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Effects of Row Spacing and Cotton Cultivars on Seedling Diseases, Verticillium Wilt, and Yield[1]

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ABSTRACT

Cotton (*Gossypium hirsutum* L.) cultivars 'Rilcot 90' (susceptible to Verticillium wilt) and 'Paymaster 266' (resistant to Verticillium wilt) were grown in one, two, and four rows per bed spaced 100 cm apart to determine the effects of cultivars and row spacings on seedling diseases, Verticillium wilt, and yield. Each treatment was applied to the same plot for 3 consecutive years. Plant stands increased with close row spacings but were not directly related to the seeding rates. The prevalence of foliar symptoms of Verticillium wilt was higher in Rilcot 90 than in Paymaster 266, but the percentage decreased with close row spacing. The number of diseased plants of each cultivar was higher with closer row spacing but did not increase directly with plant populations. Lint yield was highest in plants having two rows per bed and lowest in those having one row per bed, but the differences were not significant. The high moisture level maintained during the growing season provided good conditions for disease evaluations but probably reduced lint yield.

In the 4th year, each plot was halved. Seeds of the wilt-susceptible 'Lockett 4789A' and of the wilt-resistant 'Paymaster 909' were planted in one half of each plot in rows 100 cm apart. Stands were reduced slightly by seedling diseases. The prevalence of Verticillium wilt was lower when each cultivar was grown after Paymaster 266 rather than Rilcot 90. Close row spacing during the previous 3 years did not significantly increase the prevalence of Verticillium wilt. A disease-resistant cultivar should be grown at high plant populations to minmize losses from Verticillium wilt and to maximize lint yields.

Additional index words: Narrow rows, Irrigation.

PLANTS for commercial cotton (*Gossypium hirsutum* L.) are usually spaced from 5 to 30 cm apart in rows 100 cm apart. Disease losses and production costs have been reduced, and quantity and quality of the crop have been improved by growing cotton in rows spaced less than 100 cm apart (6, 7, 8). Yield, fiber properties, and prevalence of Verticillium wilt (caused by *Verticillium dahliae* Kleb.) vary with plant populations and row spacings in soils where this disease was prevalent (3, 4, 5, 6). However, the effects of close row spacing on disease prevalence and yield of cotton after it has been planted in various row widths for several years have not been determined, although several workers have reported reduction in this disease with high populations of cotton in rows about 100 cm apart.

The objectives of this investigation were to determine 1) the effects on disease prevalence, seedling survival, and lint yields of Verticillium wilt-susceptible and -resistant cotton cultivars grown for 3 consecutive years in one, two, and four rows per bed; and 2) the effects of these treatments on the subsequent produc-

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Table 1. Effects of row spacing and cultivar on percentage of cotton seedlings surviving 40 days after planting, 1971 to 1973.

Cultivar	Row/100 cm bed	Seedling survival			
		1971	1972	1973	Avg.
	no.	%			
Rilcot 90	1	55c*	72a	56a	61ab
	2	88a	68a	62a	73a
	4	74b	56a	54a	61ab
Raymaster 266	1	53c	87a	29b	56ab
	2	75b	56a	35b	59ab
	4	60c	60a	27b	49b

* Means within a column followed by the same letter are not significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

tivity of Verticillium wilt-susceptible and -resistant cultivars grown in rows 100 cm apart.

MATERIALS AND METHODS

The tests were conducted at the Texas A&M Research and Extension Center (Lubbock) on Amarillo loam soil (a member of the fine loamy mixed, thermic Aridic Paleustalfs) with low-profile beds (20 cm high by 25 cm wide) spaced 100 cm apart. Anhydrous ammonia, 67 kg of N per ha, was applied each year. Trifluralin (α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine) at 0.67 kg of active ingredient per ha was applied annually for weed control.

From 1971 through 1973, seed of 'Rilcot 90' (Verticillium wilt susceptible) and 'Paymaster 266' (Verticillium wilt resistant) were planted in plots having one, two, and four rows per 100 cm bed (rows were spaced 100, 25/75, and 25/25/25/25 cm apart, respectively). Each treatment was on the same plot for 3 consecutive years. Seed were planted at the rate of 17, 34, and 68 kg/ha for one, two, and four rows per bed, respectively. Each plot was 8 × 15 m, but data were recorded from the center 4 × 15 m of each plot. The experimental design was a randomized complete block, replicated four times.

During 1974, the original plots were divided in half (4 × 15 m), and seed of 'Lockett 4789A' (Verticillium wilt susceptible) and 'Paymaster 909' (Verticillium wilt resistant) were planted in single rows 100 cm apart. The seeding rate was 17 kg/ha. Data were recorded from the center 2 × 15 m of each plot. The experimental design was a split plot, replicated four times.

Supplemental irrigation used during the growing season ranged from 4 cm/ha in 1973, when the rainfall was unusually high, to 14 cm/ha in 1971, when the rainfall was low; in 1972 and 1974, 10 and 12 cm/ha of water, respectively, were applied. Irrigation was used to maintain high levels of soil moisture to encourage the development of Verticillium wilt.

The percentages of surviving plants (based on the number of seed planted) and of plants with foliar symptoms of Verticillium wilt were recorded several times each year. Lint yields were also recorded. The data were subjected to analysis of variance, and Duncan's multiple range test was used to identify significant differences among treatment means.

RESULTS

Variable Row Spacing. In 2 or 3 years, seedling emergence was lower in four rows per bed than in one and two rows. Seedling emergence was slightly lower in the two rows between the beds especially where the tractor wheel ran during planting than in the rows on the beds. Planting depths and soil moisture appeared to be more variable in the furrows between the beds than on the beds. Thus, the 3-year average percentage of seedling survival was highest for both cultivars with two rows per bed, but the stand in this treatment was not significantly higher than the stands in the plots having one and four rows per bed (Table 1). No treatment consistently gave higher stands than all other treatments for all years. In the 1st and 3rd years, plants in some row spacings had significantly higher stands in the Rilcot 90 plots than in the Paymaster 266 plots. When the 3-year average stands were converted to number of plants per hectare (data not shown), Rilcot 90 had 210 and 348% more plants in plots having two and four rows per bed, respectively, than in plots having one row per bed. Paymaster 266 had 176 and 290% more plants per plot in the two- and four-row spacings, respectively, than in the one-row spacing.

Table 2. Effects of row spacing and cultivar on the prevalence of foliar symptoms of Verticillium wilt in cotton plants, 1971 to 1973.

Cultivar	Row/100 cm bed	Verticillium wilt			
		1971	1972	1973	Avg.
	no.	%			
		21 Aug.			
Rilcot 90	1	5a*	31a	20a	19a
	2	4a	25b	16ab	15a
	4	2b	17c	11bc	10b
Paymaster 266	1	1b	4d	9cd	5c
	2	1b	3d	7cd	4c
	4	1b	3d	4d	3c
		2 Sept.			
Rilcot 90	1	29a	52a	29a	37a
	2	21b	48ab	21b	30ab
	4	15b	38b	15c	23b
Paymaster 266	1	6c	7c	13c	9c
	2	4c	7c	7d	6c
	4	3c	7c	6d	5c
		15 Sept.			
Rilcot 90	1	44a	65a	43a	51a
	2	34a	57a	34b	42b
	4	22b	43b	23c	29c
Paymaster 266	1	11c	7c	17c	12d
	2	8c	8c	9d	8d
	4	4c	9c	7d	7d
		2 Oct.			
Rilcot 90	1	57a	91a	–	74a
	2	42a	92a	–	67ab
	4	25b	89a	–	57b
Paymaster 266	1	19b	10b	–	14c
	2	15b	10b	–	12c
	4	9b	11b	–	10c

* In each column and within each date, means followed by the same letter are not significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

The percentages of plants with foliar symptoms of Verticillium wilt were significantly higher in Rilcot 90 than with Paymaster 266 in all row spacings (Table 2). The prevalence of foliar disease symptoms in Ritcot 90 on one or more observation dates each year decreased as the number of rows per 100 cm increased from one to four. The prevalence of foliar symptoms of Verticillium wilt in Paymaster 266 plants was not affected significantly by row spacing. The percentage of diseased plants did not reflect the number of diseased plants per hectare, since plant densities differed among the row spacings and cultivars.

Lint yields of each cultivar varied significantly among row spacings in individual years, but the 3-year average lint yields were not significantly different among row spacings within each cultivar (Table 3). The 3-year average lint yield of each cultivar was highest in the plots having two rows per bed. Pay-

Table 3. Effects of row spacing and cultivar on lint yield of cotton plants, 1971 to 1973.

Cultivar	Row/100 cm bed	Lint yield			
		1971	1972	1973	Avg.
		kg/ha			
Rilcot 90	1	170ab*	401e	671d	414b
	2	133bc	493d	858c	495b
	4	100c	582c	676d	453b
Paymaster 266	1	212a	788b	877bc	626a
	2	176ab	964a	979ab	706a
	4	105c	863b	1,035a	668a

* In each column, means followed by the same letter are not significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

Table 4. Residual effects of row spacing and cultivar during the previous 3 years on percentage of cotton seedlings surviving 40 days after planting and lint yield, 1974.

Cultivar		Row/100 cm bed, 1971 to 1973	Seedling survival	Lint yield
1974	1971 to 1973			
		no.	%	kg/ha
Lockett 4789 A	Rilcot 90	1	49a*	283cd
		2	42a	243d
		4	41a	265cd
Lockett 4789A	Paymaster 266	1	58a	328c
		2	51a	332c
		4	40a	265cd
Paymaster 909	Rilcot 90	1	59a	539ab
		2	54a	500b
		4	40a	487b
Paymaster 909	Paymaster 266	1	63a	588a
		2	53a	550ab
		4	43a	518ab

* Means within a column followed by the same letter are not significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

master 266 produced higher lint yields than Rilcot 90 in each row spacing.

Uniform Row Spacing. Stands were similar for Verticillium wilt-susceptible and -resistant cultivars grown in uniformly spaced rows in plots that had been planted the previous 3 years with two cultivars in various row spacings (Table 4). Although not significantly different, the percentage of seedling survival in Paymaster 900 was slightly higher than in Lockett 4789A.

The prevalence of Verticillium wilt in Lockett 4789A and Paymaster 909 was significantly lower (until 3 September) in plots previously planted with Paymaster 266 than in those previously planted with Rilcot 90 (Table 5). In Paymaster 909, prevalence of Verticillium wilt was not significantly different in the plots previously planted to the two latter cultivars. Previous row spacings did not significantly affect the prevalence of this disease.

Previous row spacings and cultivars did not affect lint yields significantly, but yields were usually slightly higher in plots having one row per bed previously planted with Paymaster 266 than for the other treatments. Paymaster 909 outyielded Lockett 4789A (Table 4).

DISCUSSION

Variation in plant survival among years was probably caused by environmental differences and by the use of different seed lots. The seed lots met the germination requirement for certification in Texas. The stands obtained during the 3rd year indicated that seed vigor was probably too low for good stand establishment.

Table 5. Residual effects of row spacing and cultivar during the previous 3 years on prevalence of Verticillium wilt in cotton, 1974.

Cultivar		Row/100 cm bed, 1971–1973	Verticillium wilt				
1974	1971–1973		12 Aug.	22 Aug.	3 Sept.	16 Sept.	30 Sept.
		no.	%				
Lockett 4789A	Rilcot 90	1	9a*	26a	62a	78ab	85a
		2	9a	26a	62a	80a	90a
		4	8ab	25a	55ab	72ab	87a
Locket 4789A	Paymaster 266	1	4cd	15bc	46b	67b	79a
		2	3cd	15bc	43b	66b	79a
		4	6bc	16b	50ab	66b	80a
Paymaster 266	Rilcot 90	1	2de	8d	17c	33c	40bc
		2	2de	8d	21c	35c	44b
		4	3de	9cd	24c	35c	45b
Paymaster 909	Paymaster 266	1	1e	5d	12c	24c	28c
		2	3de	5d	17c	29c	35bc
		4	2de	6d	17c	27c	36bc

* Means within a column followed by the same letter are not significantly different at the 0.05 level of probability, according to Duncan's multiple range test.

The reduction in foliar symptoms of Verticillium wilt in plots having two and four rows per bed in comparison to the plots having one row per bed could have been caused by several factors. Verticillium inoculum in the soil may have been unequally distributed or too low for comparable percentages of infection at all plant populations. The amount of disease at the end of the growing season was related to the number of microscleratia per gram of soil both in June and November (2). Microscleratia were not determined in our test, but the treatments may have affected the inoculum level of the causal pathogen. The root volume per plant and its distribution probably varied with row spacing and plant density. Plants having the most extensive root system would probably have more opportunities to contact the fungus than plants with smaller root systems, and different amounts of disease could develop. Fruit load was lower at the high than at the low plant density. Foliar symptoms of this disease have been related to boll load (1). Light intensity and heat may vary with row configuration and these may influence symptom expression.

The suppressior of Verticillium wilt through September is important in obtaining the maximum quality and quantity of cotton. The crop may mature earlier in narrow than in conventional rows, and severe disease late in the season would affect the crop less in narrow rows. The decline in temperatures that

begins about the middle of August is favorable for rapid development of Verticillium wilt but unfavorable for maturation of the crop. Minimizing diseases during this period is the key to maximizing returns on investment.

The prevalence of Verticillium wilt was lowest in resistant cultivars. This disease was high in Lockett 4789A grown on all plots where the wilt-susceptible or the wilt-resistance cultivars had been grown the previous 3 years. Apparently, the inoculum of *V. dahliae* in the soil after 3 years of treatments was high enough to cause economic losses, especially in Lockett 4789A.

The primary objective of this study was to evaluate the effects of row spacing and cultivar on prevalence of Verticillium wilt. Thus, high soil moisture levels were maintained during the first 3 years to encourage the development of this disease. The high soil moisture probably did not permit maximum yield production, since the yield responses to the different row spacings do not agree with those reported by others (3, 4, 6, 7, 8). The unusually low lint yields during the 1st year were probably caused primarily by late planting. The high yields during the 3rd year were related to a favorable environment for cotton production. The two rows per bed or a similar pattern will probably be used for narrow-row production, since it permits cultivation for weed control and leads to increased yields.

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