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Size, Shape and No. of Replication of Plot in Relation to Field Experiment with Wheat Variety PIRSABAK-2004

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Abstract

The need for determining a standard size and shape for an experimental plot for all crops in different area of the Khyber Pakhtunkhwa, under different condition like irrigated or rain fed is urgent. The Experiment on size and shape of plot with wheat variety pirsabak-2004 is performed in Agriculture Research Institute Tarnab during 2012-13. The land under experiment was under wheat rotation in previous year, and all operation like cultural manuring etc. were uniformly applied over all area. The variance analysis of yield was done for (a) between blocks (b) within blocks bared upon the trend in the co-efficient of variation the most feasible width of the experimental plot is 2.5. While long and narrow plots are more efficient than shorter and wider plots of the same size. Based upon theoretical numbering of replications in order to bring down C.V to 5%, it is found that the number of replication in case of plot size $10^{/}$ x $4^{/}$ is in between 2-6. The fertility trend moves gradually from west to east, as compared to the North-East, which is less fertile side. The South-Western size gives the high rate of fertility. Based on the study a plot size of $10^{/}$x$4^{/}$ or 3.05 x 1.22 meter is the most suitable for experimental purpose.

Introduction

The efficiency of field experiments depend on the standard error of the different estimates involved, it is therefore necessary that the experimental arrangement should be designed in such a way as to ensure the highest possible precision.

Among the many factors that contribute to the magnitude of errors in Agriculture field experiments, the following are of considerable importance:-

1. Shape and size of the individual plot
2. Shape and size of the block division (for elimination of soil heterogeneity)
3. The position and orientation of the plots and of the bocks in the experimental field.

Information on plot variability derived from uniformity trials is of value in planning future experiments. However, as Ferguson points out, variability often depends often depends upon local conditions and it effects the accuracy of the experiments. He states further that random variability is a highly variable statistic which may deviate 30% from the best forecast. According to Lana *et al.* a clearer picture of vegetable plot efficiency would be possible if the data from more uniformity trials under various environments could be compared.

Justesen and Kalamkar arrived at similar conclusions namely that the standard deviations were reduced when plot lengths were increased as compared with widening plots. Jacobs reviewed 101 papers on plot technique with horticultural crops. The question of economy in land and labour demands that the size of the plot should be as small as possible, consistent, efficient and sufficient in the experiments. Keeping in view the heavy expenditure involved from the growing up to harvesting, the need for fixing up a suitable plot size is actually felt.

With such aims before us, the uniformity trial with variety pirsabak-2004 was under taken to find out the most suitable plot size and shape for wheat crop uptill now, no work on the uniformity trial of wheat has been done especially in Khyber Pakhtunkhwa, which is one of the most important cereal crops of this province.

Material and Methods

The material used in the present study is yield from a uniformity trial at Agricultural Research Institute, Tarnab, in 2012-13. The land under experiment was under regular wheat rotation. The cultural methods, manuring and other operations were kept uniform all over the area. The field 240 feet long by 96 feet wide.

The whole area was planted uniformly with the variety Pirsabak-2004 in 96 rows. The space between the rows was one feet. The field was harvested in 4 row plot $5^{/}$ long and $4^{/}$ wide making up the length of the field, so that there were in total 1152 plots. The harvesting was completed in 6 days from the 6^{th} May till 11^{th} May, 2013. After harvesting the threshing and recording of the yield data with effect from 20^{th} May, 2013 and completed on 5^{th} June, 2013.

The plot yield from which the analysis was made is given in Table-I. The standard error between plots within the blocks was calculated for 80 different sizes and shapes of plots considering the entire plot as harvested. On the basis of these combinations in various ways to form and 48 units in length and 1, 2, 3, 4, 6, 8, 12, and 24 rows wide.

Experimental Results

In Table-II, the analysis of variance is a given for yield of wheat for plot of $10^{/}$ x $4^{/}$.

TABLE-II

Analysis of Variance of Yield Data of crop of $10^{/}$ X $4^{/}$ Plot

Variation	Degree of freedom	Sum of Squares	Mean Squares	F. Ratio	S.D.	Z**
Between blocks	23	5382.25	234.0109	10.297	15.30	1.1659
Within blocks	1128	25635.25	22.7263		4.77	
Total Between Plot	1151	31017.50	26.9483	..	5.19	..

- Mean Square of variance = Sum of Squares / Degrees of freedom

** Z – one half the differences between the natural logarithms of the 2 variances

The total sum of squares was obtained by squaring the yield of each plot, summing, and subtracting the product of the general total times the general mean. The sum of squares between blocks was obtained by squaring the total yield of each of the 24 blocks, summing dividing by 48 (the number of elements contributing to each total) and subtracting the same product of the general total times the general means as used in obtaining the total sum of squares. The sum of squares due to variation within the blocks is the difference between the total sum of squares and that portion due to variation between blocks. Since a total of 1152 plots were considered, there were 1151 (N-1) degrees of freedom attributable to the total sum of squares. There were 24 blocks (of 48 plots each) and consequently 23 degrees of freedom due to blocks; 1151-23 or 47 x 24 gives 1128 degrees of freedom due to variation between the 48 plots within each of the 24 blocks. The mean squares or variance (standard deviation squared) is found by dividing the sum of squares by the corresponding degrees of freedom.

The standard deviation is the square root of the mean square or variance. We see in Table-II the observed value of Z tests exceed the 1% and 5% points and we conclude that the difference was undoubtedly significant. Since the variance between blocks was significantly greater than the variance within, the elimination of variation between blocks has proved worth while. The standard error of the $10^{/}$x$4^{/}$ plot was then, 23.95 percent of the mean yield.

TABLE – III

Analysis of Yield Data of Wheat Variety Pirsabak-2004 Tarnab for the Year 2012-13

Length x Width	Plot Dimension	Ratio of length to width	Total No. of plots	Standard deviation	Variance	C.V
1x1	5x4	1.25	1152	5.191	26.95	20.08
1x2	5x8	0.63	96	5.141	26.43	25.83
1x3	5x12	0.42	144	5.122	26.24	25.73
1x4	5x16	0.31	192	5.151	26.53	25.88
1x6	5x24	0.21	288	5.210	27.15	26.18
1x8	5x32	0.16	389	4.960	24.60	24.92
1x12	5x48	0.10	576	5.031	25.32	25.28
2x1	10x4	2.50	24	4.768	22.73	23.95
2x2	10x8	1.25	48	5.114	26.15	25.69
2x3	10x12	0.83	72	5.103	26.04	25.64
2x4	10x16	0.63	96	5.063	25.63	25.44
2x6	10x24	0.16	144	4.924	29.25	24.74
2x8	10x32	0.31	192	4.860	23.62	24.42
2x12	10x48	0.21	288	4.732	22.39	23.77
3x1	15x4	3.75	16	5.187	26.90	26.06
3x2	15x8	1.86	32	5.124	26.26	25.74
3x3	15x12	1.25	48	5.167	26.69	26.96
3x4	15x16	0.94	64	5.086	25.87	25.55
3x6	15x24	0.63	96	4.950	25.51	24.87
3x8	15x32	0.47	128	4.956	24.56	24.90
3x12	15x48	0.31	192	4.796	23.00	24.10
4x1	20x4	5.00	12	5.179	26.83	26.02
4x2	20x8	2.50	24	5.089	25.90	25.57
4x3	20x12	1.67	36	5.018	25.20	25.21
4x4	20x16	1.25	48	5.021	25.21	25.22

TABLE – III (contd.)
Analysis of Yield Data of Wheat Variety Pirsabak-2004 for the Year, 2012-13

Length x Width	Plot Dimension	Ratio of length to width	Total No. of plots	Standard deviation	Variance	C.V
4x6	20x24	0.83	72	4.895	23.97	24.60
4x8	20x32	0.63	96	4.828	32.31	24.26
4x12	20x48	0.42	144	4.711	22.98	23.67
6x1	30x4	7.50	8	5.194	26.09	26.09
6x2	30x8	3.75	16	5.050	26.51	25.37
6x3	30x12	2.50	24	5.062	25.62	25.43
6x4	30x16	1.88	32	5.073	25.79	25.49
6x6	30x24	1.25	48	4.943	24.99	24.84
6x8	30x32	0.94	64	4.948	24.49	24.86
6x12	30x48	0.63	96	4.771	22.77	23.97
8x1	40x4	10.00	6	5.175	26.79	26.00
8x2	40x8	5.00	12	5.106	26.06	25.65
8x3	40x12	3.33	18	5.085	25.86	25.55
8x4	40x16	2.50	24	5.049	25.50	25.37
8x6	40x24	1.67	36	4.896	23.97	24.60
8x8	40x32	1.25	48	4.872	23.73	24.47
8x12	40x48	0.83	72	4.834	23.37	24.29
12x1	60x4	15.00	4	5.496	27.00	26.10
12x2	60x8	7.50	8	5.131	26.39	25.78
12x3	60x12	5.00	12	5.050	25.50	25.37
12x4	60x16	3.75	16	5.070	25.71	25.47
12x6	60x24	2.50	24	4.911	24.13	24.68
12x8	60x32	1.88	32	4.933	24.34	24.79

TABLE -III contd.
Analysis of yield data of wheat Variety Pirsabak-2004
for the year 2012-13

Length x Width	Plot Dimension	Ratio L/W	Total No. of plots	Standard deviation	Variance	C.V
12x12	60x48	1.25	48	4.794	22.99	24.09
16x1	80x4	20.00	3	5.193	26.97	26.09
16x2	80x8	10.00	6	5.140	26.42	25.82
16x3	80x12	6.67	9	5.058	25.58	25.41
16x4	80x16	5.00	12	5.087	25.88	25.56
16x6	80x24	3.33	18	4.936	24.36	24.80
16x8	80x32	2.50	24	4.947	24.48	24.86
16x12	80x48	1.67	36	4.806	23.10	24.15
24x1	120x4	30.00	2	5.193	26.97	26.09
24x2	120x8	15.00	4	5.139	26.41	25.82
24x3	120.12	10.00	6	5.051	25.51	25.38
24x4	120x16	7.50	8	5.073	25.74	25.49
24x6	120x24	5.00	12	4.934	25.34	24.79
24x8	120x32	3.75	16	4.946	24.46	24.85
24x12	120x48	2.50	24	4.821	23.24	24.22
48x1	240x4	60.00	48	5.200	27.05	26.13
48x2	240x8	30.00	2	5.135	26.37	25.77
48x3	240x12	20.00	3	5.068	25.69	25.42
48x4	240x16	15.00	4	5.095	25.96	25.57
48x6	240x24	10.00	6	4.973	24.53	24.87
48x8	240x32	7.50	8	4.981	24,81	25.02
48x12	240x48	5.00	12	4.883	23.85	24.52
1x24	5x96	0.05	24	5.219	27.24	26.22
2x24	10x96	0.10	48	4.690	22.00	23.57
3x24	15x96	0.16	72	4.649	21.61	23.36
4x24	20x96	0.21	96	4.639	21.52	23.31
6x24	30x96	0.31	144	4.580	20.98	23.01
8x24	40x96	0.42	192	4.573	20.91	22.96
12x24	60x96	0.63	288	4.570	20.88	22.96
16x24	80x96	0.83	384	4.161	17.31	20.91
24x24	120x96	1.25	576	4.412	19.96	22.16

The Table -III showing that by increasing the width and length of the plot, the co-efficient of variation goes down. In Table-IV is given the standard error in percentage of the mean from these combinations.

In general the standard error, in percentage of the mean, decreased with increased size of plot, which was to be expected. Increasing the width of plots from one row to two resulted in a very pronounced reduction in the standard error.

TABLE – IV
Standard Errors, in Percentage of the Mean of Yields of Plot varying in Size and Shape

Length of plot	Standard deviation of yield (percent) for plots of indicated width (rows)							
	1	2	3	4	6	8	12	24
1.	26.08	12.92	8.58	6.47	4.36	3.12	2.11	1.09
2.	11.98	6.42	4.27	3.18	2.05	1.53	0.99	0.49
3.	8.68	4.29	2.88	2.13	1.41	1.04	0.67	0.32
4.	6.51	3.20	2.10	1.58	1.03	0.75	0.50	0.24
6.	4.35	2.16	1.41	1.06	0.69	0.12	0.33	0.20
7.	3.25	1.60	1.06	0.70	0.51	0.38	0.25	0.12
12.	2.18	1.07	0.71	0.53	0.34	0.26	0.17	0.08
16.	1.63	0.81	0.53	0.40	0.26	0.19	0.13	0.05
24.	1.09	0.54	0.35	0.27	0.17	0.13	0.08	0.04
48.	0.54	0.27	0.18	0.13	0.09	0.07	0.04	

Increasing the length of rows from 1 to 2 resulted in greatly reduced standard errors. Further increase in length of plot reduced the errors. In table-5 is given the number of replications needed to reduce the standard error of the mean to 5 percent.

The standard error of mean of several replications is found by dividing the standard error of a single plot by the square root of N, where N is the number of replications.

TABLE – V

Theoretical Number of Replications Needed to Reduce the Standard Error

Entire Plot Harvested

Length of plot	Number of replications for plots of indicated number of rows							
	1	2	3	4	6	8	12	24
1.	27.2	6.7	3.0	1.0	0.8	0.4	0.2	0.5
2.	5.7	1.7	0.7	0.4	0.2	0.1	0.04	0.01
3.	3.0	0.7	0.3	0.2	0.1	0.04	0.02	0.004
4.	1.7	0.4	0.2	0.1	0.04	0.02	0.01	0.003
6.	0.8	0.2	0.1	0.1	0.02	0.01	0.004	0.003
8.	0.4	0.1	0.1	0.03	0.01	0.01	0.003	0.001
12.	0.2	0.1	0.02	0.01	0.01	0.003	0.001	0.0003
16.	0.1	0.03	0.01	0.01	0.003	0.001	0.001	0.0001
24.	0.1	0.01	0.01	0.003	0.001	0.001	0.0003	0.0001
48.	0.01	0.003	0.001	0.001	0.0003	0.0001	0.0001	

The object of replications being to secure a low error the number of replications necessary for each plot size should be examined to see whether we could afford sufficient land consistent with theoretical number of replications required.

In Table-VI is given the efficiency of plots of varying size and shape calculated on the basis of variance per unit area of land. Plot 2 rows wide will require twice as much land as will plot 1 row wide. Plots 3, 4, 6, 8, 12, and 24 rows wide will require a corresponding number of time as much land, respectively, as will single row plots. The efficiency of plots of different sizes an shapes in their rows which go to make up the plot and expressing the variance of a single row in percentage of these variances. Taking the variance of a single row as a standard, we may determine the efficiency of all other plots in relation to the efficiency of this ultimate unit of size.

TABLE– VI

Percentage Efficiency in use of Land of Plot varying in Size and Shape

Entire Plot Harvested

Length of plot	Percentage efficiency of plot of indicated width (rows)							
	1	2	3	4	6	8	12	24
1.	100	50.98	34.24	25.40	16.54	13.69	8.87	4.12
2.	59.28	25.77	17.25	13.14	9.26	7.13	5.02	2.55
3.	33.40	17.11	11.22	8.68	5.87	4.57	3.26	1.73
4.	25.11	13.01	8.91	6.68	4.69	3.61	2.44	1.30
6.	16.65	8.47	5.84	4.36	3.06	2.29	1.69	0.89
8.	12.58	6.46	4.34	3.30	2.34	1.78	1.20	0.67
12.	8.30	4.26	2.94	2.18	1.55	1.15	0.81	0.45
16.	6.25	3.19	2.20	1.63	1.15	0.86	0.61	0.41
24.	4.16	2.13	1.47	1.09	0.77	0.57	0.40	0.23
48.	2.08	1.07	0.73	0.59	0.38	0.28	0.20	..

The original yield data in Table-I, were combined to form nine (3x3) basic units based on moving average. The field was then considered as consisting of 1012 such plots. On the basis of the contour map it can be noticed that the fertility trend of the plot moves gradually from West to East, where as the North-East side of the plot is the least fertile area. The maximum fertility of the plot seems to be on the South-Western side.

Conclusions and Recommendations

The need for standardizing a suitable size and shape for an experimental plot for all crops in different area of the Khyber Pakhtunkhwa, grown under different conditions, such as irrigated or rain fed is very urgent. This question is assuming a definite importance in case of wheat, which is the most important cereal crop of this region. It is further important to recognize the need for a correct statistical technique to be applied to data recorded from experiment conducted for the purpose of deducing a suitable size and shape for an experimental plot.

The statistical section, conducted a uniformity trial (Experiment) on wheat crop variety Pirsabak-2004, at B block of the Agricultural Research Institute, Tarnab, Peshawar Khyber Pakhtunkhwa, in 2012-13 with a view to deduce a suitable plot size and shape for the experimental plot. The yields of 1152 small units of size

5X4 were analyzed. Co-efficient of variation standard error and efficiency was calculated for each plot size on the basis of different combinations, and it was concluded that high variation in fertility between plot to plot and row to row was a disturbing factor.

The land under experiment was under regular wheat rotation in pervious year, cultural methods manuring and other operations were uniform all over the area.

The analysis of variance in yield has been deduced for (a) between blocks (b) with in blocks.

The shape of plot has to be decided not only on the basis of trend in the co-efficient of variation, but also convenience of cultivation. Based upon these stand points the ratio of length and width of the experimental plot is found to be at least 2.5. long and narrow plots are more efficient than shorter and wider of the same size.

Theoretical number of replications to bring down the C.V. to five percent has been calculated in case of each plot size and it is found that in case of plot size 10X4 the number of replications required is in between 2-6,. It is advisable that less replication will not fulfill the accurate results in case of any damage to two replications.

Consider from all stand point on the basis of the data in the present study a plot size of 10'X4' or 3.05X 1.22 meters seems eminently suitable for a field experiment on wheat.

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