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Testing of 'Gisela 5' and 'Santa Lucia 64' cherry rootstocks in Bosnia and Herzegovina

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ABSTRACT

Cherry cultivation has a long tradition in Bosnia and Herzegovina mainly due to favorable climatic conditions for cherry growing in this region. However, current cherry production is insufficient because of prevailing old cultivars and rootstocks. Modern intensive production of sweet cherry (*Prunus avium* L.) requires planting of high quality cultivars on dwarfing rootstocks planted in high density orchards. Cherry rootstock breeding programs worldwide require data on tolerance and performance of their rootstocks in different climatic conditions. Therefore, the influence of two cherry rootstocks ('Gisela 5 and 'Santa Lucia 64') on phenological events (blooming), growth and pomological properties of two cherry cultivars ('Stella' and 'Burlat') planted in modern orchard (managed according to standard commercial practice for integrated fruit production), near Sarajevo was evaluated. The trees grafted on 'Gisela 5' rootstocks were planted in 2004 and on 'Santa Lucia 64' in 2005. All tress were trained in a spindle system and the analyzed parameters were monitored in 2010. Rootstocks greatly influenced blooming time, growth and fruit characteristics of both investigated cultivars. The weaker rootstock was 'Gisela 5', which stimulated earlier blooming and caused statistically significant better fruit characteristics (fruit size, % flesh of fruit as well as total soluble solids content in fruit). The results of the analysis showed that both cherry cultivars reached better fruit quality on 'Gisela 5'. 'Stella' had better fruit quality than 'Burlat'. 'Santa Lucia 64' proved a better rootstock for 'Burlat' than for 'Stella'.

Key words: cherry, cultivar, dwarfing rootstocks, trunk cross section area (TCSA), 'Stella', 'Burlat', 'Gisela 5', 'Santa Lucia 64'

IZVLEČEK

PREIZKUŠANJE ČEŠNJEVIH PODLAG 'GISELA 5' IN 'SANTA LUCIA 64' V BOSNI IN HERCEGOVINI

Gojenje češenj v Bosni in Hercegovini ima dolgo tradicijo. Glavni razlog so ugodne klimatske razmere za gojenje češenj. Vendar pa je trenutna pridelava češenj premajhna zaradi starih sort in njihovih podlag. Sodobna intenzivna pridelava češenj (*Prunus avium* L.) zahteva sajenje visokokakovostnih sort na šibkih podlagah v nasadih z gostim sajenjem. Programi vzgoje novih češnjevih podlag po svetu potrebujejo podatke o odpornosti in obnašanju podlag v različnih klimatskih razmerah. Ugotavljali smo vpliv dveh češnjevih podlag ('Gisela 5' in 'Santa Lucia 64') na fenološke lastnosti (cvetenje), rast in pomološke lastnosti dveh češnjevih sort ('Stella' in 'Burlat'), ki sta bili posajeni v sodobnem nasadu blizu Sarajeva, oskrbovanem po načelih integrirane pridelave. Drevesa na podlagi 'Gisela 5' so bila posajena leta 2004 in na podlagi 'Santa Lucia 64' leta 2005. Drevesa smo opazovali v letu 2010, vzgojena so bila v gojitveni obliki vretenast grm. Podlagi sta značilno vplivali na cvetenje, rast in na značilnosti plodov pri obeh obravnavanih sortah. Šibkejša podlaga je bila 'Gisela 5', kjer je bilo cvetenje zgodnejše in plodovi so imeli boljše značilnosti (velikost ploda, delež mesa kakor tudi vsebnost suhe snovi v plodu). Analiza je pokazala, da sta obe češnjevi sorti razvili bolj kakovostne plodove na podlagi 'Gisela 5'. Sorta 'Stella' je imela kakovostnejše plodove kot sorta 'Burlat'. Za sorto 'Burlat' je podlaga 'Santa Lucia 64' bolj primerna kot za sorto 'Stella'.

Ključne besede: češnja, sorta, šibke podlage, ploščina preseka debla, 'Stella', 'Burlat', 'Gisela 5', 'Santa Lucia 64'

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1 INTRODUCTION

Cherry growing has a long tradition in Bosnia and Herzegovina. However, the current sweet cherry production is quite small. In recent years the government and research institutions have made efforts to improve cherry production in the region. Now, the producers can get more information concerning modern systems of cultivation, recent cherry cultivars, rootstocks, etc.

Modern, high-productive cherry cultivars, which require the application of appropriate agrotechnical practices in order to achieve high yields with a good fruit quality, were introduced in cherry production in Bosnia and Herzegovina in the past years. In addition to planting new cultivars, new rootstocks must also be introduced as they are essential for high density cherry planting.

The proper choice of rootstock is one of the key factors for successful cherry production. The rootstock has a direct impact on nutrition, vegetative growth, longevity, yield, fruit quality and resistance of fruit trees (Usenik et al., 2010a). In Bosnia and Herzegovina, the cherry was traditionally grafted on generative rootstocks (*Prunus avium* and *Prunus mahaleb*), which are characterized by strong vigor resulting in higher harvesting costs.

Cherry rootstock breeding programs worldwide collect data on rootstocks tolerance to different soil properties as well as select rootstocks for "high density" orchard design and early production (Callesen, 1998; Sansavini et al., 1994, Sansavini and Lugly, 1998).

For achieving lower tree vigor it is important to select fertile land and to apply all agro-pomotechnical measures for intensive cherry production (Riesen and Ladner, 1998).

Adaptation to regional climates and soil condition is also an important criterion during the evaluation of cherry rootstocks. Big differences can exist in the vigor habits and yield of trees even between areas in close vicinity (Siegleri et al., 2000). The choice of rootstock influences the growth, precocity, blooming date, yield and fruit quality (Beckman et al., 1992; Sugar et al., 1999). Therefore, new dwarfing and semi-dwarfing rootstock for cherry must reduce vigor, be graft compatible and site adaptable, and should have good fruit quality without reduction in fruit size and quality (Reighard et al., 2006).

The aim of this study was to evaluate two cherry cultivars grafted on two rootstocks in the ecological conditions of Bosnia and Herzegovina.

2 MATERIALS AND METHODS

The cherry cultivars 'Stella' and 'Burlat' were grafted on two rootstocks: 'Gisela 5' and 'Santa Lucia 64'. Evaluation was carried out in the cherry orchard located in Podlugovi - Ilijas municipality, nearby Sarajevo. The parameters were monitored from February to June 2010.

The trees grafted on 'Gisela 5' rootstocks were planted in 2004 at a spacing of 4.0 m x 3.0 m and the trees grafted on rootstock 'Santa Lucia 64' were planted in 2005 at a spacing of 4.0 m x 3.5 m. All tress were trained to a spindle.

The experiment was arranged as a random design with five trees in 2 replications (10 trees per rootstock). The orchard was managed according to standard commercial practice for integrated fruit production. According to its textural classification, the soil was classified as medium heavy to heavy. The phenological

properties (swelling buds, first bloom, full bloom, bloom end) were monitored according to Winter (2002). Trunk circumference was measured 20 cm above the graft union and the data were used for calculation of the trunk cross section area (TCSA). Flower index (FI) was calculated as a number of flower buds in relation to the number of buds. Titratable acids were measured with Titrino 719 S (Metrohm) and expressed as % of malic acid. All quantitative parameters were analyzed statistically and the values obtained in terms of further evaluation were tested by mathematical - statistical tests (using one-way analysis of variance - ANOVA test) at $p<0.05$.

3 RESULTS AND DISCUSSION

Phenological observations are presented in Table 1.

Table 1: Flowering phenology of 'Stella' and 'Burlat' cherry cultivars grafted on two rootstocks

Phenophase	'Stella'/ 'Gisela 5'	'Burlat'/ 'Gisela 5'	'Stella'/ 'Santa Lucia 64'	'Burlat'/ 'Santa Lucia 64'
Swelling buds	27. 3. 2010	27. 3. 2010	29. 3. 2010	30. 3. 2010
Green cluster	30. 3. 2010	1. 4. 2010	31. 3. 2010	2. 4. 2010
White bud	5. 4. 2010	6. 4. 2010	07. 4. 2010	8. 4. 2010
First bloom	7. 4. 2010	9. 4. 2010	09. 4. 2010	10. 4. 2010
Full bloom	12. 4. 2010	15. 4. 2010	13. 4. 2010	16. 4. 2010
Bloom end	19. 4. 2010	22. 4. 2010	21. 4. 2010	23. 4. 2010
Flowering duration (days)	12	13	12	13

The flowering is a very important parameter affecting cherry productivity. This is a variable quantity, strongly dependent on genetic characteristics of the cultivar and growing conditions during the flowering. Stancevic (1984) researched phenology data of 48 cherry cultivars and reported that flowering duration for cherry is 11-17 days. According to Pirnat et al. (1980) the flowering period of cherry is 12 days. The results of our study showed 12 days flowering duration in 'Stella' and 13 days in 'Burlat'. It can be concluded that 'Stella' and 'Burlat' are sufficiently overlapped in the duration of flowering. This information is important for pollination, because 'Burlat' is a self – sterile cultivar. Usenik and Stampar (2011) reported that 'Burlat' had earlier first bloom (4th April) and longer flowering duration (15 days).

The pomological characteristics of analyzed cherry fruits are presented in Table 2. The average fruit weight ranged from 4.30 g to 6.69 g; the highest average fruit weight of both analyzed cultivars (6.69 g and 6.49 g) was measured on 'Santa Lucia 64' rootstock. However, cultivars grafted on 'Gisela 5' developed fruit with significantly higher fruit weight, than those grafted on 'Santa Lucia 64' rootstock.

Table 2: Average value of pomological characteristics of 'Stella' and 'Burlat' cherry cultivars grafted on two rootstocks[a]

Cultivar	Rootstock	Fruit weight (g)	Fruit height (cm)	Fruit width (cm)	Fruit diameter (cm)	Stone weight (g)	% flesh of fruit
'Stella'	Gisela 5	4.3±0.80 a	2.1±0.08 a	2.32±0.2 a	2.03±0.1 a	0.47±0.7 a	92.5±1.3 a
	Santa Lucia 64	6.49±0.6 b	1.79±0.1 b	1.94±0.5 b	1.61±0.6 b	0.37±0.7 b	91.3±1.4 b
	Average	5.35±1.3 a	1.94±0.2 a	2.13±0.4 a	1.82±0.3 a	0.42±0.9 a	91.9±1.2 a
'Burlat'	Gisela 5	4.45±0.5 a	2.1±0.09 a	2.33±0.8 a	1.88±0.7 b	0.43±0.7 a	93.5±1.2 a
	Santa Lucia 64	6.69±0.7 b	1.79±0.1 b	1.94±0.8 b	1.63±0.8 b	0.4±0.08 a	90.8±2.3 b
	Average	5.57±1.3 a	1.94±0.2 a	2.13±0.4 a	1.76±0.5 b	0.42±0.7 a	92.2±2.8 a
Average of 'Gisela 5'		6.54±0.7 a	6.54±0.7 a	2.1±0.08 a	2.32±0.1 a	1.96±0.1 a	0.45±0.7 a
Average of 'Santa Lucia 64'		4.38±0.7 b	4.38±0.7 b	1.79±0.2 b	1.94±0.7 b	1.62±0.7 b	0.39±0.8 b
Cultivar x Rootstock		NS	NS	NS	***	*	*

[a] Average values ± standard error are presented. Different letters in columns indicate significantly different values at $p < 0.05$; NS – no significant influence; *** - indicate significant influence at $p < 0.001$; * -indicate significant influence at $p < 0.05$.

Both evaluated cherry cultivars had an equal average fruit height (Table 2). On the other hand, a significantly higher fruit height (2.1 cm) was measured in cultivars grafted on the 'Gisela 5' rootstock compared to those grafted on 'Santa Lucia 64' (1.79 cm). Similar differences between the cultivars were detected in fruit width with the widest fruit determined in 'Burlat' grafted on the 'Gisela 5' rootstock (2.33 cm). The minimum average fruit width was measured on cultivars grafted on the 'Santa Lucia 64' rootstock (1.94 cm). Analysis of variance revealed that only the rootstock had a significant effect on the expression of fruit size (weigh, height and width). For all three analyzed fruit size parameters, the fruits from trees grafted on 'Gisela 5' rootstock had significantly higher mean values compared to fruit from trees grafted on 'Santa Lucia 64'. Similarly, pruning, which indirectly reduces the number of fruiting spurs, also results in increased fruit size and fruit weight (Usenik et al., 2008), but it also reduces total yield (Andersen et al., 1999; Lang, 2001; Kappel, 2002; Whiting and Lang, 2004). As 'Gisela 5' significantly alters the growth potential of cherry cultivars it also positively affects the external fruit quality characteristics.

Fruit weight of both cultivars was somewhat lower in relation to the results of other studies. Aliman (2008) stated that the average weight of 'Burlat' was 5.98 g and of 'Stella' 7.67 g. Albertini and Della Strada (1996) reported that the fruit weight of 'Burlat' was 6.65 g.

Albertini and Della Strada (1996) reported the average fruit height of 'Stella' fruit below 2.32 cm, and Aliman (2008) measured fruit height of this cultivar in the range of 2.33 cm. Radičević et al. (2011) reported that the average fruit height of the 'Burlat' was 2.23 cm and Aliman (2008) measured 2.10 cm fruit height in this cultivar.

Aliman (2008) reported higher fruit width for 'Stella' (2.47 cm) and 'Burlat' (2.34 cm), while Albertini and Della Strada (1996) reported slightly lower average fruit width for 'Stella' (2.38 cm). Radičević et al. (2011) reported an average fruit width of 2.43 cm for 'Burlat'.

The average fruit diameter of 'Stella' grafted on the 'Santa Lucia 64' rootstock was smaller

(1.61 cm) compared to 'Burlat' grafted on the same rootstock (1.63 cm). Cultivar and rootstock, as well as their interactions, exhibited statistically significant influences on fruit diameter. 'Stella' had a significantly higher fruit diameter in relation to 'Burlat'. The fruits from trees grafted on 'Gisela 5' had a significantly higher fruit diameter than those grafted on 'Santa Lucia 64' rootstock. The fruit diameter of 'Burlat' was much lower compared to 2.01 cm reported by Radičević et al. (2011) and 2.11 cm measured by Zhivondov (2011).

The analyzed cultivars grafted on the 'Gisela 5' rootstock developed averagely significantly heavier stone compared to the 'Santa Lucia 64' rootstock. The average stone weight of the cv. 'Burlat' grafted on the 'Santa Lucia 64' was higher (0.40 g) in relation to the 'Stella' grafted on the same rootstock (0.37 g). The obtained data of 'Burlat' stone weight was slightly higher in relation to the data reported by Zhivondov (2011), Aliman (2008) and Radičević et al. (2011).

The cherry cultivar did not significantly influence the percentage of flesh in the fruit but average fruit ratio was significantly higher in cultivars grafted on the 'Gisela 5' rootstock (93 %) compared to those grafted on 'Santa Lucia 64' (91.1 %). Usenik et al. (2010a) reported that 'Lapins' grafted on 'Gisela 5' rootstock had an average percentage of flesh fruit weight of 91.8 %.

Stancevic (1976) and Aliman (2008) reported slightly higher average values of fruit ratio (% of fruit flesh) of 'Stella' (94.91 and 94.88 %). The obtained average fruit ratio of 'Burlat' was also lower compared to the data reported by Aliman (2008) and Radičević et al. (2011), where the fruit ratio was between 93.73 and 91.85 %.

In Table 3 the results of total soluble solids (TSS) and titratable acids content in fruits of cherry cultivars are presented.

Table 3: Average content of total soluble solids (° Brix) and titratable acids (%) in fruits of 'Stella' and 'Burlat' cherry cultivars grafted on two rootstocks[a]

Cultivar	Rootstock	Total soluble solids (ºBrix)	Titratable acids (% of malic acid)
'Stella'	'Gisela 5'	13.0 a ± 0.29	0.29 a ± 0.10
	'Santa Lucia 64'	16.0 b ± 0.20	0.23 b ± 0.08
	Average	14.5 a ± 1.70	0.26 a ± 0.04
'Burlat'	'Gisela 5'	13.0 a ± 0.28	0.22 a ± 0.10
	'Santa Lucia 64'	12.5 a ± 0.50	0.33 b ± 0.08
	Average	12.8 b ± 0.48	0.28 b ± 0.03
Average of 'Gisela 5'		14.3 a ± 0.44	0.26 a ± 0.04
Average of 'Santa Lucia 64'		13.0 b ± 1.95	0.28 b ± 0.08
Cultivar x Rootstock		***	NS

[a] Average values ± standard error are presented. Different letters in columns indicate significantly different values at $p < 0.05$; NS – no significant influence; *** - indicate significant influence at $p < 0.001$.

The average total soluble solids content ranged from 12.5 °Brix in 'Burlat' grafted on the 'Santa Lucia 64' rootstock to 16 °Brix in 'Stella' grafted on the 'Gisela 5' rootstock. Cultivar and rootstock exhibited significant influence on the content of total soluble solids in cherry fruits. The fruits of cv. 'Stella' had significantly higher content of soluble solids in relation to fruits of 'Burlat'. The fruits from the trees grafted on 'Gisela 5' rootstock had significantly higher content of total soluble solids in relation to the fruits from tress grafted

on 'Santa Lucia 64'. The results of the average content of soluble solids for the cultivar 'Stella' (14.5 °Brix) are similar to results of Aliman (2008). Albertini and Della Strada (1996) and Stancevic (1976) obtained higher values of this parameter (15.2 and 17.2 °Brix). The obtained results of the total soluble solids in 'Burlat' fruit are lower in relation to Radičević et al. (2011) and Aliman (2008), which reported that the average content of total soluble solids of 'Burlat' was 13.77 and 15.90 °Brix. Usenik et al. (2010b) reported that leaf/fruit ratio also had significantly influences total soluble solids content in 'Lapins' fruit grafted on 'Gisela 5' rootstock.

Cultivar and rootstock had a significant influence on the fruit titratable acids content. Significantly higher average levels of titratable acids were measured in 'Burlat' cultivar than in 'Stella'. The investigated rootstock 'Santa Lucia 64' caused significant increase of titratable acids content of cherry cultivars comapred to the 'Gisela 5' rootstock.

In table 4 the results of trunk cross section area (TCSA) and flower index (FI) of 'Stella' and 'Burlat' cherry cultivars grafted on two rootstocks are presented.

Table 4: Average values of yield/tree (kg), TCSA (cm²) and flower index (FI) of 'Stella' and 'Burlat' cherry cultivars grafted on two rootstocks[a]

Cultivar	Rootstock	Yield/tree (kg)	TCSA (cm²)	Flower index (FI)
'Stella'	'Santa Lucia 64'	21.00 a ± 6.94	47.61 a ± 9.60	0.50 a ± 0.15
	'Gisela 5'	22.50 a ± 7.53	54.42 b ± 9.47	0.54 a ± 0.24
	Average	21.75 a ± 7.24	51.01 a ± 9.92	0.52 a ± 0.20
'Burlat'	'Santa Lucia 64'	20.00 a ± 6.78	50.64 c ± 10.32	0.26 b ± 0.06
	'Gisela 5'	21.50 a ± 7.06	61.64 d ± 10.55	0.60 c ± 0.14
	Average	20.75 a ± 6.92	56.14 b ± 11.62	0.42 b ± 0.21
Average of 'Gisela 5'		22.00 a ± 7.30	58.03 a ± 10.44	0.57 a ± 0.20
Average of 'Santa Lucia 64'		20.75 a ± 7.01	49.13 b ± 9.82	0.37 b ± 0.17
Cultivar x Rootstock		NS	NS	***

[a] Average values ± standard error are presented. Different letters in columns indicate significantly different values at $p < 0.05$; NS – no significant influence; *** - indicate significant influence at $p < 0.001$.

The average yield of 'Stella' (Table 4) ranged from 21.0 ('Santa Lucia 64' rootstock) to 22.5 kg/tree ('Gisela 5' rootstock). The trees of 'Burlat' averagely yielded from 20.5 to 21.5 kg/tree. There were no significant differences between rootstocks as well as between cultivars in average yield per tree. The results of average yield of 'Gisela 5' rootstock are slightly lower than the results reported by Usenik et al. (2010a). Analyses of variance showed that both factors (cultivar and rootstock) had a statistically significant influence on the TCSA. Trees grafted on 'Gisela 5' rootstock had significant higher average of TCSA (58.03 cm²) compared to trees grafted on the 'Santa Lucia 64' rootstock (49.13 cm²). However, trees grafted on 'Gisela 5' were one year older than trees grafted on the 'Santa Lucia 64' rootstock.

Radunic et al. (2011) obtained 40.1 cm² TCSA for 7 year-old cherry trees trained in a spindle bush training system. The same author reported 40.8 cm² TCSA for cherry trees trained in the "V" training system. Fajt and Komel (2008) measured an average of 63 cm² TCSA in 8 year-old cherry cultivars grafted on 'Gisela 5' rootstock.

Cultivar and rootstock had a statistically significant influence on the flower index (FI). The average value of 'Stella' flower index was significantly higher compared to the 'Burlat' cultivar. The trees grafted on 'Santa Lucia 64' rootstock had significantly higher average flower index than the trees grafted on 'Gisela 5'. Cultivar 'Stella' grafted on 'Gisela 5' rootstock had a higher average FI compared to 'Burlat' grafted on the same rootstock.

4 CONCLUSIONS

Analyses of pomological and phenological characteristics of cherry cultivars 'Burlat' and 'Stella' grafted on the 'Santa Lucia 64' and 'Gisela 5' rootstocks showed that the choice of rootstock had a significant influence on the fruit and tree characteristics. The analyzed cultivars generally developed better fruit quality when grafted on 'Gisela 5' rootstock compared to 'Santa Lucia 64' rootstock. Also, cultivar 'Stella' had a better fruit quality compared to 'Burlat'.

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