Differences in fine root traits between Norway spruce (*Picea abies* [L.] Karst.) and European beech (*Fagus sylvatica* L.) – A case study in the Kysucké Beskydy Mts.

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ABSTRACT: Interspecific comparisons of the fine root "behaviour" under stressful situations may answer questions related to resistance to changing environmental conditions in the particular tree species. Our study was focused on Norway spruce (*Picea abies* [L.] Karst.) and European beech (*Fagus sylvatica* L.) grown in an acidic soil where acidity was caused by past air pollution in the Kysucké Beskydy Mts., North-Western Slovakia. Between April and October 2006, the following fine root traits were studied: biomass and necromass seasonal dynamics, vertical distribution, production, mortality, fine root turnover and production to mortality ratio. Sequential soil coring was repeatedly implemented in April, June, July, September, and October including the soil layers of 0–5, 5–15, 15–25, and 25–35 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. The production to mortality ratio was higher in beech than in spruce, which was hypothetically explained as the effect of drought episodes that occurred in July and August. The results suggested that the beech root system could resist a physiological stress better than that of spruce. This conclusion was supported by different vertical distributions of fine roots in spruce and beech stands.

Keywords: fine root biomass and necromass; mortality; production; seasonal dynamics; turnover

Fine roots are generally recognized as a very important component of the tree root system, representing a substantial link between the tree organism and the soil (Kozlowski, Pallardy 1997). Recently, an increasing interest of forest research has been taken in tree fine roots in relation to climatic change (Norby et al. 2000).

There are two main aspects of fine root studies under climatic change:

(1) importance of fine roots in carbon cycling,

(2) their reactions to changing environment (higher CO_2 concentration in atmosphere, modification of temperature and precipitation patterns, etc.).

For instance, Jackson et al. (1997) estimated that about ⅓ of the global annual net primary productivity in terrestrial ecosystems originates through the fine root production. Effects of changing environment on tree fine roots have mostly been studied in terms of increasing CO_2 in air (Lukac et al. 2003), soil temperature (Pregitzer et al. 2000) and drought (Konôpka et al. 2007). Another "hot" issues that should be studied on tree fine roots are interspecific comparisons. They may answer questions related to different fine root behaviour under stressful situations and, consequently, also differences in the resistance of particular tree species to changing

Supported by the Slovak Research and Development Agency, Project No. APVV-0612-07 *Vulnerability of Forest Ecosystems Destabilized by Wind to the Impact of Some Disturbance Factors.*

environmental conditions. In fact, only a few studies have been conducted on this problem, for instance comparing Norway spruce (*Picea abies* [L.] Karst.) and European beech (*Fagus sylvatica* L.; Schmid 2002), Norway spruce, Scots pine (*Pinus sylvestris* L.) and European beech (Finér et al. 2007), Scots pine and Pedunculate oak (*Quercus robur* L., Konôpka et al. 2005), among a variety of broadleaves (Rewald, Leuschner 2009). Most studies have a limited possibility to generalize their findings because of including only few features of fine roots and/or site-specific results (an exception can be found in Finér et al. 2007). Hence, more comprehensive studies on fine roots (mainly necromass, biomass, vertical distribution, seasonal dynamics, turnover, morphological traits, stress responses) in a variety of tree species originating from contrasting growth conditions will be valuable. An essential problem is that for a broader surveying of fine root characteristics, a combination of several techniques (e.g. in-growth bags, sequential soil coring and minirhizotron) must be used, which is time- and effort-consuming (see for instance Smit et al. 2000).

The study was focused on Norway spruce and European beech as the most important tree species not only in Slovakia (according to Moravčík et al. (2008) they cover 26% and 31% of its forest area, respectively) but also in the European temperate zone. These tree species are interesting also from the aspect of climate change because while Norway spruce manifested itself as a sensitive species to most abiotic stresses (especially drought), European beech seems be promising even in some sites recently covered by spruce (Minďáš, Škvarenina 2003).

We selected the Kysuce region as typical, with a history of high acid deposition during the 70's and 80's and low pH values even at present. The spruce forests in this region are characterized by high sensitivity to environmental stress, since the species is allochthonous to this area. Nowadays, the main factors affecting trees are bark beetles (*Scolytidae*), honey fungus (*Armillaria* sp.), mechanical damage by wind and snow as well as drought episodes (Turčáni, Hlásny 2007).

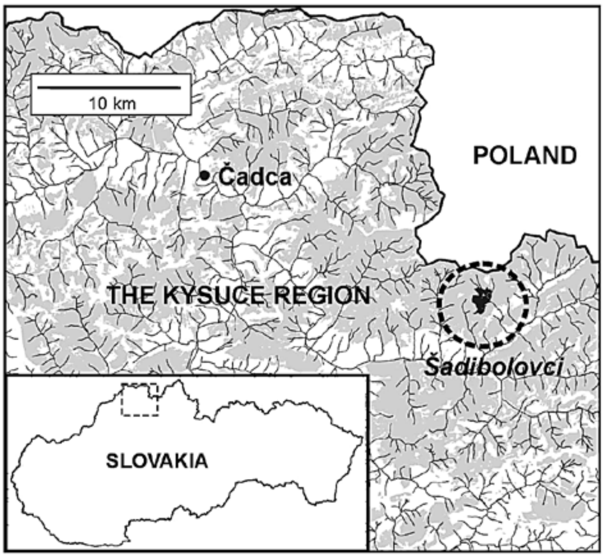

Fig. 1. Location of the research site Šadibolovci (marked by a black face inside the circle). Dark areas indicate forest cover

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

MATERIAL AND METHODS

Research was conducted in the area of the Kysucké Beskydy Mts., which is located in the North-Western

Table 1. Biomass and necromass of fine roots in Norway spruce over the soil profile on each sampling date (means and standard errors). Bold font shows maximum biomass or necromass and underlined values show minimum biomass or necromass over the season. Asterisks indicate significant differences in fine root masses between the sampling dates separately for each soil depth (letters denote significant difference; Tukey-Kramer's HSD test, α = 0.05)

Date	Biomass (kg/ha) at the soil depth (cm)				Necromass (kg/ha) at the soil depth (cm)			
	0–5	5–15	15–25	25–35	0–5	5–15	15–25	25–35
28. 4.	323 (46)^{a}	221 (32)^{a}	73 (23)^{a}	74 (26)^{a}	201 (55)^{a}	104 (26)^{a}	50 (19)^{a}	36 (12)^{a}
15. 6.	414 (53)^{ab}	249 (42)^{a}	83 (22)^{a}	81 (30)^{a}	95 (29)^{a}	86 (27)^{a}	39 (14)^{a}	27 (10)^{a}
27. 7.	450 (72)^{ab}	260 (50)^{a}	92 (26)^{a}	97 (28)^{a}	**482 (102)**^{b}	**263 (61)**^{b}	**80 (23)**^{a}	**43 (5)**^{a}
19. 9.	**490 (76)**^{b}	**300 (45)**^{a}	**105 (27)**^{a}	**108 (30)**^{a}	280 (63)^{ab}	155 (49)^{ab}	47 (14)^{a}	35 (13)^{a}
28. 10.	418 (71)^{ab}	260 (47)^{a}	88 (23)^{a}	85 (29)^{a}	212 (60)^{ab}	106 (28)^{a}	45 (15)^{a}	30 (11)^{a}

part of Slovakia (Fig. 1). The studied forest stands are situated at Šadibolovci (a local name of the area), which is situated at an altitude of ca 920–950 m above sea level, coordinates: 49°23'N, 19°01'E, about 4.5 km northwest of the Nová Bystrica village and 1.5 km from the Slovak-Polish frontier. The annual amount of precipitation in the last decade was about 1,200 mm and the mean annual temperature was 4.5°C. The slope of the site varied between 20 and 30% following the eastern direction. The soil is deep Haplic Cambisol, Dystric Endoskeletic (FAO 2006). The bedrock is prevailingly sandstone. The soil in the site showed low values of pH that might be related to an exposure of the area to high air pollution in the past. The complex of studied stands belongs to the *Abieto-Fagetum* forest type.

Two neighbouring stands were included in this research, a nearly pure Norway spruce forest and a European beech forest. The stands were selected to be similar in their size, i.e. mean stand height. Mean tree height of spruces in the main canopy was ca 28.5 m, mean diameter at breast height (dbh) 36.5 cm, age of about 80 years. Stocking of the stand was 0.8. Mean tree height of beech in the main canopy was ca 27.5 m, mean dbh 33.0 cm, age of nearly 90 years. Stocking of the stand was 0.9. While most spruce trees showed defoliation prevailingly in the range of 25–35%, beeches had the good status of the crown with defoliation mostly in the range of 15–25% (evaluated according to the ICP Forest Classification; more details at: http://www.icp-forests.org).

Study on the standing stock of spruce and beech fine roots started in spring 2006 and finished in autumn 2006. The sampling was performed five times repeatedly each 5–6 weeks. The particular sampling dates were: April 28th, June 15th, July 27th, September 19th, and October 28th. Sixteen soil cores to 35 cm depth were randomly taken in both stands always on the same areas of 50 × 50 m in size. A metal auger with an inner diameter of 6 cm was used. Then, the soil cores were split into the depths of 0–5, 5–15, 15–25, and 25–35 cm. They were transferred to plastic bags and stored in a deep freezer at –20°C till further processing.

Spruce and beech fine roots (up to diameter of 1 mm) were hand-picked from the soil samples. Root characteristics such as colour, shape, resilience, wood structure, hair existence were used to distinguish spruce or beech fine roots from other species which might occur in the samples. Roots classified as living were characterized by high resilience, firm and good adhesion between the stele and cortex. Both dead (necromass) and live (biomass) roots were carefully washed and dried to constant weight at 70°C for 24 hours. Dry matter was weighed, biomass and necromass were expressed in kg on a hectare base. Production and mortality of fine roots between samplings were estimated by using the decision matrix (see Fairley, Alexander (1985) for details of the method). In addition, the fine root turnover was expressed as the ratio between seasonal production and biomass estimated in April 2006 (see also Gill, Jackson 2000).

Apart from the fine root studies, pH of the soil at the depths of 0–5, 5–15, 15–25, and 25–35 cm was measured on the soil sampled in April 2006. Specifically, the analyses of pH in H_2O were performed for eight spots in each forest stand. Moreover, precipitation was measured with a Met One 370 rain collector and recorded with an EMS Brno data-logger between 28th April and 28th October 2006. The amount of precipitation was checked in 1–3 week intervals.

Statistical analyses were performed by means of the R computer software (Ihaka, Gentleman

Table 2. Biomass and necromass of fine roots in European beech over the soil profile on each sampling date (means and standard errors). Bold font shows maximum biomass or necromass and underlined values show minimum biomass or necromass over the season. Asterisks indicate significant differences in fine root masses between sampling dates separately for each soil depth (letters denote significant difference; Tukey-Kramer's HSD test, α = 0.05)

Date	Biomass (kg/ha) at the soil depth (cm)				Necromass (kg/ha) at the soil depth (cm)			
	0–5	5–15	15–25	25–35	0–5	5–15	15–25	25–35
28. 4.	250 (33)^{a}	430 (62)^{a}	360 (105)^{a}	411 (128)^{a}	187 (53)^{a}	147 (57)^{a}	168 (71)^{a}	155 (69)^{a}
15. 6.	288 (47)^{ab}	521 (103)^{a}	388 (124)^{a}	430 (132)^{a}	202 (51)^{ab}	153 (60)^{a}	222 (87)^{a}	201 (75)^{a}
27. 7.	295 (42)^{ab}	559 (107)^{a}	395 (70)^{a}	474 (91)^{a}	**435 (84)**^{b}	**259 (63)**^{a}	**308 (72)**^{a}	**251 (63)**^{a}
19. 9.	**357 (48)**^{b}	**612 (95)**^{a}	**408 (81)**^{a}	**476 (90)**^{a}	403 (81)^{b}	224 (62)^{a}	273 (70)^{a}	185 (79)^{a}
28. 10.	343 (56)^{ab}	550 (97)^{a}	387 (75)^{a}	466 (95)^{a}	388 (78)^{ab}	196 (58)^{a}	228 (63)^{a}	175 (76)^{a}

1996). Differences in pH values in the soil layers between spruce and beech were analyzed using the *t*-test. Statistical significance was defined at $P < 0.05$. Changes in biomass and necromass of fine roots in the particular soil layers over the season were tested by one-way analysis of variance (ANOVA) and the results were considered significant when P values were less than 0.05. Data were subjected to Tukey-Kramer's HSD test to compare fine root masses between the sampling occasions at the significance level (α) of 0.05.

RESULTS AND DISCUSSION

Vertical distribution and seasonal dynamics

Fine root biomass and necromass in Norway spruce changed over the soil profile (Table 1). In principle, the largest mass (both biomass and necromass) of fine roots was found in the top 5 cm of the soil, the lowest one at the soil depth of 25–35 cm. For instance, while the quantity of fine root biomass in April was 323 kg/ha at the soil depth of 0–5 cm, its quantity at the 25–35 cm was 74 kg/ha. In the same period, the amount of fine root necromass was 201 kg/ha and 36 kg/ha at the soil depth of 0–5 cm and 25–35 cm, respectively.

In April, the largest biomass (430 kg/ha) of beech fine roots was found at the soil depth of 5–15 cm and the lowest one (360 kg/ha) at 15–25 cm (Table 2). The largest quantity of necromass (187 kg/ha) was at 0–5 cm and the smallest amount (147 kg/ha) at 5–15 cm.

We expressed fine root biomass over the soil profile in percentage for both spruce and beech. While as much as 49% of spruce fine roots were concentrated in the top 5 cm, the proportion of beech live fine roots at the mentioned soil depth was 18%. On the other hand, at the soil depth of 15–35 cm, the percentage of fine root biomass was 21% and 51% for spruce and beech, respectively. The comparison indicates that while fine roots of spruce are distributed superficially, those of beech are more uniformly distributed. This is in accordance with the results of Schmid (2002), Schmid and Kazda (2002), who showed deeper distribution of beech fine roots than of spruce fine roots in Cambisol. He specifically commented that fine roots of beech were more evenly distributed over the soil profile of 0–80 cm in comparison with spruce.

The results concerning the pH values of soil showed that lower values across the soil profile were always found under spruce stand compared to beech stand. The values beneath spruces were 3.81, 4.16, 4.38, and 4.61 at the soil depths of 0–5, 5–15, 15–25, and 25–35 cm, respectively. The values under beeches were 4.20, 4.42, 4.68, and 4.72 at the soil depths of 0–5, 5–15, 15–25, and 25–35 cm, respectively. Significant differences between the stands ($P < 0.05$) were found at the soil depth of 0–15 cm. It is difficult to conclude whether the soil pH could have any effect on the fine root distribution there. On the other hand, we can state that pH under 4.0 is very low (stressful). Recent studies, for instance, estimated that around 25% of forest soils in Slovakia showed a very acid reaction, which is defined by the threshold value of 4.5 (Moravčík et al. 2006). In our spruce stand, the pH value increased linearly with soil depth ($r = 0.98$, $P < 0.01$). Since as much as almost 50% of spruce fine roots (with regard to our studied soil profile of 0–35 cm) grew in the top 5 cm, we can state that a substantial part of them had to survive under these, probably rather harsh, conditions.

If we take fine root quantities over the entire soil profile estimated in April, there was about twice less biomass in spruce (691 kg/ha) than in beech (1,451 kg/ha). Similarly, necromass in spruce (391 kg/ha) was 1.7 times lower than in beech (657 kg/ha). In the time of maximum biomass, i.e. in September, the quantity of live fine roots in spruce (1,003 kg/ha) was 1.8 times lower than in beech (1,853 kg/ha). Then, in the period of maximum necromass, i.e. in July, the quantity of dead fine roots in spruce (868 kg/ha) was 1.4 times lower than in beech (1,253 kg/ha). Similar results can be found in the paper of Finér et al. (2007). These authors processed the data originating from many sites all over the European temperate zone. They reported that beech had rather a large amount of fine roots in comparison with the main tree species of the zone. Similarly, Köstler et al. (1968) characterized beech as a species that forms quite a dense fine root system compared to other tree species.

Regarding the seasonal dynamics of spruce fine root biomass, the minimum amount occurred in April (691 kg/ha for the entire soil profile), then it grew during June (827 kg/ha), July (899 kg/ha), reaching the maximum in September (1,003 kg/ha) with a slight decrease in October (851 kg/ha) (Table 1). The minimum necromass (247 kg/ha) was estimated in June and the maximum (868 kg/ha) in July. In the beech live fine roots, the minimum occurred in April (1,451 kg/ha in the entire soil profile), growing in June (1,627 kg/ha), July (1,723 kg/ha) with the maximum in September (1,853 kg/ha) and decrease in October (1,746 kg/ha; Table 2). The minimum necromass (657 kg/ha) was estimated in April and the maximum (1,253 kg/ha) in July. Only

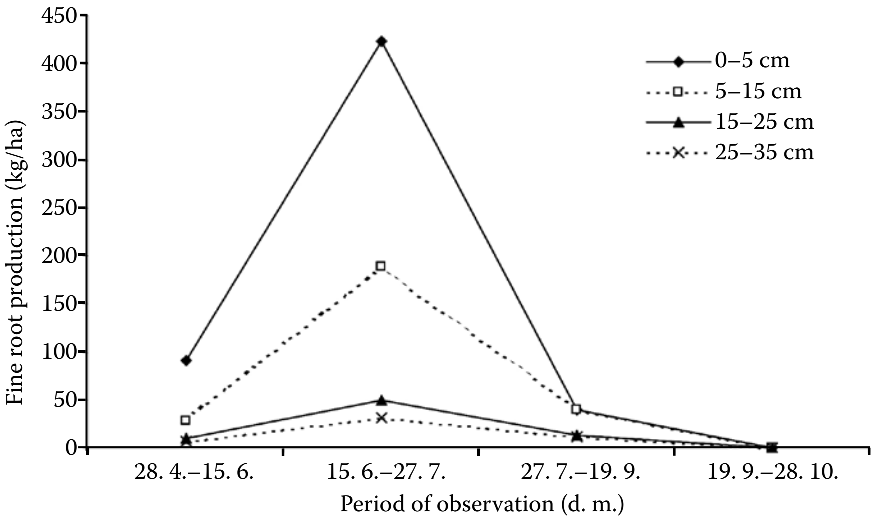

Fig. 2A. Norway spruce fine root production over the season at the surveyed soil depths

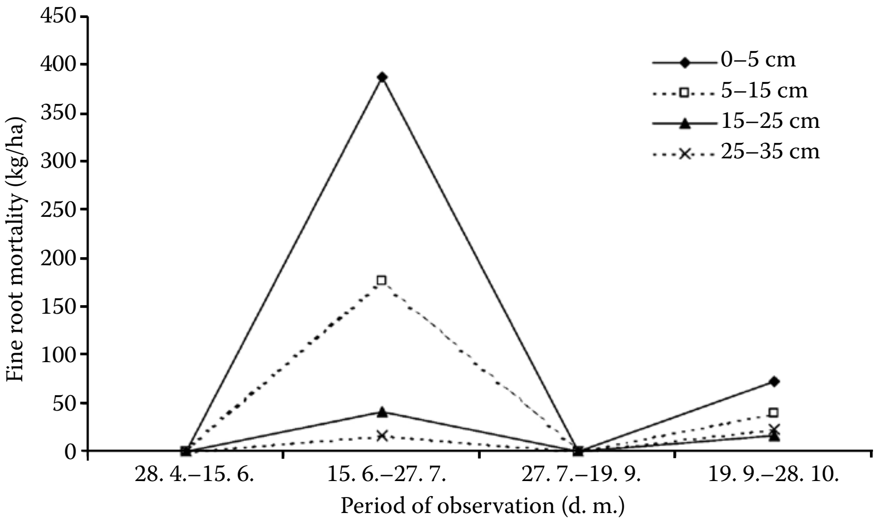

Fig. 2B. Norway spruce fine root mortality over the season at the surveyed soil depths

few cases showed statistical significant differences for biomass or necromass between the first sampling (April) and other sampling dates. They were typical of the upper soil layers and only of maximum masses (July or September; see Tables 1 and 2). To obtain significant results is a general problem in fine root studies because of high variability in their mass among microsites (Smit et al. 2000).

Fine root production and mortality

The results showed that the patterns of fine root production and mortality were similar in both trees species (Figs. 2 and 3). Regarding the fine root production, rather a high activity was recorded between 28th April and 15th June, reaching the maximum during the period from 15th June to 27th July. Fine root production decreased between 27th July and 19th September and later it was negligible. The maximum productions between June and July at all soil depths together were 693 and 561 kg/ha in spruce and beech, respectively. In the spruce stand, the largest production (554 kg/ha) over the entire period was observed in the top 5 cm of soil and the lowest (50 kg/ha) at the soil depth of 25–35 cm. Similarly, in the beech stand, the maximum and minimum production was in the top 5 cm (345 kg/ha) and at the soil depth of 25–35 cm (161 kg/ha), respectively. While as much as 59% of all production in spruce stand was estimated in the top 5 cm, it was only 35% in the case of beech stand.

Concerning the fine root mortality, certain interspecific differences were recorded for the period between 28th April and 15th June. In this case, no mortality beneath the spruces was found, however, rather high mortality was found for beeches at the soil depth of 15–35 cm. Mortality over the studied soil profile reached 621 and 465 kg/ha from 15th June to 27th July in the spruce and beech stand, respectively. In both forest stands, while negligible mortality was

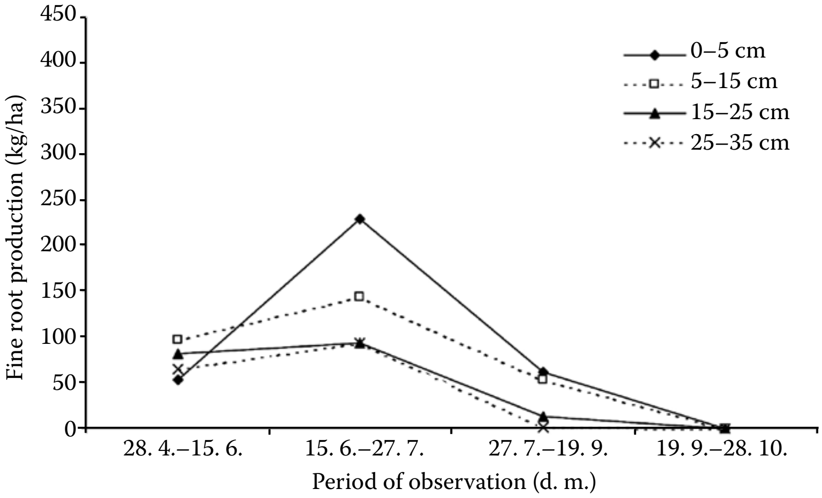

Fig. 3A. European beech fine root production over the season at the surveyed soil depths

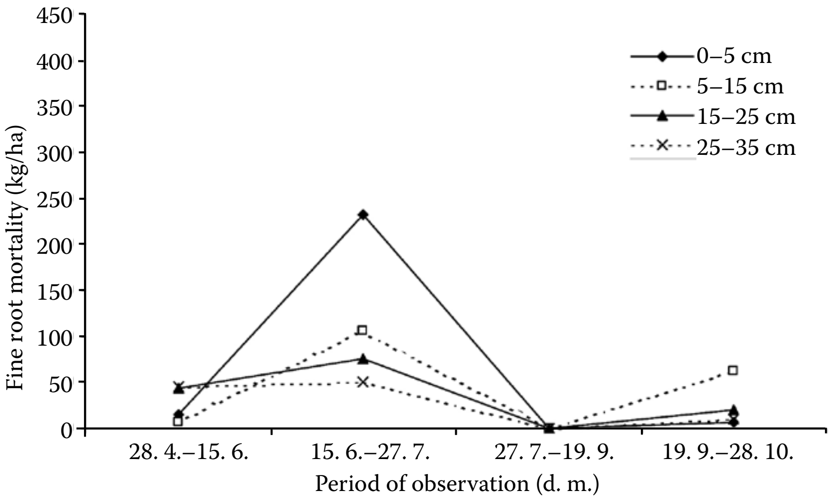

Fig. 3B. European beech fine root mortality over the season at the surveyed soil depths

recorded between 27th July and 19th September, rather relevant mortality occurred from 19th September to 28th October. In the spruce stand, the highest mortality (459 kg/ha) over the entire period was registered in the top 5 cm of soil and the lowest (39 kg/ha) at the soil depth of 25–35 cm. Also in the beech stand, the maximum and minimum mortality was observed in the top 5 cm (254 kg/ha) and at the soil depth of 25 to 35 cm (106 kg/ha). While as much as 59% of seasonal mortality in spruce stand was estimated in the top 5 cm, it was only 37% in the case of beech stand.

As the time intervals between soil core samplings were not the same, fine root production and mortality were expressed on a weekly base (rate per week) (Figs. 4 and 5). The results allow the comparison of production or mortality between these particular time periods. For instance, if we take the production rate of spruce fine roots in the top 5 cm of the soil, between 15th June and 27th July it was about 5 times and 14 times higher than during the periods of 28th April–15th June, and 27th July–19th September, respectively. In the beech fine roots, in the top 5 cm of the soil the production rate between 15th June and 27th July was almost 5 times higher than in the period between 28th April and 15th June as well as 27th July and 19th September.

Fine root production and mortality are supposed to depend on internal (especially genetic background, shoot activity) and external factors (mainly temperature and soil moisture). In the case of our stands, the main part of shoot and foliage formation was observed till the second sampling date (15th June). Thus, rather low fine root production in the period between the first and the second sampling could be connected with a high carbohydrate translocation to shoots. This opposite relation between above- and below-ground growth was explained for instance by Mooney and Chu (1974).

As for external factors influencing the fine root production in spring 2006, soil moisture was prob-

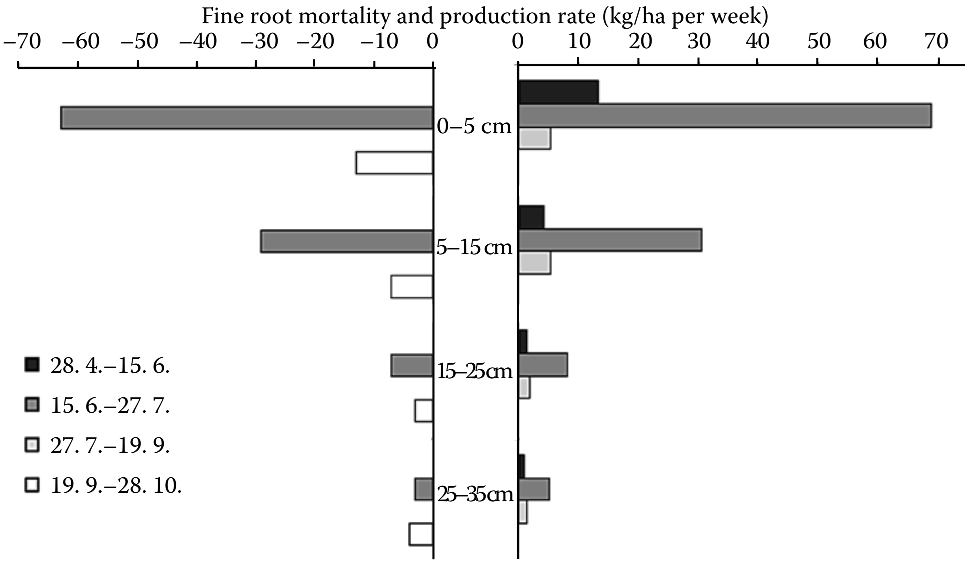

Fig. 4. Fine root production (+) and mortality (–) weekly rate of Norway spruce over the season at the surveyed soil depths

ably on a high level (positive effect) as a consequence of thick snow cover which melted in early April. The relatively low soil temperature (negative effect) during May could be another external factor. Furthermore, we confronted precipitation data with the production and mortality rate of fine roots (Fig. 6). We can conclude that the amount of precipitation was exceptionally low in entire July. Hypothetically, this could be a reason for the high mortality and necromass accumulation during this month. Similarly, necromass accumulation due to dry episodes during the growing season has been reported in a variety of papers (e.g. Teskey, Hinckley 1981; Konôpka et al. 2006a; Mainiero, Kazda 2006; Gaul et al. 2008).

Turnover and seasonal production – mortality budget

Spruce fine root turnover varied among the soil layers between 0.68 and 1.72 per year (Table 3). The turnover decreased linearly with soil depth ($r = -0.96$, $P < 0.01$). Beech fine root turnover varied among the soil layers between 0.40 and 1.38 per year. Similarly, this turnover decreased linearly with soil depth ($r = -0.88$, $P = 0.03$). In both species, the largest differences considering the successive soil layers were between the top 0–5 cm and 5–15 cm. It likely means that the conditions of fine root growth between those two soil layers are the most contrasting. We suppose that it could be caused especially

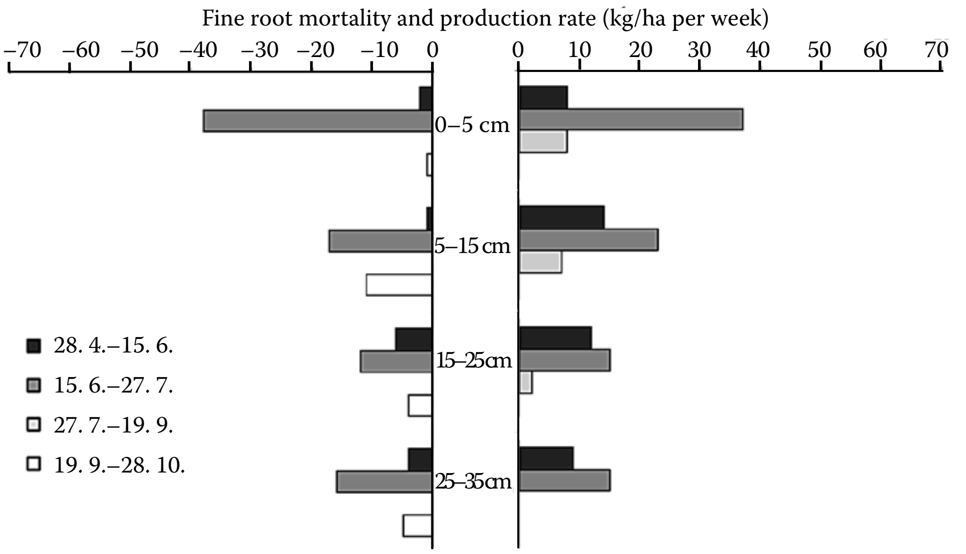

Fig. 5. Fine root production (+) and mortality (–) weekly rate of European beech over the season at the surveyed soil depths

Table 3. Comparison of seasonal fine root turnovers between Norway spruce and European beech at the surveyed soil layers

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

Table 4. Comparison of seasonal production – mortality ratios between Norway spruce and European beech at the surveyed soil layers

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

by different content of organic matters and climatic conditions (higher fluctuations of temperature and moisture in the topsoil). A similar trend of turnover over the soil depth was recorded for instance by Konôpka et al. (2006b) in Scots pine. In our case, decreasing turnover with soil depth may hypothetically be related also to increasing pH from the topsoil to deeper soil layers. This is in accordance with results of Godbold et al. (2003), who observed that the fine root turnover was accelerated due to soil acidification.

Generally, data on the fine root turnover are very scarce in literature. As for spruce fine roots, Konôpka and Lukac (2009) estimated the values of 1.44 and 0.61 for the soil layers 0–10 and 10–20 cm, respectively. However, the authors used another technique of turnover estimation, specifically ingrowth bags.

Our results contrast with the generally accepted hypothesis that root longevity (an opposite characteristic to turnover) is shorter in deciduous than in evergreen tree species (Vogt, Bloomfield 1991). On the other hand, Konôpka et al. (2005) found faster turnover in Scots pine than in Pendunculate oak (*Quercus robur* L.) in the acidic sandy soil in the exceptionally dry year 2003. Thus, the generalization of contrasting fine root turnovers between coniferous and broadleaved trees does not seem to be relevant. Hence, interspecies comparisons must also consider aspects of growth conditions (e.g. climate, soil properties) and possibly the state of trees (especially health status, age, etc.).

Interesting information can be obtained from a comparison of production and mortality over the whole period of observation (Table 4). It is clear that a higher value of the ratio was observed for beech than for spruce. In both species, the production versus mortality ratio was quite uniform in all soil layers. We suppose that in an equilibrated forest ecosystem the 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 indicated 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 winter, mortality is likely to increase due to the low temperature (see for instance Vogt et al. 1981). Hence, the missing period (from late October 2006 to late April 2007) may be characterized by a mortal-

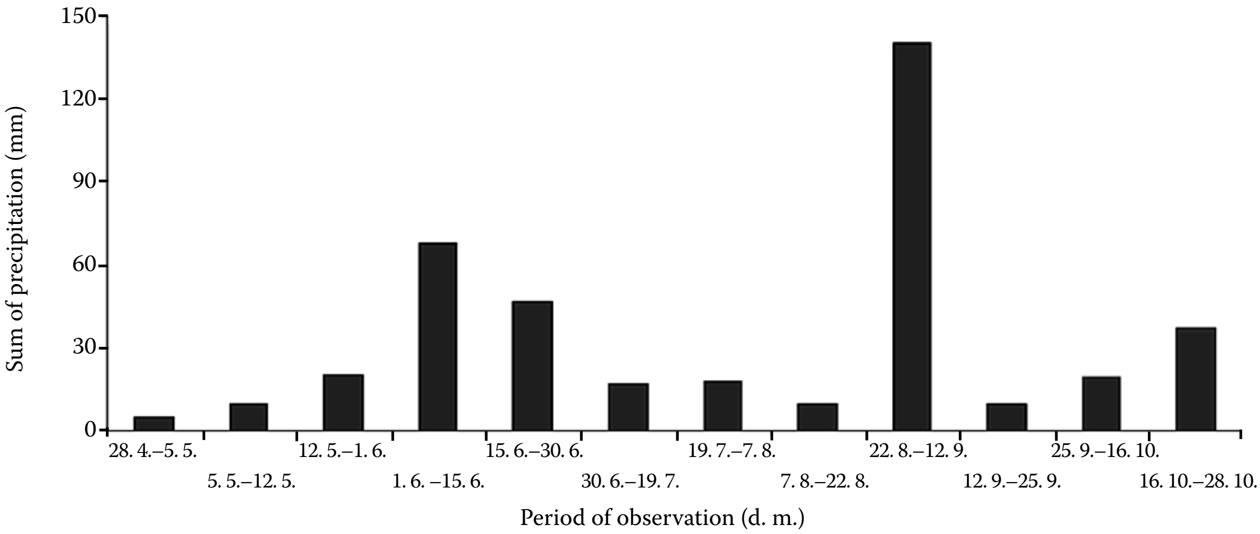

Fig. 6. Amount of precipitation during the studied time periods between April and October 2006

ity of fine roots approximately equal to the increase in biomass which occurred during the period of our observation.

CONCLUSIONS

Our findings allow an interspecies 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,
– turnover of fine roots was higher in spruce than in beech,
– production – mortality ratio was higher in beech than in spruce.

These results suggest that the beech root system could resist some physiological stresses (especially fluctuations of temperatures and moisture, soil acidification) better than that of spruce, which was indicated by different vertical distribution of fine roots. Moreover, if we admit a certain level of drought stress in July (it was only about 50% of the long-term average of precipitation) and in the first half of August, the production – mortality ratio suggested better resistance of beech fine roots than that of spruce.

The results may support a generally recognized hypothesis that beech is a more perspective trees species under the ongoing climate change than spruce in most forest sites of Slovakia (see for instance Minďáš, Škvarenina 2003). We suggest that although our findings are relevant for improving the knowledge in the field of root ecology, they cannot be broadly generalized because of the specific climatic and soil conditions on the site. A characteristic feature of this study is that the experiment was performed in the conditions of acidic soil which can substantially influence the "behaviour" of fine roots.

Acknowledgements

First of all, Dr. J. M. Mirás Avalos is acknowledged for his comments on the manuscript. The author thanks Prof. M. Turčáni for helping with the experimental site selection, Mr. Ľ. Ivanič and R. Nigríni for a technical assistance in the field. Special thanks go to Mrs. E. Takáčová MSc. and K. Turčániová for their pedantic job on the root samples. Dr. T. Hlásny prepared the map of the site location.

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http://www.icp-forests.org

Received for publication January 19, 2009
Accepted after corrections June 19, 2009

Rozdiely vo vlastnostiach jemných koreňov smreka obyčajného (*Picea abies* [L.] Karst.) a buka obyčajného (*Fagus sylvatica* L.) – prípadová štúdia v pohorí Kysuckých Beskýd

ABSTRAKT: Výskum medzidruhových rozdielov v „správaní sa“ jemných koreňov rastúcich v stresových podmienkach môže ozrejmiť otázky odlišnej rezistencie jednotlivých drevín k meniacemu sa životnému prostrediu. Preto sme sa zamerali na smrek obyčajný (*Picea abies* [L.] Karst.) a buk obyčajný (*Fagus sylvatica* L.), rastúce na pôdach zakyslených v predošlom období imisiami. Výskumné plochy sa nachádzajú v pohorí Kysuckých Beskýd, t.j. v severozápadnej časti Slovenska. V období od apríla do októbra 2006 sa sledovali vybrané charakteristiky jemných koreňov; špecificky išlo o: vertikálnu distribúciu biomasy (živé korene) a nekromasy (odumreté korene), sezónnu dynamiku, produkciu, mortalitu, obeh a pomer medzi ich produkciou a mortalitou. Pritom sa použila metóda sekvenčných pôdnych vývrtov opakovane v apríli, júni, júli, septembri a októbri, zahrňujúc hĺbky pôdy 0–5, 5–15, 15–25 a 25 až 35 cm. Výsledky ukázali, že smreky v porovnaní s bukmi mali menej jemných koreňov a boli v pôde rozmiestnené plytšie. Zároveň smreky mali vyššiu sezónnu dynamiku a aj rýchlejší obeh jemných koreňov. Zistili sme, že pomer medzi produkciou a mortalitou jemných koreňov bol vyšší pri bukoch ako pri smrekoch, čo hypoteticky mohlo súvisieť aj s epizódou sucha, ktorá sa zaznamenala v júli a auguste. Výsledky naznačili, že koreňový systém buka je v porovnaní so smrekom pravdepodobne odolnejší na fyziologické stresy. Tento záver vyplýval najmä z rozdielnej vertikálnej distribúcie jemných koreňov sledovaných drevín.

Kľúčové slová: biomasa a nekromasa; mortalita; produkcia; sezónna dynamika; obeh

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