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ANALYSIS OF POMOLOGICAL TRAITS IN NEW PROMISING SWEET CHERRY GENOTYPES

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Sweet cherry breeding programs are interested in developing new cultivars that are very early or very late in ripening, high yielding, with excellent fruit size and quality. The aim of this study was to evaluate new, promising, sweet cherry genotypes (G-1 and G-2) for ripening time, fruit morphology and fruit chemical content, and compare it with the standard sweet cherry cultivars (Bigarreau Jaboulay, B. H. Burlat, Seneca, Hedelfiger Riesenkirsche, Germersdorfer Grosse Kirsche, Emperor Francis and Bing). Experiment was done during four consecutive years (2006-2009) in Grocka, near Belgrade. The earliest fruit ripening was recorded in G-2 (22nd April) while the latest in `Bing` (2nd June). Fruit weight varied from 5.83 g (G-2) up to 8.93 g (G-1). Soluble solid content and total sugar content were the lowest in genotype G-2 (10.48%; 8.45%, respectively) but the highest in Emperor Francis (18.28%; 15.98%, respectively). No matter the fact that some standard cultivars showed better results for some traits, genotypes G-1 and G-2 are considered very promising. So, genotype G-1 could be intended for table consumption since it ripens 2-3 days after cv. B. H. Burlat, but have much higher fruit weight. Also, genotype G-2, the earliest in this trial, showed satisfactory fruit weight for this ripening time, which makes it very interesting for fresh market production.

Key words: ANOVA, chemical traits, coefficient of variation, fruit, ripening time

INTRODUCTION

The sweet cherries (*Prunus avium* L., 2n=16), as one of the first tree fruits to ripen in temperate growing regions, have been valued since ancient times. Its nice look and pleasant taste are very efficiently marketed since late May until July. World's sweet cherry production is 2,064,421 t, where Turkey is the biggest producer with around 20% of total production

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(FAOSTAT, 2010), while Serbia in on the 20th place. Sweet cherry fruits are not only consumed fresh but also used to produce jam, jelly, stewed fruit, marmalade, syrup and several types of soft drinks

The vast majority of sweet cherry breeding programs are in Europe, as these countries represent the ancestral home of cherry. The current list of breeding programs is impressive, but it gives a false sense of the potential and progress being made in cherry breeding due to the difficulty of seed germination and the field space requirement and number of years necessary before a seedling starts to fruit (IEZZONI, 2008). Thanks to classical breeding programs, within the last 10 years, 20 new varieties are gaining wide interest internationally (DIRLEWANGER *et al*., 2007). In general, all sweet cherry breeding programs are interested in developing new cultivars that are very early or very late in ripening, with regular yields and excellent fruit size and quality.

The selection and introduction of new sweet cherry cultivars are important to maintaining a competitive fruit industry in Serbia. Over the past three decades, the sweet cherry breeding program in the Serbia created only two cultivars. New genotypes are screened mainly on the basis of the field growth factors as well as postharvest fruit quality attributes such as size, color, texture, and flavor by sensory means.

Thus, the objective of this study was to evaluate new, promising, sweet cherry genotypes (G-1 and G-2) for ripening time, fruit morphology and fruit chemical content, and compare it with seven standard sweet cherry cultivars.

MATERIALS AND METHODS

Experiment was done during four consecutive years (2006-2009) in Grocka, near Belgrade. All cultivars were grown on *P. mahaleb* rootstock and planted in 1998. The orchard is established under non-irrigated standard cultural practices. Planting distance was 5 x 5 m. Besides new, promising, sweet cherry genotypes G-1 and G-2, standard sweet cherries cultivars Bigarreau Jaboulay, B. H. Burlat, Seneca, Hedelfiger Riesenkirsche, Germersdorfer Grosse Kirsche, Emperor Francis and Bing were used as well.

Fruit characteristics were measured on fruits harvested in full maturity stage. The samples of 50 fruits per tree harvested randomly. Fruit length (FL) and width (FWG) was measured by caliper in cm, respectively. Fruit shape index (FSI) was calculated as the ratio between of FL and FWG. Fruit weight (FW) and stone weight (SW) was measured for each fruit by scale in g and average was calculated. Output (OP) was determined as ration between FW and SW. Fruit stalk length (FSL) was measured by a ruler. Ripening time (RT) was the harvesting date and expressed as the number of days after April 15. Soluble solids content (SSC) was analysed by using a digital refractometer (Pocket PAL-1, Atago, Japan). Titratable acidity (TA) was measured by neutralization to pH 7.0 with 0.1 N NaOH and acidity expressed as percent of malic acid equivalent. Total sugar content (TS) and invert sugars content (IS) were measured according to Luff - Schoorl method.

The mean values of the studied properties were determined. The obtained results were processed by ANOVA in the statistic program ‘Statistica’ (StatSoft, Inc.). Differences were compared using LSD-test at $P = 0.05$ and $P = 0.01$.

RESULTS AND DISCUSSION

Since it is difficult to state definitely to the day when sweet cherries are ripe because they are edible long before they are really ripe or at best quality (BLAŽKOVÁ, 2002), we took picking time as the ripening time. Cherry harvest was staggered during a 40-days period, which allows continuity and also a long market period, with the potential to extend marketing with postharvest practices such as modified atmosphere packages. The earliest average RT (Table 1) was noticed in genotype of G-2 (7th May), and the latest in cultivar Bing (18th June). The average amplitude of the ripening time in studied cultivars/genotypes was 10 days. As going from early maturing cultivars to the later ripening time the amplitude decreased, varying from 5 days (Emperor Francis and Bing) up to 17 days (Bigarreau Jaboulay). Differences in ripening time between years of study made it difficult to classify promising genotypes into `ripening weeks`. Using the average ripening time, genotype `G-2` showed very early ripening time, while genotype `G-1` was mid-season.

Table 1. Average values of pomological traits in standard cultivars and promising sweet cherry genotypes

Cultivar/Genotype	RT	FL (mm)	FWD (mm)	FSI	FSL (cm)	FW (g)	SW (g)	OP (%)	SSC (%)	TA (%)	SSC/TA	TS (%)	IS (%)
G-2	7th May	19.71	21.8	0.90	3.43	5.83	0.42	92.88	10.48	0.35	32.61	8.45	7.07
Bigarreau Jaboulay	9th May	20.61	21.63	0.96	3.86	5.95	0.55	90.82	16.15	0.87	18.89	13.09	11.91
B. H. Burlat	25th May	21.20	22.79	0.93	3.06	6.58	0.41	93.78	16.88	0.67	25.59	12.77	11.75
Seneca	28th May	21.17	22.65	0.94	5.40	6.60	0.47	92.92	12.45	0.86	14.60	10.81	9.87
G-1	28th May	24.46	24.86	0.99	3.95	8.93	0.61	93.24	15.15	0.70	23.31	10.68	9.97
Hedelfiger Riesenkirsche	15th June	23.89	24.56	0.98	4.64	8.34	0.44	94.76	14.45	0.65	23.04	11.73	11.17
Germersdorfer Grosse Kirsche	15th June	23.36	24.20	0.97	4.64	7.34	0.41	94.49	15.15	0.66	23.22	10.79	9.59
Emperor Francis	17th June	22.18	23.15	0.96	4.04	7.30	0.37	94.90	18.28	0.68	27.81	15.98	14.68
Bing	18th June	22.09	23.07	0.96	3.39	6.85	0.44	93.48	15.10	0.63	24.68	12.16	10.75
Mean	31st May	22.07	23.14	0.95	4.04	7.08	0.46	93.47	14.90	0.67	23.75	10.83	14.90
CV (%)	32.44	7.32	5.67	3.50	18.49	15.62	17.94	1.42	17.68	27.46	29.69	24.59	17.68
$LSD_{0.05}$	7.326	0.783		0.036	0.383	0.759	0.044	0.863	1.265	0.171	6.628	2.834	2.119
$LSD_{0.01}$	10.670	1.141		0.052	0.558	1.106	0.064	1.257	1.842	0.249	9.654	4.127	3.087

Information regarding dimensional attributes is used in describing fruit shape which is often necessary in horticultural research for a range of differing purpose including cultivar descriptions in applications for plant variety rights or cultivar registers (BEYER *et al*., 2002). The lowest FL and FWD were recorded in G-2 (19.71 and 21.8 mm, respectively), while the highest in G-1 (24.46 and 24.86 mm, respectively).

The length of the fruit stalk is an important parameter for determination of sweet cherry cultivars, and has a practical significance. Longer fruit stalk means easier harvesting and less fruit rot. The FSL of ‘Seneca’, ‘Hedelfiger Riesenkirsche’ and □Germersdorfer Grosse Kirsche□ fruits was significantly larger than that of the other cultivars, varying from 4.64 to 5.40 mm and from 3.43 to 4.04 mm, respectively. It is well known that besides genetics and environment, fruit weight depends on crop load (GONÇALVES *et al*., 2006), and fruit maturity stage (SERRANO *et al*., 2009). In our study, FW (Table 1) was a variable character, with minimum values found in promising genotype G-2 (5.83 g). The highest FW was recorded in genotype G-1 (8.93 g) which is a self-incompatible chance seedling (NIKOLIĆ *et al*., 2012). Our results are in agreement of RADIČEVIĆ *et al*. (2008) who studied pomological characteristics of sweet cherry cultivars originating from Canada. Sweet cherries with large fruit size are distinctly preferred by consumers. Larger fruits have greater visual appeal and often have better taste. Since stone size is relatively constant, and in our study varied from 0.37 (Emperor Francis) to 0.61 (G-1), large cherries have proportionally more flesh. OP varied from 90.82 (Bigarreau Jaboulay) up to 94.90% (Emperor Francis). Promising genotypes had satisfactory levels of OP, around 93%. However, SÜTYEMEZ (2000) reported that flesh/stone ratio was between 9.03 and 11.91% for the different sweet cherry varieties grown at different environmental and cultivation conditions.

Table 1 also shows the chemical composition of seven sweet cherry cultivars and two promising genotypes, expressed as means, which correspond to the four years of study. The SSC is very important characteristics, giving information about sugar content of fruits. In our analyses, measured SSC was in the range from 10.48% (G-2) to 18.28% (Emperor Francis) which correlates with the results of VURSAVUS *et al*. (2006) who examined SSC in three sweet cherry cultivars grown in South-Mediterranean region of Turkey. From our results can be concluded that commercially grown sweet cherry cultivars had much lower SSC than wild sweet cherry genotypes as reported by MRATINIĆ *et al*. (2012). SSC can not be considered as an isolated characteristic, since JIMÉNEZ *et al*. (2004) showed the relationship between firmness and SSC. This correlation is important since selection of high SSC genotypes will aim first at higher firmness and second at lower susceptibility to mechanical damage during handling and packaging (CRISOSTO *et al*., 2001). TA level varied according to cultivar, environmental and orchard management conditions, but it is not highly influenced by maturation/ripening. The TA of G-2 was significantly lower than in other cultivars (0.35%), while in Seneca and Bigarreau Jaboulay were relatively high (0.86 and 0.87 %, respectively). When comparing other cultivars and genotypes TA were quite similar, ranging from 0.63-0.70%

The ratio SSC/TA has been found to be related to the perception of sweetness, sourness or cherry flavor (CRISOSTO *et al.*, 2002) is used as a quality index. Low sugar and high acid contents result in a sour taste, while low acid and high sugar contents result in a bland taste. In our study this relation varied from 14.60 in cultivar Seneca up to the 32.61 in G-2. However, in a recent study with sweet cherries (CRISOSTO, 2003) and nectarines (IGLESIAS and ECHEVERRÍA, 2009) the consumer acceptance was always greater for non-acid than for acid cultivars, even at early or advanced stages of fruit maturity.

Demonstrated differences in the content of sugars are certainly the result of cultivar characteristics, which are fully expressed during the examined period. Climatic conditions during this period have led to an increase of sugars content in all studied cultivars and promising genotypes. Under the influence of drought and high temperature in 2009 (data not shown), an increase in the content of total and invert sugars appeared in all investigated cultivars/genotypes. The lowest values for TS and IS was detected in G-2 (8.45 and 7.07%, respectively) while the highest in Emperor Francis (15.98 and 14.68%, respectively).

Table 2a. F-values obtained in the ANOVA for the studied properties

Variable	DF	MS	F-value	p-value
		Ripening time		
Cultivar	8	860.61**	31.295	0.000
Year	3	146.000**	5.309	0.006
Error	24	27.500		
		Fruit length		
Cultivar	8	10.002**	31.819	0.000
Year	3	1.264*	4.020	0.0198
Error	24	0.314		
		Fruit width		
Cultivar	8	188.042	1.195	0.343
Year	3	173.379	1.102	0.368
Error	24	157.386		
		Fruit shape index		
Cultivar	8	0.003**	4.161	0.003
Year	3	0.000	0.440	0.726
Error	24	0.001		
		Fruit stem length		
Cultivar	8	2.185**	29.069	0.000
Year	3	0.096	1.270	0.307
Error	24	0.075		
		Fruit Weight		
Cultivar	8	4.236**	14.334	0.000
Year	3	0.614	2.078	0.130
Error	24	0.296		
		Stone weight		
Cultivar	8	0.022**	22.274	0.000
Year	3	0.011**	10.804	0.000
Error	24	0.001		
		Output		
Cultivar	8	6.292**	16.495	0.000
Year	3	0.644	1.690	0.196
Error	24	0.381		

Table b2. F-values obtained in the ANOVA for the studied properties

Variable	DF	MS	F-value	p-value
		Soluble solid content		
Cultivar	8	21.402**	26.114	0.000
Year	3	17.308**	21.118	0.000
Error	24	0.820		
		Total aciditivity		
Cultivar	8	0.092**	6.074	0.0002
Year	3	0.034	2.236	0.110
Error	24	0.015		
		Soluble solid content/ Total aciditivity		
Cultivar	8	103.77**	4.610	.00166
Year	3	123.17**	5.472	.0052
Error	24	22.51		
		Total sugar content		
Cultivar	8	17.323**	4.210	0.003
Year	3	14.223*	3.457	0.032
Error	24	4.114		
		Invert sugar content		
Cultivar	8	18.118**	7.873	0.000
Year	3	15.927**	6.921	0.002
Error	24	2.301		

A large variability was observed in the set of cultivars and genotypes examined, and differences among them were found to be statistically significant at the 1 and 5% probability levels, respectively (Table 2). An important genetic diversity has been reported previously by other authors (CITTADINI *et al*., 2008; BANDI *et al*., 2010; MILATOVIĆ and ĐUROVIĆ, 2010). The results also show a significant year-by-year variation (Table 2), which is in accordance with previous work carried out in sweet cherry (RADIČEVIĆ *et al*., 2009).

Coefficients of variation (Table 1) were the lowest for traits concerning fruit size, fruit shape index and output (CV = 1.42–7.32%), while they were the highest for traits such as ripening time, total aciditivity and SSC/TA ratio (CV = 27.46–32.44%). Similar coefficient of variation, regarding fruit size, was recorded by RAKONJAC *et al*. (2010) in 41 Oblačinska sour cherry clones.

CONCLUSIONS

A high variability has been found in the set of sweet cherry cultivars and genotypes evaluated with regard to the studied pomological traits, and significant differences among sweet cherry cultivars and promising genotypes were observed for all examined attributes.

No matter the fact that some standard cultivars showed better results for some traits, genotypes G-1 and G-2 are considered very promising. So, genotype G-1 could be intended for table consumption since it ripens 2-3 days after cv. B. H. Burlat, but have much higher fruit weight. Also, genotype G-2, the earliest in this trial, showed satisfactory fruit weight for this ripening time, which would extend the relatively short season for fruit ripening. Since high, early-season prices drove this breeding program, both genotypes are considered very interesting for fresh market production and are already applied for recognition.

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ANALIZA POMOLOŠKIH OSOBINA NOVIH PERSPEKTIVNIH GENOTIPOVA TREŠNJE

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Izvod

Neki od ciljeva oplemenjivačkih programa trešnje je stvaranje novih visokoprinosnih sorti sa što ranijim ili kasnijim vremenom zrenja, velike mase ploda i odličnog kvaliteta. Cilj ovog rada bio je da se utvrde vreme zrenja, morfologija i hemijski sastav ploda novih, perspektivnih, genotipova trešnje (G-1 and G-2) kako bi se uporedili sa starim, standardnim sortama (Lionska rana, Burlat, Seneca, Hedelfingenska, Germersdorfska, Imperator fransis i Bing). Eksperiment je izveden u periodu 2006-2009, u Grockoj, u blizini Beograda. Najranije sazrevanje plodova zabeleženo je kod genotipa G-2 (22. april) dok je najkasnije zabeleženo kod sorte `Bing` (2. jun). Masa ploda varirala je od 5.83 g (G-2) do 8.93 g (G-1). Sadržaj rastvorljivih suvih materija i sadržaj ukupnih šećera bio je najniži kod genotipa G-2 (10.48%; 8.45%) dok je najveći bio kod sorte 'Imperator fransis' (18.28%; 15.98%). Bez obzira na činjenicu da neke standardne sorte su pokazale bolje osobine, genotip G-1 i G-2 se mogu smatrati veoma perspektivnim. Tako je genotip G-1 namenjen za stonu potrošnju pošto sazreva 2-3 dana posle sorte Burlat, ali ima daleko krupniji plod. Takođe, genotip G-2, najraniji u ovom eksperimentu, je pokazao zadovoljavajuću masu ploda u odnosu veoma rano vreme sazrevanja, što ga čini veoma zanimljivim za proizvodnju namenjenu tržištu svežih proizvoda.

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