Agnieszka GŁOWACKA, Elżbieta ROZPARA
Research Institute of Horticulture in Skierniewice
ul. Pomologiczna 18, 96-100 Skierniewice, Poland
e-mail: agnieszka.glowacka@inhort.pl

GROWTH, YIELDING AND FRUIT QUALITY OF THREE SWEET CHERRY CULTIVARS UNDER ORGANIC ORCHARD CONDITIONS

Summary

The experiment, conducted in 2004-2013, assessed the possibility of organic production of the fruit of three sweet cherry cultivars. The objects studied were trees of the cultivars: 'Karesova', 'Burlat' and 'Summit', grafted on Prunus avium seedlings. The experiment was established in the spring of 2004 in the Experimental Ecological Orchard in Nowy Dwór-Parcela (central Poland). The trees were grown in accordance with the principles of organic fruit-growing. The sweet cherry trees came into bearing fruit in the fourth year after planting and each year yielded poorly, therefore the cumulative yields obtained over the period 2008-2013 were low. The largest amounts of fruit were harvested each year from the trees of the cultivar 'Karesova', and the least – from the trees of cv. 'Summit'. The fruit of the cultivar 'Summit' matured about 2 weeks later than the fruits of the cultivars 'Karesova' and 'Burlat'. The cultivar 'Summit' also produced fruit with the highest mean fruit weight; however, the fruit crops of this cultivar were observed to have the highest proportion of fruits damaged by the cherry fruit fly (Rhagoletis cerasi) and infected by the brown rot of stone fruits (Monilinia laxa, Monilinia fructigena). The presented results indicate that early ripening cultivars, such as 'Karesova' and 'Burlat', are more suitable for growing under organic orchard conditions.
***Key words**: sweet cherry, cultivar, organic fruit production*

WZROST, OWOCOWANIE ORAZ JAKOŚĆ OWOCÓW TRZECH ODMIAN CZEREŚNI W WARUNKACH SADU EKOLOGICZNEGO

Streszczenie

W doświadczeniu prowadzonym w latach 2004-2013 oceniano możliwość ekologicznej produkcji owoców trzech odmian czereśni. Przedmiotem badań były drzewa odmian: 'Karesova', 'Burlat' i 'Summit', szczepione na siewkach czereśni ptasiej. Doświadczenie założono wiosną 2004 roku w Ekologicznym Sadzie Doświadczalnym w Nowym Dworze – Parceli (centralna Polska). Drzewa prowadzono zgodnie z zasadami sadownictwa ekologicznego. Czereśnie weszły w okres owocowania w czwartym roku po posadzeniu i co roku owocowały słabo, dlatego plon zebrany w latach 2008-2013 jest niski. Największe plony zbierano corocznie z drzew odmiany 'Karesova', a najmniejsze - z drzew odmiany 'Summit'. Owoce odmiany 'Summit' dojrzewały około 2 tygodnie później od owoców odmian 'Karesova' i 'Burlat'. Miały one największą masę, jednakże w plonie odmiany 'Summit' obserwowano największy udział owoców uszkodzonych przez nasionnicę trześniówkę i porażonych przez brunatną zgniliznę drzew pestkowych. Uzyskane wyniki potwierdzają większą przydatność wczesnych odmian czereśni takich jak 'Karesova' i 'Burlat' do uprawy ekologicznej.
***Słowa kluczowe**: czereśnie, odmiana, ekologiczna produkcja owoców*

1. Introduction

Sweet cherry is grown successfully in Poland in commercial orchards maintained by traditional and integrated methods [1, 2, 3, 4]. The area of cultivation of this species is more than 11,000 ha, from which about 40,000 tonnes of the fruit is harvested annually [5]. The success of sweet cherry cultivation in Polish climatic conditions is determined by several factors. Choosing the right location for the orchard is particularly important because the species is not very resistant to low sub-zero temperatures [4]. Bacterial canker is another problem in the cultivation of sweet cherry. Information on the harmful effects of this disease has been provided by Sobiczewski and Schollenberger [6]. In addition, losses in yield are caused by rainfall occurring during fruit ripening, as it contributes to the cracking and decaying of the fruits [4]. The European cherry fruit fly (*Rhagoletis cerasi*), whose larvae feed on the flesh of the fruits and cause them to become worm-infested [7] is the most serious pest of sweet cherry.

Selection of the right cultivar is important for every type of orchard, but especially so for organic orchards because of the limited ability to protect the trees against diseases and pests. Apart from resistance or low sensitivity of cultivars to diseases and pests, of major importance is also the high quality of the sweet cherry fruits, i.e. their size, good taste, and low susceptibility to skin cracking [8]. There is very little information in the literature regarding the suitability of sweet cherry cultivars for organic farming. Studies in this area have been conducted in, for example, Austria [9, 10, 11]. They are very important for the fruit-growing practice because they help to avoid making the mistake of planting in organic orchards cultivars that are susceptible to diseases and pests, and are unreliable in yielding.

Due to the increasing interest in organic cultivation of fruit plants in our country, we have made an attempt to nominate the best performing sweet cherry cultivars in orchards maintained by ecological methods. Three sweet cherry cultivars showing to be of value in integrated production [1, 2, 3, 4] were chosen for the study. Trees of these cultivars were assessed in terms of their resistance to frost, susceptibility to bacterial canker and cherry leaf spot, their growth and yielding, and fruit quality.

2. Materials and methods

The experiment was established in the spring of 2004 in the Experimental Ecological Orchard in Nowy Dwór-Parcela near Skierniewice, on a sandy-loam podzolic soil with a clay subsoil, of Class IVb of rye and potato complex. The average organic matter content was 1.3-1.4%.

Three cultivars of sweet cherry were selected for the study: 'Karesova', 'Burlat' and 'Summit'.

'Karesova' – a cultivar with very good health of tree and good yield potential, and early fruit ripening time. The fruits are medium-sized, heart-shaped. They are covered with a dark red skin that is low susceptible to cracking. The flesh is red, medium firm, juicy, aromatic, tasty.

'Burlat' – the principal, early-maturing commercial cultivar of sweet cherry. Its trees are low susceptible to diseases. The fruits are large, broad heart-shaped, characteristically wrinkled. The skin is deep purple-red, slightly marbled, shiny, almost black at full maturity, prone to cracking in the rain. The flesh is dark red, gristly, juicy, very tasty.

'Summit' – a medium-early sweet cherry cultivar distinguished by very good health of tree. Its fruits are large to very large, broad heart-shaped, with a distinctive tip. The skin is bright red, shiny, turning dark, but not black, in ripe fruit. The flesh is light red, gristly, juicy, very tasty.

Trees of the cultivars: 'Karesova', 'Burlat' and 'Summit', grafted on *Prunus avium* seedlings, were planted at a spacing of 4.5 x 3.5 m, in four replications, with five trees per plot. For the first two years, the soil in the orchard was kept in mechanical fallow. From the third year on, the tree rows continued to be kept in mechanical fallow, whereas in the interrows grass was allowed to grow by self-seeding. The crowns of the trees were trained in the form of a spindle. Every year, light sanitary and rejuvenation pruning were carried out. Since 2007, the sweet cherry trees have been watered with a drip irrigation system. Since 2008, using the meteorological station located in the orchard, data have been collected on the weather conditions in order to assess their effect on tree health and yielding, and on fruit quality (tab. 1).

The study assessed tree health, growth vigour, yielding, and fruit quality. Damage to the trees caused by frost and diseases was assessed annually. A 9-point scale, developed by COBORU in Słupia Wielka, was adopted for the assessment. The score of 1 on that scale represented serious damage leading to the destruction of the tree, and 9 – lack of any symptoms. The thickness of the tree trunk was measured every year in the autumn in a place marked permanently at a height of 30 cm above the soil surface. In the first two years after planting, the measurements concerned the diameter of the trunk, and from the third year on – its circumference. On their basis, the cross-sectional area of the trunk was calculated. After the sweet cherry trees had come into bearing fruit, fruit yields were assessed annually, separately for each tree. The fruit ripening date was recorded. Mean fruit weight was determined on the basis of a sample of 400 fruits selected randomly from each replication (4 x 100 fruits). Similar samples (4 x 100 fruits) were collected to assess the severity of infection of fruits by the cherry fruit fly (*Rhagoletis cerasi*), and by the brown rot of stone fruits (*Monilinia laxa, Monilinia fructigena*). Soluble solids content was measured with a refractometer. To determine the soluble solids each sample used content consisted of 100 randomly selected fruits.

Table 1. Annual temperatures and precipitation in the Experimental Ecological Orchard in Nowy Dwór-Parcela in 2008-2013

Tab. 1. Warunki atmosferyczne w ESD w Nowym Dworze-Parceli, w latach 2008-2013

Year	Temperature [°C]			Precipitation [mm]
	Minimum	Maximum	Mean	
2008	-15,3	31,3	8,68	415,2
2009	-22,5	32,1	8,2	682,0
2010	-26,1	33,2	7,3	659,2
2011	-20,2	32,5	8,96	541,6
2012	-22,6	34,8	8,13	524,2
2013	-16,9	36,9	8,04	501,8

Source: own work / Źródło: opracowanie własne

The results were statistically analyzed using analysis of variance in the Statistica 10 program. Differences between means were assessed with Duncan's test at a significance level of 0.05.

The trees were grown in accordance with the principles of organic fruit-growing. The programme of protection of sweet cherry trees against diseases involved 1-3 treatments annually with a copper preparation (Miedzian 50 WG or Miedzian Extra 350 SC).

Table 2. The programme of protection of the cherry trees in the Experimental Ecological Orchard in Nowy Dwór-Parcela

Tab. 2. Program ochrony roślin stosowany w uprawie czereśni w Ekologicznym Sadzie Doświadczalnym w Nowym Dworze-Parcela

Plant protection products	Application times					
	2008	**2009**	**2010**	**2011**	**2012**	**2013**
Miedzian 50 WP (3 kg ha^{-1}) (1,5 kg ha^{-1})*	31.03; 28.04; 05.05*	08.04; 27.04	07.04; 20.04			
Miedzian Extra 350 SC (3 l ha^{-1})	-	-	-	06.04; 21.04	04.04	23.04
Bioczos (15 l ha^{-1}) + horticultural soap (15 l ha^{-1})	27.05; 10.06	22.05; 26.05; 06.07	13.05; 09.06	-	-	-
Horticultural soap + denatured alcohol (15 l ha^{-1} + 15 l ha^{-1})	-	-	-	14.06	18.05; 24.05; 29.05; 06.06; 16.06; 28.06	12.06; 27.06; 08.07; 17.07; 22.07; 01.08; 09.08

Source: own work / Źródło: opracowanie własne

Aphids were controlled using one or several treatments, depending on the severity of the infestation, with a mixture of Bioczos and horticultural soap, or horticultural soap and denatured alcohol. In addition, when aphid numbers were high, the young shoots colonized by the pest were cut out. The performed protective treatments are listed in Table 2.

3. Results and discussion

3.1. Health condition of trees

During the ten years of observations (2004-2013) conducted in the Experimental Ecological Orchard, there was no frost damage, neither to the root system of the trees nor to their above-ground parts (Tab. 3).

Table 3. Health status of 3 sweet cherry cultivars under ecological growth conditions
Tab. 3. Stan zdrowotny drzew 3 odmian czereśni w warunkach sadu ekologicznego

Cultivar	Frost damage to trees[1] [2013]	Symptoms of bacterial canker on the trunk[2] [2013]	Symptoms of leaf spot[3] [2011-2013]
Karesova	9	5	7,7
Burlat	9	7	5,7
Summit	9	9	5,7

Source: own work / Źródło: opracowanie własne

[1] - a 9-point scale was used, where 9 – trees without frost damage
[2] - a 9-point scale was used, where 1 - represents the presence of numerous cankers causing the destruction of the tree; 3 - two or more very large cankers; 5 - more than five small cankers or a single large one; 7 - isolated small necrotic or cankerous spots; 9 - no symptoms.
[3] - a 9-point scale was used, where 1 – defoliation up to 90%, 3 - defoliation up to 60%, 5 - defoliation up to 40%, 7 - defoliation up to 15%, 9 - defoliation up to 2,5%

Nor did any of the trees die because of infection by bacterial canker. However, the evaluated cultivars differed in terms of their susceptibility to this disease. Dzięcioł et al. [12] and Rozpara [4] have reported medium susceptibility of the cultivar 'Karesova' to bacterial canker and low susceptibility of the cultivars 'Burlat' and 'Summit'. This is confirmed by the results of this study, in which the most numerous canker lesions were observed on the trunks and branches of the cultivar 'Karesova'. Those trees received a score of 5 on the 9-point ranking scale (Tab. 3). No indications of the disease, or only slight symptoms, were recorded on the trunks and branches of the cultivars 'Burlat' and 'Summit'. The cultivar 'Karesova', however, stood out as being less susceptible than the other cultivars to cherry leaf spot (Tab. 3). The low susceptibility of the cultivar 'Karesova' to this disease has also been reported by Blažková [13].

3.2. Tree growth and yielding

Growth vigour of trees of the three sweet cherry cultivars, expressed by the trunk cross-sectional area (TCSA), is shown in Table 4. Under the ecological cultivation conditions, the most vigorous growth was shown by the trees of the cultivar 'Burlat'. Trees of the cultivars 'Karesova' and 'Summit' grew moderately vigorously. In some years, tree growth was inhibited by aphids, which damaged the tips of young shoots, and controlling this pest was very difficult. Arnaudov and Kolev [14] have reported on the varying susceptibility of sweet cherry cultivars to infestation by the black cherry aphid (*Myzus cerasi*) and classify the cultivar 'Summit' as low susceptible, and the cultivar 'Burlat' as moderately or very susceptible, depending on the rootstock. Also in the present experiment, the lowest concentrations of aphids were observed on the trees of the cultivar 'Summit', whereas the trees of the cultivars 'Burlat' and 'Karesova' were colonized by this pest in very large numbers.

The first fruits from the trees of the sweet cherry cultivars under assessment, grafted on *Prunus avium* seedlings, were harvested in the fourth year after planting. Fruit yield varied over the years of the study and depended mainly on the weather conditions during flowering, but generally the annual yields were low (Tab. 4). The largest amounts of fruit in 2008-2013 were collected from the trees of the cultivar 'Karesova'. The lowest yielding had the trees of the cultivar 'Summit'. The productivity index expressed as the size of the fruit crop (kg) per 1 cm^2 of trunk cross-sectional area for the trees of all the evaluated cultivars was very low (tab. 4). The yielding of sweet cherry trees under organic farming conditions differed in comparison with integrated cultivation, in which protection of trees was carried out in accordance with the recommendations for sweet cherry given in the Protection Programme for Fruit Plants. In the organic cultivation, the cumulative yields from 7-year-old trees of the cultivars 'Karesova' and 'Burlat' did not exceed 7 kg per tree (tab. 4), whereas in the integrated cultivation 10-10.5 kg of fruit was already obtained from 4-year-old trees of the two cultivars [15].

Table 4. Tree growth and yielding of 3 sweet cherry cultivars under ecological growth conditions
Tab. 4. Wzrost i plonowanie 3 odmian czereśni w warunkach uprawy ekologicznej

Cultivar	TCSA*[cm^2] 2013	Yield [kg $tree^{-1}$]					Productivity index [kg $tree^{-1}$]
		2008-2010	2011	2012	2013	2008-2013	
Karesova	223,3 b	6,8 a	1,8 b	3,0 b	9,6 a	21,6 a	0,10 a
Burlat	278,9 a	6,5 a	1,0 b	4,2 a	5,3 b	17,1 b	0,06 b
Summit	196,3 b	0,5 b	4,1 a	2,5 b	4,0 b	11,0 c	0,06 b

* TCSA – trunk cross-sectional area
Source: own work / Źródło: opracowanie własne

Table 5. Fruit ripening date and fruit quality parameters of 3 sweet cherry cultivars under organic growth conditions
Tab. 5. Termin dojrzewania oraz jakość owoców 3 odmian czereśni w warunkach sadu ekologicznego

Cultivar	Fruit ripening date [2013]	Fruit weight [g][1]	Soluble solids content[2] [%]	Fruit cracking[3] [%]	Brown rot[4] [%]	Cherry fruit fly[5] [%]
Karesova	08.06	6,0 c	17,1 b	10,2 a	6,2 c	0 b
Burlat	10.06	6,7 b	17,8 a	9,3 a	10,7 b	0 b
Summit	25.06	8,3 a	15,8 c	3,2 b	19,6 a	25,5 a

[1, 2,3,4,5] – average for 2011-2013
Source: own work / Źródło: opracowanie własne

3.3. Fruit ripening time and fruit quality

Fruits of the cultivars 'Karesova' and 'Burlat' matured nearly two weeks earlier than those of the cultivar 'Summit'. The largest fruits were those of the cultivar 'Summit', and the smallest – of the cultivar 'Karesova' (tab. 5). Under organic growing conditions, the fruits reached the size typical of a given cultivar, corresponding to consumer preferences. The size of the organically-grown fruits was similar to the size of fruits from integrated production [15, 16].

During harvesting, it was found that some of the fruits were cracked and showed damage caused by diseases and pests. The degree of this damage depended on the cultivar and the year of the study. According to Rozpara [4], in integrated cultivation, the cultivar 'Burlat' is more susceptible to cracking and decay during rainfall than the cultivars 'Karesova' and 'Summit'. Under the conditions of the ecological orchard, the percentage of cracked fruits in the crop of the cultivars 'Burlat' and 'Karesova' did not differ significantly. Fruits of the cultivar 'Summit', however, were low susceptible to cracking, but they decayed most extensively when infected by the brown rot of stone fruits (tab. 5). Against this disease, treatments were performed by spraying with copper preparations registered for use in ecological cultivation of sweet cherry, but they proved to be insufficiently effective. From the research conducted by Stamenkovic et al. [17] in the climatic conditions of the former Yugoslavia it appears that fruits damaged by *Rhagoletis cerasi* are more susceptible to infection by brown rot. According to Ostojic et al. [9], *Rhagoletis cerasi* does not affect early-ripening cultivars. This is confirmed by the results of this study, in which fruits of the cultivars 'Karesova' and 'Burlat' were free from larvae of the cherry fruit fly. Larvae of this pest were observed, however, in the fruits of the moderately early-maturing cultivar 'Summit' (tab. 5).

4. Conclusions

The results indicate that:

1. Organic cultivation of sweet cherry in Poland is possible on condition that a suitable location is provided for the orchard, proper cultivars are selected, and preventive methods of protection against diseases and pests are used.
2. Organic cultivation of sweet cherry is difficult because of aphids, which feed in numerous colonies, causing the leaves and shoot tips to curl up, which in turn can lead to the inhibition of tree growth. Aphids are difficult to control in the organic orchard.
3. The cherry fruit fly (*Rhagoletis cerasi*) is a serious pest that makes the organic cultivation of sweet cherry difficult. It does not affect the fruit of early- maturing cultivars such as 'Karesova' and 'Burlat', and that is why, until an effective method of protection against this pest has been developed, only this type of sweet cherry varieties should be chosen for organic orchards.
4. The cultivar 'Summit' should not be chosen for organic cultivation because of the large share in the yield of fruits damaged by the cherry fruit fly and the brown rot of stone fruits. Moreover, its trees are unreliable in yielding.

5. References

[1] Rozpara E., Grzyb Z.S., Omiecińska B., Czynczyk A.: Ocena wzrostu i owocowania sześciu odmian czereśni na podkładce P-HL A. Rocz. AR Poznań CCCXXIII, Ogrodn., 2000, 31(2): 131-137.

[2] Rozpara E., Grzyb Z.S., Omiecińska B., Czynczyk A.: Results of eight years of research on the growth and yield of three sweet cherry cultivars grafted on PHL-A rootstock. Acta Hort., 2004, 663: 965-967.

[3] Rozpara E.: Growth and field of eleven sweet cherry cultivars in central Poland. Acta Hort., 2008795:2571.

[4] Rozpara, E.: Intensyfikacja uprawy czereśni (*Prunus avium* L.) w Polsce z zastosowaniem nowych odmian, podkładek i wstawek. Zeszyty Nauk. IO. Monografie i Rozprawy. Skierniewice, 2013, 1-118.

[5] FAOSTAT 2012. faostat3.fao.org.

[6] Sobiczewski P., Schollenberger M.: Bakteryjne choroby roślin ogrodniczych. Warszawa: PWRiL, 2002.

[7] Rozpara E., Badowska-Czubik T., Kowalska J.: Problemy ochrony ekologicznej uprawy śliwy i czereśni przed szkodnikami. Journal of Research and Applications in Agricultural Engineering, 2010, 55(4): 73-75.

[8] Żurawicz E.: Ekologiczne metody produkcji owoców. Krajowe Centrum Rolnictwa Ekologicznego – Regionalne Centrum Doradztwa Rozwoju Rolnictwa i Obszarów Wiejskich. Radom, 2004.

[9] Ostojic S., Telfser J., Spornberger A., Keppel H.: Suitability of sweet cherry cultivars for organic production in eastern Austria. 14th International Conference on Organic Fruit Growing. Hohenheim (Germany). 22-24 February 2010: 250-253.

[10] Spornberger A., Buvac D., Leder L., Böck K, Ostojic S., Telfser J., Hajagos A., Vegvary G., Keppel H., Modl P.: The impact of flower and fruit methods on yield, diseases and fruit quality of sweet cherries (*Prunus avium*) under organic growing conditions. 15th International Conference on Organic Fruit Growing. Hohenheim (Germany). 20-22 February 2012: 209-214.

[11] Spornberger A., Ostojic S., Telfser J., Buvac D., Keppel H.: Suitability of early ripening sweet cherry (*Prunus avium* L.) cultivars for organic production – results of a long term trial in Eastern Austria. 16th International Conference on Organic Fruit Growing. Hohenheim (Germany). 17-19 February 2014: 252-255.

[12] Dzięcioł W., Rejman A., Rembacz J., Atlas czereśni i wiśni. Warszawa: PWRiL, wyd. IV, 1983.

[13] Blažková J., Resistance to abiotic and biotic stressors in sweet cherry rootstocks and cultivars from the Czech Republic. J. Fruit Ornam. Plant Res. Special ed. 2005, vol. 12: 303-311.

[14] Arnaudov V., Kolev K.K.: Susceptibility of some introduced sweet cherry cultivars to the attacks of black cherry aphids Myzus *cerasi* Fab. (Homoptera: Aphididae). Acta Hort., 2009, 825: 401-406.

[15] Rozpara E., Grzyb Z.S., Omiecińska B, Zdyb H.: Growth and cropping of sixteen sweet cherry cultivars grafted on two rootstocks. Acta Hort., 1996, 410: 269-273.

[16] Hodun G., Hodunh M., Grzyb Z.S., Nowe odmiany w kolekcji czereśni w Skierniewicach. Rocz. AR Poznań CCCXXIII, Ogrodn., 2000, 31(2): 75-79.

[17] Stamenkovic S., Rajko G., Stamenkovic T., Susceptibility of some sweet cherry cultivars to *Rhagoletis cerasi* L. (Diptera, Tephritidae). Acta Hort., 1996: 410: 555-560.