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Genetic Divergence in *Bombax ceiba* L. Germplasms

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Abstract

Thirty germplasm lines of *Bombax ceiba* were evaluated for ten traits to study the pattern of genetic divergence using MAHALANOBIS' D^2 statistics. The genotypes were grouped in ten clusters. Cluster II, III and IV showed greater divergence. Cluster II was the most distant from others. Clusters mean indicated that cluster III was the best for plant height, stem girth (diameter), primary and secondary branches, root length and stem biomass, while cluster II and IV was the best for root width, leaf biomass and root biomass, respectively. Based on mean performance, genetic distance and clustering pattern hybridization involving germplasm lines, belonging to cluster II, III and IV, respectively; as parents for intra-population improvement may pave way for enhancing variability so as to select progenies with greater plant height, stem diameter and improved timber quality.

Key words: Genetic divergence, germplasm, *Bombax ceiba*.

Introduction

Bombax ceiba (semal) is an important tree species in India as economic value lies mainly in rapid growth and volume production. The wood is soft, light and whitish in colour. It is in great demand as match wood and very suitable for light plywood. The semal occurs in region showing a wide variability in temperature and rainfall, but thrives best in a comparatively moist tropical climate. It is often found scattered in mixed deciduous forests and in sal (*Shorea robusta*) forests and it is a characteristic tree on grassy savannah lands, where it often becomes gregarious. Its wide distribution is due to the fact that the cotton covered seeds are carried by the wind to very considerable distance.

The species possesses enormous wealth of variability and great potential for economic yield which attract the breeders in utilizing the species in hybridization. A logical way to start any breeding programme is to survey the variations present in the germplasm. A clear understanding of the degree of divergence for important traits in the species will be an added adequate advantage in this regards, as inter-mating of divergent groups would increase variability and range of frequency distribution (ALICCHIO and PALENZONA, 1974). Precise information on the nature and degree of genetic divergence helps the plant breeder in choosing the diverse parents for purposeful hybridization (ARUNACHALAM, 1981). In a breeding programme progenies derived from diverse crosses are expected to show a broad spectrum of genetic variability, providing a greater scope for isolating transgressive segregants in the advance generations (BEALE, 1969). In fact, the work of genetic improvement of *B. ceiba* was initiated by establishing seed orchard raised in Assam during 1917 from the seed collected from all over India. At the same time F.R.I., Dehra Dun has also establish a biclonal seed orchard of the species for frost resistance. The work on organized breeding of semal was started during 1960 at F.R.I., Dehra Dun (KEDHARNATH, 1983). However, no published information on genetic divergence of this species is available from Bihar. This study is aimed at estimating the degree of genetic divergence in *B. ceiba* germplasm lines and identifying diverse genotypes to be used in future breeding and/or population improvement programmes.

Materials and Methods

Provenance collection site

B. ceiba seed lots were collectecl during 1997 from all the six agro-climatic zones of the State of Bihar in eastern India, situated between 25°58'10"N to 27°31'15"N latitude and 83°19'50'E to 88°17'40"E longitude. Greater variabilities are present within and between zones in respect of temperature, humidity, annual rainfall and topography (*Fig.1*). Zone-I and III fall between low (<1250 mm) and medium (1250 mm to 1450 mm) annual rainfall. Zone IV and V have only medium annual rainfall. Zone IV have medium and high (>1450 mm) annual rainfall. On the basis of rainfall Zone-VI is divided into two parts i.e. east and west. East portion of the Zone-VI fall under high annual rainfall whereas west part under medium annual rainfall. In respect of annual rainfall, maximum variabilities are present in Zone II. All the three, low, medium and high rainfall areas are present in the agricultural Zone II. On the basis of topography the whole State has been divided into north and central alluvial Gangetic plain and south plateau and hilly tracts. The seed lots in the present investigation are collected from all the zones in the State. The naming and categorization of collected seed lots have been done systematically.

Fig. 1. – Map of Bihar showing geographic origin of study provenances of *Bombax ceiba* from different agro-ecological zones.

Experimental site

The experiment was conducted in the Agroforestry research nursery located at the main campus of the Rajendra Agricultural University, Pusa between 25°39' N latitude and 84°40' E longitude, 52.92 m above mean sea level. The climate of Pusa is tropical monsoon. 'Pusa' receives on an average 1160 mm of annual rainfall. Of the total annual rainfall during the experimental year (1205.3 mm), the rainy season (15^{th} June to 30^{th} September) accounted for about 88% to 90%. The mean maximum temperature varied from 19.4°C (January) to 38.5°C (June) and minimum mean temperature from 8.2°C (January) to 30.70°C (May). The soil type of experimental plot is calcareous with sandy loam to loam texture with a pH value of 8.5, exchangeable sodium 6.2%, electrical conductivity 0.64 dSm^{-1}, organic carbon 0.44%, available nitrogen 50 kg ha^{-1}, available phosphorus 16 kg ha^{-1} and available 114 kg ha^{-1}.

Experimentation and calculation

Thirty germplasm lines of *B. ceiba* were collected from Gangetic alluvial plains of north and central Bihar plateau and hilly tracts of south Bihar including tribal forest of Santhal parganas through actual visit (*Table 1*). These lines were used in the present study and evaluated for ten quantitative traits in a randomized complete block design in three replications for screening and identifying the genetically diverse germplasm lines. The experiment has been planted in 4 rows of 10 m length with row to row and plant to plant distance of 50 cm x 50 cm, respectively during the month of July 1997. Two-yr-old plants were randomly harvested from each plot and replication for recording the observation on ten traits on plant basis, viz., plant height, stem girth, number of primary and secondary branches, number of leaves, root length and width, leaves, stem and root biomass. Fresh samples (500 g) for different components of plant were oven dried to constant weight. Using fresh dry weight factor, the dry weight of the plant was calculated.

Data were subjected to analysis of variance GOMEZ and GOMEZ (1984) and genetic divergence of the germplasm genotypes were studied following MAHALANOBIS' D^2 statistics (1936). Grouping of the genotypes into various clusters was made by TOCHER's method as described by RAO (1952).

Results and Discussion

The analysis of variance revealed highly significant differences among the germplasm lines for all the characters indicating adequate genetic variability in the present set of material. The Wilk's test revealed highly significant (c^2 value = 989.396) for all the characters. On the basis of D^2 values for all possible 435 pairs of populations the thirty germplasm lines were grouped into ten clusters. Cluster I had the maximum number of 8 germplasm lines followed by 7 germplasm lines of cluster IV. Although 7 culsters out of 10 represent only one or two germplasm accessions in a particular agro-climatic zone. there are four genotypes in cluster II and two in each of cluster V, VI,VII and III. Cluster III, IX and X had single genotype in each (*Table 1*). This may be due to introduction and domestication during past years. The clustering pattern of germplasms as they are of the same geographic origin, might have resulted from genetic drift followed by natural selection. The clustering pattern of different genotypes did not follow their agricultural zonal distribution suggesting that factors other than zonal separation are also responsible for divergence. Cluster means (*Table 3*) indicated that the best cluster for plant height of 281.67 cm, stem girth of 4.56 cm, number of leaves plant^{-1} of 323.33, number of primary branches plant^{-1} of 10.0, number of secondary branches plant^{-1} of 14.67, root length of 84.33 cm and stem biomass 764.0 g was cluster III. Plant height varied from 281.67 cm in cluster III to 216.77 in cluster X. Stem girth varied from 4.56 cm in cluster III to 2.93 cm in cluster X. Maximum number of primary branches (10.0) plant^{-1} was recorded in cluster III and minimum (3.50) in cluster V. It was observed that cluster IV was better for leaf biomass whereas cluster II

Table 1. – Cluster composition based on D^2 statistics of 2-yr-old *Bombax ceiba*.

Cluster	No. of genotypes	Genotypes	Zonal distribution
I	8	ICS 97101, ICS 97401, ICS 97403, ICS 97304, ICS 97502, ICS 97102, ICS 97303, ICS 97503.	I, III and V
II	4	ICS 97501, ICS 97601, ICS 97602, ICS 97504.	V and VI
III	1	ICS 97605.	VI
IV	7	ICS 97103, ICS 97201, ICS 97603, ICS 97505, ICS 97402, ICS 97604, ICS 97204.	All zones
V	2	ICS 97305, ICS 97104.	III and I
VI	2	ICS 97205, ICS 97203.	II
VII	2	ICS 97404, ICS 97301.	IV and III
VIII	2	ICS 97302, ICS 97105.	III and I
IX	1	ICS 97405.	IV
X	1	ICS 97202.	II

Table 2. – Average intra (in bold) and inter cluster distances (D) for ten cluster of 2-yr-old *Bombax ceiba* plant provenances on the basis of ten characters.

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	**17.96**	12.1	12.89	14.4	17.97	19.97	21.68	23.78	31.17	35.4
II		**13.14**	11.55	13.55	19.94	21.49	22.96	25.57	32.67	34.88
III			**0**	14.25	24.66	26.22	27.2	30.33	30.34	41.62
IV				**28.81**	21.29	22.2	24.14	25.2	33.13	43.53
V					**6.14**	5.97	7.43	7.68	15.22	19.5
VI						**5.96**	6.56	6.49	13.34	17.97
VII							**8.2**	6.16	11.6	16.38
VIII								**3.53**	8.54	13.26
IX									**0**	7.19
X										**0**

Table 3. – Cluster mean for ten characters of *Bombax ceiba.* 2-yr-old-plant provenances.

Character	I	II	III	IV	V	VI	VII	VIII	IX	X
Plant height (Cm)	249.49	227.92	281.67	250.14	257	226	248.84	241.84	241.33	216.77
Stem girth (cm)	3.68	3.4	4.56	3.85	3.68	3.53	3.43	3.33	3.16	2.93
Leaves plant^{-1}	190.1	247.25	323.33	293.05	146.33	162.83	210	163.5	241.33	133
Primary branches plant^{-1}	6.75	8.33	10	8.29	5.5	5.5	8.5	4.83	4.33	4.67
Secondry branches plant^{-1}	5.83	6.17	14.67	7.67	3.5	7.17	8.17	5.5	8	6
Root length (cm)	73.75	77.58	84.33	76.24	73	69.83	69.83	75.33	66.33	62.33
Root width (cm)	138.71	119.75	126.67	138.72	126	135	116.33	133.83	105.67	37
Leaf biomass (gr.)	215.13	409.42	477	490.38	222.17	172.83	214.33	148.33	212.33	128
Stem biomass (gr.)	706.7	679.83	764	684.14	453.17	430	397.17	364.5	262.67	191.67
Root biomass (gr.)	192.33	146.42	242.67	199.43	152.33	141.5	147.5	120.83	82.67	50.33

was better for root biomass. Intra-cluster distances D values ranged between 0.00 to 28.808 in cluster IV which was the most diversed (*Table 2*). Inter-cluster distances ranged from 5.965 between cluster V and VI to 43.529 between cluster IV and X (*Table 2*). The cluster II, III and IV showed greater divergence with all the cluster. Cluster X showed maximum divergence with all the cluster. Inter-cluster distance was maximum (43.529) between cluster IV and X followed by that between cluster III and X (41.624). The cluster III i.e., ICS 97605 thus showed great potentiality as a breeding stock by virtue of its better plant height; stem girth, number of primary and secondary branches root length and stem biomass characters as well as maximum genetic diversity. The best genotypes of cluster IX and X i.e., ICS 97405 and ICS 97202, respectively, had higher inter-cluster distance from ICS 97605. The specific cross combination of ICS 97605 with ICS 97405 and ICS 97202 and also with genotypes from cluster II i.e., ICS 97501, ICS 97601, ICS 97602 and ICS 97504 may prove beneficial for effective selection of recombinants combining plant height and stem girth and intra-specific improvement. Earlier studies, in crop plant had indicated that inter-mating of divergent groups would lead to greater opportunity for crossing over which would release latent variation by breaking up predominantly repulsion linkage (THODAY, 1960) and utilization of diverse parents in breeding was also stressed by (SINGH *et al.*, 1981; RAO *et al.*, 1981; SINGH and SINGH, 1981; BAKSHI and HEMAPRABHA, 1991), Arya *et al.* (1999) reported that significant variation in growth and biomass of tree seedlings at 1 year age. Similar observation in seedling growth was also reported for *Acacia albida* (SNIEZEKO and STEWART, 1989), *Gliricidia sepium* (NGULUBE, 1989), *Eucalyptus* and *Casuarina sp.* (TOKY and BISHT, 1991) and *Prosopis alba, P. chilenensis* and Australian *Acacia* spp. (BISHT and TOKY, 1991).

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