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Phenological phases of introduced peach varieties

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Abstract. The article provides information on the phenological phases of peach plant varieties, such as bud opening, flowering, fruit ripening and end of vegetation. **The purpose** of the research is the study of agrobiological features of newly introduced peach varieties in Guba-Khachmaz region Azerbaijan from Spain, as well as the active development phases of varieties and selection of high-yielding varieties adapted to the soil and climatic conditions of the region. **Materials and methodology**. The research work was carried out on 18 varieties of peach and nectarine, introduced from Spain and planted in 2014: Melox-26, Melox-31, Melox-37, Netix-25, Netix-28, Netix-30, Netix-34, Redix-25, Redix-27, Redix-30, Redix-2-110, Malix-25, Malix-36, Malix-145, Guayox-30, Guayox-35, Gartairo, Gardeta. Fadai was used as a control variety. Research work on the basis of generally accepted methodology ("Methodology and program of sorting of fruits, berries and nut crops ", Michurinsk 1973; G. E. Schultz, 1981) conducted. **Scientific novelty.** For the first time, agrobiological characteristics, including phenological phases, of peach (nectarine) plant varieties introduced into the soil and climatic conditions of the Guba-Khachmaz economic region were studied. **Results.** Observations over the years of research show that the average duration of ripening of peach varieties is 82–163 days. Depending on the economic-biological characteristics of peach and nectarine varieties introduced in Guba-Khachmaz economic region and soil-climatic features of the area, the vegetation period from the opening of shoots to the end of leaf fall lasted 229–235 days. The effective air temperature (sum of temperatures above +5 °C) at the end of leaf fall was 3676.3–3815.8 °C depending on the varieties.

Keywords: introduction, peach, variety, phenological phases, Guba-Khachmaz economic region.

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Introduction

One of the leading areas of agriculture is fruit growing, the rapid development of which is possible as a result of efficient use of natural resources, existing gene pool resources and application of modern technologies. The demand for the effective functioning of the agricultural sector is increasing even more during the period of rapid growth of the world population and global climate change. The effective operation of the agricultural sector implies the production of higher agricultural products with less resources. The peach plant has a special weight and is of an industrial nature among fruit plants. Peaches and their products are considered one of the main crops of the national economy due to their high utility properties and medicinal value, as well as their valuable biological properties and economic profitability. Peach is a stone fruit plant with higher economic value. It is usually grown in 30-50° north and south latitudes. However, in recent years, interest in its cultivation in hot regions, including tropical and subtropical regions, has increased [5, p. 424]. Taking into account the biological characteristics of the development of fruit plants, including peaches, it is possible to work on the creation and selection of varieties with flower shoots that are resistant to late spring frosts, disease and drought and have a longer development period. The vegetation period of fruit plants covers the following stages of development: opening of shoots, flowering, ripening of fruits, opening of leaves, shedding of leaves. Spring development of fruit plants begins with the swelling of the shoots and continues against the background of a gradual increase in temperature.

The generative and vegetative nature of the shoots is characterized by the maximum level of auxin at the initial stage, the accumulation of chlorogenic acid during the period of flower organogenesis. Sporogenic tissue formation of pollen is synthesized by strong growth inhibitors (naringenin and prunin) and the accumulation of cytokines and gibberellin is observed. Spring development of generative shoots can be controlled by the ratio of auxin, cytokine and gibberellin with low levels of phenol inhibitors. Phenological observations showed that the flowering of peaches occurred at different times during the winter and spring, depending

on the temperature. The onset of flowering depends on both the weather conditions of the year and the area of growth.

If the air temperature is above +25 °C, it accelerates the metabolism and differentiation of shoots. However, the temperature between +30...+35 °C can prevent bud formation. Exposure of some peach varieties to temperatures higher than +25 °C for a certain period of time caused their development to stop. When the exposure period is long, growth stops and blind nodules are formed. Such a situation is observed in tropical areas [10, p. 439].

Ripening and harvesting characteristics are better determined by means of analytical measurements of the composition and density of the fruit, hardness sensor. Appearance, taste qualities, aroma and physico-chemical characteristics are the characteristics of peach and nectarine cultivars for ripening and compliance with market requirements [6, p. 234].

Jun Liu, Orville M. Lindstrom et al. (2019) conducted differential thermal analysis (DTA) of flower buds of Elberta and Flavorich peach cultivars in order to predict winter hardiness in Georgian conditions and experimented with 2 options. The DTA experiment was started at –2 °C and lowered to –27 °C by decreasing the temperature by +4 °C every 1 hour. In another option, the sample was incubated overnight at –2 °C. As a result, the researchers observed that pretreated DTA had better performance than conventional DTA after deactivation of flower buds. The authors note that as a result of DTA forecasts, it will enable producers to protect their products from frost [7, pp. 681–683].

Climatic conditions indicate a number of quality characteristics of peach fruits. Rouse and Sherman (1989a) reported that several peach cultivars requiring lower chill hours were more red in the Rio Grande Valley of Texas than those in Gainesville [15, p. 666].

Will Wheeler, Reagan Wytsalucy, Brent Black et al. (2019) in their research, Novaho and Lovell investigated the drought tolerance of peach trees and found that despite the drought stress, in our study, both cultivars optimized their transpiration rate within 3 days without irrigation. The researchers note that after the first and last two stages of the drought, Navajo transpiration rates peaked and the cultivar was under severe stress [13, p. 803].

Huihui Liu et al. (2019) performed GWAS (genome-wide association study) screening and candidate gene screening to identify a candidate gene regulating anthocyanin content of peach fruits and first identified an association signal ranging from 11.7 to 13.1 Mb in the chromosome 1 (Chr. 1) region. The authors' GO-annotation (gene ontology) of 146 genes suggests that 17 may be involved in sugar metabolism. Among these 17 genes, the expression of Prupe.1G156300, which encodes a sugar transporter, was found to be associated with anthocyanin accumulation in the fruits of two cultivars of red peach. As a result, researchers characterized the genetic basis of anthocyanin biosynthesis in peach fruits [8, p. 215].

Claudio Meneses (2020) reports that fruits with fleshy and juicy phenotypes have differences in metabolism that determine their frost resistance before refrigeration. Keeping fruits in the refrigerator (E3) causes a partial disruption of sugar metabolism. Most of the metatabolites found in small amounts in the luteal phenotype are associated with membrane stability, such as MGDG (monogalactosyldiacylglycerol) and PG (polygalacturonase (pectinase)) lipids. But higher amounts are associated with cold stress, such as sugar and LPC (lysophosphatidylcholine). These metabolites and lipids can be used as biomarkers for cold injury (CI) [9, p. 14].

Lisa Tang et al. (2019) studied that mid-December application of hydrogen cyanamide (HC) accelerated bud opening by 6 weeks in Tropic Beauty peach [12, p. 250].

Chunxian Chen and William R. Okie (2017) note that US-grown peaches exhibit low genetic diversity. Traditional hybridization is the main approach in the cultivation of peach cultivars. Results of microsatellite polymorphisms and in silico genotyping of chloroplasts in peach materials provide information on chloroplast genome variations and identify parental combinations. Amplicon length polymorphisms distinguish only eight maternal groups [4, p. 223].

Skyler Simnitt, Tatiana Borisova et al. (2017) notes that in the soil-climate conditions of Georgia, quick-ripening varieties of the peach plant are damaged by frosts and productivity decreases [11, p. 351].

I. I. Suprun et al. (2018) used 12 SSR markers for the study of SSR-fingerprinting and genetic relationships of peach cultivars and determined different levels of polymorphism: from 3 (for markers UDP98-410 and BPPCT028) to 9 (BPPCT017) local alleles for each locus with an average of 5,417 alleles, and the number of effective alleles ranging from 3,970 to 1,261 with a mean of 2,512. Heterozygosity varied between 0.207–0.748 and 0.075–0.875, respectively [2, p. 93]. The authors (2019) identified 1 (marker EMPaS06) to 7 (marker EMPaS01) alleles in 19 peach varieties based on the results of SSR genotyping. They note that the use of the "effective number of alleles" indicator to assess the level of polymorphism allows selecting the most polymorphic markers for genetically close varieties with SSR-fingerprinting [1, p. 106].

The quality of peach fruit is focused on the measurement of soluble solids concentration (SSC) sweetness and total titratable acidity (TTA). Quality indicators vary depending on the production region of peaches. Quality standards for yellow peaches in California are set at a minimum of 10 % SSC. In Italy, this figure is 10 % SSC for early season, 11 % for mid-season and 12 % for late season. Quality standards in France are

10 % SSC and TTA < 0.9 % for low acidity cultivars and 11 % SSC and TTA > 0.9 % for high acidity cultivars [3, p. 189].

Shuoli Zhao, Chengyan Yue, James Luby et al. (2017) examined marketable characteristics of peaches (fresh and processed) in California and noted that peach growers place more importance on fruit color and size [14, p. 121].

Methods

The research work was carried out on 18 varieties of peach and nectarine, introduced from Spain and planted in 2014: Melox-26, Melox-31, Melox-37, Netix-25, Netix-28, Netix-30, Netix-34, Redix-25, Redix-27, Redix-30, Redix-2-110, Malix-25, Malix-36, Malix-145, Guayox-30, Guayox-35, Gartairo, Gardeta. Fadai was used as a control variety. Research work on the basis of generally accepted methodology ("Methodology and program of sorting of fruits, berries and nut crops", Michurinsk 1973; G. E.Schultz, 1981) conducted.

Results

As a result of natural climatic factors, changes in the phenological phases of the peach plant during the vegetation and dormancy periods were observed.

During the research years (2018–2020), the vegetation period of newly introduced peach plant varieties begins in mid-March in the Guba-Khachmaz economic region of Azerbaijan (Table 1)

According to the research years, the opening of flower shoots was observed the fastest on March 12, 2020 in Gardeta variety (+9.4 °C), and the latest on April 4, 2019 in Melox 37 variety (+12.5 °C). Thus, there was an 8-day difference in the onset of vegetation for the 2018–2020 research years. Opening of flower shoots of introduced peach plant varieties 20.III–02.IV with average daily temperature +9.6 °C in 2018, 20.III–04.IV with average daily temperature +10.7 °C in 2019 and average daily temperature +9.1 °C covered the dates 12.III–25.III in 2020. Opening of leaf shoots of introduced peach plant varieties, average daily temperature in 2018 is +11.5 °C with 27.III–07.IV, in 2019 with +12.9 °C with 28.III–09.IV and in 2020 covered the dates of 19.III–29.III with +10.3 °C. The opening of flower and leaf shoots compared to the Fadai (c) variety is the same in Netix-25, Netix-30, Netix-34 and Guayox-35, Melox-26, Redix-27, Netix-28, Melox-31, Melox-37 and It was observed relatively late in Malix-36 varieties, Redix-25, Guayox-30, Redix-30, Malix-145, Redix-2-110, Gartairo and Gardeta varieties.

The beginning of the flowering phase in the introduced peach plant varieties 01.IV-10.IV with average daily temperature +13.4 °C in 2018, 03.IV-18.IV and with +15.4 °C in 2019, it covered the dates of 20.III-05.IV in 2020 with +11.9 °C. In some years, the onset of flowering compared to the Fadai (c) variety is the same in Netix-25, Netix-30, Redix-30, Netix-34 and Guayox-35, Redix-25, Malix-25, Guayox-30, Gartairo and Gardeta varieties observed quickly, relatively late in other varieties. Mass flowering 09.IV-16.IV with average daily temperature +14.9 °C in 2018, 10.IV–22.IV with +16.3 °C in 2019 and 27.III–12.IV with +13,7 °C in 2020; end of flowering 17.IV–26.IV with average daily temperature +16.5 °C in 2018, 17.IV–30.IV with +17.2 °C in 2019 and 03.IV–21.IV with +15,1 °C in 2020 covers dates.

Fruit ripening maturity in introduced peach plant varieties12.VII (+18.9 °C) – 12.X (+12.6 °C) in 2018, 09.VII (+17.2 °C) – 04.X (+10.2 °C) in 2019 and 13.VII (+20.1 °C) – 02.X (+13.5 °C) in 2020. Melox-26, Netix-25, Redix-25 and Malix-25 varieties were registered as relatively fast and other varieties as relatively slow compared to Fadai (c) (July 2-07) control variety. Compared to Fadai (n) and research varieties, Netix-25 and Redix-25 varieties were registered earlier, and Melox-37 variety was registered as the slowest growing variety.

The duration of the shoot opening phase for varieties varies from year to year depending on the climatic conditions of the area. The average effective temperature for the research years was 117.2–171.9 °C, depending on the total variety, and the duration of the shoot opening phase was 10–13 days for varieties according to the average indicators. Thus, this period was the shortest, with 10 days in Redix-2-110 and Malix-36 varieties, and 13 days in Redix-25, Redix-27, Guayox-30, Melox-31 and Melox-37 varieties. The average air temperature was 8.4–11.6 °C for these varieties. Compared to the Fadai (c) variety, this period is shorter in Redix-2-110 and Malix-36, Guayox-35, Gardeta, Netix-34, Redix-30, Netiks-30, Netiks-28, Malix-25 and Melox- 26 varieties were the same.

According to the research years of the introduced peach varieties, the flowering phase lasted 12–16 days, and the average daily temperature in the flowering phase was +8.9…+13.7 °C. The lowest average daily temperature in the flowering phase of the research years was +8.9 °C in 2018 in the Garteiro variety, and the highest temperature in 2019 was +13.7 °C in the flowering phase in the Melox-31 and Melox-37 varieties.

The duration of the fruit ripening phase of the newly introduced peach plant varieties was 74–169 days in 2018–2020. The average ripening period of fruits during the research years was 82–163 days. Based on these indicators, we can note that compared to the control variety Fadai (109 days), the ripening period of fruits Melox-26 (92 days), Netix-25 (82 days), Redix-25 (84 days) and Maliks-25 (89 days) was shorter in varieties and longer in other varieties. Among the introduced peach and nectarine varieties, the longest ripening period was observed in Melox-37 with 163 days, and the shortest in 82 days with Netix-25.

Table 1

Phenological phases of newly introduced peach plant varieties

Variety	Years	Opening of buds		Flowering			Fruit ripening
		Flowers	Leaf	Getting started	Mass	End	
Fadai (c)	2018	28.III	04.IV	05.IV	11.IV	18.IV	03.VIII
	2019	01.IV	06.IV	13.IV	17.IV	30.IV	02.VIII
	2020	20.III	25.III	31.III	07.IV	12.IV	07.VIII
Melox-26	2018	30.III	06.IV	07.IV	13.IV	21.IV	23.VII
	2019	02.IV	08.IV	14.IV	20.IV	29.IV	23.VII
	2020	22.III	27.III	03.IV	09.IV	16.IV	24.VII
Netix-25	2018	28.III	04.IV	05.IV	11.IV	19.IV	12.VII
	2019	01.IV	06.IV	12.IV	18.IV	27.IV	09.VII
	2020	20.III	26.III	02.IV	09.IV	17.IV	13.VII
Redix-25	2018	24.III	30.III	03.IV	08.IV	19.IV	12.VII
	2019	26.III	01.IV	08.IV	13.IV	24.IV	09.VII
	2020	16.III	22.III	28.III	04.IV	12.IV	13.VII
Malix-25	2018	27.III	01.IV	04.IV	10.IV	20.IV	19.VII
	2019	30.III	05.IV	10.IV	15.IV	26.IV	16.VII
	2020	20.III	26.III	01.IV	10.IV	15.IV	20.VII
Redix-27	2018	31.III	06.IV	10.IV	16.IV	23.IV	16.VIII
	2019	02.IV	09.IV	16.IV	20.IV	30.IV	14.VIII
	2020	22.III	28.III	03.IV	11.IV	16.IV	13.VIII
Netix-28	2018	31.III	06.IV	08.IV	14.IV	23.IV	25.VIII
	2019	02.IV	09.IV	14.IV	20.IV	30.IV	23.VIII
	2020	22.III	27.III	03.IV	10.IV	17.IV	18.VIII
Netix-30	2018	28.III	04.IV	06.IV	12.IV	22.IV	30.VIII
	2019	01.IV	06.IV	12.IV	18.IV	28.IV	27.VIII
	2020	21.III	27.III	01.IV	08.IV	16.IV	25.VIII
Guayox-30	2018	24.III	30.III	03.IV	09.IV	18.IV	30.VIII
	2019	26.III	01.IV	08.IV	13.IV	23.IV	27.VIII
	2020	16.III	23.III	29.III	06.IV	14.IV	25.VIII
Redix-30	2018	27.III	03.IV	05.IV	11.IV	20.IV	30.VIII
	2019	30.III	05.IV	10.IV	15.IV	24.IV	27.VIII
	2020	20.III	25.III	01.IV	05.IV	14.IV	25.VIII
Malix-145	2018	25.III	31.III	06.IV	12.IV	20.IV	23.IX
	2019	28.III	02.IV	11.IV	17.IV	27.IV	20.IX
	2020	18.III	25.III	28.III	03.IV	12.IV	18.IX
Melox-31	2018	30.III	04.IV	10.IV	16.IV	26.IV	10.IX
	2019	03.IV	08.IV	18.IV	22.IV	30.IV	05.IX
	2020	23.III	29.III	03.IV	10.IV	19.IV	04.IX
Melox-37	2018	02.IV	07.IV	10.IV	16.IV	26.IV	12.X
	2019	04.IV	06.IV	18.IV	22.IV	30.IV	04.X
	2020	25.III	29.III	05.IV	12.IV	21.IV	02.X
Redix-2-110	2018	27.III	02.IV	05.IV	11.IV	20.IV	08.IX
	2019	30.III	05.IV	10.IV	15.IV	26.IV	05.IX
	2020	22.III	29.III	01.IV	10.IV	14.IV	03.IX
Netix-34	2018	28.III	02.IV	06.IV	12.IV	21.IV	08.IX
	2019	01.IV	06.IV	12.IV	18.IV	28.IV	05.IX
	2020	20.III	26.III	31.III	08.IV	14.IV	03.IX
Malix-36	2018	30.III	04.IV	07.IV	13.IV	21.IV	29.IX
	2019	03.IV	06.IV	13.IV	17.IV	28.IV	26.IX
	2020	23.III	28.III	02.IV	08.IV	16.IV	24.IX
Guayox-35	2018	28.III	03.IV	06.IV	12.IV	21.IV	09.IX
	2019	01.IV	06.IV	12.IV	18.IV	28.IV	05.IX
	2020	20.III	27.III	30.III	06.IV	14.IV	04.IX
Gartairo	2018	20.III	27.III	01.IV	09.IV	17.IV	05.VIII
	2019	20.III	28.III	03.IV	10.IV	17.IV	01.VIII
	2020	12.III	19.III	20.III	27.III	05.IV	25.VII
Gardeta	2018	22.III	29.III	02.IV	09.IV	18.IV	08.VIII
	2019	25.III	30.III	05.IV	12.IV	21.IV	04.VIII
	2020	15.III	22.III	26.III	02.IV	10.IV	28.VII

Depending on the characteristics of the variety of peach and nectarine varieties, a total effective temperature of 1198.2–2853.5 °C is required for full ripening of fruits.

The duration of the growing season depends on the soil and climatic conditions of the area where peaches are grown and agro-technical maintenance measures. According to the research years, the beginning of leaf fall on peach and nectarine varieties was 16.X–05.XI, and the end was 08.XI–25.XI, and the leaf fall lasted for a total of 18-25 days. Compared to the Fadai (c) variety, leaf fall was observed in Guayox-30 and Malix-145 varieties at about the same time, in Netix-25, Redix-25, Malix-25, Gartairo and Gardeta varieties relatively early, and in other varieties relatively late. During the leaf fall phase of 2018–2020, the average daily air temperature varied between +5.2…+11.7 °C. Among the peach and nectarine varieties introduced during the research years, the average daily air temperature in Melox-37 variety was lower than +5.2…+6.3 °C, and in Gartairo variety it was higher than +10.5…+11.7 °C passed under conditions.

Depending on the economic-biological characteristics of peach and nectarine varieties introduced in Guba-Khachmaz economic region and soil-climatic features of the area, the vegetation period from the opening of shoots to the end of leaf fall lasted 229–235 days. Thus, the shortest vegetation period of the research varieties with 229 days was Netix-25 and Malix-25, and the longest vegetation period with 235 days was Malix-145 and Malix-36. The effective air temperature at the end of leaf fall was 3676.3–3815.8 °C depending on the varieties.

Discussion and Conclusion

Agrobiological features of peach plant varieties introduced in Guba-Khachmaz region, as well as research on the active development phases of varieties in 2018–2020 were identified in the research work:

1. The duration of the opening phase of shoots is 10–13 days for varieties according to the average indicators, the earliest on 12 March 2020 in Gardeta variety (+9.4 °C), and the latest on 04 April 2019 in Melox 37 variety (+12.5 °C) was observed. The average air temperature was + 8.4…+ 11.6 °C for these varieties.

2. The opening of flower and leaf shoots in comparison with Fadai (c) variety is the same in Netix-25, Netix-30, Netix-34 and Guayox-35 varieties, in Melox-26, Redix-27, Netix-28, Melox-31, Melox-37 and Malix-36 varieties it was observed relatively late, and relatively quickly in Redix-25, Guayox-30, Redix-30, Malix-145, Redix-2-110, Gartairo and Gardeta varieties.

3. The duration of the flowering phase lasted 12–16 days, and the average daily temperature in the flowering phase was +8.9…+13.7 °C. The beginning of the flowering phase covered the dates of 01.IV–10.IV in 2018 with an average daily temperature +13.4 °C, 03.IV–18.IV in 2019 with +15.4 °C and 20.III–05.IV in 2020 with +11.9 °C.

4. Fruit ripening maturity in introduced peach plant varieties12.VII (+18.9 °C) – 12.X (+12.6 °C) in 2018, 09.VII (+17.2 °C) – 04.X (+10.2 °C) in 2019 and 13.VII (+ 20.1 °C) – 02.X (+13.5 °C) in 2020. Melox-26, Netix-25, Redix-25 and Malix-25 varieties were registered as relatively fast and other varieties as relatively slow compared to Fadai (c) (July 2–07) control variety. Compared to Fadai (n) and research varieties, Netix-25 and Redix-25 varieties were registered earlier, and Melox-37 variety was registered as the slowest growing variety.

5. The duration of the fruit ripening phase of the newly introduced peach plant varieties was 74–169 days in 2018–2020. The average ripening period of fruits during the research years was 82–163 days. Based on these indicators, we can note that compared to the control variety Fadai (109 days), the ripening period of fruits Melox-26 (92 days), Netix-25 (82 days), Redix-25 (84 days) and Malix-25 (89 days) was shorter in varieties and longer in other varieties. Among the introduced peach and nectarine varieties, the longest ripening period was observed in Melox-37 with 163 days, and the shortest in 82 days with Netix-25.

6. According to the research years, the beginning of leaf fall on peach and nectarine varieties was 16.X–05.XI, and the end was 08.XI–25.XI, and the leaf fall lasted for a total of 18–25 days. Compared to the Fadai (c) variety, leaf fall was observed in Guayox-30 and Malix-145 varieties at about the same time, in Netix-25, Redix-25, Malix-25, Gartairo and Gardeta varieties relatively early, and in other varieties relatively late.

7. The shortest vegetation period of the research varieties with 229 days was Netix-25 and Malix-25, and the longest vegetation period with 235 days was Malix-145 and Malix-36. The effective air temperature at the end of leaf fall was 3676.3–3815.8 °C depending on the varieties.

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