ABA and Auxin Contents of Squares and Flowers In Relation to Water Deficit Stress And Subsequent Young Boll Shedding

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ABSTRACT

Water deficit increases boll shedding. Large squares, however, are much less likely to shed, possibly because they contain high concentrations of free and total auxin (indole-3-acetic acid or IAA). Our previous research indicated that much of this IAA disappears by the time the squares open as flowers and the IAA content remains low for about four days after anthesis. If water deficit decreases the IAA content, or increases the ABA content, of squares and flowers, then water deficit before flowering could have a carry-over effect and increase the shedding rate of young bolls that subsequently develop from them. In field plots, water deficit increased the ABA content of flowers as much as 66%. Water deficit first decreased and later increased the concentrations of free and total IAA in squares that were analyzed about three days before anthesis. Flowers contained much less IAA than squares. Despite pronounced effects of water deficit on the IAA content of squares it is unlikely that it had any carry-over effect on the free IAA content of young bolls that subsequently developed from them. Water deficit slightly increased the total IAA content of flowers, but had no effect on their free IAA. Because water deficit increased the ABA content but did not decrease the IAA content of flowers, any carry-over effect of water deficit on young boll shedding might have been from changes in ABA but not from changes in IAA before the young-boll stage.

INTRODUCTION

Shedding of squares and bolls can decrease yield. It has been known for many years that water deficit increases the shedding rate of young bolls. Squares, just before they flower, are much more resistant to stresses and are less likely to shed. Our earlier research showed that moisture stress increased the rate of ethylene evolution from young bolls, increased their ABA content, and decreased their free auxin (IAA) content. All of these hormonal responses should increase shedding.

Large squares, however, contain high concentrations of IAA and are very resistant to shedding just before they reach anthesis (flowering). These high levels of IAA in large squares decrease rapidly to low levels at anthesis and remain at low levels for at least four days after anthesis. Low levels of IAA in young bolls are probably a major reason for the high probability of shedding during the young-boll stage of development.

Even though the squares contain such high concentrations of IAA that they are unlikely to shed, we thought that water deficit might decrease their IAA content so that the subsequent sharp decline in IAA, as squares reach anthesis, would lead to critically low concentrations in flowers and young bolls. Likewise, water deficit might cause ABA to accumulate in squares and flowers. If such changes occur in response to moisture stress, they could have a carry-over effect, and increase the probability of shedding of young bolls that develop from them even after irrigation. To test this hypothesis, we measured the ABA and IAA contents of large squares and flowers through two irrigation cycles.

MATERIALS AND METHODS

A field at the Western Cotton Research Laboratory in Phoenix was fertilized with 167 lbs of 18-46-0 per acre on March 30, 1988. 'Deltapine 77' seeds were planted April 28 in rows spaced 39 inches apart and the soil was irrigated the next day. On May 16, the seedlings were thinned to about three per foot of row to give a population of about 40,000 plants per acre. About 5 inches of water were applied on May 17. Berms were constructed to divide the area into eight plots, each of which was four rows wide by 100 ft. long. Urea was applied on June 21 at the rate of 289 lbs per acre (130 lbs of N) to the high-N plots. No urea was applied to the low-N plots. The plots were arranged in a randomized complete block replicated four times. All plots were irrigated with about 5 inches of water each date on June 2, 25, July 13, and July 28. Rain occurred on July 29 and August 1 (0.34 and 0.2 inch, respectively).

Squares (about three days preanthesis) and white flowers were harvested in each plot from the first node of fruiting branches on June 29, July 7, 12, 18, and 27, and on August 3. Squares were harvested one mainstem node above the fruiting branch with a white flower at the first fruiting-branch node and were assumed to be three days preanthesis. Squares and flowers were rinsed in cold, deionized water, placed in labeled paper sacks, quickly frozen in aluminum pans at -80#C,freeze dried, and stored at -80#Cunder nitrogen until they could be analyzed. Free ABA and free and total IAA were analyzed by HPLC. Water potentials of the uppermost fully expanded mainstem leaf (four per plot) were measured between 12:30 p.m. and 2 p.m. on the day of each harvest with a pressure chamber.

RESULTS AND DISCUSSION

Nitrogen had relatively little effect on ABA and IAA contents of squares and flowers, and results were similar in the high-N and low-N plots. Therefore, only results from the high-N plots will be reported here.

The plants were rather severely stressed before irrigation on July 13 (18 days after the previous irrigation). Leaf water potentials declined to an average of -2.74 MPa on July 12 (day 194, Fig. 1). Stress was not quite as great before the next irrigation on July 28. The average water potential on July 27 was -2.42 MPa.

The free ABA contents of squares and flowers changed during irrigation cycles; as expected, ABA increased with water stress and decreased after irrigation (Fig. 2). The concentration of ABA changed more in flowers than it did in squares, but the changes were not great even in flowers.

Squares sampled about three days preanthesis contained very high concentrations of total IAA. However, response to stress differed from the first to the second irrigation cycle. Total IAA in squares decreased with stress before the July 13 (day 195) irrigation, but increased with stress to a very high level before the July 28 (day 210) irrigation (Fig. 3). We have no explanation for this reversal in response, but it appears real and may be related to time in the fruiting cycle. The IAA content of squares apparently <u>increases</u> with water stress as the plants enter cut-out. In 1987 we found even higher concentrations of IAA in squares at the second fruiting-branch node of stressed plants that had almost stopped flowering.

Stress had relatively little effect on the total IAA content of flowers (Fig. 3). The trend, however, was for total IAA to increase with stress in flowers. This is similar to results we obtained earlier with bolls in which ester IAA increased with stress even though free IAA decreased.

Free IAA in squares responded to stress in much the same way as total IAA; it decreased with stress during the first irrigation cycle, but increased with stress during the second (Fig. 4). These changes, however, probably do not carry over to young bolls because the free IAA content of flowers showed <u>no</u> response to stress and was completely independent of the wide fluctuations in the free IAA content of squares (Fig. 4, dashed line). Flowers contained very much less free IAA than squares, but plant water status had no apparent effect on the consistently low level of free IAA in flowers.

Previous results of Guinn and Mauney, in 1984, indicated that boll retention increased immediately when plants were irrigated. White flowers that were tagged on the day of irrigation showed a much higher retention rate than flowers that were tagged before irrigation. Therefore, it appears that stress before flowering has little effect on retention of the boll that subsequently develops from that square _if_ the stress is relieved by irrigation before the young-boll stage.

Although water deficit increased the ABA content of flowers (Fig. 2) it had no effect on the free IAA content of flowers (Fig. 4). Therefore, we conclude that the pronounced changes in the free IAA content of squares had no carry-over effect on the free IAA content of flowers and young bolls and that there is probably little effect of moisture stress during the late-square stage on shedding of young bolls that subsequently develop after irrigation. If there is an effect, it might be due to the effects of moisture stress increasing the ABA content of squares and flowers. But, because water deficit did not decrease the IAA content of flowers, any carry-over effect on young boll shedding is not likely due to preanthesis changes in auxin.

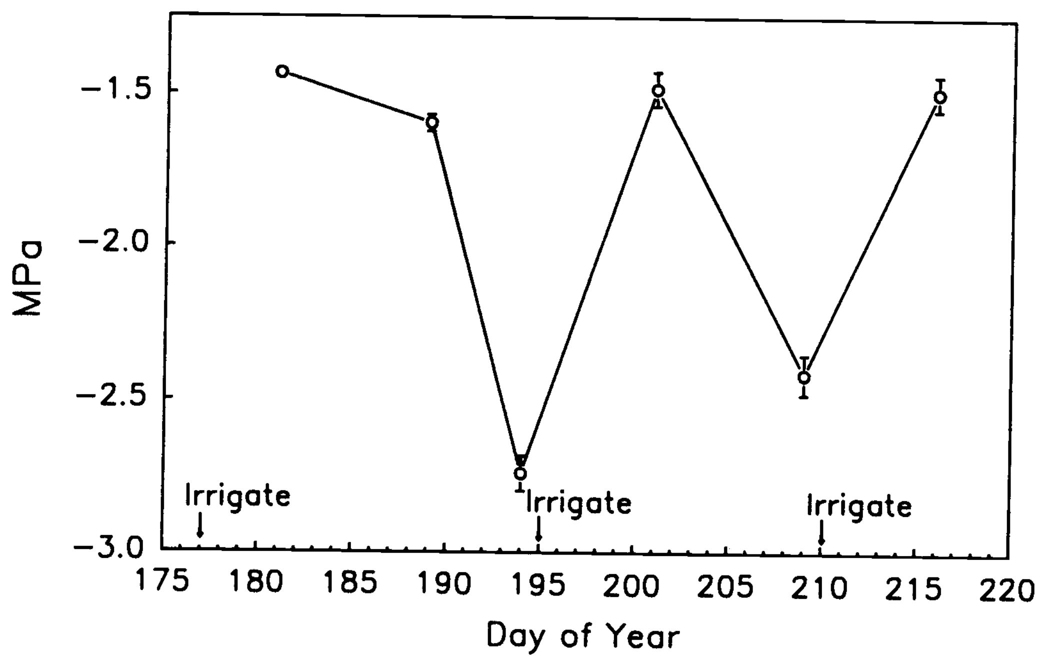

Fig. 1. Midday leaf water potentials.

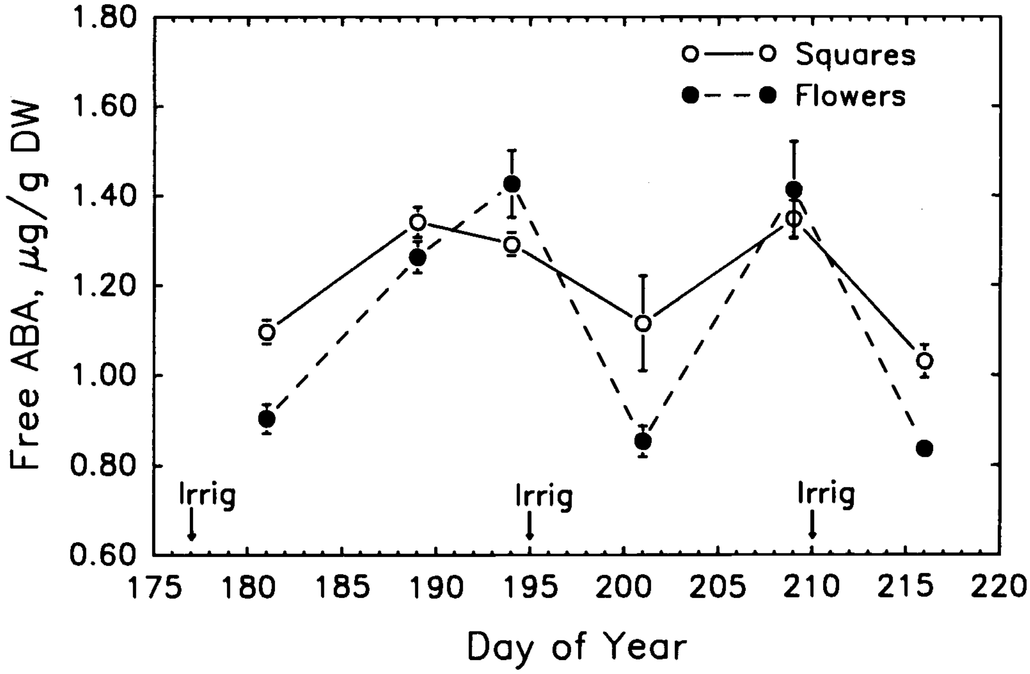

Fig. 2. Free ABA in squares and flowers.

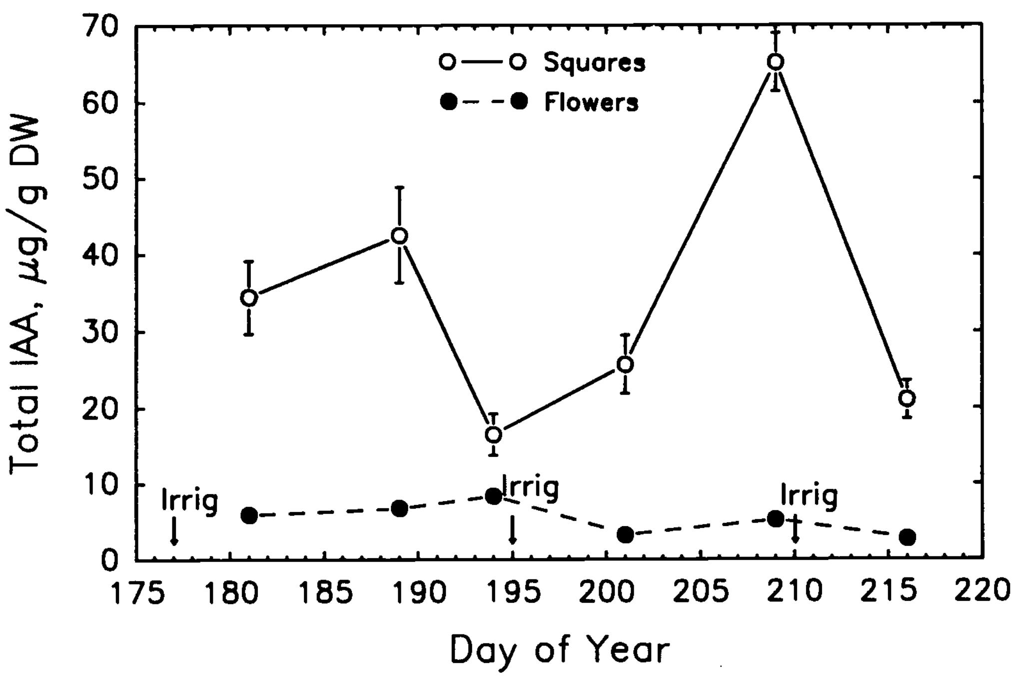

Fig. 3. Total IAA in squares and flowers.

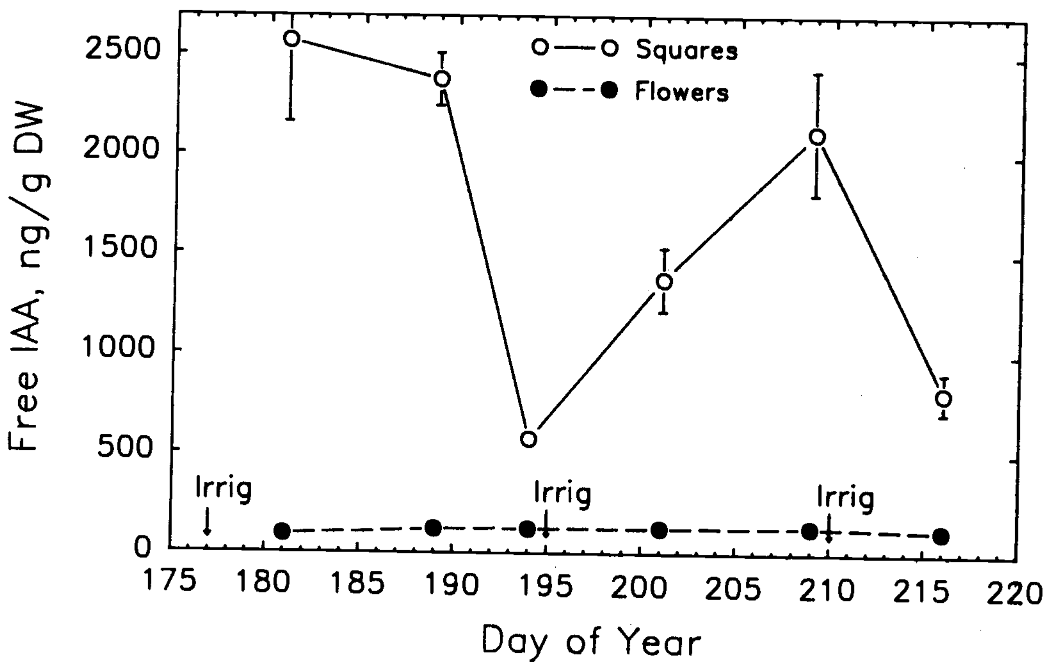

Fig. 4. Free IAA in squares and flowers.