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BEHAVIOR OF SOME BLUEBERRY VARIETIES ON DIFFERENT GROWING SYSTEMS IN THE BUCHAREST AREA

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Abstract

In Romania, interest in blueberry cultivation has increased significantly in recent years, due to the growing market demand for this nutrient-rich and antioxidant-packed fruit. Thus, cultivating blueberries can not only bring substantial economic benefits, but also contribute to environmental protection and to improving consumer health. This makes blueberries a particularly attractive choice for farmers and investors, as well as a smart and advantageous option from multiple perspectives: economic, ecological, and health-related. The objective of this study was to evaluate the main growth and fruiting characteristics of 17 blueberry cultivars (Vaccinium corymbosum L.) grown in the Bucharest area, in two ridge cultivation systems: trellised and free (no wired). The correlation analysis highlights the fact that the trellised system provides a much more coherent relationship between vegetative parameters (no of stems, shoots, and buds) and fruiting potential, suggesting a superior and more efficient use of the plant's physiological resources. At the same time, we seized that the total yield is not strictly determined by the number of fruits, reflecting differences among cultivars in terms of fruit size and average fruit weight. This aspect and results could be explained by the fact that the analysed plants are still young and have not yet reached their maximum biological fruiting potential.

Key words*: Vaccinium corymbosum L.,* trellising, growing system, productivity.

INTRODUCTION

Blueberry belongs to the Ericaceae family, genus *Vaccinium*, which includes over 200 wild and cultivated species. The bog blueberry (*Vaccinium uliginosum* L.), the bilberry (*Vaccinium myrtillus* L.), and the lingonberry (*Vaccinium vitis-idaea* L.) are among the spontaneous species found in Romania, especially in hilly pre-mountain and mountain areas. They grow as low shrubs (between 20-50 cm tall, and very rarely up to 80 cm), with creeping stems and small fruits. Cultivated blueberry varieties (highbush types) - tall shrubs that can reach 1-3 meters in height - produce fruits that are two to four times larger than those of wild blueberries, originating mostly from three American species: *Vaccinium corymbosum* (primarily), *Vaccinium lamarckii*, and *Vaccinium angustifolia*.

Blueberries are among the most popular fruits in North America, being rich in anthocyanins, which have beneficial health effects against several chronic diseases, including cardio-vascular disorders, neurodegenerative diseases, diabetes, and cancer (Routray & Orsat, 2011).

In Romania, the interest in blueberry cultivation has increased significantly in recent years due to the rising market demand for this nutrient-and antioxidant-rich fruit. An important aspect is the presence of European funding programs that support farmers in establishing and developing blueberry plantations. Access to EU funds has stimulated investment in this crop, and Romania currently reports over 2,200 hectares (Asănică et al., 2017; IBO report, 2025). Blueberry cultivation is of great importance today due to the high antioxidant content of the fruits and their contribution to a healthy diet (Asănică et al., 2023). Thus, blueberry cultivation can not only generate significant economic benefits but also contribute to environmental protection and improved consumer health. This makes blueberries an especially attractive option for farmers and investors, as well as a smart and

advantageous choice from economic, ecological, and health perspectives.
Fruit production may be delayed by climatic characteristics, and some years can significantly influence the progression of blueberry phenophases, influencing the quality of compounds accumulated in the fruits.
The results presented are important for farmers, providing the information needed to cultivate varieties that are preferred by consumers (Ojog et al., 2024), in close correlation with the phenotypic plasticity specific to each variety in response to gradual changes in environmental conditions (Cosmulescu et al., 2022). An innovative study by Asănică et al. (2023) proposed an upright training system for blueberries by transforming the natural bush architecture into one with multiple vertical axes supported by wires and posts. Results for the 'Coville' and 'Blueray' cultivars showed that although total yield per bush was slightly higher than in the traditional system, the fruits obtained in the vertical system had superior quality (larger berries, improved color), more uniform fruit set, easier harvesting, and better light utilization - all beneficial for small farms. Large differences among cultivars in growth, soluble sugar content, and antioxidant enzyme activity were found when testing 15 cultivars for tolerance to high soil pH, identifying groups of varieties with high pH tolerance (Hao et al., 2022). Alternatives to traditional open-field production include protected environments, greenhouses, high tunnels, high-density plantings, plant production systems, and pot production. All these systems have demonstrated the potential to produce high yields of top-quality berries. Recently, pot blueberry production using soilless substrates has attracted increasing interest as a viable alternative to open-field planting (Smrke et al., 2022).

MATERIALS AND METHODS

In this paper, 17 blueberry varieties (*Vaccinium corymbosum* L.) were analysed from the Experimental Field of the Faculty of Horticulture (Figure 1) in Bucharest, within the blueberry variety collection established in 2018, in two ridge cultivation systems: trellised and untrellised, with 5 plants per cultivar.

Figure 1. Experimental field of the Faculty of Horticulture

A planting distance of 3 × 0.8 m, with raised beds covered with agrotextile, and a drip irrigation system (each plant having two drippers) was provided to the experimental plot.

Figure 2. Planting blueberries on raised beds

For planting, a quantity of 60 liters of acidic peat (Kekkila FBM 525) was calculated for each plant, and in the process, the peat was mixed with the existing substrate using a rotary tiller before the ridge was formed (Figure 2). The planting layout included 17 blueberry cultivars arranged in two mirror rows, each row containing 85 plants. The trellising system was realised using concrete poles installed along the length of the row, while the trellising of the blueberry stems was carried out using a system of wires positioned laterally at two levels, 45 cm from the bed and 100 cm the second layer.
In 2023, the plants were trellised using fastening clips attached to the supporting wires.
To evaluate the 17 blueberry varieties behaviour, determinations were made on the following quantitative and qualitative characteristics of the main growth and fruiting traits (Cociu & Oprea, 1989):

• average number of stems per plant;
• average length of annual shoots (cm) measured by assessing all shoots;
• number of fruit buds before bud break;
• number of fruits set before entering in the ripening stage;
• average fruit yield (g/plant).

Natural conditions of the research area.

The Municipality of Bucharest is located in the Vlăsia Plain, the central subdivision of the Romanian Plain. It is bordered by the Titu–Gherghița Plain to the North, the Bărăganul Mostiștei (or Southern Bărăgan) Plain to the east and South-East, the middle course of the Ialomița River to the North-East, and the lower Argeș River valley to the West and South-West. The plain is typically tabular, with wide and smooth interfluves.

The geological foundation consists of Proterozoic crystalline deposits belonging to the Wallachian Platform. Above this foundation lie Paleozoic and Mesozoic sedimentary layers, which are overlain by Quaternary surface materials. These include 2-12 m thick loess layers, within which numerous depressions have formed through settlement and suffosion processes. The Bucharest Plain, a subunit of the Vlăsia Plain, has altitudes ranging from 100-115 m in the northwest to 50-60 m in the southeast, in the Dâmbovița floodplain. The city itself varies between 58 m and 90 m in elevation, while the Băneasa (or Otopeni) Field, located North of the Colentina Valley, reaches 90-95 m. Overall, the terrain has the appearance of a gently undulating plain.

The climate is temperate-continental, characterized by moderate thermal extremes caused by high urban density, heavy traffic, and industrial activities. While the annual mean temperature is 10.7°C in peripheral areas, the central zone records an average of 12°C. In climatologically normal years, summers are warm - sometimes hot - and often marked by drought, while winters are cold and with abundant snowfall, especially in the northern districts. Springs are short, with large temperature fluctuations from month to month and significant differences between day and night. Autumn is characterized by moderate temperatures and a gradual transition toward winter. The frost-free interval of 178-205 days and the growing season of about 245 days are generally favourable for cereal crops as well as various fruit, vegetable, and ornamental species.

Annual precipitation ranges between 550 and 600 mm, with maxima recorded in June-July. Showers and torrential rains are frequent. Dominant air circulation comes from the east and northeast during winter and from the west in the rest of the year. Maximum wind speeds range between 4-5 m/s.

Soil pedological and agrochemical characterization.

The predominant soil in the study area is a reddish preluvosol, characterized by a low humus content of 2.5%, a loam-clay texture, a pH of 6.2, and low to medium nutrient supply (N, P, K). Blueberry requires medium-textured, well-drained soils without gleying to a depth of 40–50 cm and an acidic reaction. The optimal soil pH range is between 4.3 and 5.5. Lowering soil pH before planting and maintaining healthy plants is essential. Soil acidification is typically achieved by adding elemental sulfur or other sulfur-based amendments (approximately 250 kg sulfur/ha to decrease soil pH by one unit). For acidifying soils intended for blueberry cultivation, the soil must be mixed with acidic peat at a 1:1 ratio to a depth of 15-30 cm.

Data interpretation.

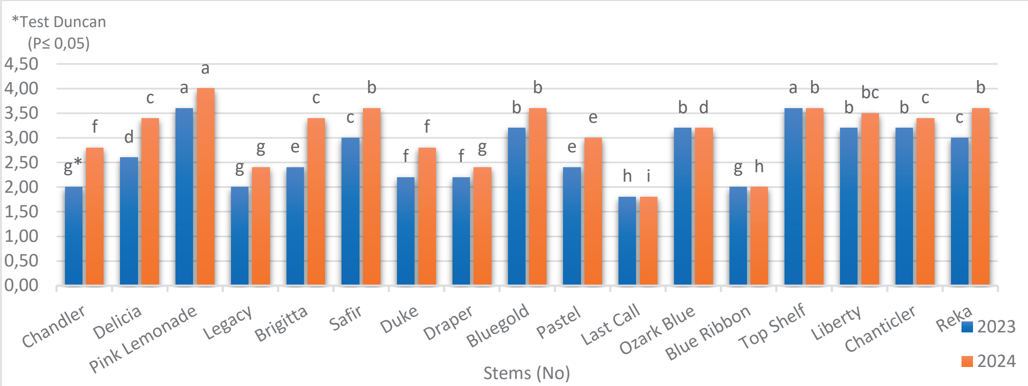
Statistical analysis was performed using IBM SPSS 14 program (SPSS Inc., Chicago, IL, USA). All results were statistically evaluated by analysis of variance (ANOVA). Differences between cultivars were highlighted through Duncan's multiple test range ($p< 0.005$). Graphical representations were performed with Microsoft Office Excel 2007.

RESULTS AND DISCUSSIONS

The comparative analysis conducted for the two growing systems, untrellising vs. trellising, was carried out over two years (2023 and 2024) for the following growth and fruiting characteristics, together with a simple correlation analysis between growth and fruiting traits.

Average number of stems per plant

For the untrellising system, the values ranged from 1.8 stems ('Last Call') to 3.6 stems ('Top Shelf', 'Pink Lemonade') in 2023, and from 1.8 stems ('Last Call') to 4.0 stems ('Pink Lemonade') in 2024 (Figure 3).

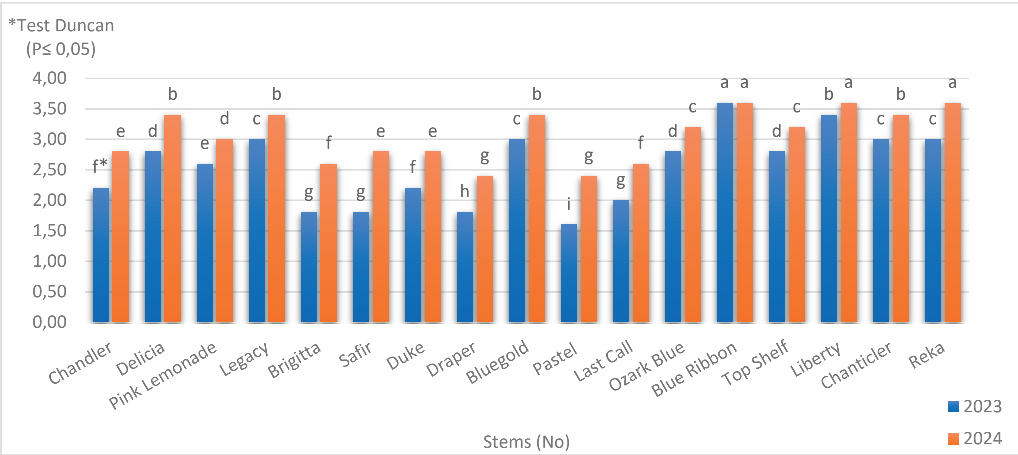


*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 3. Influence of the untrellised system on the average number of stems/plant

In the trellising system, vegetative growth was slightly lower in the first year, ranging between 1.6-3.6 stems, but became more uniform in 2024 (range: 2.4-3.6 stems) (Figure 4).

The ANOVA statistical analysis ($\alpha = 0.05$) shows that the differences among cultivars are not statistically significant ($p > 0.05$). However, the biological tendency toward increased stem production in cultivars with high vegetative potential ('Reka', 'Top Shelf', 'Pink Lemonade') is evident.

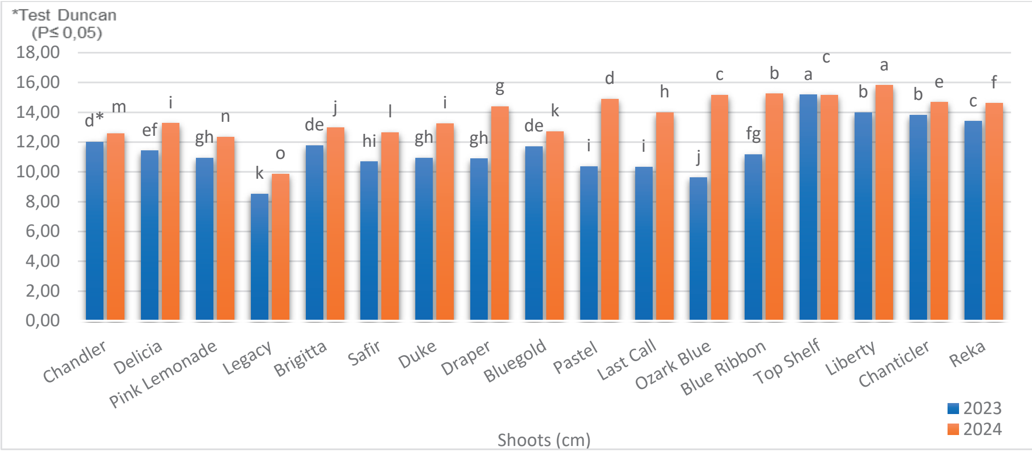


*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 4. Influence of the trellising system on the average number of stems/plant

Average length of annual shoots (cm)

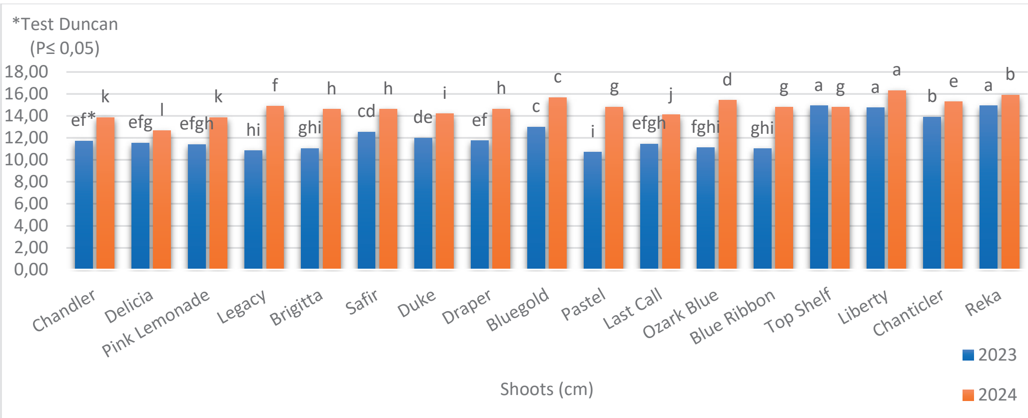
For the bush free type (non-trellised) training system, the Duncan test grouped the studied cultivars into 11 classes for 2023 and 15 classes for 2024, while for the trellised system the grouping ranged between 9 and 12 classes. In the non-trellised variant, the average shoot length increased from 8.5 cm ('Legacy') to 15.17 cm ('Top Shelf') in 2023, and in 2024 from 9.87 cm ('Legacy') to 15.81 cm ('Liberty') (Figure 5).



*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 5. Influence of the untrellised system on the average length of shoots (cm/plant)

In the trellising variant, the values were higher, reaching in 2024 a maximum of 16.32 cm (‘Liberty’) (Figure 6). The more vigorous cultivars respond better to trellising, which optimizes light exposure and ensures the balanced development of the vegetative growths.

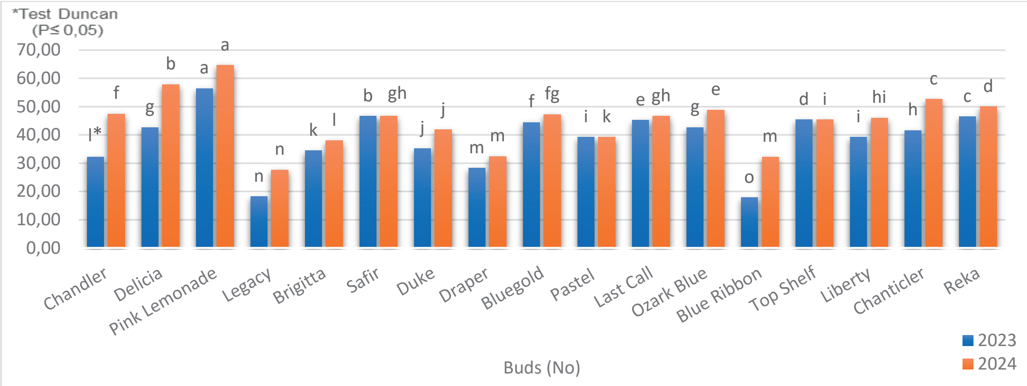


*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 6. Influence of the trellising system on the average length of shoots (cm/plant)

Number of fruit buds

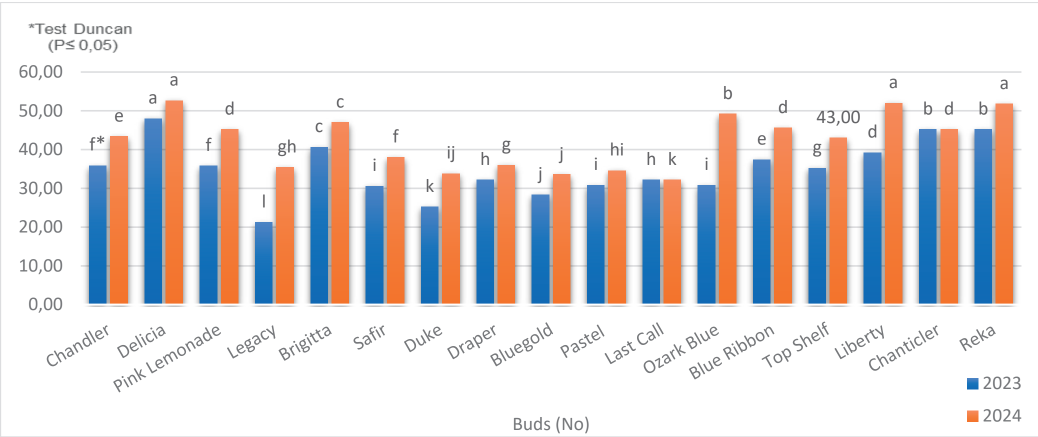
From the analysis of Figure 5, it can be observed that the average number of fruit buds per plant increased significantly from 17.8 buds (‘Blue Ribbon’, untrellised, 2023) to 64.6 buds (‘Pink Lemonade’, untrellised, 2024) (Figure 7).



*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 7. Influence of the untrellised system on the average number of fruit buds/plant

In the trellising system, more balanced values were obtained (21-52 buds per plant in 2024) (Figure 8), indicating a significant difference between the training systems ($p < 0.05$). This demonstrates that trellising leads to a more uniform distribution of buds, reducing yield alternation. Cultivars with high productive potential (‘Pink Lemonade’, ‘Reka’, ‘Delicia’) benefit more from controlled plant architecture, which favours the formation of floral buds.

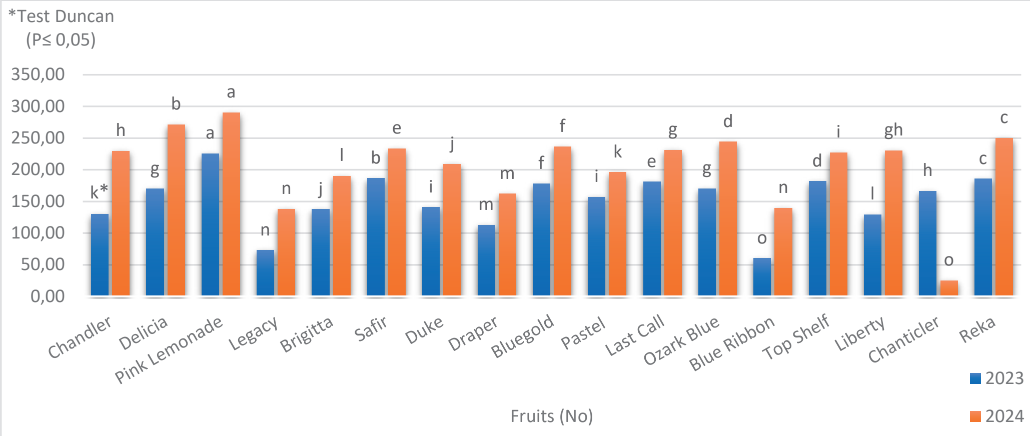


*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 8. Influence of the trellising system on the average number of fruit buds/plant

Number of fruits set

Regarding the characteristic average number of fruits per plant, the data show a clear increase in productive potential in both systems. In the untrellised variant, the values increased from 60 fruits (‘Blue Ribbon’) in 2023 to 290 fruits (‘Pink Lemonade’) in 2024 (Figure 9).

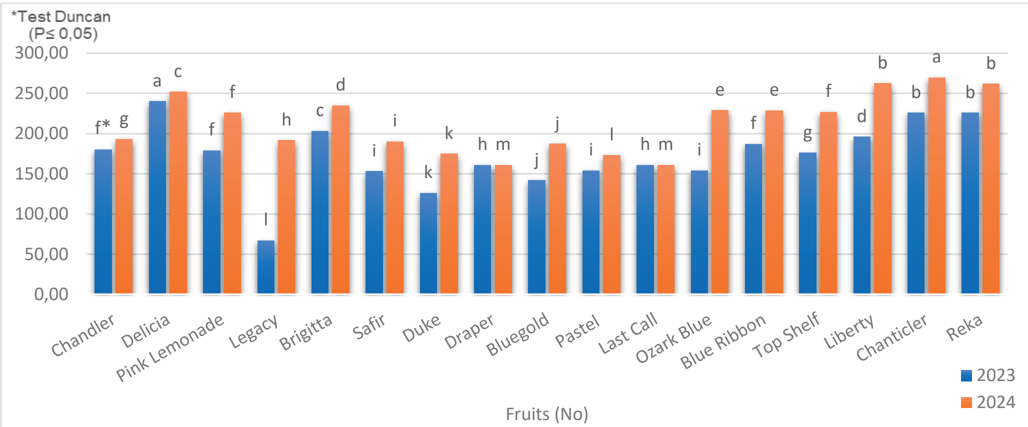


*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 9. Influence of the untrellised system on the average number of fruits/plant

In the trellising variant, more uniform yields were recorded, ranging from 67 fruits ('Legacy') to 269 fruits ('Chanticler') in 2023, and reaching approximately 270 fruits ('Delicia') in 2024 (Figure 10).

Although the variation among cultivars is significant, the Duncan test shows overlaps between significance classes (p > 0.05 for some cultivars), suggesting a complex interaction between cultivar and the chosen growing system.



*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 10. Influence of the trellising system on the average number of fruits/plant

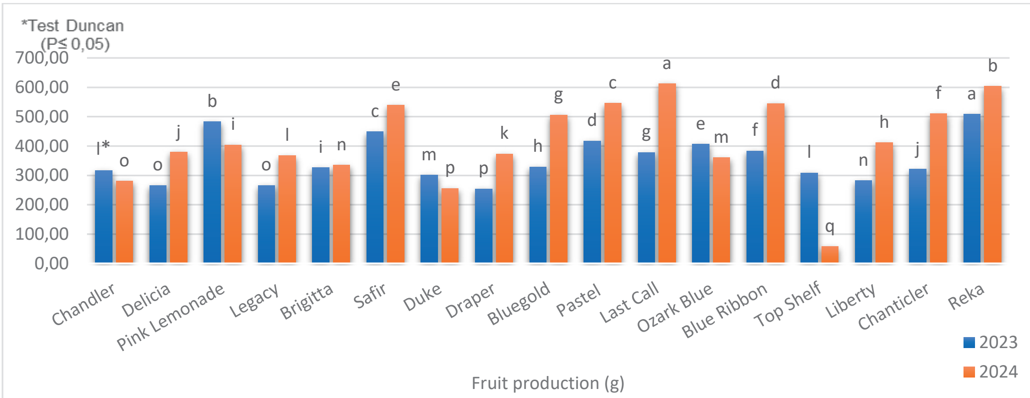
Average fruit yield per plant

From the perspective of average yield per plant, the ANOVA analysis confirms significant differences between years and training systems (p < 0.01). Thus, the cultivars 'Reka' (382 g) in 2023 and 'Liberty' (505 g) in 2024 recorded the highest yields (g) in the untrellised system (Figure 11).

*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 11. Influence of the untrellised system on average production (g)/plant

In the trellising variant, the values were significantly higher, reaching up to 382 g ('Reka') in 2023 and 612 g per plant ('Last Call') in 2024. Trellising had a significant positive effect on yield by optimizing fruit distribution, light exposure, and photosynthetic efficiency (Figure 12).



*Different letters between cultivars denote significant differences (Duncan test. p < 0.05)

Figure 12. Influence of the trellising system on average production (g)/plant

Simple correlation analysis between growth and fruiting traits in blueberry (*V. corymbosum* L.) (Table 1)

1. Untrellising system (2023)

The results indicate the presence of positive and significant correlations between the number of stems and the number of shoots (r = 0.515**) as well as between the number of shoots and the number of buds (r = 0.320*). A very strong correlation was also observed between the number of buds and the number of fruits (r = 0.986**, p < 0.01), confirming the direct dependence between flowering potential and fruit set level.

The moderate positive correlation between cultivar and the number of stems (r = 0.331*) and between cultivar and the number of shoots (r = 0.525**) suggests significant genetic variation among cultivars regarding vegetative potential.

Fruit yield did not show a significant correlation with the other morpho-vegetative parameters, indicating a strong influence of external factors (climatic and edaphic conditions) on the final yield in the untrellising system.

2. Untrellising system (2024)
In 2024, the correlation structure changed slightly. The relationship between cultivar and shoot length was strongly positive (r = 0.764**, p < 0.01), confirming the genetic stability of this trait. Additionally, the number of stems was significantly correlated with the number of buds (r = 0.647**, p < 0.01), suggesting that vegetative vigour promotes better formation of fruit buds.
The negative correlations observed between cultivar and number of fruits (r = –0.310*) or between number of shoots and number of fruits (r = –0.064) indicate a possible competition between vegetative growth and fruiting, common in young or vigorous plants.

3. Trellising system (2023)
In the trellising system, relationships between growth traits were stronger. A significant correlation was recorded between cultivar and number of shoots (r = 0.626**, p < 0.01), as well as between the number of shoots and the number of buds (r = 0.378**, p < 0.01).
The very strong relationship between the number of buds and the number of fruits (r = 0.979**) shows that in the trellising system, fruiting closely follows flowering potential, suggesting high efficiency in pollination and fruit set. However, total yield did not correlate significantly with the other factors, likely due to large differences in fruit weight among cultivars.

4. Trellising system (2024)
For 2024, correlations among vegetative parameters were even stronger. The relationship between cultivar and shoot length was high (r = 0.743**, p < 0.01), confirming a stable genetic expression of vegetative vigor.
The number of shoots was positively correlated with the number of fruits (r = 0.700**, p < 0.01), and the relationship between buds and fruits was extremely strong (r = 0.903**, p < 0.01), suggesting efficient canopy management in the trellising system, which favors fruiting.
Fruit yield did not show significant correlations, indicating that fruit weight is more strongly influenced by technological factors and annual growing conditions than by the number of vegetative organs.

Tabel 1. The values of simple correlation coefficients between growth and fruiting characteristics in 17 analyzed blueberry varieties (*V. corymbosum* L.)

Growing system	Anul	Caracteristici analizate	Variety	Stems (No)	Shoots (cm)	Buds (No)	Fruits (No)	Fruit production (g)
Untrellising	2023	Variety	1					
		Stems (No)	,331*	1				
		Shoots (cm)	,525**	,515**	1			
		Buds (No)	0,113	,699**	,320*	1		
		Fruits (No)	0,044	,650**	0,253	,986**	1	
		Fruit production (g)	,305*	0,097	-0,024	0,170	0,182	1
	2024	Variety	1					
		Stems (No)	0,023	1				
		Shoots (cm)	,764**	0,025	1			
		Buds (No)	-0,051	,647**	0,089	1		
		Fruits (No)	-,310*	,351*	-0,064	,479**	1	
		Fruit production (g)	-0,163	0,239	-0,133	,316*	0,197	1
Trellising system	2023	Variety	1					
		Stems (No)	,426**	1				
		Shoots (cm)	,626**	,396**	1			
		Buds (No)	0,251	0,255	,378**	1	,979**	
		Fruits (No)	0,274	0,179	,384**	,979**	1	
		Fruit production (g)	0,214	-0,075	0,024	0,109	0,159	1
	2024	Variety	1					
		Stems (No)	,395**	1				
		Shoots (cm)	,743**	,378**	1			
		Buds (No)	0,205	,553**	0,097	1		
		Fruits (No)	,388**	,700**	0,260	,903**	1	
		Fruit production (g)	0,276	0,080	0,239	-0,090	-0,016	1

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

CONCLUSIONS

- The general trend confirms that blueberry trellising stimulates both vegetative and reproductive growth, ensuring a balance between vigour and fertility. Trellising corrects the position of shoots within the blueberry canopy and thus conduct to influences upon the growth and fruiting processes; however, it requires material investments, more time and technical expertise.
- The differences among cultivars reflect the adaptability of genotypes to controlled bush architecture, whereas untrellised cultivars exhibit greater biological plasticity but with more pronounced year-to-year variation.
- The most stable and strongest correlations were observed between the number of buds and the number of fruits, regardless of training system or year, confirming the decisive role of flowering potential in determining production level.
- The trellising system promotes a closer relationship between vegetative parameters (stems, shoots, buds) and fruiting, indicating a more efficient use of plant resources.
- In the untrellised system, correlations are more variable, suggesting a greater influence of external factors and a less uniform structural organization of the bushes.
- Total yield (g/plant) is not directly dependent on the number of fruits, indicating cultivar-specific differences in fruit size and average fruit weight, considering that the plants are still very young and have not yet reached their maximum fruiting potential.

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