

*Miroslav ČIZMOVIĆ\**,  
*Ranko POPOVIĆ, Ahmed DŽUBUR*<sup>1</sup>

## **PHENOLOGICAL CHARACTERISTICS OF THE MAJOR POMEGRANATE (*Punica granatum* L.) CULTIVARS GROWN IN DIFFERENT AGRO-ECOLOGICAL CONDITIONS OF MONTENEGRO**

### **SUMMARY**

This paper presents the results of a three-year study (2002-2004) on phenological characteristics of the three most common pomegranate cultivars (Slatki barski, Šerbetaš and Dividiš meke kore), grown on three different agro ecological sites (Bar, Dobra Voda and Golubovci). The beginning of vegetation, which is manifested by the swelling buds and the appearance of the first leaf was the earliest in the Bar locality in cultivars Slatki barski and Šerbetaš, in average 6 days earlier comparing to two other localities. This statistically significant difference was a direct consequence of warm maritime climate and slightly higher temperatures at this time of the year compared to the other two sites. The beginning of flowering was the latest (11 to 22 days), in locality Dobra Voda for both cultivars, which was statistically significant delay comparing with two other sites. The earliest fruit ripening was registered in 2003 in cultivar Slatki barski in the locality Bar (end of September). The differences between the cultivars were in range of 14 days. The latest ripening was in Šerbetaš cultivar in Dobra Voda that was significantly later than in the other cultivars and locations. Defoliation is a direct consequence of the cold and strong north winds so, for this phenological stage it can be considered that is directly caused by these meteorological factors.

**Keywords:** phenological characteristics, pomegranate, *Punica granatum* L.

### **INTRODUCTION**

It is considered that the pomegranate, together with fig and olive trees has a long tradition of cultivation in the Montenegrin subtropical zone and its hinterland. In addition, besides the cultivated pomegranate grown on plantations, as well as the gardens, there is a large population of wild pomegranate shrubs in forest stands as far as reaching temperate Mediterranean climate. The largest number of shrubs is located in the municipality of Bar, but its spread spans the valleys of the Morača and Zeta rivers deep in the continental part. Zohary and Hopf (2000), mainly due to the richness of diversity of wild pomegranate in the

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<sup>1</sup> Miroslav ČIZMOVIĆ (corresponding author: miroslaw@t-com.me), Ranko POPOVIĆ, Biotechnical Faculty Podgorica, MONTENEGRO; Ahmed DŽUBUR, Agromediterranean Faculty Mostar, BOSNIA AND HERZEGOVINA.

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Mediterranean area, the country such as Montenegro and Albania cited as a possible wider gene center of this species.

Coastal regions, as well as Zetsko-bjelopavlići plain in their hinterland are characterized by typical Mediterranean climate - Csa subtype according to Köppen's division (Burić and Micev, 2008). For a successful development and proper ripening, pomegranate requires hot and dry summers and mild winters, which is especially noticeable in Zeta-Bjelopavlići valley. In the tropics climate condition pomegranates is an evergreen fruit tree (Ozguven and Yilmaz, 2000, Singh *et al.*, 2006).

The aim of this work was to investigate the phenological stages of three most important pomegranate cultivars as a response to agroecological conditions.

### MATERIAL AND METHODS

The investigation was conducted on three prevalent pomegranate cultivars in Montenegro: 'Slatki barski', 'Šerbetaš' and 'Dividiš meke kore' grown on three different locations in coastal region and Golubovci near Podgorica. Localities Dobra Voda (DV) and Tomba (MN) are situated in Bar municipality in the coastal region, and Balabani near Golubovci (ZP) in Zeta-Bjelopavlici valley. Orchards in Dobra Voda are located in the highest altitude (294 m). 'Slatki barski' cultivar is presented on each location, 'Šerbetaš' in Dobra voda and Tomba, while 'Dividiš meke kore' is grown only in Balabani village.

Each of the cultivars was presented with 5 shrubs per locality, and all shrubs were of the same age (13 and 14 years) and in the full productive period.

Assessment of growing stages was done visually using the phenological key (Finn *et al.*, 2007), and phenological key for pomegranate (Melgarejo *et al.*, 1997). Statistical analysis was performed by analysis of variance as a factorial trials (cultivar and observed stage), and comparison of means was tested by LSD test. The earliest date for the given stage is counted as the first day of the phenomenon and received a number 1, while the others are difference in days in relation to beginning of research stage.

Table 1. Monthly mean temperature registered during the execution of experiments

Meteorological Station	Years/ months	Monthly mean temperature of air (°C)											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Bar	2002.	7.7	11.4	13.3	15.1	19.7	24.1	26.0	24.4	20.8	17.0	14.6	11.1
Bar	2003.	10.9	6.5	10.6	14.2	20.8	26.2	26.1	27.0	20.8	17.0	14.9	10.4
Bar	2004.	8.1	9.3	11.2	15.9	17.2	22.6	25.4	24.4	21.4	19.1	13.4	11.8
Golubovci	2002.	4.1	9.3	12.4	14.8	19.9	25.0	27.0	24.5	19.6	15.0	11.6	7.2
Golubovci	2003.	6.8	3.8	9.6	13.4	22.6	27.8	28.1	29.6	20.7	14.9	12.0	6.2
Golubovci	2004.	4.3	6.4	9.6	15.3	16.9	23.0	26.6	24.8	21.3	17.1	9.4	7.7

The meteorological data for the studied period shows a slightly higher winter temperature and milder summers in the area of Bar compared to the region of Golubovci. Slightly extreme conditions in the summer months were recorded in 2003, with higher temperatures and a very low precipitation. There were 116

tropical days that year. It was also noted that the amount of rainfall in 2004 was slightly higher than in the other two years.

Table 2. Precipitation registered during the execution of experiments

Meteorological Station	Years/months	Rainfall (mm/m <sup>2</sup> )											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Bar	2002.	85.6	119.6	15.9	115.5	73.1	18.8	105.5	127.5	299.4	174.3	65.1	213.2
Bar	2003.	257.3	60.0	11.0	92.5	16.9	40.0	21.6	10.1	141.8	205.9	250.6	137.1
Bar	2004.	140.7	142.5	248.7	121.0	118.3	117.9	70.5	14.4	92.5	148.7	208.5	226.0
Golubovci	2002.	70.4	80.7	27.9	142.3	87.5	44.3	39.8	64.8	249.9	226.2	103.7	219.5
Golubovci	2003.	279.9	82.9	5.2	84.6	15.3	75.0	1.2	11.5	208.0	364.6	211.0	80.8
Golubovci	2004.	265.0	211.0	243.3	160.7	140.9	109.4	49.4	63.8	113.5	116.1	288.0	303.9

\* Data obtained from the Hydrometeorological and Seismological Service of Montenegro at the personal request

## RESULTS AND DISCUSSION

Manifestation of the phenological characteristics of some species, except that depends on hereditary basis, is largely conditioned by climatic and soil conditions. This is mainly related to air temperature (Melgarejo et al., 2000).

Initial phenological phases (bud swell, leafing and beginning of flowering) are always the earliest registered on Tomba locality, which is caused by warm maritime climate. Characteristic of this climate is mild winter, and the vegetation began on this site the earliest in 2002 (06<sup>th</sup> March), and the latest in 2003 (17<sup>th</sup> March), 12 days later. The beginning of vegetation in average at this site was on March 12<sup>th</sup>, six days later than the earliest start of the growing season. Start of swelling buds on sites Balabani and Dobra Voda in average delay 7 days in comparison with the location of Tomba, which is statistically significantly later.

Leafing beginning showed no significant differences between the years with the earliest and the latest record of this phenophase. This difference was the greatest when comparing 2002 (locality Tomba and Dobra Voda) and 2003, with registered 25 days difference. This big difference is the result of lower temperatures during 6-9<sup>th</sup> April 2003, when the temperature of only 1° was registered in Podgorica and Bar, which has significantly slowed this phenophase.

Similar results were obtained by Buljko (1985) who, observing the phenological characteristics of the cultivar 'Sladun' in Mostar area during eight years, noted that variation can be up to one month depending on the temperature conditions.

The beginning of flowering in pomegranate takes place during the period when the temperature fluctuations are still present. Comparing years 2002 and 2004 significant differences can be noticed. Lower temperatures and higher amounts of rainfall in May 2004 led to significant differences in the beginning of this phenophase in relation to the year 2002 (up to 22 days between localities Tomba and Dobra Voda. In the year 2004 the differences between sites account only 6 days. The higher temperatures in Zeta-Bjelopavlići valley accelerate the phenophases on the site Balabani, which equates with the site Tomba.

Table 3. Phenological stages of the studied cultivars of pomegranate (2002-2004)

Cultivar	Beginning of the vegetation		Flowering			Ripening 89*	End of leaf fall 97*
	Swelling 01*	Leafing 10b*	Beginning 60*	Full 65*	End 69*		
<b>2002.</b>							
Slatki barski DV	12.III	26.III	10.V	09.VI	03.VII	06.X	27.XI
Šerbetaš DV	12.III	26.III	10.V	06.VI	12.VII	12.X	27.XI
Slatki barski MN	06.III	18.III	30.IV	09.VI	06.VII	01.X	27.XI
Šerbetaš MN	06.III	18.III	30.IV	28.V	06.VII	09.X	27.XI
Slatki barski ZP	14.III	25.III	05.V	09.VI	25.VI	4.X	27.XI
Dividiš meke kore	14.III	25.III	03.V	09.VI	29.VI	10.X	27.XI
<b>2003.</b>							
Slatki barski DV	25.III	11.IV	10.V	10.VI	10.VII	04.X	21.XI
Šerbetaš DV	25.III	11.IV	10.V	10.VI	10.VII	12.X	21.XI
Slatki barski MN	17.III	02.IV	03.V	25.V	30.VI	29.IX	21.XI
Šerbetaš MN	17.III	02.IV	03.V	25.V	30.VI	09.X	21.XI
Slatki barski ZP	22.III	07.IV	05.V	28.V	01.VII	01.X	21.XI
Dividiš meke kore	22.III	07.IV	03.V	25.V	01.VII	09.X	21.XI
<b>2004.</b>							
Slatki barski DV	20.III	02.IV	21.V	13.VI	17.VII	10.X	11.XII
Šerbetaš DV	20.III	02.IV	21.V	13.VI	17.VII	17.X	11.XII
Slatki barski MN	11.III	20.III	15.V	31.V	04.VII	06.X	11.XII
Šerbetaš MN	11.III	20.III	15.V	31.V	04.VII	14.X	11.XII
Slatki barski ZP	18.III	01.IV	18.V	06.VI	11.VII	08.X	23.XI
Dividiš meke kore	18.III	04.IV	15.V	31.V	11.VII	12.X	23.XI
Comparison of average differences							
Slatki barski DV	19.III a	03.IV a	14.V a	11.VI a	10.VII a	07.X c	30.XI a
Šerbetaš DV	19.III a	03.IV a	14.V a	10.VI a	13.VII a	14.X a	30.XI a
Slatki barski MN	12.III b	24.III b	06.V b	01.VI c	03.VII b	02.X d	30.XI a
Šerbetaš MN	12.III b	24.III b	06.V b	28.V d	03.VII b	11.X b	30.XI a
Slatki barski ZP	18.III a	01.IV a	09.V ab	05.VI b	02.VII b	04.X d	04.XII a
Dividiš meke kore	18.III a	02.IV a	07.V b	01.VI c	04.VII b	10.X b	04.XII a
	LSD <sub>0.05</sub> =4.91 LSD <sub>0.01</sub> =5.87	LSD <sub>0.05</sub> =6.87 LSD <sub>0.01</sub> =8.21	LSD <sub>0.05</sub> =6.48 LSD <sub>0.01</sub> =7.74	LSD <sub>0.05</sub> =3.35 LSD <sub>0.01</sub> =4.44	LSD <sub>0.05</sub> =5.03 LSD <sub>0.01</sub> =6.01	LSD <sub>0.05</sub> =2.69 LSD <sub>0.01</sub> =3.22	LSD <sub>0.05</sub> =7.93 LSD <sub>0.01</sub> =10.5
Abbreviations for localities	DV – Dobra Voda ZP – Balabni, Golubovci			MN – Tomba, Bar			

\* Phenological stages (*Finn et al., 2007*)

Full flowering in pomegranate lasts over long period and it is quite difficult to evaluate accurately this period. According to the data presented it can be concluded that flowering takes place from the end of May or the first week in June until the first week in July. The latest full flowering was registered on the site Dobra Voda in 2004 (13<sup>th</sup> June), that is significantly delayed compared to the other two sites (7-11 days). This is a direct consequence of the lower temperatures in the plantation which is located at a higher altitude.

End of flowering at the localities Tomba and Balabani in average occur at the same time, and delays 9.33 days compared to the earliest completion, while on the site Dobra Voda the delay was from 16 to 19 days. The duration of flowering in the years of investigation ranged from 50 to 69 days.

Mars (2000) states that flowering of pomegranate last 10-12 weeks depending on the cultivar and environmental conditions, which is similar to our results. Adhikari and Adhikari (2010) also point out that the speed of development and the opening of the flowers depends the most on the temperature of external air. Blossoming of pomegranate in Central Valley (California) according to Stover and Mercure (2007) runs from early May to November, with the intensive course from half of May to the first day of June. Climatic conditions of California with a stable and uniform temperature allow such a floral phenology of pomegranate in this climate. According to Martinez et al. (2000), pomegranate blooms in southeast Spain from half of April or the beginning of June to early August, depending on the weather conditions.

According to the data from Table 4, it can be concluded that the earliest ripening cultivar was 'Slatki barski' at all three locations. Cultivars 'Šerbetaš' and 'Dividiš meke kore' in average matured 4-10 days after 'Slatki barski' depending on the year and growing region. The earliest maturing of all cultivars was in 2003, so 'Slatki barski' ripe on 29<sup>th</sup> Spetember, although that was the latest begining of the growing season. This is due to the long dry and warm periods during the summer months, and in that year even 116 tropical days were recorded. The latest ripening was registered in 'Šerbetaš' in 2004 (17<sup>th</sup> October), on the site of Dobra Voda. This site normally always had the latest fruit ripening due to its position on a higher altitude. According to the descriptor, our cultivars belong to the medium period of maturation.

According to Plamenac (2001) our cultivars should not be harvested before 10<sup>th</sup> October.

Defoliation is a trait that is most dependent on weather conditions. Leaves in conditions of long and mild autumn (2004), persist longer on the tree, although became full yellow. Pomegranate leaf fall in the studied ecological conditions has always been linked to the emergence of a strong and cold north wind during November or December, after which no single leaf stays on the branches. Leaf fall in these ecological conditions usually happen from the end November or beginning of December (30.XI-04.XII). However, the differences between years may be up to 22 days (2003 compared to 2004).

The duration of the growing season in cultivars studied ranged from 241 days in 2003 on the site Dobra Voda to 275 days in 2004 on the site Tomba.

## CONCLUSIONS

Based on the three-year results for the most important phenological characteristics of three main cultivars of pomegranate grown in Montenegro, it can be concluded that the temperature and genotype are the most important factors which influence their lasting. The effect of location is indirect, and it is practically manifested through the influence of temperature conditions. The earliest ripening cultivar is 'Slatki barski', although all the tested cultivars belong to medium maturity epoch according to the descriptor.

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