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A PROCEDURE FOR STABILITY ANALYSIS WITH MULTIVARIATE DATA IN VEGETABLE CROPS

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ABSTRACT

For overcoming the problem of dissimilar pattern of G × E interactions for different traits in a multi-trait selection programme, a simple procedure (based on principle component approach) is suggested for reducing the multivariate data set to one of univariate, which can then be subjected to usual stability analysis. The suggested procedure is used to analyse the bivariate data on six varieties of onion and seven varieties of tomato for yield and total soluble solids, generated under All-India Coordinated Vegetable Improvement Project during 1980–82 at Five locations. In onion, the two best adapted varieties are Pusa Red and Line 102, both developed at the Indian Agricultural Research Institute, New Delhi, while Udaipur 103 is the most stable cultivar. Among the tomato varieties, the two best adapted varieties are La Bonita and Roma, the latter being the most stable variety.

Key words: Stability analysis, composite score, principal component approach.

Since the value of a variety is dependent on several traits, it is necessary that varietal stability analysis is performed simultaneously for all the traits of economic importance. Thus while screening varieties of vegetable crops it is important to give due attention to yield, colour, total soluble solids, etc. Very often, however, the patterns of G × E interaction of yield and other characteristics of crops are of dissimilar nature making it difficult to draw valid inferences. With some crops G × E interaction with one set of characters may exhibit linear trend with environment while another set may show nonlinearity of regression [1–3]. In view of the different patterns of response for different characteristics of the same variety, it is desirable that the individual observations on different characters are combined suitably in a single score or composite score, before subjecting the resulting data to stability analysis. The aim of this paper is two-fold: first, to delineate one simple procedure of combining information on different characteristics; and second, to report the results of stability analyses using this procedure on the data on onion and tomato crops generated under the All-India Coordinated Vegetable Improvement Project during 1980–82 at five locations.

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MATERIALS AND METHODS

THE PROCEDURE

There could be many strategies for combining information on several characters of an individual variety. The one proposed here accounts for the maximum possible variation for any linear combination of variables in the multivariate data set. This is done using principal component approach as follows. Freeman and Dowker [4] and Mandel [5] used a similar approach for partitioning variation within genotypes or within environments, or both.

Let X_{ijp} be the value of the p-th character ($p = 1,2,\ldots,n$) of the i-th variety ($i = 1,2,\ldots, t$) and j-th environment ($j = 1,2,\ldots s$). The data for the different characters for each (i, j)-th combination are then converted into standard normal variables so that they can be combined together. The set of the converted observations for the p characters for different (i, j) combinations were treated as a set of multivariate data containing p variables. We denote by $W = (w_{cp})$ the matrix of such observations, where w_{cp} is the observations for the p-th character of the c-th combinations expressed as standard normal variables ($c = 1,2,\ldots, ts$; $p = 1,2,\ldots, n$) Then we define a matrix A, where

$$\underset{\sim}{A} = W'W$$

The eigen values θ_k ($k = 1, 2,\ldots,n$) of the matrix A can be obtained by solving the characteristic equation

$$|\underset{\sim}{A} - \theta \underset{\sim}{1}| = 0$$

where $\underset{\sim}{1}$ is an identity matrix and θ is scalar, with n as the rank of matrix A.

Corresponding to each eigen value θ_k, we obtain the eigen vector u_k, having n components ($u_{k1}, u_{k2}, \ldots, u_{kn}$).

The eigen vectors and the eigen values are connected by the relation.

$$\underset{\sim}{A}\underset{\sim}{U} = \theta \underset{\sim}{U}$$

The eigen vector u_1, corresponding to the first eigen value θ_1 has the largest possible variance (given by θ_1) of any linear combination of n variables considered in the multivariate data set. The second eigen vector u_2 has the next largest possible variance subject to being uncorrelated with the first eigen vector u_1 and so on.

Then the principal component score v_{ij} for the (ij)-th combination is obtained as

$$v_{ij} = \left(\sum_{p=1}^{n} u_{ip}\; x_{ijp}\right)/\sqrt{\theta 1}$$

where u_{ip} is the p-th component of the eigen vector u_1, corresponding to the p-th character, relating to the first eigen value θ_1. In this fashion the multivariate data are converted to univariate data set which are then subjected to the usual stability analysis.

The data utilized for the present analyses pertain to six varieties of onion and seven varieties of tomato generated under the All-India Coordinated Vegetable Improvement Project during 1980–82 and relate to two important characters, yield and total soluble solids. The six onion varieties considered are: VL-67, Line 102, Pusa Red, N-53, N-2-4-1, and Udaipur 103, VL-67 is a variety from Vivekanand Parvatiya Krishi Anusandhanshala, Almora, in the hilly humid western Himalayan region; Line 102 and Pusa Red from Indian Agricultural Research Institute, New Delhi in the arid western plains; N-53 and N-2-4-1 from Rahuri in the semiarid western region, and Udaipur 103 from Udaipur in the arid western plains of Rajasthan. These varieties were tested in five locations spread over different regions of the country, viz. Pantnagar, Almora, Ludhiana, Rahuri and Junagadh. In case of tomato, there were seven varieties: Punjab Chhuhara, Punjab Kesri and S-12 from Ludhiana in the subhumid Sutlej–Ganga alluvial plains; sel-152 from IARI, Delhi, in the arid western plains, Roma from Katrain in the hilly humid western Himalayan region; La Bonita from National Bureau of Plant Genetic Resources, Delhi; and KS-2 from Kalianpur in the subhumid northern region. These were also tested in five locations, viz. Kalyani, Almora, Pantnagar, Rahuri and Hissar. All these tests were laid out as randomized blocks with three replications.

The data were analysed following the method of Eberhart and Russell [6] after converting the multivariate data to univariate data set.

RESULTS AND DISCUSSION

The eigen values of the transformed data matrix A and the components of the eigen vector corresponding to the principle eigen root obtained for the two crops are as follows

Eigen value:	*Onion*	*Tomato*
θ_1	1.52	1.36
θ_2	0.48	0.64
Eigen vector:		
u_{11}	−0.71	0.71
u_{12}	0.71	−0.71

Thus the first eigen value accounted for as much as 76% of the total variation of the data matrix in case of onion and 68% in tomato.

Table 1. Stability analysis on reduced univariate data sets for onion and tomato varieties

Source	Onion			Tomato		
	d.f.	SS	M.S.	d.f.	SS	M.S.
Varieties	5	3.34	0.67	6	6.58	0.43
Environments	4	10.18	2.55	4	8.95	2.24*
Varieties × environments	20	24.64	1.23*	24	18.48	0.77**
Heterogeneity of regressions	5	17.64	3.53*	6	8.14	1.36**
Deviation from regression	15	7.00	0.47	18	10.34	0.57
Pooled error	50	32.50	0.65	60	20.40	0.34

* $P<0.05$; ** $P<0.01$.

Table 2. Adaptability and stability parameters for yield, total soluble solids and composite score of union varieties

Variety	Adaptability parameters						Stability parameters					
	yield		T.S.S.		composite score		yield		T.S.S.		composite score	
	b_i	rank	b_i	rank	b_i	rank	S^2_d	rank	S^2_d	rank	S^2_d	rank
VL-67	0.06	6	−0.27	4	−0.19	5	1.94	1	−0.43	3	0.10	2
Line 102	0.89	3	0.98	1	0.90	2	11.54	4	0.33	5	0.49	5
Pusa Red	1.03	1	0.51	5	0.91	1	41.71	6	2.07	6	1.23	6
N-53	1.35	4	0.78	3	1.10	2	−1.09	2	−0.58	1	0.16	3
N-2-4-1	1.61	5	3.10	6	2.40	6	17.78	5	0.32	4	0.27	4
Udaipur 103	1.06	2	0.90	2	0.89	4	0.71	3	−0.44	2	0.08	1

b_i—regression coefficient that measures the response of the ith variety to varying environments; S^2_d—deviation from regression mean square that measures the stability of the i th variety; T.S.S.—total soluble solids.

The stability analyses of the reduced univariate data sets for the two crops are presented in Table 1. Percentage of G × E interaction accounted by regression in onion is as much as 72% as against only 7% and 53% for yield and total soluble solids considered separately; the corresponding figures for tomato being 44, 25 and 21%, respectively [7].

This clearly brings out the advantage of the principal component approach to multivariate data in that it overcomes the difficulty in interpretation due to dissimilar nature of G × E interaction for individual characters.

Table 3. Adaptability and stability parameters for yield, total soluble solids and composite score of tomato varieties

Variety	Adaptability parameters						Stability parameters					
	yield		T.S.S.		composite score		yield		T.S.S.		composite score	
	b_i	rank	b_i	rank	b_i	rank	S^2_d	rank	S^2_d	rank	S^2_d	rank
Punjab Chhuhara	0.77	3	0.08	6	0.68	3	7.14	6	0.02	3	−0.08	3
Punjab Kesari	0.41	7	0.52	4	−0.64	6	−4.18	2	0.61	7	−0.22	2
La Bonita	1.14	2	0.62	2	1.03	1	−5.15	1	−0.11	1	−0.05	4
KS-12	1.44	5	−0.51	5	1.33	4	0.70	3	0.29	4	0.75	7
S-12	0.74	4	1.38	2	0.34	5	0.90	4	0.32	5	0.34	5
Sel-152	1.44	5	4.21	7	2.72	7	29.36	7	0.37	6	0.57	6
Roma	1.06	1	0.96	1	1.24	2	0.86	5	−0.07	2	−0.25	1

Note. See Table 2.

The values for the adaptability and stability parameters obtained from analysis using principal component approach as well as separate analyses of yield and total soluble solids for onion are given in Table 2, and for tomato in Table 3. It can be seen that the relative rankings of most of the varieties both in respect of their adaptability and stability differ for the two individual characters, highlighting the limitation of separate analysis for each character.

From the composite score analyses it is seen that among the onion varieties Pusa Red is the most adapted variety followed by Line 102 and N-53, but in respect of stability Udaipur 103 scores over all others. However, from the point of view of both adaptability and stability, variety N-53 would be the best choice. Among the seven tomato varieties, La Bonita and Roma are the two most adapted varieties, the later (Roma) also being the most stable.

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