COMPLETE ENUMERATION EXPERIMENT IN GROUNDNUT CROP FOR DEVELOPING THE OPTIMUM SHAPE AND SIZE OF SAMPLES FOR CROP WEATHER OBSERVATIONS

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I. INTRODUCTION

Under the all-India Co-ordinated Crop-Weather Scheme, systematic observations on the growth, development and yield of crops and the meteorological conditions experienced by the crops are being recorded at a network of selected stations. The sampling techniques for estimating these growth features as well as the yield, in regard to the different crops of India were developed after actual preliminary investigation and trial by the Agricultural Meteorology Division at Poona. Results of a number of these experiments have already been published1-9 while those of a few others will be published shortly.

The crop-weather observations are at present confined to Paddy, Wheat, Jowar, Sugarcane and Cotton. Recently, the Indian Central Oil Seeds Committee desired to extend the crop-weather observations to the groundnut crop also. In order to find out the most suitable size and shape of the sample to be used for recording the growth and yield of the groundnut crop, a complete enumeration experiment was undertaken. The results of this experiment are discussed in the present paper.

The experiment was conducted on the fields of the Agricultural College, Poona, the variety under investigation being the sub-erect type “Spanish Peanut”. When the crop was ready for harvest, a net area containing 16 rows, each row being 72 feet long (1 foot apart) aggregating to $16 \times 72$ or 1,152 foot-lengths of row, of the crop was harvested foot by foot and the following observations, for each foot-length, were recorded:—

1. Number of plants in foot-length;
2. Number of branches in foot-length; and
3. The yield of pods (gm.) from all the plants in foot-length.
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For the purpose of analysis of the data, the net area was divided into four equal plots by imaginary lines drawn across the rows so that each plot had 16 rows, each row being 18 feet long, i.e., in all 288 foot-lengths of row.

2. Analysis of Variance of the Data

The analysis of variance, for all the three characters under observation, is given in Table I below.

<table>
<thead>
<tr>
<th>Crop feature</th>
<th>Variance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between plots</td>
<td>Between rows</td>
</tr>
<tr>
<td>1. No. of plants in foot-length</td>
<td>0·44</td>
<td>1·28</td>
</tr>
<tr>
<td>2. Total number of branches in foot-length</td>
<td>82·13</td>
<td>54·85</td>
</tr>
<tr>
<td>3. Yield of pods from foot-length</td>
<td>746</td>
<td>255</td>
</tr>
<tr>
<td>Degrees of Freedom</td>
<td>3</td>
<td>60</td>
</tr>
</tbody>
</table>

It will be seen from Table I that, for all the three characters, the variance 'between rows' is greater than that 'within row'; in other words the inter-row competition is greater than the intra-row competition. This suggests that samples spread across the rows will be more efficient than those spread along the same row.

3. Size and Shape of the Sample

As has been mentioned already, the ultimate unit for the observations was 1 foot-length of row. These ultimate units were then grouped in different combinations as explained below. Thus, for a sample of 6 foot-lengths, the following different arrangements of the ultimate units are possible.

(i) All the 6 'one foot-lengths' in the same row.
(ii) '3 foot-lengths' in each of two adjacent rows.
(iii) '2 foot-lengths' in each of three adjacent rows.
(iv) 1 foot-length in each of six adjacent rows.

The above combinations are represented diagrammatically below.
However, it may be added here that as described earlier, the data from each plot consist of 16 rows, each row 18 feet long. This sets a limitation to the number of combinations that can be conveniently formed. For example, if combination number (iv) is tried the data relating to 12 rows only could be utilized (as each sample will be spread over 6 rows) and therefore the data for four rows of each plot will be left out of consideration. Hence only such combinations of the ultimate units which make it possible to include a major part of the data were considered. Thus, in the above example, combination (iv) was not included for analysis.

The following different shapes and sizes of the sample (composite groups) were considered.

The standard error of the mean for each sample $\sigma_s/\sqrt{N}$ ($\sigma_s =$ square root of variance between the ultimate units of the sample and $N =$ number of ultimate units in the sample) were calculated and plotted against the size of the sample, i.e., the number of foot-lengths in sample. Figs. 1, 2 and 3 show these curves for the three characters, viz., number of plants, number of branches and yield respectively, for both, samples spread across the rows and samples spread along the rows. Values for square shapes in samples covering as many rows as foot-lengths in each row have not been plotted as only 3 such sample sizes, i.e., $2 \times 2$, $3 \times 3$ and $4 \times 4$ are possible with the available data.
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<table>
<thead>
<tr>
<th>No. of 1 foot-length included in the sample</th>
<th>No. of 1 foot-length of each row included in the sample</th>
<th>No. of rows over which the sample is spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>1,2</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>1,2</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>1,3</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>1,2,4,8</td>
</tr>
</tbody>
</table>

Number of Plants

- Samples spread across rows.
- Samples spread along rows.

Size of sample (number of foot-lengths)

Fig. 1
NUMBER OF BRANCHES

\[ \bar{s} / \sqrt{n} \]

SAMPLES SPREAD ACROSS ROWS.

SAMPLES SPREAD ALONG ROWS.

SIZE OF SAMPLE (NUMBER OF FOOT-LENGTHS)

Fig. 2

YIELD

\[ \bar{y} / \sqrt{n} \]

SAMPLES SPREAD ACROSS ROWS.

SAMPLES SPREAD ALONG ROWS.

SIZE OF SAMPLE (NUMBER OF FOOT-LENGTHS)

Fig. 3
Experiment in Groundnut Crop for Developing Shape and Size

Fig. 4

Number of Plants

Fig. 5

Number of Branches

Percentage of crop sampled.
It is seen from Figs. 1, 2 and 3 that for all the three characters under observation, \( \frac{s}{\sqrt{N}} \) decreases as the size of the sample increases showing that the variability of the mean for the sample decreases with increase in the size of the sample. But the decrease is greater for the smaller sample sizes and as the size of the sample increases, this decrease in \( \frac{s}{\sqrt{N}} \) becomes less and less. It appears from the curves that a sample of 6 foot-lengths will be quite suitable, for all practical purposes. It is also seen from Fig. 1 2 and 3, that for the same size of the sample, sample spread across the rows, \( i.e., \) covering a larger number of rows, show less standard error of the mean than those spread along the rows, \( i.e., \) including a smaller number of rows. This is true particularly for the yield. This is in agreement with the finding mentioned earlier that inter-row competition is found to be greater than intra-row competition.

It appears therefore that a sample composed of 6 foot-lengths including 2 foot-lengths in each of three adjacent rows (as shown in the diagram below) will be quite suitable for recording the crop-weather observations.
4. **Percentage of the Crop to be Sampled**

Having arrived at a suitable size and shape of the sampling unit to be used, it is necessary to find out what percentage of the crop should be sampled in order to obtain sufficient information. For this purpose, the percentage information obtained for different percentages of the crop sampled at random, were calculated using the method developed by Yates and Zacopanay\(^\text{10}\). The relationship between the percentages of the crop sampled and the percentages of information obtained for the number of plants, number of branches and the yield is shown graphically in Figs. 4, 5 and 6 respectively. It will be seen that the increase in the percentage information obtained is rapid till a critical value in the percentage of crop sampled is reached. Further increase in the percentage sampled increases the information obtained at a slower rate. This critical value for the percentage of crop sampled, appears to be:

(i) about 4% for number of plants (Fig. 4);  
(ii) about 6% for number of branches (Fig. 5); and  
(iii) about 5% for yield (Fig. 6).

From what has been explained above as well as from practical considerations, it is seen that for all the three characters under considerations, sampling 5% of the crop using a sampling unit consisting of 2 foot-lengths in each of three adjacent rows will be quite adequate for recording crop-weather observations in the suberect type of groundnut.

5. **Acknowledgement**

Thanks are due to the authorities of Agricultural College, Poona, for permitting these observations to be recorded on the crop raised by them. The authors also acknowledge with thanks the help given by Shri J. G. Griffiths in weighing the yield of pods and that of the other colleagues who helped in recording the observations in the field.
REFERENCES

   and Gopal Rao, S.

2. Reports by the Director of Agricultural Meteorology.


