

UNIVERSITY OF MINNESOTA  
DEPARTMENT OF AGRICULTURE  
UNIVERSITY FARM, ST. PAUL

DIVISION OF AGRONOMY AND PLANT GENETICS

February 11, 1933

Dr. R.A. Fisher  
Rothamsted Experimental Station  
Harpenden, Herts., England

Dear Dr. Fisher:

I would appreciate immensely having your comments on a problem which seems extremely important in our agronomic work. Last fall I had one of the graduate students calculate the data from a corn variety test. This test was made on 9 varieties or crosses of corn tested for three years in each of four different places in western Minnesota. These 9 varieties were grown in three randomized blocks (1930 was a systematic distribution but we had to consider it as randomized. 1931 and 1932 were randomized) in each of the 12 tests (4 places x 3 years). The results we obtained were:

<u>Variation due to:</u>	<u>Deg.Freed.</u>	<u>Mean Square</u>
Varieties	8	131.7341
Varieties x places	24	38.1104
" x years	16	60.9383
" x places x years	48	41.6657
Years	2	12,895.6630
Places	3	5,702.2040
Years x Places	6	7,117.9156
Remainder Error	192	45.6389

For degrees of freedom for remainder error I used the sum of the degrees of freedom for error for each of the 12 tests, i.e., 12 x 16 or 192. In spite of the tremendous variance for years, places and years x places, indicating extremely different conditions, the interactions of varieties x places, varieties x years and varieties x places x years were not significant. That is very consoling from the standpoint of the agronomist.

Now, suppose the interactions of varieties with places and years had been significantly greater than the remainder error. I suppose we would next compare variety mean square with mean square for varieties x years. If mean square for varieties exceeded mean square for this interaction we would have some confidence in asserting that the average results from these varieties were significantly different irrespective of year tested and would be a much better measure of the reliance we might place in our predictions of the response in subsequent years. Comparing mean square for varieties with varieties x place mean square could be interpreted in a similar way. Using these four places and these three years as a random sample of future years and other places, what would be the nature of the error? Should we test variety mean square with mean

square for varieties x years, varieties x places and varieties x places x years separately or add the degrees of freedom and sums of squares for all three interactions and use that? Averaging may cover up information when one interaction is significant and others are not.

Supposing that the interactions of varieties with years and places had been significant, how would you proceed to interpret the data?

That such interactions may be significant is shown in another test we made with 23 varieties of wheat grown in three randomized blocks in each of four places in Minnesota. The results were as follows:

<u>Variation due to:</u>	<u>Deg.Freed.</u>	<u>Mean Sq.</u>
Varieties	22	33.639
Places	3	2877.704
Varieties x Places	66	14.223
Remainder error	176	6.518

Here it is plain that the varieties did not react the same in all places. I believe such significant interactions are very common in widely conducted variety tests with the cereals at least. We had had no readily usable method in the past with which we could test for significant interactions. The analysis of variance not only is a great aid in answering these questions but suggests other lines of thought previously not considered.

It is due to the general interest in this problem and its importance that I have taken the liberty of asking you for your opinion and comments.

Sincerely yours,



F. R. Immer  
Associate Geneticist, U.S.D.A.

1  
UNIVERSITY OF MINNESOTA  
DEPARTMENT OF AGRICULTURE  
UNIVERSITY FARM, ST. PAUL

SECTION OF AGRONOMY AND PLANT GENETICS

Dear Dr. Fisher:

With business out of the way I can write a personal note. Maybe business should come before pleasure but I sometimes wonder.

Mrs. Inamer had an attack of the "flu" last fall and that brought on her old trouble once more. The Mayo Clinic cleared that up finally. Now she is recovering from a bad cold. I must be tough. I've had but one cold in two years and that kept me at home for only two days. There has been a great deal of influenza in the University this winter.

We are now coming out of an extremely cold period of weather. Last Tuesday the temperature fell to 14 degrees below zero F. Then it started to become really cold. Wednesday the temperature of  $-22^{\circ}\text{F}$ , which was a four ~~year~~ year record low. Thursday it fell to  $-28^{\circ}\text{F}$ , for a 17 year record. In Northern Minnesota the temperature reached  $-50^{\circ}$ . Don't allow anyone to tell you that when the temperature falls below  $-20$  that it isn't cold. With no wind one doesn't mind the cold so much. With a strong wind a persons ears, if uncovered, would be frosted in walking five blocks. The University was burning 200 tons of coal per day to keep the "U" warm during the coldest weather. This is a wonderful country, the extremes in temperature are  $-28^{\circ}$  and  $+106^{\circ}$ .

The State Legislatures are now meeting and the Universities will soon know what their budgets are to be for the next two years. The budgets probably will be cut seriously. Congress is doing a lot of talking and making time until the new

UNIVERSITY OF MINNESOTA  
DEPARTMENT OF AGRICULTURE  
UNIVERSITY FARM, ST. PAUL

## DIVISION OF AGRONOMY AND PLANT GENETICS

President takes Office on Mar. 4. So far federal research budgets have not been cut. No one will predict what the new congress will do. We on the federal payroll still have our payless furlough of 30 days per year.

Prices of farm products have just about held their own since Christmas. Corn is selling at about \$.20 per bushel (56 pounds) in Minneapolis and is bringing about 10 cents a bushel on the farms in southern Minnesota. Wheat is selling at 48 to 50 cents per bushel (60 pounds) in Minneapolis. Such prices leave very little for the farmer. In fact, a great proportion are unable to meet taxes or interest payments on mortgages. The farm mortgage problem is one of the most ~~acute~~ acute facing congress today. Financial conditions in this country have become no worse this winter but there is no sign of improvement either. World economic conditions must be straightened out before we can see much relief here.

I am called on continually to pass judgment on field experiments already conducted and the reduction of the data. In many cases the experimental design is very bad. These problems only emphasize the fact that I have so much to learn about the designing of field trials. Once or twice I've written to Hopkins and obtained help. My difficulties are numerous. In the first place my mathematical foundation is weak. Maybe I ought to get that into better shape. In the second place I am kept too busy to do the studying I ought to do. Have you any suggestions regarding procedure in building a stronger

UNIVERSITY OF MINNESOTA  
DEPARTMENT OF AGRICULTURE  
UNIVERSITY FARM, ST. PAUL

REVISION OF AGRONOMY AND PLANT GENETICS

foundation for handling that type of problem? My ideal would be to have time to study a little mathematics and then come and work with you for some months on problems of experimental design. I have a very hazy idea how to determine whether a given design is valid or not. I wish you could write a small book, or a comprehensive article, on the designing of field experiments, covering the general types of problems that are apt to come up. Many patterns are already available in published literature but I should like to see you put the whole story together. Such would be very useful to some of us at least.

I took the time to transform your Z tables last year giving them in terms of  $e^{2z}$  so that all that is necessary to do is divide the larger by the smaller variance and see if this exceeds the 5 or 1% points. This table has been useful to have on my desk ~~but~~ <sup>since</sup> the quotient of two variances compared can often ~~be~~ seen by inspection to exceed or fail to ~~reach~~ reach the 5% point. In publishing I would use the Z table. The transformed table is useful tho for my own use when quick judgments are desired.

I trust that this finds your family well. Give the regards of Mrs. Innes & myself to Mrs. Fisher.

Sincerely yours

J. R. Innes