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Fine root growth of beech (*Fagus sylvatica* L.) seedlings during the first outplanting years in Western Bohemia (Czech Republic)

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ABSTRACT: The study analyses the growth of beech seedling fine roots and their development in the first five years. The research plots were established in 1997–2003 in community forests of Starý Plzenec (Western Bohemia, Czech Republic). The data are based on annual reviews of beech samplings extracted from surveyed plots. The whole root volume as well as the fine root volume is significantly (on a 95% significance level) growing during the first years after outplanting and there is not any disruption of growth immediately after outplanting.

Keywords: beech; seedlings; total root volume; fine root volume; root growth

European beech was the most common species in Czech forests in ancient times when the influence of the human population on forests was insignificant. The intention to increase the proportion of beech, which should become a substantial species in our forests (Šindelář 1996; Kupka 2000), is a part of "restructuring and revitalization" in our forests (Šindelář 1995; Kupka 1999). Most of the new beech forests will be planted and therefore the root volume growth of beech plants is of high significance.

European beech is naturally spread over Western and Central Europe with maritime and transient climate. Beech prefers aerated moist soils with moderate or rich nutrient availability (Uhlířová et al. 2004). Beech does not sustain either dry sandy soils or clay wet soils (Fér 1992). Špulák (2005) described the beech in the climate of the Czech Republic as a species with wide ecological magnitude.

The root system is always negatively influenced by planting but generally it is believed that the root system is flexible enough to sustain the process namely if the planting technology is appropriate (Mauer, Palátová 2004).

The main purpose of this contribution is to evaluate the growth of total root volume and fine root volume of beech plants immediately after outplanting.

Fine roots are defined by many authors as the roots thinner than 2 mm (Murach 1984; Matzne et al. 1986) or roots thinner than 1 mm (Santantonio, Hermann 1985). For this study we use the "2 mm" definition.

MATERIALS AND METHODS

Research plots were established in the forests of Starý Plzenec in similar sites in terms of soil, ground water and climate conditions.

The average annual temperature of the area is 7.6°C. The coolest month is January with average temperature –2 to –3°C, the hottest July with average temperature 17–18°C. The vegetation period lasts 150–155 days. Precipitation sum is slightly lower than the average in the country, i.e. 563 mm with the length of snow cover about 47 days (Table 1).

The beech plantations with insufficient weed control and heavy game browsing were omitted.

Table 1. Average monthly and annual temperatures

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
1999	0.4	–1.1	4.3	8.0	14.4	15.8	19.1	16.7	15.7	8.0	2.1	0.7	8.7
2000	–1.2	2.2	4.3	10.1	14.4	17.5	15.5	17.8	12.5	9.5	3.7	0.5	8.9
2001	–1.9	0.5	4.0	6.6	14.4	14.3	17.7	17.9	11.0	11.0	1.8	–2.2	7.9
2002	–1.1	3.5	3.5	7.4	15.0	17.5	17.8	18.4	11.2	7.0	3.8	–1.4	8.6
2003	–1.6	–4.3	3.2	6.7	14.6	19.5	18.1	19.9	12.0	4.8	3.9	–0.9	8.0

Data given by Czech Hydrometeorological Institute

Table 2. Basic data on beech plant research plots

Stand indication	Site quality	Plot area (ha)	Reforested
49F2	3K3	0.19	April 2003
50E8	3I4	0.14	April 2002
50E7	3I4	0.03	April 2001
49A5	3I4	0.39	April 2000
52C6	3I4	0.40	April 1999
41C0	3I4	0.02	April 1998
50B5	3I4	0.24	April 1997

All research plots are fenced and therefore no chemical protection against game damage was applied, hence the plants are not influenced in their growth by the negative effects of protective application. Seven plantations in total were finally selected which comply with the given preconditions (Table 2).

The size of each research plot varied from 0.02 to 0.40 ha depending on the size of reforestation. The site quality of plots is varying from medium to poor in terms of nutrient and ground water availability. The site is typically covered by oak and beech forests in the area.

Bare-root two-year beech plants of local provenance were used for the reforestation of these plots. The plants were undercut in the nursery first year and not replanted. The reforestation was realized gradually from 1997 to 2003 and measurements and root system evaluation were conducted in 2001–2003. Fifty-nine plants in total were randomly chosen from research plots for the root structure and measurement analysis.

The data were collected regularly after the vegetation season. The extraction of plants for the root system analysis was done on the days with suitable weather conditions when the soil was not too much dry or wet to avoid the destruction of fine roots. The root system of each plant was carefully removed of soil scraps and the root architecture was documented by a camera.

Standard statistical software was used for statistical data evaluation (MS Excel 2003 v11.8).

RESULTS AND DISCUSSION

One of the most important variables for successful regeneration is an adequate volume of fine roots which secure the water and nutrition flow of the plant for its assimilation processes. Jurásek (2004) stressed the deficient fine root volume as a common problem for broadleaved species plants in this country and it concerned namely oak and beech. The volume of fine roots below the diameter of 2 mm as well as other parameters of root systems are given in Table 3.

All data in Table 3 are significantly different on a 95% probability level. Statistical analysis suggests that the whole root system is steadily growing during the first five years after outplanting. The same is true of all variables given in Table 3, i.e. of the fine root volume as well as of dry matter of the whole root system or of its part. The results are important mainly for the first two years after outplanting when plants are under "transplanting shock" but the root system is growing permanently as data shows.

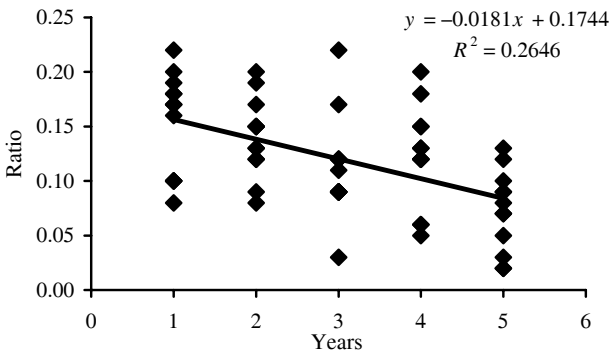

Fig. 1. The ratio of fine root volume to whole root volume (FR/WR) decreases with the plant age

Table 3. Results of basic root system analysis

Age (years after plantation)	Whole root system volume (ml)	Fine root volume (ml)	Dry matter of whole root system (g)	Dry matter of fine root (g)
			104°C during 24 hours	
1	25.46 ± 12.96	3.53 ± 1.04	12.20 ± 7.09	1.02 ± 0.55
2	48.10 ± 47.40	6.85 ± 7.26	23.80 ± 22.61	1.55 ± 1.36
3	57.02 ± 24.90	6.78 ± 5.70	29.88 ± 15.17	1.68 ± 1.28
4	75.24 ± 29.46	9.43 ± 5.80	35.53 ± 13.08	2.28 ± 1.59
5	95.87 ± 36.60	6.09 ± 4.28	48.84 ± 24.09	1.69 ± 0.82

The appropriate fine root proportion is an important prerequisite for successful performance of plants in forests within the first years (Jurásek 2004). Therefore the ratio between the fine root volume and the whole root volume and its development is the next step of our analysis. The results are presented in Fig. 1 showing a decrease in the ratio over the first five years after outplanting. However, the correlation is not very strong in the given data set explaining the relationship only in 26%. Some data (especially for the third year) are outlying but the test for remote data separation was not applied as the data set is not large enough.

The data suggests that the fine root relative increment is similar to the whole root system volume at least for the first four years after outplanting (Fig. 2). The results support the hypothesis that both the whole root systems and the very important part, i.e. fine roots, are growing comparatively and thus the nutrition flow is secured. The relationship between whole root volume and fine root volume is different for beech plants planted five years ago (Fig. 2). It seems that this fifth year could be a year of turning point when the root skeleton is growing much more than fine roots and their ratio (FR/WR) are significantly decreasing. The data and their statistical evaluations are given in Table 4.

There are significant differences (on a 95% significance level) between the ratios (FR/WR) only for five years old plants or more precisely after outplanting. The results correspond with Fig. 2, where the trend of the ratio between fine root volume and total root volume is significantly different for plants after five years of growing in the forest.

Table 4. The ratio of fine root volume (FR) to whole root volume (WR) according to plant age (years after outplanting)

Age (years after plantation)	Ratio FR/WR
1	0.155 ± 0.047[a]
2	0.138 ± 0.037[a]
3	0.114 ± 0.048[a]
4	0.123 ± 0.049[a]
5	0.065 ± 0.038[b]

The same letter indicates no significant differences between the ratio values

CONCLUSIONS

European beech forests are supposed to be extended in a large scale in the Czech Republic. The plantation of seedlings and plants will be the main technique used to accomplish this intention. The

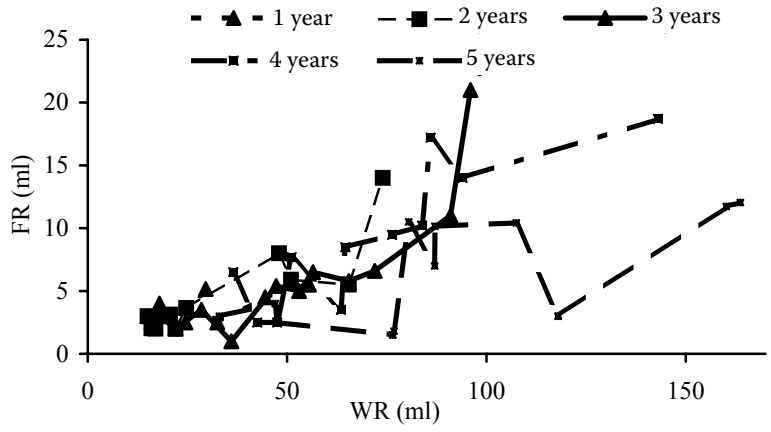

Fig. 2. The relationship between whole root system volume (WR) and fine root volume (FR) according to years after plantation

success of reforestation is strongly influenced by the plant root system and their growth during the first years after outplanting.

The main purpose of our research was to analyze the growth and development of the root system of beech plants in first years after their outplanting. There are seven research plots with similar site and climatic conditions where the same type of beech plants was used. The data were analyzed from the aspect of the volume of total root system and volume of fine roots.

The results suggest that the growth of total volume and fine root volume is maintained during the first years after outplanting, which is an important finding for beech plants as a species that is preferably planted in our forests. It seems that in the fifth year after outplanting the volume increment of fine roots is significantly lower than that of the whole root system and that the ratio FR/WR is going down from that year.

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Růst jemných kořenů bukových (*Fagus sylvatica* L.) sazenic během prvních let po výsadbě v západních Čechách (Česká republika)

ABSTRAKT: Studie analyzuje růst a vývoj jemných kořenů bukových sazenic v období prvních pěti let po výsadbě. Výzkum probíhal v letech 1997–2003 v obecních lesích města Starý Plzenec (západní Čechy, Česká republika). Analýza je založena na ročních hodnoceních bukových sazenic vykopaných na pokusných plochách. Výsledky ukazují, že jak celkový objem kořenů, tak i objem jemných kořenů se v prvních letech po výsadbě signifikantně zvětšuje (na hladině významnosti 95 %). Tato skutečnost byla potvrzena i bezprostředně po výsadbě, kdy nebylo prokázáno zastavení růstu.

Klíčová slova: buk; sazenice; objem kořenového systému; objem jemných kořenů; vývoj kořenů po výsadbě

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