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DEVELOPMENT OF VEGETATION PHENOPHASES IN SOME PLUM CULTIVARS GROWN IN THE CRAIOVA AREA

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ABSTRACT

The paper studied the development of the vegetation phenophases in three plum cultivars ('Andreea', 'Record' and 'Čačanská lepotica'), analyzing how climatic variations and environmental factors affect their development. The BBCH scale was used to record the different phenophases. The number of days from November 1 to budding, the duration of budding, the duration of the flowering period, the number of days from the appearance of the fruits to the ripeness for consumption were calculated and it was found that the phenological stages occurred without too great differences from one cultivar to another. This is due, on the one hand, to the fact that the three cultivars were grafted on the same rootstock, and on the other hand, to the close fruit ripening period.

INTRODUCTION

Due to the economic importance that plum fruits (*Prunus domestica* L.) have, at the world and national level there is an obvious concern in various research directions of this species. Phenology is the study of the developmental stages of plants in relation to environmental factors, and the analysis of phenophases in fruit trees is essential for understanding their growth and productivity cycle. In the case of the plum, one of the important species in fruit growing in Romania, the unfolding of the vegetation phenophases varies depending on the cultivar and the agroclimatic conditions. Studies on plum phenology are numerous and underline the importance of this discipline for understanding how different cultivars react to environmental conditions and climate changes (Cosmulescu et al. 2010, 2020; Woznicki et al. 2019, Milosevic & Milosevic 2023; Moghaddam et al. 2011). The study of phenology correlated with ecological factors can be used in several ways, namely: use in fruit growing, in making decisions about the creation of cultivars capable of adapting to current climate changes, to escape from climatic accidents that are frequent in certain areas and sometimes cause crop loss and in monitoring climate change, knowing that plants are the ones that record and respond to ecological factors (Cosmulescu et al. 2018a,b). Glišić et al. (2023) showed that all analyzed plum genotypes in the western area of Serbia have long flowering period and late flowering. The increase in temperature causes changes in the relative duration of vegetation phenophases and in the frequency of heat stress. Therefore, climate change adaptation strategies should focus on the use of drought-tolerant cultivars,

as well as on the adaptation of phenology to the new environmental conditions, to avoid extreme events (Cosmulescu & Gruia, 2016). Phenophases, such as budding, flowering, fruit formation and ripening, have a direct influence on crop yield and fruit quality, a number of studies report data on physical and chemical characteristics of fruits in correlation with phenology and crop area (Milatović et al. 2019; Cosmulescu & Căluşaru 2018a; Ionica et al. 2018, Cosmulescu et al. 2008). This paper aims to study the development of vegetation phenophases in some plum cultivars, analyzing how climatic variations and environmental factors affect their development. The obtained results can contribute to the optimization of culture technologies and the improvement of plum orchard management strategies.

MATERIAL AND METHODS

The biological material is represented by three plum cultivars, ˈAndreeaˈ, ˈRecordˈ and 'Čačanská lepotica', grafted on Mirobolan and located in the research field of the Banu Mărăcine Research Station, near the city of Craiova (44°20′N 23°49′ E). Vegetation phenophases were analyzed, the data being obtained in the years 2022-2023.

The BBCH scale (Meier 2001) was used to record the different phenophases. Based on these records, we calculated the number of days from November 1 to beginning of bud swelling (Nov 1st -BBCH 01; Nov 1st -BBCH 51), the duration of bud swelling (BBCH 01-BBCH 03; BBCH 51-BBCH 52), the duration of the flowering period (BBCH 60-BBCH 69), the number of days from bud swelling to the beginning of flowering (BBCH 51-BBCH 60), the number of days from the beginning of flowering to full flowering (BBCH 60-BBCH 65), the number of days from the appearance of fruits until the beginning of ripening (BBCH 71-BBCH 81), the number of days from the beginning of fruit ripening to maturity of consumption (BBCH 81-BBCH 89). In order to highlight the climatic characteristics of the culture area, maps from the website of the National Meteorological Administration were used (https://www.meteoromania.ro/clim/caracterizare-lunara/cc_2023_04.html).

RESULTS AND DISCUSSIONS

The vegetation phenophases of the three plum cultivars (ˈAndreeaˈ, ˈRecordˈ and 'Čačanská lepotica') grafted on the Mirobolan rootstock were analyzed, and the results obtained are presented in tables 1-5. Beginning of bud swelling is considered when the buds burst and green leaf tips appear. This phenophase is based on the processes of elongation of the preformed cells and the rudimentary bud from a bud that already exists from the previous year. The development of this phenophase is influenced mainly by the temperature, which triggers the flower buds when the biological threshold is reached, but also by the supply status of the trees with reserve substances.

The results regarding the vegetative and flowering bud swelling of the three plum cultivars analyzed are presented in table 1. Analyzing these results, the following were found: on March 15th for the 'Čačanská lepotica' cv., March 19th for the 'Record' cv. and March 20th for the 'Andreea' cv. the vegetative and flowering buds were still in total vegetative dormancy and had dark brown scales (BBCH 00). Bud burst, when the buds are swelled and elongated, the scales moved apart and had a lighter color border (BBCH 01) occurred earliest on March 19th in 'Čačanská lepotica' cv. and the latest, respectively on April 24th, at 'Andreea' cv. In the study by Corneanu et al. (2022) bud swelling (BBCH 01) occurred between 07th and 11th of

March, respectively between 25th March and 05th of April depending on the cultivar and the climatic year.

The end of the bud swelling of the vegetative buds, when the scales are separated and light in color and the light green bud sections are visible (BBCH 03) occurred on March 21st in 'Čačanská lepotica' and on March 23rd in 'Record' and later in 'Andreea' cv. (March 26th). The BBCH 09 stage, when the green leaves appear at the top of the buds, the brown scales have fallen, the buds are enclosed by light green scales also occurred the earliest in 'Čačanská lepotica' (March 23rd), followed by 'Record' (March 26th) and ˈAndreeaˈ cv. (March 28th), which is the latest cultivar among those analyzed.

Table 1

Vegetative and flowering budding in plum cultivars grafted on Mirobolan rootstock

Cultivar/BBCH stage	'Andreea'	'Record'	'Čačanská lepotica'
BBCH 00	20.03	19.03	15.03
BBCH 01	24.04	21.03	19.03
BBCH03	26.03	23.03	21.03
BBCH 09	28.03	26.03	23.03
BBCH 51	29.03	27.03	26.03
BBCH 52	30.03	29.03	28.03
BBCH 53	31.03	30.03	29.03

The swelling of the flower buds (BBCH 51) took place on March 26th in 'Čačanská lepotica', one day apart in 'Record' and three days apart in 'Andreea' cv. The scales of the buds become lighter in color and the primordia are visible covered with fine and felty hairs (BBCH 52) between March 28-30th and de-budding (BBCH 53) took place on March 29 in 'Čačanská lepotica', on 30th of March for the 'Record' cv. and on March 31st for 'Andreea'.

Table 2 shows data on the evolution of inflorescences in the analyzed plum cultivars. The inflorescence is closed by the light green bracts (BBCH 54) on March 30th in 'Čačanská lepotica', on April 1st at 'Record' cv. and on April 2nd in the 'Andreea' cv. Stage BBCH 55, i.e. when the flower buds are visible, green, the flower is closed and completely covered by green and closed sepals, it was recorded between 02nd and 05th of April. The flower peduncle is elongated, developed (BBCH 56) between 04-07th of April. The tip of the petals is white/pink, and the sepals open on April 6th in the 'Čačanská lepotica' cv., on April 7th in the 'Record' cv. and on April 9th in the 'Andreea' cv. (BBCH 57). The flower bud has the shape of a white/pink ball, the petals are well developed and the bud is close to flowering (BBCH 59) between 08th and 11th of April depending on the cultivar.

Table 2

Evolution of inflorescences in plum cultivars grafted on Mirobolan rootstock

Cultivar/BBCH stage	'Andreea'	'Record'	'Čačanská lepotica'
BBCH 54	02.04	01.04	30.03
BBCH 55	05.04	03.04	02.04
BBCH 56	07.04	05.04	04.04
BBCH 57	09.04	07.04	06.04
BBCH 59	11.04	09.04	08.04

Table 3

Flowering date of grafted plum cultivars on Mirobolan rootstock

Cultivar/BBCH stage	'Andreea'	'Record'	'Čačanská lepotica'
BBCH 60	12.04.2023	10.04.2023	09.04.2023
BBCH 65	19.04.2023	18.04.2023	17.04.2023
BBCH 67	26.04.2023	25.04.2023	23.04.2023
BBCH 69	05.05.2023	04.05.2023	03.05.2023

In fruit trees, many phenological phases occur in April and May. April is usually the time of year when flowering occurs (Cosmulescu et al. 2010). Table 3 presents data on the flowering of the analyzed plum cultivars. Analyzing the data in table 3, it was found that there are no big differences from one cultivar to another in terms of flowering. The first open flower (BBCH 60) occurred at the earliest on April 9th for the 'Čačanská lepotica' cv. and at the latest on April 12th at 'Andreea' cv. Full bloom (BBCH 65) occurred between April 17-19th, petals fallen (BBCH 67) occurred between April 23rd and 26th, and all petals fallen (BBCH69) between May 3rd and 5th, depending on the cultivar, that at whose flowering started and ended earlier being the 'Čačanská lepotica' cv. and the latest being the 'Andreea' cultivar. The flowering of the analyzed plum cultivars took place without too much difference from one cultivar to another, since all three cultivars are grafted on the same rootstock, namely the Mirobolan rootstock. In the study by Corneanu et al. (2022) flowering (BBCH 61) started between 04th and 07th of April, respectively between 22nd and 24th of April depending on the cultivar and the climatic year. Differences in the onset of the phenological phases within the cultivars appear depending on the rootstock, a fact that is confirmed by many authors (Sestras et al. 2007; Botu et al. 2007). The persistence of flowers on the tree for a longer period of time is a positive characteristic of the adaptation of the cultivar to unfavorable pollination conditions, a longer duration of flowering means a greater number of days that are favorable for the flight of bees and ensuring pollination (Cosmulescu et al. 2010).

Table 4 presents data on the development and ripening of the fruits of the analyzed plum cultivars. Fruit set (BBCH 71) took place on April 26th in all analyzed cultivars, fruit growth began on May 5th when the green ovary of the fruit was surrounded by dry sepals (BBCH 72), the beginning of ripening (BBCH 81) occurred on July 28th, physiological maturity (BBCH 87) was reached on August 4th and consumption maturity (BBCH 89) on August 15th.

Table 4

Fruit development and ripening in plum cultivars grafted on Mirobolan rootstock

Cultivar/BBCH stage	'Andreea'	'Record'	'Čačanská lepotica'
BBCH 71	26.04.2023	2.05.2023	29.04.2023
BBCH 72	05.05.2023	20.05.2023	10.05.2023
BBCH 81	28.07.2023	2.08.2023	30.07.2023
BBCH 87	04.08.2023	12.08.2023	07.08.2023
BBCH 89	15.08.2023	21.08.2023	17.08.2023

Regarding flowering duration, in the study reported by Cosmulescu et al. (2010), this ranged between 8 and 18 days within species due to meteorological factors and varied from 6 to 12 days with cultivar. The analysis of the obtained data indicated that "flowering duration" is a trait influenced by the meteorological factor

and the genetic factor. The influence of the meteorological factor manifests itself in different years, determining different lengths of time within the same cultivar, between the beginning and end of flowering. In general, the later flowering begins, the shorter its duration.

Table 5 shows the duration of the different phenophases of the plum cultivars grafted on the Mirobolan rootstock. A number of days between 136 and 141 passed from November 1st to the beginning of budding (November 1st - BBCH01). From the first opened flower to full bloom (BBCH 60-BBCH 65) 8-9 days passed. From the setting of the fruits to the beginning of ripening (BBCH 71-BBCH 81) 95 days passed and from the beginning of ripening to the maturity of the fruits for consumption (BBCH 81-BBCH 89) 18 days passed.

Table 5

The duration of different phenophases in plum cultivars grafted on Mirobolan rootstock

Number of days	'Andreea'	'Record'	'Čačanská lepotica'
Nov. 1st -BBCH01	141	140	136
BBCH 01-BBCH03	5	3	5
Nov. 1st -BBCH 51	150	148	147
BBCH 51-BBCH 52	2	3	3
BBCH 60-BBCH 69	24	25	25
BBCH 51-BBCH 60	15	15	15
BBCH 60-BBCH 65	8	9	9
BBCH 71-BBCH 81	95	95	95
BBCH 81-BBCH 89	18	18	18

Given that for the Craiova area, the average number of days with frost is approximately 127 days, and the most recent frost occurs in May, in some years there is a danger of climatic accidents occurring during the flowering of the plum tree. The first frost occurs in autumn, between October 20-30th, while the last frost is in February. In the study developed by Corneanu et al. (2022), depending on the climatic year and cultivar, the number of days from bud break to the beginning of flowering (BBCH 01-BBCH 61) varied between 79.3-118.05 days and between 75.75-119.35 days.

In figures 1, 2, 3 and 4 it can be seen the climatological characterization of Oltenia, in the months of April-May 2023, from the flowering period, the biological material analyzed being located in the research field of the Banu Mărăcine Research Station, Craiova, located in the S-W Oltenia. The average temperature of April 2023 had values of 11.5°C, at the meteorological stations Calafat, Turnu Măgurele and Zimnicea (figure 1). The highest values, over 10°C, were recorded in most of Muntenia and Oltenia, in the south of Moldova, in small areas of Dobrogea, in the Danube Delta and locally in Banat. The deviation of April 2023 mean air temperature from the median of the standard reference interval (1991-2020) was negative across the country. Analyzing the classification of thermal anomalies in severity classes from April 2023, it can be seen that the thermal regime was extremely cold throughout the country (figure 2).

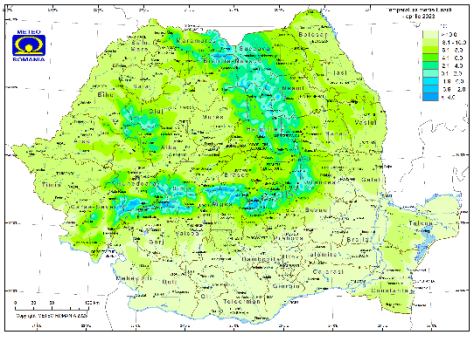
The total amount of precipitation in April 2023 had values higher than 50 mm in most of the country (figure 3). The deviation of April 2023 precipitation from the median of the standard reference interval (1991-2020), calculated as a percentage, was positive in most of the country. Analyzing the severity classes of rainfall

anomalies from April 2023, it is observed that the rainfall regime was excess, very excess and extremely excess in Dobrogea and the Danube Delta, in most of Moldova, on extensive areas in Muntenia, in some mountainous areas and locally or isolated, in Banat and Oltenia (figure 4). It was deficient and very deficient mainly in the western half of the country, but also on extensive areas in Transylvania and Oltenia, locally in the south of Moldova and isolated in Muntenia.

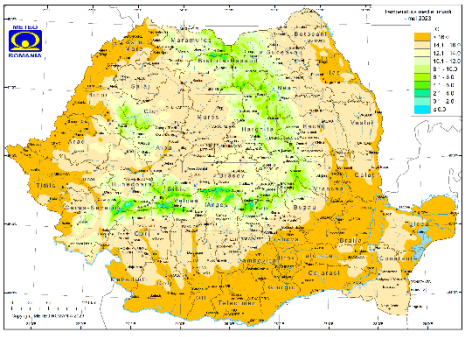
The average temperature of May 2023 (figure 1), the highest values, over 16°C, were recorded in most of Muntenia, on extensive areas of Oltenia, Banat and Crișana, in the west of Maramureș, in the east and the south of Moldova, in the north and east of Dobrogea, in the Danube Delta and locally in Transylvania. Average monthly temperatures between 14 and 16°C were recorded in most of Moldova, Transylvania and Dobrogea, in the north, north-west and east of Muntenia, on extensive areas of Oltenia, Banat and Maramureș, as well as in the hilly areas of Crisana.

The deviation of the May 2023 mean air temperature from the median of the standard reference interval (1991-2020) was negative over most of the country. Analyzing the severity classes of the thermal anomalies from May 2023, it can be seen that the thermal regime was cold in the southern half of the country, but also in the restricted areas of Moldova and the Eastern Carpathians (figure 2). The thermal regime was very cold and extremely cold in the south and east of Muntenia, as well as in the south-west of Oltenia.

The total amount of precipitation in May 2023 had values higher than 50 mm in Oltenia, Banat and Crisana, on extensive areas of Muntenia and Transylvania, in the Southern and Western Carpathians and isolated, in the other regions (figure 3). Analyzing the severity classes of rainfall anomalies from May 2023, it can be seen that the rainfall regime was deficient and very deficient in most of the country (figure 4). It was surplus on extensive areas of Banat and locally or isolated, in Crisana, Oltenia, Muntenia, Moldova and Dobrogea.

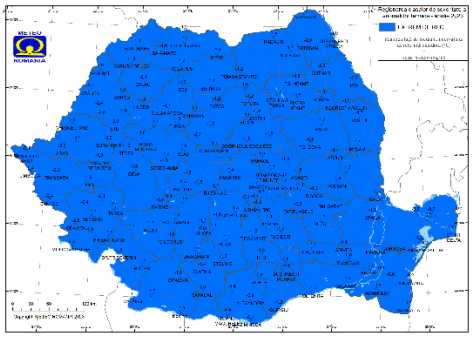


Average monthly temperature - April 2023

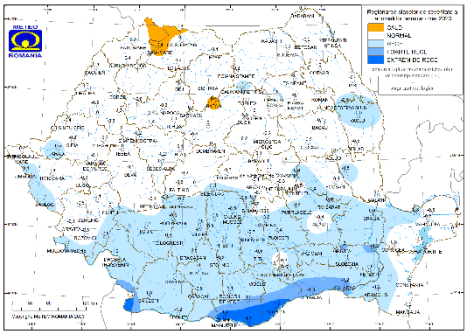


Average monthly temperature - May 2023

Figure 1. The temperature of the cultivation area in the months of April - May 2023 (Source: https://www.meteoromania.ro/clim/caracterizare-lunara/cc_2023_04.html)



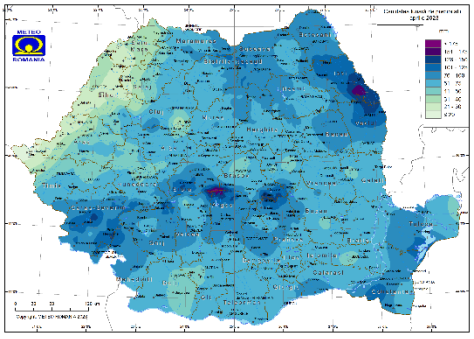
Regionalization of the severity classes of thermal anomalies from April 2023



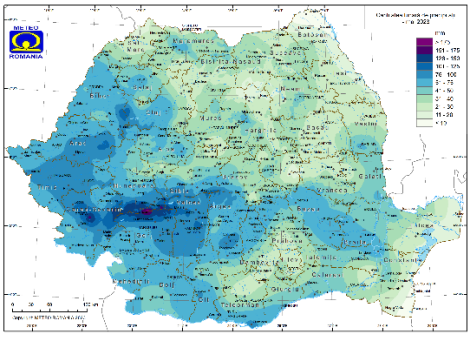
Regionalization of severity classes of thermal anomalies from May 2023

(Source: https://www.meteoromania.ro/clim/caracterizare-lunara/cc_2023_04.html)

Figure 2. Regionalization of the severity classes of thermal anomalies during the flowering period



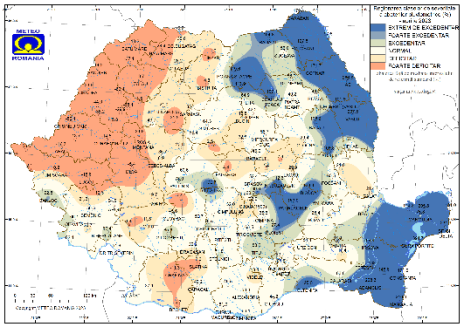
Monthly amount of precipitation - April 2023



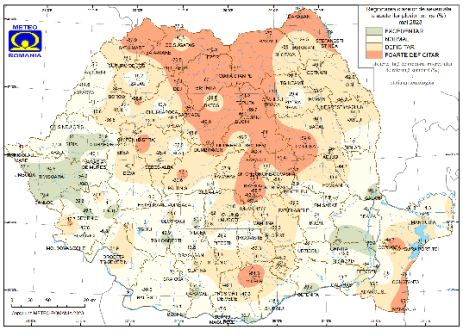
Monthly amount of precipitation – May 2023

(Source: https://www.meteoromania.ro/clim/caracterizare-lunara/cc_2023_04.html)

Figure 3. Monthly amount of precipitation during April-May 2023



Regionalization of severity classes of rainfall anomalies (%) from April 2023



Regionalization of severity classes of rainfall deviations (%) from May 2023

(Source: https://www.meteoromania.ro/clim/caracterizare-lunara/cc_2023_04.html)

Figure 4. Regionalization of the severity classes of thermal and rainfall anomalies from April 2023

CONCLUSIONS

It is obvious the importance of monitoring the vegetation phenophases of various plum cultivars, considering the significant influence of climatic variations and environmental factors on their development. The results can contribute to the optimization of cultivation techniques and the adaptation of agricultural practices to ensure the productivity and health of plum orchards in various ecological conditions.

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