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Short Communication

Efficiency of Alpha Lattice Design in Rice Field Trials in Pakistan

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Abstract

Two rice trials were conducted from 2005 to 2006 in rice research institute, Kala Shah Kako Pakistan to evaluate the efficiency of alpha lattice design in field experiments. The average standard error of difference between genotypes mean is used to calculate relative efficiency of alpha lattice design. Both experiments clearly identified the advantages of small blocks. The average gain in efficiency was 119% with maximum 128%. Mean ranks comparison for both randomized complete block and alpha lattice design were performed. It was observed that the ranks were not constant across the experiments. The results emphasize that the traditional randomized complete block designs (RCBD) should be replaced by alpha lattice in the agricultural field experiments when number of varieties to be tested in an experiment increases to more than five or ten. In such a situation finding a homogeneous block is quite difficult in field experiments.

Keywords: Rice; Alpha lattice design; RCBD; Pakistan.

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1. Introduction

There are large numbers of yield trials on different crops conducted at different locations by national coordinated program. The objective of these trials is to evaluate yield potential among different genotypes competing for recommendation to the farming community through Variety Evaluation Committee (VEC). These trials are very important and crucial in agricultural research system of Pakistan. Randomized complete block design (RCBD) is one of the widely used designs in field trials particularly in National Agricultural Research System of Pakistan. The precision of RCBD relies on the control of heterogeneity within blocks. The efficiency of RCBD is criticized by the researchers in

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advance countries while dealing with particularly large field experiment. So the use of RCBD is unsuitable when the number of genotypes is as large as sixteen in single block [1,2].

The scientists have replaced the RCBD with incomplete block (IB) and lattice square design introduced by [3-5]. These designs are widely used in plant breeding and variety testing around the world and are more efficient than RCBD [6,7]. These designs are restricted to very limited number of treatments and the field layout is very critical.

In contrast alpha lattice design would be used for unlimited entries [8]. Recent developments in several countries showed that considerable improvement in precision can be attained by using alpha lattice design. Furthermore these designs also take into account the local spatial variation. Many researchers [6, 9-14] have used alpha lattice design in field trials. They concluded that alpha lattice design is more efficient than RCBD and have potential to replace RCBD in regional and international trials [11, 14, 15]. To study the benefits and advantages of alpha lattice design in national agricultural research System of Pakistan two rice yield trials were conducted in Rice Research Institute (RRI), Kala Shah Kako. The objective of this paper is to share and present the results of these experiments with researchers and scientists and show the advantage of using alpha lattice design over conventionally used randomized completed block design (RCBD).

2. Methodology

Two field experiments were conducted at Kala Shah Kaku, Pakistan during 2004-06. The trials were conducted using an Alpha-lattice design field plan. Both trials consist of sixteen entries in four incomplete blocks of four plots. The randomization was done by alpha program and plot size was 6×4 m^2. All agronomic and plant protection measures were carried out to get healthy crop. Grain yield data were recorded in a 6 m^2 area of each plot and presented in tons ha^{-1} adjusting at 14% moisture for all plots. The impact of alpha lattice design was assessed by calculating efficiency over the conventional RCB design. This efficiency was based on average standard error (S.E.) of genotypic differences. Each trial was analyzed twice following the methodology as described in ref. [10]. Relative efficiency (R.E.) was calculated by using the following formula:

$$\text{R.E.}=\left(\frac{\text{S.E.}_{\text{RCB}}}{\text{S.E.}_{\text{Lattice}}}\right)\times 100$$

3. Results and Discussion

The results of two rice experiments during the years 2005-06 showed in Table 1 below. The relative efficiency for both years indicated that the use of the alpha lattice design instead of RCB design increased experimental precision by 28% and 10%, respectively. The results indicated that there was clear benefit of using alpha lattice design.

The error mean squares (EMS) under alpha design was smaller as compared to RCB design. It is also noted that the coefficient of variation (CV) of alpha lattice design was comparatively low as compared to RCBD. Historically agronomists have relied heavily on the CV as a measure of trial's reliability. This increase in precision resulted in alpha lattice design better detected significant differences than RCBD.

Table 1. Results of the rice experiments conducted at Rice Research Institute during 2005-2006.

Year	No. of plots	No. of varieties	No. of blocks/ replication	Mean square error		CV		Relative efficiency
				Alpha	RCBD	Alpha	RCBD	
2005	64	16	4	0.1043	0.1333	10.7	12.10	1.28
2006	64	16	4	0.4772	0.5261	19.6	20.59	1.10

Although both field trials were specialized genetic experiments, there is no reason why alpha lattice design showed less efficiency in second year. The CV after using alpha lattice design was still too high suggesting that experiment was not carried out efficiently. The efficiency of alpha design in second experiment could be improved by using neighbor or spatial analysis or row and column analyses [4,6,11,16-20].

Table 2. Rank changes of mean yield values under RCBD and Alpha lattice for the year 2005.

Variety no.	Average yield of RCBD	Rank	Average yield of Alpha lattice	Rank	Variety no.	Average yield of RCBD	Rank	Average yield of Alpha lattice	Rank
1	2.40	1.0	2.45	1.0	9	2.89	5.0	2.89	5.0
2	3.14	11.0	3.18	14.0	10	2.83	3.0	2.88	4.0
3	3.19	14.0	3.13	13.0	11	3.18	12.5	3.12	11.0
4	2.82	2.0	2.84	3.0	12	2.90	6.0	3.06	8.0
5	3.29	15.0	3.33	16.0	13	3.11	9.5	3.11	9.0
6	3.03	8.0	3.00	7.0	14	3.18	12.5	3.12	11.0
7	3.11	9.5	3.12	11.0	15	2.85	4.0	2.77	2.0
8	3.39	16.0	3.32	15.0	16	2.97	7.0	2.95	6.0

The rank orders of mean based on Alpha design (least square means) and RCBD (simple means) also change, which is relevant when selecting genotypes for the purpose of recommendations for the farmers. The effect is illustrated in Table 2 for experiment 1, where the four significant rank changes were observed when ordering 16 genotypes according to their yield performance. The treatment mean ranks differences were detected in the varieties 2, 7, 12 and 15. Similarly several shuffling in ranks of different varieties have been observed for experiment 2 (Table 3), e.g. variety number 1 ranked at number four under RCBD moved up and attained a higher rank place of 6.5 under alpha lattice with an upward adjustment of 0.02 tons per hectare, while variety number six moved from rank number 5 under RCBD to rank number 2 under alpha lattice. The observed inconsistency in ranking and reduction in mean square error under alpha lattice design suggested that alpha lattice design appears better to detect genotypic differences than the RCBD and will therefore improve the efficiency of field trials.

Table 3. Rank changes of mean yield values under RCBD and Alpha lattice for year 2006.

Variety no.	Average yield of RCBD	Rank	Average yield of Alpha lattice	Rank	Variety no.	Average yield of RCBD	Rank	Average yield of Alpha lattice	Rank
1	3.32	4.0	3.34	6.5	9	3.60	10.5	3.55	9.5
2	3.13	1.0	3.17	1.0	10	3.56	9.0	3.62	11.0
3	3.60	10.5	3.55	9.5	11	3.78	14.0	3.76	13.0
4	3.35	6.5	3.35	8.0	12	4.11	16.0	4.24	16.0
5	3.36	8.0	3.34	6.5	13	3.76	13.0	3.80	14.0
6	3.33	5.0	3.25	2.0	14	3.93	15.0	3.85	15.0
7	3.35	6.5	3.33	5.0	15	3.28	3.0	3.28	3.0
8	3.66	12.0	3.63	12.0	16	3.23	2.0	3.30	4.0

4. Conclusion

To control variability in field experiments, it is suggested that an experiment with a RCB design could be replaced with an alpha lattice design when the number of varieties in the experiment is more than say ten. The use of alpha lattice design allows the adjustment of treatment means for block effects. This in turn brings benefit from the small incomplete blocks which help varietal comparisons under more homogenous conditions. The alpha lattice design also provides effective control within replicate variability. The results presented here make a case of using alpha lattice design which enhances the chances of detecting varietal differences to a great extent.

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