Testing of wood hardiness to winter freezes in selections from progenies of *Cerapadus* × *Prunus avium* L. crosses

J. Blažková, I. Hlušičková

Research and Breeding Institute of Pomology, Holovousy, Czech Republic

ABSTRACT: Winter hardiness of genotypes pre-selected from *Cerapadus* × *Prunus avium* L. crosses was studied for 3 years (2000–2002) in comparison with clonal cherry rootstocks, presently grown in the Czech Republic using artificial freezing of the budwood applied just after the phase of deep dormancy. With a temperature drop to freezing, both the mean and the maximum rate of general frost injury was markedly increased. The greatest damage of the tested material (roughly at the level of LD 50 on the average) occurred after the application of combined low temperatures –25°C for 4 hours + –20°C for 66 hours. The results of laboratory tests were compared with the damage of natural frost that occurred during the first half of January, 2002. The single observed years did not differ from each other in the extent of injury, on the average. From standard cherry rootstocks, P-HL-B was generally the most sensitive to freeze injury. Its weak winter hardiness was approximately the same, or even somewhat worse, than that of rootstock Colt. The rootstock P-HL-C was classified as medium sensitive to winter frosts, while rootstock P-HL-A was scored as winter hardy. The average frost injury score of all 48 selected *Cerapadus* × *Prunus avium* L. genotypes included in the study was 6.7, whereas that of all control cherry rootstocks was only 5.9. According to the results of this study, the tested genotypes were classified into 5 groups with different classes of frost resistance or susceptibility. The most frequent was the class of medium resistance. The following five genotypes were the most winter hardy: CPH VODÁRNA, CPH 43, CPH 17, CPH 22 and CPH 49. On the basis of the obtained results, suggestions for improving testing procedures are also given.

Keywords: frost hardiness; freeze injury; testing; *Cerapadus*; *Prunus avium*; cherry rootstocks; hybrids

An artificial inter-generic hybrid *Cerapadus* was obtained in Russia by I.V. Michurin in 1935 from a cross of his sour cherry Ideal (*Prunus fruticosa* Pall. × *Prunus pensylvanica* L.) with the Maack bird cherry (*Prunus padus* L.). This hybrid was used in Russia as a hardy and vigorous rootstock for sour cherries, being propagated for this purpose by soft-wood cuttings (Vorobjeva 1996). Both ancestor species (*Prunus fruticosa* Pall. × *Prunus pensylvanica* L.) were used in breeding programs as donors of winter hardiness (Burke, Stushnoff 1979; Stepanov 1974).

In the Research and Breeding Institute of Pomology at Holovousy, this hybrid has also been utilised to breed new cherry rootstocks. From the interspecific hybridisation of *Cerapadus* × *Prunus avium* L. (using several selected cultivars of sweet cherries) many hybrid seedlings were obtained that are now under selection for economic characteristics. Many of these seedlings are resistant to leaf spotting (*Blumeriella jaapii* Rehm. Arx.) and to some other diseases. Several of them can be easily propagated by hardwood cuttings or by *in vitro* propagation (Kracíková et al. 1999).

Interspecific cherry hybrids were tested for frost susceptibility using an indirect method for its determination based on electrolyte diffusion (Strauch 1988). The winter frost resistance of sweet cherries was tested by a standardised laboratory method according to Fischer and Hochfeld (1995). The testing of frost resistance under laboratory conditions for cherries with *Prunus* hybrid rootstocks was done by Mittelstädt and Wolfram (1996). These authors considered the results of these tests obtained on the basis of long-proven procedures sufficiently reliable for the climatic conditions of Central Europe.

The main purpose of the present study was to estimate winter hardiness of pre-selected genotypes of *Cerapadus* × *Prunus avium* L. crosses in comparison with clonal cherry rootstocks, presently grown in the Czech Republic using artificial freezing of the budwood. At the same time, different variants of testing methods for frost hardiness were examined in an effort to improve the whole procedure.

MATERIAL AND METHODS

This three year study took place between 2000–2002. Altogether, 11 pre-selected genotypes from *Cerapadus* × *Prunus avium* L. crosses and four control clonal cherry rootstocks (Colt, P-HL-A, P-HL-B and P-HL-C) were tested in all three years. Besides these, another 37 genotypes were included in the tests either in 2001 or 2002, or in both of the years. For laboratory testing of pre-selected genotypes to frost hardiness, annual shoots of about 5 mm in thickness were used. These shoots were

This work was supported by the Ministry of Agriculture of the Czech Republic under Project EP9044.

cut from mother trees during the first half of January. This term was chosen using the experience of MITTELSTÄDT and WOLFRAM (1996), who had tested similar clonal material in similar climatic conditions. The term following the deep dormancy phase was convenient, because the treated material could easily be used for subsequent growing tests.

After storing for a short time in a cold store, the tested shoots were treated by a freeze temperature in a laboratory freeze chamber, with a possibility of temperature control and measuring accuracy of 0.1°C. The treated temperature was reached within two hours. At first, several different freezing temperatures were applied for different durations of time and were verified in 2000, from which three of the most suitable treatments were chosen and used for this three year study: –15°C for 22 hours (D), –20°C for 22 hours (E) and –25°C for 4 hours plus –20° C for 66 hours (F). In January, 2002 a natural frost at Holovousy occurred about one week before the budwood was cut for testing. The deepest natural freezing outdoors took place from January 4th till January 6th with temperature fluctuating between –15°C to –18°C.

After a freeze treatment, the tested shoots were, together with the untreated controls, placed into bulbs with water and kept at room temperature for two or three weeks. Subsequently, freeze injuries of the shoots were assessed by 3 different indicators: bud browning, wood browning and shoot bud-break. The first two types of damage were evaluated on cuts made through these organs, and the third one was assessed by determining the rate of the bud-break considering all the buds on the shoot in comparison with the controls. The evaluation was performed visually using a 1–9 rating scale. Undamaged material was ranked as 9, and completely dead wood (or no bud break) as 1.

The evaluated data after the treatments were analysed by analysis of variance (ANOVA), with a score of frost injury being the variable. Significantly different means were separated by a least significant difference at the 5% level. Relationships between treatments, frost injury indicators, and years or natural frost damage were tested by correlation analysis.

RESULTS

EFFECT OF TEMPERATURE AND DURATION OF FREEZING

With a temperature drop to freezing, both the mean and also the maximum rate of general frost injury was markedly increased (Fig. 1). The greatest damage of the tested material occurred after the application of combined low temperatures –25°C for 4 hours + –20°C for 66 hours (treatment F). On average, the treatment of the combined low temperatures resulted roughly in half the value of the frost injury rating scale that was used, or effects of this treatment could be approximated as LD 50. With the most sensitive material, this treatment generated almost complete injury (shoot killing).

Table 1. Mean injury score of buds, wood and budbreak after different freeze treatments in single years

Year	Variants of freeze treatments												
	–15°C for 22 hours (D)			–20°C for 22 hours (E)			–25°C for 4 hours + –20°C for 66 hours (F)			Mean injury			Total mean
	buds	wood	budbreak	buds	wood	budbreak	buds	wood	budbreak	buds	wood	budbreak	
2000	8.3	8.7	8.5	7.0	7.4	6.0	5.6	5.9	3.5	7.0	7.3	6.0	6.8
2001	8.0	8.4	8.5	7.2	7.5	5.8	5.5	5.7	3.3	6.9	7.2	5.9	6.7
2002	7.7	8.4	8.1	6.8	7.0	6.0	5.6	5.7	3.3	6.7	6.9	5.8	6.5
Mean	8.0	8.4	8.5	7.0	7.3	5.9	5.6	5.8	3.4	6.9	7.1	5.9	6.6
Maximum	9	9	9	9	9	8	8	8.3	6.7	8.7	8.6	7.9	8.2
Minumum	5	6.3	6	5	5	2	3	3.3	1	4.4	5.0	3.8	4.5
Span of values	4.0	2.7	3.0	4.0	4.0	5.0	5.0	5.0	5.7	4.2	3.6	4.1	3.7
F-test value	2.5	3.3	3.8	1.1	2.0	0.8	0.4	0.5	0.3	1.3	1.9	1.0	1.9
S.D. ($P = 0.05$)	0.47	0.37	0.24	0.56	0.51	0.51	0.48	0.55	0.55	0.39	0.38	0.28	0.30

Table 2. Mean injury score of particular genotypes with buds, wood and budbreak after different freeze treatments 2000–2002

Genotypes	Variants of freeze treatments									Mean injury			Total mean
	–15°C for 22 hours (D)			–20°C for 22 hours (E)			–25°C for 4 hours + –20°C for 66 hours (F)						
	buds	wood	budbreak	buds	wood	budbreak	buds	wood	budbreak	buds	wood	budbreak	
Colt	6.9	7.1	6.3	5.6	5.5	4.0	3.5	3.7	1.7	5.3	5.4	4.0	4.9
CPH 2	7.4	8.5	8.9	6.1	6.6	4.2	4.9	5.0	2.4	6.1	6.7	5.2	6.0
CPH 19	8.7	9	9	8.9	8.2	6.2	5.1	6.0	3.3	7.5	7.7	6.2	7.1
CPH 24	8.6	8.7	9	7.3	7.6	5.3	6.7	6.8	3.7	7.5	7.7	6.0	7.1
CPH 26	8.3	8.7	9	7.2	7.5	6.1	5.3	5.3	3.2	6.9	7.2	6.1	6.7
CPH 44	8.2	8.2	8.7	7.0	7.9	7.1	5.9	5.7	3.7	7.1	7.1	6.5	6.9
CPH 49	8.6	8.8	9	8.4	8.6	7.2	7.1	7.0	5.9	8.0	8.2	7.4	7.8
CPH 51	8.0	8.5	7.7	6.2	6.4	5.0	5.6	5.4	2.4	6.6	6.8	5.0	6.1
CPH 81	8.6	8.8	9	7.8	8.1	7.2	6.3	6.3	4.3	7.6	7.7	6.9	7.4
CPH 86	7.6	8.2	8.7	7.0	7.6	6.2	5.8	5.9	3.1	6.8	7.2	6.0	6.7
CPH DOS 1/3	7.7	8.3	8.8	6.4	6.9	5.8	5.2	5.7	2.4	6.5	6.9	5.7	6.4
CPH DOS 1/13	8.7	8.6	9	7.7	7.8	7.6	6.9	7.3	5.5	7.7	7.9	7.4	7.7
P-HL-A	8.9	8.8	9	8.1	8.4	6.9	7.2	7.4	4.5	8.1	8.2	6.8	7.7
P-HL-B	6.3	7.0	6.3	5.0	5.4	4.1	3.3	3.7	1.9	4.9	5.4	4.2	4.8
P-HL-C	8.0	8.3	8.7	6.4	7.2	5.8	4.9	5.3	2.6	6.4	6.9	5.7	6.4
Mean	8.0	8.4	8.5	7.0	7.3	5.9	5.6	5.8	3.4	6.9	7.1	5.9	6.6
Maximum	8.9	9	9	8.9	8.6	7.6	7.2	7.4	5.9	8.0	8.2	7.4	7.8
Minumum	6.3	7.0	6.3	5.0	5.4	4.0	3.3	3.7	1.7	4.9	5.4	4.0	4.8
Span of values	2.6	2.0	2.7	3.9	3.2	3.6	3.9	3.7	4.2	3.1	2.8	3.4	3.0
F-test value	3.7	3.7	21.4	3.4	5.4	8.5	8.9	6.5	4.9	8.4	7.5	20.1	14.0
S.D. ($P = 0.05$)	1.1	0.9	0.6	1.3	1.2	1.2	1.2	1.3	1.3	0.9	0.9	0.7	0.7

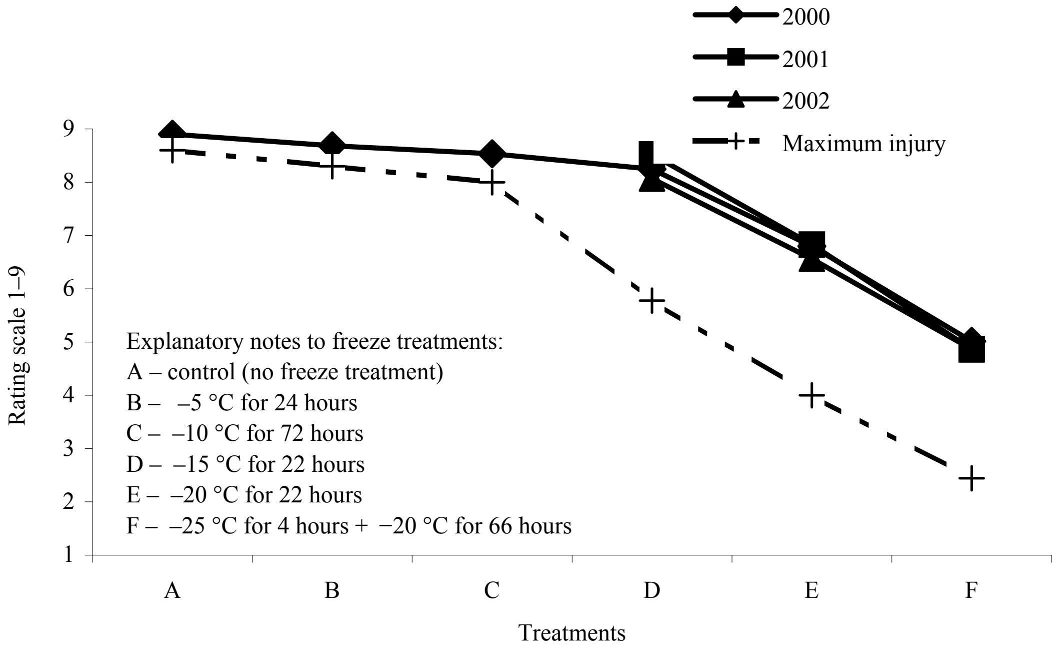

Fig. 1. Mean injury score for experimental treatments on the basis of three indicators

The treatment with a temperature of –20°C for 22 hours (E), on average, led to the damage of the tested material to an extent of about 25%. Treatment with –15°C for 22 hours (D) injured the tested material, on average, by about 10%, and it caused a more pronounced damage with the most sensitive material only. Both treatments with –10°C for 72 hours and –5°C for 24 hours (B and C) did not differ significantly in shoot damage from the control (A).

The results of treatments D, E and F were mutually highly significantly correlated (Table 3).

EFFECT OF THE YEAR

Single observed years did not differ mutually from each other in the extent of injury, on the average, after treatments F and E. Certain differences, which were noticed after treatment D, evidently were related to the light damage that already took place in 2002 in the orchard due to the natural frost before the shoots were cut (Table 1). Correlation analysis of the results of frost hardiness showed a close relationship between single years; nevertheless, a 3 year average seems to be the best tool for the rating (classification) of given genotypes (Table 3).

EFFECT OF THE INJURY INDICATOR

Greater frost injuries, on the average, and especially after deepest freezing (treatments F and E), were found in the bud-break response of treated shoots (Table 2).

Table 3. Relationships between injuries of variants within observed factors expressed as correlation coefficients *r*

		2000	2001	2002
Years	2000	1		
	2001	0.69	1	
	2002	0.60	0.77	1
	mean	0.88	0.92	0.87
Treatments		D	E	F
	D	1		
	E	0.79	1	
	F	0.72	0.80	1
	mean	0.88	0.94	0.93
Indicators		buds	twigs	budbreak
	buds	1		
	wood	0.84	1	
	budbreak	0.77	0.60	1
	mean	0.96	0.89	0.88

Table 4. Relationships between injuries after different treatments or indicators and natural damage in 2002

		D	E	F
Treatments	D	1		
	E	0.61	1	
	F	0.63	0.72	1
	natural damage	0.55	0.39	0.42
Indicators		buds	twigs	budbreak
	buds	1		
	wood	0.88	1	
	budbreak	0.48	0.39	1
	natural damage	0.52	0.44	0.23

After using the lower temperature of freezing (treatment D), however, the response in retardation of bud-break was generally smaller than the changes indicated by browning of cuts both through buds and shoots. Also, a span of injury ratings of evaluated genotypes was somewhat greater with bud-break than by using the evaluation of bud or shoot cuts. This indicator seemed to be the most suitable one for the discrimination of frost hardiness between particular genotypes. Very high correlation coefficients were found between all of the three indicators; however, relationships between the browning of buds and wood were closer than between both indicators and bud-break (Table 3).

SENSITIVITY OF THE CONTROL MATERIAL

From standard cherry rootstocks which were tested, together with selected genotypes, P-HL-B was generally the most sensitive to freeze injury. Its weak winter hardiness was approximately the same, or even somewhat worse, than that of rootstock Colt. The rootstock P-HL-C was evaluated as medium sensitive to winter frosts, while rootstock P-HL-A could be regarded as a hardy one (Table 2).

CLASSIFICATION OF TESTED GENOTYPES

From genotypes that were tested in all three years, CPH 49 was evaluated as the hardiest one. Besides this one, also CPH DOS 1/13 and CPH 81 showed good winter hardiness. The relatively weakest winter hardiness in all three years was observed in CPH 2 and CPH 51, which could in relation to control rootstocks be considered as medium susceptible to winter frosts (Table 2).

From genotypes that were tested only in two years (2001 and 2002), the highest level of winter hardiness was found in CPH VODÁRNA, CPH 43, CPH 17 and CPH 22. Their hardiness was similar to P-HL-A or even better (Tables 5 and 6). The same level was found also in the case of CPH 38 and CPH 87; however, both of them were tested only in 2002. As the most susceptible to winter frosts of the group, the following rootstocks were identified: CPH 42, CPH 75, and also CPH DOS 2/3 and CPH ST 14/127, but both of the last ones were tested only in 2000. All of these were, in this characteristic, roughly comparable to the rootstock Colt. The genotype CPH 45, which was tested both in 2001 and in 2002, and three others (CPH 28, CPH 30 and CPH 34) which were tested only in 2002, were less susceptible (somewhat better than Colt). All other tested genotypes after evaluation of their frost injury were ranked as intermediate, between the above stated extremes.

Results of single tests, with practically all the genotypes that were tested repetitively in two or three years, did not differ significantly from one to the corresponding other, with only one exception in the case of CPH DOS 1/5. This one was evaluated as susceptible to winter frost in 2000 but as winter hardy in 2002.

The average frost injury score (from all three years) of all selected *Cerapadus* × *Prunus avium* L. genotypes that were included in the present study was 6.66, whereas the score of all control cherry rootstocks was only 5.95. This means that the material was generally more winter hardy than the clonal cherry rootstocks that were used as controls in the study, and which are at the present time grown in the Czech Republic.

EFFECT OF NATURAL FROST DAMAGE

Evaluation of frost injuries after the natural period of freezing that occurred in 2002 revealed poor winter hardiness only in the case of the susceptible control rootstocks P-HL-B and Colt (Table 6). From *Cerapadus* × *Prunus avium* L. genotypes, however, only a slight frost susceptibility could be stated with CPH 75 and CPH 42. Both of these were classified as susceptible after artificial freezes.

Relationships expressed by correlation coefficients between injuries after single freeze treatments and natural frost damage, as well as interrelations between evaluations of these injuries with the help of observed indicators and average natural frost damage are given in Table 4. Generally, relationships between the results of single treatments and natural frost damage were less close than those between the results of single freezing treatments themselves. The relationship between natural frost damage and results of treatment

Table 5. Mean injury score (by three indicators) of genotypes tested in 2001

Genotypes	Variants of freeze treatments			Mean injury
	(D)	(E)	(F)	
Colt	6.6	4.7	2.8	4.7
CPH 2	8.7	5.9	4.2	6.3
CPH 17	9.0	7.7	6.3	7.7
CPH 18	8.7	5.7	5.0	6.4
CPH 19	9.0	8.1	5.1	7.4
CPH 22	9.0	7.0	6.9	7.3
CPH 24	9.0	7.1	5.0	7.0
CPH 26	8.7	6.5	4.2	6.5
CPH 29	8.3	5.7	4.3	6.1
CPH 31	9.0	6.0	5.7	6.9
CPH 32	8.7	5.0	4.3	6.0
CPH 33	8.7	5.7	5.7	6.7
CPH 42	5.0	4.5	4.4	4.7
CPH 43	8.3	7.3	7.0	7.5
CPH 44	8.2	7.0	4.2	6.5
CPH 45	5.7	5.0	5.0	5.2
CPH 49	8.7	7.0	6.7	7.5
CPH 51	8.7	7.3	5.6	7.2
CPH 69	8.3	7.0	4.3	6.6
CPH 75	5.0	4.3	4.3	4.6
CPH 81	9.0	7.9	5.3	7.4
CPH 84	9.0	5.7	5.0	6.6
CPH 86	8.4	7.0	5.2	6.9
CPH 95	8.3	5.0	3.7	5.7
CPH DOS 1/3	8.5	6.3	4.8	6.5
CPH DOS 1/13	8.6	7.3	5.8	7.2
CPH DOS 1/5	6.7	5.0	4.3	5.3
CPH DOS 1/9	8.7	5.3	4.3	6.1
CPH DOS 1/18	8.0	5.3	5.0	6.1
CPH DOS 1/19	7.0	5.7	5.7	6.1
CPH DOS 2/3	6.3	5.0	3.3	4.9
CPH DOS 2/4	8.0	6.0	4.7	6.2
CPH DOS 2/6	8.7	6.0	4.0	6.2
CPH ST 14/127	6.3	5.0	3.7	5.0
CPH ST 14/130	8.7	7.0	5.0	6.9
CPH VODÁRNA	9.0	7.7	5.7	7.5
P-HL-A	8.7	7.7	6.3	8.2
P-HL-B	6.1	4.7	2.7	4.5
P-HL-C	8.1	6.8	4.0	6.3
S.D. ($P = 0.05$)	0.8	1.5	1.7	1.3

D was relatively the strongest. Concerning single indicators, in the case of natural frost damage the strongest dependence was found between browning of the bud cuts and the weakest between the character and the bud-break.

EFFECT OF THE PARENTAGE OF THE MATERIAL

As has been described in previous paragraphs, significant differences in winter hardiness were found only

Table 6. Mean injury score (by three indicators) of genotypes tested in 2002

Genotypes	Variants of freeze treatments			Natural frost injury	Mean injury
	(D)	(E)	(F)		
Colt	6.8	5.2	3.0	4.5	4.9
CPH 1	8.7	5.8	4.0	8.5	6.8
CPH 2	8.3	5.1	3.9	8.3	6.4
CPH 3	9.0	7.3	4.5	8.8	7.4
CPH 9	8.5	7.0	5.0	8.7	7.3
CPH 17	8.8	8.0	6.7	8.5	8.0
CPH 19	8.7	7.2	4.5	8.5	7.2
CPH 21	8.3	8.2	5.7	8.7	7.7
CPH 22	9.0	7.6	6.7	8.7	8.1
CPH 23	8.5	6.7	4.7	8.5	7.1
CPH 24	8.4	6.5	6.2	8.5	7.4
CPH 26	8.5	7.6	4.8	8.7	7.4
CPH 27	8.7	6.2	6.0	8.5	7.3
CPH 28	7.3	6.0	3.3	7.5	5.8
CPH 29	7.0	5.3	5.3	8.5	6.5
CPH 30	6.7	5.3	5.0	8.7	6.4
CPH 31	8.8	7.3	5.3	8.7	7.5
CPH 32	8.2	4.8	4.3	8.3	6.4
CPH 33	9.0	6.3	5.3	8.7	7.3
CPH 34	7.7	5.2	4.3	8.7	6.5
CPH 38	8.7	7.5	7.0	8.0	7.8
CPH 39	8.2	7.0	4.7	8.2	7.0
CPH 41	8.0	7.3	5.8	8.5	7.4
CPH 42	7.0	3.7	3.5	7.0	5.3
CPH 43	8.8	8.0	7.7	8.5	8.2
CPH 44	8.2	6.8	5.3	8.8	7.3
CPH 45	8.2	5.0	4.7	9.0	6.7
CPH 49	9.0	8.1	5.8	8.5	7.8
CPH 50	8.3	7.0	5.3	8.3	7.2
CPH 51	8.0	5.6	5.1	8.3	6.8
CPH 60	8.7	7.0	4.7	8.8	7.3
CPH 65	8.5	6.8	5.0	8.7	7.2
CPH 66	8.3	5.3	4.7	8.7	6.8
CPH 70	8.0	6.0	4.8	8.7	6.9
CPH 75	8.0	4.4	3.7	6.4	5.6
CPH 81	8.3	6.9	5.9	8.7	7.4
CPH 86	7.3	6.2	4.1	8.5	6.5
CPH 87	8.7	8.0	6.3	8.5	7.9
CPH 95	8.5	6.5	4.3	8.8	7.0
CPH DOS 1/3	8.5	6.3	4.6	8.7	7.0
CPH DOS 1/5	8.7	7.8	6.2	8.7	7.8
CPH DOS 1/7	8.3	5.5	4.7	8.2	6.7
CPH DOS 1/13	8.6	7.3	5.8	8.5	7.5
CPH DOS 1/14	8.3	6.7	5.3	8.3	7.2
CPH DOS 1/15	8.7	6.7	4.0	8.3	6.9
CPH DOS 1/19	8.2	5.2	4.2	8.7	6.5

Table 6 to be continued

Genotypes	Variants of freeze treatments			Natural frost injury	Mean injury
	(D)	(E)	(F)		
CPH DOS 2/2	8.8	5.7	5.3	8.5	7.1
CPH ST 14/130	8.8	7.0	5.3	8.8	7.5
CPH VODÁRNA	9.0	8.0	8.0	8.8	8.5
P-HL-A	8.7	7.7	6.3	8.5	7.8
P-HL-B	6.1	4.7	2.7	3.7	4.3
P-HL-C	7.7	6.8	4.0	7.8	6.6
S.D. (*P* = 0.05)	1.0	1.7	1.6	1.4	1.2

between a limited number of tested genotypes. Nevertheless, a question has arisen of using different sweet cherry cultivars for crossing, as male parents could influence the winter hardiness of originated genotypes. Therefore, genotypes with markedly different evaluations of their winter hardiness were ranked into a table, in which also sweet cherry cultivars used as male parents for crossing are given (Table 7). Notwithstanding a very restricted number of compared genotypes in contending categories, it seems that using different sweet cherry cultivars as male parents does not have a significant influence on winter hardiness of given genotypes.

DISCUSSION

The effects of low temperatures that were used in this work for freezing tests more or less correspond to results of earlier published works (e.g. ROVERSI, UGHINI 1989; WU KE JUN et al. 1997). Artificial treatment of shoots (which were cut just after finishing their deep dormancy) by temperatures –20 to –25°C (treatments E and F) proved to be the best means of finding differences in winter hardiness within hybrid seedlings originating from *Cerapadus* × *Prunus avium* L. crosses. This finding is in agreement with previous results from literature. For the artificial frost treatments, the temperatures ranging between –21 and –24°C are suggested as the most suitable in the period immediately after deep dormancy (PEDRYC et al. 1999). The best correlation between natural and artificial freezing for climatic conditions of central Europe was found after freezing the shoots at –23°C (FISCHER, HOCHFELD 1998).

Bud breaking was found as the most suitable indicator of the frost injury for genotype separation in this work. Therefore, it should be recommended for rapid assessment in the routine testing of the character. For a more precise classification of the tested material, another frost injury indicator could be used – bud browning or wood browning. Regarding the high correlation between both injury indicators, however, it is not necessary to use both two simultaneously. At the present time, tissue browning is mostly used for determining frost injury after freezing tests in woody plants (LEVITT 1972).

Table 7. Sweet cherry cultivars used as male parents in genotypes with different winter-hardiness

Class of winter-hardiness	Genotype	Male parent
Very resistant	CPH VODÁRNA	Stella
	CPH 43	Dönissens Yellow
	CPH 17	Stella
	CPH 22	Van
	CPH 49	?
Resistant	CPH DOS 1/13	Stella
	CPH 81	Van
	CPH 38	Granát
	CPH 87	Granát
Susceptible	CPH 34	Büttners Röte Knorpelkirsche
	CPH 30	Stella
	CPH 28	Starking Hardy Giant
	CPH 45	Büttners Röte Knorpelkirsche
Very susceptible	CPH ST 14/127	Lambert Compact
	CPH DOS 2/3	Dönissens Yellow
	CPH 75	HL 42
	CPH 42	Granát

Regarding the high correlation between test results in different years, it seems also unnecessary for practical selection purposes to repeat the same tests for 3 years. For the attainment of reliable test results, it should be sufficient based on the results of this work to implement two-year repetitions, and only in the cases where these two tests were not in reasonable agreement, repeated in the third year. A two-year period of frost hardiness testing was used for the classification of cherry cultivars in Germany (FISCHER, HOCHFELD 1995).

Frost susceptibility of the control rootstock Colt was reported by several authors (WEBSTER, SCHMIDT 1996; CALLESEN, YSTAAS 1998) and also by MITTELSTÄDT and WOLFRAM (1996), who included it in laboratory testing. Rather high frost susceptibility of P-HL-B corresponds with some previous observations on this rootstock at Holovousy (BLAŽKOVÁ 2002).

The results of the present study confirmed the statement of STEPANOV (1974) regarding the high value of inter-generic hybrid *Cerapadus* as a donor of excellent winter hardiness for future breeding of cherry rootstocks. It appears that this characteristic is inherited polygenically, and that using a cherry cultivar as a male parent does not have a great influence on the manifestation of the character.

According to the results of this work, the following five genotypes were proved to be the most winter hardy: CPH VODÁRNA, CPH 43, CPH 17, CPH 22 and CPH 49. The authors believe that these should be used as donors of winter hardiness in future breeding, or as standard material for subsequent testing of the characteristic in future research.

References

BLAŽKOVÁ J., 2002. Not published data.

BURKE M.J., STUSHNOFF C., 1979. Frost hardiness: A discussion of possible molecular causes of injury with particular reference to deep supercooling of water. In: MUSSELL H., STAPLES R. (eds.), Stress Physiology in Crop Plants. New York, Winterscience: 197–225.

CALLESEN O., YSTAAS J., 1998. Recent development in cherry rootstock research. Acta Hort., *468*: 219–228.

FISCHER M., HOCHFELD B., 1995. Testing of resistances in sweet cherries (*Prunus avium* L.), Part III. Frost resistance and its relation to *Pseudomonas* and *Cytospora* resistance. Erverbsobstbau, *37*: 175–182.

FISCHER M., HOCHFELD B., 1998. Tests on resistances in sweet cherries (*Prunus avium* L.), Part V. Evaluation of winter frost damages at the sweet cherry collection of the Fruit Genebank Dresden-Pillnitz. Erverbsobstbau, *40*: 43–51.

KRACÍKOVÁ M., BLAŽKOVÁ J., ERBENOVÁ M., 1999. Multiplication of selected seedlings from hybrid progeny *Cerapadus* × *Prunus avium* L. tested by hardwood cuttings and *in vitro*. Proc. of the Anniversary Conference of the Hungarian Sweet Cherry Breeding. Budapest, Hungary, July 17–19, 1998: 132–140.

LEVITT R.E.C., 1972. Responses of Plants to Environmental Stresses. New York, Academic Press.

MITTELSTÄDT H., WOLFRAM B., 1996. Investigations on frost resistance in *Prunus* hybrid rootstocks for cherries. Erverbsobstbau, *38*: 66–70.

PEDRYC A., KORBULY J., SZABO Z., KARAYIANNIS I., 1999. Artificial frost treatment methods of stone fruits. Acta Hort., *488*: 377–380.

ROVERSI A., UGHINI V., 1989. Sensibilita delle gemme a fiore del ciliegio ai geli invernali. Annali Fac. Agr., Universita Cattolica del Sacro Cuore Milano, *29* (1): 43–53.

STEPANOV S.N., 1974. Species and forms of fruit trees and bushes of the USSR and their utilisation in plant breeding. Proc. 19th Inter. Hort. Congr. (Warsaw), *2*: 1–12.

STRAUCH H., 1988. Enthartung und Frostschädigung der Triebe von Kirscharthybriden (*Prunus* × spp.) und *P. avium* – Sorten und Selektionen unter Verwendung von Leitfähigkeitsmessungen an Extrakten von Internodienstucken (Exosmose-Methode). Inst. Pflanzenbau und Pflanzenzüchtung, Obstbau und Obstzüchtung, Justus-Liebig-Universität, Giessen. [Thesis.] 177.

VOROBJEVA G.M., 1996. Razmnoženije višni v Novosibirskoj oblasti. Sadov. Vinogr.: 17–18.

WEBSTER A.D., SCHMIDT H., 1996. Rootstocks for sweet and sour cherries. In: Cherries, Crop Physiology, Production and Uses by A.D. WEBSTER and N.E. LOONEY, CAB International, Wallingford, UK: 127–163.

WU KE JUN, GUO RONG PING, JIA FU MING, WU K.J., GUO R.P., JIA F.M., 1997. Performance of sweet cherry varieties in Lonxi country, Gansu province. China Fruits, *2*: 53.

Received 6 Juni 2002

Testování odolnosti vůči zimním mrazům ve dřevě u selekcí z potomstev křížení *Cerapadus* × *Prunus avium* L.

ABSTRAKT: Mrazuvzdornost genotypů předběžně vybraných z potomstev po křížení *Cerapadus* × *Prunus avium* L. byla testována po tři roky (v letech 2000–2002) v laboratorních podmínkách po ošetření roubů nízkou teplotou v době krátce po ukončení hluboké dormance. Jako kontroly byly použity klonové podnože třešní zapsané v listině povolených odrůd ČR. S poklesem teploty zmrazování se zvyšovala maximální i průměrná intenzita poškození testovaného materiálu. K nejsilnějšímu poškození testovaného materiálu (přibližně na úrovni LD 50) došlo po ošetření teplotou –25 °C po dobu čtyř hodin, po níž následovala teplota –20 °C po dobu 66 hodin. Výsledky laboratorních testů byly porovnávány s následky přirozeného mrazu, ke kterému došlo v první polovině ledna 2002. Výsledky hodnocení v jednotlivých letech se v průměru navzájem příliš nelišily. Z kontrolních podnoží byla k mrazovému poškození nejcitlivější P-HL-B, která se zdála být dokonce citlivější vůči mrazům než podnož Colt. Podnož P-HL-C byla vyhodnocena jako středně citlivá, zatímco podnož P-HL-A se projevila jako mrazuvzdorná. Průměrná bonitační známka pro 48 testovaných genotypů z křížení *Cerapadus* × *Prunus avium* L. dosáhla hodnoty 6,7, kdežto průměrná známka pro kontrolní podnože činila pouze 5,9. Podle celkových výsledků tohoto studia byly testované genotypy roztříděny do pěti tříd s různou odolností nebo citlivostí k mrazům. Nejvíce z nich byla zastoupena třída se střední odolností. Největší mrazuvzdornost mělo pět následujících genotypů: CPH VODÁRNA, CPH 43, CPH 17, CPH 22 a CPH 49. Na základě dalších výsledků získaných tímto studiem jsou navrženy některé úpravy metodiky testování mrazuvzdornosti.

Klíčová slova: mrazuvzdornost; mrazová poškození; testování; *Cerapadus*; *Prunus avium*; podnože třešní; hybridy

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Corresponding author:

Ing. JITKA BLAŽKOVÁ, Výzkumný a šlechtitelský ústav ovocnářský Holovousy, s.r.o., Holovousy 1, 508 01 Hořice v Podkrkonoší, Česká republika
tel.: + 420 493 692 821–5, fax: + 420 493 692 833, e-mail: blazkova@vsuo.cz