

Frost damage of grapevines in Poland following the winter of 2005/2006

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ABSTRACT

Following the winter of 2005/2006, an assessment of frost damage was carried out on the vines of fifty grape cultivars grown in the conditions of central Poland. The minimum winter temperature of -31.6°C was recorded on 23 January 2006. The best tolerance to extremely low temperatures (no damage to shoots or buds) was shown by the American hybrids 'Alwood' and 'Zilga' of the *Vitis labruscana* group. Some damage was found on the vines of the French-American hybrids 'Marechal Foch' and 'Aurora'. The buds of the *V. vinifera* cultivars all froze. Frost tolerance of the vines classed as interspecific hybrids varied from 45% of frozen buds ('Sibera') to 100% ('Medina'). Frost damage occurred on the shoots lying above the snow line. The plant parts covered with snow were not exposed to significant damage, even in susceptible cultivars.

INTRODUCTION

For a few years now, a growing interest in the cultivation of grapevines has been observed in Poland. Grapevines are being planted in large commercial vineyards which provide raw material for wine production, on agrotourism farms, and in home gardens. Susceptibility to frost damage is an essential characteristic which determines the suitability of grapevines for growing in countries where the climate is characterized by frosty winters (Elfving et al. 1985, Lisek et al. 1992/93, Sękowski and Myśliwiec 1996, Fallahi et al. 2001, Kozma 2002, Kriszten 2002, Lisek 2004 and 2005). Frost resistance of plants of the genus *Vitis* is to a large degree determined by a genetic factor, where selection is influenced by the climatic conditions prevailing in the areas of origin, i.e. the areas of natural diversification of the species (Galet 1988, Alleweldt et al. 1990, Hemstad and Luby 1990, Luby 1991, Reisch and Pratt 1996). Tolerance of grapevines to the effects of low temperatures is modified by the weather conditions during the vegetative period, plant age, health status and yielding (Hajdu and Gabor 1997, Wample et al. 1997).

Susceptibility of perennial plants to low temperature damage is studied by means of various methods, including survival tests carried out under controlled conditions (Hołubowicz et al. 1982, Quamme 1991). Of large practical importance is the evaluation of frost resistance of plants that over-winter in the field, being exposed not only to low temperatures, but also to temperature fluctuations and wind (Plocher and Parke 2001).

The aim of the study was to assess the frost resistance of the buds on one-year-old woody shoots as a characteristic feature which has a significant effect on the cropping of grapevines in Polish conditions. The assessment included old cultivars and a dozen or so of new prospective genotypes of which the resistance to frost in Polish conditions had not been determined on the basis of the results of systematic studies.

MATERIAL AND METHODS

The assessment of frost damage of vines was carried out in the field collection of grapevines located in the Pomological Orchard of the Institute of Pomology and Floriculture in Skierniewice, on a podsolic soil graded Class IV, slightly acidic (pH 6.3) and containing 1.3% of organic matter. Each of the genotypes was represented by three ungrafted (own-rooted) vines, planted at a spacing of 2.5×1 m and trained according to the 'low-head' method. One to three trunks, 20 cm in height, were formed on the vines. After winter pruning, 6-8 evenly spaced canes, each with 2-3 buds, were left on the vine (spur pruning). Young shoots developing from the buds were tied to stakes, loosely at the height of 0.5-0.7 m, and tightly at the height

of 1.50-1.70 m above the soil surface. In July the shoots were pruned above the 10th-12th leaf past the last cluster of grapes. Lateral branches of the young shoots were cut back above the first or second leaf counting from the base.

Frost damage of the vines was assessed following the weather conditions described in Table 1. The course of the weather in the autumn of 2005 was favourable for preparing the vines for winter properly. First mild frosts (-1°C) occurred in Skierniewice on 19 October but did not damage the partly woody shoots. Defoliation of the vines took place only after the frost recorded on 28 October 2005. There were no drops in temperature below -10°C in November and December which allowed the plants to become gradually adapted to winter conditions. In the first four days of January the maximum temperatures were above 0°C and there was an abundant snowfall. At least a 30-cm-thick snow cover stayed until the calendar end of winter. The subsequent days of January and February were cold, without a significant thaw. Extremely low temperatures below -30°C , occurred in the last ten days of January.

Table 1. Climatic conditions in Skierniewice in the period October 2005 – April 2006

Month	Air temperature and date it occurred on		Average monthly air temperature ($^{\circ}\text{C}$)
	Minimum	Maximum	
October 2005	-4.0°C (28.10)	23.0°C (09.10)	8.6
November	-5.6°C (24.11)	13.1°C (01.11)	2.7
December	-9.1°C (29.12)	5.5°C (24.12)	-0.6
January 2006	-31.6°C (23.01)	1.6°C (01.01)	-9.0
February	-19.9°C (05.02)	6.5°C (18.02)	-3.2
March	-18.0°C (08.03)	13.7°C (29.03)	-1.4
April	-2.1°C (07 and 12.04)	21.0°C (25.04)	8.5

Out of the 128 cultivars and hybrids represented in the collection, 50 valuable cultivars of grapevine were selected for the study, out of which 5 belong to *Vitis vinifera* and 45 belong to the three basic groups of hybrids:

- *Vitis labruscana*, hybrids obtained by crossing *V. vinifera* with *V. labrusca*, also called American hybrids;
- French-American hybrids, originated in France as a result of crossing *V. vinifera* with *V. rupestris*, and with *V. lincecumii*, until mid-1900s;
- interspecific (multiple) hybrids produced by crossing the French-American hybrids with *V. vinifera*, or with other hybrids originating from *V. amurensis* ('Kunbarat', 'Rondo', 'Sibera', 'Wostorg'), or from *V. labrusca* ('Alden', 'V 64035').

Information on the cultivars, such as the skin colour of the berries, what the fruits are used for, and the origin of the cultivars, is given in Table 2 which also contains the results of the study. Frost damage to the buds that were not covered with snow during the frosts was assessed at the time of cutting back the woody shoots in the second half of March and at the beginning of April. From each of the plots occupied by the cultivars, 4 samples of cane were taken, each with 50 buds. Three samples (replications) came from different vines, while the fourth one consisted of the shoots taken in equal parts from the three plants being assessed. One-year-old completely woody shoots, free from mechanical damage and disease symptoms, were taken from the vines of the age of at least 6 years. The buds under assessment were cut across with a knife and the colour of the incipient shoots was determined. The over-wintering bud was considered to be dead if both the main bud and the replacement buds underneath were dark brown. The obtained results, expressed as a percentage of the buds damaged by frost in relation to the total number of buds, were analyzed statistically using the variance analysis method which was applied to the values after Bliss' transformation. The significance of the means was evaluated using Duncan's test at the 5% level.

In the last ten days of April, an assessment of the ability to last through winter was carried out on the buds remaining on the vines, which at the time of the frosts were below the snow line. During the vegetative period, the effect of low winter temperatures on the growth and yielding of the vines was also assessed.

RESULTS

Frost resistance of 50 grapevine genotypes, expressed as the susceptibility of over-wintering buds to low temperature damage, was highly varied (Table 2). The only cultivars for which no damage to the buds overwintering without snow cover was recorded were 'Alwood' and 'Zilga', classed as the so-called American hybrids (*V. labruscana*). Very good tolerance to low temperatures was also shown by the vines of the French-American hybrids: 'Marechal Foch' (less than 4% of frozen buds) and 'Aurora' (19% of damaged buds), which originated by crossing *V. vinifera*, *V. lincedumii* and *V. rupestris*. The most susceptible to frost damage were the buds on the vines of the cultivars of the grapevine proper. In the five *V. vinifera* cultivars, two with green and yellow fruits – 'Chrupka Złota' ('Chasselas Doré'), 'Perła Czabańska' ('Pearl of Chsaba'), and three dessert cultivars from Slovakia – 'Topas', 'Diamant', 'Opal', all of the buds overwintering without snow cover froze completely.

Significant differences in frost resistance were found within each of the three groups of hybrids. The American hybrids, such as 'Bath', 'Buffalo', 'Einset', 'Iza', 'Price', 'Veldze', were significantly more susceptible to frost damage than

'Alwood'. On the vines of two of them – 'Suwile' and 'Canadice', more than 95% of the buds were frozen. Also the cultivars 'Cascade' and 'Seyval' were much more susceptible to frost damage than 'Aurora' and 'Marechal Foch', which belong to the same group of the French-American hybrids.

The so-called interspecific hybrids constituted the most varied group of cultivars. The buds of some of the interspecific hybrids, over-wintering without snow cover, among them 'Aloszeńkin', 'Arkadia', 'Gołubok', 'Kodrianka', 'Olga', 'Nero', 'Palatina', 'Rondo', 'Regent', 'Sevar', and 'Wostorg', froze completely. In others, such as 'Bianca', 'Iliczewskij Rannyj', 'Kunbarat', 'Refren', 'Sibera', 'V 71141', and 'Veeblanc', a number of the buds lasted well through the winter.

The assessment of the vines that was carried out in the last ten days of April revealed that in the vines of all the cultivars included in the study, the trunks, shoots and most of the snow-covered buds not removed during the March pruning survived the winter well. The development of buds and new shoots, and the fruiting of the vines evaluated during the vegetative season, were not disrupted by winter damage.

DISCUSSION

The results presented here confirm varied tolerance of grapevines to low temperature damage, the underlying cause of which is genetic diversification (Reisch and Pratt 1996). What remains indisputable is the high susceptibility to frost of the *V. vinifera* cultivars the buds of which froze at temperatures below –20°C, –22°C (Alleweldt et al. 1990). This has also been explicitly confirmed in the Polish conditions (Lisek et al. 1992/1993, Lisek 2005). The author's own studies have demonstrated good frost resistance of some of the American hybrids ('Alwood', 'Zilga') and the French-American ones ('Marechal Foch', 'Aurora'). *V. labrusca*, used in the breeding of the American hybrids, and *V. riparia*, used in obtaining the French-American hybrids, are a good source of resistance to frost, since the overwintering majority of their buds and shoots can tolerate the effects of temperatures from –31°C to –40°C (Galet 1988, Hemstad and Luby 1990, Luby 1991). As various studies have shown, frost resistance, resulting from the transfer of genes during breeding procedures, is markedly varied among the American and interspecific hybrids.

Table 2. Frost damages to grapevines following the winter of 2005/2006, Skierniewice

Cultivar and colour of berry skin*	Principal use**	Origin and country of breeding***	Frozen buds (%)
Alden (R-B)	T	IH (USA)	94.4 lm
Aloszeńkin (G)	T	IH (Russia)	100.0
Alwood (B)	G	AH (USA)	0 a
Arkadia (G)	T	IH (Ukraine)	100.0
Aurora (G)	P,G	FRH (France)	18.9 d
A 1704 (G)	T	IH (USA)	98.5 n
Bath (B)	T	AH (USA)	41.5 gh
Bianca (G)	P	IH (Hungary)	88.2 k
Buffalo (B)	G	AH (USA)	17.9 d
Canadice (R)	T	AH (USA)	98.9 n
Cascade (B)	P	FRH (France)	37.5 fg
Century (R-B)	T	IH (USA)	100.0
Einset (R)	T	AH (USA)	54.5 i
Festivee (B)	T	IH (Canada)	93.8 lm
Fredonia (B)	G	AH (USA)	6.8 c
Gotubok (B)	P	IH (Ukraine)	100.0
Iliczewskij Rannyj (B)	P	IH (Ukraine)	62.5 j
Iza (G)	T	AH (Unknown)	61.0 j
Kodrianka (B)	T	IH (Moldova)	100.0
Kristaly (G)	P	IH (Hungary)	98.9 n
Kunbarat (G)	P	IH (Hungary)	42.0 gh
Marechal Foch (B)	P	FRH (France)	3.9 b
Medina (B)	P	IH (Hungary)	100.0
Nero (B)	T	IH (Hungary)	100.0
Olga (G)	T	IH (Moldavia)	100.0
Palatina (G)	T	IH (Hungary)	100.0
Price (B)	T	AH (USA)	44.0 gh
Reform (G)	P	IH (Hungary)	94.7 lm
Refren (G)	P	IH (Hungary)	41.0 gh
Regent (B)	P	IH (Germany)	100.0
Rondo (B)	P	IH (Germany)	100.0
Reliance (R)	T	AH (USA)	41.0 gh
Seyval (G)	P	FRH (France)	42.0 gh
Sevar (B)	P	IH (Czech)	100.0
Sibera (G)	P	IH (Germany)	45.0 h
Supaga (G)	G	AH (Latvia)	63.5 j
Suwile (G)	T	AH (Latvia)	95.9 m
V 64 035 (G)	P	IH (Canada)	92.1 l
V 71 141 (G-R)	P	IH (Canada)	31.5 ef
Wostorg (G)	T	IH (Russia)	100.0
Veeblanc (G)	P	IH (Canada)	27.9 e
Veldze (G)	P,T	AH (Latvia)	31.0 e
Viktoria gyöngye (G)	P	IH (Hungary)	100.0
Zalagyöngye (Perla Zali) (G)	P,T	IH (Hungary)	100.0
Zilga (B)	P	AH (Latvia)	0 a
<i>Vitis vinifera cultivars</i>	-	-	100.0

Means followed by the same letter do not differ significantly at $p = 0.05$

Colour of berry skin: G – green-yellow, R – rose, B – blue-black. ** Principal use: T – table grapes, P – for processing, G – high training in home garden. *** Origin: AH – American hybrids, FRH – French-American hybrids, IH – interspecific hybrids

A comparison of the author's own results with those of other authors indicates that the introduction of new cultivars to cultivation should be preceded by an evaluation of these genotypes in specific environmental conditions. Following the fall in temperature down to -31.6°C in Skierniewice, nearly 99% of the overwintering buds of the cultivar 'Kristaly' were recorded as having suffered frost injury. However, drops in temperature down to -29°C in Hungary and -31°C in the Czech Republic did not lead to any serious damage to the buds of this cultivar (Kriszten 2002). In Hungary the cultivars 'Palatina' ('Prim') and 'Nero' are considered to be tolerant to low winter temperatures, whereas the results presented here and those obtained earlier for Skierniewice (central Poland) indicate that those cultivars are on the borderline between the sensitive and medium-sensitive cultivars (Kozma 2002, Lisek 2004). During the 2002/2003 winter season, buds of the cultivar 'Reliance' suffered frost penetration in 41% of cases, whereas in the conditions of the northern states of the USA a similar extent of damage was recorded at temperatures below -34°C (Fallahi et al. 2001). Greater susceptibility to frost damage may be a result of a shorter vegetative season and a lower sum of active temperatures.

Despite the differences mentioned above, the presented results are to a high degree in agreement with the data published earlier in Poland and abroad. The cultivars 'Marechal Foch' and 'Aurora' are more tolerant to frost than 'Seyval' (Sękowski and Myśliwiec 1996, Plocher and Parke 2001, Lisek 2004). The cultivar 'Zilga' copes extremely well with frosty winters, like it does in Northern USA, and is far more tolerant than the cultivars 'Bianca', 'Reform', 'Rondo' and 'Veldze' (Plocher and Parke 2001). In Skierniewice the hybrid 'V 71141' was found to be more tolerant to frost than 'V 64035', like it is in the south of Canada (Elfving et al. 1985).

When assessing the sensitivity of plants to frost penetration, it is necessary to take into consideration factors other than genotypical or climatic ones, such as plant age, productivity and health status. Resistance to frost is reduced by excessively abundant cropping and infections with fungal diseases (Hajdu and Gabor 1997, Wample et al. 1997). The factors can have an effect on the differences in the results of frost resistance from one year to the next and the relationships between cultivars. Studies similar to those presented here were carried out in the collection of cultivars in Skierniewice after the 2002/2003 season when the minimum winter temperature fell down to -25.4°C on 9 January 2003 (Lisek 2004). In March 2003, frost damage was found in 9% of the buds on the vines of the cultivar 'Marechal Foch', whereas in 2006, after the temperature had fallen down to -31.6°C , 4% of the buds of this cultivar suffered damage. The extent of frost damage to the buds of 3 seedless cultivars: 'Canadice', 'Einset' and 'Reliance', after the winter of 2002/2003 was similar, but following the winter of 2005/2006, the buds of the cultivar 'Canadice' proved to be far more susceptible to

frost damage than those of the cultivars 'Einset' and 'Reliance', which can be attributed to the abundant yielding of the vines in the year preceding the assessment.

The studies described here are practical in nature, and are not so much an assessment of 'frost damage' as of 'winter damage', where the extent of the losses is not only influenced by absolute temperature, but also the time of its occurrence, the range of temperature fluctuations and wind (Plocher and Parke 2001). One of the species whose plants easily undergo deacclimatization during periods of warmer weather is *V. amurensis*, and the genotypes originating from it should be carefully evaluated under the conditions of winter temperature fluctuations (Alleweldt et al. 1990). Due to climatic factors, the results of systematic studies of the frost resistance of grapevines should constitute an essential element of the assessment of the usefulness of new cultivars for cultivation in Poland. Such results should be taken into consideration when regionalizing crop production and selecting a vine training system that could potentially provide protection to grapevines in winter.

CONCLUSIONS

- Frost resistance of overwintering buds of grapevine hybrids is highly varied. This characteristic should be assessed in the area of cultivation without changing the agro-technical and plant protection methods normally used in local vineyards.
- Very high tolerance to low temperature damage was shown by some American ('Alwood', 'Zilga', 'Fredonia') and French-American hybrids ('Marechal Foch', 'Aurora').
- Frost resistance of the buds of interspecific hybrids varied significantly depending on the genotype, and must be verified in the Polish conditions. The buds of prospective interspecific hybrids developed for processing, such as 'Bianca', 'Medina', 'Regent', and 'Rondo', were much more susceptible to frost damage than the buds of frost-hardy French-American hybrids still recommended for commercial growing. Interspecific dessert hybrids, e.g. 'Aloszeńkin', 'Arkadia', 'Century', 'Nero', and 'Palatina', were significantly inferior in terms of frost resistance to the American hybrids such as 'Iza' or 'Reliance'.

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USZKODZENIA MROZOWE WINOROŚLI PO ZIMIE 2005/2006 W WARUNKACH POLSKI

Streszczenie: Po zimie 2005/2006 oceniano uszkodzenia mrozowe na krzewach pięćdziesięciu odmian winorośli uprawianych w warunkach centralnej Polski. Minimalną temperaturę zimową, wynoszącą $-31,6^{\circ}\text{C}$, zanotowano 23 stycznia 2006. Najlepsza tolerancja na ekstremalnie niską temperaturę – brak uszkodzeń pędów i pąków, cechowała odmiany ‘Alwood’ oraz ‘Zilga’, zaliczane do grupy *Vitis labruscana* (mieszańce amerykańskie). Niewielkie uszkodzenia zanotowano na krzewach odmian ‘Marechal Foch’ oraz ‘Aurora’ (mieszańce francusko-amerykańskie). Całkowicie przemarzły pąki odmian zaliczanych do *V. vinifera*. Tolerancja mrozowa krzewów zaliczanych do mieszańców niespecyficznych (wielokrotnych) była zróżnicowana, od 45% przemarzniętych pąków (‘Sibera’) do 100% (‘Medina’). Uszkodzenia mrozowe wystąpiły na pędach położonych ponad linią śniegu. Części roślin okryte śniegiem nie były narażone na istotne uszkodzenia, nawet u odmian wrażliwych.

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