The Behavior of Some Sweet Cherry Cultivars on Mazzard Rootstock on Heavy and Acidic Soil

Tomo MILOŠEVIĆ [1(✉)]
Nebojša MILOŠEVIĆ [2]
Ivan GLIŠIĆ [1]

Summary

Over 60% Serbian soils are heavy, shallow and acidic, especially in west part of this country. Basically, Serbian fruit production is mainly represented in these conditions which are not favorable for intensive fruit growing. However, repair of these soils is a long and very expensive process. Regarding to this, one of the real ways to overcome this problem faster and cheaper is to grow tolerant fruit genotypes on adequate rootstock in order to sustainable and economically justified production. Therefore, from 2008 to 2015, we investigated behavior of eight sweet cherry cultivars on Mazzard rootstock on heavy and acidic soil, i.e. their tree vigor, productivity and fruit quality attributes under high density planting system (1,250 tree ha^{-1}). Results showed that 'New Star' generally had the highest tree vigor, yield per tree and hectare, fruit thickness, sphericity, flesh rate and ripening index values. 'Sunburst' had the lowest tree vigor alongside with 'Stark Hardy Giant' ('SHG'), and the highest cumulative yield and yield efficiency. 'Summit' had the highest fruit width and the poorest yield per tree, cumulative yield and yield efficiency, whereas 'Lapins' had the lowest fruit weight and all three fruit dimensions. The highest fruit weight and fruit width was found in 'June Early', and soluble solids content (SSC) and titratable acidity (TA) in 'Hedelfinger'. The lowest SSC was observed in 'June Early' and TA in 'Stark Hardy Giant'. The best financial result was shown by 'New Star' and the poorest by 'Summit'.

Key words

acidic soil, fruit quality, gross profit, Mazzard, sweet cherry

[1] Department of Fruit Growing and Viticulture, Faculty of Agronomy,
Cara Dusana 34, 32000 Cacak, Serbia
✉ e-mail: tomomilosevic@kg.ac.rs
[2] Department of Pomology and Fruit Breedning, Fruit Research Institute Cacak,
Kralja Petra I/9, 32000 Cacak, Serbia

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Introduction

Serbian sweet cherry production increased in the past few decades. Ranged from 22,201 to 29,551 t, i.e. 26,467 t in average for period from 2006 to 2016 (FAOSTAT, 2016). Generally production is small, despite the favorable environmental conditions for its cultivation. The reasons for this situation are numerous, but the most important are: absence of adequate rootstocks, absence of new cultivars with high tree productivity and better fruit quality, heavy and acidic soil, and outdated growing technology (Milošević et al., 2014). Before 20-25 years, sweet cherry plantations in Serbia were rare. Since 2000's, most number of growers was established a new and intensive sweet cherry plantations primarily used seedlings of Mazzard (*Prunus avium* L.), sporadically seedlings of Mahaleb (*P. mahaleb* L.) and Colt as a rootstocks with relative high planting distances. Recently, new vegetative rootstocks with lower vigour than above such as GiSelA 5, GiSelA 6 and MaxMa 14 were used for new orchard establishment; however gained results were poor because grower's knowledge and experience with these rootstocks and situations with over 1,000 trees per hectare, new crown shape, training, pruning, fertilization, its behavior on poor soil conditions, etc. was very lowly. For these reasons, many growers are leaving these rootstocks and reused seedlings of Mazzard, partially seedlings of *P. mahaleb* L.

Traditionally, Mazzard has been used as a sweet and sour cherry rootstock in Serbia due to its excellent compatibility with cultivars, good roots development, low tree mortality, long orchard life, tolerance to unfavorable biotic and abiotic factors, especially to marginal soil-climate conditions, very common in the Cacak region, Serbia (Milošević, 1997). However, since the Mazzard seedlings are invigorating, not enough is known its behavior in a high dense planting system with 1,250 trees per hectare. Also, less knowledge about new more productive and marketable cultivars is attendant (Milošević et al., 2015).

For these reasons, the present work was carried out with eight sweet cherry cultivars grafted on invigorating Mazzard rootstock grown on typical heavy and acidic soil conditions with 1,250 trees per hectare in the Cacak region. The main objective was to evaluate the performance of the eight sweet cherries onto above rootstock through tree growth, precocity, yielding, gross profit and basic external and internal fruit quality attributes in order to defined possibility of sustainable sweet cherry production under high density planting system (HDP). This would allow an economically viable production of high quality sweet cherries.

Material and methods

Trial was done in Prislonica village (43°33'N, 16°21'E, 300 m a.s.l.) near Cacak (Western Serbia) on eight sweet cherry cultivars ['Stark Hardy Giant' (SHG), 'Early June', 'Hedelfinger', 'New Star', 'Summit', 'Lapins', 'Sunburst' and 'Germersdorfer'] grafted on Mazzard seedlings. Cultivars were chosen because of its appropriate characteristics and appropriate ripening time suitable for the growing area. In trial orchard fruit trees are planted at 4×2.0 m apart (1,250 trees ha^{-1}) in autumn 2008 and trained in a Zahn Vertical Axis (Zahn, 1991). The trial was established in a randomized block design with four replications of six trees per plot of each rootstock-cultivar combination (n=24). Tree vigour was controlled with summer pruning previously described by Milošević et al. (2015).

The long-term (1965–2010) average annual temperature was 11.3°C, with an average air temperature during the growing cycle of 17.0°C, and total annual precipitation was 690.2 mm. In the period April–October from 2009 to 2013, mean monthly air temperatures were considerably higher than long-term averages, while rainfall had lower values in general, except in 2014 when amount of rainfall was higher.

Soil is a typical heavy vertisol or "smonitza" with 2.46% organic matter, 0.21% total N (N_{TOT}), 35.25 μ g^{-1} P_2O_5, 107.50 μ g^{-1} K_2O, 0.07% Ca and 1.04% Mg. Soil analysis also indicated 3.5% Fe, 1,370 μ g^{-1} Mn, 30 μ g^{-1} Cu, 61 μ g^{-1} Zn and 1.1 μ g^{-1} B. Levels of organic matter and N_{TOT}, Cu, Mn and Zn were moderate to high, whereas levels of available P, K, Ca, Mg, Fe and B were low. Soil texture is clay-loam with very low pH (4.71 in 0–30 cm depth).

Vegetative growth, yield, and fruit quality data were collected from 2008 to 2015. Trunk circumferences (cm) were measured at the end of growing season 20 cm above the graft union and used to calculate the trunk cross-sectional area (TCSA, cm^2). Yield per tree (kg) and vigour data were utilized to calculate cumulative yield (kg), increases in the trunk cross-sectional area and yield efficiency, expressed as cumulative yield per final TCSA (kg cm^{-2}).

Data for the cherry fruit price (€) were obtained from the Agriculture Market Information System of Serbia. Gross profit per ha (€) for 2015 period was calculated by multiplying yield per ha and the average fruit price per kg.

Ten fully ripen fruits per each rootstock-cultivar combinations and block (n = 40) was picked to study fruit quality. Their length (L, mm), width (W, mm) and thickness (T, mm) were measured by digital caliper Sttarret 727 (Athol, MA, USA) and fruit and stone weight (g) was measured by FCB 6K (Kern & Sohn GmbH, Belingen, Germany) analytical scale. The flesh rate (%) was calculated by subtracting the stone weight from the whole cherry fruit weight. Sperichity (φ) were calculated by using the following equations: $\varphi = D_g/L$, where D_g (geometric mean diameter) derived as $\sqrt[3]{LWT}$ (Mohsenin 1986).

Soluble solids content (SSC, °Brix) was determined using a hand refractometer Milwaukee MR 200 (ATC, Rocky Mount, USA) at 20°C, and titratable acidity (TA, % of malic acid) was analyzed in juices by titration with 0.1 mol L^{-1} NaOH, up to pH 8.1 using a titrimeter Metrohm 719S (Titrino, Herisau, Switzerland). The ripening index (RI) was calculated as the ratio between soluble solids content of the juice and titratable acidity (SSC/TA ratio).

All data in the present study were subjected by analysis of variance (ANOVA) and means were separated by LSD test at $P \leq 0.05$ using Microsoft Office Excel software (Microsoft Corporation, Redmond, WA, USA).

Results and discussion

Vegetative growth, yield characteristics and gross profit

Tree growth from 2008 to 2011 slowly increased with no differences among cultivars (Fig. 1). After this year (3^{th} leaf), differences in TCSA were significant with different annual increasing rate (data not shown). Trees of 'New Star', 'Summit',

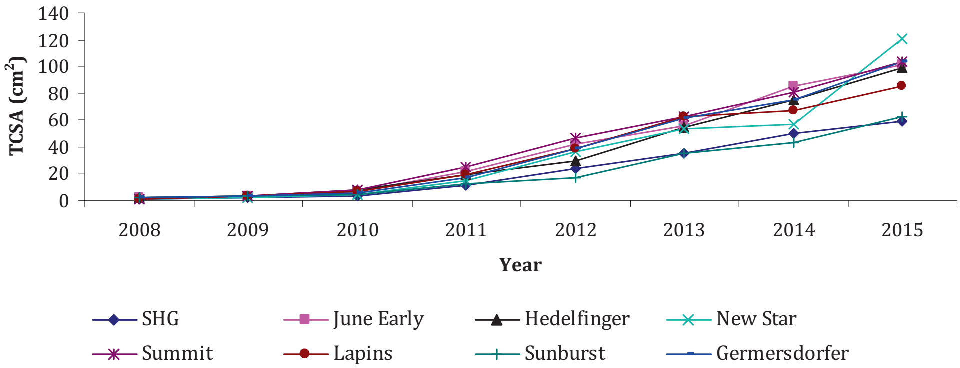

Figure 1. Tree growth as measured by trunk cross-sectional area (TCSA) of eight sweet sherry cultivars on Mazzard rootstock from the first (2008) to the eight (2015) year after grafting.

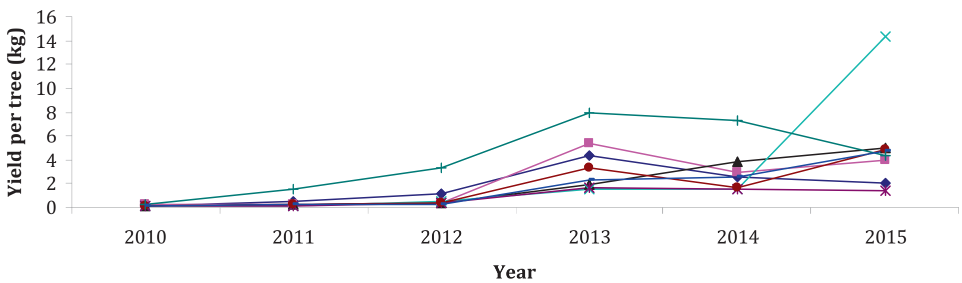

Figure 2. Cultivar effect on yield per tree grafted on Mazzard rootstock from the second (2010) to the seventh (2015) year after planting.

Table 1. Tree vigour and yield attributes of eight sweet cherry cultivars grafted on Mazzard rootstock

Cultivar	Final TCSA (cm^2) Year – 2015	Yield per tree (kg) Year – 2015	Cumulative yield (kg tree^{-1}) (2010 – 2015)	Yield efficiency (kg cm^{-2}) Year – 2015
Stark Hardy Giant	58.96 ± 2.09 e	2.02 ± 0.20 e	11.00 ± 0.36 d	0.192 ± 0.01 b
June Early	101.43 ± 2.20 bc	3.93 ± 0.06 d	13.19 ± 0.28 c	0.131 ± 0.00 cd
Hedelfinger	99.34 ± 0.61 c	5.02 ± 0.19 b	11.56 ± 0.41 d	0.117 ± 0.00 d
New Star	120.93 ± 3.37 a	14.38 ± 0.26 a	18.30 ± 1.25 b	0.152 ± 0.01 c
Summit	103.85 ± 1.65 b	1.43 ± 0.12 f	5.23 ± 0.44 e	0.051 ± 0.00 e
Lapins	85.65 ± 0.67 d	4.91 ± 0.13 bc	10.92 ± 0.63 d	0.127 ± 0.01 cd
Sunburst	62.13 ± 3.41 e	4.40 ± 0.16 c	24.82 ± 1.04 a	0.436 ± 0.04 a
Germersdorfer	103.29 ± 2.52 bc	4.77 ± 0.14 bc	10.24 ± 0.34 d	0.100 ± 0.00 d

Different small letters in same column indicate significant differences among cultivars at $P \leq 0.05$ by LSD test.

'June Early', 'Germersdorfer' and 'Hedelfinger' grew faster, 'Summit' intermediate, whereas trees of 'Sunburst' and 'SHG' grew slowly. By year eight after grafting (Table 1), trees of 'New Star' showed the highest TCSA value, i.e. tree vigour, whereas the lowest and similar found in 'SHG' and 'Sunburst'. López-Ortega et al. (2016) noted high vigour of 'New Star' at the same age. High differences among cultivars on the same rootstock for this trait were previously reported by several authors (Jiménez et al., 2007 Cantín et al., 2010).

All cultivars started to produce in 2010 (2nd leaf) but with very small yield per tree (≤ 150-200 g) without significant differences among them (Fig. 2). After this period, yield consistently increased in all cultivars, especially in 'Germersdorfer' and 'Hedelfinger', whereas in some of them ('Sunburst', 'June Early', 'SHG' and 'Lapins'), yield decreased from 2013 to 2014. The good adaptation of 'Germersdorfer' and 'Hedelfinger' on Mazzard to the growing conditions, probably favoured these tendencies, although their yield in 2015 (final year of trial) was not the highest. In that year, fruit yield was also affected by the type of cultivar, being greater in 'New Star', and lower in 'Summit' (Table 1). Other authors also reported similar data about precocity and yielding characteristics of some sweet cherries (Cantín et al., 2010).

'Sunburst' registered the highest cumulative yield at the studied period (Table 1). Conversely, 'Summit' showed the lowest cumulative yield. These cultivars had the highest and the lowest yield efficiency, respectively. This situation associated with the lowest vigour of the first cultivar or high vigour of the second cultivar and/or its limited yield potential on invigorating rootstock under Cacak growing conditions (Milošević et al., 2014). Good yield efficiency also possess 'SHG' which is in agreement with results of Jiménez et al. (2007) who reported similar data for this cultivar on invigorating rootstocks.

On the basis data from Agriculture Market Information System of Serbia, price of cherry fruits in Serbia in this year was 1.67 € per kg. According to data from Table 2, the highest gross profit per hectare in 2015 was accomplished with 'New Star' and

Table 2. Yield per unit area (ha) and gross profit per ha of eight sweet cherry cultivars grafted on Mazzard rootstock. Data are the mean ± standard error for 2015

Cultivar	Yield per hectare (kg)	Gross profit per ha (€)
Stark Hardy Giant	2521.9 ± 250.8 e	4211.5 ± 418.8 e
June Early	4908.0 ± 78.3 d	8196.4 ± 130.7 d
Hedelfinger	6278.7 ± 238.7 b	10485.5 ± 398.6 b
New Star	17987.6 ± 324.1 a	30024.2 ± 541.3 a
Summit	1787.9 ± 147.1 f	2985.9 ± 245.7 f
Lapins	6138.1 ± 168.8 b	10250.7 ± 281.9b
Sunburst	5494.9 ± 195.4 c	9176.5 ± 326.4 c
Germersdorfer	5957.5 ± 178.5 bc	9949.0 ± 298.2 bc

Different small letters in same column indicate significant differences among cultivars at $P \leq 0.05$ by LSD test.

the lowest with ‘Summit’ due to their productivity per tree and hectare. In addition, the modern HDP system of sweet cherry trees requires the desired greater precocity (2–3 years earlier than in standard orchards), profitable higher annual yields per unit area combined with higher financial results, faster return of investment, easier maintenance, faster harvests and the ability to more easily protect the orchard from rain, hail and bird damage, etc. (Manolova and Kolev, 2013).

Fruit quality attributes

Knowledge about physical properties of agricultural products and their relationships is necessary for the design of handling, sorting, processing and packaging systems (Shahbazi and Rahmati, 2013). Otherwise, consumers prefer large sweet cherry fruits with equal weight and uniform shape (Milošević et al., 2014).

In the present study, fruit physical properties significantly varied among cultivars (Table 3). The highest fruit weight and fruit length was observed in ‘June Early’, whereas ‘Lapins’ had the lowest fruit weight and all fruit dimensions. The highest fruit width was observed in ‘Summit’. Four cultivars (‘SHG’, ‘June Early’, ‘New Star’ and ‘Summit’) had similar and higher fruit thickness when compared to other cultivars. In general, bigger fruits were harvested in years when yield was lower which described in our previous studies (Milošević et al., 2014, 2015). López-Ortega et al. (2016) reported that fruit weight and fruit width of ‘New Star’ in Murcia (Spain) affected by rootstocks used and varied from 7.3 to 9.4 g and from 24.3 to 26.9 mm, respectively, whereas Lanauskas et al. (2012) noted that ‘Lapins’ under Lithuanian conditions had fruit weight of 7 g in average, i.e. higher than those of our data. In a study of Hayaloglu and Demir (2015), ‘Summit’ on Mazzard grown on sandy loam soil in Yalova (Turkey) had much higher fruit weight (9.94 g) and fruit dimensions (L = 28.18 mm, W = 28.08 mm) than our data. Many factor induced changes in fruit weight. The primarily is crop load, pedo-climatic conditions, rootstocks and cultural practice. Probably, soil conditions in our trial were not optimal for some cultivars and limited their physical properties of sweet cherry. Fruit weight is important parameter; however fruit size, i.e. fruit equatorial diameter is more inherent for commercial market value (Whiting et al., 2005; Zeman et al., 2012). For example, among others, consumers prefer sweet cherries with short peduncles, fruit equatorial diameter ≥24 mm and with bright red color- regardless of their age, gender or ethnicity (Crisosto et al., 2003).

Recently, sweet cherry cultivars with large fruits are increasingly valued at the international level because fruits of 26 mm in width are admissible into the first quality category, regardless of the ripening period (UNECE Standard, 2007). In our study, five cultivars (‘SHG’, ‘June Early’, ‘New Star’, ‘Summit’ and ‘Germersdorfer’) had fruit width >24 mm. In addition, when it comes to marketing, the size of a cherry is a substantial factor (Hajagos et al., 2012).

The fruit shape is determined in terms of its sphericity (Mohsenin, 1986). This index significantly varied among cultivars (Table 3), being higher and identical in ‘SHG’ and ‘New Star’ when compared with other. The lowest was in ‘Sunburst’. On this line, ‘SHG’ and ‘New Star’ including ‘Germersdorfer’ and ‘Summit’ had more elongated-heart-shaped fruits due to these values were equal or slightly over 1, whereas other cultivars had slightly flattened fruits in general. Otherwise, flattened sweet cherry seems more tempting than a lengthened one (Pérez-Sánchez et al., 2010). Although fruit shape is genetically controlled traits, it seems that climatic conditions maybe changing this trait of the same cultivar due to year-by-year variation was observed at the same orchard (data not shown).

Table 3. Fruit physical properties of eight sweet cherry cultivars grafted on Mazzard rootstock. Data are the mean ± standard error for 2015

Cultivar	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)	Sphericity	Stone weight (g)	Flesh rate (%)
Stark Hardy Giant	7.47 ± 0.18 c	21.34 ± 0.28 f	24.78 ± 0.23 bc	21.65 ± 0.19 a	1.06 ± 0.01 a	0.34 ± 0.00 a	95.36 ± 0.17 c
June Early	9.07 ± 0.18 a	24.58 ± 0.16 a	24.88 ± 0.15 ab	21.37 ± 0.16 a	0.96 ± 0.00 e	0.27 ± 0.01 c	97.00 ± 0.15 a
Hedelfinger	6.52 ± 0.13 e	22.35 ± 0.20 d	22.92 ± 0.18 e	19.64 ± 0.17 c	0.97 ± 0.00 de	0.24 ± 0.01 d	96.31 ± 0.11 b
New Star	7.12 ± 0.24 d	21.06 ± 0.24 fg	24.36 ± 0.23 cd	21.65 ± 0.27 a	1.06 ± 0.00 a	0.22 ± 0.01 e	96.76 ± 0.20 a
Summit	7.79 ± 0.16 b	23.18 ± 0.20 c	25.25 ± 0.34 a	21.36 ± 0.20 a	1.00 ± 0.01 c	0.26 ± 0.00 c	96.69 ± 0.10 a
Lapins	5.83 ± 0.16 f	20.92 ± 0.23 g	21.77 ± 0.28 f	19.05 ± 0.20 d	0.98 ± 0.00 d	0.26 ± 0.00 c	95.40 ± 0.16 c
Sunburst	6.61 ± 0.20 e	23.86 ± 0.26 b	22.65 ± 0.28 e	19.68 ± 0.21 c	0.92 ± 0.00 f	0.29 ± 0.01 b	95.51 ± 0.18 c
Germersdorfer	6.61 ± 0.20 e	21.69 ± 0.20 e	24.05 ± 0.22 d	20.14 ± 0.23 b	1.01 ± 0.00 c	0.26 ± 0.00 c	96.01 ± 0.12 b

Different small letters in same column indicate significant differences among cultivars at $P \leq 0.05$ by LSD test

Table 4. Fruit soluble solids content, titratable acidity and ripening index of eight sweet cherry cultivars grafted on Mazzard rootstock. Data are the mean ± standard error for 2015

Cultivar	Soluble solids content (°Brix)	Titratable acidity (%)	Ripening index
Stark Hardy Giant	16.12 ± 0.24 ab	0.43 ± 0.01 e	37.75 ± 1.22 a
June Early	12.35 ± 0.15 e	0.47 ± 0.01 de	26.39 ± 0.65 c
Hedelfinger	16.25 ± 0.18 a	0.63 ± 0.02 a	26.28 ± 0.81 c
New Star	15.89 ± 0.41 ab	0.43 ± 0.01 e	37.04 ± 1.24 a
Summit	15.10 ± 0.24 c	0.58 ± 0.01 ab	26.32 ± 0.86 c
Lapins	15.83 ± 0.22 ab	0.42 ± 0.01 e	37.76 ± 0.94 a
Sunburst	15.63 ± 0.18 b	0.50 ± 0.02 cd	32.73 ± 1.73 b
Germersdorfer	14.41 ± 0.21 d	0.54 ± 0.01 bc	26.96 ± 0.78 c

Different small letters in same column indicate significant differences among cultivars at $P \leq 0.05$ by LSD test.

Sweet cherry stones are used in genotype identification. Their characters were found to be very variable and stone relative to fresh fruit weight ranged between 3.7 and 8.4% (Blažkova, 1988) which supported our data (Table 3). 'June Early', 'New Star' and 'Summit' had the highest flesh rate, 'Hedelfinger' and 'Germersdorger' had similar and intermediate, whereas other cultivars had similar and the lowest values. In general, consumers prefer cherries with high flesh rate.

With regard to SSC, significant differences among cultivars were found (Table 4). The highest value was observed in fruits of 'Hedelfinger' and the lowest in 'June Early'. Good and similar SSC to 'Hedelfinger' was also observed in 'SHG', 'New Star' and 'Lapins'. In a study of Lanauskas et al. (2012), fruits of 'Lapins' contained more soluble solids than those obtained in our trial, whereas Gonçalves et al. (2006) noted that SSC of 'Summit' varied among rootstock from 13.87 to 18.05 °Brix with intermediate value on *P. avium* L. Under Yalova conditions, 'Summit' had much lower SSC (13.26 °Brix) than our value. In the present study, 'Hedelfinger', 'SHG' and 'Lapins' generally had low productivity per tree. Several authors reported that vigorous cherry rootstocks and low yield induced higher SSC (Cantín et al., 2010) because cherries with the lowest yields exposed higher SSC mainly due to a higher or more balanced fruit-to-leaf area ratio (López-Ortega et al., 2016). Hajagos et al. (2012) reported that basically all above attributes, including SSC, caused by scion; however, rootstock can also have a strong impact on them through controlling the transport of water and other vital substances (Gonçalves et al., 2006). Hence, this part of tree determines many aspects of tree physiology and fruiting. Otherwise, high SSC and a dark-red colour of the fruit are equally important in terms of consumer acceptance (Crisosto et al., 2003). Cultivars with SSC >15 °Brix are considered to be acceptable for sweet cherry (Kappel et al., 1996), which is case in our trial for all cultivars evaluated, except for 'June Early' and 'Germersdorfer'.

Similarly to SSC, acidity also varied among cultivars, being the highest in 'Hedelfinger' and 'Summit' whereas the lowest and similar was recorded by 'SHG', 'New Star' and 'Lapins' (Table 3). For 'Sunburst' in our study, acidity was higher than those obtained by Glišić et al. (2011) at the same tree age, probably due to different weather conditions during maturity and rootstock used. Generally, our range values for acidity were in a good agreement with results of Crisosto et al. (2003) who reported that TA in sweet cherries ranged between 0.5 and 1.5%. These authors also noted that its content is low in sweet cherries and has no dominating influence on the taste quality, i.e. simple TA values are not adequate to describe fruit taste. In addition, Cavalheiro et al. (2010) concluded that Mazzard increased acidity as compared with other rootstocks.

As expected, SSC (a large portion of the soluble solids is sugars) and TA were low in 'June Early', which is well known as an early-maturing cultivar with low sugar content and total acidity (Gonçalves et al., 2006).

The SSC/TA ratio or ripening index (RI) is the major factor which determined taste and flavor intensity. It has an important role in consumer acceptance of stone fruits, and higher ratios are usually preferred (Crisosto et al., 2003). Namely, the taste of the fruit depends primarily on sugar and acid content, more precisely, on their balanced development. In the present study (Table 4), 'Lapins', 'SHG' and 'New Star' had the highest and similar RI values, whereas the lowest was found in fruits of 'Germersdorfer', 'June Early', 'Summit' and 'Hedelfinger', respectively. Hayaloglu and Demir (2015) also reported that 'Summit' on Mazzard showed intermediate RI value. Cherries accumulate SSC, i.e. sugar and acid from the plant during ripening. If harvested too early such as 'June Early', they are unable to accumulate enough quantities to enhance their taste to the levels desired by consumers, and will be, therefore, considered commercially unacceptable (Hajagos et al., 2012). However, this cultivar has larger fruits with darker red coloured skin and can be recommended for growers in pedo-climatic conditions like our as an early ripening genotype. The intermediate RI was observed in 'Sunburst'. It should be noted that fruits of this cultivar have more or less pronounced bitter taste in Serbian conditions, which discourages consumers in markets (Milošević et al., 2014).

Conclusions

On Mazzard rootstock with 1,250 trees per ha grown on acidic and heavy soil, high variability among sweet cherry cultivars were found regarding examined traits. In general, 'Stark Hardy Giant' and 'Sunburst', somewhat 'Lapins', due to their lower vigor, relatively good productivity and respectable fruit quality posses capacity to efficient and sustainable sweet cherry production under heavy and acidic soil. Contrary, high vigour, shown by some cultivars such as 'New Star', 'June Early', 'Germersdorfer' and 'Summit' may be recommendable when planting on poor soils or under replanting conditions. In addition, 'New Star', due to their highest gross profit per hectare, may be interesting for growers. Finally, we assume that aggressive orchard management in more controlled fertilization and irrigation practices alongside with summer pruning, productivity and fruit quality of sweet cherry cultivars may be better.

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