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Physiological adaptability of sweetpotato (*Ipomoea batatas*) genotypes as influenced by seasons with emphasis on orange-fleshed sweetpotato

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ABSTRACT

A field experiment was conducted during both rainy (*kharif)* and winter (*rabi)* seasons of 2007–08 to determine the physiological basis of yield variation comprising six sweetpotato (*Ipomoea batatas*) genotypes. The improved white-fleshed sweetpotato genotype 'CIP-SWA 3' out yielded all the other genotypes in both the seasons. However, among the orange-fleshed sweetpotatoes, 'IB 97-6/15' and 'IB 97-2/5' were the second best. In *kharif*, yields were constrained by excessive vine length, greater leaf number and leaf area, lowered biomass with reduced partitioning of dry matter to tubers. A general reverse trend in these characteristics induced higher yields in *rabi*. In both seasons, the local variety followed by 'CIP SWA 3' recorded relatively better crop growth characteristics. Early tuberization was chiefly responsible for higher yields in *rabi*. Further despite low leaf area index values, a higher photosynthetic efficiency in terms of net accumulation ratio, followed by higher bulking rate and partioning coefficient values resulted in higher yields during *rabi*.

Key words: Analysis, Correlations, *Kharif*, Orange/White fleshed sweetpotato genotypes, Physiological growth, *Rabi*

Sweetpotato (*Ipomoea batatas* (L.) Lam.) is a starchy root crop and is a cheap source of vitamin A (especially those with high beta-carotene content). Orissa is the major producer of sweetpotato with an average yield of 3 94 300 tonnes from 47 100 ha (IHB 2004–05). In Orissa, sweetpotato yielded more in winter (*rabi*) (dry, post-monsoon) season with supplemental irrigation, than in rainy (*kharif*) (wet, south west monsoon) season (Nedunchezhiyan and Byju 2005). Yield variation among the sweetpotato genotypes/cultivars were noted by many researchers in India (Harischandra *et al*. 2003). A study was made to examine the causal factors for differences between yields of sweetpotato genotypes in two seasons and its relationships among vegetative and physiological growth parameters, yield attributes and yield in the two cropping seasons.

MATERIALS AND METHODS

A study was conducted at the experimental farm of the Regional Centre of Central Tuber Crops Research Institute (CTCRI), Khurda district, Bhubaneswar, situated at 20°152 N and 85°472 E at an altitude of 32 m above mean sea level. The soil has been classified as Inceptisols, being sandy loam in texture with *p*H of 5.4. The average maximum and minimum temperatures are 32.4°C and 25°C. The annual rainfall is around 1 450 mm. The experiment was conducted in both *kharif* and *rabi* seasons during 2007–08. The experiments were laid out in randomized complete block design with four replications. The treatments consisted of six genotypes—(four orange fleshed sweetpotatotes and two–white fleshed sweetpotatoes) including the local variety. The dimensions of each plot was 3.6 m × 6 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, surface irrigation at weekly intervals was given making a total of 15 irrigations. The dry matter content in different plant parts–leaves, stems and tubers were taken from 3 uprooted plants of destructive sampling area at 15, 30, 45, 60, 75, 90 and 105 days after planting (DAP). The harvest index (HI) and partitioning coefficient (between root dry weight and total biomass at a given growth stage on per cent basis) were assessed for dry matter distribution.

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The growth parameters namely, Crop Growth Rate (CGR), Net Assimilation Rate (NAR), Leaf Area Duration (LAD), Leaf area index (LAI) and specific leaf area (SLA) were computed at various growth stages. These were computed following the formulae given by Hall (1993). The extent of tuberization during the crop growth period termed the bulking rate (g/m^2/day) or yield growth rate was assessed as the storage root weight/unit time. 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.

Table 1 Storage root yield (tonnes /ha) of sweetpotato genotypes in *kharif* and *rabi* seasons

Genotype*	*Kharif*	*Rabi*	Mean
'CIP SWA 2' (O)	6.53	7.22	6.88
'IB 97 2/5' (O)	9.18	6.21	7.70
'CIP 440074' (O)	6.87	8.82	7.85
'IB 97-6/15' (O)	7.31	8.96	8.14
'CIP-SWA 3' (W)	10.75	12.43	11.59
Local (W)	7.36	8.89	8.13
Mean	8.00	8.76	
CD (P=0.05)	0.634	0.812	
CV (%)	21	25	

***** O, Orange fleshed; W, white fleshed

RESULTS AND DISCUSSION

Storage root yield

The data presented in Table 1 showed significant yield differences among the genotypes in both the seasons. In both the seasons, the improved white-fleshed genotype 'CIP SWA 3' outyielded all the other genotypes. However among the orange-freshed sweet potato, 'IB 97-2/5' in *kharif* and 'IB 97-6/15', 'CIP 440074' and the local variety in *rabi* performed relatively better. The storage root yields were found to be higher in *rabi*.

Yield component

In *kharif*, with the exception of storage root number / plant and total biomass / plant on dry weight basis all the characteristics studied showed significant differences between genotypes (Table 2). In *rabi* there were significant differences between genotypes for all the yield parameters except for storage root number/ plant and storage root length. The harvest index and partitioning coefficient were relatively higher in *rabi* over *kharif*.

Growth analysis expresses plant morpho-physiological conditions and quantifies the net yield derived from the photosynthetic processes (Fontes 2005). In sweetpotato, the parameters which contribute to yield are tuber number/plant, bulking rates of tubers and tuber weight (Mandal 2006). In

Table 2 Yield components and other yield related characteristics of sweetpotato genotypes in *kharif* and *rabi* seasons

	Vine length (cm)	Storage root number/ plant	Storage root length (cm)	Mean storage root fresh weight/ plant (g)	Mean dry storage root weight/plant (g)	Total biomass g/plant		HI (%)	PC (%)
						Fresh weight basis	Dry weight basis	Fresh weight basis	Dry weight basis
				Kharif 2007					
'CIP-SWA 2' (O)	59.75	4.93	8.10	119.0	7.85	336.8	61.6	35.3	67.9
'IB 97 2/5' (O)	64.50	5.02	5.80	165.0	10.81	370.0	85.8	44.6	69.1
'CIP 440074' (O)	84.50	5.74	7.98	124.0	11.97	240.8	70.8	51.5	68.9
'IB 97-6/15' (O)	201.70	6.16	7.81	133.0	10.73	325.8	83.0	40.8	68.0
'CIP-SWA 3' (W)	97.50	5.86	5.61	197.0	10.38	380.0	92.6	51.8	65.1
Local (W)	274.50	6.16	6.42	136.0	7.65	301.5	81.4	45.1	53.2
Mean	130.40	4.82	6.88	145.7	9.90	325.8	79.2	44.9	65.4
CD (P=0.05)	73.43	NS	1.89	26.2	1.74	56.6	NS	7.5	3.3
CV (%)	39.3	26.6	25.5	21.0	6.0	21.7	24.0	16.8	11.0
				Rabi 2007–08					
'CIP-SWA 2' (O)	39.50	5.14	9.10	130.0	8.95	204.75	79.00	63.5	56.6
'IB 97-2/5' (O)	53.75	5.32	5.50	111.8	10.76	185.25	80.00	60.3	74.6
'CIP 440074' (O)	49.25	5.93	8.93	158.8	11.03	232.75	96.25	68.2	66.8
'IB 97-6/15' (O)	179.25	6.80	7.88	161.3	7.44	290.00	85.75	55.6	58.6
'CIP-SWA 3' (W)	57.75	5.80	6.86	223.8	14.58	335.00	111.75	66.8	70.9
Local (W)	176.75	6.28	7.75	160.0	9.91	324.00	108.50	49.4	56.0
Mean	92.70	5.88	7.67	131.2	10.45	262.00	93.50	60.6	63.9
CD (P=0.05)	37.09	NS	NS	28.2	1.3	96.6	15.9	12.15	5.3
CV (%)	36.5	25.9	26.4	23.8	22.7	28.2	27	13.8	11.4

* O, Orange fleshed; W, white fleshed

the present study, the yield was significantly influenced by storage root length than storage root number and mean storage root weight (Tables 1,2). Nedunchezhiyan and Reddy (2000) and Anshebo *et al*. (2004) also observed a positive relationship or association of tuber length with yield in sweetpotato varieties. The results of the present studies also indicated that there was no significant variation in tuber numbers among the genotypes in both the seasons. It was also suggested that if maximum tuber yields are to be obtained in sweetpotato, a compromise between tuber number and vine length has to be considered in the selection programme (Anshebo *et al*. 2004). Therefore a vine length around 90–100 cm would perhaps be ideal in obtaining a potential yield of 15–20 tonnes/ha.

Growth analysis parameters

A few physiological growth analysis parameters, namely crop growth rate, (CGR), net assimilation ratio (NAR), leaf area duration (LAD) and SLA were assessed (Table 3) for both *kharif* and *rabi* during different growth stages, namely 15–60 (initial) and 60–105 days after planting (late) along with tuberous growth rate (bulking rate or yield growth rate) and partitioning coefficient.

The crop growth rate (CGR) in both the seasons relatively increased with increasing age. This was more prominent during *rabi* than in *kharif* in most of the genotypes except local variety. In *kharif*, at initial stage (15–60 days after planting) the local genotype had the highest CGR (5.43). At later stage 'CIP-SWA 3' had the highest CGR. The net assimilation ratio (NAR) also differed significantly among the genotypes in both the seasons during both the growth phases. In all the genotypes, the NAR was higher during the initial phase than that in later growth phase in both the seasons. The leaf area duration (LAD) tended to increase with increasing age in both the seasons. The specific leaf area (SLA) values decreased at later growth stages as compared to initial stage in both seasons with the exception of local genotype in *kharif*. However, this was prominent in *rabi* than in *kharif*. In both *kharif* and *rabi* seasons 'CIP-SWA 3' had significantly higher bulking rate of 6.24 g and 5.24 g respectively than that of rest of the genotypes. The genotypes differed significantly in both the seasons and at both the stages for partitioning coefficient.

The genotypes accumulated considerable amount of dry matter in tubers during the early phase of growth in the *rabi* season. But the rate of dry matter accumulation in terms of CGR during the early growth phase in *kharif* is chiefly due to LAI and NAR, indicating that leaf expansion plus high photosynthetic rates are of prime importance at this phase of crop growth to obtain a high dry matter and consequently higher yield. In general, unlike in *kharif* tuberization started early as indicated by almost similar (mean) values for bulking rate and partitioning coefficient in both the growth phases (Table 3).

In *rabi* season, the notable observations were that there was reduction in vine length which in turn reduced leaf number and consequently lowered LAI as compared to *kharif* season. One of the important dimensions of leaf area (in

Table 3 Physiological growth parameters of sweetpotato genotypes in *kharif* and *rabi* 2007–08

	CGR		NAR		LAD		SLA		BR		PC %)	
	15–60 DAP	60–105 DAP	15–60 DAP	60–105 DAP	15–60 DAP	60–105 DAP	60 DAP	105 DAP	15–60 DAP	60–105 DAP	60 DAP	105 DAP
Kharif 2007												
'CIP-SWA 2' (O)	3.69	3.64	6.26	2.34	33.6	51.5	537	346	0.87	4.84	58.3	67.9
'IB 97-2/5' (O)	4.52	5.34	7.55	3.41	35.1	59.2	440	369	1.78	3.26	52.7	69.1
'CIP 440074' (O)	3.54	4.82	4.32	2.58	55.8	67.3	820	634	2.26	3.47	60.8	68.9
'IB 97-6/15' (O)	4.76	4.91	4.85	2.71	55.5	94.6	563	298	2.62	4.38	51.8	68.0
'CIP-SWA 3' (W)	4.29	6.63	5.53	3.57	52.1	77.7	486	232	2.55	6.24	55.5	65.1
Local (W)	5.43	3.21	7.19	2.33	51.5	128.1	288	565	2.84	2.66	50.6	53.2
Mean	4.48	4.82	5.94	2.68	47.3	79.7	522	407	2.15	4.14	55.0	65.4
CD (*P*=0.05)	1.48	0.99	1.87	1.01	7.5	8.1	129	132	0.46	0.79	0.69	3.3
CV (%)	24.7	24	24	30.8	21.7	33.1	32.9	38.4	28.9	27	9	11
Rabi 2007–08												
'CIP-SWA 2' (O)	4.55	7.42	9.99	9.03	21.8	39.7	732	82	2.69	2.73	67.0	56.9
'IB 97-2/5' (O)	4.76	5.47	9.42	5.38	21.8	39.7	1299	192	2.43	3.08	55.8	74.6
'CIP 440074' (O)	3.83	5.48	5.97	4.96	23.6	45.1	3189	181	3.28	4.88	70.4	66.8
'IB 97-6/15' (O)	4.16	5.72	10.74	6.82	40.0	79.4	286	93	2.84	3.26	57.7	58.6
'CIP-SWA 3' (W)	6.04	7.30	12.65	7.23	27.6	48.3	826	151	4.39	5.24	70.4	70.9
Local (W)	6.76	6.24	19.00	5.39	24.7	75.9	792	197	3.64	3.74	52.5	56.0
Mean	5.01	6.27	11.29	6.47	27.4	54.4	1187	158	3.21	3.82	62.3	63.9
CD (P=0.05)	0.72	1.55	1.87	1.58	1.3	4.2	380	55	0.31	0.45	6.45	5.29
CV (%)	23.3	16.8	37	24.3	22.5	32	39.2	35.4	21.5	25.5	12.8	11.4

addition to LAD) is specific leaf area (SLA), a reciprocal of specific leaf weight (SLW). Thus, SLA has two components, namely leaf expansion and leaf dry matter. The SLA in general, was higher in *rabi* among all the genotypes studied (barring those at 90 and 105 days after planing) than in *kharif*. SLA is known to decrease gradually as the leaves mature (Hall 1993).

Correlations

In *kharif* during the early phase of growth (15–60 days after planting), none of the growth parameters was found to be significantly associated with storage root yield. But during the same phase TBM was found to be significantly and positively associated with CGR, NAR, PC and LAI. In *rabi*, the yield was found to be significantly and positively associated with BR (*r*=0.892), followed by TBM (*r*=0.682) and CGR (*r*=0.600). The storage root yield of sweetpotato was positively and significantly correlated with parameters such as TBM (*r*=0.810), PC (*r*=0.669), BR (*r*=0.628) and CGR (*r*=0.438) in *rabi* season.

Influence of physiological growth characteristics on yield expression

The dry matter accumulation followed a similar pattern

Table 4 Correlations (*r*) among yield and growth parameters of sweetpotato genotypes

Early growth phase (15–60 DAP) season/ growth parameter	TBM	CGR	LAI	NAR	LAD	SLA	BR	PC
Kharif								
YIELD	0.157	0.107	0.084	0.201	0.062	0.084	0.168	–0.193
TBM		0.963**	0.454*	0.643**	0.281	– 0.565**	0.300	0.631**
CGR			–0.066	0.632**	0.281	–0.066	0.281	–0.759**
LAI				–0.066	0.030	0.380	0.205	0.028
NAR					–0.480*	–0.290	0.198	–0.448*
LAD						0.490*	0.022	0.171
SLA							–0.092	0.028
BR								–0.258
Rabi								
YIELD	0.682**	0.600**	0.409*	0.231	0.295	–0.051	0.892**	0.409*
TBM		0.380	0.042	0.823**	0.028	0.259	0.768**	0.293
CGR			0.019	0.821**	–0.007	–0.488*	0.612**	–0.291
LAI				0.016	–0.030	–0.465*	0.046	–0.137
NAR					–0.502*	–0.577**	0.304	0.558**
LAD						0.832**	0.196	0.469*
SLA							0.011	0.429*
BR								0.444*
Late growthphase(60–105DAP)								
Kharif								
YIELD	0.731	–0.175	0.085	0.521**	–0.064	–0.251	0.770**	0.518**
TBM		0.093	0.061	0.435*	0.185	–0.168	0.642**	0.079
CGR			0.358	0.123	–0.058	0.377	–0.058	–0.125
LAI				0.290	–0.490*	–0.024	–0.149	–0.324
NAR					–0.502*	–0.168	0.616**	0.273
LAD						0.490*	0.016	–0.496*
SLA							–0.092	0.357
BR								0.585**
Rabi								
YIELD	0.810**	0.438*	0.223	0.158	0.150	0.187	0.628**	0.669**
TBM		0.669**	0.221	–0.112	0.534**	0.470*	0.642**	0.460*
CGR			–0.100	–0.157	0.249	0.467*	0.298	0.184
LAI				–0.543**	0.702**	0.230	–0.092	0.637**
NAR					–0.636	–0.748**	0.033	–0.058
LAD						0.676**	–0.320	0.253
SLA							0.236	0.358
BR								0.383

*P=0.05; ** P=0.01and 1% probability levels, respectively.

TBM, Total biomass; CGR, crop growth rate; LAI, leaf area index; NAR, net assimilation ratio; LAD, leaf area duration; SLA, specific leaf area; BR, bulking rate; PC, partitioning coefficient in all the tested sweetpotato genotypes. But its distribution in useful plant parts differed in *kharif* and *rabi* (Table 2) as this was reflected in lowered HI and PC values in *kharif* among the genotypes ranging from 35.3 to 51.8% and 53.2 to 69.2% respectively. Among the growth characteristics, the bulking rate and partitioning coefficient, especially during the second half of the life-cycle showed considerably high degree of association with storage root yield. Further, these associations were stronger in *rabi* than in *kharif* (Table 4). The higher yields obtained (in most of the genotypes studied) in *rabi* was due to early tuberization. Analyzing the causes of yielding short duration sweetpotato varieties, Nedunchezhiyan *et al.* (2003) also made similar observations.

Among the different yield components, only tuber length and tuber weight was found to influence the yield most. The study revealed that extended vine length as observed in *kharif* has a negative impact on yields and a genotype with moderate vine length (90–100 cm) was found to have greater impact on increasing the yields. One of the important characters noticed in all the genotypes was that they had early tuberization and higher bulking rates during early growth phase which was the principal reason for obtaining higher yields in *rabi*. In the present study the genotype CIP SWA 3 (a white-fleshed type) performed well in both seasons in terms of tuber yield and other growth characteristics. Although statistically inferior to 'CIP SWA 3' in yield and growth characteristics the genotypes 'IB 97-2/5' and 'IB 97-6/15' were either at par or superior over the local check. Therefore, the studies indicated the possibility of usefulness in popularizing the orange-freshed sweet potato genotypes possessing higher yields for improving the socio-economic conditions of the farming community and alleviating vitamin A deficiency.

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