



Distribution and Management of Black Walnut (*Juglans nigra* L.) in Croatia

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Abstract

Background and Purpose: Black walnut (*Juglans nigra* L.) was introduced in forest management around 1890 in the lowland regions of eastern Croatia to establish plantations on the sites too dry for the most valuable native species, pedunculate oak (*Quercus robur* L.). Aim of the article was to perform a preliminary research of the distribution and representation of black walnut in Croatian lowland forests, and their significance in the management of lowland forests.

Materials and Methods: A database of plantations was established from the management plans (age, area, standing volume of black walnut, total standing volume, coordinates). Gauss-Krüger coordinates were used for mapping the distribution of black walnut (ArcView 3.3 software, UTM grid). Fifty subcompartments were randomly selected for ground surveying (assessment of stand structure, collecting of samples of fertile twigs with leaves and fruit).

Results and Discussion: A total number of 416 subcompartments (3,162 ha) with black walnut as pure stands (143 subcompartments, 827 ha) and with black walnut as partial stands, groups of trees, or individual trees was established. The total standing volume of black walnut was estimated to be 239,678 m³ (in pure plantations 112,198 m³). No hybrid between black walnut and Persian walnut was found. The age structure of plantations was disrupted during the war in Croatia when the most valuable plantations of around 80 year old trees were felled on the occupied territory.

Conclusions: Black walnut became a valuable exotic species in forest management on the sites too dry for the most valuable indigenous species, pedunculate oak, in eastern Croatia.

INTRODUCTION

Black walnut (*Juglans nigra* L.) was introduced in Europe in 1629 (1, 2). It has gradually been acclimatized in many countries: Great Britain, France, Belgium, Germany, Switzerland, Italy, Poland, Czech Republic, Slovakia, Austria, Slovenia, Croatia, Serbia, Hungary, Romania, Moldova, Ukraine and Russia (3, 4, 5, 6, 7). Black walnut was first introduced in Botanical Gardens and parks. In forest management, black walnut was probably first exploited in the 19th century in Rheinland (Germany), where the forest manager Rebmann initiated its introduction into forests. Black walnut in Germany was first planted along the River Rhine, near the town of Bensheim in Hessenland and the town of Bellheim in Rheinland-Pfalz. In France, it was planted in the

vicinity of the River Rhein, near the town of Strasbourg. In Slovakia, black walnut plantations were planted in the warmer parts of southern and western Slovakia, mostly in lowlands and in the vicinity of the Váh, Hron and Nitra rivers. In the Czech Republic, black walnut is cultivated only in Southern Moravia where it has been present for more than 200 years. Today, the total area of black walnut in the Czech Republic amounts to 526 ha of reduced area (7). Black walnut plantations were also established in the regions of the River Don and River Desna in the Ukraine (4, 8). In Romania, black walnut covers an area of over 2100 ha today (5).

The first written records on black walnut introduction in Croatia are found in Ettinger (9, 10). It was introduced in the Botanical Gardens of Franjo Josip I Royal University of Zagreb and in the Maksimir Park in Zagreb. In forest management in Croatia, the first plantations of black walnut were established around 1890 in the eastern region in Baranja and in the Vukovar estate in the vicinity of the River Danube (3).

North American broadleaved trees, introduced around 1890, have held a specific position in the management of Croatian lowland forests for over 100 years. However, there have been no studies relating to some of these introduced species (11). Within the framework of systematic research on lowland forest ecosystems, financed by the Ministry of Science and Technology of the Republic of Croatia, a study was conducted on the most wide-spread North American broadleaved trees, i.e. North American ash species and black walnut. The North American ash species, introduced in Croatia was mentioned in a paper by Kremer and Čavlović (12). The aim of this study was to determine the significance and role of black walnut in the management of lowland forests in Croatia. Several primary objectives were defined: to determine the distribution and representation of black walnut in lowland forests; to study the success and growth characteristics of species; and to assess the current role of introduced species in relation to the previous period in which these species were introduced. Preliminary research results of the distribution and representation of black walnut in Croatian lowland forests, dendrological studies, and an assessment of their significance in the management of lowland forests are included in this article.

Study Site

The study area encompasses three main river basins in the north continental region of Croatia (Figure 1). The studied sites (subcompartments in 38 management units under management of 9 administrative units) are located at an altitude from 82 m in Osijek to 270 m in Sisak. According to Kremer and Čavlović (12), the climate of the investigated area is moderately warm, rainy without a dry period and with precipitation uniformly distributed throughout the year. The annual precipitation amounts to 704–900 mm, and in the vegetation period 379–489 mm. The eastern region is somewhat drier than the western region, although it does not have more significant effects on forest vegetation. In hydrographic

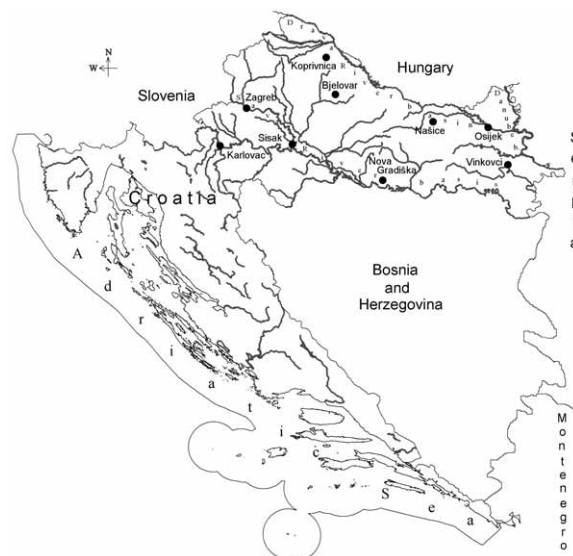


Figure 1. The map of Croatia with the main river basins and the names of headquarters of administrative units managing black walnut plantation.

terms, across the entire investigated area, there are many rivers, brooks and canals that have a very good effect on vegetation. Annual relative air humidity ranges between 74 and 92%. The mean temperature of the warmest month (July) usually does not exceed 22.2 °C, while the mean temperature of the coldest month (Jan.) does not drop below –0.4 °C.

The geological substrate consists of gravel, sand, clay and loam deposited in the Pannonian Sea in the Tertiary and river detritus in the Quaternary. Below these layers, there is sandstone, marl, and limestone. Alluvial and swampy gleyic (eugleyic) soils developed in the valleys of the large rivers (Sava, Drava, Danube) on those substrates. In the eastern region of Croatia, in the vicinity of the River Danube, there are several marly flat areas, formed by wind bringing large quantities of fine-grain dust of marl or loess during the diluvium. On some localities the depth of this substrate is nearly 30 m. Deep, rich, fertile, well-drained, moist soils developed on this substrate. The largest and best black walnut plantations in Croatia can be found on these soils.

MATERIALS AND METHODS

The research was performed in two phases. First, information was compiled from the management plans of all the management units covering lowland forests in the north continental region of Croatia. According to the management plans, subcompartments containing black walnut represented as pure stands (with at least 90% of standing volume of black walnut), partial stands or individual trees were determined. Data on age and area of plantations, standing volume of black walnut, and total standing volume of the subcompartment were entered in the database for each subcompartment. Gauss-Krüger coordinates were used for mapping the distribution of

black walnut for the center of each subcompartment that showed the presence of this species. The coordinates were read off the topographic maps. The Gauss-Krüger coordinates were then raised as data points in the Arc-View 3.3 software and overlaid with the Universal Transverse Mercator (UTM) 100 × 100-km grid.

In the second phase, 50 subcompartments were randomly selected for ground surveying. Within all 50 selected subcompartments, fertile twigs with leaves and fruit were collected to identify any hybridization between Persian walnut (*J. regia* L.) and black walnut. Hybrids between those species are known as *J. × intermedia* Carr. The condition and structure of plantations were visually assessed for comparison with the data compiled from the forest management plans, and data was collected through verbal communication with field forest officers on the role and significance of black walnut in the past and present forest management.

RESULTS AND DISCUSSION

Apart from the studies of Sevnik (3, 13) and Krajina (14), to date there are no studies in the literature on the role and significance of black walnut in forest management in Croatia. As, already mentioned the planting of black walnut began around 1890 in the eastern region of Croatia. Established black walnut plantations occur at all localities in that region, where the habitat conditions are too dry for the most valuable indigenous species, pedunculate oak (*Q. robur* L.). In the estate at Vukovar until 1926 there were only around 880 ha of black walnut plantations (3). At that time the average price of black walnut wood was more than pedunculate oak. This fact also had an influence on the selection of species for intensive forest management. Until 1925 the agro forestry method of management of black walnut plantations was common. When the forests consisting of indigenous species were cut down the soil was used for agriculture: watermelons were grown in the first year, wheat in the second year and corn in another three years. Wheat was also sown in the autumn of the fifth year, and immediately afterwards nut of black walnut and acorn of pedunculate oak. The distance between rows of black walnut was 6–9 m, and between two rows of black walnut were two rows of pedunculate oak. Within rows, the distances among the black walnut plants were 0.4–1 m. For further three years corn, and sugar-beet, potato and other vegetables were planted between rows. The first thinning was done at the age of ten to fifteen years. High quality and valuable volume increment are expected in 60 to 80-year rotations. Losche (15) also mentioned the possibility that a merchantable 16-inch log will be reduced from 100 years to about 60 years on deep soils.

Pedunculate oak was not growing well in mixed cultures with black walnut on dryer sites without periodical flooding. Consequently, black walnut has recently been planted in pure or mixed plantations with Turkey oak (*Quercus cerris* L.), common ash (*F. excelsior* L.), narrow-leaved ash (*F. angustifolia* Vahl), sweet cherry (*Pru-*

nus avium (L.) L.), common elm (*Ulmus minor* Mill. emend Richens), common linden (*Tilia cordata* Mill.). Later some other species (butternut – *Juglans cinerea* L., common walnut – *J. regia* L., manna ash – *Fraxinus ornus* L., black locust – *Robinia pseudoacacia* L., common beech – *Fagus sylvatica* L., glossy buckthorn – *Rhamnus frangula* L., maples – *Acer* L. spp.) were also planted in mixed black walnut plantations. Similar experiments with mixed plantations of black walnut were conducted in Europe, and in the USA where the black walnut is an indigenous species. In black walnut plantations, Burke and Williams (16) investigated interplantation with white ash, white pine, autumn olive, black locust and European alder. They found that European alder (*Alnus glutinosa* (L.) Gaertn.) appeared to be the best interplanting species. In addition to wind protection, pruning and accelerating height growth, European alder, in association with root nodules, attaches nitrogen in the soil which can be utilized by the walnut (17, 16). Geyer and Rink (18) found that interplanting with autumn-olive (*Elaeagnus umbellata* Thunb.) with corrective pruning statistically significantly increased the height and diameter of black walnut.

Presently, the eastern region of Croatia is still predominantly inhabited by black walnut. Probable reason for this lies in the fact that deep, rich soil is a perfect place for growing black walnut. On the other hand, such localities are too dry for the highest quality indigenous species, pedunculate oak. Today, black walnut plantations are established as pure stands. Nuts are collected in indigenous plantations and planted in rows at a distance of 2–4 m between rows and 0.2–0.4 m within the row. Rotation period is 80 years.

Figure 2 shows the distribution of black walnut in Croatia. In the investigated area, black walnut was found

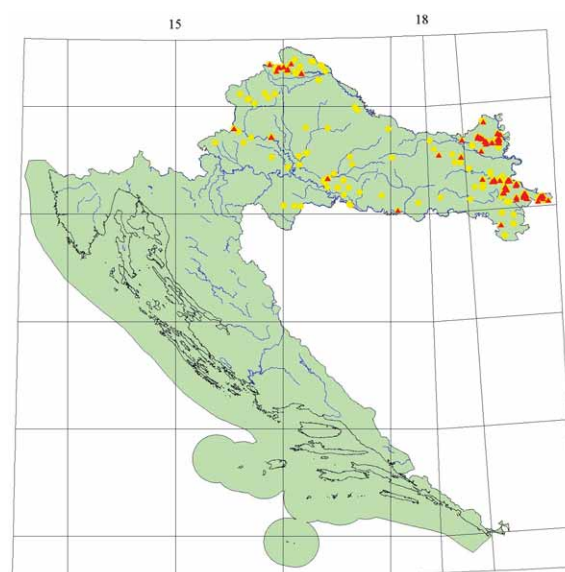


Figure 2. Distribution of black walnut in Croatia with the UTM 100×100-km grid. Yellow blotches mark 416 subcompartments that contain black walnut. Red triangles mark the 143 subcompartments with pure black walnut plantations.

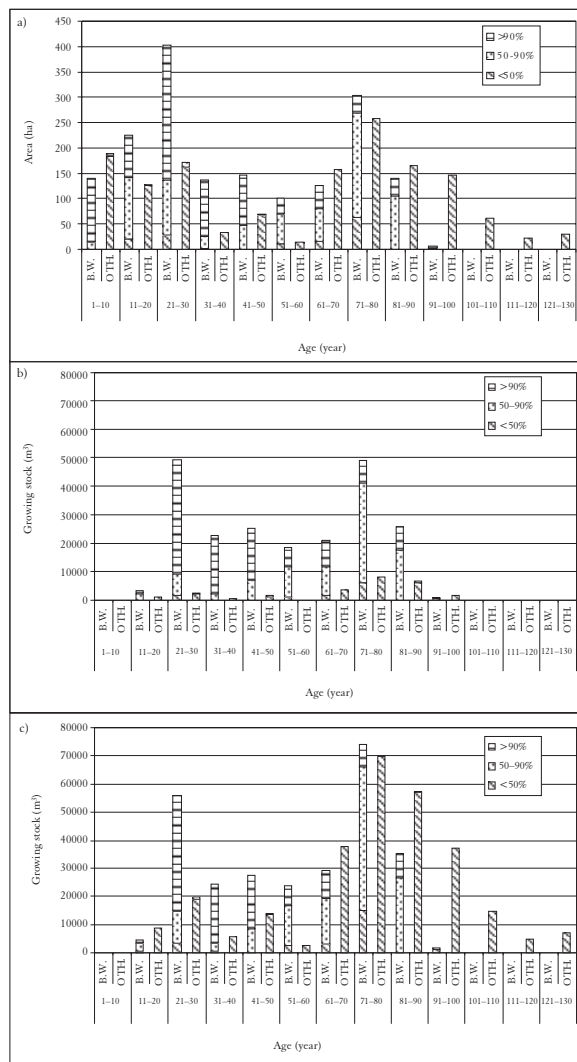


Figure 3a-c. Age class distribution of the black walnut plantations (B.W.) and other stands with black walnut presence (OTH.), according to: a) area, b) the growing stock of the black walnut, c) the total growing stock. Hatches designate the area, standing volume of black walnut and total standing volume of stands under three different black walnut standing volume ratios.

in mixed or pure stands, less frequently as groups of trees or individual trees. Table 1 shows the detailed distribution and representation structure of black walnut introduced in the lowland forest regions of Croatia. The total number of subcompartments where the black walnut is present today is 416. These subcompartments encompass an area of 3,162 ha with 239,678 m³ of standing volume of black walnut. In this way the area of black walnut plantations in Croatia surpasses the area of black walnut plantations in Romania. Actually, according to Nicolescu (5) black walnut plantations in the north-western area of Romania covers over 2100 ha and is probably the largest plantation of the species in Europe. The area of pure black walnut plantations is 826.8 ha with 112,336 m³ of standing volume of black walnut. The presence of black walnut as a partial stand or individual trees is also usually noted in the stand description, even in cases of individual trees that were not included in measurement samples during the preparation of management plans. The reason for this is usually the excellent appearance and quality of black walnut trees. This fact was confirmed by a comparison of the visual assessment of the studied plantations and data from forest management plans.

The age class distribution of black walnut plantations according to area is shown in Figure 3a. It is evident that the black walnut proportion is below 50% in the majority of old black walnut plantations. The reason for this is the interplanting of black walnut with other species (particularly with pedunculate oak) at the beginning of its introduction in Croatia. Because of its shorter rotation, black walnut was cut earlier than pedunculate oak. Also, larger areas of black walnut plantations have been established during the last thirty years. The age class distribution of black walnut plantations according to black walnut standing volume and total standing volume in plantations is also shown in Figure 3b-c. Standing volume presented in the plantations up until the age of 20 years registers only the volume of trees which reached 10 cm in diameter (primarily poplar and black locust). The age structure of plantations was disrupted during the war in Croatia when the most valuable plantations of around 80 years

TABLE 1.

Overview of the representation of black walnut within the main river basin in Croatian lowland region.

	N _{MU}	N _{SBWP}	N _{SBWt}	A _{SBWP}	A _{SBWt}	SV _{SBWP}	SV _{It}	SV _{SBWt}	SV _{2t}
	m ³								
Danube River basin	6	99	267	598.9	2,191.7	97,091	100,869	200,861	387,489
Drava River basin	17	37	113	198.7	782.0	13,659	13,962	31,635	105,199
Sava River basin	15	7	36	29.2	188.6	1,586	1,707	7,182	20,786
Total	38	143	416	826.8	3,162.3	112,336	116,538	239,678	513,474

N_{MU} = number of management unit with presence of black walnut; N_{SBWP} = number of subcompartment with pure black walnut stands; N_{SBWt} = total number of subcompartment with black walnut; A_{SBWP} = area of subcompartment with pure black walnut stands; A_{SBWt} = area of all black walnut plantation; SV_{SBWP} = standing volume of black walnut in subcompartment with pure black walnut stands; SV_{It} = standing volume of all species in subcompartment with pure black walnut stands; SV_{SBWt} = standing volume of black walnut in total number of subcompartment; SV_{2t} = standing volume of all species in total number of subcompartment with black walnut.

old were felled on occupied territory. They were old plantations which have been established at the beginning of forest management with black walnut in the estate at Vukovar. Consequently no information is available on the timber structure of the felled plantations which had reached economic maturity.

During ground examination, plants with intermediate features between the black walnut and Persian walnut were not found. It is very probable that somewhere in the field such spontaneous hybrids exist because the Persian walnut was represented as an individual tree or group of trees in the entire area of distribution of black walnut in Croatia. The first reference to the hybrid *J. × intermedia* in Europe was found in a monograph by Dippel (19), who referred to data published in a horticultural journal (*Revue horticole*) in 1863. One of the last references to such hybrids was by Hrib et al. (20), who found one spontaneous, approximately 100 year old, hybrid of *J. × intermedia* in the area of the Židlochovice Forest Enterprise in the Czech Republic.

CONCLUSION

Black walnut was introduced in forest management around 1890 in the lowland forest regions of eastern Croatia with the objective of establishing high quality plantations on sites too dry for the most valuable indigenous species, pedunculate oak. Today, black walnut is the most valuable species on those localities. Unfortunately, there are almost no plantations of black walnut which reached economic maturity because they were felled without control during the war in Croatia. However, it can be concluded that the evidence indicates that the future management of black walnut should be supported and growth characteristics of this valuable exotic species in the eastern region of Croatia should be researched.

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