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Genetic Variability and Association Studies among Morphological traits of *Leucaena leucocephala* (Lam.) de Wit. Genetic Resources

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Abstract

Experiment were undertaken to determine variability and correlation among the fifteen Leucaena leucocephala genetic resources from the three states of India viz., Tamil Nadu, Andhra Pradesh and Maharashtra. The observations were recorded on plant height, basal diameter, number of branches and volume index. The fifteen genotypes differed significantly for all the studied traits. The genotypes viz., FCRILL 8 and FCRILL 15 recorded significantly higher plant height, basal diameter and volume index than the rest of the genotypes. The volume index recorded maximum PCV (37.18) and GCV (28.89) and high heritability value of 0.60. The genetic advance as per cent of mean of volume index was 46.23 which were highest among all traits. Volume index exhibited positive and significant phenotypic and genotypic association with plant height (0.76), basal diameter (0.97). Basal diameter exhibited significant phenotypic (0.61) and genotypic (0.77) inter-correlation with plant height. Plant height had positive and non-significant phenotypic (0.02) and genotypic (0.16) inter-association with number of branches. The path analysis study indicated that plant height and basal diameter had direct effect on volume index.

Keywords: Genetic variability, genetic advance, heritability, path analysis, genetic resources and *Leucaena leucocephala.*

Introduction

Subabul (*Leucaena leucocephala* L. de wit) is a miracle tree with a wide assortment of cultivars for different uses like forage, timber, wind break, nitrogen fixation, pulp, etc. for short rotation forestry. Subabul has been introduced in India mainly as an agroforestry crop to meet the increasing demand for fuel, fodder, pulp and timber for poles and posts. It can be grown in variety of soils and climatic conditions due to its tolerance to high temperature and extended drought and remarkable regenerative capacity[1,2]. The nearly 100 varieties that comprise the species differ markedly in size and form and have been classified into three broad types, the Salvador, the Peru and the Hawaiian. Though the plant has a strong appeal for a multitude of uses, its primary reputation is as forage and feed. But Salvador types like K8, K28 and K67 referred to as Hawaiian giants are suitable for wood production[3].

Leucaena possesses enormous wealth of variability and great potential for economic yield which attract the breeders in utilizing the species in genetic improvement. A logical way to start any improvement programme is to survey the variations present in the germplasm. Hence, the todays challenging task is to screen the naturally available *Leucaena leucocephala* genetic resources to select the best planting material for higher biomass. Seeds from proven source or plus trees are the backbone of any successful tree improvement and afforestation programme. In order to adopt strategies of conservation and improvement, it is necessary to estimate the amount and distribution of genetic variation in preselected populations of *Leucaena leucocephala* genetic resources and it demands intensive research.

Most of the economic characters in trees are quantitative in nature. There is a wide range of variability in these characters which depends upon the genetic makeup of the individuals and the environment in which they are grown. Breeders use this variability for achieving improvement in economic characters through efficient selection techniqes[4] and knowledge of genetic parameters are required to formulate breeding strategies, as well as estimated breeding values and gains from selection[5]. Thus, the information on genetic parameters such as heritability; genetic advance and genetic correlation is a pre-requisite for making efficient selection strategies by the geneticists and breeders[6]. Due to long gestation period of trees, the analysis of juvenile growths traits is an important technique to establish the relative importance of different genotype as the determinant for improvement[7]. Also Burley and Wood[8] observed that if good correlations exist between measured traits at different stages of the tree's development, prediction of growth at an advanced age may be possible. The study aims at selection of better genotypes with higher plant height and stem diameter based on correlation with other juvenile growths traits of *Leucaena leucocephala.*

The objectives of this trial was not only to provide a base-population for selection of plus trees, but also to produce improved seeds for new plantings, through converting progeny trials into seedling seed orchards. Most studies in genetic parameters in different tree species were focused on Cotton;[9]

Casuarina equisetifolia[10]; *Bombax ceiba*[7]; *Azadirachta indica*[11] and *Simaruba glauca*[12]. In the present study, growth traits such as plant height, collar diameter, number of branches and volume index are used to estimate: (a) differences among the 15 genetic resources and (2) genetic parameters including variability, heritabilities, genetic advance, correlation and path coefficient in a base-population of 15 genetic resources of *Leucaena luecocephala*. Additionally, this information will be used to discuss the implications and selection strategies of Leucaena for getting higher productivity genotypes to serve as a base for short rotation forestry.

Keeping in view the importance of these parameters, the present study was conducted at the Forest College and Research Institute, Mettupalayam and Tamil Nadu News Print Ltd. Karur which are as follows.

Material and Methods

Genotype collection site: A thorough and extensive wild germplasm exploration survey was undertaken to identify high yielding candidate plus trees (CPTs). Seeds were collected from three states *viz.,* Tamil Nadu, Andhra Pradesh and Maharashtra during the fruiting season of Leucaena in 2008–2009 and planted at captive site of Tamil Nadu News Print Ltd. Karur. The genotypes used in this study are given in figure 1 and table 1.

Table-1
Details of *Leucaena leucocphala genetic* resources and their location

Location	Name of Assigned	District	State	Latitude	Longitude	Altitude
BAIF, Pune	FCRILL 1	Pune	Maharashtra	15°06' N	74° 57' E	500
Hyderabad I	FCRILL 2	Hyderabad	Andhra Pradesh	13° 40'N	79° 20' E	1758
Hyderabad II	FCRILL 3	Hyderabad	Andhra Pradesh	17° 20'N	78° 30' E	1890
MTP – I	FCRILL 4	Coimbatore	Tamil Nadu	11°20'N	76° 51' E	1784
MTP – II	FCRILL 5	Coimbatore	Tamil Nadu	11°20'N	76 °51' E	1550
MTP III	FCRILL 6	Coimbatore	Tamil Nadu	11°20'N	76° 51' E	1895
MTP IV	FCRILL 7	Coimbatore	Tamil Nadu	11°19'N	77°56' E	987
Coimbatore	FCRILL 8	Coimbatore	Tamil Nadu	11°37'N	77° 00' E	1328
Erode I	FCRILL 9	Erode	Tamil Nadu	11°46'N	77° 00' E	1149
Erode II	FCRILL 10	Erode	Tamil Nadu	11°46'N	77° 00' E	2707
TNPL, Karur	FCRILL 11	Karur	Tamil Nadu	10°58'N	78° 07' E	912
Sivagangai	FCRILL 12	Sivagangai	Tamil Nadu	9°43' N	77° 47' E	255
Pudukottai I	FCRILL 13	Pudukottai	Tamil Nadu	10° 2' N	77° 47' E	380
Pudukottai II	FCRILL 14	Pudukottai	Tamil Nadu	10° 37'N	77° 20' E	430
Pudukottai III	FCRILL 15	Pudukottai	Tamil Nadu	9.50' N	78°25' E	358

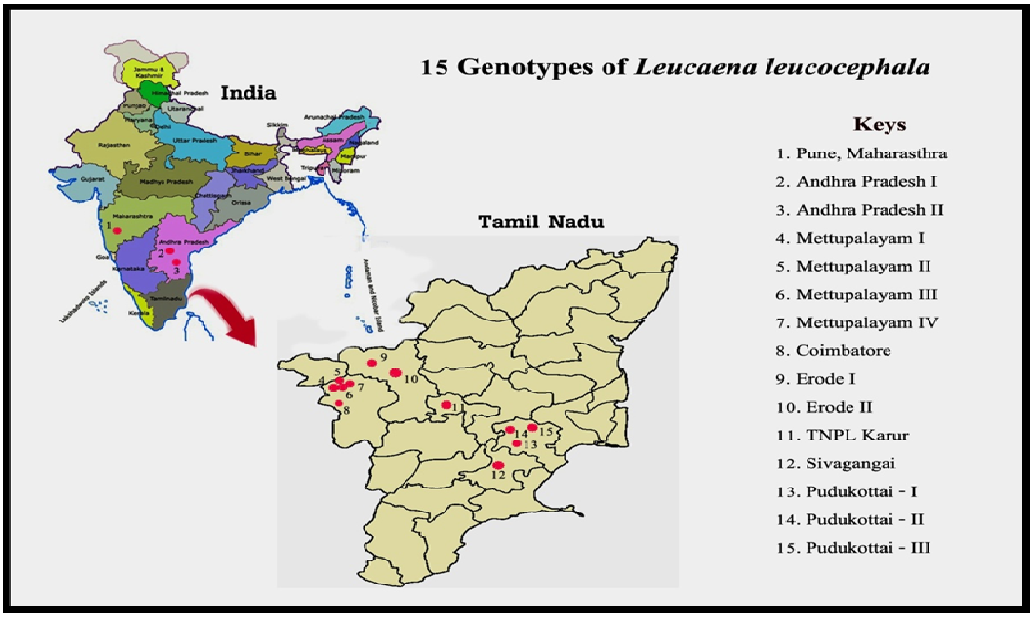

Figure-1
Distribution of 15 genotypes of *Leucaena leucocephala*

Experimental site and Morphological observation: Field evaluation trial was carried out at Athipalayam which is the captive planting site of Tamil Nadu Newsprint and Paper Ltd. (TNPL), Karur. During 2010-2011, progenies of 15 genotypes were planted in a Randomized Block Design (RBD) with three replications. The 9 plants of fifteen genotypes were planted at 3 x 3 m spacing and are replicated thrice. Observations were recorded on plant height, collar diameter, number of branches and volume index in all the 9 plants (at 9, 12 and 15 months after planting) of each replication.

Experimentation and calculation: The data on the four traits were analyzed in RBD. Genetic variability parameters, heritability and genetic advance of the traits were estimated[13,14]. Replication-wise mean values of the data of each accession were subjected to statistical analysis. The analysis of variance (ANOVA) [15] separates genetic components of variability from total variability. The broad-sense heritability[16] were calculated. Phenotypic Coefficient of variation (PCV) and Genotypic Coefficient of Variation (GCV) were estimated using following formula:

$$PCV\ (\%) = \frac{(\text{Phenotypic Variance})^{1/2}}{\text{General mean}} \times 100$$

$$GCV\ (\%) = \frac{(\text{Genotypic Variance})^{1/2}}{\text{General mean}} \times 100$$

Genotypic and phenotypic correlations co-efficients were calculated according to the method suggested by Goulden[17]. Path co-efficient analysis estimates the direct and indirect effects of each variable by using Dewey and Lu[18] methodology.

Results and Discussion

Growth performance of growth traits: Observation on morphological growth traits (15 months after planting) *viz.* plant height, basal diameter, number of branches and volume index pertaining to 15 genotypes are presented in table 2. The significant differences were found among the genotypes at 1 per cent level of significance. Only one genotype *viz.*, FCRILL 8 (565.63 cm) at one percent and three genotypes *viz.,* FCRILL 15 (554.97 cm), FCRILL 12 (547.8cm) and FCRILL 7 (545.83 cm) at five per cent level proved superior compared to grand mean (489.90 cm). The highest value of basal diameter was recorded by only one genotype FCRILL 8 (7.97 cm) at one percent level and FCRILL 15 (7.57 cm) at five percent level. A similar pattern in volume index was observed wherein FCRILL 8 and FCRILL 15 put maximum volume index. Among the 15 genotypes, two genotype *viz.*, FCRI LL 8 and FCRI LL 15 proved to be a good performer which expressed superiority for all the four characters *viz.*, height, basal diameter, volume index and number of branches investigated. A plethora of workers reported the existence of significant differences and superiority of few seed sources, progenies and provenances in various tree species like *Acacia nilotica*[19]*; Cordia alliodora*[20]; *Dalbergia sissoo*[21] which lend support to the current findings in Leucaena genetic resources.

Variability, heritability and genetic advance studies in growth attributes: The perusal of data revealed significant genetic variation among 15 genotypes of *Leucaena leucocephala* for growth attributes (table 3). Volume index registered highest Phenotypic co-efficient of variation (PCV) (37.18%) followed by basal diameter, number of branches and plant height. Volume index also registered high genotypic co-efficient of variation (GCV) (28.89%) followed by rest of the traits. The high estimates of heritability observed for number of branches (0.61) followed by volume index (0.60) and moderate heritability for height (0.55) and basal diameter (0.46). High degree of genetic advance as per cent of mean was observed for volume index (46.23%) followed by number of branches, basal diameter and plant height. The extent of variability was measured by GCV and Phenotypic co-efficient of variation (PCV) which provides information about relative amount of variation in different character[22]. In the current study; volume index registered the high PCV, GCV, heritability and genetic advance. The GCV was found to be low magnitude than the PCV for all the studied traits. This indicates that these traits are influenced by the local environmental factors as evidenced in *Acacia nilotica*[23]*,* neem[11], *Dalbergia sissoo*[24] and also in the progenies of *Melia dubia*[25] which lend supports to the results of current investigation.

The heritability states the magnitude of inheritance of quantitative traits while genetic advance provide needful information for formulating suitable selection procedure[22]. The knowledge of heredity and environment to the fullest extent will give opportunity to understand the role of heredity among quantitative traits[26]. In the present study, the high heritability with high genetic gain was observed for volume index. Hence, the higher heritability recorded in volume index, so it could be a reliable indicator for further improvement programme. High heritability coupled with high genetic advance indicated that such characters are controlled by additive gene action and it will responds effectively on phenotypic selection[5]. The findings of current study are in line with those of Ramachandra[27] in *Acacia catechu* and Devagiri[28] in *Heracleum Candicans.*

Association Studies in growth attributes of Leucaena: Correlation studies: Volume index exhibited positive and significant phenotypic association with plant height (0.76), basal diameter (0.97). It had significant genotypic correlation with plant height (0.89) and basal diameter (0.98). Basal diameter exhibited significant phenotypic (0.61) and genotypic (0.77) inter-correlation with plant height. Plant height exhibited positive and non-significant phenotypic (0.02) and genotypic (0.16) inter-association with number of branches (table 4). In the present investigation, degree of correlation co-efficient at genotypic level was higher than their corresponding phenotypic co-efficient of correlations in all the parameters indicating the genetic association among the character. The correlation

coefficient values at genotypic level were higher than phenotypic coefficient of correlations in all the parameter, which indicates the genetic association among the characters. This result is an agreement with the findings of *Pongamia pinnata.*[26] In the current study, significant and positive correlations were observed for volume index with plant height and basal diameter. The results are in agreement with earlier findings in *Casuarina equisetifolia*[10]. Plant height had positive and significant correlation with basal diameter. Similar result was reported in *Bauhinia variegata*[29]. The present investigations indicated that basal diameter and plant height could reliably serve as selection criteria to increase wood volume in Leucaena for pulp and energy wood production.

Path analysis: Though correlation analysis measures the relationship between dependent and independent characters, it does not provide exact picture of how much a character constitute on its own and *via* other characters as the dependent trait. Under such circumstances, path coefficient analysis is helpful in the resolution of correlation into components of direct and indirect effects[5]. Among the traits studied, plant height (0.33) and basal diameter (0.73) exercised higher positive direct effect on volume index. But, the number of branches (-0.017) exerted negative direct effect on volume index. The plant height exerted positive indirect effect *via* basal diameter (0.56) and number of branches (0.05). Basal diameter recorded positive and moderate indirect effect *via* plant height (0.25) and number of branches (0.19) on volume index (table 5). Path analysis gives an insight into a complex relationship between different characteristics in a biological system[30]. In the present investigation, the plant height and basal diameter exercised positive direct effect on volume index and plant height exerted positive indirect effect *via* basal diameter and number of branches. Similarly, basal diameter recorded indirect effect *via* plant height on volume index which indicated major contribution towards volume. Hence from the current study, high and positive association with intensive direct effect of plant height and basal diameter on volume index could be used as valuable and reliable measure for *Leucaena leucocephala* tree improvement programme. Wide range of research findings in different tree species *viz.*, *Simarouba glauca*[12] and *Terminalia arjuna*[31] also reported similar results these extend support to the results of current study.

Table-2
Variation in growth attributes for *Leucaena leucocephala* genetic resources (15 MAP)

Genotypes	Plant Height	Basal Diameter	Number of branches	Volume index
FCRI LL 1	421.37	5.79	6.24	14118.26
FCRI LL 2	480.63	5.52	5.25	14617.08
FCRI LL 3	450.26	5.74	6.34	14891.2
FCRI LL 4	463.89	6.68	5.52	21419.34
FCRI LL 5	481.2	6.14	6.12	18344
FCRI LL 6	499.42	5.36	5.82	14898.98
FCRI LL 7	545.83*	6.41	5.61	22633.33
FCRI LL 8	565.63**	7.97**	7.16*	35912.93**
FCRI LL 9	443.7	5.99	6.31	16272.46
FCRI LL 10	460.87	6.24	5.20	18569.49
FCRI LL 11	433.78	6.17	6.03	15473.08
FCRI LL 12	547.8*	7.59*	5.10	31785.72**
FCRI LL 13	480.94	6.25	5.40	20267.38
FCRI LL 14	518.15	6.81	7.41**	24141.33
FCRI LL 15	554.97*	7.57*	7.02*	31850.07**
Mean	489.90	6.42	6.01	21012.98
SEd	26.59	0.49	0.49	3552.35
CD (0.01)	73.50	1.35	1.35	9817.53

(* at 5% significant level, ** at 1% significant level)

Table-3
Genetic estimates for growth attributes

Traits	GCV (%)	PCV (%)	Heritability (%)	Genetic advance (%)
Height	7.77	10.49	0.55	11.85
Basal diameter	10.10	14.93	0.46	14.10
No. of branches	9.23	11.88	0.61	14.95
Volume index	28.89	37.18	0.60	46.23

Table-4
Phenotypic and genotypic correlation coefficient of growth attributes

Traits		Plant height	Basal diameter	No. of branches	Volume index
Plant height	P	1.000	0.61**	0.020	0.76**
	G	1.000	0.77**	0.16	0.89**
Basal diameter	P		1.000	0.172	0.97**
	G		1.000	0.26	0.98**
No. of branches	P			1.000	0.17
	G			1.000	0.23

**Significant at 1% level.

Table-5
Path coefficient analysis of morphometric traits on volume index

Traits	Plant height	Basal diameter	No. of branches	Correlation (r) with Volume index
Plant height	0.331	0.563	-0.003	0.331
Basal diameter	0.254	0.732	-0.05	0.732
No. of branches	0.054	0.193	-0.017	-0.017

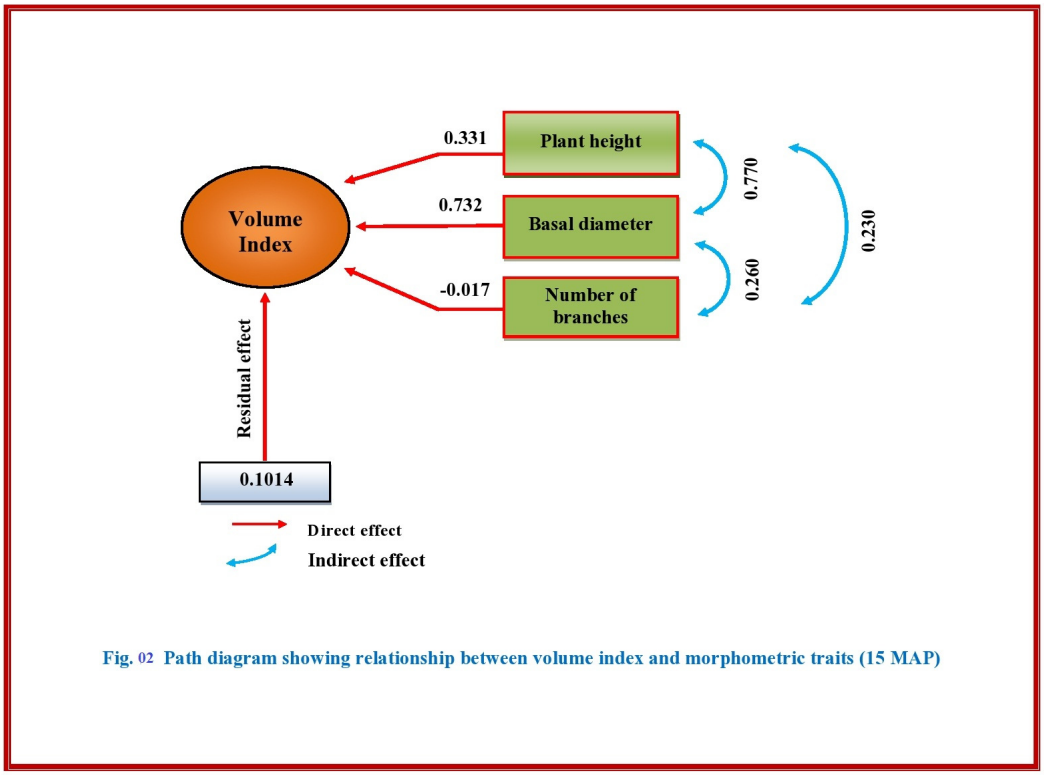

Fig. 02 Path diagram showing relationship between volume index and morphometric traits (15 MAP)

Figure 2
Path diagram showing relationship between volume index and morphometric traits (15 MAP)

Conclusion

From the current study, FCRILL 8 and FCRILL 15 recorded superiority in terms of growth characteristics *viz*., plant height, basal diameter, number of branches and volume index. These two genotypes can be exploited for future improvement programmes. Also the present investigation envisaged that high and positive association coupled with intensive direct effect by plant height and basal diameter on volume index could be used as valuable, reliable and relevant yardstick for Leucaena breeding programme. Hopefully genetic knowledge of tree species will be helpful to propagators, geneticists, breeders and tree improvement specialists in maximizing the quality and productivity of the plantation to meet their market demand over a time.

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