THE EFFECT OF PLANT POPULATION ON THE YIELD AND FIBER PROPERTIES OF COTTON UNDER NARROW-ROW CONDITIONS

By

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CHAPTER I

INTRODUCTION

The term "narrow row-high population" in cotton (Gossypium hirsutum L.) is not decidedly specific; it could be used to designate any plant population higher than that in normal use in combination with any row spacing less than the traditional 40 inches. In this study, 10 inches row spacing were used with differences in plant spacing.

Since the early 1960's, there has been considerable interest in developing cultural practices to reduce the production costs of cotton. These practices include various aspects of land preparation, planting, weed control, fertilization, irrigation, defoliation, disease control, insect control, and harvesting. The per unit cost of lint production can be reduced by obtaining higher yields, improving fiber quality, lowering production costs, or any combination thereof. The primary reason for attempting to grow cotton in narrow rows is to reduce its production costs to help maintain or improve its competitive market position relative to other fibers.

A number of researchers have evaluated the influence of row width and plant population on yield and fiber properties. Some researchers (18, 24) observed that closer spacings generally caused earlier maturity, and they therefore recommended closer spacings as a means of reducing losses due to boll weevil damage. Rayner (17) in Arizona suggested that the success of narrow-row cotton depends on its increased earliness due to closer plant spacing. Plant spacing or plant population as a means of increasing yield have been investigated for many years; however, most of the experiments were concerned with varying the space between plants within 40-inch rows. Hawkins and Peacock (5) reported that plant population may be a more important factor in determining optimum yields than either spacing or number of plants per hill, as long as stand is of a uniform density.

CHAPTER II

LITERATURE REVIEW

Lint Yield

Spacings between rows 10-, 20-, and 30-inches apart compared to the conventional 40-inch rows have been investigated by a number of researchers. Anderson and Douglas (1) reported no significant yield differences between 10- and 40-inch rows in 1971, but in 1972 the 10-inch rows produced significantly higher yields than did the 40-inch rows. Kirk, Brashears, and Hudspeth (9) found on the Texas High Plains that lint yields were higher in the 5- and 10-inch row widths than in the 20-, 30-, and 40-inch rows. Yields for the plant spacing of 1.1 inches were lower than for the 3.3 inch spacing in the narrower row widths. Ray (15) obtained a yield increase of about 15% from several commercial varieties, but a greater than 30% increase in 8-inch rows from an experimental line being developed especially for narrow-row culture. Results from their 1969 narrow-row trials, conducted cooperatively between the Texas Agricultural Extension Service and 18

High Plains cotton producers, average 12% higher yields from narrow rows (width not given) than from 40-inch rows. At Lubbock and Aiken, Texas, highest overall yields (12) were obtained with 10-inch rows, two rows per bed came in second, and 40-inch rows were third. At Welch, Texas, 10-inch rows and two rows per bed yielded approximately the same; and both yielded more than the 40-inch rows. In Georgia 20-inch rows produced a significantly higher yield than did the 10-inch spacing which in turn was significantly higher in yield than the 40-inch spacing (5). McCutcheon (11) in California obtained yields with conventional 38-inch rows ranging from 500 to 750 lb. of lint per acre, but with 10-inch row spacings, yield increased to more than 1,000 lb. per acre.

El-Zik, Cato, and Merkle (4) found that two cotton rows 8 inches apart on 20-inch or 40-inch beds gave yield increases of more than 5% over single 40-inch rows. Workers in Arkansas (22) conducted preliminary narrow-row trials in the late 1940's, but most of their results were never published. Tests in 1963 and 1964, however, showed that 20-inch rows produced more lint than 40-inch rows.

Spacings between cotton plants within the rows (rows 40 inches apart) have been investigated in the United States for many years. Burch (3) reported that one plant per linear foot of row (approximately 13,000 plants per acre) produced the highest lint yield. He found that spacings of 6 and 12 plants per foot (74,675 and 149,350 plants per acre) significantly reduced yield. Hawkins and Peacock (5) in Georgia in their 1964 test found that plants spaced 6-inches and 16-inches apart yielded significantly more lint than plants spaced 24-inches apart. In their 1967 test, the highest population (240,825 plants per hectare) produced the highest yield. In 1968, their highest yield was produced by four plants per hill spaced 40 cm apart (96,330 plants per hectare). Hoskinson et al. (8) reported nearly equal yields for plant populations ranging from 15,000 to 80,000 plants per acre. Highest yields were obtained from cotton grown in 10-inch rows at the rate of 100,000 plants per acre. All varieties at 100,000 plants per acre yielded more in 10-inch rows than in 20-inch rows at Jackson in 1970. Taylor (19), observing narrow-row, high population cotton studies in Arizona, concluded that populations of 60,000 to 80,000 plants per acre were preferred over populations of 20,000 to 40,000 plants. He reported that yield from cotton grown in narrow-row, high population tests in Arizona was virtually the same as that from cotton grown with conventional rows and populations. Thomas (20) in Oklahoma indicated that populations of 57,000 to 74,000 plants per acre were adequate for optimum production of narrow-row cotton under dryland conditions.

Lint Percent

Hawkins and Peacock (6) reported that lint percent was highest in populations of 19,433 plants per acre or less, but that an increase of 375 lb. per acre in the mean yield for populations of 38,866 plants per acre more than compensated for the advantage gained in lint percent at the lower population levels. Kirk et al. (9) in Texas reported average lint turnout to be higher in the 9.4- and 3.3-inch plant spacings than in the 1.9- and 1.1-inch spacings. El-Zik et al. (4) showed in both dryland and irrigated tests that an increase of 0.6% to 3.4% was obtained in lint percent for 8-inches apart on 24-inch or 40-inch beds over 40-inch rows. Dryland lint percent was highest in the 24-inch rows, followed by the two 8-inch rows on a 24-inch bed and the 16-inch rows. Longenecker et al. (10) obtained higher lint percent from narrower row spacings than from 38-inch rows. However, other researchers (2, 6) have found no differences in response of lint percent to different row widths.

Plant Height

Ray et al. (16) and El-Zik et al. (4) found that plant height decreased as plant population increased. Kirk et al. (9) described progressively shorter plants as row width decreased. However, Burch (3) and Young (24) reported that spacing did not significantly affect plant height in their experiments.

Height of the First Fruiting Branch

Ray et al. (16) reported that in three out of four years height of the first fruiting branch was significantly affected by population; higher populations increased the height of the branch. Burch (3) reported that first fruiting branch height became significantly greater with each increase in plant population. El-Zik et al. (4) and Kirk et al. (9) also obtained results suggesting that the height of the first fruiting branch increased with the reduction in space between plants. Row width apparently had no influence on this trait.

Fiber Length

Porterfield, Batchelder, and Taylor (14) reported that as spacing between plants within rows decreased, staple length also decreased. Tugwell and Waddle (21) in comparing single-plant hills and hills containing three-to-five plants per hill spaced 14 inches apart, observed that fiber length from single plant hills was significantly longer in one out of three years. Kirk et al. (9) detected statistically significant differences in mean fiber length between treatments, but the magnitude of the differences was so small as to be of little practical importance. Longenecker et al. (10) stated that row spacing, irrigation frequency, and plant population had little effect on mean fiber length on a clay loam soil. On a sandy soil, mean length of fiber from the narrower row spacings averaged slightly shorter than that from the regular 38-inch rows. Other researchers (2, 6, 24) have reported no effects on fiber length by different plant populations. El-Zik et al. (4) observed that row width had no effect on fiber length.

Length Uniformity

Taylor (19) reported that lint quality seemed to be improved and more uniform in narrow rows compared to conventional row spacings in only one year for length uniformity. El-Zik et al. (4) found that row width had no effect on fiber uniformity.

Fiber Strength

Kirk et al. (9) maintained that fiber strength reduced as row width and space between plants were reduced. Peebles, Den Hartog, and Pressley (13) obtained a 3% reduction in fiber strength which they associated with closer spacings. Burch (3) stated that fiber strength was reduced significantly with higher plant populations. Only El-Zik et al. (4) found that fiber strength improved in narrow-row spacings as compared with 40-inch rows. Ray (15), and Longenecker et al. (10) reported that row spacing had no effect on fiber strength. Hawkins and Peacock (7) and Bridge et al. (2) reported that plant population had no effect on fiber strength.

Micronaire

Ray et al. (16), Wanjura and Hudspeth (23), Bridge et al. (2), and Tugwell and Waddle (21) observed that high populations may result in significant decreases in micronaire. Row widths of 10-, 20-, and 30-inches gave lower micronaires than 40-inch rows in experiments conducted by Hawkins and Peacock (7) and Kirk et al. (9). Young (24) and Hawkins and Peacock (5) reported that fiber fineness was not affected by different row spacings.

CHAPTER III

MATERIALS AND METHODS

This study was conducted under dryland conditions on a Vanoss loam on the Agronomy Research Station at Perkins, Oklahoma during the 1972 and 1973 growing seasons. 'Westburn 70' was the cotton variety selected for use in the study. The experimental area was planted uniformly by machine on June 16 in both years, and the percent emergence was high. Cotton seedlings were thinned by hand when about six inches tall on July 15 in both years. In 1972, the climatic conditions were unfavorable for growth and development due to a prolonged drought during June and July. In 1973, the only unfavorable condition was an early light frost. A killing freeze occurred quite late in the season.

Experimental Design and Analysis

Nine treatments were replicated four times in a randomized complete-block design in 1972 and 1973. Each plot was 50 feet long and five feet and 10 inches wide.

Adjacent plots were approximately 0.67 feet apart. Each plot contained seven rows 10-inches apart. The treatments studied were plant spacings within rows of 4 inches, 6 inches, 8 inches, 10 inches, 12 inches, 14 inches, 16 inches, 18 inches, and 20 inches apart with a standard deviation of two inches. A range in population from 31,400 to 156,900 plants per acre was represented therein. Cultural practices were conducted as required, except irrigation.

All test data were analyzed using standard analyses of variance. When significant differences among plant spacings for a character were detected, LSD (Least Significant Differences) values were calculated for that character at the 0.05 probability level. When significant differences were not obtained, LSD values cannot be justified and were therefore not calculated for such traits. If the difference for a character between any two spacings exceeds the LSD value for that character, the chances are .05 approximately 19 out of 20 that the apparent difference is a real one.

Sampling and Measurement

Lint yield is reported in pounds of lint per acre. Bolls for the first year's test were harvested for yield determinations by hand pulling on January 20, 1973, and for the second year's test on January 16, 1974. Harvest was delayed each year because of prolonged wet weather. Three rows were harvested from each plot in the first year and one row in the second year. The snapped cotton weights per harvested plot area were converted into lint per plot using the appropriate lint percents. Lint per plot was then converted to an acre basis.

Pulled lint percent is the ratio of lint to snapped cotton by weight.

Plant height of the main stem, in inches was measured one day prior to harvest period.

Height of the first fruiting branch included all lateral branches, both vegetative and fruiting. However, short insignificant branches without bolls were not included. Measurements were taken the day before harvest in inches from the ground level to the center of the node of the first branch.

Fiber length (2.5 °/. span) is the length in inches at which 2.5 °/. of the fibers are of that length or longer as measured on the digital fibrograph.

Length uniformity (Uniformity Index) is a measure of fiber length distribution and is estimated by dividing 50 °/. span length by 2.5 °/. span length and expressing the results as a percentage.

Fiber strength (1/8" Gauge Stelometer) is the strength of a bundle of fibers as measured on the Stelometer with the two jaws (separated by a 1/8 inch spacer) holding the fiber bundle and expressed in grams per grex. Fiber strength was also measured as 0" Gauge Stelometer at the 0-inch gauge setting (i.e., without the 1/8 inch spacer separating the jaws of the machine).

Fiber fineness (micronaire) is measured on the micronaire (an air-flow instrument) and is expressed in micrograms per inch.

CHAPTER IV

RESULTS AND DISCUSSION

Lint Yield

Numerous investigations have shown that cotton adapts readily to a fairly wide range in plant populations. In this study populations ranged from approximately 31,400 to 156,900 plants per acre (Table I). Significant differences were exhibited by lint yield in 1972 among plant spacings, but not in 1973. The 1973 test yielded significantly more than the one in 1972 undoubtedly because of the more adequate rainfall in the second year. Lint yield in a combined analyses of variances over years was significant among plant spacings (Table II). There was not a significant interaction between spacings and years for this trait. The highest yield (Table III) was obtained from the 20 inch spacing with a population of about 31,400 plants per acre while the lowest yield was found at the 12 inch spacing. The closer spacings tended to exhibit reduced yield in these 10-inch rows. In studies by other

TABLE I

PLANT SPACINGS WITHIN ROWS AND THEIR PLANT POPULATIONS PER ACRE

Plant Spacing Within Rows (inches)	Populations (plants/A)
4	156,900
6	104,600
8	78,500
10	62,800
12	52,300
14	44,800
16	39,200
18	34,900
20	31,400

TABLE II

ANALYSES OF VARIANCE FOR LINT YIELD, PULLED LINT PERCENT, PLANT HEIGHT, AND HEIGHT OF FIRST FRUITING BRANCH OVER 1972 and 1973

Source	df	Mean Squares			
		Lint Yield	Pulled Lint Percent	Plant Height	Height of First Fruiting Branch
Year	1	134,148**	116.39**	71.69**	3.74**
Spacing	8	6,802*	4.17*	12.32**	1.99**
Spacing X Year	8	3,038	1.16	1.01	0.24
Error	48	2,660	1.57	0.49	0.26

*,**Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE III

MEANS OF THE FOUR AGRONOMIC CHARACTERS IN 10-INCH ROWS OF WESTBURN 70 AT PERKINS, OKLAHOMA, OVER 1972 AND 1973

Plant Spacings Within Rows (inches)	Lint Yield (lbs/A)	Pulled Lint Percent	Plant Height (inches)	Height of First Fruiting Branch (inches)
4	457	29.4	14.8	8.9
6	452	28.5	15.4	8.7
8	465	28.3	16.9	8.4
10	447	27.7	16.6	8.1
12	416	27.9	16.9	7.8
14	485	28.0	17.8	7.9
16	479	27.7	17.8	7.6
18	494	27.5	18.3	7.7
20	516	26.8	18.5	7.5
$LSD_{.05}$	52	1.3	0.7	0.1

*Spacings mean squares were significant at least at the 0.05 level of probability for these traits.

researchers, the optimum spacings and populations have been quite variable. Burch (3) reported that plant populations of 74,675 to 149,350 plants per acre significantly reduced lint yield. Hoskinson et al. (8) observed his highest yields from populations of 100,000 plants per acre. Thomas (20) suggested that plant populations of 57,000 to 74,000 plants per acre were adequate for optimum production under dryland condition in Oklahoma. Hawkins and Peacock (5) reported nearly equal yields for populations from 15,000 to 80,000 plants per acre.

Pulled Lint Percent

1973 results showed lint percent to be significantly affected by plant spacings, but no significant differences were observed in 1972. Lint percent in 1973 was significantly higher than in 1972 (Table II). Results from the combined analyses over years showed that plant spacing had a significant effect on lint percent. There did not appear to be a differential spacing effect between years. The highest lint percent was obtained from the 4 inch spacing where the 20 inch spacing gave the lowest. Increased plant spacing tended to decrease lint percent. Hawkins and Peacock (6) have previously reported that lint percent was the highest when plant populations were low.

Plant Height

Plant height in combined analyses was significantly affected by different plant spacings (Table II). Relative differences among spacings were not significantly influenced by a year effect. The tallest plants were observed at the 20 inch spacing, and the shortest plants were found at 4 inches (Table III). An increase in plant spacing increased plant height. The same results were obtained from each year. Similar results were obtained by Ray et al. (16), El-Zik et al. (4), Kirk et al. (9), and Burch (3).

Height of the First Fruiting Branch

Statistically significant differences in the height of first fruiting branch as influenced by plant spacing (Table II) were detected in the combined analyses over years. Significant interactions were not observed herein. The plant spacing of 4 inches had the highest fruiting branch, and 20 inches produced the lowest (Table III). Increased spacing between plants decreased the height of the first fruiting branch and the taller plants had lower first fruiting branches. Similar results were observed in both years. The same conclusions were drawn by Burch (3), Ray et al. (16), and Kirk et al. (9).

Fiber Properties

No statistically significant differences in fiber length, uniformity, strength, or fineness due to plant spacings were detected in any year of the study or in the combined analyses over years (Table IV). The only significant differences were found between years for fiber length and both measures of fiber strength. Fiber in 1973 was longer than 1972 undoubtedly because of the higher rainfall in 1973. Conversely, fiber strength in 1972 was higher than 1973 for the same reason. More rainfall tends to give longer, weaker fibers. The means over years are given for the fiber properties in Table V. Bridge et al. (2), Ray et al. (16), and Young (24) reported no effects on fiber length by varying plant populations. Conversely, Porterfield et al. (14) reported that as spacing between plants within rows decreased, staple length also decreased. Kirk et al. (9) and Peebles et al. (13) reported that fiber became weaker as plant spacings were reduced.

TABLE IV

ANALYSES OF VARIANCE FOR THE FIVE FIBER PROPERTIES
OVER 1972 AND 1973

Source	df	Mean Squares				
		2.5 % Span Length	Uniformity Index	1/8" Gauge Stelometer	0" Gauge Stelometer	Fiber Fineness
Year	1	0.2720**	0.87	0.1000*	0.5510**	0.56
Spacing	8	0.0016	2.15	0.0091	0.0222	0.16
Spacing X Year	8	0.0004	1.25	0.0031	0.0226	0.01
Error	48	0.0008	1.88	0.0185	0.0249	0.14

*,**Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE V

MEANS OF THE FIVE FIBER CHARACTERS IN 10-INCH ROWS OF WESTBURN 70 AT PERKINS, OKLAHOMA, OVER 1972 AND 1973

Plant Spacings Within Rows (inches)	2.5 °/. Span Length	Uniformity Index	Fiber Fineness	1/8" Gauge Stelometer	0" Gauge Stelometer
4	1.044	44.3	4.4	1.89	3.79
6	1.091	45.2	4.3	1.88	3.82
8	1.075	45.2	4.1	1.95	3.88
10	1.074	45.4	4.4	1.93	3.87
12	1.078	45.5	4.2	1.96	3.89
14	1.087	45.2	4.3	1.88	3.91
16	1.084	46.2	4.3	1.96	3.84
18	1.093	45.0	4.0	1.94	3.83
20	1.081	45.7	4.1	1.91	3.75

*LSD's were not calculated for these characters since their spacing mean squares were not significant at the 0.05 probability level.

CHAPTER V

SUMMARY AND CONCLUSIONS

Plant spacings had a statistically significant influence on lint yield, lint percent, plant height, and height of the first fruiting branch. However, none of these traits exhibited significant plant spacings x year interaction. Plant spacings of 14, 16, 18, and 20 inches in 10-inch rows with populations ranging from 31,400 to 44,800 plants per acre exhibited the optimum production of lint. Closer plant spacings gave higher lint percent and higher first fruiting branches with shorter plants. Plant spacings in this study did not have significant effect on the fiber properties of length, uniformity, strength, or fineness. No significant interactions of plant spacing x years were noted for the fiber properties.

Suggestions for further study include planting as early as possible so that harvest time will not be unduly delayed by wet weather and plant spacing from 14 to 20 inches or more apart for maximum yield production. The number of damaged bolls compared to normal bolls should be of possible interest as well.

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