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INVESTIGATION OF THE PHENOLOGICAL PHASES OF THE PINOT NOIR CLONE 777 UNDER THE INFLUENCE OF CLIMATE CHANGE IN THE SOUTHERN VINE-GROWING REGION IN BULGARIA

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Abstract

The impact of climate change on the phenological phases of the Pinot Noir variety clone 777 was studied during the period 2022-2023. The plantation was established in 2008 in the land of the village of Nikolaevo, Sliven district, in the southern wine-growing region of Bulgaria. The vines are formed on a one stem cordon with a pruning severity of 6 spurs, at planting distances of 2.4 x 0.9 m and non-irrigated conditions. The climate is transitionally continental with low mountain influence and diverse relief. In 2022, budburst begins in the first ten days of March, lasting about 35 days, flowering varies from 17 to 22 days, veraison occurs from 18 to 23. In 2023 budburst begins in the first ten days of April with a duration of 5 to 9 days, flowering began on June 04, with the standardized variants flowering 9 days longer, veraison is from 20 to 23 days. The grape harvest was carried out in the third ten days of August for 2022 and the first ten days of September for 2023. The difference in phenophases is due to the uneven distribution of rainfalls and unpredictable temperature dynamics.

Key words: *viticulture, climate, phenology, Pinot Noir clone 777.*

INTRODUCTION

Phenological phases include different stages of the annual life cycle of the vine, which occur under the influence of climatic factors. They are important both for proper cultivation and for the management of all agrotechnical activities in vineyard plantations (Popov, 2017).
The phenological stages of the vine are highly dependent on the interaction between climatic, soil and agrotechnical factors and varietal characteristics. Their successful management, including adaptation to climate change, is essential for maintaining stable yields and high grape quality. The main factors influencing the individual phases can be divided into climatic factors (temperature, rainfalls, humidity and solar radiation) soil factors (soil type, soil nutrient composition and pH) agrotechnical factors (pruning, yield regulation, irrigation, fertilization) and varietal characteristics including adaptability and genetic characteristics (Keller, 2010).
Climate change has a serious impact on agriculture, including viticulture. Changes in temperatures, rainfalls, the frequency of extreme weather events, and the length of seasons directly affect grape growth, yield, and quality (Fraga et al., 2012).
Climate change poses a serious threat to viticulture, but at the same time provides opportunities for innovation. Through the development of new technologies (smart farming, artificial intelligence, biotechnology and genetic research) some of the challenges can be overcome. Despite the difficulties, adaptation to new climatic conditions and the creation of resistant grape varieties will be key factors for maintaining grape and wine production in the future (Prada et al., 2024; Cojocaru, 2020; Georgieva & Kazandjiev, 2013).
An important problem for viticulture that needs to be solved in the near future is related to access to water, especially during droughts, which will be increasingly common. The problem of access to water is becoming increasingly serious. Due to global warming, water resources are limited, which requires the creation of varieties that are better adapted to drought (Atak, 2024).
Climate change in recent years has had a significant impact on grapevine growth and development. The main effects are related to

increasing temperatures, changes in the amount and distribution of rainfalls, the occurrence of extreme weather events, and changes in grape quality (Wasko et al., 2021; Biasi et al., 2019; Leah et al., 2018; Stott, 2016; Van Leeuwen & Darriet, 2016).

High temperatures usually accelerate the ripening process of grapes, increase the sugar content and alcohol in the wines produced, but often lead to a decrease in acidity, which is where the balance is lost (Droulia & Charalampopoulos, 2021; Venios et al., 2020).

It is possible that new wine-growing regions will be established in the coming decades that were previously unsuitable for growing grapes (Candiago et al., 2022).

According to data from the Ministry of Agriculture of the Republic of Bulgaria the areas planted with the Pinot noir wine variety amounted to 95.19 ha. These plantations are distributed among 24 farms, with 25.50 ha of them being young and not yet bearing fruit (Ministry of Agriculture, 2020).

The southern wine-growing region is one of the most important for grape and wine production in Bulgaria and covers the largest area occupied by vineyards. It is characterized by a warm climate, suitable for growing red wine varieties (Ministry of Agriculture, 2020).

The main objective of this research is related to the study of the phenological stages through which the Pinot noir variety undergoes changes in climate in the southern wine-growing region.

MATERIALS AND METHODS

The experiment was conducted during the period 2022-2023. The object of the study is the red wine variety Pinot noir, clone 777 planted in 2008 in the land of the village of Nikolaevo, Bulgaria at planting distances of 2.4/0.9 m. The vines were formed on a one stem cordon. The vines are pruned with 6 spurs with 2 buds with a total severity of 12 buds. The experiment was conducted under non-irrigated conditions. For each of the variants, data from 45 vines were collected and analyzed. A total of 3 variants were included in the experimental scheme.

V_0 – control with thinning only on the stems.

V_1 – leaving 15 inflorescence at a shoot length of 20 cm. Thinning was performed along the stem and cordon.

V_2 – leaving 15 clusters in the berry growth phase. Thinning was performed along the stem and cordon.

Phenological observations were recorded using BBCH scale and methodology described in the Ampelographic exercise manual (Meier, 1997; Roychev, 2014).

The content of the main nutrients – nitrogen, phosphorus and potassium were recorded using the following methods: BDS/ISO 10390:2011; ISO/TS 14256-1:2003; GOST 26209:1991 (BDS/ISO, 2011; ISO/TS, 2003; Riem, 1991).

Climatic data were obtained from a Meteobot meteorological station located in the vineyard.

RESULTS AND DISCUSSIONS

The average annual air temperature in the studied area is 12.4°C. The average monthly temperatures during the winter period are positive (1.2°C). This guarantees normal overwintering of winter buds and their successful development during the vegetation period. The area is characterized by mild winters and relatively hot summers with an average temperature of 23.2°C (Table 1).

Table 1. Meteorological data from the land of the village of Nikolaevo, Bulgaria in 2022-2023

Air temperature, °C			Air humidity, %			Average annual rainfalls, mm
Average annual	Average monthly for the winter period	Average monthly for the summer period	Average annual	Average monthly for the winter period	Average monthly for the summer period	
12.4	1.2	23.2	66	70	55	596

Autumn is longer than spring. The average annual air humidity is 66%. During the winter months it stays above 70%, and during the summer months it drops to 55%. On average, about 596 mm of rainfalls per year, with a maximum in summer of 165 mm and a secondary maximum in spring, and a minimum in winter of 134 mm.

The climatic conditions in the land of the village of Nikolaevo offer a continental climate with clearly defined seasons. The summer period is dry, which can be a prerequisite for stress for the vines if there is insufficient irrigation.

Agrochemical analysis provides information on the chemical composition of the soil at a depth of 30 to 60 cm. The slightly acidic reaction of the soil is suitable for the absorption of nutrients such as nitrogen, phosphorus and potassium, which have a direct impact on the development of the vine. The low content of carbonates indicates that the soil is suitable for the cultivation of vines, as it is known that high levels of carbonates can limit the absorption of some microelements such as iron (Table 2).

Table 2. Agrochemical analysis of soil

Sampling depth, cm	pH	Active carbonates g/kg	N mg/1000 g	P_2O_5 mg/100 g	K_2O mg/100 g
30-60	6.62	1.5	20.0	6.95	12.38

The mineral nitrogen content in the soil was recorded at a value of 20.0 mg N/1000 g of soil at a depth of 30 to 60 cm. The mineral nitrogen content is too low for growing vines, which is why fertilization with 174 kg per hectare of nitrogen was carried out during the study period. Regarding the content of mobile phosphates in the soil, it was found that it is poorly stocked 6.95 mg P_2O_5/100 g of soil. After the soil analysis, it was found that the content of available potassium in the soil is at the lower limit of stock 12.38 mg K_2O/100 g of soil, but it is sufficient for normal vegetation growth.

The soil conditions in the land of the village of Nikolaevo are favorable for growing vines with a direction of production of red table and sparkling wines of the Pinot noir variety. The vine is subject to continuous water erosion. This leads to the washing out of the mobile forms of N, P_2O_5 and K_2O in the root-dwelling soil horizon. The lower pH determined during the analysis does not represent a limitation for the development of grapevine culture under the soil conditions in the land of the village of Nikolaevo.

Soil analysis shows that it is suitable for growing grapes with its slightly acidic reaction. The content of phosphorus and potassium is mode-rate, but enrichment with nitrogen and phosphorus may be necessary for optimal growth.

The results of the phenological observations are reflected in Table 3.

Table 3. Timing of the phenological phases of development in the Pinot noir clone 777

Variant	Year	Beginning of bud swelling	First leaf unfolded and spread away from shoot	Inflorescence clearly visible	Beginning of flowering 10% of flowerhoods fallen	Berries groat-sized	Beginning of ripening	Berries ripe for harvest	Beginning of leaf-fall
V_0	2022	10 Mar.	22 Apr.	11 May	29 May	27 Jun.	18 Jul.	28 Aug.	10 Oct.
	2023	05 Apr.	20 Apr.	05 May	04 Jun.	19 Jun.	31 Jul.	07 Sept.	10 Oct.
V_1	2022	10 Mar.	22 Apr.	11 May	29 May	27 Jun.	25 Jul.	28 Aug.	10 Oct.
	2023	06 Apr.	19Apr.	08 May	04 Jun.	28 Jun.	07 Aug.	07 Sept.	10 Oct.
V_2	2022	10 Mar.	22 Apr.	11 May	29 May	24 Jun.	24 Jul.	28 Aug.	10 Oct.
	2023	06 Apr.	19 Apr.	08 May	04 Jun.	25 Jun.	06 Aug.	07 Sept.	10 Oct.

The different pruning severity on the vines in the experimental scheme has a specific influence on the timing of the individual phenophases in the individual variants. The phases occur relatively intensively.

In 2022, budburst begins on March 10 for all variants. In 2023, budburst is slightly delayed – It begins on April 5-6, depending on the variant. The duration of budburst is about 35 days for 2022, and for 2023 it varies from 5 to 9 days, depending on the variant. The difference of about 3-4 weeks between the two years may be due to differences in spring temperatures. The later budburst in 2023 is an indicator of a cooler or longer winter.

The first leaf in 2022 appears around April 22 for all variants. In 2023, the leaves appear earlier, on April 19-20. Despite the later budburst in 2023, the first leaves appear almost simultaneously with 2022, which shows that the vines have compensated for the delay thanks to faster growth in April.

The flowering of the Pinot noir clone 777 conditioned by the applied green operations, has led to a change in its dynamics. In 2022, at V_0 it is 17 days, at V_1 and V_2 it is 22 days. In 2023, flowering began on June 04 in all variants, with the variants with severity flowering 9 days longer. The rapid course of flowering is due to the favourable climatic conditions in 2022.

However, this is not the case in the second year of the experiment. The subsequent phases of development show that the vine crop has the ability to compensate for the time needed for the growth processes to occur. The pea size berry growth phase is formed in the second and third ten days of June, with the difference between the variants not significant and it is formed for several days.
Veraison occurs for about 18 days in the control variant for 2022, while for V_1 it is 21 and 23 in V_2. In the reporting year 2023, the results reported based on the phenological forecast follow a similar trend again, with the most dynamic process being completed in V_0 20 days followed by V_1 21 days and the variant V_2 flowered for 23 days. The grape harvest was carried out in the third ten days of August for 2022 and the first ten days of September for 2023, it was carried out simultaneously in all variants.
The budburst begins depending on the climatic features from the end of April to the beginning of May. This process occurs with a permanent retention of temperatures in the range from 6 to 9°C for 15 days (Figures 1 and 2).
The first dates of recording with the strongest growth are the shoots of variant V_2 followed by V_1 and V_0 during the two years of the experiment.

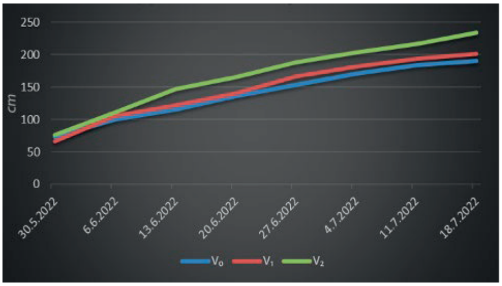

Figure 1. Growth dynamics of the shoots (cm) in 2022

The control variant V_0, which is not applied thinning along the cordon, forms weaker growth. When considering the following measurements of linear growth, a trend of a smooth increase in length is established in all variants. As the vegetation progresses and temperatures increase, growth increases, and by the third ten days of June in the reported 2022, most of the growth of all variants is formed.

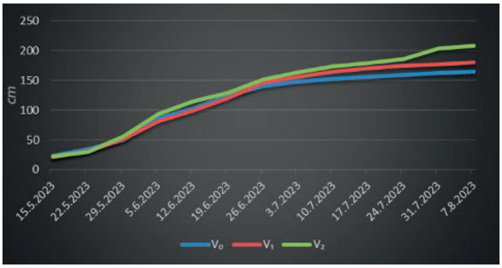

Figure 2. Growth dynamics of the shoots (cm) in 2023

In 2023, the formation of greater vegetative growth is demonstrated in all variants in the experiment, while the trend formed in the first year in terms of variants is maintained. The graphs also clearly show the influence of severity of the bunches in the fourth phase of the vegetative growth of the vine. The variant with severity of 15 bunches in the phase of berry growth significantly outperforms the vines with 15 inflorescence at the beginning of the vegetation. While in the control, growth dynamics remain smaller, regardless of the increase in average daily air temperatures. This is also due to the fact that in this variant, no suckers were planted along the cordons.

CONCLUSIONS

The Pinot noir clone, grown in the land of the village of Nikolaevo, Bulgaria, shows good adaptability, as it compensates for delays in the early phases and reaches technological maturity with minimal delay.
The variants with standardization V_1 and V_2 have a better balance between growth and yield, which makes them more effective for producing quality grapes.
The vines that are not standardized V_0 go through the different phenological phases faster, but are characterized by weaker shoot growth.
The relatively early ripening of the grapes suggests suitable conditions for the production of quality wines in the area of the village of Nikolaevo, Bulgaria.
The main differences in the timing of the phenological phases between 2022 and 2023 are mainly due to the climatic factors of the village of Nikolaevo, Bulgaria.
The data obtained show that through appropriate agrotechnical measures such as pruning and severity it is possible to optimize the quality and

quantity of the yield, regardless of climatic challenges.

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