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The growth of the beech (*Fagus sylvatica* L.) stand on former agricultural land and its comparison with the naturally regenerated beech stand under comparable conditions

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Abstract: The issue of afforestation of non-forest land (e.g. agricultural land use) is currently a significant trend in land management. Sustainable development and maintenance of its ecological stability are among the reasons. The paper compares the 30-year development of the beech stand originated from artificial regeneration on former agricultural land in the area where the Ipeľ River rises in central Slovakia. Two methods of tending were used on three long-term research plots (LTPs) established at the age of 20 years: negative crown thinning, free crown thinning and the third LTP was left to its spontaneous development. The results confirmed the positive impact of tending on the development of these stands. Compared to naturally regenerated stands under comparable site conditions, their higher quantitative production was found. Regarding the qualitative production expressed by the number of trees of selective quality, the worst results were obtained on the control plot. Based on these results, it is recommended to pay more attention to the planting stock quality used for afforestation.

Keywords: beech; former agricultural land; quantitative production; qualitative production

The issue of agricultural land afforestation has been investigated by research after World War II not only in Slovakia but also in Bohemia (Vacek, Simon et al. 2009; Špulák, Kacálek 2011). In Slovakia, about 100,000 ha of non-forest land (Nožička 1967) were afforested (including reinforcement planting) in 1945–1963.

Several studies dealt with soil properties, or more precisely with humus analysis. Cukor et al. (2017) analysed the surface humus layer in a spruce stand. This layer was compared with the adjacent grassland. Kacálek et al. (2015) analysed the properties of forest litter for seven forest tree species in a 10-year old stand on former agricultural land. Podrázský et al. (2017a) monitored the changes in humus forms of agricultural land after afforestation, in a 10-year old mixed stand of linden, spruce, beech, sycamore maple and oak trees. Obtained results were compared with the neighbouring old beech stand, arable land and permanent grassland. Dynamic changes of soil environment after the afforestation of arable land were monitored by Holubík (2017), or more precisely the influence of alginate on the growth and development of established young plantations on these areas was evaluated by Podrázský et al. (2017b). The development of fine roots of beech plants during three years after planting on agricultural land was monitored by Skrziszowski, Kupka (2008).

Selection of suitable tree species is an important prerequisite for successful growth and development of the first-generation stands. Ecological

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risks resulting from the use of non-native tree species were pointed out by Vítková et al. (2017) or by Košulič (2004, 2005) in case of climax species. Pine (e.g. Kamenský 2008) and Douglas-fir (e.g. Mondek 2017) are considered potentially suitable species for afforestation purposes. However, it is necessary to plant them at sites that are not affected by water-logging and late frosts (Sychra, Mauer 2013). Vacek et al. (2018) monitored the structure, growth dynamics and production of sycamore maple (*Acer pseudoplatanus* L.) stand in relation to the impact of climatic factors. Bachmann (1979) dealt with spruce growth along with grey alder, beech, fir and sycamore maple in a 50-year old stand on the formerly agriculturally used flysch soils in Switzerland.

Several works analysed the growth, wood production and biomass of various tree species (Bartoš, Kacálek 2011; Uri et al. 2007, 2009). Johansson (2014) derived the equations for calculating the stem volume of spruce stands. He carried it out by evaluating 145 spruce stands growing on the original agricultural land.

Fewer works investigated the impact of different methods of tending and managing stands on former agricultural land (Štefančík 2009). The effects of different thinning intensity in a 40-year old spruce stand were observed by Dušek, Slodičák (2009), who confirmed the importance of the thinning from the aspect of increased resistance to snow and wind damage. In terms of forestry, or forest management, these stands require a specific approach in more cases, as the growth and development of forest stands established on former agricultural land can be different in comparison with naturally regenerated forest stands (Novák et al. 2015).

Accordingly, the aim of the contribution was (*i*) to evaluate the development of a 50-year old beech stand established on former agricultural land for a 30-year period of different tending, (*ii*) to compare quantitative and qualitative characteristics with those of naturally regenerated stands under comparable conditions.

MATERIAL AND METHODS

Study area

The research was carried out in a research object (RO) Dobroč Hill, which was established in 1979 and where three long-term research plots (LTPs) were established in a 20-year-old beech stand in 1988. These LTPs were established on former agricultural land with the same site conditions. The differences were only in the methodology and their tending method. Forest stands of the RO Dobroč Hill are located in the western part of the Slovak Ore Mountains, Slovakia.

The RO Dobroč Hill is situated at altitudes of 740 to 917 m a.s.l.: the LTPs of specific interest are at an altitude of 835 m a.s.l. The bedrock is composed of a crystalline complex. The base rock is granodiorite, on which a deep, sandy-loamy unsaturated modal Cambisol was formed, which can be classified as a high-productive forest soil (Löffler 1987). Sandy-loamy Cambisol is a prevailing soil type. The average annual temperature is +6°C (+12°C in the growing season), the average total sum of annual precipitation is 900 mm (300 mm in the growing season). These areas rank among the *Fagetum typicum* (Ft) forest site.

Former agricultural land in the RO Dobroč Hill is well provided with nutrients (Kukla 1996), and the newly established stands show high site index (32). These are mostly the stands with above-average productivity, but they are considerably threatened by abiotic harmful agents (snow, wind), and also by rotting and weeding. Especially spruce and pine stands are considered very vulnerable to damage.

The LTP series consists of three partial plots (PP) with the following thinning programme:

- **Plot 4 (control plot)** – without deliberate intervention;
- **Plot 6** (**negative crown thinning**) – negative intervention in the crown or suppressed level, which removes the trees of worst quality, is of primary importance;
- **Plot 2** (**free crown thinning**) (Štefančík 1984) – developed by Prof. Dr. L. Štefančík at the Forest Research Institute in Zvolen (Slovakia) and which represents an individual tending of the best quality crop trees – the so-called trees of selective quality.

The Lukov LTP series was established in 1961 at the stand age of 45 years. It is located in the Čergov geomorphological unit, at an altitude of 550 m a.s.l. The bedrock is built of flysch sandstone and the soil type is typical unsaturated Cambisol. The average annual temperature is +5.5°C; the average total sum of annual precipitation is 700 mm. Forest sites are the same as for the RO Dobroč Hill. Lukov LTP

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consists of three partial plots, where heavy thinning from below is applied (C degree according to German research institutes of forestry 1902) – not included in this article, free crown thinning (Štefančík 1984) – marked as "H" and one plot is considered as a control plot (without interventions) – marked as 0.

Data collection and analysis

The diameter at breast height of all numbered trees was measured to the nearest 1 mm at two mutually perpendicular directions. Heights of trees to the nearest 0.1 m (Vertex hypsometer) were also measured for all trees of selective quality (promising and target trees). All registered trees in the stand were evaluated according to the standard methodology of thinnings in beech stands (Štefančík 1984, 2015). So far, seven comprehensive measurements have been performed on observed LTPs in 1989, 1995, 1999, 2004, 2009, 2014 and 2019. At the same time, the tending intervention was realised on these plots. The measured tree heights for each PP were specifically matched by Michailoff's function (1943) at each re-measurement.

$$h(d) = 1.3 + b_1 \times e\left(\frac{-b_2}{d}\right) \quad (1)$$

where:

b_1, b_2 – parameters of the regression function;

d – diameter at breast height (cm);

h – height (m).

Quantitative characteristics of the data from experiments were processed by common biometric and statistical methods in terms of standard methodologies for thinning research (Štefančík 1984, 2015) using the software package Excel, QC Expert (Microsoft) (Kupka 2013). The volume of trees was calculated using volume equations (Petráš, Pajtík 1991).

Stem and crown quality were assessed according to the following grades (Štefančík, Bošeľa 2014):

1 – straight high-quality stem without knots, with no visible external damage;

2 – average-quality stem, curvature allowed only in the higher one-third of the stem, low number of small knots (1 or 2 knots per running meter) is allowed, with no external damage (fungi, insects, necrosis);

3 – low-quality stem with a high number of knots (more than 2 knots per running meter), with twisted stem or stem with curvature, with external visible damage (fungi, insects, necrosis).

Crown quality was assessed according to the size: (1) appropriate-sized symmetric crown; (2) smaller-sized suppressed crown, but able to regenerate; (3) small-sized crown, unable to regenerate.

Average values of silvicultural quality were calculated separately for the stem and crown as the arithmetic mean. The source material (data) was elaborated according to Štefančík (1974) and Štefančík (2015) methodology.

RESULTS AND DISCUSSION

Quantitative production

The management of the investigated plots resulted in differences in quantitative characteristics (number of trees, basal area and merchantable volume, see Table 1), as well as in height structure documented by height curves (Fig. 1).

The highest values were found in the first-generation stand (the Dobroč Hill – the control plot) and/or on the plot with crown thinning method. The lower values were found on the plot with negative thinning due to the removal of a significant number of individual trees (especially crown level ones). This is also evidenced by the lowest number of trees on this plot (Table 1). However, the comparison of these height curves with the naturally regenerated stand (Lukov) showed their higher values (Fig. 1), despite the fact that both stands have the same site index "32". Obviously, this is due to the high nutrient supply in the soil of the former agricultural land (Kukla 1996, 1997) compared to the forest land of the Lukov LTP.

This was also confirmed by values of mean mensurational variables and production characteristics (Table 1). The lowest values of the mean height (h_g) were found on the plot with negative crown thinning, where both the highest and the thickest trees were removed most intensively. On the plot with free crown thinning, where the positive selection dominates, the mean diameter and height values are still slightly behind the values of the control plot. However, we assume that in the course of further development the impact of crown thinning will also be reflected in the observed mean variables (especially in mean diameter) by their consid-

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Table 1. Stand characteristics of research plots

Plot	Age (yr)	*n* (trees·ha^{-1})	*G* (m^2·ha^{-1})	V_{7b} (m^3·ha^{-1})	Mean	
					DBH (cm)	height (m)
2	20	4,029	12.6	–	6.4	–
	50	1,066	26.4	279	17.8	22.1
6	20	5,293	15.2	–	5.8	–
	50	902	23.2	226	18.1	20.3
4	20	5,316	14.9	–	6.0	–
	50	1,191	31.0	336	18.2	22.3
H	50	1,088	20.1	188	15.3	19.8
0	50	1,576	32.8	317	16.3	20.1

n – number of trees; *G* – basal area; V_{7b} – merchantable volume; 2 – Dobroč Hill free crown thinning; 4 – Dobroč Hill control plot; 6 – Dobroč Hill negative crown thinning; H – Lukov free crown thinning; 0 – Lukov control plot

erable increase, so that they also exceed the values from the control plot. We found this trend on all research plots established in beech stands from natural regeneration (Štefančík 2015). Stands from natural regeneration (Lukov) had lower values of mean diameter and height compared to the stand on former agricultural land (the Dobroč Hill).

At the beginning of the research (at the age of 20 years), the lowest number of trees was recorded on plot 2 (ca 4,000 trees·ha^{-1}) while the other two plots showed much higher numbers (ca 5,300 trees·ha^{-1}). After 30 years of tending interventions on the Dobroč Hill (plots 2 and 6) and/or spontaneous development (plot 4) we found the lowest values of quantitative characteristics on plot 6 with negative crown thinning. Here we also recorded the largest total decrease (by thinning, self-thinning, breaks and other decrease) – (Table 2), namely 50.4% of the total basal area production and/or 32.8% of the total merchantable volume production. Both these lowest values from plot 6 corresponded with the total volume production. On the contrary, the highest values of quantitative characteristics were recorded on the control plot (Table 1), which is related to the highest number of trees and the lowest decrease of the total basal area (27.6%) production and/or of the merchantable volume (7.4%) on this plot. However, the current annual basal area increment (i_G) was the lowest on the control plot (Fig. 2).

A comparison of investigated quantitative parameters with the stand originated from natural regeneration (Lukov) and with the same method of tending (Dobroč Hill 2, Lukov H), which have almost the identical number of trees, showed much lower

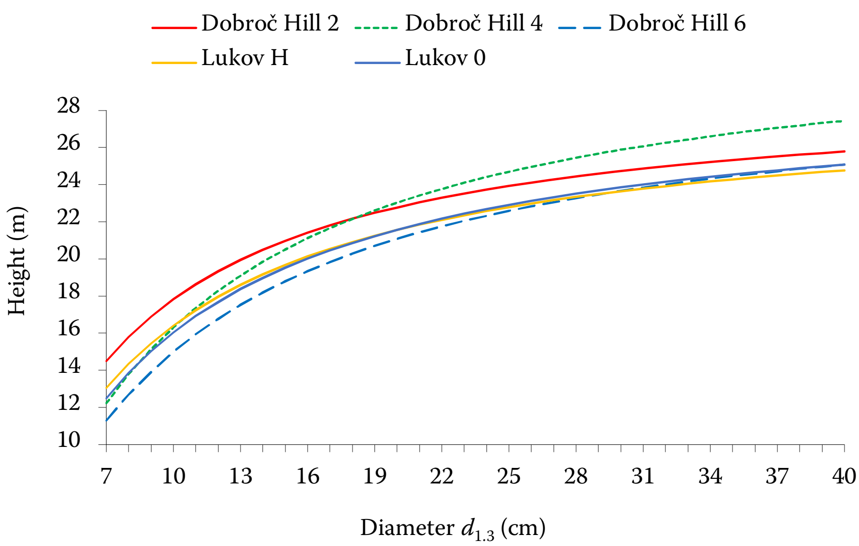

Fig. 1. Height curves on investigated plots

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Table 2. Development of quantitative production

Plot	Age range (yr)	Total decrease						Total production	
		n		*G*		V_{7b}		*G*	V_{7b}
		(trees·ha⁻¹)	(%) from TP	(m²·ha⁻¹)	(%) from TP	(m³·ha⁻¹)	(%) from TP	(m²·ha⁻¹)	(m³·ha⁻¹)
2	20–50	2,963	73.6	18.3	41.0	104	27.2	44.8	383
6	20–50	4,392	83.0	23.5	50.4	110	32.8	46.6	336
4	20–50	4,125	77.6	11.8	27.6	27	7.4	42.8	363
H	45–50	852	43.9	14.0	41.0	130	40.9	34.0	318
0	45–50	368	18.9	1.8	5.2	8	2.5	34.6	325

n – number of trees, *G* – basal area, V_{7b} – merchantable volume, 2 – Dobroč Hill free crown thinning, 4 – Dobroč Hill control plot, 6 – Dobroč Hill negative crown thinning, H – Lukov free crown thinning, 0 – Lukov control plot, TP – total production

values of basal area and merchantable volume as well as mean diameter and height on Lukov LTP. A comparison of the control plots (Dobroč Hill 4, Lukov 0), despite the lower number of trees, showed the higher merchantable volume on the planted plot, which was attributable to better production of the stand on formerly fertilized agricultural land.

A comparison with other data (Štefančík 2015) found out on control plots for beech stands from natural regeneration under comparable site and ecological conditions was also interesting. For example, on Kalša LTP, which is located in the Slanec Hills, the number of trees (N) at the age of 50 years was 2,000 trees·ha^{-1}, and the merchantable volume (V_{7b}) was 331 m^3·ha^{-1}. On the next Jalná LTP (in the Štiavnica Hills), 2,600 individuals per 1 ha produced 240 m^3·ha^{-1} of merchantable volume at the age of 49 years.

A comparison of these data showed that the number of trees was about twice lower at the Dobroč Hill (1,191 trees·ha^{-1}), but the merchantable volume (336 m^3·ha^{-1}) was still higher. The same findings were confirmed by a comparison with results from Koňuš LTP in the Vihorlat Hills, where 2,000 trees per 1 ha produced 295 m^3·ha^{-1}of merchantable volume at the age of 48 years (Štefančík 2015). These comparisons point out to good productivity of the stand on former agricultural land, mainly due to the favourable soil properties (Kukla 1996) such as sufficient nutrients, soil depth, virtually no skeletal character, good climatic conditions. This was also confirmed by the results published by Kamenský (1993) for neighbouring spruce and mixed larch-spruce stands on this site. These results exceeded the values compared to stands originated by natural regeneration. Bartoš et al. (2007) and

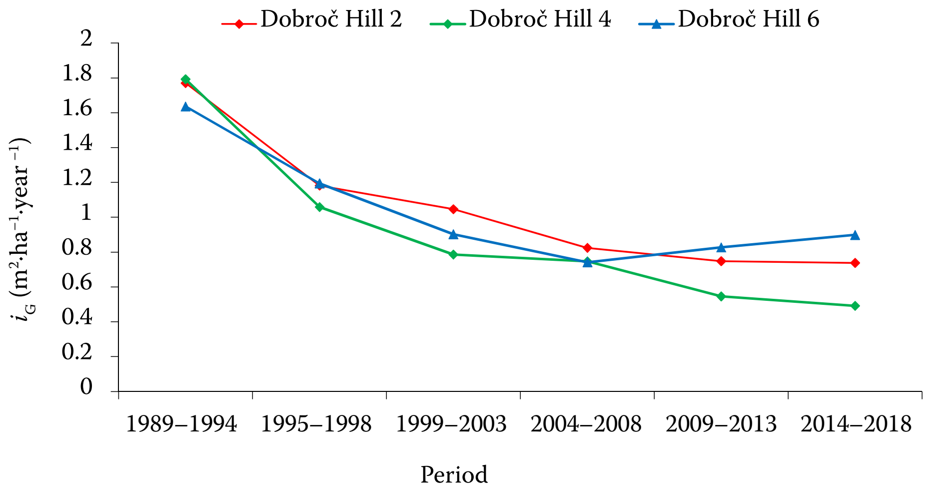

Fig. 2. Current annual basal area increment (i_G) on experimental plots (2 – Dobroč Hill free crown thinning; 4 – Dobroč Hill control plot; 6 – Dobroč Hill negative crown thinning)

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Table 3. Stand characteristics of the trees of selective quality (TSQ)

Plot	Age (yr)	n (trees·ha^{-1})	G (m^2·ha^{-1})	G (%) from main stand	V_{7b} (m^3·ha^{-1})	V_{7b} (%) from main stand	Mean DBH (cm)	Mean height (m)
2	20	271	1.2	9.4	–	–	7.5	–
	50	175	6.7	25.4	75	26.8	22.1	23.3
6	20	117	0.5	4.0	–	–	7.1	–
	50	188	7.7	33.1	80	35.5	22.8	22.0
4	26*	193	2.2	9.0	11	10.8	12.0	11.3
	50	92	3.9	12.5	45	13.5	23.2	24.2
H	50	160	4.6	22.9	46	24.7	19.2	21.3
0	50	136	5.1	15.4	53	16.8	21.8	22.1

n – number of trees; G – basal area; V_{7b} – merchantable volume; *values of TSQ on plot 4 are presented at the age of 26 years because they were not determined at the age of 20 years; 2 – Dobroč Hill free crown thinning; 4 – Dobroč Hill control plot; 6 – Dobroč Hill negative crown thinning; H – Lukov free crown thinning; 0 – Lukov control plot

Cukor et al. (2017), who found out excellent production in spruce stands established on former agricultural land in comparison with stands on forest land, attained the same findings.

Qualitative production

The qualitative production of beech stands on former agricultural land was investigated as selective one, which is represented by trees of selective quality (promising and crop trees) and also as the average value of the whole stand. In Table 3, we present the basic parameters of trees of selective quality (TSQ), which characterize the qualitative aspect of beech stands in the best way. As expected, their number is the lowest on the control plot (without thinning interventions) compared to the thinned plots.

It is known from literature that the number of TSQ (promising trees) should be about twice as many as the number of target trees at this age. For different site conditions in Slovakia, Štefančík (1984) recommended the number of crop trees in beech stands in the range of 130 to 203 trees per hectare. It follows from the mentioned above that the number of promising trees, which should range from 260 to 406 trees·ha^{-1}, corresponds exactly to the number of crop trees at the RO Dobroč Hill at present. It should be pointed out that in relation to the spacing between the current promising trees (about 4 m) and taking into account further development of these trees, it can be assumed that their number will decrease evenly until they reach their rotation age, so that the number of crop trees may ultimately be lower than expected (see Štefančík 1984).

The less favourable condition of the stands was also confirmed by the mass quality of stands on experimental plots (Fig. 3). It follows from the graphs that the worst average silvicultural quality of the stem (Fig. 3a) was found on plot 4 (control) without interventions, as expected, and on the other hand, the best was on plot 6 with negative crown thinning, where the worst quality trees were gradually removed. There is also an interesting development trend, where the improvement caused by the constant removal of the worst quality trees was seen on the plot with negative crown thinning in the first 10 years of observation, but over the past 15 years it has been more or less balanced. On the other hand, there is a very slight trend of improving the average quality of the stem on plot 2, where free crown thinning was applied, because the positive selection in favour of the TSQ is a primary task there. The positive effect of long-term tending is beginning to show.

A comparison of the average stem quality at the Dobroč Hill with beech stands of natural origin revealed their worse quality. On Kalša LTP, the average stem quality ranged from 2.517 to 2.633, on Jalná LTP it was 2.464 – 2.557, and on Koňuš LTP it was 2.245 – 2.709 after two thinning interventions. Obviously, the stem quality in naturally regenerated stands was much better than in artificially regenerated beech stands on former agricultural land, namely in the RO Dobroč Hill (2.883 to 2.983).

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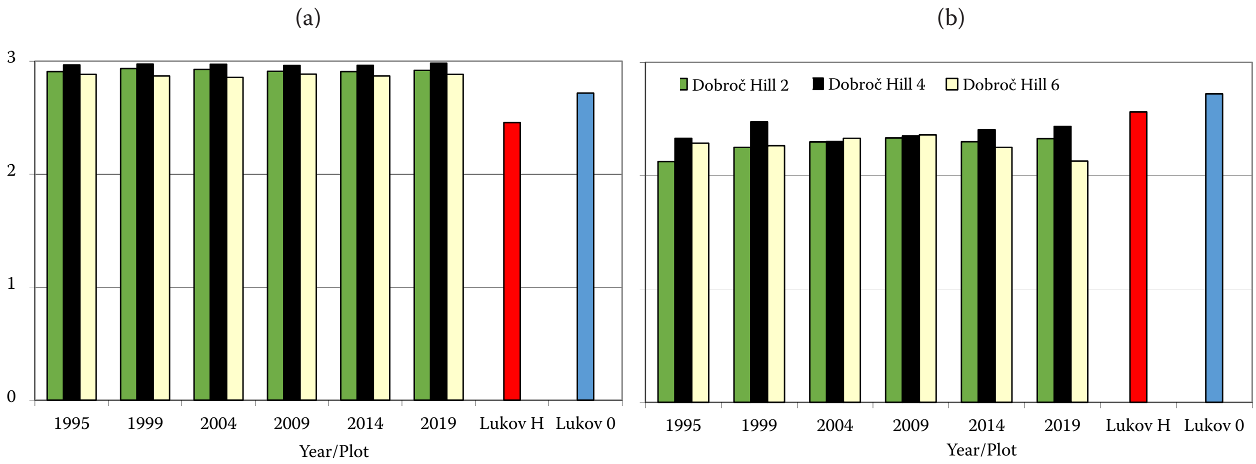

Fig. 3. An average stem quality (a) and crown quality (b) on Dobroč Hill and Lukov (2 – Dobroč Hill free crown thinning; 4 – Dobroč Hill control plot; 6 – Dobroč Hill negative crown thinning; H – Lukov free crown thinning; 0 – Lukov control plot)

One of the reasons is that the planting stock was of poor genetic quality to a large extent, or of unknown provenance in most cases, which is more obvious in beech species than for example in coniferous species. The density of the stands in which the beech grows up is also important. Houšková, Mauer (2015) found out that the denser the young beech plantation, the fewer the trees with the unsuitable shape of the stem. This was also confirmed in our experiment, when artificially regenerated stands were established with 7,000 trees per hectare. At the same time, their stem quality was worse compared to naturally regenerated stands where the initial number of individual trees was much higher. Novák et al. (2015) stated that the number of trees per hectare in the beech stand "Deštná", which was artificially regenerated, was from 2,500 to 3,100 individuals at the age of 33 years, which corresponds to our data from the Dobroč Hill at 30 years of age (ca 2,800 trees·ha^{-1}). Košulič (2004, 2005) also highlighted the relationship between the quality of deciduous trees and their unsuitability to be planted on clear-cut areas, i.e. without the use of pioneer species, especially in beech, which may also be one of the causes of the poorer quality of stems at the Dobroč Hill.

When analysing the quality of the crown in the first 20 years, which is represented primarily by its proportionate and sufficient size (Fig. 3b), the best results were obtained on the plot with free crown thinning (plot 2), where the tending of crowns is one of the basic principles. However, over the past 10 years, somewhat better quality has been observed on the plot with negative thinning. This is related to the number of trees, when crowns have more available space with a smaller number of trees. As expected, the quality of crowns from the control plot (without intervention) was worse.

In contrast to the average stem quality and the number of TSQ, the results of the average crown quality achieved on former agricultural land were even better in several cases (values from 2.125 to 2.476) compared to the stands from natural regeneration (Kalša LTP, Jalná LTP and Koňuš LTP), where the average crown quality ranged from 2.337 to 2.563, and from 2.145 to 2.781 on Koňuš LTP after applying two thinnings. Similarly, on another compared LTP, Lukov, the average quality of crowns was worse than that of the Dobroč Hill. The reason is that at the time of the 2nd measurement on Lukov LTP, no positive effect of tending in the 50-year-old stand from natural regeneration could be demonstrated yet, as it remained without any intervention until the age of 35 years.

Silvicultural analysis of interventions

From Table 4, where we analyse the type of interventions carried out in the course of 30 years (by basal area), it follows that the positive crown intervention dominates on plot 2 as it is the main principle of free crown thinning. Secondly, a negative form of selection was mostly applied, which results from the very low quality of stems. This was also confirmed by the analysis of qualitative production. A negative form of

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Table 4. Silvicultural analysis according to basal area

Plot	Order of intervention (year)	Intervention			Other decrease (%)	Thinning intensity (%)
		Positive at		Negative stem (%)		
		crown level (%)	suppressed level (%)			
2	1. (1989)	–	–	–	–	–
	2. (1995)	82.4	–	9.6	8.0	7.0
	3. (1999)	56.4	–	34.1	9.5	8.2
	4. (2004)	78.1		20.1	1.8	10.0
	5. (2009)	26.1	46.9	27.0	–	1.1
	6. (2014)	60.9	12.7	–	26.4	5.4
	7. (2019)	97.7	1.7	–	–	11.6
6	1. (1989)	7.6	0.7	91.7	–	25.2
	2. (1995)	71.6	–	20.7	7.7	5.9
	3. (1999)	66.2		32.9	0.9	13.4
	4. (2004)	36.3		20.3	43.4	15.2
	5. (2009)	–	3.3	31.9	64.8	7.4
	6. (2014)	–	–	–	100	1.1
	7. (2019)	56.7	–	43.3	–	14.2

2 – Dobroč Hill free crown thinning; 6 – Dobroč Hill negative crown thinning

selection dominated on plot 6 with negative crown thinning, especially at the first three measurements. Interestingly, in other two interventions on this plot, there was a very significant decrease due to breaks (abiotic factors), which was caused by the fact that during development on this plot there was a significant weakening of the remaining individual trees because of the stronger interventions, or a large number of removed (mainly crown level) individuals.

Regarding the intensity of the intervention (by basal area) in each year (Fig. 3), it is clear that the intensity of tending interventions was higher on the plot with negative crown thinning. The first, fourth, and last intervention were the strongest. In absolute terms, over 30 years of tending interventions on the plot with positive crown thinning (plot 2), the intensity of intervention did not exceed 12%, while on the plot with negative crown thinning it was 13–25% (except for the second and fifth intervention).

A comparison of these data with values obtained in beech stands from natural regeneration (Štefančík 2015) showed higher values for the plot with free crown thinning (Koňuš LTP 7.0–25.0%; Jalná LTP 11.0–24.0%, Kalša LTP 10.0–33.0%, or Lukov LTP 3.0–26.0). It should be noted that these values also apply to the first 5 interventions that were carried out on the plots concerned, but in much older stands (30 to 55 years and 45 to 64 years for Lukov LTP). It follows from the mentioned above that logically stronger interventions had been carried out in these stands as the number of individual trees from natural regeneration was higher at the same age than in the afforested areas of former agricultural land (Table 2). On the other hand, it is interesting that the values of the intensity of the first five interventions carried out on the plot with negative crown thinning at the Dobroč Hill are virtually identical to the data found out on plots with free crown thinning from beech stands of natural origin but in approximately 10 to 15 years older stands.

CONCLUSION

The assessment of the results of 30-year research on the growth and development of the beech stand situated in the Dobroč Hill locality and where forest stands were established on former agricultural land revealed some differences in comparison with the development of forest stands on forest land and originated from natural regeneration. The assessment can be summarized as follows:

Differences in the observed quantitative characteristics (number of trees, basal area, merchantable volume, mean diameter, mean height) pointed to the good productivity of these stands, similar to spruce and mixed larch-spruce stands in the same locality.

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The analysis of the qualitative production of beech stands on former agricultural land confirmed their lower quality, which was mainly caused by the planting stock of the worse genetic quality of unknown provenance.

The deteriorated quality was also manifested by the low number of trees of selective quality which represent one of the main qualitative indicators for the assessment of beech stands. The unfavourable condition of stands from the qualitative aspect was also confirmed by data on average stem and crown quality.

A comparison with the data found out for beech stands from natural regeneration under comparable site conditions in Slovakia showed that the quality of the stem in naturally regenerated stands was much better than in artificially regenerated beech stands on former agricultural land in the Dobroč Hill.

In contrast to the average stem quality and the number of the trees of selective quality, the results of average crown quality obtained on former agricultural land were not worse (in more cases they were even better) compared to the naturally regenerated stands.

The silvicultural analysis of tending interventions over 30 years showed that the intervention intensity did not exceed 12% on the plot with positive crown thinning (according to basal area), while it was 13–25% on the plot with negative crown thinning (except for the second and fifth intervention).

It can be stated that the quality of planting stock is one of the decisive criteria in artificially established beech stands, which also significantly influences its further development in terms of qualitative production. Losses that are evident in comparison with naturally regenerated stands cannot be prevented even by intensive systematic tending. It follows from the mentioned above that obviously some patterns and resulting knowledge of the development of forest stands on non-forest or former agricultural land are different from those obtained by long-term research or practical knowledge of forest management. Therefore, it is always necessary to take into account these facts when establishing such stands and lay down adequate management principles based on them.

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