Testing of sweet cherry cultivars on chilling requirements for endodormancy breaking

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Abstract

Temperate fruit species need to accumulate a cultivar-specific amount of a cold period (chill) to complete their life cycle during endodormancy and of a heat during ecodormancy. Without these periods they would not complete their development, flower properly in spring and produce less pollen, which would affect the fruit set and the overall harvest. Thus information on chilling requirement of sweet cherry cultivars is valuable information for growers. Totally 64 cherry cultivars was tested in the air-conditioned growth chamber in period from 2017 till 2023. Three main models (Dynamic Model, Chilling Hours Model and Utah Model) were compared. Results confirmed different chill requirements of evaluated cultivars. The lowest chilling requirement was assessed for cultivars 'Adélka' and 'Koburska rana', that are cultivars evaluated in the low chilling requirement category with chill hours (CH) below 500 calculated according the Chilling Hours Model. Cultivars 'Kasandra', 'Kišiněvskaja' and 'Klecanska' with chilling hour requirement in the range of 500-750 CH are also the only ones in the low-moderate chilling requirement category. 40 genotypes were evaluated In the category moderate-high requirement (750-1000 CH). In the high requirement category with chill hours 1000-1500 were classified 21 cultivars. Any cultivar was assessed for the category very high requirement (over 1500 CH).

Keywords: *Prunus avium* L, cold period, temperate fruits, chill models, sum of temperatures

INTRODUCTION

Fruit trees grown in the temperate climate zone are adapted to the given conditions, which in the Northern Hemisphere are defined approximately by the 40th and 60th Earth's parallel of latitude. Cherry trees (*Prunus avium* L.) enter a period of vegetative rest (endodormancy) as an adaptation to very cold winters to protect their sensitive organs (such as buds and flowers) from frost damage (Darbyshire et al., 2011). After the period of endodormance, it is necessary to expose the trees to higher temperatures in the spring in order for the trees to start sprouting and flowering (exodormance). Successful release from endodormancy needs a minimum cold temperature requirement to be reached. This cold temperature requirement is cultivar specific and referred as the "chilling requirement". With the climate change, that is currently taking place, growers need to know information on chilling requirements. These chilling requirements might not be reached in warmer regions with mild winters. Reaching the cold period (chill hours) is a limiting factor for temperate fruit species. Lack of chill affects phenological development. In the case of insufficient chill, less pollen production, pollen stems, scars deformation and other disorders appear (Crabbé, 1987) resulting in low flower pollination and lower fruit set (Mahmood et al., 2000). Results of evaluation 64 sweet cherry cultivars are presented in this study. Their chilling requirements for endodormancy release is determined.

Data on chilling requirements should always be amended with information on the location and conditions of the study in which they were determined, ideally including site-specific conversion factors between winter chilling models. This would greatly facilitate the

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transfer of such information across growing regions and help prepare growers for the impact of climate change (Luedeling and Brown, 2011).

MATERIAL AND METHODS

Research was focused on experimental cherry plantings at the location Holovousy, district Jičín, Czech Republic). Climatic conditions of Holovousy are characterized by average annual temperature of 8.1°C and average annual rainfall of 655 mm. The soil was medium loam sandy with rather deep cultivated layer on gravel substrate. The sweet cherry orchard was located at the altitude of 310 m a.s.l. Samples of cherry cultivars containing three twigs from two particular trees were collected at weekly intervals from each tested cultivar. Twig sampling of cultivars started in September 1st in each evaluated year. Samples were immersed immediately after collection from trees into glass containers filled by water and placed in the air-conditioned growth chamber. Conditions in this growth chamber was regulated to temperature 25°C, relative humidity 60% and lighting for 16 h day^{-1}. The phenological development of the flower buds was evaluated after 10 days of placement in the growth chamber. Minimum 50% of flower buds development in phenological stage C, BBCH 55 (Erez and Lavee, 1971; Richardson et al., 1974) is considered to meet the chilling requirement. Chilling requirement is usually calculated by three main models: Dynamic Model, Chilling Hours Model and the Utah Model (Luedeling and Brown, 2011; Weinberger, 1950). Values for the three main chill models forming chilling requirement categories (according Australian Cherry Production Guide 2017) are shown in Table 1. Records of temperature (each 15 min) started from September 1st were obtained from automatic meteorological stations MeteoUNI (AMET, Velké Bílovice, Czech Republic) located directly in cherry plantings served for sampling collection. Totally 64 sweet cherries cultivars of *Prunus avium* L. were included in the testing (Table 2).

Table 1. Chill unit categorization for chill portions, chill units and chill hours.

Chill requirement category	Chill portion (CP; Dynamic Model)	Utah chill units (UCU; Utah Model)	Chill hours (CH; Chilling Hours Model; 0-7.2°C)
Low	20-40	600-800	300-500
Low-moderate	40-50	800-1000	500-750
Moderate-high	50-60	1000-1200	750-1000
High	60-80	1200-1400	1000-1500
Very high	>80	>1400	>1500

RESULTS AND DISCUSSION

Grouping of tested sweet cherry cultivars in chilling requirement categories according Chilling Hours Model are shown in Table 3.

The date for dormancy completing is different in each year depending on the temperatures during autumn and early winter. The courses of values for the three main chill models in the years 2010-2018 are shown in Figures 1-3. The sufficient sum to complete the endodormancy of all tested cherry cultivars in conditions of the Czech Republic is usually reached by the end of January. Courses of sums for Dynamic Model, Chilling Hours Model and Utah Model in Figures 1-3 demonstrate differences. Courses of sums of Chill Portions (Dynamic Model) seem to be the most consistent and steady referring chilling requirement in each year from 2010-2018. Courses of sums in Utah Model and Chilling Hours Model seem to be less consistent in particular months in comparison to the courses of Dynamic Model. Differences in the chilling requirements for endodormance release were confirmed among the tested sweet cherries cultivars. Majority of tested cultivars are evaluated in categories Moderate-high and High. At the category Moderate-high chilling requirement in total 40 sweet cherry cultivars were classified. In the category High chilling requirement in total 21 cultivars were assessed. In classification group very high chilling requirement any cultivar was evaluated. The lowest chilling requirement was assessed by cultivars 'Adélka' and

'Koburska rana'. Cultivars 'Kasandra', 'Kišiněvskaja' and 'Klecanska' were assessed in the category low-moderate chilling requirement.

Table 2. List of cultivars evaluated in particular years.

Cultivar	Year of evaluation						Cultivar	Year of evaluation					
	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23		2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Adélka	x	x	x	x	x	x	Müncheberger Frühernte	N	N	N	N	N	x
Amid	x	x	x	x	x	N	Regina	x	x	x	x	x	N
Aranka	x	x	x	x	x	x	Rivan	N	N	N	x	x	N
Belise	N	x	N	x	N	N	Rychlice německá	N	N	N	N	N	x
Bigarreau de la Charmes (syn. Moreau)	N	N	N	N	N	x	Samba	N	x	x	x	x	N
							Sandra	x	x	x	x	x	N
Burlat	x	x	x	x	x	x	Sandra rose	x	N	x	x	x	N
Carmen	N	x	x	x	N	N	Santina	x	N	x	N	x	N
Early Korvik	x	x	x	x	x	N	Senčianská	N	N	N	N	N	x
Debora	x	x	x	x	x	N	Skeena	x	x	x	x	x	N
Elza	x	x	x	x	x	N	Skorospielka	N	N	N	N	N	x
Felicita	x	x	x	x	x	N	Sonata	x	N	x	N	x	N
Grace Star	N	N	x	x	x	N	Staccato	x	x	x	x	x	N
Granat	N	N	x	x	x	N	Stella	N	N	N	N	N	x
Halka	x	x	x	x	x	N	Sue	N	N	N	N	N	x
Helga	x	x	x	x	x	N	Summit	x	x	x	x	x	N
Horka	x	x	x	x	x	N	Swecja	N	N	N	N	N	x
Christiana	N	x	x	x	x	N	Sweet Heart	N	x	x	x	x	N
Irena	N	x	x	x	x	N	Sylvana	x	x	x	x	x	N
Jacinta	x	x	x	x	x	N	Symphony	x	x	x	x	x	N
Justyna	x	x	x	x	x	N	Tamara	x	x	x	x	x	N
Karešova	N	N	N	N	N	x	Tavriščanska	N	N	N	N	N	x
Kasandra	x	x	x	x	x	x	Těchlovan	x	x	x	x	x	N
Kaštánka	N	N	N	N	N	x	Tim	x	x	x	x	x	N
Kišiněvskaja	N	N	N	N	N	x	Troprichterova	N	N	N	N	N	x
Klecanska	N	N	N	N	N	x	Trušenskaja	N	N	N	N	N	x
Knauffs Schwarze	N	N	N	x	x	x	Valeska	N	N	N	N	N	x
Koburska rana	N	N	N	N	N	x	Vanda	x	x	x	x	x	N
Kordia	x	x	x	x	x	x	Vilma	x	x	x	x	x	N
Korvik	N	N	N	N	N	x	Vosenska	N	N	N	N	N	x
Laskovska rana	N	N	N	N	N	x	Ziesbergova (Mamutka)	N	N	N	N	N	x
Lívia	x	x	x	x	x	N	Žalanka	N	N	N	N	N	x
Lyonska rana	N	N	N	N	N	x							

x – evaluated, N – none evaluated.

Table 3. Grouping of tested sweet cherry cultivars in chilling requirement categories according Chilling Hours Model (chill hours, 0-7.2°C).

Chilling requirement category	Cultivar
Low (300 - 500)	Adélka, Koburska rana
Low-moderate (500-750)	Kasandra, Kišiněvskaja, Klecanska
Moderate-high (750-1000)	Aranka, Bigarreau de la Charmes (syn. Moreau), Burlat, Granat, Halka, Helga, Horka, Christiana, Jacinta, Justyna, Karešova, Kaštánka, Knauffs Schwarze, Laskovska rana, Lyonska rana, Lívia, Müncheberger Frühernte, Rivan, Rychlice německá, Sandra, Santina, Senčianska, Skeena, Skorospielka, Sonata, Staccato, Stella, Sue, Summit, Swecja, Těchlovan, Tim, Troprichterova, Trušenskaja, Vanda, Valeska, Vilma, Vosenska, Ziesbergova (syn. Mamutka), Želanka
High (1000-1500)	Amid, Belise, Carmen, Debora, Early Korvik, Elza, Felicita, Granat, Grace Star, Irena, Kordia, Korvik, Regina, Samba, Sandra rose, Sylvana, Symphony, Sweet Heart, Tamara
Very high	None

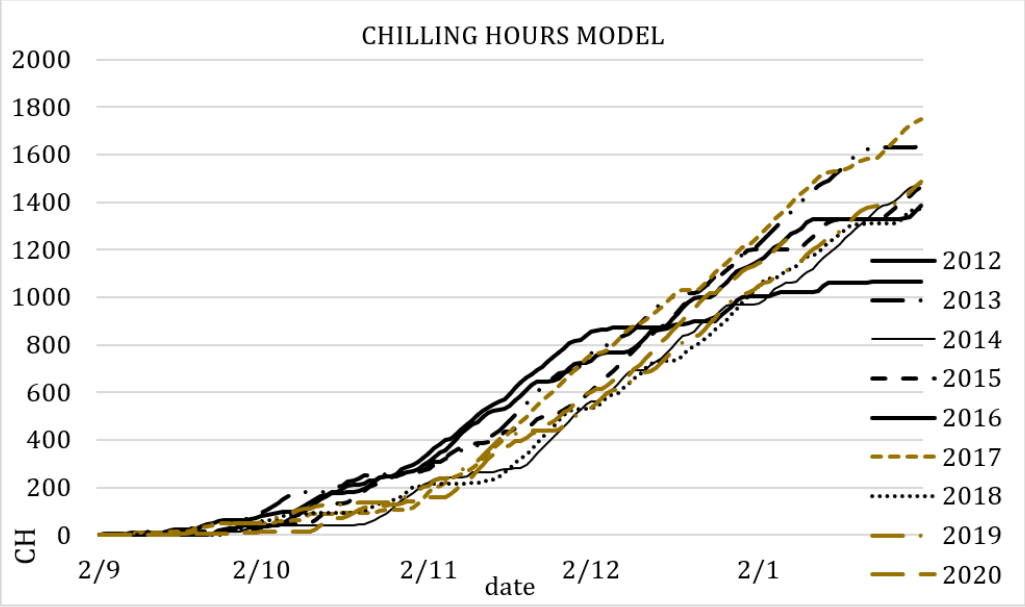

Figure 1. Course of sums of chill hours at location Holovousy in years 2010-2018.

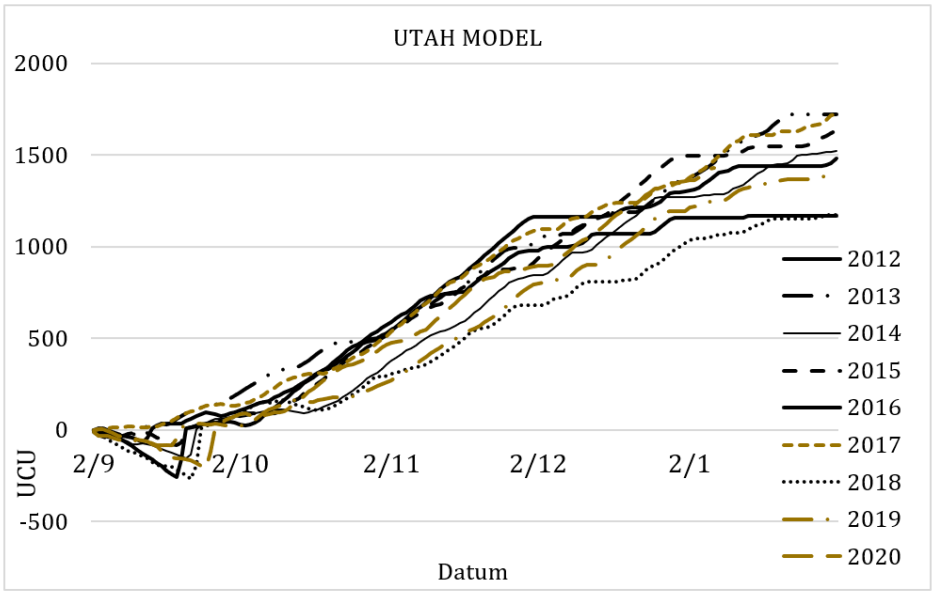

Figure 2. Course of sums of Utah chill units at location Holovousy in years 2010-2018.

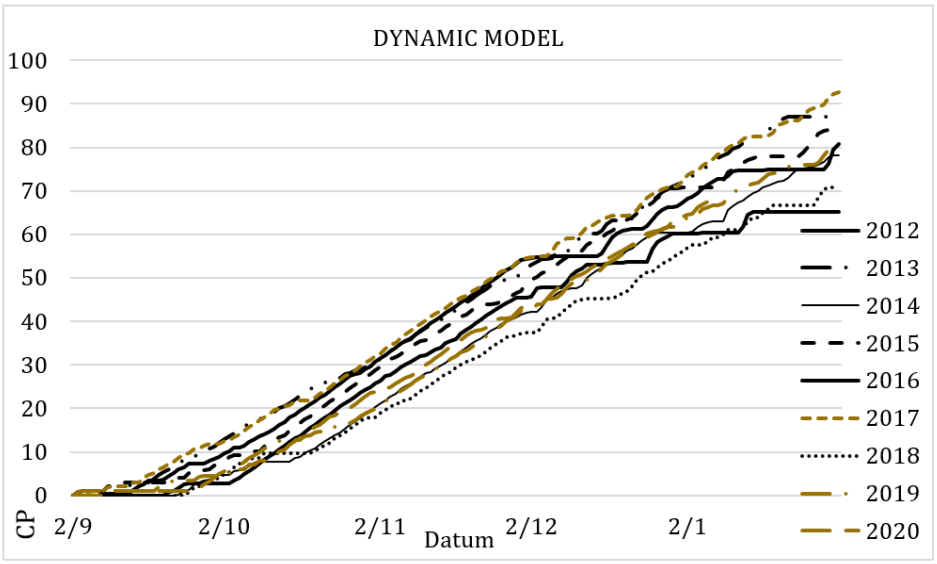

Figure 3. Course of sums of chill portions at location Holovousy in years 2010-2018.

CONCLUSIONS

Endodormancy may not be fulfilled for sweet cherry cultivars with very high, high even with moderate-high chill requirement in climatic conditions of southern Europe with mild course of winters. Regions with low safe winter chill (30-70 CP; 300-700 CH; 700-1 000 UCU) were detected in most subtropical regions (Luedeling and Brown, 2011). Global warming of 2°C is expected to be reached by approximately 2050. This level of warming will negatively affect reliable chill exposure in every growing region with low safe winter chill in the case of worse scenario development. Chilling requirement might be a limiting factor of sweet cherry cultivation in the future. Only 'Adélka' and 'Koburska rana' from all tested cultivars that are evaluated in the category Low can be recommended for cultivation in areas such as southern Spain and southern Portugal. Cultivars with the chilling requirement of less

than 500 CH (in range 0-7.2°C) can be successfully grown in those climatic conditions.

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