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Structure and Development of Etephon Induced Gum Cavities in the Stem of *Sterculia urens* Roxb.

By

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With 2 Figures

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Summary

Menon A. R. S. & Babu A. M. 1989. Structure and development of ethephon induced gum cavities in the stem of *Sterculia urens* Roxb. – Phyton (Austria) 29 (1): 41–47, with 2 figures. – English with German summary.

The normal wood of *Sterculia urens (Sterculiaceae)* lacks gum ducts. Administration of ethephon induced extensive development of gum cavities from the traumatic parenchyma. The tangential widening of a cavity is limited by multiseriate rays which remain intact, like islands amidst the ramifying cavities. The sequential development of cavities and their 3-dimensional structure are described.

Zusammenfassung

Menon A. R. S. & Babu A. M. 1989. Struktur und Entwicklung Ethephon-induzierter Gummihöhlen im Stamm von *Sterculia urens* Roxb. – Phyton (Austria) 29 (1): 41–47, mit 2 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Das Holz von *Sterculia urens (Sterculiaceae)* enthält normalerweise keine Gummigänge. Ethephon läßt im Wundparenchym ausgedehnte gummiführende Höhlungen entstehen. Diese werden tangential von den mehrreihigen Strahlen begrenzt, welche gleich Inseln inmitten der verzweigten Höhlungen intakt bleiben. Die schrittweise Entwicklung der Höhlungen und ihr dreidimensionaler Aufbau werden beschrieben.

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1. Introduction

Induction or enhancement of gummosis by the administration of ethephon, an ethylene releasing chemical, is a well known phenomenon (see BABU & SHAH 1987). Very recently a study using ethephon was carried out by BABU & MENON 1988 in *Bombax ceiba* and *Sterculia urens,* to find out the optimum concentration of ethephon for maximum yield of the exudate without adverse effect on the plant. As a continuation, the present study was undertaken to elucidate the histological changes associated with the gummosis in *S. urens*.

2. Materials and Methods

Two millilitre solution of 50% ethephon (commercial preparation of 2-chloroethyl phosphonic acid, from Agromore Chemicals, Bangalore, India in distilled water was injected into the trunk of *Sterculia urens* through holes reaching up to sapwood. The holes were made with an increment borer, 1.5 m above ground level. Besides, the experiments with ethephon were repeated on the branches of young plants. Superficial blazes were made on branches – of about 3 cm diameter – by removing the cork of 2.5 cm^2 areas, using a knife, and dilute solution of ethephon (5% in distilled water) was applied over the injury. The branches were cut at 24 hours interval and fixed in FAA, dehydrated, infiltrated with and embedded in paraffin wax using conventional methods (JENSEN 1962). 8–10 μm thick sections, cut using a rotary microtome were stained with toluidine blu O (O'BRIEN & al. 1964).

For enhanced contrast of membranes and cell wall in semi-thin sections, samples were fixed overnight in 3% gluteraldehyde containing 1000 ppm ruthenium red in cacodylate buffer at pH 6.9. (COLOMBO & RASCIO 1977). Post fixation was done in 1.7% OSO_4 containing 1000 ppm ruthenium red in cacodylate buffer at pH 6.9 for four hours. Dehydration was carried out in graded aceton series and embedded in Spurr's resin (SPURR 1969). Section, 1 μ thick, were cut on a Reichert OmU_3 ultramicrotome and stained with 1% toludine blue prepared in 1% borax (O'BRIEN & MCCULLY 1981). The photomicrographs were taken on a Carl Zeiss microscope.

3. Observations

In *S. urens,* the stem has normal gum ducts only in the pith and cortex. Gum ducts or cavities are normally absent in the wood (Fig. 1A). Wood is characterized by diffuse or occasionally banded parenchyma, broad multiseriate rays and thick walled fibers. Administration of ethephon into the stem induced extensive development of gum cavities in the secondary xylem (Fig. 1B, C). The cavities are developed from the axial parenchyma cells formed after ethephon treatment. Upon ethephon treatment, the ray cells remain intact, but only axial parenchyma cells are formed from the fusiform initials. The cambium soon renewed its normal function and consequently a band of traumatic tissue consisting of only axial and ray parenchyma cells is formed in the outer sapwood (Fig. 1 D). The axial parenchyma cells undergo active transverse divisions and the derivatives enlarge to form vertical files of isodiametric cells, the cavity initials (Fig. 2A). They are mostly thin

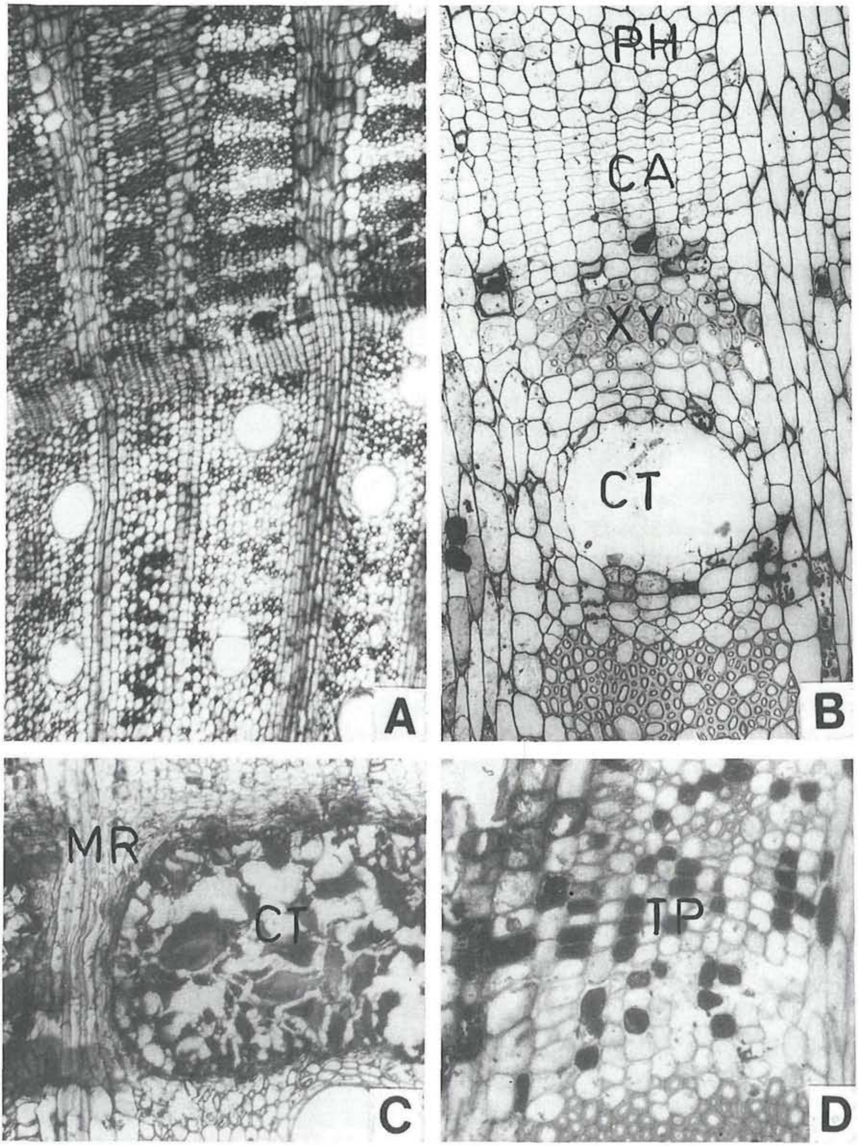

Fig. 1 A–D. Transections from the outer secondary xylem of stem. – A. Normal structure of secondary xylem and phloem. Note that the cavities are absent (× 50). – B–D. Sections from ethephon treated stem. B. Shows gum cavity in the secondary xylem near to cambium (× 100); C. A large cavity filled with gum (× 90); D. The traumatic parenchyma formed in the outer sapwood after ethephon treatment. Note that vessels and fibers are absent in this tissue (× 100).
Key to labelling: CA = cambium; CT = cavity; MR = multiseriate ray; PH = phloem; TP = traumatic parenchyma; XY = xylem.

walled, and have dense cytoplasm and large nuclei (Fig. 2A). The cavity initially develops lysigenously from a group of such cells.

The lysis is triggered by the disintegration of the vertical file of cells proceeded by the darkening of cytoplasm and disappearance of nuclei. Lysis of more cells progresses in vertical and tangential directions forming a cavity (Fig. 2B). But a definite epithelium is not formed around the cavities. Tangential widening of a cavity is limited by multiseriate rays which remain mostly intact. Almost all axial parenchyma cells undergo lysis forming a system of tangentially anastomosing cavities around the intact islands of multiseriate rays (Fig. 2C). The cavity is filled with disintegrating cells and gummy substances. Nervertheless, at places of extensive cavity formation, some multiseriate rays also disintegrate (Fig. 1C, 2D). But always ray cells are the last to be affected. In radial longitudinal sections, the cavities appear as vertically elongated system interrupted by multiseriate rays (Fig. 2D).

4. Discussion

Administration of ethephon induced copious exudation of gum/gum-resin in *S. urens* (Babu & Menon 1988). The induced exudation is associated with the development of traumatic gum cavities in the secondary xylem. The traumatic development of gum ducts or cavities in the secondary xylem, due to mechanical injury or ethephon treatment is reported in several other plants like *Anogeissus latifolia (Combretaccae,* Ghosh & Purkayastha 1959), *Prosopis glandulosa (Mimosaceae,* Greenwood & Morey 1979), *Azadirachta indica (Meliaceae,* Nair & al. 1985), *Citrus* species (Gedolovich & Fahn 1985), *Prosopis cineraria* (Venkaiah 1986), *Ailanthus excelsa (Simarubaceae,* Babu & al. 1987), and *Bombax ceiba (Bombacaceae,* Babu & Shah 1987). Purkayastha 1959 and Setia 1984 reported injury-induced gum cavities in the secondary xylem of *Sterculia urens,* but their sequential development and three dimensional orientation were not dealt with.

In *S. urens* the cavities are developed in the newly formed traumatic parenchyma in the xylem. The formation of anomalous parenchyma as a response to wounding is not uncommon (see Babu & Shah 1987). In agreement with Tippett & Shigo 1981, Babu & Shah 1987 also attributes a role to the traumatic parenchyma as a barrier zone. Thus, in *S. urens* also, the development of a barrier zone of traumatic tissue and the characteristic tangential anastamosis of cavities, further supports their involvement with protective function.

One common feature observed in the distribution of cavities in the secondary xylem of *S. urens* is that, the cavities do not traverse the ray cells. Even though a few ray cells near the site of ethephon treatment showed signs of lysis, the ray cells were the last to disintegrate. Curiously enough

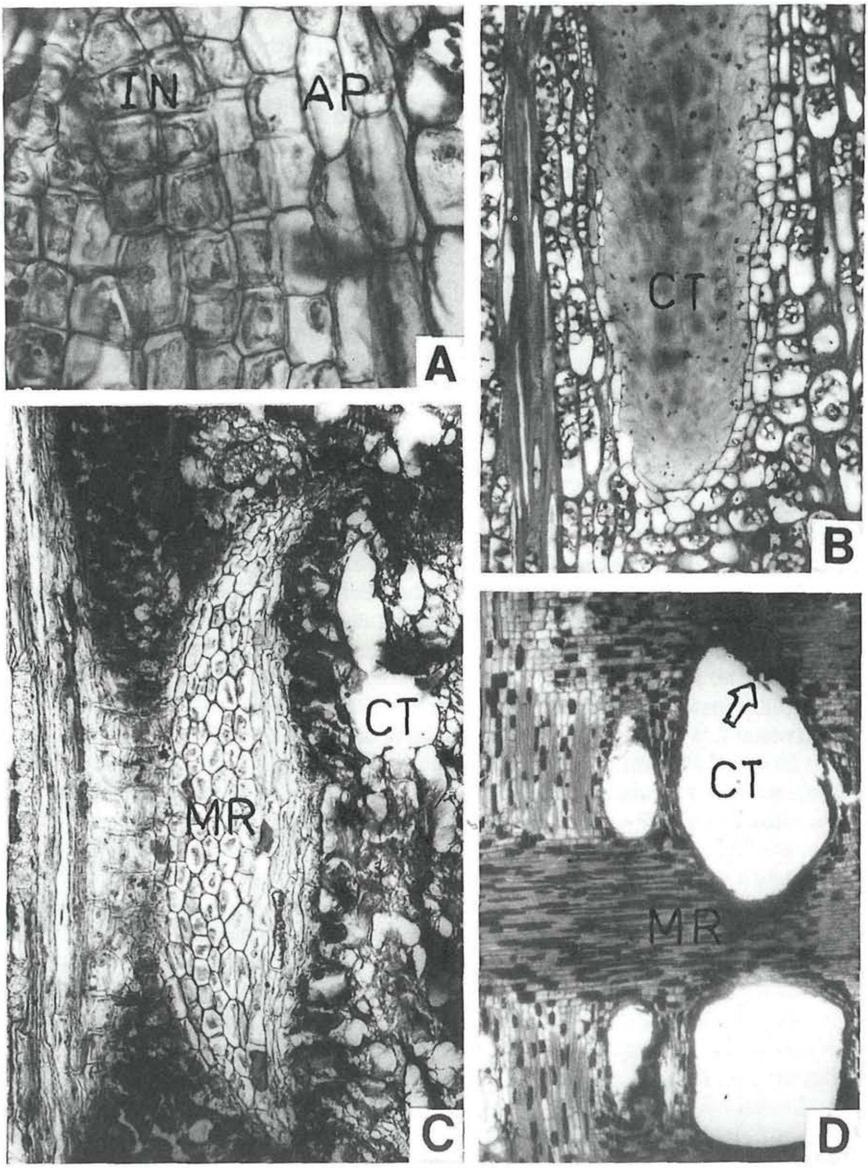

Fig. 2 A–D. Sections from ethephon treated stem. – A. Tangential longitudinal section (T. L. S) *showing vertical file of isodiametric cells (cavity initials)* being formed by the transverse divisions of axial parenchyma cells. Note that the initials have dense cytoplasm and prominent nuclei (× 150). – B. Radial longitudinal section (R. L. S.) of a young cavity (× 120). – C. T. L. S. of an island of intact multiseriate ray in the gum cavity (× 100). – D. R. L. S. showing two vertical rows of cavities. Continuity of the cavities is interrupted by the multiseriate rays. Note that at some places the ray cells are loaded with dark contents (arrow) (× 90).
Key to labelling: AP = axial parenchyma; CT = cavity; IN = cavity initials; MR = multiseriate ray.

the multiseriate rays remain like islands amidst the ramifying system of cavities. Similar observations have been made in several other plants like *Anogeissus latifolia* (GHOSH & PURKYASTHA 1959), *Eucalyptus obliqua* (SKENE 1965), *Azadirachta indica* (NAIR & al. 1985), *Ailanthus excelsa* (BABU & al. 1987). In the traumatic parenchyma, the ray cells form the only link of living cells between the secondary xylem on either side of the tangential row of cavities. BABU & al. 1987 presumed that the cavities do not traverse the ray cells because their lysis may eventually lead to the total separation of the living cells outside the row of cavities.

5. Acknowledgement

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Recensiones

BOTHE H., de BRUIJN F. J. & NEWTON W. E. (Eds.) 1988. Nitrogen Fixation: Hundred Years After. *Proceedings of the 7th International Congress on N – Nitrogen* Fixation Köln (Cologne), F. R. G., March 13–20, 1988. – Gr.-8°, (XVII) + 878 Seiten mit 150 Abbildungen und 81 Tabellen, hart gebunden. – Gustav Fischer Stuttgart, New York. – DM 186,–. – ISBN 3-437-30587-5.

Der stattliche Band enthält die 65 mündlichen Beiträge sowie Kurzfassungen der rd. 400 Poster des 7. Internationalen Kongresses „Nitrogen Fixation" in Köln, 13.–20. März 1988 (650 Teilnehmner aus 43 Ländern sämtlicher Erdteile). Die einleitenden historischen Vorträge verweisen auf die Entdeckung der symbiontischen Stickstoffbindung durch HELLRIEGEL und WILFARTH 1888 und geben einen Rückblick auf 100 Jahre Forschung auf diesem Gebiet (QUISPEL, SCHILLING, BERRIS). POSTGATE & EADY geben eine lesenswerte Übersicht über die Evolution der N-Bindung. Die Fachbeiträge sind in 11 Themenkreise gegliedert, die die symbiontische wie die asymbiontische N-Bindung so ziemlich von allen Seiten beleuchten, wobei molekularbiologische Gesichtspunkte bei mehr als der Hälfte der Beiträge im Vordergrund stehen. Angesichts der Stoffülle ist es unmöglich, ihr auch nur aufzählenderweise gerecht zu werden, der Rez. muß sich darauf beschränken, einige besonders aktuelle Themen herauszugreifen. Breiten Raum nehmen naturgemäß Untersuchungen über Rhizobien ein (zu diesem Thema allein 147 Poster!), sie umschließen Erkennungs- und Regulationsmechanismen, Stoffwechsel, Genetik, Genexpression, Nodulation. Erst seit einigen Jahren bekannt und daher Gegenstand intensiver Forschung sind die sog. alternativen Nitrogenasen in *Azotobacter vinelandii* und *Anabaena variabilis;* Nitrogenase 2 enthält statt Mo und Fe Vanadium, Nitrogenase 3 enthält überhaupt kein Metall (Defektmutante?), auch bestehen Unterschiede in den Reaktionsabläufen. Fortschritte wurden bei den Symbiosen der Erlen und von *Hippophae* (*Alnus–Frankia*-Symbiosen) erzielt. Die Wahl von *Klebsiella pneumoniae* (anaerob) und von *Azotobacter* (aerob) hat sich als überaus fruchtbar für die Aufklärung der die N-Bindung bestimmenden (der sog. nif-) Gene erwiesen. Besonderes Interesse findet auch die N-Bindung durch photoautotrophe Organismen. 7 Vorträge und rd. 70 Poster befassen sich mit angewandten Problemen (Optimierung der N-Bindung in der Land- und Forstwirtschaft, Beziehungen der N-bindenden Organismen zum Boden und einzelnen Kulturpflanzen u. a. m.). Im Anhang sind auch die offiziellen Ansprachen wiedergegben, in diese ist auch das 600-Jahr-Jubiläum der Kölner Universität einbezogen. Ein Autorenverzeichnis mit über 1000 Namen beschließt das Werk. Es ist erstaunlich, daß der Verlag den stattlichen Band noch im gleichen Jahr herausbringen konnte. Leider scheint dem unbedingt anzuerkennenden Bestreben nach möglichster Aktualität das Stichwortverzeichnis zum Opfer gefallen zu sein.

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