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# Correlation studies for yield and yield attributes in mango (*Mangifera indica* L.)

**Sridhar D, Ghosh B and Kundu S**

**Abstract**
The present investigation was conducted in a pre-established orchard named of All India Coordinated Research Project on Fruits at Regional Research Station, Gayeshpur, West Bengal from 2016 to 2018 to determine the genotypic and phenotypic correlation analysis of yield to estimate the contribution of most important characters towards yield. The genotypic (G) and phenotypic (P) correlation coefficients were worked out for twenty-six characters in sixteen mango cultivars. The genotypic correlation values were recorded higher than the phenotypic values. Fruit length (0.45, 0.49), fruit diameter (0.49, 0.51), fruit width (0.81, 0.83), pulp content (0.40, 0.41), stone length (0.45, 0.46), stone width (0.32, 0.35), stone weight (0.24, 0.25), seed length (0.23, 0.27), TSS: acid ratio (0.22, 0.27) and ascorbic acid (0.57, 0.59) showed positive association with yield both at phenotypic and genotypic levels. Total sugars, non-reducing sugars, reducing sugars, TSS: acid ratio, and ascorbic acid exhibited a significant positive correlation with TSS.

**Keywords:** Mango, correlation, fruit weight, TSS, yield

## Introduction
Mango (*Mangifera indica* L.) is one of the choicest and most admired fruit crops of the tropical and subtropical areas of the world [6]. Its significance can easily be recognized by the fact that it is known as 'King of Fruits'. To overcome the fruit productivity and quality adequate knowledge of the correlation between fruit quality, yield and their contributing characters are important. To overcome the problems of poor fruit quality and productivity, adequate knowledge of the association between fruit quality, yield, and their contributing traits are of importance. The yield is a complex character, which is highly influenced by the environment, therefore selection based on yield alone may limit the breeding progress, whereas yield component characters are less complex in inheritance and influenced by the environment to a lesser extent. Thus, effective improvement in yield may be brought through the selection of various yield component characters, which show association among themselves and also with yield. The correlation studies between different morphological and fruit biochemical characters would certainly provide an idea, which might be utilized for the 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 the 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 making some compromises including economic ones.

## Material and Methods
The present experiment was conducted in a pre-established orchard named of All India Coordinated Research Project on Fruits at Regional Research Station, Gayeshpur, West Bengal from 2016 to 2018. The experiment was conducted on 30-40 years old 16 mango cultivars. A random sampling strategy was followed for the collection of samples. Three plants in each cultivar were taken as a sample size. Distance between the plant to plant and row to row was 10 m. The experimental material consists of 16 indigenous mango cultivars. For leaf analysis, ten healthy and fully developed leaves were collected from the middle of the branches which were exposed to sunlight. Ten fruits were collected from each plant in each replication.

The percentage of total soluble solids was determined by using an ERMA hand refractometer. Reducing sugars, total sugars, and ascorbic acids were determined by Lane and Eyon method [1]. The experimental material consists of 16 indigenous mango cultivars listed as Chatterjee, Gulab Khas, Ranipasand, Sarikhas, Himsagar, Banganpalli, Langra, Fazli, Gopal Bhog, Lakhan Bhog, Kancha Mitha, Kanchan Kosa, Kamala Bhog, Gopi Bhog, Madhu Chuski, and Khota Lagga. Phenotypic and genotypic correlations were worked out by using the formulae suggested by Falconer [3].

**Results and Discussion**

Association of fruit yield with yield component was shown in table 1&2, values of genotypic correlation coefficient were higher than phenotypic correlation coefficient, hence it is understood that there is a strong genetic association between these characters. In present study, the results revealed that yield/plant was significant and positively correlation with fruit length (0.45, 0.49), fruit diameter (0.49, 0.51), fruit width (0.81, 0.83), pulp content (0.40, 0.41), stone length (0.45, 0.46), stone width (0.32, 0.35), stone weight (0.24, 0.25), seed length (0.23, 0.27), TSS: acid ratio (0.22, 0.27) and ascorbic acid (0.57, 0.59) and significant and negatively correlation with titratable acidity (-0.39, -0.46) at both phenotypic and genotypic levels respectively. Hence could be given due weightage for fruit characters during selection process for yield improvement of mango [9]. Plant height exhibited both phenotypic and genotypic positive significant correlation with leaf blade width and fruit diameter. The results were conformity with the findings of researchers in sapota [11, 12]. Leaf blade width was significant positive correlation with tree height, leaf blade length, petiole length and fruit length at both phenotypic and genotypic levels. Fruit length recorded positive significant correlation with leaf length (0.38, 0.45) and width (0.60, 0.72), fruit diameter (0.49, 0.54), fruit weight (0.61, 0.67), stone length (0.61, 0.70), stone width (0.35, 0.39), stone weight (0.28, 0.32), total sugars (0.21, 0.24), non-reducing sugar (0.20 G), ascorbic acid (0.33, 0.36) and negative significant correlation with TSS (-0.28, -0.30) and titratable acidity (-0.24). The results pertaining to fruit length were in compliance with the findings of Rathor (2005), Simi (2006) and Kumar *et al.* (2006). The fruit diameter also revealed positive and significant association with tree height (0.39, 0.41), fruit weight (0.62, 0.66), pulp content (0.31, 0.32), TSS: acid ratio (0.31, 0.38) and ascorbic acid (0.37, 0.39) however negative and significant correlation with leaf blade length (-0.30, -0.35) and TSS (-0.32, -0.34) at both phenotypic and genotypic levels respectively similar findings conformity with earlier researchers in mango [5, 7, 13, 14]. Fruit weight recorded significant positive correlation with tree height (0.44, 0.46), leaf width (0.37, 0.44), pulp content (0.48, 0.51), stone length (0.60, 0.64), stone width (0.51, 0.57), stone weight (0.41, 0.44), ascorbic acid (0.66, 0.71) and yield/plant (0.8, 0.83). It was negative significant correlated with TSS (-0.30, -0.33) and titratable acidity (-0.37, -0.43) at both levels. The selection indices based on fruit size (length and diameter) with high peel, pulp and stone content were the most important factors for identifying high fruit weight types [2, 4, 10, 13]. Pulp content positive significant correlation at both phenotypic and genotypic levels was observed for pulp content with stone length (0.21, 0.22), stone width (0.63, 0.67). Total Soluble Solids exhibited a highly significant positive correlation at phenotypic and genotypic levels with total sugars (0.43, 0.53), reducing sugars (0.21, 0.23) and non-reducing sugars (0.29, 0.35), and negatively significant correlated with fruit length (-0.28, -0.30) and fruit diameter (-0.32, -0.34). Total sugars recorded highly significant positive correlation with tree height (0.41, 0.48), fruit length (0.21, 0.24), non-reducing sugars (0.89, 0.87) and TSS: acid ratio (0.25, 0.35). Total sugars were negatively significantly correlated with titrable acidity (-0.27, -0.42). The results conformed with research findings of earlier workers with respect to the positive correlation of total sugars with non-reducing sugars [2, 4, 10, 13]. Titratable acidity recorded negatively correlated with fruit length (-0.24), fruit diameter (-0.35, -0.41), fruit skin thickness (-0.44, -0.53), reducing sugars (-0.35, -0.42), TSS: acid ratio (-0.79, -0.87), ascorbic acid (-0.31, -0.40) and yield (-0.39, -0.46) at both levels. TSS: acid ratio had a positive correlation with total sugars and a negative correlation with titratable acidity. Similar findings of TSS: acid ratio were reported by earlier workers in mango [10].

**Conclusion**

Among the fruit morphological characters studied, leaf blade length, fruit length, fruit diameter, pulp content, stone length, width, thickness, weight, and seed length exhibited a significant positive correlation with fruit weight at 5% and 1% level of significance both at phenotypic and genotypic levels and fruit length, fruit diameter, fruit weight, pulp content, stone length, stone width, stone weight, seed length, exhibited a significant positive correlation with yield/plant at 5% and 1% level of significance both at phenotypic and genotypic levels indicating that these characters could be utilized for the selection of fruit weight and yield purpose in future breeding programs. Further, among the bio-chemical characters studied, total sugars, non-reducing sugars, reducing sugars, TSS: acid ratio, and ascorbic acid exhibited a significant positive correlation with TSS at 5% and 1% level of significance at both phenotypic and genotypic levels. The highly significant positive correlation between desirable characters is favourable to a plant breeder because it might help in the simultaneous improvement of those characters.

**Acknowledgement**

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**Table 1:** Phenotypic correlation coefficients of morphological and fruit biochemical characters in mango cultivars

| Traits | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 0.09 | 0.34** | -0.20* | -0.20* | 0.06 | 0.60** | 0.39 | 0.44** | 0.12 | 0.14 | 0.60** | 0.29** | 0.10 | 0.41** | 0.59** | 0.17 | 0.05 | -0.09 | 0.41** | -0.08 | 0.40** | -0.23* | 0.11 | 0.31** | 0.08 |
| 2 | | 1.00 | 0.57** | 0.57** | -0.20* | -0.16 | 0.38** | -0.30** | 0.06 | -0.09 | -0.09 | 0.01 | -0.11 | -0.18 | 0.03 | -0.15 | 0.35** | -0.36** | -0.14 | -0.03 | -0.05 | 0.00 | 0.24* | -0.33** | 0.05 | -0.03 |
| 3 | | | 1.00 | 0.28** | 0.08 | 0.18 | 0.60** | 0.10 | 0.37** | 0.03 | 0.18 | 0.37** | 0.35** | -0.02 | -0.02 | 0.11 | 0.27** | -0.02 | -0.35** | -0.05 | 0.09 | -0.08 | -0.03 | -0.07 | 0.13 | 0.17 |
| 4 | | | | 1.00 | -0.03 | -0.06 | 0.00 | -0.27** | -0.17 | -0.17 | -0.22* | -0.15 | -0.18 | -0.08 | -0.14 | -0.34** | -0.04 | -0.14 | -0.20* | -0.09 | -0.11 | -0.03 | 0.15 | -0.15 | -0.10 | -0.08 |
| 5 | | | | | 1.00 | 0.80** | -0.09 | 0.12 | 0.03 | 0.25** | 0.00 | -0.29** | 0.11 | 0.25** | -0.08 | -0.18 | -0.06 | 0.20 | 0.16 | 0.25* | 0.21* | 0.12 | -0.34** | 0.20* | -0.03 | 0.09 |
| 6 | | | | | | 1.00 | 0.03 | 0.12 | 0.08 | 0.33** | -0.14 | -0.03 | 0.22** | 0.30** | 0.14 | 0.11 | -0.09 | 0.24* | 0.04 | 0.32** | 0.29** | 0.15 | -0.37** | 0.29** | 0.12 | -0.01 |
| 7 | | | | | | | 1.00 | 0.49** | 0.61** | 0.02 | 0.15 | 0.61** | 0.35** | 0.00 | 0.28** | 0.38** | 0.36** | 0.08 | -0.28** | 0.21* | 0.02 | 0.18 | -0.17 | 0.02 | 0.33** | 0.45 |
| 8 | | | | | | | | 1.00 | 0.62** | -0.02 | 0.31** | 0.46** | 0.56** | 0.32** | 0.23* | 0.27** | -0.11 | 0.34** | -0.32** | 0.06 | -0.19 | 0.15 | -0.35** | 0.31** | 0.37** | 0.49 |
| 9 | | | | | | | | | 1.00 | 0.02 | 0.48** | 0.60** | 0.51** | 0.19 | 0.41** | 0.39** | 0.01 | -0.10 | -0.30** | -0.06 | 0.16 | -0.12 | -0.37** | 0.15 | 0.66** | 0.81 |
| 10 | | | | | | | | | | 1.00 | -0.08 | -0.05 | 0.04 | -0.04 | 0.08 | 0.18 | 0.31** | 0.11 | 0.06 | 0.29** | 0.16 | 0.19 | -0.44** | 0.53** | 0.23* | -0.02 |
| 11 | | | | | | | | | | | 1.00 | 0.21** | 0.63** | -0.35** | -0.34** | -0.14 | 0.00 | -0.31** | -0.27** | -0.39** | 0.01 | -0.35** | -0.31** | 0.14 | 0.14 | 0.40** |
| 12 | | | | | | | | | | | | 1.00 | 0.47** | 0.00 | 0.37** | 0.68** | -0.08 | 0.30** | -0.46** | -0.06 | 0.24* | -0.16 | -0.13 | 0.02 | 0.18 | 0.45** |
| 13 | | | | | | | | | | | | | 1.00 | 0.09 | -0.05 | 0.16 | 0.01 | 0.24* | -0.61** | -0.28** | -0.12 | -0.19 | -0.28** | 0.24* | 0.12 | 0.32** |
| 14 | | | | | | | | | | | | | | 1.00 | 0.48** | 0.24* | -0.11 | 0.39** | 0.09 | 0.29** | -0.09 | 0.30** | -0.07 | 0.16 | 0.26** | 0.13 |
| 15 | | | | | | | | | | | | | | | 1.00 | 0.60** | 0.07 | -0.01 | 0.07 | 0.33** | 0.03 | 0.28** | 0.03 | -0.09 | 0.56** | 0.24** |
| 16 | | | | | | | | | | | | | | | | 1.00 | 0.03 | 0.30** | -0.18 | 0.28** | 0.15 | 0.18 | -0.08 | 0.01 | 0.25* | 0.23** |
| 17 | | | | | | | | | | | | | | | | | 1.00 | -0.11 | 0.21* | 0.35** | -0.29** | 0.44** | -0.01 | 0.08 | 0.10 | 0.07 |
| 18 | | | | | | | | | | | | | | | | | | 1.00 | -0.21* | 0.18 | 0.01 | 0.15 | -0.13 | 0.24* | -0.41** | -0.01 |
| 19 | | | | | | | | | | | | | | | | | | | 1.00 | 0.43** | 0.21* | 0.29** | -0.15 | 0.12 | 0.09 | -0.14 |
| 20 | | | | | | | | | | | | | | | | | | | | 1.00 | -0.02 | 0.89** | -0.27** | 0.25* | 0.17 | -0.03 |
| 21 | | | | | | | | | | | | | | | | | | | | | 1.00 | -0.47** | -0.35** | 0.13 | 0.01 | 0.19 |
| 22 | | | | | | | | | | | | | | | | | | | | | | 1.00 | -0.08 | 0.17 | 0.15 | -0.11 |
| 23 | | | | | | | | | | | | | | | | | | | | | | | 1.00 | -0.79** | -0.31** | -0.39** |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.30** | 0.22* |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.57** |
| 26 | | | | | | | | | | | | | | | | | | | | | | | | | | 1.00 |

** Significant at 1% level of significance * Significant at 5% level of significance. tree height-1, leaf blade length-2, leaf blade width-3, petiole length-4, inflorescence length-5, inflorescence width-6, fruit length-7, fruit diameter-8, fruit weight-9, fruit skin thickness-10, pulp content-11, stone length-12, stone width-13, stone thickness-14, stone weight-15, seed length-16, seed width-17, seed weight-18, tss-19, total sugars-20, reducing sugars-21, non-reducing sugars-22, titratable acidity-23, tss: acid ratio-24, ascorbic acid-25, yield/plant-26

**Table 2:** Genetic correlation coefficients of morphological and fruit biochemical characters in mango cultivars

| Traits | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 0.11 | 0.39** | -0.25* | -0.20* | 0.06 | 0.66** | 0.41** | 0.46** | 0.13 | 0.14 | 0.61** | 0.31** | 0.10 | 0.42** | 0.68** | 0.17 | 0.05 | -0.10 | 0.48** | -0.08 | 0.45** | -0.27** | 0.12 | 0.32** | 0.08 |
| 2 | | 1.00 | 0.75** | 0.77** | -0.23* | -0.20* | 0.45** | -0.35** | 0.05 | -0.09 | -0.12 | 0.02 | -0.14 | -0.22* | 0.01 | -0.18 | 0.41** | -0.39** | -0.14 | -0.07 | -0.06 | -0.03 | 0.33** | -0.44** | 0.07 | -0.05 |
| 3 | | | 1.00 | 0.46** | 0.10 | 0.22* | 0.72** | 0.12 | 0.44** | 0.07 | 0.21 | 0.44** | 0.46** | -0.06 | 0.00 | 0.11 | 0.31** | -0.02 | -0.41** | -0.11 | 0.09 | -0.13 | -0.07 | -0.11 | 0.12 | 0.20* |
| 4 | | | | 1.00 | -0.06 | -0.04 | 0.07 | -0.33** | -0.19 | -0.21* | -0.27** | -0.21* | -0.18 | -0.07 | -0.18 | -0.47** | -0.07 | -0.16 | -0.23* | -0.17 | -0.14 | -0.08 | 0.29** | -0.29** | -0.05 | -0.11 |
| 5 | | | | | 1.00 | 0.83** | -0.09 | 0.14 | 0.04 | 0.25* | 0.00 | -0.30** | 0.13 | 0.27** | -0.09 | -0.21* | -0.06 | 0.21 | 0.17 | 0.28** | 0.22* | 0.14 | -0.41** | 0.22* | -0.03 | 0.09 |
| 6 | | | | | | 1.00 | 0.04 | 0.13 | 0.09 | 0.35** | -0.15 | -0.04 | 0.23* | 0.34** | 0.15 | 0.12 | -0.09 | 0.25* | 0.05 | 0.38** | 0.31** | 0.17 | -0.46** | 0.35** | 0.12 | 0.00 |
| 7 | | | | | | | 1.00 | 0.54** | 0.67** | 0.02 | 0.17 | 0.70** | 0.39** | -0.02 | 0.32** | 0.48** | 0.41** | 0.08 | -0.30** | 0.24* | 0.01 | 0.20* | -0.24* | 0.03 | 0.36** | 0.49** |
| 8 | | | | | | | | 1.00 | 0.66** | -0.02 | 0.32** | 0.47** | 0.61** | 0.36** | 0.24* | 0.33** | -0.12 | 0.35** | -0.34** | 0.07 | -0.21* | 0.17 | -0.41** | 0.38** | 0.39** | 0.51** |
| 9 | | | | | | | | | 1.00 | 0.01 | 0.51** | 0.64** | 0.57** | 0.21* | 0.44** | 0.48** | 0.00 | -0.11 | -0.33** | -0.04 | 0.17 | -0.12 | -0.43** | 0.18 | 0.71** | 0.83** |
| 10 | | | | | | | | | | 1.00 | -0.08 | -0.05 | 0.05 | -0.05 | 0.09 | 0.22* | 0.32** | 0.12 | 0.08 | 0.37** | 0.17 | 0.24* | -0.53** | 0.64** | 0.24* | -0.03 |
| 11 | | | | | | | | | | | 1.00 | 0.22* | 0.67** | -0.37** | -0.34** | -0.17 | 0.01 | -0.32** | -0.27** | -0.44** | 0.01 | -0.38** | -0.37** | 0.17 | 0.15 | 0.41** |
| 12 | | | | | | | | | | | | 1.00 | 0.50** | -0.01 | 0.39** | 0.79** | -0.08 | 0.31** | -0.48** | -0.08 | 0.26** | -0.19 | -0.15 | 0.01 | 0.20 | 0.46** |
| 13 | | | | | | | | | | | | | 1.00 | 0.11 | -0.04 | 0.22* | 0.00 | 0.25* | -0.67** | -0.32** | -0.11 | -0.22* | -0.36** | 0.30** | 0.12 | 0.35** |
| 14 | | | | | | | | | | | | | | 1.00 | 0.54** | 0.32** | -0.12 | 0.44** | 0.11 | 0.33** | -0.11 | 0.34** | -0.12 | 0.18 | 0.28** | 0.14 |
| 15 | | | | | | | | | | | | | | | 1.00 | 0.72** | 0.07 | -0.01 | 0.08 | 0.38** | 0.02 | 0.31** | 0.05 | -0.12 | 0.58** | 0.25* |
| 16 | | | | | | | | | | | | | | | | 1.00 | 0.03 | 0.37** | -0.19 | 0.36** | 0.21 | 0.21* | -0.14 | 0.08 | 0.29** | 0.27** |
| 17 | | | | | | | | | | | | | | | | | 1.00 | -0.11 | 0.23* | 0.38** | -0.31** | 0.48** | -0.03 | 0.08 | 0.11 | 0.07 |
| 18 | | | | | | | | | | | | | | | | | | 1.00 | -0.23* | 0.21* | 0.02 | 0.17 | -0.16 | 0.28** | -0.43** | -0.01 |
| 19 | | | | | | | | | | | | | | | | | | | 1.00 | 0.53** | 0.20* | 0.35** | -0.16 | 0.14 | 0.08 | -0.15 |
| 20 | | | | | | | | | | | | | | | | | | | | 1.00 | -0.03 | 0.87** | -0.42** | 0.35** | 0.20* | -0.02 |
| 21 | | | | | | | | | | | | | | | | | | | | | 1.00 | -0.52** | -0.42** | 0.14 | 0.01 | 0.19 |
| 22 | | | | | | | | | | | | | | | | | | | | | | 1.00 | -0.15 | 0.23* | 0.17 | -0.11 |
| 23 | | | | | | | | | | | | | | | | | | | | | | | 1.00 | -0.87** | -0.40** | -0.46** |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.37** | 0.27** |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | 1.00 | 0.59** |
| 26 | | | | | | | | | | | | | | | | | | | | | | | | | | 1.00 |

** Significant at 1% level of significance * Significant at 5% level of significance. tree height-1, leaf blade length-2, leaf blade width-3, petiole length-4, inflorescence length-5, inflorescence width-6, fruit length-7, fruit diameter-8, fruit weight-9, fruit skin thickness-10, pulp content-11, stone length-12, stone width-13, stone thickness-14, stone weight-15, seed length-16, seed width-17, seed weight-18, tss-19, total sugars-20, reducing sugars-21, non-reducing sugars-22, titratable acidity-23, tss: acid ratio-24, ascorbic acid-25, yield/plant-26

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