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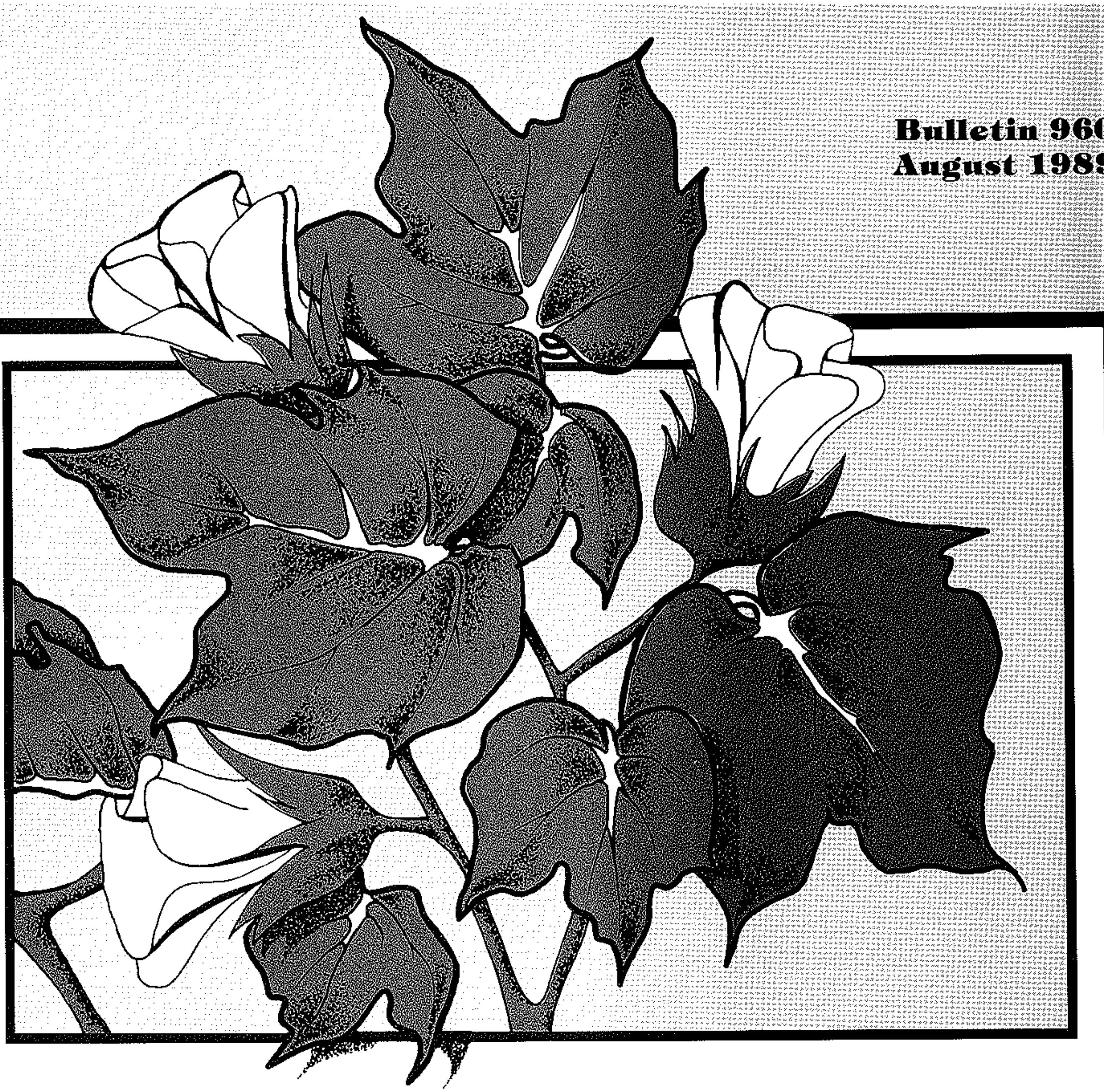
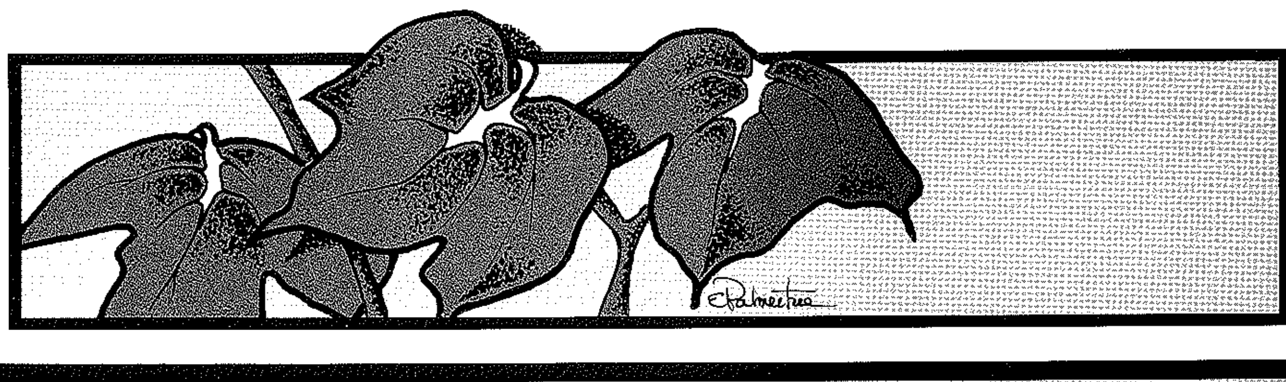


# Effect of Sprinkler Irrigation on Open Cotton Flowers



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# Effect of Sprinkler Irrigation on Open Cotton Flowers

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## Abstract

Sprinkler irrigations between sunrise and noon, on white, open cotton flowers reduced flower retention to about 35 percent of the retention of flowers not watered during the same period. Flower retention gradually increased as the timing of irrigation changed from noon to late afternoon. A similar reduction in boll set was induced by rain. Field and greenhouse experiments were conducted to estimate the potential effect of this type of fruiting losses on cotton yields. From 14 to 66 percent of the fruiting structures were removed by hand to simulate flower loss caused by sprinkler irrigation. Fruiting structures were removed as squares once a week or as white open flowers one, two, or three times a week. Results from the different methods of fruiting structure removal were similar.

Lint yields were 97.5, 95.5, 91.0, 88.2, and 74.1 percent of controls (no fruiting structures removed) for 14, 29, 33, 42, and 66 percent hand removal of fruiting structures, respectively. The lint yields, as percent of control, fit a quadratic regression of the form of $Y = 99.94 - 0.069P - 0.005P^2$ where Y = lint yields in grams per 0.001 acre, P = percent of fruiting structures removed. Sequential hand harvesting showed that flower removal delayed crop maturity by only 1 to 2 days.

These yield reductions for experimental plots may not directly indicate the magnitude of possible yield losses for large production center pivot irrigated fields. Additional calculations of expected yield losses in production fields from the increased bloom abortion caused by water on open cotton flowers showed that watering two or three times a week can result in no more than 1 or 2.2 percent, respectively, lint yield reduction in a production field. These results indicate that production sprinkler irrigation systems should not be turned off during the mornings to recover these small yield losses if there is any possibility that the crop could become water stressed due to the reduction in the amount of water that could be applied.

# Effect of Sprinkler Irrigation on Open Cotton Flowers

## Introduction

Irrigation of cotton is rapidly developing in the Midsouth. Many producers are installing center pivot sprinkler systems, which represent a good compromise of operating cost, flexibility, and capital investment. General indications are that the use of sprinkler irrigation systems will continue to expand in cotton production. Farmers who install these systems will be faced with many new management decisions and will need to develop an understanding of the interactions of soils, weather, the cotton plant, and irrigation.

With the adoption of sprinkler irrigation systems, many producers have noted that water from sprinkler irrigation or rainfall on open white cotton flowers can result in reduced retention of those flowers. Experiments were conducted to determine the effect of sprinkler irrigation and rainfall on cotton flower retention and cotton yields. The data are reported in two sections. The first experiments determined the effect of sprinkler irrigation and rainfall on flower retention and the second experiments determined the effect of flower loss on cotton yields. This information is then used to estimate the potential impact of any flower loss caused by irrigation on yields in commercial production fields.

## Materials and Methods

### *(A) Effect of Sprinkler Irrigation and Rainfall on Flower Retention*

Two field experiments were conducted in 1985 and five field experiments were conducted in 1986 to determine the effect of sprinkler irrigation on the retention of open cotton flowers in the Mississippi Delta. The experiments were conducted under center pivot sprinklers on farms at Belzoni, Silver City, Leland, Sumner, and Glendora, (seven tests total).

Planting dates in the test fields ranged from late April to early May. Stoneville, Delta and Pine Land, and DES short staple cotton varieties were used. Variety differences were not considered. Irrigation began shortly after first flower in late June or early July. Irrigations were usually made at 4-day intervals with 0.8 to 1 inch of water per application. General cultural practices were typical for this area.

In each experiment, 10 flowers were tagged at each of 15 to 25 sites located in an arc around the center pivot (Figure 1). Fruiting structures were tagged on the day before an irrigation as unopened flowers that would open on the day of the irrigation. On the same day, most large bolls were removed from tagged plants to improve the total retention of tagged flowers (Ehlig and LeMert, 1973; Patterson et al., 1978; Guinn and Mauney, 1984).

On the day of the irrigation, the time that the sprinkler passed over an individual site was recorded. Ten to 15 days after the irrigation, the number of tagged flowers remaining on the plants as bolls was recorded at each tagging site. Most boll abscission occurs before bolls are 10 days old (Guinn, 1982). The effect of irrigation on flower retention was determined as the percentage of tagged flowers that formed bolls.

At the end of the season the tagged bolls remaining on the plants were hand-harvested at the Leland location in 1985, and the Sumner location in 1986. The seed cotton from individual bolls was weighed. Each lock of each boll harvested was weighed and the number of mature seeds were counted in 1986.

In 1986, in a separate experiment on the Delta Branch Experiment Station, flowers were tagged in

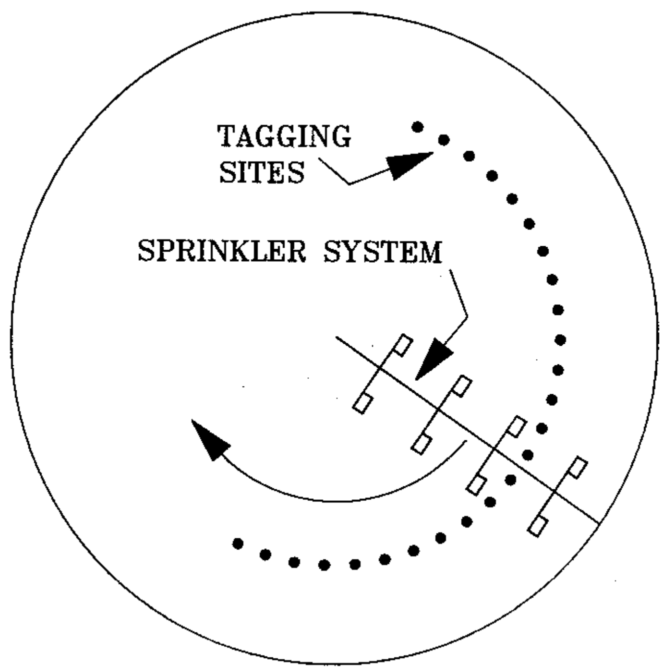


**Figure 1. Locations of tagging sites around center pivot irrigation system. The system passes over first sites near dawn. Last sites were irrigated near sunset.**

four 0.001-acre plots on the days preceding, during, and after the passage of a weather front (June 27 to July 14), which brought 2 inches of rain during the morning and afternoon of July 2. Approximately 21 days after the rain, the number of tagged flowers that developed into bolls was recorded.

## *(B) Effect of Fruiting Structure Removal on Cotton Yields*

Fruiting structure removal experiments were conducted in the greenhouse in 1982 and 1984, and in the field in 1984 and 1986, on the Delta Branch Experiment Station to determine the effect of partial fruiting structure removal on cotton yields. Fruiting structure loss was obtained by manually removing flowers or squares by the methods described below.

### Cultural practices

In the two greenhouse experiments, cotton ('Stoneville 213') was planted on June 28, 1982, (greenhouse experiment 1) and Jan. 24, 1984, (greenhouse experiment 2). Plants were grown in 4-gallon pots containing soil, sand, and peat moss mixed in a 2:2:1 ratio. Supplemental light was supplied by ten 400-W multivapor lamps that delivered a photosynthetic photon flux density of 300-$\mu$mol $m^{-2}$ $s^{-1}$ at plant height. A commercially available liquid fertilizer (N-P-K) was routinely applied to the soil mix during the experiments. Insects were controlled with soil applications of Temik® [2–methyl–2–(methylthio)proprianaldehyde–0–(methyl–carbamoly)oxime] and with topical applications of Kelthane® [1,1–Bis(chlorophenyl)–2,2,2–trichloroethanol].

Field experiments were planted on May 11, 1984 (field experiment 1), April 30, 1986 (field experiments 2 and 3), and April 28, 1986 (field experiment 4). Rows were spaced 40 inches apart and plant populations were approximately 3 plants per foot of row. Single row plots in field experiment 1 were 6.5 feet long and in field experiments 2, 3, and 4 were 13.25 feet long. Field experiment 1 was drip irrigated. Field experiments 2, 3, and 4, were sprinkler irrigated with a linear move system. Sprinkler irrigations were applied between 7:00 p.m. and 6:00 a.m. to avoid flower abortion caused by water on open flowers. All other cultural practices were those conventionally used to grow cotton in the Mississippi Delta.

### Treatments

Squares were removed from both greenhouse experiments and field experiment 1 at weekly intervals starting during early square development and continuing throughout the active growth period of the plants. The squares were removed at rates of 0, 33, and 66 percent of those that had formed on the plants in the week since the previous square removal. The squares were removed in an unbiased manner with respect to their size and position on the plant.

In field experiments 2, 3, and 4, all white open flowers were removed from the plants 0, 1, 2, or 3 times a week on a Monday, Wednesday, Friday schedule. This resulted in fruiting structure removal percentages of 0, 14, 29, and 43 percent. White flower removal started on July 9, 1986. At this time, there were about two flowers per 13.25 feet of row (0.001 acre). Flower removal continued until mid-August. The flower removal period covered the typical cotton irrigation season for the Mississippi Delta and also represents the major portion of the productive cotton flowering period in this region.

### Seed cotton harvesting

Seed cotton from all experiments was hand harvested. Harvest of seed cotton from open bolls was made a single time 145 days after planting in greenhouse experiment 1 and twice, 117 and 140 days after planting, in greenhouse experiment 2. Field experiment 1 was also harvested twice, 148 and 175 days after planting, (Oct. 6 and Nov. 2). Field experiments 2, 3, and 4 were sequentially harvested at weekly intervals from late August until early October. In all experiments, the number of bolls harvested and the total weight of the seed cotton were recorded. Seed cotton was ginned on a table top gin to determine lint percent and lint yields.

### Experimental designs and statistical analysis

Both greenhouse experiments were completely randomized with six replications in greenhouse experiment 1 and five replications in greenhouse experiment 2. Field experiments were randomized blocks with five replications in field experiment 1 and six replications in field experiments 2, 3, and 4. Values of least significant difference at alpha = 0.05 were determined using the Waller-Duncan K-ratio method to measure differences among treatments.

# Results and Discussion

## *(A) Effect of Sprinkler Irrigation and Rainfall on Flower Retention*

The average of all seven irrigation flower tagging experiments is shown in Figure 2. Retention of open, white flowers that were wetted by the sprinkler irrigation in the morning (7:00 a.m. to noon), just as flowers were opening, was reduced substantially in comparison with flowers wetted pre-dawn or very late in the afternoon. Starting at noon, flower retention gradually increased throughout the afternoon. Data

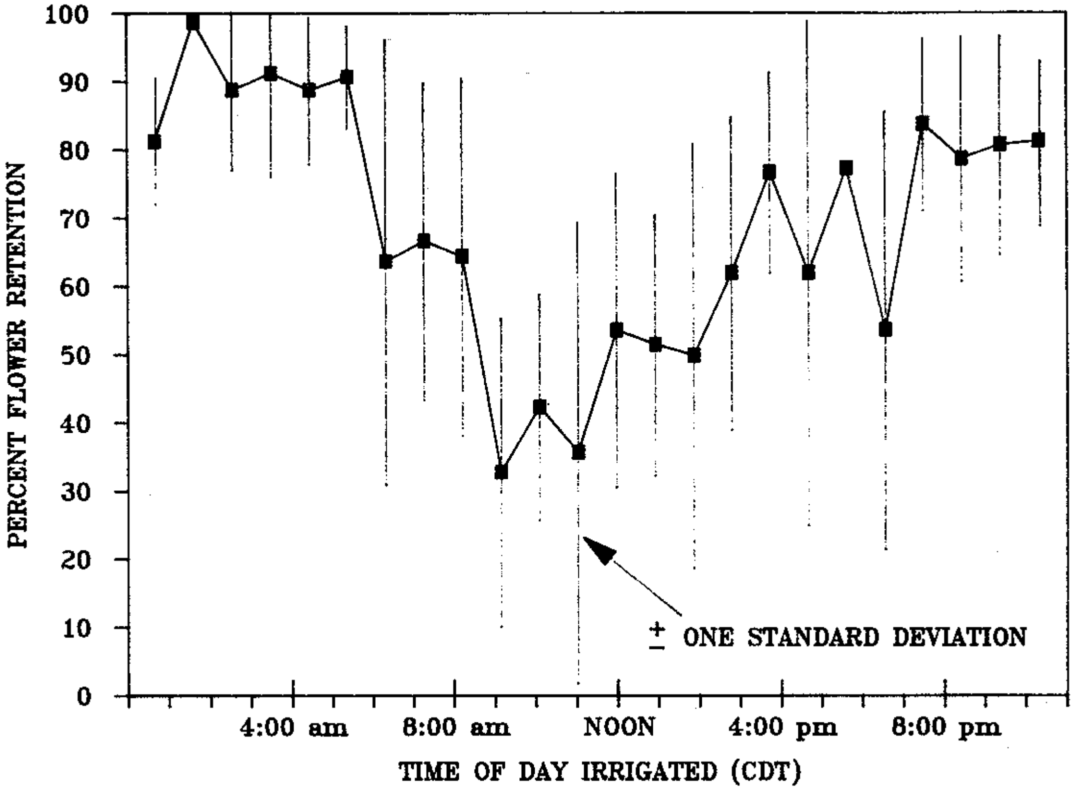


**Figure 2. Average flower retention under center pivot irrigation for seven experiments from 1985 and 1986.**

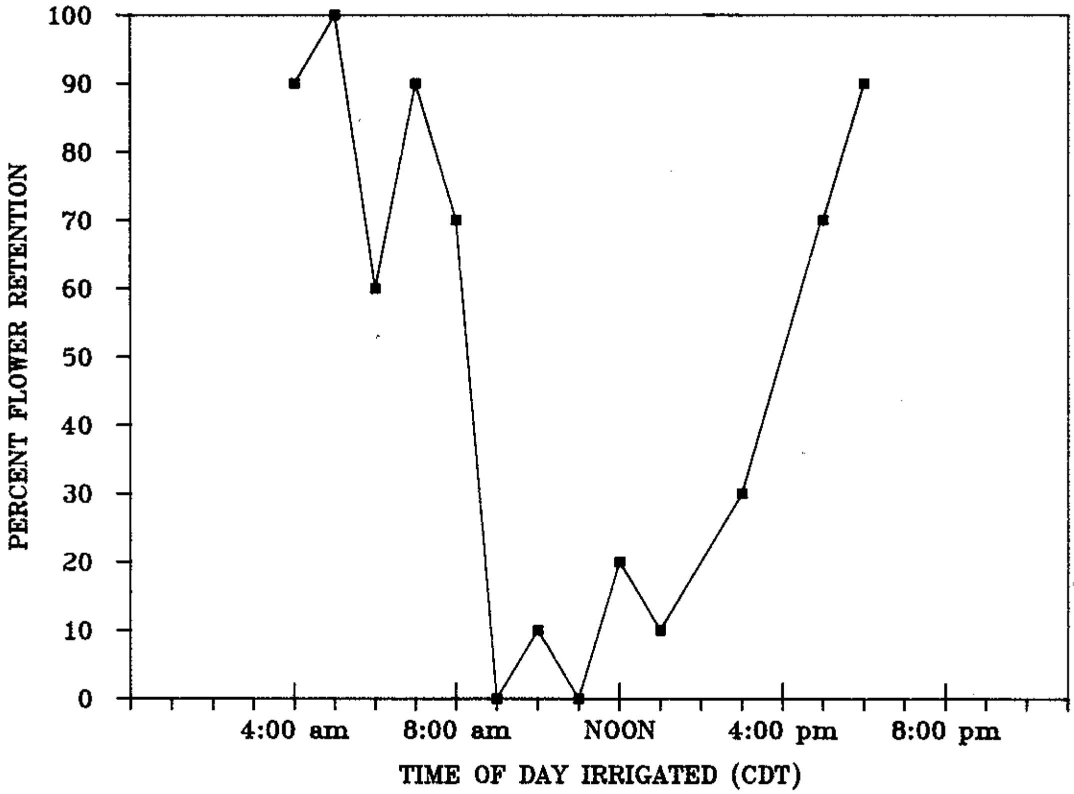


**Figure 3. Most severe reduction in flower retention. Data from Belzoni, 1985.**

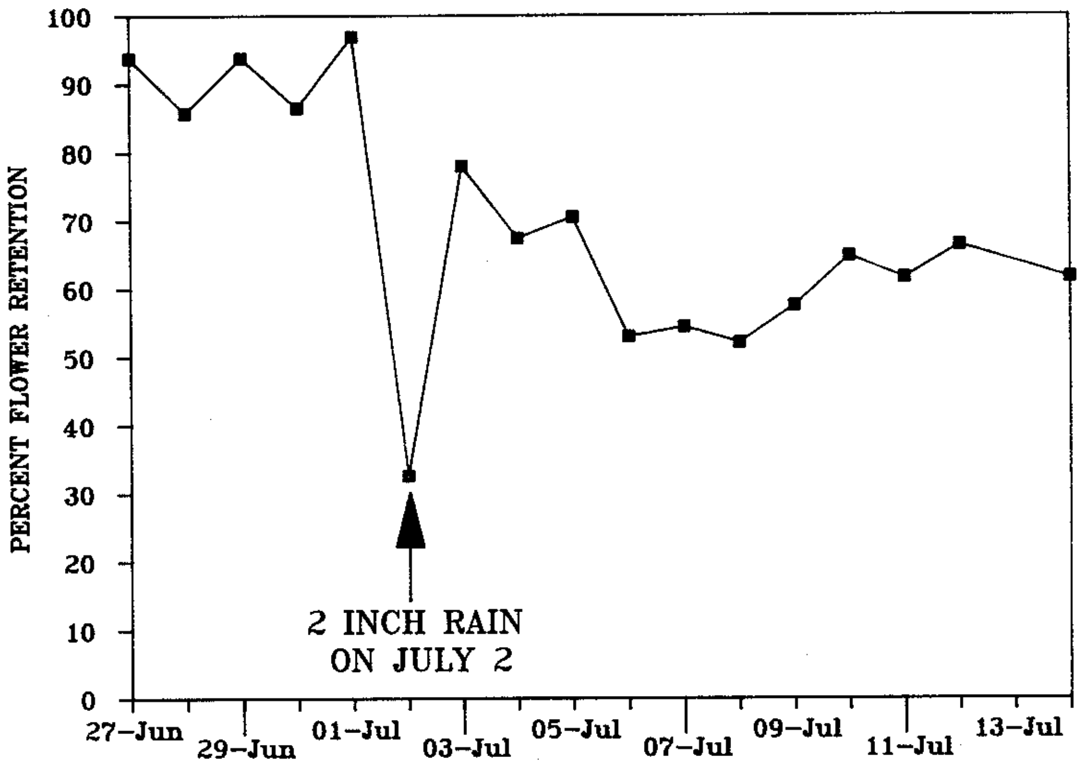


**Figure 4. Influence of natural rainfall on flower retention.**

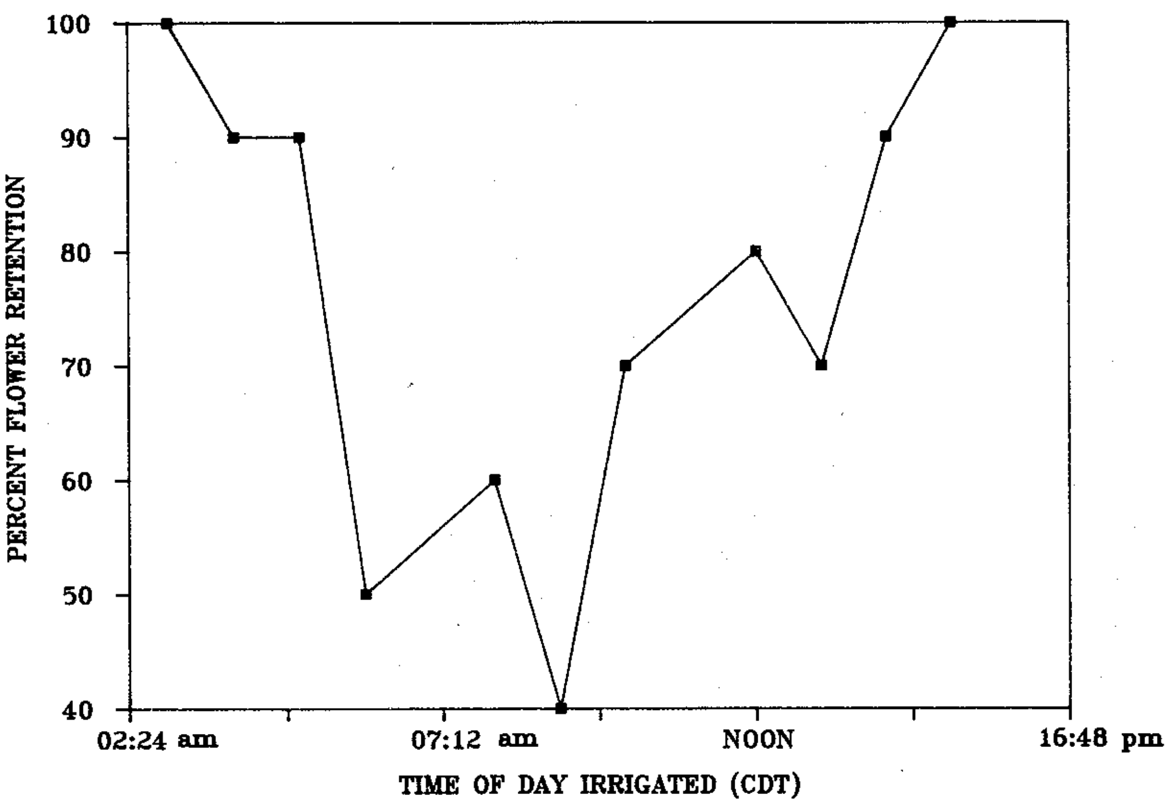


**Figure 5. Changes in flower retention due to time of day of sprinkler irrigation on open cotton flowers. Data from Sumner, 1986.**

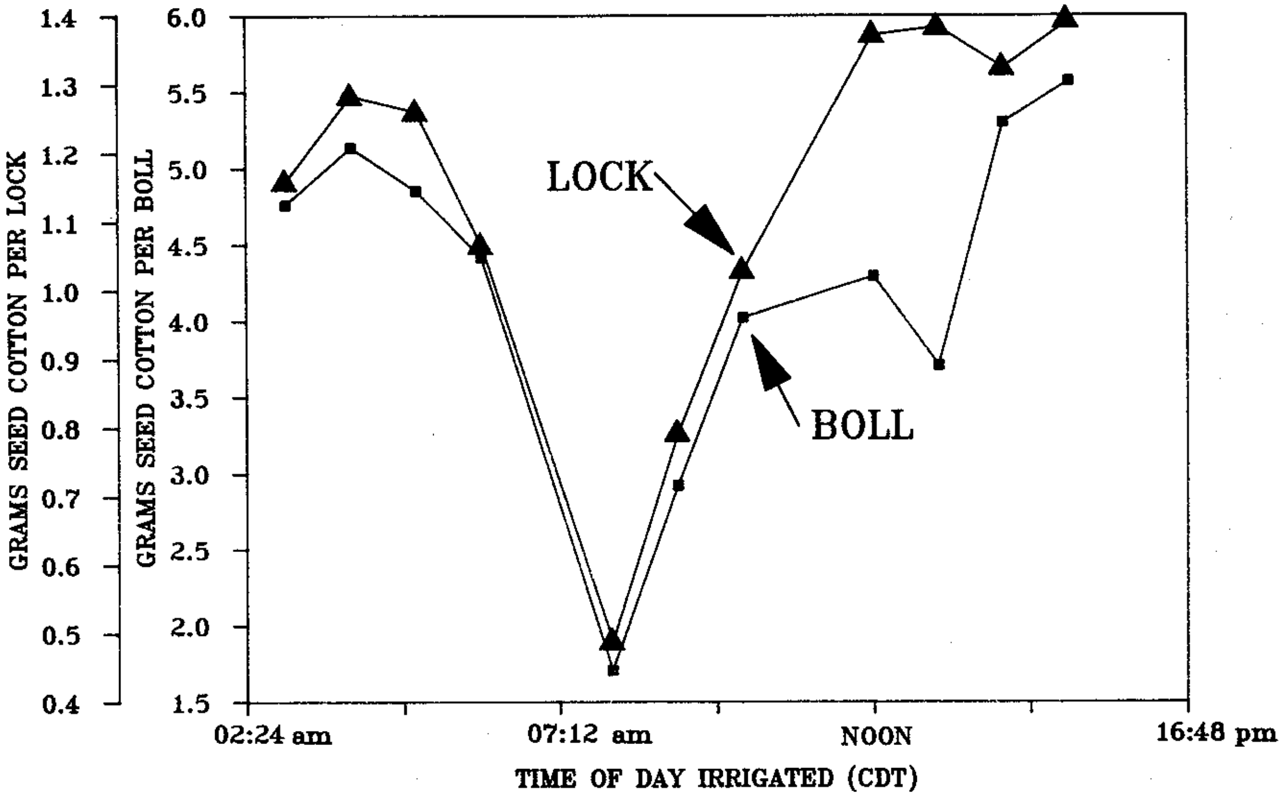


**Figure 6. Influence of time of day of sprinkler irrigation on weight of seed cotton per boll and lock. Data from Sumner, 1986.**

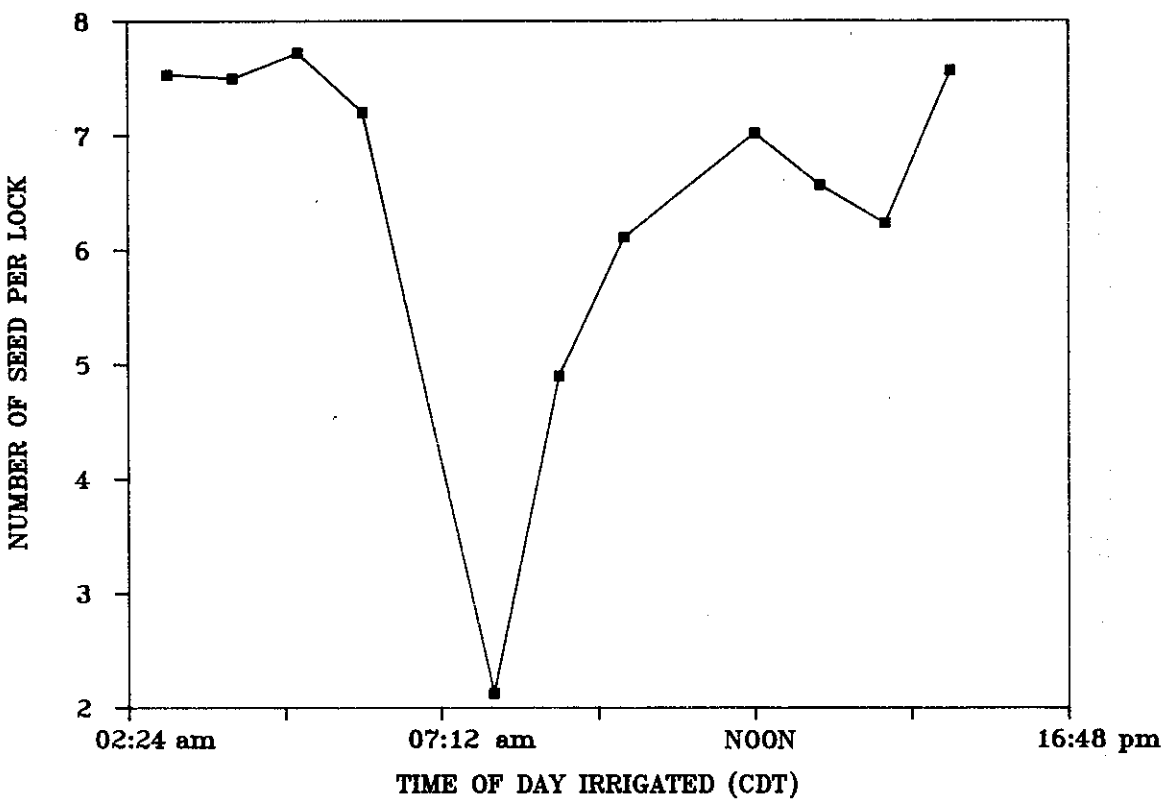


**Figure 7. Influence of time of day of sprinkler irrigation on the number of seeds per lock of cotton. Data from Sumner, 1986.**

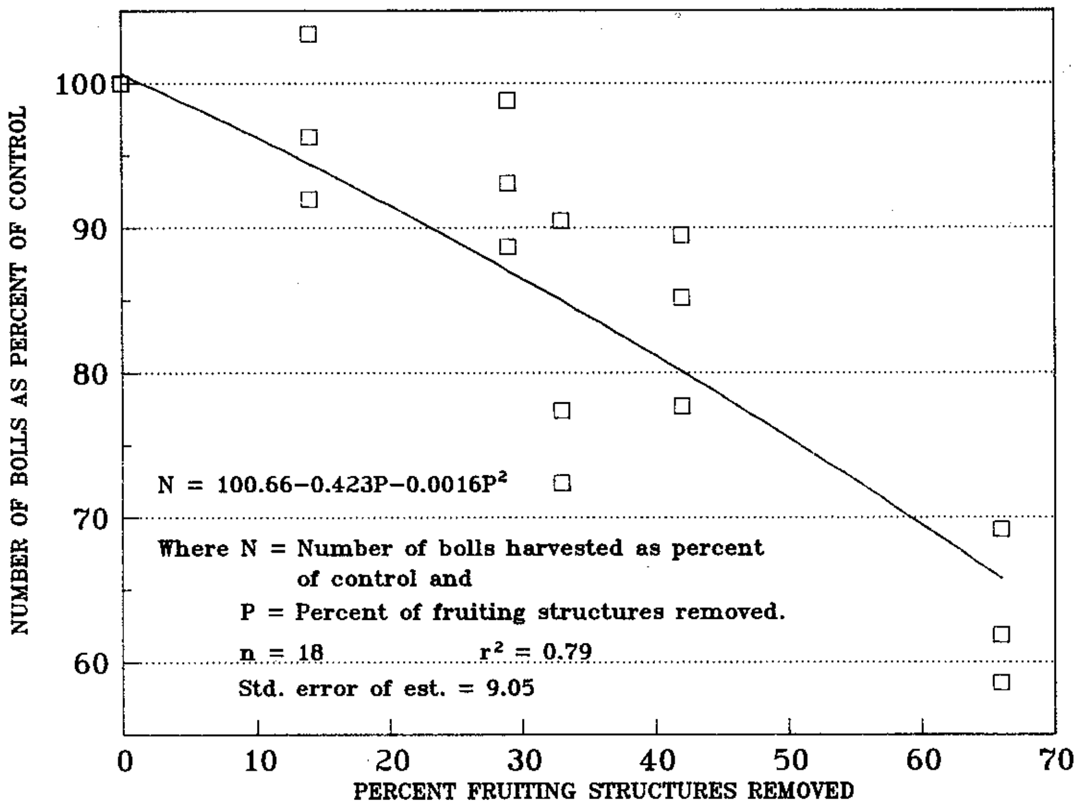


Figure 8. Average total number of bolls as percent of control for each treatment.

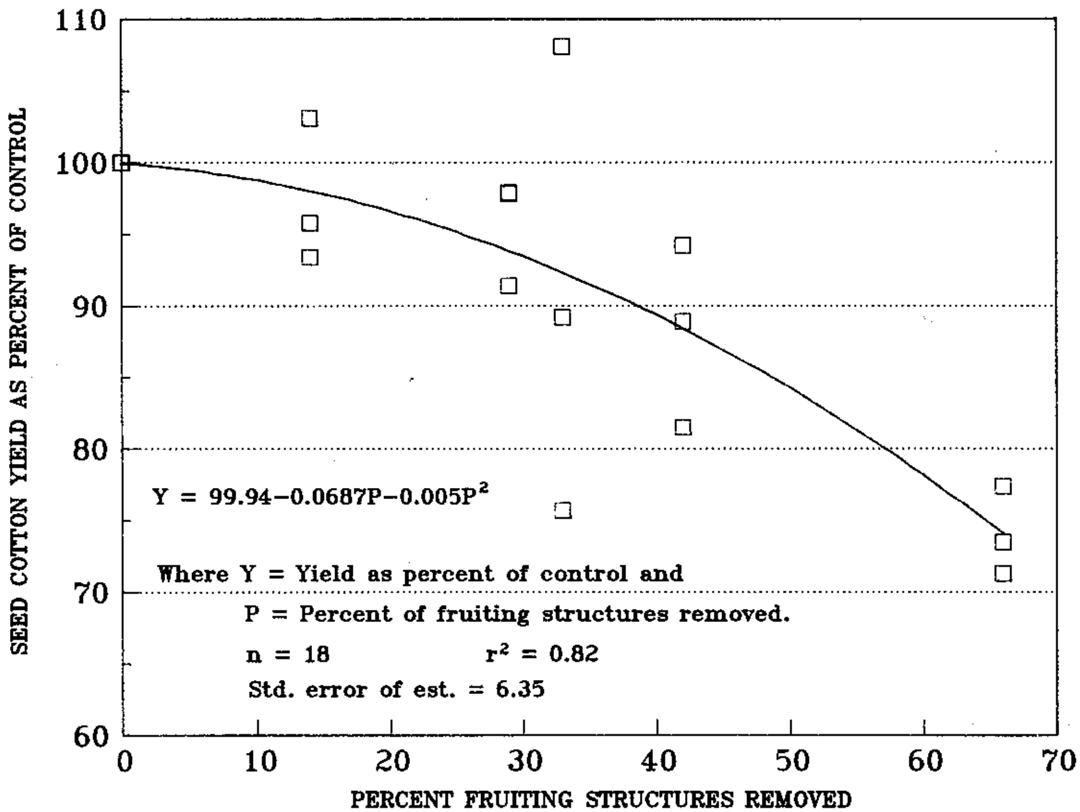


Figure 9. Average seed cotton yield at percent of control for each treatment.

from all seven experiments followed this general pattern with some differences in actual percent retention. In one notable experiment, conducted in 1985 (Figure 3), flower retention dropped to zero when sprinkler irrigation water was applied to open cotton flowers during the late morning hours.

Rainfall effects on flower retention can be seen in Figure 4. Rain on July 2, part of which fell in the morning, caused a sharp, one-day decrease in flower retention. Flowers that opened on the day of the rain had a lower retention than those flowers opening on the nonrain days.

Flower retention by time of day wetted for the 1986 test at Sumner is given in Figure 5. The tagged bolls that remained on the plants were individually hand harvested at the end of the growing season. The retention at this location is similar to other experiments. The weights of seed cotton per boll and per lock from these individually harvested bolls are given in Figure 6. Data from Leland in 1985 gave similar boll seed cotton weight reductions. Seed cotton per boll and lock was reduced with water application in the morning. In addition to reducing retention of open flowers, watering in the morning reduces the size of the retained bolls by decreasing the number of seeds in each lock (Figure 7). The daily patterns of flower retention, boll seed cotton weights, and seed numbers all suggest that water on the open flowers ruptures pollen grains and interferes with subsequent pollination of the flower (Miravalle, 1965; Stewart, 1986). Also, Pearson (1949) concluded that natural rainfall early in the day interfers with pollination and causes more ovules to form motes instead of developing into seed.

These data show a definite effect of sprinkler irrigation and rainfall on open white cotton flower retention but only suggest that there may be an effect on yields. Cotton is noted for its ability to compensate for lost fruiting structures with little or no yield loss.

Separate experiments were conducted to estimate the potential effect of flower loss on yields. The results from that work follow.

## *(B) Effect of Fruiting Structure Removal on Cotton Yields*

Yield data from the two greenhouse experiments and field experiment 1 are reported in the same tables and data from field experiments 2, 3, and 4 are reported in other tables because of difference in percent of fruiting structures removed and different harvest schedules. Data are combined within each of the two above groups of experiments to give a treatment averaged of each yield parameter reported. Figures 8 and 9 show trends in number of harvested bolls and weight of seed cotton with changing percentage of fruiting structure removal and corresponding quadratic regression results. Data will be discussed by yield parameter.

### Number of bolls harvested

As the percentage of fruiting structures removed increased, the number of harvested bolls decreased (Figure 8). The data in Tables 1 and 2 indicate that the characteristic of decreased number of bolls with increased percent fruiting structure removal was most pronounced in the earliest of the sequential harvests. This trend either decreased or reversed by the final harvests.

The increased number of bolls harvested later in the season show that cotton can compensate for fruiting structures lost during early flowering. These later set bolls did not completely compensate for the lost yield potential resulting from earlier fruit losses. Also, there was a trend toward larger bolls as the number of bolls harvested decreased (data are not given).

**Table 1. Number of bolls harvested per plant from plants with varying**

| Percent fruiting structure removed | Sequential harvest dates 1* | 2 | Totals | Percent of control |
|---|---|---|---|---|
| | ---------- Bolls per plant ---------- | | | |
| *Greenhouse Experiment 1* | | | | |
| 0 | 29.0 a** | -- | 29.0 | 100.0 |
| 33 | 21.0 b | -- | 21.0 | 72.4 |
| 66 | 17.0 c | -- | 17.0 | 58.6 |
| LSD | 3.0 | -- | | |
| *Greenhouse Experiment 2* | | | | |
| 0 | 11.0 a | 10.0 | 21.0 | 100.0 |
| 33 | 8.0 b | 11.0 | 19.0 | 90.5 |
| 66 | 5.0 c | 8.0 | 13.0 | 61.9 |
| LSD | 1.0 | NS | | |
| *Field Experiment 1* | | | | |
| 0 | 11.0 a | 2.0 a | 13.0 | 100.0 |
| 33 | 7.0 b | 2.0 a | 9.0 | 69.2 |
| 66 | 5.0 b | 4.0 b | 9.0 | 69.2 |
| LSD | 3.0 | 2.0 | | |
| *Average of Greenhouse Experiments and Field Experiment 1* | | | | |
| 0 | -- | -- | 21.0 | 100.0 |
| 33 | -- | -- | 16.3 | 77.4 |
| 66 | -- | -- | 13.0 | 63.3 |

* Harvest dates: 1 = 145, 117, and 148 days after planting (DAP) for Greenhouse Experiments 1 and 2 and Field Experiment 1, respectively; 2 = 140 and 175 DAP for Greenhouse Experiment 2 and Field Experiment 1.

** Data followed by same letter are not significantly different based on LSD at the $\alpha = 0.05$. No lettering equals no significant differences within a comparison.

### Lint yields

Yield differences between treatments with in an experiment were often not statistically different (Tables 3 and 4) but a trend is visible when treatments are compared collectively across all experiments (Figure 9). Lint yields decreased as fruiting structure removal increased. Loss of all flowers two and three times a week (a situation possible with common irrigation practices in the Midsouth with center privot irrigation) resulted in 4.3 and 11.8 percent, respectively, lint yield reductions (Table 4). Seed cotton yields (data are not given) showed a very similar yield trend because lint percent was not affected by the treatments.

The loss of any fruiting structures caused some loss in yield potential that was not completely compensated for by later developing fruit. The effect of fruiting structure removal on yield was the same for the removal of squares or open flowers. The extent of this yield reduction in terms of production field yields is discussed in the final section of this bulletin.

### Earliness

Lint yields for each sequential harvest date from field experiments 2, 3, and 4 are given in Table 4 and Figures 10, 11, and 12. The trends in these figures show that the removal of flowers resulted in a slight delay in maturity. Removal of flowers once a week delayed the date that 60% of the lint was open by 1 day for field experiments 2 and 4. Flower removal 2 and 3 times a week delayed the 60% open date by about 2 days. Field experiment 3 was particularly early because of a water stress earlier in the season which caused shedding of many later developing squares.

In addition to a decreased yield with flower removal, there was a slight delay in maturity.

**Table 2. Number of bolls harvested from 0.001 acre plots from plants with varying percentages of fruiting structures removed.**

| Percent fruiting structures removed | Sequential harvest dates | | | | | Totals | Percent of control |
|---|---|---|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | 5 | | |
| | Number of Bolls Harvested | | | | | | |
| *Field Experiment 2* | | | | | | | |
| 0 | 28.5 | 151.5 a** | 89.3 ab | 15.8 b | 15.2 b | 300.3 ab | 100.0 |
| 14 | 30.0 | 144.0 ab | 96.2 a | 24.7 a | 15.5 b | 310.4 a | 103.4 |
| 29 | 19.7 | 129.0 bc | 94.7 a | 27.7 a | 25.5 a | 296.6 ab | 98.8 |
| 42 | 22.8 | 117.5 c | 76.2 b | 26.7 a | 25.5 a | 268.7 b | 89.5 |
| LSD | NS | 21.5 | 14.4 | 7.0 | 9.1 | 34.7 | |
| *Field Experiment 3* | | | | | | | |
| 0 | 130.3 | 70.7 | 9.2 | 5.8 | -- | 216.0 | 100.0 |
| 14 | 124.2 | 71.7 | 8.0 | 4.2 | -- | 208.1 | 96.3 |
| 29 | 129.8 | 61.0 | 6.4 | 4.0 | -- | 201.2 | 93.1 |
| 42 | 102.3 | 52.3 | 6.5 | 6.8 | -- | 167.9 | 77.7 |
| LSD | NS | NS | NS | NS | -- | NS | |
| *Field Experiment 4* | | | | | | | |
| 0 | 38.8 a | 60.7 | 83.8 a | 130.3 | -- | 313.6 a | 100.0 |
| 14 | 36.2 ab | 49.3 | 72.3 b | 130.8 | -- | 288.6 ab | 92.0 |
| 29 | 31.3 ab | 52.8 | 65.8 b | 128.2 | -- | 278.1 b | 88.7 |
| 42 | 26.8 b | 49.3 | 67.5 b | 123.7 | -- | 267.3 b | 85.2 |
| LSD | 11.9 | NS | 11.3 | NS | -- | 29.3 | |
| *Averages—Field Experiments 2, 3, and 4* | | | | | | | |
| 0 | -- | -- | -- | -- | -- | 276.6 a | 100.0 |
| 14 | -- | -- | -- | -- | -- | 269.0 a | 97.2 |
| 29 | -- | -- | -- | -- | -- | 258.6 a | 93.5 |
| 42 | -- | -- | -- | -- | -- | 234.6 b | 84.1 |
| LSD | -- | -- | -- | -- | -- | 18.4 | |

* Harvest dates: Field Experiment 2 were Aug. 22, Sept. 3, 11, 18, and 29. Field Experiment 3 were Aug. 29, Sept. 11 and 18, and Oct. 1. Field Experiment 4 were Aug. 25, Sept. 3 and 11, and Oct. 1.

** Data followed by same letter are not significantly different based on LSD at the $\alpha = 0.05$. No lettering equals no significant differences within a comparison.

**Table 3. Lint yields per plant from plants with varying percentages of fruiting structures removed.**

| Percent fruiting structure removed | Sequential harvest dates 1* | 2 | Average | Percent of control |
|---|---|---|---|---|
| | ------- Grams lint per plant ------ | | | |
| *Greenhouse Experiment 1* | | | | |
| 0 | 34.2 a | -- | 34.2 | 100.0 |
| 33 | 30.5 a | -- | 30.5 | 89.2 |
| 66 | 24.4 b | -- | 24.4 | 71.3 |
| LSD | 5.7 | -- | | |
| *Greenhouse Experiment 2* | | | | |
| 0 | 18.5 a | 17.4 | 35.9 | 100.0 |
| 33 | 15.6 a | 23.2 | 38.8 | 108.1 |
| 66 | 9.4 b | 17.0 | 26.4 | 73.5 |
| LSD | 5.0 | NS | | |
| *Field Experiment 1* | | | | |
| 0 | 19.8 a | 3.7 | 23.5 | 100.0 |
| 33 | 14.3 a | 3.5 | 17.8 | 75.7 |
| 66 | 10.6 b | 7.6 | 18.2 | 77.4 |
| LSD | 5.9 | NS | | |
| *Average of Greenhouse Experiments and Field Experiment 1* | | | | |
| 0 | -- | -- | 31.2 | 100.0 |
| 33 | -- | -- | 29.0 | 91.0 |
| 66 | -- | -- | 23.0 | 74.1 |

* Harvest dates: 1 = 145, 117, and 148 days after planting (DAP) for Greenhouse Experiments 1 and 2 and Field Experiment 1, respectively; 2 = 140 and 175 DAP for Greenhouse Experiment 2 and Field Experiment 1.

** Data followed by same letter are not significantly different based on LSD at the $\alpha$ = 0.05. No lettering equals no significant differences within a comparison.

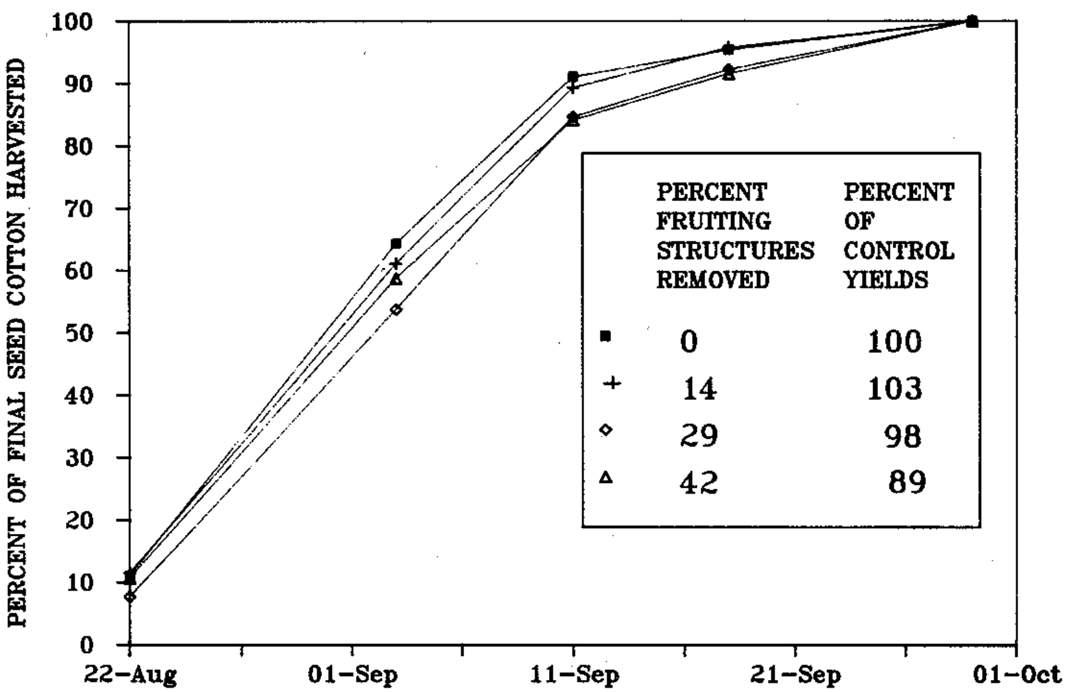


**Figure 10. Percent of final seed cotton yields harvested at different dates and final seed cotton yields as percentage of controls. Field experiment 2.**

**Table 4. Lint yields harvested from 0.001-acre plots from plants with varying percentages of fruiting structures removed.**

| Percent fruiting structures removed | Sequential harvest dates | | | | | Totals | Percent of control |
|---|---|---|---|---|---|---|---|
| | 1* | 2 | 3 | 4 | 5 | | |
| | Grams lint per plot | | | | | | |
| *Field Experiment 2* | | | | | | | |
| 0 | 43.7 | 211.6 a | 106.4 ab | 17.2 b | 18.4 ab | 397.3 ab | 100.0 |
| 14 | 47.0 | 203.2 ab | 115.5 a | 26.1 a | 17.7 b | 409.5 a | 103.1 |
| 29 | 30.0 | 179.0 ab | 120.0 a | 29.5 a | 29.9 a | 388.4 ab | 97.8 |
| 42 | 37.7 | 169.6 b | 89.6 b | 26.5 a | 29.8 ab | 353.3 b | 88.9 |
| LSD | NS | 36.8 | 18.7 | 8.1 | 12.1 | 54.0 | |
| *Field Experiment 3* | | | | | | | |
| 0 | 222.0 | 73.1 | 8.8 | 3.1 | -- | 307.1 | 100.0 |
| 14 | 212.9 | 71.3 | 7.4 | 2.5 | -- | 294.1 | 95.8 |
| 29 | 225.0 | 65.7 | 7.1 | 2.7 | -- | 300.5 | 97.9 |
| 42 | 180.3 | 58.8 | 6.1 | 5.0 | -- | 250.2 | 81.5 |
| LSD | NS | NS | NS | NS | -- | NS | |
| *Field Experiment 4* | | | | | | | |
| 0 | 57.0 | 66.3 | 98.4 a | 143.5 | -- | 365.2 | 100.0 |
| 14 | 53.6 | 58.9 | 82.8 ab | 145.6 | -- | 340.9 | 93.4 |
| 29 | 47.7 | 59.4 | 81.1 b | 145.7 | -- | 333.8 | 91.4 |
| 42 | 42.9 | 61.5 | 82.7 ab | 156.9 | -- | 344.0 | 94.2 |
| LSD | NS | NS | 15.8 | NS | -- | NS | |
| *Averages--Field Experiments 2, 3, and 4* | | | | | | | |
| 0 | -- | -- | -- | -- | -- | 356.5 a | 100.0 |
| 14 | -- | -- | -- | -- | -- | 348.2 ab | 97.4 |
| 29 | -- | -- | -- | -- | -- | 340.9 ab | 95.7 |
| 42 | -- | -- | -- | -- | -- | 315.8 b | 88.2 |
| LSD | -- | -- | -- | -- | -- | 36.7 | |

* Harvest dates: Field Experiment 2 were Aug. 22, Sept. 3, 11, 18, and 29. Field Experiment 3 were Aug. 29, Sept. 11 and 18, and Oct. 1. Field Experiment 4 were Aug. 25, Sept. 3 and 11, and Oct. 1.

** Data followed by same letter are not significantly different based on LSD at the $\alpha = 0.05$. No lettering equals no significant differences within a comparison.

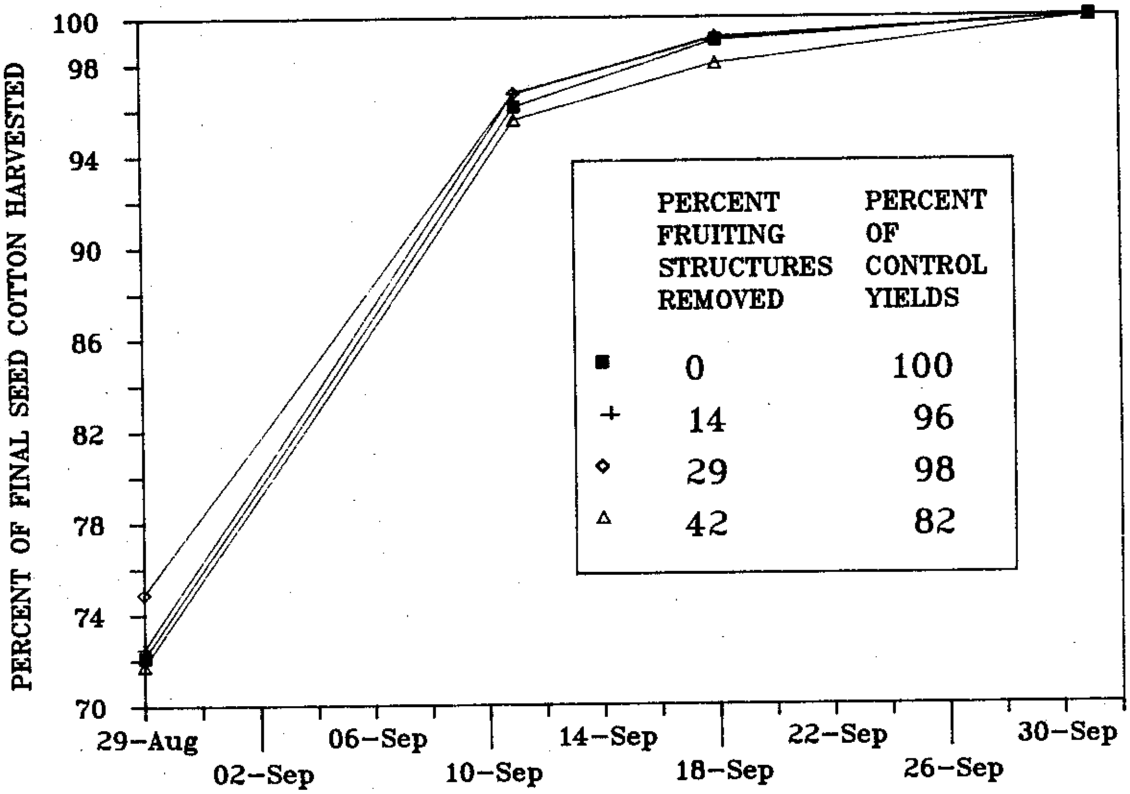


Figure 11. Percent of final seed cotton yields harvested at different dates and final seed cotton yields as a percentage of controls. Field experiment 3.

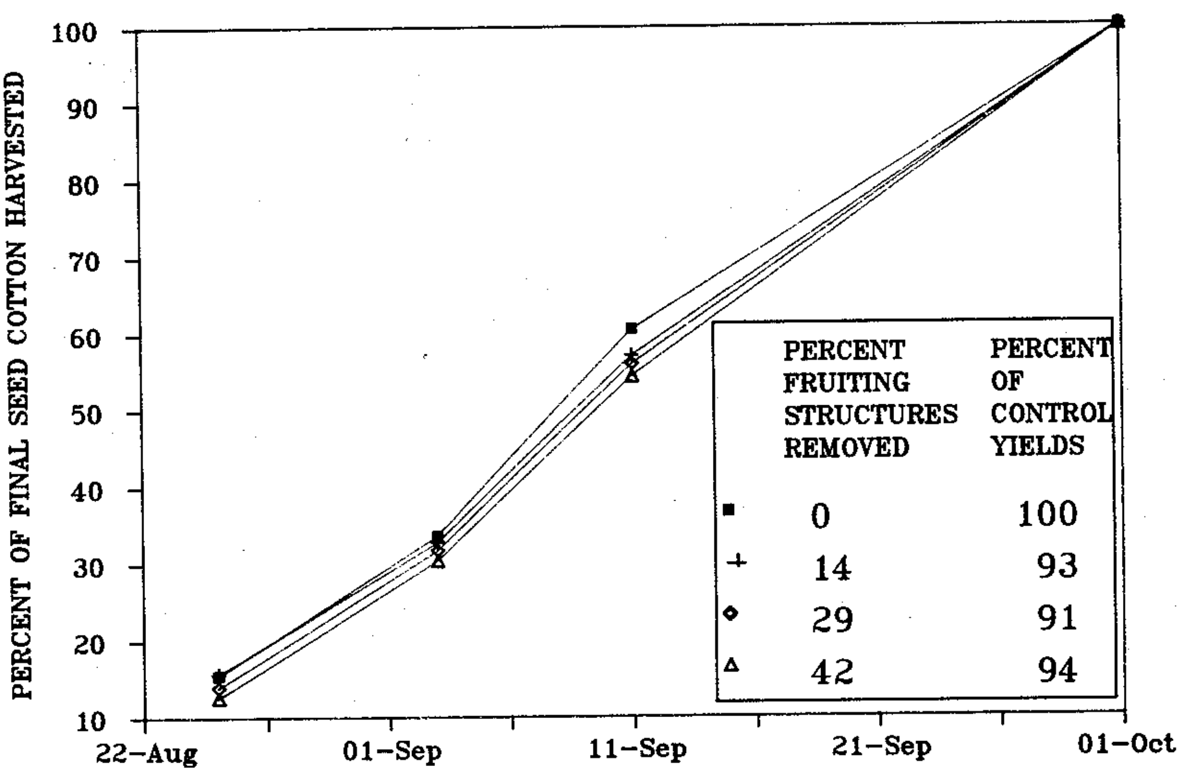


Figure 12. Percent of final seed cotton yields harvested at different dates and final seed cotton yields as a percentage of controls. Field experiment 4.

# *Projected Yield Reductions in Production Fields Due to Increased Shed of Flowers Caused by Sprinkler Irrigation on Open Flowers*

Information in the first two sections of this bulletin show that (1) flower retention is reduced when sprinkler irrigation or rainwater is applied to open cotton flowers particularly during the morning, and (2) fruiting structure removal approximating flower losses caused by sprinkler irrigations can reduce yields. The yield reductions measured on small plots may not be directly comparable to yield losses in commercial production fields. The yields obtained in fruiting structure removal experiments simulate an extreme case where a large portion of flowers are lost repeatedly on the same area of a field. This does not simulate the real world of center pivot irrigation in production fields. Usually, all white, open flowers are not lost due to sprinkler irrigation (Figure 2) and the same portion of a field need not be watered at the same time of day with each irrigation. The small plot yield data can be applied to production fields in the following fashion.

### Calculating Production Field Yield Reductions

Assume the following conditions: Water is applied twice a week to flowering cotton with a center pivot irrigation system that operates 24 hours a day. All of the white open flowers that receive the sprinkler water application from 8:00 a.m. to 2:00 p.m. (6 hours) are lost. The same part of the field is watered during the morning on every irrigation throughout the season. The average yield reductions measured in experimental plots with all flowers removed two times (treatment 2, field experiments 2, 3, and 4) a week (95.7% of yield potential) are experienced on the part of the field watered in the morning. The rest of the field yields at full (100%) potential since there is no loss of yield potential due to increased flower abortion.

The portion of the field watered form 2:00 p.m. to 8:00 a.m. is three-fourths of the total area of the field watered each day (18 hours out of 24) and this part of the field will yield full potential, i.e., 100 percent (see the wagon wheel effect in Figure 13). The part of the field watered from 8:00 a.m. to 2:00 p.m. is one-fourth of the daily portion watered (6 hours out of 24) and this area of the field will yield at just 95.7 percent of full potential because of reduced flower retention caused by the sprinkler irrigation. Calculation of the entire field yield is as follows:

$$\text{(100\% yield on 3/4 of field)} + \text{(95.7\% yield on 1/4 of field)} = 98.9\% \qquad (1)$$

Lint yield loss caused by water on open cotton flower two times a week is only 1.1 percent. Again, this represents the extreme case. The same calculation for

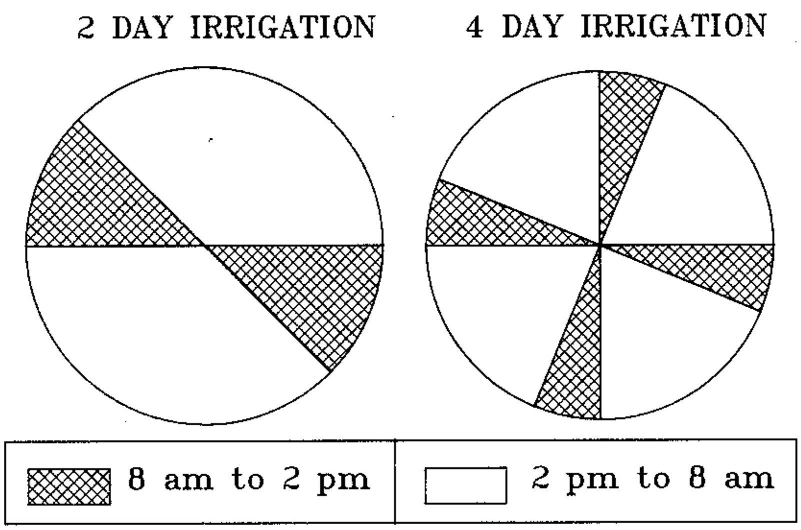


**Figure 13. Areas of center pivot irrigation system covered between 8:00 a.m. and 2:00 p.m. when complete revolution of system takes 2 or 4 days. Shaded areas in both cases are 25 percent of the field.**

irrigation 1 and 3 times a week will be, again using data from Table 4:

One irrigation a week:

$$(100\% \text{ yield on } 3/4 \text{ of field}) + (97.5\% \text{ yield on } 1/4 \text{ of field}) = 99.4\% \quad \textbf{(2)}$$

Three irrigations a week:

$$(100\% \text{ yield on } 3/4 \text{ of field}) + (88.2\% \text{ yield on } 1/4 \text{ of field}) = 97.0\% \quad \textbf{(3)}$$

These yield losses from sprinkler irrigation on open cotton flowers could be reduced or eliminated by not watering during the morning and early afternoon. But this would require that a sprinkler be turned off about one-fourth of the time, thus reducing the effective delivery capacity of the system for any extended period of time by one-fourth. Few sprinkler systems in the Midsouth have sufficient capacity to be off one-fourth of the time and still meet the water needs of the cotton crop during dry summer months. Therefore, turning off a system to improve yields by reducing flower shed associated with morning watering could easily reduce water applications sufficiently to induce yield losses due to water deficiencies. Yield losses from 100 percent of a field caused by an insufficient supply of water could easily be much larger than any yield gained by improving flower retention and yield on the fraction of the field watered during the morning.

### Minimizing Affect of Reduced Flower Retention Caused by Morning Irrigation

Staggering irrigations so that a single area of a field is not sprinkler irrigated during the morning on sequential irrigations can reduce yield losses in some cases. For this explanation, assume the same field conditions as used in the proceeding section. Irrigating once a week in the morning and early afternoon over the same location can reduce whole field yields by 0.6 percent (Equation 2, 100 − 99.4 = 0.6). Irrigating twice a week in the morning and early afternoon can reduce whole field yields by 1.1 percent (Equation 1, 100 − 98.9 = 1.1). Staggering two irrigations to cover different areas of a field will double the area irrigated in the morning and early afternoon but the field loss on that larger area will be only 0.6 percent, that yield was experienced by once a week irrigation. The net effect on yield is very small because the area experiencing decreased flower retention is doubled and the yield decrease experienced is approximately halved from 1.1 percent to 0.6 percent.

It is possible to stagger irrigations such that an area of the field would be irrigated from 8:00 a.m. to 2:00 p.m. (6 hours or one-fourth of day) once each four irrigations or once every 2 weeks with two irrigations a week. This may eliminate the effect of reduced flower retention on yield but no information is available to support or reject this option.

When sprinkler irrigations are made three times a week, some gains can be made by staggering irrigations. The total losses from irrigating one or two times a week from 8:00 a.m. to 2:00 p.m. on a larger portion of the field are less than the losses from three irrigations a week over the same area from 8:00 a.m. to 2:00 p.m.

It may be possible to avoid or substantially reduce this problem by not watering during the mornings only during the first 10 to 15 days of flowering and watering throughout the day the rest of the season. This is probably the best solution for the following reasons.

Percent retention of blooming cotton flowers is highest early in flowering and is lowest after peak bloom. Not watering in the morning during early flowering will allow the plants to keep most of the fruit setting at that time. This will help assure an early boll load. This high boll retention period occurs when plants are still small, resulting in a daily water use that is less than needed when plants are near full size. Irrigation systems are designed to meet the water requirements during the highest demand period. With the smaller water demand during early flowering, it should be possible to turn a system off for one-fourth of the day and still meet the crop water requirements. Late in the bloom period, flower retention is usually naturally low if early boll set has been good. Watering during the morning at this time will still reduce boll retention but since retention is low at this stage of development, the total loss of bolls is very small. Crop water demand is highest late in flowering and at this time it would not be advisable to turn a system off in the mornings.

## Conclusions from Research

**(1)** Applying sprinkler irrigation water to white open cotton flowers reduces retention of those flowers. This effect is most severe during the early morning, just as flowers are opening. Rainfall has a similar effect.

**(2)** Flower losses similar to those induced by sprinkler irrigation can reduce experimental plot yields by 5 to 13 percent with a 1 to 2-day delay in maturity (60% open).

**(3)** Calculations based on research results indicate that the effect of flower loss from sprinkler irrigation on yields of production fields is 3 percent or less and could be easily be held to less than 1 percent.

## Suggestions for Producton

(1) Do not turn off sprinkler irrigation systems during morning hours if there is any concern about maintaining an adequate supply of water to the crop.

(2) It may be acceptable to avoid irrigation during morning hours in the first 10 days of flowering when boll retention is high and water demands are still moderate because of the small canopy size.

(3) If a system must be turned off for maintenance or other unavoidable reasons, shut down during the morning.

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