AN ALTERNATIVE APPROACH FOR INTERPRETATION OF DATA COLLECTED FROM GROUPS OF EXPERIMENTS

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INTRODUCTION

One of the purposes of agricultural experiments is to provide observations for comparing on an average the efficacy of treatments or varieties in respect of one or more characters. After conducting an experiment through a suitable design, the observations from the treatments are analysed adopting usually the technique of analysis of variance. Mere comparison of treatments as above is not, however, sufficient as it is sometimes important to ensure that the superiority of a recommended treatment persists from year to year as also from place to place. Moreover, while investigating the data collected from experiments or otherwise it is of interest to see how far the individual treatments are stable under varying environments. In the usual method of interpretation of the data collected from groups of experiments, the aim is to see if any treatment contrast remains the same or not within permissible error from environment to environment. It does not throw any light as to if any particular treatment has a tendency to behave uniformly or otherwise with changing environment. For this purpose, we have given another approach for the interpretation of such data.

Finlay and Wilkinson (1963) used the concept of a stability coefficient for assessing different varieties of barley. Following these authors' Eberhart and Russell (1966) proposed the model,

$$Y_{ij}=\mu_i+\beta_i I_j+\eta_{ij}$$

involving a stability coefficient I_j for variety assessment. As indicated above β_i in the above model is a regression coefficient measuring the change in response of the i^{th} variety due to change in environment I_j. This regression coefficient has thus been taken as a measure of stability of the performance of any variety with changing environment,

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the relation being the less the value of the regression coefficient for a variety, the more is its stability. The present investigation attempts to exploit this approach of interpretation of data collected from groups of experiments and experiments of cultivator's fields.

Material and Methods

We shall use the data collected from an experiment conducted over a number of years or places to obtain two indexes *viz.*, (*i*) treatment index, and (*ii*) environment index. The treatment index for a treatment in an experiment is the mean yield of that treatment and the environment index is the grand mean of that experiment and hence it is the same for each of the treatments in the experiment. Thus, for a given treatment, we get a pair of indexes under each environment; which may be a season or a locality. For each treatment, there will, thus be as many pairs of values as the number of years or localities or their product. Taking the treatment index as the dependent variable and the environment index as the independent variable the regression of the treatment index on the environment index is computed. This regression coefficient which gives a measure of change in response of the treatment per unit change in the environmental index may thus be taken as a stability index for that treatment. Assessment of the efficacy of a treatment will be made according to the nature of this stability index, that is, the less the regression coefficient for a treatment the more stable is that treatment under varying environments. A treatment showing a higher performance and smaller regression coefficient is very much desirable as the effect of adverse environment is likely to be resisted by it.

Suppose Y_{ijkl} is an observation from an experiment under the i^{th} treatment ($i=1, 2.........t$) at the j^{th} place ($j=1, 2......p$) in the k^{th} year ($k=1, 2......n$) from the l^{th} replication ($l=1, 2......r$). We now obtain y_{ijk} as the mean yield of the i^{th} treatment over the replications when the experiment is repeated over years and places. If the experiment is repeated over years only we shall have the observation y_{ikl} and if it repeated over places only, it is denoted by y_{ijl}. The treatment indexes for i^{th} treatment in such situations are the respective treatment means. The environment index for the set of treatments in a year or at a place is the grand mean of the experiment, and hence, it is fixed and varies with the places or years. The usual regression of treatment index on environment index gives change in the effect of the treatment per unit change in the environment. Let b_i be the regression coefficient of the i^{th} treatment, and we define

$$\frac{1}{|b_i|}$$

as the stability index for the i^{th} treatment. If b_i is unity then the inverse of b_i will also be unity, which may be interpreted as that the i^{th} treatment has got the average stability, that is the treatment response changes as much as the environment index. If b_i is greater than unity, the inverse of it will be less than unity, which may be interpreted as that the corresponding treatment has got less stability in the sense that any change in environment causes a greater change in the treatment response. In this situation the treatment response is to some extent unpredictable as much as the environment. If b_i is smaller than unity, the inverse of it will be greater than unity which may be interpreted as that the treatment has got more stability, that is, when environment changes considerably, the treatment response lags behind.

It will be seen that the relationship between the treatment index and the environment index has been assumed to be linear, which is normally expected. However, while applying this technique to actual data, it is desirable to plot such indexes so as to set an indication of the relationship. If the relationship is not linear, the methodology given here need not apply.

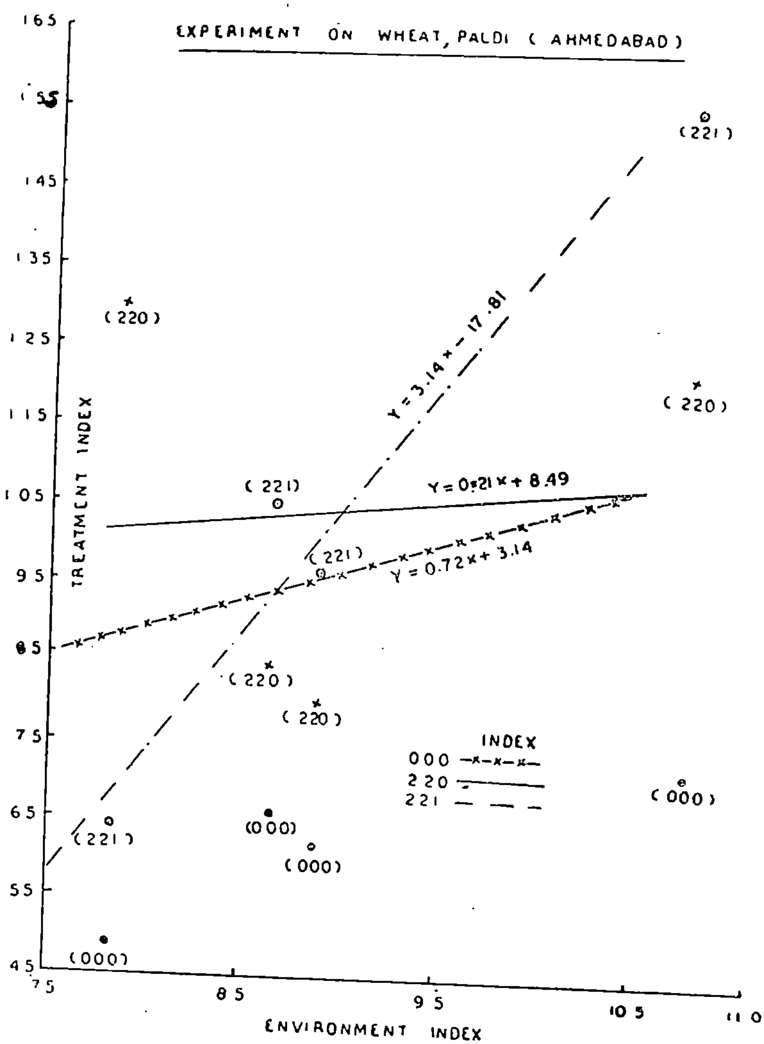
Observations on 'control' can also be taken as an index of environment. But the number of observations on 'control' being a few, the mean of the experiment has been taken to represent [the environment.

ANALYSIS OF *b's*

In the present investigation two types of data have been considered. One type of data pertained to standard factorial experiments conducted over a number of years. The other type of data is collected from simple fertilizer trials conducted in cultivator's fields in different districts over a number of years. For investigations of first type of data, a regression coefficient for each treatment has been obtained. Subsequently, in order to ascertain how the stability coefficient changes with the levels of fertilizers and if there is any interaction between the factors under study in respect of stability coefficients, the regression coefficients have been analysed through the technique of ANOVA. As in the present method of investigation, treatments are not compared directly, but each treatment is assessed on its own through a regression coefficient, blocking of the experiment does not play an important role here. The block effects rather form a part of environment. Therefore, no attempt has been made to eliminate the block effects while calculating the regression coefficients. In case of experiments conducted at a number of localities over a number of years, the error mean squares for obtaining the standard error for the regression coefficients has been obtained from the interaction of treatments and environments.

RESULTS AND DISCUSSION

The results of two examples (one on each type of data) are discussed below, for illustration.



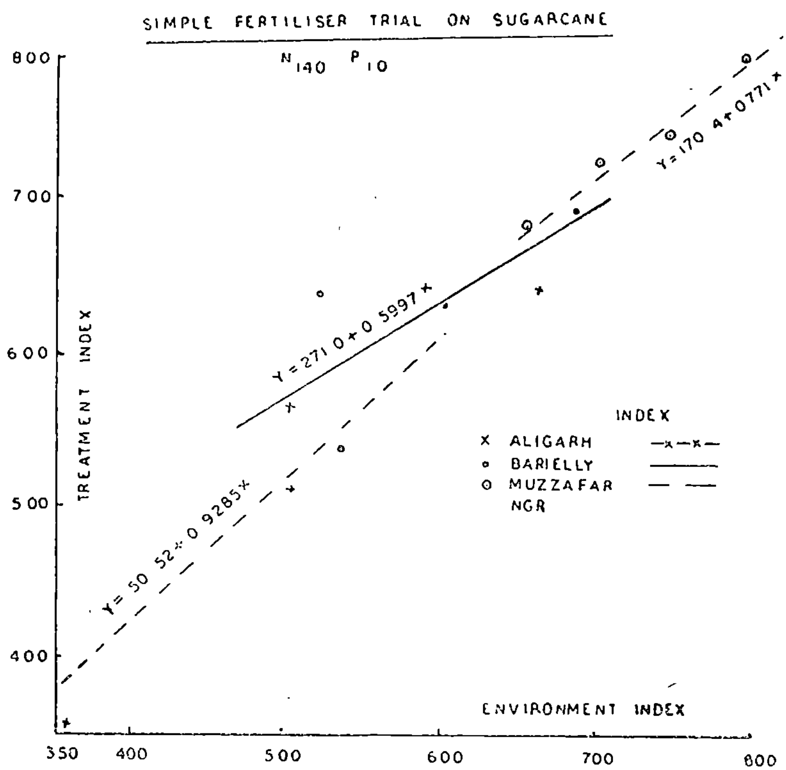
An experiment on wheat was conducted at Paldi in Ahmedabad district over four years, *i.e.*, in 1958, 1959, 1960 and 1961. The design adopted was a split-plot design with confounding. The treatments were three varieties of wheat, two levels of FYM (with and without FYM), three levels of seed rate *viz.*, 40, 60 and 80 *lb/ac.*, three levels of nitrogen *viz.*, 0, 20, and 40 *lb/ac.* and phosphorus at three levels 0, 20 and 40 *lb/ac.* The six combinations of the three varieties and two types of application of FYM were the main plot treatments and the 27 combinations of the treatment seed-rate, nitrogen and phosphorus each at 3 levels were taken as sub-plot treatments. The plot size was 30 ′ × 15′ and the yield was presented in *lbs*/plot. The number of replications was only one in each year. Taking the means over varieties and application of FYM for sub-plot treatments, the regression coefficients were computed and presented in Table 1 (all the Tables are given in Appendix). The ANOVA of these regression coefficients was given in Table 2 and the summary of the mean values of the regression coefficients in Table 3.

An examination of the values of regression coefficients shows that the highest value of *b* has been obtained for the treatment 221 and the lowest for 220. It is hard to explain such a behaviour. But an examination of the graph for the treatment 220 reveals that the points are irregularly placed and do not at all show a linear relation and the regression coefficient for the treatment 220 is not significant. The graphs for some of the treatments from this experiment have been presented. However, taking the values as they are it would appear that the treatment 220 is least affected by the environmental change while the treatment 221 proved highly mobile with the changing environment. The second treatment indicates that if a better environment is ensured, its application is likely to be more productive, while the regression coefficient for the first treatment indicates that if things are uncertain about the environment and other management conditions, it is better to apply such a treatment as any adverse condition is less likely to affect the yield under it adversely. As the average yield figures obtained from both these treatments indicate that both are equally productive, had the relation for the former treatment been linear just like the second one, this treatment is near ideal for application. Another treatment 021 has also behaved better showing considerable stability and a high level of yield. It would appear that control treatment has a tendency to be stable, which has been noticed in other studies as well.

The analysis of variance of the regression coefficients has shown that excepting for nitrogen, the regression coefficients do not show any variation from level to level. In the case of nitrogen, the regression coefficients increased with the level of nitrogen indicating thereby that any better environment and management will increase the level of yield under a high level of nitrogen more than any other factor under similar situation.

The second type of data was collected from the simple fertilizer trials conducted in cultivators' fields to test the suitability of some of the treatments which proved promising at the experimental stations, under actual conditions of the cultivators which are much different from those of the research stations. For the present investigation yield data have been collected on sugar-cane in three districts *viz.*, Barielly, Aligarh and Muzaffarnagar for the four years 1963, 1964, 1965 and 1966. There are nine treatments in all consisting 0, n_1, n_2, n_3, $n_1 p_1$, $n_3 p_1$, $n_3 p_2$ and $n_3 p_2 k_1$ where the levels of the fertilizers were

N : 0, 70, 140, 210 *kg/ha*
P : 0, 70, 140 *kg/ha*
K : 0, 70, 140 *kg/ha*



In the previous experiment the data were collected from replicated trials. But, in the present case the data were collected from unreplicated trials and the regression coefficients were computed per plot basis for a particular treatment. The yields were in kg/plot of net plot size 1/200 ha. The results are given in Table 4.

The treatment $N_{140}P_{70}$ shows sings of stability in Aligarh district with a moderately high yield. The treatment $N_{210}P_{140}K_{70}$ however shows an average stability in this district along with a highyield.

The regression coefficients obtained from the Barielly district reveal that the treatment $N_{140}P_{70}$ has smaller value of regression coefficient (though not significant) together with a sufficiently high yield. This indicates that the treatment is stable and at the same time it has given high yield. This is, therefore, a very desirable treatment in that region as it has a promise of good response even when the environment is not favourable, a conclusion which can be drawn after studying some more data. The treatment $N_{210}P_{140}$ K_{70} has yielded the highest regression coefficient attended with the highest yield such a treatment may, therefore, be recommended under assured better environment condition. Thus, this treatment can be recommended in assured better condition of environment, a conclusion which emerged from the results of Aligarh district as well.

In Muzaffarnagar district also the treatment $N_{140}P_{70}$ shows a high stability together with sufficiently high productivity. This treatment has behaved similarly in all the three districts. Hence, it appears that this treatment is very much suitable for the region andcan be recommended specially under uncertain environmental condition. In this district also the treatment $N_{210}P_{140}K_{70}$ has given a high value of the regression coefficient together with the highest yield figure. Thus, in the case of the previous two districts, this treatment can be recommended in the district as well under ensured better environment and management conditions.

In all the three districts the control treatment has got a smaller value of the regression coefficients. This reveals that the cultivators' own practice has a tendency to ensure a stable yield resisting the adverse effect of the environment. But, the productivity under this condition is consistently lower.

A combined analysis of the regression coefficients of the set of treatments tried in different districts is also of some interest. It can be easily seen that the sum of the regression coefficients of the treatments tried in a district is equal to the number of treatments. Thus, while analysing the data, suitable adjustment has to be made while conducting the combined analysis. To obviate this difficulty, the increase in the regression coefficients over that for the control has been taken as the variable for the analysis. This adjustment particularly helps in making comparison between districts. The results of the analysis are given in Table 5. The pooled ANOVA of regression coefficients indicated that the treatments are all homogeneous in respect of the regression coefficients, even though when considered separately some of the treatments can be singled out as promising.

When an experiment is conducted over different years and different places, we got a more variable type of environment index from the means of each of the $p \times k$ experiments. Accordingly, the data from simple fertilizer trials are analysed for obtaining regression coefficients and the results are presented in Table 6. An examination of such regression coefficients as discussed above and no particular interesting fact over and above those discussed earlier emerged from this analysis.

SUMMARY

In the usual analysis of groups of experiments, it is not possible to find, if any, particular treatment has a tendency to behave uniformly or otherwise with changing environment. For studying the stability of performances of different varieties of barley, a method was initiated by Finlay and Wilkinson (1963). Eberhart and Russell (1966) proposed a model involving a stability coefficient for varietal assessment. This technique has been extended here for assessing manurial treatments. The method consists of obtaining a treatment index as an average of the treatment yield and the environment index as an average of the experiment. There will be as many pairs of indexes as there are environments. An inverse of the regression coefficient of treatment index on environment index has been taken as a measure of stability of the treatment with changing environment. This methodology has been applied for interpretation of data collected from an experiment conducted in a research station and to the data from simple fertilizers trials, conducted in three districts for four years. From an interpretation of the results obtained from the analysis of the data some treatments could be singled out as promising.

ACKNOWLEDGEMENT

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APPENDIX

EXPERIMENT ON WHEAT (Paldi)

TABLE 1

Regression coefficients of the different treatments and mean yield in lbs/plot

SNP	*REG coeff.*	*Mean yield*	*SNP*	*REG coeff.*	*Mean yield*	*SNP*	*REG coeff.*	*Mean yield*
000	0.7195	6.17	100	0.9927	6.41	200	0.9785	6.05
001	0.8199	5.19	101	0.1934	6.47	201	0.8482	6.00
002	0.6642	6.38	102	0.5097	6.36	202	0.0323	7.59
010	1.1319	8.54	110	1.0386	8.41	210	1.4302	8.55
011	1.2635	9.17	111	0.5775	8.69	211	1.0830	10.59
012	0.6897	10.79	112	2.1368	10.93	212	1.7391	10.10
020	2.6323*	9.84	120	0.9206	8.26	220	0.2100	10.38
021	0.9374	12.45	121	1.9062	12.24	221	3.1421*	10.48
022	1.4762	11.89	122	1.0367	14.26	222	1.4981	13.97

*S. E. of regression coefficients: 0.6.

TABTE 2

ANOVA of the regression coefficients

Source	*d. f.*	*s. s.*	*m. s. F*	*F*
S_L	1	0.0175	0.0175	1
S_Q	1	2.4050	2.4050	6.4755*
N_L	1	3.6143	3.6143	9.7315**
N_Q	1	0.1418	0.1418	1
P_L	1	0.0056	0.0056	1
P_Q	1	0.0567	0.0567	1
S_LN_L	1	0.0037	0.0037	1
S_LP_L	1	0.4180	0.4180	1.1254
N_LP_L	1	0.2678	0.2678	1
Error	17	6.3143	0.3714	—
Total	26	13.2447	—	—

*Significant at 5% level of significance.

**Significant at 1% level of significance.

TABLE 3

Mean values of the regression coefficients

	s_0	s_1	s_2	*Mean*	p_0	p_1	p_2
n_0	0.7345	0.5653	0.5981	0.6326	0.8969	0.6205	0.3805
n_1	1.0284	1.2576	1.4174	1.2346	1.2002	0.9747	1.5285
n_2	1.6820	1.2878	1.6167	1.5288	1.2543	1.9952	1.3370
Mean	1.1483	1.0358	1.2107				
p_0	1.4946	0.9838	0.8729	1.1171			
p_1	1.0069	0.8924	1.6911	1.1968			
p_2	0.9434	1.2344	1.0683	1.0820			

S. E. of marginal means of regression coefficients : 0.20.

TABLE 4

Regression coefficients and mean yields in kg/plot

Treatment	*Barielly*		*Aligarh*		*Muzaffarnagar*	
	Reg. coef.	*Mean*	*Reg. coef.*	*Mean*	*Reg. coef.*	*Mean*
Control	0.8307	452.15	0.7115**	387.90	0.6504*	490.78
N_{70}	1.0609*	521.05	1.0842**	463.95	0.7531**	617.75
N_{140}	1·0957*	569.33	0.9485**	498.28	0.8136**	692.10
N_{310}	1.0553*	610.53	1.0696**	523.15	1.2295**	781.05
$N_{70}P_{70}$	1.0314*	539.40	1.1177**	486.60	0.7563**	644.75
$N_{140}P_{70}$	0.5997	622.03	0.9286**	517.30	0.7716**	731.68
$N_{210}P_{70}$	1.0047*	630.20	1.0253**	527.13	1.4311**	825.25
$N_{210}P_{140}$	1.1013*	652.28	1.0603**	548.30	1.2644**	876.73
$N_{210}P_{140}K_{70}$	1.2203*	671.63	1.0543**	572.73	1.3300**	886.28
S. E.	0.20		0.09		0.11	

*Significant at 5% level of significance.

**Significant at 1% level of significance.

TABLE 5

ANOVA of regression coefficients (increase over control)

Source	*d.f.*	*m. s.*	*F*
Districts	2	0.0834	2.6816
Treatments	7	0.0663	2.1318
Error	14	0.0311	—

TABLE 6

Regression coefficients and mean yields computed over years and districts

Treatment	*Reg. coef.*	*Mean yield*
Control	0.7754	443.6
N_{70}	0.8305	534.3
N_{140}	1.1748	586.6
N_{210}	0.8548	638.2
$N_{70}P_{70}$	0.8504	556.9
$N_{140}P_{70}$	0.8895	623.7
$N_{210}P_{70}$	1.2255	660.9
$N_{210}P_{140}$	1.3172	692.4
$N_{210}P_{140}K_{70}$	1.2929	710.2
S.E.	0.06	