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OPTIMUM PLOT SIZE AND NUMBER OF REPLICATIONS IN FABA BEAN

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ABSTRACT

Planning agricultural experiments and assessing their accuracy are important in determining the credibility of the results obtained from the research. Therefore, the objective of the present investigation was to estimate the optimum plot size and number of replications. Two field experiments were carried out during the two successive seasons of 2017/18 and 2018/19 at the Agricultural Research and Experiment Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The genetic materials used in this experiment included two faba bean cultivars (CV). Estimates of coefficient of variation (C.V.%) varied between 5.9% to 35.9% for Cairo 25 and Cairo 4 cultivars under Orbanche-free condition. In general, the highest estimates of coefficient of variation were detected for Cairo 25 variety under Orbanche-free condition. Standard error decreased as the number of replications and plot size increased. In the context, the rate of decrease was more obvious due to increase in number of replications than that due to increasing plot size until the plot size was increased to 6 basic units (14.4 m^2).

Key words: ***Faba bean, Vicia faba, Coefficient of variation, Standard error, Experimental precision*.**

INTRODUCTION

Faba bean belongs to the Fabaceae family. It is one of the most vital legume crops distributed in Egypt and the world. Faba bean seeds are valuable source of protein, carbohydrates, and minerals (Broughton *et al* 2003 and Dawood *et al* 2015).

Field plot technique deals with various factors essential to a properly planned agricultural field experiments. Some of these factors are size, shape, arrangement of plots as experimental units together with the effects of these units on each other. In uniformity traits, field experiment is usually planted with a single variety replicated in several basic units in order to find out optimum plot size and shape number of replications, as well as the design or field layout of the experiment; last, the method of statistical reduction of the data.

Long and narrow plot size was more efficient as it decreases variance per basic unit and increases the efficiency of experimental designs (Ashmawy 2004). Taken these points into consideration, the statistician can play an important role by evaluating the warranty use of statistical concept procedures and suggesting improvements. Mohamed (2005) concluded that based on the estimates of soil heterogeneity, the experimental optimum plot sizes for bordered and unbordered plots were 22.3 m^2 and 9.6 m^2 for plant height, 72.2 m^2 and 39.2 m^2 for number of bolls per plant, and 37.9 m^2 and 18.8 m^2 for seed cotton yield.

Masood and Raza (2012) estimated the optimum plot size and shape for field research experiments on paddy yield. The maximum curvature technique and comparable variance methods were exercised to estimate optimum plot size and shape using yield data of the 12 x 24 m (288 basic units) recorded separately from each basic unit of 1 m x 1 m. The results of maximum curvature method indicated that the optimum plot size plot size is larger than the plot size of 3 x 5 m generally used for paddy yield in the studied area. Also, results indicated that the coefficients of variation (35.24, 23.80, 21.50, 19.49 and 17.86 percent) declines with an increase in the plot size (1 m^2, 2 m^2, 3 m^2, 4 m^2, 6 m^2).

Plot sizes tend to increase with the progress of the breeding program, whereas the more advanced populations need larger plot size for experiments. With the advancement of generations, there is a reduction in the variation between the selected materials, requiring a higher number of plants to detect variation and make the selection. When the increase of plot size does not result in more precision, additional increases in accuracy will be obtained with the use of more replicates (Cargnelutti Filho *et al* 2012 and Storck *et al* 2016).

El–Rayes et al (1993) determined the optimal number of repetitions to be used in competition trials of popcorn traits related to production and quality, including grain yield and expansion capacity. The optimal number of repetitions for all of the traits was considered when all of the estimates of the parameters in question were encountered within the confidence interval. The estimates of the number of repetitions varied according to the parameter estimated, variable evaluated, and environment cultivated, ranging from 2 to 7. Consequently, there is an ongoing need for varietal evaluations. Optimum plot size, shape, and number of replications have been studied in a number of crops such as sweet potatoes [*Ipomoea batatas* (L.) Lam.], onions (*Allium cepa* L.), peppers (*Capsicum annuum* L.), and potatoes (*Solanum tuberosum* L.) to name a few (Boyhan *et al* 2003, Vallejo and Mendoza, 1992 and Singh, 1989).

Paranaíba *et al* (2009) proposed the maximum curvature of the coefficient of variation method, which has the advantage of reducing the calculation necessary to determine the optimum plot size. That was true for several crops, of them: abacaxi (Leonardo *et al* 2014), canola (Cargnelutti Filho *et al* 2015) and sunflower (Souza *et al* 2015), among others. However, Cargnelutti Filho & Storck (2009) indicated that the class limits established, heritability coefficient, determination coefficient and Fisher test value for cultivar are adequate for estimating the degree of experimental precision of cultivar competition trials in the precision of 101 trials on maize.

For a breeding program to be successful, it is necessary for experiments to be able to detect even smaller variations, since the trend is for differences between new cultivars to decrease. For this reason, the challenge for breeders is to increase the precision of experiments, which would result in genetic advances and, as a consequence, materials which are more productive and of better quality (Sousa et al, 2015). So, the objective of this study is to determine the optimum plot size and the optimum number of replicates in the faba bean experiments.

MATERIAL AND METHODS

This experiment is including two uniformity trials during two successive seasons of 2017/2018 and 2018/2019 at Agric. Res. Sta., at Giza, Fac. Agric., Cairo University at Giza, Egypt (30°02' N and 31°13' E, with an altitude of 30 m). Soil mechanical analysis was conducted at Faculty of Agriculture Research Park, Cairo University according to Bremner and and Mulvanay (1983) and chemical analysis was done according Page (1982). The experimental soil type was clay loam in both seasons. The soil of the experimental site during the two studied seasons is classified as clay soil (Table 1).

Experimental layout and crop Management

The genetic materials used in this experiment included two faba bean cultivars (Cairo 25 and Cairo 4) grown under two conditions (*Orbanche*-free and *Orbanche*-infested) during 2017/18 and 2018/19 seasons. Cairo 25 and Cairo 4 cultivars are composed of different genotypes it is an outcome of the faba bean breeding programme of the Agronomy Department, Faculty of Agriculture, Cairo university. This programme adopted development of blended and synthetic varieties to explore heterosis in this crop. These synthetic *Orobanche* tolerant cultivars (Cairo 25 and Cairo 4) registered as commercial varieties (under the Ministerial Decree No 326 on 13/3/2013) from the Agronomy Department, Faculty of

Agriculture, Cairo University and the seeds of the two cultivars are produced, multiplied and distributed to farmers commercially since 2015 season till now.

In each season the experimental area consisted of 200 rows" for each variety", one row 4.0 m long and 0.6 wide, basic units, occupying an area of 2.4 m^2. The preceding crop was maize (*Zea mays* L.) in both seasons.

Table 1. Mechanical and chemical properties of experimental site (30 cm depth) in 2017/2018 and 2018/2019 seasons.

Character	Seasons	
	2017/2018	2018/2019
Mechanical analysis		
Fine sand (%)	31	30
Silt (%)	30	32
Clay (%)	39	38
Soil type	Clay loam	Clay loam
Chemical analysis		
Available N (kg/fed)	14.2	11.4
Available P (ppm)	2010	1425
Available K (ppm)	910	740
Organic matter (%)	2.35	2.04
pH	7.21	7.41
EC (m/mohs/cm)	0.74	0.83

Sowing dates were on last week of October on both seasons. Seeds were sown in hills at 30 cm apart by hand on both sides of the ridge. Thereafter (after 30 days from germination), hills were thinned to two plants per hill. Nitrogen at rate of 20 kg N per faddan in the form of ammonium nitrate (33.5% N) was added at sowing date as one dose. Calcium super phosphate fertilizer (15.5% P_2O_5) was added at the rate of 25 kg P_2O_5 per faddan and was applied uniformly before sowing. Potassium sulphate (48% K_2O) was applied at the rate of 50 kg K_2O per faddan. Application of potassium fertilizer was done in two equal doses before the 2nd and 3rd irrigations. The weed management was carried out during the growing season by hoeing twice.

Data collection

At harvest, 20 guarded plants were randomly taken from each plot to determine seed yield per plant

a. Optimum plot size

Data of seed yield at each trial were analyzed separately to study the effect of plot size (in terms of the number of adjacent basic units grouped to form a larger plot).

Before analysis, the data were arranged in sequence for all basic units in each trial. The different combinations of plot size were determined as well as the number of basic units across and along for each plot in each combination. Accordingly, the plot length and width were calculated in meters and the area in square meters.

Variance per basic unit (V_x), average yield (Y) and coefficient of variability (C.V.) for each of the various selected combinations of plot size were estimated. One principle method was used to estimate the optimum plot size as follows:

The maximum curvature method presented by Federer (1955) was used. The point of maximum curvature (x_0) for the exponential curve, C.V. = a X^{-b} relating the coefficient of variability (C.V.) and plot size (x) was determined using the following equation:

$X_0 = [a^2 b^2 (2b + 1)/(b + 2)]^{1/(2b+2)}$

Where (a) and (b) are the Y intercept (constant c equation) and regression coefficient, respectively. The value of (a) and (b)in the above equation was estimated from using the principle of linear regression as follows:

$$b = \frac{n \sum \log(CV) \log X - \sum \log(CV) \sum \log X}{n \sum (\log X)^2 - (\sum \log X)^2}$$

$$\text{Log a} = \frac{\sum \log(CV)}{n} - b \frac{\sum \log X}{n}$$

The equation used to determine X_0 was converted to a logarithmic form as follows:

$$\text{Log } X_0 = \frac{2\log a + 2\log b + \log(2b+1) - \log(b+2)}{(2b+2)}$$

The plot size directly beyond the value X_0 was considered optimum. Also in this method no estimates of cost were considered.

b. Optimum number of replications

The effective numbers of replications vary from crop to another. The equation proposed by Hayes *et al* (1955) was used to determine the theoretical number of replications necessary to bring down the coefficient of variation to 5 % of the mean.

This equation is: $r - (CV. /d)^2$ where:

r = the theoretical number of replications.

$C.V.$ = the coefficient of variability.

d = the value magnitude of treatment differences measured as percentage of the mean.

Increasing number of replicates were decreases the standard error values (SE) more than increasing plot size, therefore analysis of variance was used in this study to estimate standard errors for five different plot sizes of replications from 2 to 10 to reach this status.

Standard error *(SE)* = $S/\sqrt{n}$.

Where S is standard deviation and n is the number of observations.

RESULTS AND DISCUSSION

Studying the optimum plot size and number of replications for two faba bean varieties

a. Optimum plot size

The experiment included two uniformity trails. The first one was assigned for cv. Cairo 25 and the second one was assigned for cv. Cairo 4.

Data presented in Table 2 indicated that the mean seed yield per plot (plot size of 10 basic units) for Cairo 25 and Cairo 4 cultivars (cv.) grown under *Orbanche*-free condition increased from 1.91 – 1.57 kg, respectively, (plot size with two basic units) to 8.38 – 8.21 kg, respectively, (plot size of 10 basic units) with an average of 5.48 – 4.93 kg, respectively, in the first season (2017/18). For 2018/19 season, seed yield varied from 1.67 - 1.28

kg, respectively, to 9.22 – 6.98 kg, respectively, with an average of 5.56 – 4.15 kg, respectively.

Observed and estimated coefficient of variability values (C.V.%) for Cairo 25 and Cairo 4 varieties grown under *Orbanche*-free condition in both seasons are presented in Table (2) and Figure (1). The results showed that C.V. % values decreased as the plot size increased from the smallest to the largest plot size.

Table 2. Mean seed yield (Y) kg, coefficient of variability (C.V. %) observed and estimated values for cv. Cairo 25 and cv. Cairo 4 grown under *Orbanche*-free condition during 2017/18 – 2018/19 seasons.

Plot size in basic units	Seed Yield (kg)	C.V.% (Ob.)	C.V.% (Est.)	Seed Yield (kg)	C.V.% (Ob.)	C.V.% (Est.)
cv. Cairo 25						
Season 2017/18				**Season 2018/19**		
2	**1.91**	**35.9**	**8.0**	**1.67**	**25.54**	**8.87**
3	**3.05**	**26.0**	**9.4**	**2.70**	**20.84**	**9.61**
4	**3.94**	**22.7**	**10.0**	**3.61**	**16.97**	**10.41**
5	**4.81**	**20.9**	**10.4**	**4.63**	**15.31**	**10.83**
6	**4.96**	**21.8**	**10.2**	**5.42**	**15.34**	**10.83**
7	**6.42**	**14.6**	**12.5**	**6.82**	**13.49**	**11.38**
8	**7.28**	**17.4**	**11.5**	**7.50**	**14.54**	**11.05**
9	**8.15**	**16.4**	**11.8**	**8.39**	**13.81**	**11.28**
10	**8.83**	**15.4**	**12.2**	**9.28**	**13.31**	**11.44**
cv. Cairo 4						
Season 2017/18				**Season 2018/19**		
2	**1.57**	**13.1**	**5.2**	**1.28**	**21.60**	**9.32**
3	**2.44**	**10.8**	**5.7**	**2.12**	**21.56**	**9.33**
4	**3.25**	**8.9**	**6.3**	**2.80**	**17.81**	**10.05**
5	**4.07**	**7.7**	**6.7**	**3.39**	**17.61**	**10.09**
6	**4.92**	**7.0**	**7.0**	**4.12**	**15.90**	**10.50**
7	**5.82**	**7.3**	**6.9**	**4.83**	**14.50**	**10.89**
8	**6.63**	**5.9**	**7.6**	**5.54**	**13.41**	**11.22**
9	**7.49**	**6.5**	**7.3**	**6.29**	**12.73**	**11.46**
10	**8.21**	**6.1**	**7.5**	**6.98**	**12.03**	**11.71**

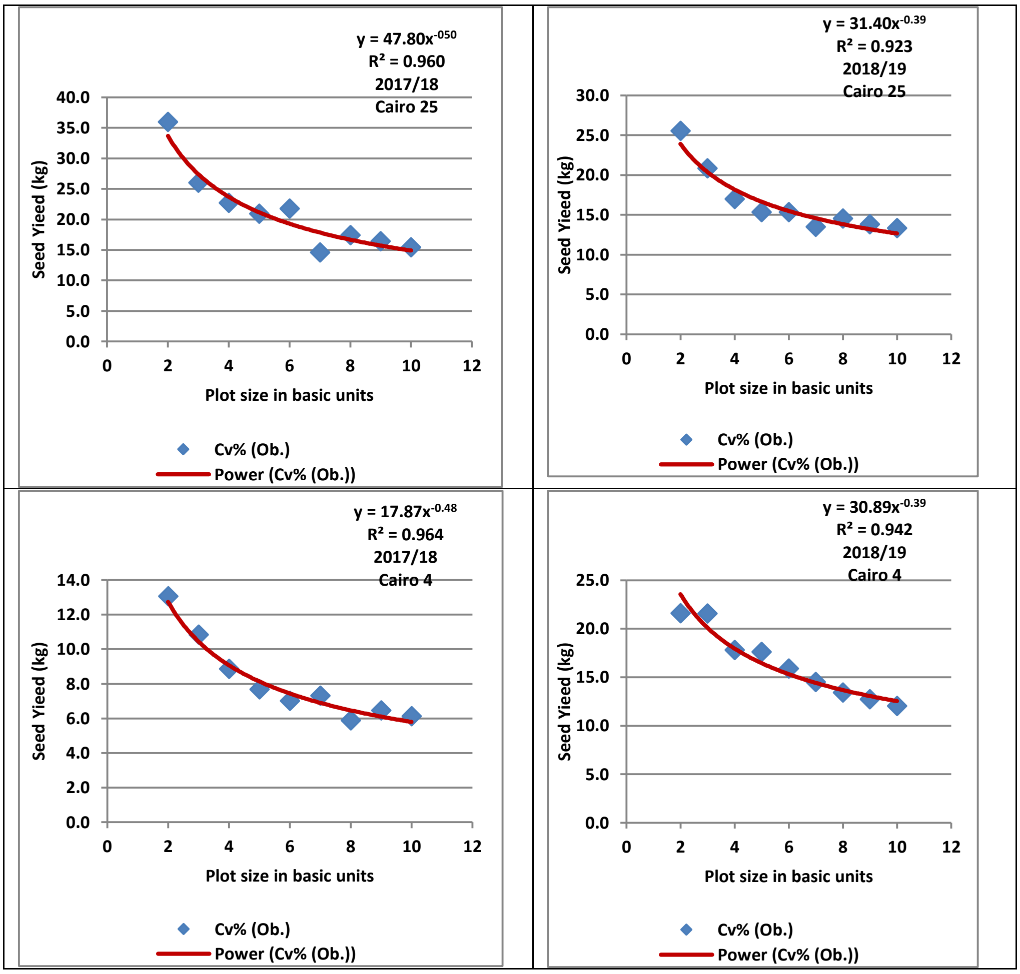

Fig. 1. The relationship between plot size and coefficient of variability (CV.%) for Cairo 25 and Cairo 4 grown under *Orbanche*-free condition during 2017/18 – 2018/19 seasons.

The data of cv. Cairo 25 and cv. Cairo 4 revealed that the observed C.V. values decreased from 35.9% to 14.4% and from 13.06% to 6.13% in 2017/18 season. The same trend was shown for the values of C.V % in both seasons.

According to the maximum curvature method, the coefficient of variability was used as an indicator to the optimum plot size and it is graphed on the Y-axis in relation to various plot sizes on the X axis (Fig. 1). The optimum plot size was considered to be the point on the curve, where the rate of change for Y estimate per increment of X is greatest, so called "The region of Maximum Curvature ". The power functions expressing that relationship for cv. Cairo 25 and cv. Cairo 4 in 2017/18 and 2018/19 seasons are presented (Fig. 1).

The general equation describing this relationship is: $C.V. = aX^{-b}$

Where (a) and (b) are constants, and X is the size of plot in basic units. The equations for cv. Cairo 25 and cv. Cairo 4 in 2017/18 and 2018/19 seasons were defined as follow:

$CV = 47.80\ X^{-0.50}$ and $CV = 31.40\ X^{-0.39}$ for cv. Cairo 25 in 2017/18 and 2018/19 seasons.

$CV = 17.87\ X^{-0.48}$ and $CV = 30.89\ X^{-0.39}$ for cv. Cairo 4 in 2017/18 and 2018/19 seasons.

Therefore the optimum plot size was 16.8 m^2 (7 basic units) for cv. Cairo 25 in both seasons of study, while the optimum plot size for cv. Cairo 4 was 19.2 m^2 and 24.0 m^2 (8 basic units - 10 basic units), respectively, in both seasons.

Data presented in Table (3) indicated that the mean seed yield per plot (plot size of 10 basic units) for cv. Cairo 25 and cv. Cairo 4 grown under *Orbanche*- infested condition increased from 1.21 – 1.19 kg, respectively, (plot size with two basic units) to 6.49 – 5.62 kg, respectively, (plot size of 10 basic units) with an average of 3.87 – 3.39 kg, respectively, in the first season (2017/18). For 2018/19 season, seed yield varied from 0.82 – 0.90 kg, respectively, to 4.13 – 4.41 kg, respectively, with an average of 2.53 – 2.65 kg, respectively.

Observed and estimated coefficient of variability values (C.V.%) for cv. Cairo 25 and cv. Cairo 4 grown under *Orbanche*- infested condition in both seasons are presented in Table (3) and Figure (2). The results showed that C.V.% values decreased as the plot size increased from the smallest to the largest plot size.

The data of cv. Cairo 25 and cv. Cairo 4 revealed that the observed C.V. values decreased from 20.2% to 13.78% and from 24.6% to 13.5% in 2017/18 season. The same trend was shown for the values of C.V % in both seasons.

Table 3. Mean seed yield (Y) kg, coefficient of variability (C.V.%) observed and estimated values for cv. Cairo 25 and cv. Cairo 4 grown under *Orbanche*-infested condition during 2017/18 – 2018/19 seasons.

Plot size in basic units	Seed yield (kg)	C.V.% (Ob.)	C.V.% (Est.)	Seed yield (kg)	C.V.% (Ob.)	C.V.% (Est.)
cv. Cairo 25						
Season 2017/18				**Season 2018/19**		
2	**1.21**	**20.23**	**9.69**	**0.82**	**25.54**	**10.11**
3	**1.95**	**18.05**	**10.01**	**1.32**	**20.84**	**10.83**
4	**2.59**	**14.84**	**10.60**	**1.77**	**16.97**	**11.62**
5	**3.20**	**13.29**	**10.94**	**2.14**	**17.26**	**11.55**
6	**3.91**	**12.52**	**11.13**	**2.56**	**15.45**	**11.99**
7	**4.51**	**11.97**	**11.28**	**2.92**	**15.67**	**11.93**
8	**5.10**	**11.61**	**11.38**	**3.38**	**14.78**	**12.17**
9	**5.91**	**13.84**	**10.81**	**3.76**	**14.52**	**12.25**
10	**6.49**	**13.78**	**10.83**	**4.13**	**14.20**	**12.34**
cv. Cairo 4						
Season 2017/18				**Season 2018/19**		
2	**1.19**	**24.61**	**9.22**	**0.90**	**14.90**	**7.21**
3	**1.65**	**23.72**	**9.36**	**1.31**	**11.88**	**7.72**
4	**2.23**	**19.28**	**10.19**	**1.76**	**9.74**	**8.19**
5	**2.77**	**16.88**	**10.76**	**2.21**	**8.49**	**8.53**
6	**3.42**	**16.16**	**10.95**	**2.60**	**9.13**	**8.35**
7	**3.99**	**14.76**	**11.36**	**3.06**	**8.53**	**8.52**
8	**4.55**	**13.71**	**11.72**	**3.55**	**9.08**	**8.36**
9	**5.03**	**14.22**	**11.54**	**4.02**	**8.63**	**8.49**
10	**5.62**	**13.49**	**11.79**	**4.41**	**9.23**	**8.32**

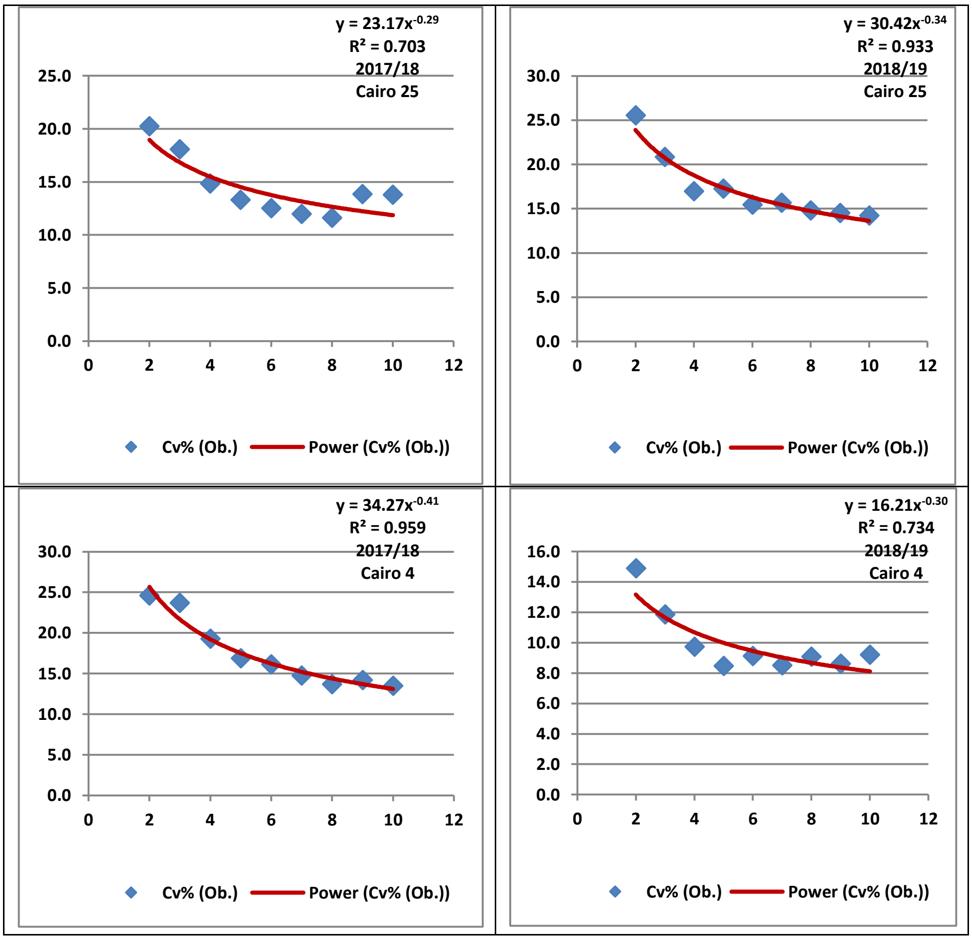

Fig. 2. The relationship between plot size and coefficient of variability (CV.%) for cv. Cairo 25 and cv. Cairo 4 grown under *Orbanche*-infested condition during 2017/18 – 2018/19 seasons.

According to the maximum curvature method, the coefficient of variability was used as an indicator to the optimum plot size and it is graphed on the Y-axis in relation to various plot sizes on the X axis (Fig. 2). The power functions expressing that relationship Cairo 25 and Cairo 4 verities in 2017/18 and 2018/19 seasons are presented (Fig. 2). The general equation describing this relationship is:

$C.V. = aX^{-b}$

Where (a) and (b) are constants, and X is the size of plot in basic units. The equations for Cairo 25 and Cairo 4 verities in 2017/18 and 2018/19 seasons were defined as follow:

$CV = 47.80\ X^{-0.50}$ and $CV = 31.40\ X^{-0.39}$ for Cairo 25 in 2017/18 and 2018/19 seasons.

$CV = 17.87\ X^{-0.48}$ and $CV = 30.89\ X^{-0.39}$ for Cairo 4 in 2017/18 and 2018/19 seasons.

Therefore the optimum plot size was 19.2 and 24.0 m^2 (8 basic units - 10 basic units), respectively, in both seasons for Cairo 25, while the optimum plot size for Cairo 4 was 19.2 m^2 and 24.0 m^2 (8 basic units - 10 basic units), respectively, in both seasons.

Significant decreases can be seen in the values of coefficient of variability (increase in experimental precision) with increases in the size of small plots, agreeing with the results obtained by various authors (Meir and Lessman, 1971, Martin *et al* 2004, Donato et al 2008, de Oliveira et al 2010, Lúcio et al 2011, Lúcio et al 2012, Santos et al 2012 and Sousa et al 2015).

Schmildt *et al* (2016) found that the optimum plots size showed variation among the variables within the same cultivar, as well as for the same variable among cultivars and also for the crop 'papaya' between planting times.

b. Number of replications

The number of replications required for certain limits of error in field experiments depends upon the coefficient of variability and the chosen confidence probability limits. For this purpose, the formula recommended by Hayes *et al* (1955) was used to determine the theoretical number of replications necessary to bring down the coefficient of variability to its desired magnitude of the mean value for each plot.

The relationship between number of replications, plot size and standard error are presented in (Table 4 and Fig. 3) for cv. Cairo-25 and (Table 5 and Fig. 3) for cv. Cairo-4. Results showed that standard error decreased as the number of replications increased with the same plot size. The standard error decreased as the number of replications and plot size increased until (7– 6 basic units), respectively, in both seasons for cv. Cairo 25 and (7– 5 basic units), respectively, for cv. Cairo 4.

Table 4. Estimates of standard error for different plot sizes and number of replications for cv. Cairo 25 grown under *Orbanche*-free condition during 2017/18 – 2018/19 seasons.

plot size basic units	Number of replications						
	R2	R3	R4	R5	R6	R7	R8
2017/18							
P2	1.93	1.8	1.54	1.5	0.89	0.81	0.76
P3	1.61	1.36	1.23	1.02	0.94	0.87	0.65
P4	1.37	1.23	0.95	0.99	0.83	0.64	0.54
P5	1.07	0.97	0.84	0.82	0.69	0.66	0.57
P6	1.15	1.08	0.89	0.88	0.72	0.68	0.61
P7	0.91	0.88	0.74	0.72	0.66	0.59	0.52
P8	1.12	1.09	0.95	0.93	0.87	0.8	0.73
P9	1.67	1.6	1.41	1.24	1.18	0.71	0.64
P10	2.19	1.76	1.68	1.17	0.84	0.74	0.49
2018/19							
P2	1.77	1.55	1.53	1.23	0.94	0.73	0.67
P3	1.54	1.42	1.25	1.15	0.89	0.65	0.57
P4	1.29	1.24	1.07	1.02	0.73	0.68	0.64
P5	0.98	0.95	0.85	0.80	0.73	0.61	0.56
P6	0.90	0.91	0.74	0.72	0.69	0.53	0.51
P7	0.90	1.04	0.87	0.85	0.82	0.66	0.64
P8	1.10	1.09	0.97	0.92	0.75	0.70	0.59
P9	1.15	1.16	0.99	0.97	0.94	0.78	0.76
P10	1.89	1.74	1.48	1.33	0.88	0.78	0.65

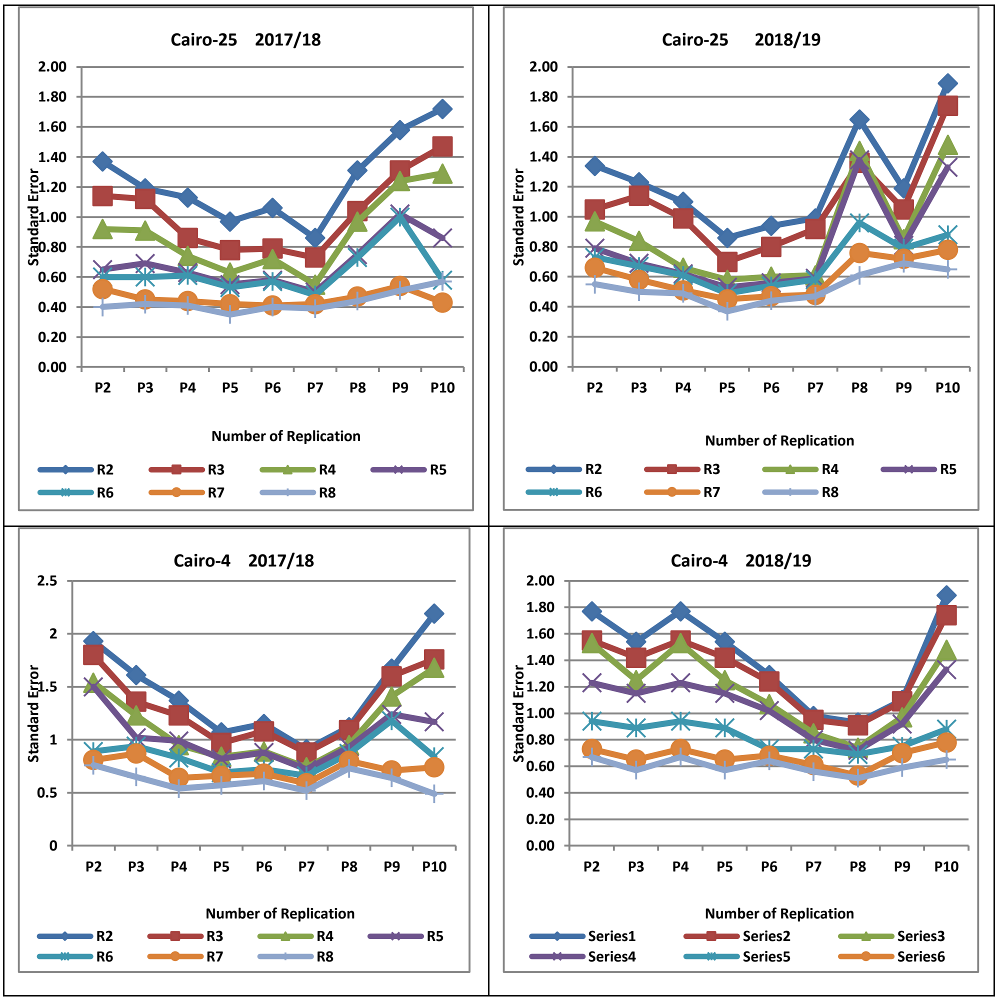

Fig. 3. Relationship between standard error for different plot sizes and various numbers of replications for cv. Cairo 25 and cv. Cairo 4 grown under *Orbanche*-free condition during 2017/18 – 2018/19 seasons

Table 5. Estimates of standard error for different plot sizes and number of replications for cv. Cairo-4 grown under *Orbanche*-free condition during 2017/18 – 2018/19 seasons.

Plot size basic units	Number of replications						
	R2	R3	R4	R5	R6	R7	R8
2017/18							
P2	1.37	1.14	0.92	0.65	0.60	0.52	0.40
P3	1.19	1.12	0.91	0.69	0.60	0.45	0.42
P4	1.13	0.86	0.74	0.63	0.61	0.44	0.41
P5	0.97	0.78	0.63	0.55	0.53	0.42	0.35
P6	1.06	0.79	0.72	0.58	0.57	0.41	0.40
P7	0.86	0.73	0.55	0.50	0.48	0.42	0.39
P8	1.31	1.04	0.97	0.75	0.73	0.47	0.44
P9	1.58	1.31	1.24	1.02	1.00	0.54	0.51
P10	1.72	1.47	1.29	0.86	0.58	0.43	0.57
2018/19							
P2	1.34	1.05	0.97	0.79	0.73	0.66	0.55
P3	1.23	1.14	0.84	0.69	0.67	0.58	0.50
P4	1.10	0.99	0.66	0.62	0.61	0.51	0.49
P5	0.86	0.70	0.58	0.53	0.49	0.45	0.37
P6	0.94	0.80	0.60	0.56	0.54	0.47	0.44
P7	0.99	0.92	0.61	0.59	0.58	0.48	0.47
P8	1.65	1.36	1.44	1.38	0.96	0.76	0.61
P9	1.19	1.05	0.85	0.81	0.79	0.72	0.69
P10	1.89	1.74	1.48	1.33	0.88	0.78	0.65

However, the rate of decrease was more obvious due to the increase in number of replications than that due to increasing plot size. This was clear for cv. Cairo 25 and cv. Cairo 4 in season 2018/19 until (6– 5 basic units), respectively. The relationship between standard error and number of replications for different plot sizes showed that the rate of decrease in standard error reached its maximum when using 8 replications for cv. Cairo 25 and cv. Cairo 4 in the two seasons.

In that respect, similar results of organization among the number of plants by plot and the number of replications were also shown by Souza *et al* (2015), who determined the optimum plot size for sunflower. The increase in number of replicates was more efficient in reducing the standard error (its mean increase of the experimental precision) when compared to the addition in plot size (Hatheway 1961, Storck *et al* 2007, Donato *et al* 2008 and Sousa *et al* 2015).

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الحجم الامثل للقطعه التجريبيه وعدد المكررات فى الفول البلدى

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التخطيط وتقييم دقة التجارب الزراعية يعد أمرا مهما في تحديد مصداقية النتائج التي يتم الحصول عليها من البحث. لذلك كان الهدف من هذه الدراسة و هو تقدير الحجم الأمثل للقطعة التجريبيه وعدد المكررات. و لتحقيق ذلك تم إجراء تجربتين حقليتين خلال موسمى الزراعه ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ بمحطة البحوث والتجارب الزراعية بكلية الزراعة جامعة القاهرة بالجيزة, مصر. تم استخدام صنفين تجاريين من الفول البلدى (قاهره ٤ وقاهره ٢٥) فى هذه الدراسه. تراوحت قيم معامل الاختلاف CV% بين ٩,٥٪ و ٣٥,٩٪ للصنف التجارى قاهرة ٢٥ والصنف التجارى قاهرة ٤ تحت ظروف الحقل الخالى من الهالوك. وبشكل عام، تم ملاحظة أعلى تقدير لمعامل التباين للصنف قاهره ٢٥ تحت ظروف الحقل الخالى من الهالوك. وكانت العلاقه عكسيه بين الخطأ المعياري و (عدد المكررات وحجم القطعة التجريبيه) حيث انخفض الخطأ المعيارى بزيادة عدد المكررات و كذلك حجم القطعه التجريبيه(وهو ما يزيد الدقه التجريبيه) وكان معدل النقصان أكثر وضوحا فى حالة زيادة عدد المكررات عن زيادة حجم القطعة التجريبيه حتى حجم ٦ خطوط فى الوحده التجريبيه (١٤,٤ م^{٢}).

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