Random Versus Systematic Arrangements in Non-Latin Square Field Experiments

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A RECENT review (2) of the literature on random and systematic arrangement of plots in field experiments led to the conclusion among others that the differences with respect to treatment and error variances are generally small, of doubtful statistical significance, and often of no practical importance. Comparisons, however, were limited to Latin Squares. Since the latter are seldom used in this country, a natural question is whether conclusions derived from them are applicable to the designs in common use. The study reported here was made to answer this question.

MATERIALS AND METHODS

Random and systematic arrangements were compared by superimposing hypothetical experiments on yield data from uniformity trials in much the same way as was done by Tedin (3) except that Tedin's study was limited to 5 by 5 Latin squares. The basic data were taken from 27 different sets of uniformity experiments with 14 different crops reported by 11 agricultural experiment stations in the United States and Canada. These comprised nearly all published uniformity data from the United States and Canada. A total of 113 separate and distinct hypothetical experiments comprising a total of 7,155 plot yields were set up. Since the same land was used for more than 1 year in some cases, the total number of individual plots of land was 5,238. In these hypothetical experiments, the number of "treatments" ranged from 10 to 48 and the number of plots of each from 2 to 4. These numbers are typical of those used in varietal trials, fertilizer comparisons, and cultural tests in this country.

The size of plot varied from single rows of a rod or less in length to tenth-acre field plots. In a few cases very small original units were combined into larger units such as would be used in actual trials. The crop, the location, the size of plots, the year in which the crop was grown, the number of "treatments", the number of plots of each, and the author or authors are listed in table 1. The number of treatments to be compared and the number of plots of each (columns 3 and 4 of table 1) were determined somewhat arbitrarily. A very large number of different kinds of hypothetical experiments could be set up for any set of uniformity data. In the present study these were determined so that (1) all or practically all plots would be included, (2) the area used for each hypothetical experiment would be as nearly a square as appeared to be feasible, and (3) the number of treatments and number of replications would be within the limits of those commonly used in the United States.

For each hypothetical experiment the treatments were arranged at random and systematically. Tables of random numbers by Tippett (4) was used for each replication of each experiment. Systematic arrangements were limited to those in which the replications were within the limits of those commonly used in the United States. These, however, are not the concern of this paper and are not referred to as the expected variance. Table 1 shows that the difference in the average of the expected for the random arrangement and systematic arrangements do, in fact, lead to biased estimates of error.

EXPERIMENTAL RESULTS

For each "experiment", variances were computed for the "treatments" and for "error". These were expressed as a percentage of the within replication variance, after referred to as the expected variance. The results are shown in table 1.

Variances and ranges for each "experiment" are given. The frequency distributions of the variances are shown in table 1. The first item of interest is the possible number of "good" systematic arrangements for these separate hypothetical experiments and a total of 1,13 separate hypothetical experiments and a total of 97.7% of the expected. These, however, are not the concern of this paper and are not considered. For those experiments in which more than one systematic arrangement is possible, the particular one included in table 1 was selected at random from the arrangements. In setting up both the random and systematic arrangements, no consideration was given to the character of the variation until after all calculations had been made.