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ABSCISSION OF FLOWER BUD PEDICELS IN BEGONIA
II. INTERACTION AND TIME SEQUENCE OF PLANT GROWTH REGULATING SUBSTANCES ON THE ABSCISSION WITH EXPLANTS

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SUMMARY

The influences of indoleacetic acid (IAA), abscisic acid (ABA), and ethylene on the abscission of *Begonia* pedicels were studied by estimating the periods of sensitivity to them and by analyzing their interactions.

Except for the alternation of sensitivity to IAA and to ethylene, the hormones affect the abscission independently from one another.

1. INTRODUCTION

In the first paper of this series (HÄNISCH TEN CATE & BRUINSMA 1973) it was shown that indoleacetic acid (IAA) inhibits the pedicel abscission of intact plants and of explants of *Begonia* cultivars, whereas abscisic acid (ABA) and ethylene promote the process. To obtain a more detailed analysis of these hormonal effects, the present study deals with the interactions between IAA, ABA and ethylene, and with an estimation of the periods in the course of the abscission process during which the process is sensitive to these hormones.

2. MATERIAL AND METHODS

Three *Begonia* clones were selected from the cross (*Begonia cinnabarina* Hook. × *B. micranthera* Griessl) × *B. davisii* Veitch. The growing, preparation, and hormonal treatment of the pedicel explants are described by HÄNISCH TEN CATE & BRUINSMA (1973). Because the sensitivity of the three clones to the hormones is the same (HÄNISCH TEN CATE & BRUINSMA 1973), the three clones have been used in turn.

When hormones were given to the explants several hours after excision, the distal 1 mm of tissue was cut off to enable application to a fresh surface.

The abscission (T_{50}) is expressed by the interpolated time at which 50% of the pedicels had abscised (HÄNISCH TEN CATE & BRUINSMA 1973). The effects of growth regulators were indicated by expressing their T_{50}-values in per cents of those of the controls, values above and below 100% representing retardation and acceleration of abscission, respectively. Per treatment 50 explants were used in at least duplicate experiments.

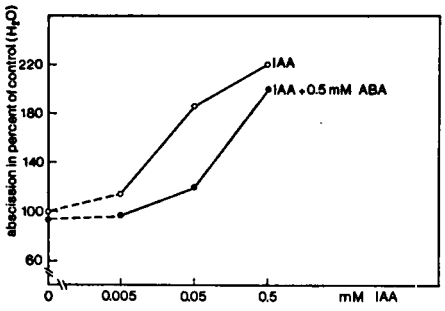

Fig. 1. The interaction of IAA and ABA, distally applied in 2 µl solutions, directly after excision, in the abscission of pedicel explants of clone 2.

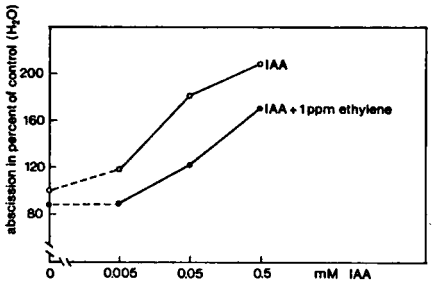

Fig. 2. The interaction of IAA, distally applied in 2 µl solutions, and of 1 ppm ethylene in the gas phase, directly after excision, in the abscission of pedicel explants of clone 2.

3. RESULTS

In a first series of experiments two growth regulators were applied simultaneously to the distal ends of the pedicel explants directly after excision. From the combinations of IAA with either ABA or ethylene (*figs. 1* and *2*), it can be concluded that the retarding effect of IAA is reduced by both substances. The effects of ABA and ethylene are larger in the presence of than without IAA. However, as in the presence of IAA the curves run about parallel instead of diverging, it must be concluded that the hormones influence the abscission process independently of one another.

The simultaneous application of ABA and ethylene results in a mere addition of their separate effects (*fig. 3*).

In a next series of experiments it was estimated during which period of time the different hormones are effective. To obtain the abscission promotive effect of ethylene, the hormone must be present in the gas atmosphere from the sixth hour after excision on, a treatment during the first three or six hours only being ineffective (*table 1*). Only when ethylene is applied after nine hours, its promotive effect is considerably reduced (*fig. 4*). Therefore the explants become sensitive to ethylene between six and nine hours after excision, the presence of the hormone earlier than six hours after excision does not influence its action in the sensitive period.

IAA, when applied directly after excision, postpones the sensitivity to ethyl-

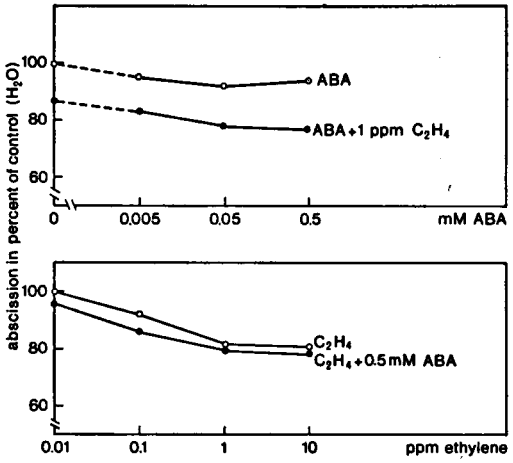

Fig. 3. The interaction of ABA, distally applied in 2 µl solutions, and of ethylene in the gas phase, directly after excision, in the abscission of explants of clone 2.

Table 1. Effect of interval between excision and ethylene treatment, alone and in combination with 2 µl ABA or IAA applied distally directly after excision. The T_{50}-values are expressed in per cents of the control values given between ( ). (clone 2).

1 ppm ethylene from	–	ABA 5.10^{-4}M	IAA 5.10^{-4}M
0–3 hrs	100 ± 3	100 ± 2	100 ± 3
0–6 hrs	99 ± 2	102 ± 2	101 ± 3
0–9 hrs	81 ± 6	89 ± 4	104 ± 4
continuously	76 ± 5	85 ± 3	90 ± 8
no ethylene	100 (13.9 hrs)	100 (12.5 hrs)	100 (16.9 hrs)

Table 2. Effect of interval between excision and the distal application of 2 µl 5.10^{-4}M IAA, applied alone and in combination with 2 µl 5.10^{-4}M ABA at 0 or 3 hrs, or ethylene directly after excision. The T_{50}-values are expressed in per cents of the control values given between ( ). (clone 1).

Interval of IAA application	–	ethylene 1 ppm	ABA at 0 hrs.	ABA at 3 hrs.
0 hrs	134 ± 27	124 ± 9	116 ± 4	—
3 hrs	131 ± 23	123 ± 6	119 ± 5	119 ± 5
6 hrs	130 ± 23	127 ± 3	116 ± 2	116 ± 7
9 hrs	97 ± 3	—	106 ± 1	112 ± 3
no IAA	100 (15,3 hrs)	100 (12.1 hrs)	100 (13.1 hrs)	100 (12.8 hrs)

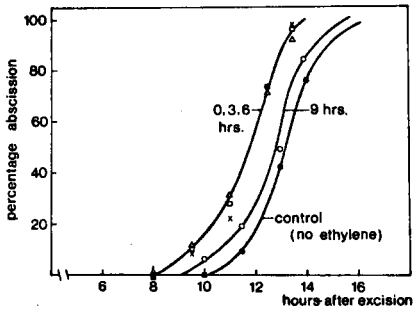

Fig. 4. The effect of the application of 1 ppm ethylene, 0, 3, 6 and 9 hours after excision, on the course of abscission of pedicel explants of clone 2.

ene until after nine hours, whereas ABA has no effect (*table 1*).

The abscission retarding effect of IAA is obtained when the hormone is applied earlier than nine hours after excision (*table 2*). In contrast with ethylene (*table 1*), IAA is effective during the whole first period. The length of the period of sensitivity to IAA is increased by ABA, both when the incubation with ABA starts immediately after excision and after three hours. Ethylene does not shorten this period; it is unlikely that it would prolong it, but this could not be established, because the explants start to abscise already after a nine hours treatment with ethylene (*table 2*).

The explants are also immediately sensitive to ABA, but this substance is most effective when applied three hours after excision (*table 3*). IAA and ethylene tend to prolong the period of sensitivity to ABA without shifting the optimum time of application.

Table 3. Effect of interval between excision and the distal application of 2 µl 5.10^{-4}M ABA, alone and in combination with 2 µl IAA or ethylene, given directly after excision. The T_{50}-values are expressed in per cents of the control values given between ( ). (clone 3).

Interval of ABA application	–	ethylene 1 ppm	IAA 5.10^{-4}M
0 hrs	94 ± 2	93 ± 1	95 ± 2
3 hrs	88 ± 4	87 ± 7	91 ± 2
6 hrs	99 ± 2	92 ± 4	93 ± 2
9 hrs	99 ± 2	–	97 ± 2
no ABA	100 (14.5 hrs)	100 (13.1 hrs)	100 (16.0 hrs)

4. DISCUSSION

In the course of abscission of pedicel explants of *Begonia* cultivars, an IAA-sensitive period can be distinguished from an ethylene-sensitive one, the former preceding the latter. This pattern is in accordance with the stages I and II which DELA FUENTE & LEOPOLD (1968) described for petiole abscission, but not

with the three stages course presented by JACKSON & OSBORNE (1972). IAA prolongs the duration of the ethylene insensitive period (stage I) as effectively when applied at the beginning or at the end of this phase, while ABA and ethylene have no reducing effect on the duration of this period (*table 2*). The way in which IAA prolongs stage I is unclear in view of the different hypotheses that have been proposed: its transport (OSBORNE & MULLINS 1969), its gradient over the abscission zone (LOUIE & ADDICOTT 1970), or its concentration (JACOBS 1968). The earlier described experiment with proximal application of IAA (HÄNISCH TEN CATE and BRUINSMA 1973) is in favour of the last hypothesis.

The abscission accelerating substance, ethylene, fails to affect the first stage but shortens stage II. In this respect *Begonia* pedicels differ from bean petioles where ethylene shortens stage I, too (ABELES et al. 1971, JACKSON & OSBORNE 1972). The main effect of ethylene in abscission, however, is generally thought to be the activation and secretion of cell wall degrading enzymes, especially cellulase, during stage II (ABELES et al. 1971, HOLM & ABELES 1967, LEWIS & VARNER 1970, POLLARD & BIGGS 1970).

The role of the abscission promoting hormone, ABA, is still controversial. In *Begonia* pedicels, ABA accelerates the abscission when applied during stage I, with an optimum time of application at about three hours after excision. This optimum time may be due to metabolism of ABA in the explants, while it has its effect only later in the course of abscission (JACKSON & OSBORNE 1972). JACKSON & OSBORNE suggest that ABA and IAA regulate the abscission by acceleration or retardation of the production of ethylene which subsequently induces cellulase synthesis. In *Begonia* pedicels, however, ABA certainly does not shorten stage I, and, moreover, has an additive effect next to that of ethylene (*fig. 3*). This agrees with the view of CRAKER & ABELES (1969) that ABA increases cellulase activity independently of ethylene.

It can be concluded that the abscission course of *Begonia* pedicels consists of two stages: stage I which is prolonged by IAA and not shortened by ethylene or ABA; and stage II which is accelerated both by ABA and by ethylene. Within these stages the hormones exert their effects independently from one another.

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