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ELEMENTS OF RECONSTRUCTION PLAN OF PURE HORNBEAM STANDS ON THE SITE OF PEDUNCULATE OAK, HORNBEAM AND ASH FOREST

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This paper deals with the elements which affect in the first place the process of reconstruction planning of the stands dominated by hornbeam on the site of pedunculate oak, hornbeam and ash forests. Of altogether 865 ha of pure hornbeam stands in the study area, 80 % of the area is dominated by the stands aged more than 20 years, so the years of abundant seed crop are primary for the process of planning their reconstruction. During the period 1989-2003 hornbeam had an abundant seed crop every second year. With the potential of abundant regeneration and intensive seedling development, hornbeam in the study site conditions represents a significant limiting factor for the maintenance of pedunculate oak. During the process of stand reconstruction, the preparation measures should be synchronised with the estimated dynamics of regeneration after an abundant seed crop.

Key words: *Carpinus betulus* L., stand reconstruction, elements of planning, preparation measures, seed crop, seedling development

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INTRODUCTION

In the process of regeneration of pedunculate oak forests and their degraded forms, seed crops of individual species represent the primary elements (BOBINAC, 1999, 2002, 2003). Hornbeam is a very expansive species and it invades the pedunculate oak sites rather fast. In the phase of stand regeneration on regeneration areas, it is defined as weed species from the silvicultural standpoint. If a sufficient quantity of acorn is provided, the process of stand reconstruction dominated by hornbeam should be primarily based on the knowledge of hornbeam bioecology.

The aim of this study is to point out the biological-ecological elements which primarily determine the process of stand reconstruction planning on the sites where hornbeam is naturally one of the edificators, but a secondary species from the management aspect. The above issue is very significant for forest economy, because in the region of Srem, predominantly on the site of pedunculate oak, hornbeam and ash forest, due to incorrect stand regeneration, the area of pure hornbeam stands already amounts to 865 *ha*.

MATERIAL AND METHODS

The main elements which determine the process of stand reconstruction planning dominated by hornbeam were analysed in south-east Srem on two regeneration areas. The site is a pedunculate oak, hornbeam and ash forest (*Carpino-Fraxino-Quercetum roboris* Jov. et Tom. 1979, *subass. caricetosum remotae* Jov. et Tom. 1978) on meadow to leached meadow black soils in the non-flooded area, JOVIĆ *et al.*, 1989-1990). Various technological solutions of preparatory measures were applied (BOBINAC, 1999) during the process of stand reconstruction on regeneration areas.

Regeneration area 1 was formed in a pure hornbeam stand, aged 27 years (GJ Vinična-Žeravinac-Puk, Compartment 22 c). Throughout the area of 1 ha, all hornbeam trees were felled outside the vegetation growth period, in 1999 - the year of abundant hornbeam seed crop. To prevent the coppicing ability of the felled trees, the stumps were coated with translocation herbicide (Roundap). Acorn was seeded at the beginning of 2000 on the regeneration area. During the following period, release treatments - liberation cuts were carried out each year.

Regeneration area 2 was formed in the pedunculate oak, hornbeam and narrow-leaved ash stand, aged 145 years dominated by hornbeam in underwood and dominant layers (GJ Vinična-Žeravinac-Puk, Compartment 14 b). Stand preparation for regeneration included the complete removal of the underwood layer of shrubs and partial removal of dominant hornbeam trees at the beginning of 1999. In the aim of preventing the coppicing, total foliar treatment was applied during the summer 1999. Acorn was seeded at the beginning of 2000, and final felling was performed at the beginning of 2002. Hornbeam trees had abundant seed crops on the regeneration area in 1999 and 2001.

The data on hornbeam seed crop years during the period 1989 - 2003 are presented based on the available file data. In late 2003, within each regeneration area hornbeam seedling numbers were determined on 20 elementary areas sized 1 m^2. 15 dominant seedlings were analysed morphometrically. The following ocularly visible biological entities were measured on each seedling:
- one-year old seedling height, i.e. hypocotyl length - from the base of cotyledon leaf to the widest part of root collar zone, i.e. the first lateral root (H_y) and the length of the "above-cotyledon-axis"-from the base of cotyledon to the base of scars of sterile scales of terminal bud ("Ep"),-height increment in the following years (ih) and total seedling height in the current year (Ht).

The following basic statistical parameters were calculated for the measured characters: arithmetic mean (ξ), limits (min-max), standard deviation (S_D) and variation coefficient (Cv%).

RESULTS AND DISCUSSION

Hornbeam flowers parallel with leafing, in late April and early May and female flowers appear from mixed buds terminally on current-year twigs in a drooping, up to 15 cm long spike. The fruit has one nutlet, its pericarp is more or less hardened, it matures in October and its position is in the axil of the three-lobed wing (JOVANOVIĆ, 2000). The first assessment of seed crop is based on the phenological phase of leafing, when elongated flower-fruit twigs appear on the top of current-year twigs. Seed cropping starts at the age of about 20 years, and abundant seed crops occur every year or every second year (ЧЕРНЯВСКИ *et al.*, 1959, JOVANOVIĆ, 2000), and after SUSKA, (1993) every 2-3 years. According to the available files, hornbeam has abundant seed yield in southeast Srem every second year (Table 1).

Table 1. Years with abundant seed crop, 1989-2003

Years														
1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
+	-	+	-	+	-	+	-	+	-	+	-	+	-	+

(+) years with abundant seed crop of the greater number of trees

Hornbeam seed germinates with difficulty, because it has a dormant embryo and hard membrane, so a part of seeds is left to lie till the following spring when it is seeded immediately after collecting. Seed keeps its germinability for 2-3 years. The seedlings and juvenile plantlets are susceptible to frost, drought and sun-heat (STILINOVIĆ, 1985, 1987). After DINIĆ (1997), considerable amount of moisture in the soil, especially in spring months, enables hornbeam, in the absence of major competition by other tree species, to reach considerable height and thickness and to dominate in the stand. Hornbeam seed dormancy and germination, after the year of abundant seed crop in 1999 developed in contrasting weather conditions. The extremely dry period in the spring 2000 conditioned the absence of hornbeam seed

germination. The seedlings were formed abundantly during 2001. Diagram 1 presents the number of hornbeam seedlings on regeneration areas.

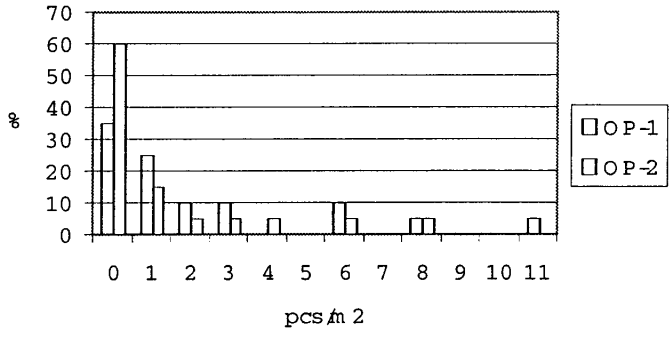

Diagram 1. - The number of hornbeam seedlings on regeneration areas in late 2003

On the regeneration area 1, in late 2003, the average number of hornbeam seedlings was 4.25 pcs/m², and the maximal number was 11 pcs/m². The dominant seedlings are three years old and originate from the seed crop 1999. On the regeneration area 2, the average number of hornbeam seedlings was 2.30 pcs/m², and the maximal number was 8 pcs/m². The dominant seedlings are 2 and 3 years old (seed crops 1999 and 2001).

Table 2 presents growth and development characteristics of the dominant hornbeam seedlings. Compared with the development characteristics of hornbeam seedlings during the same time period on Fruška Gora (BOBINAC, 2004), regeneration areas 1 and 2 can be characterised as <open sites>. Based on the hypocotyl length (Hy), and length of the above-cotyledon-axis (Ep), i.e. total seedling height in the first year, the conditions on regeneration area 2 can be characterised as less favourable for hornbeam development than the conditions on the regeneration area 1.

Based on the percentage of age classes of pure hornbeam stands in the study area (Table 3) the planning of their reconstruction on 80 % of the area should primarily be based on the elements of hornbeam seed crop.

Frequent and abundant hornbeam seed crops, seeds germination percentage 50-100 % (ЧЕРНЯВСКИ *et al.*, 1959, STILINOVIĆ, 1985) and the possibility of preserving the germinability in the stands and on felled units for 3-4 years (НАКОНЕЧНЫЙ, 1989), enable the subsequent regeneration after preparatory measures and regeneration felling on regeneration areas. Based on the estimated presetvation of germinability on regeneration area 2 in the following period, we can expect the increased number of hornbeams from the seed crop 2001. A relatively low number of hornbeam seedlings on regeneration areas should primarily be related to the elements of seed crop and with the complex factors on the regeneration areas during the period of seed dormancy and germination. The dynamics of hornbeam seeds germination and dormancy on regeneration areas is

decided by weather conditions and by the applied technological solution of preparatory measures in the process of stand regeneration and reconstruction. On regeneration area 2, along with a large number of hornbeam trees with seed crops in 1999 and 2001 (Figure 1), the low number of hornbeam seedlings is primarily related to the elements of seed crop and the conditions in the surface soil layer during the period of seed dormancy and germination.

Table 2. Development and increment of dominant hornbeam seedlings, 2001-2003

Statistical parameter	OP	1st year			2nd year		3rd year	
		Hy	*"Ep"*	*Ht*	*Ih*	*Ht*	*Ih*	*Ht*
					[cm]			
ξ	1	3.1	22.1	25.2	30.9	56.1	26.7	82.7
	2	2.3	20.1	22.4	22.7	45.1	14.6	59.6
Min	1	2.0	13.0	15.5	20.0	44.0	8.0	56.5
	2	2.0	9.0	11.5	12.0	27.0	5.5	37.0
Max	1	4.0	33.0	37.0	50.0	77.0	45.0	117.0
	2	3.0	29.0	31.5	30.0	61.5	28.0	85.0
S_D	1	0.6	6.7	6.9	7.8	10.6	10.8	17.1
	2	0.4	6.3	6.4	7.0	11.6	6.9	16.1
C_V%	1	20.6	30.3	27.5	25.4	18.9	40.4	20.6
	2	15.9	31.7	28.5	30.8	25.8	47.6	27.0

Table 3. Percentage of pure hornbeam stands in Srem

Age (years)											
< 20	%	21-40	%	41-60	%	61-80	%	81-100	%	TOTAL	%
Area (*ha*)											
174.3	20.1	460.5	53.2	52.26	6.0	89.5	10.3	89.1	10.3	865.6	100

Based on the potential abundant regeneration of hornbeam from the seed crop 1999 (BOBINAC, 2004), the intensive development of hornbeam seedlings in the study site conditions would be a significant limiting factor for the maintenance of pedunculate oak on regeneration areas. During the process of stand reconstruction planning, the year of abundant hornbeam seed crop is the primary element for the projection of the preparatory measures and regeneration felling, which should be synchronised with the estimated dynamics of seedling establishment within the applied technological solutions on regeneration areas.

Fig. 1. - Percentage of hornbeam trees on regeneration area 2 (Morović, GJ Vinična-Žeravinac-Puk, Compartment 14 b, April 2001, photo M. Bobinac)

CONCLUSIONS

During the period 1989-2003 in the region of southeast Srem hornbeam seed crops were abundant every second year.

With the potential abundant regeneration, the intensive development of hornbeam seedlings in the study site conditions would be a significant limiting factor for the maintenance of pedunculate oak on regeneration areas.

During the process of stand reconstruction with dominating hornbeam, if a sufficient amount of acorn is available, the decisive elements are the abundant hornbeam seed crops and the dynamics of seed germination in different environmental conditions.

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ELEMENTI PLANIRANJA REKONSTRUKCIJE ČISTIH GRABOVIH SASTOJINA NA STANIŠTU ŠUME LUŽNJAKA, GRABA I JASENA

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Izvod

U procesu planiranja prirodnog podmlađivanja lužnjakovo-grabovih sasastojina i pri rekonstrukciji njihovih degradiranih oblika, urod semena pojedinih vrsta predstavlja primarni elemenat. U sastojinama nepovoljne cenološke izgrađenosti suzbijanje graba predstavlja nužnost, jer grab usled veće brojnosti na podmladnim površinama predstavlja ograničavajući faktor za formiranje optimalne izgrađenosti sastojina. Za projekciju osnovnog modela rekonstrukcije sastojina analizirani su elementi uroda, karakteristike podmlađivanja i razvoja ponika i podmlatka graba na podmladnim površinama.

U periodu 1989-2003. godine na staništu šume lužnjaka, graba i jasena, grab je obilnije urodio svake druge godine. Relativno mala brojnost podmlatka graba na podmladnoj površini 1, na kojoj je izvršena rekonstrukcija mlade grabove sastojine, starosti 27 godina, može se dovoditi u vezu sa početkom plodonošenja pri kome se produkuje mala količina semena. Relativno malu brojnost podmlatka graba na podmladnoj površini 2 na kojoj je izvršena rekonstrukcija stare sastojine u kojoj je dominirao grab, pored dva obilnija uroda, primarno treba dovoditi u vezu sa elementima uroda i kompleksom faktora na podmladnim površinama u periodu mirovanja i klijanja semena.

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