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Original scientific paper

POMOLOGICAL CHARACTERISTICS OF SUPERIOR SELECTIONS OF EUROPEAN FILBERT (*C. AVELLANA* L.) AND TURKISH HAZEL (*C. COLURNA* L.)

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Eight selections of European filbert and Turkish hazel each were singled out for their prominent characteristics in an examination in Eastern Serbia over the 1998-2003 period. Coarseness, form and weight of nuts and kernels, as well as kernel chemical content, were analysed. Yielding potential was investigated as a proportion of nuts in filbert and hazel inflorescences. Average nut coarseness of the *C. avellana* L. selections was 18.0x14.7x12.6 mm, and of *C. colurna* L. 16.3x14.0x 11.0 mm, while average kernel coarseness was 13.3x9.1x7.6 mm and 13.9x 9.7x 6.5 mm, respectively. Nut weight of the former was 1.01-1.80 g, and of the latter 1.00-1.75 g, while kernel weight ranged 0.30-0.79 g, and 0.31-0.65 g, respectively. The respective kernel contents were 27.9-46.2%, and 30.7-40.8 %. The occurance of shriveled nuts was minimal, appearing in six selections of *C. avellana* (0.8-3.1%), and five selections of *C. colurna* (1.4-5.7%). The pest *Balaninus nucum* was observed in only three selections of *C. colurna* L., ranging from 1.0 to 1.6 %. Oil content in the nuts of the selected *C. avellana* L. trees was 44.6-49.9 %, and 48.6-54.4 % in those of *C. colurna* L. Crude proteins amounted to 12.3-10.8 % and 11.7-10.4 %, and mineral matter content to 2.8-2.4% and 2.6-2.0 %, respectively. The selections of European filbert were found to have 4-6 nuts to an inflorescence. Predominating were two (29.4 %), one (26.7 %) and

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three (24.5 %) nuts to a single inflorescence. *C. colurna* L. inflorescences were found to contain 8-13 nuts. Most inflorescences had five (26.6 %), four (21.5 %) and six nuts (20.3 %). Selections 1, 5, 6 and 3 of *C. avellana* were found to be especially outstanding regarding most parameters, as well as selections 7, 3, 2 and 8 of *C. colurna* L.

Key words: European filbert, Turkish hazel, selection, nut, yielding potential

INTRODUCTION

European filbert (*Crylus avellana* L.) and Turkish hazel (*C. colurna* L.) are widespread across eastern Serbia, mostly sharing their phytocoenoses with various other forest plants, or growing in homogenous strands. The forms of European filbert and Turkish hazel trees growing spontaneously in natural environments have generative origin and make a significant gene pool of various traits. Considering the existing deficiency in biological high-quality food and prospects for such production, European filbert and Turkish hazel nuts provide an excellent fresh material for the purpose.

The biodiversity and pomological and technological properties of European filbert and Turkish hazel have been studied under different agroecological conditions by MITREVSKI *et al*. (1983), MANUŠEV (1988), MITROVIĆ *et al*. (1997) and MILETIĆ *et al*. (1997), while BULATOVIĆ (1985) has reported on their yielding potentials. Based on their work, PEJKIĆ (1980) and NINIĆ-TODOROVIĆ (1987) proceeded to isolate their selections. KRSTIĆ-PAVLOVIĆ *et al*. (1990) and the aforementioned authors have pointed out the value, quality and medicinal effects of their nuts. Years of investigation of the populations of European filbert and Turkish hazel in eastern Serbia have resulted in identifying some superior *in situ* selections for that purpose, which is also the subject of this article. Our research and our selections make a contribution to preserving the biodiversity, providing high-quality multiplication and supplying fresh material for the production of biologically high-quality food.

MATERIALS AND METHODS

The investigation was carried out across a wide region of eastern Serbia, where European filbert and Turkish hazel grow in large numbers. The analysis focused on shrubs and trees with particularly luxuriant appearace, vitality, high and regular yield, tolerance to low temperatures and to the hazelnut weevil (*Balaninus nucum*). Close attention was also focused on the coarseness, shape and weight of nuts and kernels, and kernel chemical composition. Yielding capacity, i.e. the proportion of nuts to an inflorescence, was also carefully studied.

We selected eight trees of each species out of a large number of studied shrubs and trees that showed the best results over a previous period of several successive years (1998-2003). The nuts collected from them were analysed for the following properties: nut and kernel coarseness (length, width, thickness) measured

by square callipers, and weight measured on a high-precision technical balance. Oil content was determined by nuclear magnetic resonance, crude proteins by the Kjeldahl method, and mineral matter by burning off. The article presents data collected over several years and statistically processed by the analysis of variance and Duncan`s test.

RESULTS

Data on the coarseness and shape of nuts and kernels of the isolated selections of European filbert and Turkish hazel are presented in Table 1.

Table 1. Fruit and kernel size of a European filbert and Turkish hazel

Species	No.	Fruit (mm)				Kernel (mm)			
		Length mm	Width mm	Thickness Mm	Shape factor	Length mm	Width mm	Thickness Mm	Shape factor
European filbert	1/98	20.7a	16.5a	13.7a	0.73b	15.6a	10.2b	8.7b	0.60c
	2/98	18.8b	13.7cd	11.6b	0.67c	13.2b	8.8c	6.4d	0.57c
	3/98	19.2ab	16.2ab	13.3ab	0.77b	12.8b	8.6c	7.6c	0.63bc
	4/99	15.6d	14.4ced	12.1ab	0.85a	10.9c	8.6c	6.5d	0.69b
	5/99	17.6bc	14.9bc	13.0ab	0.88a	14.1b	11.7a	10.1a	0.77a
	6/00	18.0b	14.0cd	12.6ab	0.74b	13.7b	8.6c	6.9cd	0.56c
	7/01	16.2cd	13.2d	12.3ab	0.78b	13.0b	7.8c	7.0cd	0.57c
	8/01	17.9b	14.4cd	12.6ab	0.75b	13.5b	8.5c	7.3cd	0.58c
	Mx	18.0	14.7	12.6	0.76	13.3	9.1	7.6	0.63
Turkish hazel	1/98	15.1c	12.9d	10.2de	0.76bcd	12.5b	9.1de	6.4b	0.62b
	2/98	16.2bc	16.5a	12.0a	0.88a	13.0b	12.5a	7.9a	0.78a
	3/98	17.2a	14.5c	10.3sde	0.72d	13.9a	10.4b	6.5b	0.61b
	4/98	16.9ab	11.6e	12.1a	0.70d	14.2a	9.5cd	7.2ab	0.59b
	5/00	16.0bc	13.0d	11.0bcd	0.75cd	12.8b	8.4e	6.6b	0.58b
	6/00	15.8cd	14.7c	11.8ab	0.84ab	12.7b	9.9bc	6.7b	0.65b
	7/01	16.5abc	15.6b	11.1bc	0.81abc	12.9b	9.4cd	5.3c	0.57b
	8/01	16.4abc	13.4d	9.7e	0.70d	12.1b	8.4e	5.5c	0.57b
	Mx	16.3	14.0	11.0	0.77	13.0	9.7	6.5	0.62

The nuts of European filbert are generally mostly medium large or large. Those of the isolated European filbert selections were found to have coarseness ranging 15.6-20.7x13.2-16.5x11.6-13.7 mm and Turkish hazelnuts 15.1-17.2x11.6-16.5x9.7-12.1 mm, while kernel coarseness was 10.9-15.6x7.8-11.7x6.4x10.1 and 12.1-14.2x8.4-12.5x5.3-7.9 mm, respectively. The average nut coarseness of all selections of European filbert was 18.0x14.7x12.6 mm, and of Turkish hazel 16.3x14.0x11.0 mm, while average kernel coarseness was 13.3x9.1x7.6 and 13.0x9.7x6.5 mm, respectively. European filbert selections 1, 3, 2 and 5, and Turkish hazel selections 2, 3, 4 and 6 were found to stand out regarding nut and kernel coarseness. The findings agree with the results of an analysis of variance and Duncan`s test.

The average index of roundness of European filbert nuts was 0.76 (0.67-0.88), and of Turkish hazel 0.77 (0.70-0.88). Similar data was obtained for the kernel index of roundness, i.e. 0.63 (0.56-0.77) and 0.62 (0.57-0.78). This parameter identified the nuts and kernels of all selections of European filbert and Turkish hezel as having elongated shape.

Nut weight of the European filbert selections ranged 1.01-1.80 g, and of Turkish hazel 1.00-1.75 g, giving the average values of 1.50 g and 1,27 g, respectively. On the other hand, kernel weight of European filbert was 0.30-0.79 g and of Turkish hazel 0.31-0.65, the average being 0.44-0.52 g. Depending on weight, kernel content of the European filbert selections was 27.9-46.2 and of Turkish hazel selections 30.7-40.8%, or 34.7 and 34.6% on the average, Table 2.

Table 2. Fruit mass and chemical content of kernel

Species	No.	Fruit mass (g)	Stone mass (g)	Portion of flesh (%)	Hollow nuts (%)	*Balaninus nucum* %	Oil content (%)	Crude proteins (%)	Mineral matters (%)
European filbert	1/98	1.80a	0.63b	35.0c	8.8a	0.0	48.1ab	12.1a	2.8a
	2/98	1.36d	0.38d	27.9f	0.0e	0.0	48.2ab	11.9a	2.6ab
	3/98	1.32d	0.39cd	29.5e	2.0c	0.0	49.9a	12.0a	2.7ab
	4/99	1.01e	0.30e	29.7e	1.4d	0.0	46.0cd	11.8a	2.8a
	5/99	1.71b	0.79a	46.2a	0.0e	0.0	44.6d	10.8b	2.7ab
	6/00	1.65b	0.63b	38.1b	1.2d	0.0	46.0cd	11.5ab	2.6ab
	7/01	1.49c	0.46c	30.7d	3.1b	0.0	47.3bc	11.9a	2.4b
	8/01	1.69	0.59b	34.9c	2.5bc	0.0	49.1ab	12.3a	2.8a
	Mx	1.50	0.52	34.7	1.4	0.0	47.4	11.8	2.7
Turkish hazel	1/98	1.00f	0.31e	30.7e	0.0e	0.0c	53.6ab	10.7a	2.3abc
	2/98	1.43b	0.56a	39.2b	3.6b	1.6a	53.8ab	10.4a	2.5a
	3/98	1.03ef	0.42bcd	40.8a	5.7a	0.0c	52.7b	10.9a	2.1bc
	4/98	1.45b	0.45bc	31.0e	2.5c	1.2b	54.4a	11.6a	2.0c
	5/00	1.10de	0.35de	31.8d	0.0e	0.0c	49.8c	11.3a	2.3abc
	6/00	1.22c	0.38cde	31.1e	3.7b	0.0c	52.6b	11.2a	2.0c
	7/01	1.75a	0.57a	32.6c	0.0e	1.0b	53.2ab	10.8a	2.4ab
	8/01	1.16cd	0.46b	39.6b	1.4d	0.0c	48.6c	11.7a	2.6a
	Mx	1.27	0.44	34.6	2.1	0.5	52.3	11.1	2.3

The European filbert selections 1, 5 and 8 and Turkish hazel selections 7, 4 and 2 were found to stand out regarding nut weight, while their respective selections 5, 1 and 6, and 7, 2 and 8 were found to have exceptional kernel weight. Kernel content, however, was most favourable in selections 5, 6 and 1, and 3, 8 and 2, respectively. Statistical processing of data disclosed highly significant differences between most selections.

The proportion of shrivelled nuts was minimal in the chosen selections. They accounted for 0.82-3.1% in six European filbert selections, and 1.4-5.7% in five selections of Turkish hazel. A special impact on the European filbert trees came from an infestation and nut injury by the pest *Balaninus nucum*. The pest was only found in the nuts of three selections of Turkish hazel, Table 2. The injury, however, was insignificant, measuring 1.0-1.6%, which was fairly good consider-

ing a need for pesticide treatment. Oil content in the kernels of the European filbert selections measured 44.6-49.9%, and in Turkish hazel selections it was 48.6-54.4%, i.e.the average 47.4 and 52.3%, respectively. Crude protein content was 10.8-12.3% and 10.4-11.7%, respectively, with the average values of 11.3% and 11.1%. On the other hand, mineral matter content in the ashes was 2.4-2.8, and 2.0-2.6%, or 2.7% and 2.3% on the average, respectively. All selections were found to have satisfactory chemical composition of the kernel. Prominent values were recorded for the European filbert selections 3, 8 and 1, and Turkish hazel selections 4, 8 and 2. Highly significant differences between the selections were found only regarding oil content.

Putting the yielding potential into focus, we studied the number of nuts per inflorescence, Table 3.

Table 3. Number of nuts per inflorescence of European filbert and Turkish hazel

Species	No.	Number of nuts per inflorescence (%)												
		1	2	3	4	5	6	7	8	9	10	11	12	13
European filbert	1/98	21.8	19.3	20.5	20.5	11.5	6.4							
	2/98	30.0	26.7	31.7	11.6									
	3/98	15.8	32.7	30.7	15.8	5.0								
	4/99	15.3	23.5	28.2	14.1	15.3	3.6							
	5/99	32.2	42.3	22.0	3.5									
	6/00	42.1	35.0	13.7	6.7	2.1	0.4							
	7/01	26.1	29.0	26.1	18.8									
	8/01	30.0	26.7	23.3	20.0									
	Mx	26.7	29.4	24.5	13.9	4.2	1.3							
Turkish hazel	1/98	1.2	2.4	16.0	21.4	25.1	20.9	6.8	3.5	1.4	0.7	0.3	0.3	
	2/98	0.6	0.8	16.4	21.9	28.4	21.3	5.1	3.0	1.8	0.5	0.2		
	3/98	0.9	1.5	15.6	20.7	30.1	18.4	9.3	3.5					
	4/98	1.4	1.6	15.3	23.6	24.3	19.6	7.1	3.6	2.2	0.2	0.5	0.4	0.2
	5/00	1.0	1.4	15.8	19.8	25.6	21.9	6.3	4.2	1.6	1.0	0.7	0.4	0.3
	6/00	0.7	2.2	15.9	21.7	26.8	21.0	7.3	3.0	1.3	0.1			
	7/01	1.3	1.2	15.4	22.1	29.4	20.9	4.0	2.9	2.2	0.4	0.1	0.1	
	8/01	0.9	0.9	16.0	20.8	23.1	18.4	9.3	5.1	2.3	1.9	0.6	0.4	0.3
	Mx	1.0	1.5	15.8	21.5	26.6	20.3	6.9	3.6	1.6	0.6	0.3	0.2	0.1

The European filbert selections were characterized by inflorescences containing between 1 and 4, or 6 nuts. Three selections had up to six nuts, one selection had five, while the others had four nuts. Two nuts predominated in all other selections with 29.4% (19.3-42.3%), followed by a single nut, 26.7% (15.3-42.1%), and three nuts, 24.5% (13.7-30.7%). Inflorescences with five clustered nuts accounted for 4.2% (2.1-15.3%), while those with six nuts had a minimum percentage of 1.3% (0.4-6.4%). Selections 1 and 4 stood out as exceptional regarding the number of nuts per inflorescence.

On the other hand, the Turkish hazel selections had between 1 and 8, or 13 nuts per inflorescence. Those containing 9 and 10 nuts predominated. Despite such a wide range, predominating were those containing between two nuts, 15.8% (15.3-16.4%), and seven nuts per inflorescence, 6.9% (4.0-9.3%). On the average,

5 nuts per inflorescence predominated with 26.6% (23.1-30.1%), followed by four-nut inflorescences, 21.5% (19.8-23.6%), and those with six nuts, 20.3% (18.4-21.3%). Eight or more nuts to an inflorescence accounted for 6.4%, and one and two nuts for 2.5%. Selections 5, 7 and 6 were found exceptional in that respect.

DISCUSSION

With regard to the generative reproduction of European filbert and Turkish hazel trees, their progeny is heterogenous with different nut coarsenesss and weight. MITRESKI *et al*. (1983) had reported nut coarseness of European filbert selections ranging 17.0-23.4x16.0-19.6x12.7-16.0 mm, nut weight of 1.45-2.08 g, kernel weight of 0.48-1.15 g and kernel content of 31.0-53.0%. In a study on Pešter Plain, PEJKIĆ (1980) had selected European filbert forms measuring 14.4-22.1 mm nut length, 14.1-16.9 mm width and 1.13-1.51 g weight.

Similar findings have been reported for Turkish hazel. NINIĆ-TODOROVIĆ (1987) reported biotypes with 16.4-18.6x14.4-17.8x11.0-15.8 mm nut coarseness, 1.17-2.54 g nut weight, and 0.52-0.71 g kernel weight. Studying the biodiversity of Turkish hazels in Serbia, MITROVIĆ *et al*. (1997) found an average nut coarseness of 13.8-19.1x11.6-19.1x9.0-16.7 mm, kernel coarseness of 11.3-15.4x8.0-13.4x5.7-10.2 mm, nut weight of 0.63-2.86 g, kernel weight of 0.24-0.86 g and kernel content of 25.9-38.1%.

As reported MANUŠEV (1988), hollow shells or shrivelled nuts are caused by factors other than parasite activity. Infestation by *Balaninus nucum* is detrimental and a factor discouraging a more widespread cultivation of those selections.

Fresh filbert and hazel nuts provide a rich and high-calory nourishment with high energy and dietary potentials. This agrees with data reported on European filbert and Turkish hazel selections. KRSTIĆ-PAVLOVIĆ (1990) reported oil content in the kernels of European filbert as ranging 33.9-47.9%, while MILETIĆ *et al*. (1997) found it to range 41.7-50.7%, crude proteins 8.7-13.1% and ashes 2.4-2.8%. These findings agree with those showing 60.58-64.62% oil content in Turkish hazel kernels, NINIĆ-TODOROVIĆ (1987). MITROVIĆ *et al*. (1997) reported an oil content of 47.38-65.15%, crude proteins of 17.9-16.1% and mineral matter 2.04-2.63%.

Regarding kernel chemical composition, European filbert and Turkish hazel lag behind the cultivars, MILETIĆ (1994), but it still shows their worth and secures a possibility for them to be used fresh or processed. Besides, their habitats are mostly situated in ecologically favourable environments, i.e. on and around mountainous areas far from industrial or other pollution, so that their nuts meet the standards of biologically high-quality food. It is worth mentioning that European filbert and Turkish hazel grow spontaneously in natural environments and yield nuts without any special care, cultivation, fertilization or protection from diseases and pests. Adding to these facts are the potentials and value of their nuts as nourishment, which is by all means a special merit of the *Corylus* genus.

Filberts and hazels are characterized by multiple nuts clustered in their inflorescences. MANUŠEV (1988) had reported 1-10 nuts borne by the inflorescences

of certain cultivars, with predominating 2 and 4 nuts to an inflorescence. According to BULATOVIĆ (1985), the number of nuts borne by an inflorescence is 1-4, with predominating 1 or 2 nuts. MILETIĆ *et al*. (1997) reported inflorescences with up to five or more nuts, the majority however being single or paired.

The isolated selections of European filbert and Turkish hazel were characterized by a high yielding potential. As they grow and yield at different habitats and under different microclimatic conditions, the true value of the selections can be evaluated through their collection and cultivation under uniform conditions. Besides, they are able to grow spontaneously in natural environments without any agricultural practices applied. The nutritive area is mostly limited and competitive with other plant species. Their collection and intensive cultivation could further clarify their full productive capacities, properties and nut qualities. Our *in situ* findings pointed at the European filbert selections 1, 5, 6 and 3 as being particularly promising, as well as Turkish hazel selections 7, 3, 2 and 8. The other selections, however, were found competitive enough in this respect.

CONCLUSION

Studying European filbert and Turkish hazel over the 1996-2000 period, we identified selections with a number of outstanding properties.

The average nut coarseness of our European filbert selections was 18.0x14.7x12.6 mm, while the Turkish hazel nut coarseness was 16.3x14.0x11.0 mm, with their respective average kernel coarseness being 13.3x9.1x7.6 mm and 13.0x9.7x6.5 mm. The nut weight of European filbert was 1.01-1.80 g and of Turkish hazel 1.00-1.75 g, and their respective kernel weights 0.30-0.79 g and 0.31-0.65 g. Kernel contents were 27.9-46.2% and 30.7-40.8%, respectively.

Shrivelled nuts were found in nimimal number in six European filbert selections (0.8-3.1%) and five Turkish hazel selections (1.4-5.7%). The pest *Balaninus nucum* was found only in three Turkish hazel selections, ranging 1.0-1.6%.

Oil content was 44.6-49.9% in the kernels of the European filbert selections, and 48.6-54.4% in those of the Turkish hazel selections, while the respective crude protein contents were 12.3-10.8% and 11.7-10.4%, and mineral matter contents 2.8-2.4% and 2.6-2.0%.

The European filbert selections were found to have inflorescences containing 4-6 nuts. Predominating were two nuts per inflorescence (29.4%), followed by a single nut (26.7%), and three nuts (24.5%). The Turkish hazel inflorescences had 8-13 nuts, but most were with five (26.6%), four (21.5%) and six nuts (20.3%).

Considering most parameters, the European filbert selections 1, 5, 6 and 3, and Turkish hazel selections 7, 3, 2 and 8 were singled out as especially promissing, but the value of others nevertheless remains approximate.

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POMOLOŠKO-TEHNOLOŠKE OSOBINE SUPERIORNIH SELEKCIJA ŠUMSKE LESKE (*CORYLUS AVELANA* L.) I MEČJE LESKE (*CORYLUS COLURNA* L.) U ISTOČNOJ SRBIJI

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I z v o d

Izučavajući šumsku i mečju lesku u višegodišnjem periodu od 1996 do 2000. godine, na području istočne Srbije izdvojene su po osam selekcija koji se po mnogim osobinama posebno ističu. Analizirana je krupnoća, oblik i masa ploda i jezgre kao i hemijski sastav jezgre. Izučena je i potencijalna rodnost, odnosno prosečna zastupljenost plodova u cvasti leske. Prosečna krupnoća plodova odabranih selekcija šumske leske je 18,0x14,7x12,6 i mečje leske 16,3x14,0x11,0 mm, a jezgre 13,3x9,1x7,6 odnosno 13,0x9,7x6,5 mm. Masa plodova šumske leske je 1,01-1,80 g i mečje leske 1,00-1,75 g, jezgre 0,30-0,79 i 0,31-0,65 g. Sadržaj jezgre je od 27,9 do 46,2% i od 30,7 do 40,8%. Pojava šturih plodova je minimalna i to u šumske leske u šest selekcija (0,8-3,1%), a u mečje leske u pet (1,4-5,7%). Štetočina *Balaninus nucum* registrovana je samo u tri selekcije mečje leske u granicama od 1,0 do 1,6%. Sadržaj ulja u jezgri odabranih tipova šumske leske je 44,6-49,9%, a u mečje leske 48,6-54,4%, sirovih proteina je 12,3-10,8 i 11,7-10,4%, a sadržaj mineralnih materija 2,8-2,4 i 2,6-2,0%.

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