Genetic variability, correlation and path analysis in tamarind (Tamarindus indica L.)

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Abstract

The present study was conducted at the Horticultural College and Research Institute, Periyakulam with the objective to estimate the extent of genotypic and phenotypic coefficient of variation, correlation and path analysis among tamarind genotypes. A remarkable variability was observed among the tamarind collections for all the characters. In all the cases, phenotypic variance was higher than the genotypic variance. Also, phenotypic coefficient of variation was found higher than genotypic coefficient of variation for all the traits. The high heritability coupled with high genetic advance as per cent over mean was observed in the traits such as pod yield plant\(^{-1}\) (98.07%; 76.103%), fruit weight (89.11%; 63.668%), fibre weight (89.95%; 91.967%), shell weight (86.19%; 58.534%) and pulp weight (74.13%; 51.533%) whereas the lowest values were recorded for pod length (34.91%; 13.945%) and tree circumference (20.34%; 8.198%). Thus, it indicated better scope for improvement of these traits through selection programme. Pod yield tree\(^{-1}\) was significantly and positively correlated with pod width, tree circumference and pulp weight. Path coefficient analysis showed that pod yield tree\(^{-1}\) contributed the maximum positive direct effect.

Keywords: GCV, heritability, PCV, tamarind genotypes, yield traits

Introduction

Tamarind (Tamarindus indica L.) is a monotypic genus tree belonging to the family Fabaceae, sub-family Caesalpiniaeae (Purseglove et al. 1987) indigenous to Tropical Africa and Southern India (Nas 1979). It is also called as ‘Indian date’, a multipurpose tree known for drought tolerance and used primarily for its fruits, which are eaten fresh or processed and used as a seasoning or spice, or the fruits and seeds are processed for non-food uses. Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Maharashtra and Karnataka are the major tamarind growing states of India. In Tamil Nadu, it is extensively cultivated in Sivagangai, Virudhunagar, Tirunelveli, Salem, Krishnagiri, Madurai, Dindigul, Theni, Dharmapuri, Tuticorin and Vellore districts. Tamarind is drought tolerant and frost tender tree and can be cultivated in any type of soil. It is estimated that India’s annual pulp production is over 1.99 lakh tonnes and it exported tamarind products worth Rs. 57 crores during 2017-2018 (Anon. 2017). The sticky pulp is often eaten fresh but has many other culinary
uses also such as pickles, jam, candy, juices, curries, sauces, chutney's and certain drinks (Archana et al. 2013). Tamarind is a highly cross pollinated and seed propagated crop; hence wide variability is common in this species. The individual variation among the trees within a population is of paramount importance and it may be worthwhile concentrating only on best trees with respect to neighbouring ones and plus trees may be selected within ecological zones for increasing their frequencies. The magnitude of variability and its quantitative estimation for each character would indicate the potential of each tree and scope for improving the desirable and economic characters through selection. With this background, the present investigation on genetic variability, correlation and path analysis in tamarind was carried out at the Horticultural College and Research Institute, Periyakulam.

Materials and methods

The study was conducted with available tamarind germplasm (31 genotypes) collected from different parts of Tamil Nadu (Table 1) in a Randomized Block Design (RBD) with 31 treatments and three replications (Panse & Sukhatme 1985) following the cultural practices as per the Crop Production Guide (2014). The genotypic and phenotypic coefficient of variation (GCV & PCV), heritability and genetic advance were estimated for eleven quantitative and qualitative characters which included tree height (m), pod length (cm), pod width (cm), tree circumference (m), shell weight (g), fibre weight (g), pulp weight (g), number of seeds pod⁻¹, fruit weight (g), acidity (%) and pod yield tree⁻¹ (kg) from ten randomly selected representative samples. Biometrical analyses were carried out to estimate genotypic and phenotypic coefficients of variation (Burton & De Vane 1953), broad sense heritability (Hanson et al. 1956), and genetic advance mean (Johnson et al. 1955), correlation studies (Al- Jibouri et al. 1958) and path co-efficient analysis (Dewey & Lu 1959) to partition the genotypic correlation coefficient into measures of direct and indirect effects.

Table 1. Tamarind collections from Tamil Nadu used in the study

| Treatment | Place of collection          |
|-----------|------------------------------|
| T1_1      | Jayamangalam, Periyakulam   |
| T1_2      | Kullapuram, Periyakulam     |
| T1_3      | Vaigaidam, Aundipatti       |
| T1_4      | Vettaikaranputhur, Pollachi |
| T1_5      | Sethumadai, Pollachi        |
| T1_6      | Rajapalayam                 |
| T1_7      | Vemparpatti, Natham         |
| T1_8      | Kanniyapuram, Natham        |
| T1_9      | Parali, Natham              |
| T1_10     | Velampatti, Natham          |
| T1_11     | Ganesapuram, Kandamanur     |
| T1_12     | Endapuli, Periyakulam       |
| T1_13     | Puthupatti, Periyakulam     |
| T1_14     | Kumbakarai, Periyakulam     |
| T1_15     | Genguvarpatti               |
| T1_16     | Senthurai, Dindigul         |
| T1_17     | Tamaraiipadi, Dindigul      |
| T1_18     | Kottampatti, Madurai        |
| T1_19     | Podinayakkakanur            |
| T1_20     | Chinnamanur                 |
| T1_21     | Chothuparai dam, Periyakulam|
| T1_22     | Gudalur                     |
| T1_23     | Lowercamp, Cumbum           |
| T1_24     | Tamaikulam, Gudalur         |
| T1_25     | Kombai, Theni               |
| T1_26     | Cumbum mettu, Theni         |
| T1_27     | Vettikadu, Cumbum           |
| T1_28     | Puthukulam, Cumbum          |
| T1_29     | Ekaluthu road, Cumbum Reserve Forest |
| T1_30     | Kailasapatti, Periyakulam   |
| T1_31     | Eriyodu, Dindigul           |
Table 2. Analysis of variance (mean squares) for eleven morphological and qualitative traits of 31 tamarind genotypes

| Character                      | Source of variation | SEd | CD 5% | CV % |
|-------------------------------|---------------------|-----|-------|------|
|                               | Replications        |      |       |      |
| Degree of freedom             | 1                   | 30  | 30    |      |
| Pod length                    | 15.85               | 10.46| 5.05  | 16.05|
| Tree height                   | 1.13                | 13.46| 5.51  | 15.64|
| Pod width                     | 1.39                | 0.61 | 0.25  | 13.48|
| Tree circumference            | 3.95                | 1.65 | 2.50  | 21.46|
| Shell weight                  | 4.10                | 4.54 | 0.34  | 12.25|
| Fibre weight                  | 0.41                | 0.41 | 0.02  | 15.73|
| Pulp weight                   | 9.27                | 11.67| 1.73  | 17.17|
| No. of seeds pod \(^1\)       | 8.89                | 4.65 | 1.08  | 12.21|
| Fruit weight                  | 7.18                | 153.89| 8.86 | 11.44|
| Acidity                       | 27.96               | 9.33 | 3.14  | 15.03|
| No. of fruits tree \(^1\)     | 1308.93             | 31146.51| 303.08| 5.23 |

Results and discussion

Analysis of variance showed significant difference among various plant parameters studied. The mean sum of squares due to various sources for different characters are presented in Table 2. The range for eleven characters of 31 tamarind genotypes is presented in Table 3. Maximum variability was recorded in pod yield (92.0–550.33 kg tree\(^{-1}\)) while the minimum was observed in fibre weight (0.27–1.67 kg tree\(^{-1}\)). The phenotypic and genotypic coefficients of variations for eleven morphological and qualitative characters of 31 tamarind genotypes are presented in Table 4. Significant difference was registered among the various characters studied. PCV was higher than GCV for all the characters reflecting the influence of environment on the phenotypic expression of these characters. Highest PCV was observed in fibre weight (49.63%) followed by pod yield (37.67%), fruit weight (34.68%), pulp weight (33.75%) and shell weight (32.97%) and the lowest PCV value was noticed with pod width (17.73%), pod length (19.39%) and tree circumference (19.56%). GCV is a better tool to understand useful variability, as it is free from the environmental components and also helps in comparison and measurement of genetic variability among different characters. The highest value was recorded for the characters such as fibre weight (47.07%), pod yield (37.30%), fruit weight (32.74%), shell weight (30.61%) and pulp weight (29.06%) whereas the lowest value was registered in tree circumference (8.82%), pod length (11.46%), pod width (11.52%), acidity (14.92%) and number of seeds pod\(^{-1}\) (16.96%). However, PCV recorded higher than GCV for all the characters of tamarind ‘genotypes’ Arif et al. (2019), Bhogave et al. (2017) and Singh & Nandini (2014) also reported similar findings.

In the present study, most of the characters exhibited high estimates of heritability such as pod yield tree\(^{-1}\) (98.07%), fibre weight (89.95%), fruit weight (89.11%), shell weight (86.19%), pulp weight (74.13%) and number of seeds pod\(^{-1}\) (62.26%). It suggests that direct selection is most effective for these characters. Moderate heritability was observed for tree height (41.92%), pod width (42.22%) and acidity (49.63%) whereas the lowest was noticed for
Table 3. Phenotypic variability for different characters in 31 tamarind genotypes

| Character                        | Mean ± S.E. | Range       | CD at 5% |
|----------------------------------|-------------|-------------|----------|
| Tree height (m)                  | 14.62 ± 2.34| 10.67 – 19.23| 4.79     |
| Pod length (cm)                  | 14.35 ± 2.24| 9.67 – 18.23 | 4.59     |
| Pod width (cm)                   | 3.68 ± 0.49 | 2.50 – 4.67  | 1.01     |
| Tree circumference (cm)          | 7.36 ± 1.58 | 5.77 – 9.23  | 3.23     |
| Shell weight (g)                 | 4.73 ± 0.58 | 2.11 – 7.34  | 1.19     |
| Fibre weight (g)                 | 0.93 ± 0.14 | 0.27 – 1.67  | 0.30     |
| Pulp weight (g)                  | 7.67 ± 1.32 | 3.10 – 11.38 | 2.69     |
| Number of seeds pod⁻¹            | 7.87 ± 1.04 | 4.67 – 10.67 | 2.13     |
| Fruit weight (g)                 | 26.00 ± 2.97| 11.17 – 50.88| 6.08     |
| Acidity (%)                      | 11.79 ± 1.77| 8.25 – 15.90 | 3.62     |
| Pod yield tree⁻¹ (kg)            | 332.89 ± 17.40| 92.00 – 550.33| 35.55    |

Tree circumference (20.34%). Arif et al. (2019) reported that high heritability was exhibited due to favourable influence of environment rather than genotype. They stated that the high estimates of heritability were recorded for the traits such as tree height, trunk diameter, tree spread, pod length, pod thickness, pod weight, pulp weight, number of seeds pod⁻¹, seed weight pod⁻¹ and pod yield etc. Our results are in accordance with the findings of Keskar et al. (1989), Karale et al. (1999), Biradar (2001), Patil (2004), Singh et al. (2008), Prasad et al. (2009) in tamarind. Genetic advance as per cent over mean was the highest for fibre weight (89.95%), pod yield tree⁻¹ (76.10%), fruit weight (63.67%), shell weight (58.53%) and pulp weight (51.53%) where as the lowest for tree circumference (8.20%), pod length (13.95%) and pod width (15.42%). High

Table 4. Estimates of PCV, GCV, heritability and genetic advance for growth parameters of 31 tamarind genotypes

| Character                        | PCV (%) | GCV (%) | Heritability (%) | Genetic advance as per cent over mean (%) |
|----------------------------------|---------|---------|------------------|------------------------------------------|
| Tree height (m)                  | 21.06   | 13.64   | 41.92            | 18.19                                    |
| Pod length (cm)                  | 19.39   | 11.46   | 34.91            | 13.95                                    |
| Pod width (cm)                   | 17.73   | 11.52   | 42.22            | 15.42                                    |
| Tree circumference (cm)          | 19.56   | 8.82    | 20.34            | 8.19                                     |
| Shell weight (g)                 | 32.97   | 30.61   | 86.19            | 58.53                                    |
| Fibre weight (g)                 | 49.63   | 47.07   | 89.95            | 91.97                                    |
| Pulp weight (g)                  | 33.75   | 29.06   | 74.13            | 51.53                                    |
| Number of seeds pod⁻¹            | 21.49   | 16.96   | 62.26            | 27.57                                    |
| Fruit weight (g)                 | 34.68   | 32.74   | 89.11            | 63.67                                    |
| Acidity (%)                      | 21.18   | 14.92   | 49.63            | 21.66                                    |
| Pod yield tree⁻¹ (kg)            | 37.67   | 37.30   | 98.07            | 76.10                                    |
heritability along with high genetic advance as per cent over mean is an important factor for predicting the resultant effect for selecting the best individuals. In the present study, genetic advance as per cent over mean recorded the highest for the characters like pod yield plant, fibre weight, fruit weight, shell weight and pulp weight and thus indicating predominance of additive gene component. Thus, there is ample scope for improving these characters based on direct selection. This is in accordance with the findings of Arif et al. (2019) and Divakara (2008) who reported high heritability coupled with high genetic advance over per cent mean for these characters.

Correlation studies were conducted to know the suitability of various characters for indirect selection (Prabhu et al. 2015). It also provides information on the nature and extent of association between any two metric traits and it will be possible to bring about genetic upgradation in one trait by selection against the other. Results of the correlation studies revealed that the pod yield tree was significantly and positively correlated with pod width (0.26), tree circumference (0.34), pulp weight (0.30), number of seeds pod (0.45) and fruit weight (0.59) (Table 5). Hence it might be inferred that these traits could be considered as the most important yield contributing traits in tamarind. This is in accordance with the findings of Prasad et al. (1998), Divakara (2008), Singh & Nandini (2014) and Mayavel et al. (2018) in tamarind. Pulp weight is one of the most important economic traits that exhibited highest positive association with fruit weight, pod length, number of seeds pod, tree circumference and pod width. Similar findings were reported by Challapilli et al. (1995) and Divakara (2008) where the fruit weight was positively and significantly associated with acidity and pod yield plant.

Path coefficient analysis of pod characters revealed that the yield tree is the most pronounced character contributing directly to the pulp weight (0.30) and fruit weight (0.59)

### Table 5: Simple correlation coefficient analysis for 11 morphological characters of 31 tamarind genotypes

| Character | Tree height (m) | Pod length (cm) | Pod width (cm) | Tree circumference (cm) | Shell weight (g) | Fibre weight (g) | Pulp weight (g) | Number of seeds pod | Fruit weight (g) | Acidity (%) | Pod yield tree (kg) |
|-----------|----------------|----------------|----------------|-------------------------|-----------------|-----------------|----------------|----------------------|----------------|-------------|-------------------|
| Tree height (m) | 1.000 | -0.099 | 0.198 | 0.508 | 1.000 | 0.946 | 0.455 | 0.904 | 0.261 | 0.213 | 0.293 |
| Pod length (cm) | 1.000 | 0.588 | 0.308 | 0.508 | 1.000 | 0.946 | 0.455 | 0.904 | 0.261 | 0.213 | 0.293 |
| Pod width (cm) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Tree circumference (cm) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Shell weight (g) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Fibre weight (g) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Pulp weight (g) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Number of seeds pod | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Fruit weight (g) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Acidity (%) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Pod yield tree (kg) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
Table 6. Path coefficient analysis of 11 morphological characters of 31 tamarind genotypes

| Character                  | Tree height (m) | Pod length (cm) | Pod width (cm) | Tree circumference (cm) | Shell weight (g) | Fibre weight (g) | Pulp weight (g) | Number of seeds pod⁻¹ | Fruit weight (g) | Acidity (%) | Pod yield tree⁻¹ (kg) |
|---------------------------|-----------------|-----------------|----------------|-------------------------|------------------|-----------------|-----------------|-------------------------|----------------|-------------|---------------------|
| Tree height (m)           | 0.3641          | 0.0303          | -0.2214        | 0.0290                  | -0.1459          | 0.012           | -0.0071         | -0.0210                 | 0.0762         | 0.0057      | 0.0810              |
| Pod length (cm)           | -0.1209         | -0.0912         | -0.3922        | 0.0406                  | 0.0455           | 0.025           | 0.1348          | 0.2743                  | 0.1376         | 0.1325      | 0.1490              |
| Pod width (cm)            | 0.1489          | -0.0661         | -0.5414        | 0.0884                  | 0.0481           | 0.005           | 0.1320          | 0.2120                  | 0.1346         | 0.1810      | 0.2570              |
| Tree circumference (cm)   | 0.1856          | -0.0651         | -0.8420        | -0.0569                 | -0.0162          | 0.007           | 0.0568          | 0.4747                  | 0.1923         | 0.4807      | 0.3400              |
| Shell weight (g)          | 0.1295          | 0.0101          | 0.0635         | 0.0023                  | -0.4101          | 0.046           | 0.0264          | 0.1591                  | 0.0292         | -0.0242     | 0.0320              |
| Fibre weight (g)          | 0.0303          | -0.0153         | 0.0198         | 0.0026                  | -0.1266          | 0.151           | 0.1252          | 0.1416                  | 0.0369         | -0.0629     | 0.2460              |
| Pulp weight (g)           | -0.0108         | -0.0515         | -0.2993        | 0.0135                  | -0.0453          | 0.079           | 0.2387          | 0.2474                  | 0.1251         | 0.0252      | 0.3000              |
| Number of seeds pod⁻¹     | -0.0143         | 0.0467          | -0.2141        | 0.0504                  | 0.1218           | 0.040           | 0.1102          | 0.5359                  | 0.1409         | 0.0415      | 0.4470              |
| Fruit weight (g)          | 0.1369          | -0.0619         | -0.3593        | 0.0539                  | -0.0591          | 0.027           | 0.1473          | 0.3724                  | 0.2028         | 0.1496      | 0.5880              |
| Acidity (%)               | 0.0053          | -0.0311         | -0.2522        | 0.0703                  | 0.0255           | -0.024          | 0.0155          | 0.0572                  | 0.0781         | 0.3868      | 0.2400              |

RESIDUAL EFFECT = 0.7060

Therefore, direct selection of these traits could be useful in tamarind improvement programme. Most other characters associated with fruit yield are contributing indirectly through the above characters (Kulkarni et al. 1995; Prasad et al. 1998; Divakara 2008; Singh & Nandini 2014; Mayavel et al. 2018) in tamarind.

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