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Biological and Agricultural Properties of Sweet Cherry (*Prunus avium* L.) Cultivars in Georgia

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Abstract: ***The article presents the results of study of biological and agricultural properties of nine introduced foreign cultivars of sweet cherry in Georgia. The research aims at study of sweet cherry cultivars and selection of the best cultivars with the purpose of further propagation in Shidakartli itself and also in various fruit growing regions of Georgia.***

Keywords: yield, fruit quality, flowering, ripening

1. Introduction

Sweet cherries are grown worldwide, on all continents, in all parts of temperate climate. The 10 main producing countries are: Turkey, the USA, Iran, Italy, Germany, Spain, Lebanon, Rumania, France, the Russian Federation. The southern hemisphere (mainly Chile, South Africa, Australia and Argentina) contributes only 2.6% of the world's production. The expansion of sweet cherry production was anticipated in Eastern Europe, especially areas whose climate is influenced by the Black Sea [11; 33].

According to Skrzyński et al. (2016) indicates that "The world's sweet cherry production reached 2294 thousand tones in 2013 from 2072 thousand tones in 2010"based on the (FAOSTAT 2016). The world leaders in sweet cherry production are Turkey 438 tones followed by the USA 303thousand tones in 2011.Almostinallcountries in the world an increase in cherry production is observed. An increase in production of sweet cherries, as well as profitability of its growing, depends on biological and economic properties of the cultivar and the root stock.

Sweet cherries are a leader fruit in the East and West Europe. They are one of the earliest fresh fruits of the season. Among other European countries Poland produces sweet cherries for domestic use and exports it to other countries too [6] annual production in Polandwas 48.1 thousand tones in 2014 and almost 50%ofsweetcherryproducedhere is exported to Germany and Russia [33].

Commercial cultivation of Sweet cherry (*Prunusavium*L.) is available in Western and Eastern regions of Georgia, but ShidaKartli province gives the best quality product among those. Speaking in general, soil and climate conditions of Georgia enables us to have a wide range of agricultural crops. [40.p.26-79].The agricultural land area is about 3 million hectares and 9% among those is cultivated by the perennial crops. The average yield per hectare of fruits is 3-4 tons from the 60 000 hectares of orchards. 25% of fruit orchards from total area is located in the ShidaKartli region [8].

In the past few decades, sweet cherry production has greatly increased in Georgia. In 2008, the yield of cherry fruit was made up to 4.6 thousands of tons, and in 2014 it reached to 5.6 thousands of tons. The average yield is 10 - 15 tons / ha. In favorable conditions in intensive orchards it is possible to obtain 20-25 tons of fruit per 1 ha[8].

Sweet cherry is a fruit crop with a high economic importance due to the nutritional, technological and commercial value of its fruits. Because their regular consumption was reported to decrease the risk of arthritis, gout and headache [20], cherries have recently received increased interest as a healthy food stuff. The health benefits of cherry fruit are usually attributed to their chemical composition, since they are a good source of antioxidant compounds and other phyto chemicals suchassugars, organic acids, minerals, etc. [21; 24; 25].

The fruits of local cultivars like Gogra Bali, Shavi Bali, Kakha Bali, have relatively small size of fruits in respect of modern cultivars, a high content of sugar and soft flesh consistency, black and red color of fruit. In the same times the early-introduced cultivars like Drogana Yellow (German origin) and Bulls Heart are spread in Georgia also [39].

Despite of wide distribution of sweet cherry in Georgia, the assortment of early ripening cultivars is still poor in our country. Sweet cherry assortment is mainly comprised of the cultivars: Drogana Yellow (40%), Gogra Bali (30%), and BullsHeart (20%). Among those the Georgian sweet cherry of early ripening period is characterized by very small fruits

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and low sugar content. Giorgian producers have the best fruit quality from sweet cherry cultivars of the late ripening period [39].

Several new cultivars of sweet cherry of foreign origin have been introduced to Georgia fifteen years ago [1], but adaptability of these cultivars to the environmental conditions of Georgia has not been evaluated yet including agronomical and commercial peculiarities as well as suitability of their cultivation in various regions of Georgia.

Cracking of sweet cherry fruit due to rain near harvest time is a major cause for crop loss in the cherry industry. Cracking susceptibility varies according to cherry varieties and amount of seasonal precipitation too. Researchers are attempting to explain these differences by studying the factors which appear to be involved in the cherry cracking process [10]. Usually the rainfall in maturity period of fruitin East Georgia is not so much that is quite sufficient for normal development of fruit of sweet cherry.

General objective of our research is to observe, evaluate and adapt the introduced modern varieties of fruit crops in Georgia, and among them -the cultivars of sweet cherries. Coming from this general objective, the goal of our research was to study biological and agronomical properties of introduced cultivars of sweet cherries in the conditions of the fruit growing zone of Georgia named as "ShidaKartli".

2. Materials and Methods

Collection site

The study of the cultivars has been carried out in the collection plot of the Scientific - Research Center of Agriculture, East Georgia, located in the village Jighaura of Saguramo (Mtskheta municipality, ShidaKartli) during 2014-2016. The orchard has been established with 5.0 x 2.5 m planting layout in 2012. The trees were trained as free spindle training system and tree height was kept at 3 m by pruning. The soil was alluvial calcareous, characterized by low organic matter content(less than 3% in humus). Texture content of the soil is granular - cumulose. It is characterized by lightweight structure, good physical properties and sufficient moistness. With the increasing of depth the soil is characterized by high carbonate content and alkali reaction. The pathways were kept under natural grass cover system, which was frequently mown. Along the trees rows were herbicide stripes - 1 m broad. The drip irrigation is used in the orchard for guaranteed water supply – in the same time the average rainfall in the area is 518 mm during the growing season (May 90 mm, June 79 mm, July 84 mm, August 96 mm, September 169 mm).

The orchard of village Jighaura is located in the eastern part of ShidaKartli, on the 630 m above sea level. The zone characterized by warm climate, moderately humid air, cold winter and hot summer is appropriate for cultivation of stone fruits. The average yearly temperature is 10.8 ^{0}C, the absolute minimum temperature is -17.8 ^{0}C.

July and August are the hottest months. The average temperature in this period is +22^{0}C. The absolute maximal temperature in this period attains to +39^{0}C. The average temperature in the coldest month (January) is -1.1^{0}C.In the average increase of the transition air temperature above +5^{0}C begins since 16th March, and decreasing of temperature (below +5 ^{0}C) begins from 21st November.

The duration of vegetation period is 245 days on an average. The late spring frosts may be caused once in 10-15 years till 20th May. The sum of active temperatures is 3870 ^{0}C. The annual precipitation is 591 mm.

Plant material

It was included 9 introduced sweet cherry (*Prunus avium* L.)cultivars in this study like: Early Lory, Burlat, Moro, Lory Strong, Samba, Giorgia, Celeste, Krupnoplodnaja, and Van (Table 1). Each accession in the collection were represented with 15 plants grafted on the rootstock Colt. The one tree was a replication.

Table 1: Description of the cultivars studded

#	Cultivars	Country of Origin	Originator	Fruit Characteristics
1	Burlat	France	L. Burlat	Medium size, heart-shaped, dark red skin, red flesh, sweet and juicy, of medium firmness; medium stem length; good flavor, of medium susceptibility to cracking with pre-harvest rain.
2	Celeste	Canada	D.W. Lane 1981	Large fruit, intense wine-red skin, red flesh of medium firmness; good flavor, sweet and aromatic; short thick stem; medium-small pit. Susceptibility to cracking of very low
3	Early lory	France	P. Argot 1977	Larger fruit, dark red skin; flesh medium-firm, good flavor;use of covering films advised to protect fruit from cracking
4	Giorgia	Italy	ISF Verona	Good size considering the harvest date, bright to dark red skin, very firm flesh, crisp, excellent flavor; susceptibility to cracking- low
5	Krupnoplodnaja	Russan	N/A	Medium size, red flesh of medium firmness; flavor; short thick stem; medium pit. Susceptibility to cracking – medium
6	Lory Strong	France	P. Argot 1990	Large size; dark red skin, firm pulp, excellent flavor. Susceptibility to cracking – medium
7	Moro	France		Medium size, dark red skin and flesh, firm flesh, crisp, well-balanced flavor. Susceptibility to cracking of very medium
8	Samba	Canada	D.W. Lane 1978	Large size, glossy dark red skin, firm flesh, holds well on tree, good flavor; susceptibility to cracking- low
9	Van	Canada	A.J. Mann 1944	Medium-large, bright red skin, red firm flesh, pleasant sweet flavor; medium length stem; small pit. Susceptibility to cracking- medium.

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Phenological development of cultivars was done according to the modified version of the BBCH scale [16]. The calendar periods of the following phenological phases have been studied: swelling of bud, flowering, fruit ripening. The beginning of bud swelling time was taken when light brown scales of buds were visible, scales with light colored edges. The date of beginning of flowering was taken when about 10% of flowers were open. Full flowering – when at least 50% of flowers were opened and first petals fell. The end of flowering – when 90% of petals were fallen. The duration of flowering was determined by the number of days from the beginning to the end of flowering. Abundance was assessed according to a scale from 1 (no flowers) to 5 (abundant bloom).

The date of harvest has been taken as the time of ripening of fruit and seed, and when fruits had typical taste and firmness. The date when ripening started was estimated for each cultivar, considering typical coloring of the majority of fruits, strength of fruit stem attachment and characteristic taste of fruit. On that date samples of 50 fruits were takenat random from each replication.

Pomological characteristics of cultivars were collected by instructions of UPOV (2006) harmonized descriptors for sweet cherry.

Fruit characteristics were measured on fruits harvested in full maturity stage. The samples of 50 fruits per from each tree harvested randomly for a cultivar. Fruit samples were taken repeatedly in 3 day's interval (usually 3 times) during harvest time for each cultivar for determining of physical properties (length of fruit and fruit stalk, weight of fruit and stone). Fruit length and width was measured by caliper in mm, respectively. Fruit shape index was calculated as the ratio between fruit length of and fruit width. Fruit weight and stone weight was measured for each fruit in gram totally for 50 fruits and average was calculated. Output was determined as ration between fruit weight and stone weight. Fruit stalk length was measured in cm by a ruler.

Productivity characteristics of the sweet cherry cultivars were studied according to Program and methods cultivar fruit, berry and nut crops [26].Productivity were studied according to following parameters: the yield per tree and yield efficiency, were computed from the harvest date. Harvest date, the date when fruits have full(commercial) maturity stage. Since it is difficult to state definitely to the day when sweet cherries are ripe because they are edible long before they are really ripe or at best quality [2]. We took picking fruits when it was fully ripe (when the berry is dark red or black). The yield efficiency was expressed as the ratio of total cumulative yield per final trunk circumferences sectional areas. The trunk circumferences were converted into trunk cross-sectional areas. Additional the canopy diameter (in two opposite directions) were recorded annually.

Biochemical analysis of cultivars was carried out for detection of dry soluble solids, total sugars, inverse sugars and titratable acidity. Samples were prepared according to general laboratory procedures [26]. Fruits were homogenized with a manual blender. Homogenate was used as first step for several analyses as listed below. Manual press was used to obtain clear juice from homogenized fruit for sugar evaluation. The soluble solids were determined by refract meter, (PAL-1, Atago, Tokyo Tech)and expressed as degree Brix (°Brix). Total sugar content and inverse sugars content were measured according to Luff - Schoorl method [20].The acid content in sweet cherries is low and has no dominating influence on the taste quality [38].Total acidity is determined by titration with 0.1N NaOH.

Statistical analyses

The mean values of the studied properties were determined. Statistical differences among cultivars were verified using ANOVAfor each year separately. When the *F*-test was significant, means were compared with the LSD test at P=0.05.

3. Results and Discussion

Phenological study

The results of three years (2014-2016) observations on calendar periods of phenological stages are given in the Table 2.

Table 2: Phenological stages of cherry cultivars (average 2014-2016)

#	Cultivars	Beginning of bud swelling	Flowering					Time of maturity (date)	Fruit development period
			Beginning	Full	End	Abundance (1-5 scale)	Duration /days		
1	Burlat	06.03	01.04	05.04	13.04	5.0	13	03-06.06	59
2	Celeste	12.03	10.04	15.04	20.04	5.0	11	10-14.06	56
3	Early Lory	03.03	28.03	01.04	10.04	4.2	14	28.05-02.06	57
4	Giorgia	15.03	11.04	16.04	20.04	5.0	10	08-12.06	53
5	Krupnoplodnaja	11.03	06.04	11.04	14.04	3.5	9	15-19.06	65
6	Lory Strong	18.03	15.04	20.04	24.04	4.0	10	12-15.06	56
7	Moro	08.03	04.04	09.04	15.04	4.4	12	06-09.06	58
8	Samba	09.03	05.04	10.04	11.04	4.5	11	12-16.06	58
9	Van	11.03	12.04	17.04	22.04	3.8	11	11-15.06	55

The observations have shown that the cultivars begin vegetation on an average in the first or second decade of March: among those the earliest (26.03) vegetation began in 2016 (the cultivar Early Lory), the latest (10.03) in 2014 (the cultivar Van). The difference between cultivars according to the periods of beginning of vegetation is 3-6 days.

The three year observations have determined that out of the studied 9 cultivars the following cultivars begin vegetation

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relatively early: Early Lory, Burlat and Moro (03.03-08.03), and relatively lately – Lory Strong and Giorgia (12.03-15.03).

Flowering is one of the most important phenological stage for all crops including sweet cherry as well, because the future yield depends on the start, duration and abundance of flowering. The flowering time is greatly influenced by weather condition of that period, particularly is influenced by the temperature, rains and relative humidity considering that many high-quality cultivars of sweet cherries are self – incompatible and they need to have a pollinator with correspondent flowering period for sufficient supply of pollen. That is why having information about the phenological stage of flowering is very important for choosing of proper cultivars before orchard planting - successful pollination needs a combination of the cultivars having corresponding period of flowering [34].

As the Table 2 shows, the cultivar Early Lory flowers most early (28.03-02.04) out of the studied cultivars according to the average data for three years; the cultivars Van and Early Strong – the most lately (12-15.06). The duration of flowering is 9-14 days on an average according to the cultivars.

During the study the periods of flowering are quite variable. The most early flowering began in 2016 (26th March) and the most lately in 2014 (15th April). The sum of active temperatures during the flowering period is 86-120 ^{0}C.

Intensity of flowering has been estimated together with determination of periods of flowering. The high intensities (4-5 mark) of flowering characterize the cultivars Burlat, Giorgia and Celeste.

The number of days from full flowering until ripening is 54-65 days.

The blossoming time and duration are important in cherry cultivar selection for planting on spring frost-prone sites. Beside cultivars, most of authors reported that season (year) importantly influenced blossoming date [7].

The most favorable climatic conditions for flowering were in 2014. During the flowering the weather was sunny and windless. The relative humidity varied within 40-60%, precipitation was low, and therefore the cultivars ended flowering very quickly, in 7-8 days on an average.

The winter in 2015 was very warm and frostless, so the cultivars of sweet cherry began flowering relatively early, on 23rd March, however the climatic conditions during the flowering period were not favorable due to excessive precipitation that prolonged the period of flowering up to 10-14 days. That is why the flowering of the cultivars Early Lory, Moro and Celeste continued during 14 days; of the cultivars Krupnoplodnaja and Van – 9 days.

In addition, climatic conditions can affect fruit set with both low and high temperatures having negative effects. Low temperatures at blossoming reduce pollen tube growth and may shorten the effective pollination period [28.p.1-17],whereas high preblossom temperatures (≥ 27°C) can negatively affect ovule longevity and pollination effectiveness [26].

The flowering periods results are in accordance with data of Milošević (1997);Kazantzisetal. (2011); Lichev et al. (2004); Milatović et al. (2013), who all reported similar blossoming date tendencies forcvs. In the present study,cv.Celeste blossomedrelativelyearlyunderBulgarian[14]andSerbian[20] conditions,whereasKappeletal.(1996)notedthat the bloom period of this cultivar is latein Canada, which confirmed our results.

As the observation has shown, like the flowering periods, the periods of ripening are also variable that is caused by the influence of ambient conditions. The difference between the periods of ripening of individual cultivars is 6-8 days. The studied cultivars of sweet cherry are always in the group of early ripening cultivars according to the periods of ripening and their transition in the group of mid-ripening and moreover late-ripening period is not mentioned. The most early the fruits of sweet cherry cultivar Early Lory ripened in 2016 (18th – 22nd May); relatively lately – in 2014 (15th -20th June) – the same cultivar Lory Strong and Van.

The results of three-year (2014-2016) observations on the course of the phenologocal phases allow to draw a conclusion that calendar periods of phenological phases depend on biological features of a cultivar, orchard location and ambient conditions [3] Coming from here choosing of sweet cherry cultivars needs determination of phenological phases for each cultivar.

Yields and yield efficiency: Yield is the most important economic characteristic of a cultivar that determines its economic value. Besides the peculiarities of cultivar and climatic conditions it depends on agronomical activities and on a rootstock [15].

All cultivars in our experiment were grafted on the same rootstock Colt. The agronomical background for all cultivars was the same. Therefore the difference between cultivars according to growth parameters can be explained by the biological peculiarities of the cultivars.

In the Table 3 the yield per tree of each cultivar according to years (2014-2016) and the average yield for three years are given.

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Table 3: Yields per tree and yield efficiency of cherry cultivars(average 2014-2016).

#	Cultivars	Yield (kg)				Crown Volume (m^3)	Trunk cross-sectional area (cm^2)	Yield efficiency Per tree	
		2014	2015	2016	Average			Kg/m^3	Kg/cm^2
1	Burlat	2.6±0.05^a	4.8±1.11^b	14.0±0.02^a	7.2±0.14^a	21.9±0.01^b	68.8±1.82^a	0.32±0.16^a	0.10±0.01^a
2	Celeste	2.4±0.02^a	4.6±0.05^b	8.4±0.02^b	5.1±0.12^b	22.4±0.01^b	64.2±1.52^a	0.22±0.05^b	0.07±0.01^b
3	Early Lory	2.0±0.00^b	4.0±0.12^b	10.2±1.14^b	5.4±0.04^b	22.4±0.02^b	90.4±0.30^d	0.24±0.02^b	0.05±0.00^c
4	Giorgia	2.8±0.04^a	5.4±0.04^a	11.2±1.10^a	6.5±0.03^b	20.4±0.05^a	81.6±0.58^c	0.31±0.04^a	0.07±0.02^b
5	Krupnoplodnaja	3.0±0.01^a	5.0±0.12^a	8.2±0.02^b	5.4±0.11^b	34.5±0.04^c	102.1±0.22^d	0.15±0.02^d	0.05±0.00^c
6	Lory Strong	1.5±0.00^b	3.7±0.04^c	6.5±0.05^c	4.0±0.06^c	20.6±0.05^a	91.7± 1.42^d	0.19±0.01^c	0.04±0.00^d
7	Moro	1.4±0.02^b	3.5±0.01^c	8.4±0.12^b	4.4±0.56^c	27.0±0.00^c	78.5±0.11^b	0.16±0.05^d	0.05±0.02^c
8	Samba	3.0±0.11^a	8.2±1.16^a	12.0±0.04^a	7.8±0.02^a	17.4±0.00^a	59.2±0.16^a	0.44±0.12^a	0.13±0.02^a
9	Van	1.2±0.00^c	3.2±0.04^d	6.8±0.04^c	3.7±0.04^d	26.0±0.02^a	78.4± 1.22^b	0.14±0.01^d	0.04±0.00^d

Cultivar means in the same column followed by the same letter are not significantly different according to the LSD test (P=0.05). (mean±SE)

As the Table 3 shows, in the first bearing year (2014), yields were very low (1.2-3.0 kg/tree). In 2015 and 2016 the production increased. These data are in accordance with the results of Moreno et al. (2001), Wociór (2008) and Milosevic et al.(2014),who reported that, on average, sweet cherry cv in the first two bearing years, yields were very low(<0.2kg/tree), and there were no significant cultivar differences and production increased in the 3rd and 4th years.

Out of the studied cultivars the cultivars Samba, Burlat and Giorgia are the most productive – the average yield per tree for them is 7.8, 7.2 and 6.5 kg, respectively. The highest-yield year was 2016 (14.0- 11.2 kg), the lowest yield – in the year of 2014 (1.2- 2.0 kg).

The average yield on the 1 m^2 of crown projection vary from 0.04 kg/cm^2 to 0.13 kg/cm^2. The average yield on the 1 m^3 on the volume of crown vary from 0.14 kg/m^3 to 0.32 kg/m^3 (Van – Samba). The cultivars Samba, Burlat and Giorgia are distinguished by the highest average yield of 1 m^3 crown volume and respectively on 1 cm^2 of crown projection.

This parameter is relatively low for the cultivars Van, Early Lory and Lory Strong. The differences between our results and those of the above authors could be explained by differences in the tree shape and size and in the pruning regimes. Several studies distinguished problems related to poor yields, which are frequently found in some sweet cherry cultivars [7].

Fruit and stone weight and its dimensions

It is well-known that during evaluation of cultivars not only quantity of yield, but quality of fruit is also important. The best is a cultivar that together with high yield is characterized by good commercial properties of fruit. The commercial parameters of the fruit are weight, size, and form, length of stem, skin color, and taste. The commercial properties of fruit, besides peculiarities of a cultivar, depend on soil and climatic factors and a complex of agronomical activities. It is important to note that many aspects of growing cherries such as pruning, rootstocks, pollination and irrigation can modify or overcome some of these cultivar characteristics [17].

With the purpose of estimation of fruit quality, the fruit parameters (weight and size of the fruit, length of stem and size of stone) have been studied.

The weight and size of fruit are the most important indicators of quality of sweet cherry fruit, because the fruits are mainly used for fresh consumption. For most European countries, the weight of fruit of sweet cherry should be between 11 and 12g [12]. In the present study, as the Table 4 shows, the big weight of fruit is characteristic for the cultivars: Celeste, Sambaand Krupnoplodnaja; and the cultivar Moro has relatively small fruit.However, this cultivar (Moro) may be of interest to growers primarily due to its early maturity. All cv fruits weight <11 g, which is in agreement with a previous study on sweet cherry [20]. For cv. Celeste, Lichev et al. (2004) noticed that its fruits are large (9.9 g in aver- age). The fruit weight is an important external fruit quality trait; the fruit size and diameter are essential agronomic characteristics also and have commercial market value [41].

Table 4: Fruit traits of cherry cultivars (average 2014-2016)

#	Cultivars	Fruit weight (g)	Fruit Dimension (mm)			Fruit stalk length (cm)	Stone properties	
			Length	Width	Fruit shape index		Weight (g)	Output %
1	Burlat	7.84±0.19^c	23.4±0.22^b	24.8±0.52^c	0.94±0.14^a	3.6±0.12^c	0.41±0.01^d	94.8±0.06^d
2	Celeste	10.2±0.14^a	25.6±0.41^a	28.0±0.36^a	0.91±0.22^b	3.5±0.06^d	0.56±0.02^a	94.6±0.08^d
3	Early Lory	7.34±0.18^c	24.2±0.12^a	25.6±0.24^b	0.94±0.16^a	3.8±0.09^c	0.43±0.00^c	94.2±0.12^b
4	Giorgia	7.46±0.12^c	23.2±0.32^b	26.1±0.08^a	0.88±0.12^c	4.6±0.11^a	0.44±0.02^c	94.3±0.04^b
5	Krupnoplodnaja	8.72±0.16^b	23.6±0.16^b	25.2±0.18^b	0.93±0.36^a	4.4±0.16^b	0.48±0.00^b	94.5±0.11^c
6	Lory Strong	8.11±0.11^b	23.5±0.16^b	26.4±0.14^a	0.89±0.24^c	4.8±0.24^a	0.46±0.00^b	94.4±0.01^b
7	Moro	6.91±0.17^d	22.8±0.24^c	24.3±0.32^c	0.94±0.15^a	4.0±0.10^b	0.44±0.10^c	93.7±0.08^a
8	Samba	9.0±0.24^a	24.8±0.28^a	26.4±0.21^a	0.94±0.12^a	4.5±0.07^a	0.50±0.02^a	94.5±0.04^c
9	Van	7.45±0.11^c	22.6±0.15^c	25.4±0.08^b	0.89±0.36^c	3.6±0.05^c	0.48±0.06^b	93.6±0.02^a

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Cultivar means in the same column followed by the same letter are not significantly different according to the LSD test (*P*=0.05). (mean±SE)

Thus, sweet cherry cultivars with large fruits (in both weight and width) are increasingly valued at the international level. For example, fruits of 26 mm in diameter are admissible into the first quality category, regardless of the ripening period [34]. These category ranges varied among countries, i.e. 25 mm in Spain to 29–30 mm in Canada [42]. Generally, consumers prefer sweet cherries with short peduncles, fruit diameter ≥ 24 mm and with bright red color [3].

The sphericity of the fruits is an index of its roundness [20].In our study, all cultivars had slightly elongated heart-shaped fruits, with width was larger than the length. Differences in the fruit form are interesting, since a flattened sweet cherry seems to be more tempting than a lengthened one [25].

The length of peduncles is an important parameter in cultivar determination. Longer peduncles is better than shorter one because of easier picking and lesser tendency to decay and cracking of the fruit. The cvs. Lory Strong, Giorgia and Samba have the longer stalks. According to Schick and Toivonen(2000) short and green stalk reminds buyers on freshness and juiciness of the fruit [34].

Average weight of the stone in studied cultivars ranged from 0.42 g in the cv. Burlat to 0.56 g in the cv. Celeste. The lowest portion of the stone in total weight of the fruit was observed in the cv. Burlat and the highest in the cv. Van. Sweet cherries with lower weight of stone have better value, as well as those having lower portion of stone in total weight of the fruit. The relative weight of stone to fresh fruit weight ranged between 3.7% and 8.4% - our results are in an accordance with Blažková (1988).

Chemical composition of cherry cultivars

Fruit quality of sweet cherry cultivars was defined on the basis of chemical properties of the fruit, and the results are presented in the Table 5.

Table 5: Chemical composition of charry cultivars (average, 2014-2016)

#	*Cultivars*	*Soluble solids (%)*	*Total sugars (%)*	*Inverted sugars (%)*	*Total acids (%)*
1	Burlat	13.8±0.10^{b}	8.3±0.18^{b}	7.2±0.20^{b}	0.44±0.01^{c}
2	Celese	12.4±0.12^{c}	9.2±0.12^{a}	8.50±0.10^{a}	0.45±0.02^{c}
3	Early Lory	11.8±0.26^{d}	7.2±0.10^{c}	6.40±0.12^{c}	0.41±0.05^{b}
4	Giorgia	14.6±0.11^{a}	8.6±0.11^{b}	7.20±0.24^{b}	0.42±0.56^{b}
5	Krupnoplodnaja	12.8±0.10^{c}	7.1±0.21^{c}	6.4±0.16^{c}	0.48±0.02^{c}
6	Lory Strong	11.5±0.26^{d}	7.4±0.12^{c}	6.0±0.12^{c}	0.36±0.04^{a}
7	Moro	12.6±0.18^{c}	6.8±0.18^{d}	5.6±0.12^{d}	0.38±0.56^{a}
8	Samba	13.6±0.20^{b}	9.4±0.16^{a}	8.4±0.22^{a}	0.41±0.02^{b}
9	Van	14.2±0.14^{a}	8.1±0.22^{b}	7.0±0.11^{b}	0.53±0.21^{d}

Cultivar means in the same column followed by the same letter are not significantly different according to the LSD test (*P*= 0.05). (mean±SE).

Sugars are the main organic compound in sweet cherry, they gave specific taste sensations when eating fruit and affect consumer acceptance [3]. Total soluble solids (TSS) dominant chemical component are sugars (90%).The soluble solids content (consisting mostly of sugars) varies between 11 and 25°Brix in sweet cherry [31;32]. In the present study, total soluble solids(TSS) ranged between 11.5 and 14.6°Brix. Fruits of the cv. Giorgia have the highest TSS, followed by cv. Van, the lowest were cv. Lory Strong (11.5) and Early Lory (11.8).

Majority of cultivars were found to have TSS about 12.5%. The result in terms of the total soluble solid content in our study was lower, than to the sweet cherries grown in other countries [41], but similar results have been reported by Milatovićetal. (2013),at the same tree age and grafted on to Colt root stock in conditions like ours. Lower content of sugar in studied cultivars is in accordance of the results of Milatović et al. (2014).

The content of total sugars ranged from 7.1 to 9.4%. The highest sugar content level was found in the cv Samba, while the lowest content of sugar was found in the cv Krupnoplodnaia. Organic acids are the second main group of organic compounds found in sweet cherries after carbohydrates. There are important components of sweet cherries in terms of their impact on the flavor[36]. The content of titratable acids ranged from 0.36% (cv. Lory Strong) to 0.53% (cv. Van). Vangdal, (1985) states that the acid content does not significantly determine the quality of sweet cherry, considering that most of sweet cherries cultivars have almost the same low level of acids**[**34]. Our results for majority of cultivars indicate lower content of titratable acidity than in other studies. The differences between our results and results of other authors can be explained by the influence of different rootstock, soil and climate conditions, cultural practices, and stage of maturity in general [4; 3; 34].

4. Conclusions

Having studied some biological and agricultural properties of sweet cherry (*Prunusavium*L.) cultivars grafted on the rootstockColt in Kartli Region of Georgia we have drawn the following conclusions:

- The procession of observed phenological stage showed, that sweet cherry cultivars annual phenological phases calendartiming and duration depend on the cultivar and local environmental conditions.
- Flowering begins in the second decade of March and lasts for 8-14 days. The cultivar Early Lory begins a flowering the earliest date (28.03) and the cultivar Lory Strong – most lately (15.04).

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- The calendar periods of flowering for one and the same cultivar were very variable according to years; it is explained by the difference of climatic conditions, but the sequence of cultivars according to flowering periods is constant and does not change.
- Ripening of fruit begins on the end of May and lasts till the second decade of June. Two cultivars like Burlat and Early Lory can be grouped in the early ripening period's cultivars. Out of the mentioned cultivars the cultivar Lory Strong ripens the most lately (12.06). Comparing the years of studies, it can be concluded, that the differences in the time of ripening for the same cultivar were not expanded (6 – 8 days).
- All studied cultivars - except Moro - could be classified as sweet cherry with large fruit size. The weight of fruit ranged from 6.9 g (Moro) to 10.2 g (Celeste). The longest pedicel has the cv Lory Strong – 4.8 cm and Giorgia - 4.6 cm. The average weight of a stone is 0.43 g.
- The cultivars Samba, Burlat and Giorgia contain the biggest contents of soluble dry substance – respectively, 13.6%, 13.8% and 14.6%. The contents of total sugars in the cultivars varies from 9.4% (Samba) to 6.8% (Moro). The acidity of cultivars is on an average 0.42%.
- The results of three- year research allow to choose from the cultivars of sweet cherry the three cultivars with the best biological and commercial properties - these are Burlat, Samba and Giorgia. These varieties are recommended for planting in ShidaKartliprovine as well as in the similar soil and climatic conditions of other regions of Georgia.

References

[1] Avanzato D. (2002). Sweet cherry cultivars in Georgia. Actual Questions of fruit-growing Publishing by FAO project. Tbilisi-Gori-Akhaltsikhe. pp. 58-62. (In Georgian).
[2] BlazkovaJ.(1988).The evaluation of stone character for the identification of sweet cherry cultivars. ISHS Act a Horticulturae, 224. pp. 285–294.
[3] CrisostoC., CrisostoM.,MetheneyP.(2003).Consumeracceptance of'Brooks'and 'Bing' cherriesis mainly dependent on fruit SS Candvisual skin color.PostharvestBiologyandTechnology.28. pp.159-167.
[4] Drake,S., Elfving, D.(2002). Indicators of maturity and storage quality of 'Lapins' sweet cherry. Hort Technology. 12(4). pp.687-690.
[5] FAOSTAT(2016): http://faostat.fao.org/default.aspx.
[6] Florkowski, W.J. Lysiak G. Quality Attribute-Price Relationship:Modernization of the Sweet Cherry Sector in Poland Abstract (2015) SGGW Problems of World Agriculture volume 15 (XXX) N4. pp: 41–55.
[7] García-MontielF.,Serrano M.,Martinez-RomeroD., Al- burquerque N.(2010):Factorsinfluencing fruitsetand quality in different sweet cherry cultivars. Spanish Journal of AgriculturalResearch,8. pp. 1118–1128.
[8] Geostat (2014). Geostatic National Statistics Office of Georgia. 2014. www.geostat.ge.
[9] Growth stages of vegetables, pome- stone- and berry fruits and grape and weed species (BBCH-Code). Ed. SPAAR, D.: Ecologisation of plant protection of in the vegetable, - fruit- and grapeproduction. Vol. 2, 2005, Sankt-Petersburg-Puschkin pp.162-228 (Russian).
[10] JedlowLeo K., Schrader, Larry E. (2005). FruitCrackingandSplitting. Whiting,M.D.(ed.)Pacific NorthwestFruitSchoolCherryShort courseProceedings,Chapter10. pp. 65-66
[11] IngG.(2008). Wherewill sweet cherries be grown? ActaHortic.795pp.451-456.
[12] KappelF.,Fisher-FlemingB.,HogueE.(1996).FruitcharacteristicsandSensoryattributes of anideal sweet cherry. Hort Science, 31(3). pp.443–446.
[13] Kazantzis K., Chatzicharissis I., Papachatzis A., Sotiropoulos T., Kalorizou H., Koutinas N. (2011): Evaluation of sweet cherry cultivars introduced in Greece. Journal of University of Kraiova, SeriaHorticultură, 16.pp. 293–296
[14] LichevV.,GovedarovG.,TabakovS.,YordanovA.(2004) : Evaluation of sweet cherry cultivars recently introduced into Bulgaria compared with two Bulgarian cultivars. Journal of FruitandOrnamentalPlantResearch,12.pp.281–286.
[15] Lopez-Ortega G., Garcia-Montiel F.,Bayo-Canha A., Frutos-Ruiz C., Frutos-Tomás D. (2014). Sweet Cherry cultivar evalution in the region of Murcia, Spain. Annual Meeting Bordeaux, 13rd-15th October 2014.
[16] Meier, U. (2001) Growth Stages of Mono and Dicotyledonous Plants. BBCH Monograph, Federal Biological Research Centre for Agriculture and Forestry, Bonn.
[17] Menzies R. (2004): Increasing cherry fruit size. Agfact H5.4.2. Available at www.dpi.nsv.gov.au Milatović P.D., Đurović B.D., Đorđević
[18] Milatović P.D., Đurović B.D., Đorđević S.B., Vulić B.T., Zec N.Z. (2013): Pomološkeosobinenovijihsortitrešnjenapodlozi Colt. [Pomological Properties of sweet cherry cultivars grafted on 'Colt' rootstock.] Journal of Agricultural Sciences, 58. pp.61–72.
[19] Milošević T. (1997): Specijalnovoćarstvo. [Special topics in fruit growing] Cacak-Belgrade, Faculty of Agronomy and Community for Fruits and Vegetables. pp. 215–236.
[20] MilosevicT., Milosevic N., Glisic I.(2013): Tree growth yield, fruit quality Attributes and leaf nutrient content of 'Roxana' doi: 10.17221/119/2014-HORTSCI apricotas influenced by natural zeolite, organic and in- organic fertilizers. ScientiaHorticulture,156.pp.131–139.
[21] Milosevic T., Milosevic N., Glisic I., Nikolic R., Milivojevic J. (2014). Early tree growth, productivity, fruit quality and leaf nutrients content of sweet cherry grown in a high density planting system. Hort. Science. (Prague), 42.pp.1-12.
[22] Mohsenin N.N. (1980): Physical Properties of Plant and Animal Materials. New York, Gordon and Breach Science Publishers Inc.pp. 51–87.
[23] Moreno M.A., Adrada R., Aparicio J., Betrán J.A. (2001): Performance of 'Sunburst' sweet cherry grafted on different rootstocks. Journal of

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Horticultural Science and Biotechnology, 76.pp.167–173.
[24] Nagy P., Thurzó T., Szabo Z., Nyeki J. (2008). Impact of boron foliar fertilization on Annual fluctuation of B in sweet cherry leaves and fruit quality. International Journal of Horticultural Science, 14. pp. 27–30.
[25] Perez-SanchezR.,Gómez-SánchezM.,Morales-Corts M. (2010). Description and quality evaluation of sweet cherry culture in Spain. Journal of Food Quality.33. pp 490–506.
[26] Postweiler K, StosserR, Anvari A. (1985) The effect of different temperatures on the viability of ovules in cherries. Scientia Horticulturae 25(3); pp.235-239
[27] Program, (1999). Program and methods Cultivar fruit, berry and nut crops. Orel, 1999. pp. 430-486. (In Russian).
[28] Sanzol J, Herrero M. (2001) The"effective pollination period" in fruit trees. Scientia Horticulturae; 90 pp.1–17.
[29] Schick J., Toivonen M. (2000). Optimizing cherry Stem quality. 16th Annual Postharvest Conference Yakima, WA, March. pp. 14-15.
[30] Shirokov, E., Polegaev V. (1988). Storage Technology and processing of fruits and vegetables horticulture and viticulture. Moscow. Pubisher 'Agropromizdat' (in Russian).
[31] Serrano M., Guillén F., Martínez-Romero D., Castillo S., Valero D. (2005): Chemical constituents and antioxidant activity of sweet cherry at different ripening stages. Journal of Agricultural and Food Chemistry, 53: 2741–2745.
[32] Sirbu S., Niculaua M., Chiriţa O. (2012). Physico-chemical and antioxidant properties of new Sweet cherry cultivars from Iași, Romania. Agronomy Research 10 (1–2). pp. 341–350.
[33] SkrzyńskiJ., Lea M., Gonkiewicz A., Banach P. (2016). Cultivar effect on the sweet cherry antioxidant and some chemical attributes. FoliaHort.28/1pp:95-102.
[34] Stojanovik M., Milatovic D.,Kulina M., Alic-Dzanovic Z. (2012). Pomological properties of sweet cherry cultivars on Gisela 5 rootstock in the region of Sarajevo. Third International Scientific SympoziumAgrosumJahoria. pp. 183-187.
[35] UNECE (2010).UNECE Fresh Fruit and Vegetables – Standards. 2010. Edition of the United Nations. New York and Geneva.
[36] UPOV (2006). International Union the Protection of New Varieties of Plants. (2006). Sweet Cherry UPOV Code: PRUNU_AVI *Prunusavium* L. TG/35/7.
[37] USenikV., FabcicJ., StamparF., (2008). Sugars, organic acids, phenolic composition and antioxidant activity ofsweetcherry(*Prunusavium*L.).FoodChem.107.pp.185-192.
[38] VangdalE. (1985). Quality criteria for fruitfor fresh consumption. ActaAgriculturaeScandinavica,35. pp.41–47.
[39] Vardzelashvili M., Tsertsvadze T. (1978). Sweet cherry and Cherry. In: Khomizurashvili, N. (Ed), Fruit Growing. In four volumes. Volume 4 – stone fruits. Tbilisi, pp. 335-344 (In Georgian, Russian, English).
[40] Vavilov N. (1935). Theoretical basis of plant breeding. Volume I, Moscow. Publishing house 'Selkhozizdad, pp.26-79 (in Russian).
[41] Voca S, Dobricevic N, Druzic J, Cmelik Z, Knezevic A, Vokurka A, Pliestic S (2007). Chemical characteristics of the sweet cherry species (Prunusavium L.) from the island of Cres. Source: PomologiaCroatica, 13(3). pp. 173-180.
[42] Whiting M., LangG.,OphardtD.(2005): Rootstockand training system affect sweet cherry growth, yield, and fruit quality. Hort Science,40. pp.582–586.
[43] Wociór S. (2008): The effect of rootstock on the growth and yielding of cultivar 'Kordia' sweet cherry trees. ActaScientiarumPolonorum, HortorumCultus, 7 pp.21–26.
[44] Zhukovsky P. (1971). Cultivated plants and their relatives. Moscow. Kolos publishing house. pp. 481-565 (in Russian).

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