

Correlation Studies in Mango (*Mangifera indica* L.)

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Abstract The present investigation was undertaken during 2012-2014, the experimental material involved thirty four mango cultivars collected from coastal districts of Andhra Pradesh. The pooled re-

sults illustrated that fruit weight had highly significant and positive association with pulp to stone ratio, edible to non-edible ratio, pulp per cent at 0.1% level of significance both at phenotypic and genotypic levels indicating that these characters could be utilized for selection of fruit weight in future breeding programs which ultimately have direct effect on yield. Among the bio-chemical characters studies, TSS showed significant positive correlation with total sugars, TSS : acid ratio, peel per cent and ascorbic acid at 0.1% level of significance at both phenotypic and genotypic levels. The highly significant positive correlation between desirable characters is favorable to a plant breeder, because it might help in simultaneous improvement of those characters. The work was an attempt to identify the elite ones for development of high yielding quality mango varieties among diverse cultivars.

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Introduction

Mango (*Mangifera indica* L.) is an important member of the family Anacardiaceae in order Sapindales

and is the most important fruit crop in India having a great cultural, socio-economic and religious significance since ancient times. By virtue of its excellent flavor, delicious taste, attractive color, delicious fruit quality with richness in vitamins and minerals, accessibility to common man, liking by the masses, mango has been assigned the status of the King of the fruits in the tropical world and it is the National Fruit of India. The intended improvement in plant type needs greater attention for making its cultivation more profitable by increasing production with low inputs. Greater attention is thus needed for the collection of *Mangifera* species, wild types, cultivars, clones and land races and their characterization and evaluation for immediate use and posterity.

In India mango ranks first in terms of area with 2.50 million ha, second in respect of production with 18.00 million tonnes and with a productivity of 7.2 million tonnes/ha, while Andhra Pradesh ranks second in terms of area and production with 0.30 million ha and 2.70 million tones, respectively and with a productivity of 9.0 million tonnes/ha [1]. Correlation analysis measures the mutual relationship between various characters and determines the component character on which selection can be based for genetic improvement in yield. The present study was undertaken with the objective to study the correlation analysis among different traits in mango cultivars.

Materials and Methods

The present study was conducted to study the performance of mango cultivars of coastal districts in Andhra Pradesh at Horticultural Research Station, Venkataramannagudem during the period from 2012 to 2014. A well-planned germplasm collection survey based on diversity richness was conducted in coastal districts of Andhra Pradesh which includes Horticultural Research Station and private owned mango orchards. Random sampling strategy was followed for collection of samples. Three trees in each cultivar were taken as sample size. The experimental material consists of 34 indigenous mango cultivars and variants within them obtained from the coastal districts of Andhra Pradesh. The indigenous mango cultivars used are :

Sl. No.	Name of the cultivar	Sl. No.	Name of the cultivar
1	Banganapalli-1	18	Nalla Andrews
2	Banganapalli - 2	19	Nalla Rasalu
3	Banganapalli -3	20	Navaneetam
4	Banglora - 1	21	Nuzividu Tiyya Mamidi
5	Banglora -2	22	Nuzividu Rasalu
6	Baramasi	23	Panchadara Kalasa
7	Cherukurasam	24	Pandurivari Mamidi
8	Chinnarasam	25	Paparao Goa
9	Chinna Suvarnarekha	26	Peddarasam
10	Elamandala	27	Panukula Mamidi
11	Hyder	28	Royal Special
12	Imampasand	29	Rajamanu
13	Jalal	30	Sora Mamidi
14	Jehangir	31	Suvarnarekha
15	Kolanka Goa	32	Tella Gulabi
16	Kottapalli Kobbari	33	Tella Rasalu
17	Kowsuri Pasand	34	Rajamamidi

Five fruits of each cultivar were taken per replication for evaluating fruit characters. Fruits were weighed with the help of electronic balance separately and the average fruit weight was expressed in grams. The peel and stone of five fruits were taken and weighed with the help of electronic balance separately and peel and stone content were expressed in percentage. Pulp weight was calculated by subtracting the peel and stone weight from total weight of the fruit and the pulp content was expressed in percentage.

The total soluble solids ($^{\circ}$ Brix) and titratable acidity (%) was recorded [2]. Total soluble solids/ acidity ratio (TSS : acid ratio) was calculated by dividing the value of TSS with that of corresponding titratable acidity. β - Carotene ($\mu\text{g}/100\text{g}$) was determined by using spectrophotometer as petroleum ether as blank [3].

To determine the degree of association among the characters, the correlation coefficients were calculated. Both genotypic and phenotypic coefficients of correlation between two characters were determined by using the variance and covariance components [4].

Results and Discussion

A wide range of variation in quantitative characters

Table 1. Phenotypic correlation coefficients of fruit morphological and bio-chemical characters in mango. * : 50% level of significance, ** : 1% level of significance, *** : 0.1% level of significance.

Characters	TSS (°Brix)	Total sugars (%)	Titrateable acidity (%)	β-carotene (µg/100g)	Ascorbic acid (mg/100g)	TSS acid ratio
TSS (°Brix)	1.0000	0.8286 ***	0.0439	0.0425	0.2622 ***	0.6560 ***
Total sugars (%)		1.0000	-0.1987**	0.1591 *	0.0352	0.7354***
Titrateable acidity (%)			1.0000	-0.2243 **	0.7344 ***	-0.6117 ***
β-carotene (µg/100g)				1.0000	-0.2757 ***	0.2331 ***
Ascorbic acid (mg/100g)					1.0000	-0.3445 ***
TSS : acid ratio						1.0000
Fruit weight (g)						
Peel per cent (%)						
Pulp to stone ratio						
Pulp per cent (%)						
Stone per cent (%)						
Edible to non-edible ratio						

Table 1. Continued

Characters	Fruit weight (g)	Peel per cent (%)	Pulp to stone ratio	Pulp percent (%)	Stone percent (%)	Edible to non-edible ratio
TSS (°Brix)	-0.1853 **	0.2861***	-0.0822	-0.1250	0.0391	-0.1597 *
Total sugars (%)	-0.0310	0.1073	0.0381	0.0499	-0.1000	-0.0106
Titrateable acidity (%)	-0.1529 *	0.2413***	-0.0846	-0.1320	0.0491	-0.1296
β-carotene (µg 100g)	0.0834	-0.1278	0.0590	0.0409	0.0064	0.1213
Ascorbic acid (mg/100g)	-0.3071 ***	0.2164**	-0.1164	-0.1490 *	0.0977	-0.1453 *
TSS : acid ratio	0.0162	0.0195	0.0280	0.0334	-0.0307	0.0038
Fruit weight (g)	1.0000	-0.3097 ***	0.7258 ***	0.6248 ***	-0.6401 ***	0.6462 ***
Peel per cent (%)		1.0000	-0.4984 ***	-0.6568 ***	0.2868 ***	-0.7324 ***
Pulp to stone ratio			1.0000	0.8638 ***	-0.8261 ***	0.9386 ***
Pulp per cent (%)				1.0000	-0.8613 ***	0.9283 ***
Stone per cent (%)					1.0000	-0.7714 ***
Edible to non-edible ratio						1.0000

provides the basis for selection in plant breeding program. The knowledge of association among the characters is useful to the breeder for improving the efficiency of selection. The aim of correlation studies is primarily to know the suitability of various characters for indirect selection, because the selection of any particular trait may bring about undesirable changes in other associated characters. The correlation studies between fruit morphological and biochemical characters would certainly provide an idea, which might be utilized for selection of desirable parameters for future breeding programs. The highly significant positive correlation between desirable

characters is favorable to a plant breeder, because it might help in simultaneous improvement of those characters. On the other hand, the negative correlation would hinder the synchronized expression of those characters. In such a situation, it would require to make some compromise including economic ones. In the present investigation correlations were worked out both at phenotypic and genotypic levels for all possible character combinations. In general, genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients indicated that there is a strong inherent association between each pair of character (s) which might be

due to masking or modifying effect of the environment. The phenotypic expression of correlation was lessened possibly due to multiple influences of environmental components. In view of their association, selection on phenotypic basis would be effective. Correlation coefficient analysis measures the mutual relationship between plant characters and determines the component character on which selection can be made for genetic improvement of yield. Coefficient of correlation provides a clear picture of the extent of association between a pair of traits and indicates whether simultaneous improvement of the correlated traits may be possible or not. very close values of genotypic and phenotypic correlation were also observed between some character combinations, which might be due to reduction in error (environmental variance) to minor proportions. A wide difference between genotypic and phenotypic correlations between two characters is due to dual nature of phenotypic correlations which is determined by genotypic and environmental correlations and heritability of the characters. When characters having direct bearing on yield are selected their associations with other characters are to be considered simultaneously as this will indirectly affect yield.

Total soluble solids exhibited highly significant positive (Tables 1 and 2) correlation with total sugars ($r_p=0.8286$, $r_g=0.8374$), TSS : acid ratio ($r_p=0.6560$, $r_g=0.6772$), peel per cent ($r_p=0.2861$, r_g

$=0.3064$) and ascorbic acid ($r_p=0.2622$, $r_g=0.2711$) at both phenotypic and genotypic levels. Significant negative correlation was found with fruit weight ($r_p=-0.1853$, $r_g=-0.1936$) and edible to non-edible ratio ($r_p=-0.1597$, $r_g=-0.1669$). Non-significant correlation was observed for the rest of the characters. The value of genotypic correlation coefficient (r_g) is higher than phenotypic correlation coefficient (r_p), it means that there was strong genetic association between these characters, but the phenotypic value was lessened by the significant interaction of environment. Similar correlation was reported with respect to TSS of total sugars in mango [5].

At both phenotypic and genotypic levels (Table 1 and 2), total sugars recorded highly significant positive correlation with TSS : acid ratio ($r_p=0.7354$, $r_g=0.7612$ and β -carotene ($r_p=0.1591$, $r_g=0.1711$). Total sugars were negatively correlated with titratable acidity ($r_p=-0.1987$, $r_g=-0.1985$). There was no significant correlation among the rest of characters. Phenotypic and genotypic correlations were in perfect agreement with each other and relatively higher magnitude of the latter indicated the masking of environmental effect on gene expression.

Titratable acidity recorded significant positive (Tables 1 and 2) correlation with ascorbic acid ($r_p=0.7344$, $r_g=0.7452$) and peel per cent ($r_p=0.2413$, $r_g=0.2572$). Similar observations with regard to

Table 2. Genotypic correlation coefficients of fruit morphological and bio-chemical characters in mango.

Characters	TSS (°Brix)	Total sugars (%)	Titratable acidity (%)	β - carotene ($\mu\text{g}/100\text{g}$)	Ascorbic acid ($\text{mg}/100\text{g}$)	TSS : acid ratio
TSS (°Brix)	1.0000	0.8374	0.0507	0.0385	0.2711	0.6772
Total sugars (%)		1.0000	-0.1985	0.1711	-0.0446	0.7612
Titratable acidity (%)			1.0000	-0.2423	0.7452	-0.6188
β -carotene ($\mu\text{g}/100\text{g}$)				1.0000	-0.2912	0.2650
Ascorbic acid ($\text{mg}/100\text{g}$)					1.0000	-0.3610
TSS : acid ratio						1.0000
Fruit weight (g)						
Peel per cent (%)						
Pulp to stone ratio						
Pulp per cent (%)						
Stone per cent (%)						
Edible to non-edible ratio						

Table 2. Continued.

Characters	Fruit weight (g)	Peel per cent (%)	Pulp to stone ratio	Pulp per cent (%)	Stone per cent (%)	Edible to non-edible ratio
TSS (°Brix)	-0.1936	0.3064	-0.0878	-0.1317	0.0392	-0.1669
Total sugars (%)	-0.0319	0.1115	0.0451	0.0497	-0.1084	-0.0075
Titrateable acidity (%)	-0.1559	0.2572	-0.0894	-0.1350	0.0516	-0.1333
β -carotene (μ g/100g)	0.0902	-0.1387	0.0655	0.0447	0.0067	0.1307
Ascorbic acid (mg/100g)	-0.3118	0.2293	-0.1186	-0.1520	0.0978	-0.1464
TSS : acid ratio	0.0185	0.0168	0.0321	0.0364	-0.0364	0.0055
Fruit weight (g)	1.0000	-0.3249	0.7563	0.6345	-0.6497	0.6553
Peel per cent (%)		1.0000	-0.5366	-0.7006	0.2953	-0.7490
Pulp to stone ratio			1.0000	0.9037	-0.8393	0.9518
Pulp per cent (%)				1.0000	-0.8825	0.9478
Stone per cent (%)					1.0000	-0.7731
Edible to non-edible ratio						1.0000

positive correlation of titrateable acidity with ascorbic acid were earlier reported in mango [6].

Significant positive correlation at both phenotypic and genotypic levels (Tables 1 and 2) was observed for β -carotene with TSS : acid ratio ($r_p=0.2331$, $r_g=0.2650$). From the observations of morphological characters, it was evident that the consumer should select the mango fruits with yellow pulp color to have maximum β -carotene content.

At both phenotypic and genotypic levels (Tables 1 and 2), ascorbic acid content recorded significant positive correlation with peel per cent ($r_p=0.2164$, $r_g=0.2293$).

TSS : acid ratio had positive correlation with TSS and negative correlation with titrateable acidity. Similar finding was reported with regard to TSS : acid ratio in mango [6].

Fruit weight recorded significant positive correlation (Tables 1 and 2) with pulp to stone ratio ($r_p=0.7258$, $r_g=0.7563$), edible to non-edible ratio ($r_p=0.6462$, $r_g=0.6553$), pulp per cent ($r_p=0.6248$, $r_g=0.6345$). It was negatively correlated with stone per cent ($r_p=-0.6401$, $r_g=-0.6497$) and peel per cent ($r_p=-0.3097$, $r_g=-0.3249$). Non-significant correlation was observed for the rest of characters. The selection indices based on fruit size (length and di-

ameter) with high peel, pulp and stone content were the most important factors for identifying high fruit weight types. The results are in agreement with earlier findings in mango [5].

Significant positive correlation at both phenotypic and genotypic levels (Tables 1 and 2) was observed for peel per cent with stone per cent ($r_p=0.2868$, $r_g=0.2953$). It recorded significant negative correlation with edible to non-edible ratio ($r_p=-0.7324$, $r_g=-0.7490$), pulp per cent ($r_p=-0.6568$, $r_g=-0.7006$), pulp to stone ratio ($r_p=-0.4984$, $r_g=-0.5366$). No significant correlation was observed for the rest of the characters. Similarly negative correlation of peel per cent with pulp per cent was earlier reported in mango [5].

At both phenotypic and genotypic levels (Tables 1 and 2), pulp to stone ratio recorded significant positive correlation with edible to non-edible ratio ($r_p=0.9386$, $r_g=0.9518$), pulp per cent ($r_p=0.8638$, $r_g=0.9037$). Similarly significant positive correlation of pulp to stone ratio with edible to non-edible ratio in mango was reported by earlier workers.

Significant positive correlation at both phenotypic and genotypic levels (Tables 1 and 2) was observed for pulp per cent with edible to non-edible ratio ($r_p=0.9283$, $r_g=0.9478$). It recorded significant negative correlation with stone per cent ($r_p=-0.8613$, $r_g=-0.8825$) at 0.1% level of significance.

The results were in conformity with research findings of earlier worker in mango who reported negative correlation of pulp per cent with stone per cent [6].

At both phenotypic and genotypic levels (Tables 1 and 2), stone per cent was negatively correlated with edible to non-edible ratio ($r_p = -0.7714$, $r_g = -0.7731$).

Conclusion

The genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic ones, indicating thereby a strong inherent association between different traits studied. In the present study, significant and positive genotypic and phenotypic correlation was observed for fruit weight with pulp to stone ratio, edible to non-edible ratio, pulp per cent and similarly in case of bio-chemical characters TSS showed significant positive correlation with total sugars, peel per cent, TSS : acid ratio and

ascorbic acid which is considered significant to breeder because component breeding would be very effective. Selection for all these traits might be helpful in evolving high yielding varieties of mango.

References

1. NHB, (2013) Indian Horticulture Database, National Horticulture Board, Guargon, India. http://www.nhb.gov.in/area_production.html
2. Ranganna S (1986) Handbook of analysis and quality control for fruits and vegetable products. Tata Mc Graw Hill Publ Company Ltd., New Delhi.
3. Srivastava RP, Sanjeev K (2014) Fruit and vegetable preservation principles and practices, 3rd edn. Kalyani Publ, New Delhi.
4. Al-Jibouri HA, Miller PA, Robinson HV (1958) Genotypic and environmental variances and co-variances in an upland cotton cross of interspecific origin. *Agron J* 50 : 533—536.
5. Simi S (2006) Characterization of traditional mango (*Mangifera indica* L.) varieties of southern Kerala. Ph D thesis. The Kerala Agric Univ.
6. Rathor CS (2005) Genetic characterization of mango (*Mangifera indica* L.) germplasm under North Indian conditions. MSc thesis. The Ind Agric Res Inst.