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POTENTIAL FROST-RESISTANCE OF CHAENOMELES ON SOUTH COAST OF THE CRIMEA

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Introduction

Chaenomeles (*Chaenomeles* Lindl.) is not so large (05,-1,5 sometimes it reaches 3 m by height), early-blooming, fruit and decorative bush, its homelands are China and Japan. Blooming period lasts from March up to April till the leaves appear. This plant is characterized by early ripeness and annual fruiting, functions as phytoameliorative element. Chaenomeles fruits are valuable raw material for food, pharmaceutical and perfumery industries due to their various chemical composition [6, 7]. Wide ecological plasticity of chaenomeles determines its large introduction areal. Considerable variability of this culture by most morphological and biological, economically valuable parameters, dependence of its crop capacity from biotical and abiotical factors in different regions of cultivation require thorough investigation of the plant respond to new ecological conditions. Successful introduction mainly depends upon correspondence of the cultivar ecological characteristics to new growing conditions. [2, 9]. Assortment selection for each of ecological zones is a quite actual task, what is extremely important for breeding, green building and areal expansion.

Originality of the Crimean climatic conditions can guarantee full ripening and preservation of chaenomeles crop, opportunity to have various and rich by vitamins, medicinal and dietetic production. Besides it makes possible to grow not enough winter-hardy, but the most large-fruited cultivars [6]. The principal factor of worsening *Chaenomeles* ornamental characteristics and crop capacity under conditions of South Coastal Crimea can be damages by negative temperatures. Winter winds, mainly east and northeast result temperature dropping till -5°...-15°C. According to data of many years the first frost weather occurs in the end of November, last – in the end of March, the coldest month is January. Winter weather is characterized by changeability of thermal regime, often probability of tissue damage due to provocative thaws in January-February, what has negative effect for plant wintering. As a critical spring factor, especially early spring, returnable colds should be noted, which are very dangerous for plants with early vegetative period. High humidity in cold season aggravates this situation. Plants having obtained cold acclimatization (resistance to cold) during autumn and in the beginning of winter, lose it starting to grow before frost-dangerous period comes to the end [1]. That`s why study object became researching the potential frost-resistance of Chaenomales some selective forms belonging to different cultivars to breed the most prospective, capable to keep viability of vegetative and generative buds to maximum after low-thermal stress, what could guarantee the light loss of ornamental characteristics and a high crop capacity.

Objects and research methods

Selection Chaenomales fund of Nikitsky Botanical Gardens includes more than 400 forms [8]. During autumn-winter-spring period of 2011-2013 26 selective forms, belonging to

3 cultivars were being studied: *Ch. japonica* (forms 2-1, 2-2, 2-3, 2-4, 2-5, ПХ 2/5, ПХ 2/6, ПХ 2/7, ПХ 7/7, ПХ 7/10), *Ch. spesiosa* (forms 3-1, 3-2, 3-3, 3-4, ПХ 8/3, ПХ 8/5, ПХ 8/6), *Ch. cathayensis* (forms 4-1, 4-2, 4-3, 4-4), and one hybrid group *Ch. x superba* (forms1-1, 1-2, 1-3, 1-4, 1-5). In our research method of phased direct freezing of annual shoots in the cool room was applied. The experiment took place under low temperatures [4], lasting 12-20 hours. Gradient of temperature dropping was 2°C/hour, preliminary conditioning to the cold was lasting for 10-18 hours with 0°C. Taking into consideration disability of Chaenomeles to general bud developing, their different quality on shoots, simultaneous freesing shoots of those specimens where buds are on the same development stage was used for correct interpretation of results. Damage degree was determined visually and by binocular, frost resistance was measured by degree of survived buds (percentage). Resting period was determined during field works and under conditions of laboratory [3], watering of buds and shoots tissue – by gravimetric method.

Results and discussion

In researches of 2011 high water level was registered in buds and therefore some specimens of each cultivar were damaged a lot by negative temperatures. For example, *Ch. Spesiosa* buds of seedling 3-1 contained 80% of water in a damp mass, while buds of seedling specimens 3-2 – 58%. Difference in a degree of low-temperature damages made 45%. Moisten content in buds is much higher than in shoots, parameters of watering for specimens of intraspecies is differed much. The least content of water was registered in shoots of *Ch. x superba* 1-1 and *Ch. japonica* 2-1, while form *Ch. japonica* 2-2 was characterized by highest water level.

After freezing (temperature regime -8-10°C), about 8% of buds on seedlings *Ch. x superba* 1-1, 1-4; *Ch. japonica* 2-1, 2-2 and *Ch. spesiosa* 3-2 started to develop after resting period, what indicates relatively high level of resistance to low temperatures. The smallest percentage of bud survival was fixed for seedlings 3-3 and 3-4 of *Ch. Spesiosa (damages – 65 and 89% relatively).* Form *Ch. x superb* 1-5 lost 49,5% of buds; specimens *Ch. japonica* 2-4, 2-5 – 24,5 - 41%. Freezing in February and the first decade of March didn`t cause any loss for forms *Ch. japonica* 2-2 and *Ch. spesiosa* 3-1, but in April they were damaged a lot. In the end of March and middle of April the following cultivars had damages of generative sphere under influence of temperature -5°C: *Ch. x superba* – from 10 up to 17% (forms 1-5, 1-4, 1-3), *Ch. japonica* –30-32% (forms 2-2, 2-4), *Ch. spesiosa* – up to 45% (forms 3-3, 3-1). In April vegetative buds reduced their frost-resistance. The highest loss percentage was fixed for forms: *Ch. spesiosa* 3-3 (necrosis 50%), *Ch. japonica* 2-2, 2-4 (45,5% and 32%), *Ch. x superba* 1-5 (17,6%). The most typical damages on plants of *Chaenomeles* genus subjected to imitation of spring light frosts is blackening of the edge on the external leave plates (especially it concerns *Ch. japonica* 2-5 and *Ch. spesiosa* 3-2) and necrotic spots (seedlings *Ch. x superba* 1-5 up to ⅓ of leaf area). The least resistant to negative temperatures were specimens of *Ch. japonica* 2-3 and *Ch. spesiosa* 3-4 – bud damages of different character was 87 and 62%. As a results in winter-spring period of 2011 according to potential frost-resistance *Ch. spesiosa* (3-2), *Ch. x superba* (1-4, 1-2, 1-1), *Ch. japonica* (2-2, 2-1) are the most resistant forms of *Chaenomeles* which were arranged in decreasing order.

In experiments of 2012 *Ch. spesiosa* 3-1 (table 1) presented the lowest indicator of bud survival after being influenced by negative temperature (-10°C) in the climatic room – 42%.

Table 1

Potential frost-resistance of forms of *Chaenomeles* cultivars (2012)

Form	Water content in buds, % in a moistened mass	Water content in shoots, % in a moistened mass	Living buds,% (climatic room, January, 14 hours -10°C	Living buds, % (open ground, February, -11,9°C	General plant status, %
1	2	3	4	5	6
Chaenomeles x superba					
1-1	72,7	46,4	83,0	96,0	96
1-2	79,2	46,5	91,8	100	100
1-3	62,5	46,8	88,0	100	100
1-4	60,0	43,8	100	99,8	99,8
1-5	68,2	45,5	100	100	100
Chaenomeles japonica					
2-1	71,4	45,0	100	75,0	75
2-2	71,4	50,6	100	82,0	82
2-3	81,0	48,0	95,5	93,0	93
2-4	80,0	48,3	100	97,5	97,5
2-5	70,0	46,3	99,0	0	100
Chaenomeles spesiosa					
3-1	88,1	45,5	42,0	81,5	78
3-2	72,2	45,0	100	91,6	86
3-3	68,7	42,5	91,5	98,0	98
3-4	71,9	47,7	100	87,0	87
Chaenomeles cathayensis					
4-1	50,0	51,4	96,2	99,5	99,5
4-2	68,6	51,8	99,9	100	100
4-3	65,2	52,5	100	100	100
4-4	70,0	57,7	100	99,0	99,0

Specimens *Ch. x superba* 1-1 and 1-3 had 83-88% of survived different buds without any damages; seedling of the same cultivar 1-2 and *Ch. spesiosa* 3-3 – about 92%. Other selective forms of study cultivars with not so considerable damages or their absence made 5%. Results of artificial shoot freezing and assessment of plant damages in natural environment (especially after winter minimum -11,9°C and -19°C on the ground) made it possible to determine thresholds of damage temperatures for Chaenomales cultivars under conditions of South Coast of the Crimea. The initial damage temperature is that one which damages no more than 15% of buds, while critical temperature could damage future crop [5]. For convenience acceptable fruiting is kept even if 60% of buds were damaged.

Quite short period of biological rest (it`s over up to the II and III decades of December) and high sensitivity to low temperatures was registered for cultivars *Ch. spesiosa* and *Ch. Japonica* – bush frosting-up can reach 17-25% with partial or complete damage of shoots. -7-9°C are damage temperatures. It was found out that damage percentage correlates the number of generative buds, which started to develop after biological rest. Due to resting

buds (as a rule there is a majority of such buds) decorative characteristics and crop capacity are kept in spite of any damages. Biological rest of *Ch. x superba* is much longer – till the I-II decades of January, frost damages make no more than 4%, borders of damage temperatures are -8-10°C. Forms of this hybrid group are seldom blooming in winter, what gives an opportunity to keep ornamental properties. Seedlings of *Ch. Cathayensis* finish their biological rest later than others (from the III decades of January till the II decade of February), that`s why almost all of them stay undamaged if temperature drop makes 11-12°C below zero. Blooming period is late as well, that`s why ornamentality and crop capacity have good characteristics.

Applying model experiment of returnable light frosts imitation within climatic room, the maximum damage degree of Chaenomales plants in phenophases of the closed buds and beginning of blooming after negative temperature (-10°C) effect was determined (table 2).

Table 2

Bud potential frost-resistance of Chaenomeles cultivars (living buds, %)

Form	22.02.2013 0°C (18 h), -11°C (20 h)	19.03.2013 0°C (18 h), -10°C (19 h)	
1	2	3	4
	Buds of different purpose	Vegetative buds	Generative buds
Chaenomeles superba			
1-1	98,0	100	70,2
1-2	51,4	44,5	40,0
1-3	47,7	75,0	38,9
1-4	100	100	100
1-5	38,0	90,6	26,3
Chaenomeles japonica			
2-1	78,8	50,2	0
2-2	86,7	76,4	12,5
2-3	65,5	100	7,5
2-4	76,2	80,0	54,5
2-5	84,6	100	63,6
ПХ 2/5	80,0	90,5	100
ПХ 2/6	92,4	88,3	97,2
ПХ 2/7	91,0	93,1	100
ПХ 7/7	35,5	5,1	5,5
ПХ 7/10	32,8	90,0	10,3
Chaenomeles spesiosa			
ПХ 8/3	85,0	80,1	45,0
ПХ 8/5	77,8	77,3	69,0
ПХ 8/6	63,7	70,6	42,4
3-4	100	100	10,0
Chaenomeles cathayensis			
4-1	73,6	85,0	10,2
4-2	72,8	81,4	10,0
4-3	75,0	64,2	10,1
4-4	71,4	62,0	9,8

Vegetative buds of almost all *Ch. x superba* plants survived, in some areas insignificant border necrosis was registered, only some specimens had 60% of damaged leaves [10]. On the leaf area there were necrotic spots (10-45% of the leaf area). Sometimes damage of inside leaves. Survival of flower buds ranged from 26,3 – 100%.

Specimens of *Ch. Japonica* had maximum index in vegetative buds damage – 94,9%. All plants had necrotic spots (from 13,8% up to 50% of the whole leaf area), damage of

outside (up to 18,2%) or inside leaves (8-12%), necrosis of leaf plate borders and top (10-27,3%), partial necrosis of veins (till 20%), not so often – dotted necrosis. Loss of ornamental characteristics by some forms made 80-95%.

Ch. Spesiosa had 20-29,4% of damaged vegetative buds, survived buds got partial necrosis of leaf plate borders, necrotic spots of different size were registered as well. Flower buds had more serious defects as from 4,1 up to 69,0% left undamaged on the shoot, and as a fact ornamentality of some plants worsened.

As to *Ch. Cathayensis,* it had 90% of damaged generative sphere and up to 36% of damaged vegetative buds on different parts of shoots. As period of biological resting finished earlier than ever before due to quite warm average daily temperatures in winter 2013, damaged reached such indices.

For previous study period in spite of moisture concentration, neither of specimens had damaged shoots. Only after negative temperature effect (-15°C) necrosis on tops of annual shoots (1-6 sm) was fixed, which involved even core of some forms: *Ch. x superba* (1-3), *Ch. spesiosa* (ПХ 8/5) and *Ch. japonica* (2-2, ПХ 7/7). Level of bud watering for more frost resistant seedlings of *Ch. x superba* in January-February ranged from 60,0-68,8% (according to moistened mass) and 69,2-75,0% in March. Specimens of *Ch. Japonica* cultivars this parameter made 71,4-72,0% in January-February and 77,8-78,3% in March; *Ch. Spesiosa* – 72,2-88,1% - in January-February and 58,3-60,2% in March; *Ch. Cathayensis* – 65,2-68,6% in January-February and no more than 70% in March. Moisture level in buds of the same cultivars can be quite various.

Conclusions

According to data analysis applying different regimes of low-temperature affect (from -5 up to -15°C) and quantitative analysis of different functions shoots and buds damage it was determined that first of all generative buds are subjected to injury then vegetative buds and in the end – shoots. Therefore ornamental characteristics and crop capacity of Chaenomeles bushes directly depends upon adaptive ability of generative buds. Typical damage for cultivars of Chaenomeles genus subjected to imitation of spring light frosts is blackening of borders on outside leaf plates and necrotic spots. The following specimens were sorted out as plants with relatively high level of low-temperature resistance under conditions of South Coast of the Crimea: *Ch. x superba* 1-1, 1-2, 1-4; *Ch. japonica* 2-4, 2-5, ПХ 2/6, ПХ 2/7; *Ch. spesiosa* 3-2, ПХ 8/3, ПХ 8/5; *Ch. cathayensis* 4-1, 4-2.

Warm temperatures of autumn months favor fast development of some generative buds after biological resting, what determines degree of frost-resistance and wintering in general. Changes of frost-resistance reflect the followings: its indices in November-December are higher than in January-February for all study cultivars, what probably caused by depth of plant biological rest. Seedlings of some specimens in different years show various frost-resistance depending upon environmental conditions.

Investigation of water regime of plants being in biological rest in the beginning of vegetation showed that dropping of moisture level in such tissues is one of the most important factors specifying frost-resistance of *Chenomeles* plants. In winter-spring over moistened buds and as a result high percentage of damages by negative temperatures is typical for some specimens of each cultivar. Frost-resistant forms are characterized by deeper and longer biological rest, which comes to an end approximately since the II decade of January up to the II decade of February and rather low level of moisture in bud tissues.

Considerable variability of Chaenomeles cultivars gives an opportunity to sort out the most adaptive forms according to frost-resistance. Frost-resistant selective forms are of scientific interest for breeding and industry adoption, in the field of ornamental gardening and introduction. That`s why sorting out not only among cultivars but individual sorting out

within each cultivar would be more prospective for large-scale industrial testing and successful cultivation of Chaenomeles crop.

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The article presents results of comprehensive analysis of 26 selective forms which belong to 3 cultivars: *Ch. japonica, Ch. spesiosa, Ch. Cathayensis* and hybrid group *Ch. x superb.* A character of injured buds with various specialization and a range of damaging temperature were determined under conditions of different low-temperature regimes. In terms of investigation it was revealed frost-resistance depends upon watering level of shoots and bud tissue, depth and duration of biological rest. Specimens with high potential resistance to negative temperatures were marked out: *Ch. x superba* 1-1, 1-2, 1-4; *Ch. japonica* 2-4, 2-5, ПХ 2/6, ПХ 2/7; *Ch. spesiosa* 3-2, ПХ 8/3, ПХ 8/5; *Ch. cathayensis* 4-1, 4-2.

Key words: *Chaenomeles, frost-resistance, watering, necrosis, biological rest.*