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Estimation of Optimum Field Plot Size and Shape and Number of Replicates in Sorghum Yield Trials

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Abstract. Two uniformity trials were conducted to determine the index of soil variability, optimum size and shape of plots and the suitable number of replicates for sorghum fodder yield trials. Optimum plot size was calculated using three methods viz. Smith's method, modified maximum curvature technique and the comparable variance. Obtained results revealed that index of soil variability was 0.485 and 0.467 in the first and second seasons, respectively. The optimum plot size was estimated to be 4, 5 and 6 times the basic unit, comprising an area of 4.80, 6.00 and 7.20 m^2 for Smith's method, modified maximum curvature technique and the comparable variance, respectively. Plot shape had insignificant effect on variance in this investigation whenever the variability in soil was not clear. Therefore, a rectangular plot (2.0 x 3.6 m) might be most efficiently handled. Increasing number of replications resulted in marked reduction in standard error. The rate of the decrease reached its maximum up to 4-6 replicates. The recommended number of replicates to detect differences at 20 and 15% of the mean were 4 and 6 replicates, respectively.

Introduction

One of the problems that usually face research workers in all phases of field experimentation, regardless of how the trial is handled with respect to the treatment, is the variation in yield and other character estimates. This variation fluctuates according to the size and shape of plots as well as the number of replicates in a trial. This variation is different for each crop and varied from site to another and even in different fields in the same site. Experimenters are concerned with decreasing the size of this variation to increase the accuracy of the experiment. Uniformity trials have been used to estimate soil variation and hence to determine the optimum plot size and shape as well as the suitable number of replications (Lin *et al.* [1]). Abuse the optimum plot size is a problem that confronts researchers in field trials. The problem often arises because the variability of the experimental area is usually unknown, and, consequently, the precision desired to detect differences may not be attained because of an insufficient size and number of plots. Lin *et al.* [1] reported that the optimum plot size for field experiments depends on the soil heterogeneity in the field. A soil heterogeneity index can be used to calculate optimum plot size, but the use of this index is affected by whether the value is persistent over years and crops. Lakhera and Ali [2] in sunflower yield trial found that Smith's coefficient of heterogeneity (b) was 0.2133 which explained 93.92 % of variation.

Mohamed [3] stated that the optimum plot size for sorghum was estimated over three seasons as 6.9 m^2 with guard rows and 4.4 m^2 for unguarded plots, with long narrow plots being less variable. Seif *et al.* [4] worked on sweet sorghum and berseem forage crops and found that as the plot size increased, the variance among plots increased, the variance per basic unit and coefficient of variability tended to decrease. Optimum plot size was recommend to be 9.0 x 1.0 m for Egyptian clover trials and 6.0 x 2.8 m for sorghum trials. Patil and Yaduraju [5] reported that the optimum plot size of wheat ranged from 2.3 to 9.2 m^2 depending on the ratio of overhead cost : cost per unit area. Blocks of 20 plots (1.8 - 3.6 X 4.0 m) in 2 rows of 10 plots or in a single row of 20 plots had low variation as compared with other plot arrangements. The recommended number of replications depended on the size of plots and blocks. Saad [6] determined the optimum plot size of soybean as 0.60 X 3.5 m which represents a 3.5 m length of a single ridge. Lakhera and Ali [2] found that coefficient of variation (CV) decreased with an increase in plot size. They added that the efficiency was higher for smaller plots. Smaller plots required more replications but less area than larger plots. A plot size of 20 basic units (i.e. 9.0 m^2) appeared as an optimum plot size with 10 rows each of 2.0 m long. Lin *et al.* [1] stated that the optimum plot size for field experiments depends on the heterogeneity of plots in the field. The persistence of the index across different years was measured by two statistics: (1) a simple correlation of b-values between two corresponding sets of coordinates and (2) a percentage of the total number of grid points, in each paired set, where the b-value categories matched (b = 0.0-0.3, 0.3-0.7, and 0.7-1.0). The former statistic measured the persistence of b-values across years, and the latter measured the pattern persistence. Positive correlation was observed in two of the four fields, while the percentage of pattern persistence was 50% or greater in five out of the 10 cases compared. Saad [7] stated that the optimum plot size for *Vicia faba* in the two seasons studied was 0.6 X 3.5 m. Singh *et al.* [8] conducted a uniformity trial on chickpea (*Cicer arietinum* L.) to determine the optimum plot size using multivariate approach and relative precision of experimental designs. They found that the optimum plot size was 5.0 m^2.

In considering plot shape, many researchers found that plot shape generally had a little effect on the variance value. The long and narrow plots were effective in reducing the variance per unit area or the coefficient of variability in the more heterogeneous soils or when the long axis of the plot was oriented to the fertility gradient (El-Kalla *et al.* [9], Leilah [10], Seif *et al.* [4], El-Kalla *et al.* [11]and Leilah [12]).

Increasing number of replications resulted in marked reduction in standard error (Leilah *et al.* [13]). The suitable number of replications varies from a trial to another according to soil heterogeneity value. El-Kalla *et al.* [14] showed that the number of replications required to detect mean differences decreased as plot size increased. The recommended number of replications required to detect 15 and 20% differences of the mean was 10 and 6 replicates, respectively.

Objective: The purpose of the present investigation was to search in some factors that help experimenters in the current of field trials for minimizing the variation in yield estimates in order to assure the most reliable results from their experiments and consequently to increase its precision. Therefore, estimating the index of soil variability, the optimum size and shape of plots and the suitable number of replicates for sorghum (*Sorghum Vulgare*, L.) fodder yield trials was the main objective.

Materials and Methods

Two uniformity trials on sorghum were conducted during 2000 and 2001 summer seasons at the Agriculture and Veterinary Experimental Station, King Faisal University. Cultivar " Sorgo" was used in this investigation. The field was well prepared, thereafter, it was ridged and divided into 12 strips, each strip contained 36 ridges, in addition to five guarded ridges in each side of strip end. The ridge (basic unit) was 60 cm in width and 2.0 m in length with an area of 1.2 m^2.

Seeds were sown manually during the first week of March at the rate of 75 kg/ha on ridges, 15 cm apart and thereafter, plots were immediately irrigated. Other irrigations were performed approximately at 10 days intervals. Phosphorus fertilizer at a rate of 60 Kg P_2O_5 /ha in the form of calcium super phosphate (15.5% P_2O_5) was broadcasted prior to sowing. Nitrogen with at a rate of 150 kg N / ha in the form of Urea (46.6 % N) was applied into two equal doses 20 and 40 days after sowing. The previous crop was potatoes in both seasons. Weeds were manually controlled twice. Normal cultural practices for cultivation sorghum crop were practiced.

At flowering stage, sorghum plants in each ridge (basic unit) for the inner 12 strips and inner 36 ridges in each strip were separately harvested. Thereafter, plants were weighed to the nearest gram to obtain 432 basic unit values. Values of fodder yield in each ridge per each strip were organized in a sheet which were combined to give 53 combinations of different plot sizes and shapes and subjected to the statistical procedures to estimate the following statistical parameters:

1. Testing normality

Test of goodness of fit of the observed data to the normal distribution was conducted using the following chi-square test equation:

$$\text{chi-square } (X^2) = \Sigma (O - E)^2 / E$$

Where:

Σ = The sum of.
O = Observed frequency.
E = Expected frequency.

2. Soil heterogeneity index "b"

The soil heterogeneity index (b) was calculated for each trial as proposed by Federrer [15] as follows:

$$b = \frac{\Sigma W_i \text{ Log } V_x \times \text{Log } X_i - \Sigma (w_i \text{ Log } V_x) (\Sigma w_i \text{ Log } X_i) / \Sigma W_i}{\Sigma W_i (\text{Log } X_i)^2 - \Sigma(w_i \text{ Log } X_i)^2 / \Sigma W_i}$$

Where:

b = Weighted index of soil variability.
V_x = The variance per unit area among plots.
X_i = The number of basic units in the plot.
W_i = The degrees of freedom associated with variance.

3. Optimum plot size

Three main methods were used to estimate optimum plot size (in terms of number of adjacent basic units grouped to form a larger plot):

I) The first method used was that proposed by Smith [16] and developed by Hatheway [17].

The optimum plot size (x) for unguarded plot ignoring cost factors was estimated from the following equation: X = b / (1 - b)

Where: X = number of basic unit.
b = index of soil variability.

II) The second method used was the comparable variance (V) as suggested by Keller [18]: $V = V(x)/X^2$

Where: V = comparable variance.
$V_{(x)}$ = is the variance among plots.
X = is the number of basic units in the plot.

Ratio between values of comparable variance (V) for different plot sizes were compared with that obtained from one basic unit size as percent to obtain a measure of relative information (R.I.) which decreased rapidly to a point (the optimum plot size) and changed relatively in small amount after this point.

III) The maximum curvature technique, which was modified by Lessman and Atkins [19], Meier and Lessman [20] and Galal and Abou El-Fittouh [21]. The point of maximum curvature (X_0) for the curve C.V. = A X^{-b} describe the relationship between the coefficient of variability (C.V.) and plot size (X). It was determined using the following equation: $X_0 = [A^2 B^2 (2B + 1)/(B + 2)^{1/(2B + 2)}]$.

The previous equation may be converted to a logarithmic form as follows:

$$\log X_0 = \frac{2 \log A + 2 \log B + \log (2B + 1) - \log (B + 2)}{(2B + 2)}$$

Using the principles of linear regression, values A and B in the above equation were estimated as follows:

$$B = \frac{n \sum \log (C.V.) \log x - \sum \log (C.V.) \sum \log x}{n \sum (\log x)^2 - (\sum \log x)^2}$$

$$\text{Log } A = \frac{\sum \log (C.V.)}{n} - B \frac{\sum \log x}{n}$$

The plot size directly beyond the X_0 value presented in the curve is considered the optimum size.

4. Plot shape:

The effect of plot shape (in terms of varying the basic units grouping in various patterns) on the variability among plots was determined by dividing the larger comparable variance by the smaller one within the same size to obtain value. The two-tail F test was used to test the significance of the F value.

5. Number of replications

The relationship between standard error ($s_{\bar{x}}$) and number of replications (r) for plot sizes contained from 2 to 12 basic units was determined using the following formula:

$$s_{\bar{x}} = \sqrt{\frac{V_x}{r}}$$

The number of replication (R) required to detect true differences of 15 and 20% of the means at the 5% level of significance with 80% of experiments (assurance) was estimated using the following formula, according to Hatheway [17]:

$$R = 2(t_1 + t_2)^2 (C.V.)^2/d^2 x^b$$

Where:

t_1 : is the significant value of t in the test of significant (0.05).
t_2 : is the value of t in the table corresponding to 2 (1 - P).
P : is the probability of obtaining a significant result and detecting the difference.
C.V. : is the coefficient of variability of plots one unit in size.
d : is the true difference to be detected between means in percent of the mean.

Results and Discussion

1. Testing normality

Test of goodness of fit of the observed data (fodder yield of sorghum) to the normal distribution revealed that the collected data were normally distributed during the two seasons. Thus, no transformation of data was needed.

2. Index of soil variability

The weighed index of soil variability (b) was estimated to be 0.485 and 0.467 in the first and second seasons, respectively. This indicates that an intermediate homogeneity is existing in the experimental site. So, some attention needs to be taken in the determination of plot size in sorghum experiments or fodder yield production under this condition. Knowing the variation present in the soil that will be used for experimental purposes is very important in influencing the size and shape of plots in field trials for various crops, i.e. the optimum plot size and shape largely depends on the coefficient of soil heterogeneity estimates. Soil variability (b) ranges from 0 to 1. A value of b approaching unity indicates a low correlation between adjacent units and conversely, a value near zero indicates a high degree of similarity between adjacent plots. In other words, it can be stated that as the coefficient of soil heterogeneity increased, the optimum plot size increased and vice versa [9, 10,13].

3. Plot size

Data listed in Table (1) reveal that as the plot size (x) increased, the variance among plots (V(x)) and comparable variance (v) increased. On the contrast, the variance per basic unit (Vx), and coefficient of variability (c.v.%) tended to decrease with each increase in plot size. These results are in harmony with those obtained by several investigators, including El-Kalla *et al.* [14], Leilah [10], Leilah *et al.* [13]. The convenient plot size was estimated using the following three methods:

3.1. Smith method

Smith's index of soil variability (b), the regression of plot variances on plot size, is used primarily to derive optimum plot size. The index gives a single value as a quantitative measure of soil heterogeneity in the adjacent plot yields. Substitution these values into Smith's equation gave an estimation of optimum plot size (without border) as 2.0 basic units in the first and second seasons.

Table 1. Variance among plots, V(x), variance per basic unit, Vx, and coefficient of variability, C.V%, for the different combinations of plot size and shape in sorghum uniformity trials

Plot size Units (X)	Strip	Row	2000			2001		
			$V_{(x)}$	V_x	CV %	$V_{(x)}$	V_x	CV %
1	1	1	2.17	2.17	18.82	2.42	2.42	21.07
2	1	2	5.51	1.38	15.00	6.04	1.51	16.65
3	1	3	9.22	1.02	12.93	10.59	1.18	14.69
4	1	4	14.38	0.90	12.11	17.30	1.08	14.09
6	1	6	26.04	0.72	10.87	30.94	0.86	12.56
9	1	9	51.44	0.64	10.18	60.34	0.74	11.69
12	1	12	76.71	0.53	9.33	99.28	0.69	11.25
18	1	18	108.72	0.34	7.40	155.42	0.48	9.38
36	1	36	223.84	0.17	5.31	210.02	0.16	5.45
2	2	1	5.63	1.41	15.16	6.00	1.50	16.59
4	2	2	15.71	0.98	12.66	16.87	1.05	13.91
6	2	3	28.52	0.79	11.37	33.28	0.92	13.02
8	2	4	44.39	0.69	10.64	54.36	0.85	12.48
12	2	6	85.45	0.59	9.84	103.45	0.72	11.48
18	2	9	184.03	0.57	9.63	199.85	0.62	10.64
24	2	12	274.85	0.48	8.83	341.32	0.59	10.43
36	2	18	386.21	0.30	6.98	508.57	0.39	8.49
72	2	36	782.30	0.15	4.96	583.50	0.11	4.54
3	3	1	10.80	1.20	14.00	10.94	1.22	14.94
6	3	2	31.67	0.88	11.98	32.89	0.91	12.95
9	3	3	58.00	0.72	10.81	67.36	0.83	12.35
12	3	4	92.94	0.65	10.26	111.45	0.77	11.92
18	3	6	174.46	0.54	9.38	207.85	0.64	10.85
27	3	9	379.70	0.52	9.22	424.10	0.58	10.33
36	3	12	534.02	0.41	8.20	714.02	0.55	10.05
54	3	18	841.13	0.29	6.86	1140.8	0.39	8.47
108	3	36	1532.2	0.13	4.63	1258.9	0.11	4.45
4	4	1	16.89	1.06	13.13	17.71	1.11	14.25
8	4	2	50.70	0.79	11.37	55.45	0.87	12.61
12	4	3	95.45	0.66	10.40	117.85	0.82	12.25
16	4	4	153.41	0.60	9.89	193.95	0.76	11.79
24	4	6	308.50	0.54	9.35	391.44	0.68	11.17
36	4	9	655.48	0.51	9.09	734.93	0.57	10.20
48	4	12	1063.0	0.46	8.68	1401.0	0.61	10.56
`72	4	18	1443.9	0.28	6.74	2093.5	0.40	8.61
144	4	36	3097.0	0.15	4.94	2775.0	0.13	4.96
6	6	1	27.42	0.76	11.15	27.39	0.76	11.82
12	6	2	83.16	0.58	9.71	86.82	0.60	10.52
18	6	3	160.72	0.50	9.00	191.85	0.59	10.42
24	6	4	245.56	0.43	8.34	323.68	0.56	10.15
36	6	6	519.11	0.40	8.09	661.30	0.51	9.68
54	6	9	1162.8	0.40	8.07	1325.9	0.45	9.13
72	6	12	1891.1	0.36	7.72	2577.5	0.50	9.55
108	6	18	2826.9	0.24	6.29	3866.2	0.33	7.80
216	6	36	4324.5	0.09	3.89	5304.5	0.11	4.57
12	12	1	82.36	0.57	9.66	71.22	0.49	9.53
24	12	2	256.38	0.45	8.52	232.38	0.40	8.60

36	12	3	525.11	0.41	8.13	531.11	0.41	8.67
48	12	4	796.00	0.35	7.51	901.75	0.39	8.47
72	12	6	1838.3	0.35	7.61	2038.3	0.39	8.49
108	12	9	4221.5	0.36	7.69	3980.9	0.34	7.91
144	12	12	7951.0	0.38	7.91	9073.0	0.44	8.96
216	12	18	12324.0	0.26	6.57	14280.0	0.31	7.49

3.2. Comparable variance method

Data listed in Table 2 show the comparable variance (V) and relative information (R.I.%) in response to plot size. It is evident that relative information decreased as plot size increased. This decrease in relative information was most rapid up to a plot size of 6 basic units in both seasons, as illustrated in Fig. 1. Based on these results, a plot of about 6 times the basic units might be considered as the optimum plot size.

Table 2. Comparable variance (V) and relative information (RI) under various plot sizes in sorghum uniformity trials during 2000 and 2001 seasons.

Plot size (X)	2000		2001	
	V	R.I.	V	R.I.
1	2.17	100.00	2.42	100.00
2	1.39	64.17	1.51	62.19
3	1.11	51.25	1.20	49.43
4	0.98	45.10	1.08	44.66
6	0.79	36.37	0.86	35.73
8	0.74	34.23	0.86	35.45
9	0.68	31.13	0.79	32.57
12	0.60	27.53	0.68	28.22
16	0.60	27.62	0.76	31.31
18	0.48	22.33	0.58	24.07
24	0.47	21.71	0.56	23.12
27	0.52	24.00	0.58	24.04
36	0.37	16.85	0.43	17.86
48	0.40	18.59	0.50	20.65
54	0.34	15.83	0.42	17.48
72	0.29	13.24	0.35	14.53
108	0.25	11.30	0.26	10.75
144	0.27	12.28	0.29	11.81
216	0.18	8.22	0.21	8.67

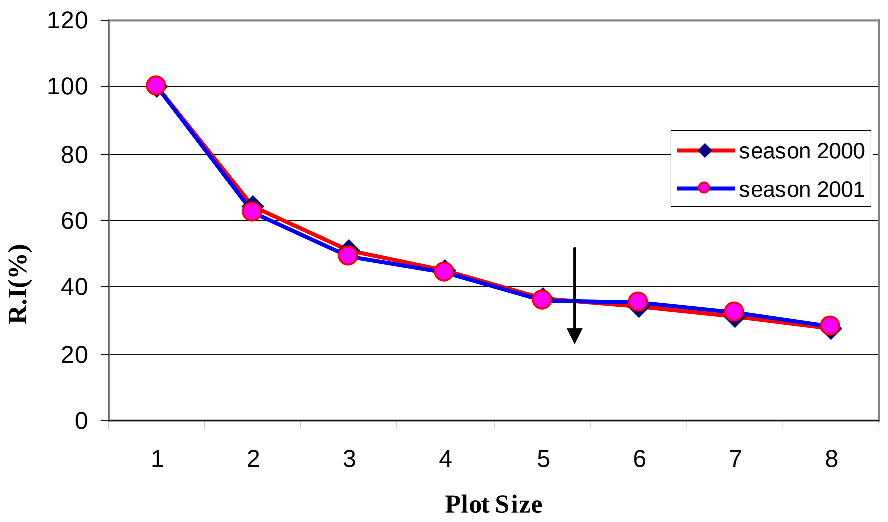

Fig. 1. Relative informaiton (R.I.) in response to plot size.

3.3. Maximum curvature technique

The point of maximum curvature (X_0) for the curve described from the equation (C.V.= A X^{-b}) describe the relationship between the coefficient of variability (C.V.) and plot size (X). In this method, the coefficient of variability is used as an indicator to the optimum plot size. The relationship between plot size and the observed and expected coefficient of variability in the first and second seasons are graphically illustrated in Figs. 2 and 3. The expected C.V. values in the first and second seasons were described from the following two equations:

$$C.V = 17.38\ X^{-0.220} \qquad (2000\ \text{season}).$$
$$C.V = 19.41\ X^{-0.219} \qquad (2001\ \text{season}).$$

The coefficient of variation decreased rapidly with the increase in plot size up to 4 - 6 basic units and the decrease was slight after this. The point of maximum curvature technique (X^o) was 4.0 and 3.0 in the first and second seasons, respectively. In light of these results, a plot of 5 basic units was the optimum plot size in both seasons.

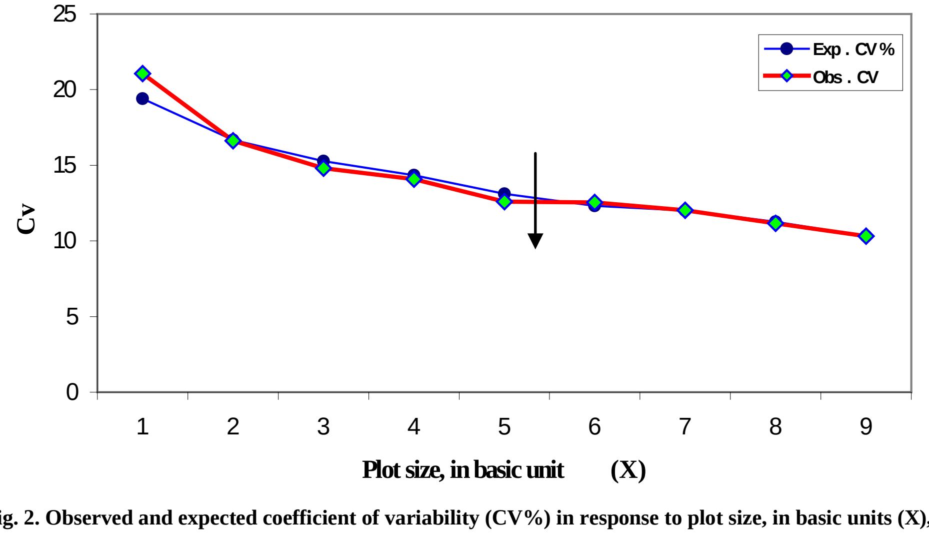

Fig. 2. Observed and expected coefficient of variability (CV%) in response to plot size, in basic units (X), in 2000 season.

4. Plot shape

Data on F-Test presented in Table (3) show that plot shape was found unimportant on plot to plot variability with the smaller plot sizes in the two seasons. Thus, the arrangement of basic units within the plot size in the field area of experimentation can be accomplished in several different ways to suite the needs of the investigator and fit his conditions. This may be attributed to the intermediate soil

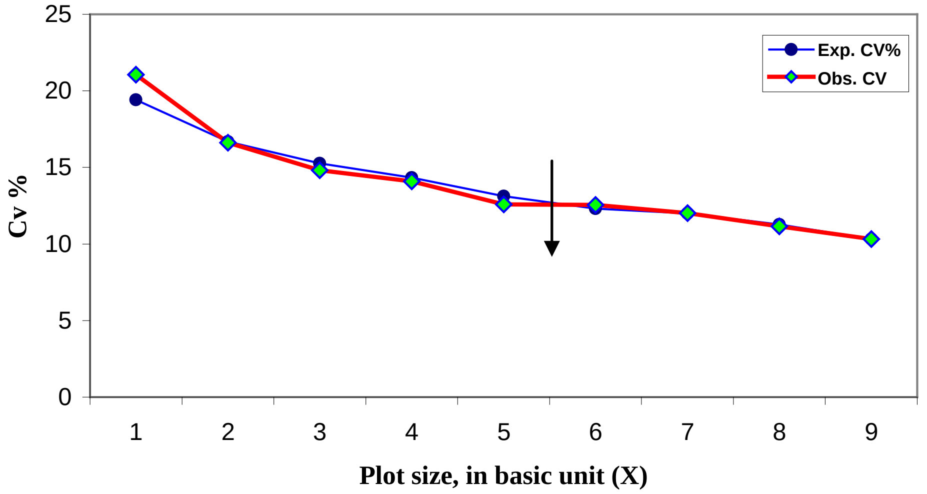

Fig. 3. Observed and expected coefficient of variability (CV%) in response to plotsize, in basic units (X) in 2001 season.

Table 3. Comparable variance (V) for the different plot shapes and F values during 2000 and 2001 seasons in sorghum uniformity trials

Plot shape		Plot size in basic units(X)	Degrees of freedom	2000		2001	
Strip	Row			V	F	V	F
1	2	2	215	1.38		1.51	1.01
2	1			1.41	1.02	1.50	
1	3	3	143	1.02		1.18	
3	1			1.20	1.18	1.22	1.03
1	4	4	107	0.90		1.08	1.03
2	2			0.98	1.09	1.05	
4	1	4		1.06	1.18	1.11	1.06
1	6	6	71	0.72		0.86	1.13
2	3			0.79	1.10	0.92	1.21
3	2			0.88	1.22	0.91	1.20
6	1			0.76	1.06	0.76	
2	4	8	53	0.69		0.85	
4	2			0.79	1.14	0.87	1.02
1	9	9	47	0.64		0.74	
3	3			0.72		0.83	1.12
1	12	12	35	0.53		0.69	1.40
2	6			0.59	1.11	0.72	1.47
3	4			0.65	1.23	0.77	1.57
4	3			0.66	1.25	0.82	1.67
6	2			0.58	1.09	0.60	1.22
12	1			0.57	1.08	0.49	

Table 3. ***Contd.***

Plot shape		Plot size in basic units(X)	Degrees of freedom	2000		2001	
Strip	Row			V	F	V	F
1	18	18	23	0.34		0.48	
2	9			0.57	1.68	0.62	1.29
3	6			0.54	1.59	0.64	1.33
6	3			0.50	1.47	0.59	1.23
2	12	24	17	0.48	1.12	0.59	1.48
4	6			0.54	1.26	0.68	1.70
6	4			0.43		0.56	1.40
12	2			0.45	1.05	0.40	
1	36	36	11	0.17		0.16	
2	18			0.30	1.76	0.39	2.44
3	12			0.41	2.41	0.55	3.44
4	9			0.51	3.00	0.57	3.56
6	6			0.40	2.35	0.51	3.19
12	3			0.41	2.41	0.41	2.56
4	12	48	8	0.46	1.31	0.61	1.56
12	4			0.35		0.39	
3	18	54	7	0.29		0.39	
6	9			0.40	1.38	0.45	1.15
2	36	72	5	0.15		0.11	
4	18			0.28	1.87	0.40	3.64
6	12			0.36	2.40	0.50	4.55
12	6			0.35	2.33	0.39	3.55
3	36	108	3	0.13		0.11	
6	18			0.24	1.85	0.33	3.00
12	9			0.36	2.77	0.34	3.09
4	36	144	2	0.15	1.67	0.13	
12	12			0.38	4.22	0.44	3.38
6	36	216	1	0.09		0.11	
12	18			0.26	2.89	0.31	2.82

variability (0.47) in this investigation. However, the general trend for the other previous results indicate that long and narrow plots were more effective in reducing soil variation (Leilah [10]; Leilah *et al.* [13]). Neverthless, several workers on different crops, among them, Lessman and Atkins [19], El-Kalla *et al.* [14], Leilah *et al.* [13] came to conclusion reporting that plot shape did not significantly affect the variance of yield trials.

5. Optimum plot size and shape

Once the optimum plot size is determined, the choice of plot shape is detected. In this study, the optimum plot size was estimated as 4 basic units (ridges) without border (guard ridges) so, the recommended plot size should consist of one or two ridges along the outer ridges, as border (Gomez and De-Datta [22]).

Since plot shape was found to be unimportant, consequently the recommended plot size and shape for sorghum field trials was estimated as 6-8 ridges, i.e. 3.6- 4.8 m x 2.0 m occupying an area of 7.20 to 9.60 m2. Owing to the great differences between crops and cultivars in their response to agricultural practices and treatments, climatic and soil conditions, wide variations in the convenient plot size were found by several investigators (El-Hindi *et al.* [23]; El-Kalla *et al.* [14]; Aly [24]; El-Kalla *et al.* [9]; Leilah [10]; Leilah *et al.* [13] and Katyal and Gangwar [25]).

6. Number of replications

Data presented in Table 4 and graphically illustrated in Figs. 4 and 5 indicate that the standard error ($s\bar{X}$) decreased as number of replications (R) or plot size (X) increased . The rate of decrease was more due to the increase in number of replications rather than plot size. The rate of standard error decrease reached its maximum with 4 - 6 replicates and plot size of 6 basic units. Similar conclusions were obtained by El-Kalla *et al.* [15]; Leilah [11] and El-Sergany and Badr [26].

Table 4. Standard error ($s\bar{X}$) as affected by different plot size and number of replicates in sorghum uniformity trials

Season	2000						2001					
Replicates	2	4	6	8	9	12	2	4	6	8	10	12
Plot size (X)												
2	0.83	0.59	0.48	0.42	0.39	0.34	0.87	0.61	0.50	0.43	0.41	0.35
4	0.70	0.49	0.40	0.35	0.33	0.29	0.74	0.52	0.42	0.37	0.35	0.30
6	0.63	0.44	0.36	0.31	0.30	0.26	0.66	0.46	0.38	0.33	0.31	0.27
8	0.61	0.43	0.35	0.30	0.29	0.25	0.65	0.46	0.38	0.33	0.31	0.27
9	0.58	0.41	0.34	0.29	0.27	0.24	0.63	0.44	0.36	0.31	0.30	0.26
12	0.55	0.39	0.32	0.27	0.26	0.22	0.58	0.41	0.34	0.29	0.28	0.24

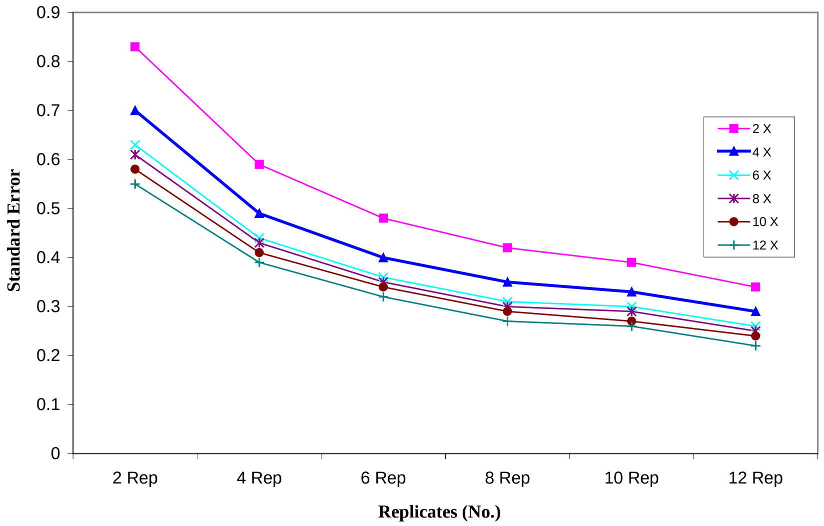

Fig. 4. The relationship between plot size and replicates number on the standard error value in 2000 season.

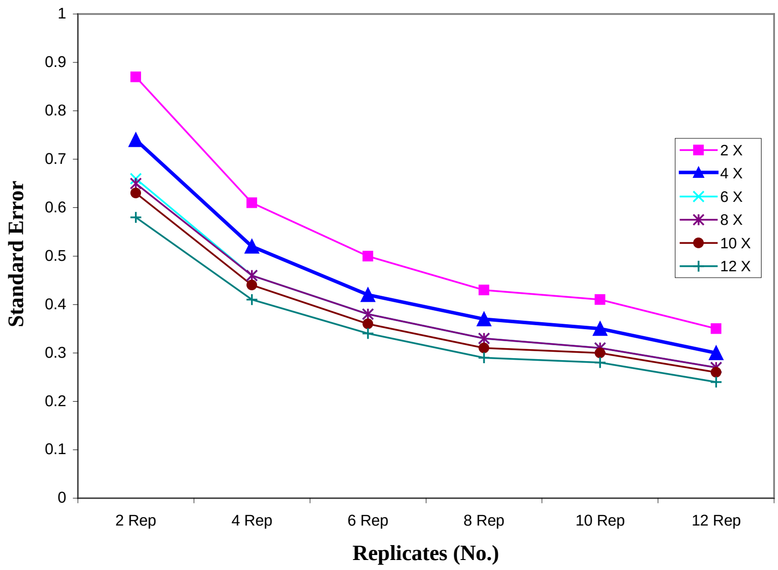

Fig. 5. The relationship between plot size and replicates number on the standard error value in 2001 season.

Data collected in Table (5) reveal that the theoretical number of replications required to detect true differences of 15 and 20 % of the mean was estimated as 4 - 8 replicates in the two seasons, with the plot size of 6.0 basic units. Thus, 4 - 6 replicates were the suitable number for raising the precision of sorghum fodder yield trials.

Table 5. Theoretical number of replicates required to detect differences of 10 and 15 % of the mean in sorghum uniformity trials

Season	**2000**		**2001**	
Differences	**15 %**	**20 %**	**15 %**	**20 %**
Plot size (X)				
2	16	9	18	10
4	10	6	10	6
6	8	4	8	4
8	6	4	6	3
10	6	3	5	3

In conclusion, it can be stated that using plots of 7.20 - 9.60 m^2 (3.6X2.0 m – 4.8X3.0 m) with 4-6 replicates is the recommended to raise the precision of sorghum field experiments under the conditions of this investigation.

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تقدير أنسب حجم وشكل للوحدة التجريبية وعدد المكررات في التجـارب الحقلية لمحصول الذرة السكرية العلفية

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ملخص البحث. أقيمت تجربتي تجانس بغرض تقدير معامل اختلاف التربة، أنسب شكل وحجم (مساحة) وأفضل عدد من المكررات لتجارب الذرة السكرية الحقلية. وقد قدر أنسب حجم للوحدة التجريبية باستعمال ثلاثة طرق :

١ - طريقة Smith (1961)

٢ - طريقة التباين المقارن Keller (1949)

٣ - طريقة أقصى انحناء Lessman and Atkins (1963)

وتم دراسة أنسب شكل للوحدة التجريبية باستعمال اختبار F كما قدر عدد المكررات النظري اللازم لتحديد فروق مقدارها ١٥ و ٢٠ % من المتوسط. وقد أشارت نتائج الدراسة أن معامل اختلاف التربة بلغ ٠,٤٩ في الموسم الأول و ٠,٤٧ في الموسم الثاني مما دل على وجود اختلاف في أرض التجربة بدرجة متوسطة. كما أشارت النتائج أن أنسب مساحة للوحدة التجريبية هي الوحدة التي تتكون من ٦ - ٨ خطـوط (عرض الخط ٦٠ سم وطوله ٢,٠ متر) مكونة مساحة قدرها ٧,٢ – ٩,٦ متراً مربعاً (متضمنة بذلك النطاق الخارجي للوحدة التجريبية) ولم يكن لشكل الوحدة التجريبية أي تأثير معنوي على قيمة التباين . كما أوضحت النتائج أن أنسب عدد من المكررات يلزم استخدامه لرفع كفاءة التجربة تراوح من٤-٦ مكررات.