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# COTTON SPACING--A REVIEW AND DISCUSSION

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## SUMMARY

Cotton spacing or plant population has received extensive investigation in the general belief that it has considerable influence on yields. Such a premise is not borne out by the results of experiments conducted over the cotton belt during the past 40 years.

Although this publication discusses the optimum and the minimum stands for maximum yields, plant populations less than the minimum can produce a good crop of cotton.

Some of the replanting done after June 1 on the High Plains because stands have been reduced by sand-burn, hail or other causes are not justified on a yield basis nor in terms of fiber quality.

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## Introduction

Cotton plants grow and develop in proportion to the space about them. When cotton plants spaced some distance apart in the row fail to produce as much or more lint per acre than when the stand is thick, something in the complex of variables affecting the crop is amiss. The factor responsible may be declining soil fertility, excessively dry or hot weather, or a disease such as cotton root rot or verticillium wilt.

This publication reviews a number of spacing studies and furnishes a mathematical description of the relationship among thickness of stand, bolls per foot of row and yield.

Spacing has been studied from a number of different points of view. Spacing influences earliness in the opening of bolls. In the warmer parts of the cotton belt, thick stands seem to promote earliness. The size of bolls was affected in some of the experiments. Usually the boll size increases slightly as the space between plants increases from 3 to 12 inches.

Close spacing reduces both the number of vegetative limbs on the plants and the number of bolls per fruiting limb, and raises node-wise the position of the first square. It decreases the individual measurements of a single plant but increases the dry weight per acre of the parts of the plants above ground.

## Review and Analysis

Table 1, which should be analyzed by sections of the cotton belt, summarizes the results of a number of spacing studies conducted over the cotton belt between 1915 and 1955. The highest yielding population in any test or average of years testing is recorded as 100, and the lower yielding populations as a percentage of 100.

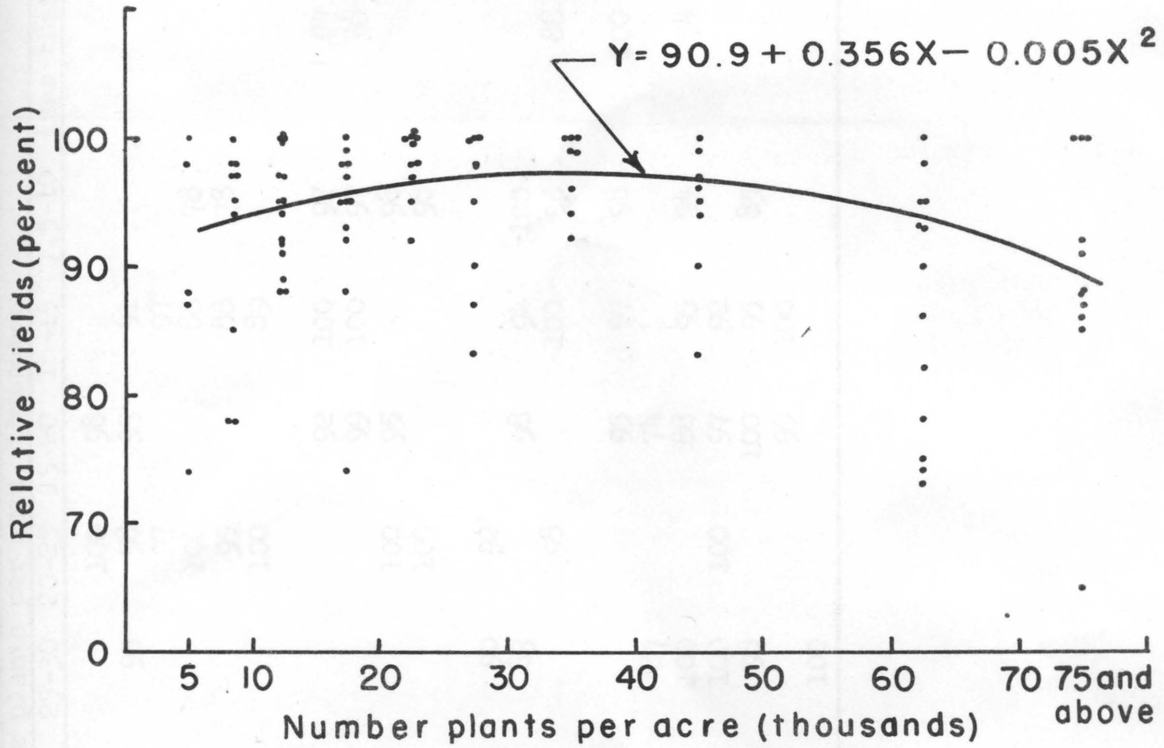


Figure 1. Least squares equation through points recorded in Table 1.

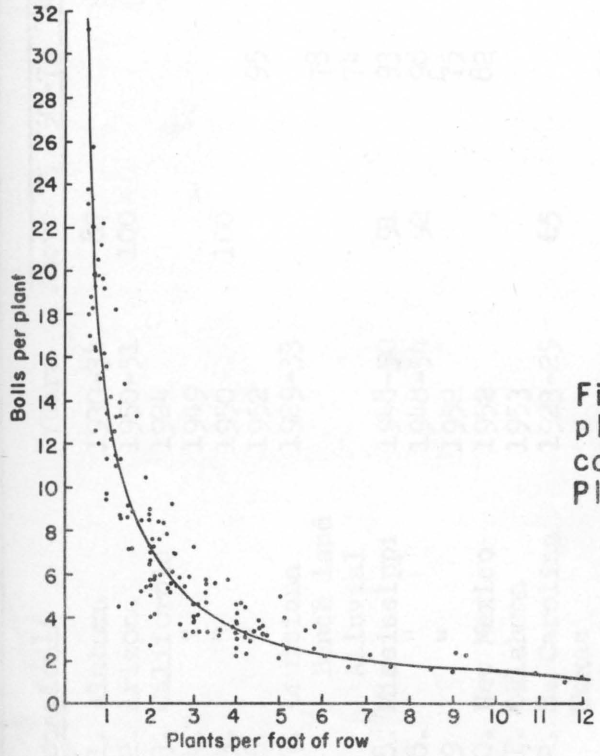


Figure 2. Relation between bolls per plant and stands. Data are based on counts in cotton on the Texas High Plains.

Table 1. Yields in relation to cotton plant populations

| Location[1/] | Years | Number plants per acre, thousands: Above 75 | 50-75 | 40-50 | 30-40 | 25-30 | 20-25 | 15-20 | 10-15 | 7.5-10 | Less than 7.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Alabama | 1930-34 | 87 | | 90 | 94 | | 100 | 98 | | | |
| 2. Arizona | 1950-51 | 100 | | 99 | | 95 | 98 | 93 | 91 | | |
| 3. California | 1924 | | | 100 | | | 97 | | 97 | | |
| 4. " | 1949 | | | | 96 | | 100 | | 88 | 78 | |
| 5. " | 1950 | 100 | | | 92 | | 95 | | 88 | 78 | |
| 6. " | 1952 | | 95 | | 100 | | 100 | | 89 | | |
| 7. Louisiana | 1929-33 | | | | | | | | | | |
| Bench land | | | 78 | | | | | 92 | 100 | 97 | 87 |
| Alluvial | | | 74 | | | | | 99 | 100 | 97 | 98 |
| 8. Mississippi | 1948-50 | 91 | 93 | 96 | 99 | | 100 | 95 | | 98 | |
| 8. " | 1948-54 | 92 | 98 | 97 | | | 100 | | | 98 | |
| 9 " | 1952 | | 75 | 95 | 100 | | | | | | |
| 10. New Mexico | 1952 | | 82 | | 100 | 90 | 92 | | | | |
| 11. Oklahoma | 1953 | | | | | 83 | | 98 | 94 | 100 | |
| 12. S. Carolina | 1923-25 | 65 | | 83 | | | 98 | | 100 | 95 | 88 |
| Texas | | | | | | | | | | | |
| 13. Temple | 1915-21 | | 86 | | | | | 95 | 97 | 98 | 100 |
| 14. " | 1951 | 100 | 100 | | | 87 | | 74 | | | |
| 15. Lubbock | 1913-24 | | 73 | | | 100 | | 88 | 95 | 94 | 74 |
| 16. " | 1951-54 | 88 | 95 | 94 | 99 | 100 | 100 | 97 | 92 | | |
| 17. " | 1953-55 | | 90 | | | 98 | | 100 | 95 | 85 | |
| 18. Brazos Valley | 1952 | 85 | | | | | | 95 | 100 | | |
| 19. " " | 1955 | 86 | 94 | | | 100 | | | | | |

1/ Reference numbers for bibliography.

Figure 1 shows the curve fitted to these data by the method of least squares. The equation of the curve can be used to approximate yields when plant populations vary from 10,000 to 75,000 per acre. The curve does not show fully the variability in yields at the extremely low and high populations.

Thick stands have been better in most years in the western part of the cotton belt (California, Arizona, New Mexico and far West Texas). A desirable stand for this section seems to be 30,000 to 40,000 plants per acre. In the cooler years, the vetetative-fruiting balance of cotton has moved toward vegetative growth. Very thick cotton made excessive vegetative growth, which was accompanied by lodging, boll rotting and poorer grades. Researchers recommend a conservative spacing of 6 to 8 inches per plant for this section since this spacing seems to offset to some degree the effect of cool weather on fruiting (20). Excellent yields have been made in this section with spacing at 15 inches (21). Table 1 indicates little difference in yield when stands vary from 15,000 to 75,000 plants per acre.

In the southeastern section of the cotton belt (South Carolina, Georgia, Alabama, Mississippi, Louisiana and Arkansas), stands may vary from 15,000 to 60,000 plants per acre without an appreciable influence on yield. Thick stands seem to give better yields on poorer soils. The optimum stand for this section seems to be about 25,000 plants per acre, an increase from the 15,000 plants formerly recommended.

Thin stands have been better in Oklahoma. Yields have been increased by thinning plants to 15 to 20 inches apart in the row.

The optimum stand for the Texas Blacklands has changed more since these tests were started than for any other area. From 1915 through 1921, the optimum stand at Temple was less than 7,500 plants per acre. In recent years, it has been 75,000 plants per acre. This population is not recommended for all parts of the Blacklands, but seems to be best for areas infested with cotton root rot. At Denton in 1955, Lankart 57 had the highest yield at the lowest population in the test, but Stormproof 1 produced the best yield at the highest stand (19).

In East and South Texas, stands of 15,000 to 60,000 plants per acre produce about the same yield. An optimum stand is 2 to 3 plants per foot of row, or 26,000 to 40,000 plants per acre.

On the Texas High Plains, stands can vary from 10,000 to 50,000 plants per acre, on both dry and irrigated farms, without influencing yields greatly. Farmers in this area have always planted cotton at somewhat heavy rates and have not practiced thinning. Figure 2 shows the relation between bolls per plant and plants per foot of row on the High Plains. These data include counts from experiments at the Lubbock station and a similar number of counts taken at random in cotton growing over the entire area.

## Discussion

There is a tendency on the High Plains to plant cotton too thick. This, combined with the fact that planting rate recommendations are increased ever so often, eventually may be harmful in terms of cotton quality. Early summer temperatures at Lubbock in some years are too low to favor fruiting. The effect of low temperature adds to the effect of close spacing in delaying the appearance of the first square, and the combination often produces a decided delay in fruiting. The past 3 seasons (1953-55) show that a spacing of 4 to 8 inches tends to offset the effect of low temperature on fruiting.

The most immature cotton produced in the area was grown where stands were extremely thick and crowded. Table 1 shows that 20,000 to 30,000 plants per acre consistently outyielded higher populations.

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APPENDIX

The number of feet of row in an acre depends on the row width. Rows 36 to 42 inches apart are used. To find the number of feet of row in an acre, divide 43,560 by the row width in feet. Since the 40-inch row is standard, 43,560 ÷ 3 1/3 = 13,068 feet of row in an acre. The relationship between spacing and the number of plants per foot of row and per acre in a field having 40-inch rows is shown following:

| Spacing, inches | Number plants per foot of row | Number plants per acre |
|---|---|---|
| 1 | 12 | 156816 |
| 2 | 6 | 78408 |
| 3 | 4 | 52272 |
| 4 | 3 | 39204 |
| 6 | 2 | 26136 |
| 9 | 1 1/3 | 17424 |
| 12 | 1 | 13068 |
| 15 | 4/5 | 10454 |
| 18 | 2/3 | 8712 |
| 20 | 3/5 | 7840 |
| 24 | 1/2 | 6534 |

If the highest average yield for each spacing interval in Table 1 is designated as 100 percent, and the lower yields proportionately, the following agreement is found between the formula in Figure 1 and these averages:

| Plant population (thousands) | From the table | By formula |
|---|---|---|
| 75 & above | 91 | 89 |
| 62.5 | 89 | 93.5 |
| 45 | 96 | 96.5 |
| 35 | 99 | 97 |
| 27.5 | 96 | 97 |
| 22.5 | 100 | 96.5 |
| 17.5 | 95 | 95.5 |
| 12.5 | 96 | 94.5 |
| 8.75 | 94 | 93.5 |
| 7.5 & less | 91 | 93 |

Figure 2 shows that the average stand on the High Plains is 2 to 4 plants per foot of row. The freehand curve drawn through the points has the form of an equilateral hyperbola. The goodness of fit was determined from the "read-off" deviations. The standard error of estimate ($S_{yx}$) from "read-off" deviations has basically the same meaning as a calculated one, and in a sample this size, one $S_{yx}$ plus and minus should include two-thirds of the sample points. $S_{yx}$ for the curve is slightly more than one boll per plant. The coefficient of curvilinear correlation (Rho) for Figure 2 is 0.99. An equilateral hyperbola has the equation of $XY = \text{constant}$. In other words, Figure 2 indicates that over the range of 0.6 of a plant to 12 plants per foot of row (spacing of 20 inches to 1 inch), the number of bolls per foot of row is a constant. The equation of a straight line calculated from the number of bolls per foot of row plotted against plants per foot for these same counts is $Y = 14.27 + 0.07X$. Thus the trend toward more bolls per acre as the number of plants increases is very weak.