J. Indian bot. Soc. **65** : 81—85, 1986.

SHOOT APEX ORGANIZATION AND LEAF DEVELOPMENT IN *ANTIRRHINUM MAJUS* (SCROPHULARIACEAE)[1]

D. K. AWASTHI, V. KUMAR[2] AND Y. S. MURTY[2]

Department of Botany, M.M.P.G. College, Modinagar

ABSTRACT

The duplex type of shoot apex has one layered tunica throughout the plastochron. Cytohistological zonation pattern is well manifested during maximal phase and is lost during minimal phase. Central mother cell zone is described as an active zone. Leaf is initiated in the second layer of corpus. In the initial stages corpus contributes cells to the developing leaf. Later, vertical growth is because of sub apical initials. Middle layers of leaf primordium are derived directly from the sub marginal initials. Differentiation of procambium is acropetal in the leaf primordium as well as in the shoot.

INTRODUCTION

The shoot apices of vascular plants although differ in detailed structure have in common many functional activities and features of organisation (Wardlaw, 1965a). That the role of shoot apical meristem depends on its organisation has been amply emphasized (Wardlaw, 1965a, b ; Steward, 1961) and therefore, it has received considerable attention of both morphologists and physiologists. Organisation of shoot apex has been investigated in a number of dicotyledons (see Gifford and Corson, 1971) but the representatives of the family Scrophulariaceae have not been worked out so far. Thus, the present communication deals with the shoot apex organisation, leaf development and procambium differentiation in *Antirrhinum majus* L. of family-Scrophulariaceae.

MATERIAL AND METHODS

The shoot apices of *Antirrhinum majus* L. were collected during December and fixed in formaline-acetic acid-alcohol for 24 hrs. The apices were dehydrated and embedded in paraffin wax (58-60°C) to cut longitudinal and transverse section of 6-8μm thickness. The sections were stained with tannin acid-ferric chloride and haidenhain's Iron haemotoxylin. Fast green was used as counter stain.

OBSERVATIONS

The shoot apex appears slightly convex to dome shaped in different phases of the plastochron (Figs. A-C). It measures 70.5 to 83.5μm in breadth and 16.0 to 20.5μm in height in minimal phase and 122.4 to 136.5μm in breadth and 55 to 60μm in height in maximal phase. It

1 Accepted for publication on December 2, 1984.

2 Department of Botany, Meerut University, Meerut.

We are grateful to Dr. V. P. Dube, Modinagar for his help in various ways.

appears stratified with one layered tunica throughout the plastochron. The cells constituting tunica divide exclusively anticlinally and frequency of divisions is more in the flank cells than in the axial cells. The latter are isodiametric while the cells of the tunica of flanks are radially elongated. On the basis of staining reactivity axial tunica cells during minimal phase are not clearly discernible from the flank cells of tunica (Fig. B) and appear densely stained with thick granular cytoplasm, while in other phases of the plastochron these appear lightly stained like in cells of central mother cell zone (Figs. A & B).

The stratified corpus shows well marked cytohistological zonation pattern during maximal phase (Fig. A). The zonation pattern is lost for a short duration during minimal phase (Fig. B).

The summit of the corpus is occupied by 7-10 cells which are large in size and are lightly stained with large nuclei. These constitute central mother cell zone (CMZ). The mitotic activity of these cells is very low during maximal and mid phase of the plastochron. During minimal phase, these cells are darkly stained with thick granular cytoplasm and show maximum divisional activity. At this time, these cells can not be differentiated on the basis of staining reactivity from the cells of flank zone. Thus the cytohistological zonation pattern is not well marked in minimal phase (Fig. B.) Cells of this zone divide anticlinally as well as periclinally contributing cells to the flank and rib zones.

In the flank zone (fz) cells are arranged in four to six files encircling the rib zone (Fig. A) and are comparatively smaller in size with densely stained nuclei and thick granular cytoplasm (Figs. A, C). Predominantly anticlinal divisions have been observed in these cells with a few periclinal divisions apart from those at the time of leaf initiation (Fig. B). The cells of the rib zone (rz) are arranged in irregular manner. Those near the central mother cell zone show less vacuolation which increase progressively towards the axis.

At the time of leaf initiation, 2 to 3 cells of the second stratification of corpus present near the central mother cell zone divide periclinally (Fig. B). Soon some cells of the outer layer of corpus also follows the same fate. Later underlying cells of the flank zone also divide and push out a small hump on the apex (Fig. C.). Concomitantly, cells of the tunica present above it also start dividing anticlinally thus keeping pace with the underlying dividing cells of corpus. The tunica remains discrete in the hump and in a fully formed leaf becomes abaxial and adaxial epidermis. Upto this stage the hump grows because of the divisions in the derivative cells of the flank zone. Before it could surpass the height of the shoot apex, a group of 2-3 initials become discernible in sub-apical position (subapical initials) (Figs. D, E). These initials divide further and are responsible for vertical growth of the leaf primordium. Both anticlinal as well as periclinal divisions are observed which cut derivatives contributing to the abaxial, adaxial and middle layers.

Besides vertical growth, the leaf primordium grows laterally also due to the activity of marginal and submarginal initials (Smi). Cells derived from marginal initials are contributed to adaxial and abaxial epidermis only. Submarginal initials divide in all planes and add cells to the adaxial, abaxial and middle layers (Fig. G). Cells of the middle layer further divide periclinally, thus increasing the number of middle layers. Because of higher frequency of periclines in the abaxial region of the primordium more abaxial

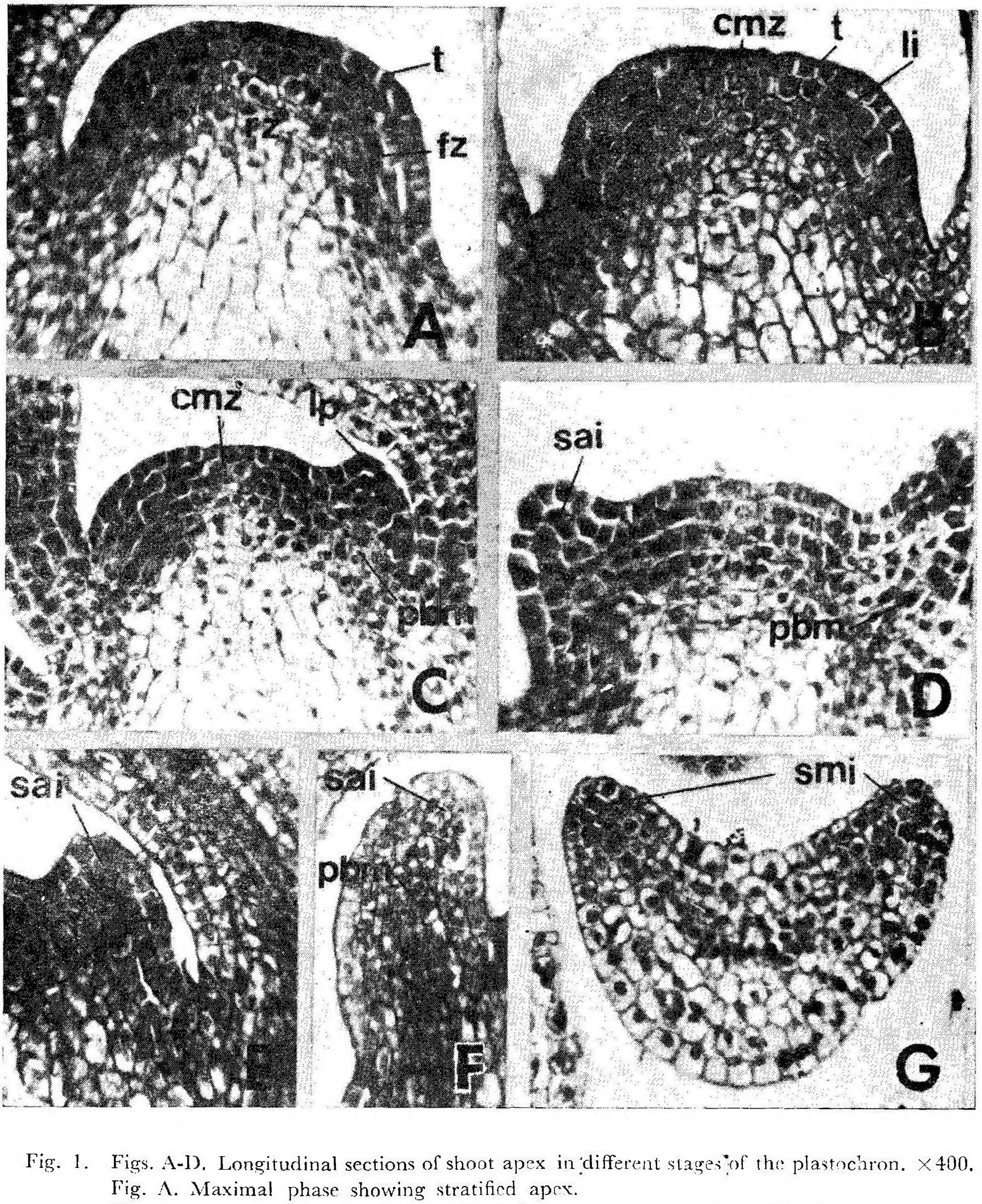

Fig. 1. Figs. A-D. Longitudinal sections of shoot apex in different stages of the plastochron. ×400.
Fig. A. Maximal phase showing stratified apex.
Fig. B. Minimal phase showing periclinal divisions for the initiation of leaf.
Fig. C. Late minimal phase showing growth in leaf primordium and procambium differentiation.
Fig. D. Apex not in plane showing subapical initials in the developing leaf.
Figs. E & F. Two different stages of leaf development. × 500.
Fig. E. Showing subapical initials and Fig. F. showing differentiation of procambium in the basal derivatives of subapical initials.
Fig. G. Transverse section of leaf primordium showing marginal and submarginal growth. × 500.

layers than adaxial ones are formed so that leaf primordium at this stage appears triangular in a cross section and the mature leaf appears conduplicately folded structure. Pallisade and mesophyll differentiation occur at a very late stage.

Differentiation of procambium in the leaf primordium is observed among the derivative cells of flank zone contributed to the formation of leaf (Fig. G.). Later the basal derivatives of subapical initials in the leaf primordium elongate among which progressive differentiation of procambium (Figs D, E, F) is observed. The procambialization in the leaf is thus acropetal. The procambium of the leaf primordium from the very beginning is connected to the acropetally differentiating procambium of the shoot.

DISCUSSION

In *Antirrhinum majus* L., the stratified shoot apex is of duplex type (Newman, 1956). The shoot apex possesses only one tunica layer which remains discrete throughout the plastochron. The term tunica has been used in senso-stricto following Clowes (1961). Plasticity in usage of the term tunica as emphasized by Reeve (1948), Tolbert (1961), Gifford and Corson (1971) etc., would deny "entity in perpituity" status of tunica and thus the contention of Clowes (1961) is fully substantiated. No variability in the number of tunica layers has been observed (Rouffa and Gunckel, 1951).

Stratified corpus has been described in terms of cytohistological zonation pattern. Such differentiation is prominent during maixmal phase and disappears during minimal phase due to periclinal divisions in the cells of first and second stratification of corpus apart for the initiation and early development of leaf primordia.

Cells of central mother cell zone show mitotic activity mostly during mid phase. The nuclei and cytoplasm are also darkly stained during this phase. These cells thus, though with low mitotic activity, do act as initials and are equivalent to the continuing maristematic residue of Newman (1965). There is no indication of existence of meristeme d' attente (Buvat, 1952, 1955).

The leaf is initiated by periclinal divisions in the second layer of corpus. The latter contributes cells in elevating the leaf buttress. The tunica remains as a discrete layer with cells dividing anticlinally thus keeping pace with the underlying dividing cells. Esau (1965) correlated the participation of corpus with the number of tunica layers. According to her, fewer the number of tunica layers, more is the contribution of corpus. Vertical growth of primordium is due to subapical initials which differentiate quite early in the primordium and thus restrict the contribution of the corpus. Girolami (1954) also observed similar type of growth of leaf in *Linum usitatissimum*. In the leaf primordium middle layers are derived directly from the submarginal initials and thus conforms to the second type of activity described by Foster (1936). Adaxial layers also contribute to the middle layers through proliferation.

The present observations support the views held by earlier workers (Esau, 1954 ; Clowes, 1961) that the procambium differentiation is acropetal in the shoot. In the leaf the procambium also differentiates acropetally among the cells of flank zone and among the basal derivatives of subapical initials. Sharman (1942), Esau (1965) and Sharman and Hitch (1967) have also reported acropetal differentiation of median procambial strand in a number of taxa.

REFERENCES

BUVAT, R. 1952. Structure, evolution et functionnement du meristeme apical de quelques dicotyledones. *Ann. Des. Sci. Nat. Bot.* **11 :** 199-300.

BUVAT, R. 1955. Le meristeme apical de la tige. *Ann. Biol.* **31 :** 596-656.

CLOWES, F. A. L. 1961. *Apical meristems.* Blackwells Scientific Publications Ltd., Oxford.

ESAU, K. 1954. Primary vascular differentiation in plants. *Biol. Rev.* **29 :** 46-86.

ESAU, K. 1966. *Plant anatomy.* 2nd ed. John Willey & Sons Ltd., N. Y.

FOSTER, A. S., 1936. Leaf differentiation in angiosperms. *Bot. Rev.* **2 :** 349-372.

GIFFORD, E. M. JR. AND G. E. CORSON 1971. The shoot spex in seed plants. *Bot. Rev.* **37 :** 143-229.

GIROLAMI, G. 1954. Leaf histogenesis in *Linum usitatissimum. Am. J. Bot.* **41 :** 264-273.

NEWMAN, I. V. 1956. Pattern in meristems of vascular plants. I. Cell partition in living apices and in the cambial zone in relation to the concept of initial cells and apical cells. *Phytomorphology* **6 :** 1-19.

NEWMAN, I. V. 1965. Pattern in the meristems of vascular plants III. Pursuing the patterns in the apical meristem where no cell is a permanent cell. *Jour. Linn. Soc.* (Bot.) **59 :** 185-214.

REEVE, R. M. 1948. The tunica-corpus concept and development of shoot apices in certain docotyledons. *Am. J. Bot.* **35 :** 65-75.

ROUFFA, A. S. AND J.E. GUNCKEL 1951. A comparative study of vegetative shoot apices in Rosaceae. *Am. J. Bot.* **38 :** 290-300.

SHARMAN, B. C. 1942. Shoot apex in grasses and cereals. *Nature* **149 :** 82-83.

SHARMAN, B. C. AND P. A. HITCH 1967. Initiation of procambial strands in leaf primordia of bread wheat *Triticum aestivum* L. *Ann. Bot.* (N. S.) **31 :** 229-243.

STWEARD, F. C. 1961. Vistas in plant physiology : Problems of organization and Morphogenesis. *Can. J. Bot.* **39 :** 441-460.

TOLBERT, R. J. 1961. A seasonal study of the vegetative shoot apex and the pattern of pith development in *Hibiscus syriacus Am. J. Bot.* **48 :** 249-255.

WARDLAW, C. W. 1965a. The morphogenetic role of apical meristems : fundamental aspects. In : *Encyclopedia of Plant Physiology* **15 :** 443-451.

WARDLAW, C. W. 1965b. The organization of the shoot apex. In : *Encyclopedia of Plant Physiology* **15 :** 966-1076.