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Influence of different germplasm on physiological and biochemical characters in sweet potato (*Ipomoea batatas*)

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Abstract
Present investigation entiteled 'Influence of Different Germplasm on Physiological and Biochemical Characters in Sweet Potato (*Ipomoea batatas*)' was carried out in the Department of Horticulture, Rajasthan College of Agriculture, Udaipur to evaluate the physiological and biochemical variation in sweet potato (*Ipomoea batatas* L.) germplasm". In this research, sixteen diversified sweet potato germplasm were evaluated under randomized block design with three replications. The result reveled that maximum protein (7.24%) in 'CO-3-4', starch (22.80%) in 'Sree Nandini' However, Overall with respect to physiological character i.e leaf area index (3.30), photosynthesis rate (1.01 µmol $m^{-2}s^{-1}$) and respiration rate (4.70 µmol $m^{-2}s^{-1}$) at 90 DAP and tuber yield (40.73 t ha^{-1}) attributing characters 'CO-3-4' found to be superior over other genotypes.

Keywords: sweet potato, germplasm, attributes, physiological, biochemical

Introduction
The sweet potato, *Ipomoea batatas* (L.) is a dicotyledonous herbaceous trailing vine. It belong to the family Convolvulaceae. The plant is generally characterized by starchy, succulent and tuberous storage roots, alternating palmately lobed leaves and medium sized sympetalous flowers which grow individually and vary in colour from white to purple. Sweet potato is particularly attractive as a crop because of its adaptability to different growing conditions and low susceptibility to natural disasters like droughts. The growing market potential for the crop, as it is now recognized as a healthy food with significant antioxidant and antimicrobial properties, has also contributed to its attractiveness.

The area covered by sweet potato in India is 111.0 thousand ha with a production of 1338.0 thousand Tonne and productivity 12.1 T ha^{-1} (Anonymous, 2015). In Rajasthan it is grown on 790 ha with a production of 2240 Tonnes and Nagaur, Jhalawar, Bundi and Sikar are major growing districts (Anonymous, 2015) [1].

Biochemical composition of sweet potato tubers varies widely according to cultivar, climatic condition, degree of maturity and the duration of storage after harvesting. The usual range of values for the edible portion is: energy 490 KJ 100 g^{-1}, water 65-81per cent, protein 0.95 per cent, fat 0.4-6.4 per cent, carbohydrate 25-32 per cent, fiber 0.9 per cent, ash 0.9-1.4 per cent, calcium 30-34 mg 100 g^{-1}, iron 0.8-1 mg 100 g^{-1}, phosphorous 49 mg 100 g^{-1}, potassium 373 mg 100g^{-1}, sodium 13 mg 100 g^{-1}, carotene 12 mg 100 g^{-1}, thiamine 0.1 mg 100 g^{-1}, riboflavin 0.05-0.06 mg 100 g^{-1}, niacin 0.6-0.9 mg 100 g^{-1} and ascorbic acid 23-25 mg 100 g^{-1} (Palaniswami and Peter, 2008) [14].

Physiological and biochemical factors determine the storage quality of any crop. As the tuber forms major proportion of total dry weight of plant, productivity is largely governed by the process of tuberisation and photosynthetic efficiency of the leaf canopy in support of the storage root sink. Both the process are being controlled by environmental factor (Ghosh *et al.*, 1988) [8]. The existence of high degree of variability between adjacent plants is a major factor that accounts for the low production yield in sweet potato (Haynes, 1970) [9].

Starch and carotenoids are major component in the storage root of the sweet potato. In the cultivar Red Jewel, starch accounts for 27 per cent of the storage root dry weight (Chang, 1979) [4]. Interest in carotenoids has increased due to their possible health benefits as carotenoids are often associated with health preventive effort and reduced risk of aged related macular degeneration, anticancerogenic activity, antioxidant capacity, antiulcer activity and also reduced risk of cardio vascular disorders (Montilla *et al.*, 2011) [10].

Flesh of sweet potato can be white, yellow, orange or purple (Woolfe, 1992) [17]. Orange,

white and creamy flesh sweet potato is most commonly grown and eaten. In orange and yellow fleshed sweet potato colour is due to the presence of carotenoids of which β-carotene is most abundant.

A lot of variability exist in sweet potato for physiological and biochemical characters which can be utilized for improving tuber yield coupled with high nutritive value. The Potentials of improved germplasm cannot be utilized unless they are evaluated to identify genotypes with desirable attributes in the study area. Keeping all these facts in view the present investigation was conducted to evaluate selected improved genotypes for adaptation, higher root yield potential, antioxidant and carotenoids.

Material and Methods

Materials and Agronomic practices

The experiment was laid out at the AICRP Tuber Crops field, Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during October 2011 to January 2012. The experimental material comprises with sixteen diversified sweet potato germplasm and evaluated under randomized block design with three replications. Photosynthesis rate, respiration rate, and LAI were recorded at 60 and 90 days after planting (DAP) while tuber protein and starch were recorded at harvest.

Table 1: Detail of Germplasm and their source

S. No	Name	Source
1	CIPSWA-2	World Potato Regional Centre, New Delhi
2	CO-3-4	CTCRI, Thiruvananthapuram
3	Gauri	CTCRI Regional Centre, Bhubaneshwar
4	Gautam	CTCRI Regional Centre, Bhubaneshwar
5	H-109-2	Navsari Agricultural University, Navsari
6	Navsari Local	Navsari Agricultural University, Navsari
7	Pol-19-8-10	CARI, Port Blair
8	Samrat	CTCRI, Thiruvananthapuram
9	SI-1	Navsari Agricultural University, Navsari
10	Sree Arun	CTCRI, Thiruvananthapuram
11	Sree Nandini	CTCRI, Thiruvananthapuram
12	Sree Ratna	CTCRI, Thiruvananthapuram
13	Sree Vardhini	CTCRI, Thiruvananthapuram
14	ST-10	CTCRI, Thiruvananthapuram
15	ST-14	CTCRI, Thiruvananthapuram
16	SV-71	BCKV, Kalyani

Crop was raised as per standard practices according to the package of practices for the region. The primary nursery was raised at the field of AICRP on Tuber Crops in the month of July-August. Cuttings taken from primary nursery and secondary nursery were also raised. Cuttings were taken from secondary nursery for experiment purpose. Five hundered kg FYM was applied at the time of preparation of the nursery. The vines were planted at a spacing of 30 cm on ridges formed 60 cm apart. Only the middle of vine with nodes was buried to 5-10 cm depth keeping both ends exposed. The crop was fertilized with FYM @ 10 tons ha^{-1} as basal dose, nitrogen, phosphorus and potassium as per recommended dose which is 100:50:50 kg NPK ha^{-1}, respectively. Half dose of nitrogen and full dose of phosphorus and potassium were applied at the time of planting while remaining half dose of nitrogen was applied one month after planting along with first weeding and earthing up. To maintain sufficient moisture for proper establishment of the crop, a light irrigation after transplanting was applied. Sweet potato is tolerant to drought but continuous long phase of drought reduces the tuber yield. So irrigation was given 15-20 days interval. After proper establishment, sweet potato starts growing vigorously. Therefore vines were lifted at nodes 30 days after planting to prevent rooting and to facilitate better tuber development at the basal end. First hoeing and weeding was done after 30 days of transplanting and second after 40 days of first weeding to keep plots weed free. In order to protect the vines against incidence of sweet potato weevil (*Cylas formicarius*) which cause serious damage to tubers, sprays with Feninthrion (0.05%) at monthly intervals was done. The crop was harvested manually 120 days after planting. Proper care was taken to minimize the losses during harvesting. Light irrigation 2-3 days before harvesting of tubers was given for easier digging.

LAI

LAI is the ratio of the leaf area to the ground area. It was measured between 10 AM to 12 Noon by Canopy Analyzers (LP 80, ATEXCE, BW Technology, UK) under natural conditions.

Photosynthesis rate (µ mol $m^{-2}s^{-1}$)

Photosynthesis rate was measured between 10 AM to 12 Noon by Portable Photosynthesis System (CIRAS-2, Version 2.01, PP System Limited, UK) under natural radiation.

Respiration rate (µ mol $m^{-2}s^{-1}$)

Respiration rate was measured between 10 AM to 12 Noon by IRGA (CIRAS-2, Version 2.01, PP System Limited, UK) under natural radiation.

Protein in tuber (% fresh weight)

In tubers protein was measured by the method of Snell and Snell (1949) [15]. Fresh tubers were washed with 0.2 per cent lab detergent, 0.1N HCl and distilled water subsequently after that spread them on paper to wash off excess water. They were dried in oven at 60ºC for 24 hours and were grinded. 0.1 g well ground and dried sample were taken with 2 ml concentrated H_2SO_4 in 100 ml Kjeldal flask and place on digestion assembly till it was digested. After cooling of flask add 0.5 ml of 30 per cent H_2O_2, again heating till become colorless. Then digested solution was transferred into 100 ml volumetric flask and made volume. Five ml of digested solution was taken into 50 ml volumetric flask and added few ml water, 2 ml 10 per cent NaOH, 1ml 10 per cent sodium silicate solution, 1.6 ml Nessler reagent and made its volume. Reading of sample using spectrophotometer at a wavelength of 420 nm was taken and calculated nitrogen with the help of standard curve (Snell and Snell, 1949) [15] and multiplied with 6.25 for estimating the protein value.

Starch (% dry weight)

Two gram tuber in flask was mixed with 20 ml of 80 per cent ethanol and left overnight. Next day sample was filtered by filter paper Whatman No. 40. Filtrate was collected for starch estimation. Residue on filter paper was washed with 2 lot of distill water (10 ml each) and mixed with filtrate. Residue was transferred back into Conical flask using 20 ml 2N HCl. Starch in residue was hydrolyzed by leaving the flask on hot plate at 100ºC for 30 min. Hydrolysates were cooled to room temperature and make the volume up to 100 ml. Supernatant was directly used for titration for starch. In a 100 ml Erlenmeyer flasks, 10 ml Potassium Ferricyanide and 5.0 ml NaOH (2.5 N) was added and kept over flame for boiling. When the reagent begins to boil, add 3 drops of dilute

methylene blue. The starch hydrolysates in 2 ml blow pippet were added drop by drop to the boiling reagent. The end point was indicated by change of colour from blue green to violet (Moorthy and Padmaja, 2002) [11].Each lot of potassium ferricyanide was calibrated using standard glucose solution and the relation was as follows:

$$Starch\ \ (g\ 100\ g^{-1}\ fresh\ \ weight\ ) = \frac{10^{a} \times 100^{b} \times 0.9^{c} \times 100}{T \times 2^{d} \times 1000}$$

10 mg of glucose = 10 ml of potassium ferricyanide was to be estimated

a = Titre obtained for ferricyanide reagent, while calibrating standard glucose solution
b = Total volume of starch hydrolysates
c = 0.9, morric factor, for converting sugar to starch
d = weight of tuber sample (g) used for analysis
T = Titre value for starch hydrolysates

$$Starch\ \ (g\ 100\ g^{-1}\ DM\ ) = \frac{Starch\ \ content\ \ (g\ 100\ g^{-1}\ fresh\ \ weight\ ) \times 100}{DM\ \ (\%)}$$

$$Dry\ \ matter\ \ (\%) = \frac{Dry\ \ weight\ \ of\ \ tuber\ \times 100}{Fresh\ \ weight\ \ of\ \ tuber}$$

Results and Discussion

Leaf area index, photosynthesis rate and respiration rate

The result indicates that leaf area index, photosynthesis rate and respiration rate showed significant differences at 60 and 90 DAP in 16 sweet potato genotype (table 1). Maximum leaf area index (3.30), photosynthesis rate (1.01 µmol $m^{-2}s^{-1}$) and respiration rate (4.70 µmol $m^{-2}s^{-1}$) were recorded in 'CO-3-4' at 90 DAP. In most of the germplasm LAI, photosynthesis and respiration rate decreased from 60 to 90 DAP. This may be due to lower rate of stomatal conductance caused by the low leaf water potential, and presumably due to photo-inhibition caused by too long an exposure to high irradiance (Ogren, 1988 and Bunce, 1990) [13, 3], feed back inhibition caused by photosynthesis exceeding starch, and sucrose synthesis (Dowton *et al*., 1988) [6], or prolonged exposure to low humidity (El-Sharkawy and Cock, 1984) [7]. In sweet potato, the optimum LAI for 95 per cent of photosynthetic active radiation interception was estimated to vary between 3 to 4 (Brown, 1992) [2]. This indicates that under adequate soil moisture conditions, leaf area is not a limiting factor for light interception and storage root yield. Throughout the growth period, sweet potato leaves show the largest proportion (50%) of total respiration (Tsuno and Fujise, 1964) [16]. Hence, Loss of assimilated carbon through dark respiration will be greater when more leaves are produced than the optimum. Secondly, excess leaf production means more dry matter allocation to shoot growth than to storage root growth. Thus, in the present study, most of the germplasm has different source size and roots source activity (photosynthetic rates), the difference in their storage root yield is also attributed to the difference in their sink capacity also (storage root number and size), which in turn influenced their transportation potential and storage root yield. Thus, growing sweet potato germpalsm with high sink capacity in high humid environments may be of advantageous for maximizing productivity.

Protein (%) and starch (%)

It is evident from the data (Table 2) that protein content in tubers varied from 2.88 to 7.24 per cent. The highest protein per cent was recorded in 'CO-3-4' (7.24%) followed by 'Sree Arun' (6.84 %) and 'CIPSWA-2' (6.39%). Starch content in tubers varied from 7.50 to 22.50 per cent. The maximum Starch per cent was recorded in 'Sree Nandini' (22.50%).Observed differences may be due to genetic differences among germplasm These findings are in close agreement with the results Nyiawung *et al*. (2010). Similar results were also reported for Xushu18, Sushu2 and Sushu8 varieties by Chan *et al.*, (2006) [5].

Table 4.1: Leaf Area Index, photosynthesis rate (µ mol m^{-2} s^{-1}) and respiration rate (ml CO_2 m^{-2} s^{-1}) in sweet potato at 60 and 90 DAP

Genotype	LAI		Photosynthesis (µ mol m-2 s-1)		Respiration (ml CO_2 m-2 s-1)	
	60 DAP	90 DAP	60 DAP	90 DAP	60 DAP	90 DAP
CIPSWA-2	3.23	2.27	1.01	0.66	3.00	3.90
CO-3-4	4.32	3.70	1.16	1.01	3.70	4.70
Gauri	3.71	2.91	0.94	0.91	2.90	3.50
Gautam	3.43	3.07	0.92	0.76	2.80	3.40
H-109-2	3.32	2.53	1.05	0.87	2.87	3.30
Navsari Local	2.17	2.99	0.81	0.78	2.70	3.20
POL-19-8-10	3.37	3.16	0.89	0.84	2.80	3.90
Samrat	3.38	3.40	0.88	0.72	3.40	4.10
SI-1	3.38	2.94	0.87	0.85	3.40	4.20
Sree Arun	2.84	2.85	1.12	0.90	3.10	3.80
Sree Nandini	3.50	2.40	1.10	0.89	3.50	4.10
Sree Ratna	3.45	3.30	0.94	0.90	3.30	4.40
Sree Vardhini	3.30	3.20	0.92	0.87	2.90	3.80
ST-10	3.54	1.91	0.96	0.84	3.50	4.20
ST-14	3.68	3.29	0.99	0.84	3.40	3.90
SV-71	4.26	2.62	1.01	1.00	2.80	3.60
Mean	3.43	2.91	0.97	0.85	3.13	3.88
Range	2.17-4.32	1.91-3.70	0.81-1.16	0.66-1.01	2.70-3.70	3.20-4.70
SEm ±	0.13	0.11	0.03	0.03	0.12	0.14
CD (P=0.05)	0.37	0.32	0.10	0.09	0.34	0.42
CV (%)	6.42	6.67	6.37	6.26	6.45	6.45

Table 4.2: Protein (%) and starch (%) in sweet potato tubers

Genotype	Protein (%)	Starch (%)
CIPSWA-2	6.39	15.41
CO-3-4	7.24	10.71
Gauri	3.36	11.25
Gautam	3.31	16.30
H-109-2	5.67	11.84
Navsari Local	3.70	11.30
POL-19-8-10	3.97	16.66
Samrat	5.36	22.50
SI-1	3.42	13.23
Sree Arun	5.41	16.75
Sree Nandini	3.68	22.48
Sree Ratna	6.84	7.50
Sree Vardhini	3.61	12.45
ST-10	2.88	9.18
ST-14	3.78	11.53
SV-71	3.88	10.00
Mean	4.53	13.69
Range	2.88-7.24	7.50-22.50
SEm±	0.17	0.53
CD (0.05)	0.49	1.53
CV (%)	6.53	6.7

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