

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

Summary

The experiment assessed the possibility of organic production of fruit of three sour cherry cultivars. Among the cultivars under evaluation were two cultivars of Hungarian breeding: 'Debreceni Bötermö' and 'Erdi Bötermö', and one cultivar of Polish breeding – 'Sokówka Nr 6'. Trees grafted onto *Prunus mahaleb* seedlings were planted in the spring of 2005 in the Experimental Ecological Orchard in Nowy Dwór-Parcela (central Poland). The experiment was conducted in accordance with the principles of organic fruit-growing. Serious problems in organic growing of sour cherry were posed by: the cherry leaf spot disease, the brown rot and the bitter rot of stone fruits, and the cherry fruit fly. Symptoms of cherry leaf spot appeared on the leaves of the evaluated sour cherry cultivars during every growing season. The severity of the disease was closely associated with weather conditions and the cultivar. During rainy summers, complete defoliation of the most susceptible sour cherry cultivars occurred already at the end of July. As a consequence a reduction in growth vigour and poor yielding of the trees took place. Under organic orchard conditions, the strongest growing trees were those of the cultivar 'Erdi Bötermö'. Yielding of the sour cherry trees varied over the years of the study, but the cumulative yields obtained in the period 2006-2013 were low. In addition to cherry leaf spot, spring frosts and windy and rainy weather during flowering had an adverse effect on the setting of fruit and crop size. In the years 2006-2013, the largest amounts of fruit were harvested from the trees of the cultivar 'Debreceni Bötermö', and the lowest – from the trees of the cultivar 'Erdi Bötermö'. The fruit of the cultivar 'Erdi Bötermö' had the highest mean weight, but the crop was also observed to have the highest percentage of fruit damaged by the cherry fruit fly and affected by the brown rot of stone fruits. The most susceptible to infection by the bitter rot of sour cherry was the fruit of the cultivar 'Debreceni Bötermö'.

Keywords: sour cherry, cultivar, organic fruit production, fruit quality

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

Streszczenie

W doświadczeniu oceniano możliwość ekologicznej produkcji owoców trzech odmian wiśni. Wśród ocenianych odmian były dwie odmiany hodowli węgierskiej: 'Debreceni Bötermö' i 'Erdi Bötermö' oraz jedna odmiana hodowli polskiej – 'Sokówka Nr 6'. Drzewa szczepione na siewkach antypki posadzono wiosną 2005 roku w Ekologicznym Sadzie Doświadczalnym w Nowym Dworze-Parceli (centralna Polska). Doświadczenie prowadzono zgodnie z zasadami sadownictwa ekologicznego. Poważny problem w ekologicznej uprawie wiśni stanowiły: drobna plamistość liści drzew pestkowych, brunatna i gorzka zgnilizna drzew pestkowych oraz nasionnica trześniówka. Objawy drobnej plamistości liści drzew pestkowych pojawiały się na liściach ocenianych odmian wiśni we wszystkich sezonach wegetacyjnych. Stopień jej nasilenia był ściśle związany z przebiegiem pogody oraz z odmianą. W deszczowe lata całkowita defoliacja najpodatniejszych na porażenie odmian wiśni następowała już w końcu lipca. Konsekwencją tego było osłabienie siły wzrostu i słabe plonowanie drzew. W warunkach sadu ekologicznego najsilniej rosły drzewa odmiany 'Erdi Bötermö'. Plonowanie wiśni zmieniało się w latach badań, jednak sumaryczne plony zebrane w latach 2006-2013 były niskie. Oprócz drobnej plamistości liści drzew pestkowych niekorzystny wpływ na zawiązanie owoców i wielkość plonów wiśni miały wiosenne przymrozki oraz wietrzna i deszczowa pogoda w czasie kwitnienia. W latach 2006-2013 najwięcej owoców zebrano z drzew odmiany 'Debreceni Bötermö', a najmniej z drzew odmiany 'Erdi Bötermö'. Owoce odmiany 'Erdi Bötermö' miały największą masę, jednak w jej plonie obserwowano największy udział owoców uszkodzonych przez nasionnicę trześniówkę i porażonych przez brunatną zgniliznę drzew pestkowych. Najbardziej podatne na porażenie przez gorzką zgniliznę drzew pestkowych były owoce odmiany 'Debreceni Bötermö'.

Słowa kluczowe: wiśnie, odmiany, ekologiczna produkcja owoców, jakość owoców

1. Introduction

The sour cherry is a species of fruit trees widely grown in Poland. In terms of both the number of trees and the production volume it occupies second place after the apple. Its cultivation area is more than 33,000 ha, and nearly 170,000 tonnes of the fruit is harvested annually [2]. Sour cherry trees are grown successfully in commercial orchards managed by the integrated method. Cultivation of sour cherry in

organic orchards presents, however, many difficulties [3, 4, 8, 9, 13, 14]. In orchards managed by ecological means it has not yet been possible to effectively protect the trees against the cherry leaf spot disease, that is why the most important commercial sour cherry cultivar 'Łutówka' (English Morello) is not suitable for this type of planting [5]. Also pests and diseases that damage the fruit, reducing their quality are a serious problem. Especially dangerous under organic orchard conditions is the European cherry fruit fly

(*Rhagoletis cerasi*), whose larvae feed inside the fruit [1,10]. During periods of persistent heavy rainfall, a lot of problems are caused by the brown rot of stone fruits (*Monilinia laxa*, *Monilinia fructigena*), and the bitter rot of sour cherry (*Glomerella cingulata*) [8, 9, 12, 13].

In the literature, there is little information regarding the suitability of sour cherry cultivars for organic fruit-growing. Studies in this area have been conducted, for example, in Hungary [8, 9] and Germany [12, 13]. They are very important for the fruit-growing practice because they help to avoid the error of planting in organic orchards cultivars that are susceptible to pests and diseases, and unreliable in yielding.

Due to the increasing interest in the organic cultivation of fruit plants in Poland, attempts have been made to select the best performing varieties of sour cherry in orchards managed by ecological means. On the basis of observations made in the collection of sour cherry trees in the Experimental Orchard in Dąbrowice, selection was made of three cultivars that in the integrated cultivation stood out in terms of high resistance to fungal diseases and of good quality fruit.

‘Erdi Bötermö’ – an early variety of sour cherry, moderately sensitive to frost and low susceptible to disease. The tree forms a round, moderately dense crown. This cultivar comes early into fruiting and is moderately prolific. The fruits ripen in the first ten days of July. They are spherical, flattened on the top. The skin is dark red, glossy. The flesh is red, medium firm, juicy, aromatic, very tasty. The juice is slightly staining.

‘Debreceni Bötermö’ – a variety resistant to frost and low susceptible to disease, including bacterial canker and the brown rot and leaf spot of stone fruit trees. The tree forms a tall crown. Fruit yields are moderate or good, depending on the year and weather conditions during flowering. The fruits usually ripen around the middle of July. They are heart-shaped, covered with a red skin. The flesh is bright red, medium firm, sweet and sour, very tasty. The juice is slightly staining.

‘Sokówka Nr 6’ – a variety resistant to frost and low susceptible to disease. The tree forms a spreading crown. Fruit yields are moderate. The fruits ripen around the middle of July. They are spherical, flattened at the top. The skin is dark red, shiny. The flesh is dark red, firm, juicy, quite tasty. The juice is staining.

2. Material and Methods

The experiment was established in the spring of 2005 in the Experimental Ecological Orchard (ESD) in Nowy Dwór-Parcela near Skierniewice, on a podzolic sandy loam soil, underlain by a clay subsoil, of Class IVb rye-potato complex. The average organic matter content was 1.3-1.4%. Trees of the cultivars: ‘Erdi Bötermö’, ‘Debreceni Bötermö’ and ‘Sokówka Nr 6’, grafted onto *Prunus mahaleb* seedlings, were planted at a spacing of 4.5 × 2.5 m, in four replications, with three trees per plot. For the first two years, the soil in the orchard was kept in mechanical fallow. From the third year onward, mechanical fallow was still maintained in the rows of trees, while the inter-rows were kept under self-seeding grass cover. The tree crowns were trained in the form of a spindle. Light sanitary and rejuvenation pruning was carried out every year. From 2007, the sour cherry trees were watered via a drip irrigation system.

From 2008, using the meteorological station located in the orchard, data were collected on weather conditions in order to assess their impact on the health status and yielding of the trees, and on fruit quality. The trees were managed in accordance with the principles of ecological horticulture. The programme of sour cherry protection against diseases involved 1-3 treatments annually with a copper plant protection (Miedzian 50 WG or Miedzian Extra 350 SC) in the dose 1,5-3 kg/ha or 1,5-3 l/ha. Aphids were controlled by performing one or several treatments, depending on the severity of the pest, with a mixture of Bioczos – extract of garlic *Allium sativum* (L.) (dose 15 l/ha) and potassium soap (dose 15 l/ha) or potassium soap (dose 15 l/ha) with the addition of alcohol (dose 7,5-15 l/ha).

Annual assessments included the health status and growth vigour of the trees, and, after they had come into fruiting, of the size and quality of the fruit crop. To evaluate the susceptibility of the trees to frost and disease, a 9-point scale, developed by COBORU in Słupia Wielka, was adopted [11]. The thickness of the tree trunk was measured every year in the autumn, at a permanently marked place, at a height of 30 cm above the soil surface. In the first two years after planting, it was the diameter of the trunk that was measured, and from the third year on – its circumference. On that basis, the cross-sectional area of the trunk was calculated. After the sour cherry trees had come into fruiting, fruit yields were assessed annually for each tree. The fruit ripening time was recorded. Mean fruit weight was determined on the basis of a sample of 400 fruits collected randomly from each replication (4 × 100 fruits). Similar samples (4 × 100 fruits) were collected to assess the extent of infection of fruit by the bitter rot of sour cherry and the brown rot of stone fruits, and the level of infestation with the cherry fruit fly.

The results were statistically analyzed using analysis of variance in the Statistica 10 program. To evaluate the differences between the means, the Duncan test was used at a significance level of 0.05.

3. Results and Discussion

3.1. Tree health status

In the first years after planting, the health condition of the sour cherry trees was good. However, symptoms of the cherry leaf spot disease were observed every year. The harmful effects of this disease have been reported on by Grzyb and Rozpara [5], Hodun and Grzyb [7] and Schuster [15]. During rainy summers, cherry leaf spot caused defoliation of trees already at the end of July. This resulted in the lowering of tree growth vigour and a reduction in their resistance to frost. For this reason, following the 2009/2010 winter, when the temperature had dropped to -26°C, two trees of the cultivar ‘Sokówka Nr 6’ and one tree each of the cultivars ‘Erdi Bötermö’ and ‘Debreceni Bötermö’ had withered away. Subsequent losses of trees were observed after the 2011/2012 winter, with a temperature drop-down to nearly -23°C, and after the relatively mild winter of 2012/2013, with a temperature drop to -17°C (Tab. 1).

On the basis of observations made in the collection of sour cherry trees located in the Pomological Orchard in Skierniewice, Hodun and Grzyb [7] had found that ‘Sokówka Nr 6’ was low susceptible to cherry leaf spot, ‘Erdi Bötermö’ – was medium susceptible, and ‘Debreceni Bötermö’ – very susceptible. This is not confirmed by the

results of our own observations. Under organic orchard conditions there were no significant differences in the susceptibility of these cultivars to the cherry leaf spot disease (Tab. 2). In addition to cherry leaf spot, the sour cherry trees were observed to show symptoms of the brown rot of stone fruits. Large losses caused by this disease in sour cherry orchards managed by ecological means have been reported by Holb and Schnabel [8], Pfeiffer [12] and Pfeiffer et al. [13]. Holb and Schnabel [8] reported on the high susceptibility to brown rot of 'Erdi Bötermö' trees, and Pfeiffer et al. [13] – on the medium susceptibility of 'Debreceni Bötermö' trees. This is confirmed by the results of the experiment presented here, in which the most numerous symptoms of the brown rot disease were observed on the trees of 'Erdi Bötermö'. Those trees received a score of 3 on a 9-point grading scale (Tab. 2). In the case of the cultivar 'Debreceni Bötermö', in the years with conditions favourable to infections (rain during flowering), up to 25 small lesions of brown rot were observed per tree. The fewest brown rot lesions were on the trees of 'Sokówka Nr 6'; their number did not exceed 5 per tree.

Table 1. Weather conditions in ESD orchard in Nowy Dwór-Parcela in the years 2008-2013

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

Year	Min. temp.	Max. temp.	Mean temp.	Precip. [mm]
2008	-15.3	31.3	8.7	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	9.0	541.6
2012	-22.6	34.8	8.1	524.2
2013	-16.9	36.9	8.0	501.8

Source: own work / Źródło: opracowanie własne

Table 2. Tree health status of 3 sour cherry cultivars under organic orchard conditions in the years 2008-2013

Tab. 2. Stan zdrowotny drzew 3 odmian wiśni w warunkach sadu ekologicznego w latach 2008-2013

Cultivar	Susceptibility to:		
	frost ¹	leaf spot ²	brown rot ³
Erdi Bötermö	5	5	3
Debreceni Bötermö	7	5	5
Sokówka Nr 6	5	5	7

^{1,2,3} severity of infection on 1-9 point scale, where: 1 – very severe symptoms, 3 – severe, 5 – moderate, 7 – mild, 9 – no symptoms 9-point scale, developed by Research Center of Cultivar Testing (COBORU) in 2007 year

Source: own work / Źródło: opracowanie własne

Table 3. Growth and yielding of 3 cultivars of sour cherry (*Prunus cerasus* L.) under organic orchard conditions

Tab. 3. Wzrost i plonowanie 3 odmian wiśni (*Prunus cerasus* L.) w warunkach uprawy ekologicznej

Cultivar*	TCSA** [cm ²] 2013	Fruit yield [kg/tree]						Cumulative fruit yield 2006-2013 [kg/tree]
		2006-2008	2009	2010	2011	2012	2013	
Erdi Bötermö	63.9 a	0.5 b	1.1 b	0.5 a	0.5 b	3.1 b	0.3 c	5.9 b
Debreceni Bötermö	44.3 b	3.6 a	2.9 a	0.6 a	2.7 a	4.9 a	1.6 b	16.3 a
Sokówka Nr 6	44.6 b	1.0 b	2.7 a	0.1 b	0.4 b	0.7 c	2.2 a	7.2 b

* Average values marked with the same letter in a column are not significantly different according to Duncan's t-test at a significance level of 0.05; ** TCSA – trunk cross-sectional area

Source: own work / Źródło: opracowanie własne

3.2. Tree growth and yielding

The trunk cross-sectional area (TCSA) of the three sour cherry cultivars is shown in Table 3. The trees of the cultivars 'Debreceni Bötermö' and 'Sokówka Nr 6' were characterized by similar growth vigour, whereas the trees of the cultivar 'Erdi Bötermö' grew significantly more strongly than them. In some years, tree growth was restricted by aphids, which damaged the tips of young shoots, and controlling these pests was very difficult.

The first fruits from the trees of the sour cherry cultivars under evaluation were harvested in the second year after planting. The fruit yield varied over the years of the study and depended, among other things, on the weather conditions during flowering. In 2007, at the beginning of May, there occurred spring frosts that damaged, depending on the cultivar, from around 40 to more than 70% of sour cherry fruitlets. In the years 2008, 2010, 2011 and 2013, the windy and rainy weather during flowering was not favourable to bees foraging around, which consequently resulted in a low fruit set and low yields. The decrease in fruit yield in the ecological orchard in 2010 and 2013 was also caused by infection of the trees with the brown rot of stone fruits. In those circumstances, the amount of fruits collected from the trees of the test cultivars was from 0.1 to 0.6 kg in 2010, and from 0.3 to 2.2 kg in 2013. In 2012, which was the most favourable year to sour cherry yielding, from 0.7 kg to almost 5 kg of fruits, depending on the cultivar, were obtained from a tree (Tab. 3). Grzyb and Rozpara [6] have reported that the cultivars that are suitable for cultivation in commercial orchards are those that produce fruit each year and at the same level, such as 'Erdi Bötermö' and 'Debreceni Bötermö'. Under organic orchard conditions, the trees of the cultivar 'Erdi Bötermö' yielded poorly and irregularly, and so did the trees of 'Sokówka Nr 6'. The trees that stood out as the best yielding were those of the cultivar 'Debreceni Bötermö' (Tab. 3).

3.3. Fruit ripening time and quality

The fruit of the evaluated cultivars of sour cherry ripened in early or mid-July. The fruits of 'Erdi Bötermö' were the earliest to reach harvest maturity (Tab. 4).

The cultivars differed in terms of fruit size. The largest fruits were produced every year by the earliest maturing cultivar 'Erdi Bötermö'. An exception was the year 2010, when the largest fruits were those of 'Debreceni Bötermö'. The smallest in weight were the fruits of 'Sokówka Nr 6' (Tab. 4). The deterioration in tree health from year to year resulted in a reduction in fruit size, so the smallest fruit were harvested in the last years of the study.

Table 4. Fruit ripening time and weight of 3 cultivars of sour cherry (*Prunus cerasus* L.) under organic cultivation
 Tab. 4. Termin dojrzewania i masa owoców 3 odmian wiśni (*Prunus cerasus* L.) w warunkach uprawy ekologicznej

Cultivar*	Fruit ripening time	Fruit weight [g]						2008-2013 [g]
		2008	2009	2010	2011	2012	2013	
Erdi Bötermö	2 July	5.4 a	6.5 a	4.5 b	5.6 a	4.7 a	4.5 a	5.1 a
Debreceni Bötermö	12 July	5.2 a	5.8 a	5.5 a	4.7 b	3.8 b	3.7 b	4.9 b
Sokówka Nr 6	8 July	4.3 b	5.5 a	4.3 b	4.1 c	3.8 b	3.5 b	4.2 c

* See Table 3

Source: own work / Źródło: opracowanie własne

The fruits produced under organic orchard conditions were smaller in size in comparison with integrated cultivation, in which the protection of trees was in accordance with the recommendations for sour cherry contained in the Fruit Plant Protection Programme. In a study by Grzyb and Rozpara [6], the mean fruit weight in integrated cultivation was 7.0-7.5 g for the cultivar 'Erdi Bötermö' and 6.0 g for the cultivar 'Debreceni Bötermö'. In the case of fruit from organic cultivation this was 5.1 g and 4.9 g, respectively (Tab. 4).

During harvesting, it was found that many fruits showed damage caused by pests and diseases. The degree of damage varied depending on the cultivar and the year of the study. The largest number of fruits that were rotting because of infection with the bitter rot of sour cherry was observed in the crop of 'Debreceni Bötermö' (Tab. 5). By comparison, the fruits of the cultivar 'Erdi Bötermö' were mostly affected by the brown rot of stone fruits (Tab. 5). To control this disease, spraying was performed with copper preparations, registered for use in organic cultivation of sour cherry, but they proved to be insufficiently effective. The same was true in a study conducted in Hungary. Holb and Schnabel [8] and Holb et al. [9] found that at a high disease pressure the effectiveness of copper preparations in the prevention of infections was low in comparison with those used in conventional orchards. In addition, research conducted by Stamenkovic et al. [16], Głowacka et al. [3, 4] and Rozpara and Głowacka [14] indicates that the fruits damaged by the cherry fruit fly are more susceptible to infection by the brown rot of stone fruits. This is confirmed by the results of this experiment, in which the largest percentage of fruits with larvae of the cherry fruit fly was in the crop of the cultivar 'Erdi Bötermö' (Tab. 5).

Table 5. Degree of infection of three cultivars of sour cherry (*Prunus cerasus* L.) with diseases and pests under organic cultivation

Tab. 5. Porażenie przez choroby i szkodniki owoców 3 odmian wiśni w warunkach sadu ekologicznego

Cultivar*	Bitter rot ¹ [%]	Brown rot ² [%]	Cherry fruit fly ³ [%]
Erdi Bötermö	4.4 c	16.3 a	10.7 a
Debreceni Bötermö	14.1 a	6.3 b	0.5 c
Sokówka Nr 6	8.5 b	8.5 b	5.7 b

^{1,2} - average for the period 2009-2013, ³ - average for the period 2008-2013; * See Table 3

Source: own work / Źródło: opracowanie własne

4. Conclusions

1. There was a high variation among the cultivars of sour cherry evaluated under the conditions of organic cultivation due to the differences in the susceptibility to disease, the yielding of trees and fruit quality.

2. The sour cherry cultivars notable for low susceptibility to disease in integrated cultivation proved to be sensitive under the conditions of organic cultivation.

3. The best performing cultivar in organic cultivation proved to be 'Debreceni Bötermö', whose trees were moderately susceptible to disease, and its fruits were sporadically inhabited by larvae of the cherry fruit fly.

4. The cultivars 'Erdi Bötermö' and 'Sokówka Nr 6' are not suitable for growing in orchards managed by ecological means. Their trees yield poorly and irregularly, and the cultivar 'Erdi Bötermö' is also sensitive to the brown rot of stone fruits.

5. References

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