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REACTION OF TABLE GRAPE VARIETIES TO LOW WINTER TEMPERATURES

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ABSTRACT

The aim of this study was to investigate the resistance of winter buds to low winter temperatures on eight table varieties of different ripening time. The study was conducted during vine dormancy at three testing dates during winter i.e. over the last ten days of the three winter months of December, January and February. At the first, second and third dates, the air temperature in the freezing chamber was reduced to - 15 ^{o}C, -20^{o}C, and -10^{o}C, respectively.The analysis of the average values for the study period shows that Muscat Hamburg and Smederevo Muscat had the lowest and highest average percentage of completely frozen buds (48.97% and 58.84%, respectively). The average values for partly frozen buds ranged from 29.17 % in Afuz-Ali to 33.11 % in Muscat Hamburg. The evaluation of the data on unfrozen buds suggests that the average values were within the range of 11.15 % (Smederevo Muscat) to 17.91 % (Muscat Hamburg).

INTRODUCTION

In vine-growing areas having a continental and temperate continental climate, table grape varieties often suffer substantial damage from exposure to low temperatures. At some sites, this abiotic factor generally poses a risk to grape production. The results of many studies show higher susceptibility of table varieties to low temperatures as compared to wine varieties (Korać 1989, Žunić et al. 1998, Todić 2000).

The degree of winter cold hardiness is governed by both the underlying genetic background and cultivation conditions. Moreover, no clear estimate of cold hardiness can be provided, due to its dependence upon a range of variable biotic and abiotic factors. Therefore, the evaluation of cold hardiness is restricted to the assessment of relative cold hardiness and determination of differences between individual varieties. Typically, cold hardiness begins to increase in late summer or early autumn, well in advance of low temperatures. Differences in winter cold hardiness can be associated with tissue maturity and bud position (Wolpert et al. 1985).

Cold-hardy varieties have the ability to store sufficient amounts of natural antifreeze carbohydrates and proteins in their trunk and shoots during autumn, also exhibiting a severe tissue moisture decline during a short photosynthetic period in cold weather immediately before the onset of winter (Meiering et al. 1980).

Proebsting et al. (1980) studied seasonal changes in bud cold hardiness in three varieties, including Concord (*Vitis labrusca*), White Riesling (Rhine Riesling) and Cabernet Sauvignon. A constant temperature of –26 ^{o}C for Concord and –23 ^{o}C for White Riesling and Cabernet Sauvignon induced freezing in 50% of grapevine buds. The authors observed that Concord grapevines began to lose the ability to adapt to freezing

temperatures on 19 February, whereas White Riesling and Cabernet Sauvignon retained the trait until 6 March. (Hubáčková, 1996 *b*) observed that cold hardiness considerably declined from mid-February through the beginning of March, regardless of the slight increase in temperature. The author assumed that the transient lack of correspondence between ambient temperature and cold hardiness in the latter half of February and partly in the first 10 days of March is due to activation of the growth process inside vine buds.

MATERIAL AND METHODS

The material used in this study included mature segments of shoots (cuttings) of the following varieties: Demir Kapija, Early Muscat, Radmilovac Muscat, Banat Muscat, Black Muscat, Smederevo Muscat, Italia and Dattier. The degree of bud cold hardiness was determined through exposure of mature shoot cuttings to low temperatures *in vitro* in a freezing chamber following a modified method of (Korać 1989). The plant material was collected from a 16-year old vineyard. The varieties tested were grafted onto Kober 5BB rootstock. The study was conducted during vine dormancy at three testing dates during winter i.e. over the last ten days of the three winter months of December, January and February. At the first, second and third dates, the air temperature in the freezing chamber was reduced to - 15 ^{o}C, -20^{o}C, and -10^{o}C, respectively. The cuttings of the sampled shoots were initially kept for 24 h in the freezing chamber at a temperature of – 5^{o}C so that they could gradually acclimate to chamber conditions. Then, the temperature was gradually lowered at a rate of 3^{o}C / h to the pre-determined freezing temperature. The cuttings were kept for 12 hours at this temperature, which was subsequently again increased to room temperature. The cuttings subjected to the above treatment were kept for 7 days under room conditions for frozen tissues to darken. Thereafter, 2-3 cross-sectional cuts were made through the winter bud using a sharp blade, the first cut serving to remove the top third of the bud, and the additional one or two cuts taken towards the base of the bud to obtain the most adequate section for close inspection. Bud colour was observed in the bud cross section. The colour of intact buds was clear light green, whereas that of cold-injured buds ranged from olive green to dark brown. The frozen bud (--) includes frozen central and secondary latent buds. Partly frozen buds (-+) had at least one live secondary latent bud. Surviving live buds suffered no injury (++). The experimental data of the three-year study were subjected to a multivariate analysis of variance (MANOVA) using the STATISTICA (Version 6.0) statistical software. The significance of differences between individual treatments was tested using the LSD test at 0.05 and 0.01 significance level.

RESULTS AND DISCUSSION

The results on bud freezing show significant variations both among the test cultivars and among testing dates (Table 1). In terms of the testing dates, the percentage of completely frozen buds in December was found to be lowest in Muscat Hamburg (48.20%) and highest in Afuz-Ali (61.13%). The percentage of partly frozen buds at this date ranged from 27.26% in Afuz-Ali to 36.93% in Demir Kapiija. Muscat Hamburg and Smederevo Muscat gave, respectively, the highest (18.73%) and lowest (11.06%) percentage of live buds at the December testing date.

The January testing date revealed the highest average percentage of frozen buds in Smederevo Muscat grapevines (60.06%) and the lowest in Muscat Hamburg (50.20%). The estimated values for partly frozen buds were within an average range of 28.86% in Demir Kapija to 32.73% in Radmilovac Muscat. Identically to the previous testing date, the highest percentage of unfrozen buds was observed in Muscat Hamburg (17.60%), and the lowest in Smederevo Muscat (9.46%).

Table 1. Percentage of frozen buds in the table grape varieties tested

Cultivar	Date: December (-15°C) --	-+	++	January (-20°C) --	-+	++	February(-10°C) --	-+	++
Demir Kapija	52.20	37.80	10.00	56.40	27.20	16.40	55.80	32.80	11.40
	51.60	37.60	10.80	53.40	28.60	18.00	55.00	31.20	13.80
	50.80	35.40	13.80	54.80	30.80	14.40	54.80	33.00	12.20
Average	51.53**a**	36.93**b**	11.53**a**	54.86**a**	28.86**b**	16.26**a**	55.20**a**	32.33**a**	12.46**a**
Early Muscat	57.60	32.20	10.20	53.80	30.20	16.00	50.40	31.20	18.40
	56.60	31.00	12.40	54.80	29.60	15.60	49.60	31.60	18.80
	54.20	33.80	12.00	54.80	29.20	16.00	49.80	34.00	16.20
Average	56.13**a**	32.33**a**	11.53**a**	54.46**a**	29.66**a**	15.86**a**	49.93**b**	32.26**a**	17.80**b**
Radmilovac Muscat	50.60	31.00	18.40	50.40	32.60	17.00	46.00	32.00	22.00
	49.60	33.20	17.20	51.00	31.20	17.60	53.20	30.20	16.60
	51.40	33.80	14.80	51.00	34.40	14.60	53.20	31.00	15.80
Average	50.53**a**	32.66**b**	16.80**b**	50.80**a**	32.73**b**	16.40**a**	50.80**b**	31.06**b**	18.13**b**
Banat Muscat	50.40	33.00	16.60	52.20	31.00	16.80	57.80	30.40	11.80
	50.80	33.80	15.40	52.40	30.60	17.00	56.60	32.80	10.60
	50.20	33.20	16.60	51.40	31.80	16.80	56.60	31.60	11.80
Average	50.46**a**	33.33**b**	16.20**a**	52.00**a**	31.13**b**	16.86**a**	57.00**a**	31.60**b**	11.40**a**
Muscat Hamburg	44.60	32.60	22.80	46.40	32.80	20.80	47.80	33.40	18.80
	50.00	34.00	16.00	50.00	32.00	18.00	48.60	34.60	16.80
	50.00	32.60	17.40	54.20	31.80	14.00	49.20	34.20	16.60
Average	48.20**a**	33.06**b**	18.73**b**	50.20**a**	32.20**b**	17.60**a**	48.53**b**	34.06**a**	17.40**b**
Smederevo Muscat	62.80	27.20	10.00	62.20	29.60	8.20	53.80	32.20	14.00
	59.20	29.20	11.60	60.40	31.00	8.60	56.80	30.40	12.80
	58.40	30.00	11.60	57.60	30.80	11.60	58.40	29.60	12.00
Average	60.13**b**	28.80**a**	11.06**a**	60.06**b**	30.46**a**	9.46**b**	56.33**a**	30.73**b**	12.93**a**
Muscat Italia	57.20	29.80	13.00	55.00	31.20	13.80	53.80	31.20	15.00
	54.40	29.00	15.60	57.20	29.00	13.80	51.40	34.00	14.60
	53.60	30.00	16.40	57.00	30.40	12.60	52.00	34.00	14.00
Average	55.06**a**	29.60**a**	15.00**a**	56.40**a**	30.20**a**	13.40**b**	52.40**b**	33.06**a**	14.53**a**
Afuz - Ali	62.00	26.80	11.20	59.20	30.60	10.20	54.60	32.60	12.80
	60.60	27.20	12.80	61.20	30.00	8.80	56.60	29.40	14.00
	60.80	27.80	11.40	58.20	28.60	13.20	55.40	29.60	15.00
Average	61.13**b**	27.26**a**	11.80**a**	59.53**b**	29.73**a**	10.73**b**	55.53**a**	30.53**b**	13.93**a**

Treatment	% frozen buds		% partly frozen buds		% intact unfrozen buds	
	$LSD_{0.05}$	$LSD_{0.01}$	$LSD_{0.05}$	$LSD_{0.01}$	$LSD_{0.05}$	$LSD_{0.01}$
Cultivar	1.401	2.396	1.473	2.520	1.487	2.544
Date	0.858	1.467	0.902	1.543	0.911	1.558
Cultivar x Date	2.427	4.151	2.552	4.365	2.576	4.407

During the third testing date (February), the highest average percentage of frozen buds was found in Banat Muscat (57.00%) and the lowest in Muscat Hamburg grapevines (48.53%). The percentage of partly frozen buds ranged from 30.53% in Afuz-Ali to 34.06% in Muscat Hamburg on average. The average percentage of intact unfrozen buds at this date was within the 11.40% - 18.13% range, as observed in Banat Muscat and Radmilovac Muscat, respectively.

No markedly pronounced variations in the percentage of completely frozen buds were observed across years. Much higher fluctuations in the percentage of completely frozen buds were found between individual testing dates. Significant differences were determined between the third date, and the first and second dates. The percentage of frozen buds was significantly lower at the third date (February) as compared to the first

and second dates that showed no statistically significant difference in mean values. It is noteworthy, however, that the freezing temperature during February was much higher than at previous dates. The percentage of partly frozen buds also showed higher variations across testing dates than across years. The analysis of data showed a significant difference between the second date relative to the first and third dates. All varieties gave a significantly lower percentage of partly frozen buds during the second date as compared to the first and third dates. Apart from the decrease in the percentage of partly frozen buds, January was also marked by an increase in the percentage of completely frozen buds and that of live buds as compared to the previous date.

The results obtained are in complete agreement with those of Meiering et al. **(**1980), Wolpert et al. **(**1985), Korać (1989, 1995), Žunić et al. (1998) and Todić (2000), who reported that winter resistance of grapevine varieties gradually increases from the onset of winter dormancy period, reaching its maximum in mid-winter i.e. during January, and gradually declining thereafter. Interestingly, the highest cold hardiness involving the lowest percentage of completely frozen buds at the third testing date (February) was observed in Early Muscat and Muscat Hamburg, suggesting that these cultivars retain their resistance for longer periods of time as compared to the other cultivars analyzed. This complies with the findings of Proebsting et al. (1980) who found that some varieties lose the ability to adapt to freezing temperature earlier than some other varieties that manage to retain the ability much longer. An analysis of cold resistance in grapevine varieties in terms of their ripening time suggests that early ripening varieties exhibit a higher degree of cold resistance as compared to late ripening varieties. The results on the percentage of completely frozen, partly frozen and live buds are similar to or within the range of values reported by other authors Isaenko (1980), Damborska (1980), Korać (1989, 1995), Žunić, 1993, Hubáčková (1996 *a*), Hubáčková (1996 *b*) Žunić et al. (1998), Todić (2000), Matijašević (2001).

CONCLUSION

The highest cold resistance was exhibited by Muscat Hamburg among all test varieties. Radmilovac Muscat stands out among the early ripening varieties in terms of cold hardiness. Early ripening varieties show a higher average degree of cold hardiness as compared to late ripening varieties. In terms of testing dates, cold hardiness in all varieties increased from December, reaching its maximum during January. At the end of February, the varieties tested exhibited a decline in their cold hardiness, although the February temperature the cuttings were exposed to were considerably higher than the freezing temperatures used at previous dates.

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