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Selection of isoresponsive genotypes in toria (*Brassica campestris* L.) based on the pattern of response to environmental variations: a proposed method

D. Singh
G. B. Pant University of Agriculture and Technology, Western Campus, Daurala, P.O. Modipuram, Meerut, India

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Summary. Thirty-one toria genotypes were compared with three well-established cultivars, 'Ludhiana Composite-2', 'K-1' and 'TCSU-2' (standard testers). The genotypes, which were almost identical to a standard tester in response to environmental variations and which also had other desirable characteristics, were considered to be acceptable for commercial cultivation. Using this criterion, 'TCSU-7', 'TH-5' and 'TH-4' were found to be acceptable for commercial cultivation. 'TH-4' and 'TCSU-7' were found superior to 'TH-5' if r^2 can be considered as a measure of the agronomical manipulations expected in environmental variations.

Key words: Toria – *Brassica campestris* – Isoresponsive genotypes – Standard tester – Correlation coefficient – r^2

Introduction

Manifestation of genotype-environment (G×E) interaction is indicated by an inconsistent relative performance of different genotypes in different environments. The occurance of such G×E interaction interferes with the evaluation of genotypes and reduces the progress of selection.

In recent years a great deal of emphasis has been placed on the estimation of nature and the magnitude of G×E interactions exhibited by different genotypes in a variety of crops. A technique now known as joint regression analysis, which originally was proposed by Yates and Cochran (1936) is commonly used for this purpose. The technique employs the regression of genotypic performance onto environmental additive effects. Finlay and Wilkinson (1963) used this technique and using regression coefficients as a parameter of stability, screened barley genotypes with respect to their adaptation reactions towards environmental variation. However, a considerable amount of variation in genotypic performance is not accounted for by even the best fitting regression line. Keeping this in mind, Eberhart and Russell (1966) used the deviations about regression as a parameter of stability in addition to the regression coefficient. Further, Freeman and Perkins (1971) and Freeman (1973) raised some objections based on statistical grounds against the validity of stability parameters estimated through joint regression analysis. Some other non regression techniques (Wricke 1962; Shukla 1972; Francis and Kannenberg 1978; Binswanger and Barah 1980) also have drawn the attention of breeders and merit special considerations. However, they were not as efficient as regression analysis because they could not provide an unambiguous picture of genotypic response in terms of linear and non linear components and were based mainly on variance in genotypic performance over a range of environments.

In the present paper an empirical method has been suggested for selecting commercially desirable genotypes with respect to their adaptation reactions based on a pattern of correlations between the performance of pairs of genotypes over a series of similar environments and also between deviations in performance from the respective environmental mean. For illustration data were used from an experiment in toria (*Brassica campestris* L.) involving 31 genotypes grown in twelve environments.

Materials and methods

Thirty-one toria genotypes were grown in a randomized block design at Meerut for two years (1977/78, 1978/79) 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; Singh and Gupta 1984a). Data were recorded on a plot basis in each of the three replications.

Correlation coefficients (r^s) between the seed yield over 12 environments and correlation coefficients (r^d) between deviations in seed yield from respective environmental means

Table 1. Seed yield, r^2 and correlation coefficients

Genotypes	Mean seed yield (Singh and Gupta 1983)		Correlation coefficients when the following three genotypes were used as standard testers					
	(g)	r^2	Ludhiana composite -2		K-1		TCSU-2	
			r^s	r^d	r^s	r^d	r^s	r^d
'Toria -17/18'	10.61	0.89	0.54	−0.62*	0.64*	−0.10	0.63*	0.03
'Bhabri'	9.44	0.75	0.82**	−0.19	0.67*	−0.77**	0.77**	−0.21
'Ludhiana Composite-2'	13.54	0.94	1.00	1.00	0.97**	0.66*	0.88**	0.22
'Gurdaspur Composite-1'	10.33	0.64	0.78**	−0.33	0.54	−0.57*	0.82**	0.24
'TL-5'	7.47	0.76	0.88**	−0.43	0.87**	−0.13	0.75**	−0.21
'PT-8'	9.68	0.77	0.84**	0.35	0.80**	−0.24	0.53	−0.67*
'Type-9' (1)	10.77	0.93	0.93**	0.21	0.86**	−0.29	0.83**	0.20
'Type-9	10.55	0.92	0.93**	0.12	0.87**	0.15	0.78**	−0.51
'PT-600'	11.98	0.79	0.81**	−0.23	0.78**	−0.32	0.76**	−0.21
'TH-8'	11.71	0.88	0.89**	−0.09	0.86**	−0.13	0.77**	−0.44
'TH-5'	12.02	0.78	0.89**	0.05	0.95**	0.58*	0.84**	0.14
'ITSA'	11.71	0.85	0.87**	0.05	0.80**	−0.28	0.78**	−0.20
'TCSU-1'	11.23	0.89	0.95**	0.34	0.92**	0.30	0.89**	−0.19
'PT-30'	9.89	0.88	0.95**	0.13	0.93**	0.30	0.92**	0.47
'PT-10'	10.11	0.83	0.88**	0.20	0.79**	0.29	0.71**	−0.50
'Toria 2/8'	10.65	0.75	0.92**	0.22	0.84**	0.04	0.88**	0.36
'Synthetic-2'	10.77	0.87	0.91**	−0.03	0.85**	0.20	0.95**	0.74**
'K-1'	11.51	0.87	0.96**	0.66*	1.00	1.00	0.85**	0.15
'TH-43'	13.17	0.70	0.78**	−0.17	0.71**	−0.32	0.83**	0.39
'Toria-1/16'	10.96	0.89	0.92**	0.38	0.92**	0.41	0.80**	0.17
'TCSU-7'	12.04	0.92	0.97**	0.60*	0.92**	0.29	0.93**	0.58*
'Toria-1/17'	9.28	0.82	0.91**	−0.02	0.88**	0.04	0.81**	−0.08
'Synthetic-1'	12.53	0.77	0.83**	0.23	0.89**	0.50	0.79**	0.08
'TH-4'	11.58	0.94	0.96**	0.47	0.95**	0.59*	0.88**	0.18
'PT-330'	11.22	0.78	0.83**	−0.10	0.77**	−0.34	0.74**	−0.25
'TL-15'	9.08	0.80	0.86**	−0.37	0.90**	0.13	0.85**	0.10
'TCSU-2'	14.42	0.80	0.88**	0.22	0.85**	0.15	1.00	1.00
'Ludhiana Composite-1'	15.01	0.53	0.59*	−0.34	0.61*	−0.22	0.56*	−0.17
'PT-18'	8.97	0.92	0.97**	0.37	0.93**	0.20	0.84**	−0.12
'M-3'	10.24	0.72	0.83**	−0.07	0.87**	0.32	0.73**	−0.05
'Toria-4/10'	10.38	0.74	0.78**	−0.24	0.70**	−0.47	0.71**	−0.26
Grand mean	11.06							

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

were estimated for all 31 pairs of genotypes. For the sake of brevity, both types of correlations (r^s and r) for all pairs of only three genotypes, Ludhiana 'Composite-2', 'K-1' and 'TCSU-2', (which were found to be of commercial interest (Singh and Gupta 1983) and are used here as standard testers) with thirty other genotypes are given presently.

Coefficients of determination (r^2) for all 31 genotypes were estimated as suggested by Pinthus (1973).

Results and discussion

Correlation coefficients (r^s and r^d) for all pairs of 31 genotypes with each of the three standard testers are given in Table 1. Mean yield (g) over 12 environments and coefficient of determination (r^2) for all the 31 genotypes are also given in Table 1.

Earlier, Perkins and Jinks (1968) proposed a way of estimating the relative similarities between the genotypes in their interactions with environmental differences, which were not accounted for by the linear component estimating the deviations from the linear regressions over environments for the pair of genotypes. This idea was utilized by Habgood (1977) in an attempt to measure genetic diversity between barley cultivars based on genotype-environment interactions. Although he took over Perkins and Jinks' idea, he applied it to deviations from the environmental mean and not to deviations from the regression line. Habgood used a negative correlation coefficient between a pair of genotypes, which had been estimated from their respective deviations from mean yield of all genotypes in each environment, as a measure of dissimilarity between both the genotypes – assuming that the genotypes of the pair were diverse with respect to the factors governing the response. The author further supposed that a cross made between such diverse genotypes should manifest heterotic effects in yield. I feel, however, that it no longer holds true because of the fact that yielding ability and response are two independent attributes of a genotype and are governed by separate sets of gene systems (Finlay and Wilkinson 1963; Bucio-Alanis et al. 1969; Bains 1976; Verma et al.

1978; Singh and Gupta 1984b). Therefore, a hybrid obtained by crossing such diverse genotypes may possibly be expected to exhibit heterotic effects in response but not necessarily in yield.

In the present paper positive correlations (r^d) between deviations in seed yield from environmental means, which were ignored by Habgood, are used as a measure of similarity of the genotypes with respect to their response to environmental variations. In addition, correlations (r^s) between seed yield over a series of similar environments of different pairs of genotypes are also used for the same purpose. Statistically significant r^s estimates for pairs with a standard tester indicate that such genotypes are identical to the standard tester with respect to response patterns to environmental variations. If some of these pairs also had positive and significant estimates of r^d, patterns of response of the genotypes involved in such pairs is expected to be almost identical to their respective standard tester both in rich and poor environments as both direction and magnitude in deviations from environmental means were utilized. Such genotypes exhibiting similarities for response pattern to environmental variations could reflect similarities of gene complexes governing the response and may well be termed as isoresponsive genotypes.

From the Table 1, it can be seen that for the six pairs which had statistically significant positive values of r^d the corresponding values of r^s were also very high-approaching unity. The reverse was not the case. This could be explained on the basis that in the estimation of r^d, both the magnitude and direction of deviations in seed yield from environmental means were utilized, while in the estimation of r^s only the magnitude in seed yield was utilized. However, from of the four pairs which had significant negative values of r^d, only one pair (Bhabri with 'k-1') had a significant positive value of r^s.

For two pairs of 'TCSU-1' and 'PT-30' with 'Ludhiana Composite-2' the value of r^s was 0.95 but the corresponding values of r^d were different (0.34 and 0.13, respectively). Such variations appeared within the limits of error. Both pairs of 'PT-18' and 'TCSU-7' with 'Ludhiana composite-2' had similar values of r^s (0.97) but different values of r^d(0.37 and 0.60, respectively) which are not entirely random and may be attributed to the fact that genotypic response and environmental variations are not always linearly related (Freeman 1973). If genotypic response and environmental effects were linearly related, as was the basic assumption of the joint regression analysis, then such an anomaly would never have been expected to appear.

'TCSU-7' had significant positive values of r^d in pairs with two standard testers, 'Ludhiana Composite-2' and 'TCSU-2'. Both 'TH-5' and 'TH-4' had significant and positive values of r^d in pairs with standard tester 'K-1' and therefore, appeared to be identical to their corresponding standard testers with respect to the factors governing the response. Each of 'TCSU-7', 'TH-5' and 'TH-4' also exhibited high mean yield as well and therefore were acceptable for commercial cultivation. Also, 'TCSU-7' and 'TH-4' were among the three genotypes which were found to be of commercial interest, in an attempt made to select genotypes which could fit well in multiple crop rotation, keeping in view, that toria is a short duration crop and is generally grown as a catch crop in India (Singh et al. 1984).

Although, 'TCSU-1', a good yielder, had very high values of r^s in pairs with each of the standard testers used in the present study, its response pattern in rich and poor environments could be predicted with limited reliability, as the values of r^d did not significantly deviate from zero in each of the three pairs.

'Synthetic-2' was identical to standard tester 'TCSU-2' in response pattern but had a poor mean yield, therefore, there is a need of a further improvement for yielding ability by incorporating the necessary genes is indicated.

The coefficient of determination (r^2) which indicates the scope of possible manipulations in environmental effects has also been used as an additional parameter for selecting those genotypes of commercial interest for different agroclimatic conditions. r^2 measures how much of the variation in genotypic performance across a given range of environments is linearly related with environmental effects and therefore, predicts the potentiality of a genotype manageable by using different levels of agronomical management. In the present context, 'TH-4' and 'TCSU-7' were superior to 'TH-5', as is evident from values of r^2 given in Table 1.

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