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OPTIMUM SIZE AND SHAPE OF PLOTS IN FIELD EXPERIMENTS WITH CASHEW*

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One of the major factors contributing to experimental error in agricultural field trials is the size and shape of experimental plots and their arrangement in blocks. Unusually large plots resuit in the wastage of resources and very small plots may not give reliable results. Thus optimum sizes and shape of plots and blocks are to be determined in order to improve the efficiency of field experimentation. Uniformity trials have been conducted by various workers on different crops to estimate suitable plot sizes, Eden (1931). Govinda Iyer (1957). Bavappa (1959), Narayanan (1965), Menon and Tyagi (1971) and Prabhakaran *et al*. (1971) estimated optimum plot sizes for tea, coconut, arecanut, rubber, mandarin orange and banana respectively. But no such studies are known to have been made for estimating the plot size for field trials on cashew, a very important dollar earning commercial horticultural crop of Kerala, At present field trials on cashew are being conducted by using extremely large plots involving 9 or more trees in the net region of the plot excluding the guard rows. As a result, it has become difficult to plan field trials on cashew with a limited number of experimental trees unless the plot size has been reduced to a convenient size.

Thus the object of the present study is to determine a suitable plot size for field trials on cashew which might help the researcher in planning future experiments on cashew on similar lines.

Materials and Methods

The data required for this study were obtained from the available records of the Cashew Research Station, Madakkathara. The experimental material consisted of a compact block of 625 trees in a 25 x 25 arrangement. A single row of trees on either side of the field was discarded to eliminate border effect. Thus the final stand consisted of 576 trees in 24 x 24 arrangement in the experimental area. Observations on a few missing trees were estimated by a simple averaging process. The seedlings were raised from the same parental stock. All the trees were of the same age group and were subjected to the same cultural and management practices. Both genetic and environmental factors contributed to the large amount of variation observed in the experimental trees. Alt the trees had reached the stage of yield stability. The mean yield/tree was calculated for each of the 576 trees.

Plots of different sizes and shapes were formed by combining adjacent trees, a tree respresenting the basic unit. The plots were grouped into blocks of different sizes and shapes.

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Among the different methods for estimating the optimum plot size the well known empirical relationship between plot size and variance of mean per plot developed by Smith (1938) is considered to be the best. Smith's equation is of the form $V_x = V_1/x^b$ where Vx is the variance of mean yield per unit area among plots of size x units, V1 is the variance of yield of plots of size unity and b is a measure of correlation among contiguous units. The limiting values of b are 0 and 1. But for a crop like cashew a tree is the ultimate unit and the entire cost is proportional to the number of trees per plot. Thus it is more logical to define the optimum plot size as the one giving maximum information from the data per unit tree. The optimum plot size was estimated with this objective in view.

Results and Discussions

The yields of adjacent trees were combined together to form plots of 1, 2, 4, 6, 8 and 12 trees. Since a single tree was considered to be the sampling unit there was a serious limitation in varying the shape of the plot to all geometrical configurations. A fixed number K, of contiguous trees of the same row or column or alterations of square or rectangular arrangement of a cluster of K trees constituted a plot of size K, Plot length was defined in east-west direction and breadh in north-south direction. The mean, sum of squares, variance, standard deviation and coefficients of variation for various plot dimensions were worked out. The variability of plots of different sizes and shapes was estimated by using the coefficient of variation and is given in Table 1.

Coefficient of variation was found to decrease consistently with an increase in plot size. CV was found to vary from 46.89 per cent to 116.85 per cent. The CV was highest in the case of single tree plots and lowest in 12 tree plots arranged in 3 rows each consisting of 4 trees. The shape of the plot did not seem to have any consistent effect on variability. For smaller plot sizes, shape had some influence on variability. In 4 tree plots, a square arrangement of trees showed a variation of 79 per cent while 4 trees arranged in row-wise and column-wise directions showed only 6: and 67 per cent of variations respectively. But as the plot size increased, shape of the plot did not seem to exert any appreciable effect on the precision of the estimate.

Adjacent plots were grouped to form blocks of different sizes, namely, 2, 4, 6, 8 and 12 plot blocks were formed by combining adjacent plots in various possible ways. Thus a block of size 4 was formed in 3 ways such as in a 1 x 4, 2 x 2 and 4 x 1 arrangements. The total, between and within sum of squares in each case was calculated and the "pooled within sum of squares" was found out for calculating variances and coefficient of variation. The percentage reduction in variability due to blocking was calculated as the ratio of between block sum of squares to total sum of squares. The singificance of block variation was tested by using the F-test of significance (Table 2). The coefficient of variation of plots of different dimensions when arranged in blocks of 2, 4, 6, 8 and 1 2 plots are given in Table 3. The results showed that The CV decreased steadily with an increase in plot size irrespective of the shape of the plot. The minimum CV (36.77) was noticed in 2 plot blocks. As the block size increased the range of variation of CV decreased. In 12 plot blocks it was from 115 to 141. Coefficient of variation seems to be stable for the same plot size in different blocks. The statistical significance of between biock variation showed that environmental variation was not negligible and local control was effective in separating the components of variation arising due to differences between blocks, Tne percentage variation removed by blocks of different sizes was found to decrease with an increase in plot size. But the rate of decrease was rather slow from 2 plot to 4 plot blocks.

The Fair Fie!d Smith's equation was fitted on the basis of observed variances of plot means both in the case when plots are grouped into blocks of various sizes and not grouped in blocks. The observed variances are given in Table 4, The observed variances decreased with an increase in block size. The fitted equations were given in Table 5. The values of 'b' ranged from 0.975 to 0.8224 in the case whan plots are arranged in blocks and 0,6843 when plots are not arranged. These results were similar to those obtained by Prabhakaran *et al.* (1978) in banana, and Menon and Tyagi (1971) in mandarin orange. This indicated a very poor correlation between neighbouring units suggesting that positional variation was not as important as inherent genetic variation between the tre33. It could also be seen that 'b' value showed a decreasing tendency as the block size increased. The value of 'b' was statistically significant in all the cases and the multiple correlation coefficients ranged from 0.96 to 0.98 as the block size increased from 2 to 12. It was 0,99 in the case of without blocking.

It can be seen that the relative percentage information was maximum for single tree plots both in the case when plots are arranged in blocks and also without arranging them in blocks. Thus single tree plots are the most efficient ones in conducting field trials on cashew. The results were in agreement with the findings of Agarwal *et al.* (1938) Menon and Tyagi (1971), and Prabhakaran *et al.* (1978).

Since single tree plots provide maximum information we can safeiy recommend single tree plots for conducting field experiments with cashew, But one disadvantage of single tree plots is that the experimenter has to sacrifice the entire information from the plot on account of missing a single tree from the plot. As an alternative suggestion, 2-tree plots can also be recommended because the loss in information due to 2 tree plots as compared to single tree plots was not appreciable. In smaller blocks plots of various sizes might be used without much loss in information. Thus in 2 plot or 4 plot blocks 2 trees or even 4 tree plots could be used without much loss in precision. Practical convenience often give place to experimental precision. Thus with larger blocks single tree plots were found to be the most efficient and would be used unless the experimenter fears that some of the trees might be destroyed in the course of the experiment due to some unforeseen causes, in which case 2 tree plots could also be used as an alternative to single tree plots. For a given number of trees the method of increasing replications per treatment was found to be more advantageous than the method of increasing the plot size. So whenever possible the minimum plot size should be used by providing the maximum number of replications per treatment.

Table 1

Relationship between plot size and variability for ungrouped data

Plot size	Plot shape	.CV	Number of replications	Number of trees
1	1:1	116.85	546	546
	1:2	88,32	315	622
	2:1	86.11	296	592
4	1:4	60.90	148	592
	4:1	67.59	182	728
	2:2	78,72	248	992
6	3:2	69.50	193	1158
	2:3	61.95	153	918
	1:6	60.83	148	888
	6:1	52.13	108	648
8	1:8	53.23	113	904
	8:1	60.69	102	822
	2:4	51.94	108	863
	4:2	56.42	127	1018
12	12:1	51.52	106	1272
	1:12	51.27	105	1260
	4:3	54,50	118	1416
	3:4	46.90	88	1056
	6:2	50.64	102	1224
	2:6	52.69	110	1320

Table 2

Percentage reduction in sum of squares due to blocks of different sizes

Block size	Percentage reduction	F
2	65.96	2.981**
4	54.20	4.012**
6	40.91	4.331**
8	36.81	5.552**
12	28.22	7.319**

Table 3

Coefficient of variation of plots of different sizes with arrangement in blocks of varying sizes

Plot size (number of trees)	Number of plots per block				
	2	4	6	8	12
1	123.50	119.43	118.20	115.64	115,8
2	88.09	86.58	85.59	86.45	87.08
4	62.83	62.76	62.54	64.61	65.48
6	51.56	51.76	51.92	54.80	55.45
8	44.82	45.49	45.49	48.41	49.24
12	36.77	37.08	37.77	40.75	41.68

Table 4

Smith's equation fitted to the data

Number of plots per block	Fitted equation	r	r^2
2	$V(x) = 2.1966\, x^{-0.9751}$ **	0.9624	0.9262
4	$V(x) = 2.0541\, x^{-0.9283}$ **	0.9820	0.9643
6	$V(x) = 2.012\, x^{-0.9184}$ **	0.9864	0.9730
8	$V(x) = 1.9257\, x^{-0.8396}$ *"	0.9808	0.9620
12	$V(x) = 1,9311\, x^{-0.8224}$ **	0.9891	0.9783
Without blocking	$V(x) = 1.887\, x^{-0.68437}$ **	0.9915	0.9831

Table 5

Relative percentage information per tree for plots and blocks of different sizes

Plot size (number of trees)	Without blocking	Number of plots per block				
		2	4	6	8	12
1	100	100	100	100	100	100
2	8535	98.20	95.15	94.50	89.61	83.42
4	64.56	96,61	90.55	89.30	80.05	78.18
6	56.81	95.64	87.36	86 40	75.01	72.75
8	51.88	94.95	86.15	84.39	71.64	69.11
12	45.64	94.01	83.70	81.64	67.12	64.38

Summary

The data from a uniformity trial were analysed to find the optimum size and shape of plots and blocks. Considerable variability was observed in the yields of trees eventhough they were raised from the same parental stock. The relative percentage information was found to be maximum in single tree plots both in the case when the plots are arranged in blocks and when they are not arranged. Thus single tree plots could be recommended as optimum for conducting field experiments on cashew. In order to avoid enhanced chance of loss in information with single tree plots as an alternative suggestion two tree plots could also be used for conducting field experiments on cashew. It was observed that two plot blocks were the most efficient for conducting field experiments on cashew.

The Fair Field Smith's equation gave a good fit to the data on the 2 cases when the plots are arranged in blocks and not arranged. The relatively high value of the parameter 'b' indicated that genotypic variation was more predominant than positional variation.

The number of replications required to provide estimate with a given level of precision decreased with an increase in plot size. But for a given experimental material an increase in number of replications rather than plot size was found to provide more precise information.

സംഗ്രഹം

കശുമാവിൽ കൃഷിപരീക്ഷണത്തിന് ഉപയുക്തമാക്കേണ്ട പ്ലോട്ടിന്റെ അനുകൂലതമ വിസ്തൃതിയും ആകൃതിയും നിർണ്ണയിക്കുന്നതിന് ഒരേകസമാനതാ പരീക്ഷണത്തിൽനിന്നും ശേഖരിച്ച ദത്തങ്ങളെ സാംഖികീയമായി വിശ്ലേഷണം ചെയ്യുകയുണ്ടായി. ഒരേ ജനയിതാക്കളിൽനിന്നും പ്രവർധനം ചെയ്യപ്പെട്ടവയാണെങ്കിലും വൃക്ഷങ്ങൾ വർദ്ധമാനമായ വിധത്തിലുള്ള വൈയക്തിക വിചരണം പ്രദർശിപ്പിച്ചു. പ്ലോട്ടുകളെ ഖണ്ഡങ്ങളാക്കി സമൂഹനം ചെയ്ത അവസ്ഥയിലും, അല്ലാത്ത സാഹചര്യത്തിലും ഏക വൃക്ഷ പ്ലോട്ടുകളാണ് സാപേക്ഷദക്ഷത അധികം പ്രകടിപ്പിച്ചത്. അതിനാൽ കശുമാവിൽ കൃഷിപരീക്ഷണങ്ങൾ നടത്തുന്നതിന് ഏകവൃക്ഷപ്ലോട്ടുകൾ ന്യായമായും ശുപാർശ ചെയ്യാവുന്നതാണ്. എന്നാൽ അനിയന്ത്രിത കാരണങ്ങളാൽ നിർദ്ദിഷ്ട മരങ്ങളിൽ ചിലത് അപ്രാപ്തമാകാനുള്ള സാധ്യത കണക്കിലെടുക്കുകയാണെങ്കിൽ ദ്വിവൃക്ഷപ്ലോട്ടുകൾ ഉപയോഗിക്കുന്നതായിരിക്കും കൂടുതൽ അഭിലഷണീയമെന്നു കാണാം. ഖണ്ഡങ്ങളുടെ വിസ്തൃതിയെ സംബന്ധിച്ചിടത്തോളം രണ്ടു പ്ലോട്ടുകൾ വീതമുള്ള ചെറുഖണ്ഡങ്ങളാണ് ഏറ്റവും ദക്ഷത കാണിച്ചത്. ഫെയർഫീൽഡ് സ്മിത്തിന്റെ വ്യതിയാനനിയമം തൃപ്തികരമായ വിധത്തിൽ സ്പഷ്ടീകരിക്കുന്നതിന് ദത്തങ്ങൾ പ്രയോജനപ്പെട്ടു. വിചരണ സൂചിക 'b'യുടെ മൂല്യം താരതമ്യേന ഉയർന്നതായതിനാൽ ജനിതകവിചരണം മൃത്തികാ വിചരണത്തേക്കാൾ കൂടിയ തോതിലാണെന്ന് അനുമാനിക്കാം. ഒരു നിശ്ചിത പരീക്ഷണ വസ്തുവിനെ സംബന്ധിച്ചിടത്തോളം പ്ലോട്ടിന്റെ വലിപ്പം കൂട്ടുന്നതിനേക്കാൾ മെച്ചമായി കണ്ടത് പ്ലോട്ടിന്റെ വലിപ്പം പരമാവധി കുറച്ച് പുനരാവൃത്തികളുടെ സംഖ്യ വർദ്ധിപ്പിക്കുകയാണ്.

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