Chapter 6

EFFECTS OF HIGH TEMPERATURE AND CONTROLLED FRUITING ON COTTON YIELD

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INTRODUCTION

The fruit load is the primary cause for mid-season decreases in fruit retention and flower production—commonly called cut-out. (Ehlig and LeMert, 1973; Tugwell and Waddle, 1964). Temperature affects the rate of fruit development by determining metabolic rates and, in turn, the interval between flower opening and boll opening. This chapter addresses two factors: (1) the limiting effects of high temperature on the fruiting capacity of cotton (*Gossypium hirsutum* L.) and (2) studies on lengthening the boll retention period by limiting cotton fruiting to maintain a constant rather than cyclic fruiting pattern.

TEMPERATURE

With increases in average daily temperature, the plant metabolic rate increases and the time interval between flower opening and boll opening decreases. In the High Plains of Texas, Gipson and Joham (1968a) showed that low night temperatures or a combination of low night and low day temperatures increased the time for development and fruiting of cotton. Their primary concern was with the adverse effects of low temperatures on lengthening the fruit development period (See Chapter 5). In the Imperial Valley, the primary concern is with the adverse effects of high temperatures on shortening the boll development time and, thereby, limiting the fruiting capacity.

For the first fruiting cycle of cotton, the average time interval between flower opening and boll opening is about 60 to 65 days in the Texas High Plains, 50 to 55 days in Mississippi or California's San Joaquin Valley, and 40 to 45 days in California's Imperial Valley. During this period a boll must gain its entire dry weight and mature the seed and lint.

In Figure 1, a typical relationship between boll dry weight and time for three

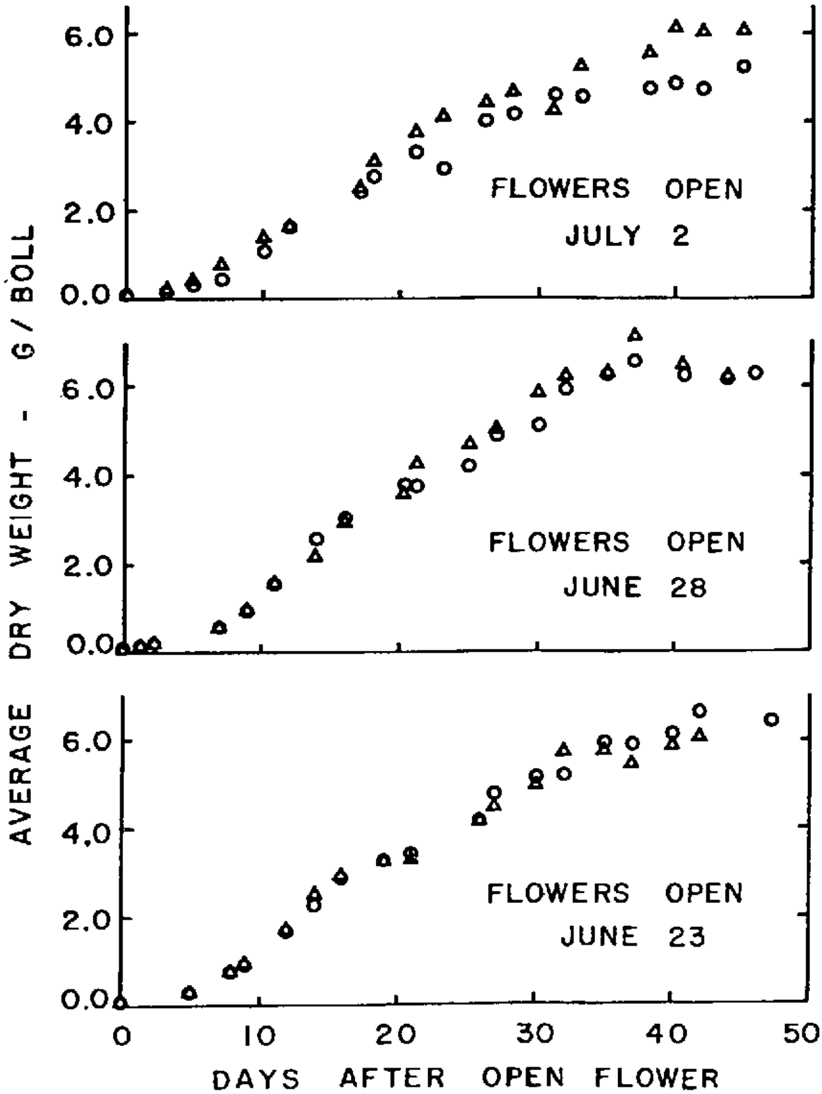

Figure 1. Average boll dry weight, in grams, as a function of days after flower opening for Deltapine 16 cultured on single (o) and double (Δ) row beds. (Proceedings 1972 Beltwide Cotton Production Research Conferences, pg. 42).

flowering dates is shown for Deltapine 16 at Brawley California. Boll dry weight gain was similar for double or single row beds with 1 meter between centers. The three dates bracketed the ranges in medium to high flowering rates and high to low boll retention rates. For an individual cotton boll, the daily gain in dry weight was greatest and nearly constant between days 6 and 32. Baker and Hesketh (1969) showed a similar type relationship with Deltapine Smooth Leaf in Mississippi, except that the time period was longer. In our tests, about 80 percent of the final boll dry weight was seed cotton and 20 percent was carpel and receptacle tissue.

The shorter the time period between flower opening and boll opening, the more photosynthate is required per day per unit of boll or fruit production. Since potential solar irradiation is very similar across the Cotton Belt during the major period of boll production, the maximum potential fruit load is inversely related to the photosynthate required/boll/day or with the average daily temperature. Based on the photosynthate required/boll/day, the upper limit of cotton fruiting capacity during the first fruiting cycle seems to be about 2240 to 2520 kg/ha (4 to 4½ bales/acre) in the Texas High Plains, 1960 to 2240 kg/ha (3½ to 4 bales) in the San Joaquin Valley and Mississippi, and 1400 to 1680 kg/ha (2½ to 3 bales/acre) in southeastern California and southwestern Arizona (See Chapter 16). This assumes that plants completely cover the soil surface before the fruit load completely represses vegetative growth. The highest yields from the first fruiting cycle in the Imperial Valley have occurred when early spring temperatures were higher and late spring and early summer temperatures were lower than normal.

In past years, valleys in southeastern California and southwestern Arizona have recorded yields of 2240 to 2520 kg/ha (4 to 4½ bales/acre), but this was for total yield from two fruiting cycles, and it was before the current pink bollworm (*Pectinophora gossypiella*) invasion and subsequent secondary problems with cotton leaf perforator *(Bucculatrip thurberiella)* and tobacco budworm *(Heliothis virescens)*.

Researchers have studied, and are currently studying, cultural practices to complete cotton production by early September and, thereby, minimize the numbers of overwintering diapausing larvae of the pink bollworm. Present emphasis is to alter the spacial planting configurations from standard practices to obtain early coverage of plants over the soil surface and obtain earlier crop maturity of the first fruiting cycle.

What is really needed to increase yields in the lower elevation valleys of southeastern California and southwestern Arizona is an additional 10 to 20 days in the time interval for development from flower opening to boll opening to fully utilize the long summer season. Such a cultivar would produce a potential yield of 2240 kg/ha (4 bales/acre), or more, from one fruiting cycle and still permit termination of pink bollworm-susceptible fruiting structures by early September. It would also delay cut-out until September, which would limit the number of fruiting structures produced during the critical diapausing period for pink bollworm and would discourage farmers from attempting to obtain a second fruiting cycle. This suggested cultivar would only be adapted to hot climates like the lower elevation valleys of California and Arizona. It should also possess the same efficiency for converting photosynthate to seed cotton and lint as present cultivars.

I am not aware of a sufficient range in genetic variability for this character, nor have I heard of a chemical treatment that will decrease the boll development rate without adversely affecting photosynthate conversion efficiency. Plant breeders should seek a genetic factor or factors for this character.

CONTROLLED FRUITING

During 1968 to 1970, studies were conducted to test a hypothesis that seed cotton and lint yield would be increased by limiting boll retention during the early period of high boll retention and thereby lengthen the period of boll retention. This would prevent mid-season cessation in fruiting and flowering, or at least delay it, with resultant higher early season yields.

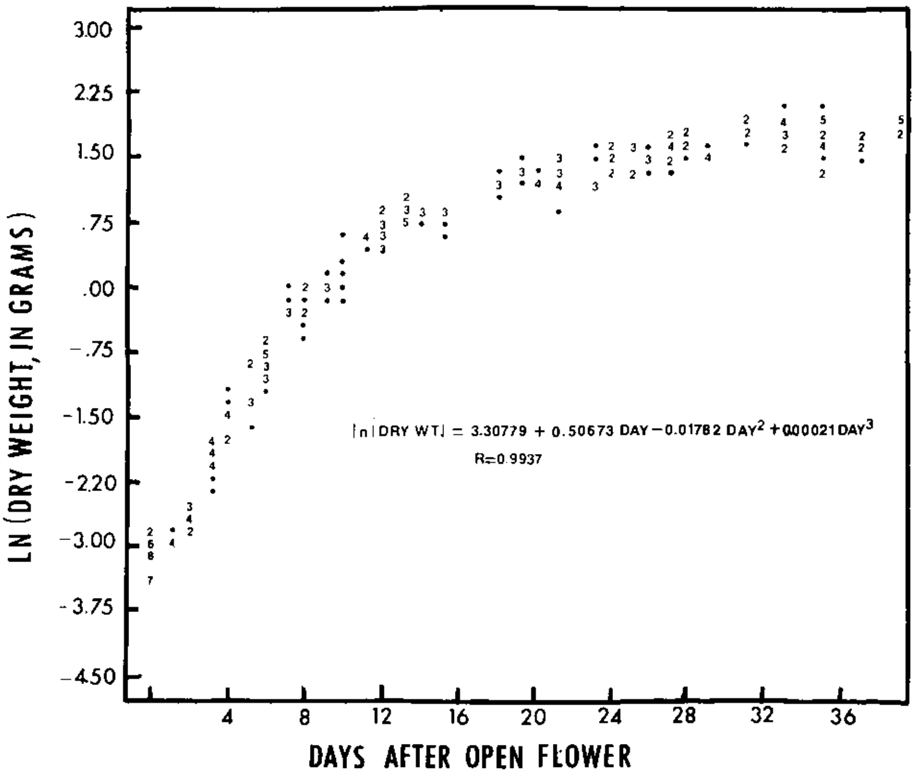

Figure 2. Ln (boll dry weight, in grams) as a function of time after flower opening during the first fruiting cycle for Deltapine 16 cultured at Brawley, California, in 1969, 1970, and 1971. (Numbers within the graph indicate the number of samples with the same average).

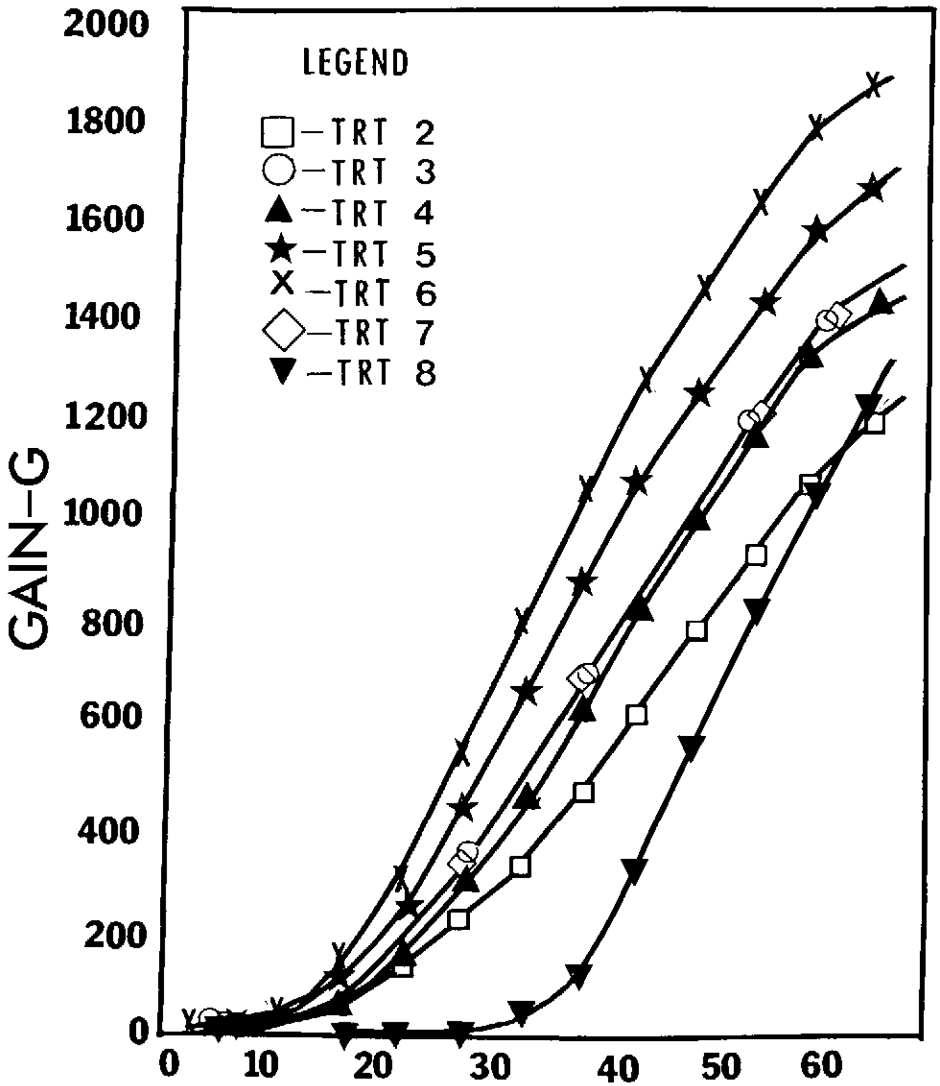

Figure 3. Average cumulative gain in boll dry weight in a 4-m length of Deltapine 16 under seven different fruiting treatments in 1969. Fruiting was graded from normal in treatment 6 to the most limited in treatment 2. Treatments 7 and 8 were alternate weekly flower removal and delayed date to first fruit retention, respectively.

Open flowers were counted daily and either tagged or removed (by hand) to obtain different levels of fruit loading. Retained bolls were counted after opening and each boll's date for flower opening was recorded to obtain curves for daily boll retention and cumulative boll retention for each treatment. A logarithmic regression between net dry weight gain and time after flower opening was determined. (Figure 2). From this relationship, estimated daily net dry weight gain and cumulative dry weight gain were computed for each treatment. Sample data from the 1969 studies illustrated the general conclusions for the project. Deltapine 16 was planted in single-row beds on one meter centers. Fruiting was graded from most limited in Treatment 2 to normal on Treatment 6. Treatments 7 and 8 were variations of alternate weekly flower removal and time to first retention. First flowers occurred in early June.

For the first 60 days after initial flower opening, cumulative boll retention was highest with normal fruiting and decreased with increase in fruit limiting. Net dry weight gain in fruit was increasingly depressed by limiting fruiting. The highest net fruit gain per day was about 140 kg/ha (125 pounds/acre) on the normal fruiting treatment. Cumulative dry weight gain was greatest with the natural cyclic fruiting pattern of Treatment 6 (Figure 3). In general, each increase toward smoothing the fruiting pattern was at a cost in lint yield. In 1970 a constant flowering and fruiting pattern was achieved, but with a considerable reduction in yield.

In 1969, massive insecticide applications prevented continued tagging beyond 63 days after initial flowering, but the tests were long enough that the hypothesis could be evaluated. Plants with normal fruiting started their second flowering cycle by about day 70. Hence, the cumulative gain for altered fruiting cycles should have exceeded that for normal fruiting by day 70. This could not have occurred. Had the tests favored limited fruiting, a genetic or chemical means would have been sought to control fruit retention.

SUMMARY

High temperatures limit the fruiting capacity of cotton in hot climates like southeastern California and southwestern Arizona. The high temperatures increase the plant metabolic rate, increase the photosynthate requirement per day per unit of ultimate yield, and decrease the time interval between flower opening and boll opening. Higher seedcotton yields per fruiting cycle appear obtainable from cultivars with 10 to 20 additional days between flower and boll opening.

Studies were conducted to determine if seedcotton yields could be increased by limiting daily fruit retention so that plants did not cease vegetative growth and fruiting during mid-season, as occurs naturally. Altered fruiting patterns prevented mid-season cessation of vegetative growth and fruiting but also produced lower seed cotton yields than the natural fruiting cycle.