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*Original Contribution*

# SHOOT REGULATION THROUGH SUMMER PRUNING AT THE BULGARIAN GRAPE VARIETY MAVRUD

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**ABSTRACT**

The present study evaluates the influence of different summer (green) prunings on the shoot growth dynamics of the Mavrud variety, grown in the area of the village of Benkovski, Plovdiv region, Bulgaria. In 2023 and 2024, four variants of summer pruning were applied – control ($V_0$ – without summer pruning), thinning only ($V_1$), thinning and secondary shoot removal ($V_2$) and combined summer pruning – thinning, secondary shoot removal and bunch removal ($V_3$). The results show that all types of summer pruning stimulate shoot growth compared to the control, with the most pronounced effect observed in $V_3$ – the growth in August reached 293.8 cm (over 58 cm more than $V_0$). The increased temperatures and better water supply in 2024 lead to significantly more intensive growth compared to the previous year. The analysis of variance confirms statistically significant differences between the variants ($p \leq 0.05$), with the greatest annual progress being recorded for $V_2$ and $V_3$. The study emphasizes that combined summer pruning effectively regulates vegetative growth in strong-growing varieties such as Mavrud, which is of great importance for the balance between growth and productivity of the vine. The results obtained can serve as a basis for optimizing agrotechnical measures in the conditions of climate change in the cultivation of the Mavrud variety.

**Keywords:** summer pruning, canopy management, grapevine, Mavrud variety

## INTRODUCTION

Summer (green) pruning are an indispensable part of the modern system of viticultural practices, with an important role in maintaining a balance between vegetative and generative growth in the vine (1-7). It includes a series of operations such as thinning, secondary shoot removal, thinning of bunches and leaves, which aim to improve the light and air regime in the vineyard, reduce shading and diseases and increase the quality of the grapes (8-10).

Due to changing climatic conditions and the increasingly urgent need for sustainable management of vineyards, attention to summer pruning is increasing both in research and practice. Summer pruning have a direct impact on photosynthetic activity, transpiration and carbohydrate balance of the vine (11, 12). Their impact on shoot growth dynamics is particularly significant, as excessive vegetative growth leads to competition between organs and delayed ripening of production (13, 14). In wine varieties, the vine is often grown in conditions where high quality, not only quantity, of production is sought. Therefore, the management of vegetative mass through green pruning is of crucial importance (15). The Mavrud variety (*Vitis vinifera* L.), one of the most valued Bulgarian varieties, is characterized by strong growth and high plasticity to agrotechnical and climatic influences (16, 17). Its sensitivity to bud severity and shading makes it a suitable object for studying the influence of various summer prunings.

The aim of this study is to analyze the effect of various summer prunings on the length and growth dynamics of shoots, with a view to formulating scientifically based recommendations for optimizing green operations for Mavrud variety in the conditions of the Plovdiv wine-growing region.

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## MATERIAL AND METHODS

The study was conducted in 2023 and 2024 in a vineyard located in the area of the village of Benkovski, Plovdiv region, Bulgaria on the Mavrud variety, grafted onto the *Berlandieri x Rupestris* 110 Richter rootstock. The vines were grown on the Guyot training system without irrigation. The planting distances were 2.90 × 1.30 m. The vine severity include 2 fruiting canes with 12 buds and two spurs.

The experiment was set up in four variants with three replications. Each variant included 20 vines, subjected to different methods of green pruning, as follows:
$V_0$ – control variant, without summer pruning;
$V_1$ – thinning on the stems and fruiting cane;
$V_2$ – thinning and secondary shoot removal;
$V_3$ – thinning, secondary shoot removal and bunch thinning in phase pea size berry – 8 bunches are left per vine.

Observations were conducted monthly from May to August, measuring the length of the shoots (in cm) using a tape measure. Growth dynamics are presented as mean values ($\bar{X}$) and standard deviation (SD). Meteorological data (average monthly temperature and rainfall) were obtained from an agrometeorological station located in the vineyard.

Correlation analysis was used to determine the influence of temperature and rainfalls on shoot growth dynamics.

## RESULTS AND DISCUSSION

The data from **Table 1** show a moderate to warm climate typical for Plovdiv region, suitable for growing wine varieties such as Mavrud. The annual temperature range follows the typical continental amplitude – from 4.2–4.5°C in January to about 26.6–26.9°C in July-August.

***Table 1.*** *Average monthly air temperature (°C) in Benkovski village for the period 2023-2024*

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2023 | 4.2 | 7.8 | 10.3 | 13.5 | 18.3 | 23.3 | 26.0 | 26.6 | 20.9 | 15.4 | 8.2 | 5.7 |
| 2024 | 4.5 | 8.1 | 11.0 | 14.2 | 18.9 | 23.7 | 26.4 | 26.9 | 21.3 | 15.0 | 7.1 | 4.4 |

Throughout the spring and summer months, temperatures in 2024 were higher than in 2023 (by an average of 0.4–0.7°C). This suggests faster shoot development, accelerated phenology, and potentially an earlier harvest.

There is a decrease in temperatures in November and December 2024 compared to the previous year, which may lead to a longer dormancy period.

May, June and July are verry important for the elongation of shoots. In these months, temperatures for both years were optimal for the vine (between 18.3 and 26.4°C), with the values from 2024 being slightly higher. August is among the hottest months (26.6°C in 2023 and 26.9°C in 2024), coinciding with the beginning of grape ripening – such a temperature favors the accumulation of sugars. September and October are important for the ripening of grapes. Temperatures here remain moderate (15–21°C), which helps maintain acidity in the Mavrud variety.

**Table 2** presents the amount of rainfalls in the Mavrud variety vineyard during the period 2023-2024. The area of the village of Benkovski demonstrates a regime characterized by higher rainfall activity in spring and autumn and significantly drier summer months, especially in July and August.

The average annual rainfalls in 2023 is 379.0 mm, while in 2024 it is 392.4 mm. This shows a slight increase of 13.4 mm.

***Table 2.*** *Amount of rainfalls (mm) in (Benkovski village for the period 2023-2024*

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2023 | 28.1 | 7.7 | 34.8 | 53.3 | 43.5 | 40.7 | 8.9 | 14.2 | 27.0 | 4.9 | 60.4 | 55.5 |
| 2024 | 39.2 | 24.3 | 25.8 | 45.8 | 55.6 | 35.9 | 18.9 | 10.5 | 19.5 | 9.9 | 57.4 | 49.6 |

In 2024, significantly more rainfalls were recorded in January and February, which led to better soil water storage before the start of the growing season.
March was drier compared to 2023 (–9.0 mm), which most likely affected the start of sap flow. April and June were slightly drier in 2024, but this did not prevent active shoot growth. May and July were wetter in 2024, with July 2024 having significantly more rainfall (18.9 mm compared to 8.9 mm in 2023) which supported shoot growth and berry formation. August and

September in 2024 were drier, which limited excessive vegetative growth and was favorable for the accumulation of sugars in the grapes. July–August remained the driest months in both years – which is typical for the Southern wine-growing region in Bulgaria.

Rainfalls in autumn and early winter were relatively high in both years. This contributed to better storing the soil with water, which was needed during the next growing season.

The data in **Figure 1** clearly demonstrate the positive linear relationship between the average monthly temperature and shoot length of the Mavrud variety in the conditions of the Benkovski village region for the period May–August in 2023 and 2024. All green pruning options ($V_0$–$V_3$) show a consistent increase in vegetative growth with increasing temperatures.

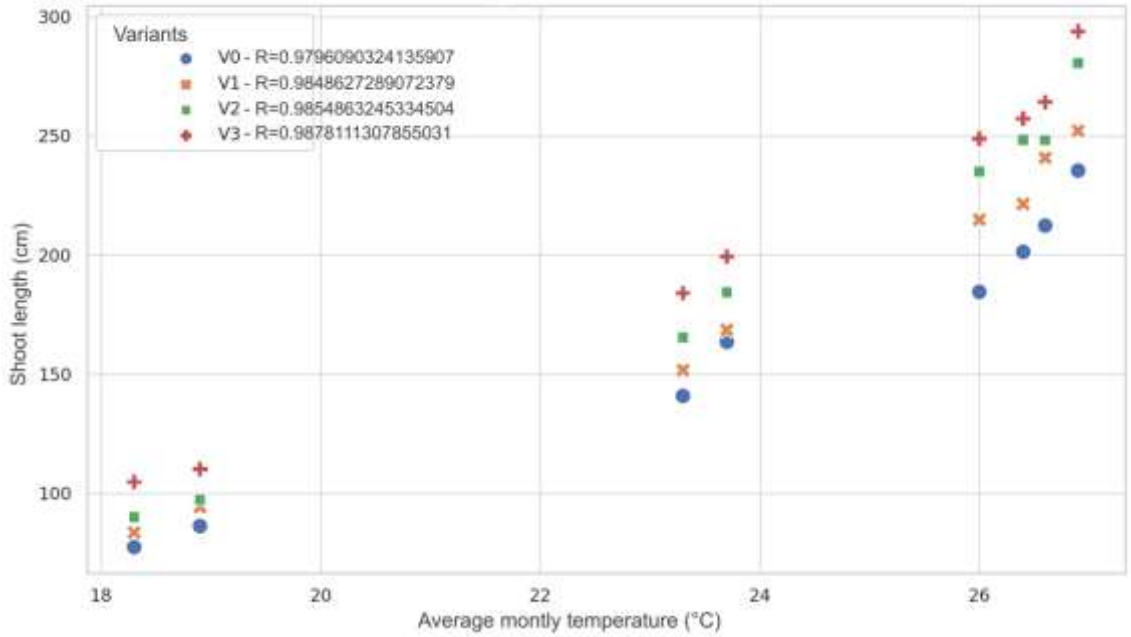


**Figure 1.** Relationship between temperature and shoot length by variant in 2023 and 2024 for the months of May-August

The correlation coefficient (R > 0.97) for all variants confirms that temperature is a major limiting and stimulating factor for shoot growth. This is particularly important for practice, since in conditions of climate warming, the correct application of green pruning can be used as a tool for optimizing the vegetative growth of vines.

The most significant practical conclusion from the graphical analysis is that at temperatures above 23°C the growth response is more intense in variants with two or three green pruning methods, while the control remains with a limited capacity to use the heat resource.

The graphical representation of the relationship between the amount of monthly rainfalls and the length of shoots **(Figure 2)** shows a clear negative correlation for all studied variants with summer pruning. With increased rainfall amounts, especially in the spring months, weaker vegetative growth is observed, while under drier conditions – mainly in July and August – the length of shoots reaches maximum values.

The correlation coefficients for all variants (R – 0.93) confirm the high degree of inversely proportional relationship between rainfall and vegetative growth.

The control variant $V_0$, although without green pruning, also follows this pattern – its lowest values coincide with rainfall intensive months, while relatively increased growth is recorded during dry and warm periods.

This result emphasizes that pruning, which reduces leaf mass and optimizes the microclimate of the habitus, enhances the vine's ability to take advantage of dry and warm conditions, which is particularly relevant in conditions of climate change.

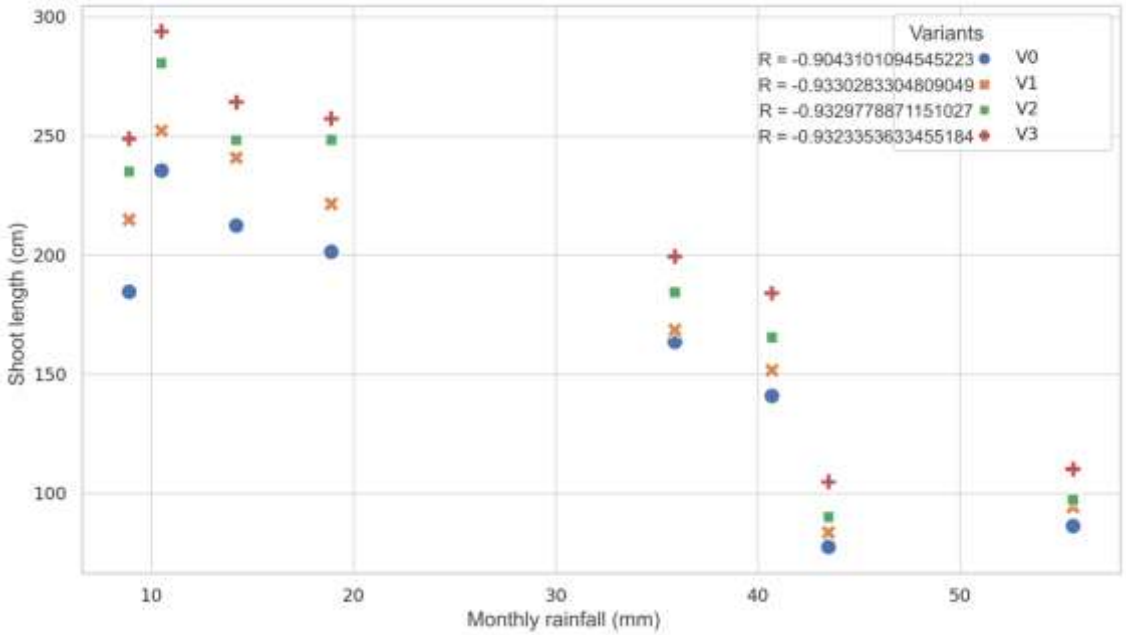


**Figure 2.** Relationship between fainfall and shoot length by variants in 2023 and 2024 for the months of May-August

**Table 3** presents the average shoot lengths (in cm) for four summer pruning variants ($V_0$–$V_3$) during the period May–August in 2023 and 2024.

***Table 3.*** *Shoot growth dynamics in cm during the period 2023-2024, (Xcp±SD)*

| Year | Months | Variants | | | |
|---|---|---|---|---|---|
| | | $V_0$ | $V_1$ | $V_2$ | $V_3$ |
| 2023 | May | 77.4±4.321 | 83.5±4.934 | 89.9±4.998 | 104.7±5.298 |
| | June | 140.8±4.073 | 151.6±4.847 | 165.4±5.091 | 183.9±4.640 |
| | July | 184.5±5.974 | 214.8±5.693 | 234.9±5.866 | 248.8±5.128 |
| | August | 212.3±4.209 | 240.8±5.982 | 248.2±7.234 | 264.1±6.853 |
| 2024 | May | 86.2±4.984 | 94.3±3.983 | 97.2±4.332 | 110.1±3.583 |
| | June | 163.5±3.012 | 168.5±4.456 | 184.3±3.298 | 199.3±4.643 |
| | July | 201.3±5.340 | 221.4±4.492 | 248.3±3.977 | 257.2±4.841 |
| | August | 235.4±4.121 | 252.1±4.083 | 280.6±4.936 | 293.8±5.221 |

Variant $V_3$ demonstrated the greatest growth in each month, most clearly since May (+35% compared to the control). Combined green pruning ($V_2$ and $V_3$) significantly stimulated the elongation of shoots compared to $V_0$. The variant with thinning only ($V_1$) also showed good results, but with a less expressed increase. All variants show better development compared to 2023, especially in May and June, which is related to slightly warmer and wetter conditions in these months **(Tables 1 and 2).**

The differences between $V_2$ and $V_3$ remain clearly pronounced, with $V_3$ exceeding 290 cm in August – the highest value for both seasons. The control variant ($V_0$) reaches only 235.4 cm in August – nearly 60 cm less than $V_3$. The greatest progress between years is in $V_2$, followed by $V_3$, which confirms that complex pruning most effectively promotes growth.

Increased humidity in early 2024 (February–May) and moderate temperatures likely contributed to more intense vegetative growth. The combination of thinning, secondary shoot removal and bunch thinning ($V_3$) results in a significant increase in vegetative mass, which is beneficial in vine systems with high leaf area (e.g. Guyot), but may require additional regulation to avoid shading and uneven ripening of the grapes.

The standard deviation values are within 3–7 cm, which indicates stability of the results and reliability of the applied agrotechnical measures.

## CONCLUSION

The results of the two-year study clearly confirm the significant influence of different summer (green) prunings on the shoot growth dynamics of the Mavrud variety, grown after the Guyot training system in the area of the village of Benkovski.

All applied summer pruning variants stimulate vegetative growth compared to the control variant without pruning ($V_0$), with the highest values being recorded with the combined application of thinning, secondary shoot removal and bunch removal ($V_3$).

Variant $V_3$ demonstrated the greatest growth in all phases of vegetation, reaching an average shoot length of 293.8 cm in August – 58.4 cm more than the control. This highlights the effectiveness of complex green pruning in varieties with intensive growth such as Mavrud. Weather conditions in 2024 were more favorable for vegetative development, with higher temperatures and better water supply, especially in the period February–May. This led to significantly more intensive shoot growth compared to 2023.

The greatest progress between the two years was recorded in $V_2$ and $V_3$, which shows that these variants are particularly effective under favorable climatic conditions and can be recommended for practical application in the region. Despite the increased growth, in variants with combined pruning it is necessary to monitor possible shading and uneven ripening, which requires a precise approach on loading and additional regulation of leaf mass.

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