Vitis **36** (4), 213–214 (1997)

Research Note

Potential frost resistance of grape: Kinetics of temperature-induced hardening of Riesling and Silvaner buds

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Summary: Buds of field-grown Riesling and Silvaner vines were sampled in January and exposed to three subzero temperatures for different lengths of time. The higher potential frost resistance of Riesling is ascribed to its rapid and intensive acclimation to frost after hardening at -17 and -20 °C and to the maintenance of its frost resistance during hardening up to 48 h at various subzero temperatures. Potential frost resistance of Silvaner was achieved by hardening at higher temperature (-14 °C) for 48 h.

Key words: frost, resistance, bud, chlorophyll fluorescence, hardening, temperature.

Introduction: The frost resistance of grape buds depends, *inter alia*, on genotype, viticultural prehistory, e.g. yield and vigour, stage within the annual periodicity of growth and dormancy and weather conditions. While in autumn the induction of frost resistance is supposed to be regulated by endogenous processes the maintenance of frost resistance in winter appears to be controlled predominantly by low temperatures (PROEBSTING 1963, TYURINA *et al.* 1978). The maximum ('potential') frost resistance, a useful parameter to classify the degree of frost resistance of genotypes, is achieved by hardening, *i.e.* acclimation of buds to low temperatures (LARCHER 1985). In the experiments described in this paper buds of Riesling and Silvaner vines were exposed to different temperatures for different lengths of time to study the kinetics of hardening.

Material and methods: In winter 1995, on January 9, 16 and 23 with minimum temperatures of -2.8, -1.3 and +5.2 °C, respectively, canes of Riesling and Silvaner vines were sampled in the field from 9 to 10 a.m. Frost resistance of buds was determined (a) directly, *i.e.* after 4 h of exposure to 20 °C (control), (b) after hardening (exposure to -14, -17 or -20 °C for 12, 24 or 48 h), and (c) after hardening and exposure to -23 or -26 °C for 20 h (freezing test). All buds exposed to freezing temperatures were finally allowed to thaw at 20 °C (4 h). For each of the 37 controls and treatments per variety 15 bud-bearing nodes (length: 4 cm) were sealed in plastic bags. The vitality of bud segments was determined by the chlorophyll fluorescence method which has been described in detail by SCHREIBER and BILGER (1987). The fast kinetics of chlorophyll fluorescence was determined using a PAM fluorometer system (H. Walz, Effeltrich, Germany). Fo and Fm were measured at the distal part of dissected buds using PAM 101 and 102. Fv (Fm-Fo) was calculated utilizing the data acquisition system Da 100 (Walz). It has been shown earlier that bud injury due to frost is closely correlated to the Fv/Fm ratio (DÜRING *et al.* 1990). To calculate relative frost resistance Fv/Fm values obtained from treated buds were related to those of the untreated control.

Results: Determination of frost resistance directly after sampling or after hardening (a and b, respectively, see Material and methods) indicated no injury of buds due to frost. The results obtained from experiments including a final freezing test (-23 °C) are summarized in the Table. Comparing the two varieties indicates that after all treatments frost resistance of Riesling was superior to that of Silvaner (the significance of differences between the two varieties is not shown in the Table). The degree of frost resistance depends on the hardening temperature and its duration. After a short hardening (12 h) highest frost resistance was obtained with the lowest hardening temperature (-20 °C) in both varieties. After prolonged hardening (24 h) this tendency was observed again in both varieties however, differences are not significant. While in Riesling hardening for 48 h led to the maintenance of high frost resistance, in Silvaner the highest frost resistance was reached at the highest hardening temperature (-14 °C); values decreased with decreasing temperature.

Table

Effects of temperature and duration of hardening on the average relative frost resistance (%, control = 100 %) of Riesling and Silvaner buds sampled on January 9, 16 and 23. For each variety values followed by different indices are significant at the 5 % level; the significance of differences between the varieties is not shown. Results were obtained after a freezing test at -23 °C

Hardening temperature, °C	Riesling			Silvaner		
	Duration of hardening, h					
	12	24	48	12	24	48
-14	46a	77c	72c	45a	57b	67c
-17	68b	78c	76c	41a	60b	62b
-20	78c	81c	73c	52b	63b	48a

Discussion: The results indicate that hardening of buds in winter is time and temperature dependent, *i.e.* a high degree of frost resistance can be achieved either by a long period of relative high temperature (48 h/-14 °C) or by a short period of relative low temperature (12h/-20 °C). These results are partly supplemented by an earlier finding indicating that long-term hardening (72 h) at -10 °C increased frost resistance of Silvaner buds (DÜRING *et al.* 1990). Comparing Riesling and Silvaner it appears that Riesling buds react more rapidly and intensively to short-term low temperature (-17 and -20 °C) than Silvaner; in addition, long-term hardening (48 h) at -20 °C maintains frost resistance in Riesling but is detrimental for Silvaner. These reactions are assumed to be an essential part of the mechanism(s) leading to the often observed high frost resistance of Riesling (NIKOV 1966, MÜLLNER und MAYER 1970, HILLEBRAND *et al.* 1993). From the results it can be deduced that a long-term exposure (48 h)

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to -14 °C is most suitable to determine potential frost resistance; however more experiments with a broad spectrum of genotypes are necesssary to corroborate our findings.

The author thanks Mrs. E. BRÄUTIGAM, L. KOST, E. SCHREIBER and Mr. A. PREISS for excellent technical collaboration.

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