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Selection of diverse genotypes for heterosis in yield and response in toria (*Brassica campestris* L.)

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Summary. Thirty-one genotypes of toria (*Brassica campestris* L.) were grown in twelve environments and subsequently analysed in order to select potential parents which expressed diversity for both 12 different characters (estimated by Mahalanobis' D^2 technique) and response to the environments (estimated on the basis of negative correlation between deviations in seed yield of a pair of genotypes from their respective environmental means). Coefficients of determination (r^2) were also used to measure the reliability of correlation, which is the basis of diversity of response. Stability parameters (b and S^2d) and mean seed yield were also considered in selecting potential parents. On the basis of these criteria, three pairs of genotypes (ITSA and TCSU-1, TCSU-7 and TH-8 and Ludhiana Composite-1 and TH-4) are recommended to be used as parents for hybridization programmes so that heterosis both in seed yield and response may be exploited.

Key words: Toria – Genetic diversity – D^2-correlation coefficient – Heterosis – Basic yield potential – *Brassica*

Introduction

Different methods for the selection of parents for a hybridization programme have been suggested in the past for a variety of crops. More frequently it is suggested that parents be selected through estimates of diversity measured through D^2 analysis (Mahalanobis 1936). However, in a method recently suggested by Habgood (1977), selection of parents was suggested on the basis of diversity estimated through negative correlation between deviations of performance of two genotypes from environmental means. However, since the diversity has been estimated on the basis of pattern of variation in deviations from respective environmental means, this negative correlation will only exhibit diversity in response and not necessarily in yield. Therefore, when genotypes selected on this basis are utilized in hybridization programmes the hybrids so produced may exhibit heterosis for response but not necessarily for yield. The same premise will hold true for segregants in the following generations. We therefore feel that parents in hybrid programmes should be selected not only on the basis of diversity as mentioned above, but also on the basis of diversity estimated through the Mahalanobis' D^2 technique.

It is already well established that the response of a genotype to environmental variations and its basic yield potential are governed by separate gene systems (Finlay and Wilkinson 1963; Bucio-Alanis et al. 1969; Bains 1976; Verma et al. 1978; Singh 1982). Therefore, when we select genotypes which are diverse for various morphological characters, it is not necessary that they express diversity for response to environmental variations, and vice versa.

In view of this it may be meaningful to select diverse genotypes which express diversity for different morphological characters and which are also diverse for response. In this communication, utilizing the data from our experiments in toria (*Brassica campestris* L.), we attempt to demonstrate that parents can be selected for a hybridization programme which will be genetically diverse not only for the morphological characters, but also diverse with respect to response to environmental variations. We hope that if such parents are utilized in a hybrid programme then the hybrid and progenies so obtained will express heterosis and variability not only for yield but also for response to environmental variations and, therefore, will lead to the development of cultivars suitable for cultivation under different agroclimatic conditions.

Materials and methods

Thirty-one toria genotypes were grown in a randomized block design, at Meerut for two years (1977–78) and at Kanpur for one year (1978–79), under four microenvironments (narrow and wide spacing, with and without fertilizer), resulting in a total of twelve environments (Singh 1982). Data were recorded on a plot basis in each of the three replications. Correlation coefficients between different pairs of 31 genotypes were estimated for deviations in seed yield from environmental mean. Data for only five genotypes are given in Table 1 as an illustration. Data were also analysed for stability parameters following the method suggested by Eberhart and Russell (1966). Coefficient of determination (r^2) for the 31 genotypes were estimated as suggested by Pinthus (1973).

D^2 estimates were made following Mahalanobis' generalized distance as described by Rao (1952). The twelve characters involved in the analysis included the following: 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 the 12 environments and by pooled analysis (Singh 1982; Singh and Gupta 1984).

Results and discussion

Correlations of deviations in seed yield from environmental means of each of the five selected genotypes with those in each of the 31 genotypes are given in Table 1. Estimates of stability parameters, i.e., regression coefficient (b) and deviation from regression (s^2d) along with seed yield and coefficient of determination (r^2) are also given in the Table 1.

Statistically significant negative correlations between the deviations of a pair of genotypes from the environmental means is suggested to be used as a measure of diversity between both the genotypes with respect to response. This may provide a measure of

Table 1. Stability parameters and correlation coefficients

Genotypes	Yield (g)/ plant	r^2	b	S^2d	Correlations between genotypes for deviations in seed yield from environmental means				
	(Singh and Gupta 1983)				TCSU-1	TH-4	M-3	Ludhiana Composite-2	TH-8
Toria-17/18	10.61	0.89	1.11*	3.83	–0.45	–0.14	0.03	–0.62*	–0.10
Bhabri	9.44	0.75	0.88**	3.08	–0.17	0.22	–0.39	–0.19	0.34
Ludhiana Composite-2	13.54	0.94	1.33**	2.16	0.34	0.47	–0.07	1.00	–0.09
Gurdaspur Composite-1	10.35	0.65	0.68**	8.20	0.03	0.25	–0.44	–0.33	–0.15
TL-5	7.47	0.76	0.54**	1.19	0.53	–0.35	0.24	–0.43	–0.14
PT-8	9.68	0.77	0.74**	4.37	0.64*	–0.37	–0.01	0.35	0.09
Type-9 (1)	10.77	0.93	1.07**	1.77	–0.06	–0.07	–0.58*	0.21	0.63*
Type-9	10.55	0.92	0.99**	1.00	0.41	–0.02	–0.26	0.12	0.59*
PT-600	11.98	0.79	1.06**	10.03	–0.46	0.16	0.14	–0.23	0.04
TH-8	11.71	0.88	1.00**	2.74	–0.26	0.18	–0.39	–0.09	1.00
TH-5	12.09	0.78	0.85**	5.87	–0.06	0.53	0.59*	0.05	0.07
ITSA	11.71	0.85	1.12**	7.08	–0.56*	0.09	–0.59*	0.05	0.44
TCSU-1	11.23	0.89	0.95**	1.91	1.00	–0.21	0.01	0.35	–0.26
PT-30	9.89	0.88	0.89**	1.70	0.37	0.25	0.18	0.13	–0.55
PT-10	10.11	0.83	1.06**	7.32	–0.0.18	0.03	–0.30	0.20	0.51
Toria-21/8	10.65	0.75	0.96**	10.68	0.35	0.33	0.27	0.22	–0.22
Synthetic-2	10.77	0.88	0.96**	3.16	–0.38	–0.02	0.25	–0.03	–0.67*
K-1	11.51	0.87	1.16**	5.57	0.30	0.59*	0.32	0.66*	0.13
TH-43	13.17	0.70	1.03**	16.82*	0.09	–0.47	–0.69*	–0.17	–0.17
Toria-1/16	10.96	0.89	1.25**	5.25	–0.40	0.32	–0.19	0.38	0.51
TCSU-7	12.04	0.92	1.10**	1.78	0.29	0.21	0.09	0.60	–0.77**
Toria-1/17	9.28	0.82	0.83**	3.55	–0.02	0.04	0.09	–0.02	–0.42
Synthetic-1	12.52	0.77	1.43**	22.99**	–0.58*	–0.53	0.34	0.23	0.09
TH-4	11.58	0.94	1.05**	0.55	–0.21	1.00	0.24	0.47	0.18
PT-330	11.22	0.78	1.04**	10.45	–0.18	–0.48	–0.05	–0.10	–0.26
TL-15	9.08	0.80	0.78**	3.72	0.14	0.06	0.80**	–0.37	–0.38
TCSU-2	14.42	0.80	1.08**	10.02	–0.19	0.18	–0.05	0.22	–0.44
Ludhiana Composite-1	15.01	0.53	1.18**	49.64	0.15	–0.59*	0.07	–0.34	–0.03
PT-18	8.97	0.92	0.93**	0.59	0.47	0.14	0.13	0.37	0.27
M-3	10.24	0.72	0.86**	0.70	0.01	0.24	1.00	–0.07	–0.39
Toria 4/10	10.38	0.74	1.08**	14.74*	0.09	–0.64*	–0.66*	–0.24	–0.27

*, ** Significant at 5% and 1% level of probability, respectively

potential breeding value of the cross made between them and, hence, possibly the heterotic effects may be obtained in response of the hybrid to environmental variations. The crosses so obtained will be screened for magnitude and direction of heterosis. Positive heterosis will be indicated by increased sensitivity of the hybrid towards environmental variations. As a matter of fact, the genotypes exhibiting a higher response towards rich environmental conditions will be equally responsive towards conditions of stress. Therefore, the hybrid exhibiting positive heterosis in response will be more suitable for farming conditions where a farmer can economically afford to save the crop from the adverse effects of higher responses causing more susceptibility towards pests and disease. However, some uncontrollable effects of positive heterosis may limit its utility for commercial purposes. Negative heterosis in response will be desirable under economically poor farming conditions where scant use of agricultural chemicals and machinery limits the farmer's control over the adverse effects of G×E interactions.

Further, an estimate of coefficient of determination (r^2) (Pinthus 1973), as an additional parameter (it is not derived from the r values discussed above), can be used to measure the reliability of correlation coefficient. The coefficient of determination is equal to $b^2 x_i^2$, where b is regression coefficient of genotypic performance onto x_i, the environmental additive effects (Perkins and Jinks 1968). It (r^2) measures the extent of linear variation in genotypic performance over a range of environments. Therefore, with the help of r^2, genotypes can be ranked in order of the linear component of variation in seed yield over different environments. The correlation coefficient between genotypes which had high r^2 estimates will be more reliable than that between the genotypes which had low r^2 estimates, since in the latter case, estimates of correlations between the deviations- from environmental means of genotypes will also be influenced by random variations in genotypic performance ascribed to unpredictable factors. For instance, in toria (*Brassica campestris* L.), the correlation (0.60) between the genotypes Ludhiana composite-2 ($r^2=0.94$) and TCSU-7 ($r^2=0.92$) will be more reliable than the correlation (−0.69) between the genotypes TH-43 ($r^2=0.70$) and M-3 ($r^2=0.72$), irrespective of their magnitude and direction (Table 1).

The heterosis obtained in response does not rule out the possibility of simultaneous manifestations of heterosis in yield. Therefore, it will be highly desirable to select the parents which showed negative correlations between deviations in their performance from environmental means and were divergent with respect to several morphological characters. In the data presented in Table 1, it may be noticed that 11 pairs of genotypes exhibited divergence with respect to response (as identified on the basis of significant negative correlation) and therefore may be used for obtaining heterosis in response. But only those crosses which involve high yielding parents will be more valuable. However, it may also be argued that some of these crosses involving parents poor in yield may exhibit heterotic effects in response and may also give higher yield because such hybrids may respond to increased doses of fertilizers. Among the 11 pairs mentioned above, three crosses (ITSA×TCSU-1; TCSU-7×TH-8; and Ludhiana Composite-1×TH-4) involve parents, which are *firstly*, high yielding, secondly, had significant and negative correlation between their deviations in seed yield from environmental means; *thirdly*, were divergent with respect to 12 characters used for D^2 analysis; *fourthly* were stable, except for Ludhiana Composite-1 which had highest seed yield, but was unstable due to high value of deviation from regression and finally they have high values of r^2, except in case of Ludhiana Composite-1. Therefore, these crosses may be used to obtain heterosis in response as well as in yielding ability.

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