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Fine Root Regenerative Potential of Montane Norway Spruce under Pollution Impact

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Summary

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Fine roots of six probably autochthonous Norway spruce stands in the Krkonose Mts. have been investigated since 1993. Fine root (roots with diameter < 1 mm) regenerative potential was estimated as the ratio between the fine root quantity in soil cores and fine roots ingrown into bags of silon net sieve. These bags were filled with the same humus soil substrate without roots, and installed into the same soil cores, and then harvested two years later. In addition, representative fine root tips were classified under dissecting microscope into five mycorrhizal developmental stages and three classes of vitality. Forest stands with high values of fine root quantity in soil cores (installed in 1994) had middle or low values of fine root regenerative potential (estimated in 1996). Root tip analysis revealed the decreasing vitality (percentage of turgid root tips) from the less developed, nonmycorrhizal root tips to the fully developed mycorrhizae in the dying forest stand in the Mumlavska hora plot. This tendency was not found in other forest stands.

Introduction

The direct or indirect impact of air pollution on tree assimilative organs is considered often as a key factor of forest decline in - Middle Europe. Nevertheless, fine root regenerative potential can give us important additional information about the regenerative ability of the counterpart organ, relative to assimilative organs, when considering source-sink relationships (RUESS & al. 1996). Root tips growing on fine roots, regenerated in ingrowth-bags, have been shown a suitable object for evaluation of their development phase, including formation of ectomycorrhizal structures and their vitality classes (CARNOL & al. 1997). The purpose of our study

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was to compare Norway spruce root quantity in soil cores with roots ingrown into "ingrowth-bags", installed into the same soil cores. In addition, new method of root tip development and vitality was demonstrated.

Materials and Methods

The regenerative ability of Norway spruce (*Picea abies* (L.) Karst.) fine roots have been studied in six permanent research plots (50 x 50 m), established in 1992 in the Krkonoše Mts., one of the most valuable and endangered national parks in Europe. Basic site characteristics are briefly described in CUDLÍN & al. 1995.

In June 1994, ten soil cores (10 cm in diameter, O_L, O_F, O_H and A soil horizons) were sampled; roots were washed and divided into four diameter categories (<1 mm-fine roots, 1-2 mm, 2-5 mm, >5 mm), and evaluated for length, dry weight and root tip, and mycorrhizal developmental phases (5 grade scale, from F 1 – start of rhizogenesis to F 5 – fully developed mycorrhizae), and for three vitality classes (turgid - root tips with assumed proper absorptive function, shrivelled – live, absorptively non-functioning tips, dead – dead tips) (RUESS & al. 1996). Ten root ingrowth bags (PERSSON 1990) per plot (nylon net with 5 mm sieve mesh, filled by sieved soil from the same soil horizons without roots) were placed into holes just after soil core removal. They were harvested and evaluated in autumn 1996 as described above. Results were processed by ANOVA and LSD test. The ratio between the fine root quantity in the soil cores and roots ingrown into bags indicates the fine root regenerative potential of trees. Results obtained from analysis of root tip and mycorrhizal developmental phases as well as vitality classes were analysed by relative frequency and conditional probability calculations.

Results and Discussion

The highest values of fine root (roots with diameter < 1 mm) length were found in soil cores in 1994 from sites in the eastern Krkonose Mts. (Slunecne udoli and Paseracky chodnicek), and from the plot Pudlava site (middle part of the Krkonose Mts.), an area that has undergone a significant change in forest health condition during the last 5 years (Fig. 1). The lowest values were estimated in plots situated in the more exposed western Krkonose plots, Mumlavska hora and Alzbetinka. On the contrary, trees from the Modry dul plot (site in the eastern Krkonose Mts. with the best health status of forest stand) had the highest quantity of roots, extracted from ingrowth bags in 1996 (Fig. 2), and the largest fine root regenerative potential, too, compared to all remaining plots (Table 1). There were significant differences in fine root length among research plots (tested by ANOVA). While fine root quantity in soil cores did not correspond either to the anthropogenic impact on the site or to the health status of the forest stand (CUDLÍN & CHMELÍKOVÁ 1996), the fine root regenerative potential did. Length values of other root diameter categories were mostly too low to show significant differences.

The values of relative frequency of root tip categories from in-growth bags gave approximately the same percentage of fully developed mycorrhizae (development phase 5 - about 80 %). A relatively higher percentage of non-completely developed mycorrhizae, without fungal mantle, was found (phase 4) in bags from Mumlavska hora, Alzbetinka and Modry dul. Analysis of the conditional probability of root tip occurrence in the three vitality classes within the individual development phases with higher tip representation (phases 3-5), indicated the decreasing vitality (percentage of turgid root tips), from the less developed phase 3 (nonmycorrhizal root tips) through phase 4 (non-completely developed mycorrhizae) to phase 5 (fully developed mycorrhizae), in the Mumlavska hora plot (Fig. 3). The vitality of phases 4 and 5 was the same in the remaining plots, with the exception of the Slunecne udoli plot, where the percentage of turgid, fully developed mycorrhizae (phase 5) increased, compared to non-completely developed mycorrhizae (phase 4).

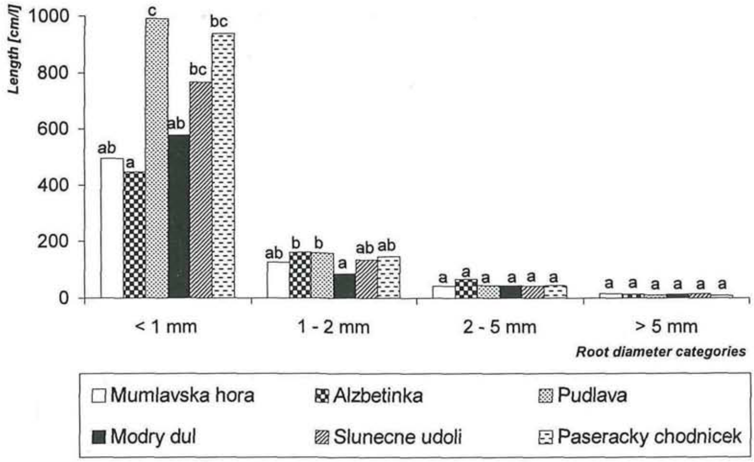

Fig. 1. Length of Norway spruce roots from soil cores from permanent research plots in the Krkonoše Mts. in 1994. For each root diameter category, values having same letter are not significantly different (P=0.05).

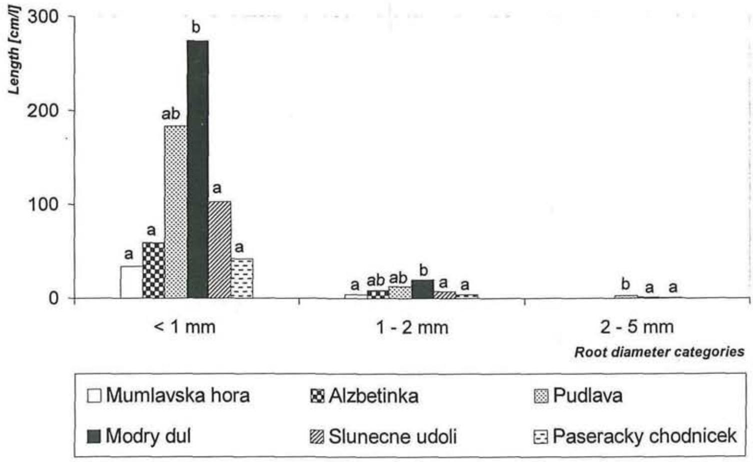

Fig. 2. Length of Norway spruce roots from ingrowth bags (1994 – 1996) from permanent research plots in the Krkonoše Mts. For each root diameter category, values having same letter are not significantly different (P=0.05).

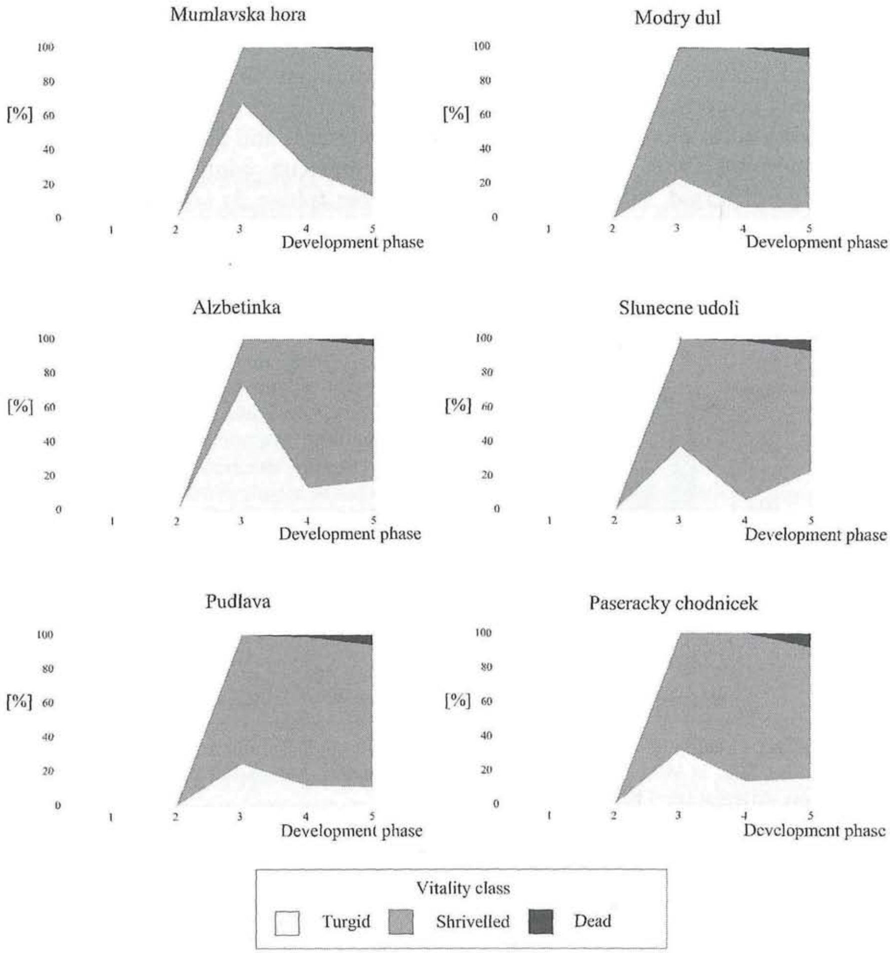

Fig. 3. Conditional probability of the root tip occurrence of Norway spruce from ingrowth bags (1994 -1996) in three vitality classes within individual development phases on permanent research plots in the Krkonoše Mts.

Table 1. Regenerative potential of Norway spruce fine roots, counted as the ratio of root length from in-growth bags (1994 - 1996) to root length from soil cores, sampled in the Krkonose plots in the spring 1994.

Plots	Mumlavska hora	Alzbetinka	Pudlava	Modry dul	Slunecne udoli	Paseracky chodnicek
Regenerative potential [%]	15	18	24	68	13	6

The values of the fine root regenerative potential provide us higher representativeness of results obtained from a relatively small quantity of replicates, compared to the root values from soil cores. They informed us about the tree ability to replace its damaged root tips in last two years.

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