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Influence of container type on growth and development of holm oak (*Quercus ilex* L.) seedlings in a nursery

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Abstract

Background and Purpose: Development of holm oak seedlings, which were grown in various containers, was observed during two years in nurseries, with the aim to state the influence of containers on the development of holm oak seedlings.

Materials and Methods: Three types of containers were used: Bosnaplast 12, Bosnaplast 18 and PVC 7/24, which were filled with standard mixture of peat and soil 2:1. The measurements and analyses were done on one-year and two-year old seedlings, successively every two months, four times for one-year old and seven times for two-year old seedlings. Variables which were examined in nursery and laboratory were: plant height, upper part of root diameter, root weight, total root lenghth, leaves weight, plant weight, total plant weight, relation between weight of plant and root.

Results: The volume of container positively influenced the morphology of one-year and two-year old plants in nursery. The largest and best quality plants were produced in PVC containers, then in Bosnaplast 18 containers, and the smallest in Bosnaplast 12 containers. Different degree of deformation of root system was stated, depending on container type and growth duration.

Conclusions: The growth of holm oak seedlings in Bosnaplast 12 and Bosnaplast 18 containers for longer than one vegetation season is not recommended, because of root deformations, and for PVC containers not longer than one and a half to two vegetation seasons.

INTRODUCTION

The holm oak (*Quercus ilex* L.) is a basic native species of Croatian Eumediterranean area with estimated 35 000 ha *(8, 9, 15)*. It comes in all forms and degradation phases, but stems and macchia as a degradation phase of holm oak forests are the most common. There are holm oak seed stands on small protected areas and private plots, mainly on islands (Brijuni, Rab, Krk, Brač, Lastovo, Mljet). Although it is a native species of great economic, ecologic and landscape value very little is known about its usability for afforestation of degraded areas of Mediterranean karst in Croatia, as well as about the types of containers in which seedlings of good quality could be produced in nurseries. Many nurseries prefer small containers because they are less expensive and more seedlings can be grown per unit area. These containers are adapted to sorts of small seeds, but not to decidious trees of quick

TABLE 1

Average morphologic values of holm oak seedlings grown in various container types in a nursery.

Parametres	Bosnaplast 12		Bosnaplast 18		PVC container 7/24	
	1+0	2+0	1+0	2+0	1+0	2+0
Stem Height, cm	14.30	25.0	15.30	31.30	21.30	39.30
Root collar diameter, mm	3.30	3.70	3.50	4.30	4.30	6.00
Root Weight, g	1.27	2.50	1.93	3.10	3.60	7.13
Total root length of root, mm	1972	1283	2333	3216	4802	6197
Average diameter, mm	1.47	2.36	1.47	1.72	0.97	1.20
Stem Weight, g	1.33	2.03	1.73	2.80	3.70	7.03
Weight of leaves, g	0.80	1.40	1.07	2.20	2.20	3.96
Biomass, g	2.60	4.53	3.67	5.96	7.30	14.20

growth, big seeds and strong root system as Quercus, which needs bigger containers *(2, 6, 12, 13)*.

Container variables such as volume, diameter, depth (height) have influence on the physiology and morphology of seedlings in nurseries and open areas. It is important to state which variables have more influence on morphologic characteristics of seedlings in nurseries and their development with least possible root deformation caused mainly by container volume. Big containers have more water and nutrients and more space for development of root system, which is especially important for sorts with strong roots.

The research was done in the nursery of Forestry department Split with the aim to state which of the containers, used in production of seedlings, have the greatest impact on the development of holm oak in nurseries.

MATERIALS AND METHODS

The species to be investigated was sown in three container types mostly used in Croatia: Bosnaplast 12 with dimensions 36 x 25.5 x 12 cm with 55 openings in the block and the volume of each opening 120 cm^3; Bosnaplast 18, dimensions 32 x 21.5 x 18 cm with 33 openings in the block and the volume of each opening 220 cm^3, and PVC container 7 x 24 cm, volume 923 cm^3.

The seeds were sown manually in containers on the 4th of March 2002. The containers were filled with standard mixture of peat and soil 2:1 generally used in nurseries. Four to five kg of NPK 7:14:21 was added per 1 m^3 mixture. The plants in nurseries were regularly watered and protected against plant patogens, grown as one and two-year old plants. The following parameters were analyzed and measured: plant height, the tap root length and total root length, upper root diameter, plant weight, leaf weight, root weight and total plant weight, relation between plant and root.

Root deformation was observed separately for every container. Measurements were done successively every two months, four times for one-year old and seven times for two-year old plants. Each time, 5, or 3 plants were chosen for morphologic determination. The first analysis was done on May 15th 2002, the last on October 25 th 2003. The plant height was measured by ruler in cm, the upper root diameter with preciseness of one mm. The weight of the upper part and underground part of plant was measured precisely to two decimals. With the help of scanner STD 1600 and software Vin RHizo Pro the total values of all root parts according to diameter degrees, total volume, volume according to diameter degrees, average diameter root, number of links, forking and overlapping were measured. The correlation and regression analyses were done to correlate the container variables with variables growth and development of plants in nursery. The variables of containers included its volume, depth and width, and plant variables included morphologic characteristcs.

RESULTS AND DISCUSSION

The size of container did not influence the survival of holm oak in the nursery, which was demonstrated by analysis of one and two-year seedlings, while their volume had a strong and positive impact on the growth and development of seedlings (Table 1).

It is evident from the table that bigger container produced bigger plants with bigger diameters and biomass both for one and two old year plants. The average height of holm oak seedlings in PVC container, volume 923 cm^3, was greatest in the first year of growth and they were 21.3 cm high, in the second year 39.3 cm, and the smallest in containers Bosnaplast 12, 14.3 cm by age 1+0 and 25,0 by age 2+0. Container volume also correlated positively with the plant volume, biomass of root and plant in the nursery. Total biomass of plant in PVC container was 7.3 g for one year old plants and 14,2 g for two year plants, while the diameter of plant and upper part of root was 4.3 mm and 6,0 mm, respectively. In Bosnaplast 18 containers, the total biomass of plants amounted to 3.67 g for one year old plants and 5.96 g for two year old plants and

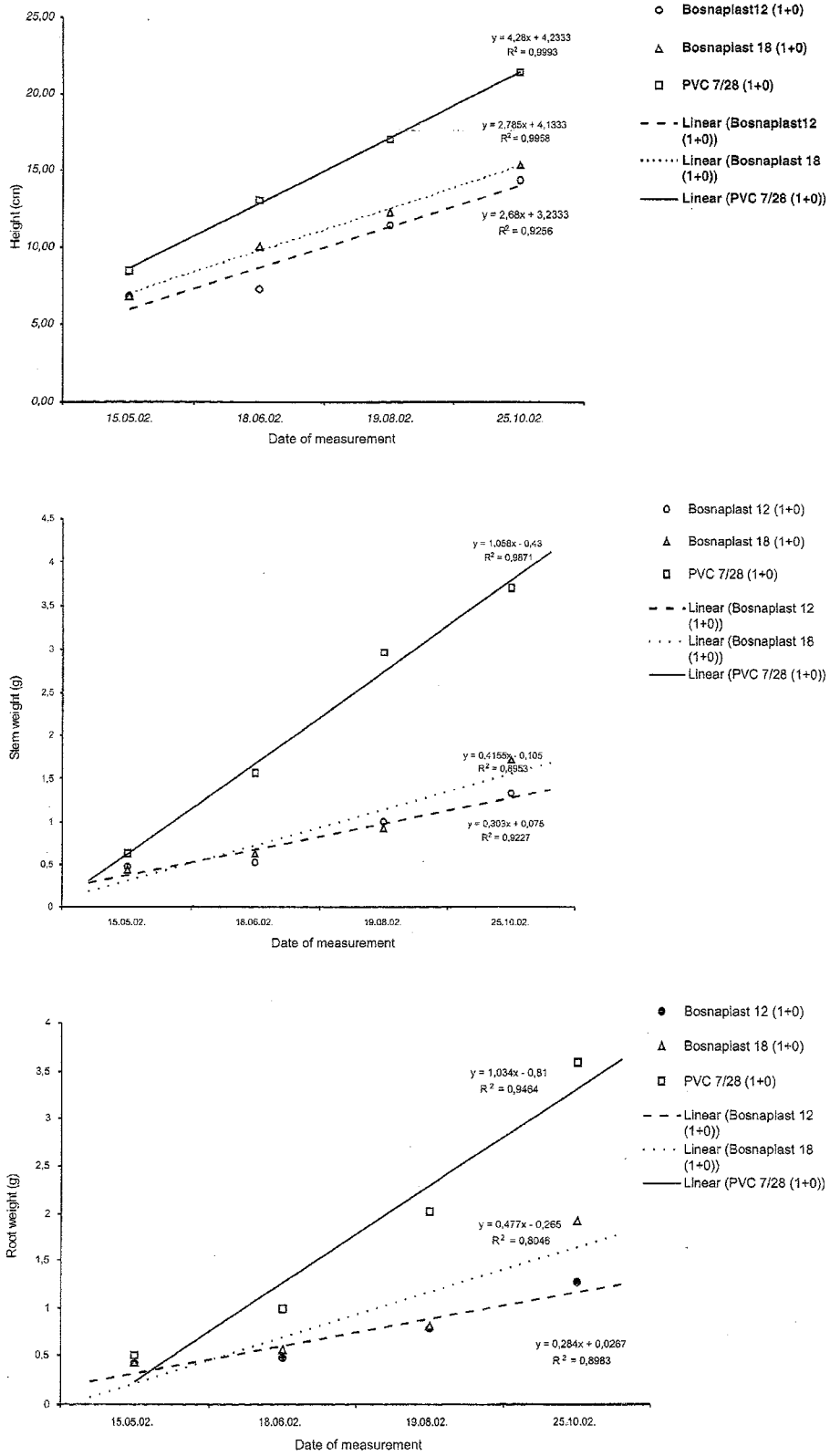

Figure 1. *Regression analysis of dependence of plant height, stem and root weight (1+0) in nursery with the container type.*

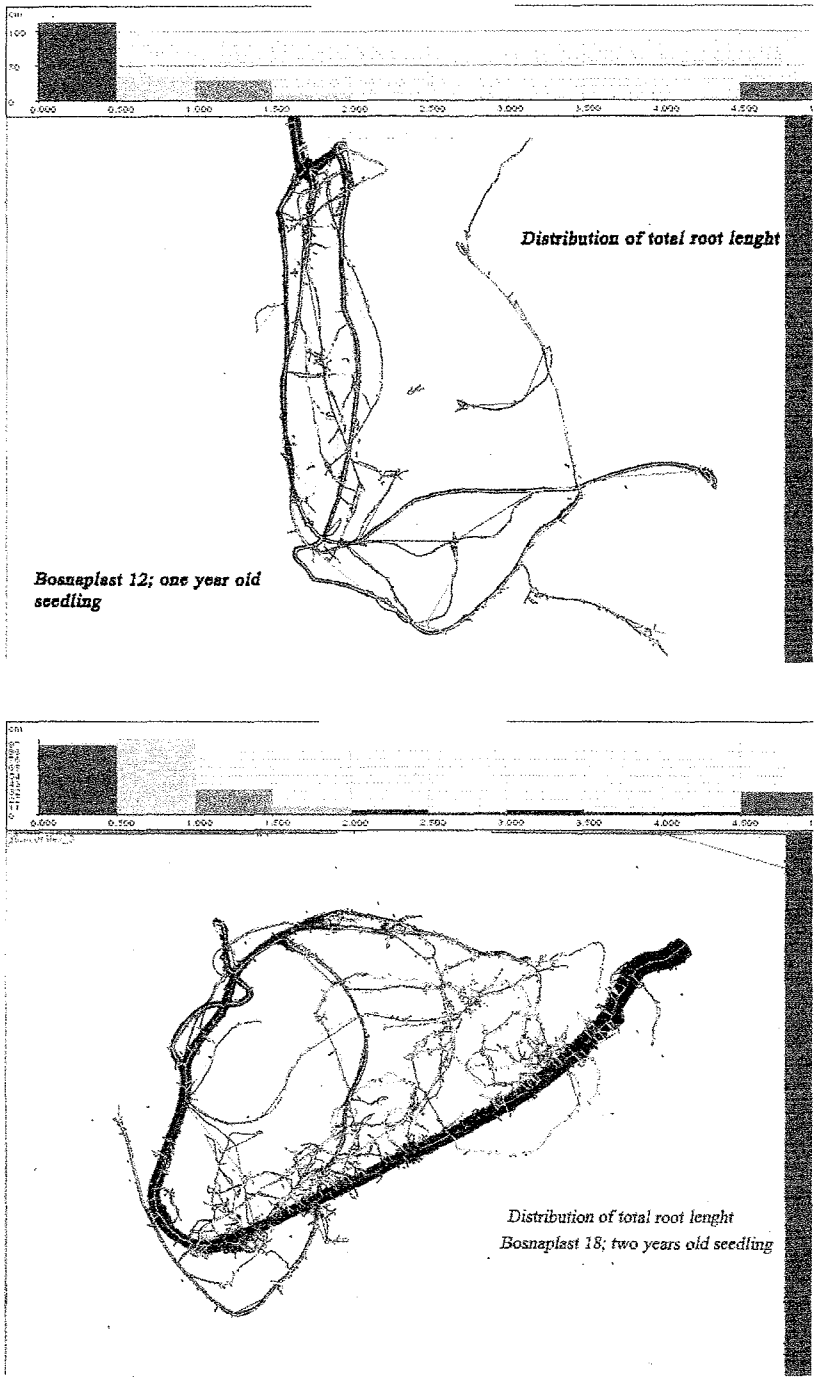

Figure 2. *Deformation and distribution of the root system total length by one and two years old seedlings of holm oak in Bosnaplast 12 and Bosnaplast 18 container.*

the diameter of upper root plant was 3.5 and 4.3 mm; respectively. The least values were recorded for containers Bosnaplast 12 with biomass 2.6 g for 1+0 plants and 4.53 g for 2+0, with diameter of plant, and the upper part of root 3.3 and 3.7 mm, respectively.

So the type of container has great impact on the growth and development of holm oak plants in nurseries. Using regression analysis in this research, a strong connection between the volume of a container and morphologic parameters of the seedling, has been stated.

One and two-years-old plants which were growing in the containers with bigger volume (PVC container 7/24) had greater height ($r^2 = 0.9641$, $p = 0,01$), greater plant diameter ($r^2 = 0.991$, $p = 0.01$), greater stem weight ($r^2 = 0.09735$, $p = 0.01$), greater leafs weight ($r^2 = 0.977$, $p = 0.01$), greater root weight ($r^2 = 0.9681$, $p = 0.01$) and greater total biomass of the seedling ($r^2 = 0.9772$, $p = 0.01$) than those which grew in smaller containers (Bosnaplast 18) and especially Bosnaplast 12 (Figure 1).

The quality and root system development play very important part in the growth of a good seedling. Root system analysis showed that the seedlings of holm oak in PVC containers had much richer and twice longer root system than in Bosnaplast 18 and Bosnaplast 12 containers when one and two-year old seedlings were observed (Table 1).

During the production of seedlings in nursery, the root development is controlled several times. It was stated that the root system of holm oak has simple architecture with a very strong and pointed tap root which dominates by its thickness and length and numerous very thin side roots, which can be very poor; this was also stated by Ocvirek *(12)* for the seedlings of pedunculate oak.

In the first analysis of root system, two months after seeding, the tap root of holm oak was as long as the height of a container, with very poor side roots. This proved that the development and deformity of root system in containers were different already in the first vegetation season. Bunch intertwinement by holm oak in containers Bosnaplast 12 and Bosnaplast 18 was very similar. The difference was that in Bosnaplast 12 container the bunch intertwinement naturally occurred earlier along with deformations because of smaller container volume. Circular and rebound growth of root system in containers Bosnaplast 12 and Bosnaplast 18 was noticed at the beginning of August, but the root development was not satisfactory because the bunch fell off during plant removal from the container. Only at the end of October of the first year was the bunch intertwining satisfactory, but with noted deformity of the root system.

The circular growth in these containers ranged from 90° to 360°. In one year and especially two-year old seedlings, where there were multiple interflexing and later growth of the tap root and rich smaller parts to the very top of the container (Figure 2).

Therefore it is suggested not to grow seedlings for longer than one year in containers Bosnaplast 12 and Bosnaplast 18, especially not in Bosnaplast 12, where it can last shorter than one vegetation season. However, it often happens that seedling are kept longer, also of holm oak, in these containers as two year old seedlings, for which there is no biological or ecological justification. It is true that two year old seedlings in these containers reached good height and development but with very deformed root system, whose biological value is very problematic in afforestation.

In PVC container the root system developed better and was richer in small parts than in Bosnaplast 18 containers or especially Bosnaplast 12 containers. No

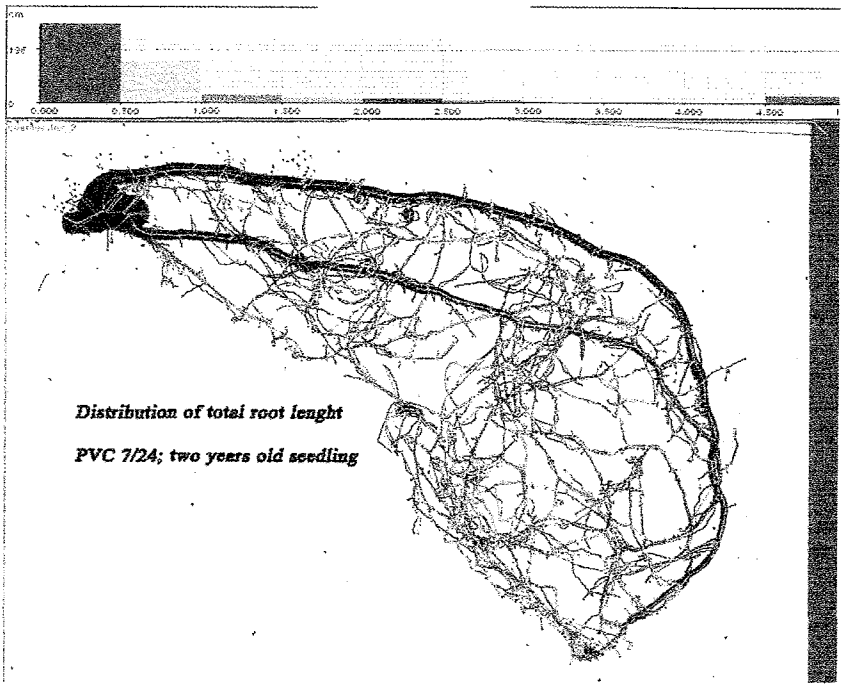

Figure 3. *Deformity and distribution of root system total length of two year old seedling of holm oak in PVC container.*

deformity of root system was found during one vegetation season, or it was very rare.

Good growth of bunch of holm oak in PVC container 7/24 was stated after one and a half vegetation season, when the beginning of root system deformities and its spiralling could be noted. At the end of the second vegetation, the highest concentrations of root parts at the bottom of containers was noted, as well as the beginning of reversibile growth of the tap root (Figure 3).

Therefore the growth of holm oak seedlings in PVC 7/24 container should not be longer than one and a half or two vegetations. These containers showed positive impact on the growth and development of holm oak seedling in nurseries where seedlings of good quality were produced for afforestation of Mediterranean karst areas characterized by mainly shallow soil and low rainfall in vegetation period. Well fed seedlings and root system of good quality are important variables and good precondition of future growth after planting. Big plants have a large root system which can grow in deeper zones of soil where moisture can be within reach also during dry periods, while smaller containers (Bosnaplast 12, Bosnaplast 18) shorten the growth of roots and reduce the reachability of bioelements and water, which influences the growth of plants.

Similar research was done by Ocvirek *(12)* by growing of pedunculate oak (*Quercus robur* L.) in nurseries. He came to the conclusion that air drying of rich small root particles and tap root has positive effect on the quality of root system of pedunculate oak. He claimed that cut tap root of pedunculate oak is compensated by more vertical streaks and better development of side streaks. More authors *(1, 4, 5, 7, 10)* wrote about importance of cutting side streaks and tap root and the methods used.

CONCLUSION

The following conclusion may be reached based on the research and results obtained: physical characteristics of containers did not exert impact on survival of holm oak seedlings in nurseries. The average value of survival of one and two year old seedlings in containers Bosnaplast 12, Bosnaplast 18 and PVC container 7/24 amounted from 72.5 till 76.3 %. The container type influenced directly the growth and development of holm oak in nurseries. In greater containers, better species were produced, seedlings with greater height, diameter, plant weight, leaf weight, root weight, total root length and biomass. The best values of morphologic characteristics, both in one and two year growth, were stated for PVC containers, then in containers Bosnaplast 18, and the smallest in Bosnaplast 12, which means that even small differences in the volume of containers influenced the growth and development in nurseries. The volume of containers also had positive influence on the quality of root system. Evergreen oak seedlings in PVC containers developed better and more regular side stripes than in Bosnaplast 18 and Bosnaplast 12. Besides, the deformation of root system in containers was small, which made these seedlings of better quality and very usable for afforestation of Mediterranean karst. The results show that growth duration of holm oak seedlings in containers was of special importance and directly influenced the quality of seedlings, development of root system and their deformity.

The container Bosnaplast 12 recommended for shorter growth (less than one vegetation season), and Bosnaplast 18 for one vegetation season. There is no economic or biological reason for keeping the seedling longer than one vegetation season in the container because of great deformity of holm oak root system. In PVC containers of 923 cm3 volume, one and a half to two vegetation seasons is recommended for good quality seedlings. Big, good quality seedlings with satisfactory growth potential for afforestation will be produced in these containers.

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