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Short communication

Genetic variation for morphological and fruit characteristics among sweet orange accessions

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ABSTRACT

Genetic variation in 27 sweet orange accessions was undertaken at Citrus Research Station (AICRP on Tropical Fruits), Tirupati with three replications of one tree in each accession. The observations on 32 quantitative morphological characters with respect to plant, fruit and quality characters were done following IPGRI descriptors. High GCV and PCV were recorded for seed weight (GCV = 67.24%; PCV = 74.79%) and average number of seeds per fruit (GCV = 33.83%; PCV = 34.16%). Moderate PCV and GCV values were reported for rind thickness (GCV = 19.61%; PCV = 20.39%), width of epicarp (GCV = 17.95%; PCV=20.38%), diameter of fruit axis (GCV= 15.02%; PCV = 15.61%) and fruit weight (GCV = 12.64%; PCV = 13.40%) among fruit characters. The high heritability associated with high genetic advance was observed in petiole length, leaf lamina width, anther length, pedicel length, stamen length, petal length, diameter of fruit axis, rind thickness, fruit weight, width of epicarp, average number of seeds per fruit, seed width, seed weight, ascorbic acid content, titrable acidity, total sugars, reducing sugars and ratio of soluble solids to titrable acids indicating the scope for improving these traits through selection.

Key words: Genetic diversity, fruit characteristics, sweet orange, vegetative traits.

Sweet orange (*Citrus sinensis* (L) Osbeck) is prime representative and recognizable species of citrus group. The sweet orange, is the main evergreen fruit-crop species, responsible for 75% of citrus production used both as fresh fruit and processed juice (Spiegel-Roy and Goldschmidt, 6). It is performing well in different agro-climatic regions of India, particularly, in Maharashtra, Andhra Pradesh, Punjab, Rajasthan and Tamil Nadu. Since germplasm is a vital resource and if properly described, characterized and evaluated once, can be utilized for long term methodical crop improvement. The estimates of heritability coupled with genetic advance as percent of mean with moderate PCV and GCV are important factors behind the entire success due to selection in this crop. The heritability in combination with intensity of selection and amount of variability present in population, influence the gains to be obtained from selection. However, information on the performance of the sweet orange cultivars and extent of genetic variation for different morphological characters in different agro-climatic situations is lacking. Hence, the present study was conducted.

The present investigation was conducted on 27 sweet orange accessions at Citrus Research Station (AICRP on Tropical Fruits), Tirupati with three replications using individual tree plants in each accession. The observations on 32 quantitative morphological characters with respect to plant, fruit and quality characters were done following IPGRI descriptors. The collected data were subjected to statistical analysis adopting standard procedures with computer based INDOSTAT package.

The analysis of variance for 32 quantitative morphological characters except number of petals per flower, revealed highly significant difference among the accessions (Table 1 & 2). High GCV and PCV were recorded for seed weight (GCV = 67.24%; PCV = 74.79%) and average number of seeds per fruit (GCV = 33.83%; PCV = 34.16%) among seed characters and anther length (GCV = 28.74%; PCV = 29.63%) and pedicel length (GCV = 20.12%; PCV = 21.95%) among flower characters. These variations in these characters may be attributed to their geographical origin of the accessions and relatively offers wide scope for selection among these characters. Moderate PCV and GCV values were reported for the characters petiole length (GCV = 12.74%; PCV = 13.43%), leaf lamina width (GCV = 11.84%; PCV = 12.59%) and leaf lamina length (GCV = 10.01%; PCV = 10.56%) among leaf characters while for stamen length (GCV = 14.40%; PCV = 15.47%) and petal length (GCV = 11.65%; PCV = 12.21%) among flower characters, rind thickness (GCV = 19.61%; PCV = 20.39%), width of epicarp (GCV = 17.95%; PCV =20.38%), diameter of fruit axis (GCV = 15.02%; PCV = 15.61%) and fruit weight (GCV = 12.64%; PCV = 13.40%)

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Table 1. Analysis of variance for 32 quantitative morphological characters in sweet orange accessions.

S. No.	Character	Mean sum of squares		
		Replication (df = 2)	Treatment (df = 26)	Error (df = 52)
1.	Leaf lamina length (mm)	107.37	217.22*	22.04
2.	Leaf lamina width (mm)	17.40	111.07*	12.91
3.	leaf lamina length/ width	0.08	0.04*	0.00
4.	Leaf thickness (mm)	-	-	-
5.	Petiole length (mm)	2.98	11.59*	1.16
6.	Pedicel length (mm)	0.12	4.20*	0.67
7.	Petal length (mm)	4.30	11.24*	1.01
8.	Petal width (mm)	1.12	0.98*	0.31
9.	No. of petals/flower	0.21	0.14	0.10
10.	No. of stamens/flower	2.94	5.91*	2.43
11.	Calyx diameter (mm)	0.15	0.79*	0.41
12.	Stamen length (mm)	1.00	5.83*	0.77
13.	Anther length (mm)	0.00	0.18*	0.01
14.	Fruit wt. (g)	98.39	1501.22*	165.38
15.	Fruit dia. (mm)	0.85	52.20*	10.66
16.	Fruit length (mm)	12.31	36.09*	10.69
17.	Rind thickness (mm)	0.06	1.57*	0.11
18.	Epicarp width (mm)	0.19	0.28*	0.07
19.	No. of segments/fruit	0.11	0.64*	0.02
20.	Diameter of fruit axis (mm)	1.04	6.03*	0.45
21.	Juice content (%)	3.94	63.25*	11.22
22.	Av. No. of seeds/fruit	6.42	105.86*	2.07
23.	Seed weight (g)	0.00	0.04*	0.00
24.	Seed length (mm)	0.02	4.44*	0.38
25.	Seed width (mm)	0.20	1.87*	0.16
26.	Titrable acidity (%)	0.08	0.06*	0.00
27.	pH	0.00	0.19*	0.07
28.	TSS (°Brix)	0.32	1.31*	0.11
29.	Ratio of soluble solids: titrable acids	21.79	15.31*	2.58
30.	Total sugars (%)	0.28	2.17*	0.32
31.	Reducing sugars (%)	0.08	0.55*	0.09
32.	Ascorbic acid (mg/100 g FW)	3.66	120.66*	15.67

*Significant at 5% level; - = Negligible values

among fruit characters, seed width (GCV = 11.86%; PCV = 12.42%) among seed characters and ratio of soluble solids to titrable acids (GCV = 17.15%; PCV = 18.82%), titrable acidity (GCV = 16.94%; PCV = 18.29%), total sugars (GCV = 15.09%; PCV = 16.34%), reducing sugars (GCV = 14.00%; PCV = 15.34%) and ascorbic acid GCV = 10.70%; PCV = 11.47%) among physico-chemical characters. These traits having considerable genetic variability, offer good opportunity for crop improvement through selection. These results are also in consonance with that of Roy *et al.* (5) and Mitra *et al.* (1) in pummelo, Rabha *et al.* (3) in citrus genotypes and Ranpise and Desai (4) in acid lime.

Table 2. Variability and genetic parameters for leaf, flower, fruit, seed and physico-chemical characters based on 27 sweet orange accessions.

Character	Mean	S.Em±	Range	Phenotypic variance	Genotypic variance	Phenotypic covariance	Genotypic covariance	Heritability (broad sense) in percentage	Genetic advance	Genetic advance as per cent of mean
Leaf characters										
Leaf lamina length (mm)	80.56	2.71	63.31 - 102.76	72.40	65.05	10.56	10.01	89.8	15.75	19.55
Leaf lamina width (mm)	48.30	2.07	35.28 - 59.24	37.02	32.72	12.59	11.84	88.3	11.08	22.94
Ratio of leaf lamina length/width	1.68	0.06	1.45 - 1.87	0.01	0.01	6.92	6.05	76.2	0.18	10.89
Leaf thickness (mm)	0.29	0.01	0.24 - 0.36	0.00	0.00	10.47	9.44	81.3	0.05	17.55
Petiole length (mm)	14.63	0.62	0.99 - 18.12	3.86	3.47	13.43	12.74	89.9	3.64	24.91
Flower characters										
Pedicel length (mm)	5.39	0.47	3.03 - 7.51	1.40	1.17	21.95	20.12	83.9	2.05	37.99
Petal length (mm)	15.85	0.58	10.50 - 18.70	3.74	3.40	12.21	11.65	90.9	3.63	22.89
Petal width (mm)	6.42	0.32	4.80 - 7.34	0.32	0.22	8.93	7.37	68.1	0.80	12.54
No. of petals/flower	5.08	0.19	4.63 - 5.47	0.04	0.01	4.30	2.25	27.4	0.12	2.44
No. of stamens/ flower	24.23	0.90	21.40 - 26.97	1.97	1.15	5.79	4.44	58.7	1.70	7.01
Calyx dia. (mm)	6.06	0.37	5.08 - 7.21	0.26	0.12	8.48	5.87	47.9	0.51	8.37
Stamen length (mm)	9.02	0.51	5.93 - 11.08	1.94	1.68	15.47	14.40	86.7	2.49	27.63
Anther length (mm)	0.84	0.06	0.55 - 1.44	0.06	0.05	29.63	28.74	94.0	0.48	57.45
Fruit characters										
Fruit weight (g)	166.86	7.42	120.09 - 202.43	500.40	445.28	13.40	12.64	88.9	41.01	24.57
Fruit diameter (mm)	68.79	1.89	58.18 - 76.08	17.40	13.84	6.06	5.40	79.5	6.83	9.94
Fruit length (mm)	65.65	1.89	59.23 - 73.03	12.03	8.46	5.28	4.43	70.3	5.03	7.66
Rind thickness (mm)	3.55	0.20	2.28 - 4.69	0.52	0.48	20.39	19.61	92.4	1.38	38.86
Width of epicarp (mm)	1.50	0.15	0.93 - 2.17	0.09	0.07	20.38	17.95	75.3	0.48	32.12
No. of segments/ fruit	10.50	0.09	9.63 - 1.70	0.21	0.20	4.40	4.31	95.8	0.91	8.71
Diameter of fruit axis (mm)	9.08	0.39	6.24 - 2.75	2.01	1.86	15.61	15.02	92.5	2.70	29.76
Juice content (%)	41.67	1.93	31.02 - 50.76	21.08	17.34	11.01	9.99	82.2	7.78	18.67
Seed characters										
Av. No. of seeds/ fruit	17.39	0.83	3.80 - 6.20	35.28	34.59	34.16	33.83	98.0	12.00	69.01
Seed wt. (g)	0.16	0.05	0.04 - 0.64	0.01	0.01	74.79	67.24	80.8	0.20	124.55

Contd...

Table 2 Contd...

Character	Mean	S.Em±	Range	Phenotypic variance	Genotypic variance	Phenotypic covariance	Genotypic covariance	Heritability (broad sense) in percentage	Genetic advance	Genetic advance as per cent of mean
Seed length (mm)	12.20	0.36	8.45 - 15.03	1.48	1.35	9.97	9.54	91.4	2.29	18.79
Seed width (mm)	6.36	0.23	4.02 - 7.54	0.62	0.56	12.42	11.86	91.2	1.49	23.35
Physico-chemical characters										
Titrable acidity (%)	0.81	0.06	0.56 - 1.14	0.02	0.01	18.29	16.94	85.7	0.26	32.32
pH	3.76	0.15	3.26 - 4.26	0.06	0.04	6.72	5.33	63.0	0.33	8.73
TSS (^{0}Brix)	9.33	0.19	8.23 - 10.88	0.43	0.40	7.09	6.79	91.5	1.25	13.38
Ratio of soluble solids to titrable acids	12.00	0.93	9.18 - 17.55	5.10	4.24	18.82	17.15	83.1	3.87	32.22
Total sugars (%)	5.21	0.33	3.91 - 7.24	0.72	0.61	16.34	15.09	85.2	1.49	28.71
Reducing sugars (%)	2.81	0.18	2.10 - 3.69	0.18	0.15	15.34	14.00	83.3	0.74	26.35
Ascorbic acid (mg/100 g FW)	55.26	2.29	36.25 - 68.88	40.22	34.99	11.47	10.70	87.0	11.37	20.57

High estimate of heritability (> 70%) was recorded for different traits in sweet orange, *viz.*, petiole length, leaf lamina length, leaf lamina width, leaf thickness and ratio of leaf lamina length/ width among leaf characters, anther length, petal length, stamen length, pedicel length and petal width among flower characters, number of segments per fruit, diameter of fruit axis, rind thickness, fruit weight, fruit diameter, width of epicarp and fruit length among fruit characters, average number of seeds per fruit followed by seed length, seed width and seed weight among seed characters and TSS, ascorbic acid, titrable acidity, total sugars, reducing sugars, ratio of soluble solids to titrable acids, juice content and pH among physico-chemical characters, which indicated the least influence of environment on these traits. On contrary, moderate heritability was observed for number of stamens per flower and calyx diameter and low heritability for number of petals per flower indicating relatively more influence of environment on these traits.

The high value of genetic advance (>20%) as percent of mean was recorded for petiole length (24.91%), leaf lamina width (22.94) among leaf characters, for anther length (57.45%), pedicel length (37.99%), stamen length (27.63%) and petal length (22.89%) among flower characters, for rind thickness (38.86%), width of epicarp (32.12%), diameter of fruit axis (29.76%) and fruit weight (24.57%) among fruit characters, for seed weight (124.55%), average number of seeds per fruit (69.01%), and seed width (23.35%) among seed characters, for titrable acidity (32.32%), ratio of soluble solids to titrable acids (32.22%), total sugars (28.71%), reducing sugars (26.35%), and ascorbic acid (20.57%) among physico-chemical characters indicating that the influence of additive gene effects in their genetic control. Moderate estimate of genetic advance was recorded for leaf lamina length (19.55%), leaf thickness (17.55%) and ratio of leaf lamina length/ width (10.89%) among leaf characters, for petal width (12.54%) among flower characters, for juice content (18.67%) among fruit characters, for seed length (18.79%) among seed characters and for TSS (13.38%) among physico-chemical characters which indicated the genetic control of both additive and non-additive gene effects. On contrary, low value of genetic advance was recorded for calyx diameter (8.37%), number of stamens per flower (7.01%) and number of petals per flower (2.44%) among flower characters, for fruit diameter (9.94%), number of segments per fruit (8.71%) and fruit length (7.66%) among fruit characters, for pH (8.73%) among physico-chemical characters indicating the operation of non-additive gene effects in their genetic

control. Similar associations between traits studied have also been reported in citrus genotypes by Rabha *et al.* (3), in pummelo by Mitra *et al.* (1) and in guava by Mrinalini and Tiwari (2). High heritability coupled with high genetic advance as percent of mean was recorded for petiole length and leaf lamina width among leaf characters, anther length, pedicel length, stamen length and petal length among flower characters, diameter of fruit axis, rind thickness, fruit weight and width of epicarp among fruit characters, average number of seeds per fruit, seed width and seed weight among seed characters and ascorbic acid content, titrable acidity, total sugars, reducing sugars and ratio of soluble solids to titrable acids among physico-chemical characters indicated that selection in sweet orange for these traits may be effective due to the genetic control of additive gene effects in them. The results confirm the findings of Rabha *et al.* (3) in citrus genotypes, Mitra *et al.* (1) in pummelo and Ranpise and Desai (4) in acid lime. The remaining characters had moderately low heritability coupled with low genetic advance in the present study indicating the limited scope of selection for these traits as the gene effects were found to be non-additive in nature. The present study showed high genetic diversity in sweet orange accessions for different plant, leaf, flower, fruit, seed and physico-chemical traits. The high heritability associated with high genetic advance was observed in petiole length, leaf lamina width, anther length, pedicel length, stamen length, petal length, diameter of fruit axis, rind thickness, fruit weight, width of epicarp, average number of seeds per fruit, seed width, seed weight, ascorbic acid content, titrable acidity, total sugars, reducing sugars and ratio of soluble solids to titrable acids indicating the scope for improving these traits through selection.

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