Pomological Identification of Hazel Cultivars (*Corylus avellana* L.) in Plantations in Bosnia and Herzegovina

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Summary

The paper presents the results of the analysis of pomological-technological characteristics of 13 hazel cultivars present in production plantations in the area of Bosnia and Herzegovina (BIH). Through previous analysis of pomological characteristics of fruit in several hazel plantations it was noted that there was a possibility of erroneous cultivar denomination. These fruits are sold at the domestic market as hazels for consumption, as well as for confectionary and cosmetic industry. Due to the increasing interest of producers in BIH for hazel cultivation and the uncontrolled spread of seedlings by producers through the offshoots from the existing production plantations, a possibility has been created to establish a plantation with erroneous assortment and thus an inadequate cultivar composition, particularly in terms of pollination and fertilization. Therefore, a comparison was carried out of pomological characteristics of fruit and the content of oil in the kernel of 13 hazel cultivars from older plantations in BIH with cultivars from the Collection of Nuts in Maribor owned by the Biotechnical Faculty of Ljubljana. Based on the analysis conducted, a deviation of fruit characteristics of some cultivars was determined, compared to the standard features of cultivars by which names they were labelled. Cultivars labelled by the producer during the collection of samples as: 'Istrian Round', 'Tonda di Giffoni 2', 'Hall´s Giant' and 'N.N.1' were identified and they fully corresponded with their characteristics to the following cultivars: 'Istrian Long', 'Mortarela', 'Fertile de Coutard' and 'Hall´s Giant'. The research also showed that the fruits of the examined cultivars in BIH according to their pomological properties are as good as the fruits of cultivars grown in other areas.

Key words

descriptors, kernel, oil content, pomology

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Introduction

A more frequent occurrence of late frost due to the impact of climate change in the area of Turkey (Ustaoglu and Karaca, 2014) causes the freezing of hazel and reduction in yield in the country that produces 70% of world hazelnuts (FAO) that is directly reflected in the deficiency of hazelnuts on the world market and multiple increase of its demand and price. The high price of hazelnuts has increased the interest of farmers in the Balkans for the cultivation of this crop. According to the data of the Statistical Institutes of Serbia and Croatia, areas under hazel have increased several times over the past 10 years, in Serbia 2 239 ha in 2012 (Keserović and Magazin, 2014) and in Croatia 3 015 ha in 2015 (Statistical Institute of the Republic of Croatia, 2016). There are no official data on new hazel plantations in BIH. However, based on the demand for seedlings, the increased interest for the cultivation of this species is apparent (Davidović, 2015). The increase of area under hazel in BIH has not been followed by a research and study of new introduced cultivars of hazel in agro-ecological conditions of BIH. Due to the uncontrolled spread of seedlings by the manufacturers through the offshoots from existing production plants, as well as due to the import of badly or incorrectly labelled seedlings of hazel and its reproduction, and expansion of unregistered sales by manufacturers, a series of problems have been created in plantations where these seedlings are used. The regularity and genetic purity of seedlings are of great importance when raising young hazel plantations and they have to be under constant supervision of authorised institutions and experts. Planting of incorrectly labelled cultivars and ignorance of their agrobiological characteristics creates conditions for a reduced and irregular fruiting in production plantations, primarily due to the characteristics of auto-incompatibility and inter-incompatibility between some cultivars (Hampson and Azarenko, 1993; Mechenbacher, 1997; Vicol et al., 2009). During research of the diversity of cultivars and genotypes of hazel, their identification and determination of their origin in the area of the southern Europe based on morphological and molecular characterisation, Boccacci et al. (2006) found that a large number of synonyms for cultivars have been widely used. Using a large number of synonyms for the same cultivar can lead to the appearance of duplicates in plantations, as well as to an incorrect labelling of cultivars in a production. A large number of scientists have analysed and studied pomological-technical characteristics of hazelnuts in the Balkan. Miletić et al. (2009) in their research of hazelnuts varieties that have been present in Balkan plantations for several decades, recommend varieties the 'Istrian Long Range' and the 'Lambert White' for cultivation. The study of introduced varieties of hazelnut from France in Čačak territory was carried out by Mitrović et al. (2009). Based on the results, they gave a recommendation for the cultivation and spread of these varieties. In Slovenia territory, Solar and Stampar (2009) have carried out research of characteristics of new varieties from Oregon in comparison to the variety of 'Tonda Gentile delle Langhe' as a standard variety, and it was found that varieties from Oregon had better results and could be grown in conditions with a similar climate. Based on these studies, it can be concluded that the Balkan region is suitable for growing hazelnuts except in areas with poor soil characteristics such as pseudogley (Čmelik and Mališević, 1996).

The aim of this study was to examine pomological characteristics of hazel cultivars present in region of Banja Luka and based on them to perform identification of cultivars.

Material and methods

Samples of 100 fruits of 13 cultivars were collected for the research from two hazel production plantations in the area of Banja Luka (Jošavka and Romanovci) during 2015. The names of the cultivars were obtained from the owner of the plantation: 'Istrian Long', 'Istrian Round', 'Romische Zellernuss', 'Tonda Gentile Romana', 'Merveille de Bollwiller', 'Hall's Giant', 'Lambert White', 'Lambert Red', 'Tonda di Giffoni 2', 'Tonda Gentile delle Langhe' (TGDL`), 'Nocchione' and two cultivars labelled as 'Title Unknown 1' (N.N.1) and 'Title Unknown 2' (N.N.2) In the laboratories of the Agricultural University of Maribor morphometric measurements were carried out: the dimensions of fruit and kernel (lenght, width and thickness) and thickness of the husk using a movable scale (HM Mullner, Freilassing Germany); weight and kernel using analytical balances (EW-220 3NM, Kern, Balingen, Germany) and kernel percentage was calculated using the formula: kernel percentage (%) = (kernel mass / fruit mass) × 100). The index of roundness of the fruit and kernel calculated with the formula: fruit roundness index = {(fruit width + fruit thickness) : 2 × fruit length}. The chemical analysis conducted, was the measuring of oil content in the fruits with the method of Soxhlet extraction (kernel oil extraction), using Buchi Extraction System B-81 (BÜCHI Labortechnik AG, Flawil, Switzerland). Measurements were performed in triplicate and the chemical used was petroleum ether (Centrohem, Stara Pazova, Serbia). The identification based on pomological characteristics was carried out using International Bioversity Descriptors for hazelnut (IPBGR, 2008) by describing the following fruit characteristics: fruit shape, the shape of the cross-section part of the fruit, the colour of husk, the shape of the fruit end, the prominence of the fruit end, the size of the scar on the fruit end, fruit end hairiness, the size of the lower scar compared to the size of the fruit, the curvature of basal scar, the number of empty fruits, the number of dual fruits, the appearance of brown dots in kernel centre, the deformations of fruits, kernel shape, the texture of kernel fibre, kernel blanching, the size of the kernel cavity and fruit aroma. Together with a descriptor, samples of fruits from the Collection of nuts in Maribor owned by the Biotechnical Faculty of Ljubljana were used for the comparison of identicalness. Blanching of the fruits was conducted in an oven at a temperature of 115°C for a period of 20 minutes (according to International Bioversity Descriptor). The data were analysed by general linear modelling in statistical software package SPSS 22 (IBM 2013). Post-hoc analysis of variance (ANOVA) in cases of statistically significant differences ($p<0.05$) was carried out by Tukey's test ($p<0.05$). All data were presented as mean ± SE (standard error).

Results and discussion

Based on the pomological fruit analysis of 13 cultivars, the total of 12 were identified, whereas the cultivar labelled as N.N.2 was not identified and there is no similarity with 80 other cultivars in the Collection of Nuts in Maribor (Table 1).

It has been established that four cultivars did not meet the characteristics of cultivars which names they were given by the owners

Table 1. Identification of cultivars based on pomological characteristics

Names of cultivars obtained from the grower (local name / original title)		Names of cultivars after the identification (original title)
Bolvijerov / Merveille de Bollwiller	=	Merveille de Bollwiller
Halski Džin / Hall`s Giant	→	Fertile de Coutard
N.N.1	→	Hall´s Giant
Istarski dugi (Istrian Long)	=	Istrian Long I
Istarski okrugli (Istrian Round)	→	Istrian Long II
Lambert bijeli (Lambert White)	=	Lambert White
Lambert crveni (Lambert Red)	=	Lambert Red
Tonda di Giffoni 2	→	Mortarela
N.N.2	=	N.N.2
Nokione / Nocchione	=	Nocchione
Rimski / Romische Zellernuss	=	Romische Zellernuss
TGDL`	=	TGDL`
Tonda Gentile Romana	=	Tonda Gentile Romana

Hereinafter the names of cultivars after identification are used.

of plantations. Cultivar labelled as 'Istrian Round'on the basis of the completed pomological analysis was completely identical to the cultivar 'Istrian Long' (further below labelled as cultivar 'Istrian Long II') (Fig. 1). The cultivar labelled as 'Hall`s Giant' fully corresponded with its characteristics to cultivar 'Fertile de Coutard' (Fig. 2), whereas cultivar labelled as 'N.N.1' was identified as cultivar 'Hall`s Giant' (Fig. 3). Cultivar labelled as 'Tonda di Giffoni 2', which seedlings were imported from Italy under the same name, was identified as cultivar 'Mortarela' (Fig. 4).

Thus, some researchers state in their studies that cultivar 'Hall's Giant' is synonym for cultivar 'Merveille de Bollwiller', because they are characterized by very similar genotypic and biological characteristics (Boccaci et al., 2006; Baldwin et al., 2007). In this study, these two cultivars are presented as different due to certain dissemblance between themin some pomological characteristics and because they are marked as different in collection in Maribor.

Important cultivar characteristics on the basis of pomological descriptions are presented in Table 2. Based on the size of the fruit, examined cultivars can be divided into several groups: cultivars

Figure 1. 'Istrian Long II' (labelled by the manfacturer as cultivar 'Istrian Round')

Figure 2. 'Fertile de Coutard' (labelled by the manfacturer as cultivar 'Hall`s Giant')

Figure 3. 'Hall`s Giant' (labelled by the manufacturer as cultivar 'N.N.1.')

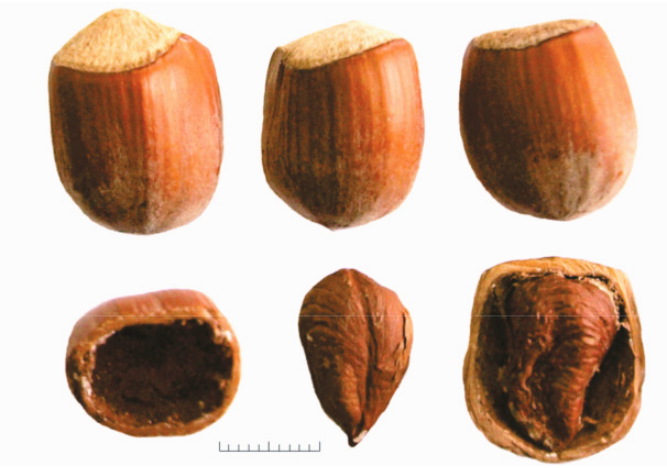

Figure 4. 'Mortarela' (labelled by the manufacturer as cultivar 'Tonda di Giffoni 2')

Table 2. Important cultivar characteristics based on pomological description

Cultivar	Fruit size	Presence of dual fruits	Fruits with a deformation (%)	Kernel size	Kernel cavity	Fruit blanching (1-5)	Aroma (1-5)	Fruit roundness index	Kernel percentage (%)
M. de Bollwiller	Medium-large	None	4.16	Medium-small	None	4	5	1.06	28.89
Fertile de Coutard	Mediam-large	Present	6.16	Medium	Medium	4	4	0.91	43.41
Hall`s Giant	Medium-large	None	6.80	Small	None	3	5	0.91	26.57
Istrian Long I	Large	None	9.00	Large	Large	5	2	0.71	35.59
Istrian Long II	Large	Present	17.51	Large	None	4	5	0.73	29.88
Lambert White	Medium-small	None	3.92	Medium	None	4	4	0.67	48.24
Lambert Red	Small	None	2.89	Medium	None	2	5	0.65	55.35
Mortarela	Medium small	None	8.08	Medium small	Small	5	3	0.73	44.50
N.N.2.	Small	None	3.78	Small	Medium	3	3	0.91	37.90
Nocchione	Medium-large	None	4.31	Medium	Small	5	4	1.03	41.95
Romische Zeller	Medium-large	None	3.24	Medium small	Small	5	4	1.15	39.58
TGDL`	Medium-small	None	5.71	Medium-small	Small	5	4	0.91	42.57
Tonda Romana	Medium	Present	*	Medium	Medium	5	4	0.97	45.04

Table 3. Measured characteristics of fruits of examined hazel cultivars (mean and standard error)

Cultivar	Nut mass (g)		Kernel mass (g)		Nut length [mm]		Nut width [mm]		Nut thickness [mm]		Kernel length [mm]		Kernel width [mm]		Kernel thickness [mm]		Huskthickness [mm]		Oil content [g g^{-1}]	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
M. de Bollwiller	3.08 ef	±0.06	0.89bcd	±0.03	21.22c	±0.11	23.12g	±0.18	21.92h	±0.13	15.90b	±0.15	11.42bcd	±0.22	9.59ab	±0.19	1.36cde	±0.03	0.55	±0.02
Fertile de Coutard	2.82de	±0.10	1.22fg	±0.05	21.28c	±0.19	20.57e	±0.16	18.22e	±0.12	16.10b	±0.22	13.62ef	±0.36	11.91d	±0.40	1.40def	±0.03	0.54	±0.02
Hall`s Giant	2.86def	±0.06	0.76ab	±0.04	23.86e	±0.18	22.30f	±0.15	21.40h	±0.15	15.64b	±0.27	10.06a	±0.22	8.80a	±0.28	1.47efg	±0.03	0.58	±0.03
Istrian Long I	4.28h	±0.11	1.53h	±0.05	28.24g	±0.14	20.82e	±0.15	19.30f	±0.12	21.18e	±0.34	13.72ef	±0.25	11.35cd	±0.21	1.54g	±0.03	0.57	±0.01
Istrian Long II	3.59g	±0.08	1.07def	±0.04	27.10f	±0.14	20.80e	±0.13	19.22f	±0.14	18.87d	±0.22	12.04cd	±0.24	9.97ab	±0.21	1.50fg	±0.03	0.54	±0.01
Lambert White	1.99bc	±0.05	0.97cde	±0.03	22.39d	±0.17	15.70ab	±0.16	13.68ab	±0.10	18.48cd	±0.17	10.28ab	±0.19	9.33ab	±0.17	1.17ab	±0.02	0.50	±0.01
Lambert Red	1.69ab	±0.07	0.94bcd	±0.03	21.41c	±0.18	14.98a	±0.11	13.22a	±0.11	17.56c	±0.20	10.78abc	±0.14	9.53ab	±0.15	1.10a	±0.02	0.55	±0.02
Mortarela	2.10c	±0.05	0.93bcd	±0.03	20.71c	±0.15	16.36b	±0.16	14.09b	±0.11	16.28b	±0.20	10.99abc	±0.29	9.79ab	±0.22	1.32cd	±0.03	0.55	±0.02
N.N.2.	1.54a	±0.05	0.59a	±0.03	19.46b	±0.15	19.05d	±0.16	16.32d	±0.16	13.66a	±0.27	9.96a	±0.22	8.84a	±0.18	1.07a	±0.02	0.56	±0.01
Nocchione	3.18f	±0.06	1.33g	±0.03	19.29b	±0.13	21.80f	±0.19	18.31e	±0.07	14.08a	±0.20	16.18g	±0.28	13.95e	±0.17	1.45efg	±0.01	0.56	±0.03
Romische Z-nuss	2.89def	±0.10	1.15ef	±0.07	19.46b	±0.17	24.12h	±0.20	20.69g	±0.16	13.67a	±0.33	12.50de	±0.57	11.53cd	±0.56	1.24bc	±0.03	0.56	±0.02
TGDL`	2.03c	±0.04	0.86bc	±0.03	18.52a	±0.16	18.26c	±0.19	15.54c	±0.21	13.70a	±0.15	12.49de	±0.23	10.39bc	±0.23	1.07a	±0.03	0.50	±0.02
Tonda Romana	2.62d	±0.06	1.19fg	±0.03	18.52a	±0.09	19.79d	±0.12	16.39d	±0.13	13.65a	±0.20	14.67e	±0.27	12.08d	±0.18	1.37de	±0.02	0.58	±0.03
F	121.29**		42.38**		408.41**		318.17**		461.64**		108.57**		49.14**		36.25**		41.56**		1.72ns	

* indicates statistically significant difference ($p<0.05$), ** indicates statistically highly significant difference ($p<0.01$), ns indicates statistically non-significant difference ($p>0.05$) in ANOVA; a,b,c letters indicate significant differences and grouping of the cultivars according to HSD tests with 95% significance

with large fruits ('Istrian Long I' and 'Istrian Long II'), cultivars with medium-large fruits ('Merveille de Bollwiller', 'Romische Zellernuss', 'Hall`s Giant'), cultivars with medium-size fruits ('Fertile de Coutard', 'Nocchione', 'Tonda Gentile Romana'), cultivars with medium-small fruits ('Mortarela', 'TGDL' and 'Lambert White') and cultivars with small fruits ('Lambert Red' and 'N.N.2'). The presence of dual fruits was observed on the following cultivars: 'Istrian Long II', 'Fertile de Coutard' and 'Tonda Gentile Romana', whilst the percentage of fruits with deformations in all cultivars was below 9%, except for 'Istrian Long II' cultivar with 17.51%. After the blanching, epidermis removal for most cultivars was satisfactory, except for cultivars 'Hall`s Giant', 'Lambert Red' and 'N.N.2.' Cultivars TGDL', 'Tonda Gentile Romana', 'Nocchione' and 'Istrian Long I' showed very good characteristics of epidermis removal. Based on the aroma of the fruit, it was concluded that there were significant differences between cultivars. Cultivars with extremely good aroma were 'Merveille de Bollwiller' and 'Hall`s Giant', whereas the aroma of fruits of 'Lambert Red' and 'Lambert White' cultivars came to the fore only after blanching. Characterised as cultivars with weak aroma were 'Istrian Long I' and 'N.N.2.'. Fruit roundness index was the lowest for 'Lambert Red' (0.65) and 'Lambert White' (0.67) cultivars, whilst it was the highest for 'Romische Zellernuss' (1.15) cultivar. 'Tonda Gentile Romana' and 'Nocchione' cultivars had the most pronounced fruit roundness characteristics. Kernel percentage was the lowest in 'Hall`s Giant', 'Merveille de Bollwiller' and 'Istrian Long II' cultivars (below 30%) which can be brought in connection with fruit size and insufficient amount of water required for fruits to fill in with kernel during fruit rise. The highest kernel percentage was noted for 'Lambert Red' (55.35%), and besides this cultivar, it is necessary to emphasize 'Lambert White', 'Tonda Gentile Romana' and 'Mortarela' cultivars that had yield kernel utilization over 45%. Kernel percentage was insignificantly lower or higher, depending on the cultivar, compared to the study of Solar and Štampar (2011).

Examined hazel cultivars statistically highly significantly differ in all tested fruit characteristics except in terms of fruit oil content (Table 3). Minimum nut mass (1.54 ± 0.05 g) was found in 'N.N.2', while the maximum in 'Istrian Long I' (4.28 ± 0.11 g). In comparison with the research conducted by Solar and Štampar (2011), fruit mass was lower in examined cultivars except for 'Istrian Long' cultivar with fruit weighs almost 1 g higher. In relation to the research of Miletić et al. (2002) 'Hall`s Giant', 'Istrian Long' and 'Romische Zellernuss' cultivars had 50 to 100% higher fruit weight, whilst 'TGDL' and 'Lambert White' cultivars had almost similar values. The highest kernel mass was noted in 'Istrian Long I' cultivar (1.53 ± 0.05 g), and the lowest in 'N.N.2' cultivar (0.59 ± 0.03 g).

Minimum length of fruit was recorded in 'Tonda Gentile Romana' (18.52 ± 0.09 mm) and 'TGDL' (18.52 ± 0.16 mm), while it was the longest for 'Istrian Long I' (28.24 ± 0.14 mm). The width of the fruit ranged from 14.98 ± 0.11 mm in 'Lambert Red' to 24.12 ± 0.20 mm in 'Romische Zellernuss'. The thickness of the fruit ranged from 13.22 ± 0.11 mm in 'Lambert Red' to 21.92 ± 0.13 mm in 'Merveille de Bollwiller' and 21.40 ± 0.15 mm 'Hall`s Giant'. Kernel length ranged between 13.65 ± 0.20 mm in 'Tonda Gentile Romana' together in the same group with 'N.N. 2', 'Romische Zellernuss', 'TGDL', 'Nocchione', up to 21.18 ± 0.34 mm in 'Istrian Long I'. Minimum width (9.96 ± 0.22 mm) was recorded in 'N.N. 2' together with 'Hall`s Giant' (10.06 ± 0.22 mm), and maximum (16.18 ± 0.28 mm) in 'Nocchione'. Fruit thickness was between 8.80 ± 0.28 mm in 'N.N. 2' and 13.94 ± 0.17 mm in 'Nocchione'. Husk thickness was the highest in 'Istrian Long I' (1.54 ± 0.03 mm), and the lowest in 'TGDL', 'N.N. 2' (1.07 ± 0.03 mm) and 'Lambert Red' (1,10 ± 0.02 mm). Average oil content in the kernel of all cultivars had an approximately similar value without major deviations and ranged between 49.60 ± 0.01% in 'Lambert White' and 58.14 ± 0.03% in 'Tonda Gentile Romana'. Oil content was lower in 'Istrian Long' (3%), 'Romische Zelernuss' (8%) and 'TGDL' (13%) comparing to Oparnica study (2006) , as well as comparing to Miletić et al. (2002) study who found a higher oil content by 5 to 15% in identical cultivars.

Conclusion

The results of the pomological identification research of hazel cultivars in plantations in BIH show that a certain number of cultivars present in plantations in BIH were erroneously labelled by another cultivar's name. This can cause problems primarily due to the cross-fertilization and incompatibility between certain hazel cultivars. After identification, analysed cultivars showed good results with regards to other researches in the region although the observed plantations still do not have any irrigation systems and special and regular agro and pomotechnical measures are not being applied. Based on this research, for further planting of hazels in BIH the following cultivars can be recommended: 'Fertile de Coutard', 'Nocchione', 'Tonda Gentile Romana' and 'Lambert White'. These results confirm the lack of hazel research in BIH, and therefore the lack of knowledge about hazel cultivars and their agro-biological characteristics in agro-ecological conditions of BIH. The problem is increased by uncontrolled production and expansion of seedling by the manufacturer without prior control by professionals and authorised institutions, but also through the import of hazel seedlings from other states under incorrect names.

References

Baldwin B., Gilchrist K., Lester S. (2007): Hazelnut variety assessment for South-eastern Australia, Rural industries research and development corporation, Australian Government, Publication No. 09/178, Canbera Australia.

Bioversity, FAO and CIHEAM. (2008). Descriptors for hazelnut (*Corylus avellana* L.). Bioversity International, Rome, Italy; Food and Agriculture Organization of the United Nations, Rome, Italy; International Centre for Advanced Mediterranean Agronomic Studies, Zaragoza, Spain.

Boccacci P., Akkak A., Botta R. (2006): DNA typing and genetic relationship among European hazelnut (*Corylus avellana* L.) cultivars using microsatellite markers. Genome, 49:598–611.

Čmelik Z., Mališević E. (1996): Priroda i kakvoća ploda lijeske uzgajane na pseudogleju. Pomologia Croatica, 2:3-11.

Davidović J. (2015): Usklađenost regulatornih okvira za rasadničku proizvodnju u Republici Srpskoj i Bosni i Hercegovini sa regulatornim okvirom Evropske Unije. Magistarski rad. Poljoprivredni fakultet Univerziteta u Banjoj Luci.

FAO Stat (2016). Available at http://www.fao.org/faostat/en/#data/QC. Accesed 15.03.2016.

Hampson R.C., Azarenko A.N. (1993): Pollen stigma interactions following compatible and incompatible pollinations in hazelnut. J. Am. Soc. Hortic. Sci., 118 (6), 814-819.

Keserović Z., Magazin N. (2014): Voćarstvo Srbije - stanje i perspektive, Zbornik radova – Primjena podataka Popisa poljoprivrede 2012. u analizi stanja poljoprivrede i u planiranju agrarne politike u Republici Srbiji, Subotica, Republika Srbija Republički zavod za statistiku, 211-228.

Mechlenbacher S.A. (1997): Revised dominance hierarchy for S-alells in *Corylus avellana* L.. Theor. Appl. Genet., 94:360-366.

Miletić R., Ogašinović D., Mitrović M., Petrović R. (2002): Rezultati izučavanja važnijih pomološko-tehnoloških osobina plodova leske u istočnoj Srbiji. Jugosl. Voćar., 36: 137-138.

Mitrović M., Miletić R., Lukić M. (2009): Pomološko-tehnološke osobine introdukovanih sorti lijeske. Voćarstvo 43, 53-56.

Oparnica Č. (2006): Uticaj rezidbe na hemijske osobine plodova sorti lijeske. Voćarstvo, 40:91-96.

Solar, A., Stampar, F. 1997. First experiences with some foreign hazelnut cultivars (*Corylus avellana* L.) in Slovenia, Acta Hort., 445:83-90.

Solar A., Štampar F. (2009): Performance of Hazelnut Cultivars from Oregon in Northeastern Sloven. Hort. Techn., 19: 653-659.

Solar A., Štampar F. (2011): Characterisation of selected hazelnut cultivars: phenology, growing and yielding capacity, market quality and nutraceutical value. J. Sci. Food Agric., 91:1205–1212.

Statistical Institute of the Republic of Croatia (2016). Available at http://www.dzs.hr/default_e.htm. Accesed 15.03.2016

Ustaoglu B., Karaca M. (2014): The effects on climate change on statiotemoral changes on hazelnut (*Corylus avellana* L.) cultivation areas in Black sea region, Turkey. Appl. Ecol. Env. Res., 12 (2):309-324.

Vicol A., Botu I., Botu M., Giorgota A. (2009): Preliminary Study of Incompatibility Alleles Expressed in Pollen of Romanian Hazelnut Cultivars. Bulletin UASVM Horticulture, 66: 480–483.

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