EFFECTS OF THE CANOPY ENVIRONMENT AND OF THE NUTRITION IMPROVEMENT ON THE BEECH PLANTATION PROSPERITY

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European beech represents a forest tree species with the highest support at this moment. It is aimed at high increase in the species composition of the Czech as well as Central European forests, from the natural dominance of 38%, through actual one of 6.2% to the forestry management target of some 18.0% of the forested area in the Czech Republic. The average annual increase in the last years is 0.1% of the total forest lands. The problem is the regeneration and re-introduction of beech in large areas, due to its ecological needs and susceptibility. The presented article documents the different prosperity potential of beech plantation in particular environments – on the clear-cut and under canopy (50% light intensity, compared to open space). Plantations were established in the spring 1994, healthy status and height increment is determined annually. Two variants of the soil amelioration were additionally tested – 1 kg of limestone or 2 kg of amphibolite, mixed with the soil in the planting pit at the plantation. Soil amelioration played more important role on the clear-cut, decreasing mortality by 8 to 13%, decreasing the frost damage and increasing height growth. More important was the shelter effect – mortality and damage to the plantations were not observed under stand canopy, height growth was much more intense here. Height reached the values ca 360–400 cm comparing to 130–230 cm on the clear-cut.

beech plantation; canopy; clear-cut; amelioration; plantation growth; nutrition

INTRODUCTION

The re-introduction of European beech (*Fagus silvatica* /L./) on its former sites represents one of key tasks of European as well as Czech forestry at present. Beech represents one of basic climax tree species in the Central Europe, including the Czech Republic. Its original, natural dominance through all vegetation altitudinal zones is estimated to 38% of the total forest area. This percentage was lowered by the forest management to 6.2% in the Czech Republic during the last centuries, and a similar trend is documented in the whole mid-European region. The forest management evidence documents an annual increase of the beech portion of 0.1% of the total Czech forest area (Report, 2004) in the last years. This correction of the species composition of mid-European forests is necessary because of their lowered biodiversity, stability and also productivity in some cases (Korpel, 1991). The increase of the potential of ecological and environmental functions of forests is assumed after enhancing the tendency to close-to-nature forests. Considerable problem is represented by the biological as well as ecological characteristics of this tree species, manifesting themselves especially in the European beech regeneration (Otto, 1994). Being present in the maternal tree stand on convenient sites, beech is regenerated naturally with minor problems. But, this situation is very rare at present tree species composition of forest stands in the Europe with prevailing coniferous mono-cultures. Artificial regeneration using planting and sowing is necessary on majority of sites. Under-plantings are assumed as a favorable management tool (Vacek et al., 1995). Many sites were degraded by the long-lasting mono-specific stands cultivations and the new plantations can suffer by dis-balanced and poor nutrition. The cultivation of spruce instead of the beech or mixed stands can cause relatively rapid soil degradation and acidification (Podrázský et al., 2004). The presented paper documents the mutual effects of shelter position and soil nutrition amelioration on the beech plantations prosperity in the typical Mid-European conditions for beech re-introduction

MATERIAL AND METHODS

The plantations are located on the typical original beech sites in the Czech-Moravian Highland, close to Žďár nad Sázavou town. The altitude of the research locality is 580 m a.s.l., the forest type is determined as 5K8, *i.e.* acid fir-beech forest, soil type is Cambisol. The research plots were established in the spring 1994 in the stand 324G, on clear-cut and in the shelter position in the vicinity (50% of light intensity of the open space, minor fir and larch trees remaining in the upper canopy). The spacing was 1 x 1 m, each variant grouped 2 replications of 50 individuals. Particular variants were: (1 – K) control one, without any ameliorative treatment, (2 – V) application of 1 kg of limestone per planting pit, mixed with the soil material immediately before planting, (3 – A) application of 2 kg of amphibolite – basic silicate rock. Both rocks were finely ground.

In the next years, it was measured and registered: mortality, damage by abiotic factors (plots are fenced to prevent roe-deer browsing), height increments, nutrition status in August 2003 (bulk sample of 30 dominant individuals through particular variants, sampling late August 2003). The results were processed by the one-way analysis of variance at 95% significance. Statistical software S-PLUS, version 6.1 was used for data processing.

RESULTS AND DISCUSSION

Results documented totally different development of beech plantations in both cases. On the clear-cut, the high damage rate was observable since the first year (Table 1). The mortality was 39% in 1994 (control – variant K), respectively 31% (limestone application – variant V) and only 26% (amphibolite application – variant A). Higher losses were registered also the next year, the re-plantation was necessary to keep the vital plantation. The use of basic-rocks flours so lowered considerably the plantation mortality. Also the late-frost as well as dryness damage were lower on fertilized variants in all years, when they have occurred. On the other hand, they were practically not observed in the shelter position.

Table 2 documents the height growth of the plantations in the period 1994–2003, i.e. during 10 vegetation seasons following the stand establishing. Besides the favorable effect of the ecological shelter on the plantation vitality, there is visible the crucial influence on the height growth (Figs. 1–3). The limited light input was documented as a stimulating factor also in some other cases for the beech species. E.g. Larcher (1988) described the maximum shoot growth and biomass production at the light intensity of 45–50%, too.

The amelioration did show also considerable favor for the plantation growth. On the clear-cut, the average height was determined as 129 cm on the liming variant, 161 cm for the control and 228 cm, i.e. 56% higher to the limed one, on the amphibolite variant. The liming lowered the damage intensity of the plantations, but slowed down also their growth. The height growth was accelerated on both fertilized variants in the shelter position. The differences were statistically significant to the control variant; on the contrary, there were not differences among them.

The height increment was higher on the amphibolite plot since the experiment establishing comparing to the control, liming caused the increment of height growth in the initial stage, this being changed into significant growth depression later (Table 3). As a possible explanation, the nitrogen deficit may play a role after nitrogen extensive mineralization as a liming consequence. All variants show deficient N-nutrition (Table 4, limits after Šach et al., 1995), the liming can result in the more profound nitrogen deficiency increase because of extensive mineralization (Popovic, 1984). These liming effects were confirmed also in other site conditions, e.g. on immission clear-cuts in the Jizerské Hory Mts. (Kuneš et al., 2003).

Table 1: Damage to plantations at the Babín locality on the clear-cut

Variant	Frost 94	Frost 97	Frost 98	Mortality 94		Mortality 94 + 95		Dry terminal 94	
	%	%	%	pcs	%	pcs	%	pcs	%
Control	41	28	33	49	39	61	45	34	39
Limestone	40	27	34	36	31	53	55	20	31
Amphibolite	30	25	28	26	26	42	38	22	26

Table 2: Height of plantations on the Babín locality on the clear-cut and in the shelter position

Year Variant	H 1993 cm	H 1994 cm	H 1995 cm	H 1996 cm	H 1997 cm	H 1998 cm	H 1999 cm	H 2000 cm	H 2001 cm	H 2002 cm	H 2003 cm
Clear-cut											
Control	20	22	29	34	37.8 a	53.6	75.4 ab	106.6 ab	129.8 a	135.0 a	161.0 a
Limestone	18	21	29	32	38.8 ab	53.2	65.5 a	101.1 a	120.8 a	109.0 a	129.0 a
Amphibolite	18	21	28	35	44.5 b	62.7	89.1 b	133.6 c	173.8 b	194.0 b	228.0 b
Under-planting											
Control	24.4	27.2	36.4	54.6	72.8 a	121.5 a	169.1 a	207.6 a	260.8 a		362.0 a
Limestone	24.3	28.0	39.7	64.5	89.4 b	138.0 b	190.0 b	226.4 a	288.1 b		401.0 b
Amphibolite	24.9	28.7	43.5	70.6	98.3 b	147.8 b	204.1 b	252.4 b	302.4 b		408.0 b

Different indexes indicate statistically significant differences at 95% significance level. Data from particular years (1997–2003) and two types of light regime (clear-cut and under-planting) were evaluated separately. It means: mutual comparison was done for amelioration variants twice in particular years.

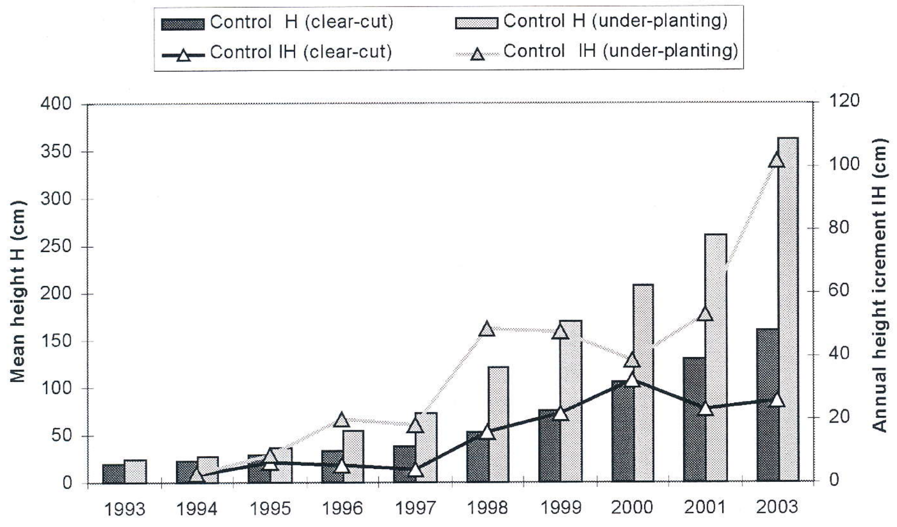

Fig. 1. Height growth dynamic of beech plantations influenced only by light regime (control plot without nutrition improvement)

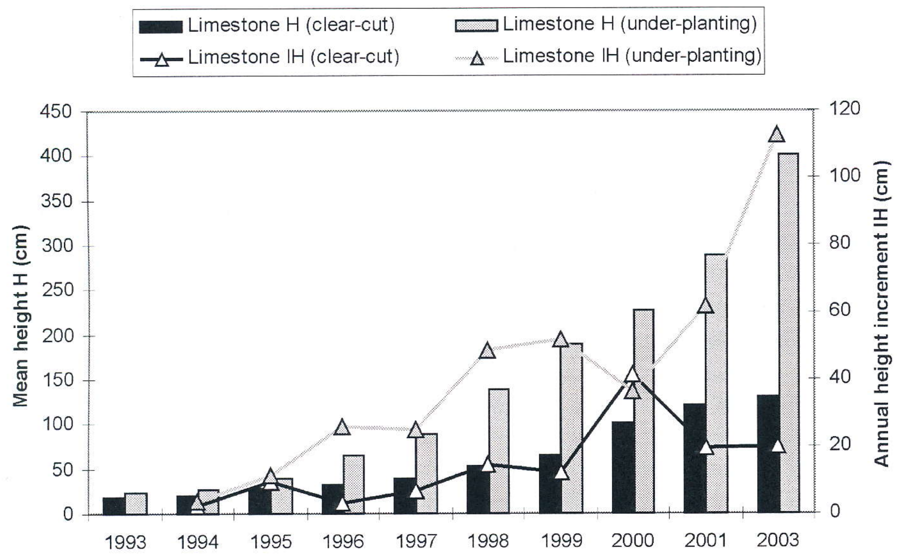

Fig. 2. Height growth dynamic of beech plantations influenced by different light regime and limestone fertilization

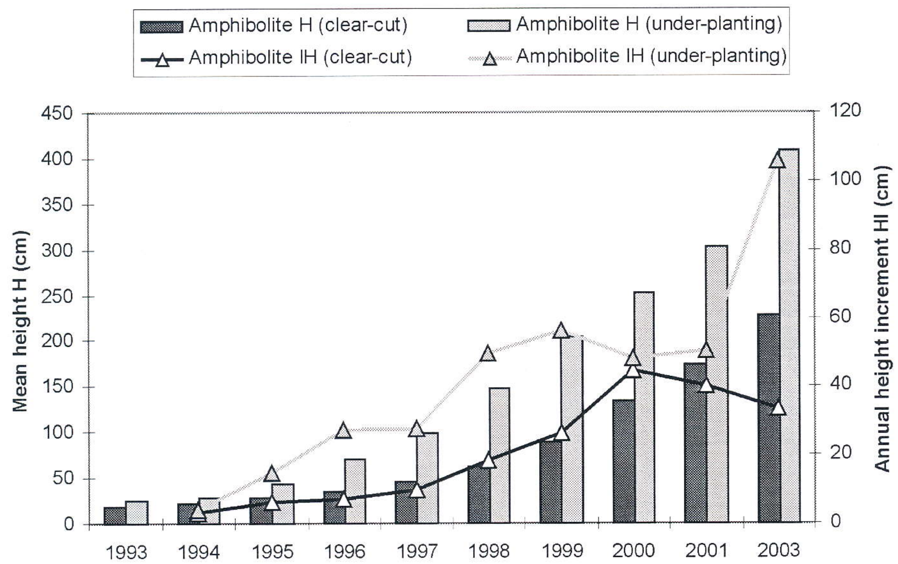

Fig. 3. Height growth dynamic of beech plantations influenced by different light regime and amphibolite application

Table 3: Height increment of plantations on the Babín locality on the clear-cut and in the under-planting

Variant	IM 1994 cm	IC 1994 cm	IC 1995 cm	IC 1996 cm	IC 1997 cm	IC 1998 cm	IC 1999 cm	IC 2000 cm	IC 2001 cm	IC 2003 cm
Clear-cut										
Control	4.4	2.2	6.2	5.3	4.1	15.8	21.8	32.2	23.2	26.0 a
Liming	5.0	2.4	9.4	3.2	6.8	14.4	12.3	41.5	19.7	20.0 a
Amphibolite	5.0	3.2	6.1	7.0	10.0	18.2	26.4	44.5	40.2	33.5 b
Under-planting										IC 02+03
Control	4.0	2.8	8.5	20.2	18.2	48.7	47.6	38.50	53.2	102.0
Liming	5.1	3.7	11.5	25.8	24.9	48.6	52.0	36.40	61.7	112.9
Amphibolite	5.3	3.8	14.8	27.2	27.7	49.5	56.3	48.10	50.2	105.6

Different indexes indicate statistically significant differences at 95% significance level
IM – increment measured as terminal shoot length, IC – increment calculated as terminal height difference in consequent years

Table 4: Nutrition status analysis results on the Babín locality - clear-cut

Variant	N %	P %	K %	Ca %	Mg %
Control	1.308	0.102	0.636	0.310	0.051
Limestone	1.272	0.095	0.566	0.590	0.057
Amphibolite	1.444	0.079	0.652	0.380	0.074
Deficient nutrition limit	1.900	0.150	0.900	0.300	0.120

Table 4 documents the state of nutrition of plantations on the clear-cut. With the exception of calcium, the deficient nutrition was documented for all macro-nutrients. The amfibolite application increased the foliar content of all nutrients (excluding phosphorus), the liming lowered the foliar contents of nitrogen and also potassium, probably due to cation antagonism. As mentioned yet, the liming and even more the amphibolite application lowered the contents of phosphorus. This macro-element is probably the limiting one on the locality studied. The variant increasing the growth so enhanced its deficiency.

The shelter position of the beech conditioned the rapid increase of the growth intensity in the first 10 years since the plantation. The result of this trend is the almost double height of the beech thicket comparing to the clear-cut plantation. European beech shows more intense growth in the partial canopy in the young stage, which corresponds to Larcher (1988). Concrete results utilizable by the forestry practice were missing up to now in the Czech literature. In conditions, where the other production factors are not limited by the canopy, the under-plantings can be recommended.

The further favorable production effect, in this case the qualitative one, is the gain of considerably higher stem quality for under-planted beech – fine, regular branching, dominant terminal, reduced/eliminated forking *etc*. In the shelter position, the effect of both amelioration variants is comparable, the height difference to the control variant is some 40 cm only, it is absolutely both relatively much lower comparing to the clear-cut. Fertilisation so shows lower effects comparing to open area, where it eliminates unfavorable site conditions for the beech plantations.

CONCLUSIONS

The results of the experiment documented relatively favorable effects of the ameliorative treatments, the negative impacts of the liming sole on the clear-cut and the protective and environment improving role of the shelter for the young beech plantations:

- the fertilization by the basic rock powders lowers the damages on beech plantations by unfavorable abiotic factors of the clear-cut, as well as it lowers the plantation mortality,
- the liming effects are temporary only, this treatment has prevailing negative impacts in the longer period, it increased the shortage in nitrogen and potassium in given conditions,
- the silicate rock powder showed more favorable effects,
- the shelter position was decisive for the beech plantation prosperity and quality, also the damages were negligible,
- we can suppose also lower damages by biotic factor in this case (rodents, weeds),
- in the 4th to 6th vegetation altitudinal zones, the under-plantings can be recommended,
- the fertilization plays much lower role in this case, its contribution can increase on more extreme sites.

Next observations of experimental plots on the Babín locality will focus on growth evaluation with distinct respect on qualitative parameters of beech trees after canopy release. The release of beech plantations from shelter of previous forest stand generation is the necessary next silvicultural measures. We are awaiting growth acceleration and consecutive thinning application.

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PODRÁZSKÝ, V. – REMEŠ, J. (Česká zemědělská univerzita, Fakulta lesnická a environmentální, katedra pěstování lesů, Praha, Česká republika):

Vliv clonného postavení a zlepšení výživy na kvalitu výsadeb buku

Scientia Agric. Bohem., *36*, 2005: 108–112.

Podpoře zavádění buku do porostní skladby se v současné době věnuje mimořádná pozornost. Po antropogenně podmíněném poklesu zastoupení z hodnoty 38 % na současných 6,2 % je cílem jeho zvýšení na zhruba 18 % porostní plochy České republiky – podobné trendy lze pozorovat v lesním hospodářství celé střední Evropy. Meziroční nárůst podílu buku tak představuje přibližně 0,1 %. Jistý problém představuje obnova této dřeviny, především pro její vysoké stanovištní nároky a citlivost. Předkládaný příspěvek dokumentuje různý potenciál vitality a prosperity výsadeb buku v různém prostředí – na holině a při světelné intenzitě snížené zápojem na 50 % hodnoty volné plochy. Výsadby byly založeny na jaře 1994, ročně pak byl sledován zdravotní stav a výškový růst. Byly sledovány i dvě varianty přihnojení výsadeb – aplikace 1 kg vápence a 2 kg amfibolitu na sadební jamku při výsadbě. Přihnojení kultur mělo vyšší význam na holině, kde snížilo mortalitu o 8 až 13 %, snížilo poškození mrazem a zvýšilo přírůst. Významnější však byl vliv clonného postavení – poškození mrazem a mortalita zde nebyly pozorovány a přírůst byl pronikavě vyšší. Výška dosáhla po 10 vegetačních sezonách hodnot 360–400 cm oproti 130–230 cm na jednotlivých variantách na holině.

výsadby buku; clona; holina; meliorace; růst výsadeb; výživa

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