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BIOLOGICAL MANIFESTATIONS OF THE LOCAL BULGARIAN VARIETY PAMID IN THE CONDITIONS OF A CHANGING CLIMATE

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Abstract. *The aim of the research work is to analyze the biological manifestations of the local Bulgarian variety Pamid grown in the South central region. The experiment was conducted during the period 2022-2024. The duration of the main phenological phases in days during the vegetation of the vines was monitored (bud burst-first leaf, first leaf-flowering, flowering-pea size, pea size-veraison, veraison-technological ripeness, bud burst-technological ripeness). Emphasis is also placed on agrobiological indicators, in order to determine the reproductive variety potential, giving an overall assessment of its economic efficiency. High values of developed buds (84.63%) and a relatively high percentage of fruiting shoots (73.86%) were established, which contributes to the formation of a sustainable yield. The coefficient of actual fertility varies depending on climatic conditions, remaining within the limits for the variety (1.28) and reflecting the influence of the environment on the fruiting processes. The obtained average yield per vine (3.35 kg) and per hectare (10486.95 kg) shows relative stability even in the presence of climatic changes. Variety Pamid exhibits good adaptability to variations in temperature regime and water deficit. The study contributes to a better understanding of the response of local grape varieties to environmental changes and their role in the future development of the viticulture and wine sector. The obtained results confirm the importance of the variety Pamid as an adaptive local genotype with potential for sustainable viticulture, provided that appropriate agrotechnical practices are applied.*

Keywords*: bud burst, climatic conditions, coefficient of actual fertility, fruiting shoots, variety Pamid, yield*

INTRODUCTION

Biological manifestations of grape varieties represent a complex of morphological, physiological and productive characteristics that determine adaptability to environmental conditions and their economic value (JACKSON, 2020). The study of these manifestations is of great importance for optimizing agricultural techniques, selection and yield management. The main aspects include phenological development, agrobiological indicators, reproductive potential and yield (KELLER, 2020). In the grapevine, phenological phases are significantly influenced by climatic conditions - temperature, sunlight and water regime - which undoubtedly makes them important indicators in studying the impact of climate change on viticulture (PIÑA-REY et al., 2021; KELLER, 2020) and have a direct impact on grape yield and grape quality (PARKER et al., 2013; NISTOR, et al., 2025). Studies have shown that high temperatures accelerate the course of phenological phases, which can lead to ripening before the optimal balance of sugars and acids, or loss of aromatic compounds. (PARKER, et al., 2024). According to DUCHÊNE & SCHNEIDER (2005), increasing temperatures lead to accelerated ripening and changes in the chemical composition of grapes. According to NISTOR et al. (2025), warmer and drier conditions are associated with higher sugar accumulation and lower acidity, while cooler and wetter conditions reduce yields and delay ripening. Agrobiological indicators, such as the percentage of fruiting shoots, fertility coefficient and bunch mass, are strongly dependent on both the genetic characteristics of the variety and agroecological conditions (REYNOLDS, 2015). Bud fertility is one of the most important indicators and is determined by the number of primordial inflorescences into the buds. It is formed during the previous growing season and depends on the conditions of light and nutrition (KELLER, 2020). The reproductive potential is determined by its ability to form inflorescences, normal fertilization and form normally

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developed clusters (MAY, 2004). Pruning, irrigation and fertilization have a direct impact on agrobiological indicators. Increased stress can lead to a decrease in the bunch mass and production quality (KELLER, 2020). Disturbances in reproductive processes (adverse climatic conditions during flowering) can lead to a yield reduction. Yield is determined by the number of bunches per vine, the average bunch mass, the planting density (PONI et al., 2006) and represents the amount of grapes produced per unit area or per vine and is the result of the interaction of all biological processes (REYNOLDS, 2015). Studies by BADUCA et al. (2020), show that yield is highly dependent on climatic conditions and technological practices. According to Van LEEUWEN et al. (2004), the water regime is an important factor for the growth and productivity of the vine. Water shortage reduces yield, but often increases the quality of the produce (MEDRANO et al., 2003). On the other hand, excessive rainfall increases the risk of diseases and reduces the product quality (JONES et al., 2005). Based on the analysis of the literature sources, it can be summarized that grape varieties have different productive potential and their realization depends largely on climatic conditions. In Bulgarian viticulture, Pamid variety has traditional importance. Studies by YONCHEVA et al., (2014) show significant differences in some selected forms in terms of sugar content and yield. In recent decades, a decrease in its distribution has been observed, which requires a more in-depth study of its biological characteristics and adaptation to climate change.

The aim of the study is to analyze the biological manifestations of the local Bulgarian variety Pamid, grown in the South Central region.

MATERIAL AND METHODS

The subject of the study was the Pamid variety, grafted onto the Berlandieri x Riparia SO4 rootstock, planted in the region of the town of Pazardzhik, Plovdiv region, Southern Bulgaria. The vineyard is located in a transitional-temperate-continental zone with slight Mediterranean influences. The average altitude is 467 m. The terrain has a hilly relief and a wide valley, which defines it as a local microclimate favorable for viticulture. The vines are in full fruiting, grown under non-irrigated conditions. The planting distance is 3.20 m between rows and 1.00 m between vines in the row - 3120.5 vines per hectare. The training system is a high-stemmed double cordon with corresponding trellis structure. The vines are pruned on spurs with two buds, a total of 6 spurs /12 buds/ per vine. The inter-rows are cultivated with a disk harrow.

Pamid variety is a late-ripening wine variety in the second half of September. The vines are characterized by vigorous growth, upright shoots and hard wood. The bunch is medium-sized, cylindrical-conical, semi-compact to loose (Figure 1). The berries are medium-large, rounded, weakly attached to the stalk. The skin is red, in some variations dark red, thin, fragile, covered with a waxy coating. The consistency of the mesocarp is juicy and crunchy. The taste is sweet, harmonious and neutral. Pruning is carried out mainly on short fruiting units - spurs with 2-3 buds, but if necessary, long fruiting units - arrows are also left. The variety is not resistant to diseases and pests. In Bulgarien climatic conditions, it rarely suffers from low winter temperatures and is used to make light, red or rosé wines with a pleasant taste. The grapes are also preferred for fresh consumption. The variety was included in the official list of Republic of Bulgaria in 2010 (ROYCHEV, 2014).

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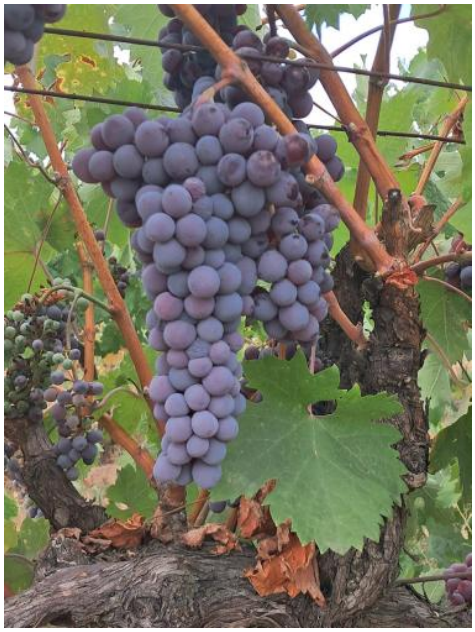

Figure 1. Bunch of Pamid

During the three experimental years (2022, 2023, 2024), phenological observations were conducted of the main phases of vine development during the vegetation: sap flow, bud burst, first leaf appereance, first inflorescens appereance, flowering, berry growth /pea size/, softening /color changing/, technological ripeness. For this purpose, normally developed vines that have entered full fruiting were selected. The beginning of the phase is considered to be the day on which 5% of the vines have entered it, mass entry - 50% of the vines and the end, when 95% of the vines have entered the corresponding phase (BRAYKOV et al., 2005).

The duration of main phenological phases in days is presented: sap flow - bud burst, bud burst - first leaf appearance, first leaf - flowering, flowering - pea size, pea size - veraison, veraison - technological ripeness, bud burst – technological ripeness.

Included indicators characterizing the actual fertility and grape yield: developed buds (%), fruiting shoots (%), coefficient of actual fertility /Kr/, average yield from per vine (kg), average yield per ha (kg), determined according to the generally accepted methodology of Roychev, (2014).

The data on the climatic indicators: average monthly air temperature (ºC) and amount of precipitation (mm), were taken from the meteorological station located in the experimental vineyard (Figure 2 and 3).

The region is characterized by warm and sunny summers, with prevailing daily temperatures in July–August often above 25 °C. Mild to moderately cold winters, with minimum temperatures, sometimes below 0 °C on the coldest days. The average monthly air temperature in 2022 is 14.26 ºC, in 2023 it is 15.30 ºC, and in 2024 it is 16.70 ºC.

The indicator for assessing the moisture security of plants is the amount of precipitation, which under non-irrigated conditions is the main element of the water balance. The annual amount of precipitation for 2022 is 556.6 mm, in 2023 it is 489.7 mm, and in 2024 - 574.9 mm.

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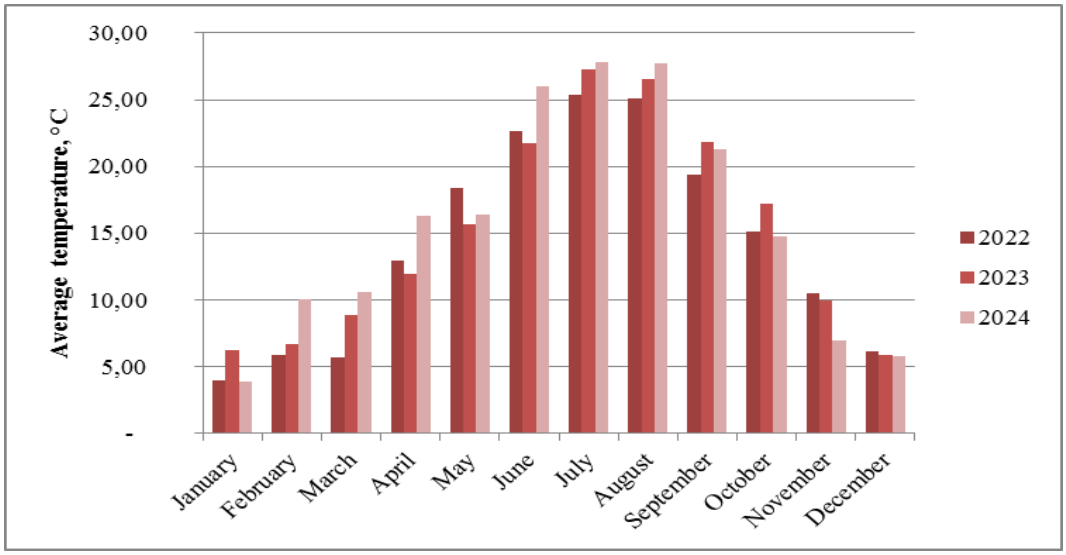

Figure 2. Average monthly air temperature, 2022-2024

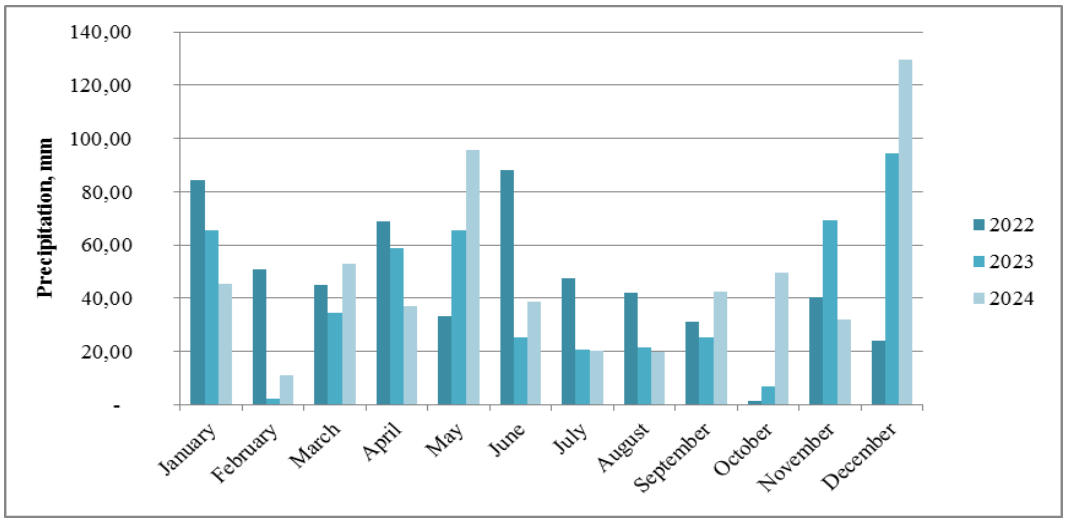

Figure 3. Precipitation, 2022-2024

The correlation analysis was performed using MS Excel.

RESULTS AND DISCUSSIONS

Pamid variety is one of the oldest and traditional Bulgarian wine varieties, grown for centuries mainly in Southern Bulgaria. It is distinguished by its early ripening and relatively short growing season, which makes it adaptable to a variety of climatic conditions.

Its phenological phases follow the typical vine cycle, but occur relatively earlier compared to other red varieties.

The results obtained for the duration of phenophases in days during the period 2022–2024 show a clear dependence on climatic conditions during the individual growing seasons (Table 1). The observed variations between years are mainly due to the temperature regime and water status of the plants.

In 2022, an extension of the phases from pea size to veraison (43 days) and from veraison to technological ripeness (51 days) was found, which is due to the lower temperature and increased humidity in the second half of the growing season. These conditions led to a longer ripening period.

In 2023, an extension of the early and intermediate phenophases was recorded - from bud burst to the first leaf appereance (12 days), from the first leaf to flowering (46 days) and from flowering to the pea size berries (30 days). This is an indicator of a cooler and wetter spring, which has slowed down the initial development and led to an extension of the growing season (165 days).

2024 is characterized by an extension of the period from the first leaf to flowering (11 days), combined with a shortening the time from veraison to technological ripeness (40 days). This dynamics is due to the presence of cooler conditions in the spring, followed by higher temperatures and drought during the ripening period, which has accelerated physiological processes and shortened the period from bud burst to the onset of technological ripeness (158 days).

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	13 a	9a	41a	26a	43b	51b	159a
2023	12 a	12b	46a	30b	35a	45a	165a
2024	12 a	11a	48b	29a	34a	40a	158a
Average	12,33	10,66	45,00	28,33	37,33	45,33	160,66

* Mean values denoted by different letters differ statistically significantly at $p < 0.05$ (one-way ANOVA)

The results obtained for the actual fertility and yield of the Pamid variety during the period 2022–2024 show distinct interannual variability, mainly determined by climatic conditions during the growing season.

The highest values of the percentage of developed buds (86.40%) and a relatively high share of fruiting shoots (78.70%) were established in 2022, which was also accompanied by the highest coefficient of actual fertility (Kr - 1.32).

This has a positive effect on the yield, when the highest average yield per vine (3.74 kg) and per unit of area (11680.75 kg/ha) was also recorded. These results suggest favorable conditions for the setting and development of buds in the previous year, as well as good conditions during the growing season.

In 2023, there was a slight decrease in the percentage of fruiting shoots (72.40%) and the coefficient of actual fertility (1.28), although the percentage of developed buds remained relatively high (84.70%). This led to a slight reduction in yield (3.36 kg per vine and 10500.00 kg per ha).

Table 2

Actual fertility and grape yield during the period 2022 - 2024

Year	Developed buds %	Fruiting shoots, %	Coefficient of actual fertility Cf.	Average yield per vine, (kg)	Average yield per ha (kg)
2022	86,40a	78,70b	1,32b	3,74b	11680,75b
2023	84,70a	72,40a	1,28a	3,36a	10500,00a
2024	82,80a	70,50a	1,25a	2,97a	9280,12b
Average	84,63	73,86	1,28	3,35	10486,95

* Mean values denoted by different letters differ statistically significantly at $p < 0.05$ (one-way ANOVA)

The lowest values of all studied indicators were recorded in 2024 – both for developed buds (82.80%) and fruiting shoots (70.50%), as well as for the coefficient of actual fertility (1.25) and yield (2.97 kg per vine and 928.12 kg per ha). The established statistically significant differences in yield indicate a clear deterioration in productivity. This is probably due to the combined influence of unfavorable climatic conditions – weaker fruit bud setting in the previous season and stress factors during the current vegetation (drought, high temperatures), which limited the development and yield realization.

CONCLUSIONS

Pamid variety exhibits variability in phenological development, fertility and yield, determined by climatic conditions. The average duration of the period from bud burst to technological ripeness is 160.66 days, with the longest in 2023 (165 days) and the shortest in 2024 (158 days).

Actual fertility varies from 1.25 to 1.32, with the highest in 2022 (1.32), accompanied by the highest percentage of fruiting shoots (78.70%) and the highest yield - 3.74 kg per vine and 11680.75 kg per ha. In 2024, the lowest values were recorded for both fertility (1.25) and yield (2.97 kg per vine and 9280.12 kg per ha).

A direct relationship were established between the duration of the phenological phases, the level of fertility and yield, with a more balanced course of vegetation in 2022 ensuring higher productivity, while deviations in the temperature and water regime during the study period led to a yield reduction.

The Pamid variety demonstrates good biological resistance and relatively stable development, but its productivity is sensitive to changes in climatic conditions. The results obtained emphasize the need to optimize agrotechnical measures and implement adaptive practices in order to maintain stable yields in conditions of climatic variability.

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