The usefulness of stone fruit species and cultivars for organic fruit production in Poland

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Abstract

In the spring of 2004, thanks to a grant received from the Ministry of Agriculture and Rural Development, Poland's first Ecological Experimental Orchard was founded at the Institute of Pomology and Floriculture (now the Institute of Horticulture). The orchard is located in Nowy Dwór near Skierniewice. It is certified annually and has the status of an organic farm. Right from the beginning the orchard has been used to conduct studies whose aim is, among other things, the selection of species and cultivars of stone fruit trees suitable for ecological cultivation. In the absence of the possibility of using mineral fertilizers and herbicides, and because of the limited use of plant protection products in ecological orchards, an extremely important role is played by a proper selection of cultivars. This is not an easy task because there are no cultivars resistant to pests and only a relatively small number of cultivars resistant to diseases. Consequently, the cultivars of stone fruit trees that were selected for research in ecological cultivation are those that for many years have been recommended for cultivation in commercial orchards in Poland, show tolerance or low susceptibility to pests and diseases, and produce fruit of high quality. In the case of sweet cherry, special attention was also paid to the time of fruit ripening because the fruit of early cultivars is not damaged by the cherry fruit fly. Trees of five species of stone fruit trees: sweet cherry, sour cherry, apricot, Prunus domestica *L. and* Prunus salicina *Lindl. were planted in the spring of 2004. On the basis of several years of research, two apricot cultivars, 'Wczesna z Morden' and 'Harcot', were found to show high suitability for ecological cultivation because of the very low susceptibility of the trees and fruit to being affected by pests and diseases. Obtaining good quality fruit was also ensured by the early varieties of sweet cherry: 'Karesova' and 'Burlat', although in the conditions of the ecological orchard their trees were colonized by large numbers of aphids. Ecological cultivation of sour cherry proved to be more difficult than the cultivation of apricot and sweet cherry. Among more than a dozen of the tested cultivars the most suitable for an organic orchard were sour cherry trees selected at the Institute of Horticulture in Skierniewice, marked with the symbols: W2/02, W10/02 and W12/02. They showed relatively low susceptibility to infection by leaf spot and infestation by the cherry fruit fly. Ecological cultivation of plum trees was also difficult. Early varieties of* P. domestica *('Herman', 'Cacanska Rana') and* P. salicina *('Najdiena') proved to be better in the organic orchard than the late maturing varieties, mainly because of their lower susceptibility to infestation by the plum moth, which is a pest posing a serious problem in plum orchards.*

Keywords: stone fruits, cultivars, cherry, plum, apricot

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Introduction

Owing to the increased interest in organic products, a comprehensive study was undertaken in Poland in 2004 on the development of effective methods of organic fruit production. The aim of the study is to determine, for example, which species and varieties of stone fruit trees are the most suitable for organic orchards. They should be resistant or at least have low susceptibility to the most dangerous pests and diseases because these characteristics play a vital role in reducing the extent to which fruit trees are affected by pathogens (Roen *et al.,* 2007). In ecological orchards, particularly dangerous is a group of pests that feed directly on or inside the fruit. When they occur *en masse*, they can substantially reduce fruit yields and impair fruit quality (Rozpara *et al*., 2010). The most dangerous pest of sweet cherry, and one that has recently become increasingly common also in sour cherry orchards, is the cherry fruit fly. In plum orchards, the plum moth is particularly dangerous. A lot of problems in the cultivation of stone fruit trees is also caused by the brown rot disease, and in the cultivation of sour cherry also bitter rot and leaf spot. The development of these diseases is favoured by prolonged periods of heavy rain. There are large differences between different species and varieties in the degree of their susceptibility to being affected by pests and diseases (Kahu & Klaas, 2007). It is thus very important to select those species and varieties of stone fruit trees that are the most suitable for cultivation in orchards managed with ecological methods, and this is the aim of this work.

Methodology

In the spring of 2004, in the Ecological Experimental Station in Nowy Dwór-Parcela near Skierniewice, experiments were set up to assess the suitability of 5 species of stone fruit trees for organic cultivation. The experiments included: 3 sweet cherry cultivars (‘Karesova’, ‘Burlat’, ‘Summit’); 16 sour cherry varieties (‘Stevensbaer’, ‘Elmer’, ‘Pamiati Vavilova’, ‘Włodzimierska’, ‘Wanda’, ‘Naumburger’ ‘Słupia Nadbrzeżna’, ‘Oblacińska’, ‘Lucyna’ and 7 types of juicing sour cherry marked with the symbols: W1/02, W2/02, W7/02, W8/02, W9/02, W10/02, W12/02); 2 apricot cultivars (‘Wczesna z Morden’, ‘Harcot’); 4 cultivars of *Prunus domestica* L. (‘Herman’, ‘Cacanska Rana’, ‘Żółta Afaska’, ‘Valjevka’) and four cultivars of *Prunus salicina* Lindl. (‘Najdiena’, ‘Shiro’, ‘Vanier’, ‘Black Amber’). For the first two years, the soil in the orchard was kept in mechanical fallow. From the third year, the soil in the tree rows was still kept in mechanical fallow, while in the inter-rows grass cover was introduced. The trees were trained in the form of a spindle. Light sanitary and rejuvenation pruning was carried out every year. Irrigation of the trees began in 2007. Protection of the trees was based on biological preparations allowed for use in organic farming in Poland.

During the study, tree growth vigour, fruiting and fruit quality were assessed. In the first two years after planting, trunk diameter was measured, and from the third year – its circumference. Fruit yields were recorded annually, separately for each tree. In addition, the time of fruit ripening and fruit weight were recorded, with the latter parameter assessed on the basis of a sample of 50 fruits collected randomly from each replication. After harvesting, an assessment of the health status of the fruit was carried out, particularly in terms of the infestation of the sweet and sour cherry trees by the cherry fruit fly, and the plum trees – by the plum moth. The occurrence of these pests was assessed on the basis of 25 fruits taken from each replication of each tree variety. In total, 100 fruits were assessed for each variety. The same samples were used to assess the extent of infection with brown rot, and, in the case of sour cherry, also with bitter rot.

The results obtained during the study were evaluated statistically by the analysis of variance method, separately for each species. To assess the differences between means, Duncan's test was used at a significance level of 0.05.

Results

Sweet cherry

A serious problem in the ecological cultivation of sweet cherry were aphids, which fed in numerous colonies, causing the leaves and the tips of shoots to twist and, consequently, inhibited the growth of trees. The three varieties of sweet cherry, 'Karesova', 'Burlat' and 'Summit', did not differ in their degree of susceptibility to infestation by aphids, but differed in tree growth vigour, yielding, fruit quality and fruit ripening date. The largest cross-sectional area of the trunk after eight years of growth in the orchard was produced by the trees of the cultivar 'Burlat' (Table 1). Unfavourable weather conditions during flowering contributed to poor fruiting of sweet cherry trees in the years 2008-2011. Under those conditions, the most fruit was harvested from the trees of cv. 'Karesova', and the least – from the trees of cv. 'Summit'. Fruits of the cultivars 'Karesova' and 'Burlat' were free of larvae of the cherry fruit fly. Larvae of this pest were observed, however, in the fruits of the medium-early ripening cultivar 'Summit'. The fruits of this cultivar were also susceptible to decay during rainy years because of infection with the brown rot disease of stone fruit trees (Table 1).

Table 1. Tree growth and yielding, and fruit quality of three sweet cherry cultivars under ecological growth conditions

Cultivar	TCSA* [cm²] 2011	Cumulative yield 2008-2011	Productivity index [kg/cm²]	Fruit ripening date	Fruit weight [g]	% damaged fruits	
						cherry fruit fly	brown rot
'Karesova'	165.6 a	9.2 c	0.057 c	15.06	6.2 a	0	3.3
'Burlat'	190.8 b	7.9 b	0.042 b	17.06	6.8 b	0	13.0
'Summit'	163.3 a	4.9 a	0.031 a	30.06	10.1 c	14.3	28.5

*- trunk cross-sectional area

Sour cherry

Ecological cultivation of sour cherry was not easy. The major problems in the cultivation of this species included: the leaf spot disease of stone fruit trees, pathogens causing fruit decay and the cherry fruit fly. Symptoms of the leaf spot disease appeared on the leaves of the evaluated sour cherry cultivars in all growing seasons. The degree of its severity was closely associated with the course of the weather and the cultivar. During rainy years, total defoliation of the most susceptible cultivars of sour cherry, which included 'Elmer', 'Stevensbaer', 'Naumburger' and W9/02, occurred as early as the end of July. The consequence of this was weak growth of trees of these cultivars and significantly lower yields produced by them in comparison with the cultivars less susceptible to the disease (Table 2). In the ecological orchard, the most strongly growing and best-yielding were the trees of the cultivar 'Lucy'. The largest and healthiest fruits were produced by the trees of sour cherry marked W12/02. Smaller, but of good quality, were also the fruits of the cultivars marked with the symbols W2/02 and W10/02. Obtaining good quality fruit from the trees of most of the sour cherry cultivars under evaluation was, however, difficult because of their being affected by the cherry fruit fly and brown and bitter rot. The degree of infestation of the fruits of the individual sour cherry cultivars by the cherry fruit fly

depended on their size. Fruits of a greater weight were significantly more damaged by this pest than smaller fruits (Table 2). The exception was the sour cherry W12/02, whose fruits were the largest among the fruits of all the evaluated cultivars, and the larvae of the cherry fruit fly fed in them only occasionally. This might have been affected by the fruit ripening date. It was observed that fruits of the later ripening cultivars were less infested than those of the early ripening cultivars. A similar relationship was found for the extent of infection of sour cherries with the brown rot disease (Table 2).

Table 2. Tree growth and yielding, and fruit quality of sixteen sour cherry cultivars under ecological growth conditions

Cultivar	TCSA* [cm²] 2011	Cumulative yield 2008-2011	Productivity index [kg/cm²]	Fruit weight [g]	Fruit ripening date	% damaged fruit		
						cherry fruit fly	brown rot	bitter rot
'Pamiati Vavilova'	66.9 h	6.7 cd	0.101 a	4.8 g	02.07	18.7 f	11.2 de	2.3 abcd
'Wanda'	43.0 de	18.0 i	0.419 g	3.7 d	07.07	13.1 de	10.8 d	4.8 e
'Oblacińska'	35.1 bc	17.2 i	0.496 h	3.4 c	08.07	14.2 def	9.6 cd	0.0 a
'Lucyna'	99.5 i	15.1 h	0.154 bc	4.3 ef	10.07	24.3 g	19.0 f	0.0 a
'Naumburger'	38.7 cd	6.1 c	0.160 bc	3.9 d	12.07	16.8 ef	13.1 e	2.8 bcde
W 1/02	47.5 ef	8.6 e	0.185 cd	4.5 ef	12.07	7.5 bc	7.5 c	2.3 abcd
'Elmer'	21.9 a	1.9 a	0.087 a	5.0 g	13.07	28.1 g	21.0 f	7.0 f
'Włodzimierska'	56.2 g	8.0 de	0.142 b	4.3 e	13.07	14.7 def	8.0 c	2.8 bcde
W 8/02	48.8 ef	8.5 e	0.175 bc	3.9 d	13.07	10.2 cd	4.8 b	2.8 bcde
W 2/02	36.1 bc	7.6 de	0.214 de	3.1 bc	15.07	0.6 a	1.6 a	0.5 ab
W 9/02	30.1 b	2.4 ab	0.079 a	3.0 b	15.07	3.4 ab	1.7 a	3.0 cde
W 7/02	34.8 bc	2.6 ab	0.076 a	4.5 f	16.07	10.8 cd	5.0 b	1.8 abc
W 10/02	47.8 ef	6.8 cd	0.144 b	2.8 a	17.07	3.4 ab	2.2 a	1.3 abc
W 12/02	50.1 f	11.7 f	0.234 e	5.6 h	19.07	1.0 a	0.0 a	0.0 a
'Stevensbaer'	33.6 bc	3.4 b	0.102 a	2.6 a	20.07	1.2 a	0.7 a	2.5 bcde
'Słupia Nadbrzeżna'	36.9 c	13.1 g	0.360 f	3.2 bc	23.07	3.2 ab	0.7 a	4.5 de

*- trunk cross-sectional area

Apricot

The study showed a high suitability of apricot cultivars for ecological cultivation. The health condition of the trees of the evaluated cultivars was very good. Diseases and pests were not a serious problem in the cultivation of this species. Unfortunately, apricot flower buds were susceptible to damage from freezing during winter dormancy or in the spring during flowering, which was the reason why the apricot trees quite often failed to produce satisfactory yields. There were no significant differences in tree growth vigour between the cultivars 'Wczesna z Morden' and 'Harcot' in the ecological orchard, but they differed in terms of yield, fruit size, and fruit health status (Table 3). 'Wczesna z Morden' was a more productive cultivar and notable for healthier fruits than 'Harcot'. Fruits harvested from the trees of the two cultivars ripened in the last ten days of July, but not at the same time, so harvesting was carried out twice.

Table 3. Tree growth and yielding, and fruit quality of two apricot cultivars under ecological growth conditions

Cultivar	TCSA* [cm²] 2010	Cumulative yield 2008-2010** [kg/tree]	Productivity index [kg/cm²]	Fruit weight [g]	Fruit ripening date	% decaying fruit (brown rot)
'Harcot'	115.2 a	15.9 a	0.139 a	55.7 b	22-25.07	16.5
'Wczesna z Morden'	128.2 a	25.8 b	0.203 b	47.8 a	28-31.07	0

*- trunk cross-sectional area

**- no fruits in 2011

Prunus domestica and *Prunus salicina*

Ecological cultivation of plum trees was difficult. After eight years of growth in the orchard, the largest cross-sectional area of the trunk among the *P. domestica* cultivars was achieved by 'Cacanska Rana' (Table 4), and among the *P. salicina* cultivars – trees of the cultivar 'Shiro' (Table 5). The cumulative yields obtained in 2008-2011 were not satisfactory for any of the plum cultivars. The poor yields in 2009 were partly attributed to late spring frosts, and in 2010 and 2011 pollination was adversely affected by windy and rainy weather during flowering. Under those conditions, the best-yielding among *P. salicina* trees was the cultivar 'Vanier' (Table 4), and among *P. domestica* trees – 'Herman' (Table 5). The largest fruits were produced by the cultivar 'Żółta Afaska' (*P. domestica* L.) and 'Black Amber' (*P. salicina* Lindl.). The largest numbers of the plum moth colonized the fruits of the *P. salicina* cultivar 'Vanier', but strongly infested by it were also fruits of the cultivar 'Shiro'. Among the *P. domestica* cultivars, the largest numbers of the plum moth were found on the fruits of 'Żółta Afaska'. Fruits of the late ripening cultivars were usually more strongly affected by the pest than the fruits of the early ripening cultivars. The highest percentage of decaying fruits was observed in the yield of the cultivars 'Żółta Afaska' (*P. domestica* L.) (Table 4) and 'Vanier' (*P. salicina* Lindl.) (Table 5).

Table 4. Tree growth and yielding, and fruit quality of four *Prunus domestica* cultivars under ecological growth conditions

Cultivar	TCSA* [cm²] 2010	Cumulative yield 2008-2010	Productivity Index [kg/cm²]	Fruit weight [g]	Fruit ripening date	% damaged fruits	
						plum moth	brown rot
'Herman'	70.0 a	11.8 d	0.173 d	30.0 a	23.07	2.7 ab	3.2 a
'Cacanska Rana'	88.6 c	3.3 a	0.037 a	48.4 c	30.07	2.0 a	3.3 a
'Valjevka'	82.4 bc	5.1 b	0.063 b	33.8 b	10.09	5.3 b	2.0 a
'Żółta Afaska'	75.4 ab	9.9 c	0.136 c	62.8 d	10.09	17.3 c	28.8 b

*- trunk cross-sectional area

**- no fruits in 2011

Table 5. Tree growth and yielding, and fruit quality of four *Prunus salicina* cultivars under ecological growth conditions

Cultivar	TCSA* [cm²] 2010	Cumulative yield 2008-2010**	Productivity Index [kg/cm²]	Fruit weight [g]	Fruit ripening date	% damaged fruit	
						plum moth	brown rot
'Najdiena'	71.5 b	13.5 c	0.191 c	39.2 a	30.07-06.08	1.3 a	8.5 a
'Shiro'	112.7 d	10.6 b	0.095 b	50.7 b	07-10.08	16.7 b	19.3 b
'Vanier'	50.6 a	23.9 d	0.488 d	50.9 b	21-25.08	44.5 c	28.5 c
'Black Amber'	82.4 c	4.3 a	0.053 a	64.7 c	05.09	13.0 b	11.1 a

*- trunk cross-sectional area

**- no fruits in 2011

Discussion

The growth and yield of each tree species is influenced by many factors, but the most important are climatic conditions and the cultivar (Turcu et al., 1998). It was mainly unfavorable weather conditions during the flowering of the stone fruit trees that adversely affected their yielding in the Ecological Experimental Orchard in Nowy Dwór-Parcela. Moreover, in the absence of the traditional protection the weather conditions contributed to the trees becoming more strongly affected by pests and diseases. In the organic cultivation of sweet cherry, the most problems were caused by the cherry fruit fly, although aphids were also a troublesome pest. This is confirmed by the observations of Badowska-Czubik et al. (2010). The cherry fruit fly, while laying its eggs, destroys the skin of the fruits, making them more susceptible to infection with brown rot. The fruit crops of those varieties of sweet and sour cherry that were more numerously inhabited by the larvae of the cherry fruit fly also contained a greater percentage of rotting fruit. These results are consistent with those obtained by Stamenkovic et al. (1996) in experiments carried out in former Yugoslavia.

In the case of plum trees, the quality of the fruits was determined by the extent to which they were infested by the plum moth and infected with brown rot. According to Rozpara et al. (2010), there is a chance of solving the plum moth problem in ecological orchards because the product SpinTor 240 SC used against this pest in the experiments in the Ecological Experimental Orchard in Nowy Dwór-Parcela has shown satisfactory performance. Spray treatments against the brown rot disease have been carried out with copper preparations registered for use in organic cultivation of stone fruit trees (Śliwa & Wiercińska, 2009). However, during the years favourable to the development of the disease they were not sufficiently effective in the cultivars susceptible to infection.

Conclusions

The presented results indicate that:

1. Ecological cultivation of stone fruit trees in Poland is possible provided that the appropriate location of the orchard, the proper selection of cultivars and the use of preventive methods of protection against pests and diseases are all ensured.
2. Great usefulness for ecological cultivation is shown by apricot trees, which are relatively rarely affected by pests and diseases, and produce good quality fruit. Unfortunately, flower buds of this species are susceptible to damage from freezing during winter dormancy or during the flowering period in the spring, and fruit yields of apricot trees are therefore quite often unreliable.

3. A serious pest of sweet cherry, making ecological cultivation difficult, is the cherry fruit fly. It does not affect the fruit of early ripening cultivars such as 'Karesova' and 'Burlat', and until an effective method of protection against this pest is developed, only sweet cherry cultivars of this type should be selected for ecological orchards.
4. Ecological cultivation of sour cherry is difficult because of the lack of an effective method of preventing tree infection by leaf spot and fruit infection by decay-causing diseases, as well as infestation by the cherry fruit fly. Despite these difficulties, the varieties denoted as W2/02, W10/02 and W12/02 perform relatively well in an orchard maintained by ecological means.
5. Many problems in the cultivation of plum can be avoided by choosing the right cultivar. Among the *P. domestica* cultivars, 'Herman', 'Cacanska Rana' and 'Valjevka' proved to be better in organic cultivation than 'Żółta Afaska', whose fruits were significantly more strongly affected by the plum moth and the brown rot disease.
6. Ecological cultivation of the cultivar 'Najdiena' was easier than the cultivation of the other cultivars of *P. salicina* because of its lower susceptibility to being affected by pests and diseases.

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