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Biomass allocation to roots and shoots is more sensitive to shade and drought in European beech than in Norway spruce seedlings

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ABSTRACT

We investigated the effect of light availability and soil moisture on growth and biomass partitioning of Norway spruce and European beech seedlings in a three (light availability levels) × two (soil moisture levels) factorial greenhouse experiment. The effects of factor levels on allocation to biomass compartments were analyzed using ANCOVA. As plant allocation patterns are size-dependent, tree size was used as a covariate. In both tree species, growth and biomass allocation to above and belowground plant components were affected by light availability. European beech showed a distinct increase in allocation to leaves, stem and branch biomass at the expense of fine and coarse roots with decreasing light availability. For Norway spruce, only allocation to stem biomass increased and allocation to fine root biomass decreased under low light. To drought a significant increase of the percentage of belowground compartments was found for European beech but not for Norway spruce. Overall, European beech seedlings were more plastic than Norway spruce seedlings. European beech seedlings appear better able to adjust biomass partitioning to resource availability. In contrast Norway spruce responded languidly. Our results indicate that biomass partitioning is not only driven by ontogeny, and thus tree size, but is environmentally determined to a substantial degree. A possible explanation for this divergence from other results on the role of ontogeny in biomass partitioning may be that seedling plasticity in response to limited resources declines with increasing age and/or time of exposure to the limited resources.

1. Introduction

Long-living and immovable life forms such as trees are most likely more affected by climate change than other taxa. In the main range of the two economically important species Norway spruce (*Picea abies* [L.] Karst.) and European beech (*Fagus sylvatica* (L.)) in Central Europe, reduced summer rainfall and warmer winters are predicted (Bréda et al., 2006; Allen et al., 2010). For some tree species, this may be a problem if their ability to adapt to the expected climate changes is limited. However, predictions of the impact of environmental stresses are difficult as (i) tree species differ in their response strategies to abiotic stress such as drought, (ii) the response to stress varies during ontogeny (Niinemets, 2010), (iii) a single stress, e.g. drought, may have different impacts in combination with other environmental factors, e.g. reduced light availability, and (iv) not only direct impacts of stressors on individual trees need to be taken into account, but also changes in the interspecific competition with neighbouring trees, which might be affected differently.

Because of the different abilities to respond to environmental stress, the future suitability of the economically most important tree species for forest management in a changing climate is discussed. Both, European beech and Norway spruce are classified as sensitive to increasing water shortage in summer (Meier and Leuschner, 2008b; Roloff and Grundmann, 2008; Kölling et al., 2009). However, as long as large scale mortality does not occur, these two species will form future mixed forest stands on many sites. For ecological and economical reasons, many of the existing pure Norway spruce stands around Central Europe have been converted into mixed stands, mainly by planting or by directly sowing European beech (Ammer et al., 2008; Knoke et al., 2008). As a result, stands of naturally regenerated mature Norway spruce with European beech introduced under canopies of varying density are, and will be common stand types for a long time. In these kinds of stands, tree regeneration has always been exposed to limited resource availability due to the impact of the overstorey trees. However, with decreasing summer rainfall, water availability during the vegetation period is likely to be further reduced. Given the different abilities of the species to cope with further limitations in resource availability, changes in competitiveness among regenerating trees are assumed (Grundmann et al., 2011). Thus it may be that species

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