Tea Q. 48 (1 & 2), 4—7, 1979. *Printed in Sri Lanka*

RECTANGULAR LATTICE DESIGN FOR EVALUATING YIELD OF TEA CLONES

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A rectangular lattice design was compared with the traditional randomized block design to test its efficiency in evaluating the yield of a large number of tea clones. The reduction in the block size which is inherent in the layout of the lattice design, minimized the errors due to soil heterogeneity and increased the precision of the clonal comparisons by about three times. A single clone was repeated six times in each replicate as a check on the precision of the designs. The rectangular lattice succeeded in grouping this genetically identical material, as being of similar yield potential; whereas, the randomized block design failed to do so and, the yield differences between repetitions of this single clone were found to be significant.

Use of rectangular lattice design would reduce considerably the land, planting material and personnel requirements of clonal experiments.

INTRODUCTION

The plant breeder is not only involved in the selection and propagation of improved varieties of crop plants, but is also required to evaluate the performance of the selected varieties on a field scale in regional trials. These trials frequently involve the comparison of a large number of varieties and unless appropriate statistical techniques are employed to overcome environmental influences, particularly soil heterogeneity, the precision of the varietal comparison would suffer.

Tea soils of Sri Lanka are highly heterogeneous (Hasselo 1963). When a large number of clones are to be tested in a randomized block design, the block accommodating a full replicate covers a wide area and is not likely to be sufficiently homogeneous. This implies that the residual variation in clonal testing trials could be large. The coefficient of variation for randomized block designs in tea soils were found to vary between 2.8% and 72.5% (Kanapathipillai 1971). Even after adjustment with co-variance analysis the coefficient of variation ranged from 1.5 to 53.2%.On the basis of these findings Kanapathipillai is of the view that in experiments using a randomized block design the block size should not exceed nine plots.

To minimize the error due to soil heterogeneity two types of designs are usually employed. In one, the treatments are randomized in such a way that each treatment has a control plot with which it may be compared. This design increases the accuracy of comparisons of treatments with the controls at the expense of comparisons between the treatments themselves, as the treatments are spread over a large area of land. Consequently, the efficiency of these designs is low. In the other type, certain treatment comparisons are sacrificed in order to obtain greater accuracy in others. Here a complete replication is divided or confounded into two or more blocks of equal size in the hope that the smaller blocks would be more homogeneous. This process of 'confounding' pre-supposes the existence of higher order interactions. The smaller block size and, hence greater homogeneity of soil factors is achieved at the expense of information on higher order interactions. The loss of such information may be partial or total. These higher order interactions are of less interest and in any case difficult to interpret and hence, we can afford to lose information on them. Confounded factorial designs have been used in tea fertilizer experiments where interactions between treatments are known to exist. The coefficient of variation for these factorial designs where the block size was nine plots, was found to range from 4.9% to 7.5% (Kanapathipillai, 1971).

In varietal trials we do not expect any interactions. That is, we do not expect the performance of one clone to be dependent on the performance of some other clone. Therefore, the principle of confounding interactions cannot be applied to increase the precision of varietal trials. Yates (1936) overcame the problem of reducing the block size in the absence of interactions, by introducing lattice designs. The lattice designs are part of a larger class of designs known as incomplete block designs. Wettasinghe (1971) laid out an experiment employing a rectangular lattice design for comparing the yield of 30 clones. Special features of this trial were its layout which enabled the results to be analysed as a randomized block design as well, and the repetition of a check clone in each block. These features provided for a rigorous test of the relative efficiency of the rectangular lattice and the randomized block designs. This paper reports the results of this experiment.

EXPERIMENTAL METHODS

Thirty clones were tested at the Tea Research Institute, Low-Country Station, Ratnapura, (30 m amsl) in a 5x6 rectangular lattice design (Cochran & Cox 1957). There were six blocks of five plots each in a single replicate. The blocks were laid out contiguously to form a compact, full replicate. Each block contained four clones together with a check clone, TRI 2023. It would be seen that clone TRI 2023 was repeated six times designated A, B, C, D, E and F in each replicate so that it served as a check on the precision of this design. Each plot consisted of 25 experimental plants surrounded by a single guard row of the same clone. The tea was planted in June 1969 and plucking commenced 18 months after planting. Fresh weights of harvests were recorded at approximately weekly intervals for a period of one year. On the basis of results reported by Sebastiampillai & Solomon (1976), the yield of clones in the first year of plucking was considered adequate for these comparisons.

RESULTS AND DISCUSSION

When incomplete block designs are laid out in contiguous blocks to form complete and entire replicates, as in the rectangular lattice reported here, it is legitimate to subject the data to an analysis appropriate to a simple randomized block design (Panse & Sukhatme, 1957). The data analysed as randomized blocks gave an error mean square of 57.63 (Table 1) while the effective error mean variance in a rectangular lattice analysis turned out to be 20.08 (Table 2). Thus the relative accuracy of the lattice design as compared with the randomized block design was 287%. This means that the lattice design increases the precision of the experiment by 187%. This increase in precision was achieved at the cost of 15 degrees of freedom from the error term, leaving a substantial number of degrees of freedom, *viz* 43, to estimate the error variance in the lattice design. Thus the gain in accuracy has more than compensated for the relatively small loss in the degrees of freedom for error.

TABLE 1 — *Yield of 30 clones analysed as randomized blocks*

Source	Degrees of Freedom	Sum of Squares	Mean Square
Replicates	2	2222.32	1111.16
Treatments	29	6607.29	227.84
Error	58	3342.73	57.63
Total	89	12172.34	

TABLE 2 — *Yield of 30 clones analysed as 5 x 6 rectangular lattice*

Source	Degrees of Freedom	Sum of Squares	Mean Square
Replicates	2	2222.32	1111.16
Treatments	29	6607.29	227.84
Blocks (adjusted for treatments)	15	2479.39	165.29
Intra-block error	43	863.34	20.08
Total	89	12172.34	

The analysis of the rectangular lattice design involves an adjustment of the actual plot yields for block effect, as clonal differences are partially confounded with block differences. The adjusted yields and the actual yields of clones are compared in Table 3.

TABLE 3 — *Yield (kg/ha/annum) of 30 tea clones in the first year of plucking*

Clone	5 x 6 rectangular lattice analysis (adjusted yields)		Randomized block analysis (actual yields)
W/2-145	1015		1132
TRI 2045	1083		1020
TRI 2043	1171		990
MO 20	1288		1332
H 13/4	1288		1415
GMT 9	1298		1220
MPA 1	1332		1376
NK 4B 29	1347		1176
H 1/58	1556		1483
MT 18	1561		1620
TRI 2024	1576		1459
DG 7	1639		1415
PUH 5	1654		1678
DG 39	1664		1386
TRI 2022	1669		1727
TRI 2151	1771		1532
PGG 2	1786		1874
S 106	1795		1791
TRI 2025	1839		1805
KEN 16/3	1878		1835
TRI 2026	1903		2152
TRI 2027	1956		2035
CW 21	1976		2313
TRI 2021	2020		2152
TRI 2023F		2078	2259
TRI 2023B		2093	1908
TRI 2023A		2122	2113
TRI 2023C	2200	2220	1970
TRI 2023D		2283	2371
TRI 2023E		2400	2576
LSD ($P = 0.05$)	273	361	605

The randomized block analysis of the experiment gave an LSD ($P = 0.05$) of 605 Kg/ha/annum for comparing the yield of clones (Table 3). On this basis, it is shown that the clones designated 2023B and 2023C were significantly different from clone 2023E although, all of them are genetically identical material. When the same experiment was analysed as a lattice design, the analysis did succeed in grouping the yields of TRI 2023 A to F as being not significantly different even though the LSD ($P = 0.05$) for this comparison was only 361. This is a clear indication of the superiority of the rectangular lattice design over the randomized block design for testing tea clones.

It is evident from the results presented here that the grouping of plots into compact, small blocks in the rectangular lattice has reduced the error due to soil heterogeneity to an acceptable level. The lattice design was seen to be nearly three times more accurate than the randomized block design. This means that the randomized block design would have to be replicated nine times (270 plots) in order to attain the level of accuracy obtained from a rectangular lattice replicated thrice (90 plots). In other words the use of the lattice design has effected a saving of 180 plots. The use of the rectangular lattice therefore would not only increase the precision of clonal trials, but also effect considerable economies in the land, planting material, staff and labour required for these trials. The rectangular lattice saves land not only by cutting down on replication, but also by cutting down on the block size and thus dispensing with the need for large contiguous areas to accommodate large blocks. The compact blocks of the lattice designs enable the land available for experimentation to be more fully utilized with little wastage. The saving in planting material is an important advantage as in the early stages of the development of a new clone the quantity of planting material available is usually limited.

ACKNOWLEDGEMENT

The assistance of Mr. D. D. Kroon, Experimental Officer, in the layout and conduct of the experiment is gratefully acknowledged.

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Accepted for publication: 30th March 1979