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Optimum Plot Size for Experiments on Sugarcane

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ABSTRACT

In 1983, a uniformity trial was carried out at the Sugarcane Research and Training Institute to determine the optimum size and shape of plots for use in sugarcane field experimentation. The results showed that, the coefficient of variation (cv) decreased with : 1. the increase of plot size, 2. a decrease in length of the plot along the row and at the same time, an increase in length of the plot across the row , 3. rectangular plots compared with square ones, and 4. square and nearly square blocks compared with rectangular ones. The coefficient of variation was found to be minimum for 38.4 sqm. to 115.2 sqm. sizes of plots but the optimum plot size was found to be 96. sqm. (12m x 8m). Coefficient of variation was found maximum for smaller plots compared to optimum (96 sqm) sized plots. In an experiment, smaller plots require a large number of replications compared to optimum ones for the same pecision.

INTRODUCTION

Different types of designs are used for field experimentation to obtain response to different treatments. Osman and Manshi (1970), Sreenath and Marwaha (1977), Reddy and Chetty (1983) observed that the afficiency of a design depends on the size and shape of plot and block. On the other hand, the size of plot and the number of replication required for an experiment vary from place to place, crop to crop and also depends on environmental conditions. To increase the efficiency, an optimum plot size, shape and required number of replications for an experiment are essential. A definite plot size for a particular crop is determined and used for experimental purposes in all the Agricultural Research Institutes of the world. Different scientists worked on different crops for determination of optimum plot size. The optimum plot size for sugarcane was found out by Osman and Manshi (1970) in Sudan, for mustard by Kaushik *et. al.* (1977) in India for rice by Katyal and Rajput (1978) in India and for tossa jute by Sasmal and Katyal (1980) in India.

In Bangladesh, no such work has been conducted as yet. As such, a uniformity trial was conducted to study an optimum plot size, and number of replications required per treatment to obtain statistically precise results, in all sugarcane field experiments.

Since the sensitivity of an experiment also depends on the number of replication, hence, for some particular size and shape of plots and size of blocks, it is necessary to know the number of replications and total area required per treatment to obtain a significant results between the treatment means.

MATERIALS AND METHODS

A uniformly grown sugarcane plot having Co. 1158 variety planted in 1982 crop season was taken for the experimental purpose at the Sugarcane Research and Training Institute farm. A net area of 0.432 sqm. standing cane from about one hectare crop was taken for the experiment. All recommended cane production practices were followed throughout the growing period of the crop. The crop was planted mechanically with row to row spacing of 1.20 m. The net area was composed of 60 m in length along the rows and 72 m. across the rows. Each 60m long row was divided in 30 equal sections each 2m. in length. These sections were then harvested by sickles and weights were recorded separately. Finally, the yield records of 1800 (30x60) ultimate units were obtained. The yields of adjacent plots were then combined to estimate the yields of different plot sizes and shapes.

The data were examined statistically for the study of :

1. the coefficient of variation (cv) of plot and block sizes and shapes
2. the effective number of replications and the total area required per treatment for specified accuracy
3. optimum plot size.

The coefficients of variation were calculated by the formula $\frac{s}{\bar{x}} \times 100$ where "s" is the standard deviation and "$\bar{x}$" the mean of the plot yield. The efficiencies of the blocks were obtained by the ratio of error variance before and after eliminating the differences due to blocks. If the ratio is greater than one, blocking is efficient. As the ratio decreases towards one, the abvantage due to blocking decreases (Kempthorne, 1973).

For the estimation of minimum number of replications, the table 2.1 of Cochran and Cox (1964) were used to detect a mean difference as small as 20% of the experimental mean for 90% probability of obtaining a significant result at 5% level.

The minimum area required per treatment were then obtained by the product of the number of replications and the corresponding plot size. The optimum plot size was determined by studying the variations of different sizes of plots for the same size and number of blocks.

RESULTS AND DISCUSSION

The variability of each plot size and shape was expressed in terms of coefficient of variation. As the size of plots increases in either direction, the coefficient of variation decreased (Table 1).

Table 1. Coefficient of variation for different plot sizes and shapes.

Length (m)	Width (m)							
	1.2	2.4	6.0	12.0	24.0	36.0	48.0	60.0
2	21.77	16.42	12.32	9.80	8.41	7.96	5.30	5.41
4	17.79	13.24	10.95	9.08	8.03	7.66	4.78	5.15
6	15.83	11.87	10.30	8.75	7.70	7.36	4.62	4.85
8	15.32	11.28	9.96	8.37	7.53	7.38	4.72	5.04
10	12.70	10.74	9.55	8.24	7.44	7.30	4.39	4.70
20	9.95	9.01	8.08	6.96	6.11	6.08	2.87	3.23
30	9.60	8.37	7.79	6.78	5.99	6.08	0.32	1.74
40	8.29	6.94	6.15	4.30	2.40	0.88	—	—
50	7.15	5.59	4.94	3.62	0.62	2.86	—	—

The coefficient of variation for 2.4 sq.m. (2mx1.2 m) plots was 21.77 but it decreased to less than 8.75 for plots sizes 72 sq.m. (6 m x 12 m) and above. Otherwise, for a constant size of plot, the c.v. decreased with the decrease in length along the row and simultaneously increased in length across the row (Table 2). Besides, the same is somewhat

Table 2. Coefficient of variation at different shape of plot.

Size sq.m.	Length (m)	Width (m)	C.V.	Size sq.m.	Length (m)	Width (m)	C.V.	Size sq.m.	Length (m)	Width (m)	C.V.
	2	18	9.56		2	60	5.41		6	48	4.62
36	6	6	10.30	120	4	30	6.89	288	8	36	7.38
	10	3.6	9.92		10	12	8.24		12	24	7.30
	2	24	8.41		20	6	8.08		16	18	8.35
	4	12	9.08		4	36	7.66		6	54	4.70
48	8	6	9.96	144	6	24	7.70	324	12	27	6.57
	2	36	7.96		8	18	8.71		27	12	6.83
	6	12	8.75		12	12	8.09		18	18	7.79
72	10	7.2	9.10		4	48	4.78		6	60	4.85
	12	6	9.33	192	8	24	7.53	360	12	30	6.20
	2	48	5.30		10	19.2	8.50		20	18	7.29
	4	24	8.03		16	12	7.87				
96	8	12	8.37		4	54	4.98				
	10	9.6	9.23		6	36	7.36				
	16	6	9.30	216	10	21.6	8.04				
					12	18	8.19				
					18	12	7.45				

higher for square plots than the rectangular one. The c.v. for the plot shape 2 m x 48 m (96 sq.m.) was only 5.30 but for the shape 16 m x 6 m (96 sq.m.) was 9.30. The coefficient of variation for the shapes 6m x 6m (36 sq.m.) and 18 m x 18 m (324 sq.m.) of the plots were 10.30 and 7.89, but for all other possible shapes of the plot sizes 36 sq.m. they were found to be less than 10.30 and 7.79.

When the Smith's equation (Smith, 1938) $Y = ax^{-b}$ where Y is the c.v. and x is the corresponding area were fitted to the data of rectangular and square plots, the coefficient of heterogeneity "b" was found to be 0.1681 for rectangular plots, and 0.1322 for square plots explaining 98% and 94% of the variability in c.v. by the plot area. So that the rate of reduction in c.v. was found to be more for rectangular plots. Hence, the rectangular plots were more efficient for use than the square ones. Keeping the plot size and shape constant, the block shape (Table 3) should be square or nearly square for efficient

Table 3. Coefficient of variation for different shape of block.

Plot size (in sq.m.)	Plot shape (mxm)	6 plots		9 plots		12 plots	
		Block shape (mxm)	C.V.	Block shape (mxm)	C.V.	Block shape (mxm)	C.V.
		2x7.2	20.16	2x10.8	20.61	2x14.4	20.57
2.4	2x1.2						
		4x3.6	19.94	6x3.6	19.96	6x4.8	19.94
		2x14.4	14.83	2x21.6	14.87	2x28.8	15.26
4.8	2x2.4						
		4x7.2	14.06	6x7.2	14.08	6x9.6	14.14
		2x28.8	12.01	2x43.2	12.21	2x57.6	12.51
9.6	2x4.8						
		6x9.6	10.08	6x14.4	10.96	12x9.6	10.42
		4x36	8.66	4x54	10.27	4x72	9.87
24	4x6						
		12x12	8.20	12x18	7.90	16x18	7.73
		4x72	7.86	36x12	7.54	48x12	8.37
48	4x12						
		12x24	6.17	12x36	6.48	16x36	6.17
		6x72	7.75	54x12	8.08	12x72	7.76
72	6x12						
		18x24	5.94	18x36	6.28	36x24	7.63
		8x72	7.12	—	—	48x24	8.38
96	8x12						
		16x36	5.41	—	—	32x36	8.34
		10x72	7.15	—	—	—	—
120	10x12						
		30x24	6.58	—	—	—	—

use of the block The c.v. for block shape 4m x 36 m was 8.66, but the same was 8.20 for the shape 12m x 2m of the block. Although, the block shape was nearly saquare, the efficiency of the blocks decreases with the increasing size of the block (Table 4). The efficiency was 2.47 for two ploted block whereas 1.13 for 15 ploted block. As long as the efficiency is greater than one, the blocking is efficient. The plot and block sizes for which effciency is less than one, it is not advantageous to use the block. For a plot size, say 96 sq.m. the block should not contain 10 or more than 10 plots.

Table 4. Efficiencies of blocks at variable plots.

Plot size (in Sq. m)	No. of plots in Blocks					
	2	4	6	10	15	20
2.4	1.16	1.18	1.16	1.12	1.14	1.10
4.8	1.40	1.30	1.22	1.20	1.28	1.21
9.6	1.70	1.78	1.56	1.44	1.35	1.35
16.8	1.87	1.89	1.98	1.86	1.44	1.37
36.0	2.66	1.83	2.02	1.39	1.42	1.05
48.0	2.19	2.36	2.02	1.37	1.27	
72.0	2.47	2.10	1.85	1.26	1.13	
96.0	2.33	2.50	1.89	0.88	0.50	
120.0	1.89	1.38	0.89	0.72	0.51	
144.0	1.34	1.07	0.75	0.75	0.52	
216.0	1.18	—	0.50	—	—	
288.0	0.82					

For constant size and number of block, the result (Table 5) indicated that, as the size of the plot was increased from 2.4 sq.m. to 144 sq.m., the c.v. decreased up to certain level and then was found to increase steadily. The c.v. was found to be smaller for

Table 5. Coefficient of variations for various plot sizes.

Plot		Replication		
Area sq.m.	Shape (in m.)	10*	15	18
2.4	2x1.2	18.33	16.73	15.56
4.8	2x2.4	10.20	10.60	10.10
12	2x6	7.50	7.34	7.16
24	4x6	5.95	6.14	6.24
38.4	4x9.6	5.43	5.52	5.42
50.4	6x8.4	5.15	4.66	4.62
72	6x12	4.63	4.39	4.51
96	8x12	4.15	3.74	3.54
115.2	8x14.4	4.88	4.34	4.37
120	10x12	6.03	6.11	6.36
132	10x13.2	7.82	6.58	
144	10x14.4	7.63	6.73	

*All through two-plotted blocks were considered.

the plot sizes from 38.4 sq.m. to 115.2 sq.m. But the minimum variation was obtained in plot size 96 sq.m. Hence the optimum plot size was 96 sq.m, with shape 8m x 12m.

Table 6. Figures indicate minimum number replications required per treatment. The figure in the parenthesis indicates area with all replication per treatment.

Plot		Block of plots											
Size sq. m.	Shape (in m x m)	2	4	5	6	7	8	10	12	14	15	16	20
2.4	2x1.2	22 (52.8)	22 (52.8)		22 (52.8)		22 (52.8)	22 (52.8)	24 (57.6)	24 (57.6)	24 (57.6)		24 (57.6)
28.8	4x7.2	5 (144.0)	5 (144.0)		5 (144.0)		5 (144.0)	6 (172.8)	7 (201.6)				7 (201.6)
48.0	4x12	3 (144.0)	3 (144.0)		3 (144.0)		3 (144.0)	5 (240.0)	5 (240.0)		5 (240.0)		7 (336.0)
72	4x18			3 (216)				4 (288)					5 (360)
	6x12	3 (216)		4 (288)	3 (216)		6 (432)		6 (432)	7 (504)		7 (504)	7 (504)
76.8	8x9.6			6 (460.8)			6 (460.8)					6 (460.8)	
86.4	6x14.4	3 (259.2)		4 (345.6)	4 (345.6)		5 (432)	5 (432)			6 (518.4)		8 (691.2)
	8x10.8	3 (259.2)	3 (259.2)	6 (518.4)		6 (518.4)		7 (604.8)		8 (691.2)			9 (777.6)
96	4x24			3 (288)		4 (384)					4 (384)		
	8x12	3 (288)		5 (480)		5 (480)		6 (576)		7 (672)	8 (768)		9 (864)
100.8	6x16.8			3 (302.4)	3 (302.4)			5 (504)					6 (604.8)
108	6x18			3 (324)	4 (432)				5 (540)				6 (648)
115.2	8x14.4	2 (230.4)		4 (460.8)	5 (576)				5 (576)	8 (921.6)	8 (921.6)	8 (921.6)	

Using the table 2.1 of Cochram and Cox (1964), the minimum number of replications and total area required per treatment were worked out (Table 6). The table 6 revealed that for smaller plots, a large number of replications were required for the same size of the block. As the plot size was increased from 2.4 sq.m. to 48.0 sq.m. the number of replications decreased from 22 to 5 for ten plots block. The experimental plot size should be optimum or around the optimum for efficient use of the plot and block (Table 4).

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