

CARACTERISTICILE UNOR SOIURI DE MĂR PRETABILE PENTRU PRODUCȚIA ORGANICĂ

CHARACTERISTICS OF APPLE CULTIVARS SUITABLE FOR ORGANIC PRODUCTION

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Abstract

The study aimed to make a more detailed assessment of ten scab resistant apple cultivars ('Besapara', 'Marlena', 'Gorana', 'Martinika', 'Elegia', 'Siyana', 'Gold Milenium', 'Free Redstar', 'Melfree' and 'Brina') in terms of their requirements for the temperature conditions, flowering, ripening, yield and fruit quality. It was found that the temperature sums ($> 5^{\circ}\text{C}$) from the beginning of vegetation to the beginning of flowering in the studied cultivars varied from 137.2 to 180.9 $^{\circ}\text{C}$, and temperature sums ($>10^{\circ}\text{C}$) from the end of flowering to the fruit ripening varied from 2114.5 to 2662.8 $^{\circ}\text{C}$. The relationship between average daily air temperatures and phenological phases was very strong. All cultivars had high productive potential and produced very good quality fruit.

Cuvinte cheie: suma temperaturilor, înflorire, maturare, producție, calitate fruct.

Key words: temperature sums, flowering, ripening, yield, fruit quality.

1. Introduction

The apple (*Malus × domestica* Borkh.) is one of the main fruit species and occupies one of the first places in terms of area and fruit production in the world. Its fruits contain valuable nutrients and rank among the best fruit foods. People's desire to consume safe foods requires a reduction in the use of pesticides in agriculture. Resistance to the main fungal diseases (*Venturia inaequalis* Cke. Wint.) and (*Podosphaera leucotricha* (Ellis et Everh.) Salm) cultivars are an alternative solution for obtaining ecologically clean fruits (Godec, 2004; Ikase & Dumbravs, 2004). That is why, in the modern breeding programs, in addition to improving fruit quality, high productivity and lower tree growth, great emphasis is placed on the resistance of cultivars to diseases, and if possible, to insects (Laurens, 1999; Farooqui et al., 2014; Wicklund et al., 2021; Mamalova, 2021). Resistant cultivars lead to a reduction in plant protection costs and, ultimately, the economic efficiency of apple plantations is higher (Kairova et al., 2023). In European Union countries, apple cultivars that are resistant or partially resistant to apple scab are preferred (Czynczyk et al., 2008). Thus, for example, in Poland, which is the largest producer of apples, in recent years 'Rubinola', 'Topaz', 'Novamac', 'Sawa', 'Freedom' and 'Gold Milenium', which are resistant to this disease, have been most widely grown cultivars (Niemczyk, 2000).

This study aimed to make a more detailed characterization of ten scab-resistant apple cultivars, in terms of phenology, tree productivity, and fruit quality about changing climatic conditions.

2. Material and methods

The study was conducted in a collection plantation of the Institute of Agriculture - Kyustendil (Western Bulgaria) during the period 2018-2021. The object of research was the scab-resistant Bulgarian apple cultivars 'Besapara', 'Marlena', 'Gorana', 'Martinika', 'Elegia', and 'Siyana', created in the same Institute, approved as new cultivars in 2010 and 2015, as well as the Polish cultivars 'Gold Milenium', 'Free Redstar' and 'Melfree' and the Italian cultivar 'Brina'. The trees were grafted onto 'MM 106' rootstock and were formed into free-growing crowns, with a well-developed central stem. 'Golden Delicious' cv. were used for the control. The experimental plantation was created in the spring of 2013 at a planting scheme of 4.5 × 2.5 m, on a Leached cinnamon forest, slightly sandy-clay soil with a neutral reaction. The soil surface between the rows was maintained by regular mowing of the grass, which was left for mulch, and in the rows stripes it was treated once with a total foliar herbicide. Each cultivar was represented by five trees on which the necessary observations and measurements were carried out, and each of them was counted as a replicate in connection with the statistical processing of the collected data.

The phenological phases were evaluated annually according to the BBCH scale (Meier, 2001) - beginning of flowering (BBCH 61), full flowering (BBCH 65), end of flowering (BBCH 75), and fruit ripening (BBCH 87). The temperature sums for the occurrence of the different phases and the number of days with a temperature above 5 and 10 $^{\circ}\text{C}$ for which the respective degrees were accumulated were also calculated.

The yield from each tree (kg) was recorded and the fruits were divided into classes according to their diameter, respectively in class Extra (>65 mm), class I (55-65 mm), and class II (50-55 mm), according to Regulation № 108/12.09.2006 for the quality requirements of fresh fruit in Bulgaria.

Analysis of variance (ANOVA) and Duncan's test at $p \leq 0.05$ were used for statistical processing of data on the yield and biometric parameters of the fruits.

3. Results and discussions

From the phenological observations during the research period, it was found that apple cultivars bloom at different times in different years depending on the weather conditions and especially on the average daily air temperatures in the January-April period. To calculate the temperature sums from the beginning of vegetation to the beginning of flowering, only the days with an average daily air temperature above 5°C were taken, and the number of days for accumulation of these degrees was also determined.

The number of days from the beginning of vegetation to the beginning of flowering in the studied cultivars varied from 22 days ('Besapara') to 27 days ('Marlena') when gaining a temperature sum above 5°C from 137.2 to 180.9°C (Table 1).

In 2019, the earliest warming of the air was recorded, which led to the accumulation of the necessary temperature sum for the start of flowering. The beginning of flowering (10% open flowers or BBCH 61) occurred the earliest in 'Gold Milenium' trees - on April 8, and three to five days later in 'Gorana', 'Free Redstar', and 'Siyana'. The trees of 'Elegia' started to bloom the latest - on April 18. In the other three years, flowering started significantly later, which was due to lower air temperatures.

Averaged over the 4-year studied period, 'Elegia' started flowering at the latest, at the same time as 'Golden Delicious', followed by 'Brina', 'Marlena', 'Martinika' and 'Melfree' (Fig. 1). This gives them a certain advantage over other cultivars for growing in the conditions of the Kyustendil region (Western Bulgaria), where late spring frosts are a frequent phenomenon and cause significant damage to apple production.

'Gold Millennium', 'Gorana', 'Siyana' and 'Besapara' had the longest flowering which give them a better chance of pollination in bad weather conditions during flowering.

The end of flowering (BBCH 69) occurred between 1 and 5 May, i.e. the duration of the flowering period in the studied apple cultivars for the conditions of the area was 14-19 days.

The calculated value for the correlation coefficient ($r = 0.786$) expressing the relationship between $\Sigma t > 5^\circ\text{C}$ and the number of days from the beginning of vegetation to the beginning of flowering and determination ($r^2 = 61.78\%$) showed that flowering depends extremely much from the temperature sums (Fig. 2). A positive correlation between the date of flowering and daily air temperatures was also reported by other authors (Djouvinov, 2003; Pertille et al., 2022).

The studied cultivars ripen mostly in September, except for 'Gold Milenium', which under the conditions of the region ripened between August 18 and 28. The fruit of 'Martinika' ripened the latest - between 24 September and 3 October, but the rest are also typically winter cultivars (Fig. 3). The required number of days from the end of flowering to fruit ripening in the cultivars ranged from 112 ('Gold Milenium') to 149 ('Besapara'), with temperature sums above 10°C, respectively 2114.5 to 2662.8°C (Table 1).

The established relationship between $\Sigma t > 10^\circ\text{C}$ and the number of days from the end of flowering to fruit ripening is presented in Fig. 4. The value of the correlation coefficient ($r = 0.978$) showed a high dependence on the ripening period from average daily air temperatures. From the regression coefficient ($R_{y/x}$) was found that when the effective temperature sum changes by 10°C, the duration of the ripening period changes by 0.6 days. From the linear regression equation $y = a + bx$, fruit ripening can be predicted depending on this temperature sum for each region.

Fruit production varied in the different years between 11 and 43 kg/tree, depending on the cultivar and climatic conditions. The highest cumulative 4-year yield was obtained from 'Free Redstar' (132.6 kg) and 'Gorana' (113.8 kg) trees, which significantly exceeded the standard 'Golden Delicious' (88 kg). A good yield was also realized from 'Martinika', 'Gold Milenium', and 'Marlena' (about 100 kg/tree), but the other cultivars did not differ significantly from 'Golden Delicious' (Fig. 5). Our results on the high fertility of Free Redstar and Gold Milenium cultivars correspond with those of other authors (Czynczyk et al., 2008; Czynczyk et al., 2011; Żurawicz et al., 2013).

On average for the studied period, the biggest percentage of fruits of class 'Extra' (between 85 and 100%) were obtained from the 'Besapara', 'Gold Milenium' and 'Brina' cultivars, which exceeded the standard 'Golden Delicious' (Table 2). The fruit of 'Martinika', 'Elegia' and 'Siyana' were mostly assigned to class I. In most cultivars, fruits class II were absent, or their percentage was insignificant, which indicates that the studied cultivars are large-fruited.

4. Conclusions

Climatic changes in recent years lead to earlier emergence of fruit trees from dormancy and earlier initiation of flowering, which poses the risk of frostbite of blossoms or young fruits in the spring from late frosts. In the Kyustendil region, late spring frosts are a common phenomenon, which is why the selection of cultivars with later flowering is extremely important to reduce possible damage. In this regard, 'Elegia', 'Brina', 'Marlena', 'Martinika', and 'Melfree', which start to bloom a little later, have a certain advantage among the studied cultivars.

The temperature conditions in the region are suitable for the cultivation of apples, but each of the cultivars requires certain temperature sums to pass from one phenological phase to another.

From the derived linear regression equations, the timing of flowering and fruit ripening can be predicted depending on these temperature sums for each region.

The studied cultivars have good adaptability to the local climatic conditions and high productivity. Their fruits are of very good quality and as they should be practically resistant to apple scab, we recommend them for wider use in production to obtain organic apple production.

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Tables and figures

Table 1. Required temperature sums to pass from one phase to another and the number of days for their accumulation in different apple cultivars (average 2018-2021)

Cultivar	Beginning of vegetation - Beginning of flowering		End of flowering - Fruit ripening	
	Number of days	$\Sigma t > 5^{\circ}\text{C}$	Number of days	$\Sigma t > 10^{\circ}\text{C}$
Gold Milenium	24	153.7	112	2114.5
Free Redstar	26	156.3	142	2549.4
Melfree	25	150.1	138	2536.8
Brina	26	155.9	143	2558.0
Besapara	22	137.2	149	2662.8
Marlena	27	180.9	138	2429.9
Martinika	25	152.1	148	2659.4
Elegia	26	179.7	142	2577.1
Gorana	23	145.3	143	2600.6
Siyana	23	148.4	142	2585.9
Golden Delicious (Ct.)	25	172.4	143	2621.6

Table 2. Percentage distribution of apple fruits by classes, in individual years

Cultivar	2018			2019			2020			2021		
	Class 'Extra'	Class I	Class II	Class 'Extra'	Class I	Class II	Class 'Extra'	Class I	Class II	Class 'Extra'	Class I	Class II
Gold Milenium	85	15	-	87	13	-	91	9	-	85	12	3
Free Redstar	85	15	-	89	11	-	72	24	4	78	14	8
Melfree	84	16	-	21	71	8	98	2	-	82	18	-
Brina	94	6	-	93	7	-	94	6	-	91	9	-
Besapara	91	9	-	89	11	-	100	-	-	98	2	-
Marlena	62	20	18	81	19	-	87	13	-	89	11	-
Martinika	12	78	10	24	79	3	73	21	6	78	22	-
Elegia	22	63	15	25	62	13	90	10	-	83	17	-
Gorana	72	24	4	81	17	2	94	6	-	91	9	-
Siyana	75	25	-	79	19	2	64	30	6	73	27	-
Golden Delicious (Ct.)	78	13	9	70	24	6	81	11	8	53	36	11

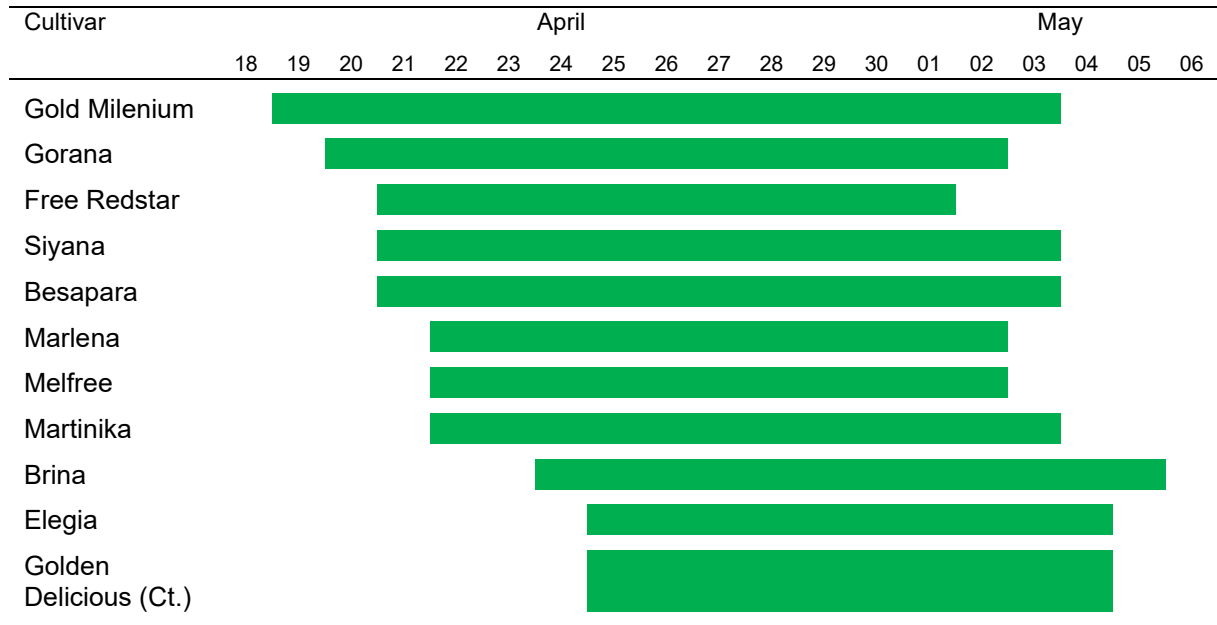


Fig. 1. Flowering phenogram of apple cultivars (average 2018-2021)

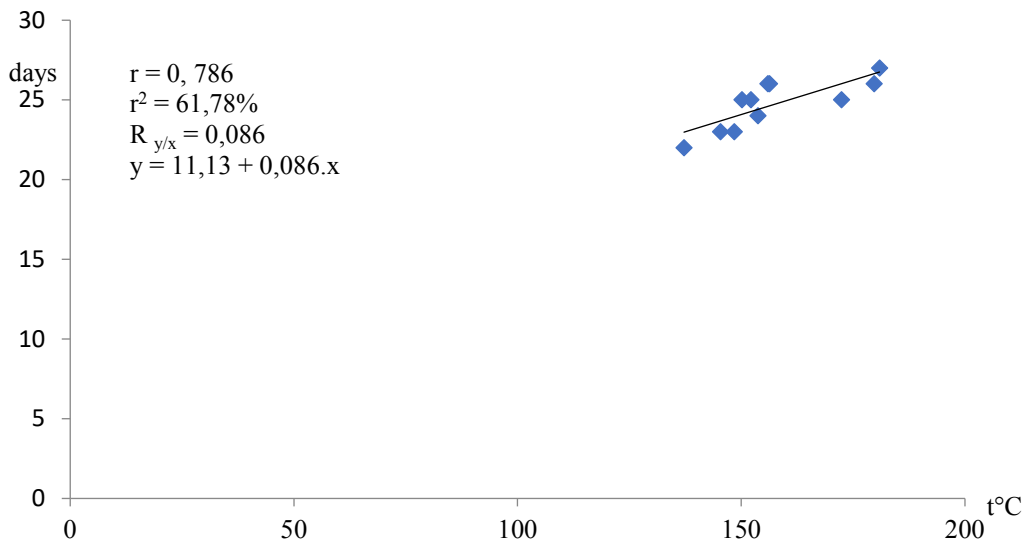


Fig. 2. Relationship between the temperature sum above 5°C and the number of days from the beginning of vegetation to the beginning of flowering (2018-2021)

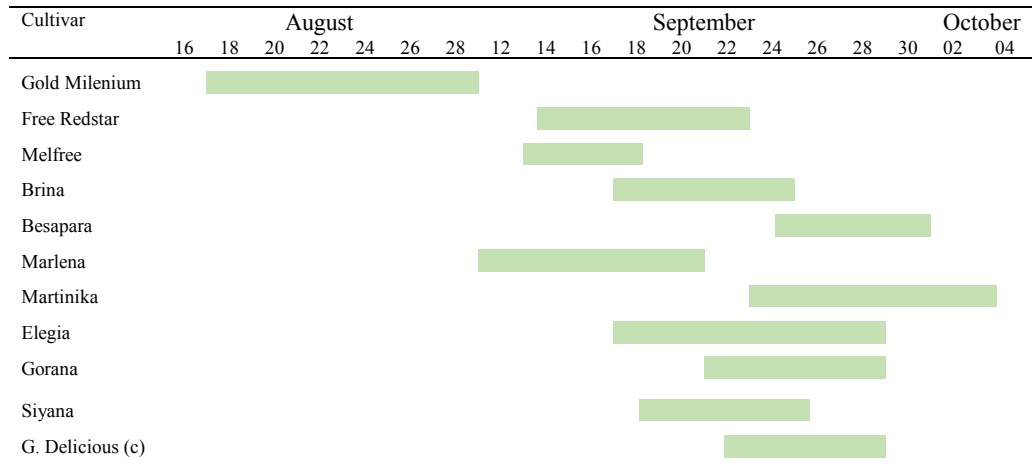


Fig. 3. Phenogram of ripening (2018-2021)

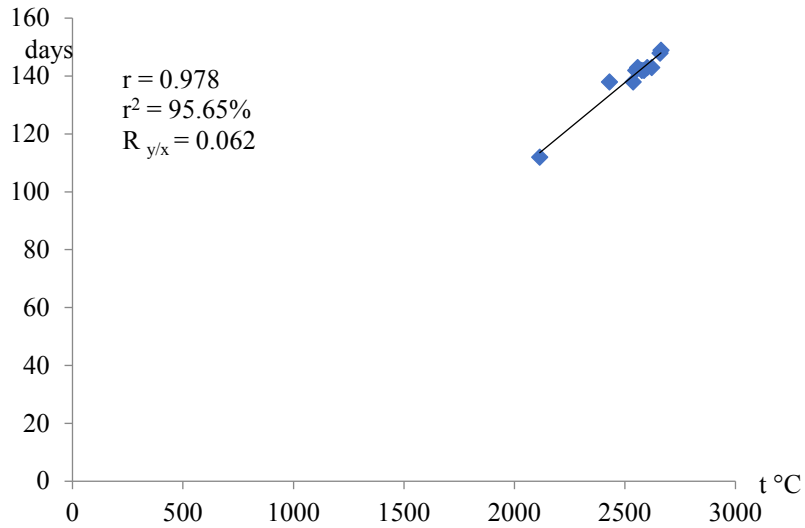


Fig. 4. Relationship between the temperature sum above 10°C and the number of days from the end of flowering to fruit ripening (2018-2021)

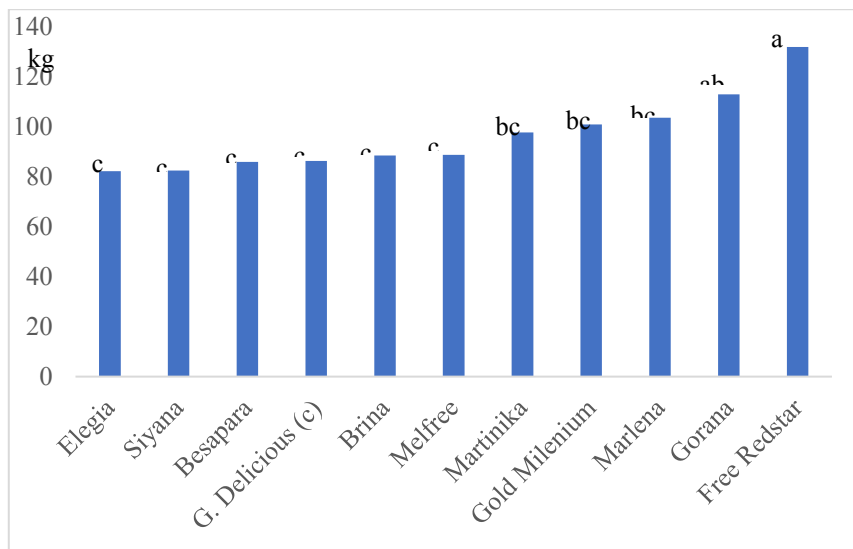


Fig. 5. Cumulative fruit yield of the apple cultivars (kg/tree, average 2018-2021)