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Identification of elite seedling progenies of mango (*Mangifera indica* L.) for the qualitative traits of the fruit and correlation studies on quality parameters under north eastern transitional zone of Karnataka

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Abstract
The evaluate correlation study was conducted to the elite seedling progenies of mango in major growing parts of Bidar district for their quality its parameters. Among the 61 seedling selections selected in the present investigation, 'YMS-05' has recorded the highest TSS (24.00 ºB) values and non-reducing sugars (14.39%). 'CMS-47' has the maximum amount of total sugar (20.9%) and reducing sugars (7.49%) while, the lowest titrable acidity (0.14%) and the highest TSS to acid ratio (160.00) were recorded in 'CMS-25'. The highest ascorbic acid content was noticed in 'CMS-01' (84.86 mg/100g pulp), The maximum carotenoid content was noticed in 'CMS-63' (6496.36 µg/100g). The TSS was positively correlated with total sugar, reducing sugar, non- reducing sugar, ascorbic acid content and TSS to acid ratio.

Keywords: Seedling progenies, TSS, total sugars, titrable acidity, carotenoid and correlation studies

Introduction
Mango (*Mangifera indica* L.) is an important member of the family Anacardiaceae, belongs to the order Sapindales and is the most important fruit crop in India having a great cultural, socio-economic and religious significance since ancient times. It is said to be originated in the Indo-Burma (Myanmar) region (De Candolle, 1904, Vavilov, 1926 and Popenoe, 1920) [6, 20]. Based on geographical distribution, polygenic trend, pollen morphology, chromosome number and breeding behavior indicated the highest concentration of species of *Mangifera* were found in Malayan peninsula followed by Sudan Islands and the Eastern peninsula comprising Burma, Thailand and Indo- China. Its long period of domestication in India is well evidenced from its mention in the ancient scripture.

Enormous genetic diversity of mango exists in India, which is the primary center of domestication. There are nearly 1000 monoembryonic and polyembryonic mango cultivars in India (Negi, 2000) [11]. Considerable genetic diversity of this fruit exists in Karnataka with several named local cultivars and unnamed local land races. This genetic variability of mango can be exploited in breeding programs to produce high quality mangoes suitable for multifarious purposes.

Identification of superior elite clones is an important activity in the management of genetic resources in mango in the context of the present scenario of rapid extinction of such useful material. Still there is an immense potential of locating superior seedlings for collection, evaluation, conservation and utilization for the future crop improvement works. Keeping the above facts in view, was taken up the present study aims to identify the superior seedling progenies of mango by the evaluation of their fruit morphology and quality parameters.

Material and Methods
The present study was carried out at Farmers field in Bidar district. The fruits were brought to the Department of Fruit Science, College of Horticulture, Bidar and were used for analysing the physicochemical characters during 2017-18.

Ten fruits were collected from each of the selected elite trees from the farmer's field in villages of Bidar. Forty eight trees from Chitta, six trees from Gonahalli, three trees from Mudbi and five trees from Yadlapura were selected. The fruits were labeled after they were plucked from the tree.

TSS (º Brix)

The percentage of total soluble solids was determined by using ERMA hand refractometer by placing a drop of filtered juice on the prism of the refractometer and observed the coincidence of shadow of the sample with the reading on the scale and expressed as º Brix. Before taking the reading, the refractometer was tested for its error with distilled water, corrected accordingly and TSS content was recorded.

Titrable acidity (mg/100g)

Ten ml of homogenized sample was taken and made up to 100 ml volume with distilled water in a volumetric flask. The contents were filtered through Whatman No.1 filter paper. An aliquot of 10 ml was taken in 250 ml conical flask for titration against 0.1N NaOH by using phenolphthalein as an indicator. The turn of the aliquot to light pink colour which persists for 15 seconds was considered as an endpoint and the titratable acidity was estimated in terms of per cent citric acid.

Table 1: Tree details of mango seedling selections

Sl. No.	Tree	Place	Farmer's name	Age of a tree (years)
1	CMS - 01	Chitta	Mohammed Jaffer	10
2	CMS - 05	Chitta	Mohammed Jaffer	10
3	CMS - 06	Chitta	Mohammed Jaffer	10
4	CMS - 09	Chitta	Mohammed Jaffer	10
5	CMS - 14	Chitta	Mohammed Jaffer	10
6	CMS - 15	Chitta	Mohammed Jaffer	10
7	CMS - 16	Chitta	Mohammed Jaffer	10
8	CMS - 17	Chitta	Mohammed Jaffer	10
9	CMS - 18	Chitta	Mohammed Jaffer	10
10	CMS - 19	Chitta	Mohammed Jaffer	10
11	CMS - 23	Chitta	Mohammed Jaffer	10
12	CMS - 24	Chitta	Mohammed Jaffer	10
13	CMS - 25	Chitta	Mohammed Jaffer	10
14	CMS - 26	Chitta	Mohammed Jaffer	10
15	CMS - 27	Chitta	Mohammed Jaffer	10
16	CMS - 29	Chitta	Mohammed Jaffer	10
17	CMS - 30	Chitta	Mohammed Jaffer	10
18	CMS - 31	Chitta	Mohammed Jaffer	10
19	CMS - 32	Chitta	Mohammed Jaffer	10
20	CMS - 33	Chitta	Mohammed Jaffer	10
21	CMS - 34	Chitta	Mohammed Jaffer	10
22	CMS - 35	Chitta	Mohammed Jaffer	10
23	CMS - 37	Chitta	Mohammed Jaffer	10
24	CMS - 40	Chitta	Mohammed Jaffer	10
25	CMS - 41	Chitta	Mohammed Jaffer	10
26	CMS - 42	Chitta	Mohammed Jaffer	10
27	CMS - 43	Chitta	Mohammed Jaffer	10
28	CMS - 44	Chitta	Mohammed Jaffer	10
29	CMS - 45	Chitta	Mohammed Jaffer	10
30	CMS - 46	Chitta	Mohammed Jaffer	10
31	CMS - 47	Chitta	Mohammed Jaffer	10
32	CMS - 49	Chitta	Mohammed Jaffer	10
33	CMS - 51	Chitta	Mohammed Jaffer	10
34	CMS - 52	Chitta	Mohammed Jaffer	10
35	CMS - 53	Chitta	Mohammed Jaffer	10
36	CMS - 54	Chitta	Mohammed Jaffer	10
37	CMS - 55	Chitta	Mohammed Jaffer	10
38	CMS - 56	Chitta	Mohammed Jaffer	10
39	CMS - 57	Chitta	Mohammed Jaffer	10
40	CMS - 58	Chitta	Mohammed Jaffer	10
41	CMS - 59	Chitta	Mohammed Jaffer	10
42	CMS - 60	Chitta	Mohammed Jaffer	10
43	CMS - 61	Chitta	Mohammed Jaffer	10
44	CMS - 62	Chitta	Mohammed Jaffer	10
45	CMS - 63	Chitta	Mohammed Jaffer	10
46	CMS-67	Chitta	Mohammed Jaffer	10
47	GMS - 06	Gonahalli	Gundappa	9
48	YMS - 01	Yadlapura	Shivakumara Swamy	16
49	YMS - 04	Yadlapura	Shivakumara Swamy	16
50	YMS -05	Yadlapura	Shivakumara Swamy	16
51	YMS - 06	Yadlapura	Shivakumara Swamy	16
52	YMS - 07	Yadlapura	Shivakumara Swamy	16
53	CMS - 68	Chitta	Mohammed Jaffer	55
54	GMS - 01	Gonahalli	Gundappa	60

55	GMS - 02	Gonahalli	Gundappa	60
56	GMS - 03	Gonahalli	Gundappa	60
57	GMS - 04	Gonahalli	Gundappa	60
58	GMS – 05	Gonahalli	Gundappa	60
59	MMS – 01	Mudbi	Sathish Patil	75
60	MMS – 02	Mudbi	Sathish Patil	75
61	MMS – 03	Mudbi	Sathish Patil	75

TSS: Acid Ratio
The ratio was calculated by dividing TSS with the acidity.

$$\text{TSS: Acid Ratio} = \frac{\text{TSS}}{\text{Titratable Acidity}}$$

Total sugars (%)
The percentage of total sugars present in the fruit pulp was estimated by the principle of reducing sugar after inversion [5]. One milliliter of evaporated extract was taken and kept in boiling water till the alcohol was completely evaporated and allowed it to cool. Then phenolphthalein indicator was added followed by 1 N sodium hydroxide till the solution turned to pink. Again 0.1 N hydrochloric acid was added to discolour the solution. Then, Dinitrosalicylic acid (DNSA) method for estimation of reducing sugar was followed. The values obtained were expressed as percentage on pulp weight basis.

Reducing sugars (%)
The percentage of reducing sugars in the mango pulp was determined by Dinitrosalicylic acid (DNSA) method. A known volume of alcohol extract was allowed to evaporate the alcohol completely. Clear solution was taken for the estimation of reducing sugar using DNSA- reagent by following the above method and values were expressed in percentage.

Nonreducing sugars (%)
The percentage of non reducing sugars was obtained by subtracting the values of reducing sugars from total sugar which was multiplied by the correction factor.
Non-reducing sugar (%) = Total sugars (%) - reducing sugars (%)

Ascorbic acid (mg/100ml)
Ten ml of juice was blended with metaphosphoric acid (3% HPO3) and volume was made up to 100 ml with HPO3 (3%).The content after shaking well was filtered through Whatman No.1 filter paper. Ten ml of filtrate was titrated against 2,6 dichlorophenol-indophenol dye until light pink colour was observed.

Carotenoid (µg/100g)
Five gram of fresh sample was weighed with the help of electronic balance and crushed with 10-15 ml of acetone and a few crystals of anhydrous sodium sulfate, with the help of mortar and pestle. Decant the supernatant into a beaker. Repeat the process twice and transfer the combined supernatant sample into a separatory funnel, 10-15 ml petroleum ether was added and mixed thoroughly. Two layers were separated out on standing. Discard the lower layer and collect the upper layer into a 100 ml volumetric flask, made up the volume to 100 ml with petroleum ether and record the optical density at 425 nm by using Thermo Evolution 201 Model spectrophotometer as petroleum ether as blank (Srivastava and Sanjeev, 2014) [19].

Statistical analysis
The statistical mean was calculated using the method suggested by Goulden (1952) [7]. Range was calculated based on the difference between the lowest and the highest values present in observation. The coefficient of variation was computed according to Burton and Devane (1953) [5]. The coefficient of simple correlation between various characters was estimated to determine the degree of association of characters with yield. Correlation was computed as per the formula given by Pearson (1895) [14].

Results and Discussion
Quality parameters
The TSS which mainly imparts sweetness to the pulp of fruits showed variation among different seedling selections which ranged from 11.80 ºB in 'CMS-42' to 24.00 ºB in 'YMS-05' (Table-2). The TSS of mango fruits similarly ranged from 15.31 ºB in 'Gen Alphonso' to 18.07 ºB in 'MA-1' (Mukunda, 2004) [10]; 10.00 ºB in 'Janisahab Karkan' to 19.50 ºB in 'Clone V-2' (Pandey *et al.*, 2006) [13]; 15.20 ºB in 'BN Acc-20' to 22.00 ºB in 'BN Acc-23' (Begum *et al.*, 2013) [3]; 14.50 ºB in 'CKR Acc-22' to 19.70 ºB in 'CKR Acc-30' (Begum *et al.*, 2014) [4] and 15.55 ºB in 'Pusa Mango-7' to 21.50 ºB in 'Pusa Mango-10' (Singh *et al.*, 2015) [17].
The acidity present in fruit is due to the presence of organic acids, which give the sour taste to fruits. The titrable acidity in the present study was found to be varied from 0.14 per cent in 'CMS-25' to 1.21 per cent in 'YMS-1.21' (Table-2). Likewise, titrable acidity ranged from 0.06 per cent in 'Abdullah Great' to 0.30 per cent in 'Clone S-1'(Pandey *et al.*, 2006) [13]and 0.20 per cent in 'Pusa Mango-13' to 0.75 per cent in 'Pusa Mango-3' (Singh *et al.*, 2015) [17].
The sweetness of the fruit pulp is due to conversion of starch into sugars resulting from starch hydrolysis (Aina, 1990) [2]. In fruits, different sugars are present in certain forms like reducing and non-reducing in varying amount. Reducing sugars are those sugars (Hexose-$C_6H_{12}O_6$), which can reduce compounds such as alkaline silver nitrate solution, cupric salt solution *etc*. When these sugars make reduction reactions, they themselves get oxidized (Mazumdar and Majumdar, 2003) [9]. In the present study, the range was from 7.82 per cent in 'CMS-49' to 20.91 per cent in 'CMS-47' for total sugars, 2.25 per cent in 'CMS-42' to 7.49 per cent in 'CMS-47' for reducing sugars and 4.25 per cent in 'CMS-29' to 14.39 per cent in 'YMS-05' for non reducing sugars (Table-2). Similarly, the total sugars varied from 12.97 per cent in 'Gen Alphonso' to 13.93 per cent in 'AA-5' among the clones of Alphonso (Mukunda, 2004) [10].
The Brix acid ratio mainly creates a sense of taste. Sweetness due to sugars from conversion of the starch and sourness from organic acids are principal components in the taste of many fruits (Kays, 1991) [8]. Brix acid ratio of seedling selections in the present study ranged from 9.75 in 'YMS-07' to 171.43 in 'CMS-25' (Table-2). Mukunda (2004) [10] reported the similar range of Brix acid ratio of the clones of Alphonso from 48.80 in 'Gen Alphonso' to 62.03 in 'MA-2'.

The ascorbic acid content of pulp in all the selections varied from the lowest 21.09 mg per 100g was recorded in MMS-02 to the highest 84.86 mg per 100g was recorded in CMS-01. The results are in agreement with Palaniswamy *et al.* (1974) [12] and Rathor (2005) [16] who stated that smaller sized mango fruits recorded higher ascorbic acid content than larger sized fruits.

The carotene content of the sixty-one selections ranged from the lowest 2490.00 µg per 100g (CMS-62) to the highest 6496.36 µg per 100g (CMS-63) (Table-2). Similar result was reported by Aatla (2015) [1] in mango. He observed that the β-carotene values were found to be significant. The β-carotene content ranged from 623.71 to 1679.89 µg/100g with a mean value of 1111.49 µg/100g.

Table 2: Fruit quality parameters of seedling selections

Selections	TSS (ºB)	Acidity (%)	TSS: Acidity	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)	Ascorbic acid (mg/100g)	Carotenoid (µg/100g)
CMS - 01	21.60	0.15	144.00	18.91	6.66	12.25	84.86	5728.56
CMS - 05	13.60	0.40	34.00	9.20	2.66	6.54	32.76	3895.44
CMS - 06	17.40	0.32	54.38	13.40	5.14	8.26	21.46	3339.76
CMS - 09	21.20	0.28	75.71	18.46	6.73	14.18	30.36	3308.20
CMS - 14	16.80	0.36	46.67	14.18	5.10	9.08	37.46	5514.44
CMS - 15	18.20	0.26	70.00	15.65	5.65	10.00	35.70	3659.32
CMS - 16	17.20	0.31	55.48	16.40	4.88	11.52	23.85	4393.80
CMS - 17	13.20	0.44	30.00	8.94	3.16	5.78	21.96	4257.52
CMS - 18	16.20	0.34	47.65	12.82	4.47	8.35	33.25	3869.00
CMS - 19	16.20	0.31	52.26	13.34	4.34	9.00	26.38	4038.24
CMS - 23	17.40	0.33	52.73	13.48	4.75	8.73	26.72	4098.44
CMS - 24	14.60	0.39	37.44	11.18	4.17	7.01	29.03	4670.48
CMS - 25	22.40	0.14	160.00	20.45	6.74	13.71	40.95	5232.24
CMS - 26	17.40	0.36	48.33	13.48	5.03	8.45	29.78	3944.76
CMS - 27	16.60	0.33	50.30	14.69	5.00	9.69	38.85	3635.36
CMS - 29	12.40	0.47	26.38	7.82	3.40	4.42	40.98	3469.32
CMS - 30	17.40	0.42	41.43	12.96	4.29	8.67	36.43	4648.32
CMS - 31	18.00	0.23	78.26	15.40	5.44	9.96	27.87	3144.56
CMS - 32	11.80	0.46	25.65	8.14	2.92	5.22	26.37	4017.04
CMS - 33	19.00	0.29	65.52	18.78	7.21	11.57	24.37	3926.36
CMS - 34	17.20	0.32	53.75	14.25	5.42	8.83	26.61	3357.48
CMS - 35	16.40	0.33	49.70	13.57	4.80	8.77	31.27	3387.00
CMS - 37	16.80	0.33	50.91	13.79	5.03	8.76	24.95	3672.32
CMS - 40	20.20	0.41	49.27	19.82	5.73	14.09	44.21	4497.36
CMS - 41	14.90	0.43	34.65	12.78	4.33	8.45	31.66	3739.44
CMS - 42	11.80	0.46	25.65	7.92	2.25	5.67	26.00	4086.92
CMS - 43	15.80	0.24	65.83	13.21	4.97	8.24	37.45	3586.68
CMS - 44	16.40	0.26	63.08	13.37	4.46	8.91	31.49	3501.52
CMS - 45	19.20	0.23	83.48	16.49	5.56	10.93	26.02	3528.04
CMS - 46	16.80	0.31	54.19	13.80	5.46	8.34	28.03	4654.64
CMS - 47	23.00	0.17	135.29	20.91	7.49	13.42	53.37	5138.64
CMS - 49	15.80	0.35	45.14	11.86	4.13	7.73	34.68	2866.96
CMS - 51	15.20	0.35	43.43	12.17	3.62	8.55	23.36	3851.24
CMS - 52	16.40	0.34	48.24	13.82	4.88	8.94	29.15	2974.00
CMS - 53	14.20	0.41	34.63	11.19	3.90	7.29	24.57	3245.32
CMS - 54	14.80	0.38	38.95	10.86	3.53	7.33	24.72	3504.04
CMS - 55	15.60	0.31	50.32	12.43	4.19	8.24	26.32	3617.12
CMS - 56	22.20	0.25	88.80	19.91	6.37	13.54	32.72	2773.88
CMS - 57	19.40	0.26	74.62	18.68	6.42	12.26	65.84	3357.96
CMS - 58	15.40	0.28	55.00	11.43	4.09	7.34	39.84	3178.64
CMS - 59	15.80	0.35	45.14	12.40	4.62	7.78	21.25	5593.00
CMS - 60	18.40	0.28	65.71	15.82	5.22	10.61	24.55	3498.68
CMS - 61	17.20	0.29	59.31	16.43	6.13	10.30	31.87	4147.36
CMS - 62	20.00	0.21	95.24	18.90	6.44	12.46	25.30	2490.00
CMS - 63	20.80	0.23	90.43	17.77	6.69	11.08	24.98	6496.36
CMS - 67	19.80	0.19	104.21	20.08	7.20	12.88	22.16	3266.64
CMS - 68	17.00	0.34	50.00	16.40	5.58	10.82	34.37	3267.36
GMS - 01	16.40	0.33	49.70	11.04	4.16	6.88	31.42	4184.20
GMS - 02	17.00	0.32	53.13	13.72	5.00	8.72	39.54	3678.72
GMS - 03	14.60	0.41	35.61	11.39	3.84	7.55	26.89	4955.04
GMS - 04	17.20	0.32	53.75	13.59	5.38	8.21	61.26	2980.12
GMS - 05	20.80	0.21	99.05	18.46	6.61	11.85	36.46	3350.72
GMS - 06	18.40	0.30	61.33	15.21	5.79	9.42	26.48	3926.92
YMS - 01	19.40	0.28	69.29	16.89	5.88	11.01	24.61	3614.56
YMS - 04	19.10	0.29	65.86	15.63	5.64	9.99	22.16	5727.44

YMS -05	24.00	0.22	109.09	20.48	6.09	14.39	38.19	3225.96
YMS - 06	14.80	0.47	31.49	9.94	3.51	6.43	26.91	4875.44
YMS - 07	19.00	1.21	15.70	15.27	5.32	9.95	56.38	3706.00
MMS - 01	18.80	0.29	64.83	14.62	4.75	9.87	47.62	2824.24
MMS - 02	16.40	0.33	49.70	13.73	4.62	9.11	21.09	3906.16
MMS - 03	16.00	0.32	50.00	10.75	3.44	7.31	28.97	2865.68
Max	24.00	1.21	160.00	20.91	7.49	14.39	84.86	6496.36
Min	11.80	0.14	15.70	7.82	2.25	4.42	21.09	2490.00
Range	12.20	1.07	144.30	13.09	5.24	9.97	63.77	4006.36
Mean	17.33	0.33	60.00	14.41	5.03	9.42	32.85	3899.86
SD	2.65	0.13	27.96	3.35	1.18	2.33	11.74	828.43
S.Em±	0.34	0.02	3.58	0.42	0.15	0.30	1.51	106.07
CV	15.26	41.70	46.60	23.27	23.51	24.75	35.73	21.24

The difference in chemical constituents of the fruit can be attributed to the clonal variation. The clone might have mutated at micro and macro level leading to the variation in these quality attributes (Mukunda, 2004) [10].

Quality characters *viz.*, total sugar, reducing sugar, non reducing sugar, ascorbic acid and TSS to acid ratio recorded highly significant and positive correlation with TSS of fruit pulp (0.945, 0.896, 0.931, 0.347 and 0.827 respectively) (Table-3). There was no significant correlation between TSS and carotenoid (0.070) and there was a negative correlation between TSS and acidity (-0.387). These findings are in agreement with Singh *et al.* (1985) [18] in mango only.

Table 3: Correlation Studies between quality parameters

	TSS	TA	TS	RS	NRS	AC	CC
TA	-0.387**						
TS	0.945**	-0.417**					
RS	0.896**	-0.421**	0.945**				
NRS	0.931**	-0.393**	0.980**	0.877**			
AAC	0.347**	0.050^{NS}	0.299*	0.292*	0.277*		
CC	0.070^{NS}	-0.010^{NS}	0.042^{NS}	0.081^{NS}	0.007^{NS}	0.055^{NS}	
TSS:TA	0.827**	-0.669**	0.799**	0.773**	0.767**	0.350**	0.147^{NS}

* - Correlation is significant at the 0.05 level (2-tailed)
** - Correlation is significant at the 0.01 level (2-tailed)

TSS: Total soluble solids
NRS: Non-reducing sugars
TA: Titrable acidity
AA: Ascorbic acid content
TS: Total sugars
CC: Carotene content
RS: Reducing sugars
TSS: TA: TSS: Titrable

Conclusion

Among the sixty-one seedlig selections selected in the present investigation, 'YMS-05) had the highest values for TSS (24.00 ^{o}B) and non-reducing sugars (14.39%). 'CMS-47' had the maximum amount of total sugar (20.9%) and reducing sugars (7.49%). The highest ascorbic acid content was noticed in 'CMS-01' (84.86 mg/100g pulp), the maximum carotenoid content was noticed in 'CMS-63' (6496.36 µg/100g).

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