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THE PHENOLOGY OF SOME NEW ALMOND CULTIVARS TESTED IN NORTHERN DOBROGEA

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Abstract

The almond (Prunus dulcis (Miller) D.A. Webb) crop started to regain interest for the farmers in Romania. Dobrogea is one of the most suitable regions for almond orchards. The key factor that limits the almond crop in Romania is the early flowering time, flowers and young fruits being suddenly affected by the spring frosts. In this study, the phenology of four Romanian and four foreign almond cultivars, grown in a super high-density trial orchard, in Greci, Tulcea County, is presented. The phenology study using BBCH scale was performed in 2021 and 2022 vegetative seasons, in order to determine the most suitable late and very late blooming cultivars for Dobrogea region. It resulted that Marinada and Lauranne have a very late blooming time, while the Romanian cultivars Nico and April, have an medium, medium to late blooming time. This study presents original data that could be of interest for scientists but also for farmers whom intend to plant new almond orchards.

Key words*: Prunus dulcis, climate, late blooming, early ripening.*

INTRODUCTION

The blooming time is one of the most important periods for the almond crop. Late frosts can occur during this time of the year, resulting in the freezing of flowers or young fruits. This phenomenon happens especially in Europe, in areas suitable for almond orchards. One way to avoid this phenomenon is to choose cultivars with late blooming period, adapted to the growing region. Knowing the phenology of the available cultivars on the market can help us take better decision when we establish new orchards.

Based on the phenological observations, growers could easily monitor developmental stages and schedule timely various agronomic managements such as frost protection, pollination, fruit thinning, irrigation, fertilization, pruning, pests and diseases management, and harvesting. To optimize these agronomical managements, it is advisable to take action when most of tree branches are in the same phenophase (Sakar et al., 2019).

The almond's phenological growth stages of flowering have been one of the main interests for scientists in the field, since the beginning of breeding almond cultivars in Europe. Different almond breeding programs from Europe had, among its main objectives, developing cultivars with late and very late blooming time, being a necessity to develop new cultivars more adapted to the medium conditions (Batlle et al., 2017).

During the blooming time and depending on numerous factors, like the phenological stage, temperature and exposure time, the temperatures below -1°C or -2°C, can cause severe flowers loss. Therefore, breeders were interested in delaying the flowering time of new cultivars, to bloom when the risk of late frosts are minimal (Dicenta et al., 2017).

Some researchers argue that the climate change and it's immediate implications for agricultural systems, are concerning the earlier onset of sexual reproductive development, higher or lower reproductive output, expansion of crop plants and shifts in the geographic distribution of natural populations towards higher latitudes (Hedhly et al., 2009), for the almond crop this can represent new perspectives, Romania being at its northern limit.

Over the centuries of almond growing, many attempts have been undertaken to shift its cultivation from the Mediterranean shores towards inland regions where, in most of the years, spring frosts occur during the time of the almond blooming or soon after (Socias i

Company et al., 2012). A main objective of many current almond breeding programmes is the development of cultivars adapted to cold climates, usually inland or at higher altitudes. Like other temperate trees, almond is typically without leaves and dormant during the winter. Under these conditions the almond can endure very low temperatures. In contrast, the almond tree is very susceptible to cold damage during flowering and early fruit development. At this time, temperatures below −1°C can cause crop loss. Therefore, breeders are interested in developing new cultivars possessing later flowering times in order to reduce the risk of cold damage (Martínez-Gómez et al., 2017).

The Black Sea basin was less important for the almond crop, fewer cultivars were adapted and commercially efficient here, and spring frosts were causing important damages. Since the climate changed, in the last decades, less harsh winters are encountered. In addition, the newly developed very late blooming cultivars, gained more potential for the almond crop in the Black Sea basin.

In Romania, the almond crop is regaining in popularity among farmers and scientific community. In the last decades some new medium and late blooming cultivars have been developed. In Europe different very late blooming cultivars have been released. These cultivars could present potential for growing in Romania, and can be a viable option for the farmers.

In this study is analyzed and presented the phenology of eight, medium to very late blooming time almond cultivars, for the years 2021 and 2022.

MATERIALS AND METHODS

The paper presents the phonological stages of inflorescence emerge and flowering of different almond cultivars grown in a super high-density trial orchard, located in Greci, Tulcea County. The study was realised in two years consecutively, 2021 and 2022.

Eight cultivars were taken into study, four Romanian, and four from abroad. The Romanian cultivars studied are Ana, April, Mirela and Nico, all grafted on the rootstock Tomis 1. The foreign cultivars are Lauranne, Marinada, Supernova and Vairo, all grafted on GF677. The trial orchard was planted in 2020, on a surface of 1000 m^2. It is a randomized complete block, with three samples of six trees, for each cultivar. Eighteen trees per cultivar, one hundred and forty four in total, were observed. The rows are displayed north-south. The distance of planting is four meters between rows and one and a half meters between plants per row. The canopy is formed as a vertical axe.

Ana cultivar was created at the University of Oradea by crossing Ardechoise x H 1/9-1fa, being registered in 2006 (Șcheau, 2013). It's a vigorous, self-incompatible cultivar, fruiting mainly on spurs. It is a late blooming cultivar, starting to bloom at the beginning of April, and has a medium ripening, in the third decade of August (Asănică & Hoza, 2013). The production at maturity is 1677 kg/ha in shell, the fruits are medium size (3 g). The kernel production is 823 kg/ha, with a total 49% shelling.

April was created at the University of Oradea by crossing Primorski x [(Preanâi x Crâmski], being registered in 2006 (Șcheau, 2013). It is a vigorous tree, self-incompatible, fruiting mainly on long branches. It is a medium-late blooming cultivar, starting to bloom at the end of March, and has a medium ripening that begins in the last decade of September (Braniste N., 2008). The production is 2064 kg/ha in shell at maturity, the fruits are medium-big size (4.4 g). The kernel production is 614 kg/ha, with a total 30% shelling.

Lauranne was created at INRA Bordeaux by a crossing between Ferragnes x Tuono, being registered in 1989. It is a medium-high vigor tree, self-fertile, fruiting mainly on spurs. It is a very late blooming cultivar, starting to bloom at the beginning of April, and has a medium ripening time, that begins in the last decade of August. The production is very high, the fruits are medium size, and kernel weights 1g in average. The shelling is 29-35%.

Marinada was created at IRTA Catalunia by a crossing between Lauranne x Glorieta, being registered in 2008. It is a medium vigor tree, self-fertile, fruiting mainly on spurs. It is a very late blooming cultivar, starting to bloom at the beginning of April, and has a late ripening time, that begins in the first decade of October. The production is very high, the fruits are

medium size, and kernel weights 1.3 g in average. The shelling is 32% (Vargas et al., 2008).

Mirela was created at the S.C.D.P Constanța by a free selection from a local almond population, being registered in 2016. It's a medium vigor, self-compatible cultivar, fruiting mainly on spurs. It is a medium to late blooming cultivar, starting to bloom at the beginning of April, and has a late ripening, beginning in the second decade of September. The production at maturity is 5060 kg/ha of kernels, with a 49% shelling. The kernels are big (2.5 g). (Gavăt et al., 2015).

Nico was created at the University of Oradea by a crossing between Ferragnes x (Nikitski Pozdno. x Lovrin 18), being registered in 2006. It is a medium vigor tree, self-incompatible, fruiting mainly on long branches. It is a medium blooming cultivar, starting to bloom at the half-end of March, and has a medium ripening that begins in the middle of August. The production at maturity is 2337 kg/ha in shell, the fruits are medium-big size (4.4 g). The kernel production is around 930 kg/ha, with a total 35.5% of shelling (Șcheau, 2013).

Supernova was created at ISF Roma and has been registered in 1988. It is a medium vigor tree and self-fertile. It is a late blooming cultivar, starting to bloom in the first days of April, and has a medium-late ripening time, that begins in the last decade of September. The production is very high, the fruits are big in size (6.4 g), and kernel weights 2 g in average. The shelling is 33%.

Vairo was created at IRTA Catalunia by a crossing between ('Primorskij' × 'Cristomorto') × Lauranne, being registered in 2008. It is a high vigor tree, self-fertile, fruiting mainly on spurs. It is a late to very late blooming cultivar, starting to bloom at the beginning of April, and has a medium ripening time, that begins in the last decade of August. The production is very high, the fruits are medium size, and kernel weights 1.2 g in average. The shelling is 29% (Vargas et al., 2008).

In order to characterize the flower buds development and blooming period of the cultivars studied, the growth stages from the BBCH scale of stone fruits (Meier et al., 1994) has been considered. The scale is compound by a code formed from numbers and the description of the code, as is present it next.

Principal growth stage 5: Inflorescence emergence.

51 - Inflorescence buds swelling: buds closed, light brown scales visible (Figure 1 A).

53 - Bud burst: scales separated, light green bud sections visible (Figure 1 B).

54 - Inflorescence enclosed by light green scales, if such scales are formed (not all cultivars).

55 - Single flower buds visible (still closed) borne on short stalks, green scales slightly open (Figure 1 C).

56 - Flower pedicel elongating; sepals closed; single flowers separating (Figure 1 D).

57 - Sepals open: petal tips visible; single flowers with white or pink petals (still closed) (Figure 1 E).

59 - Most flowers with petals forming a hollow ball (Figure 1 F).

Principal growth stage 6: Flowering.

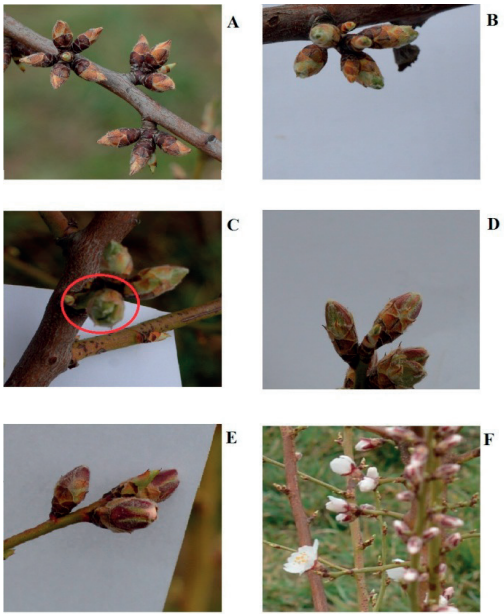

Figure 1. Principal growth stage 5: Inflorescence emergence

60 - First flowers open (Figure 2 G).

61 - Beginning of flowering: about 10% of flowers open.

62 - About 20% of flowers open.

63 - About 30% of flowers open.

64 - About 40% of flowers open.

65 - Full flowering: at least 50% of flowers open, first petals falling (Figure 2 H).
67 - Flowers fading: majority of petals fallen (Figure 2 I).
69 - End of flowering: all petals fallen (Figure 2 J).

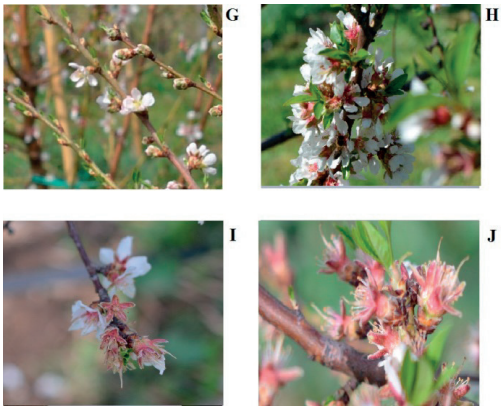

Figure 2. Principal growth stage 6: Flowering

In general, twice a week field visual assessments have been done. The observations started on 28th of February and lasted until 28th of April in 2021 and from 17th of February to 21th of April in 2022.
To characterise each cultivar, the UPOV terminology was considered, based on the guidelines for the conduct of tests for distinctness, uniformity and stability for almond.

RESULTS AND DISCUSSIONS

The almond is the first species of the genus *Prunus* to bloom (Segura et al., 2017). Due to the European breeding programs, in the last decades, many cultivars with late and very late blooming time have been created. In Romania, very late blooming time cultivars, bloom later than the apricot and close, in time, to the peach. In figure 1 are presented as thumbnails the stages of the principal growth stage 5, the inflorescence emergence. The development of flower buds is correlated with the growing degree hours and the evolution of temperatures. In the present study, inflorescence emergence lasted between 28 days (April & Nico) and 40 days (Lauranne and Marinada), in 2021, and between 33 days (Nico) and 44 days (Lauranne & Marinada) in 2022.

In Figure 2 can be observed as thumbnails the stages of the principal growth stage 6, the flowering. The flowering stage is influenced by the climatic and geographic conditions. In the present study it lasted between 17 days (April & Nico) and 23 days (Vairo), in 2021, and between 16 days (Ana, Nico & Vairo) and 20 days (Lauranne and Marinada) in 2022.
The most critical period for the almond crop is the flowering. The cultivars studied have a big diversity regarding the flowering period. In table 1 have been summarised the stages 60 - First flowers open (Figure 2 G) and 65 - Full flowering, at least 50% of flowers open, first petals falling (Figure 2 H). During this stages, the almond crop is the most sensible to spring frosts. How early this stages are attained and how fast or slowly from the stage 60 to 65 the almonds go through, shows a cultivar possibility to be affected by spring frosts or not. The cultivar first to open the flowers was Nico, in both years of study. On 18th of March in 2021 and on 25th of March in 2022. Nico has attained the full flowering on 2nd April, in 2021 respectively 29th March in 2022. It followed April cultivar on 2nd of April in 2021 and 29th March in 2022 reaching the full flowering on 5th April, in 2021 respectively 1st March in 2022.
The cultivars that had the most belated flowering were Lauranne and Marinada. Both open the first flowers on 9th April in 2021 and 1st of April in 2022, reaching the full flowering on 20th of April in 2021 and 9th of April in 2022.

Table 1. The flowering stage. The stages first flowers open and full flowering

Year	2021	2021	2022	2022
Cultivar / Stage	60	65	60	65
Ana	02-Apr	13-Apr	01-Apr	06-Apr
April	02-Apr	05-Apr	29-Mar	01-Apr
Lauranne	09-Apr	20-Apr	01-Apr	09-Apr
Marinada	09-Apr	20-Apr	01-Apr	09-Apr
Mirela	02-Apr	09-Apr	29-Mar	01-Apr
Nico	18-Mar	02-Apr	25-Mar	29-Mar
Supernova	02-Apr	09-Apr	01-Apr	06-Apr
Vairo	05-Apr	13-Apr	01-Apr	06-Apr

The evolution of the growth stages studied for the year 2021 can be observed in Figure 3. The cultivars with a medium and medium to late flowering, Nico and April, present also a shorter period of floral bud development. And cultivars with very late flowering like Marinada, Lauranne and Vairo, had a longer period for floral bud development.

The inflorescence emergence lasted 28 days for Nico and April, from 28th of February until 28th of March. 33 days for Ana, Mirela and Supernova from 28th of February until 2nd of April. 36 days for Vairo from 28th of February until 5th of April. 40 days for Lauranne and Marinada from 28th of February until 9th of April. The flowering lasted 17 days for Nico and April, from 28th of March until 13th of April. 18 days for Ana, Mirela and Supernova from 2nd of April until 20th of April. 23 days for Vairo from 5th of April until 28th of April. 20 days for Lauranne and Marinada from 9th of April until 28th of April.

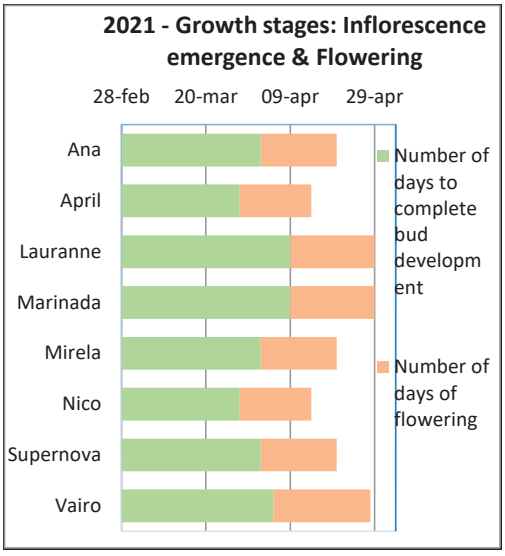

Figure 3. The evolution of the phonological stages of inflorescence emergence and flowering in 2021

In Figure 4 is presented as the evolution of the stages studied, for the year 2022. The cultivars April and Nico, as in the year of study 2021, this cultivars had a shorter period of floral bud development. Cultivars with a very late flowering like Marinada, Lauranne, also had a longer period for floral bud development in 2022.

In 2022 the inflorescence bud development for Nico lasted 33 days, from 17th of February until 21th of March. 37 days for April and Mirela, from 17th of February until 25th of March. 41 days for Vairo, Supernova and Ana, from 17th of February until 29th of March. 44 days for Lauranne and Marinada from 17th of February until 1st of April. The flowering lasted 16 days for Nico, Ana and Vairo. 17 days for April and Mirela. 18 days for Supernova. 20 days for Lauranne and Marinada.

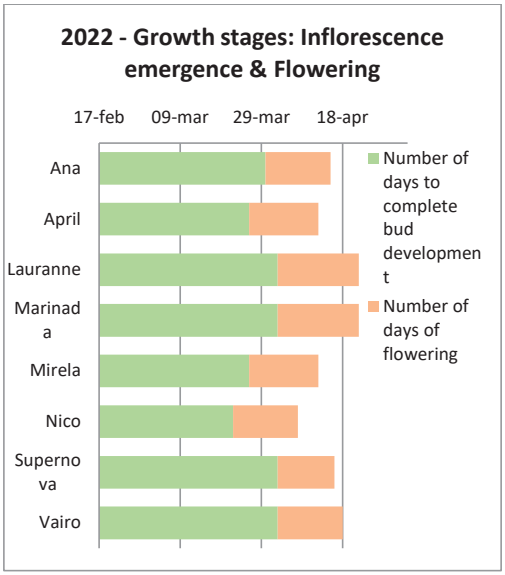

Figure 4. The evolution of the phonological stages of inflorescence emergence and flowering in 2022

In average, the number of days of flowering were 17 for Ana and April, 17.5 for Mirela, 16.5 for Nico, 16 for Supernova, 19.5 for Vairo and 20 for Lauranne and Marinada,.

In average for the years of study, the number of days to complete both stages were, 47 days for Nico, 49.5 days for April, 52.5 days for Mirela, 54 days for Ana, 55 days for Supernova, 59.5 days for Vairo and 62 day for Lauranne and Marinada.

CONCLUSIONS

Nico cultivar presents a medium time of beginning of flowering. April presents a medium to late time of beginning of flowering. Ana, Mirela and Supernova have a late time of beginning of flowering. Vairo, Lauranne and

Marinada have a late to very late time of beginning of flowering.

Nico and Supernova had the shortest period of flowering, while Lauranne and Marinada, the longest period.

To avoid the late spring frosts it is recommended to establish new plantations with cultivars that have a very late or late to very late time of beginning of flowering, and with a long period of flowering for a better pollination.

With the latest developed cultivars that bloom very late or late to very late, the spring frosts can be avoided. While this problem for the almond crop can be solved by a careful selection of cultivars, a new one had arisen. In the present experiment, the apple blossom beetle (*Epicometis hirta* Poda) became active and was very attracted by the flowers of Lauranne, Marinada and Vairo, while they were the only cultivars that had the flowers still open. This can become a new challenge for the farmers, knowing that insecticides are not recommended to be used when the almonds are in bloom.

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