

## THE MORPHOLOGICAL PROPERTIES OF THE FLOWER AND THE PER CENT OF FERTILISED PISTILS OF PROMISING YELLOW FRUITING RASPBERRY HYBRIDS

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### Abstract

The work of creating new raspberry cultivars has been started at the Experimental field “Radmilovac” of the Faculty of Agriculture in Belgrade. As a result of that work ten yellow fruiting raspberry hybrids have been selected. In the selected hybrid, over the two-year period of investigation, apart from other properties, morphological properties of the flower (diameter of the flower, number of stamens and pistils in a flower), number of drupelets in an aggregate fruit and per cent of fertilised pistils were monitored. On the basis of the analysed results it is determined that hybrids significantly differed among themselves regarding all studied properties, except for the diameter of the flower. Significant differences for the majority of studied properties were also determined according to the years of research. The four hybrids (2, 3, 6A and 17) were selected from these researches primarily regarding the number of drupelets in an aggregate fruit and the per cent of fertilised pistils as very significant parameters that condition fruit weight and finally raspberry cropping. Similarly, the knowledge of the morphological properties of the flower is of great practical importance for the description and identification of raspberry hybrids.

**Key words:** raspberry, hybrid, flower, fruit, morphological properties.

### Introduction

Hilly and mountainous areas of the western and central Serbia, as well as the eastern part of the Republic of Srpska possess very favourable natural conditions for growing raspberry. Slightly sloping and moderately moist terrains with a northern exposition which are not exposed to high temperatures, especially over summer months suit raspberry best.

The greatest portion of the produced raspberry in the world is frozen and processed. However, in recent times, raspberry has been increasingly grown out of season and sold as a fresh product, which leads to a higher selling price, particularly in North America and England (Knight, 2004).

The flowers of raspberry are perfect (hermaphrodite), gathered in cymose inflorescences. The top flowers open first, and the lowest ones open last. They consist of five sepals, then five petals of white or pinkish colour, a greater number of stamens and pistils. The flower is fragrant, and honey bee (*Apis mellifera*) is the most significant pollinator. A fruit is an aggregate drupelet, composed of 20 to 200 individual drupes of red, purple, black and yellow colour, spherical or conical shape, juicy and freestone (Mišić, 1998).

The fruits are very delicious and aromatic, rich in sugar, acids, vitamin C, mineral substances (K, P, Ca, Mg, S) (Mišić, 2002; Mišić et al., 2004; Hristov, 2008). In addition to that, raspberry fruits represent a rich source of bioactive compounds such as anthocyanins and phenols (Badjakov et al., 2008; Weber et al., 2008). In particular, the presence of the

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anthocyanins and ellagic acid, which have a pronounced antioxidant activity, is very significant (Rommel i Wrolstad, 1993; Weber i Lui, 2001; Mullen et al., 2002).

All over the world, and in our country, an increasing attention is paid to the programmes of raspberry breeding. In 19 countries of the world, there are about 40 programmes of breeding of the genus *Rubus* and since 1980, 142 raspberry cultivars and 50 blackberry cultivars have been recognised (Knight, 2004). The main goals of raspberry breeding are creation of cultivars without thorns, suitable for mechanised harvesting, of longer harvest season, high productivity, large and high quality fruits, as well as creation of the cultivars of increased resistance to unfavourable biotic and abiotic factors of the environment (Jennings, 2001; Mišić, 2002; Knight, 2004; Knight and Fernandez, 2008).

In order to achieve stated goals in raspberry breeding, the following methods are used: hybridisation, inbreeding and clonal selection, and in recent times biotechnology methods, of which the greatest attention was drawn by the creation of genetically modified plants.

The aim of this paper was to investigate the most important morphological properties of the flower, as very important elements which participate in the process of raspberry fertilisation as well as to determine the per cent of fertilised pistils, on which in a large measure the largeness of the fruit and finally the cropping of raspberry depend.

### **Material and Methods**

The researches were carried out at the collective raspberry plantation on the Experimental field "Radmilovac", of the Faculty of Agriculture in Belgrade. The plantation was raised in 2005 from the seed of raspberry of yellow clone "Lisa", which was developed from Meeker cultivar as a consequence of mutation (Nikolić i Milivojević, 2008). The researches were conducted during 2007 and 2008. The hybrids were grown as individual shrubs, at the intermediate spacing of 3 x 0.5 m. The subject of these researches was ten promising yellow fruiting raspberry hybrids which have the following codes: 1A; 2; 3; 4; 5; 6A; 6C; 9; 10; 17 and standard cultivar Meeker.

These investigations comprise the morphological properties of the flower (diameter of the flower, number of stamens and pistils in a flower), number of drupelets in an aggregate fruit and per cent of fertilised pistils. For the needs of analysis 20 flowers were collected in the phenophase of full bloom with a higher number of shoots in the shrub. The number of drupelets in an aggregate fruit was determined on the sample of 30 fruits. The diameter of the flower (cm) was determined by measuring with a ruler, and the number of stamens and pistils in a flower and the number of drupelets in a fruit by counting. By means of proportion the per cent of fertilised pistils was determined from the ratio between the number of developed drupelets and the number of pistils.

The obtained results were statistically processed by the method of two-factor analysis of variance, and the significance of differences between the individual hybrids was determined by LSD test for the significance levels of 0.05 and 0.01.

### **Results and Discussion**

The diameter of the flower represents an important parameter of the generative potential and is determined primarily by the genetic characteristic of the cultivar. The largest average diameter of the flower in both investigated years was noticed in the hybrid 17 (2.2 cm), and insignificantly smaller average diameter of the flower (2.1 cm) was noticed in the 1A, 6A, 9

hybrids and cultivar Meeker (Table 1). The diameter of the flower in other hybrids was smaller in comparison with the standard cultivar and amounted to 2.0 cm.

Table 1. The diameter of the flower and the number of stamens in a flower of the investigated raspberry hybrids and standard cultivars.

Hybrid/ Cultivar	The diameter of the flower (cm)			The number of stamens in a flower		
	Year		Mx	Year		Mx
	2007	2008		2007	2008	
1A	2.1	2.0	2.1	96.8	75.7	86.3
2	2.1	1.9	2.0	82.0	80.5	81.3
3	2.0	1.9	2.0	82.0	88.5	85.3
4	2.1	1.9	2.0	87.7	88.8	88.3
5	2.0	2.0	2.0	90.0	83.8	86.9
6A	2.1	2.0	2.1	101.7	94.0	97.9
6C	2.1	1.9	2.0	101.8	78.8	90.3
9	2.2	2.0	2.1	89.5	80.3	84.9
10	2.1	1.9	2.0	81.8	77.8	79.8
17	2.1	2.2	2.2	92.7	87.7	90.2
Meeker	2.0	2.1	2.1	93.2	88.5	90.9
F-test	Hybrid		1.859 <sup>ns</sup>			10.279 <sup>**</sup>
	Year		12.047 <sup>**</sup>			53.152 <sup>**</sup>
	Hybrid x Year		1.176 <sup>ns</sup>			7.967 <sup>**</sup>
LSD-test	Hybrid	0.05	-			4.413
		0.01	-			5.904
	Year	0.05	0.056			1.882
		0.01	0.075			2.517
	Hybrid	0.05	-			6.241
	x Year	0.01	-			8.350

<sup>ns</sup> no significant; <sup>\*\*</sup> p<0.01

The important factor of good fertilisation is a presence of a certain number of stamens in a flower. There are a lot of stamens in raspberry and they form two rings around the pistils. Pollen grains (microspores) are formed inside the anther sacs.

The highest average value of the number of stamens per flower for both years of research was observed in 6A hybrid (97.9). On the other hand, the lowest average value was noted in hybrid 10 (79.8). The standard cultivar Meeker has averagely 90.9 stamens per flower and 6A hybrid only had higher average values for this property. The approximate value of the number of stamens per flower of standard cultivar was observed in hybrids 6C and 17. The results obtained in these researches mainly correspond to the statements of Mišić (1998), according to which the number of stamens in a flower of raspberry ranges from 60 to 90. Regarding the years of research, the variations in the average values for the given parameter are observed. In most hybrids, higher values are obtained in the first year of research, except for the hybrids 3 and 4.

By means of statistical analysis it is determined that the year showed a very considerable impact on the average value of flower diameter, while the impact of hybrid and the interaction (hybrid x year) was not statistically significant. In contrast to that, for the other investigated parameter (number of stamens in a flower) it is determined that both factors (hybrid and year), as well as their interaction showed statistically considerable impact.

Table 2. The number of pistils in a flower, the number of drupelets in a fruit and per cent of fertilised pistils of investigated hybrids of raspberry and standard cultivar.

Hybrid/ Cultivar	The number of pistils in a flower			The number of drupelets in a fruit			The per cent of fertilised pistils		
	Year		Mx	Year		Mx	Year		Mx
	2007	2008		2007	2008		2007	2008	
1A	115.8	86.2	101.0	112.7	84.5	98.6	93.7	98.0	95.9
2	102.8	88.0	95.4	103.3	86.5	94.9	96.6	98.3	97.5
3	89.5	95.5	92.5	88.7	93.3	91.0	97.9	97.5	97.7
4	105.8	92.6	99.2	69.5	56.8	63.2	66.4	63.9	65.2
5	131.3	115.7	123.5	82.7	100.8	91.8	63.0	87.5	75.3
6A	121.2	117.2	119.2	110.2	105.8	108.0	91.3	90.2	90.8
6C	103.5	99.7	101.6	78.3	86.8	82.6	71.8	88.0	79.9
9	97.5	99.0	98.3	82.7	87.2	85.0	87.9	88.2	88.1
10	96.8	89.3	93.1	85.5	85.7	85.6	91.5	95.8	93.7
17	94.3	97.3	95.8	91.2	95.8	93.5	97.4	98.4	97.9
Meeker	98.0	84.5	91.3	92.2	74.8	83.5	94.6	89.1	91.9
F-test	Hybrid		8.835**			14.882**			19.369**
	Year		14.884**			3.937 <sup>ns</sup>			5.712*
	Hybrid x Year		2.086*			5.457**			3.209**
LSD-test	Hybrid	0.05	10.245			8.404			7.051
		0.01	13.707			11.245			9.433
	Year	0.05	4.369			-			3.006
		0.01	5.845			-			4.022
	Hybrid x Year	0.05	14.488			11.885			9.971
		0.01	19.385			15.902			13.341

<sup>ns</sup> no significant; \* p<0.05; \*\* p<0.01

The average number of pistils per flower for both investigated years (Table 2) was the lowest in the standard cultivar Meeker (91.3), and the highest in the hybrid 5 (123.5). Similar to the hybrid 5, 6A hybrid had a great number of pistils per flower (119.2). Great differences are also noticed in the average values of the number of pistils in a flower regarding the years of the research, which were higher in most hybrids in the first year. According to Mišić (1998) the number of pistils in a flower of raspberry ranges from 20 to 200. The number of pistils obtained in these researches is in the mentioned interval.

The number of drupelets in an aggregate fruit of raspberry represents a very important selective characteristic, because the weight and firmness of the fruit to a great extent depends on the number of drupelets in an aggregate fruit. The number of drupelets in a fruit varied from 63.2 in the hybrid 4 to 108.0 in 6A hybrid. Except for the hybrids 4 and 6C, the remaining hybrids had higher average number of drupelets in a fruit of standard cultivar Meeker, which had averagely 83.5 drupelets in a fruit. Variations in an average number of drupelets in a fruit were also observable regarding the years of research. In 2007, the number of drupelets in a fruit ranged from 69.5 in the hybrid 4 to 112.7 in 1A hybrid. The hybrid 4 in 2008 had the smallest number of drupelets in a fruit (56.8) and the highest values were determined in hybrids 6A (105.8) and 5 (100.8).

The variation of the number of drupelets among the hybrids in our paper corresponds to the results of Milutinović et al. (2008a), in which the number of drupelets differed among the cultivars grown in western Serbia, bearing in mind that the cultivar Meeker had higher number of drupelets (112.0) in comparison with our results. The results of Milutinović et al.

(2008b) indicate that the remontant cultivar of yellow fruiting raspberry Golden Bliss consists of averagely 90.6 drupelets in a fruit.

Observing tetraploid genotypes of raspberry in Canada, Jamieson and McLean (2008) found that the ploidy level influences the flower size, flower fertility, number and size of drupelets, size of seed and morphology of leaf. The authors also state that the number of drupelets in a fruit varies among the hybrids, and that the hybrids with coarser leaves have fruits with smaller number of drupelets.

The per cent of fertilised pistils has a great significance in raspberry, because it influences the number of developed drupelets, which directly reflects on the amount of the yield. According to Mišić (1998) it is necessary to have fertilisation carried out in all or almost all pistils of one flower and to be approximately simultaneous in order to develop normally an aggregate fruit of raspberry.

The highest per cent of fertilised pistils was observed in hybrid 17 (97.9%), and an approximate value was noticed in hybrids 2 and 3 (over 97%). The lowest per cent of fertilised pistils was in hybrid 4 (65.2%). The cultivar Meeker as a standard had fairly high per cent of fertilised pistils (91.9%), and higher values than standard cultivar were observed in hybrids 1A and 10, besides above mentioned ones. In the hybrids 5 and 6C, significantly higher per cent of fertilised pistils was observed in the second year of the research.

On the basis of the results of the analysis of variance (Table 2) it can be concluded that factors (hybrid and year) as well as their interaction showed significant, that is, very considerable impact on all investigated properties. The exception comprises the number of drupelets in an aggregate fruit, on which only the year had no statistically significant impact.

## Conclusion

On the basis of the results of the research of the morphological properties of the flower and per cent of fertilised pistils in ten promising yellow fruiting raspberry hybrids and standard cultivar Meeker the following conclusions can be drawn:

The diameter of the flower was not significantly different among the investigated hybrids and ranged from 2.0 to 2.2 cm. The number of stamens and pistils in a flower very significantly differed both in investigated hybrids and regarding the years of research. The greatest number of stamens in a flower was observed in 6A hybrid (97.9), and the smallest in the hybrid 10 (79.8), while the greatest number of pistils was obtained in the hybrid 5 (123.5) and the 6A hybrid (119.2), and the lowest in the standard cultivar Meeker (91.3).

The number of drupelets in a fruit varied from 63.2 in the hybrid 4 to 108.0 in 6A hybrid. The highest per cent of fertilised pistils was observed in hybrid 17 (97.9%), and an approximate value was noticed in hybrids 2 and 3 (over 97%). The lowest per cent of fertilised pistils was in hybrid 4 (65.2%).

Of 10 investigated raspberry hybrids four can be chosen (2, 3, 6A and 17) regarding the number of drupelets in an aggregate fruit and per cent of fertilised pistils on which to a great extent largeness and firmness of fruit as well as the total yield of raspberry depend. Similarly, morphological properties of a flower can serve as a very reliable parameter for the description and identification of the studied raspberry hybrids.

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# MORFOLOŠKE OSOBINE CVETA I PROCENAT OPLOĐENIH TUČKOVA PERSPEKTIVNIH HIBRIDA MALINE ŽUTOG PLODA

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## **Rezime**

Na Oglednom dobru “Radmilovac” Poljoprivrednog fakulteta u Beogradu započet je rad na stvaranju novih sorti maline. Kao rezultat toga rada izdvojeno je deset hibrida maline žutog ploda. Kod izdvojenih hibrida, u dvogodišnjem periodu ispitivanja, pored ostalih osobina prućene su i morfološke osobine cveta (prečnik cveta, broj prašnika i tučkova u cvetu), broj koštunica u zbirnom plodu i procenat oplođenih tučkova. Na osnovu analiziranih rezultata ustanovljeno je da su se hibridi međusobno veoma značajno razlikovali u svim proučavanim osobinama, osim za prečnik cveta. Značajne razlike za većinu proučavanih osobina utvrđene su i po godinama ispitivanja. Iz ovih istraživanja izdvojena su četiri hibrida (2, 3, 6A i 17) pre svega u pogledu broja koštunica u zbirnom plodu i procenta oplođenih tučkova, kao veoma značajnih parametara koji uslovljavaju masu ploda i na kraju rodnost maline. Takođe, poznavanje morfoloških osobina cveta od velikog je praktičnog značaja za opis i identifikaciju hibrida maline.

**Ključne reči:** malina, hibrid, cvet, plod, morfološke osobine.

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