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OPTIMUM SIZE AND SHAPE OF PLOTS FOR FIELD EXPERIMENTS IN BRINJAL*

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Soil heterogeneity is one of the major sources of variability in crop yields, devoid of, that induced by genetic differences. Apart from the considerations of increasing the number of replications, exercising local control or resorting to analysis of covariance, use of plots of optimum size and shape is a well adopted means for controlling experimental error. The fundamental problem in determining plot size in field trials is that, spatially associated experimental units tend to give correlated responses in plant growth due to their shared microenvironmental factors. Because of this positive correlation, it is less efficient in terms of precision of treatment comparison, to increase plot size by a given number of units (Mojeska and Rowling 1983). This leads to the establishment of a relation between plot size and variance among plots. For a given cost structure, optimum plot size can then be taken as that which minimises the cost per unit information.

The empirical model developed by Smith (1938) for relating soil heterogeneity to field plot size and shape has been the basis for analysis of uniformity studies for many decades. A number of workers had followed this technique to determine suitable size and shape of plots (Torrie *et al.*, 1963; Wiedemann and Leininger, 1963; Hatheway and Williams, 1958).

On annual crops like rice, wheat jowar, maize and sugarcane and perennial crops like arecanut, mango, coconut, black pepper, orange and apple, a large number of studies have been made in India and abroad. But regarding the suitable size and shape of plots on vegetables, comparatively less work has been done in this country. Vegetable crops such as potato, cabbage, sweet potato and onion which normally are single harvested crops; given much more precise experimental data, in terms of the coefficient of variation per experimental unit, as compared to multiple harvest crops such as brinjal, bhindi and tomato. Keeping these points in view a uniformity trial was conducted in brinjal (*Solanum melongena* L.) one of the important vegetables in Kerala.

Materials and Methods

A uniformity trial was conducted at the main campus of the Kerala Agricultural University during the third crop season, 1980 using the variety SM 6. The crop was planted in N-S direction, with a row to row spacing of 60 cm and plant

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distance of 45 cm. The trial consisted of 68 rows each comprising of 64 plants. Harvesting of crop was done in small units of four plants, the size of unit being 1.2 m X 0.9 m. Thus units were arranged in 32 rows each consisting of 30 units excluding two border rows on all sides. The number and weight of fruits for each unit were recorded separately in each harvest. For the purpose of study, yield (total weight of brinjal fruit of each unit), number of fruits (total number of fruits in each unit), height and number of primary branches were considered. The height of the individual plants was measured in centimeters and added to per unit basis. The number of primary branches was counted and the total number of primary branches per unit was worked out.

The uniformity trial data thus obtained was used to determine the optimum size and shape of plots. A fertility contour map depicting the heterogeneity of the field was constructed by taking the moving averages of the yield of unit plots and demarcating, the regions of same soil fertility by considering those areas which have yields of same magnitude. Optimum plot size was arrived at by two methods. In the tirst method, viz., maximum curvature method, yield data from basic units were combined into plots of different sizes. The corresponding coefficient of variation (CV) were plotted against plot sizes (X). The optimum plot size is the point on the curve, where the rate of change for the variability index (CV) per increment of plot size is the greatest.

Smith (1938) proposed a method which will be referred to as the heterogeneity index method, for detemining the optimum plot size from the uniformity trial data. He proposed that $V(X) = V1/X^b$, X being the number of basic units in a plot, V (X) is the variance of yield per unit area among plots of X units in size, V1 is variance among plot of one unit in size, b is the soil heterogeneity index. The b can be computed by the method of least squares.

The optimum plot size was arrived at finally using the following formula, $X_{opt} = (b\ C_1)/(1-b)\ C_2$ where C_1 is the overall cost of experimental units. and C_2 the cost of individual item within the experimental unit, which is independent of the size. (Wiedeman and Leininger, 1963; Koch and Rigney, 1951).

Result and Discussion

The fertility contour map obtained was as shown in Fig. 1. From this figure, it could be concluded that there is no specific trend for the soil fertility and on the whole, the land can be considered not homogeneous. The fertility corresponding to each plot size and shape was determined by means of CV. An increase in the size ot plots in either direction, decreases the CV (Table 1). The CV for rectangular plots was slightly less than that for square or nearly square plots. The

FIG 1. FERTILITY CONTOUR MAP OF WEIGHT OF BRINJAL FRUITS

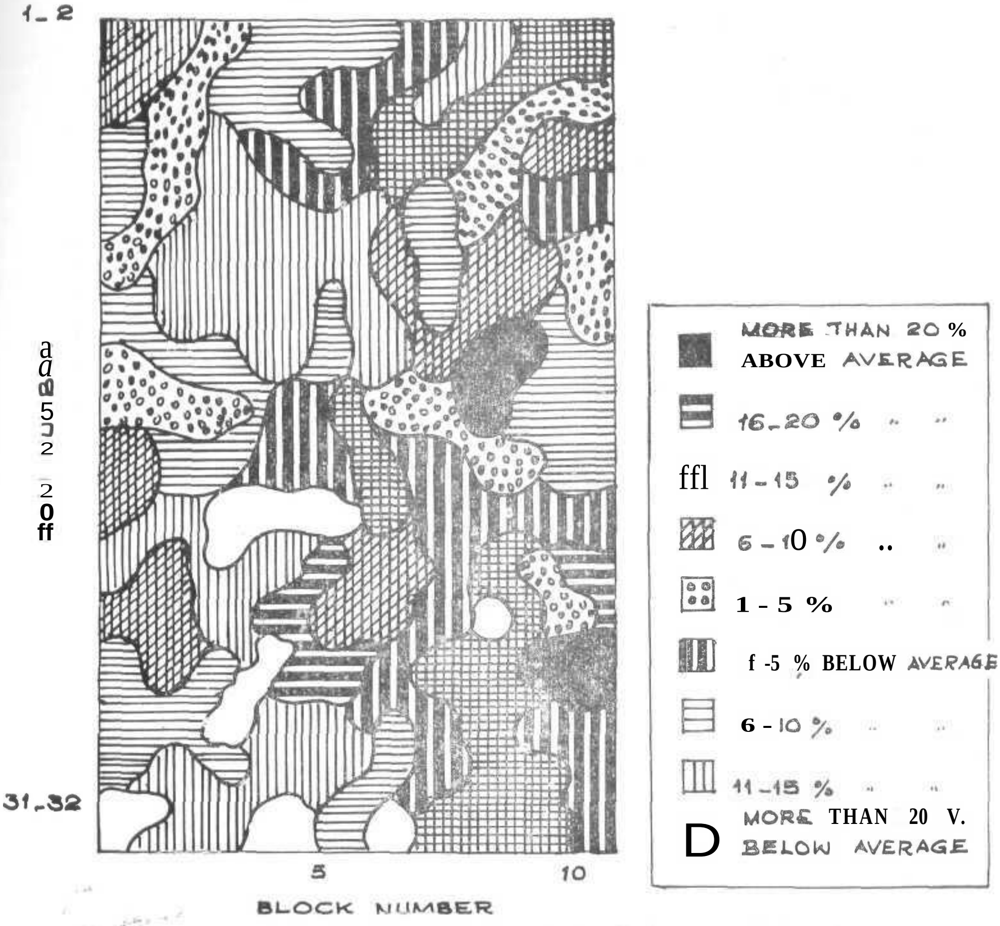
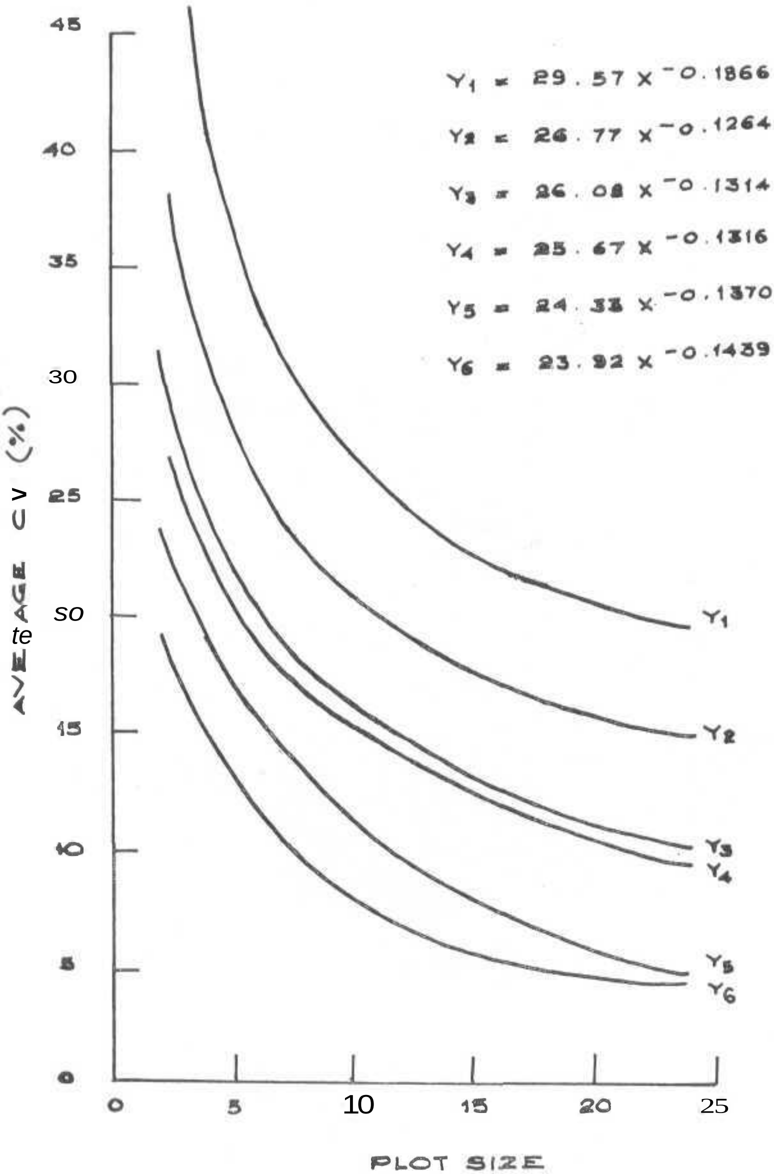


FIG: 2. EFFECT OF PLOT SIZE ON VARIABILITY



reduction in CV was not proportional to the number of basic units combined. To examine the shapes of plots the CV for different plot sizes and shapes was obtained. It was found that CV was smaller in general for plots elongated in direction of the

Table 1

CV for different plot sizes and shapes

Weight of brinjal fruits		Number of units along N-S direction							
		1	2	3	4	6	8	12	24
Number of units along E-W direction	1	66.11	50.66	44.38	39.49	29.64	23.58	22.64	21.20
	2	48.56	38.25	32.90	30.86	25.90	22.19	15.19	12.46
	3	42.98	33.76	28.63	22.75	22.25	17.72	13.77	11.89
	4	31.75	29.06	22.26	24.09	21.93	17.22	12.75	9.54
	6	30.38	26.22	23.51	20.92	20.02	13.90	12.50	8.93
	8	21.94	15.35	14.62	1232	13.68	7.36	6.37	5.57
	12	21.94	15.35	14.62	12.32	13.68	7.36	6.37	5.57
	24	20.30	14.55	14.29	11.56	12.82	4.70	3.51	—

Table 2

Relation between CV (Y) and plot size (X) yield data

Block size	Smith's equation $Y=a\ x\text{-}b$	amount of variation explained (%) R'^2
960	29.5678 $x^{-0.1866}$	99 40
2	26.7659 $x^{-0.1264}$	97.02
4	26.0787 $x^{-0.1314}$	96.97
6	23.6705 $x^{-0.1336}$	93 19
8	24.3334 $x^{-0.1370}$	93.89
12	23.9228 $x^{-0.1439}$	93.69
24	19.2742 $x^{-0.1463}$	93.89

Table 2a

Smith's equation $Y=a\ X^{-b}$ for various characters/plant

Block size	Average no. of fruits	Average no. of primary branches	Average height
960	26.32 $X^{-0.2264}$	26.67 $X^{-0.1725}$	28 64 $X^{-0.2475}$
2	24.95 $X^{-0.1861}$	26.01 $X^{-0.2247}$	24.68 $X^{-0.2364}$
4	24.83 $X^{-0.1075}$	25.68 $X^{-0.1895}$	25.34 $X^{-0.2436}$
6	24.85 $X^{-0.1648}$	24.80 $X^{-0.1650}$	24.11 $X^{-0.1952}$
8	24.93 $X^{-0.2417}$	29.94 $X^{-0.2026}$	23.17 $X^{-0.2200}$
12	28.13 $X^{-0.1625}$	23.89 $X^{-0.2528}$	21.27 $X^{-0.2491}$
24	23.44 X^{-0} 1607	24.84 $X^{-0.2243}$	16.28 $X^{-0.1113}$

Table 3

Optimum plot size when cost of experimentation is also considered

C_1	C_2	Basic units	Area (m^2)
4	1	0.65	0.70
4	2	0.32	0.35
4	3	0.22	0.24
4	4	0.16	0.17
8	1	1.29	1.39
8	3	0.44	0.46
12	1	1.93	2.08
12	2	0.97	1.05
12	4	0.48	0.52
24	1	3.87	4.18
32	1	5.16	5.57
32	2	2.58	2.79
32	3	1.72	1.86
48	1	7.74	8.36
50	4	2.02	2.18
50	3	2.69	2.91
50	2	4.03	4.35
50	1	8.05	8.64

row. The shape of plot had no consistent effect on CV. But long and narrow plots along East West showed lower CV. This might be due to field slope in east-west direction. Similar results were obtained by Sreenath (1973) in fodder sorghum.

For determining the optimum plots size by the method of maximum curvature, the yields of adjacent units are combined to form plots of different sizes and shapes. The average CV for plots of different shapes of same size was obtained. A free hand curve was drawn (Fig 2) in which plot size is plotted against average CV(%).The optimum plot size is one just beyond the point of maximum curvature. From Fig 1, it will be seen that the CV decreased as the size of the plot was increased upto 8 m^2 there after the decrease is rather slow.

The average CV shows a definite relationship with the size of the plot, the number of plots being the same. Smith's law (1938). $Y = ax^{-b}$ where Y is the average CV for fixed plot size of 'X' units, fitted to th observed values of CV for different block sizes separately. For the yield data, the value of 'b', Smith's coefficient of heterogeneity, varied from 0.1264 to 0.1370 for different block sizes and was 0.1866 without arrangement in blocks. Thus there appears to be high positive correlation between the neighbouring plots. Similar results were also obtained by Singh *et al.* (1975) and Sreenath (1978) in bhindi and fodder sorghum respectively. The correlation between the neighbouring plots was further confirmed by the data on other biometrical characters as the range of 'b' values for data on fruit/plant is 0.1 1 to 0.24, for number of primary branches per plant is 0.165 to 0.253 and for height to 0 1 1 to 0.249 respectively (Table 2,2a). It was shown that smaller plots were more efficient than the bigger ones and the total area required by them was also comparatively less. However to obtain a practical minimum, it is necessary to work the optimum plot size for field experiments in brinjal. Optimum plot size was computed by assuming arbitrary values of the ratio $C_1 : C_2$ and then taking the average value of 'b' over blocks of various sizes to be equal to 0.1368.

The optimum plot size varied between 0.65 and 8.05 basic units for various ratios. For wider ratios, the optimum plot size was bigger and for narrower ones, it was smaller. An increase in the cost per unit area and decrease in the cost per replication had reduced the optimum plot size. Assuming the cost to plot area to be *2%,* the optimum plot size was 8.05 basic units or about 8.64 m^2. This was reduced to approximately one basic unit or 1.08 m^2 when cost due to area increased to 88% of the total.

Summary

A uniformity trial in brinjal *(Solanum melongena* L). was conducted at main campus of the Kerala Agricultural University, Vellanikkara, during the third crop season, 1980. Observations on yield, number of fruits and primary branches were recorded. The variability among plots of different sizes and shapes was determined by calculating coefficient of variation (CV). It was observed that an increase in the plot size in either direction decreased the CV. But decrease was more rapid along N-S direction. Long and narrow plots showed lower CV than approximately square plots.

The observed relation between plot sizes and variance was in conformity with Smith's variance law. At larger plot sizes the regression line showed a tendency to come down although negligible. The optimum plot size observed through smith's method and maximum curvature method was almost same. From the above consideration a plot size of 8.64 m^2 (9.6 m X 0.9 m) was found to be most advisable for conducting most of the field experiments in brinjal.

സംഗ്രഹം

വഴുതിനങ്ങാ കൃഷിക്ക് ഉത്തമമായ ഏകക പരിമാണം കണ്ടുപിടിക്കുവാൻ ഒരു ഏകക സമാനതാപരീക്ഷണം നടത്തപ്പെട്ടു. ഓരോ ഏകകങ്ങളുടെ പരിമാണത്തിലും, വലിപ്പത്തിലുമുള്ള വ്യതിയാനം വിചരണഗുണാങ്കം ഉപയോഗിച്ചളന്നപ്പോൾ ഏകകപരിമാണം ഇരു ദിശയിലേക്ക് വർദ്ധിപ്പിക്കുംതോറും വിചരണഗുണാങ്കം കുറയുകയും മാത്രമല്ല തെക്കുവടക്കു ദിശയിൽ ഉള്ളതും നിബിഡങ്ങളുമായ ഏകകങ്ങളിൽ ഈ കുറവ് കൂടുതൽ രേഖപ്പെടുത്തുകയും ചെയ്തു. സ്മിത്തിന്റെ വിധിപ്രകാരവും അധികമതവക്രതാ രീതിയിലും ഉചിതമായ ഏകക പരിമാണം തിട്ടപ്പെടുത്തിയപ്പോൾ ഇരു രീതിയിലും ഒരേ അളവു തന്നെ കാണിച്ചു. മേൽകാണിച്ച അനുഭവത്തിൽ നിന്ന് 8.64 ചതുരശ്രമീറ്റർ rerogru^gg ഏകകങ്ങൾ (9.6 മീ x 0.9 മീ) ഈ rffcjnMlaa0 വളരെ അനുയോജ്യമായി കാണുന്നു.

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