Basic mechanism of secondary cell wall formation in softwood tracheids

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The structure of annual rings and thereby the structure of tracheids is influenced by external factors:

- Temperature
- Nutrient availability
- Water
- Climate
- Sun light
- Others
Genetically controlled growth and inwintering

Birch with different proveniences planted at Ultuna in a North to South row.
Background

The differentiation of tracheids in the xylem of conifers occurs from the cambium with four arbitrary phases:

- Cell division in the cambium and formation of primary wall
- Surface growth/expansion of daughter cells to the size of mature tracheids
- Formation of the secondary wall
- Lignifications of the cell wall

(Wardrop and Harada, 1963)
Hosoo et al. (2005) were able to demonstrate that the deposition of cellulose microfibrils onto the developing secondary wall of tracheids occurs during daylight and that hemicelluloses and maybe also lignin precursor are deposited during the night.
A particular annual ring of spruce

Fibres in a radial row are more genetically related with each other, originate from the same mother cell in the cambium

Earlywood

Latewood

Wall area of tracheids along a radial row across an annual ring: IMAGE ANALYSIS
Measurements on other annual rings

Spruce 1.5 m - annual ring 38
CELL WALL AREA and LUMEN AREA

Square microns vs Tracheid number
Spruce 1.5 m - annual ring 20
CELL WALL AREA and LUMEN AREA

Square microns

Cell wall
Lumen

Tracheid number
Spruce 1.5 m - annual ring 38
CELL WALL AREA and LUNEN AREA

Square microns

Tracheid number

Cell wall
Lumen
Pine 1.5 m - annual ring 19
CELL WALL AREA and LUMEN AREA

Square microns

Tracheid number

Cell wall
Lumen
Pine 1.5 m - annual ring 10
CELL WALL AREA and LUMEN AREA

Square micrometers

Tracheid number

Cell wall
Lumen
Context

Deposition of cellulose microfibrils onto the developing secondary wall of tracheids occurs during daylight and that hemicelluloses and lignin precursor are deposited during the night (Hosoo et al., 2005). Latitude and availability of sunlight may influence annual ring formation.

Earlywood/Latewood

During biosynthesis the geometry of softwood tracheids is already determined and completed before formation of the secondary cell wall (Larson, 1994).

The speed and ratio of secondary wall formation will be determined by external factors but the intrinsic mechanism of cell wall deposition may be in operation through the whole growing season.

Hypothesis

“Given constant conditions with regard to availability of water, nutrients, temperature, and cyclic equal day/night intervals, secondary cell wall deposition will occur in a constant manner. As a direct consequence of that, the transverse wall area of tracheids in a radial row across a growth ring is expected to be the same.”
Study of factors affecting secondary cell wall deposition (for forestry, wood biomass production) and annual ring formation solely through measurement of transverse wall area on single rows
Experimental approach

1. Norway spruce (*Picea abies*) plants grown under controlled conditions in growth cabinets.

2. Norway spruce plants grown outdoors
First growth period

Three months in continuous light at 20°C humidity 75% (optimal growth conditions for all Norway spruce provenances). All other factors are constant.

Inwintering = eight weeks of long nights (16 h) at 20°C, then one week of long nights at 10°C, one week of long nights at 5°C, one week in darkness at 2°C, one week of long nights at 10°C, after which → second growth period.

Second growth period

Group 1: Constant conditions: 16h day and 8h darkness

Group 2: “Day length”: from 16h to 22h, and back to 16h

Group 3: Effect of temperature: 16h day at 25°C and 8h darkness at 15°C (10°C)

All other factors are constant. “Third growth period”

Group 4: Planted outdoors (analysis matched to meteorological data)
Inwintering: start - Sept. 2010
**Expected result**

**Group 1:** Constant conditions: 16h day and 8h darkness
Expected result

Group 2: “Day length” variation

Transverse cell wall area

Tracheids
Expected result

Group 3: Effect of temperature

- Less tracheids formed?
- Smaller transverse cell wall area?
Expected result

**Group 4:** Planted outdoors (2 years)

**Analysis against meteorological data**
Other experimental set-ups

Effect of photoperiod: grow the plants under continuous light with correspondingly reduced light intensity

Effect of reduced total light energy

Effects of drought

Formation of latewood

Others…
What do you think?

Thank You!

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