# TIMING OF IRRIGATION OF COTTON AND ITS EFFECT UPON YIELD OF LINT AND PER CENT FIRST HARVEST

BY

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# INTRODUCTION

For many years cotton has been one of the leading cash crops in Southern Oklahoma. Relatively large acres are grown under both dry-land and irrigated conditions.

The irrigation of cotton in Oklahoma is a relatively recent development. Consequently, many problems involving the irrigation of cotton under Oklahoma conditions have not been solved.

The stage of development at which cotton should receive its first irrigation may be of great importance to efficient and profitable cotton production. In addition, some varieties may respond differently to irrigation, which could be important from the standpoint of testing varieties. If the varieties respond differently, irrigation without regard to the relative stage of development of the various varieties might introduce bias into the tests.

The purposes of this study were to determine the effects of initiating irrigation when the cotton is in different stages of development, to determine whether different varieties respond differently, and to determine whether any differences found might vary with different locations within the state.

The present investigation is limited to a comparison of the effects of initiating irrigation of two varieties of cotton at two stages of development at three locations in Oklahoma.

## REVIEW OF LITERATURE

For sometime it has been recognized that three environmental conditions are necessary for successful cotton production. These are; freedom from frost for a minimum growing and ripening period, abundant sunshine, and an adequate supply of moisture. Doyle (3) has listed a mean annual temperature of over $60^{\circ}$ F. and a minimum rainfall of twenty inches with proper distribution as conditions favorable to cotton production.

In much of the cotton producing area, conditions are favorable for successful cotton production from the aspect of temperature and sunshine, but either the amount of rainfall is too low, or its distribution is such, that maximum yields are not obtained. An attempt to obtain better yields has resulted in irrigation becoming important in many areas.

Irrigation:

There are many theories concerning the amount of water required to produce maximum yields of cotton. Jones et al. (11) reported that cotton uses about $\frac{1}{4}$ acre inch of water per day at the peak of the blooming period. They further stated that the cotton plant utilizes water to a depth of six feet. Hawkins, Matlock, and Hobart (10) obtained indications that the development of cotton flowers and bolls is dependent, in part at least, on organic substances synthesized elsewhere in the plant. From this Harris and Hawkins (9) concluded that maximum fruiting is dependent upon the accumulation of organic substances in the plant. Such materials do not accumulate when plants are making rapid increase in size, therefore, the quantity of water applied during the fruiting period should be less than that applied prior to the fruiting period. Hawkins et al. (10), in agreement with Adams, Veihmeyer, and Brown (1), further stated that highest yields were obtained from cotton by maintaining the soil moisture at 12 per cent prior to fruiting, then allowing the soil moisture to be reduced to 8 per cent for the remainder of the season. However, in a later publication, Harris et al. (8) obtained maximum yields when the soil moisture was maintained at 12 per cent during the entire season.

Spooner, Caviness, and Spurgeon (15) found that yields were increased by irrigation; however, water applied before the blooming period did not significantly increase yield and in general irrigation delayed maturity. They found shedding to be decreased by irrigation and boll size increased by irrigation. In addition, they found the total number of blooms for any given day were not increased by irrigation, but the length of the blooming period was extended by about two weeks.

Ellwood (5) has shown that the first irrigation after planting should not be applied until the soil moisture has been reduced to the extent that irrigation will stimulate plant growth. Later irrigations should be applied according to plant needs as determined by plant color and increased temperature of the leaves. He (5) also recommended that if the soil has maintained a high percentage of moisture the last irrigation should be applied 45 to 60 days prior to the average frost date. Thomas (18) recommended that irrigation water be applied to cotton as early as May 20 in Arizona. He further recommended irrigation every ten days to two weeks beginning when the plant starts to bloom and extending to about September 15.

Cotton sometimes responds differently to irrigation water at different locations. For instance, Spooner, Brown, and Waddle (16) discovered more difference in location and years in four Arkansas locations than they did in irrigated versus non-irrigated conditions.

Limited study has been given to the effects of irrigation on lint quality. Sturkie (17), however, found a marked relation between lint length and the amount of soil moisture available to the plant during the period of lint elongation. In addition, he found a reduction in per cent lint by increasing the amount of irrigation water applied. He also found that temperature, humidity, and evaporation did not affect length of lint or per cent lint.

Flowering of Cotton:

The flowering date of cotton was used as an indication of maturity in this study; therefore, a review of the work done previously on flowering date as a measure of maturity is necessary.

Evenson (6) found that the blooming period in upland cotton is about 12 weeks under favorable conditions. He reported that seed weight and lint index depended more upon the physiological age of the plant at which flowering was initiated, than on environmental conditions.

Work done by Bailey and Trought, as reported by McClelland (13), shows an absence of correlation between intervals of blooming and vigor, height of plant, or temperature. Bailey and Trought also called attention to the fact that flowering curves in cotton are rhythmic, with peaks occurring at intervals of 6.5 days. However, McClelland (13) found the correlation between the vigor of cotton plants and the length of the blooming season to be significant though small.

Buie (2) suggests the flowering interval in days and the mean boll period of a variety are more effective in the prediction of earliness than the appearance of the first flower or first open boll.

In work with four varieties of cotton which represented early, medium, and late varieties, Ewing (7) found all four varieties began blooming at about the same time, but the rate of blooming was accelerated at different times during the flowering season, depending upon the variety.

Ewing (7) also found a great deal of difference among varieties as to the number of flowers produced and number of flowers shed. He found that some of the varieties with the highest rates of flowering also had the highest rates of shedding.

Martin, Ballard, and Simpson (12) reported a great deal of difference in the "square period" (the interval between the appearance of the square and the date of flowering) for three upland varieties of cotton and pima cotton. They also found as the season progressed, the square period increased. They determined the mean period from bloom to maximum length of boll to be 17.3 days.

Dunlap (4) reported that cloudy weather encourages shedding in cotton. He also lists a varietal difference in shedding rates.

McNamara et al. (14), in vestigations involving six varieties of upland cotton, found considerable difference among varieties in the number of days required from flower to open boll. They also found the large bolled varieties matured bolls from 26 to 28 per cent of their flowers. The small bolled varieties set 39 to 42 per cent of their flowers. Approximately 76 to 79 per cent of the total crop of bolls was set within four weeks after the appearance of the first bloom in most varieties. Some earlier varieties set 90 to 100 per cent during the first four weeks.

Irrigation in general has increased cotton yields across the cotton belt. This can be attributed to increased boll set, decreased boll shedding, and increased boll size. The use of irrigation water also increases the length of lint. A great deal of research has been devoted to the study of proper amounts and time of irrigation, since excessive amounts of water or extremely late applications may result in poor quality fiber or delayed maturity. From work done by Adams et al. (1), Harris et al. (8), and Hawkins (10), it may be concluded that for highest yields soil moisture in a field of cotton should be maintained at a high level prior to boll set and then reduced to about 66 per cent of that level. Irrigation water in Southern Oklahoma should not be applied after September 15 based upon information reported by Ellwood (5).

## MATERIALS AND METHODS

Location of experiments and soil types:

This study was conducted at three locations; the Oklahoma Cotton Research Station near Chickasha, the Southwest Cotton Sub-Station near Tipton, and the Perkins Agronomy Research Station near Perkins, Oklahoma. The soil types at these three locations were McLain Silty clay loam, Tipton loam, and Vanoss loam, respectively.

The Vanoss loam soil has a brown loam surface, 11 to 12 inches deep, over a brown clay loam subsoil that grades to a sandy clay loam substratum which becomes more sandy below 36 to 48 inches.

The Tipton loam soil is moderately granular in structure, firable, and weakly alkaline, but non-calcareous.

The McLain silty clay loam soil has a silty-clay loam surface, a light silty clay subsoil, and a clay loam substratum somewhat stratified with silt loams.

Varieties:

In order to study the amount of flowering (which was the criterion for initiating irrigation) varieties of cotton with considerable differences in their rate of maturity were chosen. Based upon four to six years of data on the per cent of total lint harvested the first harvest and on previous bloom count data, Paymaster 54-B and Empire were selected for this study to represent varieties with different rates of maturation.

The differences in these two varieties with respect to agronomic characters are as follows:

> Empire is a Stoneville derivative, medium to late in maturity. Boll size is medium and is a desirable variety for hand harvesting. The length of staple ranges from one inch to one and one-sixteenth inches.
>
> Paymaster 54-B is a very early maturing variety developed in the Texas plains area and grown more commonly in the north central cotton producing area of Oklahoma. The length of staple ranges from fifteen-sixteenth of an inch to one inch.

Treatments:

In treatment 1 (both Paymaster 54-B and Empire) irrigation was initiated when the staked rows in Paymaster 54-B had an accumulated average of 50 blooms.

In treatment 2 (both Paymaster 54-B and Empire) irrigation was initiated when the staked rows in Empire had an accumulated average of 50 blooms.

Subsequent irrigations were at approximately 14-day intervals.

Experimental design and procedure:

A factoral design was used for the experiment. Each experimental site contained six replications, each composed of 16 rows of cotton, 4 rows of Paymaster 54-B, treatment 1; 4 rows of Paymaster 54-B, treatment 2; 4 rows of Empire, treatment 1; and 4 rows of Empire, treatment 2. One-hundred plants were staked in each plot for the purpose of taking bloom counts.

In this study major emphasis was placed on lint yields and earliness of maturity for comparing varieties and treatments. Earliness was determined by the per cent of the cotton which was harvested at the first harvest.

Cotton yields were obtained by harvesting the center two rows of each 4 row plot. The weight of snapped cotton was recorded and a representative sample from each treatment was ginned to determine the per cent of lint.

Boll size was determined by harvesting 25 bolls per treatment from 2 replicates. The seed cotton from these was weighed, and the average weight of seed cotton per boll calculated.

Statistical analyses were computed on lint yields and per cent cotton harvested during the first harvest.

Other cultural conditions:

The cotton at all three locations was planted with a conventional lister type planter. Seed was planted at a rate sufficient to insure an adequate stand. After emergence plants were thinned to 4 plants per foot. Plots were weeded with hoes as necessary, and cultivation was accomplished by a tractor driven 2-row cultivator. All locations were planted in late April or early May. Table I shows planting dates, initial irrigation dates, and dates of harvest.

Commercial fertilizer was used only at the Tipton station where 150 pounds of 12-24-12 were applied when the soil was listed. Insecticides were applied as needed to prevent serious insect damage. These applications were accomplished by means of tractor driven equipment unless soil or vegetative conditions prohibited their use. In such instances, applications were made by airplane.

Tables II, III, and IV show the distribution of rainfall, and the average maximum and minimum temperatures by month for the three locations. The temperatures were generally favorable for cotton production; however, the June temperatures were considerably above average for the month, which may account in part for the relatively early blooming of the variety, Empire.

TABLE I

DATE OF PLANTING, INITIAL IRRIGATION, AND HARVEST

| Location | Treatment | Planting Date | Date of Initial Irrigation | Harvest Dates |
|---|---|---|---|---|
| Chickasha | 1 & 2 | May 6 | | Sept 23 |
| | 1 | | July 21 | Oct 14<br>Nov 20 |
| | 2 | | July 19 | Oct 14<br>Nov 20 |
| Tipton | 1 & 2 | April 29 | | Sept 3 |
| | 1 | | July 3 | Oct 2<br>Nov 3 |
| | 2 | | July 1 | Oct 2<br>Nov 3 |
| Perkins | 1 & 2 | May 8 | Not Irrigated | Sept 25<br>Nov 11 |

TABLE II

CLIMATOLOGICAL DATA - CHICKASHA 1958

| Month | Rainfall (inches) | Temperature (average) Maximum | Minimum |
|---|---|---|---|
| January | 1.64 | 52.0 | 28.7 |
| February | .32 | 47.1 | 28.6 |
| March | 3.20 | 51.7 | 33.8 |
| April | 3.09 | 69.8 | 46.4 |
| May | 2.56 | 81.8 | 58.1 |
| June | 6.11 | 91.5 | 66.2 |
| July | 2.75 | 92.1 | 69.8 |
| August | 3.57 | 91.8 | 68.1 |
| September | 3.20 | 82.9 | 63.6 |
| October | .11 | 74.9 | 49.0 |
| November | .64 | 66.6 | 36.2 |
| December | 1.00 | 49.9 | 25.7 |

TABLE III

CLIMATOLOGICAL DATA - TIPTON 1958

| Month | Rainfall (inches) | Temperature (average) Maximum | Minimum |
|---|---|---|---|
| January | 2.75 | 51.3 | 30.8 |
| February | .91 | 49.3 | 32.0 |
| March | 2.64 | 53.9 | 37.2 |
| April | 2.00 | 69.6 | 43.4 |
| May | 1.74 | 88.5 | 60.0 |
| June | 3.34 | 95.1 | 65.3 |
| July | 4.34 | 95.0 | 72.0 |
| August | 1.34 | 96.4 | 70.2 |
| September | 2.09 | 87.0 | 65.4 |
| October | .13 | 82.9 | 53.2 |
| November | .70 | 68.9 | 40.1 |
| December | .13 | 56.0 | 27.9 |

TABLE IV

CLIMATOLOGICAL DATA - STILLWATER* 1958

| Month | Rainfall | Temperature (average) Maximum | Minimum |
|---|---|---|---|
| January | 1.41 | 52.9 | 27.6 |
| February | .90 | 47.6 | 26.2 |
| March | 4.71 | 50.2 | 33.4 |
| April | 2.14 | 69.8 | 46.5 |
| May | 1.70 | 81.4 | 58.3 |
| June | 7.52 | 92.0 | 66.3 |
| July | 4.13 | 92.1 | 70.7 |
| August | 4.83 | 92.2 | 67.9 |
| September | 3.07 | 85.5 | 63.7 |
| October | .74 | 76.8 | 49.5 |
| November | 1.07 | 68.0 | 38.6 |
| December | 1.03 | 50.6 | 25.5 |

* Approximately ten miles from Perkins Experiment Site.

TABLE V

IDENTITY OF CODE NUMBERS

| Location | Variety | Treatment |
|---|---|---|
| 1 - Chickasha | 1 - Paymaster 54-B | 1 - Irrigation initiated when Paymaster 54-B had 50 blooms per 100 plants. |
| 2 - Tipton | 2 - Empire | |
| 3 - Perkins | | 2 - Irrigation initiated when Empire had 50 blooms per 100 plants. |

## RESULTS AND DISCUSSION

Temperatures and rainfall supplemented by irrigation during the 1958 season were conducive for the production of high yields of cotton. At the Perkins location, soil moisture remained so high during the season that irrigation water was not used.

Based upon prior bloom count data, it was anticipated that Paymaster 54-B would reach a certain stage of blooming 7 to 10 days prior to Empire. However, as shown by figures 1 and 2, Empire reached the desired number of blooms 2 to 3 days prior to Paymaster 54-B. The similarity in blooming habit resulted in the initial irrigations being accomplished with less time interval than is desirable for an experiment of this type.

As shown in Tables VI and VII, the different irrigation treatments had no effect on either lint yield or per cent first harvest. Furthermore, there were no interaction of treatments with either variety or location, indicating that the treatments applied in these tests did not affect either the yield or the rate of maturity.

On the other hand, the data presented in Tables VI and VII indicate significant location variety differences as well as a significant variety-location interaction for both yield and per cent first harvest.

In order to understand the basis for the significant differences as shown in Tables VI and VII, the means of the variety yields and per cent first harvest results at each location and over all locations are presented in Tables VIII and IX.

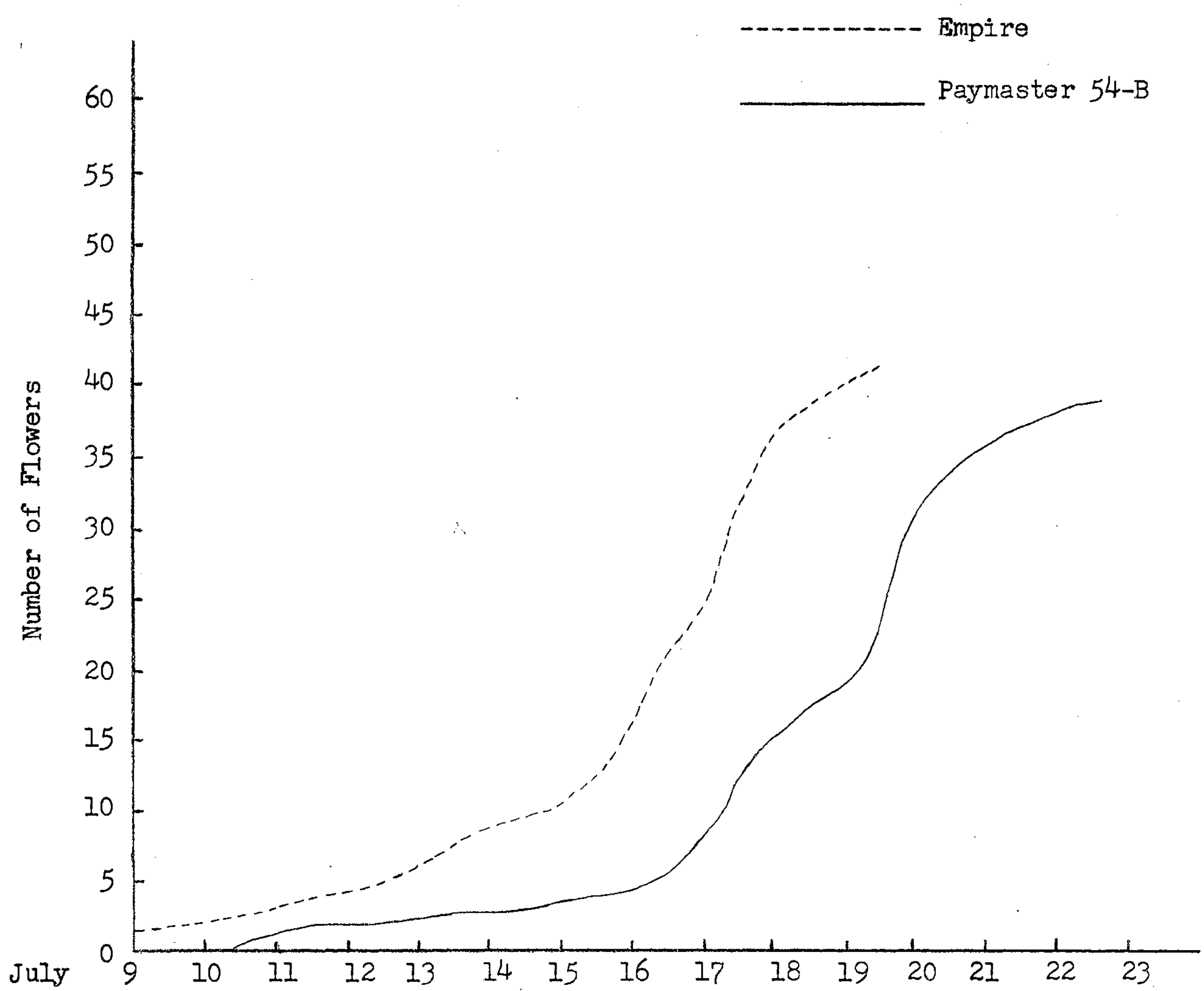


Figure 1. Average number of cotton flowers per 100 plants at Chickasha.

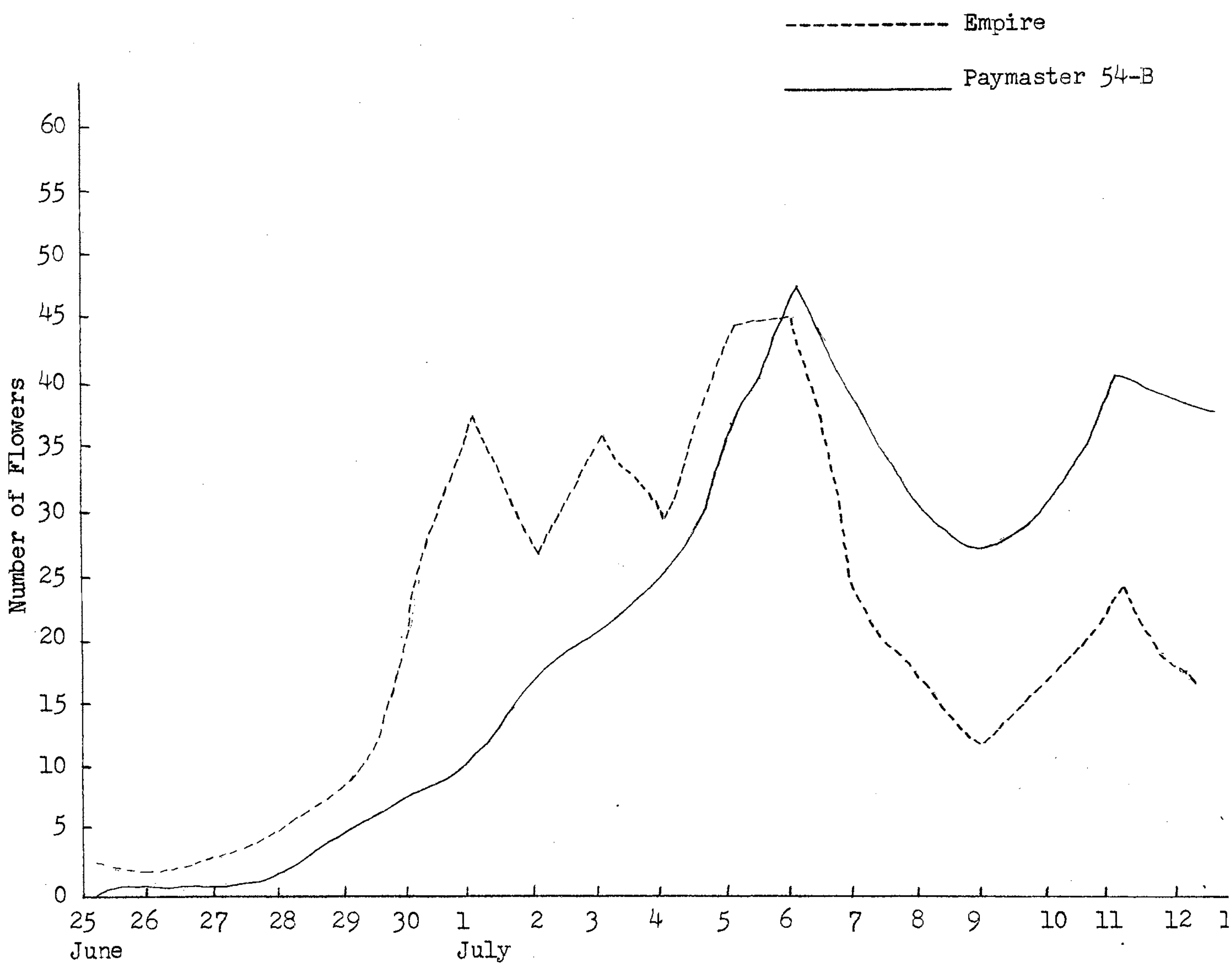


Figure 2. Average number of cotton flowers per 100 plants at Tipton.

TABLE VI

ANALYSIS OF VARIANCE FOR PER CENT OF TOTAL LINT HARVESTED AT THE FIRST HARVEST AT CHICKASHA, TIPTON, AND PERKINS

| Source of Variation | d. f. | Means Square |
|---|---|---|
| Total | 71 | |
| Replications in location | 2 | |
| Error (Replications + Locations x Replications) | 15 | 94.73 |
| Varieties | 1 | 356.00* |
| Varieties x Locations | 2 | 381.50** |
| Error A (Replications x Varieties + Replications x Varieties x Locations) | 15 | 65.93 |
| Treatments | 1 | 57.0 |
| Treatments x Varieties | 1 | 40.0 |
| Treatments x Locations | 2 | 7.5 |
| Treatments x Varieties x Locations | 2 | 34.0 |
| Error B (Replications x Treatments + Replications x Treatments x Locations + Replications x Treatments x Varieties + Replications x Treatments x Varieties x Locations) | 30 | 21.63 |

* Significant difference at 5% level
** Significant difference at 1% level

TABLE VII

ANALYSIS OF VARIANCE FOR LINT YIELDS AT CHICKASHA, TIPTON, AND PERKINS

| Source | d. f. | Means Square |
|---|---|---|
| Total | 71 | |
| Replications in locations | 2 | |
| Error (Replications + Locations x Replications) | 15 | 42460. |
| Varieties | 1 | 88642.** |
| Varieties x Locations | 2 | 30882.* |
| Error A (Replications x Varieties + Replications x Varieties x Locations) | 15 | 8170. |
| Treatments | 1 | 56. |
| Treatments x Varieties | 1 | 13102. |
| Treatments x Locations | 2 | 5691. |
| Treatments x Varieties x Location | 2 | 9118. |
| Error B (Replications x Treatments + Replications x Treatments x Locations + Replications x Treatments x Varieties + Replications x Treatments x Varieties x Locations) | 30 | 6248. |

* Significant difference at 5% level
** Significant difference at 1% level

The results presented in Table VIII show that Paymaster 54-B had a significantly higher average yield over all three locations, but Perkins was the only single location where the yield of Paymaster 54-B was significantly higher.

As shown by the data presented in Table IX, Empire was much earlier than Paymaster 54-B at Chickasha, but there were no significant differences between the two varieties for earliness at either Perkins or Tipton. When the means at all locations are considered the differences in earliness are barely significant.

The average lint yields and per cent of total lint obtained at first harvest for the two varieties at the three locations are diagramed in Figures 3 and 4, respectively in order to show the sources of the variety x location interactions. The data presented in Figure 3 shows that the variety x location interaction for yield is caused by Empire being rather inferior to Paymaster 54-B at Tipton and Perkins but nearly as good at Chickasha. Figure 4 verifies that the variety x location interaction for earliness is caused by Paymaster 54-B being earlier than Empire at Perkins but later at Chickasha and Tipton.

The results presented above indicate that varieties and locations had a great effect on both yield and earliness but the irrigation treatments applied did not affect either yield or earliness. These results indicate that at least under the conditions that existed in Oklahoma in 1958 bloom count is not a sensitive criterion by which to initiate irrigation.

The finding that these irrigation treatments had no effect on yield is not surprising for a number of reasons. First, the plants may not have been under water stress at the time of either irrigation treatment. Secondly, there was such a short interval between the two treatments that any stress the plants were under would have been for such a short duration that no permanent

TABLE VIII

MEANS FOR YIELD OF LINT

| Location | Variety | Yield of Lint in Pounds |
|---|---|---|
| Chickasha | Paymaster 54-B | 1191 |
| | Empire | 1174 |
| Tipton | Paymaster 54-B | 1041 |
| | Empire | 999 |
| Perkins | Paymaster 54-B | 1180 |
| | Empire | 1028 |
| All | Paymaster 54-B | 1137 |
| | Empire | 1067 |

L.S.D. (within locations) - 76 pounds

L.S.D. (between locations) - 31 pounds

TABLE IX

MEANS FOR PER CENT OF TOTAL LINT OBTAINED AT THE FIRST HARVEST

| Location | Variety | Per Cent of Lint Harvested at First Harvest |
|---|---|---|
| Chickasha | Paymaster 54-B | 29.42 |
| | Empire | 41.50 |
| Tipton | Paymaster 54-B | 31.67 |
| | Empire | 36.75 |
| Perkins | Paymaster 54-B | 67.67 |
| | Empire | 63.83 |
| All | Paymaster 54-B | 42.92 |
| | Empire | 47.36 |

L.S.D. (within locations) - 6.87

L.S.D. (between locations) - 3.95

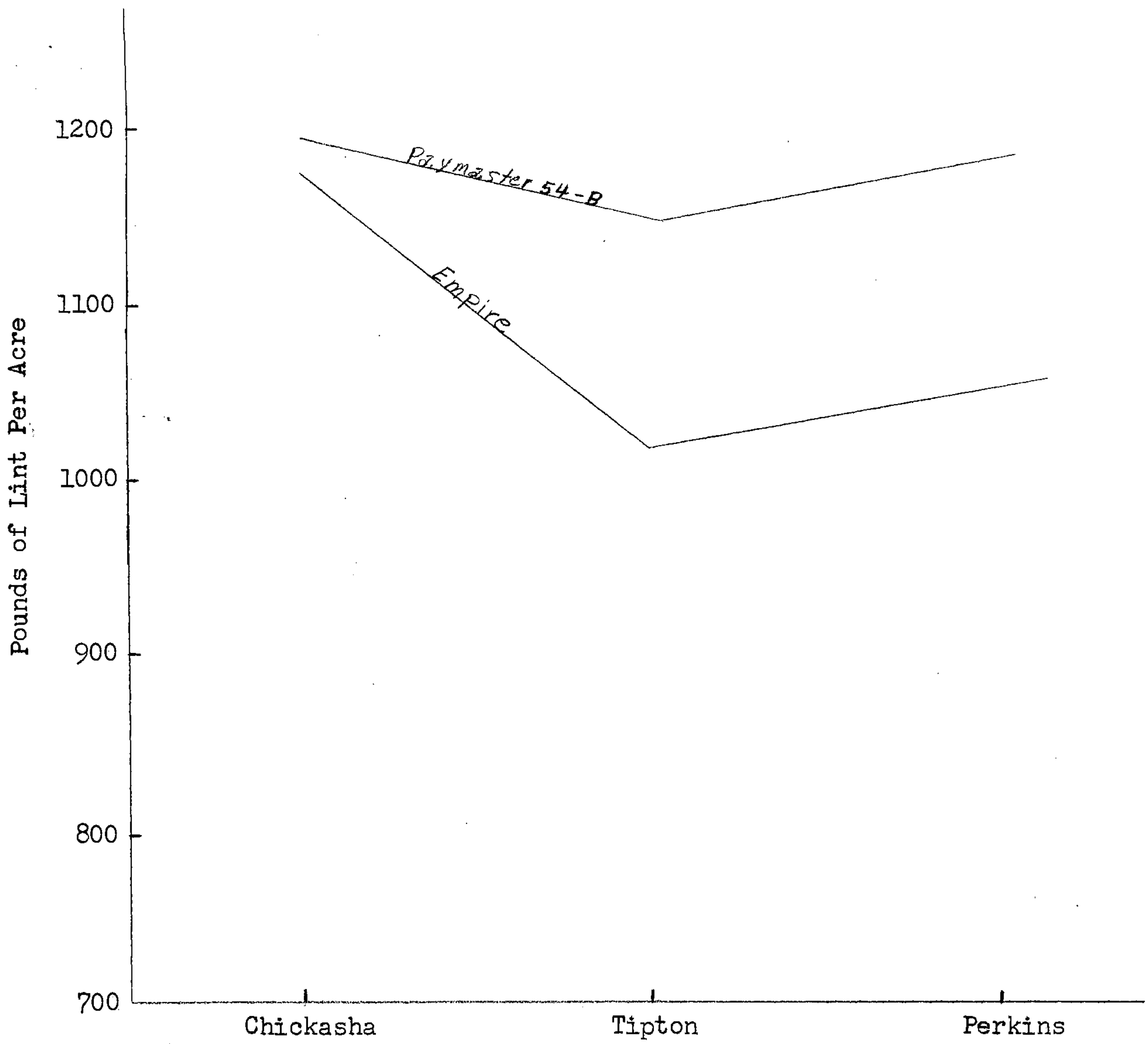


Figure 3. Lint yield by location.

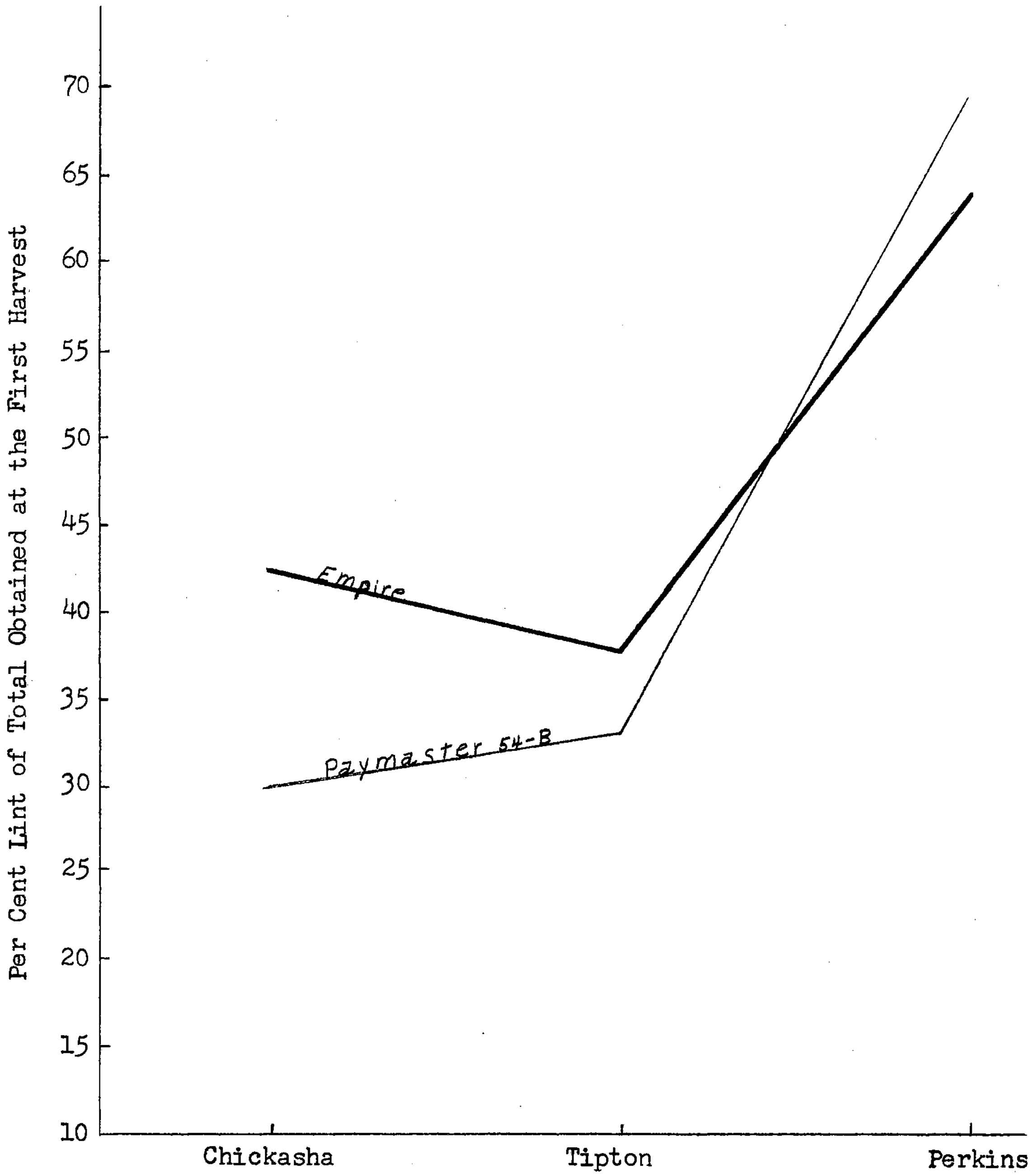


Figure 4. Per Cent of total lint obtained at first harvest at three locations.

injury occured. Third, even though there may have been slight differences in bloom counts, there may not have been differences between the two varieties in maturity by other criteria of measurement. This last possibility is suggested by the conclusions of Ewing (8) that first bloom in cotton is not an accurate method of determining earliness.

X

## SUMMARY AND CONCLUSIONS

This study was conducted to determine the yield, quality of lint, and per cent first harvest differences in two varieties of cotton when irrigation was initiated at different stages of maturity. Bloom count, lint quality, yield of lint, and per cent lint harvested at first harvest were determined on two upland varieties at three locations in Oklahoma.

Based on previous data for the per cent of the lint harvested at the first harvest, and bloom count, an early and a late variety of cotton were chosen to study their response to irrigation. Paymaster 54-B was chosen as the early variety and Empire as the late one. Dates of initial irrigation were determined by early season bloom counts.

The differences in dates of blooming were from 2 to 3 days with Empire being the first to reach the desired bloom count at all 3 locations.

There were no significant differences among treatments from the standpoint of yield or per cent of the lint obtained at first harvest.

From the data gathered here there can be only one conclusion, however nugatory, that the differences in time of irrigation used in this study on these two varieties of cotton did not in 1958 affect yield or earliness to any measurable extent.

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