

Genetic divergence in Brazilian cotton, *Gossypium hirsutum* var. *latifolium* Hutch.*

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ABSTRACT

Analysis of genetic divergence has been used by breeders to group genotypes and to select parents for hybridization. In this work, the D^2 statistic of Mahalanobis and canonic variables coupled with the grouping methods of Tocher and nearest neighbor were used to study divergence in seven cotton cultivars *Gossypium hirsutum* L. var. *latifolium* Hutch. The seven cultivars were, in general, divided into four groups. There was an apparent association between genetic divergence and geographic origin. Selection for disease resistance, especially against "ramulose" was an important factor in the divergence among the materials. The most divergent traits were plant height, fiber percentage and earliness.

INTRODUCTION

Analysis of genetic divergence has been used by breeders for more than two decades to classify genotypes in groups and facilitate the choice of parents for hybridization. The D^2 statistics of Mahalanobis (Jeswani *et al.*, 1970; Singh, 1981) have been used as the basis for the divergence calculation. Castro and Andrews (1971) observed that the genetic divergence among the parents used in crosses is directly related to the variability of a segregant population. Maurya and Singh (1971) commented that parents with wide genetic divergence should be used to produce better segregant types.

Divergence among populations can be assessed by genealogical studies, ecogeographical diversity, diallel analysis and, when the parents are

included, by multivariate analysis. The multivariate methods can be used to study divergence by turning the morphological and physiological data into multivariate statistics of dissimilarity in an attempt to predict the hybrid performance.

Singh *et al.* (1971) worked in India with 25 varieties of *Gossypium hirsutum* L. and studied the genetic diversity using the D^2 Mahalanobis generalized distance statistic. The 25 cultivars were divided into six groups, which were only partially dependent on their place of origin and adaptation to India. In general, no relationship between the genetic and the geographical diversity was observed, indicating that other factors besides geographical distribution were important for cultivar variability. Singh and Bains (1968) studied 33 cotton *G. hirsutum* L. hybrids derived from several crosses. The types of cotton differed significantly in a set of eight traits and in the production components; the boll size contributed maximum divergence. The 33 hybrids were organized into nine groups. The group standards were influenced by the "pedigree". The

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polygenic and pleiotropic mechanisms reduced the distances among groups. On the whole, yield contributed the most to divergence and the number of bolls had the least effect on divergence.

MATERIAL AND METHODS

A diallel cross among seven cotton cultivars was developed. The 49 treatments, including parents, hybrids and reciprocals were assessed in a randomized complete block design experiment with two replications, in Viçosa, MG in 1990. Seven traits were assessed to study the divergence of the cultivars.

The genetic divergence was studied from the phenotypic covariance matrices, obtained from the genotype means (T), and the residual covariances matrix (E).

The following techniques were used in the genetic divergence analysis:

Analysis by canonical variables

The canonical variables are used to reduce the information about the initial set of traits to a few components, which are linear combinations of those traits, thus simplifying the data analysis. The divergence, initially influenced by a *n*-dimensional set of variables (*n* = number of variables), is then assessed by a bi- or tri-dimensional set for easier geometrical interpretation.

The variance of each canonical variable was estimated by the characteristic roots of the matrix $E^{-1}T$

and the weighting coefficients by the corresponding autovector elements (Rao, 1952).

Analysis by grouping

Two methods of grouping were used, based on Mahalanobis D^2 generalized distance: Tocher's optimization method and the nearest neighbor method, both described by Singh and Chaudary (1979).

The contribution of each trait for divergence of the material studied was also assessed. The following techniques were used for this purpose:

a) The weighted coefficient of the traits in the canonical variables: According to Cruz (1990), the least relevant variables in the study of genetic divergence are those associated by the last autovectors. Standardized variables should be used for this identification, and consequently the transformed autovectors.

b) The Mahalanobis generalized distance estimates. The procedure described by Singh (1981), in which the statistic *S* is the relative importance of the trait for the divergence, was used.

RESULTS AND DISCUSSION

The results of the Table I show that there is considerable genetic variability for the most of the traits evaluated in this study. Seven genotypes were used. Three came from the USA (HR 102, C-23-3-78, C-28-28-80), and four are Brazilian cultivars (CNPA 6H, CNPA 3H, IAC 20, SU-0450-8909).

Table I - Mean performance of the cultivars used in the study of divergence in cotton. Viçosa, 1990^a.

Parents ^b	BW	NBP	NOS	PH	Y	ELS	WHS	FP	RES	MAT	FIN	L
C-28-28-80 (-)	5.65a	9.1ab	6.20a	108.1a	1576.5a	59.25b	11.10a	40.05ab	7.15a	49.30a	3.60a	32.05a
C-23-3-78 (-)	5.80a	8.30a	5.50a	82.1a	1517.5a	58.90b	10.75a	41.50b	7.55a	64.20c	4.60ab	32.05a
HR102 (R)	5.80a	11.50ab	5.90a	105.8ab	1914.0b	60.25b	9.85a	42.75b	7.00a	51.40ab	4.85ab	31.05a
CNPA 6H (I)	6.70ab	9.60ab	6.30a	114.9ab	2000.0ab	29.15ab	11.80ab	42.00b	6.60a	63.95c	4.80b	30.30a
IAC 20 (I)	7.50b	8.4a	5.80a	107.6ab	2498.0bc	90.10ab	13.15b	39.95ab	7.05a	61.40bc	4.55ab	30.90a
SU 045-8909 (S)	5.90a	10.30ab	6.60a	146.6bc	1867.5ab	10.40a	11.25ab	37.10a	6.90a	62.80c	4.10ab	32.10a
CNPA 3H (S)	5.95a	14.2b	6.30a	171.1c	2986.5c	21.65a	11.50ab	40.30ab	6.45a	61.10bc	4.65ab	30.25a
Mean	6.57	10.20	6.00	118.31	2051.43	38.52	11.34	40.52	6.95	59.16	4.30	31.24
CV(%)	4.16	13.00	4.59	8.68	8.03	22.38	4.24	1.90	6.77	4.25	5.97	1.47

a - Traits from BW to L are described in Table III.

b - Letter in parentheses means degree of resistance to ramulose: R = Resistant; S = Susceptible; I = Intermediate; - = unknown.

abc - Numbers in the same column, followed by the same letters, are not significantly different from each other.

The estimates of the D^2 distances among each pair of parents are shown in Table II. Excluding the cultivar CNPA 3H, the least distance of the cultivar SU 0450-8909 from others is still greater than among any other cultivar, showing the large divergence of SU 0450-8909, compared to the other parents. The cultivar CNPA 3H also showed large distances from the other cultivars in spite of having shown the third smallest general distance. This fact is reflected by the canonical analysis which separated SU 0450-8909 in a group isolated from other three. The analysis of the scores of the two first canonic variables which explained nearly 70% of the total variability (Table IV) suggests (Figure 1) that the genotypes fall into four groups: 1) one with the cultivar SU 0450-8909; 2) one with CNPA 6H and IAC 20; 3) one with CNPA 3H and 4) one with C-28-28-80, C-23-3-78 and HR 102. Apparently, there is an association between genetic divergence and geographic origin, but there is also a possibility that directional selection, in this case for disease resistance, has contributed to the apparent association between genetic divergence and geographic origin. Singh and Bains (1968) showed the importance of selection and adaptation for the divergence of cotton varieties in India.

Table II - Similarity measurements between pairs of parents obtained from the Mahalanobis generalized distance (D^2).

Parents	b	c	d	e	f	g
a. HR 102	120.34	43.46	46.38	52.93	22.41	85.78
b. SU0450-8909		76.61	128.80	108.47	101.22	64.94
c. CNPA 6H			67.46	26.97	57.04	27.56
d. C-23-3-78				69.02	46.05	113.88
e. IAC-20					48.45	65.95
f. C-28-28-80						93.05
g. CNPA 3H						-

The cultivars C-23-3-78, C-28-28-80 and HR 102 were introduced in Brazil and derived from CAMD, material obtained in the program of Bird (1982) through selection in intercrosses carried out to obtain gene recombinations conferring multiple resistance to diseases. They make up the fourth group, as shows the Figure 1. According to Bird (1982), the multiple resistance mechanism is due to genes causing resistance to two or more diseases, linkage among genes for resistance to several diseases, expressing an effective mechanism against pathogens which cause several diseases or with a wide pleiotropic effect. "Ramulose" is not included among this diseases considered by the author since it does not exist in the

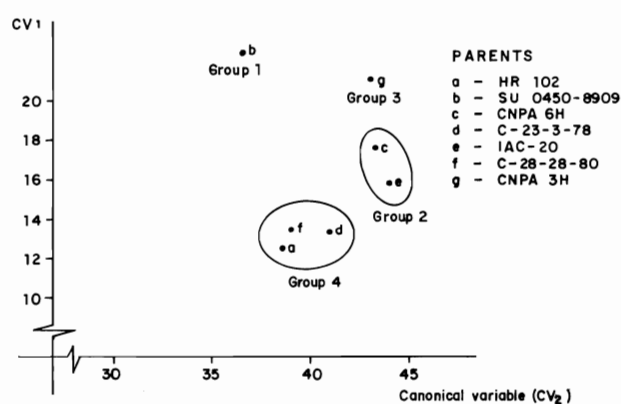


Figure 1 - Dispersion of cotton parental scores relative to the first two canonical variables.

USA. However among the introduced cultivars, HR 102 is highly resistant to ramulose.

Cultivar IAC 20 was selected for resistance to "fusariose" and is intermediate in response to ramulose, compared with HR 102. CNPA 6H also is intermediate. The level of resistance to ramulose of IAC 20 and CNPA 6H is smaller than HR 102, as shows the Table I. They form group 2.

The susceptible progenitors SU 0450-8909 and CNPA 3H make up the distinct groups 1 and 3, respectively. No selection has been carried out for disease resistance in these two late cultivars. They show great susceptibility to ramulose disease. Therefore, it seems correct to indicate selection for disease resistance as the main factor for divergence between cultivars of group 4 and the other groups. On the other hand, plant height and percentage fiber were the characteristics with the largest contribution to divergence (Table III).

Table III - Relative contribution (%) of each trait to divergence between parents based on statistic S of Singh (1981).

Trait	Abreviation	Contribution %
Boll weight (g)	BW	5.35
Nº of bolls per plant	NBP	2.68
Nº of nodes/1st fruitful branch	NOS	9.29
Plant height (cm)	PH	26.21
Yield (kg/ha)	Y	0.55
Fiber percentage (%)	FP	17.15
Weight of a hundred seeds	WHS	9.40
Earliness	ELS	11.99
Resistance of fiber (lb/mg)	RES	1.29
Maturity of fiber (astm)	MAT	6.22
Fineness of fiber (mic.)	FIN	5.75
Length of fiber (2.5% span)	L	4.05

The Tocher method showed only two groups: one with the cultivars C-28-28-80, HR 102, C-23-3-78, IAC 20, CNPA 6H and another with SU 0450-8909 and CNPA 3H. This method did not isolate CNPA 6H and IAC 20 from the cultivars C-28-28-80, HR 102 and C-23-3-78, as these have the second smallest general distance and similar pedigree, maybe due to the great divergence of the cultivar SU 0450-8909 in relation to the others. According to Singh and Bains (1968) the pedigree influences the grouping of the traits. In our work CNPA 6H and IAC 20 have the same pedigree but are kept in distinct groups by canonical analysis.

Using the nearest neighbor method as shown in Figure 2, the grouping of C-23-23-80 and HR 102, CNPA 6H and IAC 20 and the identification of SU 0450-8909 as a divergent progenitor is similar to that obtained with the other methods.

Tables III and IV show the relative importance of the traits. The most important traits for the study of genetic divergence were plant height (PH), percentage fiber (PF) and earliness (ELS).

Falconer (1987) shows that heterosis in the intervarietal hybrids depends on the dominance of the genes and on the square of the difference of the gene frequency among the parents. Therefore the great initial genetic variability included in the divergent parents is important for genetic improvement of the population (Paterniani and Miranda Filho, 1987). The analysis in Figures 1 and 2 shows that in spite of the similarity among the parents, the segregant generation from crossings among these materials can have considerable

variability. The cultivars a, f and d are similar, mainly in earliness and disease resistance, and for breeding purposes, some of them could be omitted without reducing the variability of the segregant generations.

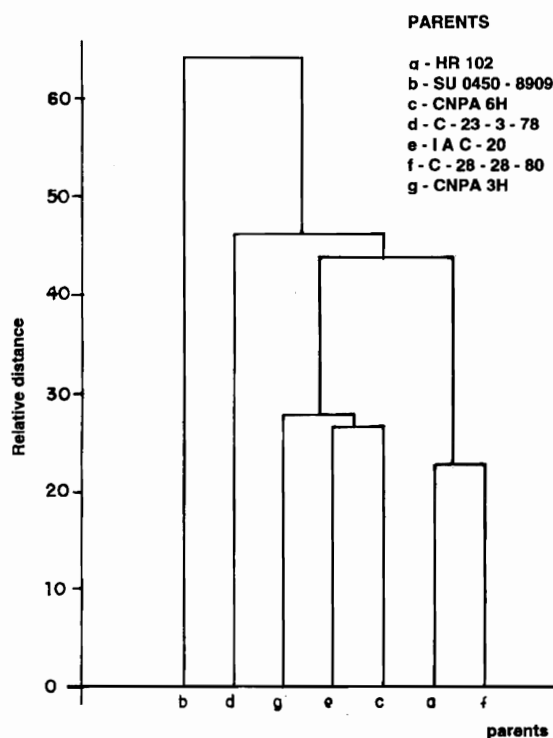


Figure 2 - Dendrogram of the genetic divergence between parents, obtained by the nearest neighbor grouping technique, using Mahalanobis D² distance as a measure of similarity.

Table IV - Estimates of the weighting coefficients of the original standardized variables expressing the relative importance of the traits for the divergence between cultivars, and accumulated variances for the canonic variables^a.

Canonical variable	BW	NBP	NOS	PH	Y	ELS	WHS	PF	RES	MAT	FIN	L	Accumulated variance
													%
1a	0.140	-0.027	0.422	0.867	-0.331	-0.591	-0.153	-0.135	-0.107	0.335	0.040	0.128	46.403
2a	-0.153	-0.079	0.038	-0.226	-0.305	-0.034	-0.943	-1.058	0.072	0.187	0.077	0.672	69.359
3a	-0.290	0.427	-0.573	-0.132	-0.188	-0.069	-0.257	-0.152	0.149	0.435	0.799	0.179	81.884
4a	0.552	0.027	-0.072	-0.487	0.133	-0.165	0.280	-0.514	0.124	0.155	-0.328	0.203	92.896
5a	-0.329	0.792	-0.164	0.246	-0.026	0.651	0.783	-0.105	0.045	0.001	-0.239	0.210	97.831
6a	-0.295	0.290	0.309	-0.024	-0.793	-0.090	0.577	0.384	-0.035	-0.181	0.162	-0.240	99.997
7a	0.166	-0.031	0.518	0.202	0.258	0.290	0.102	0.337	0.872	0.487	-0.327	0.197	99.998
8a	0.118	0.035	-0.128	0.000	-0.201	-0.339	-0.224	-0.094	0.137	-0.932	0.817	0.409	99.998
9a	0.699	0.610	-0.097	-0.126	-0.110	-0.045	-0.561	-0.069	-0.157	-0.124	-0.027	0.299	99.998
10a	0.384	-0.157	-0.262	0.867	-0.8518	0.433	0.160	-0.072	-0.008	-0.103	0.209	-0.110	99.908
11a	0.135	-0.171	0.481	-0.365	0.626	0.396	-0.380	-0.487	-0.385	0.015	0.435	0.282	99.998
12a	-0.265	-0.193	-0.184	0.389	-0.163	0.003	0.599	0.6052	-0.303	0.491	-0.580	0.579	100.000

^aTraits from BW to L are described in Table III.

RESUMO

A análise de divergência genética tem sido usada pelos melhoristas, ajudando-os a agrupar genótipos e a escolher progenitores para hibridações. No presente trabalho procurou-se estudar a divergência de sete cultivares de *Gossypium hirsutum* L. var *latifolium* Hutch, através da técnica das variáveis canônicas e de dois métodos de agrupamento o de Tocher e do vizinho mais próximo. Os sete cultivares, de maneira geral, podem ser reunidos em quatro grupos, e, apesar da aparente associação entre divergência genética e origem geográfica, deve-se levar em consideração a seleção para resistência a doenças, notadamente a ramulose como fator importante na divergência destes materiais. As características mais importantes para a diversidade foram altura de plantas, porcentagem de fibra e precocidade.

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