Comparative Efficiency of Alpha Lattice Design Versus Randomized Complete Block Design in Wheat Field Trials

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Abstract

The present study was designed to estimate the relative efficiency of alpha lattice design over Randomized Complete Block design (RCBD) when the numbers of entries/genotypes are fifty in single block The precision of RCBD relies on the control of heterogeneity within blocks. The efficiency of RCBD is criticized by the researchers in advanced countries while dealing with particularly large field experiments. Therefore the use of RCBD is being considered unsuitable when the number of entries/genotypes is as large as sixteen in single block.The yield data were collected from preliminary yield trials conducted at NARC during 2012-13, 2015-16 and 2016-17 and analysed in RCBD and alpha lattice design using software MINITAB and PBTools. The coefficients of variation calculated for wheat yield trial were 5.11, 6.81, and 8.19 percent for alpha lattice design and 10.57, 7.03, 8.47 percent for RCBD respectively. Mean square error for alpha lattice design were 46638, 64421, 135472 and 49882, 68748, 144801 for RCBD. Similarly standard errors of difference were 216.6, 259.77, and 376.86 for alpha lattice design and 223.34, 262.19, 380.52 for RCBD. These results clearly depicted that values were minimum under alpha lattice design as compared to RCBD. The relative efficiency 1.06, 1.06, 1.07 showed that the use of alpha lattice design increased experimental efficiency by 6 to 7 percent over RCBD. Hence, It is recommended that an experiment usually planned with RCB arrangement at NARC could be replaced/laid out in an alpha lattice design when the number of entries/varieties of the experiment is more than 10 t. The alpha lattice design also provides effective control within replicate in large blocks.

Key words: Alpha lattice design, Randomized complete block design, Relative efficiency

Introduction and Background

The biological scientists are carrying out research on various crops at their research centers including NARC. Different types of experiments are conducted including breeding/screening trials, agronomic trials and national uniformity trials used for wider adaptation. Classical methods are being used to analyze the data from such experiments. It has been observed that these methods do not take into account the spatial variability among the experimental units, due to which the experimental error is inflated and results are low in precision.

Good quality statistical design and analysis of agricultural research is a prerequisite to meeting the future demands for food and improving the incomes and livelihoods of poor people. Different Statistical designs in agriculture field experiments are being used to control and reduce inflate variation of experimental error. Inherent soil variability among the selection of suitable statistical design for the available field situation can provide the estimates of desired effects and contrasts with maximum precision having a simple layout and analysis. The experimental design with minimum error variance is called to be more efficient as compared to those which have relatively larger error variance. On the basis of relative efficiency, the more efficient design can be used to improve the precision in field experiments at the time of planning rather than at the end of work. Khan and Mead (2001) has also given importance of alpha lattice design and stated that gain in efficiency can be achieved when these experiments are used in field research comparing many varieties.

Soil heterogeneity complicates the design and analysis of field experiments. In order to minimize the experimental error, suitable experimental design was selected from many available designs to meet experimenters' requirements under different circumstances. The prospects of increased accuracy by a proper choice of experimental plan have been widely explored (Mujahid,*et al*, 2017).

Experimental error under can be reduced as much as possible using blocking with the arrangement of Randomized Complete Block Design (RCBD). To improve RCBD by eliminating more sources of variation and Alpha Lattice Design is one such improved design with provision for the elimination sources of variation. (Yang *et al* 2004) has highlighted the significance of alpha lattice design over RCBD when the number of genotypes is large. In these cases RCBD gives less precision and experimental error is not reduced. The use of alpha designs is recommended in variety trials involving large numbers of varieties when the trials are conducted on variable soil and when differences between the varieties are relatively small.

The precision of RCB relies on the control of heterogeneity within blocks. The efficiency of RCBD is criticized by the researchers in advanced countries while dealing with particularly large field experiments. So the use of RCBD is unsuitable when the number of entries/Genotypes is as large as sixteen in single block Yang *et al*, (2004). Efficiency of alpha lattice has also been studied by Kashif ,*et al*, (2011) for nine maize trials at maize and millet research institute. The results indicated that alpha lattice design was more effective than RCBD. Due to the restriction on the number of genotypes that may be evaluated, there have been a number of proposed lattice type designs, the most popular being the alpha designs Giesbrecht and Gumpertz, (2004) and Hinkelman and Kempthorne, (2006).

Keeping in view the importance of Alpha Lattice design the present study was planned in collaboration with wheat program of NARC to compare the relative efficiency of alpha lattice designs with RCBD with two main objectives 1) To evaluate the efficiency of experimental designs such as alpha lattice and RCBD in terms of increasing precision and 2) To explore the benefits of sub-blocks within super block in alpha lattice design over RCBD.

Materials and Methods

Experiments on wheat crop were conducted by Wheat Program, NARC in Alpha lattice Design with 2 replications, 50 entries, 10 blocks and 5 plots per block NARC during, 2012-13, 2014-15 and 2015-16. The collected data on

yield was analyzed in RCBD and alpha lattice design using statistical software like MINITAB version 16. Since the main objective was to explore the benefits of sub-blocks within super block in Alpha lattice design over RCBD.

The Coefficient of Variation (CV) was calculated using error mean square (S^2) of ANOVA and dividing by grand mean of the total observations of the experiment . CV indicates the degree of precision with which the treatments are compared and is a good index of the reliability of the experiment. The C.V. expresses the amount of experimental error relative to average value of the data. The small value of C.V. indicates that the results of the experiment are reliable. Historically, agronomists have relied heavily on the C.V. as a measure of trial's worth. A rejection value of 10% is often quoted, but this value appears to be arbitrary [3]. The C.V. varies greatly with the nature of the experiment and the character measured, so there is no hard and fast rule for the acceptability of a particular cv. value. The cv value for each experiment is calculated as

Coefficient of variation (CV%) = $\frac{\sqrt{\text{Error variance}}}{\text{Grand mean}}$ x 100

$$\text{SED} = \sqrt{Error\ MSS\ x\ 2} \div \sqrt{Reps}$$

Relative Efficiency = $\frac{\text{MSS of error of RCBD}}{\text{MSS of error of Alpha Lattice Design}}$

The impact of Alpha Lattice design over RCBD was assessed by relative efficiency in term of the size of the experimental error in term of improvement in precision or efficiency. An estimated relative efficiency (ERE) less than 1 indicates that an alpha lattice over RCBD is not efficient, while value nearly equal to 1 suggests that the two designs yield similar results. Value greater than 1 suggests that Alpha lattice design is more efficient design than RCBD.

Results and Discussion

The results of the experiment showed that there was large difference between error mean squares (EMS) under RCBD and alpha design. The coefficient of variation (CV) of alpha lattice design is comparatively low as compared to RCBD. Low value of CV indicated good index of reliability. The relative efficiency indicated how much more efficient alpha lattice design to a RCBD, if the value of relative efficiency is greater than 1 then the alpha lattice results in a smaller error variance than RCBD and it adjusts genotype means for block effects. In addition to that the relative efficiency is less than 1.0, Alpha lattice design is less efficient than the RCBD. When the data of three yield trail is analyzed as by RCBD, means are not adjusted for block effects. There was a big difference between standard error of difference under RCBD and alpha lattice design respectively (Table1). The smaller values of S.E. of differences for alpha lattice design helped to detect smaller differences for the comparisons of mean.

Table 1: Results of the Wheat Experiments at NARC, 2012-13, 2015-16 and 2016-17

Year	Mean Square Error		Standard Error of Difference		Coefficient of Variation		Relative Efficiency Alpha Lattice Vs RCBD
	RCBD	ALPHA	RCBD	ALPHA	RCBD	ALPHA	
2012-13	49882	46638	223.34	216.6	10.57	5.11	1.06
2015-16	68748	64421	262.19	259.77	7.03	6.81	1.06
2016-17	144801	135472	380.52	376.86	8.47	8.19	1.07

Results of three wheat experiments were compared in respect of error mean square, standard error of difference, coefficient of variation and relative efficiency in RCBD and alpha lattice design (Table 1). The values of mean of sum of square (MSS) of Error and standard error of difference (SED) and coefficient of variation (CV) of RCBD were comparatively smaller in Alpha Lattice design as compared to RCBD. It is revealed that analysis in alpha lattice design resulted in reducing the experimental error and thus enhancing the capability of the experimenter/researcher to detect significant differences among the fifty genotypes. Gain in efficiency of three trials indicate that the experimental precision increased by six to seven percent respectively by using Alpha lattice which was not very large and significant. The findings of this study are similar to the results of wheat experiments under ALP project at NARC in 2004-05 where the relative efficiency of two experimental designs was compared and gain in efficiency of alpha lattice design was seven (7) and nine (9) for NARC however different in other institutes. Some of the studies have reported different results about gain in efficiency in wheat experiments such as Masood, *et al* (2008) where the relative efficiency of wheat yield trials was 124 percent. In study by Kashif, *et al*, (2011) the relative efficiency of wheat experiments was reported to be 105,132 and 104 for the years 2004-05, 2005-06 and 2006-07 respectively.

Conclusion and Recommendations

Generally alpha design provided smaller standard errors of differences thus providing greater efficiency in comparing different varieties. Thus these designs are recommended for more propagation for field research in Pakistan. There is a need to extend experimentation to more research stations for wider applicability of these designs for studied crops and for some other crops too.

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