

Winter resistance of sour cherry and sweet cherry flower buds in extreme winter 2009-2010 and 2020-2021

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Abstract. This article is devoted to the problem of field winter hardiness of sour cherry and sweet cherry flower buds as the main element of winter hardiness of fruit plants in the Oryol region. The issue is considered from the point of view of winter hardiness in extremely cold winters of 2009-2010. and 2020-2021, which allow you to more accurately determine the level of winter hardiness of each individual variety, which is rarely possible in mild comfortable winters. More than 30 varieties of sour cherries and sweet cherries from the gene pool of the All-Russian Research Institute of Fruit Crop Breeding were taken as objects of study. In both cultures, a number of varieties with high winter hardiness of flower buds were identified – sour cherry varieties Griot Ostgeimsky, Volochaevka, Otrada, Shokoladnitsa, Otrada, Uifekher toy Furtosh and sweet cherry varieties – Zarya Vostoka and Orlovskaya Yantarnaya.

1 Introduction

Sour cherry is a popular stone fruit crop in many countries of the world. It is grown in Russia [1], Latvia [2], Poland [3, 4], Germany [5], USA [6], Afghanistan [7] and others. Sour cherry is a fairly winter-hardy fruit crop. It is inferior in this respect only to the apple tree. Winter hardiness is determined not only by the hereditary characteristics of varieties, but also, to a certain extent, the physiological state of the tree, growing conditions. Critical negative temperatures damaging various organs of the cherry plant are at the level of -35...-45°C for tissues of branches and growth buds, -30...-35°C for generative buds -10...-12°C for roots [8]. At temperatures down to -35 °C, annual branches can strongly freeze or freeze out, and when the temperature drops to -40°C, perennial branches or whole sour cherry plants [9, 10].

Sweet cherry is a favorite crop among the population. It is valued for its early ripening and high quality fruit [11]. Sweet cherry is one of the most popular fruit crops in Europe, and in most countries where it is grown, its gross harvest tends to increase [12].

Sweet cherry is a hardy crop that can adapt to various soil and climatic conditions, but its development is limited by climatic and physiological restrictions [13]. Due to the weak frost resistance, severe frosts (-35 ... -38 °C) cause significant damage to sweet cherry trees during a withering wind in the winter-spring period. After such frosts, sweet cherry trees die,

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perennial branches freeze significantly, and flower buds completely freeze out [14-16]. Severe night frosts after prolonged deep thaws at the end of winter often cause the death of flower buds [17-19]. Burns on sunny days in March, with a large contrast in day and night temperatures, observed from the southern and southwestern sides of the tree trunk, subsequently lead to cracking of the stem bark and the bases of skeletal branches [20].

The problem of winter hardiness of the variety is one of the main ones today. Due to sharp fluctuations in temperature, frequent thaws in winter, and the absence of snow cover, plants experience stress, which can lead not only to a decrease in productivity, but even to their death [21].

In recent years, due to the occurrence of more frequent thaws in winter with subsequent frosts, severe environmental pollution, reduced soil fertility, fruit trees almost every year suffer from winter damage in central Russia [22]. These factors are especially pronounced in some extreme winters, when the difference between day and night temperatures is especially high. In recent years, there have been two such winters in the Oryol region – in 2009-2010 and 2020-2021.

Therefore, it is extremely important to know the main indicators that can characterize the resistance of plants to certain adverse factors. By regulating growing conditions and selecting varieties resistant to adverse environmental factors, it is possible to significantly reduce the number of damaged and frozen fruit plants [23-24].

In the middle zone of horticulture, varieties must withstand early winter frosts down to -25 ... -30 °C; have maximum frost resistance at -38 ... -40 °C; not be damaged during thaw at -25 and re-hardening at -30°C. Therefore, varieties and hybrids of horticultural crops need to be assessed for their resistance to a complex of damaging winter factors in the growing zone [25]. The area of distribution of sour cherries and sweet cherries is directly dependent on the winter hardiness of the tree and generative buds [26].

The purpose of the work is to determine the winter hardiness potential of generative buds of sweet cherry varieties in the field.

2 Materials and methods

The objects of study were 25 varieties of sour cherries and 14 varieties of sweet cherries of various genetic and ecological-geographical origin from the genetic collection of RRIFCB.

The studies were carried out on the experimental plots of the laboratory of selection and variety study of stone fruit crops RRIFCB. The degree of damage to the kidneys and tissues was determined in the second or third decade of March (March 22 ... 25, 2010, March 15 ... 19, 2021) after growing one-two-year-old branches after dangerous frosts. Freezing of wood and core was assessed in points (from 0 to 5) on cross sections of branches according to the intensity of tissue browning (from light to dark brown) [27]. The sections made along the bud were examined and the freezing of the vascular-conducting bundles feeding the fruit buds was detected in points on the wood freezing scale.

3 Results of research

Temperature conditions for winters 2009-2010 and 2020-2021 are presented in table 1. From the table it follows that the coldest month of winter 2009-2010, it was January – the average temperature of the month was -16.4 °C. In the winter of 2020-2021, February was the coldest month. The average temperature was -10.7 °C. On some days (February 16), the average temperature dropped to -30 °C.

Table 1. Weather conditions for winters 2009-2010 and 2020-2021.

Month	Year							
	2009-2010				2020-2021			
	Average air temperature, °C	Minimum air temperature, °C	The amount of precipitation, mm	The sum of positive temperatures, about C	Average air temperature, °C	Minimum air temperature, °C	The amount of precipitation, mm	The sum of positive temperatures, about C
November	2.5	-5.2	53.6	89.7	1.6	-9.0	27.4	72.0
December	-6.1	-28.8	35.7	21.3	-4.0	-11.9	24.3	1.8
January	-16.4	-29.1	54.3	0.0	-5.1	-26.6	53.2	8.2
February	-7.1	-18.5	24.3	1.3	-10.7	-29.3	35.2	6.3
March	-2.7	-19.2	5.7	96.6	-2.2	-23.4	6.3	19.4

The studied sour cherry varieties endured the winter of 2009-2010 better than the winter of 2020-2021. If in the first case the average damage to the flower buds of varieties was 34.1%, then in the second case the flower buds were already damaged by 54.4%. The highest winter hardiness (9-14%) on average for both winters was shown by the varieties Griot Ostgeimsky, Shokoladnitsa and Uifehertoy Furtosh. The varieties Konkurentka, Orlicsa, Bystrinka suffered the most from the unfavorable factors of winter periods (70-80%) (Table 2).

Table 2. Winter hardiness of generative buds of sour cherry varieties.

Variety	2009-2010, %	2020-2021, %	The average, %
Novella	68.1	18.7	43.4
Prevoskhodnaya Kolesnikova	57.1	67.9	62.5
Bystrinka	61.8	100.0	80.9
Volochaevka	25.5	9.0	17.3
Konkurentka	53.5	91.0	72.3
Pamyati Mashkina	22.3	100.0	61.2
Zhukovskaya	11.0	55.2	33.1
Obnovlennaya	53.6	80.9	67.3
Prevoskhodnaya Veniaminova	61.6	54.9	58.3
Otrada	13.8	26.8	20.3
Orlica	74.3	70.3	72.3
Proshchal'naya	13.7	38.2	26.0
Muza	38.9	59.4	49.2
Gurtievka	30.1	100.0	65.1
Turgenevka	15.8	98.3	57.1
Griot Ostheimsky	18.0	0.0	9.0
Nepolodskaya	11.4	92.2	51.8
Podarok Uchitelyam	29.1	29.9	29.5
Shokoladnica	2.9	21.5	12.2
Rovesnica	76.2	45.2	60.7
Veteranka	41.8	66.5	54.2
Livenskaya	27.6	30.3	29.0
Uifehertoy Furtosh	13.8	14.1	14.0
Orlais	9.9	50.5	30.2
Tikhonovskaya	19.9	39.5	29.7

The average, %	34.1	54.4	
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Depending on the degree of damage, all studied sour cherry varieties were divided into five groups according to the degree of their winter hardiness (Table 3). Most of them are included in III – IV resistance groups, which indicates their average winter hardiness. Only the Griot Ostgeimsky variety was included in the I group of resistance, because its generative buds were damaged due to the action of winter frosts by 9.0%, which indicates their comparative winter hardiness.

Table 3. Differentiation of sour cherry varieties by winter hardiness groups of generative buds.

Sustainability Group	Dead generative kidneys, %	Variety
I	0.0-10.0	Griot of Ostheim
II	10.1-25.0	Volochaevka, Otrada, Shokoladnica, Uifehertoy Furtosh
III	25.1-50.0	Novella, Zhukovskaya, Proshchal'naya, Muza, Podarok Uchitelyam, Livenskaya, Orleya, Tikhonovskaya
IV	50.1-75.0	Prevoskhodnaya Kolesnikova, Konkurentka, Pamyati Mashkina, Obnovlennaya, Prevoskhodnaya Veniaminova, Orlitsa, Gurtievka, Turgenevka, Nepolodskaya, Rovesnica, Veteranka
V	75.1-100	Bystrinka

A two-way analysis of variance showed that the share of the influence of the conditions of the year on the winter hardiness of sour cherry flower buds is 12.52%. The influence of the genotype of sour cherry varieties on the winter hardiness of flower buds is insignificant (Table 4).

Table 4. Analysis of variance of winter hardiness of flower buds in sour cherry varieties.

Source of Variation	F	P-Value	F crit.	Share of influence, %
Genotype	1.60	0.13	1.98	F < F crit
Conditions of the year	8.92	0.006	4.26	12.52

As in the case of sweet cherries, winter 2020-2021 had a stronger impact on sweet cherry plantations than the winter of 2009-2010. In the first case, the percentage of damaged buds for all varieties was 76.8%, while after the winter of 2009-2010. this figure was 55.5%. The lowest damage to flower buds on average over two years of research was characterized by the Zarya Vostoka variety (24.4%), the highest damage was by the Chermashnaya variety (97.7%) (Table 5).

Table 5. Winter hardiness of generative buds of sweet cherry varieties.

Variety	2009-2010, %	2020-2021, %	The average, %
Bryanskaya Rozovaya	51.8	75.7	63.8
Donetsky Velikan	45.1	100.0	72.6
Odrinka	43.2	100.0	71.6
Orlovsakaya Feya	52.4	83.7	68.1
Poezia	53.3	100.0	76.7
Orlovskaya Rozovaya	33.6	100.0	66.8
Zarya Vostoka	23.1	25.6	24.4
Malysh	95.7	39.3	67.5
Orlovskaya Yanernaya	36.9	12.5	24.7
Seyanec Chernyshevsky	65.2	100.0	82.6
Raditsa	66.5	85.6	76.1

Fatezh	49.8	73.7	61.8
Chermashnaya	100.0	95.4	97.7
Adelina	60.7	84.0	72.4
The average, %	55.5	76.8	

Depending on the degree of damage, all studied sweet cherry varieties were divided into five groups according to the degree of their winter hardiness. Most of them were included in the IV – V resistance groups, which indicates their insufficient winter hardiness. Only varieties Zarya Vostoka and Orlovskaya yantarnaya were included in resistance group II, because their generative buds were damaged due to the action of winter frosts by 24.4% and 24.7%, which indicates their comparative winter hardiness (Table 6).

Table 6. Differentiation of sweet cherry varieties by winter hardiness groups of generative buds

Sustainability Group	Dead generative kidneys, %	Variety
I	0.0-10.0	-
II	10.1-25.0	Zarya Vostoka, Orlovskaya Yantarnaya
III	25.1-50.0	-
IV	50.1-75.0	Bryanskaya Rozovaya, Donetsk Velikan, Odrinka, Donetsk Velikan, Orlovskaya Rozovaya, Malysh, Fatezh, Adelina
V	75.1-100	Poezia, Seyanets Chernyshevsky, Raditsa, Chermashnaya

Two-way analysis of variance showed that the share of the influence of the conditions of the year on the winter hardiness of sweet cherry flower buds is 15.42%. The influence of the genotype of sweet cherry varieties on the winter hardiness of flower buds is insignificant (Table 7).

Table 7. Analysis of variance of winter hardiness of flower buds in sweet cherries.

Source of Variation	F	P-Value	F crit .	Share of influence, %
Genotype	1.40	0.28	2.58	F < F crit
Conditions of the year	5.69	0.03	4.67	15.42

4 Findings

Thus, genotypes with high field winter hardiness in critical winters were identified among the sour cherry and sweet cherry varieties of the RRIFCB gene pool. Among the sour cherry cultivars, the samples Griot Ostheimsky, Volochaevka, Otrada, Shokoladnitsa, Otrada, Uifehertoy Furtosh showed the greatest resistance to adverse factors of the winter period, among the varieties of sweet cherries – Dawn of the East and Oryol amber. Under the conditions of the Oryol region, the studied sour cherry varieties have a higher field winter hardiness than the sweet cherry varieties. In critical winters, flower buds in sour cherry varieties were damaged by 25-75%, in sweet cherry varieties – by 50-100%. Two-factor analysis of variance showed that the share of the influence of the conditions of the year on the winter hardiness of flower buds in sour cherry varieties is 12.52%, in sweet cherry varieties – 15.42%. The share of the influence of the genotype on the winter hardiness of flower buds in sour cherry and sweet cherry varieties is insignificant. In breeding for winter hardiness of flower buds, it is recommended to use the varieties of sour cherries Griot Ostgeymy, Shokoladnitsa, Uifehertoy Furtosh, a variety of sweet cherry Zarya Vostoka.

Conflict of interest. The authors declare no conflict of interest.

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