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FROST RESISTANCE OF SOME SWEET CHERRY CULTIVARS IN THE BUCHAREST AREA

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Abstract

Sudden low temperatures could occur in the spring when some of sweet cherry cultivars are more susceptible to freeze and floral buds injuries. These are delicate moments for growers year by year. In this study, differences in cold hardiness and lethal temperatures were observed during the same phenological stage (bud burst) for the same cultivar as well as among tested cultivars ('Katalin', 'Kordia', 'Burlat', 'Rivan' and 'Regina'). It was used the frost induced method for determining cold hardiness of cherry buds (-7 ⁰C/0,5h; -7 ⁰C/1h; -1,5 ⁰C/0.5h; -1,5 ⁰C/1h; -2,5 ⁰C/1 h). The injuries observed were highly dependent on the stage of development of flower buds. Progressive vulnerability of the bud to low temperatures was observed. During 2012-2014, it was noticed that the cultivars were sometimes sensitive, semi-sensitive or hardiness, varying with the amount of active temperatures over 7⁰C. Although the determination of the maximum hardiness is genetically attainable, the description of changes in hardiness is possible; more years of observations are needed as a result of the strong climatic influence.

Key words*: sweet cherry, phenology, temperature stress, hardiness, cultivars*

INTRODUCTION

Nowadays, sweet cherry is getting more and more importance due to their nutritional and fresh fruits quality (Budan and Gradinariu, 2000), new orchards being setting up in different geographic areas.

As part of the Prunoideae group, *P. avium* L. in one of the species with medium cold hardiness (Snyder and de Melo-Abreu, 2005). Tree resistance (buds, flowers, woody tissue, roots) depends on the cultivar traits respectively age, water content of the tissues, rootstock as well as of environmental conditions (thermal oscillations, amplitude from autumn till spring, frost/defrost processes, intensity and freezing duration).

Intense frostbite occur when sudden transition from autumn to winter happened, in November-December or after repeated defrosts in January-February, when flowering buds are the end of the dormant period.

Reproductive buds of cherries are more susceptible to freezing injury than vegetative buds, while the blossoms of the growing cherry trees are extremely susceptible to frost damage (Asanica et al., 2013). Frost resistance varies within the tree itself and in the same extent within orchard cultivars, flowers of cultivars in the same phenological stage. The resistance of the flower bud to low temperatures changes rapidly and predictably in response to both temperature and the stage of floral development (Proebsting, 1982).

Differences in cold hardiness and lethal temperatures were observed during different developmental stages for the same cultivar as well as among cultivars. Differential thermal analysis (DTA) is an effective method for determining cold hardiness of dormant cherry buds (Melba R. Salazar-Gutierrez, 2014).

The aim of this study was to determine the critical temperatures for some sweet cherry cultivars in the South-East part of Romania at specific phonologic stage of the trees.

MATERIALS AND METHODS

The research was carried at the Faculty of Horticulture Bucharest and the biological material was collected from the Experimental Field of the Fruit Growing Department, located in the geomorphological unit Romanian Plain, subdivision Vlasiei to 44⁰29′50″N and 26⁰15′26″E.

The climate is temperate-continental with warm, sometimes hot and frequent droughts and cold winters, with large amounts of snow. The springs are short, with big jumps in temperature from month to month with significant variations between day and night; autumns are distinguished by thermal moderation and slow transition to winter. The annual rainfall is between 500 and 600 mm, the maximum occurring in the period May-July.

Five sweet cherry cultivars with different harvest time were tested: 'Rivan', 'Katalin', 'Burlat', 'Kordia' and 'Regina', all grafted on *Prunus mahaleb* L. The experimental temperatures and the duration of induced frost were designed as follows:

Variant	Temperature (induced freeze) (^{0}C)	Exposure time (h)
V1	-7^{0}C	1/2 h
V2	-7^{0}C	1 h
V3	-1,5^0	1/2 h
V4	-1,5^0	1 h
V5	-2,5^{0}C	1 h
Control	field tested resistance	

The phenological stage for cold hardiness test of the cultivars was bud burst, corresponding to 5th of April in 2013 and 12th of March in 2014. The temperature controller used for inducing frost was the refrigerator TENAK LT300.

In order to start the experiment, it were collected 30 fruiting branches for each cultivar splitted in five samples for every experimental variant. The branches were quickly worked out and the order in which the samples were exposed to induced frost was V2, V1, V5, V4 and V3.

Immediately after pulling out the refrigerated branches it were made transversal sections and was noted the viability of the floral buds on the branches. For the control samples (not freeze) the sections through the floral buds was previously made in the lab.

For fruit trees, the effects of the winter frost could be emphasized based on the agrometeorological index respectively cold units, represented by the amount of negative average air temperatures ($\sum$Tav <0°C = cold unit, XI-III). This reflect the degree of harshness and intensity of cold for the entire cold season (XI-III). This index characterizes the overall vegetation conditions in autumn and winter season, given the possible of sporadic February heating periods *("hot windows")* that may result in reloading and boost of early spring vegetation (Mateescu, 2004).

Hardiness degree / winter type:
cold units ($\sum$T av < 0 ℃, XI-III):

< 100° very low intensity / warm winter
101-200° reduced intensity / soft winter
201-300° moderate intensity / regular winter
301-400° high intensity / cold winter
> 400° huge intensity / very harsh winter

Hardiness degree / winter type:
freezing units ($\sum$T av < -15 ℃, XII-II):

< 10 reduced intensity / soft winter
11 - 30° moderate intensity / regular winter
31 - 50° high intensity / cold winter
51 - 100° very high intensity / very cold winter
>100° huge intensity / very harsh winter

The flowering period and fruit maturation were determined by distinct stages of each phenophase. The amounts of accumulated temperatures were calculated by summing, for each cultivar, based on daily temperature corresponding trigger data and fruiting performance of each phase separately. The amount of the average active temperatures over 7^{0}C for the bud burst and blossoming start phenophases were summed during the dormancy (end of December-start of January).

RESULTS AND DISCUSSIONS

From the current period analysed (2012-2014) results that the cultural years 2012-2013 and 2013-2014 accumulated an index of 128ºC CU (cold units) respectively 132ºC CU. These are correspondingly with soft winter and with reduce intensity.

From the hardiness point of view, an index of -32ºC was calculated for the winter 2012-2013 which means a regular/moderate winter and one of -64ºC for 2013-2014 meaning a very cold winter (Table 1).

Table 1. The degree of winters harshness based on the cold and freezing units

Agrometeorological index	2012-2013	2013-2014
Cold units (^{0}Tav < 0^0C, XI-III	128	132
Freezing units (^{0}Tmin < -15^0C, XII-II	-32	-64

The average winter monthly temperatures for both periods were lower with -1.6^{0}C in December 2012 and with -0.6^{0}C in December 2013 comparative with the multiannual average of -0,1^{0}C.
The warming trend is observed from the monthly average temperatures increase of January (1,7^{0}C in 2013 and 2.2^{0}C in 2014), February (2.3°C in 2013 and 2.4°C in 2014) and March (normal for 2013 - 3.7°C and 3,7^{0}C in 2014) versus the average annual temperatures (Figure 1, 2).

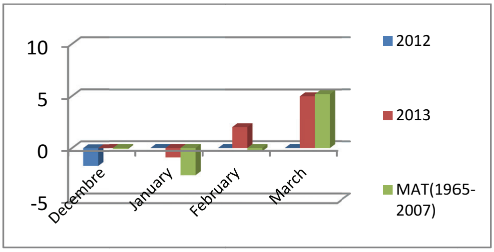

Figure 1. The monthly average temperatures of the 2012-2013 winter versus multiannual average temperatures (Bucharest)

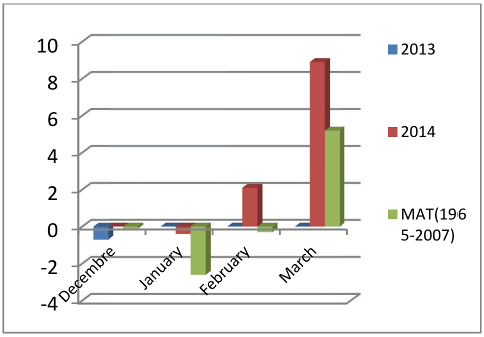

Figure 2. The monthly average temperatures of the 2013-2014 winter versus multiannual average temperatures (Bucharest)

During January and February, floral buds of the studied cherry cultivars have suffered visible injuries under the binocular magnifier. December 2012 was marked by negative minimum temperatures between -17.4°C and 1.7°C, with 3 consecutive days of low temperatures between -4.4°C and -17°C (January, 13-15) and with maximum negative temperature 4 days consecutive by -3.6°C and -4.7°C (January, 19-22); the significant differences compared to the values of multiannual minimum of -3°C and maximum of 2°C.
Significative fluctuations of daily temperatures occurred also in January occurring the minimum -12°C and -14°C over three consecutive days (January, 8-10) and positive maximum temperatures of 10-13°C (January, 21-23) which led to a slight decrease of buds resistance (determined at the of field resistance for control variant) and a delay of the vegetation start.
During the 2013-2014 winter, it was recorded higher values than the annual thermal average, sometimes registering proeminent negative temperatures of -15°C (11.XII), -14°C (14.XII) and -17°C (28.XII). February begins with temperatures somewhat lower than normal period with minimum temperatures between -6°C and -11°C (1 8.II) continuing 15 days with consecutive maximum between 8°C to 19°C, at which buds flowering are rushing to get in vegetation. On 10th of March, they were in the swelling phase and at the end of March the flowering stage already begun.
In general, resistance of cherry to winter frosts depends on tree evolution condition and the evolution of lower temperatures in order to produce frost. Depending on hereditary characteristics of cultivars, age, weather conditions accompanying frosts, the duration and intensity of freeze, it were found different degrees of injuries. Regarding the role of air temperature during the out of dormancy period and subsequently on the development of vegetation and fruiting phenophases they are determined by the cumulative action of daily average temperatures that exceed the amount of 7°C. There is a level of optimum temperatures for each phenophase, along with other factors which ensure normal growth and development of the trees and is required for knowing in time the disturbances that occur in the growth and fructification cycle.

In Tables 2 and 3 are presented the main fruiting phenophases studied and temperature requirements of each cultivar for swelling bud stage, early flowering, late flowering and fruit maturation. From 2012-2013 and 2013-2014 winters characterization it was revealed a soft winters and with low intensity in terms of harshness winter (2013 - 2014) which signify it was moderate and rough winter in case of 2013-2014 winter (Table 1).

In terms of phenological dates, 2013 was a normal cherry year (Table 2) and a very early one in 2014. Bud swelling was triggered between 5.04-10.04 (2013) during 6 days and between 12.03-16.03 during 5 days (2014).

The cultivars accumulated active temperature above 7ºC meeting their individual needs based on the order of ripening in the Bucharest area. Early cultivars 'Rivan' and 'Burlat' accumulated between 199.2ºC and 224.5ºC in 2013 and 78ºC respectively 88ºC in 2014, while the cultivar with late ripening 'Regina' garnered 256ºC and 111ºC. The differences between the early and the late cultivar was of 56ºC in 2013 and 33ºC in 2014. For early flowering phenophase in 2013, 269.5ºC and 352ºC, the difference between maturation groups was of 82.5ºC. In 2014, limits of 164.5ºC and 229.5ºC concerning the temperatures accumulated till flowering counted a 65ºC difference.

Blossoming period lasting between 5-7 days (in 2013) and 5-6 days (in 2014) and the amount of degrees of temperature during flowering ranged from 35.5ºC to 85.5ºC and 46ºC to 57.5ºC under the influence of big temperature variations from respective periods (Table 2, 3). In the Bucharest-Ilfov area, given the above conditions, the studied cultivars have accumulated between 70 to 96ºC (in 2013) and 86 to 118.5ºC (in 2014). Budan and Gradinariu (2000) mention a need of 202 to 310ºC from the swelling buds to the blossom phenophase in the Pitesti-Maracineni region. The importance of air temperature decreases as relevance from blossom time to stone fortification and returns in importance during fruit maturation. From this point of view, the early cultivars (mid early) had accumulated between 799ºC ('Rivan') and 879ºC ('Burlat') medium season cultivars between 867.5ºC ('Katalin') and 912ºC ('Kordia') and late maturity cultivar 'Regina' 1125.5ºC according to the warm demand established by Kolesnikov (1959).

Table 2. Development of fruiting phenophases in 2013 at sweet cherry cultivars in the Bucharest area

Cultivar	Bud swelling	∑º active temp. above 7º C till bud burst	Start of blossom	∑º active temp. above 7º C till blossom	∑ºt from bud burst to blossom	End of flowering	Blossom period (days)	∑ºt during the blossom	Fruit ripening	∑ºt from bud swelling.	Growth and develoment stage (days)	∑ºt from blosoom to fruit maturation
Katalin	10.04	242	15.04	328	86	19.04	5	48	05.06	1374,5	48	867,5
Kordia	10.04	242	15.04	328	86	20.04	6	61	08.06	1432	50	912
Burlat	08.04	224,5	13.04	300,5	76	18.04	6	69	05.06	1374,5	49	879
Regina	11.04	256	17.04	352	96	21.04	5	35,5	18.06	1660,5	59	1125,5
Rivan	05.04	199,5	11.04	269,5	70	17.04	7	85,5	30.05	1283,5	45	799

Table 3. Development of fruiting phenophases in 2014 at sweet cherry cultivars in the Bucharest area

Cultivar	Bud swelling	∑º active temp. above 7º C till bud burst	Start of blossom	∑º active temp. above 7º C till blossom	∑ºt from bud burst to blossom	End of flowering	Blossom period (days)	∑ºt during the blossom	Average temp. limits (ºC)
Katalin	16.03	111	03.04	197	86	08.04	6	46	4-13,5
Kordia	16.03	111	05.04	212	101	10.04	6	51,5	4-16,5
Burlat	12.03	88	01.04	174	86	05.04	5	47,5	7-15
Regina	16.03	111	08.04	229,5	118,5	13.04	6	56,5	8-16,5
Rivan	10.03	78	31.03	164,5	86,5	05.04	5	57,5	7-13,5

In order to test the hardiness of buds flowering, fruit-bearing branches samples were placed in a freezer at different temperatures and exposure times (ET).

Flowering buds of the control variant, in the bud burst stage suffered minor injuries in 2013 ranging between 0.9% at early cultivar 'Burlat' and 8.7 % at late ripening cultivar 'Regina'. In 2014, it weren't recorded losses of buds in any of the cultivars studied (Table 4).
Exposure time (ET) for one hour significantly affect fruit buds, for each of negative temperatures used: -7°C (V2), -2.5°C (V5) and -1.5°C (V4). V2 registered losses between 100% at 'Katalin' and 'Burlat', 73.3% at 'Kordia', 50% at 'Regina' and 36.6% at 'Rivan' in the 2013 experiment. Smaller percentages of losses were recorded in the same variants in 2014, between 29% at 'Katalin', 26.4% at 'Kordia', 25.9% at 'Rivan', 24.2 % at 'Regina' and 9.6% at 'Burlat' cultivar.

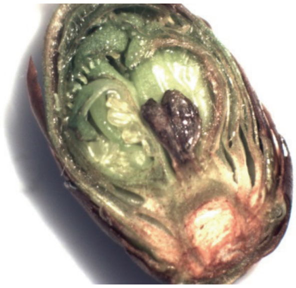

Figure 3. Cross cutting section of the flower bud ('Rivan', 2013)

V3 in the spring of 2014, which consist of -1.5°C temperature and exposure time of half an hour freeze has not encounting problems regarding the viability of flowering buds, which confirms that hardiness of the flowering buds belongs to specie/cultivar genetic structure (Table 3).
The two years study indicate 'Rivan' as the cultivar which recorded the biggest loss of flowering buds (34%) at V5 (-2.5°C/1h) with significant differences of percentages between years as well. He gathered 199.5^{0}C in 2013 (Table 3) and injuries of 18.4% (Table 4) and 78^{0}C in 2014 (Table 3) with 34% losses (Table 4).
Significant deviation recorded in 2013 compared to temperature variations and exposure times greater in V4 (-1.5^{0}C/1h) and 50.9 % bud losses.
Similar proportions of flowering buds losses was found at 'Burlat' cultivar with 10.3% (2013) and 10.4% (2014) when they acquired 88^{0}C and 224.5^{0}C in 2014. From the data presented in the Table 4, we found that at the same experimental variant V5, percentages were close enough at the late ripening cultivar 'Regina' (16.1% in 2013 and 10.7% in 2014) comparing to 'Katalin' or 'Kordia'.

Table 4. Bud losses in the field cold hardiness and induced freeze conditions at some sweet cherry cultivars (2013-2014)

Variant	Lost buds (%)									
	'Katalin'		'Kordia'		'Burlat'		'Regina'		'Rivan'	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Control (field)	6,8	0	7,1	0	0,9	0	8,7	0	7,3	0
V1 (-7°C/1/2h)	48	16,6	37,5	2,2	18,1	0	19,6	0	24,2	12,5
V2 (-7°C/1h)	100	29	73,3	26,4	100	9,6	50	24,2	36,6	25,9
V3 (-1,5°C/1/2h)	13,6	0	23,8	0	32	1,8	12	0	22,5	0
V4 (-1,5°C/1h)	20	2,9	47	0	58,7	5,6	17,7	0	50,9	0
V5 (-2,5°C/1h)	27,2	5,1	27,2	5,1	10,3	10,4	16,1	10,7	18,4	34

From the two years analyses it results that the most sensitive cultivar was 'Rivan' at the temperatures of -2.5^{0}C/1h in 2014.

CONCLUSIONS

Looking at the 2012-2014 period, it was noted that 2012-2013 winter time accumulated 128ºC cold units and the 2013-2014 period 132ºC which correspond to the soft winters with reduced intensity.

Regarding the hardiness, for 2012-2013 period the index of -32ºC matching the regular winter time and for the 2013-2014 period, the index of -64ºC indicate a very cold winter.
The phenology of 2013 year has recorded a normal developing phases and the 2014 year a very earliness stages.

Knowing the different amount of temperatures above 7^0C for each cultivar, the sweet cherry growers could estimate and predict the development of each phenophase and choose the right management for technological measures.

Induced freeze of -7^0C for 1 hour in the bud burst stage produce 100% injuries at 'Katalin" and 'Burlat' cultivars and important losses for the rest of cultivars too. Also 1 hour of -2.5^0C exposure time indicate 'Rivan' as the most sensitive cultivar in 2014 and 'Kordia' & 'Katalin' in 2013.

Doubling the exposure time of -1.5^0C produced an increase of buds losses at all cultivars, the biggest injuries being recorded by 'Burlat' and 'Rivan' cultivars (over 50%).

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