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DIVERGENCE ANALYSIS IN DIFFERENT MULBERRY SPECIES

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ABSTRACT

Divergence analysis at species level in mulberry was conducted on morphological, anatomical and reproductive traits. Based on these traits the species are grouped into clusters. *Morus alba* alone formed individual cluster for all the traits whereas *M. laevigata* formed seperate cluster for morphological and reproductive traits. *M. laevigata* formed cluster with *M. bombycis* for anatomical traits. *M. indica* and *M. sinensis* are grouped in one cluster for reproductive and morphological traits except anatomical traits exhibiting close association with each other. *M. macroura* and *M. rotundiloba* are grouped in one cluster for anatomy and reproductive traits except morphological traits which indicates their close association. Other species formed cluster with each other in different traits.

Key Words : Divergence analysis, mulberry species, morphology, anatomy, reproductive traits

Mulberry is a perennial heterozygous plant having different species. It exhibits a wide range of variation for utilization in breeding programme for further crop improvement. According to Hooker [1], the wild taxa of the genus *Morus* in India are represented by four species viz., *M. indica, M. alba, M. serrata* and *M. laevigata.* But Koidzumi [2, 3] classified the genus *Morus* into 35 species under two sections, the Doluchostylae (long style) and Macromorous (short style), under which he recognized the group Papillosae and Pubescentae based on the nature of stigmatic hairs. For further classification he used morphological characters of leaf, inflorescence and sorosis. Among the reported species, some workers tried to conduct breeding at inter or intraspecific level to exploit the performance of individual species or varieties or cultivars [4-6]. In these taxonomical classification, different species are grouped in the same class but exhibit considerable variation among themselves in respect of morphological characteristics of the shoot, bud, leaf and flower. Artificial hybridization between species is an effective way of combining the different traits of similar species than waiting for the rare appearance of chance seedlings [7, 8]. Interspecific crosses showed that the different species could hybridize readily among themselves indicating the close affinity among them [4]. *M. indica, M. latifolia, M.*

multicaulis and *M. alba* showed hybrid vigour and large number of promising plants may be obtained which are due to their high combining ability. Gupta *et al* [9] reported high genetic diversity among indigenous and exotic accessions of mulberry. But sufficient information is not available about the genetic divergence at species level based on different characters of morphological, anatomical and reproductive parameters.

Therefore, the present study was undertaken to workout the divergence among the species on different traits, to help breeders in selecting appropriate breeding material for the desired improvement.

MATERIALS AND METHODS

The germplasm accessions were collected from different Institutes and countries and maintained at SMGS, Hosur at 8′ × 8′ with 4 plants per accessions. The cultural practices, fertilizer and FYM application was followed as per recommended norms. Altogether 17 mulberry species (Table 1) are available in this germplasm station, out of which 10 species were considered for the present study.

Table 1. Distinguishing features of different species

Sl. No.	Name of the species	Origin	Salient features of species
1.	*M. australis*	Indonesia	Dorsal part of leaf rough, long style, stigma with hairs inside, black sorosis, dark purple sorosis.
2.	*M. alba*	France	Branch thick long, black grey, green, style short, fruit purplish red or white.
3.	*M. nigra*	Indonesia	Thin branch, elliptical bud shape, near round, no style, stigma with hairs inside, black sorosis.
4.	*M. cathyana*	Indonesia	Bark colour green and grey no style, leaf tip obtuse, big serrated, purplish red or white sorosis.
5.	*M. bombycis*	Japan	Bark colour blackish brown, leaf dorsal side rough, short style sharp or obtuse with short prickles, purple sorosis.
6.	*M. macroura*	Japan	Bark colour purple brown, leaf long ovate, style long,black sorosis, stigma long.
7.	*M. rotundiloba*	Burma	Bark colour purple brown, leaf long ovate, style long, black sorosis.
8.	*M. indica*	India	Style hairy long, fruit medium, long ovoid, black sorosis, bark colour greenish to brown and grey
9.	*M. sinensis*	India	Long style/short style, fruit medium, black sorosis, bark colour dark brown, leaf dark green, wrinkled and smooth.
10.	*M. laevigata*	India	Very short style

All the 17 species were not considered because some of them did not attain maturity to record reproductive traits. Six characters in morphology (leaf weight., lamina weight., lamina width, petiole length, leaf size, total shoot length), seven characters in anatomy (Idioblast frequency, palisade layer, spongy layer, lower cuticle, upper cuticle, lower epidermis and upper epidermis) and five reproductive characters (No. of flowers, style length, stigma length, fruit length and fruit diameter) were considered for this study (Table 1). For anatomical traits, leaf on 5-9th position on a twig from descending order were collected and hand section made and observed under light microscope. For morphological and reproductive characters, the data were recorded on individual plant being maintained as tree type plantation. Divergence analysis was done following the methods of Sneath and Sokal [10].

RESULTS AND DISCUSSION

In the present study 10 species were grouped into different clusters. Cluster mean, contribution (%), intercluster and intracluster distances of different species towards divergence were also worked out (Table 2-5). In morphological parameters, 10 species distributed among 5 clusters, *M. alba* and *M. laevigata* grouped in separate clusters whereas two or more than two species grouped in different clusters. Maximum inter cluster distance was observed in between cluster I and V (33.03) followed by cluster III and IV, II and V and minimum in cluster IV and V (19.45). Intra cluster distance was maximum in cluster I (9.92) and minimum in cluster III (6.18).

Table 2. Inter and intra cluster distance based on morphological characters of mulberry

Cluster	I	II	III	IV	V
I	**9.92**	11.57	17.27	17.81	33.03
II		**7.17**	12.08	9.66	24.22
III			**6.18**	8.74	24.24
IV				**0.00**	19.45
V					**0.00**

In anatomical characters, 10 species formed 6 cluster. *M. sinensis* and *M. alba* formed separate cluster (Table 3). Maximum intercluster distance was in between group IV and VI (36.30) and minimum intercluster distance was in V (5.04). So,

depending on intercluster distances, the desired accessions may be selected for further breeding purposes for crop improvement.

Table 3. Inter and intra cluster distance based on anatomical characters of mulberry

Cluster	I	II	III	IV	V	VI
I	**8.33**	10.19	10.75	17.79	17.34	28.33
II		**8.93**	10.38	15.06	12.02	27.84
III			**0.00**	13.10	13.50	28.93
IV				**14.34**	18.98	36.30
V					**5.03**	28.44
VI						0.00

In reproductive characters, 10 species formed 7 clusters. In this case more number of species alone formed separate cluster i.e. *M. australis (II)*, *M. cathyana* (IV), *M. nigra* (V), *M. alba* (VI) and *M. laevigata* (VII). Maximum inter cluster distance observed in between cluster IV and cluster VII (91.55) and minimum in cluster III and IV (3.87) whereas maximum intra cluster distance value was observed in cluster I (5.57) and minimum in cluster III (3.87). When the species are considered in combined way in respect of different characters *M. alba* and *M. laevigata* falling apart from other species in different clusters except for clusters on anatomical traits and also in different clusters but in close affinity with each other (Table 4).

Table 4. Inter and intra cluster distance based on reproductive characters of mulberry

Cluster	I	II	III	IV	V	VI	VII
I	**5.56**	9.26	7.72	6.62	7.52	13.50	87.92
II		**0.00**	11.24	12.14	6.92	18.19	91.30
III			**3.87**	4.53	5.02	14.42	89.87
IV				**0.00**	7.23	12.21	87.96
V					**0.00**	16.32	91.55
VI						8.00	76.02
VII							0.00

M. macroura and *M. rotudiloba* are always grouped in same cluster irrespective of different characters though the cluster position changed to I (morphology), II

Table 5. Cluster means and percentage contribution of morphological, anatomical and reproductive traits in classification of clusters

Character \ Cluster	I	II	III	IV	V	VI	VII	% contribution
Morphology								
Lamina width (cm)	10.08*	12.29	17.59	15.22	17.82**	-	-	4.44
Petiole length (cm)	4.59	4.09	6.66**	4.47	3.18*	-	-	15.56
Leaf weight (g)	2.17*	3.73	6.62	5.85	8.19**	-	-	33.33
Lamina weight (g)	1.86*	3.31	5.69	5.16	7.70**	-	-	20.00
Leaf size (sq.cm)	119.08	167.33*	334.83	413.33	990.33**	-	-	6.67
Tot. shoot length(cm)	980.50	1601.00**	635.67*	288.33	804.67	-	-	20.00
Anatomy								
Idioblast freq. (sq. mm)	16.07*	24.82	22.55	16.93	39.53**	20.10	-	15.56
Palisade thick (µm)	52.87	60.92	54.02	66.68	39.83*	109.35**	-	6.67
Spongy thick (µm)	51.72	59.48	54.02	75.30**	45.73	29.03*	-	28.89
Lower cuticle thick (µm)	0.92*	1.42	2.00	2.48**	1.01	1.01	-	2.22
Upper cuticle thick (µm)	6.90**	6.61	5.75	4.94	3.04*	4.05	-	20.00
Lower epidermal thick (µm)	3.74*	3.74	10.92**	9.41	6.41	4.05	-	8.89
Upper epidermal thick (µm)	19.83	25.86	19.54*	28.36**	23.63	24.30	-	17.78
Reproductive								
No. of flowers	38.33	29.67	32.17	45.66	26.33*	83.00	334.22**	42.22
Style length (mm)	0.26	0.07*	0.72**	0.63	0.51	0.52	0.20	28.89
Stigma length (µm)	1.73*	2.46	2.55	2.19	2.69**	2.54	1.79	2.22
Fruit length (cm)	2.57	1.03*	2.08	2.74	1.42	3.87	10.17**	20.00
Fruit diameter (cm)	1.02	0.81	0.86	1.29	0.77*	1.27	1.37**	6.67

*, ** indicates lower and higher mean values in cluster

(anatomy) and III (reproductive). *M. indica* and *M. sinensis* are also grouped in same cluster except for anatomy where they fill in different but closer clusters (V and VI).

The characters which show more contribution (%) towards the divergence should be considered during selection. In morphology, leaf weight (33.3%), lamina weight (20.0%) and total shoot length (20.0%), in anatomy, spongy thickness (20.0%), upper cuticle (20.0%), upper epidermal thickness (17.7%) and in reproductive, number of flowers (42.2%), style length (28.8%) and fruit length (20.0%) showing the possibility for selection of these characters.

It has been reported that some of the species do not combine with other species due to incompatibility and some of the species are commonly mixed up with each other at interspecific and intraspecific levels [4, 5]. The present study was conducted with 10 species, out of which 7 are exotic in origin and 3 are indigenous. The species like *M. australis, M. alba, M. nigra, M. cathyana, M. bombycis, M. rotudiloba, M. indica, M. sinensis* and *M. laevigata* have been used for breeding purposes [4, 5]. Among them *M. laevigata, M. cathyana* and *M. nigra* showed poor seed setting percentages. The reason may be due to their higher ploidy level or incompatibility. In the present study, the same species are also falling in different clusters and differ from each other. In general, the exotic species formed cluster among themselves. In morphological characters, no exotic species grouped with indigenous species. In anatomy, only *M. laevigata* and *M. indica* formed clusters with *M. bombycis* and *M. nigra.*

In reproductive parameters *M. sinensis* and *M. indica* grouped into same cluster with *M. bombycis.* The result indicates their close association irrespective of geographical origin which may be considered for selection of species. In the present study, the species which are closely related and grouped with each other can be selected for further utilization in breeding programmes. It has also been reported [11] that manifestation of heterosis in F1 is related to the optimum level of genetic divergence between parents. The species like *M. nigra, M. indica, M. bombycis, M. alba* and *M. sinensis* may be selected and exploited for breeding because they always show close relationship by grouping themselves in same cluster or a nearer cluster. Moreover, when different group of characters are considered, the desirable result may not be obtained due to genetic distance or otherwise but same type of characters i.e. morphological or anatomical or reproductive may help to select the species for further utilization.

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