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The influence of climate on the phenological development of nectarine cultivars in the Plovdiv region

Sashka Savchovska

Agricultural Academy, Institute of Fruit Growing – Plovdiv, 4000 Plovdiv, Bulgaria
Corresponding author: kirilova.savchovska93@abv.bg

Abstract

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This paper presents the results of tracking the growing season over the last five years (2020–2024) in nectarine cultivars. The study was conducted on the territory of the Institute of Fruit Growing-Plovdiv, and the subjects were six nectarine cultivars with different fruit ripening periods. The very early ripening cultivars Adriana and Gergana (25–30 June), the early cultivar Big Top (15–20 July), followed by Independence (25–30 July), and the two late ripening cultivars Goldengrand (20–25 August) and Mossiani 90 (20–25 September). In the first year, bud swelling phenophase was recorded between 14 and 18 February. In the following two years, 2021–2022, the same phenophase was detected in early March. In 2023, the onset of vegetation was from 24 to 27 February, and in the last year of the study bud swelling occurred from 19 to 20 February. The average duration of flowering from onset to petal fall was 8 days in Adriana, Gergana, Big Top and Independence. The other two late-maturing cultivars, Goldengrand and Morsiani 90, had an average flowering duration of 9 days. The average duration of the entire growing season is 243 to 261 days.

Keywords: climate; nectarines; vegetation; phenology; flowering; buds

Introduction

Climatic conditions are changing more and more dynamically and increasing their impact on agriculture. From a report by the Intergovernmental Panel on Climate Change (IPCC), an increase of 1.1–6.0 C° is expected for the global mean surface temperature (Change, 2007). In different parts of Europe, temperature increases and precipitation amounts vary from region to region (Olesen et al., 2011). The changing climate in northern Europe may lead to the introduction of new crops, while in southern Europe the situation is becoming more serious. Rising temperatures and lack of water may lead to the death of entire species (Reidsma et al., 2010). The worst affected countries appear to be Hungary, Serbia, Bulgaria and Romania. Heat waves and rainless seasons make it difficult to grow crops (Olesen et al., 2011). In fruit cultivation, lack of water leads to lower productivity and also accelerates ripening (Moretti et al., 2010). Both low and high temperatures are required for normal development and progression of key phases in plants (Penfield, 2008). Excessively high temperatures in turn block physiological, biochemical and morphological processes in plants, and can lead to growth inhibition, yield reduction or complete plant death (Wahid et al., 2007; Hasanuzzaman et al., 2013). The phenological development of fruit species is mainly determined by the temperature, when temperatures increase, the entire growing season is prolonged (Chmielewski et al., 2004). Very high temperatures during flowering phenophase reduce the period available for pollination (Haokip et al., 2020). Peach (*Prunus persica* L.) Batsch is grown in temperate climates and ranks third in the world after apple and pear (Bassi et al., 2016). It needs an accumulation of low positive temperatures for normal development and fruiting (Campoy et al., 2011). Li et al. (2013) found that the flowering date

in peach occurs earlier, while dormancy is delayed, which extends the growing season. Through phenological observations, we can track not only plant development, but also the rise in temperatures, thus we can also predict changes in crop growth (Vanalli et al. 2021). The aim of the present study is to follow the growing season in nectarines and to identify changes under the influence of climatic conditions for the Plovdiv region.

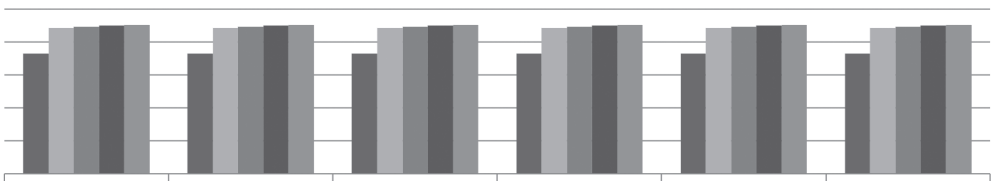
Material and Methods

The study was conducted during the period 2020 – 2024, on the territory of the Fruit Growing Institute – Plovdiv in a collection plantation. The trees were in full fruit production and were planted at a spacing of 5 m between rows and 3 m within rows. Six nectarine cultivars with different ripening dates were observed. The two cultivars Adriana and Gergana, ripened between 25–30 June, the Big Top cultivar ripened between 20–25 July, followed by Independence 25–30 July and the two late ripening cultivars Goldengrand (20–25 August) and Mossiani 90 (20–25 September). Annual phenological observations were made, the different phenological phases were determined using the BBCH scale, from bud swelling to leaf fall (Baggiolini, 1980). Monthly average temperatures from the time of dormancy to the beginning of vegetation were recorded. The duration of flowering in days as well as the duration of the entire growing season was recorded.

Results and Discussion

For normal development, temperate trees need low positive temperatures during dormancy for the growing season to proceed normally. Of course, the requirements differ from cultivar to cultivar because they differ in their genotypes.

In 2020, phenological development (BBCH 51 – bud swelling) started in February, with the earliest occurrence was recorded on 14 February in the cultivar Morssiani 90 (Fig. 1). On 15 February the same phase occurred in Big Top, and on 16 February the buds of Gergana, Independence and Goldengrand swelled. The latest this phase was recorded was in the cultivar Adriana on 18 February. Average temperatures for the first three months of 2020 are high compared with those of the next two years (Table 1). In the first year of the study, the beginning of flowering was first recorded in the cultivar Morssiani 90 on 11 March (Fig. 2). On 13 and 14 March the same phase was found in the Big Top and Independence cultivars. For Gergana and Goldengrand on the



	Gergana	Adriana	Big top	Independence	Goldengrand	Morsiani 90
2020 BBCH - 51	16-Feb	18-Feb	15-Feb	16-Feb	16-Feb	14-Feb
2021 BBCH - 51	8-Mar	5-Mar	1-Mar	4-Mar	4-Mar	1-Mar
2022 BBCH - 51	4-Mar	6-Mar	5-Mar	6-Mar	4-Mar	4-Mar
2023 BBCH - 51	24-Feb	27-Feb	24-Feb	24-Feb	24-Feb	27-Feb
2024 BBCH - 51	20-Feb	20-Feb	20-Feb	20-Feb	20-Feb	19-Feb

Fig. 1. Budbreak dates for the period 2020–2024
Source: Author' own elaboration

Table 1. Average monthly temperatures by year

Year	Month			Year	Month		
	October	November	December		January	February	March
2019	14.6 C°	11.4 C°	4.5 C°	2020	3.2 C°	6.7 C°	9.2 C°
2020	15.7 C°	6.7 C°	5.5 C°	2021	2.7 C°	5.9 C°	3.6 C°
2021	12 C°	8.2 C°	4.2 C°	2022	3.6 C°	5.4 C°	5.8 C°
2022	14.4 C°	9.4 C°	5.7 C°	2023	5.6 C°	6.1 C°	8.7 C°
2023	16.2 C°	9.2 C°	4.7 C°	2024	3.2 C°	9.1 C°	13.9 C°

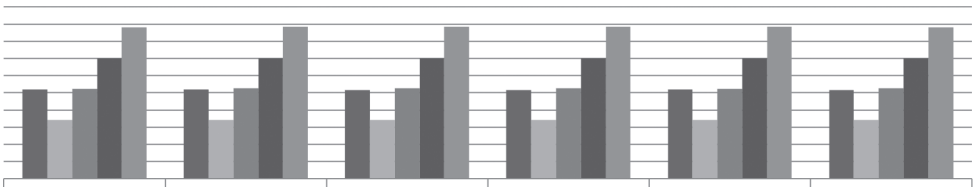
Source: Author' own elaboration

16th, and the latest this phase occurred in the cultivar Adriana. This year, on average, 29 days elapsed from budbreak to the beginning of flowering. The average duration of flowering from the beginning to petal fall is longest in Adriana – 11 days, and shortest in Big Top – 8 days (Table 2). Flowering lasted nine days for Goldengrand, Independence and Morsiani 90, and 10 days for Gergana (Fig. 3). This year, the duration of the entire growing season ranged from 256 days for Adriana to 272 days for Morssiani 90 (Table 3).

In the second and third year of the study, the bud swelling phase (BBCH 51) occurred in early March. In the first months of 2021, January and February, temperatures were lower than in the previous year, which was also responsible for the later bud swelling (Fig. 1). The trees have satisfied the requirements for low positive temperatures, but, due to the lack of high spring temperatures, cannot emerge from forced dormancy. The first buds swelled on the Big Top cultivar on 1 March and the last on the Gergana cultivar on 8 March. This year the beginning of flowering occurred on 30 and 31 March (Fig. 2). It took 28 days from budbreak to the beginning of flowering. The flowering period ranged from 10 days for Big Top and Morssiani 90 to 8 days for Gergana and Independence. The cultivars Adriana and Goldengrand had an intermediate flowering time of 9 days (Table 2, Fig. 3). The growing season this year ranged from 238 days in the early-maturing cultivar Adriana to 259 days in the two late-maturing cultivars Goldengrand and Morssiani 90 (Table 3). The difference in the duration of the entire growing season was 13 to 18 days shorter than the previous year.

Average temperatures in the early months of 2022 are similar to those of the previous year for this and early growing seasons coincide (Table 1). Budbreak occurred between 4 and 6 March for all cultivars studied (Fig. 1). As a result of the high temperatures, the average period from this stage to the start of flowering was 26 days. Accordingly, it occurred at almost the same time in all six cultivars observed. The duration of flowering this year was 7 to 9 days (Table 2). The duration of the growing season was similar to that of the previous year and falls within the range 236 days to 259 days.

In the last months of 2022, temperatures allow for faster satisfaction of the genotypic requirements of the cultivars, and in the first months of 2023, spring temperatures favor a faster onset of vegetation. Thus, this year, the BBCH 51 phase occurred between 24 and 27 February (Fig. 1). The earliest flowering was recorded for the Morssiani 90 cultivar on 15 March, and on 16 and 17 March for both Goldengrand and



	Gergana	Adriana	Big top	Independence	Goldengrand	Morsiani 90
2020 BBCH 61-62	16-Mar	17-Mar	13-Mar	14-Mar	16-Mar	11-Mar
2021 BBCH 61-62	1-Apr	30-Mar	31-Mar	31-Mar	30-Mar	31-Mar
2022 BBCH 61-62	29-Mar	30-Mar	31-Mar	31-Mar	29-Mar	30-Mar
2023 BBCH 61-62	19-Mar	19-Mar	17-Mar	19-Mar	16-Mar	15-Mar
2024 BBCH 61-62	14-Mar	17-Mar	18-Mar	17-Mar	17-Mar	15-Mar

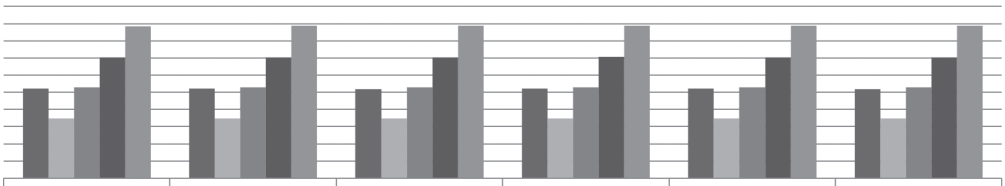
Fig. 2. Start of flowering dates for the period 2020–2024

Source: Author' own elaboration

Table 2. Average flowering duration over the years and average over the period

Cultivor	Average duration of flowering					Average for the period
	2020	2021	2022	2023	2024	
Gergana	10	8	9	5	7	8
Adriana	11	9	8	6	8	8
Big top	8	10	7	7	9	8
Independence	9	8	8	6	9	8
Goldengrand	9	9	8	8	10	9
Morsiani 90	9	10	7	8	10	9

Source: Author' own elaboration



	Gergana	Adriana	Big top	Independence	Goldengrand	Morsiani 90
2020 BBCH 67	26-Mar	27-Mar	20-Mar	22-Mar	25-Mar	20-Mar
2021 BBCH 67	7-Apr	7-Apr	9-Apr	7-Apr	7-Apr	9-Apr
2022 BBCH 67	6-Apr	6-Apr	5-Apr	7-Apr	5-Apr	5-Apr
2023 BBCH 67	23-Mar	24-Mar	23-Mar	25-Mar	23-Mar	23-Mar
2024 BBCH 67	20-Mar	24-Mar	26-Mar	25-Mar	26-Mar	24-Mar

Fig. 3. Petal fall dates for the period 2020–2024
Source: Author' own elaboration

Table 3. Average length of growing season by year and average over the period

Cultivar	Duration of vegetation in days					Average for the period
	2020	2021	2022	2023	2024	
Gergana	259	234	237	241	245	243
Adriana	256	238	236	240	244	243
Big top	268	243	243	250	248	250
Independence	261	243	247	253	250	251
Goldengrand	266	259	259	264	249	259
Morsiani 90	272	259	259	259	260	262

Source: Author' own elaboration

Big Top (Fig. 2). The same phase was recorded for the cultivars Gergana, Adriana and Independence on 19 March. The average period between the two phases of bud swelling and the start of flowering was the shortest observed during the study period at only 21 days. In this year, the average flowering period was the shortest, lasting only 5 days in the case of the cultivar Gergana (Table 2). In Adriana and Independence flowering lasted 6 days and in Big Top 7 days. Only the two late ripening cultivars Goldengrand and Morsiani 90 had a flowering period of 8 days. This year the growing season was up to 5–6 days longer than the previous year. The shortest was again 240 days for the early variety Adriana and the longest 264 days for the variety Goldengrand (Table 3).

In 2024, budbreak was at the same time in almost all observed cultivars on 20 February, the only exception being the cultivar Morsiani 90 on 19 February (Fig. 1). On average, 26 days elapsed between this stage and the onset of flowering, with flowering starting from 14 to 18 March (Fig. 2). This year, the average temperatures for February and March are the highest (Table 1). The shortest flowering time is in Gergana and the longest in Goldengrand and Morissani 90. The intermediate position is occupied by Adriana with 8 days and Big Top, and Independence with a duration of 9 days. The length of the growing season this year ranges from 244 days for Adriana to 260 days for Morssiani 90 (Table 3).

With the data thus obtained, the average flowering duration for the entire study period was 8 days for the cultivars Adriana, Gergan, Big Top and Independence, which ripen from late June to late July. The two late-maturing varieties, Goldengrand and Morsiani 90, had an average flowering period of 9 days.

The two early maturing cultivars Adriana and Gergana had the lowest average duration of the entire growing season in the study, 243 days, while the late maturing cultivar Morsiani 90 had the longest, 262 days. With a difference of one day between them are the two varieties Big Top – 250 days and Independence 251 days. The average length of vegetation for Goldengrand is 259 days.

Conclusions

The rapid satisfaction of cooling requirements and the rapid warming in spring lead to an earlier start of vegetation. Rising temperatures shorten the period from bud swelling to

the start of flowering. The early start of vegetation and the prolonged warm weather until late autumn extend the entire growing season. However, early-maturing cultivars have a shorter growing season than late-maturing cultivars. The smallest average length of the entire growing season in the study was for the two early maturing cultivars Adriana and Gergana – 243 days, and the longest was for the late maturing cultivar Morsiani 90 – 262 days. During the study period, the earliest vegetation started in 2020, then the duration of the whole vegetation period was the longest. The average flowering duration for the whole study period was 8 days for the cultivars Adriana, Gergana, Big Top and Independence. In the two late maturing cultivars Goldengrand and Morssiani 90 the average flowering duration was 9 days. The prolonged warming of the weather may compromise the plants' dormancy, which will affect flowering and fruiting.

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