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SIZE and SHAPE of PLOTS and DISTRIBUTION of PLOT YIELD for FIELD EXPERIMENTS with PEANUTS

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Experiments are often done in order to learn how to conduct a future experiment. Uniformity trials are examples in point. Many such experiments are reported in the literature of agriculture. A catalogue giving the location of the data accompanying such trials was published in 1937 (1)[4].

The only available information to date concerning the optimum size and shape of plots for peanut variety testing was published by Beattie, et al (2). Their work was mainly concerned with plant variations, but one conclusion was that a plot of 100 square feet, consisting of a single 100-foot row or five or six 20-foot rows, 3 feet apart was satisfactory.

The data presented here are from an experiment conducted solely to determine the optimum size and shape of plot for future peanut experimentation. In addition to furnishing data for the study of size and shape of plots, uniformity data also furnishes a sample frequency distribution that may be tested for departure from normality.

No attempt was made to vary the number of treatments or the shapes of the replicates, since the amount of data was of limited extent. Only the randomized block design was assumed. No attempt was made to determine the relative efficiency on the basis of costs as well as land use.

MATERIAL and METHODS

The data were obtained from two parts of the same field, hereafter designated as Part I and Part II. The field is located at the Wiregrass Substation, Headland, Alabama. Each part contained 18 rows, 3 feet wide, and 100 feet long.

The area was planted to corn the preceding year and received 400 pounds per acre of 4-10-7 fertilizer and a side dressing of 200 pounds per acre of soda. There was no cover crop during the intervening winter. Both parts were planted to Runner peanuts and were fertilized at the rate

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of 300 pounds per acre of 0-12-20. The peanuts were planted with a horse-drawn planter. The first two cultivations were with a horse-drawn rotary hoe; afterwards the two parts were cultivated with a mule-drawn cultivator. The area was considered to have received an average amount of rainfall during the growing season. The peanuts were picked by hand on September 12, 1946, and green weights in pounds were recorded by plots. Each plot consisted of 16-2/3 linear feet of row and was 3 feet in width, making a plot area of 50 square feet. Part I and Part II each contained 108 plots. This uniformity trial differs from other uniformity trials reported in the literature in that it was arranged as a duplicate uniformity trial, i.e., any result obtained from Part I may be checked for the particular year under consideration against the result from Part II and vice versa. The two parts were taken as representative sample of the experimental area assigned to peanuts.

In order to study the distribution of weights, frequency tables were made for both Part I and Part II; and the statistics g_1 and g_2, measuring skewness and kurtosis, were calculated for each (3). The standard deviations of g_1 and g_2 were also calculated . With these statistics, tests of significance can be made to measure the departure from normality of the two distributions of weights.

One assumption in the use of the analysis of variance for analyzing modern statistical designs, is that the populations be normally distributed. The probabilities associated with the variance ratio is only slightly disturbed for moderate departures from normality.

To determine whether the soil heterogeneity is equally variable in two directions, the mean squares between rows may be compared with the mean squares between columns for both Part I and Part II.

To study the question of the most efficient shape and size of plots, a randomized block design was assumed; each block or replication was assumed to contain 6 varieties or treatments (3). This particular design and number of varieties or treatments were chosen, since certain future trials were to be so designed. As far as possible, compact blocks or blocks approaching a square were used. Plots within a block extended the whole length of the respective block. Different shapes and sizes of plots within replications were formed by combinations of the unit plots. An analysis of variance was obtained in each case. Since here were actually no differences between varieties or treatments, the variety or treatment source of variation was not removed in the analyses of variances. Presented below as an example, is the analysis of variance for the design in which each plot contains only one unit plot for Part I. In such a case there will be 18 replications.

ANALYSIS of VARIANCE

Source of variation	Degrees of freedom	Sum of squares	Mean square
Among blocks	17	4.672674	.274863
Within blocks	90	11.693470	.129927
Total	107	16.366141	

The within-block mean square in each case will be taken as a measure of experimental error for each change made in the design. From such a table of variances, a corresponding table was calculated of coefficients of variation or standard deviations, on a single plot basis, as percentages of the means. The relative efficiencies for the different shapes and sizes of plots were derived by dividing the square of the coefficient of variation for the unit size plot in turn by the product of the ratio of the area of the large size plot to the area of the unit size plot and the square of the coefficient of variation for the larger size plot (4). In cases where all the yields are used, these relative efficiencies may also be obtained by dividing in turn the variance for the unit size plot by the quotient of the other variances and the number of unit size plots contained in the larger plot. It is easy to see that these two methods are identical. Consider the unit plot design as compared to the design with plots twice the unit size. Let n be the total number of plots in the unit plot design and V_1 and V_2 be the within block variances for the unit plot and the larger plot design, respectively. Let C_1 and C_2 be the respective coefficients of variation and S be the overall sum.

Then --

$$(C_1)^2 = \frac{n^2 V_1}{S^2}$$

and $$(C_2)^2 = \frac{n^2 V_2}{4S^2}$$

or $$2(C_2)^2 = \frac{n^2 V_2}{2S^2}$$

Therefore, using method one --

$$\text{Relative efficiency} = \frac{n^2V_1}{S^2} \cdot \frac{2S^2}{n^2 V_2}$$

$$= V_1 / \frac{V_2}{2}$$

But, the right side reduces to method two.

EXPERIMENTAL RESULTS

The weights of peanuts from each 16-2/3-foot plot are given in Table 4-A and B. The mean weight per plot for Part I is 2.461 and for Part II is 2.049

For Part I, the mean square between columns with 5 degrees of freedom is $s_1^2 = .13728$, while the mean square between rows with 17 degrees of freedom is $s_2^2 = .19102$, indicating no significant difference between soil heterogeneity in the two directions. For Part II, $s_1^2 = .33204$ and $s_2^2 = .49672$, which indicates a similar conclusion.

For Part I, $g_1 = .0014$ and the standard error of g_2 was $Sg_1 = 2.325$, hence $t = .0006$ with an infinite number of degrees of freedom. Therefore, the skewness is not significantly different from that of the normal curve. To test kurtosis, $g_2 = .0052$, $Sg_2 = 1.458$, hence $t = .0036$, which indicates that there is no departure from normality as far as kurtosis is concerned. For Part II, $g_1 = .0131$, $Sg_1 = 2.325$ and $t = .006$, while $g_2 = .0159$, $Sg_2 = 1.458$, and $t = .0109$, again indicating no departure from normality as far as skewness and kurtosis are concerned.

The variances on an individual plot basis obtained from analyses of variance tables are given in Table 1.

TABLE 1

(A) Variances 1/ for Part I

Width in rows	Lengths in units of 16-2/3': 1	2	3	6
1	.129927	.271107	.513597	1.155147
2	.555153 2/	1.427613 2/	2.194160 2/	
3	.818360	1.948653	2.875860	
6	1.241253			

(B) Variances 1/ for Part II

Width in rows	Lengths in units of 16-2/3': 1	2	3	6
1	.119631	.267140	.505754	1.354661
2	.767419 2/	2.035144 2/	4.297270 2/	
3	1.093494	3.257508	6.524035	
6	1.274701			

1/ On a per-plot basis

2/ Result based on 72 unit plots instead of all 108 due to size and shape of plot.

The standard deviations, on a single plot basis, as a percentage of the mean, i.e., the coefficients of variation, are given in Table 2.

TABLE 2
(A) Coefficients of Variation1/ for Part I

	Lengths in units of 16-2/3'			
Width in rows	1	2	3	6
1	14.65%	10.58	9.71	7.28
2	15.38 2/	12.33 2/	10.19 2/	
3	12.25	9.45	7.66	
6	7.55			

(B) Coefficients of Variation1/ for Part II

	Lengths in units of 16-2/3'			
Width in rows	1	2	3	6
1	16.88%	12.61	11.57	9.46
2	20.81 2/	16.94 2/	16.41 2/	
3	17.01	14.68	13.85	
6	9.19			

1/ On a per-plot basis
2/ Result based on 72 unit plots instead of all 108 due to size and shape of plot.

It will be noted that as the sizes of the plots increase these coefficients of variation tend on the whole to decrease, which is a result noticed on previous uniformity trials with other crops (5). The relative efficiencies are given in Table 3.

TABLE 3
(A) Relative Efficiencies for Part I

	Lengths in units of 16-2/3'			
Width in rows	1	2	3	6
1	100%	95.9	75.9	67.5
2	45.4 1/	35.3 1/	34.4 1/	
3	47.6	40.0	40.7	
6	70.5			

(B) Relative Efficiencies for Part II

	Lengths in units of 16-2/3'			
Width in rows	1	2	3	6
1	100%	89.6	71.0	53.0
2	32.9 1/	24.8 1/	17.6 1/	
3	32.8	22.0	16.5	
6	55.3			

1/ Result based on 72 unit plots instead of all 108 due to size and shape of plot.

TABLE 4

(A) Weight of Green Peanuts in Pounds per Unit Plot

16-2/3' by 1 row, Part I

Row No.	16-2/3-Foot Sections A	B	C	D	E	F
1	1.86	2.40	2.88	3.75	2.60	3.30
2	2.32	1.50	2.30	3.10	2.30	2.60
3	2.55	1.75	1.90	2.88	2.68	2.75
4	1.68	1.40	2.93	1.88	2.55	2.42
5	2.18	2.12	2.95	2.36	2.43	2.40
6	2.55	2.48	2.70	2.46	2.23	2.95
7	2.53	3.00	2.10	1.55	2.24	2.53
8	2.30	2.86	2.21	2.04	2.55	2.34
9	2.35	3.05	2.23	2.48	2.75	2.82
10	2.23	2.85	2.85	2.25	2.92	2.65
11	2.20	1.65	2.11	2.12	2.52	2.08
12	2.43	1.68	2.44	2.27	2.79	2.39
13	2.54	2.78	2.17	2.57	2.09	2.22
14	2.50	2.67	2.52	2.44	2.50	2.55
15	2.68	3.05	2.94	2.43	2.52	2.40
16	3.08	2.52	2.12	2.35	2.84	2.30
17	2.15	2.65	2.55	2.65	2.40	3.30
18	2.48	2.38	2.22	2.55	2.60	2.65

(B) Weight of Green Peanuts in Pounds per Unit Plot

16-2/3' by 1 row, Part II

Row No.	16-2/3-Foot Sections A	B	C	D	E	F
1	1.60	3.48	2.86	2.00	2.61	2.73
2	2.35	2.79	2.66	2.16	2.72	2.21
3	2.56	2.65	2.86	2.61	2.40	2.57
4	2.70	2.13	3.15	2.25	2.36	1.77
5	2.04	2.15	2.04	2.36	1.48	2.27
6	2.30	2.01	1.66	2.10	1.82	2.24
7	2.23	2.05	2.04	2.38	1.93	2.60
8	2.04	1.52	2.20	2.25	1.40	1.55
9	2.06	1.41	2.08	1.96	1.42	1.65
10	2.00	1.52	1.92	1.67	1.58	1.56
11	2.36	1.72	1.85	1.38	1.86	1.40
12	2.41	1.91	2.10	1.26	1.93	1.71
13	2.31	2.19	1.88	1.42	1.61	1.71
14	1.55	2.00	1.59	1.64	1.80	1.84
15	2.21	2.45	1.85	1.63	1.71	1.76
16	1.89	1.82	2.26	1.90	2.18	2.28
17	2.68	2.36	2.35	1.46	1.86	1.80
18	1.94	2.24	2.08	1.50	1.86	2.08

It is pointed out that in no case is the relative efficiency greater than that of the unit size plot. However, for the plot of 1 row width and 2 units length in Part I, there is little loss of efficienty, i.e., the relative efficiency is about 96 per cent. This plot in Part II gives about 90 per cent for the relative efficiency.

From a study of the relative efficiencies, it is noted that increasing the size of the plot along the row is much more efficient than across the row. This would indicate that narrow rectangular shaped plots are more efficient. However, increasing the length of the plot more than two times the unit length, with one row width, may reduce the efficiency by as much as 25 per cent or more. Even though the smaller size plot was the most efficient in land use, other considerations may lead one to select a somewhat larger plot. Lower yield in a plot due to one or two missing plants is less serious in the larger plot. Missing plants have been observed to occur most frequently at the end of a plot row, i.e., adjacent to a buffer space between blocks or replications. This effect was absent in the reported uniformity trial, since no buffer space was provided between blocks or replications.

SUMMARY

A uniformity trial for peanuts is reported in this study. No difference was noted in soil heterogeneity in two directions. No departure from normality was noted in the frequency distributions. Table of relative efficiencies indicate that a plot in the shape of a long narrow rectangle, along the row, is more efficient; plots of one row width and 16-2/3 feet in length are the most efficient, although plots of the same width but somewhat longer may be preferred because of such considerations as uneven stands. If plots are increased in length to over 33-1/3 feet with one row width or more, then there may be a material decrease in efficiency.

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