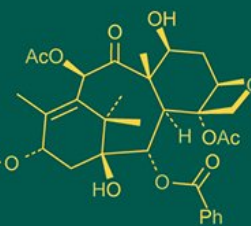
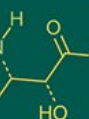
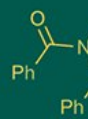


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**M Sandhyarani**  
Ph.D. Scholar, Department of  
Fruit Science, Dr. Y. S. R.  
Horticultural University, College  
of Horticulture,  
Venkataramannagudem, Andhra  
Pradesh, India

**Dr. R Rajya Lakshmi**  
Professor, Dr. Y. S. R.  
Horticultural University, College  
of Horticulture, Parvathipuram,  
Andhra Pradesh, India

**Dr. M Madhavi**  
Professor and Head  
(Horticulture), Associate Dean,  
Dr. Y.S.R. Horticultural  
University, College of  
Horticulture,  
Venkataramannagudem, Andhra  
Pradesh, India

**Dr. B Kanaka Mahalakshmi**  
Principal Scientist (Plant  
Pathology) and Head, Dr. Y.S.R.  
Horticultural University, Mango  
Research Station, Nuzvid,  
Andhra Pradesh, India

**Dr. M Paratpara Rao**  
Associate Professor (Genetics and  
Plant Breeding), Dr. Y.S.R.  
Horticultural University, College  
of Horticulture,  
Venkataramannagudem, Andhra  
Pradesh, India

**V Sekhar**  
Assistant Professor (Statistics),  
Dr. Y.S.R. Horticultural  
University, College of  
Horticulture,  
Venkataramannagudem, Andhra  
Pradesh, India

## Studies on relationship among yield and its components through path coefficient analysis in mango germplasm

**M Sandhyarani, R Rajya Lakshmi, M Madhavi, B Kanaka Mahalakshmi, M Paratpara Rao and V Sekhar**

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### Abstract

The investigation entitled “studies on relationship among yield and its components through path coefficient analysis in mango germplasm” was carried out during the period 2021-22 and 2022-2023 at Mango Research Station, Nuzvid, Eluru District, Andhra Pradesh. In the study pulp weight (g) and number of fruits/tree were showed high positive direct effect on fruit yield per tree (kg). These traits are critical in bringing an overall improvement of fruit yield directly in mango.

**Keywords:** Mango, Positive direct effect, Fruit yield per tree, Overall improvement

### 1. Introduction

Mango (*Mangifera indica* L.) is the most nutritive and delicious fruit crop belonging to the Anacardiaceae family and originated in Indo-Burma region. Due to its popularity and importance, mango is often named ‘King of fruits’ for its luscious flavour and taste. It is recognized as the pride fruit of India, being the richest source of vitamin A (4800 I.U.), vitamin C, minerals and other nutrients (Bhamini *et al.*, 2018) [2]. In India, mango is cultivated in an area of 2325 thousand hectares with production of 208.99 lakh tonnes and 9.0 MT/ha productivity. The major mango-growing states in India encompass Uttar Pradesh, Karnataka, Andhra Pradesh, Telangana, Bihar, West Bengal and Gujarat *etc.* Notably, in Andhra Pradesh it is cultivated in an area of 378.94 thousand ha, yielding a production of 4926.22 MT and productivity of 13 MT/ha (NHB Data base, 2020-21). The path coefficient analysis reveals that, whether the association of the component characters with fruit yield per tree is due to their direct effect on fruit yield per tree or is a consequence of their indirect effect via some other traits. Thus, path analysis helps in partitioning the genotypic correlation coefficient into direct and indirect effects of the component characters on fruit yield on the basis of which improvement programmes can be devised effectively.

### 2. Material and Methods

The experiment was conducted to study the relationship among yield and its components through path coefficient analysis. The experiment was laid out in an Augmented Block Design consisting of 36 genotypes and 4 checks. The details of genotypes are furnished in Table 1. Genotypes are named as per the names of the blocks *i.e.* B, C, D, E, F, G, H and I.

### Corresponding Author:

**M Sandhyarani**  
Ph.D. Scholar, Department of  
Fruit Science, Dr. Y. S. R.  
Horticultural University, College  
of Horticulture,  
Venkataramannagudem, Andhra  
Pradesh, India

**Table 1;** List of 36 genotypes and 4 checks used in the study.

| S. No. | Genotype | S. No. | Genotype                      |
|--------|----------|--------|-------------------------------|
| 1      | B-6      | 21     | F-16                          |
| 2      | B-9      | 22     | G-7                           |
| 3      | B-10     | 23     | G-19                          |
| 4      | B-17     | 24     | G-28                          |
| 5      | B-20     | 25     | G-30                          |
| 6      | C-1      | 26     | H-5                           |
| 7      | C-6      | 27     | H-7                           |
| 8      | C-13     | 28     | H-16                          |
| 9      | C-24     | 29     | H-17                          |
| 10     | D-7      | 30     | H-32                          |
| 11     | D-12     | 31     | H-49                          |
| 12     | D-13     | 32     | H-58                          |
| 13     | E-2      | 33     | I-1                           |
| 14     | E-3      | 34     | I-2                           |
| 15     | E-6      | 35     | I-3                           |
| 16     | E-8      | 36     | I-4                           |
| 17     | E-11     | 37     | Banaganapalle (Table variety) |
| 18     | F-4      | 38     | Chinnarasam (Juicy variety)   |
| 19     | F-10     | 39     | Jalal (Pickle variety)        |
| 20     | F-12     | 40     | Suvarnakha (Coloured variety) |

Path coefficient analysis was carried out by using the correlation coefficient to know the direct and indirect effects of the component characters on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959). Standard path coefficients which are the standardized partial regressing coefficients were obtained using statistical software packages called GENRES. These values were obtained by solving the following set of 'p' simultaneous equation using the above package.

$$P_{01} + P_{02}r_{12} + \dots + P_{0p}r_{1p} = r_{01}$$

$$P_{02}r_{21} + P_{02} + \dots + P_{0p}r_{2p} = r_{02}$$

$$P_{01}r_{p1} + P_{02}r_{2p} + \dots + P_{0p} = r_{0p}$$

Where,  $P_{01}$ ,  $P_{02}$ , -----  $P_{0p}$  are the direct effects of variables 1,2,-----p on the dependent variable  $0/r_{12}, r_{13}, \dots$  -----  $r_{1p}$  -----  $r_{p(p-1)}$  are the possible correlation coefficients between various independent variables/ $r_{01}$ ,  $r_{02}$ ,  $r_{03}$  -----  $r_{0p}$  are the correlation between dependent and independent variables.

The indirect effects of the  $i^{th}$  variable via  $j^{th}$  variable is attained as  $P_{0j} \times r_{ij}$ . The contribution of remaining unknown factor is measured as the residual factor, which is calculated and given below.

$$P_{0x}^2 = 1 - [P_{01}^2 + 2P_{01}P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \dots + P_{02}^2 + 2P_{02}P_{03}r_{23} + \dots + P_{0p}^2]$$

$$\text{Residual factor} = \sqrt{(P_{0x}^2)}$$

The direct and indirect effects were categorized as suggested by Lenka and Mishra (1973) [6].

| Values of direct (or) indirect effects | Rate (or) scale |
|----------------------------------------|-----------------|
| 0.00 to 0.09                           | Negligible      |
| 0.10 to 0.19                           | Low             |
| 0.20 to 0.29                           | Moderate        |
| 0.30 to 0.99                           | High            |
| > 1.00                                 | Very high       |

### 3. Results and Discussion

#### 3.1 Direct effects

It was observed from Table 2 and Figure 1 that, inflorescence length (0.045), inflorescence width (0.062), fruit weight (0.068) and total soluble solids (0.042) were showed negligible positive direct effect on fruit yield per tree. Similar results were earlier reported by Gill and Navprem (2015) [4] who revealed that fruit weight and total soluble solids had positive direct effect on fruit yield in mango.

No. of hermaphrodite flowers in the inflorescence (0.104), fruit diameter (0.189), stone length (0.105) and stone width (0.112) were showed low positive direct effect on fruit yield per tree (Table 2 and Figure 1). Similar observations with regard to positive direct effect of fruit diameter, stone length and stone width on fruit yield was earlier reported by Lal *et al.* (2017) [5] in mango. Peel weight (0.255) showed moderate positive direct effect on fruit yield per tree (Table 2 and Figure 1). The results were in line with the findings of Gill and Navprem (2015) [4] who reported that peel weight had positive direct effect on fruit yield per tree in mango. Pulp weight (0.493) and number of fruits/tree (0.729) were showed high positive direct effect on fruit yield per tree (Table 2 and Figure 1). The results were in agreement with the findings of Abdul *et al.* (2022) [1] who reported that number of fruits per tree had high positive direct effect on fruit yield per tree in mango.

Height of mature tree (-0.168), pulp to stone ratio (-0.186) and stone weight (-0.189) exhibited low negative direct effect and fruit length (-0.384) exhibited high negative direct effect on fruit yield per tree at genotypic level (Table 2 and Figure 1).

#### 3.2 Indirect effects

##### 3.2.1 Height of mature tree (m)

Height of mature tree showed positive negligible indirect effect on fruit yield per tree through inflorescence width (0.011), fruit length (0.009), number of fruits/tree (0.004) and total soluble solids (0.043). However, it had shown negative negligible indirect effect on fruit yield per tree via inflorescence length (-0.010), no. of hermaphrodite flowers

in the inflorescence (-0.043), fruit diameter (-0.040), fruit weight (-0.028), pulp weight (-0.048), peel weight (-0.029), pulp to stone ratio (-0.025), stone length (-0.000), stone width (-0.058) and stone weight (-0.009) (Table 2 and Figure 1). Similar findings with respect to plant height showed positive indirect effect on fruit yield via fruit length were earlier reported by Majumder *et al.* (2012)<sup>[7]</sup> in mango.

### 3.2.2 Inflorescence length

Inflorescence length had showed negligible positive indirect effect via inflorescence width (0.025), fruit length (0.011), fruit weight (0.004), pulp weight (0.004), peel weight (0.000), pulp to stone ratio (0.001), stone length (0.011) and stone weight (0.000) on fruit yield per tree. Further, it showed negative negligible indirect effect on fruit yield per tree via no. of hermaphrodite flowers in the inflorescence (-0.015), fruit diameter (-0.003), number of fruits/tree (-0.004), stone width (-0.002) and total soluble solids (-0.003) (Table 2 and Figure 1).

### 3.2.3 Inflorescence width

Inflorescence width exhibited negligible positive indirect effect via fruit length (0.016), fruit diameter (0.007), fruit weight (0.009), pulp weight (0.005), peel weight (0.006), pulp to stone ratio (0.004), number of fruits/tree (0.000) and stone length (0.007) on fruit yield per tree. While, it had negative negligible indirect effect through no. of hermaphrodite flowers in the inflorescence (-0.011), stone width (-0.005), stone weight (-0.002) and total soluble solids (-0.009) on fruit yield per tree (Table 2 and Figure 1).

### 3.2.4 No. of hermaphrodite flowers in the inflorescence

No. of hermaphrodite flowers in the inflorescence had showed negligible positive indirect effect via fruit length (0.034), fruit diameter (0.028), fruit weight (0.040), pulp weight (0.036), peel weight (0.028), number of fruits/tree (0.003), stone length (0.025), stone width (0.033) and stone weight (0.036) on fruit yield per tree. Further, it had negligible negative indirect effect via pulp to stone ratio (-0.011) and total soluble solids (-0.011) on fruit yield per tree (Table 2 and Figure 1).

### 3.2.5 Fruit length

Fruit length exhibited positive negligible indirect effect via number of fruits/tree (0.097) and total soluble solids (0.054) on fruit yield per tree. Further, it had negative negligible indirect effect via pulp to stone ratio (-0.057), low negative indirect effect via fruit diameter (-0.130) and stone width (-0.190), moderate negative indirect effect via fruit weight (-0.275), pulp weight (-0.273), peel weight (-0.277) and stone weight (-0.207) and high negative indirect effect via stone length (-0.319) on fruit yield per tree (Table 2 and Figure 1). Similar results were earlier reported by Gill and Navprem (2015)<sup>[4]</sup> who revealed that fruit length showed negative indirect effect on fruit yield via pulp weight and stone weight in mango.

### 3.2.6 Fruit diameter

Fruit diameter exhibited positive negligible indirect effect via pulp to stone ratio (0.071), stone length (0.020), stone width (0.065) and stone weight (0.081) and it also had low positive indirect effect via fruit weight (0.156), pulp weight (0.140) and peel weight (0.108) on fruit yield per tree. Further it showed negative negligible indirect effect via

number of fruits/tree (-0.044), total soluble solids (-0.038) on fruit yield per tree (Table 2 and Figure 1).

### 3.2.7 Fruit weight

Fruit weight showed positive negligible indirect effect via pulp weight (0.061), peel weight (0.051), pulp to stone ratio (0.017), stone length (0.037), stone width (0.038) and stone weight (0.045) on fruit yield per tree and it also showed negative negligible indirect effect via number of fruits/tree (-0.016) and total soluble solids (-0.017) on fruit yield per tree (Table 2 and Figure 1). Similar findings were earlier reported by Lal *et al.* (2017)<sup>[5]</sup> who revealed positive indirect effect on fruit yield via pulp to stone ratio, stone length and stone width in mango.

### 3.2.8 Pulp weight

Pulp weight exhibited low positive indirect effect via pulp to stone ratio (0.171) and moderate positive indirect effect via stone width (0.244) and it also showed high positive indirect effect via peel weight (0.392), stone length (0.316) and stone weight (0.334) on fruit yield per tree. Further, it had negligible negative indirect effect via number of fruits/tree (-0.073) and low negative indirect effect via total soluble solids (-0.126) on fruit yield per tree (Table 2 and Figure 1). Similar findings with respect to pulp weight which showed positive indirect effect via stone length, stone width and pulp to stone ratio on fruit yield were reported by Lal *et al.* (2017)<sup>[5]</sup> in mango.

### 3.2.9 Peel weight

Peel weight showed negligible positive indirect effect via pulp to stone ratio (0.076) and low positive indirect effect via stone length (0.153), stone width (0.145) and stone weight (0.135) on fruit yield per tree. Whereas, it had negligible negative indirect effect via number of fruits/tree (-0.007) and total soluble solids (-0.058) on fruit yield per tree (Table 2 and Figure 1). Similar results were earlier reported by Gill and Navprem (2015)<sup>[4]</sup> who revealed that peel weight showed negative indirect effect on fruit yield via total soluble solids in mango.

### 3.2.10 Pulp to stone ratio

Pulp to stone ratio had negligible positive indirect effect via number of fruits/tree (0.042), stone weight (0.073) and total soluble solids (0.028) on fruit yield per tree. It had further negligible negative indirect effect via stone length (-0.007) and stone width (-0.007) on fruit yield per tree (Table 2 and Figure 1).

### 3.2.11 Number of fruits/tree

Number of fruits/tree showed negligible positive indirect effect via total soluble solids (0.093) on fruit yield per tree. Further, it had negligible negative indirect effect via stone length (-0.081), stone width (-0.046) and stone weight (-0.017) on fruit yield per tree (Table 2 and Figure 1).

### 3.2.12 Stone length

Stone length exhibited negligible positive indirect effect via stone width (0.043) and stone weight (0.060) on fruit yield per tree. It also had negligible negative indirect effect via total soluble solids (-0.007) on fruit yield per tree (Table 2 and Figure 1). Similar findings were earlier reported by Lal *et al.* (2017)<sup>[5]</sup> who revealed positive indirect effect on fruit yield via stone length in mango.

**3.2.13 Stone width:** Stone width showed negligible positive indirect effect via stone weight (0.050) and it also had negligible negative indirect effect via total soluble solids (-0.033) on fruit yield per tree (Table 2 and Figure 1).

### 3.2.14 Stone weight

Stone weight exhibited negligible positive indirect effect via total soluble solids (0.022) on fruit yield per tree (Table 2 and Figure 1).

**Table 2:** Path coefficient analysis for different characters of mango genotypes at genotypic level.

| Characters | HMT    | IL     | IW    | NHFI   | FL     | FD     | FW     | PW     | PEW    | PSR    | NFT    | SL     | SW     | SWT    | TSS    | FYPT   |
|------------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| HMT        | -0.168 | -0.010 | 0.011 | -0.043 | 0.009  | -0.040 | -0.028 | -0.048 | -0.029 | -0.025 | 0.004  | -0.000 | -0.058 | -0.009 | 0.043  | 0.091  |
| IL         |        | 0.045  | 0.025 | -0.015 | 0.011  | -0.003 | 0.004  | 0.004  | 0.000  | 0.001  | -0.004 | 0.011  | -0.002 | 0.000  | -0.003 | -0.076 |
| IW         |        |        | 0.062 | -0.011 | 0.016  | 0.007  | 0.009  | 0.005  | 0.006  | 0.004  | 0.000  | 0.007  | -0.005 | -0.002 | -0.009 | 0.069  |
| NHFI       |        |        |       | 0.104  | 0.034  | 0.028  | 0.040  | 0.036  | 0.028  | -0.011 | 0.003  | 0.025  | 0.033  | 0.036  | -0.011 | 0.264  |
| FL         |        |        |       |        | -0.384 | -0.130 | -0.275 | -0.273 | -0.277 | -0.057 | 0.097  | -0.319 | -0.190 | -0.207 | 0.054  | 0.158  |
| FD         |        |        |       |        |        | 0.189  | 0.156  | 0.140  | 0.108  | 0.071  | -0.044 | 0.020  | 0.065  | 0.081  | -0.038 | 0.339  |
| FW         |        |        |       |        |        |        | 0.068  | 0.061  | 0.051  | 0.017  | -0.016 | 0.037  | 0.038  | 0.045  | -0.017 | 0.369  |
| PW         |        |        |       |        |        |        |        | 0.493  | 0.392  | 0.171  | -0.073 | 0.316  | 0.244  | 0.334  | -0.126 | 0.434  |
| PEW        |        |        |       |        |        |        |        |        | 0.255  | 0.076  | -0.007 | 0.153  | 0.145  | 0.135  | -0.058 | 0.476  |
| PSR        |        |        |       |        |        |        |        |        |        | -0.186 | 0.042  | -0.007 | -0.007 | 0.073  | 0.028  | -0.026 |
| NFT        |        |        |       |        |        |        |        |        |        |        | 0.729  | -0.081 | -0.046 | -0.017 | 0.093  | 0.721  |
| SL         |        |        |       |        |        |        |        |        |        |        |        | 0.105  | 0.043  | 0.060  | -0.007 | 0.202  |
| SW         |        |        |       |        |        |        |        |        |        |        |        |        | 0.112  | 0.050  | -0.033 | 0.276  |
| SWT        |        |        |       |        |        |        |        |        |        |        |        |        |        | -0.189 | 0.022  | 0.386  |
| TSS        |        |        |       |        |        |        |        |        |        |        |        |        |        |        | 0.042  | -0.019 |

Residual effect - 0.334

HMT-Height of mature tree (m), IL- Inflorescence length (cm), IW-Inflorescence width (cm), NHFI- No. of hermaphrodite flowers in the inflorescence, FL- Fruit length (cm), FD-Fruit diameter (cm), FW- Fruit weight (g), PW-Pulp weight (g), PEW- Peel weight (g), PSR- Pulp to stone ratio, NFT- Number of fruits/tree, SL-Stone length(cm), SW-Stone width (cm), SWT - Stone weight (g), TSS-Total soluble solids (°Brix), FYPT- Fruit yield (kg/tree).

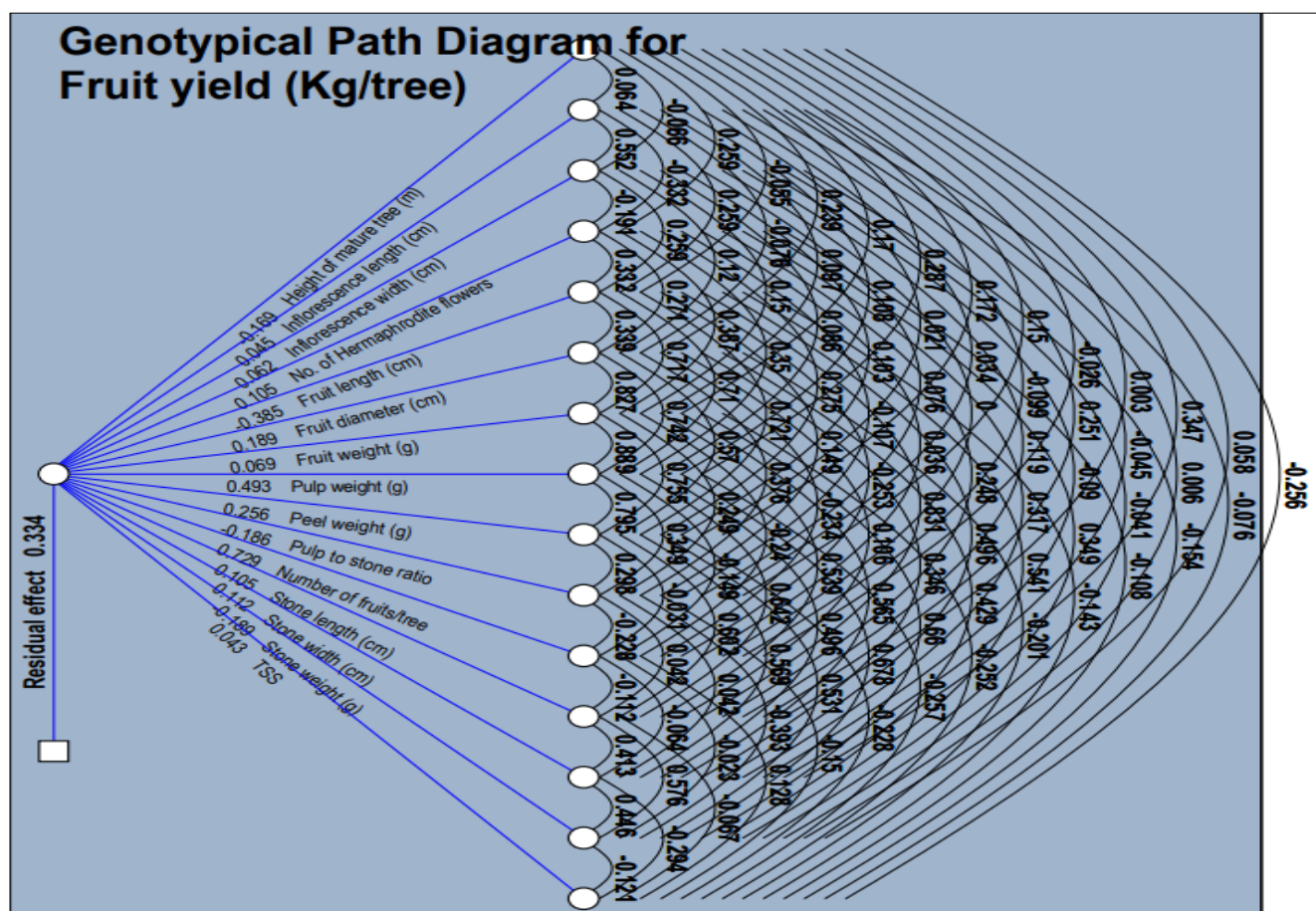


**Fig 1:** Genotypical path diagram representing direct and indirect effects on fruit yield per tree (kg) in mango genotypes.

## 4. Conclusion

In the present findings, study pulp weight (g) and number of fruits/tree were showed high positive direct effect on fruit yield per tree (kg). These traits are critical in bringing an overall improvement of fruit yield directly in mango.

## 5. Authors' Contribution

Conceptualization of research (RL,PR); Designing of the experiments (RL,PR); Contribution of experimental materials (RL,KL,M); Analysis of data and interpretation (S); Preparation of the manuscript (SR, RL, PR); Review

and editing (RL,PR).

## 6. Funding Declaration

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## 7. Conflict of Interest

The authors declare that they do not have any conflict of interest.

## 8. Data Availability

The data that support the findings of this study are available from the corresponding author, [MS], upon reasonable request.

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