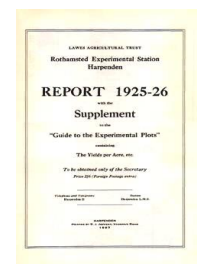


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The Use of the Standard Error in Field Experiments

Rothamsted Research

Rothamsted Research (1926) *The Use of the Standard Error in Field Experiments* ; Report 1925-26 With The Supplement To The Guide To The Experimental Plots, pp 122 - 122 - DOI: <https://doi.org/10.23637/ERADOC-1-84>

THE USE OF THE STANDARD ERROR IN FIELD EXPERIMENTS.

With the present report the departure is made of giving in the summaries of the results of replicated experiments a standard error by which the precision of the results may be judged; a practice which, originating in astronomy, has for several years been applied in various ways in scientific agriculture, but not hitherto in the Rothamsted reports. This caution has in fact been justified by recent investigations in statistical theory, which show that only when special precautions are taken in the design of the experiment can we be certain that the estimate of error made represents with validity the actual errors to which the results are exposed. Systematic methods of arrangement, into which no element of chance is admitted, are in fact liable to components of real error which find no place in the estimate, and it is only where the relative position of the individual treatments are deliberately assigned by appropriate chance operations, that the standard error as estimated can claim to represent the experimental errors actually present. All the replicated experiments of 1926 and all but a few in 1925 conform to this condition; for the sake of comparison estimates have been made for some of the 1925 experiments which do not admit of strictly valid estimation, the uncertainty arising from this cause being noted in each case.

The statistical procedure by which the standard errors have been obtained is in all cases that known as the Analysis of Variance. In this method the whole of the variation exhibited by the experimental yields is divided into the parts appropriate to the different components of which it is composed; in consequence it is possible to be sure that differences in yield due to causes, such as the different fertility of different blocks of land, which have no influence on the experimental comparisons, have been completely separated from that portion of the variation which is ascribable solely to experimental error.

Of the two measures of error in common use, the "probable error" and the "standard error," the latter has been adopted, as the more readily calculated and in other ways the more conformable to modern practice. The probable error is in fact obtained from the standard error merely by multiplying by a constant factor, 0.6745, or approximately $2/3$. The standard error is therefore the larger measure, but in respect of all considerations arising out of the theory of estimation the two measures are on precisely the same footing.

The practical use of the standard error is to discriminate between cases in which a particular difference in yield can be reasonably set aside as accidental, and cases in which such an explanation requires that an improbable coincidence should be postulated, and in which therefore we have a sound basis for interpreting the difference as a real response to the treatments applied. As a working rule differences between treatments exceeding three times the standard error may be accepted as significant. Full and precise tests of significance have, however, been applied to all tables.