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RESULTS AND ECONOMIC IMPORTANCE OF THE NORTH-EASTERN HUNGARIAN SOUR CHERRY LANDRACE CULTIVAR SELECTION

**Abstract of the thesis**

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## 1. Precedents and aims set

During the latest decades sour cherry growing became of primary importance in Hungary. As the result of the leading Hungarian sour cherry breeding, nearly all the cultivated cultivars are of domestic origin, so they can be considered as „hungaricums”. Fruit can be consumed either fresh or in processed form. Sour cherries are popular raw material of the processing factories.

In addition to canned fruits, significant amount of jam is produced from this fruit species, and the demand for deep frozen fruits is increasing, while the sweets and liqueur factories also process high quantities. Certain cultivars are used for making cosmetics, too. Due to it’s antioxidant content it is a component of several medicines produced abroad (USA).

Sour cherries have been well known in Hungary since the ancient times. The conquering Hungarians had been collecting it’s wild grown fruits, later on propagated from suckers and seeds. The Carpathian Basin can be considered as a secondary gene pool, because the parent species required for the sour cherries (sweet cherry and steppe cherry) could be found here. The abundance of sour cherry types that can be found in our country, and especially in North-Eastern Hungary is probably the consequence of spontaneous crossings.

Sour cherries grown in Hungary gained reputation in the market of the neighbouring countries centuries ago. This fame was established by the ‘Pándy meggy’. The disadvantage of this cultivar is the inadequate fertility resulting from self-sterility. The clone-group cultivation method developed by Brózik was based on planting cultivars that flower in the same time near each other tried to solve this problem. But in the practice it sometimes happened, that the same clone pair in another growing site flowered in different time. Yields increased significantly after the introduction of the self-fertile hybrids and landrace cultivars.

In the workshop of cross breeding (Horticultural Research Institute, Budapest) several self-fertile hybrids that suit market demands (’Meteor korai’,

’Érdi bőtermő’, ’Érdi jubileum’, etc.) were bred. In the Eastern part of the country the landrace selection work started, which resulted in the introduction of cultivars like ’Újfehértói fürtös’, ’Debreceni bőtermő’ and ’Kántorjánosi’ and it’s selected clone ’Kántorjánosi 3’.

The share of ’Érdi bőtermő’ and the three selected landrace cultivars in the Hungarian sour cherry propagation is more than 80%. The collection of canditate cultivars and evaluation is continued at the Research and Extension Centre for Fruitgrowing, Újfehértó.

The success of sour cherry growing is greatly influenced by climatic factors. The weather of the winter months and the flowering period determines the yield of the current growing season. The weather of our region is influenced by three main factors: the Atlantic, Mediterranean, and most by the Eastern-European effects.

In order to widely disseminate the results of our several decade long investigations we tried to publish only the most important findings.

1. Introducing the spreading and acknowledgement of the North-Eastern Hungarian landrace sour cherries.
2. Reviewing the growth characteristics of the cultivars.
3. Reviewing the most important phenological properties of the cultivars (duration of dormant period, date of bud burst, beginning and length of flowering, duration between flowering and fruit ripening, date of fruit ripening).
4. Comparing the self-fertility and open pollination of the cultivars.
5. Evaluating the productivity of the cultivars.
6. Presenting the cultivar characteristics influencing crop safety and analysing the climatic factors.
7. Presenting the main pomological properties of the fruits.
8. Investigating the storability and shelf life of the fruits.

# 2. Materials and methods

Since 1972 I am continuously doing cultivar research in my workplace, commercial orchards, home gardens and scattered orchards. We gradually included all the landrace sour cherry cultivars and types selected in North-Eastern Hungary into the investigations. Observations were carried out before the state recognition and after introducing the given cultivar to commercial production, that is a continuous work from the first year and it is still going on.

The trees of cultivars investigated at the Research Station of Újfehértó are cultivated under the same conditions (growing site, tree density, canopy form, phyto- and agro-technique, plant protection). Samples and data were collected from a randomised block design experimental orchard accepted by the National Institute for Agricultural Quality Control.

Data were processed with traditional statistical methods described by SVÁB, and evaluated using Microsoft Excel and SPSS 12.0 for Windows software.

## 2.1. Spreading and recognition of sour cherry cultivars

The commercial value of the investigated North-Eastern Hungarian sour cherry cultivars (easiness of nursery propagation, share of propagation, spreading in commercial production, etc.) was determined from nursery publications, published charts, domestic and foreign statistical data, and from market analysis published by the FruitVeB Hungarian Interprofessional Organization for Fruit and Vegetables.

## 2.2. Growth properties of the cultivars

When investigating the properties determining the growing value of the cultivars (tree size, growth characteristics, etc.) we relied on the publication of OMFI from 1976. Trunk circumference was measured 0.4 m above soil level in centimetres, while canopy dimensions were measured in decimetres.

## 2.3. The most important phenological properties of the cultivars

When determining the flowering time of the cultivars, we used the methods described by MALIGA (1961) and NYÉKI (1980). Ripening time of the fruits is expressed in days.

## 2.4. Comparative study of self-fertility and open pollination of the cultivars

The degree of self-fertility (autogamy) was determined in isolated flowers, so only own pollen could get to the stigma. Data is calculated after counting the number of fruits before harvest; when grouping the cultivars we used the scale elaborated by NYÉKI (1989). In case of open pollination the flowers can be fertilized by pollen originating from the neighbouring trees. It's degree is calculated according to the guidelines of BRÓZIK and NYÉKI (1980).

When choosing pollination partner we rely on cross pollination results. Before the opening of the flowers of the cultivar to be pollinated we remove the stamina of it's flowers, then we isolate the castrated flowers. After the opening of the isolation bag we apply viable pollen to the stigma with a brush, and we carefully reinstall the isolation bag. The number of fruits developing from the artificially pollinated flowers is counted three times, and fruit set resulting from cross pollination (expressed in %) is calculated.

## 2.5. Cropping potential of the cultivars

Yield was measured per tree and expressed in kilograms. Specific yield is calculated per trunk circumference and per canopy size.

## 2.6. Cultivar properties and climatic factors determining crop safety

The degree of winter frost damage of the flower buds and spring frost damage of the flowers is expressed in the percentage of intact and browned buds or flowers. Samples were randomly collected from the four cardinal points of the canopy and were investigated under stereo microscope.

The climatic data is originated from the premises of the Research and Extension Centre for Fruitgrowing, Újfehértó and was collected between 1965 and 2006. We observed the following weather data:

daily mean temperature (°C), daily maximum temperature (°C), daily minimum temperature (°C), daily level of precipitation (mm), daily number of sunny hours (h), daily mean relative humidity (%).

From the above data we calculated the following climatic parameters:

number of frosty days ($T_{min} < 0$ °C), number of frost-free days ($T_{min} > 0$ °C), absolute minimum temperature, absolute maximum temperature, maximum length of continuously frost-free periods, maximum length of continuously frosty periods, number of cooling down periods, number of precipitation-free ($p < 0.1$ mm) days, maximum length of continuously rainy periods, maximum length of continuously precipitation-free periods, number of days with more than 5 mm precipitation, number of days with relative humidity below 50%.

We investigated the changes of these variables, and calculated regression and correlation between 1965 and 2006.

## 2.7. The most important pomological properties and inner quality parameters of the fruits

The investigation of the market value (fruit size and weight, pit weight, stipulae coverage) of the fruits of selected cultivars was carried out according to the methodological publication issued in 1976 and titled „Observation method of fruit trees in cultivar trials". The most important inner quality parameters (dry matter content, sugar content, vitamin C content) were measured in the accredited laboratory of the University of Debrecen, Agricultural Centre, considering the relevant standards.

2.8. Storability and shelf life of the fruits

Storability and shelf life of the fruits was investigated during three years, between 2005 and 2007. Freshly picked fruits were stored either in M10 boxes or in plastic trays (0.5 kg) in different temperature and gas levels. We measured the weight loss of the fruits, in case of non-edible fruits the share of mouldy, decayed, shrivelled fruits and the changes of inner quality parameters during cold storage.

Storage parameters

| 2006 | | | | 2007 | | | |
|---|---|---|---|---|---|---|---|
| Chamber No. | Temp. | $O_2$ (%) | $CO_2$ (%) | Chamber No. | Temp. | $O_2$ (%) | $CO_2$ (%) |
| - | - | - | - | 2 | 1 °C | | |
| 3 | 1 °C | 2.4-3.4 | 0.0-0.8 | 3 | 2 °C | 3-5% | 0.0% |
| 4 | 3 °C | 3.5-4.8 | 0.0-0.9 | 4 | 3 °C | | |
| 5 (control) | 2 °C | regular air | regular air | 5 (control) | 2 °C | regular air | |

After cold storage the fruits stored in plastic trays were kept at room temperature (19-22 °C) for a week to investigate shelf life.

## 3. Results

3.1. Spreading and recognition of the North-Eastern Hungarian landrace cultivars

According to the data of the survey of fruit orchards in 2001, the share of cultivars in the Hungarian sour cherry orchards is the following: 'Újfehértói fürtös': 28.0%, 'Érdi bőtermő': 25.5%, 'Kántorjánosi': 14.9%, 'Debreceni bőtermő': 9.6%. 22% of the total area is still covered by 'Cigánymeggy' and 'Pándy meggy' types and 'Meteor korai', 'Érdi jubileum' and other cultivars *(Table 1 and 2)*.

**Table 1.** Area of the Hungarian sour cherry orchards in 2001 (ha)

| Cultivars | Bács-Kiskun county | Heves county | Budapest, Pest county | Sz-Sz-Bereg county | Other counties | Total | % |
|---|---|---|---|---|---|---|---|
| Debreceni bőtermő | 163.5 | 147.9 | 249.1 | 415.3 | 294.6 | 1270.4 | 9.6 |
| Érdi bőtermő | 798.7 | 215.9 | 847.5 | 553.0 | 978.6 | 3393.7 | 25.5 |
| Érdi jubileum | 109.1 | 0.4 | 38.1 | 64.4 | 72.8 | 284.8 | 2.1 |
| Kántorjánosi | 56.8 | 75.6 | 77.8 | 1570.5 | 199.2 | 1979.9 | 14.9 |
| Meteor korai | 53.6 | 5.3 | 12.5 | 26.3 | 64.4 | 162.1 | 1.2 |
| Újfehértói fürtös | 566.3 | 160.4 | 704.6 | 1285.1 | 1003.8 | 3720.2 | 28.0 |
| Cigánymeggy types | 198.2 | 88.2 | 277.9 | 90.3 | 550.7 | 1205.3 | 9.1 |
| Pándy clones | 145.9 | 61.3 | 224.6 | 24.9 | 263.6 | 720.3 | 5.4 |
| Other cultivars | 65.3 | 48.0 | 135.2 | 97.1 | 211.2 | 556.8 | 4.2 |
| Total | 2157.4 | 803.0 | 2567.3 | 4126.9 | 3638.9 | 13293.5 | 100.0 |

Source: KSH

**Table 2.** Share of nursery propagation between 1992 and 2005

| Cultivars | Produced nursery trees | |
|---|---|---|
| | pcs | % |
| Debreceni bőtermő | 1 698 684 | 18.6 |
| Kántorjánosi | 1 045 155 | 11.4 |
| Újfehértói fürtös | 2 038 426 | 22.3 |
| Three cultivars total | 4 782 265 | 52.3 |
| Érdi bőtermő | 3 037 624 | 33.2 |
| Other cultivars | 1 329 480 | 14.5 |
| *Grand total* | *9 149 369* | *100* |

Source: OMMI

Hungarian sour cherry growing is over a cultivar change. Due to the introduction and widespread of ’Érdi bőtermő’ (1970) and ’Újfehértói fürtös’ (1970) yields and growing area had increased. The introduction of similar cultivars (’Érdi jubileum’ 1980, ’Debreceni bőtermő’ 1986, ’Kántorjánosi’ 1994) provided for cultivar innovation.

The next renewing of the cultivar usage may be accomplished by the introduction of the new candidate cultivars (eg. ’Petri’, ’Éva’), which have improved characteristics (e.g. cropping potential, density of bearing wood).

The North-Eastern Hungarian landrace cultivars are known in several countries of the World. There are 400 hectares of mature 'Újfehértói fürtös' orchards in Michigan state (USA), while in Germany 120 hectares of mature orchards and 250 hectares of orchards younger than seven years. 'Debreceni bőtermő' is included in the list of recommended cultivars, and is considered the main cultivar for sour cherry orchard replantings in Poland.

3.2. Growth properties of the cultivars

The six cultivars investigated can be classified in three groups according to their trunk circumference and canopy size (*Table 3*).

**Table 3.** Vigour of the North-Eastern Hungarian landrace sour cherry cultivars (Újfehértó, 1983-1994; 1994-2003)

| Vigour | Cultivar | Main branches (pcs/tree) | Crotch angle |
|---|---|---|---|
| Strong | Éva (T) | 6.6 | 51° |
| Medium | Újfehértói fürtös<br>Kántorjánosi 3<br>Petri (R)<br>D clone | 6.2 | 44° |
| Weak | Debreceni bőtermő | 6.1 | 41° |

We counted the number of main branches and measured their crotch angles. While there is no significant difference between the cultivars regarding the number of main branches, it's decreasing figure well describes the vigour of the tree.

Crotch angle is a much better index to describe tree vigour. Both canopy characteristics are useful not only for the description of a given cultivar, but also during the elaboration of phytotechnological procedures.

The density of bearing wood is of high importance for the pruning and cropping of trees, and it is expressed by the number of bearing wood per 1 metre of branch length *(Table 4)*.

**Table 4.** Density of bearing wood in case of sour cherry cultivars (Újfehértó, 2002-2006)

| Cultivars | Number of bearing wood (pcs/1 m branch) | In the 7th year (bearing wood pcs/1 m branch) | In the 15th year (bearing wood pcs/1 m branch) |
|---|---|---|---|
| Újfehértói fürtös | 5.07 | 7.4 | 18.3 |
| Kántorjánosi | 3.88 | 5.7 | 27.6 |
| Debreceni bőtermő | 5.16 | 5.4 | 23.2 |
| Petri (R) | 15.81 | 19.0 | 41.1 |
| Éva (T) | 5.41 | 7.1 | 27.7 |
| D clone | 6.91 | 11.5 | 28.6 |

Date of planting: spring 1990; spring 1999

We got the most favourable figures in case of cv. 'Petri', as it had almost 16 bearing woods per 1 m branch, while the second best 'D' clone had less than 7.

In case of all cultivars there is a tendency to produce more bearing wood during the mature years, apparently due to the evolvement of the vegetative/generative balance.

During the elaboration of cultivar-specific pruning methods the knowledge of bearing wood types and their share is of great importance *(Table 5)*.

**Table 5.** Distribution of bearing wood types in trees of sour cherry cultivars (Újfehértó, 2006)

| Cultivars, clone | Number of bearing wood investigated | Share of bearing wood types (%) | | | |
|---|---|---|---|---|---|
| | | Multi-bud spurs (1-2 cm) | Short bearing shoots (2-3 cm ) | Mid-length bearing shoots (3-12 cm) | Long bearing shoots (>12 cm) |
| Újfehértói fürtös | 209 | 62.2 | 5.7 | 9.1 | 23.0 |
| Kántorjánosi | 196 | 62.3 | 4.6 | 7.1 | 26.0 |
| Debreceni bőtermő | 236 | 51.3 | 14.4 | 7.2 | 27.1 |
| D clone | 205 | 69.8 | 2.9 | 4.4 | 22.9 |
| Petri (R) | 373 | 82.0 | 5.4 | 2.1 | 10.5 |
| Éva (T) | 199 | 73.4 | 2.0 | 1.5 | 23.1 |

Date of planting: spring 1999

It is to be noted, that the density of bearing wood influences the share of multi-bud spurs greater than tree vigour. We measured the highest share of multi-bud spurs in case of cv. ’Petri’, but in case of the weakest ’Debreceni bőtermő’ it’s share was only 51%. Theoretically the highest share of long bearing shoots is expected from the most vigorous cultivars, that is the cultivars producing the longest shoots (too). Contrary, the measured data demonstrate, that the weakest ’Debreceni bőtermő’ produced the most, and ’Petri’ produced the least long bearing shoots.

The most vigorous ’Éva’ produced long bearing shoots only moderately (23%). All the above mentioned observations attract the attention that neither growth characteristics should be exclusively taken into consideration for the elaboration of cultivar-specific pruning and phytotechnical procedures, but all the parameters (number of main branches and their crotch angle, type and density of bearing wood, etc.) should be considered. In any case, it is a fundamental rule, that during the pruning of trees of cultivars producing more multi-bud spurs – similar to sweet cherry cultivars – we have to form a tree with adequate number of laterals sooner, and we can not carry out a strong bearing wood thinning pruning hastily early.

### 3.3. Most important phenological properties of sour cherry cultivars

There was no significant difference between the cultivars concerning the length of period between bud burst and beginning of flowering (32-33 days). We observed a slight difference in the average duration of flowering, but it was not significant either. It means that the investigated North-Eastern Hungarian sour cherry cultivars belong to the same group according to the time of flowering, and they do not differ neither in the beginning nor in the duration of flowering. On the one hand it makes possible the mixed planting of them to enhance fruit set, on the other hand they can substitute each other when looking for pollinators, if they meet the other criteria. The data of *Table 6* also demonstrate, that there is no significant difference between the ripening time of fruits, since it takes 63-66 days on average from flowering until the beginning of harvest.

**Table 6.** Duration of three main phenological stages in different sour cherry ultivars (Újfehértó, 1983-2005)

| Cultivars | Duration between bud burst and beginning of flowering (days) | Duration of flowering (days) | Duration between the end of flowering and fruit ripening (days) |
|---|---|---|---|
| Újfehértói fürtös | 32.9 | 10.1 | 66.1 |
| Kántorjánosi | 32.4 | 10.9 | 66.1 |
| Debreceni bőtermő | 32.0 | 11.0 | 63.8 |
| Petri (R) | - | 9.9 | 64.2 |
| Éva (T) | - | 11.1 | 64.4 |
| D clone | - | 9.6 | 63.1 |
| | n.s | n.s | n.s |

Note: n.s. = no significant difference

Based on the yearly investigation of the time of beginning and end of flowering we concluded, that the beginning of flowering is three days earlier, and the end of flowering is five days earlier when compared to 1983 *(Fig. 1)*.

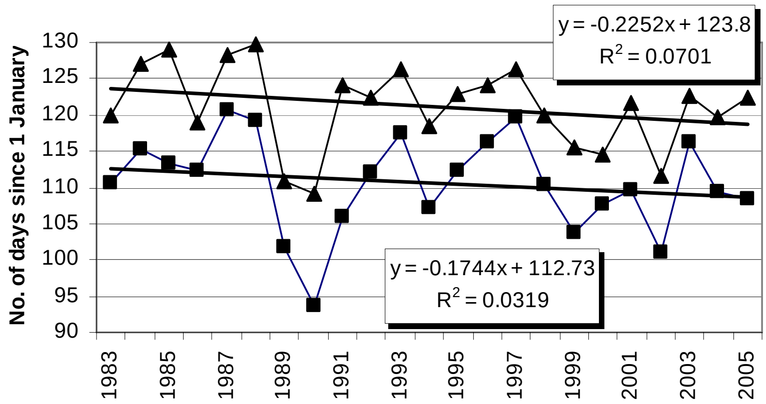


**Fig. 1.** Average time of beginning and end of flowering of sour cherry cultivars (Újfehértó, 1983-2005)

The date of full bloom is also five days earlier when compared to 1983. In our opinion, these changes in flowering time are attributed to the climate change and it may increase the risk of fertility problems *(Fig. 2)*.

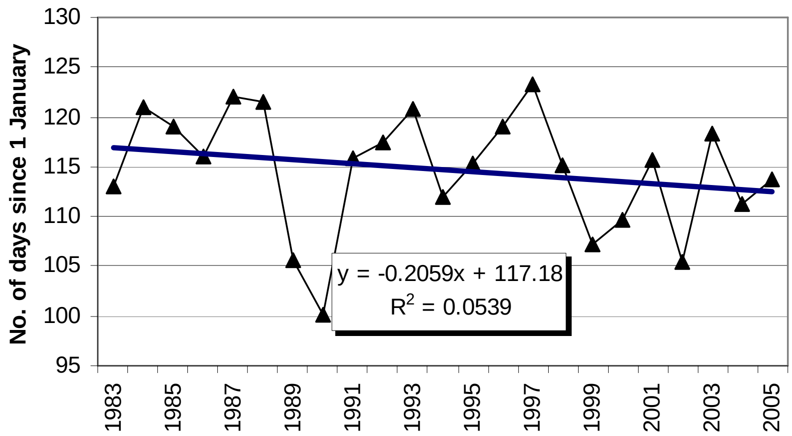


**Fig. 2.** Average date of full bloom of sour cherry cultivars (Újfehértó, 1983-2005)

3.4. Investigating the self-fertility and open pollination of the cultivars

The degree of self-fertility is highest in case of cv. 'Petri', it surpasses the desired level of 10% required for safe fruit set. In case of other cultivars the average degree of self-fertility is between 3 and 6%. According to the degree of self-fertility we can classify the cultivars into three groups. The average degree of open pollination is 16-28%. We classified the cultivars into three groups, also *(Table 7)*.

**Table 7.** Grouping of sour cherry cultivars according to fertility relations (Újfehértó, 1985-2005)

| Self-fertility | | Open pollination | |
|---|---|---|---|
| Degree | Cultivar | Degree | Cultivar |
| *Adequate* (above 10%) | Petri (R) | *Very high* (above 25%) | Petri (R) |
| *Acceptable* (5-10%) | Debreceni bőtermő<br>Kántorjánosi 3<br>D clone | *High* (20-25%) | Újfehértói fürtös<br>Kántorjánosi 3<br>Debreceni bőtermő<br>Éva (T) |
| *Weak* (below 5%) | Újfehértói fürtös<br>Éva (T) | *Medium* (15-20%) | D clone |

We could not observe a strong correlation between self-fertility and open pollination. The high dispersion of data refers to the importance of the growing season. It reminds us that the mixed planting of the North-Eastern Hungarian sour cherry cultivars to promote cross pollination is risky, in spite of their perfectly simultaneous flowering. The mutual and one-sided sterile combinations support the assumption, that not only the fruits of the investigated cultivars is similar, but the genetic background of their fertility, too. Our data prove that cv. 'Újfehértói fürtös' is a good pollinator for the other two varieties, but it is pollinated by neither of them. The reasons are to be clarified *(Table 8)*.

**Table 8.** Comparing the self-fertility and open pollination of different sour cherry cultivars (Újfehértó, 1985-2005)

| Cultivars | Self-fertility % | Open pollination % |
|---|---|---|
| Újfehértói fürtös | 4.97 a | 24.47 ab |
| Kántorjánosi | 5.70 a | 21.10 ab |
| Debreceni bőtermő | 5.96 ab | 23.30 ab |
| R (Petri) | 11.50 b | 27.90 b |
| T (Éva) | 4.30 a | 21.77 ab |
| D clone | 7.73 ab | 16.77 a |
| | ** | ** |

Note: **: p < 5 %

3.5. Evaluating the cropping potential of the cultivars

We can compare the specific indices of cropping potential only under the same circumstances. 'Újfehértói fürtös' was the best cropping cultivar in the orchard planted in 1980, but 'Debreceni bőtermő' was the best in the orchard planted 10 years later. When raking the six investigated cultivars, the merged data of the different orchards were taken into consideration *(Table 9)*.

**Table 9.** Average specific yield of different sour cherry cultivars (Újfehértó, 1983-2003)

| Cultivars | Specific yield | | |
|---|---|---|---|
| | kg/cm trunk circumference | $kg/m^2$ under-canopy area | $kg/m^3$ canopy volume |
| Újfehértói fürtös | 0.68 | 2.93 | 1.39 |
| Kántorjánosi | 0.70 | 2.95 | 1.42 |
| Debreceni bőtermő | 0.69 | 2.94 | 1.40 |
| R (Petri) | 0.91 | 3.64 | 1.77 |
| T (Éva) | 0.90 | 3.73 | 1.65 |
| D clone | 0.51 | 2.50 | 1.29 |

Notes: merged investigation of two evaluation periods (1983-1984; 1994-2003)
Data of 'D' clone is from the measurements of 1994-2003

3.6. Cultivar properties and climatic factors influencing cropping safety

The average degree of winter frost damage of flower buds of six cultivars was between 21 and 45% in 2001 and 2002. We observed the greatest damage in cv.

‘Éva’, but even it’s value was lower than that of the reference cultivar ‘Érdi bőtermő’.

Later on, we compared the degree of winter frost damage of the flower buds of six cultivars in a 3-year period. We could observe differences between the cultivars only in 2003 and 2005; due to the very low frost damage in 2006 the differences were minimal. In 2003 and 2005 the cultivars ranked in a different order. The flower bud damage of ‘Újfehértói fürtös’ was 21% in 2001, while it was one of the hardiest cultivars in 2005. It attracts our attention, that other factors than cultivar properties may have a great influence on frost damage, including sampling errors. The degree of frost damage of the North-Eastern Hungarian cultivars was lower than that of cv. ‘Érdi bőtermő’ in each year *(Table 10)*.

**Table 10.** Winter frost damage of flower buds of sour cherry cultivars (Újfehértó, 2001-2006)

| Cultivars | Average of years 2001-2002 | Average of years 2003-2006 | Average |
|---|---|---|---|
| Érdi bőtermő | 45.5 | 43.8 | 44.6 |
| Újfehértói fürtös | 21.4 | 8.1 | 14.7 |
| Kántorjánosi | 27.0 | 4.6 | 15.8 |
| Debreceni bőtermő | 25.4 | 4.8 | 15.1 |
| Petri (R) | 33.7 | 1.0 | 17.3 |
| Éva (T) | 39.1 | 11.6 | 25.3 |
| D clone | 33.3 | 2.2 | 17.7 |

The rank of cultivars based on the winter frost damage of their flower buds was different each year. The effect of the growing season is clearly greater than that of cultivar properties. The North-Eastern Hungarian cultivars were less susceptible to cold periods than cv. ‘Érdi bőtermő’. The earlier flowering ‘Érdi bőtermő’ was more exposed to frost risk each year.

*Climatic factors*

Successful sour cherry growing is greatly influenced by climatic factors. The stability of temperature during the dormant period of sour cherries is characterized by the number of frost-free days, and the occurrence and length of frost-free periods. If the occurrence of frost-free periods is frequent during winter, we can expect higher risk in the orchards, since the temperature changes may break deep dormancy, increasing the risk of frost damage. One of the most important climatic factors during flowering is the probability of frosts, the changes of minimum and maximum temperature, and the occurrence and quantity of rainfall. For the fertilization of flowers the number of days with mean temperature above 10 °C, and relative humidity below 50% is of great importance.

Our climate has started warming up during the last 40 years. It is justified by the increase of the number of frost-free days, and by the increase of the length of frost-free periods during the dormant period. The number of frosty days during the flowering period decreased, while the absolute minimum temperature, minimum temperature, maximum temperature and number of days with relative humidity below 50% increased *(Table 11)*.

The direction of the arrows indicate the changes of climatic factors between 1965 and 2006. These changes indicate the warming of the climate. The risk of frost during flowering hadn't decreased significantly, but can be characterized by two peak values. The probability of frost occurrence between 24-25 April is 25%, and 33% on 28 April.

**Table 11.** The agro-climatical description of the dormant and flowering period based on data from Újfehértó (1965-2006)

| | Factors | Long-term average | Change | |
|---|---|---|---|---|
| | | | course | degree |
| Dormant period | 1. Number of frost-free days | 74 days | ↗ | 10 days |
| | 2. Length of frost-free period | 23 days | ↗ | 10 days |
| | 3. Average temperature | 2.3 °C | ↗ | 0.8-6.0 °C |
| | 4. Number of cooling down periods during winter | 8 | | n.s. |
| Flowering period | 5. Probability of frosts | 14-33% | – | 24-25 Apr.<br>28-29 Apr. |
| | 6. Number of frosty days | 2 days | ↘ | 3 days |
| | 7. Absolute minimum temperature | 1.4 °C | ↗ | 5 °C |
| | 8. Minimum temperature | 6.3 °C | ↗ | 4 °C |
| | 9. Number of days with average temperature over 10 °C | 9 days | ↗ | 4 days |
| | 10. Average of maximum temperature | 18.3 °C | ↗ | 3 °C |
| | 11. Precipitation | 22 mm | ↗ | 30 mm |
| | 12. Daily maximum precipitation | 12 mm | ↗ | 19.9 mm |
| | 13. Number of precipitation-free days | 7 days | ↘ | 0.5 days |
| | 14. Number of days with precipitation above 5 mm | 1 days | ↗ | 1.4 days |
| | 15. Number of days with relative humidity below 50% | 1 days | ↗ | 2 days |

3.7. Pomological properties and inner quality of the fruits

Only the 'D' clone had significantly bigger fruits, which clearly resulted in better pit/fruit flesh ratio. The fruit weight, pit weight and pit/fruit flesh ratio of the other cultivars is similar *(Table 12)*.

We observed significant diferrence in the stipulae coverage and length of peduncles. Stipulae coverage of cv. 'Éva' is 30% less when compared to the other cultivars *(Table 13)*.

**Table 12.** Comparing the weight of 100 fruits and pits, and their ratio of different sour cherry cultivars (Újfehértó, 1983-2005)

| Cultivars | Weight of 100 fruits (g) | Weight of 100 pits (g) | Pit/fruit flesh ratio (%) |
|---|---|---|---|
| Újfehértói fürtös | 528.5 ab | 36.00 | 7.35 ab |
| Kántorjánosi | 538.7 ab | 39.96 | 7.40 ab |
| Kántorjánosi 3 | 486.0 a | 34.80 | 7.82 b |
| Debreceni bőtermő | 549.5 ab | 36.76 | 7.19 ab |
| Petri (R) | 529.8 ab | 36.36 | 7.42 ab |
| Éva (T) | 538.5 ab | 34.09 | 6.84 a |
| D clone | 564.2 b | 36.00 | 6.91 a |
| | ** | n.s. | *** |

Note: ***: p < 1 %
**: p < 5 %
n.s. : not significant

**Table 13.** Comparing the stipulae coverage and peduncle length of different sour cherry cultivars (Újfehértó, 1983-2003)

| Cultivars | Stipulae coverage (%) | Peduncle length (mm) |
|---|---|---|
| Újfehértói fürtös | 60.82 ab | 48.41 b |
| Kántorjánosi | 66.09 ab | 48.68 b |
| Debreceni bőtermő | 71.09 b | 49.59 b |
| Petri (R) | 60.80 ab | 48.40 b |
| Éva (T) | 48.80 a | 43.20 a |
| D clone | 57.00 ab | 49.20 b |
| | ** | *** |

Note: ***: p < 1 %
**: p < 5 %

We could not observe significant difference between the cultivars regarding the inner quality parameters of the fruits *(Table 14)*.

We investigated the changes of the above mentioned parameters. Using the available climatic database of 1965–2005 we distinguished warmer and wetter, and cooler and wetter seasons. Inner quality parameters of sour cherries were available from 1998 until 2005.

**Table 14.** Comparing the inner quality parameters of the fruits of different sour cherry cultivars (Újfehértó, 1998-2005)

| Cultivars | Dry matter content (%) | Sugar content (%) | Total acidity (%) | Vitamin C content (mg %) |
|---|---|---|---|---|
| Újfehértói fürtös | 17.92 | 16.15 | 0.99 | 11.62 |
| Debreceni bőtermő | 16.58 | 15.01 | 0.89 | 11.74 |
| Kántorjánosi | 17.51 | 15.56 | 1.02 | 11.37 |
| Petri (R) | 16.41 | 14.91 | 1.04 | 10.97 |
| Éva (T) | 16.89 | 15.39 | 1.01 | 11.66 |
| D clone | 17.25 | 15.53 | 1.10 | 12.04 |
| | n.s. | n.s. | n.s. | n.s. |

Note: n.s. : not significant

According to our findings, there is a strong correlation between the maximum temperature, difference of day and night temperature, minimum temperature and inner quality parameters of sour cherries.

The correlations were often non-linear, in most cases the fittings of second degree were significant. Based on these correlations we could set up a model to forecast the probable values of inner quality parameters in a given season by using mainly climatic data.

***Total acidity***

Based on the linear regression we can conclude, that in case of higher rainfall the acidity of the fruits is lower, while in dry years fruits of sour cherries have more acidity *(Fig. 3)*.

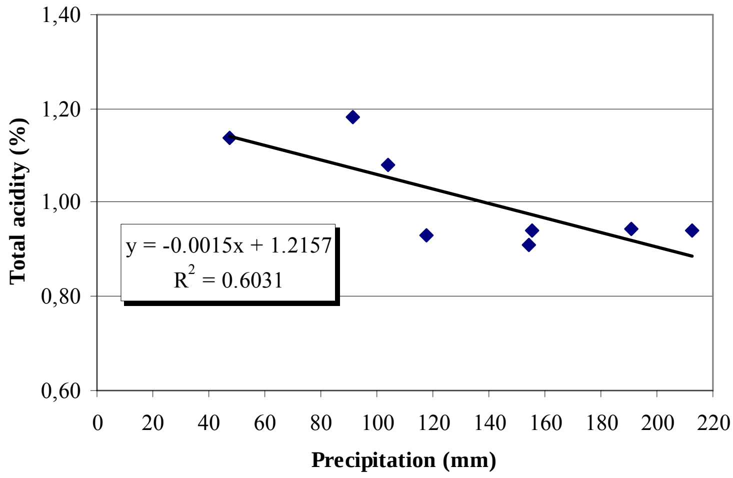


**Fig. 3.** Correlation between the amount of rainfall from the end of flowering until fruit ripening and total acidity of fruits of cv. 'Kántorjánosi 3' (Újfehértó, 1998-2005)

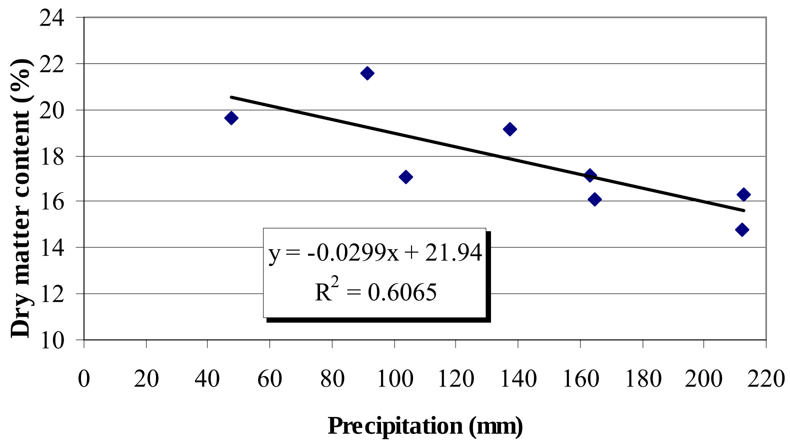


**Fig. 4.** Correlation between the amount of rainfall from the end of flowering until fruit ripening and dry matter content of fruits of cv. 'Újfehértói fürtös' (Újfehértó, 1998-2005)

***Dry matter content***

Higher rainfall results in the significant decrease of dry matter content. During years with abundant rainfall the dry matter content of the fruits was lower *(Fig. 4)*.

***Sugar content***

We discovered significant (at 1% level) correlation between the difference of day and night temperature and the sugar content of fruits of cv. 'Kántorjánosi'. The linear regression means, that the higher the difference between the temperature of day and night, the higher is the sugar content of the fruits of sour cherries *(Fig. 5)*.

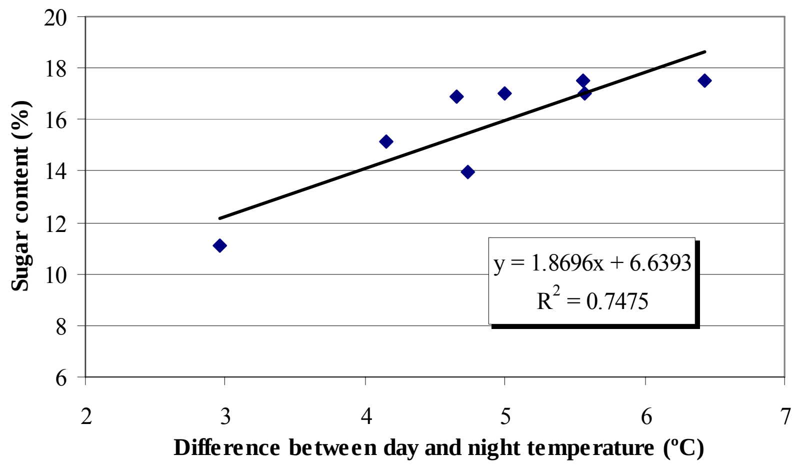


**Fig. 5.** Correlation between the difference of day and night temperature from the end of flowering until fruit ripening and dry matter content of fruits of cv. 'Kántorjánosi' (Újfehértó, 1998-2005)

***Vitamin C content***

Water supply conditions play an important role in the vitamin C content of the fruits. We can point out, that vitamin C content of the fruits is higher in those years, when the amount of rainfall is adequate and climatic water balance has a minor negative, zero or positive value *(Fig 6)*.

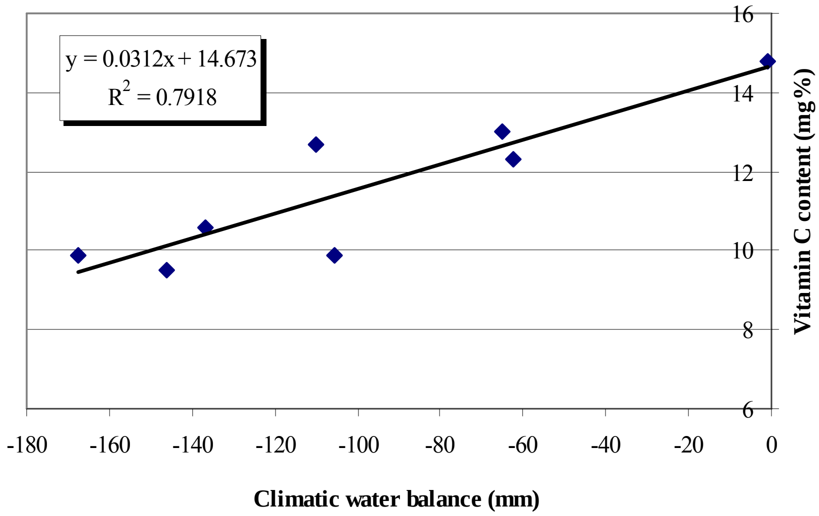


**Fig. 6.** Correlation between the climatic water balance from the end of flowering until fruit ripening and vitamin C content of fruits of cv. 'Debreceni bőtermő' (Újfehértó, 1998-2005)

Juice, bottled fruit and frozen products were made from the fruits of the investigated sour cherry cultivars. Panels evaluated cv. 'Petri' and 'D' clone the best.

3.8. Storability and shelf life of the fruits

Data obtained from the storage trial in 2005 did not indicate the values specific to the cultivars due to the high amount of rainfall during harvest.
The observations of 2006 and 2007 are the following.

Storability is primarily influenced by storage temperature, the oxygen and carbon-dioxide content of the storage room is less important. We got the best results in the control chamber, where we stored the fruits in regular air at 2 °C.

Sour cherries stored in M10 boxes suffered more weight loss, and the ratio of intact fruits were less when compared to fruits kept in small plastic trays. Dry matter content, sugar content and total acidity decreased significantly during cold storage.

Later on it is necessary to determine the length of storage, when the decrease of inner quality parameters does not influence considerably the enjoyment of the fruits.

The importance of sour cherry storage will be gradually more valued, as the ratio of fruits for fresh consumption grows, so the knowledge related to storage will have a more important role when utilizing cultivar information.

### 3.9. Our most important findings are as follows:

1) We classified the investigated cultivars into three groups based on their vigour, canopy size, number of main branches and their crotch angles. Vigorous: 'Éva'; medium vigour: 'Újfehértói fürtös', 'Kántorjánosi 3', 'Petri', 'D' clone; weak: 'Debreceni bőtermő'

2) We specified the types of bearing wood, their ratio and density that can be utilized during phytotechnological procedures. 'Petri' produces the most bearing wood, and 82% of them are multi-bud spurs.

3) We proved, that the genetically closely related North-Eastern Hungarian sour cherry cultivars have the same flower phenology and fertility properties, that are favourable in terms of simultaneous flowering when combining various cultivars to be planted in a new orchard, but is a drawback for cross-pollination.

4) For the first time we publish the indices suitable for the agro-climatical description of the dormant and flowering period.

5) We determined the susceptibility of flower buds to the winter frosts. The degree of frost damage of the North-Eastern Hungarian cultivars was lower than that of cv. 'Érdi bőtermő' in each year.

6) We determined and described the most important pomological properties (fruit size, pit ratio, stipulae coverage, inner quality parameters) of sour cherry cultivars selected and investigated by us.
7) We determined the incidence of stipulae on the peduncles of fruits for each cultivar, and demonstrated a correlation between the length of peduncles and the degree of stipulae coverage.
8) We determined the storage potential and shelf life of the North-Eastern Hungarian local cultivars. Storability is primarily influenced by storage temperature, the gas levels of the storage room are less important.

## 4. Conclusions, recommendations

The North-Eastern Hungarian landrace sour cherry cultivars contribute to more than half of the sour cherries produced in Hungary. The utilization of this rich gene pool will enable not only further research, but also the enrichment of the domestic sour cherry production. With our work we would like to contribute to the adequate efficiency of the exploration and utilization of this gene pool.

The three vigour groups will enable the classification of cultivars to be selected in the future.

During the pruning and cropping of sour cherries the type and density of bearing wood is of great importance. Or results show, that all the parameters (number and crotch angle of main branches, types and density of bearing wood, etc.) should be taken into consideration while elaborating cultivar specific pruning methods and other phytotechnological procedures.

During the pruning of trees of cultivars producing more multi-bud spurs we have to form a tree with adequate number of laterals sooner, and we can not carry out a strong bearing wood thinning pruning hastily early.

The investigated cultivars belong to the same flowering group, so their mixed planting is favourable for cross pollination. The investigated cultivars do not fertilize 'Újfehértói fürtös' (reasons to be clarified), so it is better to plant it on the side of the orchard in wind direction. The degree of self-fertility is highest in case of cv. 'Petri', it surpasses the desired level of 10% required for safe fruit set. However, crop safety is better when it is planted mixed with other cultivars.

The changes in the investigated climatic factors indicate warming up, consequently the flowering dates have changed. Earlier flowering increases the risk of fertilization problems, so the promotion of flower bud formation should be of primary importance while carrying out different agro-technical procedures.

The degree of winter frost damage of flower buds is different each year. Probably it is in connection with the warming up of the dormant period. It can be decreased by keeping the orchard in good condition.

We could not observe significant differences between the cultivars concerning fruit size, except 'D' clone, where the bigger fruit size is accompanied by smaller pits.

The cropping potential of 'Petri' and 'Éva' was the best. According to the results of the panel tests, fruits of cv. 'Petri' were the best for processed products.

We could not observe significant differences between the cultivars concerning inner quality parameters of the fruits. The comparison of certain inner quality parameters with the indices of the climatic database revealed a strong correlation. It is important, because based on these correlations we could set up a model to forecast the probable values of inner quality parameters in a given season by using climatic data.

With the increase of fresh consumption, storability and shelf life of sour cherries will become more important. We have not heard about such storage trials yet. The data of our experiments may contribute to the successfulness of future storage trials.

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