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PRODUCTION AND USE OF THE CORNELIAN CHERRY – *CORNUS MAS* L.

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Abstract

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The objective of the study was to evaluate the growth and yields of selected varieties of Cornelian cherry ('Elegantní', 'Fruchtal', 'Jaltský', 'Jolico', 'Lukjanovský', 'Vydubecký', 'Vyšegorodský') over a 5-year period. We evaluated the following: differences in growth, plant volume, external appearance, yield data and from samples of the fruit the composition and content of selected mineral elements. The following mineral elements were determined in the fruit samples: P, K, Ca, Mg, Na, Zn, Fe, Cu and Mn, as well as other parameters: content of solids, degree of refraction, content of acids, vitamin C and pectin.

Evaluations were carried out in 2007–2011 and statistically significant differences in the plant volume were discovered among the varieties; Vyšegorodský is a high-volume variety (3.25 m^3); the volume of variety Jolico is small (1.86 m^3). In terms of yields the variety Fruchtal ranks among the more productive varieties (6.99 $kg.plant^{-1}$); in contrast the yields of the variety Jaltský were lower (5.07 $kg.plant^{-1}$). Differences among the varieties were significant only in the contents of K, Mg, Na and Fe. The Ca and P contents ranged between 301 and 365 $mg.kg^{-1}$ and 313 and 412 $mg.kg^{-1}$, respectively. The K content in the fruit was the lowest in variety Vydubecký (3411 $mg.kg^{-1}$) and the highest in the variety Fruchtal (3798 $mg.kg^{-1}$). The Mg content was lower in varieties Elegantní (241 $mg.kg^{-1}$) and Fruchtal (237 $mg.kg^{-1}$); the Mg content was higher in varieties Jaltský (281 $mg.kg^{-1}$), Jolico (288 $mg.kg^{-1}$), Lukjanovský (292 $mg.kg^{-1}$) and Vyšegorodský (290 $mg.kg^{-1}$). The Na content was the lowest in the fruit of variety Fruchtal (58 $mg.kg^{-1}$); the Na content was significantly higher in varieties Vydubecký (81 $mg.kg^{-1}$) and Jaltský (82 $mg.kg^{-1}$). The Zn content ranged between 2.65 and 3.52 $mg.kg^{-1}$. The Fe content in fruit was the lowest in variety Fruchtal (41 $mg.kg^{-1}$) and was significantly higher in variety Lukjanovský (49 $mg.kg^{-1}$). The Cu content ranged between 1.09 and 1.74 $mg.kg^{-1}$. The Mn content ranged between 24 and 29 $mg.kg^{-1}$.

The average degree of refraction was 15 ° Bx. The acid content was significantly the highest in variety Fruchtal (2.78 %); the content was medium in varieties Elegantní (2.24 %) Jolico (2.28 %) and Vydubecký (2.11 %), and was significantly the lowest in variety Lukjanovský (1.76 %).

No significant differences in the content of vitamin C were discovered among the varieties. The average content of vitamin C was 61 mg in 100 g of fresh mass of the fruit. The achieved data confirmed that Cornelian cherry is a valuable plant due to its undemanding cultivation, wide-ranging possibilities of its commercial use and its properties when used in landscape and ornamental gardening.

Cornelian cherry, yields, volume of shrub, mineral elements, vitamin C

Minor fruit species round off the fruit species produced in the conditions of the temperate zone of the Czech Republic. They are grown predominantly at a small-scale level and their production is focused on the preservation of genetic sources in gene pools. At the same time, efforts are made to spread production of these species among small producers and to incorporate these plants into the agrarian sector (Dolejší *et al.*, 1991). Cornelian cherry (*Cornus mas* L.) is a widely spread species native to Europe. There are about 65 species of dogwood (Cornus) representing a morphologically diverse

group of primarily woody plants, widely distributed throughout the temperate regions of the northern hemisphere, with centres of origin in eastern Asia, eastern and northwest North America, and the mountains of Central America, South America and east Africa (Eyde, 1988). Many *Cornus* species are used as ornamentals, but only a few are grown for their edible fruits, and Cornelian cherry *Cornus mas* L. is among them (Ercisli, 2004).

The Cornelian cherry is valuable because it is undemanding in terms of its position and cultivation; it often grows in an extreme environment. Its greatest asset is the high biological value of harvested fruit and its early ripening. It has an important landscape-forming as well as an aesthetic, rehabilitation, isolation and cultural function (Koblížek, 2006; Paprštein *et al*., 2009).

The Cornelian cherry grows in altitudes of up to 1400 meters. The species is very tolerant to abiotic and biotic factors and can survive and produce high yields even in conditions unfavourable for its growth, such as a temperature of –36 °C. It can grow to an age of 250–300 years (Asadov *et al*., 1990). The fruits can be eaten fresh or used to make syrups, juices, jams and other traditional products. It has a great potential to be grown in monoculture group plantings (Brindza *et al*., 2007). Cornelian cherries are usually olive shaped, single-seeded fruits, 10–20 mm long. They are typically red, but can also be found in pink and yellow. They contain twice as much vitamin C as oranges on a fresh weight basis and are rich in sugar, anthocyanins, organic acids and tannins (Seeram *et al*., 2002; Demir and Kalyoncu, 2003). In addition to fresh consumption, the fruit can be dried, pickled like olives, or used to prepare preserves or wine (Karadeniz, 2002). The fruit is sweet-sour in taste, slightly astringent and is used primarily to make preserves, compotes, juices, and wine (Asadov *et al*., 1990; Damirov *et al*., 1983). Cornelian cherries have been grown in the Caucasus and Central Asia for centuries, mainly for food and medicine, but also as ornamental and honey plants. Because it is drought-resistant and has hard wood, it is used in many Central Asian countries for making furniture, jewellery and traditional musical instruments. Its primary utilisation is fruit production. In its natural habitat, the Comelian cherry can yield from 500 to 1000 kg of fruit per hectare but, in orchard plantings, fruit yields can reach up to 5000 kg per hectare (Asadov *et al*., 1990; Damirov *et al*., 1983).

In the past decades, a collection of minor species, varieties and ecotypes has been gathered on the experimental plots, Department of Breeding and Propagation of Garden Plants, Faculty of Horticulture, Mendel University in Brno, which are located at the School Farm in Žabčice. The collection includes quince, Cornelian cherry, sorb (service tree), sea-buckthorn, Japanese quince, mulberry, common medlar, serviceberry, viburnum, black elder, apple rose and honeysuckle. The regular monitoring of their growth, data on their phenology, yields and health will enable us to specify how demanding these species are in terms of soil, climate and cultivation. Important are also results of laboratory assessments of the harvested fruit and their use. The main objective of the study is to evaluate the agro-ecological conditions in the plantings together with possibilities of practical use. The study is focused on Cornelian cherry (*Cornus mas*. L.*)*.

MATERIALS AND METHODS

Strip planting was established of seven varieties of Cornelian cherry: Elegantní, Fruchtal, Jaltský, Jolico, Lukjanovský, Vydubecký and Vyšegorodský, and they were evaluated for 5 years (2007–2011). The strip around the stems was kept free of weeds by regular cultivation. The inter-row space was grassed and mowed six-times during vegetation. Cultural practice of these stands was focused on plant nutrition, disease and pest control and cutting. The combined fertiliser Cererit Z was applied at a rate of 35 g.m^{-2} in the spring as supplementary fertilisation. The insecticide Pirimor DP 50 was used repeatedly for pest control (aphids). Cutting in early spring was done as maintenance pruning to remove the broken, dry or otherwise damaged parts of the bush or crown.

Cornelian cherry (*Cornus mas* L.) comes from south Europe and from the foothills of the Caucasus; from there it spread over Turkey, Romania, Bulgaria and Italy to the inland European continent (Dolejší *et al*., 1991). Cornelian cherry ranks among a biologically highly valuable fruit; the fruit can be eaten out of hand or be further processed. It forms a rich root system, stabilises the soil on slopes and prevents erosion. It is an excellent pollen-bearing woody species. It improves the environment in ecologically damaged areas (Dolejší *et al*., 1991; Paprštein *et al*., 2009).

On a yearly basis, biometric data of some varieties and ecotypes were recorded after the end of the vegetation period. The growth intensity, volume of the shrub based on Neumann's formula ($Vk = Pp^2.v/1.91$ m^3), growth habit of the shrub and fruit yields from one shrub were evaluated; the effective fertility expressing the weight of fruit from one shrub in kg was related to the shrub volume. The harvesting of Cornelian cherry was divided into three dates based on the ripeness of the fruit. The resulting yields were calculated by summing up the partial harvests. The harvested fruit was sampled for laboratory analyses of the content of solids, acids, vitamin C and pectin and at the same time the content of mineral elements. Laboratory analyses of the contents of these substances were performed at the Department of Food Chemistry and Biotechnology, Faculty of Chemistry of the Brno University of Technology and the Department of Food Technology and Microbiology, Faculty of Technology of Tomáš Bata University in Zlín.

The chemical analysis of solids content was made after drying to a constant weight at 105 °C (± 2 °C). The refraction of solids was measured in juice, obtained by fruit juicing, using polarimetric measurements and was expressed in Brix degrees. The total content of acids was assessed by potentiometric titration; the homogenised sample was extracted in re-distilled water followed by filtration and titration with sodium hydroxide to pH 7.8 and the result was re-calculated to g of malic acid per kg^{-1} of fresh mass (Novotný, 2000). Vitamin C was determined using the modified method according to Miki (1981). An extractive agent was added to the charge which was then placed in a water bath where the sample was extracted, filtrated and before column feeding diluted in the given ratio by the extraction mixture (chromatogram ESA, electro-chemical detector Couloch III, column Supelcosil LC8). The amount of vitamin C was expressed in v $g.kg^{-1}$ of fresh mass. The amount of pectin was assessed using the method after Rop *et al.* (2008). After preparing the extract from the fruit squash the pectin was determined photometrically. Samples and standard of pectin were measured on the Libra S6 apparatus and the pectin amount was expressed in $g.kg^{-1}$ of fresh mass. Determination of mineral substances followed the preparation of the sample by measuring the mineralisate on the absorption spectrometer Philips PU 9200X. The amount of mineral substances was expressed in $mg.kg^{-1}$ of fresh mass.

Basing on the data obtained by measurements, determination of the weight of the yields, laboratory data etc. we can deduce which species, varieties or ecotypes are suitable for different use, for growing in various climate and soil conditions, but particularly for integration in the agrarian sector and commercial utilisation of the harvest. The data obtained were analysed statistically by an analysis of variance (ANOVA) and Tukey's multiple range test for comparison of means (Snedecor and Cochran, 1968) using the statistical package Statistica v. 10.

RESULTS AND DISCUSSION

In terms of the **plant volume, yield and yield efficiency** a significant difference ($p = 0.05$) was discovered among the varieties, years and interactions among these factors (Tab. I).

The **plant volume** ($p = 0.05$) was significantly the highest in the variety Jaltský (4.87 m^3); mean values in varieties Lukjanovský (4.17 m^3), Elegantní (2.97 m^3), Vydubecký (2.92 m^3) and Vyšegorodský (3.25 m^3); the plant volume was the lowest in varieties Fruchtal (1.96 m^3) and Jolico (1.86 m^3) (Tab. II). The difference between the highest and the lowest plant volume was 3.01 m^3, i.e. 38 % of the value of the highest volume (Tab. II).

In terms of **yields** a significant difference was discovered among the varieties Fruchtal (6.99 $kg.plant^{-1}$), Vyšegorodský (6.37 $kg.plant^{-1}$) and Elegantní (5.90 $kg.plant^{-1}$) – with higher yields, compared to varieties Lukjanovský (4.78 $kg.plant^{-1}$), Vydubecký (4.85 $kg.plant^{-1}$) and Jaltský (5.07 $kg.plant^{-1}$) – with lower yields. The difference between the most productive and least productive variety was 2.21 $kg.plant^{-1}$, i.e. 32 % of the value of the highest yield (Tab. II).

In terms of the **yield efficiency** (weight of fruit in kg per m^3 of the plant volume) the fertility of the variety Fruchtal significantly surpassed the other varieties (3.73 $kg.m^{-3}$), followed by the variety Jolico (3.07 $kg.m^{-3}$). The fertility of varieties Vydubecký (1.78 $kg.m^{-3}$), Elegantní (1.97 $kg.m^{-3}$) and Vyšegorodský (2.05 $kg.m^{-3}$) was medium. In terms of the plant volume the yields of the varieties Jaltský and Lukjanovský were lower (1.03 $kg.m^{-3}$ and 1.14 $kg.m^{-3}$, respectively). The difference in efficient

I: *Analysis of variance results for plant volume, yield and yield efficiency*

		Plant volume (m^3)		Yield ($kg.plant^{-1}$)		Yield efficiency ($kg.m^{-3}$)	
Source of variation	**df**	**MS**	**p**	**MS**	**p**	**MS**	**p**
Variety	6	17.96	0.000	10.41	0.000	14.48	0.000
Year	4	6.29	0.000	42.03	0.000	5.09	0.000
Variety*year	24	0.04	0.995	4.66	0.000	0.97	0.000
Error	70	0.11		0.43		0.16	

II: *Plant volume, yield and yield efficiency of the tested varieties (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05) (data are related to Fig. 1–3)*

Variety	Plant volume (m^3)	Yield ($kg.plant^{-1}$)	Yield efficiency ($kg.m^{-3}$)
Elegantní	2.97 ± 0.13 b	5.90 ± 0.64 bc	1.97 ± 0.20 b
Fruchtal	1.96 ± 0.14 a	6.99 ± 0.39 d	3.73 ± 0.29 d
Jaltský	4.87 ± 0.15 d	5.07 ± 0.59 a	1.03 ± 0.11 a
Jolico	1.86 ± 0.12 a	5.44 ± 0.40 ab	3.07 ± 0.25 c
Lukjanovský	4.17 ± 0.15 c	4.78 ± 0.41 a	1.14 ± 0.07 a
Vydubecký	2.92 ± 0.21 b	4.85 ± 0.22 a	1.77 ± 0.13 b
Vyšegorodský	3.25 ± 0.14 b	6.37 ± 0.44 cd	2.05 ± 0.21 b

III: *Plant volume, yield and yield efficiency according to year (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05)*

Year	Plant volume (m^3)	Yield ($kg.plant^{-1}$)	Yield efficiency ($kg.m^{-3}$)
2007	2.43 ± 0.23 a	5.68 ± 0.33 c	2.89 ± 0.36 c
2008	2.85 ± 0.24 b	4.03 ± 0.35 a	1.75 ± 0.24 a
2009	3.13 ± 0.24 b	5.47 ± 0.30 bc	1.97 ± 0.17 ab
2010	3.45 ± 0.23 c	5.08 ± 0.32 b	1.68 ± 0.18 a
2011	3.86 ± 0.24 d	7.89 ± 0.25 d	2.25 ± 0.19 b

IV: *Yield efficiency in individual years of observation (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05)*

Variety	Year	Yield efficiency ($kg.m^{-3}$)
Elegantní	2007	5.77 ± 0.24 cdefghi
Elegantní	2008	1.53 ± 0.43 a
Elegantní	2009	6.69 ± 0.22 fgijkl
Elegantní	2010	7.07 ± 0.39 gijklm
Elegantní	2011	8.45 ± 0.49 lm
Fruchtal	2007	7.92 ± 0.20 jklm
Fruchtal	2008	5.30 ± 0.30 cdefg
Fruchtal	2009	5.56 ± 0.5 cdefgh
Fruchtal	2010	7.23 ± 0.32 gijklm
Fruchtal	2011	8.96 ± 0.18 m
Jaltský	2007	5.32 ± 0.22 cdefg
Jaltský	2008	2.24 ± 0.18 ab
Jaltský	2009	5.27 ± 0.54 cdefg
Jaltský	2010	3.80 ± 0.30 bcd
Jaltský	2011	8.72 ± 0.30 lm
Jolico	2007	5.35 ± 0.23 cdefg
Jolico	2008	4.70 ± 0.56 cdef
Jolico	2009	4.20 ± 0.26 bcde
Jolico	2010	4.91 ± 0.21 cdef
Jolico	2011	8.05 ± 0.76 klm
Lukjanovský	2007	4.05 ± 0.26 bcde
Lukjanovský	2008	4.01 ± 0.25 bcde
Lukjanovský	2009	3.66 ± 0.28 abc
Lukjanovský	2010	4.49 ± 0.20 cde
Lukjanovský	2011	7.70 ± 0.25 ijklm
Vydubecký	2007	4.09 ± 0.27 bcde
Vydubecký	2008	4.60 ± 0.21 cdef
Vydubecký	2009	5.25 ± 0.35 cdefg
Vydubecký	2010	4.26 ± 0.21 bcde
Vydubecký	2011	6.05 ± 0.41 efghijk
Vyšegorodský	2007	7.27 ± 0.94 gijklm
Vyšegorodský	2008	5.81 ± 0.61 defghij
Vyšegorodský	2009	7.66 ± 0.34 hijklm
Vyšegorodský	2010	3.83 ± 0.37 bcd
Vyšegorodský	2011	7.30 ± 0.26 gijklm

fertility between the most fertile and the least fertile variety was 2.70 $kg.m^{-3}$, i.e. 32 % of the highest efficient fertility (Tab. II.).

If we summarise the total **yield efficiency** of all varieties and express it in the **individual years of monitoring** (Tab. III), it is evident that the efficient fertility is most frequently the highest of varieties in the first year after planting; in the following year, apparently due to high fertility and low growth activity in the preceding year, the efficient fertility markedly drops and again gradually begins to grow in the following years. The **plant volume in the individual years** increases year by year.

Detailed expression of the yield efficiency of the varieties in the individual years is given in Table IV and Graphs 1 to 3. It shows a drop in productiveness in the year following planting (2008), for example in varieties Elegantní and Jaltský. Yield efficiency of variety Lukjanovský did not drop markedly until 2009. Since all varieties were grown in the same conditions and in the same locality we may see variability among varieties which is typical for this fruit species (Brindza *et al*., 2007; Kim *et al*.,2003).

The contents of important elements – P, K, Ca, Mg, Na, Zn, Fe, Cu and Mn – were assessed in the fruit of the varieties. Significant differences among the varieties were discovered only in the contents of K, Mg, Na and Fe (Tab. Va. and Tab. Vb.).

The content of **P** ranged between 313 and 412 $mg.kg^{-1}$; no significant differences in the P content were found among the varieties (Tab. VI). The content of **K** in the fruit was the lowest in variety Vydubecký (3 411 $mg.kg^{-1}$) and the highest in variety Fruchtal (3 798 $mg.kg^{-1}$). The difference in the K content between these varieties was statistically significant (Tab. VIIa.) The **Ca** contents ranged between 301 and 656 $mg.kg^{-1}$; no significant differences in the Ca content among the varieties were detected (Tab. VI).

The **Mg** content was lower in varieties Elegantní (241 $mg.kg^{-1}$) and Fruchtal (237 $mg.kg^{-1}$) and higher in varieties Jaltský (281 $mg.kg^{-1}$), Jolico (288 $mg.kg^{-1}$), Lukjanovský (292 $mg.kg^{-1}$) and Vyšegorodský (290 $mg.kg^{-1}$). The Mg content in these 2 groups of varieties significantly differed (Tab. VIIa).

The content of **Na** in the fruit was the lowest in variety Fruchtal (58 $mg.kg^{-1}$). The Na content was significantly higher in varieties Vydubecký (81 $mg.kg^{-1}$) and Jaltský (82 $mg.kg^{-1}$) (Tab. VIIb). The contents of **Zn** ranged between 2.65 and 3.52 $mg.kg^{-1}$; no statistically significant differences among the varieties were detected in the content of Zn (Tab. VI). The content of **Fe** in the fruit was the lowest in variety Fruchtal (41 $mg.kg^{-1}$). The Fe content was

Va: *Results of the analysis of variance for the content of selected elements in fruits (mg.kg^{-1})*

		P		K		Ca		Mg		Na	
	df	MS	p	MS	p	MS	p	MS	p	MS	p
Variety	6	1 236	0.095	36 171	0.046	7 838	0.440	1 104	0.001	130.30	0.039
Error	7	426		9 002		7 051		71		30.48	

Vb: *Results of the analysis of variance for the content of selected elements in fruits (mg.kg^{-1})*

		Zn		Fe		Cu		Mn	
	df	MS	p	MS	p	MS	p	MS	p
Variety	6	0.048	0.388	17.48	0.021	0.039	0.585	3.318	0.342
Error	7	0.039		3.21		0.047		2.418	

VI: *Content of selected elements in fruits in mg.kg^{-1} (mean, standard error of the mean, maximum and minimum value)*

Element	x		s_e	Min	Max
P	371.27	±	6.70	312.87	411.57
Ca	594.12		15.24	301.18	655.72
Na	74.55	±	2.17	54.61	93.05
Zn	3.05	±	0.06	2.65	3.52
Cu	1.32	±	0.06	1.09	1.74
Mn	26.60	±	0.45	24.12	29.38

VIIa: *The content of selected elements in fruits in mg.kg^{-1} (mean, standard error of the mean, different letters indicate significant differences among the varieties, p = 0.05)*

Variety	K	Mg
Elegantní	3 547.86 ± 112.21 ab	241.02 ± 9.25 a
Fruchtal	3 798.15 ± 338.63 b	236.87 ± 2.57 a
Jaltský	3 708.12 ± 114.59 ab	280.83 ± 5.99 b
Jolico	3 666.99 ± 78.85 ab	287.66 ± 6.97 b
Lukjanovský	3 585.64 ± 27.69 ab	292.03 ± 1.69 b
Vydubecký	3 411.44 ± 77.63 a	261.60 ± 6.02 ab
Vyšegorodský	3 760.20 ± 79.15 ab	289.73 ± 3.61 b

VIIb: *The content of selected elements in fruits in mg.kg^{-1} (mean, standard error of the mean, different letters indicate significant differences among the varieties, p = 0.05)*

Variety	Na	Fe
Elegantní	73.63 ± 3.56 ab	47.01 ± 0.21 ab
Fruchtal	58.05 ± 1.79 a	41.24 ± 1.22 a
Jaltský	82.34 ± 4.09 b	43.12 ± 3.03 ab
Jolico	75.68 ± 4.15 ab	43.85 ± 0.23 ab
Lukjanovský	72.89 ± 1.39 ab	48.68 ± 0.49 b
Vydubecký	81.89 ± 4.02 b	41.98 ± 0.39 ab
Vyšegorodský	74.98 ± 1.14 ab	47.65 ± 0.31 ab

significantly higher in variety Lukjanovský (49 mg.kg^{-1}) (Tab. VIIb). The contents of **Cu** ranged between 1.09 and 1.74 mg.kg^{-1}; no statistically significant differences among the varieties were detected in the Cu contents (Tab. VI). The contents of **Mn** ranged between 24 and 29 mg.kg^{-1}; no statistically significant differences among the varieties were detected in the Mn contents (Tab. VI).

We assessed the dry matter content, degree of refraction, content of acids, vitamin C and pectin in the fruit. The contents of dry matter, acids and pectin differed significantly among the varieties (Tab. VIII).

As against the varieties Jaltský and Vydubecký the content of **solids** was significantly higher in the variety Jolico (Tab. X). The average value of **refraction of solids** was 15 ° Bx. No significant difference was detected among the varieties. The vitamin content is considered an important indicator of the nutritional value. The average content of **vitamin C** was 0.61 g.kg^{-1}, i.e. 61 mg.100g^{-1} of the weight of fresh fruit. There were no significant differences among the varieties (Tab. IX). Güleryüz *et al.* (1996) reported that the fruit of Cornelian cherry contains 43–77 mg.100 g^{-1} of vitamin C. According to Demir and Kalyoncu (2003) the vitamin C content ranged from 55 to 73 mg.100 g^{-1} in 6 genotypes of Cornelian cherry. During a 5-year research

VIII: *The results of the analysis of variance for the content of solids, degree of refraction, acids and pectin*

		Solids (%)		RS (° Bx)		Acids (g.kg^{-1})		Vit. C (g.kg^{-1})		Pectins (g.kg^{-1})	
	df	MS	p	MS	p	MS	p	MS	p	MS	p
Variety	6	1.20	0.017	1.59	0.996	31.75	0.000	0.00	0.991	9.84	0.006
Error	14	0.31		17.42		1.29		0.01		1.96	

IX: *Content of RS and vitamin C in fruits (mean, standard error of the mean, maximum and minimum value)*

	x		s_e	Min	Max
RS (° Bx)	15.19	±	0.78	9.30	18.90
Vit. C (g.kg^{-1})	0.61	±	0.02	0.42	0.77

X: *The content of solids, acids and pectin (mean, standard error of the mean, different letters indicate significant differences among varieties, p = 0.05)*

Variety	Solids (%)	Acids (g.kg^{-1})	Pectin (g.kg^{-1})
Elegantní	16.79 ± 0.31 ab	22.36 ± 1.21 b	14.57 ± 0.53 ab
Fruchtal	17.31 ± 0.17 ab	27.80 ± 0.26 c	11.75 ± 0.38 ab
Jaltský	16.00 ± 0.01 a	19.81 ± 0.42 ab	15.55 ± 0.23 b
Jolico	17.65 ± 0.59 b	22.77 ± 0.90 b	14.71 ± 1.75 b
Lukjanovský	16.69 ± 0.17 ab	17.57 ± 0.62 a	10.70 ± 0.41 a
Vydubecký	16.02 ± 0.40 a	21.07 ± 0.24 b	13.75 ± 0.75 ab
Vyšegorodský	16.32 ± 0.25 ab	19.75 ± 0.26 ab	15.00 ± 0.53 b

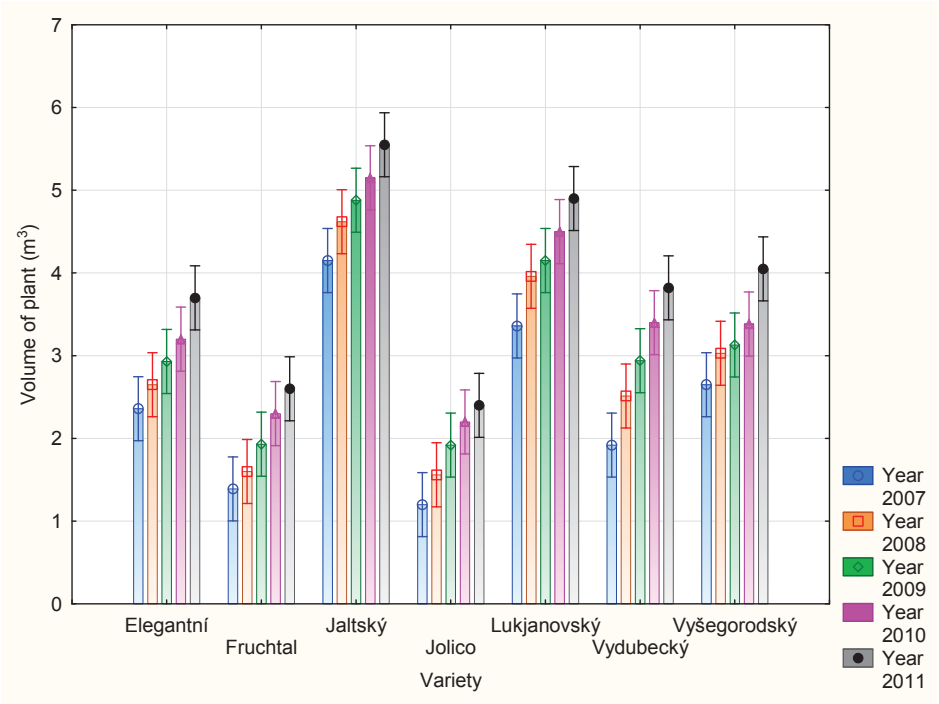
Klimenko (2004) carried out chemical analysis of fruit from freely growing selected genotypes and he reported that the content of ascorbic acid ranged between 71 and 100 mg%. The average content of vitamin C in our experiments corresponds to the literary sources.

The content of **acids** was significantly the highest in variety Fruchtal (2.78 %); a mean content in varieties Elegantní (2.24 %), Jolico (2.28 %) and Vydubecký (2.11 %); the significantly lowest content of acids in variety Lukjanovský (1.76 %) (Tab. X). These data correspond with the data of Karadeniz *et al.*, 2001; Karadeniz, 2002; Yalcinkaya and Eti, 2000; the titratable acidity in Cornelian cherry was also reported between 1.34 and 4.56 %.

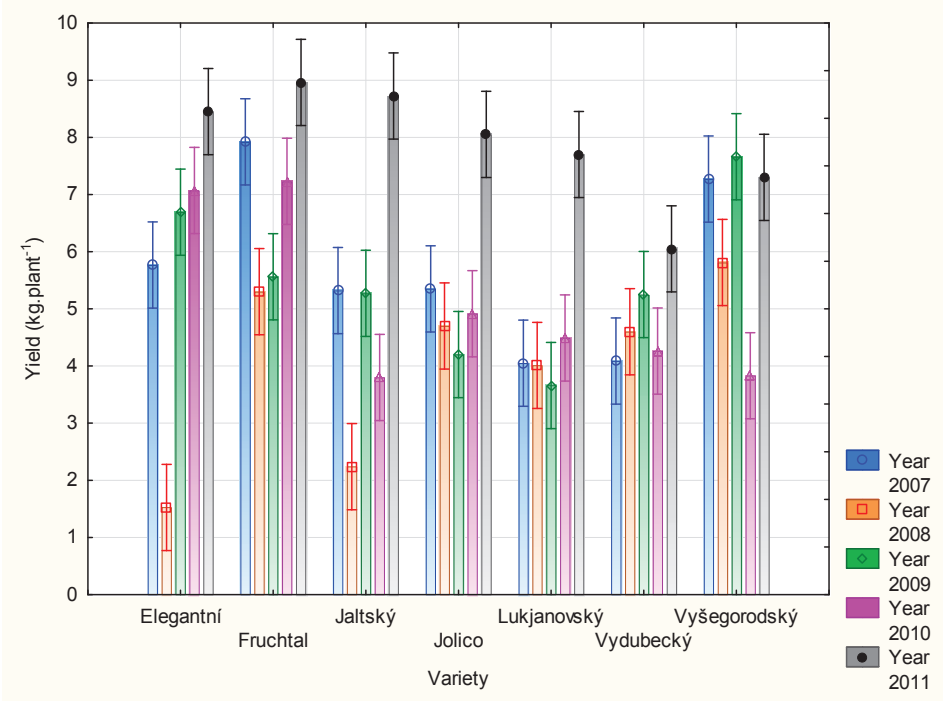
The amount of **pectin** was the highest in varieties Jaltský (15.55 g.kg^{-1}), Jolico (14.71 g.kg^{-1}) and Vyšegorodský (15.00 g.kg^{-1}); the content was significantly lower in variety Lukjanovský (10.70 g.kg^{-1}) (Tab. X).

CONCLUSION

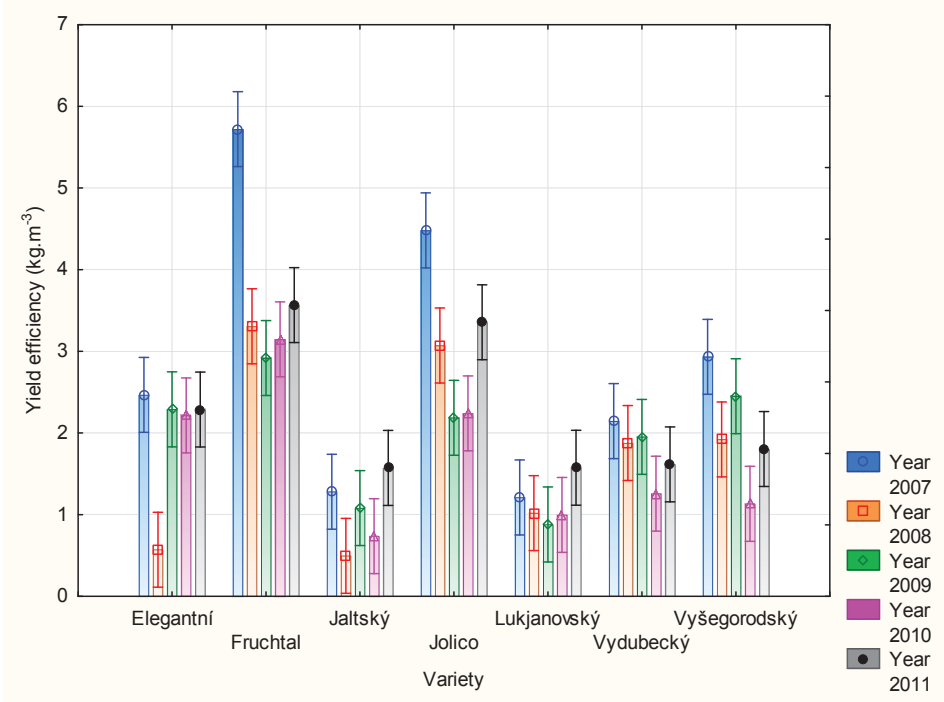
The **plant volume** was the highest in variety Jaltský (4.87 m^3); the plant volume was the lowest in varieties Fruchtal (1.96 m^3) and Jolico (1.86 m^3). **Yields** were the highest in varieties Fruchtal (6.99 kg.plant^{-1}), Vyšegorodský (6.37 kg.plant^{-1}) and Elegantní (5.90 kg.plant^{-1}); the varieties Lukjanovský, Vydubecký and Jaltský gave the lowest yields (4.78 kg.plant^{-1},



1: *Volume of plant in each year of the observations (p = 0.05)*



2: *Yield in each year of the observations (p = 0.05)*



3: *Yield efficiency in each year of the observations (p = 0.05)*

4.85 kg.plant^{-1} and 5.07 kg.plant^{-1}, respectively). In terms of the **yield efficiency** (weight of fruit in kg per m^3 of the plant volume) the fertility of the variety Fruchtal significantly surpassed the other varieties (3.73 kg.m^{-3}), followed by the variety Jolico (3.07 kg.m^{-3}). Converted to plant volume the yields were the lowest in varieties Jaltský (1.03 kg.m^{-3}) and Lukjanovský (1.14 kg.m^{-3}).

The **P** content in the fruit ranged between 313 and 412 mg.kg^{-1}. The **K** content in the fruit was the lowest in variety Vydubecký (3411 mg.kg^{-1}) and the highest in variety Fruchtal (3798 mg.kg^{-1}). The contents of **Ca** ranged between 301 and 656 mg.kg^{-1}.

The content of **Mg** was lower in varieties Elegantní (241 mg.kg^{-1}) and Fruchtal (237 mg.kg^{-1}) and higher in varieties Jaltský (281 mg.kg^{-1}), Jolico (288 mg.kg^{-1}), Lukjanovský (292 mg.kg^{-1}) and Vyšegorodský (290 mg.kg^{-1}). The content of **Na** in the fruit was the lowest in variety Fruchtal (58 mg.kg^{-1}). The content was significantly higher in varieties Vydubecký (81 mg.kg^{-1}) and Jaltský (82 mg.kg^{-1}). The **Zn** contents ranged between 2.65 and 3.52 mg.kg^{-1}. The lowest content of **Fe** in the fruit was detected in variety Fruchtal (41 mg.kg^{-1}). The content of Fe was significantly higher in variety Lukjanovský (49 mg.kg^{-1}). The **Cu** contents ranged between 1.09 and 1.74 mg.kg^{-1}. The contents of **Mn** ranged between 24 and 29 mg.kg^{-1}.

The **solids** content was significantly the highest in variety Jolico (17.65 %), compared to Jaltský (16.00 %) and Vydubecký (16.02 %). The average **degree of refraction** was 15 ° Bx.

The average content of **vitamin C** was 0.61 g per kg of fresh fruit. The content of **acids** was significantly the highest in variety Fruchtal (2.78 %); mean values were seen in varieties Elegantní (2.24 %), Jolico (2.28 %), Vydubecký (2.11 %) and significantly the lowest acid content in variety Lukjanovský (1.76 %). The amount of **pectin** was the highest in varieties Jaltský (15.55 g.kg^{-1}), Jolico (14.71 g.kg^{-1}) and Vyšegorodský (15.00 g.kg^{-1}); the content was significantly lower in variety Lukjanovský (10.70 g.kg^{-1}).

SUMMARY

The evaluation of the growth and yield data and content composition of the fruit including the assessment of mineral elements confirmed the differences among the varieties; we also evaluated the agro-ecological conditions and possibilities of cultivation in practice.

Plantings of seven varieties of Cornelian cherry ('Elegantni', 'Fruchtal', 'Jaltský', 'Jolico', 'Lukjanovský', 'Vydubecký' and 'Vyšegorodský') were evaluated on a regular basis for 5 years. The plantings were arranged in strips and were subject to traditional agronomy practice. We monitored the growth intensity, volume of the plant – shrub and yields. The fruit was sampled at harvest and was processed in the laboratory. Mineral elements were determined (P, K, Ca, Mg, Na, Zn, Fe, Cu, Mn), the composition of the fruit, content of solids, refraction degree, content of acids, vitamin C and pectin.

Differences in plant volumes, yields and efficient yields among the varieties and individual years were significant. The variety Jaltský showed the highest plant volume (4.87 m^3); the varieties Lukjanovský, Elegantní, Vydubecký and Vyšegorodský showed mean values. The plant volume was the smallest in varieties Fruchtal (1.96 m^3) and Jolico (1.86 m^3). In terms of fruit yields a significant difference was discovered between the group of high-yielding varieties Fruchtal (6.99 kg.plant^{-1}), Vyšegorodský (6.37 kg.plant^{-1}) and Elegantní (5.90 kg.plant^{-1}) and the group of low-yielding varieties Lukjanovský (4.78 kg.plant^{-1}), Vydubecký (4.85 kg.plant^{-1}) and Jaltský (5.07 kg.plant^{-1}). The continuously evaluated volume of the plant – shrub increased in the individual years in dependence on the growth properties of the variety, yield efficiency and site conditions.

Laboratory assessments of the contents of mineral elements K, Mg, Na and Fe showed significant differences among the varieties. No significant differences among the varieties in the contents of P, Ca, Zn, Cu and were proved. The **P** content in the fruit ranged between 313 and 412 mg.kg^{-1}. The **K** content in the fruit was the lowest in variety Vydubecký (3411 mg.kg^{-1}); the highest in variety Fruchtal (3798 mg.kg^{-1}). The **Ca** content ranged between 301 and 656 mg.kg^{-1}. The content of **Mg** was lower in varieties Elegantní (241 mg.kg^{-1}) and Fruchtal (237 mg.kg^{-1}) and higher in varieties Jaltský (281 mg.kg^{-1}), Jolico (288 mg.kg^{-1}), Lukjanovský (292 mg.kg^{-1}) and Vyšegorodský (290 mg.kg^{-1}). The content of **Na** was the lowest in variety Fruchtal (58 mg.kg^{-1}); varieties Vydubecký and Jaltský had a significantly higher content (81 mg.kg^{-1} and 82 mg.kg^{-1}, respectively). The content of **Zn** ranged between 2.65 and 3.52 mg.kg^{-1}. The content of **Fe** in the fruit was the lowest in variety Fruchtal (41 mg.kg^{-1}) and was significantly higher in variety Lukjanovský (49 mg.kg^{-1}). The content of **Cu** ranged between 1.09 and 1.74 mg.kg^{-1}. The contents of **Mn** ranged between 24 and 29 mg.kg^{-1}.

The content of **solids** was significantly higher in variety Jolico (17.65 %) than in varieties Jaltský (16.00 %) and Vydubecký (16.02 %). The average **degree of refraction** was 15 ° Bx. The average content of **vitamin C** was 0.61 g per kg of fresh weight of fruit. The content of **acids** was significantly the highest in variety Fruchtal (2.78 %); a mean value was detected in varieties Elegantní (2.24 %), Jolico (2.28 %) and Vydubecký (2.11 %), and the significantly lowest in variety Lukjanovský (1.76 %). The amount of **pectin** was the highest in varieties Jaltský (15.55 g.kg^{-1}), Jolico (14.71 g.kg^{-1}) and Vyšegorodský (15.00 g.kg^{-1}); the content was significantly lower in variety Lukjanovský (10.70 g.kg^{-1}).

The obtained data of the individual evaluated parameters of growth, volume of plant – shrub, harvested fruit and laboratory analyses indicate the suitability of growing this species and that it provides a number of potential uses; it can be grown in various climatic conditions and the harvested fruit can be well utilised.

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