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A Case Study

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Survey for superior types of sweet orange (*Citrus sinensis* Osbeck) in Nanded and Parbhani district of Marathwada region

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ABSTRACT : A survey was undertaken during October-2012 to November-2012 during fruiting of *Ambia Bahar* in Nanded and Parbhani district of Marathwada region of Maharashtra state and 29 samples were collected from different locations. In present study, the performance of types PBN-2, PBN-3, PBN-6 and NAD-2 showed superiority in regards too many characters like number of fruits per tree, length and breadth of fruit, weight of fruit, TSS, total sugar and yield of fruits per tree. Hence, the overall studies indicated that the type PBN-2, PBN-3, PBN-6 and NAD-2 being productive and superior in quality stands for selection and further improvement.

KEY WORDS : Sweet orange, Physico-chemical characters, Correlation, Path analysis

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Sweet orange is a most popular citrus fruit both in tropics and sub-tropics. In Maharashtra state and Marathwada region of the state innumerable seedling of sweet orange are in cultivation. The variation existing in these seedlings has not been exploited for improvement. Attempts to improve sweet orange by selection have been very meagre. Therefore, there are very few released varieties are available for commercial cultivation. Similarly, information about extent of variability, correlation and physico-chemical characters of fruit and yield of different types is needed to plan improvement programme. The present survey and selection work was undertaken with this sole objective.

RESEARCH METHODS

The Nanded and Parbhani district of Marathwada region were selected for survey for superior types of sweet orange. The survey was undertaken during October-2012 to November-2012 during regular fruiting of *Ambia Bahar*. The selected sweet orange locations were visited to collect required information and samples. The promising type from each location was observed carefully for fruiting along with other desirable characters. The yield of selected tree was recorded in terms of number of fruits per tree and weight of fruits in kg. From selected tree of each orchard, 5 fruits of uniform size and maturity were collected randomly from all the sides of the tree. The fruit sample were packed in polythene bag separately for each genotype and brought to laboratory for further study. Physico-chemical analysis of fruit samples were carried out in laboratory, Department of Horticulture, College of Agriculture, M.K.V., Parbhani (M.S.) as per the scientific standard and methods. The data obtained on physico-chemical characters of fruit and other aspects of sweet orange were analyzed statistically for the variability, correlation co-efficient and path co-efficient.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Variability studies:

Selected sweet orange types showed a wide range of variation for physico-chemical characteristics presented in Table 1.

Table 1 : Physico-chemical characteristics of different sweet orange types

Sr. No.	Sample	Fruits per tree	Weight of fruit (g)	Yield per tree (kg)	Length of fruit (cm)	Breadth of fruit (cm)	Rind thickness (mm)	Rind %	No. of seeds per fruit	No. of segments	Juice %	TSS (°Brix)	Acidity (%)	Total sugar	Reducing sugar	Non-reducing sugar
1.	NAD 1	232	234.20	54.33	8.30	7.16	6.26	21.50	14.33	10.66	41.73	8.20	0.46	5.42	3.43	1.90
2.	NAD 2	488	173.80	84.81	6.43	7.00	4.30	21.34	16.66	10.66	41.16	9.20	0.31	6.66	4.15	2.51
3.	NAD 3	478	130.33	62.29	5.43	5.60	3.70	33.18	14.67	10.00	37.75	8.86	0.38	6.10	4.00	2.09
4.	NAD 4	356	198.56	70.68	6.86	7.10	5.23	33.16	16.33	10.33	45.99	8.40	0.46	5.56	3.48	2.08
5.	NAD 5	310	197.56	61.24	6.60	6.46	4.43	34.36	18.00	11.00	33.70	8.66	0.38	6.74	4.26	2.48
6.	NAD 6	196	310.86	60.92	9.06	8.30	9.80	41.11	18.33	9.33	31.76	9.00	0.41	5.56	3.52	2.00
7.	NAD 7	218	255.90	55.78	8.00	7.40	7.90	33.35	17.33	11.66	33.12	8.36	0.40	5.54	3.49	2.05
8.	NAD 8	380	191.00	72.58	6.53	6.40	5.60	33.72	18.66	9.66	35.54	7.93	0.43	5.53	3.55	1.97
9.	NAD 9	374	206.10	77.08	7.13	6.93	5.66	30.25	15.00	10.66	35.10	9.10	0.40	5.88	3.63	2.24
10.	NAD10	420	169.10	71.02	6.00	6.00	4.20	26.59	16.66	9.66	37.70	9.53	0.38	6.34	3.96	2.38
11.	NAD11	396	173.76	68.80	6.60	6.93	4.30	31.44	18.33	10.00	41.17	8.46	0.44	5.45	3.53	1.92
12.	NAD12	448	227.63	101.97	6.83	7.20	5.46	30.64	18.00	10.00	34.85	9.36	0.34	6.05	3.35	2.70
13.	NAD13	464	147.53	68.45	6.00	6.00	4.10	30.53	14.70	10.66	42.37	10.06	0.36	7.05	4.46	2.59
14.	NAD14	386	171.20	66.08	8.00	8.00	5.10	37.27	19.00	10.00	44.91	9.33	0.43	5.68	3.77	1.90
15.	NAD15	242	189.33	45.81	7.00	6.46	4.70	24.28	18.00	10.33	42.06	10.86	0.34	7.44	4.32	3.12
16.	NAD16	278	173.40	48.20	6.16	6.30	5.06	25.15	18.00	9.33	39.04	9.13	0.39	6.38	3.54	2.84
17.	PBN 1	366	252.36	92.36	7.13	6.83	5.26	22.37	14.33	11.33	40.60	11.46	0.34	7.74	4.45	3.28
18.	PBN 2	424	257.23	109.06	7.30	7.40	4.93	23.65	19.33	12.00	48.19	10.66	0.31	7.33	4.48	2.84
19.	PBN 3	436	220.90	96.31	7.43	8.13	4.06	24.51	16.33	11.00	46.39	10.36	0.35	7.07	4.56	2.50
20.	PBN 4	376	214.53	80.66	7.56	7.60	5.06	27.49	15.00	10.00	43.89	8.73	0.48	5.69	3.54	2.13
21.	PBN 5	402	175.86	70.69	6.90	6.13	3.56	23.81	14.66	10.66	42.24	11.70	0.34	7.54	4.38	3.16
22.	PBN 6	412	226.06	93.13	7.73	7.23	4.83	22.00	18.33	11.33	48.46	10.70	0.33	7.52	4.32	3.20
23.	PBN 7	388	237.56	92.17	7.63	7.66	5.56	24.87	15.66	9.66	55.54	9.36	0.42	6.02	3.36	2.66
24.	PBN 8	442	204.16	90.23	6.93	6.86	5.90	29.10	18.33	10.00	45.15	9.63	0.39	6.53	3.74	2.79
25.	PBN 9	434	154.43	67.02	6.03	6.00	4.16	28.50	14.33	8.33	46.62	9.00	0.45	5.94	3.60	2.48
26.	PBN 10	416	178.63	74.31	6.86	6.90	4.86	25.66	14.62	9.00	43.72	8.76	0.47	5.58	3.41	2.17
27.	PBN 11	342	202.70	69.32	7.00	6.63	6.10	27.50	21.66	10.66	41.56	11.56	0.32	7.68	4.48	3.20
28.	PBN 12	364	224.86	81.84	7.00	6.83	4.53	27.66	17.66	11.66	47.74	9.10	0.47	5.57	3.51	2.06
29.	PBN 13	320	252.66	80.85	8.06	7.86	6.96	30.31	18.33	10.66	39.22	8.73	0.47	6.04	3.67	2.36
	Mean	372	205.24	74.75	7.05	6.94	5.22	28.45	16.91	10.35	41.63	9.45	0.39	6.33	3.86	2.46
	SE	14.476	7.323	2.924	0.147	0.127	0.241	0.919	0.353	0.155	1.007	0.193	0.010	0.144	0.077	0.081
	SD	77.9560	39.4376	15.7465	0.7926	0.6875	1.3002	4.9527	1.9016	0.8396	5.4239	1.0399	0.0538	0.7791	0.4200	0.4410
	Min.	196	130.33	45.81	5.43	5.60	3.56	21.34	14.33	8.33	31.76	7.93	0.31	5.42	3.35	1.90
	Max.	488	310.86	109.06	9.06	8.30	9.8	41.11	21.66	12	55.54	11.70	0.48	7.74	4.56	3.28

Physical characteristics:

The number of fruits per tree ranged from 196 (NAD-6) to 488 (NAD-2). It may be due to more height and spread. Jadhao (2012) recorded 299 to 410 range for number of fruits per tree which support present findings. The average weight of fruit was 205.24g and it ranged from 130.33g (NAD-3) to 314.06g (ABD-9). It may be due to variation in package of practices. The average yield of fruits per tree was 74.75 kg. The variability in yield of fruits per tree ranged from 45.81 kg (NAD-3) to 109.06kg (PBN-2). This difference observed due more number of fruits and variation in weight. Length of fruit ranged from 5.43 cm (NAD-3) to 9.06 cm (NAD-6). Breadth of fruit ranged from 5.60 cm (NAD-3) to 8.30 cm (NAD-6). Kale (2009) and Jadhao (2012) recorded analogous results to the present finding. Rind thickness of fruit varied from 3.56 mm in PBN-5 to 9.80 mm in NAD-6. It may be due to variability in size of fruit. NAD-2 recorded significantly minimum rind percentage (21.34), while NAD-6 recorded highest rind percentage (41.11). It may be due to variability in size of fruit and more rind thickness. In case of juice percentage, PBN-7 (55.54%) recorded highest juice percentage while the lowest juice percentage was recorded in NAD-6 (31.76%). Tilekar (2011) also reported maximum juice content 57.86% in sweet orange. The average number of seeds per fruit was found 16.91 and PBN-9 (14.33) recorded minimum numbers of seeds per fruit, while PBN-11 (21.66) recorded highest numbers of seeds per fruit. PBN-2 (12.00) recorded maximum number of segments per fruit while the lowest number of segments per fruit was recorded in PBN-9 (8.33). The variation in number of segments may be due to size of fruits. Findings of Patil (2004), Kale (2009) and Jadhao (2012) are in agreement with the observations recorded in the present investigation.

Chemical characters of fruits:

The highest TSS was obtained from the fruits of PBN-5 (11.70 ^{0}Brix) while the lowest TSS was found in NAD-8 (7.53 ^{0}Brix). The acidity of juice of selected 29 types varied between 0.31 in NAD-2 and PBN-2 to 0.48 per cent in PBN-4 with the mean value 0.40 per cent. The percentage of total sugars was highest in PBN-1 (7.74%) and lowest in NAD-1 (5.42%). The percentage of reducing sugars was highest in PBN-3 (4.56%) and lowest in NAD-12 (3.35%). The percentage of non-reducing sugars was highest in PBN-1 (3.90) and lowest in NAD-14 (1.90%). Results are similar as observed by Barkule *et al.* (2008).

Correlation studies:

Correlation co-efficient between different pairs of characters presented in Table 2. Yield of fruits per tree was highly significant and positively correlated with the number of fruits per tree and juice percentage. Kakde (1982) reported yield of fruits and number of fruits per tree were highly correlated with each other. The correlation of number of fruits

Table 2 : Correlation coefficient for different characteristics

Characters	Number of fruits per tree	Weight of fruit (g)	Yield (kg/tree)	Length of fruit (cm)	Breadth of fruit (cm)	Rind thickness (mm)	Rind percentage (%)	Number of seeds per fruit	Number of segments	Juice (%)	TSS (^{0}Brix)	Acidity (%)	Total sugar	Reducing sugar	Non-reducing sugar
Number of fruits per tree	1	-.535**	.599**	-.591**	-.286	-.687**	-.229	-.217	-.079	.373*	.181	-.247	.205	.255	.147
Weight of fruit (g)		1	.320	.826**	.733**	.763**	.055	.251	.378*	-.079	.041	.017	-.040	-.134	.027
Yield (Kg/tree)			1	.090	.355	-.142	-.320	.055	.320	.425*	.296	-.274	.258	.182	.286
Length of fruit (cm)				1	.860**	.740**	.131	.210	.249	.026	-.025	.200	-.173	-.197	-.155
Breadth of fruit (cm)					1	.574**	.965**	.260	.917**	.151	.837**	.186	.845**	-.215	.849**
Rind thickness (mm)						1	.441*	.315	-.013	-.393*	-.253	.211	-.335	-.399*	-.238
Rind percentage (%)							1	.266	.990**	-.505**	.945**	.347	.950**	-.357	.950**
Number of seeds per fruit								1	.194	-.111	.117	-.248	.141	.110	.137
Number of segments									1	.051	.977**	-.402*	.981**	.498**	.978**
Juice percentage (%)										1	.286	.074	.187	.109	.243
TSS (^{0}Brix)											1	.736**	.999**	.789**	.991**
Acidity (%)												1	-.833**	-.773**	-.736**
Total sugar													1	.907**	.995**
Reducing sugar														1	.653**
Non-reducing sugar															1

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Direct and indirect effect of different characteristics on yield of fruits

Characters	Number of fruits per tree	Weight of fruit (g)	Length of fruit (cm)	Breadth of fruit (cm)	Rind thickness (mm)	Rind percentage (%)	Number of seeds per fruit	Number of segments	Juice (%)	TSS (^{0}Brix)	Acidity (%)	Total sugar	Reducing sugar	Non-reducing sugar
Number of fruits per tree	0.9881	-0.4823	0.0433	-0.0423	0.1691	0.0092	-0.0220	-0.0056	-0.0161	-0.0056	-0.0310	0.1248	-0.1150	-0.0148
Weight of fruit (g)	-0.5290	0.9009	-0.0605	0.1085	-0.1877	-0.0022	0.0255	0.0269	0.0034	-0.0012	0.0021	-0.0245	0.0605	-0.0027
Length of fruit (cm	-0.5839	0.7442	-0.0732	0.1274	-0.1820	-0.0052	0.02137	0.0177	-0.0011	0.0007	0.0251	-0.1052	0.0885	0.0156
Breadth of fruit (cm)	-0.2824	0.6600	-0.0630	0.1481	-0.1412	-0.0061	0.0264	0.0138	-0.0065	0.0035	0.0233	-0.1413	0.0970	0.0236
Rind thickness (mm)	-0.6788	0.6870	-0.0541	0.0850	-0.2461	-0.0178	0.0320	-0.0009	0.0170	0.0079	0.0265	-0.2036	0.1797	0.0240
Rind percentage (%)	-0.2260	0.0497	-0.0096	0.0226	-0.1086	-0.0403	0.0270	-0.0184	0.0218	0.0151	0.0436	-0.3159	0.1608	0.0583
Number of seeds per fruit	-0.2140	0.2262	-0.0154	0.0385	-0.0775	-0.0107	0.1016	0.0138	0.0048	-0.0036	-0.0312	0.0855	0.0495	-0.0138
Number of segments	-0.0782	0.3407	-0.0182	0.0288	0.0031	0.0104	0.0197	0.0712	-0.0022	-0.0110	-0.0506	0.2549	-0.2241	-0.0241
Juice percentage (%)	0.3685	-0.0709	-0.0018	0.0223	0.0967	0.0203	-0.0112	0.0036	-0.0433	-0.0089	0.0092	0.1134	-0.0488	-0.0245
TSS (^{0}Brix)	0.1791	0.0370	0.0018	-0.0167	0.0623	0.0195	0.0119	0.0251	-0.0123	-0.0313	-0.0925	0.5546	-0.3553	-0.0875
Acidity (%)	-0.2442	0.0157	-0.0146	0.0274	-0.0519	-0.0140	-0.0252	-0.0286	-0.0031	0.0231	0.1257	-0.5069	0.3480	0.0745
Total sugar	0.2028	-0.0363	0.0126	-0.0344	0.0824	0.0209	0.0142	0.0298	-0.0080	-0.0286	-0.1047	0.6082	-0.4087	-0.0920
Reducing sugar	0.2523	-0.1210	0.0144	-0.0319	0.0982	0.0144	0.0111	0.0354	-0.0047	-0.0247	-0.0971	0.5519	-0.4504	-0.0660
Non-reducing sugar	0.1450	0.0242	0.0113	-0.0345	0.0584	0.0232	0.0139	0.0170	-0.0105	-0.0271	-0.0925	0.5529	-0.2940	-0.1012

Residual factor 0.0130, Bold values denote direct effect

per tree was highly significant and positive with the yield of fruits per tree and juice percentage. The correlation of weight of fruit was highly significant and positive with the length of fruit, breadth of fruit, rind thickness and number of segments. Similar association was observed by Tilekar (2011) and Khandavi (2012).

Length of fruit was highly significant and positively correlated with the breadth of fruit, weight of fruit and rind thickness. Breadth of fruit was highly significant and positively correlated with the length of fruit, weight of fruit, rind thickness, rind percentage, number of segments. Kakde (1982) reported size of fruit and weight of fruit were highly correlated with each other.

Correlation observed between rind thickness and weight of fruit, length of fruit, breadth of fruit and rind percentage was positive and significant. Rind percentage showed significant and positive correlation with the rind thickness, breadth of fruit, number of segments, TSS, total sugar and non-reducing sugar. Pingle (2011) reported similar correlations.

Juice percentage was highly significant and positively correlated with the yield of fruit per tree and number of fruits per tree. Number of segments was significant and positively correlated with the weight of fruit, breadth of fruit, rind percentage, TSS, total sugar, non-reducing sugar.

TSS, total sugar, reducing sugar and non-reducing sugar exhibited highly significant and positively correlated with each other as well as having negative but highly significant correlation with the acidity. Tilekar (2011) reported similar result and correlation about TSS, total sugar, reducing sugar, non-reducing sugar and acidity while, Pingle (2011) reported that the negative association of acidity with TSS.

Path analysis studies:

Values for direct and indirect effects of different characters on yield presented in Table 3. Path analysis indicated that number of fruits per tree showed highest positive direct effect on yield of fruits followed by weight of fruit. Breadth of fruit, number of seeds per fruit, number of segments, acidity and total sugar also showed positive direct effect on yield of fruits. Remaining other characters showed negative direct effect on yield and this have no significance in selection programme.

Conclusion:

The above results of present investigation showed relationship between various characters of fruit and yield of various sweet orange types under study. The correlation between yield and number of fruits per plant was found to be positively significant. As well as number of fruits per tree showed highest positive direct effect on yield of fruits. The study of variability also indicated that effective improvement can be made for number of fruits per tree and yield per tree by selection from existing population. Thus, these two statistical

parameters proved very useful in exercising the selection of promising sweet orange types in the present investigation. So, the overall studies indicated that the type PBN-2, PBN-3, PBN-6 and NAD-2 being productive and superior in quality stands for selection and further improvement.

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