WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Estimation of Optimum Plot Size and Shape for Field Experiments of Paddy (*Oryza Sativa*)

Athulya C. K.[1*], Abhinav M C[2]

[1] Doctoral Research Scholar, Department of Statistics, KE College, MG University,

[2] Post Doctoral Fellow, Department of Economics, Dr. John Matthai Centre, University of Calicut

DOI : https://doi.org/10.55248/gengpi.5.1224.250130

ABSTRACT

The study was based on primary data collected from a uniformity trial conducted in an area of $800m^2$ with Uma variety of paddy in virippu season at Integrated Farming System Research Station (IFSRS), Karamana. The crop was transplanted at a spacing of 20 cm × 15 cm. The field was divided in to 1.2 m × 1.2 m (1.44 m^2) plots, after leaving a border of one meter from all the sides of the plot to eliminate the border effects, thus give rise to 400 basic units. Maximum curvature method and Fair field Smith's variance law was used for estimating the optimum plot size. The maximum curvature method estimated a plot size of 34.56 m^2 (24 basic units) with rectangular shape. Whereas it was 8.64 m^2 under Fairfield Smith's variance law method. But the plot size under later method was not considered as it was smaller in size.

Keywords: Fairfield Smith's variance law, Maximum curvature method, Optimum plot size, Soil fertility contour map, Soil heterogeneity.

INTRODUCTION

It is important for crop scientists to thoroughly understand the field plot techniques to optimize the shape and size of plots for consistent experimental results. The reliability of these results is significantly influenced by the plots size and shape, which are, in turn, determined by the size and shape of experimental area and the nature of fertility variations or other field variations. To tackle such issues in agricultural research, it is essential to standardize an appropriate plot size and shape for crops grown under different conditions, which may expect to reduce the experimental error. Hence, to improve the quality as well as reliability of research results, there is a need to carry out research on optimum plot size based on field plot techniques (Masood *et al*., 2012).

Determination of optimum plot size is not an end by itself. Its arrangement in suitable shape and number in a block is known to greatly influence the experimental error. Thus, in nutshell, the choice of plot size and shape constitute an important landmark in planning field experiments (Kavitha, 2010). The general problems in estimating optimum plot size are increased variability with decrease in plot size and increased cost for large plots. Moreover, all plot sizes and shapes are not equally efficient in the point of view of cost considerations. In order to make a balance between cost and precision of the experiment, it is important to have a proper choice of optimum plot size. The optimum plot size of a crop can be estimated by using the data on uniformity trails as well as using information on previous field experiments (Bharati *et al*., 2017).

The present work is an attempt to estimate optimum plot size of Uma variety of paddy based on uniformity trial data. Uma (MO-16) is a medium duration, high yielding variety of rice having duration of 115-120 days in mundakan and 120-135 days in virippu season. The crop is dwarf, medium tillering and non-lodging. The variety is suited to the three seasons and is especially good for the additional crop season of Kuttanad (KAU, 2016). Uniformity trial consists of planting an experimental area with a single crop, and applying cultural and management practices as uniformly as possible. All the sources of variation are kept constant throughout the experimental period. Then the experimental site is divided into small basic units of same size and shape and observations on yield and biometric characters are recorded separately from each basic unit. The size of the basic unit is mainly governed by the availability of resources. Smaller basic units provide a detailed study on soil heterogeneity. Here, the maximum curvature method and Fairfield Smith's variance law are being used for the estimation of optimum plot size. The optimum plot size estimated for a crop may varies across the treatments, locations, and the method of transplanting.

MATERIALS AND METHODS

A uniformity trial was conducted by selecting the Uma variety of paddy and uniform treatments are given for the entire experimental area. There was a total of 140 rows and 180 columns of plants in the experimental plot. Yield was recorded separately from each basic unit. The basic units of uniformity trials are combined and curve is plotted by taking plot size and coefficient of variation (CV) under maximum curvature method, whereas Smith variance law was used for fixing optimum plot size under Fair field method.

Soil fertility contour map

It gives a useful demarcation about the fertility status of the experimental plot. It helps to delineate the regions of same fertility. The fertility gradient is divided in to 6 number of classes based on the values and different shades were given to each group. Soil fertility map is used to describe the heterogeneity of the land and also provide the direction of variation in fertility status

$$Fertility\ gradient = \frac{Y_i - \overline{Y}}{\overline{Y}} \times 100$$

Where Y_i is the grain yield from each basic unit and $\overline{Y}$ is the mean yield of the entire plot.

Methods to determine optimum plot size and shape

Maximum curvature method: The basic units of uniformity trial are combined to form new units. Rows, columns or both the units are combined for forming new units in such a way that no rows or columns are left out. Coefficient of variation is calculated for each unit. A graph is plotted with plot size (in terms of basic units) on the X axis and CV on the Y axis. The point at which curve takes a turn *i.e.*, the point of maximum curvature will be taken as the optimum plot size (Prabhakaran *et al*., 1978).

Coefficient of variation per unit area for all possible groupings of different plot size and shape combinations can be calculated with the formula;

$$CV = \frac{\sigma_x}{\overline{Y}_x} \times 100$$

Where, σ_x is the standard deviation per unit area and $\overline{Y}_x$ is the general mean.

The plot size can be identified in this method for which rate of reduction in coefficient of variation is a minimum, and such plot would be just beyond the point of maximum curvature of the curve relating to the plot size and coefficient of variation (Federer, 1967).

Fair field smith variance law: Smith (1938) gave the empirical relation between variance and plot size. For representing the empirical relation between plot size and variance of mean per plot Smith developed a model. The model is represented by,

$$V_x = \frac{V_1}{x^b}$$
$$logV_x = log\,V_1 - b\,log\,x$$

Where x is the number of basic units in a plot, V_x is the variance of mean per plot of x units, V_1 is the variance per plot of one unit and b is the soil heterogeneity index and is the characteristic of soil and measure of correlation among adjacent units.

The first two derivatives of V_X with respect to X were

$$\frac{dV_X}{dX} = V_1(-b)X^{-b-1}$$

$$\frac{d^2V_X}{dX^2} = V_1 b(b+1)X^{-(b+2)}$$

The curvature can be obtained with the formula given by Chopra and Kochhar (1967);

$$C = \frac{[1 + (dV_X/dX)]^2]^{\frac{3}{2}}}{d^2V_X/dX^2}$$

Now, by substituting the values of dV_X/dX and d^2V_X/dX^2 we get the simplified form of the equation as;

$$C = \frac{1}{V_1 b(1+b)}[1 + V_1{}^2 b^2 X^{-2(1+b)}]^{\frac{3}{2}} X^{(2+b)}$$

Equating the first derivative dC/dX to zero will maximize the curvature,

$$\frac{1}{V_1 b(1+b)}\{3/2\,[1 + V_1{}^2 b^2 X^{-2(1+b)}]^{1/2}(V_1{}^2 b^2 - 2 - 2b)X^{-3-2b}X^{2+b}\} + \{[1 + V_1{}^2 b^2 X^{-2(1+b)}]^{3/2}(2+b)X^{(1+b)}\}$$

Equating this to zero and simplifying we get the formula given by Agarwal, 1973.

$$X_{opt}{}^{2(1+b)} = V_1{}^2 b^2\{[3(1+b)/(2+b)] - 1\}$$

RESULTS AND DISCUSSION

Fertility contour map

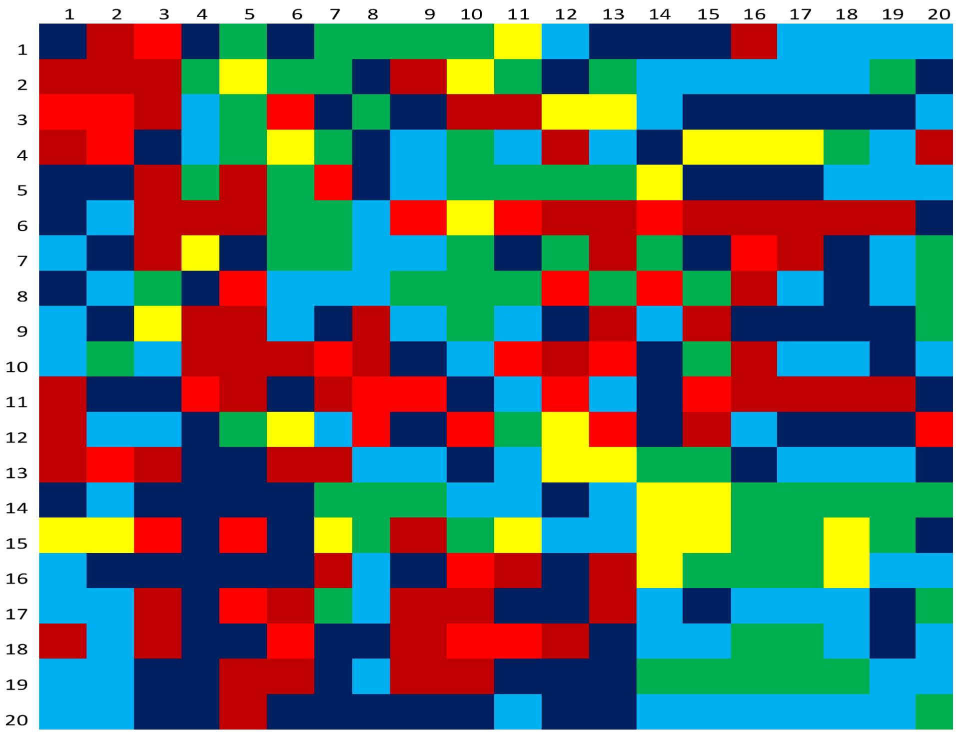
The fertility contour map was prepared based on yield data of 400 basic units from the uniformity trial.

Table 1. Fertility gradient ranges and frequency (number of basic units and percentage) in the experimental area of paddy

Cass interval	Colour	Frequency	Percentage	Cumulative percentage
<-40		28	7	7
(-40 to -20)		72	18	25
(-20 to 0)		93	23.25	48.25
(0 to 20)		104	26	74.25
(20 to 40)		70	17.5	91.75
>40		33	8.25	100

From the table 1 it is very clear that highly fertile areas and very low fertile areas are very less which is accounted for 7 per cent and 8.25 per cent respectively. Almost 50 per cent of area is under average fertility gradient (-20 to 20). Fertility gradient between 0 to 20 per cent shows 26 per cent of area. The fertility gradients 0 to 20 per cent and -20 to 0 are distributed almost equally in area, which can be combined together to estimate the average fertility of the soil.

Fig 1. Fertility contour map of paddy based on yield of original basic units

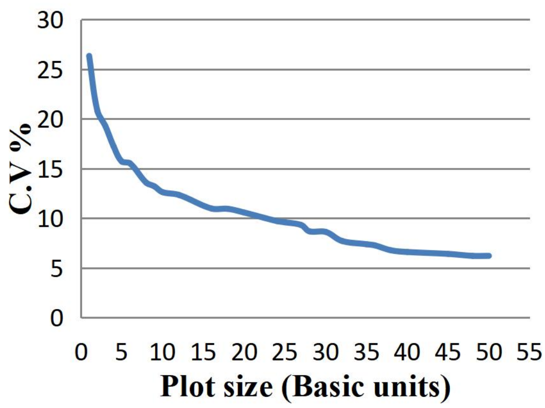


Estimation of Optimum Plot Size

Maximum Curvature Method

It was clearly evident that as the plot size increases the value of coefficient of variation decreases and gradually it approaches a constant value (Fig 2). Since the coefficient of variation is the criteria for selecting optimum plot size under maximum curvature method, the plot size at which the CV becomes a constant can be selected as the optimum plot size. This process becomes difficult to understand about optimum plot size. Hence, reduction in coefficient of variation was considered. Analysing the value of percentage reduction in coefficient of variation, the plot size with 8 basic units showed maximum percentage reduction in CV (12.56%). A similar steep reduction in coefficient of variation was also visible for plot sizes which are the multiples of 8 basic units such as 16 basic units (7.34%), 24 basic units (8.13%) and for 32 basic units (10.54). The per cent reduction in coefficient of variation gradually reduces after a plot size of 24 basic units.

Fig 2. Curve depicting the reduction in coefficient of variation with plot size



The plots of different sizes can be arranged in to different shapes such as vertical plots, horizontal plots, rectangular plots and square shaped plots. The changes in coefficient of variation was different for different plot shapes. To study the changes in CV with plot shapes, they are grouped into different shapes and CV was estimated. A summary of different plot shapes with their coefficient of variation was given in the following table 2.

Table 2. Summary table of plot size and shape along with coefficient of variation

Plot size	Shape	CV	Percentage reduction in CV
18	9 × 2	9.74	0.27
20	10 × 2	9.51	3.37
24	8 × 3	9.34	8.13
25	5 × 5	9.6	1.23

For Uma variety of paddy, coefficient of variation decreases from plot size 1 to 50 units. Gradual decrease in coefficient of variation can be seen up to the plot size 24 basic units and there after the CV remains constant. When we consider the percentage reduction in coefficient of variation the maximum percentage of reduction was seen for the plot size of 24 basic units and also the CV value remains a constant there after for the remaining plot sizes. The percentage reduction in CV also reduces after the plot size of 24 basic units. For the plot size of 24 basic units, different plot shape combinations can be made *i.e.,* 2 × 12 (2 unit breadth and 12 unit length) and 12 × 2 (12unit breadth and 2 unit length), 8 × 3 (8 unit breadth and 3 unit length), 3 × 8 (3 unit breadth and 8 unit length), 4 × 6 (4 unit breadth and 6 unit length) and 6 × 4 (6 unit breadth and 4 unit length). Since long narrow plots were being not recommended for field experiments, rectangular shaped plots can be taken as the optimum plot size. From these different combinations, the plot shape 8 × 3with minimum CV is considered *i.e*, 9.34. So the shape of optimum plot size obtained by this method is 8 unit in breadth and 3 units in length. The area required was 34.56 m^2 (24 × 1.2 m × 1.2 m).

Fairfield Smith's Variance Law

The goodness of fit of regression provided a R^2 value of 0.97 and an adjusted R^2 of 0.97. The ANOVA model of regression and the estimated coefficients are presented as follows (Table 3 and 4).

Table 3. ANOVA model for regression

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	3.94	3.94	730.22	<0.05
Residual	24	0.13	0.005		
Total	25	4.07			

Table 4. Estimated coefficients along with standard error

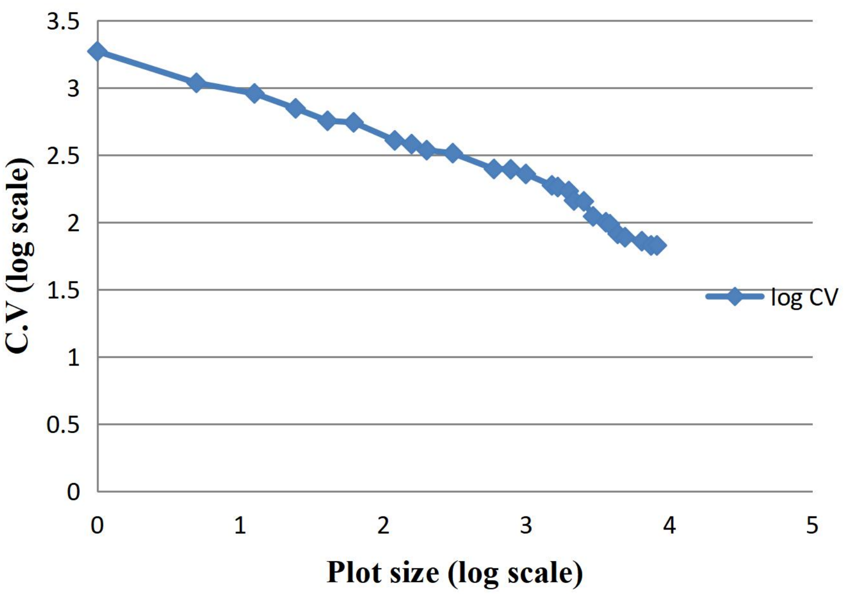
	Coefficients	Standard Error	t Stat	P-value
Intercept	3.37	0.04	84.31	<0.05
b	-0.373	0.01	-27.02	<0.05

The assumed relationship between plot size and coefficient of variation was estimated a multiple R square value of 0.98 and an adjusted R square of 0.97. The R^2 values indicated the best fit of the model. Analysis of variance table shows that regression sum of squares is significant at 5 per cent level of significance. The estimated intercept was 3.37 and b coefficient was 0.373. Hence, the soil heterogeneity coefficient was estimated as 0.373. So, the equation obtained under Fairfield Smith's variance law was written as

$$Y = 29.08X^{-0.373}$$

The R^2 obtained under this method is very high and the value of b is 0.37. It indicates that the field was heterogeneous in fertility.

Fig 3. Graph of coefficient of variation (on log scale) obtained under Fairfield Smith's variance law.



The optimum plot size using Fairfield Smith variance law was given as

$$X_{opt}^{2(1+b)} = V_1^2 b^2\{[3(1+b)/(2+b)] - 1\}$$

The optimum plot size obtained under this method was 6 basic units. So, the area obtained under this method was 8.64 m^2. The plot size of 6 basic units didn't have a minimum value for coefficient of variation when compare the result with maximum curvature graph. Moreover, the area obtained under this method was very less and hence it cannot be recommended as optimum plot size for field experiments on paddy.

CONCLUSION

The Soil fertility contour map revealed that the study area is heterogeneous in fertility. The optimum plot size estimated by combining the basic units of 1.44 m^2 into plots of different sizes along with CV for each plot size. Maximum curvature method and Fair field Smith's variance law was used for estimating the plot size. Generally, these methods need not provide a unique estimate of plot size. The optimum plot size estimated under maximum curvature method was 34.56 m^2 (24 basic units) with rectangular shape and it was same for both methods. Whereas, the optimum plot size estimated under Fairfield Smith's variance law method was 8.64 m^2 and it was not considered as optimum because it was smaller in size.

Funding

Nil

Conflict of interest

Nil

LITERATURE CITED

Agarwal K N 1973. Uniformity trial on apple. *J Hortic* Sci 30: 525-528.

Bharati R C, Chaudhary K K, Singh A K, Kumar A, Kumar U and Chandra N 2017. Efficiency of optimum plot size using information of previous experiments conducted in split plot design. *J Agric Search* 4(1): 60-67.

Federer W T 1967. Experimental Designs. Oxford and IBH Publishing company, Calcutta, Ind Ed 59-85.

KAU (Kerala Agricultural University) 2016. *Packages of Practices Recommendations: Crops* (15th Ed.). Kerala Agricultural University, Thrissur, 392p.

Kavitha B 2010. Study on optimum plot size and plot shape of soybean crop. M.Sc.(Ag. Statistics) thesis, University of Agricultural sciences, Dharwad, 124p.

Masood A, Raza I and Yaseen M 2012. Estimation of optimum field plot size and shape in paddy yield trial. *Pakist J Agric Res* 25(4): 280-287.

Prabhakara P V, Balakrishnan S and George M 1978. Optimum plot size for field trials with banana. *Agric Res J Kerala*. 16(1): 23-25.

Smith H F 1938. An empirical law describing heterogeneity in the yields of agricultural crops. *J Agric Sci* 28(1): 1-23.