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BIOLOGICAL TRAITS OF CORNELIAN CHERRY GENOTYPES (*Cornus mas* L.) FROM TERITORY OF MONTENEGRO

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In this paper are presented three years data (2009-2011) of biological traits of 30 cornelian cherry genotypes selected from the natural population of the region Upper Polimlje in Montenegro. Time of maturity, cropping, fruit and stone weight, size, fruit shape index and peel colour, content of flesh in total fruit mass and the soluble solids continent are presented. The aim of this paper is selection and preservation of cornelian cherry genotypes from natural population of Upper Polimlje that deserve attention due to their biological traits and recommendation of these genotypes for future propagation in present agricultural conditions or as a starting material in breeding of this fruit species.

Genotypes BA 70, BP 04, BP 17 and BP 44 with high cropping coefficient from 0.34 to 0.50 are worthy of attention as a big biological potential. For table consumption genotypes BA 70 and BP 21 are interesting, with fruit weight above 4 g, and genotypes PL 98, BP 44, PL 99, BP 36 and BP 22 with content of flesh in total fruit mass above 89% for processing. High content of soluble solids in the fruit, above 19%, are characteristic for genotypes BP 01, BP 06, BA 13, BP 38 and BP 40.

Key words: biological traits, Cornelian cherry, Montenegro, natural populations

INTRODUCTION

Montenegro is a part of the Balkan Peninsula, which is an important secondary centre of diversity of a large number of fruits, including the cornelian cherry *Cornus mas* L. (OGNJANOV *et al.,* 2009; BOŠNJAKOVIĆ *et al.,* 2012). Complex and specific herbal composition, geographical

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location, climatic and soil factors have influenced this area to become a rich source of natural, indigenous genetic resources. The existence of a high degree of genetic variability between different genotypes within individual fruit species is of special importance for the breeding of cultivated and wild plants.

Cornelian cherry is a deciduous shrub or small tree, up to 8 m tall, with a dense rounded crown. It belongs to the family *Cornaceae*, genus *Cornus*, which includes more than 50 species of grasses and woody plants, among which the most notable is the cornelian cherry, *Cornus mas* (BIJELIĆ *et al.,* 2010). The Latin name of cornel cherry "*Cornus*" dates from era of Virgil and Pliny and it is related to the "*cornee*" which is the cornea of animals and the addition of "*maschile*" or "*mas*"–strong, refers to an extremely hard wood of this plant. It grows everywhere, mostly on the dry, sunny, rocky sides of light deciduous oak forests, along with other brushwood and shrub. It endures shade and it is present in the forest with hornbeam, Hungarian oak and Adriatic oak (ŠILIĆ, 2005).

As wild, cornelian cherry is wide-spread in Central and Southeast Europe and Southwest Asia (BIJELIĆ *et al*., 2008). It grows up to 1400 m above sea level (ROP *et al.,* 2010). In last 50 years intensive work began in Turkey, Ukraine, Serbia, Iran, Bulgaria, the Czech Republic and Montenegro on the study of cornelian cherry natural populations with the aim to select promising genotypes (BIJELIĆ *et al.,* 2008; BIJELIĆ *et al.,* 2012; BOŠNJAKOVIĆ *et al.,* 2012; DOKOUPIL and REZNIČEK, 2012; KLIMENKO, 2004; HASSANPOUR *et al.,* 2012, PIRLAK *et al*., 2003; ERCISLI, 2004; YALCINKAYA, 2009, JAĆIMOVIĆ *et al*., 2013).

Cornelian cherry provides healthy fruits, without the use of chemical protection, which are used as healthy, delicious and medicinal foods. Fruit of cornelian cherry is used in the diet for 7 000 years. In North Greece were found the remains of human meals from Neolithic containing cornelian cherry. To cornelian cherry fruit has exceptional nutritional value known in ancient Greece, Rome and the Medieval period, when was often grown in monastery gardens (DUJMOVIĆ - PURGAR *et al*., 2012). The fruits can be used for fresh consumption or in the form of a numerous products: marmalade, jam, slatko (thin fruit preserve made of fruit or rose petals in Balkan cuisine), compote, syrup, juice, fruit yogurt, liquor, wine, and spirits (BRINDZA *et al.,* 2007; BIJELIĆ *et al.,* 2008) and immature fruits are conserved in saline solution as olives - marinated cornelian cherry (JAĆIMOVIĆ *et al.,* 2005; JAĆIMOVIĆ and BOŽOVIĆ, 2007). Cornelian cherry fruits are used in pharmaceutical and cosmetic industry (BIJELIĆ *et al.,* 2011).

Almost all organs of cornelian cherry are used in modern and traditional medicine (ERCISLI, 2004; GRLIĆ, 2005). Thus, for the treatment of stomach diseases, rheumatic diseases and anaemia teas are made out of root, stem bark, leaf, flower and fruit (JAĆIMOVIĆ *et al*., 2002; DEMIR and KALYONCU, 2003).

In Montenegro cornelian cherry is widespread wild fruit. In the area of the Upper Polimlje, cornelian cherry is mainly located in the forests so some forest areas covering up to several acres and groves where this fruit prevails are simply called "drenovi-cornelian cherries". Individual trees are grown in the rural households (JAĆIMOVIĆ *et al.* 2002).

Montenegro has great potential for cultivation of cornelian cherries in plantation. Therefore, it is necessary to study the native population of this fruit species in order to select the best genotypes that could be recommended for further propagation, suitable for the existing agro-ecological conditions or serve as starting material in breeding of this fruit. The aim of this paper is to select and preserve cornelian cherry genotypes from natural populations of the Upper Polimlje that, due to their biological properties, deserve attention.

MATERIALS AND METHODS

Associates of the Centre for continental fruits, medicinal and aromatic plants in Bijelo Polje have been studding for a long time the cornelian cherry populations in Montenegro. In this paper three-year data (2009-2011) of studding biological traits of 30 genotypes of cornelian cheery from natural populations in Upper Polimlje are presented. Municipalities of Andrijevica, Berane, Plav, Gusinje and Bijelo Polje represent one territorial, climatic and orographic unit known as the Upper Polimlje. It extends from 42° 10\` to 43° 50\` North latitude and 19° 40 to 20° 30 East Longitude, and includes the basin of the river Lim with an altitude of 528 to 2500 m. Relief has an important impact on the climate in the Upper Polimlje which is influenced by the humid continental and mountainous climate. In the studied area brown acid soil are predominant (FUŠTIĆ and ĐURETIĆ, 2000).

During the research standard methods were used. Elevation was measured with the altimeter "Compens N-28042". In addition to the recording of the period of full maturity, the dates of initiations and end of ripening are recorded as well. Cropping is shown as yield in kg/tree and by cropping coefficient which is the ratio between the yield in kg and diameter of the trunk in cm^2 (PIRLAK *et al*. 2003). Analysis of the fruit was performed at the stage of full maturity, on an average sample of 50 fruits per genotype. Fruit and stone weight was determined by measuring on the analytical balance "Mettler" 1200. The result is expressed in grams of precision of 0.01 g. Utilization of fruit is presented as a content of flesh in total fruit mass expressed as a percentage and as the flesh stone ratio. Length and width of fruit are measured with Vernier scale. Fruit shape index was calculated according to the formula $I = lenght^2/width^2$. Soluble solids content - SSC was determined by refractometer RHBS - 32ATS at a constant temperature of 20 ^oC.

Statistical analysis was performed in SPSS version 19 predictive analytics software. Statistical analysis includes the analysis of variance and testing the significance of differences for analysed genotypes using Duncan's multiple range tests.

RESULTS AND DISCUSSION

Centuries-growing and relatively high incidence of cornelian cherry in different agro-ecological conditions of the Upper Polimlje caused formation of rich natural population of this fruit species. Genotypes presented in this paper are growing between 540 and 1125 m above sea level (Tab. 1). The upper vertical limit where cornelian cherry shrubs can be found is on 1280 m in this area (hills Kurilo and Kaludar), which is consistent with the quotes of BJELIĆ *et al*. (2012) stating that cornelian cherry grows up to 1300 m above sea level. However, ROP *et al.* (2010) point out that cornelian cheery can be found at altitudes up to 1400 m, and HASSANPOUR *et al.* (2012) describing the Iranian cornelian cherry genotypes, presented genotype that is on 1511 m above sea level.

Cornelian cherries from this area are ripening from 28th August until 13th October. The average duration of growth stage of fruit ripening for genotypes presented in this paper ranged from 13 to 27 days, with 22 days average for all genotypes, whereas genotypes studied by BIJELIĆ *et al.* (2008) had an average ripening time of 27 days. Depending on the genotype, full ripening has been achieved in the period from 7th September the 13th October. Genotypes were late maturity stage. Some early maturing genotypes of cornelian cherry, from 17th August to 20th September, were noted by BOŠNJAKOVIĆ *et al.* (2012). The cornelian cherry genotypes that were examined by BIJELIĆ *et al.* (2008) have reached full ripening much earlier; 27th July – 29th August. Wide interval of ripening is influenced by several factors: characteristics of the genotype, climate, soil conditions, altitude, terrain exposure, insolation and micro-climatic conditions.

Table 1. Biological traits of the selected Cornus mas genotypes

Genotipe	Altitude (m)	Ripening				Cropping			
		Onset	Full	End	Duration (days)	Yield ($kg\ tree^{-1}$)		Cropping coefficient ($kg\ cm^{-2}$)	
BP 01	878	02.IX	11.IX	25.IX	24	6.67	n *	0.12	efgh
BP 04	875	06.IX	14.IX	29.IX	24	20.67	jklmn	0.37	b
BP 06	860	07.IX	16.IX	26.IX	20	9.33	mn	0.15	cdefg
BP 07	810	17.IX	28.IX	13.X	27	43.00	defg	0.06	hij
BA 13	630	07.IX	13.IX	25.IX	19	55.00	cde	0.04	ij
BP 16	780	13.IX	21.IX	02.X	20	21.00	jklmn	0.05	ij
BP 17	540	02.IX	10.IX	25.IX	24	36.67	efghi	0.48	a
BP 21	730	24.IX	02.X	11.X	18	48.33	de	0.02	j
BP 22	608	08.IX	20.IX	28.IX	21	14.33	klmn	0.18	cde
PL 23	860	07.IX	17.IX	30.IX	24	93.33	a	0.19	cde
BP 25	850	04.IX	13.IX	25.IX	22	19.33	jklmn	0.10	fghij
BP 33	575	28.VIII	07.IX	20.IX	23	21.67	jklmn	0.22	c
BP 36	770	31.VIII	08.IX	19.IX	20	76.67	ab	0.19	cde
BP 38	730	08.IX	17.IX	21.IX	13	65.33	bc	0.05	ij
BP 40	840	10.IX	19.IX	30.IX	21	26.67	hijkl	0.03	ij
BP 41	605	03.IX	11.IX	24.IX	22	45.67	def	0.20	cd
BP 44	875	02.IX	12.IX	23.IX	22	40.33	defgh	0.50	a
BP 48	1125	15.IX	24.IX	04.X	20	17.67	jklmn	0.12	efgh
BA 49	678	10.IX	18.IX	30.IX	21	11.33	lmn	0.07	hij
AN 50	780	13.IX	22.IX	03.X	21	19.67	jklmn	0.15	cdefg
BP 51	610	01.IX	10.IX	17.IX	17	9.00	mn	0.09	ghij
BP 53	605	30.VIII	10.IX	22.IX	24	72.00	ab	0.04	ij
BP 54	590	29.VIII	13.IX	19.IX	22	17.33	jklmn	0.14	defg
BP 58	540	01.IX	11.IX	27.IX	27	17.67	jklmn	0.12	efgh
BA 70	660	04.IX	15.IX	27.IX	24	78.00	ab	0.34	b
BP 75	810	03.IX	13.IX	25.IX	23	24.00	ijklm	0.09	ghij
PL 98	843	30.VIII	09.IX	24.IX	26	48.33	de	0.15	cdefg
PL 99	895	09.IX	20.IX	30.IX	22	32.67	fghij	0.04	ij
AN 103	900	31.VIII	07.IX	15.IX	16	30.00	ghijk	0.14	defg
AN 104	890	14.IX	22.IX	05.X	22	44.00	defg	0.17	cdef

** Significance of differences was tested by Duncan`s Multiple Range tes (p<0.05)*

Table 2. Fruits traits of the selected Cornus mas genotypes

Genotipe	Fruit weight (g)		Stone weight (g)		Content of flesh (%)		Flesh stone ratio	Soluble solids content (%)	
BP 01	2.72	ij*	0.38	g	86.03	efgh	6.30	19.00	abcd
BP 04	2.28	no	0.40	f	82.46	kl	4.70	17.13	abcdefgh
BP 06	0.89	s	0.18	o	79.78	l	3.94	20.10	a
BP 07	2.51	lm	0.29	l	88.43	abcd	8.22	15.67	efghijk
BA 13	1.91	q	0.32	k	83.25	jk	4.97	19.30	abc
BP 16	2.80	h	0.46	c	83.57	ijk	5.09	16.90	abcdefghij
BP 17	2.27	no	0.35	hij	84.91	hij	5.65	17.79	abcdefgh
BP 21	4.03	b	0.61	a	85.53	fgh	5.61	13.67	jkl
BP 22	2.30	n	0.24	n	89.57	ab	8.58	18.93	abcde
PL 23	2.18	op	0.32	k	85.32	fghi	5.81	15.60	fghijk
BP 25	1.90	q	0.29	l	84.74	hij	5.55	17.53	abcdefgh
BP 33	2.28	no	0.27	m	88.16	abcd	7.44	14.60	hijkl
BP 36	1.92	q	0.20	o	89.58	ab	8.60	18.80	abcdef
BP 38	3.12	e	0.42	e	86.54	defgh	6.43	19.88	ab
BP 40	2.60	kl	0.34	ij	86.92	cdefg	6.63	19.37	abc
BP 41	2.43	m	0.35	hij	85.60	fgh	5.94	14.90	ghijl
BP 44	3.04	f	0.31	l	89.80	a	8.81	13.57	kl
BP 48	1.52	r	0.27	m	82.24	kl	4.63	12.23	l
BA 49	2.03	p	0.25	n	87.68	bcde	7.12	15.40	ghijk
AN 50	2.12	p	0.24	n	88.68	abc	7.83	16.73	bcdefghijk
BP 51	3.53	d	0.43	d	87.82	bcde	7.21	17.30	abcdefgh
BP 53	2.10	p	0.32	k	84.76	hij	5.56	18.17	abcdefg
BP 54	3.86	c	0.45	cd	88.34	abcd	7.58	16.20	cdefghijk
BP 58	3.01	f	0.38	fg	87.41	cde	6.92	17.00	abcdefghi
BA 70	4.24	a	0.55	b	87.03	cdef	6.71	16.67	bcdefghijk
BP 75	2.87	g	0.34	ij	88.16	abcd	7.41	17.23	abcdefgh
PL 98	2.68	jk	0.27	m	89.93	a	8.93	16.50	cdefghijk
PL 99	3.64	c	0.38	fg	89.56	ab	8.58	16.00	defghijk
AN 103	3.25	e	0.38	fg	88.31	abcd	7.55	13.77	ijkl
AN 104	2.42	m	0.36	hi	85.12	ghi	5.72	15.47	ghijk

** Significance of differences was tested by Duncan`s Multiple Range tes (p<0.05)*

The average fruit weight varied from 0.89 g in genotype BP 06 to 4.24 g in genotype BA 70, and stone weight from 0.18 g - genotype BP 06 to 0.61 g - BP 21 genotype (Tab. 2). Genotypes BA 70 and BP 21 with fruit weight above 4 g are interesting for table consumption. Fruit and stone weight of the studies genotypes was mainly near the limits stated by many other authors (PIRLAK *et al.,* 2003; DEMIR and KALYONCU, 2003, BIJELIĆ *et al.,* 2008; BIJELIĆ *et al.,* 2011; HASSANPOUR *et al.,* 2012). However, BOŠNJAKOVIĆ *et al.* (2012) selected genotype VR 10 from natural populations in Serbia with a mass of 14.55 g far exceeding the others, indicating that the study of cornelian cherry populations must continue. All of these differences indicate the specificity of each population and the high variability of fruits in the wider regions of the cornelian cherry growth.

Table 3. Dimensions, shape and colour of fruit of selected Cornus mas genotypes

Genotipe	Fruit length (mm)		Fruit width (mm)		Shape index		Fruit colour
BP 01	18.19	j*	14.73	e	1.56	kl	Dark red
BP 04	16.63	m	14.22	f	1.37	m	Red
BP 06	14.33	p	10.46	m	1.88	ef	Dark red
BP 07	18.14	j	14.30	f	1.61	ijkl	Dark red
BA 13	18.22	j	12.81	k	2.02	cd	Yellow
BP 16	19.66	h	14.66	e	1.80	efg	Dark red
BP 17	20.67	de	13.02	j	2.52	a	Dark red
BP 21	21.80	b	16.91	a	1.66	hijk	Dark red
BP 22	17.60	k	14.26	f	1.52	l	Red
PL 23	19.05	i	13.35	i	2.04	c	Dark red
BP 25	16.83	lm	12.80	k	1.73	ghi	Dark red
BP 33	18.28	j	13.76	gh	1.76	fgh	Dark red
BP 36	16.15	n	12.86	k	1.58	jkl	Dark red
BP 38	18.98	i	14.94	de	1.61	ijkl	Dark red
BP 40	17.99	j	13.20	ij	1.86	ef	Dark red
BP 41	21.07	c	13.84	gh	2.32	b	Dark red
BP 44	20.22	fg	15.38	c	1.73	ghi	Dark red
BP 48	14.89	o	11.76	l	1.60	jkl	Light red
BA 49	16.61	m	13.31	i	1.56	kl	Dark red
AN 50	17.56	k	13.22	ij	1.76	fgh	Dark red
BP 51	22.03	b	16.09	ab	1.87	ef	Dark red
BP 53	17.13	l	13.50	hi	1.64	hijkl	Red
BP 54	20.52	ef	16.59	a	1.52	l	Dark red
BP 58	19.74	h	12.97	j	2.32	b	Dark red
BA 70	22.83	a	16.49	a	1.92	de	Dark red
BP 75	17.52	k	15.04	d	1.36	m	Dark red
PL 98	20.92	cd	13.36	i	2.45	a	Dark red
PL 99	21.39	c	16.43	a	1.70	ghij	Red
AN 103	20.05	gh	15.89	b	1.59	jkl	Red
AN 104	19.11	i	14.25	f	1.80	efg	Red

** Significance of differences was tested by Duncan`s Multiple Range tes (p<0.05)*

Utilization of fruit is presented as a content of flesh in total fruit mass expressed as a percentage and as the flesh stone ratio. Flesh content in the total fruit mass varied from 79.78 to 89.93%, and the flesh stone ratio from 3,94 to 8,93.Particularly high utilization of fruits have genotypes with flesh content above 89%: PL 98, BP 44, PL 99, BP 36 and BP 22, and these can be recommended for industrial processing. With respect to the data presented a similar utilization of the fruit have genotypes from Serbia with flesh content from 79.32 to 88.55% and from 79.24 to 88.29% respectively (BIJELIĆ *et al.,* 2010; BIJELIĆ *et al.,* 2011), and the genotypes from Turkey and Iran, with flesh stone ratio from 3.80 to 8.51 and from 6.0 to 9.4 (PIRLAK *et al.*, 2003; HASSANPOUR *et al*., 2012).

The content of soluble solids in the fruits of studied genotypes varied from 12.23% to 20.10%. High content of soluble solids in the fruit, above 19%, are characteristic for genotypes: BP 01, BP 06, BA 13, BP 38 and BP 40. Cornelian cherry genotypes in Iran and Turkey are characterized by lower soluble solids content from 5% to 12.5% (HASSANPOUR *et al.,* 2012) and from 8.0% to 13.5% and from 11.5$ to 16.8% (KARADENIZ *et al.,* 2001.; PIRLAK *et al*., 2003), whereas genotypes in Serbia have soluble solids content from 12.9 to 23.74% and in particular from 18.10 to 29.38% higher compared to the tested parameter of genotypes included in this work (BOŠNJAKOVIĆ *et al*., 2012; BIJELIĆ *et al.*, 2011). The reason for this variation is the fact that besides the genetic constitution of genotypes, the amount of soluble solids in the fruit is significantly affected by different agro-ecological conditions (DEMIR and KALYONCU, 2003).

Dimensions, shape and colour of fruit of cornelian cherry genotypes are presented in Table 3. Fruit length was in the range of 14.3 to 22.83 mm and width from 10.46 to 16.91 mm. Comparing our data with other authors, it can be concluded that the dimensions of the fruits is in the approximate limits (PIRLAK *et al.,* 2003; DEMIR and KALYONCU, 2003; HASSANPOUR *et al.,* 2012), suggesting that similar fruit weight causes similar dimensions, as between these traits there is a positive correlation. The smallest fruit shape index was 1.37 in genotype BP 04, while the fruits of genotype BP 17 with an index of 2.52 were the most elongated. A similar interval of variation of these traits from 1.18 to 2.50 is shown in the works of DEMIR and KALYONCU (2003); TURHAN *et al.* (2007); BIJELIĆ *et al.* (2012); HASSANPOUR *et al.* (2012).

In the studied population dark red skin colour of the fruit dominated, much less was present red colour, while the bright red colour was in the genotype BP 48, and yellow skin colour in genotype BA 13. Immature fruits of genotype BA 13 preserved in saline solution as olives were excellently rated (JAĆIMOVIĆ *et al.,* 2005; JAĆIMOVIĆ and BOŽOVIĆ, 2007). The selected genotypes from the territory of Serbia had a predominantly red skin colour, less dark red and the least light red colour and no genotypes with yellow fruit colour (BOŠNJAKOVIĆ *et al.,* 2012). DOKOUPIL and REZNIČEK (2012) suggest that the red colour is typical for cornelian cherry fruit, although there can be found fruits with pink and yellow colour.

CONCLUSION

The great diversity in the population of cornelian cherry in Upper Polimlje allows selection of variety of genotypes with positive biological traits that make them highly recommended for plantation cultivation in order to obtain fruit for table use and industrial processing. In the studied population, depending on the genotype, the full ripening ranged from 7th September to 13th October. Genotypes were of late maturity stage.Genotypes BA 70, BP 04, BP 17 and BP 44, characterised by a high cropping coefficient varying from 0.34 to 0.50, are worthy of attention as a major biological potential. Cornelian cherry fruits that are produced without spraying against pests and diseases, use of fertilizers, and thus without pesticide residues meet the highest standards of production of safe food. Genotypes BA 70 and BP 21 having fruit weight above 4 g are interesting for table consumption. Genotypes with flesh content in the total fruit mass above 89%; PL 98, BP 44, PL 99, BP 36 and BP 22 can be recommended for industrial processing.High content of soluble solids in the fruit, above 19%, are characteristic of genotypes: BP 01, BP 06, BA 13, BP 38 and BP 40. The lowest fruit shape index was 1.37 in genotype BP 04, while the fruits of genotype BP 17 with an index of 2.52 were the most elongated. In the studied population dark red skin colour of the fruit was predominant, much less red colour, while the bright red colour of skin had genotype BP 48 and yellow in genotype BA 13.

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BIOLOŠKE OSOBINE GENTIPOVA DRIJENA (*Cornus mas* L.) SA PODRUČJA CRNE GORE

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Izvod

U ovom radu su prikazani trogodišnji podaci vezani za zrenje, rodnost i pomološki opis ploda 30 genotipova drijena izdvojenih iz prirodne populacije Gornjeg Polimlja, regiona u Crnoj Gori. Cilj rada je izdvajanje i očuvanje onih genotipova drijena koji zbog svojih bioloških osobina zaslužuju pažnju, kako bi se mogli preporučiti za dalje širenje u postojećim agroekološkim uslovima ili kao početni materijal u oplemenjivačkom radu u okviru ove voćne vrste.

Genotipovi BA 70, BP 04, BP 17 i BP 44 koji se ističu visokim koeficijentom rodnosti su vrijedni pažnje kao veliki biološki potencijal za dobijanje kvalitetne i jeftine hrane. Za stonu potrošnju interesantni su genotipovi BA 70 i BP 21, sa masom ploda iznad 4 g, a za preradu genotipovi čiji je udio mezokarpa u ukupnoj masi ploda iznad 89 %: PL 98, BP 44, PL 99, BP 36 i BP 22. Visokim sadržajem rastvorljive suve materije u plodu, iznad 19 %, karakterišu se genotipovi: BP 01, BP 06, BA 13, BP 38 i BP 40.

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