Frost resistance of grapevine cultivars of different origin

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Summary: The tests of resistance to low temperature which included a large number of grapevine cultivars showed that the cultivars bore sign of their ecological-geographical and genetic origins with respect to the resistance to low temperature.

The tests, conducted over several years, consisted of exposing cuttings of annual shoots to low temperature in a cold chamber. The tests were repeated three times each winter, following the uniform method and time, in order to be able to distinguish relative differences in the degree of resistance between the cultivars tested.

Most cultivars from Western Europe (*occidentalis* NEGR., *gallica* NÉM.) had a high degree of resistance to low temperature. They tended to reach the peak of the resistance in mid winter.

The cultivars from the continental part of the Balkans (*pontica* NEGR., *balcanica* NEGR.) were unanimously sensitive to low temperature. The cultivars from the warm Mediterranean climate of Southern Europe (*pontica* NEGR., *balcanica* NEGR. and *occidentalis* NEGR., *iberica* NÉM.) were still more sensitive than the cultivars in the previously mentioned group.

The wine cultivars developed from interspecific crosses of European grapevines and American species exhibited a high degree of resistance in the middle and at the end of winter while the hybrids *vinifera x amurensis* were highly resistant at the beginning and in the middle of winter. Both groups can be used as donors of resistance to low temperature in programs of breeding cold hardy grapevine cultivars.

The tested table cultivars were found to be sensitive to low temperature, with the exception of the well-known cultivars Muscat Hamburg and Chasselas and the new cultivars Strugurash and Moldova.

Key words: cold , resistance, breeding, genetics, selection, geography, ecology, wine grape, table grape, variety of vine.

Introduction

In many grape-growing regions consistent production depends largely on the occurrence of low temperatures in winter. However, grapevine cultivars differ considerably in resistance to low temperature (ZILAI 1981, 1987). These differences are primarily due to genetic factors but they may also depend on the method of growing as well as on actual climatic conditions in the period of dormancy.

If it is intended to screen for a degree of inherited frost resistance, it is necessary to standardize all other factors, i. e. the location and method of growing and the time and method of screening. Even then it is not feasible to assess accurately the absolute values of frost resistance in individual grapevine cultivars. If, however, all factors are made uniform and a uniform low temperature treatment is applied, it is possible to obtain information on the relative frost resistance of the cultivars compared. Low temperatures are a potential threat over a period of several months. Grapevine cultivars tend to vary in the degree of frost resistance during that period. Some cultivars are less resistant at the beginning, some in the middle and some at the end of the period. This circumstance imposes a need for repeated screenings for frost resistance in the course of winter (EIFERT 1975).

The direction and intensity of biochemical and physiological processes which in fact determine the degree of frost resistance in overwintering plant parts are directly affected by actual temperature conditions preceding the occurrence of critical low temperatures (KONDO 1970; POGOSJAN 1975; REUTER 1975; MARUTJAN 1978). As temperature conditions vary from one year to another, screenings should be repeated for several years in order to secure reliable results.

The objective of this investigation was to establish differences in the degree of frost tolerance among grapevine cultivars differing in geographic and genetic origins.

Investigated cultivars and number of years investigated

Group	Cultivar prime name	Synonyms (parents)	Number of years investigate
1. Cultivars			
iriginating	1. Pinot gris	Ruländer	9
from	2. Pinot blanc	Weissburgunder	9
West	3. Pinot noir	Blauer Spätburgunder	8
Europe	4. Chardonnay	-	9
	5. Traminer	-	9
	6. Riesling	Rhein Riesling	9
	7. Italian Rizling	Welschriesling	9
	8. Müller-Thurgau	-	9
	9. Sauvignon	-	9
	10. Muscat Ottonel	-	9
	11. Cabernet sauvignon	-	9
	12. Merlot	-	9
2. Ancient	1. Medenac beli	Honigler	7
Balkan	2. Ezerjo	-	9
cultivars	3. Slankamenka crvena	Plovdina crvena	9
cultivated in	4. Slankamenka bela	-	5
continental	5. Kreaca	Banati rizling	7
parts of	6. Bagrina	-	6
the Balkans	7. Smederevka	Dimjat	9
	8. Kevidinka	Ružica, Crvena Dinka	9
	9. Prokupac	Zarcsin	8
	10. Plovdina crna	Pamid	7
	11. Izsáki	Izsáki sárfehér	5
	12. Sremska zelenika	Szerémi zöld	7
3. Cultivars	1. Blatina	-	7
cultivated	2. Vranac	-	8
in south of	3. Kratošija	-	5
Yugoslavia	4. Stanušina	-	5
and south	5. Aramon	-	7
of Europe	6. Carignan	-	7
	7. Refošk	Terano d'Istria	5
	8. Barbera	-	5
	9. Malvasia blanc	-	5
	10. Ugni blanc	St. Emillion	5
	11. Žilavka	-	8

(Continued overleaf)

Methods

In vitro test similar to that used by MUELLNER and MAYER (1970), GUZUN *et al.* (1972), EIFERT (1975), CSERNOMOREC (1976) and SCHÖFFLING (1980) was used in this investigation.

Cuttings of annual shoots were exposed to low temperature in a cold chamber. After sampling 30 representative buds from each cultivar, the cuttings were first kept at -5 °C for 24 h and then the temperature was lowered to -21°C at the rate of 3°C/h. That temperature was maintained for 12 h and then raised gradually to room temperature. The tested materials were kept at room temperature for 1 week and then scored for the number of survived winter buds. Central buds and lateral buds were scored separately.

The test was repeated three times in the course of several winters: in late December, second half of January and second half of February. These dates corresponded to cultivars resistance to frost at the beginning, the middle and the end of winter.

Table (continued)

Group	Cultivar prime name	Synonyms (parents)	Number of of years investigated
4. Cultivars originating from interspezific hybridzation	1. SV 12-375	Villard blanc	8
	2. SV 18-315	Villard noir	7
	3. Seibel 70-53	Chancellor	7
	4. Seibel 49-86	Rayon d'or	7
	5. Bianka	(SV 12-375 x Bouvier)	7
	6. Göcsei zamatos	(SV 18-315 x Medoc noir)	6
	7. Zalagyöngye	(SV 12-375 x Csaba gyönge)	9
	8. Kunleany	(BC_1 V.vinifera x V.amurensis)	9
	9. Kunbarat	(")	9
	10. SK 77-12/6	Kunleany x Ruländer	8
	11. SK 77-5/3	Kunbarat x Pinot noir	8
	12. SK 77-14/17	Kunleany x M.Ottonel	8
5. Table grape cultivars of different origin	1. Cardinal	-	9
	2. Queen of vineyard	Szölökertekkirálynöje	9
	3. Chasselas	Gutedel; Fendant	9
	4. Italia	-	9
	5. Dattier de Beyrouth	Afuz-ali; Regina	9
	6. Ribier	Alfonse Lavallée	9
	7. Muscat Hamburg	-	9
	8. Muscat Pölöskei	(Zalagyönge x /Gloria-hungarie x Erzsébet kiralyne emléke/)	7
	9. Ljana	(Csaus x Pierelle)	9
	10. SV 20-473	Muscat de St.Vallier	9
	11. Strugurash	(Koarna njagra x Pierelle)	9
	12. Moldova	(SV 12-375 x Guzalj kara)	9

Plant samples to be tested were taken from the ampelographic collection at Sremski Karlovci in which all cultivars are grown according to the latest cultivation methods (CINDRIC *et al.* 1986). The investigation was commenced in 1980/81 when the plants started to bear fruit and it was continued for several years. Most cultivars were tested for 9 years, as presented in the table.

Let it be emphasized once again that all cultivars were tested uniformly with respect to method and time. Therefore, the results should indicate those differences among the cultivars which are genetically controlled.

The table presents some basic data for the cultivars tested. The cultivars had been grouped according to their origin, location of large-scale commercial production or their use.

Results

1. Cultivars originating from Western Europe

According to their ecological-geographical classification, the cultivars from Western Europe belong to convarietas *occidentalis* NEGR. (NEGRUL 1956), subconvarietas *gallica* NÉM. (NÉMETH 1976; CSEPREGI and ZILAI 1976). In general, these cultivars exhibited a relatively high degree of frost resistance (Fig. 1). Regarding the three dates of testing, their resistance was highest in mid winter and lowest at the beginning of winter. A high level of resistance was exhibited by the cultivars Riesling, Traminer and the cultivars from conculta Pinot (P. gris, P. blanc, P. noir and Chardonnay). A somewhat lower resistance was displayed by Sauvignon, Italian Riesling and Müller Thurgau. The cultivars Muscat Ottonel and Cabernet Sauvignon had a different pattern of resistance in the course of winter – they reached the peak of the resistance in the second half of February and not in mid January as the other cultivars in this group. CSEPREGI and ZILAI (1976) did not class Muscat Ottonel in the same group with the other cultivars but in convarietas *orientalis* NEGR., subconvarietas *caspica* NEGR., along with the cultivar Chasselas. This appears to be correct since Muscat Ottonel and Chasselas share not only a number of morphological characters but also the pattern of frost resistance which is characteristic for the cultivars of subconvarietas *caspica* NEGR. (CINDRIC *et al.* 1987). This supports the opinion of GALET (1958) that Muscat Ottonel draws origin from Chasselas.

It should be mentioned that the cultivar Merlot had a perceptibly lower resistance in the middle and at the end of winter than Cabernet Sauvignon, in spite of a number of similarities between the two cultivars.

2. Old Balkan cultivars

Fig. 2 shows the results of the cold tests for cultivars grown in the continental part of the Balkans. According to their ecological-geographical classification, NÉMETH (1976), CSEPREGI and ZILAI (1976) classed them in convarietas *pontica* NEGR., subconvarietas *balcanica* NEGR. In general, their resistance to low temperature was low. Namely, most of them exhibited an exceptionally low degree of resistance at the beginning of winter and a somewhat higher resistance in the second half of winter. In the climatic conditions of their original habitat, these cultivars could be grown successfully only when hilled before winter. After the introduction of modern cultivation methods which imply high training and the omission of hilling as a regular agrotechnical practice, the productivity of these cultivars became quite unstable. This, in addition to a somewhat lower wine quality, was an important reason why these cultivars were abandoned from commercial production in the last several decades.

3. Cultivars originating from southern parts of Yugoslavia and Southern Europe

Fig. 3 shows the tested cultivars which are grown in warm regions of Southern Europe. Those were well-known Southern French cultivars Aramon and Carignan, classed in convarietas

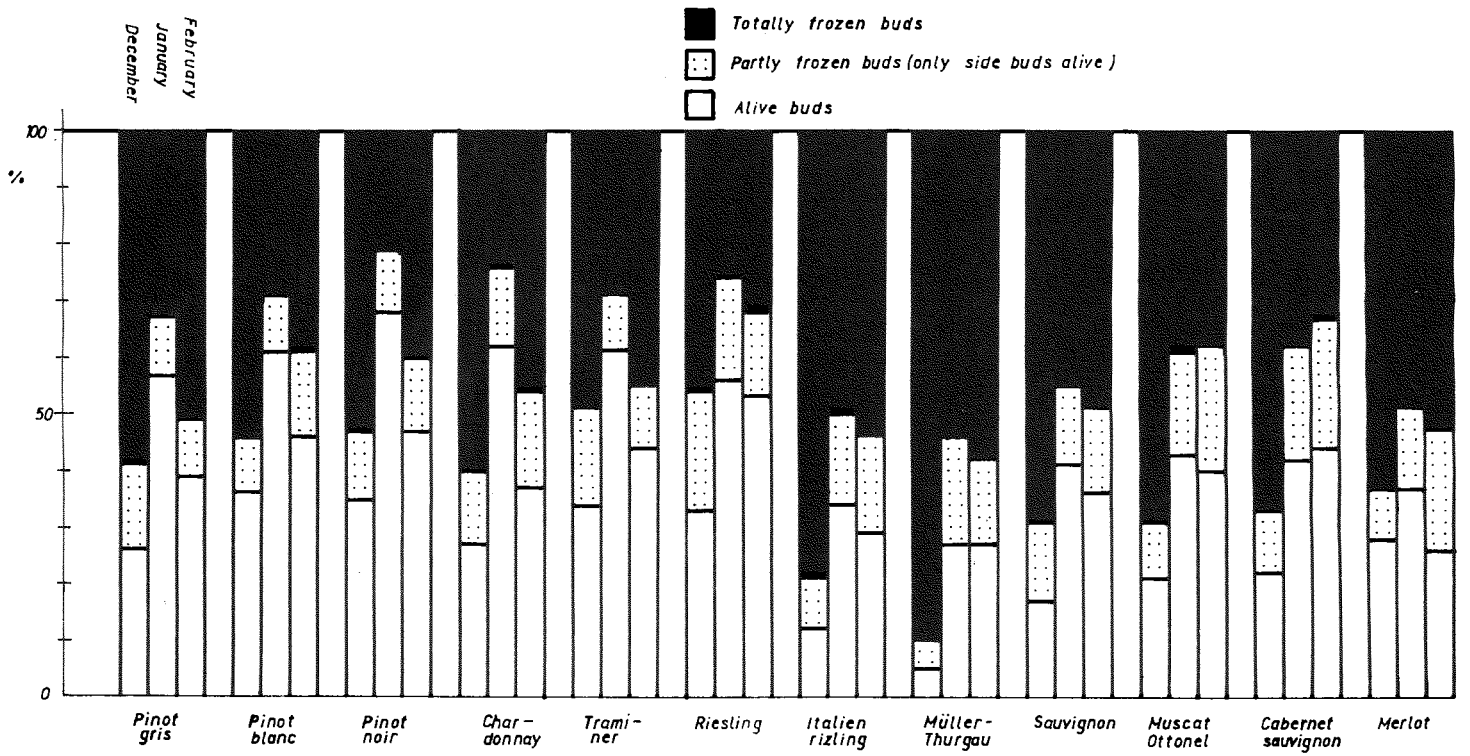

Fig.1: Results of cold tests with wine grape cultivars originating from West Europe.

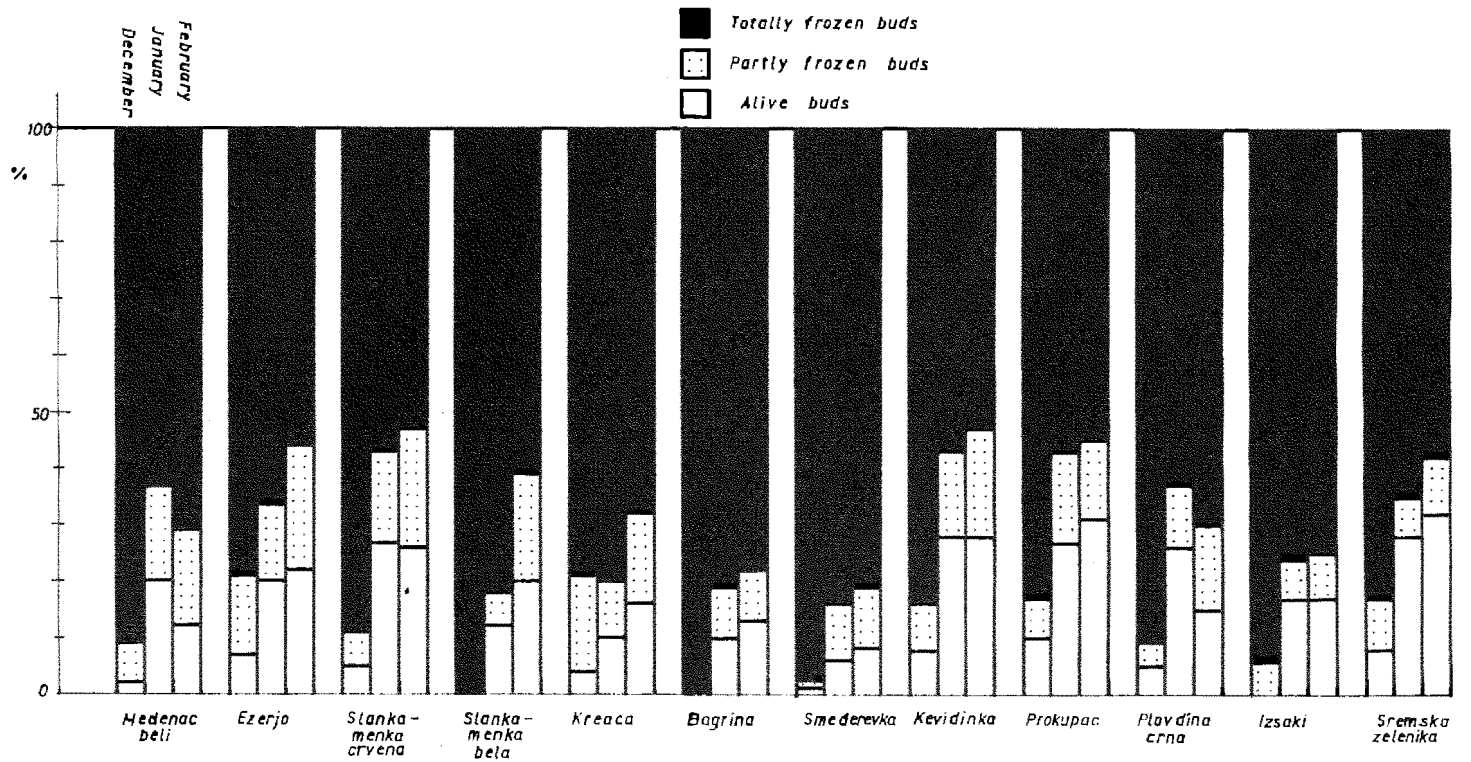

Fig. 2: Results of cold tests with ancient Balkan cultivars grown in the continental part of the Balkans.

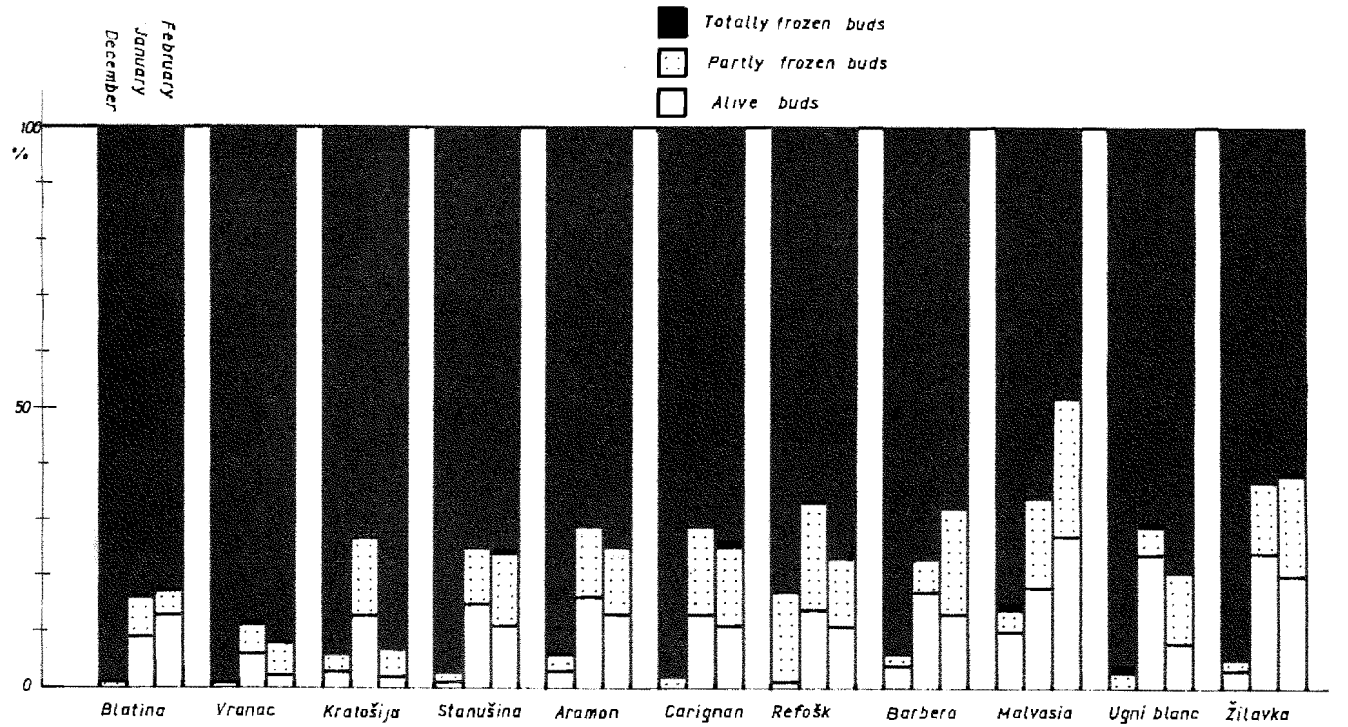

Fig. 3: Results of cold tests with wine grape cultivars originating from south of Yugoslavia and South Europe.

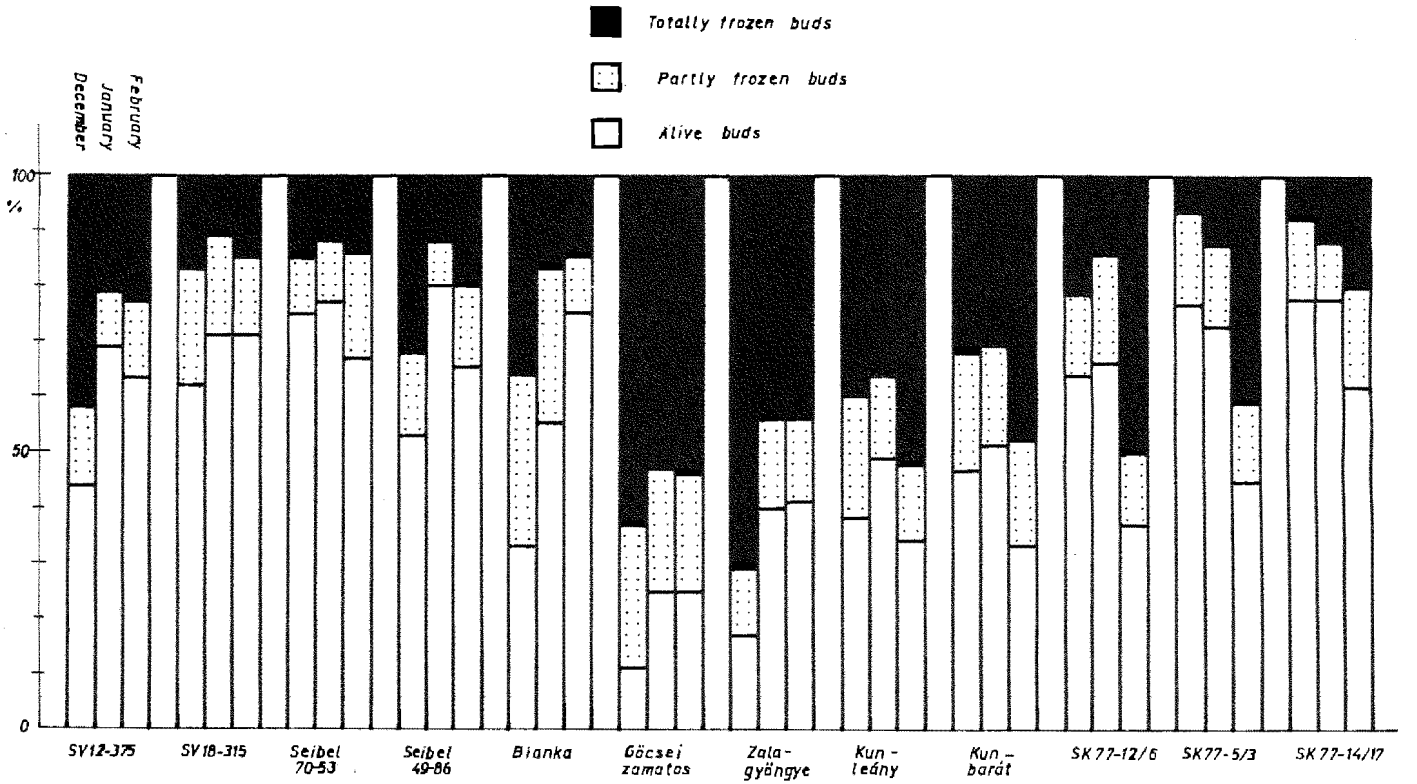

Fig. 4: Results of cold tests with wine grape cultivars based on interspecific hybridization.

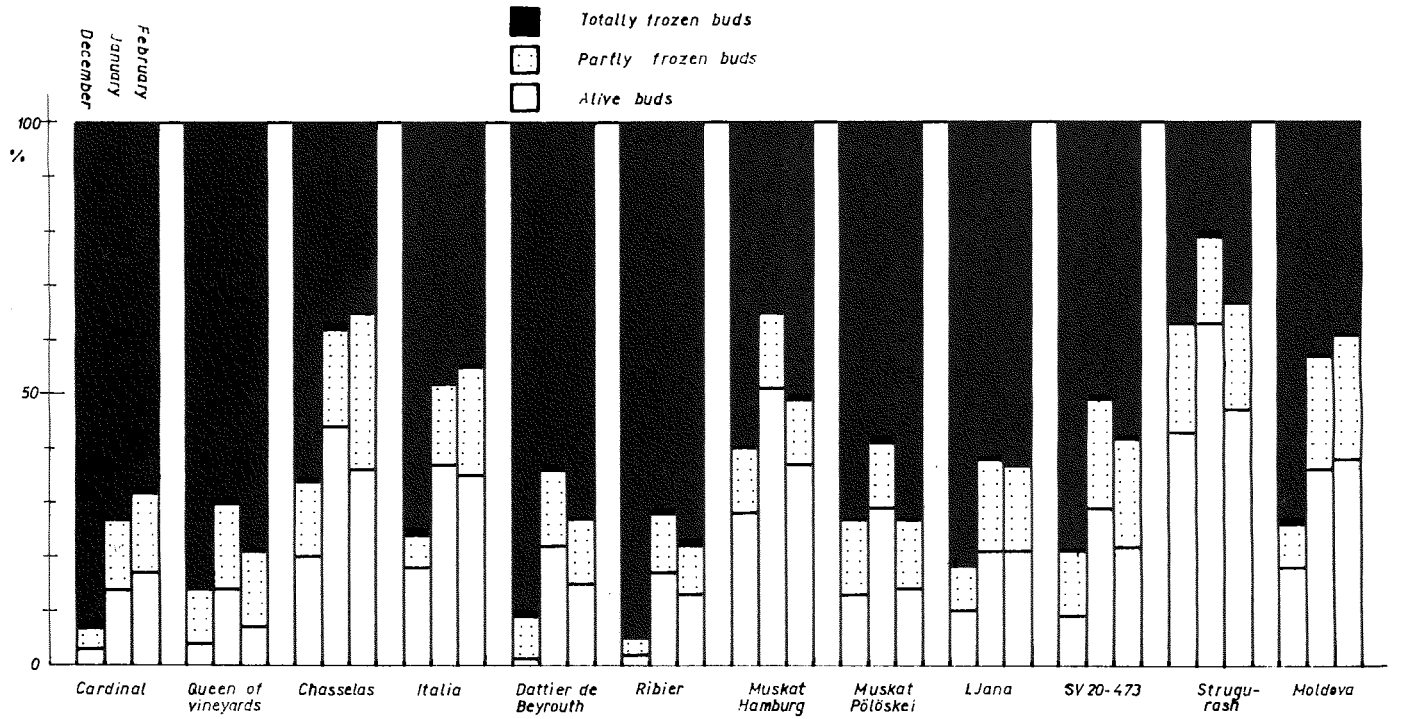

Fig. 5: Results of cold tests with table grape cultivars of different origin.

occidentalis NEGR., subconvarietas *iberica* NÉM., and cultivars native to the southern parts of Yugoslavia (Macedonia, Montenegro, Herzegovina and Istria) which require a high temperature sum to mature and which may be classed in convarietas *pontica* NEGR., subconvarietas *balcanica* NEGR. Of course, this classification does not apply to the cultivar Ugni blanc which has only recently been introduced in southern parts of Yugoslavia. Fig. 3 shows that all of these cultivars had a very low degree of frost resistance. This is quite understandable since they come from regions which are risk-free with respect to the occurrence of low temperatures in winter. These cultivars may rightfully bear a collective name *Vitis mediterranea* ANDRAS., as suggested by ANDRASOVSKY (1926) in his proposal of a polyphyletic classification (as cited by KOZMA 1967).

4. Cultivars based on interspecific hybridization

Fig. 4 shows the results of the cold test for 12 wine cultivars which had been developed on the basis of interspecific hybridization. The first 7 resulted from complex crossings between *V. vinifera* cultivars and American species. The remaining 5 cultivars are interspecific crosses based on *V. amurensis*. These two groups of genotypes were clearly distinctive with respect to resistance to low temperature. The interspecific hybrids in the first group exhibited a particularly high degree of resistance in the middle and at the end of winter. The interspecific hybrids based on *V. amurensis* had a high degree of resistance at the beginning and in the middle of winter but their resistance was diminished at the end of winter. The above data should be taken in consideration when breeding new frost resistant cultivars. It was concluded that most cultivars from both groups of interspecific hybrids may serve as donors of frost resistance. Understandably, best results would be obtained if the inheritance bases of the two groups were combined.

The data presented in the graphs are sufficiently self-explanatory as to render a discussion of individual cultivars unnecessary. Still, a new Hungarian cultivar, Bianka, developed by J. CSIZMAZIA and L. BEREZNAI (CSIZMAZIA 1977), deserves to be mentioned for its high tolerance to low temperature combined with early maturity, high resistance to major fungal diseases and good wine quality (MAJOROS 1983). The cultivar Bianka is evidently superior in a number of important biological characters to the hybrids Seyve Villard and Seibel which have extensively been used in programs of interspecific crossings as donors of resistance to fungal diseases (VERDEREVSKI and VOJTOVICS 1970; CSIZMAZIA 1977; ALLEWELDT 1979; BECKER 1980; BECKER and ZIMMERMANN 1980; DOAZAN 1980; VOJTOVICS 1981). Unfortunately, the cultivar Bianka is prone to berry drop causing yield fluctuations from one year to another. In our new program of breeding resistant cultivars, Bianka has been crossed to several *vinifera x amurensis* genotypes.

5. Table cultivars

It is common knowledge that the table cultivars are sensitive to low temperature. This investigation indicated considerable differences in this character among the tested cultivars (Fig. 5). Of the well-known table cultivars, Chasselas and Muscat Hamburg exhibited the highest level of resistance. The cultivar Italia was less sensitive than Dattier de Beyrouth, Ribier, Cardinal and Queen of Vineyards which in their turn confirmed their high sensitivity to frost.

Of the tested cultivars which are also resistant to fungal diseases, the cultivar Strugurash displayed a surprisingly high level of resistance while Moldova had a relative high resistance. These are two new cultivars developed by means of interspecific hybridization by ZSURAVELY and GUZUN in Kishinev (KORAC 1989). The other interspecific table cultivars (Muscat Poeloeskei, Ljana and Muscat de St. Vallier) were sensitive to low temperature.

Finally, it should be mentioned that the authors are aware that the results presented are based on a single method of testing. Since the resistance to low temperature is a very complex biological character, a more precise definition of cold hardiness in the tested cultivars would require a study of other parameters too, e. g., date of budding in spring, fertility of lateral buds and regeneration capacity following damage incurred by low temperature.

Conclusion

The long-term testing of resistance to low temperature showed that certain cultivars bore in themselves the sign of their ecological-geographical and genetic origins.

1. Most cultivars from Western Europe (convarietas *occidentalis* NEGR., subconvarietas *gallica* NÉM.) exhibited a proportionally high resistance to low temperature. They tended to reach the peak of the resistance in mid winter.

2. The cultivars which were previously grown or are still grown in the continental part of the Balkans (convarietas *pontica* NEGR., subconvarietas *balcanica* NEGR.) featured a low resistance to low temperature and could be grown in that area only if hilling was regularly practised as a means of prevention against low temperature in winter.

3. The cultivars from the warm Mediterranean climate of Southern Europe were sensitive to low temperature. According to their ecological-geographical classification, these cultivars belong to convarietas *occidentalis* NEGR., subconvarietas *iberica* NÉM. and to convarietas *pontica* NEGR., subconvarietas *balcanica* NEGR.

4. The interspecific wine cultivars developed by crossing European grapevines to American species may, in addition to the resistance to fungal diseases, serve as donors of resistance to low temperature. A new Hungarian cultivar, Bianka, deserves to be mentioned for its positive characters. The Euro-American hybrids displayed a high degree of resistance in the middle and at the end of winter. On the other hand, the interspecific hybrids *V. vinifera x V. amurensis* exhibited a high degree of resistance at the beginning and in the middle of winter. It is obvious that a significant progress in breeding for resistance to low temperature could be achieved by combining these two complex inheritance bases.

5. The true table cultivars such as Dattier de Beyrouth, Queen of Vineyard, Cardinal and Ribier were highly sensitive to low temperature whereas the cultivar Italia performed somewhat better. Of the well-known table cultivars, Muscat Hamburg displayed a relatively high degree of resistance. Chasselas, another popular table-wine cultivar, also exhibited a relatively high resistance, especially in the second half of winter.

Of the 5 interspecific table cultivars tested, the new Soviet cultivars, Strugurash and Moldova, had a high level of resistance to low temperature.

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