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ECOLOGICAL CONDITIONS IN THE CASTANETARIUM HORNÉ LEFANTOVCE AND GROWTH OF EUROPEAN CHESTNUT (*Castanea sativa* M i l l.)

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Abstract

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The Castanetarium (14.38 ha) was established in 1965–1969 on locality Ferdinandka (220-250 m a.s.l.), near village H. Lefantovce (West Slovakia), Mts Tríbeč. The mean values of litter production (on 10 plots) were following: assimilative organs and flowers (13 229 kg.ha^{-1} – 64%), twigs (5448 kg.ha^{-1} – 27%), cupules and/or cones (1816 kg.ha^{-1} – 9%). In the 1968 the delimited agricultural soils were classified as Luvisols, in present they have characteristics typical for Albic Luvisols. The 36 years after forestation a considerable drop in the pH_{KCl} values was recorded in upper 30 cm of the soil pit 4 (by a 1.0–1.1 pH) and soil pit 8 (by a 0.73–1.04 pH) and in upper 20 cm of soil pit 1 (by a 0.75–1.05 pH). The content of humus within the upper 20 cm of soils increased by a 29–157% and ranges between 1.77–3.86%, the ratio C/N in the clone orchard by a 1.5–2.0 times (to 12.9–16.1), on the PRP Radošiná 2 by a 1.4–2.0 times (to 14.4–17.1), and on the PRP H. Lefantovce even by a 2.5–7.2 times (to 15.8–16.8). From the adjacent forest stands 25 woody species including 11 (44%) shrubs have been invaded into PRP. The further 85 species have been found in the herb layer, including 14 (16%) grasses, 12 (14%) synanthropic species, 8 (9%) heminitrophilous species and 16 (19%) indicators of the 3rd forest vegetation tier. The geobiocoenoses of the Castanetarium belong to the group of forest types *Fagetum pauper inferiora.* In the age of 35 years (in 2001) the plantations of 86 seed progenies of chestnut-trees cultivated in 12 localities of Slovakia have a mean breast-height diameter (cm) from 8.4 (Modrý Kameň 7) to 24.7 (Tlstý Vrch 9), height (m) from 9.5 (Krná 3) to 20.2 (Radošina 3), standing volume (m^3.ha^{-1}) from 2.67 (Modrý Kameň 7) to 410.00 (Duchonka 2) and total volume yield (m^3.ha^{-1}) from 40.37 (Krná 3) to 877.49 (Duchonka 12). The 15 (17.44%) of seed progenies were very good and 24 (27.91%) good.

In 2001 at the stand age of 38 years, the higher volume stock, as a result of the higher number of trees, has been observed in untended stands. In tended stands the highest volume stock (410.89 m^3.ha^{-1}) was assessed in the mixed stand *Castanea sativa* M i l l. and *Tilia cordata* M i l l. with the admixture of chestnut by 63.48% (260.85 m^3.ha^{-1}).

Key words: Castanetarium Horné Lefantovce, European chestnut, growth, production, succession, Luvisol

Introduction

The Castanetarium Horné Lefantovce was established in 1965–1970 with the purpose to concentrate under the same ecological conditions the European chestnut (*Castanea sativa* M i l l.) genetic resources of both Slovak and foreign origin. The forestation began in 1965 on agricultural land near the former forest enterprise Nitra, forest district Horné Lefantovce. At present belongs the Castanetarium to the forest enterprise Topoľčianky, forest district Nitrianska Streda, forest range Lefantovce.

The research oriented on ecology and production of the European chestnut has been focussed on the following problems:

1. Growth processes in seedlings and young cultures.
2. Impact of tending interventions performed in non-mixed and mixed stands from young-growth stage to pole timber stage (shaping and shortening cut, cleanings and thinnings) on growth, production and quality of the stands.
3. Centralisation of the whole Slovak assortment of the European chestnut genetic reserves, with the purpose to study biological cycles (phenology, increment), and establishment of an archive of chestnut stands for verification of genetic stability with a particular accent on morphology of flowers and fruits.
4. Study of morphogenetic and pedoecological changes induced with chestnut cultures afforested in the agricultural land.
5. Study of resistance of chestnut trees against biotic and abiotic injurious agents.

This work is aimed at evaluation of ecological conditions, as well as growth and production of various stand types of European chestnut (chestnut monocultures and mixed stands of chestnut with sessile oak, with small-leaved linden and with Scotch pine) and of 35-year old seed progenies of chestnut trees. Discussed is also their influence on development of the phytocoenoses and soils.

Site description

The Castanetarium has an area of 14.38 ha and is situated at 220–250 m a.s.l. It represents a valuable gene pool of the European chestnut, collected from over the whole the Slovak Republic. Consequently, it requires an appropriate attention, both in terms of research and forestry practice and specific-oriented management. Since 2002 (the actualisation of forest management plans, Fig. 1) belongs the locality to special purpose forests.

The Castanetarium is situated in the cadastral territory of the village Horné Lefantovce (local name Ferdinandka) situated 20 km north from the district town Nitra. It belongs to the geomorphological unit Podunajská pahorkatina hills, subunit Nitrianska pahorkatina hills and part Tríbečské podhorie hills (Mazúr, 1986). In terms of phytogeography (Futák, 1966) it belongs to the West-Carpathian region (*Carpaticum occidentale*), district of Pre-Carpathian flora (*Praecarpaticum*).

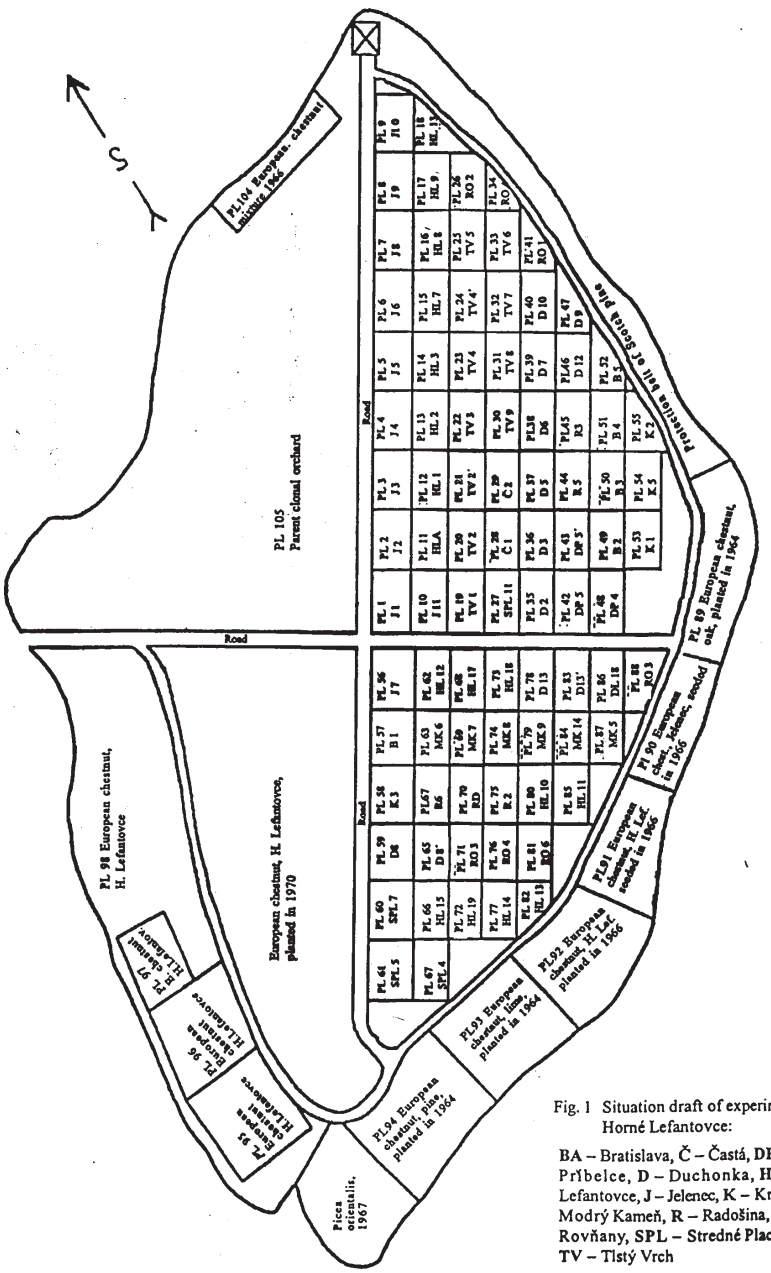

Fig. 1 Situation draft of experimental plot Horné Lefantovce:

BA – Bratislava, Č – Častá, DP – Dolné Príbelce, D – Duchonka, HL – Horné Lefantovce, J – Jelenec, K – Krná, MK – Modrý Kameň, R – Radošina, RO – Rovňany, SPL – Stredné Plachtince, TV – Tlstý Vrch

Fig. 1. Castanetarium Horné Lefantovce – situation plan.

T a b l e 1. Number of trees in Castanetarium Horné Lefantovce

Permanent research plot	Number of site in the year of establishment	Tree species	Origin of tree species	Type of forestation	Trees planted in 1965-1970	Number of trees in 2001		Note
					n	n	[%]	
I, II	92	*Castanea sativa* M i l l.	Lefantovce	planting	1471	433	29.43	six thinning interventions at PRP II from 1976
III, IV	90	*Castanea sativa* M i l l.	Protected area Jelenec	sowing	7691	2807	36.50	observation of sprouting capacity from 1982
V, VI	89	*Castanea sativa* M i l l.	Lefantovce	planting	1365	742	54.36	without observation on account of oak decline from 1986
		Quercus petraea L i e b l.			1389	31	2.23	
VII, VIII	93	*Castanea sativa* M i l l.	Lefantovce		2151	248	11.53	six thinning interventions at PRP VIII from1976
		Tilia cordata M i l l.			1207	324	26.84	
IX, X	94	*Castanea sativa* M i l l.	Lefantovce		1100	319	29.00	six thinning interventions at PRP X from 1976
		Pinus sylvestris L.			650	116	17.85	
Seed progenies	1-88	*Castanea sativa* M i l l.	Slovakia (12 localities)	planting	24 145	3798	15.73	86 seed progenies; five thinning interventions
Clonal orchard	105	*Castanea sativa* M i l l.	Slovakia (12 localities)	planting	2791	712	25.50	in 1972 re-grafted with grafts of 124 plus trees taken from 12 localities in SR
The other plots	91, 95-99 106	*Castanea sativa* M i l l.	Lefantovce, mixture of Slov.	sowing, planting	16 342	4530	27.72	–
Total	–	*Castanea sativa* M i l l.	Slovakia		57 056	13 589	23.82	–

The territory belongs to the warm climatic region with the number of summer days (with maximum temperature ≥ 25 oC) in a year ≥ 50 (according to Miklós et al., 2002). The climate sub-region is warm, moderately dry, with moderately cold winters (temperature in January > –3 °C). The mean annual temperature is 9.2 °C (–2.8 °C in January, 18.4 °C in July) and the mean annual precipitation is 550–600 mm (35–40 mm in January, 55–60 mm in July).

Material and methods

The studied European chestnut monocultures and mixed stands (with sessile oak, with small-leaved linden and with Scotch pine) were established in 1965 on permanent monitoring plots (PRP) with dimensions of 50x50 m. Chestnut one and two years old seedlings of admixed species were betted by slit planting into overall prepared soil in triangular spacing 2x1 m (2 m distance between the rows, 1 m distance between the plants in a raw). Since 1976, the impact of moderate crown thinnings with positive selection and 5-year interval of repetition on development of growth, production and quality of homogeneous and mixed chestnut stands is monitored, following the methods proposed by Tokár (1980, 1987, 1998). The results of the last evaluation accomplished in 2001 present Tokár, Krekulová (2003).

In years 1966–1969, the one year old seedlings of 86 seed progenies (SP) of the European chestnut from 11 localities in Slovakia (Jelenec –11 SP, Horné Lefantovce – 16 SP, Tlstý Vrch – 11 SP, Duchonka – 13 SP, Radošina – 5 SP, Bratislava – 5 SP, Častá – 2 SP, Dolné Príbelce – 3 SP, Stredné Plachtince – 4 SP, Rovňany – 6 SP, Krná – 4 SP, Modrý Kameň – 6 SP) and the clone orchard were planted in a similar way (the plot dimensions 30x20 m). In 1972 the clone orchard was re-grafted with scions taken from 124 plus trees from 12 localities in SR.

In total, there were planted 57 056 chestnut seedlings (Tokár, Juhásová et al., 2004), most of them in the monocultures of SP and clone orchard. In 2001, after five thinnings and sanitation cuttings of dry trees, there had been left 23.82% trees from the original planting (Table 1).

Since 1976, quantitative (breast-height diameter – $d_{1.3}$, height, growing stock, total volume production) and qualitative (quality of stems and crowns) characteristics of stands have been evaluated after each 5 years. The stands have been assorted to six qualitative classes: 1 – excellent, 2 – very good, 3 – good, 4 – bad, 5 – very bad, 6 – insufficient, in connection with the corresponding plus tree and locality and based on the mean tree characteristics and their variability (mean deviation – Šmelko, Wolf, 1977). The last evaluation was performed in 2001, at the age of SP stands 35 years (Tokár, 2003).

Soil samples were taken in 2004, air dried, and passed through a sieve with mesh size of 2x2 mm. The particle-size distribution was determined by means of laser analyser (FRITSCH Analysette 22), using sodium hexametaphosphate and super-sound. The values of active and potential soil reaction (ratio of fine earth to water and KCl 1:2.5) were obtained using glass and calomel electrodes of a digital pH-meter, the type 08211/1 Radelkis. The carbon content was determined oxidimetrically by Ťurin (Šály, Ciesarik, 1991). The soils have been classified according to WRB (1994, in Collective, 2000).

The phytocoenological relevés (plots 20x20 m) were described according to Zlatník (1976) and geobiocoenoses were classified according to Zlatník (1959) and Hančinský (1972). The names of the plant taxa are listed according to Dostál (1989).

Results

Geological and soil conditions

The permanent research plots of the Castanetarium are situated on undulated base of slope formed from Neogene rocks buried with irregularly thick loess loam. In 1968, the soils

have been classified as Haplic and Calcic Luvisols, washed off on convex slopes and with surface depositions in depressions, due to erosion-accumulation processes (Sotáková et al., 1968). In addition to carbonate leaching and intensive weathering of primary minerals, an illimerisation process run in the soils. The soils had, according to mentioned authors, 18–20 cm thick humus horizon with rather low humus content (1.6–1.8%) and with expressive predominance of fulvic and humic acids. The share of fraction < 0.001 mm was significantly higher in the illuvial horizon.

It has been commonly accepted that the Calcic Luvisols were formed from Chernozems during Holocene in connection with humidizing of climate, propagation of forest and decarbonisation of soil-forming substrates, primarily loesses. In the upper soil layers were these processes accompanied with a decrease in soil reaction and with changes in quality and quantity of the humus. The typical Calcic Luvisols have according to Šály (1991) horizon sequence Am-Bt-Ca-C_1, the thickness of mildly acid to neutral horizons A ≤ Bt >15 cm, C/N 10–11 in A horizon, and the humus stock in the upper 1m layer is 280 $t.ha^{-1}$.

The three selected representative soils in the Castanetarium do not correspond to the just described facts. Their humus horizon is thick 3–4 cm only, elluvial horizon is very thick and the reaction of upper horizons is acid – what is characteristic for Albic Luvisols. According to the scale designed by Novák (1952, in Šály, 1991), the soils are sandy loam to loamy, according to the triangle-diagram (Collective, 2000), they are dusty loam to dusty. The vertical shift of clay is not distinctive, probably because the illimerisation process was disturbed by tilling or also by erosion-accumulation processes. The maximum amount of dust particles is present in a depth of 30–40 cm.

The changes in textural fractions is not possible to asses objectively because in 1968 the soil samples were taken from different thick soil layers and the content of textural fractions (not always of the same size) was determined by means of apparatus of Kopecký not used at present.

In 1968, the soils were in general mildly acid to neutral (pH_{H_2O} 5.5–6.6) in the Castanetarium, on the plots with SP Duchonka 6 and Radošina 2 in the lower part even mildly alkaline. Although in 2004 the samples were not taken from totally identical soil layers, it is evident that the present soil reaction (pH_{H_2O} 5.02–6.25) is somewhat lower on three representative plots compared to 1968, when the impact of former tillage and probably also of fertilisation could still be effective. The 36 years after forestation the biggest decrease in the pH_{H_2O} values was recorded on PRP SP Radošiná 2, soil pit 4 (by a 1.53 pH in a depth of 70-80 cm) and on PRP clone orchard, soil pit 1 (by a 0.77 pH in a depth of 20–30 cm). A considerable drop in pH_{KCl} values was recorded in upper 30 cm of the soil pit 4 (by a 1.0–1.1 pH) and in soil pit 8 (by a 0.73–1.04 pH) and in upper 20 cm of soil pit 1 (by a 0.75–1.05 pH). From the viewpoint of edaphic-trophic conditions, this acid soil reaction indicates the occurrence of mesotrophic order of geobiocoens with equilibrium limit values of pH_{H_2O} 4.9–6.0 (Kukla, 1993).

The decrease in soil reaction has been caused as owing to interruption of agricultural utilisation and fertilisation of the soils as in consequence of the acid litter produced by cultivated woody plants. In general, the rate of forest litter decomposition increases with increasing content of basic ions and nitrogen. In case of the European chestnut, it is com-

parable with the decomposition rate of oak litter. The total amounts of litter ranged from 13 528 kg.ha^{-1} (clone orchard – plot 1, chestnut 100%) to 25 438 kg.ha^{-1} (PRP V. – control; chestnut 95%, oak 5%). The greatest share (60-70%) had assimilative organs and flowers – from 8119 kg.ha^{-1} (clone orchard – plot 1) to 19 357 kg.ha^{-1} (PRP V. – control), the lowest (2.5–12.6%) as a rule the cupules and/or cones – from 99 kg.ha^{-1} (seed progeny Duchonka 6; chestnut 100%) to 5962 kg.ha^{-1} (Protected area Jelenec; chestnut 95%). The amount of twigs ranged from 2 218 kg.ha^{-1} (PRP IX. – control; chestnut 60%, pine 40%) to 13 326 kg.ha^{-1} (Duchonka 6). The mean values of litter production (from 10 plots) were following: assimilative organs and flowers (13 228.85 kg.ha^{-1} – 64%), twigs (5448.01 kg.ha^{-1} – 27%), cupules and/or cones (1816 kg.ha^{-1} – 9%).

Over the last 36 years, the humus content in the upper 20 cm of soils increased by a 29–157% and ranges between 1.77–3.86%. On the other hand, the quality of soil humus dropped considerably. The ratio C/N in the clone orchard had been increased by a 1.5–2.0 times (to 12.9–16.1), on the PRP Radošiná 2 by a 1.4–2.0 times (to 14.4–17.1), and on the PRP H. Lefantovce even by a 2.5–7.2 times (to 15.8–16.8). The values of C/N were considerably higher even if the total nitrogen amount in the soil increased. This is an indirect confirmation of supply of difficult decomposable litter and of progressive soil acidification.

Character of phytocoenoses and their goebiocoenoses

Before plantation of introduced woody species, the plots of the Castanetarium were exploited as arable land. The succession processes running in growing cultures resulted in forest communities with the species composition described in Table 2.

In the phytocoenoses on the particular PRP we found in overall 86 mainly mesotrophic species, from which there were 14 (16%) grass species. From 8 (9%) heminitrophilous and nitrophilous species there were present in very low amounts *Alliaria petiolata, Chaerophyllum hirsutum, Galium aparine, Galeobdolon luteum* and *Torilis japonica*. More abundant, even co-dominant (on PRP V, X and Radošiná 2) were *Geranium robertianum, Lamium maculatum* and *Urtica dioica*. More or less grass species (more abundant only in the clonal orchard where the chestnut trees had been planted in open spacing) were 6 (7%) – *Alopecurus pratensis, Carex hirta, Achillea millefolium, Holcus lanatus, Agrimonia eupatoria* and *Jacea pannonica, synanthropic* 12 (14%) – *Arctium* sp., *Arthemisia vulgaris, Aster lanceolatum, Chelidonium majus, Carduus acanthoides, Carlina vulgaris, Cirsium arvense, Clematis vitalba, Cucubalus baccifer, Xanthoxalis dillenii, Stenactis annua and Taraxacum officinalis* agg.

The geobiocoenoses of PRP were originally classified into 2nd forest vegetation tier (fvt), mesotrophic order, and group of forest types (gft) *Fageto-Quercetum*, probably because this group of forest types is widespread in the neighbouring forest stands. The present geobiocoenoses, however, contain also 13 herb species indicating the presence of the 3rd fvt such as *Carex sylvatica, Milium effusum, Chaerophyllum hirsutum, Circaea lutetiana* (with increased abundance already on 6 PRP), *Dryopteris dilatata, Epilobium montanum, Eupatorium cannabinum, Lamium maculatum, Polygonatum multiflorum, Rubus caesius, Ru-*

T a b l e 2. Geobiocoenological characteristics

Permanent research plot	I.	V.	VII.	VIII.	IX.	X.	Clone orchard	Seed progeny Radošiná 2
	control			thinnings	control	thinnings		
Forest vegetation tier	3[n] oak-beech							
Edaphic-hydric order/subord.	leading/normal							
Edaphic-trophic order	B – mesotrophic							
Group of forest types	*Fagetum pauper inferiora*							
Forest type	3313 *Dentaria bulbifera nudum*							
Parent rock	loess loam							
Soil subtype	Albic Luvisol							
Stocking	0.9	0.8	1.0	0.7	0.9[0.8]	0.7–0.8	0.5	0.7
Canopy [%]	90	80–90	100	70	80–90	80	70	80
Date of reléves	August, 2004							
Woody species complex								
Taxon	[%]							
1 *Castanea sativa*								5–10
2 *Castanea sativa*	90	90	50	50	50	50	90	80–90
Pinus sylvestris					40	40–50		
Tilia cordata			30	40				
3 Castanea sativa	10	5–10	10	10	10	5–10	10	10
Quercus petraea		+–5						
Robinia pseudoacacia								+
Tilia cordata			10–20	5–10				
4 *Acer campestre*	10–20	70–80				20–30		5
Carpinus betulus	+–5	10–15				+		+–5
Castanea sativa	10	5–10			5	+	+	+–5
Fagus sylvatica						–		
Fraxinus angustifolia						–		
Padus avium					5–15	+		+
Robinia pseudoacacia		+						+
Tilia cordata			+–5			+		
Sambucus nigra	+				5	5–10[30]		
5[u] *Acer campestre*		5		5–10	5	10	+–5	
Acer platanoides	+							
Betula pendula							–	
Carpinus betulus	5–10	5–10		+	+–5	5–10		+–5
Castanea sativa	+	+–5	–		+–5	+	+	+–5[20]
Cerasus avium	+	+						
Fagus sylvatica					+			
Fraxinus angustifolia	+				10–20	+	–	+–5
Fraxinus excelsior		–						
Padus avium						+–5		
Quercus cerris	+	–				+	+	
Robinia pseudoacacia		+–5						
Sorbus aucuparia	+				5–10	+	–	
Tilia cordata	5		–	+	+–5	5		

T a b l e 2. (Continued)

Permanent research plot	I.	V.	VII.	VIII.	IX.	X.	Clone	Seed progeny Radošiná 2
	control			thinnings	control	thinnings	orchard	
Cornus mas							–	–
Crataegus monogyna	+	+			+	+	–	–
Euonymus europaeus		+–5						
Grossularia uva-crispa	+							
Lonicera xylosteum					+			
Prunus spinosa		+					+–5	
Ribes sp.	–				+	+		
Rosa sp.						–	+	–
Sambucus nigra	+	+–5			10–20	+		+
Swida sanquinea	+							
5_{1b} *Acer campestre*	5	5–10	5^{10}	$30–40^{60}$	+–5	+–5	5	5
Acer platanoides	+–5			+–5	+			+
Betula pendula							–	
Carpinus betulus	5–10	$5–15^{40}$		5	5–10	5	5	5–10
Castanea sativa	+–5	+	+–5	5–10	+	5	10^{20}	5–10
Cerasus avium			+	+	+–5	+		+
Fagus sylvatica				–	+	–		+
Fraxinus angustifolia			+	+	5		+	+–5
Padus avium					10			
Quercus cerris	+			–	+	+	+	+
Quercus sp.	+	–		–	–	–	–	+
Robinia pseudoacacia		+	–		+		+	–
Sorbus aucupariae			+	+	5	+–5	+	
Sorbus torminalis		–						
Tilia cordata			+	5–10	5–10	5–10		+
Cornus mas				–				
Crataegus monogyna			$+^{5}$	+	+			+
Euonymus europaeus		10^{30}		–				
Ligustrum vulgare						+		
Prunus spinosa				–				
Rosa sp.				–		–	+	–
Sambucus nigra	+	+–5	$+^{10}$			+–5	+	+
Swida sanquinea							–	
5_2 *Tilia cordata*			+					
Herb layer								
Taxon	Cover							
Alopecurus pratensis							–	
Brachypodium sylvaticum	$+^{1}$	$+^{-2}$					$1÷–2^{+2}$	$+^{-2}$
Calamagrostis epigeios							$1÷–2^{+3}$	$+^{-2}$
Carex hirta	$+^{1}$							
Dactylis glomerata							+	
Festuca giganthea							–	
Festuca ovina							$1÷+2^{-3}$	$+^{-2}$

T a b l e 2. (Continued)

Permanent research plot	I.	V.	VII.	VIII.	IX.	X.	Clone	Seed
	control			thinnings	control	thinnings	orchard	progeny Radošiná 2
Holcus lanatus							+[1]	
Melica uniflora	+ ÷–2[+3]	+		+[+2]	+[+2÷+3]	+[+2]		
Milium effusum		+[1]						
Poa angustifolia							1÷–2[+3]	+[-2]
Poa nemoralis	+[-2]	+[1]		+[-2]	+[1]	+[1]	±2[+3]	+[1]
Vignea divulsa							+[-2]	
Vignea muricata	+[-2]	+[-2]		+[1]		+[+2]		+[+3]
Achillea millefolium							+ ÷1	
Agrimonia eupatoria							+	–
Alliaria petiolata	+[1]		–					
Anthriscus sylvestris					+	–		+
Arctium sp.							+	–
Arthemisia vulgaris							+	
Aster lanceolatum								–
Chaerophyllum hirsutum	–			+				
Chaiturus marrubiastrum								–
Chelidonium majus						–		
Campanula patula							–	
Carduus acanthoides							–	
Carlina vulgaris							+ ÷1	
Centaurium erythraea							–	
Cephalanthera longifolia			+[1]÷1				–	
Circaea lutetiana	+÷1[-2]	+ ÷1[-2]	–	+[-2]	+[+2]	+ ÷1[-2]		+[1] ÷1[-4]
Cirsium arvense							–	
Clematis vitalba		+				+		
Clinopodium vulgare							1÷–2	+[1]
Cucubalus baccifer	+			+[-2]	+ ÷1[-2]	–		+
Cynoglossum germanicum	+			+[1]		+		+
Dryopteris dilatata	–				–	–		
Dryopteris filix-mas	+							+ ÷1
Epilobium montanum		–		+		+		–
Eupatorium cannabinum		+						
Fallopia dumetorum								+
Fragaria vesca	+[1÷+2]	+	+	1[-2]	+	+	–2÷–3	1
Galeobdolon luteum	+ ÷1[-3]							
Galium aparine		+						
Galium odoratum					+[+2]			
Galium schultesii								+[1]
Galium verum							–	
Geranium robertianum	+–1[-2]	1÷–2[-3]	+[1÷-2]	+ ÷–2	1÷–2[-3]			± 2
Geum urbanum	+2÷–3	+ ÷1	+[1] ÷1	1÷–2	+ ÷1	1÷–2	1÷–2	–2[+2]
Glechoma hederacea	+		+[+2]	+[+2]	+[-3]	+ ÷1[-2]		
Hieracium bauhinii							+[+2]	

T a b l e 2. (Continued)

Permanent research plot	I.	V.	VII.	VIII.	IX.	X.	Clone	Seed
	control			thinnings	control	thinnings	orchard	progeny Radošiná 2
Hieracium lachenali				–			–	
Hieracium murorum agg.				+				
Hieracium sabaudum	+	+	–				+ ÷1[-2]	+[1]÷1
Hypericum perforatum							–	
Jacea pannonica							+ ÷1	
Lamium maculatum					+ ÷1[+2]	1÷–2[+3]		
Mycelis muralis	+			+	+			
Omalotheca sylvatica							+[1]	
Pimpinella saxifraga							+	
Plantago major							–	
Polygonatum multiflorum					–			
Prunella vulgaris							+[-2]	+[+2]
Pulmonaria obscura	+					1÷–2		
Pulmonaria officinalis				+[1]	1	+ ÷1		
Pyrethrum corymbosum								–
Ranunculus polyanthemus							–	
Rubus caesius		+ ÷–2[-3]						
Rubus idaeus	–	+[1]						
Rubus fruticosus agg.	+ ÷1	+	–	+	±2[-3]	+ ÷1[+2]	+	
Rumex conglomeratus								+[1]÷1
Senecio jacobea							+	
Senecio nemorensis, subsp. *jacquinianus*	+							
Stachys sylvatica			–					–
Stenactis annua		+		–			–	+
Taraxacum officinale agg.							–	
Torilis japonica	+	+ ÷1	+	+			+	+
Urtica dioica	+ ÷1	± 2		+[1a -2]	+	+ ÷1[-2]	–	± 2[+3]
Veronica chamaedrys						+[1]	+ ÷1	+[1]
Veronica officinalis				+[-2]			+[1]	
Vincetoxicum hirundinaria			–					
Viola hirta								+
Viola reichenbachiana	+		+	+[-2]	+[+2]	+[1]	1÷–2	
Xanthoxalis dillenii							+	–
Atrichum unduatum	+[5]							

bus idaeus, Senecio ovatus and *Stachys sylvatica*. The presence of the 3rd fvt is indicated also by the woody plants as *Carpinus betulus* – wholesale expanding on the border of the clonal orchard, *Fagus sylvatica*, *Fraxinus angustifolia, subsp. danubialis* and *Padus avium*.

Propagation of the plant species indicating the presence of the 3rd fvt was promoted by favourable ecological conditions, the moisture regimen of the soils at the first place. The forest herbs could utilize these moisture conditions only after the light supply had considerably been suppressed by more and more closed crown canopy as a result of growth of the introduced species. The lack of light initiated the origin of succession processes resulting in a considerable reduction of presence, and consequently, competition abilities of non-forest, mainly grass species.

From these facts it is evident that the Castanetarium was established in the zone of the third, no second fvt. In the geobiocoenological system by Zlatník (1959) the two groups of forest types (gft) are placed into mesotrophic order in the 3rd fvt – *Querceto-Fagetum* and *Fagetum pauper inferiora*. Edaphic factors responsible for differentiation of these gft have not yet been identified sufficiently and ecologically comparable natural or slightly altered forest geobiocoenoses are not present in proximity of Castanetarium.

From the theoretical viewpoint the gft *Fagetum pauper inferiora* is situated between gft *Querceto-Fagetum*, with deeper, texturally heavier soils, and gft *Fageto-Quercetum*, with shallow soils having insufficient (for beech) maximum water capacity in the zone of the 3rd fvt (Kukla, 1992; Kukla et al., 1998). Because the soils of the Castanetarium are deep or very deep with water regimen favourable for the species occurring from the 3rd fvt higher, it is more probable that the geobiocoenoses on the PRP belong to the gft *Fagetum pauper inferiora*. From the forest types (ft) by Hančinský (1972), comes into account ft 3313 Toothwort beech-wood of lower fvt, passing in lower situated sites gradually into ft 3312 Sedge-grass beech-wood of lower fvt.

Succession of woody plants

After more than 35 years, the chestnut monocultures and mixed stands with sessile oak, small-leaved linden and Scotch pine have been naturally penetrated with 25 woody plants from the surrounding forest stands, including 11 (44%) bush species (Table 2).

The most expansive were the species with winged seeds disseminated by means of wind, primarily *Acer campestre*, occurring in the underground in all stands. This woody species has reached a very high abundance in the stand underground on PRP V where oak was failed in competition with chestnut and also on PRP VIII where chestnut has been growing together with small-leaved linden. Similarly expansive is also *Carpinus betulus*, at present only lacking on PRP VII with fully closed stand of chestnut mixed with small-leaved linden (insufficient amount of light). The species as *Cerasus avium, Fraxinus angustifolia*, subsp. *danubialis, Quercus cerris, Robinia pseudoacacia* and *Sorbus aucuparia* were also recorded on 7 PRP, however, in low amounts only. From the shrubs *Sambucus nigra* is present on 7 PRP (rather abundant is on PRP V, IX and X) and *Crataegus monogyna*, with low abundance up to now.

From the planted woody species, the regeneration of the European chestnut is the best, found on all PRP. The presence of small leaved linden was recorded on 5 PRP, while the regeneration of oak and pine was not registered.

Trends in growth of homogeneous and mixed chestnut stands and their standing volumes

After 25 years from the establishment of the thinning experiment (in 1976), the stands in the Castanetarium Horné Lefantovce reached the stage of pole-stage stand. In 2001, at stand age of 38 years, the number of trees per hectare ranged from 1018 (tended chestnut monoculture – PRP II) to 3 009 (non-tended mixed stand of chestnut with small-leaved linden – PRP VII). The average stem values (Table 3) ranged: the breast-height diameter ($d_{1.3}$) in chestnut from 13.56 cm (PRP IX) to19.20 cm (PRP VIII), in small-leaved linden from 10.62 cm (PRP VII) to 18.53 cm (PRP VIII) and in Scotch pine from 21.78 cm (PRP IX) to 24.86 cm (PRP X); height in chestnut from 16.7 m (PRP IX) to 19.6 m (PRP VIII), in small-leaved linden from 12.0 m (PRP VII) to 19.0 m (PRP VIII) and in Scotch pine from 20.7 m (PRP IX) to 22.8 m (PRP X) (Fig. 2, 3, 4).

At stand age of 38 years the standing volume ranged from 335.66 $m^3.ha^{-1}$ (tended chestnut monoculture) to 433.51 $m^3.ha^{-1}$ (non-tended mixed stand of chestnut with Scotch pine).

Growth and production of 35 year old seed progenies of European chestnut

At stand age of 35 years (in 2001), the seed progenies of European chestnut acquired from 86 plus trees from whole Slovakia reached the average stand diameter ($d_{1.3}$) from 8.4 cm (Modrý Kameň 7) to 24.7 cm (Tlstý Vrch 9) and average stem height from 9.5 m (Krná 3) to 20.2 m (Radošina 3). The standing volume ranged from 2.67 $m^3.ha^{-1}$ (Modrý Kameň 7) to 410.00 $m^3.ha^{-1}$ (Duchonka 2) and total volume production from 40.37 $m^3.ha^{-1}$ (Krná 3) to 877.49 $m^3.ha^{-1}$ (Duchonka 12).

Based on the overall assessment of the seed progenies of European chestnut for which there were computed average values of all the evaluated quantitative (breast-height diameter – $d_{1,3}$, height, standing volume, total volume production) and qualitative characteristics (stem quality, crown size, density and type), the seed progenies were statistically classified to the following categories:

1. excellent – no one from seed progenies
2. very good – 15 (17.44%) seed progenies (Jelenec 2, Horné Lefantovce A, Tlstý Vrch 1, 2, 2´, 3, 4, 9, Duchonka 2, 3, 5, 6, 10, 12, Bratislava 4)
3. good – 24 (27.91%) seed progenies (Jelenec 1, 5, 11, Horné Lefantovce 3, 10, 17, 18, Tlstý Vrch 4´, 5, 6, 7, 8, Duchonka 7, 9, 13, Radošina 3, 5, D, Bratislava 2, 3, 5, Stredné Plachtince 11, Rovňany 4´, Modrý Kameň 9) (Fig. 5)
4. bad – 37 (43.02%) seed progenies (Jelenec 3, 4, 6, 8, 9, 10, Horné Lefantovce 1, 2, 7, 8, 9, 11, 12, 13, 14, 15, 19, Duchonka 8´, 13´,18, Radošina 2, 6, Bratislava 1, Častá 1, 2, Rovňany 1, 3, 4, 6, Dolné Príbelce 4, 5, 5´, Krná 2, Modrý Kameň 5, 6, 8, 14)

T a b l e 3. Developmental trends in mensurational characteristics of the mean stem and standing volume in various stand types of chestnut (*Castanea sativa* M i l l.) on the PRP Horné Lefantovce in 1976–2001 (age stands 13 and 38 year)

Permanent research plot	Species	Number of trees	Mean stem		Standing volume	Number of trees	Mean stem		Standing volume
			DBH[1)]	height			DBH[*]	height	
		in 1976 (after thinning)				in 2001 (before thinning)			
		[ts.ha^{-1}]	[cm]	[m]	[m^3.ha^{-1}]	[ts.ha^{-1}]	[cm]	[m]	[m^3.ha^{-1}]
I. (control)	*Castanea sativa* M i l l.	10 379	4.17	5.6	41.80	2138	14.65	17.3	356.10
II.	*Castanea sativa* M i l l.	8029	4.54	6.0	41.54	1501	16.96	19.1	335.66
VII. (control)	*Castanea sativa* M i l l.	5490	4.94	6.6	33.15	1018	15.75	12.8	194.80
	Tilia cordata M i l l.	5928	3.78	5.3	19.88	1991	10.62	12.0	221.49
	Total	11 418	–	–	53.03	3009	–	–	416.29
VIII.	*Castanea sativa* M i l l.	3648	5.89	7.1	40.35	861	19.20	19.6	260.85
	Tilia cordata M i l l.	2978	4.24	5.0	11.68	457	18.53	19.0	150.04
	Total	6626	–	–	52.03	1318	–	–	410.89
IX. (control)	*Castanea sativa* M i l l.	5466	3.92	4.5	19.35	1596	13.56	16.7	213.82
	Pinus sylvestris L.	1908	6.82	5.2	25.97	565	21.78	20.7	219.69
	Total	7374	–	–	45.32	2161	–	–	433.51
X.	*Castanea sativa* M i l l.	3977	4.17	5.0	15.28	928	17.07	19.2	199.55
	Pinus sylvestris L.	1698	6.85	5.1	23.14	317	24.86	22.8	171.02
	Total	5675	–	–	38.42	1245	–	–	370.57

[*]DBH – diameter at breast height

Fig. 2. Good-quality stem of European chestnut with fork-like crovn.

Fig. 3. Non tended pure stand of European chestnut (PRP I).

Fig. 4. Tended mixed stand of European chestnut and little linden (PRP VIII).

Fig. 5. Seed progeny Horné Lefantovce 17.

5. very bad – 7 (8.14%) seed progenies (Jelenec 7, Duchonka 8, Stredné Plachtince 4, 7, Rovňany 2, Krná 1, 5)
6. insufficient – 3 (3.49%) seed progenies (Stredné Plachtince 5, Krná 3, Modrý Kameň 7).

The plus trees whose seed progenies have been classified to categories bad, very bad and insufficient should not have been used for establishment of stands.

Discussion

The problem of woody plants selection and mutual mixing in stands is basic also for growing introduced woody plants. It is key-important from aspect of their production and influence on the soil.

The research has revealed that the aboveground volume and weight production is higher in mixed stands of chestnut with the other woody species compared with chestnut monocultures cultivated under the same conditions (site conditions, stand age, method of stand establishment, tending and evaluation). The share of chestnut dendromass from the total production of various stands is different. It is dependent on a result of competition relations between the woody plants during the stand development. The background of higher production is necessary to see even in favourable ecological conditions governing in such stand types (Hanáková, 1982; Tokár, 1980, 1987, 1998).

On the formation of forest soil and energy accumulation in it share a considerable part of woody plant phytomass in form of litter that can be considered as a humus-forming organic matter. Hanáková (1982) found in 1976–1979 in litter of chestnut stands considerable differences between the rate of micro-organisms respiration, the pH values, amounts of C and N, humic and fulvic acids, values of their ratio (HA/FA) and colour coefficient Q 400/600. The highest amount of litter (6.3 $t.ha^{-1}$) this author recorded in the mixed stand of chestnut with sessile oak. In comparison with the present state on this PRP listed amount represents only 25%.

Hanáková (1985) also pointed out the qualitative changes in soil properties affected with different stand types consisting of young chestnut trees. The author found the most remarkable drop in soil reaction and increase in the total N in the soil under the mixed chestnut stand with Scotch pine, and the smallest fluctuations in soil pH values were in the mixed chestnut stand with small leaved linden. The ratio C/N was low in all the stand types.

Konôpková (2003) studied the dynamics of nutrient content in soil and aboveground dendromass in various stand types of the European chestnut over 1995–1997. The changes in content of accessible nutrients and pH values in the soil and in aboveground dendromass depended on the wood species, stand type and sampling year or also on the season. The most favourable results were found in the chestnut stand mixed with small-leaved linden.

Physical properties of soils improved from Albic Luvisols to Chernozems, pH decreased in retrograde order. In eluvial horizon with reduced clay also content of mineral nutrients was decreased.

The soil under different types of stand of Austrian pine (*Pinus nigra* A r n o l d), black locust (*Robinia pseudoacacia* L.), sweet chestnut (*Castanea sativa* M i l l.), red oak (*Quercus rubra* L.), and black walnut (*Juglans nigra* L.) were evaluated by Bublinec (2002). The author identified favourable conditions for chestnut trees on Albic Luvisols, Calcic Luvisols and on Chernozems. The reaction of these soils ranged between 4.3–8.0 and the humus of high quality, rich in nitrogen and a very good nutrient stock belong between their common characteristics. The physical properties of soils were improved from Albic Luvisols to Chernozems, pH decreased in the opposite direction. The elluvial horizon was poor in clay and also had lower content of mineral nutrient.

Conclusions

The Castanetarium in Horné Lefantovce was established in 1965–1970 on the 14.38 ha of agricultural land belonging to the Arboretum Mlyňany – Institute of Dendrobiology SAS. Today it represents a valuable chestnut gene pool gathered from over whole Slovakia suitable for investigations aim at production ecology and protection. In various stand formations (86 seed progenies from 12 localities in Slovakia, homogeneous and mixed stands, clone parent orchard) were planted 57 056 nurslings of European chestnut, 1389 nurslings of English oak, 1207 nurslings of small-leaved linden and 650 nurslings of Scotch pine.

In 2001, that means 35 years after the plantations, the number of chestnut trees decreased to 13 589 (23.82%) as the result of stand development, competitive relations, tending interventions (thinnings) and sanitary cuttings. From the viewpoint of growth, quality and production (growing stock, total yield), 15 (17.44%) seed progenies were evaluated as very good, and 24 (27.91%) as good. More productive were the mixed stands than the monocultures.

In period of Castanetarium foundation the delimited agricultural soils were classified as Calcic and Haplic Luvisols. The actual properties of these soils – thin humus horizon (< 4 cm), high coefficient of vertical clay transport and absence of carbonates point at presence of Albic Luvisols. The growing of chestnut trees has mainly resulted in a decrease in topsoil reaction having at present mesotrophic character. The moisture of soils is not so low as it is common in the gft Fageto-Quercetum, into which the geobiocoenoses were classified formerly. This fact is indicated by occurrence of plant species of the 3rd fvt and gft Fagetum pauper inferiora.

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Tokár F., Kukla J.: **Ekologické podmienky v Kastanetáriu Horné Lefantovce a rast gaštana jedlého** (*Castanea sativa* M i l l.)**.**

Kastanetárium (14,38 ha) bolo založené v rokoch 1965–1969 v pohorí Tríbeč na lokalite Ferdinandka (220–250 m n.m.) v blízkosti obce Horné Lefantovce (Lesná správa Nitrianska Streda, Lesný závod Topoľčianky). Do Kastanetária bolo vysadených 57 056 ks sadeníc gaštana jedlého, z ktorých v r. 2001 v rôznych porastových typoch rástlo 13 589 ks (23,82 %).

Priemerné hodnoty produkcie opadu (na 10 plochách) boli nasledovné: asimilačné orgány a kvety (13 229 kg.ha^{-1} – 64 %), konáriky (5448 kg.ha^{-1} – 27 %), čiašky alebo šišky (1816 kg.ha^{-1} – 9 %). V roku 1968 boli delimitované poľnohospodárske pôdy klasifikované ako hnedozeme, v súčasnosti majú charakteristiky typické pre luvizeme. Po 36 rokoch od výsadieb sa zistil značný pokles hodnôt pH_{KCl} vo vrchných 30 cm pôdnej sondy 4 (o 1.0–1.1 pH) a pôdnej sondy 8 (o 0.73–1.04 pH) a vo vrchných 20 cm pôdnej sondy 1 (o 0.75–1.05 pH). Obsah humusu vo vrchných 20 cm pôd sa zvýšil o 29–157 % a pohyboval sa medzi 1,77–3,86 %, pomer C/N v klonovom sade 1,5–2,0 krát (na 12,9–16,1), na TVP Radošiná 2 1,4–2,0 krát (na 14,4–17,1) a na TVP H. Lefantovce dokonca 2,5–7,2 krát (na 15,8–16,8). Zo susedných lesných porastov preniklo do TVP 25 druhov drevín, z toho 11 (44 %) krov. Ďalších 85 druhov, vrátane 14 (16 %) druhov tráv, 12 (14%) synantropných druhov, 8 (9 %) heminitrofilných druhov a 16 (19%) indikátorov 3. lesného vegetačného stupňa sa zistilo v bylinnej vrstve. Geobiocenózy Kastanetária patria do mezotrofného radu geobiocénov a skupiny lesných typov Fagetum pauper inferiora.

V r. 2001 pri veku 35 rokov 86 semenných potomstiev gaštana jedlého z 12 lokalít Slovenska dosiahli priemernú porastovú hrúbku $d_{1,3}$ od 8,4 (Modrý Kameň 7) do 24,7 cm (Tlstý Vrch 9); priemernú porastovú výšku) od 9,5 m (Krná 3) do 20,2 m (Radošina 3); zásobu od 2,67 m^3.ha^{-1} (Modrý Kameň 7) do 410,00 m^3.ha^{-1} (Duchonka 2) a celkovú objemovú produkciu od 40,37 m^3.ha^{-1} (Krná 3) do 877,49 m^3.ha^{-1} (Duchonka 12). V celkovom hodnotení (rast, produkcia, kvalita kmeňa a koruny) bolo 15 semenných potomstiev (17,44%) zaradených do kategórie veľmi dobré, 24 (27,91%) do kategórie dobré, 37 (43,02%) do kategórie zlé, 7 (8,14%) do kategórie veľmi zlé a 3 (3,49%) do kategórie nevyhovujúce.

Pri vyhodnocovaní vplyvu prebierok na rast a produkciu rôznych porastových typov gaštana jedlého sme v 38 ročných porastoch zistili v dôsledku vyššieho počtu stromov vyššiu objemovú zásobu v nevychovávaných porastoch. Pri vychovávaných porastoch najvyššiu zásobu (410,89 m^3.ha^{-1}) dosiahol zmiešaný porast *Castanea sativa* M i l l. s *Tilia cordata* M i l l., pričom na gaštan jedlý pripadá 63,48% (260,53 m^3.ha^{-1}).