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COMPARISON OF FIVE NEW SWEET CHERRY CULTIVARS BRED IN ROMANIA, WITH THEIR PARENTAL FORMS

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ABSTRACT

The studies were performed for four consecutive years (2016–2019) at the Fruit Growing Research Station (North-East part of Romania), using eleven sweet cherry genotypes as research material. Five of them are new cherry cultivars – 'Cătălina', 'Andreiaş', 'Maria', 'George', and 'Margonia' – obtained by means of controlled hybridization or open pollination, and six of them are their progenitors ('Van', 'Boambe de Cotnari', 'Stella', 'Fromm', 'Ciliegia di Ottobre', and the 'HC 27/4' hybrid). The experiment compared the traits of new cultivars with those of their progenitors. The following traits were evaluated: tree vigor, frost damage, the phenological stages, and the physical and chemical traits of the fruit. The highest values concerning the fruit's weight have been recorded for 'Andreiaş' (10.0 g) and 'Maria' (7.6 g), the content of soluble substance was between 16.6 and 19.5°Brix, the titratable acidity was between 0.413 and 0.675 mg malic acid·100 mL^{-1} juice, and the total content of polyphenols was recorded with values between 268.00 and 488.75 mg GAE·100 mL^{-1} of fresh juice. The new cultivars have mostly superior traits, especially frost damages, productivity, fruit quality, and fruit's cracking percentage compared with their parental genotypes.

Key words: sweet cherry, *Prunus avium*, frost resistance, fruit cracking, fruit quality, tree vigor

INTRODUCTION

Romania is a country that has a tradition in the growing of sweet cherries (*Prunus avium* L.), which is favored by climatic conditions (Budan & Grădinariu 2000). The fruit is desired and appreciated by consumers as the first fruit to be eaten in spring (Ganopoulos et al. 2018; Maglakelidze et al. 2017; Quero-García et al. 2017). The deliberate breeding of cherry cultivars has been performed in Romania for over 50 years, under well-defined programs. Therefore, a rich germplasm collection of genotypes both local and foreign was created for breeding purposes. The following are main objectives of the cherry breeding goals: obtaining of cultivars with early yielding, productive, self-compatible, low vigor of trees and crown compactness, resistant to anthracnose and monilia, frost, and fruit cracking, late blooming, superior quality of the fruit, and wide range of ripening terms to extend the cherry yielding season (Sansavini & Lugli 2008; Milatović 2011; Schuster et al. 2014). To obtain new cherry cultivars, it is recommended to know the progenitors, the traits to be improved, and the mode of their transmission to offspring (Branişte et al. 2007; Höfer & Giovannini 2017). Following this activity at Fruit Growing Research Station Iaşi, during 1981–2018, 28 new sweet cherry cultivars were obtained through controlled hybridization, open pollination, and clonal selection. All these cultivars were approved and patented during 1999–2018, but only one cultivar – 'Maria' – is self-fertile.

The aim of the research was to characterize new sweet cherry cultivars that are superior to their parental forms (♀ × ♂), obtained at the Fruit Growing Research Station Iaşi, Romania, increasing the domestic assortments and beyond.

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MATERIALS AND METHODS

The studies were conducted over four consecutive years (2016–2019) at the Fruit Growing Research Station Iaşi. The studied biological material consists of five new cherry genotypes: 'Cătălina', 'Andreiaş', 'Maria', 'George' (obtained through controlled hybridization), and 'Margonia' (obtained through open pollination), and six their progenitors: 'Van', 'Boambe de Cotnari', 'Stella', 'Fromm', 'Ciliegia di Ottobre', and the 'HC 27/4' hybrid (Table 1). All the genotypes were grafted on *Prunus mahaleb* L. seedlings as rootstock and planted at 5 × 4 m distances in the spring of 2000 in the experimental plot. The experimental setup is linear; nine trees (3 replications × 3 trees) per cultivar were evaluated for 4 years. The trees were trained as free palmette system, without support or irrigation. In the rows of the trees, the soil was cultivated with a rotary cultivator, and between the rows, the grass was mowed several times during the season. The control of diseases and pests was typical for the *Prunus avium* L. cultivars.

Among the eleven studied genotypes, one genotype belongs to early maturing ('Cătălina'), seven genotypes belong to medium-season maturing ('Andreiaş', 'Maria', 'Van', 'Boambe de Cotnari', 'Stella', 'Fromm', and 'HC 27/4'), and three genotypes belong to late ripening ('Margonia', 'George', and 'Ciliegia di Ottobre').

The weather conditions (temperature and precipitations) have been recorded by the meteorological station, located in the experimental fields. The Iaşi area is characterized by the average multiannual temperature of 10.5 °C and 562.6 mm of the multiannual sum of precipitations. During the 4 years of study, the average temperature was 11.5 °C, with the absolute maximum of 37.7 °C (2017), the absolute minimum of −21.9 °C (2017), and the total amount of precipitations were in excess in 2016 (690.8 mm) and 2017 (1045.8 mm) and in deficit in 2018 (530.6 mm) and 2019 (451.0 mm). The estimation of resistance to frost during the complete cherry bloom phenophase (90–100% open flowers) was determined based on the rate of the gynoecium harm (ovary, style, and stigma) of each third part of the tree crown from one hundred flowers for each cultivar. For the estimation of the growing and fructification phenophases, the Fleckinger system was used (1964).

The index of productivity of the cultivars was determined from fruit set under the open pollination. Highly productive cultivars are considered to have an index of productivity (percentage of resulted fruits, determined 25–30 days after petals fall) with minimum values of 30–35% (Cociu & Oprea 1989).

Specific *Prunus avium* L. descriptors were used for the fruits assessment in accordance with the UPOV TG/35/7, 2006 questionnaire. The evaluated fruits have been harvested per each cultivar and repetitions in full maturation stage. The average weight of the fruit and stone (g) was measured by weighting 30 fruits and 30 stones individually per repetition with the electronic scale of sensitivity 0.01 g and then calculating the average on the obtained data. The equatorial diameter (D) of the fruit (mm) was determined with the digital calipers for 30 fruits from three repetitions. The pulp firmness, the pulp adherence to stone, and the taste of the fruit were rated on a scale of 1–9 (UPOV). The content in soluble dry substance was determined using the manual refractometer Zeiss (in degrees Brix). The titratable acidity of fruit was determined using the potentiometric method (Ghimicescu 1977), and the total content of polyphenols was determined using the Folin–Ciocalteu method (Jayaprakasha et al. 2001). The resistance of fruit to cracking was determined using the Christensen method, counting the cracked fruits after immersion in distilled water at 20 °C for 6 hours (Webster & Looney 1996).

The experimental data were statistically interpreted using ANOVA and the multiple comparisons method with the Duncan test, with $p = 0.05$.

RESULTS AND DISCUSSION

The bloom phenophase took place between 2nd and 28th of April. Bloom duration was from 8 to 11 days when the sweet cherry cultivars pollinated each other (Table 2). In 2016 and 2017, the bloom was triggered beginning earlier by 2–10 days in comparison with 2018 and 2019. It was noticed that 'Margonia', and 'Ciliegia di Ottobre' bloomed 1 week later than the other cultivars (Table 2).

The lateness of bloom in cherry is an extremely important trait to avoid losses caused by late spring frosts and hoar frosts. From the other site, the weather conditions had an important effect on the flowering period and then on the setting of fruits in sweet cherry (Głowacka & Rozpara 2014).

Fruit maturity of 'Cătălina' takes place one month earlier than in the parents, but in 'George' one month later than in the pollinator and two months earlier in comparison with their maternal progenitor. In 'Margonia' fruit maturation was 13–15 days later in comparison with their maternal progenitor 'Van'. 'Maria' and 'Andreiaş' fruit ripened in the similar time to their parents (Table 2). The number of days between end of bloom and maturation was between 35 days for cultivar 'Cătălina' (22–27 days less than the two progenitors) and 85 days for cultivar 'George' (28 days later than the paternal progenitor 'Fromm' and 52 days earlier than the maternal progenitor 'Ciliegia di Ottobre').

The flowers' resistance to spring frost is an important trait both economically in fruit production and scientifically for genetic experiments. In our study, in the second decade of April 2017, when the sweet cherries were blooming, the trees were covered with a heavy layer of snow for a period longer than 24 hours and the minimum temperature recorded was −2.8 °C. Under these conditions, the ovaries that were already fertilized got affected, compromising largely the production of fruits. These results are in concordance with other research concerning the flowers' resistance to spring frost in sweet cherry cultivars (Rodrigo 2000; Long 2013), which show that the ovaries are the most susceptible cherry organ to frost. Hence, the effect of extremely low temperatures on the gynoecium of cherry flowers, under the above conditions, was damaged for 49.0% lost in cultivar 'George' and 66% in cultivar 'Cătălina'. Comparing each cultivar with their progenitors, statistically, cultivar 'George' (49.0%) and cultivar 'Maria' (54.8%) were less susceptible for frost damage in comparison with their paternal progenitors. The other three cultivars did not differ in frost damage compared with their parents (Table 3). Our results are in accordance with those of Fotirić Akšić et al. (2013), which showed that climatic conditions affect floral biology and have an influence on differences between genotypes and the yearly variation of fruit production.

In terms of productivity, the new sweet cherry cultivars recorded values of the fruit set percentage from 21% to 51.4%, and 'Maria', 'Andreiaş', and 'George' set fruits higher than their parents although differences were not significant (Table 2).

The cultivar 'Andreiaş' recorded superior values in the fruit weight and equatorial diameter (10.0 g and 25.3 mm, respectively) that were significantly higher in comparison with their progenitors 'Boambe de Cotnari' (7.4 g and 24.3 mm) and 'HC 27/4' (7.1 g and 23.4 mm). The cultivar 'George' fruit was intermediate between parents (7.3 g and 23.0 mm). The cultivar 'Maria' did not differ in weight but its equator value surpassed the parental. The weights of cultivars 'Cătălina' (7.5 g and 24.0 mm) and 'Margonia' (7.4 g and 24.5 mm) recorded similar values as their progenitors (Table 3).

The fruit's size (equatorial diameter and fruit's weight) is a genetic trait particular to every cultivar, but it is also under the influence of the growing technology, the quantity of the fruits' production, the pedoclimatic factors, rootstock, and so on. These traits represent an extremely important element in defining the market value (Ruisa 2008). Usually, on a global scale, the consumers prefer a big-sized fruit of cherry, with a high sweet taste and shiny red color (Turner et al. 2008).

The proportion of stone's weight (g) values to the total fruit's weight (%) in the five sweet cherry cultivars was superior or inferior compared with that in progenitors (Table 3). The cultivars 'Andreiaş' and 'George' recorded lower values in comparison with their progenitors. This value in cultivar 'Maria' did not differ compared with that in parents, and the recording values of cultivars 'Cătălina' and 'Margonia' were slightly higher than those of their progenitors 'Van' and 'Boambe de Cotnari' (Table 3).

The sweet cherry fruit's cracking is a negative phenomenon that can damage under certain conditions up to 90% of the harvest (Demirsoy & Demirsoy 2008). Therefore, a selection for this trait is so important in sweet cherry breeding. The rate of damaged fruits in cultivars 'Cătălina' (6.0%), 'Margonia' (1.3%), 'Maria' (9.3%), 'Andreiaş' (5.5%), and 'George' (5.8%) displays a superior resistance for cracking in comparison with their progenitors: 'Van', 'Boambe de Cotnari', 'Stella', or 'Fromm' (Table 3).

Table 1. Female (♀) and male (♂) progenitors of the new sweet cherry cultivars

Cultivar	Progenitors (♀ × ♂); cultivar					
	'Van'	'Boambe de Cotnari'	'Stella'	'Ciliegia di Ottobre'	'HC 27/4'	'Fromm'
'Cătălina'	♀	♂	-	-	-	-
'Margonia'	♀ (OP*)	-	-	-	-	-
'Maria'	♀	-	♂	-	-	-
'Andreiaş'	-	♀	-	-	♂	-
'George'	-	-	-	♀	-	♂

* open pollination

Table 2. The evolution of the growing phenophases in sweet cherry cultivars (FGRS Iaşi 2016–2019)

Genotypes	Beginning of bloom (61)	Average date for the beginning of bloom	End of bloom (69)	Bloom duration (days)	Ripening time (89)	Number of days between the end of bloom and harvesting maturity[1] (n = 5)	Natural fertility[1] (%)
'Cătălina'	02–10 IV	06 IV	10–19 IV	10	17–28 V	35[f]	27.9[b]
'Van'	04–11 IV	06 IV	15–18 IV	10	08–15 VI	62[d]	37.8[b]
'Boambe de Cotnari'	04–10 IV	06 IV	12–19 IV	10	06–16 VI	57[e]	21.0[b]
'Margonia'	09–16 IV	14 IV	15–28 IV	10	20–29 VI	65[c]	51.4[a]
'Maria'	04–09 IV	06 IV	11–19 IV	10	06–15 VI	62[d]	47.2[b]
'Stella'	04–11 IV	07 IV	14–20 IV	11	10–15 VI	57[e]	30.4[b]
'Andreiaş'	04–13 IV	08 IV	14–20 IV	10	06–15 VI	55[e]	49.3[b]
'HC 27/4'	06–11 IV	07 IV	11–20 IV	8	05–15 VI	56[e]	34.0[b]
'George'	04–14 IV	09 IV	14–23 IV	11	07–16 VII	85[b]	41.5[b]
'Ciliegia di Ottobre'	07–14 IV	10 IV	15–23 IV	10	01–13 IX	142[a]	40.2[b]
'Fromm'	06–12 IV	08 IV	13–20 IV	8	08–15 VI	57[e]	41.0[b]

[1] different letters correspond with the significant statistical difference for P ≤ 5%, Duncan test

Table 3. Ovary frost damages, fruit and stone size and cracking resistance of new sweet cherry cultivars compared with their progenitors (FGRS Iaşi 2016–2019)

New cultivars and progenitors	Ovary frost damages[1,2] (%)	Fruit average weight (g)	Fruit equatorial diameter (mm)	Stone average weight (g)	Stone weight share in the fruit (%)	Fruit's resistance to cracking (%)
'Cătălina'	66.0[a]	7.5[a]	24.0[c]	0.31[b]	4.13[b]	6.0[c]
'Van' (♀)	64.0[a]	7.6[a]	25.7[a]	0.28[b]	3.68[b]	43.3[a]
'Boambe de Cotnari' (♂)	64.0[a]	7.4[a]	24.3[b]	0.36[a]	4.86[a]	21.3[b]
'Margonia'	62.0[a]	7.4[a]	24.5[a]	0.35[a]	4.73[a]	1.3[b]
'Van' (♀OP*)	64.0[a]	7.6 [a]	24.5[a]	0.28[b]	3.68[b]	43.3[a]
'Maria'	54.8[c]	7.6 [a]	25.2[a]	0.25[b]	3.29[a]	9.3[b]
'Van' (♀)	64.0[a]	7.6 [a]	24.5[b]	0.28[a]	3.68[a]	43.3[a]
'Stella' (♂)	60.8[b]	7.5 [a]	23.4[c]	0.30[a]	4.00[a]	70.3[a]
'Andreiaş'	58.3[a]	10.0[a]	25.3[a]	0.33[b]	3.30[c]	5.5[b]
'Boambe de Cotnari' (♀)	64.0[a]	7.4[b]	24.3[b]	0.36[b]	4.86[b]	21.3[a]
'HC 27/4' (♂)	61.0[a]	7.1[b]	23.4[c]	0.40[a]	5.63[a]	2.2[b]
'George'	49.0[b]	7.3[b]	23.0[b]	0.33[c]	4.52[b]	5.8[b]
'Ciliegia di Ottobre' (♀)	55.0[b]	2.6[c]	13.5[c]	0.45[a]	17.31[a]	17.3[a]
'Fromm' (♂)	63.0[a]	8.0[a]	25.8[a]	0.38[b]	4.75[b]	10.0[b]

[1] different letters correspond with the significant statistical difference for $P \leq 5\%$, Duncan test

[2] statistical differences was calculated between each new cultivar and its progenitors

The epidermis color was yellow ('Margonia'), shiny red ('Maria', 'George'), or dark red ('Cătălina', 'Andreiaş'). For all the cultivars, the fruits were heart-shaped and tasted sweet, without the pulp adherence to stone, with the firm pulp, except for cultivar 'Cătălina' (early maturation) whose pulp firmness was average (Table 4).

Several chemical compounds of the sweet cherry fruit represent a major source of antioxidants (Beceanu 2008; Usenik et al. 2008).

The values of the fruit composition are extremely important because they determine the taste and nutritional value of fruit (Kappel et al. 1996). In our results, SDS values in cultivars 'Maria' (19.5 Brix), 'Andreiaş' (18.7 Brix), 'Cătălina' (18.1 Brix), and 'George' (17.5 Brix) were superior in comparison with those in their progenitors (Table 5). Transmission of this trait was similar to that in other studies on SDS values in sweet cherry cultivars (Vursavuş et al. 2006; Jänes et al. 2010).

The ratio between the soluble dry substance and the titratable acidity is the parameter that reflects the balance between the sweet and sour taste of the fruit, influencing the quality of the taste (Vangdal 1985; Crisosto et al. 2002). In our study, cultivars 'Maria', 'Andreiaş', and 'George' recorded superior statistical differences in comparison with their progenitors (Table 5). Similar proportions were reported by Fotirić Akšić and Nikolić (2013).

The total content of polyphenols is important for defining the taste and flavor of the cherries and for an antioxidant value (Chaovanalikit & Wrolstad 2004; Skrzyński et al. 2016; Hallmann & Rozpara 2017).

Contents of polyphenols found in the fruit of 'Maria' and 'Catalina' were instantly higher in at least one of their parental genotypes, but in 'Andreiaş' and 'George', the values were much higher than those in mother cultivar and almost the same as in the paternal cultivar. 'Margonia' (314.75 mg GAE·100 mL^{-1}) recorded a value close to its maternal progenitor 'Van' (323.56 mg GAE·100 mL^{-1}) (Table 5). The five new sweet cherry cultivars have a sweet taste and nice flavor, being extremely attractive for consumers.

The sweet cherry genotypes are strongly heterozygotic, and the newly obtained cultivars have a high possibility to differ in morphological, physiological, and biochemical traits compared with parents.

Table 4. Physical and organoleptic traits of the fruit of the new sweet cherry cultivars (FGRS Iaşi 2016–2019), according to UPOV (2006)

New cultivars	Epidermis color[1]	Pulp firmness[2]	Fruit's shape[3]	Pulp adherence to stone	Taste[4]
'Cătălina'	7	5	1	non-adherent	7
'Margonia'	1	7	1	non-adherent	5
'Maria'	5	7	1	non-adherent	7
'Andreiaş'	7	7	1	non-adherent	7
'George'	5	7	1	non-adherent	7

[1] a scale of 1–8: 1 – yellow; 2 – yellow with red; 5 – shiny red; 7 – dark red; 8 – black;
[2] a scale of 3–9: 3 – soft; 5 – average; 7 – firm; 9 – very firm;
[3] a scale of 1–5: 1 – heart-shaped; 2 – kidney-shaped; 4 – circular;
[4] a scale of 3–7: 3 – weak; 5 – average sweet; 7 – very sweet

Table 5. The content of soluble dry substance, titratable acidity, polyphenols and ratio of soluble dry substance to titratable acidity of the fruit of sweet cherry cultivars (FGRS Iaşi 2016–2019)

Genotypes	SDS[1]* (°Brix)	TA** (mg malic acid per 100 mL)	SDS : TA*** (%)	Total content of polyphenols (mg GAE per 100 mL)
'Cătălina'	18.1[c]	0.880[a]	20.568[f]	420.75[b]
'Van'	17.2[c]	0.680[b]	25.220[e]	323.56[d]
'Boambe de Cotnari'	17.9[c]	0.705[b]	25.390[e]	92.25[f]
'Margonia'	16.6[c]	0.675[b]	24.555[e]	314.75[d]
'Maria'	19.5[a1]	0.633[b]	30.805[c]	488.75[a]
'Stella'	18.0[c]	0.813[a]	22.109[f]	363.50[c]
'Andreiaş'	18.7[b]	0.413[c]	45.338[a]	271.25[e]
'HC 27/4'	17.8[c]	0.755[b]	23.509[e]	293.50[e]
'George'	17.5[c]	0.535[b]	32.616[b]	268.00[e]
'Ciliegia di Ottobre'	16.2[d]	0.915[a]	17.704[f]	68.03[f]
'Fromm'	17.0[c]	0.658[b]	25.835[d]	266.25[e]

[1] different letters correspond with the significant statistical difference for $P \le 5\%$, Duncan test
* SDS – the soluble dry substance;
** TA – the titratable acidity;
*** SDS : TA – the soluble dry substance and titratable acidity ratio

CONCLUSIONS

Using sexed hybridization, five new sweet cherry cultivars have been obtained with traits that are superior to their parental genotypes: good resistance to frost (‘George’, ‘Maria’, and ‘Andreiaş’), late bloom (‘Margonia’), earliness (‘Cătălina’), lateness (‘George’), high productivity, fruit quality, and resistance to cracking.

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