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APICAL DOMINANCE IN VICIA FABA L.

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ABSTRACT

A side-effect of plant surgery was an interference with apical dominance. From the results of three experiments involving plant surgery, decapitation and the usage of ^{14}C-1AA, it appeared that the movement of the apically produced auxin to the region of the lateral buds was an essential part of the dominance mechanism. There is evidence in the present investigation that the mechanism of apical dominance in broad bean involves an auxin or a similar metabolite diffusing from the apex and exerting an inhibitory effect directly or indirectly on the basal lateral buds.

INTRODUCTION

Apical dominance in plants is an area of intensive current research with a lack of consensus amongst different workers as to the mechanism of inhibition of axillary buds. The role exerted by different plant hormones in the regulation of lateral bud release in dicotyledonous (Sachs and Thimann, 1967; Aung and Byrne, 1978; Tucker, 1980) and in monocotyledonous plants (Leopold, 1949; Langer *et al*, 1973; Harrison and Kaufman, 1980) has been studied by several workers. Leopold (1949) suggested that monocotyledonous and dicotyledonous are under the same type of apical control i.e. auxin control.

Went (1939) suggested that apical dominance was the result of diversion of nutrients towards actively growing meristems and that this was brought about by auxin synthesized in the meristem. In other words auxin induced the movement of nutrients (carbohydrate, N. P. K) to the terminal meristem and this resulted in the lateral buds becoming deprived of an adequate supply of nutrients. This hypothesis has generally been supported by Gregory and Veale (1957) and McIntyre (1964, 1968, 1975). On the other hand the whole question of apical dominance may concern the inhibitory action of a substance secreted by the apical bud (Thimann and Skoog, 1934) or by leaves (Snow, 1939) and transported to the region of the lateral buds. According to Thimann and Skoog (1934) the substance may act directly in prohibiting the outgrowth of lateral buds but according to Snow (1937) it may act indirectly.

There is now considerable evidence that suggests that auxin exerts such an inhibitory action in apical dominance and the transport of IAA from the apical bud down the stem has been clearly demonstrated (Morris *et al*, 1969; McDavid *et al*, 1972).

The broad bean *(Vicia faba* L.) can be regarded as a plant with naturally weak apical dominance (Phillips, 1969) and during the experiments described in an earlier work (Ismail & Sagar, 1981a) it was routinely observed that lateral branches developed as the plant entered its reproductive phase whereas they were rarely observed in the early vegetation stage. However, when

vegetative plants were excised to a single vascular bundle between L1 and L3 (counting upward from the base of the plant - See Figure 1) in every case it was observed that the lateral buds were released from inhibition and that they grew rapidly to a considerable length in only a few days. This effect of plant surgery on lateral bud development is examined further in this investigation and the results are discussed in relation to the current hypotheses on the concept of correlative inhibition of lateral buds.

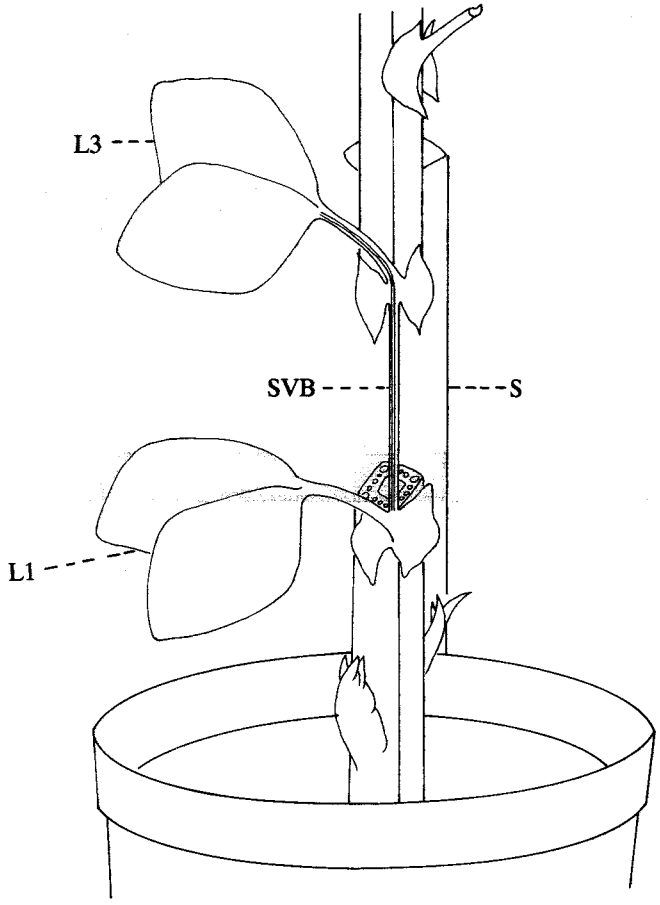

Figure 1. Plant material after surgery to a single bundle.

L1 Leaf 1
L3 Leaf 3
SVB Separated Vascular Bundle
S stands for stake.

MATERIALS AND METHODS

Broad beans (*Vicia faba* L. cv. Express Longpod) were raised throughout the experiments as follows: two seeds were sown per 15 cm pot in John Innes No. 1 Compost, and at the 1-2 expanded leaf stage they were thinned to one per pot. The plants were grown in a glasshouse under a 16th daylight with supplementary lightly by 400 W mercury vapour lamps. Plants grown under these conditions showed very little development of the basal lateral branches. The plants required for experimental work were transferred 24h before treatment from the glasshouse to growth cabinets with a light intensity of 9.0-12.0 k lux., a 14h photoperiod and a temperature 24±1°C.

Experiment 1

The effect of excising the stem in a single bundle on the growth of lateral branches.

Twenty four plants at the 4-5 expanded leaf stage were selected for uniformity and four treatments each with six plants were set up as shown in Figure 2. They were as follows:

1. Control - no treatment
2. Decapitation (the terminal bud was excised)
3. Restricting the vascular system at the middle of the stem between L1 and L3 to a single-bundle for a distance of 2cm.
4. Restricting the vascular system at the middle of the stem between L1 and L3 to a single-bundle for the whole distance (10 cm).

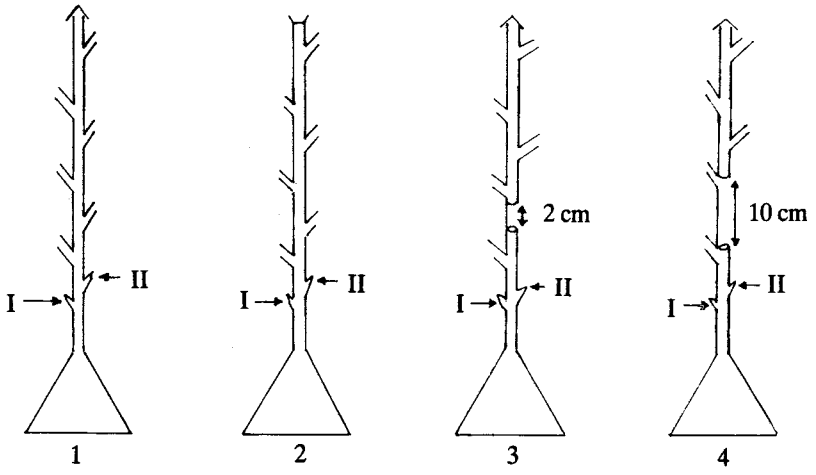

Figure 2. Diagrams of broad bean plants showing the four treatments in Experiment 1.

1. Control
2. Decapitation
3. Single bundle (2 cm)
4. Single bundle (10 cm)

I Lower lateral branch
II Upper lateral branch

Measurements of the length of the lower lateral branch (LBI) and the upper lateral branch (LBII) were taken at 7, 9 and 11 days. after the treatments were imposed (Ismail & Sagar, 1981b). After 11 days the lateral branches were harvested, dried in an oven and weighed with the weight of LBI+LBII combined for each replicate.

RESULTS

The restriction of the vascular system between L1 ad L3 to a single vascular bundle released the basal lateral buds from inhibition and resulted in their rapid subsequent growth (Figure 3a and b; Table 1).

Although the total lateral branch dry weights were very similar for the 2 cm and 10 cm single-bundle treatments (Table 1) the data on branch length for both LBI and LBII clearly show that restricting the length of single-bundle to 2 cm had less effect compared with the 10 cm treatment (Figure 3). However, the effect of decapitation on axillary branch dry weight was considerably greater than either of the single-bundle treatments but this effect was not evident from the branch length data.

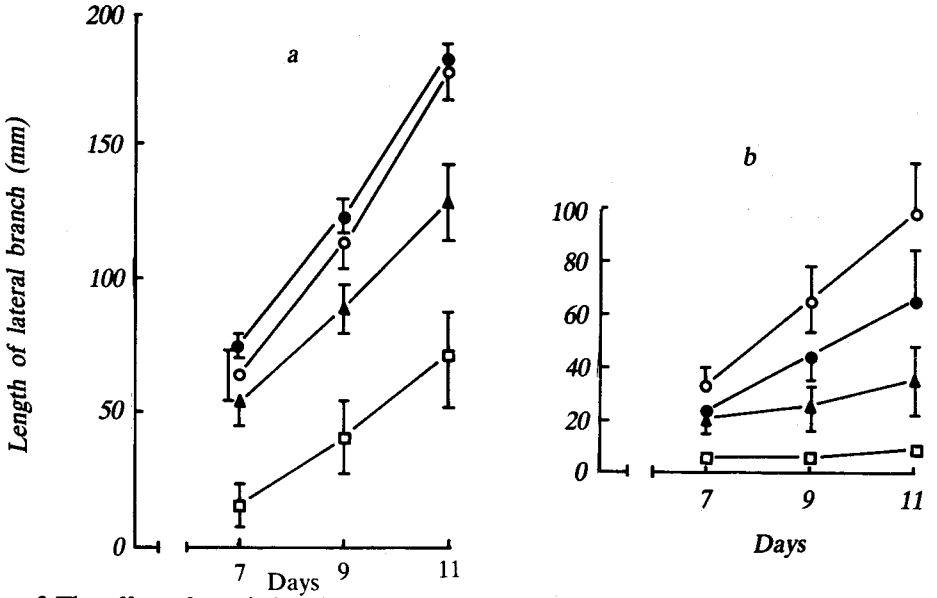

Figure 3 The effect of restricting the vascular system to a single bundle on the development of lateral branches. (Values are means of 6 replicates) ± S.E. given

a *LBI*
b *LBII*
□ *Control*
○ *Decapitation*
△ *Single bundle (2 cm)*
● *Single bundle (10 cm)*

Table 1

Dry weight (mg) of lateral branches (LBI+LBII) after 11 days. (Values are means of 6 replicates) ± S.E. given.

	Treatment	Dry weight (mg)
1.	Control	124±42
3.	Decapitation	632±87
3.	Single-bundle (2 cm)	377±43
4.	Single-bundle (10 cm)	374±13

Experiment 2

The relationship between IAA application and lateral branch inhibition.

Thirty-four plants at the 4-5 expanded leaf stage were selected for uniformity with the lateral buds at LBI and LBII positions inhibited from growth. Twelve plants were cut so that they were connected by a single-bundle for the whole distance between L1 and L3. After 24h five treatments each with six plants were set up as shown in Figure 4. They were as follows:

1. Control - no treatment.
2. Decapitation - the terminal bud was excised and lanolin was applied to the cut surface of the shoot.
3. Decapitation - as (2) but lanolin containing 1% IAA was added to the cut surface of the shoot.
4. Lanolin was applied to the surface of the cut stem at the node of L1 in six of the single-bundle plants.
5. As (4) but lanolin with 1% IAA was applied

The lanolin treatments were renewed every 3 days. Measurements of the length of the lateral branches were taken 7, 9, 11 and 13 days after the treatments were imposed. After 13 Days the lateral braches were harvested, dried in an oven and weighed with the weight of LBI + LBII combined for each replicate.

Of the four plants remaining, two were excised to single-bundle plants and the other two were left intact. The four plants were treated as follows: the young expanding leaves surrounding the apex were carefully raised and 0.5% Tween 20 in water was rubbed on to the surface of the

apex. After drying a 5 μl droplet of IAA-2 ^{14}C (with an activity of 0.5. μCi) was added using an 'Alga' syringe. The plants were harvested after 24th, cut into component parts, oven dried and prepared for autoradiography following the method of Yamaguchi and Crafts (1958) and exposed to Kodirex X-ray film for three weeks.

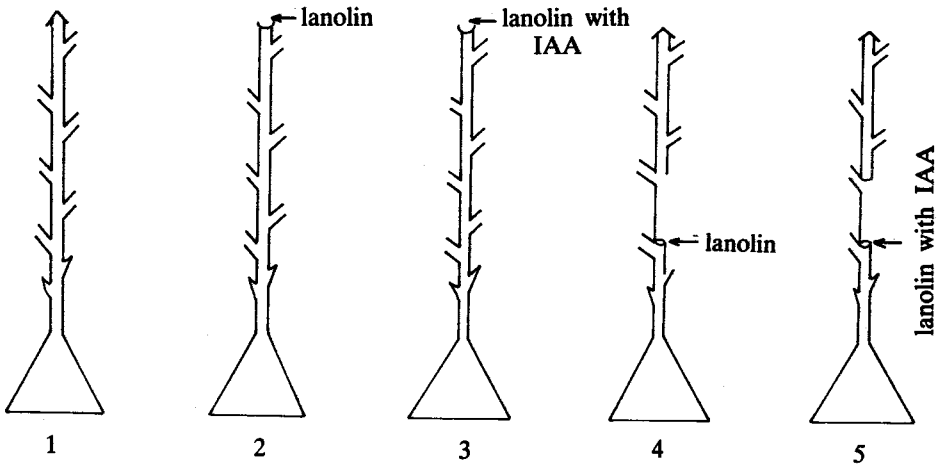

Figure 4 Diagrams of broad bean plants showing the five treatments in Experiment II.

1. Control
2. Decapitated + lanolin
3. Decapitation + lanolin with IAA
4. Single bundle + lanolin
5. Single bundle + lanolin with IAA

RESULTS

From Figure (5a and b) it can be seen that the reduction of the vascular system to a single-bundle again released the lateral branches from inhibition and generally their performance was similar to decapitated plants although the decapitation treatment resulted in greater bud development (Table 2). Overall the application of IAA reversed these effects but where IAA was applied to the decapitated shoot it inhibited the growth of LBII but had only a slight inhibitory affect on the development of LBI. IAA applied to the cut surface of the stem in the single-bundle plants completely inhibited the development of both basal branches and gave results similar to the intact control plants.

Table 2

Dry weight (mg) of the lateral branches (LBI+LBII) after 13 days. (Values are means of 6 replicates) ± S.E. given.

	Treatment	Dry weight (mg)
1.	Control	44±16
2.	Decapitation+lanolin	1268±86
3.	Decapitation+lanolin with IAA	758±60
4.	Single-bundle+lanolin	893±103
5.	Single-bundle+lanolin with IAA	19±5

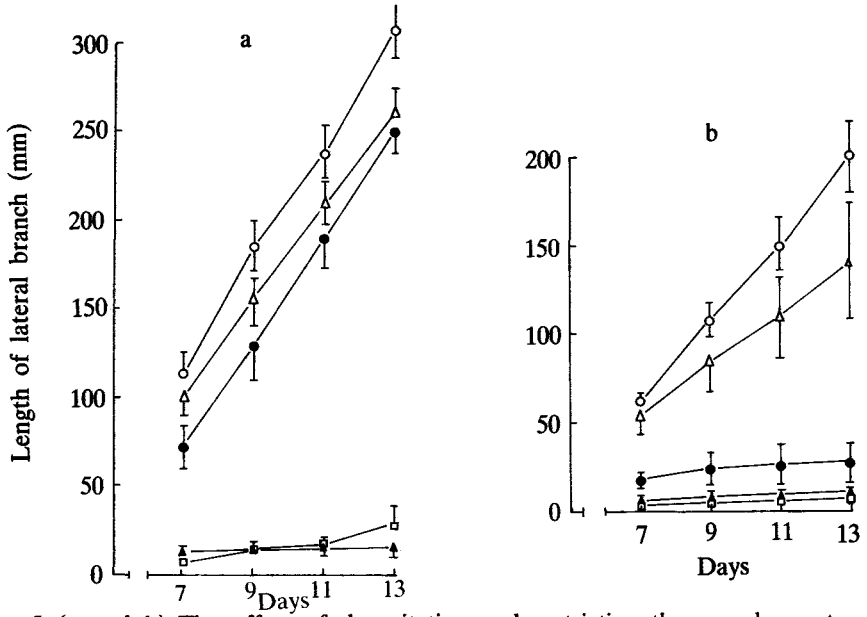

Figure 5 (a and b) The effect of decapitation and restricting the vascular system to a single-bundle in the presence and absence of IAA, on the development of lateral branches. (Values are means of 6 replicates) ± S.E given.

a = LBI
b = LBII
□ Control
○ Decapitation + lanolin
● Decapitation + lanolin with IAA
△ Single bundle + lanolin
▲ Single bundle + lanolin with IAA

The autoradiograph shown in Plate IA (a and b) shows that in an intact control plant IAA-2[14]C applied to the apex moved basipetally down the stem. However, when IAA-2[14]C was applied to the apex of single-bundle plant (Plate 1B) it moved down the stem only as far as the beginning of the single-bundle section and accumulated at this point. There was no evidence of any movement of radioactivity into the single-bundle region of the stem. There was very good agreement between the replicates for both treatments.

DISCUSSION

The results clearly show that the restriction of the vascular system to a single-bundle for a short distance along the stem released the basal lateral buds from apical dominance. The removal of the shoot apex gave a similar response but the application of IAA to both the tip of the shoot and to the cut surface of the stem below the single-bundle length firmly inhibited the development of the basal buds. These responses suggest that the growth of the basal lateral buds is regulated by the concentration of auxin or a related metabolite diffusing down the stem from the apex and that the retriction of the stem to a single vascular bundle interrupted the downward movement. However, although such a restriction did not arrest the downward movement of ^{14}C-assimilates from leaves (Ismail, 1976) the movement of ^{14}C-1AA was clearly arrested. This suggest that the downward movement of IAA and assimilates occurs via different pathways and this agrees with the study of Morris *et al* (1969) where it was concluded that ^{14}C-IAA transport from the apex of pea seedlings was not via the phloem. Goldsmith (1969) has also suggested that auxin transport in the stem may be mediated via a cell to cell movement rather than in the sieve tubes of the phloem.

Overall the results are not consistent with a nutrient diversion hypothesis as suggested by Went (1939) and supported by the results of Gregory and Veale (1957) and McIntyre (1964, 1968, 1975) but supported the view that apical dominance is principally mediated by the transport of auxin down the stem where it exerts an inhibitory influence on bud development, (Harrison and Kaufman, 1980; Hago and Rubenstien, 1975). However, it is not clear whether IAA acts directly or indirectly at the site of the basal buds. There are alternative explanations possible, e.g. one might argue that root produced kinins are implicated in apical dominance control, in intact plants the meristematic apex region acting as a kinin sink and so depleting the kinin concentration around he lateral bud, so inhibiting their growth. Conversely the absence of such a sink in decapitated braod bean plants may result in sufficient kinin being present to encourage bud growth. In IAA-lanolin treated decapitated plants the IAA could well stimulate meristematic activity (Wareing and Phillips, 1978) at the cut surface creating a new kinin sink and thus restoring apical dominance control. Tucker and Mansfield (1973) have shown that abscisic acid may be involved directly or indirectly; and the conclusions of Bellandi and Dorffling (1974) that the prime effect of abscisic acid applied to the apical bud of intact seedings of *Pisum sativum* L. was local growth inhibition which subsequently leads to lateral branch release. Tucker (1976) suggested that in tomato, auxin controls lateral bud development by regulating ABA-like substance concentrations in the buds. Harrison and Kaufman (1980) in *Avena sativa* L. indicated that the cytokinin to auxin ratio played a decisive role in tiller release and that ABA was a bud growth suppressor.

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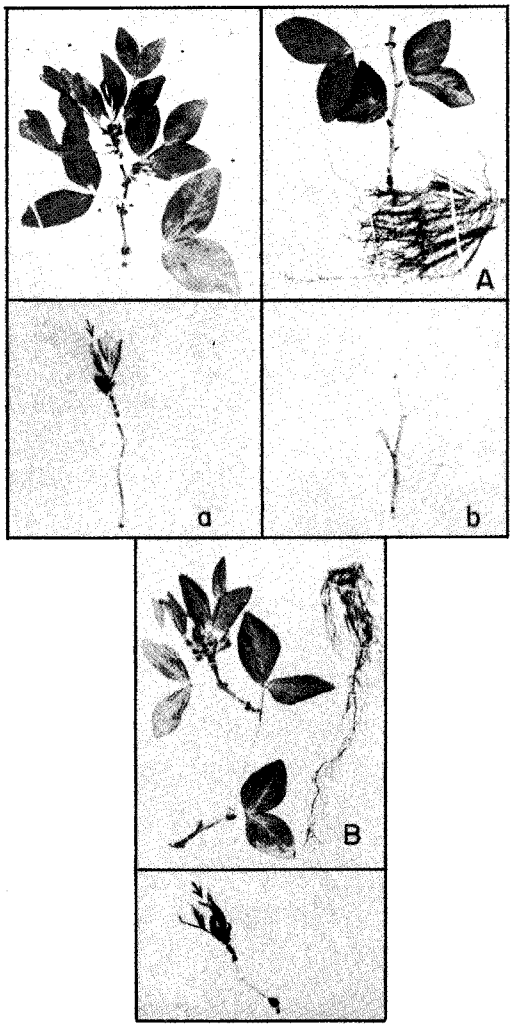

Plate 1 The movement of IAA-2^{14}C from the apex on intact and single-bundle plants.

0.5μCi of IAA-2^{14}C (specific activity 58 mCi/m mol) was applied onto the surface of the apex of each plant and the plants were harvested after 24h. Autoradiographs are presented below the plants.

A Intact plants were treated

a Upper part of the shoot

b Lower part of the shoot

B Single-bundle plants were used

Arrows indicate fed regions

السيادة القمية في نبات الفول

أحمد محمد على إسماعيل

أدى استئصال الجزء من ساق نبات الفول بين الورقة ١ ، ٣ ما عدا حزمة وعائية واحدة إلى نمو البراعم الجانبية السفلى إلى أفرع . بينت التجارب التي استعمل فيها اندول - ٣ حامض الخليك المرقم بالكربون المشع ان انتقال هرمون الأوكسين له أثر فعال على آلية السيادة القمية . وتبين من هذا البحث أن أنتشار الأوكسين أو مركب كيماوي شبيه له من القمة إلى أسفل له دور هام في عملية تثبيط نمو براعم الأفرع الجانبية السفلى في النباتات المستعمل .