

THE REACTION OF SOME APRICOT CULTIVARS AND SELECTIONS TO THE ATTACK OF SOME PATHOGENS AND FROST IN THE CONTEXT OF CLIMATE CHANGE

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Abstract

The main objective of the works was to identify genotypes with increased tolerance or resistance to pathogens under the current climatic conditions for their extension into the culture. The trials on 20 apricot cultivars and selections were carried out in the orchard, during 2020-2022, under natural infection conditions, tracking the frequency and intensity of the attack on different organs of the plants and how they were influenced by current climate changes. These studies demonstrated that the most resistant to *Monilinia laxa*, *Cytospora cincta* and *Stigmata carpophila* were 4 cultivars ('Mamaia', 'Roșii de Mărculești', 'Olimp' and 'Elmar'), while 3 other cultivars ('Litoral', 'Pionier' and 'Sirena') had sensitivity to the attack of *Cytospora cincta* and *Stigmata carpophila*. The biggest losses caused by frost were recorded during the winter/spring of 2021 in terms of damaged fruit buds: 90% on 'Comandor' 88% on 'Pionier', 85% on 'Roșii timpurii' and 'Sulina', 67% on 'Sirena' and 65% on 'Mari de Mărculești'. The nursery has propagated resistant cultivars and selections, while the most valuable genotypes are grown in commercial orchards.

Key words: *Prunus armeniaca*, genotypes, diseases, frequency, intensity, warning.

INTRODUCTION

Apricot (*Prunus armeniaca* L.) is cultivated with good results in the Southeastern region of Romania and is a highly valued fruit tree due to its desirable biological traits, including early fruiting, consistent and abundant yields, ecological adaptability and exceptional fruit quality. However, this species remains highly vulnerable to infections from multiple fungal pathogens, such as *Monilinia laxa* (brown rot), *Stigmata carpophila* (shot hole disease), *Stereum purpureum* (silver leaf), *Gnomonia erythrothoma* (leaf spot), *Cytospora cincta* (perennial canker), and *Schizophyllum commune*, included among the fungal threats to this species. The genetic resistance of various varieties and selections to diseases plays a crucial role in reducing costs and minimizing environmental impact. These benefits have led to disease and pest resistance becoming a key priority at RSFG Constanța. Multiple studies have previously aimed at improving genetic resistance to diseases and pests, including the work of Trandafirescu Marioara (1989), Trandafirescu M. et al. (2005; 2006) and the

creation of apricot varieties Topor E. (1997). Susceptibility and resistance of apricot cultivars and selections to *Monilinia laxa* was studied by Benedek et al. (1990) in Hungary, Komar-Tyomnaya and Richter (2000) in Ukraine, Tzonev and Yamaguchi (1999) in Japan, Balan et al. (1999) in Romania, Crossa-Raynaud (1969) in Tunisia, Nicotra et al. (2006) in Italy. In the Mediterranean region, Crossa-Raynaud (1969) identified 'Hamidi' as a variety resistant to *Monilinia laxa*. Additionally, both Nicotra et al. (2006) and Balan et al. (1999) reported a high level of resistance in 'Precoce de Italia'. Research by Komar-Tyomnaya and Richter (2000) at the Nikita Botanical Garden indicated that all studied apricot varieties were vulnerable. In Europe, brown rot of decaying fruit had its first published description in 1796. In the USA it was observed in 1807 for the first time. Identified for the first time in Romania in 1878, this disease has progressively expanded over time (Amzăr and Ivașcu, 2003). European apricot breeding programs primarily focus on developing resistance to major diseases, such as plum pox virus, bacterial infections, brown rot, and chlorotic leaf roll phytoplasma, while also

addressing apricot decline syndrome. Other major aims include boosting adaptability to environmental conditions (such as water stress and temperature shifts), extending the harvesting window, enhancing both productivity and fruit quality, and optimizing tree structure and size (Bassi & Audergon, 2006). Numerous researchers worldwide have studied the adaptability of different varieties and the breeding of new ones tailored to the specific biotic and abiotic factors of their respective countries (Audergon et al., 1995; Bassi et al., 1995; Witherspoon, 1999).

MATERIALS AND METHODS

This study was carried out at the Research Station for Fruit Growing Constanța, situated in the Dobrogea region of Romania. The experimental area is positioned in Valu lui Traian, close to the Black Sea, at coordinates 44°10' N and 28°28' E. Between 2020 and 2022, experiments were performed at RSFG Constanța, Romania, with the goal of analyzing the resistance of various apricot selections and cultivars to pathogen attacks in a changing climate. The study focused on 20 apricot genotypes cultivated in a demonstration plot set up in 2011. The orchard layout consists of rows with 20 trees each, spaced at 4 × 4 meters, resulting in a density of 625 trees per hectare. 'Constanța 14' was used as the rootstock, with trees trained in an improved vase form. The soil type is calcareous chernozem (CZKa), characterized by a loamy texture and an alkaline pH of 8.2. Over the past decade, climate changes have disrupted the natural expression of varietal traits, further influenced by biotic factors and inconsistent cultivation conditions, such as periodic water shortages. Among the genotypes studied are: 'Litoral', 'Comandor', 'Mari de Geoagiu', 'Mamaia', 'Pioner', 'Mărculești 22/4', 'Augustin', 'Roșii de Mărculești', 'Olimp', 'Dulci de Vișani', 'Centenarul Unirii', 'București 500', 'Roșii Timpurii', 'Elmar', 'Mărculești 10/5', 'Mari de Aiud', 'Sulina', 'Sirena', 'Mari de Mărculești', 'Saturn'. Observations were conducted to assess the response of various apricot genotypes to infections by major pathogenic agents, particularly *Monilinia laxa* (Aderh. & Ruhl) Honey, *Cytospora cincta* Sacc and *Stigmina carpophila* (Lév.) M.B. Ellis.

Data collection was performed on each row in four replicates per variety/selection, with at least five trees included in each replicate. The research focused on the most sensitive genotypes after a general assessment was carried out, aiming to highlight the most sensitive and tolerant to some pathogens in the context of climate change.

$$F [\%] = (n / N) \times 100,$$

where: F [%] = attack frequency; n = number of diseased organs; N = total number of examined organs.

$$DD\% [\%] = [(sum (F\% \times I_notes) / n) / 100]$$

where: DD [%] = damages degree, F% = class attack frequency; I = attack intensity scored with 0-7 notes; n = number of attack classes.

The response of apricot genotypes to infections by major pathogens - *Monilinia laxa* (Aderh. & Ruhl) Honey, *Cytospora cincta* Sacc., and *Stigmina carpophila* (Lév.) M.B. Ellis - was evaluated under natural infection conditions based on the method developed by Crossa-Raynaud (1969). The assessment involved recording both the frequency of infected organs and the severity of symptoms, which were then used to determine varietal resistance.

The study involved recording pathogen attack frequency (F%) and attack intensity (I) on several tree organs, such as leaves, blossoms, young shoots, branches, and fruit. A scale from 0 to 4 was used to assess disease severity. Based on these parameters, apricot genotypes were divided into four resistance classes and further assigned to eight resistance groups, as detailed in Table 1.

Table 1. Classification of Cultivars by Resistance Classes and Groups

Resistance class	Resistance group	Frequency (F%)	Intensity (I%)
1 = tolerant (T)	1	0	0
2 = medium resistance (MR)	2	0.1-11.0	+
	3	11.1-25.0	+
3 = sensitive (S)	4	25.1-34.0	++
	5	34.1-50.0	++
4 = very sensitive (VS)	6	50.1-59.0	+++
	7	59.1-75.0	+++
	8	75.1-100	++++

WA (Without Attack): No infection detected (F% = 0, I = 0).

T (Tolerant): Infection levels remain very low (F% = 0.1-5%, I = +).

WeA (Weakly Attacked): Slight infection observed (F% = 5.1-10%, I = +).

MA (Moderately Attacked): Infection reaches moderate levels (F% = 10.1-25%, I = ++).

S (Sensitive): High infection pressure noted (F% = 25.1-50%, I = +++).

VS (Very Sensitive): Severe infection recorded (F% = 50.1-100%, I = ++++).

The average temperature for the period 01.03.2020 ÷ 17.03.2020 was between 6.3°C and 10.5°C. Average lows ranged from 0.7°C to 6.1°C. The absolute minimum was -5.6°C and the absolute maximum was 17.1°C. During this period, the amount of precipitation was 3.4 mm. The minimum temperatures recorded on March 15, 16, 17, of -3.4°C, -5.2°C and -5.6°C, respectively, affected the apricot genotypes in full bloom, the resistance of the floral organs decreasing as the vegetation progressed. Between 01.01. and 31.01.2021, the average air temperature fluctuated between -0.8°C and 7.0°C. The average lows were between -3.4°C and 3.5°C. The absolute minimum was -9.3°C (17.01.2021) and the absolute maximum was 15.7°C (23.01.2021). In January, the amount of precipitation was 86.0 mm, above the normal of the area (records stretching over 27 years), respectively 32.9 mm for the month of January. Between 01.02. and 28.02.2021, the average air temperature varied between -1.9°C and 7.0°C. The average lows were between -6.5°C and 3.2°C. The absolute minimum was -13.4°C and was recorded on 13.02.2021, and the absolute maximum was 18.9°C and was recorded on 11.02.2021. The amount of precipitation was 18.8 mm, below the normal of the area, respectively 24.4 mm for the month of February. In the interval 01.03. - 15.03.2021, the average air temperature varied between 3.9°C and 4.2°C. The average minimum was between -0.8°C and -1.0°C, with an absolute minimum of -5.5°C (03.07.2021). Average highs varied between 8.7°C and 10.0°C, with an absolute high of 18.5°C (03/05/2021). The amount of precipitation recorded in this time interval was 30.4 mm, a value close to the normal of the area for the month of March, namely 36.9 mm. There were production losses that occurred due to the high temperature amplitude that occurred between February, 10-13. On February 13, the on-board weather station indicated a minimum temperature of -13.4°C, while the previous days saw temperatures above +15.0°C. In the years 2022, the genotypes studied did not register losses. Observations and determinations took place 3-5 days after the recorded climatic accidents. This study examined the response of various apricot varieties and selections to changing climatic conditions in Southeastern Romania during the

winters of 2020, 2021, and 2022. Due to recent climate variations, the resistance of these varieties fluctuated from year to year. Throughout the study period (2020-2022), climatic data were collected using an automated WatchDog weather station (Spectrum Technologies Inc., IL, USA) and analyzed in terms of daily mean values. Data collected were periodically moved to a laptop for detailed examination. The occurrence of late frosts and frosts must be taken into account, which due to the climate changes of recent years are making their presence felt more and more often and can completely compromise fruit production. It is a physiological trait of frost resistance of apricot flower buds conditioned by a series of factors such as: absolute temperature, the physiological state of the trees and the temperature evolution from the end of winter dormancy to flowering (Balan et al., 2008). All collected data were stored, organized, analyzed, and visually represented using MS Excel xxx tools. A correlation was determined between the average frost-damaged buds and the mean disease incidence during the 2020-2022 vegetation periods, applying the regression calculation method.

RESULTS AND DISCUSSIONS

Although Southeastern Romania has traditionally been regarded as highly favorable for apricot cultivation, the species has been increasingly affected by climatic variations over the past decade. The primary challenge has been the fluctuation between extreme low temperatures and sudden warm spells, particularly after the trees have resumed growth.

The influence of temperatures on apricot during the studied period had very varied aspects in correlation with many other factors such as: the variety with its genetic characteristics and properties (early-flowering varieties were sometimes saved over late-flowering ones and even vice versa); agrotechnical soil and plant maintenance (well-maintained and properly developed trees have a greater tolerance to low temperatures); the moment of negative temperatures (after waves of positive temperatures above the biological threshold of

+6.5°C or alternatively); the topographical position of the parcels, as a result of the fact that negative temperatures manifest themselves differently both on the coordinates of altitude (large variations between the values of soil and air temperatures), as well as on those of latitude and longitude (the downstream part being more or totally affected, and the upstream part less or not at all, sometimes even vice versa; the direction and intensity of the wind, drought, etc. Late frosts in March and April, occurring after a period of relative warmth, pose a greater threat to apricot trees than those during the mandatory dormancy period in December and January. Additionally, the notable climatic shifts in recent years have severely affected flowering onset, fruit set, and, as a result, disease occurrence and total apricot yield. In 2021, the 'Comandor' variety experienced the highest losses due to late frosts, reaching 90%, despite an abundant initial flowering. Similarly, the 'Pioneer' variety suffered an 88% loss in the same year. In contrast, the lowest percentage of affected fruit was recorded in the 'Litoral' variety, with only 12% damage in 2022 (Figure 1).

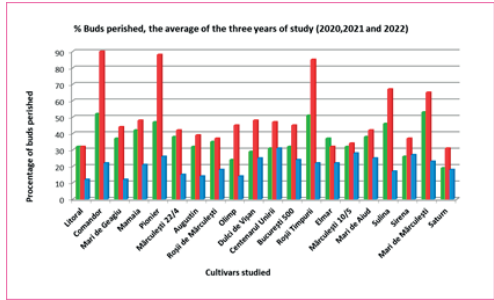


Figure 1. Extent of frost damage to apricot flowering buds during the winters of 2020, 2021, and 2022 in Valu lui Traian, Constanța

The three-year study average indicated that the evaluated apricot varieties and selections demonstrated good resistance to winter frost. The recorded bud loss percentages were as follows: 'Saturn' – 23%, 'Litoral' – 25%, and 'Augustin' and 'Olimp' – 28% (Figure 2). The minimum temperatures recorded on March 15, 16, 17, of -3.4 °C, -5.2 °C and -5.6 °C, respectively, affected the apricot cultivars ('Comandor' and 'Pioneer') in full bloom, the resistance of the floral organs decreasing as the vegetation progressed (Figure 3 a, b).

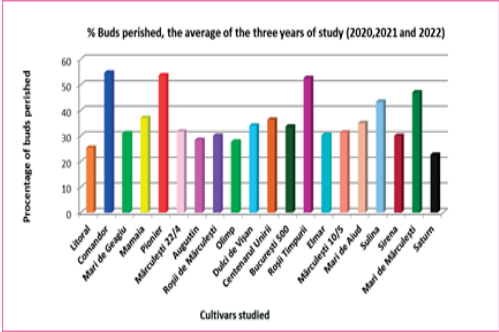


Figure 2. Percentage of apricot tree flowering buds lost to frost (three-year average) in Valu lui Traian, Constanța

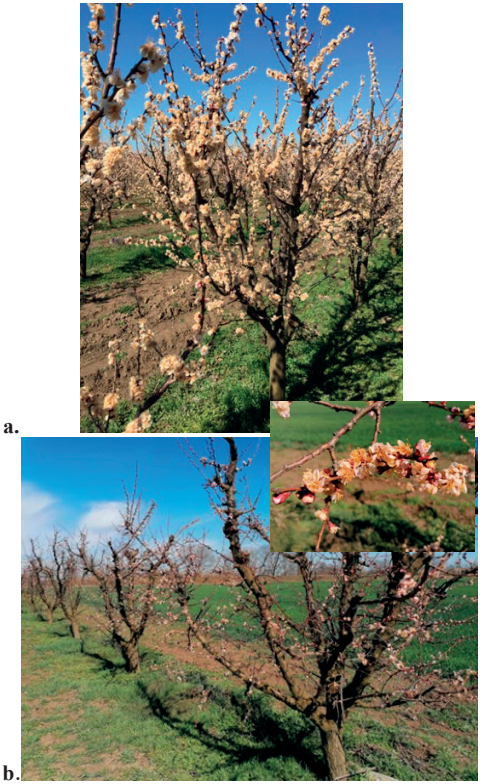


Figure 3. 'Comandor' cultivar 90% affected (a); 'Pioneer' cultivar 88% affected (b)

Every year apricot plantations are attacked by a large number of diseases and pests, which produces significant damage from an economic point of view. Practical knowledge of some elements essential biology and ecology of diseases and pests in apricot species as well as the mode of attack on the plants and the effect of the damage, allows the concerned fruit

grower to choose the best decisions to control them rationally (Grigore Mihăescu, 1998). Given that observations were conducted on a large number of apricot varieties and selections, Table 2 presents the behavior of only a selected subset of the extensive biological material studied.

Thus, the genotypes were included in the class with genetic resistance (T) to *Monilinia laxa*, *Cytospora cincta* and *Stigmata carpophila* were

4 cultivars 'Mamaia', 'Roşii de Mărculeşti', 'Olimp' and 'Elmar', while the other three cultivars 'Litoral', 'Pionier' and 'Sirena', exhibited susceptibility to infections caused by *Cytospora cincta* and *Stigmata carpophila*. In the very sensitive (VS) class, the 'Comandor' and 'Mari de Mărculeşti' cultivars were highlighted in the 2020 study year and the 'Bucureşti 500' variety in 2021.

Table 2. The behavior of apricot genotypes when attacked by the main pathogens during 2020-2022

No	Cultivars	Year	<i>Monilinia laxa</i>			<i>Cytospora cincta</i>			<i>Stigmata carpophila</i>		
			F %	I	Resist. class	F %	I	Resist. class	F %	I	Resist. class
1.	Litoral	2020	25	2	S	37.6	2	S	31.3	2	S
		2021	4.6	+2	MR	32.4	2	S	25.4	3	S
		2022	15.6	+2	MR	43.6	3	S	52.4	2	S
2.	Comandor	2020	80.5	4	VS	73.2	3	VS	69.5	3	VS
		2021	78.2	4	VS	80.3	4	VS	73.2	3	VS
		2022	69.1	3	VS	24.2	1	MR	13.2	1	MR
3.	Mari de Geagiu	2020	22.5	2	S	16.4	2	MR	24	1	MR
		2021	76.4	4	VS	0	0	T	19.4	2	MR
		2022	35.2	2	MA	12.6	1	MR	14.6	2	MR
4.	Mamaia	2020	0	0	T	0	0	T	0	0	T
		2021	0	0	T	0	0	T	0	0	T
		2022	0	0	T	0	0	T	0	0	T
5.	Pionier	2020	4.7	1	MR	35.3	2	S	32	2	S
		2021	4.5	1	MR	45.7	3	S	37.3	2	S
		2022	0	0	T	37.4	2	S	22.9	3	S
6.	Mărculeşti 22/4	2020	44.2	1	MR	65.4	3	VS	0	0	T
		2021	42.4	1	MR	72	3	VS	65.7	3	VS
		2022	47.2	1	MR	21.4	1	MR	24.3	2	MS
7.	Augustin	2020	10.2	0	MR	0	0	T	0	0	T
		2021	12.6	1	MR	0	0	T	0	0	T
		2022	17.4	1	MR	0	0	T	0	0	T
8.	Roşii de Mărculeşti	2020	0	0	T	0	0	T	0	0	T
		2021	0	0	T	0	0	T	0	0	T
		2022	0	0	T	0	0	T	0	0	T
9.	Olimp	2020	0	0	T	0	0	T	0	0	T
		2021	0	0	T	0	0	T	0	0	T
		2022	0	0	T	0	0	T	0	0	T
10.	Dulci de Vişani	2020	58.7	3	VS	13.5	2	MR	32.2	2	MR
		2021	45.4	3	S	61.6	3	VS	0	0	T
		2022	15.7	1	MR	37.2	2	MR	18	2	MR
11.	Centenarul Unirii	2020	14.2	1	MR	0	0	T	73	4	VS
		2021	17.1	1	MR	12.2	2	MR	39	2	MR
		2022	21.4	1	MR	0	0	T	25.9	3	S
12.	Bucureşti 500	2020	44.4	2	S	61.7	3	VS	23.7	2	MS
		2021	18.4	1	MR	22.4	1	MR	0	0	T
		2022	24.9	2	MR	24.4	2	MR	24.3	2	MS
13.	Roşii Timpurii	2020	64.5	4	VS	64.5	3	VS	68.4	3	VS
		2021	77.2	4	VS	74.9	3	VS	65.7	3	VS
		2022	32.4	2	MR	16.4	2	MR	24	1	MR
14.	Elmar	2020	0	0	T	0	0	T	0	0	T
		2021	0	0	T	0	0	T	0	0	T
		2022	0	0	T	0	0	T	0	0	T

15.	Mărculești 10/5	2020	26.6	2	S	55.7	3	VS	21.4	2	MS
		2021	13.2	1	MR	27.2	2	MR	17.9	2	MS
		2022	47.2	2	S	22.4	2	MR	21.7	2	MS
16.	Mari de Aiud	2020	0	0	T	63.4	3	VS	0	0	T
		2021	12.1	1	MR	74.5	3	VS	63.2	3	VS
		2022	17.3	1	MR	21.4	1	MR	24.3	2	MS
17.	Sulina	2020	21.4	2	MR	65.7	3	VS	75.3	3	VS
		2021	61.2	3	VS	61.4	3	VS	71.7	3	VS
		2022	13.6	1	MR	18.3	2	MS	0	0	T
18.	Sirena	2020	0	0	T	32.7	2	S	42.7	2	S
		2021	19.3	1	MR	41.5	2	S	32.5	2	S
		2022	0	0	T	44.6	3	S	36.3	2	S
19.	Mari de Mărculești	2020	65.4	3	VS	58.4	3	VS	23.5	2	MS
		2021	59.4	3	VS	65.4	3	VS	78.4	3	VS
		2022	36.4	2	S	19.7	2	MS	62.7	3	VS
20	Saturn	2020	0	0	T	21.2	2	MR	0	0	T
		2021	22.5	2	MR	0	0	T	67.7	3	VS
		2022	0	0	T	64.2	3	VS	19.3	2	MS

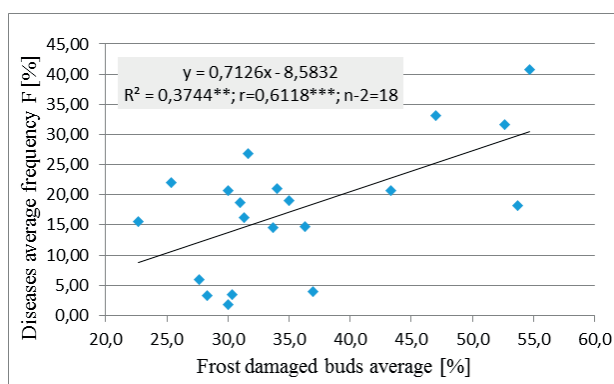


Figure 4. Correlation between the perished buds average damaged by the frost and diseases average frequency during the vegetation season

Assessment of the Figure 4 revealed a strong positive correlation between the buds average percentage damaged by the frost and the average incidence of the diseases occurred on the vegetation periods 2020-2022.

This correlation, is described by the trend of regression equation $y=0.7126x-8.5832$, and its associated coefficients $R^2=0.3744^{**}$; $r=0.6118^{***}$, statistically insured even at 18 liberty degrees ($n-2=18$).

CONCLUSIONS

In recent years, climate changes have contributed to the increased impact of certain fungal pathogens that pose the greatest economic threat to apricot trees, leading to premature decline.

The most notable ones are *Stigmina carpophila*, *Cytospora cincta*, and *Monilinia laxa*.

The analyzed data highlighted that the late frosts are more damaging nowadays than in the past and we concluded that they are more damaging when they occur at the end of the winter and beginning of the spring, between the bud break and early flowering. In this period vegetative and generative tissues are developing but are also vulnerable to the piercing action of the ice crystals and contamination with pathogenic fungi.

The cultivars 'Mamaia', 'Roșii de Mărculești', 'Olimp' and 'Elmar' are used as genitors in the breeding activity due to their resistance to the attack of the three pathogens studied.

As a result of the conducted studies, resistant and high-value apricot varieties have been integrated into commercial orchards, playing a significant role in the varietal structure of apricot cultivation in southeastern Romania.

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