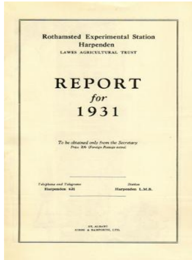
ROTHAMSTED RESEARCH

# Report for 1931




Rothamsted Experimental Station
Harpenden

REPORT
*for*
1931

## Field Plot Technique

### Rothamsted Research

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shelter from the grass banks at the side and perhaps from the chicken pens. Three earwigs captured from the plants at night were kept in the laboratory confined with 2 swede and 3 mangold plants. Within 5 days the plants were destroyed but no preference was shown.

## WOBURN

An attack on the micro-plots of sugar beet was the only thing of interest this year. Only a few plants were lost, the stems being eaten off a short distance above ground level with a short length of the central strand left. Mammals or birds are suspected. A *Harpalus* was collected by spreading sacking at night, but no damage could be ascribed to this insect.

## FIELD PLOT TECHNIQUE

The Statistical Department has been largely concerned with the methods of the interpretation of field and laboratory experiments, and with the principles of their design. The principles which govern the dependence of interpretation on design have been made clear in previous years. Many voluntary workers, however, are anxious to illustrate particular aspects of these principles and to explore further the practical bearing of the observations made in uniformity trials and in explicit experimentation.

During the year three workers (F. R. Immer, S. H. Justensen and R. J. Kalamkar) have taken up the question of the most efficient use of land in experiments in which an edge row must be discarded. In such cases the narrower the strip used as a plot, the larger the proportion of the crop rejected from the experimental data. On the other hand, it has been widely verified that, for the same area harvested, subdivision into numerous small plots generally leads to a considerable increase in precision. Using independent data relating in two cases to potatoes and in one to sugar beet, each enquiry showed that the best use of a given area can be made by using 4-row plots, where half the total area is discarded. Consequently where the precision of the experiments is chiefly restricted by the experimental area available, this width of plot may be expected to give the best results.

The efficiency of the sampling method, both in its application to yield trials and to the progress and growth of crops, largely depends on the choice of the sampling unit, or set of drill lengths fixed by a single act of randomisation. Experience in previous years had thrown doubt upon whether the form of sampling unit originally chosen for crop weather observations was the best possible: (1) because the 4 quarter metres of which it was composed were all taken from the same drill row, and as had been first shown by Clapham, lengths from the same drill row were somewhat highly correlated; (2) because it was doubtful if any additional precision was gained by spreading the sampling unit over a length of 10 feet, when probably there was a real competition between the growth of parallel adjacent rows. By harvesting a small area completely in ½-metre lengths, Kalamkar was able to test experimentally the efficiency of different forms of sampling unit, with the result that a unit of four parallel lengths on adjacent rows was found to be actually the most efficient. Since this form of unit is very convenient to take in the field, and in

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the crop weather observations can be used to simplify the whole sampling procedure, its use in future is to be recommended.

As the existence of an accurate theory of small samples has come to be known, mathematical statisticians on both sides of the Atlantic have devoted much work to investigations by experimental sampling. Much of this work has been aimed at solving (practically) somewhat abstract problems of distribution, which presented analytical difficulties to the mathematician. Rightly approached, however, the subject has a practical and scientific interest, for the experimenter in designing his experiments will want to know whether the analysis of variance, or one of the tests which are particular cases of this analysis, will, without additional precautions, be sufficiently applicable to his material, even if it exhibits anomalies of the third degree, such as skewness, correlation of mean with variance, etc. An extensive sampling experiment has recently been carried out by T. Eden, to test whether the analysis of variance, applied to a randomised blocks *schema*, on such skew material, would in fact indicate the true limits of significance. The distribution of 1,000 tests of significance was found to be in complete conformity with theoretical expectation for normal data.

The analysis of variance has not, however, always been rightly applied. The great simplicity of the arithmetical processes, when applied to experiments designed to secure this simplicity, has sometimes led to a neglect of the fact that any interactions which, as is often advantageous, have been confounded with components of soil heterogeneity, or which, as is usually less satisfactory, are between non-orthogonal sets of treatments, as in many of the older types of experiment, require special care to obtain the true estimate of error. Through neglect of this precaution the interpretation to be placed on two of our previous experiments in 1929 and 1930 have been revised in the current report (p. 150 ; p. 156). Although no important conclusions, but only the significance of certain manurial interactions, are affected, the point is one which deserves attention, as it is very liable to give trouble to inexperienced computers, and should especially be considered in experimental design.

An increasingly important aspect of the application of the principles of experimental design, concerns the design of co-ordinated experiments carried out at a number of centres. During the year two workers from Canada have been working on these problems, and a report with recommendations has been made by J. W. Hopkins to the National Research Council of the Dominion, on their co-operative experiments on the influence of seed rate on the yield of varieties of oats. Professor Summerby also was engaged in the design of comprehensive manurial experiments on fields under rotation.

In the field of Agricultural Meteorology, A. L. Murray, of Dublin, has taken up the question of the interpretation of the heavy loss in wheat yield from Broadbalk, ascribable to winter rain ; finding, contrary to expectation, that this loss is not to be avoided by using spring in place of autumn dressings of nitrogeneous fertilisers. The spring dressed plots show, however, an advantage in years with a wet summer. The classical experiment with mangolds, on Barnfield, has been analysed by R. J. Kalamkar, in connection with the amount and distribution of the rainfall. The yields from these plots are, however, so variable that it would be unsafe as yet to interpret the data, until the influence of varying root number has been separately assessed.

The year has seen considerable progress in theory, especially in regard to the analysis of covariance, as well as in the practice of its various applications.

## THE ACCURACY OF THE FIELD EXPERIMENTS

The standard errors per plot of experiments carried out in 1931 are given in Tables X, XI and XII together with an average of those obtained in previous years. It will be seen that these errors are of the same magnitude as in previous years, and that there is little difference in the accuracy obtained at Rothamsted and the outside centres.

### TABLE X.

STANDARD ERRORS PER PLOT, 1931.
Rothamsted.
*Weight per acre.*

| | *Potatoes.* tons. | *Sugar Beet* Roots. tons. | *Sugar Beet* Tops. tons. | *Barley.* Grain. cwt. | *Barley.* Straw. cwt. | *Wheat.* Grain. cwt. | *Wheat.* Straw. cwt. |
|---|---|---|---|---|---|---|---|
| *Latin Squares—* | | | | | | | |
| Average 1925-1930 .. | 0.4 | 0.6 | 0.7 | 1.3 | 1.9 | — | — |
| 1931 .. .. | — | — | — | 2.0 | 2.1 | 1.5 | 3.1 |
| *Randomised Blocks—* | | | | | | | |
| Average 1925-1930 .. | 0.7 | 0.3† | 1.2† | 1.5 | 1.9 | 2.9 | 4.3 |
| 1931 .. .. | 1.2 | 0.5 | 1.0 | — | — | 1.8 / 1.4 | 4.2 / 3.2 |

†Single figure.

| | *Oats.* Grain. cwt. | *Oats.* Straw. cwt. | *Forage.* Hay. cwt. | *Forage.* Grain. cwt. | *Forage.* Straw. cwt. | *Hay.* cwt. |
|---|---|---|---|---|---|---|
| *Latin Squares—* | | | | | | |
| Average 1925-1930 .. .. | — | — | — | — | — | — |
| 1931 .. .. .. | — | — | 4.2 | 2.4 | 3.6 | 3.1 |
| *Randomised Blocks—* | | | | | | |
| Average 1925-1930 .. .. | — | — | — | — | — | — |
| 1931 .. .. .. | 2.4 | 2.6 | 1.4 | — | — | — |

*Per cent of Yield.*

| | *Potatoes.* | *Sugar Beet.* Roots. | *Sugar Beet.* Tops. | *Barley.* Grain. | *Barley.* Straw. | *Wheat.* Grain. | *Wheat.* Straw. |
|---|---|---|---|---|---|---|---|
| *Latin Squares—* | | | | | | | |
| Average 1925-1930 | 4.4 | 5.7 | 5.6 | 5.6 | 7.4 | — | — |
| 1931 .. | — | — | — | 12.4 | 9.4 | 8.3 | 8.7 |
| *Randomised Blocks* | | | | | | | |
| Average 1925–1930 | 8.4 | 10.2* | 10.9* | 9.1 | 7.2 | 14.0 | 10.8 |
| 1931 .. | 10.0 | 4.1 | 6.4 | — | — | 8.3 / 8.9 | 9.5 / 8.2 |

*Single figure.

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