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CONSIDERATIONS REGARDING THE INFLUENCE OF CLIMATE ON THE PLUM IN THE CULTIVATION CONDITIONS IN ROMANIA

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Abstract

As result of two years of research this paper presents the phenological and fruit quality parameters of five plums (Prunus domestica L.) cultivars. Observations and determinations were performed in regards to the phenological stages and the physical and chemical traits of the fruit. The climatic differences between the two years of study had an impact on the plum varieties. Temperature was one of the important factors in triggering the phenological stages. The swelling of the buds started with March 07th (`Centenar`) in 2020 and with March 25th (`President`) in 2021. Also, together with the precipitations accumulated in the studied period, significant differences of the characteristics and qualities of the fruits were observed. Fruit weight ranged from 24.23 g to 61.82 g, with higher values obtained by the cultivar `Minerva` in both years. The aim of the research is to suggest the introduction in the culture of some plum varieties with good ecological adaptability to the conditions in NE of Romania and with a good combination of qualitative and quantitative parameters of the fruits.

Key words*: plums, cultivar, climate conditions, phenological stages, fruit quality.*

INTRODUCTION

Plum culture in Romania has special importance due to the dominance of this species as well as for the use of fruit (Butac, 2020). The assortment of plums is diverse, especially in the characteristics of the fruit, such as size, shape, color, texture, aroma, and quality. Some cultivars are especially suitable for consumption in the fresh state, and others are grown as raw materials for various processed products: compote, jam, prunes, etc (Glišić et al., 2015). In the synthesis work "Genetic Resources of Temperate Fruit and Nut Crops", D.W. Ramming and V. Cociu presented the average data on the chemical and mineral components of fresh plums compared to dehydrated ones. Fruits are appreciated by consumers as sources of health for the high content of minerals and the diversity of vitamins (Ramming & Cociu, 1991). The importance of the species is also due to the aspects related to the adaptability to the environmental conditions, having high ecological plasticity (Grădinaru, 2002; Sottile et al., 2022). The favorable climatic conditions in Romania made the plum occupy an area of 69.600 ha, which represents approximately 47.42% of the total of 137.300 ha of plantations with fruit trees (MADR, 2021). According to FAO data, plum cultivation offers an annual output of 842.132 tons (FAOSTAT, 2021), thus placing our country in second place in the world top of plum producing countries, along with China, Serbia, Chile, and others. The plum cultivation area in Romania has a higher share in the southern sub-Carpathian area and in the western part of the country, but it is cultivated almost everywhere due to the low requirements due to environmental factors (Coman et al., 2012). In the period 1971-1993 at RSFG Iași observations and determinations were made regarding the vigor of the trees, the productivity, and the quality of the fruits in some varieties and selections of plum (Cârdei & Bodi, 1987).

The purpose of this study was to assess the relationship between climate and phenology of stone fruit in NE of Romania and to analyze the pomological aspects of five plum genotypes that have been created in various breeding programs, both in the country and abroad.

MATERIALS AND METHODS

The experimental research was conducted for two years (2020-2021) at the plum plantation within Research and Development Station for

Fruit Growing (RSFG) Iași using as biological material five plum cultivars. Four of them were created in Romania at Research Institute for Fruit Growing Pitești: 'Centenar', 'Carpatin', 'Silvia', 'Minerva', and the cultivar 'President', originally from the U.K. and introduced into the culture by Rivers Nursery in 1901.

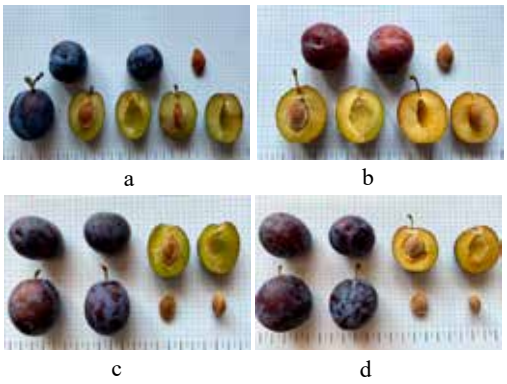

Figure 1. The fruits of the studied plum cultivars
a. 'Centenar' b. 'Carpatin' c. 'President' d. x (photo original)

The selected cultivars have been grafted on 'Roșior' as seedling rootstock. The plum trees were planted in 1988 in an experimental design of randomized blocks with three replicates. Planting distance was 4 x 3.5 m and training as free palmette, without sustaining or irrigation system. During the vegetation period, general maintenance works were carried out on the plantation, aiming at annual pruning, soil mobilization, and control of diseases and pests.
Phenological data were determined through the BBCH scale (Meier et al., 1994): bud development (01) - beginning of bud swelling (leaf buds); beginning of flowering (61) - about 10 % of flowers open; ripening time (87) - fruit ripe for picking. Based on this, the growing degree-days (GDD) from bud swelling to the beginning of flowering and after that until the start of ripening were calculated according to the equation (McMaster & Wilhelm, 1997; Aydin et al., 2019):

$$GDD=(T_{max}+T_{min})/2- T_{base},$$

where $\mathbf{T_{max}}$ and $\mathbf{T_{min}}$ are daily max and minim temperatures, $\mathbf{T_{base}}$ is base temperature. The plum base temperature for European temperate climate zones used is 6°C (Darbyshire et al., 2012; Woznicki et al., 2019; Fadón et al., 2020).

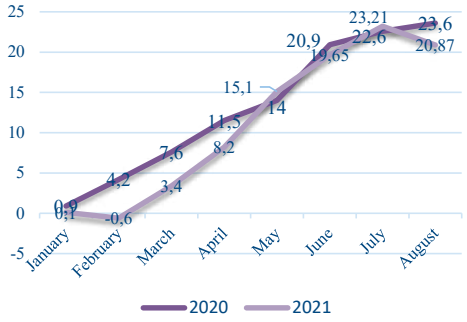

Figure 2. Average temperature in the studied period (RSFG Iași-Romania, 2020-2021)

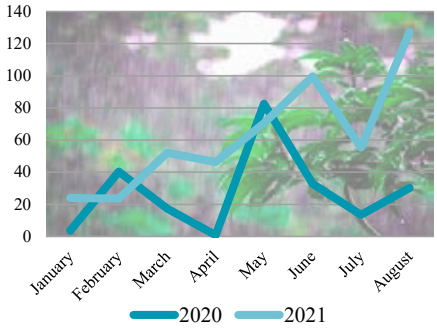

Figure 3. Accumulated rainfall in the studied period (RSFG Iași-Romania, 2020-2021)

The required active temperature for the beginning of flowering is on average about 321°C depending on the cultivar, and for fruit ripening between 2200°C and 3500°C (Grădinaru, 2002). To determine the pomological qualitative parameters were collected fruits at the full maturity stage. For each cultivar were collected 30 fruits of similar size and without visible external damage. Biometric measurements and determinations were performed: equatorial diameter of the fruit (mm), thickness (mm), and length (mm) using the Lumytools sliding tool. The fruit weight was measured using an analytical balance Radwag. The biochemical analysis consisted in determining the soluble dry solids (SDS %) using a Zeiss refractometer (Cociu & Oprea, 1989). The research results were synthesized and interpreted statistically by Microsoft Excel Starter using the Duncan test ($p \leq 0.05$).

RESULTS AND DISCUSSIONS

The climatic conditions of the growing area have strong effects on many aspects of plant life, such as phenology and productivity (Lambers et al., 2008). During the two years of study, the evolution of the phenophases of growth and fruiting in the climatic conditions in northeast Romania was followed. To evaluate the relationship between weather temperature and temperature required for the different stages of development, the amounts of heat for the relevant periods in Growing Degree-Days (GDD) terms were used.

Temperature is a key factor in the timing of biological processes, and hence the growth and development of plants (Parthasarathi et al., 2013). Growing degree days are used to assess the suitability of production of studied plum cultivars in NE of Romania.

According to the meteorological data registered at the station from RSFG Iași-Romania, was calculated firstly GDD from bud development (01) to the beginning of flowering (61). Thus, in the conditions of spring 2020, the bud development starts between at 7th of March ('Centenar' and 'President') and the 11th of March ('Carpatin' and 'Silvia') with an average temperature of 12.1°C. In the 2021 year, the bud development started much later at a difference of about 18 days, due to the low temperatures recorded in the first part of March. This phenological stage took place between 25th March ('President') and 4th April ('Carpatin').

Based on the registered observations on the plum cultivars in the first year, it was established the stage from the bud development to the beginning of flowering.

Plums have a hiatus between the phenophases and GDD is sometimes used to estimate growing season length (Castillo et al., 2021). It is observed that within the same cultivar, in the two years of study, different GDD were accumulated for each of the phenophases. Based on this fact, it can be seen that ecological factors (especially temperature) have a greater impact on the flowering phenophase than the genetic characteristics of the variety. This is in line with the conclusions of Milatović (2019). The difference in the flowering phenophase of the plum in the two years of study can be explained by the differences in the environmental conditions in the region in the spring season. in 2020, the average duration from bud swelling to the start of flowering varied between 25 days ('Silvia') and 29 days ('President'), respectively 79.3 GDD and 118.05 GDD. In the spring season of 2021, the number of days between stages 01 and 61 varied between 20 days ('Minerva') and 32 days ('Minerva'). Thus, because the average temperatures of the spring months in 2021 were lower by 4.2°C (March) and respectively 3.3°C (April), compared to the previous year, it determined a different behavior of the cultivar. They required 13 to 27 extra GDD for 61 BBCH stage.

To start ripening, the fruits needed the highest amount of GDD depending on the precocity and the temperature. Romanian cultivars are notable for the early ripening of the fruits, since the end of July (Butac et al., 2014). The cultivars 'Minerva' and 'Centenar' had an early ripening in 2020 (20th July, 24th July), while the 'President' showed the latest ripening (10th August). The last column of Table 1 shows that the varieties needed less GDD in 2021 compared to 2020. This is confirmed in Figure no. 2, where it is observed that the temperatures in the summer months were higher than in the same period of the year. Thus, 'Centenar' needed 952.05 GDD in 2020, but in 2021 only 901.2 GDD. A significant difference in GDD was registered in the case of the 'Carpatin' cultivar, which in 2020 accumulated 1023.37 GDD until the ripening time, while in 2021 it needed only 901.2 GDD. It recorded a difference of 114 GDD between the two consecutive years.

For the ripening stage, the lowest value in 2021 was 901.2 GDD for 'Centenar', but 'President' was a cultivar that needed a sum of 1023.37 GDD, in the climatic conditions of this year.

Regarding the degree of adaptability of the plum cultivars studied to the ecological conditions in Iasi, the biometric measurements of physical and chemical characteristics of the fruit were performed such as weight, diameter, thickness, height, and soluble dry matter content. The centralized averages were statistically interpreted and presented in Tables 2 and 3.

Table 1. The growing degree-days (GDD) to the beginning of flowering and fruit ripening of plum cultivars (RSFG Iași, 2020-2021, n = 3)

Cultivars		Bud development (01 BBCH)	Start of flowering (61 BBCH)	No. days from 01 to 61	GDD (days)	Start of flowering (62 BBCH)	Ripening time (87 BBCH)	No. days from 62 to 87	GDD (days)
CENTENAR	**2020**	07.03	04.04	29	**96**	04.04	24.07	112	**952.05**
	2021	26.03	24.04	30	**112.05**	24.04	30.07	98	**901.2**
CARPATIN	**2020**	11.03	07.04	28	**118.05**	07.04	30.07	114	**1015.25**
	2021	04.04	24.04	21	**78.45**	24.04	30.07	98	**901.2**
PRESIDENT	**2020**	07.03	06.04	29	**105.45**	06.04	31.07	117	**1030.9**
	2021	25.03	25.04	32	**119.35**	25.04	10.08	108	**1023.37**
SILVIA	**2020**	11.03	04.04	25	**79.3**	04.04	30.07	118	**1029.85**
	2021	25.03	22.04	29	**106.2**	22.04	01.08	102	**937.1**
MINERVA	**2020**	10.03	05.04	26	**88.4**	05.04	20.07	107	**903.1**
	2021	05.04	24.04	20	**75.75**	24.04	31.07	99	**904**

*BBCH scale - Biologische Bundesantalt, Bundessortenamt und Chemische Industrie (Meier et al., 1994)
*GDD - The growing degree-days

Table 2. Physical and chemical characteristic of the fruit in the investigated plums cultivars (RSFG Iași, 2020, n = 3)

Cultivar	Fruit`s weight (g)	Fruit`s equatorial diameter (mm)	Fruit`s thickness (mm)	Fruit`s length (mm)	Chemical characteristics
					SDS%
Centenar	29.70^{b}	34.17^{b}	42.50^{b}	42.10^{b}	13.20^{c}
Carpatin	24.34^{c}	31.83^{b}	30.02^{d}	39.06^{c}	16.51^{a}
President	26.11^{c}	31.67^{b}	29.99^{d}	41.83^{b}	14.66^{b}
Silvia	30.74^{b}	33.28^{b}	34.51^{c}	41.50^{b}	16.60^{a}
Minerva	44.13^{a}	46.32^{a}	47.43^{a}	46.82^{a}	14.54^{b}

Different letters after the numbering within a column corresponds with statistically signifiant differences for p≤0.05 according to Duncan's multiple range test.

Table 3. Physical and chemical characteristic of the fruit in the investigated plums cultivars (RSFG Iași, 2021, n=3)

Cultivar	Fruit`s weight (g)	Fruit`s equatorial diameter (mm)	Fruit`s thickness (mm)	Fruit`s length (mm)	Chemical characteristics
					SDS%
Centenar	62.21^{a}	45.89^{a}	53.43^{a}	53.57^{a}	14.15^{b}
Carpatin	46.12^{b}	41.86^{b}	42.42^{c}	49.44^{bc}	12.15^{c}
Prezident	48.90^{b}	41.27^{b}	39.57^{c}	53.36^{a}	18.16^{a}
Silvia	50.62^{b}	41.86^{b}	42.09^{c}	49.78^{b}	12.51^{c}
Minerva	61.10^{a}	46.32^{a}	47.43^{b}	46.74^{c}	14.41^{b}

Different letters after the numbering within a column corresponds with statistically significant differences for p≤0.05 according to Duncan's multiple range test.

One of the important factors in the marketing of plum cultivars designated for fresh consumption is the fruit size (Altunas et al., 2020).

Regarding the weight of the fruit, were significant differences between all cultivars. On the fruit`s equatorial diameter, the differences were significant just between the cultivar 'Minerva' and the rest of them.

Interpreted statistically, there were significant differences between the plum cultivars. Insignificant differences were between 'Carpatin' and 'Silvia' respectively, 'Prezident' and 'Minerva'. In the climatic conditions of 2021, the water regime from March to July favorably influenced the size of the fruits. Thus, the rainfall accumulated in this period (319.2 mm) determined small differences regarding the weight of the fruit of the five cultivars, the values varying between 46.12 g at 'Carpatin' and 62.21 g for 'Centenar' cultivar, but differences significant compared to the fruits obtained the previous year when the sum of the accumulated precipitations was 201.4 mm. Also, regarding the soluble dry solids (SDS%), was observed that the 'Prezident' variety has the highest value in 2021, approximately 18.16%.

CONCLUSIONS

Following the study carried out during the two years, the selected cultivars: 'Centenar', 'Carpatin', 'Silvia', 'Minerva' and 'President'

have high ecological plasticity, good adaptability to the conditions in North-Eastern Romania.

Phenological periods of the same plum cultivars are variable, depending on the climate year conditions and the cultivation area.

Regarding the pomological qualitative parameters of fruits, the rainfall accumulated during the observation period of the two years of study had a favorable influence on the weight of the fruits and the equatorial diameter. The selected varieties 'Centenar', 'Carpatin', 'Silvia', 'Minerva', and 'President' represent cultivars with a good combination of positive features and are recommended for the establishment of plantations and expansion in the area of culture in NE of Romania.

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