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PHENOLOGY AND YIELD OF NINE SOUR CHERRY CULTIVARS UNDER CENTRAL SERBIA CONDITIONS

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Abstract

Phenological properties (beginning of flowering, full flowering, end of flowering, beginning of fruit colouring and harvest date) and yield of nine sour cherry cultivars, grafted on *Prunus avium* seedling rootstock, were studied in the region of Kraljevo (central Serbia), during a ten – year period (2000-2010). The mean date of beginning of flowering was 12 April, full flowering 17 April, and the end of flowering April 23. Flowering lasted, on the average, 11 days. Difference in flowering dates of the earliest and the latest flowering cultivars was 10 days, and the time span between years was 18 days. Early flowering was observed in cultivars 'Richmorency', 'Oblačinska', 'Heimanns Rubinweichsel' and 'Čačanski Rubin', followed by 'Heimanns Konservenweichsel', 'Kelleriis 16' and 'Rexelle', while late flowering was observed in 'Schattenmorelle' and 'Kelleriis 14'. The time span between the cultivars of the earliest and the latest average fruit ripening was approximately 16 days, and the biggest difference between years with the earliest and the latest average fruit ripening was 22 days. 'Richmorency' and 'Oblačinska' are characterized by middle-early ripening (25-30 June), followed by medium late cultivars, such as 'Čačanski Rubin', 'Heimanns Rubinweichsel', 'Rexelle', 'Kelleriis 16' and 'Heimanns Konservenweichsel' (1-2 July). 'Schattenmorelle' and 'Kelleriis 14' proved to be late maturing (8-9 July). The average annual yield per tree amounted to 14-28 kg. The highest cumulative yield per tree was recorded in 'Rexelle' (224 kg), and the lowest in 'Keleriis 16' and 'Schattenmorelle' (113.2 kg).

Keywords: sour cherry, cultivars, flowering, fruit maturation, yield.

Introduction

The sour cherry belongs to a group of high quality delicacy fruit. It has significant nutritional, medicinal, dietary and technological value. It is used as fresh fruit, or as raw material in processing industry, mostly in juices, jams, jelly, yoghurt, marmalade, brandy, liqueurs, compotes, as well as raw material in confectionery industry (Cerovic et al., 2005). The Republic of Serbia has very favorable natural and climatic conditions for sour cherry growing. The sour cherries are important and highly perspective Serbian fruits, primarily from the aspect of export on the international market. In the structure of fruit growing in Serbia, sour cherry ranks third, with 8.7 million trees and production of 89,746 t in 2008, and Serbia is ranked seventh in the world in the production of sour cherries, with a share of around 7% (Sredojevic, 2011). Sour cherry is one of the most important export products of Serbia, the greatest part being produced as frozen and subsequently exported (Radičevic et al., 2012). The current assortment of sour cherries is directed mainly to the cultivars that are used for industrial processing. The most represented cultivars in Serbia are 'Oblačinska' (accounting for 60% of the total number of cherry trees) and the spontaneously spread 'Cigančica' (20%).

Other cultivars represented are ‘Heimanns Konservenweichsel’, ‘Rexelle’, ’Šumadinka’ and ‘Schattenmorelle’, all accounting for 20%. ’Schattenmorelle’ and ‘Heimanns Konservenweichsel’ are also grown in many countries as a highly valued cultivars (Nikolic and Milatovic, 2011).
Knowledge of ecophysiological and economic characteristics of genotypes of fruit trees is a basis for assessing the suitability of their growing in certain environmental conditions and defining the appropriate cultivar specificcultural practeces . The objective of this study is to determine the phenological characteristics and yield of nine sour cherry cultivars in the ecological conditions of Kraljevo (central Serbia).

Materials and methods

The present study was carried out at village Dedevci (43°43′ N, 20°29′ E, about 392 m above sea level), near Kraljevo (central Serbia), during a ten–year period (2000-2010) on nine sour cherry cultivars: ‘Čačanski Rubin’, ‘Heimanns Konservenweichsel’, ‘Heimanns Rubinweichsel’, ‘Kelleriis 14’, ‘Kelleriis 16’, ‘Oblačinska’, ‘Richmorency’, ‘Rexelle’ and ‘Schattenmorelle’. All cultivars were grafted on *Prunus avium* seedling rootstock. The orchard was built in the fall of 1997. The trees were planted at a spacing 5 x 3 m. Five representative trees within each replicate were selected for sampling and data collection. The five replicates were arranged in a randomized completely block design. Trees were trained to the standard open vase system. Standard cultural practices, such as fertilization, pruning, pest control and soil management were performed annually, in accordance to normal commercial practices, except irrigation. Fertilizers were applied according to soil analyses. The orchard was clean cultivated during the complete investigation period.
Weather conditions of Kraljevo are characterized by the average annual temperature of 11°C and total annual rainfall of 720 mm. The soil texture in the orchard is clay-loam. The content of organic matter in 0–30 cm soil depth was 2.8%, 13.4% P_2O_5 and 21.1% K_2O. Soil pH in 0,01 M KCl was 5.8.
The phenological characteristics of cherry trees have been studied as follows:
beginning of flowering – when 10% of flowers were open (flowers are considered to be opened if the anthers and pistils are easily recognized from above and the stigma is green or yellow);
full flowering – when 80% of flowers were open;
end of flowering – when 90% of petals were fallen;
beginning of fruit colouring (when the fruit skin begins to change color from green to red);
fruit ripening time (was determined as the day when the fruits were sufficiently coloured and soft for eating).
The yield (per tree and per hectare) was studied from the sixth year after planting (when the trees reached full production) up to the thirteenth year. The data obtained from yield measurements are processed by the statistical method of the analyses of variance. The significance of differences between mean values is determined by Tukey´s test at P=0.05.

Results and discussion

Bloom time

The results of the study of the bloom time of sour cherries are shown in the table 1. The average date for the beginning of blooming of all tested cultivars was April 12, for the full bloom April 17, and for the end of blooming April 23. The interval from the beginning to the end of blooming is 11 days and from the full bloom to the end of blooming six days.
The earliest sour cherry blooming time was recorded in the year 2007, when the beginning of blooming was on April 07, full bloom on April 11, and the end of blooming on April 18. The latest blooming time was in the year 2005, when the beginning of blooming was on April 25, full bloom on April 29, and the end of the blooming on May 06. The difference in bloom time between the years with the earliest and the latest recorded blooming is 18 days.
The cultivars ‘Richmorency’ and ‘Čačanski Rubin’ had the earliest average beginning of blooming (April 10), while the cultivar ‘Kelleris 14’ had the latest (April 20), so the difference between cultivars with the earliest and the latest beginning of blooming was 10 days. Based on these data, the examined cultivars can be classified into the following groups: 1) early blooming cultivars: ‘Richmorency’, ‘Oblačinska’, ‘Heinmanns Rubinweichsel’ and ‘Čačanski Rubin’; 2) middle blooming cultivars: ‘Heinmanns Konservenweichsel’, ‘Rexelle’ and ‘Kelleriis 16’; 3) late blooming cultivars: ‘Schattenmorelle’ and ‘Kelleriis 14’. Similar conclusions were reached by Stančevic (1969) in the area of Čačak, but Mišic (2002) classified cultivars ‘Rexelle’, ‘Oblačinska’, ‘Čačanski Rubin’ and ‘Heinmanns Konservenweichsel’ in the middle blooming group, and ‘Schattenmorelle’, ‘Kelleriis 14’ and ‘Kelleriis 16’ in the group of late blooming cultivars. Blasse (1964) and Kellerhals (1986) also classified ‘Schattenmorelle’ in the late blooming group. According to several authors (Milutinovic et al., 1980; Nikolic et al., 2005; Rade et al., 2008; Rakonjac et al., 2010), ‘Oblačinska’ represents a heterogeneous population, which is a mixture of numerous genotypes. Fotiric Akšic et al. (2013) observed genetic diversity among the 41 genotypes of ‘Oblačinska’ for several traits, including flowering time, maturing time and yield. According to the authors, most of the ‘Oblačinska’genotypes flowered during April 16 and 17, which is consistent with our results.

Table 1. Flowering of the studied sour cherry cultivars

Cultivar	Begining of flowering		Ful flowering (average)	End of flowering		Duration of flowering (days)
	Earliest date	Average date		Average date	Latest date	
Richmorency	04. IV	10. IV	14. IV	20. IV	03. V	11
Čačanski Rubin	05. IV	10. IV	14. IV	20. IV	03. V	11
Oblačinska	05. IV	11. IV	15. IV	21. IV	04. V	11
Heimanns Rubinweichsel	04. IV	11. IV	16. IV	22. IV	03. V	12
Heimanns Konservenweichsel	06. IV	12. IV	16. IV	22. IV	06. V	11
Rexelle	07. IV	13. IV	18. IV	24. IV	07. V	12
Kelleriis 16	08. IV	15. IV	18. IV	24. IV	08. V	10
Schattenmorelle	10. IV	18. IV	23. IV	29. IV	13. V	12
Kelleriis 14	13. IV	20. IV	24. IV	30. IV	14. V	11
The average for all cultivars	07. IV	12. IV	17. IV	23. IV	07. V	11

2. Fruit ripening time

The average date of the beginning of ripening for all examined cultivars was June 19. The earliest average date of the beginning of ripening was in the cultivar ‘Richmorency’ (June 15), and the latest in the cultivar ‘Schattenmorelle’ (June 26), so the time range between the cultivars with the earliest and the latest beginning of ripening was 11 days (Table 2). The earliest average beginning of ripening was on June 15 (2007), when the time range between the earliest and the latest cultivars was 22 days, and the latest average beginning of ripening was on June 27 (2005), with a time range of 14 days between cultivars.

Table 2. Fruit ripening time of the studied sour cherry cultivars

Cultivar	Beginning of fruit colouring		Ripening time		Interval from full bloom to ripening
	Earliest date	Average date	Earliest date	Average date	
Richmorency	10. VI	15. VI	19. VI	25. VI	72
Oblačinska	11. VI	16. VI	22. VI	28. VI	74
Čačanski Rubin	13. VI	18. VI	26. VI	30. VI	77
Rexelle	14. VI	18. VI	23. VI	01. VII	74
Heimanns Rubinweichsel	14. VI	19. VI	24. VI	01. VII	76
Kelleriis 16	14. VI	18. VI	26. VI	01. VII	74
Heimanns Konservenweichsel	15. VI	19. VI	25. VI	02. VII	77
Kelleriis 14	20. VI	24. VI	01. VII	08. VII	77
Schattenmorelle	22. VI	26. VI	03. VII	09. VII	77
The average for all cultivars	15. VI	19. VI	25. VI	01. VII	75,3

Full ripening occured approximately 12 days after the change in fruit skin colour. The period between the cultivar with the earliest (‘Richmorerncy’) and the latest full fruit ripening (‘Schattenmorelle’) was 14 days.

The earliest fruit ripening was recorded in 2007, and the latest in 2005, when the time range in fruit ripening was 12-16 days. During the entire period of the examination there were no variations in the order of the fruit ripening in cultivars. Based on the fruit ripening period, the studied cultivars can be classified into following groups: 1) medium early cultivars (‘Richmorency’ and ‘Oblačinska’); 2) medium late cultivars (‘Čačanski Rubin’, ‘Heimanns Rubinweichsel’, ‘Rexelle’, ‘Kelleriis 16’ and ‘Heimanns Konservenweichsel’); and 3) late cultivars (‘Kelleriis 14’ and ‘Schattenmorelle’). Milatovic et al. (2011) classified ‘Oblačinska’, ‘Čačanski Rubin’, ‘Richmorency’ and ‘Rexelle’ in the group of middle ripening cultivars, that ripen in the second half of June, and ‘Schattenmorelle’, ’Kelleriis 14’ and ’Heimanns Konservenweichsel’ as the late ripening cultivars, with ripening time from late June till early July. According to Radičevic et al. (2010), the average ripening date for ‘Heimanns Konservenweichsel’ in ecological condions of Čačak for the research period 2006-2007 was 28 June, that is consistent with our results. Fruits of ten examined ‘Oblačinska’ sour cherry clones averagely ripened at „Radmilovac“ (near Belgrade) in the three years of the experiment (2000-2002) in first decade of June (Nikolic et al., 2005). That is much earlier than in our experiment, which is a consequence of different ecological conditions in Belgrade and Kraljevo.

3. Yield

The average yield of the studied sour cherry cultivars varied between 14.2 kg and 33.6 kg per tree, or 9424 kg and 18648 kg per hectare. The largest yield was recorded in the cultivars ‘Rexelle’ and ‘Heimanns Konservenweichsel’, and the smallest in ‘Schattenmorelle’, ‘Kelleriis 16’ and ‘Richmorency’. Based on the yields obtained per tree, the cultivars can be classified into following groups: 1) high yielding cultivars (over 21 kg per tree) – ‘Rexelle”, ‘Heimanns Konservenweichsel” and ‘Heimanns Rubinweichsel’; 2) medium yielding cultivars (18-21 kg per tree) – ‘Oblačinska’, ‘Kelleriis 14’ and ‘Čačanski Rubin’; 3) low yielding cultivars (14-16 kg per tree) – ‘Richmorency’, ‘Kelleriis 16’ and ‘Schattenmorelle’.

Table 3. Yield of the studied sour cherry cultivars

Cultivar	Average yield per tree (kg)								Cumulati-ve yield per tree for eight years (kg)	Average yield for eight years (kg)	
	2003	2004	2005	2006	2007	2008	2009	2010		Per tree	Per hectare
Richmorency	15.4	24.2	31.4	30.5	29.0	35.4	24.5	33.6	224.0	28.0 a	18 648
Oblačinska	15.5	22.2	27.6	27.2	25.8	31.6	24.4	30.2	204.5	26.0 ab	17 024
Čačanski Rubin	12.3	20.5	23.7	25.6	20.2	19.8	20.1	28.5	170.7	21.3 bc	14 210
Rexelle	13.7	17.8	20.6	21.6	21.0	18.5	17.4	22.8	153.4	19.2 cd	15 340
Heimanns Rubinweichsel	14.5	16.6	18.9	20.8	20.5	17.5	18.3	18.6	145.7	18.2 cd	14 570
Kelleriis 16	8.2	13.6	18.7	19.2	18.5	17.1	15.6	20.3	131.2	16.4 cd	10 922
Heimanns Konservenweichsel	14.5	16.8	17.5	15.2	13.2	15.4	14.3	16.6	123.5	15.4 cd	10 281
Kelleriis 14	9.1	12.6	18.7	16.2	15.2	12.7	14.2	16.1	114.8	14.4 d	9 557
Schattenmorelle	9.7	12.2	15.4	17.2	15.2	11.8	16.2	15.5	113.2	14.2 d	9 424

Means followed by the same letter do not differ significantly according to Tukey´s test at P=0.05

As opposed to our results, Stančevic (1969) in ecological conditions of Čačak evalueted ‘Richmorency’, ‘Heimanns Rubinweichsel’ and ‘Schattenmorelle’ as very productive and productive cutivars. Nikolic et al. (2000), under similar ecological conditions, assessed as the most productive ‘Oblačinska’, ‘Heimanns Konservenweichsel’, ‘Rexelle’, ‘Kelleriis 14’ and ‘Kelleriis 16’.

Conclusion

Flowering of examined cherry cultivars in ecological conditions of Kraljevo, on average, occurs in the second decade of April, and lasted about 11 days. Early flowering was observed in cultivars ‘Richmorency’, ‘Oblačinska’, ‘Heimanns Rubinweichsel’ and ‘Čačanski Rubin’, followed by ‘Heimanns Konservenweichsel’, ‘Kelleriis 16’ and ‘Rexelle’, while late flowering was observed in ‘Schattenmorelle’ and ‘Kelleriis 14’. The difference in flowering time between cultivars was almost twice higher than that between years.

The time span between the cultivars of the earliest and the latest average fruit ripening was approximately 16 days, and the biggest difference between years was 22 days. ‘Richmorency’ and ‘Oblačinska’ are characterized by middle-early ripening (25-30 June), followed by medium late ‘Čačanski Rubin’, ‘Heimanns Rubinweichsel’, ‘Rexelle’, ‘Kelleriis 16’ and ‘Heimanns Konservenweichsel’ (1-2 July). ‘Schattenmorelle’ and ‘Kelleriis 14’ proved to be late maturing (8-9 July).

The average annual yield per tree amounted to 14-28 kg. The highest cumulative yield per tree was recorded in ‘Rexelle’ (224 kg), and the lowest in ‘Keleris 16’ and ‘Schattenmorelle’ (113.2 kg). Productivity of sour cherry cultivars, in addition to their biological properties, depends to a large extent on the ecological conditions of the area where they are grown**.**

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