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Sclerosed Tyloses in a Medicinal Plant *Millettia speciosa* (Leguminosae)

Dao-Feng CHEN[a], Guo-Jun XU[b], Luo-Shan XU[b] and Tsuneo NAMBA[c,*]

[a]School of Pharmacy, Shanghai Medical University, 138 Yixueyuan Road, Shanghai, 200032 CHINA;
[b]Department of Pharmacognosy, China Pharmaceutical University, 24 Tongjiaxiang, Nanjing, 210009 CHINA;
[c,*]Research Institute for Wakan-Yaku, Toyama Medical and Pharmaceutical University, 2630 Sugitani, Toyama, 930-01 JAPAN

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Sclerosed tyloses of *Millettia speciosa* Champ. a medicinal plant of Leguminosae were discovered and described with illustrations under light microscope and scanning electron microscope. The sclerosed tyloses development of *Millettia speciosa* was found to have no relation to the vessel size, but to correlate with the ray and axial parenchyma.

Millettia speciosa Champ. (Leguminosae) is a climbing shrub widely distributed in Southeastern China. As an allied drug of "Jixueteng" (Chen et al. 1993), the root of this plant has been used for the treatment of lumbocrural pain, lumbar muscle strain, rheumatism, chronic hepatitis, pulmonary tuberculosis, postpartum asthemia and so on (Fujian Institute of Traditional Chinese Medicine 1982, Nanjing College of Pharmacy 1976, New Medical College of Jiangsu 1977).

During an anatomical study on the root and the rhizome of *Millettia speciosa*, development of sclerosed tyloses in some vessels was first discovered in medicinal plants. In this paper, the characteristics of the sclerosed tyloses in *Millettia speciosa* were described with illustrations under light microscope and scanning electron microscope. The possible causes of sclerosed tyloses formation and its correlation with other anatomical features were also discussed.

Materials and Methods

The root and rhizome of *Millettia speciosa* Champ. were collected in San-Ya, Hainan province of China, in July 1987. The plant was identified by Prof. Zhi Wei, a member of Editorial Committee of Flora Sinica, and voucher specimens of the species are deposited in the Herbarium of Materia Medica of China Pharmaceutical University. The fine structures were observed with a light microscope and a SX-40 Scanning Electron Microscope (AKASHI, Japan) after coating with an IB-3 Ion Coater (EIKO, Japan).

Observation

Characteristics of sclerosed tyloses (Fig. 1A, 1B, Fig. 2) In the root and the rhizome of *Millettia speciosa* Champ., vessels are mostly solitary or sel-

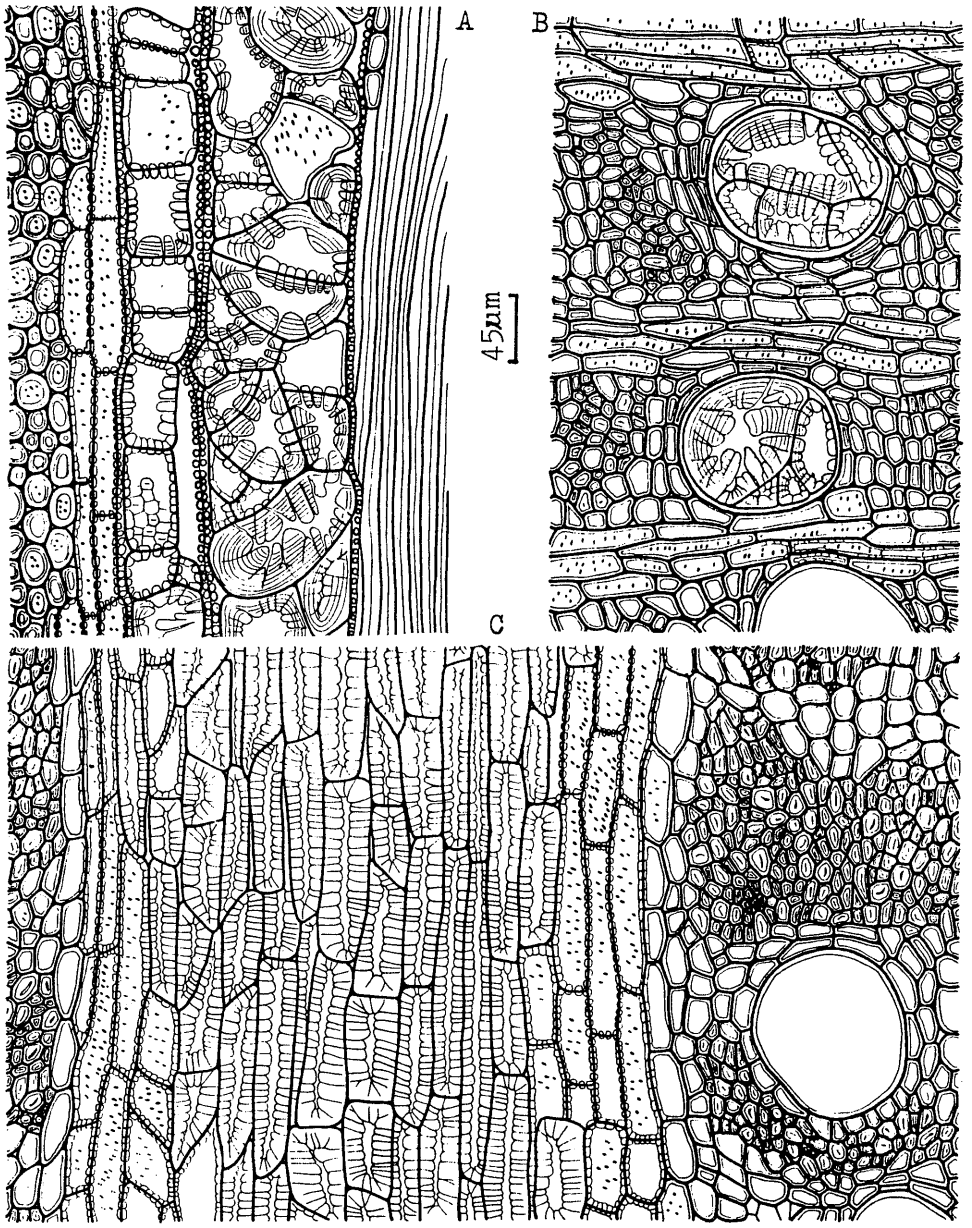

Fig. 1. Xylem structures of the rhizome (A, B) and root (C) of *Millettia speciosa* Champ. A. longitudinal section, B. transverse section, C. transverse section, showing thick-walled ray cells.

dom paired, and circular or semicircular in transverse section. A lots of vessels tend to be present with tyloses, some of which developed into stone cells, forming sclerosed tyloses. Vessels which contain sclerosed tyloses were much more found in the rhizome than in the root.

The majority of the tyloses have thin walls, some of which differentiated into sclereids whose walls are lignified and thickened in different degree, forming sclerosed tyloses. Sclerosed tyloses with different

thickness can be present crowdedly by themselves or with parenchymatous tyloses in a same vessel. Mutual compression made them polygonal in transverse and longitudinal sectional view. Most of sclerosed tyloses possess narrow lumen and very thick secondary wall in which numerous concentric layers and branched pits can usually be distinguished, and some ones have no conspicuous secondary thickening. Under scanning electron microscope, the concentric layers become more clear, meanwhile the pits are hardly distinguished, though a lots of wider pits can be easily observed with light microscope. The presence of sclerosed tyloses in this plant was finally described as a mass of stone cells crowded in a cylinder with little

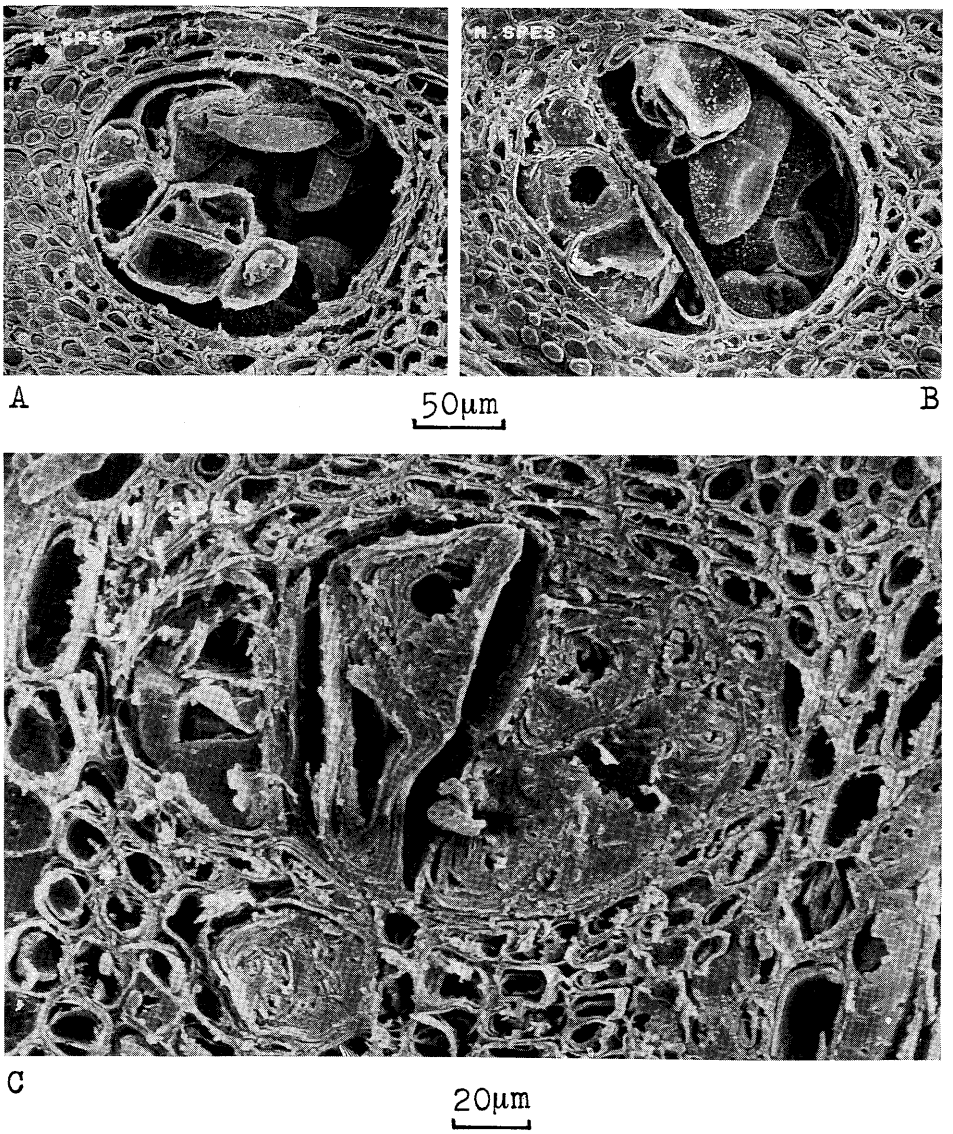

Fig. 2. Structures of tyloses in the rhizome of *Millettia speciosa* Champ. under scanning electron microscope. A. parenchymatous tyloses, B. thick-walled and parenchymatous tyloses in a same vessel, C. strikingly thick-walled tyloses in polygonal shape.

apertures.

Conclusion and Discussion

1. When vessels become inactive, adjacent axial and ray parenchyma cells may develop out-growths through the pit cavities into the lumina of the vessels to form tyloses. They were best illustrated as ballooning of parenchyma cells into contiguous vessels when the pit membrane of the latter becomes degraded enzymically. The nucleus and a part of the cytoplasm of the parenchyma cell commonly migrate into the tyloses. So tyloses store ergastic substances and may develop secondary walls, or even differentiate into sclereids to form sclerosed tyloses (Esau 1977). In *Millettia speciosa*, secondary development of tyloses seems to last and results in the formation of sclerosed tyloses with strikingly thickened and lignified walls. The presence of thick-walled tyloses with parenchymatous tyloses in a same vessel gives a support of this point (Fig. 2B).

2. Tyloses formation is concluded in relation to wounding, but the immediate cause for it is not trauma but loss of vessel water. It does not take place in water-filled vessels, and is somewhat less likely in root than in shoot infections, because water pressure is always higher in the roots (Zimmermann 1983). An agreement to this theoretical consideration was found in *Millettia speciosa*, sclerosed tyloses formation of which is much more in the rhizome than in the root, as regard that the water pressure in rhizomes is commonly lower than that in roots. Pit aperture of the vessels, axial parenchyma and ray type were considered to correlate with tyloses development. Carlquist (1988a) found that tyloses tend to be present in larger earlywood vessels. As shown in Table 1, although smaller vessels with sclerosed tyloses (VST) (<104 μm, 57%) seem more than larger VST ($\geqslant$104 μm, 43%), there is no statistical significance between the size of VST and that of the vessels with no or parenchymatous tyloses (VNPT) in rhizome of *Millettia speciosa*. No correlation of sclerosed tyloses formation with vessel size could be found in this species. Two phenomena that xylem ray cells may develop into thick-walled sclereids or fibres (Fig. 1C), and that wall characteristics of sclerosed tyloses simulate to that of stone cells which are abundant in the phloem, suggest us to conclude that sclerosed tyloses development of *Millettia speciosa* correlates with ray and axial parenchyma in high degree.

3. The presence of tyloses is a common phenomenon in many plant families (Metcalfe and Chalk 1983), but no particular pattern of distribution in certain taxa has been found. Most tyloses have thin primary walls. Sclerosed or stone-cell tyloses (wall thick and lignified) have been reported in Asteraceae, Connaraceae, Euphorbiaceae, Lauraceae, Moraceae, Myrtaceae and Scytopetalaceae (Record 1925, Carlquist 1988a). However, no report has referred them in Leguminosae and in medicinal plants. Sclerosed tyloses do characteristically occur in a few

Table 1. Measurements of the vessels with sclerosed tyloses (VST) and the vessels with no or parenchymatous tyloses (VNPT) in the rhizome of *Millettia speciosa* Champ.

	number of vessels in different size (%)			diameter of vessels
	total	<104 μm[a]	$\geqslant$104 μm	mean±SD (μm)
VNPT	110	53 (48)	57 (52)	108±42.7
VST	76	43 (57)	33 (43)	97±46.6[b]

[a]average size of 186 vessels.
[b]$p>0.05$, there is no statistical significance between the size of VST and that of VNPT.

species, especially in tropical woods (Record 1925). Of 5 species of *Millettia* medicinal plants investigated anatomically, sclerosed tyloses were found only in *Millettia speciosa*. Something noteworthy is that sclerosed tyloses of this plant occur in root and rhizome, underground organs in which tyloses development is recognized less likely (Zimmermann 1983). The sclerosed tyloses of *Millettia speciosa* may be prominently sclerosed, as in *Frichia speciosa* of Asteraceae (Carlquist 1988a), or lightly wall-thickened, as in *Scytopetalum klaineanum* of Scytopetalaceae (Carlquist 1988b).

4. No special function has been claimed for sclerosed tyloses. Zimmermann (1983) considered that tyloses and gums are means by which the plant seals off injured xylem which has become useless and could serve as an entrance for infections, but the injured tissue is not entirely isolated from the functioning tissue until the entire apoplast, including the cell walls, is sealed off. Suberization, lignification and other form of plugging of cell walls are requisite for the accomplishment of this sealing. In *Millettia speciosa*, most of the vessels with sclerosed tyloses were found to have brown substances, which were recognized as the pathological products of infections, because they are absent in vessels with no tyloses, rare in the vessels with parenchymatous tyloses, and commonly present in the injured xylem tissues characterized in brown. So we think that the sclerosis of tyloses makes the sealing more effective and complete, limiting the movement of pathogens in the plant.

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陳 道峰，徐 国釣，徐 珞珊，難波恒雄：**薬用植物 *Millettia speciosa*（マメ科）に認められる厚壁化チロースについて**

マメ科の薬用植物 *Millettia speciosa* Champ.に，厚壁化したチロースを認め，それを走査型電子顕微鏡で観察した．ここでは，厚壁化したチロースの形態と，その成因について報告した．