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

ABSTRACT

A uniformity trial for the determination of optimum size and shape of blocks was conducted at CCS Haryana Agricultural University research farm, Hisar, Haryana from February 2014 to June 2014 on sunflower hybrid 66A507 Pioneer, on a field of size 35 m × 40 m, which reduced to 32 m × 36 m after eliminating border effects. The crops of each basic unit (1 m × 1 m) were separately harvested and the contiguous plots grouped into blocks of 4, 8, 12 and 16 plots. The blocks elongated in the N-S direction were more effective in reducing error variation than those elongated in the E-W direction. The coefficient of variation decreased from 14.88 to 7.30 with increase in block size from 4 to 16 for plot size 1 m^2, thus larger blocks were found to be more efficient (R^2 = 0.963 for 16-plot blocks) than smaller ones. The 16 size block was found to be more efficient with block shape of 16 m × 1 m, which should be recommended for further researches on sunflower crop in the particular area. In general, blocking arrangements were found to be more efficient than those without blocking.

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

INTRODUCTION

In agricultural field experiments, the interest of the researcher is to study 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 causes of variations. Principles of experimental designs like randomization, replication and local control can help in improving the efficiency of experimental techniques. Beside these, the size and shape of plots and their arrangement in blocks, significantly affect the efficiency of the experiment and 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 was grown in the experimental area under exactly uniform conditions throughout the duration. The entire experimental area was divided into small units of same dimensions, at the time of harvest. The crops of each unit are then separately harvested and yield was also recorded separately. The adjoining units were combined to the plots and blocks of various sizes and shapes. The coefficient of variation of each combination of plots or blocks was worked out. From this, we can estimate the variation due to the uncontrolled factors. This information was 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 was fitted. Various methods can then be applied to obtain the optimum size and shape of the plot or block. As the plots were arranged within the blocks in an experimental design, the blocks being of different sizes and shapes, 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 was expressed in percentage.

Little 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 [1], [2], [3], [4], [5], [6], [7], [8], [9], [10] and [11]. Therefore, it is desirable to study the problem of uniformity trials for sunflower crop, as it is 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 Department of Genetics and Plant Breeding research farm, CCS Haryana Agricultural University, Hisar, Haryana on a field of size 35 m × 40 m and net area 32 m x 36 m to eliminate the border effects from February 2014 to June 2014. The experimental field was divided into rows (East-West direction) and columns (North-South direction). The crops of each basic unit (1 m × 1 m) 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) to study the effect of block sizes on soil variability was obtained using Smith's law [12] which states that:

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

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 will be that having maximum R^2 value.

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 was 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 [13] is commonly used method for determining the optimum plot and block size for various crops, which states that:

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

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 [12], as follows:

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

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 the method of Agarwal and Deshpande [14], as follows:

$$\text{R.E.} = (CV_1/CV_2)^2 \times (X_1/X_2)^2 \tag{4}$$

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 no blocking. It can be defined by [14] as the ratio of variance without blocking to the variance obtained with blocking, which may be expressed as

$$\text{B.E.} = \frac{V_0}{V_B} \tag{5}$$

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 block sizes and it was found minimum for the 16 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 blocks	8-plot blocks	12-plot blocks	16-plot blocks
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 had a considerable effect on reducing error variation. For a given block size, generally, the blocks elongated along the N-S direction have lower CV as compared to blocks elongated along the E-W direction. The CV decreased with increasing size of plots and blocks. It was observed that long and narrow blocks elongated in the N-S direction were more efficient than those elongated in the E-W direction. N-S direction is effective to reduce the error. Error reduces due to direction or more penetration of light in the crop. Similar results were also reported by [6] and [11].

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 as shown in Table 2.

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

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 of this study concluded that 16 plot blocks were more efficient than the other block sizes on the basis of CV and for 16 plot blocks, the most efficient block shape was 16:1 as it have minimum coefficient of variation, so we have concluded that 16 plot blocks elongated in N-S direction was found to be efficient with block shape 16:1 for sunflower crop.

Smith's relation between plot size (X) and coefficient of variation (V_X) was found to be the most suitable for all blocks as shown 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 blocks	$14.644\ X^{-0.329}$	0.813
8 plot blocks	$10.286\ X^{-0.329}$	0.907
12 plot blocks	$11.464\ X^{-0.369}$	0.835
16 plot blocks	$7.0452X^{-0.229}$	0.963

The coefficients of determination (R^2) for various block arrangements of the Smith's equations varied from 0.813 to 0.963 when plot sizes were considered. Also, the index of soil variability (b) varied from 0.229 to 0.329, which also indicated that 16 plot blocks were more efficient than other block sizes since they had the highest R^2 value. This observation is in conformity with previous findings of [4], [6] and [11].

The relationship between the plot sizes and the coefficients of variation for the different block sizes has been represented graphically in Figure 1- Figure 4.

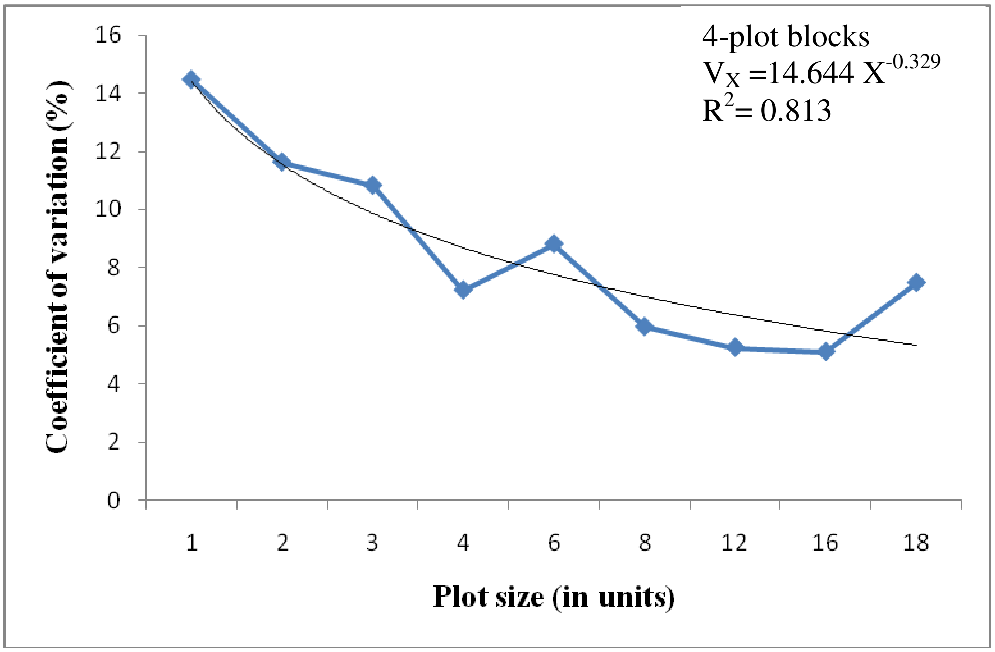

Figure 1: Coefficient of variation in relation to size of plot for 4-plot blocks

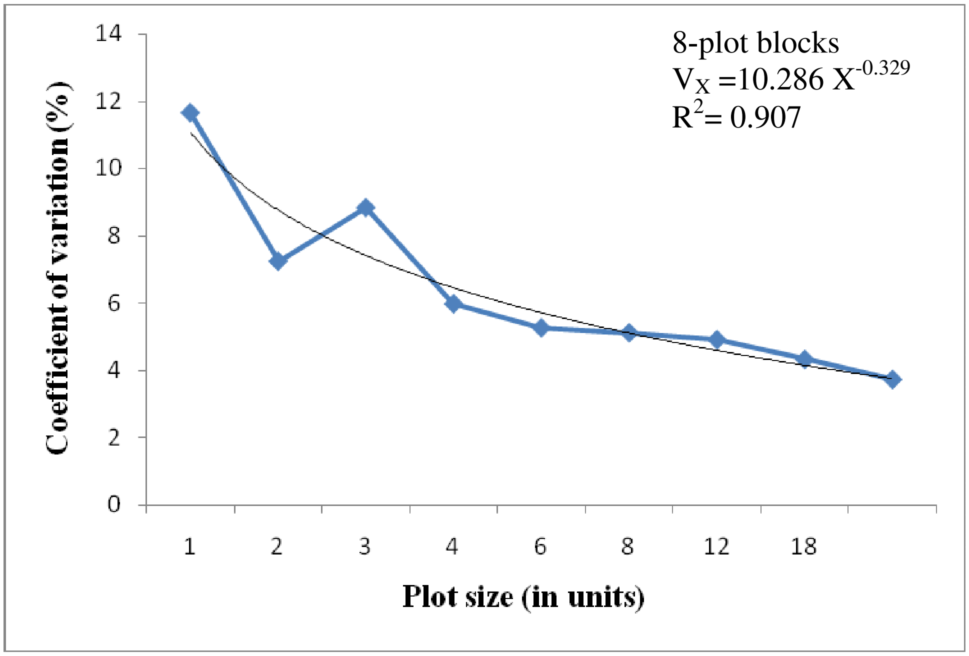

Figure 2: Coefficient of variation in relation to size of plot for 8-plot blocks

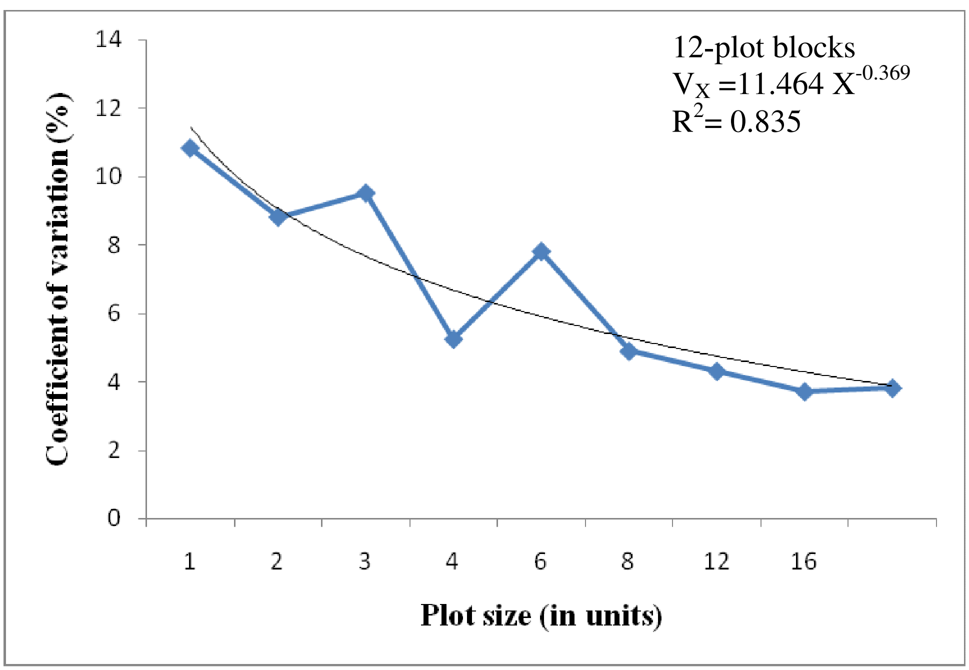

Figure 3: Coefficient of variation in relation to size of plot for 12-plot blocks

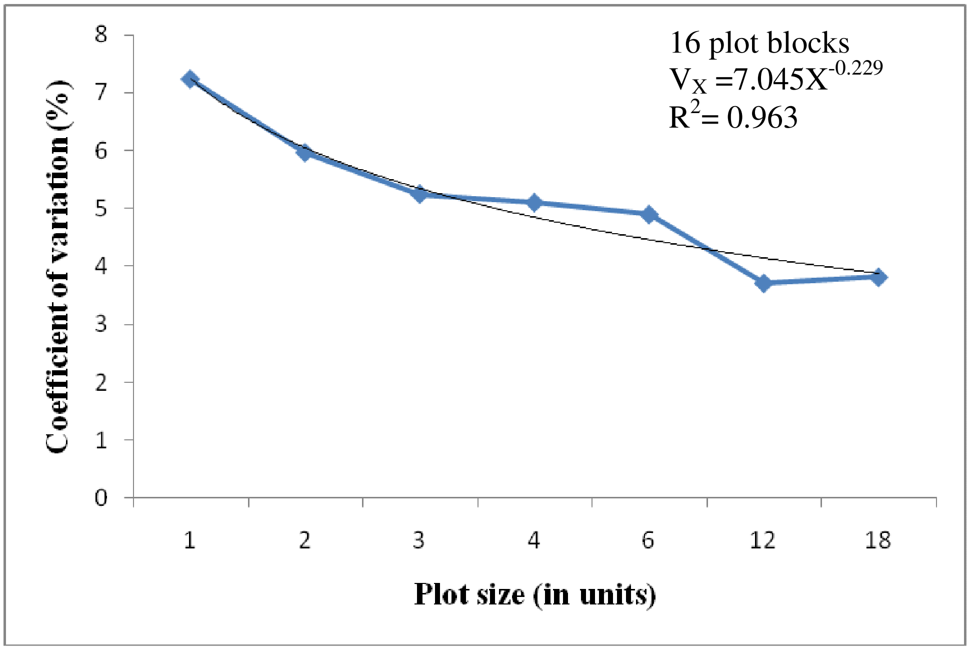

Figure 4: Coefficient of variation in relation to size of plot for 16-plot blocks

The optimum plot sizes were 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 1 m^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 blocks	14.01	0.329	2	2
8-plot blocks	10.29	0.329	1	1
12-plot blocks	11.44	0.369	2	2
16-plot blocks	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 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 blocks	0.329	0.246	0.492	0.983	1.475	1.967	2.458	2.949	3.441	3.933

8-plot blocks	0.329	0.246	0.492	0.984	1.476	1.968	2.460	2.953	3.445	3.937
12-plot blocks	0.369	0.293	0.586	1.172	1.758	2.344	2.930	3.516	4.102	4.688
16-plot blocks	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 are presented in Table 6. It was observed that the relative efficiency decreases from 1 to 0.011 for 16-plot blocks with increase in the plot size from 1 m^2 to 18 m^2 and the pattern was same for all other 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 blocks	8-plot blocks	12-plot blocks	16-plot blocks
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 are presented in Table 7, along with respective coefficients of variation. It was recorded that the block efficiency generally increases with 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 the N-S direction were more effective in reducing error variation than those elongated in the E-W direction. The coefficient of variation decreased with increase in block size, indicating that as the size of block increases, the homogeneity within the block also increases. The 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 varies from 2 m^2, 1 m^2, 2 m^2 and 1 m^2 respectively. Also, coefficient of variation without blocking was much higher compared to coefficient of variation with blocking; meaning that blocking is beneficial in reducing error variation.

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REFERENCES

1. Agnihotri Y, Agarwal MC. Uniformity trials for determination of optimum size and shape of plots/ blocks for experimentation with *Acacia catechu*. Indian Forest. 1995;**121**(8):711-716.

2. Handa DP, Sreenath PR, Rajpali SK. Uniformity trial with Lucerne grown for fodder. Grass and Forage Sci. 1995;**50**(3):209-216.

3. Agnihotri Y, Agarwal MC, 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.

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

5. Masood MA, Javed MA. Variability in field experiments in maize crop in Pakistan. Pakistan Jour Agric Sci Faisalabad. 2003;**40**(3-4):207-209.

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

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

8. Lucas LG. Field plot techniques for cotton experiments. M.S. Thesis, University of Philippines, Los- Baos. 2007.

9. Kumar A, Pandey V, Shekh AM, Dixit SK, Kumar M. Evaluation of crop soybean (*Glycine max* [L] Merrill) model under varying environmental condition. American-Eurasian Jour Agron. 2008;**1**(2):34-40.

10. Storck L, Filho AC, Lopes SJ, Toebe M, de Silveira TR. Experimental plan for single, double and triple hybrid corn. Maydica. 2010;**55**:27-32.

11. Khan M, Hasija RC, Aneja DR, Sharma MK. A uniformity trial on Indian mustard for determination of optimum size and shape of blocks. Journal of Applied and Natural Sci. 2016;**8**(3):1589-1593.

12. Smith HF. An empirical law describing heterogeneity in the yields of agricultural crops. Jour Agric Sci. 1938;**28**:1-23.

13. Agarwal KN. Uniformity trial on apple. Jour Hort Sci. 1973;**30**:525-528.

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