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PHENOLOGICAL OBSERVATIONS OF GENUS PRUNUS (*Prunus sp.*) AT THE TERRITORY OF NOVI SAD

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Summary:*Sweet and sour cherry fruit is mostly used for human consumption. However, some genotypes can be successfully employed in the establishment of green spaces in horticulture and landscape architecture. This paper presents the results of observations of phenological phenomena pertaining to the genus Prunus sp. representatives. As a part of this study, individual cultivars of oriental cherry (Prunus serrulata Lindl.) and ground cherry (Prunus fruticosa Pall. 'Globosa') were monitored during a three-year period. We recorded the leafing and flowering phenophases on a sample of 73 genotypes of ornamental cherries at three locations in Novi Sad, and in the collection orchard in Rimski Šančevi, which comprises five genotypes planted in 2011 and 2012.Biometric data and phenological observations of green space dendroflora are important for the economical production of planting materials, as well as use, control and management of new green spaces.*

Key words: *phonological observations, Prunus serrulata Lindl., Prunus fruticosa Pall. 'Globosa', decorative forms of sweet and sour cherry*

INTRODUCTION

Green spaces are important elements of each city. They are a part of the image of the city and its surroundings and, by expanding ecological diversity, they are essential structural and functional elements that make cities and urban regions better suited for living.

Their role in improving the urban living conditions has prompted the European commission (2000) to confirm the importance of urban green spaces, not only due to their ecological functions, but also because of their importance for citizens' health, social wellbeing, economic gain and the central role in the sustainable development of cities.

Owing to their multifunctional characteristics, green spaces have a wide range of beneficial properties for the city. Urban space dendroflora contributes to the structure and functionality of each green space. The function of tall trees is well known, and a variety of genotypes at the territories of Serbian cities contributes to the significant floristic richness. Given their multifunctionality, decorative sweet and sour cherry genotypes in urban cenoses certainly contribute to the diversity of dendroflora.

Development of the system of green spaces in cities improves the residents' quality of life, promotes work and recreation, as well as improves climate, hygienic and aesthetic factors (Chen, 2004). Green spaces are the basic

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structural and functional element, and their content makes cities and urban regions suitable for living and housing (Ninić-Todorović et al., 2010).

In cities, presence of trees improves environmental indicators by lowering the ambient air temperature and radiation temperature of residential buildings, through evapotraspiration and wind speed reduction (Akbari et al., 2001).

Altered environmental conditions in urban areas indicate the need for choosing flora that is resilient and adaptable to urban conditions (Zerbe et al., 2003). According to the findings of extant studies (Ninić-Todorović, 1990, Anastasijević, 2011, Ocokoljić, 2006), the emphasis should be on green space multifunctionality, which should be achieved through the use and application of dendroflora and genotypes of taxa that are highly resistant and require minimal protection.

Sweet and sour cherry varieties are primarily used as consumable fruits, and are successfully planted in gardens of many homes in rural areas in Serbia. Introduction of genotypes has expanded their variety, which led to an increased interest in the application of decorative taxa in urban areas. Oriental cherry (*Prunus serrulata* Lindl.) with cultivars characterized by ornamental flowers, crown shape, size and potential for shaping by pruning, is suitable for forming alleys, as well as planting in parking areas, walkways, or on lawns.

Oriental cherry cultivar 'Kanzan' is very popular in landscape architecture (Maurer et al., 2000). As stated by Forrest (2006), cultivars 'Shirotae' and 'Taihaku' can be planted along footpaths, in places such as shopping centers and hospitals. Similarly, Manić et al. (2011) indicate that oriental cherry trees are suitable for planting in green spaces in urban areas. Although oriental cherry may tolerate lighter air and land pollution, when not adequately protected, it can be susceptible to diseases caused by monilia (*Monilia laxa* /Ehrenb./ Sacc.).

'Globosa', the form of ground cherry *Prunus fruticosa* Pall., is a taxon that is increasingly being used for forming alleys in the narrow streets of Novi Sad (Ninić-Todorović et al., 2012). It has no special maintenance requirements, provided that the soil is well drained. Mratinić and Kojić (1998) reported that the main species (*Prunus fruticosa* L.) in the territory of the Republic of Serbia typically grows at forest edge, as a lower shrub. On the eastern and southern slopes of Fruška gora, two associations of ground cherry (*Prunetum fruticosae* Korn. /1974/ and *Prunetum spinosae-fruticosae* Jov. /1968/ cit. Tomić /2004/) have been recorded.

MATERIAL AND METHODS

In the Novi Sad area, the phenological study included 73 trees at three sites, namely Petra Drapšina street with 17 oriental cherry trees (*Prunus serrulata* Lindl.), Stevana Musića street where only one very old oriental cherry tree grows, and Vojvode Šupljikca street, where 55 individuals of the spherical form of ground cherry (*Prunus fruticosa* Pall. 'Globosa') are recorded.

On the experimental field of Faculty of Agriculture at Rimski Šančevi, during the 2011 to 2012 period, a collection of 25 trees representing five oriental cherry and ground cherry taxa was formed.

Monitoring of the phenological phenomena was conducted in spring of 2012, 2013 and 2014, and included individual taxa of ornamental *Prunus sp.*, present in the green spaces of Novi Sad, as well as in the collection orchard in Rimski Šančevi. The collected data included the phenophases of the vegetative and generative organ formation, using the BBCH (Biologische Bundesanstalt, Bundessortenamt and Chemical industry) key for stone fruits 1, 5 and 6 (Meier et al., 1994). Within the indicated phases, the following interphase tag numbers were distinguished: 10 – separation of the top layer of leaf buds; 11 – development of first leaves; 19 – full leafing; 51 – flower bud swelling; 55 – flower buds partially open; 59 – coronal leaves in the balloon forming phase; 61 – flowering onset, with 10% of open flowers; 65 – full flowering, with 50% of open flowers and loss of the first petals; and 69 – end of flowering.

With respect to the phenological phenomena, the following phases were observed: leafing with intermediate phases, flowering onset, full flowering, and end of flowering.

The obtained data were processed using the statistical software package Statistica 12 (StatSoft Inc. Tulsa, USA).

RESULTS

Owing to their high decorative value and resistance to diseases and pests, oriental cherry (*Prunus serrulata* Lindl) and ground cherry (*Prunus fruticosa* Pall.) taxa are increasingly being introduced to public green spaces in urban areas in Serbia.

The development of phenological characteristics of ornamental sweet and sour cherries in the three-year observation period was most significantly affected by the air temperature. A comparison of the duration of observed the phenological phenomena and intermediate phases revealed that the process intensified and the phase duration

shortened with increasing temperature. The results pertaining to the phenological phenomena and intermediate phases are shown in Table 1 and 2.

At the Rimski Šančevi site, depending on the cultivar, the process from bud activation until the end of flowering took place in April. The only exception was *Prunus fruticosa* Pall.'Globosa' cultivar, where separation of the top layer of leaf buds was recorded on March 27, 2012, and flowering ended on the 25th day.

During 2013 and 2014, the same cultivar exhibited the monitored phenological characteristics over a period of 27 days. In addition, during the three-year study period, the observed phenophases were uniform for this cultivar.

For cultivar *Prunus serrulata* 'Kanzan', from the separation of the top layer of leaf buds interphase to the end of the flowering phase, the shortest period of 19 days was recorded in April 2012, while in mid-April and early May of 2013, the duration was 23 and 25 days, respectively, from the final decade of March to mid-April 2014.

In terms of the pyramidal cultivar *Prunus serrulata* 'Amanogawa', we registered a 23-day period during 2012. In 2013, the shortest period of 18 days was noted, and the longest period of 27 days during 2014, whereby bud activation was observed on March 18th.

Table 1: Phenological characteristics of the ornamental taxa of genus *Prunussp*. in the collection orchard in Rimski Šančevi and green spaces of Novi Sad during 2012, 2013 and 2014.

Locality	Rimski Šančevi					Novi Sad			
Cultivar / Phenological phases	*P.serrulata* 'Kanzan'	*P. serrulata* 'Amanogawa'	*P. serrulata* 'Kiku shidare'	*P. serrulata* 'Royal burgundy'	*P. fruticosa* 'Globosa'	*P. serrulata* 'Kanzan'	*P. serrulata* 'Amanogawa'	*P. serrulata* 'Kiku shidare'	*P. fruticosa* 'Globosa'
Growth phase 1: Leaf development									
Top leaf separation (10)	02.04.2012. 12.04.2013. 20.03.2014.	02.04.2012. 15.04.2013. 18.03.2014.	02.04.2012. 06.04.2013. 20.03.2014.	02.04.2012. 06.04.2013. 20.03.2014.	27.03.2012. 06.04.2013. 18.03.2014.	27.03.2012. 09.04.2013. 18.03.2014.	27.03.2012. 11.04.2013. 18.03.2014.	27.03.2012. 02.04.2013. 18.03.2014.	25.03.2012. 02.04.2013. 20.03.2014.
Development of first leaves (11)	11.04.2012. 19.04.2013. 01.04.2014.	11.04.2012. 22.04.2013. 03.04.2014.	11.04.2012. 12.04.2013. 01.04.2014.	11.04.2012. 12.04.2013. 01.04. 2014.	02.04.2012. 12.04.2013. 22.03.2014.	07.04.2012. 12.04.2013. 20.03.2014.	07.04.2012. 18.04.2013. 20.03.2014.	07.04.2012. 09.04.2013. 20.03.2014.	27.03.2012. 09.04.2013. 25.03.2014.
Full leafing (19)	15.04.2012. 25.04.2013. 03.04.2014.	15.04.2012. 25.04.2013. 03.04.2014.	15.04.2012. 19.04.2013. 03.04.0214.	15.04.2012. 19.04.2013. 03.04.2014.	11.04.2012. 19.04.2013. 03.04.2014.	13.04.2012. 18.04.2013. 01.04.2014.	13.04.2012. 23.04.2013. 01.04.2014.	13.04.2012. 16.04.2013. 01.04.2014.	08.04.2012. 16.04.2013. 03.04.2014.
Growth phase 5: Appearance of bloom									
Bud swelling (51)	02.04.2012. 05.04.2013. 01.04.2014.	02.04.2012. 05.04.2013. 01.04.2014.	27.03.2012. 12.04.2013. 27.03.2014.	02.04.2012. 05.04.2013. 01.04.2014.	27.03.2012 12.04.2013. 01.04.2014.	28.03.2012. 01.04.2013. 20.03.2014.	28.03.2012. 01.04.2013. 20.03.2014.	25.03.2012. 09.04.2013. 20.03.2014.	25.03.2012 08.04.2013. 20.03.2014.
Partially open buds (55)	04.04.2012. 12.04.2013. 03.04.2014.	05.04.2012. 12.04.2013. 03.04.2014.	02.04.2012. 18.04.2013. 01.04.2014.	07.04.2012. 09.04.2013. 03.04.2014.	02.04.2012. 18.04.2013. 03.04.2014.	01.04.2012. 07.04.2013. 22.03.2014.	01.04.2012. 07.04.2013. 22.03.2014.	30.03.2012. 12.04.2013. 22.03.2014.	30.03.2012. 10.04.2013. 25.03.2014.
Balloon formation (59)	10.04.2012. 19.04.2013. 05.04.2014.	11.04.2012. 19.04.2013. 05.04.2014.	04.04.2012. 19.04.2013. 03.04.2014.	11.04.2012. 12.04.2013. 05.04.2014.	04.04.2012. 20.04.2013. 05.04.2014.	06.04.2012. 16.04.2013. 25.03.2014.	05.04.2012. 13.04.2013. 25.03.2014.	01.04.2012. 16.04.2013. 25.03.2014.	04.04.2012. 15.04.2013. 27.03.2014.
Growth phase 6: Flowering									
Onset (61)	11.04.2012. 21.04.2013. 07.04.2014.	15.04.2012. 21.04.2013. 07.04.2014.	06.04.2012. 21.04.2013. 05.04.2014.	15.04.2012. 16.04.2013. 07.04.2014.	11.04.2012. 21.04.2013. 07.04.2014.	09.04.2012. 19.04.2013. 27.03.2014.	11.04.2012. 15.04.2013. 27.03.2014.	04.04.2012. 15.04.2013. 27.03.2014.	08.04.2012. 18.04.2013. 01.04.2014.
Full (65)	15.04.2012. 25.04.2013. 10.04.2014.	20.04.2012. 25.04.2013. 10.04.2014.	11.04.2012. 25.04.2013. 07.04.2014.	18.04.2012. 19.04.2013. 10.04.2014.	15.04.2012. 25.04.2013. 10.04.2014.	13.04.2012. 23.04.2013. 01.04.2014.	16.04.2012. 18.04.2013. 01.04. 2014.	09.04.2012. 19.04.2013. 01.04.2014.	11.04.2012. 23.04.2013. 03.04.2014.
End (69)	21.04.2012. 03.05.2013. 14.04.2014.	25.04.2012. 03.05.2013. 14.04.2014.	16.04.2012. 30.04.2013. 10.04.2014.	24.04.2012. 25.04.2013. 14.04.2014.	21.04.2012. 03.05.2013. 14.04.2014.	19.04.2012. 30.04.2013. 09.04.2014.	22.04.2012. 25.04.2013. 09.04.2014.	14.04.2012. 25.04.2013. 09.04.2014.	20.04.2012. 30.04.2013. 11.04.2014.

In 2012, in cultivar *Prunus serrulata* 'Kiku shidare',the observed phases lasted only 14 days, due to the high average daily temperatures in mid-March and during flowering in April. The longest period for unfolding the observed phenological characteristics, 24 days, was noted for this cultivar in April 2013, while it lasted 21 days in March and April of 2014.

Table 2.Average duration of leafing and flowering phenophases (days) for the genus *Prunus* cultivars at the Rimski Šančevi and Novi Sad localities

Locality	Cultivar	Leafing phenophase				Flowering phenophase			
		2012.	2013.	2014.	$\bar{X}$	2012.	2013.	2014.	$\bar{X}$
Rimski Šančevi	'Kanzan'	13	13	14	13.33	19	28	13	20
	'Amanogawa'	13	10	16	13	23	28	13	21.33
	'Kiku shidare'	13	13	14	13.33	20	18	14	17.33
	'R. burgundy'	13	13	14	13.33	22	20	13	18.33
	'Globosa'	15	13	16	14.66	25	21	13	19.66
	X	13.4	12.4	14.8	-	21.8	23	13.2	-
Novi Sad	'Kanzan'	18	10	14	14	22	29	20	23.66
	'Amanogawa'	18	12	14	14.66	25	24	20	23
	'Kiku shidare'	18	14	14	15.33	20	16	20	18.66
	'Globosa'	14	14	14	14	26	22	22	23.33
	X	17	12.5	14	-	23.25	22.75	20.5	-

Cultivar *Prunus serrulata* 'Royal burgundy' exhibited the observed phenological characteristics in April 2012, for a period of 22 days. In April 2013, the process lasted only 19 days, while it took 25 days—from mid-March to mid-April—in 2014. In the green spaces of the city of Novi Sad, for cultivar *Prunus serrulata* 'Amanogawa', 26 days was the longest recorded period for unfolding of the observed phenophases, which took place in April 2012. In contrast, the shortest period of 14 days was noted in April 2013, due to the very high average daily air temperature and radiation temperature stemming from road surfacing asphalt. During 2014, the phase lasted 21 days. Cultivar *Prunus serrulata* 'Kiku shidare' in Novi Sad, Petra Drapšina street, in 2012, began vegetation at the end of March, while the flowering ended 18 days later, in mid-April. The longest duration of the observed phenological phenomena, 23 days, was recorded in April of 2013. It lasted 22 days in 2014, from the end of the second decade of March to the end of the first week in April.

Observed phenophases of ornamental *Prunus* taxa are shown in Figure1.

Figure 1. a)Top leaf separation on Rimski Šančevi locality; b)Development of first leaves on Rimski Šančevi locality; c)Balloon formation - cultivar Kanzan; d) Full flowering - cultivar Kanzan; e)Full leafing and flowering - *Prunus serrulata*; f)Full leafing and flowering - *Prunus fruticosa* 'Globosa'; g)Cultivar 'Kanzan' in phase of full flowering; h)Tree line of *Prunus fruticosa* 'Globosa'

Principal component analysis (PCA) allowed the investigated cultivars to be grouped according to similar duration of leafing and flowering phenophases (Table 3). The first principal component (PC_1) pertains to the leafing phenophase. For all monitored ornamental cherry cultivars, variability of this phenological characteristic contributed

by 55.96%. The second major component (PC_2) refers to the variability in the flowering phenophase for the ornamental cherry cultivars during the three-year observation period. Variability associated with this phenophase is 44.03%.

The above analysis indicates that both phenophases are of great importance, as the main component value is ≥ 0.7. In the years included in the analysis, the leafing phenophase is 1.11, which deviates from the analytically obtained threshold value by 0.41. This indicates that, during the observation period, at the Rimski Šančevi site, the average duration of the leafing phenophase for all cultivars was the longest in 2014, and was equal to 14.8 days, as shown in Table 2. This is due to a mild winter, which caused early onset of the leafing phase, due to which flowering also commenced early. The flowering phenophase, in relation to the main component value, with the limit set at ≥ 0.70, does not indicate the importance of the duration of the flowering phase in the three-year observation period. Statistical analysis indicates a value of 0.88.

Table 3. Principal component analysis of the duration of the leafing and flowering phenophases for genus *Prunus* cultivars

	PC_1	PC_2
Leafing phenophase	1.11*	0.10
Flowering phenophase	0.88*	0.18
Adopted value	1.20	2.00
Total variance	55.96	44.03
Cumulative contribution	55.96	100.00

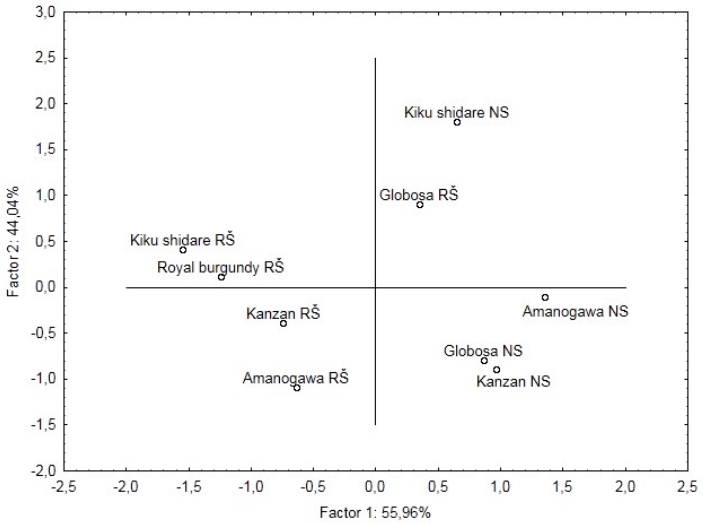

Figure 2.Grouping of the genus Prunus cultivars based on the duration of the leafing and flowering phenophases

In Figure 2, clustering of the variability in the duration of the observed phenophases depending on the cultivar is notable. As can be seen, cultivars 'Kiku shidare' at locations in Novi Sad and *Prunus fruticosa* 'Globosa' Pall, from the Rimski Šančevi locality, are positioned on the graph farthest from the x-axis, indicating the variability of the observed phenological phenomena. In addition, greater variability was observed in the cultivar 'Kanzan' from the Novi Sad locality. Closer to the axis is the group of ornamental cherry cultivars from the Rimski Šančevi locality ('Kanzan', 'Royal burgundy' and 'Kiku shidare'), with uniform duration of the leafing phenophase.

A comparison of the leafing and flowering phenophases of the studied ornamental cherry genotypes from the Rimski Šančevi and Novi Sad localities reveals grouping of cultivars according to the duration. The exception is the ground cherry from the Rimski Šančevi locality, which is in terms of the duration of leafing and flowering phenophases similar to ornamental cherry cultivars from the Novi Sad locality.

DISCUSSION

Drawing parallels between the occurrence of the observed phenological phenomena of the ornamental taxa at the site of the Rimski Šančevi and those in green spaces of Novi Sad, depending on the year, a difference in the onset can be noted. This disparity is most pronounced in the separation of the protective top layer of the buds and the

development of the first leaves interphase, as well as the flowering phase, commencing with bud swelling and in the appearance of the balloon interphase. Given that the collection orchard in Rimski Šančevi is formed on chernozem soil type, radiation temperature has no tangible impact on the development of the observed phenological characteristics of ornamental sweet and sour cherry taxa, unlike asphalt surfacing on Novi Sad streets.

The air temperature in the city is about 2°C higher than the temperature measured at the Rimski Šančevi meteorological station. Correlation between microclimatic parameters affects the individual ornamental taxa in the unfolding of the observed phases. Individuals in Rimski Šančevi are exposed to sunlight and air currents throughout the day, which reflects favorably on the progress of phenological phenomena. In contrast, the individuals forming alleys in the city, especially in Petra Drapšina street, are under the shade of the surrounding buildings for at least part of the day. Irrespective of the environmental indicator differences, sweet and sour cherry cultivars at the monitored sites do not differ significantly in terms of the onset and duration of phenological phases.

Grouping genotypes based on the duration of leafing and flowering phenophases provides data on the timing of the examined phenophases, which is important for the future use of these cultivars, horticulture and landscape architecture applications in particular.

CONCLUSION

In the Novi Sad area, 18 oriental cherry (*Prunus serrulata* Lindl.) trees were recorded, 17 of which formed an alley in Petra Drapšina street, and one was found in the private garden on Stevana Musića street. In the alley in Vojvode Šupljikca street, 55 ground cherry trees of spherical shape (*Prunus fruticosa* 'Globosa' Pall.) were recorded.

In order to monitor phenological phenomena, as well as resistance to pests, diseases and abiotic stress, varietal collection of ornamental taxa of the genus *Prunus* was formed in Rimski Šančevi. Phases with interphases were concurrently observed at all localities.

In the environmental growing conditions, for the representatives of the genus *Prunus* on these localities, over the three-year observation period, on average, the onset of vegetation and leafing phenophase lasted from 13,53 to 14,50 days. The optimum flowering took place in April, lasting 19,33 to 21,16 days. In this period, in the environmental conditions in Novi Sad and its surroundings, the risk of late spring frosts is reduced. The observed taxa exhibited vitality, decorative value and resistance to disease and pests.

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FENOLOŠKA OPAŽANJA KULTIVARA RODA PRUNUS (*PRUNUS SP.*) NA PODRUČJU NOVOG SADA

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Izvod: Plodovi trešnje i višnje se upotrebljavaju kao konzumno voće. Međutim, postoje genotipovi koji mogu uspešno da se primenjuju pri podizanju zelenih prostora u hortikulturi i pejzažnoj arhitekturi. U radu su prikazani rezultati osmatranja fenoloških pojava predstavnika roda *Prunus sp.* Osmatrane su jedinke kultivara orijentalne trešnje (*Prunus serrulata* Lindl.) i stepske višnje (*Prunus fruticosa* Pall. 'Globosa'), u toku trogodišnjeg perioda. Beležene su fenofaze listanja i cvetanja na uzorku od 73 genotipa ukrasnih trešanja i višanja na tri lokaliteta u Novom Sadu i kolekcionom zasadu na Rimskim Šančevima. Kolekcioni zasad zasnovan je od 5 genotipova zasađenih tokom 2011. i 2012. godine.Biometrijski podaci i fenološka opažanja dendroflore zelenih prostora od značaja su za ekonomičnu proizvodnju sadnog materijala, primenu, kontrolu i upravljanje novim zelenim površinama.

Ključne reči:fenološka osmatranja, *Prunus serrulata* Lindl., *Prunus fruticosa* Pall. 'Globosa', dekorativne forme višnje i trešnje.

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