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HEIGHT GROWTH OF WHITE ASH (*Fraxinus excelsior* L.) IN THE REGION OF MAJDANPECKA DOMENA

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ABSTRACT

This paper considers the height growth characteristics of white ash in the region of Majdanpečka Domena. The regularities of height growth of this species were analyzed in 10 young stands (with 30 dominant trees felled for growth reconstruction), for different site conditions. For the purpose of comparing the growth of white ash and the other individually recorded species, six additional trees of sessile oak, wild service tree and aspen (two of each) were felled. Defined models of growth and incremen thave confirmed that white ash is a fast-growing tree species, with early culmination of current height increment (6-8 years), which indicates the time period when it is biologically suitable to carry out the most intensive treatment, by which the complete management of these species' stands becomes far more effective.

Key words: height growth, white ash, time of increment culmination, silvicultural importance.

INTRODUCTION

In the past, areas covered by valueble broadleaves throughout Europe, including those where we are, were far more widespread. However, a lack of silvicultural measures, along with excessive and uncontrolled use, have brought these areas to a state of neglect (Stajić, 2003). An increased share of valuable deciduous trees, in addition to economic gain (rapid achievement of usable dimensions, high-quality and appreciated wood type etc.), would also be biologically and ecologically significant due to increase in stability and resilience of pure beech and oak stands against the effects of various abiotic and biotic factors (Burschel, 1990; Stamenković, Vučković, 1998; Stajić, 2010, etc.).

Economically and ecologically speaking, white ash (*Fraxinus excelsior*) represents one of the most interesting species in the valuable broadleaves tree species category. Numerous uncertainties, which are related to environmental requirements and the selection of appropriate sites, the type of growth in different site conditions, the character of silvicultural operations, the duration of the production cycle (rotation) and

the production effect of white ash, are all hampering the development of relevant concepts of how to manage pure and mixed ash stands in particular. Therefore, great practical significance is given to doing research on this species's growth characteristics under different site conditions, which enables the existing knowledge to be complemented, deepened or rectified as its scope and quality are still insufficient.

MATERIAL AND METHODS

The research object (10 sample plots in pure stands of white ash) is located in the area of north-eastern Serbia (Majdanpek), within the M. U."Crna Reka" in Educational Base of the Faculty of Forestry in Belgrade. The climate is mild-humid (B1), i.e.it belongs to low-forest humid climate. The analyzed stands are classified into two ecological units: ecological unit A (EUa) – the site of sessile oak and hornbeam (*Querco - Carpinetum moesiacum*Rudski (40) 1945) on humus-siliceous soil on andesite (SP1-5), and ecological unit B (EUb) - the site of sessile oak and hornbeam (*Querco - Carpinetum moesiacum* Rudski (40) 1945) on eutric brown soils on andesite-amphibolite schists (SP6-10). Stand age is about 23 years.

The aim of the study is to investigate the regularities of growth and define height growth models of white ash for the analyzed sites and thereby indicate the applicability of the information obtained. For this purpose, three dominant trees from each sample plots were felled (a total of 30 trees) and cross-sectional slices were taken at every 0.5 m from the base to the top of the trees. In addition, for the purpose of comparison of growth and increment trends, two more dominant trees were felled of each of the mixed species: sessile oak, wild service tree and aspen (a total of 6). In order to determine the existence of statistically significant differences in the growth of the trees analyzed on white ash sample plots, analysis of variance was applied.

For the presentation of height growth depending on age, the Chapman-Richards function was applied:

$$h = a \cdot \left(1 - e^{-b \cdot T}\right)^c$$

Current height increment is obtained as the first derivative of the growth function:

$$i_{th} = f(T) = F'(T) = \frac{dh}{dT}$$

Average height increment is obtained on the basis of the formula:

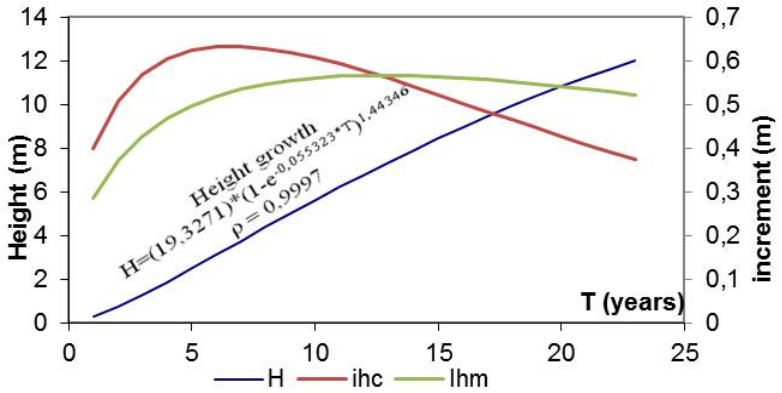
$$i_{ph} = \frac{h_t}{T} = \frac{\int_0^T f(T) \cdot dT}{T} = \frac{F(T)}{T},$$

or as the quotient of reached tree height (h_t) and age (T).

RESULTS

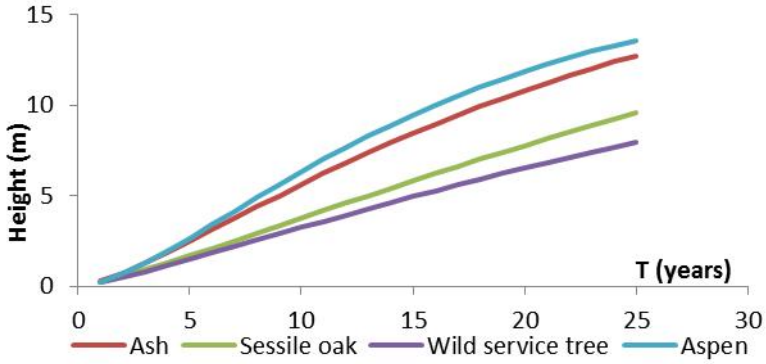
Although very small differences in height growth of dominant trees were established among the analyzed sample plots, in order to define the significance of the differences observed, an analysis of variance was carried out, related to achieved height of dominant trees within each ecological unit at 5, 10, 15, 20 and 23 years of age. Established empirical values of F-test in EUa (0.17, 2.88, 3.01, 1.00, 0.35) and EUb (1.0, 1.25, 0.50, 0.55, 2.15) at all analyzed ages were smaller than the critical value (F_{crit} = 3.48), indicating a lack of statistically significant differences in the heights of dominant trees with respect to sample plots within ecological units. In order to come to conclusions about whether the observed differences in heights of analyzed dominant trees between EUa and EUb were of accidental nature or there was a significant difference, the reached heights at the aforementioned ages were tested using the t-test.Calculated t-values (1.52, -0.51, -0.84, -1.99 and 1.92) were always smaller than the critical value from the t-distribution table (t_{crit} = 2.05), so a hypothesis of equal trees heights between the EUs in all observed periods was acceptible. On the basis of these facts, i.e. on the basis of all the data on the analyzed trees at the ages of 5, 10, 15, 20 and 23, a height growth model of white ash trees for both ecological units was established.The defined height growth model of dominant trees for both ecological units, as well as graphic illustrations of height growth and current (i_{hc}) and mean height increment (i_{hm}) are presented in Graph 1.

With all of the 30 analyzed white ash trees, i_{hc} culminated between 6 and 8 years of age, with values ranging from 0.60 m to 0.67 m, and i_{hm} between 11 and 14 years of age. With all the trees, as it had already been stated earlier, there was a non-significant variation in height growth. Therefore, on the basis of a defined model for the representation of height growth for both ecological units, it was concluded that the culmination of i_{hc} occurred in year 7 with the value of 0.63 m, and the culmination of i_{hm} in year 13 with the value of 0.57 m.



Graph 1. Height growth model of dominant trees for both ecological units and curves of height growth, current and mean height increment

In order to compare the growth dynamics of white ash and mixed species, height growth models of sessile oak, wild service tree and aspen were defined. Height growth lines of all the tree species are shown in Graph 2. In year 23, aspen reaches the biggest height (13.0 m), followed by ash (12.0 m), sessile oak (8.9 m) and wild service tree (7.4 m).



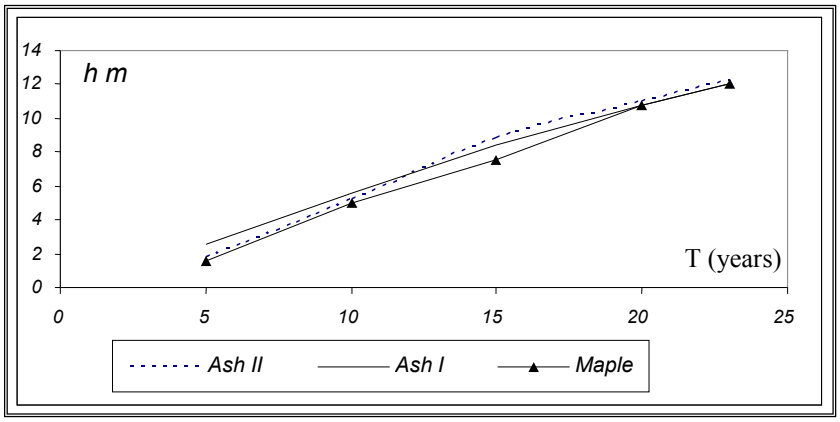
Graph 2. Height growth of white ash, sessile oak, wild service tree and aspen

DISCUSSION

According to Plavšić (1960), initial research on growth and increment of white ash was done by Schuberg (1887) and Endres (1888) who published their results on 20 ash trees aged between 52 and 107. The first detailed technical data on the growth and increment of individual white ash trees and stands in Serbia were a result of research by Miščević and Stamenković (1972, 1976). Stamenković et al. (1991), Stamenković and Vučković (1995, 1998), Vučković et al. (2001) and Stajić (2003, 2004, 2010) continued further research on growth characteristics of white ash in pure and mixed stands in Serbia.

In principle, white ash falls into the category of fast-growing tree species. Defined models of height growth and increment of dominant trees in this research have confirmed the aforementioned statement that white ash is a rapidly growing species in youth, with a very early culmination of current height increment (between the years of 6 and 8) and a relatively rapid decline of current increment after the peak. Misčević and Stamenković (1972) discuss a similar growth rate and age at the time of culmination, whereby they emphasize that in the analysis of 12 white ash trees of different biological positions, a culmination of current height increment with the 2 highest trees is established in year 7. Kadunc (2004a) also points to rapid height growth of young white ash, and notes that a maximum height increment is achieved by year 10, and the average height increment by year 20. According to Faliński and Pawlaczyk, height increment of white ash culminates depending on the site conditions in the period between years 10 and 25 (Dobrowolska et al. 2008). Current height increment of white ash trees in the area of "Đerdap" National Park culminates in years 11 and 12 (Stajić 2010). According to the data from European textbooks on the subject matter of growth and forest

increment (Assmann 1961, Erteld, Hengs 1966, Krammer 1988, Wenk et al., 1990, Kotar 2005), white ash is added to the group of woody species where culmination of height increment occurs over a period of 2 -15 years.

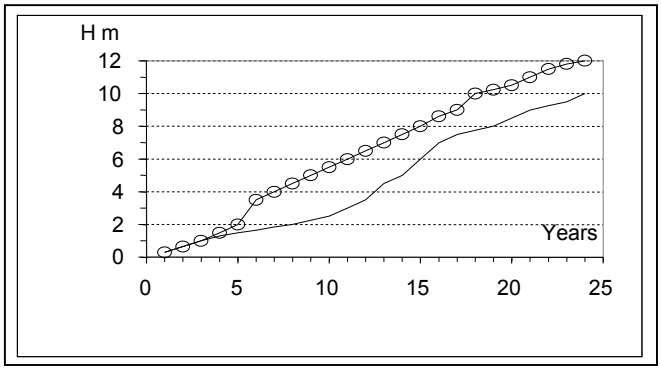


Graph 3. Height growth of white ash and Norway maple

For the purpose of analysis and comparison, trends of height growth of white ash (ash I - the result of research in this paper) and white ash and Norway maple (ash II and Norway maple - the result of research by Stamenković and Vučković 1998) are presented in *Graph 3.* The results show that the established trends of height growth are very similar according to height growth dynamics, both to each other and in relation to Norway maple. In addition, if trends of height growth are analyzed for the purpose of evaluating competitive ability of tree species recorded in this stand, the fastest growth up to approximately year 25 is to be found in aspen and ash, followed by sessile oak and wild service tree (*Graph 2.*).

Early culmination of height increment of white ash indicates to the necessity of intensive silvicultural treatment of this species from an early age, which can significantly speed up and "facilitate" undisturbed growth of individual trees and boost their competitive ability and resilience against the effects of a number of adverse factors (Stajić 2010). It is known that during the period or development phase of a large height increment, trees have the strongest respond to increased growth space and that space regulation for growth has its full biological sense and economic justification. An illustrative example, which confirms the aforementioned, is given through research results by Vučković et al. (2001). According to these authors, all up to year 5, height growth of white ash was even to a high degree on two analyzed surfaces (*Graph 4*). After year 5, when on sample plots II (growth in height during the age represented by a line with circles) the number of trees started to be reduced, a strong growth and increment differentiation of ash was initiated on the treated and non-treated areas, whereby the strongest effects of reduction had already been achieved between years 5 and 10. Similar conclusions can be drawn in relation to the here analyzed growth trends of white ash and aspen. It is clear that from approx. year 5, aspen constantly dominates growth compared to white ash, hindering it progressively through more pronounced

shading, reduction of canopy and competitive interference. On the other hand, white ash dominates growth and competitively interferes and dampens the growth of sessile oak and wild service tree. Therefore, with the aim of preserving the mixture and quality of these two species, appropriate practical professional operations must be applied towards reducing competitive ability of white ash and "supporting" sessile oak and wild service tree. It is evident that cleaning at the sapling stage is generally considered important for growing ash stands of good quality, and it is also believed that ash needs intensive tending (Dobrowolski et al. 2011).



Graph 4. Height growth of white ash of one treated (line with circles) and one non-treated young stand (***Source:*** *Vučković et al. 2001*)

A pronounced decline in height increment of white ash after culmination, which was determined based on conducted research study, clearly points to the conclusion that any further delay in silvicultural intervention would represent a belated and forced-choice management measure depending on the situation existing prior to it, due to its trivial effect and considerably intensified dangers to stand stability, whereby there is a deterioration and damage to a large number of trees. In this case, after cutting devitalized, bent and broken trees, an inadequate number of trees with adequate production potential is often left in stands that are unevenly distributed on the surface, so considerable losses in increment occur that are multiplied depending on rotation length (Vučković, Stajić 2003).

CONCLUSIONS

White ash is a forest tree species that is characterized by beauty and quality of its wood, but also intensive growth in youth and early achievement of usable dimensions (Stajić 2004). According to Kadunc (2004b), white ash can reach a 50 cm diameter at breast height already at the age of 70. At good sites, pure stands of white ash can have a capacity of up to 700 $m^3 \cdot ha^{-1}$(Knorr 1987). One of the most impressive white ash trees in Serbia (height of 44 m, breast-height diameter of 192 cm) has been recorded in the area of "Đerdap" National Park.

In order to make the management of this forest type as efficient as possible, both economically and environmentally, it is necessary to practically detect growth regularities of white ash in different site conditions. In addition, special importance and attention paid by the relevant profession and science must be directed towards determining the characteristics of height growth, given that height growth contains within itself two components whose knowledge enables adequate planning and execution of management: growth of species depending on age and the species's relationship to the site (Vučković 1989). In this way, an approach which assumes permanent monitoring of height increment trends, a good-quality biological basis is provided for early separation of the future trees and their proper tending, a timely and appropriate implementation of an overall effective silvicultural treatment and, consequently, intensive growth, stability and quality of economically interesting stands of white ash. At the same time, realistic assumptions are made for the return of white ash to the forests in our area, which proves a great deal of attention that has been paid to this species by professional and scientific circles in European forestry in recent decades. After all, white ash undoubtedly represents an elite tree species in the majority of European forests and should be treated as such.

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