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

S. RAWLO

Institute of Agricultural Research Statistics - Library
ACC No 2138(R)
Cale No 043:102

Dissertation submitted in fulfilment of the requirements for the award of Diploma in Agricultural and Animal Husbandry Statistics of the Institute of Agricultural Research Statistics

(I.C.A.R.)

NEW DELHI

1969

ACKNOWLEDGEMENTS

I am much indebted and have great pleasure in expressing my deep sense of gratitude to Dr. M.N. Das, Senior Professor of Statistics, Institute of Agricultural Research Statistics (I.C.A.R.), New Delhi, for his valuable guidance, keen interest and constant encouragement throughout the course of investigation and immense help at the time of writing up the thesis by critically going through the manuscript.

I am also highly thankful to Dr. G.R. Seth, Statistical Adviser, Indian Council of Agricultural Research, New Delhi for providing me the necessary facilities.

(SURENDRA RAWLO)

CONTENTS

CHAPTER I

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. The design for any particular experiment depends upon the nature of the experiment. After conducting an experiment through a suitable design, the observations from the treatments are analysed using usually the technique of analysis of variance. Mere comparison of treatments as above is not, however, sufficient as it is equally important to ensure that the superiority of a recommended treatment persists from year to year as also from place to place. Moreover, while investigating data collected from experiments or otherwise, it is of interest to see how far the individual treatments are stable under varying environments. The main object of the present investigation is to determine such a stability coefficients for treatments and then obtain such coefficients for various treatments involved in different experiments.

To make the recommendation firmer, the existing practice is to conduct an experiment using the same design and treatments at different locations and /or over a number of years. The analysis of such groups of experiments is usualy laborious. Primarily, analyses of the individual experiments are carried out as usual. To get the overall results of these experiments, pooled analysis of such experiments is undertaken. Before carrying out the pooled analysis, the error mean squares of individual experiments are tested for homogeniety. Now two cases arise viz., (i) error mean squares are homogeneous and (ii) error mean squares are heterogenous. When the error mean squares are homogeneous, data are analysed forming two-way tables of treatments and places. Different sums of squares are obtained per plot basis along with the places x treatments interaction sum of squares. Forming the analysis of variance table, the interaction component is tested against the error mean squares. If the interaction component is not significant, it is pooled with the pooled error and then test of significance for the treatments is carried out. When the interaction component is found to be significant, the 'treatment mean square' is tested against the 'interaction mean square'; assuming that the interaction components are homogenous. If the interaction components are not homogenous, the valid test is to test each component of treatment sum of squares against its own interaction component with the places, which involves extra computations and loss of degrees of freedom for F in the denominator.

(A)

When the error mean squares are heterogeneous, the test of the interaction mean squares against the pooled error mean squares is not valid. In this case, the different sums of

(B)

squares are obtained from the two-way table formed by the means of treatments and weighting them with corresponding inverses of error mean squares.

The above is usually the method of interpretation of the data collected from groups of experiments. In this method 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. This has been described below.

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 following model involving a stability coefficient for variety assessment :

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

$i = 1, 2, \ldots, v$

$j = 1, 2, \ldots, n$

where y_{ij} is the mean yield of the i th variety in j th environment

β_i is the regression coefficient that measures the change of response of i th variety to varying environments.

η_{ij} is the deviation from regression of i th variety at the j th environment and I_j is the environmental index obtained as the mean of of all the varieties at j th environment minus grand mean;

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 measure of stability of the performance of any variety with changing environment , the relation being the less the value of the regression coefficient for a variety, the more is its stability. Though such a coefficient has been used to assess the stability of varieties to changing environment, no attempt seems to have been made to study the stability of fertiliser or other types of treatments. Such a study for assessing the stability or otherwise of fertiliser responses might be useful to find out fertilisers or cultivation practices which are likely to counteract adverse environment. The present investigation attempts to exploit this approach of interpretation of data collected from groups of factorial experiments and experiments on cultivators' fields.

CHAPTER II

METHODOLOGY

When an experiment is conducted over a number of years or places, we shall use the data collected from them 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 that an experiment involving the treatment is carried out. Taking the treatment index as the dependent variable and the environment index as the independent variable, the regression of treatment index on the environmental index is computed. This regression coefficient which gives a measure of the change in the 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 i.e. the less the regression coefficient for a treatment the more stable is that treatment under varying environment. A treatment with higher performance and a larger stability 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 ($i = 1, 2, \ldots, t$) at the j th place ($j = 1, 2, \ldots, p$) in the k th year ($k = 1, 2, \ldots, n$) from the l th replication ($l = 1, 2, \ldots, r$). We now obtain $y_{ijk.}$ as the mean yield of the i th treatment i.e.

$$y_{ijk.} = \frac{1}{l} \sum_{l} y_{ijkl}$$

when the experiment is repeated both over years and places. If the experiment is repeated over years only, we shall have the observation as y_{ikl}. If it is repeated over places only, the observation is denoted by y_{ijl}. The treatment indexes for i th treatment in such situations are the respective treatment means. Then environment indexes in such situations are

$$y_{.j.} = \frac{1}{il} \sum_{i} \sum_{l} y_{ijl} \qquad \text{when repeated over places}$$

$$y_{.k.} = \frac{1}{il} \sum_{i} \sum_{l} y_{ikl} \qquad \text{when repeated over years}$$

$$y_{.jk.} = \frac{1}{il} \sum_{i} \sum_{l} y_{ijkl} \qquad \text{when repeated over years and places}$$

Hence, for the set of treatments in a year or at a place the grand mean i.e. the environment index remains fixed and it varies with the places or years. Therefore, there will be as many pairs of indexes as the number of years or localities. The usual regression

regression of treatment index on environment index gives change in the effect of the treatment per unit change in the environment. If b_i is the regression coefficient so obtained for the i th treatment, it is obtained from

$$b_i = \left[\sum_j y_{ij.} y_{.j.} - \frac{1}{j} \left(\sum_j y_{ij.} \right) \left(\sum_j y_{.j.} \right) \right] / \sum_j y_{.j.}^2 - \frac{1}{j} \left(\sum_j y_{.j.} \right)^2$$

when the experiment is repeated over places

$$b_i = \left[\sum y_{ik.} y_{.k.} - \frac{1}{k} \left(\sum y_{ik.} \right) \left(\sum y_{.k.} \right) \right] / \sum y_{.k.}^2 - \frac{1}{k} \left(\sum y_{.k.} \right)^2$$

when the experiment is repeated over years

and

$$b_i = \frac{\sum_j \sum_k y_{ijk.} y_{.jk.} - \frac{1}{jk} \left(\sum\sum y_{ijk.} \right) \left(\sum\sum y_{.jk.} \right)}{\sum\sum y_{.jk.}^2 - \frac{1}{jk} \left(\sum\sum y_{.jk.} \right)^2}$$

when the experiment is repeated over years and places.

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 smaller than unity the inverse of b_i will be greater than unity, which may be interpreted as that the treatment has got more stability i.e. when environment changes considerably, the treatment response lags behind. If the regression coefficient is more than unity, the stability index is naturally less than unity i.e. 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 is to some extent unpredictable as much as the environment. Such a treatment is useful if better environment is ensured.

Average stability: When the stability index is unity for any treatment, we may then say that the treatment has an average stability i.e. change in treatment index is as much as the change in the environment index.

Stability index which has the value more than unity indicates that the treatment responds better for the better environments as the treatment index changes more rapidly than the environment index, as the environment changes. We have already indicated corresponding interpretation in the case when the stability index is less than unity. Negative values of b_i 's are unlikely and such values may be ignored.

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 get an indication of the relationship. If the relationship is not linear, the methodology given here need not apply.

The units of the treatment index and that of the environment index are the same. Hence the regression of treatment index on the environment index is independent of the units and hence it is also independent of the scale of measurement.

The mean of the experiment is taken as the index of environment, which includes all the observations of the experiment, including the observations on control. The control yield can also be taken as an index for 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 the data pertained to standard factorial experiments conducted over a number of years. The other type of data is collected from simple fertilizer trials d conducted on cultivators' fields in different districts over a number of years. For investigation of the 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 Analysis of Variance. It can be easily seen that each such regression coefficient has the same variance. 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 the regression coefficients.

In case of an experiment conducted at a number of localities over a number of years, the error mean squares for obtaining the standard error for the regression coefficients of treatment index on environment index has been obtained from the interaction of treatments and environments.

CHAPTER III

APPLICATION TO VARIOUS CASES

In this chapter , an attempt has been made to investigate different types of data by applying the method discussed in the previous chapter. Data from two types of experiments have been considered. These are (i) factorial experiments carried over a number of years and (ii) simple fertiliser trials conducted in cultivators' fields in different districts for a number of years .

Data from three experiments have been investigated. Of these, one experiment was on wheat and the other two on sugar-cane . These experiments have been discussed below.

An experiment was conducted on wheat 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 Farm Yard Manure)

three levels of seed rate

viz. 40, 60 and 80 lbs/ac

Nitrogen at three levels O, 20 and 40 lbs/ac

and Phosphorous at three levels O, 20 and 40 lbs/ac .

The six combinations of the three varieties and the two types of application of FYM were the main plot treatments and the 27 combinations of the treatments seed-rate, nitrogen and phosphoreus each at 3 levels were taken as the sub-plot treatments. The plot size was 30' x 15'. The number of replications was only one in each year. The yields are presented in lbs/plot. Taking the means over varieties and application of FYM for the sub-plot treatments, the regression coefficients of treatment index on environment index are computed for all the 27 treatment combinations and the results are presented in Table 1.1. The analysis of variance of these regression coefficients is given in Table 1.2 and the summary of the mean values of the regression coefficients in Table 1.3. The standard error of the marginal means of the regression coefficients is obtained from the interaction of treatments and environments which is given below the table 1.3.

An examination of the values of the 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. The graphs for some of the treatments from this experiment have been presented in

Table 1.1.

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	5.41	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	2.1568	10.93	212	1.7391	10.10
020	2.6323	9.84	120	0.9208	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

Table 1.2

ANOVA of the regression coefficients

Source	d.f.	s.s.	m.s.	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
$S_L N_L$	1	0.0037	0.0037	1
$S_L P_L$	1	0.4180	0.4180	1.1254
$N_L P_L$	1	0.2678	0.2678	1
Error	17	6.3142	0.3714	-
Total	26	13.2447	-	-

* Significant at 5 per cent level of significance

** Significant at 1 per cent level of significance

Table 1.3

Means of regression coefficients

	a_o	a_1	a_2	Mean	P_o	P_1	P_2
n_o	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_o	1.4946	0.9839	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

appendix. 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. The average yield figures obtain from them indicate that both are equally productive. Under these circumstances 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 the control treatment has a tendency to be stable. Even though the environment changes considerably it does not show so much changes. This property has been noticed in other studies as well.

In order to study how the factors behave under varying environment, the regression coefficients were analysed through the technique of analysis of variance. The results show 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 betterment in environment and management will increase the level of yield under a high level of Nitrogen more than any other factor under similar situation.

The following two experiments on sugarcane were carried out at Sugarcane Research Station, Bhograsan, Pusa in Bihar for the four years 1960, 1961, 1962 and 1963. In both the experiments the experimental sites remained unchanged in all the four years and the net plot size 80' x 18' remained the same.

The objective of one of these two experiments was to study the effect of short term rotation of sugarcane with maize in permanent blocks under fixed doses of N, P and K. Each of the fertiliser N, P and K had three levels as shown below.

N as A/S O, 40, 80 lbs/ac

P as P_2O_5 O, 50, 100 lbs/ac

K as K_2O O, 80, 160 lbs/ac

This experiment was conducted with 4 replications using a 3^3 confounded design arranged in the blocks of size 3^2 plots, completely confounding the second order interaction component NP^2K^2 in all the 4 replications and in all the four years. The yields are recorded in kgs/plot. The regression coefficients have been computed for all the 27 treatment combinations of N, P and K which are presented in Table 2.1. The analysis of variance of these regression coefficients is given in Table 2.2.

Summary tables of the mean values of these regression coefficients are given in table 2.3 and the standard error of the marginal means of the regression coefficients obtained from the interaction of environment and treatments is given below the table 2.3.

The objective of the second experiment on sugarcane was to study the effect of short term rotation of sugarcane with green manuring in permanent blocks under fixed doses of N, P and K. The design adopted was 3^3 confounded design in blocks of size 3^2 with 4 replications. The levels of each of these fertilisers were the same as in the previous experiment. In this experiment also, the second order interaction component NP^2K^2 was completely confounded in all the four years. Though the objective was to study the rotation, in the present investigation the data have been used to study the stability or otherwise of the treatment used in the experiment. The regression coefficients are computed and presented in Table 3.1. The analysis of variance of the regression coefficient is given in Table 3.2 and the summary of the mean values of the regression coefficients in table 3.3 and the standard error of the margin means of the regression coefficients is given below the table 3.3.

The regression coefficients from the second experiment with maize in permanent blocks presented in table 2.1 indicate that it is maximum for the treatment formed of the highest doses

Table 2.1

Regression coefficients and mean yields in kgs/plot (sugarcane rotation with maize)

NPK	Reg. Coeff.	Mean yield	NPK	Reg. Coeff.	Mean yield	NPK	Reg. Coeff.	Mean yield
000	0.6320	151.5	100	0.7055	243.8	200	1.3571	257.7
001	0.8678	180.8	101	1.2345	242.6	201	0.8321	263.4
002	0.8317	184.6	102	0.4869	224.8	202	1.8851	277.9
010	0.9327	181.6	110	1.5543	221.6	210	1.8194	331.8
011	0.3654	168.4	111	0.7228	266.1	211	0.9648	309.6
012	1.2743	194.3	112	1.2313	239.2	212	1.1644	313.7
020	0.6037	182.7	120	1.4936	253.6	220	0.6915	343.3
021	0.8187	194.7	121	0.3709	281.7	221	1.2380	363.0
022	0.4532	171.9	122	0.8971	269.0	222	2.0416	390.2

S.E. of regression coefficients = 0.36

Table 2.2.

ANOVA of regression coefficients.

Source	d.f.	s.s./m.s.	F
N_L	1	1.3417	7.4127**
N N_Q	1	0.0215	1
P_L	1	0.0028	1
P_Q	1	0.0753	1
$N_L P_L$	1	0.0103	1
$N_L K_L$	1	0.1068	1
$P_L K_L$	1	0.0007	1
K_L	1	0.0334	1
K_Q	1	0.4493	2.4823
Error	17	0.1810 (m.s.)	-
Total	26	5.1161 (s.s.)	-

** Significant at 1 per cent level of significance

Table 2.3

Mean values of regression coefficients

	a_o	a_1	a_2	Mean	k_o	k_1	k_2
p_o	0.7772	0.8090	1.3581	0.9814	0.8982	0.9781	1.0679
p_1	0.8575	1.1695	1.2162	1.0810	1.3355	0.6843	1.2233
p_2	0.6252	0.9205	1.3237	0.9565	0.9296	0.8092	1.1306
Mean	0.7533	0.9663	1.2993				
k_o	0.7228	1.2511	1.1893	1.0546			
k_1	0.6840	0.7761	1.0116	0.8239			
k_2	0.8531	0.8718	1.6970	1.1406			

Standard error of marginal means of regression coefficients = 0.12

Table 3.1

Regression coefficients and mean yields in kgs/plot
(Sugarcane rotation with green manuring)

NPK	Reg. Coeff.	Mean yield	NPK	Reg. Coeff.	Mean yield	NPK	Reg. Coeff.	Mean yield
000	0.1533	237.5	100	0.7104	309.3	200	1.7593	322.2
001	1.1470	246.4	101	0.8961	333.0	201	1.3892	351.6
002	0.7962	257.1	102	1.6246	305.0	202	1.9607	362.7
010	0.5832	306.7	110	1.4175	336.5	210	0.4395	398.3
011	0.8763	253.8	111	1.8496	364.7	211	0.8980	400.7
012	0.2645	286.0	112	0.2593	339.0	212	1.2273	396.1
020	0.2800	268.1	120	1.0709	368.3	220	1.2991	436.5
021	0.6573	297.3	121	1.0573	317.9	221	0.8672	445.1
022	0.5670	283.5	122	0.6047	324.8	222	0.9594	480.4

Standard error of regression coefficients = 0.42

Table 3.2

Analysis of variance of Regression Coefficients

Source	d.f.	s.s./m.s.	F
N_L	1	1.6653	8.7051 **
N_Q	1	0.1511	1
P_L	1	0.5249	2.7439
$N_L P_L$	1	0.1613	1
P_Q	1	0.0871	1
K_L	1	0.0168	1
$N_L K_L$	1	0.0001	1
$P_L K_L$	1	0.4322	2.2593
K_Q	1	0.2015	1.0533
Error	17	0.1913 (m.s.)	-
Total	26	6.4923 (s.s.)	-

** Significant at 1 per cent level of significance

Table 3.3

Mean values of regression coefficients

	n_o	n_1	n_2	Mean	k_o	k_1	k_2
p_o	0.6990	1.0770	1.7031	1.1596	0.8743	1.1441	1.4605
p_1	0.5747	1.1755	0.8549	0.8684	0.8134	1.2080	0.5837
p_2	0.5014	0.9110	1.0419	0.8181	0.8833	0.8606	0.7104
Means	0.5916	1.0545	1.2000				
k_o	0.3388	1.0663	1.1660	0.8570			
k_1	0.8935	1.2677	1.0515	1.0709			
k_2	0.5426	0.8295	1.3825	0.9182			

Standard error of regression coefficients = 0.14

of all the three factors. This indicates that this treatment is very much sensitive to the change in environment and management condition. The control treatment again shows a tendency of stability. The most stable treatment however turns to be : O11. Generally, absence of nitrogen is attended with more stability which is also indicated by the analysis of variance of the regression coefficients. Such stability decreases with the increase in the level of nitrogen.

The results of the third experiment with green manuring in the permanent blocks indicate that the treatment 202 is most sensitive and should be applied under ensured better environment and management conditions. The control treatment is again very stable. Further, here also the stability decreases with the increase in the level of nitrogen.

CHAPTER IV

APPLICATION TO DATA COLLECTED FROM SIMPLE FERTILIZER TRIALS

The objective of simple fertiliser trials is 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 from those simple fertilizer trials which were carried out in different districts of Uttar Pradesh over several years, on the crops paddy, wheat and sugarcane. In these trials the following three sets of suitably chosen treatments viz., A_1, A_2 and A_3 as described below were applied in randomly selected fields in randomly selected villages within each district. For wheat and paddy the types were as below :

A_1 : O, n_1, n_2, p_1, n_1p_1, n_2p_1, n_2p_2, $n_2p_2k_1$

A_2 : O, n_1, p_1, p_2, n_1p_1, n_1p_2, n_2p_2, $n_2p_2k_2$

A_3 : O, n_1, k_1, k_2, n_1k_1, n_1k_2, n_2k_2, $n_1p_1k_1$

the levels of N, P and K being O, 35, 70 kg/ha for each fertilizer. For sugarcane, there are 9 treatments in each set comprising

A_1 : O, n_1, n_2, n_3, n_1p_1, n_2p_1, n_3p_1, n_3p_2, $n_3p_2k_1$

A_2 : O, n_1, n_2, n_1p_1, n_1p_2, n_2p_1, n_2p_2, n_3p_2, $n_3p_2k_2$

A_3 : O, n_1, n_2, n_1k_1, n_1k_2, n_2k_1, n_2k_2, n_3k_2, $n_2p_2k_1$

where the levels of N, P and K are

N : 0, 70, 140, 210 kg/ha

P : 0, 70, 140 kg/ha

K : 0, 70, 140 kg/ha

All the trials were conducted under irrigated conditions. The plot size was 1/100 ha, but the net plot size harvested for the yields was 1/200 ha and yields are in kgs/plot of size 1/200 ha. The names of the districts and years from which the data we are collected are given in Table 4.1.

Table 4.1.

Paddy : A_1

	Districts	Years
1.	Barielly	1963-64, 1964-65, 1965-66, 1966-67
2.	Moradabad	1963, 1965, 1966
3.	Allahabad	1964, 1965, 1966
4.	Kanpur	1963, 1965, 1966
5.	Varanasi	1963, 1965, 1966

Paddy : A_2

	Districts	Years
1.	Barielly	1963, 1964, 1965, 1966
2.	Moradabad	1963, 1964, 1965, 1966
3.	Allahabad	1964, 1965, 1966,
4.	Rai Barielly	1964, 1965, 1966
5.	Kanpur	1963, 1964, 1965, 1966
6.	Varanasi	1963, 1964, 1965, 1966
7.	Lucknow	1963, 1965, 1966
8.	Shaharanpur	1964, 1965, 1966

Table 4.1 (Contd.)

Paddy : A_3

	Districts	Years
1.	Barielly	1963, 1964, 1965, 1966
2.	Moradabad	1964, 1965, 1966,
3.	Kanpur	1964, 1965, 1966
4.	Varanasi	1963, 1964, 1965, 1966
5.	Lucknow	1963, 1965, 1966

Wheat : A_1

	Districts	Years
1.	Agra	1962, 1963,1964,1965,1966
2.	Aligarh	1962, 1963,1964,1965,1966
3.	Barielly	1962, 1963,1964,1965,1966
4.	Bijnor	1962, 1963,1964,1965,1966
5.	Muzzafarnagar	1962, 1963,1964,1965,1966
6.	Meerut	1962, 1963,1964,1965,1966
7.	Shaharanpur	1962, 1963,1964,1965,1966
8.	Allahabad	1962, 1963,1964,1965,1966

Wheat : A_2 and Wheat : A_3

The A_2 and A_3 types of treatments on wheat were tried in the same districts and years as in the case of Type A_1 treatments.

Sugarcane : A_1

	Districts	Years
1.	Barielly	1963, 1964, 1965, 1966
2.	Aligarh	1963, 1964, 1965, 1966
3.	Muzafarnagar	1963, 1964, 1965, 1966

Sugarcane A_2 and Sugarcane A_3

The A_2 and A_3 types of treatments on sugarcane were tried in the same districts and years as in the case of type A_1 treatments.

For calculating the regression coefficients the treatment index has been obtained from the average of all the yield figures under that treatment in the different villages of the district. The environment index is the district average for each year. The standard errors of the regression coefficients and the mean yields for each treatment are given for each type of experiment for all the districts and crops. The error mean squares needed for working out the standard errors of the regression coefficients are obtained from the interaction of years and treatments. The results are presented in tables Nos. 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10 .

The regression coefficients along with their standard errors and average yield figures for the treatments under the A_1 type on sugarcane conducted in the districts of Barielly, Aligarh and Muzzafarnagar are presented in table 4.2. The regression coefficients obtained from the Barielly district reveals that the treatment $N_{140}P_{70}$ has a smaller value of the regression coefficient 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. 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.

The treatment $N_{140}P_{70}$ again shows signs 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 high yield. Thus this treatment can be recommended in assured better condition of environment, a conclusion which emerged from the results of Barielly district as well.

In Muzzafarnagar district also the treatment N_{140} P_{70} shows a high stability together with a 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 and can be recommended specially under uncertain environmental conditions. In this district also the treatment N_{210} P_{140} K_{70} has given a a high value of the regression coefficient together with the highest yield figure. Thus, as 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 values 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.

Table 4.2

Sugarcane $A1_1$

Regression coefficients and mean yields in kgs/plot

	Barielly		Aligarh		Muzafarnagar	
Treat.	Reg. Coeff.	Mean	Reg. Coeff.	Mean	Reg. Coeff.	Mean yield
O	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_{210}	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	

Sugarcane A_2

Table 4.3

O	0.7856	438.13	0.6511	436.98	0.6742	489.73
N						
N_{70}	0.8877	499.70	1.0405	531.63	0.6642	610.00
N_{140}	1.0720	550.63	1.0042	562.05	0.7276	701.45
$N_{70}P_{70}$	0.9035	517.63	0.9296	520.08	0.6482	633.80
$N_{70}P_{140}$	1.2584	545.90	1.1335	566.93	0.8487	671.80
$N_{140}P_{70}$	0.8129	556.15	1.0060	581.83	0.8353	720.88
$N_{140}P_{140}$	1.0330	586.50	1.2837	571.35	1.2602	758.80
$N_{210}P_{140}$	1.1181	634.50	1.1567	633.28	1.5982	862.30
$N_{210}P_{140}K_{140}$	1.1288	649.95	0.7946	622.18	1.7445	884.25
S.E.	0.13		0.21		0.14	

Table 4.4.

Sugarcane A_3

Regression coefficients and mean yields in kgs/plot

Treat.	Barielly Reg. Coeff.	Mean yield	Aligarh Reg. Coeff.	Mean	Muzaffarnagar Reg. Coeff.	Mean yield
O	0.9911	420.80	0.7207	399.65	0.6300	492.00
N_{70}	0.9356	485.25	1.0487	508.03	0.8509	599.23
N_{140}	0.9956	531.45	1.0961	541.53	0.9979	671.03
$N_{70}K_{70}$	1.1007	507.05	0.9870	490.40	0.9035	606.40
$N_{70}K_{140}$	0.9563	538.78	1.1298	516.90	1.3682	626.90
$N_{140}K_{70}$	0.8267	540.63	0.8225	537.95	0.7271	667.98
$N_{140}K_{140}$	1.0222	559.90	1.0641	558.98	1.0258	697.10
$N_{210}K_{140}$	0.9051	608.08	1.0522	600.85	1.5045	806.35
$N_{140}P_{140}K_{70}$	1.2665	582.75	1.0792	583.35	0.9917	735.88
S.E.	0.17		0.13		0.09	

The regression coefficients of the A_2 type of treatments tried on sugarcane in the same three districts as above are presented in Table 4.3. These treatments are characterised by a higher dose of potassium and some treatments are common in the A_1 and A_2 types.

The treatment $N_{140}P_{70}$ has again shown considerable stability in the Barielly and Musafarnagar districts. The yield performance is also sufficiently high. Thus it appears that this treatment is very suitable for this region. The treatment $N_{70}P_{140}$ has accounted for a high value of the regression coefficient in the districts of Barielly and Aligarh but not in Muzarfarnagar. But as it is not attended with a good yield this treatment does not seem suitable for the region. The treatment $N_{210}P_{140}K_{140}$ has behaved in a very stable manner in Aligarh district. Its response is also very high. These results, therefore, indicate that this is a very suitable treatment for this district. But the same treatment has behaved differently in the Musafarnagar district where the high value of the regression coefficient indicates that this treatment is suitable under good environment.

The third type of treatments A_3 tried on sugarcane in the same three districts as above are characterised by a high dose of potassium. Again there are several common treatments in this set and the previous two sets. The regression coefficients for these treatments are presented in Table 4.4. An examination of these regression coefficients indicate that the treatment $N_{140}K_{70}$ has a smaller regression coefficient in all the three districts. The yield from this treatment is also above average. Thus it seems for sugarcane the treatment $N_{140}K_{70}$ is expected to give uniformly better performance even out-doing some of the effects of adverse environment. The treatment $N_{210}K_{140}$ has also an above average stability together with a very high yield in Barielly and Aligarh. This treatment has however, the highest value of regression coefficient in Musafarnagar district together with a very high yield. Such findings indicate in general that very high doses of the fertilizers tried should be recommended in assured better conditions of environment and management. The control treatment has a tendency to lag behind the change in environment. The treatment $N_{140}P_{70}$ shows uniformly a high stability wherever it has been tried, with above average yield performance and is therefore a suitable treatment for recommendation in the region.

Three types of treatments were tried on paddy. The type A_1 treatments consisting of 8 treatment combinations involving N and P with only one treatment involving k with highest dose 70 kgs/ha of nitrogen and phosphorus. These treatments were tried in 5 districts Barielly, Moradabad, Allahabad, Kanpur and Varanasi. The regression coefficients corresponding to these

Table 4.5

Paddy A_1

Regression coefficients and mean yields in kgs/plot

Treat.	Barielly Reg. Coeff.	Barielly Mean yield	Moradabad Reg. Coeff.	Moradabad Mean yield	Allahabad Reg. Coeff.	Allahabad Mean yield	Kanpur Reg. Coeff.	Kanpur Mean yield	Varanasi Reg. Coeff.	Varanasi Mean yield
O	0.7965	18.25	0.8708	17.83	0.7775	13.87	0.7983	16.30	0.6698	8.62
N_{35}	0.9491	21.38	1.0200	20.86	0.7859	17.79	1.0080	19.66	0.9404	9.73
N_{70}	0.9052	23.74	1.0008	22.74	0.9751	19.58	0.9865	21.85	1.1100	12.22
P_{35}	0.8793	19.50	0.9302	19.47	0.8719	15.36	1.1108	17.62	0.7879	14.15
$N_{35}P_{35}$	0.9261	22.24	0.9608	22.04	1.0971	18.22	0.9879	20.76	0.9818	10.42
$N_{70}P_{35}$	1.0230	24.94	1.0149	24.01	1.1993	19.92	0.9167	23.20	1.1319	13.14
$N_{70}P_{70}$	1.2254	26.77	1.0539	25.10	1.0976	22.09	1.0621	24.90	1.1759	14.95
$N_{70}P_{70}K_{35}$	1.2955	27.89	1.1486	26.17	1.1956	21.70	1.1297	25.83	1.2023	15.57
S.E.	0.11		0.07		0.17		0.09		0.14	

treatments were presented along with average yield for each district. An examination of regression coefficients shows that the control treatment had a high stability figure in all the districts, but the yield obtained under this treatment is consistently low. The treatments $N_{70}P_{70}K_{35}$ has accounted for a regression coefficient which is greater than unity in all the districts along with a very high yield. This indicates that this treatment can be recommended in assured better environment in the region. The treatment $N_{70}P_{70}$ which differs from the above treatment by not having the potassium dose shows a regression coefficient which is slightly less than, but not significantly, from that of the treatment $N_{70}P_{70}K_{35}$ in all the districts. This possibly indicates the application of potassium did not contribute much either in respect of stability or in respect of productivity. As in sugarcane there does not seem to be a treatment which has shown high stability together with high productivity. The regression coefficients obtained from different treatments do not generally differ much from all the districts. A further fact noted is that the average yield and the regression coefficients seems to have a high correlation.

The type A_2 treatments on paddy were tried in 8 districts shown in table 4.1. This set is characterised by a higher dose of phosphorus along with a treatment combination $N_{70}P_{70}K_{70}$

Paddy A_2

Regression coefficients and mean yields in kgs/plot

Treat.	Barielly Reg. Coeff.	Barielly Mean yield	Moradabad Reg. Coeff.	Moradabad Mean yield	Allahabad Reg. Coeff.	Allahabad Mean yield	Rae Barielly Reg. Coeff.	Rae Barielly Mean yield
O	0.7894	18.86	0.8001	17.00	0.7914	13.43	1.1045	15.20
N_{35}	0.9822	22.13	0.9400	20.17	0.9331	16.78	0.4515	17.89
P_{35}	0.8569	21.65	0.8966	18.32	0.7323	14.92	1.1377	16.51
P_{70}	0.9309	21.14	0.9228	19.12	0.6349	15.54	1.4450	17.65
$N_{35}P_{35}$	0.9587	23.17	1.0234	21.27	1.1304	17.72	0.4900	17.46
$N_{35}P_{70}$	1.0122	24.14	1.0067	21.78	1.1652	17.82	0.6619	20.26
$N_{70}P_{70}$	1.3146	27.17	1.1635	24.05	1.3288	20.15	1.5072	22.90
$N_{70}P_{70}K_{70}$	1.1511	28.21	1.2470	25.47	1.2838	20.58	1.2045	24.03
S.E.	0.11		0.11		0.21		0.09	

Table 4.6 (Contd.)

Treat.	Kanpur Reg. Coeff.	Kanpur Mean yield	Varanasi Reg. Coeff.	Varanasi Mean yield	Lucknow Reg. Coeff.	Lucknow Mean yield	Shaharanpur Reg. Coeff.	Shaharanpur Mean yield
O	0.7914	15.88	0.7284	11.98	1.0900	10.77	0.7573	16.51
N_{35}	0.8326	19.34	0.9447	14.61	0.9373	12.84	0.9559	20.69
P_{35}	0.9821	17.11	0.8059	12.58	0.7602	11.62	0.8211	18.11
P_{70}	1.1203	17.79	0.8582	13.42	0.9930	11.96	0.8912	19.28
$N_{35}P_{35}$	1.0562	20.38	1.0390	15.69	1.0697	13.60	1.0274	22.08
$N_{35}P_{70}$	1.0914	21.39	1.0737	16.34	1.2110	14.06	1.0444	22.73
$N_{70}P_{70}$	1.0617	24.86	1.2578	18.77	0.8758	16.11	1.2168	25.03
$N_{70}P_{70}K_{70}$	1.0643	24.97	1.2923	19.40	1.0629	16.64	1.2857	25.78
S.E.	0.10		0.13		0.18		0.13	

as against $N_{70}P_{70}K_{35}$ in the previous set. The regression coefficients of these treatments have been presented in Table 4.6. The treatment $N_{70}P_{70}$ has accounted for a high regression coefficient in the districts of Barielly, Allahabad, Rae Barielly, Varanasi and Saharanpur. The yield from this treatment in these districts is also sufficiently high. This treatment thus may be recommended under ensured better environment. In Lucknow district this treatment has indicated a high stability along with sufficiently high yield. There does not seem to be uniform behaviour of the regression coefficients of various treatments in different districts. The low yielders have again shown a tendency of low regression.

The type A_3 treatments on paddy consisting of 8 treatments characterised by a higher dose of potassium given alone and also in various combinations of N and P were tried in five districts Barielly, Varanasi, Moradabad, Kanpur, and Lucknow. The regression coefficients from these districts are presented in Table 4.7. In this case the treatment $N_{35}P_{35}K_{35}$ has shown an average stability in all the districts. The treatment $N_{70}K_{70}$ has , however, shown regression coefficients which are generally greater than unity. The yield figures of these treatments are also greater. None the less , it appears such treatment cannot be recommended because of lower productivity than that from some of the treatments in the other two types. Barring the

Table 4.7

Paddy A_3 Regression coefficients and mean yields in kgs/plot

Treat.	Barielly Reg.Coeff.	Barielly Mean yield	Moradabad Reg. Coeff.	Moradabad Mean yield	Kanpur Reg.Coeff.	Kanpur Mean yield	Varanasi Reg.Coeff.	Varanasi Mean yield	Lucknow Reg.Coeff.	Lucknow Mean yield
O	0.8392	16.99	0.8140	16.02	0.8915	14.84	0.7719	13.96	0.9217	9.47
N_{35}	0.9930	19.56	0.9733	19.30	0.9878	18.44	0.9963	12.96	1.0428	11.40
K_{35}	0.9175	17.96	0.8814	17.03	0.8425	15.57	0.8147	10.87	0.9383	10.17
K_{70}	0.9808	18.67	0.9341	17.93	0.9495	16.12	0.8574	11.21	0.9344	10.71
$N_{35}K_{35}$	0.9215	20.27	1.0577	20.32	1.0556	18.96	1.0520	13.41	0.9587	11.72
$N_{35}K_{70}$	1.0660	22.50	1.0484	20.75	1.0165	19.68	1.1193	13.67	0.9945	12.12
$N_{70}K_{70}$	1.1849	24.55	1.2321	23.60	1.1155	22.41	1.2174	16.17	1.1548	14.47
$N_{35}P_{35}K_{35}$	1.0971	23.33	1.0589	21.92	1.1410	21.44	1.1710	14.83	1.0547	13.11
S.E.	0.09		0.12		0.09		0.10		0.07	

control treatment, the other treatments have shown more or less homogenous regression coefficients and homogeneous set of yield figures in all the districts. This perhaps concludes application of potassium could not create much heterogeneity in the yield.

Three types of treatments were tried on wheat over five years. Type A_1 treatments as shown in Table 4.8 were tried in the districts of Agra, Aligarh, Bijnor, Barielly, Muzafarnagar, Meerut, Shaharanpur and Allahabad. The regression coeffients obtained from each treatments were shown in Table 4.8. An examination of the regression coefficients reveals that the treatment $N_{70}P_{70}$ has got sufficiently high regression coefficient in the districts of Agra, Bijnor and Muzafarnagar indicating thereby that these treatments might be recommended under ensured better environment. The treatment $N_{70}P_{70}K_{35}$ which differs from the previous one by having a dose of potassium has the regression coefficient slightly greater than those obtained from $N_{70}P_{70}$ from all the districts except in Meerut. The average yields from these two treatments do not differ in any of the districts. The treatment with phosphorous only has indicated high stability in all the districts. But the productivity under this treatment is just above the average. But when this treatment

Table 4.8.

Wheat A_1 Regression coefficients and mean yields in kgs/plot

Treat.	Agra Reg.Coeff.	Agra Mean yield	Aligarh Reg.Coeff.	Aligarh Mean yield	Bijnor Reg.Coeff.	Bijnor Mean yield	Barielly Reg.Coeff.	Barielly Mean yield
O	0.2246	15.76	0.7660	16.08	0.6600	16.92	0.7913	15.48
N_{35}	0.9973	21.10	0.9166	20.95	0.9301	20.25	0.9345	18.23
N_{70}	0.9561	23.13	1.2976	23.74	1.0185	22.07	1.1375	20.47
P_{35}	0.8344	18.26	0.4381	17.79	0.7133	18.42	0.8626	16.61
$N_{35}P_{35}$	1.2178	22.20	1.4028	22.38	0.9532	21.91	1.0149	19.27
$N_{70}P_{35}$	1.2265	23.76	1.3948	25.42	1.1253	23.76	1.0855	21.29
$N_{70}P_{70}$	1.2397	25.53	1.0640	26.70	1.2614	25.21	1.1078	22.60
$N_{70}P_{70}K_{35}$	1.3037	26.35	1.0801	27.40	1.3383	26.87	1.0659	23.42
S.E.	0.21		0.20		0.08		0.16	

Table 4.8 (Contd)

Treat.	Muzaffarnagar Reg. Coeff.	Muzaffarnagar Mean yield	Meerut Reg. Coeff.	Meerut Mean yield	Shaharanpur Reg. Coeff.	Shaharanpur Mean yield	Allahabad Reg. Coeff.	Allahabad Mean yield
O	0.5411	16.32	0.6881	17.71	0.8284	14.21	0.9047	14.87
N_{35}	0.8152	20.77	0.8928	22.26	0.8960	17.71	1.2211	17.64
N_{70}	1.0104	24.40	0.8410	24.92	1.0256	20.07	1.0451	19.51
P_{35}	0.7002	17.88	0.8227	19.48	0.8760	15.82	0.7297	15.72
$N_{35}P_{35}$	0.8516	22.88	1.1351	23.97	1.0237	19.04	0.9574	18.78
$N_{70}P_{35}$	1.0437	25.94	1.0128	26.95	1.1521	21.63	0.9055	20.67
$N_{70}P_{70}$	1.6110	28.76	1.1970	28.57	1.0556	22.89	1.1296	21.10
$N_{70}P_{70}K_{35}$	1.5268	29.80	1.4105	28.93	1.1425	23.65	1.1070	21.43
S.E.	0.18		0.18		0.08		0.15	

Table 4.9

Wheat A_2 Regression coefficients and mean yields in kgs/plot

	Aligarh		Agra		Barielly		Bijnor	
Treat.	Reg. Coeff.	Mean yield	Reg. Coeff.	Mean yield	Reg. Coeff.	Mean yield	Reg. Coeff.	Mean yield
O	0.8290	16.43	0.2578	15.15	0.8830	15.65	0.6107	16.89
N_{35}	1.1478	21.82	1.0622	20.70	1.0514	18.97	0.8642	20.44
P_{35}	0.9512	18.93	0.5104	16.90	0.9148	16.64	1.0120	18.64
P_{70}	0.9271	19.64	0.7525	18.32	0.9708	17.42	0.7354	19.54
$N_{35}P_{35}$	0.9615	23.39	1.3959	21.59	1.0774	19.93	1.0756	22.00
$N_{35}P_{70}$	1.0723	24.46	1.3653	22.50	1.0977	20.82	1.2091	23.23
$N_{70}P_{70}$	0.9142	27.63	1.2820	24.60	1.0491	23.04	1.1571	24.89
$N_{70}P_{70}K_{70}$	1.1968	28.66	1.3737	25.92	0.9558	23.71	1.3358	26.80
S.E.	0.16		0.27		0.02		0.18	

Table 4.9 (Contd.)

Treatment	Muzafarnagar Reg. Coeff.	Muzafarnagar Mean yield	Meerut Reg. Coeff.	Meerut Mean yield	Shaharanpur Reg. Coeff.	Shaharanpur Mean yield	Allahabad Reg. Coeff.	Allahabad Mean yield
O	0.5648	15.50	0.5930	17.58	0.8620	13.71	0.8196	13.73
N_{35}	0.9329	19.90	0.8219	21.50	0.9379	17.58	0.9328	17.68
P_{35}	0.6898	16.80	0.8048	19.14	1.0088	15.17	0.8934	15.23
P_{70}	0.8059	17.92	0.9303	20.19	0.8778	16.40	0.9239	15.78
$N_{35}P_{35}$	1.0249	21.80	0.9728	23.21	0.9982	18.83	0.9986	18.94
$N_{35}P_{70}$	1.0359	22.62	1.1739	24.15	1.0745	19.83	1.0549	19.03
$N_{70}P_{70}$	1.4861	27.08	1.2673	26.85	1.0821	22.24	1.2443	20.59
$N_{70}P_{70}K_{70}$	1.4597	27.27	1.4360	27.38	1.1588	22.94	1.1325	21.02
S.E.	0.16		0.16	0.09	0.09		0.14	

Table 4.10

Wheat A_3 Regression coefficients and mean yields in kgs/plot

Treatment	Agra		Aligarh		Bareilly		Bijnor	
	Reg. Coeff.	Mean yield	Reg. Coeff.	Mean yield	Reg. Coeff.	Mean yield	Reg. Coeff.	Mean yield
O	0.4006	14.32	0.6533	15.74	0.9459	15.07	0.7743	15.74
N_{35}	1.1779	19.43	1.1094	20.39	0.9152	18.06	0.9594	19.37
K_{35}	0.6228	15.83	0.9684	17.28	0.9528	16.05	0.7503	16.93
K_{70}	0.8852	16.73	0.8222	17.59	0.9370	16.64	0.8017	17.82
$N_{35}K_{35}$	1.0832	19.70	1.1316	20.80	1.0028	18.90	1.0168	20.62
$N_{35}K_{70}$	1.1570	20.48	1.0172	21.60	1.0696	19.57	1.1523	21.46
$N_{70}K_{70}$	1.3046	22.73	1.1632	24.84	1.1334	21.67	1.3049	23.36
$N_{35}P_{35}K_{35}$	1.3688	22.04	1.1350	23.59	1.0438	21.00	1.2403	23.45
S.E.	0.25		0.17		0.14		0.15	

Table 4.10(Contd)

Treat.	Muzaffarnagar Reg. Coeff.	Muzaffarnagar Mean yield	Meerut Reg. Coeff.	Meerut Mean yield	Shaharanpur Reg. Coeff.	Shaharanpur Mean yield	Allahabad Reg. Coeff.	Allahabad Mean yield
O	0.7652	14.99	0.7343	16.92	0.9627	12.95	0.7351	14.69
N_{35}	1.0099	19.19	1.0830	21.32	0.9446	16.88	1.0397	17.36
K_{35}	0.7943	15.31	0.7880	17.57	1.0060	14.01	0.9843	15.33
K_{70}	0.8157	15.67	0.8486	18.43	1.0020	14.67	0.9621	15.21
$N_{35}K_{35}$	1.0047	19.79	1.0098	22.47	0.9847	17.21	1.0573	18.14
$N_{35}K_{70}$	1.0266	20.18	1.1192	23.18	1.0594	17.87	1.1236	18.33
$N_{70}K_{70}$	1.3178	23.90	1.2921	26.40	1.0845	20.87	1.0822	20.31
$N_{35}P_{35}K_{35}$	1.2258	22.90	1.1250	25.11	0.9560	19.93	1.0157	19.23
S.E.	0.11	O	0.13		0.09		0.17	

was applied alongwith N_{35}, the regression coefficients increased considerably and also the yields. This indicates that the application of nitrogen causes a greater mobility of response.

The type A_2 treatments are shown in table 4.9 (along with their regression coefficients) which were tried in the same eight districts over 5 years. In these treatments the higher dose of P_{70} along with $N_{35}P_{70}$, $N_{70}P_{70}$ and $N_{70}P_{70}K_{70}$ were tried. Thus four of the eight treatments had a high level of phosphorous. In Aligarh district, the treatment $N_{70}P_{70}$ behaved in a stable manner together with a high yield, though in all the other districts, the same treatment has shown a mobility together with a higher yield. The treatment $N_{70}P_{70}K_{70}$ has accounted for a high value of regression coefficient in the districts Agra, Bijnore, Muzafarnagar and Meerut. The yieldsfrom this treatment are also high in these districts. Normally in these trials, where phosphorous is given alone, the regression coefficientas also the yields are lower.

Coming to the regression coefficients of Type A_3 treatments given in Table 4.10, it is observed that wherever K is given alone the regression coefficients are smaller and the yields are also low. This shows that potassium has a tendency of stability but lacks in productivity. On the other hand where nitrogen is applied the regression coefficient has gone up,indicating thereby that nitrogen is suitable under assured better environment.

CHAPTER V

VARIATION OVER PLACES AND YEARS

In the previous chapter, we have discussed the results obtainable from individual districts. It was mentioned here that some sets of treatments were tried in different districts. It is therefore, desirable to investigate how far the treatments behave similarly or otherwise in different districts in respect of these regression coefficients. A combined analysis of regression coefficients of a set of treatments tried in different districts is also of some interest. In the present chapter, such combined analyses have been conducted on three sets of treatments tried in different districts. For wheat crop, each of the three sets of treatments were tried in 8 districts and for sugarcane each of the three sets of treatments were tried in three districts. But for paddy each of the three sets A_1, A_2 and A_3 were tried in 5, 8 and 5 districts respectively. The regression coefficients obtained from each district for each set of treatments have already been shown in tables 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9 and 4.10 respectively for three crops.

It can be seen easily 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 have been presented in the tables 5.1, 5.2, and 5.3.

The pooled analysis of variance of the regression coefficients obtained from different types of treatments applied to sugarcane 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. In the case of paddy the pooled lanalysis indicates that the treatment m.s. is significant in the case of all the three types of treatments. An examination of the treatment means pooled over the districts indicates that the among the type A, treatments, the regression coefficients went increasing along with the levels of nitrogen and phosphorous. The type A_2 treatment which are significantly different indicate also the same tendency. As a matter of fact the regression coefficient varied directly with the total amount of fertilisers applied, excepting the case of the treatment $N_{70}P_{70}K_{70}$ which showed a fall in the regression coefficient from that obtained from that of the treatment $N_{70}P_{70}$. The type A_3 treatment means involving predominantly potassium indicates that the regression coefficients increased with the level of nitrogen. Potassium does not seem to have influenced the regression co-efficients.

The results obtained from wheat are more or less similar to those obtained from paddy i.e. the regression coefficients increased with increasing levels of nitrogen and phosphorous, being

Table 5.1

ANOVA of Regression coefficients (increase over controll)
(increase

Sugarcane

Source	d.f.	A_1 m.s.	A_1 F	A_2 m.s.	A_2 F	A_3 m.s.	A_3 F
Districts	2	0.0834	2.6816	0.0504	1	0.3219	10.84
Treatments	7	0.0663	2.1318	0.1057	1.4701	0.0455	1.53
Error	14	0.0811	-	0.0719	-	0.0297	-

Treat. means (reg. coefficients)

A_1		A_2		A_3	
Control (O)	0.7309	Control	0.7036	Control	0.7806
N_{70}	0.9661	N_{70}	0.8338	N_{70}	0.9451
N_{140}	0.9189	N_{140}	0.9346	N_{140}	0.9562
N_{210}	1.1182	$N_{70}P_{70}$	0.8271	$N_{70}K_{70}$	0.9971
$N_{70}P_{70}$	0.9685	$N_{70}P_{140}$	1.0802	$N_{70}K_{140}$	1.1513
$N_{140}P_{70}$	0.7666	$N_{140}P_{70}$	1.8847	$N_{140}K_{70}$	0.7921
$N_{210}P_{70}$	1.1537	$N_{140}P_{140}$	1.1923	$N_{140}K_{140}$	1.0374
$N_{210}K_{140}$	1.1420	$N_{210}K_{140}$	1.2910	$N_{210}K_{140}$	1.1539
$N_{210}P_{140}K_{70}$	1.2016	$N_{210}P_{140}K_{140}$	1.2303	$N_{140}P_{140}K_{70}$	1.1125

Table 5.2

ANOVA of regression coefficients (increase over control)

Paddy	A_1			A_2			A_3		
Source	d.f.	m.s.	F	d.f.	m.s.	F	d.f.	m.s.	F
Districts	4	0.0451	4.60**	7	0.2068	5.83**	4	0.0402	27.33**
Treatments	6	0.0480	4.90**	6	0.1573	4.44**	6	0.0568	37.87**
Error	24	0.0098	-	42	0.0355	-	24	0.0015	-

Means of regression coefficients

A_1		A_2		A_3	
Control(O)	0.7826	Control	0.8566	Control	0.8477
N_{35}	0.9409	N_{35}	0.8722	N_{35}	0.9987
N_{70}	0.9616	P_{35}	0.8741	K_{35}	0.8789
P_{35}	0.9805	P_{70}	0.9746	K_{70}	0.9313
$N_{35}P_{35}$	0.9520	$N_{35}P_{35}$	0.9744	$N_{35}K_{35}$	1.0091
$N_{70}P_{35}$	1.0581	$N_{35}P_{70}$	1.0334	$N_{35}K_{70}$	1.0490
$N_{70}P_{70}$	1.1230	$N_{70}P_{70}$	1.2158	$N_{70}K_{70}$	1.1810
$N_{70}P_{70}K_{35}$	1.1944	$N_{70}P_{70}K_{70}$	1.2245	$N_{35}P_{35}K_{35}$	1.1048

Table 5.3

ANOVA of regression coefficients (increase over control)

Wheat

Source	d.f.	A_1 m.s.	A_1 F	A_2 m.s.	A_2 F	A_3 m.s.	A_3 F
Districts	7	0.4161	14.44**	0.4175	15.58**	0.2821	26.87 **
Treatments	6	0.1767	6.13**	0.1994	7.44**	0.1315	12.52 **
Error	42	0.0288	-	0.0268	-	0.0105	-

Means of regression coefficients

A_1		A_2		A_3	
Control	0.6755	Control	0.6775	Control	0.7464
N_{35}	0.9504	N_{35}	0.9689	N_{35}	1.0324
N_{70}	1.0446	P_{35}	0.8482	K_{35}	0.8584
P_{35}	0.7471	P_{70}	0.8653	K_{70}	0.8843
$N_{35}P_{35}$	1.0245	$N_{35}P_{35}$	1.0631	$N_{35}K_{35}$	1.0414
$N_{70}P_{35}$	1.1183	$N_{35}P_{70}$	1.1355	$N_{35}K_{70}$	1.0907
$N_{70}P_{70}$	1.4457	$N_{70}P_{70}$	1.1853	$N_{70}K_{70}$	1.2104
$N_{70}P_{70}K_{35}$	1.2468	$N_{70}P_{70}K_{70}$	1.2562	$N_{35}P_{35}K_{35}$	1.1989

influenced more by nitrogen. Potassium did not show again any marked effect on regression coefficients.

When an experiment is conducted over different years and different places, we get a more variable type of environment index from the means of each of the $p \times k$ experiments where p stands for number of places and k for number of years. Taking such environment index, the regression coefficients for each treatment can be obtained. Accordingly, the data from simple fertilizer trials are analysed for obtaining regression coefficients and the results are presented in table 5.4. An examination of such regression coefficients indicates similar results as discussed in the previous section for all the three crops. No particular interesting fact over and above those discussed earlier emerged from this analysis.

Table 5.4

Regression coefficients and mean yields in kgs/plot computed over districts and years.

Sugarcane A_1			Sugarcane A_2			Sugarcane A_3		
Treatment	Reg. Coeff.	Mean yield	Treat.	Reg. Coeff.	Mean yield	Treatment	Reg. Coeff.	Mean yield
Control	0.7754	443.6	Control	0.8497	455.0	Control	0.6680	437.5
N_{70}	0.8305	534.3	N_{70}	0.8693	387.8	N_{70}	0.8540	530.8
N_{140}	1.1748	586.6	N_{140}	0.8681	604.7	N_{140}	0.9740	581.3
N_{210}	0.8548	638.2	$N_{70}P_{70}$	1.0061	557.2	$N_{70}K_{70}$	0.8670	534.6
$N_{70}P_{70}$	0.8504	556.9	$N_{70}P_{140}$	1.0110	594.5	$N_{70}K_{140}$	0.8980	560.9
$N_{140}P_{70}$	0.8895	623.7	$N_{140}P_{70}$	1.0006	619.4	$N_{140}K_{70}$	0.8660	582.2
$N_{210}P_{70}$	1.2255	660.9	$N_{140}P_{140}$	1.1758	638.9	$N_{140}K_{140}$	0.9780	605.3
$N_{210}P_{140}$	1.3172	692.4	$N_{210}P_{140}$	1.3215	710.0	$N_{210}K_{140}$	1.1550	671.8
$N_{210}P_{140}K_{70}$	1.2929	710.2	$N_{210}P_{140}K_{140}$	1.1978	718.8	$N_{140}P_{140}K_{70}$	1.0530	634.0
S.E.	0.06			0.12			0.07	

Table 5.4 (Contd)

	Paddy A_1			Paddy A_2			Paddy A_3	
Treatment	Reg. Coeff.	Mean yield	Treatment	Reg. Coeff.	Mean yield	Treatment	Reg. Coeff.	Mean yield
Control	0.8400	15.18	Control	0.7950	15.09	Control	0.8344	15.40
N_{35}	0.9300	18.10	N_{35}	0.9620	18.20	N_{35}	0.9940	16.32
N_{70}	0.9740	20.26	P_{35}	0.8520	16.50	K_{35}	0.8830	14.33
P_{35}	0.9190	17.38	P_{70}	0.9080	17.11	K_{70}	0.6290	14.93
$N_{35}P_{35}$	0.9660	18.96	$N_{35}P_{35}$	0.9860	19.09	$N_{35}K_{35}$	1.0090	16.92
$N_{70}P_{35}$	1.0480	21.29	$N_{35}P_{70}$	1.0640	19.97	$N_{35}K_{70}$	1.0700	17.78
$N_{70}P_{70}$	1.1130	23.01	$N_{70}P_{70}$	1.4140	22.57	$N_{70}K_{70}$	1.1540	20.25
$N_{70}P_{70}K_{35}$	1.2090	23.71	$N_{70}P_{70}K_{70}$	1.2180	23.33	$N_{35}P_{35}K_{35}$	1.1370	18.94
S. E.	0.04			0.03			0.04	

Table 5.4 (Contd.)

	Wheat A_1			Wheat A_2			Wheat A_3	
Treatment	Reg. Coeff.	Mean yield	Treatment	Reg. Coeff.	Mean yield	Treatment	Reg. Coeff.	Mean yield
Control	0.6550	15.91	Control	0.7170	15.58	Control	0.6610	15.05
N_{35}	0.9240	19.86	N_{35}	0.9310	19.82	N_{35}	1.0220	19.00
N_{70}	1.0440	22.29	P_{35}	0.8540	17.18	K_{35}	0.8350	16.05
P_{35}	0.6940	17.50	P_{70}	0.8720	18.15	K_{70}	0.8640	16.60
$N_{35}P_{35}$	1.0080	21.30	$N_{35}P_{35}$	1.0050	21.20	$N_{35}K_{35}$	1.0520	19.71
$N_{70}P_{35}$	1.1270	23.68	$N_{35}P_{70}$	1.3610	22.08	$N_{35}K_{70}$	1.1200	20.33
$N_{70}P_{70}$	1.2800	25.17	$N_{70}P_{70}$	1.2360	24.62	$N_{70}K_{70}$	1.2260	23.04
$N_{70}P_{70}K_{35}$	1.3080	25.93	$N_{70}P_{70}K_{70}$	1.2960	25.46	$N_{35}P_{35}K_{35}$	1.1620	22.16
S.E.	0.06			0.05			0.05	

SUMMARY

The usual approach of interpretation of data collected from groups of experiments aims at finding out, if any treatment contrasts 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. Keeping the later objective in view, an alternative approach of interpretation of such data has been presented in the thesis. This method was initiated by Finlay and Wilkinson (1963) and later by Eberhart and Russell (1966) for studying the stability of performance of different varieties of barley. The same technique has been extended here for assessing manurial treatments from data obtained from groups of experiments conducted by adopting regular designs and also from simple fertilizer trials conducted on cultivators' fields. The methodology adopted consists essentially of obtaining a treatment index as an average of the treatment yield from an experiment conducted in an environment (i.e. a place in an year) and also an enviroment index as the average of the experiment. Thus for every treatment we have a pair of observations consisting of treatment index and an environment index. For every treatment in the experiment, there will thus be as many such pairs as there are environments. An inverse of the regression coefficient of the treatment index on the environment index has been taken as a measure of stability of the treatment with changing environment

(*) from page 5 — (P-3)

A treatment with higher stability and sufficiently high productivity can be considered as suitable for adoption under uncertain environmental conditions. Again a treatment with high regression coefficient and also a high yield can be considered suitable for adoption under ensured better environment. This methodology has been applied for interpretation of data collected from three controlled experiments conducted in research stations. Of these experiments one was on wheat, and two on sugarcane, each running over four years. Data from simple fertiliser trials considered for interpretation were collected from trials on sugarcane, paddy and wheat conducted generally for four to five years in several districts am ranging from three to eight in number.

From an interpretation of the results obtained from the analysis of these data, some treatments could be singled out as promising in specific regions.

REFERENCES

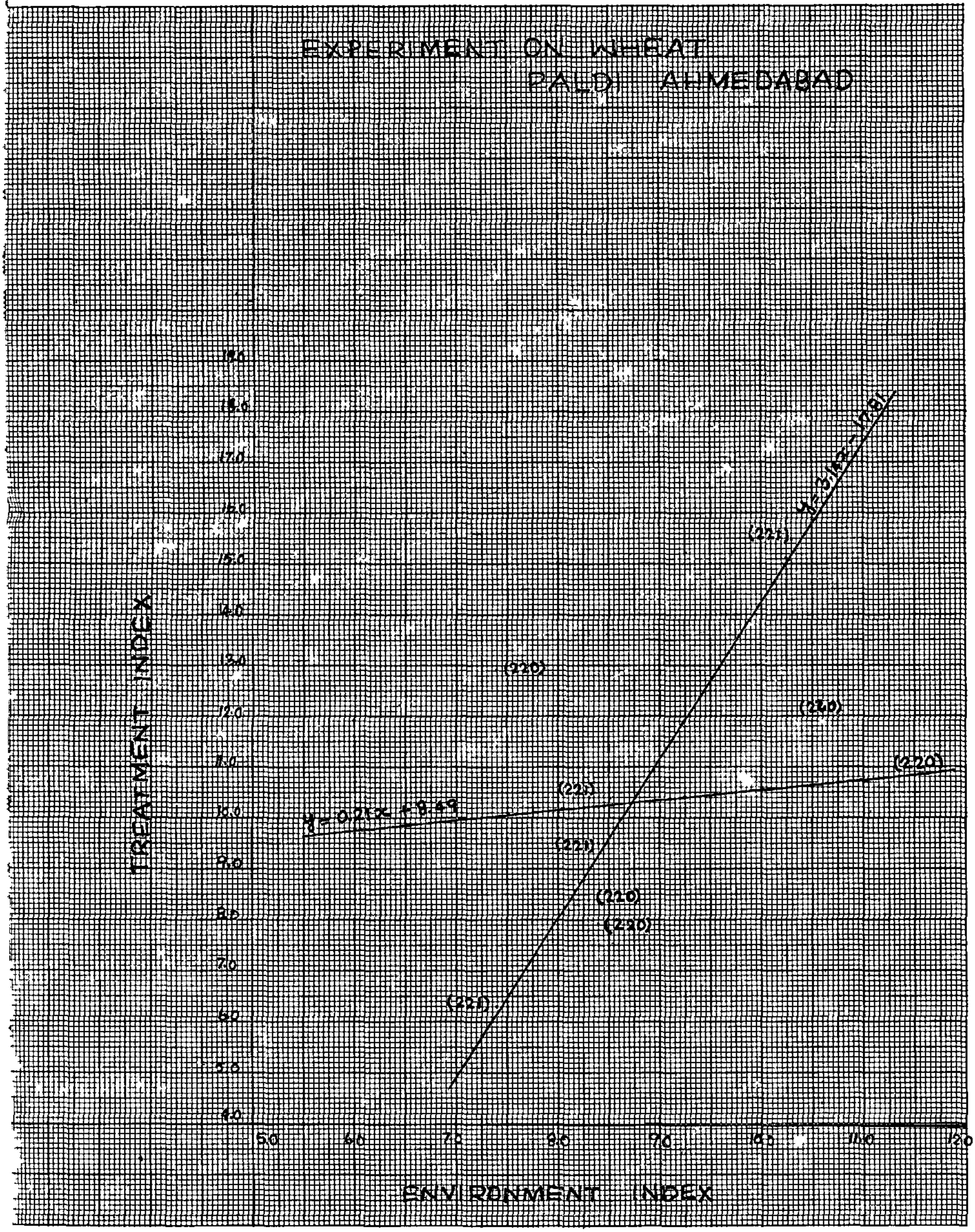
1. Cochran and Cox : Experimental Designs, 2nd Edition, 1959, Asia Publishing House

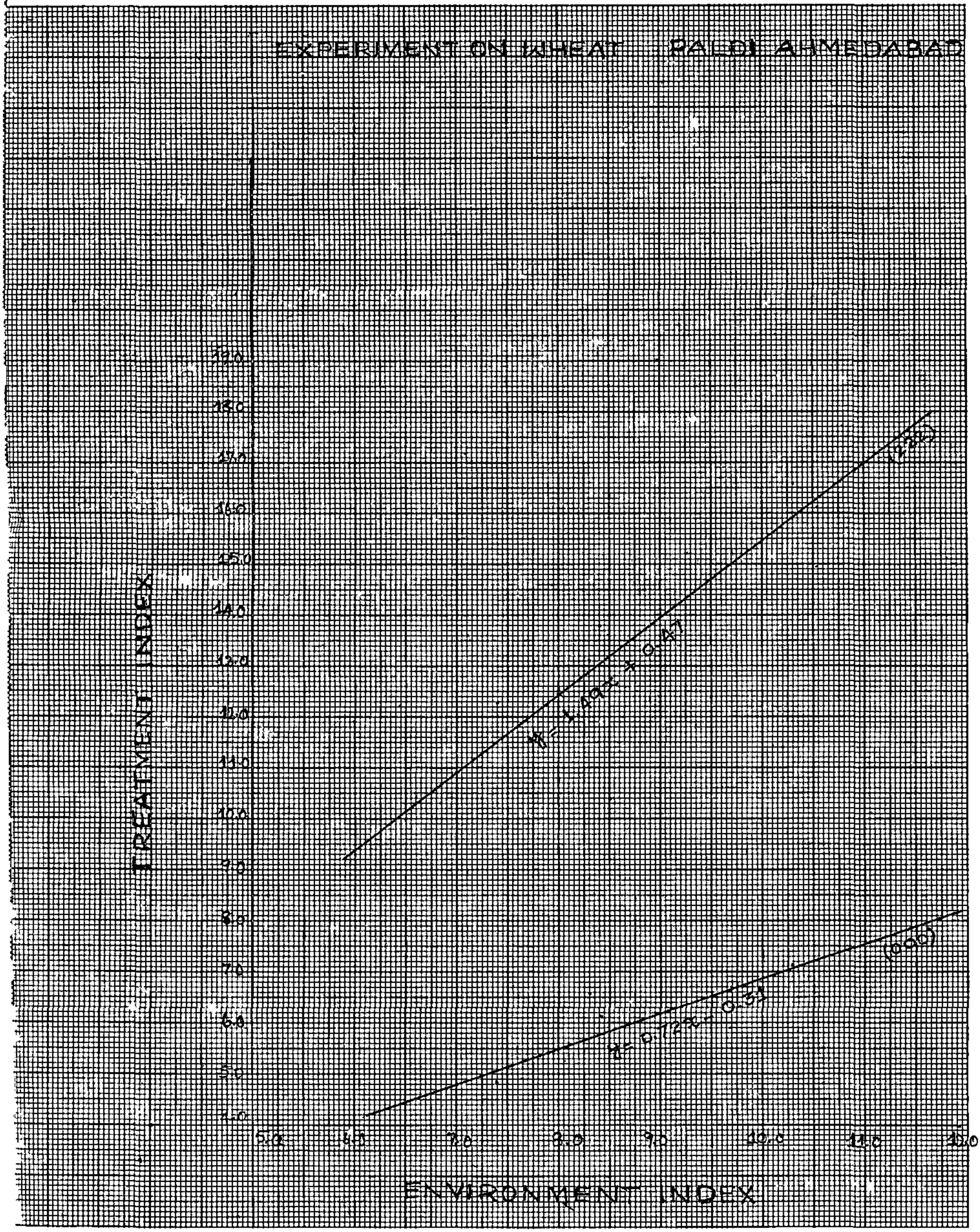
2. Eberhart, S.A. and Russell W.A. (1966) Stability Parameters for comparing varieties. Crop Science Vol 6 No.1 PP 336 to 40.

3. Finaly K.W. and Wilkinson, G.N. (1963) The analysis of adaptation in a plant breeding programme. Aust. Jour. A ri. Res. Vol. 14, 1963 PP 742-754.

4. Tehnical Programme and instructions to field staff Co-ordinated Scheme of Simple Fertiliser Trials on Cultivators' Fields. I.C.A.R. - 1965

APPENDIX


EXPERIMENT ON WHEAT
PALDI AHMEDABAD
TREATMENT INDEX
ENVIRONMENT INDEX
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
5.0
6.0
7.0
8.0
9.0
10
11.0
12.0
y = 0.21x + 9.49
y = 3.14x - 17.81
(221)
(220)
(220)
(220)
(221)
(221)
(220)
(220)
(220)
(221)


EXPERIMENT ON WHEAT PALDI AHMEDABAD
TREATMENT INDEX
ENVIRONMENT INDEX
Y = 1.49x + 0.47
Y = 0.72x - 0.31
(222)
(000)
5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0