Professor R. A. Fisher, F.R.S.,
Galton Laboratory,
University College,
Gower Street,
London, W. C. 1.,
England.

Dear Fisher,

I am afraid this is going to be a long letter which I hope you will bear with resignation.

I have been exercising myself with MacKell's resistance formula as elaborated by Balmukand and Kalamkar with some surprising results. Whether they mean anything or not is the question at issue. First of all I should say that my experiment is with incremental doses of nitrogen and potash and that the crop is tea and that I have two years yields. I realise that a perennial crop with considerable means of storage of reserves is a very different thing from an annual from seed and that n and k if not a and b may mean completely different things in the two cases. Furthermore I have not employed any refinement such as the method of least squares in fitting, being content to find my marginal values for weighted discrepancies between reciprocals of observed and expected values of yield small in comparison with the other entries in the table.

I append the skeleton data for your comment and raise the following points.

2nd. Year results. Large and negative value for n. As far as I can judge this is a result of the fact that the increment in yield for the 2nd. dose of N was greater than that for the first although the analysis of variance of the crude yields shows the difference not to be significant.
Negative value of k. I regard the k figures as being hopeless because I got no response at all. Am I right in assuming that if the errors do not wash out the whole thing, that the negative n value can be interpreted as an indication that there is a hypothetical nitrogen storage level which must be maintained before yield response is evident?

3rd year results. These appear more normal but the value for s_n compared with the first year seems queer, especially as in an agricultural sense nitrogen would be deemed important, judged by response.

I don't want to waste time on using a tool which is unsuited for the material and so I approach you at this early stage.

My second query relates to the use of t. Generally my significance can be judged purely on a Z test but I am getting cases where comparison of means is necessary. I never use t unless Z is significant. I gather that t is really only strictly appropriate when a comparison of two means is the whole of the information available and that it is unsafe to use it when selecting two means from a group of several. In this connection I have been interested in Tippett's Range and Largest Variation Concept and have corresponded with him about how to use them in cases where the small number of degrees of freedom do not justify a value of t = 2. Suppose out of six treatments two only gave large differences from a chosen control. The largest deviation method seems appropriate for one of them but what about the other?

I have recently had my attention drawn to a passage in Hoblyn's "Field Experiments in Horticulture", Bureau of Fruit Production, Technical Communication, No.2 (pages 31 & 33), in which with the following analysis of variance

<table>
<thead>
<tr>
<th></th>
<th>Blocks</th>
<th>Varieties</th>
<th>Error</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>7</td>
<td>35</td>
<td>47</td>
</tr>
</tbody>
</table>

he enters t with 10 degrees of freedom.
I should use 35, and to me the \( n_1 + n_2 - 2 \) rule seems all wrong. I base my argument on two passages in your book in which (paragraph 38) you insist that tests of significance must agree and paragraph 41, in which you show the relation between \( Z \) and \( t \) for \( n_1 = 1 \). Am I right in interpreting these as indicative of the fact that \( t \) must be entered with the same number of degrees of freedom as \( n_2 \) would be in a \( Z \) test which has been my normal procedure? Student seems to agree with me in his Mathematics and Agronomy.

Yours sincerely,

[Signature]

Encl:
# Resistance Formula

<table>
<thead>
<tr>
<th>2nd. Year</th>
<th>lb. N. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>lb. K₂O per acre</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

First values of \( m \):

\[
\begin{align*}
880.1 & \quad 946.8 & \quad 1029.8 \\
889.9 & \quad 923.4 & \quad 1002.2 \\
889.5 & \quad 957.7 & \quad 1042.6 \\
\end{align*}
\]

\( S(y-m)^2 = 3681.00 \)

Reciprocals of Expectations (after equalisation):

\[
\begin{align*}
0.00113413 & \quad 0.00105723 & \quad 0.00097185 \\
0.00115496 & \quad 0.00107806 & \quad 0.00099268 \\
0.00112775 & \quad 0.00105085 & \quad 0.00096547 \\
\end{align*}
\]

Weighted Discrepancies Between Reciprocals Of Observed And Expected Values Of Yield:

\[
\begin{align*}
+3.5218 & \quad -6.6135 & \quad +3.0927 & \quad \pm 0.010 \\
+25.7198 & \quad -9.4952 & \quad -16.2220 & \quad \pm 0.022 \\
-29.2661 & \quad +16.1097 & \quad +13.1512 & \quad \pm 0.052 \\
-0.0250 & \quad +0.0010 & \quad +0.0219 &
\end{align*}
\]

Expectations (\( m \)):

\[
\begin{align*}
861.7 & \quad 945.9 & \quad 1029.0 \\
865.8 & \quad 927.6 & \quad 1007.4 \\
885.7 & \quad 951.6 & \quad 1035.8 \\
\end{align*}
\]

\( S(y-m)^2 = 3511.15 \)

\[
\begin{align*}
\frac{a_n}{n} - \frac{a_n}{n+20} &= 0.00007690 & n = 402.74 \\
\frac{a_n}{n+20} - \frac{a_n}{n+40} &= 0.00008538 & a_n = 0.5927 \\
\frac{a_k}{k} - \frac{a_k}{k+20} &= -0.00002083 & k = 22.556 \\
\frac{a_k}{k+20} - \frac{a_k}{k+40} &= +0.00002721 & a_k = -0.00006267
\end{align*}
\]
3rd Year.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>594</td>
<td>676</td>
<td>747</td>
</tr>
<tr>
<td>K_2O</td>
<td>547</td>
<td>676</td>
<td>738</td>
</tr>
<tr>
<td></td>
<td>505</td>
<td>663</td>
<td>742</td>
</tr>
</tbody>
</table>

First Values of m

587  680  752  \(S(y-m)^2 = 1868\)
569  656  724
586  679  751

Reciprocals Of Expectations (after equalisation).

0.0017029  0.0014758  0.0013342
0.0017373  0.0015102  0.0013696
0.0017111  0.0014840  0.0013424

Weighted Discrepancies Between Reciprocals Of Observed
And Expected Values of Yield.

<table>
<thead>
<tr>
<th></th>
<th>.2244</th>
<th>+.0684</th>
<th>+.1535</th>
<th>-.0025</th>
</tr>
</thead>
<tbody>
<tr>
<td>+.9507</td>
<td>-.5778</td>
<td>-.3737</td>
<td>-.0006</td>
<td></td>
</tr>
<tr>
<td>-.6851</td>
<td>+.5101</td>
<td>+.1781</td>
<td>+.0051</td>
<td></td>
</tr>
<tr>
<td>+.0412</td>
<td>+.0007</td>
<td>-.0421</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Expectations (m).

587.2  677.6  749.5  \(S(y-m)^2 = 1668\)
575.8  652.2  730.7
564.4  673.9  744.9

\(n = 66.035\)  \(k = -17.294\)
\(a_n = .06452\)  \(a_k = +.00005159\)