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Belowground carbon demand causes early culmination of radial stem growth in Norway spruce exposed to drought stress in spring

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Drought is one of the primary environmental factors affecting tree growth and wood formation. We tested the hypothesis that early culmination of radial stem growth in late spring found in several coniferous species in a dry inner Alpine environment (Oberhuber et al. 2014) is an adaptation to cope with drought stress at the start of the growing season, which might require an early switch of carbon (C) allocation to belowground. To accomplish this, we manipulated tree C status by physical blockage of phloem transport at different phenological stages during the growing season (before budbreak, during and after cessation of aboveground stem growth) and experimentally applied two levels of soil humidity (well-watered versus drought) in six year old Norway spruce (Picea abies) saplings (n=80 trees). Non-structural carbohydrates (NSC; soluble sugars and starch) in the stem and coarse root were determined at the time of girdling and after the growing season to evaluate changes in tree C status. Fine root elongation growth was monitored by applying the non-destructive minirhizotron technique. Results revealed a significant increase in radial stem growth of the girdled trees compared to the controls above the girdling zone, while directly below girdling radial growth stopped in both soil humidity treatments. Surprisingly, radial growth in coarse roots strikingly increased in drought-stressed girdled trees at the expense of C reserves. Furthermore, reactivation of cambial activity in drought-stressed girdled trees was detected. The findings that (i) girdling stimulated radial growth in the stem and root and (ii) radial growth increase in girdled trees was significantly more intense in the drought-stressed compared to watered treatment indicate that wood formation in Picea abies saplings is controlled by internal and external factors, i.e. C availability and environmental stress (drought), respectively. We conclude that drought stress at the start of the growing season prioritizes early shift of C allocation to belowground to sustain adequate tree water status at the expense of aboveground stem growth.

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Reference

Oberhuber W, A Gruber, W Kofler, I Swidrak (2014) Radial stem growth in response to microclimate and soil moisture in a drought-prone mixed coniferous forest at an inner Alpine site. Eur J For Res 133:467-479.