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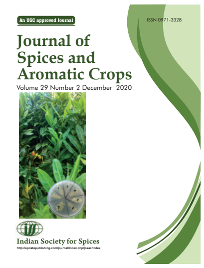

Genetic variability, correlation and path analysis in tamarind (*Tamarindus indica* L.)

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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 Caesalpiniaceae (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, chutneys 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
TI_1	Jayamangalam, Periyakulam
TI_2	Kullapuram, Periyakulam
TI_3	Vaigaidam, Aundipatti
TI_4	Vettaikaranputhur, Pollachi
TI_5	Sethumadai, Pollachi
TI_6	Rajapalayam
TI_7	Vemparpatti, Natham
TI_8	Kanniyapuram, Natham
TI_9	Parali, Natham
TI_{10}	Velampatti, Natham
TI_{11}	Ganesapuram, Kandamanur
TI_{12}	Endapuli, Periyakulam
TI_{13}	Puthupatti, Periyakulam
TI_{14}	Kumbakarai, Periyakulam
TI_{15}	Genguvarpatti
TI_{16}	Senthurai, Dindigul
TI_{17}	Tamaraipadi, Dindigul
TI_{18}	Kottampatti, Madurai
TI_{19}	Podinayakkanur
TI_{20}	Chinnamanur
TI_{21}	Chothuparai dam, Periyakulam
TI_{22}	Gudalur
TI_{23}	Lowercamp, Cumbum
TI_{24}	Tamaraikulam, Gudalur
TI_{25}	Kombai, Theni
TI_{26}	Cumbum mettu, Theni
TI_{27}	Vettikadu, Cumbum
TI_{28}	Puthukulam, Cumbum
TI_{29}	Ekaluthu road, Cumbum Reserve Forest
TI_{30}	Kailasapatti, Periyakulam
TI_{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	Treatments (genotypes)	Error			
Degree of freedom	1	30	30			
Pod length	15.85	10.46	5.05	2.25	4.59	16.05
Tree height	1.13	13.46	5.51	2.35	4.79	15.64
Pod width	1.39	0.61	0.25	0.50	1.01	13.48
Tree circumference	3.95	1.65	2.50	1.58	3.23	21.46
Shell weight	4.10	4.54	0.34	0.58	1.19	12.25
Fibre weight	0.41	0.41	0.02	0.15	0.30	15.73
Pulp weight	9.27	11.67	1.73	1.32	2.69	17.17
No. of seeds pod^{-1}	8.89	4.65	1.08	1.04	2.13	12.21
Fruit weight	7.18	153.89	8.86	2.98	6.08	11.44
Acidity	27.96	9.33	3.14	1.77	3.62	15.03
No. of fruits tree^{-1}	1308.93	31146.51	303.08	17.41	35.55	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^{-1}, 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^{-1} was significantly and positively correlated with pod width (0.26), tree circumference (0.34), pulp weight (0.30), number of seeds pod^{-1} (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^{-1}, 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^{-1}.

Path coefficient analysis of pod characters revealed that the yield tree^{-1} 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^{-1}	Fruit weight (g)	Acidity (%)	Pod yield tree^{-1} (kg)
Tree height (m)	1.000	-0.099	0.198	0.261	0.213	0.095	-0.043	-0.022	0.250	0.093	0.081
Pod length (cm)		1.000	0.508	0.455	-0.152	0.122	0.368	0.364	0.476	0.134	0.149
Pod width (cm)			1.000	0.946	-0.102	0.030	0.311	0.277	0.493	0.289	0.257
Tree circumference (cm)				1.000	-0.084	0.027	0.230	0.384	0.543	0.446	0.340
Shell weight (g)					1.000	0.289	0.092	0.240	0.145	-0.012	0.032
Fibre weight (g)						1.000	0.490	0.249	0.171	-0.122	0.246
Pulp weight (g)							1.000	0.351	0.520	0.024	0.300
Number of seeds pod^{-1}								1.000	0.605	0.086	0.447
Fruit weight (g)									1.000	0.316	0.588
Acidity (%)										1.000	0.240
Pod yield tree^{-1} (kg)											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	0.3886	0.2400

RESIDUAL EFFECT= 0.7060

(Table 6). 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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References

Al-Jibouri H H, Miller P A & Robinson H F 1958 Genotypic and environmental variances and covariances in upland cotton crosses of interspecific origin. Agron. J. 50: 633–637.

Anonymous 2017 Area and production of spices in India. Spices Board, Cochin, Kerala.

Archana P, Kukanoor L, Prabhuling G & Praveen J 2013 Standardization of methods for extraction of tamarind pulp. Karnataka J. Agric. Sci. 26: 570–571.

Arif A A, Swamy G S K, Naik N, Jagadeesha R C, Gangadharappa P M & Thammaiah N 2019 Genetic variability studies in tamarind (*Tamarindus indica* L.). Int. J. Curr. Microbiol. App. Sci. 8: 1929–1935.

Bhogave, Anilfanchu & Dalal S R 2017 Genetic variability and divergence studies in tamarind (*Tamarindus indica* L.). Ph.D. Thesis, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra.

Biradar S 2001 Evaluation of different tamarind (*Tamarindus indica* L.) genotypes. M.Sc. (Hort.) Thesis, University of Agricultural Sciences, Dharwad.

Burton G W & De Vane E W 1953 Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. Agron. J. 45: 478–481.

Challapilli A P, Chimmad V P & Hulamini N C 1995 Studies on correlation of some fruit characters in tamarind fruits. Karnataka J. Agric. Sci. 8: 114–115.

Dewey D R & Lu K A 1959 Correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agron. J. 51: 515–518.

Divakara B N 2008 Variation and character association for various pod traits in *Tamarindus indica* L. Indian Forester. 15: 687–695.

Hanson C H, Robinson & Comstock R E 1956 Biometrical studies of yield in segregating populations of Korean Lespedeza. Agron. J. 48: 268–375.

Johnson H W, Robinson H F & Comstock R E 1955 Estimates of genetic and environmental variability in soybean. Agron. J. 47: 314–318.

Karale A R, Wagh A P, Pawar B G & More T A 1999 Association of fruit characters in tamarind. J. Maharashtra Agric. Univ. 24: 319–320.

Keskar B G, Karale A R, Dhwale B C & Choudhari K G 1989 Improvement of tamarind by selection. Maharashtra J. Hort. 4: 121–124.

Kulkarni R S, Kumar B M K, Swamy G S K, Gangaprasad S & Dushyanthakumar B M 1995 Path analysis of pulp yield in tamarind (*Tamarindus indica*) across provenances of Karnataka. J. Non-Timber Forest Prod. 2: 157–159.

Mayavel A, Nagarajan B, Muthuraj K, Nicodemus A & Prabhu R 2018 Correlation and path coefficient analysis of selected red tamarind (*Tamarindus indica* var. *rhodocarpha*) genetic resources. Int. J. Curr. Microbiol. App. Sci. 7: 794–802.

Nas S 1979 In: Tropical Legumes: Resources for the Future (pp.117–121). Washington DC.

Panse V G & Sukhatme P V 1985 Statistical methods for agricultural workers. 2nd edition, ICAR, New Delhi.

Patil S S 2004 Genetic and propagation studies in tamarind (*Tamarindus indica* L.). Ph.D. (Hort.) Thesis, University of Agricultural Sciences, Dharwad.

Prabhu R, Manivannan N, Mothilal A & Ibrahim S M 2015 Correlation coefficient analysis for yield and yield attributes in groundnut (*Arachis hypogaea* L.). Plant Arch. 15: 685–689.

Prasad S G, Nagaraj T, Kulkarni R S & Swamy G S K 1998 Correlation and path analysis in tamarind (*Tamarindus indica*. L.) across two diverse provinces of Southern Karnataka. J. Agric. Sci. 11: 227–229.

Prasad S G, Rajkumar S M H, Ravikumar R L, Angadi S G, Nagaraj T E & Shanthakumar G 2009 Genetic variability in pulp yield and morphological traits in a clonal seed orchard of plus trees of tamarind (*Tamarindus indica* L.). MyForest. 45: 411–418.

Purseglove J W 1987 Tropical crops. Dicotyledons, Longuma. Science and Technology. pp. 204–206.

Singh S, Singh A K & Joshi H K 2008 Genetic variability for floral traits and yield attributes in tamarind. Indian J. Hort. 65: 328–331.

Singh T R & Nandini R 2014 Genetic variability, character association and path analysis in the tamarind (*Tamarindus indica* L.) population of Nallur tamarind grove. SAARC J. Agric. 12: 20–25.