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Intra-annual leaf phenology, radial growth and variation in non-structural carbohydrates in wood and bark of Quercus pubescens from drought-prone environment

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Non-structural carbohydrates (NSC, i.e. starch and soluble sugars) in tree tissue are frequently quantified in the context of tree response to environmental cues, because stored NSC are considered to play a prominent role in the case of extreme weather events, such as drought. Intra-annual leaf phenology, radial growth and seasonal variation in NSC in the xylem and bark tissues of Quercus pubescens were analysed. For this purpose, samples of outer xylem and phloem (separately for non-collapsed and collapsed living phloem) tissues of Q. pubescens trees from sub-Mediterranean karst region in SW of Slovenia were collected from September 2015 until September 2016. Moreover, Q. pubescens trees growing at two nearby sites differing in the soil structure (i.e. eutric cambisol on eocene flysch bedrock and rendzic leptosol soil type on paleogenic limestone bedrock) were sampled to check the impact of soil structure on radial growth capacity of the selected trees. Results showed that some of the patterns of radial growth coincided in oaks from the two plots (i.e. onset of cambial cell production, peak of xylem / phloem growth, transition from early to late xylem/ phloem and cessation of wood formation), whereas others differed (i.e. cessation of cambial cell production, rate of xylem / phloem production and width of xylem / phloem increments). The amounts of NSC significantly differed among the tree tissue parts (i.e. xylem, inner phloem and outer phloem) and sampling dates but not between the two sites. The highest starch concentrations were found in outer xylem. Two clear seasonal peaks of the starch amount were detected in the xylem, the first one in autumn, in the period of leaf colouring and falling, and the second one in March–April, i.e. at the onset of cambial cell production followed by bud development. In outer and inner phloem, the concentrations of starch were considerably lower, however the same pattern of increase / decrease in the values were detected as in the case of outer wood. In contrast to starch values, the amount of free sugars was generally highest in inner bark and lowest in xylem. Among the analysed free sugars, significant seasonal variations in the amounts were detected for raffinose, fructose and glucose. Highest starch concentrations found in outer xylem are in contrast to the previous observations in conifers, where highest starch amounts were found in inner bark; however, it could be explained by the differences in basic anatomy of wood and bark tissues of conifers and hardwoods. Finally, local environmental conditions as well as differences in leaf structure and phenology need to be considered as they may greatly affect the amount or distribution of NSC.