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SPRING FROST DAMAGES OF PLUM AND APRICOT CULTIVARS GROWN IN THE REGION OF PLOVDIV, BULGARIA

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Abstract

Frost injuries are one of the main limiting factors to fruit crops production. In the region of Plovdiv, Bulgaria the rising temperatures early in the spring force the development of flower buds and some fruit trees are often affected by the late spring frosts. Studying the cultivars under natural stress conditions provides a good basis for the selection of suitable ones for growing in each region. This study was conducted in plum and apricot collection orchards at the Fruit Growing Institute in Plovdiv. Spring frosts were observed in 2012, 2018 and 2019. In 2018, yields only from the apricot cultivars 'Goldrich', 'Perle Cot', 'Sweet Cot' and 'Harcot' were obtained. Of the 31 apricot samples examined in 2019, 21 were 100% injured and for 10, the damages ranged from 68% to 98%. In 2012, severe spring frost damages were observed for the plum cultivars 'Toptaste' - 51%, 'Topking' - 30% and 'Bellamira' - 20%. In 2019, the plum cultivars 'Jojo' and 'Pacific' showed as highly sensitive to spring frosts. The lowest damages were recorded for 'Tita' - 6%, followed by the standard 'Stanley' - 12%.

Key words*: apricot, plum, spring frost, damages.*

INTRODUCTION

Winters and early springs are predicted to become warmer in temperate climates under continued global warming, which in turn is expected to promote earlier plant development (Vitasse et al., 2018). The Plovdiv region is situated in the South Central part of Bulgaria. The most commonly grown fruits are apples, plums and cherries. Plum is a traditional fruit crop for Plovdiv and the region is the second biggest producer of plum fruits in Bulgaria (SENTER, 2000). The South - Central Region represents 25.6 % of the total area occupied with plum trees, which is the first place among the six regions of the country (Agrostatistics, 2018). The region is not typical for apricots growing. Due to their short dormancy period apricots are among the first fruit species that start their development, especially in the last years when winters are getting warmer. Sustainable yields from these fruit trees could be obtained only in separate regions of the country, where the meteorological conditions are most suitable for their growth and development (Kazandjiev & Malasheva, 2019). Climate change and especially the variation of spring temperatures is reflected by changes in the timing of phenology which is dependent on a combination of internal (genetic) settings and environmental influences.

In the Plovdiv region, a considerable number of incidences of spring frosts occurred over the last decade - 2008, 2013, 2016, 2019 and 2020 (Malchev & Savchovska, 2020). Thus, late freezing injuries are a major limiting factor to both cultures production in the region (Bozhkova & Ivanova, 2001; Bozhkova & Zhivondov, 2004).

The effects of spring frosts on the reproductive organs of deciduous fruit trees are highly variable and depend on the characteristics of both the freezing stress and the plant material (Rodrigo, 2000).

One of the effective and long-lasting solutions is the development of genotypes with frost resistance as well as late flowering (Dumanoglu et al., 2019). Studying the cultivars under natural stress conditions provides a good basis for selecting suitable for growing in each region of the country and predicting the economic results of them. It is also important for breeders to choose proper parental cultivars as donors of this characteristic in the controlled hybridization schemes. This study aimed to select apricot and plum cultivars that exhibit resistance to spring frosts and are suitable for growing in the Plovdiv region.

MATERIALS AND METHODS

The study was conducted in plum and apricot collection orchards at the Fruit Growing Institute - Plovdiv. For determining the phenological stage of the cultivars BBCH scale was used (Meier, 2018). The frost damages of flowers and young fruitlets were recorded three days later. For each plum and apricot cultivar, 100 flowers or young fruitlets located in 3 different directions of the crown and up to 2.00 m high were studied. The results were expressed in the percentage of damaged flowers or fruitlets. Data were statistically processed by Duncan's multiple range test of the IBM SPSS statistics 26 software.

RESULTS AND DISCUSSIONS

In the Plovdiv region, late spring frosts that affected the flower buds of both plum and apricot cultures were recorded on 03.04. 2012 (-2.8°C), 20.03.2018 (-2.5°C) and on 29.03.2019 (-5.0°C). Data for the minimum temperatures fluctuation in March and April, in 2012, 2018 and 2019 is shown in Figure 1. The impact of these critical temperatures lasted for more than two hours in the three years of observations.

During these weather conditions, the apricot and plum trees were in different phenological stages, which caused variation in the damages.

Severe frost injuries for the apricot cultivars planted in the collection orchard were observed in 2018 and 2019. On 20.03.2018, the apricot cultivars were in different phenophases to the principal growth stage "flowering". In an earlier stage of their development (BBCH 60) were the cultivars Augustin, Litoral, Selena, Sirena, Euxin, Perlecot and Veharda (Table 1). At that time the flowers of Sweetcot were fading (BBCH 67). The percentage of damaged flower buds for all cultivars ranged from 94% to 99% with statistically non-significant differences. No matter the earlier phenological stage, the Romanian cultivars also were severely injured. In this year the least injured was 'Goldrich' cv. - with only 1% damaged flowers.

In 2018, yields were obtained only from the cultivars 'Goldrich', 'Perle Cot', 'Sweet Cot' and 'Harcot'.

In 2019, the apricot cultivars were between the phenophases end of flowering and ovary growing - 69-71 BBCH, when the late spring frost occurred. Of the 31 genotypes examined this year, 21 were 100% damaged and 10 ranged from 68% to 98%. The lowest percentage of injured flowers was recorded for 'Tomcot' cv. - 68%, followed by 'Euxin', 'Sirena' 'Harcot', and 'Silistrenska ranna'. The lower damages of this cultivars are statistically significant compared to the others. All flowers and fruitlets of the studied apricot hybrids were injured and for them, the damages were 100%.

In our other studies, as in this one, 'Harcot' has been found to be cold resistant and therefore it is recommended for growing in the Plovdiv region (Bozhkova et al., 2013). Hybrids obtained with this cultivar used as a parent in the cross did not show any kind of resistance at this stage. The fact that these trees are young and with a still undeveloped crown (hybrids with the abbreviation HH in Table 1) may also have an impact.

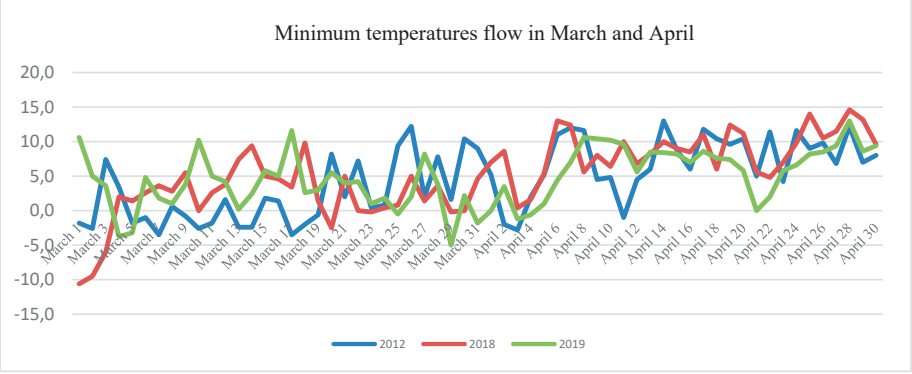

Figure 1. Minimum temperatures fluctuations for the observation period

Table 1. Spring frost damages of the apricot flowers (2018) and fruitlets (2019)

Cultivar/ Elite	BBCH code	Damages in 2018 (%)	BBCH code	Damages in 2019 (%)
Harcot	60	90 a**	69-71	82 bc
Sweetcot	67	90 a	69-71	90 ab
Augustin	60	99 a	69-71	100 a
Litoral	60	95 a	69-71	100 a
Selena	60	95 a	69-71	96 a
Euxin	60	95 a	69-71	74 cd
Sirena	60	95 a	69-71	84 bc
Perlecot	60	90 a	69-71	100 a
Flavorcot	65	95 a	69-71	94 a
Veharda	60	97 a	69-71	100 a
Tomcot	65	96 a	69-71	68 d
Jennycot	61	96 a	69-71	100 a
Bergecot	60	94 a	69-71	100 a
Lito	65	96 a	69-71	100 a
Goldrich	61	1 b	69-71	96 a
Sil. ranna	65	98 a	69-71	80 bc
Harlayne	65	94 a	69-71	98 a
HH 12-60	md*	md	69-71	100 a
HH 12-58	md	md	69-71	100 a
HH 9-1	md	md	69-71	100 a
HH 9-2	md	md	69-71	100 a
HH 12-53	md	md	69-71	100 a
HS 12-20	md	md	69-71	100 a
HS 12-19	md	md	69-71	100 a
HH 12-47	md	md	69-71	100 a
HS 12-16	md	md	69-71	100 a
HH 13-3	md	md	69-71	100 a
HH 14-34	md	md	69-71	100 a
HH 13-67	md	md	69-71	100 a
HH 13-51	md	md	69-71	100 a
HH 12-22	md	md	69-71	100 a

md* - missing data, due to the young age of the trees
** - different letters show a statistically significant difference in the same column

Figure 2. Frost injury in 2019

Studies on the effect of low winter temperatures showed that the cultivars of *P. domestica* species demonstrated good winter hardiness. Problems arise at the end of the winter and the beginning of spring, in case the temperatures drop down below -1°C (Bozhkova, 2013). Frost injuries of the plum cultivars in the Plovdiv region are not a frequent phenomenon and the damages usually are not as high percentage as for apricots.

Figure 3. Flowers of 'Stanley' (left) and 'Jojo' (right) on 01.04.2019

Table 2. Spring frost damages of plum cultivars

Cultivar	BBCH code	Damages in 2012 (%)	BBCH code	Damages in 2019 (%)
Jojo	62	16 cd**	65	100 a
Haganta	62	13 cd	65	50 cde
Top First	62	17 cd	65	34 fg
Top Hit Plus	62	5 e	65	52 cd
Bellamira	62	20 c	65	44 de
Topking	62	33 b	65	48 cde
Toptaste	62	51 a	65	26 gh
Topstar Plus	md*	md	65	32 gh
Roman	md	md	65	42 ef
Robelle	md	md	65	22 h
Tita	md	md	65	6 i
Yalomita	md	md	67	72 b
HL 20-30	md	md	67	100 a
Pitestean	md	md	65	24 h
Stanley	62	11 de	65	12 i
Pasific	61	20 c	65	100 a
Cacanska Najbolja	62	10 de	65	56 c
Sirma	md	md	67	100 a
Pagane	md	md	67	100 a

md* - missing data, due to the young age of the trees
** - different letters show a statistically significant difference in the same column

In 2012, during the spring frost, the plum cultivars were at beginning of the flowering phase (60-62 BBCH). A high rate of frost damage was recorded for the cultivars 'Toptaste' cultivar - 51%, 'Topking' - 30% and 'Bellamira', respectively 20% (Table 2). The lowest percentage of damaged flower buds was

observed for ‘Top Hit Plus’, ‘Cacanska najbolja’ and ‘Stanley’. For the standard cultivar, the frost damage rate was 11%. In 2018, the plum cultivars were not affected by the late spring frosts.

In 2019, during the frost, the plum cultivars were in full flowering phenophase and flowers fading (65-67 BBCH). The lowest damages were recorded in the ‘Tita’ cultivar - 6%, followed by the standard ‘Stanley’ - 12%. The differences in the calculated percentage of damages for these two cultivars and the others are statistically significant. Low freezing rates were also reported for the cultivars ‘Top First’, ‘Toptaste’, ‘Topstar Plus’, ‘Robelle’ and ‘Pitestean’. A hundred percent frost-damaged flowers were observed for ‘Jojo’, ‘Pacific’, the new cultivars of the Fruit Growing Institute – ‘Sirma’ and ‘Pagane’ and the Romanian plum hybrid HL 20-30. The ‘Jojo’ cultivar was in full bloom, while the other cultivars and hybrids were at the end of flowering when considered to be more sensitive. The data from the different years show great differences depending on the phenophases of development, and during the flowering period, the cold resistance decreases. In some cultivars, this decrease is gradual and in others drastic. Besides, other factors, such as the duration of the low temperatures, the relief, the health status of the trees, the yield of the previous year, and the nutrient reserve, have an impact on the frost sensitiveness of the cultivars. This allows us when grown under the same environmental conditions, to select frost resistant cultivars for growing and breeding purposes.

CONCLUSIONS

From several years of observations, it can be said that the apricot cultivars ‘Goldrich’, ‘Harcot’, ‘Perle Cot’ and ‘Sweet Cot’ exhibit some resistance to early spring frosts. The ‘Jojo’ plum cultivar is highly sensitive to spring frosts, as is ‘Pacific’. This year's data once again prove the good cold resistance of the standard ‘Stanley’.

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