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SECONDARY POPULATIONS OF TURKISH HAZELNUT (CORYLUS COLURNA L.)IN NOVI SAD

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SUMMARY: Results of nuts morphological analysis for selected genotypes of Turkish hazel (Corylus colurna L.) refer to secondary origin trees. Seed germination and graft acceptance on seedlings was established for examined genotypes. Dependence correlation of seed germination from examined morphological features was determined. These findings could have significant importance on process of selecting mother plants for production of seedlings and planting material. Selected genotypes from nursery Gradsko zelenilo (A4, A5, A8, A13, A14, A16, B7, C1, C2, C3, C4) had high seed germination and formed thick line composition during examination year. Grafting of genotypes was done at beginning of April year 2011 intent to get high grafted hazel trees. During vegetative period percentage of graft acceptance ranged from 70.00% (genotype C1) to 93.3% (genotype A4) which implies high compatibility of rootstocks with Tonda Gentile Romana cultivar.

Key words: *Corylus colurna, genotype, hazel grafting, population, seed germination, rootstocks.*

INTRODUCTION

Department of Pomology, Viticulture, Horticulture and Landscape Architecture in Faculty of Agriculture, University of Novi Sad, is engaged in hazel selection, breeding and planting material production. Three decades ago, in year 1983 started program of selecting Turkish hazel (*Corylus colurna* L.) genotypes from trees growing in natural populations and trees of secondary origin growing in green areas of Novi Sad. Selection undertook 45 individual Turkish hazels out of which several genotypes were selected.

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Genotypes are characterized with alternative fruiting, high morphological, technological and physiological features of nuts, as well as with excellent medical conditions (Ninić-Todorović, 1990). Biochemical compound of Turkish hazel seed is significant for confectionary industry as shown in publications Ninić-Todorović (1992; 2000).

Sowing material of Turkish hazel examined fruits was planted in Faculty of Agriculture nursery in Rimski Šančevi where ground germination was established, followed with development of seedlings in examination year. Three year old Turkish hazel seedlings were grafted with tongue grafting method, what led to determination of remarkable compatibility and acceptance percentage. High grafted hazel plants are suitable for growing plantations with hazel trees, where full application of mechanization and appropriate protection is possible.

Grafting of hazel cultivars on rootstock of Turkish hazel in Serbia is successfully done since 1989. Results are published in publications Ninić-Todorović et al. (1994; 2003; 2006, 2007), Korać et al. (1995; 1996), Cerović et al. (2007) and others.

Figure 1. Turkish hazel populations of secondary origin in area of Novi Sad
Slika 1. Populacije mečje leske sekundarnog porekla u Novom Sadu

In city area of Novi Sad totally 231 trees of Turkish hazel in park areas are recorded, planted in groups or solitary. On green lines of roads, as line planting, 501 tree of Turkish hazel is noted. Trees are from different age class and size depending on time

of roads building. Tendencies for growing new tree lines of Turkish hazel exist (streets Janka Veselinovića, Pasterova, Ive Andrića, Kolo srpskih sestara, Cankareva, Bulevar oslobođenja). In relation to the total length of tree lines in the city of Novi Sad, which amounts 80 km, Turkish hazel trees cover 5.3 km or 6.7% of the total tree lines length (Ninić-Todorović et al., 2011).

MATERIAL AND METHODS

Turkish hazel fruits were gathered in moment of physiological independence of cupule petiole from mother plant. Indicator for maturity determination is yellow-green color of cupule and light brown color of nuts visible part (Ninić-Todorović, 1990). Pomological testing of samples in groups of 30 fruits determined length, width, thickness and pericarps thickness with micrometer precision of 0.01mm, nut and kernel mass were determined on technical scale with precision of 0.01 g.

Ground nut germination from mother plants in Nursery Gradsko zelenilo was determined in June 2008, and expressed in percentages out of total nuts amount sowed in October year 2007. Graft acceptance of cultivar Tonda Gentile Romana is determined in June year 2011.

In table are presented measuring results, for nuts morphological features, processed by appropriate statistical methods. For variability determination, with each examined feature coefficient of variance (CV) is presented, importance of differences between genotypes was tested with LSD test of statistical program STATISTICA 10 (StatSoft, Inc., Tulsa, OK, USA). Internal dependencies correlations were determined between nuts examined features. In table are presented values and simple correlation coefficients (r) between examined morphological traits. Genotype groups were determined by Discriminant Analysis in relation to examined morphometric features and influence on germination.

RESULTS AND DISCUSSION

Turkish hazel genotypes of secondary origin, during testing showed variability of fruits morphological features. Shape of fruit is constant for certain genotypes and directly influenced with heritage features of mother plants. The size of nuts and fruits mass vary over the years, depending on fruiting amount. On fruits size and amount of fruiting influence tree age and volume of tree crown (Ninić-Todorović, 1990).

Significant individual diversity of Turkish hazel genotypes are shown in nuts morphological, technological and physiological features. Amount of trees fruiting is alternative. Extensive fruiting of trees from park surfaces and alley on average is every third year. In Table 1 are presented measuring results and variability of nuts basic morphological traits for selected genotypes from nursery Gradsko zelenilo in Novi Sad.

Table 1. Morfometric fruit traits of selected Turkish hazelnut (*Corylus colurna* L.) at locality Gradsko zelenilo - nursery

Tabela 1. Morfometrijske osobine plodova turske leske (Corylus colurna L.) obranih na području rasadnika Gradskog

Genotypes *Genotipovi*	Fruit length *Dužina orašica*		Fruit width *Širina orašica*		Fruit thickness *Debljina orašica*		Fruit mass *Masa orašica*		Kernel mass *Masa jezgra*		Pericarp thickness *Debljina perikarpa*		Kernel/ fruit mass ratio *Randman*	
	mm	CV (%)	mm	CV (%)	mm	CV (%)	g	CV (%)	g	CV (%)	mm	CV (%)	%	CV (%)
A_4	17.89	3.16	13.94	1.23	11.40	2.88	1.48	4.96	0.55	6.15	1.91	2.73	37.05	4.39
A_5	17.17	1.60	18.32	1.14	14.45	2.98	2.58	4.35	0.89	6.27	2.71	5.93	34.52	3.82
A_8	17.17	0.96	14.82	3.28	12.45	3.16	1.80	6.03	0.61	4.14	2.31	5.04	33.97	6.51
A_{13}	17.93	0.53	16.54	2.54	12.45	3.18	2.04	5.09	0.70	7.33	2.49	7.46	34.21	6.21
A_{14}	17.40	2.47	15.05	2.64	12.46	3.93	1.93	6.35	0.63	5.73	2.43	5.93	32.75	8.62
A_{16}	17.42	1.61	14.49	2.86	10.89	3.22	1.47	6.80	0.63	5.58	0.70	9.31	42.95	4.90
B_7	16.43	1.60	14.38	8.13	11.19	3.00	1.51	11.21	0.69	10.28	0.56	5.60	45.97	4.12
C_1	18.34	1.50	15.59	3.04	12.02	4.22	1.57	6.02	0.64	5.07	0.63	3.95	40.82	5.35
C_2	16.87	1.97	17.42	4.76	13.91	5.64	2.25	7.03	0.70	4.89	2.05	4.18	31.48	10.13
C_3	19.22	2.53	14.02	2.22	11.50	2.98	1.31	11.47	0.56	5.09	1.57	5.54	43.10	14.44
C_4	18.89	1.95	14.62	2.45	11.99	4.25	1.78	5.43	0.63	4.16	0.64	6.52	35.61	3.12
Mean	17.71		15.38		12.26		1.80		0.66		2.15		37.50	
SD	0.88		1.48		1.13		0.39		0.10		0.37		5.33	
$LSD_{0.05}$	0.44		0.70		0.59		0.15		0.05		0.16		3.54	
$LSD_{0.01}$	0.59		0.94		0.79		0.21		0.07		0.22		4.73	

Nuts length for examined genotypes ranged from 16.43 (B7) to 19.22 mm (C3), while the largest nuts length variability expressed genotype A4 (CV=3,16%). Genotype A5 had the largest width of nuts (18.32 mm), statistically highly important difference in relation to all other genotypes, whilst minimal value of nuts width was noticed with genotype A4 (13.94 mm). Genotype B7 showed largest variability of tested trait (CV=8.13%), and with genotype A5 (CV=1.14%) was noted lowest variance in nuts width. Statistically significant larger nuts thickness in relation to other genotypes had genotype A5 (14.45 mm), while smallest had genotype A16 (10.89 mm). Most consistent nuts thickness, with lowest CV is recorded for genotypes A4, A5 and C3. Examined nuts mass was in range from 1.31 g, for genotype C3, to 2.58 g for genotype A5. Supporting results were found by Erdogan and Aygun, (2005) and also by Srivastava et al. (2010), testing nuts morphological characteristics and chemical compound of seed in seven different Turkish hazel genotypes.

Variance in nuts mass was from 4.35% (A5) to 11.47% (C3). The largest kernel mass had genotype A5 (0.89 g), and smallest mass had genotype A4 (0.55 g). The smallest variation in kernel mass is noted for genotype A8 (CV=4.14%), while largest mass for genotype B7 (CV=10.28%). Individual A5 had largest measured pericarps' thickness (2.71 mm), statistically significant larger in relation to genotypes A16, B7, C1 and C4. Most consistent pericarps thickness had genotype A4 (CV=2.73%), while genotype A16 (CV=9.31%) had largest variability in this feature. Biggest kernel / fruit mass ratio had genotypes B7 (45.97%), C3 (43.10%) and A16 (42.95%). Biggest coefficient of kernel / fruit mass ratio variance is noted with genotype C3 (CV=14.44%), while lowest coef-

ficient of fluctuation is recorded for genotype C4 (CV=3.12%). (figure 2)

Noticed nuts morphological features are important for planning depth and distance of planting in nursery production. Coefficients of variation imply weak fluctuation in size of nuts, so the same depth and distance is applied (6cm, 7 cm respectively) in sowing of selected nuts genotypes, on ground type chernozem.

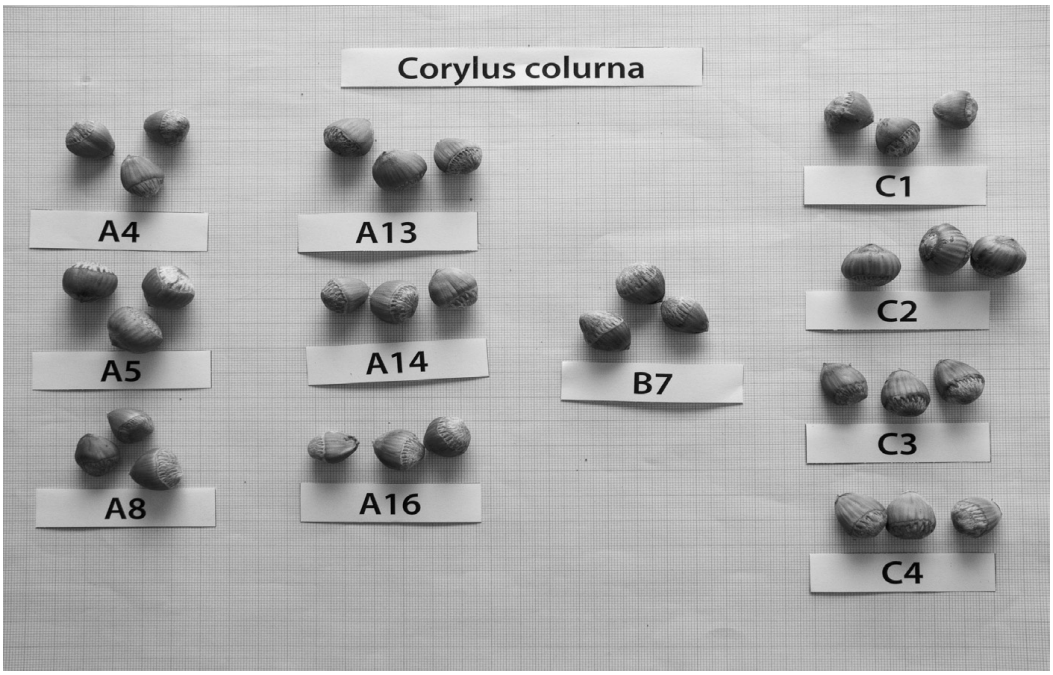

Figure 2. Genotypes of *Corylus colurna* L.
Slika 2. Genotipovi mečje leske

Correlation analysis included relations between morphometric features for selected genotypes of Turkish hazel nuts (Table 2). Significant negative correlations are noticed among length with width, thickness and mass of nuts, while correlation with thickness of pericarp is very significantly negative (r= - 0.557 **). Width and thickness of nuts had highly positive correlation between themselves, as well as with all examined features. Mass of nuts and kernel mass had highly significant positive correlation (r=0.783**). Relation of nuts mass, kernels mass and pericarps thickness are also in highly positive correlation. Kernel / fruit mass ratio, as significant economic entity, is in highly significant negative correlation with pericarps thickness as expected, since that with increase of pericarps thickness part of kernel mass is lowered.

Table 2. Simple correlation coefficients among investigated fruit traits of Turkish hazelnut genotypes (*Corylus culurna* L)
Tabela 2. Prosti koeficijenti korelacije između ispitivanih osobina osobina orašica genotipova mečje leske (Corylus colurna L.)

Trait *osobina*	Fruit width *Dužina orašica*	Fruit thickness *Debljina orašica*	Fruit mass *Masa orašica*	Kernel mass *Masa jezgra*	Pericarp thickness *Debljina perikarpa*	Kernel/fruit mass ratio *Randman*
Fruit length / *Dužina orašica*	-0.455*	-0.383*	-0.352*	-0.241	-0.557**	0.283

Fruit width / *Širina orašica*	0.878**	0.891**	0.779**	0.758**	-0.520**
Fruit thickness / *Debljina orašica*		0.913**	0.637**	0.763**	-0.709**
Fruit mass / *Masa orašica*			0.783**	0.852**	-0.713**
Kernel mass / *masa jezgra*				0.577**	-0.144
Pericarp thickness / *Debljina perikarpa*					-0.717**

* Significant correlations (p<0,05); ** High significant correlations (p<0,01).

Seed germination for examined Turkish hazel genotypes and percentage of graft acceptance are presented in Table 3. Based on presented data, very high values of seed germination in field conditions can be determined.

Table 3. Seed germination in terms of nursery and percentage of accepted grafts
Tabela 3. Klijavost semena u rasadniku i procenat primljenih kalemova

Genotype *Genotip*	Field germination *Klijavost u polju* (%)	Graft height *Visina kalemljenja* (cm)	Number of grafted rootstocks *Broj kalemljenih podloga*	Number of accepted grafts *Broj primljenih kalemova*	Percentage of acceptance *Udeo uspešnih kalemova* (%)
A_4	93.00	85	300	280	93.33
A_5	89.00	90	150	120	80.00
A_8	86.00	85	150	115	76.67
A_{13}	90.00	80	200	175	87.50
A_{14}	83.00	95	200	160	80.00
A_{16}	87.00	90	150	120	80.00
B_7	82.00	90	150	110	73.33
C_1	76.00	85	100	70	70.00
C_2	88.00	95	150	110	73.33
C_3	85.00	90	200	170	85.00
C_4	91.00	85	300	275	91.67

At beginning of April year 2011, hazel cultivars were grafted on rootstocks of Turkish hazel produced from nuts of mentioned genotypes. Three year old rootstocks in fourth vegetation period were used. Grafting height was from 80 cm on rootstock A13 to 95 cm on rootstocks A14 and C2, depending on rootstocks' thickness at grafting point.

Method used was tongue grafting. Percentage of grafting acceptance was in range from 70.00% (genotype C1) to 93.3% (genotype A4) at the end of vegetation period, which implies high scion / rootstock compatibility.

Figure 3. Hazelnuts grafted on *Corylus colurna* L. rootstocks
Slika 3. Leska kalemljena na podloge mečje leske

Applying Discriminant statistical analysis in relation, brought results connected to morphological characteristics. According to mentioned analysis most significant morphometric features of Turkish hazel nuts are length and nuts mass, and kernel mass (table 4.), influencing seed germination, or selection of best genotypes. In first group genotypes A5 and C2 outstand, with largest mass of nuts (2.58 and 2.25 g respectively), statistically significant larger than other genotypes. On chart, genotype B7, A16, A4, C4 and C3 have small nuts mass, but diversify on based on maximal values for nut length (16.43-19.22 mm). In third and fourth group are genotypes A8, A14, A13 and C1, with very similar values for morphological features and low variability in tested parameters.

Table 4. Discriminant Analysis on the basis of the selected parameters. Marked loadings are >0.7000 and significant for the axis.
Tabela 4. Diskriminantna analiza na bazi izabranih osobina.

Trait / *Osobina*	Root 1	Root 2	Root 3	Root 4	Root 5	Root 6	Root 7
Fruit length / *dužina orašica*	0.758*	-0.380	0.626	0.315	0.288	-0.174	-0.125
Fruit width / *širina orašica*	-0.144	-0.086	-0.208	1.039*	0.608	0.600	-0.276
Fruit thickness / *debljina orašica*	-0.098	-0.234	-0.318	-1.122*	0.849*	-0.709*	-0.289
Fruit mass / *masa orašica*	-0.264	-1.252*	1.173*	-0.078	-0.908*	0.768*	2.734*

Kernel mass / *masa jezgra*	-0.563	0.343	-1.001*	-0.233	-0.402	-0.579	-2.274*
Pericarp thickness / *debljina perikapra*	-0.166	0.649	0.445	0.509	0.378	-0.671	0.014
Kernel/fruit mass ratio / randman	0.216	-0.166	0.342	0.228	0.298	-0.206	2.525*
Eigenval	21.973	5.077	3.838	1.598	1.1079	0.3869	0.219
Cumulative %	0.642	0.791	0.903	0.950	0.9823	0.9936	1.000

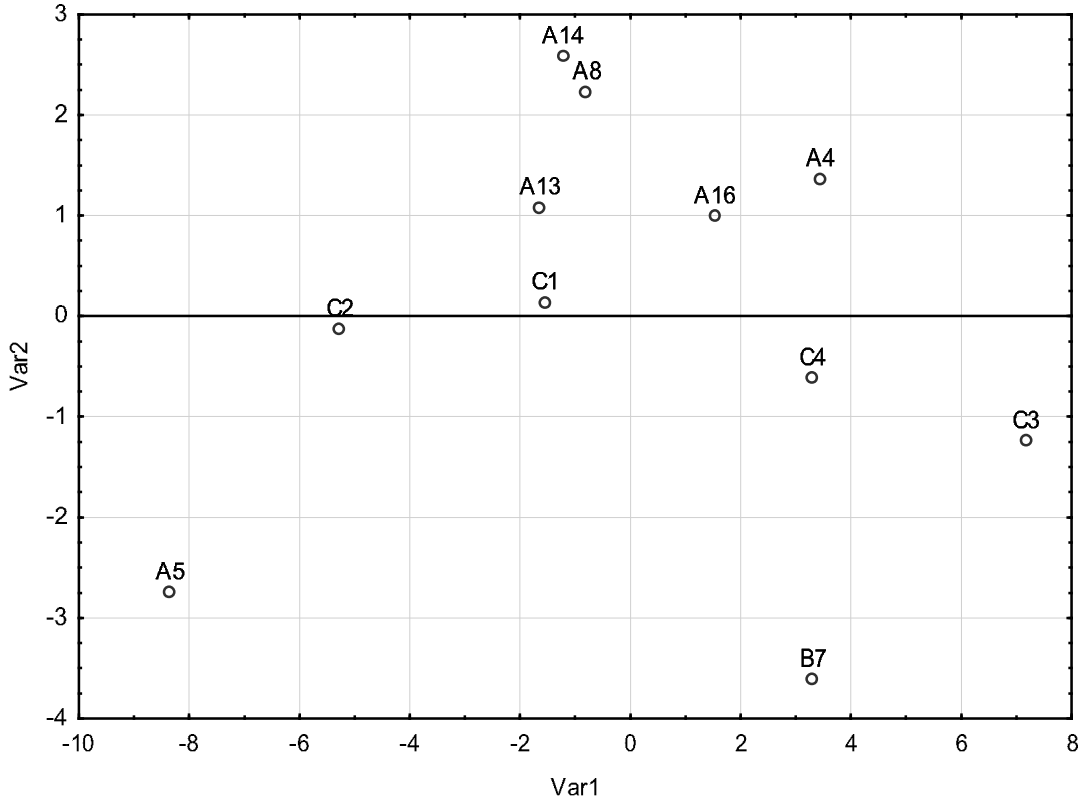

Figure 4. Discriminant Analysis Scatter plot based on investigated genotypes and parameters
Slika 4. Diskriminantna analiza (Scatter plot) bazirana na istraživanim genotipovima i parametrima

Stated findings draw conclusion that process of selecting nuts that is mother plants for production of generative rootstocks, should select genotypes with lengthier nuts, larger kernel / fruit mass ratio, and thinner pericarp. Considering that, larger fruit mass provides greater amount of available food to embryo, while with thinner pericarp enables easier germination, results are as expected. These findings however should be taken as guidelines, and not as specific determinants. Environmental conditions influence nuts germination in a year of gathering, sowing and follow up of seedling germination in nursery. As well, as manner and length of stratification, pests and disease resistance.

CONCLUSION

Large numbers of Turkish hazel trees in different age class are available in parks and tree lines in Novi Sad. Those secondary origin populations are used as a source of

sowing material for planting material production. Considering the range and alternative fruiting, recorded trees in park surfaces, depending on year and locality can provide enough nuts for planting material production for cities' green spaces needs.

Morphological and physiological traits of nuts, primarily germination, guide technological procedures toward achieving high productivity and profitability of producing Turkish hazel planting material. In nursery Rimski Šančevi, Turkish hazel is used as rootstock for hazel cultivars grafting.

Based on morphological measurements, most significant genotypes for nursery production in testing period are A4, A16, B7, C3 and C4 also confirmed with results of Discriminant Analysis.

Field germination of nuts implicates high percentage of technical germination, as especially showed in year 2007/2008. Reasons for high germination are affordable ecological conditions in period of seed production and germination readings, as well as successful protection of nuts from rodents in seed plot.

At beginning of April year 2011 tongue grafting was done on seedlings of examined hazel genotypes sowed in year 2007. Achieved graft acceptance, in range from 70.00% (genotype C1) to 93.3% (genotype A4), imply high affinity and compatibility of scion with rootstocks.

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SEKUNDARNE POPULACIJE TURSKE LESKE (*CORYLUS COLURNA L.*) U NOVOM SADU

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Izvod

Rezultati morfometrijske analize orašica odabranih genotipova mečje leske (*Corylus colurna* L.) odnose se na stabla sekundarnog porekla. Ustanovljena je klijavost semena i prijem kalemova na sejancima ispitivanih genotipova. Utvrđena je korelaciona zavisnost klijavosti semena od ispitivanih morfometrijskih osobina, što bi moglo imati značaja pri izboru matičnih stabala za proizvodnju sejanaca i sadnog materijala. Odabrani genotipovi sa lokaliteta rasadnika Gradsko zelenilo (A4, A5, A8, A13, A14, A16, B7, C1, C2, C3, C4) imali su visoku klijavost semena u godini ispitivanja i formirali su gust sklop u redovima. Kalemljenje genotipova obavljeno je početkom aprila 2011. godine u cilju dobijanja visokokalemljenih leski - stablašica. U toku vegetacionog perioda procenat prijema kalemova kretao se od 70.00% (genotip C1) do 93.3% (genotip A4) što ukazuje na visok afinitet podloga sa plemkama sorte Tonda Gentile Romana. Izdvojeni genotipovi pokazuju ujednačen rast i razvoj sejanaca, što je od značaja za primenu metoda kalemljenja engleskim spajanjem.

Ključne reči: *Corylus colurna*, populacija, genotip, klijavost semena, kalemljene leske, podloge.