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EVALUATION OF FRUIT GROWTH AND POSTHARVEST PHYSICAL AND CHEMICAL PROPERTIES OF NECTARINE [*Prunus persica* var. *nectarina* (Ait.) Maxim.]

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Abstract. A 3-year study was done to compare the blossoming and harvesting date, fruit physical and chemical composition of six nectarine cultivars grown with High Density Planting system under western Serbian conditions. A high variability among and within cultivars was found and significant differences were observed among them in all properties analyzed. Year-by-year variations were observed for blossoming and harvesting date, length of fruit growth, soluble solids content, fruit weight and fruit firmness. On the basis of evaluated data, the best fruit performance registered in 'Caldesi 2000' and 'Syrio' grown with HDP on heavy soil. Contrary, the poor fruit physico-chemical properties were observed in 'Mayfire', especially in 'Nectared 4'. This evaluation may help to select a set of nectarine cultivars with better fruit quality attributes, which in our growing conditions might be indicated in 'Caldesi 2000', 'Syrio', somewhat 'Weinberger' and 'Fantasia'.

Key words: chemical composition, flesh firmness, fruit size, fruit shape, high density planting system

INTRODUCTION

Nectarine [*Prunus persica* var. *nectarina* (Ait.) Maxim.] is a sub-tropical fruit tree which requires irrigation, thinning and disease protection to be commercially viable [Naor et al. 2001]. In recent years, nectarine growing has been rapidly improving in the world. This improvement is based on the adaptability of cultivars to different environmental conditions and precocity of trees [Seferoglu and Tekintaş 2004; Szklarz and Radajewska 2009]. The good appearance and taste of fruit at different maturation times of cultivars due to the spreading of production in extended period of time have been playing key role [Cantín et al. 2010].

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In recent years, increasing of nectarine production in Serbia includes new cultivars with different growth and fruiting characteristics, harvest date, more full red fruit colour and better eating quality than the existing old cultivars [Zec et al. 2009]. However, new imported cultivars are also often not as well adapted to the Serbian climate, soil and water conditions as old bred cultivars. In addition, nectarines grown in Serbia are mostly earmarked for the local consumption and export market and thus necessitate strict adherence to export standards [Milošević 1997]. Also, to ensure superior fruit quality in overseas markets, special attention must be given to all aspects of production, picking, packing and shipping of new nectarine cultivars.

Over the past few decades, models of peach and nectarine fruit growth and plant development have identified useful principles for assisting growers in making horticultural management decisions [Naor et al. 2001]. For example, early estimation of blooming and harvest date, fruit development, and fruit quality attributes can help nectarine fruit growers plan crop management practices efficiently [Lopez et al. 2007; Day et al. 2008].

Fruit growth represents a quantitative process, which conducts to increase of fruit weight and volume [DeJong 2005]. Peach and nectarine fruit growth has been described as a double sigmoid growth curve for nearly a century and researchers have been trying to understand the cause of the three traditional stages of peach growth ever since [DeJong, Goudriaan 1989]. Additionally, fruit maturation is characterized by changes in physiological, biochemical and morphological treats of the fruit, which determine the qualitative characteristics of any cultivar and finally its depreciation during senescence [Day et al. 2008]. Fruit quality is a combination of physical and chemical characteristics accompanied by sensory properties (appearance, texture, taste and aroma), nutritional values, chemical compounds, mechanical properties and functional properties [Kramer and Twigg 1966]. Nowadays, fruit quality is fundamental for the acceptance of peach and nectarine cultivars by consumers, due to the high competition in the market with numerous new released cultivars and other fruit species [Crisosto and Crisosto 2005]. However, there is limited information on the evaluation of fruit quality in nectarine cultivars grown in high density planting (HDP) system. In this study, we investigated different agronomic and fruit quality attributes in six nectarine cultivars over three consecutive years under HDP system.

The aim of the present investigation was to find out nectarine cultivars which are suitable to commercial production with good fruit quality attributes under the soil and climate conditions of Cacak region (Western Serbia). The effect of cultivars on fruit growth was also studied.

MATERIAL AND METHODS

Plant material and field trial. Six nectarine cultivars were evaluated during 2009–2011 in private orchard at Prislonica (43°57’ N, 20°26’ E, 310 m a.s.l.) near Cacak (Western Serbia). The plant material included commercial cultivars ‘Mayfire’, ‘Weinberger’, ‘Caldesi 2000’, ‘Nectared 4’, ‘Fantasia’ and ‘Syrio’ grafted on seedlings of vineyard peach (*Prunus persica* ssp. *vulgaris* Mill.). Trees were trained to the “Fusseto” tree form and planted at a spacing of 3 m × 1.3 m. Orchard was established in

2006. Hand thinning was carried out to reduce fruit load when young fruits were in diameter about 10 mm. Trees were grown under standard conditions of summer pruning, fertilization and pest and disease control, except irrigation. Three replicates and five trees per replication were used for each measurement per cultivar.

Soil mineral status and weather conditions. The orchard soil was vertisol (USDA Soil Taxonomy) with a pH 5.19 in 0.1 M KCl. The soil chemical analysis showed that the soil contained 1.71% organic mater, 0.15% N_{TOT}, 73.0 mg kg^{-1} and 281.0 mg kg^{-1} available P_2O_5 and K_2O, respectively. Generally, soil characteristics were not suitable for normal growth and development of nectarine trees [Milosevic 1997].

Weather conditions of Cacak are characterized by the average annual temperature of 11.3°C and total annual rainfall of 690.2 mm.

Measurement of the fruit growth and fruit physico-chemical properties. During the 2009, 2010 and 2011 seasons, agronomic and fruit quality traits were measured individually in each cultivar tree. All data are the mean ±SD (phenological data) and mean ±SE (physico-chemical properties) for three consecutive years.

Blossoming date was recorded for each cultivar according to Fleckinger [1945], i.e., the average date for start of blossoming (SF) (E stage), full blossoming (FB) (F stage) and end of blossoming (EB) (G stage) was scored in each cultivar. All dates were converted prior to analysis into days after 31 December, hereafter day of the year (DOY) where 1 = 1 January, etc.

Fruit growth was recorded in period between full bloom and full maturity. Fruit samples during their growth of each cultivar were taken repeatedly in interval 20 days after full bloom (DAFB) for determining the dynamics and length of its growth period. For each measurement during fruit growth, 25 fruits with three replicates were used from all parts of crown for evaluation of fruit weight (FW). The mean harvesting date was also calculated for each cultivar. Fruits were considered ripe in the tree when their growth had stopped, they began softening, exhibited yellow or orange ground colour and red or dark red skin colour (which is also representative for each cultivar) and were easily detached [Cantín et al. 2010]. After harvest, the fruit were immediately taken to the laboratory, where maturity at harvest was determined on three repetitions of 25 fruit.

For each sample of ripe fruits, FW (g) was measured and determined with a digital balance Tehnica (ET-1111, Iskra, Slovenia) to an accuracy of 0.01 g. For each nectarine fruit, three linear dimensions, length (L), width (W), and thickness (T), were measured by using a digital caliper gauge with a sensitivity of 0.001 cm. The measurement of length was made on the polar axis of fruit, i.e. between the apex and stem. The arithmetic mean diameter (D_a), geometric mean diameter (D_g), sphericity (φ) and surface area (S) was calculated by using the following relationships [Mohsenin 1986]:

$$D_a = \frac{L + W + T}{3}, \tag{1}$$

where: D_a – arithmetic mean diameter – średnia arytmetyczna średnicy (mm),
L – length of nectarine fruit – długość owocu nektaryny (mm),
W – width of nectarine fruit – szerokość owocu nektaryny (mm),
T – thickness of nectarine fruit – grubość owocu nektaryny (mm),

$$D_g = LWT^{\frac{1}{3}}, \tag{2}$$

where: D_g – geometric mean diameter – geometryczna średnia średnica (mm),

$$\phi = \frac{D_g}{L}, \tag{3}$$

where: φ – sphericity – sferyczność,

$$S = \pi D_g^2, \tag{4}$$

where: S – surface area – obszar powierzchni (mm^2).

The aspect ratio (R_a) was calculated [Maduako and Faborode 1990] as:

$$R_a = \frac{W}{L} \times 100, \tag{5}$$

where: R_a – aspect ratio – stosunek aspektowy (%).

The fruit volume (V_m) was determined by using the liquid displacement method. Toluene (C_7H_8) was used instead of water because it is absorbed by the fruit to a lesser extent. The V_m was calculated by the following equation [Mohsenin 1986]:

$$V_m = \frac{m_w}{\rho_w}, \tag{6}$$

where: V_w – volume of displaced water – objętość przemieszczonej wody (cm^3),
m_w – mass of displaced water – masa przemieszczonej wody (g),
ρ_w – density of water – gęstość wody (kg m^{-3}).

Flesh firmness (FF) was determined with an electronic fruit texture analyzer (Bertuzzi FT-327, Facchini, Alfonsine, Italy) with an 8 mm-diameter plunger, on both cheeks of the fruit after skin removal. Data are given as kg 0.5 cm^{-2}.

Two slices of flesh were taken from each fruit and juiced to determinate soluble solids content (SSC in °Brix) with a digital refractometer Milwaukee MR 200 (ATC, Rocky Mount, USA) at 20°C and titratable acidity (TA in % of malic acid) by titration of 10 mL of juice with 0.1M NaOH to a pH of 8.2. On the basis of the measured data, SS/TA ratio or ripening index (RI) was calculated.

Statistical analysis. Data for each parameter measured were subjected to an analysis of variance (ANOVA) using the MSTAT-C statistical package [Michigan State University, East Lansing, MI, USA]. Differences between treatments were assessed using the *F* test, and the least significant difference (LSD) was calculated at 0.05 probability level ($P \leq 0.05$).

RESULTS AND DISCUSSION

Time of blossoming and harvest ripening. Blossoming date for the six cultivars during three years of the study are shown in tab. 1. Differences among cultivars and year-by-year variations were observed. However, differences among cultivars for the SB, FB and EB were lower than differences observed among years. The earliest SB was recorded in 'Caldesi 2000', which was blossomed in 93.7 ± 4.2 DOY (that is on the April 4th). The latest SB was observed in 'Fantasia' and 'Syrio' (97.0 ± 6.1 DOY and 97.3 ± 7.2 DOY, respectively). Similar data for SB in 'Fantasia' reported Papanikolau et al. [2005]. Early flowering is a desirable character in warm areas to obtain earliest yield even though spring frost may reduce production in some years, as previously observed [Byrne 2003; Cantín et al. 2010]. Regarding FB, the earliest data was recorded in 'Mayfire' and 'Caldesi 2000' (98.7 ± 4.9 DOY and 99.0 ± 3.6 DOY respectively), whereas all cultivars, except 'Caldesi 2000' and 'Fantasia', had EF in 107.7 ± 2.5 DOY and 108.3 ± 3.8 DOY, respectively (that is on the April 7th). Thus, the differences for the blossoming date observed among cultivars were somehow expected. Namely, according to Dirlewanger et al. [1999], blossoming date is considered as a quantitative trait in peach, nectarine and other *Prunus* species.

Important variations among years were found for all evaluated cultivars (tab. 1), which could be due to the influence of environmental conditions, as previously reported [Papanikolau et al. 2005; Zec et al. 2009].

The deviations in the present study regarding the stages of blossoming among years were induced by the mild winter of 2009/2010 and the very early onset of the growing season in Serbia in 2010 (data not shown).

All cultivars used were harvested between late June and late September (tab. 2); there were large variations in harvest season among the evaluated cultivars. The earliest nectarine cultivar was 'Mayfire', (69.3 ± 5.5 DAFB, i.e. June 23rd), followed by 'Weinberger' (91.7 ± 4.9 DAFB). The start of fruit ripening of 'Nectared 4' and 'Caldesi 2000' were intermediate (101.7 ± 3.5 DAFB and 102.7 ± 3.5 DAFB, respectively), whereas fruits of 'Fantasia' (129.3 ± 7.2 DAFB) and 'Syrio' (159.3 ± 8.1 DAFB) harvested late and very late, respectively.

The harvesting time showed a normal distribution within each cultivar [Zec et al. 2009], reflecting a quantitative genetic control [Dirlewanger et al. 1999]. This trait has been established as characteristic of each cultivar, as previously reported [Seferoglu and Tekintaş 2004; Cantín et al. 2010; Milosevic and Milosevic 2010]. Generally, the ripening period of fruits showed the same tendency as the blossoming period [Papanikolau et al. 2005].

Early estimation of harvest date can help peach and nectarine fruit growers plan crop management practices efficiently [Day et al. 2008]. Also, this variability allows selecting the most interesting harvesting date among the cultivars in order to cover market demands [Byrne 2003]. Year-by-year variations were found (tab. 2). This trait depended on environmental conditions (temperature, altitude etc) and may change every year [Mounzer et al. 2008].

Table 1. Blossoming time for the six nectarine cultivars under Cacak conditions
Tabela 1. Czas kwitnienia dla sześciu odmian nektaryny w warunkach Cacaku

Cultivar Odmiana	Start of blossoming Początek kwitnienia			Mean ±SD Średnio ±SD	Full blossoming Pełnia kwitnienie			Mean ±SD Średnio ±SD	End of blossoming Koniec kwitnienia			Mean ±SD Średnio ±SD
	2009	2010	2011		2009	2010	2011		2009	2010	2011	
Mayfire	100	88	98	95.3 ± 6.4	102	93	101	98.7 ± 4.9	112	103	106	107.0 ± 4.6
Weinberger	97	90	99	95.3 ± 4.7	103	95	102	100.0 ± 4.4	110	105	107	107.3 ± 2.5
Caldesi 2000	95	89	97	93.7 ± 4.2	102	95	100	99.0 ± 3.6	110	105	108	107.7 ± 2.5
Nectared 4	98	91	99	96.0 ± 4.3	102	95	102	99.7 ± 4.0	107	105	109	107.0 ± 2.0
Fantasia	101	90	100	97.0 ± 6.1	105	94	103	100.7 ± 5.9	111	104	110	108.3 ± 3.8
Syrio	102	89	101	97.3 ± 7.2	105	92	104	100.3 ± 7.2	111	102	109	107.3±4.7
Średnio	99	89	99	95.8 ± 1.3	103	94	102	99.7 ± 0.8	110	104	108	107.4 ± 0.5

Values in columns are days after 31 December, hereafter day of the year (DOY) where 1 = 1 January, etc.
Wartości w kolumnach to dni po 31 października, następnie dzień roku (DOY-DR), gdzie 1= 1 stycznia itd.
SD – Standard deviation – Odchylenie standardowe

Table 2. Date of start of fruit ripening in six nectarine cultivars
Tabela 2. Termin rozpoczęcia dojrzewania owoców sześciu odmian nektaryny

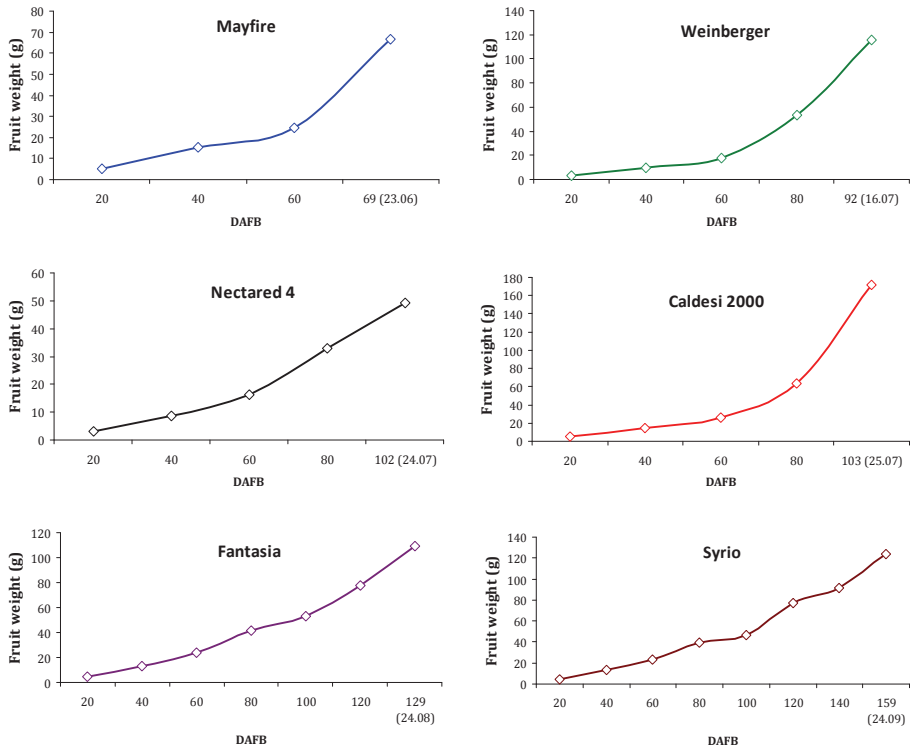
Cultivar Odmiana	Start of fruit ripening Początek dojrzewania owoców			Mean ±SD Średnio ±SD
	2009	2010	2011	
Mayfire	72	63	73	69.3 ± 5.5
Weinberger	94	86	95	91.7 ± 4.9
Caldesi 2000	103	99	106	102.7 ± 3.5
Nectared 4	102	98	105	101.7 ± 3.5
Fantasia	134	121	133	129.3 ± 7.2
Syrio	165	150	163	159.3 ± 8.1
Średnio	112	103	113	109.0 ± 31.3

Values in columns are days after full bloom (DAFB)
Wartości w kolumnach to dni po pełnym kwitnieniu (DAFB)
SD – Standard deviation – odchylenie standardowe

Fruit growth. In the case of fruit growth, we observed classical double sigmoid growth curve with three traditional stages (I, II, III) in all cultivars (fig. 1), as previously reported by DeJong and Goudriaan [1989] and DeJong [2005].

There were significant differences among years for fruit growth within the same cultivar (tab. 1). All cultivars showed faster fruit growth in 2010, when compared with 2009 and 2011 (data not shown). According to data from fig. 1, the faster fruit growth was recorded in 'Mayfire', followed by 'Weinberger'; fruits of 'Caldesi 2000' and 'Nectared 4' grew moderately, while the fruits of 'Fantasia' and 'Syrio' grew slowly and very slowly, respectively. These data are in agreement with the results of Naor et al. [2001] and Mounzer et al. [2008], who all reported that peach and/or nectarine fruit growth is highly dependent on cultivar. On the other hand, earlier studies showed an influence of spring temperatures on the fruit growth and harvest date of peach and nectarine cultivars [Lopez et al. 2007; Day et al. 2008]. DeJong [2005] reported that the number of days between FB and harvest for several cultivars was related to growing degree hours (GDH 30) accumulated during the first 30 days after full bloom; increased GDH 30 values were related to decreases in the number of days between full bloom and harvest.

For example, in 2010 the mean daily temperatures at 30 DAFB were higher than in 2009 and 2011 (data not shown). Very early-maturing, as well as very late-maturing nectarine cultivars, are of considerable interest for the nectarine growers and consumers in the Serbia [Milošević 1997], and the main difference between these cultivars is the length of their fruit development period [Mounzer et al. 2008].



Fruit weight – Masa owoców

Fig. 1. Fruit growth of six nectarine cultivars between full bloom and start of fruit ripening (average values from 2009–2011)

Rys. 1. Wzrost owoców sześciu odmian nektaryny pomiędzy pełnym kwitnieniem, a początkiem dojrzewania owoców (średnie wartości z lat 2009–2011)

Flesh chemical attributes. The SSC, TA and RI are chemical parameters that better permit to evaluate the fruit quality perception from consumer [Di Vaio et al. 2008]. In this study, greater variability in above attributes was found among nectarine cultivars (tab. 3). 'Syrio' had significantly higher SSC than 'Caldesi 2000' and 'Mayfire', whereas differences among other cultivars were not significant. We observed tendency that late ripening cultivars had higher SSC than earliest, as previously reported [Dirlewanger et al. 1999]. All cultivars had SSC levels greater than 10°Brix. The minimum SSC established by the EU to market peaches and nectarines is 8°Brix [Commission Regulation (EC) No. 1861/2004 of 28 October 2004], although SSC below 11°Brix are generally unacceptable to consumers [Crisosto and Crisosto 2005]. Our range of values is in agreement with previous work in nectarine [Cantín et al. 2010]. Year-by-year variations were registered (data not shown), as previously observed by other authors [Wu et al. 2005].

The TA of nectarine cultivars is given in tab. 3. Significant differences were found among all cultivars because this characteristic is genotype dependent [Dirlewanger et al. 1999]. Also, the fruit maturity stage at the harvest date is the principal factor affecting fruit acidity and also the SSC. Among all cultivars, only 'Caldesi 2000' had lower mean TA value than 0.9%, which is considered the maximum limit for normal acidity peaches [Hilaire 2003].

Table 3. Flesh chemical attributes of six nectarine cultivars (2009–2011)
Tabela 3. Cechy chemiczne miąższu sześciu odmian nektaryny (2009–2011)

Cultivar Odmiana	Soluble solids Rozpuszczalne ciała stałe (°Brix)	Titratable acidity Miareczkowalna kwasowość (%)	Ripening index Wskaźnik dojrzewania
Mayfire	10.70 ± 0.49 c	1.10 ± 0.03 a	10.08 ± 0.61 b
Weinberger	13.29 ± 0.79 abc	1.08 ± 0.04 b	12.29 ± 0.47 ab
Caldesi 2000	12.38 ± 0.17 bc	0.88 ± 0.05 f	14.48 ± 1.05 ab
Nectared 4	13.29 ± 0.29 abc	1.02 ± 0.04 d	12.98 ± 0.31 ab
Fantasia	14.60 ± 0.40 ab	0.99 ± 0.06 e	15.29 ± 1.06 a
Syrio	15.95 ± 0.36 a	1.07 ± 0.03 c	14.91 ± 0.39 a

Values are the averages of triplicate samples from each year
Wartości te to średnie z potrojonych próbek z każdego roku
The different letters in same columns indicate significant differences among means within each cultivar at $P \leq 0.05$ by LSD test
Różne litery w tych samych rzędach wskazują na znaczące różnice pomiędzy średnimi w obrębie każdej odmiany przy $P \leq 0{,}05$ według testu LSD

Significant differences were detected only among 'Fantasia' and 'Syrio' versus 'Mayfire' for RI, depending on their SSC and TA (tab. 3). As expected, higher RI values were usually found in cultivars with the highest SSC. However, some of the cultivars such as 'Weinberger' and 'Nectared 4' with high SSC had low RI because of their high TA, as previously reported [Cantín et al. 2010]. The RI or SSC/TA ratio has an important role in consumer acceptance of some apricot, peach, nectarine and plum cultivars, and higher ratios are usually preferred [Crisosto et al. 2004]. Also, above authors reported that in the case of cultivars with TA >0.90% and SSC <12.0%, consumer acceptance was controlled by the interaction between TA and SSC rather than SSC alone. Therefore, a single generic RSSC quality index would not be reliable with regard to assuring consumer satisfaction across all cultivars [Crisosto and Crisosto 2005]. However, in a recent study with nectarines the consumer acceptance was always greater for non-acid than for acid cultivars, even at early or advanced stages of fruit maturity [Iglesias and Echeverría 2009].

Flesh physical attributes. Physical attributes of six nectarine cultivars are given in tab. 4. All physical properties considered in our study were found to be statistically significant. According to Dirlewanger et al. [1999], FW is a major quantitative inherited

factor determining yield, fruit quality and consumer acceptability. The cultivars 'Caldesi 2000' and 'Syrio' produced the highest FW, whereas the cultivars 'Mayfire', especially 'Nectared 4', produced the lowest FW. Mean FW and its variation recorded in our study corresponded quite well to data observed in literature [Iglesias and Echeverría 2009; Cantín et al. 2010; Milosevic and Milosevic 2010], although the mean FW was generally a little smaller.

In earlier study obtained by Seferoglu and Tekintaş [2004] and Papanikolau et al. [2005], the FW of 'Nectared 4' and 'Fantasia' was 65.88 g and 173–183 g, respectively. It is due to the different environmental conditions and cultural practices. Year-by-year variations were significant (data not shown). The highest FW was recorded in year with high rainfall before harvest, such as 2009 and 2010, and the lowest in 2011 with high spring temperatures in stage I of fruit growth and absence of rainfall and/or irrigation before maturity, which is in agreement with previous works on peach and nectarine [Naor et al. 2001; DeJong 2005; Day et al. 2008].

The greatest L and W were found for 'Syrio' and 'Caldesi 2000', whereas the greatest T was found for 'Caldesi 2000'. 'Nectared 4' had the lowest values of L, W and T among the studied cultivars. In a study conducted by Seferoglu and Tekintaş [2004], two linear dimensions (L, W) of 'Nectared 4' fruits are 41.8 mm and 51.0 mm, respectively. The major axis (L) has been found to be useful by indicating the natural rest position of the material and hence in the application of compressive force to induce mechanical rupture [Erdogan et al. 2003].

The highest D_a and D_g values were found for 'Syrio' and 'Caldesi 2000', respectively, but the lowest ones were for 'Nectared 4' (tab. 4). In general, the knowledge related to D_a and D_g would be valuable in designing the grading process [Mohsenin 1986].

Significant differences were detected among cultivars for φ and R_a (tab. 4). The highest φ value was registered in 'Caldesi 2000', and the lowest in 'Mayfire' and 'Fantasia', while the highest R_a was found in 'Mayfire', and the lowest in 'Veinberger', 'Nectared 4' and 'Caldesi 2000', respectively. Sphericity (φ) is an expression of the shape of a solid relative to that of a sphere of the same volume, while the R_a relates the W to the L of the fruit which is indicative of its tendency toward being spherical in shape [Maduako and Faborode 1990]. In our study, three cultivars ('Caldesi 2000', 'Veinberger', 'Nectared 4') showed ratios very close to 1, which means that fruits were almost spherical, as previously reported [Cantín et al. 2010]. Additionally, when φ values is different from 1, the shape is oval, flattened or with protruding sutures. Above authors also reported that in peach and nectarine, round shapes without protruding tips are preferred by consumers.

The S of each nectarine cultivar resulted in different means (tab. 4). The highest values observed in 'Syrio', and the lowest in 'Nectared 4'. Similar tends for many plants and foods materials have been reported in the literature [Mohsenin 1986; Maduako and Faborode 1990].

The V_m of the 'Caldesi 2000' cultivar was significantly greater than that of the other ones (tab. 4). The lowest value observed in 'Nectared 4'. Considering the latter result, it is clear that a large number of 'Nectared 4' fruits could be packed in the predetermined volume compared with the other cultivars.

Table 4. Fruit weight (FW), fruit three linear dimensions (L, W, T), arithmetic (D_a) and geometric mean diameter (D_g), sphericity (φ), aspect ratio (R_a), surface area (S), fruit volume (V_m) and flesh firmness (FF) of six nectarine cultivars

Tabela 4. Masa owoców (WO), trzy wymiary liniowe owoców ((D,SZ,G), arytmetyczna i geometryczna średnia średnica (D_a i D_g), sferyczność (φ), stosunek aspektowy (R_a), obszar powierzchni (S), objętość owocu (V_m) oraz zwięzłość miąższu (ZM) sześciu odmian nektaryny

Parameter	Mayfire	Weinberger	Caldesi 2000	Nectared 4	Fantasia	Syrio
FW (g)	66.77 ± 2.16 e	115.80 ± 4.46 c	171.30 ± 6.69 a	49.30 ± 2.26 f	109.40 ± 4.47 d	123.60 ± 3.93 b
L (mm)	50.26 ± 0.54 c	58.67 ± 0.96 b	66.44 ± 0.74 a	44.33 ± 0.70 c	59.20 ± 0.61 b	68.60 ± 0.82 a
W (mm)	48.71 ± 0.57 cd	58.53 ± 0.60 b	66.85 ± 1.01 a	44.28 ± 0.61 d	56.85 ± 0.70 bc	67.50 ± 0.71 a
T (mm)	46.85 ± 0.86 e	59.23 ± 0.69 c	68.01 ± 1.30 a	42.99 ± 0.76 f	56.49 ± 1.01 d	66.16 ± 0.95 b
D_a (mm)	48.61 ± 0.48 cd	58.81 ± 0.68 ab	67.10 ± 0.80 a	43.87 ± 0.65 d	57.51 ± 0.69 bc	67.42 ± 0.69 a
D_g (mm)	48.56 ± 0.49 bc	58.79 ± 0.67 a	67.07 ± 0.80 a	43.86 ± 0.65 c	57.49 ± 0.69 b	67.40 ± 0.69 a
φ	0.97 ± 0.01 e	1.00 ± 0.01 b	1.01 ± 0.01 a	0.99 ± 0.01 c	0.97 ± 0.01 e	0.98 ± 0.01 d
R_a (%)	107.62 ± 2.34 a	100.23 ± 1.18 c	99.55 ± 1.58 c	100.11 ± 0.73 c	104.18 ± 0.77 b	103.85 ± 1.75 b
S (mm^2)	7412.83 ± 149.4 e	10869.30 ± 252.3 c	14141.80 ± 336.3 b	6051.65 ± 182.1 f	10391.10 ± 253.3 d	14276.80 ± 292.5 a
V_m (cm^3)	66.51 ± 2.59 d	118.18 ± 4.37 b	175.37 ± 6.81 a	50.94 ± 2.27 e	108.97 ± 4.80 c	118.62 ± 2.18 b
FF (kg 0.5 cm^{-2})	1.53 ± 0.09 c	1.39 ± 0.05 d	2.01 ± 0.24 a	1.39 ± 0.05 d	1.20 ± 0.04 e	1.80 ± 0.12 b

The different letters in same rows indicate significant differences among means within each cultivar at $P \leq 0.05$ by LSD test

Różne litery w tych samych rzędach wskazują na znaczące różnice pomiędzy średnimi w jednej odmianie przy $P \leq 0.05$ według testu LSD

There were significant differences among cultivars concerning the FF (tab. 4). The higher values observed in 'Caldesi 2000' and lower in 'Fantasia'. All cultivars showed values between 1 and 2 kg 0.5 cm^{-2}, suitable for consumers [Valero et al. 2007]. Also, FF is an important fruit quality trait consider to growers, since it is directly related to susceptibility to mechanical damage during harvest and postharvest [Crisosto et al. 2001]. In addition, a significant year-by-year variation regarding FF was observed and depending on the nectarine cultivar (data not shown), fruit maturity stage on the harvest date and climatic conditions before harvesting [Cantín et al. 2010].

CONCLUSSIONS

1. Differences among and within cultivars for the blossoming stages were lower when compared with year-by-year variations.

2. All cultivars used were harvested between late June and late September. The earliest nectarine cultivar was 'Mayfire', followed by 'Weinberger', 'Nectared 4' and 'Caldesi 2000', whereas fruits of 'Fantasia' and 'Syrio' harvested late and very late, respectively.

3. Nectarine fruit growth has been obtained as a double sigmoid growth curve with three traditional stages (I, II, III).

4. The best fruit physico-chemical attributes had 'Caldesi 2000' and 'Syrio', whereas the poor properties were observed in 'Mayfire', especially in 'Nectared 4'.

5. This evaluation may help to select a set of nectarine cultivars with better fruit quality attributes, which in our growing conditions with high density planting system might be indicated in 'Caldesi 2000', 'Syrio', somewhat 'Weinberger' and 'Fantasia'.

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OCENA WZROSTU ORAZ FIZYCZNYCH I CHEMICZNYCH WŁAŚCIWOŚCI OWOCÓW NEKTARYNY [*Prunus persica* var. *nectarina* (Ait.) Maxim.] PO ZBIORZE

Streszczenie. Przeprowadzono trzyletnie badanie porównawcze nad terminem kwitnienia i zbioru oraz własności fizycznych i składu chemicznego owoców sześciu odmian nektaryny uprawianych systemem wysokiej gęstości sadzenia w warunkach zachodnioserbskich. Stwierdzono wysoką różnorodność odmian oraz w obrębie każdej odmiany. Stwierdzono istotne różnice we wszystkich analizowanych własnościach. Z roku na rok obserwowano odmienności w terminach kwitnienia i zbioru, długości wzrostu owoców, zawartości rozpuszczalnych ciał stałych, masie oraz zwięzłości owoców. Na podstawie ocenianych danych najlepszą wydajność owoców zarejestrowano u 'Caldesi 2000' oraz 'Syrio' uprawianych według systemu wysokiej gęstości sadzenia (HDP) na ciężkiej glebie. Przeciwnie, słabe własności fizyczno-chemiczne obserwowano u 'Mayfire', zwłaszcza zaś u 'Nectared 4'. Ocena ta może pomóc w wyborze zestawu odmian nektaryny z lepszymi właściwościami owoców, które w naszych warunkach uprawy można wskazać u odmian: 'Caldesi 2000', 'Syrio', niekiedy u 'Weinberger' oraz 'Fantasia'.

Słowa kluczowe: skład chemiczny, zwięzłość miąższu, masa owocu, kształt owocu, system wysokiej gęstości sadzenia, nektaryna

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