Seasonal dynamics of *Picea abies* and *Fagus sylvatica* fine roots in an acidified cambisol

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ABSTRACT

The study focused on Norway spruce (*Picea abies* L. Karst) and European beech (*Fagus sylvatica* L.) grown in Kysucké Beskydy Mts., North-Western Slovakia. In the growing season 2006, the following fine root (upper diameter of 1 mm) traits were studied: biomass and necromass seasonal dynamics, vertical distribution, production, mortality, fine root turnover and production-mortality ratio including soil depth 0-35 cm. Results indicated that spruce had a lower standing stock of fine roots than beech, and fine roots of spruce were more superficially distributed than those of beech. Furthermore, we estimated higher seasonal dynamics and also higher turnover of fine roots in spruce than in beech. Production–mortality ratio was higher in beech than in spruce, which was hypothetically linked to the effect of the drought episode occurred in July and August. The results suggest that beech fine roots may resist the physiological stresses better than that of spruce.
KEYWORDS: biomass, mortality, necromass, production, stress, turnover

INTRODUCTION

Inter-specific comparisons in fine root "seasonal behaviour" under stressful environment may answer questions related to resistance to changing environmental conditions between particular tree species. In fact, only a few studies have been conducted on this, for instance, comparing Norway spruce and European beech (Schmid, 2002) or Scots pine and Pedunculate oak (Konôpka et al., 2005). Most studies have a limited possibility to generalize their findings because of including only few features of fine roots and/or site-specific results. Hence, more comprehensive studies on fine roots (mainly necromass, biomass, vertical distribution, seasonal dynamics, turnover, morphological traits, biochemical properties) in a variety of tree species originating from contrasting growth conditions will be valuable.

This paper aims to evaluate biomass and necromass, vertical distribution, seasonal dynamics and turnover in Norway spruce and European beech. Since both species grew on the same site, interspecific comparisons of root characteristics were also carried out.

METHODS

The study focused on Norway spruce and European beech stands grown on an acidified soil caused by past air pollution in Kysucké Beskydy Mts., North-Western Slovakia. Mean tree height of spruces in the main canopy was circa 28.5 m, mean diameter at breast height (DBH) 36.5 cm, with age about 80 years. Mean tree height of beech in the main canopy was circa 27.5 m, mean DBH 33.0 cm, with age nearly 90 years. In the growing season 2006, sequential soil coring was repeatedly implemented in April, June, July, September, and October (i.e. each 5-6 weeks) including soil layers 0-5, 5-15, 15-25 and 25-35 cm. The following fine root (defined by upper diameter of 1 mm) traits were studied: biomass and necromass seasonal dynamics, vertical distribution, production, mortality, fine root turnover and production-mortality ratio. Production and mortality of fine roots between sampling periods were estimated by using the decision matrix (Farley and Alexander, 1985). Moreover, fine root turnover (Gill and Jackson, 2000) was expressed as the ratio between seasonal production and biomass estimated in the beginning of the growing season.

RESULTS AND DISCUSSION

Our findings allow inter-species comparison between Norway spruce and European beech in terms of fine root standing stock, vertical distribution, seasonal dynamics and turnover. The results indicated the following:

- spruce maintained less fine roots than beech,
- fine roots of spruce were more superficially distributed than those of beech ,
- higher seasonal dynamics (production and mortality) of fine roots was found in spruce than in beech (Fig. 1 and 2),
- turnover of fine roots was higher in spruce than in beech (Table 1),
- production-mortality ratio was higher in beech than in spruce (Table 2).

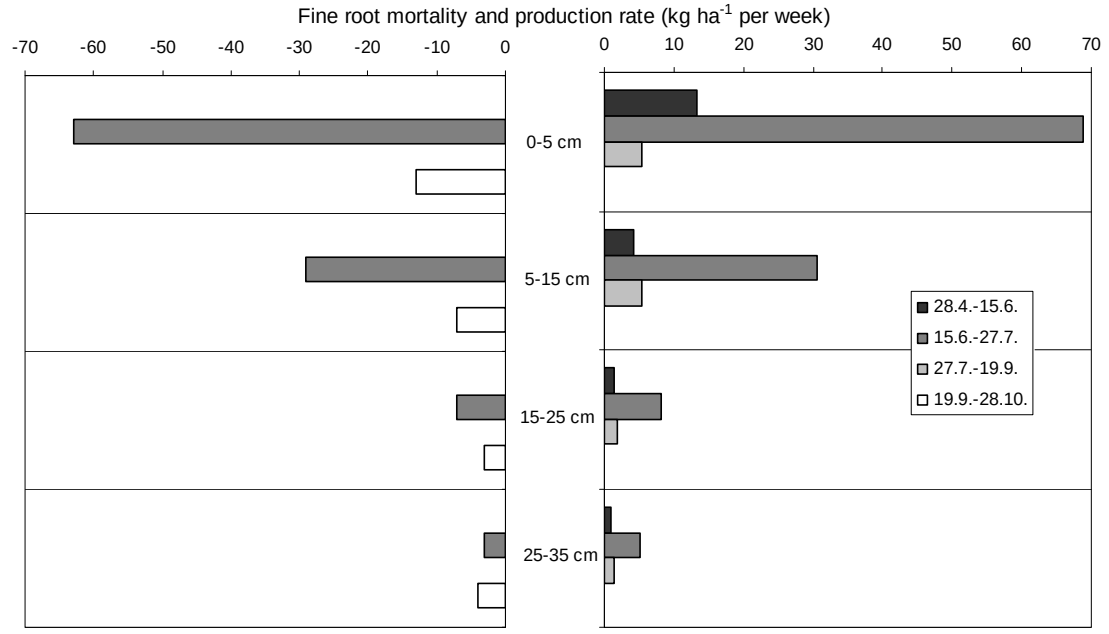

Fig. 1. Fine root production (+) and mortality (-) weekly rate of Norway spruce over the season (legend shows period of observations: day and month) in the surveyed soil depths

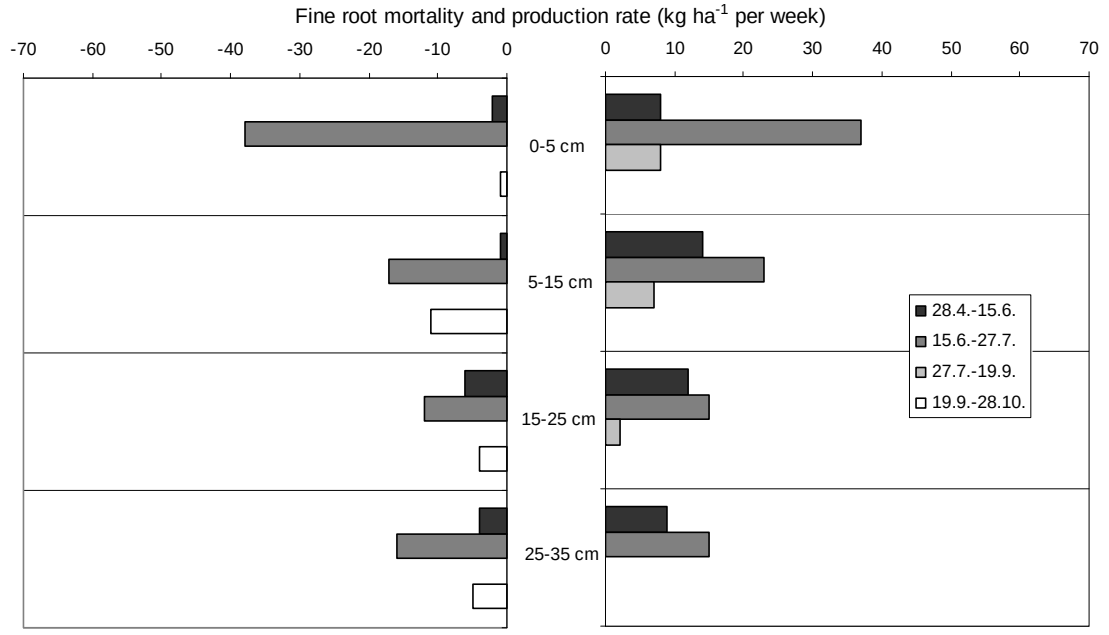

Fig. 2. Fine root production (+) and mortality (-) weekly rate of European beech over the season (legend shows period of observations: day and month) in the surveyed soil depths

Table 1. Comparison of seasonal fine root turnovers between spruce and beech in the soil layers

Tree species	Soil depth 0-5 cm	5-15 cm	15-25 cm	25-35 cm
Spruce	1.72	1.16	1.00	0.68
Beech	1.38	0.68	0.52	0.40

Spruce and beech fine root turnovers varied among the soil layers (Table 1). The turnovers decreased linearly with soil depth ($r = 0.96$; $p < 0.01$ for spruce; $r = 0.88$; $p = 0.03$ for beech). In both species, the largest differences considering subsequent soil layers were between the top 0-5 cm and 5-15 cm. Likely, it means that fine root growth conditions between those two soil layers are the most contrasting. We suppose that it could be caused especially by different content of organic matters and climatic conditions (higher fluctuations of temperature and moisture in the topsoil). Similar trend of turnover over soil depth was recorded for instance by Konôpka et al. (2006) in Scots pine. In our case, decreasing turnover with soil depth may be hypothetically related also to increasing pH from the topsoil (3.8) to deeper soil layers (4.2, 4.4 and 4.7 in 5-15, 15-25 and 25-35 cm respectively). This is in accordance with the results of Godbold et al. (2003) who observed that fine root turnover is speed up due to soil acidification.

The results contrast with the generally accepted hypothesis that root longevity (opposite characteristics to turnover) is shorter in deciduous than in evergreen tree species (e.g. Vogt and Bloomfield 1991). On the other hand, Konôpka et al. (2005) found faster turnover in Scots pine than in Pedunculate oak in the acidic sandy soil on the exceptionally dry year of 2003. Our experiment suggests that beech fine roots could resist some physiological stresses (especially fluctuations of temperatures and moisture, soil acidification) better than that of spruce what was indicated by the different vertical distribution of fine roots. Moreover, if we admit a certain level of drought stress in July (it was only about 50% of long-term average of monthly precipitation) and in the first half of August (see also Fig. 3), production-mortality ratio suggested better resistance of beech fine roots than that of spruce.

Table 2. Comparison of seasonal production-mortality ratios between spruce and beech in the soil layers

Tree species	Soil depth 0-5 cm	5-15 cm	15-25 cm	25-35 cm
Spruce	1.21	1.18	1.26	1.28
Beech	1.36	1.66	1.33	1.52

In both species, the production versus mortality ratio was rather uniform in all soil layers (Table 2). We suppose that in an equilibrated forest ecosystem, production and mortality of fine roots should be at about the same level during one year. Higher production followed by mortality during the period of our observation meant that fine root biomass increased. On the other hand, our estimation did not include the wintertime. While negligible fine root production can be expected during the winter, mortality is most likely to increase due to low temperature. Hence, missing period (from late October 2006 to late April 2007) may be characterized by a mortality of fine roots approximately equal to the increase in biomass, which occurred during the period of our observation.

The results may support generally recognized theorem that beech is a more perspective trees species under ongoing climate change than spruce in most forest sites of Slovakia. We suggest that although our findings are relevant for improving the knowledge in the field of

root ecology, they can not be broadly generalized because of the specific climatic and soil conditions on the site, especially in terms of intensive soil acidification.

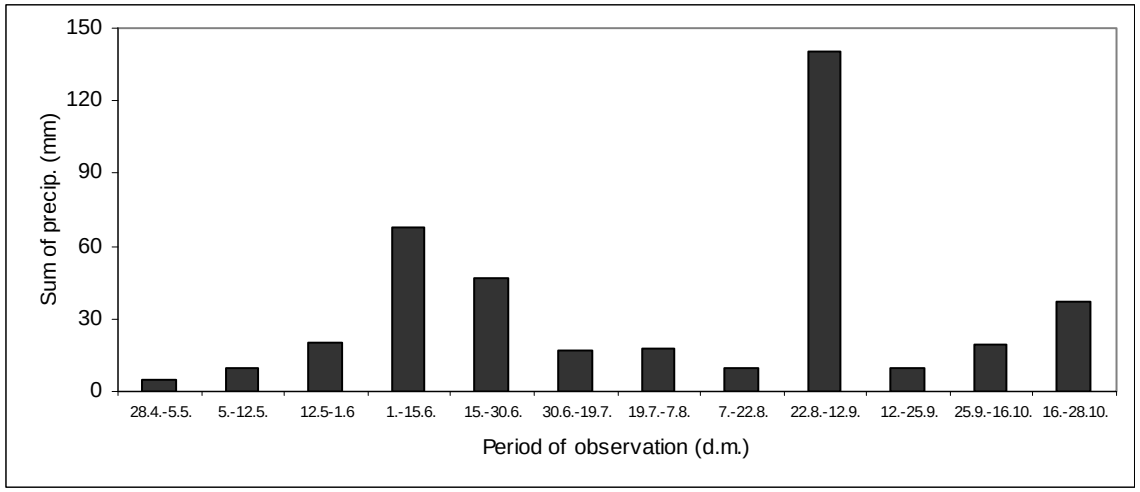

Fig. 3. Sum of precipitation during the studied time periods - between April and October 2006

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