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ORIGINAL ARTICLE

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Carbon, nitrogen, phosphorus, and sulphur concentration and partitioning in beech ecotypes (*Fagus sylvatica* L.): phosphorus most affected by drought

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Abstract Beech seedlings of different drought sensitivity originating from 11 German provenances were grown in pots and cultivated in a greenhouse. The present paper aims to give insights on uptake, transport and use of macronutrients, since the knowledge of drought effects on the nutrition of trees is low compared to water relations. Therefore, the elemental composition, the ratio of inorganic to total content, and the partitioning between roots and shoots of carbon, nitrogen, phosphorus, and sulphur were investigated as affected by provenance and drought treatment. Phosphorus and phosphate concentrations decreased in all tissues after a 3 week drought treatment simulating a summer drought period. In roots carbon increased and nitrate decreased, in stems nitrogen decreased but nitrate increased following drought. The observed effects on phosphorus and phosphate are discussed in terms of lower phosphate mobility in the substrate due to lower water availability. The decrease in the ratio of phosphate to phosphorus in the tissues suggests the use of vacuolar phosphate pools for maintaining organic phosphorus homeostasis. The partitioning of all macronutrients was not affected by drought, although phosphorus and phosphate were significantly lowered in tissues. In most of the parameters studied significant differences between provenances were found. The recently observed drought sensitivity of provenances was not reflected in the strength of concentration changes or partitioning of macronutrients by drought over provenances.

Keywords European beech (*Fagus sylvatica* L.) · Drought · Nutrition · Partitioning · Phosphorus

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Introduction

Actual predictions of climate changes due to anthropogenic atmospheric CO_2 increase project an average warming of 1–3.5°C for mid-latitude regions within the next 100 years (Saxe et al. 1998; UNEP/IUC 1999). For Europe, changes in the frequency of extreme precipitation events are expected, resulting in more drought and flooding (IPCC 1997; UNEP/IUC 1999). Longer periods of reduced rainfall are expected, particularly in summer, when a number of crops and fruit ripen and trees like European beech undergo a second phase of growth. The pace of climate change will be fast compared to the speed at which forest trees grow. Therefore, present forest ecosystems will face new environmental conditions during their lifetime. Alteration in species composition of forest ecosystems are likely to occur (IPCC 1997; Saxe et al. 2001).

Changes in atmospheric CO_2 concentrations are known to influence plant physiology and morphology in past (Pataki 2002) as well as today's and future climate. A considerable biomass increment for trees caused by elevated CO_2 has been predicted as long as other environmental parameters are not growth limiting (Saxe et al. 1998; Ceulemans et al. 1998). The multiple interacting changes due to global warming will therefore result in an orchestrated response of a number of physiological processes, the outcomes of which are difficult to predict. The benefit of enhanced drought tolerance due to reduced stomatal conductance at elevated atmospheric CO_2 may be more than compensated by higher leaf biomass (Saxe et al. 1998; Wullschleger et al. 2002).

The effects of predicted climate changes on nutrient availability for ecosystems are still under debate with contrasting statements (Saxe et al. 1998, 2001; Ceulemans et al. 1998). In general, plants increase their nutrient capacity under elevated CO_2 (Ceulemans et al. 1998).

Drought is a form of stress which affects gas exchange, cell growth and division, phytohormones, metabolic and transport processes of plants (Hsiao 1973). The effects of