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Tree age-related effects on seasonal dynamics of carbon reserves in Quercus petraea: an in situ experimental approach

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Forest productivity plays an important role in wood production and forest carbon storage capacity. It is well known that forest productivity declines with tree age (Genet et al., 2009). This decline could result from a carbon assimilation decrease and/or a modification of carbon allocation (Ryan et al., 2006 ; Genet, 2009).
Relationships between tree age and leaf surface (Bond-Lamberty et al., 2002 ; Louis et al., 2012), light interception (Niinemets et al., 2005) or hydraulic constraint (Bond, 2000 ; Zaehle, 2006) have been widely studied. Yet, studies of relationships between tree age and carbon storage/remobilization processes are scarce in deciduous trees. Therefore in situ experiments appear necessary to have a better understanding of the carbon functioning of deciduous forest ecosystems.

Our objective was to compare the seasonal carbon dynamics of different age oak trees classes. We studied three age categories (8, 20, 100 years) of Quercus petraea in the Barbeau national forest (France) over one leafy season. Leaves, 2010 and 2011 twigs, stem, fine and coarse roots were sampled at different key phenological stages (before budburst, at budburst, maximum leaf area index, maximum leaf mass area, summer, yellowing and winter) for determination of starch concentrations.

We observed only differences between classes for 2010 twigs and fine roots. After carbon reserves remobilization during budburst, starch concentrations of 2010 twigs for 8 and 20 years old trees don't increase before the end of wood growth (i.e. end of july). Starch concentrations increase occurs just after budburst for the oldest tree category. Starch concentrations in fine roots in the two oldest trees categories are stable throughout the year. On the contrary, juvenile trees present an enhanced starch concentration in autumn. Nevertheless, for oldest tree coarse roots starch concentration increase from summer to yellowing.
These first results highlight that starch storage is different between tree ages in sessile oak only in recent twigs and roots. It suggests a distinct pattern of carbon allocation between young and oldest trees: growth could be followed by storage for young trees and could be simultaneous to storage for oldest trees. Moreover, fine roots of juvenile trees seem to have a similar function of starch storage as coarse roots of mature trees. According to Bazot et al. (2012), twigs and roots are major compartments of carbon storage. It strengthens the importance of these suggested different strategies of carbon allocation to growth and reserves between tree ages.

Finally, this study completed with future data (soluble sugars and nitrogen reserves) will help to complete our knowledge on carbon and nitrogen allocation patterns between tree ages. Allometric rules based on our experimental data and literature currently allow us to establish a carbon and nitrogen balances at tree level for each age category. These data are used for comparison with outputs of the CASTANEA mechanistic model adapted to each age class. This is used to compute the carbon balance and assess the relative influences of the processes of carbon assimilation, respiration and allocation of each age class.