieties

The analysis of variance revealed that there were high significantly differences ($p<0.01$) among varieties for agronomic parameters: internode diameter and days to physiological maturity (Table 2). Significant difference ($p<0.05$) were also observed among varieties in internode length. Accordingly, variety Dubo was significant out produced the highest internode diameter (0.58 mm), but variety Me'e produced the lowest internode diameter (0.46 mm). The highest and lowest internode lengths were recoreded over variety Me'e (3.68 mm) and Dubo (3.27 mm), respectively. Concerning to days to physiological maturity there were highly significant difference among varieties. Variety Me'e was the lowest days to physiological maturity of 94 days while the highest days to maturity was recorded over variety Dubo (147.67 days). This variability of agronomic traits may be due to genetic factors. The current study was in line with the result of who reported that longer vine was exhibited by Ex-Igbariam over TIS8164 variety at University of Calabar Teaching and Research Farm from March-September in 2007 and 2008 cropping seasons [20].

Variety	**Parameters**			
	VL	**ID**	**IL**	**DPM**
Dubo	1.52	0.58a	3.27b	147.67a
Mee	1.38	0.46d	3.68a	94.00c
Koka 6	1.49	0.55ab	3.32b	115.67bc
Kudadie	1.45	0.52bc	3.50ab	128.00ab
Fallaha	1.51	0.49cd	3.49ab	142.67ab
Mean	1.47	0.52	3.45	125.6
LSD (0.05)		0.05	0.28	27
P-Value	NS	**	*	**
CV	5.79	5.55	4.31	11.79
R-Sqr	0.68	0.79	0.66	0.78

Means followed by the same letter within the same column are not significantly different at 5% level of significance; DPM: Days to Physiological Maturity (days); ID: Internodes Diameter (mm); IL: Internodes Length (cm); VL: Vine Length (m).

Table 2: Agronomic parameters of sweet potato varieties evaluated at Bonta Kebele Variety Parameters.

Correlation analysis of sweet potato varieties

The result of the correlation analysis of sweet potato varieties (Table 3) revealed that, the marketable storage root yield was highly significant and positively correlated with different parameters: total storage root number ($r=0.89^{**}$), total storage root yield ($r=0.95^{**}$), average storage root yield ($r=0.89^{**}$), internode length ($r=0.92^{**}$) and days to physiological maturity ($r=0.66^{**}$). The result of this study is supported by the previous studies that showed similar results, where the storage root yield was positively correlated with the total number of storage roots [21-24].

In contrast, negative and significant correlation was also detected between marketable storage root yield and other parameters: unmarketable storage root number (r=-0.89**), unmarketable storage root yield (r=-0.72**), above ground biomass yield (r=-0.89**), vine length (r=-0.89**), and internode diameters (r=-0.92**). The result of this study indicated that most vegetative parameters: aboveground biomass yield, vine length and internode diameters were negatively correlated with marketable tuber yield. The result of this study was reinforced, who reported length of vine showed significant negative correlation with weight of tuber yield [25]. Also indicated negatively correlated with petiole length(r=-0.028). According to number of branches per plant and vine length were negatively correlated with fresh tuber yield in sweet potato [26].

	MRN	**MRY**	**UMRN**	**UMRY**	**TRN**	**TRY**	**ARY**	**ABY**	**VL**	**ID**	**IL**	**DPM**
MRN		0.56*	-0.83**	-0.51*	0.83**	0.58**	0.82**	0.82**	0.83**	0.77**	-0.79**	-0.89**

MRY			-0.89*	-0.72**	0.89**	0.95**	0.89**	-0.89**	-0.89**	-0.92**	0.92**	0.66**
UMRN				0.70**	1.00**	0.87	-1.00**	1.00**	1	0.99	-0.99**	-0.92**
UMRY					0.70**	0.91**	-0.71**	-0.70**	0.72	-0.72	0.74	0.53
TRN						0.87**	-1.00**	0.99	1	0.99	-0.99	-0.92**
TRY							0.87	-0.87**	-0.88**	-0.90**	0.91	0.65
ARY								0.99	1	0.99	-0.99	-0.92
ABY									0.99**	0.99**	0.98**	0.91**
VL										0.99**	0.99**	0.91**
ID											-0.99**	0.89**
IL												0.87

*and ** significant at P<0.05 and P<0.01 level, respectively and figure with no anthrax (*)=non-significant at P<0.05, MRN: Marketable Storage Root Number; MRY: Marketable Storage Root Yield; UMRN: Unmarketable Storage Root Number; UMRY: Unmarketable Storage Root Yield; TRN: Total Storage Root Number; TRY: Total Storage Root Yield; ARY: Average Storage Root Yield; ABY: Above Ground Biomass Yield; DPM: Days To Physiological Maturity; ID: Internodes Diameter, IL: Internodes Length and VL: Vine Length.

Table 3: Pearson correlation analysis.

Agro pastoral preference

The final goal of participatory variety evaluation is to identify the agro pastorals interest in variety of their need which is beyond breeder's eye. The strengths were farmer participation and training that resulted in a feeling of ownership selection at the same low input farming conditions that farmer's use, therefore addressing the needs of more marginalized farmers and a rapid and cost effective way to assess and select potential varieties was facilitated by the process [27-29]. Accordingly, agro pastorals rank all varieties based on earliness, yield, above ground biomass yield, sweetness and cooking time (Table 4). 50% of agro pastorals were participated for selection of varieties based on the criteria of earliness and above ground biomass yields. Similarly, 43.33% and 40% were participating on selection criteria of cooking time and yield, respectively. The agro pastorals mainly depend on those criteria for their interest of consumption (earliness), market (yield) and their animal feed (above ground biomass yield). According to this finding the variety Me'e, Kudadie and Dubo ranked by agro pastorals as first, second and third choice, respectively based on averaged over all selection criteria. This study also demonstrated the vital role of farmers in variety development and the energy in farmer's perception of new varieties.

Varity	**Criteria**								**Average**		**Rank**	
	Earliness		**Yield**	**ABY**	**Sweetness**	**Cooking Time**						
	Cards	**%**	**Cards**	**%**	**Cards**	**%**	**Cards**	**%**	**Cards**	**%**	**Cards**	**%**
Dubo	1	3.33	2	6.67	15	50	5	16.67	4	13.33	5.4	18	3
Me'e	15	50	12	40	3	10	9	30	13	43.33	10.4	34.67	1
Koka-6	5	16.67	7	23.33	5	16.67	3	10	3	10	4.6	15.33	4
Kudadie	6	20	4	13.33	3	10	9	30	6	20	5.6	18.67	2
Fellaha	3	10	5	16.67	4	13.33	4	13.33	4	13.33	4	13.33	5

The most preferred variety according to the agro-pastorals selection criteria acquired more number of cards or the highest percentage gain. Varieties have been ranked pair-wise in a table with the varieties both horizontally in the rows and vertically in the columns.

Table 4: Agro pastorals preference ranking of varieties at Bonta Kebele.

Conclusion

The results of this study have showed that variations among the five sweet potato varieties were noted for most of the yield and yield parameters assessed. The analysis of variance revealed that there were high significantly differences among varieties for all yield and yield parameters: marketable storage root yield, total storage root number and yield, marketable, unmarketable storage root number and yield and above ground biomass yield. Generally, variety Me'e was out yielded in marketable storage root yield but Dubo was the lowest performing variety even though, Dubo high yielder in above ground biomass yield.

The analysis of variance revealed that there were high significantly differences among varieties for agronomic parameters: internode diameter and days to physiological maturity. Accordingly, variety Dubo was significant out produced the highest internode diameter but variety Me'e produced the lowest. The highest and lowest internode lengths were recorded over variety Me'e and Dubo, respectively.

The result of the correlation analysis of sweet potato varieties revealed that the marketable storage root yield was highly significant and positively correlated with different parameters: total storage root number ($r=0.89^{**}$), total storage root yield ($r=0.95^{**}$), average storage root yield ($r=0.89^{**}$), internode length ($r=0.92^{**}$) and days to

physiological maturity ($r=0.66^{**}$). In contrast, negative and significant correlation was also detected between marketable storage root yield and other parameters: unmarketable storage root number ($r=-0.89^{**}$), unmarketable storage root yield ($r=-0.72^{**}$), above ground biomass yield ($r=-0.89^{**}$), vine length ($r=-0.89^{**}$), and internode diameters ($r=-0.92^{**}$).

The strengths of this study were agro pastorals participation and training that resulted in selection of their own varieties. Accordingly, Agro pastorals were ranked all varieties based on earliness, yield, above ground biomass yield, sweetness and cooking time and finally variety Me'e, Kudadie and Dubo ranked by agro pastorals as first, second and third choice, respectively.

Recommendation

- Agro pastorals preference is the basic concept in participatory variety evaluation program that should be followed because agro pastoralists select varieties from different perspectives than farmers as they think of above ground biomass yield for their animals feed.
- Agro pastorals participatory variety evaluation and demonstration work should be consistently continued for search of new varieties which have high nutritive value and yield than present varieties.
- Rapid multiplication and delivery of selected sweet potato planting materials should be needed to sustain the adoption of sweet potato by agro pastorals.
- Constant survey program should be conducted to ensure adoption rate and performance of selected sweet potato varieties.

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