FORESTRY IDEAS, 2013, vol. 19, No 2 (46): 167–172

INCREASING THE DOLOMITE STONE CONTENT IN THE GROWING MEDIA REDUCES THE GROWTH OF TWO-YEAR BAREROOT SEEDLINGS OF EUROPEAN HOP-HORNBEAM (*OSTRYA CARPINIFOLIA* SCOP.)

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Received: 18 October 2013 Accepted: 19 November 2013

Abstract

European hop-hornbeam is a broadleaf deciduous tree, found from Southern France to Anatolia and Transcaucasia, mainly on limestone and dolomite bedrock. The seedlings produced in a mixture of quartz sand and peat in the ratio of 2:1 were transplanted after the first growing season in raised beds filled with growing media of 3 different mixture ratios of peat and dolomite stone. Detailed morphological development and nutrient concentration and content after a second growing season were compared. An increase of the dolomite stone in the growing media has a negative impact on the growth of European hop-hornbeam seedlings. The seedlings from growing media with the highest content of peat in relation to the dolomite stone (70:30) had highest values of all measured morphological attributes. Unlike morphological parameters, influence of the dolomite stone content on studied macronutrients concentration is not conclusive.

Key words: growing media, European hop-hornbeam, nutrient ratio, *Ostrya carpinifolia***,** seedling quality.

Introduction

Areal of European hop-hornbeam covers the Western Balkans from Greece, Albania, Bosnia and Herzegovina, Croatia, Serbia and southern Hungary and extends to the Southern Alps. It occurs in Provence and in Italy including Sardinia and Corsica. In the southeast, European hop-hornbeam areal extends across Asia Minor to the Caucasus and Lebanon (Jovanović 2007). European hop-hornbeam is a semi-shade species with narrow tolerance limit to soil moisture (Popović et al. 1997).

Besides its importance as species inhabiting the least fertile soils, particularly on steep slopes where protective function is predominant, European hop-hornbeam has a great practical value. Wood is hard, sound, heavy and lackluster (Vilotić 2000). Korkut and Korkut (2008) present the results of studies that indicate possibility of European hop-hornbeam utilization for different wood products and recommend the Turkish forest enterprise to “give more at-

tention to European hop-hornbeam wood, which is more valuable wood source for forest industry". Despite wide possibilities for its use in afforestation (Jović et al. 1998, Tomić et al. 2011), foresters neglect European hop-hornbeam in choice of species for afforestation programmes.

Our study objective was to quantify and compare seedlings grown in growing media with 3 different ratios of peat and dolomite stone, in order to investigate their response on production in growing media more similar to soil condition on planting site and to promote the use of European hop-hornbeam in production of planting material and afforestation.

Materials and Methods

Stratified seeds from 3 provenances (Jagnjenica – 720 m elevation, Junaci – 950 m – elevation and Vojmisliće – 1160 m elevation) were sown in a mixture of quartz sand and peat in the ratio of 2:1. Seeds from all 3 provenances were equally and randomly represented. After the first growing season, 945 seedlings were transplanted into three modified beds (315 per bed with growing density of 160 seedlings per m^2), 100 cm wide, 200 cm long, 40 cm height, with 30 cm layer of growing media. Each bed was filled with a growing media made of mixture of peat and dolomite stone at different ratios: treatment A – 70:30, treatment B – 50:50 and treatment C – 30:70. A low mineralized peat, with *pH* in *KCl* of 4.9, *pH* in H_2O of 5.8,89 % of organic components, 2.41 % of nitrogen, 0.18 % of potassium, 0,18% of phosphorous and 2,43 % of other minerals; originate from local source at Pešter plateau, Southwestern Serbia. A dolomite faction – buffer 0/30, originated from local dolomite quarry near Belgrade, Serbia. A study was installed in Belgrade, at nursery of Faculty of Forestry, University of Belgrade. Seedlings were grown under standard nursery practices, irrigated on need and weeded on 15 days.

Values of *pH* in mixture of growing media and deionized water were measured at beginning and end of the study from 3 samples from each bed. Temperature of growing media was measured on daily basis during growing season at 10 cm depth, on 3 spots in each bed.

At the end of the second growing season, all seedlings were measured for morphological attributes of quality: height (*H*), root collar diameter (*D*) and dry masses: the total seedling dry mass (M_{sd}), shoot dry mass (M_{sh}), root dry mass (M_{ro}). Dry masses were measured after drying the seedlings in the thermostat cabinet at a temperature of 68 °C for 48 hours.

From the measured morphological parameters after second growing season, the quality index (*QI*) has been calculated by the formula (1) (Dickson et al. 1960):

$$QI = \frac{Msd\ (g)}{\left(\frac{H(cm)}{D(mm)}\right) + \left(\frac{Msh\ (g)}{Mro\ (g)}\right)} \qquad (1)$$

Concentrations of nitrogen, phosphorus and potassium in shoot and root were measured at the end of the second growing season. Sample preparation for the determination of *P* and *K* was performed with wet combustion of plant material in nitric acid and hydrogen peroxide. From the obtained extract, phosphorus was determined colorimetric with the use tin chloride and ammonium molybdate. Potassium was determined by flame photometry. Nitrogen content was determined by the Kjeldahl method.

Normality of data was tested by Kolmogorov-Smirnov test. Data distribution was not normal, but given a large sample (307 valid pairs for comparison), we did not apply nonparametric statistics, and continued with analysis of variance with growing media as factor. The significant differences between the groups, and the homogeneity of groups were examined by post hoc multiple comparison test or Tukey HSD test. All statistical analyzes were performed using the computer program STATISTICA 7, StatSoft Inc.

Results

The *pH* value of mixture of growing media and deionized water increased at the end of the study, but there are no significant differences between treatments (Table 1).

There is no significant differences in temperature of substrates in with different treatment (Table 2).

Seedlings from growing media with lowest content of dolomite stone (A) had greater mean values of all measured attributes except nitrogen concentration in both, shoot and root and phos-

Table 1. Average values of *pH* in mixture of growing media and deionized water at beginning and end of the study from 3 samples from each bed.

Treatment	*pH*	
	beginning	end
A	5.8	6.3
B	5.9	6.2
C	5.8	6.3

Table 2. Average value, standard deviation (*Sd*), minimum and maximum temperature (°C) from three seedbeds with different substrates in last three month of vegetation period.

Month		July	August	September	All
Days		31	31	30	92
treatment					
Average	A	18.745	18.952	17.947	18.554
	B	18.913	19.003	17.750	18.564
	C	18.790	18.823	17.500	18.380
Sd	A	0.8254	1.2902	1.2364	1.2035
	B	0.9872	1.5105	1.4229	1.4298
	C	1.1998	1.5935	1.5281	1.5605
min-max	A	17.6-21.1	17.3-21.8	16.0-19.7	16.0-21.8
	B	17.5-21.4	17.4-22.5	15.8-19.6	15.8-22.5
	C	17.1-22.1	16.9-22.6	15.3-19.0	15.3-22.6

Table 3. Height (*H*), diameter (*D*), seedling dry mass (M_{sd}), shoot dry mass (M_{sh}), root dry mass (M_{ro}) and Quality Index (*QI*) of European hop-hornbeam seedlings from three growing media.

Indicators	Growing media			Statistics	
	A	B	C	*F*	*p*
***H*, cm**	28.99^{c}	22.57^{b}	20.33^{a}	49.09860	0.000000
***D*, mm**	3.14^{c}	2.84^{b}	2.51^{a}	22.27941	0.000000
M_{sd}, g	0.99^{b}	0.68^{a}	0.57^{a}	28.46041	0.000000
M_{sh}, g	0.65^{b}	0.42^{a}	0.34^{a}	35.83220	0.000000
M_{ro}, g	0.34^{b}	0.26^{a}	0.22^{a}	15.99357	0.000000
QI	0.09^{b}	0.07^{a}	0.06^{a}	12.95882	0.000003

Note: For each measured attribute from each growing media, means with different letters are significantly different at the α=0.05 level.

Table 4. Nitrogen concentration in shoot (N_s) and root (N_r), phosphorus concentration in shoot (P_s) and root (P_r), potassium concentration in shoot (K_s) and root (K_k) and nutrient ratios in shoot (N_s:P_s, Ns:K_s) and root (N_r:P_r, N_r:K_r) of European hop-hornbeam seedlings from growing media.

Nutrient concentration, %	A	B	C	*F*	*p*
N_s	1.65	1.79	1.80	1.689897	0.209842
N_r	1.43	1.60	1.58	2.613844	0.098068
P_s	0.05	0.03	0.03	1.174716	0.329333
P_r	0.03	0.04	0.02	1.962280	0.166671
K_s	0.30	0.27	0.28	0.861018	0.437819
K_r	0.36^{c}	0.26^{ab}	0.21^{a}	4.246619	0.029032
Ratio					
N_s:P_s	33	60	60		
N_s:K_s	5.5	7	6		
N_r:P_r	48	40	79		
N_r:K_r	4	6	7.5		

Note: For each measured concentration from each growing media, means with different letters are significantly different at the α=0.05 level.

concentration in both, shoot and root and potassium concentration in shoot. Seedlings grown in growing media C had a greater concentration of nitrogen in shoot. Seedlings grown in growing media B had a greater concentration of nitrogen and phosphorous in root.

Mean values of all measured morphological attributes, as well as potassium concentration in root, are significantly different at $\alpha = 0.05$ level.

phorous concentration in root (Table 3 and 4). Quite opposite, seedlings from growing media with highest content of dolomite stone (C) had smallest mean values of all measured attributes except nitrogen

Table 5. The mean value of content of *N*, *P* and *K* in seedlings (in mg), *N*:*P* and *N*:*K* ratio and root shoot mass ratio (*R*:*S*) from 3 growing media.

	Growing media		
Content, mg	**A**	**B**	**C**
N	15.60	11.70	9.65
P	0.40	0.20	0.10
K	0.31	0.18	0.14
Ratios			
N*:*P	39	58	96
N*:*K	5	6	7
R*:*S	0.52	0.62	0.65

Unlike concentrations, the content of *N*, *P* and *K* in seedlings decrease with increase of dolomite content in growing media. In the same time, all ratios increase with increase of dolomite content in growing media (Table 5).

Discussion

There are no significant differences in *pH* value between different treatments at end of the study and expected increasment in all three seedbeds is mainly due to irrigation process.

The results of impact of dolomite stone content in growing media on morphological attributes of seedlings are

consistent with results of similar research with different ratio of peat and stone in the production of Austrian pine (Mataruga 2006). Heiskanen and Rikala (2003) find lack of influence of peat content decreasing on height of Scots pine seedlings, but relatively small negative influence on heights of Norway spruce and birch seedlings. Given to lack of standard dimensions prescribed, as well as the results of other research about production of the European hop-hornbeam seedlings, it is difficult to discuss the quality of the plants examined in this study. However, by comparison with seedling of other species inside the same age, it can be concluded that the seedlings of European hop-hornbeam from the three treatments do not meet their quality, in all observed morphological attributes.

Unlike morphological attributes, influence of dolomite content on concentration of observed nutrients is less pronounced. These results are similar to those reported by Valdecantos et al. (2006) for *Quercus ilex* L. and *Pinus halepensis* Mill. foliar *N* and *P* concentrations. On the other hand, nutrient content decrease with increase of dolomite in growing media, but these differences are not significant.

However, nutrient ratios are more useful than nutrient concentrations in defining of critical nutrient limits (Flückiger and Braun 2003). Results of *N*:*P* ratio indicates that growing of seedlings on all three growing media was very limited by *P*, considering a much larger values than 16, as suggested by Koerselman and Meuleman (1996).

Different conclusions can be made by comparison of nutrient concentrations and nutrient content. The increasment of *R*:*S* biomass ratio with *N* and *P* deficiencies based on nutrient content is consistent with Hermans et al. (2006), which is not so conclusive for ratios based on nutrient concentrations. Nutrient content is dependent on seedling size (Landis et al. 2005) and it is more comparable to *R*:*S* biomass ratio.

There are no defined critical nutrient levels for European hop-hornbeam to our knowledge. Compared to nutrient critical levels suggested by Binns et al. (1983) for other broadleaved species, seedlings grown in all 3 growing media was limited by all 3 observed nutrients.

Conclusions

An increase of the dolomite stone in the growing media has a negative impact on the growth of European hop-hornbeam seedlings. This impact is more noticeable on morphological attributes compared to content of major nutrients in seedlings. European hop-hornbeam seedlings can be produced in substrates with large level of dolomite stone as part of conditioning process, but further research of field success should be performed.

Acknowledgment

This paper was realized as a part of the project “Studying climate change and its influence on the environment: impacts, adaptation and mitigation” (43 007) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011–2014.

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