



Climate change and its impact on the course of basic phenological processes in table grape varieties

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Abstract: Grapevine (*Vitis vinifera* L.) is among the most valuable and widespread crops in world agriculture, distinguished by its rich varietal diversity and wide economic significance. Within this diversity, table varieties occupy a special place as a crop intended for direct consumption, distinguished by an attractive appearance, balanced taste and high nutritional value. The phenological development of table grapevine varieties is an important indicator of their adaptability to agroclimatic conditions and effective production management in modern viticulture. The present study aims to assess the influence of climatic factors on the course of phenological phases in the local varieties "Super ran Bolgar", "Brestovitsa" and the introduced variety "Italia", grown in the Thracian Lowland region, by applying the unified BBCH scale. The experiment was conducted during two growing seasons (2023-2024). The main phenological stages were monitored: bud burst (BBCH 0:05 - 0:08), leaf development (BBCH 1:11), flowering (BBCH 6:60, 6:61, 6:65 and 6:69), fruit development (BBCH 7:75), fruit ripening (BBCH 8:81 - 8:85) and reaching technological ripeness (BBCH 8:89). The analysis was based on agrometeorological indicators - air temperature and precipitation. The results show that the temperature regime has a significant impact on the speed of transition between the individual BBCH phases, with a tendency to delay with increasing temperature. The variety "Super ran Bolgar" reaches the phases from 8:81 to 8:89 earlier, being characterized by the shortest vegetation period. "Italia" exhibits a longer phenological cycle and higher heat requirements, while "Brestovitsa" is characterized by intermediate indicators and good adaptability to varying climatic conditions. The obtained results emphasize the importance of the BBCH scale as a reliable tool for standardized assessment of phenological development and provide a scientific basis for optimizing agrotechnical practices and varietal selection in conditions of climate change.

Keywords: air temperature; BBCH scale; climate change; table grape varieties; phenological stages; precipitation

• Introduction

Early varieties, such as "Super ran Bolgar" and "Brestovitsa", have a shorter growing season and lower heat requirements. This makes them suitable for areas with more limited heat resources. On the other hand, the variety "Italia" belongs to the medium-late to late varieties, requiring a significant amount of heat to reach technological ripeness (Köse, 2014). For a standardized description of phenological stages in modern scientific literature, the BBCH scale (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) is widely used, which is a universal decimal system for coding plant development (Meier, 2018). The adaptation of the BBCH scale for the grapevine was developed by Lorenz et al. (1995), who created a detailed scheme for describing all the main and secondary phenological stages. The aim of the study is to assess the influence of climatic factors on the course of phenological phases in the local varieties "Super ran Bolgar", "Brestovitsa" and the introduced variety "Italia", grown in the Thracian Lowland region, by applying the unified BBCH scale.

• Material and method

The Super ran Bolgar is an early ripening table variety. Its grapes ripen in the first week of August. Brestovitsa variety is an mid-early ripening. Its grapes ripen in the second half of August. The vines are with vigorous growth, good fertility and high yield (Figure 1b). Italia variety is a late ripening. Its grapes ripen in the second half of September. Italia is a valuable variety with beautiful bunches and large amber-yellow berries, with sufficient sugars and acids (Figure 1c).



Figure 1. Super ran Bolgar (a); Brestovitsa (b); Italia (c)

The BBCH scale was used to determine the vine phenology. In this study, the phenological phases used were: bud burst (beginning, end), first leaf appearance, first inflorescens appearance, flowering (beginning, mass, end), fruit development (pea size) and veraison from beginning to technological ripeness (Table 1).

Table 1. Phenological phases and development with BBCH identification keys for grapevine

Main phases	Stage description	BBCH codes
0: Bud burst/buds development	05 „Wooly bud“: brown moss is clearly visible	0:05
	08 Bud burst: green shoot tips clearly visible	0:08
	11 The first leaf is open and spreads out to the shoot side.	1:11
6: Flowering	60 The first inflorescens is released from the bud	6:60
	61 Beginning of flowering: 10% inflorescens drop	6:61
	65 Mass flowering	6:65
	69 End of flowering	6:69
7: Berry development	75 Grape berries are the size of a pea	7:75
8: Veraison	81 Beginning of ripening: the berries begin to develop the varietal characteristics	8:81
	85 Berry softening	8:85
	89 Berries are ready for picking	8:89

Climatic data for the experimental period (2023 - 2024) were taken from the meteorological station located in the vineyard. The indicators of average monthly air temperature (°C) and precipitation (mm) are presented, which characterize the climatic features of the studied area (Figure 2 and 3).

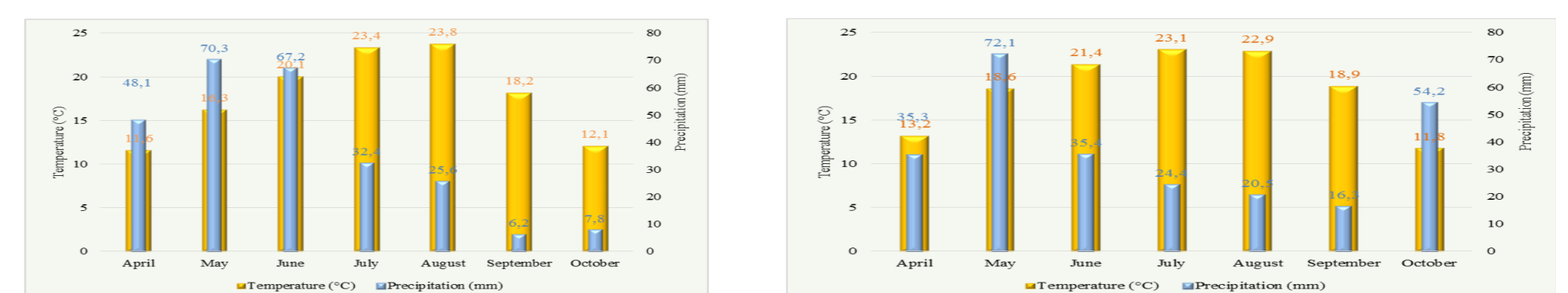


Figure 2. Average temperatures (°C) and precipitation (mm), April to October, 2023
 Figure 3. Average temperatures (°C) and precipitation (mm), April to October, 2024

• Results and discussions

Table grape varieties used are characterized by different ripening periods. Analysis on the BBCH scale shows a clearly pronounced interannual variability. In 2024, all observed phases occur earlier compared to 2023, with the shift varying between 5 and 14 days depending on stage and variety (Table 2).

Table 2. BBCH codes and dates of occurrence of phenological phases during 2023 and 2024

BBCH codes	Year	Super ran Bolgar	Brestovitsa	Italia
		Date	Date	Date
0:05	2023	04/04	06/04	07/04
	2024	26/03	28/03	30/03
0:08	2023	10/04	11/04	13/04
	2024	01/04	04/04	06/04
1:11	2023	12/04	13/04	15/04
	2024	03/04	06/04	08/04
6:60	2023	16/04	17/04	20/04
	2024	08/04	10/04	12/04
6:61	2023	03/06	05/06	07/06
	2024	20/05	27/05	28/05
6:65	2023	06/06	09/06	10/06
	2024	23/05	01/06	02/06
6:69	2023	11/06	13/06	15/06
	2024	31/05	03/06	05/06
7:75	2023	27/06	29/06	30/06
	2024	07/06	09/06	12/06
8:81	2023	17/07	27/07	10/08
	2024	13/07	20/07	28/07
8:85	2023	31/07	18/08	01/09
	2024	01/08	01/08	22/08
8:89	2023	14/08	25/08	13/09
	2024	10/08	18/08	02/09

• Conclusions

Phenological analysis on the BBCH scale shows a clear influence of climatic conditions on the development of the studied table grape varieties. In 2024, a significant shift of all phenological phases to earlier dates was found compared to 2023, which is an indicator of a faster accumulation of effective temperatures. Regardless of the interannual variability, the varieties maintain a stable sequence in terms of development, with Super ran Bolgar characterized by the earliest phenology, Brestovitsa occupying an intermediate position, and Italia the latest. The difference in harvest dates between varieties reaches 3–4 weeks, which creates an opportunity to extend the period of fresh grape supply. At the same time, interannual climatic conditions have a significant influence, with warmer years (e.g. 2024) observing a delay in the harvest to earlier dates. These results have important practical significance, as they allow for better planning of the harvest campaign, optimal allocation of labor resources, and increased market competitiveness through a longer presence on the market.