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ESTIMATING THE EFFICIENCY OF ALPHA LATTICE DESIGN IN PRELIMINARY YIELD TRIALS OF MUSTARD

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ABSTRACT

The present investigation was undertaken during the *rabi* season of 2015-16 and 2016-17 at experimental farm of Agricultural Botany section, College of Agriculture, Nagpur, with a view to study the benefits and advantages of alpha lattice design over the conventionally used RCBD. The experiment consisted of 64 genotypes along with six checks of mustard grown in Alpha lattice design with three replications. Data were recorded for ten quantitative characters i.e. days to 50 % flowering (on plot basis), days to maturity (on plot basis), plant height (cm), main shoot length (cm), primary branches plant^{-1}, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, 1000 seed weight (g), seed yield plot^{-1} (kg ha^{-1}) and seed yield plant^{-1} (g).The analysis of variance to test the significant differences in the mean values in RCBD as well as alpha lattice design revealed that highly significant differences existed among genotypes for all the ten quantitative characters. Estimates of relative efficiency indicated that values above unity for the characters studied indicated wider use of alpha lattice design under field conditions.

(Key words: Mustard, alpha lattice, analysis of variance, relative efficiency, preliminary yield trial)

INTRODUCTION

Alpha designs are essentially resolvable block designs. In alpha designs the variation between blocks within replication helps in reducing the experimental error, increasing there by the precision of estimation of treatment contrasts of interest. The randomized block, Latin square, and other complete block types of experiments are inefficient for large number of treatments, because of their failure to adequately minimize the effect of soil heterogeneity. Generally, the greater the heterogeneity within blocks, the poorer the precision of variety effect estimates.

Agricultural field experiments are important part of a research program and Randomized complete block design (RCBD) is one of the widely used designs in field trials. The precision of RCBD relies on the control of heterogeneity within blocks. The efficiency of RCBD is criticized by the researchers in 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. The scientists have replaced the RCBD with incomplete block (IB) and lattice square design introduced by Yates (Hinkelman and kemporne, 2006). These designs are widely used in plant breeding and variety testing around the world and are more efficient than RCBD. These designs are restricted to very limited number of treatments. In contrast, alpha lattice design would be used for unlimited entries with considerable improvement in precision. Furthermore these designs also take into account the local spatial variation. Many researchers concluded that alpha lattice design is more efficient than RCBD and have potential to replace RCBD in regional and international trials Masood *et al.* (2008).

Alpha designs are introduced by Patterson and Williams (1976) are more flexible than lattice designs and can accommodate any number of varieties. The advantage of alpha designs is that they are easy to construct, and can be constructed in cases where balanced incomplete block designs and lattice designs don't exist. The early alpha designs were aimed primarily at controlling variation down the columns of plots in the field. This is often adequate when plots are long and narrow. Patterson and Hunter (1983) have demonstrated the value of alpha designs in such circumstances in terms of gain in efficiency. The usual approach through local control by blocking is inefficient and a lot of research has recently been carried out which suggest new methods of local control in field experiments Gleeson and Cullis (1987), Cullis and Gleeson (1991).

MATERIALS AND METHODS

The experiment was conducted at the farm of Agricultural Botany section, College of Agriculture, Nagpur

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during *rabi* 2015-16 and 2016-17. The experimental material for the present study consisted of 64 recombinant lines and six checks (Table 1) planted in alpha lattice design with three replications with a plot size of 3 m x 1.5 m. The row to row and plant to plant distance was maintained at 45 cm x 15 cm. All the recommended packages of practices were undertaken to raise a good crop. The data was recorded for yield and yield contributing characters include days to 50 % flowering (on plot basis), days to maturity (on plot basis), plant height (cm), main shoot length (cm), primary branches plant^{-1}, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, 1000 seed weight (g), seed yield plot^{-1} (kg ha^{-1}) and seed yield plant^{-1} (g).Data was subjected to statistical analysis for RCBD (Ragaswamy, 2014) as well as alpha lattice design (Parsad *et al.*, 2009). The statistcal analysis was done by using NARS statistical portal provided by IASRI, New Delhi.

The mean square error from each analysis was used to estimate the relative efficiency of an alpha lattice design compared with a RCBD according to the following equation:

$$\text{Relative Efficiency} = \frac{\text{Mean Square Error in RCBD}}{\text{Mean Square Error in Alpha Lattice Design}} \text{ X } 100$$

RESULTS AND DISCUSSION

Analysis of variance for RCBD for the data of 2015-16 and 2016-17 (Table 2b and 3b) indicated the mean squares due to genotypes were highly significant for all ten characters studied i.e. days to 50 % flowering (on plot basis), days to maturity (on plot basis), plant height (cm), main shoot length (cm), primary branches plant^{-1}, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, 1000 seed weight (g), seed yield plot^{-1} (kg ha^{-1}) and seed yield plant^{-1} (g) indicating the presence of considerable genetic variation among the genotypes for characters studied.

Analysis of variance for alpha lattice design for the data of 2015-16 and 2016-17 (Table 2a and 3a) indicated the mean squares due to genotypes were highly significant for all ten characters studied i.e days to 50 % flowering (on plot basis) , days to maturity (on plot basis), plant height (cm), main shoot length (cm), primary branches plant^{-1}, number of siliqua plant^{-1}, no of seeds siliqua^{-1}, 1000 seed weight (g), seed yield plot^{-1} (kg ha^{-1}) and seed yield plant^{-1} (g) indicating the presence of considerable genetic variation among the genotypes for characters studied.

An estimated relative efficiency (ERE) less than 1 indicates that a RCBD is a more efficient design, 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. Efficiency of Alpha Lattice Design and Randomized Complete Block Design (RCBD) was compared and experimental error was minimized along with coefficient of variation and error mean square for yield and yield contributing characters.

Relative efficiency for the data of 2015-16 and 2016-17 (Table 4a and 4b)indicates that the use of alpha lattice design instead of RBD increased experimental precision by 11 and 12 for days to 50 % flowering, 9 and 10 for days to maturity, 5 and 14 for plant height (cm), 2 and 11 for main shoot length (cm), 7 and 13 for number of primary branches plant^{-1}, 9 and 14 for number of siliqua plant^{-1}, 5 and 6 for number of seeds siliqua^{-1}, 1 and 13 for 1000 seed weight (g), 13 and 15 for Seed yield plot^{-1} (kg ha^{-1}), 7 and 16 for Seed yield plant^{-1} (g) for 2015-16 and for 2016-17 respectively. These results indicated that enough variation existed in replications to justify the use of alpha lattice design.

The results of the experiments showed that there was large difference between error mean squares (EMS) under alpha design and RCB design for 2015-16 and 2016-17. The coefficient of variation (CV) of alpha lattice design was comparatively low as compared to RCBD. Low value of CV indicated good index of reliability. The relative efficiency of all the characters indicated more efficiency of alpha lattice design as compared to RCBD. The value of relative efficiency greater than one revealed that the alpha lattice results in a smaller error variance and it adjusts the genotype means for block effects. But, if relative efficiency was less than one, the alpha lattice design would have been less efficient than the RCBD. In RCBD the means were not adjusted for block effects. There was big difference between standard error of difference under RCBD and average standard error of difference under alpha design. The smaller values of S.E. difference for alpha lattice design helps to detect smaller differences for the comparisons of mean.

Kashifa *et al.* (2011) reported the use of alpha lattice design in yield trials of rice and found average efficiency of 10-28 per cent higher than the RCBD. Masood *et al* (2007 and 2008) compared efficiency of alpha lattice design. The results indicated that alpha lattice design improved the efficiency 8-9 and 14 per cent as compared to RCBD in these studies. The results of this study showed that Alpha lattice Design provided smaller standard errors of differences, coefficients of variation and error mean squares as compared to RCBD providing efficiency in comparing different entries/lines. Therefore, this design should be employed while conducting field research trials on different crops when number of varieties in the experiments is large. For plant breeding and selection trials alpha lattice design should be used in such a way that they form a resolvable incomplete block design so that the results could be analyzed through RCBD for comparison to check the required gains in efficiency.

Table 1. Pedigree of recombinant inbred lines

Sr. No	Lines	Pedigree	Sr. No	Lines	Pedigree
1	ACN 141	(Pusa Bahar X HUJM)-03-05-1	36	ACN 176	(Seeta X Pusa Bold) X ACN-9)-1-7
2	ACN 142	(Pusa Bahar X HUJM)-03-05-4	37	ACN 177	(Seeta X Pusa Bold) X ACN-9)-3-2
3	ACN 143	(Pusa Bahar X HUJM)-03-05-5	38	ACN 178	(Seeta X Pusa Bold) X ACN-9)-5-4
4	ACN 144	(Pusa Bahar X HUJM)-03-05-7	39	ACN 179	(Seeta X PCR-7) X ACN-9)-3-1
5	ACN 145	Pusa Bahar X TM 41)-4-3-1	40	ACN 180	(Seeta X PCR-7) X ACN-9)-3-5
6	ACN 146	Pusa Bahar X RLM 619)-6-2-3	41	ACN 181	(Seeta X Rohini) X Pusa Bold)-1-4
7	ACN 147	(Rohini X TM 41)-5	42	ACN 182	(Seeta X Rohini) X Pusa Bold)-2-7
8	ACN 148	(Rohini X TM 41)-9	43	ACN 183	(Seeta X Rohini) X Pusa Bold)-3 -1
9	ACN 149	(Pusa Bahar X TM 41)-1-2	44	ACN 184	(Seeta X ACN -9) X Rohini) -2-9
10	ACN 150	Pusa Bahar X TM 41)-1-7	45	ACN 185	(Seeta X ACN -9) X Rohini) -3-2
11	ACN 151	Pusa Bahar X TM 41)-2-1	46	ACN 186	(Seeta X ACN -9) X Rohini)-3-3
12	ACN 152	Bio 902 X HUJM)- 03-05	47	ACN 187	(Seeta X ACN -9) X Rohini) -4-1
13	ACN 153	Bio 902 X TPM-1)-1-1	48	ACN 188	(Seeta X Rohini) X Pusa Bold)-4-2
14	ACN 154	Bio 902 X TPM-1)-3-2	49	ACN 193	Bio 902 X IC 34271)-4-3-1
15	ACN 155	Bio 902 X TM-41)-13-10-1	50	ACN 194	Bio 902 X IC 355314) -6-2-2
16	ACN 156	Laxmi X YRN-6)-11-10-2	51	ACN 195	Bio 902 X IC 3331999)-2-3-2
17	ACN 157	Laxmi X TPM-1)-12-5-2	52	ACN 196	Bio 902 X IC 355327)-3-3-1
18	ACN 158	Laxmi X TM-41)-13-10-1	53	ACN 197	Pusa Bold X Bhawani)-2-3-2
19	ACN 159	Laxmi X RL-1359)-4-2	54	ACN 198	Pusa Bold X Bhawani) -11-2-1
20	ACN 160	Laxmi X RL-1359)-5-4	55	ACN 199	Pusa Bold X Bhawani)-10-3-1
21	ACN 161	Laxmi X RLM -619)-15 -7	56	ACN 200	Pusa Bold X Ragini)- 16a-3-1
22	ACN 162	Laxmi X RLM -619)-16 -7	57	ACN 201	Pusa Bold X Ragini) -16a-5-2
23	ACN 163	Vardhan X Laxmi)-3-1	58	ACN 202	GSL-1 X Pusa bold)- 4-3-2
24	ACN 164	Vardhan X Laxmi)-4-2	59	ACN 203	Pusa Bold X GSL-1)-8-2-1
25	ACN 165	Kranti X RL -1359)-1-7	60	ACN204	Pusa Bold X GSL-1)-8-2-2
26	ACN 166	Kranti X RL -1359) -2-1	61	ACN 205	Pusa Bold X PC-5)-3-2
27	ACN 167	Kranti X RL -1359)-3-3	62	ACN 206	Pusa Bold X Ragini)-16a-6-2
28	ACN 168	Kranti X Bio 902)-2-3-3	63	ACN 207	PC -5 X Pusa Bold) -2-1-1
29	ACN 169	Kranti X Pusa Bharani) -10-2-1	64	ACN 208	Pusa Bold X PC -5)-2-1
30	ACN 170	Vardhan X Rohini) -22-1-5	65	GM 3	
31	ACN 171	(Seeta X Rohini) X Pusa Bold)-4-1	66	NRCHB 101	
32	ACN 172	(Seeta X Rohini) X Pusabold)-5-3	67	Pusa Bold	
33	ACN 173	(Seeta X Pusa bold) X TM-17)-3-2	68	Shatabdi	Check Varieties
34	ACN 174	(Seeta X Pusa bold) X TM-17)-4-1	69	BIO 902	
35	ACN 175	(Seeta X Pusa bold) X TM-17)-4-4	70	Kranti	

Table 2a. Analysis of variance of alpha lattice design for 2015 -16

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Main shoot length (cm)	Primary branches $plant^{-1}$	Number of siliqua $plant^{-1}$	No of seeds $siliqua^{-1}$	1000 seed weight (g)	Seed yield $plot^{-1}$ ($kg\ ha^{-1}$)	Seed yield $plant^{-1}$ (g)
Replication	2	0.80	6.99	5.71	9.30	0.02	173.03	2.13	0.12	1957.88	0.11
Blocks in replications	18	1.53	3.12	10.90	104.14	0.11	111.47	3.04	0.06	2444.80	0.21
Genotypes	69	73.19**	36.36**	644.71**	214.03**	0.90**	4535.38**	6.55**	1.36**	67656.71**	6.84**
Error	120	1.05	2.67	50.61	63.15	0.16	160.20	2.82	0.14	2203.29	0.23

Table 2b. Analysis of variance of Randomised Complet e Block Design for 2015 -16

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Main shoot length (cm)	Primary branches $plant^{-1}$	Number of siliqua $plant^{-1}$	No of seeds $siliqua^{-1}$	1000 seed weight (g)	Seed yield $plot^{-1}$ ($kg\ ha^{-1}$)	Seed yield $plant^{-1}$ (g)
Replication	2	0.80	6.99	5.70	9.30	0.02	173.03	2.13	0.12	1957.88	0.11
Genotypes	69	81.21**	39.54**	679.29**	218.43**	0.95**	4955.17**	6.86**	1.36**	76551.40**	7.31**
Error	138	1.11	2.72	45.43	68.49	0.16	153.84	2.85	0.13	2234.80	0.22

Table 3a. Analysis of variance of alpha lattice design for 2016 -17

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Main shoot length (cm)	Primary branches plant^{-1}	Number of siliqua plant^{-1}	No of seeds siliqua^{-1}	1000 seed weight (g)	Seed yield plot^{-1} (kg ha^{-1})	Seed yield plant^{-1} (g)
Replication	2	32.00	12.78	302.46	54.99	0.06	45.67	2.23	0.08	3725.52	0.18
Blocks in replications	18	13.84	5.44	129.29	120.97	0.09	243.40	2.15	0.18	1969.89	0.21
Genotypes	69	71.12**	59.96**	435.02**	380.19**	2.51**	18427.31**	6.25**	0.91**	277078.60**	24.77**
Error	120	27.05	5.62	265.87	126.80	0.07	154.47	3.71	0.12	3221.19	0.18

Table 3b. Analysis of variance of Randomised Complete Block Design for 2016 -17

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Main shoot length (cm)	Primary branches plant^{-1}	Number of siliqua plant^{-1}	No of seeds siliqua^{-1}	1000 seed weight (g)	Seed yield plot^{-1} (kg ha^{-1})	Seed yield plant^{-1} (g)
Replication	2	34.13	14.24	291.39	54.99	0.07	45.67	2.23	0.08	3725.23	0.18
Genotypes	69	79.34**	66.14**	497.55**	423.65**	2.83**	21071.83**	6.60**	1.02**	318841.00**	28.62**
Error	138	25.08	5.66	246.77	126.04	0.07	166.07	3.51	0.13	3057.94	0.18

Table 4a. Estimated relative efficiency of alpha lattice design and Randomised complete block design for 2015-16

Parameters	Mean Square Error		Coefficent of Variation (CV)		S.E.(Diff)		Relative Efficiency (RE)
	Alpha	RBD	Alpha	RBD	Alpha	RBD	
Days to 50 % flowering	73.19	81.21	2.10	2.16	0.83	0.86	1.11
Days to maturity	36.36	39.54	1.76	1.78	1.33	1.35	1.09
Plant height (cm)	644.71	679.29	5.82	5.51	5.81	5.50	1.05
Main shoot length (cm)	214.03	218.43	15.14	15.77	6.49	6.76	1.02
Primary branches plant^{-1}	0.90	0.95	12.54	12.28	0.33	0.32	1.07
Number of siliqua plant^{-1}	4535.38	4955.17	16.34	16.02	10.33	10.13	1.09
Number of seeds siliqua^{-1}	6.55	6.86	13.70	13.77	1.37	1.38	1.05
1000 seed weight (g)	1.36	1.36	9.26	8.93	0.30	0.29	1.01
Seed yield plot^{-1} (kg ha^{-1})	67656.71	76551.40	11.16	11.24	38.33	38.60	1.13
Seed yield plant^{-1} (g)	6.84	7.31	19.32	19.23	0.39	0.39	1.07

Table 4b. Estimated relative efficiency of alpha lattice design and Randomised complete block design for 2016-17

Parameters	Mean Square Error		Coefficent of Variation (CV)		S.E.(Diff)		Relative Efficiency (RE)
	Alpha	RBD	Alpha	RBD	Alpha	RBD	
Days to 50 % flowering	71.12	79.34	11.22	10.80	4.25	4.09	1.12
Days to maturity	59.96	66.14	2.36	2.37	1.94	1.94	1.10
Plant height (cm)	435.02	497.55	11.25	10.84	13.31	12.83	1.14
Main shoot length (cm)	380.19	423.65	15.00	14.95	9.19	9.17	1.11
Primary branches plant^{-1}	2.51	2.83	6.22	6.36	0.22	0.22	1.13
Number of siliqua plant^{-1}	18427.31	21071.83	6.97	7.22	10.15	10.52	1.14
Number of seeds siliqua^{-1}	6.25	6.60	13.86	13.47	1.57	1.53	1.06
1000 seed weight (g)	0.91	1.02	6.83	7.02	0.28	0.29	1.13
Seed yield plot^{-1} (kg ha^{-1})	277078.60	318841.00	8.46	8.24	46.34	45.15	1.15
Seed yield plant^{-1} (g)	24.77	28.62	5.50	5.58	0.34	0.35	1.16

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