

120-81  
CZECH ACADEMY OF AGRICULTURAL SCIENCES

302-119  
NC 11364  
NÁRODNÍ KNIHOVNA  
\*1001183359\*



# HORTICULTURAL SCIENCE

## Zahradnictví



INSTITUTE OF AGRICULTURAL AND FOOD INFORMATION

# 2

VOLUME 28  
PRAGUE 2001  
ISSN 0862-867X

An international journal published under the authorization by the Ministry of Agriculture and under the direction of the Czech Academy of Agricultural Sciences

Mezinárodní vědecký časopis vydávaný z pověření Ministerstva zemědělství České republiky a pod gescí České akademie zemědělských věd

## Editorial Board – Redakční rada

### Chairman – Předsedkyně

Doc. EVA PEKÁRKOVÁ, CSc. (vegetable-growing), Praha

### Vice-chairman – Místopředseda

Ing. JAN BLAŽEK, CSc. (fruit-growing), Holovousy

### Members – Členové

Prof. Dr. habil. HORST BÖTTCHER (post-harvest processing), Halle (Saale)

Ing. EVA DUŠKOVÁ, CSc. (phytopathology), Praha

Prof. Ing. JAN GOLIÁŠ, DrSc. (post-harvest processing), Lednice

Doc. Ing. MARTA HUBÁČKOVÁ, DrSc. (viticulture), Karlštejn

Doc. Ing. ANNA JAKÁBOVÁ, CSc. (floriculture), Veselé pri Piešťanoch

Prof. Ing. FRANTIŠEK KOBZA, CSc. (floriculture), Lednice

Ing. HANA ŌPATOVÁ, CSc. (post-harvest processing), Praha

Ing. JAROSLAV ROD, CSc. (phytopathology), Olomouc

Ing. IRENA SPITZOVÁ, CSc. (medicinal herbs), Praha

Prof. Ing. ZDENĚK VACHŮN, DrSc. (fruit-growing), Lednice

Ing. RUDOLF VOTRUBA, CSc. (ornamentals), PrŮhonice

Doc. Ing. MAGDALĚNA VALŠÍKOVÁ, CSc. (vegetable-growing), Nové Zámky

### Editor-in-Chief – Vedoucí redaktorka

Mgr. RADKA CHLEBEČKOVÁ

**Aims and scope:** The journal is for scientific, pedagogic and technical workers in horticulture. The published original scientific papers cover all these sectors of horticulture: fruit-growing, vegetable-growing, wine-making and viticulture, growing of medicinal and aromatic herbs, floriculture, ornamental gardening, garden and landscape architecture. The subjects of articles include both basic disciplines – genetics, physiology, biochemistry, phytopathology, and related practical disciplines – plant breeding, seed production, plant nutrition, technology, plant protection, post-harvest processing of horticultural products, quality of horticultural products and economics.

The journal Horticultural Science publishes original scientific papers written in English. Abstract from the journal are comprised in the databases: AGRIS/FAO database, CAB – Horticulturae Abstracts and Plant Breeding Abstracts, Czech Agricultural Bibliography.

**Periodicity:** The journal is published quarterly (4 issues per year). Volume 28 appearing in 2001.

**Acceptance of manuscripts:** Two copies of manuscript should be addressed to: Mgr. Radka Chlebečková, editor-in-chief, Institute of Agricultural and Food Information, Slezská 7, 120 56 Praha 2, Czech Republic, tel.: + 420 2 27 01 03 55, fax: + 420 2 27 01 01 16, e-mail: forest@uzpi.cz.

**Subscription information:** Subscription orders can be entered only by calendar year and should be sent to: Institute of Agricultural and Food Information, Slezská 7, 120 56 Praha 2, Czech Republic. Subscription price for 2001 is 62 USD (Europe) and 64 USD (overseas).

Up-to-date information are available at address <http://www.uzpi.cz>

**Cíl a odborná náplň:** Časopis slouží vědeckým, pedagogickým a odborným pracovníkům v oboru zahradnictví. Uveřejňuje původní vědecké práce a studie typu review ze všech zahradnických odvětví: ovocnářství, zelinářství, vinařství a vinohradnictví, léčivých a aromatických rostlin, květinářství, okrasného zahradnictví, sadovnictví a zahradní a krajinářské tvorby. Tematika příspěvků zahrnuje jak základní vědecké obory – genetiku, fyziologii, biochemii, fytopatologii, tak praktická odvětví na ně navazující – šlechtění, semenářství, výživu, agrotechniku, ochranu rostlin, posklizňové zpracování a jakost produktů a ekonomiku.

Časopis Horticultural Science uveřejňuje práce v angličtině. Abstrakty z časopisu jsou zahrnuty v těchto databázích: AGRIS/FAO database, CAB – Horticulturae Abstracts a Plant Breeding Abstracts, Czech Agricultural Bibliography.

**Periodicita:** Časopis vychází čtvrtletně (4krát ročně). Ročník 28 vychází v roce 2001.

**Přijímání rukopisů:** Rukopisy ve dvou kopiích je třeba zaslat na adresu redakce: Mgr. Radka Chlebečková, vedoucí redaktorka, Ústav zemědělských a potravinářských informací, Slezská 7, 120 56 Praha 2, Česká republika, tel.: + 420 2 27 01 03 55, fax: + 420 2 27 01 01 16, e-mail: forest@uzpi.cz.

**Informace o předplatném:** Objednávky na předplatné jsou přijímány pouze na celý rok a měly by být zaslány na adresu: Ústav zemědělských a potravinářských informací, Slezská 7, 120 56 Praha 2. Cena předplatného pro rok 2001 je 336 Kč.

Aktuální informace najdete na URL adrese <http://www.uzpi.cz>

# Yield potential of new apricot cultivars and hybrids within the first eight years after planting

Z. VACHŮN

*Mendel University of Agriculture and Forestry, Brno, Faculty of Horticulture, Lednice na Moravě, Czech Republic*

**ABSTRACT:** The author evaluated yield potential of 21 apricot cultivars and hybrids grafted on the rootstock M-LE-1 (*Prunus armeniaca* L.). In the majority of genotypes, economically significant productivity began in the fourth year after planting. In control cultivar Velkopavlovická LE-12/2, the average yield after five years of production was 11.2 kg (5.6 t/ha), while in the cultivar Bergeron it was 13.6 kg (6.8 t/ha). In the period of five years, the highest average yield was recorded in cultivar Lejuna (21.4 kg per tree, i.e. 10.7 t/ha). In 1999, i.e. in the year with favourable climatic conditions, the yield was higher than 20 t/ha in the majority of genotypes. In individual years, no significant correlations were found between the ranks of individual production of cultivars under study. Genotypes responded differently to identical climatic conditions of particular years. The average and/or summarised individual yield of apricots for the period of several years could be used above all as the most important criterion for evaluation of the yield potential of trees. Particular genotypes without fruit thinning responded to excessive productivity by lower yields in the following year. The level of yield, causing excessive productivity in the years with good climatic conditions, depends on genotype. Cultivars Lejuna and hybrid LE-498, with highest yield potential in five years, showed low sensitivity to high yield in 1999. Cultivars Lebelá, Leskora and hybrids LE-3709 and LE-3662, with lower yield potential in five years, were sensitive to excessive productivity caused by relatively lower yield in 1999. Genotypes with lower index of biennial bearing gave a higher sum of yields.

**Keywords:** genotype; weight of harvested fruit; sensitivity to excessive productivity; correlations between individual years

Apricots are a fruit-bearing species more and more interesting for fruit growers worldwide. Since 1951, the world production of apricots has increased more than four times (ANONYMUS 1998). Good productivity and quality of fruit represent the most important parameters enabling a profitable production of apricots. A suitable cultivar, rootstock, site and soil can be mentioned as the most important preconditions of good results. The method of management and growing can either support or suppress effects of these basic factors.

In the Czech Republic, Velkopavlovická, Karola and Bergeron are the most common cultivars of apricots and, in intensive orchards, their average yield was 2.3 t/ha in the period of 1996–2000. These average yields were comparable with results obtained in countries of Central and South-East Europe (Hungary, Bulgaria, Romania). In Greece, France and Italy, the yields (reached with the other cultivars) are usually significantly higher.

Recently, the problem of improvement of productivity and regularity of yields has been studied in several research institutes both in Europe and overseas (CIFRANIČ 1986; SMYKOV 1989; DELLA STRADA et al. 1989; COCIU et al. 1993; NYUJTÓ, KERÉK 1996; AUDERGON et al. 1997; KARAYIANNIS et al. 1997; PAUNOVIČ 1997; MOLNÁR, VÁGÓ 1999).

In the Czech Republic, a long-term breeding programme is implemented in the Research and Breeding Institute of Pomology at Holovousy, Seva-Flora at Valčice and at the Mendel University of Agriculture and Forestry, Faculty of Horticulture at Lednice. At Lednice, methods of clonal selection of the most frequent varieties and breeding of new ones are being used (VACHŮN et al. 1996, 1997; VACHŮN, KRŠKA 2000). Until now, 11 new apricot varieties have been registered and approved for propagation in the Czech Republic. Because of their small production areas, these promising as well as new foreign varieties have shown no significant effect on average per-hectare yields up to now in the Czech Republic. The increase in per-hectare yields due to new selections will be relatively slow and it can be expected that it will be manifested later, after the establishment of further hectares of orchards. With only several exceptions, these new varieties have not been tested in pilot field experiments which enable to evaluate their economic traits, especially yields and their stability. Only some newer cultivars (e.g. Karola) may be considered as tested under field conditions because their orchards are of larger size at present. The onset of fruit-bearing capacity in new genotypes was evaluated under pilot field conditions by KEBLOVSKÝ (1997) and JÍCHA (1997).

This research is one of results of the research order No. MSM 435100002 financed by the Ministry of Education, Youth and Sports and solved at Mendel University of Agriculture and Forestry, Faculty of Horticulture at Lednice.

The objective of this study was to evaluate selected new apricot cultivars and hybrids from the viewpoint of their yield potential under pilot field conditions and to compare them with the most important Czech cultivar Velkopavlovická as control and some very known cultivars of the world assortment of apricots.

## MATERIAL AND METHODS

An experimental pilot orchard was established in 1993. The soil was of alluvial loamy-sandy type with 0.05% of CaCO<sub>3</sub> and pH 6.8. Trees were planted in rows with the spacing of 5 times 4 m. Altogether 21 apricot cultivars and hybrids on M-LE-1 rootstock (*Prunus armeniaca* L.) were included in this orchard. All new genotypes were selected at the Faculty of Horticulture, Mendel University of Agriculture and Forestry at Lednice. All of them were selected above all on the basis of their fruit-bearing capacity and quality of fruit, at first in experimental orchards and thereafter in station tests. Until now, cultivars Ledana, Leskora, Lejuna, Leala, Lerosa and Lebela have been registered and approved for propagation.

The cultivar Velkopavlovická LE-12/2, selected also at the Faculty of Horticulture at Lednice, was used as control. For comparison, this experiment involved also cultivars Šalach and Bergeron. The first one is an important Ukrainian and Central-Asian variety while Bergeron is very popular in Central and Western Europe.

Stems of trees were 0.7 m high and their crowns were of vase (hollow) shape. Fifty trees of each variety were planted on long plots. Only three variants had less trees (cultivars Leskora [41], LE-4725 [46] and Šalach [49]).

Drip irrigation was used in June and July in the total dose of 60–70 mm.

Yield potential of this collection of apricot cultivars and hybrids was evaluated for the period of 1993–2000. Under the term “yield potential” we understand the capacity of each genotype to produce certain and variously regular amounts of fruit with a different onset of yields and increasing of yields. Economically important productivity (more than 0.5 kg per tree) was observed in the fourth year of age.

The total weight of harvested fruits was estimated in kilograms at the beginning of harvest ripeness. For the sake of objectivity, this parameter was also evaluated by another two independent experts. Correlation coefficients of these estimates ranged from 0.70<sup>++</sup> to 0.92<sup>++</sup> so that it could be concluded that their estimates were highly significant. Average values of one expert were used.

Index of yield depression was used to evaluate the effect of extremely high yield in one year on yield in the next year. This index was expressed as the difference between two subsequent yields divided by their sum and multiplied by 100. Index of biennial bearing (IBB) was calculated as follows:

$$IBB\% = \frac{(P1 - P2) + (P3 - P4)}{P1 + P2 + P3 + P4} \cdot 100$$

(P = yield per tree in the year concerned)

## RESULTS AND DISCUSSION

In the experimental orchard, economically important productivity started in the fourth year after planting. In

Table 1. Evaluation of yields in new apricot cultivars and hybrids (kg per tree) as compared with control cultivars of the world assortment

Genotype	Yield (kg per tree) in the year					Yield in 5 years	
	1996	1997	1998	1999	2000	Total	Average
LE-3204	12.7	0.6	2.0	55.0	1.0	71.3	14.3
LE-3709	10.3	0.2	0.2	45.0	0.1	55.8	11.2
Ledana (LE-1041)	12.6	1.7	1.0	65.0	0.1	80.4	16.1
Lejuna (LE-805)	10.5	1.7	32.0	48.0	15.0	107.2	21.4
Lerosa (LE-1328)	9.1	2.8	0.3	55.0	7.0	74.2	14.8
Lemira (LE-1446)	6.0	7.3	0.5	42.0	6.0	61.8	12.4
LE-3662	4.7	0.3	0.5	39.0	0.1	44.6	8.9
<b>Velkopavlovická LE-12/2</b>	<b>0.6</b>	<b>0.1</b>	<b>0.5</b>	<b>35.0</b>	<b>20.0</b>	<b>56.2</b>	<b>11.2</b>
Lebela (LE-1309)	6.4	0.1	4.0	33.0	0.3	43.8	8.8
Hargrand	7.8	3.3	0.5	51.0	0.1	62.7	12.5
<b>Bergeron LE-2</b>	<b>3.8</b>	<b>2.9</b>	<b>5.0</b>	<b>48.0</b>	<b>8.0</b>	<b>67.7</b>	<b>13.5</b>
Leskora (LE-836)	11.6	1.1	7.0	47.0	1.0	67.7	13.5
LE-4725	12.8	0.6	25.0	45.0	6.0	89.4	17.9
LE-3255	8.8	1.0	9.0	48.0	0.5	67.3	13.5
Legolda (LE-980)	4.5	2.6	16.0	60.0	1.0	84.1	16.8
Lebona (LE-984)	5.8	1.4	0.5	60.0	2.0	69.7	13.9
Lefreda (LE-833)	12.8	1.4	6.0	56.0	0.5	76.7	15.3
<b>Šalach</b>	<b>3.4</b>	<b>0.3</b>	<b>0.5</b>	<b>49.0</b>	<b>7.0</b>	<b>60.2</b>	<b>12.0</b>
Lednická (M 90 A)	3.2	1.4	2.5	50.0	12.0	69.1	13.8
LE-498	0.6	5.6	14.0	51.0	20.0	91.2	18.2
Leala (LE-352)	2.6	4.1	12.0	37.0	25.0	80.7	16.1
Total	150.6	40.5	139.0	1,019.0	132.7	1,481.8	296.4
Average	7.2	1.9	6.6	48.5	6.3	70.6	14.1

Bold – control cultivars from the world assortment

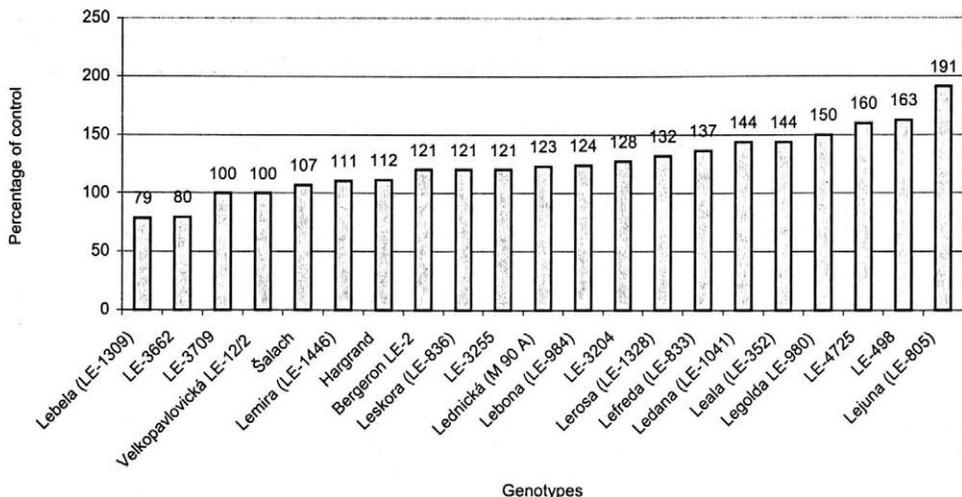


Fig. 1. Average five-year yields of new apricot cultivars and hybrids (kg/tree) expressed as percentages of control cultivar Velkopavlovická LE-12/2

the period of 1996–2000, the average annual yield per tree was 14.1 kg. The control variety Velkopavlovická LE-12/2 with the yield of 11.2 kg was classified as slightly below average among cultivars under study. When calculating the values of productivity as percentage of control, the cultivar Bergeron was better by 21%. The best variety Lejuna gave yields higher by 91% in the same period of investigation. This shows that the cultivars respond in a different way to the same growing conditions. The onset of commercial productivity (i.e. more than 0.5 kg per tree) was rather different in individual genotypes. Velkopavlovická LE 12/2 and LE-498 began to produce one year later. However, the hybrid LE-498 was evaluated in view of productivity as one of the best cultivars tested in this experiment. This means that a quick onset of productivity after planting need not guarantee higher production of fruits within a longer period.

The rank of genotypes in productivity in individual subsequent years was not the same. This fact was demonstrated by non-significant positive and/or negative coefficients of correlation ranging from  $r = 0.07$  to  $r = -0.37$ . This observation concerned also pairs of years in relatively different periods ( $r = 0.37$  to  $r = -0.30$ ). The correlation of years 1996 and 2000 ( $r = -0.60^{**}$ ) can be held for random. An objective evaluation of differences in productivity can be carried out only on the basis of summing of yields obtained in several years (Table 1, Fig. 1).

An even better survey of the yield potential of genotypes under study may be obtained after the calculation of individual yields per hectare. When using the spacing of  $5 \times 4$  m, the total number of trees per hectare is 500. In this case the average per-hectare yield of experimental trees was 7.1 tons for the five-year period. Regarding the

fact that in apricots the dying of planted trees is as much as 30% in the first ten years after planting it can be concluded that even under these conditions the average per-hectare yield was higher by approximately 1 ton than in current orchards. The conditions of the year 1999 demonstrated that yields above 20 t/ha are possible to reach under conditions of the Czech Republic (Table 2). However, in such years, thinning would be quite necessary both for the higher quality of harvested fruit and for the prevention of stress caused by excessive yields.

In apricots, marked fluctuations in the total weight of harvested fruit may be caused most frequently by frost damage of blossom buds and/or young fruit, by bad pollination and fertilisation caused by low temperatures during the period of blossom and by *Monilinia laxa*. Effects of excessive productivity on the yield depression in the subsequent year cannot be excluded either. Some apricot varieties show tendency to yield fluctuation even in periods of generally favourable conditions (VACHŮN 1966). Such differences in yields were demonstrated as a genetic trait for instance also in plums (COURANJOU 1983). This type of fruit-bearing can be denominated as biennial bearing.

In the five-year experimental period, the yields were influenced by unfavourable weather in the period of blossom and shortly thereafter only in 1997 and 1998. This means that the trees were not excessively exhausted by too high yields. In 1999, the fruit yield was extraordinarily high due to very favourable climatic conditions existing from blossom to harvest (without artificial thinning and with application of drip irrigation). The level of very high yield per tree was different in dependence on genotype. In the following year 2000, there was a marked yield depression in spite of the fact that the climatic conditions

Table 2. Yields of new apricot cultivars and hybrids (t/ha) as compared with control varieties of the world assortment

Genotype	Yield (t/ha) in the year					Yield in 5 years	
	1996	1997	1998	1999	2000	Total	Average
LE-3204	6.4	0.3	1.0	27.5	0.5	35.7	7.1
LE-3709	5.2	0.1	0.1	22.5	0.1	27.9	5.6
Ledana (LE-1041)	6.3	0.9	0.5	32.5	0.1	40.2	8.0
Lejuna (LE-805)	5.3	0.9	16.0	24.0	7.5	53.6	10.7
Lerosa (LE-1328)	4.6	1.4	0.2	27.5	3.5	37.1	7.4
Lemira (LE-1446)	3.0	3.7	0.3	21.0	3.0	30.9	6.2
LE-3662	2.4	0.2	0.3	19.5	0.1	22.3	4.5
<b>Velkopavlovická LE-12/2</b>	<b>0.3</b>	<b>0.1</b>	<b>0.3</b>	<b>17.5</b>	<b>10.0</b>	<b>28.1</b>	<b>5.6</b>
Lebela (LE-1309)	3.2	0.1	2.0	16.5	0.2	21.9	4.4
Hargrand	3.9	1.7	0.3	25.5	0.1	31.4	6.3
<b>Bergeron LE-2</b>	<b>1.9</b>	<b>1.5</b>	<b>2.5</b>	<b>24.0</b>	<b>4.0</b>	<b>33.9</b>	<b>6.8</b>
Leskora (LE-836)	5.8	0.6	3.5	23.5	0.5	33.9	6.8
LE-4725	6.4	0.3	12.5	22.5	3.0	44.7	8.9
LE-3255	4.4	0.5	4.5	24.0	0.3	33.7	6.7
Legolda (LE-980)	2.3	1.3	8.0	30.0	0.5	42.1	8.4
Lebona (LE-984)	2.9	0.7	0.3	30.0	1.0	34.9	7.0
Lefreda (LE-833)	6.4	0.7	3.0	28.0	0.3	38.4	7.7
<b>Šalach</b>	<b>1.7</b>	<b>0.2</b>	<b>0.3</b>	<b>24.5</b>	<b>3.5</b>	<b>30.1</b>	<b>6.0</b>
Lednická (M 90 A)	1.6	0.7	1.3	25.0	6.0	34.6	6.9
LE-498	0.3	2.8	7.0	25.5	10.0	45.6	9.1
Leala (LE-352)	1.3	2.1	6.0	18.5	12.5	40.4	8.1
Total	75.3	20.3	69.5	509.5	66.4	740.9	148.2
Average	3.6	1.0	3.3	24.3	3.2	35.3	7.1

Bold – control cultivars from the world assortment

were favourable and the drip irrigation was also used. This resulted from an excessive exhaustion of trees in the preceding year 1999. In the set under study, the average fruit yield per tree was reduced from 48.5 kg to 6.3 kg only (Tables 1 and 2). Also in this case, however, it was obvious that not all genotypes responded to excessive yields in the same way. This means that if the rule

“the higher the yield in one year, the lower the yield in the next year” were correct, then a significant negative correlation should exist between ranks of individual genotypes. However, the correlation coefficients showed only a slight negative dependence. The calculated value of  $r = -0.37$  was not significant. Some genotypes are able to produce enough buds of good quality for the next year

Table 3. Classification of apricot genotypes on the basis of yield depression index (1999/2000) and on the basis of biennial bearing index

Group of genotypes	Genotype	Level of excessive productivity in 1999	Index of yield depression 1999/2000	Genotype	Index of biennial bearing in 1997–2000
A	Leala (LE-352)		19.3	Leala (LE-352)	25.5
	Velkopavlovická LE-12/2		27.3	Velkopavlovická LE-12/2	27.8
	LE-498	aa	43.7	LE-498	43.5
	Lejuna (LE-805)	aa	52.4	Lednická (M 90 A)	59.3
	Lednická (M 90 A)	aa	61.3		
B	Bergeron LE-2	aa	71.4	Bergeron LE-2	65.4
	Lemira (LE-1446)		75.0	Lemira (LE-1446)	76.7
	Šalach	aa	75.0	Šalach	74.3
	LE-4725		76.5	LE-4725	82.8
	Lerosa (LE-1328)	aa	77.4	Lerosa (LE-1328)	77.6
C	Lejuna (LE-805)			Lejuna (LE-805)	65.5
	Lebona (LE-984)	aa	93.5	Lebona (LE-984)	92.2
	Leskora (LE-836)		95.8	Leskora (LE-836)	96.1
	LE-3204	aa	96.4	LE-3204	94.5
	Legolda (LE-980)	aa	96.7	Legolda (LE-980)	91.0
	LE-3255	aa	97.9	LE-3255	96.6
	Lebela (LE-1309)		98.2	Lebela (LE-1309)	97.9
	Lefreda (LE-833)	aa	98.2	Lefreda (LE-833)	94.0
	LE-3662		99.5	LE-3662	98.8
	LE-3709		99.6	LE-3709	98.7
Hargrand	aa	99.6	Hargrand	97.8	
Ledana (LE-1041)	aa	99.7	Ledana (LE-1041)	98.2	

Group of genotypes:

A – Group with low sensitivity (index below 60)

B – Group with medium sensitivity (index 61–90)

C – Group with high sensitivity (index above 90)

Type of productivity in the year 1999 with good conditions for extremely high yields

aa – average and/or above-average yield per tree in 1999

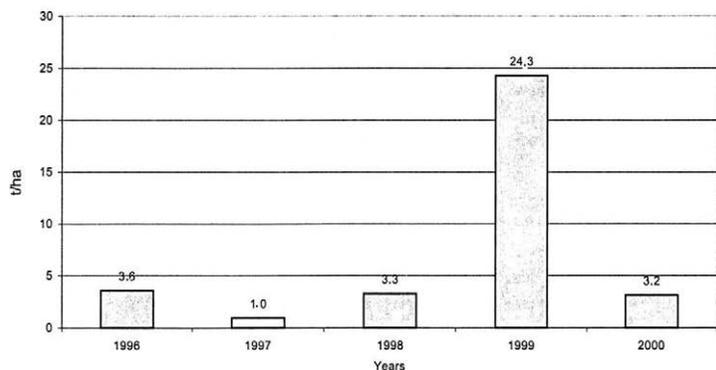


Fig. 2. Average yields (t/ha) of apricot genotypes in 1996–2000 (the first economically important harvest after planting in the year 1996)

and this trait can be defined as a different sensitivity to excessive high yields.

Based on the values of the index of yield depression, the varieties under study could be classified into three groups (Table 3). The first one (index below 60), showed the least sensitivity to excessive yields and a high level of total productivity and involved above all the genotypes LE-498 and Lejuna. This group involved also the cultivar Velkopavlovická, but its yield in 1999 was lower and its total yield within five years was medium and/or even lower than average. This group also comprised the cultivar Leala with the lower yield in 1999 but with the high total yield in the five year period. The second one (index 61–90), showing a medium sensitivity to excessive yields, involved six cultivars and the highest level of production was shown above all by the cultivars LE-4725, Lerosa, and Lednická. The last one (index above 90), showing a very high sensitivity to excessive productivity, involved above all the cultivars Legolda,

Ledana, Lefreda, LE-3204 and Lebona with a high total yield in five years. Hybrids LE-3709, LE-3709 and LE-3662 as well as cultivars Lebela and Hargrand showed the high sensitivity to yields in 1999 and medium to lower level of productivity in five years. The index of yield depression should also be evaluated in similar years with excessive productivity in the future to confirm the presented conclusions. Genotypes with lower index of biennial bearing gave a was higher sum of yields. This fact demonstrated by a highly significant coefficient of correlation ( $r = 0.92^{**}$ ) (Fig. 3). It would be useful to evaluate biennial bearing in a longer period.

#### Acknowledgements

The author thanks J. JANDÁSEK and Ing. I. MUSILOVÁ for their assistance when preparing and evaluating this experiment.

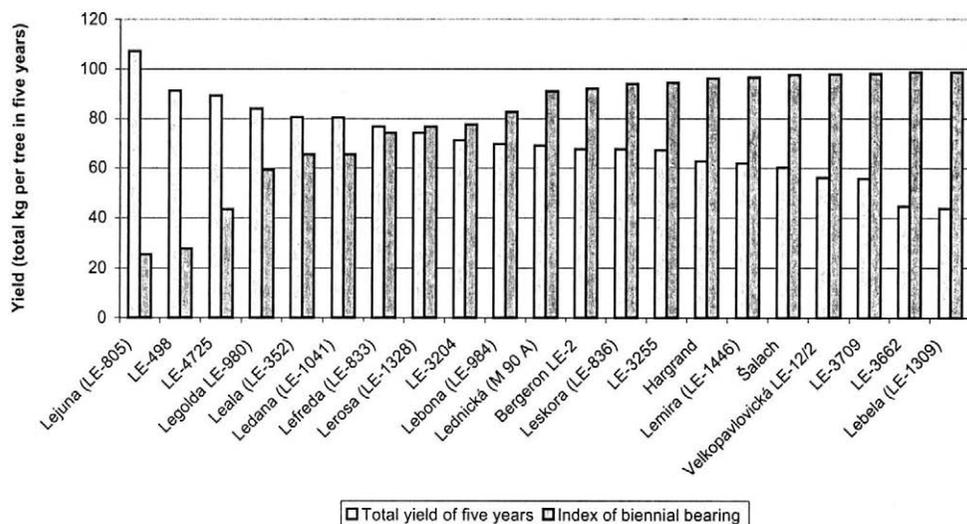


Fig. 3. Total yield per tree and index of harvest fluctuation in 21 apricot genotypes (coefficient of correlation  $r = 0.92^{**}$ )

## References

- ANONYMUS, 1998. FAOSTAT.
- AUDERGERON J.M., 1997. Apricot breeding in France: Two new apricot selections for French growers. In: Proc. of XI<sup>th</sup> Intern. Symp. on Apricot Culture Veria 25–30 May 1997, Greece, Acta Horticulture ISHS, Vol. 1, 488: 143–147.
- CIFRANIČ P., 1986. Marhule. Bratislava, Príroda: 110.
- COCIU V., AMZAR V., BALAN V. et al., 1993. Caisul. Bucuresti, Editura Ceres: 139.
- COURANJOU J., 1983. Facteurs variétaux de l'alternance des arbres fruitiers. Resultats de quinze années de recherches chez le Prunier domestique. Fruits, 10: 705–727.
- DELLA STRADA G., PENNONE F., FIDIGHELLI C. et al., 1989. Monografia di cultivar di albicocco. Roma, Frutticoltura-Agrumicoltura: 239.
- JÍCHA M., 1997. Hodnocení meruňkových odrůd a hybridů v poloprovozní výsadbě část A v Lednici v letech 1995–1996. [Diplomová práce.] 60, 21 obr., 42 tab.
- KARAIYANNIS I., MAINOU A., TSAFTARIS A., 1997. Apricot breeding in Greece for fruit quality and resistance to plum pox virus disease. In: Proc. of XI<sup>th</sup> Intern. Symp. on Apricot Culture Veria 25–30 May 1997, Greece, Acta Horticulture ISHS, Vol. 1, 488: 111–117.
- KEBLOVSKÝ M., 1997. Hodnocení meruňkových odrůd a hybridů v poloprovozní výsadbě část A v Lednici v letech 1995–1996. [Diplomová práce.] 83, 29 obr., 54 tab.
- MOLNÁR L., VÁGÓ E., 1999. Kajsziertesztés képekben. Kecskemét, Acrux BT: 263.
- NYUJTÓ F., KEREK M., 1996. Breeding and introduction of apricot varieties in Cegléd. In: Results of using the gene resources of apricots and peaches. Břeclav, 18–19. 7. 1996, Proc. of the Sci. Conf.: 23–29.
- PAUNOVIČ S.A., 1997. New apricot cultivars. In: Proc. of XI<sup>th</sup> Intern. Symp. on Apricot Culture Veria 25–30 May 1997, Greece, Acta Horticulture ISHS, Vol. 1, 488: 48.
- SMYKOV V.K., 1989. Abrikos. Moskva, Agropromizdat: 239.
- VACHŮN Z., 1966. Pěstitelské vlastnosti meruňkových odrůd Velkopavlovická a Rakovského. Acta Univ. Agric. (Brno), Fac. Agron., 1: 13–20.
- VACHŮN Z., KRŠKA B., SASKOVÁ H. et al., 1996. Šlechtitelský program a nové odrůdy meruňek na Zahradnické fakultě MZLU Brno v Lednici. In: Výsledky využití genových zdrojů meruňek a broskvoní. Břeclav, 18.–19. 7. 1996, Sbor. věd. konf.: 33–42.
- VACHŮN Z., KRŠKA B., SASKOVÁ H. et al., 1997. Apricot selection at the Horticultural Faculty in Lednice. In: Proc. of XI<sup>th</sup> Intern. Symp. on Apricot Culture Veria 25–30 May 1997, Greece, Acta Horticulture ISHS, Vol. 1, 488: 225–227.
- VACHŮN Z., KRŠKA B., 2000. Šlechtění a výzkum meruňek v České republice. In: Seminář Šlechtění a výzkum okrasných a ovocných rostlin ve XX. století v ČR a SR. Sbor., Brno: 130–134.

Received 2 March 2001

## Výnosový potenciál nových odrůd a hybridů meruňek v prvních osmi letech po výsadbě

**ABSTRAKT:** Byl hodnocen výnosový potenciál 21 odrůd a hybridů meruňek na podnoži M-LE-1 (*Prunus armeniaca* L.). Hospodářsky významná plodnost začala u většiny genotypů od čtvrtého roku po výsadbě. Průměrná individuální sklizeň u kontrolní odrůdy Velkopavlovická LE-12/2 byla za pět let plodnosti 11,2 kg na strom (5,6 t/ha) a u odrůdy Bergeron 13,6 kg na strom (6,8 t/ha). Nejvyšší průměrná individuální výnos za pět let byl u odrůdy Lejuna (21,4 kg na strom, tj. 10,7 t/ha). V klimaticky příznivém roce 1999 byla u většiny genotypů sklizeň vyšší než 20 t/ha. Mezi pořadím odrůd podle individuální výkonnosti v jednotlivých letech nebyl zjištěn průkazný korelační vztah. Genotypy reagují na stejný průběh podmínek rozdílně a rozhodujícím kritériem pro hodnocení výnosového potenciálu je především průměrný nebo sumární individuální výnos za víceleté období. Jednotlivé genotypy reagují na přeplození bez probírky rozdílným snížením sklizně v roce následujícím. Úroveň sklizně, způsobující nadměrné zatížení, je závislá na genotypu. Málo citlivé na přeplození a s vysokým výnosovým potenciálem jsou genotypy Lejuna a LE-498. Mezi genotypy citlivé na střední zatížení a se středním až nižším výnosovým potenciálem patří genotypy Lebela, Leskora, LE-3709 a LE-3662. Mezi indexem kolísání a plodnosti genotypů meruňek byla zjištěna průkazná negativní velká závislost ( $r = -0,92$ ).

**Klíčová slova:** genotyp; hmotnost sklizně; citlivost na přeplození; vztahy mezi roky

---

Corresponding author:

Prof. Ing. ZDENĚK VACHŮN, DrSc., Mendelova zemědělská a lesnická univerzita, Brno, Zahradnická fakulta, Valtická 337, 691 44 Lednice na Moravě, Česká republika, tel.: + 420 627 34 01 05–7, fax: + 420 627 34 01 59, e-mail: vachun@mendelu.cz

# Dynamics of ethylene in apples during maturation and cold storage

J. GOLIÁŠ

*Mendel University of Agriculture and Forestry, Brno, Faculty of Horticulture, Lednice na Moravě, Czech Republic*

**ABSTRACT:** Natural ethylene production in the intact apple fruit was taken as an indicator of the speed of metabolism both during maturation on the tree and subsequent cold storage. The same indicator has been used to assess the effectiveness of the coating emulsion Semprefresh. The effectiveness of the preparation depends on the variety and storage temperature. As shown by ethylene measurements, the protecting coat slows down the metabolism in Golden Delicious at the temperature of 3°C. Ethylene production from cold-stored fruits differs across varieties and also depends on the maturity at the time of harvest. The fruits of Rezista variety, which were harvested after the optimal maturity, showed a higher ethylene production at 3°C. No post-harvest peak of ethylene production was observed at this temperature. The protecting effect of the Semprefresh coating was demonstrated in Golden Delicious, where it delayed the ripening process, while no similar effect could be shown in Selena. This deviation can be related to the visually perceivable difference of the skin in the latter fruit based on a natural wax layer in the epidermis. By the method of ethylene measurements described in this article, it is possible to distinguish the metabolic activity of fruits stored at the temperatures of 3°C and 16°C.

**Keywords:** ethylene; apples; cold storage; preparation Semprefresh

The metabolic activity of pomes during storage has been studied by using different indicators. One of the main indicators is the concentration of ethylene in the inner atmosphere of fruits, or the natural ethylene production inside an intact fruit. In order to demonstrate physiological concentrations of ethylene at their threshold values, it is necessary to accumulate a sufficient quantity of ethylene from the percolating gas by means of a suitable enrichment method. This must be done because in the majority of cases a direct measurement through feeding the chromatographic column with the inner atmosphere of the fruit would be unable to bring any provable results due to the given low sensitivity of the analytical apparatus. Thus the methodology used in our approach can be fully justified since its utilization made it possible to measure threshold concentrations of ethylene in completely unripe fruits or in fruit and vegetable species which are characterized by a low natural ethylene production.

Ethylene gas has profound effects on ripening process, ageing of tissues, and fading of dormancy. The concentrations typical of these effects were described as above-the-threshold (BLANPIED 1984). In the ambient atmosphere of the storage chamber, ethylene accumulates (GOLIÁŠ 1985) and the current concentration is a result of the imbalance between the physiological activity of the fruit and the efficiency of the device for its active elimination from the storage area.

Removing ethylene from the controlled atmosphere is difficult. It is usually achieved through its catalytic burning (DILLEY et al. 1982; DOVER 1985; CONTE et al. 1992), its adsorption on active carbon, its chemical binding on ethylene oxidants (WOJCIECHOWSKI et al. 1985). One technique recommended in the usual type of hermetic cold storage chamber is appropriate ventilation with outside air.

Apples differ in the production of ethylene across varieties and so the natural production can lead to such concentrations that in the ambient atmosphere act as an exogenous catalyst of ripening. As a result, the preservation potential is diminished, which is even enhanced when different varieties of apples or different fruit or vegetable species are stored together. On the other hand, it can be reasonably expected that varieties within a species with naturally low level of ethylene release display an analogical slow-down in metabolism as measured by other indicators (oxidation of fruit acids, decomposition of pectins). In apricots, it is possible to establish the ripening speed on the basis of the half-time of ethylene concentration in the inner atmosphere of the fruit and the half-time of tissue softening. This applies both to the period of maturation and the storage at a corresponding transport temperature (GOLIÁŠ 1987).

Apart from the storage temperature and the effects of the ambient atmosphere, hemibiotic preservation of fruit can also be influenced by emulsion coatings which mo-

dify the ability of the skin to act as a barrier for the communication of physiological gases with the outer atmosphere. Edible coats contain saccharose esters with polycarbon aliphatic acids supported by some auxiliary components designed to improve the effects of the substance and its application. One of the commercially available preparations in this group is the emulsion product Semperfresh.

In this article we concentrate on comparing the activities of different apple varieties under different conditions as shown by a variety's ethylene production taking place both during maturation and subsequent cold storage. On the basis of the quantity of ethylene released from intact fruit, the effectiveness of the coating preparation Semperfresh has been assessed.

## MATERIALS AND METHODS

### MEASURING RELEASED ETHYLENE

Fruits were harvested from six-year-old experimental plantations of the Research Station Mendeleum in Lednice (Florina, Produkta, Rezista) and ten-year-old production orchards Agrosad, Ltd., Velké Bílovice. During maturation on the tree, the measurements of ethylene released by the intact fruit were carried out in the period between 14<sup>th</sup> and 21<sup>st</sup> October. The varieties were picked when their ethylene production was below 1  $\mu\text{l/kg per h}$ ; in Rezista this value was 3  $\mu\text{l/kg per h}$ . Golden Delicious variety was harvested at the ethylene values below 1  $\mu\text{l/kg per h}$ , but the first measurement at the storage temperatures showed the production at 3  $\mu\text{l/kg per h}$ . These values correspond to the storage temperatures of 3°C. For the evaluation of Semperfresh emulsion, the temperatures of ethylene measurement were 3°C and 16°C.

The quantity of ethylene measured in intact fruits of a given variety is always that released by a single fruit. The used methodology is described in GOLIÁŠ and NOVÁK (1985). The measurements were carried out at

regular intervals from the beginning to the middle of the period of normal effective cold storage of a variety.

## TREATMENT OF FRUITS WITH THE PREPARATION SEMPERFRESH

Fruits of Golden Delicious variety were dipped into a 1% water solution of the commercial preparation Semperfresh and kept there for 2 minutes (the preparation is sold as emulsion solution by Agricoat Industries Ltd.). After surface evaporation which took place for several minutes, the treated fruits were put into storage at 16°C with relative air humidity 85–95%, and at 3°C with relative air humidity 88–94%. The untreated fruits (control) were kept under analogical conditions. At regular intervals, the ethylene production inside intact fruits was measured.

## RESULTS AND DISCUSSION

### LEVEL OF METABOLIC PROCESSES IN THE INTACT FRUIT BASED ON ETHYLENE CRITERION

The climacteric phase is studied by measuring either the ethylene concentration in the inner atmosphere of the fruit or its natural production determined by capturing the diffuse flow into a suitable sorption material. Both techniques are currently used.

The former method, however, is more demanding for the quality of the available apparatus. There is no direct mathematically expressible relation between the two values (ethylene concentration inside the fruit and ethylene production) but the time patterns are consistent because the diffusion coefficient of the skin in the quasi-static determination does not change (GOLIÁŠ, NOVÁK 1983).

After the introduction into cold temperature and subsequent adaptation of the tissues to the climatic conditions in a cold storage chamber, the values of ethylene production, confirmed at several short intervals, express the properties of the given variety. According to this cri-

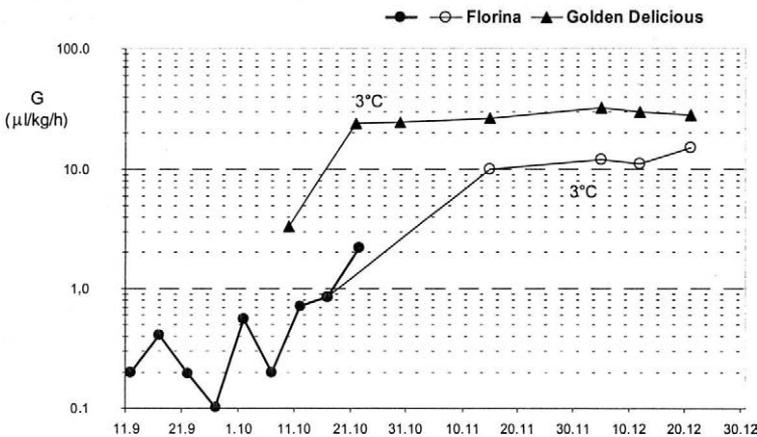


Fig. 1. Ethylene production (G) of Florina and Golden Delicious varieties during maturation on the tree and at cold storage temperature 3°C. Ethylene release in Golden Delicious was observed only in cold chamber (the arrow indicates the date of harvest)

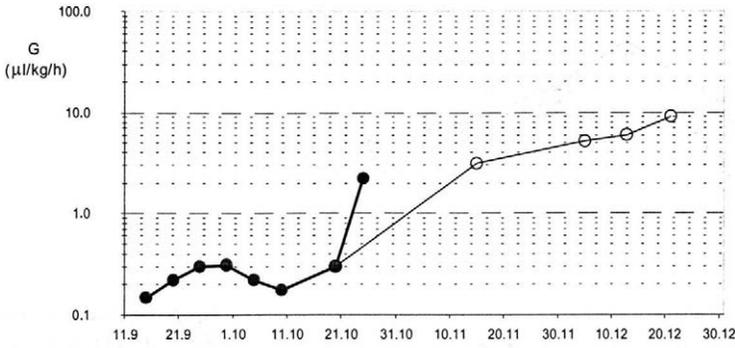


Fig. 2. Ethylene production (G) of Produkta variety during maturation on the tree (see black dots) and at cold storage temperature 3°C

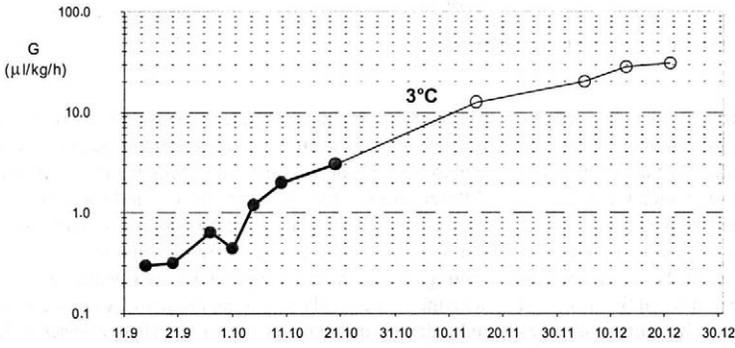


Fig. 3. Ethylene production (G) of Rezista variety during maturation on the tree (black dots) and at cold storage temperature 3°C

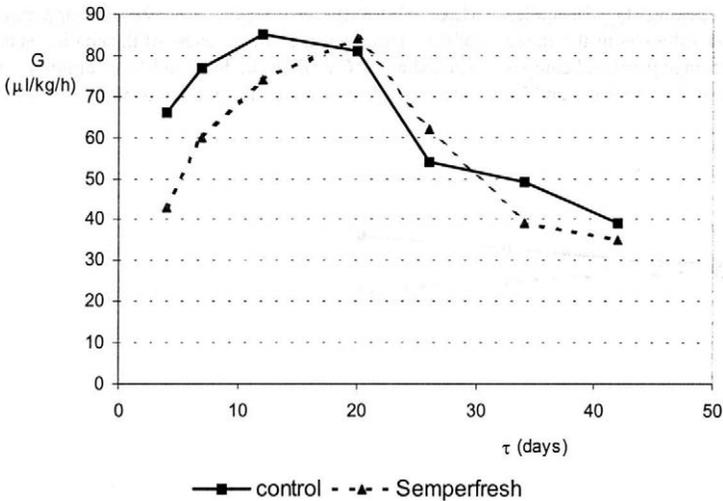


Fig. 4. Ethylene production (G) of Selena variety stored at 16°C and treated with Semperfresh as well as untreated fruits of the same variety

terion, Florina (Fig. 1) and Produkta (Fig. 2) varieties display a lower physiological activity in the period of cold storage than Golden Delicious variety (Fig. 1). For all these varieties, the production of ethylene at the time of harvest when the fruits were picked and kept for fu-

ture measurements was similarly at 0.3–0.6 μl/kg per h. This was different in Rezista whose fruits were picked in a state of visibly excessive maturity, which was also confirmed by the content of non-volatile components expressed as three-parameter index (pulp firmness, soluble

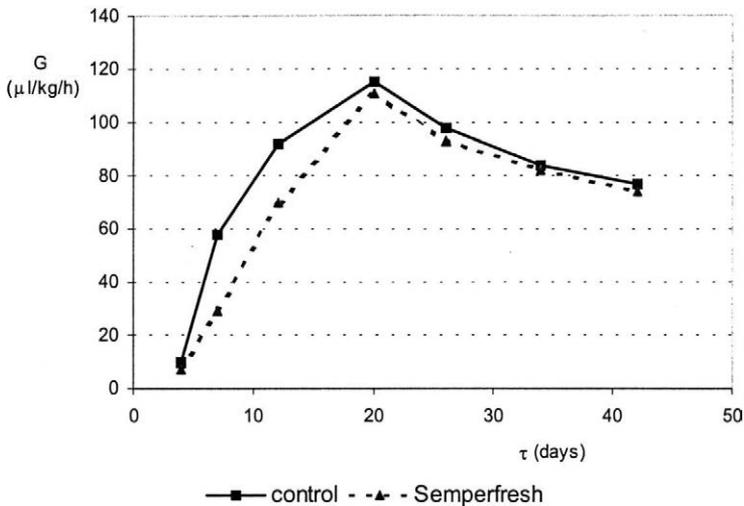


Fig. 5. Ethylene production (G) of Golden Delicious variety stored at 16°C and treated with Semperfresh as well as untreated fruits of the same variety

dry matter, starch content). Thus, Rezista fruits have a permanently rising ethylene production, starting at 0.3 µl/kg per h, which corresponds to the onset of climacteric and going to 3 µl/kg per h, which were the values of over-matured fruits on the tree (Fig. 3).

The effect of Semperfresh on metabolic activity was determined from ethylene production. The emulsion layer forms a secondary coat on the surface of the fruits and so slows down the diffusion of physiological gases through the skin into the ambient atmosphere. The fruits which were stored at 16°C had a much higher speed of metabolism typical of quicker ripening ( $Q_{10}$  for apples based on the original respiration values is in the range between 3.6 and 4.0). The cold storage fruits had comparably lower values (see Figs. 4 and 5, as well as 6 and 7).

The ethylene production values measured in the fruits treated with Semperfresh and those not treated in this way (control group) do not show any statistically significant differences (at reliability level 90% – see Figs. 4 and 5). The Semperfresh coat is little effective at 16°C as it quickly dries out, especially after the first symptoms of wilting appear. At this temperature, the ripening process with the immediately following phase of tissue ageing is unhindered and can proceed to the clearly observable peak. Polyester and fatty acid coats cause a delay of tissue softening and the neutralization of the initial acidity (LAU, MEHERIUK 1994) even at the storage temperature of 0°C. However, the effectiveness of the coating is dissipated at 20°C at both the high and low humidity. The quality of fruits from controlled atmosphere is thus bet-

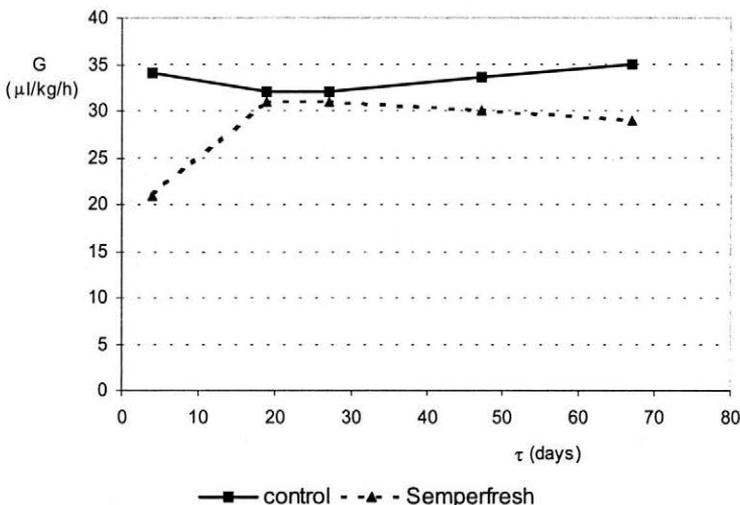


Fig. 6. Ethylene production (G) of Selena variety stored at 3°C and treated with Semperfresh as well as untreated fruits of the same variety

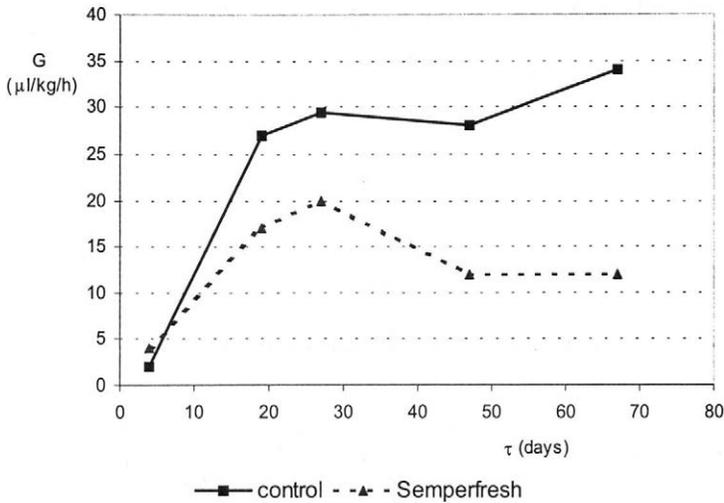


Fig. 7. Ethylene production (G) of Golden Delicious variety stored at 3°C and treated with Semperfresh as well as untreated fruits of the same variety

ter than that of fruits protected by coating and kept at normal cold storage.

At the storage temperature of 3°C, the effect of the preparation was observed in Golden Delicious where the treated fruits had a permanently lower ethylene production. This was probably due to the circumstance that the protective action of wax was maintained in the climate of the chamber acceptably saturated with water vapours. This variety has a rather tough and dry skin and the wax coat forms a selective membrane acting as an obstacle in the gas exchange. A similar finding was described by BLAŽEK et al. (1999), who could demonstrate that, only in cold storage, Semperfresh has the ability to diminish weight losses only in Nabella variety. Needless to say, Nabella's skin resembles that of Golden Delicious, unlike the skin of Selenia variety which is smooth and greasy, especially in the state of advanced maturity, with the result that the cuticle permanently serves as a semi-permeable membrane even when there is no added coating. This observation is in harmony with the differences in weight losses through evaporation in treated and untreated variety which, after cold storage in the duration of 69 days, were 1.71% in Golden Delicious, and only 0.19% in Selenia. The wax layer of the preparation slows down free water diffusion from the inner atmosphere of the fruit into the surrounding atmosphere. The opposite effect occurs when the evaporation increases in the form of cuticle evaporation. Then the biochemical conditions of ripening are deteriorated. Post-harvest ripening connected with a low water deficit in the intact fruit was observed to lead to a diminished ethylene production in Golden Delicious variety, the fruits of which were coated with protective emulsion (Fig. 7).

## References

- BLAŽEK J., LÁNSKÝ M., BLAŽKOVÁ J., HLUŠIČKOVÁ J., 1999. Influence of Semperfresh on storage of three apple cultivars grown without chemical protection. *Zahradnictví – Hort. Sci. (Prague)*, 26: 45–54.
- BLANPIED G.D., 1984. Observations of the variations in the initiation of the ethylene climacteric in apples attached to the tree. *Acta Hort.*, 157: 143–145.
- CONTE J., EL BLIDI A., RIGAL L., TORRES L., 1992. Ethylene removal in fruit storage rooms: A catalytic oxidation reactor at low temperature. *J. Food Eng.*, 15: 313–329.
- DILLEY R.D., IRWIN P.L., MCKEE M.W., 1982. Low oxygen, hypobaric storage and ethylene scrubbing. In: RICHARDSON D.G., MEHERINK M. (eds.), *Controlled atmospheres for storage and transport of perishable agricultural commodities*. Beawerton, Or, Timber Press: 317–329.
- DOVER C.J., 1985. Commercial scale catalytic oxidation of ethylene as applied to fruit stores. In: ROBERTS J.A., TUCKER G.A. (eds.), *Ethylene and Plant Development*. London, Butterworths: 373–382.
- GOLIÁŠ J., 1985. Veränderungen des Ethen- und Aromastoffgehaltes in Kühlräumen während der Lagerung von Äpfeln. *Arch. Gartenbau*, 33: 1–9.
- GOLIÁŠ J., 1987. Relationships between ethylene biogenesis in apricot fruits and their ripening. *Symposium papers. Fruit growing. 60 Years of Horticultural Research in Czechoslovakia*. Praha, 18.–21. 8. 1987: 204–206.
- GOLIÁŠ J., NOVÁK J., 1983. Simultane Bestimmung flüchtiger von unverserhten Äpfeln abgegebener und im Apfelsaft befindlicher Stoffe mit Hilfe der gaschromatographischen Head-space-Analyse. *Die Nahrung*, 27: 221–229.
- GOLIÁŠ J., NOVÁK J., 1985. Äthenmessung durch eine gaschromatographische Anreicherungs- und Nachweisdetektion. *J. Chrom.*, 346: 43–52.

LAU O.L., MEHERIUK M., 1994. The effect of edible coatings on storage quality of McIntosh, Delicious and Spartan apples. *Can. J. Plant Sci.*, 74: 847–852.

WOJCIECHOWSKI J., BLANPIED G.D., BARTSCH J.A., 1985. A comparison of ethylene removal by means of cata-

lytic combustion and chemical absorption. Fourth National Controlled Atmosphere Research Conference. Raleigh, July 23–26, U.S.A.

Received 16 August 1999

## Dynamika etylenu během sklizně a chladírenského skladování jablek

**ABSTRAKT:** Produkce etylenu v neporušeném plodu odrůd jablek byla měřítkem látkového metabolismu v období zrání na stromě a následném chladírenském skladování a při posouzení účinku ochranného povlaku emulzí Semperfresh. Účinnost přípravku závisí na odrůdě jablek a na teplotě skladování. Podle kritéria etylenu ochranný povlak přípravkem působí zpomalení metabolismu v teplotě skladování 3 °C pro odrůdu Golden Delicious. Produkce etylenu u plodů jablek uložených v chladírenské teplotě je odrůdově odlišná a závisí na stupni zralosti v období sklizně. Plody odrůdy Rezista, sklizené jako přezrálé, mají v teplotě uložení 3 °C vyšší produkci etylenu. V této teplotě nebyl zaznamenán posklizňový vrchol produkce etylenu. Pокryvný účinek přípravku Semperfresh se prokázal jako tlumivý u plodů odrůdy Golden Delicious, nikoliv u plodů odrůdy Selena. Rozdíly jsou vztaženy na vizuálně vnímanou odlišnost slupky s obsahem přirozené voskové vrstvy v epidermu. Hodnotou produkce etylenu lze rozlišit metabolickou aktivitu plodů skladovaných v teplotách uložení 3 °C a 16 °C.

**Klíčová slova:** etylen; jablka; chladírenské skladování; přípravek Semperfresh

---

*Corresponding author:*

Prof. Ing. JAN GOLIÁŠ, DrSc., Mendelova zemědělská a lesnická univerzita, Brno, Zahradnická fakulta, Valtická 337, 691 44 Lednice na Moravě, Česká republika, tel.: + 420 627 34 01 05–7, fax + 420 627 34 01 59, e-mail: golias@mendelu.cz

---

# Reaction of selected lamb's-quarters species (*Chenopodium* sp.) to mechanical inoculation with *Celery mosaic virus*

J. CHOD, D. CHODOVÁ, M. JOKEŠ

Research Institute of Crop Production, Prague-Ruzyně, Czech Republic

**ABSTRACT:** Sensitivity of six lamb's-quarters species: *C. quinoa*, *C. ficifolium*, *C. strictum*, *C. album*, *C. polyspermum* and *C. ambrosioides* to mechanical inoculation with *Celery mosaic virus* (CeMV) was investigated. *C. quinoa* and *C. strictum* plants were the best indicators for virus testing since they produced a high number of necrotic local lesions in a short incubation period after infection. Systemic reactions to CeMV infection were observed in *C. ficifolium*, *C. ambrosioides* and *C. polyspermum*. The aim of these experiments was also to investigate symptom intensity, number of infected plants, absorbance value determined by immunoenzymatic technique ELISA and number of virions examined by electron microscopically in selected preparations. Lamb's-quarters species with systemic reactions had higher absorbance values and higher number of virions. There were no large differences between the inoculum from celery leaves and roots either in the number of infected plants or in the other examined properties.

**Keywords:** mechanical inoculation; *Chenopodium* sp.; *Celery mosaic virus*

*Celery mosaic virus* (CeMV), taxonomically the member of the family *Potyviridae*, is mechanically transmissible to a number of herbaceous hosts from different families. Following methods were used for the virus diagnosis: immunoenzymatic technique ELISA, electron microscopic examination, immunosorption electron microscopy and indicator plant method. Indicators from the family *Chenopodiaceae* are *Chenopodium amaranticolor* (syn. *C. giganteum*) and *C. quinoa*; following the mechanical inoculation chlorotic or necrotic local lesions appear on their leaves in 7–9 days. CeMV was mechanically transmitted by POLÁK (1966) to the cow-parsnip (*Heracleum sphondylium*), causing systemic chlorosis and moderate leaf. Hosts from the family *Chenopodiaceae* that reacted to infection by local lesions were investigated by WOLF (1969). He published new details on some of his previous results with *C. amaranticolor* after inoculation with CeMV and reported irregularly dispersed brown local lesions. But another pair of leaves did not show any symptoms. Besides infection of selected indicators by mechanical inoculation he detected CeMV in naturally infected plants of the family *Daucaceae* that were infected by other viruses: *Cucumber mosaic virus* and *Tropaeolum mosaic virus*.

The objective of this paper is to describe reaction to CeMV infection in the lamb's-quarters species that have not been investigated before.

## MATERIAL AND METHODS

Experiments were carried out with *Chenopodium quinoa*, *C. ficifolium*, *C. strictum*, *C. album*, *C. polyspermum* and *C. ambrosioides*. Thirty plants of each species were mechanically inoculated with CeMV at the stage of the first pair of true leaves. The inoculum was made of a sap from

leaves and roots of celery plants from the parts with highest concentration of virus particles (CHOD, JOKEŠ 1996). To the inoculum chilled phosphate buffer at a concentration of 0.007 M with chelaton and veronal was added. Löwe-produced commercial antibodies were used for serological diagnosis applying ELISA at 405 nm in an ELISA apparatus manufactured by Dynatech company. Electron microscopic examinations of preparations were made in a Philips electron microscope at 20,000× magnification. Following characteristics were examined in investigated plants: type of symptoms, their intensity, number of infected plants, length of incubation period, absorbance value, presence of virus particles and their number. *C. quinoa* was used as a control (CHOD 1984), which reacted to CeMV isolate by necrotic local lesions, high number of virions and short incubation period. The CeMV isolate was maintained in the indicator plant of *Ammi majus*, which reacted by bright yellow spots in leaves after mechanical inoculation.

## RESULTS AND DISCUSSION

The results (Table 1) document different reactions of selected lamb's-quarters species to CeMV mechanical inoculation.

*Chenopodium quinoa*, *C. strictum* and *C. album* reacted by necrotic local lesions. The highest incidence of necrotic local lesions was determined in *C. quinoa*. *C. strictum* and *C. album* produced less local lesions. Systemic yellow spot appeared after infection in *C. ficifolium*, *C. ambrosioides* and *C. polyspermum*. Diffuse necrotic local lesions were observed in *C. strictum*, resulting in necrotization of the whole leaf blade. Yellow spots in *C. ficifolium* result in yellowing and dieback of whole leaves. The lamb's-quarters species with systemic

Table 1. Reactions of selected lamb's-quarters species to mechanical inoculation with *Celery mosaic virus*

<i>Chenopodium</i> :	Type of symptoms	Symptom intensity	Per cent of infected plants	Absorbance value	Number of virions in EM field	Incubation period (in days)
<i>quinoa</i>	LL	4	95	0.810	A	7
<i>ficifolium</i>	S	3	62	0.990	C	12
<i>strictum</i>	LL	3	54	0.727	B	8
<i>album</i>	LL	2	48	0.821	A	8
<i>ambrosioides</i>	S	4	67	1.101	C	10
<i>polyspermum</i>	S	2	42	1.151	B	14

Notes: LL – local lesions, S – systemic symptoms

Symptom intensity: 4 – very severe, 2 – mild

Number of virions in EM field: 1–3 = A, 4–10 = B, > 10 = C



Fig. 1. Electron micrograph of CeMV particles, magnification 20,000x

response to infection had longer incubation periods, and systemically infected species of lamb's-quarters showed a higher number of CeMV virions (average of 50 electron microscopic grids – Fig. 1).

Substantially higher absorbance values were determined by ELISA in the species with CeMV systemic infection.

*C. quinoa* can be recommended for rapid diagnosis by an indicator plant method due to short incubation period and higher number of necrotic local lesions. *C. strictum* is also suitable for its similar reaction. The well-discernible local lesions in both species facilitate quantitative assessment of the virus. *C. album* and *C. strictum* were mentioned in the context of CeMV infection by LENNON (1984), who considered them for suitable indicators too. KVIČALA (1957) recommended *C. quinoa* as a suitable indicator plant for CeMV identification. Besides local lesions, his isolate showed systemic infection. For maintenance of isolates the lamb's-quarters species with sys-

temic infection should be used, such as *C. ficifolium* and *C. ambrosioides* (CHOD et al. 2000).

The examined lamb's-quarters species are hazardous and wide-spread weeds in the Czech Republic since most of them are spontaneous hosts of vegetable viruses such as *Lettuce mosaic virus*, *Carrot mosaic virus*, *Beet yellows virus*, *Beet mosaic virus* and *Beet western yellows virus* (CHOD 1983) and *Cucumber mosaic virus* (KLINKOWSKI 1977; CHOD 1980).

#### References

- CHOD J., 1983. The occurrence of *Beet western yellows virus* on lettuce. Sbor. ÚVTIZ, Ochr. Rostl., 19: 237–239.
- CHOD J., 1984. Nález viru mozaiky celeru na mrkvi odrůdy Nantéz. Sbor. ÚVTIZ, Ochr. Rostl., 20: 91–96.
- CHOD J., HNÍZDIL M., 1980. Reaction of some spinach cultivars and hybrids to Beet mosaic, beet yellows and *Cucumber mosaic virus* infection. Sbor. ÚVTIZ, Ochr. Rostl., 16: 165–170.
- CHOD J., CHODOVÁ D., JOKEŠ M., 2000. Biologische und Immunogenetische Eigenschaften von Gemüseviren bei Verschiedenen Konzervierungs Methoden. Proc. 52 Deut. Pflanzenschutztagung: 558.
- CHOD J., JOKEŠ M., 1996. Distribution of *Celery mosaic virus* in celery leaves, leaf rosette, bulbs and roots. Ochr. Rostl., 32: 77–82.
- KLINKOWSKI M., 1977. Pflanzliche Virologie. Berlin, Regis-terband, Akademie Verlag: 337.
- KVIČALA B., 1957. On the identification of *Celery mosaic virus*. Rostl. Vyr., 5: 697–708.
- LENNON A.M., 1984. Umbelliferous weeds as hosts of celery viruses. [PhD Thesis.] University of Manchester: 52.
- POLÁK Z., 1966. The mechanical transmission and some properties of virus disease of cow – parsnip (*Heracleum sphondylium*). Biol. Plant, 8: 73–79.
- WOLF P., 1969. *Chenopodium* Arten als Lokalläsionswirte des Selerienmosaik-Virus. Monatsberichte der Deutsche Akad. der Wiss., Bd. 11: 293–297.

Received 8 November 2000

## Reakce vybraných druhů merlíků (*Chenopodium* sp.) na mechanickou inokulaci virem mozaiky celeru

**ABSTRAKT:** Byla vyšetřena citlivost šesti druhů merlíků: *Ch. quinoa*, *Ch. ficifolium*, *Ch. strictum*, *Ch. album* a *Ch. ambrosioides* na mechanickou inokulaci virem mozaiky celeru (CeMV). Pro testování viru se ukázaly jako nejvhodnější indikátory rostliny *Ch. quinoa* a *Ch. strictum*, které po infekci za krátkou inkubační dobu vykazovaly velké množství nekrotických lokálních lézí. Systémově reagovaly na infekci CeMV *Ch. ficifolium*, *Ch. ambrosioides* a *Ch. polyspermum*. V pokusu byla také vyšetřena intenzita příznaků, počet infikovaných rostlin, výška absorbance stanovená imunoenzymatickým testem ELISA a četnost virionů vyšetřená elektronmikroskopicky ve vybraných preparátech. Systémově reagující druhy merlíků vykazovaly vyšší hodnotu absorbance a vyšší četnost virionů. Mezi inokulem použitým z listů a kořenů merlíku celeru jsme nenašli podstatné rozdíly ani v počtu infikovaných rostlin, ani v ostatních vyšetřovaných parametrech.

**Klíčová slova:** mechanická inokulace; *Chenopodium* sp.; virus mozaiky celeru

---

*Corresponding author:*

Ing. JIŘÍ CHOD, DrSc., Výzkumný ústav rostlinné výroby, Drnovská 507, 161 06 Praha 6-Ruzyně, Česká republika, tel.: + 420 2 33 02 21 11, fax: + 420 2 33 31 06 36, e-mail: chodova@hb.vurv.cz

---

# Evaluation of resistance of apricot to *Monilinia laxa* (Aderh. et Ruhl.) Honey

I. MUSILOVÁ

Mendel University of Agriculture and Forestry, Brno, Faculty of Horticulture, Lednice na Moravě, Czech Republic

**ABSTRACT:** In 1998–2000 the resistance of 30 genotypes of apricot to *Monilinia laxa* (Aderh. et Ruhl.) Honey (brown rot) was evaluated in natural conditions and in laboratory. 24 genotypes are intraspecies hybrids obtained from crossings carried out in Lednice, 5 foreign varieties and 1 foreign hybrid. The control genotype is Velkopavlovická, the clone LE-12/2. 50 trees of each of 21 genotypes were planted in one orchard, 5 trees of each of the other genotypes were planted in another orchard. Natural infection of fruits was observed and two tests were made in laboratory. The best genotypes were Nugget, LE-3709 and Bergeron LE-2, the worst genotypes were Šalach, LE-3662 and Hargrand. The highest correlations were obtained between fruit infection and harvest ( $r = 0.51^{**}$ ), between fruit infection and setting of small green fruits ( $r = 0.48^{**}$ ) and the correlation between fruit infection in tests without injury and with injury was very high and very significant ( $r = 0.81^{**}$ ) in 2000.

**Keywords:** apricot; *Monilinia laxa*; brown rot; resistance

In the last years *Monilinia laxa* has become an important pathogenic fungus that attacks stone fruits, apricots, peaches, cherries and plums. Damage caused by *M. laxa* can reach 40–50% in favorable conditions. *Monilinia laxa* (Aderh. et Ruhl.) Honey belongs to the phylum *Ascomycota*, class *Ascomycetes*, subclass *Ascohymenomycedidae*, order *Leotiales*, the imperfect form is *Monilia laxa* (Ehrenb.) Sacc which is classed to the phylum *Deuteromycota*, subphylum *Deuteromycotina*, class *Hypohymycetes*, superorder *Leotinae*, order *Moniliales*. *M. laxa* causes blossom blight in spring and brown rot of fruits in summer. The first symptoms appear on sepals, then on petals, anthers and stigmata as the blossoms open. Blight symptoms appear when the fungus girdles the peduncle (OGAWA et al. 1995). Mycelium grows through blossoms into the xylem. Blossoms and one-year old shoots become brown and dry. Fruits are infected at ripening and maturing. Brown and soft places appear on fruits and then expand on the whole fruit. Later irregular gray layer of conidia is formed on the fruit surface. These fruits become a source of conidia for successive infections during the same year. Attacked fruits fall down onto the ground and rot or remain on the tree during the winter and mummify. The following year the mummified

fruits become a source of infections. Apothecia are sometimes formed on the mummified fruits in spring. Apothecia produce asci and ascospores (BAUDYŠ et al. 1962).

Favorable climatic conditions support the disease spreading in spring, a fall of temperature below 12°C and a high relative humidity (HLUCHÝ et al. 1997) and in summer, a temperature between 20–24°C and rainy weather. According to OGAWA et al. (1995), infection and development of blossom and twig blight occur in humid periods at temperatures above 13°C (optimum 24°C). Injuries of fruits (insect, hails, bursting of fruits) also increase the infection of fruits.

## MATERIAL AND METHODS

A commercial orchard with 21 genotypes was planted in spring 1993 in Lednice on a parcel belonging to the Department of Fruit Growing and Viticulture. 50 trees were planted of each genotype, spacings were 6 m between rows and 4 m between trees. M-LE-1 rootstock was used; it is a Czech selected seedling of *Prunus armeniaca* L. Tree type is a free-standing tree with low stem and concave top (crown). 5 trees of each of the other genotypes were planted in an experimental orchard in

Table 1. Chemical protection in the orchard

1998		1999		2000	
4. 3.	Kupricol 50	15. 3.	Champion 50 WP	29. 2.	Kupricol 50
24. 4.	Baycor 25 WP	6. 4.	Sporgon 50 WP	10.–11. 4.	Sporgon 50 WP
28. 5.	Syllit 65 + Baycor 25 WP	14. 4.	Sporgon 50 WP	2. 5.	Syllit 65
7. 6.	Baycor 25 WP	4. 5.	Baycor 25 WP + Zolone WP	11. 5.	Baycor 25 WP
		17. 5.	Syllit 65 + Fytovit	26. 5.	Syllit 65

Table 2. Evaluation of apricot to brown rot

Genotype	Observations in the orchard				Observations in the laboratory <sup>1)</sup>				Total average
	1998	1999	2000	average	1998	1999	2000	average	
LE-3204	2.50	8.61	8.45	6.29	8.30/5.80	8.80/7.60	7.80/5.20	8.30/6.20	7.93
LE-3709	6.09	9.00	8.71	7.85	8.60/7.00	9.00/8.20	9.00/8.20	8.87/7.80	8.17
Ledana	8.00	8.36	8.62	8.26	7.30/6.00	8.70/9.00	8.60/6.80	8.20/7.27	7.91
Lejuna	9.00	8.44	5.41	7.82	9.00/6.40	9.00/8.20	7.75/7.80	8.58/7.47	7.96
Lerosa	5.28	9.00	8.55	7.37	9.00/6.60	9.00/8.60	8.80/2.60	8.93/5.93	7.41
Lemira	1.88	8.31	5.21	5.06	8.80/8.40	9.00/9.00	9.00/7.00	8.93/8.13	7.38
LE-3662	1.36	8.81	5.17	4.78	9.00/7.40	9.00/8.00	6.40/3.40	8.13/6.27	6.4
VP-LE-12/2	5.33	9.00	8.15	7.44	8.90/7.00	9.00/7.80	7.30/4.80	8.40/6.53	7.46
Lebela	4.76	7.48	8.79	6.71	8.90/7.00	9.00/8.40	9.00/9.00	8.97/8.13	7.94
Hargrand	4.51	8.87	5.36	6.15	9.00/7.40	9.00/8.20	6.10/1.00	8.03/5.53	6.57
Bergeron LE-2	5.56	8.71	7.92	7.40	9.00/6.60	9.00/9.00	8.90/8.00	8.97/7.87	8.08
Leskora	7.89	8.50	8.53	8.30	8.90/5.80	8.90/8.20	6.50/5.40	8.10/6.47	7.62
LE-4725	6.95	8.76	4.25	6.84	8.50/5.60	8.20/8.60	8.50/5.00	8.40/6.40	7.21
LE-3255	4.56	8.64	8.81	7.09	8.50/5.60	8.90/8.20	8.20/7.20	8.53/7.00	7.54
Legolda	5.00	8.77	8.70	7.38	8.30/6.60	8.90/7.60	6.00/3.40	7.73/5.87	6.99
Lebona	1.60	8.83	8.73	6.04	8.20/7.00	9.00/9.00	5.90/2.40	7.70/6.13	6.62
Lefreda	4.07	9.00	8.70	7.14	8.80/7.00	9.00/8.00	8.50/7.20	8.77/7.40	7.77
Šalach	2.19	8.16	5.47	5.22	8.50/6.20	9.00/7.60	5.40/2.60	7.63/5.47	6.11
Lednická	2.87	8.83	8.35	6.56	8.30/7.00	9.00/9.00	9.00/7.80	8.77/7.93	7.75
LE-498	5.38	8.05	3.98	5.83	9.00/6.40	8.90/7.80	8.80/8.20	8.90/7.47	7.4
Leala	5.98	7.89	4.16	6.26	8.90/6.80	9.00/8.60	9.00/8.00	8.97/7.80	7.68
Veecot	5.80	8.60	7.20	7.20	8.20/5.80	8.90/8.40		8.55/7.10	7.62
Strepet	5.80	8.33	5.00	6.17	8.60/7.20	9.00/8.20	6.50/2.40	8.03/5.93	6.71
Morava (LE-1547)	3.80	5.50		4.56	7.70/5.80	8.80/8.60		8.25/7.20	6.67
LE-1549	3.00	9.00		6.00	9.00/6.80	9.00/9.00		8.95/7.90	7.62
Pálava (LE-1599)	4.60	9.00		6.80	8.30/6.40	9.00/8.80		8.65/7.60	7.68
LE-1915	5.80	7.50	7.00	6.64	8.90/7.20	8.50/8.60	8.20/5.40	8.53/7.07	7.41
Leronda	5.80	7.80	6.50	6.71	8.10/7.60	8.90/7.40	9.00/8.80	8.67/7.93	7.77
Nugget		9.00		9.00		9.00/7.60		9.00/7.60	8.53
M-52	5.67	7.00	8.33	7.00	7.60/7.00	8.80/8.00	9.00/9.00	8.47/8.00	7.82

1991–1993. The rootstock and the tree type were the same, but they were planted at spacings of 6 m between rows and 2 m between trees. The system of cultivation was black fallow with a herbicide-treated strip under the trees.

Climatic characteristics of the station: 164 m above sea level; annual average temperature (from 1901 to 1980) 9°C; annual average rainfall (from 1901 to 1980) 524 mm. Lednice belongs to a maize production type, warm and dry subregion with mild winter and slightly shorter sunshine.

Soil properties: pH 6.05; CaCO<sub>3</sub> content 0.05%; texture loam-sandy; soil type Chernozem; content of P 72.1 mg/kg; content of K 262.0 mg/kg; content of Mg 328.2 mg/kg (in 1994).

Chemical protection carried out in the orchard in 1998–2000 is indicated in Table 1. All these chemical treatments were aimed at the control of *Gnomonia erythrostoma*, except the one with Spogon 50 WP, which was performed to control blossom and twig blight (*Monilinia laxa*).

The results of visual evaluation of fruit resistance were ranked from 1 to 9: 9 – very high resistance, a tree with 0.0–1.0% of infected fruits; 7 – high resistance, 1.1–3.0% of infected fruits; 5 – medium resistance, 3.1–10.0% of infected fruits; 3 – low resistance, 10.1–30.0% of infected fruits; 1 – very low resistance, more than 30.0% of infected fruits.

In laboratory, the results of evaluation of fruit resistance were ranked from 1 to 9: 9 – very high resistance, a fruit without infection; 7 – high resistance, infection on a third of the fruit; 5 – medium resistance, infection on a third to a half of the fruit; 3 – low resistance, infection on a half to two thirds of the fruit; 1 – very low resistance, infection on more than two thirds of the fruit. Artificial inoculation of fruits was carried out in the maturity period. Twenty mature fruits without injury and 10 mature fruits with artificial injury of each genotype were inoculated by the fungal mycelium (5 × 5 mm) on the surface. The mycelium was cultivated on PDA and it was 12 days old. Inoculated fruits were placed on a tray under plastic sheet. The temperature was 22–25°C and a glass of water ensured high humidity under plastic sheet. The test was evaluated after 3 days.

Tested genotypes: LE-3207, LE-3709, Ledana, Lejuna, Lerosa, Lemira, LE-3662, Velkopavlovická (VP-LE-12/2), Lebela, Hargrand, Bergeron LE-2, Leskora, LE-4725, LE-3255, Legolda, Lebona, Lefreda (LE-833), Šalach, Lednická (M-90-A), LE-498, Leala, Veecot, Strepet, Morava (LE-1547), LE-1549, Pálava (LE-1599), LE-1915, Leronda, Nugget, M-52 (interspecific hybrid).

## RESULTS AND DISCUSSION

The infection of fruits was most severe in 1998. It can be explained by two factors. First, there was no protec-

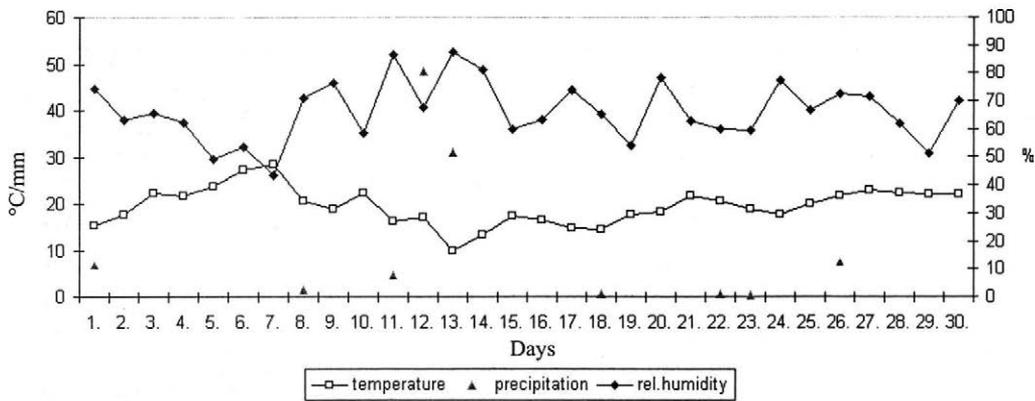


Fig. 1. Climatic conditions in June 1998

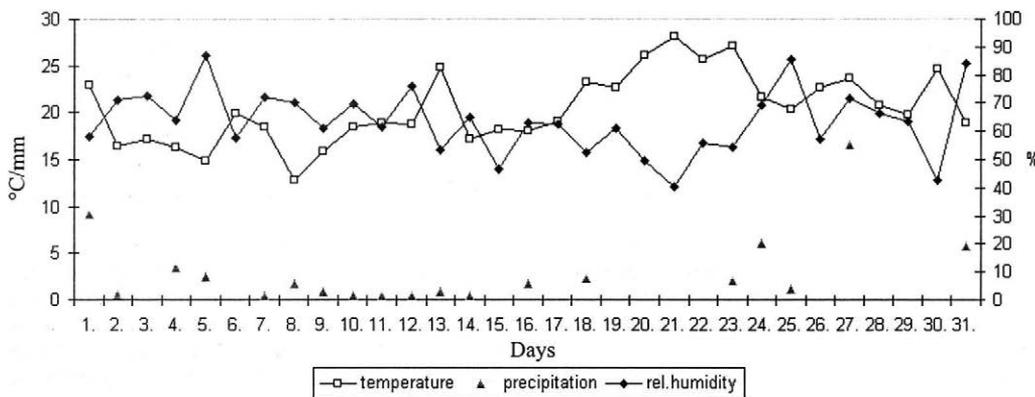


Fig. 2. Climatic conditions in July 1998

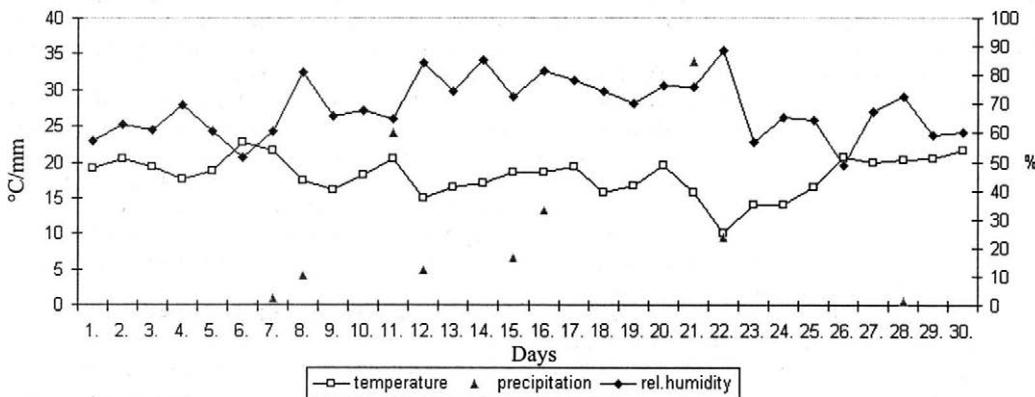


Fig. 3. Climatic conditions in June 1999

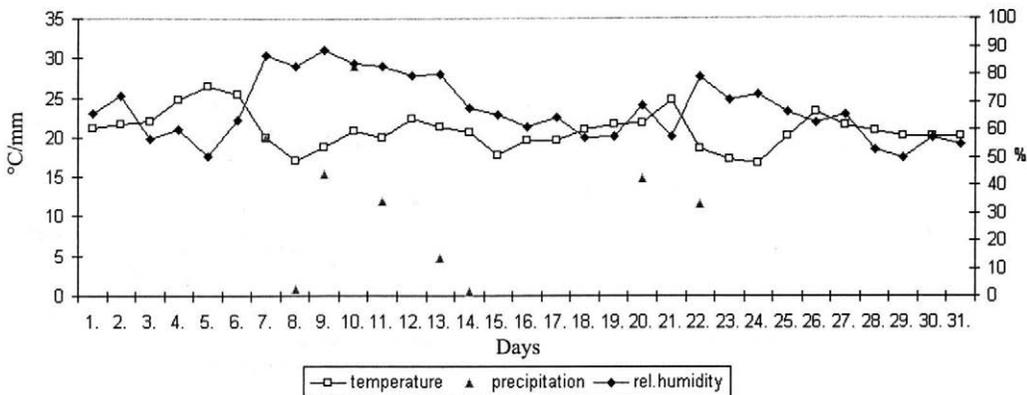


Fig. 4. Climatic conditions in July 1999

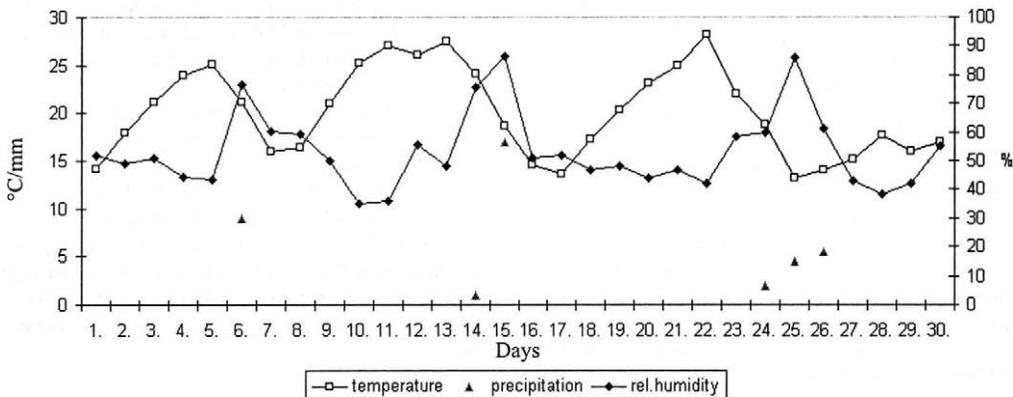


Fig. 5. Climatic conditions in June 2000

tion against blossom blight and infected flowers became a source of conidia for successive infection of fruits. The second factor is a high precipitation amount in the periods before and during ripening (Figs. 1, 2). Higher precipitation on 12.–13. 6. (79.3 mm) promoted the spreading and development of disease on precocious genotypes LE-3204 (2.50 degree), LE-3709 (6.09 d.), LE-4725 (6.95 d.), LE-3255 (4.56 d.). Other events of rainfall were on 26. 6. (7.4 mm) and on 1. 7. (9.2 mm) and favoured the infection of Lerosa (5.28 d.), Lemira (1.88 d.), LE-3662 (1.36 d.), Lebona (1.60 d.) (Table 2).

In the second year, 1999, the total infection was lower even though the fertility of all genotypes and precipitation in June and July were high (Figs. 3, 4). In that year, the protection against blossom blight was carried out (zero occurrence) and the source of infection was reduced strongly. The evaluation of genotypes is indicated in Table 2.

In 2000, climatic conditions were different (Figs. 5, 6), the spring was very hot and dry. These conditions caused the drying of pistils and pollen in the flowering period. Very high fertility in the previous years also reduced the flower differentiation (Table 2).

Generally, the best genotypes in the orchard were Nugget, Leskora, Ledana and Lejuna. But Nugget produced only one year and that is why the result cannot be taken as objective.

In 1998, the correlation between fruit infection and blossom setting was slightly positive ( $r = 0.22^{++}$ ), between fruit infection and setting of small green fruits, and between fruit infection and harvest (kg/tree) it was positive,  $r = 0.58^{++}$  and  $r = 0.62^{++}$ , respectively. In 1999 correlations between fruit infection and setting of small green fruits, and between fruit infection and harvest (kg/tree) were slightly positive too ( $r = 0.31^{++}$  for both correlations). In 2000, these correlations were positive,

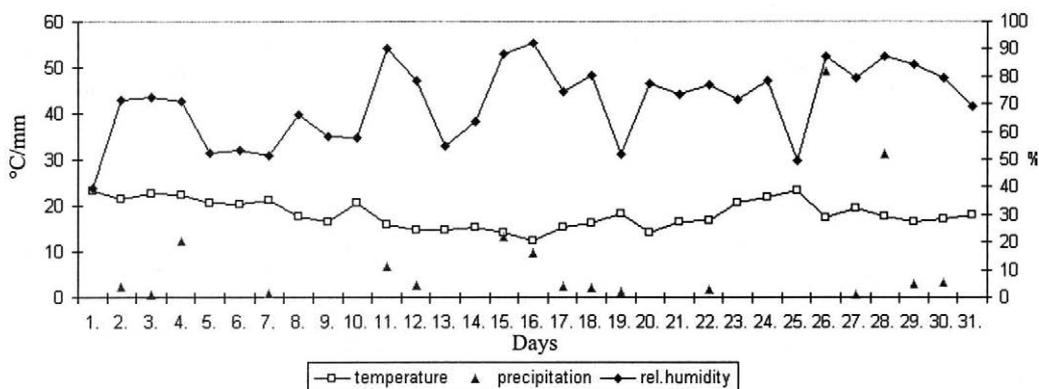


Fig. 6. Climatic conditions in July 2000

but negative between fruit infection and blossom setting,  $r = -0.48^{**}$ ; between fruit infection and setting of small green fruits,  $r = -0.51^{**}$  and between fruit infection and harvest (kg/tree),  $r = -0.50^{**}$ . Globally, the highest correlations were obtained between fruit infection and harvest ( $r = 0.51^{**}$ ) and between fruit infection and setting of small green fruits ( $r = 0.48^{**}$ ).

In the laboratory test, differences between the two tests were found. The influence of injury was confirmed, fruits with artificial injury were more susceptible to infection, and it caused the development of brown rot. Evaluation of genotypes was more variable in the test of fruits without injury. PASCAL et al. (1994) made similar tests with fruits and their results were identical.

In the test without injury, the best genotypes were Nugget (9.00), but the variety produced only one year (1999), Bergeron LE-2, Leala, Lebela (8.97) and LE-1549 (8.95) and the worst genotypes were Šalach (7.63), Lebona (7.70) and Legolda (7.73).

In the test with artificial injury, Lemira, Lebela (8.13), M-52 (8.00) and Leronda (7.93) were the best genotypes and Šalach (5.47), Hargrand (5.53), Legolda (5.87) and Strepet (5.93) were the worst genotypes in this test.

Correlations between fruit infection in the orchard and laboratory tests were very slight, the correlation between fruit infection in tests without injury and with injury was very high and very significant ( $r = 0.81^{**}$ ) in 2000, high and very significant in a summary evaluation (1998–2000,  $r = 0.78^{**}$ ). PASCAL (1994) also presents a difference between fruit infection in tests with and without injury, but he does not confirm the independence between these tests. Other higher correlations were determined between fruit infection in the orchard and the test of fruits with injury in 1998 ( $r = -0.33$ ), between fruit infection in the orchard and the test of fruits without injury in 1999 ( $r = 0.25$ ) and between the average of fruit infection in the orchard and the average of the test of fruits without injury ( $r = 0.22$ ).

BARGIONI (1993) presents Veecot as a resistant variety and DELLA STRADA (1989) as a medium resistant to slightly susceptible, and that was also shown in this test. Nugget is a medium resistant variety according to DELLA STRADA (1989) and these tests. On the contrary, Strepet and Šalach have similar pomological qualities and degree of resistance, these varieties were more susceptible to *Monilinia*.

Velkopavlovická LE-12/2 is presented as a medium resistant variety (DELLA STRADA 1989) and it showed this level in all tests. Lejuna is evaluated as a susceptible variety when it has high fertility. Lejuna showed high resistance in the orchard in 1998–1999, but in 2000 it was more susceptible. It had similar results in laboratory tests.

## CONCLUSION

Resistance of varieties to diseases is a very important quality for fruit-growers at the present time. Resistance is influenced by more factors, climatic conditions, variety, by the condition of the tree.

Generally, the best genotypes were Nugget (8.53), LE-3709 (8.17) and Bergeron LE-2 (8.08), the worst genotypes were Šalach (6.11), LE-3662 (6.40) and Hargrand (6.57).

## References

- BARGIONI G., 1993. Apricot varieties resistant to *Monilia*. Vita in Campagna, 11: 22–23.
- BAUDYŠ E. et al., 1962. Zemědělská fytopatologie 4. Praha, ČSAZV, SZN: 356.
- DELLA STRADA G. et al., 1989. Monografia di cultivar di albicocco. Roma, Frutticoltura – Agrumicoltura: 219.
- HLUCHÝ M. et al., 1997. Obrazový atlas chorob a škůdců ovocných dřevin a révy vinné. Brno, Biocont Laboratory, s.r.o.: 100–101.

Received 18 January 2001

## Hodnocení rezistence meruněk k *Monilinia laxa* (Aderh. et Ruhl.) Honey

**ABSTRAKT:** V letech 1998–2000 byla zjišťována rezistence plodů vybraných genotypů meruněk k *Monilinia laxa* (Aderh. et Ruhl.) Honey jak v polních, tak v laboratorních podmínkách. V kolekci bylo celkem 30 genotypů, z toho 24 genotypů ze šlechtitelského programu Ústavu ovocnictví a vinohradnictví v Lednici, pět zahraničních odrůd a jeden mezidruhový hybrid (M-52). Kontrolní odrůdou byla Velkopavlovická LE-12/2 (dále VP-LE-12/2). Kolekce 21 genotypů (LE-3204, LE-3709, Ledana, Lejuna, Lerosa, Lemita, LE-3662, VP-LE-12/2, Lebel, Hargrand, Bergeron LE-2, Leskora, LE-4725, LE-3255, Legolda, Lebona, Lefreda, Šalach, Lednická, LE-498 a Leala) se nachází v poloprovazní výsadbě v Lednici, kde byly tyto genotypy vysazeny po 50 kusech. Dalších devět genotypů (Veecot, Strepet, Morava, LE-1549, Pálava, LE-1915, Leronda, Nugget a M-52) bylo vysazeno ve staničních zkouškách po pěti kusech. Ve všech sledovaných letech byl zjišťován přirozený výskyt moniliové hniloby v době sklizňové zralosti a zároveň byly provedeny umělé infekce zralých plodů v laboratorních podmínkách. Přirozená infekce byla hodnocena podle devítibodové stupnice, kde 9 – velmi vysoká rezistence, napadeno bylo 0,0–1,0 % plodů, 1 – velmi nízká rezistence, napadeno více než 30,0 % plodů. Umělé infekce byly hodnoceny opět podle devítibodové stupnice, kde 9 – plod bez projevu hniloby, velmi vysoká rezistence, 1 – napadeny více než dvě třetiny plodu, velmi nízká rezistence. Laboratorní test byl rozdělen na dvě části – infekce plodů bez poranění a infekce plodů s umělým poraněním. Nugget (celkový průměr 8,53 bodů), LE-3709 (8,17 b.) a Bergeron LE-2 (8,08 b.) byly vyhodnoceny jako nejlepší genotypy. Byly zjištěny korelace mezi napadením plodů v polních podmínkách a sklizní (kg/strom) ( $r = 0,51^{**}$ ) a mezi napadením plodů a bohatostí násady plodů ( $r = 0,48^{**}$ ). V roce 2000 byla také velmi silná pozitivní korelace mezi napadením plodů bez poranění a napadením plodů s poraněním v laboratorním testu ( $r = 0,81^{**}$ ).

**Klíčová slova:** meruňky; *Monilinia laxa*; moniliová hniloba plodů (hnědá hniloba); rezistence

---

Corresponding author:

Ing. IVANA MUSILOVÁ, Sempra Litoměřice, s.r.o., Českolipská 6, 412 01 Litoměřice, Česká republika, tel.: + 420 416 73 11 80, fax: + 420 416 73 11 80, e-mail: musilova.ivana@centrum.cz

---

# Stability of yellow and red rose pigments during their storage under different conditions

J. LACHMAN, M. ORSÁK, V. PIVEC, D. KRATOCHVÍLOVÁ

*Czech University of Agriculture, Faculty of Agronomy, Prague, Czech Republic*

**ABSTRACT:** The composition and stability of pigments isolated from yellow rose (cv. *Papillon* or *Papillion Rose*) and red rose (cv. *Red France*) were investigated. Thin layer chromatography and spectral data were used for pigment identification.  $\beta$ -carotene, its 5,6,5',6'-diepoxide, lutein, lycopene, zeaxanthin and phytofluene were identified as major carotenoids in acetone extract of the yellow rose petals. Cyanin and chrysanthemin were found as major anthocyanin constituents in acidic (HCl) methanolic extract of the red rose petals. The extracts were stored in a closed glass bottle under four different conditions (temperatures 22, 4 and  $-8^{\circ}\text{C}$ , dark or daylight at  $22^{\circ}\text{C}$ ) and the pigments were determined periodically up to 132 days. Carotenoids were found to be much more stable (42–100.9% of the initial values on day 132) than anthocyanins (9.2–14.9% of the initial values). Losses of carotenoids fit to Arrhenius equation (correlation coefficient 0.894) and low activation energy indicates oxidation reaction with lesser temperature dependence. No correlation was found for anthocyanin decomposition. Light had the greatest destabilizing effect on both pigments (in carotenoids a decrease to 42%, in anthocyanins to 9.2% of the initial values). The effect of temperature was of lower significance. The anthocyanins were best preserved under storage in a freezer.

**Keywords:** yellow rose; red rose; carotenoids; anthocyanins; stability; effect of light and temperature

Flower pigments are of different chemical nature and structures (GOODWIN 1965). Carotenoids, anthocyanins, flavonoids, chalcones, auronos, and anthraquinones are the most widespread. The nature of a pigment can affect its stability and changes in colouration of ornamental plants during their storage and use.

Carotenoids, anthocyanins and flavonoids were found in *Rosa* species as the dominant pigments. VALADON and MUMMERY (1968a,b) analyzed flowers of ten varieties of yellow to orange roses, two *Posentilla* spp. and two *Geum* spp. for their carotenoid contents.  $\beta$ -carotene and  $\beta$ -carotene oxide mutatochrome were found in all samples. Lutein, a leaf xanthophyll, was found in low amounts in all flowers except for four rose varieties. Epoxy carotenoids were obtained in fairly large amounts. Those identified were phytoene, phytofluene,  $\beta$ -,  $\gamma$ -, and  $\delta$ -carotene,  $\beta$ -zeacarotene, and lycopene. Rubixanthin, a specific pigment of rose hips, was found in eight roses but not elsewhere. In six of the roses was found a yellow pigment to that the trivial name rosaxanthin was given.  $\beta$ -carotene, auroxanthin, 5,6,5',6'-diepoxide of  $\beta$ -carotene, flavoxanthin and chrysanthemaxanthin were revealed as the main carotenoids (VALADON, MUMMERY 1969). GOODWIN (1965) reported that carotenoid occurrence is similar in many *Rosa* species and rubixanthin is the dominant pigment. Data suggest that roses are yellow

or orange depending upon types of occurring carotenoids (acyclic or cyclic) and their ratio (Figs. 1 and 2). VALADON and MUMMERY (1969) found in anthers of fully opened flowers, anthers and styles of ripe hips from floribunda, hybrid tea and dog rose (*Rosa canina* L.) sixteen carotenoids in flowers and twenty two carotenoids in hips.  $\beta$ -carotene and its epoxides, from  $\beta$ -carotene derived xanthophyll, auroxanthin and from the  $\alpha$ -carotene derived flavoxanthin and chrysanthemaxanthin were found in all developmental stages studied. With the age the control of carotenoid synthesis was removed and oxidation processes took place, leaving very few members of  $\alpha$ -carotene series, and giving as main constituents the epoxy carotenoids and their derivatives. Rubixanthin (3-hydroxy- $\gamma$ -carotene) characteristic of rose hips was abundant in anthers and styles as derived from  $\gamma$ -carotene. Only the hips of the floribunda rose cv. *All Gold* contained vitamin A.

Yellow roses contain only carotenoids whereas pink flowers of *Rosa rugosa* also anthocyanins. Pure peonidin bound in glycosides was identified (GOODWIN 1956). The ratio of present carotenoids and non-carotenoid pigments, mainly anthocyanins (Fig. 3) determines the tinge of roses (VALADON, MUMMERY 1968b). A mixture of glycosides derived from cyanidin and peonidin was found in *Rosa rugosa* and its hybrids whereas carmine

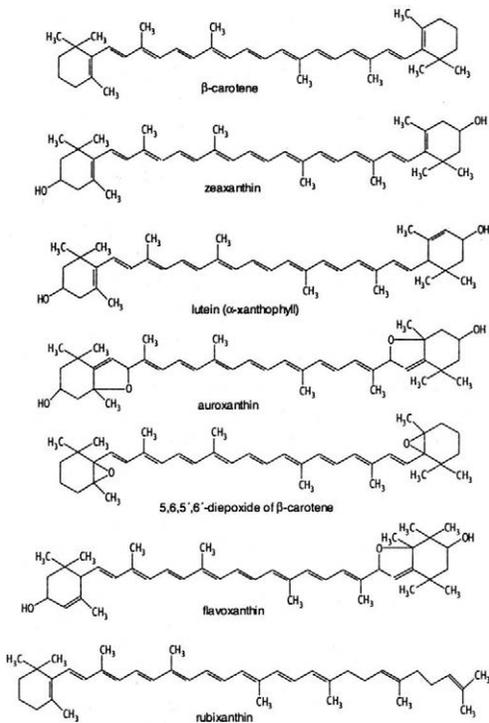
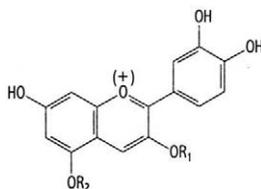


Fig. 1. Major carotenoids of yellow-orange roses with rings

coloured roses contained only cyanidin glycosides (HARBORNE 1963). Copigmentation is also a factor controlling flower colour in genus *Rosa*. There were investigated lily and purple coloured varieties containing cyanin (cyanidin-3,5-O-diglucoside). In this case cyanin is copigmented in greater deal with gallotannin and the spectral shift changes from 507 to 512 nm (HARBORNE 1963). This copigmentation causes blue tinge of certain roses. Copigmentation complexes of cyanidin-3-glucoside, cyanidin-3-malonylglucoside and cyanidin-3-malonyllaminaribioside with chlorogenic acid or protocatechuic acid were intensively studied (DONNER et al. 1998; DAVIES,



$R_1 = \text{Glu}, R_2 = \text{Glu}$  cyanin  
 $R_1 = \text{Glu}, R_2 = \text{H}$  cyanidin-3-O-glucoside  
 $R_1 = \text{Malonylglu}, R_2 = \text{H}$  cyanidin-3-O-malonylglucoside  
 $R_1 = \text{Malonyllaminaribioside}, R_2 = \text{H}$  cyanidin-3-O-laminaribioside

Fig. 3. Dominant glycosides of cyanidin in red roses

MAZZA 1993). A series of twelve structurally related anthocyanins, extracted from red-purple flowers of *Dendrobium Pramot*, pink flowers of *Senecio cruentus*, orange-red flowers of *Sophranitis coccinea*, red-purple flowers of *Phalaenopsis* and also red-purple flowers of *Laeliocattleya* cv. *Mini Purple* and *Bletilla striata* allowed the confirmation of the existence of strong intramolecular copigmentation effects (FIGUEIREDO et al. 1998). Anthocyanins and chlorogenic acid copigmentation influence the colour of strawberry and chokeberry juices (WILSKA-JESZKA, KORZUCHOWSKA 1996). Anthocyanins having catechol or pyrogallol group in their structure are widespread in flowers and fruits as glycosylated derivatives of cyanidin, delphinidin and petunidin chromophores. In particular, flowers have developed very efficient strategies in the production of colour which led to the biosynthesis of structurally very complicated biorganic pigments, e.g. with  $\text{Al}^{3+}$  or  $\text{Ga}^{3+}$  (ELHABIRI et al. 1998). The important role that anthocyanins could play as antioxidants in living systems may be well explained by their regulation of iron uptake and activity within the most complicated biological media. Values of a complexation constant  $K_{\text{global}}$  for the reaction

$$\text{AH}_2^+ + \text{Fe}^{3+} \rightleftharpoons [\text{C}_2(\text{Fe})]^{3+} + \text{H}^+$$

range between 85 (5,7-dihydroxy-3,4'-dimethoxyflavylium) to 700 for malvin (GEORGE et al. 1998).

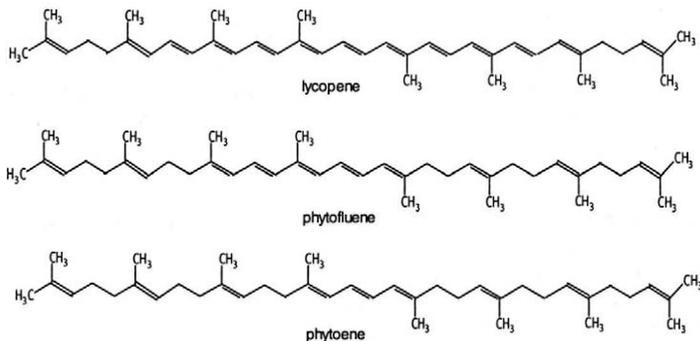


Fig. 2. Dominant acyclic carotenoids of yellow-orange roses

The other types of complex forming are interactions between anthocyanins and different flavan-3-ols, as was studied in young red wines (SANTOS et al. 1998). Formation of complex pigments and its influence on the colour were investigated in more stable complex pigments between malvidin-3-O-glucoside and (-)-epicatechin, (+)-catechin, and procyanidins (epi-4,8-epi and cat-4,8-cat). The other examples are major pigments in purple lisianthus (*Eustoma grandiflorum*) – delphinidin-3-O-β-D-[6-O-α-L-rhamnogalactoside]-5-O-β-D-[(E and Z)-p-coumaroyl]glucosides] (MARKHAM et al. 1998). Tiliroside (7-O-p-coumaroyl-3-O-glucoside of kaempferol) was reported in *Rosa canina* L. (GOODWIN 1965).

The interest in using anthocyanins as food colourants has increased in recent years (BRIDLE, TIMBERLAKE 1997), however, these colours are affected by a number of factors (FRANCIS 1989). Nearly all reports on colour and stability of pure anthocyanins under pH influence deal with acid or neutral solutions (BROUILLARD 1988). A comparison between the colour intensity and stability of petanin, i.e. petunidin-3-[6-O-(4-O-E-p-coumaroyl-O-α-rhamnopyranosyl)-β-glucopyranoside]-5-O-β-glucopyranoside and the anthocyanidin 3-monoglucosides revealed rather extensive differences (ANDERSEN et al. 1998). Visible  $\lambda_{\max}$  absorption of petanin at pH 8.1 after five days was similar or higher than the corresponding absorption of fresh cyanidin-3-glucoside solutions at any observed pH. Anthocyanins with two or more OH-groups in ortho-position to each other on anthocyanidin B-ring show dramatic hypsochromic shifts going from pH 8.0 to 9.0 in comparison with anthocyanins with different number of methoxyl groups, however, with only one OH-group on the B-ring (pelargonidin, cyanidin, peonidin vs. delphinidin, petunidin and malvidin-3-O-glucosides). The difference between the flowers is the fluid pH in pigment-bearing tissues: alkaline for cornflowers, and acidic for roses. Acylation of cyanidin-3-O-sophoroside-5-O-glucoside with *p*-coumaric, ferulic, sinapic and malonic acids or their two molecules in red cabbage causes the greater stability of these glycosides (BUCKENHÜSKES et al. 1988; LACHMAN et al. 1991).

Many recent works deal with floriculture and landscaping of flowers, with roses playing an important role (BOSE et al. 1999; PEGRUM 1990; JOYCE et al. 1998). Many of them concern with artificial drying of flowers that eliminates some weather hazards and provides opportunity for much smoother marketing of the product (ROBERTS et al. 1998; THAL 1991; EPHRAUMS, IRON-SIDE 1992). As reported by BASAPPA et al. (1991), each of drying methods produced different tinges of flower colour. Colouration of *Helichrysum bracteatum* Andr. ranged from canary yellow to cream, orange, copper, crimson red, carmine, amethyst and rose pink. The effects of different drying temperatures (room, full sun or in an oven at 40 or 50°C) were investigated. There was described a solar-powered drier (SILHOL, DENIS 1994). The drier has to operate at moderate temperatures in order to preserve colour, flavour and active ingredients of

the plant material. ORDUNO-CRUZ and BALTAZER-BERNAL (1995) referred about the effect of different mixtures of sand and borax on the drying of three flower species. Rose, gerbera and carnation flowers were dried for 10, 15 or 20 days in river or sea sand mixed with borax in various proportions (sand: borax ratios of 1:1, 2:1 or 3:1). Moisture loss was measured and flower quality was assessed in terms of blemishes, texture, general appearance, etc. River sand containing a high proportion of borax and drying time of 15 or 20 days were considered as the best conditions for roses and carnations.

Anthocyanins can be divided into two groups based on the possibility to form intramolecular copigmentation, e.g. *Gymioa bicolor* and *Hibiscus sabdariffa* L. ( TSAI et al. 1992). Red anthocyanins from *G. bicolor* possessed better stability toward heating, oxygen and ascorbic acid. The extracts of *Hibiscus sabdariffa* L. (*Malvaceae*) and its main coloured components were evaluated as a red colour additive. The results of colorimetric determination revealed a linear relationship between absorbance and concentration of the colour solution at absorption maximum  $\lambda_{\max} = 518$  nm (NOUR et al. 1993). It was due to delphinidin-3-O-β-D-xylopyranosyl-(1→2)-β-D-glucopyranoside (SATO et al. 1991). KOSWIG and HOFSSOMMER (1995) stated that the anthocyanin fingerprints of different products such as blackberry, strawberry, blood orange and blueberry obtained by reversed-phase high-pressure liquid chromatography or an RP-18 column with gradient elution are sufficiently differentiated.

TSAI and ANDI (1996) determined in red coloured roselle that after drying and storage either at room temperature (about 25°C) or low temperature (5°C) under light or in the dark, the colour of dried roselle remained relatively stable in the dark and low temperature storage for up to eight months. The stability of anthocyanins is now studied very intensively (LIN, LI 1992; RASTELLI 1993). This is the reason why we decided to study the stability of rose pigments under different storage conditions.

## MATERIAL AND METHODS

### Extraction:

Cut petals of the yellow large-sized rose cv. *Papillon* or *Papillon Rose* (143.71 g) were extracted with acetone (1,250 mL) and petals from the red rose cv. *Red France* (120.69 g) with 668 mL methanol acidified with HCl (635 mL methanol + 33 mL 35% w/w HCl) in the darkness at laboratory temperature (22°C) for 24 hours. Dry matters were 13.37 and 16.55 % for yellow and red rose, respectively.

The extracts were stored in a glass bottle under four types of conditions:

- exposed to diffused daylight at laboratory temperature 22°C (L),
- in the darkness at laboratory temperature 22°C (D),
- in a refrigerator at 4°C (R),
- in a freezer at -8°C (F).

The extracts were sampled for the pigment determination twelve times until day 132 of storage period.

#### TLC:

The anthocyanin pigments in the filtered extract of red rose were separated on Polygram Cell 300 (Macherey – Nagel Co.) – 0.1 mm cellulose MN 300 layer sheets in the following developing systems:

- (1): conc. HCl – HCOOH – H<sub>2</sub>O (2:5:3 v/v/v),
- (2): HCOOH – conc. HCl – H<sub>2</sub>O (10:1:3 v/v/v),
- (3): CH<sub>3</sub>COOH – conc. HCl – H<sub>2</sub>O (5:1:5 v/v/v),
- (4): CH<sub>3</sub>COOH – H<sub>2</sub>O (15:75 v/v).

Anthocyanins were eluted from the chromatograms with 0.01% HCl solution in methanol and their spectra were measured in visible region.

The filtered extract of yellow rose was analysed for carotenoids on Kieselgel 60 Merck sheets in the developing system (5): toluene – dioxane – acetic acid (90:25:4 v/v/v).

#### VIS – spectrophotometry:

Spectra of anthocyanins were measured using a spectrophotometer Specord UV-VIS (Zeiss, Jena, Germany) against 0.01% methanolic HCl. Absorbancies of extracts were measured at  $\lambda_{\max} = 530$  nm in 0.5 cm cuvettes and concentrations were calculated as cyanin using specific absorbancy of 1% solution in 1.0 cm cuvette  $A_{1\%}^{1\text{cm}} = 34,300$ .

Carotenoid spectra from yellow rose extracted into acetone were measured using the same spectrophotometer against acetone (purity for spectrophotometry). Absorbancies of extracts were measured at  $\lambda_{\max} = 435$  nm in 0.5 cm cuvettes and concentrations were expressed as  $\beta$ -carotene with specific absorbancy of 1% solution in 1.0 cm cuvette  $A_{1\%}^{1\text{cm}} = 2,500$ .

The used chemicals were of analytical grade.

Obtained results were statistically evaluated using correlation coefficient, Student's *t*-test and *F*-test.

## RESULTS AND DISCUSSION

Seven carotenoids were observed in visible light on TLC chromatograms of the yellow rose (Table 1). Three of them were very intensively coloured in yellow and orange. The amount of carotenoids, expressed as  $\beta$ -carotene, was calculated using the initial absorbancy, specific absorbancy and petal dry matter. The yellow rose petals contained 62 mg carotenoids per kg fresh matter or 461 mg per kg dry matter. The spectrum of the extracted carotenoids in acetone (Table 2) has shown four distinctive maxima at 354, 402, 429 and 448 nm. According to

Table 1. Carotenoids of the yellow rose separated using thin-layer chromatography

Compound No.	R <sub>F</sub> value in developing system (5)	Colour
1	0.99	Deep intensive yellow
2	0.93	Pale yellow
3	0.83	Deep intensive orange
4	0.76	Pale ochre
5	0.68	Deep intensive yellow
6	0.63	Pale yellow
7	0.54	Pale yellow

CRAFT and SOARES (1992) and BRITTON et al. (1995a, b), maximum at  $\lambda = 448$  nm corresponds to absorption maximum of  $\beta$ -carotene (448.5–452 nm), lutein ( $\alpha$ -xanthophyll) with 11 double bonds in the molecule and lycopene (446–448 nm) with 13 double bonds in the chain, while maximum at  $\lambda = 429$  nm is typical of  $\beta$ -carotene (427 nm) and zeaxanthin (429 nm). Also 5,6,5',6'-diepoxide of  $\beta$ -carotene has its main absorbancy maximum lowered to this value in comparison with  $\beta$ -carotene regarding two 5,6-epoxide structures in the molecule causing its hypsochromic shift about 16 nm (MOSS, WEEDON 1976). The maximum at 354 nm corresponds with the maximum of phytofluene (MOSS, WEEDON 1976).

In contrary to the complexity of carotenoids present in the yellow roses, the anthocyanin complex of red roses seems to be much simpler. Only two major anthocyanins were observed (Table 3) on the red rose extract chromatograms. Separated spots were eluted with 0.01% methanolic HCl and their spectra were measured against blank (methanolic HCl). Results are given in Table 4. Three or four drops of 5% w/v AlCl<sub>3</sub> solution in methanol were added to 0.01% methanolic HCl and the bathochromic shifts were determined. R<sub>F</sub> values observed in four developing systems indicate glycosides, and the spectral data fit to glycosides derived from cyanidin. Comparison of R<sub>F</sub> values and spectroscopic data obtained from literature (GEISSMAN 1962) confirmed that compound No. 1 is cyanin (cyanidin-3, 5-O-diglucoside) and No. 2 chrysanthemine (cyanidin-3-O-glucoside).

It can be concluded from the observed results that cyanin is the main anthocyanin pigment of the red rose. Its proportion is 75–80% of total anthocyanin content. Chrysanthemine content is lower. Some unidentified anthocyanins were detected in trace levels only. There were not found any glycosides derived from peonidin. Using calculation similar to that for carotenoids, *Red France* red rose petals contained 3.06 mg anthocyanins per kg

Table 2. Spectral data of carotenoids in acetone extract isolated from yellow rose

$\lambda_{\max} = 354$ nm	$\lambda_{\max} = 402$ nm	$\lambda_{\max} = 429$ nm	$\lambda_{\max} = 448$ nm
phytofluene*		$\beta$ -carotene, zeaxanthin, 5,6,5',6'-diepoxide of $\beta$ -carotene*	$\beta$ -carotene, lycopene, lutein*

\* Measured values were compared with absorption maxima for individual compounds given by CRAFT and SOARES (1992), BRITTON et al. (1995b), MOSS and WEEDON (1976) and GOODWIN (1965)

Table 3. Anthocyanins of the red rose separated using thin-layer chromatography with four different developing systems

Compound No.	R <sub>F</sub> (1)	R <sub>F</sub> (2)	R <sub>F</sub> (3)	R <sub>F</sub> (4)	Colour	Approximately intensity
1	0.86	0.91	0.75	0.49	Red	75–80%
2	0.74	0.81	0.67	0.17	Red	20–25%

Table 4. Spectral data of anthocyanins isolated from the red rose

Compound No.	0.01% methanolic HCl λ <sub>max</sub> (nm)	+AlCl <sub>3</sub> λ <sub>max</sub> (nm)	Bathochromic shift (nm)
1	521	539	+18
2	529	542	+13

fresh matter or 18.5 mg anthocyanins per kg dry matter expressed as cyanin.

It is apparent from the obtained data (Tables 5 and 6) that the stabilities of carotenoids in the yellow rose and anthocyanins in the red rose are quite different. As can be seen in Fig. 6, the final decrease after 132 days of storage was much higher in anthocyanins (to 9.2–14.9% of the original content) in comparison to carotenoids (to 42–100.9% of the original content). In both cases (Figs. 4 and 5) light had the greatest destabilizing effect (carotenoids to 42% of the initial value, anthocyanins to 9.2% of the initial value). No decrease of carotenoids content was observed in the extract stored in darkness at laboratory temperature. It could be concluded from the statistical evaluation that light had a highly significant effect ( $P < 0.01$ ) on the degradation of the pigments stored at laboratory temperature. There were also found highly significant differences between the storage at lab-

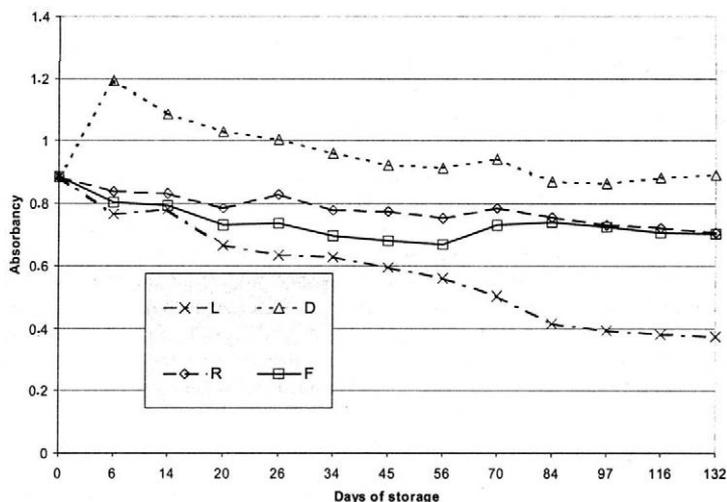


Fig. 4. Degradation of the yellow rose pigments

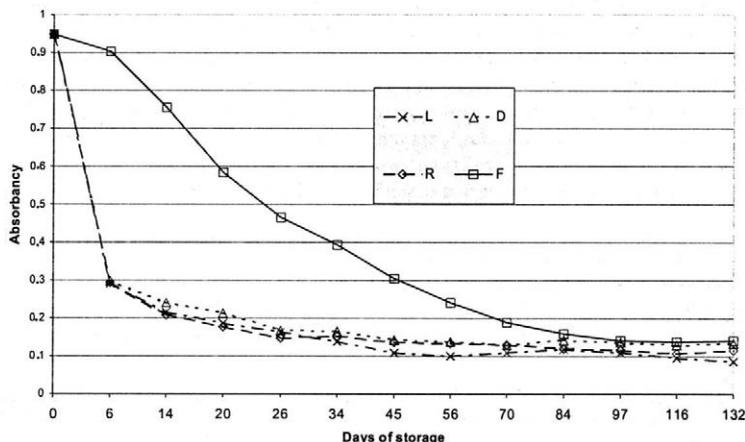


Fig. 5. Degradation of the red rose pigments

Table 5. Absorbancy values of the yellow rose

Conditions of storage	Dates of analyses													Final content (% rel.)
	26. 5.	1. 6.	9. 6.	15. 6.	21. 6.	29. 6.	10. 7.	21. 7.	4. 8.	18. 8.	31. 8.	19. 9.	5. 10.	
						Days of storage								
	0	6	14	20	26	34	45	56	70	84	97	116	132	
Light, 22°C	0.885	0.767	0.782	0.666	0.633	0.627	0.592	0.560	0.501	0.414	0.392	0.380	0.372	42.0
Darkness, 22°C	0.885	1.194	1.086	1.031	1.005	0.962	0.923	0.913	0.941	0.870	0.862	0.881	0.893	100.9
Refrigerator, +4°C	0.885	0.838	0.831	0.786	0.830	0.777	0.775	0.753	0.785	0.756	0.730	0.722	0.707	79.9
Freezer, -8°C	0.885	0.805	0.795	0.731	0.738	0.697	0.680	0.668	0.732	0.740	0.726	0.706	0.704	79.6

Table 6. Absorbancy values of the red rose

Conditions of storage	Dates of analyses													Final content (% rel.)
	26. 5.	1. 6.	9. 6.	15. 6.	21. 6.	29. 6.	10. 7.	21. 7.	4. 8.	18. 8.	31. 8.	19. 9.	5. 10.	
						Days of storage								
	0	6	14	20	26	34	45	56	70	84	97	116	132	
Light, 22°C	0.947	0.292	0.215	0.187	0.163	0.138	0.108	0.099	0.110	0.118	0.108	0.096	0.087	9.2
Darkness, 22°C	0.947	0.297	0.241	0.213	0.169	0.166	0.143	0.139	0.130	0.143	0.136	0.130	0.134	14.2
Refrigerator, +4°C	0.947	0.295	0.210	0.178	0.147	0.152	0.136	0.134	0.130	0.120	0.117	0.107	0.115	12.1
Freezer, -8°C	0.947	0.902	0.754	0.585	0.466	0.393	0.305	0.242	0.189	0.159	0.141	0.138	0.141	14.9

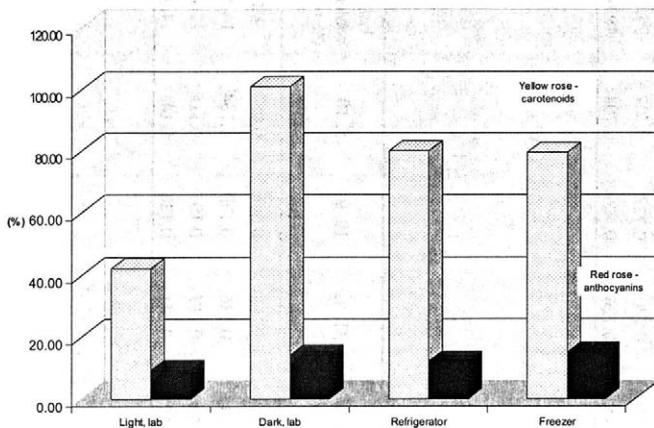


Fig. 6. Final content (per cent of the initial value) of the pigments after 132 days of storage

oratory temperature and in a refrigerator for the yellow rose. Insignificant differences were found between the variants refrigerator – freezer for pigments of both roses. In the refrigerator or in the freezer the final decrease of carotenoids was about 20%. Losses of anthocyanins were about 85–90% of the initial content.

The obtained data were used for the calculation of Arrhenius equation. These fit for carotenoids for the equation  $\ln = A + E/RT$ : pre-exponential factor  $A = 4.418$ ,  $E/R = 10,697.650$ , low activation energy  $-88,940.259$  [J/mol] indicates oxidation reaction and a lesser temperature dependence of the reaction rate. The pre-exponential factor  $A$  was used to calculate the activation entropy from the equation  $A = e^{S^{\ddagger}/R} \cdot K_B \cdot T \cdot e/h$  [ $-718.834$  J/K.mol]. The correlation coefficient (0.894) fits to the equation quite well. On the other hand, there was no correlation found for losses of anthocyanins. The highest statistically significant correlation coefficients were found for a decrease of pigments of yellow rose extract stored at laboratory temperature in diffused light ( $-0.952$ ) and in a refrigerator ( $-0.906$ ). In red rose extract the highest correlation was found for the extract stored in a freezer ( $-0.873$ ).

Thus, the carotenoid pigments in yellow and orange roses are much more stable in comparison with anthocyanins in the red roses. Light is the main factor affecting the decomposition of both types of pigments. Temperature has a lesser effect and for anthocyanins low storage temperatures were favourable. This is in accordance with results obtained by BIACS et al. (1992), who investigated the colour degradation after 150 days of storage of coloured substances in paprika (red pepper) powders. The colour degradation was estimated to 27, 20 and 15% at ambient storage conditions and 15, 13 and 5% under refrigeration in untreated,  $\delta$ -tocopherol-treated, and ascorbic acid-treated powders, respectively. Antioxidants as  $\delta$ -tocopherol and ascorbic acid decrease the rate of carotenoid degradation.

## References

- ANDERSEN Ø., FOSSEN T., CABRITA L., 1998. Colour and stability of pure anthocyanins in aqueous solutions at high pH values. In: CHARBONNIER F., DELACOTTE J.M., POLANDO, C. (eds.), Polyphenol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 261–262.
- BASAPPA H.S., PATIL A.A., SHIROL A.M., SHARANA-BASAPPA H., 1991. Effect of drying on the colour intensity of everlasting flower (*Helichrysum bracteatum* Andr.). S. Ind. Hortic., 39: 172–173.
- BIACS P.A., CZINKOTAI B., HOSCHKE A., 1992. Factors affecting stability of colored substances in paprika powders. J. Agric. Food Chem., 40: 363–367.
- BOSE T.K., MAITI R.G., DHUA R.S., DAS P., 1999. Floriculture and Landscaping. Calcutta, Naya Prokash: 757.
- BRIDLE P., TIMBERLAKE C.F., 1997. Anthocyanins as natural food colours – selected aspects. Food Chem., 58: 103–109.
- BRITTON G., LIAAEN-JENSEN S., PFANDER H., 1995a. The Carotenoid Series: Isolation and Analysis. Basel, Birkhäuser Verlag, Vol. 1A: 400.
- BRITTON G., LIAAEN-JENSEN S., PFANDER H., 1995b. The Carotenoid Series: Spectroscopy. Basel, Birkhäuser Verlag, Vol. 1B: 360.
- BROUILLARD R., 1988. The Flavonoids. In: HARBORNE J.B. (ed.), Advances in Research Since 1980. London, Chapman and Hall: 525.
- BUCKENHÜSKES H., CLAUS M., GIERSCHNER K., 1988. Untersuchungen zur Stabilität von Anthocyanen aus Rotkraut (Rotkohl). Ernährung/Nutrition, 12: 620–625.
- CRAFT N.E., SOARES J.H., 1992. Relative solubility, stability, and absorptivity of lutein and  $\beta$ -carotene in organic solvents. J. Agric. Food Chem., 40: 431–434.
- DAVIES A.J., MAZZA G., 1993. Copigmentation of simple and acylated anthocyanins with colourless phenolic compounds. J. Agric. Food Chem., 41: 716–720.
- DONNER H., KALT W., MAZZA G., 1998. Simple and monoacylated cyanidin 3-glycosides copigmented with chlorogenic acid, protocatechuic acid and caffeine. In: CHARBONNIER F., DELACOTTE J.M., POLANDO C. (eds.), Polyphenol

- nol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 177–178.
- ELHABIRI M., FIGUEIREDO P., GEORGE F., BRUILLARD R., 1998. Synthesis, photochromism and metallic complexation of synthetic and natural anthocyanins. In: CHARBONNIER F., DELACOTTE J.M., POLANDO C. (eds.), Polyphenol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 197–198.
- EPHRAUMS M., IRONSIDE J., 1992. Dried flowers from the garden. A practical guide to growing, drying and arranging. London, Harper Collins: 128.
- FIGUEIREDO P., GEORGE F., TATSUZAWA F., TOKI K., SAITO N., BROUILLARD R., 1998. New features of intramolecular copigmentation by acylated anthocyanins. In: CHARBONNIER F., DELACOTTE J.M., POLANDO C. (eds.), Polyphenol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 199–200.
- FRANCIS F.J., 1975. Anthocyanins as food colors. Food Technol., 29: 52–54.
- GEISSMAN T.A., 1962. The Chemistry of Flavonoid Compounds. Oxford, London, N.Y., Paris, Pergamon Press: 666.
- GEORGE F., FIGUEIREDO P., BROUILLARD R., 1998. New views (III) on complexation by anthocyanins. In: CHARBONNIER F., DELACOTTE J.M., POLANDO C. (eds.), Polyphenol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 193–194.
- GOODWIN T.W., 1956. Studies in carotenogenesis. A survey of the polyenes in a number of ripe berries. Biochem. J., 62: 346–352.
- GOODWIN T.W., 1965. Chemistry and Biochemistry of Plant Pigments. N.Y., Academic Press: 583.
- HARBORNE J.B., 1963. Distribution of anthocyanins in higher plants. In: Swain T., Chem. Plant Taxon.: 359–388.
- HRAZDINA G., 1981. Anthocyanins and their role in food products. Lebensm.-Wiss. Technol., 14: 283–286.
- JOYCE D.C., CONSIDINE J.A., GIBBS J., 1998. Dried and preserved ornamental plant material not new, but often overlooked and underrated. Proc. 3<sup>rd</sup> Int. Symp. On new floricultural crops, Perth, 1996, Acta Hort., 454: 133–145.
- KOSWIG S., HOFSSOMMER H.J., 1995. HPLC method for determination of anthocyanins in colored juices and other pigmented foods. Flüss. Obst., 62: 125, 128–130.
- LACHMAN J., PIVEC V., ŘEHÁKOVÁ V., HAKR T., 1991. Anthokyany v odrůdách červeného zeli Mars a Vysocké a jejich stabilita. Potravní Vědy, 9: 287–294.
- LIN D., LI W., 1992. Appraisal of the stability of anthocyanin with spectrographic method. Shipin Yo Fajiao Gongye, 5: 83–85.
- MARKHAM K.R., SMITH G.J., GOULD K.S., 1998. Investigation of flower color at the cellular level. In: CHARBONNIER F., DELACOTTE J.M., POLANDO C. (eds.), Polyphenol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 583–584.
- MOSS G.P., WEEDON B.C.L., 1976. Chemistry of the Carotenoids. In: GOODWIN T.V. (ed.), Chemistry and Biochemistry of Plant Pigments. London, N.Y., San Francisco, Academic Press, Vol. 1: 149–224.
- NOUR S.A., ABDELHADY S.E., GHOURAB M., 1993. A natural coloring agent from *Hibiscus sabdariffa*. Bull. Fac. Pharm. (Cairo Univ.), 31: 387–392.
- ORDUNO-CRUZ A., BALTAZER-BERNAL O., 1995. Influencia de diferentes mezclas de arena y borax sobre el secado de tres especies de flores. Revista-Chapingo – Serie Horticultura, 1: 93–97.
- PEGRUM J., 1990. Flowers for export – not so cut and dried. Agric. Sci., 3: 13–16.
- RASTELLI G., 1993. Physico-chemical properties of anthocyanidins. 1. Theoretical evaluation of the stability of the neutral and anionic tautomeric forms. Theochem., 98: 157–166.
- ROBERTS W.J., GREENBERG R., KANIA S., 1998. Design of a chamber for drying hanging flowers. NABEC Paper Halifax, Nova Scotia 9807: 6.
- SANTOS B.C., FRANCIÁ A.E., VIVAR Q.A., RIVAS G.J.C., 1998. New contributions to the interpretation of the colour changes in anthocyanin-flavanol solutions. In: CHARBONNIER F., DELACOTTE J.M., POLANDO C. (eds.), Polyphenol Communications 98, XIX<sup>th</sup> Int. Conf. on Polyphenols. Lille: 335–336.
- SATO K., GODA Y., YOSHIHIRA K., NOGUCHI H., 1991. Structure and contents of main coloring constituents in the calyces of *Hibiscus sabdariffa* and commercial roselle color. Shokuhin Eiseigaku Zasshi, 32: 301–307.
- SILHOL M., DENIS P., 1994. Sechoir solaire. Plasticsulture, 103: 31–38.
- THAL J., 1991. Trockenblumenproduktion: Vermehrung und Kultur, Ernte und Lagerung, Farbe- und Preparationstechnik, Vermarktung, Sortiment. Berlin, Verlag Paul Parey: 194.
- TAI P.R., ANDI S.M., 1996. Color degradation of dried roselle during storage. Shipin Kexuo (Taipei), 23: 629–640.
- TAI T.C., CHEN C.W., YEH P.Y., 1992. Stability study of anthocyanins: anthocyanins from *Gymioa bicolor*, grape and *Hibiscus*. Donghai Xuebao, 33: 1085–1099.
- VALADON L.R.G., MUMMERY R.S., 1968a. Taxonomic significance of carotenoids. Nature (London), 217: 1066.
- VALADON L.R.G., MUMMERY R.S., 1968b. Carotenoids of some *Rosaceae* flowers. Phyton (Buenos Aires), 25: 151–157.
- VALADON L.R.G., MUMMERY R.S., 1969. Changes in carotenoid composition of certain roses with age. Ann. Bot. (London), 33: 671–677.
- WILSKA-JESZKA J., KORZUCHOWSKA A., 1996. Anthocyanins and chlorogenic acid copigmentation. Influence of the color of strawberry and chokeberry juices. Z. Lebensm.-Unters. Forsch., 203: 38–42.

Received 1 February 2001

## Stabilita barviv růží během skladování za různých podmínek

**ABSTRAKT:** Bylo sledováno složení a stabilita barviv v korunních plátcích žluté růže (cv. *Papillon* či *Papillion Rose*) a červené růže (cv. *Red France*). Na základě  $R_f$  hodnot (chromatografie na tenké vrstvě) a spektrálních dat byla jako hlavní karotenoidní barviva v acetonovém extraktu z květů žlutých růží identifikována  $\beta$ -karoten a jeho 5,6,5',6'-diepoxid, lutein, lykopen, zeaxanthin a fytofluen. V kyselém (HCl) methanolickém extraktu z květů červené růže byly jako dominantní konstituenty nalezeny anthokyaniny kyanin a chrysothemin. Sledování dynamiky úbytků barviv v extraktech skladovaných v uzavřených skleněných lahvích při čtyřech různých podmínkách skladování (při 22, 4 a  $-8$  °C, ve tmě či na denním světle při 22 °C) po dobu 132 dní prokázalo, že karotenoidy jsou mnohem stabilnější (42–100,9 % počátečního množství po 132 dnech) než anthokyaniny (9,2–14,9 % z počátečních hodnot). Úbytky karotenoidů odpovídají Arrheniově rovnici (korelační koeficient 0,894) a nízká aktivační energie naznačuje oxidační reakci s malou teplotní závislostí. Pro rozklad anthokyanů nebyla nalezena žádná korelace. Největším destabilizujícím faktorem u obou typů barviv bylo světlo (u karotenoidů se původní obsah snížil na 42 % a u anthokyanů na 9,2 % původní hodnoty po 132 dnech). Vliv teploty byl menší. U anthokyanů byly nejnižší úbytky zjištěny při skladování extraktu v mrazničce.

**Klíčová slova:** žlutá růže; červená růže; karotenoidy; anthokyaniny; stabilita; vliv světla a teploty

---

*Corresponding author:*

Doc. Ing. JAROMÍR LACHMAN, CSc., Česká zemědělská univerzita, Agronomická fakulta, katedra chemie, 165 21 Praha 6-Suchbát, Česká republika, tel.: + 420 2 24 38 27 20, fax: + 420 2 20 92 16 48, e-mail: lachman@af.czu.cz

---

# Parasitic mycoflora of the genus *Acer*

G. JUHÁSOVÁ, H. IVANOVÁ

*Institute of Forest Ecology SAS Zvolen, Department of Woody Plants Biology, Nitra, Slovak Republic*

**ABSTRACT:** In this paper parasitic mycoflora of the genus *Acer* (*A. platanoides* L., *A. pseudoplatanus* L., *A. campestre* L. and *A. tataricum* L.) was evaluated. The microscopic fungi *Rhytisma acerinum* (Pers. ex St. Amans) Fr., *Mycosphaerella latebrosa* (Cke.) Schröt. and *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. were identified on assimilative organs. Using these fungi we investigated their whole developmental cycle in 16 phenological stages of these trees and in the period of dormancy. We determined the limit values of reproductive organs and we evaluated the germination of conidia. Growth rates of the fungus mycelium (*Septoria acerina* Pk.) from localities Nitra and Arboretum Mlyňany were investigated on different media. The degree of leaf damage was high in the low part of the crown and was annually high at some localities. Prevention of infection is possible by taking suitable plant protection measures.

**Keywords:** *Acer*; *Mycosphaerella latebrosa*; *Rhytisma acerinum*; *Sawadaea bicornis*; syn. *Uncinula bicornis*

Decorative woody species, which grow in towns, form important parts of public and private greenery. These are ever more subjected to negative influences of the environment and of men. These factors of a general change in the settlement environment vary for different species of animals, plants and fungi, which live in this changing environment and are becoming dangerous pests for living organisms. Organisms with modified conditions are more or less compensated, some of them are weakening, in others we could observe visible development. The high plant support is weakened by the development of parasitic microscopic fungi which damage single parts of the woody species and decrease their aesthetic and decorative value. Relatively often the greenery of parks and streets in front of public and private buildings consists of the trees of the genus *Acer* as a solitary tree or in groups in an alley. For their toleration of polluted environmental conditions, they are recommended by specialists to be planted along main roads.

In the world about 150 species of the genus *Acer* grow. In Slovakia *Acer platanoides* L., *A. pseudoplatanus* L., *A. tataricum* L. and *A. campestre* L. grow freely. A great deal of cultivars with unusual variability are cultivated in culture (KOTEK 1975). Due to many sorts and forms, decorative timber, quick growth, valuable physical-mechanical quality of the timber, and because of their nice-looking texture, melliferous flowers and phytoncid effects, these cultivars are highly valued in the national economy and also in ornamental gardening (KOCHNO 1982).

BENČAŤ (1982) identified 58 taxons from the genus *Acer*. During our research we evaluated the health condition of the following taxons: *Acer campestre* L., *A. circinatum* Pursch., *A. dasycarpum* Ehrh., *A. ginnala* Maxim., *A. macrophyllum* Pursch., *A. monspessulanum* L., *A. pal-*

*matum* Thunb., *A. palmatum* var. *dissectum* (Thunb.) Miq., *A. platanoides* L., *A. platanoides* Globosum, *A. platanoides* Rubrum, *A. platanoides* Lorbergii, *A. pseudo-platanus* L., *A. tataricum* L.

The following species of parasitic microscopic fungi occur on the leaves: *Mycosphaerella latebrosa* (Cke.) Schröt. with conidial stages *Septoria acerina* Pk. and *Phyllosticta aceris* Sacc., *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc., *Trochila aceris* (Lib.) Hohn. with conidial stages *Didimosporina aceris* (Lib.) Hohn., *Phyllactinia guttata* (Wallr. ex Sch.) Lev., *Rhytisma punctatum* (Pers.) Fr. and *Rhytisma acerinum* (Pers. ex St. Amans) Fr. with conidial stage *Melasmia acerina* Lev. and *Mycocentrospora acerina* (Hartig) Deight. On the branches we observed the following fungal species: *Nectria cinnabarina* (Tode ex Fr.) Fr., *Giberella baccata* (Wallr.) Sacc. with conidial stage *Fusarium lateritium* Nees. and *Verticillium albo-atrum* (Hartig) Arm.

Our aim was to evaluate the parasitic mycoflora of the genus *Acer* that occurs at the localities Nitra and Arboretum Mlyňany with regard to the presence of parasitic fungi on the assimilative organs. We also studied some biological questions of the most frequent sorts of the fungi *Rhytisma acerinum*, *Mycosphaerella latebrosa* and *Sawadaea bicornis*, syn. *Uncinula bicornis* in field and laboratory conditions and proposed optimal protective measures.

## MATERIAL AND METHODS

Selection of the localities in Nitra was done so that the woody species in different types of functional greenery (street greenery, public greenery, greenery between the blocks of houses, greenery along main roads, park green-

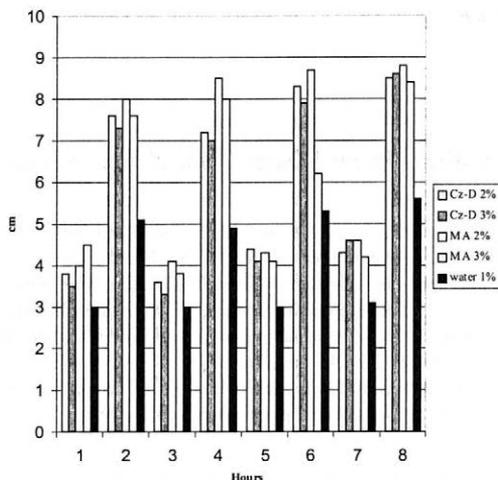


Fig. 1. Growth rates of mycelium hyphae of the fungus *Mycosphaerella latebrosa* (Cke.) Schröt. and fungus *Septoria acerina* Pk. on the different media – locality Nitra

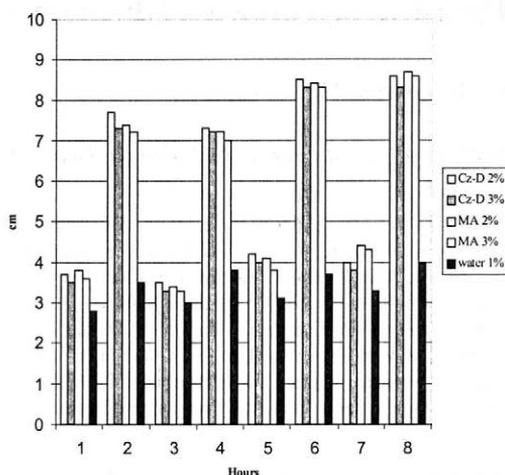


Fig. 2. Growth rates of mycelium hyphae of the fungus *Mycosphaerella latebrosa* (Cke.) Schröt. and fungus *Septoria acerina* Pk. on the different media – locality Arboretum Mlyňany

ery, forest fringe) were represented. General health condition of the woody species were evaluated. From the damaged trees we took samples for laboratory testing and the presence of parasitic fungi was determined with a microscope.

Phenological observations were made according to BENČAĎ and TOKÁR (1978). Health condition of the genus *Acer* during the vegetation period was evaluated once weekly from bud swelling to the beginning of the leaf burst. In the next phenological phases once a fortnight, during the period of dormancy once every ten to fourteen days. Degree of leaf damage was evaluated by 100-leaves method. Calculation of the degree of damage was made according to the method Townsend-Heuberger (DUBOVSKÝ 1969). Next, we determined spore dimensions by measuring under a binocular light microscope at 8 × 20 and/or 8 × 45 magnification using eye an ocular and objective micrometer. In each replication 100 spores were measured.

Growth rate of the hyphae of the fungal mycelium was evaluated on 1% water agar, 2% and 3% Czapek-Dox

agar (Cz-D 2%, 3%) and maltose 2% and 3% agar (MA 2%, 3%) (Tables 1 and 2, Figs. 1 and 2). For the isolation of infection originator, the fungus *Mycosphaerella latebrosa* was used on 2% and 3% maltose agar and 2% and 3% Czapek-Dox agar.

After surface sterilization (3% SAVO) the pieces of the infected tissue were placed on selected media and cultivated at temperatures 20°C to 26°C, constant relative atmospheric humidity 80–85% and pH 6.5.

Germination of the conidia of the fungus *M. latebrosa* was evaluated on 1% and 2% water agar, on 1% and 2% Czapek-Dox agar and 1% and 2% maltose agar. From the spots on damaged leaves we cut thin longitudinal and cross sections which were immersed into the pot with distilled water. After some time water droplets were placed on slides that were inserted into the exsiccators that were put into a thermostat with the temperature from +20°C to +26°C. Germination was evaluated microscopically after 24 and 48 hours, 3 × 100 conidia were evaluated (Table 3).

Table 1. Growth rates of mycelium hyphae of the fungi *Mycosphaerella latebrosa* (Cke.) Schröt. (Nitra, AM) and *Septoria acerina* Pk. (Nitra, AM) on the different media

Fungus Medium	<i>Mycosphaerella latebrosa</i>				<i>Septoria acerina</i>			
	Nitra	Nitra	AM	AM	Nitra	Nitra	AM	AM
Hours	24	72	24	72	24	72	24	72
Cz-D 2%	3.8	7.6	3.6	7.2	4.4	8.3	4.3	8.5
Cz-D 3%	3.5	7.3	3.3	7	4.1	7.9	4.6	8.6
MA 2%	4	8	4.1	8.5	4.3	8.7	4.6	8.8
MA 3%	4.5	7.6	3.8	8	4.1	8.1	4.2	8.4
Water 1%	3	5.1	3	4.9	3	5.3	3.1	5.6

Table 2. Growth rates of mycelium hyphae of the fungi *Mycosphaerella latebrosa* (Cke.) Schröt. (Nitra, AM) and *Septoria acerina* Pk. (Nitra, AM) on the different media

Medium	<i>Mycosphaerella latebrosa</i>				<i>Septoria acerina</i>			
	Nitra	Nitra	AM	AM	Nitra	Nitra	AM	AM
Hours	24	72	24	72	24	72	24	72
Cz-D 2%	3.7	7.7	3.5	7.3	4.2	8.5	4	8.6
Cz-D 3%	3.5	7.3	3.3	7.2	4	8.3	3.8	8.3
MA 2%	3.8	7.4	3.4	7.2	4.1	8.4	4.4	8.7
MA 3%	3.6	7.2	3.3	7	3.8	8.3	4.3	8.6
Water 1%	2.8	3.5	3	3.8	3.1	3.7	3.3	4

Table 3. The germination of the fungus *Mycosphaerella latebrosa* (Cke.) Schröt. on different nutrient media (T 22–23°C), locality Arborétum Mlyňany

Media (%)	Hour	Number of germinated conidia			Average			Number of germinated conidia			Average			
Water	1	24	16	22	26	21.3	22	24	28	24.6	20	24	22	22.0
Water	1	48	34	38	31	34.3	37	40	39	38.6	30	34	36	33.3
Water	2	24	21	28	34	27.6	26	31	37	31.3	23	25	28	25.3
Water	2	48	41	42	38	40.3	40	43	46	43.0	37	39	32	36.0
Cz-D	1	24	22	28	25	25.0	25	29	30	28.0	22	26	25	24.3
Cz-D	1	48	38	43	42	41.0	38	45	43	42.0	34	38	37	36.3
Cz-D	2	24	33	36	31	33.3	37	32	28	35.6	33	29	34	32.0
Cz-D	2	48	49	41	44	44.6	42	47	53	47.3	40	43	46	43.0
MA	1	24	28	31	34	31.0	19	32	30	27.0	22	25	28	26.0
MA	1	48	35	39	40	38.0	26	33	46	35.0	24	26	33	27.0
MA	2	24	32	30	38	33.3	20	19	22	20.3	25	29	33	29.0
MA	2	48	43	49	44	45.3	24	25	28	25.6	30	25	24	26.3

## RESULTS AND DISCUSSION

By determination of the occurrence and distribution of the genus *Acer* in the Nitra locality we ascertained their representation in the whole city territory where they represented a significant component of the greenery. They occurred most frequently in parks and less frequently in the housing estates, in public and special-purpose greenery. The assimilative organs of *Acer pseudoplatanus* L., *A. platanoides* L. and *A. campestre* L. were most frequently damaged by the following parasitic microscopic fungi: *Rhytisma acerinum*, *Mycosphaerella latebrosa* and *Sawadaea bicornis*, syn. *Uncinula bicornis*. The other observed locality was Arborétum Mlyňany where tree species were the component of the park greenery.

The fungus *Rhytisma acerinum* (Pers. ex St. Amans) Fr. is responsible for the black spot of leaves of the genus *Acer*. The first symptoms of infection appeared at the beginning of June in form of small, roundish spots which continually enlarged and gradually coalesced. They change into black flat formations, stroma of the fungus, which emerged above the leaf surface (Fig. 3). In these stromata pycnidia of the conidial stage of *Melasmia acerina* Lev. were formed. Conidia are oval to rod-shaped. In humid periods they are shed in form of jelly-like substance.

Apothecia of the fungus were formed in stromata on shed leaves in winter. They opened by very fine, irregular apertures. In them colourless paraphyses were produced. Eight ascospores formed in one ascus that were filiform, obtuse at one end, with marked oily drops. They matured in April to May and rarely occurred on the leaves also at the end of June and at the beginning of July. Mature ascospores were actively released by expulsion from the apothecia. They were carried by air flows to a great distance. The infection on the leaves was manifested by one or several spots (Figs. 4 and 5). It is interesting that the infection intensity was higher on the leaves of the genus *Acer* in forest stands than on the leaves of *Acer* trees growing in towns or in factory surroundings.

The fungus *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. caused powdery mildew of maples by formation of white, floury coating on leaves and leaf stalks. The fungus mycelium penetrated through haustoria to the epiderma cells from where it obtained food. Conidia are formed on short conidiophores. At the end of the vegetation period free, visible cleistothecia were produced. At the beginning they were white and later yellow or brown-black. Mature cleistothecia are black (Fig. 6). They contain longitudinal asci with single-cell, colourless, oval ascospores. Perithecia are roundish to oval and on one perithecium are 50–60 ap-



Fig. 3. The fungus *Rhytisma acerinum* (Pers. ex St. Amans) Fr. on the *Acer* leaves

Fig. 4. The fungus *Rhytisma acerinum* (Pers. ex St. Amans) Fr. on the leaves of *Acer platanoides*



Fig. 5. The fungus *Rhytisma acerinum* (Pers. ex St. Amans) Fr. on the leaves of *Acer campestre*

Fig. 6. Mature perithecia of the fungus *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. are black



Fig. 7. *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. on the leaves of *Acer platanoides*



Fig. 8. The fungus *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. formed a very intensive coating

pendages with endings typical of this genus. In one perithecium are 5–10 asci with 8 ascospores. On the leaves of *A. platanoides* L. (Fig. 7) there formed most intensively floury coating of mycelium with perithecia on the upper and lower sides. The coating was so intensive on the upper side that leaves seemed as if they were painted with a layer of lime (Fig. 8). The mycelium hibernates in the leaf buds. Young leaves were infected in the spring and the whole developmental cycle was repeated.

*Mycosphaerella latebrosa* (Cke.) Schröet. and its conidial stages: *Septoria acerina* Pk. and *Phyllosticta aceris* Sacc. form small, roundish or polygonal spots on the leaves of the genus *Acer* which were concentrated later. Especially at the beginning of the infection the spots have a light-yellow rim. Their number is very variable on a single leaf (from 1 to 230). From spots it is possible to isolate conidia of the fungus *S. acerina*. The first infection symptoms occur at the beginning of June. Pyc-

Table 4a. Developmental stages of the fungus *Sawadaea bicornis* (Wallr.:Fr.) Homma in some phenological phases of *Acer platanoides* L. at locality Nitra (Agrokomplex, Sihot' – park)

Phenological phases	Date of phenological phases		Developmental stages of the fungus							
	AX	Sihot'	AX	Sihot'	1	2	3	4	5	6
Bud swelling	15. 3.	18. 3.			+	+				
Bud burst	12. 4.	22. 3.			+	+				
Beginning of leaf burst	30. 4.	4. 4.			+	+				
General leaf burst	7. 5.	5. 5.			+	+				
Beginning of blooming	12. 4.			30. 7.	+	+				
General blooming	30. 4.			10. 8.	+	+	+			
Blooming begins to end	12. 5.			30. 8.	+	+		+	+	
General end of blooming	17. 5.			9. 9.	+	+		+	+	
Bud-formation period	1. 7.		30. 7.			+				
Fruits begin to mature	16. 9.		6. 8.		+		+	++	+	
General maturing of fruit	9. 10.	20. 9.			++			++	++	
Leaves begin to yellow	30. 9.	15. 10.			++			++	++	
General yellowing of leaves	15. 10.	20. 9.			++				++	
Leaves begin to fall	30. 9.	15. 10.			++				++	
General falling of leaves	28. 10.	30. 11.			++				++	+
Period of dormancy	20. 11.	30. 12.				+			++	++

Table 4b. Developmental stages of the fungus *Mycosphaerella latebrosa* (Cke.) Schröet. in some phenological phases of *Acer platanoides* L. in Arboretum Mlyňany and Nitra

Phenological phases	Date of phenological phases				Developmental stages of the fungus					
	AM	AX	AM	AX	1	2	3	4	5	6
Bud swelling	15. 3.	15. 3.			+	+	++			
Bud burst	8. 4.	12. 4.			++		++	++	+	
Beginning of leaf burst	13. 4.	30. 4.			+	+		++	+	
General leaf burst	23. 4.	7. 5.			+		+	+	++	
Beginning of blooming	17. 4.	12. 4.			+		+	+	+	
General blooming	23. 4.	30. 4.			+		+	+	++	
Blooming begins to end	1. 5.	12. 5.			+		+	+	++	
General end of blooming	20. 5.	17. 5.		20. 7.	+	+			+	
Bud-formation period	1. 6.	1. 7.		10. 8.	+	+			+	+
Fruits begin to mature	10. 9.	16. 8.	11. 7.			++			+	
General maturing of fruit	29. 9.	9. 10.	1. 8.			+				+
Leaves begin to yellow	20. 9.	30. 9.				++				
General yellowing of leaves	10. 10.	15. 10.				++				
Leaves begin to fall	29. 9.	30. 9.				++				
General falling of leaves	27. 10.	28. 10.				++				
Period of dormancy	27. 11.	20. 11.					+			

Table 4c. Developmental stages of the fungus *Rhytisma acerinum* (Pers. ex St. Amans) Fr. in some phenological phases of *Acer platanoides* L. in localities Nitra – Agrokomplex and *Acer campestre* L. in Nitra-Drážovce

Phenological phases	Date of phenological phases				Developmental stages of the fungus					
	Drážovce	AX	Drážovce	AX	1	2	3	4	5	6
Bud swelling	18. 3.	15. 3.			++		++			
Bud burst	8. 4.	12. 4.			++		++	++		
Beginning of leaf burst	28. 4.	30. 4.			++			++	+	+
General leaf burst	10. 5.	7. 5.			++			++	++	
Beginning of blooming		12. 4.			+			+	+	
General blooming		30. 4.	30.6.		+	+		+	+	
Blooming begins to end		12. 5.	17.7.		+	+			+	
General end of blooming		17. 5.			+				+	
Bud-formation period		1. 7.	15.8.				+		+	+
Fruits begin to mature		16. 8.					+			+
General maturing of fruit		26. 9.					+			
Leaves begin to yellow	15. 10.	9. 10.					++			
General yellowing of leaves	30. 10.	30. 9.					++			
Leaves begin to fall	20. 10.	15. 10.					++			
General falling of leaves	30. 11.	30. 9.					++	+		
Period of dormancy	20. 12.	20. 11.					++	++		

nidia of the conidial stage of the fungus *Ph. aceris* are formed on lower sides of leaves at the end of August.

Fast located pycnidia under the epidermis are submerged in the tissue. They are small, dark spheres with dimensions 50–60 µm. They contain very small, colourless conidia. Reproductive organs of this fungus form on the lower leaf side and the spots are expressive on the upper side. On the shed leaves there originate pycnidia of the ascus stage. Asci are oblong and contain ascospores located in two lines. Ascospores are two celled, oblong-screwed, colourless, in the middle gently con-

stricted with thinned endings. Strong infection by this fungus was manifested on the locality Arboretum Mlyňany. *M. latebrosa* did not belong to the group of important pests from an economic aspect but it created an aesthetic defect.

At the localities Nitra (Nitra-Drážovce, park on the Sihoť, Agrokomplex, Kukučín street) and Arboretum Mlyňany phenological phases and developmental stages of the fungi *S. bicornis*, syn. *U. bicornis*, *M. latebrosa* and *Rh. acerinum* were observed and they are listed in Tables 4a,b,c. On the basis of these observations it is

Table 5. The degree of leaf damage in the genus *Acer* by *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. at selected localities of Slovakia

Trees	Locality	Damage degree in July	Damage degree in August	Damage degree in October
<i>A. platanoides</i>	Arborétum Mlyňany	II.	III.	I.
	Nitra-Drážovce	II.	III.	II.
	Nitra-Lomonosova	II.	II.	I.
	Nitra-Kukučínova	III.	III.	II.
	Nitra-Jelenecká	II.	II.	I.
	Nitra - Castle	II.	II.	I.
<i>A. campestre</i>	Arborétum Mlyňany	I.	II.	I.
	Nitra-Drážovce	II.	III.	I.
	Nitra - Castle	I.	II.	I.

possible to ascertain at these localities in what period the leaves are still healthy, when the floury coating with conidia was formed or conidia in the pycnidia were produced, when the pycnidia of the fungus were differentiated, ascospores matured and in what period there are already empty asci on leaves. It was stated by observation of the developmental stages of the fungi at selected localities that infection of the host by parasitic fungi was only rarely continuous. Usually the infection originates in certain developmental stages of the parasitic fungus and the same time by disease inclination of host tree species simultaneously. The obtained results correlated with data reported by several authors: PŘÍHODA (1959), PEIKER (1964), BRANDENBURGER (1985), who described the process of the developmental stages of the parasite from primary infection by ascospores (*Rh. acerinum*, *M. latebrosa*), or fungal mycelium at powdery mildew to formation of the secondary conidial infection in a similar way. Time period of the course of parasitic developmental cycle at the concrete localities was defined by evaluation of the developmental cycle in 16 phenological stages on the genus *Acer*. This enabled us to recommend suitable protective measures to prevent primary infection by the ascospores and to reduce the infections pressure of secondary infection by the conidia.

The results of evaluation of the degree of damage to maple leaves by the fungus *S. bicornis* are listed in Table 5. The degree of leaf damage on *A. platanoides* during the observation period was high at all evaluated localities. Lower degree of damage in autumn to the aging leaves was

caused by reduction of the fungus mycelium. The results of evaluation of the degree of damage to maple leaves by the fungus *M. latebrosa* are in Table 6. *A. platanoides* L. was found to have a range from 18.6% (in Nitra) to 22.6% (Arborétum Mlyňany). *A. campestre* L. was found to have lower values (Arborétum Mlyňany 9.3%, Nitra 6.2–8.6%). On the leaves of *A. platanoides* Lorbergii (Arborétum Mlyňany 52.8%) a very high percentage of damage was observed. The results of leaf damage by the fungus *Rh. acerinum* are in Table 7. The values of damage in Arborétum Mlyňany on *A. platanoides* L. were 9.3% and in Nitra only 4.8%. The degree of damage to leaves of *A. pseudoplatanus* L. was relatively low at both localities (Arborétum Mlyňany 3.8%, Nitra 2.2–8.3%). On the basis of these values it was possible to observe that the degree of leaf damage was very different in relation to time and evaluated locality.

In national literature, no distinct data on dimensions of reproductive organs of the observed fungi were found. On the basis of multiple measurements the following dimensions of the reproductive organs was determined (Table 8). Data on dimensions of fungal reproductive organs can be found in foreign mycological and phytopathological literature. They were often different. The values of these organs measured at Slovakian localities were not known. These original data were used to compare to values acquired from other localities of Slovakia.

Growth rate of the hyphae of the fungal mycelium (*M. latebrosa* and *S. acerina*) was observed on the leaf samples of *A. platanoides* from locality Nitra and *A. pseudo-*

Table 6. The degree of leaf damage in the genus *Acer* by *Mycosphaerella latebrosa* (Cke.) Schröt. at selected localities in Slovakia

Trees	Locality	Degree of damage (%)
<i>Acer platanoides</i>	Arborétum Mlyňany	22.6
	Nitra	18.6
<i>Acer campestre</i>	Arborétum Mlyňany	9.3
	Nitra-Drážovce	8.6
	Nitra-Krškany	6.2
<i>Acer platanoides</i> Lorbergii	Arborétum Mlyňany	52.8

Table 7. The degree of leaf damage in the genus *Acer* by *Rhytisma acerinum* (Pers. ex St. Amans) Fr. at selected localities in Slovakia

Trees	Locality	Degree of damage (%)
<i>Acer platanoides</i>	Arborétum Mlyňany	9.3
	Nitra - park Sihot'	4.8
	Nitra-Chrenová	4.4
<i>Acer pseudoplatanus</i>	Arborétum Mlyňany	3.8
	Nitra - park Sihot'	2.2
	Nitra-Chrenová	8.3

Table 8. Dimensions of reproductive organs of the fungi *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc., *Rhytisma acerinum* (Pers. ex St. Amans) Fr. and *Mycosphaerella latebrosa* (Cke.) Schröter.

Originator of the disease	Dimensions of reproductive organs ( $\mu\text{m}$ )		
	Cleistothechia	Ascospores	Asci
<b><i>Sawadaea bicornis</i></b>			
<i>A. platanoides</i>	106.4 $\times$ 209.0	3.8–11.4 $\times$ 3.8–17.1	57.0–79.8 $\times$ 38.0–52.2
<i>A. campestre</i>	103.8 $\times$ 144.4	3.8–11.4 $\times$ 3.8–19.0	60.8–72.2 $\times$ 38.0–52.2
<b><i>Rhytisma acerinum</i></b>			
	Conidia	Ascospores	Asci
<i>A. platanoides</i>	1.9–3.8 $\times$ 10.4–20.9	56–98 $\times$ 1.9	5.7–8.5 $\times$ 91.0–110
<i>A. campestre</i>	1.9–3.8 $\times$ 11.4–19.0	60–98 $\times$ 1.9	7.2–9.5 $\times$ 95.0–120
<i>A. pseudoplatanus</i>	1.9–3.8 $\times$ 10.4–20.9	58–96 $\times$ 1.9	6.6–8.5 $\times$ 98.8–114
<b><i>Mycosphaerella latebrosa</i></b>			
	Conidia		
<i>A. platanoides</i>	22–27 $\times$ 1–1.9		
<i>A. platanoides</i> Lorbergii	22–25 $\times$ 1–1.9		

*platanus* from locality Arborétum Mlyňany. The cultivation of the fungi was realized on Czapek-Dox 2% and 3% agar and on maltose 2% and 3% agar ( Tables 1 and 2, Figs. 7 and 8). The fastest growth rate of the hyphae of the fungal mycelium was observed on Czapek-Dox agar at 2% concentration. In our work we did not confirm the occurrence a new sort of the fungus *M. mycopappii* sp. which was described by some foreign authors (FUNK, DORWORTH 1987). The data from GRZYWACZ and VAŽNY (1973) we also did not acknowledge. According to those authors the fungus *Rh. acerinum* did not occur in the urban or intensively polluted environment. This fungus appeared not only in parks and in high forest stands but it was also possible to identify it in the urban environment in street greenery. Several taxons of outlandish species of the genus *Acer* in parks and urban greenery from the observed localities (mainly in Arborétum Mlyňany) was observed. Great leaf damage by the fungus *M. latebrosa* on *A. platanoides* Lorbergii was ascertained. Occurrence of this fungus in the conditions of Slovakia (locality Arborétum Mlyňany) was observed for the first time.

Plant protection measures proposed in this paper are generally accepted principles (PŘÍHODA 1959; PEIKER 1964; KRUTÁ 1969; BRANDENBURGER 1985; JANČAŘÍK 1986; JUHÁSOVÁ 1983, 1993). Prevention of infection is possible by taking suitable plant protection measures. At the towns the mechanical protection is recommended. The source of infection – the leaves from the last years – is necessary to remove. The infection pressure and degree of damage reduce. Chemical protection can be used for emergency reasons in towns only rarely.

The prevention is not often used in ornamental gardening. The health condition of the seedlings is very inferior controlled. The source of infection is damaged tree species and the fungi spread on the other localities. By the evaluation of the health condition of tree species was determined that application of suitable cultural procedures in public greenery is important.

## References

- BENČAŤ F., 1982. Atlas rozšírenia cudzokrajných drevín na Slovensku a rajonizácia ich pestovania. Bratislava, VEDA: 359.
- BENČAŤ F., TOKÁR F., 1978. Výsledky fenologického pozorovania gaššana jedlého na experimentálnej ploche v Horných Lefantovciach. Folia Dendrol., 4: 49–85.
- BRANDENBURGER W., 1985. Parasitische Pilze am Gefäßpflanzen in Europa. Stuttgart, New York, Gustav Fischer Verlag: 1248.
- DUBOVSKÝ J., 1969. Polné pokusy. Bratislava, Príroda: 154.
- FUNK A., DORWORTH C.E., 1987. *Mycosphaerella mycopappii* sp. Nov. and its anamorphs on leaves of *Acer macrophyllum*. Can. J. Bot., 66: 295–298.
- GRZYWACZ A., VAŽNY J., 1973. The impact of industrial air pollutants on the occurrence of several important pathogenic fungi of forest trees in Poland. Eur. J. Forest Pathol., 3: 129–141.
- JANČAŘÍK V., 1986. *Rhytisma acerinum* (Pers.) Fr. Lesn. Práce, 65: 36.
- JUHÁSOVÁ G., 1983. Parazitické hriby na asimilatívnych organoch drevesných rastení v gorodskoj srede. In: Introdukcia drevesných rastení i zelenoje strojiteľstvo. Dokl. AN SSSR, 9: 131–137.
- JUHÁSOVÁ G., 1993. Rezultaty izučeniya mikoflory gorodskich nasaždenij. In: Bjuletin glavnogo botaničeskogo sada RAN. Moskva, Nauka: 64–71.
- KOCHNO N.A., 1982. Kleny Ukrainy. Kyjev, Naukova Dumka: 182.
- KOTEK V., 1975. Javory v našich zahrádkách. Zahradkář, 11: 233.
- KRUTÁ E., 1969. Súčasný stav zelene v Nitre. Záhradník, 3: 29.
- PEIKER J., 1964. Ochrana rostlin v zahradnictví. Praha, SZN: 298.
- PŘÍHODA A., 1959. Lesnická fytopatologie. Praha, SZN: 363.

Received 26 October 2000

## Parazitické mikroskopické huby na javoroch

**ABSTRAKT:** V práci sme sledovali poškodenie asimilačných orgánov vybraných druhov rodu *Acer* (*A. platanoides* L., *A. pseudoplatanus* L., *A. campestre* L. a *A. tataricum* L.) na vybraných lokalitách Slovenska z hľadiska parazitických mikroskopických húb *Rhytisma acerinum* (Pers. ex St. Amans) Fr., *Mycosphaerella latebrosa* (Cke.) Schröet. a *Sawadaea bicornis* (Wallr.:Fr.) Homma, syn. *Uncinula bicornis* (DC) Sacc. Hodnotili sme vývojový cyklus v 16 fenologických fázach javorov a vymedzili sme časové obdobie priebehu vývojového cyklu parazitov. Stanovili sme hraničné hodnoty reprodukčných orgánov, vyhodnotili klíčivosť konídií a rýchlosť rastu hýf mycélia konídiového štádia (*Septoria acerina* Pk.) huby *Mycosphaerella latebrosa* (Cke.) Schröet. z lokalít Nitra a Arborétum Mlyňany na rôznych živných médiách. Určili sme stupeň poškodenia asimilačných orgánov javorov v dôsledku infekcie nami sledovaných parazitických mikroskopických húb. Záverom sme navrhli ochranné opatrenia na zamedzenie ďalšieho rozširovania infekcie.

**Kľúčové slová:** javor horský; javor mliečny; javor babyka; javor tatarský; *Mycosphaerella latebrosa*; *Rhytisma acerinum*; *Sawadaea bicornis*; syn. *Uncinula bicornis*

---

*Corresponding author:*

Doc. Ing. GABRIELA JUHÁSOVÁ, CSc., Ústav ekológie lesa SAV Zvolen, Pobočka biológie drevín Nitra, Akademická 2, 949 01 Nitra, Slovenská republika, tel.: + 421 87 733 57 38, fax: + 421 87 733 56 96, e-mail: nruejuha@savba.sk

---

## Zahradnický slovník naučný

Pátým dílem byl ukončen *Zahradnický slovník naučný*, jehož vydávání zajistil v letech 1994–2001 Ústav zemědělských a potravinářských informací v Praze. Slovník představuje základní encyklopedické dílo, zahrnující všechny zahradnické obory – ovocnářství, zelinářství, květinářství, sadovnictví, vazačství a dekoratérství, vinařství a sklepní hospodářství, školkařství, léčivé a aromatické rostliny, pěstování hub i hlavní druhy tropického a subtropického zahradnictví. Zevrubně pojednává o šlechtění a semenářství zahradních rostlin, o jejich ochraně, uchování a zpracování zahradních produktů, o zahradnické technice a mechanizaci. Významné zastoupení mají hesla z vědních oborů, které tvoří základ zahradnictví – botaniky, fyziologie, genetiky, mikrobiologie, ekologie, fytopatologie, pedologie a meteorologie. Důležitou část tvoří informace o základní hortitechce – výživě rostlin, závlaze, pěstování v chráněných prostorách. Velmi široce a důkladně jsou zpracována hesla z ochrany rostlin, osvětlující především biologickou podstatu chorob a škůdců. Ve slovníku jsou zastoupena i hesla z velmi speciálních oblastí – např. kaktusy, sukulenty, orchideje, palmy aj. Značná část hesel je věnována životnímu prostředí a poskytuje návod, jak zahradnický řešit jeho problémy.

Slovník obsahuje informace o zahradnických nejvyspělejších zemích, významných botanických zahradách a národních parcích, o zámeckých zahradách a důležitých parcích naší vlasti i nejvýznamnějších sadovnických objektech v cizině. Slovník přináší v jednotlivých heslech množství statistických údajů o stavu zahradnictví a jeho produkci v České republice i v zahraničí. Podává také přehled o historii a vývoji českého zahradnictví, organizací, spolicích a časopisech zahradníků. Významnou součástí jsou početná životopisná hesla o českých i zahraničních zahradnicích a botanicích; uvádějí jejich hlavní přínos pro rozvoj zahradnictví. Slovník encyklopedicky vykládá nejzávažnější terminologické pojmy užívané v botanice, ekologii, fyziologii, genetice a šlechtění, biotechnologii a ochraně rostlin. Je tedy užitečný pro každého, kdo pracuje s odbornou a vědeckou literaturou. Ve slovníku jsou s velkou zodpovědností uvedeny platné vědecké i české názvy rostlin, jejich systematické začlenění a autoři názvů, což umožňuje napravit časté nepřesnosti v naší odborné literatuře.

Širokým pojetím zahradnické problematiky se *Zahradnický slovník naučný* značně liší od zahraničních zahradnických slovníků, které jsou většinou zaměřené jen botanicky a také méně rozsáhlé. Obsah slovníku i jednotlivých hesel vychází ze současného vědeckého a odborného poznání. Hesla mají obecnou platnost, přitom jsou zaměřena především k potřebám českého zahradnictví a využití v našich podmínkách. Předností textu je jeho srozumitelnost i pro laika a konkrétnost údajů. Slovník také sjednocuje zahradnickou terminologii a u botanických názvů rostlin, latinských i českých, vychází z posledních botanických úprav.

Obsah slovníku je určen především zahradníkům, velmi dobře však poslouží i zemědělcům, lesníkům, šlechtitelům rostlin, pracovníkům v oblasti vědy i studentům. Pro aktuálnost a srozumitelnost jej mohou dobře využít i zahrádkáři a milovníci přírody.

Všech pět dílů Slovníku zahrnuje 13 000 hlavních a 15 000 vedlejších (navazujících) hesel celkem na 3 000 stranách formátu A4. Na 208 tabulích je 1 750 barevných obrázků a v textu 3 800 černobílých snímků a pérovek. Obrazově jsou znázorněny především rostliny, choroby a škůdci zahradních rostlin, ale také popisované technologie, informace o zemích, parcích a sadovnických úpravách, portréty osob aj.

Slovník napsali naši přední odborníci z řad vysokoškolských profesorů, pracovníků Akademie věd ČR a výzkumných zahradnických ústavů, učitelé zahradnických škol i praktičtí zahradníci. Autorský kolektiv zahrnul 160 členů. Je to v moderní historii druhý český zahradnický slovník. Jeho předchůdcem byl *Ovocnicko-vinařský a zahradnický slovník*, vydaný koncem třicátých let minulého století. Současný slovník, koncipovaný jako základní dílo české zahradnické literatury, je plně srovnatelný s podobnými zahraničními publikacemi tohoto typu. Jistým nedostatkem je méně reprezentativní technická stránka, která je však plně vyvážena více než bohatým obsahem a množstvím informací.

Slovník, jehož 5 dílů stojí 2 100 Kč, lze zakoupit ve všech větších knihkupectvích. Zájemcům jej také zasílá přímo vydavatel – Ústav zemědělských a potravinářských informací, Slezská 7, 120 56 Praha 2 – za sníženou cenu 1 780 Kč za celý komplet.

Ing. František Mareček

## INSTRUCTIONS FOR AUTHORS

The responsibility for the contents of a manuscript rests with the authors. The Editorial Board will decide on suitability for publication, after considering the scientific importance and overall technical quality of the manuscript and the comments of the referees.

The manuscript should be typed on standard A4 paper. A PC diskette with the complete text and including references, tables and figure legends of graphical documentation should be provided with each manuscript, indicating the used editor program.

Manuscript should consist of the following sections: Title page, Abstract, Keywords, Introduction, Materials and Methods, Results, Discussion, References, Address of corresponding author, Tables, Legends to figures.

The Title page must contain an informative title, complete name(s) of the author(s), the name(s) and address(es) of the institution(s) where the work was done.

The Abstract should state in a short and concise form what was done and how, and should contain basic numerical and statistical data representative of the results. It should be submitted in English and, if possible, also in Czech.

**Keywords** follow the abstract; they are ranked from general to specific terms, and are written in lower case letters and separated by semicolons.

The **Introduction** (without a subtitle) should consist of a short review of literature relevant to and important for the study. The reason(s) for carrying out the work may be included.

In **Materials and Methods**, the description of experimental procedures should be sufficient to allow replication. Abbreviations can be used if necessary; first use of an abbreviation should be just after its complete name or description. The International System of Units (SI) and their abbreviations should be used.

**Results** should be presented clearly and concisely. In this section figures and graphs should be used rather than tables for presentation of quantitative values. A statistical analysis of recorded values should be summarized in tables.

The **Discussion** should interpret the results, without unnecessary repetition. Sometimes it is possible or advantageous to combine Results and Discussion in one section.

If **Acknowledgments** are needed, they come next.

**References** used in the text consist of author's name and year of publication. The list of references should include only publications quoted in the text. These should be in alphabetical order under the first author's name, citing all authors, year (in brackets), full title of the article, abbreviation of the periodical, volume number, first and last page numbers.

**Contact address** should include the postal address, telephone, fax and e-mail numbers of the corresponding author.

**Tables and Figures** shall be enclosed separately. Each of them must be referred to in the text. Figures should be restricted to material essential for documentation and understanding of the text. Duplicate presentation of data in both tables and figures is not acceptable. All illustrative material must be of publishable quality. Both line drawings and photographs are referred to as figures. Photographs should have high contrast. Each figure should be accompanied by a concise, descriptive legend.

**Reprint:** Ten (10) reprints of each published paper are supplied free of charge.

## POKYNY PRO AUTORY

Autor je plně odpovědný za původnost práce a za její věcnou i formální správnost. O uveřejnění práce rozhoduje redakční rada se zřetelem k lektorským posudkům, vědeckému významu a přínosu i kvalitě práce.

Rukopis musí být zaslán vytištěný na papíru formátu A4. K rukopisu je vhodné přiložit disketu s textem práce, popř. grafickou dokumentaci pořízenou na PC (uvést použitý program).

Vědecká práce musí mít toto členění: titulní strana, abstrakt a klíčová slova, úvod, materiál a metody, výsledky, diskuse, literatura, kontaktní adresa, tabulky a obrázky včetně popisů.

Titulní strana musí obsahovat název práce, plné jméno autorů, název a adresu instituce, kde byla práce dělána.

**Souhrn** musí vyjádřit všechno podstatné, co je obsaženo ve vědecké práci, má obsahovat základní číselné údaje včetně statistických hodnot. Je uveřejňován a měl by být autory dodán v angličtině a češtině.

**Klíčová slova** (keywords, index terms) se připojují po vyečarání řádku pod souhrn. Řadí se směrem od obecných výrazů ke speciálním; začínají malým písmenem a oddělují se středníkem.

**Úvod** (bez nadpisu) by měl obsahovat krátký přehled důležitých literatury vztahující se k tématu a cíli práce.

**Materiál a metody:** Model pokusu musí být popsán podrobně a výstižně. Popis metod by měl umožnit, aby kdokoli z odborníků mohl práci opakovat. Zkratky jsou používány jen pokud je to nutné; první použití zkratky musí být uvedeno úplným popisem nebo vysvětlením. Používané měrové jednotky musí odpovídat soustavě měrových jednotek SI.

**Výsledky:** Doporučuje se nepoužívat k vyjádření kvantitativních hodnot tabulek, ale dát přednost grafům anebo tabulky shrnout v statistickém hodnocení naměřených hodnot. Tato část práce by neměla obsahovat teoretické závěry ani dedukce, ale pouze faktické nálezy.

**Diskuse** obsahuje zhodnocení práce. Je přípustné spojení s předchozí kapitolou (Výsledky a diskuse).

**Poděkování** se uvádí před přehled použité literatury.

**Literatura:** Měly by být citovány práce uveřejněné v lektorovaných periodikách. Odkazy na literaturu v textu se provádějí uvedením jména autora a roku vydání publikace. V části Literatura se uvádějí jen práce citované v textu. Citace se řadí abecedně podle jména prvního autora: příjmení, zkratka jména, rok vydání (v závorce), plný název práce, úřední zkratka časopisu, ročník, první–poslední stránka; u knih je uvedeno místo vydání a vydavatel.

**Kontaktní adresa** obsahuje vedle poštovní adresy také čísla telefonu, faxu a e-mail adresu autora pověřeného korespondencí.

**Tabulky a obrázky:** Tabulky, obrázky a fotografie se dodávají zvlášť a všechny musí být citovány v práci. Akceptovány budou pouze obrázky, které jsou nezbytné pro dokumentaci výsledků a umožňují pochopení textu. Není přípustné dokumentovat výsledky jak v tabulkách, tak pomocí grafů. Všechny ilustrativní materiály musí mít kvalitu vhodnou pro tisk. Fotografie i grafy jsou v textu uváděny jako obrázky a musí být průběžně číslovány. Každý obrázek musí mít stručný a výstižný popis.

**Separáty:** Autor obdrží 10 separátních výtisků publikované práce.

## CONTENTS

VACHŮN Z.: Yield potential of new apricot cultivars and hybrids within the first eight years after planting .....	41
GOLIÁŠ J.: Dynamics of ethylene in apples during maturation and cold storage .....	47
CHOD J., CHODOVÁ D., JOKEŠ M.: Reaction of selected lamb's-quarters species ( <i>Chenopodium</i> sp.) to mechanical inoculation with <i>Celery mosaic virus</i> .....	53
MUSILOVÁ I.: Evaluation of resistance of apricot to <i>Monilinia laxa</i> (Aderh. et Ruhl.) Honey .....	56
LACHMAN J., ORSÁK M., PIVEC V., KRATOCHVÍLOVÁ D.: Stability of yellow and red rose pigments during their storage under different conditions .....	62
JUHÁSOVÁ G., IVANOVÁ H.: Parasitic mycoflora of the genus <i>Acer</i> .....	71
INFORMATION	
Encyclopedia of Horticulture .....	80

## OBSAH

VACHŮN Z.: Výnosový potenciál nových odrůd a hybridů meruněk v prvních osmi letech po výsadbě .....	41
GOLIÁŠ J.: Dynamika etylenu během sklizně a chladírenského skladování jablek .....	47
CHOD J., CHODOVÁ D., JOKEŠ M.: Reakce vybraných druhů merlíků ( <i>Chenopodium</i> sp.) na mechanickou inokulaci virem mozaiky celeru .....	53
MUSILOVÁ I.: Hodnocení rezistence meruněk k <i>Monilinia laxa</i> (Aderh. et Ruhl.) Honey .....	56
LACHMAN J., ORSÁK M., PIVEC V., KRATOCHVÍLOVÁ D.: Stabilita barviv růží během skladování za různých podmínek .....	62
JUHÁSOVÁ G., IVANOVÁ H.: Parazitické mikroskopické huby na javoroch .....	71
INFORMACE	
Zahradnický slovník naučný .....	80