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SYMPOSIUM* ON "STATISTICAL ASPECTS OF STABILITY OF CROP YIELDS"

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CONVENORS : DR. D. V. SUBBA RAO, *Scientist S-2, C. T. R. I., Rajahmundry (A. P.)*
SHRI S. C. RAI, *Senior Scientist, I. A. S. R. I., New Delhi*

After the Chairman's opening remarks, the speakers presented their papers.

Dr. K. C. George presented the review of work relating to study of stability. He described Eberhart-Russell Method, Perkins-Jinks Method, Freeman-Perkins Method, Wricke Ecovalence and Shukla's Stability Variance Method giving their suitability in different experimental situations. He discussed the stability of the performance of the yield of 20 sesame varieties conducted at three locations by using all the above methods. The three regression approaches given by Eberhart-Russel, Perkins-Jinks and Freeman-Perkins gave almost the same results. This was also confirmed by Wricke's and Shukla's Method. One of the drawbacks of the study was the inadequacy of the linear regression coefficients to account for the G. E. interaction.

Dr. V. K. Bhatia discussed some statistical aspects relating to stability and stated that the performance of a particular variety was the result of its genetic constitution and the environment in which it had been grown. He presented different methods of reducing the effective number of varieties for testing purposes. For reducing the effective number of varieties or selecting superior genotypes, a procedure using the concept of order statistics had been advocated wherein one could work out the pro-

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bability of any given variety being selected in at least one location. These probabilities could be used for further decision making processes. The concept of similarity or dissimilarity had been used in grouping the like genotypes to a smaller number of groups. This was mainly a non-parametric approach and advantage was that varietal's response characteristics could be assessed qualitatively without the need of mathematical characterisation. For the incomplete G.E. tables, a modified joint regression analysis was suggested which would be suitable to both the situations for missing observations and data sets with unequal experimental errors.

Shri C. K. Ramanatha Chetty mentioned different concepts of stability and gave various statistics useful to quantify it from different view points. He discussed genotype stability and pointed out that more research was needed to standardize the concept of stability and for developing valid statistics which quantify it.

Dr. K. V. S. Rao demonstrated the risk function approach for the study of stability. He pointed out that since risk analysis depended on the existence of variability of both temporal and spatial nature, it would be appropriate to estimate the mean and variance through a response function. He gave the estimates of risk associated yields at farm level through an example.

Shri S. C. Rai presented measures of stability for binary responses. He discussed the case of binary responses in pre-post treatment situations and gave a simple measure of stability along with its sampling distribution. He also presented a test-statistic for comparing two or more stability coefficients. A procedure for testing the significance of change in binary response was also given.

Shri M. G. Sawant stated the use of coefficient of variation as a measure of stability by taking the yield data of Maharashtra. It was pointed out that number of observations should be sufficiently large for calculating coefficient of variation at tehsil or block level.

Shri G. S. V. Subrahmanyam presented a comparison of different methods of stability statistics. He stated that the concept of stability and the environments chosen for the experiment were to be clear before conducting the trials.

Dr. R. P. Goswami gave the technique of harmonic analysis using trignometric functions to uncover inherent periodicity of a series. He stated that a phenomenon dependent upon time could be thought of as comprising of oscillatory movements—represented by a sine or cosine functions. He explained the method through an example from the price data of sugarcane and cotton.

In general remarks and comments, Prof. Prem Narain stated that the

concept of stability should be very clear. The papers presented could be divided into two categories. One category of papers dealt with the stability problems based on multilocation trials for selection of varieties on the geno-type performance in different environments. The other category of papers dealt with the problems of stability based on the performance of a variety over the years. The two concepts should be clearly distinguished before conducting the studies. He further stated that the methods of pattern analysis or cluster analysis should be pursued for selecting varieties.

Recommendations

During the discussions on the papers presented, the following points emerged.

1. Since stability is an important quality of a variety, its concept and definition must be made very clear before conducting the studies.
2. There should be further studies through symposia or discussions on the technique of pattern or cluster analysis for selection of promising varieties. The methods of clustering should be thoroughly studied.

In his closing remarks, the Chairman pointed out that the research carried out by the scientists should be self accountable and it should be in the wider national interest. The statisticians should be useful to other branches and disciplines through their researches and consultations.

The detailed summaries of the papers are as follows.

1. A Comparative Study of Stability Parameter Analysis in the Yield of Crop Sesame Through Different Statistical Models

by
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A genotype is said to be stable relative to a set of genotypes if its response to differing environments is similar to overall response. A number of statistical methods are now known for the estimation of phenotypic stability. In the present investigation, a comparative study of different techniques for the estimation of the genotype-environment interactions in the yield of the crop sesame cultivated in three different locations, viz ; Vellayani, Kayamkulam aud Pattambi, were made for the

purpose of finding the most stable variety, to be released to the farmers for wide cultivation.

In the present investigation. the yield data on 20 sesame varieties cultivated at three different locations during the year 1982-83 season, conducted in an RBD with three replications were used for the study of stability. The stability parameter analysis has been done by using five different methods—viz: Eberhar t and Russell's method, Perkins and Jinks method, Freeman and Perkins method, Wrieke's method and Shukla's method. The first three methods were based on regression models.

But the fourth and fifth methods were based on the stability parameters W_i and σ_i^2 respectively. In the first three methods the stability parameters studied were b_i, s_{di}^2, $\beta_2 = i - b_i$, b_i' and $s_{di}'^2$: The stable varieties were those which gave almost unit values to b_i and b_i' and nearly zero values to β_i, s_{di}^2 and s'^2_{di}. Similarly stable verieties will be having comparatively smaller values to W_i and σ_i^2. The varieties 3, 6, 11 and 20 revealed almost unit values to the stability parameters b_i and b_i' and nearly zero values to β_i, s_{di}^2 and $s_{di}'^2$, showing thereby stable varieties. These facts along with the mean performances indicated the varieties 6 and 20 were high yielding stable varieties, variety 3 (K—284) was a medium yielding stable variety and variety 11 ($S_i - 1$) was a low yielding stable variety. These results were confirmed through the values of W_i and σ_i^2.

Correlations between various pairs of stability parameters were also studied. A correlation coefficient of value unity was obtained between W_i and σ_i^2. This clearly showed that W_i was a function of σ_i^2. Similarly σ_i^2 had the same coefficient of correlations with other parameters as W_i had with them. The regression coefficients (b_i and b_i') showed positive correlations with W_i. Also s_d^2 and W_i were highly positively correlated.

The main drawback of this study was in the analysis of variance under ER, PJ and FP methods, heterogeneity among regression was not significant and deviations from regression were significant. This showed the inadequacy of linear regression coefficients to account for the GE-interaction. Hence the regression approach failed to give very clear information on the relative stability of genotypes.

2. Some Statistical Aspects Relating to Stability of Crop Yields

by
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For varietal adaptation, plant breeders are generally interested in that new variety which is to be adapted for commercial purposes should show high performance of yield along with its stability over a wide range of different environmental conditions. This stability aspect has been studied in detail by various research workers by enumerating the different parameters of stability along with the practical situations where they can be used in a most efficient manner. Besides this, there are still the situations where the usual measures of stability can not be as such applied because of various reasons like size and physical conduct of the experiment, large number of varieties under test etc. In these cases the stability aspects have to be looked into through different angles and this article is mainly devoted to study these aspects of varietal adaptation in the presence of GE interation.

The various aspects discussed in this paper are the methods of reducing the effective number of varieties to be tested, grouping the similar lines and methods of stability analysis for the case of missing observation and unequal weightage of data.

For reducing the effective number of varieties or selecting superior genotypes, a procedure using the concept of order statistics has been advocated wherein one can work out the probability of any given variety being selected in at least one location. These probabilities can be made use in further decision making processes. The concept of similarity or dissimilarity has been used in grouping the like genotypes to a smaller number of groups.

This is mainly a non-parametric approach and advantage of this is that a varietal's response characteristics can be assessed qualitatively without the need of mathematical characterisation. For the incomplete GE tables, a modified joint regression analysis is suggested which will be suitable to both the situations for missing observations and data sets with unequal experimental errors. This technique not only helps in estimating the regression coefficient but the varietal sensitivity can be assessed in a more efficient way by taking into account the environment effect estimates.

3. Measurement of Stability in Crop Yields—A Review of Concepts and Statistics

by
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The concept of stability in crop yields is defined in many ways depending on how a scientist wishes to look at the problem, while the statistics which are useful to quantify stability are also numerous. An attempt has been made in this paper to review the different concepts of stability that appear in literature and finally suggest two new approaches.

4. A Risk Function Approach for the Choice of Varieties With Differential Stability

by
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One of the criteria to assess the phenotypic superiority of a crop variety is through its stability in performance. The methods generally followed to measure it are mostly based on variance concept or regression against evironmental indices. The evaluation of a crop variety through these methods provides blanket cover base in the sense, they do not consider alternate risk based decision make, which may alter the relative ranking of a variety at a given or different risks. Since risk analysis mainly rests on the existence of variability of both temporal and spatial, the yield variability of a variety is appropriate to estimate through a response function by incorporating the independent variables influenced by the above type of variation. Assuming that the coefficient of the explanatory variables β's vary considerably from variety to variety and suppose the response of the *i*th variety is expressed as

$$Y_i = X\beta_i + e_i$$

where Y_i is a $n \times i$ vector of observations on yield at n environments of ith variety, X is a $n \times k$ matrix of observations on k explanatory variables, β_i is a $k \times i$ vector of regression coefficient of an ith variety, and e_i is a $n \times i$ random disturbance vector. Here we assume that e_i's have mean zero and variance σ_i^2. Further assuming yields are normally distributed with mean XB_i and variance σ_i^2, i.e., $Y_i \sigma N (XB_i, \sigma_i^2)$, the risk associated

expected yields of an ith variety μ_{ik} at a given probability (risk) P_k is measured from the function

$$\text{Prob}\,(Y \leqslant \mu_{ik}) = P_k\,(\text{risk})$$

The probability distribution of yields obtained from the above function can be used to rank the varieties at a given risk or over varying risks. This method is also useful to estimate the uncertain response in yields due to varying inputs. At the farm decision-making level, the farmers generally differ in their resources, psychological set up and previous experience and, therefore, different input vectors are visualised. In such situations the yield distribution of the ith variety for the jth farmer can be obtained as $Y_{ji} \sim N\,(x_j\,B_i\,(\sigma_i^2)$ where X_j is the $1 \times k$ input vector of the jth farmer. The risk associated expected yields of ith variety for the jth farmer can now be obtained through the probability function mentioned earlier. This approach has been applied to an experimental data on pulses as an illustration.

5. Measures of Stability for Binary Responses in Crop Yields

by
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There are many measures and testing procedures for the study of treatment-induced-changes. Here observations are taken twice, once before and then after the application of the treatment. These observations represent same symptoms or symptom-configurations, and they may be taken as binary variables.

Two samples of fixed sizes n_1 and n_2 are drawn. Sample 1 is taken from a population of points in which a given symptom is present (+) before treatment. Sample 2 is drawn from a population in which this symptom is absent (—). n_1 points of sample 1 and n_2 points of sample 2 are then binarized into points which have lost their symptom after treatment. If symptom observations before treatment are denominated as pre-observations and after treatment as post-observations, then 2×2 table may be prepared as given below :

Pre-observation	*Post-observation* (+)	(—)	
first sample (+)	a	b	n_1
Second sample (—)	c	d	n_2

By stability we mean that the treatment does not change the symptom of a point. Thus, for such a point, pre- and post-observations are equal with either (+) or (—). For evaluating treatment effects, we propose a measure of stability of a binary response variable as

$$S = \frac{a}{n_1} + \frac{b}{n_2} - 1 \tag{1}$$

Perfect stability $S = 1$ indicates that treatment has no effect on points showing the same symptom response pre and post i.e. $a = n_1$ and $d = n_2$. Perfect instability $S = -1$ indicates that all points change their symptom responses with $b = n_1$ and $c = n_2$

For obtaining the sampling distribution of S the following model is assumed :

For an individual with pre-observation (+) we assume that probability of his post-observation to be equal to (+) is p_1 and to be equal to (—) is $(1-p_1) = q_1$. Similarly for an individual with pre-observation (—), the probability is p_2 for his post-observation to be equal to (—) and $(1-p_2) = q_2$ to be equal to (+). We further assume that all individuals behave independently of each other. Let X_1 be the number of units with pre- and post-observations (+) and X_2 be number of units with pre- and post-observations (—). Then X_1 and X_2 are both independent binomial variables with parameters (n_1, p_1) and (n_2, p_2) respectively. The first two moments of S can be obtained as given below :

$$\begin{aligned} E(S) &= p_1 + p_2 - 1 \\ &= a/n_1 + d/n_2 - 1 \end{aligned} \tag{2}$$

and $\text{Var}(S) = p_1q_1/n_1 + p_2q_2/n_2$

$$= \frac{ab}{n_1^3} + \frac{cd}{n_2^3} \tag{3}$$

The exact null distribution of S depends on the value of p_1 and p_2 and n_1 and n_2. But the normal approximation by the central limit theorem is satisfactorily good for moderate sized n_1 and n_2 and for p_1 and p_2 not too small as X_1 and X_2 are both binomial. The asymptotic testing against $E(S) = 0$ is made by normal approximation by evaluating

$$Z = \frac{S - E(S)}{\sqrt{\text{Var}\,(S)}} \tag{4}$$

as a standard normal variable.

A test has also been developed for comparing two or more stability

coefficients. In case of two stability coefficients S_1 and S_2, we can test

$H_0 : S_1 = S_2$ against

$H_1 : S_1 \neq S_2$

by obtaining the difference $d_s = s_1 - s_2$ which under H_0 is normally distributed with zero mean and variance $\sigma_d^2 = V(s_1) + V(s_2)$.

A test-statistic has been presented for study of change in variability using only the cells which have registered change.

The procedures developed have been explained by numerical examples.

6. Statistical Aspects of Stability of Crop Yields in Maharashtra

by
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The stability of yields of paddy and kharif jowar was studied in relation to the coefficient of variation in Maharashtra.

It is observed that year to year variation in the coefficient of variation for paddy in Konkan region is small where the cultivation is mainly carried out under rainfed conditions.

As regards kharif jowar, it is observed that the coefficient of the variation is mainly dependent upon the spread of hybrid/high yielding varieties.

7. A Comparison of Different Methods of Stability Statistics

by
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The diversity of parametric methods of stability statistics and their inter-relationship are given. The stability statistics are grouped according to the following different concepts. A genotype is stable, if

i. the environmental variance is small;
ii. the response to enviornments is parallel to the mean response of the genotypes; and
iii. the residual mean square from regression model on the environmental index is small.

An example on tobacco varieties for different stability statistics is given and their merits and demerits are discussed.

8. Stability in Commercial Crops in Haryana

by
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The instability in any crop is manifested through its prices and production. Harmonic analysis using trigonometric functions is a technique employed to uncover inherent periodicity of a series. A phenomenon dependent upon time could be thought of as comprising of oscillatory movements (cycles), represented by a sine or cosine functions and a time trend. The ordinary least squares procedure was used to estimate the unknown parameters. Data on production and prices of cotton and sugarcane crops were collected from Statistical Abstracts of Haryana for the years 1966 to 1983. Period of cycle used in the analysis was obtained after plotting the actual data on graph. The production and price series of cotton and price series of sugarcane contained a hidden cycle of three years while the production series of sugarcane contained the cycle of four years and a linear time trend.