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Research Article

STUDY OF VEGETATIVE AND REPRODUCTIVE SHOOT APEX IN *ACACIA CATECHU* WILLD

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ABSTRACT
Acacia catechu Willd. (Mimosaceae) is a medium sized, perennial woody tree, flowers during July-August, having a cymose type inflorescence with axillary cylindrical yellow/pale-yellow spikes, commonly known as Khair tree. The shoot apex of the plant was investigated at different stages of vegetative and reproductive growth. The vegetative apex exhibits a tunica-corpus organization in all plastochronic stages with gradual increase in height and width of dome. The apex enters the reproductive phase through a transitional stage. The inflorescence apex shows a mentle-core organization and entire apex is consumed in producing bracts and florets.

Keywords: *Shoot Apex, Spikes, Tunica-Corpus, Plastochronic Stage, Transitional Stage, Mentle-Core Organization*

INTRODUCTION
One of the fundamental differences between plant and animal development is that plants produce new organs throughout their lifetime, which can span hundreds of years (Lodha *et al.*, 2009). In plants all shoot parts and their tissues originate from the shoot apical meristem (SAM), which is a population of meristematic cells not yet differentiated into primordia of a stem and lateral organs, the shoot apex comprises the SAM and the youngest primordia of lateral organs and growth of the shoot apex is complex and unsteady in time and space (Erickson, 1976; Tras and Doonan, 2001).
Vegetative leaves are generated by the vegetative developmental phase, while in the reproductive phase either bracts subtending lateral flower primordia, or perianth and strictly reproductive organs are formed (Kwiatkowska, 2008).
Some resent studies on shoot apical apices have used the terms ‘shoot apex’ and ‘apical meristem’ with broad definitions or interchangeably (Ursin *et al.*, 1991; Yamamoto *et al.*, 1991). Dengler (2006) stated that the shoot apical meristem (SAM) functions to generate external architecture and internal tissue pattern as well as to maintain self-perpetuating population of stem-cell-like cells. The internal three-dimentional architecture of the vascular system corresponds closely to the external arrangement of lateral organs, or phyllotaxis. In our laboratory, work on shoot apical meristem have been done by many researchers (Pillai and Sharma, 1983; Goyal and Pillai, 1985; Sharma *et al.*, 1986; Sharma and Pillai, 1986; Sharma and Sharma, 1988).
Lakshmi *et al.*, (2012) stated that *Acacia catechu* Willd. (Mimosaceae), also known as Khair, is a medium sized deciduous tree with crooked and forked trunk, is found growing in both natural and plantation forms in most of the parts of the country and have been in use in Indian traditional medicine, ‘Ayurveda’ since antiquity. In this research article we present a study on Vegetative as well as different stages of reproductive shoot apex of *Acacia catechu* Willd.

MATERIALS AND METHODS
Vegetative and reproductive apices of *Acacia catechu* Willd. were collected from the few selected mature plants growing in different localities at Jaipur. 25-30 samples of shoot apices at each stage were fixed in FAA, maintained in 70% alcohol, dehydrated through TBA series (Johanson, 1940) and embedded in paraffin wax.
Serial longitudinal sections cut at 5-7 micro meter on a rotary microtome and affixed to the slide using Haupt’s (Johanson, 1940) adhesive. Dried sections passed through xylene series and stained with general

morphological stains and mounted in DPX. Photomicrographs of selected median longitudinal sections were taken using Nikon E-400 (Anti fungus type) microscope. Measurements of apices were taken using an oculometer.

RESULTS AND DISCUSSION

Results

Acacia catechu Willd. is a perennial woody tree, flowers during July-August. Before flowering, plant is full of vegetative growth. Vegetative apices are rare during flowering and abort during fruit ripening. Most of the reproductive shoots develop from axillary buds. The inflorescence is Cymose type having axillary cylindrical yellow/pale yellow spikes.

The Vegetative Apex

The vegetative shoot apex produces leaf primordia in an alternate manner. The vegetative apex is convex and low to high dome depending upon the stage of plastochron said to be minimal, mid and maximal. The two layered tunica is present in all plastochronic stages. There is a gradual increase in the value of H/D ratio (Height /Diameter ratio) at minimal, mid and maximal stages. The corpus can be distinguishable into three regions based on planes of divisions followed by consequential cell net formation. These are, the central mother cell zone (CMZ), the peripheral zone (PZ) and pith meristem or pith rib meristem (PM). All the zones are uniformly densely stained. Measurements of shoot apex at different vegetative stages varies according to the plastochron stage (Table 1).

Minimal stage: The apex is a low dome covered by two layered tunica, measures about 40µm and 120µm in height and diameter with H/D ratio of 0.33 value.

The corpus is well distinguishable into three regions represent CMZ zone at 26µm at this stage. The cells on flank divide predominantly by anticlinal divisions and are arranged in regular cell files in the PZ zone and are 4-5 layered at this stage.

The PM zone is clearly seen and represented by 4-5 regular longitudinal files. Cells of PZ, proximal CMZ and PM zone are arranged like cambial zone in a 3-4 cells wide arch across the apex and showed more frequency of divisions and termed as cambium-like zone. Depth at which mature pith occurs is 100µm at this stage (Figure 1A).

Mid stage: There is an increase in size of the apex with H/D ratio of 0.45 value. The apex shows 60µm and 134µm values of height and diameter respectively.

The tunica is two layered. The CMZ cells are slightly regularly arranged and present at the 30µm depth and depth at which mature pith occurs is 120µm. All the zones are uniformly densely stained at this stage (Figure 1B).

Maximal stage: Height of youngest leaf primordium and size of the apex are further increased. The height and diameter of the apical dome measure about 90µm and 136µm with an H/D ratio of 0.66 value. Regularity in arrangement of CMZ cells is increased further. At this stage depth of CMZ and depth at which mature pith occurs is 40µm and 120µm respectively. The staining behavior of cells in all the zones is uniform and they are densely stained (Figure 1C).

Table 1: Measurements of Shoot Apex at Vegetative Stage in *Acacia Catechu*

S. No.	Observation	Minimal	Mid	Maximal
1.	Height of dome (in µm)	40	60	90
2.	Width of dome (in µm)	120	134	136
3.	H/D ratio	0.33	0.45	0.66
4.	Depth of CMZ (in µm)	26	30	40
5.	Depth at which mature pith occurs (in µm)	100	120	120

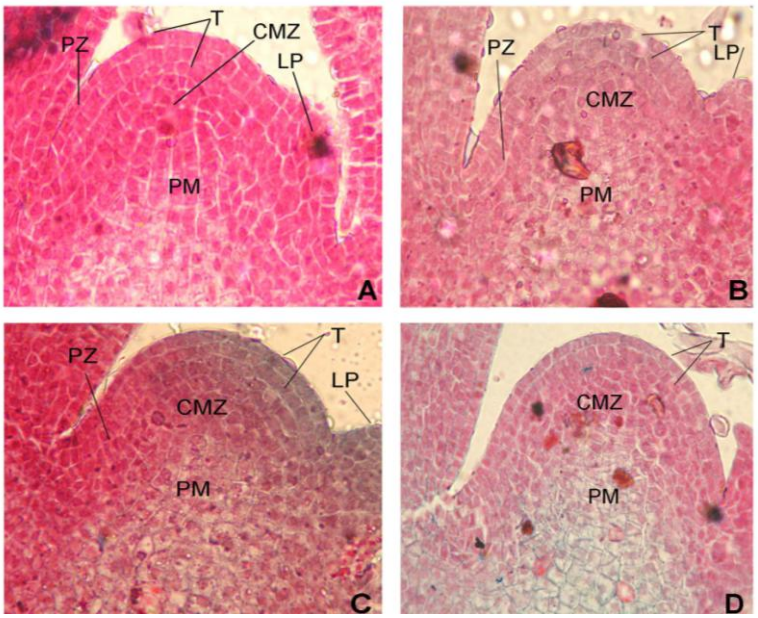

Figure 1 (A-D): Median Longitudinal Sections of the Vegetative Shoot Apices at Different Plastochronic Stages in *Acacia Catechu*

Figure A: At Minimal Stage (x100); B: At Mid Stage (x100); C: At Maximal Stage (x100); D: At Maximal Stage Prior to Flowering (x100)

CMZ - Central Mother Cell Zone; LP - Leaf Primordium; PM - Pith Meristem; PZ - Peripheral Zone; T - Tunica Layer

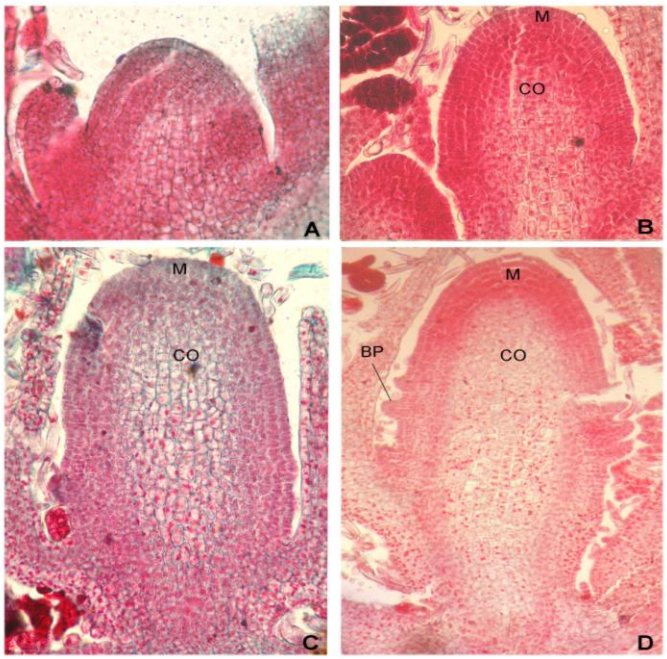

Figure 2 (A-D): Median Longitudinal Sections of the Shoot Apices during Reproductive Phase in *Acacia Catechu*

Figure A: A Transitional Apex (x100); B-D: Different Developmental Stages of Inflorescence Apices (x100, x100, x100)

BP- Bract Primordia; CO – Core; M- Mantle

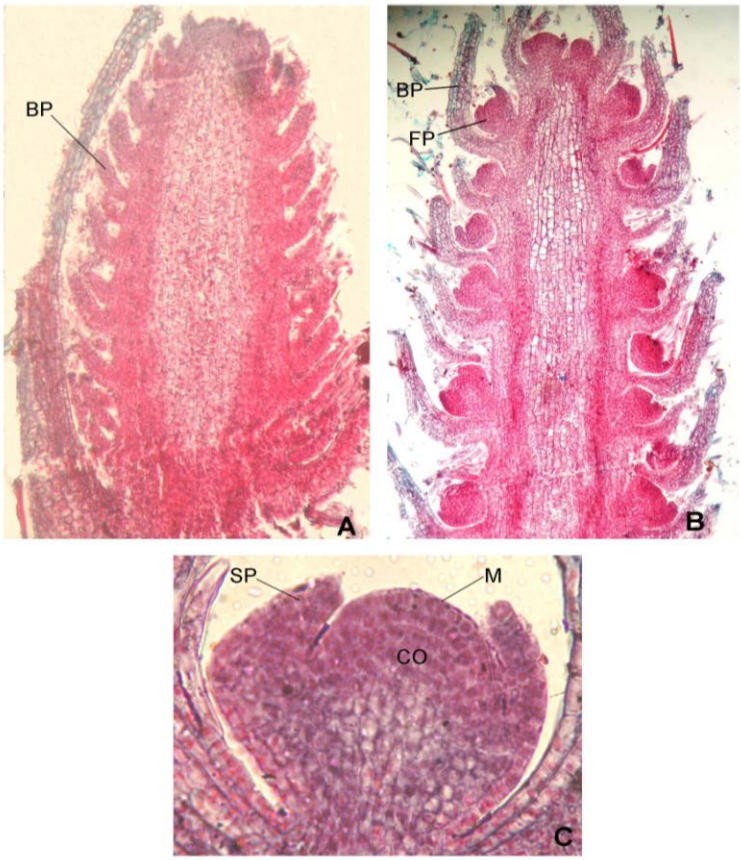

Figure 3 (A-C): Median Longitudinal Sections of the Shoot Apices during Reproductive Phase in *Acacia Catechu*
Figures A-B: Inflorescence Apices at Different Stages (x100, x100); C: The Apex of Young Floret (x400)
BP- Bract Primordium; CO – Core; FP- Floret Primordium; M – Mantle; SP- Sepal Primordium

The Reproductive Apex
Apex prior to flowering: The reproductive apex, prior to flowering, increases considerably and measures about 94µm and 150µm height and diameter with an H/D ratio of 0.63 value. It resembles to the apex of maximal stage of plastochron (Figure 1D).
The transitional apex: The dome becomes squared and enlarged at this stage. The cellular organization of tunica-corpus changes to the mantle-core pattern with 5-6 layered densely stained mantle and a lighter stained subjacent core. Cells in the mental are smaller than the core (Figure 2A).
The inflorescence apex: Apex during flowering season enters into reproductive phase through the transitional phase. The height and diameter of the apex (young inflorescence apex) measures about 253.77µm and 192.25µm respectively and start producing bracts and florets (Figure 2B-D). The mantle becomes more stratified and denser stained. Bracts and floret primordia start originating from the lateral basal part of the apex. Gradually, the whole inflorescence apex is consumed in producing bracts and florets. Thus, no residual apex remaining (Figure 3A-B).
Floret apex: The floret apex bulges out in the axil of bract in the form of a high dome which gradual increases in size and start forming sepal primordia. Now the apex is seen as a high dome with mantle-core organization. The 3-4 layered former zone is densely stained where as the later, covered by the former zone, is lighter stained and broader celled. The apex produces all the floral parts in an acropetal order and totally consumed (Figure 3C).

Discussion

The shoot apex is a convex low to high dome depending upon the developmental stage. The size of apex increases during a plastochron and there is a considerable increase prior to flowering. The H/D ratio taken to be an indicative for proportionate gradual increase in elongation of the apex from minimal to maximal phase showed the height of dome increases more than diameter during a plastochron. The data are in accord with the earlier reports like Gifford (1950), Ramji (1960), Tucker (1962). Authors like Philipson (1947) and Reeve (1948) correlated shape and size of shoot apex and growth habit of plant. The data presented here indicate that the shoot apex in woody plants is a convex and low to high dome.

Shah and Jain (1964) found plastochron related periodic shifting of activities in the apical meristem from central to peripheral zone and from later to the former zone. Earlier Plantefol (1947) was of the opinion, that the central region has no role in vegetative growth and only the lateral meristem is involved in organogenesis. The increased size of the apex goes hand in hand with increased stratification. The divisions in central zone indicate that this zone is also active and involved in vegetative growth.

Observations reported here showed uniformly densely stained regions throughout the apex at vegetative, transitional and reproductive phases. Some vegetative apices, though showed faintly stained central region indicating lower activity in this zone. The data indicate that all the zones are active during all phases of growth, though the peripheral zone might be more active. Sharma and Sharma (1989) also suggested the similar conclusions.

Present study shows that the vegetative apex produces leaf primordia in an alternate manner. Depending upon the height of leaf primordium, the time interval between two successive leaf primordia, called the plastochron is divided into minimal, mid and maximal phases. This vegetative apex, during flowering season (through the transitional phase) enters into reproductive phase.

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