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*Original scientific paper*

## **POMOLOGICAL PROPERTIES OF PROMISING RASPBERRY SEEDLINGS WITH YELLOW FRUIT**

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From over a 100 seedlings obtained by open pollination of Meeker's yellow raspberry clone, 10 seedlings with yellow fruit were selected at the Experimental Station »Radmilovac« of the Faculty of Agriculture, University of Belgrade. Phenological characteristics, as well as physical, chemical and sensorial fruit properties were investigated during the period 2007-2008 in selected seedlings and standard cultivar Meeker. Results showed that all examined seedlings expressed later flowering and maturing time than the standard cultivar. The best results of physical fruit properties had the standard cultivar, whereas for the majority of the chemical fruit characteristics selected seedlings showed much better results.

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Seedling 5 had the highest soluble solid content (15.3 %), while the highest vitamin C content was recorded in the fruits of seedlings 9 (51.04 mg/100g), 10 (51.92 mg/100g), and 17 (50.16 mg/100g). The highest values of the sensorial fruit quality achieved seedling 17 (18.9).

*Key words:* Meeker, raspberry, seedling, selection, yellow fruit.

## .INTRODUCTION

Several breeding programs on raspberry are interested in the creating new yellow or apricot-colored cultivars (Alkoopina, Anne, Arta, Dita, Essenna Poslata, Poranno Rosa, Valentina and Varnes) and most of these have been released for the amateur market (KNIGHT, 2004). Yellow raspberries have not increased in importance to the same extent as red raspberries but it has great potential for future expansion. Some of the more important breeding objectives include high yields of large, easily harvested fruits of good quality, with relatively upright cane habit, disease and pest resistant.

Objectives have also been influenced by product diversification, by changing cultural practices, and by the need for season extension in both florican and primocane fruiting types (DAUBENY, 1996). With regard to this fact the main goal of our breeding program was to breed commercially acceptable florican raspberry cultivars with yellow fruit, suitable for fresh consumption, with a proper balance of sugar and acids that gives desirable level of organoleptic quality. The consumers who do not wish to consume too many anthocyanins and antioxidants can enjoy the wonderful taste of raspberry with these yellow-fruited cultivars (NIKOLIĆ and MILIVOJEVIĆ, 2008).

## MATERIALS AND METHODS

Fruits of raspberry Meeker yellow clone were taken fully ripen in 2003. Seeds were cleaned, dried, and placed in the paper bags. Stratification was done in natural conditions, in pots with peat, at the end of autumn in 2003. First seedlings appeared in May 2004. Then, seedlings were replanted in containers, with dimensions 7 x 7 cm, and grow in the screen house. Till the end of vegetation, majority of them reached the height of 50 cm or more. Seedlings planting were done in the spring of 2005 on the Experimental Station »Radmilovac« of the Faculty of Agriculture, University of Belgrade. Over 100 seedlings were planted at distance of 3 x 0.5 m. In preliminary selection 10 seedlings with yellow fruit were determined and compared with the standard cultivar Meeker. Phenological characteristics (flowering and ripening time), as well as physical, chemical and sensorial fruit properties were investigated during the period 2007-2008 in selected seedlings and standard cultivar Meeker. For the analysis of variance, the beginning, full and the end of flowering time was calculated as the number of days from May 1<sup>st</sup>, while the beginning and the end of ripening time was counted as the number of days from June 1<sup>st</sup>.

Physical fruit properties (fruit weight, fruit length, fruit width, fruit shape index and number of drupelets per fruit), chemical fruit properties (total content of soluble solids, total sugar content, inverted sugar content, sucrose content, total acid content and vitamin C), and organoleptic assessment of the fruit quality (attractiveness, taste, aroma and consistency) in selected seedlings were studied according to UPOV (2003) guidelines for raspberry. Investigations were done on sample of 60 fruits in three replications per 20 fruits. Difference between selected seedlings and standard cultivar was established by analysis of variance, and individual testing was done by Dunnett-test for 0.05 and 0.01 probabilities.

## RESULTS AND DISCUSSION

Phenological properties of studied raspberry seedlings are presented in Table 1. Considering results of the beginning of flowering time it can be noticed that all studied seedlings started flowering from 4 up to 17 days after standard cultivar (8th May). The same differences were recorded for the full flowering, while for the end of flowering time observed differences ranged from 3 to 14 days. Several seedlings expressed longer flowering time than standard cultivar Meeker, while only two seedlings were on the level of the standard and two of them had shorter duration of flowering time. Without regard to these facts, analysis of variance showed no significant differences for the beginning, full, the end and duration of flowering time among examined seedlings and standard cultivar.

The beginning and the end of maturing time in investigated seedlings were later than in the standard cultivar (Meeker), which is more important objective in our breeding program because of the increased interest in season extension for the fresh market. Extremes in early and late ripening of floricanе fruiting types are of particular interest (DAUBENY, 1996). Duration of ripening time in standard cultivar Meeker was 19 days as well as in two studied seedlings (10 and 1A), whereas in the others was shorter ranged from 9 to 18 days. Seedlings showing a particularly concentrated season are those one that mature from 6 to 12 days (KINGSTON *et al.*, 1990). This can be considered as a useful property for increasing the efficiency of hand harvesting.

According to results of physical fruit properties showed in Table 2, it can be concluded that average fruit weight varied from 2.08 g (seedling 4) to 3.56 g (Meeker) confirming the previously established finding for cultivar Meeker (NIKOLIĆ *et al.*, 2008). Analysis of variance showed very significant differences among seedlings and standard cultivar, years of investigation, and interaction seedling x year. Since, fruit size has been discussed as one of the main components of yield, large size is preferred for fresh market and improves hand-harvest efficiency.

*Table 1 – Phenophase of flowering and ripening time of examined raspberry seedlings with yellow fruit and standard cultivar*

Seedling	Flowering time				Ripening time		
	Beginning	Full	End	Duration of flowering (days)	Start	End	Duration of ripening (days)
1A	17.05	23.05	30.05	14	15.06	03.07	19
2	13.05	20.05	25.05	13	12.06	29.06	18
3	15.05	20.05	26.05	12	14.06	27.06	14
4	18.05	26.05	31.05	14	20.06	28.06	9
5	21.05	26.05	01.06	12	15.06	01.07	17
6A	15.05	23.05	28.05	14	14.06	01.07	18
6C	18.05	24.05	31.05	14	19.06	05.07	17
9	25.05	31.05	03.06	10	21.06	04.07	14
10	14.05	21.05	29.05	16	13.06	01.07	19
17	13.05	19.05	23.05	11	12.06	26.06	15
Meeker	08.05	14.05	20.05	13	06.06	24.06	19
Dunnett's test	<b>0.05</b>					8.82	
	<b>0.01</b>					12.03	

*Table 2 – Physical fruit properties of examined raspberry seedlings with yellow fruit and standard cultivar*

Seedling	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Index of fruit shape	No. drupelets per fruit	
1A	2.29	16.80	15.99	1.07	98.2	
2	3.28	18.78	18.82	1.00	95.4	
3	2.67	17.48	16.96	1.03	90.4	
4	2.08	16.76	15.32	1.10	63.4	
5	2.30	16.55	16.18	1.02	91.8	
6A	2.77	18.41	16.76	1.10	108.2	
6C	2.18	15.84	15.74	1.00	82.5	
9	2.12	15.26	15.88	0.96	84.2	
10	2.36	17.18	17.12	1.00	85.8	
17	2.47	17.7	16.54	1.08	93.5	
Meeker	3.56	20.16	18.50	1.09	107.3	
Dunnett's test	<b>0.05</b>	0.61	1.74	1.53	0.052	10.04
	<b>0.01</b>	0.77	2.20	1.94	0.066	12.72

Based on fruit dimensions (fruit length and width), index of fruit shape was also calculated in this study and varied from 0.96 (seedling 9) to 1.10 (seedlings 4 and 6A). Fruit shape does not appear to be an objective in breeding programs, but there has been a tendency to select for conic rather than round shapes. Conic shapes are associated with deeper receptable cavities and there is some evidence the cavity depth is positively associated with fruit firmness (ROBBIN and SJULIN, 1989).

Number of drupelets per fruit obtained in this study, as an important parameter of the fruit quality, indicate that the highest value for this trait had seedling 6A (108.2) followed by standard cultivar Meeker (107.3). With regard to results of fruit shape index and number of drupelets per fruit, analysis of variance showed very significant differences between seedlings and standard cultivar as well as interaction seedling x year.

Important chemical parameters of examined seedlings are shown in Table 3. The highest soluble solids content was recorded in seedling 5 (15.3 %), which also expressed the highest values for total sugar content (9.58 %) and inverted sugars (8.78 %). The lowest results for the most of mentioned chemical properties had standard cultivar Meeker. Results of our study are not in accordance with NIKOLIĆ and MILIVOJEVIĆ (2008) where a new yellow clone of Meeker raspberry cultivar named Lisa showed lower percentage of soluble solid content (10.1 %) and total sugars (5.45%). This fact can be explained by influence of different climatic conditions in years of investigation. Furthermore, these data are interesting because it indicates that new raspberry cultivars with high fruit quality can be obtained through the classical breeding techniques such as hybridization or clonal selection. High sugar content is generally desirable for both fresh and processed fruit, but without a proper balance of acids, a fruit may be perceived as bland and lacking fullness of flavor for fresh consumption.

Table 3 – Chemical properties of examined raspberry seedlings with yellow fruit and standard cultivar

Seedling	Soluble solid content (%)	Total acid content (%)	Total sugar content (%)	Invert sugar content (%)	Sucrose (%)	Vitamin C content (mg/100g)
1A	12.25	1.1	7.98	6.90	0.94	40.44
2	13.9	1.34	9.15	8.22	0.88	39.60
3	13.6	1.3	8.50	6.12	0.84	43.12
4	14.5	1.4	8.51	7.7	0.77	36.08
5	15.3	1.43	9.58	8.78	0.76	37.84
6A	12.75	1.40	8.01	7.21	0.76	38.72
6C	13.6	1.30	8.43	7.63	0.76	46.64
9	12.15	1.77	7.38	6.72	0.63	51.04
10	12.85	1.17	8.31	7.36	0.90	51.92
17	12.9	1.24	8.22	7.41	0.78	50.16
Meeker	10.05	1.18	7.60	6.66	0.89	44.88

Values of total acids varied from 1.1% (seedling 1A) to 1.77 % (seedling 9), which means that majority of examined seedlings had higher acid content than standard cultivar Meeker (1.18%). Soluble solids/titratable acidity ratio was also measured in this study. It ranged from 6.9:1 (seedling 9) to 11.1:1 (seedling 1A), which is not in accordance with CAHN *et al.* (1992) who claimed that yellow fruited raspberry cultivars have ratios ranging from 5.0:1 to 6.8:1. Considering that our seedlings are sweeter and have typical taste similar to the reddest cultivars.

The highest vitamin C content was recorded in the fruit of seedlings 9 (51.04 mg/100g), 10 (51.92 mg/100g), and 17 (50.16 mg/100g), whereas all the others expressed lower values for this property. Considering chemical fruit properties among the studied seedlings, analysis of variance did not establish significant differences which are similar to the results of FOTIRIĆ *et al.* (2009).

Sensorial evaluation of the fruit quality, obtained by sensory test (methods of positive points) is presented in Table 4. This method was used to evaluate attractiveness and fruit taste (maximal 6 points each), and flavor and fruit firmness (maximal 4 points each).

Table 4 – Sensorial properties of examined raspberry seedlings with yellow fruit and standard cultivar

Seedling	Attractiveness (0-6)	Taste (0-6)	Aroma (0-4)	Consistency (0-4)	Total mark
1A	5.6	6.0	3.5	3.6	18.8
2	5.5	4.6	3.2	2.8	16.1
3	6.0	5.8	3.5	3.4	18.6
4	2.2	4.2	2.8	2.0	11.4
5	3.5	5.2	3.6	2.8	15.1
6A	5.8	6.0	4.0	2.2	18.0
6C	4.5	6.0	3.1	3.8	17.4
9	3.5	3.0	2.2	3.5	12.2
10	4.4	5.0	3.5	4.0	16.8
17	5.6	5.9	3.8	3.6	18.9
Meeker	6.0	4.9	3.5	4.0	18.4
Dunnett's test	<b>0.05</b>	1.47	1.64	0.96	4.27
	<b>0.01</b>	2.01	2.23	1.31	5.82

Total sensorial mark was presented as the sum for all four investigated parameters which can achieve maximal 20 points. When a taste panel took place, the panelists gave the best mark to fruits of seedling 17 (18.9) and only three investigated seedlings had higher sensorial mark than standard cultivar Meeker (18.4). Analysis of variance showed very significant differences between examined

seedlings and standard cultivar for fruit attractiveness, taste, consistency and total sensorial mark. No differences were determined for years of investigation.

## CONCLUSION

The results obtained in this study could be of interest for better definition of the breeding strategies, and confirm the importance of the genetic background in improvement of raspberry production. Through breeding efforts, cultivars will be developed that produce relatively large fruits and have extended ripening season, better taste and high sensorial marks. Regarding to the results of all examined fruit characteristics, seedlings 2, 5, 10 and 17 can be recommended for further investigation. Seedling 2 is distinguished by its large fruit. In the case of the soluble solid and sugar content, seedling 5 gave the highest results, whereas seedlings 10 and 17 achieved the highest values of vitamin C content.

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## **POMOLOŠKE OSOBINE PERSPEKTIVNIH SEJANACA MALINE SA ŽUTOM BOJOM PLODA**

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### **I z v o d**

Od preko 100 sejanaca dobijenih slobodnim oprašivanjem žutog klona sorte Miker izdvojeno je 10 sa žutom bojom ploda koji su kolekcionisani na Ogladnom dobru »Radmilovac» Poljoprivrednog Fakulteta, Univerziteta u Beogradu. U periodu 2007-2008. godina kod izdvojenih sejanaca i standardne sorte Miker, pored fenoloških, ispitivane su fizičke, hemijske i senzoričke osobine ploda. Rezultati istraživanja su pokazali da su svi ispitivani sejanci kasnije počinjali fenofaze cvetanja i zrenja u odnosu na sortu standard. Najbolje rezultate fizičkih osobina ploda ispoljila je sorta standard, dok su prema većini hemijskih osobina izdvojeni sejanci bili daleko bolji od standardne sorte. Sejanac 5 se odlikuje najvišim sadržajem rastvorljive suve materije (15,3 %), a u pogledu sadržaja vitamina C najviše vrednosti su registrovane kod sejanaca 9 (51,04 mg/100g), 10 (51,92 mg/100g) i 17 (50,16 mg/100g). Najvišu senzoričku ocenu kvaliteta ploda imao je sejanac 17 (18,9).

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