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Use of Information on Positional Variation in Increasing Precision of Field Experiments in Tea

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ABSTRACT

The best size of the plot and the shape has been the subject of much discussion in tea field experiments. With that view, the optimum-plot size and shape of the plot for tea field experiments was determined using uniformity trial data. It was found that the correlation among adjacent units notably changed with the degree of slope of the site, but the pattern of change of CV with the plot size did not vary depending on the degree of slope. Irrespective of slope, the CV reached a constant at the plot size of 16 bushes. Therefore, in tea field experiments, it is recommended to have 16-20 bushes per plot as the optimum in a rectangular shape so that the length along the gradient is at the best.

Key words: positional variation, optimum plot size, Heterogeneity index

INTRODUCTION

In field experiments, the efficiency of testing treatment effect depends on experimental precision. In view of improving the precision, the concept of "control of extraneous variation" plays a very prominent role in experimental research. This has a two-fold origin. One is the inherent variability in the experimental material. The second and the most critical facet is the failure to standardize the experimental unit i.e. the degree the experimenter be able to control the positional variation in the experimental site.

The genetic variability of the experimental material is an important factor in determining plot size (Viana, et al., 2002). In tea crop experiments, experimenter can reasonably assume homogeneity with respect to the experimental material because the vegetatively propagated planting material is usually used in the trials. However, due to the sloppy nature of tea lands in Sri Lanka, positional variation creates problems to greater intricacy in precision of tea field experiments. One way of handling the problem is by introducing efficient blocking and use of optimum plot size. Therefore, an adequate characterization of positional variation in an experimental site is a good guide and even a prerequisite to choose a good experimentation design with efficient plot size. Because of the increased diversity of experiments and costly labour and supplies, information is needed on the most efficient plot size and shape for experimental work in tea. Although large number of field experiments have been conducted on tea, only limited work has been directed toward estimating efficient plot size (Kanapathipillai, 1967).

Research studies on tea have been made in diverse environments. Many times, the heterogeneity of local conditions has led to high experimental error, which hinders the statistical confirmation for differences among the appraised treatments. This study made an attempt to investigate how best the experimenter can evade the positional variation and increase the precision of the field experiments in tea.

MATERIALS AND METHODS

A uniformity trial was established at St. Coombs Estate, Tea Research Institute of Sri Lanka and the fields in question were selected from near by locations and average of 10^0 differences in slope (site 1: average of 41^0 slope and site 2: average of 51^0). The planting material (TRI 2024), date of planting and all the other cultural practices were kept uniform for both sites.

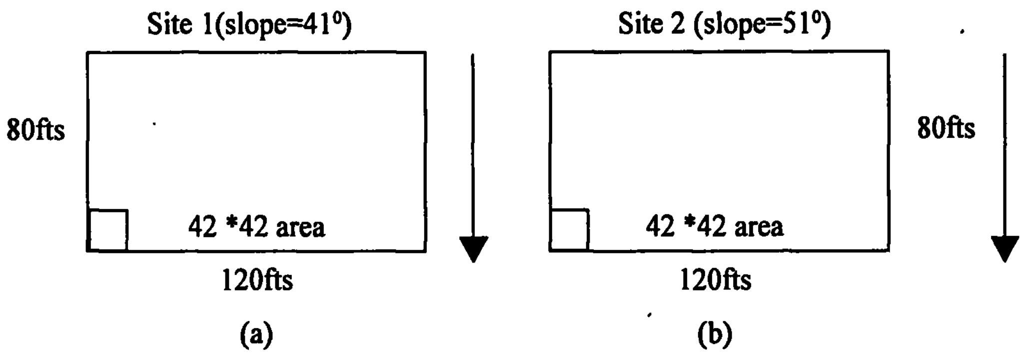


Figure 1: Layout of uniformity trials at two sites

The area (80fts X 120fts) of each site was divided into sub plots of 2 bushes (Figure 1a and b) and each site contained approximately 1200 bushes. The appropriate area was obtained by measuring up bushes. Young shoots were plucked for complete one-year at weekly intervals by employing the same team of pluckers randomly through out the experiment.

Indicators of soil heterogeneity

To evaluate the patterns of soil heterogeneity in the experimental sites, four methods, viz., soil productivity contour map, serial correlation, means square among strips and Smith's index of soil heterogeneity were utilized (Gomez and Gomez, 1983). Soil productivity contour map based on the moving averages of the contiguous units describes graphically the productivity levels of the experimental site. Moving averages of four basic units were used in the analysis.

As a method of a characterizing, the trend in soil fertility using uniformity trial data, serial correlations and means square between strips were computed for horizontal and vertical directions. They indicate the possible direction of the fertility gradient and the suitable orientation of the plots and blocks.

Heterogeneity index (Smith's index) was computed as the fourth method of characterizing soil heterogeneity. The effect of changing plot size on variance over the whole experimental area for each of several plot sizes is given by simple formula (Smith, 1938).

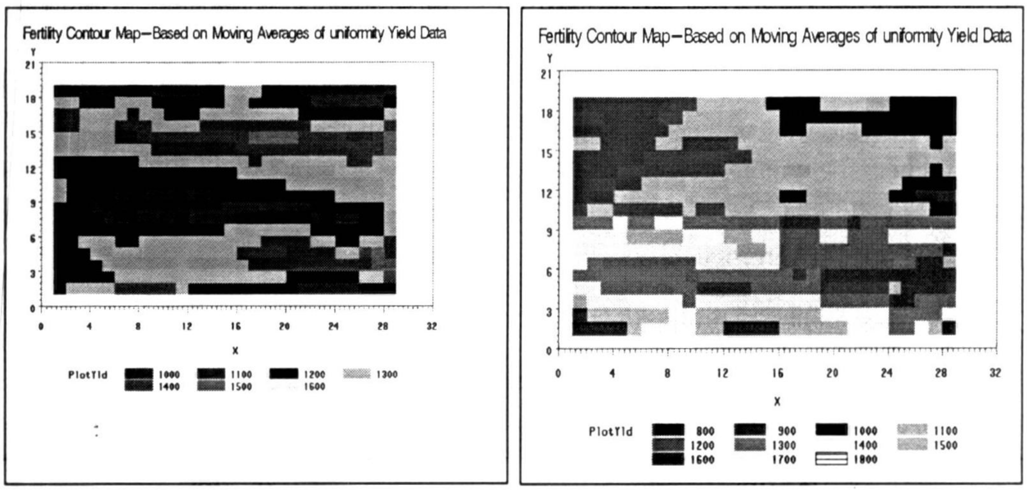
$$\log V_X = \log V_1 - b \log x \qquad (A)$$

Where V_1 is the variance of the standard unit sized plot. The size of b ($0 \leq b \leq 1$) is a measure of similarity between plots and x is the number of basic units.

RESULTS AND DISCUSSION

Soil productivity contour map

Soil productivity contour map for two sites is shown in Figure 2. As the iterative technique of moving averages cancels out the large random variation that is expected with very small plots, it gives a good description about the positional variation in the experimental site. From the map, it is possible to see that there is a regular order of productivity in both selected sites. It clearly indicates the fertility gradient along the direction of the slope. These maps provide useful information on actual variability within site-specific areas. With knowledge of characteristics of low yielding areas and the availability of accurate maps, application of site-specific corrective measurements and selection of proper experimental design is now possible. Therefore information on soil productivity contour maps could allow the researcher to have more efficient comparison of the appraised treatments and ultîmately it leads to an increase in the precision of the experiment.



(Site 1) **(Site 2)**

(Slope is for north to south direction for both sites)

Figure 2: Productivity contour maps for site 1 and 2

Serial correlation and means square among strips

Serial correlations and means square among strips for both horizontal and vertical directions are shown in Table 1. All four serial correlation coefficients computed for horizontal and vertical directions in two sites are significant at 0.0001 level. Though the serial correlation coefficients for both directions are equally high in site 2, wilks lambda statistic shows that the difference is significant (F=78.04, P=0.001). In site 1, coefficient for horizontal direction is significantly higher than the vertical (F=109.48, P=0.001). However, we cannot use this statistic to indicate the relative degree of the gradient in the two directions.

Table 1: Results of four methods of analysis to characterize soil heterogeneity

Method	Direction	Site Number	
		1	2
Serial Correlation	Vertical	0.375256 (P<0.0001)	0.610355 (P<0.0001)
	Horizontal	0.827566 (P<0.0001)	0.904106 (P<0.0001)
Mean Square among strips	Vertical	337863.4	903688.4
	Horizontal	9338842	25561296
Smith's index (computed)		-0.71017	-0.32859
Smith's index (adjusted)		-0.71	-0.3863
R^2		66.22	78.7

For both sites, coefficients are equally high in horizontal direction. However, according to Table 1, coefficient for vertical direction is comparatively smaller than that of horizontal. However, if there is serial correlation for measurements within a treatment (across blocks), then the reported F test is misleading. If the serial correlation is positive, then the actual P value is much greater than the reported P value, making it possible to falsely conclude that there are significant differences when it does not exist. Conversely, if the serial correlation is negative, then the actual P value is much smaller than the reported P value, making it possible to falsely conclude that there are no significant differences when the treatment means are in fact significantly different.

According to the mean square among strips in site 1 and 2 (Table 1), there is a fertility pattern in both directions. However, trend in soil fertility is more pronounced along the length than the width of the field. In addition, site with high slope (site 2) has very higher fertility gradient in the both directions.

Smith's index of soil heterogeneity

According to Viana, et al. (2002), the soil heterogeneity coefficient is the main element in estimating the optimum plot size. Table 2 gives the computed variance and coefficient of variation (CV) for each of the different plot sizes and shapes and for tea uniformity data. From table 2, it is possible to observe (Fig. 3) the general pattern of CV with the increase in plot size. The pattern is same for both sites. However, the variance per unit area in site 1 is almost half of that of site2. This implies the text that higher variability is observed at high slope.

Table 2: The coefficient of variation and variance per unit area for plots of Different sizes and shapes, computed from uniformity trial data of site 1 and 2

Plot size and shape			Site 1	Site 2		
Basic Units	Raw	Column	CV%	Variance/unit area	CV%	Variance/unit area
1	1	1	10.87	72.96	15.13	138.62
2	1	2	10.42	66.92	14.84	133.22
2	2	1	9.08	50.86	14.22	122.28
3	1	3	10.19	64.09	14.62	129.30
3	3	1	8.04	40.76	12.32	93.83
4	1	4	9.90	59.94	14.00	118.83
4	4	1	7.11	31.20	14.05	119.47
4	2	2	8.74	47.13	11.91	85.73
5	1	5	9.79	59.18	13.52	112.52
5	5	1	5.72	20.16	12.24	90.42
6	1	6	9.65	57.48	13.41	111.33
6	2	3	8.63	45.95	13.92	117.17
6	3	2	7.77	38.00	12.21	92.09
6	6	1	5.78	21.02	10.20	64.35
8	1	8	9.12	51.00	13.30	109.52
8	2	4	8.26	41.80	13.31	107.39
8	4	2	6.90	29.38	11.81	84.43
8	8	1	3.38	7.25	8.72	48.63
9	1	9	9.23	52.05	13.49	110.88
9	3	3	7.63	36.70	12.11	90.64
9	9	1	3.41	7.32	11.00	74.81
12	3	4	7.47	34.86	11.75	85.48
12	4	3	6.83	28.78	11.75	83.50
12	6	2	5.63	19.99	10.14	63.58
12	2	6	8.16	41.12	13.68	113.16
16	4	4	6.61	26.71	11.40	78.83
16	8	2	3.16	6.30	8.68	48.17
16	2	8	7.52	14.19	12.86	102.31
25	5	5	4.94	15.08	12.36	58.85

The size of the soil heterogeneity coefficient (0£b1) is a measure of similarity between plots: when neighboring plots are highly correlated, b is close to 0, and when they are almost uncorrelated, b is close to 1. Using the results of a uniformity experiment, a scientist can predict the precision of future experiments for any plot size (Binns, 1982).

Smith's index of soil heterogeneity values computed for both sites adjusted for the size of the area used in collecting the data are shown in table 1. Values of index for both sites indicate that with high slope, the correlation between adjacent experimental plots is higher than that of the low slope site.

Coping with soil heterogeneity

If the experimenter can identify the positional variation of the experimental area, several options are available to reduce its effect.

(a) Influence of plot size in reducing error

One of the first methods used to determine the optimum plot size in field experiments for several crops was the maximum curvature method. The optimum plot size was determined corresponding to the point of maximum curvature (Fedder, 1955). Fig. 3 clearly indicates that the stabilize value of CV i.e. the point that the level of CV comes to a constant with increasing plot size is much lower in less slope site than in the site with higher slope. It is around 4% and 10% for site 1 and 2 respectively. However, the amount of reduction in CV at both sites is more or less equal (6-7%).

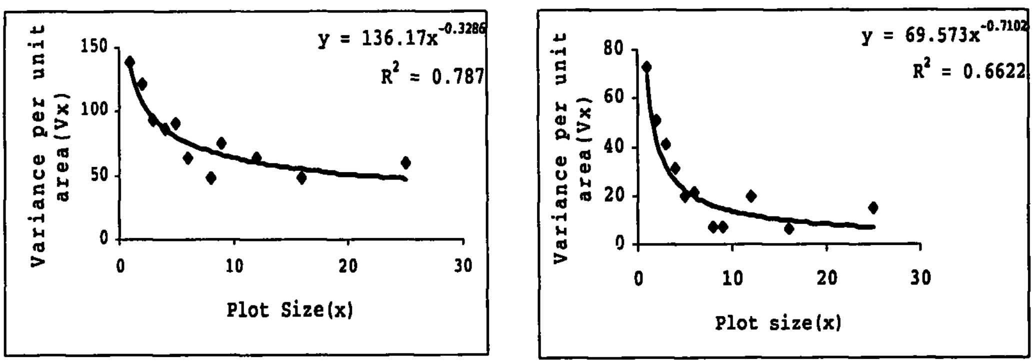


Figure 3: Relationship between variance per unit area (V_x) and plot size (x).

(a) Site 1 (b) Site 2

A notable characteristic here is that when the CV become stable, the plot size is around 16 bushes in both sites. This indicates that the optimum plot size is independent from the level of slope. Therefore, increasing the plot size beyond 16 bushes at any level of slope is not worth while.

(a) The effect of plot shape in reducing errors in tea experiments

The shape of the experimental plot plays a very prominent role in tea experimental sites due to its nature of slope. This was confirmed by the results presented in Table 3. The lowest CV% has been obtained in plots with higher length along the gradient for each plot size in both slope levels. The CV values in square shape plots are lesser than the plots of higher length across the gradient but higher than along the gradient for both sites.

Table 3: Coefficient of variation for different plot sizes and shapes

	Coefficient of Variation (%)					
	Site 1			Site 2		
Plot size	Higher length along the gradient	Higher length across the gradient	Square Shape	Higher length along the gradient	Higher length across the gradient	Square Shape
2	9.08	10.42		14.22	14.84	
3	8.04	10.19		12.32	14.62	
4	7.11	9.90	8.74	11.91	14.00	14.05
5	5.72	9.79		12.24	13.52	
6	5.78	9.65		10.20	13.41	
8	3.38	9.12		08.72	13.30	
9	3.41	9.23	7.63	11.00	13.49	12.11
12	5.63	8.16		10.14	13.68	
16	3.16	7.52	6.61	08.68	12.86	11.40
25			4.94			12.36

CONCLUSIONS

From the results obtained, it is evident that the correlation among adjacent plots significantly varies with the degree of slope of the site. However, irrespective of the level of slope, the change of coefficient of variation is not significant after 16 bushes per plot. Therefore, the optimum size of the experimental plot for tea can be reasonably recommended as 16-20 bushes per plot based on the coefficient of variability as well as the economic considerations. Though the gradients subsist for both directions, the square shape of the plot is not advisable. The plot shape should be narrow and long and the length of the plot should be along the gradient.

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