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RELATIVE PRECISION OF SOME INCOMPLETE BLOCK DESIGNS FOR SOYBEAN UNIFORMITY TRIALS AND OPTIMUM SAMPLE SIZE

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ABSTRACT

Experiments of the present study were conducted at the Experimental Station, Faculty of Agriculture, Cairo University, Egypt in 1998 and 1999 seasons. Cutler and Crawford soybean cultivars were used. In 1998 and 1999 four uniformity trials were conducted to estimate the relative precision of incomplete block design i.e. simple lattice, triple lattice, square lattice and balanced lattice relative to randomized complete blocks design.

During 1998 and 1999, two separate experiments were carried out to estimate the optimum size of random sample for the determination of seed yield/plant and some yield components. Lattices were always more efficient than randomized complete blocks. The relative precision average of the two seasons ranged from 110.95 % to 167.89 % for Cutler and from 123.40 to 166.13 % for Crawford. The two lattices squares designs of 3 x 3 and 5 x 5 exhibited the highest relative precision of 147.12 % and 167.89 % for Cutler and of 166.13 % and 145.45 % for Crawford, for the two forementioned designs in the same order. Consequently, it could be concluded that although lattice square designs resulted in the highest relative precision for soybean, different cultivars reacted differently where lattice square of 3 x 3 and 5 x 5 resulted in the highest relative precision values for Crawford and Cutler, respectively.

The results revealed that the optimum sample sizes for Cutler cultivar were 9, 3, 24, 15 and 21 plants for plant height, number of branches/plant, number of pods/plant, seed index and seed yield/plant, respectively. Similar results were obtained for Crawford except for number of branches/plant and seed yield/plant in which 6 and 24 plants were the optimum, respectively.

INTRODUCTION

In uniformity trials, field experiment is usually planted with a single variety replicated in several basic units in order to find out the major field plot technique. It is also very important to secure information as much as possible from the use of small plot size in order to minimize the experimental error. Recently, considerable interest has been focused on the use of different types of incomplete block design.

Block designs have a long tradition in agriculture field trials. Treatments are then compared within blocks and variation between blocks is simply eliminated. With many treatments, as may be the case in variety trials, blocks become very large, the variation between plots within blocks increases and the efficiency in comparing treatments suffers. Therefore, agronomists started to use smaller blocks, not containing all treatments, in balanced incomplete block designs and also in square and rectangular lattice designs (Seeger and Kjeller, 1988).

Incomplete block designs were introduced by Yates (1936) as an improvement over randomized complete blocks. The value of lattice designs stems largely from the following properties: (i) orthogonal sets of Varietal contrasts are confounded with blocks in different superblocks; (ii) the designs are resolvable, i.e. the blocks of each superblock constitute a complete replication (Patterson *et al*, 1987). (iii) data from lattice experiments may be analyzed either as lattice or as randomized complete blocks, so that a measure of their relative efficiency is possible (Cochran and Cox, 1957).

The efficiency of lattice designs was investigated by (Saad, 1994 in wheat; Barreto *et al,* 1996 in maize; Yau, 1997 in barley and wheat and El-Deeb, 1999 in sesame).

Sampling technique are practiced to secure representative samples which gives precise estimates for different characteristics of a given population. Accordingly, all data depended on the validity of these samples. Increase in sample size reduce coefficient of variation, but rate of reduction varied depending on the parameter considered (Hamid and Aftabuzzaman, 1989). It should be avoided to make the sample so small that the estimate may be inaccurate to be useful (Gai, 1995; Goth, 1997 and El-Deeb, 1999).

The objective of this study was to obtain estimates of the expected relative precision of certain incomplete block designs, i.e. simple lattice, triple lattice, lattice square and balanced lattice designs in comparison with the randomized complete blocks deigns while assuming different number of entries (or treatments). Also, to estimate the optimum size of a random sample for determination of seed yield/plant and some seed yield components of two soybean cultivars.

MATERIALS AND METHODS

Two field experiments were carried out for two consecutive seasons (1998 and 1999), at the Agriculture Experiment and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt.

The first experiment aimed to estimate the relative precision of incomplete block designs in comparison with the randomized complete blocks design. To satisfy this objective, two soybean cultivars (Cutler and Crawford) were planted in two separate uniformity trials during 1998 and 1999 seasons. Each uniformity trial consisted of 400 ridges, each was 3 m long and 0.6 m wide, as a basic units. Seeds were sown on May 22 and 26 in 1998 and 1999, respectively in hills 10 cm apart within the ridge. Seedlings were thinned to two plants/hill after 20 days from sowing. Normal cultural practices were applied.

Seed yield of each basic unit (1.8 m2) was recorded in grams. Weight values from adjacent basic units were combined to obtain all possible combinations desired for this study. A plot size of five basic units was used. In each trial, 97 tests for the incomplete block designs were superimposed on the experimental area. For three of incomplete block designs simple lattice, triple lattice and lattice square, 9 and 25 treatments were assumed. Regarding to the balanced lattice designs, 9 treatments were only assumed.

Error variance were estimated and compared according to Gomez and Gomez (1984). They reported that the analysis of variance appropriate for uniformity trial data is as follows:

S.V.	d.f.	M.S.
Replication	r-1	
Block in replications	r (k-1)	E_b
Error	rk (k-1)	E_e
Total	rk^2-1	

Where:
E_b = inter block mean square
E_e = intra block or error mean square
r = number of replications
k = number of incomplete blocks in the replicate.

The form of the analysis of variance table, when Lattice square was compared with randomized complete blocks design, is as follows:

S.V.	d.f.	M.S.
Replications	r-1	
Rows	r (k-1)	E_r
Columns	r (k-1)	E_c
Error	r $(k-1)^2$	E_e
Total	rk^2 -1	

Where:
E_r = rows error mean square
E_b = columns error mean square
E_e = error mean square

Because no treatment effects are presented in uniformity trial, the analysis of variance was reduced to each of the above forms. For the same reason, the inter-block sum of square (in the first form) does not require an adjustment for treatment effects, and therefore, estimation of E_b is fully efficient.

The effective error mean squares for the simple, triple, balanced lattice and lattice square designs are as follows:

Simple lattice (2 replicates) = E_e [1 + (2/k+1) ((E_b – E_e)/ (E_b + E_e))]
Triple lattice (3 replicates) = E_e [1 + (3/k+1) ((E_b – E_e)/ (E_b + E_e))]
Balanced lattice = E_e [1 + ((E_b – E_e)/ (kE_b + E_e))]
Lattice square = E_e [1 + (½ (/E_r-E_e) / (E_e + ½ (k-1)E_r))]

The error mean square of randomized complete blocks design was estimated by adding the intra-and the inter-block sum of squares, in simple, triple and balanced lattice whereas, in the case of lattice square sum of squares for rows, columns and error were added and then divided by their pooled degrees of freedom.

Values of relative efficiency were calculated by dividing the error mean square for the randomized complete blocks design by the effective error mean square of the performed lattice design multiplied by 100.

The second experiment aimed to estimate the optimum sample size for determining seed yield/plant and some yield components i.e. plant height, number of branches/plant, number of pods/plant and seed index (100-seed weight). Thus, two experiments were carried out during 1998 and 1999.

A split-plot design with four replications was used. Cultivars (Cutler and Crawford) were assigned to main plot, however, sample sizes (3, 6, 9, 12, 15, 18, 21, 24, 27, 30 plants and the whole plot sample) assigned to sub-plot. The whole plot sample consisted of all plants in the ten inner ridges, which are considered as a control. Each plot contained 14 ridges, 3 m long and 0.6 m wide. Sowing date and all agriculture practices were done as in the first experiment of this study.

At harvest, in order to discard the border effects plants of the outer two ridges and two hills from each end of the ridges were discarded. Seed yield/plant and some yield components were estimated for each sample.

Data were statistically analyzed by analysis of variance for split-plot design according to procedures obtained by Snedecor and Cochran (1980). Combined analysis was conducted for data in both seasons. Duncan's Multiple Range Test was applied to compare sample means.

RESULTS AND DISCUSSIONS

1- Relative precision of incomplete block designs.

The results of four uniformity trials for Cutler and Crawford cultivars were used to study the efficiency of incomplete block designs i.e. simple lattice, triple lattice, lattice square and balanced lattice, relative to randomized complete block design. For Cutler cultivar (Table 1), the results indicated higher value of relative precision ranging from 100.12 to 156.97 % with an average 129.76 % in 1998 season and from 100.17 to 175.29 % with an average 135.91 % in 1999 season. On the average of both seasons, relative precision of 3 x 3 lattices were 114.47, 126.26, 147.12 and 110.95 % for simple lattice, triple lattice, lattice square and balanced lattice, respectively. with an average of 124.79 %. However, for 5 x 5 lattices it was 145.43, 139.26 and 167.89 % for simple lattice, triple lattice and lattice square, respectively with an average of 150.86 %.

Taking the average of both seasons for each design over all arrangements (3 x 3 and 5 x 5) the relative precisions were 129.95, 132.94, 157.51 and 110.95 % for simple lattice, triple lattice, lattice square and balanced lattice, respectively with an average of 132.84 %. It is then clear that lattice square was the most favourable design for Cutler uniformity trial.

The relative precisions of incomplete block designs over randomized complete blocks design were also reported by Abd El-Mohsen, 1992; Uzik and Zofajova, 1992, Lin *et al,* 1993 and Yau, 1997.

Since the balanced incomplete block designs require more replications than the unbalanced incomplete block, it is not valid to compare them directly on the basis of their relative precision. Hence, valid comparisons should be done between designs for the equal numbers of entries and replications at the same field. Consequently, for 25 entries in 3 replications lattice square and triple lattice could be compared. The average relative precision of the lattice square was 167.89 % (average of both seasons) as compared to 139.26 % for triple lattice. A difference of 28.63 % in favour of the Lattice square was obtained. Also, the average relative precision in 28 tests for lattice square with nine entries (3 x 3) and two replications was 147.12 % as compared to 114.47 % for simple lattice, reflecting a difference of 32.65 % in favour of the lattice square. However, relative precision was in favour of 25 entries in 3 replications than 9 entries in two replications. The foregoing comparisons ensured that lattice square design was apparently more effective than triple and simple lattice designs in reducing the experimental error to an adequate extend. These results are in agreement with those obtained by El-Rassas, 1982 and Taha, 1983. However, El-Deeb, 1999 reported that the highest estimates of relative precision were detected with simple lattice.

Table 1: Relative precision of the incomplete block design in comparison with randomized complete block design for Cutler uniformity trials in 1998 and 1999 seasons.

Type of design	No.of		1998		1999		Av. of two seasons
	Replica-Tion	Tests	Relative precision		Relative precision		
			Range	Av.	Range	Av.	
Simple lattice							
3 x 3	2	28	103.47-137.24	115.59	102.28-140.29	113.35	114.47
5 x 5	2	3	101.36-154.87	140.65	120.28-184.23	150.21	145.43
Average				128.12		131.78	129.95
Triple lattice							
3 x 3	3	21	100.12-148.24	124.37	100.17-168.25	128.87	126.62
5 x 5	3	1		137.94		140.57	139.26
Average				131.16		134.72	132.94
Lattice square							
3 x 3	2	28	112.51-156.97	141.67	113.48-175.29	152.57	147.12
5 x 5	3	1		159.21		176.57	167.89
Average				150.44		164.57	157.51
Balanced lattice							
3 x 3	4	15	101.24-112.25	109.32	100.24-119.91	112.58	110.95
5 x 5							
Average				109.32		112.58	110.95
Grand average				129.76		135.91	132.84
Total number of tests		97					
Average relative precision for all types of incomplete block design							
3 x 3				122.74		126.84	124.79
5 x 5				145.93		155.78	150.86

***Replicates sizes were 9 x 9 m^2 for 3 x 3 and 15 x 15 m^2 for 5 x 5 arrangement.**

Results on Crawford uniformity trial presented in Table 2. Distinct values of relative precision was observed for 97 tests ranging from 104.21 to 181.29% with an average of 135.25 % for 1998 season and 105.59 to 179.91 % with an average of 138.89 % for 1999 season. Differences in relative precision were greater for (3 x 3) arrangements in both seasons (126.68 to 162.39 % in 1998 and 130.11 to 169.87 %) in 1999 than for (5 x 5) arrangements (125.40 to 141.28 in 1998 and 121.39 to 149.61 % in 1999). In both seasons, regardless of type of arrangements, lattice square resulted in the highest relative precision values (151.84 in 1998 and 159.74 in 1999).

Also, combined results over seasons confirmed that lattice square over all arrangements (relative precision = 155.79) could be the favourable design.

For Crawford balanced incomplete block design, the Lattice square is compared with triple lattice for 25 entries in 3 replications (one test) and with simple lattice for 9 entries in two replications (28 tests). These comparisons were in favour of lattice square.

The results also indicated obviously the higher relative precision of lattices for Cutler experiment with 25 entries, when dimension of replicates was 15 m in length and 15 m in width (Table 1). However, it was for Crawford experiment with 9 entries, when dimension of replicates was 9 m x 9 m (Table 2). The differences between results could be attributed to the difference in soybean cultivar used, environmental factors, and/or to number of performed comparisons.

Generally, the results indicated that the lattice square design was the most favourable design for soybean uniformity trial. It was more effective than simple, triple and balanced lattices in reducing the experimental error.

Table 2:Relative precision of the incomplete block design in comparison with randomized complete block design for Crawford uniformity trials in 1998 and 1999 seasons.

Type of design	No.of		1998		1999		Av. of two seasons
	Replica-tion	Tests	Relative precision		Relative precision		
			Range	Av.	Range	Av.	
Simple lattice							
3 x 3	2	28	107.85-142.25	130.25	119.27-161.28	138.67	134.46
5 x 5	2	3	109.54-142.23	125.40	112.25-131.28	121.39	123.40
Average				127.83		130.03	128.93
Triple lattice							
3 x 3	3	21	112.39-154.68	138.95	108.84-148.69	142.64	140.80
5 x 5	3	1		130.28		128.75	129.52
Average				134.62		135.70	135.16
Lattice square							
3 x 3	2	28	109.25-181.29	162.39	114.28-179.91	169.87	166.13
5 x 5	3	1		141.28		149.61	145.45
Average				151.84		159.74	155.79
Balanced lattice							
3 x 3 5 x 5	4	15	104.21-139.83	126.68	105.59-141.27	130.11	128.40
Average				126.68		130.11	128.40
Grand average				135.24		138.89	137.07
Total number of tests		97					
Average relative precision for all types of incomplete block design							
3 x 3				139.57		145.32	142.45
5 x 5				132.32		133.25	132.79

***Replicates sizes were 9 x 9 m^2 for 3 x 3 and 15 x 15 m^2 for 5 x 5 arrangement.**

2. Optimum sample size:

The results of the combined analysis (Table 3) revealed significant effect for years (seasons) only on seed yield/plant. Highly significant differences among cultivars were obtained for all measured traits (plant height. Number of branches/plant, number of pods/plant, seed index and seed yield/plant). Plants of Cutler were significantly taller (90.37) than

Crawford (Table 4). However, plants of Crawford produced significantly higher number of branches/plant (2.16), number of pods/plant (70.6), seed index (16.04) and higher seed yield/plant (15.43). The combined analysis (Table 3) indicated that sample size had a highly significant effect on seed yield/plant and its components. Comparing the sample sizes with the whole plot sample (control) over seasons and cultivars (Table 4) indicated that the optimum sample sizes were 9, 6, 24, 15 and 24 plants for plant height, number of branches/plant, number of pods/plant, seed index and seed yield/plant, respectively.

Table 3: Significance of mean squares of combined analysis over years, cultivars and sample size for the studied traits..

Source of variation	df	Plant height	No.of branches/plant	No. of pods/plant	Seed index	Seed yield/plant
Years	1	81.37	0.19	193.45	0.31	16.06**
Rep. (year)	6	30.77	0.17	31.20	0.50	0.35
Cultivars	1	232.29**	6.08**	9750.27**	131.38**	115.62**
Years x cultivars	1	27.41	0.12	38.30	0.69	0.06
Error	6	15.80	0.09	38.27	0.96	2.40
Sample size	10	190.14**	0.02**	336.02**	52.25**	190.86**
Years x sample sizes	10	36.76	0.01	17.80**	0.6**	1.49**
Cultivars x sample sizes	10	29.85	0.01	4.67	1.15**	5.97**
Years x cultivars x sample	10	22.79	0.01	18.33**	0.12	1.14**
Error	120	26.82	0.01	4.68	0.11	0.36
Total	175					

***, ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 4: Average of seed yield/plant and some seed yield components as affected by cultivars and sample size.

Cultivars	Plant height	No.of branches/plant	No .of pods/plant	Seed index	Seed yield/plant
Cutler	90.37	1.97	55.71	14.31	13.81
Crawford	88.07	2.16	70.60	16.04	15.43
F-test	**	**	**	**	**
Sample sizes					
3 plants	82.22 d	1.89 b	56.86 g	11.84 e	9.95 g
6 plants	83.64 cd	1.95 ab	57.97 fg	12.67 d	10.80 f
9 plants	89.47 ab	1.96 ab	58.96 ef	13.45 c	11.42 e
12 plants	90.12 ab	1.96 ab	59.90 de	14.01 b	11.83 e
15 plants	86.90 bc	2.00 a	60.99 cd	16.40 a	12.76 d
18 plants	90.88 a	2.00 a	62.18 c	16.41 a	13.61 c
21 plants	91.12 a	2.00 a	64.48 b	16.52 a	17.55 b
24 plants	91.47 a	2.00 a	68.45 a	16.38 a	18.04 a
27 plants	91.79 a	2.00 a	68.39 a	16.45 a	18.26 a
30 plants	91.86 a	2.00 a	68.34 a	16.42 a	18.29 a
whole plants	91.97 a	2.00 a	68.22 a	16.40 a	18.28 a
F-test	**	**	**	**	**

In each column, means having the same latter are not significantly different at 0.05 level of probability.

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Mean square from combined analysis (Table 3) indicated that years x sample size interaction had significant effect on number of pods/plant, seed index and seed yield/plant. However, cultivar x sample size interaction was significant for seed yield/plant and one of its components i.e. seed index. Meanwhile, years x cultivars x sample size interaction was significant for number of branches/plant and seed yield/plant.

Average of seed yield/plant and some yield components as affected by the interaction between cultivars and sample size are presented in Table 5. Significant differences between the whole plot sample (control) and the other sample sizes in plant height extended to the second sample size (6 plants) for both cultivars, revealing that 9 plants could be consider as optimum sample size to estimate the plant height. No significant differences were found for number of branches/plant in Cutler cultivar. However, the differences extended only to the first sample size for Crawford. Thus, 3 and 6 plants could be recommended as optimum sample size for number of branches/plant for Cutler and Crawford, respectively.

Regarding to number of pods/plants and seed index, results indicated that the optimum sample size were 24 and 15 in the same order for both cultivars. Comparing the sample sizes versus the control showed that 21 and 24 plants were optimum to estimate seed yield/plant for Cutler and Crawford, respectively. Similar results were obtained by Gai (1995), Goth (1997) and El-Deeb (1999).

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الكفاءة النسبية لبعض تصميمات القطاعات غير الكاملة فى تجارب التجانس لفول الصويا والحجم الأمثل للعينة

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تهدف هذه الدراسة لتقدير الكفاءة النسبية لبعض تصميمات القطاعات غير الكاملة (الشبكى البسيط-الشبكي الثلاثى- المربع الشبكى- الشبكى المتزن) بالمقارنة بتصميم القطاعات كاملة العشوائية وذلك لمحصول فول الصويا. ولتحقيق هذا الهدف نفذت أربعة تجارب تجانس فى محطة التجارب بكلية الزراعة-جامعة القاهرة فى موسمى 1998، 1999 واستخدم فى كلا الموسمين الصنفين كتلر وكراو فورد. كذلك أجريت تجربتين منفصلتين فى نفس الموسمين وباستخدام نفس الصنفين وذلك لتقدير الحجم الأمثل للعينة لتقدير صفة المحصول/نبات وبعض مكونات المحصول. وقد وجد ان التصميمات الشبكية كانت اكثر كفاءة من تصميم القطاعات الكاملة حيث أن متوسط الموسمين تراوح من 110.95 % لآي 167.89 % للصنف كتلر ، من 123.40 % إلى 166.13% للصنف كراو فورد. كذلك أظهرت النتائج أن تصميم المربع الشبكى هو اكفأ تصميمات القطاعات غير الكاملة لاعداد المعاملات المختلفة حيث كانت الكفاءة النسبية للتصميم المربع الشبكى 3 x 3 ، 5 x 5 هى 147.12 % و167.89% للصنف كتلر، 166.13% و 145.45 % للصنف كراوفورد على التوالى. أيضا اختلفت كفاءة التصميمات المربعة الشبكية طبقا للأصناف حيث كان التصميم 3 3x هو الأكفأ للصنف كراوفورد والتصميم 5 x 5 هو الأكفأ للصنف كتلر. أظهرت النتائج أن الحجم الأمثل للعينة للصنف كتلر هو 9، 3، 24، 15، 21 نبات لصفات طول النبات، عدد الأفرع/نبات، عدد القرون/نبات، وزن 100 بذرة، محصول البذور/نبات. وتم الحصول على نفس النتائج للصنف كراو فورد فيما عدا صفتى عدد الأفرع/نبات ومحصول البذور/نبات حيث كان الحجم الأمثل للعينة هو 6، 24 نبات على التوالى.

Table 5: Average of seed yield/plant and some yield components as affected by the interaction between cultivars and sample size.

Cultivars	**Sample size (no. of plants)**										
	3	6	9	12	15	18	21	24	27	30	Whole plot
	Plant height										
Cutler	82.29 c	83.52 bc	90.70 a	91.25 a	91.93 a	91.43 a	91.60 a	92.47 a	92.84 a	92.97 a	93.08 a
Crawford	82.15 c	83.77 bc	88.25 ab	89.00 b	81.88 c	90.33 a	90.63 a	90.46 a	90.74 a	90.74 a	90.86 a
	No. of branches/plant										
Cutler	1.76 c	1.78 c	1.79 c	1.78 c	1.80 c	1.80 c	1.80 c	1.80 c	1.80 c	1.80 c	1.80 c
Crawford	2.03 b	2.12 ab	2.13 ab	2.14 ab	2.20 a	2.20 a	2.20 a	2.20 a	2.19 a	2.19 a	2.19 a
	No. of pods/plant										
Cutler	49.71 l	51.01 kl	52.03 jk	52.89 jk	53.89 ij	55.32 hi	56.76 h	60.31 g	60.23 g	60.40 g	60.22 g
Crawford	64.02 f	64.93 ef	65.89 def	66.92 cde	68.00 cd	69.03 c	72.20 b	76.57 a	76.54 a	76.28 a	76.23 a
	Seed index (1000-seed weight)										
Cutler	11.10 i	12.14 h	13.05 f	13.52 e	15.37 b	15.37 b	15.46 b	15.30 b	15.43 b	15.36 b	15.34 b
Crawford	12.57 g	13.20 ef	13.86 d	14.50 c	17.43 a	17.44 a	17.58 a	17.45 a	17.47 a	17.47 a	17.46 a
	Seed yield/plant (gm)										
Cutler	9.99 jk	10.57 ij	11.26 h	11.55 gh	12.26 f	12.94 e	16.24 c	16.69 c	16.81 c	16.80 c	16.79 c
Crawford	9.91 k	11.03 hi	11.59 gh	12.11 fg	13.26 e	14.29 d-g	18.85 b	19.39 ab	19.72 a	19.77 a	19.77 a

Within any trait, means having the same letter are not significantly different at 0.05 level of probability.