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PHENOLOGICAL CHARACTERISTICS AND PRODUCTIVE POTENTIAL OF THE CABERNET SAUVIGNON (V. VINIFERA L.) VARIETY GROWN UNDER NON-IRRIGATED CONDITIONS

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Abstract: *The favorable combination of soil and climatic conditions in a significant part of Bulgaria, the diverse terrain and presence of suitable microregions create excellent conditions for growing vines and producing high-quality grapes. The study was conducted in the Sub-Balkan viticultural region, under non-irrigated conditions. Climatic conditions during the study period (2022–2024) were characterized by an average annual air temperature of 13.5ºC and an average precipitation of 444 mm. These specific conditions during the growing season affect phenological development, fertility and vines productivity. The period from budburst to technological ripeness of the grapes has an average duration of 167.3 days. The actual fertility was 83.43% and the developed buds from spurs accounted for 92.77%, with an actual fertility coefficient of 1.48. An average of 21.7 bunches per vine were formed, with an average weight of 114.33 g and an average weight of 100 berries of 121.67 g. The yield reached 2.47 kg per vine with a planting density of 3 330 vines per hectare, resulted in a productivity of 8225.10 kg per hectare. The comprehensive assessment shows a good degree of variety adaptation to conditions of limited water supply, outlining its potential for producing wine grapes under similar soil and climatic conditions and creating prerequisites for development and improvement of agrotechnical approaches for sustainable grape production.*

Keywords: *actual fertility, Cabernet Sauvignon, developed buds, fertility coefficient, fruiting shoots, non-irrigated conditions, phenological phases, productivity, yield*

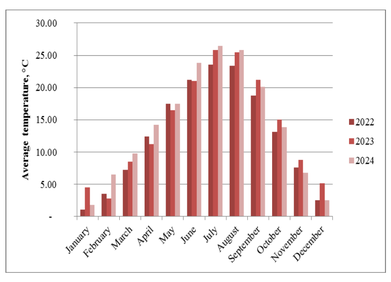
• Introduction

The increased variability of climatic conditions and limitations in water resources underscore the need to investigate the varietal response of grapevines under non-irrigated cultivation. Phenological development, physiological status, yield and grape quality are determined by the combined influence of temperature, water availability and the specific characteristics of a given growing season (CHAVES et al., 2010; HOCHBERG et al., 2017; COOLEY et al., 2017). The timing and duration of these phenological phases are determined by the genetic characteristics of the variety, as well as the interplay between temperature, precipitation, and cultivation conditions (PARKER et al., 2011). BASILE et al. (2011) found that the effects of water stress on grapevine physiology and berry composition vary depending on the timing of the stress. COOLEY et al. (2017) also demonstrated that water regime and seasonal characteristics interact to influence berry mass, yield and certain technological quality parameters. The objective of this study is to investigate the phenological characteristics and production potential of the Cabernet Sauvignon variety (Vitis vinifera L.) grown under non-irrigated conditions. This involves monitoring key developmental phenophases and evaluating growth and reproductive performance, as well as grape yield and quality parameters. The research aims to determine the variety's adaptive capacity to conditions relying solely on natural water supply and to assess its potential for sustainable production under limited water resources.

• Material and method

The subject of this study is the red wine variety Cabernet Sauvignon, grafted onto the Berlandieri x Riparia SO4 rootstock and planted in 2005 on the southern slopes of Sredna Gora mountain range. The bunch is small, cylindro-conical sometimes winged and compact (Figure 1). The peduncle is short of medium thickness, woody towards the base and tough. During the study period (2022, 2023 and 2024), phenological observations were conducted on the key developmental stages of grapevines throughout the growing season. The duration of the main phenophases is presented in days: sap flow to budburst, budburst to the first leaf appearance, first leaf to flowering, flowering to "pea-size" berry stage, "pea-size" berry stage to véraison (onset of ripening), véraison to technological ripeness and budburst to technological ripeness. For this purpose, normally developed grapevines were selected. The onset of a phase is defined as the day when 5% of the vines have entered that stage; the "mass" onset is defined as 50% of the vines and the end is defined as the point when 95% of the vines have entered the respective stage (BRAYKOV et al., 2005). The study includes indicators characterizing the actual fertility of the grapevines specifically the percentage of developed buds and the percentage of fruiting shoots as well as the Actual Fertility Coefficient (Cf). These parameters were assessed annually in June on 30 grapevines. Indicators characterizing grape yield were also examined including: average bunch number per vine; average bunch mass (g); average mass of 100 berries (g); average yield per vine (kg) and average yield per hectare (kg/ha). Phenological observations, the actual fertility and grape yield were assessed according to standard methods described in the Handbook of Exercises in Ampelography (ROYCHEV, 2014). Climatic data for the study period (2023–2024) were obtained from a meteorological station located within the vineyard. For the three experimental years, data on mean monthly air temperature (°C) and precipitation (mm) are presented, characterizing the climatic conditions of the study area (Figures 2 and 3).





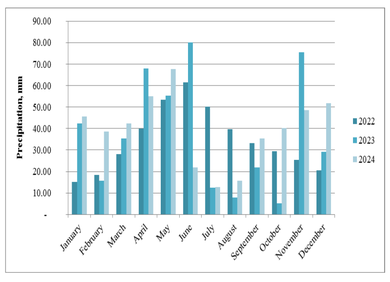


Figure 1. Cabernet Sauvignon variety bunch and leaf
Figure 2. Average monthly air temperature, 2022-2024
Figure 3. Precipitation, 2020-2022

• Results and discussions

The results reflect the influence of interannual variations in key climatic indicators on the phenological development, actual fertility and productivity of the grapevines. The presented data (Table 1) show the duration of the main phenological phases, which makes it possible to determine the differences between years and specific developmental varietal characteristics.

Table 1. Duration of phenophases in days during the period 2022 - 2024

Year	SAP flow to bud burst	Bud burst to first leaf appearance	First leaf to flowering	Flowering to pea size	Pea size to veraison	Veraison to technological ripeness	Bud burst to technological ripeness
2022	16b	10a	51a	18a	48b	38b	173a
2023	10a	11a	55a	21b	45a	32a	165a
2024	10a	11a	51a	20a	43a	31a	164a
Average	12	10,6	52,3	19,7	45,3	33,7	167,3

The actual fertility of the Cabernet Sauvignon grapevines is a relatively stable metric (Table 2). The average percentage of developed buds is 83.43%, while the percentage of fruiting shoots is 92.77%. The coefficient of actual fertility for the period averages 1.48.

Table 2. Actual fertility during the period 2022 – 2024

Year	Developed buds %	Fruiting shoots, %	Coefficient of actual fertility Cf.
2022	84,28a	94,47a	1,51a
2023	83,93a	92,24a	1,48a
2024	82,10a	91,60a	1,46a
Average	83,43	92,77	1,48

The average number of grape bunches per vine decreased from 24 in 2022 to 19 in 2024, while the average mass per single bunch increased from 110 g (2022) to 118 g (2024). The mass of 100 berries remained relatively stable, with an average value of 121.67 g for the period. Despite the increasement in bunch mass, the average yield per vine decreased from 2.64 kg (2022) to 2.24 kg (2024) and the yield per hectare dropped from 8 791.20 kg/ha (2022) to 7 459.20 kg/ha (2024). The average yield for the three-year period was 8 225.10 kg/ha (Table 3).

Table 3. Grape yield during the period 2022 - 2024

Year	Average number of bunches per vine	Average weight per bunch, (g)	Average weight of 100 berries, (g)	Average yield per vine, (kg))	Average yield per ha (kg))
2022	24b	110,00a	123,29a	2,64b	8791,20b
2023	22a	115,00a	120,14a	2,53b	8424,90b
2024	19a	118,00a	121,60a	2,24a	7459,20a
Average	21,7	114,33	121,67	2,47	8225,10

• Conclusions

Phenological development of the grapevines across the years is characterized by a shortening of the period from bud burst to technological ripeness from 173 days in 2022 to 164 days in 2024 with the most pronounced change occurring during the phase from véraison (onset of ripening) to technological ripeness. Actual fertility remained relatively constant, with an average of 83.43% developed buds, 92.77% fruiting shoots and an actual fertility coefficient (Cf) of 1.48. A downward trend was observed in the number of bunches per vine, as well as in the yield per vine and per hectare, despite an increase in the average bunch weight. This identifies the number of bunches as a key component of productivity during the period under review. The weight of 100 berries and the average bunch weight remained relatively stable, indicating that the primary differences in yield are linked mainly to the number of bunches formed, rather than to significant changes in their size. The practical significance of this research lies in the potential to use these findings to refine cultivation practices for the Cabernet Sauvignon variety under variable weather conditions. In this regard, the results contribute to more informed vineyard management, aimed at stabilizing yields and preserving the technological quality of the grapes required for production of high-quality red wines.