STUDY ON OPTIMUM SIZE AND SHAPE OF BLOCKS IN UNIFORMITY TRIAL OF SUNFLOWER (*Helianthus annus*) CROP

ABSTRACT

A uniformity trial for determination of optimum size and shape of blocks was conducted at Research Farm of CCS Haryana Agricultural University, Hisar, Haryana during the February 2014 to June 2014 on sunflower hybrid 66A507 Pioneer, on a field of size 35m × 40m which reduced to 32m × 36m after eliminating border effects. The crops of each basic unit (*i.e.* 1m × 1m) were separately harvested and the contiguous plots were then grouped into blocks of 4, 8, 12 and 16 plots. The blocks elongated in N-S direction were more effective in reducing error variation than those elongated in E-W direction. The coefficient of variation decreases from 14.88 to 7.30 with the increase in block size from 4 to 16 for plot size $1m^2$, thus larger blocks were found to be more efficient than smaller ones. The 16 size block was found more efficient with block shape of 16m × 1m, which should be recommended for further researches on sunflower crop in the particular area. In general, blocks were found to be efficient than without blocking arrangements.

Keywords: Blocks, Coefficient of variation, Efficient, Optimum block size and shape, Sunflower, Uniformity trial

INTRODUCTION

In the agricultural field experiments, the interest of the researcher is studying the effects of various treatments on the crops and making comparisons between them. Examination of new varieties of crops and improved technology adopted in agricultural experiments is also carried out by the researcher. Therefore, the researcher has to estimate the treatment effects with maximum precision and accuracy for the efficient planning of field experiments. For this purpose he has to take into consideration the area under cultivation, the variety of crop, methods adopted and the causes of variations. Principles of design of experiments like randomization, replication and local control can help in improving the efficiency of experimental techniques. Besides these, the size and shape of plots and their arrangement in blocks, significantly affect the efficiency of the experiment and the precision of treatment comparisons. This can be studied by conducting the uniformity trials on the crop in a given area.

In uniformity trials, the same crop variety is grown in the experimental area, under exactly uniform conditions throughout the duration. The entire experimental area is divided into small units of same dimensions, at the time of harvest. Then the crops of each unit are separately harvested and the yield also recorded separately. The adjoining units are combined to the plots and blocks of various sizes and shapes. The coefficient of variation of each combination of plots or blocks is worked out. From this, we can estimate the variation due to the uncontrolled factors. This information is used to compute the relative efficiencies of various plots or block sizes and shapes, taking smallest plots or blocks as the standard unit. A model representing the relation between the coefficients of variation and the plot or block size is fitted. Then various methods can be applied to obtain the optimum size and shape of the plot or block. As the plots are arranged within the blocks in an experimental design, the blocks being of different sizes and shapes, then the investigator requires the information on the efficiency of various types of blocking. The relative efficiency (R.E.) of various block sizes can be obtained by taking the ratio of the error variance of the particular block arrangement to that without block arrangement, and is expressed in percentage.

Not much information is available regarding the real nature of the frequency distribution of the plot yields of various agricultural crops in India. Optimum size and shape of blocks for yield have been estimated for several crops by Agnihotri *et al.* (1995, 1996), Handa *et al.* (1995), Kumar and Hasija (2002), Masood and Javed (2003), Kumar *et al.* (2007), Leilah and Al-Khateeb (2007), Lucas (2007), Kumar *et al.* (2008), Storck *et al.* (2010) and Khan *et al.* (2016). Therefore, it is desirable to study the problem of uniformity trials for sunflower crop, as it being the third most important oilseed crop in India after groundnut and mustard.

MATERIALS AND METHODS

The uniformity trial on 66A507 Pioneer hybrid of sunflower was conducted at Research Farm, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, Haryana over a field of area 35 m × 40 m during the February 2014 to June 2014. Some of the border area from all sides was left as non-experimental area to eliminate the border effects, thereby making area of 32m × 36m at the centre of the field. The experimental field was divided into rows (E-W direction) and columns (N-S direction). The crops of each basic unit (*i.e.* 1m × 1m) were separately harvested and the adjoining basic units were combined to the plots of various sizes and shapes. The contiguous plots were then grouped into blocks of 4, 8, 12 and 16 plots. Coefficient of variation (CV) for each size and shape of blocks was calculated and the coefficient of variation so obtained was utilized to determine optimum size and shape of blocks.

The empirical relationship between block size (X) and block variance (V_x) was given by Smith (1938) to study the effect of block sizes on soil variability. The law states that,

$$V_x = V_1 / X^b \qquad (1)$$

where,

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

V_1 is the variance among plots of size unity,

b is the linear regression coefficient and

X is the number of basic units per block.

The coefficient of determination (R^2) was computed for various fitted equations to examine their suitability. The most suitable equation was reported to have maximum value of R^2.

Optimum block size for a given crop depends on the extent of soil heterogeneity and the cost of experimental operations. As the relative importance of factors responsible for the variability in the data of yield may vary with experiments, therefore, optimum block size is also different for different field experiments. Two methods for determining optimum size and shape of blocks were used, maximum curvature method and Smith's variance law method.

The maximum curvature method (Agarwal, 1973) is the most commonly used method to determine optimum plot and block size for various crops, which states that

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

The cost of field experimentation is an important factor responsible for the optimum block size obtained and hence must be reflected in optimum block size. Optimum block size for different values of costs under assumption of linear cost structure was given by Smith (1938), as

$$X_{opt} = \frac{bC_1}{(1-b)C_2} \qquad (3)$$

where,

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

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

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

Relative efficiencies (R.E.) of different block sizes were calculated using Agarwal and Deshpande (1967) method, as

$$R.E. = (CV_1/CV_2)^2 \times (X_1/X_2)^2 \qquad (4)$$

where,

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

Block efficiency (B.E.) was calculated to estimate the effect of blocking on without blocking. It can be defined by Agarwal and Deshpande (1967) as the ratio of variance without blocking to the variance obtained with blocking, which may be expressed as

$$B.E. = \frac{V_0}{V_B} \qquad (5)$$

RESULTS AND DISCUSSION

It was observed that the minimum coefficient of variations for 4, 8, 12 and 16 plot blocks, for the plots of size 1 unit were 14.48, 11.64, 10.84 and 7.23 per cent, respectively. The same pattern of decreasing CV was observed for all other plot sizes and it was minimum for the largest block size (Table 1). Thus, 16 plot blocks were more efficient than the other block sizes 4, 8 and 12, for the given plot sizes.

Table 1: Coefficient of variation of various plot sizes for different block arrangements

Plot size (in units)	**4-plot block**	**8-plot block**	**12-plot block**	**16-plot block**
1	14.48	11.64	10.84	7.23
2	11.64	7.23	8.82	5.96
3	10.84	8.82	9.53	5.25
4	7.23	5.96	5.25	5.10

6	8.82	5.25	7.82	4.90
8	5.96	5.10	4.90	-
12	5.25	4.90	4.31	3.71
16	5.10	-	3.71	-
18	7.48	4.31	-	3.82

The block shape also has a considerable effect on reducing error variation. For a given block size, generally, the blocks elongated along N-S direction have less C.V. as compared to the block elongated across E-W direction. The reduction was large for bigger size of plots and blocks. It was observed that the long and narrow blocks elongated in N-W direction were the more efficient than the blocks elongated in E-W direction.

The coefficients of variation of different plot sizes and shapes for various sizes of blocks were calculated and the minimum coefficient of variation for a particular plot size and shape was selected for further calculations and are given in Table 2.

Table 2: Coefficient of variation for different plot sizes and shapes under 16 plots block

Plot size (in units)	Plot shape	Block size	Block shape	Minimum CV
1	1:1	16	16:1	7.23
2	1:2	16	16:1	5.96
	2:1		8:2	
3	1:3	16	16:1	5.25
4	1:4	16	16:1	5.10
	2:2		8:2	
	4:1		4:4	
6	1:6	16	16:1	4.90
	2:3		8:2	
8	-	16	-	-
12	1:12	16	16:1	3.71
	2:6		8:2	
	4:3		4:4	
16	-	16	-	-
18	1:18	16	16:1	3.82
	2:9		8:2	

The earlier findings concluded that 16 plots block were more efficient than the other block sizes and for 16 plots block, the most efficient block shape was 16:1 as it have minimum coefficient of variation, so we have concluded that 16 plots block elongated in N-S direction was found to be efficient with block shape 16:1 for sunflower crop.

The Smith (1938) relation between plot size (X) and coefficient of variation (V_X) was found to be most suitable for all blocks and the results are presented in Table 3.

Table 3: Fairfield Smith's equation for different block arrangements

Type of arrangement	Smith's equation $V_X = V_1 X^{-b}$	R^2
4 plot block	$14.644\ X^{-0.329}$	0.813
8 plot block	$10.286\ X^{-0.329}$	0.907
12 plot block	$11.464\ X^{-0.369}$	0.835
16 plot block	$7.0452X^{-0.229}$	0.963

The coefficients of determination (R^2) for various block arrangements of the Smith's equations vary from 0.813 to 0.963 when plot sizes were considered. Also the index of soil variability (b) varies from 0.229 to 0.329, which also indicated that 16 plots block was more efficient than other block sizes as it has highest value of R^2 and supported the previous findings of the study.

The optimum plot size have been worked out for 4, 8, 12 and 16 plot blocks using equation (2) and are presented in Table 4. It was observed that the optimum plot size for different block arrangements comes out to be 2 or 1 units. Hence, it was concluded that optimum plot sizes for various block sizes was 2 or 1m^2.

Table 4: Optimum plot size with blocking

Type of arrangement	Value of V	Value of b	Optimum plot size (in units)	Optimum plot size (in m^2)
4-plot block	14.01	0.329	2	2
8-plot block	10.29	0.329	1	1
12-plot block	11.44	0.369	2	2
16-plot block	7.04	0.229	1	1

The optimum plot sizes were computed for the various block arrangements considering the values of C_1/C_2 from 0.5 to 8 using equation (3) and the results are presented in Table 5. It was observed that for a given block arrangement, the optimum plot size increases with the increase in the cost ratio i.e. when the fixed cost becomes larger than the variable cost.

Table 5: Optimum plot size under cost consideration

Type of arrangement	Value of b	C1/C2								
		0.5	1	2	3	4	5	6	7	8
4-plot block	0.329	0.246	0.492	0.983	1.475	1.967	2.458	2.949	3.441	3.933

8-plot block	0.329	0.246	0.492	0.984	1.476	1.968	2.460	2.953	3.445	3.937
12-plot block	0.369	0.293	0.586	1.172	1.758	2.344	2.930	3.516	4.102	4.688
16-plot block	0.229	0.148	0.298	0.595	0.896	1.191	1.488	1.786	2.084	2.382

The relative efficiencies of various plot sizes for 4, 8, 12 and 16 plot blocks were calculated using equation (4) and presented in Table 6. It was observed that the relative efficiency decreases with increase in the plot size for all the block arrangements, indicating that the smallest plots were the most efficient ones.

Table 6: Relative efficiency of different plot sizes in various block arrangements

Plot size (in units)	4-plot block	8-plot block	12-plot block	16-plot block
1	1	1	1	1
2	0.387	0.648	0.377	0.367
3	0.198	0.193	0.144	0.211
4	0.251	0.238	0.266	0.125
6	0.075	0.137	0.053	0.061
8	0.092	0.081	0.076	-
12	0.053	0.039	0.044	0.026
16	0.032	-	0.033	-
18	0.012	0.022	-	0.011

The block efficiencies for different plot arrangements within the blocks were calculated using equation (5) and presented in Table 7, along with respective coefficients of variation. It was observed that the block efficiency generally increases with the increase in the block size, for the given size and shape of plots. Thus the 16 plots block was more efficient than 4, 8 and 12 plot blocks. There is no consistency in the effect of the shape of the blocks, so long as its size was the same. However, the coefficients of variation in case of blocking was less than those in without blocking, thus indicating the gain in efficiency due to blocking. The increase in the block size for a given plot size leads to the increase in the block efficiency. Hence larger blocks were found more effective in reducing the error variability than the smaller blocks.

Table 7: Coefficient of variation and block efficiency for various plots and block sizes

Plot size (in units)	Without blocking	4-plot block		8-plot block		12-plot block		16-plot block	
	CV	CV	BE	CV	BE	CV	BE	CV	BE
1	13.92	14.48	0.961	11.64	1.196	10.84	1.284	7.23	1.926
2	8.45	11.64	0.726	7.23	1.169	8.82	0.958	5.96	1.417
3	7.71	10.84	0.712	8.82	0.874	9.53	0.809	5.25	1.469
4	7.08	7.23	0.980	5.96	1.188	5.25	1.349	5.10	1.388
6	4.30	8.82	0.487	5.25	0.818	7.82	0.549	4.90	0.877
8	3.34	5.96	0.559	5.10	0.654	4.90	0.681	-	-

12	1.75	5.25	0.333	4.90	0.357	4.31	0.405	3.71	0.471
16	0.28	5.10	0.056	-	-	3.71	0.076	-	-
18	0.05	7.48	0.006	4.31	0.012	-	-	3.82	0.013

CONCLUSIONS

It was observed that the blocks elongated in N-S direction were more effective in reducing error variation than those elongated in E-W direction. The coefficient of variation decreases with increase in the block size, indicating that as the size of block increases, the homogeneity within the block also increased. 16 plot blocks were more efficient than the other block sizes, for the given plot sizes. The optimum block size obtained by the maximum curvature method for 4, 8, 12 and 16 plot blocks was varied from 1 m^2 or 2 m^2. Also coefficient of variation without blocking was much higher in comparison with the coefficient of variation with blocking, proving that blocking is beneficial in reducing error variation.

REFERENCES

Agarwal, K.N. Uniformity trial on apple. Jour. of Horti. Sci. 1973; **30**:525-528.

Agarwal, K.N. and Deshpande, M.R. Size and shape of plots and blocks in field experiments with dibbled paddy. Indian Jour. of Agril. Sci. 1967; **37**(6):445-455.

Agnihotri, Y. and Agarwal, M.C. Uniformity trials for determination of optimum size and shape of plots/ blocks for experimentation with *Acacia catechu*. The Indian Forester. 1995; **121**(8).

Agnihotri, Y., Agarwal, M.C. and Kumar, N. Size and shape of plots and blocks for field experiment with Eucalyptus in Shivalik Hills. Indian Jour. Forestry. 1996; **19**(1):74-78.

Handa, D.P., Sreenath, P.R. and Rajpali, S.K. Uniformity trial with Lucerne grown for fodder. Grass and Forage Science. 1995; **50**(3):209-216.

Khan, M., Hasija, R.C., Aneja, D.R. and Sharma, M.K. A uniformity trial on Indian mustard for determination of optimum size and shape of blocks. Jour. of Applied and Natural Science. 2016; **8**(3):1589-1593.

Kumar, A., Kapoor, K., Gupta, S.C. and Hasija, R.C. Uniformity trial on sesame (*Sesamum indicum*). Environment and Ecology. 2007; **255**(2):295-298.

Kumar, A., Pandey, V., Shekh, A.M., Dixit, S.K. and Kumar, M. Evaluation of crop soybean (*Glycine max* [L] Merrill) model under varying environmental condition. American-Eurasian Journal of Agronomy. 2008; **1**(2):34-40.

Kumar, M. and Hasija, R.C. A study in size and shape of plots with wheat (*Triticum aestivum* L.). Annals of Agric. Bio. Res. 2002; **7**(1):89-93.

Leilah, A.A. and Al-Khateeb, S.A. Convenient quadrat size, shape and number in the desert rangeland of Saudi Arabia. Pakistan Jour. Agric. Res. 2007; **20**:62-70.

Lucas, L.G. Field plot techniques for cotton experiments. M. S. Thesis, University of Philippines, Los- Baos; 2007.

Masood, M.A. and Javed, M.A. Variability in field experiments in maize crop in Pakistan. Pakistan J. Agric. Sci. Faisalabad. 2003; **40**(3-4):207-209.

Smith, H.F. An empirical law describing heterogeneity in the yields of agricultural crops. Journal of Agricultural Science. 1938; **28**:1-23.

Storck, L., Filho, A.C., Lopes, S.J., Toebe, M. and de Silveira, T.R. Experimental plan for single, double and triple hybrid corn. Maydica. 2010; **55**:27-32.