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Size and Shape of Plots for Wheat Yield Trials in Field Experiments

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ABSTRACT

The Lin and Binns (1984) method was studied alongwith a method based on residuals from randomized complete block design (RCBD). It has been observed from RCBD correlation (p), that the Lin and Binns method is not much helpful; whereas, the method based on residuals works quite well. The new proposed method based on residuals has also been studied posing completely randomized design for field experiments.

Key Words: RCBD; Residuals; Smith's law

INTRODUCTION

In any field experiment, one of the basic questions is the size of the plot alongwith the number of replications. Usually the plot size and number of replications are based on the previous experience of the experimenter or results of a uniformity trial conducted in that area used. Smith's (1938) law is used to calculate plot size from a uniformity trial, which is still unchallenged despite its lack of a theoretical basis (Pearce, 1976). Smith's law is as follows.

$$V_x = \frac{V_1}{x^b}$$

Where

V_x = the variance per basic unit of plots of size x units.
x = the number of basic units un the combined plot size.
V_1 = the variance among units of size one basic unit.
b = a measure of the degree of correlation between adjacent basic units or coefficient of heterogeneity.

Recently, Lin and Binns (1984) have given a method based on intrablock correlation from RCBD, which calculates the plot size and it alternative to the Smith's law in the absence of uniformity trial. Some studies regarding wheat plot size have been made using uniformity trial by Ashfaq and Yab (1974) and Ashaq *et al.* (1984).

We propose that the plot size can be calculated from the data of any CRD or RCBD with sufficient number of treatments and replications using their residuals. The purpose of this study is to calculate the plot size using residual method and Lin and Binns (1984) method and suggest some suitable plot sizes.

METHODOLOGY

We have collected the data sets on wheat from Univeristy of Agriculture, Faisalabad and Ayub Agricultural Research Institute, Faisalabad. There are 29 data sets of wheat with the characteristics measured, plant height (cm), grain yield (kg) and straw yield (kg)

Following two methods are applied on the data sets to calculate the index of heterogeneity 'b' and ultimately the plot size under different situations. To apply these methods, it is necessary to conduct the uniformity trials, which are expensive and time consuming.

The first method is due to Lin and Binns (1984) where they have described the calculations of plot size through the four steps.

The second method makes use of the smith's empirical relation (1). The value of 'b' is estimated through uniformity trial but here we use the adjusted Yij's of RCBD instead of uniformity trials and the following steps are required to compute the optimum plot size.

Step 1

The adjusted Yij's are calculated as follows:

The model for RCBD is

$$Y_{ij} = \mu + \beta_j + \tau_i + \epsilon_{ij} \quad (2)$$

and

$$\epsilon_{ij} = Y_{ij} - \mu - \beta_j - \tau_i \quad (3)$$

Adjusted Yij = func Y bar G + eij

where Yij = The observation in the ith treatment and jth block; μ = Overall mean; Y bar G is overall mean, the estimate of μ, βj = the jth block effect, τi = the ith treatment effect, and Єij = the error term or residual; eij is the estimate of Єij.

It seems sensible to get the adjusted values without subtracting the block effects since blocks are formed to remove the effect of soil variability. Thus, the adjusted Yij is: Adjusted Yij = func Y barG + e'ij or

Adjusted Yij = func Y barG + Yij - func T bar_i

Here e'ij = Yij - func T bar_i (func T bar_i is the mean of the ith treatment)

Step 2

Using the adjusted Yij 's calculated in step 1 we calculate the variance V_x among plots of all possible sizes and shapes that fit exactly within all the basic units. First the variance $V_{(x)}$ is calculated for the set of values as:

$$V_{(x)} = \frac{\sum (Y_i - Y\,bar)^2}{n - 1} \quad (4)$$

we will denote $V_{(x)}$ by s^2 .

Then V_x is computed as the variance ($V_{(x)}$) divided by the square of the size in basic units. i .e .

$$V_x = \frac{V_{(x)}}{X^2} \quad (5)$$

The coefficient of variation is also calculated as:

$$CV = \frac{\sqrt{V(\text{x})}}{Y\ bar} \times 100 \quad (6)$$

The plot of CV versus plot size (X) can be drawn to verify the Smith ' s empirical relation (1) .

Step 3

Taking logarithm of equation (1) we get

$$\log V_x = \log V_i - b \log X$$

where, 'b' is the slope of slope of a line in the form Y=a+bX, therefore, we can obtain Smith's 'b' as the slope of the linear regression between log V_x and X .

The index of soil heterogeneity 'b' is simply the regression coefficient of the logarithm of the plot variance on a per unit basis, on the logarithm of the number of basic units. The value of 'b' varies between plus and minus infinity. A value close to zero indicates very uniform field or the neighbouring plots are highly correlated while its value near '1' would indicate a very heterogeneous field or the neighbouring are almost uncorrelated. The value of 'b' obtained this way has come under some criticism because in a uniformity trial there are different number of plots for the different plot sizes uniformity the trial the area. Since different number of units will give different confidence (as degrees of freedom) to the estimate of the variance among plots therefore, Federer (1955) suggested the need to obtain a weighted estimate of variance in which the weights were the degrees of freedom (number of units of size X minus one) used in calculating the variance. The formula for calculating 'b' by weighted least square is:

$$b = \frac{\sum(W_i \log V_x \log X_i) - \dfrac{(\sum W_i \log V_x)(\sum W_i \log X_i)}{\sum W_i}}{\sum W_i (\log X_i)^2 - \dfrac{(\sum W_i \log X_i)^2}{\sum W_i}} \quad (7)$$

Step 4. Whatever method used to calculate 'b' we must proceed to determine the optimum plot size. In smith's method, it is necessary to; have some estimates for variable and fixed costs incurred in conducting a trial. Since many of these cost estimates are hard to come by, Hatheway (1961) provides a formula that allows the calculation of the number of replications and plot size required to detect a statistical difference of a specified magnitude, irrespective of costs. Such a formula makes use of the 'b' index, the measured coefficient of variability for the smallest plot size used in the experiment, the proposed number of replications to be used in the trial, and the values for the desired statistical difference to be detected. Hatheway (1961) modified the formula by Cochran and Cox (1957) and come up with the following formula:

$$Xb = \frac{2(t_1 + t_2)^2\, CV^2}{r\, d^2}$$

where X is plot size in basic units, 'b' is the soil heterogeneity index, VC is the coefficient of variability for plot size of one basic unit, 'd' is the true statistical difference that is desired to be detected (expressed as a percent of the mean), t_1 is the tabulated 't' value for 5% probability and the number of degrees of freedom in the experiment to be conducted, t_2 is the tabulated t value corresponding to 2(1-p) where 'p' is the probability of obtaining a significant result.

RESULTS

The results obtained are given in the following tables and paragraphs The results indicate that the plot size using Lin and Binns (1984) method (Method I) is usually higher than the plot size calculated by residual method (Method II) and the required plot size is almost always smaller than the current plot size.

The relationship between the required plot size calculated by both the methods is almost linear. It should be noted that the residual method can only be applied when the number of replications is even. In case the number of treatments or blocks is odd, one treatment and /or block can be ignored to make the number of blocks and treatments even. One thing is quite clear that it is difficult to recommend a single specific plot size for all future experiments of the same crop because the two methods give different plot sizes and also all the experiments conducted for grain yield result in different plot sizes. However the required plot size calculated can be used for the same type of experiment in the next year in a certain place. It is also apparent from the calculations on the characteristics wheat plant height and wheat straw yield that the different characters to be studied require different plot sizes. These results are in agreement with Hallauer (1964) who concluded that different values of b are obtained using the different uniformity trials so there would be different plot sizes for the same crop.

For method I, the plot size becomes very small when the value of b is small or □ is large. So this method is not helpful to calculate plot size in these situations. Also when blocks are not effective, the □ becomes negative and we cannot estimate required plot size.

Shape of plots

The coefficient of variations (CV's) were calculated for the experiments on wheat crop with all plot sizes in basic

Estimation of required plot size by method I
Wheat grain yield

No.	CPS	CV	Δ	b	Required plot size (at desired CV)					
					5%	10%	15%	20%	25%	30%
1	12.6	3.88	0.040	0.865	7.025	1.417	0.555	0.285	0.170	0.112
2	12.6	4.42	0.015	0.942	9.695	2.226	0.941	0.511	0.318	0.216
3	12.6	4.65	0.547	0.215	6.463	0.010	0.000	0.000	0.000	0.000*
4	12.5	2.20	0.054	0.844	1.788	0.346	0.132	0.067	0.039	0.025
5	24.0	7.22	0.301	0.487	108.6	6.317	1.195	0.367	0.146	0.069
6	43.2	6.00	0.398	0.388	110.4	3.114	0.386	0.087	0.027	0.010
7	9.0	9.55	-ve							
8	14.6	2.85	0.833	0.075	0.000	0.000	0.000	0.000	0.000	0.000*
9	12.0	12.24	0.001	0.994	72.70	18.03	7.981	4.475	2.857	1.980
10	50.6	12.17	-ve							
11	23.4	7.84	-ve							
12	21.0	7.01	0.169	0.624	62.07	6.740	1.839	0.731	0.358	0.199
13	21.0	7.05	-ve							
14	33.4	3.00	-ve							
15	50.0	5.35	0.215	0.557	63.62	5.291	1.235	0.440	0.197	0.102
16	50.0	9.03	0.168	0.625	331.3	36.14	9.889	3.942	1.932	1.078
17	33.4	6.43	-ve							
18	36.8	2.92	0.290	0.499	4.263	0.265	0.052	0.016	0.006	0.003
19	24.0	7.22	0.300	0.488	108.3	6.336	1.204	0.370	0.148	0.070
20	15.0	5.76	-ve							
21	15.0	11.76	-ve							
22	12.6	3.88	0.040	0.865	7.025	1.417	0.555	0.285	0.170	0.112
23	27.3	7.06	-ve							
24	30.0	10.89	0.477	0.293	6037.	53.75	3.396	0.478	0.104	0.030
25	52.7	10.17	-ve							
26	9.0	7.40	0.128	0.667	29.10	3.643	1.080	0.456	0.233	0.135
27	50.4	3.96	-ve							
28	12.6	4.61	-ve							
29	32.4	3.77	0.160	0.670	13.95	1.767	0.527	0.223	0.115	0.066

* indicates close to zero plot size, which are not practically feasible; where CPS = current plot size; and -ve indicates the negative value of Δ; RSP(%) = the required plot size at 5% desired CV, similarly RPS(10%), RPS(15%), RPS(20%), RPS(25%) and RPS(30%) represent the required plot sizes at 10%, 15%, 20%, 25% and 30% respectively.

Estimation of required plot size by method II
Wheat grain yield (RCBD)

No.	b	CV1	Required plot size for P = 70%				Required plot size for P = 80%				Required plot size for P = 90%			
			d=15	d=20	d=25	d=30	d=15	d=20	d=25	d=30	d=15	d=20	d=25	d=30
1.00	1.94	3.24	4.80	3.59	2.85	2.36	5.45	4.05	3.22	2.67	6.34	4.71	3.71	3.10
2.00	2.07	3.68	5.80	4.39	3.54	2.96	6.50	4.92	3.96	3.32	7.49	5.67	4.57	3.83
3.00	0.74	3.90	1.70	0.77	0.42	0.26	2.29	1.06	0.58	0.35	3.40	1.57	0.86	0.53
4.00	1.50	2.53	2.60	1.81	1.34	1.05	3.10	2.11	1.57	1.23	3.77	2.57	1.91	1.50
5.00	2.13	5.84	17.90	13.70	11.11	9.37	20.03	15.29	12.40	10.45	22.99	17.55	14.23	11.99
6.00	1.08	4.84	17.30	10.14	6.72	4.80	21.43	12.59	8.34	5.95	28.12	16.52	10.93	7.81
7.00	2.79	7.85	8.80	7.15	6.09	5.35	9.56	7.78	6.63	5.82	10.61	8.64	7.36	6.46
8.00	1.80	2.35	3.70	2.67	2.09	1.71	4.19	3.05	2.38	1.94	4.94	3.59	2.80	2.29
9.00	0.94	10.40	19.00	10.31	6.42	4.35	24.40	13.23	8.23	5.59	32.57	17.66	10.98	7.46
10.00	1.40	10.25	68.00	45.22	32.85	25.30	80.97	53.62	38.95	30.00	99.84	66.12	48.03	36.99
11.00	2.24	6.33	19.10	14.76	12.09	10.28	21.18	16.38	13.42	11.41	24.15	18.68	15.30	13.01
12.00	0.99	5.78	10.50	5.90	3.76	2.60	13.38	7.48	4.77	3.30	17.99	10.06	6.41	4.44
13.00	0.72	5.81	8.20	3.69	1.98	1.19	11.44	5.13	2.75	1.66	17.21	7.72	4.14	2.49
14.00	0.91	2.42	2.40	1.28	0.78	0.52	3.12	1.65	1.01	0.68	4.32	2.29	1.40	0.93

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No.	b	CV1	Required plot size for P = 70%				Required plot size for P = 80%				Required plot size for P = 90%			
			d=15	d=20	d=25	d=30	d=15	d=20	d=25	d=30	d=15	d=20	d=25	d=30
15.00	2.21	4.40	28.70	22.15	18.10	15.35	31.97	24.64	20.14	17.07	42.02	23.83	15.34	10.71
16.00	1.01	7.44	42.00	23.83	15.34	10.71	53.01	30.06	19.36	13.51	70.78	40.14	25.85	18.04
17.00	1.74	5.19	20.50	14.69	11.36	9.21	23.41	16.81	13.00	10.54	27.73	19.91	15.40	12.48
18.00	1.57	2.36	7.80	5.45	4.10	3.25	9.11	6.32	4.76	3.78	10.97	7.61	5.74	4.55
19.00	2.13	5.83	17.90	13.67	11.08	9.34	20.00	15.26	12.37	10.42	22.97	17.52	14.20	11.96
20.00	2.27	4.65	9.30	7.26	5.96	5.08	10.36	8.04	6.61	5.63	11.79	9.16	7.52	6.41
21.00	0.94	9.51	26.30	14.27	8.89	6.03	33.69	18.29	11.38	7.73	46.03	24.98	15.55	10.56
22.00	1.94	3.24	4.80	3.59	2.85	2.37	5.46	4.06	3.22	2.67	6.34	4.72	3.75	3.11
23.00	2.30	5.83	20.50	15.96	13.15	11.22	22.70	17.68	14.56	12.43	25.78	20.08	16.54	14.12
24.00	0.86	8.95	37.60	19.23	11.44	7.48	49.46	25.31	15.05	9.85	69.59	35.61	21.18	13.85
25.00	1.80	8.37	54.50	39.55	30.86	25.20	62.08	45.09	35.18	28.73	73.08	53.07	41.41	33.81
26.00	1.57	6.16	6.20	4.31	3.24	2.57	7.24	5.02	3.77	2.99	8.73	6.05	4.55	3.60
27.00	3.99	3.26	31.90	27.60	24.68	22.53	33.82	29.28	26.19	23.90	36.40	31.51	28.18	25.72
28.00	2.04	3.83	6.00	4.50	3.62	3.02	6.70	5.05	4.06	3.40	7.73	5.83	4.69	3.92
29.00	1.10	3.04	5.70	3.37	2.25	1.62	7.02	4.17	2.78	2.00	9.16	5.44	3.63	2.61

b = the index of heterogeneity; CV1 = the coefficient of variation for one basic unit; d=15' = the true statistical difference of 15% from the mean, similarly 'd=20'; 'd=25' and 'd=30' represent the true statistical differences of 20%,25% and 30% from the mean respectively.

Wheat grain yield (CRD)

No.	b	CV1	Required plot size for P = 70%				Required plot size for P = 80%				Required plot size for P = 90%			
			d=15	d=20	d=25	d=30	d=15	d=20	d=25	d=30	d=15	d=20	d=25	d=30
1	0.77	3.48	1.33	0.63	0.35	0.22	1.81	0.86	0.48	0.30	2.66	1.26	0.70	0.44
2	0.81	3.91	2.02	0.99	0.58	0.37	2.70	1.33	0.77	0.49	3.86	1.91	1.10	0.70
3	0.23	6.05	0.83	0.07	0.01	0.00	2.31	0.19	0.03	0.01	8.17	0.68	0.10	0.02
4	1.05	2.78	1.60	0.92	0.60	0.43	2.00	1.15	0.75	0.53	2.59	1.50	0.98	0.69
5	1.66	7.65	22.56	15.94	12.18	9.78	25.99	18.37	14.03	11.26	31.02	21.92	16.75	13.44
6	0.33	6.84	16.19	2.86	0.74	0.25	32.87	5.80	1.51	0.50	79.65	14.05	3.66	1.22
7	1.68	8.05	8.84	6.27	4.81	3.87	10.17	7.21	5.53	4.45	11.95	8.48	6.50	5.23
8	0.22	6.16	1.11	0.08	0.01	0.00	3.24	0.23	0.03	0.01	11.19	0.81	0.11	0.02
9	0.85	10.76	22.72	11.52	6.80	4.42	30.05	15.23	8.99	5.85	42.46	21.53	12.71	8.26
11	1.90	6.55	18.85	13.94	11.02	9.10	21.33	15.76	12.47	10.30	24.88	18.39	14.55	12.01
12	0.58	6.77	11.01	4.08	1.89	1.01	16.49	6.11	2.83	1.51	26.36	9.76	4.52	2.41
13	0.67	6.18	9.12	3.85	1.97	1.14	12.96	5.47	2.80	1.62	19.47	8.22	4.21	2.44
14	0.96	2.50	2.89	1.58	0.99	0.68	3.70	2.03	1.27	0.87	5.03	2.76	1.73	1.18
15	0.62	5.31	12.51	4.95	2.41	1.34	18.26	7.22	3.51	1.95	28.29	11.18	5.44	3.02
16	0.68	8.72	60.52	26.10	13.59	7.97	85.24	36.75	19.14	11.23	126.70	54.66	28.01	14.91
17	1.27	5.58	18.37	11.90	8.36	6.24	22.55	14.32	10.07	7.55	28.43	18.05	12.69	9.52
18	0.81	3.07	3.40	1.67	0.96	0.61	4.54	2.23	1.29	0.82	6.52	3.21	1.85	1.18
19	1.65	7.64	22.52	15.91	12.14	9.74	25.96	18.33	14.00	11.23	31.00	21.89	16.71	13.41
20	2.10	4.70	8.99	6.84	5.53	4.65	10.05	7.65	6.19	5.20	11.56	8.79	7.11	5.98
21	0.99	10.09	23.72	13.24	8.42	5.82	30.10	16.80	10.69	7.38	40.53	22.62	14.39	9.94
22	0.77	3.48	1.33	0.63	0.35	0.22	1.81	0.86	0.48	0.00	2.65	1.25	0.70	0.44
23	1.63	6.03	18.84	13.34	10.08	8.06	21.75	15.29	11.63	9.30	25.69	18.06	13.74	10.99
24	0.36	13.24	454.70	90.30	25.77	9.25	878.20	174.30	49.76	17.86	988.00	373.90	106.70	38.38
25	1.23	8.80	59.43	37.20	25.86	19.22	71.93	45.02	31.30	23.20	89.73	56.16	39.40	29.01
26	0.56	6.95	4.89	1.75	0.79	0.41	7.46	2.68	1.21	0.63	12.56	4.51	2.04	1.06
27	1.41	3.41	14.55	9.66	7.03	5.45	17.19	11.41	8.30	6.41	20.85	13.85	10.08	7.77
28	0.91	4.02	2.60	1.38	0.85	0.57	3.37	1.79	1.10	0.73	4.65	2.47	1.51	1.01
29	0.77	3.64	4.07	1.92	1.07	0.67	5.53	2.60	1.46	0.90	8.12	3.83	2.14	1.33

where the number of treatments were 8 or 12. The summary of the CV's for the experiments is as follows.

In wheat experiments the CV of plot size of 1×4 basic units is greater than the CV of plot size of 2×2 basic units in 17 experiments out of a total of 22 experiments considering CRD layout. Similarly CV for 1×4 basic units is greater than 2×2 basic units in 11 experiments out of a total of 22 experiments considering RCBD layout.

In all the above experiments although the CV is greater but in most cases the difference is very small. These results do not endorse the usual assertion of long and narrow plots. Wiedemann and Leininger (1963) also concluded that there is very little difference in variance due to shape. Similar results are obtained by Kempthorne (1952), Rampton and Petersen (1962), Crews *et al*. (1963) and Reddy and Chetty (1985).

Grain yield

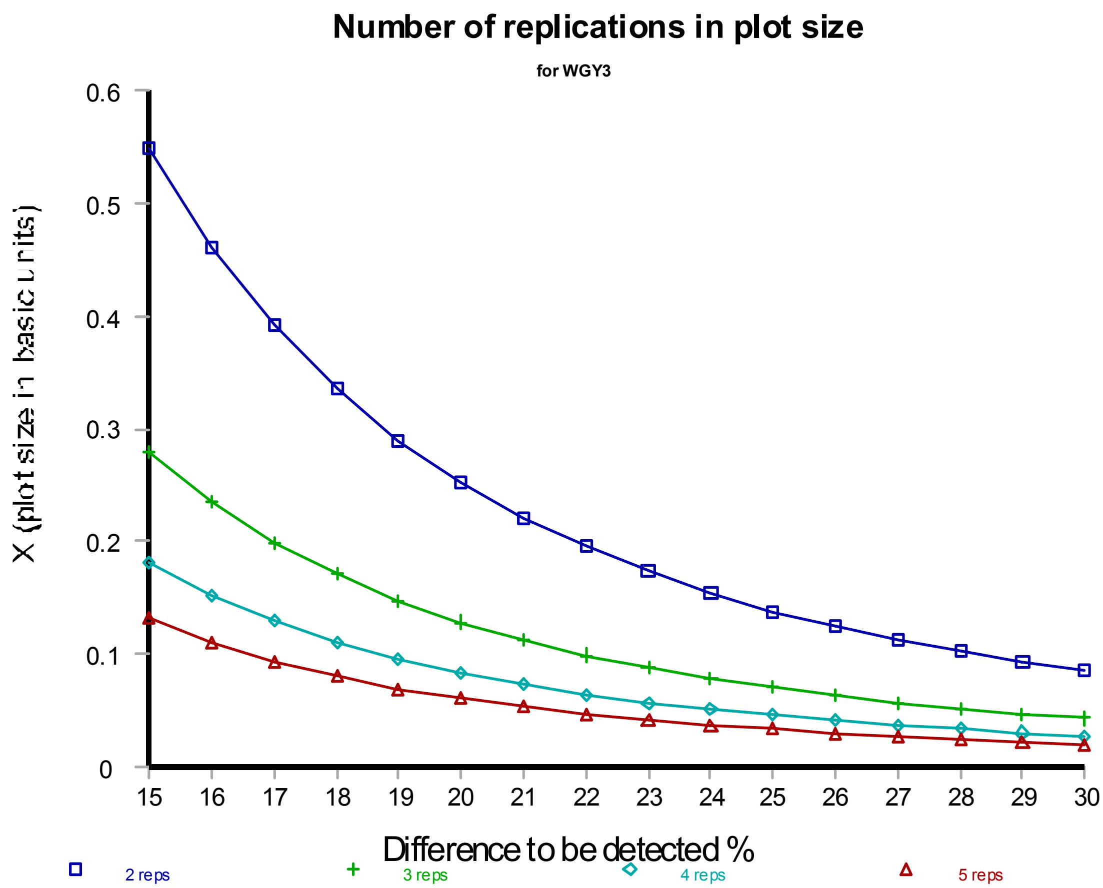
	Mean	Median	Trmean	SD	SE	Min.	Max.	Q1	Q3
CPS	**25.99**	**23.40**	**25.63**	**14.56**	**2.70**	**9.00**	**52.65**	**12.60**	**35.12**
Method I									
RPS(5%)	410.00	29.00	62.00	1452.00	352.00	0.00	6037.00	7.00	108.00
RPS(10%)	8.64	3.11	6.20	14.67	3.56	0.00	53.75	0.88	6.54
RPS(15%)	1.82	0.94	1.41	2.82	0.69	0.00	9.89	0.26	1.54
RPS(20%)	0.75	0.37	0.55	1.32	0.32	0.00	4.47	0.08	0.49
RPS(25%)	0.40	0.15	0.26	0.78	0.19	0.00	2.86	0.03	0.27
Method II									
RCBD									
RPS70-15	17.58	10.54	16.30	16.37	3.04	1.66	68.29	5.74	23.39
RPS70-20	11.89	7.26	11.07	11.12	2.07	0.77	45.22	3.64	15.36
RPS70-25	8.93	6.09	8.36	8.56	1.59	0.42	32.85	2.85	11.76
RPS70-30	7.14	4.80	6.72	7.06	1.31	0.26	25.30	2.36	9.82
RPS80-15	20.80	13.38	19.25	19.53	3.63	2.29	80.97	6.60	28.18
RPS80-20	13.91	8.04	12.92	12.95	2.40	1.05	53.62	4.54	17.99
RPS80-25	10.37	6.63	9.67	9.80	1.82	0.58	38.95	3.22	13.99
RPS80-30	8.24	5.63	7.73	7.99	1.48	0.35	30.00	2.67	10.98
RPS90-15	25.96	17.99	24.06	24.76	4.60	3.40	99.84	7.61	34.49
RPS90-20	16.85	10.06	15.60	15.75	2.92	1.57	66.12	5.55	21.95
RPS90-25	12.28	7.52	11.38	11.57	2.15	0.86	48.03	3.95	15.48
RPS90-30	9.60	6.46	8.92	9.22	1.71	0.52	36.99	3.11	12.74
CRD									
RPS70-15	29.60	10.10	14.40	84.70	16.00	0.80	454.70	2.70	21.60
RPS70-20	10.69	4.51	8.04	17.85	3.37	0.07	90.30	1.43	13.24
RPS70-25	5.90	2.19	5.36	7.13	1.35	0.01	25.86	0.75	9.66
RPS70-30	3.98	1.24	3.55	4.63	0.87	0.00	19.22	0.42	7.55
RPS80-15	48.90	14.70	18.80	163.70	30.90	1.80	878.20	3.50	26.00
RPS80-20	15.61	6.66	10.10	32.91	6.22	0.19	174.30	1.85	15.64
RPS80-25	7.92	3.17	6.61	10.93	2.07	0.03	49.76	1.13	11.40
RPS80-30	5.09	1.79	4.58	5.94	1.12	0.01	23.25	0.55	8.86
RPS90-15	92.50	20.20	27.10	352.10	66.50	2.60	1883.00	6.90	31.00
RPS90-20	25.90	9.30	13.50	69.60	13.20	0.70	373.90	2.50	20.70
RPS90-25	11.18	4.52	7.80	20.87	4.02	0.10	106.70	1.51	13.74
RPS90-30	6.7	2.44	5.71	9.06	1.74	0.02	38.31	1.01	9.94

Plant height

	Mean	Median	Trmean	SD	SE	Min.	Max.	Q1	Q3
CPS	**32.31**	**31.2**	**32.27**	**12.43**	**3.32**	**14.58**	**50.59**	**23.25**	**44.9**
Method I									
RPS(5%)	14.09	4.78	8.95	24.73	6.61	0.13	89.71	1.11	14.1
RPS(10%)	1.68	0.28	0.95	3.26	0.87	0	12.1	0.05	1.95
RPS(15%)	0.5	0.07	0.27	1	0.27	0	3.75	0.01	0.62
RPS(20%)	0.21	0.03	0.11	0.43	0.12	0	1.63	0	0.27
RPS(25%)	0.11	0.01	0.06	0.23	0.06	0	0.86	0	0.14
Method II									
RPS70-30	3.27	2.87	3.04	2.9	0.78	0	9.33	0.91	4.75
RPS90-15	11.16	7.03	10.15	9.51	2.54	0.18	34.22	4.46	17.84
CRD7030	1.53	0.6	1.33	1.92	0.56	0	5.05	0.01	3.52
CRD9015	10.19	6.18	7.93	13.15	3.8	0.04	42.98	0.46	16.69

Straw yield

	Mean	Median	Trmean	SD	SE	Min.	Max.	Q1	Q3
CPS	**31.4**	**31.2**	**31.49**	**16.11**	**4.31**	**9**	**52.65**	**12.58**	**50**
Method I									
RPS(5%)	121.2	42.7	101.5	166	44.4	0	478	11.2	219.6
RPS(10%)	13.65	4.36	10.31	20.1	5.39	0	67.33	0.37	25.21
RPS(15%)	3.99	1.57	2.75	6.34	1.69	0	22.86	0.05	7.03
RPS(20%)	1.7	0.71	1.1	2.86	0.76	0	10.62	0.01	2.68
RPS(25%)	0.88	0.37	0.54	1.55	0.42	0	5.86	0	1.28
Method II									
RPS70-30	8.1	5.55	7.78	7.61	2.03	0.76	19.27	1.2	16.89
RPS90-15	28.57	22.68	27.01	24.83	6.64	2.84	73.02	7.37	44.49
CRD7030	4.7	1.27	4.05	6.42	1.72	0	17.24	0.34	8.42
CRD9015	40.5	21.6	36.6	46.4	12.4	0	127.5	9.5	67.3



replications for smaller plots as compared with the larger plots. It is also clear from Figures that for the same number of replications as the difference d increases the plot size decreases. Similarly fixing the plot size the number of replications decreases for small differences d (15,16,...,25) and for large differences the decrease is not clearly detectable. Similar results have been obtained by Kempthrone (1952), Fleming *et al.* (1957), Rampton and Petersen (1962) and Crews *et al.* (1963).

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