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The effect of higher winter temperatures on changes of the frost resistance of grapevine buds

by

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L'influence de températures élevées au cours de l'hiver sur le changement de la résistance au froid de bourgeons de vigne

Résumé. — Des sarments de vigne d'un an avec bourgeons endurcis dans des conditions naturelles ou contrôlées, ont été soumis à l'influence de températures positives élevées et, après cela, à l'influence du froid dans des chambres frigorifiques. La perte de résistance a été constatée par une comparaison de la résistance des témoins avec celle des variantes influencés avant l'exposition au froid par des températures élevées. Le niveau de résistance a été déterminé d'après le pourcentage des bourgeons poussés sur les boutures à un oeil après l'exposition au froid.

On a pu constater que la vitesse de l'abaissement de la résistance dépendait de la variété, de la durée de l'action des températures favorables et probablement de la date, ou mieux de l'époque du prélèvement des bourgeons sur les ceps.

La meilleure stabilité de la résistance au cours de l'hiver après l'action de températures de +10, +12, +15 °C a été trouvée chez la variété Riesling, suivie des variétés Portugais bleu et Müller-Thurgau. En fin d'hiver la stabilité de la résistance des bourgeons de la variété Riesling est tombée au-dessous de celle de la variété Portugais bleu.

Dans le cas où l'action des températures élevées se prolongeait de 24 à 120 h on a vu s'approfondir la baisse de la résistance au froid. Cette baisse s'est intensifiée au fur et à mesure que la fin de l'hiver approchait.

Si les bourgeons avaient été exposés pendant 96 h à des températures induisant l'adaptation au froid (—3 °C) la résistance était élevée sans toutefois atteindre le niveau initial.

Introduction

In vine-growing regions with frequent frosts alternating with higher temperatures above zero in winter, the evaluation of the frost resistance of grapevine should be performed not only with respect to its ability to endure severe frosts or develop sufficient hardiness but also to its ability of keeping high resistance throughout the winter season. The methods of such evaluation of newly bred and introduced varieties and forms of grapevine should therefore include evaluation of this highly important physiological character.

As an induced trait, frost resistance develops in the course of adaptation in exposure to low temperatures. Like in the majority of hibernating crops, temperatures close to 0 °C or slightly below this point are deemed to be the best for the buds of grapevine to develop resistance to frost (Kondo 1960, Pogosyan 1960, Chernomorets 1968, Reuther 1971 and others). If exposed to higher positive temperatures instead of those mentioned, the vines may partially or completely loose their adaptation.

This study was aimed at obtaining, under controlled conditions, data on the action of different time of exposure to higher temperatures on the loss of adaptation and drop of frost resistance in three selected varieties of grapevine.

Material and methods

The study was performed with the shoots of the varieties Riesling (RR), Müller-Thurgau (MT), and Blue Portuguese (BP) separated from vines in 1976 and Riesling and Blue Portuguese in 1977 and 1978. The annual shoots were taken from own-rooted vines trained by Guyot pruning and growing in one locality. In each sampling term, 12 shoots well-lignified under the first 13 buds from base were taken in each variant. All buds, except the first bud at base, were included in the experiment, making a total of 144 each variant.

Table 1

Percentage of burst buds after hardening under natural conditions influenced by a higher positive temperature for 24, 72 and 120 h with subsequent exposure to frost

Pourcentage des bourgeons poussés aprés l'endurcissement dans des conditions naturelles influencés par une température positive élevée pendant 24, 72 et 120 h et après l'exposition ultérieure à l'action du froid

Date of sampling	Variety	Viability immediately after sampling	Level of exposure to frost °C	Resistance immediately after sampling	Action of + 10 °C and exposure to frost		
					24 h	72 h	120 h
19. 1. 1976	RR[1])	98.6	—18	94.4	91.4	—	87.8
	MT	99.3	—18	79.3	82.8	—	56.6
	BP	99.3	—18	99.3	89.8	—	96.5
23. 2. 1976	RR	96.4	—19	100	97.9	95.7	—
	MT	97.9	—19	98.6	76.4	48.2	—
	BP	97.9	—19	97.9	98.4	83.4	—
					Action of +15 °C		
16. 1. 1978	RR	86.6	—17	83.8	96.4	94.4	77.9
	RR	86.6	—19	92.0	93.7	73.6	64.5
	BP	86.6	—17	96.0	84.9	77.5	66.2
	BP	86.6	—19	73.8	81.5	69.1	12.9
20. 2. 1978	RR	84.3	—19	80.8	61.2	79.4	70.8
	RR	84.3	—21	78.1	50.7	38.1	31.5
	BP	80.7	—19	84.2	22.8	42.5	11.7
	BP	80.7	—21	67.2	17.3	11.2	9.9

[1]) Abbreviations of varieties see text.

In each sampling term, the viability of the buds was determined, to learn the possibility of injury under natural conditions, according to a method described in a previous paper (DAMBORSKÁ and SEGETA 1972) using budding of one-bud cuttings immediately made after taking the shoots from the vineyard. The resistance level of the buds against frost at the time of sampling was also determined in each of the sampling terms. For determining frost resistance in this and all other variants, the shoots with buds wrapped in PE foil were placed in freezing chambers in which the temperatures, starting at 0 °C, decreased at the rate of 3 °C/h until it reached the degree of frost required for each sampling term (cf. tables). The shoots with buds

were exposed to the frost for 24 h. Then the freezing chambers were turned out and when the temperature reached 0 °C the shoots were taken out, divided into separate one-bud cuttings and placed in boxes with water for budding in a glasshouse at +25 °C.

Table 2

Percentage of burst buds after hardening under natural conditions influenced by the temperature of +12 °C for 24, 72 and 120 h and by subsequent exposure to frost, and after rehardening at—3 °C and exposure to frost. Blue Portuguese sampled on Feb. 2, 1977

Pourcentage des bourgeons poussés après l'endurcissement dans des conditions naturelles influencés par une température de +12 °C pendant 24, 72 et 120 h exposés ensuite à l'action du froid et de nouveau endurcis à —3 °C et exposés au froid. Portugais bleu, prélèvement: 2 février 1977

Level of exposure to frost	Resistance immediately after sampling	Action of +12 °C			Action of +12 °C		
		24 h	72 h	120 h	24 h	72 h	120 h
					and then 96 h —3 °C		
No exposure to frost	98.5 ±1.23[1])	99.1 ±0.55	100 ±0.0	97.6 ±2.04	99.2 ±0.88	100 ±0.0	96.6 ±0.84
—17 °C	95.9 ±2.91	80.0 ±6.50	91.3 ±3.15	78.1 ±4.52	89.2 ±5.02	88.7 ±5.64	82.5 ±5.69
—19 °C	89.8 ±3.06	82.3 ±2.68	59.3 ±3.70	66.2 ±4.66	—	77.9 ±5.34	58.5 ±3.12

[1]) $s_{\bar{x}}$.

For evaluating the effect of positive temperatures on the loss of adaptation to frost, the shoots with buds were also wrapped in PE foil and exposed to +10 °C for 24, 72 and 120 h in 1976 and to +15 °C in 1978. When the time of exposure elapsed, the shoots were placed in freezing chambers and exposed to the same frost as the control variant.

In the sampling term of Feb. 2, 1977, the tests included besides the variants in which the shoots with buds had been held at +12 °C for 24, 72 and 120 h and exposed to frost of —17 and —19 °C also variants in which after the same duration of exposure to + 12 °C the buds were exposed anew to the inductive temperature for adaptation (—3 °C) for 96 h and, after that, to frost of —17 and —19 °C. Like in the tests described above, it was also in this term that frost resistance was determined immediately after taking the buds from the vines. In addition, there were controls in which the buds were not exposed to any frost (immediately after sampling on the vines, after exposure to +12 °C for 24, 72 and 120 h, and after the same exposure with subsequent hardening at —3 °C for 96 h).

In the experiment with buds sampled on March 18, 1977, the shoots with buds were first exposed to inducing temperature of —3 °C for 96 h and then to +15 °C for 24 and 72 h, followed by exposure to frost of —15 °C. Like in all previous sampling terms, the viability and resistance of the buds was determined immediately after sampling from the vines in the vineyard.

All experimental results were subjected to biometrical evaluation.

Table 3

Percentage of burst buds after 96 h of exposure to —3 °C with subsequent exposure to +15 °C for 24 and 72 h and to frost of —15° C. Date of sampling: March 18, 1977

Pourcentage des bourgeons poussés après l'endurcissement pendant 96 h à —3 °C suivi par une exposition a +15 °C pendant 24 et 72 h et par une exposition au froid à —15 °C. Prélèvement: 18 mars 1977

Variety	Viability immediately after sampling	Resistance immediately after sampling	—3 °C for 96 h and then		—3 °C for 96 h and then +15 °C for 24 h		—3 °C for 96 h and then +15 °C for 72 h	
			without exposure to frost	with exposure to frost	without exposure to frost	with exposure to frost	without exposure to frost	with exposure to frost
RR[1])	99.3 ±1.04[1])	79.6 ±2.90	97.2 ±1.58	55.9 ±0.95	97.9 ±1.99	16.7 ±5.61	96.4 ±2.48	20.1 ±5.34
BP	96.9 ±1.52	58.6 ±7.90	89.5 ±4.39	27.6 ±10.3	98.4 ±0.84	28.5 ±10.9	98.5 ±0.84	33.6 ±6.70

[1]) Abbreviations of varieties see text.

[2]) $s_{\bar{x}}$.

Results and discussion

The results presented in Tables 1 and 3 prove that in the winter season the frost resistance of vine buds is reduced by exposure to higher temperatures (+10, +12, +15 °C). This drop of resistance depends on the length of exposure to positive temperatures and, most probably, also on the term of sampling. In our experi-

Table 4

Values of variance analysis for individual terms of bud sampling on vines
Les valeurs de F de l'analyse de variance pour les époques particulières du prélèvement des bourgeons sur les ceps

Sampling date	Action of varieties	Action of positive temperatures	Action of positive temperatures × varieties
19. 1. 1976	8.55345427*	15.6447776*	5.10346610*
23. 2. 1976	35.0127117*	14.6466082*	5.76130174*
16. 1. 1978	16.1994351*	12.8666773*	5.01466020*
20. 2. 1978	19.1155490*	15.1828505*	5.91736577*

* : Significant at $P \leq 0.05$.

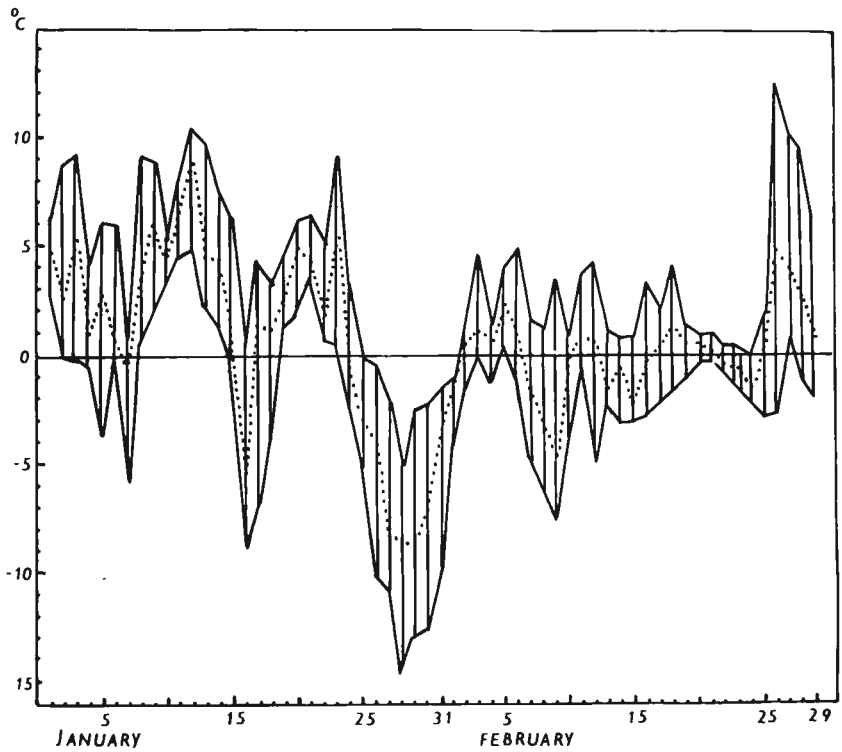

Fig. 1: Average, maximum and minimum daily temperatures in 1976.
Températures journalières moyennes, maxima et minima en 1976.

ments, the resistance did not always decrease compared with the control after the shortest exposure of 24 h. After 72 h of action of the higher positive temperatures, the resistance of the buds decreased in all the three varieties under study and in all sampling terms compared with the control (Tables 1 and 3), with the exception of the buds of the variety Riesling in the sampling term of Jan. 16, 1978 after exposure to frost of —17 °C. (Before this term, the buds had been exposed to natural conditions with daily minimum temperatures below 0 °C and average daily temperatures just slightly above 0 °C for a longer time (Fig. 3).) After 120 h action of higher constant temperatures, the resistance of the buds showed a significant drop in all varieties tested and in all the sampling terms. (The cours of temperatures in natural conditions before sampling in 1976 is shown in Fig. 1.)

The larger proportion of burst buds after 72 h as well as 24 h action of warmer conditions and after exposure to frost of —19 °C in the sampling term of Feb. 20, 1978 (Tab. 1), was most probably also influenced by the level of the actual temperature in the freezing chambers in the course of the action of the frost. In the freezing chambers, the level of the temperature is controlled by thermostat which turns the freezing aggregate in and out at levels about zero. When exposuring to frost after 24 h action of warmer conditions in this sampling term the actual average temperature throughout the exposure time (24 h) was somewhat lower (—19.4 °C) than in exposure to frost after 72 h action of higher temperatures (—18.7 °C).

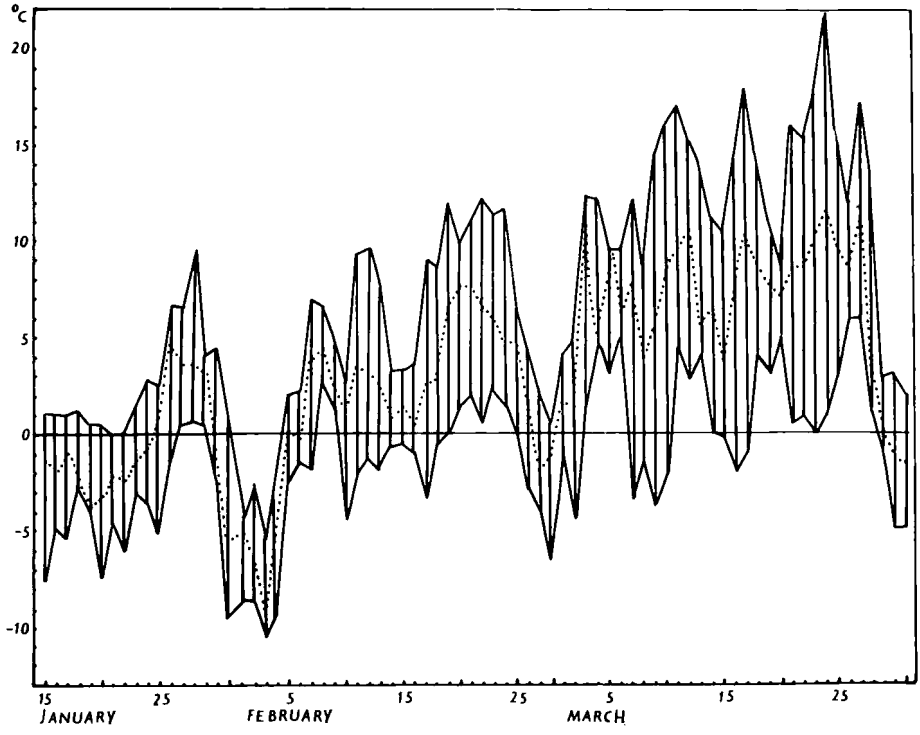

Fig. 2: Average, maximum and minimum daily temperatures in 1977.
Températures journalières moyennes, maxima et minima en 1977.

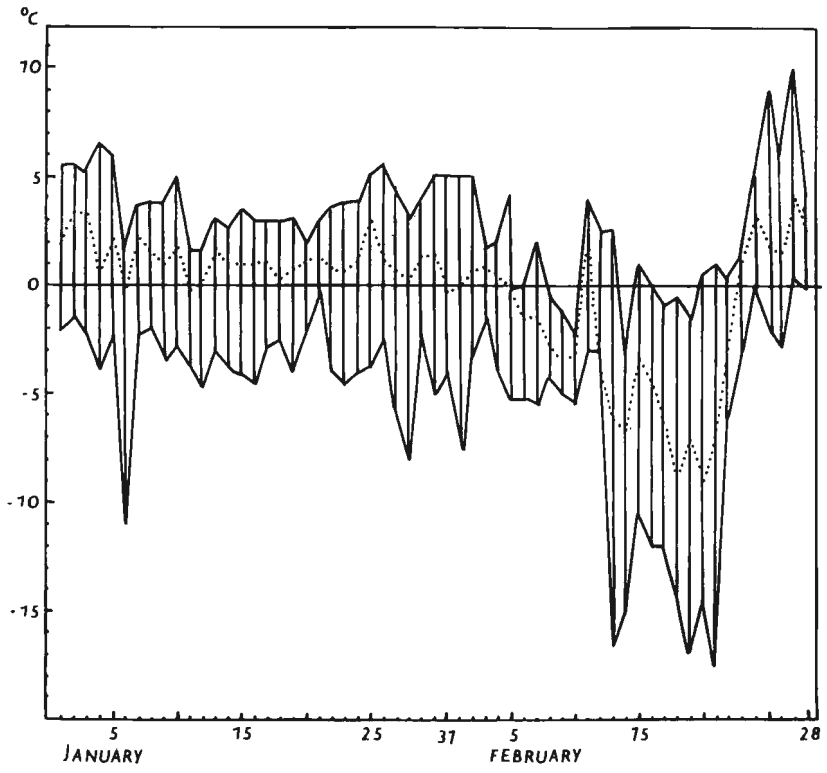

Fig. 3: Average, maximum and minimum daily temperatures in 1978.
Températures journalières moyennes, maxima et minima en 1978.

The drop of resistance of vine buds to frost after action of higher temperatures — but only after 120 h — in varieties grown in the continental climate of Armenia was demonstrated by POGOSYAN (1975). In the varieties Riesling, Müller-Thurgau and Blue Portuguese, the drop of resistance already after 24 and 48 h is in accordance with the rate of the reduction of sugar content, as observed in the varieties Riesling, S 88 and Perle von Alzey by REUTHER (1971).

The mentioned results suggest that at the end of winter when budding is initiated, the buds loose resistance much more quickly than in the preceding months, if exposed to higher temperatures.

Buds of different varieties gave different responses to the warmer conditions of winter. The highest stability of resistance, i.e. the slowest and slightest response to the action of higher positive constant temperatures, with the exception of the end of winter (Table 3), was found in the buds of the variety Riesling, unlike the remaining varieties studied. The buds of the variety Müller-Thurgau and also the buds of the variety Blue Portuguese, in 1977 (Table 2) and 1978, gave a much more pronounced response to warming.

Frosts do not necessarily occur in winter after a warmer period, the temperatures may drop only to the level of inducing temperatures for adaptation. We wanted to learn if the buds can resume their hardiness after warming. After exposure to

the constant temperature of +12 °C they were exposed to the inducing temperature of —3 °C for 96 h and then to frost again. The buds of Blue Portuguese were taken from the vines in the vineyard on Feb. 2, 1977. Although after rehardening of the buds under the mentioned conditions their resistance increased in comparison with the level after warming, the original resistance as before action of the constant temperature of +12 °C was not reached (Table 2). After this rehardening, resistance was the lower, the longer had been the exposure to the constant positive temperature before hardening.

The fact that in this test the original level of resistance was not obtained after rehardening may not or not only be due to the vine buds' inability of resuming their resistance; another reason may be that in the given physiological condition the buds may need a longer exposure than 96 h for inducing adaptation.

The original test was repeated another time a month later on March 18, 1977. Owing to the approaching start of bud burst, changing the physiological state of the buds, this repeated experiment cannot be treated as a replica of the previous trial. Since the maximum and average daily temperatures before bud sampling were fairly high (Fig. 2), the buds were first exposed to temperature inducing adaptation (—3 °C) for 96 h and then after 24 h and 72 h action of the constant temperature of +15 °C to frost of —15 °C. In this sampling term, the slight frost of —3 °C used for the induction of adaptation to frost had no inducing action, on the contrary, the resistance still dropped, as compared with the situation immediately after sampling in both varieties included in the experiment (Riesling and Blue Portuguese). The high percentage of the burst buds in the variant with exposure to the inducing temperature (— 3°C) and without subsequent action of frost proves that the injury of the buds was not caused by the frost of —3 °C but by the reduced frost resistance. After subsequent warming +15 °C for 24 and 72 h, frost resistance further dropped. We are not able to explain why the drop was more pronounced after 24 h than after 72 h of warming with subsequent exposure to frost; the actual level of frost in the freezing chamber was exactly the same (—15 °C), for both periods of exposure.

It was found earlier (DAMBORSKÁ 1978) that at constant temperatures, at which our tests were also performed, the adaptation to frost is somewhat slower than under similar, but fluctuating temperatures under natural conditions. It would be useful, therefore, to examine also the rate of dehardening under similar conditions in the natural environment.

The results of our trials as described in this paper have been treated by biometric analysis. The values of the F test of variance analysis are shown in Table 4, values of $s_{\bar{x}}$ for each variant in Tables 2 and 3.

Summary

One-year-old shoots of vine with buds hardened under natural or controlled conditions were exposed to the action of higher positive temperatures and then to frost in freezing chambers. The rate of dehardening was derived from comparison of resistance of the control with the treatments influenced by higher temperatures before exposure to frost. The level of resistance was determined according to the proportion of burst buds on one-bud shoots after action of frost.

It was found that the rate of dehardening depends on the variety, on the length of action of positive temperatures, and most probably also on the term of bud sampling from the vines.

Of the varieties studied, the stability of hardiness in winter after action of the constant temperatures of +10, +12 and +15 °C was at the highest level in Riesling, and somewhat lower in Blue Portuguese and Müller-Thurgau. However, at the end of winter the stability of the resistance of Riesling buds dropped below that of Blue Portuguese.

The drop of frost resistance intensified with prolongation of the time of exposure to higher temperatures from 24 to 120 h. The closer to the end of winter, the more pronounced this intensification.

When the buds were exposed to temperatures inducing frost adaptation (—3 °C) for 96 h, their resistance improved again, but failed to reach the original level of resistance.

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