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SHOOT APICAL ORGANISATION IN *HAMELIA PATENS* JACQ.

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Developmental studies on shoot apical meristems of *Hamelia patens* Jacq. are presented. The shoot apex shows a lightly stained axial zone throughout the vegetative and reproductive stages excepting the transitional phase. The central meristem in the reproductive apex, separated from the flank meristem by an arcuate shell zone, is consumed in formation of floral parts of the flower terminating the branch. The monochasial branches are differentiated from the flank meristem of the reproductive apex. The stamens are ontogenetically epipetalous. All the floral parts are differentiated successively in an acropetal order.

Keywords : Cytohistological zonation; Reproductive apex; Shoot apex; Transitional apex; Vegetative apex.

Introduction

Following Foster[1] many investigators have described the presence or absence of a cytohistological zonation pattern in the angiosperm shoot apical meristems[2-5]. Variations in zonation in relation to plastochronic and other development stages have been reported. Ontogenetic studies on shoot apical meristems all round the year at different plastochronic stages and particularly during transition to flowering in *Hamelia patens* Jacq. are reported here.

Materials and Methods

Shoot apices of *Hamelia patens* Jacq. were collected and fixed in FAA at monthly intervals all round the year. 15-25 samples from each collection were processed through TBA series, sectioned at 6-8 µm and stained with safranin, light green and tannic acid - iron chloride combinations. Height and width of the apex, depth of the CMZ, height of youngest leaf primordium etc. were taken using an oculometer.

Results and Discussion

Hamelia patens, a perennial shrub flowers almost all round the year with profuse flowering during winters. Both vegetative and reproductive buds continue to develop simultaneously. Most of the axillary apices change to reproductive ones through a transitional phase.

The vegetative apex : The vegetative apex is flat to low and narrow to broad dome depending upon the plastochronic stage and shows a cytohistological zonation superimposed on a tunica corpus organisation. The corpus is demarcated into central mother cell zone (CMZ), peripheral zone (PZ) and pith meristem (PM). The plastochron was divided into minimal, mid and maximal stages. Size of the apex and depth of the CMZ showed an increase from the minimal to mid and maximal stages.

The apex is flat and 53.5 µm broad with two-layered tunica and subjacent central mother cell zone at the minimal stage. Cytohistological zonation is very faint at this stage (Fig. 1A). CMZ has irregularly arranged cells and represents the major part of the corpus. It shows cell divisions and blocks of 2-3 cells within a common cell wall and remains below the level of youngest leaf primordia (about 27.9 µm deep). Both tunica and CMZ are uniformly lightly stained. PZ is not very clear and the PM is represented by a small group of lighter stained and larger cells subjacent to the CMZ.

The apex size increases during the plastochron and measures about 7.6 and 13.2 µm in height and 93.6 and 131.3 µm in diameter respectively at mid and maximal stages. Distal cells of the corpus show more regular arrangement at these stages simulating additional (2-3) tunica layers (Fig. 1B, C). Cytohistological zonation is well developed at the maximal stage with markedly lighter cytoplasmic cells of the axial tunica and

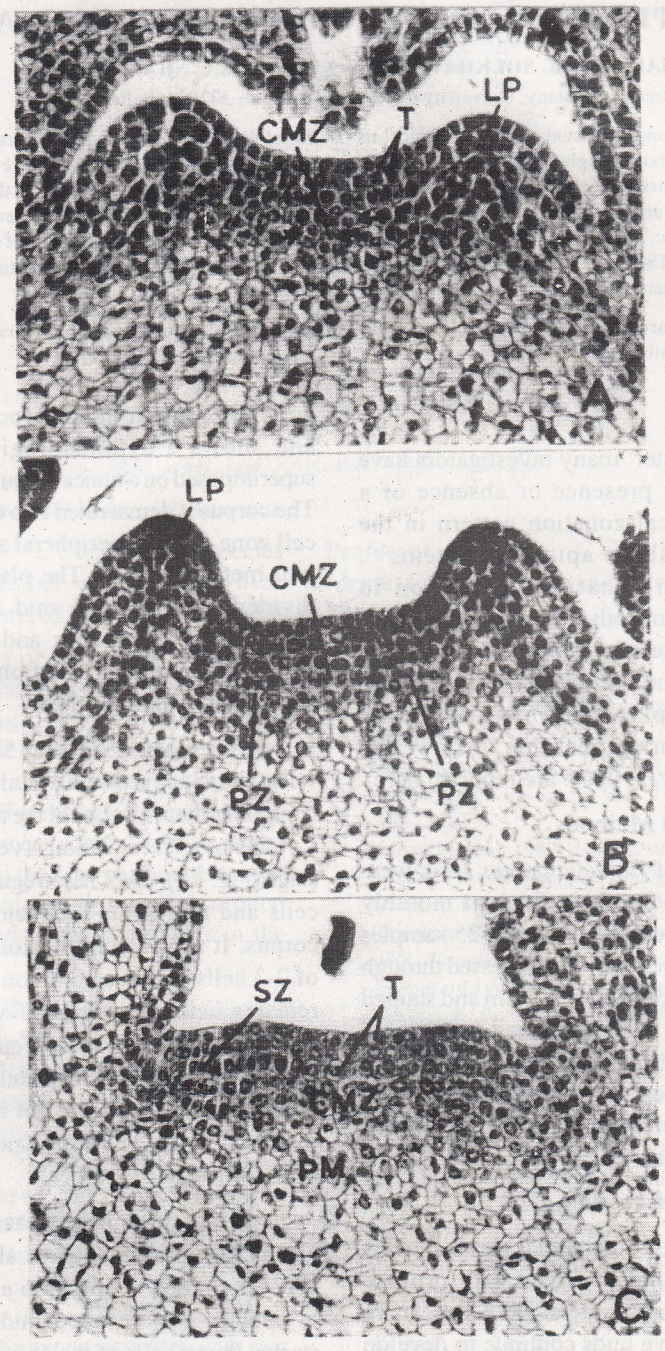

Fig. 1 A-C. Median L. S. of vegetative shoot at different plastochronic stages. A - minimal (x 300); B - mid (x 300); C - maximal (x 250).

Legends to Fig. 1,2.

cmz - central mother cell zone; cfp - central floret primordium; co - core; f - floret primordium; lfp - lateral floret primordium; lp - leaf primordium; m - mantle; pm - pith meristem; pz - peripheral zone; sp - sepal primordium; stp - stamen primordium; sz - shell zone; arrows - indicate cell packets.

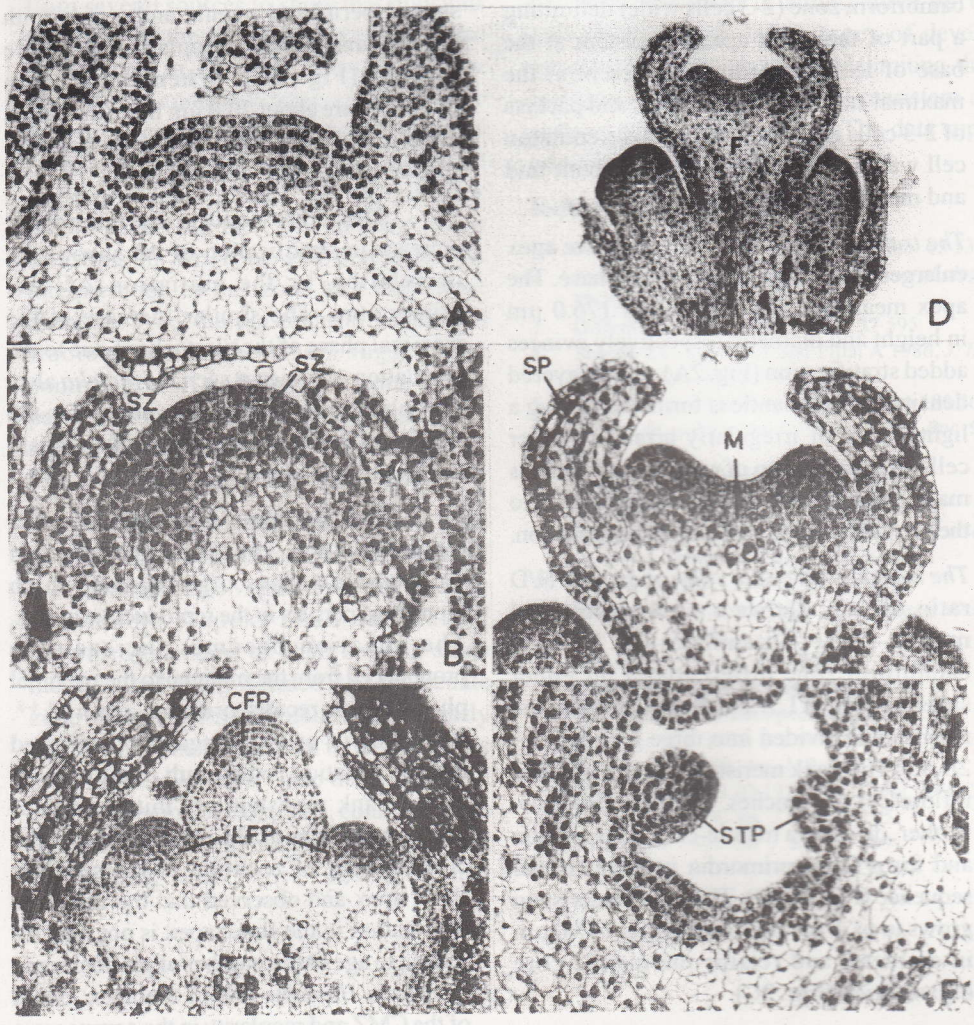

Fig. 2 A - F. Median L. S. of shoot apex at different developmental stages.
A - transitional apex (x 250). B - reproductive apex (x 250); C - reproductive apex showing one central and two lateral floret primordia (x 150); D - reproductive apex showing developing florets (x 150); E - floret apex showing sepal primordia (x 150); F - floret apex showing stamen primordia at the base of petal primordia (x 150).

CMZ and denser cells of the 4-5 layered PZ (Fig. 1C). The CMZ remains below the level of youngest leaf primordia throughout the plastochron (31.1 and 41.1 µm deep at the mid and maximal stages). An arcuate cambiform zone (2-3 cells wide) delimiting a part of the shoot apical meristem at the base of leaf primordium is present at the maximal stage. Division figures and packets of 2-3 cells each enclosed within a common cell wall are seen in the CMZ of both mid and maximal stage apices.

The transitional apex : The vegetative apex enlarges prior to the reproductive phase. The apex measuring about 62.4 and 176.0 µm in height and diameter respectively evinces added stratification (Fig. 2A). A 4-5 layered density stained mantle is formed covering a lighter core of irregularly arranged larger cells. A small group of axial mantle cells is marginally lighter stained as compared to the peripheral ones exhibiting a faint zonation.

The reproductive apex : The apex with H/D ratio of 0.37 shows a well established mantle-core organisation. Arcuate cambiform zone differentiates on either sides (as seen in L.S.) of the apex so that the meristem is divided into three groups (Fig. 2B, C). The flank meristems form the lateral inflorescence branches. These groups grow further, develop a mantle-core organization and form floret primordia in monochasial sequence (Fig. 2C, D). The central meristem grows to 61.8 µm high measuring 147.0 µm in diameter and retains the mantle core organization (Fig. 2C).

The floret apex : The main reproductive as well as floret apices are totally consumed in florets and inflorescence branches and in the floral parts formation respectively. The floret apex with two sepal primordia (in L.S.) measures about 26.0 µm in diameter and shows a densely stained mantle covering a lighter core. As the sepal primordia reach to a height of 55.6 µm the petal primordia are developed. After this, the remaining apex becomes concave and 30.0 µm broad. The stamen primordia are initiated from the flanks and at the adaxial base of the 73.2 µm high petal primordia. During subsequent growth the stamen primordia remain adnate to the petal primordia. At this stage a lightly stained axial group of mantle cells, a densely stained peripheral mantle and a core with broader and lightly cytoplasmic cells are evident (Fig. 2F). When the stamen primordia are about 20.0 µm high, the carpel primordia are initiated and the meristem is consumed in carpel formation.

There are reports on temporary increase in stratification of the shoot apex in relation to the initiation of leaf primordium. The similar increase at the maximal phase of the plastochron due to the simulation of tunica is seen in *Hamelia* also. This plastochron dependent variation in the number of layers may be primarily to satisfy the biophysical need.

The vegetative shoot apex shows a cytohistological zonation superimposed on a tunica-corpus organisation which (zonation) persists in the reproductive apices. The zonation becomes increasingly pronounced from the minimal to the maximal phase which recalls previous reports[3, 6-8]. Regarding its origin Nougarede[9] expressed that the zonation is the result of the activity of the flank meristem or "initial ring" of the French School. Mauseth[10] traced the development of zonation in the seedling shoot apex and observed that the initiation of zonation in the shoot apex is not directly related to age or the number of plastochronic cycles. In *Hamelia* size of the apex, depth of the CMZ and regularity in the corpus were increased alongwith the development of a well marked cytohistological zonation from minimal to the maximal stage of a plastochron. These seem to support Nougarede *et al.*[11], and suggest a possible relation between zonation and size of the apex in relation to leaf initiation. Buvat[12] discussing functional aspects of different parts of the shoot apical meristems, concluded that the most distal region of the shoot apex, the meristeme d'attente, has no organogenetic or histogenetic role during

vegetative growth and becomes active during reproductive phase. The most active zone during vegetative growth is the peripheral and subdistal zone, the anneau initial. But Newman[13] and Ball[14] and other cited evidence from several sources to show that divisions do occur in the meristeme d'attente. The shoot apex in *Hamelia* shows a lighter stained axial zone, indicating a lesser mitotic activity as compared to the densely stained peripheral zone, throughout the vegetative and reproductive phases. But the presence of cell packets in the CMZ indicate recent divisions in this zone and precludes the interpretation of this zone as a meristeme d'attente. And the plastochron dependent fluctuations in the CMZ suggest the contribution of cells by this zone to the peripheral and proximal zones. Hence it is at least indirectly involved in leaf initiation. This is in agreement with previous reports[13-16].

Two to three cells wide arcuate zone of cambiform cells is seen on the flanks of the maximal stage vegetative apex and the reproductive apex. Shah and Patel[17] described this zone as shell zone in some dicotyledons. They defined it as an arcuate zone of cambiform cells delimiting the early axillary bud meristem from the tissue of the axis. Earlier Garrison[18] also described shell zone as a region of elongated, columnar cells that initially delimits the bud meristem from surrounding cells. Reeve[19] described shell zone as bud meristem along with outer layers of the meristem. Gifford[20] included bud meristem alongwith cambiform cells under shell zone. The cambiform cells at the flanks of reproductive apex in *Hamelia* divide the apical meristem in almost three parts and disappears at later stages of development suggesting its role in delimiting the bud meristem from the apical meristem at early stages of development. The data support Shah and Patel[17].

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