A NOTE ON USE AND LIMITATION OF FAN DESIGN

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(Received : December, 1979)

Nelder [4] advocated the use of systematic design for the spacing trials. The layout plan of this design looks like a Japanese fan hence it is termed as FAN design, which permits single row plots per treatment each having constant number of plants. Hence large number of spacing treatments, compacted in much smaller area as compared to the conventional designs could be tested in it. The crop is planted in rows radiating from a point, making the distance between adjacent plants along a radius being approximately equal to the distance between adjacent plants along the arc.

The systematic scheme results in biased estimate of error (Tedin, [6]; Barbacki and Fisher, [1]; Greenberg, [2] and Salmon, [5], In case of FAN design the treatment effects are also likely to be influenced by the border effect, which lead to an inflation of error variance by increasing heterogeneity among plots (Hutchinson and Panse, [3].

The results reported herein relate to the field experiments conducted during the years 1973-74 and 1974-75 to assess the relative utility of the FAN design in relation to randomized block and split plot designs for spacing experiments. Cotton variety IAN 579-188 was used for this purpose.

Experimental

Since it is not possible to estimate border effect as well as bias in the treatment estimates obtained from the FAN design, the alternative layouts were considered. Layouts with systematic as well as random arrangements following the same sqacing (Table 2) as in FAN design were simulated for obtaining estimates of border effect. The ptot size were considered on area basis as well as equal number of row basis. Thus the following layouts were studied.

(*i*)	FAN Design	FAN
(*ii*)	Systematic arrangement with equal number of rows per plot	SER
(*iii*)	Random arrangement with equal number of rows per plot	RER
(*iv*)	Systematic arrangement with unequal unmber of rows but equal area per plot...	SEA
(*v*)	Random arrangement with unequal number of rows but equal area per plot (Randomized block design)	REA=RBD

In addition, a split plot design (SPL) was taken to include nine spacing combinations (Table 2) by choosing 3 levels each of inter (30, 60 & 90 cm) and intra row (15, 22.5 & 30 cm) such that the lowest and the largest spacings matched with that of fan design respectively.

Keeping in view the growth habit of the cotton IAN 579-188, the different spacings were considered, which varied from 0.045 m^2 to 0.270 m^2 per plant in each layout. Utilizing the information of minimum spacing and maximum spacing, various spacings in terms of area per plant, the radii of the acrs and angle were worked out for FAN design (Nelder, [4]). The spacings (S_1 through S_{10}) were followed in SER, RER, SEA and RBD. The data on cotton yield were collected to assess border effect as well as bias in the treatment estimates.

Results and Discussion

The difference in performance of the border row as compared to the corresponding net row (adjacent to border row) is an indication of the border effect. The *t*-test was used to test border effect. The frequency distribution ot the calculated *t*-values for cotton yield per plant is presented in Table 1.

The results (Table 1) reveal that out of 11 *t*-values which exceeded the range -3.0 to $+3.0$, seven were significant indicating

TABLE 1

The frequency distribution of t-values

Lay ont	*Class*	*1973-74*				*1974-75*			
		Stde 1		*Side 2*		*Side 1*		*Side 2*	
		−	+	−	+	−	+	−	+
SER	0.0—1.0	5	2	4	6	6	1	2	3
	1.0—2.0	1	2	0	0	1	1	0	4
	2.0—3.0	0	0	0	0	0	0	0	1
	>3.0	0	0	0	0	1	0	0	0
	Total	6	4	4	6	8	2	2	8
RER	0.0—1.0	4	5	3	5	2	3	2	5
	1.0—2.0	0	0	1	0	1	3	1	1
	2.0—3.0	0	1	0	1	1	0	0	0
	>3.0	0	0	0	0	0	0	1	0
	Total	4	6	4	6	4	6	4	6
SEA	0.0—1.0	2	1	3	3	3	3	3	2
	1.0—2.0	4	0	2	1	0	2	1	1
	2.0—3.3	2	0	1	0	1	0	0	1
	>0.3	0	1	0	0	0	1	1	1
	Total	8	2	6	4	4	6	5	5
RBD	0.0—1.0	3	0	4	3	3	0	3	4
	1.0—2.0	1	2	0	2	0	3	0	0
	2.0—3.0	0	2	0	1	1	1	1	2
	>3.0	1	1	0	0	1	1	0	0
	Total	5	5	4	6	5	5	4	6

TABLE 2

Spacing-wise cotton yield, g per plant

SP_j	*Area per plant sq. m.*	*SPL*		*S_j*	*Arca per plant, sq. m.*	*FAN*		*RBD*	
		1973-74	*1974-76*			*1973-74*	*1974-75*	*1973-74*	*1974-75*
SP_1	0.045	11,52	7.87	S_1	0.045	19.11	12.09	13.16	6.93
SP_2	0.067	18.45	10.37	S_2	0.055	16.77	10.58	12.60	6.30
SP_3	0.090	22.58	13.77	S_3	0.067	18.25	9.78	17.89	6.70
SP_4	0.090	24.63	15.04	S_4	0.081	20.18	10.30	14.93	5.87
SP_5	0.135	37.49	20.04	S_5	0.100	20.84	11.32	17.89	6.76
SP_6	0.180	47.41	22.15	S_6	0.122	26.83	12.30	26.76	8.37
SP_7	0.135	43.31	23.80	S_7	0.148	34.34	12.98	23.03	11.07
SP_8	0.202	59.13	28.54	S_8	0.182	40.63	16.28	46.12	14.58
SP_9	0.270	69.06	32.23	S_9	0.221	45.06	18.28	48.17	17.69
—	—	—	—	S_{10}	0.270	53.42	22.89	42.86	16.76

the presence of border effects on cotton yield per plant. The data were further scrutinized for average yields of border rows and net rows and found that the variation observed was due to sampling fluctuation. The cotfon variety IAN 579-188 has monopodial habit of plant growth and hence cotton yield per plant was not affected by the border effect in SER, RER, SEA and RBD. Further, inspite of wide differences in spacing treatments in the adjacent plots due to randomisation in RER and RBD; monopodial plant type did not respond to the border variation.

On the basis of two seasons' information it can be concluded that the fan design having single row plots can be used for spacing experiments on monopodial type of çotton, in place of systematic or random arrangements with equal or unequal (equal area) row plots.

Bias in Treatment Means

The average yields of cotton per plant (Table 2) in FAN, SPL and RBD were used to assess bias, if any, in the treatment means.

It is evident from the results (Table 2) that the cotton yield per plant was more in SPL than that in FAN when area per plant is 900 sq. cm. and above.

The average differences between cotton yield per plant in S_1 through S_{10} (FAN *vs* RBD) over seasons ranged from −1.57% in S_9 to 59.84% in S_1 with an overall average difference of 23.80%. Spacing S_1 through S_7 and S_{10} had positive differences in both the years as well as on average basis; S_8 and S_9 had inconsistent differences.

The experiments conducted on the same field with the same set of treatments in random as well as systematic arrangements may show variation in performance of different treatments largely due to fertility variation. Since adjacent plots are positively correlated in field experiment, fertility variation introduces bias in the treatment estimates of the systematic arrangements.

The results, therefore lead to the inference that the FAN design, though useful for spacing trials on crops with monopodial type of growth habit such as cotton IAN 579-188, gives biased estimates of the treatment means.

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