

Morphological variability of fruits in the European chestnut (*Castanea sativa* Mill.) seed progenies in the Castanetarium Horné Lefantovce

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Abstract

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The paper provides a comprehensive survey of parameters describing morphological variability of chestnut fruits (weight, shape index, colour, size of hilum, fruit partition, colour of kernel, ease of seed coat peeling, taste of kernel) for 86 seed progenies of European chestnut (*Castanea sativa* Mill.) planted in the Castanetarium Horné Lefantovce. The research was being conducted in 1996–1998. The age of seed progenies at the beginning of the survey was 30–32 years. The results revealed that many morphological traits were dependent on the seed progeny's provenance (selection tree, locality and sub-region of cultivation) and on climate history in the relevant year.

Key words

morphological traits of fruits, seed progenies, *Castanea sativa* Mill.

Introduction

The cultivation success of European chestnut (*Castanea sativa* Mill.) in climatic conditions of Slovakia is close dependent on thorough recognition of its biological and ecological properties. To meet this requirement, in 1965 was established the experimental Castanetarium in Horné Lefantovce (BENČAĽ and TOKÁR, 1971), coordinated by the Arboretum Mlyňany, Institute of Woody Plants Biology SAS (Fig 1). The main goal was centralisation of comprehensive research on biology, ecology and production of European chestnut trees into uniform ecological site conditions.

At present, the Castanetarium Horné Lefantovce represents the precious centralised national gene pool of European chestnut, requiring a special attention in both research and forest management as well as specific management methods. For this reason, with forest management plans updated in 1999, the territory has been assigned to special-purposed forests.

Apart from biological manifestations of the examined woody plant, the research in the Castanetarium Horné Lefantovce was also aimed at verification of genetic stability or variability of morphological parameters of fruits in selected seed progenies.

In this work we present ecological description of the Castanetarium and the results of fruit morphological variability for 86 seed progenies of European chestnut (*Castanea sativa* Mill.) belonging in the year 2001, at their age of 35 years, into five categories (TOKÁR, 2003).

Material and methods

Ecological description of the Castanetarium

The Castanetarium having an area of 14.38 ha is situated at 220–250 m asl, north of the Nitra town, cadastre territory Horné Lefantovce, locality "Ferdinandka" in

the Tríbeč Mts. It was established in years 1965–1970, on former agricultural land, by the founder Institute of Woody Plants Biology SAS in Nitra. As for administration, it belongs to the national forests, Forest Enterprise Topoľčianky, Forest Management Unit Nitrianska Streda, Forest District Lefantovce.

The climate is warm, type A. At the time of establishment, the soil type was brown soil loamy or clayey-loamy (BENČAĎ and TOKÁR, 1971). Under a 35-year influence of the planted chestnut stands, the soils have been converted to luvisols with the typical illimerisation horizon (TOKÁR and KUKLA, 2006).

As for phyto-geography, the Castanetarium belongs to the West Carpathian area (Carpaticum occidentale), Pre-Carpathian region (Praecarpaticum).

Before the plantation of chestnut trees, the territory had been used as arable land. The succession processes, for 35 years associated with growing woody plants, have resulted in formation of forest communities of the third (oak-beech) forest vegetation tier. In the phytocenoses we identified 86 mostly mesotrophic species, characteristic for the group of forest types Fagetum pauper inferiora (TOKÁR and KUKLA, 2006).

In 1965–1970, the Castanetarium was planted with 57,056 European chestnut plants configured as corresponding to various stand formations, mostly as seed progenies (86 seed progenies making a total of 24,145 trees, Fig 1). The tree number in the year 2001, at the age of 35 years was 13,589 chestnut trees, representing 23.82% of the original plants. This final number has been reached with repeated tending (thinning six times) and sanitary cuts (damaged and dry trees).

Fruit morphology

We were conducting a thorough survey on weight and perception-related variability of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) assembled into the Castanetarium Horné Lefantovce, from 123 selection trees from 12 localities in Slovakia (BENČAĎ and TOKÁR, 1971). In 1996, 1997 and 1998 we performed detailed evaluations of fruit morphology for 86 seed progenies at their physical age of 30–32 years. This problem was studied also in the framework of the diploma work (PERHÁČOVÁ, 1999). However, some phenological manifestations as the first flowering (types and anomalies of inflorescence, the first fruits, types of fruits grouping, timing of maturity, damage by late frosts), we also recorded during the development (growth) of the seed progenies and grafted trees concentrated in the clone orchard in the Castanetarium.

The fruits of European chestnut were assorted into the following weight classes:

	Weight
Very light	less than 4.1 g
Light	4.2–4.9 g

Medium weighty	5.0–5.5 g
Weighty	5.6–6.0 g
Very weighty	more than 6.1 g.

The shape was classified based on the shape index (fruit width to the fruit length) into the following shape categories:

	Index
Triangular	less than 0.90
Round	0.91–1.04
Narrow elliptic	1.05–1.15
Broad elliptic	1.16–1.30
Very broad elliptic	above 1.31.

Immediately after the collection we examined the colour:

- o Yellowish-red
- o Brown-red
- o Brown
- o Brown-black.

Another important morphological trait of chestnut fruits is the size of hilum:

- o Small
- o Medium
- o Large.

The fruit partition was evaluated as:

- o Without concretions (single fruit)
- o Partially grown together (short septa)
- o Entirely grown together (multi-seed fruit) fully.

The colour of kernel was evaluated as:

- o White
- o Creamy-white
- o Yellowish.

Seed coat peeling was classified as:

- o Very good
- o Good
- o Bad.

For consummation is important the taste of kernel.

It was categorised as:

- o Sugar-like sweet
- o Medium sweet
- o Low sweet.

The seed progenies were labelled following the original labelling of the European chestnut selection trees in each of the Slovak localities monitored by BENČAĎ (1960), based on morphological and chemical analysis of their fruits (BENČAĎ et al., 1980; BENČAĎ and TOKÁR, 1998; BENČAĎ et al., 1999), in such a way as to enable assessment of their hereditary and genetic connectivity. The seed progenies were labelled as: Bratislava (BA), Častá (Č), Radošina (RA), Duchonka (D), Horné Lefantovce (HL), Jelenec (J), Tlstý Vrch (TV), Dolné Príbelce (DP), Stredné Plachtince (SPL), Modrý Kameň (MK), Rovňany (RO), Krná (K).

Morphometric and perception-related characteristics of fruits of European chestnut progenies were evaluated yearly, on samples consisting of 30 fruits from each seed progeny.

The data about climate in 1996–1998, necessary for assessing the influence of climate on development of the fruit weight were provided by the Slovak Agricultural University in Nitra (ŠPÁNIK et al., 2002).

Results

Fruit weight

An important morphological trait in fruits of European chestnut is their weight. BENČAĎ and TOKÁR (1972, 1979a,b) report that the fruit weight is positively correlated with the height of plants and cultures of European chestnut up to three years after the plantation. Several-year observations allow us to conclude that the chestnut fruits in Slovakia have a mean weight of 7.3 g with variation range of 3.8–15.2 g and the variation coefficient of 27.8% (BENČAĎ et al., 1980).

The statistical evaluation of weight of fruits from 86 seed progenies from European chestnut performed in 1996–1998 (tree age 30–32 years) resulted in classification into five weight categories, from very light up to very weighty (Table 1).

The experience gained with 12 localities, 4 sub-regions and 3 climatic years of growing European chestnut trees in the Castanetarium Horné Lefantovce, allows us to draw the following conclusions about the weight of chestnut fruits:

- o Fruits of European chestnut seed progenies are characterised with high individual, local, regional and climate-related (annual) variability.
- o The average weight of fruits from 86 seed progenies ranged from 2.20 g (Duchonka 13) to 8.44 g (Jelenec 11) with variation coefficient from 32% (Radošina 2) to 40.09% (Duchonka 10). The lowest (min) weight of individual fruits (1.40 g) was found in the seed progeny Duchonka 5 in year 1996, the highest absolute weight (14.40 g) was observed in seed progeny Duchonka 8 in 1998. The lowest variability of fruit weight (6.32%) was reached in seed progenies from the locality Radošina in 1997, the highest (40.09%) in seed progenies from the locality Duchonka in 1997. The both localities belong to the sub-region the Inovecko-Tríbečské Mts (Table 1).
- o For development of fruits of European chestnut, the key important period was always from June to September. The values of climatic variables for 1996–1998 are listed in Table 2. We can see that temperature and precipitation values were different in the three different growing seasons. The difference in mean temperature was found biggest (1.9 °C) between

years 1998 and 1996, the difference between the precipitation totals was found most conspicuous (51.2 mm) between 1998 and 1997. For the fruit development is also decisive the course of the two variables over the vegetation period. The year 1996 was favourable in precipitation, but September was rather cold. The years 1997 and 1998 were normal in temperature, but precipitation in July 1997 and September 1998 was remarkably above the normal. On the other hand, precipitation amounts in August and September 1997 and in June and August 1998 were deeply below the normal value. For the sound fruit development are favourable lower precipitation totals and less favourable (lowering the fruit weight) is more abundant precipitation. The critical value has been set to 30 mm. This value was not reached in August and September 1997, only.

- o Apart from genetic factors, the weight of developing fruits in seed progenies is also influenced by the environmental (climatic) conditions and by the tree age. In case of the seed progenies, the first fruits were recorded already in 1971, at the tree age of 5 years. The fruits were found in 18 seed progenies (SP) from the localities Jelenec (6 SP), Horné Lefantovce (2 SP), Tlstý Vrch (6 SP), Častá (1 SP), Duchonka (3 SP). In 1972 fructified 21 seed progenies (SP) from the localities Jelenec (9 SP), Horné Lefantovce (4 SP), Tlstý Vrch (4 SP), Častá (1 SP), Duchonka (3 SP), in 1973 there were fructifying 33 seed progenies from Jelenec (9 SP), Duchonka (6 SP), Častá (2 SP), Tlstý Vrch (10 SP), Horné Lefantovce (5 SP), Radošina (1 SP), in 1974, 30 seed progenies from Horné Lefantovce (6 SP), Tlstý Vrch (9 SP), Jelenec (9 SP), Častá (2 SP), Duchonka (4 SP). The number of fructifying seed progenies and the weight of their fruits were always significantly dependent, apart from age, on ecological site conditions (primarily by light supply).

Since 1975 (age of seed progenies 10 years), the fruit collection has been being organised by the Forest Management Unit Nitrianska Streda.

Fruit shape

Based on their shape index (fruit width/fruit length), the fruits of European chestnut progenies were classified according to shape categories, from triangular up to very broad elliptic (Table 3, Figs 2, 3). The least frequent was the category of round-shaped fruits (1.16%), the most abundant were broad-elliptic (33.72%) and very broad elliptic fruits (32.56%).

Table 1. Weight variability of fruits of European chestnut seed progenies (SP) according to localities and sub-regions in Slovakia

Locality/ Subregion	Number SP	Years	Weight [g]					
			Abs min	Abs max	x		v _x [%]	
					Min	Max	Min	Max
Bratislava	5	1996	1.50	9.40	4.79	6.18	15.26	35.60
		1997	1.50	9.50	4.46	5.62	15.91	26.47
		1998	1.80	11.80	4.73	7.93	17.01	26.99
Častá	2	1996	2.20	8.00	4.25	5.86	20.38	30.44
		1997	2.30	8.10	3.98	4.97	25.89	35.10
		1998	3.40	10.30	4.99	6.15	22.83	26.33
Malé Karpaty Mts subregion	7	1996	1.50	9.40	4.25	6.18	15.26	35.60
		1997	1.50	9.50	3.98	5.62	15.91	35.10
		1998	1.80	11.80	4.73	7.93	17.01	26.99
Jelenec	11	1996	2.20	9.40	4.05	5.87	17.03	34.04
		1997	2.00	9.60	3.82	8.44	10.78	38.90
		1998	1.80	9.60	3.40	5.43	19.70	28.90
Horné Lefantovce	16	1996	1.60	10.30	2.34	6.41	16.54	39.39
		1997	2.00	10.80	3.97	6.99	10.05	31.90
		1998	1.90	11.80	4.31	7.45	16.61	33.31
Radošina	5	1996	2.30	10.00	3.54	5.65	20.36	33.43
		1997	2.40	10.40	3.28	5.98	6.32	34.40
		1998	2.40	9.30	4.04	6.23	17.42	30.25
Duchonka	14	1996	1.40	10.40	3.49	6.15	20.38	39.35
		1997	1.50	10.40	2.20	6.51	17.48	40.09
		1998	1.69	14.40	3.97	6.93	13.53	31.23
Inovec – Tríbeč Mts subregion	46	1996	1.40	10.40	2.34	6.41	16.54	39.39
		1997	1.50	10.80	2.20	8.44	6.32	40.09
		1998	1.69	14.40	3.40	7.45	13.53	33.31
Tlstý Vrch	11	1996	1.90	10.10	3.67	5.90	16.43	39.98
		1997	2.20	8.40	2.54	6.80	10.12	38.46
		1998	2.40	13.20	4.16	8.31	15.36	25.35
Modrý Kameň	6	1996	2.10	8.30	4.10	5.49	16.05	31.96
		1997	2.30	8.60	3.97	5.35	12.02	25.80
		1998	2.50	10.70	4.32	6.85	21.20	30.24
Stredné Plachtince	4	1996	2.00	7.90	3.38	5.39	17.07	28.57
		1997	2.10	8.20	3.87	4.89	11.58	18.07
		1998	2.30	10.30	4.37	6.19	18.69	31.29
Dolné Příbelce	2	1996	3.20	10.30	5.40	6.18	15.26	29.89
		1997	2.80	10.20	4.62	5.62	17.36	57.85
		1998	3.10	9.90	4.71	6.80	17.01	19.99
Štiavnica – Krupina Mts subregion	23	1996	1.90	10.30	3.38	6.18	15.26	39.98
		1997	2.10	10.20	2.54	6.80	10.12	38.46
		1998	2.30	13.20	4.16	8.31	15.36	31.29

Table 1. Continued

Locality/ Subregion	Number SP	Years	Abs min	Abs max	Weight [g]		v_x [%]	
					x			
					Min	Max	Min	Max
Rovňany	6	1996	2.40	9.40	4.41	5.88	18.62	32.34
		1997	2.50	9.50	4.02	5.31	10.47	30.22
		1998	2.70	8.42	4.92	5.74	18.25	23.24
Krná	4	1996	2.10	9.48	3.16	5.70	23.08	29.78
		1997	2.30	9.60	3.19	5.04	25.01	32.26
		1998	2.60	8.40	4.65	5.67	20.14	23.58
Central Slovakia Mts subregion	10	1996	2.10	9.48	3.16	5.88	18.62	32.34
		1997	2.30	9.60	3.19	5.31	10.47	32.26
		1998	2.60	8.42	4.92	5.74	18.25	23.58
Slovakia	86	1996	1.40	10.40	2.34	6.41	15.26	39.98
		1997	1.50	10.80	2.20	8.44	6.32	40.09
		1998	1.69	14.40	3.40	8.31	13.53	33.31

Table 2. Climatic data for the years 1996, 1997, 1998

Year	Climatic data	Month				
		VI	VII	VIII	IX	VI–IX
1996	Mean temperature [°C]	19.2	18.3	19.4	11.9	17.2
	Precipitation total [mm]	49.8	69.4	59.4	78.1	256.7
1997	Mean temperature [°C]	18.6	19.0	20.8	15.3	18.4
	Precipitation total [mm]	61.3	117.2	13.4	27.9	219.8
1998	Mean temperature [°C]	19.6	21.0	20.9	15.1	19.1
	Precipitation total [mm]	28.8	61.4	31.2	149.6	271.0

Table 3. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the fruit shape

Shape	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
Triangular	HL17, RA 3, K1
Round	D 9
Short-elliptic	BA 3, Č 2, J 2, 3, 4, 5, 8, 11, HL 3, 8, 11, 12, 13, 14, RA 5, D 2, 5, 6, 13, TV 4', MK 6, 7, SPL 4, 5, K 3
Broad-elliptic	BA 1, 4, 5, Č 1, J 1, 9, 10, HLA 1, 9, 10, D 3, 7, 8', 10, 12, 13', TV 2, 2', 3, 4, 6, 8, 9, MK 8, 9, 14, DP 4, K 2
Very-broad-elliptic	BA 2, J 6, 7, HL 2, 7, 15, 18, 19, RA 2, 6, D, D 8, 18, TV 1, 5, 7, MK 5, RO 1, 2, 3, 4, 4', 6, DP 5, 5', SPL 7, 11, K 5



Fig 2. Triangular shape of fruits in trees from the seed progenies of European chestnut (*Castanea sativa* Mill.)



Fig 3. Short elliptical shape of fruits in trees from the seed progenies of European Chestnut (*Castanea sativa* Mill.)

Fruit colour and size of hilum

The fruit colour and size of hilum are important morphological traits for visual classification of European chestnut fruits. The most frequent (53.49%) colour-

ing was brown (Table 4), the most frequent (74.42%) hilum's size was medium (Table 5).

Rather rare were yellowish-red fruits and fruits with large hilum.

Table 4. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the fruit colour

Colour	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
Yellowish-red	BA 4, D 8'
Brown-red	BA 1, 2, J 2, 7, 11, HL 3, 10, 12, RA 3, 5, D 2, 5, 6, 7, 8, TV 2, 2', 8
Brown	BA 3, 5, Č 2, J 1, 3, 5, 6, 8, 9, HLA 1, 2, 9, 11, HL 13, 14, 15, 18, 19, RA 6, D 3, 10, 12, 13, 18, TV 1, 3, 4, 4', 7, 9, MK 5, 6, 7, 14, SPL 4, 5, 7, 11, DP 4, 5, 5', K 1, 2, 3, 5
Brown-black	Č 1, J 4, 10, HL 7, 8, 17, RA 2, D, D 9, 13', TV 5, 6, MK 8, 9, RO 1, 2, 3, 4, 4', 6

Table 5. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the hilum's size

Size of hilum	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
Small	Č 2, J 4, HL 8, RA 2, D 9, 18, MK 5, SPL 5, 7, 11, DP 5', K 6
Medium	BA 1, 2, 3, 4, 5, Č 1, J 2, 3, 5, 6, 7, 8, 9, 10, 11, HLA 2, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, RA 3, 5, 6, D, D 2, 3, 5, 6, 8, 8', 12, 13, TV 1, 2, 2', 4', 5, 6, 7, MK 6, 7, 8, 9, 14, SPL 4, DP 5, RO 1, 2, 3, 4, 4', K 1, 2, 3, 5
Large	1, HL 1, D 7, 10, 13', TV 3, 4, 8, 9, DP 4

Perception-related properties of European chestnut fruits

The perception-related properties of European chestnut fruits mean: fruit partition, colour of kernel immediately after the fruit crosscutting, ease of seed coat peeling and taste of fresh kernel.

Fruit partition was evaluated based on the number

and length of septa (Fig 4). The most frequent (38.37%) were (Table 6) fruits fully concreted with septa (multiple-seed fruit). The rarest (27.91%) were separated fruits (single-seed fruit).

As for the kernel colour, the most frequent were seed progenies coloured creamy-white (76.65%), the rarest 9.30% were seed progenies with white-coloured kernel (Table 7).



Fig 4. Short elliptic shape, partition of fruits and pellicle intrusion from the left: multiseed fruit, fruit with pellicle intrusion and non-parted fruit in trees from the seed progenies of European chestnut (*Castanea sativa* Mill.)

Consumption value of European chestnut fruits is evaluated based on ease of seed coat peeling (separation of the hard pericarp from the kernel) and based on sugars amount. Confectioner's trade is interested in consumable chestnut fruits with easy coat peeling and high contents of sugars.

In our seed progenies are most abundant (45.35%) seed progenies producing fruits easy to peel, the least frequent (12.79%) are fruits with poor peeling (Table 8).

According to the taste of kernel (Table 9), the seed progenies belong to the categories sugar-like sweet (29.07%), medium sweet (60,46%) and low sweet (10.47%).

Table 6. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the fruit partition

Fruit partition	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
Single	B 1, 4, 5, J 1, 4, 5, 9, 11, RA D, 2, D 10, 13, 18, TV 2, 2', 3, 4, 4', 5, 6, 8, 9, MK 6, K 1
Partially grown together	BA 2, 3, Č 1, 2, J 2, 6, 8, 10, HL 11, RA 3, 5, D 2, D 3, 6, TV 7, MK 5, 7, 9, 14, SPL 4, 7, 11, DP 4, RO 1, 2, 3, 4, 4', 5
Totally grown together	J 3, 7, HL A, 1, 2, 3, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18, 19, RA 6, D 5, 7, 8, 8', 9, 12, 13', TV 1, MK 8, SPL 5, DP 5, 5', K 2, 3, 5

Table 7. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the colour of kernel

Color of kernel	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
White	BA 5, Č 1, 2, J 7, HLA, TV1, MK 9, DP 5'
Creamy white	BA 1, 2, 3, 4, J 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, HL 1, 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, RA D 2, 3, 5, 6, D 2, 3, 5, 6, 7, 8, 8', 9, 10, 12, 13, 18, TV 2', 3, 4, 4', 5, 6, 7, 9, MK 6, 7, 14, SPL 4, 7, DP 4, 5, RO 1, 2, 4, 6, K 1, 2, 5
Yellowish	HL 15, 19, D 13', TV 2, 8, MK 5, 8, SPL 5, 11, RO 3, 5, K 3

Table 8. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the seed coat peeling

Ease of seed coat peeling	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
Very good	BA 2, 3, 4, J 3, 8, 9, HL 3, 7, 8, 12, 13, 14, 18, 19, RA 2, D 5, 6, 7, 8', 9, RA 2, TV 2', 4', 6, 9, MK 14, SPL 4, 5, 7, 11, RO 3, 4, 6, K 1, 2, 3
Good	BA 1, 5, Č 2, J 1, 4, 6, 7, 10, RA D, 3, 5, 6, D 2, 10, 13, 13', 18, HLA, 1, 2, 5, 11, 15, 17, TV 1, 3, 5, 7, 8, MK 5, 6, 7, 8, 9, DP 4, 5', RO 1, 2, K 5
Bad	Č 1, J 2, 5, 11, HL 9, 10, D 5, 8, TV 2, 4, DP 5

Table 9. Categorization of fruits of seed progenies of European chestnut (*Castanea sativa* Mill.) according to the taste of kernel

Taste of kernel	Fruits of seed progenies of European chestnut (<i>Castanea sativa</i> Mill.)
Sweet	Č 1, J 9, HL 1, 2, 3, 9, 19, RA 5, D 3, 5, 8, 13, 13', TV 8, MK 5, 6, 7, 9, 14, SPL 4, 7, 11, RO 1, 2, K 5
Medium sweet	RA D, 2, 3, 6, D 2, 6, 7, 9, 10, 12, 18, TV 1, 2, 4, 4', 5, 6, 9, MK 8, SPL 5, DP 4, 5, 5', RO 4, 4', 6, K 1, 2, 3
Low sweet	J 1, 5, 7, HL 13, D 8', TV 2', 3, 7, RO 3

Discussion

Our results show that biometric variables and perception-related properties of seed progenies of European chestnut assembled under homogenous ecological conditions (TOKÁR and KUKLA, 2006) are very variable, and that they have not been stabilised yet. Some of them, eg weight and taste, are influenced to a considerable extent by the tree age and sociological status in the stand. Consequently, they can still be influenced with appropriate physiologically-oriented management methods. All the seed progenies have got through the same development, and to present, they have reached thick-pole stage (Figs 5, 6). The 35-year development of production and resistance potential of the seed progenies in the Castanetarium Horné Lefantovce has been mapped by BENČAĚ and TOKÁR (1984), TOKÁR (1993, 1996, 2003), TOKÁR and BOLVANSKÝ (2002) and TOKÁR and JUHÁSOVÁ et al. (2004).



Fig 5. View of 30-year-old seed progeny of European chestnut Tlstý Vrch 3 in Castanetarium Horné Lefantovce



Fig 6. Seed progeny of European chestnut at the age of 30-years Duchonka 2 in Castanetarium Horné Lefantovce

Morphometric parameters of fruits of European chestnut seed progenies are significantly influenced by genetic factors, environment (controlled with stand phytotechnique) and climate history in the given year. Over the period of fruits development, the influence of these factors switches between profit for temperature or precipitation, primarily when these variables are exceeding their normal limits. BENČAĚ (1968), BENČAĚ and BOLVANSKÝ (1984) and BENČAĚ and TOKÁR (1998) suggest that production of European chestnut fruits can be empowered in amount and quality by long dry period or, on the other hand, by too abundant precipitation, primarily in the flowering period when it represents a serious danger to the pollination process. BRICCOLI (1934 ex BENČAĚ, 1960) suggests a value of 30 mm as the critical limit for monthly precipitation total for fruit development in this period. Also the contents of sugars in European chestnut fruits in Slovakia are favourably influenced by higher temperature and lower precipitation,

namely when the second is uniformly distributed over the period of fruit development (BENČAĎ et al., 1999).

Quantitative characteristics of fruits (weight, shape index, hilum size, number of seeds in the capsule) in seed progenies obtained by means of intraspecific and interspecific hybridisation (*Castanea sativa* × *Castanea crenata*) in Slovakia have been evaluated by BOLVANSKÝ (1988) and BOLVANSKÝ and MENDEL (2001). The fruit weight was found positively correlated with mean temperature and precipitation total both over the vegetation period and all over the year.

The fruit morpho-metrics (shape index) and septa morphology in multiple-seed (grown together) fruits of European chestnut at four Slovak localities has been evaluated by BOLVANSKÝ and UŽÍK (2005). The referred authors suggest that fruit quality of European chestnut is also possible to improve by means of hybridisation.

The shape index of fruits of European chestnut parent trees of the seed progenies in the Castanetarium Horné Lefantovce was evaluated by BENČAĎ and TOKÁR (1998) in the original localities and sub-regions in Slovakia in 1976–1978. The lowest value (0.87) was obtained in the locality Stredné Plachtince, the highest (1.32) in Radošina. The Slovak average value was 1.06. Fruits of most selection were classified as narrow-elliptic (27.18%). Twelve of the seed progenies in the Castanetarium have preserved the shape categories of the original trees. We can conclude about genetic contingency.

From the other characteristics, for fruit consumption is primarily important taste of kernel. Consumers and confectioners seek edible chestnuts with higher or medium weight, brown-coloured, easy or very easy to peel and sugar-sweet to medium sweet kernel. Following the long term (9 years) evaluation of chemical composition of fruits of 123 selection (parent) trees growing in 12 Slovak localities (BENČAĎ et al., 1999) and their seed progenies in the Castanetarium, we can suggest the following categorisation: low sweet (content of sugars less than 20.00%) – 23 trees (18.89%), medium sweet (sugars content 20.10–25.00%) – 76 trees (61.79%) and very sweet (sugars content 25.1–30.00%) – 24 trees (19.51%). The content of sugars in fruits of European chestnut is influenced by climatic conditions (more favourable is higher temperature and lower precipitation). The average values of sugars contents in the natural area of this woody plant range from 14–26% (BENČAĎ, 1968). The results of chemical analyses of fruits of Slovak chestnut trees (BENČAĎ et al., 1999) allow us to conclude that the content of sugars in Slovak chestnuts is not below the values from the natural area.

In the seed progenies are also present several botanic forms as var. *spicata* (Krná 1), f. *rubida* (Bratislava 1), f. *elongata* (Radošina 3).

Conclusions

The work evaluates biometric and perception-related traits (weight, shape index, colour, kernel colour, hilum size, ease of seed coat peeling, kernel taste) of fruits from 86 seed progenies of European chestnut (*Castanea sativa* Mill.) in the Castanetarium Horné Lefantovce, at the tree age of 30–32 years (1996, 1997 and 1998).

Several features are variable and not stabilised yet. Their values are influenced, apart from the tree age, also by genetic outfit (selection tree, locality, region), physiologically oriented cultivation methods, and mostly by weather conditions. The influence of these factors is positive either depending on temperature or depending on precipitation, mainly when the two variables are exceeding their normal values.

The average fruit weight ranged from 2.20 g (Duchonka 13) to 8.44 g (Jelenec 11), with variation coefficient from 6.32% (Radošina 2) to 40.09% (Duchonka 10).

According to the shape index, the fruits of seed progenies of European chestnut in the Castanetarium were classified to shape categories, from triangular to very broad-elliptic. The most frequent (33.72%) were broad-elliptic fruits.

As for the fruit colour, the most abundant (53.49%) were brown fruits, as for the hilum size, the most abundant (74.42%) were fruits with medium-sized hilum. Most seed progenies (38.37%) produce multiple-seed fruits, the biggest was proportion of fruits with creamy-white coloured kernel (76.74%).

The seed progenies of European chestnut produce most (45.35%) fruits easy to peel and most fruits (60.46%) with sweet kernel. The content of sugars in fruits of edible chestnut is influenced by climate (more favourable is higher temperature and lower precipitation).

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Morfologická variabilita plodov semenných potomstiev gaššana jedlého (*Castanea sativa* Mill.) v Castanetariu Horné Lefantovce

Súhrn

Práca zhodnocuje biometrické a senzorické znaky (hmotnosť, tvarový index, farba, zrastenosť, farba jadra, veľkosť jazvy, lúpatelnosť a chuť jadra) plodov 86 semenných potomstiev gaššana jedlého (*Castanea sativa* Mill.) v Castanetariu Horné Lefantovce pri veku 30–32 rokov (v r. 1996, 1997 a 1998).

Mnohé znaky sú variabilné a doposiaľ ešte neustálené. Ich hodnoty sú ovplyvnené okrem fyzického veku aj genetickou dispozíciou (výberový strom, lokalita, oblasť) a ďalšími fyziologicko-pestovnými opatreniami, najviac však klimatickými faktormi. Ich vplyv sa presúva v období vývinu plodu buď v prospech teploty alebo zrážok, a to najmä vtedy, keď vybočujú zo svojich normálnych hodnôt.

Priemerná hmotnosť plodov bola od 2,20 g (Duchonka 13) do 8,44 g (Jelenec 11) s variačným koeficientom od 6,32 % (Radošina 2) do 40,09 % (Duchonka 10).

Podľa tvarového indexu boli plody semenných potomstiev gaššana jedlého v Castanetariu Horné Lefantovce zatriedené do kategórií od trojuholníkovitých až k veľmi širokoeliptickým. Najviac je zastúpená kategória plodov širokoeliptických (33,72 %).

Z hľadiska farby plodov sú najviac zastúpené plody farby gaššanovej (53,49 %) a s jazvou strednej veľkosti (74,42 %). Najviac semenných potomstiev prináša plody zrastené (viacsemenné, 38,37 %) s krémovito bielou farbou jadra (76,74 %).

Semenné potomstvá gaššana jedlého prinášajú najviac plody s dobrou lúpatelnosťou (45,35 %) a polosladkou chuťou jadra (60,46 %). Obsah cukrov v plodoch gaššana jedlého ovplyvňujú klimatické podmienky (priaznivejšie vplývajú vyššie teploty a nižšie zrážky).

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