Phenological stages of some grapevine cultivars in North Serbia: Historical data and current state

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Abstract. Phenological stages of many grapevine cultivars appear in earlier parts of the year. However, we do not know how different cultivars are affected by this trend. The aim of this study was to compare the phenological stages of grapevine cultivars recorded in two different periods (1986–1998 and 2013–2018) in North Serbia (Vojvodina). The investigation was carried out on five red (Cabernet sauvignon, Merlot, Pinot noir, Prokupac, Probus) and five white cultivars (Chardonnay, Muscat ottonel, Riesling italico, Smederevka and Petra). The phenological observations included the beginning of budburst, flowering and veraison. The beginning of all phenological stages in all cultivars in the period (2013–2018) occurred in earlier parts of the year, compared to the historical data. Local cultivars (Prokupac, Probus, Smederevka and Petra) showed less shift of the beginning of budburst in respect to the historical data (only six days earlier) compared to the international cultivars. One of the most important phenological stages, flowering, has been shifted ten days in the earlier part of the year. The biggest differences were observed for the beginning of veraison. Now, it occurs earlier from 9 (Petra) to 17 days (Merlot). Duration of the period from budburst to flowering was inconsistent and cultivars required almost the same number of days as it was in the past. However, the duration between flowering and veraison was shorter in the last six years. The biggest difference was observed in Merlot where the period between flowering and veraison has been seven days shortened.

1. Introduction

Phenological studies based on the long-term data set are important in determining the vine cultivars suitability for a given climate regime. Through studying grapevine phenology, the effect of climate change on grapevine has been evaluated over recent decades in many regions [1–4].

In most of the wine regions worldwide, it is a challenge to produce high quality wine. Among many environmental factors, climate has the greatest impact on phenology and therefore on grape quality. The optimum development of quality fruit for wine production is tied to phenological occurrence and timing [5,6]. Wine-producing regions are characterized by mean climatic conditions which are major drivers of wine quality in relation to its origin [7]. Climate characteristics of North Serbia (Vojvodina) and its wine regions are presented in papers [8,9].

However, in a given wine region these conditions vary from year to year. Climatologists forecast an increase in air temperature by the end of the XXIst century, depending on the rate of greenhouse gas emissions [10]. Serbia, which is in the south-east part of Europe at Balkan Peninsula, is experiencing warming trend with accelerated temperature increase [11].

Currently, 190 varieties are present in the Serbian national vine register. However, only 10 varieties, mostly "international", represent 70% of the total surface area (22150 ha) [12]. The areas planted with "local" varieties are on the increase.

Phenology of some grapevine cultivars in Serbia has been previously analyzed [13], but cultivar respond to climate conditions was not disscused. Growing cultivars less sensitive to climatic variables offer an adaptation option to climate change.

The aim of this study was to compare the phenological stages of some grapevine cultivars recorded in two different periods (1986–1998 and 2013–2018) in North Serbia (Vojvodina).

2. Material and methods

The phenological observations were made over a six-year period at the Experimental filed of the University of Novi Sad, Faculty of Agriculture, situated in Sremski Karlovci – Fruska Gora wine region (45°10′ N, 20°10′ E).

The investigation was carried out on five red (Cabernet sauvignon, Merlot, Pinot noir, Prokupac, Probus) and five white cultivars (Chardonnay, Muscat ottonel, Riesling italico, Smederevka and Petra). Prokupac, Probus, Smederevka and Petra are Serbian cultivars.

The collection was initially planted in 1979, and during 2007 the collection was completely replanted in a block next to the original vineyard (same soils), and

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Figure 1. The map of Serbia and its wine region Fruska Gora.

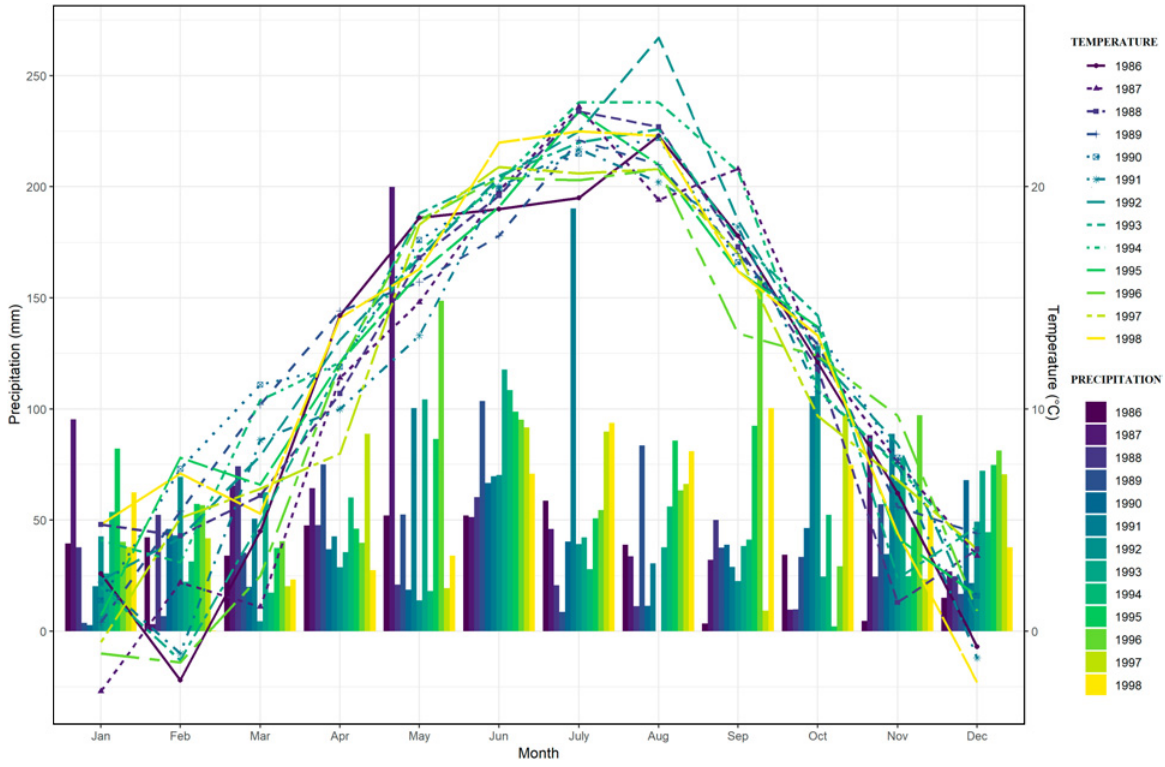

Figure 2. Climate conditions (average temperature and precipitation) in Sremski Karlovci for the period 1986–1998.

after four years the yearly phenological observations came from the new collection. Vines were trained to Guyot training system with one cane and one spur (14 buds per vine).

We examined three key phenological stages that were defined on the basis of the BBCH-scale [14]: BBCH-07 corresponding to the beginning of budburst, that is the date when green shoot tips became visible; BBCH-60 corresponding to the beginning of flowering, that is the date when first flower hoods were detached from the receptacle; and BBCH-81 corresponding to the beginning of veraison, that is the date when the first green berries changed color.

Figures were prepared in statistical program R using the package *ggplot2*.

3. Results and discussion

Climate conditions (1986–1996)

High difference in average temperature among the years was observed in March (Fig. 2). The lowest temperature was in 1987 (1.1 °C), while the highest was in 1990 (11.1 °C).

In 1997, April was the coldest with an average temperature of 8.0 °C. In August 1993, the temperature was extremely high. The highest difference in precipitation among the months was observed in May. In 1991, extremely high precipitation was recorded in July.

Climate conditions (2013–2018)

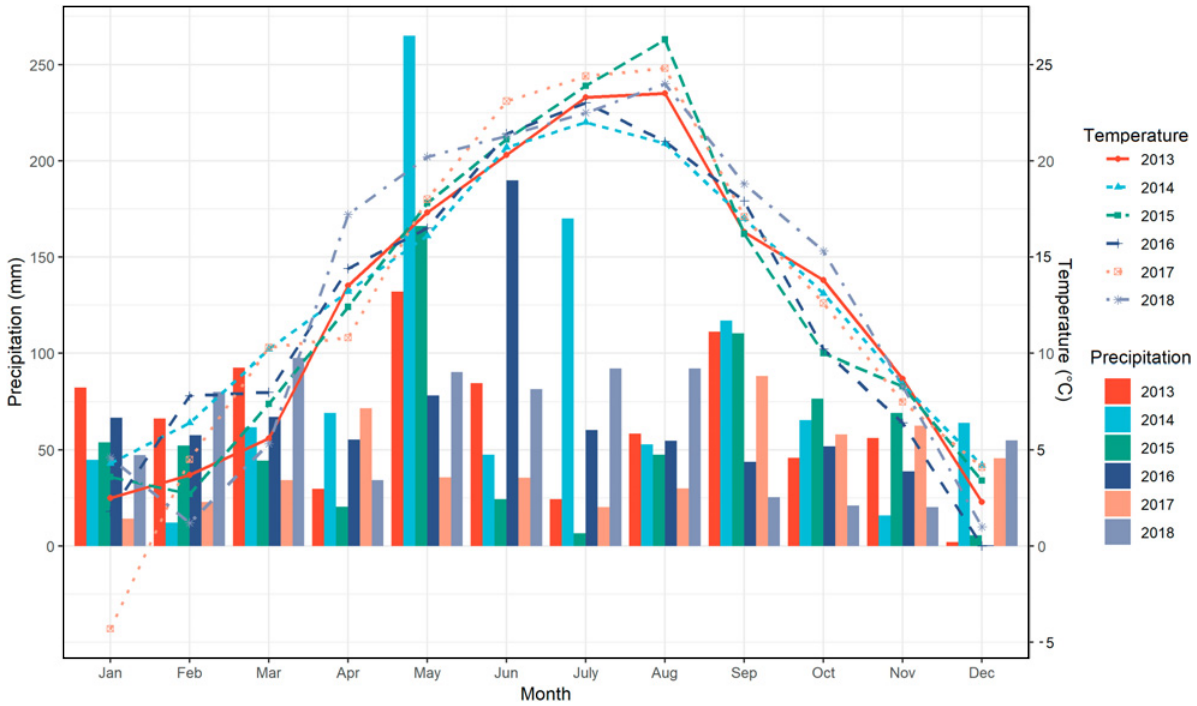

Figure 3. Climate conditions (average temperature and precipitation) in Sremski Karlovci for the period 2013–2018.

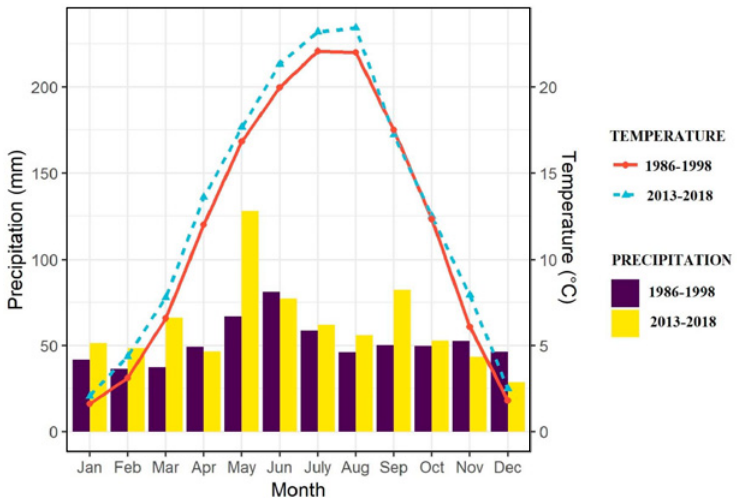

Figure 4. Average climate conditions for the periods 1986–1998 and 2013–2018.

Season 2014 was extremely rainy, especially in May and July (Fig. 3). 2013, 2015 and 2016 were dry and hot. 2017 was extremely hot during the summer. Spring in 2018 was significantly hotter compared to other seasons.

Average temperatures in period 2013–2018 were higher compared to 1986–1998 (Fig. 4). Precipitation amount in May for the period 2013–2018 was almost twice higher compared to 1986–1998.

The beginning of all phenological stages in all cultivars (Tables 1 and 2) in the period (2013–2018) occurred in earlier parts of the year, compared to the historical data. Local cultivars (Prokupac, Probus, Smederevka and Petra) showed less shift of the beginning of budburst in respect to the historical data compared to the international cultivars. One of the most important phenological stages, flowering, has been shifted ten days in the earlier part of the year. In Sremski Karlovci, the beginning of flowering exhibited the least inter-annual variation [13]. The biggest differences were observed for the beginning of veraison. Now, it occurs earlier from 9 (Petra) to 17 days (Merlot). Many authors also showed that the main phenological stages (budbreak, flowering and veraison) have advanced significantly in the last few decades [15,16]. Grapes now ripen at temperatures that are approximately 1.2–1.8 °C higher than a few decades ago [17]. For early ripening varieties, the temperatures are predicted to become too hot to produce high-quality wines.

Duration of the period from budburst to flowering was inconsistent and cultivars required almost the same number of days as it was in the past. However, the duration between flowering and veraison was shorter in the last six years. The biggest difference was observed in Merlot where the

Table 1. Descriptive statistics of phenological stages for selected red grapevine cultivars for the periods 1986–1998 and 2013–2018 in Sremski Karlovci, Serbia.

Phenological stages	Period	Statistics (date)	Cabernet sauvignon	Merlot	Pinot noir	Prokupac	Probus
Beginning of budburst	1986–1998	Mean	20. April	17. April	15. April	12. April	19. April
		Max	01. May	29. April	29. April	30. April	30. April
		Min	07. April	04. April	04. April	21. March	6. April
	2013–2018	Mean	11. April	5. April	5. April	6. April	10. April
		Max	21. April	16. April	16. April	16. April	21. April
		Min	4. April	27. March	27. March	24. March	03. April
Beginning of flowering	1986–1998	Mean	03. June	01. June	29. May	01. June	5. June
		Max	16. June	16. June	13. June	15. June	18. June
		Min	24. May	22. May	20. May	23. May	27. May
	2013–2018	Mean	24. May	22. May	20. May	22. May	24. May
		Max	29. May	26. May	25. May	29. May	29. May
		Min	16. May	12. May	10. May	11. May	10. May
Beginning of verasion	1986–1998	Mean	05. August	04. August	25. July	02. August	7. August
		Max	17. August	20. August	12. August	15. August	21. August
		Min	28. July	20. July	13. July	26. July	30. July
	2013–2018	Mean	24. July	18. July	12. July	20. July	23. July
		Max	28. July	23. July	14. July	26. July	01. August
		Min	16. July	14. July	07. July	11. July	17. July

Table 2. Descriptive statistics of phenological stages for selected white grapevine cultivars for the periods 1986-1998 and 2013-2018 in Sremski Karlovci, Serbia.

Phenological stages	Period	Statistics (date)	Chardonnay	Muscat Ottonel	Riesling italico	Smederevka	Petra
Beginning of budburst	1986–1998	Mean	11. April	14. April	14. April	10. April	14. April
		Max	26. April	30. April.	29. April	26. April	27. April
		Min	21. March	26. March	25. March	20. March	29. March
	2013–2018	Mean	2. April	04. April	08. April	02. April	04. April
		Max	15. April	15. April	19. April	14. April	17. April
		Min	25. March	22. March	30. March	22. March	25. March
Beginning of flowering	1986–1998	Mean	29. May	01. June	02. June	01. June	28. May
		Max	12. June	16. June	16. June	14. June	03. June
		Min	18. May	22. May	24. May	22. May	23. May
	2013–2018	Mean	17. May	22. May	23. May	21. May	20. May
		Max	25. May	28. May	27. May	26. May	25. May
		Min	03. May	05. May	13. May	15. May	09. May
Beginning of verasion	1986–1998	Mean	27. July	26. July	05. August	04. August	02. August
		Max	08. August	07. August	17. August	20. August	12. August
		Min	19. July	19. July	30. July	22. July	27. July
	2013–2018	Mean	13. July	13. July	22. July	20. July	24. July
		Max	20. July	30. July	26. July	30. July	31. July
		Min	05. July	17. June	19. July	11. July	21. July

period between flowering and veraison has been seven days shortened.

4. Conclusion

Changes in the phenology of several grape cultivars in recent decades are particularly in connection with the increase of temperature. The beginning of all phenological stages in all cultivars in the period (2013–2018) occurred in earlier parts of the year, compared to the historical data. One of the most important phenological stages, flowering, has been shifted ten days in the earlier part of the year. However, cultivars differently react to climate change. The biggest change in phenology was observed in Merlot where the period between flowering and veraison has been seven days shortened. Local cultivars were less affected by the weather conditions compared to the "international" cultivars.

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