XYLEM FORMATION IN CONIFEROUS SPECIES IN CĂLIMANI MTS. DURING THE 2013 GROWTH SEASON

Semeniuc I. Anca *, **Popa Ionel** *

*Forest Research and Management Institute, Bld. Eroilor, 128, Voluntari, Romania,
e-mail: semeniuc.anca@yahoo.ro
*Stefan cel Mare University of Suceava, Forestry Faculty, 13 Universității, Suceava, Romania,
e-mail: popaicas@gmail.com

Abstract

The xylem growth and cambium activity of European larch (Larix decidua) and Scots pine (Pinus sylvestris) from the Călimani Mountains were studied during the 2013 growth season. Wood microcores were collected weekly from April to October and prepared to describe and to determine the number of cells. Phases of tree ring development were described and discussed, in number of cells and phase duration: cambial phase, cells enlargement, cell wall thickening and mature cells. The start of the cell division occurred in April 15 for larch, while for Scots pine about a week earlier when occurred when the first cell division. Tree ring formation ended in late September-early October. The highest numbers of cells and maximum phase duration was observed in Scots pine, whereas a reduced cell number was observed in larch.

Key words: cambial activity, xylem growth ring, European larch, Scots pine

INTRODUCTION

The formation of annual tree rings in coniferous species with qualitative and quantitative evaluation of xylem cells, represent an interest for researchers. The xylem formation is an important process that takes place in four successive phases during the growing season. (Rossi S. et al, 2006). In most cases, the process of xylem growth varies from one year to another (Deslauriers A. et al, 2008). Climatic fluctuations during the growing season are the most important factor in growth (Rossi S. et al, 2006). For understanding of the dynamics of cell production and maturation repeated investigations are needed on forming cells during xylem developing (Rossi S. et al, 2006; Wimmer R., 2002). Other studies show the problem of intra-annual variation of the xylem, even more the dynamics of radial growth phases (Schmitt U. et al, 2004, Oberhuber W. et al, 1998). Most studies on monitoring the processes of xylem formation are considering coniferous species (Deslauriers A. et al, 2008, Gricar J. et al, 2009, Moser L. et al, 2010, Rossi S. et al, 2006b, Vaganov EA., 2004). In growth radial onset and duration in during growing season, is remarked an variability because of intra-annual differences in weather (Deslauriers A. and Morin JA. 2005, Rossi S. et al, 2006). The onset of cambial activity in Scots pine was analyzed between altitudinal levels in northern Finland (Seo WJ. 2007 et al, 2007). Radial growth in Scots pine was reduced by limiting water comparing with larch growth which is increased by higher temperature (Keller et al. 1997). The earlier onset of phenological phases in spring influences the radial growth (Studer et al. 2005). The object of this research is to analyse the dynamics of the cambial activity and different stages of the annual tree ring formation during the period 2013 for larch and Scots pine from Calimani Mts..

MATERIAL AND METHOD

The study is located on the northern slope (47° 06' N 25°15'E) of the Călimani Mountains in the North of the Eastern Carpathians. The altitude of the research plot is 1400 meters a.s.l.. Five trees of larch and similar five of Scots pine were chosen to take samples weekly from April to October 2013. Wood microcores were collected with a Trephor tool (Rossi S. et al, 2006a), samples were taken with a thickness of 2.5 mm and a length of 3-5 cm and collected at the height of 1.30 m at a distance of 5 cm one from another to avoid tissue injury. Immediately after sampling, microcores were placed in a solution of 1:1 ethanol-water in Eppendorf microtubes, in order to avoid their drying. The microcores were processed in the laboratory according to methodology by Rossi S. et al (2006b). The first procedure consisted in dehydration of microcores in ethanol with various concentrations immersed in RotiClear and paraffin using STP 120 Microm tissue processor. The samples mounted in paraffin blocks have been processed with Microm HM335 microtome to give sections of 7-8µm thickness. The samples were stained with 0.32% solution of cresyl violet acetate. The microsections were analysed at microscope in polarized visible light at X50-400 magnification to identify the cells in different stages of development. The microscopic observations of the growing xylem were done for each phases of tree ring development: cambial phase, cells enlargement, cell wall thickening (lignification phase) and mature cells (Rossi S. et al, 2006b, Cufar K. et al, 2008,). Observations were made on the onset and cessation of each phase. The radial number of cells in each phase of development was counted along 3 files for each sample (Antonova GF. et al, 1995; Deslauriers A. et al, 2003). Number of cells varies along tree circumference and standardization methods were applied using the precedent tree ring cells number as reference (Rossi S. et al, 2003, 2006b).

RESULTS AND DISSCUSIONS

The dynamics of xylem formation have been studied in order to assess the radial growth, including onset and ending of growing season. In tree ring development were analysed more successive phases during the growing season: cambial cell activity, development of cells, thickening of cell walls, respectively completely lignified cells. Detailed analysis of xylem cells shows that start of the growing season occurred in April 15 for larch, when cambial cell division occurred. A significant increase of cambial cells number was observed for Scots pine about a week earlier than larch. The duration of cambial cell production was lower for larch comparing with Scots pine (Fig. 1). More studies show that high spring temperatures influence positively radial growth (Deslauriers A. et al, 2008) and summer temperature is the important controller of radial growth (Fritts H. et al, 1976). Significant differences among species were noticed in research (Schmitt U. et al, 2004; Deslauriers A. et al, 2008). The differences in onset of cell enlargement were observed between the two species, with an onset earlier of cell development in Scots pine. Comparing number of cells enlargement of both species, can be observed a reduced number of cells enlargement in larch (Fig.1).

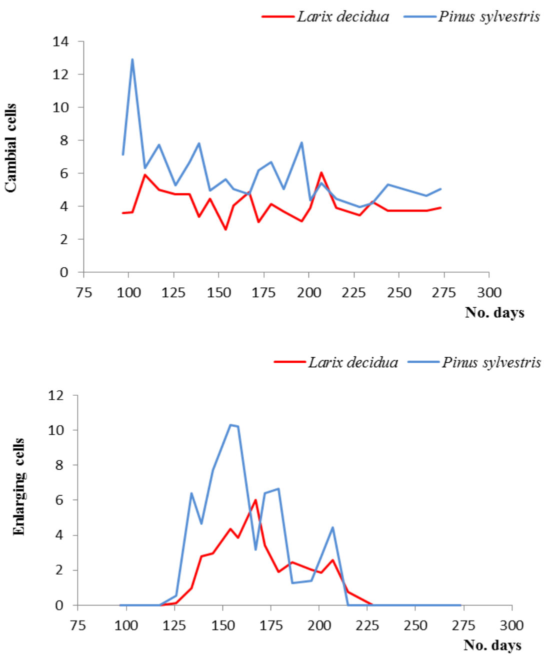

Fig. 1 Number of xylem cells observed in the cambial zone and enlargement phase, in larch and Scots pine during 2013.

The onset of lignification phase occurs in middle May to early June, when in the polarized light, the first cells undergoing lignification were observed. The differences among species are of 7-19 days, reported on phase debut of lignification. The duration of the lignification phase is of 100-110 days in Scots pine and of 86-100 days in larch. The lignification process occurred until late September for both species. The first mature cells, fully lignified was observed around June 16 in Scots pine, with about one week earlier than larch (Fig.2) The differences of radial growth on number of cell and times spent in cell differences, were observed in study carried out at three species in Italia (Rossi S. et al, 2003b). The complete formation of the xylem was noticed in late September-early October, when the last mature cells are registered. The duration of all xylem development phases varies between species.

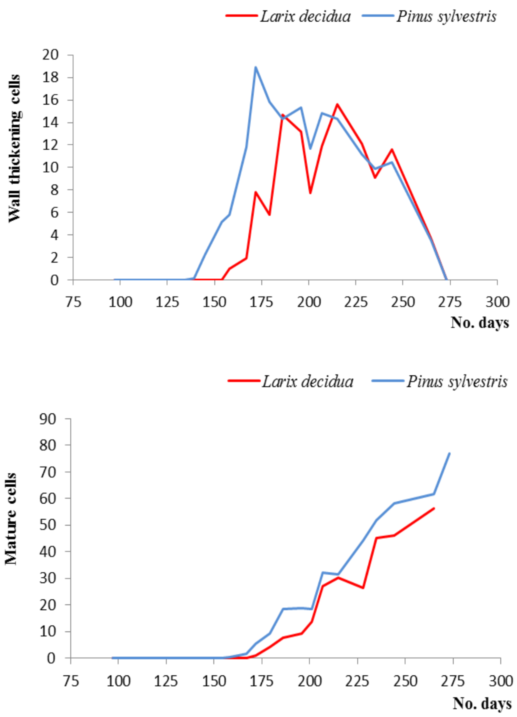

Fig. 2 Number of xylem cells observed in wall thickening phase and number of mature xylem cells in larch and Scots pine during 2013.

CONCLUSIONS

Xylem growth is a complex process and to evaluation the dynamics of phase formation of the annual ring are necessary repeated xylem analysis. The research on the study of annual xylem formation on cell number, can offer essential information during the growing season in relationships with environmental factors. According by (Fritts H. et al, 1976), radial tracheid growth depends by the climatic conditions and induce differences in the cell rate production of the annual tree-ring. The onset and duration of each xylem development phase (division cambial, radial enlargement and secondary cell wall thickening) showed differences between larch and Scots pine from Calimani Mts..

Acknowledgments

This paper has been financially supported within the project entitled ***„SOCERT. Knowledge society, dynamism through research***", contract number POSDRU/159/1.5/S/132406. This project is co-financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007-2013. ***Investing in people!*** Also, is supported by project PN09460110, PN09460108.

REFERENCES

1. Antonova G. F., Stasova V.V 1997. Effects of environmental factors on wood formation in larch (Larix sibirica Ldb.) stems. Trees 11: 462-468.
2. Antonova, G.F., Cherkashin, V.P., Stasova, V.V., Varaksina, T.N., 1995: Daily dynamics in xylem growth of Scots pine (Pinus sylvestris L.). Trees 10:24-30.
3. Antonova, G.F., Stasova, V.V., 1993, Effects of environmental factor son wood formation in Scots pine stems. Trees 7:214-219.
4. Camarero Julio J., Guerrero-Campo J., Gutierrez E. 1998. Tree-ring Growth and Structure of Pinus uncinata and Pinus sylvestris in the Central Spanish Pyrennes Artic and Alpine Research, Vol.30 pp.1-10.
5. Carrer M. Urbinati C. 2006. Long-term change in the sensitivity of tree-ring growth to climate forcing in Larix decidua. New Phytologist 170:861-872.
6. Cufar K., Prislan P., Gricar J., 2008, Cambial activity and wood formation in beech *(Fagus sylvatica)* during the 2006 growth season. Wood Research 53: 1–12.
7. Deslauriers A., Morin H., 2005 Intra-annual tracheid production in balsam fir stems and the effect of meteorological variables. Trees 19: 402–408.
8. Deslauriers A., Rossi S., Anfodillo T., Saracino A., 2008, Cambial phenology, wood formation and temperature thresholds in two contrasting years at high altitude in southern Italy. Tree Physiology 28:863-871.
9. Deslauriers, A., Morin, H., Begin, Y., 2003, Cellular phenology of annual ring formation of Abies balsamea in the Quebec boreal forest (Canada). Canadian Journal of Forest Research 33:190-200.
10. Fritts HC 1976. Tree rings and climate. Academic Press London, New York.
11. Gricar J., Krze L., Cufar K ., 2009, Number of cells in xylem, phloem and dormant cambium in silver fir *(Abies alba)*, in trees of different vitality. IAWA J. 30 (2), 121–133.
12. Gruber A., Strobl S., Veit B., Oberhuber W. 2010. Impact of drought on the temporal dynamics of wood formation in Pinus sylvestris. Tree Physiology 30:490-501.
13. Keller T., Guiot J., Tessier L., 1997, Climatic Effect of Atmospheric CO_2 Doubling on Radial Tree Growth in South Eastern France, J. Biogeogr. 24, 857-864.
14. Martin J. A., Esteban L. G., Palacios P., Garcia Fernandez F. 2010, Variation in wood anatomical traits of *Pinus sylvestris* L. between Spanish regions of provenance. Trees 24:1017-1028.
15. Moser L., Fonti P., Buntgen U., Esper J., Luterbacher J., Franzen J., Frank D., 2010, Timing and duration of European larch growing season along altitudinal gradients in the Swiss Alps. Tree Physiol. 30 (2), 225–233.
16. Oberhuber W., Stumbock M., Kofler W. 1998 Climate-tree-growth relationships of Scots pine stands *(Pinus sylvestris L.)* exposed to soil dryness. Trees 13:19-27.
17. Rossi S., Anfodillo T., Menardi R., 2006a, Trephor: a new tool for sampling microcores from tree stems. IAWA J. 27 (1), 89–97.

18. Rossi S., Deslauriers A., Anfodillo T., 2006b, Assessment of cambial activity and xylogenesis by microsampling tree species: and example at the alpine timberline. IAWA Journal 27:383-394.
19. Rossi, S., Deslauriers, A., Morin, H., 2003, Application of the Gompertz equation for the study of xylem cell development. Dendrochronologia 21:33-39.
20. Schmitt U., Jalkanen R., Eckstein D., 2004, Cambium Dynamics of *Pinus sylvestris* and *Betula spp.*in the Northern Boreal Forest in Finland Silva Fennica 38(2).
21. Seo WJ., Eckstein D., Jalkanen R., Rickebusch S., Schmitt U., 2007, Estimating the onset of cambial activity in Scots pine in northern Finland by means of the heat-sum approach. Tree Physiology 28, 105–112.
22. Studer S., Appenzeller C., Defila C., 2005, Inter-annual variability and decadal trends in alpine spring phenology: a multivariate analysis approach. Clim. Change 73:395–414
23. Vaganov EA., Hughes MK., Shashkin AV., 2006., Growth Dynamics of Conifer Tree Rings. Images of Past and Future Environments. Ecol Stud 183:1-354.
24. Wimmer R., 2002, Wood anatomical features in tree-rings as indicators of environmental change. Dendrochronologia, 20:21-36.