PHENOLOGICAL MODELS FOR PREDICTING THE BUDBURST AND FLOWERING DATE OF GRAPEVINE

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Introduction

Many viticultural activities require information on the onset of grapevine phenological events. Prediction of buds and foliage appearance can provide dates for well-timed fertilization, pruning, irrigation, crop protection, leading to more stable grape yield and quality, but also decreasing production expenses and mitigating environmental impacts.

This study aimed to develop simple, easy to use phenological models at the species level for prediction of grapevine budburst and flowering. Models are based on results from our earlier study (Ruml et al., 2016), where key temperature variables and sub-periods during grapevine development were determined for a range of cultivars from the Serbian wine region of Sremski Karlovci, one of the oldest European grapevine growing areas.

Materials and methods

Phenological data were collected at the experimental station of the Novi Sad Faculty of Agriculture situated in Sremski Karlovci (45°10' N, 20°10' E, 110 m a.s.l.). The climate of the region is mid-latitude moderate continental with an average annual air temperature of 12.3°C and an average annual rainfall of 650 mm. The soil at the site is classified as pararedzina on loess.

For the study, a group of 20 wine grape cultivars (Tab. 1) was selected from the ampelographic collection established in 1979. Cultivars were represented by 20 vines, planted with a spacing of 3 x 1 m, and grown with a Simple Guyot system. Two phenological stages of grapevine were examined over the period 1986–2011: the beginning of budburst – the date when green shoot tips became just visible, identified as stage 7 on the BBCH scale (Lorenz et al., 1995) and the beginning of flowering – the date when first flower hoods were detached from the receptacle (stage 60 on the BBCH scale). The temperature was measured at 2 m height in the experimental vineyard.

The linear regression functions between the onset dates of phenological stages and temperature variables for selected periods were used to develop prediction models. The key temperature variable that most influenced the onset of budburst was the mean daily temperature averaged over the period from 1 March to the event onset (r=–0.86, P<0.001). For the beginning of flowering, the key variable was the maximum daily temperature averaged over the period from 15 April to the event onset (r=–0.92, P<0.001).

Since the onset of the phenological stage differs considerably among cultivars (Tab. 1), the same regression equation could not be used for all grapevine cultivars. Instead of determining the best-fitting equations for each cultivar, the general model equations, obtained using phenological data averaged over all cultivars, were adjusted for each cultivar by adding a correction factor. The correction factor (Tab. 1) was determined as a difference between the mean date of the phenological event for a given cultivar and the average value for all cultivars.

The mean absolute error (MAE) is used to estimate the accuracy of the models:

$$MAE = \frac{\sum_{i=1}^{N} \left| n_i^p - n_i^o \right|}{N}$$

where n_i^p and n_i^o are the predicted and observed number of days within the development period in the ith year and N is the number of years.

Table 1. *. Mean, the earliest and the latest dates of budburst and flowering, and corresponding correction factors (CF, differences between the mean date of phenological stage onset and the average value for all cultivars) for the 1986–2007 period.*

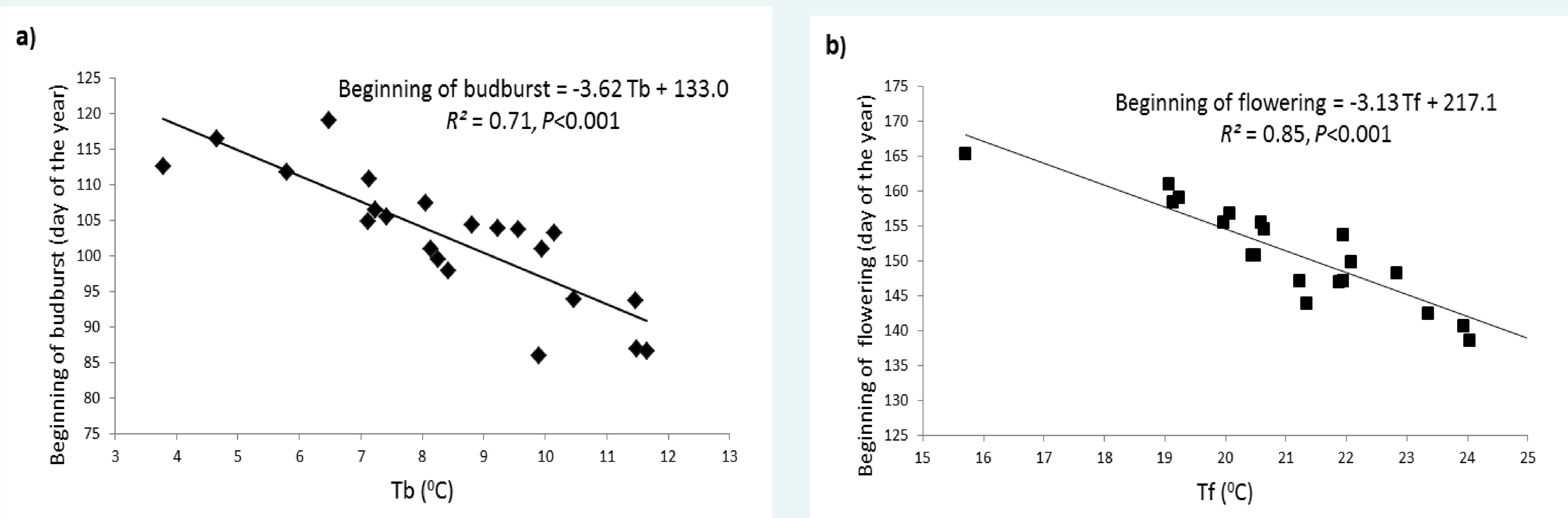
Cultivar	**Budburst**				**Flowering**			
	Mean	Min	Max	CF	Mean	Min	Max	CF
Pinot Noir	9 Apr	20 Mar	29 Apr	-1	28 May	15 May	13 June	-2
Cabernet Sauvignon	18 Apr	6 Apr	1 May	7	31 May	17 May	16 June	1
Gamay	8 Apr	21 Mar	28 Apr	-3	27 May	15 May	13 June	-2
Merlot	14 Apr	3 Apr	29 Apr	3	29 May	16 May	16 June	0
Probus	16 Apr	26 Mar	30 Apr	5	2 June	19 May	16 June	4
Limberger	8 Apr	20 Mar	27 Apr	-2	28 May	15 May	13 June	-1
Prokupac	10 Apr	19 Mar	30 Apr	-1	31 May	18 May	15 June	1
Chardonnay	7 Apr	15 Mar	26 Apr	-4	26 May	15 May	12 June	-3
Bouvier	7 Apr	20 Mar	27 Apr	-4	28 May	15 May	12 June	-2
Ezerjo	8 Apr	21 Mar	26 Apr	-3	28 May	16 May	13 June	-2
Petra	7 Apr	18 Mar	27 Apr	-4	28 May	16 May	13 June	-2
Pinot Blanc	9 Apr	18 Mar	26 Apr	-2	27 May	15 May	15 June	-2
Neoplanta	11 Apr	23 Mar	27 Apr	0	31 May	17 May	17 June	2
Kreaca	11 Apr	26 Mar	30 Apr	1	31 May	17 May	16 June	2
Muscat Ottonel	11 Apr	27 Mar	26 Apr	0	30 May	17 May	16 June	1
Riesling 239 20 Gm	12 Apr	21 Mar	29 Apr	1	29 May	17 May	14 June	0
Pinot Gris	12 Apr	27 Mar	30 Apr	1	27 May	16 May	12 June	-2
Beli Medenac	13 Apr	22 Mar	1 May	2	31 May	16 May	16 June	2
Bagrina	13 Apr	1 Apr	30 Apr	3	26 May	18 May	20 June	4
Riesling Italico	13 Apr	27 Mar	29 Apr	2	30 May	18 May	11 June	1
Average cultivar	10 Apr	24 Mar	28 Apr		29 May	16 May	14 June	

Results and discussion

The study results suggest that the relationship between temperature and the budburst and flowering time is approximately linear. The variation of the temperature explained 71% of the variation in budburst dates and 85% of the variation in flowering dates.

The MAE for average cultivar was 4 days for budburst, and 3 days for flowering. The MAE among cultivars varies from 3 (Riesling Italian) up to 6 days (Petra) for budburst, and from 2 (Pinot Noir, Gamay, Muscat Ottonel) up to 4 days (Chardonnay) for flowering. Considering great year-to-year variability of budburst and flowering dates, models successfully characterize the timing of these phenological events in the grapevine. Whether that considerably departs from average climate conditions lessens the prediction accuracy of models. Between individual years, the observed and predicted dates for average cultivar differed between 0 and 11 days for budburst, and between 0 and 6 days for flowering.

Figure 1. *Regression equations for: a) budburst of grapevine based on the mean daily temperature averaged over the period from 1 March to the event onset (Tb); b) flowering of grapevine based on the maximum daily temperature averaged over the period from 15 April to the event onset (Tf)*



Conclusion

The study results demonstrated that the proposed temperature-based phenological models are successful in predicting the timing of budburst and flowering for the grapevine at both the species and varietal level. The models are simple for users, can be utilized for a range of grapevine cultivars and also, they can be used to assess climate change impact on grape and wine production in the studied area.

Literature Cited

Ruml, M., Korać, N., Vujadinović, M., Vuković, A. & Ivanišević, D. (2016). Response of grapevine phenology to recent temperature change and variability in the wine-producing area of Sremski Karlovci, Serbia. *The Journal of Agricultural Science,* 154, 186–206.