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THE IMPACT OF CLIMATE CHANGES ON THE PHENOLOGICAL DYNAMICS OF SOME PEAR VARIETIES IN THE MĂRĂCINENI AREA, ROMANIA

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Abstract

Climate change has impact on the phenology of fruit trees brings changes on the quality and productivity of the fruits, on the resistance/tolerance to frost, diseases and pests and implications on the zoning of the fruit tree species. The study was carried out in pear collection from ICDP Pitesti - Maracineni on seven Romanian pear varieties (‘Argessis’, ‘Carpica’, ‘Monica’, ‘Ervina’, ‘Paramis’, ‘Paradox’, ‘Isadora’) compared with ‘Packham’s Triumph’ cv., between 2014-2024 periods. It has been studied for 11 years the phenophases of flowering in relation with climatic factors (temperature, and precipitation). Thus, from the multiannual observations it was found that all the flowering phenophases of pear were realized earlier, with about 9 days (for beginning of flowering) and 10 days (for end of flowering). Climate accidents were also recorded in 2017 (late spring frosts, -4.2°C on April, 21-22th), 2020 (late spring frost, -6.2°C ...-7.1°C on March, 16-17th and on April, 1-7th), 2022 (late spring frosts -1.8...5.5°C on April, 18-21th), in 2023 (low temperatures - 4°C... -6.4°C on March, 29-30th), and 2024 (high temperature, +27°C, April, 1st). All these climatic accidents had visible negative effects on fruit production (e.g.: low temperatures from April, 2017 led to the loss of yield in a proportion of 95 % on ‘Monica’ cv.).

***Key words**: changes climatic, genetic resources, pear, phenology, late frost.*

INTRODUCTION

Climatic changes cause significant agricultural obstacles, negatively influencing productivity, water and soil resources. Extreme weather events negatively affect global agriculture and food security, disrupt fruit production leading to increased food prices (Jovović et al., 2024; Razzaghi, 2024).

The quantitative and qualitative basis of production is the result of the interaction between genetic, technological and environmental factors.

Fruit species, as perennial organisms composed of cultivar and rootstocks that interact, are strongly influenced by the environment throughout the life period, during which the annual cycles follow each other, each involving the passage through growth, fructification and physiological processes (Chitu et al., 2023).

In fruit growing, the adaptation of varieties and hybrids to the different climatic conditions from year to year constitutes a breeding objective that remains current.

The adaptability of the genotypes is closely correlated with different factors: rootstocks, precocity and resistance to low temperatures, late spring frosts, high temperatures (drought) or excess humidity.

The positive response to climatic changes can be obtained by appropriate technologies or cultural means; by cultivating in favourable areas (appropriate zoning) or by breeding programs that follow the creation of varieties that incorporate genes for resistance to these extreme factors. Some of the physiological processes of trees, such as vegetative growth, flowering, fruiting and quality of fruits are strongly influenced by climate changes. And in the pear species, phenology is influenced by climatic changes (especially temperature, drought and precipitation), with an interaction between genotype and environmental factors.
In Europe, previous research shows that, due to

the warming of the climate, flowering phenology of fruit trees is advancing, with studies indicating earlier flowering in apples, sweet cherries, pears and plums (Sparks et al., 2005; Craufurd and Wheeler, 2009; Unterberger et al., 2018; Reeves et al., 2022). This research area is a concern for the agricultural sector, given the possible influence on pollination, yield capacity and ultimately food security (Craufurd and Wheeler, 2009).

In Romania, according to Cosmulescu et al. (2010) and Chițu and Paltineanu (2020), there was an advance between 2 - 10 days in the pear phenology, this being smaller than at the apple, at which the advance is 7-15 days.

The increases of temperatures between January and March and the advance of the flowering phenophases have increased the risk of frost damages. Also, late spring frost from the beginning or ending of flowering can cause damage in flower buds or destroy flower elements with negative implications on fruit production.

The aim of this paper is to study the major effects of the climate changes on the pear flowering phenology and the damages caused by the late frosts in the Southern part of Romania.

MATERIALS AND METHODS

The studies were carried out in pear collection of Genetic and Breeding Department from Research Institute for Fruit Growing Pitești (RIFG), Romania in 2014-2024 periods using a climate database from 1969 to 2024. Phenological data on pear flowering were collected according to BBCH Meier (2001), ECPGR Characterization and Evaluation Descriptors for Pear Genetic Resource (2022), respectively: beginning of flowering - code 61 and end of flowering - code 69 (Table 1).

Table 1. The stages of phenological development at pear (after Meier, 2001)

Growth stage	Code	Description
Flowering (main shoot)	61	Beginning of flowering: about 10% flowers open
	69	End of flowering: all petals fallen

The appreciation of the flowering phenophase was performed on seven pear Romanian cultivars ('Argessis', 'Carpica', 'Monica', 'Ervina', 'Paramis', 'Paradox', 'Isadora') compared with 'Packham's Triumph' cv., very widespread in the plantations from Europe.

The data were included in an Excel and interpreted statistical using average, standard deviation and coefficient of variability.

RESULTS AND DISCUSSIONS

In order to determine the effect of climatic factor on the phenological stages of pear cultivars studied the evolution of meteorological parameters was analyzed. In the South part of Romania, the climate it is temperate-continental, characterized by an average annual temperature of 10.1ºC and an amount of precipitation of 673.2 mm for the period 1969-2023 (Figure 1).

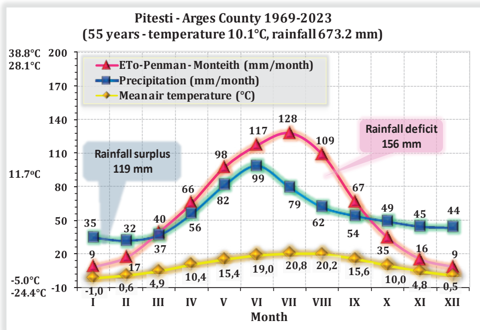

Figure 1. The values of the main meteorological parameters (1969-2023)

During the study period (2014-2024) the average annual temperature was 11.5ºC being with 1.4ºC higher than the multiannual average; the average maximum temperature was with 1.6ºC higher than the multiannual average; the average minimum temperature was with 0.8ºC higher than the multiannual average and the average amount of precipitation was 677.8 mm, closely to the multiannual average, but with decreasing trends in the last 3 years (Table 2).

In Romania, significant increases of average air temperature were also noted in January, February and March which causes an early start of trees in vegetation with negative influences on resistance to late spring frosts (Chițu et al., 2013; Florea et al., 2019; Chițu and Păltineanu, 2020). Also, in different countries from Europe there have been increases in average air temperature,

such as: 1.1-1.3ºC in France; 0.6-1.9ºC in two regions of Germany; 1.2ºC in Serbia; 1.4ºC in Slovenia (Guedon and Legave, 2008; Blanke and Kunz, 2017; Drkenda et al., 2018; Waldau and Chmielewski, 2018; Milisévič and Milosévič, 2023).
In the study period (2014-2024) there is also a tendency to increase temperatures, which causes an earlier flowering. Thus, average temperature was in January with 1ºC higher, in February with 2.3ºC higher, in March with 1.5ºC higher and in April with 0.8ºC higher than the multiannual average temperature (Table 3).

Table 2. Average values of the main meteorological parameters in the period 2014-2024 compared to the baseline for 54 years period (1969-2023)

Year	Average tempera-ture (ºC)	Average maximum temperature (ºC)	Average minimum Temperature (ºC)	Precipitation (mm)
2014	10.6	16.3	5.8	1,011.3
2015	11.3	17.8	5.8	725.2
2016	11.0	17.5	5.4	776.0
2017	11.0	17.8	5.1	632.3
2018	11.2	17.8	5.8	745.9
2019	11.9	18.9	5.9	634.7
2020	11.8	18.9	5.8	679.1
2021	10.7	17.4	5.2	636.2
2022	11.6	18.9	5.4	525.3
2023	12.3	19.2	6.5	562.8
2024	12.7	20.2	6.3	527.0
2014-2024	**11.5**	**18.2**	**5.7**	**677.8**
1969-2023	**10.1**	**16.6**	**4.9**	**673.2**

Table 3. Temperature values recorded in the first four month of years (2014-2024) compared to the baseline for 54 years period

Year	**Mean temp.** (°C)			
	Jan.	Febr.	March	April
2014	0.1	1.7	8.1	10.9
2015	0.6	1.2	5.6	9.9
2016	-2.4	5.7	6.7	13.5
2017	-4.5	1.5	8.5	9.8
2018	0.6	0.6	3.7	15.2
2019	-1.2	2.6	7.8	10.8
2020	0.3	4.2	7.7	10.9
2021	0.5	3.0	4.1	8.6
2022	0.8	3.1	3.6	10.1
2023	4.0	2.6	7.1	9.7
2024	0.2	6.5	7.8	13.4
2014-2024	**-0.1**	**3.0**	**6.4**	**11.2**
1969-2023	**-1.0**	**0.7**	**4.9**	**10.4**

All these increases of temperatures from the beginning of the year have had the effect of earlier flowering than the normal flowering time in Mărăcineni - Argeş area.
The beginning of flowering is a specific trait of each cultivar, being genetically determined and is not correlated with the ripening time of fruits.
The average date of the beginning of flowering of pear is April 17 being considered a landmark for pear flowering in Mărăcineni - Argeș area.
It is observed that in the period 2014-2024 the average date regarding the beginning of flowering was April 8, the standard deviation between cultivars being 0.70 days, indicating a flowering grouped of the studied cultivars. It can also be noted that the beginning of flowering was with 9 days earlier than the average flowering date in the Mărăcineni -Argeş area (Figure 2).

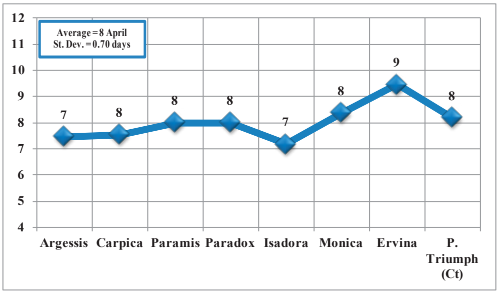

Figure 2. The oscillation of average values (2014-2024) regarding the date of beginning of flowering at the pear cultivars studied

Analyzing the phenophase beginning of flowering by the years it can be seen that the earliest blooming was achieved in the years: 2014 and 2019 - April 3, 2016 and 2024 - April 2, 2023 - April 6, 2020 - April 10.
In the years 2015, 2018, 2021 and 2022 the beginning of flowering was carried out within normal limits (April, 13-19) (Figure 3).

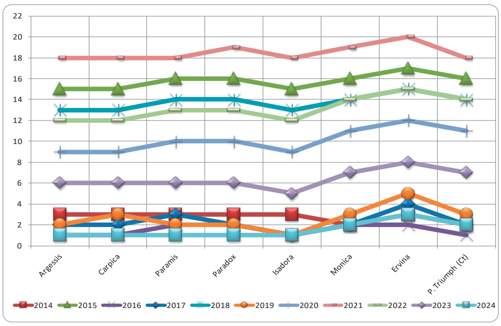

Figure 3. The oscillation of the date regarding the beginning of flowering on the pear cultivars between 2014 and 2024

On cultivars the situation is presented as follows: 'Argessis' and 'Isadora' cvs.

blossomed earlier than 'Packham's Triumph' cv., and 'Ervina' cv. blossomed a little later than the 'Packham's Triumph' cv. (Figure 2).

Regarding the end of flowering, it can be said that the average date of this phenophase is April 27 considered a landmark for the Mărăcineni-Argeș area.

In the last 11 years, the average date of the end of flowering was April 17, being with 10 days earlier than the normal average date of this phenophase (Figure 4).

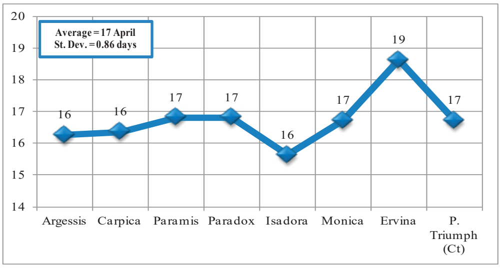

Figure 4. The oscillation of average values (2014-2024) regarding the date of ending of flowering at the pear cultivars studied

The oscillation of the average values regarding the end of flowering in the study period was similar to that of the beginning of flowering (Figure 5).

Thus, the end of flowering was earlier in the years 2014, 2016, 2017, 2019, 2023, 2024 and within normal limits in the years 2015, 2018, 2020, 2022 (Figure 5).

It can be seen that in the years when the flowering was earlier, the average air temperature of February and March were much higher than the normal of the Mărăcineni, Argeș area (Table 3, Figures 3 and 5).

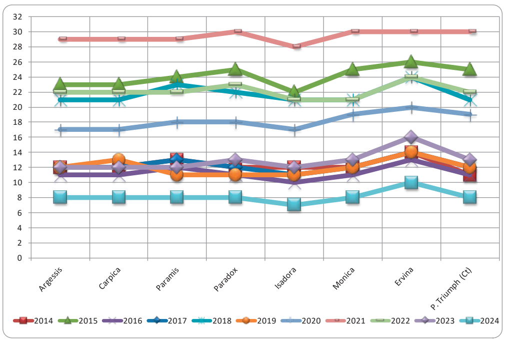

Figure 5. The oscillation of the date regarding the ending of flowering on the pear cultivars between 2014 and 2024

These advances of flowering had serious implycations on the damage caused by late frosts.

Climate change has introduced more unpredictability and extreme temperature events that can have major impacts on dormancy, cold-hardiness of wood and buds, accumulation of chilling hours and fruiting phenology of pear.

Late fall and early spring warming can shorten the number of chilling hours accumulated, particularly in warmer climates, which leads to issues with fruits production (Vyse et al., 2019; Waite et al., 2024).

The frequency of the climatic accidents occurrence between March 11 and April 10 and April 26-May 10, is low (on average every 50 years). Higher damage can be recorded between April 11 and 20, when the probability increases to 4% (so in a year of 25, the floral organs can freeze). The most critical period is April 21-25 when the probability of destroying the floral organs by frost reaches 6.3%, respectively in a year of 16 the harvest is compromised (Butac and Chițu, 2009).

In the Mărăcineni - Argeș area, in the period 2014-2024, climate accidents were recorded in 2017 (late spring frosts, -4.2°C on April, 21-22th), 2020 (late spring frost, -6.2°C …-7.1°C on March, 16-17th and on April, 1-7th), 2022 (late spring frosts -1.8...5.5°C on April, 18-21th), in 2023 (low temperatures -4°C... -6.4°C on March, 29-30th), and 2024 (high temperature, +27°C, April, 1st) (Table 4). All these climatic accidents had visible negative effects on fruit production.

Table 4. Climatic accidents in the 2014-2024 period, specific to the pear species

Year	Climatic accident	Date	Min. temp. (°C)	Phenophase	Level of damages (%)
2017	Late spring frost	April, 21-22	-4.2	End of flowering	28-95
2020	Late spring frost	March 16-17 April 1-7	-6.2..-7.1 -5	Bud burst Beginning of flowering	15-30
2022	Late spring frost	April 18-21	-1.8..-5.8	Begining of flowering	10-15
2023	Late spring frost	March, 29-30	-1.4..-6.4	Bud burst	10-67
2024	High temp.	April 1	+27	Begining of flowering	Low fruit set

In 2017, the level of damages was in average 60.83% varying between 28.00% at 'Carpica' cv. and 95.00% at 'Monica' cv. (Table 5; Figure 6).

In 2020 and 2022 the percentage of flowers destroyed was slightly lower, 20.67 in 2020 and 12.42% in 2022, the fruit production being not economically affected (Table 5).
Also in 2023, the late spring frosts from the end of March when the trees were in the phenophase bud burst had a negative effect, the average percentage of damages being 40.71% (Table 5). However, fruit production has not been much diminished.
The most sensitive cultivars were ‘Argessis’, ‘Monica’, ‘Ervina’ and ‘Paramis’ to which the percentage of flowers destroyed was higher, and implicitly the fruit production was very small or even absent at the ‘Ervina’ and ‘Monica’ cvs.

Table 5. Damage caused to pear by late frosts from March, 29-30, 2023, Romania

No.	Cultivar	Level of damages (%)			
		2017	2020	2022	2023
1	Argessis	79.33	23.67	13.33	64.67
2	Carpica	28.00	15.00	10.00	13.33
3	Monica	95.00	30.33	15.00	67.00
4	Ervina	93.00	25.00	15.00	65.33
5	Paramis	84.67	24.67	14.33	62.00
6	Paradox	32.33	15.33	10.33	20.00
7	Isadora	36.67	15.67	10.67	16.67
8	Packham’s Triumph	37.67	15.67	10.67	16.67
Average		**60.83**	**20.67**	**12.42**	**40.71**
Standard deviation		**29.58**	**5.95**	**2.21**	**25.80**
Coefficient of variability		**48.62**	**28.78**	**17.79**	**63.37**

Figure 6. Pear flowers - ‘Monica’ cv., unaffected and affected by the late frosts from April 21-22, 2017 (Mărăcineni - Argeș)

CONCLUSIONS

Climate changes from the last years have a negative effect on the growth and fruiting of pear species.
In the Southern part of Romania, in the last time, were recorded increasing of mean, maximum and minimum temperatures.
The increase of average air temperature was also noted in January, February, March and April.
Due to the significant increase in these months, the flowering phenophases of pear were realized earlier, with about 9 days (for beginning of flowering) and 10 days (for end of flowering).
This advance had serious implications on the damage caused by late frosts.
Climate accidents were recorded in 2017 (late spring frosts, -4.2°C on April, 21-22th), 2020 (late spring frost, -6.2°C …-7.1°C on March, 16-17th and on April, 1-7th), 2022 (late spring frosts -1.8...5.5°C on April, 18-21th), in 2023 (low temperatures -4°C... -6.4°C on March, 29-30th), and 2024 (high temperature, +27°C, April, 1st).
All these climatic accidents had visible negative effects on fruit production (e.g.: low temperatures from April, 2017 led to the loss of yield in a proportion of 95 % on ‘Monica’ cv.).

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