

GROWTH, YIELDING AND FRUIT QUALITY OF FOUR CULTIVARS OF THE JAPANESE PLUM (*Prunus salicina* Lindl.) UNDER ORGANIC ORCHARD CONDITIONS

Summary

In an experiment conducted in the years 2004-2013, the possibility of organic production of the fruit of four cultivars of the Japanese plum (*Prunus salicina* Lindl.) was evaluated at the Experimental Ecological Orchard in Nowy Dwór-Parcela (central Poland). The studied objects included trees of the cultivars 'Najdiena', 'Shiro', 'Vanier' and 'Black Amber' grafted onto Myrobalan seedlings. Under organic orchard conditions, the strongest growing trees were those of the cultivar 'Shiro' and the least vigorous those of 'Vanier'. The highest cumulative yields for the period 2006-2013 were obtained from the trees of the cultivars 'Najdiena' and 'Vanier'. 'Black Amber' trees were the lowest-yielding, but the fruits of this cultivar were the biggest. During harvesting, it was found that many fruits had lesions caused by diseases and pests. The extent of the injuries varied depending on the cultivar and the year of the study. The cultivar 'Vanier' was the most susceptible to infestation by the plum moth (*Laspeyresia funebrana*), and the least - the early ripening 'Najdiena'. Regardless of the year of the study, the highest percentage of decaying fruit due to infection by the brown rot of stone fruits was observed in the crop of the cultivar 'Vanier'. Among the four cultivars studied, the plum cultivar 'Najdiena' characterized by an early fruit ripening time was the most useful for organic orchards.

Key words: Japanese plum, cultivar, organic fruit production, fruit quality

WZROST, OWOCOWANIE ORAZ JAKOŚĆ OWOCÓW CZTERECH ODMIAN ŚLIWY JAPÓŃSKIEJ (*Prunus salicina* Lindl.) W WARUNKACH SADU EKOLOGICZNEGO

Streszczenie

W doświadczeniu prowadzonym w latach 2004-2013 w Ekologicznym Sadzie Doświadczalnym w Nowym Dworze – Parceli (centralna Polska) oceniano możliwość ekologicznej produkcji owoców czterech odmian śliwy japońskiej (*Prunus salicina* Lindl.). Przedmiotem badań były drzewa odmian: 'Najdiena', 'Shiro', 'Vanier' i 'Black Amber', szczepione na siewkach ałycz. Najsilniej w warunkach sadu ekologicznego rosły drzewa odmiany 'Shiro', a najslabiej drzewa odmiany 'Vanier'. Najwyższe sumaryczne plony za okres 2006-2013 uzyskano z drzew odmiany 'Najdiena' i 'Vanier'. Najslabiej plonowały drzewa odmiany 'Black Amber', ale owoce tej odmiany miały największą masę. W czasie zbiorów stwierdzono, że wiele owoców ma uszkodzenia spowodowane przez choroby i szkodniki. Stopień tych uszkodzeń był różny w zależności od odmiany oraz roku prowadzenia badań. Najbardziej podatna na porażenie przez owocówkę śliwkóweczkę (*Laspeyresia funebrana*) była odmiana 'Vanier', a najmniej wcześniej dojrzewająca 'Najdiena'. Niezależnie od roku badań, najwięcej gnijących owoców z powodu porażenia przez brunatną zgniliznę drzew pestkowych obserwowano w plonie odmiany 'Vanier'. Spośród czterech badanych odmian najbardziej przydatna do sadu ekologicznego okazała się śliwa 'Najdiena', charakteryzująca się wczesną porą dojrzewania owoców.

Słowa kluczowe: śliwa japońska, odmiana, ekologiczna produkcja owoców, jakość owoców

1. Introduction

The plum is a fruit species commonly grown in Poland. The dominant cultivated cultivars are those of the European plum (*Prunus domestica*), while the varieties of the Japanese plum (*Prunus salicina*) are less popular. The research conducted by [8] and [16] has shown, however, that cultivars of the Japanese plum are suitable for cultivation under the climatic conditions of central Poland. Unfortunately, it is difficult to grow plums in organic orchards [1, 4, 11, 12, 14, 18]. Serious problems are posed by pests and diseases that damage fruits, reducing their quality. The plum moth, whose larvae feed inside the fruit, is particularly dangerous under organic orchard conditions. During periods of persistent heavy rains many problems are caused by the brown rot of stone fruits.

An important role in the organic cultivation of plums is played by the selection of cultivars. Trees of the varieties recommended for organic plum orchards should be resistant

or low susceptible to diseases and pests. Fruit quality, i.e. size, colour, and good taste [22] are also of considerable importance.

The aim of the study was to determine the suitability of four cultivars of the Japanese plum for organic cultivation. Tree health status, growth and yielding, and fruit quality were assessed.

2. Material and methods

The experiment was established in the spring of 2004 at the Experimental Ecological Orchard in Nowy Dwór-Parcela near Skierniewice, on a sandy-loam podzolic soil, with a clayey subsoil. The following cultivars of the Japanese plum were selected for the experiment:

'Najdiena' – a cultivar characterized by a high tree productivity and very early fruit ripening time. The fruit is medium in size, round or slightly elongated. The skin is almost entirely covered with a pinkish-claret blush. The flesh is

yellow, medium firm, aromatic, tasty, adhering to a small stone.

‘Shiro’ – a cultivar that comes early into fruiting, yielding abundantly and regularly, with a medium-early fruit ripening time. Its fruits are medium-sized, heart-shaped, covered with a thin, yellow skin, without a blush. The flesh is yellow, quite compact, juicy and aromatic, adhering to the stone.

‘Vanier’ – a cultivar characterized by a high tree productivity and medium-early fruit ripening time. The fruit is medium in size, covered with a yellow or orange-yellow skin with a pinkish red blush. The flesh is quite soft, yellow, juicy and aromatic, with a hard-to-separate stone.

‘Black Amber’ – a cultivar with moderately productive trees and late fruit ripening time. Fruits are large, spherical, covered with a thin, dark-blue skin. The flesh is yellow, compact, tasty, aromatic. The stone is small, difficult to separate from the flesh.

The trees, grafted onto Myrobalan plum seedlings, were planted at a spacing of 4.5 × 3.5 m, in four replicates, with five trees per plot. For the first two years the orchard soil was maintained in mechanical fallow. From the third year on, mechanical fallow was continued in the rows of trees, while self-seeded grass was introduced in the interrows. The tree crowns were trained in the shape of a spindle. Since 2007, the trees have been irrigated with a drip system. Two or three treatments with a copper preparation (Miedzian 50 WG or Miedzian Extra 350 SC) against diseases were performed every year. The programme for the protection of the plum trees against pests included one treatment with Treol 770 EC or Promanal 60 EC against the red spider mite (*Panonychus ulmi*) and the brown scale (*Parthenolecanium corni*). Aphids were controlled by performing from one to several treatments, depending on the severity of the pest, with a mixture of Bioczos and horticultural soap. In 2009, 2010 and 2012, 2-3 treatments with the bacterial preparation SpinTor 240 SC were performed against the plum moth (*Laspeyresia funebrana*).

The health status and growth vigour of the trees were assessed each year, and after they had come into fruiting – also the yield and quality of the fruit crop. The assessment of the susceptibility of the trees to frost and disease was carried out according to the methodology developed by COBORU in Słupia Wielka [13]. The thickness of the trunk was measured each year in a permanently marked place, at a height of 10 cm above the graft union. This was the basis for calculating the cross-sectional area of the trunk. Once the plum trees had come into fruiting, fruit yield and fruit ripening time were recorded every year, separately for each tree. Fruit weight was determined on the basis of a sample of 400 fruits taken randomly from each replication (4 × 100 fruits). Similar samples (4 × 100 fruits) were taken to assess fruit infestation by the plum moth (*Laspeyresia funebrana*) and infection with the brown rot of stone fruits.

The results were statistically analyzed using variance analysis in the Statistica 13 program. To assess the differences between mean values, the Duncan test was used, assuming a significance level of 0.05.

3. Results

3.1. Trees health status

In the first years after planting, the health condition of the Japanese plum trees was good. However, symptoms of the shot-hole disease (*Clasterosporium carpophilum*) were observed on the leaves every year. The disease developed especially in warm and rainy years. The ‘Black Amber’ trees were the worst affected, but the symptoms were also observed on the trees of the other cultivars. The weakened trees were less resistant to frost and susceptible to infection with leucostoma canker (*Leucostoma cincta*, *Leucostoma persoonii*), which initially manifested itself in underdeveloped and wilting leaves, and consequently caused withering of whole trees. For this reason, after the winter of 2008/2009 with temperatures dropping to as low as -22.5°C, 1 tree of the cultivar ‘Najdiena’, 2 trees of the cultivar ‘Vanier’, and 4 trees of the cultivar ‘Black Amber’ were lost. Subsequently, losses of more trees were observed after the winters of 2009/2010, 2010/2011 and 2011/2012 with temperatures dropping to -26, -20 and -23°C respectively (Tab. 1).

3.2. Tree growth and yielding

The cross-sectional area of the trunk (TCSA) of the four cultivars of the Japanese plum is shown in Table 2. The ‘Shiro’ trees were the most vigorous under the organic orchard conditions were the ‘Shiro’ trees and the least vigorous the ‘Vanier’ trees.

The first fruits of the evaluated Japanese plum cultivars grafted onto Myrobalan seedlings were harvested in the third year after planting. In 2007, there were spring frosts which caused no fruiting by the trees of the cultivar ‘Black Amber’ and poor yielding by the trees of the other cultivars. Late spring frosts also had an adverse impact on the yielding of the plum trees in 2009. The reduction in fruit yield in the organic orchard in 2010 was a result of damage to fruitlets caused by plum sawflies (*Hoplocampa minuta* and *Hoplocampa flava*). In addition, pollination and fruit setting were adversely affected by windy and rainy weather during flowering. Similar conditions occurred at the time of flowering of the Japanese plum cultivars in 2011. In 2012, the year most favourable to plum tree yielding, from nearly 3 to over 24 kg of fruit, depending on the cultivar, was collected from a single tree (Tab.2). The highest cumulative yields were obtained from the trees of the cultivars ‘Najdiena’ and ‘Vanier’. The trees of ‘Black Amber’ were the lowest-yielding (Tab. 2).

Table 1. Lost trees of four cultivars of the Japanese plum (number of trees per year) under organic orchard conditions
Tab. 1. Wypadki drzew 4 odmian śliwy japońskiej (szt./rok) w warunkach sadu ekologicznego

Cultivar	2008	2009	2010	2011	2012	2013	Total*
Najdiena	0	1	5	5	1	0	12
Shiro	0	0	2	6	4	0	12
Vanier	1	2	1	5	2	0	11
Black Amber	0	4	3	3	4	1	15

* the number of trees of each cultivar planted was 20

Source: own work / Źródło: opracowanie własne

Table 2. Tree growth and yielding of four *P. salicina* cultivars under ecological growth conditions
 Tab. 2. Wzrost i plonowanie 4 odmian śliwy japońskiej w warunkach uprawy ekologicznej

Cultivar	TCSA [cm ²] 2013	Yield [kg tree ⁻¹]						Total yield 2006-2013
		2006-2008	2009	2010	2011	2012	2013	
Najdiena	118,8 b	4,6 a	9,1 b	0,1 c	8,5 a	16,1 b	14,0 a	52,4 a
Shiro	169,9 a	4,3 a	5,4 c	0,5 b	2,6 b	24,3 a	6,8 b	44,0 b
Vanier	78,2 c	2,3 b	21,7 a	1,3 a	4,3 b	12,0 b	13,3 a	54,8 a
Black Amber'	113,3 b	1,4 b	1,3 d	1,2 a	2,6 b	2,9 c	4,8 b	14,3 c

* TCSA – trunk cross-sectional area

Source: own work / Źródło: opracowanie własne

3.3. Fruit ripening time and fruit quality

Fruits of the earliest cultivar 'Najdiena' ripened in the last ten days of July, and those of the latest-maturing cultivar 'Black Amber' in the second decade of September (Tab. 3).

The largest fruits were produced each year by 'Black Amber', and the smallest ones – by 'Najdiena' (Tab. 3). Fruit size was largely influenced by the weather conditions during the fruit setting and ripening period in the individual years of the study.

During harvesting, it was found that many fruits had lesions caused by diseases and pests. The highest percentage

of fruit damaged by the plum moth was recorded in 2011 (Tab. 4). In 2009, 2010 and 2012, the level of infestation by this pest was significantly lower. This was caused by the use of the preparation SpinTor 240 SC. The cultivar 'Vanier' was the most susceptible to infestation by the fruit plum moth was the cultivar 'Vanier', and the least susceptible the early ripening 'Najdiena' (Tab. 4).

The most extensive rotting of fruit due to infection with the brown rot of stone fruits was observed in 2010-2011, and was caused by relatively low temperatures and abundant rainfall persisting during fruit ripening. Regardless of the year of the study, the highest percentage of decaying fruit was observed in the cultivar 'Vanier' (Tab. 5).

Table 3. Fruit ripening date and fruit weight of four *P. salicina* cultivars under ecological growth conditions
 Tab. 3. Termin dojrzewania i masa owoców 4 odmian śliwy japońskiej w warunkach uprawy ekologicznej

Cultivar	Fruit ripening date	Fruit weight [g]						Mean fruit weight
		2008	2009	2010	2011	2012	2013	
Najdiena	25-28.07	35,4 c	44,6 c	35,3 c	35,3 c	29,5 b	29,0 c	35,0 c
Shiro	2-5.08	49,1 b	54,1 b	48,9 b	43,8 b	29,7 b	34,0 b	43,3 b
Vanier	20.08	48,8 b	52,9 b	43,4 b	43,9 b	34,0 b	35,8 b	43,1 b
Black Amber	12.09	72,5 a	56,9 a	64,3 a	59,0 a	64,2 a	55,8 a	62,1 a

Source: own work / Źródło: opracowanie własne

Table 4. Degree of infestation of four *P. salicina* cultivars by larvae of the plum moth under ecological growth conditions
 Tab. 4. Stopień porażenia owoców 4 odmian śliwy japońskiej przez owocówkę śliwkóweczkę w warunkach uprawy ekologicznej

Cultivar	Number of fruits with plum moth larvae [%]						Mean 2008-2013
	2008	2009*	2010*	2011	2012*	2013	
Najdiena	3,0 c	1,0 c	0,0 c	37,3 c	9,3 c	1,5 d	8,7 d
Shiro	19,0 b	20,0 b	11,0 b	51,3 b	13,5 b	36,7 c	25,3 c
Vanier	46,0 a	43,0 a	31,0 a	92,2 a	19,0 a	57,3 b	48,1 a
Black Amber	26,0 b	8,9 c	32,8 a	84,3 a	14,5 b	77,8 a	40,7 b

* after 3-times treatments with SpinTor 240 SC against the plum moth

Source: own work / Źródło: opracowanie własne

Table 5. Degree of infection of four *P. salicina* cultivars with the brown rot disease under ecological growth conditions
 Tab. 5. Stopień porażenia owoców 4 odmian śliwy japońskiej przez brunatną zgniliznę w warunkach uprawy ekologicznej

Cultivar	Number of fruits infected with brown rot [%]						Mean 2008-2013
	2008	2009	2010	2011	2012	2013	
Najdiena	0,0 c	2,3 d	23,3 c	5,8 d	10,3 b	0,0 c	6,9 d
Shiro	7,5 b	11,3 c	39,3 b	46,5 c	11,5 b	17,8 b	20,8 c
Vanier	21,8 a	35,3 a	91,0 a	92,3 a	24,3 a	53,8 a	49,7 a
Black Amber	0,0 c	22,3 b	83,5 a	62,1 b	12,8 b	58,3 a	39,8 b

Source: own work / Źródło: opracowanie własne

4. Discussion

The growth and yielding of plum trees is influenced by many factors, but the most important ones are the cultivar, rootstock [10, 15, 17, 19] and climatic and soil conditions [20]. The choice of cultivar is important for all types of orchards, and in particular for organic orchards because of the limited number of plant protection products allowed for use on such crops [2, 4-6, 11, 12, 21]. Four cultivars of the Japanese plum: 'Najdiena', 'Shiro', 'Vanier' and 'Black Amber', which had performed well in integrated cultivation [9, 16], were chosen for the experiment under organic orchard conditions. Garcia-Gavalis et al. [3] reported considerable differences in the severity of disease infection and pest infestation among more than a dozen varieties of the Japanese plum evaluated in the climatic conditions of Spain. This is confirmed by our own research, in which, under organic orchard conditions, the cultivar 'Najdiena' performed better than the other cultivars. Its fruits were the least susceptible to decay and infestation by the plum moth, and in terms of size were not inferior to fruits from integrated cultivation. By contrast, fruits of the cultivar 'Vanier' were markedly smaller than those in the collection located in the Experimental Orchard in Dąbrowice [8].

Climatic conditions are another important factor affecting the yield and quality of plum fruit. In 2010, windy and rainy weather persisting during flowering was not conducive to pollination and contributed to plum sawflies (*Hoplocampa minuta* and *Hoplocampa flava*) damaging, depending on the cultivar, from 25 to 60% of plum fruitlets. Rozpara et al. [19] reported that the number of trapped Hymenoptera insects per one white sticky trap did not exceed, at that time, the accepted risk threshold, so with a large fruit yield such a population of sawflies would probably not be a problem. In addition to sawflies, the plum moth is a serious pest of plum trees in Polish climatic conditions. Rozpara et al. [18] demonstrated that SpinTor 240 SC used in experiments located in the Experimental Ecological Orchard in Nowy Dwór-Parcela considerably reduced the population of this pest. This is confirmed by the results of our own research. In 2009, 2010 and 2012, the percentage of fruit affected by the plum moth was significantly lower than in 2008, 2011 and 2013, when the above-mentioned preparation was not used. Since 2013, SpinTor 240 SC is not authorized for use on fruit crops. Atmospheric conditions influence the extent to which plum trees become infected with the brown rot of stone fruits. Grabowski [7] reports that infections caused by fungi of the genus *Monilinia* tend to occur on mechanically damaged fruit at moderate temperatures and large amounts of precipitation. Our results are consistent with the literature. In the discussed experiment, with hot weather and infrequent rainfall during plum ripening in 2008, 2009 and 2012 the development of fungal infections was observed, but their incidence was significantly lower than in 2010, 2011 and 2013, when temperatures were lower and rainfall occurred more frequently. The brown rot of stone fruits was controlled by spraying with copper preparations registered for use in the organic cultivation of plums. However, in the years conducive to the development of the disease they were not sufficiently effective, especially for the cultivars 'Vanier', 'Black Amber' and 'Shiro'.

5. Summary and conclusions

1. 'Najdiena' was the best performing cultivar in organic cultivation, its trees yielded regularly, and the extent of fruit decay and infestation by the plum moth was the lowest.
2. 'Shiro' and 'Vanier' trees yielded fairly regularly, but the quality of the fruit was unsatisfactory because it was susceptible to damage by the plum moth and the brown rot of stone fruits.
3. 'Black Amber' is not suitable for organically grown orchards because of its high susceptibility to diseases, especially the shot-hole disease of stone-fruit trees, poor yielding and high susceptibility of the fruit to infestation by the plum moth and pathogens causing fruit decay.

6. References

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