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Evaluation of efficient Experimental Design for Leaf Analysis of Apple Cultivar "Red Delicious" as affected by Sample Size under Kashmir Climatic conditions

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ABSTRACT: Much of the scientific advance in crop science relies on field experiments. The use of proper design in field experiments plays an important role in the achievement of accurate results. Comparative study of two major designs, *i.e.* the randomized complete block design (RCBD) and the Latin Square Design (LSD), was conducted to study the mineral composition of the leaves of the 'Red Delicious' apple cultivar affected by the size of the sample. The relative efficiency of LSD to RCBD was calculated using data on the macro and micro nutrient content of leaves of Red delicious apple trees affected by the size of the sample. The Latin square design was found to be superior to the randomized complete block design and the LSD efficiency gain over RCBD was 52% when the number of experimental units per replication was one. When the experimental units per replication were increased significantly RCBD becomes superior to LSD. The study is going to help soil scientists in determine mineral composition of the leaves accurately there by making appropriate fertilizer recommendations based on these results.

Keywords: Field experiments, Relative efficiency, Sample size, RCBD and LSD.

INTRODUCTION

Experimental design refers to the process by which an experiment is planned so that the appropriate data is collected and analyzed using statistical methods to achieve valid and objective conclusion Montgomery (1976). Experimental design is concerned with detailed methods of carrying out an experiment in order to achieve maximum desired response objective. In his first paper on field experimental designs, Fisher (1926) emphasized the importance of randomized arrangements in estimating experimental error and described the randomized complete block and Latin square designs. In agricultural field experimentation use of proper design play an important role in attaining precision of results. To maximize the information that can be extracted from such experiments, the use of efficient experimental design is crucial. Experimental designs have been widely used for control of experimental error. Some of the natural variations between the set of experimental units are physically handled in these designs these designs in order to make a minimum contribution to the differences between the means of treatment. Various experimental designs are available to meet the requirements of the experimenter in different practical situations in order to control the nature of variation.

The best design to be used in any given situation is the one that provides the maximum precision (efficiency) for estimating the desired effects and contrasts and has a simple layout and analysis. Thus, the experimental design with adequate variability control or with minimum error variance is said to be more efficient than the one with relatively larger variance. The design, which is found to be more efficient, is used to carry out the experiments and to obtain better results. In general, the relative efficiency of one design to another is measured in relation to reduced error, expected error mean squares or standard error of difference between genotype means (Cochran and Cox, 1957, Binns 1987; Magnussen 1990). The Relative Efficiency (RE) of the design say A to another design say B denoted as RE (A:B) in experimental design is defined in terms of number of design a replicates needed to achieve same result as one replicate of design A. The design an analysis of field experiments is complicated by soil heterogeneity. In order to mitigate experimental error, an acceptable experimental design is chosen from several available designs to satisfy the requirements of the experimenter under various circumstances.

MATERIAL AND METHODS

The experiment was designed in a randomized, complet e block design and latin square design consisting of 3 replicates for RCBD and 7 replicates for LSD with leaf samples of different sizes (10, 20, 30, 40, 50, 60, 70) as an treatment and an apple tree(variety "Red Delicious") as an experimental unit. The leaf samples were analyzed for various macro and micro nutrients, and the results were used to compute the efficiency of experimental designs.

Relative efficiency of latin square design (LSD): In estimating the efficiency of LSD over RCBD, we have to consider the type of blocks. If the LSD had been RCBB with columns as blocks it is termed as column blocking. Similarly, if LSD had been RCBD with rows as blocks it is termed as row blocking.

Using rows as blocks and columns as blocks, the appro ximate relative accuracy of LSD over RCBD can be ob tained as

$$\text{E (LS to RB)} = \frac{E_e(RB)}{E_e(LS)} X100$$

When the error degrees of freedom is less than 20, the precision factor is taken into account. The precision factor is computed as

$$PF = \frac{(n_1+1)(n_2+3)}{(n_1+3)(n_2+1)}$$

Therefore, when error degrees of freedom is less than 20, the relative efficiency can be estimated by the formula

$$\text{E (LS to RB)} = \frac{E_e(RB)(n_1+1)(n_2+3)}{E_e(LS)(n_1+3)(n_2+1)} X100$$

Where, E_e (LS) and E_e (RB) are error mean squares of LSD and RCBD respectively and n_1 and n_2 are their respective degrees of freedom. Since, the rows and columns are equal in number the precision factor formula holds good for both row and column blockings.

If rows are the only blocks, the mean square error of the randomized block design can be calculated as

$$E_e \text{ (RB)} = \frac{n_c E_c + n_e E_e}{n_c + n_e}$$

But, if the columns are the only blocks, i.e. row blocking is ignored, then we obtain

$$E_e \text{ (RB)} = \frac{n_r E_r + n_e E_e}{n_r + n_e}$$

Where, E_c, E_r and E_e are mean squares for columns, rows and error in RCBD and n_c, n_r and n_e are their respective degrees of freedom.

The efficiency of LSD relative to CRD is given as

$$\text{E (LS to CR)} = \frac{E_e(CR)}{E_e(LS)} X100$$

When the error degrees of freedom is less than 20, the precision factor is taken into account. The precision factor is computed as

$$PF = \frac{(n_1+1)(n_2+3)}{(n_1+3)(n_2+1)}$$

Therefore, when error degrees of freedom is less than 20, the relative efficiency can be estimated by the formula

$$\text{E (LS to CR)} = \frac{E_e(CR)(n_1+1)(n_2+3)}{E_e(LS)(n_1+3)(n_2+1)} X100$$

Where, E_e (LS) and E_e (CR) are error mean squares of Latin Square Design and CRD respectively and n_1 and n_2 are their respective degrees of freedom.

Error mean square of CRD can be estimated as

$$E_e \text{ (CR)} = \frac{n_c E_c + n_r E_r + n_e E_e}{n_c + n_r + n_e}$$

Where, E_c, E_r and E_e are the mean squares for columns, rows and error in Latin Square, respectively and n_c, n_r and n_e are the degrees of freedom for columns, rows and error in LSD.

RESULTS AND DISCUSSION

The relative efficiency of the latin square design of order 7 with number of experimental units per replication 1, 2, 3, 4, 5, 6 with respect to the randomized complete block were determined and are shown in Table 1.

Table 1: Relative efficiency of LSD to RCBD for studying mineral composition of leaves of apple cultivar "Red Delicious".

Experimental units per replication	RCBD	LSD	Efficiency Factor	Percentage increase in efficiency
	σ_e^2 with r=3	σ_e^2 with r=7		
1	0.00760	0.00500	1.52	52
2	0.00576	0.00412	1.40	40
3	0.00422	0.00300	1.41	41
4	30.22591	23.6240	1.28	28
5	30.82533	25.3307	1.22	22
6	37.3690	43.5980	0.86	-14

The study found that the latin square design was superior to the randomized complete block design to control the experimental error. The improvement in efficiency of the latin square design over randomized complete block design was 52% when the number of experimental units per replication was one. When the number of experimental units per replication was two, the efficiency of the latin square design increased by 40% over the randomized complete block design. However, with the increase in the number of experimen tal units per replication, the efficiency of the latin square design is reduced over the randomized complete block design.

It was found that randomized complete block design was superior to Latin square design when the number of experimental units per replication were 6. Therefore, it is evident that RCBD becomes more efficient than LSD as the number of replications is increased significantly. Moreover, RCBD is more efficient than LSD in the sense that it uses relatively small amount of experimental material as compared to latin Square design.

Nishu *et al.* (2017) also found that randomized complete block design is more effective than completely randomized design in reducing error variation, and Latin square design is superior to both completely randomized design and randomized complete block design. Syed *et al.* (2017) also concluded that in wheat yield trials, randomized complete block design is optimal of experimental designing compared to Latin square design.

SUMMARY AND CONCLUSION

The study revealed that lain square design is superior to randomized complete block design as it provides adequate control over variability. However, with the increase in the size of experimental material the efficiency of latin square design relative to randomized complete block design is reduced and randomized complete block design becomes superior to latin square design. Therefore, it is recommended to use latin square design for leaf analysis when the experimental material per replication is small.

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Conflict of Interest. None.

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