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Bud Inhibition and Correlative Growth of Petiole in Sweet Potato Stem[1]

By

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It has been known from investigations of various plants that the apical bud inhibits the growth of lateral buds near it, and the young leaf inhibits the axillary bud at that node. Concerning the mechanism of the inhibition, however, no definite conclusion has yet been attained (4, 6, 7).

The author reported in 1953 (3) on experimentation with the sweet potato plant, that the IAA (indole-3-acetic acid)-paste could substitute for the leaf blade in the bud inhibition, and that the inhibition by the blade and by the application of IAA was counteracted by the application of TIBA (2,3,5-triiodobenzoic acid)-paste at the middle of the petiole. Studies of this have been continued. This paper reports the results of comparing the growth of petiole with that of bud at the axil, in regard to the effects of auxin and TIBA.

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Material and methods

Single-node cuttings of growing stems of the sweet potato (*Ipomoea batatas*, var. Norin No. 1) were used. The node bore the oldest of immature folded leaves, of which the midrib and the petiole were at the beginning of experiments 4.5 and 3 cm. average length, respectively. The method of keeping the cuttings in experiment, the composition of the nutrient solution and the other experimental procedures were the same as in the previous paper (3). The lanolin pastes containing 0.1 % of acid form of IAA and 2 % of sodium salt of TIBA respec-

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tively were used. The TIBA-paste was smeared around the petiole in an area of about 2 mm. at one of the three sites as illustrated in Fig. 1. In every case, the apical cut end of the stem piece was smeared with plain lanolin.

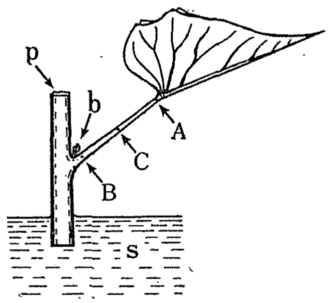

Fig. 1. Diagram of the stem cutting showing the sites (A, C and B) of application of TIBA-paste on petiole. p: Plain lanolin, b; lateral bud, s: culture solution.

The growth in length is represented in tables by the absolute increment in the case of bud, since it is too short to measure at the beginning of experiment, and by the percentage increment in the case of midrib and petiole. The dry weight of the lateral bud at the close of experiments and the number of leaves which had developed from the bud during the experimental period were also recorded.

Results

Experiment 1. The experiments previously reported (3) showed that TIBA applied at the middle of petiole which had either leaf blade intact, or the IAA-paste in place of it, reversed the bud-inhibiting effect of these. The present experiment was performed in order to see if the effect of TIBA differs according to the site of treatment on petiole.

Stem cuttings, 5 cm. long, were divided into seven groups according to the excision of leaf blade and the treatment by IAA and TIBA at the respective sites, as shown in I ~ VII, Table 1. They were kept standing for six days at about 1.5 m. apart from the south window of a room after the treatment.

A representative set of results as depicted in Table 1 show that the young developing leaf (II) and IAA applied on the cut surface of petiole in place of the blade (V) strongly inhibited the growth of lateral bud on its axil. When TIBA was applied at the apical part of the petiole (III, VI), the inhibition by the blade and by IAA was very much reduced; instead, a promotion was observed in the latter case. When TIBA was applied at the basal part of petiole (IV, VII), the counteracting effect of TIBA was not so pronounced as in the case of apical treatment. So the effect of TIBA differs according to the site of application.

Experiment 2A. Cuttings, 4 cm. long, were divided into the five groups (I ~ V, in Table 2). The points of TIBA treatment, A, B and C, were marked with Indian ink prior to smearing of the paste. The increase in lengths of AC and CB and of the midrib during the experimental period was measured, and the percentage elongation referred to the length at the start of the experiment was computed.

Results of a representative experiment are summarized in Table 2. They not only corroborate the results in columns I ~ IV, Table 1, but show that the

Table 1. Interaction of TIBA with the leaf blade or the substituting IAA, with respect to the growth of lateral bud under diffuse light, when the apical (A) or the basal (B) part of petiole was treated by the former. Measured 6 days after the treatment, Aug. 10, 1953. Mean of 5 samples each.

Leaf blade:	Cut off	Intact			Cut off		
Smear at cut tip of petiole:	Plain lanolin	—			0.1 % IAA		
Site of TIBA-treatment	(I) None	(II) None	(III) A	(IV) B	(V) None	(VI) A	(VII) B
Elongation of bud (mm)	12.6	2.8	8.6	3.6	5.8	13.4	7.8
Ratio	*100*	*22*	*68*	*29*	*46*	*106*	*62*
Dry weight of bud (mg)	7.6	1.4	5.0	1.2	2.0	9.2	3.6
Ratio	*100*	*18*	*66*	*16*	*26*	*121*	*47*
No. of new leaves on lateral bud	1.0	0	1.2	0.4	0	0	0

Table 2. Effect of TIBA treatments at the apical (A), the middle (C) and the basal (B) parts of petiole which was bearing the intact blade, exhibited on the growth of petiole, midrib and axillary bud. Measured after 7 days in diffuse light, Sept. 17, 1953. Mean of 5 samples each.

Leaf blade:	Cut off	Intact			
Site of TIBA-treatment	(I) None	(II) None	(III) A	(IV) C	(V) B
Elongation of bud (mm)	12.2	2.4	9.4	7.8	6.2
Ratio	*100*	*20*	*77*	*64*	*51*
Dry weight of bud (mg)	10.6	1.0	6.2	4.1	2.1
Ratio	*100*	*9*	*59*	*39*	*20*
Elongation of midrib (%)	—	27	22	33	24
Elongation of petiole (%)					
Apical half	22	100	78	234	196
Basal half	11	133	35	18	78
Entire length	16	113	56	125	134
No. of new leaves on lateral bud	1.4	0	1.0	0.4	0.2

effect of the TIBA treatment at C is intermediate between those at A and B.

While petiole in the normal case (II) grew to double its length during the experimental period, the debladed petiole (I) grew little. Even when the blade was present, the TIBA treatment at the apical part of the petiole inhibited the growth of petiole to some extent (III). The TIBA treatments at the middle and the basal parts (IV, V), however, rather increased the elongation, specially stimulating the growth in the apical half. It is interesting to see that the basal half grew more than the apical half when TIBA was not applied (II).

The comparison of the effects on the petiolar growth of the TIBA treatments at A, C and B invites a speculation that TIBA considerably blocks the downward translocation of auxin from the blade, the stagnant auxin promoting the respective parts of petiole.

In the experiment represented in Table 2, the growth of midrib seemed to be correlated with the growth of the apical half of petiole. This tendency strengthens the hypothesis that auxin is dammed up in the parts distal to the site of TIBA application. However, data in the other similar experiments do not necessarily demonstrate the correlation conclusively.

Experiment 2B. The blade was excised and the 0.1 % IAA-paste was smeared in place of it. The methods and treatments other than this were the same as in the preceding experiment.

Table 3. The same as Table 2, except that the blade was excised and the IAA-paste was given in place of it. Measured after 7 days, Sept. 26, 1953. Mean of 5 samples each.

Smear at cut tip of petiole:	Plain lanolin	0.1% IAA			
Site of TIBA-treatment	(I) None	(II) None	(III) A	(IV) C	(V) B
Elongation of bud (mm)	7.8	6.4	10.0	9.0	5.6
Ratio	*100*	*82*	*128*	*115*	*72*
Dry weight of bud (mg)	5.8	3.4	7.6	4.3	2.0
Ratio	*100*	*59*	*131*	*74*	*35*
Elongation of petiole (%)					
Apical half	21	41	19	92	100
Basal half	12	56	11	11	70
Entire length	16	49	15	50	85
No. of new leaves on lateral bud	1.0	0.4	1.0	0.6	0

The representative results as given in Table 3 show that the general trend of the effect of TIBA, including the effect of position, was quite similar to the case of Table 2. So it may be inferred that TIBA blocks the descent of IAA along the petiole, just as it does for the natural auxin coming from the intact blade.

The values in Table 3 are on the same basis with those in Table 2, when the values in column I, which represents the treatment common to both of the experiments, are roughly the same in the two tables. This requirement is satisfied in the case of the petiolar elongation, but not in the bud growth, in length as well as in dry weight. Hence the italicized values which are relative to column

Table 4. Experiment in the dark, corresponding to Table 2. Measured after 7 days, Sept. 18, 1953. Mean of 5 samples each.

Leaf blade:	Cut off	Intact			
Site of TIBA-treatment	(I) None	(II) None	(III) A	(IV) C	(V) B
Elongation of bud (mm)	9.4	1.8	17.0	5.0	4.2
Ratio	*100*	*19*	*182*	*53*	*45*
Dry weight of bud (mg)	2.6	0.8	2.9	1.6	1.2
Ratio	*100*	*31*	*112*	*62*	*46*
Elongation of midrib (%)	—	10	7	7	10
Elongation of petiole (%)					
Apical half	13	45	22	93	61
Basal half	12	55	10	12	78
Entire length	12	50	16	52	70
No. of new leaves on lateral bud	0	0	0	0	0

Table 5. Experiment in the dark, corresponding to Table 3. Measured after 7 days, Sept. 28, 1953. Mean of 5 samples each.

Smear at cut tip of petiole:	Plain lanolin	0.1 % IAA			
Site of TIBA-treatment	(I) None	(II) None	(III) A	(IV) C	(V) B
Elongation of bud (mm)	11.7	3.4	10.2	7.4	4.8
Ratio	*100*	*29*	*87*	*63*	*41*
Dry weight of bud (mg)	3.8	1.3	2.6	2.2	1.7
Ratio	*100*	*34*	*69*	*58*	*45*
Elongation of petiole (%)					
Apical half	18	29	23	48	45
Basal half	15	58	15	10	42
Entire length	16	44	19	28	44
No. of new leaves on lateral bud	0	0	0	0	0

I are to be used in the comparison of the bud growth in the two experiments.

By comparing the two tables each other it is found that the petiole grows better when it carries the blade than when the blade is replaced by IAA. The bud growth, on the other hand, is inhibited more strongly by the blade than by IAA, as already confirmed in Experiment 1.

Such difference between the effect of intact blade and of IAA may be due either a) to greater effectiveness of the natural auxin on the growth of petiole and on the bud inhibition, or b) to the greater supply of nutritive factors to the petiole by the blade. The immature leaf used seems to consume the nutritive factors rather than to send them out, since most of the blades unfolded during the experimental period and their midribs elongated 22 to 33 per cent of their original length. Therefore the second alternative should be considered due to a secondary effect of the natural auxin.

The distribution of growth in petiole suggests that either the natural auxin or the applied IAA was strongly blocked at the point of TIBA treatment when this was at the apical and the middle parts of petiole. Nevertheless, a significant difference in the bud growth was observed between these TIBA treatments. So the compensatory growth seems to be a factor controlling the bud growth, in addition to the possible more direct effect of auxin on the bud. There is no clear evidence that IAA is blocked as much by the basal TIBA treatment as by the treatment at the more distal parts. However, including the case of basal treatment, the negative correlation is apparent between the petiole growth and the bud growth in the five cases in each of Tables 2 and 3. Hence the correlative growth seems to play, partly at least, a role when the bud is inhibited by a leaf blade as well as by the applied IAA.

Experiment 3. In order to see if the effect of TIBA, in combination with the blade and IAA, will be modified in the dark, the cuttings treated in the same way as above were put in a wooden cabinet in the laboratory. A set of repre-

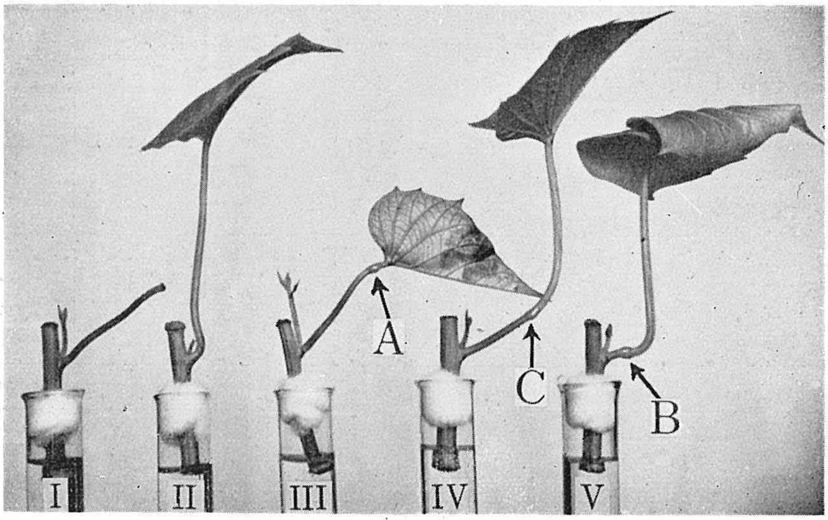

Fig. 2. A representative set of cuttings from the experiment summarized in Table 4. Roman numerals correspond to those in the table. Note the geotropic reaction of petioles in relation to the site of TIBA treatment. The petioles in I and *III* are staying in the initial position .Photographed at the close of experiment on Sept. 18, 1953.

sentative results measured seven days later is shown in Tables 4 and 5, which correspond to Tables 2 and 3, respectively.

According to the absolute values in columns I, the elongations of bud and of petiole in the dark did not differ much from those in the light. However, the dry weight of bud was less in the dark.

The variation in the effect of TIBA according to the point of application had the same pattern as in the light, though the amount of stimulated growth of petiole was much less in the dark. The negative correlation between the growth of petiole and of bud was apparent also in the present case. The effect of the blade and of the TIBA treatments on the growth and geotropism (cf. 3) of petiole is apparent in Fig. 2.

The midrib elongated in the dark, but no significant effect of TIBA was observed.

Discussion

THIMANN and BONNER (8), using *Avena* coleoptile, showed that TIBA was growth-inhibiting when the mol-ratio TIBA : IAA was higher than a certain value, and growth-promoting when it was lower. A similar result has been reported by ÅBERG (1) in the root growth of flax seedling. In any of the experiments so far made with sweet potato, the TIBA application at the middle of petiole caused a marked contrast in the growth between the parts distal and basal to the point of application. Even if the above mentioned theory of mol-ratio is introduced to explain this fact, the abrupt change in the growth distribution along the petiole can be elucidated most easily by assuming that TIBA inhibits the basipetal transport of auxin, the stagnant auxin stimulating the growth of the distal portion. The effect of TIBA on the distribution of growth along the petiole in the cases of apical and basal treatments, too, supports the view.

The difference in the bud growth between the apical and the middle TIBA treatments are not explicable solely by the mol-ratio, because the amount of growth of the basal half of petiole indicate that the mol-ratio at this part, which is adjacent to the bud, does not differ much between the two cases. The damming up of auxin by TIBA, too, can not explain the difference. There seems to be a compensatory relation between the growth of petiole and that of the bud at its axil.

However, a significant difference in the bud growth is noticed between I and III, in Tables 3 and 4. The petiolar growth is very low in any of these cases. Hence some factor other than compensatory growth reveals its effect when the amount of petiolar growth is roughly the same between the cases to be compared. Possibilities are, 1) that the amount of auxin passing over the blockage by TIBA is so small as to promote the bud growth, and 2) that TIBA also acts in the bud. No data are now available for discussing these possibilities.

SNYDER (5), using red kidney bean, observed that the elongation of primary axillary bud was followed by a marked decrease in the elongation of main shoot when TIBA-paste was applied on the shoot as a ring above the primary leaves. Similar experiments are being tried by the present author using the stem tip of sweet potato.

JACOBS and BULLWINKEL (2) observed that the excision of young leaves on the main shoot of *Coleus* caused a marked drop in the stem elongation, this being restored to the level of the control by the application of IAA to the petiolar stump. However, in the present experiments, IAA could not substitute so completely for the blade, in the light as well as in the dark. The relations, with respect to auxin and nutritive factors, among the growing leaf, the petiole and the lateral bud remain to be studied more in detail.

Summary

1) Using very young single-node cuttings of sweet potato stems, the growth of bud and petiole was observed after the various treatments.

2) IAA can substitute, though not completely, for the young blade in inhibiting the bud growth and in stimulating the petiole growth.

3) TIBA applied at the various parts of petiole inhibits the basipetal transport of natural auxin and of IAA at the site of its application, resulting in a disproportionate elongation of petiole at the portion distal to that site, possibly due to stagnant auxin.

4) In that case, the growth of bud is negatively correlated with the growth of petiole, even though auxin supply to the axil must be strongly blocked in any of the TIBA treatments. Hence the compensatory inhibition of bud growth should be assumed, at least supplementary to a more direct inhibition by auxin.

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