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

DIVISION OF AGRONOMY AND PLANT GENETICS

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

Dear Dr. Fisher:

This has been a rather hectic winter, with two years results to summarize, but the job has been finished for some little time now. In two weeks we will start planting sugar beets again.

I am beginning to believe that I have too much work. I have had very little time for reading since I returned and that is bad. I need to read statistical literature very badly and can't find time to do so. Next fall I am going to hire someone to run many of my routine calculations.

There is tremendous interest in statistics on this campus. Some time ago a man from Forestry asked me if some of the men could talk over statistical problems with me some evening. I agreed to meet with them and 27 men came to the meeting. Many of these men have taken Dr. Treloar's courses in Biometry. Now they want to know what to do with their newly acquired knowledge. Most of their problems are correlation, regression and field experiments. The analysis of variance is what they need most. Some of these men took your elementary course last summer. They know the mechanics of the calculations but need experience in interpreting actual problems. They appreciate greatly having someone to talk problems over with. I have helped several of Dr. Hayes' graduate students in calculating problems for Master's or Doctor's theses. Biometry in relation to agronomic experiments has become a new tool since we have obtained your "Analysis of Variance" system for handling such data. Plant Breeders and Agronomists owe you a tremendous debt for your work in this field.

I find considerable interest in the paper you, Tedin and I wrote for Genetics. I have inbred lines and F_1 crosses of sugar beets I want to use for such a study. Dr. Johnson wants to make such a study in corn also, if he can find time and land. He has F_1 and F_2 crosses already. In 1933 he can test F_1, F_2, and F_3 plants, the latter from both selfed F_2 and F_2 mated inter-se. I'll help him all I can.

I have a little problem I would like to ask your opinion on. It troubles me at present but seems of such interest that it should be worked out. I believe this point of great general interest for field experiments with crops like corn or beets, which are spaced within the row. The data I have is on 600 single row plots of sugar beets harvested in the same way as two years ago. I assumed blocks of 20 rows each (5 varieties of 4 rows each). This is a uniformity trial.

What is usually done here is to remove beets next to skips in the row prior to harvest. Only beets with normal competition on all sides are harvested. The competitive beets are counted and weighed. The weight per beet is calculated and then the yield of the plot determined by multiplying the weight per beet by the total number of beets which could have been on the plot with a perfect stand. We call this putting the yields on a perfect stand basis. Doing this I found the variance within blocks for such weights on a "perfect stand basis" to be 34.4577. I had the number of beets before removal of beets next skips and the weights of these. I calculated the regression of weight of all beets on total number of beets and found it to be $\bar{w}^1 = 50.7022 + 1.566,211\ (r^1 - \bar{r}^1)$ where w^1 = total weight in pounds and r^1 is total roots per plot. Regression was linear in this study, where stand varied from 50 to 100%. I used to guess it would have to be quadratic but I can't demonstrate it. The mean square of deviations from regression within blocks, of total weight on total number of roots was 19.5544, much lower than the variance within block obtained when the yields were corrected to a perfect stand basis as described above. 28.2096

I next calculated the regression of weight of competitive beets (beets with normal competition on all sides) on number of competitive beets. This was: $\bar{w} = 37.2497 + 1.736,746\ (r - \bar{r})$, where w and r are weight and number of competitive roots, respectively. Mean square for deviation from regression, within blocks, was now 12.8254. This is very much lower than the mean square for variation within blocks obtained when the weight of each row separately was projected up to where it is assumed it would have been for a perfect stand (34.4577) and lower than the deviations from regression when all roots were used, regardless of competition (19.5544). Thirty-three beets per row would have been a perfect stand. The average total number of beets was 27.4750. The average number of competitive beets was 20.7317. 59.1978

We will want to express the yields, in finally reporting them, on the perfect stand basis. Why can't we merely add up the number of beets for each variety and the total weight, get the average weight per beet and thence weight per full stand? Or, have you some other method to suggest? For the error we can use deviations from regression, calculated from the error part of the analyses of variance. This error would, in my case be on the basis of an average of 20.7317 beets (using the competitive beets). To get the variance on a perfect stand basis (33 beets) I assume I multiply variance due to deviations from regression, of weight of competitive beets on number of competitive beets (12.8254), by $\frac{33}{20.7317}$ to get 20.4150 as the variance on a 33 beet basis. If such is legitimate the precision has been increased in the ratio of 34.4577 to 20.4150 or about 60% of the value found when each plot yield is corrected to the 33 beet basis instead of the regression being used. 37.4956

I have been groping about for an explanation of this reduction. I assume it is due to the fact that if only, say, a 50% stand is obtained, the error is exaggerated greatly when we multiply the yield obtained by two to get the expected yields of that plot on a 100% stand basis. Deviations from regression are concerned only with the discrepancy between the weight obtained and weight expected for that number of roots. Have you any comments or suggestions to make as to the validity of this procedure or to the way to calculate the average yield per variety so that these errors are valid?

In corn trials the common practice is to do as I originally did with beets, harvest competitige plants in each plot, project this yield per plot to that expected on a perfect stand and then calculate errors on these so-called perfect stand yield figures. If we can work out this regression method I believe we will be able to increase the precision of such tests greatly.

The financial depression is much worse here than when I left for Europe 18 months ago. It doesn't seem to be getting any worse but I see little improvement either. The government is threatening to cut our salaries. Congress wants to cut federal salaries 11%. Hoover wants to give us a month's vacation without pay. Farm prices are just "holding their own". Food, I believe, is cheaper here than in England. Eggs at 21 cents a dozen in the city and as low as 8 cents a dozen on the farms in western Minnesota. Clothing, I believe, is no more expensive here than in England, at the present time. That wasn't true 18 months ago.

Give the regards of Mrs. Immer and myself to Mrs. Fisher. I expect to see you next August at the Genetics Congress. We can get the Iowa and Minnesota groups together and have a reunion with you.

Sincerely yours,

F. R. Immer

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

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