COTTON PLANTS I HAVE KNOWN

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Introduction

I devoted my career to studying the factors which limit production of the cotton crop. As a perennial shrub the cotton plant is an open ended system for capturing sunlight and converting into seed. It is open ended because it makes wood as well as fruit, as all perennials do. The factors which determine the productivity of the crop are the initiation of flowering sites and the environmental influences on the maturation of those sites.

Floral Initiation

The first question I asked was "Where do the flowers form?" Mauney and Ball (1959) established that at each node on the plant one (and only one) axillary branch is developed (Fig. 1). If the branch is vegetative the axis behaves just like the vegetative terminal of the stem. If it is floral the branch has a single leaf before the apex of the branch converts to a flower. This conversion is by means of altering the leaf-and-two- stipules mode of a vegetative node into the three bracts of the square. Ordinarily this conversion occurs at the fifth to seventh node of the stem. Those nodes are being developed at the terminal when the plant has only two true leaves as a seedling (Fig. 1).

The fact that the flower consumes the apex of the branch promordium means that that axillary is terminated. The flowering branch continues to length by the developmet of the axillary at the base of the subtending leaf of the flower. Thus the sympodial. Zig zag, character of the cotton flower branch.

If the signal to flower is not strong for genetic or environmental reasons, the flower may be malformed in such a way that a fourth bract is added to the ordinary three. This malformation may make the four-bract squares vulnerable to shed.

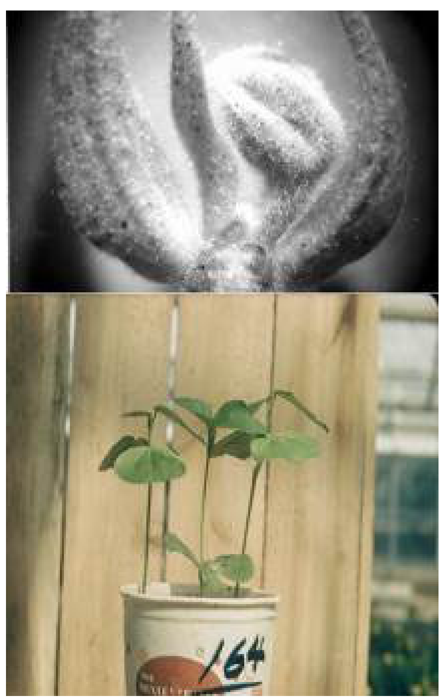

Figure 1. Seedling with two true leaves. At this stage the plants are transistioning to floral initation.

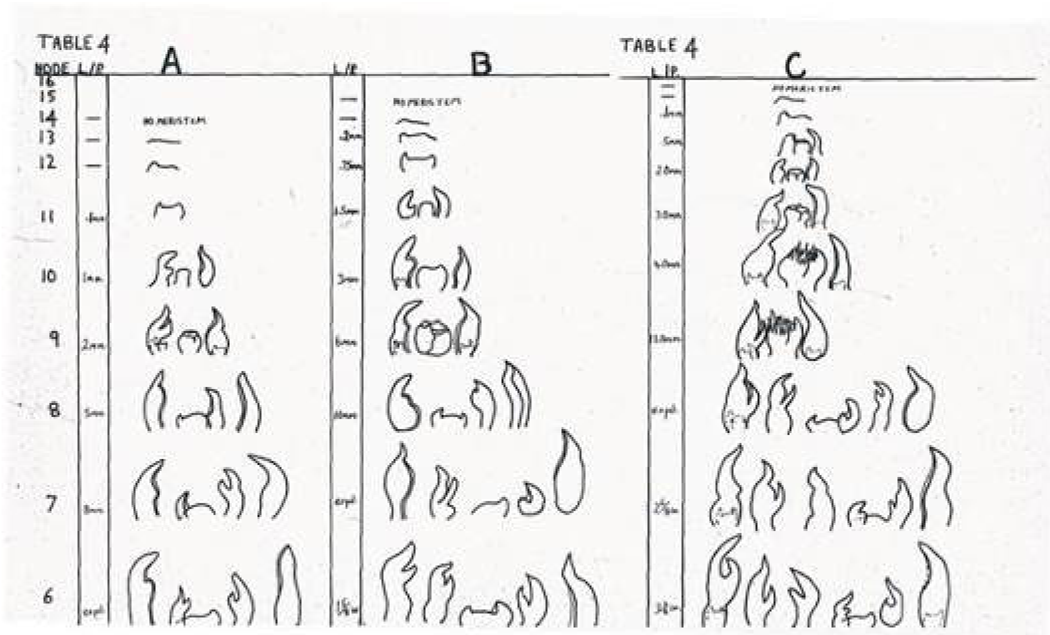

Figure 2. Depiction of the transition from vegetative branching to flower branching. In this depiction the axillary of the 8th main stem node is vegetative and the axillary of the 9th node is floral.(From Mauney, 1968)

Figure 3. Typical sympodial branch.

INTERACTION OF DAY AND NIGHT TEMPERATURE ON NODE OF FLORAL INITIATION.

Night Temperature (° C.)	Day Temperature (°C.) 22	25	28	32
	Node	of first	floral	branch
32	13.0	13.0	16.6	24.5
28	8.7	9.5	8.8	11.7
25	9.1	8.7	8.7	8.5
22	9.0	8.5	7.6	7.3
20	8.9	8.7	7.3	7.2

Figure 4. Node of the first flowering branch when seedlings were exposed to various day and night temperatures (From Mauney, 1966)

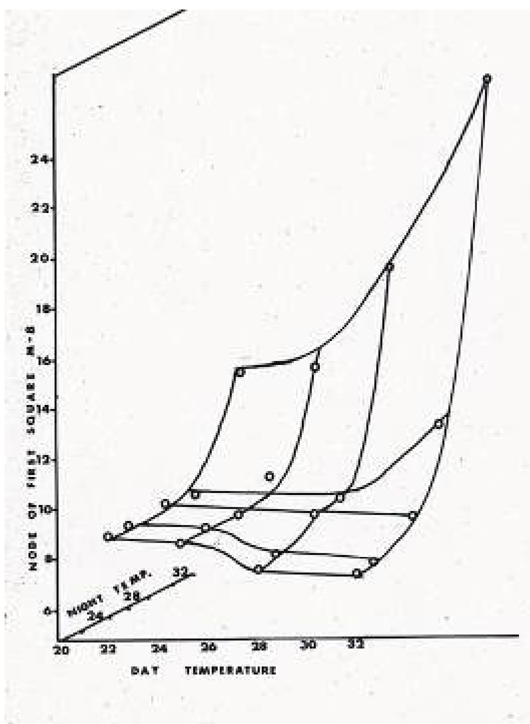

Figure 5. Graphical depiction of the data in Figure 4

A plant that taught a lot about the flowering habit of cotton was an individual from the species *G. aridum* (Fig. 6). This species is a member of the D species from the deserts of central America. When it flowers, its blossoms open progressively backwards down the stem. This means that in the genus there are examples of flower buds which remain dormant until the flowering signal is strong. This trait is observed in Upland cotton when the first flower is delayed in blossoming until after the second flower has opened.

Figure 6

<u>Shedding of Squares</u>

Figure 7. Squares with three and four bracts.

Figure 8. A severe case of square shedding that happened in California about 1969. Reasons for the shed were difficult to assign after the season.

Square shedding is always a threat to productivity. The reasons for the shed may be difficult to determine by casual examination of the plant. Therefore when plants in my experimental plots showed excess square shed in 1975, I sought to determine to possible cause. The flower counts in July,1974 exceeded 100 flowers per 40 feet of row, while they rarely exceeded 20 per 40 row-feet during July, 1975. Examination of the temperature patterns of the two years showed no dramatic differences (Fig. 10). However, the population counts for plant bugs (Lygus sp.) in 1975 were consistently higher than 1974. That lead me to develop a visual technique by which I could distinguish insect damaged squares from those shed for physiological reasons (Fig. 11).

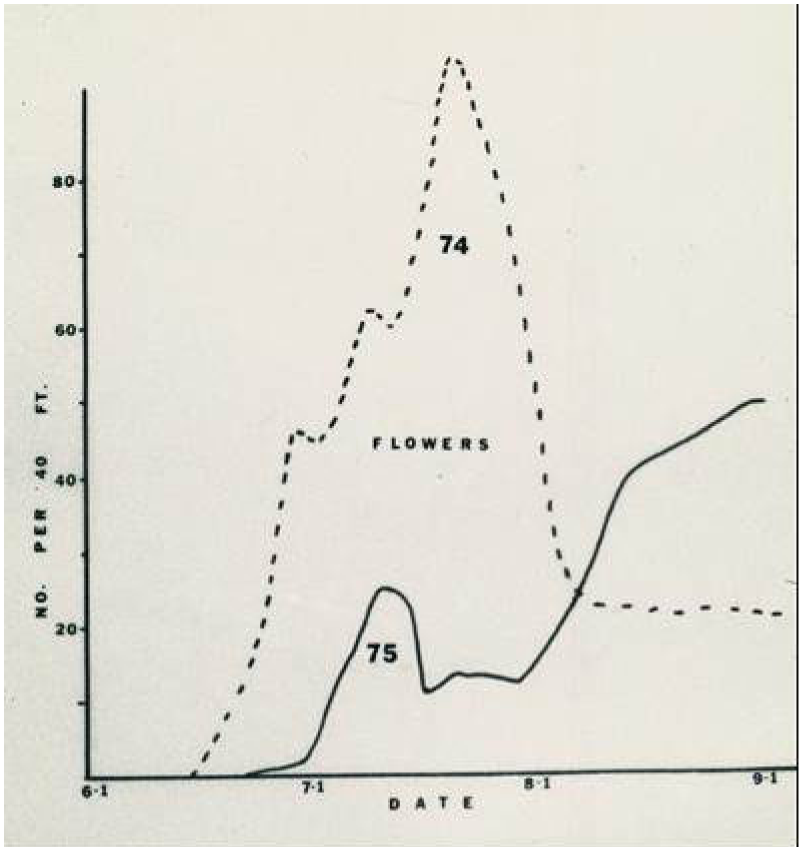

Figure 9. Flower counts as the season progressed in 1974 and 1975 in experimental plots on the Universty of Arizona Cotton Research Center in Phoenix

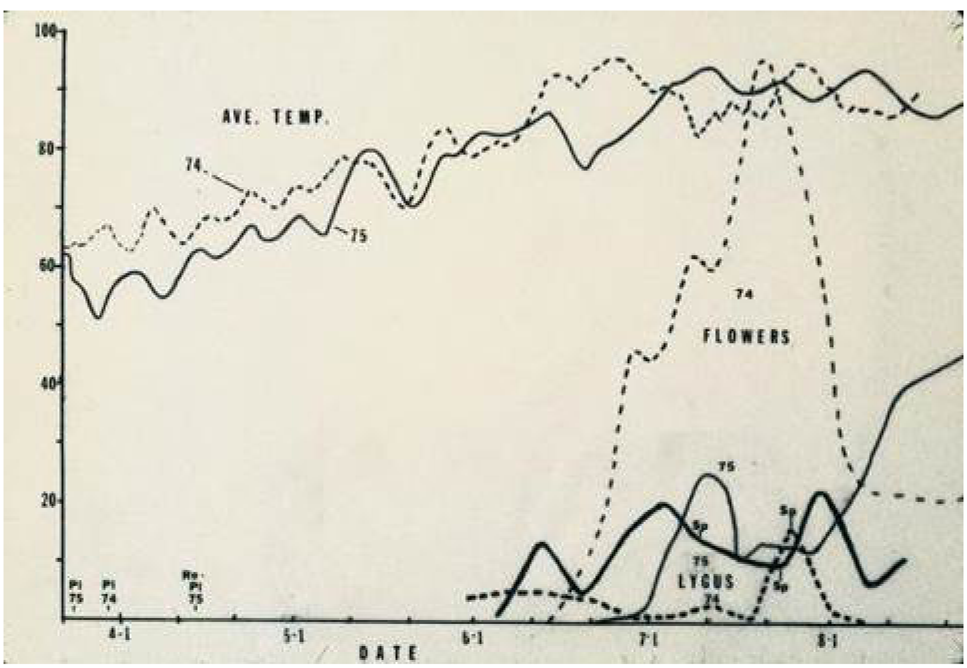

Figure 10. Temperature and plant bug populations in fields of the Cotton Research Center in 1974 and 1975 compared to the Flower counts in those years.

Figure 11. Test system for developing a visual measure to determine square by plant bugs (Lygus sp)

Figure 12 Young squares fed upon by plants bugs are easily identified by the total destruction of the developing ovary and anthers.

Almost 90 percent of shedding in June and early July was caused by insects. The rot observed is caused by thrips feeding. The fourth bract of four-bract squares does not seal the bud sufficiently to prevent thrips entry during the time when the floral meristem is vulnerable. Thrips feeding introduces the rot bacteria. To demonstrate that this could also be true in three-bract squares if they were similarly exposed I trimmed a portion of a bract so that it no longer protected the flower meristem. Those squares also showed rot symptoms (Table 1).

Table 1 Observed soft rot in square in which the end of a bract was removed compared to squares with the bract intact.

Soft Rot in "Clipped Bract"

Squares

Date Treated	7/17	7/23	7/27	7/27	8/2
Rotted / Treated	2/11	9/21	5/13	4/13	7/21
Untreated	0	0	0	0	0

The controversy regarding the effect of plant bug injury on yield was settled when the yield plateau of the 1960's and 70's was reversed in 1980 when plant bugs were taken more seriously (Fig. 13).

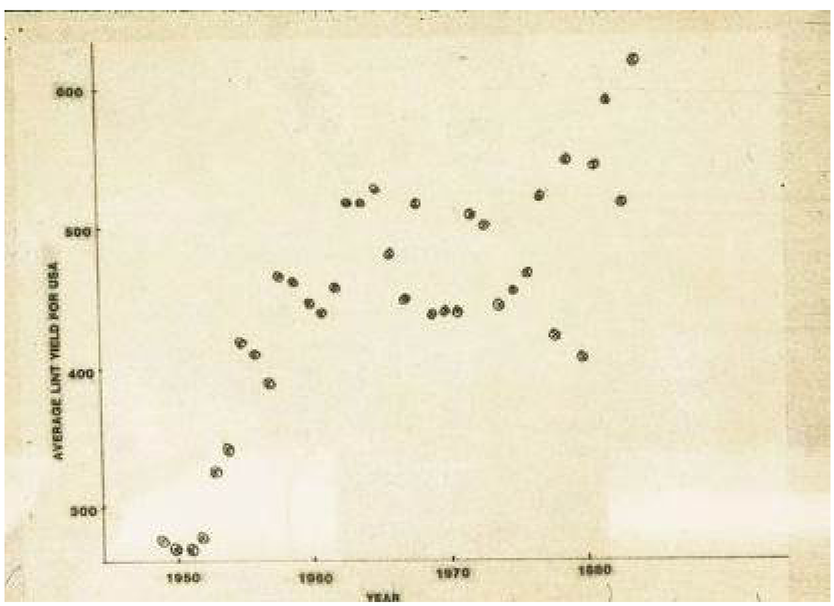

Figure 13

Figure 14

One of the effects of severe insect damage is plants which los e the terminal growth point and do not assume a central stem. These are often referred to as "Crazy Cotton".

In order to be classified as "Crazy" in my opinion, the plant must not only have lost its growing point and have two or more vegetative stem. It must also have a central group of disorganized stem and leaves which continue producing malformed structures (Fig 14). I have observed that the apical meristem of these plants is infested by a group of thrips who continue to prune the unprotected meristem and prevent it from developing a plumule of developing leaves which ordinarily keep thrips from attacking the tender meristematic dome.

That photosynthesis determines productivity is obvious. Factors that limit photosynthesis are not always obvious. In experiments using "specific leaf weight" (SLW) to track starch accumulation in leaves (Fig 15) It was found that SLW increased during the afternoon each day (Fig 16) and that this accumalation of starch and water stress seemed to inhibit photosynthesis during afternoon hours. The SLW returned to base level by midnight to be repeated the following day. (Hendirx and Mauney)

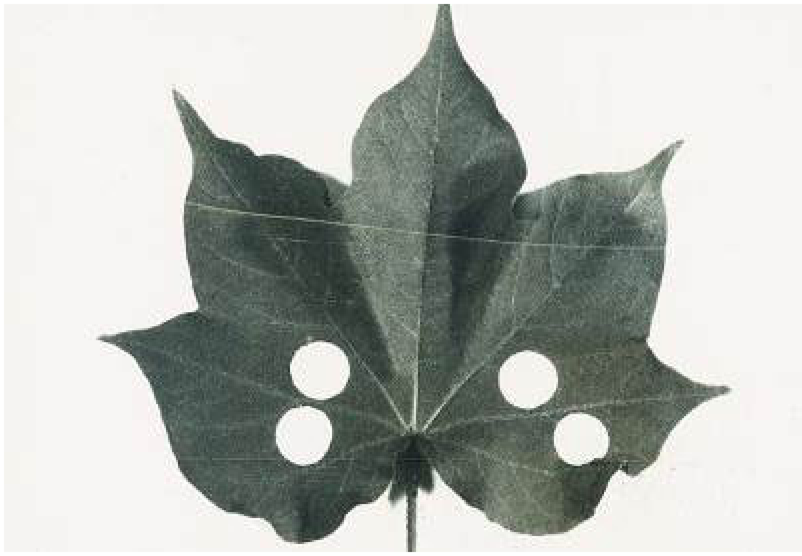

Figure 15. Leaf from which tissue punches have been taken to measure "Specific Leaf Weight"

SLW CHANGES DURING DAY

TIME	0600	1000	1400	1800	2200
AVE WT (mg)	7.4	7.4	9.1	8.7	7.7
% CHANGE	0	0	+22	+17	+4

Figure 16. Changes in the Specific Leaf Weight (SLW) of cotton leaves during a day. These weights reflect the build up of starch in leaf tissues.

The "Cutout" Phenomenon

As production practices have enabled the crop to retain most of its fruit, the phenomenon of "cutout" has become a benchmark of the completed season. Cutout is the cessation of growth and flowering and may occur when the plants have 10 to 25 nodes depending on cultivar and growth conditions. Though cutout can be seen as a limitation to yield because it terminates flowering, it is a management tool to aid in harvesting the crop.

Cutout is caused by the fact that with the onset of flowering the carbohydrates are diverted from vegetative production of roots and leaves to the maturation of fruits with seed. Rate of flower blossoming starts to exceed the production of new flowering sites (Fig.17) and the Cessation of flowering must ensue once the reservoir of developing squares is exhausted.

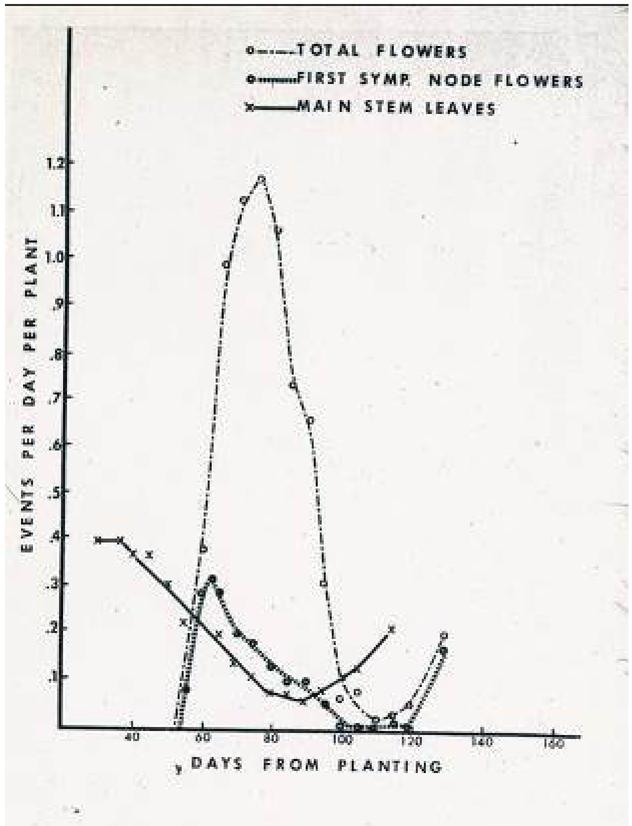

Figure 17. Production of main stem leaves and first position flowers during a season.

When plants were exposed to higher level of carbon dioxide, the greater photosythesis delayed cutout but did not increase vegetative growth rate (Fig 18). This shows that vegetative growth limited by translocation of carbohydrates while cutout is determined by the ability of roots to remain active due to the additional storage of carbohydrates.

In1989-1991 in cooperation a great many entities (see Mauney et al 1994) an irrigated field in Maricopa, Arizona was exposed to controlled level of CO2 enrichment through a series of vertical vents in an open field (Figure 19). This enabled an estimate of the increase in productivity of the crop to be expected as atmospheric CO2 increases. The performance of the crop is shown in Fig. 20 and summarized in Fig. 21.

From the data which show a 45% increase in yield from a 45% increase in CO2 concentration (350 to 550 ppm), we can argue that the 45% increase in the atmospheric CO2 between 1940 and today (280 to 400) should have increased the average cotton yield by 45%. The yield has actually increased 250% (200 lbs/ac to 800 lbs/ac). So approximately 20% of the yield increase is due to atmospheric CO2 enrichment. The remainder is due to improved cultural practices or improved genetic material.

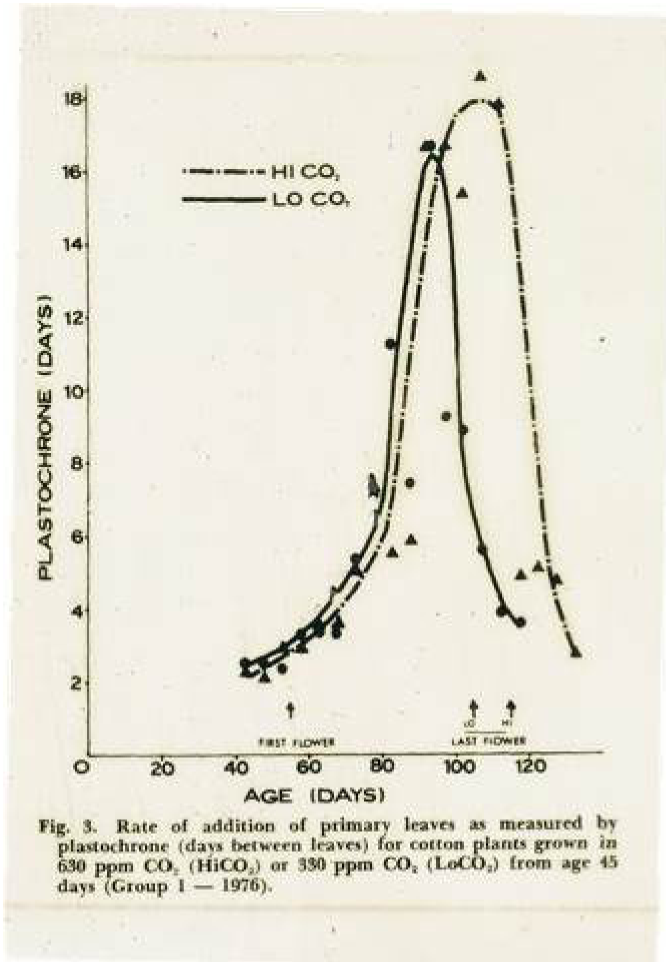

Figure 18. Data from Mauney et al 1978

Figure 19. Aerial view of two of the plots from the Free Air CO2 Enrichment (FACE) study

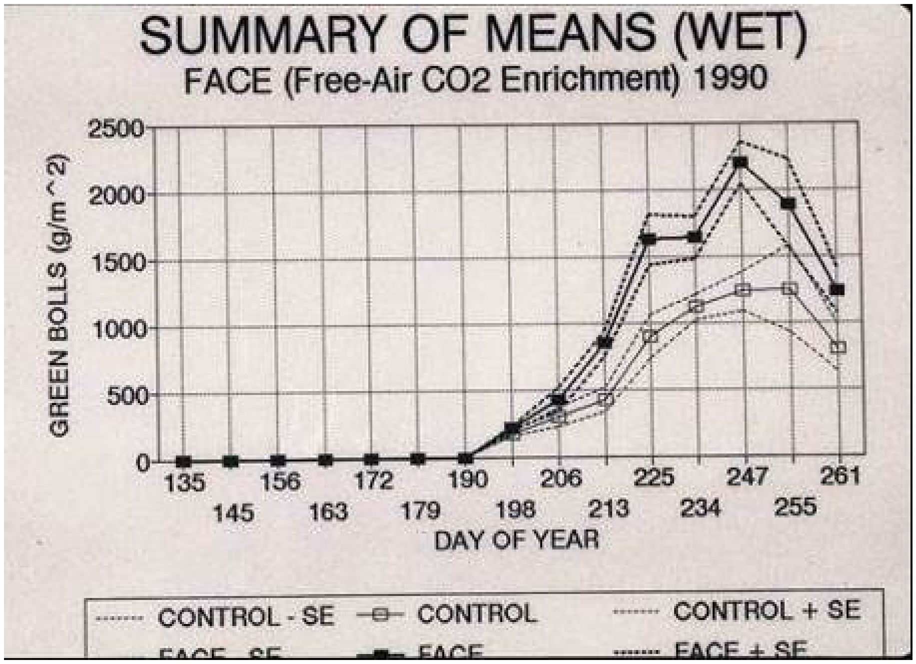

Figure 20. Boll production by irrigated plants with and without CO2 enrichment to the level of 550 ppm.(From Mauney et al 1994)

FINAL YIELD 1991

	FW	CW	F/C	FD	CD	F/C
NO TRAFFIC BOLLS/M^2	174	122	1.43	159	112	1.42
TAGGED ROWS BOLLS/M^2	162	133	1.22	152	113	1.35
DESTRUCTIVE BOLLS/M^2	195	135	1.44	165	115	1.43
TOTAL BIOMASS GM^{2}/M^2	1927	1422	1.36	1501	1148	1.31

Figure 21. Yield from the FACE experiment in 1991. (From Mauney etal 1994)

 

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