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COMPARISON OF FIELD PERFORMANCE AND FRUIT QUALITY AMONG NEWLY RELEASED ITALIAN JUNE-BEARING STRAWBERRY CULTIVARS

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Abstract: The aim of this study was to compare newly released June-bearing strawberry cultivars (‘Quicky’, ‘Sandra’, ‘Lofty’, ‘Nadja’ and ‘Aprica’) in terms of their phenology, vegetative growth, productivity and fruit quality to identify their potential for wider cultivation. A field study was conducted in a strawberry plantation established in July 2020 in double rows on beds covered with black polyethylene foil (Šid, Serbia). The cultivars were evaluated in 2021–2022 for their flowering and ripening time, productivity, plant growth, biometrical and nutritional fruit traits (soluble solids content – SSC, total acids – TAs, vitamin C, total anthocyanins – TACY, total phenolics – TPC and total antioxidant capacity – TAC). The cultivar ‘Quicky’ started to ripen earliest, while ‘Aprica’ was the latest in both experimental years. The number of branch crowns per plant was significantly higher in ‘Sandra’ and ‘Lofty’, whereby ‘Sandra’ had also the highest number of leaves per rosette (41.5) in comparison with the other tested cultivars. The cultivar ‘Aprica’ was superior in terms of productivity (1061 g/plant and 4.67 kg/m^2), fruit weight (29.9 g) and fruit shape index (1.15). Contrary to this, ‘Nadja’ was the least productive cultivar (608 g/plant and 2.68 kg/m^2). The cultivars ‘Lofty’ and ‘Sandra’ showed the highest SSC values and were also characterized by a considerably high level of TPC (1.29 mg GAE eq g^{-1} FW) and TACY (24.4 mg pg-3-g eq 100 g^{-1} FW), respectively. Variability among the tested cultivars could serve as an important criterion for the selection of new high-performing cultivars for a given growing region.

Key words: strawberry, cultivar, plant growth, ripening time, productivity, fruit quality.

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Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is an economically important fruit crop worldwide, whose production has increased steadily in recent decades (Milivojević et al., 2021; Milosavljević et al., 2021; Fotirić Akšić et al., 2019a). With an annual production of 22,427 t, Serbia is grouped among countries with low-intensive production. One of the important factors of highly intensive strawberry production is the introduction of new, promising cultivars well adapted to certain growing regions that are not only highly productive but also possess consistently high external (size, shape, color) and internal fruit quality traits (texture, taste, nutritional and health-promoting compounds). In recent years, public and private breeding activities have intensified greatly to provide growers with new cultivars that meet market needs (Simpson, 2014). The ultimate goal of numerous breeding programs in the world is to integrate new scientific knowledge from genetic, agronomic and biomedical studies (Mezzetti et al., 2016). These programs are expected to release new cultivars that are adapted to local conditions, have resistance to pathogens, and offer high productivity and fruit quality in terms of sweetness, flesh firmness, attractive appearance and long shelf-life (Meulenbroek et al., 2015; Martinez-Ferri et al., 2014). Plant growth, phenological phases, productivity, fruit size and content of phytochemicals vary among strawberry genotypes, but also these traits can be affected by environment, cultivation techniques and postharvest conditions (Vittori et al., 2018; Tomić et al., 2018; Krüger et al., 2012).

On the other hand, producers still do not recognize the benefits of growing new strawberry cultivars selected for their bioactive potential. A huge number of scientific studies confirm the nutritional and health-promoting values of strawberry fruits based on a higher concentration of particularly potent phenolic compounds, which mainly include anthocyanins, flavonols, flavanols, phenolic acids (hydroxybenzoic/hydroxycinnamic acids) and ellagitannins (Milosavljević et al., 2021; Fotirić Akšić et al., 2019b; Manganaris et al., 2014; Milivojević et al., 2013; Giampieri et al., 2012; Panico et al., 2009). Their assessment is important for discovering new sources of natural antioxidants, and cultivars with abundant quantities of phenolic compounds should be promoted and consumed more frequently due to their health-promoting properties.

This study aimed to compare five newly released June-bearing strawberry cultivars bred in Italy (‘Quicky’, ‘Sandra’, ‘Lofty’, ‘Nadja’ and ‘Aprica’) to determine their vegetative growth, flowering and ripening time, yield potential, biometrical and nutritional/antioxidant fruit traits. The knowledge of the inter-cultivar variation of evaluated parameters could be used at a commercial level as an important criterion for the selection of new high-performing cultivars for certain growing conditions.

Material and Methods

The field study was conducted in the strawberry plantation located in the municipality of Šid (45°07’ N, 19°13’ E, 113 m a.s.l.) in 2021–2022. The temperate continental climate, with a mean annual air temperature of 10.7°C and a mean annual precipitation of 650 mm, is characteristic of the region. The soil consisted of a fine sandy loam, and had a pH of 6.8 and medium levels of all nutrients (10 mg P_2O_5 and 22 mg K_2O 100 g^{-1} of the soil). Cold stored plants of Italian June-bearing strawberry cultivars (‘Quicky’, ‘Sandra’, ‘Lofty’, ‘Nadja’ and ‘Aprica’) were planted on raised double beds covered with black polyethylene foil in July 2020 with a planting density of 44,440 plants per ha. Drip irrigation was used with two laterals per raised bed and emitters were spaced at a 10-cm distance. Plants were fertigated in accordance with crop requirements as previously reported by Tomić et al. (2018).

The trial was set up in a completely randomized design with 3 replications and 20 plants per replication for each cultivar. According to the UPOV Code for strawberries (2012), the following phenological properties were studied: beginning of flowering – 10% of flowers are open; end of flowering – when the petals have fallen from 90% of flowers; beginning of ripening – 10% of fruits are ripe and can be easily removed from the plant; end of ripening – date of the last harvest.

Vegetative traits were studied by measuring the number of branch crowns per plant, plant height (cm) and the number of leaves per rosette in both studied years using counting and standard morphometric methods.

Yield components, such as the number of inflorescences and fruits per plant, as well as yield per plant (g) were determined by counting inflorescences and fruits and weighing the harvested fruits from each plant. Yield per m^2 (kg) was calculated as the product of the number of plants per m^2 (4.4) and the yield obtained per plant.

Fruits were harvested in triplicate in the first (2021) and the second year (2022) after planting and evaluated for biometrical and chemical traits. At the second harvest, 20 fruits per replication (60 fruits per cultivar) were picked at the commercial maturity stage. The fruit fresh weight was measured by a technical scale with a sensitivity of ± 0.01 g (Acom JW-1, Korea). Two linear dimensions, height and width (in mm) of each fruit were measured using a digital caliper Prowin (China), while the ratio of the maximum height and width was presented as a fruit shape index. Previously frozen fruits of each replication were homogenized by liquid nitrogen to analyze soluble solids content (SSC), total acids (TAs), and vitamin C content, or further extracted in 80% methanol at a ratio of 1:3 (w/v) to determine total anthocyanins (TACY), total phenolic content (TPC), and total antioxidant capacity (TAC).

SSC was read by a digital refractometer (Pocket PAL-1, Atago, Japan) and the results were expressed as a percentage of dissolved solids in the fruit extract. Total acids in the samples were analyzed using a digital burette for titration of 0.1 M NaOH to the endpoint and the acidity was expressed as a percentage of malic acid equivalents. Vitamin C was measured by a reflectometer set (Merck RQflex, Merck KGaA, Germany) as described by Pantelidis et al. (2007) and the results were expressed as mg ascorbic acid per 100 g of fresh weight (mg 100 g^{-1} FW).

Spectrophotometric analyses of TACY, TPC and TAC were performed on Multiscan® Spectrum (Thermo Electron Corporation, Vantaa, Finland) using supernatants obtained by centrifugation at 10000×*g* for 10 min at 4°C. The modified pH differential absorbance method (Cheng and Breen, 1991) was used for TACY measurement with 0.025 M potassium chloride buffer at pH 1.0 and 0.4 M sodium acetate buffer at pH 4.5. The absorbance was read at 510 and 700 nm, and the results were expressed as micrograms of pelargonidin-3-glucoside (ε=17330 $L \cdot mol^{-1} \cdot cm^{-1}$) equivalents per 100 g of fresh weight (μg pg-3-g eq 100 g^{-1} FW).

TPC was determined using gallic acid (GA) as a standard solution (0 to 340 μg of GA mL^{-1}) for the calibration curve (Dragišić Maksimović and Živanović, 2012). Standards and samples were combined with 0.25 N Folin-Ciocalteu reagent and after 3 min of incubation at 22°C, 0.2 M sodium carbonate was added and additionally incubated for 60 min at 22°C. The absorbance was recorded at 724 nm and the results were expressed as milligrams of GA equivalent per gram of fresh weight (mg GA eq g^{-1} FW).

The TAC was measured by the ABTS method of Arnao et al. (1999). The results were expressed as milligrams of ascorbic acid equivalent per gram of fresh weight (mg AsA eq g^{-1} FW).

Statistical analysis

The data were processed by the Fisher model of variance analysis (ANOVA, F test) using the statistics software package STATISTICA version 8.0 (StatSoft, Inc., Tulsa, OK, USA). The analyses were performed in three replications per year and the obtained values were expressed as the means ± standard error. The significance of differences between factor levels was determined using the LSD test at the lowest significance level of $P \leq 0.05$.

Results and Discussion

Phenology of newly released June-bearing strawberry cultivars

The earliest flowering in 2021 was recorded for ‘Sandra’ (April 11), which also had the longest flowering period (32 days). Contrary to this, ‘Aprica’ began to flower the latest (April 25) with a duration of 28 days (Table 1). In the second year of trial, a similar beginning of flowering was observed among tested cultivars ranging from April 14 (‘Quicky’, ‘Sandra’ and ‘Nadja’) to April 15 (‘Lofty’ and

‘Aprica’). The shortest flowering period was observed for ‘Lofty’ (30 days), while the longest was for ‘Aprica’ (33 days), which also ended this phase the latest (May 17). Although the temperature is the primary factor determining strawberry phenology, day length often modifies temperature responses, and this effect can be taken into account to explain asynchronous flower production in two consecutive years (Li et al., 2018).

Table 1. Flowering and ripening time of newly released June-bearing strawberry cultivars in two consecutive years.

Cultivar	Year	Flowering time			Ripening time		
		Beginning	End	Duration (days)	Beginning	End	Duration (days)
Quicky	2021	April 12	May 12	31	May 15	June 10	27
	2022	April 14	May 14	31	May 13	June 1	20
Sandra	2021	April 11	May 12	32	May 15	June 8	25
	2022	April 14	May 14	31	May 14	June 3	21
Lofty	2021	April 18	May 14	27	May 17	June 8	23
	2022	April 15	May 14	30	May 14	June 3	21
Nadja	2021	April 12	May 8	27	May 18	June 12	26
	2022	April 14	May 14	31	May 15	June 3	20
Aprica	2021	April 25	May 22	28	May 20	June 16	28
	2022	April 15	May 17	33	May 19	June 8	21

The harvest in 2021 began early for ‘Quicky’ and ‘Sandra’ (May 15), while ‘Aprica’ started to ripen the latest (May 20). The ripening season lasted from 23 days (‘Lofty’) to 28 days (‘Aprica’). Some earlier beginning of harvest for one to three days was observed in the second year of the trial when ‘Quicky’ started to ripen earliest (May 13) and ‘Aprica’ was the latest (May 19). The duration of the ripening season was shorter, ranging from 20 days (‘Quicky’ and ‘Nadja’) to 21 days (‘Sandra’, ‘Lofty’ and ‘Aprica’). The accelerated ripening can be explained by the influence of higher temperatures during fruit maturation in 2022.

The vegetative potential of newly released June-bearing strawberry cultivars

In strawberry plants, a crown is a primary stem in which leaves, roots and runners are cyclically formed. Crowns consist of a variable number of internodes and terminate with an inflorescence (Savini et al., 2005). Branch crowns (secondary crowns) originate from the axillary meristem or lateral buds. After winter dormancy, several branch crowns per plant may develop from latent buds depending on climatic conditions and cultural practices (Sugiyama et al., 2004). Our study shows that the number of branch crowns per plant differed among the tested cultivars, whereby ‘Sandra’ and ‘Lofty’ expressed significantly higher values along with ‘Aprica’ in comparison with the other tested cultivars (Table 2). An increase in the number of branch crowns per plant was significant only for ‘Quicky’ and ‘Aprica’ in the second year of the trial ($P \leq 0.05$). Cultivars did not differ in terms of plant height, but this parameter was significantly affected by year ($P \leq 0.001$) and cultivar × year interaction ($P \leq 0.01$).

Table 2. The vegetative potential of newly released June-bearing strawberry cultivars in two consecutive years.

Factor			Number of branch crowns per plant	Plant height (cm)	Number of leaves per rosette
Cultivar (A)	Quicky		3.62±0.26b	33.2±2.84	28.0±2.27d
	Sandra		4.65±0.24a	34.2±2.07	41.5±4.18a
	Lofty		4.55±0.22a	34.1±1.31	33.2±1.86c
	Nadja		3.87±0.19b	34.6±1.45	33.8±2.38c
	Aprica		4.62±0.45a	33.6±0.83	37.5±1.89b
Year (B)	2021		3.84±0.14	30.5±0.60b	29.2±4.62
	2022		4.68±0.20	37.4±0.59a	26.7±1.70
A×B	Quicky	2021	3.13±0.30e	27.0±1.01d	29.2±4.62de
		2022	4.10±0.10cd	39.5±0.62a	26.7±1.70e
	Sandra	2021	4.30±0.00bcd	29.8±0.62cd	50.5±2.11a
		2022	5.00±0.40abc	38.6±1.20a	32.6±1.72bcde
	Lofty	2021	4.23±0.23bcd	31.5±0.39c	34.0±3.61bcde
		2022	4.87±0.30abc	36.7±1.33ab	32.3±1.88bcde
	Nadja	2021	3.87±0.30de	32.1±1.33c	37.6±3.64ab
		2022	3.87±0.30de	37.0±1.66ab	30.1±0.95cde
	Aprica	2021	3.67±0.20de	31.9±0.57c	35.1±1.44abc
		2022	5.57±0.30a	35.3±0.40b	39.8±3.21b
F test	Cultivar		**	ns	**
	Year		ns	***	ns
	Cultivar × year		*	**	**

Values within each column followed by the same letter are not significantly different at $P \leq 0.05$ (LSD test). *, **, ***Significant at $P \leq 0.05$, 0.01 and 0.001, respectively; ns – not significant.

The number of leaves per rosette significantly varied among the cultivars, ranging from 28.0 (‘Quicky’) to 41.5 (‘Sandra’). This parameter was also significantly affected by the cultivar × year interaction, showing a significant decrease in the number of leaves per rosette only in ‘Sandra’ and ‘Nadja’ in the second year of the trial ($P \leq 0.01$). Leaves are one of the main organs for absorbing sunlight and influencing photosynthetic rates and growth. Recent studies have also highlighted that the number of leaves is strongly affected by genotype and environment; however, many other factors including the application of growth retardants and different fertilizers may also contribute to leaf development (Molano et al., 2021; Min Kim et al., 2019; Tomić et al., 2018).

Yield potential of newly released June-bearing strawberry cultivars

Productivity is usually an important trait that a producer takes into consideration when deciding to grow some new cultivars. Vittori et al. (2018) reported that plant yield is the amount of harvested commercial fruits for each production cycle. In our study, the number of inflorescences and fruits per plant was significantly higher in ‘Sandra’ (7.15 and 43.3, respectively), whereas the cultivar ‘Nadja’ had the lowest values regarding all parameters of yield potential (Table 3). On the contrary, the cultivar ‘Aprica’ was characterized by the highest productivity (1061 g/plant and 4.67 kg/m^2, respectively). As opposed to the obtained results, Capocasa et al. (2017) noted a much lower yield per plant for the cultivar ‘Aprica’ (652 g/plant) grown organically under a plastic tunnel in the Marche region of Italy, probably due to different climatic conditions and cultivation methods employed.

Table 3. Yield components of newly released June-bearing strawberry cultivars in two consecutive years.

Factor			Number of inflorescences per plant	Number of fruits per plant	Yield per plant (g)	Yield per m^2 (kg)
Cultivar (A)	Quicky		4.50±0.22c	27.1±0.98d	633±83.17c	2.78±0.50c
	Sandra		7.15±0.16a	43.3±1.85a	850±40.93b	3.74±0.25b
	Lofty		5.35±0.15b	31.6±2.48c	710±28.35c	3.12±0.17c
	Nadja		4.20±0.19c	22.3±1.51e	608±38.10c	2.68±0.23c
	Aprica		5.90±0.26b	38.9±2.53b	1061±52.69a	4.67±0.36a
Year (B)	2021		5.52±0.28	29.9±2.20b	801±48.1	3.53±0.31
	2022		5.32±0.33	35.3±2.28a	744±59.2	3.27±0.35
A×B	Quicky	2021	4.93±0.18	28.0±0.60d	808±42.05cd	3.56±0.25cd
		2022	4.07±0.13	26.1±1.88d	459±50.04g	2.02±0.29g
	Sandra	2021	7.13±0.29	41.6±3.33ab	926±40.57bc	4.07±0.24bc
		2022	7.17±0.20	44.9±1.80a	774±30.86cde	3.40±0.18cde
	Lofty	2021	5.40±0.31	26.3±0.41d	669±20.47def	2.94±0.13def
		2022	5.30±0.15	36.9±1.62bc	751±44.08de	3.30±0.26de
	Nadja	2021	4.40±0.35	19.2±0.92e	581±70.93fg	2.56±0.42g
		2022	4.00±0.12	25.4±0.95d	636±38.21ef	2.80±0.23ef
	Aprica	2021	5.73±0.52	34.6±3.52c	1023±81.37ab	4.50±0.65ab
		2022	6.07±0.18	43.2±1.10a	1099±76.16a	4.84±0.46a
F test	Cultivar		***	***	***	***
	Year		ns	***	ns	ns
	Cultivar × year		ns	*	**	**

Values within each column followed by the same letter are not significantly different at $P \leq 0.05$ (LSD test). *, **, ***Significant at $P \leq 0.05$, 0.01 and 0.001, respectively; ns – not significant.

The number of fruits per plant in our study was significantly affected by year ($P \leq 0.001$) and cultivar × year interaction ($P \leq 0.05$), with higher values obtained for three strawberry cultivars (‘Lofty’, ‘Nadja’ and ‘Aprica’) in 2022. Apart from the differences in some yield potential parameters, most of the tested cultivars showed yield stability between two consecutive growing seasons which is in accordance with the findings reported by Choi et al. (2014). Unfortunately, there is a lack of information on how these newly released strawberry cultivars perform in terms of yield potential under field conditions.

Fruit quality traits of newly released June-bearing strawberry cultivars

Besides the agronomic performance of the strawberry cultivars, the biometrical and chemical fruit traits are also considered to be important factors generally related to consumers’ perception of fruit quality. Since fruit size has been considered one of the main components of the yield, larger fruits are preferred for the fresh market and they improve hand-harvesting efficiency.

In the present study, ‘Aprica’ and ‘Nadja’ were found to have significantly higher fruit weight (29.9 g and 27.8 g, respectively) than the other cultivars, among which ‘Sandra’ had the lowest value (20.3 g). This is the expected result, since this cultivar produced the highest number of fruits per plant and was the second most productive cultivar belonging to the group of small-fruited cultivars. Regarding all tested cultivars, the fruit shape index ranged from 1.15 (‘Aprica’) to 1.42 (‘Quicky’), corresponding to a conical and long conical shape, respectively. Fruit height did not differ between two consecutive years. However, significantly higher values for fruit weight and width accompanied by fruit shape index were registered in the first year of the trial ($P \leq 0.001$). Fruit weight and fruit height were not affected by the cultivar × year interaction, whereas the fruit shape index was significantly increased in the second year of the trial (Table 4).

Consumer acceptance of strawberries is highly dependent on sweetness, which is often correlated with a high SSC. A minimum of 7% SSC is considered the recommended standard for acceptable taste (Dragišić Maksimović et al., 2015). Among evaluated cultivars, ‘Lofty’ and ‘Sandra’ surpassed the SSC values of all other cultivars, whereas ‘Aprica’ had the lowest content (Table 5). Capocasa et al. (2017) also reported a very low SSC value (5.8%) for ‘Aprica’, grown organically under protected conditions in the Marche region of Italy.

In our study, significantly higher SSC values were found in 2021 in all cultivars except for ‘Aprica’, which showed the opposite trend. This cultivar also had the lowest total acid content (0.58%), which is in line with the recently published data of Capocasa et al. (2017). On the other hand, ‘Quicky’ was the predominant cultivar in terms of total acid content (0.62%), which was below the recommended maximum value of 0.8% for exceptional taste (Dragišić Maksimović et al., 2015).

Table 4. Biometrical fruit traits of newly released June-bearing strawberry cultivars in two consecutive years.

Factor			Fruit weight (g)	Fruit height (mm)	Fruit width (mm)	Fruit shape index
Cultivar (A)	Quicky		23.5±2.49b	47.7±0.66ab	33.9±1.30cd	1.42±0.06a
	Sandra		20.3±1.51c	41.9±0.77b	32.9±0.44d	1.27±0.02c
	Lofty		23.0±1.16b	47.0±0.74ab	35.0±0.79c	1.35±0.02b
	Nadja		27.8±1.46a	49.2±0.70a	37.9±0.59b	1.30±0.01bc
	Aprica		29.9±1.37a	47.0±0.95ab	41.2±0.85a	1.15±0.01d
Year (B)	2021		27.8±1.08a	46.9±0.87	37.7±0.84a	1.25±0.02b
	2022		22.0±1.16b	46.2±0.72	34.6±0.88b	1.35±0.03a
A×B	Quicky	2021	28.8±1.33	47.4±0.79	36.7±0.47c	1.30±0.03c
		2022	18.2±1.01	47.9±1.22	31.0±0.38e	1.55±0.02a
	Sandra	2021	22.6±2.14	41.0±0.38	33.5±0.22d	1.23±0.01d
		2022	17.9±1.23	42.7±1.46	32.3±0.79de	1.32±0.01c
	Lofty	2021	25.5±0.44	48.0±1.02	36.6±0.52c	1.31±0.03c
		2022	20.4±0.47	45.9±0.81	33.3±0.17d	1.38±0.03b
	Nadja	2021	30.0±2.24	49.2±1.52	38.8±0.88 b	1.28±0.02cd
		2022	25.5±0.71	49.1±0.35	36.9±0.23c	1.33±0.00c
	Aprica	2021	31.9±1.37	48.6±0.55	42.6±0.82a	1.14±0.01e
		2022	27.9±1.92	45.5±1.32	39.7±0.91b	1.16±0.02e
F test	Cultivar		***	***	***	***
	Year		***	ns	***	***
	Cultivar × year		ns	ns	*	***

Values within each column followed by the same letter are not significantly different at $P \leq 0.05$ (LSD test). *, *** Significant at P ≤ 0.05 and 0.001, respectively; ns – not significant.

The nutritional value of strawberry fruit is also influenced by the content of vitamin C (Milosavljević et al., 2021; Milivojević et al., 2013; Capocasa et al., 2008). Significantly higher vitamin C content was recorded in 'Sandra' and 'Aprica' (36.0 and 36.4 mg 100 g-1 FW, respectively) in comparison to the other cultivars analyzed. These results confirm a previous finding of Milosavljević et al. (2021), who determined the range of vitamin C content from 32.27 to 56.32 mg100 g-1 FW in various strawberry cultivars.

The red color of the fruits can be attributed to high content of anthocyanins, which also have a strong antioxidant capacity (Milosavljević et al., 2021; Milivojević et al., 2013; Scalzo et al., 2005; Wang et al., 1997). The highest quantity of total anthocyanins (TACY) in this study was found in 'Sandra' with a value of 24.4 mg pg-3-g eq 100 g-1 FW, followed by 'Quicky' (21.5 mg pg-3-g eq 100 g-1 FW), whereas significantly lower TACY content was recorded in 'Aprica' (13.8 mg pg-3-g eq 100 g-1 FW). The anthocyanin concentrations obtained herein were similar to those previously reported by Milosavljević et al.

(2020). However, TACY was significantly affected by year and cultivar × year interaction contributing to a greater accumulation of TACY in the second year of the study for all cultivars tested. Kalt et al. (1999) also confirmed that the anthocyanin content of a single cultivar may differ by 30% between two seasons. In addition to the genetic background and its interaction with climatic factors, cultivation techniques and the site can also strongly influence anthocyanin content in strawberries (Vittori et al., 2018).

Table 5. Chemical fruit traits of newly released June-bearing strawberry cultivars in two consecutive years.

Factor			Soluble solids (%)	Total acids (%)	Vitamin C (mg 100 g^{-1} FW)	TPC (mg GAE eqg^{-1} FW)	TACY (mg pg-3-g eq 100 g^{-1} FW)
Cultivar (A)	Quicky		9.00±0.15c	0.62±0.01a	34.1±1.02b	1.20±0.08ab	21.5±1.81b
	Sandra		9.80±0.07a	0.59±0.02c	36.0±0.34a	1.04±0.06d	24.4±2.32a
	Lofty		9.87±0.10a	0.60±0.02bc	33.2±0.47b	1.29±0.15a	19.5±2.23bc
	Nadja		9.22±0.09b	0.61±0.01b	34.0±0.43b	1.16±0.18cd	18.2±1.43c
	Aprica		8.40±0.30d	0.58±0.01d	36.4±0.74a	1.10±0.19cd	13.8±0.70d
Year (B)	2021		9.29±0.22	0.62±0.01a	35.7±0.45a	0.88±0.04b	22.4±1.58a
	2022		9.22±0.11	0.58±0.00b	33.7±0.42b	1.44±0.05a	16.6±0.61b
A×B	Quicky	2021	9.33±0.09c	0.65±0.00a	36.3±0.38	1.02±0.05cd	24.2±2.89b
		2022	8.67±0.03e	0.59±0.00c	31.9±0.50	1.38±0.04b	18.7±0.69cd
	Sandra	2021	9.93±0.03a	0.63±0.00ab	36.6±0.43	0.94±0.05de	29.3±1.26a
		2022	9.67±0.07	0.56±0.01d	35.4±0.17	1.14±0.08c	19.5±0.90c
	Lofty	2021	10.07±0.09a	0.64±0.00b	33.9±0.63	0.97±0.01cd	24.3±1.30b
		2022	9.67±0.03b	0.57±0.00d	32.5±0.39	1.61±0.10a	14.70.52±e
	Nadja	2021	9.40±0.00c	0.63±0.00b	34.6±0.60	0.77±0.06ef	21.3±0.83bc
		2022	9.03±0.09d	0.59±0.01c	33.4±0.43	1.54±0.04ab	15.1±0.13de
	Aprica	2021	7.73±0.07f	0.58±0.00c	37.4±1.33	0.70±0.06f	12.7±0.85e
		2022	9.07±0.03d	0.57±0.01d	35.5±0.30	1.51±0.09ab	14.8±0.80e
F test	Cultivar		***	***	***	**	***
	Year		ns	***	***	***	***
	Cultivar × year		***	***	ns	**	***

Values within each column followed by the same letter are not significantly different at $P \leq 0.05$ (LSD test). **, *** Significant at $P \leq 0.01$ and 0.001, respectively; ns – not significant.

Among the tested cultivars, 'Lofty' was dominant in total phenolic content (1.29 mg GAE eq g^{-1} FW). In general, TPC values were much higher than those previously reported by Milosavljević et al. (2021). Mean TPC values differed between two consecutive years with a significant increase in the first year as opposed to the trend observed for TACY content. In this context, Dragišić Maksimović et al. (2015) explained that anthocyanin concentrations are more susceptible to changes than the phenolics during fruit storage mainly due to their degradation.

Strawberries are known to possess a high total antioxidant capacity (TAC), with wide variability among different cultivars (Milosavljević et al., 2021). A significant variation in TAC values among the tested cultivars was found only in the second year of our study, where 'Aprica' dominated (1.68 mg AsA eq g^{-1} FW) (Figure 1), probably due to the contribution of vitamin C (Table 5).

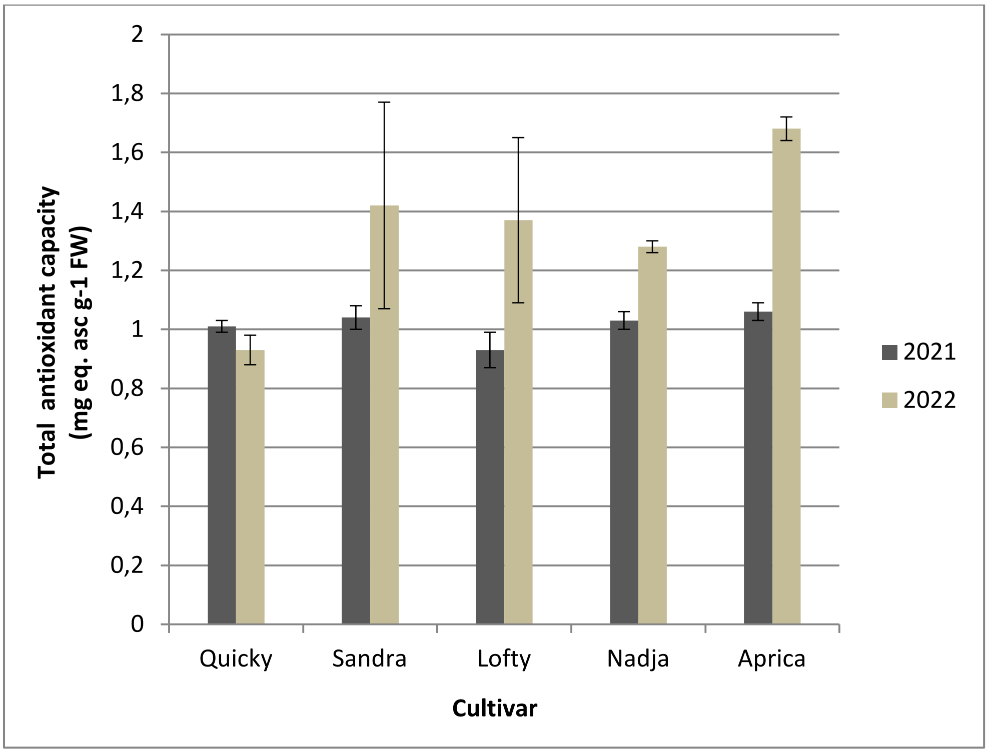

Figure 1. Comparison of total antioxidant capacity among newly released June-bearing strawberry cultivars in two consecutive years.

Slightly lower TAC values were registered in 'Sandra' and 'Lofty' (1.42 and 1.37 mg AsA eq g^{-1} FW, respectively). As previously reported, the range of TAC values in most of the tested cultivars appeared to be lower than the values previously published by Milosavljević et al. (2021), except for 'Aprica', which showed up to three-fold higher antioxidant activity in our study. This discrepancy may be attributed to the adaptability of these cultivars to various climatic conditions among the years of study, locations and production cycles.

Conclusion

A comparative study of five newly released June-bearing strawberry cultivars reveals great variability in agronomic and nutritional fruit properties, reflected in the earlier ripening time of ‘Quicky’ and ‘Sandra’, the higher productivity and larger fruits rich in vitamin C in ‘Aprica’, as well as in the superior nutritional quality of ‘Lofty’ and ‘Sandra’. The latter cultivar had significantly lower average fruit weight (20.3 g) in comparison with the other cultivars, which is the expected result since it produced the highest number of fruits per plant and was therefore the second most productive, classified in the group of small-fruited cultivars. Contrary to this, ‘Nadja’ had the lowest values regarding all yield potential parameters. Most of the tested cultivars showed yield stability between two consecutive growing seasons, except for ‘Quicky’ which had an almost twice lower yield in the second experimental year (459 g/plant). Fruit weight and fruit height were not affected by the cultivar × year interaction, whereas the fruit shape index was significantly increased in the second year of the trial. The cultivars ‘Lofty’ and ‘Sandra’ surpassed the SSC found in all other cultivars (9.87 and 9.80%, respectively), while ‘Quicky’ was the predominant cultivar in terms of total acids (0.62%). The highest quantity of TACY was found in ‘Sandra’ (24.4 mg pg-3-g eq 100 g^{-1} FW), followed by ‘Quicky’ (21.5 mg pg-3-g eq 100 g^{-1} FW), whereas ‘Lofty’ was dominant in TPC (1.29 mg GAE eq g^{-1} FW). Mean TPC values significantly increased in the first year as opposed to the trend observed for TACY content indicating that anthocyanin concentrations were more susceptible to changes than those of other phenolics due to the specific influence of climatic factors between the years. The comprehensive knowledge of the referred variability among the tested cultivars could serve as an important criterion for the selection of new high-performing cultivars for certain growing conditions.

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POREĐENJE PROIZVODNIH PERFORMANSI I KVALITETA PLODA IZMEĐU NOVOSTVORENIH ITALIJANSKIH JEDNORODNIH SORTI JAGODE

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Rezime

Ovaj rad prikazuje rezultate ispitivanja fenologije, produktivnosti i kvaliteta ploda novostvorenih jednorodnih sorti jagode („kviki”, „sandra”, „lofti”, „nadja” i „aprika”) poreklom iz Italije sa ciljem prepoznavanja njihovog potencijala za širi uzgoj. Istraživanja su izvedena u plantažnom zasadu jagode koji je podignut u julu 2020. godine u blizini Šida (Srbija). Primenjen je dvoredni sistem gajenja na gredicama prekrivenim crnom polietilenskom folijom. Tokom perioda 2021–2022. godina, ispitivani su: vreme cvetanja i zrenja, komponente prinosa, vegetativni rast, kao i biometrijska i nutritivna svojstva ploda (sadržaj rastvorljive suve materije, ukupnih kiselina, vitamina C, ukupnih antocijana, ukupnih fenola i antioksidativni kapacitet ploda). Najraniji početak zrenja imala je sorta „kviki”, dok je najkasniji registrovan kod sorte „aprika” u obe eksperimentalne godine. Broj krunica po bokoru je bio značajno veći kod sorti „sandra” i „lofti”, pri čemu je sorta „sandra” takođe imala i najveći broj listova u rozeti (41,5) u poređenju sa ostalim ispitivanim sortama. Sorta „aprika” je imala najveću produktivnost (1061 g/biljci i 4,67 kg/m^2), krupnoću ploda (29,9 g) i indeks oblika ploda (1,15). Suprotno tome, najniži rodni potencijal utvrđen je kod sorte „nadja” (608 g/biljci i 2,68 kg/m^2). U pogledu sadržaja rastvorljive suve materije najviše rangirane su bile sorte „lofti” i „sandra”, koje su se karakterisale i značajno višim sadržajem ukupnih fenola (1,29 mg ekv. galne kis. g^{-1} sveže mase ploda) i ukupnih antocijana (24,4 mg ekv. pg-3-g 100 g^{-1} sveže mase ploda). Ustanovljena variabilnost među ispitivanim sortama bi mogla biti korišćena kao važan kriterijum za odabir novih sorti visokih performansi za određene uslove gajenja.

Ključne reči: jagoda, sorta, vegetativni rast, vreme zrenja, produktivnost, kvalitet ploda.

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