FROST DAMAGE OF BUDS ON ONE-YEAR-OLD SHOOTS OF WINE AND TABLE GRAPEVINE CULTIVARS IN CENTRAL POLAND FOLLOWING THE WINTER OF 2008/2009

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(Received September 14, 2009/Accepted November 9, 2009)

A B S T R A C T

Following the winter of 2008/2009, an assessment of frost damage was carried out on the vines of forty-one wine and twenty-five table grape cultivars grown in central Poland. The minimum winter temperature of –23°C was recorded on 6 January 2009. The best tolerance to low temperatures (no damage to shoots or buds) was shown by the interspecific hybrids 'Price', 'Supaga' and 'Zilga' of the *Vitis labruscana* group and hybrid 'Baco Noir' originated from *V. vinifera* and *V. riparia*. Frost injuries of the other grapevines classed as interspecific hybrids varied from 0.7% of frozen buds ('Aurore' and 'Refren' – hybrids of *V. vinifera*, *V. rupestris*, and *V. lincecumii*) to 99.5% ('Kodrianka'). 'Riesling' (13.5% of frozen buds) showed the best tolerance to frost damage from all the *V. vinifera* cultivars. The buds of the *V. vinifera* cultivar 'Favorit' all froze. Plant parts which were covered with soil and snow were not exposed to significant damage, even in susceptible cultivars.

Key words: buds, grapevine, cultivars, frost, winter injuries

INTRODUCTION

Tolerance to frost damage is an essential characteristic which determines how suitable grapevines are for being grown in countries where the climate is characterized by cold winters (Elfving et al., 1985; Lisek et al., 1992/93, Sękowski and Myśliwiec, 1996; Fallahi et al., 2001; Korbuly, 2002; Kozma, 2002; Kriszten, 2002; Lisek, 2004; 2007; Kuleba, 2005). Frost resistance of plants of the genus *Vitis* is to a large extent determined by a genetic factor (Galet, 1988; Alleweldt et al., 1990;

Hemstad and Luby, 1990; Luby, 1991; Reisch and Pratt, 1996).

Average cold resistance of buds wintering on *V. vinifera* bushes amounts to –16°C (Nikov et al., 1983). Frost-resistance of grapevine cultivars commonly widespread in Central Europe is described in Slovak conditions, which are similar to Polish, by Pospišilová (1981). According to this author and other researchers (Alleweldt et al., 1990; Korbuly, 2002), 'Riesling' cultivar of *V. vinifera* proved to be most tolerant to cold, with its buds able to endure drops of temperature even to 22-25°C below zero. 'Traminer Rot' and 'Zweigelt' (Moser, 1962) are marked by a similar tolerance. Pospišilová counts 'Pinot Gris', 'Pinot Noir' and 'Chardonnay' among cultivars with good tolerance. Their buds most often freeze at temperatures from –20°C to –22°C. Average tolerant cultivars, with buds that freeze at temperatures from –18°C to –20°C, are 'Sylvaner', 'Mueller Thurgau' and 'Scheurebe'. Low tolerant variants which can endure –16°C are, according to Pospišilová, 'Portugieser' and 'Sauvignon'. Table cultivars tolerant to low temperatures are 'Chaselas Dore' (also for wine) and 'Pearl of Csaba'. 'Favorit' is more susceptible.

From the newer cultivars of *V. vinifera* or interspecific hybrids, which are also considered as *V. vinifera*, and which are resistant to frost are 'Cabernet Cortis', 'Regent', 'Rondo', 'Roesler', 'Solaris', 'Milia', 'Muscat Bleu'. The less tolerant are 'Acolon', 'Kerner' and 'Sieger', and little tolerance is observed in the case of 'Dornfelder' (Hillebrand et al., 2003; Kaserer and Blahous, 1999; Basler, 2002; Pospišilová et al., 2005). Hybrids originating in Hungary are characterized by very high ('Refren', 'Bianca'), high ('Nero', Medina') or moderate ('Palatina') tolerance to cold (Hajdu and Gabor, 1997; Korbuly, 2002; Kozma, 2002). In Belarus, Ukraine and southern Russia, overwintering buds of East European hybrids are able to endure to –30°C ('Ananasnyj Rannyj', 'Zilga'), –25°C ('Aloszeńkin', 'Supaga'), from –21°C to –23°C ('Arkadia'), and to –22°C ('Kodrianka') (Łojko and But-Gusaim, 1990; Kostrikin, 2002; Abuzov, 2009).

In the northern states of the USA and south-eastern Canada (Ontario region), interspecific hybrids are grown. They were created by crossing *V. vinifera* with American species which are more tolerant to winter frosts of –25°C than *V. vinifera* (Elfving et al., 1985; Plocher and Parke, 2001). According to the authors cited, in France, in the second half of 19th century and at the beginning of the 20th, highly resistant hybrids were created such as 'Aurore', 'Baco Noir', 'Marechal Foch', 'Seyval' and 'Verdelet'. This was done by crossing *V. vinifera, V. riparia, V. rupestri,* and *V. lincecumii*. These exceptionally frost-resistant grapevines are known as French-American hybrids. Among hybrids obtained by crossing *V. vinifera* with *V. labrusca*, 'Buffalo', 'Reliance', and 'Canadice' proved very frost resistant, and 'Einset', 'Price' and 'Festivee' were a little less frost resistant

(Elfving et al., 1985; Reisch et al., 1999; Fallahi et al., 2001).

Various methods are used to study the resistance of perennial plants to low temperature damage. One such method includes the survival tests carried out under controlled conditions (Hołubowicz et al., 1982; Quamme, 1991). The scale of frost damage depends not only on low temperature but also on temperature fluctuations and wind. This is the reason why evaluation of frost resistance in field conditions is of such importance (Plocher and Parke, 2001). Tolerance of grapevines to the effects of low temperatures is modified by the plant age, health status, yielding, and weather conditions during the vegetative period (Hajdu and Gabor, 1997; Wample et al., 1997).

The aim of the study was to assess the frost tolerance of the buds on one--year-old woody shoots of standard and perspective grape cultivars. These are cultivars recommended for home gardens, farm tourism as well as commercial vineyards providing material for wine production.

MATERIAL AND METHODS

The assessment of frost damage on vines was carried out in the field collection of grapevines located in the Pomological Orchard of the Institute of Pomology and Floriculture in Skierniewice, Poland. The test took place 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 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). In July the shoots were pruned above the 10^{th}-12^{th} leaf beyond the last cluster of grapes. Lateral branches of the young shoots were cut back above the first or second leaf counting from the base. In the season of 2008, a chemical protection against fungal diseases was carried out, using agents containing copper, sulphur, mancozeb and difenoconazol. Bushes of those cultivars which are potentially susceptible to frost were covered in November with 30 cm of soil and uncovered in the first two weeks of March.

Frost damage was assessed following the weather conditions described in Table 1. The course of weather in the summer and autumn of 2008 was unfavourable for properly preparing the vines for winter. August was rainy and the average temperature in September was significantly lower than usual. First frosts causing mass leaf-falling appeared relatively late – on the 17^{th} of November. The minimal winter temperature occurred on the 6^{th} of January 2009, when there was just a thin layer of snow.

A collection consisting of 234 bushes has been added to annually since 1992. An evaluation of frost resistance was carried out separately for the old, ownrooted vines planted in the years 1992-1998,

Table 1. Climatic conditions in Skierniewice in the period July 2008 – April 2009

Month	Air temperature and date it occurred on		Average monthly air temperature [°C]	Precipitation monthly [mm]
	Minimum	Maximum		
July 2008	7.0°C (03.7)	31.2°C (12.07)	18,6	52,4
August	5.7°C (31.08)	30.5°C (12.08)	18.1	92.2
September	1.9°C (26-27.09)	31.0°C (06.09)	11.9	55.0
October	0.2°C (26.10)	20.5°C (30.10)	9.5	25.8
November	–3.5°C (18.11)	16.3°C (01.11)	5.0	20.8
December	–8.6°C (29.12)	10.4°C (01.12)	1.1	47.0
January 2009	–23.0°C (06.01)	5.0°C (26.01)	–3.1	18.8
February	–16.5°C (22.02)	11.1°C (07.02)	–1.2	21.0
March	–9.1°C (26.03)	12.0°C (31.03)	2.4	38.0
April	–4.0°C (20.04)	24.8°C (30.04)	10.0	11.0

and for the young vines grafted on the *V. berlandieri* x *V. riparia* rootstocks (SO 4, 5 BB, 125 AA) planted in the year 2007.

Information on the cultivars, such as the skin-colour of the berries and the origin of the cultivars, is given in Table 2. Table 2 also contains the results of the study. Frost damage to the buds that were not covered with soil or snow during the frosts was assessed at the time of cutting back the woody shoots. This was done 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, well matured woody shoots were free from mechanical damage and disease symptoms. A cut was made across the buds under assessment 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. Obtained results, expressed as a percentage of the buds damaged by frost in relation to the total number of buds on a shoot, were analyzed statistically. The variance analysis method which was applied to the values after Bliss' transformation was used. The significance of the means was evaluated using Duncan's test at 5% probability level. At the end of April and the beginning of May, an evaluation of buds wintering on shoots covered with soil during winter was carried out.

RESULTS

Frost resistance of 66 grapevine cultivars, expressed by the tolerance of overwintering buds to low temperature damages, was highly varied (Tab. 2 and 3). Acquired results were compared in 4 groups separately: old bushes of wine cultivars planted in the period 1992-1998, young bushes

Table 2. Frost damage to wine grapevines following the winter of 2008/2009, Skierniewice, Poland

Cultivar and colour of berry skin[1]	Origin and country of breeding[2]	Frozen buds [%]
Planted 1992-1998		
Aurore (B)	IH (France)	0.7 b*
Baco Noir (N)	IH (France)	0.0 a
Bianca (B)	IH (Hungary)	56.5 g
Marechal Foch (N)	IH (France)	11.4 d
Medina (N)	IH (Hungary)	43.0 f
Refren (B)	IH (Hungary)	0.7 b
Regent (N)	IH (Germany)	58.5 g
Rondo (N)	IH (*Amur*) (Germany)	56.5 g
Seyval (B)	IH (France)	19.4 e
Sibera (B)	IH (*Amur*) (Germany)	5.4 c
Zilga (N)	IH (*Lab*) (Latvia)	0.0 a
Planted 2007		
Acolon (N)	*Vin* (Germany)	99.9 p
Cabernet Cortis (N)	IH (Germany)	55.5 f-h
Chardonnay (Gm 53) (B)	*Vin* (France – Germany)	66.5 ij
Chasselas Dore (B)	*Vin* (unknown)	60.1 hi
Cserszegi Fueszeres (B-R)	*Vin* (Hungary)	37.5 de
Dakapo (N)	*Vin* (Germany)	91.6 no
Dornfelder (N)	*Vin* (Germany)	40.9 e
Dunaj (N)	*Vin* (Slovakia)	91.6 no
Johanniter (B)	IH (Germany)	33.3 c-e
Kerner (B)	*Vin* (Germany)	76.7 k
Merzling (B)	IH (Germany)	49.5 f
Milia (B-R)	*Vin* (Slovakia)	61.0 hi
Mueller Thurgau (B)	*Vin* (Germany)	99.3 p
Nektar (B)	*Vin* (Hungary)	25.5 c
Orion (B)	IH (Germany)	59.1 g-i
Pinot Gris (R)	*Vin* (France)	84.2 lm
Pinot Noir (N)	*Vin* (France)	75.1 k
Pinot Noir Precoce (N)	*Vin* (France)	63.1 hi
Portugieser (N)	*Vin* (Austria)	99.7 p
Rathay (N)	IH (Austria)	75.5 k
Riesling (B)	*Vin* (Germany)	13.5 b
Roesler (N)	IH (Austria)	30.0 cd
Saphira (B)	IH (Germany)	5.9 a
Sauvignon (B)	*Vin* (France)	94.5 o
Scheurebe (B)	*Vin* (Germany)	73.2 jk
Sieger (B-R)	*Vin* (Germany)	84.0 lm
Solaris (B)	IH (Germany)	50.5 fg
Sylvaner (B)	*Vin* (Austria)	89.6 mn
Traminer Rot (R)	*Vin* (Italy)	65.7 ij
Zweigelt (N)	*Vin* (Austria)	80.5 kl

*Means followed by the same letter do not differ significantly at p = 0.05. The averages were compared separately for both planting dates.

[1]Colour of berry skin: B (blanc) – green-yellow, R – rose, N (noir) – blue-black

[2]Origin: IH – interspecific hybrid from crossing *V. vinifera*, *V. riparia or V. rupestrisor V. lincecumii*, *Amur* – hybrid with *V. amurensis*, *Lab* – hybrid with *V. labrusca*, *Vin* – *V. vinifera*

Table 3. Frost damages to table grapevines following the winter of 2008/2009, Skierniewice, Poland

Cultivar and colour of berry skin[1]	Origin and country of breeding[2]	Frozen buds [%]
Planted 1992-1998		
Aloszeńkin (B)	Seedling of *Vin* (Russia)	57.5 g*
Ananasnyj Rannyj (B)	IH (*Lab*) (Ukraine)	6.9 b
Arkadia (B)	IH (Ukraine)	93.2 I
Buffalo (N)	IH (*Lab*) (USA)	18.0 c
Canadice (R)	IH (*Lab*) (USA)	7.4 b
Century (R-N)	IH (USA)	45.0 ef
Einset (R)	IH (*Lab*) (USA)	27.5 d
Festivee (N)	IH (*Lab*) (Canada)	13.5 c
Kodrianka (N)	IH (Moldova)	99.5 j
Nero (N)	IH (Hungary)	39.0 e
Palatina (B)	IH (Hungary)	48.0 f
Pearl of Csaba (B)	*Vin* (Hungary)	51.5 fg
Price (N)	IH (*Lab*) (USA)	0.0 a
Supaga (B)	IH (*Lab*) (Latvia)	0.0 a
Reliance (R)	IH (*Lab*) (USA)	18.9 c
Topas (B)	*Vin* (Slovakia)	79.0 h
Planted 2007		
Eszter (N)	IH (Hungary)	79.1 b
Fanny (B)	*Vin* (Hungary)	98.5 d
Favorit (B)	*Vin* (Hungary)	100.0 e
Galanth (N)	IH (Germany)	92.1 c
Ganita (R)	IH (Germany)	83.7 b
Garant (B)	IH (Germany)	17.4 a
Lilla (B)	*Vin* (Hungary)	84.6 b
Muscat Bleu (N)	IH (Switzerland)	14.4 a
Verdelet (B)	IH (France)	16.3 a

[1], [2], *Explanation, see Table 2

of wine cultivars planted in the spring of 2007, old vines of table cultivars planted in the years 1992-1998 and young bushes of table cultivars planted in the spring of 2007.

In the group of cultivars for processing, whose vines were planted in 1992-1998, the buds of 'Baco Noir' and 'Zilga' survived the winter best and no frost damage was observed. Vines of 'Aurore' and 'Refren' also proved frost resistant (under 1% of damaged buds), along with 'Sibera' (5.4%) and 'Marechal Foch' (11.4%). Considerably more susceptible to frost damage were buds of 'Seyval' and 'Medina'. Most susceptible in this group were 'Bianca', 'Rondo' and 'Regent' cultivars.

Within the group of cultivars, whose vines were planted in the spring of 2007, the highest frost resistance was shown by 'Saphira', with only 5.9% of buds frozen. Among *V. vinifera* cultivars, the least

frost damage was observed in the case of 'Riesling' (13.5% of buds frozen) and 'Nektar' (25.5%). Satisfactory and statistically equal was the frost resistance of 'Cserszegi Fuesze-res', 'Dornfelder', 'Johanniter' and 'Roesler', which were significantly ahead of 'Merzling'. Among the cultivars where the damage did not exceed 60%, 'Cabernet Cortis', 'Orion' and 'Solaris' were placed. More susceptible than those listed so far were 'Chardonnay' (clone Gm 53), 'Chasselas Dore', 'Milia', 'Pinot Noir Precoce' and 'Traminer Rot'. But their damage was not higher than 70%. Damage not exceeding 81% was recorded in the 'Kerner', 'Pinot Noir', 'Rathay', 'Scheurebe' and 'Zweigelt' cultivars. In the next category of susceptibility, where more than 81% of buds froze, belonged 'Pinot Gris', 'Sieger' and 'Sylvaner'. 'Dakapo', 'Dunaj' and 'Sauvignon' were the cultivars where more than 90% of the buds did not survive. In the most susceptible group with damages of 95% and higher were 'Acolon', 'Mueller Thurgau' and 'Portugieser'.

Table grapevines cultivar planted in the years 1992-1998, where no frost damage was observed, were 'Price' and 'Supaga'. Good frost resistance, with damages below 10%, was noted in the case of 'Anansnyj Rannyj' and 'Canadice'. Considerably more buds froze on the bushes of 'Buffalo', 'Festivee' and 'Reliance' cultivars, but still the damage was not higher than 20%. 'Einset' and 'Nero' turned out to be more susceptible. Frost damage not exceeding 50% was observed in the case of 'Century' and 'Palatina'. Vines of 'Aloszeńkin', 'Pearl of Csaba' and 'Topas' cultivars suffered more than 50% damage. The most susceptible among the table cultivars assessed in this group were 'Arkadia' and 'Kodrianka', with frost damage of buds higher than 90%.

Among dessert cultivars whose vines were planted in the spring of 2007, 'Muscat Bleu', 'Verdelet' and 'Garant' were most tolerant to low temperatures (less than 20% of frozen buds). Far more susceptible were the buds of 'Eszter', 'Ganita' and 'Lilla' which suffered damage of about 80%. More than 90% of buds froze on the bushes of 'Fanny' and 'Galanth'. All buds froze in the case of 'Favorit' cultivar.

Buds which were covered for the winter with at least 5 cm of soil continued to develop properly in the second half of April even in the case of those cultivars which are most susceptible to frost damage.

DISCUSSION

A moderately mild winter with a minimum temperature of –23°C allowed the assessment and comparison of frost resistance in cultivars considered to have an average tolerance to frost damage, including numerous genotypes of *V. vinifera*. In this group, temperatures falling below –25°C caused all the wintering buds (or the majority of them) that were not covered with soil, mulch or snow, to freeze.

Our observations concerning frost resistance of buds overwintering on the vines of the *V. vinifera*

grapevine generally coincided with other researchers' results, but some differences were observed. According to other authors (Pospišilová, 1981; Alleweldt et al., 1990), among the *V. vinifera* cultivars, 'Riesling' survived the winter best. In Slovakia and Austria, according to Moser (1962) and Pospišilová (1981), the 'Zweigelt' cultivar is frost resistant at a similar level as 'Reisling'. In Skierniewice, Poland, however, the buds of the 'Zweigelt' froze to a considerable degree and the size of damage was even larger than in the case of cultivars considered to have average susceptibility (such as 'Scheurebe') or as being susceptible ('Dornfleder'). The new Slovakian cultivar 'Milia' showed similar resistance as the standard 'Traminer Rot', much the same as in Slovakia (Pospišilová et al., 2002). Among the table cultivars of *V. vinifera*, 'Pearl of Csaba' and 'Chasselas Dore' proved more tolerant to cold than 'Topas' and 'Favorit', as in Slovakia (Pospišilová, 1981; Pospišilová et al., 2005).

Examining the frost resistance of *V. vinifera* bushes, it should be remembered that it is planted in large commercial vineyards in areas where winter temperatures below –25°C are considered abnormal weather conditions. Meanwhile, such drops of temperature in Central Poland are quite common. Looking only at the last couple of years, in January 2003 temperature reached –25.4°C and in January 2006 –31.6°C. The risk of plants freezing in central Poland is too high to recommend those cultivars (even the most resistant ones) unless they are covered with soil for the winter. Research on the frost resistance of *V. vinifera* cultivars and relatively susceptible hybrids may prove helpful to grapevine planters in western Poland. This research may prove helpful especially if climate warming takes on the form of a constant process rather than periodic anomalies. The winters in western Poland are milder than in the central and eastern parts of the country. Until the 1950s, in the south-western part of Poland (Zielona Góra area), there existed large, commercial plantations of highly frost resistant *V. vinifera* cultivars. The bushes were traditionally covered during winter-time to prevent the high risk of frost damage which could occur even in this area (Kuleba, 2005).

Taking into consideration climatic realities and costs of running vineyards covered during winter, growing the interspecific hybrids would be an interesting perspective in Poland. Frost resistance of hybrids is highly varied which results from their diverse origins and genetic background (Galet, 1988; Hemstad and Luby, 1990; Luby, 1991). According to research conducted previously in Skierniewice, Poland and by other authors in Poland (Sękowski and Myśliwiec, 1996; Lisek, 2004; 2007) and abroad (Plocher and Parke, 2001; Elfving et al., 1985), the group of hybrids most resistant to low temperatures are those which originated in France. They were created by crossing *V. vinifera, V. riparia, V. rupestris* and *V. lincecumii*.

Very good resistance was also shown by some hybrids obtained by crossing *V. vinifera* and *V. labrusca (*like for example 'Zilga'). This was confirmed by other results acquired in Belarus, Latvia, the northern states of the USA (Łojko and But-Gusaim, 1990; Plocher and Parke, 2001) and previous observations in Skierniewice, Poland. In Skierniewice in the case of this cultivar, no frost damage was noted at the temperature of –31.6°C in January 2006 (Lisek, 2007). After the 2008/2009 winter, the buds of the 'Supaga' cultivar also did not suffer any frost damage but it should be noted that the scale of damage will increase at drops of temperature below –25°C (Łojko and But-Gusaim, 1990; Lisek, 2004; 2007). The 'Ananasnyj Rannyj' cultivar turned out to be well-resistant, though not as well-resistant as in the Ukraine (Abuzov, 2009). During a moderately cold winter, no damage was observed in the case of the 'Price' cultivar. This confirms previous data on its good frost resistance and ability to survive well even at drops of temperature below –30°C (Lisek, 2007). It is interesting though, that in Canada 'Price' is considered average-tolerant to frost (Elfving et al., 1985). In the light of the discussed research, other *V. labrusca* hybrids should be found tolerant, for instance 'Canadice', 'Reliance', 'Buffalo', 'Einset' and 'Festivee'. Data from Poland, Canada and the USA (Elfving et al., 1985; Sękowski and Myśliwiec, 1996; Reisch et al., 1999; Lisek, 2004; 2007) confirm this. The vines of the cultivar 'Reliance', however, did not demonstrate such resistance as it did in the north-western part of the USA where it survived frosts of –34°C (Fallahi et al., 2001).

Among the Hungarian hybrids, according to previous data, the most frost resistant proved to be the cultivar 'Refren' (Hajdu and Gabor, 1997). The cultivars 'Medina' and 'Palatina' (Korbuly, 2002; Kozma, 2002) were more susceptible. The high resistance of 'Bianca' (Kozma, 2002) was not confirmed, as it suffered more damage than 'Medina'. After the 2008/2009 winter, results similar to those previously acquired in research done in Skierniewice, Poland, concerning the cultivar 'Bianca', were obtained (Lisek, 2004; 2007).

Interspecific hybrids 'Regent', 'Rondo' and 'Roesler' proved to have a higher resistance to frost than most *V. vinifera* cultivars as was found in Germany and Slovakia (Hillebrand et al., 2003; Pospišilová et al., 2005). The cultivar 'Roesler' was observed to be more frost resistant than 'Rathay', as was the case in Austria (Keserer and Blahous, 1999). However, it is disputable whether the 'Regent' and 'Rondo' cultivars commonly found in Poland would be able to winter well or yield regularly without being covered during winters in Central Poland. Buds of interspecific hybrids 'Arkadia' and 'Kordianka' were more susceptible to frost than many of the *V. vinifera* cultivars which stands in contradiction to data from the Ukraine and Russia. Data from the Ukraine and Russia show that those cultivars winter well in temperatures similar to the

ones recorded in January of 2009 in Poland (Kostrikin, 2002; Abuzov, 2009).

Frost resistance depends not only on genetic factors but also on the age of plants, their health, good or poor harvest and climatic course of the season preceding the overwintering. The sum of active temperatures (STA) in the year 2008 in Skierniewice, Poland, came to 2519°C which did not differ from the long-standing average of the years 1981-2000. It was, however, less than in warm years. For instance, in 2003 STA exceeded 2700°C and in 2009 2900°C. Taking into consideration the rainy August and cold September of 2008, it is possible that cultivars with early ripening fruits (the end of August and the beginning of September) such as 'Aloszeńkin', 'Pearl of Csaba' and 'Pinot Noir Precoce' were better prepared for winter. Pospišilová (1981) reports that young, average yielding and fungal--free vines of the cultivar 'Scheurebe' are more resistant to frost damage than the old, well yielding ones. Infection by the fungus *Unicunula negator* drastically decreases the frost resistance of the cultivar 'Chardonnay' in Canada (Elfving et al. 1985). The health status of plants in Skierniewice was good and the scope of occurrence of the main fungal diseases: downy mildew, powdery mildew and excoriose was minimum. Henceforth it is hard to decide whether health is an important cause of differences in frost resistance. Although it is possible that infection by the pathogen *Phomopsis viticola,* which causes excoriose, could have influenced bud freezing in those cultivars which are relatively susceptible to this pathogen, despite being considered as frost resistant, e.g. 'Bianca' or 'Marechal Foch'. The varied fertility of vines, which is a genetic trait, may have some significance in frost resistance. On the average from 1.5 to 3.0 kg of grapes were gathered from the vines planted in the time period from 1992-1998. The most fertile proved to be vines of the cultivars 'Aloszeńkin', 'Reliance', 'Rondo', 'Regent' and 'Festivee'. The vines of cultivars planted in the spring of 2007 produced 0.5-1.5 kg of grapes the next year, with the exception of cultivars 'Muscat Bleu' and 'Solaris' which gave about 2.5-3.0 kg of fruits.

Less than 4% of the buds froze on the vines of the frost resistant cultivar 'Marechal Foch', when the temperature went down to –31.6°C in January 2006 (Lisek, 2007). After the temperature of –23°C recorded in January 2009, 11.4% of the buds froze. This demonstrates the possibility of far-reaching differences in frost resistance of cultivars in Poland between seasons. It also shows that further systematic study is needed, in the face of climatic changes, mounting interest in grapevine-growing in Poland, and popularization of new cultivars.

In order to widen the use of the obtained results (Tab. 2 and 3), it can be assumed that grapevine cultivars which had wintering buds even after being exposed to temperature –23°C, and which suffered damaged in 50% or

less of the cases, are prospective and can be recommended for production in Polish climatic conditions.

CONCLUSIONS

1. Among *V. vinifera* genotypes, overwintering buds on the vines of the cultivar 'Riesling' showed the highest frost resistance.
2. Frost resistance to winter damage of interspecific hybrids was highly varied. The group most resistant to cold includes some hybrids which originated as a result of crossing *V. vinifera* with *V. labrusca* ('Zilga', 'Price', 'Supaga'); *V. riparia, V. rupestris,* and *V. lincecumii* ('Aurore', 'Baco Noir', Marechal Foch', 'Saphira') and *V. amurensis* ('Sibera'). Buds of hybrids 'Arkadia' and 'Kodrianka' were more susceptible to frost damage than the most resistant among the *V. vinifera* cultivars.
3. Frost resistance of 'Rondo' and 'Regent', which are the most common wine cultivars in Poland, was good compared to most *V. vinifera* cultivars but not sufficient in the conditions of cold winters which occur in central Poland every couple of years.

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USZKODZENIA MROZOWE PĄKÓW PO ZIMIE 2008/2009 NA KRZEWACH WINIARSKICH I DESEROWYCH ODMIAN WINOROŚLI W CENTRALNEJ POLSCE

Jerzy Lisek

S T R E S Z C Z E N I E

Po zimie 2008/2009 oceniano uszkodzenia mrozowe na krzewach 41 winiarskich i 25 deserowych odmian winorośli uprawianych w warunkach centralnej Polski. Minimalną temperaturę zimową wynoszącą –23,0°C zanotowano 6 stycznia 2009 roku. Najlepszą tolerancję na działanie niskiej temperatury (brak uszkodzeń pędów i pąków zimujących) wykazały krzewy mieszańców międzygatunkowych: 'Price', 'Supaga' i 'Zilga' hodowanych przez krzyżowanie *V. vinifera* i *V. labrusca* oraz 'Baco Noir' uzyskanego przez krzyżowanie *V. vinifera* i *V. riparia*. Odsetek przemarzniętych pąków na krzewach innych odmian klasyfikowanych jako mieszańce międzygatunkowe wynosił od 0,7% ('Aurora', 'Refren' – krzyżówki *V. vinifera*, *V. rupestris, V. lincecumii*) do 99,5% ('Kodrianka'). Spośród odmian winorośli właściwej (*V. vinifera*) najmniejszą podatność na uszkodzenia mrozowe wykazał 'Riesling' (13,5% przemarzniętych pąków). Na krzewach odmiany 'Favorit', należącej również do *V. vinifera* przemarzły wszystkie pąki. Części krzewów okryte glebą lub śniegiem nie doznały widocznych uszkodzeń mrozowych, nawet u najbardziej wrażliwych na mróz odmian.

Słowa kluczowe: pąki, winorośl, odmiany, mróz, uszkodzenia mrozowe