ESTIMATION OF OPTIMUM PLOT SIZE AND SHAPE FROM A UNIFORMITY TRIAL FOR FEILD EXPERIMENT WITH SUNFLOWER (*Helianthus annus*) CROP IN SOIL OF HISAR

ABSTRACT

A study of uniformity trial for assessing the nature and magnitude of soil variability and to determine the optimum size and shape of plots was conducted on 66A507 Pioneer hybrid of Sunflower crop at Research Farm of CCS Haryana Agricultural University, Hisar, Haryana during the February 2014 to June 2014, on a field of size 35m×40m which after eliminating border effects reduced to 32m×36m. The total area (~~*i.e.*~~1152 m^2) divided into 1152 basic units, each have size 1m×1m and yield data of all the basic units was recorded separately for further investigations. The coefficient of variation of yield of individual harvested units was observed to be as high as 13.92 per cent indicating high degree of soil heterogeneity. The coefficient of variation decreased with increase in plot size in both the directions *i.e.* when plots were elongated in N-S direction or elongated in E-W direction and the decrease was near about same for both the directions but was more when plots were elongated in N-S direction (~~*i.e.*~~96.48 per cent decrease). The long-narrow plots elongated in N-S direction were found to be more useful than the compact and square plots. It was observed that the smallest plot has the maximum efficiency and the optimum plot size was estimated to be 2 m^2.

Keywords: Coefficient of variation, Direction, Optimum plot size and shape, Sunflower, Uniformity trial

1. INTRODUCTION

The experimental material consists of certain variations which may be inherent like soil variability hence the agricultural field experiments are subject to high degree of error variation. This variability causes variations in the yield from plot to plot in the entire area even when the crops are grown in the similar sized plots and given same treatments, under exactly identical conditions. This sort of variation in the field experiments is measured by the coefficient of variation (CV). Coefficient of variation is directly proportional to the variation in soil fertility and hence high coefficient of variation indicates large variation in the soil fertility and low coefficient of variation indicates small variation in the soil fertility.

In practice, soil fertility has different magnitude for different sizes and shapes of plots. Thus for efficient planning of experiments, our problem will be to find out the best possible sizes and shapes of the plots for experimentation, so that the error variation has minimum effect on treatment comparisons.The selection of suitable sizes and shapes of plots ~~and~~depends both on statistical consideration as well as practical feasibility. From statistical consideration, the estimate of treatment on a given experimental area should be obtained with maximum accuracy, and~~,~~ from a practical point of view, the plots should be sufficiently large so that the various field operations can be done correctly and probably reduce the experimental error.

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For finding the suitable size and shape of plots arrangements that will be most accurate for estimating the treatment means for the given amount of experimental area, it is necessary to have an idea of the magnitude of the experimental error associated with different sizes and shapes of plots. This can be studied by conducting the uniformity trials on the crop in a given area.~~Literature reports~~N~~n~~umerous ~~evidences~~reports (Shafi*et al*., 2009; Storck*et al*., 2010; Patil*et al*.,2010; Prajapati*et al.,* 2011; Masood and Raza, 2012; Khan *et al*., 2017) suggest~~ing~~that optimum plot size for different crops of the region differ. Realizing the importance of sunflower (*Helianthus annuus*), being the third most important oilseeds crop in India after groundnut and mustard, the present study was undertaken to estimate the magnitude of the experimental error associated with the varying sizes and shapes of plots.

2. MATERIALS AND METHODS

The experiment of uniformity trial on sunflower hybrid 66A507 Pioneer was carried out at Research Farm, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during February 2014 to June 2014. The uniformity trial was conducted over a field of area 35m × 40m. At the time of harvest, the experimental field was divided into rows (E-W direction) and columns (N-S direction). But to eliminate the border effects, ~~some of~~the border area from all sides was left as non-experimental area, thereby making out an area of 32m × 36m at the centre of the field. Harvesting of the crop was done separately for all the basic units *i.e.* 1m × 1m and the produce of each unit were recorded separately in grams for further investigation.

The adjacent basic units were combined to form plots of different shapes and sizes, and yield was recorded. ~~Such~~ Theseplots were formed by taking 1, 2, 4, 8 and 16 units along the rows (E-W direction) and also 1, 2, 3, 4, 6, 9, 12 and 18 units along the columns (N-S direction), thus having different shapes and sizes. Coefficient of variation for each size and shape of plot was calculated and the coefficient of variation so obtained was utilized to determine optimum size and shape of plots.

Relationship between CV and size and shape of plots was computed using Smith (1938) equation, which states that

$$V_x = V_1 / X^b \tag{1}$$

Where:~~,~~

V_x is the variance of yield per unit area among plots of size X units,

V_1 is the variance among plots of size unity,

b is thelinear regression coefficient and

X is the number of basic units per plot.

The relative efficiencies (R.E.) of different plot sizes were calculated using method suggested by Agarwal and Deshpande (1967). Taking the efficiency of smallest plot as unity, the relative efficiencies of various plot sizes has been calculated.

$$\text{R.E.} = (CV_1/CV_2)^2 \times (X_1/X_2)^2 \tag{2}$$

where,

CV_1 and CV_2 are the coefficients of variation corresponding for plot sizes X_1 and X_2 respectively.

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The optimum plot size was~~has been~~ calculated using Maximum curvature method and Smith's variance law method.The maximum curvature method(Agarwal, 1973) has frequently been used to determine plot size for various field crops. The formula given by Agarwal (1973)

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

Smith (1938) worked out optimum plot size for different values of costs under assumption of linear cost structure.

$$X_{opt} = \frac{bC_1}{(1-b)C_2} \tag{4}$$

Where~~;~~:

X_{opt} is the optimum plot size which provides the maximum information per unit of cost,

C_1 is that part of total cost which is proportional to no. of plots per treatment and

C_2 is that part of total cost which is proportional to the total area per treatment.

3. RESULTS AND DISCUSSION

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The coefficient of variation of yields of harvested units for various sizes and shapes of plots is given in Table 1.

Table 1: Coefficient of variation for various plot sizes

		No. of units in E-W direction							
		1	**2**	**3**	**4**	**6**	**9**	**12**	**18**
No. of units in N-S direction	**1**	13.92	8.45	7.71	7.08	4.36	1.62	1.75	0.58
	2	10.93	7.51	4.30	3.34	3.26	1.97	0.91	-
	4	8.20	6.14	6.26	5.18	3.77	1.61	-	-
	8	4.21	5.36	4.30	2.21	1.77	-	-	-
	16	0.49	-	-	-	-	-	-	-

A high degree of variability *i.e.* 13.92 per cent was observed which indicates high degree of soil heterogeneity. This variation further reduced with increase in plot size in either direction but the decrease was more when plots were elongated in N-S direction (96.48 per cent) than those elongated in E-W direction (95.83 per cent), indicating thereby that the plots become more homogenous when elongated along N-S direction . This is in agreement with earlier reports of Kaushik*et al.* (1974, 1976, 1977, 1989), Hasija*et al.* (1985), Kumar and Hasija (2002), Kumar *et al.* (2007) and Shafi*et al.* (2009).

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The coefficient of variation for various plot shapes for a given plot size have been calculated are presented in Table 2.

Table 2: Coefficient of variation for various plot sizes and plot shapes

Plot size (in units)	Plot shape	CV (%)	Minimum CV (%)
1	1:1	13.92	13.92
2	1:2	8.45	8.45
	2:1	10.93	
3	1:3	7.71	7.71
4	1:4	7.08	7.08
	2:2	7.51	
	4:1	8.20	
6	1:6	4.36	4.30
	2:3	4.30	
8	2:4	3.34	3.34
	4:2	6.14	
	8:1	4.21	
12	1:12	1.75	1.75
	2:6	3.26	
	4:3	6.26	
16	4:4	5.18	0.28
	8:2	5.36	
	16:1	0.28	
18	1:18	0.05	0.05
	2:9	1.97	

The long-narrow plots elongated in N-S direction had less coefficient of variation than compact and square plots for a given particular plot size. Thus, best plot shape was 1:X, where '1' is the number of units in E-W direction and 'X' is the number of units in N-S direction. The same results were obtained by Hasija*et al.* (1985), Kaushik*et al.* (1989), Kumar and Hasija (2002), Naliyadara*et al.* (2005), Chaudhary *et al.* (2011) and Khan *et al.* (2017).

After having known the best shape, a functional relationship between plot size and coefficient of variation was examined by fitting the equation (1), which comes out to be

$$V_X \quad = \quad 24.785\, X^{-0.299} \qquad\qquad (R^2 = 0.679)$$

The equation was in conformity with Smith's law, where the soil variability index (b) was 0.299, indicating the positive correlation between the adjacent basic units.

The relative efficiencies were computed using equation (2) and are presented in Table 3. Relative efficiency of smallest plot was maximum but efficiency decreases as the plot size increases. Hence, smallest plot was most efficient but convenience of practical operation is to be given due attention.

Table 3: Relative efficiencies of various plot sizes

Plot size (in units)	Plot shape	C.V.	Relative efficiency
1	1:1	13.92	1
2	1:2	8.45	0.678
3	1:3	7.71	0.362
4	1:4	7.08	0.241
6	2:3	4.30	0.292
8	2:4	3.34	0.272
12	1:12	1.75	0.440
16	16:1	0.28	0.076
18	1:18	0.05	0.059

The optimum plot size was worked out by maximum curvature method using equation (3) and was found to be 2 units *i.e.* 2 m^2. The optimum plot sizes were also calculated by Smith's method using equation (4) and results are presented in Table 4. It was observed that the optimum plot size increases with the increase in cost ratio for a given plot arrangement.

Table 4: Optimum plot size under cost consideration

Value of b = 0.299	
C_1/C_2	**Optimum size of plot (m^2)**
0.5	0.214
1.0	0.428
2.0	0.855
3.0	1.283
4.0	1.710
5.0	2.138
6.0	2.565
7.0	2.993
8.0	3.420
9.0	3.848
10.0	4.275

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