Physiology and Growth Regulation

Changes in Free and Bound Auxin with Development of Squares and Bolls in Relation to Shedding

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ABSTRACT

Hormone analyses were conducted to determine why large squares seldom shed while young bolls do. Large squares contained five times as much free auxin as flowers, and they contained 16 times as much bound auxin. The high auxin content of large squares is probably a major reason that they almost never shed unless injured (for example, by insects). Free and bound auxin both decreased to very low levels at flowering and remained low for four days thereafter. This low concentration of auxin at, and just after, flowering is probably a major reason that bolls are likely to shed during the week after flowering. Both free and bound auxin increased rapidly between 7 and 9 days after flowering, possibly accounting for the decrease in boll shedding rate at this stage of development. Amide-linked IAA was the major form of auxin in squares, whereas ester IAA (presumably bound to sugars) was the major form of auxin in bolls.

INTRODUCTION

Large squares almost never shed during the week before flowering unless they are damaged or injured by insects. But, young bolls are very likely to shed during the week after flowering. Something happens about the time the square opens as a flower that greatly increases the probability that it will shed shortly thereafter. Fortunately, the probability that the boll will shed starts decreasing about a week after flowering and declines to practically zero chance of shedding by 18 days after flowering. We conducted tests to determine what causes these changes in probability of shedding.

Auxin (indole-3-acetic acid or IAA) is the major plant hormone that inhibits or prevents abscission (shedding) of leaves and fruiting forms. It does this by inhibiting the production of hydrolytic enzymes, pectinase and cellulase, that cause weakening of cells in the separation layer in the abscission zone of leaf petioles or fruit peduncles. Conversely, abscisic acid (ABA) and ethylene are plant hormones that stimulate shedding by stimulating the production of cellulase and pectinase. We reported earlier that ethylene production is high for a few days after flowering and then decreases as bolls become more resistant to shedding. We recently determined changes in ABA and IAA from 9 days before flowering to 9 days after flowering. Squares that were 9, 6, and 3 days preflower; white flowers; and bolls that were 2, 4, 7, and 9 days old were all harvested the same day, freeze dried, and stored under nitrogen at about 120ł below zero until they could be analyzed for free and bound ABA and IAA.

RESULTS AND DISCUSSION

Squares contained high concentrations of free IAA and exceptionally high concentrations of amide IAA 6 days before flowering (Table 1). These high concentrations of free and bound auxin probably prevent the synthesis of the hydrolytic enzymes that weaken cell walls; therefore, they prevent shedding of large squares. There was approximately a 5-fold decrease in free IAA and a 16-fold decrease in amide IAA by the time the squares opened as white flowers. Concentrations of free, amide, and total IAA remained low during the next 4 days (Table 1) while the ABA content increased (not shown). The low concentration of IAA plus the increasing concentration of ABA during this time probably promoted the shedding of young bolls. By 7 days after flowering,

however, the IAA content was increasing faster than the ABA content so that the ratio of ABA to IAA was decreasing. This coincided with a decrease in the rate of boll shedding (Fig. 1), and with an increase in the rate of boll growth (Fig. 2).

Amide IAA was the major form of auxin in squares, whereas ester IAA was the major form of auxin in bolls (Table 1). The decrease in free IAA before flowering did not appear to be caused by conversion to a bound form because ester IAA didn't increase much before flowering, and amide IAA decreased. We don't know what happened to the amide IAA. It may have been incorporated into protein.

Changes in free and total IAA appear to be a major cause of the changes in shedding rate before and after flowering. Large squares and older bolls contain large amounts of IAA (Table 1 and Fig. 2), and they seldom shed. Young bolls, on the other hand, contain little IAA, and they are much more likely to shed. We reported earlier that stresses, such as water deficit or inadequate photosynthate, decrease the IAA content of young bolls to even lower values and cause more of them to shed. The week after flowering is a critical time in the development of each young boll. Its auxin content is naturally low at this stage of development. Therefore, any stress that further decreases the already low level of auxin is likely to cause the young bolls to shed. Large squares or older bolls contain enough IAA to keep them from shedding unless the stress is very severe.

Table 1. Concentrations of free, ester, amide, and total IAA in fruiting forms before and after anthesis (flowering).[1]

Days before or after flowering	Free IAA	Ester IAA	Amide IAA	Total IAA
Days	ng/g	ng/g	ng/g	ng/g
-9	386±20	7 ± 7	6,527± 720	6,920± 723
-6	617±52	0	19,140±1655	19,753±1707
-3	523±42	15 ± 5	11,429±1487	11,977±1522
0	116± 6	79 ± 3	1,164± 118	1,359± 118
2	120± 3	612 ± 15	394± 43	1,125± 48
4	112± 3	716 ± 26	601± 68	1,430± 64
7	152± 2	1,735 ±122	568± 147	2,455± 151
9	240± 5	4,433 ±137	353± 208	5,025± 180

[1] Data are averages of four replications ± SE.

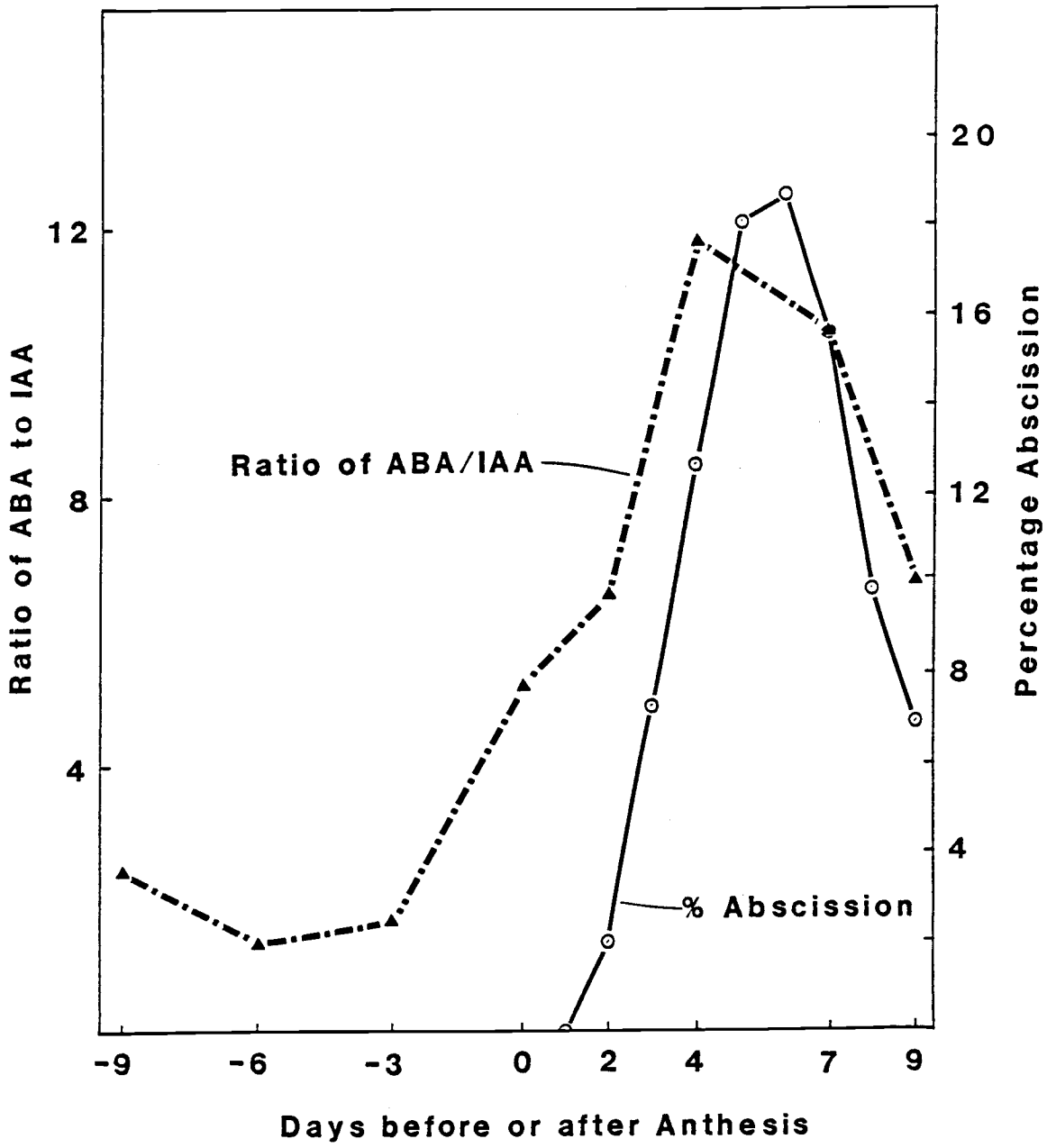

Figure 1. Ratio of ABA to IAA before and after anthesis (flowering) in relation to abscission (shedding) of young bolls.

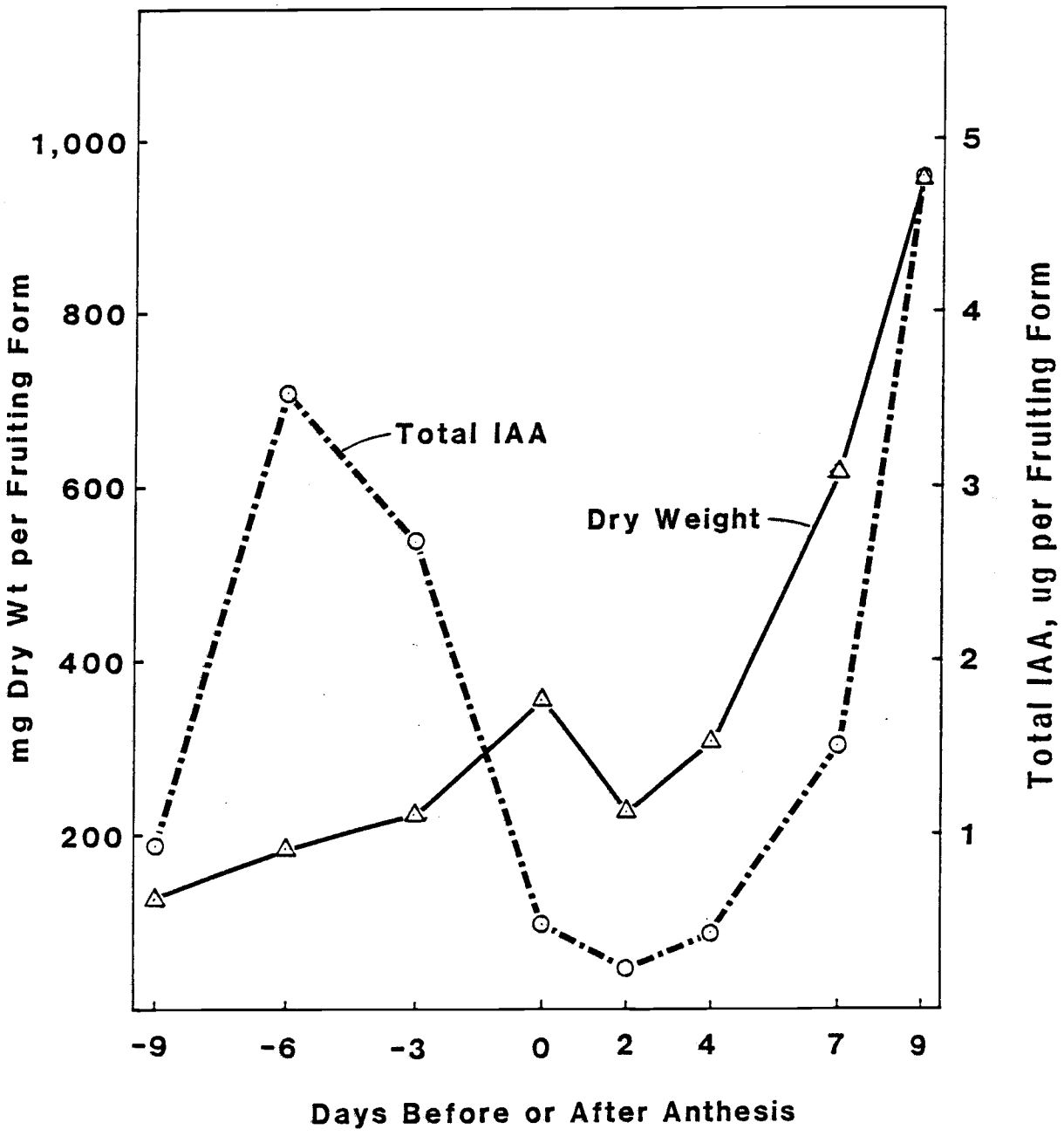

Figure 2. Changes of total IAA and dry weight per fruiting form before and after anthesis (flowering).