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Stability analysis for yield in sweetpotato (*Ipomoea batatas*) genotypes with special reference to orange-fleshed sweetpotato

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ABSTRACT

Field studies were conducted to assess the relative performance of recently introduced orange-fleshed sweetpotato genotypes [*Ipomoea batatas* (L.) Lam.] (OFSPs) in comparison with the commonly cultivated white-fleshed genotypes (WFSP). The study used six genotypes (four OFSPs and two WFSPs) across three locations, namely Bhubaneswar (experimental station), Chanabahal and Lausahi (farmer's fields), for two consecutive years (2005–06 and 2006–07) during both rainy (*kharif*) and winter (*rabi*) seasons. Storage yields of sweetpotato were affected by the genotypes, locations and seasons. The interaction effects were significant for genotype × season and genotype × location. Yields of the improved WFSP genotype, CIP-SWA-3 were high at all locations. Among the OFSPs, IB-97-2/5 and IB-97-6/15 were on par with CIP-SWA 3, but only in two out of three locations. Among the locations, yields were consistently and significantly higher at Lausahi in both the seasons and years. This was attributed to prevailing relatively lower temperatures at Lausahi. Between the growing seasons, higher yield were observed in *rabi* than in *kharif* season. The adaptability of sweetpotato genotypes across environments was also assessed using pooled stability analysis for root yield. Based on the marker values for stability parameters namely, bi=0 (regression coefficient), S^2di =1 (deviation from regression) and R^2 (coefficient of determination), only one genotype IB-97-6/15 (OFSP) was found to be stable across environments.

Key words: Adaptability, Interaction effects, *Kharif*, Orange/white fleshed sweetpotato genotypes, *Rabi*

Sweetpotato [*Ipomoea batatas* (L.) Lam.] has a high carotene content, especially those with an orange flesh colour, typically known as orange-fleshed sweetpotato (OFSP). In India, Odisha is the largest producer of sweetpotato with an average yield of 394 300 tonnes from 47 100 (Indian Horticultural data base 2004–05). Sweetpotato is grown both in rainy *(kharif)* (wet, south west monsoon) and winter *(rabi)* (dry, post-monsoon) seasons in Odisha. However, little information is available about genotype × environment interactions in sweetpotato as there could be physiological expression of growth characteristics that may influence the growth of the sweetpotato genotypes in different seasons. In this study, improved genotypes were compared with local variety to examine the growth and yield of sweetpotato genotypes with special reference to OFSPs at three selected agro-ecological conditions of Odisha over the two cropping seasons. Stability analysis for yield was also resorted to determine the adaptability of sweetpotato genotypes, especially the OFSPs.

MATERIALS AND METHODS

The study was conducted at three locations namely Bhubaneswar in Khurda district (20°152 N, 85°472 E, altitude 32 m), Chanabahal in Bolangir district (20°272 N, 83°12 E, altitude 260 m) and Lausahi in Gajapati district (19°42 N, 84°142 E, altitude 632 m). Soil physical and chemical properties are shown in Table 1.

In both *kharif* and *rabi* seasons during 2005–06 and 2006–07, the experiments were laid out in randomized complete block design with four replications. The treatments consisted of four orange-fleshed sweetpotato (OFSP) genotypes and two white-fleshed sweetpotato (WFSP) genotypes including the local variety. The dimensions of each plot was 3.6 m × 6.0 m.Vines having 4–5 nodes and 20 cm in length were used for planting with a spacing of 60 cm × 30 cm. Fertilizers and crop management practices were followed as per the recommended package of practices proposed by CTCRI, Thiruvananthapuram. In *kharif* season, no irrigation was provided except at the time of planting but in *rabi* season

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Table 1 Physical and chemical properties of soils at different experimental sites

Soil property	Experimental sites		
	Bhubaneswar	Chanabahal	Lausahi
Physical properties			
Sand (%)	78.8	79.8	74.8
Silt (%)	2.0	2.0	4.0
Clay (%)	19.2	18.2	21.2
Textural class	Sandy loam	Sandy loam	Sandy-clay loam
Soil order (USDA classification)	Inceptisol	Inceptisol	Alfisol
Chemical properties			
*p*H (1:2)	5.40	6.09	5.36
EC (dS/m)	0.017	0.069	0.036
Available nitrogen (kg/ha)	125.44	85.12	113.12
Available phosphorous P_2O_5 (kg/ha)	44.66	34.91	57.27
Available potassium K_2O (kg/ha)	165.3	188.2	393.8

surface irrigation at weekly intervals was given making a total of 15 irrigations. At the final harvest (105 days) the fresh weights of total storage root yield was recorded. The data on storage root yields were analyzed as a factorial experiment with three factors namely locations (three) genotypes (six) and seasons (two) conducted in a randomized complete block design with four replications. The main effects and the interaction effects were analyzed using the standard statistical procedures. The data collected on different parameters were subjected to appropriate statistical analysis using SAS (Statistical Analysis System) 6.12 for WINDOWS (SAS Inc. NC, USA) programme. The stability analysis was carried out by using the phenotypic mean values across three environments for storage root yield using the model of Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Storage root yield

The data on storage root yield presented in Table 2 showed varietal variation in yield and was comparatively less at BHU than the other two locations in 2005 and 2006. IB-97-2/5 was best performing genotype in both the years and seasons at CHA. The *rabi* season recorded a significantly higher yield in both the years in most of the locations. Significant differences were observed for genotypes, locations, seasons and interactions of genotype × location and season × location. In three out of four seasons at BHU and LAU the superior WFSP genotype CIP-SWA 3 had a yield which was similar to the superior OFSP genotype IB 97-2/5. However, the superior WFSP genotype significantly out yielded other OFSPs. This is reflected by the significant location × genotype interaction. It is only at CHA that the superior OFSP significantly out yielded the superior WFSP genotype. It is only at LAU that all OFSPs tested yielded higher than the local WFSPs. Among the locations, Lausahi had the highest mean yield of 19.55 tonnes/ha in both the seasons. Between the seasons, the mean yields were significantly higher in *rabi* (17.51 tonnes/ha) over *kharif* (13.98 tonnes/ ha). Among the interactions only location × genotype and season × location was significant.

In 2006–07 significant differences were observed in respect of genotypes, locations and interactions for genotypes × location as well as season × location. The mean *rabi* season yields were significantly higher (15.69 tonnes/ha) over *kharif* season (13.5 tonnes/ha). In general, the results indicated that among the four OFSPs only one namely IB 97-2/5 was consistently superior over the improved local variety at only one out of three locations (as at CHA).

Stability Analysis

The pooled analysis of variance over locations, seasons and years for storage root yield is presented in Table 3. The mean sum of squares due to genotypes, environments and genotype × environment interaction were found to be significant suggesting the occurrence of genetic variability. However, an environment linear component accounted for major portion of environment variance. The highly significant differences for the genotypes, environment and GxE interaction effect (linear) indicated differential genotypic responses to different environments. The stability parameters in respect of yield for all genotypes are presented in Table 4.

Eberhart and Russell emphasized the need for considering both linear (bi) and non-linear (S^2di) components of G×E interaction in judging the stability of a genotype. A genotype with wide adaptability is defined as one with bi=1 and S^2di=0. The values for regression coefficient (bi) ranged from 0.3026 (local variety) to 1.40 (IB-97-2/5) for storage root yield. The regression coefficient of genotypes IB-97-6/15 and CIP-SWA 2 were found to be not significantly different from unity. These could be considered most stable for storage root yield. Further, their coefficient of determination (R^2) were high (85.54 and 89.48, respectively) confirming their stability. Both the local selection and CIP-440074 gave below average performance besides significantly lower regression from unity. A plot of genotypic means against environment means with the corresponding regression lines illustrated the differential response of genotypes to changing environments (Fig 1). Representation of genotype regression coefficients plotted against the environment mean as well as location mean yields (i e general mean of each location) are shown in Fig 2. The local and the improved OFSP genotype CIP 440074 had regression coefficients significantly lower than the unity and mean yields lower than the overall average yield. Therefore, they may be characterized as poorly sensitive to varying environments. Further examination of the data showed, that IB-97-6/15, with non- significant regression coefficient

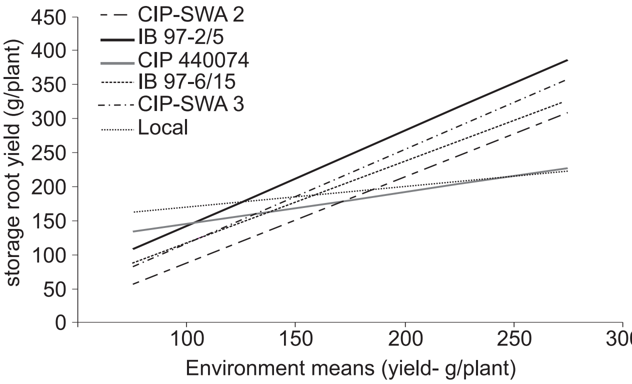

Fig 1 Plot of storage root yield means for six genotypes with corresponding regression lines (2005–07)

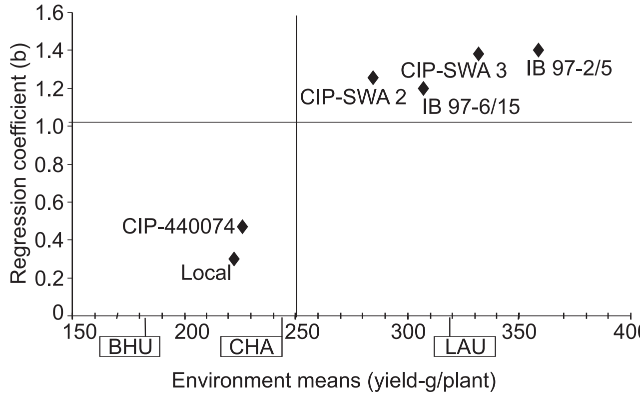

Fig 2 Scatter diagram depicting the relationship between storage root yields (environment means) and regression coefficient

(1.20), non-significant S^2di value (–181.11) and with higher (307 g /plant) than mean yields of all locations (250 g /plant) (Fig 2) may be considered as the most adaptable genotype over diverse environments. CIP-SWA 2 having non-significant regression coefficient (1.26) but with significant S^2di values (609.49), as well as higher than mean yields (285 g /plant). Another high yielder IB 97-2/5 (358 g /plant) had non-significant S^2di values (46.96) and higher regression coefficient (1.40) but significantly differing from the marker values also could be characterized as sensitive to environments.

A considerable storage root yield advantage over locally preferred cultivars may be achieved by recommending new cultivars. In some areas, sweetpotato is the major source of

Table 2 Total storage root yield (tonnes / ha) of sweetpotato genotypes at different locations and seasons over two years.

Genotype *	*Kharif season*				*Rabi season*				
	Location				Location				
	BHU•	CHA•	LAU•	Mean	BHU•	CHA•	LAU•	Mean	Grand mean
2005–2006									
CIP SWA 2 (O)	8.09	16.02	17.41	13.84	9.50	19.91	22.73	17.38	15.61
IB 97-2/5 (O)	13.40	17.81	23.54	18.25	14.41	21.54	28.47	21.47	19.86
CIP 440074 (O)	9.95	10.72	10.31	10.33	13.76	13.66	16.02	14.48	12.41
IB 97-6/15 (O)	9.93	15.29	19.01	14.74	13.69	18.62	24.47	18.93	16.83
CIP-SWA 3 (W)	13.13	13.56	22.02	16.24	14.36	16.62	27.48	19.49	17.86
Local (W)	11.15	11.26	8.97	10.46	11.58	14.27	14.15	13.33	11.89
Mean	10.94	14.11	16.88	13.98	12.88	17.44	22.22	17.51	
CV (%)	18.2	10.9	5.7		19.9	4.8	3.4		
2006-2007									
CIP-SWA 2 (O)	7.70	14.73	17.49	13.31	8.37	15.16	23.79	15.77	14.54
IB 97-2/5 (O)	13.12	16.50	23.66	17.76	10.40	16.66	29.00	18.69	18.23
CIP 440074 (O)	8.94	10.70	10.30	9.98	10.25	11.01	16.43	12.56	11.27
IB 97-6/15 (O)	10.00	13.87	18.43	14.10	9.16	14.06	26.05	16.42	15.26
CIP-SWA 3 (W)	11.55	13.38	21.86	15.60	12.63	13.95	28.94	18.51	17.05
Local (W)	11.13	11.88	7.88	10.30	9.08	11.91	15.50	12.16	11.23
Mean	10.24	13.51	16.60	13.51	9.98	13.79	23.29	15.69	
CV (%)	14.7	10.9	8.6		30.1	11.4	7.7		
Grand mean of locations					10.11	13.65	19.94		

• BHU, Bhubaneswar; CHA, Chanabahal; LAU, Lausahi; * Genotypes: O, Orange fleshed, W, white fleshed CD (P=0.05)

	2005–06	*2006–07*
Genotype	1.05	1.11
Location	0.61	0.67
Genotype × location interaction	1.82	1.83
Genotype × season interaction	NS	NS
Season × location interaction	1.05	1.06
Genotype × season × location interaction	NS	NS

Table 3 Stability model: genotype × environment interactions

Analysis of variance By Eberhart and Russel's Model

Source	df	SS	MS
Total	71	759 786.0382	
Genotypes	5	184 491.8611	36 898.3722**
Env. + (genotypes × env.)	66	575 294.1771	8 716.5784**
Environment (linear)	1	454 844.9965	454 844.9965**
Genotypes × env. (linear)	5	89 029.2490	17 805.8498**
Pooled deviation	60	31 419.9315	523.6655
CIP-SWA 2	10	8 469.0076	846.9008**
IB 97-2/5	10	2 843.9076	284.3907
CIP 440074	10	3 306.8091	330.6809
IB 97-6/15	10	563.1936	56.3193
CIP-SWA 3	10	10 530.5331	1 053.0533**
Local	10	5 706.4806	570.6481
Pooled error	216	51 285.3750	237.4323

Statistical significance is noted on mean sum of squares for all the important parameters using asterisk marks

nourishment and quality aspects are likely to determine whether or not a new clone is accepted by farmers (Gruneberg *et al*. 2005). In spite of its ability to adapt to harsh growing conditions, sweetpotato is sensitive to environmental variations. Genotype by environment interactions (G × E) is of great interest when evaluating the stability of clones under varied environmental conditions (Manrique and Hermann 2000). It is important that high and stable levels of carotenoids are incorporated into a good and stable agronomic background to enhance their acceptability (Ssemakula *et al*. 2007). Based on the overall performance over four seasons in two years and at three different locations it was observed that among the genotypes IB 97-6/15 and improved CIP-SWA 3 performed consistently well over other genotypes. Incidentally IB 97-6/15 happens to possess orange flesh in the storage roots. The storage root yields were relatively higher in *rabi* season as compared to that in *kharif* in most of the genotypes. Similar observations were made for sweetpotato yields in Bhubaneswar by Nedunchezhiyan and Byju (2005). The reason for higher yields in LAU could be attributed to prevailing relatively lower maximum temperatures both in *kharif* and *rabi*.

Location effects

The three locations chosen were located geographically apart and had varied weather conditions such as, rainfall pattern and temperature and even soil characteristics, especially the nutrient availability (Table 1). Among these three locations Lausahi recorded consistently higher yields in both the seasons almost reaching the potential yield levels (20–30 tonnes/ha). Evidently LAU had optimal conditions for better expression of yield. In addition to prevailing favourable maximum temperature yields at LAU both in *kharif* and *rabi* could be to certain extent attributable to its altitude. Compared to the other locations LAU is situated at higher altitudes (632 m above MSL). Manrique and Hermann (2000) noticed that higher altitudes could favour not only higher yields but also higher carotene content in sweetpotato. Although the available nitrogen was low in all the three locations, Lausahi soil had considerably higher levels of both available phosphorus and potassium (Table 1). A variety with a stable yield is desirable for commercial exploitation of any crop over a wide range of agro-climatic conditions. Genotypes whose GxE is insignificant are said to be stable (Fernandez 1991). The chief objective of the present study was to identify genotypes for stable high yields over diverse environments where the emphasis was on OFSPs because it is important that high and stable levels of carotenoids are incorporated into a good and stable agronomic background to enhance their acceptability. With the Eberhart and Russell (1966) model, ANOVA for pooled analysis showed significant genotype, environment effects and G × E interaction in respect of all the characters in both the years of study. Further, the regression analysis also indicated differences in yield studied among the genotypes as well as the significant G × E interaction effect. Based on the marker values for bi = 1, S^2 di = 0, coefficient of determination (R^2),

Table 4 Estimates of stability parameters for storage root yields of sweetpotato for six genotypes evaluated for two years in three locations of Odisha

Genotypes	Mean	Regression coefficient (b)	S^2di (mean square deviation from linear	Coefficient of determination -R^2 (%) regression)
CIP-SWA 2	284.75	1.26	609.49**	89.48
IB 97-2/5	358.58	1.40*	46.96	87.00
CIP 440074	226.04	0.47**	93.25	32.89
IB 97-6/15	306.77	1.20	–181.11	85.54
CIP-SWA 3	331.72	1.38**	815.62**	89.68
Local	222.58	0.30**	333.21**	16.18

* Indicate significant differences from respective marker values (b =0; S^2di=1)

regression graphs and mean yields, only IB-97-6/15 with bi values nearer to unity (non-significant), S^2di (non-significant) and high coefficient of determination with higher average mean yields was found to be highly stable across locations (Tables 3, 4, Figs 1, 2) in two different seasons and in two consecutive years. Therefore, the studies indicated that OFSP genotypes possessing high yields were as good as improved WFSP or better than local WFSP and these could be largely popularized for nutrition, food and income among farming communities.

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