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INFLUENCE OF CLIMATIC FACTORS ON THE PHENOLOGICAL AND REPRODUCTIVE MANIFESTATIONS OF INTRODUCED APPLE CULTIVARS IN THE REGION OF TROYAN, BULGARY

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Abstract

The main phenological and biological features of the introduced apple cultivars were studied, for the period 2019-2021 in the region of Troyan. In order to establish their influence on the phenological manifestations of apple cultivars in order to be able to recommend them for cultivation from a practical point of view. It was found that in 2021 flowering was abundant and occurred 5-8 days later than the previous year. The latest date for the end of flowering was registered for the "Reanda" cultivar on May 12. The period from the beginning of flowering to its end is about 15-17 days. The fruits of the observed apple cultivars ripened in the period from mid-September to the first 10 days of October. The fruits of 'Remo' and 'Revena' reached the earliest stage of ripening, and 'Granny Smith' was the latest.

Key words*: Troyan region, climatic conditions, apple, cultivar, phenology.*

INTRODUCTION

The main ecological force of the phenology of fruit species in the temperate climate zone is temperature. Temperature increases because of global warming clearly have an impact. Nevertheless, predicting the effects of temperature fluctuations on tree phenology is challenging because the relationship between specific dormancy temperatures and blossoming time remains unclear. After a period of low temperatures, in order to overcome winter dormancy, buds require warm weather, which will trigger their growth (Fadón et al., 2021).

Kalvane et al. (2021) found that the blossoming and ripening period in apples are genetically determined to occur almost simultaneously: in the last week of May, in an interval of 4-5 days.

Koutinas (2010) presented new information on apple and cherry trees over the last 20-30 years, on factors and conditions that affect the flower bud formation and reproductive organ quality, paying attention to agronomics, particularly summer pruning, fertilizing, irrigation and treatment with growth regulators, through which the processes of flower bud formation can be regulated.

As a consequence of rising spring temperatures, apple blossoming in Europe has occurred significantly earlier over the last thirty to forty years with an average advance of 2-3 days per decade (Unterberger et al., 2018; Vitasse et al., 2018). Grauslund (1996) determined the blossoming dates of apple cultivars over a ten-year period (1985-94) and found that the beginning of flowering occurred about 1 month apart over the period, and the phenophase length varied from 16 to 37 days.

The long-term selection program of Dresden-Pilnitz apples are recognized and established cultivars resistant to economically important diseases and to critical changes in the conditions of climatic factors. Characteristics determining the influence of abiotic factors, for different ripening periods and the direction of use of the fruit production of these cultivars are combined (Fischer & Fischer, 2002).

To expand the assortment of apple cultivars for the Troyan region, trees of scab-resistant cultivars of the Re series and low susceptibility to powdery mildew of the Pi series were imported from Germany 20 years ago, which were selected in the Institute in Dresden-Pillnitz (Peil et al., 2004).

At this stage of their cultivation in the conditions of the Troyan region have been established their growth and reproductive manifestations, biological and economic

significance, suitability for cultivation in the conditions of the region and the actual resistance to diseases (Dinkova et al., 2009; Stefanova et al., 2016). Correct identification of phenological stages in plants is very important for cultivar characterization, crop management, as well as disease and enemy management Martínez et al. (2019).

The analyzes on the phenology of development and the phenophases during the vegetation are the main key element for establishing the suitability of a given cultivar to the local agroecological conditions, in particular the climatic ones, such as temperature, precipitation, air humidity. In combination with the applied agricultural techniques, stable yields and quality of the fruit production can be guaranteed. Given the need for constant changes in the structure of the apple assortment and the fact that climate conditions have a significant impact on the yield and quality of fruits, the objective of the present study is to determine and describe the agroecological conditions of the Troyan region and their impact on the phenological performances of some apple cultivars, so that they can be recommended for cultivation from a practical point of view.

MATERIALS AND METHODS

Materials

The main phenological and biological features of the introduced apple cultivars were studied: 'Melrose', 'Reanda', Revena, Retina, Pilot, Topaz, Jonathan and Granny Smith, grafted on the rootstock MM 106, whereas Pingo, Remo, Reglindis, Idared, Grafenstein and Roseneisenapfel were on a seedling rootstock. The planting scheme is 5x4m. They are cultivated according to the generally accepted technology in RIMSA in Troyan, under nonirrigated conditions, without plant protection. The row-spacing are covered by grass.

Methods

The phenophases of flowering and fruit ripening were studied, according to the generally accepted methodology for studying plant resources in fruit plants (Nedev et al., 1979). The plot was periodically visited to observe each of the identified stages.

Experimental site

Climate factors for the study period (2019-2021) were compared with a 20-year base period. The factors were measured in a weather station on the territory of RIMSA Troyan. The climate is moderately continental with mild and warm winters and dry, not hot summers. The altitude is 420 m.

Indicators

Phenology flowering and ripening periods of cultivars

Reproductive - yield per a tree (kg)

RESULTS AND DISCUSSIONS

Temperatures (°C) in March was higher by over 1°C in 2019 and 2020 than the base (6.1°C), and by 2.5°C lower in 2021 (3.6°C). In April, the trend is reversed as in 2019 the average monthly temperature was higher (10.2°C), whereas in 2021 and 2020 it was 1.3°C less than the base (10.7°C). The base average temperature in May was 15.3°C, as in 2021 it was the same, whereas in 2020 and 2019 it was 14.7°C, which was 0.6°C less (Table 1). Precipitation in the spring months of March, April, May was less than the base period (norm), except for April 2019, when it was 109 mm. The months of blossoming (end of March, April) had a lower average monthly temperature in 2021, compared to the previous 2 years. This strongly affects the blossoming periods of the studied apple cultivars by delaying it. The best precipitation amount was reported for the fruit ripening processes in 2020 in every summer month, incl. July, August and September, but the quantities were significantly smaller compared to the base 20 year period. The temperature values are the same as the base period, as in 2019 the same phenomena were reported, whereas the summer months in 2021 were with 2°C warmer than the average and there were extremely low amounts of precipitation (respectively 12; 56; 12 mm for July, August and September), and already in June the rainfall was only 64 mm, compared to 120 mm for the base period (Table 1).

Table 1. Climate factors (2019-2021) and average 20-year base period (2001-2020)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2001-2020 precipitation (mm)	45.2	46.0	62.6	69.3	106.8	120.4	109.1	67.2	79.7	70.9	33.1	51.0
2021	82.8	25.6	47.7	57.0	82.8	64.8	12.4	56.2	11.8	72.8	14.4	68.6
2020	15.4	66.2	53.4	24.4	63.8	129.0	75.4	56.4	33.6	114.2	20.4	27.4
2019	40.4	55.2	16.5	106.9	82.4	234.6	106.7	37.7	21.9	16.2	29.6	16.8
2001-2020 T (°C)	-0.3	2.2	6.1	10.7	15.3	18.7	20.7	20.9	15.9	11.0	6.4	2.1
2021 T°C	1.6	3.7	3.6	9.4	15.4	18.9	22.7	22.7	16.2	8.7	7.5	2.6
2020 T°C	0.4	4.4	7.1	9.4	14.7	17.8	20.4	21.1	17.8	12.7	5.2	3.8
2019	-0.4	2.5	7.5	10.2	14.8	19.9	20.2	20.4	16.2	13.5	8.5	3.2

For the conditions of the warmer spring in 2019, the earliest start of blossoming period was registered in 'Grafenstein' cv. (March 29), followed by 'Remo' and 'Reglindis' (April 1), as 'Melrose' cv. registered the latest star of blossoming (11.04) (Figure 1). The same year was registered the longest flowering blossoming from 16 days for 'Ravena' to 25 days for 'Melrose' and 'Pingo'. Throughout the month of April 2019, the average daily temperatures were from 8.5°C to 12.2°C with moderate rainfall, allowing the maintenance of favorable conditions for prolonged blossoming.

In 2020, blossoming was weak. It started on 15.04 for 'Reglindis', as this date was preceded by 5 consecutive days with temperatures above 10°C. Several days with low temperatures followed, and by 25.04 the lastest blossoming began for 'Melrose' and 'Remo' cultivars were the cultivars, which started their blossoming.

For the conditions of 2021, blossoming was abundant and took place 5-8 days later than the previous year. It started on 14.04 for 'Grafenstein', the last blossoming started for 'Melrose' 29.04, 'Granny Smith' and 'Revena' 28.04 (Figure 1). The latest date for the end of blossoming was registered for 'Reanda' cultivar on 12.05. Similar occurrences and timing were reported in 2015 by Stefanova et al. (2016) for the same cultivars. Kalvane et al. (2021) has been found that in recent decades the full blossoming of apple trees is earlier, i.e. for the sub-period (1959-1967) full blossoming occurred on May 28 (148th day of the year), and in 2002–2019 even earlier on May 21 (142 th day of the year).

From one year to the next, the order in which budding occurred is preserved, but the period of development changes depending on environmental factors, location, habitat, etc. (Cosmulescu et al., 2022). Gheorghiu & Cosmulescu (2022), determine that in depending on climatic conditions, the duration between phenophases differs by year, from the flowering stages of BBCH 60 "first open flowers" to BBCH 69 "end of flowering: all fallen petals") have a different duration on average 10 days in 2018 and 2020, 6.7 days in 2019 and 8.3 days in 2021.

For our study the total matching of all cultivars for each year is 6 days, as in 2019 it is in the period from April 06 to April 12, in 2020 from 24.04 to 30.04), in 2021 from 27.04 to 05.05. This is important for their mutual pollination and fertilizing.

'Grafenstein' apple cultivar is distinguished not only as an early bloomer but also as the earliest ripe. Its characteristic is that the fruits do not ripen at the same time. 'Retina', 'Reglindis' and 'Remo' reached ripening stage at the beginning of September, in 2019 even at the end of August. 'Melrose', 'Pilot' and 'Revena' trees ripened at the end of September, in 2021 even at the beginning of October (Figure 2). The harvesting period of individual cultivars is about 5-6 days, after which the fruits remain on the tree for a long time.

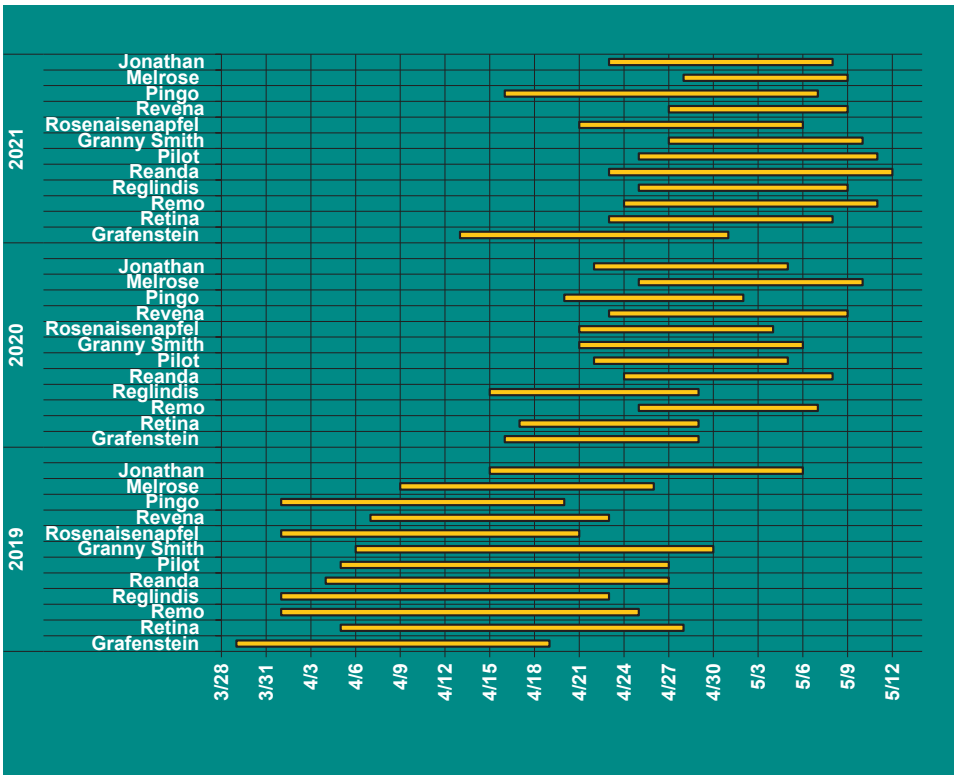

Figure 1. Blossoming phenogram (2019-2021)

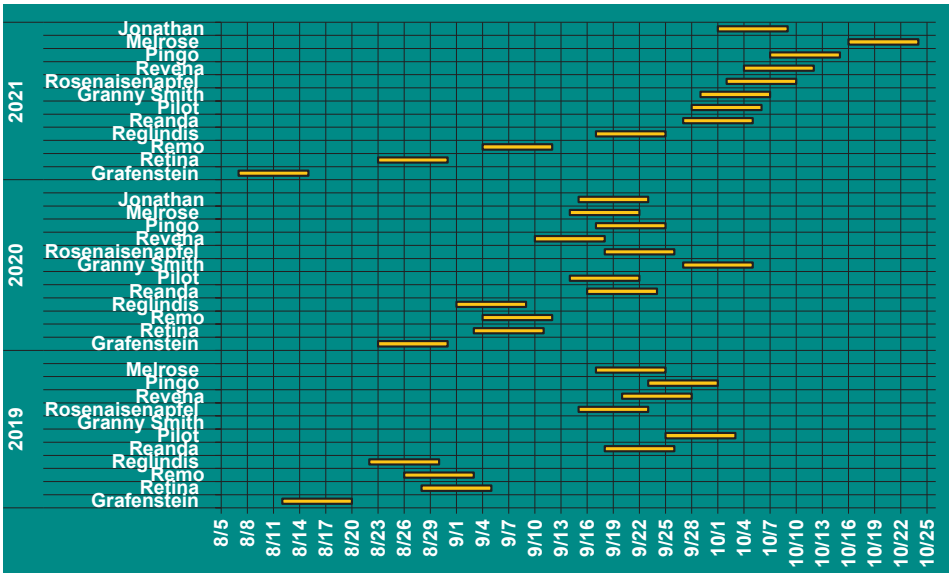

Figure 2. Ripening phenogram (2019-2021)

According to the period of fruit ripening, 'Reglindis' and 'Retina' are autumn cultivars, and Rewena and Topaz are winter. The highest 3-year total yield was obtained from 'Florina'

(75.1 kg/tree) and 'Reglindis' (63.6 kg/tree) trees Dimitrova & Sotirov (2020).

Favorable climatic conditions in 2019 allowed prolonged flowering and good pollination of flowers, retention of a useful knot and formation of the highest yields for the period of the study. The 'Grafenstein', 'Roseneisenapfel' and 'Reglindis' cultivars each having 80-90 kg/tree (Table 2). 'Retina' cultivar has the lowest yields 15-35 kg/tree, followed by 'Pilot' and 'Remo'.

As a result of the weak flowering in 2020, the apple cultivars produced poorly. In the earlier cultivars ('Retina', 'Reglindis', 'Grafenstein') there was no fruiting. The fruits that reached harvesting maturity were mainly from representatives of the winter cultivars, for which during ripening (September, October) sufficient humidity was not provided, precipitation was 35 mm (Table 1). In 2021, climate conditions favoured normal blossoming and the fruit bearing of apple cultivars was abundant. The highest yield for the 'Grafenstein' cv. was recorded (70.0 kg), and the lowest for 'Granny Smith' (7.0 kg). For the rest of the apple cultivars, the yield was relatively high (Table 2). Fruits that reached ripening stage were smaller in size than the average standard fruit for the cultivars studied. The fruits of the early ripening apple cultivars do not ripen together and remain on the tree for almost a month.

'Melrose', 'Pilot', 'Revena' (the latest ripening of the studied group) - ripen in early October (Figure 2), are larger, with a fruit weight > 100 g, and exhibit high drought resistance and the fruits manage to grow (plump) sufficiently.

Table 2. Reproductive parameters of apple cultivars (2019 and 2021)

	Fruit weight (g)		Yield (kg/tree)	
	2019	**2021**	**2019**	**2021**
Remo	112	93±15.10	50	45
Reglindis	100	80±11.22	80	40
Retina	126	69±5.41	35	15
Reanda	133	64±5.77	40	52
Revena	107	114±11.55	55	28
Rosenaisennapfel	150	104±13.04	85	15
Grafenstein	**106**	69±11.81	90	70
Pingo	134	128±15.18	70	55
Pilot	142	110±11.07	50	20
Melrose	156	83±4.28	65	41
Granny Smith	150	106±7.75	50	7
LSD 0,05		*13.66*		
LSD 0,01		*18.22*		
LSD 0,001		*23.81*		

Dinkova et al. (2009) registered the highest yields in 2006, for the initial fruit bearing period 2003-2007, as 'Reanda' and 'Revena' each having 28-30 kg yield per tree. In the present study, after 12 years of cultivation, the yields were significantly higher for these cultivars.

The extent to which plants are affected by changes in temperature and precipitation, their inherent capacity to adapt, will ultimately determine the potential for sustainable ecological stability and food security (Fitchett et al., 2015).

CONCLUSIONS

The studied apple cultivars from Re and Pi groups are suitable for cultivation in the mountaine region of Troyan and are recommended for enriching the assortment.

For each year of the study period, 'Grafenstein' was the earliest to blossom and 'Melrose' was the latest. 'Grafenstein' apple cultivar is distinguished not only as an early bloomer but also as the earliest ripener.

The cultivars 'Retina', 'Reglindis' and 'Remo' reach harvesting maturity at the beginning of September, 'Melrose', 'Pilot', 'Revena' at the

October. The largest are the fruits of the 'Pingo' and 'Pilot' cultivars.

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