JOURNAL OF FOREST SCIENCE, *53*, 2007 (3): 113–118

The root-plant ratio changes in the first growing periods of wild cherry (*Prunus avium* L.) plantations

I. Kupka

Faculty of Forestry and Environment, Czech University of Life Sciences Prague, Prague, Czech Republic

ABSTRACT: The root-plant ratio is one of the important parameters for planting stock quality. We suppose that the ratio is one of the driving variables for the growth performance of new plantation in the forest. The study summarises data on the volume of major parts of 4 years old wild cherry trees. An allometric analysis of different parts of plants in relation to the growth performance of wild cherry trees was done. The results show a close positive relationship between the volume of the whole root system and aboveground biomass. The same is true of the fine root proportion in the root system. Data also document that the efficiency of root system is not decreasing during the root development – at least in the investigated period. The same results were obtained for fine root efficiency. Data confirm the importance of the root-plant ratio for the growth performance of new plantation in the forest provided that harmful factors are not at a limiting level.

Keywords: regeneration; root system; growth performance of young plantation; wild cherry

Artificial regeneration remains the main system of silviculture in the Czech Republic (Anonymous 2005). Forest Act No. 289/1995 lays down to perform the regeneration of forest land after final cut within a 2-year period and to get the new reforestation in "safe" growing conditions within 7 years after final cut. This underlines the importance of good growth performance of new plantations provided that the reforestation is well protected from harmful biotic and abiotic factors e.g. weed competition, game browsing, beetle infestation, etc. The overcoming of "planting shock" is an important factor where the root system role is substantial (Jurásek 2004b). Mauer and Palátová (2004a) propose to check the quality and quantity of root system any time when the new plantation quality is assessed or checked. The root system of a plant is one of the driving variables for good performance of reforestation in forests (Mauer, Palátová 2004b). The idea of checking the root system is widely accepted for containerized planting stock (Nárovcová 2004) but much less for bare-root seedlings and plants (Jurásek 2004a; Mauer, Palátová 2004a).

There has been a long tradition in the Czech standards to fix up the necessary quantitative and qualitative parameters for seedlings and plants planted out. However, until the last Czech standard came out (Jurásek et al. 2002), the root system quality was not described precisely using the wording like "the root system should comply with development of the aboveground part of the plant". Today the valid Czech standard requires the root system volume to correspond to the aboveground volume and this ratio is given in exact figures. There is quite a precise description of quality requirements for planting stock as well but in this paper we concentrate only on quantitative parameters of plants.

Published data document different behaviour of root growth for different species and in different soil conditions (Mauer et al. 2004c) and therefore any data on the root system growth of different species are an important contribution to the common knowledge of the basic factor for new plantation prosperity. For instance Mauer and Palátová (2004b) found out that the oak root system was not influenced by the type of regeneration while the pine root system was significantly determined. On the other hand, Rytter et al. (2003) reported that the pine plants given different treatments in the nursery differed in size at planting out, but they had similar heights and root system after 3 years in the forest. This indicates that the root-plant ratio

is important for growth performance provided that the nutrient status is not at a growth-limiting level.

Some studies found out significant differences between naturally and artificially regenerated young stands (Holen, Hanell 2000), other findings indicate that the differences are species specific (Mauer, Palátová 2004b).

A strong relationship between aboveground biomass and its root system was supported by many studies (cf. Agestam et al. 2003; Jurásek 2004b; Kupka 2004). An adequate root system is important also for competition conditions a new plantation will undergo (Ammer 2002).

The purpose of the present study is to evaluate the relationship between aboveground biomass and its root system in terms of fresh volume for a young plantation of wild cherry trees and to assess the importance of different sections for plant performance in the forest.

MATERIAL AND METHODS

Research plots of wild cherry plantation were established in April 2002 at the Training Forest Enterprise in Kostelec nad Černými lesy near Truba Research Station. The plots are a part of forest compartment 20B9. Generative bare-root plants were used as a planting stock. The plants were set out manually into 30 by 30 cm sockets at a 1m spacing. Regular care of the plantation was done every year to control weeds. The plots are fenced and thus the game damage is insignificant.

Site quality could be described according to the Czech typological system as 2K0 on a flat terrain. The site quality is not very rich in terms of nutrients but it is quite a warm site. The site is not favourable for wild cherry ecological requirements but it is quite good for successful growing.

The research plot with three replications is about 8 by 8 m in size each. There were 50 plants on each research plot at the beginning of the experiment, i.e. 200 plants in total.

Samples of 46 plants were randomly extracted from all research plots on May 9, 2006. Samples were cleaned of soil and put into labelled plastic bags and they were taken into a laboratory for allometric measurements. They were deposited in a refrigerator. The measurements of fresh samples were executed. The volume of aboveground biomass without leaves, the volume of whole root system and volume of fine roots (thinner than 2 mm) were measured in a glass scaled cylinder filled up with water. The accuracy of scaled cylinder was 50 mm^3.

The data were processed by Excel 2003 (11.5 version).

RESULTS AND DISCUSSION

The relationship between root system and aboveground biomass is one of the basic parameters for seedlings and plants according to the Czech standard (Jurásek et al. 2002). But for the time being there are not many papers dealing with the root-plant ratio changes after planting in the forest. There are only few data on the influence of the root-plant ratio changes on their growth performance (Mauer, Palátová 2004a). As the root system is crucial for the growth of a new plantation, we try to analyze this relationship from different points of view.

The basic data on the volume of fresh aboveground biomass, roots and fine roots are given in Table 1.

First of all, we wanted to know if the aboveground biomass growth was supported by the commensurate growth of root system. Fig. 1 shows the exponential regression in the first period of the plantation growth in the forest, indicating that the best aboveground biomass growth is supported by excellent growth of root system. One can expect that the exponential growth will not last for a long period and thus the growth function with upper asymptote would be more appropriate for regression analysis, but there are not enough data for that period of plant development for the time being and available data gave only poor results for that type of regression. However, there is a clear trend "the bigger the root

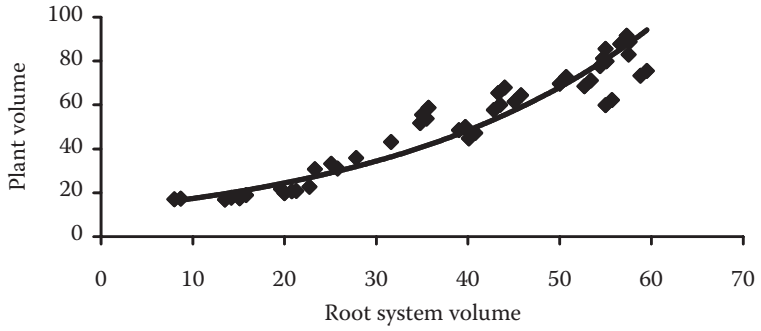

Fig. 1. The relationship of plant to root system volume in 4 years old wild cherry plantation (in cm^3)

Table 1. Data on the volume of fresh plant, roots and fine roots in cm^3 for 4 years old wild cherry plants

Tree number	Plant (cm^3)	Roots (cm^3)	Fine roots (cm^3)	Tree number	Plant (cm^3)	Roots (cm^3)	Fine roots (cm^3)
1	32.2	20.7	6.5	24	67.9	44.0	11.5
2	22.7	14.2	4.9	25	20.8	13.5	3.9
3	43.2	31.6	8.6	26	60.0	43.5	12.0
4	85.5	55.0	14.4	27	88.8	57.6	13.9
5	50.0	39.7	10.6	28	62.2	55.7	14.0
6	68.5	52.7	11.7	29	36.8	25.8	5.9
7	29.3	20.2	5.0	30	27.9	15.8	4.8
8	47.3	40.8	10.8	31	34.8	20.3	6.7
9	55.5	35.0	10.0	32	17.1	8.0	3.55
10	79.9	55.1	14.5	33	75.5	59.5	16.0
11	91.5	57.3	14.9	34	61.5	45.1	9.8
12	26.6	15.1	3.8	35	30.3	20.0	5.5
13	77.7	54.4	13.5	36	64.4	45.8	10.8
14	19.4	8.7	4.55	37	57.7	42.8	11.0
15	59.9	55.0	13.0	38	81.2	54.7	14.0
16	73.3	58.8	15.0	39	33.3	25.1	4.9
17	40.9	30.9	7.6	40	72.8	50.7	11.0
18	69.7	50.0	10.0	41	58.7	35.7	11.0
19	87.8	56.6	15.1	42	65.5	43.3	10.5
20	71.1	53.4	12.7	43	44.8	40.1	9.8
21	31.7	19.6	5.7	44	51.8	34.8	8.9
22	83.0	57.5	13.8	45	53.8	35.5	9.9
23	48.5	39.0	9.6	46	30.8	20.9	6.0

system volume, the bigger the plant", supporting the requirement of the Czech standard for an adequate root system volume as one of the preconditions for good plant performance in the forest. The coefficient of reliability for exponential regression is very high explaining 92% of the relationship.

An adequate proportion of fine roots (thinner than 2 mm) in the root system is another important parameter of planting stock and thus the changes in the fine root volume in the first growing periods of new plantation were also the focus of the study. The data show a similar relationship between the fine root volume and the whole root system volume (see Fig. 2). The exponential curve will not most probably last for a long period and again the growth curve would be more appropriate for the regression if data allow it.

The important role of fine roots for physiological processes of plants is very well known and thus the fine root proportion may play a key role for young plant performance in the forest. The aboveground biomass volume per unit of fine roots was chosen as an indicator of their effectiveness. Fig. 3 shows the relationship between this unit and fine root volume.

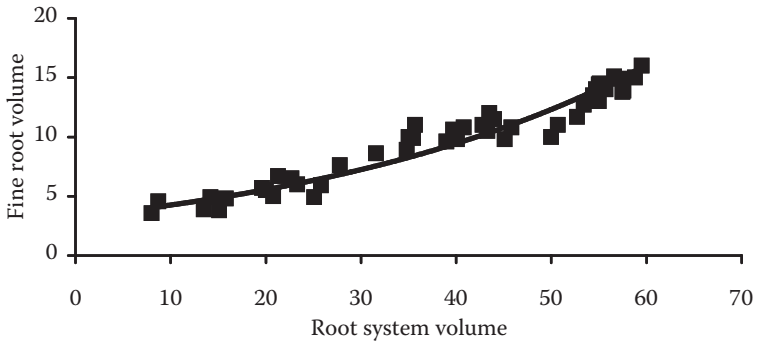

Fig. 2. The relationship of fine root to whole root system volume in 4 years old wild cherry plantation (in cm^3)

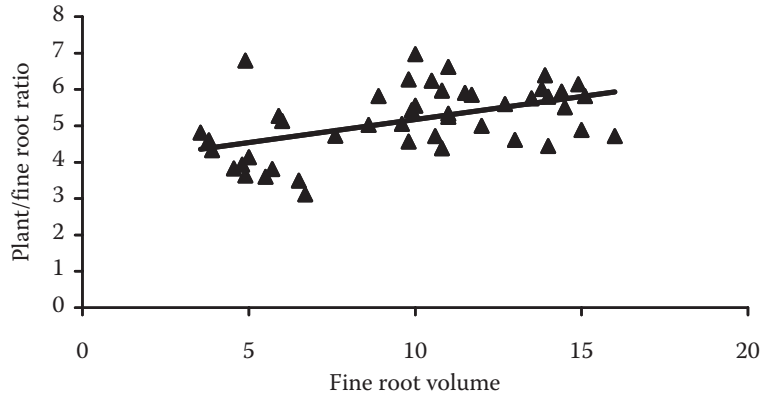

Fig. 3. The relationship between fine root volume and the ratio of plant to fine roots in 4 years old wild cherry plantation

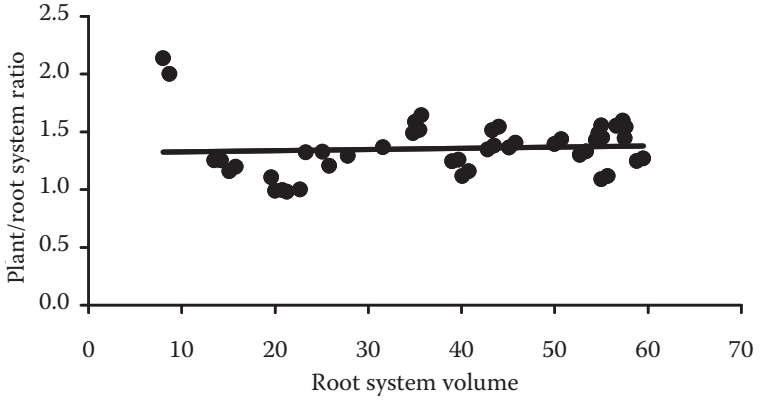

Fig. 4. The relationship between root system volume and the ratio of plant to roots in 4 years old wild cherry plantation

The data suggest that the fine root ratio is stable at least in the first growing period of new plantation and the best growing plants have about the same fine root ratio as the poorly growing ones. Even the regression analysis shows an increasing tendency, the relationship is very poor and the coefficient of reliability for linear regression is only $R^2 = 0.24$ and therefore it could be neglected.

The next step is to evaluate the root-plant ratio and its relationship with root system as the driving variable for young plant performance in the forest. The results are given in Fig. 4. Again, the low coefficient of reliability for linear regression, which is only $R^2 = 0.005$, confirms that the root system shows the same efficiency for the best and poorly growing plants.

As the first order roots which conduct water and embed plant into soil are steadily growing and become a relatively bigger part of the root system not contributing to plant growth, one could expect a decrease of efficiency with an increase in the root system volume. This tendency is not evident from Fig. 4 and from the regression analysis.

Our interpretation of the data is that the efficiency of root system in terms of plant growth remains stable at least in that first growing period of plant in the forest disregarding their functions of conduction and embedding.

CONCLUSIONS

The root system, namely its architecture and volume, is the driving variable for growth performance of young plantations in the forest. This study concentrates on the root volume and its relationship with plant biomass and effectiveness of plant components to its growth, neglecting the quality aspect of roots.

The relationship of plant to root system volume in 4 years old wild cherry plantation is very close. The coefficient of reliability for exponential regression is very high explaining 92% of the relationship. It confirms that the growth performance of young plants in the forest is strongly determined by the root system volume (Fig. 1).

The data show a similar relationship between the fine root volume and the whole root system volume (Fig. 2). The aboveground biomass volume per unit of fine roots was chosen as an indicator of their effectiveness. Fig. 3 shows the relationship between this unit and fine root volume. The data suggest that the fine root ratio is stable at least in the first growing period of new plantation and the best growing plants have about the same fine root ratio as the poorly growing ones.

As the first order roots which conduct water and embed plant into soil become step by step a bigger

part of the root system not contributing to plant growth, one could expect a decrease of efficiency with an increase in the root system volume. This tendency is not evident from Fig. 4 and from the regression analysis. In other words, the root system keeps their efficiency for that period of their life in the forest.

Our study supports the importance of the relationship between root system and aboveground biomass. The root system volume is a driving variable for the new plantation performance in the forest and therefore it is important to keep this parameter as one of the basic parameters for seedlings and plants according to the Czech standard (ČSN 48 2115).

References

AGESTAM E., EKÖ P.-M., NILSSON U., WELANDER N.T. , 2003. The effects of shelterwood density and site preparation on natural regeneration of *Fagus sylvatica*. Forest Ecology and Management, *176*: 61–73.

AMMER CH., 2002. Response of *Fagus sylvatica* seedlings to root trenching of overstorey *Picea abies*. Scandinavian Journal of Forest Research, *17*: 408–416.

ANONYMOUS, 2005. Report on the state of forests and forestry in the Czech Republic. Prague, Ministry of Agriculture of the Czech Republic: 114.

HOLÉN P., HÄNELL B., 2000. Performance of planted and naturally regenerated seedlings in *Picea abies* – dominated shelterwood stands and clearcuts in Sweden. Forest Ecology and Management, *127*: 129–138.

JURÁSEK A. et al., 2002. ČSN 48 2115/Z1 Sadební materiál lesních dřevin. Praha, ČNI: 25.

JURÁSEK A., 2004a. Kořenový system vegetativně množených lesních dřevin. In: Kořenový systém – základ stromu. Sborník z konference MZLU, 25. 8. 2004. Křtiny: 137–149.

JURÁSEK A., 2004b. Dosavadní zkušenosti s použitím KSM buku z intenzivních technologií. In: Možnosti použití sadebního materiálu z intenzivních školkařských technologií pro obnovu lesa. Sborník z konference VÚLHM, 3–4. 6. 2004. Opočno: 57–64.

KUPKA I., 2004. Vliv způsobu výsadby na kořenový systém bukových sazenic. In: Hlavní úkoly pěstování lesů na počátku 21. století. Sborník z mezinárodního vědeckého sympozia MZLU, září 2004. Brno: 129–138.

MAUER O., PALÁTOVÁ E., 2004a. Deformace kořenového systému – vznik a možnosti eliminace. In: Kořenový systém – základ stromu. Sborník z konference MZLU, 25. 8. 2004. Křtiny: 85–91.

MAUER O., PALÁTOVÁ E., 2004b. Vývin kořenového systému lesních dřevin z umělé a přirozené obnovy. In: Kořenový systém – základ stromu. Sborník z konference MZLU, 25. 8. 2004. Křtiny: 115–124.

MAUER O., PALÁTOVÁ E., RYCHNOVSKÁ A., 2004c. Porosty náhradních dřevin a jejich kořenový systém. In: Kořenový systém – základ stromu. Sborník z konference MZLU, 25. 8. 2004. Křtiny: 75–84.

NÁROVCOVÁ J., 2004. Zkušenosti s hodnocením kvality kořenového systému sadebního materiálu lesních dřevin. In: Kořenový systém – základ stromu. Sborník z konference MZLU, 25. 8. 2004. Křtiny: 103–114.

RYTTER L., ERICSSON T., RYTTER R.M., 2003. Effects of demand-driven fertilization on nutrient use, root: plant ratio and field performance of *Betula pendula* and *Picea abies*. Scandinavian Journal of Forest Research, *18*: 401–415.

Received for publication August 7, 2006
Accepted after corrections September 27, 2006

Vývoj poměru objemu kořenového systému a nadzemní části v prvních fázích výsadby třešně ptačí (*Prunus avium* L.)

ABSTRAKT: Objemový poměr kořenového systému k nadzemní části je jedním z hlavních kvalitativních parametrů sazenic. Předpokládáme, že je tento poměr jednou z určujících veličin pro ujímavost a růst nových výsadeb v lese. Příspěvek shrnuje data o vývoji čtyřletých sazenic třešně ptačí. Byla provedena analýza alometrických vztahů důležitých částí sazenic k růstu a vývoji výsadby. Výsledky ukázaly signifikantní vztah mezi objemem kořenového systému a nadzemní částí rostliny. Totéž platí o podílu jemných kořenů. Z dat rovněž vyplývá, že efektivita kořenového systému neklesá během zvětšování jeho objemu – alespoň v této fázi vývoje výsadeb. Totéž lze tvrdit i o efektivitě jemných

kořenů. Data potvrdila významnost objemového poměru kořenového systému k nadzemní části rostlin pro jejich vývoj a růst po výsadbě za předpokladu, že nedochází k významnému poškozování těchto výsadeb.

Klíčová slova: obnova lesa; kořenový systém; růst a vývoj výsadeb; třešeň ptačí

Corresponding author:

Doc. Ing. Ivo Kupka, CSc., Česká zemědělská univerzita v Praze, Fakulta lesnická a environmentální,
165 21 Praha 6-Suchdol, Česká republika
tel.: + 420 224 383 791, fax: + 420 224 377 917, e-mail: kupka@fle.czu.cz