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Anatomical Characteristics of Swollen Tissue in a Stem of *Platanus occidentalis* L.[1]

Phil Woo Lee[2] and Youn Jib Chung[2]

양버즘나무(*Platanus occidentalis* L.) 膨脹組織의 解剖學的 特性[1]

李弼宇[2] · 鄭然likelihood[2]

ABSTRACT

The swollen tissue of wound origin formed after nailing ㄷ-shaped fastener to a stem of *Platanus occidentalis* L. was compared with normal tissue in the qualitative and quantitative anatomical aspects.

The swollen tissue appeared to differ from normal tissue in irregular cell orientation, occurrence of tyloses in vessel element, less common appearance of pore multiples, narrower and shorter vessel element, lower vessel frequency, shorter and highly thick-walled wood fiber, greater number of bars per scalariform perforation plate in vessel element, larger ray frequency, larger ray width and lower ray height.

Key words : *Swollen tissue*, Platanus occidentalis *L.*, *anatomical characteristics*.

要 約

傷害에 기인하여 양버즘나무(*Platanus occidentalis* L.) 수간에 형성된 膨脹組織의 解剖學的 特性을 組織學的 및 數量的 側面에서 正常組織과 比較 考察하였다.

팽창조직은 정상조직에 비하여 세포배열이 불규칙적이고 도관요소내 타일로시스가 현저하게 발달되어 있으며, 厚壁化된 목섬유가 흔히 관찰된다는 점, 복합관공이 덜 나타난다는 점에서 차이를 나타내었고, 관공의 직경이 작고 도관요소와 목섬유의 길이가 짧으며 도관빈도(vessel frequency)는 작은 반면, 도관요소내 계단상 천공판의 bar 數가 많으며, 방사조직 빈도(ray frequency)가 크고 방사조직의 폭이 넓으나 높이가 작은 特性을 나타내었다.

INTRODUCTION

Swollen tissues of xylem such as tumor, burl, *etc.* may be formed as a result of damages by fungi or insects and mechanical injuries to the vascular cambium in living tree.

The occurrence and anatomy of these swollen xylem tissues, especially tumors, in softwoods have been widely investigated in comparison with those in hardwoods(White 1958 ; Tsoumis 1965 ; Kucera 1977 ; Kuroda and Shimaji 1984 ; Yamanaka 1985). Recently Tsoumis *et al.*(1988) reported that the briarwood, a hardwood tumor-like overgrowth occurred between root and stem in *Erica arborea*, have shorter and irregular fibers, irregular tissue structure in comparison to normal wood. Eom(1988, 1991) described abnormalities of the growth ring and

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[2] 서울大學校 農業生命科學大學 林產工學科 Dept. of Forest Products, College of Agriculture & Life Sciences, Seoul National University, Suwon 441-744, Korea.

cellular anatomy in detail in an artificially induced tumorous woods of two Korean hardwoods, *Ailanthus altissima* and *Robinia pseudoacacia*.

This paper was intended to investigate the anatomy of swollen tissue of wound origin in a stem of *Platanus occidentalis* L., one kind of hardwood overgrowth tissue hitherto not studied extensively.

MATERIAL AND METHODS

The swollen tissue in a stem of *Platanus occidentalis* L., about 25 years old and 40cm in DBH, was chosen in the campus of the College of Agriculture and Life Sciences, Seoul National University, Suwon(Fig. 1). The sample tree was wounded by nailing a ㄷ-shaped fastener at approximately 120cm above the ground level in May 1984. In September 1991, small blocks(1.5×1.5×1.5cm) from the swollen tissue formed after wounding and normal tissue were cut with a chisel from the living stem and then immediately fixed in FAA solution.

Transverse, radial, and tangential sections of 15-20μm thickness were sliced with a sliding microtome, stained with safranine, dehydrated in ethyl alcohol and xylene series, and permanently mounted on slides with Canada balsam(The Japan Wood Research Society 1985).

The woods in size of matchstick subdivided from sample blocks were macerated with Schultze's solution for quantitative analysis of wood fiber and vessel element lengths, and number of bars per scalariform perforation plate in vessel element.

The observation and photomicroscopy of qualitative features were made from permanent slides by an Olympus Model BHC microscope. In quantitative features, 100 fiber lengths, 50 vessel element lengths including number of bars per scalariform perforation plate in vessel element were measured by random selection from macerations using an optical bench comparator, Ernst Leitz GmbH, Wetzlar, Model TP 201 and a light microscope. From permanent slides, 30 measurements of vessel frequency(number of pores per mm^2) and 50 measurements of radial and tangential diameters of pores on cross section, and 50 measurements of ray height and width and 10 measurements of ray frequency(number of rays per mm^2) on tangential section were also made by random selection.

In statistical analyses of the measured quantitative features between swollen and normal tissue, LSD (least significant differences) at 0.05 and 0.01 probability level was determined by analysis of variance procedures from SAS statistical package.

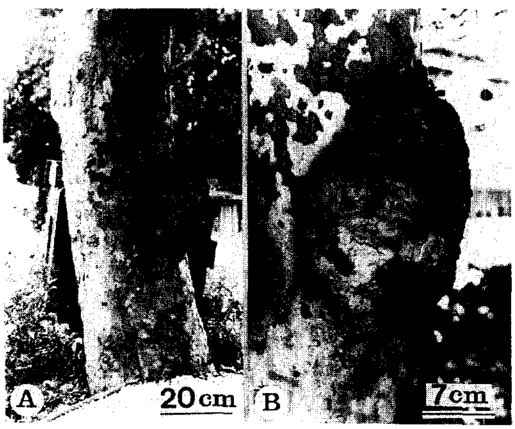

Fig. 1. Swollen tissue of wound origin formed after nailing a ㄷ-shaped fastener into the stem (A) in *Platanus occidentalis* L. and its close view(B).

RESULTS AND DISCUSSION

Normal anatomical characteristics of *Platanus occidentalis* were diffuse-porous wood, growth rings distinct, perforation plates simple for the most parts occasionally scalariform, parenchyma not uniformly distributed, paratracheal-scanty, apotracheal diffuse among the fibers, prismatic crystal present in ray(Fig. 3B), rays homocellular, unstoried(Fig. 4C and D).

In the histological structures, swollen tissue in *Platanus occidentalis* is altered in cell orientation which deviated from normal arrangement(Fig. 2). The most outstanding deformities in the swollen tissue are the appearances of rays, vessels and wood fibers on cross surfaces as if seen on the radial surfaces(Fig. 2C) and of horizontally oriented wood fibers in radial surfaces like cross sectional view (Fig. 3A). These change in cell orientation may be resulted from the alteration or destruction of vascular cambium through nailing by a ㄷ-shaped fastener

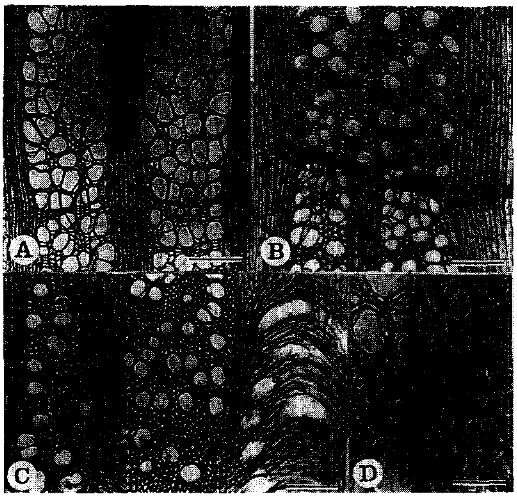

Fig. 2. Cross sections of normal tissue(A) and swollen tissue showing irregular cell orientation and decreased vessel frequency(B, C) and thick-walled wood fibers(D). Scale bar A, B, C=200μm, D=50μm.

to the living cambium. Another interesting fact is that wood fibers in the swollen tissue are thicker than those in the normal tissue(Fig. 2D).

Most pores in swollen tissue on cross surfaces are solitary except for the vicinity of growth ring boundary while pores of normal tissue are frequently grouped into pore multiple and cluster(Fig. 2A, B and C). The cross section also reveals clearly that vessel elements are narrower in diameter than normal ones and that pore multiples are less common in swollen tissue. In radial section, tyloses are commonly observed in the vessel elements of swollen tissue but are not observed in those of normal tissue, like in the case of mechanical injury, fungus, or virus infection(Fig. 3C and F). These tyloses of pathological causes considered to play a protective role through occlusion of the vessels by protoplasmic protrusions penetrating into a vessel lumen through bodered pits, resulting in a barrier against parasitic or saprophytic infections(Beckman 1971).

Vessel element length, vessel frequency, radial and tangential diameters of pores, and fiber length are significantly lower in swollen tissue than in normal tissue. The number of bars per scalariform perforation plate are significantly greater in vessel element of swollen tissue than in normal tissue

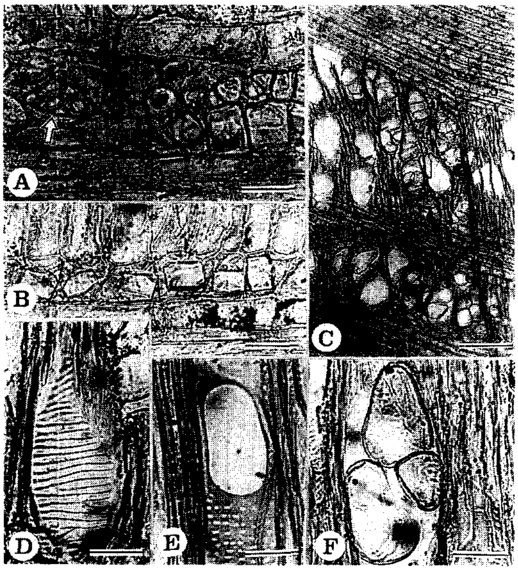

Fig. 3. Radial sections of swollen tissue showing prismatic crystals(A, B) in ray parenchyma cells, tyloses(C, F), scalariform(D) and simple perforation plate(E) in vessel element. Arrow indicates abnormally arranged wood fibers as if seen on cross section. Scale bar A, B, D, E, F=50μm, C=200μm.

(Table 1). These characteristics of the vessel element in swollen tissue are generally similar to those in tumor wood and wound-associated wood in hardwoods (Lowerts *et al*. 1986 ; Tsoumis *et al*. 1988 ; Eom 1989). But anomalous vessel element and wood fiber are not found in swollen tissue differently from their occurrence in the massive overgrowth tissue of tumor wood. The occurrence of tyloses in vessel elements and the absence of misshaped vessel elements or fibers in swollen tissue might be the result of less severe damage of cambium caused by partial destruction or irritation of vascular cambium than in the massive overgrowth tissue of tumor wood by the irritation or injury in most of vascular cambium after wounding.

Ray frequency and width are significantly greater but ray height is lower in swollen tissue than in normal tissue(Fig. 4 and Table 1). Lowerts *et al*. (1986) reported in *Liriodendron tulipipera* that ray height and width were greater in wound-associated wood than in normal wood. The rays of the tumorous wood formed by artificial banding and subse-

Table 1. Mean values and standard deviations* for quantitative features in swollen and normal tissues of *Platanus occidentalis* L.

Quantitative features	Swollen tissue	Normal tissue	LSD 0.05**	LSD 0.01**
Vessel element length(μm)	484.4(104.4)	654.4(144.5)	50.0	66.2
Vessel frequency(numbers/mm²)	49(18)	109(17)	9	12
Number of bars per scalariform perforation plate in vessel element	11.2(4.1)	7.8(4.3)	1.7	2.2
Radial pore diameter(μm)	63(12)	77(18)	6	8
Tangential pore diameter(μm)	56(11)	62(15)	5	7
Fiber length(μm)	1230(273)	1746(336)	85	112
Ray frequency(numbers/mm²)	3.9(0.5)	1.9(0.2)	0.4	0.5
Ray height(μm)	1515(691)	1836(512)	242	320
Ray width(μm)	316(152)	250(68)	47	62

* Standard deviation in parentheses.
** LSD 0.05 and LSD 0.01 are least significant differences at 0.05 and 0.01 probability level, respectively.

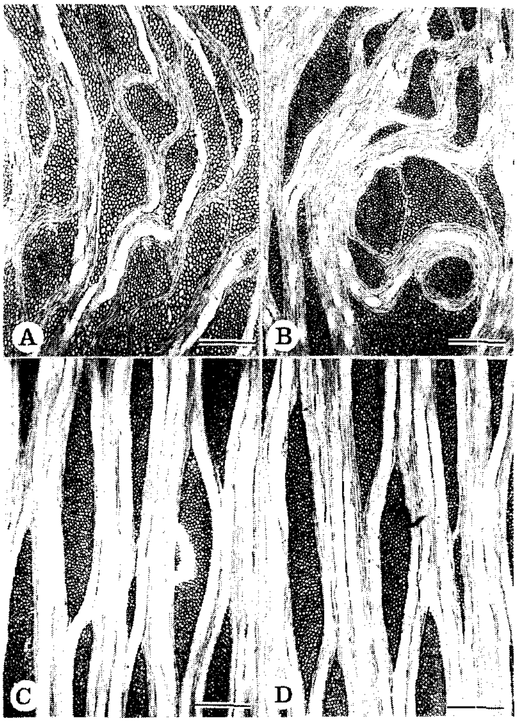

Fig. 4. Tangential sections of swollen tissue(A, B) and normal tissue(C, D) showing irregular and normal ray structures, respectively. Scale bar A, B, C, D=400μm.

quent release in *Ailanthus altissima* were known to show irregular appearances deviated from the normal fusiform shapes and to be wider and taller in size by Eom(1989). Only the ray height of swollen tissue in this study appears to be lower than in normal tissue, differently from the taller rays in Lowerts *et al*.(1986) and Eom(1989).

Ray parenchyma cells were generally responsible for the synthesis of various fungitoxic chemicals in living trees(Shortle 1979) and were the source of tyloses(Chattaway 1947). Therefore the increased number of ray parenchyma cells may result in increased vessel to ray parenchyma contacts, thus enhancing the transport of fungitoxic compounds into vessel and consequently preventing the spread of microorganisms into the wood(Lowerts *et al*. 1986). Also the decrease in vessel diameter with numerous bars in scalariform perforation plates and vessel frequency may result in the reduced water conductivity, since the hydraulic conductivity of capillaries was known to be proportional to the fourth power of the radius of capillary(Zimmerman and Millburn 1982), and then would serve to inhibit the spread of microorganisms via conducting vessel elements.

Because the decreased vessel frequency and diameter and increased ray volume in swollen tissue(Table 1) which formed after nailing ㄷ-shaped fastener to living cambium seems to reflect these specific adaptations of tree xylem for protection as in wound-associated wood, the swollen tissue, though the mechanisms are completely unknown, may be caused by the partial destruction of vascular cambium.

CONCLUSION

Anatomical differences between swollen and normal tissues in a stem of *Platanus occidentalis* L. were compared in qualitative and quantitative aspects.

In swollen tissue, the vessels, rays, and wood fibers on cross sections generally appear as if seen on radial sections. Thick-walled wood fibers were commonly observed. Pore multiples were less common and vessel element were narrower in swollen tissue than in normal tissue. Vessel element length, vessel frequency, and fiber length were lower than in normal tissue but bars per scalariform perforation plate were more numerous in swollen tissue. Tyloses frequently occurred only in the vessel element of swollen tissue. Ray frequency and width were greater but ray height was lower in swollen tissue than in normal tissue.

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