Freeze Susceptibility of Fruit Buds in 67 Apple Cultivars in Hungary

G. Tóth M.

BUESPA, Faculty of Horticultural Science, Department of Fruit Science
1118 Budapest, Villányi út 29-43., Hungary, e-mail: gtothm@omega.kee.hu

Summary: Frost damage is one of the most important risks of apple production. Outstanding importance has been attributed to the frost resistance of flower-buds as decisive sites of fruit production. Browning of plants parts and tissues exposed to natural weather adversities are considered as effects of frost. In Hungary, frost damage on flower buds of both the market and new cultivars has not been assessed earlier. Observations referring to the consequences of frost damages of over four critical years, marked by their peculiar winter and spring frost hazards. Parallel observations have been made in four sites of the growing area in the Great-Plain region. 67 apple cultivars have been assessed. Each cultivar was represented by 3 trees, which were sampled at about 1–1.5 m height over ground, where the buds or inflorescences were picked for the purpose to assess the injury. The buds and flowers are cut longitudinally and rated visually according to the extent of browning of the organs and tissues. Susceptibility of different organs of the flower (pistils and anthers) were rated separately. According to our results, most resistant to spring frosts are the following cultivars: 'Gloster', 'Granny Smith' and appreciable tolerance is attributed in 'Gala' and 'Jonathan' with derivatives. Preliminary results that among the scab resistant cultivars, 'Baujade', 'Rewena', 'Liberty', 'Resi' and 'Renora' are rather frost resistant. Information, lacking hitherto, is obtained upon 'Reka' and 'Reglindis' as for their increased susceptibility.

Key words: *Malus x domestica*, apple, cultivar, spring frost, blossom, freeze damage

Introduction

Frost damage is one of the most important risks of apple production. Growers observed, since long, conspicuous differences in frost injury between cultivars over the same orchards, so the existence of a genuine frost resistance/tolerance has been postulated. As the heaviness and appearance of damage varied also according to organs of the trees and to the seasons, a reliable method to fix some criteria of determining resistance/tolerance of particular cultivars or trees subject to experimental treatments became necessary. Outstanding importance has been attributed to the frost resistance of flower-buds as decisive sites of fruit production, thus an assessment of frost injury offers immediate information for yield forecast or frost resistance, at the same time, may characterise the cultivar. According to *Szabó* (2002), the basic and most applied method of exploring frost resistance/susceptibility is the field observation. Death or browning of plants parts and tissues exposed to natural weather adversities are considered as effects of frost.

Frost damage of flower buds has been assessed earlier by several authors. In Germany *Mittelstadt & Koch* (1979) stated that 'Idared' and 'McIntosh' belong to the group of frost resistant cultivars, whereas 'Jonathan', 'Mutsu' and the types of 'Delicious' are frost susceptible. *Warner* (1987) at the central-eastern part of Ontario, Canada, raised data of frost damage in flowers of different cultivars after a critical cold spell of 4.5 °C below zero. The cultivar 'Idared' was the less damaged one over two seasons, whereas 'Red Delicious' suffered heavy injuries in the flower parts. 'McIntosh' resembled 'Red Delicious' in one season but showed even heavier damages in the other.

In Hungary, frost damage on flower buds of quite a few cultivars has been explored first in the Department of Fruit Science (*Tóth*, 1982). Once, at the end of April, 6 °C below zero offered an opportunity to score the injury in flower buds. The 'Delicious' group, furthermore, 'Mutsu' and 'Winesap' cultivars showed the most deleterious effects, 'Jonagold' and relatives and clones of 'Golden Delicious' and 'Jonathan' were intermediate, whereas 'Gloster' and 'Granny Smith' proved to be the most tolerant. Those results have been confirmed by *Szabó & Davary-Nejad* (1989) and also by *Davary-Nejad* et al. (1995), but the susceptibility of 'Idared' had been underlined too.

According to *Longstroth* (2004), late spring frosts are hurting mainly the first, "king bloom" of the cyme inflorescence, having the best chance to produce most precious fruit. The loss used to be compensated by the plant by the next healthy lateral flower, sometimes more developed than the central one.

Bubán (2002) assessed the frost injuries in several apple cultivars under less dangerous (–4.3 °C) conditions but of longer duration. The browning in flowers of spurs and on

Table 1: Critical temperatures causing frost injuries in apple flowers buds and flowers being subject to examination

Site of observations	Year	Critical days	Minima measured at the station °C	Radiation minima °C	Date and site of flower-sampling
Kecskemét	1991	April 23	0	–5	May 2. Helvécia
		April 22	–1	–6	May 6. Kecskemét
		April 21	1	–2	
Szigetcsép	1992	April 22	–1	–4	April 27.
		April 12	–1	–4	Szigetcsép
		April 11	–1,2	–4,6	
Szigetcsép	1995	April 16	–2.1	–2.4	April 17.
		April 15	–2.4	–4.5	Szigetcsép
		April 14	0.8	–2	
		April 13	–0.5	–2	
		April 12	–0.5	–3.4	
		April 11	–2.5	–5.6	
Eger	1995	April 12	-3	–5	April 12.
		April 11	-5	–7	Heves
		April 10	0	–3	
		April 09	1	–1	
Szigetcsép	2002	April 10	–1.5	–2.4	April 16.
		April 09	–4.9	–5.7	Szigetcsép
		April 08	–5.2	–8	
		April 07	–3.5	–7	

long shoots, moreover, the position of flowers within the inflorescences was distinguished. On the spurs, there was no essential difference between the damage of the cultivars studied ('Pinova', 'Schneica' (Jonica), 'Idared', 'Sampion', 'Freedom'), i.e a mean of 90%. On the long shoots, more differences were shown, namely, 'Pinova' and 'Freedom' suffered about 30% damage, only.

Late spring frosts harm not only the buds, flowers and fruit primordia but also the leaves and leaf rudiments got distorted, moreover, earlier observations (*G. Tóth* 2001) referring to the "chill", which means loss of yield and quality, distortion, corky stripes, rings and caps around the calyx depression.

There are a lot of results indicating that winter frosts and spring frosts cannot be evaluated independently, the damage experienced in springtime is often the consequence of winter hazards too. Low temperatures may have visually observed effects, but often the development of living flower organs is also impaired. *Zatykó* (1986) called our attention to the fact that injuries (or yield loss) are not proportional with the severity of frost. Full yields occurred after –4 °C temperatures, whereas only –0.6 °C caused another time almost a complete loss, as registered in Hungary. The author explained it with the different developmental stage of flowers and the temperatures throughout the respective winter.

In the Department of Fruit Sciende, characterisation of traditional and new cultivars over several critical seasons has been attempted. The present study aimed to display those accumulated observations.

Material and method

Location and circumstances of the experiments

Observations referring to the consequences of frost damages over four critical years marked by their peculiar winter and spring frost hazards (1991, 1992, 1995 and 2002). Most of the cultivars have been grown at the experimental farm of the Horticultural Faculty, Szigetcsép. Parallel observations have been made in orchards of fruit growing areas, Heves as well as Kecskemét. Laboratory tests took place in the Department of Fruit Science, Budapest.

Szigetcsép shared the temperature regime of the Great Plain. The soil was sandy loam combined with raw alluvial sediment. The orchard was planted in 1990 on M106 at a spacing of 4.5 × 2.5 m and trained to spindle crown. Flower samples of the scab-resistant cultivars were collected in 1995 on trees grafted in 1993. A plantation of the new scab-resistant accessions ensued in 1994 and the first samplings of the spindle–trained trees on M26 are dated of 2002. Their spacing was 3.5 × 1.5 m, and the standard agro- and phytotechniques have been applied, however, without regular watering.

Heves represented the climate of the northern Great-Plain region. The sandy loam had a meadow character. The orchard is dated to 1991 on M9 rootstock, trained to slender spindle at 3.5 × 1.2 m spacing. Regular irrigation produced well fed trees.

Helvécia and *Kecskemét* had the typical light, moving sand soil with the most excessive continental climatic properties. The orchard of Helvécia was planted in 1984 on M4 rootstocks. At Kecskemét, trees are on M106 as free spindles spaced to 4 × 2 m.

Temperatures of the respective frosty seasons are shown in *Table 1;* jointly, the dates of flower samplings are indicated. The minimum temperatures registered due to nightly radiation were a good deal below the critical minima determined by *Teskey* (1972) as critical.

Methods of the analysis

Each cultivar was represented by 3 trees, which were sampled at about 1–1.5 m height over ground, where the buds or inflorescences were picked for the purpose to assess the injury. The number of samples is reported in each table in every case and season examined. The buds and flowers are cut longitudinally and rated visually according to the extent of browning of the organs and tissues. Susceptibility of different organs of the flower (pistils and anthers) were rated separately.

The most meticulous inspections were performed in 1991, as the extent of injury was expressed on a scale of 5 degrees. 1 – healthy flower, 2 – some of the pistils are damaged, 3 – all pistils are damaged; 4 – all pistils and some of the anthers are damaged, 5 – all reproductive organs (pistils and anthers) are damaged.

Table 2: Frost damage in flowers and buds of the main apple cultivar groups and cultivars (1991)

Cultivar	Growing site	Organ examined	Number exa-mined	Total	Some pistils	All pistils	All pistils & some anthers	All pistils & all anthers
				damage (%)				
Jonathan types (clones and derivatives)								
Jonathan M 40	Helvécia	flower buds	57	44	5	32	7	0
		open flowers	56	57	0	27	7	23
Jonathan M 41	Helvécia	flower buds	52	14	0	6	0	8
		open flowers	51	59	0	20	25	14
	Kecskemét	flower buds	50	10	10	0	0	0
		open flowers	50	6	6	0	0	0
Jonathan Csány 1	Helvécia	flower buds	54	74	0	24	35	15
		open flowers	50	86	0	70	10	6
Akane	Helvécia	flower buds	55	45	0	13	14	18
		open flowers	52	49	0	2	42	5
Kovelit	Helvécia	flower buds	61	20	0	8	10	2
		open flowers	52	81	2	75	4	0
Nyári zamatos	Helvécia	flower buds	53	72	4	66	2	0
		open flowers	54	87	6	74	5	2
Idared	Helvécia	flower buds	54	45	4	28	11	2
		open flowers	52	60	2	58	0	0
	Kecskemét	flower buds	50	10	0	10	0	0
		open flowers	51	65	6	53	6	0
Jonagold	Helvécia	flower buds	50	6	0	4	2	0
		open flowers	56	52	0	0	21	31
	Kecskemét	flower buds	50	8	0	8	0	0
		open flowers	50	6	6	0	0	0
	Golden types (clones and derivatives)							
Golden Delicious	Helvécia	flower buds	53	66	0	62	4	0
		open flowers	51	100	12	41	45	2
Gibson Golden Del. (Smoothee)	Helvécia	flower buds	50	16	0	6	10	0
		open flowers	50	78	0	14	26	38
Golden Spur	Helvécia	flower buds	52	14	0	8	0	6
		open flowers	50	40	8	8	18	6
Mutsu	Helvécia	flower buds	53	42	0	8	21	13
		open flowers	54	98	0	59	9	30
Ozark Gold	Helvécia	flower buds	57	19	0	7	7	5
		open flowers	51	82	4	35	37	6
	Delicious types (clones and derivatives)							
Starking Nm. 251	Helvécia	flower buds	52	61	0	40	21	0
		open flowers	53	92	0	66	24	2
Starkrimson Delicious	Helvécia	flower buds	53	62	0	56	6	0
		open flowers	50	62	0	96	0	0
Topred Delicious	Helvécia	flower buds	52	46	2	44	0	0
		open flowers	54	96	0	61	26	0
Redspur Delicious	Helvécia	flower buds	60	58	0	58	0	0
		open flowers	51	85	0	65	20	0
Wellspur Delicious	Helvécia	flower buds	51	71	0	67	4	0
		open flowers	50	94	4	90	0	0
Pirtospur Delicious	Helvécia	flower buds	49	77	2	61	14	0
		open flowers	51	90	2	76	8	4
Skyspur Delicious	Helvécia	flower buds	63	51	0	38	11	2
		open flowers	56	77	2	67	4	4
Gloster Kecskemét	Helvécia flower buds	flower buds 50	53 2	44 0	6 2	38 0	0 0	0
		open flowers	50	38	28	10	0	0
Other cultivars								
Granny Smith	Helvécia	flower buds	52	4	2	2	0	0
		open flowers	51	35	0	35	0	0
Mollies Delicious	Helvécia	flower buds	54	26	0	9	15	2
		open flowers	52	87	0	33	23	31
Red Rome Van Well	Helvécia	flower buds	50	94	28	54	8	4
		open flowers	43	91	0	82	0	9
	Kecskemét	flower buds	50	2	0	2	0	0
Summerred	Helvécia	flower buds	50	12	0	0	0	0
		open flowers	54	0	0	4	18	72
Staymared Nk. 573	Helvécia	flower buds	53	62	0	19	30	13
		open flowers	51	94	0	66	22	6

The number, i.e. the rate of damaged flowers determined separately according to their stage development (generative buds, flower buds, flowers). For the main cultivars, which were represented over several years, a numerical index of susceptibility/resistance has been calculated. The formula applied by *Warner* (1982) has been modified for our purpose:

$$Hi = (E\% * 3) + (R\% * 2) + (T\% * 1),$$

where H = index of cold tolerance,
E = healthy flower,
R = partially damaged flower (only pistils froze),
T = totally destroyed flower (pistils and anthers are killed).

Results

Frost damages observed in 1991 at Helvécia and Kecskemét are presented in *Table 2*. Cultivars are grouped in the *Table* as to their relations and also individually. At both localities, injuries proved to be more severe in open flowers than in closed "red" flower buds. Frost damages were more severe at Helvécia, where the 'Red Delicious' and related clones suffered the most. Similar damage showed up on flowers of 'Nyári zamatos', 'Jonathan Csány 1', 'Golden Delicious', 'Red Rome Van Well' and 'Staymared Nk. 573'. The less affected were in 'Granny Smith' flowers.

Susceptibility of flower parts was different. Most susceptible were the pistils, as in the majority of cases, not single pistils were damaged but rather all of them within one flower. Differences were more accentuated in the fate of stamina. In the majority of cultivars but a few anthers suffered. In the flowers of 'Jonathan M41', 'Akane', 'Gibson Golden Delicious' and 'Mollies Delicious', the anthers were more susceptible than the pistils.

Table 3: Frost damage in flower buds and open flowers of the main apple cultivars (Szigetcsép, 1992)

Cultivar	Organ examined	Number of samples examined	Damage (%)
Jonathan M41	flower bud	50	0
	open flower	55	22
Idared	flower bud	58	14
	open flower	43	28
Jonagold	flower bud	50	16
	open flower	39	28
Mutsu	flower bud	50	8
	open flower	35	29
Gloster	flower bud	56	2
	open flower	27	26

Table 3 shows the damage experienced in 5 cultivars at Szigetcsép, 1992. Following the period of low temperature, 5 and 14 days later, the damage tended to show similar symptoms as a year earlier. Differences among cultivars were less expressed, but 'Jonathan M41' and 'Gloster' proved to be less susceptible than the triploid 'Mutsu' and 'Jonagold'.

In 1995, at Heves and Szigetcsép frost damage of flower buds was scored twice: April 12 and 17 *(Table 4)*. Several days elapsed with temperatures lower than 0 °C at the level of the tree crowns, all that being for developing flower buds below the level determined as critical by *Teskey* (1972). At this time, new scab resistant cultivars were also included into the assortment examined. Two growing sites involved also differences in temperatures as shown in *Table 1*. At Heves, more severe injuries were experienced than at Szigetcsép. To the lower temperatures, the higher frequency of injured flower buds (in pistils and in anthers) has been attributed.

Damages of cultivar-types and of individual cultivars were conspicuous. Highest injuries hit the cultivars 'Idared', 'Jonagold' clones, 'Mutsu' and 'Summerred'. Outstanding frost tolerance was manifested by 'Gala', relatives of 'Jonathan' and its clones, 'Golden Delicious' and its diploid hybrids ('Ozark Gold', 'Snygold'), moreover, by 'Granny Smith', 'Gloster' and 'Red Rome Van Well'. Cultivars belonging to the Red Delicious group, in this year, were not as extremely susceptible as before. Out of the new cultivars, 'Elstar', 'Braeburn', 'Fuji' and 'Rafzubin' (Rubinette) suffered intermediate losses.

A scab resistant cultivar, 'Freedom', was injured almost totally in 1995. Heavy losses hit 'Florina', 'Reka', 'Prima' and 'Relinda', whereas a slight damage characterised the flowers of 'Resi', 'Reanda', 'Renora' and 'Releika'.

In 2002 at Szigetcsép, frost tolerance of scab resistant cultivars obtained special attention *(Table 5)*. This year experienced the most heavy temperature minima. One week later, injury wase checked in dissected flowers. Cultivars susceptible to scab, which were in a weakened condition – except 'Idared' – suffered much more than earlier, but the relative resistance of 'Granny Smith' was still obvious.

Table 5: Frost damage of flowers in scab-resistant and non-resistant cultivars (Szigetcsép, 2002)

Name of the cultivar	Number of flowers observed	Whole flower	Pistils	Pistils and anthers
		Damage (%)		
Scab-resistant cultivars				
Baujade	352	27	22	5
Freedom	53	100	0	100
Liberty	327	40	18	22
Reanda	165	73	36	37
Reglindis	257	88	24	64
Reka	313	94	29	65
Releika	368	64	13	51
Relinda	220	95	7	88
Remo	503	52	19	33
Renora	208	50	24	27
Resi	144	63	37	26
Retina	499	81	22	59
Rewena	275	37	28	9
Non scab resistant cultivars				
Braeburn	44	100	0	100
Fuji	62	94	9	85
Granny Smith	113	72	31	41
Idared	46	100	0	100
Mitchgla (Mondial Gala)	110	88	17	71

Table 4: Frost damage in buds of the main apple cultivar groups and of the new cultivars (1995)

Name of the cultivar	Locality	Phenological stage	Number of flowers observed	Total	Pistils	Pistils and anthers
				damage (%)		
Jonathan type clones and derivatives						
Jonathan	Szigetcsép	red buds	122	39	29	10
Jonathan M41	Heves	green buds	129	8	2	6
Watson Jonathan	Szigetcsép	green buds	106	3	1	2
Kovelit	Szigetcsép	green buds	119	24	7	17
Idared	Szigetcsép	red buds	148	39	27	12
	Heves	green-red	140	87	7	80
Jonagold	Szigetcsép	red buds	114	38	5	33
	Heves	green buds	130	88	5	83
Jonagold Wilmuta	Heves	green-red	131	62	6	56
Schneica (Jonica)	Heves	green buds	132	83	6	77
Jonagored	Heves	green buds	128	80	2	78
	Golden types (clones and derivatives)					
Golden B	Heves	green buds	132	24	3	21
Golden Delicious C-4-49	Szigetcsép	green buds	92	15	1	14
Gibson Golden D. (Smoothee)	Heves	green buds	126	36	8	28
Golden Spur	Szigetcsép	green buds	123	33	3	30
Mutsu	Szigetcsép	green buds	93	65	7	58
	Heves	green buds	135	40	7	33
Charden	Heves	green buds	127	52	15	37
Ozark Gold	Szigetcsép	intermediate	72	1	0	1
Snygold (Earligold)	Szigetcsép	red buds	58	12	9	3
	Delicious types (clones and derivatives)					
Starking	Szigetcsép	green buds	95	24	21	3
Starkrimson Delicious	Szigetcsép	intermediate	126	15	7	8
Redspur Delicious	Szigetcsép	green-red	142	20	8	12
Campbell (Redchief) Delicious	Heves	green buds	136	31	21	10
Gloster	Szigetcsép	green buds	101	0	0	0
	Other cultivars					
Mitchgla (Mondial Gala)	Heves	green buds	126	28	2	26
Tenroy (Royal Gala)	Heves	green buds	135	14	2	12
Granny Smith	Szigetcsép	green buds	101	1	1	0
Jim Brian (Early Smith)	Szigetcsép	green buds	53	8	6	2
	Heves	green buds	127	39	3	36
Elstar	Heves	green buds	130	52	0	52
Red Elstar	Heves	green buds	121	55	0	55
Akane	Szigetcsép	intermediate	96	42	18	24
Arlet	Heves	green buds	141	48	11	37
Braeburn	Szigetcsép	red buds	142	30	30	0
Delgollune (Delbard Jubilé)	Heves	green buds	127	29	9	20
Delcorf (Delbarestivale)	Heves	green buds	136	20	7	13
Fuji	Heves	green buds	131	48	11	37
Fuji Yataka	Heves	green buds	133	24	12	12
Pilot	Szigetcsép	green buds	89	29	2	27
Pinova	Szigetcsép	intermediate	121	35	12	23
Piros	Szigetcsép	green buds	85	31	12	19
Red Rome Van Well	Szigetcsép	green buds	114	0	0	0
Rafzubin (Rubinette)	Heves	green buds	129	50	6	44
Summerred	Szigetcsép	red buds	83	66	31	35
	Scab-resistant cultivars					
Florina	Heves	green-red	134	73	1	72
Freedom	Heves	green-red	130	91	1	90
Prima	Szigetcsép	intermediate	102	65	32	33
Reanda	Szigetcsép	intermediate	98	5	3	2
Reglindis	Szigetcsép	green buds	93	24	0	24
Reka	Szigetcsép	green buds	101	72	6	66
Releika	Szigetcsép	green buds	68	9	0	9
Relinda	Szigetcsép	red buds	106	61	11	50
Remo	Szigetcsép	green buds	87	43	7	36
Renora	Szigetcsép	green buds	59	8	0	8
Resi	Szigetcsép	green buds	79	1	0	1
Retina	Szigetcsép	green buds	80	44	0	44

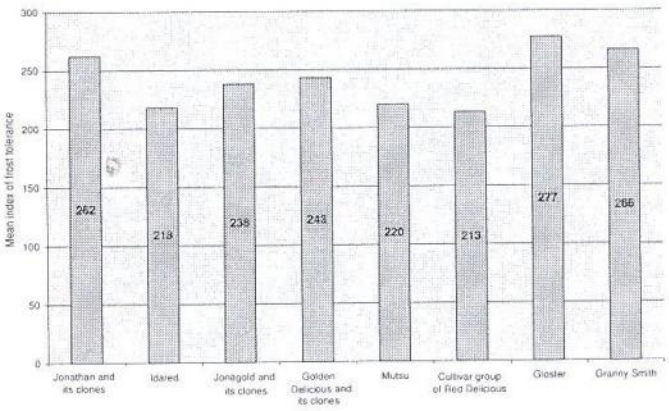

Figure 1 Indices of cold tolerance of the main apple cultivars and group of cultivars

Out of the scab resistant cultivars, which were not represented in the earlier years, 'Baujade', 'Rewena' and 'Liberty' were the less damaged in their flowers. Almost total losses were experienced, similarly to 1995, in 'Freedom', 'Relinda' and 'Reka', and in the earlier less damaged 'Reglindis'. Heavy losses were registered in 'Retina' and in 'Reanda', the latter though showed less browning in 1995.

The indices of cold tolerance in cultivars and groups of related cultivars calculated on the basis of data accumulated over several years are shown in *Figure 1*. Each value of the *Table* was derived from 5–18 data – all of them being raised by original observations. Within the groups of cultivars, the individual data of accessions or clones are averaged, as in 'Jonathan', 'Jonagold', 'Golden Delicious' and 'Red Delicious'. The cultivar group of 'Red Delicious' proved to be the most cold susceptible, then 'Idared' and 'Mutsu' followed, whereas most tolerant are, according to their indices, 'Gloster' followed by 'Granny Smith' and 'Jonathan'.

Discussion and conclusions

Results presented in *Tables 2–5* have been compared with our own earlier data as well as with those published in the literature. Most of the results referring to the most important cultivars and cultivar-groups were corroborated. *Mittelstadt & Koch* (1979), *Warner* (1982) *Tóth* (1982), *Davary-Nejad* et al. (1995) approved our statements as to the high susceptibility of flowers in the cultivar group of 'Red Delicious' and 'Mutsu', moreover, the relatively high tolerance of 'Gloster' and 'Granny Smith'.

Contradictory results referring to the cold tolerance of 'Idared' are also revealed in our present results, which appeared in the difference between the data of the years. Susceptibility depends on the temperature as well as from the phenological status of the plant. So, the freeze of 5°C below zero caused heavy losses on the crown level at April 10. Consequently, 'Idared' has been rated to be frost susceptible, in Hungary.

Our values of the index expressing cold tolerance are coincident with the experiences of *Warner* (1987), rating 'Mutsu' and the cultivar group of 'Red Delicious' (with the means of 12 cultivars) as less tolerant, whereas the groups of 'Jonnee' and 'McIntosh' as the highest.

Results related to new cultivars first studied in Hungary as for their frost tolerance are to be utilised in production. The scab resistant assortment of cultivars proved to be conform with their earlier characterisation (*Fischer & Fischer* 1996, *Bubán* 2002). The majority of new German resistant cultivars (the Re-series) produced the same indices, which were first published by *Fischer & Fischer* (1996). As exception, higher frost susceptibility of flowers was experienced in 'Reanda' and 'Relinda'. Information, lacking hitherto, is obtained upon 'Reka' and 'Reglindis' as for their increased susceptibility, whereas as for the better tolerance of 'Baujade'.

About the controversy around the susceptibility of flower buds and open flowers there was hardly enough proof for answering the questions. *Mittelstadt & Koch* (1979) emphasise the decisive role of the phenotypical stage of the flowers (the ratio of open flowers and closed flower buds), whereas *Teskey* (1972) assigned different critical temperatures to different developmental stages. On the contrary, American experiences did not recognise differences in frost injuries after the red flower bud stage (*Anonymus* 2004).

As we experienced, flower buds in the green stage stopped growing as the consequence of heavy frost injury, subsequently, started dropping after 10 days. That was the supposed cause of the fact that 2 weeks after the severe frost, at Kecskemét, the picked flowers were less damaged. The flower buds, as then mentioned, in green stage, most likely, were not represented in the samples, any more. Earlier, *Szabó & Davary-Nejad* (1989) reported also about the shedding of injured flower buds within 10–14 days.

We are confident of our results being in harmony with the earlier findings published elsewhere that, in the future, growers should be aware of the results related to the different degrees of spring frost tolerance represented by the commonly grown cultivars. An adequate strategy to prevent or moderate losses caused by low temperatures, could be based, potentially, on that information. The way of lowering risks is to follow the knowledge of the eco-tolerance of cultivars, especially frost tolerance. The choice of the most suitable cultivar for the respective growing site, alone, may avoid the most severe risks. New cultivars should be tested at different growing sites as for their frost tolerance in order to base recommendations on reliable information. For that purpose, continental and variable climatic conditions of growing sites in Hungary offer especially excellent conditions to check climatic hazards as winter- and spring frosts within a period of several years.

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