SOIL TEMPERATURE

A Guide to Timely Cotton Planting

THE AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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in Cooperation with the
UNITED STATES DEPARTMENT OF AGRICULTURE
Summary

A uniform stand of cotton with desirable spacing between plants is imperative for mechanizing cotton production. Since such a stand requires precise planting operations, both equipment improvements and planting practices are important. The relatively short growing season on the Texas High Plains emphasizes the need of obtaining a satisfactory stand at the first planting.

Soil temperature is a valuable guide in planting cotton. Good cotton stands more likely will be obtained when the minimum soil temperature at an 8-inch depth averages 60° F. or above for the 10 days preceding planting.

Soil temperatures were observed with cotton plantings during a 7-year period, 1952-58, to determine their value as a guide in finding the optimum time to plant cotton at Substation No. 8, Lubbock, Texas. The data obtained support the following conclusions:

1. Minimum soil temperatures at an 8-inch depth for the 10-day period before planting were useful as a planting guide.

2. Cotton seedlings emerged in 5 to 9 days when the preplanting soil temperatures at 8-inch depths averaged 60° F. or above for 10 days. It took as many as 15 days for the seedlings to emerge when the average soil temperature was below 55° F.

3. The total percentage of seedling emergence was highest when the average minimum soil temperature was in the 60 to 70° F. temperature range and decreased rapidly when temperatures were outside this range. Good stands can be expected with two out of three plantings under these conditions, while in colder soils the odds are one out of five.

4. Using soil temperatures, rather than the currently recommended dates as a planting guide, resulted in earlier plantings when favorable growing conditions prevail and in later plantings when unfavorable conditions exist. Planting on the basis of soil temperature did not reduce yields in this study.

5. The 7-year average date when minimum soil temperatures at the 8-inch depth averaged 60° F. for the previous 10 days was May 3. The earliest date was April 23 and the latest was May 16.

6. The highest average lint yields were obtained in 5 of the 6 years of study by planting on or after the date the soil temperature reached the recommended average of 60° F.

7. Fiber characteristics were not affected adversely by delaying plantings until the soil reached the recommended 60° F.

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COTTON SHOULD BE PLANTED at the earliest feasible date in areas with relatively short growing seasons such as the Texas High Plains. The mean frost free period at Lubbock is 205 days (1) and the mean summer temperatures are 67.7, 76.2, 79.1, 78.1 and 71.3 for May, June, July, August and September, respectively (6). A minimum of about 200 frost free days with a mean summer temperature of 77°F. is necessary for satisfactory cotton production (2). Thus, in the High Plains area, cotton should be planted at the earliest date when the probability of obtaining a satisfactory stand is relatively high. The earliest date a stand can be obtained depends on seasonal conditions from year to year.

Temperature is a major factor in seed germination. Cottonseed germinates poorly at temperatures lower than 70°F., and the seedlings grow more slowly and less vigorously at these low temperatures than those which germinate at 70° to 85°F. (4). Thus, planting in cold soil not only results in a lower germination percentage but also in delayed emergence and weakened plants that are more susceptible to seedling diseases. Therefore, soil temperature may be considered as a guide to determine the earliest feasible planting date for cotton in a given season.

These investigations were initiated in 1952 at Substation No. 8, Lubbock, Texas to determine the relationship between soil temperature, seedling emergence and yield. Crop maturity and fiber property data also were obtained.

**Experimental Procedure**

**SOIL TEMPERATURE**

Soil temperatures were recorded from early April through May at 2, 4, 6 and 8-inch depths in 1952, 1953 and 1954 with a dial stem-type thermometer. From 1955-58 temperatures were obtained only at the 8-inch depth. The soil temperatures from 1953-58 also were obtained with a continuous recording thermometer.

**CULTURAL PRACTICES**

Cotton was planted at intervals of 7 to 10 days to obtain a range of soil temperatures.

The seedling rates, seed types and varieties used in the experiments are shown in Table 1. A shallow furrow planter was used for all plantings except in 1952 when the plots were hand planted and in 1958 when the plateau and the shallow furrow planters were used. Replicated plots were used in 1952-55 and large unreplicated plots, 6 to 8 rows wide, were used during the last 3 years.

The land was bedded, irrigated, and cultivated before it was planted. Recommended irrigation and cultural practices were followed during the growing season. Plots were harvested with a single roll machine stripper 3 to 4 weeks after frost.

**TABLE 1. VARIETIES, TYPE OF SEED, GERMINATION DATA AND SEEDING RATES USED FOR SOIL TEMPERATURE PLANTING STUDIES**

<table>
<thead>
<tr>
<th>Year</th>
<th>Variety</th>
<th>Type of seed</th>
<th>Laboratory germination percent</th>
<th>Seeding rate, pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952</td>
<td>Stormmaster</td>
<td>Fuzzy</td>
<td>84</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine delinted</td>
<td>77</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid delinted</td>
<td>73</td>
<td>39</td>
</tr>
<tr>
<td>1953</td>
<td>Stormmaster</td>
<td>Fuzzy</td>
<td>75</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine delinted</td>
<td>71</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid delinted</td>
<td>68</td>
<td>28</td>
</tr>
<tr>
<td>1954</td>
<td>CA 119*</td>
<td>Fuzzy</td>
<td>75</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine delinted</td>
<td>72</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid delinted</td>
<td>86</td>
<td>26</td>
</tr>
<tr>
<td>1955</td>
<td>CA 119</td>
<td>Fuzzy</td>
<td>64</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine delinted</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>1956</td>
<td>CA 119</td>
<td>Fuzzy</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>1957</td>
<td>CA 119</td>
<td>Fuzzy</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

*An experimental stormproof cotton strain developed by the Texas Agricultural Experiment Station, Substation No. 8, Lubbock, Texas.
SOIL TEMPERATURE

The fluctuation of soil temperature at the 2 and 8-inch depths for a typical clear day are shown in Figure 1. The daily variations of minimum soil temperatures at 2 and 8-inch depths are shown in Figure 2. Similar fluctuations are shown by Russel (5). Lower soil temperatures were noted after rains, clear nights or when the preceding day was cloudy. These data show that the soil temperature at the 2-inch depth fluctuated 30 degrees from the minimum to the maximum for any single day. However, this fluctuation was only one-third as much at the 8-inch depth with a higher minimum and lower maximum, Figure 1. The minimum temperature for the 8-inch depth usually occurred between 7 and 9 a.m. on clear days. The time for recording temperatures at the 8-inch depth was not as critical as it was at more shallow depths.

Since daily minimum temperatures at either depth are highly variable, more than 1 day's reading is necessary to provide a valid guide to determine the optimum time to plant cotton, Figure 2. A 10-day average for the 8-inch depth was selected as the best guide for planting cotton because the fluctuations were smaller and not as erratic as those for more shallow depths or shorter periods, Figure 3. The 10-day average of 60°F. minimum soil temperature at the 8-inch depth occurred on May 5, April 28, April 25, April 23, April 29, May 16, and May 10 in 1952-58, respectively. The mean date of occurrence was May 3.

EMERGENCE

The emergence of seedlings increased as the minimum pre-planting soil temperature rose to 66°F.; above this temperature data became more erratic and unreliable, Figure 4. The highest emergence percentage occurred when the average temperature at the 8-inch depth was between 60° and 70°F. for the 10 days before planting. The regression equation calculated for emergence on the average minimum soil temperature at the 8-inch depth for 10 days before planting was 

\[ E = 4.358 T - 0.07577T^2 - 0.001116T - 251.67 \]

where E is the percent of seed to emerge and T is the soil temperature. From this equation maximum emergence occurs when the 10-day average minimum temperature reaches 65° F. before planting. However, the regression curve is relatively flat within the 60° to 70°F. soil temperature range. The low multiple correlation coefficient, \( R^2 = 0.289 \), was expected because a number of other factors affecting germination and emergence could not be held constant in field tests. For example, seed quality varied from year to year and rains during the emergence period and subsequent diseases also increased the emergence variability. In 1954 the percentage of seed emergence varied widely between two plantings even though the 10-day average temperature before planting was approximately the same. On May 3, when 2.20 inches of rain fell during the emergence period, only 13 percent of the seed emerged. Sixty percent emergence was obtained from the May 27 planting when no rain fell during the emergence period.
Linear regression calculated for the emergence percentage as affected by preplanting 10-day average minimum soil temperature in the 50 to 65°F. range was \( E = 1.663T - 59.76 \) with a coefficient of correlation, \( r = 0.523 \), where \( E \) is the emergence percentage and \( T \) is the soil temperature. Linear regression shows that emergence increased 1.7 percent for each degree of rise in the preplanting 10-day average of minimum soil temperature up to 66°F. The linear regression line almost paralleled the curvilinear regression through this temperature range, Figure 4. The low coefficient of correlation resulted from the unmeasured variables described above.

An analysis of emergence percentage as affected by planting dates is shown in Figure 5. The calculated linear regression was \( E = 0.292P + 27.65 \) with \( r = 0.416 \), where \( E \) is the percentage of emergence and \( P \) is the planting date. The increase in emergence was approximately 1 percent for every 3.5 days that plantings were delayed. If a satisfactory stand is defined as 40 percent emergence of the seed planted, the odds of obtaining satisfactory stands are two successful plantings out of three, for the commonly recommended planting dates, May 10 to 30. Before May 10, the odds are only one successful planting out of three. A similar analysis by 10-day average soil temperatures at the 8-inch depth before planting shows that the odds for successful plantings are 2 out of 3 in the 60° to 70°F. range and 1 out of 5 in soils colder than 60°F.

The preplanting temperature was more reliable in predicting the number of days required to establish a stand than in predicting the seedling emergence. The lower the soil temperature the greater the number of days necessary for the seedlings to emerge, Figure 6. The emergence period was slightly less than 15 days when the 10-day average temperature was below 55°F. and was about 6 days when the temperature reached 70°F. The number of days required for seed emergence decreased beyond 70°F. as 10-day average minimum soil temperatures increased, although the relative amount of seeds which emerged as seedlings was erratic. When the preplanting average temperature reached 60°F., emergence occurred in less than 9 days. The regression equation for time of emergence on temperature is \( D = 52.0 - 0.5347T - 0.010,56T^2 - 9.000,13T^3 \) with \( R^2 = 0.627 \) where \( D \) is the number of days and \( T \) is the soil temperature.

Mean soil temperatures at the seed level during the emergence period were above 70°F. after a 10-day average minimum preplanting temperature of 60°F. was reached at the 8-inch depth, Figure 7. Linear regression indicates that the soil temperature surrounding the seed during emergence average approximately 1 degree lower for each degree decrease in the preplanting 10-day average minimum soil temperature at the 8-inch depth. Recent findings of Johnson et al (3) have shown that a higher emergence percentage and a shorter emergence period resulted when the temperature surrounding the seed was held at, or averaged 70°F., than when the temperatures were held at or averaged 65°F. and 60°F. A regional study (7) of the effect of soil temperature on cottonseed emergence and stands has shown that emergence increased and stands were better as the soil warmed.

**PLANT SURVIVAL**

The survival of cotton seedlings varied from season to season. In 1957 plant survival was poor when the preplanting soil temperature average was below 60°F.

**FIRST BLOOM**

The first bloom appeared 65 to 95 days after planting in cold soils with a lower than 60°F.
average. But when the temperature went above the 60°F average, the first bloom appeared between 46 and 68 days after plantings were made. This indicates more rapid plant development in warmer soils and that the length of time to first bloom decreases between early and late plantings.

**EARLINESS**

The percentage of open bolls on a given date in the fall varied considerably with seasons. In 1957 little cotton was open on October 16 as compared with 1953, 1954, 1955 and 1958. Usually the earlier the cotton was planted the greater was the percentage of open bolls on a given date in the fall. The earliest crops generally were those which had been planted in late April or early May. The crop produced from the May 24 planting in 1957 was the earliest and had the highest yield although cold soil temperatures prevailed until the latter part of May. This was the first planting date that the average 60°F preplanting temperature was reached. The earliness of the crop was not affected appreciably by delayed planting until the average 60°F preplanting temperature occurred. However, on a pounds-of-lint per acre basis, the differences between the amount of open cotton produced by plantings made before the 60°F temperature was reached was not necessarily greater than that produced by plantings made after the 60°F temperature was reached.

**YIELDS**

In 5 out of 6 years the highest lint yields were obtained from plantings made after the 60°F 10-day average soil temperature was reached at the 8-inch level. The above average yields usually were obtained from plantings made when preplanting soil temperature averaged between 60° and 65°F, Figure 8.

**GRADES AND STAPLE LENGTHS**

Grades and staple lengths were not affected materially by the date of planting or soil temperature at planting time. The extremely early or late plantings had the lowest grades in years when there were grade differences.

**OTHER FIBER PROPERTIES**

Only small differences were noted in the relationship of the upper half mean fiber length to the planting date or soil temperature at planting time. However, the early, or cold soil plantings tended to produce a fiber with a slightly shorter upper half mean length than that produced by plantings made when the soil temperature range was 60° to 65°F. Fiber length uniformity did not vary noticeably because of the planting time.

Seasonal variations caused greater differences in fiber strength than did the planting times. Fiber strength from plantings made in the 60° to 65°F soil temperature range generally was as high as the fiber strength of earlier plantings.

Fiber fineness, as indicated by micronaire measurements, was affected by season, variety and planting date. Plantings in the 60° to 65°F soil temperature range generally had satisfactory micronaire readings except in 1957 when all readings were low.

**Soil Temperature as a Planting Guide**

Cotton planting should be delayed until a 60°F, 10-day average minimum soil temperature at the 8-inch depth is reached. Using soil temperature as a guide results in earlier plantings more often than when optimum dates are used. This guide should be used only to establish the earliest feasible time for planting. Soil temperature is not a determining factor for late season plantings.
Cottonseed planted at recommended soil temperatures should not be covered more than 2 inches for quick emergence and proper planting practices and equipment should be used for best results. Heavy soil-crusting rains are detrimental to cotton emergence and it is advisable to delay plantings when such rains are in immediate prospect. Long range weather forecasts are valuable considerations at planting time. With the 10-day minimum average soil temperature at 60°F. at the 8-inch depth as a planting guide, seedlings can be expected to emerge in 9 days or less; whereas, emergence from plantings in colder soils may require 13 to 15 days. Thus, seed rotting will be reduced greatly.

Daily soil temperatures can be determined readily when the sensing element of the thermometer is placed at the recommended 8-inch depth in the center of the preplanting bed. A thin-stemmed thermometer, like a dial thermometer with a bimetalic sensing unit, can be inserted easily into the soil to the desired depth. The minimum soil temperatures should be taken daily between 7:30 and 8:30 a.m. and recorded for at least 10 days.

**Acknowledgments**

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Grateful acknowledgment is made to D. L. Jones, agronomist emeritus, and to H. C. Lane, plant physiologist, Substation No. 8, Lubbock, Texas for assistance in planning and conducting this investigation.

Fiber tests were conducted by the fiber laboratories of the Texas Cotton Research Committee at Texas Technological College. Cotton classifications were made by the Cotton Division.

**References**


**SUPPLEMENTARY DATA AVAILABLE**

Tabulated data regarding the effect of soil temperature on cottonseed emergence, yields and fiber properties for the plantings used in this study for 1952-58 can be obtained from the Texas Agricultural Experiment Station, Substation No. 8, Lubbock, Texas.
State-wide Research

The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of the parts of the A&M College of Texas.

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- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
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- Plant diseases

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