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Correlation and Path Analysis Studies Between Biomass and Other Characters in *Bombax ceiba* L.

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Abstract

The genotypic and phenotypic correlation and path analysis of plant biomass, plant height, stem diameter and other biomass component traits were analyzed in thirty provenances of *Bombax ceiba*. In general, the magnitude of genotypic correlations was higher than phenotypic correlations. Stem diameter and plant biomass showed highly significant genotypic correlations with all the traits except the number of secondary branches and plant biomass with leaf biomass. Plant height had the highest positive direct effect on plant biomass followed by the number of primary branches/plant and the number of leaves/plant. On the basis of this study, a higher plant biomass would be achieved through direct selection based on plant height, the number of primary branches and the number of leaves/plant. Therefore, the study is important in selection of traits of economic importance based on other characters, whose direct effect is not visible.

Key words: Bombax ceiba L., provenance, plant biomass, biomass characters, genotypic and phenotypic correlation, path coefficient.

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Introduction

Bombax ceiba (*Semal*) is an important tree species in India because its economic value lies mainly in rapid growth and volume production. The wood is soft and whitish having great value in the match and plywood industries. It is used for packing cases, planking, well-curbs and brush handles. The bark excludes a gum, known as mocha-ras which is of great medicinal value. It occurs in the region showing wide variability in temperature and rainfall, but grows best in a comparatively moist tropical climate. It is often found scattered in mixed deciduous forests and it is a characteristic tree on grassy savannah lands, where it often becomes wide spread. Its wide distribution is due to the fact that the cotton covered seeds are carried by the wind to considerable distances. It is also suitable for introduction in agroforestry system due to its clear bole and self-pruning habit of branches.

The ultimate goal of the tree breeder is to improve tree species in terms of the quality and the quantity of wood produced. This can be achieved through the selection of superior genotypes for which an indirect selection is often performed. Biomass is a complex entity and is associated with a number of component characters, which in turn are interrelated. Such interdependence of contributing factors often affects their direct relationship with fresh or dry biomass, thereby, making correlation coefficient unreliable as selection indices. As more variables are included in the correlation studies, the inherent association becomes complex, hence, role of path co-efficient analysis becomes important. In such situations, the path coefficient helps to measure the direct influence of one variable upon another and permits the separation of relative contribution of different traits to the trait of measure interest.

Correlation and path analysis, though frequently used in agricultural crops, has only recently been used in tree species (KHOSLA *et al.,* 1985; SIDDIQUI *et al.,* 1993; SRIVASTAVA and CHAUHAN, 1996; GERA *et al.,* 1999). Due to long rotation length of trees, the analysis of seedling characters is an important technique to establish the relative importance of different traits as the determinant of plant biomass. The study aims at selection of better plants with higher biomass based on correlation with other characters of *B. ceiba.*

Materials and Methods

Thirty germplasm lines of *B. ceiba* were collected from all the six agro climatic zones of undivided Bihar (now Bihar and Jharkhand) state in 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 to temperature, humidity, annual rainfall and topography (*Fig. 1*). Zones I and III fall between low (< 1,250 mm) and medium (1,250 to 1,450 mm) annual rainfall. Zone IV has both medium and high (> 1,450 mm) annual rainfall. Zone V has only medium rainfall. On the basis of rainfall, Zone VI is divided into an eastern part having high annual rainfall and a western part having medium rainfall. Maximum variabilities in rainfall occur in Zone II where all three, low, medium and high rainfall areas are present. On the basis of topography, the whole state has been divided into north and central alluvial Gangetic plain and south plateau and hilly tracts. These seed lots have been named and categorized systematically and referred as provenances.

The experiment was conducted in the Agroforestry Research Nursery of Rajendra Agricultural University, Pusa located at 25° 39' N latitude and 84° 40'E longitude, 52.9 m above mean sea level. Pusa receives 1,205 mm annual rainfall, of which the rainy season between 15th June to 30th September accounts for

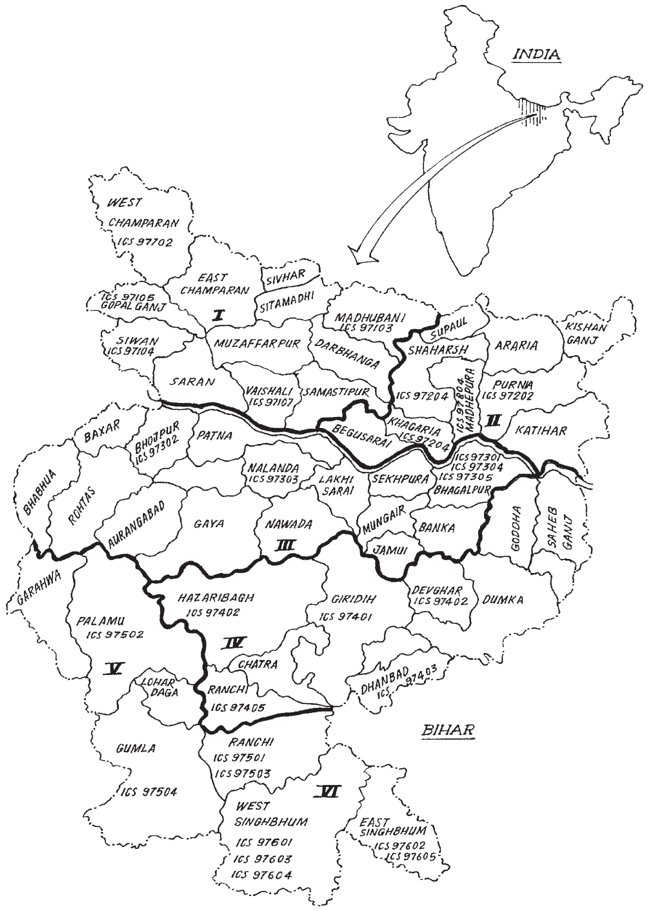

Figure 1. – Map of undivided Bihar state (now Bihar and Jharkhand states) in India showing geographic origins of the studied provenances of Bombax cieba from six different agro-ecological zones.

88 to 90% of the total annual rainfall. The mean maximum temperature varies from 19.4°C (January) to 38.5°C (June) and the mean minimum temperature from 8.2°C (January) to 30.7°C (May). The soil of the experimental plot is calcareous with sandy loam texture, pH 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 potassium 114 kg ha^{-1}.

Seed was sown in 10.0 x 1.0 m size raised (0.25m) beds in the nursery in a randomized block design with three replications during July 1997. Spacing between rows and between seeds within rows was kept at 50 cm and 25 cm, respectively. Observations on ten randomly selected and harvested two-year old seedlings included: plant height, stem diameter, the number of primary and secondary branches, the number of leaves, root length and spread and leaf, stem and root dry biomass. Fresh samples for different components of plant were oven dried to constant weight. Using fresh : dry weight factor, the dry weight of the plant was calculated. The correlation coefficients between different pairs of traits, were determined at phenotypic and genotypic levels as suggested by ROBINSON *et al.* (1951) and AL-JIBOURI *et al.* (1958). It measures the mutual relationship between plant characters and determines the characters on which selection can be made for genetic improvement. Path coefficient analysis was performed as suggested by DEWAY and LU (1959). The path coefficient analysis is simply a standardized partial regression coefficient which divides the correlation coefficient into the measures of direct and indirect contribution of independent variables on dependent variable (biomass).

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Results and Discussion

In general, the genotypic correlation coefficient values were higher than corresponding phenotypic values (*Table 1*). The genotypic correlation is an estimated value whereas, phenotypic correlation is a derived value from the genotype and environmental interaction. The genotypic correlation is, therefore, a more reliable estimate for examining the degree of relationship between character pairs. Further, the genotypic portion of the association can be indirectly judged from the estimate of coheritability.

Plant height had highly significant genotypic correlation with stem diameter (r = 0.775), root width (r = 0.479), root biomass (r = 0.369) and plant biomass (r = 0.672), whereas, at the phenotypic level it showed a significant, but negative correlation with stem diameter (r = 0.395). Stem diameter had a highly significant correlation with all the traits studied except the number of secondary branches at genotypic level, whereas, at the phenotypic level none of the characters showed a significant association. The number of leaves/plant exhibited a highly significant correlation with stem diameter, the number of pri-

Table 1. – Correlation Coefficients involving ten quantitative characters in 2-year-old *B. ceiba* plants.

Character	Stem diameter (cm)	Leaf/plant	Primary branches/ plant	Secondary branches/ plant	Root length (cm)	Root spread (cm)	Leaf biomass (gm)	Plant biomass (gm)	Root biomass (gm)
Plant height (cm)	0.775** -0.395*	0.222 0.133	0.079 0.027	0.346 0.136	1.215** 0.218	0.479** 0.198	0.164 0.115	0.672** 0.159	0.369* 0.174
Stem diameter (cm)		0.464** 0.333	0.475** 0.171	0.356 0.139	1.438** 0.224	0.527** 0.105	0.438* 0.307	0.503** 0.313	0.463** 0.308
Leaf/plant			0.791** 0.622**	0.391* 0.264	0.677** 0.008	0.242 0.207	0.951** 0.931**	0.369* 0.303	0.303 0.261
Primary branches/plant				0.023 0.028	1.246** 0.093	0.369* 0.185	0.751** 0.638**	0.512** 0.403**	0.376* 0.271
Secondary branches/ plant					-0.481** -0.068	-0.002 0.027	0.369* 0.269	-0.031 -0.021	0.091 0.074
Root length (cm)						0.524** 0.151	0.768** 0.054	0.988** 0.186	1.481**– 0.308
Root spread (cm)							0.251 0.215	0.625** 0.465**	0.476** 0.375*
Leaf biomass (gm)								0.036 0.378*	0.143 0.369*
Plant biomass (gm)									0.791** 0.769**

*, **, Significant at P = 0.05 and 0.01, respectively
Upper values for genotypic correlation coefficient and lower values for phenotypic correlation coefficient.

Table 2. – Direct (diagonal) and indirect effects in 2-year-old *B. ceiba* plants.

Character	Plant height (cm)	Stem diameter (cm)	Leaf/plant	Primary branches/ plant	Secondary branches/ plant	Root length (cm)	Root spread (cm)	Leaf biomass (gm)	Root biomass (gm)
Plant height (cm)	<u>0.879</u>	0.681	0.195	0.069	0.304	1.068	0.421	0.144	0.325
Stem diameter (cm)	-0.398	<u>-0.513</u>	-0.238	-0.244	-0.183	-0.738	-0.271	-0.225	-0.238
Leaf/plant	0.561	1.171	<u>0.521</u>	1.994	0.986	1.207	0.610	2.398	0.764
Primary branches/ plant	0.065	0.391	0.652	<u>0.824</u>	0.019	1.026	0.304	0.619	0.311
Secondary branches/ plant	-0.041	-0.042	-0.046	-0.008	<u>-0.117</u>	0.056	-0.002	-0.043	-0.011
Root length (cm)	-0.069	-0.082	-0.039	-0.071	0.027	<u>-0.057</u>	-0.031	-0.044	-0.084
Root width (cm)	0.155	0.171	0.078	0.119	0.006	0.171	<u>0.329</u>	0.082	0.154
Leaf biomass (gm)	-0.424	-1.267	-2.751	-2.172	-1.067	-2.221	-0.226	<u>-2.892</u>	-0.414
Root biomass (gm)	-0.006	-0.007	-0.005	-0.006	-0.002	-0.023	-0.003	-0.003	<u>-0.016</u>
'r' with plant biomass	0.672**	0.503**	0.369*	0.512**	-0.031	0.988**	0.625**	0.036	0.791**

Residual effect = –1.718
*, **, Significant at P = 0.05 and 0.01, respectively.

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mary branches, root length and leaf biomass at genotypic level, while only the number of primary branches and leaf biomass exhibited a positive and highly significant correlation at the phenotypic level. The number of primary branches/plant showed a positive and significant genotypic correlation with stem diameter, the number of leaves/plant, root length, root spread, leaf biomass and plant biomass. The number of primary branches was correlated at the phenotypic level with the number of leaves, leaf biomass and plant biomass (r = 0.622 and r = 0.638 and r = 0.403, respectively). The number of secondary branches was negatively correlated with root length (r = –0.481) and had a positive correlation with leaf biomass (r = 0.369) at the genotypic level. However, none of the traits were significantly correlated at the phenotypic level. Root length had higher positive effect on the genotypic correlation with all the traits at genotypic level, but was not correlated at the phenotypic level. Leaf biomass exhibited positive and significant correlation with all traits except plant height and root spread at the genotypic level. Four traits, leaves/plant, the number of primary branches, plant biomass and root biomass were positively and significantly correlated with leaf biomass at the phenotypic level. Plant biomass had a positive and highly significant correlation with all the traits except the number of secondary branches and leaf biomass at the genotypic level while the number of primary branches, root spread, leaf biomass and root biomass were positive and significantly correlated at the phenotypic level. Such results have also been reported by THOMPSON and SCHULTZ (1995) in *Quercus rubra;* SRIVASTAVA and CHAUHAN (1996) in *Bauhinia variegata;* TIKADER and ROY (1999) in *Morus species* and DHILLON *et al.* (2000) in *Dalbergia sissoo.*

Simple correlations only measures interrelationships between characters, whereas, path coefficient analysis partitions the total correlation between direct and indirect effects of other characters. Path analysis (*Table 2*) revealed that at the genotypic level plant height had the highest positive direct effect (r = 0.879) and greatest correlation with plant biomass (r = 0.672). This suggest that plant height should invariably be given the most attention in the selection for plant biomass production in *B. ceiba.* Similar results were obtained by KHOSLA *et al.* (1985) in *Pinus roxburghii* and SRIVASTAVA and CHAUHAN (1996) in *Bauhinia variegata.* The number of primary branches/plant had a direct effect on plant biomass and interrelationship (r = 0.369 and r = 0.512, respectively). Total correlation values were reduced by a higher negative indirect value of leaf biomass. The characters such as stem diameter, number of secondary branches, root length and root biomass, although having a significant positive correlation, their direct effects were negative and this is due to a higher negative value of the indirect effect of other characters. In the same way root spread had a significant correlation (r = 0.625) with plant biomass, but its direct effect was about half of the correlation value (r = 0.329) and this was due to the negative indirect effect of leaf biomass and stem diameter. The correlation values of secondary branches and its direct effect both are negative (r = –0.031 and r = –0.117, respectively). This suggested that for improvement in plant biomass, selection for the number of secondary branches should be increased. The present results are similar to the findings of JINDAL *et al.* (1987) in *Acacia senegal* and SIDDIQUI *et al.* (1993) in *Terminalia species.* High value of residual effect indicated that there could be other characters, which were not included in the present study, contributing to the variability in plant biomass.

The correlation coefficient and path analysis only analyses the relationship and dependence of variables and can not measure the effect of genotypes/provenances on dependent variable. However, CHATURVEDI and PANDEY (2001) have grouped all these thirty germplasm lines into ten clusters on the basis of D^2 values. The clustering pattern of different germplasms did not follow their agricultural zonal distribution as they are of the same geographic origin, might have resulted from genetic drift followed natural selection and suggest that factors other than zonal separation are also responsible for variance. Therefore, the provenances variable in biomass and other plant characters could not be segregated on the basis of their zonal distribution.

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