THERMAL REQUIREMENTS FOR WHITE GRAPEVINE VARIETIES GROWN IN THE REGION OF SREMSKI KARLOVCI, SERBIA

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ABSTRACT

Thermal requirements to reachbudburst, flowering, veraison and harvest for thirteenwhite grapevine varieties grown in the Sremski Karlovci region were determined using a growing degree-days (GDD) method and base temperature of 10°C. The accumulated GDD for the beginning of budburst ranged from 60 ('Petra') to 79 ('Bagrina'). The thermal requirements for the beginning flowering varied between 334 GDD in 'Chardonnay' to 404 GDD in 'Bagrina'. The smallest accumulated GDD to reach the beginning of veraison was observed in 'Bouvier' (869) and the greatest in'Riesling Italian' (1106). The GDD for harvest spanned the range from 1530 in 'Muscat Ottonel' to 1717 in 'Riesling Italian'. Greater variation in GDD was displayed between years for a single variety *than among varieties within individual years. Considering phenological stages, the greatest year-to-year variability was found for the beginning of budburst and the least for harvest.*

INTRODUCTION

Climate, in particular temperature, is the key factor for grapevine(*Vitisvinifera*L.) yield and quality (van Leeuwen et al.,2004) and its geographical distribution (Jones, 2006).Traditionally, grapevines are cultivated in areas where mean growing season temperatures is within the 12–22 °C range(Jones, 2006). Prolonged temperatures above 10°C initiate vegetative growth in the spring (Mullins et al.,1992). Temperature determines the beginning and duration of the phenologicalphases. Grapevine is a phenologically distinct crop with the main stages being bud break, flowering, veraison and harvest (Jones and Davis 2000). Every grapevine variety has its own climatic requirement for well-balanced ripeningand high quality wine production. The varietal thermal requirementsare most often expressed in growing degree-days (GDD) for a base temperature of 10°C (Winkler et al., 1974). This study is aimed to determine thermal requirements to reach major phenological stages for thirteenwhite varieties grown in the region of SremskiKarlovci,one of the oldest wine-producing European regions,where grapevine cultivation goes back to Roman times.Information on thermal requirements for different varieties are very important for selecting varieties that may reach maturity under conditions favorable for *terroir* expression, particularly having in mind the present (Ruml et al., 2016a) and future climatic change (Ruml et al., 2012) in this region.

MATERIALS AND METHODS

Phenological and temperature data for the period 1986–2007 were used in the study.Phenological monitoring was performed at the Novi Sad Faculty of Agriculture experimental station. The station is situated on the Mt. Fruška Gora's slopes by the Danube River in Sremski Karlovci (45°10' N, 20°10' E, 110 m a.s.l.), little town in the northern Serbia. Danube moderates temperature extremes, while the inclined slopes ensure maximum light and heat exposure. The climate of the region is temperate continental.Mean annual air temperature is 12.3 °C and mean annual precipitation 650 mm. The soil at the site is pararedzina on loess. The ampelographic collection was

established in 1979. Each variety was represented by 20 vines planted with a spacing of 3 x 1 m and trained using the single Guyot system.

Thirteen white wine varieties, both Serbian and internationally recognized ones, were selected from the ampelographic collection for this study. Following phenological events of grapevine were examined: the beginning of budburst – the date when green shoot tips became just visible, stage 7 on the BBCH scale (Lorenz et al.1995); the beginning of flowering – the date when first flower hoods were detached from the receptacle (stage 60 on the BBCH scale); the beginning of veraison – the date when berries begin to develop variety-specific colour (stage 81 on the BBCH scale); and harvest (stage 89 on the BBCH scale). Harvest cannot be considered a true phenological stage, because it is mostly subjective and depends upon winery requests, weather conditions, disease occurrence, etc.

Temperature data were obtained from the Republic Hydrometeorological Service of Serbia, which performed technical and critical controls of the measurements. Daily maximum (T_x) and minimum (T_n) air temperature were observed at a meteorological station near the ampelographic collection.

Daily GDD was calculated as a difference between daily mean air temperatures ($T_d = (T_n+T_x)/2$) and base temperature ($T_b = 10°C$). If daily GDD was negative, it was set equal to zero. Total GDD was obtained by summing up daily values:

$$GDD_i = \sum_{k=1}^{n_i} \max[0, (T_d^k - T_b)] \quad (1)$$

where GDD_i is GDD for i*th* year, and n_i the number of days from 1 January to the beginning of phenological event in the i*th* year.

RESULTS AND DISCUSSION

Average GDD over the period for studied phenological events are shown in Figure 1, while relevant descriptive statistics are displayed in Table 1.

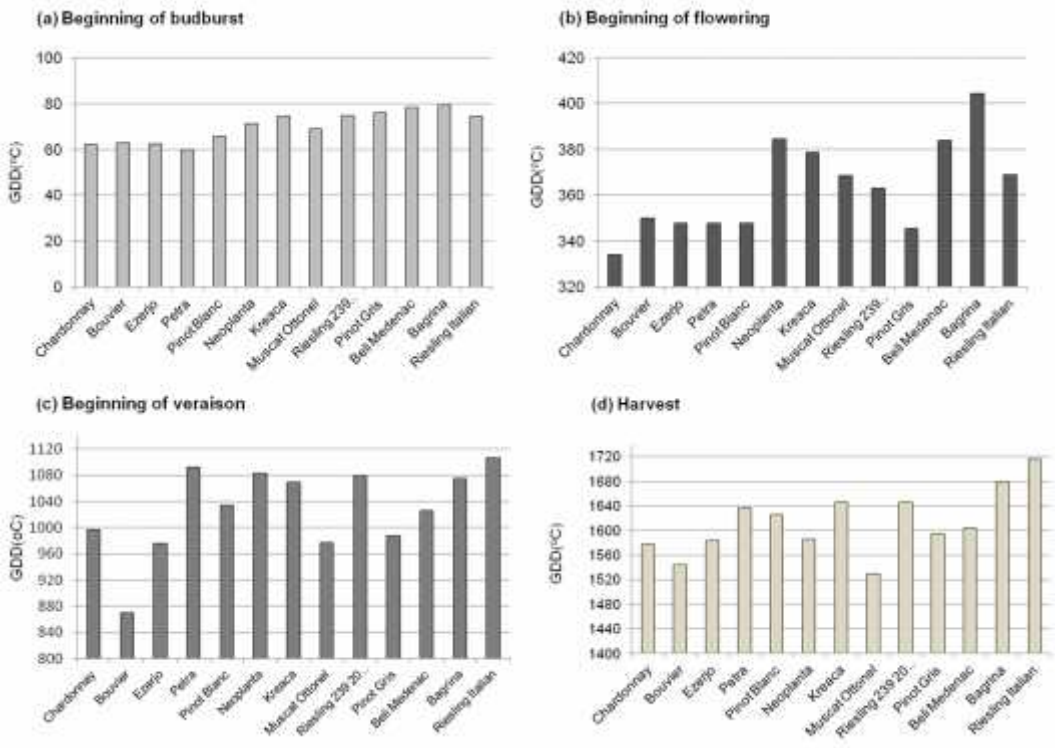

Figure 1. Thermal requirements for the main phenological stages of grapevine in the region of Sremski Karlovci (1986–2007)

The least thermal requirements for the beginning of budburst was observed in ‘Petra’ (60 GDD) and the greatest in ’Bagrina’(79 GDD). ’Pinot Blanc’ displayed the least inter-annual variation, while the smallest range in GDDswas exhibited for‘Bouvier’. ‘Muscat Ottonel’shown the highest inter-annual variation and the greatest range in GDDs for the beginning of budburst.

The variety with the smallest average temperature sum for the beginning of flowering was ‘Chardonnay’ (334 GDD), while the variety with the greatest average temperature sum was ‘Bouvier’(404 GDD). In contrast to the beginning of budburst, ‘Muscat Ottonel’ exhibited the lowest year-to-year variability and the least range in GDDs for the beginning of flowering. ‘Riesling Italian’ was the variety with the highest inter-annual variability and the greatest GDD range.

The thermal accumulation for the beginning veraison ranged from 869 GDD in ‘Bouvier’to 1106 GDD in‘Riesling Italian’. ‘Chardonnay’had the lowest year-to-year variationand the smallest range, while ’Kreaca’ had the highest year-to-year variation and the greatest range in GDDs for the beginning of veraison.

The smallest thermal requirements for harvest was observed in ‘Muscat Ottonel’(1530 GDD) and the greatest in ‘Riesling Italian’(1717 GDD). ‘Chardonnay’ exhibited the lowest inter-annual variation and the smallest rangein GDDs.‘Neoplanta’and ‘Beli medenac’ had the highest inter-annual variation, while‘Petra’ had the greatest range in GDDs for harvest.

Similar analysis of thermal requirementswas done for eight red grapevine varieties grown in the same region over the same period (Ruml et al., 2016b). Obtained results from these two sutudies were very similar considering average thermal requirements of examined varieties as well as inter-annual variaton in GDDs.

Table 1

Descriptive statistics of thermal requirements for white varieties in the region of Sremski Karlovci (1986–2007)

Phenological stage	GDD	Chardonnay	Bouvier	Ezerjo	Petra	Pinot Blanc	Neoplanta	Kreaca	Muscat Ottonel	Riesling 239 20 Gm	Pinot Gris	Beli Medenac	Bagrina	Riesling Italian	Average
Beginning of budburst	Mean (ºC)	62	63	63	60	66	71	74	69	75	76	78	79	75	75
	Range (ºC)	76	70	90	72	76	91	87	97	83	86	94	87	86	89
	CV[1] (%)	26.7	26.5	29.4	29.2	25.1	28.9	25.3	30.7	26.2	27.1	28.6	27.1	29.2	27.9
Beginning of flowering	Mean (ºC)	334	350	348	348	348	384	378	368	363	345	384	404	369	375
	Range (ºC)	155	124	126	126	132	111	145	104	132	120	149	121	179	133
	CV (%)	10.0	9.0	9.7	9.7	9.2	8.5	9.7	8.1	10.0	9.9	9.8	8.5	10.3	8.9
Beginning of veraison	Mean (ºC)	997	869	976	1092	1034	1084	1070	978	1080	988	1026	1075	1106	1051
	Range (ºC)	187	255	340	249	245	278	366	220	278	193	262	311	235	243
	CV (%)	4.9	8.3	7.9	6.6	6.4	6.0	8.2	5.8	6.2	5.9	5.9	6.9	6.2	5.3
Harvest	Mean (ºC)	1577	1544	1583	1637	1626	1586	1647	1530	1646	1594	1604	1680	1717	1625
	Range (ºC)	330	511	448	533	417	500	386	398	420	404	531	425	425	412
	CV (%)	5.2	7.8	7.5	6.9	6.2	8.2	6.2	5.8	6.2	6.3	8.2	6.7	7.8	6.2

[1]CV: Coefficient of variation

Obtained temperature sums to reach maturity for‘Chardonnay’in our study were higher (1577 GDD) than those (1267 GDD) reported by van Leeuwen et al. (2008) in their study based on the data obtained mainly from French vineyards. Conversely, the same variety exhibited somewhat lower heat requirements for veraison in our study than in the study of van Leeuwen et al. (2008)– 997 vs. 1068 GDD .Thermal requirements to reach maturity were also higher for red varieties ’Gamay’, ’Pinot Noir’, ’Merlot’ and ’Cabernet

Sauvignon' in the region of SremskiKarlovci(Ruml et al., 2016b) than those reported by van Leeuwen et al. (2008).

Temperature sums for the beginning of budburstshowed the greatest inter-annul variation in terms of coefficient of variation (CV) for both white (Table 1) and red (Ruml et al., 2016b) varieties. Among examined phenological stages,the least inter-annul GDD variation was exhibited for varaison for white varieties (Table 1) and for harvest for red varieties (Ruml et al., 2016b).

Absolute difference in the average temperature sums among white varieties was the smallest for thebeginning budburst (19 GGD) and the greatest for the beginning of verasion (237 GGD). The same results were gotten for red varieties with absolute difference of 23 GGD for the beginningbudburst and 180 GGD for the beginning of verasion.

A variation in GDD among white grapewine varieties within individual years was also investigated and results are summarized in Table 2. In terms of CV, the greatest variation in GDD among varieties was for the beginning of budburst and the smallest for harvest. The phenological event with the greatest GDD range between varieties within individual years was harvest. The same results were obtained for red grapewine varieties (Ruml et al., 2016b), except for the greatest GDD range between varieties. For the red varieties, the phenological event with the greatest GDD range was veraison.

Table 2

Descriptive statistics of GDD variation among white grapevine varieties within individual years in the region of Sremski Karlovci (1986–2007)

Phenological stage	Range (°C)			CV[1] (%)		
	Mean	Max	Min	Mean	Max	Min
Beginning of budburst	20	48	6	9.8	22.6	2.4
Beginning of flowering	67	148	20	6.1	13.6	2.0
Beginning of veraison	173	248	59	5.8	8.4	2.3
Harvest	195	364	51	4.2	7.7	1.5

[1]CV: Coefficient of variation

A greater variation in GDD was found between years for a single variety (Table 1) than between varieties within individual years (Table 2) for all phenological stages, except for the beginning of veraison when the CV is considered. The same results were obtained for red grapevine varieties (Ruml et al., 2016b). This findingimplies that climatic factors generally had a stronger impact on thermal accumulations than genetic characteristics of varieties. Nevertheless, in some climatologically extreme years, the difference in accumulated GDD between varieties was quite large or small (Table 2), pointing to the fact that a wide diversity exists among grapevine varieties in response to critical meteorological variables, whichmay offer adaptation options to climate change.

CONCLUSIONS

An analysis of thermal requirements for thirteenwhite grapevine varieties grown in the region of Sremski Karlovci based on long-term data are presented in the paper. The study results may find use in the varieties selection, vineyard management,crop modeling as well as for assessing the adaptation potential to changing climate in the studied region, but also in other vine growing areas with similar climatic conditions but with no long-term phenological data available**.**

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