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Genetic divergence among thirty-one genotypes of toria (*Brassica campestris* L.) grown in twelve environments

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Summary. Thirty-one toria genotypes were grown in 12 artificially created environments in order to study genetic divergence. D^2 estimates based on 12 characters were used in obtaining the clustering pattern and inter- and intracluster distances. Selection of divergent parents has been made in three ways, i.e., on the basis of (a) genetic divergence exhibited when grown in the richest and most productive environment; (b) stable and consistent values of divergence over all 12 environments and (c) pooled analysis. Out of 31 genotypes, on the basis of stability, high yield and divergence six genotypes were found to be suitable for use in a breeding programme.

Key words: Toria – Consistent genetic divergence – D^2 – Tocher method – Stable genotypes – Heterosis

Introduction

An analysis of genetic divergence among the available germplasm appears to be important for selecting genetically diverse and stable parents for breeding cultivars. However, since genetic divergence is based on metric traits which are greatly influenced by environmental fluctuations, the selected genotypes may not carry the genes for stability. For selecting high yielding and stable genotypes on the basis of consistent divergence, it would be desirable to conduct divergence analysis in varied environments in order to overcome environmental influences to some extent.

In the present study, divergence analysis of 31 genotypes grown in 12 artificially manipulated environments is presented. Based on this analysis, genotypes have been selected for a further breeding programme.

Materials and methods

Thirty-one toria genotypes were grown in a randomised block design at Meerut for two years (1977–78, 1978–79) and at Kanpur for one year (1978–79) under four micro-environments (narrow and wide spacing; with and without fertiliser), resulting in a total of 12 environments (Singh 1982). Data were recorded on plot basis in each of the three replications.

D^2 estimates were made following Mahalanobis' (1936) generalized distance as described by Rao (1952). The 12 characters involved in the analysis were: days to flowering, days to maturity, plant height, branches per plant, siliquae per plant, grains per siliqua, length of siliqua, weight of siliqua, seed index, seed yield, dry weight and harvest index. Clusters were prepared following Tocher's method (Rao 1952) in all twelve environments and by pooled analysis (Singh 1982). For the sake of brevity, only clusters based on the richest and the most productive environment and those based on pooled analysis are presented in this article. Clustering pattern in the 12 environments and the pooled analysis were also used to select genotypes which showed consistent divergence.

Results

Clustering patterns of 31 toria genotypes estimated from the most productive environment and from data pooled over all environments are given in Table 1. The inter- and intracluster distances estimated from the most productive environment and from data pooled over all environments are given in Tables 2 and 3, respectively. Clustering pattern of 11 high yielding and stable genotypes exhibiting consistent divergence in 12 environments and in the pooled analysis is presented in Table 4.

Discussion

Toria is a cross-pollinated crop, but the development of hybrid varieties is not practiced due to lack of prerequisites for

Table 1. Distribution of 31 genotypes into different clusters in the most productive environment, and pooled analysis

Clusters	Genotypes	
	The richest and the most productive environment	Pooled analysis
I	Toria 17/18, Gurdaspur Composite-1, PT-8, Type-9(1), TH-5, PT-30, PT-10, K-1, TH-4, TL-15, PT-18, M-3	Toria 17/18, Gurdaspur Composite-1, PT-8, Type-9(1), PT-30, PT-10, Toria 2/8 Synthetic-2, K-1, Toria 1/16, PT-330, Toria 4/10
II	Ludhiana Composite-2, TH-8, Toria 1/16, Synthetic-1, TCSU-2, Toria 4/10	Type-9, TH-8, TH-5, ITSA, TCSU-1, TCSU-7, TH-4, M-3
III	Synthetic-2, Ludhiana Composite-1	TL-5, Toria 1/17, TL-16, PT-18
IV	Type-9, TH-43	Ludhiana Composite-2, Ludhiana Composite-1,
V	ITSA, TCSU-7	TH-43, TCSU-2
VI	PT-330	Bhabri
VII	Toria 1/17	Synthetic-1
VIII	Toria 2/8	PT-600
IX	TCSU-1	
X	PT-600	
XI	TL-5	
XII	Bhabri	

Table 2. Average intra- and intercluster distances ($\sqrt{D^2}$) estimated from the richest and the most productive environment. (Average intracluster distances are given in parenthesis)

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	(7.91)	13.42	12.36	9.87	13.87	16.57	11.15	9.88	11.82	21.09	10.79	19.99
II		(8.02)	11.00	9.76	9.74	10.21	12.45	16.77	13.43	16.95	19.49	17.50
III			(6.33)	13.04	14.43	12.95	10.35	11.64	17.81	24.82	18.97	11.75
IV				(6.59)	9.94	12.36	11.29	13.93	10.59	15.12	13.40	21.30
V					(9.16)	10.18	14.18	18.94	11.71	13.28	19.43	21.82
VI						–	11.17	18.27	16.64	18.49	22.71	18.79
VII							–	9.92	14.09	21.83	16.47	15.91
VIII								–	16.65	26.99	12.52	16.16
IX									–	12.51	13.30	24.88
X										–	23.58	31.53
XI											–	26.16
XII												–

Table 3. Average inter- and intracluster distances ($\sqrt{D^2}$) estimated from data pooled over 12 environments. (Average intracluster distances are given in parenthesis)

Clusters	I	II	III	IV	V	VI	VII	VIII
I	(1.87)	2.95	2.52	3.88	4.58	3.09	2.51	7.61
II		(1.88)	3.99	2.90	3.10	4.87	3.07	5.73
III			(2.06)	5.07	6.03	2.94	4.00	8.50
IV				(1.99)	2.21	5.84	4.45	6.61
V					(2.16)	6.74	5.90	5.74
VI						–	3.31	9.81
VII							–	7.22
VIII								–

developing hybrid seed for commercial purposes. Heterosis is exploited by developing synthetic and composite varieties. Breeders often select lines on the basis of their average performance. Lines which perform better under favourable environments may not do so, however, under conditions of stress. The potentiality of genotypes may as such remain concealed in poor environments. Gama and Hallauer (1980) and Gupta (1980) have also emphasized this fact. In the present study 31 genotypes were used in group constellations but only eleven genotypes were found to be of commercial interest (Singh and Gupta 1983) and were considered for breeding purposes based on their consistency in divergence. The genetic divergence between genotypes need to be comparatively stable in different environments to be of use to plant breeders. The grouping pattern of genotypes in the

Table 4. Consistency in divergence among the selected genotypes in 12 environments, and pooled analysis

Commercially desirable genotypes	Genotypes which never clustered with the genotype given in the first column in 12 environments, and in pooled analysis
Ludhiana Composite-2	PT-600, ITSA, TH-4, PT-330
PT-600	Ludhiana Composite-2, TH-8, TH-5, TCSU-1, K-1, TCSU-7, PT-330, TH-4 and TCSU-2
TH-8	PT-600
TH-5	PT-600
ITSA	Ludhiana Composite-2, PT-330
TCSU-1	PT-600
K-1	PT-600
TCSU-7	PT-600
TH-4	Ludhiana Composite-2, PT-600
PT-330	ITSA, Ludhiana Composite-2, PT-600
TCSU-2	PT-600

present study was not, however, consistent in all the environments. This could be expected because the estimates in the present study have been obtained on quantitative characters which are influenced by genotype-environment interactions. Therefore, when these estimates are obtained over a number of environments it is likely that grouping may not be exactly identical. This, however, does not mean that a breeder should study divergence in only individual environments. The need to study divergence in varying environmental conditions is apparent. Three approaches could be followed for selecting parents on the basis of divergence in different environments.

1. For the optimum expression of genetic potential of a genotype the parents could be selected on the basis of divergence exhibited in the richest and the most productive environment. Based on this criterion the clustering pattern of the 11 high yielding and stable selected genotypes from different clusters would be K-1, TH-5 and TH-4 from cluster I; Ludhiana Composite-2, TH-8 and TCSU-2 from cluster II; ITSA and TCSU-7 from cluster-V; PT-330 from cluster VI; TCSU-1 from cluster IX and PT-600 from cluster X. If intercluster distances are taken into consideration, the parents could be selected from cluster X and I or from IX and VI or from VI and I or from II and X or from VI and X as these clusters exhibit maximum intercluster distances.

2. Selection of parents could also be made on the basis of consistent divergence in different environments. Utilising this criterion, the divergence of high yielding and stable genotypes selected on the basis of stability estimates (Singh and Gupta 1983) is given in Table 4. PT-600 differs from nine other genotypes (except ITSA). TH-8, TH-5, TCSU-1, TCSU-7, K-1 and TCSU-2 are the six other genotypes which do not differ from any other genotype, except from PT-600. While PT-600 can, therefore, be involved in crosses with nine genotypes, the other six genotypes should only be crossed with PT-600.

3. PT-600, which maintains its identity even in pooled analysis, can be used in crossing programmes with any of the other 10 (rather than 9 as in 2) genotypes using this criterion. However, it must be recognised that pooled analysis may underestimate divergence since measures of divergence estimated in different environments may cancel each other out in pooled analysis. This would be apparent from the fact that the intracluster and intercluster distances in pooled analysis (Table 3) are generally much lower than those obtained in any of the twelve different environments.

It can be concluded that in view of the cross-pollinated nature of the crop, breeding strategy in toria should include the development of composites and synthetics and for this purpose stable, high yielding and divergent parents like TH-5, TCSU-2, TCSU-7, PT-330, TCSU-1 and PT-600 may be used. However, before using them for the development of synthetics, it would be desirable to find out their combining ability and genotypes with good g.c.a. could be composited into a synthetic.

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References

Gama EEG, Hallauer AR (1980) Stability of hybrids produced from selected and unselected lines of maize. Crop Sci 20:623–626

Gupta ML (1980) Genotype × environment interaction and stability analysis in Indian mustard (*Brassica campestris* L.). Unpublished PhD Thesis, Punjab Agricultural University, Ludhiana

Mahalanobis PC (1936) On the generalised distance in statistics. Proc Natl Inst Sci India 2:49–55

Rao CR (1952) Advanced statistical methods in biometric research. Wiley and Sons, New York, pp 390

Singh D (1982) Studies on genetic variability and genotype-environment interaction in toria (*Brassica campestris* L. Var. 'Toria Duth'.). Unpublished PhD Thesis, Meerut University, Meerut

Singh D Gupta PK (1983) Phenotypic stability for grain yield in toria (*Brassica campestris* L.). Indian J Genet 43 (in press)