FOLIA OECOLOGICA – vol. 40, no. 2 (2013). ISSN 1336-5266

Results of an ecological-production research on forest ecosystems of woody plants introduced to Slovakia

Ferdinand Tokár

Kalinčiakova 3, Zlaté Moravce, Slovak Republic, e-mail: ferdinandtokar@centrum.sk

Abstract

Tokár, F. 2013. Results of an ecological-production research on forest ecosystems of woody plants introduced to Slovakia. *Folia oecol*., 40: 282–289.

The work gives a chronological list of the results obtained in an ecological and production research on 49 coniferous and 10 broadleaved exotic woody plants in 298 parks and woody subjects across Slovakia. The results can be used in orchard and forestry practice. Since 1971, the research has been oriented to assessment of forest ecosystems and phytotechnique for forest stands consisting of selected exotic woody plants *Pinus nigra* Arnold, *Castanea sativa* Mill., *Quercus rubra* L. and *Juglans nigra* L. In the area of the Little Carpathians the best results in growth and production were achieved in *Pinus nigra* Arnold at the age of 100 years under proportion rate up to 30% in the group of forest types (slt) Querceto-Fagetum (464 m^3 ha^{-1}), Fagetum pauper (463 m^3 ha^{-1}) and Fageto Quercetum (432 m^3 ha^{-1}). In the pure stands the highest stock was observed in the group of forest types Querceto-Fagetum (310 m^3 ha^{-1}). In Castanetarium Horné Lefantovce the best results out of 86 *Castanea sativa* progenies were obtained in 15 progenies (Jelenec 2, Horné Lefantovce A, Tlstý Vrch 1, 2, 2', 3, 4, 9, Duchonka 2, 3, 5, 6, 10, 12, Bratislava 4) and the worst results were obtained in seed progenies Stredné Plachtince 5, Krná 3, Modrý Kameň 7. Following evaluation of phytotechnique impact on production of different stand types of *Castanea sativa* Mill. at age of 38 years, the highest stock was observed in mixed stands *Tilia cordata* Mill. (416 m^3 ha^{-1}, 190 t ha^{-1}, total production 635 m^3 ha^{-1}, 333 t ha^{-1}). In mixed stands of *Juglans nigra* L. (20%) and *Quercus rubra* L. (80%) in the locality Ivanka pri Nitre, the highest stock was observed at the age of 48 years (438 m^3 ha^{-1}, 263 t ha^{-1}) and total production 662 m^3 ha^{-1} and 410 t ha^{-1}. In the locality Sikenica in pure stands of *Juglans nigra* L. the highest stock at the age of 64 years was found in the stand with the strong crown thinning (464 m^3 ha^{-1}, 195 t ha^{-1}, total production 573 m^3 ha^{-1} and 246 t ha^{-1}). In addiction to these production characteristics also leaf area indices were assessed (LAI).

Keywords

ecology, exotic woody plant, forest ecosystems, production

Analysis of the issue and the research focus

In the past in Slovakia attention was given predominantly to the growth and production of autochthonous woody plant species (Halaj, 1963; Halaj and Řehák, 1979; Šebík and Polák, 1990; Šmelko, 2000). In allochthonous woody plant species issues of growth, production and distribution were evaluated (Holubčík, 1968; Benčať, 1982). The aim of our work is to introduce chronological survey of obtained results from ecologic-production research.

The Department of system and ecology of woody plants of the former Institute of Dendrobiology SAS in the Arboretum Mlyňany SAS focused their research on forest ecosystems of woody plants introduced to Slovakia on the following points:

- Taxonomy of exotic species in selected dendrological subjects in Slovakia (assortment, mensurational data, fertility, natural regeneration)
- Valorisation of structure and production (volume, mass) and quality of various stands of selected exotic woody plants in Slovakia (*Castanea sativa* Mill., *Quercus rubra* L., *Juglans nigra* L., *Pinus nigra* Arnold)
- Assessment of effects of phytotechnique (thinning) on production, dendrochronology, quality, leaf area

index (LAI) and energy potential in a variety of stand types of woody plants introduced into Slovakia
- Monitoring of physiological-biochemical aspects of biomass production in various stand types of exotic woody plants (fluorescence, contents of selected elements in soil and leaves)
- Assessment of resistance of stands of selected exotic woody plants against biotic and abiotic harmful agents
- Evaluation of herb vegetation in various stand types of exotic woody plants and changes to this component due to long term introduction (Castanetarium in Jelenec, Castanetarium Horné Lefantovce)
- Evaluation of natural regeneration of stands of exotic species in Slovakia
- Quantitative assessment of selected chemical elements accumulated in aboveground biomass and in soil in stands consisting of exotic woody plants in Slovakia.

Material and methods

The ecological description of the exotic species distribution in parks and dendrological objects in Slovakia has been adapted from Benčať, 1982.

With using our own measured data and the data from Forest management plans (FMP), we have accomplished ecological-production analysis for 613 stands of black pine (*Pinus nigra* Arnold) in the region Malé Karpaty Mts. We considered the group of forest types (gft), stand age and structure and black pine proportion (1–30%, 31–60%, 61–90% and 100%). The results were processed with using the Korf growth function, on a computer TESLA 200 in the Computing centre of the Technical University in Zvolen.

The phytotechnique of various stand types (pure and mixed stands with different rates of domestic and alien woody plants) of *Castanea sativa* Mill., *Quercus rubra* L. and *Juglans nigra* L. works with thinning from above applied in graded intensity (moderate, heavy), with positive selection, at different repetition intervals (5–10 year), focusing on tending promising trees on the permanent research plots series (PRP) Žirany (7 partial PRPs with homogeneous and mixed stands of *Castanea sativa* Mill.), Ivanka pri Nitre (6 partial PRPs with homogeneous and mixed stands of *Quercus rubra* L. and *Juglans nigra* L.), Sikenica (3 partial PRP with homogeneous stands of *Juglans nigra* L.) and Castanetarium Lefantovce (86 seed progenies of *Castanea sativa* Mill. from 12 localities in Slovakia). The ecological description of the PRP series Žirany, Lefantovce, Ivanka pri Nitre and Sikenica can be found in Tokár, 1987, 1998; the Castanetarium Lefantovce is characterised in Tokár, 2003; Tokár and Kukla, 2006.

Biometrical measurements of the stand height, diameter $d_{1,3}$ and standing volume (volume production) were performed by methods commonly used in forestry practice (Halaj, 1963; Šmelko, 2000). For the calculation of the volume of large black pine timber, we used, due to the lack of our own tables, the mass tables for forest pine, red oak, black nut; for edible chestnut the mass tables for oak converted per one hectare.

The aboveground wood biomass was obtained by the destructive method (method of sample trees). The total number of sample trees for each woody species in the stand was determined by stratified selection (Šmelko and Wolf, 1977). The mass of stem, branches, annual shoots and leaves was obtained by weighing on a scale Kamor in dry mass at 105 °C.

Photosynthetically active leaf surface area was estimated with the aid of a photo-planimeter EIJKELKAMP.

The time dependence of the values of standing volume and mass as well as the values of overall volume and mass production (growing stock + thinning + mortality + other losses) and the LAI values was fitted with a mathematical function – specific for each tree species and stand type (an exponential or a 2nd degree polynomial). On each PRP series, the production results expressed through growth index and through index increment per cent were compared with the control PRP (without intervention) and tested statistically with the t-test (Šmelko and Wolf, 1977).

The principle of phytotechnique of stands of exotic woody plants is tending the promising trees (Tokár 1987, 1998). The contents of elements (Mg, Ca, K, Na, Zn, Pb, Fe, Cu, Mn) in the aboveground biomass and in the soil were assessed with the aid of an absorption spectre-photometer IL VIDEO 12 (Tokár and Konôpková, 1995).

Results

The ecology and production of exotic woody plants is an issue studied by the researchers in the „Arboretum Mlyňany“ – Institute of Dendrobiology SAS since 1966. Their activities began with an evaluation of growth and production performance of selected 59 exotic taxa (49 conifers, 10 broadleaves) in 298 parks and dendrological subjects in Slovakia. The results of this survey, useful for orchard management and, principally, for forest practices are in the works Tokár (1976, 1979). These results not only justify and confirm the success of introduction of these woody plants into our climatic conditions, mainly in terms of growth and production, but they also represent a new knowledge concerning fructification, natural regeneration and other important features (also concerning orchards – such as habitus). The results should be reputed as a valuable source of scientific knowledge about the gene pool of the cultural dendroflora in Slovakia waiting for use in dispersion, protection and saving of these taxa.

Beginning with 1976, the ecological-production research was oriented on valorisation of forest stands of exotic woody plants in the region Malé Karpaty Mts (in frame of the programme Man and Biosphere) and on phytotechnique of young forest stands of selected exotic woody plants (*Castanea sativa* Mill., *Quercus rubra* L. and *Juglans nigra* L.) on four PRP series (Žirany, Lefantovce, Ivanka pri Nitre and Sikenica).

In the region Malé Karpaty Mts (Tokár, 1985, 1991b), exotic woody plants are grown on 2,270 ha of the actual forest area and 1,579 ha of the reduced forest area. The major part concerns *Pinus nigra* Arnold (2,212 ha actual forest area and 1,533 ha reduced forest area). Many minor proportions concern *Pinus strobus* L. (1.78 ha actual forest area), *Pseudotsuga menziesii* (Mirbel) Franco (26.07 ha), *Aesculus hippocastanum* L. (5.36 ha), *Castanea sativa* Mill. (17.53 ha), *Quercus rubra* L. (5.30 ha) and *Juglans nigra* L. (1.91 ha).

As for the ecology, in the Malé Karpaty Mts, the exotic woody plants are most abundant in the groups of forest types (GFT): Fageto-Quercetum (892 ha actual forest area), Corneto-Quercetum (490 ha), Fagetum pauper (302 ha) and Querceto-Fagetum (169 ha). From the viewpoint of age, the first age class of 1–10 years (597 ha) and the sixth class encompassing 51–60 years (585 ha) are dominant.

Black pine is mostly grown in the gft-s Fageto-Quercetum (867 ha), Corneto-Quercetum (490 ha), Fagetum pauper (295 ha), Corneto-Fagetum (156 ha), and Querceto-Fagetum dealpinum (100 ha).

The results of the ecological-production analysis of the black pine in the Malé Karpaty Mts demonstrate that the most favourable conditions for growth and volume (mass) production in this region are in the gft-s Querceto-Fagetum, Fageto-Quercetum and Fagetum pauper. The biggest overall standing volume is in the mixed stands – with the black pine proportion less than 30% (younger than 100 years, in gft FQ 432 m^3 ha^{-1}, in QF 464 m^3 ha^{-1} and in Fp 443 m^3 ha^{-1}). In the pure stands, the highest standing volume was found in the gft-s Querceto-Fagetum (310 m^3 ha^{-1}) and Fageto-Quercetum (295 m^3 ha^{-1}). The mixed stands had by from 10% (Corneto-Quercetum) to 64% (Fagetum pauper) more volume stock than the pure stands.

The results documenting the influence of phytotechnique on volume and mass production in the homogeneous stands of *Castanea sativa* Mill. on the PRP series Žirany (Table 1, Figs 1–2) show that a stronger positive influence during the whole stand growth (years 1972–2001) was obtained in heavy thinning from above applied after each 10 years. The total mean increment in the 46-year-old trees was from 19.4 to 23.9 m^3 ha^{-1} $year^{-1}$ and from 10.5 to 13.3 t ha^{-1} $year^{-1}$ (Tokár 1998, 2002).

The phytotechnique (moderate thinning from above with positive selection and 5-year interval of repetition) in the pure (Fig. 3) and mixed stands of *Castanea sativa* Mill. on the PRP series Lefantovce (Table 2) resulted in better volume and mass production in the mixed (*Castanea sativa* Mill. + *Tilia cordata* Mill. (Fig. 4), *Castanea sativa* Mill. + *Pinus sylvestris* L.) stands than in the pure *Castanea sativa* Mill. stands (in volume by 5.31%–34.3%, in mass by 10.53%– 31.60%). The cause underlying the better production in the mixed stands compared to the pure ones should be assigned to the favourable allopathic relations and soil conditions developed in these stands. The total mean increments in the 38-year-old trees were from 14.42 to 19.17 m^3 ha^{-1} $year^{-1}$ and from 7.23 to 9.79 t ha^{-1} $year^{-1}$ (Tokár, 2002; Tokár and Krekulová, 2003, 2004).

Table 1. Volume and mass production in the pure stands of *Castanea sativa* Mill. on the PRP series Žirany in 2001 (stand age 46 years)

PRP	Thinning degree	Interval	Growing stock		Total production	
			m^3 ha^{-1}	t ha^{-1}	m^3 ha^{-1}	t ha^{-1}
I	Moderate	5	536	271	939	493
II	Moderate	10	566	260	894	486
III	Heavy	10	749	372	1,102	612
IV	Moderate	10	621	292	888	487
V	Heavy	10	755	384	1,094	597
VI	Control		676	325	876	483
VII	Heavy	10	634	331	965	541

Fig. 1. Stem of a high-quality edible chestnut (*Castanea sativa* Mill.) tree on the PRP Žirany (photo F. Tokár).

Fig. 2. Homogeneous stand of edible chestnut (*Castanea sativa* Mill.) on the PRP Žirany (photo F. Tokár).

Table 2. Volume and mass production in various stand types of *Castanea sativa* Mill. on the PRP series Lefantovce in 2001 (stand age 38 years)

Partial PRP	Species	Growing stock		Total production	
		m^3 ha^{-1}	t ha^{-1}	m^3 ha^{-1}	t ha^{-1}
I (Control)	*Castanea sativa* Mill.	356	174	548	292
II	*Castanea sativa* Mill.	336	152	556	282
III (Control)	*Castanea sativa* Mill.	195	88	411	211
	Tilia cordata Mill.	221	94	325	149
	Together	416	182	736	360
IV	*Castanea sativa* Mill.	261	129	426	232
	Tilia cordata Mill.	150	61	209	101
	Together	411	190	635	333
V (Control)	*Castanea sativa* Mill.	214	105	358	204
	Pinus sylvestris L.	220	124	316	173
	Together	434	229	674	377
VI	*Castanea sativa* Mill.	200	95	322	186
	Pinus sylvestris L.	171	73	263	130
	Together	371	168	585	316

Fig. 3. Homogeneous stand of edible chestnut (*Castanea sativa* Mill) on the PRP Lefantovce (photo F. Tokár).

Valuable ecological-production results were attained in the Castanetarium Horné Lefantovce (14.38 ha) by improving growth and production of 86 seed progenies of edible chestnut from 12 localities in Slovakia (Benčať and Tokár, 1978). In a tree age of 35 years, very good results were obtained in 15 seed progenies (Tokár, 2003). The production and resistance potential has been evaluated in Tokár et al., 2004.

The results of assessment of soils and phytocoenoses in the Castanetarium Horné Lefantovce and in the Castanetarium Jelenec showed that the edible chestnut was an important factor causing changes in the phyto-

Fig. 4. Thinning PRP of edible chestnut and small-leaf linden on the PRP Lefantovce (photo F. Tokár).

coenoses. The phytocoenoses in these localities belong into the 3rd forest vegetation tier, the group of forest types Fagetum pauper inferiora (Tokár and Kukla 2005, 2006).

In the pure (Fig. 5) and mixed stands of *Quercus rubra* L. and *Juglans nigra* L. on the PRP series Ivanka pri Nitre (Table 3), the overall production was most effectively controlled by moderate thinning from above with positive selection and repetition interval of 5 years in the mixed stands of *Juglans nigra* L. and *Quercus rubra* L. or *Tilia cordata* Mill. (Fig. 7). The overall mean increments in the trees aged 48 years were from 12.76 to 16.29 $m^3 ha^{-1} year^{-1}$ and from 8.16 to 11.54 $t ha^{-1} year^{-1}$ (Tokár 1991a, 1998, 2005).

In the pure stands of *Juglans nigra* L. on the PRP series Sikenica (Table 4, Fig. 6), stronger posi-

Table 3. Volume and mass production of various stand types of *Quercus rubra* L. and *Juglans nigra* L on the PRP series Sikenica in 2003 (stand age 48 years)

Partial PRP	Species	Proportion	Age	Growing stock		Total production	
		[%]	[years]	$m^3 ha^{-1}$	$t ha^{-1}$	$m^3 ha^{-1}$	$t ha^{-1}$
I	*Quercus rubra* L.	20	49	32	24	61	48
	Juglans nigra L	80	48	402	343	552	421
	Together	100		434	367	613	469
II	*Quercus rubra* L.	100	49	438	263	662	410
III	*Quercus rubra* L.	80	49	304	216	460	331
	Juglans nigra L.	20	48	175	125	242	162
	Together	100		479	341	702	493
IV	*Juglans nigra* L.	100	47	430	320	630	416
V	*Juglans nigra* L.	20	46	369	258	407	281
	Tilia cordata Mill.	80	42	132	56	180	86
	Together	100		501	314	581	367
VI (Control)	*Quercus rubra* L.	80	49	426	293	505	355
	Juglans nigra L.	20	48	261	194	287	206
	Together	100		687	487	792	561

Fig. 5. Homogeneous stand of red oak (*Quercus rubra* L.) on the PRP Ivanka pri Nitre (photo F. Tokár).

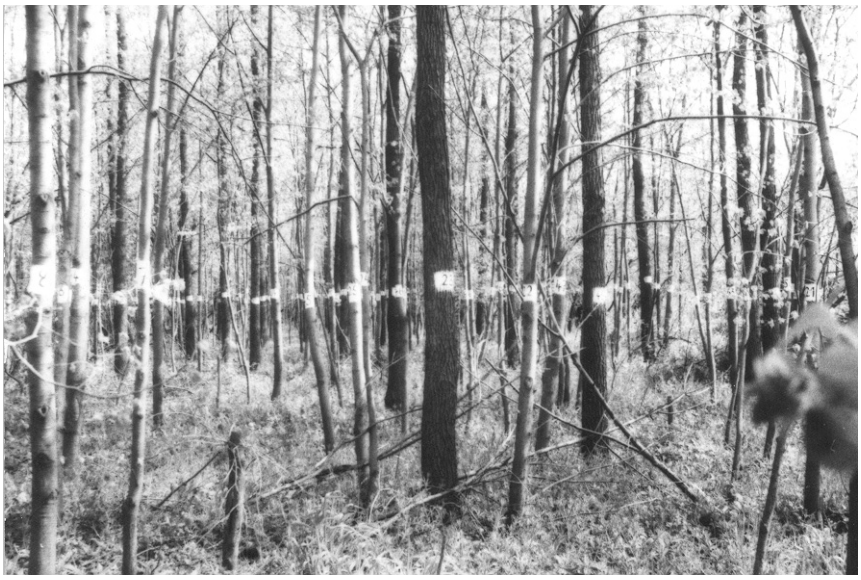

Fig. 7. Mixed stand of blacknut with small-leaf linden on the PRP Ivanka pri Nitre (photo F. Tokár).

tive impacts on the overall volume and mass production in years 1979–2003 were found for heavy thinning from above with positive selection and 5-year interval of repetition. The overall mean increments in the 64-year-old trees were from 7.22 to 8.95 m^3 ha^{-1} $year^{-1}$ and from 3.31 to 3.84 t ha^{-1} $year^{-1}$ (Tokár 1992, 1998; Tokár and Krekulová 2005).

Table 4. Volume and mass production in the pure stands of *Juglans nigra* L. on the PRP series Sikenica in 2003 (stand age 64 years)

PRP	Thinning degree	Growing stock		Total production	
		m^3 ha^{-1}	t ha^{-1}	m^3 ha^{-1}	t ha^{-1}
III	Moderate	381	173	468	215
IV	Heavy	464	195	573	246
V	Control	454	208	462	212

Fig. 6. Homogeneous stand of blacknut (*Juglans nigra* L.) with natural regeneration on the PRP Sikenica (photo F. Tokár).

On all PRP series, we used thinning methods focused on tending promising trees, selected from the trees with suitable quantitative and qualitative parameters (Tokár, 1987, 1998).

The content of elements in aboveground biomass and in soil in the forest stands composed of exotic woody plants varied with the plant species and the biomass compartment (e.g. Ca bark, stem; K leaves, Na stem xylem) (Tokár and Konôpková, 1995).

In the forests of Slovakia (primarily in southern areas of gft Carpineto-Quercetum), black locust (*Robinia pseudoacacia* L.) – one of the first woody plants introduced to Europe, has a specific status. Today the black locust forest stands represent about 34,000 ha, which is 1.87% of the total forest land area in Slovakia. The black locust production in forest stands in SW Slovakia was evaluated by Benčať (1988).

The destructive method used (sample trees) for assessment of aboveground biomass production in model stands of exotic woody plants was also suitable for deriving eco-physiological characteristics of these stands and woody plants (leaf area index – LAI, biomass production per leaf area unit, and similar) (Tokár 1987, 1998; Konôpková, 2003; Kmeť and ŠalgovičovÁ, 2003; Šalgovičová and Kmeť, 2004).

References

Benčať, F. 1982. *Atlas rozšírenia cudzokrajných drevín na Slovensku a rajonizácia ich pestovania* [Atlas of distribution of exotic woody species in Slovakia and zoning of their cultivation]. Bratislava: Veda. 368 p.

Benčať, T. 1988. *Black locust biomass production in Southern Slovakia*. Bratislava: Veda. 192 s.

Benčať, F., Tokár, F. 1978. Výsledky fenologického pozorovania gaštana jedlého (Castanea sativa Mill.) na experimentálnej ploche v Horných Lefantovciach [Results on phenological observations of the chestnut tree (Castanea sativa Mill.) on experimental plot in Horné Lefantovce. *Folia dendrol*., 4: 49–89.

Halaj, J. 1963. *Tabuľky na určovanie hmoty a prírastku porastov* [Tables to the determination of mass and increment of forest stands. Bratislava: SVPL. 328 p.

Halaj, J., Řehák, J. 1979. *Rastové tabuľky hlavných drevín ČSSR* [Yield tables of main woody plants in the ČSSR]. Bratislava: Príroda. 325 p.

Holubčík, M. 1968. *Cudzokrajné dreviny v lesnom hospodárstve* [Exotic woody plants in forest management]. Bratislava: SVPL. 371 p.

Kmeť, J. Šalgovičová, A. 2003. Ecophysiological aspect of growth of the European chestnut (Castanea sativa Mill.) in Slovakia. *Folia oecol*., 30: 141–147.

Konôpková, J. 2003. *Produkcia, energetický ekvivalent a obsah živín vybraných drevín. Autoreferát dizertačnej práce* [Production, energy equivalent and nutrient content of selected woody plants. Shortened version of PhD thesis]. Nitra: Slovenská poľnohospodárska univerzita v Nitre. 32 p.

Šalgovičová, A., Kmeť, J. 2004. Influence of site conditions on physiological status of black walnut (Juglans nigra L.) stands. *Folia oecol*., 31: 100–110.

Šebík, L., Polák, L. 1990. *Náuka o produkcii dreva* [Wood production science]. Bratislava: Príroda. 322 p.

Šmelko, Š. 2000. *Dendrometria* [Dendrometry]. Zvolen: Technická univerzita vo Zvolene. 399 p.

Šmelko, Š., Wolf, J. 1977. *Štatistické metódy v lesníctve* [Statistical methods in forestry]. Bratislava: Príroda. 330 p.

Tokár, F. 1976. Rastové a produkčné schopnosti vybraných lesnícky upotrebiteľných cudzokrajných ihličnatých drevín v parkoch na Slovensku [Yield and production abilities of selected forestry usable exotic coniferous trees in parks in Slovakia]. In Benčať, F. *Štúdie o ihličnatých drevinách*. *Zborník Dendrologickej sekcie Československej botanickej spoločnosti*. Bratislava: Veda, p. 201–211.

Tokár, F. 1979. *Zhodnotenie vybraných cudzokrajných listnatých drevín na Slovensku z hľadiska ich rastu a možnosti pestovania* [Evaluation of selected exotic broadleaved woody plants from viewpoint of their growth and cultivation possibilities]. Acta dendrobiologica, 1–2. Bratislava: Veda, p. 119–146.

Tokár, F. 1985. *Rozšírenie cudzokrajných drevín v lesných porastoch Malých Karpát a ekologicko-produkčná analýza ich hlavných druhov* [Distribution of exotic woody plants in the Little Carpathian stands and an ecological-production analysis of the main species]. Lesnictví, 31, 6, s. 501–518.

Tokár, F. 1987. *Biomasa vybraných cudzokrajných drevín v lesných porastoch juhozápadného Slovenska* [Biomass of selected exotic woody plants in forest stands of south-western Slovakia]. Acta dendrobiologica. Bratislava: Veda. 116 p.

Tokár, F. 1991a. Vplyv úrovňových prebierok na objemovú a hmotnostnú produkciu nadzemnej biomasy rôznych typov porastov Quercus rubra L. a Juglans nigra L. [Influence of crown thining on volume and weight production of above ground biomass of various stand types consisting of red oak (Quercus rubra L.) and black walnut (Juglans nigra L.)]. *Lesn. Čas*., 37: 349–362.

Tokár, F. 1991b. *Výskyt a produkcia vybraných cudzokrajných drevín v lesných ekosystémoch Malých Karpát* [Occurence and production of selected exotic woody plants in forest ecosystems in the Litte Carpathians]. Acta dendrobiologica. Bratiskava: Veda. 128 p.

Tokár, F. 1992. Vplyv prebierok na vývoj objemovej a hmotnostnej produkcie u nezmiešaných porastov orecha čierneho (Juglans nigra L.) [Influence of thinning on development of volume and weight production of pure black walnut (Juglans nigra L.)]. *Lesn. Čas. – For. J.*, 38: 189–203.

Tokár, F. 1998. *Fytotechnika a produkcia dendromasy porastov vybraných cudzokrajných drevín na Slovensku* [Phytotechnics and dendromass production of selected exotic woody plants in Slovakia]. Acta dendrobiologica. Bratislava: Veda. 157 s.

Tokár, F. 2002. Growth and production of dendromass in European chestnut stands (Castanea sativa Mill.) in Slovakia and their phytotechnics. *Ekológia (Bratislava)*, 21, Suppl. 2: 124–142.

Tokár, F. 2003. Growth, production and quality of 35-year old seed progenies of European chestnut (Castanea sativa Mill.). *Folia oecol*., 30: 99–106.

Tokár, F. 2005. Dub červený (Quercus rubra L.) a orech čierny (Juglans nigra L.) – významné cudzokrajné dreviny v sadovníctve, lesnej a poľnohospodárskej krajine [Red oak (Quercus rubra L.) and black wall nut (Juglans nigra L.) – important exotic woody plants in landscaping, forest and agricultural landscape]. In Bernadovičová, S., Juhásová, G. (eds). *Dreviny vo verejnej zeleni. Zborník z konferencie s medzinárodnou účasťou. Bratislava, 10. – 11. 5. 2005*. Zvolen: Ústav ekológie lesa SAV, p. 215–222.

Tokár, F., Juhásová, G., Bernadovičová, S., Adamčíková, K., Kobza, M., Pavlíková, A. 2004. Production and resistance potential of European chestnut (Castanea sativa Mill.) in the Castanetarium Horné Lefantovce. *Folia oecol*., 31: 40–52.

Tokár, F., Konôpková, J. 1995. Fytotechnika a dynamické zmeny obsahu vybraných chemických prvkov v nadzemnej dendromase rovnorodých porastov gaštana jedlého (Castanea sativa Mill.) [Silvicultural practices and dynamic changes in the content of some chemical elements in aboveground dendromass of pure stands of the Spanish chestnut (Castanea sativa Mill]. *Lesnictví – Forestry*, 41: 125–131.

Tokár, F., Krekulová, E. 2004. Aboveground biomass production and leaf area index in various types of chestnut (Castanea sativa Mill.) stands in Slovakia. *Ekológia (Bratislava)*, 23: 342–352.

Tokár, F., Krekulová, E. 2005. Influence of phytotechnology on growth, production and leaf area index of black walnut (Juglans nigra L.) monocultures in Slovakia. *J. Forest Sci*., 51: 213–224.

Tokár, F., Kukla, J. 2005. European chestnut (Castanea sativa Mill.) aboveground dendromass and its impact on composition of phytocoenoses in Jelenec Castanetarium PA. *Ekológia (Bratislava)*, 24: 217–230.

Tokár, F., Kukla, J. 2006. Ecological conditions in the Castanetarium Horné Lefantovce and growth of European chestnut (Castanea sativa Mill.). *Ekológia (Bratislava)*, 25: 188–207.

Received December 12, 2012
Accepted May 27, 2013