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Effect of Wide Plant Spacing on Six Cultivars of Upland Cotton[1]

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ABSTRACT

Six *Gossypium hirsutum* L. cultivars were compared under conditions of wide (40 cm) and normal (10 to 12 cm) spacing between plants, with 1 m between rows. Plant spacing had no significant effect on boll weight, boll retention, fiber length uniformity, or fiber strength or fineness. Lint percent was increased and fiber length was decreased by wide spacing, but there were no cultivar × spacing interactions for these traits. Lint and seed cotton yields, boll number, and flower number (per unit area) were usually decreased by wide spacing, but significant cultivar × spacing interactions were detected for these traits. 'Acala 1517C' and 'Del Cerro' were affected more strikingly than the other cultivars by plant spacing, probably because of their pyramidal plant-type and short fruiting branches. The relative performance of genotypes for lint yield and associated traits, when evaluated under wide spacing, may therefore not be valid for more closely spaced plantings.

Additional index words: Gossypium hirsutum, Cultivar × spacing interaction, Lint yield, Fiber quality.

IN some types of experiments cotton (*Gossypium hirsutum* L.) plants are grown at wide spacings (35 to 50 cm between plants in the row) in order to allow detailed observations on each individual plant. This is the usual procedure for evaluating plants in early segregating generations (F_2 or F_3) of a breeding program. Also, in experiments involving the F_1 generation, plants are usually widely spaced because of seed scarcity. Is many cases the results from these experiments are used to predict the performance of cotton genotypes under commercial field conditions, where plants are usually more narrowly spaced (10 to 15 cm between plants in the row).

Wilkes and Corley (1968) reviewed the results of many plant-spacing experiments and concluded that plant spacing could vary considerably without materially affecting cotton yields, provided the plants were distributed uniformly. However, most of these experiments included plant populations of 37,500 or more plants per ha, which is equilavent to an average spacing of 26 cm or less between plants in 1-m rows. Tavernetti and Ewing (1951) found that under irrigated conditions in California, lint yields decreased when plants were spaced 26 cm or more apart in 1-m rows (37,500 plants or less per ha). Hawkins and Peacock (1970) reported that 'Empire WR61' and 'Atlas' plants spaced 20 and 40 cm apart yielded significantly more lint than plants spaced 60 cm apart. Bridge, Meredith, and Chism (1973) reported that when 'Deltapine 16' plants were spaced 38 cm apart within rows, their lint yield was lower than at 12.7-cm or 7.6-cm spacings in 2 of the 3 years in which the experiments were conducted.

Peebles, Den Hartog, and Pressley (1956) conducted spacing experiments with a number of cotton cultivars under irrigation in Arizona. They found that close spacing (5 to 15 cm) between plants in 'Upland' and 'American-Egyptian' cultivars increased lint yield by 9.5 and 12.9%, respectively, as compared with yield of wide spacings. This increase was associated primarily with the production of more bolls, but the effect of spacing on individual boll weight was rather small. Peebles et al. did not find any effect of spacing on lint percentage, seed index, fiber length, or fiber fineness of Upland cotton cultivars, but weaker fiber was associated with close spacing in some of the experiments. Hawkins and Peacock (1971) also found weaker fibers associated with close spacing of 'Atlas' cotton.

Very few additional data on the effects of wide spacon modern high-yielding Upland cultivars are available. The purpose of the present study was to evaluate these effects and to determine if different cultivars would be affected similarly by spacings between plants in the row.

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MATERIALS AND METHODS

Two spacing treatments and six cultivars of Upland cotton were compared in an experiment conducted on an alluvial clay soil at Bet Dagan, in the coastal plain of Israel. Cotton was planted on April 25, 1969, in rows spaced 1 m apart. The spacing treatments were: wide, 40 cm between plants in the row; and normal, 10 to 12 cm between plants in the row. The cultivars were: 'Carolina Queen;' 'Acala 4-42;' 'Acala 1517C;' 'Acala SJ-1;' 'Del Cerro;' and 'Deltapine smoothleaf.'

The experimental design was a split-plot randomized block design, with the spacing treatments as the main plots. There were six replicates, with each plot consisting of one row, 3.20 m long. The wide spacing was obtained by planting two seeds, which were later thinned to one seedling, in each 40-cm-spaced hill. For the normal spacing, 20 seeds were planted per 1 m of row, and the seedlings were thinned to the desired spacing. The usual cultural practices for irrigated cotton were adopted, and insect pests were kept under control.

Flowers were counted daily, at anthesis, from the beginning of flowering until August 16th. The plots were picked by hand, and all the harvested bolls were counted and weighed. Seed cotton yield, average boll weight, number of bolls per m^2, and boll retention (the ratio of the number of harvested bolls to the total number of flowers) were calculated from hand-picked cotton. Seed-cotton was ginned on a miniature (40-cm) roller-gin for determination of lint percent and lint yield. Fiber length was measured by a Digital Fibrograph and fiber fineness by a Micronaire. Fiber strength was measured on a Pressley-breaker with the two jaws holding the fiber bundle separated by 0.317 cm, and expressed in T_1 units (g of force per tex).

RESULTS AND DISCUSSION

The mean squares from the analysis of variance of all the traits examined in this experiment are given in Table 1. There were significant differences among the cultivars for all measured traits. The effect of plant spacing was significant for 7 of the 12 traits examined; the traits not significantly affected by spacing were boll weight, boll retention, fiber length uniformity, fiber strength, and fiber fineness. Lint percent of all the cultivars was increased in the wide spacing compared with the normal, and fiber length was decreased, but no significant cultivar × spacing interaction was detected for these traits.

Detailed results of the traits for which significant cultivar × spacing interaction was detected are presented in Table 2. Performance for these traits was generally lower in the wide spacing than in the normal one, but Acala SJ-1 and Deltapine smoothleaf were less affected by spacing treatments than the other cultivars tested. The effect of plant spacing on Acala 4-42 and Carolina Queen was somewhat more pronounced, but the differences were not significant for seed cotton and lint yields. The largest effect of plant spacing was found on Acala 1517C and Del Cerro, and significant differences were obtained for all the five traits exhibiting a cultivar × spacing interaction.

Table 1. Mean squares of the analyses of variance of several cotton traits.

Trait	Mean squares: Spacing	Error(a)	Cultivars	Inter-action	Error(b)
Seed-cotton yield, g/m^2	59,022*	5,616	13,840**	5,663*	1,708
Lint yield, g/m^2	6,345*	871	1,240**	800*	255
Seed yield, g/m^2	26,663*	2,117	7,438**	2,241*	683
Boll number/m^2	1,623**	94	958**	132*	48
Lint percent	10.94*	1.60	23.48**	.50	1.40
Boll weight, g/boll	.03	.14	11.30**	.09	.18
Flower number/m^2	13,314**	262	4,792**	459*	184
Boll retnetion, percent	10.10	82.70	280.16**	38.60	21.92
2.5% span fiber length, inches	105.12**	8.36	507.41**	5.19	6.19
Fiber length uniformity ratio	2.72	2.92	14.32**	2.89	3.42
T_1 fiber strength, g/tex	.94	.55	71.15**	.13	.94
Fiber fineness, Micronaire units	.89	17.32	68.42*	1.32	11.50

*, ** Statistically significant at the 0.05 and 0.01 levels, respectively, according to F-tests. The significance of spacing was tested by using the main-plot error mean square (error a, with 1 and 5 df). The significance of cultivars and of the cultivar × spacing interaction was tested by using the split-plot error mean square (error b, with 5 and 50 df).

Table 2. Effects of cultivar and of spacing treatment on several cotton traits.

Spacing	Cultivar†	Seed-cotton yield (g/m^2)	Lint yield (g/m^2)	Seed yield (g/m^2)	Bolls (#/m^2)	Flowers (#/m^2)
Wide	CQ	327 ab‡	127 ab	201 ab	58 ab	144 a
	4-42	288 b	114 b	175 b	38 c	96 d
	1517C	299 b	112 b	187 b	49 b	108 cd
	SJ-1	376 a	142 a	234 a	57 ab	115 cd
	DCR	331 ab	118 b	213 ab	49 b	124 bc
	DP	308 b	120 b	188 b	63 a	139 ab
Normal	CQ	377 ab	143 ab	233 bc	69 a	170 a
	4-42	323 b	126 bc	198 c	43 b	118 c
	1517C	425 a	158 a	267 ab	70 a	138 b
	SJ-1	404 a	151 a	253 ab	61 a	129 bc
	DCR	425 a	146 ab	278 a	62 a	174 a
	DP	320 b	121 c	200 c	67 a	160 a
Difference	CQ	50	16	32	11*	26*
	4-42	35	12	23	5	22*
	1517C	126*	46*	80*	21*	30*
	SJ-1	28	9	19	4	14
	DCR	94*	28*	65*	13*	50*
	DP	12	1	12	4	21*

* Difference between spacing treatments significant (0.05 level). † CQ = Carolina Queen; 4-42 = Acala 4-42; 1517C = Acala 1517C; SJ-1 = Acala SJ-1; DCR = Del Cerro; DP = Deltapine smoothleaf. ‡ Results for cultivars (within spacing treatment) which are followed by the same letter, are not significantly different (0.05 level) by the Student-Newman-Keuls Multiple Range Test.

The detailed results indicated that for the traits for which no spacing × cultivar interaction was detected, the ranking of the cultivars was the same in both spacing treatments. Therefore, the results from comparing several genotypes for these traits (lint percent, boll size, boll retention, 2.5% span lint length, T_1 lint strength, lint length uniformity, and Micronaire) in trials with widely spaced plants would be expected to be valid also for closely spaced plants. These traits may, therefore, be evaluated on widely spaced plants during the early stages of a breeding project. Some of these traits have considerable economic value and are usually part of the objective of breeding programs.

The ranking of the cultivars included in our experiment was entirely different in the normal spacing from that in the wide spacing for lint yield, seed yield, yield of seed cotton, boll number, and flower number. For instance, lint yield of Acala 1517C, the highest under normal spacing, was the lowest when grown at wide spacing. Similar though somewhat less extreme results were found for Del Cerro. Differences between spacing treatments in the lint yield of these two cultivars were associated with similar differences in flower number and boll number. The other components of yield, namely, boll weight, boll retention, and lint percent, were not affected significantly by spacing treatments. These results suggest that it would not be advisable to evaluate yield data of genotypes under wide spacing and use these data to predict their performance in normal, closely spaced fields.

Spacing × cultivar interactions will probably vary depending on the environmental conditions that exist during a particular year or at a particular location. Our results demonstrate the existence of a significant spacing × cultivar interaction, which should be of major concern in a cotton breeding program, even though the magnitude and direction of the spacing effects may vary from one environment to another.

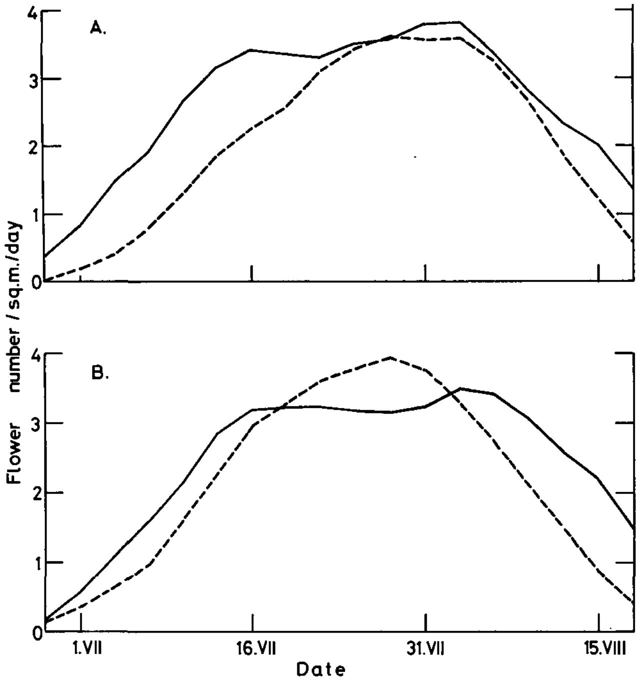

Fig. 1. Daily flowering of two cotton cultivars (A=Acala 1517C; B=Acale SJ-1) in two spacing treatments (- - - - wide spacing; —— normal spacing). A "moving average" for 9-day periods was calculated at 3-day intervals. 1.VII=July 1; 16.VII=July 16; 31.VII=July 31; 15.VIII=August 15.

The flowering pattern of two cultivars under both spacings treatments is presented in Fig. 1. In Acala 1517C, which was affected most strikingly by the spacing treatments, daily flowering per unit area from the widely spaced plants was much lower than that of the normally spaced plants during the first 3 weeks of the flowering period. This effect was much smaller in Acala SJ-1, the lint yield of which was not affected significantly by the spacing treatment.

Acala 1517C and Del Cerro plants are typically tall and pyramidal, with relatively short fruiting branches. These cultivars are probably not able to utilize beneficially the increased space available for each individual plant at the 40-cm spacing treatment. This was manifested in fewer flowers per unit area during the first 3 weeks of flowering, fewer bolls, and lower yields per unit area. The four other cultivars, on the other hand, are more spreading-plant types, with longer fruiting branches, and therefore probably can utilize more efficiently the increased available space.

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