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Two seasons (2013-2014) observation of carbon fate (sequestration, transport and allocation) after 13C labelling of Larix trees growing on permafrost in Siberia

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Despite large geographic extent of deciduous conifer species Larix gmelinii, its seasonal photosynthetic activity and translocation of photoassimilated carbon within a tree remain poorly studied. To get better insight into productivity of larch trees growing on permafrost soils in Siberian larch biome we aimed to analyze dynamics of foliage parameters (i.e. leaf area, biomass, %N, %P etc.), seasonal dynamics of photosynthetic activity and apply whole tree labeling by $13CO_2$, which is powerful and effective tool for tracing newly developed assimilates translocation to tissues and organs of a tree (Kagawa et al., 2006; Keel et al., 2012).
Experimental plot has been established in mature 105 year-old larch stand located within the continuous permafrost area near Tura settlement (Central Siberia, 64o17'13" N, 100o11'55" E, 148 m a.s.l.). Trees selected for experiments represented mean tree of the stand. Measurements of seasonal photosynthetic activity and foliar biomass sampling were arranged from early growing season (June 8, 2013; May 14, 2014) until yellowing and senescence of needles (September 17, 2013; September 14, 2014). Labeling by 13C in whole tree chamber was conducted by three pulses ($[CO_2]$max 2,500 ppmv, $13CO_2$ (30% v/v)) at the early (June) and late (August) phase of growing season for different trees in 3 replicates each time. Both early season and late season labeling experiments demonstrated high rate of $13CO_2$ assimilation and respective enrichment of needle tissues by 13C: 13C increased from -28.7 up to +670 per mil just after labeling. However, there was distinct post-labeling dynamics of needle 13C among two seasonal experiments. At the early season 13C depletion in labeled needles was slower, and 13C approached after 40 days ca. +110 per mil remained constant till senescence. In the late season (August) needles were losing labeled C with much faster rate and approached only +1.5 per mil upon senescence (28 days exposition). These findings suggest that in early season ca. 20% of assimilated C was used for needle structures development. In opposite, in late season the 13C label having fewer fixation in needle was translocated to other tissues/organs (i.e. label appearing in twigs, phloem and accumulating in fine roots). One year after labelling, high levels of 13C were registered in May, 2014 in just appeared needles of short shoots (50-70 per mil), roots (70 per mil) and small twigs (80-100 per mil). Early season 13C labelled trees characterized by higher amount of last year attracted 13C assimilates in small twigs (not in roots), there as late season 13C labelled trees showed the opposite tendency – 13C abundance was found in roots (not in twigs). Short shoot needles of all labelled trees in May 2014 did not differ by 13C, labelled neither in early season nor in late season. Different 13C translocation rate in early and late season shows the importance of needle phenology as well as differences in dominant physiological processes among seasons. The research is supported by RFBR grant 13-04-00659a.