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Effects of Row and Plant Spacings on Verticillium Wilt of Cotton[1]

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ABSTRACT

The effects of row and plant spacings on percent Verticillium wilt (*Verticillium albo-atrum* Reinke and Berth.) in 'Gregg 35,' a wilt-susceptible cotton (*Gossypium hirsutum* L.) adapted to a wide range of row and plant spacings, were studied in single- and double-row planting patterns. Percent wilt was decreased slightly in double-row and significantly in single-row patterns by close row spacings. In both planting patterns percent wilt decreased as plant populations (seeding rates) increased from low to medium levels, but percent wilt remained constant or decreased slightly at higher plant populations. The interaction of row widths × seeding rates was significant only for the single-row patterns.

***Additional index words:* *Gossypium hirsutum, Verticillium albo-atrum,* Seeding rates, Plant populations, Single- and double-row plantings.**

GENERALLY, cotton (*Gossypium hirsutum* L.) is grown in spacings ranging from 5 to 30 cm between plants in rows approximately 101 cm apart. Ray and Hudspeth (6) found only small differences in yield and fiber properties in wilt-free plants at populations between 37,000 and 185,000/ha in 101-cm row widths. Brashears, Kirk, and Hudspeth (1), however, and Kirk, Brashears, and Hudspeth (2) found significant differences in yield and fiber properties for variable plant populations and row spacings in soil where wilt was severe, and the effects of their treatments on wilt are discussed in this paper. Reduced production costs, increased yields, and improved fiber qualities have been obtained from row widths narrower than 101 cm (5, 8, 9).

Young, Fulton, and Waddle (10) reported no significant differences in either percent wilt or yield in thick, thin, and normal stands. Leyendecker, Blank, and Nakayama (3) showed that 2.68 to 3.26 plants per hill spaced 30 cm apart as compared to 1 plant per hill reduced wilt but increased yield. Longnecker, Thaxton, Hefner, and Lyerly (4) observed that thick stands reduced wilt and suggested that 10 to 12 plants per 30 cm of row probably would give maximum control of the disease for variable row spacings.

The objective of the tests reported here was to determine the effects of plant populations and row spacings on Verticillium wilt, caused by the soil-borne fungus *Verticillium albo-atrum* Reinke and Berth., of cotton in single- and double-row planting patterns. The data discussed in this paper were recorded from tests containing a wider range in both row and plant spacings than that reported by previous workers.

MATERIALS AND METHODS

Two row spacing tests were conducted on Amarillo loam soil at the Texas A&M University Agricultural Research and Extension Center at Lubbock. The test plots were planted May 3, 1965. The soil was plowed approximately 20 cm deep, fertilized

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with anhydrous ammonia at 101 kg of N/ha, and sprayed with 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron) at 0.84 kg/ha. 'Gregg 35,' susceptible to Verticillium wilt but adapted to a wide range of row and plant spacings, was planted in both tests. Each experiment was a randomized block design, replicated four times. Foliar symptoms of wilt were used for identification of diseased plants, since Ray, Minton, and Berry (7) reported highly significant correlations between wilt percent and yield, wilt percent and wilt grade, and wilt grade and yield. The highest correlation values between wilt percent and yield occurred during September. In our tests wilt counts were made from 0.000405 ha on September 25-27, the 2nd year of the test. The same treatments were located in the same area both years. Disease symptoms of the host indicated that the area was severely infested with the fungus, with some variation among replications in the double-row test. The first killing freeze occurred November 30. Additional information on each test is presented below.

Double-row Test. Five row spacings, (10-91, 20-81, 30-71, 40-61 and 0-101 cm apart) and three seeding rates (21, 43, and 87 kg/ha) were used. The plots were 13.7 m long and 3.0 m wide. The soil was listed, shaped with a bed shaper, and furrow irrigated before planting.

Single-row Test. Five row spacings (13, 25, 51, 76, and 101 cm apart) and four seeding rates (9, 21, 43, and 73 kg/ha) were used. The seeding rates in the order listed gave approximately 23, 8, 5, and 3 cm between plants within the row. The plots were 13.7 m long and 2.2 m wide. The soil was left flat and was sprinkler irrigated before planting. After planting, the plots were sprinkler irrigated to provide moisture for germination of seed and emergence of seedlings.

RESULTS AND DISCUSSION

Double-row Test. The F value for average percent wilt for row spacing was almost significant at the 0.05 level of probability, but the F and r values for linear regressions for the sums of squares for row spacing were significant. The incidence of wilt decreased 3.41% for each 10-cm increase in width of rows on 101-cm bed, rows spaced 40-61 cm gave the lowest percent wilt for 21- and 43-kg/ha seeding rates, while rows spaced 30-71 cm gave the lowest percent wilt for 87 kg/ha (Table 1). The number of diseased plants/ha for row spacings ranged from 56,833 for 30-71 cm to 79,072 for 20-81 cm but was not directly related to plant populations. Wilt was 25% or less for all row spacings when stands exceeded 270,000 plants/ha (Fig. 1). The correlation coefficient ($r = -0.65$) for percent wilt $\times$ plant population was highly significant. From 130,000 to 160,000 plants/ha are suggested for maximum yield in double-row plantings.

Average percent wilt decreased highly significantly with increased seeding rates or plant populations (Table 1, Fig. 1). Wilt decreased 0.53% for each 1 kg/ha increase in seeding rates. The greatest reduction in percent wilt caused by increased seeding rates was obtained with rows spaced 20-81 cm and the least was obtained with rows spaced 40-61 cm. At the 21-kg/ha seeding rate, percent wilt increased as the distance between rows on the bed increased from 0 to 20 cm, and then wilt decreased for wider row spacing. At the 43-kg/ha seeding rate, percent wilt decreased with increasing spacing between rows on the bed. At the 87-kg/ha seeding rate, percent wilt was not affected by row spacings. In the absence of Verticillium wilt on the South Plains of Texas, 21- and 43-kg/ha seeding rates are within the range suggested for production of irrigated cotton for conventional and double-row patterns, respectively. Higher seeding rates should be used where wilt is a problem.

The number of diseased plants/ha increased from 54,362 for the low seeding rate to 76,601 for the medium rate but decreased to 71,659 for the high.

Table 1. Relation of row widths and seeding rates in double-row planting to percent Verticillium wilt.

Row width, cm	% wilt for seeding rates, kg/ha 21	43	87	Avg % wilt for row width
0-101	54 a	51 a	15 a	39 a
10-91	56 a	44 a	17 a	39 a
20-81	67 a	39 a	21 a	42 a
30-71	49 a	29 a	11 a	29 a
40-61	42 a	20 a	16 a	27 a
Average % wilt for seeding rate	52 a	37 b	17 c	

* Numbers for average for seeding rate, average for row width, and seeding rate × row width followed by the same letter are not significantly different at the 0.05 level of probability based on Duncan's multiple range test.

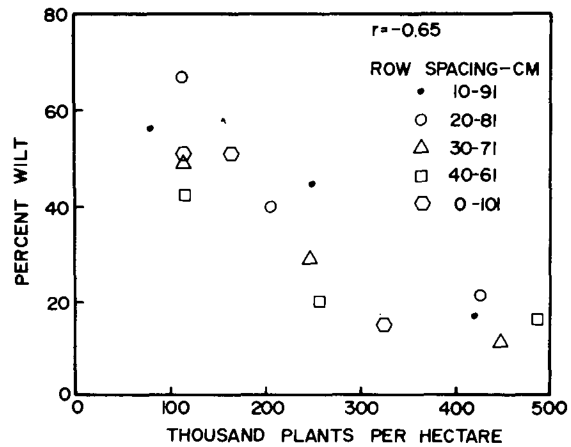

Fig. 1. Relation of plant populations in double-row planting to percent Verticillium wilt.

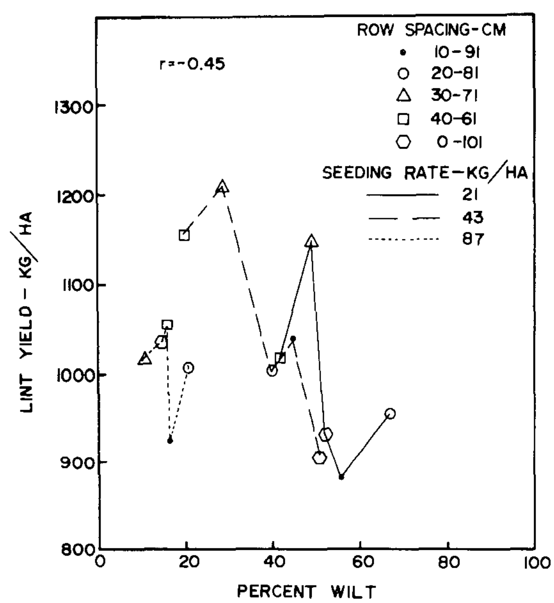

Fig. 2. Relation of lint yield in double-row planting to percent Verticillium wilt as influenced by seeding rates.

There were no significant differences in percent wilt for the interaction of row spacings $\times$ seeding rates (Table 1). The 87- and 21-kg/ha seeding rates gave the lowest and the highest percent wilt, respectively, for all row widths. The small increase in percent wilt for rows spaced 20-81 cm at the 21-kg/ha seeding rate can not be explained.

The correlation coefficient ($r = -0.45$) for percent wilt $\times$ yield was highly significant (Fig. 2). The highest yield occurred at the medium level of wilt for all row spacings except for rows spaced 20-81 and 0-101 cm, where the highest yield occurred at the lowest percent wilt. Lowest percent wilt and highest yield were obtained with two rows spaced 30 cm apart on 101-cm beds.

Single-row Test. Average percent wilt varied significantly among row spacings (Table 2) and was inversely related to the distance between rows, although there were no differences between rows spaced 76 and 101 cm or 13 and 25 cm. Wilt decreased 0.4% for each 1-cm reduction in row width. The number of diseased plants/ha ranged from 51,891 for rows spaced 51 cm to 69,188 for rows spaced 76 cm.

Average percent wilt decreased significantly with increasing seeding rates (Table 2). Wilt decreased 0.7% for each 1 kg/ha increase in seeding rate. The greatest reduction in percent wilt between two adjacent seeding rates occurred for the 9- and 21-kg/ha rates, and the least, for the 43- and 73-kg/ha rates. Wilt was 10% or less in plant populations of 400,000/ha or more (Fig. 3). Approximately 300,000 to 400,000 plants/ha are suggested for maximum yield of irrigated narrow-row cotton. Plant populations in this range can be obtained with 73-kg/ha seeding rate. Percent wilt and plant populations were significantly correlated ($r = -0.60$). The number of diseased plants/ha among the seeding rates ranged from 49,420 to 64,246 and was not directly related to seeding rates or plant populations for all row spacings.

There were significant differences in percent wilt for the interaction of row spacing $\times$ seeding rate (Table 2). Low percent wilt was related to both close row spacing and high seeding rate. Increased within the row plant population was more effective in reducing wilt for 51-, 76-, and 101-cm row widths than for

Table 2. Relation of row widths and seeding rates in single-row planting to percent Verticillium wilt.

Row spacing, cm	% wilt by seeding rate, kg/ha				Average % wilt, row spacing
	9	21	43	73	
13	19 def	10 fg	2 g	3 g	8 c
25	34 c	7 fg	8 fg	5 fg	13 c
51	52 b	25 cde	15 ef	4 fg	24 b
76	83 a	54 b	27 cde	7 fg	43 a
101	83 a	30 cd	28 cdc	26 cde	43 a
Average % wilt, seedling rate	54 a	25 b	15 c	9 d	

• Numbers followed by the same letter for row spacing, seeding rate, and row spacing × seeding rate are not significantly different at the 0.05 level of probability based on Duncan's multiple range test.

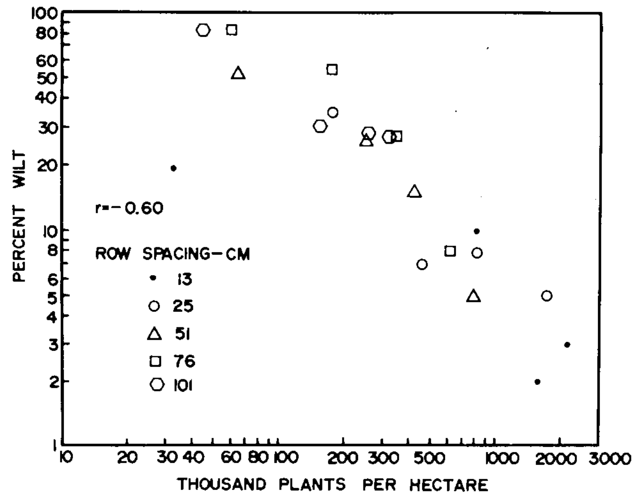

Fig. 3. Relation of plant populations in single-row planting to percent Verticillium wilt.

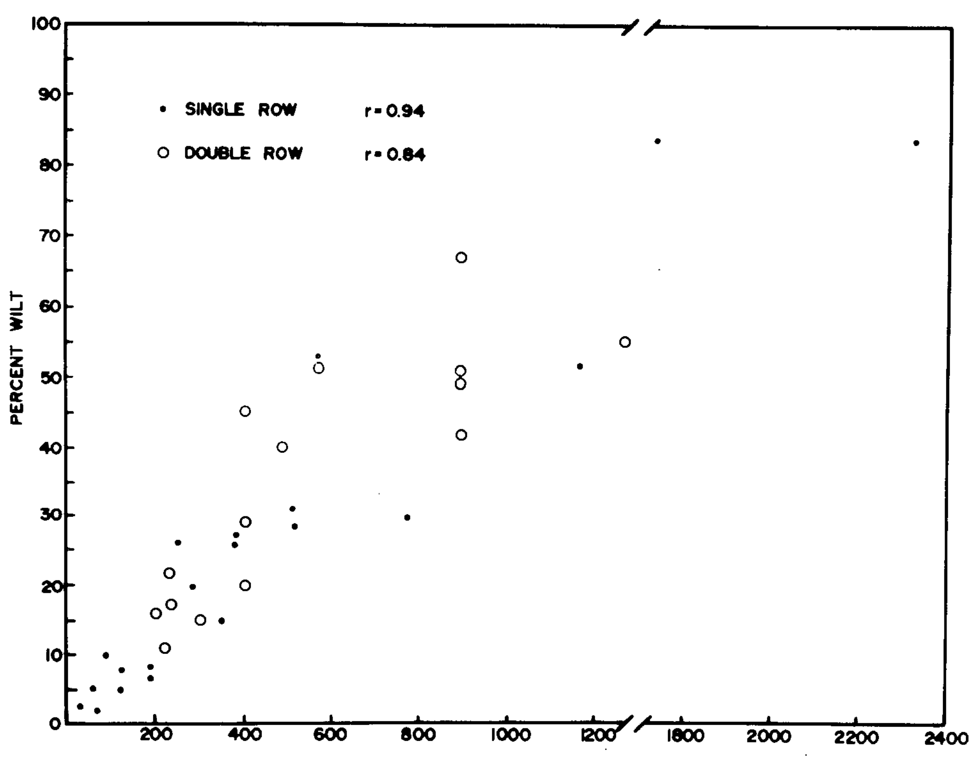

Fig. 4. Relation of area occupied by each plant in double-row and single-row plantings to percent Verticillium wilt.

closer spacings. Wilt was 10% or less for 21-, 43-, and 73-kg/ha seeding rates in rows spaced 13 and 25 cm.

A nonsignificant correlation ($r = -0.12$) occurred for percent wilt × yield. The lowest percent wilt occurred for the highest within-row plant populations (3 cm between plants) or seeding rate for each row width, but maximum yield occurred for 8-cm (21-kg/ha seeding rate) spacing between plants within the row.

Low percent wilt was highly significantly correlated ($r = 0.84$ and $r = 0.94$ for double- and single-row planting patterns, respectively) with a small area (cm^2) occupied by each plant (Fig. 4). These data showed that the incidence of wilt can be reduced by increasing within-row plant populations for various row patterns and that single-row plantings were slightly more effective in reducing wilt than were double-row. Also, the seeding rate suggested for control of wilt for conventional row widths (97 to 101 cm) gives too low within-row plant populations for maximum control of the disease. Apparently, the reduction in percent wilt at high plant populations was restricted by the level of fungal propagules in the soil, since the number of diseased plants for both row patterns did not increase proportionally with increased plant populations. Observations have shown that wilt-tolerant cottons are more effective in reducing wilt than are wilt-susceptible ones grown at high plant populations or in close rows. Additional tests are needed to determine the effects of both row spacings and seeding rates on wilt of susceptible and tolerant cotton varieties where the same treatments are grown on the same plot for several years.

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