THE GROWTH, YIELDING AND RESISTANCE TO SPRING FROST OF NINE SOUR CHERRY CULTIVARS IN CENTRAL POLAND

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A B S T R A C T

The experiments were carried out in 2005-2007. The aim of the study was the evaluation of the growth and yielding of sour cherry cultivars in central Poland. The explored cultivars differed in vigour, cropping and also in response to spring frost. The most vigorous, indicated by the trunk cross-sectional area (TCSA), length of one--year shoots and leaf area, were 'Sabina', 'Lucyna', 'Karneol' and 'Újfehértói Fürtös'. The weakest in vigour were 'Northstar', 'Schattenmorelle IR-2' and 'Koral'. The best fruit set was observed in 'Schattenmorelle IR-2' and the worst in 'Karneol'. The cultivars 'Lucyna', 'Schattenmorelle IR-2', 'Sabina' and 'Vowi' gave the highest yield per tree. 'Karneol', 'Újfehértói Fürtös', 'Northstar' and 'Debreceni Bötermö' gave the lowest yield per tree. The greatest damage by the spring frosts of 2007 was observed in the following cultivars: 'Lucyna', 'Debreceni Bötermö', 'Karneol' and 'Sabina'. The most resistant to spring frosts turned out to be 'Northstar' and 'Schattenmorelle IR-2'.

Key words: sour cherry, cultivars, growth, yield, spring frost

INTRODUCTION

The sour cherry (*Prunus cerasus*) is the one of the most cultivated species in Poland. They are popular because of their frost resistance, reliable yields and the great market demand for sour cherry fruits as well. The production of this species has developed dynamically during the last few years. In the Polish National List of Varieties of Fruit Plants there are a dozen or so of new cultivars of sour cherry at present. But most of them do not play much of a role in commercial production. The advantages of

of those cultivars is the earlier maturity of the fruit compared with 'Schattenmorelle', and their fruit presence on the fresh fruit market.

Poland produces about 30% of the sour cherries in Europe. Countries like Hungary, Germany and Serbia are also important producers of sour cherries on our continent. These countries also carry on research aimed at cultivating new sour cherry cultivars. Hungarian scientists gained a huge success in this field (Apostol, 2007). The research on the selection of new cultivars in Hungary began about 60 years ago and several years later they registered the first cultivars there. The main goals of the Hungarian research are the attainment of cultivars in which the maturity time of fruits differentiate, and the attainment of cultivars with high quality fruit in which the fruit can be used on the fresh market and also in processing. Among the cultivars produced in Hungary only a few are used in Poland ('Pandy 103', 'Újfehértói Fürtos', 'Debreceni Bötermö'). Most of the Hungarian cultivars exhibit strong growth and bear fruits late. This would cause poor yields in Poland (Grzyb, 2003).

Poland has also played an important role in varying the assortment of sour cherry cultivars. In the first half of the nineties new Polish cultivars were registered in the Polish National List of Varieties of Fruit Plants. The new Polish cultivars were bred at two Polish institutes: the Research Institute of Pomology in Skierniewice – 'Sabina', 'Lucyna'®, 'Wanda' and 'Koral'®, and at University of Horticulture in Poznań – 'Agat', 'Diament', 'Dradem' and 'Ametyst'.

The aim of the study was to evaluate the growth, intensify of yielding and the resistance to spring frosts of some sour cherry cultivars in central Poland.

MATERIAL AND METHODS

The experiments were carried out in 2005-2007. The material was the 9 cultivars of sour cherry. Six of them were planted in the spring of 2001. They were: 'Schattenmorelle IR-2' (British type of 'Schattenmorelle'), 'Koral' (Poland), 'Debreceni Bötermö' and 'Újfehértói Fürtös' (Hungary), 'Karneol' and 'Vowi' (Germany). The three remaining cultivars were planted in the spring of 2002. They were: 'Sabina', 'Lucyna' (Poland) and 'Northstar' (USA). All cultivars were examined for vigour, leaf area, yielding, and resistance of the flowers and fruit primordia to spring frost. Vigour was indicated by the trunk cross--sectional area (TCSA) and the length of one-year shoots. The leaf area was measured on Li–Cor planimeter. It determined the percentage of fruit set. The yield was counted in kilograms from each tree. The cropping efficiency coefficients (CEC) were calculated as a ratio of the yield to the TCSA in the same year. The frost damage in 2007 made it impossible to count the percentage of fruit set and yield that year. The resistance of the cultivars to spring frost was evaluated by the percentage of frozen flowers and fruit primordia.

The results were analyzed statistically with the Statgraphics® *Plus* 4.1 program using one-way analysis of variance. Significant differences among treatment means were evaluated using the Newman-Keuls test at $p = 0.05$

RESULTS AND DISCUSSION

The growth of the trees

In the pomological research the trunk cross-sectional area (TCSA) is the generally used index to define the vigour of the trees (Szczepański and Rejman, 1987). Among the trees planted in 2001, the highest vigour in 2005-2007 was observed in 'Karneol' (60 cm^2) and 'Újfehértói Fürtös' (58 cm^2) (Tab. 1). The smallest TCSA was noted in 'Schattenmorelle IR-2' – 44 cm^2. There were no differences in the cultivars: 'Koral', 'Debreceni Bötermö' and 'Vowi' in TCSA during the three years of research.

Among the cultivars planted in 2002, 'Lucyna' and 'Sabina' had a similar TCSA; there were no significant differences between them. But the 'Northstar' cultivar had a significantly smaller TCSA compared with the Polish cultivars. This data does not confirm Rozpara's (1998) results stating that 'Lucyna' has higher vigour than 'Sabina'. But the information about the low vigour of the 'Northstar' cultivar, which was confirmed in our results, has been known for a long time (Rembacz, 1994).

In the case of trees planted in 2001, there were only significant differences in the length of one-year-old shoots between examined cultivars in 2006 (Tab. 1). The longest one-year-old shoots in 2006 were on trees of the 'Karneol' cultivar – about 35 cm, and the shortest were on trees of the 'Koral' cultivar – about 12 cm. It was also found that the longest one-year-old shoots were found in every cultivar in 2007. The average length of one-year-old shoots in 2007 was above 30 cm in each cultivar.

The trees which were planted one year later, in 2002, did not show any differences in 2005 and 2006 in the length of one-year-old shoots. Whereas significant differences were observed in 2007 when the longest shoots were created by the 'Lucyna' cultivar and the shortest by the 'Northstar'.

It was found that all trees, except the 'Northstar' cultivar, had the highest vigour in 2007. The reason for this may have been the spring frosts which appeared that year. Almost all of the trees completely lost their yield. In the case of the 'Northstar' cultivar about 40% of the flowers were saved from frost. During fruit growth there is an insufficient quantity of metabolites in a plant. It causes competition in some parts of the plant. A lot of active top merystems, cambium, seeds, and fruit primordia compete between each other over for metabolites (Plich, 1984). Wertheim (1973, cited by Plich, 1984) said that the dropping of the primordia is higher in situations where there is a strong vegetative shoot on the branch. Quinlan and Preston (1968, cited by Plich, 1984) found that after removing the flowers or fruit primordia of the trees, the

Table 1. Growth of sour cherry trees and the leaf area in 2005-2007

Cultivar	TCSA [cm^2]			Average length of one--year-old shoots [cm]			Leaf area [cm^2]		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Schattenmorelle IR-2	43.7 a*	44.2 a	46.1 a	24.0 a	24.3 abc	34.0 a	28.5bc	30.7 a	38.3 ab
Koral	45.9 a	51.0 ab	54.0 ab	25.8 a	12.2 a	32.1 a	24.0 a	28.3 a	34.3 a
Debreceni Bötermö	47.3 a	52.2 ab	55.4 ab	24.0 a	17.2 ab	32.0 a	32.7 c	39.6 c	46.3 c
Újfehértói Fürtös	53.9 ab	57.8 a	62.0 b	32.6 a	26.6 abc	36.4 a	32.1 c	37.1 bc	51.3 d
Karneol	58.7 b	60.0 a	61.0 b	31.0 a	35.1 c	35.5 a	32.4 c	41.5 c	41.7 b
Vowi	48.2 a	51.5 ab	53.0 ab	31.1 a	23.3 abc	30.6 a	23.6 a	29.8 ab	37.2 ab
Lucyna	75.5 b	79.2 b	84.5 b	21.3 a	25.2 a	29.5 b	30.8 b	30.2 b	39.1 c
Northstar	29.1 a	30.0 a	31.1 a	22.6 a	22.2 a	22.0 a	19.5 a	20.2 a	21.9 a
Sabina	73.2 b	75.8 b	79.1 b	35.4 a	28.3 a	38.7 c	28.9 b	28.7 b	35.1 b

*Mean values within the column marked with the same letters are not significantly different at p = 0.05

longest increase in shoots took place and vice versa. Our experimental data are consistent with the results obtained by other authors. It can be concluded that after losing the fruit primordia caused by the spring frosts, the competitiveness over metabolites in the trees was considerably less and the plant could use these substances only for the growth of the vegetative parts.

The leaf area

The biggest leaf area of the first group of cultivars (planted in 2001) was noted in 'Újfehértói Fürtös', 'Debreceni Bötermö' and 'Karneol' (Tab. 1). For the whole research project the average leaf area of those cultivars was evaluated to be above 30 cm^2, and in 2007 the Újfehértói Fürtös cultivar reached more than 50 cm^2 of leaf area. The smallest leaves in 2007 were observed in the 'Koral' cultivar.

In the group of cultivars planted in 2002, the trees of 'Lucyna' and 'Sabina' during the whole research period had considerably bigger leaves compared with the 'Northstar' cultivar. Both Polish cultivars were characterized by similar leaf areas in the years

2005-2006. Only in 2007 did the cultivar 'Sabina' have significantly smaller leaves than the 'Lucyna' cultivar.

The yielding indexes

Lech (1984) said that a satisfactory yield from sour cherry trees can be obtained when 30% of the flowers set fruit. According to Hungarian researchers (Nyéki et al., 1997) a satisfactory yield can be obtained when 20% of the flowers set fruit.

Among the trees planted in 2001, the cultivar 'Schattenmorelle IR-2' set fruit very well (above 30%), which undoubtedly had the influence on high yielding of this cultivar - almost 11 kg/tree (Tab. 2). In results presented by Ugolik and Kantorowicz-Bąk (1992), the cultivar 'Schattenmorelle IR-2' is characterized as being high yielding as well. Rozpara (2000) also said that it is the one of the most valuable cultivars which can be used in commercial orchards and it is reliable in yielding. The cultivar 'Koral' and 'Schattenmorelle IR-2' gave similar effects in fruit setting and yielding. For the two years of this research project 'Koral' set an average of about 33% fruit, and its yield average above 8 kg/tree. The cultivars 'Vowi' and 'Debreceni Bötermö' were also characterized as having good fruit setting. Each of them set an average of 23% fruit during the two year research period. The second Hungarian cultivar – 'Újfehértói Fürtös' set less fruit compared with 'Debreceni Bötermö,' but in 2006 there were no significant differences between them. The worst fruit set was observed in the 'Karneol' cultivar. It did not set much fruit above 4%, and probably that was the cause of poor yielding. The yield in 'Karneol' both in 2006 and 2007 did not exceeded 2 kg tree^{-1}. Poor yielding was noted also in the cultivar 'Újfehértói Fürtös'. The average from the two years of research was about 2.5 kg tree^{-1}. 'Debreceni Bötermö' had a yield of about 1.5 kg higher than 'Újfehértói Fürtös'. The average yield in the 'Vowi' trees was almost 10 kg tree^{-1}.

When evaluating the yielding of cultivars, it is necessary to take into consideration the cropping efficiency coefficients (CEC), which are the measure of productivity of the tree. In 2005 the cultivar 'Schattenmorelle IR-2' was unbeatable in CEC, but in 2006 such cultivars like 'Vowi' and 'Koral' were characterized by a CEC as high as 'Schattenmorelle IR-2'. The lowest CEC in 2005 was noted in 'Karneol' trees and in Hungarian cultivars as well. In 2006 the cultivar 'Debreceni Bötermö' had a significantly higher level of productivity than the cultivars 'Karneol' and 'Újfehértói Fürtös'.

All trees planted in 2002 were characterized by a good fruit setting (Tab. 2). Polish cultivars also showed a good yield. Only the trees of the 'Northstar' cultivar gave a considerably lower yield compared with the remaining cultivars despite having a good fruit setting. Taking into consideration the CEC of the 'Northstar' cultivar, we can see that its trees in 2006 were more productive than 'Sabina'. There were no significant differences in the productivity of 'Northstar' and 'Lucyna' trees in 2006.

Table 2. Yielding indexes of sour cherry cultivars in 2005-2006

Cultivar	Fruit setting [%]			Yield [kg tree^{-1}]			CEC	
	2005	2006	Average in 2005-2006	2005	2006	Average in 2005-2006	2005	2006
Schattenmorelle IR-2	33.6 e*	54.3 d	44.0	13.6 c	8.2 bc	10.9	0.31 c	0.18 c
Koral	33.6 e	31.4 c	32.5	8.8 b	8.0 bc	8.4	0.19 b	0.15 c
Debreceni Bötermö	22.5 cd	24.0 b	23.3	2.6 a	5.3 ab	4.0	0.06 a	0.10 b
Újfehértói Fürtös	14.9 b	21..3 b	18.1	2.5 a	2.7 a	2.6	0.04 a	0.05 a
Karneol	11.4 a	3.3 a	7.4	1.2 a	1.8 a	1.5	0.02 a	0.03 a
Vowi	24.5 d	225 b	23.5	9.1 b	10.2 c	9.7	0.18 b	0.19 c
Lucyna	37.8 b	41.2 b	39.5	15.5 b	14.4 c	15.0	0.20 b	0.18 b
Northstar	19.8 a	40.9 b	30.4	3.2 a	4.65 a	3.9	0.11 a	0.15 b
Sabina	37.5 b	35.7 a	36.6	13.1 b	8.53 b	10.8	0.18 b	0.11 a

*Explanation, see Table 1

Of the remaining yielding indexes the 'Lucyna' requires attention. Despite the fact that its trees are younger than 'Schattenmorelle IR-2', it still gave the highest yield and it seems to be the most promising of all the examined cultivars. Grzyb (2003) thinks that its fruits have high dessert value. Its fruits mature earlier than 'Schattenmorelle', and this could make the supply of cherry fruit last longer in Poland. This means it is likely to also obtain a higher price for its fresh fruit. The Polish cultivar 'Sabina' gave a yield that was similar to 'Schattenmorelle' as well. The cultivars 'Vowi' and 'Koral' are also of interest. They are characterized as having a yield comparable to 'Schattenmorelle'.

The Hungarian's cultivars, which are shown by many scientists as cultivars for the fresh market, do not bear well nor yield well in Poland. From the preliminary research of Szpadzik et al. (2008) it follows that they need pollinators to give a satisfactory yield. Those authors think that good pollinators for them are the 'Koral' and 'Schattenmorelle' cultivars. After using the pollen of these two cultivars as pollinators, the cultivar 'Debreceni Bötermö' set above 34% of fruits in each situation, and 'Újfehértói Fürtös' set above 21% of the fruits in both combinations. The scientists claim that the matter of pollination and fertilization of the flowers is very complicated, and they are to a great extent dependent on the climate. It is necessary to confirm the Hungarian ideas about pollinators by further research in Poland.

The resistance to spring frosts

The year 2007 was unfavourable for fruit-growing in central Poland because of the meteorological conditions. After a short, smooth, snow-free winter period, the spring frosts appeared at blooming time. In addition, there was a big temperature fluctuation between day and night at that time. During the first frost (21-22.04 and 22-23.04) the temperatures went down to –4˚C. Cultivars: 'Koral', 'Debreceni Bötermö', 'Újfehértói Fürtös', 'Lucyna', and 'Sabina' were in a full bloom phase then ('Sabina' and 'Lucyna' started flowering on 17.04 and finished on 25.04; 'Debreceni Bötermö', 'Újfehértói Fürtös' flowered from 19 to 29.04; 'Koral' from 22 to 27.04). The remaining cultivars were in the white bud phase, just before the flowering. They started their blooming period on 24.04 ('Karneol'), 25.04 ('Schattenmorelle' and 'Vowi') and finished on 30.04. The whole blooming period lasted 14 days. Among the cultivars planted in 2001 an average of over 14% of damaged flowers was noted during that spring frost (Tab. 3). The greatest damage was observed in the 'Vowi' cultivar and the least in 'Schattenmorelle IR-2'. The later spring frosts (30.04-1.05; 1-2.05 and 2-3.05; 3-4.05) with temperatures below –5˚C appeared when all cultivars were in the fruit primordia growth phase. An average of 92% of the fruit primordia were damaged in cultivars from the first group. The most damage was noted then with the primordia of fruits in Hungarian cultivars (with an average above 95% of fruit primordia damaged) and 'Karneol' cultivar (2% more of fruit primordia damaged). Grzyb (2003) agrees with this data and believes that Hungarian cultivars should be cultivated in an area not threatened with spring frosts, because their yielding depends on the weather during the blooming period.

In the case of the trees planted one year later, the most damage after their first spring frost period was observed on the flowers of the 'Sabina' cultivar and the least in 'Northstar' flowers (Tab. 3). The damage to the flowers in all cultivars planted in 2001, reached the average of 28% then. After the next spring frosts the greatest damage of fruit primordia was noted in the 'Lucyna' cultivar. The trees of 'Sabina' had only 2% less damage compared with 'Lucyna'. The most resistant to the spring frost, both from the cultivars planted in 2002 and in 2001, turned out to be the trees of the 'Northstar' cultivars. Above 40% of its fruit primordia survived.

According to Hungarian scientists (Szabó et al., 1993), when the temperature is below –2.5˚C during the full bloom period, it can cause 100% frost damage to the flowers. But they also added that even a 50% frost damage can guarantee a satisfactory yield. Results of the research showed that an average of 77.4% of flowers survived during the frost when the temperature was –4˚C. Above 90% of the damage was observed in the fruit primordia after the second spring frost at the beginning

Table 3. Frost damage on our cherry cultivars in 2007

Cultivar	The first frost. Damage of flowers [%]	The second frost. Damage of fruit primordia [%]
Planted in 2001		
Schattenmorelle IR-2	13,2	83
Koral	17	90
Debreceni Bötermö	17	97
Újfehértói Fürtös	18	94.5
Karneol	22	97
Vowi	32	95
Planted in 2002		
Lucyna	28.5	98.5
Northstar	21	59.2
Sabina	34.5	96.5
Average	22.6	90.1

of May (with temperatures below –5˚C). This data is in agreement with the results of Hołubowicz (2006) that the fruit primordia just after blooming time are the most sensitive to frost.

CONCLUSIONS

1. The Hungarian cultivars are not competitive with the small-in--vigour and high yielding cultivar 'Schattenmorelle'.
2. Promising cultivars which could fill the niche in the Polish sour cherry fruit market in the first half of July seem to be the early Polish cultivars: 'Koral', 'Lucyna' and 'Sabina'.
3. Low temperature (–4˚C) during the blooming time does not cause complete damage to the flowers and a chance for a good yield is still possible.
4. Low temperature (–5˚C) shortly after the blooming period can cause damage to almost all fruit primordia and not leave the chance for a good yield.

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WZROST, PLONOWANIE I WYTRZYMAŁOŚĆ NA PRZYMROZKI DZIEWIĘCIU ODMIAN WIŚNI W WARUNKACH CENTRALNEJ POLSKI

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S T R E S Z C Z E N I E

Badania nad wzrostem i plonowaniem 9 odmian wiśni (‘Łutówka – IR-2’, ‘Koral’, ‘Debreceni Bötermö’, ‘Újfehértói Fürtös’, ‘Karneol’, ‘Vowi’, ‘Sabina’, ‘Lucyna’ i ‘Notrhstar’) prowadzono w latach 2005-2007 w Sadzie Doświadczalnym Katedry Sadownictwa SGGW w Warszawie-Wilanowie. Celem badań była ocena cech morfo-

logicznych odmian wiśni w centralnej Polsce. Badane odmiany różniły się siłą wzrostu, plonowaniem, a także wytrzymałością na przymrozki wiosenne. Najsilniejszym wzrostem wyrażonym w przyroście pola przekroju poprzecznego pni (PPPPP) i długości jednorocznych przyrostów oraz największymi liśćmi cechowały się odmiany: ‘Sabina’, ‘Lucyna’, ‘Karneol’ i ‘Újfehértói Fürtös’. Najsłabiej rosły drzewa odmian: ‘Northstar’, ‘Łutówka IR-2’ i ‘Vowi’. Najlepszym zawiązywaniem owoców spośród badanych odmian odznaczały się: ‘Łutówka IR-2’ i ‘Koral’, natomiast najmniej owoców zawiązywała odmiana ‘Karneol’. Drzewa odmian: ‘Lucyna’, ‘Łutówka IR-2’, ‘Sabina’ i ‘Vowi’ dawały najwyższy plon, a drzewa: ‘Karneol’, ‘Újfehértói Fürtös’, ‘Northstar’ i ‘Debreceni Bötermö’ plonowały słabo. Największe uszkodzenia mrozowe w 2007 roku odnotowano u odmian: ‘Lucyna’, ‘Debreceni Bötermö’ i ‘Sabina’. Najbardziej wytrzymałymi na przymrozki wiosenne okazały się natomiast odmiany ‘Northstar’ i ‘Łutówka IR-2’.

Słowa kluczowe: wiśnia, odmiana, wzrost, plon, przymrozki