Long-term study reaffirms yield increases of narrow-row cotton

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Narrow-row cotton spacing raised yields and lowered production costs, but also created trash problems. Experimental brush stripper harvested 30-inch rows at right; conventional spindle picker harvested 40-inch rows at left.

Cotton has traditionally been grown in rows spaced 38 or 40 inches apart. Research and field testing began in 1970 in the San Joaquin Valley to determine how growing cotton in narrower row spacings would affect yield, production costs, earliness, and fiber quality. This research program was prompted by grower interest in lowering production costs for a greater net return. Attention in recent years has also been focused on the use of narrow-row spacings in a shorter production season that would provide a longer host-free period as a potential means of controlling the pink bollworm and avoiding other late-season pests.

This coordinated research effort spanning an 11-year period from 1970 through 1980 has included experiments at the various cotton research stations and with growers throughout the cotton areas of the San Joaquin Valley. Harvesting equipment is a major emphasis, because conventional spindle pickers for 38- and 40-inch row spacings cannot be used to harvest rows spaced 30 inches or less. The ginning process and ginning equipment are also affected, in that the stripper-type harvesters used in narrow-row cotton normally result in more trash being delivered to the gins.

Pre-1978 tests

Several row spacings were evaluated from 1970 through 1977, primarily 7, 10, and 20 inches, and two rows 14 inches apart on beds spaced 40 inches apart (14-26-inch). Lint yield from Acala varieties was increased on the average by about 10 percent when planted in narrow-row spacings. In some experiments, where there was a high infestation of verticillium wilt, narrow-row plantings produced yield increases as high as 50 percent.

The first narrow-row harvester used in this program was a combine-type spindle picker that cut the cotton plant and fed it through spindle-picking units inside the machine. This method soon proved to be unsatisfactory and was abandoned after the first year. A continuous-width, finger-type stripper, used exclusively for harvesting the narrow-row experiments from 1971 through 1973, did not work well where plants were tall and heavily branched. It also required dry conditions and a fully matured, well-defoliated crop. These years of testing with the finger stripper showed that it was not suitable for year-in, year-out harvesting of Acala varieties in the San Joaquin Valley.

By 1973 it became evident that the double-row, 14-26-inch spacing produced good yields and was easier to cultivate and irrigate than the other narrow-row spacings. As a result, testing was restricted to this row spacing during 1974 through 1977. In 1974 a two-row, brush-type stripper head was rebuilt to harvest the double-row, 14-26-inch spacing and was used for the narrow-row experiments during the 1974-77 period.

In tests comparing the double-row, brush stripper and the finger stripper in 1974 and 1975, the brush stripper resulted in lower field losses (2.7 versus 8.3 percent) and higher gin turnouts (28.6 versus 26.65 percent). Both

TABLE 1. Average lint yield, gin turnout, and fiber quality from 14 tests of Acala SJ-2 grown on 30- and 40-inch rows, 1978 to 1980

Treatment	Lint yield per acre	Gin turnout	Lint	Fiber length: 2.5% S.L.	Fiber length: 50% S.L.	Uniformity index†	Strength, T_1	Elongation, E_1‡	Micronaire§
	lb	%	%	*inches*	*inches*		*grams/tex*	%	
Row spacing									
40 inches	816**	30.0**	34.4	1.15**	0.54	47	2.36	8.1	3.87*
30 inches	970	21.9	33.4	1.13	0.54	47	2.35	7.9	3.74
Average	893	25.9	33.9	1.14	0.54	47	2.36	8.0	3.81
L.S.D. (0.05)	69	1.6	N.S.	0.01	N.S.	N.S.	N.S.	N.S.	0.10
C. V.%	10.8	4.3	3.2	1.8	3.7	2.6	2.8	5.0	6.4

Note: 40-inch row spacing was harvested with spindle pickers, and the 30-inch row spacing with brush strippers.

*Significant at the 0.05 level.
**Significant at the 0.01 level.
†Uniformity index = 50 percent span length divided by 2.5 percent span length times 100.
‡Elongation = percentage elongation in the fiber at the breaking point.
§Micronaire = fineness of the fiber expressed in standard micronaire units; premium range is 3.9 to 4.5.

harvesters were equipped with a saw-type cleaner. The brush-type stripper also was more tolerant of adverse crop and weather conditions and could be operated at higher travel speeds.

Even though the 14-26-inch row spacing performed well in conjunction with the brush stripper, there were limitations, primarily: (1) the spacing was not used to any extent for other crops typically produced by cotton growers; (2) planting near the shoulders of the bed sometimes resulted in moisture loss in the seed row and poor germination; and (3) it was difficult to cultivate in the 14-inch space between rows on top of the bed.

These limitations led to evaluation of the 30-inch row spacing from 1978 through 1980. In cotton plant spacing, the 30-inch row was a compromise, but it was already being used for other crops, such as corn, sugarbeets, and beans. Also, equipment companies were already producing planting and cultivating equipment for 30-inch rows, and a brush-type harvester for that spacing would be relatively easy to build.

Tests of 30-inch spacing

The three years of tests, conducted in growers' fields in five cotton-producing counties of the San Joaquin Valley, covered a wide range of environmental conditions, soil types, insect and disease pressures, and yield potential. The 30- and 40-inch row spacings were compared in each test. Only the Acala SJ-2 variety was planted in the 1978 tests; both Acala SJ-2 and Acala SJ-5 were planted in 1979 and 1980. Fourteen tests were conducted—six in 1978, five in 1979, and three in 1980—each with four replications.

All 30-inch treatments were harvested on a once-over basis with brush-type stripper harvesters—in most cases, an International Harvester Company Model 95 (lent by the company) without a cleaner and fitted with an experimental, three-row brush head. The 40-inch treatments were harvested with the growers' spindle pickers on a twice-over basis.

It should be pointed out that the yields reported here represent the amount of cotton harvested, and therefore reflect any differences in losses due to the method of harvest. In tests before 1978, losses were about 5 percent of gross yield (harvested yield plus losses) for twice-over harvest with the spindle picker versus 2 to 2.5 percent for once-over with the brush stripper.

The 30-inch row spacing increased lint yield 19 percent over yield from the 40-inch spacing when the 14 tests for the three-year period were averaged (fig. 1). This increase represented 154 pounds of lint per acre. On a yearly basis, the 30-inch spacing yielded 14, 21, and 22 percent more lint than the conventional 40-inch spacing in 1978, 1979, and 1980, respectively. In 1978, a poor cotton year, yields were low in the San Joaquin Valley.

The 1978 Kern County test was the only one of the 14 with a yield decrease from 30-inch row spacing. Especially severe lygus insect pressure in this test resulted in plants that were 57 inches tall for 30-inch spacing compared with 48 inches for the 40-inch spacing, so that more lygus damage occurred and the crop matured later in 30-inch rows.

Two Acala cotton varieties, SJ-2 and SJ-5, were compared in three tests in 1979 and 1980. Acala SJ-2 yielded an average of 24 percent and Acala SJ-5 18 percent more lint in the 30-inch than in the 40-inch spacing. In 1979, SJ-2 yielded 26 percent more in the 30-inch row spacing, and SJ-5 yielded only 10 percent more. The reverse was true in 1980, when SJ-5 yielded 26 percent more in the 30-inch spacing and SJ-2 yielded 22 percent more. Apparently the variety best adapted to the environment of a given year is the one that performs best in the 30-inch spacing. Such performance may reflect a difference in verticillium wilt tolerance, since wilt was considered light in 1979 and severe in 1980.

Average gin turnout for the stripper-harvested, 30-inch spacing in all 14 tests was 21.9 percent as compared with 30 percent for the spindle-picked 40-inch spacing. This difference resulted from the additional trash in stripper-harvested cotton. There was no significant difference in lint percentage between the two row spacings.

Fiber length, as measured by the 2.5 percent span length, was slightly greater for 40-inch than for 30-inch spacing, but the values for both row spacings are equivalent to 1⅛ inch or 36 staple (table 1). Row spacing had no effect on 50 percent span length, uniformity index, fiber strength (T_1), or fiber elongation (E_1). Micronaire values were lower for the 30-inch than for the 40-inch spacing but were still within the premium price range. The reduced micronaire values probably resulted from harvest of immature bolls by the brush stripper; the spindle picker used for 40-inch rows leaves immature bolls in the field.

Open bolls were measured at three stages of maturity in four tests comparing Acala SJ-2 and SJ-5 varieties (fig. 2). Neither row spacing nor variety had a conclusive effect on earliness: reversals occurred from test to test, indicating that cultural practices or other causes may override these two factors. However, crop maturity was not delayed by the substantial yield increases of the 30-inch row spacing.

Row spacing had no effect on average plant height: plants in 30-inch rows averaged 38.8 inches in height, as compared with 39.5 inches in 40-inch rows. A comparison between Acala varieties shows an average height of 41.3 inches for SJ-2 and 36.9 inches for SJ-5. These plant heights indicate that the tests were on good, high-production Valley soils.

Row spacing did not affect the number of nodes up to the first fruiting branch or its height from the soil surface, nor did the number of nodes to the top fruiting branch significantly vary with variety or row spacing (see table 2).

For satisfactory operation of the brush-type stripper used to harvest the 30-inch spacing, the weather must be dry, and the crop mature, with a minimum of green bolls, and completely defoliated. Otherwise, harvest rate is reduced by lower travel speeds and plugging of the machine. Also, more green plant materials are harvested with the cotton, lowering grades and creating a ginning problem. The required conditions were achieved in varying degrees during harvest of the 14 tests. The 1978 cotton crop matured late, causing severe harvesting problems in most of that year's tests.

Under optimum harvesting conditions, the brush stripper was operated at travel speeds

TABLE 2. Average plant characteristics of Acala SJ-2 and Acala SJ-5 grown in 30- and 40-inch rows at three locations in 1979 and three in 1980

Treatment	Nodes to first fruiting branch	Nodes to top fruiting branch	Distance from soil surface to: First fruiting branch	Distance from soil surface to: Top fruiting branch	Plant height
	Number	*Number*	*inches*	*inches*	*inches*
40-inch rows:					
Acala SJ-2	7.7**	17.5	9.5**	33.8*	41.8**
Acala SJ-5	6.9	17.2	7.9	30.4	37.1
30-inch rows:					
Acala SJ-2	7.8	17.3	9.8	32.1	40.8
Acala SJ-5	7.1	16.5	8.0	29.1	36.7
Average	7.4	17.2	8.8	31.3	39.1
L.S.D. (0.05)	0.6	N.S.	0.6	3.0	2.6
C.V.%	8.2	5.6	12.5	7.8	7.0

*Significant at the 0.05 level.
**Significant at the 0.01 level.

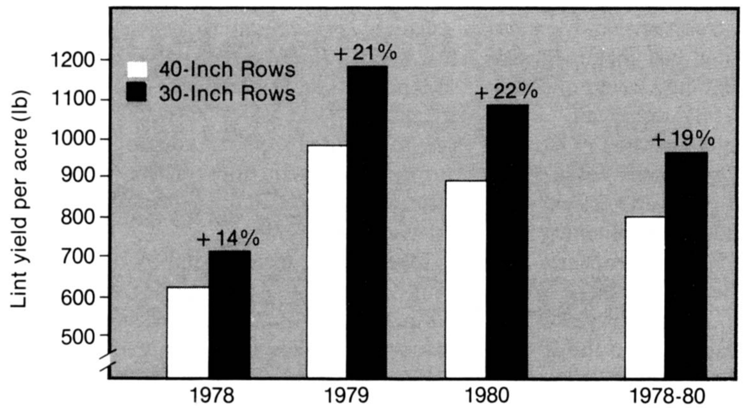

Fig. 1. Lint yield of Acala SJ-2 in 30- and 40-inch rows and percent increase in lint yield (averages of 14 tests).

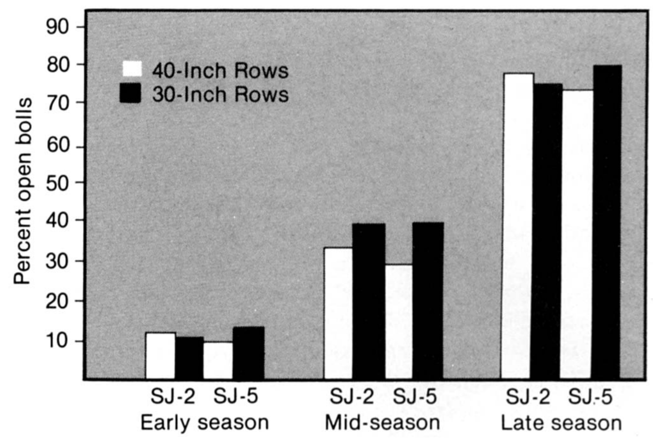

Fig. 2. Open bolls at 3 stages of maturity (averages of 4 tests).

of 2.5 to 3 miles per hour; capacity of the conveying system was the limiting factor. Under poor conditions, travel speed was reduced to approximately half, and even then plugging occasionally occurred in the conveying system. Plugging resulted from excessive green plant material, green bolls, and sticks.

Plant size did not adversely affect harvesting unless the plants were taller than 4.5 to 5 feet and had large branches. Some plugging problems occurred at the brush head, when plants were pulled out of the soil by the brushes, especially when the soil was wet.

When harvested under optimum conditions, the 30-inch, brush-stripped cotton was dry, and the major problem at the gin was reduced throughput caused by additional trash and sticks. Under poor harvesting conditions, the green plant material and higher moisture content of the seed cotton resulted in severe ginning problems, including greatly reduced throughput and frequent plugging. It should be pointed out that the gins did not have the extra cleaning equipment that is normally used for ginning stripped cotton.

A stationary, saw-type cleaner was built and used during the 1978 and 1979 seasons to clean the seed cotton before it was delivered to the gins. The stationary cleaner operated satisfactorily as long as the seed cotton was relatively dry and free from green plant material. High moisture and green leaves or bolls in the seed cotton gummed the saws and frequently plugged the machine.

Gin managers are generally reluctant to gin stripped cotton because of the possible problems. Most California gins do not have the additional cleaning equipment required to gin stripped cotton efficiently.

In summary, three years of tests with narrow-row cotton in growers' fields in the San Joaquin Valley have shown an average yield increase of 19 percent when 30-inch spacing was compared with spindle-picked cotton in conventional 40-inch rows. Previous tests with other narrow-row spacings showed increases averaging 10 percent.

The effect of row spacing on earliness is unclear at this point, and may be overridden by cultural practices and other factors.

The brush stripper is superior to the finger stripper for harvesting narrow-row cotton in California and is being used commercially. The crop must be planted and managed so that it can mature and be harvested before damp, rainy, fall weather, because the brush stripper requires dry weather and a mature, well-defoliated crop for satisfactory operation. Four companies are now producing brush-stripper harvesters: two makes have integral saw-type lint cleaners, and two have no cleaning equipment.

Problems occur in ginning because of additional trash and slower throughput, unless gins are modified to handle stripper-harvested cotton. Ginning difficulties are increased when cotton is harvested under poor conditions with a high moisture content and excessive green plant material.

In these tests, lint grade and fiber property differences, if any, tended to favor spindle-picked, conventional cotton over stripper-harvested, narrow-row when the narrow-row cotton had been properly matured and harvested under good weather conditions. Grade and fiber differences heavily favored conventional cotton when the narrow-row had been harvested under poor conditions. In a 1972 evaluation of effects on spinning, narrow-row cotton that was finger-stripper-harvested under optimum conditions was almost equal in quality to cotton grown in 40-inch rows and spindle-picked.

Production costs of narrow-row and conventional cotton in Tulare County were compared in 1977 by surveying several growers, some of whom were producing narrow-row cotton. This comparison was based on the use of finger-stripper harvesters for the narrow-row and an increased lint yield of 11 percent for narrow-row over conventional (1,000 versus 900 pounds per acre). Preharvest cash costs and harvesting costs were lower for narrow-row than for cotton grown in conventional row spacing, but ginning costs were higher. Total cash costs per hundredweight of lint were 15 percent less for narrow-row than for conventional 40-inch cotton.

Narrow-row, brush-stripped cotton was grown on an estimated 20,000 acres in the San Joaquin Valley during 1981, primarily in the 30-inch spacing. A new project was begun in 1981 to study the feasibility of harvesting the 30-inch row spacing with a spindle picker. A spindle picker rebuilt to harvest 30-inch rows in a single-row basis is being compared with the conventional spindle picker on 40-inch rows and the brush stripper on 30-inch rows. Cotton from this project will be spun at the U.S. Department of Agriculture spinning laboratory in Clemson, South Carolina, to further evaluate effects of growing and harvesting procedures on spinning quality.

Evaluation of narrow-row cotton is a long-term project involving many U.C. staff members. Those participating in the phase of the study reported here include: Robert G. Curley, Extension Agricultural Engineer, Davis; Clay Brooks, Extension Development Engineer, Davis; Robert A. Kepner, Professor of Agricultural Engineering, Emeritus; Kamal El-Zik, former Extension Cotton Specialist; Alan G. George, Farm Advisor, Tulare County; Thomas A. Kerby, U.C. Extension Cotton Specialist, USDA Cotton Research Station, Shafter; Offa D. McCutcheon (deceased), Farm Advisor, Kings County; Leslie K. Stromberg, Farm Advisor, Emeritus, Fresno County; Ronald N. Vargas, Farm Advisor, Madera County; Bill L. Weir, Farm Advisor, Merced County; David L. West, former Farm Advisor, Kern County; Kent Brittan, U.C. Extension Staff Research Associate, USDA Cotton Research Station, Shafter.

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