Agric. Res. J. Kerala, 1887, 25 (2) 241—248

OPTIMUM SIZE AND SHAPE OF PLOTS UNDER COLOCASIA

(COLOCASIA ESCULENT A L.)

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Soil heterogeneity constitutes a major source of error in field experiments and hence it is necessary to eliminate this upto maximum extent. Proper experimental techniques such as analysis of covariance, increasing number of replications and exercising local control can considerably reduce the effect of soil heterogeneity. The use of plots of optimum size and shape can also reduce the experimental error. But the adjacent experimental plots will exert correlated response due to initial, physical and chemical similarities of the soil or to the influence of previous crop upon the nature and composition of soil. Because of this correlation it is less efficient in terms of precision of treatment comparison, to increase the plot size by a given number of units than to use an equal number of independent units (Modjeska and Rawling, 1983). This leads to the establishment of a relation between plot size and variability. The costs of field experimentation must also *b&* reflected in optimum plot size. The plot size which gives maximum information per unit cost can be considered to be optimum for a given experiment.

The first theoretical consideration of plot shape was made by Christids (1931). A large number of research workers established that long and narrow plots were more efficient than square plots. This was established by Kripasankar *et al.* (1972) on soyabean; Saxena *et al.* (1972) on fodder and Sreenath (1973) on sorghum. Smith (1938) proposed the first theoretical formula for relating plot size on variability. A number of research workers had adopted Smith's technique to determine suitable size and shape of plots. The method of maximum curvature has been adopted by Gupta and Raghavarao (1971) on onion bulbs.

Many attempts were made in evaluating optimum size and shape of plots for many crops. But regarding the suitable size and shape of the plot on tuber crops very little information is available. Since the crop colocasia plays an important role jn the food habits of common man, it is appropriate to find out the optimum size and shape of plots of colocasia crop.

Materials and Methods

A uniformity trial on colocasia *(Colocasia esculenta* L) was conducted at the College of Agriculture, Vellayani, Kerala during Kharif 1984. The crop was sown in April 1984 over an area of 93.6 m^2. The experimental field contained 464 plants arranged in 29 rows and 1 6 columns with a spacing of 60 cm between rows and

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45 cm between plants within each row. The basic or unit plot selected in this study was 0.27 m^2. The crop was harvested on 21 October, 1984 and observations regarding the yield characteristics such as yield, weight of mother sucker, weight of marketable tubers, number of marketable tubers, weight of small tubers and number of small tubers were made.

A study of variation of plot size and shape is important in a field trial. A measure of studying such variation is coefficient of variation. For this the yields of adjacent units were combined suitably both in east-west and north-south direction to form plots of different sizes "and shapes. The coefficients of variations in the different arrangements were calculated for each of the data set considered.

To obtain the optimum plot size, two methods are available viz, maximum curvature method (graphical approach), and modified maximum curvature method (mathematical approach). In the graphical method, the average coefficient of variation for different plot shapes of a particular plot size was plotted against the plot size in basic units. A smooth freehand curve was drawn through the resulting co-ordinates. The optimum plot size is determined as the one just beyond the point of maximum curvature and the shape of the plot that gives least coefficient of variation for that optimum plots size will be recommended.

Modified maximum curvature method is a more precise method which locates mathematically the exact region of maximum curvature by maximising the curvature of the curve relating the plot size (X) to the coefficient of variation (Y). For this, a curve of the type.

$$Y = aX^{-b} \qquad (1)$$

where Y is the coefficient of variation, X is the plot size, a and b are constants used to define the relationship between plot size and variability was fitted. The constants a and b of the function can be computed by the method of least squares.

Generally the value of the soil heterogeneity index b lies between 0 and 1. The larger the value of the index, lower is the correlation between adjacent experimental plots indicating that fertile spots are distributed randomly. The optimum then can be determined by substituting the values of a and b in the relation.

$$X = [\,(ab)^2\ (2b+1)/(b+2)\,]\ 1/2\ (b+1) \qquad (2)$$

Given an estimate of soil heterogeneity index b and cost estimates for conducting the experiment, optimum plot size can *be* calculated by the formula given by Gomez and Gomez (1976)

$$X_{opt} = b\ (K_1 + K_g A)/(1-b)\ (K_2 + K\ B_2) \qquad (3)$$

where K_1 is the part of the cost associated with number of plots only, K_2 is the cost per unit area, K_g is the cost associated with the borders, B the ratio of the side borders to the test area, A is the area of the plot end borders and B is the Smith's index of soil heterogeneity. If unbordered plots are used, K_0 is zero. Therefore for unbordered plots

$$X_{opt} = bK_1/ (1-b) K^2 \ldots \quad ..(4)$$

Results and Discussion

The coefficient of variation (c. v.) in the different arrangements were calculated. The results are presented in Table 1. The c. v. decreased from 74.6396 to 1.9081 for the yield data. The decreases in c. v. for the characters such as weight of mother sucker, weight of marketable tubers, number of marketable tubers and weight of small tubers were respectively 71.36 to 17.11, 98.26 to 21.50, 82.55 to 19.03, 67.32 to 15.81 and 55.99 to 6.45 percent. That is, coefficient of variation decreased with the increase in plot size either in north-south or in east-west direction for all the concerned characters. The same trend was observed by Kalamkar (1932) in potato and Abraham and Vachani (1964) in rice. For a given plot size, long and narrow plots gave lower coefficient of variation than approximately square plots. This was in agreement with the conclusion drawn by Sreenath (1973) in sorghum and by Prabhakaran and Thomas (1974) in tapioca. Further it could be noticed that it would be better to combine more number of rows than more number of columns.

Smiths empirical law in the form $Y = a X^{-b}$ was fitted and the parameters were estimated for all the concerned characters. The result is given in Table 2. The coefficients of heterogeneity b for yield, weight of marketable tubers, weight of small tubers number of marketable tubers, weight of small tubers were respectively 0.6067, 0.1906, 0.2534, 0.2730, 0.2072 and 0.4521. Since the b value was between 0.19 and 0.61, one could assume that there exists a positive correlation between neighbouring plots. As the values of coefficient of determination were significant (between 0.5216 and 0.9757), it could be concluded that this curve gave a good fit to the data. The curve was plotted and presented in Fig 1. While inspecting the curve, It was found that c. v. decreased rapidly at first when plot size was increased, but after a certain point the rate of decrease was slow and then tended to zero. The optimum which was found out using this method for the yield data was about 12 units (3.24 m^2 approximately). The optimum plot size determined using equation (2) was 12.3761 units (3.34 m^2) i. e., both the methods approximately gave 12 units which was approximately 3 m^2 as the optimum plot size. The optimum plot size computed by considering the cost incurred in conducting the experiment was 1.636 m^2 (approximately 2m^2). The cost estimates are given in Table 3. The optimum plot size for other characters using equation (2) are presented in Table 2.

Table 1

Coefficient of variation for different characters for various plot shapes

Plot* shape	Yield	Weight of mother sucker	Weight of marketable tubers	Number of marketable tubers	Weight of small tubers	Number of small tubers
1	2	3	4	5	6	7
1x1	7463	71.36	98 25	82.55	67.32	55 98
2x1	52.96	54.16	76.77	63.24	49.13	38.76
1x2	58 23	49.90	81.01	55 24	47.38	41.02
3x1	44.83	47.56	64.36	54.47	43.89	33.05
1x3	46.55	42.72	73.40	49.03	40.44	3434
4x1	33.04	41.29	57.67	48.48	39.65	28.90
1x4	41.61	36.30	60 21	43 08	34.68	29.27
2x2	42.36	42.52	63.65	49.14	36.68	29.75
5x1	32.66	38.10	54.87	46.21	37.36	27.28
1x5	42.55	35.77	63.50	36.28	34.27	27.17
6x1	2690	37.41	52.81	43.91	33.85	24.81
1x6	36.26	34.59	61.82	39.29	31.76	26.38
2x3	35.92	34.31	62.94	41.45	29.74	23.34
3x2	36.76	37.96	58.41	43.18	33.66	25.40
7x1	27.00	36.83	54.05	44.31	33.17	23.93
1x7	35.70	23.85	43.08	31.42	30.36	26.26
8x1	22.54	34.58	48.94	39.82	31.17	19.78
2x4	33.46	29.63	52.42	36.64	25.96	21.62
4x2	25.30	33.43	47.58	38.18	30.62	23.63
9x1	22.12	33.36	4708	39.27	23.19	15.33
3x3	33.47	31.49	59.77	35.59	27.22	20.32
10x1	21.71	32.50	49.89	39.49	28.03	18.10
2x5	32.84	27.59	45.07	31.53	24.67	17.17
5x2	25.74	30.67	46.38	36.29	30.03	22.76
11x1	18.98	32.48	47.52	39.84	28.18	17.37
12x1	17.14	32.19	49.15	29.93	38.12	18.68
3x4	30.97	27.19	49.16	32.48	24.64	19.79
4x3	20.02	28.56	45.85	33.26	26.12	17.80
2x6	30.88	29.36	54.56	34.12	24.40	17.82
6x2	21.96	31.81	43.69	35.21	26.92	19.45
13x1	16 49	28.70	47.59	39.62	26.97	17.15
2x7	23.91	31.70	39.42	41.90	28.29	20.58
7x2	23.60	29.15	44.97	34.78	26.61	18.22
3x5	31.62	28.74	44.02	28 25	25.00	17.33
5x3	22.24	27.37	44.22	32.35	25.32	18.15

1	2	3	4	5	6	7
4x4	18.10	23.34	39.19	29.79	23.19	17.48
8x2	18.14	28.70	41.55	32 32	23.75	16 09
3x6	29.17	28.13	5493	31 20	24.14	16.83
6x3	20.86	27.44	42.41	30.03	22.00	15.28
9x2	15.13	27.58	45.11	32.17	24.17	15.19
10x2	17.61	28.05	42.70	31.09	21 16	14.25
5x4	20.76	21.29	39.10	28.03	22.69	17.41
4x5	24.12	25.24	35.90	26.25	22 60	13.92
7x3	18.71	25.84	44.17	30 10	20.54	12.14
3x7	22.66	30.88	39.29	39.81	28.44	1906
11x2	15.25	27.89	40.67	30.88	21.91	13.39
6x4	19.32	22.40	34.49	25.74	19.19	13.89
4x6	15.37	26.80	43.62	29.80	22.18	24 81
8x3	14.14	25.68	40.09	29.83	21.74	13.16
12x2	11.92	27.65	42.29	31.71	22.01	14.37
5x5	24.21	27.65	42.29	31.71	22.01	14.37
13x2	12.04	24.69	42.14	3202	21.36	14.28
9x3	12.82	23.74	46.37	29.53	22.17	14.16
4x7	10.07	29.87	28.13	36.82	25.31	16.79
7x4	20.86	20.61	36.16	25.52	21.30	13.35
10x3	15.58	23.80	40.37	27.51	16.90	10.98
6x5	20.81	24.82	29.88	19.61	19.46	12.43
5x6	20.02	24.99	43.62	28 57	21.34	14 73
8x4	11.95	20.40	33.72	25.42	17.69	1216
11x3	14.64	24.51	39.00	27.26	17.51	10.43
5x7	15.58	27.21	2643	35.91	25.31	16.10
7x5	21.25	24.47	31.72	20.04	19.88	10 30
6x6	17.75	2601	40.09	25.47	19.40	12.33
9x4	7.65	18.43	38.31	25.76	19.32	12.49
12x3	9.90	25.68	40.91	29.24	18.66	11.45
13x3	8.97	24.71	43.26	29.40	17.91	10.08
8x5	11.21	25.04	29.44	20.55	19.04	10.29
10x4	9.59	20.07	35.40	24.14	16.12	8 64
6x7	15.85	28.76	23.18	33.79	2431	16.08
7x6	16.27	24.73	43.64	2634	17.77	6 10
1x4	11.47	19 91	31.85	23.60	16.77	8.86
9x5	9.29	25.15	35.96	21.52	20.71	9 73
8x6	11.03	25.24	39.97	26.74	17.94	10.27
12x4	6.40	21.41	33.93	25.30	17.04	10.23
7x7	13.17	28.93	23.18	37.21	24.28	13.67

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13x4	644	17.11	34.04	26.20	17.38	11.34
9x6	10.20	23.49	48.10	37.89	20.58	11.94
11x5	8.16	24.94	28.35	19 02	15.93	5.35
8x7	8.05	2683	21.80	34.60	21.26	12.61
10x6	12.56	23.73	42.88	26.29	13.30	2.23
12x5	1.90	25.92	30.81	19.85	16·50	7.37
9x7	4.81	26.83	31.49	37.26	23.80	13,40
13x5	3.99	24.71	3213	20.14	15.81	6.45
11x6	3256	25.53	41.78	24.45	14.60	4.74
10x7	5.95	27.61	21.92	35.89	19.48	7.70
12x6	5.21	2658	42.22	27.43	15.73	7.55
11x7	8.32	29.47	21.50	36.08	21.11	10.21
13x6	4.34	22.88	46.53	28 89	15.81	7.32
12x7	5.09	29.09	22.09	36.25	22.36	13.04
13x7	5.10	26.18	26.94	38.75	22.57	13.12

* Plot shape = No. of plants in row x No. of plants in column

Table 2

Fitting of the curve $Y = aX^{-b}$

Number	Character	a	b	R-square	Optimum plot size (units)
1	Yield	101.8684	0.60676	0.8652	12
2	Weight of mother sucker	41.7438	0.19060	0.7360	5
3	Weight of marketable tubers	82.2197	025340	0.7955	10
4	Number of marketable tubers	59.7818	0.20720	0.6771	2
5	Weight of small tubers	53.1881	0.27300	0.8750	10
6	Number of small tubers	56.4019	0.45210	0.9267	8

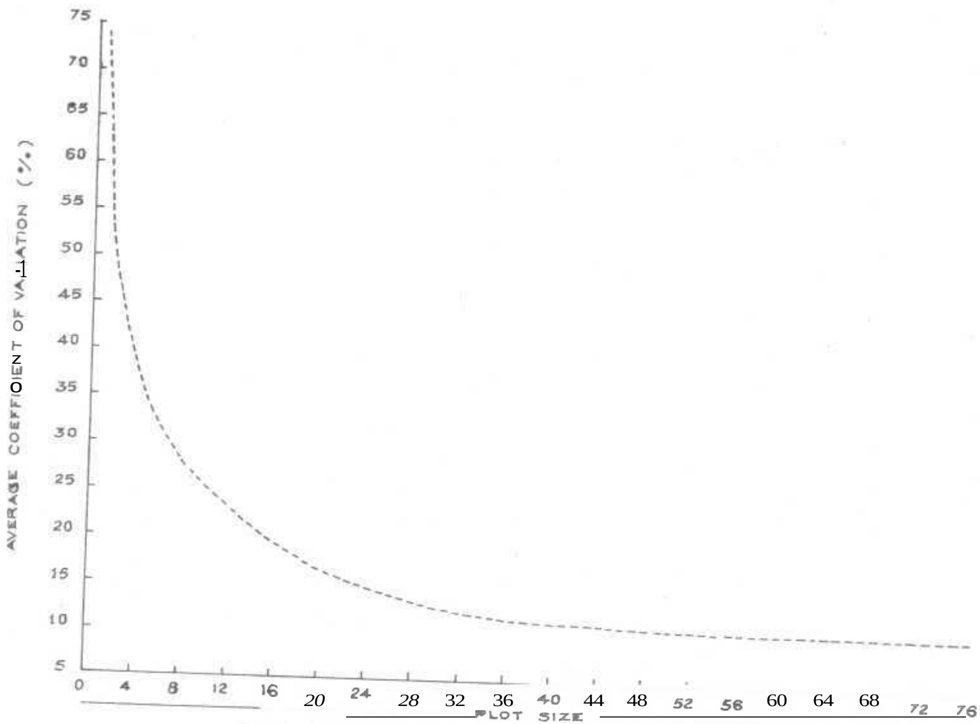

FIG f EFFECT OF PLOT SIZE ON VARIABILITY - YIELD

Table 3

Estimates of cost in man-hours for conducting a field experiment in colocasia

Number	Operation	Cost K_2 (man-h/m^2)	Cost K_1 (man-h/plot)
1	Land preparation	0.7761	—
2	Seed bed preparation	0.5038	—
3	Laying out of plots	—	0.1960
4	Fertilizer and farm yard manure application	1.0076	—
5	Periodic observation and after care	—	1.5677
6	Spraying plant protection chemicals	0.2723	—
7	Harvesting, weighing and transportation	—	0.9504

Summary

A uniformity trial on colocasia was conducted at the experimental field of the College of Agriculture, Vellayani, Kerala during April-September, 1984. At the time of harvest the observations regarding the yield characteristics were recorded. From the study of the size and shape of the plot it was found that an increase in plot size in either direction decreased the coefficient of variation. For a given size of the plot, the best shape was that having more number of rows than columns. The heterogeneity coefficient b in the Smith's equation for yield was 0.6057. The optimum plot size found out by maximum curvature method and by modified maximum curvature method was approximately 3 m^2. When the cost of experimentation was considered, a plot size of 1.636 m^2 was found optimum for conducting experiments with colocasia.

References

Abraham, T. P. and Vachani, M. V. 1964. Investigations on field experimental technique with ricecrop. *Indian J. Agric. Sci.* 35: 152-165

Christids, B. G. 1931. The importance of the shape of the plots in field experimentation. *J. Agric. Sci. Camb.* 21: 14-37

Gomex, K. A. and Gomex, A. A. 1976. *Statistical Procedures for Agricultural Research with Emphasis on Rice.* The International Rice Research Institute, Manila, Philippines, pp. 203

Gupta, J. P. and Raghavrao, D. 1971. Optimum size of plots for experiments on the weight of onion bulbs. *Indian J. Hon..* 28: 234-236

Kalamkar, R. J. 1932. Experimental error and the field plot technique with potato *J. Agric. Sci. Camb. 22:* 373-385

Kripasankar, M. S , Lal, M. S. and Goswami, U. 1972. Size and shape of plots and blocks in yield trials on soyabean. *Indian J. Agric. Sci.* 42 901-904

Modjeska, J. S. and Rawling, J. 0. 1983. Spatial correlation analysis of uniformity data. *Biometric* 39: 373-384

Prabhakaran, P. V. and Thomas, E. J. 1974. Optimum plot size for field experiments with tapioca. *Agric. Res. J. Kerala* 12: 19-23

Saxena, P. N., Kavitkar, A. G. and Monga, M. K. 1972. Optimum size for oat grown for fodder. *Indian J. Agric. Sci.* 42: 63-69

Smith, H. F. 1938. An empirical law describing heterogeneity in the yield trials of agricultural crops. *J. Agric. Sci. Camb.* 28: 1-23

Sreenath, P. R. 1973. Size and shape of plots and blocks in field trials with 'MP-chari' sorghum. *Indian J. Agric. Sci.* 43: 110-112