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A COMPARISON OF TWO METHODS FOR THE STUDY OF PERMANENT MANURIAL TRIALS *

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It is customary in agriculture to repeat the same experiment over different places/seasons. The usual method adopted for comparison of treatments over different seasons is by the technique of analysis of groups of experiments (Cochran and Cox, 1957; Panse and Sukhatme, 1954). If the treatments are equal in effect over the different places/seasons they are stable over ;the places/seasons. Hence in order to compare the treatments the stability approach initiated Finlay and Wilkinson (1963) can be used. This approach is based on the linear relation between treatment means and seasonal/place means. A comparison of the two approaches is the theme of the article. Further a rigorous justification of the method due to Finlay and Wilkinson has been attempted. As a rigorous proof of the analysis of groups of experiments when place/seasonal variations are equal and they interact with treatments is conspicuously absent in the literature the necessary theoretical developments have been indicated.

Materials and Methods

The data from Rice Research Station, Pattambi on permanent manurial trials on Jaya variety of rice for seasons - *7 kharif* and 6 *rabi* seasons - were used for the study. The experiment in each season was the same and was laid out in a four replicate randomised block design with 8 treatments. A uniform spacing of 15 cm x 15 cm was adopted. The gross plot size was 7.80 x 5.25 sq. m. and the net plot size 7.6 x 4.95 sq m. The treatments were as given -below.

1 Cattle manure at 18,000 kg/ha to supply 90 kg N/ha

2 Green leaf at 18,000 kg/ha to supply SO kg N/ha

3 Cattle manure at 9000 kg/ha + green leaf at 9000 kg/ha to supply 90 kg N/ha

4 Ammonium sulphate to supply 90 kg N/ha

5 Cattle manure at 9000 kg/ha + ammonium sulphate to supply 45 kg N/ha + superphosphate to supply 45 kg P_2O_5/ha + 45 kg K_2O as muriate of potash

6 Green leaf at 9000 kg/ha + ammonium sulphate to supply 45 kg N/ha + superphosphate to supply 45 kg P_2O_5/ha + 45 kg K_2O as muriate of potash

7 Cattle manure 4500 kg/ha + green leaf 4500 kg/ha + 45 kg N as ammonium sulphate + superphosphate to supply 45 kg P_2O_5/ha + 45 kg K_2O as muriate of potash

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8 Ammonium sulphate to supply 90 kg N/ha+superphosphate to supply 45 kg P_2O_5/ha+ muriate of potash to supply 45 kg K_2O/ha (ammonium sulphate was applied half as basal and the rest as top-dressing at panicle initiation).

Let x be the mean yield of a treatment in a season and y the mean yield for all treatments in the season. Then the regression of x on y (Finlay and Wilkinson, 1963) is $x - \bar{x} = b(y - \bar{y})$

Consider a unit change in the value of y. This represents average variation in the response of all treatments. If now the corresponding change in x is $= \frac{(x - \bar{x})}{(y - \bar{y})} = 1$. for x and y are measured in the same unit ' ' change in the average response of all treatments is equal to the change in a treatment. Hence we say that treatment has got only average variation when b = 1.

When the change in $y - \bar{y}$ is larger than the change in $x - \bar{x}$, for a unit change in y the relative change in the treatment response is b is less than unity and we say that the treatment has better than average consistency in different seasons.

In the same way if the change in $x - \bar{x}$ is greater than the change in $y - \bar{y}$, b is greater than unity and the treatment has lower consistency (stability).

A rigorous justification of the aptness of the method to measure consistency (stability) has been given by Krishnan (1981) as follows · If

$$x - \bar{x} = b(y - \bar{y})$$

$$b = \frac{\text{Cov}(x, y)}{v(y)}$$

$$= \frac{\text{Cov}\left[x_i, \frac{(x_1 + x_2 + \dots\dots\dots + x_v)}{v}\right]}{v(y)} \quad \because y = \frac{1}{v}\sum_i x_i$$

$$= \frac{\frac{1}{v} v(X_i)}{\frac{1}{v^2}\sum_i v(X_i)}$$

$$= \frac{v(X_i)}{\frac{1}{v}\sum_i v(X_i)}$$

$= 1$, if $v(X_i) = \frac{1}{v}\sum_i v(X_j)$ — average variation ;

Less than 1, if $v(X_i)$ less than $\frac{1}{v}\sum v(X_i)$;

Greater than 1, if $v(X_i)$ greater than $\frac{1}{v}\sum v(X_i)$.

Hence a treatment has got average, less than average or greater than average consistency according as the variations in that treatment is equal to, greater than or less than the average of the variations of all the treatments.

In order to establish the analysis of groups of experiments when interaction is present and variance are equal, the linear model is

y_{ijk} a + bj + Cj + d_{ij} + e_{ijk}
i = 1, 2......, r., j = 1,2 ....v.,
k = 1 2......., p where
a = general effect ;
bj effect of i^{th} replication ;
Cj = effect of j^{th} treatment ;
d_{ij} = interaction between i and j classifications ;
y_{ijk} yield of the k* plot of the i^{th} replication receiving treatment j ;
and e_{ijk} are IN [0, $(sigma)^2$]

If a, bi , c_j , dij are respectively the least square estimates of a, bj , Cj and d_i and $y_{ij.}$ = p (a + bi + cj + dij), where $y_{ij.} = \sum_k y_{ijk}$

Thus by Marcov's theorem (Kempthone, 1952).

iik $(y_{ijk}$ — a — bj - c

$\sum_{ijk} y^2_{ijk}$ $\sum^v_{ij}$ = s_1^2 is a $(sigma)^2$

with $(p-1)rv$ degrees of freedom.

This is independent of hypothesis. (1) is called the within cell sum of squares. As the variation due to i and j classifications is completely contained in the between cell sum of squares their study should be based on the analysis of cell totals. The linear model for this is (Das and Giri, 1979).

$y_{ij.}$ = p(a + bi + c_j + d_{ij}) + $e_{ij.}$ or

y_{ij} = a + b; + c + t_{ij} , where t_{ij} — d_{ij} + $e_{ij.}$
p = (say) $\frac{}{p}$

and v(tjj) = $(sigma)^2$ $\underline{(sigma)^2}$ $(sigma)^2_1$

If a , bi and Cj are the least square estimates of a, b_i and Cj respectively,

$\bar{a} = \frac{y_{...}}{prv}$

$\bar{bj} = \frac{y_{i..}}{pv} - \bar{a}$

$\bar{Cj} = \frac{y_{.j.}}{pr} - \bar{a}$

To test $c_1 = c_2 = ... = c_v = o$ we minimise $\sum_{ij} (y_{ij.} — a — b_i)^2$ with respect to a and b_i . This leads to $s_2^2 = \left[\frac{y^2_{ij}}{p} - \frac{y^2_{...}}{prv} \right]$ ——

$\frac{y^2}{pv}$ _/ is a chi-square (sigma) with r(v~1) degrees of freedom

Similarly when $b_1 = b_2 = \ldots\ldots b_r - 0$ \ ' $\frac{Y_{i..}}{pv}$ $\frac{}{prv}$) is a chi-square $(sigma)^2_2$ with (r—1) degrees of freedom.

In order to develop tests it is required to find expectations of the various sums of squares. It is easy to show that;

E (MSS due to a_i s) = $(sigma)^2 + P(sigma)_d + \frac{pv}{(r-1)} \Sigma a_i^2$

E (MSS due to c_{is}) = $(sigma)^2 + p(sigma)_d + \frac{pv}{} \Sigma c$.

IE (|) - : $(sigma)^2 + p(sigma)_d$

and E (Mean error SS) — $(sigma)^2$

Thus the mean sum of squares due to each of i and j classifications should be compared against interaction sum of square for Testing significance. For examining the presence of interaction the mean sum of squares due to it should be compared against mean error sum of squares. This procedure may have to be modified when the variances associated with the different experiments are not equal. The analysis of the 13 experiments has been dealt with as in Cochran and Cox (1957) and Panse and Sukhatme (1954)

Results and discussion

The eight treatments applied to Jaya variety in 13 seasons—7 *kharif* and 6 *rabi*- will hereafter be denoted as treatment 1, treatment 2,................treatment 8 respectively in the order in which they are described in the materials and methods. The mean yields of the treatments are given in Table 1.

The seasonal means for the kharif seasons ranged from 11.91 kg to 16.43 kg. whereas the range was 8.5 kg to 12.20 kg in the *rabi* seasons When all the treatments were taken into consideration rheir *rabi* means had a range of 9 35 kg to 11.34 kg while the *kharif* means were from 13.47 kg to 15.79 kg.

The coefficients of regression of treatment means on the seasonal means are presented in Table 4. This coefficient of regression was 1.10 for treatment 1, 1.13 for treatment 2; 0.97 for treatment 3; 0.97 for treatment 4; 1.11 for treatment 5 0.97 for treatment 6; 1 04 for treatment 7 and 0.76 for treatment 8. All but the second and last treatments were not significantly different from 1. Regression coefficients of treatments 2 and 8 were significantly different from 1.

The ANOVA tables of seasonal experiments are given in Table 2. The treatments were not homogeneous for the seasons *viz; kharif* 1973, *kharif* 1974, *kharif* 1975 *rabi* 1 975 *rabi* 1976, *kharif* 1977, *kharif* 1978; *kharif* 1979 and *rabi* 1979. They were homogeneous in *rabi* 1973, *kharif* 1976, *rabi* 1977 and in *rabi* 1978.

Table 1

Mean yield, kg/plot

Season		Treatments								Seasonal
		1	2	3	4	5	6	7	8	mean
Kharif	1973	13.76	13.18	13.81	13.93	15.71	14.34	15.98	13.70	14.30
Rabi	1973	7.83	8.10	8.78	8,80	8.50	8.30	8.75	8.95	850
Kharif	1974	14,23	13.75	15.45	13.45	15 05	14.13	14.65	13.35	14.24
Kharif	1975	16.20	14.53	15.63	14.15	16.40	15.53	15.88	14.58	15 36
Rabi	1975	9.75	9.35	10.63	8.50	11.83	10.68	11.50	10.43	10.33
Kharif	1976	14.10	13.20	14.50	14.00	15.13	13.98	14.50	12.68	14.02
Rabi	1976	13.88	11 .33	12.98	10.88	13.50	11.48	11.53	12,05	12.20
Kharif	1977	15.88	15.18	16.60 "	13.48	17.20	14.85	15.93	13.43	15.32
Rabi	1977	11.03	11 .30	12.15	10.60	12.10	11.33	12.38	11.83	11.59
Kharif	1978	18.03	16.03	17.40	14.50	17.98	15.63	17.20	14.65	16.43
Rabi	1978	12.13	11 .20	11.55	10.95	12.25	10.90	11.74	11.53	11.53
Kharif	1979	14.00	10,31	12.33	11.40	13.10	9.93	12.20	11.93	11.91
Rabi	1979	11.18	6.13	10.98	6.45	9 88	8.05	9.28	8.35	8.77
Overall mean		13.23	11 81	13.28	11.61	13.74	12.24	13.20	12.11	
Rabi mean		10,96	9.57	11.18	9.35	11.34	10.12	10.86	10.52	
Kharif mean		15.18	13.74	15.09	13.56	15.79	14.05	15.20	13.47	

Table 2

Analysis of variance of experiments

Seasons	Source	df	SS	F
Kharif 1973	Replications	3	26.462	11.59
	Treatments	7	28.243	5.30**
	Error	21	15.977	
Rabi 1973	Replications	3	2,908	3.03
	Treatments	7	4.345	1.94
	Error	21	6.728	
Kharif 1974	Replications	3	5.616	3.30
	Treatments	7	14.903	3.T5
	Error	21	11.919	
Kharif 1975	Replications	3	8.948	6.53
	Treatments	7	19.710	6.16**
	Error	21	9.599	
Rabi 1975	Replications	3	5.836	5.05
	Treatments	7	33.861	12.55**
	Error	21	8.096	
Kharif 1976	Replications	3	4.061	
	Treatments	7	16.758	
	Error	21	42.709	
Rabi 1976	Replications	3	8.648	4.46
	Treatments	7	34.752	7.68**
	Error	21	13.569	
Kharif 1977	Replications	3	0.881	0.21
	Treatments	7	52.335	5.41"
	Error	21	29.027	
Rabi 1977	Replications	3	10.323	4.58
	Treatments	7	10.796	2.05
	Error	21	15.778	
Kharif 1978	Replications	3	5.476	1.95
	Treatments	7	56.602	8.65
	Error	21	19.627	
Rabi 1978	Replications	3	13.001	9.21
	Treatments	7	7.054	2.05
	Error	21	10.334	
Kharif 1979	Replications	3	2.935	0.54
	Treatments	7	51.540	4.04**
	Error	21	38.304	
Rabi 1979	Replications	3	30.856	11.22
	Treatments	7	102.677	16.00**
	Error	21	19.252	

Significant (P 0.01)

In the analyses where treatment sum of squares were significant, treatments were classified into homogeneous sub-groups (Table 3).

In *kharif* 1977 treatments 5 and 7 were in one group and the rest in another homogeneous sub-group.

The classification of the treatments into homogeneous sub-groups in *kharif* 1974 revealed that treatments 4 and 8 belonged to the homogeneous sub-group with smaller mean values. All the rest belonged to a homogeneous sub-group with larger mean value.

In the *kharif* that followed means of treatments, 2, 4 and 8 were smaller than the means of others which belonged to a homogeneous sub-group.

In *rabi* 1975 the smallest mean was that of treatment 4 and this was significantly different from others. The rest of the treatments belonged to two significantly different sub-groups 1, 2 and 8 in one group and 2,5,6 and 7 in the other.

There were two distinct homogeneous sub-groups of treatments in *rabi* 1976. Treatments 2,4,6,7 and 8 formed one homogeneous sub-group of smaller means and the other group consisted of 1,3 and 5.

In *kharif* 1977 treatments belonged to two distinct homogeneous sub-groups one with the lower mean values consisted of treatments 4 and 8 while the rest formed the other group. This was a repetition of the groups in *kharif* 1974.

There were two homogeneous sub-groups of treatment means in 1978. Treatments 4,6 and 8 were in one group and the rest formed the other homogeneous sub-group. The former consisted of means with lower manitude.

In *kharif* 1979 treatments 2 and 6 belonged to one group and the rest in another homogeneous sub-group.

There were three homogeneous sub-groups of treatment means in *rabi* 1977. Treatments 2 and 4 were in one group. The second group consisted of treatments 6,7 and 8. The last group with the highest means consisted of treatments 1,3 and 5.

No significant difference was observed between the mean yields of Jaya to the treatments during *rabi* 1973, *kharif* 1976, *rabi* 1977 and *rabi* 1978.

From the above discussion it is evident that the effect of seasons on the treatments was not uniform. Putting it in the language of design of experiments there was interaction between treatment and seasons.

The mean square errors ranged from 0.32 to 2.03. When the mean square errors were tested for homogeneity by Bartlet's test for homogeneity of variances they were found to be heterogeneous.

Table 3

Seasonwise homogeneous sub-groups of treatments

Kharif	1973	Treatment No.	2	8	1	3	4	6	5	7
		Mean	1318	13 70	13.78	13.81	14,81	14.34	15.71	15.97
Kharif	1974	Treatment Mo.	8	4	2	6	1	7	5	3
		Mean	13,35	13.45	1375	14.13	1423	14.65	15.C5	15.35
Kharif	1975	Treatment No.	4	2	8	6	3	7	1	5
		Mean	14.15	14,53	14.58	15.53	15.63	15.88	16.2	16.4
Rabi	1975	Treatment No.	4	2	1	8	3	6	7	5
		Mean	8.5	9.35	9.75	10.43	10.63	10.68	11.5	11.83
Rabi	1976	Treatment No.	4	2	6	7	8	3	5	1
		Mean	10.85	11.33	11.48	11.53	12.05	12.98	135	1388
Kharif	1977	Treatment No.	8	4	6	2	1	7	3	5
		Mean	13.43	13.48	14.85	15.18	15.88	15.93	16,6	17.2
Kharif	1978	Treatment No.	4	8	6	2	7	3	5	1
		Mean	14.5	14.65	15.63	16.03	17.2	17.4	17 98	18,03
Kharif	1979	Treatment No.	6	2	4	8	7	3	5	1
		Mean	9,93	10.31	11.4	11.93	12.3	12.33	13.1	14
Rabi	1979	Treatment No.	2	4	6	8	7	5	3	1
		Mean	6.13	6 35	8.05	8.35	9 23	988	10.98	11.18

An unbroken line indicates a homogeneous sub-group

Table 4

Regression coefficients and their students' t values

Treatment	'b' Value	't' Value
1	1.10	0.71
2	1.13	2.47
3	0.97	0.37
4	0.97	0.30
5	1.11	2.19
6	0.97	0.25
7	1.04	0.67
8	0.76	4.64

Since the errors were heterogeneous, weighted analysis was used for testing interaction. In that analysis (Cochran & Cox 1957) the total sum of squares was 4655.69, sum of squares for places 4118.29, sum of squares due to treatments 314.95 and sum of squares due to interaction 222.44. The degree of freedom for error was 21. While testing for interaction 342.14 was found to be a chisquare with 714 degrees of freedom and as such interaction was present.

Since interaction was present, the means of treatments for the different seasons were set out in a two way table. Further analysis revealed that the treat- ment were homogeneous.

The stability coefficients of treatments also tell the same story. The treat- ments 2 and 8 had regression coefficients significantly different from 1. For other treatments they were not significantly different from unity thereby indicating that treatments 1,3,4,5,6 and 7 had average stability over all the seasons. Since treatment 2 had a regression co-efficient greater than unity it was adapted only to some seasons i. e., it gave better yield in some seasons and poorer yields in some other seasons. This was similar to the findings of Finlay and Wilkinson (1963) in barley varieties. The treatment 8 had coefficient of stability. This was similar to the findings of Rawlo and Das (1978) on the effect of farm yard manure on the yield of wheat.

Thus the result obtained by the method of stability coefficients and those obtained by the analysis of groups of experiments are equivalent The former has the advantage of being simple. Further it reveals the interaction and stability simult- aneously and helps to choose stable treatments based on their overall mean performance. Analysis of groups of experiments is a protracted procedure and this makes the regression approach more acceptable.

Summary

A rigorous justification for the comparison of treatments by the stability approach initated by Finlay and Wilkinson (1963) has been attempted. The data on Jaya variety of rice were analysed both by the method of stability co-efficients as also by the method of analysis of groups of experiments. The results obtained by the above two methods revealed that they are equivalent

സംഗ്രഹം

ഫിൻലേയും വിൽക്കിൻസണും കൂടി 1963-ൽ തുടങ്ങിവച്ചതാണ് സുസ്ഥിരത സമീപനം. ഈ സമീപനത്തിൽ കൂടിയുള്ള താരതമ്യ പ്രതിപാദനത്തിന് വ്യക്തമായ ഒരു ന്യായീകരണം കണ്ടെത്താൻ കഴിഞ്ഞിട്ടുണ്ട്. ജയ നെല്ലിന്റെ അടിസ്ഥാന വിവരങ്ങൾ കോയഫിഷ്യന്റെ സുസ്ഥിരതാ പദ്ധതി മൂലവും പരീക്ഷണങ്ങളുടെ വിശകലനം മൂലവും അപഗ്രഥിച്ചു നോക്കിയിട്ടുണ്ട്. ഈ രണ്ടു രീതിcolലുള്ള പഠനങ്ങളുടെ ഫലങ്ങളിലും അവ തുല്യമാണെന്നു കണ്ടു.

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