NO. 10—THE ANALYSIS OF A MANURIAL EXPERIMENT ON WHEAT CONDUCTED AT SAKRAND, SIND.

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Mr. V. A. Tamhane, the Agricultural Chemist and Soil Physicist in charge of Agricultural Research Station, Sakrand, Sind, conducted a manurial experiment on wheat with five different treatments, replicated 8 times. The experiment was conducted on a block of two acres and a half, divided into 40 plots of $\frac{1}{16}$ acre each. Owing to a change of programme, the number of plots available for analysis for treatment A (no manure) was 5, while for the other 4 manurial treatments was 8 each.

The experimental arrangement is shown in Fig. 1. The plots marked "spoiled" had a dose of compost and cannot, therefore, be considered untreated. It will be noticed that originally all the 5 treatments had been distributed once in each column. But in columns 2, 4 and 8, treatment A was spoiled by the addition of compost, thus rendering it impossible to compare these columns directly with the rest.

Rows \	1	2	3	4	5	6	7	8
1	E 51	C 54	D 58	B 37	D 48	A 44	E 59	C 58
2	D 46·5	B 52	A 42	C 52	E 60	C 50	D 50	A(spoiled) 45·5
3	C 48	A(spoiled) 60	E 82	D 53	A(spoiled) 51	B 43·5	A 52	B 49·25
4	B 44·25	D 50	B 35	A 36	C 45	E 51	C 49	E 50
5	A 17·25	E, 	C 27	E 22	B 41	D 52	B 30	D 24

Cols. → 1 2 3 4 5 6 7 8

FIG. 1.

The experimenter himself divided the field into an extremely artificial system of blocks shown in thick lines in Fig. 1. It is not clear why this was done, unless of course results of previous uniformity trials had definitely indicated the usefulness of such a division.

2. The present analysis has, however, been made both with the experimenter's own type of block-division, as well as with a straightforward columnar division. In the first instance blocks with the spoiled plots were left out.

(*a*) The analysis according to columnar division is shown in Table I.

TABLE I.

— —	D. F.	Sum of squares	Mean square	Value of z	
				Observed	5 per cent.
Between treatment . . .	4	995·09	248·77	0·2201	·5265
Block . . .	4	353·36	88·34		
Error . . .	16	2,849·98	178·12		
Within treatment . . .	20	3,203·34	160·17		
		4,198·43			

The observed *z* is considerably lower than the 5 per cent. point, and therefore the treatment differences cannot be considered significant. The differences between the 5 blocks also appear to be insignificant and thus the columnar system of block division has been ineffective in enhancing the precision of the experiment. The "block" and "error" variances were, therefore, combined, and the residual variance was calculated for a larger number of degrees of freedom.

3. (*b*) The experimenter's system of block division gave the following analysis:—

TABLE II.

——	D. F.	Sum of squares	Mean square
Treatment	4	192·63	48·16
Blocks	4	1,086·60	271·65
Error	16	1,912·64	119·54

The variance for treatment is smaller than the residual variance, indicating that the treatment differences are not significant.

4. The experimental data may be studied from another standpoint. We have here studied the yields for 5 plots for treatment A and for 8 plots for the other 4 treatments. Assuming that these yields are independent measures of the mean yield of the 5 treatments, we obtain the following analysis for Fisher's *t*-test.

TABLE III.

—	Degrees of freedom	Sum of squares	Mean square	Variance of mean
A . . .	4	682·25	170·56	34·11
B . . .	7	492·87	70·41	8·80
C . . .	7	607·00	86·71	10·84
D . . .	7	726·47	103·78	12·97
E . . .	7	2,236·87	319·75	39·97

TABLE IV.

—	Mean diff.	Variance of mean diff.	S. E. of mean diff.	*t*	*n*	*P* greater than
A—B . . .	2·70	34·72	5·89	0·46	11	0·6
A—C . . .	7·35	38·09	6·17	1·19	11	0·2
A—D . . .	7·05	41·62	6·45	1·10	11	0·2
A—E . . .	5·15	86·25	9·29	0·54	11	0·6
B—C . . .	6·38	19·67	4·44	1·44	14	0·1
B—D . . .	6·19	21·77	4·67	1·33	14	0·2
B—E . . .	9·63	48·75	6·98	1·38	14	0·1
C—D . . .	7·72	23·81	4·88	1·58	14	0·1
C—E . . .	7·93	50·79	7·13	1·11	14	0·2
D—E . . .	12·15	52·92	7·28	1·67	14	0·1

The probability of occurrence of "*t*" is obtained in each case from Fisher's Table IV [1930].

If we work with the conventional value $P=·05$ as the level of significance, the last column of the Table IV definitely indicates that none of the differences reached

the required level; it would not, therefore, be possible to draw any positive conclusion from these experimental data.*

5. In conclusion, a few words on the principles underlying the division of the field into "blocks" may prove useful. The factors producing differences in soil fertility may be divided broadly into two groups: (*a*) systematic changes in fertility from one part of the field to another, and (*b*) chance fluctuations which are distributed in a random manner all over the field. The purpose of division into blocks is to eliminate the systematic changes, while the purpose of replication of plots within blocks is to furnish a reliable estimate of the random fluctuations. The blocks should then be arranged in such a way as to include within each block an appreciable portion of the systematic variation in fertility.

Consider a square or rectangular field with sides running in a north-south and an east-west directions. If we know that the systematic variation in fertility occurs only in one particular direction, say from north to south, then it will be necessary to use block divisions only in this particular direction. It is clear that block divisions in a perpendicular (that is east-west direction) will not show any systematic change in fertility, and hence will be of no use in eliminating effects due to soil heterogeneity. Now suppose that we have no information available regarding the direction of change of the systematic variation in fertility. It will now be obviously desirable to provide blocks in two directions at right angles. Generally speaking, information regarding soil heterogeneity is not available beforehand. This is why we usually provide block divisions in two directions at right angles so that systematic fluctuations in fertility along two perpendicular directions may be simultaneously eliminated. Fisher's "Randomized Block" and "Latin Square" (in which the number of blocks is same in each direction) are typical examples of arrangements based on this principle.

In case, however, previous knowledge regarding the distribution of fertility of the soil is available from uniformity trials, it is possible and it may be desirable to make special arrangements of the blocks so as to eliminate the effects of soil heterogeneity in the most effective manner.

* The manurial treatments used were :—

A=Control : untreated

B=Half usual organics (7½ cart loads of compost)

C= " *plus* sulphate of ammonia @ 10 lbs. nitrogen per acre

D= " " @ 20 lbs. "

E= " " @ 30 lbs. "

Variety : Pusa 12. *Sowing dates* : 23/24 December, 19 1.