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Winter-hardiness and frost resistance of clones of an apple (Malus domestica Borkh.) of the grade Jonagold of domestic selection

Tarnavska K.

Podilsk experimental gardening station of the Institute of gardening of NAAS, Naukova Str., 1, Vedmezhe Ushko, Vinnytsia region, Vinnytsia oblast, 23226, Ukraine; e-mail: ktarn1235@ukr.net

The purpose. To determine extent of winter-hardiness and frost resistance of 20 clones of an apple of the grade Jonagold in conditions of Podillia. **Methods.** Field (determined extent of winter-hardiness of trees of clones), laboratory (test exposition of plant material to frost), comparative, generalizations. Statistical analysis of results of frost resistance was spent with application of the method of system of quotients. **Results.** In zone of Western Forest-steppe they selected clones with high level of winter-hardiness and frost resistance. **Conclusions.** According to probes trees of clones DP-9, DP-11, DP-17, DP-18, DP-19, DP-20 had the higher extent of winter-hardiness (8,5 – 8,8 points). Plants of clones DP-2, DP-5, DP-9, DP-10 and DP-15 were characterized by high potential of frost resistance (2% of damage).

Key words: *clones, winter-hardiness, frost resistance, temperature variations.*

Introduction. The minimum temperatures in winter and the frequency of their repeatability can cause the death of fruit trees. It is therefore important to take into account the climatic factors of a particular region when choosing varieties. The resistance of trees to winter damage depends on the biological characteristics of the varieties and rootstocks, and on the ratio of the components of the complex of environmental factors in the growing regions [1].

Jonagold's variety and his best clones - Wilmuta, Jonagored, Jonica, Jonaweld, Boerekamp Early Qveen, Dekosta, King Jonagold, Rubinstar are quite popular commercial apple varieties of the 20th century [2]. Jonagold and some of his clones test more than 35 years in different regions of Ukraine. The first studies conducted within the framework of the primary variety study conducted in the Crimea, the steppe zone in Southern Polissya and the Western Forest-steppe showed that under sufficient agrotechnical care, Jonagolds on M.9 and MM.106 can withstand the usual winter conditions for these regions and form a high yield [2]. However, in the severe winter, according to T.E. Kondratenko [2, 3], D. Kruczynska [4, 5], the trees of Jonagold and his clones are significantly frozen, not fully recovered and in subsequent years fetal weakly. According to the research V.P. Ripamel'nyk [6], conducted in the Western Forest-Steppe zone, found that in some winters, the decomposition of the trees of the clones of Dekosta, Boerekamp Early Qveen and Jonagored resulted in their deaths by 13%, 10% and 7%, respectively. According to O.P. Dovbysh [7], under Podillya conditions in some years there was a subsidence of the crust of Johnagold's trees up to 3-4 points (on a 5-point scale), and the total point of its freezing was 2,1 points.

In Ukraine, work on obtaining their own Jonagold clones was conducted only in the last 15 years in the Crimea and Podillya Research Station of Horticultural Institute NAAS. As a result, in the plantations of the Crimean Fruit Company, was allocated Jocos - a clone of Dekosta with the best economic and valuable features. Jonagold's spontaneous clones obtained from the Podillya experimental gardening plant HI NAAS in 2003-2006, which prevail in the original variety on the basis of the main economic and valuable features, require the study of the degree of their winter resistance, which is the purpose of our research. The task of research is to establish the ability of the trees of Jonagold clones to withstand certain minus temperatures and to withstand unfavorable winter conditions. Solving this problem will allow them to be rationally arranged in growing zones.

Method. The research was conducted at Podillya Research Station of Horticultural Institute NAAS during 2013 - 2015. With the help of state strain testing method 20 Jonagold clones of home selection were studied, these clones were selected at Podillya Research Station of Horticultural Institute NAAS on the industrial apple plantations established in 1991 with the planting material of Jonagold variety brought from Yugoslavia. These clones were selected by research assistants of the station O.P. Dovbysh, A.O. Mukharsky and O.Y. Boroday during the years 2003-2006.

Trees of Jonagold clones (2007 landing) are situated in three repetitions each having 6 - 7 trees. Rootstock MM.106, layout of trees is 4.5 x 1.5 m (1481 trees / hectare), the shape of the crown is slender spindle. Control variety is Idared, conditional control is Jonagold. The soil of the plot under the study is gray forest podzolized sandy loam. The system of soil maintenance in between the rows is sod-humous, and soil around trunks has herbicide fallow. Plantations of Jonagold clones are not provided with drip irrigation. Complex work concerning care about plants was performed according to farming practices indicated in technological instructions of the research station.

Accounting and monitoring was carried out in accordance with "Methods of examination of fruit, berry and nut crops varieties and grape varieties" [8], "Programs and methods of variety testing of fruit, berry and nut crops" [9].

Data analysis was performed using the system of coefficients (on a 100-point scale) [10].

Research results. During 2013-2015, winter research was not severe. The lowest air temperature was recorded in the winter period of 2014/2015 -22,0 °C in January; the highest daily air temperature fluctuation was 10,8 °C. Winter 2012/2013 was "soft". The coldest was December, the lowest air temperature was -19,7 °C. Winter 2011/2012 was indicative of determining the adaptive capacity of spontaneous clones to low negative temperatures. In February, the lowest air temperature in the last nine years was noted -30,2 °C, fluctuations of temperature during this period amounted to 17,3 °C, and in January it was 18,0 °C.

Under these conditions, the winter resistance of the six-year-old trees of Jonagold clones was 7,7 – 8,6 ball; damage to plants at low temperatures in the majority of clones was negligible – 0,4 – 1,3 points (on a 9-point scale) (table 1). Most snow was observed in the trees of the conventional control grade Jonagold (2,0 points); the freezing of the plants of the control strain Idared was 0,9 points. The highest winter resistance (8,5-8,6 ball) during this period was found in clones DP-9, DP-11, DP-17, DP-18, DP-19 and DP-20.

In the seven-year old trees of most clones, the frosting of bark and perennial wood was insignificant and amounted to 0,2 – 1,0 points. The plants of clones DP-9, DP-11, DP-17, DP-19 and DP-20 and lowest - Jonagold (1,9 points) had the highest winter resistance (8,7-8,8 points); the freezing of the control variety Idared was 0,6 points.

The winter resistance of eight-year trees of spontaneous clones is estimated at 7,3 – 8,3 points. Underdevelopment of bark and perennial wood in most of the studied clones was insignificant – 0,2 – 1,4 points, and damage to annual growths and fruit formations was not detected.

Table 1. Degree of winter resistance of Jonagold's clones in the winter of 2013-2015, ball.

Variety, clone	Bark on the tree trunk and skeletal branches			Four-year-old wood			General freezing			Winter resistance		
1	2	3	4	5	6	7	8	9	10	11	12	13
Idared (c.)	0,4	0,4	0,8	0,6	0,3	0,5	0,9	0,6	1,1	8,1	8,4	7,9
Jonagold (c. c.)	0,6	0,5	1,6	2,0	1,9	0,7	2,0	1,9	1,6	7,0	7,1	7,4
DP-1	0,2	0,2	0,6	0,4	0,3	0,4	0,6	0,5	0,9	8,4	8,5	8,1
DP-2	0,4	0,2	0,5	0,3	0,3	0,4	0,6	0,4	0,8	8,4	8,6	8,2
DP-3	0,5	0,3	0,6	0,5	0,3	0,7	0,7	0,4	1,1	8,3	8,6	7,9
DP-4	0,6	0,4	0,8	1,1	0,6	0,6	1,2	1,0	1,0	7,8	8,0	8,0
DP-5	0,4	0,3	0,6	0,5	0,4	0,2	0,8	0,6	0,7	8,2	8,4	8,3
DP-6	0,4	0,4	0,5	0,9	0,8	0,8	1,1	0,9	1,0	7,9	8,1	8,0
DP-7	0,4	0,3	0,8	0,7	0,4	0,3	0,7	0,5	1,0	8,3	8,5	8,0
DP-8	0,5	0,3	0,6	1,2	0,6	0,6	1,3	0,8	1,0	7,7	8,2	8,0
DP-9	0,2	0,2	0,8	0,4	0,2	0,8	0,5	0,3	1,0	8,5	8,7	8,0
DP-10	0,3	0,2	0,6	0,9	0,5	0,7	1,0	0,5	1,1	8,0	8,5	7,9
1	2	3	4	5	6	7	8	9	10	11	12	13
DP-11	0,3	0,3	0,5	0,1	0	1,0	0,4	0,3	1,1	8,6	8,7	7,9
DP-12	0,3	0,2	0,5	0,5	0,5	0,6	0,7	0,6	1,2	8,3	8,4	7,8
DP-13	0,9	0,6	0,9	0,5	0,3	0,4	1,0	0,7	0,9	8,0	8,3	8,1
DP-14	0,3	0,2	0,6	0,5	0,4	0,5	0,7	0,6	1,0	8,3	8,4	8,0
DP-15	0,6	0,3	0,6	0,7	0,5	0,6	1,1	0,6	0,8	7,9	8,4	8,2
DP-16	0,5	0,2	0,7	0,4	0,6	0,5	0,8	0,7	0,8	8,2	8,3	8,2
DP-17	0,4	0,3	0,8	0,1	0,1	0,9	0,5	0,3	1,1	8,5	8,7	7,9
DP-18	0,3	0,2	0,7	0,5	0,3	1,0	0,8	0,5	1,1	8,2	8,5	7,9
DP-19	0,1	0,1	0,4	0,4	0,2	0,7	0,5	0,2	0,8	8,5	8,8	8,2
DP-20	0,5	0,3	1,4	0	0	1,4	0,5	0,3	1,7	8,5	8,7	7,3

The artificial freezing of one-, two- and three-year branches of spontaneous clones in the state of forced rest in the winter 2014/2015 and 2015/2016 allowed to find that the temperature -25 °C did not cause significant damage to the phloem, cambium, wood, core and generative kidneys. The most tempered were the one-year increments of the clones DP-2, DP-5, DP-7, DP-9, DP-10, DP-14, DP-15, DP-18 and DP-19 (1-9%), at the level control varieties Idared and Jonagold. The most sensitive to the temperature -25 °C during this period were annual increases in the DP-16, their degree of damage was 26%. Under these conditions, biennial increments (cambium, wood, core) showed more frost resistance in the trees of the vast majority of studied clones, their degree of freezing was 1-6%, in DP-1, DP-3, DP-12, DP-16, DP-18 and DP-19 - 12-19%. The freezing of tissues of three-year branches in the trees of all clones and control varieties was insignificant (0-8%). The damage to the kidneys from clone trees was at the level of control varieties (2,0-3,8 points).

The trees of all clones in average for the years of study were in good condition (8,1 – 8,7 points). The general condition of trees of the control varieties, Idared and Jonagold, was estimated at 8,2-8,1 points.

Conclusions.

The conducted researches during 2013-2015 showed that the highest level of acclimatization ability to winter hibernation in the conditions of the Western Forest-steppe had trees of the clones DP-9, DP-11, DP-17, DP-18, DP-19 and DP-20 (8, 5-8,8 points), the highest potential of frost resistance - plants of spontaneous clones DP-2, DP-5, DP-9, DP-10 and DP-15 (2% damage).

So, the estimation of frost and winter resistance by field and laboratory methods proved that spontaneous clones DP-2, DP-5, DP-9, DP-10, DP-11, DP-15, DP-17, DP-18, DP- 19 and DP-20 have a high degree of adaptability to the conditions of the Western Forest-steppe of Ukraine, there fore, it is advisable to recommend them for industrial testing in this zone.

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