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COMPARISON OF DIFFERENT MODELS FOR THE DETERMINATION OF OPTIMUM PLOT SIZE FOR COLOCASiA *(COLOCASIA ESCULENTA L.)*

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The crop colocasia plays an important role in the food habits of common man. The field experiments are often taken up to standardise its cultivation practices. Not much work has been done towards the assessment of optimum size and shape of plots of this crop. Usage of plots of optimum size and shape will surely improve the efficiency of experimental technique. Keeping this point in view Smith (1938) gave a method of determining optimum plot size (hereinafter referred as 'heterogeneity index method'). The law given by Smith ($Y=aX^{-b}$) has been used by several research workers. They include Gupta and Raghavarao (1971) on onion bulbs and Bist *et al.* (1975) on potato. Generalisation of Smith's law in the form $Y=ar^{-g_1}c^{-g_2}$ (where Y is the coefficient of variation of a plot with 'r' rows and V columns, 'a' is a constant, g_1 is the rowwise heterogeneity coefficient and g_2 is the columnwise heterogeneity coefficient) was tried by George *et al.* (1979) on turmeric for comparing heterogeneity of rows (r) and columns (c).

Ramanadachetty (1985) suggested the model

$$V_x = V_1 / X_1^{B_1} X_2^{B_2}$$

Where X_1 is the length of the plot, X_2 is the breadth of the plot and B_1 and B_2 are the heterogeneity coefficients. Some research workers suggested alternate models to Smith's law. Lessman and Atkins (1963) found that the function $\log Y = a/(a + b \log X)^b$ was an improvement over Smith's function in describing the relation between plot size and variability. Nair (1984) used several alternate models such as, $Y = a + b \log X$, $Y = a + b/X^{1/2} + c/X$, $1/Y = a + bX^{1/2} + cX$ and among them the model $Y = a + b/X^{1/2} + c/X$ gave a better fit than Smith's law for turmeric. But optimum was never achieved for these models.

Materials and Methods

A uniformity trial on colocasia *(Colocasia esculents* L.) was conducted at the College of Agriculture, Vellayani during Khariff 1984. The crop was sown over an area of 125.28 m^2. The experimental field contains 29 rows and 16 columns with a spacing of 60 cm between rows and 45 cm between plants within row. A border row was left out from each side, thus giving rise to an arrangement of 27 rows and 14 columns. The basic plot selected in this study is 0.27 m^2. Biometrical observations such as height, girth, number of suckers, number of leaves and leaf area were taken from all plants when they were at 60 days and 90 days after sowing (DAS). Then

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at the time of harvest 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 recorded.

Smith's law in the modified form $Y=aX^{-b}$, 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 coefficient of variation was fitted and the parameters were estimated by the principle of least squares.

The maximum curvature of the curve $Y=aX^{-b}$ was attained when the first derivative with respect to X is zero and the second derivative corresponding to the value of X which makes the first derivative zero, is negative. Thus the optimum plot size in the case of Smith's equation was derived as :

$$X=[(ab)^2(2b+1)/(b+2)]^{1/2(b+1)} \quad (1)$$

This value can be obtained by substituting the values of a and b in the relation (i). Smith's law was generalised as $Y=ar^{-g_1}c^{-g_2}$ (g_1 and g_2 are as explained before). In the present study four other models were tried to express the relation between plot size (X) and coefficient of variation (Y). The fitted models were, $Y=a+b\log X$, $Y=a+b/X^{1/2}+c/X$, $1/Y=a+b\log X$, $1/Y=a+bX^{1/2}+cX$

In all the four models the parameters were estimated by the principle of least squares. The optimum plot sizes are found out by modified maximum curvature method. While considering the model $Y=a+b\log X$, the curvature of the curve is obtained as follows:

$$C=Y_2/(1+Y_1^2)^{3/2} \quad (2)$$

where 'C' is the curvature of the curve, Y_1 and Y_2 are the first and second derivatives of the curve with respect to X.

$$Y_1=b/X, \quad Y_2=-b/X^2$$

Substituting in (2) and equating $dC/dX=0$.

$X=+b/\sqrt{2}$ if 'b' is positive and $-b/\sqrt{2}$ if 'b' is negative. With regards to curves $Y=a+b/X^{1/2}+c/X$, $1/Y=a+b\log X$ and $1/Y=a+bX^{1/2}+cX$, the method of obtaining optimum plot size is by finding out the first and second derivatives of Y and substituting them in (2). Then by the iterative procedure the maximum value of 'C' is found out. For this a graph was drawn between plot sizes and expected coefficient of variations. Then from the graph two points of X within which the maximum value of 'C' may lie are obtained. Then using trial and error method the maximum value between two consecutive 'X' values is reached.

Results and Discussion

Smith's relation in the modified form $Y=aX^{-b}$ was fitted and the values of the parameters were estimated for yield. R^2 values due to this fitted equation were found within 52.16 per cent and to 97.57 per cent. Hence the curve gave a good fit to most of the characters. The generalisation of Smith's law in the form $Y=ar^{-g1}-c^{g2}$ was also fitted and this also gave a good fit to the data. It was found that the row-wise heterogeneity coefficients g_1's were higher than columnwise heterogeneity coefficients g_2's, thereby established [that formation of plots with more number of rows would give more homogeneous blocks for experiments. For the models $Y=a+b\log X$, $Y=a+b/X^{1/2}+c/X$, $1/Y=a+b\log X$ and $1/Y=a+bX^{1/2}+c/X$ also the parameters were estimated by the principle of least squares and R^2 values were found out. The results are presented in Tables 1 and 2. While comparing the R^2 values obtained by these models, it could be noticed that the model $Y=a+b/X^{1/2}+c/X$ gave the best fit to the data. The optimum plot sizes determined by maximising the curvature of Smith's equation was 12.3761 units (3.3415 m^2) when considering the data on yield. The optimum plot sizes computed by the models $Y=a+b\log X$, $Y=a+b/X^{1/2}+c/X$, $1/Y=a+b\log X$ and $1/Y=a+bX^{1/2}+cX$ for the yield were respectively 20.1796, 10.8730, 17.7503 and 21.9000 units. The optimum for remaining characters using all the models is presented in Table 3.

While comparing the optimum plot sizes calculated by using the yield data, It was found ranging between 10.870 and 21.900 units. As the R^2 values were highly significant for the model $Y=a+b/X^{1/2}+c/X$, the optimum plot size corresponding to this model (equal to 10.87 units, 2.93 m^2 (approximately 3 m^2) can be taken for further investigations with colocasia.

Although the model $Y=a+b/X^{1/2}+c/X$ gave the best fit to the data, one could not attribute any physical meaning to the parameters of this model. However this model can be utilised to determine the optimum plot size.

Table 1

Fitting of different models for the yield data

Number	Models	a	b	c	g_1	g_2	R-square
1	$Y=aX^{-b}$	101.8684	0.6068	—	—	—	0.8652
2	$Y=ar^{-g1}c^{-g2}$	102.9723	—	—	0.7186	0.4563	0.9028
3	$Y=a+b\log X$	57.3506	—28.5380	—	—	—	0.8567
4	$1/Y=a+b\log X$	—0.0560	0.1027	—	—	—	0.0014
b	$Y=a+b/X^{1/2}+c/X$	-3.5085	102.4939	-26.3067	—		0.8902
6	$1/Y=a+bX^{1/2}+cX$	0.0333	—0.0099	0.0032	—	—	0.7522

Table 2

R^2 values obtained for various characters under different models

No.	Character	$Y=aX-b$	$Y=a+b\log X$	$Y=a+b/X^{1/2}+c/X$	$1/Y=a+b\log X$	$1/Y=a+b^{1/2}X+cX$
1	Height at 60 DAS	0.8873	0.8165	0.9368	0.9353	0.9128
2	Height at 90 DAS	0 7223	0 6208	0 8549	08116	0 7859
3	Girth at 60 DAS	0 9090	0 8216	0 8235	0 7908	0 9017
4	Girth at 90 DAS	0 7099	0 7700	0 8411	0 5975	0 8392
5	Number of suckers at 60 DAS	0 9643	0 8750	0 9465	0 1904	0 9577
6	Number of suckers at 90 DAS	0 5216	0 4963	0 5253	0 4973	0 5185
7	Number of leaves at 60 DAS	0 8388	0 7784	0 8651	0 8602	0 8562
&	Number of leaves at 90 DAS	0 9339	0 8332	0 9498	0 6945	0 9310
9	Leaf area at 60 DAS	0 9741	0 8709	0 9856	0 4986	0 9854
10	Leaf area at 90 DAS	0 9757	0 8860	0 9813	0 4132	0 9799
11	Weight of mother sucker	0 7360	0 7489	0 8671	0 8086	0 8737
12	Weight of marketable tubers	0 7955	0 7489	0 8537	0 7740	0 7800
13	Number of marketable tubers	0 6771	0 6005	0 7658	0 7423	0 7971
14	Weight of small tubers	0 8750	0 7789	0 9135	0 8994	0 9132
15	Number of small tubers	0 9267	0 8506	0 9264	0 2003	0 9134

Table 3

Optimum plot sizes; computed by the method of maximum curvature using all the fitted equations

No.	Character	$Y=aX^{b}$	$Y=a+b \log X$	$1/Y=a+b \log X$	$Y=a+b/X^{1/2}+c/X$	$1/Y=a+bX^{1/2}+cX$
1	Yield	12.3761	20.1796	17.7503	10.8730	21.9000
2	Height at 60 DAS	3 3102	5 2650	7 2000	4 7933	51315
3	Height at 90 DAS	3 6763	6 5408	2 0000	6 0000	5 5256
4	Girth at 60 DAS	4 2156	6 0653	8 3661	5 0148	6 8464
5	Girth at 90 DAS	3911°	5 2828	2 9999	4 3535	2 0000
6	Number of suckers at 60 DAS	20 6200	50 0360	27 1588	20 5103	23 4654
7	Number of suckers at 90 DAS	7 1057	11 9573	13.4970	7 5614	10 1961
8	Number of leaves at 60 DAS	3 0142	4 9862	6 7506	4 0636	4 5636
9	Number of leaves at 90 DAS	3 2200	3 7735	2 0000	3 8027	4 9606
10	Weight of mother sucker	5 4500	7 5299	2 1478	7 9999	10 0000
11	Weight of marketable tubers	10 1580	19 1080	14 0000	5 0000	13 8572
12	Number of marketable tubers	2 3586	12 8094	10 0000	4 9999	6 9999
13	Weight of small tubers	9 7089	12 5946	5 0000	7 9648	10 6424
14	Number of small tubers	8 5256	13 0992	14 6026	8 2485	11 1867
15	Leaf area at 60 DAS	11 7668	23 2821	18 4861	12 3104	14 1962
16	Leaf area at 90 DAS	15.3620	21.4770	17.8885	14.0001	14.6710