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USING POWER FUNCTION OF THE ANALYSIS OF VARIANCE TEST IN WHEAT EXPERIMENTS

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ABSTRACT

The uniform plots and blocks are very important to test and detect the true differences between experimental units in field experiments (treatments). The size of block and number of plots per block and number of samples per plot depends upon the variability of the sample, which depends upon the degree of soil homogeneity. Two uniformity trials were applied at sids Agricultural research station Bein Suef governorate during 2001/2002 and 2002 seasons. Sids 7 variety was sown in rows 3m long and 20 cm apart in 8 strips with 200 rows for each strip. Each trial for each season was assigned in randomized Complete Block design (RCBD) in four replications. Data were analyzed with sub sampling method in different number of experimental units, different number of sample units and different plot and block sizes. To determine optimum combinations of sampling units, experimental units, block and plot sizes to detect the true effect of treatments, the power function of the analysis of variance $\varnothing^2$ was used according to Dixon and Massey (1951). The suggestion in this study is the changing of the number of samples and number of experimental units, followed by changing in the plot and the block sizes. This change will be followed by changing in the power function of the analysis of variance ($\varnothing^2$).

Results of comparing calculated and tabulated power function of the analysis $\varnothing^2$ cleared that the power increased for all combinations as a result of increasing sample units. Increasing number of experimental units per block led to a decrease in number of sample units and increases the power function of the analysis $\varnothing^2$ for all combinations. Increasing number of experimental units to ten in each block, the number of sample unit starts to be constant being seven. Results also indicated that increasing sample units clearly decreased sampling errors and this decrease became slight up to the combinations, which were selected by the power function of the analysis of variance $\varnothing^2$ and started to be constant.

INTRODUCTION

The uniform plots and blocks are very important to test and detect the true differences between experimental units in field experiments. The size of block and number of plots per block and number of samples per plot depends upon the variability of the sample, which depends upon the degree of soil homogeneity.

Tang (1938) detect the differences between two or more plots by deriving the noncentral F distribution and prepared tables for clearing the number of replications to be used. Dixon and Massey (1951) determine number of sampling units to detect the dispersion between treatment means by using power function of the analysis of variance $\varnothing^2$. Gomez (1969) pointed out that the gain in precision increased slightly by increasing the number of treatments as well as plot size. Cochran (1977) estimated the optimum samples size by minimizing the expected product of cost and variance components. EL- kalla and Gommaa (1977) recommended that the plot size consisted of five basic units being $3m^2$ in wheat field trials. Steel and Torrie (1980) determination of minimum sample size to detect true differences

among treatment means, which estimated by specifying power and estimated variances. EL- Rassas (1982) on wheat found that the optimum plot size ranged from 4 to 8 basic units with 1/300 to 1/500 feddan. Casler and Ehike (1985) reported that increasing sample size increases precision, but also increases the cost. Lin and Binns (1986) in their studied relative efficiency of two randomized blocks design with different plot size and numbers of plots per block. They reported that the purpose is to use information of past experiments to improve the proposed design either through increasing the plot size. Lefoet (1987) provide that, the efficiency of comparisons between treatment means is particularly related to the size and number of experimental units. Nasr (1991) found that the convenient number of samples were various from one character to other and number of sample size ranged from 6 to 80 samples. Surin (1992) studied the sensitivity of statistical tests to detect the differences between treatment means. He found that, when the sample size ranged from 20 to 24 plants caused higher efficiency in estimation than simple random sampling. EL- Rayes *et.al.* (1993) worked for wheat and concluded that increasing plot size decreased the variance per basic units and the optimum plot size ranged from 1/1000 to 1/750 feddan. Zedaker, *et. al.* (1993)concluded that, tha ability to detect small differences between treatment means depend on relation among sample size, type I and II errors probability and coefficient of variability of the data. Poultney and Webster (1997) showed that, the optimum plot size ranged from 1x1 m to 4x4 m^2 on their studied optimizing plot size and shapes for field experiments on trasses. Wei Wei *et. al.* (2001) mentioned that, the amount of replication depend on the size of treatment differences (plot differences) to be detect the variation in the data. Ashmawy *et. al.* (2003) recommended that the optimum plot size was 4 sample units being 2.8 m^2 in wheat.

MATERIALS AND METHODS

Two uniformity trials were conducted at sids Agricultural research station Bein Suef governorate during the two successive growing seasons of 2001/2002 and 2002/2003. Sids 7 wheat variety sown in rows 3m long and 20 cm apart in 8 strips with 200 rows for each strip. Culture practices for growing wheat were carried out as recommended. Data were collected and weighted for each row (0.2x3=0.6m^2) separately.

Statistical analysis:

Each trial for each season was assigned in randomized Complete Block design (RCBD) with sub sampling method as the produced outlined by Steel and Torrie 1980 as shown in Table 1.

Table 1: Sources of variation, degree of freedom and expected mean squares for randomized complete block design with sub sampling analysis.

Source of variance	Degree of freedom	Expected mean square
Blocks	b-1	
Treatments	k-1	$\sigma^2_s + n\sigma^2_e + nb(\sum k^2_l)/(k-1)$
Experimental error	(b-1)(k-1)	$\sigma^2_s + n\sigma^2_e$
Sampling error	Bk(s-1)	σ^2_s

Where:
b = blocks, k = treatments (number of experimental units), s = samples
Data were analyzed in different number of experimental units, different number of sample units and different plot and block sizes with four replications as shown in Table 2.

Table 2: The combinations between number of experimental units' (K), number of sample units' (S), block and plot sizes which were analyzed.

No. of experimental units (K)	No. of Sample units (S)	Plot size m^2	Block size m^2
2	2,3,4,...,20,25,30,.....,100	1.2,1.8,2.4,....,12,15,18,.....,60	2.4,3.6,4.8,....,24,30,36,....,120
3	2,3,4,....20,25,30,....,95	1.2,1.8,2.4,....,12,15,18,.....,57	5.4,3.6,7.2,....,36,45,44,....,171
4	2,3,4,....20,25,30,....,100	1.2,1.8,2.4,....,12,15,18,.....,60	4.8,7.2,9.6,.....,48,60,72,.....,240
5	2,3,4,....20,25,30,....,80	1.2,1.8,2.4,....,12,15,18,.....,48	6,9,12,.....,60,75,90,....., 240
6	2,3,4,....20,25,30,....,65	1.2,1.8,2.4,....,12,15,18,.....,39	7.2,10,8,14,4,....,72,90,108,....,234
7	2,3,4,....20,25,30,....,55	1.2,1.8,2.4,....,12,15,18,.....,33	84,12.6,16.8,....,84,105,126,....,231
8	2,3,4,....20,25,30,....,50	1.2,1.8,2.4,....,12,15,18,.....,30	9.6,14.4,19.2,....,96,120,144,....,240
9	2,3,4,....20,25,30,....,44	1.2,1.8,2.4,....,12,15,18,.....,27	10.8,16.2,21.6,....,102,135,162,....,243
10	2,3,4,....20,25,30,....,40	1.2,1.8,2.4,....,12,15,18,.....,24	12,18,14,.....,120,150,180,.....,240
11	2,3,4,....20,25,30,....,35	1.2,1.8,2.4,....,12,15,18,.....,21	13.2,19.8,26.4,.....,132,165,198,231
12	2,3,4,....20,25,30,33	1.2,1.8,2.4,....,12,15,18,.....,19.8	14.4,21.6,28.8,.....,144,180,216,252
13	2,3,4,....20,25,30	1.2,1.8,2.4,....,12,15,18	15.6,23.4,31.2,.....,156,195,234
14	2,3,4,....20,25,28	1.2,1.8,2.4,....,12,15,16.8	16.8,25.2,33.6,.....,168,210,252
15	2,3,4,.....,20,25,26	1.2,1.8,2.4,....,12,15,15.6	18,27,36,.....,180,225,270
16	2,3,4,.....,20,25	1.2,1.8,2.4,....,12,15	19.2,28.8,38.4,.....,192,240
17	2,3,4,.....,20,23	1.2,1.8,2.4,....,12,13.8	20.4,30.6,40.8,.....,204,255
18	2,3,4,.....,20,21,22	1.2,1.8,2.4,....,12,12.6,13.2	21.6,32.4,43.2,.....,216,270,324
19	2,3,4,.....,20,21	1.2,1.8,2.4,....,12,12.6	22.8,34.2,45.6,.....,228,285
20	2,3,4,.....,20	1.2,1.8,2.4,....,12	24,36,48,.....,240

To determine optimum combinations of sampling units, experimental units, plot and block sizes to detect the true effect of treatments, the power function of the analysis of variance $\varnothing^2$ was calculated according to Dixon and Massey (1951) as follows:

1- The analysis of variance technique is used to compare means of several experimental units has a normal distribution with common value σ^2 for the variance.

2- The hypothesis is assumed that the $\mu_1=\mu_2=\ldots.=\mu_k$ for experimental units in uniform trials and the alternative to this hypothesis would specify values for $\mu_1, \ldots, \mu_k$ not all the same.

3- We can measure the dispersion of the μi by using the variance of these quantities, $\Sigma (\mu i-\mu^-)^2/k$ where $\mu^-= \Sigma \mu i/k$.

4- It is convenient to divide this quantity by σ^2/n, and call it $\varnothing^2$.

$\varnothing^2=\Sigma [(\mu i-\mu^{-2})/k] /(\sigma^2/s)$

Where: (s) is the number of sample units.

5- The probability of rejecting the hypothesis μ1 ? μ_2 ? ... ? μi when $\varnothing^2$ calculated less than (<) $\varnothing^2$ tabulated.

6- To estimate the tabulated $\varnothing^2$ the values corresponding to levels of significance $\propto$= 1 % and $\propto$= 5 %. These valuès were f_1 (across the top) and f_2 (down the left side). The value of f_1 is degree of freedom in the numerator being k-1 and f_2 denotes degree of freedom in the denominator with value equal (k x s)-k.

The suggestion in this research is, the changing of the number of sample units and number of experimental units, followed by changing in the plot and the block sizes. This change will be followed by changing in the power function of the analysis of variance ($\varnothing^2$). If values of calculated $\varnothing^2$ greater than or equal (?) tabulated values then we except the null hypothesis and we reach to the homogeneity in the experimental units and blocks. Then, we start to detect the true effect between treatment means without error types.

RESULTES AND DISCUSSION

The estimates of calculated and tabulated power function of analysis of variance $\varnothing^2$, number of experimental units, number sample units, plot and block sizes in the two seasons were arranged in Tables 3. The results of comparing calculated and tabulated power function of the analysis $\varnothing^2$ cleared that this power increased for all combinations as a result of increasing sample units. Increasing number of experimental units per block led to a decrease in number of sample units and increases the power function of the analysis $\varnothing^2$ for all combinations.

Using Table 3 we can choose the combinations from number of experimental units, number of sample units, plot and block sizes which were obtained when power function of the analysis $\varnothing^2$ calculated started to be greater than or equal (?) tabulated values which were written in italic and bold face. These values indicated that, if we start by this number of combinations we could detect the true effect of treatments without error types. Increasing number of sample units more than selected numbers, also give continuos increase in the power function of the analysis $\varnothing^2$. Table 3 also clear that

increasing number of experimental units to ten in each block, the number of sample units starts to be constant being seven.

Table 3: The combinations between number of experimental units (k), number of sample units (s), plot and block sizes which were analyzed and selected by sampling error and power function of analysis of variance $\varnothing^2$ $\propto$= 5 %in the two seasons.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($\varnothing^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	∅ tabulated
2	2	2x0.6=1.2	2x1.2=2.4	4.59	5.58	0.1024	0.08	15.19
2	3	3x0.6=1.8	2x1.8=3.6	4.66	5.54	0.2560	0.10	7.02
2	4	4x0.6=2.4	2x2.4=4.8	4.90	5.52	0.3170	0.26	5.67
2	5	5x0.6=3.0	2x3.0=6	4.91	5.69	0.5006	0.37	5.12
2	6	6x0.6=3.6	2x3.6=7.2	4.65	5.34	0.5530	0.39	4.84
2	7	7x0.6=4.2	2x4.2=8.4	4.60	5.73	0.3289	0.42	4.66
2	8	8x0.6=4.8	2x4.8=9.6	4.61	5.83	0.5523	0.49	4.54
2	9	9x0.6=5.4	2x5.4=10.8	4.58	5.95	0.0877	0.65	4.45
2	10	10x0.6=6.0	2x6.0=12	4.75	5.13	0.1818	0.69	4.39
2	11	11x0.6=6.6	2x6.6=13.2	4.90	4.43	0.8946	0.72	4.34
2	12	12x0.6=7.2	2x7.2=14.4	4.87	4.64	0.4783	0.77	4.34
2	13	13x0.6=7.8	2x7.8=15.6	4.01	4.91	0.9978	0.79	4.34
2	14	14x0.6=8.4	2x8.4=16.8	4.24	4.53	0.9684	0.81	4.34
2	15	15x0.6=9.0	2x9.0=18	4.20	4.32	1.9471	0.89	4.34
2	16	16x0.6=9.6	2x9.6=19.2	4.20	4.93	2.1135	0.99	4.19
2	17	17x0.6=10.2	2x10.2=20.4	4.20	4.93	2.2996	1.02	4.19
2	18	18x0.6=10.8	2x10.8=21.6	4.39	4.21	2.4661	1.56	4.19
2	19	19x0.6=11.4	2x11.4=22.8	4.37	4.83	2.5965	1.67	4.19
2	20	20x0.6=12.0	2x12.0=24	4.28	4.16	2.6531	1.92	4.19
2	25	25x0.6=15.0	2x15.0=30	4.59	4.97	2.9256	2.00	4.12
2	30	30x0.6=18.0	2x18.0=36	4.72	4.23	3.0426	2.56	4.12
2	35	35x0.6=21.0	2x21.0=42	3.85	4.30	3.9849	3.02	4.12
2	40	40x0.6=24.0	2x24.0=48	3.68	3.73	4.6347	4.99	4.12
2	45	45x0.6=27.0	2x27.0=54	3.40	3.97	5.4735	5.00	4.12
2	50	50x0.6=30.0	2x30.0=60	3. 38	3.38	19.6685	9.63	4.12
2	55	55x0.6=33.0	2x33.0=66	3.33	3.52	49.7719	9.99	4.12
2	60	60x0.6=36.0	2x36.0=72	3.39	3.45	106.6753	10.15	4.12
2	65	65x0.6=39.0	2x39.0=78	3.43	3.47	66.5120	20.62	4.12
2	70	70x.06=42.0	2x42.0=84	3.50	3.20	55.2450	36.70	4.12
2	75	75x0.6=45.0	2x45.0=90	3.52	3.15	74.7099	50.06	4.06
2	80	80x0.6=48.0	2x48.0=96	3.45	3.85	124.5544	66.20	4.06
2	85	85x0.6=51.0	2x51.0=102	3.63	3.27	16.8411	40.33	4.06
2	90	90x0.6=54.0	2x54.0=108	3.61	3.96	25.3348	23.65	4.06
2	95	95x0.6=57.0	2x57.0=114	3.52	3.81	29.5109	36.21	4.06
2	100	100x0.6=60	2x60.0=120	3.60	3.45	46.4473	40.25	4.06
3	2	2x0.6=1.2	3x1.2=3.6	4.05	6.84	0.2275	0.03	20.78
3	3	3x0.6=1.8	3x1.8=5.4	4.30	6.65	0.2783	0.07	5.53
3	4	4x0.6=2.4	3x2.4=7.2	4.22	6.89	0.4165	0.12	4.79
3	5	5x0.6=3.0	3x3.0=9	4.34	6.10	0.8781	0.17	4.17
3	6	6x0.6=3.6	3x3.6=10.8	4.34	6.72	1.5353	0.26	4.01
3	7	7x0.6=4.2	3x4.2=12.6	4.42	6.82	1.6213	0.42	3.81
3	8	8x0.6=4.8	3x4.8=14.4	4.24	6.35	1.0780	0.92	3.74
3	9	9x0.6=5.4	3x5.4=16.2	4.37	5.70	1.8044	1.06	3.65
3	10	10x0.6=6.0	3x6.0=18	4.41	5.01	1.5528	1.33	3.65
3	11	11x0.6=6.6	3x6.6=19.8	4.50	5.34	1.6383	1.72	3.56
3	12	12x0.6=7.2	3x7.2=21.6	4.72	5.07	1.5045	1.79	3.56
3	13	13x0.6=7.8	3x7.8=23.4	4.77	5.75	1.9084	1.82	3.56
3	14	14x0.6=8.4	3x8.4=26.2	4.84	5.12	2.2947	1.88	3.46
3	15	15x0.6=9.0	3x9.0=27	4.04	5.35	2.3403	1.92	3.46
3	16	16x0.6=9.6	3x9.6=28.8	3.16	5.24	2.4300	2.00	3.46
3	17	17x0.6=10.2	3x10.2=30.6	3.15	4.24	2.7220	2.23	3.46
3	18	18x0.6=10.8	3x10.8=32.4	3.11	4.51	2.8050	2.34	3.46
3	19	19x0.6=11.4	3x11.4=34.2	3.08	4.61	2.9021	3.00	3.46
3	20	20x0.6=12.0	3x12.0=36	3.03	4.11	3.1289	3.09	3.46
3	25	25x0.6=15.0	3x15.0=45	3.01	3.81	3.9764	3.49	3.38

Table 3: Cont.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($Ø^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	Ø tabulated
3	30	30x0.6=18.0	3x18.0=54	3.07	3.98	4.0709	3.99	3.38
3	35	35x0.6=21.0	3x21.0=63	3.09	3.94	4.8320	4.02	3.38
3	40	40x0.6=24.0	3x24.0=72	3.09	3.74	15.1588	4.78	3.38
3	45	45x0.6=27.0	3x27.0=81	3.05	3.91	27.3344	6.62	4.00
3	50	50x0.6=30.0	3x30.0=90	3.06	3.40	47.9547	12.16	4.00
3	55	55x0.6=33.0	3x33.0=99	3.01	3.63	24.8771	19.46	4.00
3	60	60x0.6=36.0	3x36.0=108	3.03	3.23	66.5693	30.90	3.35
3	65	65x0.6=39.0	3x39.0=117	3.35	3.21	64.3195	34.43	3.35
3	70	70x.06=42.0	3x42.0=126	3.37	3.73	65.6846	52.23	3.35
3	75	75x0.6=45.0	3x45.0=135	3.47	3.85	85.7869	65.01	3.35
3	80	80x0.6=48.0	3x48.0=144	3.39	3.21	35.9337	71.13	3.35
3	85	85x0.6=51.0	3x51.0=153	3.44	3.94	66.1440	70.23	3.35
3	90	90x0.6=54.0	3x54.0=162	3.78	3.42	86.9531	80.26	3.35
3	95	95x0.6=57.0	3x57.0=171	3.47	3.78	73.7433	76.72	3.35
4	2	2x0.6=1.2	4x1.2=4.8	2.05	3.94	0.2771	0.10	7.57
4	3	3x0.6=1.8	4x1.8=7.2	2.03	3.24	0.7871	0.17	4.49
4	4	4x0.6=2.4	4x2.4=9.6	2.20	3.11	0.9910	0.23	3.79
4	5	5x0.6=3.0	4x3.0=12	2.36	3.30	1.0091	0.36	3.49
4	6	6x0.6=3.6	4x3.6=14.4	2.54	3.41	1.2376	0.52	3.32
4	7	7x0.6=4.2	4x4.2=16.8	2.47	3.55	1.5421	0.92	3.21
4	8	8x0.6=4.8	4x4.8=19.2	2.36	3.16	1.7950	1.23	3.21
4	9	9x0.6=5.4	4x5.4=21.6	2.40	3.70	2.2177	1.82	3.11
4	10	10x0.6=6.0	4x6.0=24	2.42	3.75	2.5428	2.06	3.11
4	11	11x0.6=6.6	4x6.6=26.4	2.52	2.49	2.8837	2.65	2.99
4	12	12x0.6=7.2	4x7.2=28.8	2.47	2.17	3.37906	2.80	2.99
4	13	13x0.6=7.8	4x7.8=31.2	2.39	2.37	11.6364	2.89	2.99
4	14	14x0.6=8.4	4x8.4=33.6	2.34	2.59	14.8663	3.01	2.99
4	15	15x0.6=9.0	4x9.0=36	2.42	2.14	18.0916	7.23	2.99
4	16	16x0.6=9.6	4x9.6=38.4	2.45	2.32	18.8312	9.12	2.91
4	17	17x0.6=10.2	4x10.2=40.8	2.48	2.18	20.9214	15.66	2.91
4	18	18x0.6=10.8	4x10.8=43.2	2.45	2.23	21.2607	18.02	2.91
4	19	19x0.6=11.4	4x11.4=45.6	2.38	2.56	29.4459	22.73	2.91
4	20	20x0.6=12.0	4x12.0=48	2.31	2.89	29.1255	25.62	2.86
4	25	25x0.6=15.0	4x15.0=60	1.16	2.75	26.1455	22.32	2.86
4	30	30x0.6=18.0	4x18.0=72	1.09	2.08	41.8832	32.65	2.86
4	35	35x0.6=21.0	4x21.0=84	2.95	2.39	30.1675	30.27	2.86
4	40	40x0.6=24.0	4x24.0=96	2.82	2.80	79.7724	49.23	2.86
4	45	45x0.6=27.0	4x27.0=108	2.71	2.98	125.6060	57.65	2.86
4	50	50x0.6=30.0	4x30.0=120	2.72	2.11	166.1070	88.26	2.86
4	55	55x0.6=33.0	4x33.0=132	2.67	2.60	200.6958	80.56	2.86
4	60	60x0.6=36.0	4x36.0=144	2.62	2.95	269.6464	97.30	2.86
4	65	65x0.6=39.0	4x39.0=156	2.79	2.28	285.553	106.02	2.86
4	70	70x.06=42.0	4x42.0=168	2.77	2.08	353.4406	120.35	2.86
4	75	75x0.6=45.0	4x45.0=180	2.83	2.58	362.8705	160.67	2.86
4	80	80x0.6=48.0	4x48.0=192	2.75	2.32	419.3002	203.52	2.82
4	85	85x0.6=51.0	4x51.0=204	2.77	2.50	459.8138	250.02	2.82
4	90	90x0.6=54.0	4x54.0=216	2.80	2.64	500.2088	270.78	2.82
4	95	95x0.6=57.0	4x57.0=228	2.76	2.13	569.7316	306.25	2.82
4	100	100x0.6=60	4x60.0=240	1.75	2.15	7.3.9537	370.02	2.82
5	2	2x0.6=1.2	5x1.2=6	4.44	7.62	1.3761	0.78	7.59
5	3	3x0.6=1.8	5x1.8=9	4.46	7.51	1.4779	0.92	3.81
5	4	4x0.6=2.4	5x2.4=12	4.39	7.06	2.2929	1.02	3.33
5	5	5x0.6=3.0	5x3.0=15	4.14	7.63	2.3654	1.72	3.02
5	6	6x0.6=3.6	5x3.6=18	3.90	7.64	2.436	1.92	2.9
5	7	7x0.6=4.2	5x4.2=21	3.61	7.29	2.4580	1.99	2.79
5	8	8x0.6=4.8	5x4.8=24	3.50	7.61	2.561	2.02	2.79
5	9	9x0.6=5.4	5x5.4=27	3.61	7.47	2.6853	2.09	2.69
5	10	10x0.6=6.0	5x6.0=30	3.57	6.81	2.6853	2.19	2.69

Table 3: Cont.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($Ø^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	Ø tabulated
5	11	11x0.6=6.6	5x6.6=33	3.46	6.89	3.9908	2.50	2.69
5	12	12x0.6=7.2	5x7.2=36	3.47	6.50	5.0296	3.09	2.69
5	13	13x0.6=7.8	5x7.8=39	3.31	6.55	18.4934	6.82	2.58
5	14	14x0.6=8.4	5x8.4=42	3.25	6.61	22.3974	10.17	2.58
5	15	15x0.6=9.0	5x9.0=45	3.27	6.33	24.7022	15.01	2.58
5	16	16x0.6=9.6	5x9.6=48	3.36	6.58	29.3273	26.32	2.58
5	17	17x0.6=10.2	5x10.2=51	3.38	6.33	30.5117	29.32	2.53
5	18	18x0.6=10.8	5x10.8=54	3.35	5.19	37.8826	32.57	2.53
5	19	19x0.6=11.4	5x11.4=57	3.46	5.20	46.1265	49.23	2.53
5	20	20x0.6=12.0	5x12.0=60	3.50	5.14	52.8322	60.72	2.53
5	25	25x0.6=15.0	5x15.0=75	3.36	6.14	85.0124	69.47	2.53
5	30	30x0.6=18.0	5x18.0=90	3.40	3.54	103.9905	77.00	2.53
5	35	35x0.6=21.0	5x21.0=105	3.50	3.80	117.8915	96.23	2.53
5	40	40x0.6=24.0	5x24.0=120	3.36	3.43	126.4684	115.11	2.53
5	45	45x0.6=27.0	5x27.0=135	3.35	3.97	126.8812	122.37	2.50
5	50	50x0.6=30.0	5x30.0=150	3.41	2.55	148.5105	136.72	2.50
5	55	55x0.6=33.0	5x33.0=165	3.50	2.70	144.5671	140.48	2.50
5	60	60x0.6=36.0	5x36.0=180	3.48	2.91	199.0816	170.66	2.50
5	65	65x0.6=39.0	5x39.0=195	3.47	3.52	237.3762	210.62	2.50
5	70	70x.06=42.0	5x42.0=210	3.51	3.78	249.4048	260.02	2.50
5	75	75x0.6=45.0	5x45.0=225	3.75	3.86	259.7633	285.31	2.50
5	80	80x0.6=48.0	5x48.0=240	3.71	3.73	295.1225	315.16	2.50
6	2	2x0.6=1.2	6x1.2=7.2	4.37	5.21	0.0285	0.001	5.05
6	3	3x0.6=1.8	6x1.8=10.8	4.47	5.44	0.2419	0.03	3.33
6	4	4x0.6=2.4	6x2.4=14.4	4.81	5.34	0.4743	0.09	2.88
6	5	5x0.6=3.0	6x3.0=18	4.06	5.21	1.0569	0.23	2.68
6	6	6x0.6=3.6	6x3.6=21.6	4.08	4.63	1.6175	0.77	2.56
6	7	7x0.6=4.2	6x4.2=25.2	4.85	4.64	1.8107	0.92	2.56
6	8	8x0.6=4.8	6x4.8=28.8	3.91	4.71	2.2744	1.25	2.46
6	9	9x0.6=5.4	6x5.4=32.4	3.05	4.16	3.6057	1.37	2.46
6	10	10x0.6=6.0	6x6.0=36	3.26	4.17	4.1047	2.99	2.46
6	11	11x0.6=6.6	6x6.6=39.6	3.88	4.39	4.7137	3.10	2.46
6	12	12x0.6=7.2	6x7.2=43.2	3.05	4.07	5.2808	4.68	2.34
6	13	13x0.6=7.8	6x7.8=46.8	3.07	3.24	6.4500	4.92	2.34
6	14	14x0.6=8.4	6x8.4=0.4	3.15	3.36	8.0257	5.64	2.34
6	15	15x0.6=9.0	6x9.0=54	3.12	2.81	10.7967	5.99	2.28
6	16	16x0.6=9.6	6x9.6=57.6	3.23	2.91	13.5273	7.20	2.28
6	17	17x0.6=10.2	6x10.2=61.2	3.18	2.68	14.3652	7.73	2.28
6	18	18x0.6=10.8	6x10.8=64.8	3.22	2.23	15.9411	9.56	2.28
6	19	19x0.6=11.4	6x11.4=70.8	3.19	2.59	19.7339	10.15	2.28
6	20	20x0.6=12.0	6x12.0=72	3.26	3.90	20.1156	15.16	2.28
6	25	25x0.6=15.0	6x15.0=90	3.37	1.46	21.2822	18.20	2.28
6	30	30x0.6=18.0	6x18.0=108	3.78	2.87	26.9000	20.66	2.25
6	35	35x0.6=21.0	6x21.0=126	3.84	2.54	28.6416	25.25	2.25
6	40	40x0.6=24.0	6x24.0=144	3.68	3.10	39.0542	30.68	2.25
6	45	45x0.6=27.0	6x27.0=162	3.57	2.78	70.7241	55.16	2.25
6	50	50x0.6=30.0	6x30.0=180	3.55	2.39	99.6145	76.11	2.25
6	55	55x0.6=33.0	6x33.0=198	3.73	2.82	124.0683	89.82	2.25
6	60	60x0.6=36.0	6x36.0=216	3.77	2.08	157.0164	120.11	2.25
6	65	65x0.6=39.0	6x39.0=234	3.70	2.06	179.8879	156.17	2.25
7	2	2x0.6=1.2	7x1.2=84	5.21	8.32	0.2238	0.011	4.96
7	3	3x0.6=1.8	7x1.8=12.6	5.63	8.94	0.5265	0.96	2.97
7	4	4x0.6=2.4	7x2.4=16.8	5.02	7.07	0.7266	1.12	2.63
7	5	5x0.6=3.0	7x3.0=21	5.42	7.33	0.9779	1.17	2.38
7	6	6x0.6=3.6	7x3.6=25.2	5.43	7.78	1.2762	1.23	2.38
7	7	7x0.6=4.2	7x4.2=29.4	5.82	7.80	1.5683	1.40	2.28
7	8	8x0.6=4.8	7x4.8=33.6	4.90	6.72	2.6667	1.88	2.28

Table 3: Cont.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($\varnothing^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	∅ tabulated
7	9	9x0.6=5.4	7x5.4=37.8	3.03	6.98	2.8286	2.00	2.28
7	*10*	*10x0.6=6.0*	*7x6.0=42*	*3.08*	*5.76*	*3.8838*	*2.25*	*2.16*
7	11	11x0.6=6.6	7x6.6=46.2	3.06	5.83	4.2985	3.65	2.16
7	12	12x0.6=7.2	7x7.2=50.4	3.76	5.84	12.0959	13.92	2.16
7	13	13x0.6=7.8	7x7.8=54.6	3.12	5.95	13.8509	13.99	2.10
7	14	14x0.6=8.4	7x8.4=58.8	3.15	5.55	13.7846	14.65	2.10
7	15	15x0.6=9.0	7x9.0=63	3.17	5.07	14.1234	15.21	2.10
7	16	16x0.6=9.6	7x9.6=86.4	3.29	4.82	12.1209	15.99	2.10
7	17	17x0.6=10.2	7x10.2=71.4	3.24	5.82	14.3571	17.28	2.10
7	18	18x0.6=10.8	7x10.8=75.6	3.31	5.62	15.3616	20.23	2.10
7	19	19x0.6=11.4	7x11.4=79.8	3.34	5.31	18.4195	22.46	2.04
7	20	20x0.6=12.0	7x12.0=84	3.41	4.63	16.6554	25.33	2.04
7	25	25x0.6=15.0	7x15.0=105	3.37	4.16	25.0849	25.96	2.04
7	30	30x0.6=18.0	7x18.0=126	3.25	4.27	36.004	37.12	2.04
7	35	35x0.6=21.0	7x21.0=147	3.18	4.44	46.7369	49.01	2.04
7	40	40x0.6=24.0	7x24.0=168	3.45	4.54	53.9468	60.66	2.04
7	45	45x0.6=27.0	7x27.0=189	3.50	4.81	65.9545	79.17	2.04
7	50	50x0.6=30.0	7x30.0=210	3.51	4.15	88.6274	95.22	2.04
7	55	55x0.6=33.0	7x33.0=231	3.72	4.53	106.6818	115.11	2.04
8	2	2x0.6=1.2	8x1.2=9.6	5.14	6.92	0.5410	0.26	3.88
8	3	3x0.6=1.8	8x1.8=14.4	5.47	6.11	0.5799	0.32	2.70
8	4	4x0.6=2.4	8x2.4=19.2	5.62	6.04	0.9568	0.55	2.37
8	5	5x0.6=3.0	8x3.0=24	5.74	6.93	1.0689	0.72	2.24
8	6	6x0.6=3.6	8x3.6=28.8	4.90	6.18	0.9684	0.912	2.13
8	7	7x0.6=4.2	8x4.2=33.6	4.84	6.18	1.7111	1.52	2.13
8	*8*	*8x0.6=4.8*	*8x4.8=38.4*	*4.64*	*5.79*	*2.2073*	1.77	*2.13*
8	9	9x0.6=5.4	8x5.4=43.2	4.61	4.54	3.8365	1.90	2.01
8	*10*	*10x0.6=6.0*	*8x6.0=48*	*4.64*	*4.95*	*5.6189*	*2.43*	*2.01*
8	11	11x0.6=6.6	8x6.6=52.8	4.02	4.27	3.8699	2.96	1.96
8	12	12x0.6=7.2	8x7.2=57.6	4.20	4.31	4.3854	3.54	1.96
8	13	13x0.6=7.8	8x7.8=62.4	4.14	4.58	5.6123	4.02	1.96
8	14	14x0.6=8.4	8x8.4=67.2	4.06	4.15	7.2669	6.62	1.90
8	15	15x0.6=9.0	8x9.0=72	4.11	4.73	8.3218	6.95	1.90
8	16	16x0.6=9.6	8x9.6=76.8	4.07	4.94	10.1041	9.12	1.90
8	17	17x0.6=10.2	8x10.2=81.6	4.12	4.31	12.3070	10.03	1.9
8	18	18x0.6=10.8	8x10.8=86.4	4.07	4.80	13.6401	12.56	1.9
8	19	19x0.6=11.4	8x11.4=91.2	4.00	4.75	17.2421	15.67	1.9
8	20	20x0.6=12.0	8x12.0=96	4.84	4.23	17.6307	16.20	1.9
8	25	25x0.6=15.0	8x15.0=120	4.97	3.41	17.748	16.92	1.9
8	30	30x0.6=18.0	8x18.0=144	3.80	3.70	25.6721	20.21	1.9
8	35	35x0.6=21.0	8x21.0=168	3.78	3.25	33.4505	29.62	1.9
8	40	40x0.6=24.0	8x24.0=192	3.76	3.00	45.2334	36.54	1.9
8	45	45x0.6=27.0	8x27.0=216	3.66	2.50	62.7406	55.04	1.9
8	50	50x0.6=30.0	8x30.0=240	3.65	2.46	88.6204	76.04	1.9
9	2	2x0.6=1.2	9x1.2=10.8	7.48	8.30	0.3817	0.12	3.08
9	3	3x0.6=1.8	9x1.8=16.2	6.21	8.91	0.4365	0.25	2.48
9	4	4x0.6=2.4	9x2.4=21.6	4.83	8.77	0.8739	0.43	2.25
9	5	5x0.6=3.0	9x3.0=27	4.35	8.51	1.3722	0.75	2.02
9	6	6x0.6=3.6	9x3.6=32.4	4.18	8.80	1.4640	0.94	2.02
9	7	7x0.6=4.2	9x4.2=37.8	4.22	8.62	1.7905	1.52	2.02
9	*8*	*8x0.6=4.8*	*9x4.8=43.2*	*4.21*	*7.18*	*2.1888*	1.79	*1.89*
9	*9*	*9x0.6=5.4*	*9x5.4=48.6*	*4.28*	*6.88*	*2.8060*	*1.92*	*1.82*
9	10	10x0.6=6.0	9x6.0=54	*4.21*	*6.08*	2.0497	2.12	1.82
9	11	11x0.6=6.6	9x6.6=59.4	4.32	6.31	2.6934	2.43	1.82
9	12	12x0.6=7.2	9x7.2=64.8	4.36	6.39	2.9080	3.65	1.82
9	13	13x0.6=7.8	9x7.8=70.2	4.16	6.06	4.0343	3.99	1.82
9	14	14x0.6=8.4	9x8.4=75.6	4.06	6.52	4.7865	5.12	1.82

Table 3: Cont.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($Ø^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	Ø tabulated
9	15	15x0.6=9.0	9x9.0=81	4.01	5.53	6.1505	5.91	1.77
9	16	16x0.6=9.6	9x9.6=86.4	4.01	5.58	7.2652	6.02	1.77
9	17	17x0.6=10.2	9x10.2=91.8	3.92	5.71	8.6609	6.92	1.77
9	18	18x0.6=10.8	9x10.8=97.2	3.89	5.26	9.7042	7.158	1.77
9	19	19x0.6=11.4	9x11.4=102.6	3.86	5.54	11.0785	9.78	1.77
9	20	20x0.6=12.0	9x12.0=102	3.85	5.29	10.2368	12.15	1.77
9	25	25x0.6=15.0	9x15.0=135	3.85	4.42	15.8325	19.20	1.77
9	30	30x0.6=18.0	9x18.0=162	3.95	5.82	24.4010	22.12	1.77
9	35	35x0.6=21.0	9x21.0=189	3.80	5.28	37.4082	26.18	1.77
9	40	40x0.6=24.0	9x24.0=216	3.77	6.91	43.1161	36.17	1.77
9	44	45x0.6=27.0	9x27.0=243	3.69	6.70	57.0766	49.02	1.77
10	2	2x0.6=1.2	10x1.2=12	4.36	9.73	0.6445	0.23	3.20
10	3	3x0.6=1.8	10x1.8=18	3.36	9.96	0.6591	0.42	2.3
10	4	4x0.6=2.4	10x2.4=24	3.37	9.34	1.2630	0.78	2.04
10	5	5x0.6=3.0	10x3.0=30	3.15	8.60	1.3906	0.90	1.90
10	6	6x0.6=3.6	10x3.6=36	3.04	8.02	1.6916	1.02	1.90
10	7	7x0.6=4.2	10x4.2=42	2.89	8.96	2.1099	1.70	1.79
10	8	8x0.6=4.8	10x4.8=48	2.89	7.45	4.1415	1.97	1.79
10	9	9x0.6=5.4	10x5.4=54	2.92	7.98	5.5041	2.65	1.74
10	10	10x0.6=6.0	10x6.0=60	2.92	7.04	6.9372	4.23	1.74
10	11	11x0.6=6.6	10x6.6=66	2.100	7.40	7.4344	5.23	1.74
10	12	12x0.6=7.2	10x7.2=72	3.02	7.99	7.2391	6.78	1.74
10	13	13x0.6=7.8	10x7.8=78	3.05	7.77	7.9091	8.82	1.69
10	14	14x0.6=8.4	10x8.4=84	3.03	7.09	8.4667	8.90	1.69
10	15	15x0.6=9.0	10x9.0=90	3.18	7.29	9.1318	10.65	1.69
10	16	16x0.6=9.6	10x9.6=96	3.26	7.10	10.3275	11.12	1.69
10	17	17x0.6=10.2	10x10.2=102	3.26	7.52	11.9981	13.23	1.69
10	18	18x0.6=10.8	10x10.8=108	3.24	7.77	14.3501	15.47	1.69
10	19	19x0.6=11.4	10x11.4=114	3.36	7.02	17.4358	20.66	1.69
10	20	20x0.6=12.0	10x12.0=120	3.32	7.99	20.2953	25.36	1.69
10	25	25x0.6=15.0	10x15.0=150	3.33	7.52	28.8233	29.00	1.69
10	30	30x0.6=18.0	10x18.0=180	3.40	7.48	37.2843	35.74	1.69
10	35	35x0.6=21.0	10x21.0=210	3.70	7.61	42.8722	39.77	1.69
10	40	40x0.6=24.0	10x24.0=240	3.56	7.39	54.6469	49.45	1.69
11	2	2x0.6=1.2	11x1.2=13.2	4.08	7.46	0.268	0.67	3.68
11	3	3x0.6=1.8	11x1.8=19.8	4.84	7.63	0.8941	0.09	2.22
11	4	4x0.6=2.4	11x2.4=26.4	4.50	7.54	0.6087	0.18	1.96
11	5	5x0.6=3.0	11x3.0=33	4.45	7.52	0.6421	0.56	1.82
11	6	6x0.6=3.6	11x3.6=39.6	4.80	7.60	0.6573	0.72	1.71
11	7	7x0.6=4.2	11x4.2=46.2	3.20	7.78	2.1164	0.95	1.71
11	8	8x0.6=4.8	11x4.8=52.8	3.04	6.52	2.9207	1.83	1.71
11	9	9x0.6=5.4	11x5.4=59.4	2.79	6.79	4.3955	2.03	1.64
11	10	10x0.6=6.0	11x6.0=66	2.98	6.71	4.3544	3.21	1.64
11	11	11x0.6=6.6	11x6.6=72.6	2.95	6.93	4.9928	3.72	1.64
11	12	12x0.6=7.2	11x7.2=79.2	3.09	6.28	4.5658	4.21	1.59
11	13	13x0.6=7.8	11x7.8=85.8	3.16	6.04	4.7442	4.70	1.59
11	14	14x0.6=8.4	11x8.4=92.4	3.15	6.63	5.8196	4.998	1.59
11	15	15x0.6=9.0	11x9.0=99	3.23	5.33	6.1318	5.267	1.59
11	16	16x0.6=9.6	11x9.6=105.6	3.24	5.90	6.7205	5.84	1.59
11	17	17x0.6=10.2	11x10.2=112.2	3.22	5.83	8.5683	6.330	1.59
11	18	18x0.6=10.8	11x10.8=118.8	3.20	5.52	9.0388	7.11	1.59
11	19	19x0.6=11.4	11x11.4=125.4	3.20	5.07	10.9666	9.26	1.59
11	20	20x0.6=12.0	11x12.0=132	3.16	4.26	12.0215	9.92	1.59
11	25	25x0.6=15.0	11x15.0=165	3.42	3.18	18.7046	12.13	1.59
11	30	30x0.6=18.0	11x18.0=198	3.47	4.73	21.8019	15.24	1.59
11	35	35x0.6=21.0	11x21.0=231	3.65	5.04	25.8561	20.68	1.54
12	2	2x0.6=1.2	12x1.2=14.4	4.17	4.03	0.2594	0.02	2.81

Table 3: Cont.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($\varnothing^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	∅ tabulated
12	3	3x0.6=1.8	12x1.8=21.6	4.79	4.67	0.5601	0.09	2.09
12	4	4x0.6=2.4	12x2.4=28.8	4.69	4.08	1.0170	0.35	1.96
12	5	5x0.6=3.0	12x3.0=36	4.77	3.01	1.1408	0.82	1.82
12	6	6x0.6=3.6	12x3.6=43.2	2.65	3.71	1.5678	1.05	1.71
12	7	7x0.6=4.2	12x4.2=50.4	2.57	3.22	1.8998	1.52	1.64
12	8	8x0.6=4.8	12x4.8=57.6	2.85	3.89	2.5215	1.92	1.64
12	9	9x0.6=5.4	12x5.4=64.8	3.00	3.20	2.5857	2.11	1.64
12	10	10x0.6=6.0	12x6.0=72	2.97	3.07	3.7478	2.78	1.64
12	11	11x0.6=6.6	12x6.6=79.2	2.88	2.54	4.8485	3.02	1.59
12	12	12x0.6=7.2	12x7.2=86.4	2.93	2.48	5.6097	3.92	1.59
12	13	13x0.6=7.8	12x7.8=93.6	2.92	3.02	7.1509	4.00	1.59
12	14	14x0.6=8.4	12x8.4=100.8	3.43	3.27	6.8763	6.26	1.59
12	15	15x0.6=9.0	11x9.0=108	3.42	3.21	7.7693	6.95	1.59
12	16	16x0.6=9.6	12x9.6=115.2	3.49	3.17	8.1024	7.23	1.59
12	17	17x0.6=10.2	12x10.2=122.4	3.51	3.13	9.3038	7.77	1.59
12	18	18x0.6=10.8	12x10.8=129.6	3.58	3.57	10.5406	8.02	1.59
12	19	19x0.6=11.4	12x11.4=136.8	3.52	3.84	12.3877	10.82	1.59
12	20	20x0.6=12.0	12x12.0=144	3.56	3.22	12.5280	10.90	1.59
12	25	25x0.6=15.0	12x15.0=180	3.57	3.32	17.1052	11.11	1.54
12	30	30x0.6=18.0	12x18.0=216	3.66	3.93	21.7701	15.25	1.54
12	33	33x0.6=19.8	12x21.0=252	3.65	3.84	26.6530	17.21	1.54
13	2	2x0.6=1.2	13x1.2=15.6	4.44	4.66	0.2571	0.11	2.70
13	3	3x0.6=1.8	13x1.8=23.4	4.62	5.95	0.3993	0.32	1.96
13	4	4x0.6=2.4	13x2.4=31.2	4.18	10.75	0.6119	0.52	1.96
13	5	5x0.6=3.0	13x3.0=39	4.77	7.27	0.6667	0.74	1.69
13	6	6x0.6=3.6	13x3.6=46.8	3.92	7.65	0.7887	0.94	1.57
13	7	7x0.6=4.2	13x4.2=54.6	3.97	7.64	1.8492	1.12	1.57
13	8	8x0.6=4.8	13x4.8=62.4	2.81	8.14	1.9391	1.66	1.56
13	9	9x0.6=5.4	13x5.4=70.2	2.88	8.37	2.2254	1.95	1.56
13	10	10x0.6=6.0	13x6.0=78	2.92	9.14	2.9588	2.16	1.56
13	11	11x0.6=6.6	13x6.6=85.8	3.81	9.25	2.7987	2.54	1.46
13	12	12x0.6=7.2	13x7.2=93.6	3.93	9.74	3.0853	2.77	1.46
13	13	13x0.6=7.8	13x7.8=101.4	3.81	10.16	3.4851	3.21	1.46
13	14	14x0.6=8.4	13x8.4=109.2	3.87	10.41	4.1020	4.25	1.46
13	15	15x0.6=9.0	13x9.0=117	3.89	9.15	4.2971	4.32	1.46
13	16	16x0.6=9.6	13x9.6=124.8	3.90	9.44	4.3514	4.34	1.46
13	17	17x0.6=10.2	13x10.2=132.6	3.89	8.99	5.3611	5.02	1.46
13	18	18x0.6=10.8	13x10.8=140.4	3.88	9.49	5.8174	5.73	1.46
13	19	19x0.6=11.4	13x11.4=148.2	3.84	9.78	7.9752	8.06	1.46
13	20	20x0.6=12.0	13x12.0=156	3.87	10.74	8.5180	10.12	1.39
13	25	25x0.6=15.0	13x15.0=195	3.71	13.13	15.2699	12.11	1.39
13	30	30x0.6=18.0	13x18.0=234	3.57	15.20	24.6362	20.36	1.39
14	2	2x0.6=1.2	14x1.2=16.8	5.21	9.09	0.5774	0.12	2.48
14	3	3x0.6=1.8	14x1.8=25.2	5.16	9.00	0.5909	0.23	1.69
14	4	4x0.6=2.4	14x2.4=33.6	3.37	9.25	1.1229	0.73	1.69
14	5	5x0.6=3.0	14x3.0=42	4.04	9.47	1.2095	0.92	1.57
14	6	6x0.6=3.6	14x3.6=50.4	3.82	7.13	1.2046	1.23	1.57
14	7	7x0.6=4.2	14x4.2=58.8	3.94	6.69	1.0083	1.49	1.51
14	8	8x0.6=4.8	14x4.8=67.2	3.79	6.94	2.1271	1.97	1.51
14	9	9x0.6=5.4	14x5.4=78.4	3.75	6.82	2.2341	2.06	1.51
14	10	10x0.6=6.0	14x6.0=84	3.16	6.23	2.0603	2.25	1.46
14	11	11x0.6=6.6	14x6.6=92.4	3.71	6.35	2.3054	2.72	1.46
14	12	12x0.6=7.2	14x7.2=100.8	3.71	6.84	2.2970	2.91	1.46
14	13	13x0.6=7.8	14x7.8=109.2	3.67	6.20	2.8768	3.06	1.46
14	14	14x0.6=8.4	14x8.4=117.6	3.63	6.37	3.0162	3.25	1.46
14	15	15x0.6=9.0	14x9.0=126	3.69	6.83	3.8969	3.25	1.46
14	16	16x0.6=9.6	14x9.6=134.4	3.69	6.12	4.5213	3.96	1.46

Table 3: Cont.

No of (k)	No of (S)	Plot size m²	Block size m²	Sampling error		Power of the analysis of variance test (Ø²)		
				2001/2002	2002/2003	2001/2002	2002/2003	Ø tabulated
14	17	17x0.6=10.2	14x10.2=142.8	3.73	6.49	5.3330	4.12	1.46
14	18	18x0.6=10.8	14x10.8=151.2	3.70	6.80	6.2496	4.97	1.46
14	19	19x0.6=11.4	14x11.4=165.2	3.72	6.80	7.3568	6.60	1.39
14	20	20x0.6=12.0	14x12.0=168	3.70	8.84	8.1929	6.96	1.39
14	25	25x0.6=15.0	14x15.0=210	3.69	6.58	13.4529	10.24	1.39
14	28	28x0.6=16.8	14x18.0=252	3.62	6.43	15.9493	13.13	1.39
15	2	2x0.6=1.2	15x1.2=18	3.27	8.62	0.5231	0.35	2.48
15	3	3x0.6=1.8	15x1.8=27	3.21	8.45	1.1379	0.78	1.83
15	4	4x0.6=2.4	15x2.4=36	3.56	8.73	1.2911	0.94	1.69
15	5	5x0.6=3.0	15x3.0=45	3.34	8.34	1.3300	1.125	1.57
15	6	6x0.6=3.6	15x3.6=54	3.55	7.76	1.491	1.26	1.57
15	7	7x0.6=4.2	15x4.2=63	3.15	7.14	2.1250	1.82	1.51
15	8	8x0.6=4.8	15x4.8=72	3.14	7.53	2.4500	2.06	1.51
15	9	9x0.6=5.4	15x5.4=81	3.19	7.71	2.7712	2.45	1.46
15	10	10x0.6=6.0	15x6.0=90	3.06	6.39	3.0031	2.93	1.46
15	11	11x0.6=6.6	15x6.6=99	3.15	6.88	3.3109	2.98	1.46
15	12	12x0.6=7.2	15x7.2=108	3.00	6.85	3.4735	3.12	1.46
15	13	13x0.6=7.8	15x7.8=117	3.02	6.29	3.7800	3.42 -	1.46
15	14	14x0.6=8.4	15x8.4=126	3.14	6.87	4.4165	3.68	1.46
15	15	15x0.6=9.0	15x9.0=135	3.03	6.21	5.1476	4.26	1.46
15	16	16x0.6=9.6	15x9.6=144	3.04	6.21	5.1764	4.94	1.46
15	17	17x0.6=10.2	15x10.2=153	3.02	6.20	5.7862	5.02	1.39
15	18	18x0.6=10.8	15x10.8=162	3.15	6.26	6.6352	5.99	1.39
15	19	19x0.6=11.4	15x11.4=171	3.19	6.95	8.9597	7.12	1.39
15	20	20x0.6=12.0	15x12.0=180	3.44	6.16	8.7455	7.79	1.39
15	25	25x0.6=15.0	15x15.0=225	3.25	6.94	12.4303	10.10	1.39
15	26	26x0.6=15.6	15x18.0=270	3.22	6.53	13.3601	11.13	1.39
16	2	2x0.6=1.2	16x1.2=19.2	2.59	5.07	0.2872	0.09	2.07
16	3	3x0.6=1.8	16x1.8=28.8	2.41	5.86	0.4527	0.17	1.56
16	4	4x0.6=2.4	16x2.4=38.4	2.72	5.71	0.6512	0.66	1.43
16	5	5x0.6=3.0	16x3.0=48	2.77	5.41	0.7544	095	1.37
16	6	6x0.6=3.6	16x3.6=57.6	2.93	5.21	0.9224	1.01	1.37
16	7	7x0.6=4.2	16x4.2=67.2	2.89	5.28	1.1696	1.70	1.37
16	8	8x0.6=4.8	16x4.8=76.8	2.82	5.04	1.6168	1.91	1.30
16	9	9x0.6=5.4	16x5.4=86.4	2.14	5.34	2.9359	2.03	1.30
16	10	10x0.6=6.0	16x6.0=96	2.21	4.53	2.9151	2.21	1.30
16	11	11x0.6=6.6	16x6.6=105.6	2.18	5.21	2.7569	2.43	1.30
16	12	12x0.6=7.2	16x7.2=115.2	2.26	5.40	3.3772	2.96	1.30
16	13	13x0.6=7.8	16x7.8=124.8	2.52	5.97	3.8546	3.25	1.30
16	14	14x0.6=8.4	16x8.4=134.4	2.49	5.51	5.1743	3.40	1.30
16	15	15x0.6=9.0	16x9.0=144	2.51	5.39	5.9699	4.78	1.23
16	16	16x0.6=9.6	16x9.6=153.6	2.53	4.78	6.4997	4.96	1.23
16	17	17x0.6=10.2	16x10.2=163.2	2.53	5.63	7.3284	5.50	1.23
16	18	18x0.6=10.8	16x10.8=172.8	2.49	2.89	8.3340	6.92	1.23
16	19	19x0.6=11.4	16x11.4=182.4	2.43	3.42	9.9631	7.24	1.23
16	20	20x0.6=12.0	16x12.0=192	2.43	3.59	10.7777	8.19	1.23
16	25	25x0.6=15.0	16x15.0=240	2.53	4.73	13.9589	12.11	1.23
17	2	2x0.6=1.2	17x1.2=20.4	4.06	5.63	0.2010	0.10	2.19
17	3	3x0.6=1.8	17x1.8=30.6	4.53	5.63	0.4043	0.23	1.69
17	4	4x0.6=2.4	17x2.4=40.8	4.53	4.49	0.4418	0.29	1.56
17	5	5x0.6=3.0	17x3.0=51	4.44	4.55	0.5968	0.74	1.43
17	6	6x0.6=3.6	17x3.6=61.2	4.38	4.34	0.8046	0.912	1.37
17	7	7x0.6=4.2	17x4.2=71.4	3.48	4.40	1.8962	1.49	1.37
17	8	8x0.6=4.8	17x4.8=81.6	3.48	4.88	1.9712	1.62	1.37
17	9	9x0.6=5.4	17x5.4=91.8	3.41	4.21	1.4821	1.92	1.34
17	10	10x0.6=6.0	17x6.0=102	3.31	4.01	1.7952	2.02	1.34
17	11	11x0.6=6.6	17x6.6=112.2	3.18	4.72	2.5178	2.34	1.34

Table 3: Cont.

No of (k)	No of (S)	Plot size m²	Block size m²	Sampling error		Power of the analysis of variance test ($Ø^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	Ø tabulated
17	12	12x0.6=7.2	17x7.2=122.4	3.69	4.38	2.3398	2.57	1.34
17	13	13x0.6=7.8	17x7.8=132.6	3.59	4.06	2.8331	2.91	1.34
17	14	14x0.6=8.4	17x8.4=142.8	3.55	4.86	3.5991	3.20	1.34
17	15	15x0.6=9.0	17x9.0=153	3.48	4.23	4.4247	3.62	1.34
17	16	16x0.6=9.6	17x9.6=163.2	3.43	4.33	5.215	5.21	1.33
17	17	17x0.6=10.2	17x10.2=173.4	3.46	4.49	6.0030	5.90	1.33
17	18	18x0.6=10.8	17x10.8=183.6	3.44	4.09	9.458	5.99	1.33
17	19	19x0.6=11.4	17x11.4=193.8	3.5	4.53	7.3417	8.02	1.33
17	20	20x0.6=12.0	17x12.0=204	3.5	3.16	8.2069	8.26	1.33
17	23	23x0.6=13.8	17x15.0=255	3.58	3.69	9.7200	10.23	1.23
18	2	2x0.6=1.2	18x1.2=21.6	4.5	9.94	0.3336	00.09	2.07
18	3	3x0.6=1.8	18x1.8=32.4	4.26	9.75	0.4003	0.12	1.69
18	4	4x0.6=2.4	18x2.4=43.2	4.62	9.68	0.6704	0.26	1.69
18	5	5x0.6=3.0	18x3.0=54	4.55	9.15	0.8619	0.77	1.43
18	6	6x0.6=3.6	18x3.6=64.8	3.38	87.79	1.0787	0.96	1.37
18	7	7x0.6=4.2	18x4.2=75.6	3.87	8.64	1.4434	1.39	1.37
18	8	8x0.6=4.8	18x4.8=86.4	3.98	8.14	1.5282	1.56	1.30
18	9	9x0.6=5.4	18x5.4=97.2	3.13	7.47	1.8002	1.77	1.30
18	10	10x0.6=6.0	18x6.0=108	3.02	7.24	2.2796	1.99	1.30
18	11	11x0.6=6.6	18x6.6=118.8	3.94	7.75	2.7799	2.00	1.30
18	12	12x0.6=7.2	18x7.2=129.6	3.87	7.99	3.2072	2.25	1.30
18	13	13x0.6=7.8	18x7.8=140.4	3.81	7.15	3.6819	3.32	1.30
18	14	14x0.6=8.4	18x8.4=151.2	3.77	7.79	3.9852	3.52	1.30
18	15	15x0.6=9.0	18x9.0=162	3.77	7.89	4.5978	3.69	1.23
18	16	16x0.6=9.6	18x9.6=172.8	3.77	7.79	5.1094	3.92	1.23
18	17	17x0.6=10.2	18x10.2=183.6	3.74	7.01	5.5248	4.74	1.23
18	18	18x0.6=10.8	18x10.8=194.4	3.69	7.28	6.0150	4.92	1.23
18	19	19x0.6=11.4	18x11.4=205.2	3.68	7.48	6.8933	5.71	1.23
18	20	20x0.6=12.0	18x12.0=216	3.64	7.73	6.9814	6.61	1.23
18	21	21x0.6=12.6	18x15.0=270	3.68	7.14	7.4313	6.89	1.23
18	22	22x0.6=13.2	18x18.0=324	3.64	7.33	8.2450	7.92	1.23
19	2	2x0.6=1.2	19x1.2=22.8	2.66	5.03	0.2491	0.10	1.93
19	3	3x0.6=1.8	19x1.8=34.2	2.75	5.19	0.5944	0.27	1.53
19	4	4x0.6=2.4	19x2.4=45.6	2.83	5.98	0.8040	0.62	1.39
19	5	5x0.6=3.0	19x3.0=57	2.78	5.81	1.0859	0.91	1.39
19	6	6x0.6=3.6	19x3.6=68.4	2.82	5.59	1.0549	1.02	1.19
19	7	7x0.6=4.2	19x4.2=79.8	2.72	5.15	2.3298	1.53	1.19
19	8	8x0.6=4.8	19x4.8=91.2	2.73	5.09	2.9776	1.62	1.12
19	9	9x0.6=5.4	19x5.4=102.6	2.68	5.22	3.7106	1.93	1.12
19	10	10x0.6=6.0	19x6.0=114	2.79	5.22	3.8255	2.02	1.12
19	11	11x0.6=6.6	19x6.6=125.4	2.86	5.64	4.4240	2.74	1.12
19	12	12x0.6=7.2	19x7.2=136.8	2.90	4.67	4.8642	3.63	1.12
19	13	13x0.6=7.8	19x7.8=148.2	2.90	4.14	5.1180	3.90	1.12
19	14	14x0.6=8.4	19x8.4=159.6	2.13	4.50	5.0078	4.25	1.06
19	15	15x0.6=9.0	19x9.0=171	2.23	4.01	5.4951	5.74	1.06
19	16	16x0.6=9.6	19x9.6=182.4	2.25	4.68	6.2486	5.92	1.06
19	17	17x0.6=10.2	19x10.2=193.8	2.52	4.36	6.4410	7.35	1.06
19	18	18x0.6=10.8	19x10.8=205.2	2.49	4.78	7.2832	7.92	1.06
19	19	19x0.6=11.4	19x11.4=216.6	2.47	2.81	7.9295	8.51	1.06
19	20	20x0.6=12.0	19x12.0=228	2.48	2.97	8.1805	9.02	1.06
19	21	21x0.6=12.6	19x15.0=285	2.48	3.61	8.8549	9.74	1.06
20	2	2x0.6=1.2	20x1.2=24	4.42	7.01	0.2500	0.29	1.83
20	3	3x0.6=1.8	20x1.8=36	4.09	6.31	0.3491	0.44	1.39
20	4	4x0.6=2.4	202.4=48	4.03	6.24	0.7099	0.56	1.26
20	5	5x0.6=3.0	203.0=60	4.93	6.46	0.9818	0.93	1.19
20	6	6x0.6=3.6	20x3.6=72	4.94	6.80	1.1231	1.00	1.19
20	7	7x0.6=4.2	20x4.2=84	2.00	5.01	1.5327	1.25	1.12

Table 3: Cont.

No of (k)	No of (S)	Plot size m^2	Block size m^2	Sampling error		Power of the analysis of variance test ($\varnothing^2$)		
				2001/2002	2002/2003	2001/2002	2002/2003	∅ tabulated
20	8	8x0.6=4.8	20x4.8=96	2.90	5.51	1.9386	1.66	1.12
20	9	9x0.6=5.4	20x5.4=108	2.96	5.40	2.7139	1.71	1.12
20	10	10x0.6=6.0	20x6.0=120	3.02	5.23	3.2671	1.912	1.12
20	11	11x0.6=6.6	20x6.6=132	3.48	4.93	2.9397	2.60	1.12
20	12	12x0.6=7.2	20x7.2=144	3.46	2.29	3.2615	2.91	1.12
20	13	13x0.6=7.8	20x7.8=156	3.47	2.48	3.5560	3.14	1.06
20	14	14x0.6=8.4	20x8.4=168	3.46	3.14	3.9621	3.92	1.06
20	15	15x0.6=9.0	20x9.0=180	3.52	2.63	4.3122	4.12	1.06
20	16	16x0.6=9.6	20x9.6=192	3.51	3.01	4.8753	4.91	1.06
20	17	17x0.6=10.2	20x10.2=204	3.52	2.80	5.4455	4.99	1.06
20	18	18x0.6=10.8	20x10.8=216	3.46	3.24	6.1685	5.17	1.06
20	19	19x0.6=11.4	20x11.4=228	3.44	3.24	7.3703	6.12	1.06
20	20	20x0.6=12.0	20x12.0=24	3.43	3.95	8.3958	7.96	1.06

Researcher can determine his optimum combinations depending upon the variability of his variables, nature of treatments and costs. This selected numbers of combinations are the minimum numbers that were estimated by the power function of the analysis of variances $\varnothing^2$ and we should start by it to detect the true treatment effect without error types as shown in Table 3. Also these estimates of $\varnothing^2$ for these combinations indicate that the homogeneity started to be clear in the plots and blocks and we can considered this power $\varnothing^2$ as a tool to measure a homogeneity. Results in Table 3 also indicated that increasing sample units clearly decreased sampling errors and this decrease became slight up to the combinations of selected numbers and started to be constant.

These results are similar to those obtained by Dixon and Massey (1951), Gomez (1969),EL- kalla and Gomma (1977), EL- Rassas (1982), Binns (1986), Nasr (1991), Surin (1992), EL- Rayes et.al. (1993), Webster (1997) and Ashmawy *et. al.* (2003).

REFERENCES

Ashmawy, F., N. A. mohamed and A. A. Hamada (2003). The precision of field experiments with wheat as influenced by plot size, shape and number of replications. J. AL. Azhar Agric. Res., 37: 25-38.

Casler, M.D. and N.J.Ehike.(1985). Sample size and experimental design for detecting differential anatomical composition of smooth Brane grass stems and leaves Crop Sci. 25:543-547.

Cochran.W.G.(1977). Sampling techniques. 3rd ed. John Wiley and sons, New York.

Dixon, W. J. and Massey, F. J., JR, (1951). Introduction to statistical analysis. New York Toronto London, McGRAW-Hill Book Company, INC.

El-Kalla and Gommaa.(1977). Estimation of soil variability and optimum plot size and shape from wheat *(triticum aestivum L.)* trials.Agric. Res. Reu. 9:81-88.

EL- Rassas, H.N. (1982). Precision of some statistical procedure in evaluating yield component of some cereal crops. Ph.D. These, Fac. Of Agric., Cairo Univ., Egypt.

El-Rayes, F.M., Thanaa M.El-Gamal, T.A. mohamed and L.I. Hanna.(1993). Optimum plot size and shape and number of replications for wheat yield trials in middle Egypt. Agric. Res. Rew., Caio. 71:1-16.

GomeZ,K.a.(1969). Relative efficiency of lattice design in rice field experiments. Phillipp Agr. 32 (9-10): 578-585.

Lefoet, P.L. (1987). Some fudamental aspects of experimentation on perennial fruit plants. Sixieme colloque sur les recherches fruitieres, Dec. 21-28.

Lin,C.S. and M.R. Binns. (1986).Relative efficiency of two randomized block designs having different plots sized and number of replications and plots per block. Agron.J.78:531-534.

Nasr, S. M. (1991). determination of the convenient number of sample units in maize. Egypt.J. Appl. Sci., 6(2): 38-43.

Poultney, R.J.Riley and R Webster. (1997). Optimizing plot size and shape for field experiments on terraces. Expl. Agric. 33:51-64.

Steel, R. G. D. and J.h. Torrie.(1980). Principles and procedures of statistics. 2nd ed. Mc Graw-Hill, New York.

Surin, N.(1992). Estimation of leafhopper population on cotton plants by sinulation. Sci. J., Fac. Of. Sci. K.U. (thailand) 10 (2): 20-28.

Tang, P.C. (1938). The power function of the analysis of variance test, with table and illustrations of their use. Statistical Researech Mermories. 2:126-149.

Wei Wei, J. Richard Alldredge, Douglas L. Young and Frank L. Young.(2001). Downsizing an integrated crop management field study affects economic and Biological results. Agron. J. 93:412-417.

Zedaker, S.M., T. G. Gregoire and J.H. Miller (1993). Sample size needs for forestry herbicide trials.Candian J. Of forest research. 23(10): 2153-2158.

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استخدام معادلة قوة اختبار تحليل التباين في تجارب القمح

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يعد تجانس القطعة والقطاع في تجارب الحقل ذو أهمية كبيرة بالنسبة للباحثين للوصول إلي الاختلافات الحقيقية بين متوسطات المعاملات وذلك لان مساحة القطعة تعتمد على عدد مفردات العينة كما أن مساحة القطاع تعتمد على عدد الوحدات التجريبية بكل قطاع والتي تعتمد بدورها على درجة التجانس فى التربة ولاجل ذلك تم زراعة الصنف سدس ٧ في تجربة تجانس في محطة بحوث سدس ببني سويف خلال عامي ٢٠٠١/٢٠٠٢ ، ٢٠٠٢/٢٠٠٣ وقد صممت كل تجربة في كل موسم على أنها قطاعات كاملة العشوائية في نموذج Sub sample في أعداد مختلفة من الوحدات التجريبية واعداد مختلفة من مفردات العينة ومساحات مختلفة من القطعة والقطاع ولإمكانية تحديد التوليفة المثلى من مفردات العينة والوحدات التجريبية والمساحات المختلفة من القطعة والقطاع للوصول إلي التأثير الحقيقي للمعاملات وقد تم استخدام معادلة Dixon and Massey (1951) لحساب قوة تحليل التباين $\varnothing^2$. والفكرة في هذه الدراسة انه بتغير عدد مفردات العينة وعدد الوحدات التجريبية في القطعة والقطاع يتبع ذلك تغير في مساحة القطعة ومساحة القطاع يتبعه تغير في قوة تحليل التباين $\varnothing^2$.

وقد أوضحت النتائج لمقارنة قوة تحليل التباين لقيم $\varnothing^2$ المحسوبة مع الجدولية في كل التوليفات أن قوة التحليل تزيد بزيادة عدد مفردات العينة كما أن هذه الزيادة تستمر بزيادة عدد الوحدات التجريبية في القطاع مع تقليل عدد مفردات العينة في داخل الوحدة التجريبية كما أوضحت النتائج إلى انه بزيادة عدد الوحدات التجريبية في القطاع إلى عشرة وحدات فإن عدد مفردات العينة يثبت عند سبعة مفردات.

وأشارت النتائج أيضا إلى أن زيادة عدد مفردات العينة يقلل من قيمة خطا المعاينة بحيث يقل هذا الانخفاض مقابل كل التوليفات التي تم اختيارها عن طريق قوة تحليل التباين $\varnothing^2$ من الوحدات المختلفة من مفردات العينة والوحدات التجريبية والمساحات المختلفة من القطعة والقطاع إلي أن يصبح انخفاض قيمة خطا المعاينة شبه ثابتا في النهاية.