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Performance of Orange and Purple-Fleshed Sweet Potato Genotypes in Coastal Locations of Odisha

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Abstract

Orange and purple-fleshed sweet potato (*Ipomoea batatas* L.) genotypes have immense importance as cheap source of vitamins and antioxidants. Screening and evaluation of these genotypes for stress tolerance further add to their value as biofortified climate resilient food and nutrition source. In the present study, 15 orange-fleshed sweet potato genotypes were initially evaluated for yield and β-carotene content through Initial Evaluation Trial (IET). Based on the yield performance in IET, five genotypes were selected and evaluated along with one check variety (Kamalasundari) in Uniform Regional Trial (URT). Both IET and URT were conducted in the farm of Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar, Odisha, India (RC, CTCRI), under the All India Co-ordinated Research Project (AICRP) on tuber crops. Three genotypes selected through progressive evaluation in URT were tested further along with two check varieties (Kamalasundari and Gouri) by Multi-Location Trials (MLT) at four different locations (Balasore and Kendrapara-under saline conditions and Nuapada and Mangarajpur - under non-saline conditions) across Odisha and the farm of RC, CTCRI (under AICRP). In another study, under AICRP, the performance of four orange (SB-198/115, CIP-420027, CIPSWA-2 and ST-14) and one purple-fleshed (ST-13) genotypes were evaluated under On Farm Trials (OFT) at five different coastal locations (Kendrapara, Puri, Jagatsinghpur, Astaranga and Balasore - under saline conditions) across Odisha. Pooled analysis of yield and other characters through MLT and OFT revealed that all the six genotypes, ST-14, SB-198/115, CIPSWA-2, CIP-420027, CIP-440127 and ST-13 showed tolerance to soil salinity (6-8 dS m^{-1}) with high tuber yield (16.69-22.49 t ha^{-1}), high β-carotene content (4-12 mg $100g^{-1}$) in orange-fleshed genotypes and anthocyanin content (85-90 mg $100g^{-1}$) in purple-fleshed genotype. All the six genotypes were found to perform better than the check varieties. The genotypes, ST-14, CIPSWA-2, CIP-420027, CIP-440127 and ST-13 are recommended for cultivation to supplement food and nutrition requirement in the economically backward coastal regions of Odisha.

Key words: Sweet potato, orange-flesh, purple-flesh, on farm-multilocation test, salinity tolerance

Introduction

Sweet potato (*Ipomoea batatas* L.) is the seventh most important staple food of many developing nations. In India, the production of sweet potato is 1.17 m t and area under cultivation is 0.14 m ha (FAO, 2009). Sweet potatoes are rich in carbohydrates and minerals. The orange and purple-fleshed tubers are cheap sources of β-carotene and anthocyanin, respectively. Despite its wider adaptability in diverse agro-ecological conditions and higher calorie yield, the productivity of sweet potato is affected to a great extent by salinity stress (Mukherjee et al., 2009a; 2009b).

Salt stress is referred to as the incapability of a plant to grow on high salt medium. Worldwide nearly 800 m ha area is affected by salinity and sodicity, which accounts for 20% of the agricultural land and 50% of the crop

land. This is alarming both from the point of environmental safety as well as food security (Mukherjee et al., 2006; 2007).

Soil salinity is caused by the presence of chlorides and sulphates of sodium, calcium and magnesium. In semi-arid regions, the problem of salinity is further aggravated due to loss of water by evaporation and transpiration under the prevailing hot dry climate. Poor drainage in agricultural field also increases salinity by raising the water table near the surface. Reclamation, drainage and irrigation management can minimize the extent and spread of soil salinity. However, increasing cost of water management necessitates the need for alternate management strategies. In this regard, breeding salt tolerant crop can be a promising energy efficient strategy that can be integrated with water and land management strategies. For evolving salt tolerant breeding lines, cultivation of crops under high salt concentration and determination of growth and yield response under saline conditions is the prime selection strategy. By this, the crop can acclimatize with stress conditions by maintaining osmotic balance, removal of reactive oxygen species and homeostasis of various ion pumps.

As Odisha shares a major chunk of the eastern coastline of India, considerable part (Kendrapara, Puri, Balasore, Bhadrak, Jagatsinghpur) of the cultivable land of this state falls in the coastal area. Further the land under cultivation is gradually and steadily encroached by saline water. This leads to significant change in agro-climatic conditions of the coastal regions. Sweet potato, a short duration crop with adaptability to a wide range of climatic conditions, can help in reclamation of agriculture lands in the coastal regions. Sodium chloride tolerance in sweet potato genotypes has been reported by Mukherjee (1999, 2001, 2002) under both *in vivo* and *in vitro* conditions. An attempt has been made in this paper to evaluate the yield and other attributes of orange and purple-fleshed sweet potato genotypes, in comparison with check varieties in order to recommend genotypes with good performance for commercial cultivation to ensure food and nutritional security in the coastal regions of Odisha.

Materials and Methods

Fifteen genotypes (listed in Table 1) were evaluated for yield, dry matter, starch, sugar and carotene content in an Initial Evaluation Trial (IET) during 2004-2005 and 2005-2006 in the farm of Regional Centre of Central Tuber Crops Research Institute (RC of CTCRI), Bhubaneswar, Odisha, India, under non-saline field conditions. The five genotypes (CIPSWA-2, CIP-440127, CIP-420027, CIP-187017-1, ST-14) which performed well in IET were forwarded to Uniform Regional Trial (URT) during 2006-2007 and 2007-2008 in the farm of RC of CTCRI. Three genotypes (CIPSWA-2, CIP-440127, ST-14) selected from the URT (CTCRI, 2006), based on their yield, were evaluated further in Multi-Location Trial (MLT) at four different locations (coastal Balasore and Kendrapara - under saline conditions and non-coastal Nuapada and Mangarajpur - under non-saline conditions) of Odisha and the farm of RC, CTCRI during 2008 and 2009. The IET, URT and MLT were conducted under AICRP.

To identify location specific suitability, four orange (CIPSWA-2, ST-14, SB-198/115, and CIP-420027) and one purple-fleshed (ST-13) genotypes, which showed salinity tolerance (Mukherjee et al., 2009a; 2009b) were forwarded to On Farm Multi-Location Trials (OF -MLT) in five different locations (Kendrapara, Puri, Jagatsinghpur, Astaranga and Balasore) in the coastal saline regions of Odisha (CTCRI, 2010) (EC 6-8 dS m^{-1}). The trials were conducted for three consecutive years during 2006-2007, 2007-2008 and 2008-2009. The IET, URT and OF-MLT were conducted under irrigated conditions following recommended package of practices in Randomized Block Design with four replications. In all the trials, ridge method of planting and a spacing of 60 cm x 20 cm were followed. The crop was planted in the month of September and harvested during December under irrigated conditions. Yield and other quality attributes were measured following standard methodologies (Padmaja et. al., 2005; Mukherjee, 2005; Mukherjee et al., 2009a). The dry matter, starch and carotene content were analyzed by standard procedures (Goodwin, 1980; Padmaja et al., 2005).

Results and Discussion

Fifteen orange-fleshed genotypes selected through germplasm screening at the farm of RC of CTCRI, Bhubaneswar, were tested in IET under non-saline field conditions during 2004-2005 and 2005-2006. The genotypes which performed well (Table 1) under IET,

Table 1. Tuber yield of sweet potato genotypes in IET at Bhubaneswar

Genotypes	Yield (t ha^{-1})		
	2004-2005	2005-2006	Mean
362-7	12.33	12.68	12.50
SV-98	10.64	11.16	10.90
S-1281	12.33	12.25	12.29
S-594	10.76	11.45	11.10
IGSP-C.15	9.10	10.83	9.96
IGSP-C.16	10.18	11.96	11.07
IGSP-C.17	12.19	11.90	12.04
CIPSWA- 2	17.56	17.59	17.57
CIP-187017.1	15.48	15.08	15.28
CIP-440038	14.19	14.03	14.11
CIP-440127	16.24	16.41	16.32
CIP-420027	16.66	16.33	16.49
ST-14	13.88	14.56	14.22
S-61	9.25	11.57	10.41
S-1156	12.11	11.50	11.80
CD (0.05)	0.69	3.81	

viz., CIPSWA-2, CIP-440127, CIP-420027, CIP-187017.1 and ST-14 were forwarded to URT along with the check variety Kamalasundari at the farm of RC of CTCRI, Bhubaneswar during 2006-2007 and 2007-2008.

The mean tuber yield of five sweet potato genotypes in comparison with the check variety Kamalasundari is given in Table 2. The genotypes, CIP-440127 (24.37 t ha^{-1}), CIPSWA-2 (24.01 t ha^{-1}) and ST-14 (22.41 t ha^{-1}) were on par (Table 2).

Based on the mean tuber yield in URT, three genotypes *viz.*, CIPSWA-2, CIP-440127 and ST-14 along with Kamalasundari and Gouri were selected for MLT at four

Table 2. Tuber yield of orange-fleshed genotypes in URT at Bhubaneswar

Entries/ Genotypes	Tuber yield (t ha^{-1})		
	2006-2007	2007-2008	Mean
CIPSWA-2	22.48	25.54	24.01
CIP-440127	23.28	25.45	24.37
CIP-420027	12.99	16.66	14.83
CIP-187017.1	12.15	16.52	14.34
ST-14	20.24	24.58	22.41
Kamalasundari	19.80	20.46	20.13
CD (0.05)	3.15	4.5	3.68

different locations encompassing coastal (Balasore and Kendrapara) and non coastal (Nuapada and Mangarajpur) locations of Odisha and the research farm of RC of CTCRI. In both the years (2008 and 2009) the performance of the genotypes, CIP-440127 and CIPSWA-2 were found to be superior than the check varieties, Kamalasundari and Gouri (Table 3).

The pooled analysis data of MLT revealed that the genotypes, CIPSWA-2 and CIP-440127 were significantly superior for yield, dry matter and harvest index than the two standard check, Kamalasundari and Gouri (Table 4). The harvest index and dry matter content of ST-14 was significantly superior to the checks.

From the yield data of IET, URT and MLT, the genotypes, CIP-440127, CIPSWA-2 and ST-14 were identified as good performers with high β-carotene content than the check varieties, Kamalasundari and Gouri. Evaluation of the nutrition value of these promising genotypes further reinforced them as superior types for commercial cultivation. The β-carotene content was observed to be the highest in ST-14 (11-12 mg 100g^{-1}) followed by CIP-440127 and CIPSWA-2 (6-7 mg 100g^{-1}). Starch content

Table 3. Tuber yield of orange-fleshed sweet potato under MLT

Genotypes/ Varieties	Tuber yield (t ha^{-1}) at different locations of Odisha									
	Farm (RC of CTCRI)		Balasore		Kendrapara		Nuapada		Mangarajpur	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
CIPSWA-2	22.07	22.89	21.91	23.50	22.19	23.42	22.31	23.69	22.35	23.51
ST-14	20.36	21.59	19.12	21.29	20.05	20.87	19.36	20.54	20.32	21.58
CIP-440127	23.91	23.92	23.46	24.11	23.77	24.71	23.61	24.84	23.35	24.43
Kamalasundari	18.97	20.26	20.62	21.10	19.23	20.50	19.43	20.70	19.12	20.38
Gouri	19.16	18.88	19.81	19.15	18.57	18.53	19.21	18.92	19.16	18.28
CD (0.05)	3.21	2.57	3.02	2.58	3.22	2.87	3.30	3.33	3.51	3.87

Table 4. Pooled analysis data of MLT

Genotypes/ Varieties	Tuber yield (t ha^{-1})	Harvest index	Dry matter (%)
CIPSWA-2	22.78	0.547	23.59
ST-14	20.50	0.522	28.29
CIP-440127	24.01	0.569	25.77
Kamalasundari	20.02	0.497	21.99
Gouri	18.96	0.482	21.03
CD (0.05)	1.95	0.026	1.34

was also found to be very high in ST-14 (18.8-19.7%), fairly high in CIP-440127 (17.8-18.8%) and CIPSWA-2 (16.6-17.2%) (Table 5).

To identify location specific suitability of salinity tolerant sweet potato genotypes, *viz.*, SB- 198/115, ST-13, CIP-420027, CIPSWA-2 and ST-14, a separate OF-MLT was conducted at five different coastal locations *viz.*, Kendrapara, Puri, Astaranga, Jagatsinghpur and Balasore (Data not shown) consecutively for three years (2006-2007, 2007-2008 and 2008-2009). At all the locations the mean yield of orange-fleshed genotypes *viz.*, CIPSWA-2, ST-14, SB-198/115 and purple-fleshed

Dry matter (%) : 27-29
Starch (%) : Extractable starch 18.8-19.7
Total sugar (%) : 2-2.4
β-carotene content
(mg 100g^{-1}) : 11.5-12
Cooking quality : Excellent and mealy
Average yield : 19.8 t ha^{-1}
Can tolerate salinity stress (6-8 dS m^{-1})

Fig. 1. Orange-fleshed sweet potato genotype ST-14 with quality parameters

Dry matter (%) : 24-25.5
Starch (%) : Extractable starch 16.5-17
Total sugar (%) : 1.9-2.2
Anthocyanin content
(mg 100g^{-1}) : 85-90
Cooking quality : Fair
Average yield : 18 t ha^{-1}
Can tolerate salinity stress (6-8 dS m^{-1})

Fig. 2. Purple-fleshed sweet potato genotype ST-13 with quality parameters

Table 5. Bio-chemical constituents of high yielding orange-fleshed genotypes of sweet potato

Bio-chemical constituents	CIPSWA-2	CIP-440127	ST-14
Dry matter content (%)	23.2-24.8	25-27	27-29
Starch content (%)(total/extractable)	16.6-17.2(total)	17.8-18.8(total)	18.8-19.7(extractable)
β-carotene content (mg $100g^{-1}$)	5.5-6.2	5.5-6.6	11.5-12
Total sugar content (%)	2.4-3.0	2.5-2.8	2-2.4
Cooking quality	Good	Good and mealy	Excellent and mealy

Table 6. Mean tuber yield of five sweet potato genotypes under OF-MLT in Odisha

Genotypes / Varieties	Yield (t ha^{-1}) under four coastal locations									Pooled mean
	Kendrapara			Puri		Jagatsinghpur		Astaranga		
	2006-2007	2007-2008	2008-2009	2006-2007	2008-2009	2007-2008	2008-2009	2006-2007	2007-2008	
CIPSWA-2	20.83	20.83	22.09	20.83	20.28	18.74	27.72	21.71	20.13	21.46
ST-14	16.66	17.49	17.65	20.25	16.79	19.16	17.98	19.16	18.74	18.21
SB-198/115	20.83	21.66	20.46	19.55	18.23	18.74	19.67	18.33	19.16	19.63
ST-13	18.33	18.74	18.86	17.16	16.96	16.66	16.48	18.33	17.49	17.67
CIP-420027	18.33	18.74	19.95	18.56	19.81	16.66	18.97	17.49	16.66	18.35
Gouri	16.66	17.74	17.61	17.58	17.84	16.66	15.20	15.83	16.49	16.85
CD (0.05)	2.87	4.15	3.26	2.35	3.25	1.78	4.48	2.57	3.87	1.51

genotype, ST-13, were found to be higher than the standard check, Gouri (Table 6).

Based on the pooled analysis of data from MLT and OFT across Odisha, sweet potato genotypes *viz.*, CIP-440127, CIPSWA-2, ST-14, SB-198/115, CIP-420027 and ST-13 performed better than the check. Among these all are orange-fleshed, except ST-13, which is purple-fleshed. The genotype, CIPSWA-2, was found to be significantly superior to the check, Gouri for yield. On the other hand, the genotype ST-14, though on par with the check for yield, was found to be superior for β-carotene content (11-12 mg $100g^{-1}$) than Gouri (4-5 mg $100g^{-1}$). Similarly the yield of the genotype ST-13 was on par with Gouri, but ST-13 was found to be enriched with anthocyanin. The high tuber yield (> 15 t ha^{-1}) coupled with the high β-carotene content (6-12 mg $100g^{-1}$) in orange-fleshed genotypes like ST-14 (Fig.1) and anthocyanin content (85-90 mg $100g^{-1}$) in purple-fleshed genotypes like ST-13 (Fig. 2) indicates immense agricultural implications towards food and nutritional security especially in the fragile and insecure coastal zones.

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