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# Cotton Planting Rate Studies on the High Plains

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## Summary

Cotton spacing and plant population have been studied extensively but mechanical stripper harvesting has created a need for additional information.

The purpose of this work was to find the effect of plant population on factors that might affect the performance of the mechanical stripper. Five planting rates ranging from 8 to 45 pounds per acre were tested at the Lubbock station during 1951-56.

The following effects of planting rate were found:

1. Emergence varied inversely with planting rate.
2. Lint yield differences for planting rates up to 25 pounds per acre were not significant.
3. Boll size decreased as the plant population increased.
4. Weed population was suppressed in the higher planting rates.
5. Harvest loss, amount of stems gathered by the stripper, and machine stoppages caused by large plants were less in the heavier rates of planting.
6. Plant characteristics of the higher populations were modified by increasing the height of the first branch and decreasing the plant height, the length and number of branches and the main stem diameter.
7. Total main stem weight increased, while branch weight decreased as the plant population was increased.
8. Plant population effects on the fiber characteristics were slight.

Planting rates of about 20 pounds per acre should give high stripper-harvesting efficiency, good yields and a minimum probability of having to replant.


## Definition of Terms

**Branches** includes all lateral branches, both vegetative and fruiting. Short insignificant branches, without bolls, were not included.

**Main stem** is the central axis of the plant, not including any of the lateral branches. The plant was cut off at ground level.

**Earliness** is given as the percentage of bolls open on or about October 1.

**Upper-half mean (UHM)** is the average length of the longest half of the fiber by weight and corresponds very closely to staple length as determined by the cotton classer.

**Fiber Uniformity** is a measure of fiber length distribution and is secured by dividing the mean fiber length by the upper-half-mean and expressing the result in percent. Above 80 is considered uniform in fiber length, 76 to 80 average, 71 to 75 slightly irregular and 70 or below irregular.

**Fiber tensile strength (PSI)** is the force in 1,000 pounds required to separate the equivalent of a surface area of 1 square inch. Ninety or above is considered excellent, 83 to 89, very good; 78 to 82, average; 72 to 77, fair; and below 72, weak.

**Fiber fineness (Micronaire)** is the relative weight of the fiber expressed in micrograms per inch of fiber length. From 1.8 to 2.9 micrograms per inch is considered extra fine; 3.0 to 3.9, fine; 4.0 to 4.9, average; 5.0 to 5.9 coarse; and above 6.0, very coarse.

**Fiber maturity** represents the percentage of thick-walled fibers. Eighty-four or above is considered very mature; 77 to 84, mature; 68 to 76, average; 60 to 67, immature; and 60 or below, very immature.

**Light reflectance** is a measure of color and trash in the fiber. Range is from 0 to 100 with the higher value being the brightest; readings of 60 to 90 will be bright.

# Cotton Planting Rate Studies on the High Plains

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COTTON SPACING AND PLANT POPULATION have been studied extensively. Lane (4), Peebles, *et al*, (5) and Ray (7) have reviewed the subject adequately. In early investigations only yield was studied, while many of the more recent experiments have related plant population to efficiency of machine harvest, Porterfield, *et al*, (6), Colwick, *et al* (1) and Tavernetti and Ewing (9). It has been found that close spacing makes the plants more suitable for machine harvest by decreasing the overall plant height and plant spread, increasing the height to the first branch and decreasing the diameter of the base of the stalk.

Mechanical-spindle pickers have not been used generally on the High Plains, but the use of the machine stripper is widespread on both dryland and irrigated farms. Planting to a stand is standard practice in the area, that, is, cotton is seldom chopped or thinned. However, the low rates often recommended for planting to a stand in other areas are seldom used; often 1 bushel or more of seed per acre is planted. In these experiments the planting rates were varied to establish the various population levels, while in most of the previous investigations thinning was used to obtain the desired plant spacings.

The purpose of this study was to determine the influence of planting rate on the plant population and the effect of the resulting population on plant characteristics that affect the performance of the mechanical stripper. Stripper efficiency was measured in terms of losses, stoppages, the quality of the machined cotton and the speed at which the stripper could be operated.

## Experimental Procedure

The study was made over a 6-year period, 1951-56, under irrigation at Substation No. 8, Lubbock, Texas, on Amarillo fine sandy loam soil. Data on rainfall and first frost date are given in Table 1.

### *Treatments*

Planting rates were used to control the plant population (treatment); the different populations were not achieved by thinning as in most previous investigations. The treatment designations (45, 35, 25, 15 and 8) shown in Table 2 will be used to identify the different levels of population.

The number of seed per pound was carefully determined by counting ten 25 gram lots each year. The number of seed varied from 4,150 to 5,600 per pound, Table 3.

### *Test Design*

A 5 x 5 Latin square design was used. Each plot consisted of 6 rows 110 feet long. Row width was 40 inches. Ten feet of the row (5 feet at each end) were used as guards. Significant differences between treatments were determined by the "F" test obtained from the analysis of variance.

### *Variety*

The varieties used were Stormmaster in 1951, 1952 and 1953; CA 119 in 1954 and 1955 and Blightmaster in 1956. These are stormproof varieties developed at the Lubbock station.

### *Cultural Practices*

This was a field experiment in which the best known practices for cotton production under irri-

## Contents



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TABLE 1. RAINFALL AND FIRST FROST DATE AT THE LUBBOCK STATION, 1951-56

| Year | Inches of rainfall | | | | | | | Date of first killing frost |
|---|---|---|---|---|---|---|---|---|
| | May | June | July | August | September | October | Annual total | |
| 1951 | 2.61 | 1.91 | 1.92 | 3.93 | .50 | .64 | 13.73 | November 4 |
| 1952 | 1.73 | 1.76 | 3.31 | 1.17 | .90 | 0.0 | 14.53 | October 7 |
| 1953 | .85 | .45 | 1.07 | 2.21 | .08 | 4.02 | 10.69 | November 8 |
| 1954 | 5.33 | .39 | .36 | 1.68 | T | 3.08 | 13.67 | November 2 |
| 1955 | 2.13 | 1.10 | 3.97 | .85 | 2.38 | 4.46 | 15.39 | October 30 |
| 1956 | 2.00 | 2.56 | 1.30 | .53 | .03 | 1.14 | 9.50 | November 5 |

gation on the High Plains were used. The land was bedded and furrow-irrigated before planting. An additional post-planting irrigation was applied about the time the cotton began to bloom. Eight to 10 acre-inches of water were applied before planting and 4 to 5 acre-inches at time of bloom. The crop was machine harvested with a single roll-type stripper harvester.

### *Disease and Insect Conditions*

Bacterial blight was prevalent throughout the season each year. Less blight occurred in 1956 when Blightmaster (a resistant variety) was seeded in the test.

Insect damage was light; however, it was necessary to control bollworms with an application of dust in 1951 and 1956. The plots also were sprayed for thrip in 1954.

### *Sampling and Measurements*

*Lint yield.* One hundred feet of the two center rows from each plot were harvested with the stripper harvester. A 20-pound sample from each plot was ginned on a Continental huller breast brush type gin and a Mitchell cleaner extractor. A classer's estimate of grade and staple length was obtained for every plot. Lint yields represented harvested cotton only.

*Stripper loss.* Preharvest losses are included in the stripper loss figures. The losses before harvest were negligible with all stormproof varieties. The stripper losses are given as percent of total yield. Calculations were on a seed cotton basis.

*Stems in the stripped cotton.* A 5-pound sample of stripped cotton was taken from each plot and the stems were separated by hand and weighed.

*Plant populations counts.* Emergence counts were made on 200 feet of row approximately 2 weeks after the first seedlings emerged. Final plant population counts were made on the same section of row after harvest.

*Plant characters.* Twenty random plants were taken from rows adjacent to the center rows and the following data were obtained.

1. Number of bolls per plant, divided into mature and immature (bollie) classes.
2. Height of the first branch, measured in inches, from ground level to the center of the node at the first branch.
3. The number of branches per plant.
4. The number of branches over 8 inches long.
5. Length, in inches, of the longest branch.
6. Diameter, in inches, of the largest branch, measured at the first internode to the nearest 0.1 of an inch.
7. The height, in inches, of the main stem.
8. The diameter, in inches, of the main stem at ground level.

*Weight of plant and component parts.* Air-dry weights were obtained for the following aboveground component parts of 20 plants from each plot: main stems, branches, seed cotton and burs.

*Moisture use.* Bouyoucos moisture blocks were placed at 12 and 18-inch depths in high and low plant populations to obtain moisture use.

TABLE 2. PLANTING RATES USED IN COTTON PLANT POPULATION STUDY, 1951-56

| Treatment designation | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|---|
| | Planting rate, pounds per acre | | | | | |
| 45 | 45 | 39 | 45 | 42 | 45 | 45 |
| 35 | 34 | 30 | 35 | 35 | 35 | 35 |
| 25 | 26 | 20 | 25 | 25 | 25 | 25 |
| 15 | 14 | 14 | 15 | 15 | 15 | 15 |
| 8 | 8 | 8 | 8 | 8 | 8 | 8 |

## Results and Discussion

### *Relationship of Planting Rate to Emergence*

A higher percentage of seed emergence and better stand survival were obtained with the lower planting rates with significant treatment differences in 5 out of the 6 years, Table 4. Seedling disease was probably the main contributing factor to a lower percentage of seed emergence and also to the greater loss of plants during the growing season with the higher seeding rates. Crusting-over, caused by heavy rains immediately following planting, did not occur in any of these tests. Ray, *et al* (8) showed that higher planting rates gave a greater percent emergence under crusting conditions.

A relatively wide variation in emergence existed among years. Thus, planting rate should be slightly higher than just sufficient to obtain the optimum stand for the average year. This will give some insurance against having to replant in the years when very poor emergence occurs.

TABLE 3. SUMMARY OF CULTURAL PRACTICES IN COTTON PLANTING RATE STUDY, 1951-56

| Item | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|---|
| Planting date | 5/22 | 5/28 | 5/23 | 5/31 | 5/23 | 5/18 |
| Laboratory germination of seed | 66% | 81% | 83% | | | |
| Number seed per pound | 4,400 | 4,550 | 5,600 | 4,600 | 4,600 | 4,150 |
| Type of seed | Machine delinted | Machine delinted | Chemically delinted | Chemically delinted | Chemically delinted | Chemically delinted |
| Variety | Storm-master | Storm-master | Storm-master | CA 119 | CA 119 | Blight-master |
| Irrigations | 4/30<br>8/1 | 4/15<br>8/12 | 4/16<br>7/23 | 4/15<br>8/2 | 2/23<br>8/11 | 3/26<br>7/30 |
| Harvest date | 11/23 | 11/11 | 11/20 | 11/29 | 11/22 | 11/15 |

### *Yield*

Numerous investigations have pointed out that the cotton plant adapts readily to a fairly wide range in plant population. Although maximum yield occurred with the 15 pounds per acre seeding rate, little difference exists among the three lowest rates, Table 4. This represents a planting range of from 8 to 25 pounds per acre. Figure 1 shows the relationship between lint yield and planting rate; Figure 2 shows the relationship of yield to plant population. Recommendations should be slightly higher than the optimum to assure the farmer of a fairly regular stand even in those years when emergence is extremely low. In such years skippy stands resulting from low planting rates could severely reduce yields. The very high planting rates also adversely affect yields.

### *Lint Percent*

Lint percent or gin turnout was obtained for both seed cotton and stripped cotton. The average of all tests gave less than 1 percent difference in lint percent of stripped cotton for the treatment extremes, Table 4. In 2 of the 5 years there was a significant difference in lint percent, the higher populations having slightly lower turnouts. This may be associated with the smaller boll and finer fiber found with close spacing in this and other experiments in cotton spacing.

### *Boll Size*

Boll size decreased as the plant population increased, Table 4. In the low seeding rate, treatment 8, with a plant population of 18,100 plants per acre, only 73 bolls were required to make one pound of seed cotton. In the high seeding rate, treatment 45 with a plant population of 77,400, 85 bolls were required per pound of seed cotton.

### *Earliness*

No consistent effect on earliness was found, Table 4. In 1951 the thicker plants were significantly earlier, while in 1955 the thinner plantings were significantly earlier. In other years the differences were not significant.

The variable reaction of earliness to the plant population level is not altogether surprising. As the plants are spaced closer together, two effects on the earliness of the cotton plant might be noticed. First, the formation of the first squares may be delayed and the first fruit occurs at a higher node on the plant. Second, close spacing affords the young plants more fruiting points on an area basis, providing for a more rapid set of bolls. The spacing effect on earliness depends on the timing of favorable or unfavorable en-

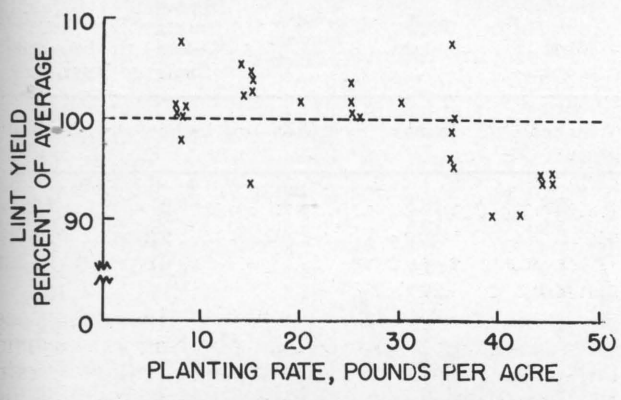


Figure 1. Scatter diagram of acre lint yield plotted as percent of mean yield against the planting rate. Data from cotton planting rate studies, 1951-56.

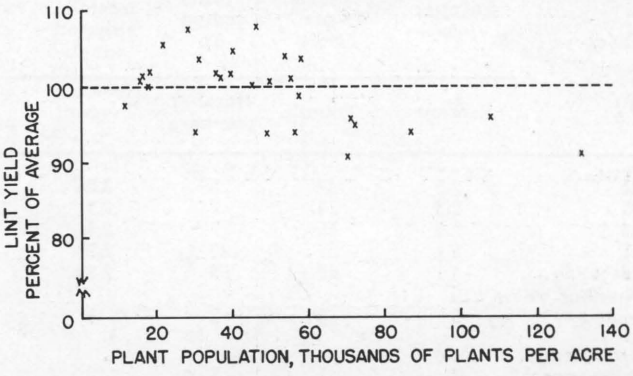


Figure 2. Scatter diagram of acre lint yield plotted as percent of mean yield against the plant population. Data from cotton planting rate studies, 1951-56.

TABLE 4. SUMMARY OF RESULTS COTTON RATE PLANTING TEST, LUBBOCK, 1951-56

| Treatment | Plants per acre | Average spacing between plants | Final stand for seed planted | Yield of lint | Lint from stripped cotton | Bolls to make pound seed cotton | Earliness[1] | Staple length | Weeds per square yard |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Inches | Percent | Pounds per acre | Percent | Number | Percent | 32nd of inch | Number |
| 45 | 77,400 | 2.0 | 38.0 | 595 | 23.6 | 85 | 51 | 29.2 | 0.09 |
| 35 | 64,600 | 2.9 | 40.0 | 636 | 24.2 | 83 | 53 | 29.4 | 0.26 |
| 25 | 50,000 | 3.1 | 44.0 | 648 | 24.4 | 80 | 55 | 29.5 | 1.37 |
| 15 | 33,500 | 4.7 | 48.0 | 658 | 24.5 | 78 | 55 | 29.4 | 1.80 |
| 8 | 18,100 | 8.7 | 49.0 | 653 | 24.4 | 73 | 54 | 29.7 | 1.54 |
| Number years tested | | | 6 | 6 | 5 | 5 | 5 | 5 | 1 |
| Significant differences[2] | | | 5 | 1 | 2 | 4 | 2 | 0 | 1 |

[1]Open bolls as a percent of total bolls on October 1.
[2]Number years in which treatment differences were significant at the 5 percent level.

vironmental conditions with the stage of growth of the cotton plant.

### *Weed Population*

In most years weeds did not present a problem in any planting rate. In the only year for which any data were obtained, 1951, the weed population was definitely suppressed in the higher planting rates, treatments 45 and 35, Table 3. A thick uniform stand tends to prevent weed growth in the row through shading and competition.

### *Influence on Stripper Efficiency*

*Losses.* The highest machine stripper efficiency was obtained each year in the heavier plant populations and high planting rates. The machine losses varied from 2.6 percent for the heaviest rate of planting to 4.2 percent for the light rate. The difference was significant in 4 out of 5 years of this test, Table 5.

*Stems in harvested cotton.* The amount of stems and limbs in the stripped cotton was measured in each of 3 years. The low seeding rate treatment averaged 22 pounds more stems per bale of harvested cotton than the high seeding rate, Table 4. Stems are difficult to remove from the seed cotton at the gin and can result in "barky cotton," a serious grade reduction.

*Stoppages.* The entrance or throat of most mechanical strippers is narrow, ranging from one-half to three-fourth inches, which may cause pulling up of large plants and result in choking of the harvester. As many as 50 plants per acre were pulled up in the low planting rate while no stoppages occurred in the heaviest rate of planting.

### *Plant Characteristics*

Plant population had the following effects on the height of first branch, plant height, number and length of branches and main stem diameter, Table 5.

TABLE 5. EFFECT OF PLANT SPACING ON STRIPPER EFFICIENCY AND PLANT CHARACTERS ASSOCIATED WITH STRIPPER EFFICIENCY

| Treatment | Stripper loss | Stems per bale | Plants pulled up | Fine trash in stripped cotton | Plants with split lower limbs | Height to first branch | Plant height | Length longest branch | Diameter main stem base | Significant branches per stalk |
|---|---|---|---|---|---|---|---|---|---|---|
| | Percent | Pounds | Number per acre | Percent | Number per acre | Inches | Inches | Inches | Inches | Number |
| 45 | 2.3 | 47 | 0 | 3.3 | 26 | 6.6 | 18.5 | 4.4 | 0.26 | 7.5 |
| 35 | 2.8 | 54 | 7 | 2.7 | 26 | 5.8 | 19.5 | 5.0 | 0.27 | 8.1 |
| 25 | 2.9 | 55 | 7 | 2.6 | 78 | 5.9 | 20.4 | 5.8 | 0.29 | 9.5 |
| 15 | 3.1 | 57 | 20 | 2.7 | 170 | 5.0 | 22.2 | 8.1 | 0.32 | 11.5 |
| 8 | 4.1 | 69 | 59 | 2.5 | 222 | 4.0 | 26.2 | 12.2 | 0.39 | 13.8 |
| Number years tested | 5 | 3 | 2 | 1 | 1 | 4 | 4 | 4 | 4 | 2 |
| Significant differences[1] | 4 | 1 | 1 | 0 | 1 | 3 | 4 | 4 | 4 | 2 |

[1]Number years in which treatment differences were significant at the 5 percent level.

(1) The first branch averaged 2.6 inches higher from the ground in the high plant populations. This was one of the factors that contributed to lower harvester losses with high plant populations, Figure 3.

(2) The total plant height was reduced by heavy rates of planting. This reduction was highly significant every year of the test.

(3) More and longer branches were found in the lower plant populations.

(4) The diameter of the main stem at the ground level was significantly smaller, in every test, in the higher planting rates.

### *Weight of Plant Parts*

The weights (air-dry weight) of main stems, branches, burs and bollies and seed cotton were affected by plant populations as follows:

(1) Weight per acre of the main stems was greater in the higher plant populations.

(2) Branch weight per acre was less in the higher plant populations. The total weight per acre of main stems and branches balanced out with the lower rates having a high branch weight and a higher main stem weight in the thicker planting, Figure 4.

(3) There was no significant difference in the total weight per acre of burs and bollies produced in any of the rates of planting.

(4) The total weight per acre of seed cotton produced with the heavier plant populations was greater but not significantly different from the other treatments. As the seed cotton weight here was based on 20 plants per plot there was more variability than for yield determinations based on 200 feet of row.

### *Effect on Fiber Properties*

Grade and staple were not significantly different for the planting rates used.

Plant population had the following effects on the length, strength, fineness, color and maturity of fibers, Table 6.

(1) Fiber length was not affected by plant population in this study.

(2) There was no significant difference in strength for any treatments.

(3) There was a trend toward lower micronaire in the higher planting rates; however, the difference was small for the plant populations studied. Other experiments have indicated that extremely high plant populations may result in a significant decrease in micronaire reading (finer fibers) Hudspeth (2).

(4) Color, as measured by light reflectance was not affected by plant population per acre in this study.

(5) Fiber maturity was not affected by spacing.

### *Water Use*

A complete log of soil moisture in the 8 and 45 pound seeding rates was kept, Figure 5. The high planting rate showed a slightly faster rate of water consumption, especially up to the second

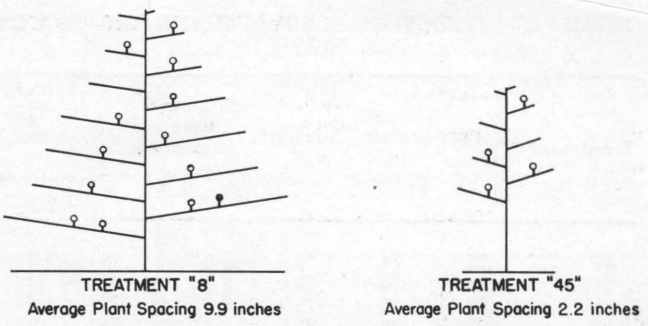


**Figure 3. Diagrammatic representation of typical plants from thick and thin stands in planting rate tests, 1951-53.**

week after blooming. After that there was very little difference and at the end of the fruiting period the moisture level was about the same in both treatments.

## Application to Farm Practices

Complete mechanization for any crop first requires planting to a stand without thinning. Although farmers in the High Plains area have followed this practice for a number of years, there is a wide variation in the planting rates used. Cotton adjusts itself, yieldwise, to a wide range of spacing, but stand will modify plant characters which in turn affect stripper efficiency.

Close spacing makes the plant more suitable for stripper harvest by decreasing the overall plant height and plant spread, increasing the height to the first limb and decreasing the diameter of the stalk at the base, Figure 3. Popu-

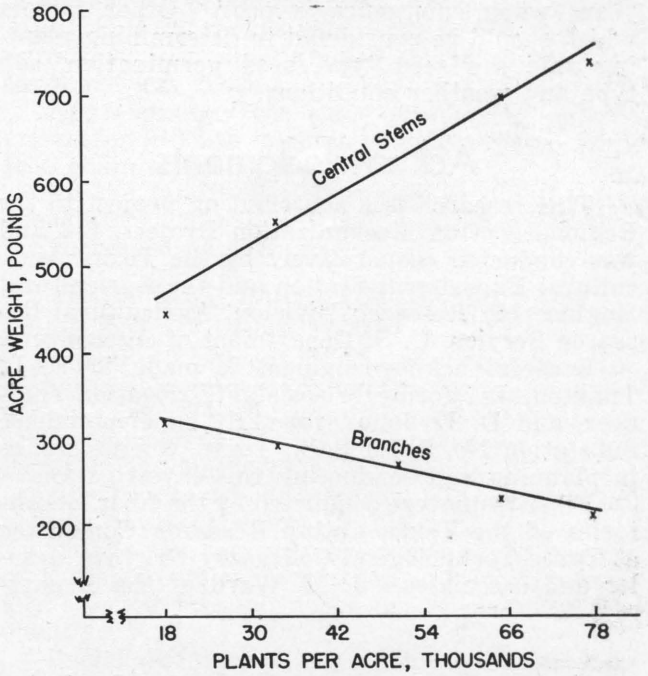


**Figure 4. Weight relationship of component plant parts as affected by population density. Data from cotton planting rate studies, 1951-54.**

TABLE 6. EFFECT OF PLANT SPACING ON COTTON FIBER PROPERTIES[1]

| Treatment | U H M, inches | Length uniformity, percent | Strength, P. S. I. | Micronaire, micrograms per inch | Light reflectance | Fiber maturity, percent |
|---|---|---|---|---|---|---|
| 45 | .95 | 74 | 75.6 | 3.5 | 66 | 77 |
| 35 | .94 | 74 | 76.5 | 3.5 | 64 | 76 |
| 25 | .93 | 75 | 76.7 | 3.6 | 71 | 77 |
| 15 | .93 | 75 | 75.8 | 3.7 | 65 | 79 |
| 8 | .95 | 74 | 75.9 | 3.6 | 65 | 78 |
| Number years tested | 5 | 5 | 5 | 5 | 3 | 3 |
| Significant differences[2] | 1 | 0 | 0 | 2 | 0 | 0 |

[1]Fiber properties explained in "Definition of Terms."
[2]Number of years in which treatment differences were significant at the 5 percent level.

lations of above 50,000 plants per acre do not significantly increase harvesting efficiency and may reduce yields. Conversely, plant populations below 20,000 plants per acre should be avoided because of harvesting loss and the possibility of lower yield if enough skips are present.

By breeding or by modification of cultural techinque it might be possible to raise the population level without lowering the yield. This would be desirable from the standpoint of stripper harvesting.

A planting rate of 15 pounds per acre will give a satisfactory plant population in most years but increasing this rate to about 20 pounds per acre will give insurance against replanting in years when emergence is poor. Other factors which should be considered in determining planting rate are seed type, seed germination, soil type and weather conditions.

## Acknowledgments

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Fiber tests were conducted by the fiber laboratories of the Texas Cotton Research Committee at Texas Technological College by Dr. Lyle Hessler and associates. J. M. Ward of the Department of Agricultural Economics and Sociology, Texas A&M College System, classed the fiber samples.

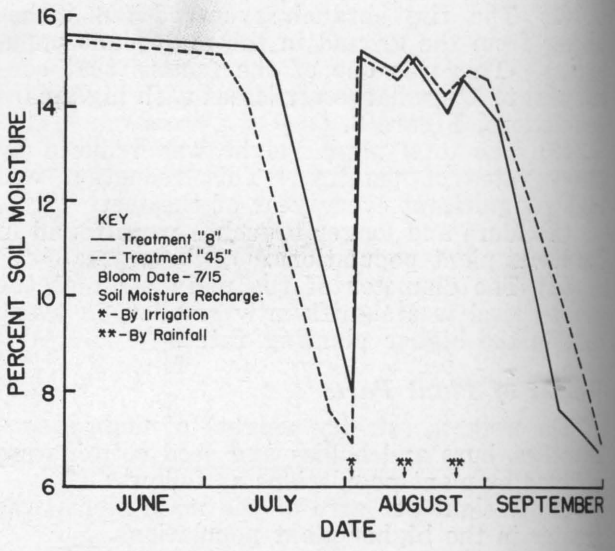


Figure 5. Soil moisture log for two plant populations in cotton planting rate test as determined by soil moisture blocks at 12-inch depth.

## References

1. Colwick, Rex F., *et al.* Planting in the mechanization of cotton production. Southern Cooperative Series Bulletin No. 49. 1957.
2. Hudspeth, E. B. Unpublished data. 1956.
3. Jones, D. L., *et al.* Cotton production on the Texas High Plains. Texas Agr. Exp. Sta. Bul. 830. 1956.
4. Lane, H. C. Cotton spacing—A review and discussion. Texas Agr. Exp. Sta. Misc. Pub. 170. 1956.
5. Peebles, R. H., Den Hartog, G. T. and Pressely, E. H. Effect of spacing on some agronomic and fiber characteristics of irrigated cotton. USDA Tech. Bul. 1140. 1956.
6. Porterfield, Jay G., Batchelder, O. G. and Taylor, W. E. Plant population for stripper harvested cotton. Oklahoma Agr. Exp. Sta. Bul. B-514. 1958.
7. Ray, L. L. The effect of cotton plant population on certain characteristics associated with stripper efficiency. M. S. Thesis, Texas Technological College. 1952.
8. Ray, L. L., Hudspeth, E. B. and Jones, D. L. Influence of planting rate on seedling emergence of cotton under crusting conditions. Texas Agr. Exp. Sta. Progress Report 1415. 1951.
9. Tavernetti, J. R. and Ewing, B. B. Cotton mechanization studies in California. Agr. Engin. 32: 489-492. 1951.