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CHANGES IN WINE GRAPE YIELD AND COMPOSITION FOR THE REGION OF SREMSKI KARLOVCI

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Abstract

The study aimed to evaluate changes in wine grape yield and composition in response to observed warming and advanced phenology in the region of Sremski Karlovci over last few decades. The analysis was based on long-term observations (1986–2007) of temperature, phenology, yield, grape cluster mass, sugar content and total acidity in the must for Riesling Italian and Lemberger, the most common grape varieties in the studied region. A significant temporal trend was observed only for yield in Riesling Italian, while in Limberger, both yield and grape cluster mass showed significant positive change over time. The yield in both varieties was most affected and positively correlated with warm growing season of pre-harvest year. For sugar content in the must, the most influential temperature variable was growing season diurnal temperature range in Riesling Italian, while in Limberger that was diurnal temperature range during ripening. The number of warm days (maximum daily temperature >90th percentile) for Riesling Italian and the number of cool nights (minimum temperature <10th percentile) for Limberger were identified as temperature variables in the harvest year that could explain, to a certain extent, variation in total acidity in the must.

Key words: *Riesling Italian, Limberger, yield, composition, Serbia*

Intorduction

Climate is one of the most important factors controlling grape and wine production from selection of a suitable grapevine varieties to the type and quality of wines produced (Gladstones, 1992). Climate change is now unequivocal. Thirteen of the 14 warmest years on record have all occurred in the 21st century (WMO, 2014). Changes in climate are not uniform and may have positive or negative effects on viticulture depending on the region and the ways in which the climate changes. Recent warming generally improved the quality of wine (Nemani et al., 2001; Jones and Goodrich, 2008; Ramos et al., 2008), especially in cooler vineyard regions (Caprio and Quamme, 2002; Lisek, 2008). The warming was recognized as a problem in viticultural regions where grapevine is grown close to temperature optimum (Webb et al., 2008).

Viticultural regions of Serbia have not been much studied in this regard. Ruml et al. (2013a) analyzed temperature-based indices in the region of Sremski Karlovci over the last few decades and found considerable changes in both average and heat-related temperature indices. In response to increased temperature the significant advances of grapevine phenology was detected in the vineyard area of Sremski Karlovci (Ruml et al., 2013b). Advances in the phenological events resulting in ripening during a warmer period may hasten the ripening process and affect the balance between sugar content and acidity in grapes at harvest (Bock et al., 2010). The aim of this study is to examine how recent changes in climate and phenology affected the yield and composition characteristics of Riesling Italian and Limberger, two most planted grape varieties in the wine producing area of Sremski Karlovci.

Materials and methods

Phenological and temperature observations were performed at the experimental station of the Novi Sad Faculty of Agriculture (45°10' N, 20°10' E, 110 m a.s.l.), located in Sremski Karlovci. The climate is mid-latitude moderate continental with mean annual air temperature of 12.3°C and mean annual precipitation of 650 mm. The coldest month is January, the warmest July. The precipitation maximum occurs in May and June. Experimental vineyard was established in 1979 on Mt. Fruška Gora's slopes by the Danube River.
Four phenological stages were analyzed for wine grape varieties Riesling Italian and Limberger over the period 1986–2007: beginning of budburst, beginning of flowering, beginning of veraison and harvest. Production and quality data included: yield, grape cluster mass, sugar content and total acidity in the must. Sugar content in the must was measured with a refractometer, while total acid in the must was determined by neutralization method. Temperature was measured with standard National Weather Service thermometers at 2 m above the soil surface at climatological station located in the experimental vineyard. Precipitation data were not included in the study, because these measurements did not pass quality control.
A number of climatically important parameters for viticulture (Table 1) were derived from daily mean, maximum and minimum temperatures for calendar year, growing season and different grapevine growth periods. Pearson correlation coefficient (R) was used to relate yield and composition characteristics of Riesling Italian and Limberger to phenology and temperature variables of both harvest and pre-harvest years.

Table 1. Definition of indices based on daily mean (TM), maximum (TX) and minimum (TN) temperatures used in the study

Index	Descriptive name	Definition	Unit
TN90p	Warm nights	Number of days with TN > 90th percentile	days
TN90p	Warm nights	Number of days with TN > 90th percentile	days
TX90p	Warm days	Number of days with TX > 90th percentile	days
TN10p	Cool nights	Number of days with TN < 10th percentile	days
TX10p	Cool days	Number of days with TX < 10th percentile	days
ndTX>25	Summer days	Number of days with TX > 25°C	days
ndTX>30	Tropical days	Number of days with TX > 30°C	days
ndTX>35	Hot days	Number of days with TX > 35°C	days
ndTN>20	Tropical nights	Number of days with TN > 20°C	days
ndTN<0	Frost days	Number of days with TN < 0°C	days
ndTN<−2.5	Moderate cold days	Number of days with TN < −2.5°C	days
ndTN<−10	Extreme cold days	Number of days with TN < −10°C	days
LF	Last spring frost	Date of last day in spring with TN < 0°C	Day of year
FF	First autumn frost	Date of first day in autumn with TN < 0°C	Day of year
FFP	Length of the frost-free period	Number of days between the last date in spring and the first date in autumn with TN < 0°C	days
DTR	Diurnal temperature range	Average difference between TX and TN	°C
GDD	Growing Degree Days	Sum of TM above 10°C	°C

Results and discussion

Time series of yield, grape cluster mass, sugar content and total acidity in the must are shown in Figs 1 and 2 for Riesling Italian and Limberger, respectively. Significant temporal trends were detected in yield for Riesling Italian and in yield and grape cluster mass for Limberger. The yield trend for Limberger exhibited greater slope, higher coefficient of determination and higher level of statistical significance than yield trend for Riesling Italian. No significant temporal trends were found in data on sugar content and total acidity in the must for both varieties. Periodicity in data series can be noticed for all variables in both varieties, most clearly for total acidity in the must for Riesling Italian. Future research should investigate this very interesting finding about periodicity of data using in-depth statistical analysis.

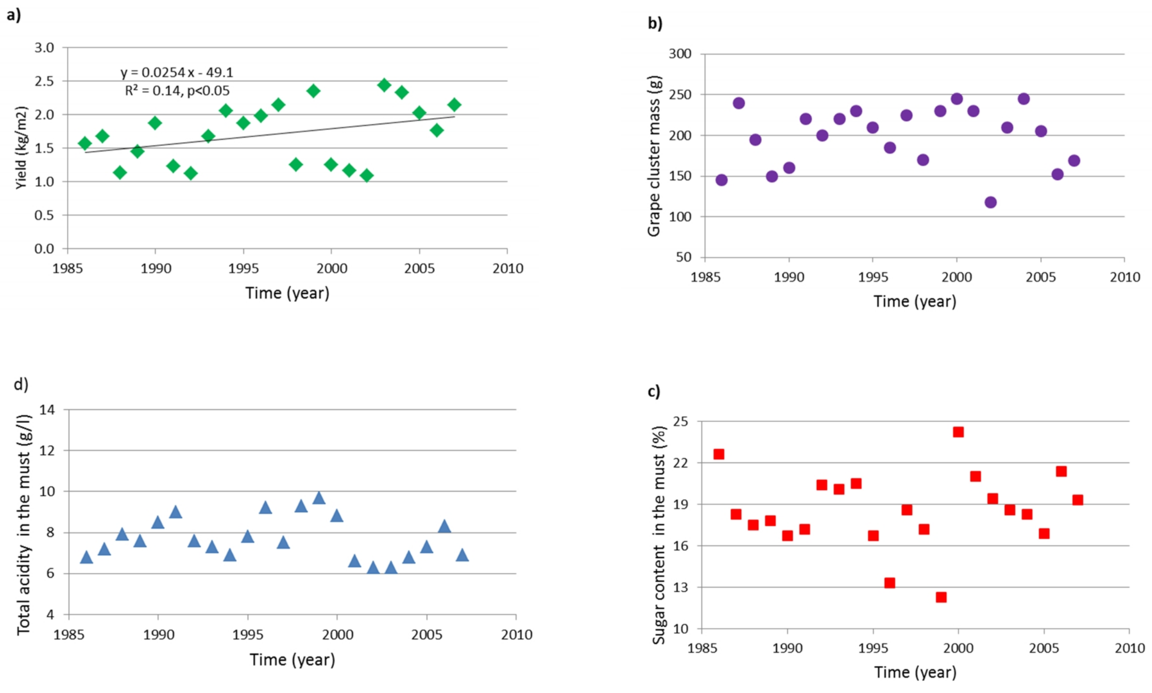

Figure 1. Time series and linear trends of a) yields, b) grape cluster mass, c) sugar content in the must, d) total acidity in the must for Riesling Italian grown in Sremski Karlovci (1986–2011). Line represents best-fit linear regression for significant trend.

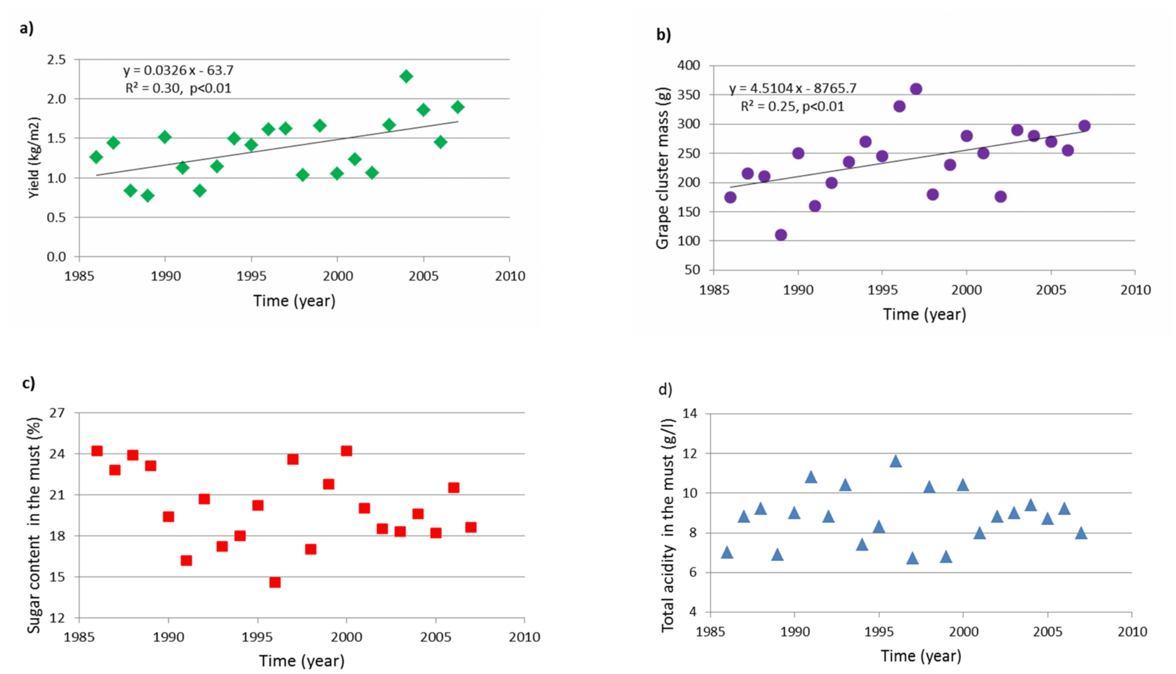

Figure 2. Time series and linear trends of a) yields, b) grape cluster mass, c) sugar content in the must, d) total acidity in the must for Limberger grown in Sremski Karlovci (1986–2011). Lines represent best-fit linear regressions for significant trends.

Correlation analysis between production and composition characteristics of studied varieties showed that in Riesling Italian, sugar content in the must were significantly correlated with yield (R=0.38, p<0.05) and total acidity in the must (R=0.48, p<0.05). In Limberger, sugar content were significantly correlated with total acidity in the must (R=0.56, p<0.01), while yield showed significant correlation with mass of grape cluster (r=0.68, P<0.001).

Correlation coefficients significant at the 5% level between the production and composition data and the phenological timing and temperature indices are displayed in Tables 2 and 3 for Riesling Italian and Limberger, respectively. In cases with no significant correlations, the relationship with the highest coefficient of correlation is shown.

Table 2. Correlation matrix between production and composition data for Riesling Italian and data on phenological timing and temperature for the region of Sremski Karlovci over the period 1986–2007. The highest correlation for each variable is displayed in bold.

HARVEST YEAR

	Calendar year								
	FW* date	TN	TX	TX90p	ndTX>25	ndTX>30	ndTX>35	ndTN>20	ndTN<−10
Yield (kg/m2)									**-0.31**#
Grape cluster mass (g)	**0.34**#								
Sugar content (%)	**-0.50**	0.43	0.51	0.48	0.51	0.50	0.39	0.52	
Total acidity (g/l)				**-0.36**					

	Growing season (1 Apr – 31 Oct)				Budburst – flowering (1 Apr – 31 May)			Flowering – veraison (1 Jun – 31 Jul		Veraison – harvest (1 Aug – 30 Sep)	
	TM	TX	DTR	GDD	TM	TN	TX	ndTX>25	ndTX>30	TM	ndTN>20
Yield (kg/m2)											
Grape cluster mass (g)					0.33#	0.32#	0.31#				
Sugar content (%)	0.56	0.57	**0.59**	0.51			0.41	0.35	0.52	0.50	0.47
Total acidity (g/l)											

PRE-HARVEST YEAR

	Calendar year												
	TM	TX	TX90p	TN90p	ndTX>25	ndTX>30	ndTX>35	ndTN>20	ndTN<−10	FF	FP	TX Jun	TM Apr-Jul
Yield (kg/m2)				0.36									**0.57**
Grape cluster mass (g)			0.43			0.37			-0.42			**0.58**	
Sugar content (%)													
Total acidity (g/l)	-0.39	-0.41	-0.46	-0.40	-0.43	-0.49	-0.61	-0.40		-0.48	-0.41		

	Growing season (1 Apr – 31 Oct)				Budburst – flowering (1 Apr – 31 May)			Flowering – veraison 1 Jun – 31 Jul)							
	TM	TX	TN	GDD	TM	TN	TX	TM	TX	TN	DTR	ndTX>25	ndTX>30	ndTX>35	ndTN>20
Yield (kg/m2)					0.38	0.36	0.39	0.38		0.37			0.41		
Grape cluster mass (g)	0.41	0.45		0.40	0.45	0.46	0.41				0.40				
Sugar content (%)															
Total acidity (g/l)	-0.50	-0.51	-0.40	-0.39	-0.44	-0.49		-0.38	-0.42		-0.39	-0.39	-0.41	**-0.64**	-0.41

#significant at the 0.1 level

*FW – the beginning of flowering

Phenology was not significantly correlated with production and composition data, except the beginning of budburst in Frankovka that showed significant correlation with mass of grape cluster and the beginning of flowering in Riesling Italian, which was significantly correlated with sugar content in the must. None of examined temperature variables showed strong correlation with yield and composition characteristics of studied varieties. The strength of significant correlations was mostly moderate. The yield and mass of grape cluster in both varieties were positively related with warm growing season of pre-harvest year and negatively, to a lesser extent, with the number of days with negative temperatures during harvest year. Among examined temperature indices, the strongest correlation coefficient with sugar content in the must exhibited growing season diurnal temperature range in Riesling Italian and diurnal temperature range during ripening in Limberger. Interestingly, acidity in the must in Riesling Italian was more affected by temperature regime in the pre-harvest year than in the harvest year. Even though we do not have a physiologically-based explanation for dependence of sugar and acidity levels in the must on temperature regime in pre-harvest year, this finding cannot be ignored, since the strength of these correlations were comparable with others and even the highest coefficient of correlation (R=–0.64) among all examined variables was displayed between acidity in the must for Riesling Italian and temperatures higher than 35°C in the period from flowering to veraison in the pre-harvest year.

Table 2. Correlation matrix between production and composition data for Limberger and data on phenological timing and temperature for the region of Sremski Karlovci over the period 1986–2007. The highest correlation for each variable is displayed in bold.

HARVEST YEAR

	Calendar year					Flowering – veraison (1 Jun – 31 Jul	Veraison – harvest (1 Aug – 30 Sep)
	BB* date	TN10p	ndTN<-2.5	ndTN<−10	TX June	DTR	DTR
Yield (kg/m2)			**-0.40**	-0.39			
Grape cluster mass (g)	**0.45**		**-0.44**	-0.41	0.36		
Sugar content (%)		-0.37					**0.44**
Total acidity (g/l)		**0.51**				0.40	

PRE-HARVEST YEAR

	Calendar year										
	TM	TX	TX90p	TN90p	TX10p	ndTN>20	ndTN<0	ndTN<−2.5	ndTN<−10	FF	FFP
Yield (kg/m2)			0.39	0.43		0.40					
Grape cluster mass (g)					0.41						
Sugar content (%)	-0.39	-0.38					0.38	0.48	**0.50**		
Total acidity (g/l)								-0.37	-0.31	**-0.43**	-0.40

	Growing season (1 Apr – 31 Oct)					Budburst - flowering (1 Apr – 31 Jul)			Flowering - veraison (1 Jun – 31 Jul)				Budburst - veraison (1 Jun – 31 Jul)			Rippening (1 Aug-30 Sep)
	TM	TX	TN	GDD	DTR	TM	TX	TN	ndTX>30	TM	TX	DTR	TM	TX	TN	DTR
Yield (kg/m2)	0.36	0.35	0.45	0.41		0.52	0.47	0.56	0.39	0.37	0.42		0.54	0.46	**0.60**	
Grape cluster mass (g)						-0.39	-0.38	-0.39								**-0.48**
Sugar content (%)						-0.44	-0.46	-0.41								
Total acidity (g/l)					-0.38				-0.39			-0.38				

*BB – the beginning of budburst

Conclusion

The results from this study can be used to assess the potential impacts of predicted climatic changes on grape and wine production. According to climate projection for Serbia (Ruml et al., 2012), rising trends of temperature and frequency of heat-related extremes will likely continue and become even stronger. Since it was found that grape composition of studied varieties is influenced by temperatures, possible consequences of predicted warming may include changes in wine styles or necessity of costly measures to maintain the regional tipicity of wines. On the other hand, revealed relationship between grape yield and temeperature suggests that projected reduction in frost occurrence with longer frost-free period and warmer growing season could lead to increased yields and thus favor grape production.

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