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EVALUATION OF THE PRODUCTIVITY AND MORPHOMETRIC CHARACTERISTICS OF THE SIBERIAN BLUEBERRY FRUITS (*LONICERA CAERULEA* L.)

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Abstract

Siberian blueberry (Lonicera caerulea L.) is an emerging berry crop, which is attracting increasing interest due to its high nutritional value and adaptability to various climatic conditions. This study evaluated the productive performance and morphometric characteristics in Siberian blueberry fruits in the fifth year of cultivation under pedoclimatic conditions of the Bucharest-Băneasa area. Productivity was analysed using descriptive statistics and Pearson correlations, highlighting a very strong and positive correlation between number of fruits and total production (r = 0.956), while the average fruit mass had an insignificant influence on the yield. The analysis of the fruit morphometric characteristics of the fruits included determinations of the height, diameter, and individual mass, complemented by Pearson correlations and linear regressions, highlighting that the mass of the fruit was strongly correlated with its height (r = 0.763), compared to a moderate correlation with the diameter (r = 0.465). Therefore, production was determined by fruit load, and fruit mass accumulation was associated with fruit elongation. The results confirm the productive stability and adaptability of Siberian blueberry to the real conditions in south-eastern Romania.

Key words*: Siberian blueberry, Lonicera caerulea L., productivity, fruit morphometry, Pearson correlation, linear regression.*

INTRODUCTION

The global transition to healthy, predominantly plant-based diets has driven a sharp increase in demand for berries, recognized as important sources of bioactive compounds and antioxidants (Bujor et al., 2025; Lobos & Hancock, 2015). In this context, the tall blueberry (*Vaccinium corymbosum* L.) and the Siberian blueberry (*Lonicera caerulea* L.) have become species of major interest for horticulture and the functional food industry (Xu et al., 2025). If the blueberry is a pillar of the global berry market (Bujor et al., 2025), *Lonicera caerulea* L. stands out for its very rich nutraceutical profile, characterized by high contents of polyphenols, anthocyanins, and ascorbic acid, with documented beneficial effects on human health (Boyarskikh, 2017; Grobelna et al., 2020; Svarcova et al., 2007).

The expansion of the cultivation of these species outside their traditional areas is, however, limited by pedoclimatic and biological constraints. For acidophilic species, the high soil pH constitutes a major agronomic barrier, which has led to the adoption of soilless cultivation systems, in containers or raised beds, with controlled substrates, as a viable technological solution in pedologically unfavorable areas (De Salvador et al., 2017; Çelik & Acar, 2025). Although these systems favor vigorous early vegetative growth, their sustainability and productive performance in the medium and long term depend on the adaptation of the cultivated genotypes (Pinto et al., 2017; Starast et al., 2017). Fruit development is a complex process that follows distinct growth patterns (e.g., a double “S" curve) and involves coordinated cell division and expansion, ultimately determining the final morphology (Wan et al., 2024).

The productivity of both species is also closely linked to reproductive biology, with fruit set being dependent on efficient cross-pollination, influenced by pollen viability and floral morphology (Lyrene, 1994; Boyarskikh, 2017). The use of inappropriate combinations of

pollinator varieties can lead to significant reductions in yield and fruit mass (Boyarskikh, 2017).

Overcoming these limitations requires rigorous selection and improvement of genetic material, based on the phenotypic and genetic diversity existing within both genera (Qi et al., 2025; Truta et al., 2013). The main objectives of breeding are aimed at phenological adaptation to local conditions and optimization of yield, fruit quality, and stress tolerance (Lobos & Hancock, 2015; Pavliuk et al., 2025; Gerbrandt, 2018), by evaluating germplasm in target environments (Malodobry et al., 2013; Ochmian et al., 2012). In this context, fruit size and weight are essential economic traits, directly correlated with commercial acceptability and yield, and are determined both genetically and by environmental factors and the cultivation system (Jorquera-Fontena et al., 2017; Starast et al., 2017).

Although there has been recent progress, research on the species *Lonicera caerulea* L. remains limited in the specific conditions of southern Romania. Although data are available on the biochemical composition, reproductive biology, and phenotypic diversity of the species (Boyarskikh, 2017; Grobelna et al., 2020; Qi et al., 2025), integrated studies that simultaneously evaluate plant productivity and morphometric determinants of fruit weight in cropping systems are lacking.

Therefore, the objective of the present study was to analyse, at two complementary levels, the productive performance of *Lonicera caerulea* L. plants cultivated in south-eastern Romania, as well as the quantitative relationships between fruit dimensions (height and diameter) and their individual weight. The results obtained contribute to clarifying the morphological bases of fruit yield and quality and provide relevant information both for growers and for breeding programs oriented towards the optimization of this emerging crop.

MATERIALS AND METHODS

The study was conducted on Siberian blueberry plants (*Lonicera caerulea* L.) in their fifth year of cultivation under field conditions in the Bucharest-Băneasa area, Romania. The study area is characterized by pedoclimatic conditions specific to south-eastern Romania, favourable for fruit shrub crops.

The soil on which the blueberry experimental plot was located, in the Băneasa, area of Bucharest, is of the cambic chernozem type, with a weakly acidic reaction (pH = 6.6). The chemical analysis of the soil indicated heavy metal concentrations below the alert thresholds, namely Pb < 17.0 mg/kg, Ni 24.7 mg/kg, Cu 27.84 mg/kg, Cd 0.20 mg/kg and Zn 62.92 mg/kg, as well as a high content of Mn (591.5 mg/kg). The soluble salt content was moderate, with values of 108.49 mg/kg for chlorides and 39.0 mg $S–SO_4^{2-}$/kg, the soil being classified as non-saline. From a physical point of view, the soil presented an apparent density of 1.31 g/cm³, a total porosity of 53% and a loamy texture, characteristics that ensure adequate conditions for the development of the blueberry root system.

The experimental blueberry plot, with an area of approximately 500 m², was organized according to the agrotechnical norms specific to the species. The plants were arranged in rows, at a distance of 1.0 m between plants in a row and 3.0 m between rows, ensuring good air circulation, optimal exposure to light, and easy access for maintenance work. The crop was maintained by grassing with alfalfa (*Medicago sativa* L.) between the rows, keeping the strip in the row free of vegetation. Agricultural work was carried out uniformly over the entire surface, so that all plants benefited from similar conditions of nutrition and natural humidity, minimizing the influence of technological differences on the experimental results.

The biological material was represented by an experimental lot consisting of a single plot, without experimental variants or treatments applied. The analysis was observational in nature, following the natural expression of the production and morphological characters of the fruits under real cultivation conditions. The evaluations were carried out during the period of full maturity of the fruits, during the harvest season, mid-May 2025.

Determination of production at plant level

Seven individual plants (n = 7) were selected for production analysis. The following parameters were determined for each plant:

• total number of fruits per plant;

• Total production (g/plant), determined by weighing the harvested fruits;
• Average fruit weight (g), calculated as the ratio of total production to the number of fruits per plant.
The data obtained at the plant level were used exclusively for the evaluation of productive performance and were not combined with the data obtained at the fruit level to avoid pseudoreplication.

Morphometric analysis of fruits

The morphometric characteristics of the fruits were evaluated on a sample of 35 fruits (n = 35), randomly harvested from several plants in the experimental plot. For each fruit, the following were determined:
• fruit height (mm);
• fruit diameter (mm);
• individual fruit mass (g).
Fruit dimensions were measured using a digital calliper, and individual mass was determined with a precision electronic balance. Measurements were performed on fresh fruits, immediately after harvest.
Aspects of the experimental research, including plants in the fifth year of cultivation, fruit harvesting, and the measurement of morphometric characteristics, are illustrated in Figure 1.



Figure 1. Aspects during experimental research on *Lonicera caerulea* L.

Statistical analysis

The experimental data were subjected to descriptive statistical analysis, calculating the mean, standard deviation, minimum and maximum values, as well as the coefficient of variation (CV, %). The relationships between the analysed parameters were evaluated by the Pearson correlation coefficient.

To quantify the influence of morphometric traits on fruit mass, simple linear regression models were applied between:
• fruit mass and fruit height;
• fruit mass and fruit diameter;
• fruit diameter and fruit height.
Statistical analyses were performed separately for plant-level and fruit-level data to ensure correct biological interpretation. Statistical significance was assessed at $p < 0.05$. Results were plotted to highlight relationships between variables.

RESULTS AND DISCUSSIONS

The fifth year of cultivation represents a critical stage in the productive maturation of *Lonicera caerulea* L., when plants are expected to express a stable yield potential and characteristic fruit morphology.

1. Yield performance at plant level

The main yield components and their descriptive statistics at plant level are presented in Table 1.

Table 1 - Descriptive statistics of yield-related traits at plant level (n = 7)

Plant	No. of fruits	Yield (g/plant)	Average fruit weight (g)
1	74	44.7	0.60
2	174	106.6	0.61
3	102	58.8	0.58
4	89	49.0	0.55
5	34	21.3	0.63
6	180	86.2	0.48
7	125	83.1	0.67
Mean ± SD	111.14 ± 52.90	64.24 ± 29.21	0.59 ± 0.06
Min.-Max.	34-180	21.3-106.6	0.48-0.67
CV (%)	47.59	45.47	10.23

It can be seen from Table 1 that Siberian bilberry (*Lonicera caerulea* L.) recorded an average production of approximately 64 g per plant, with significant individual variations ranging from 21.3 g to 106.6 g per plant. The number of fruits per plant fluctuated between 34 and 180, indicating a moderate variability in productive load between plants. The average mass of a fruit was relatively stable, ranging from 0.48-0.67 g, which reflects a good development of the morphological characters specific to the species in the pedoclimatic conditions of the Bucharest-Băneasa area.

Regression equation:

$$Total\ yield\ (g) = 5.58 + 0.528 \times Number\ of\ fruits$$

In Figure 2 it shows relationship between the number of fruits per plant and total yield in *Lonicera caerulea* L.

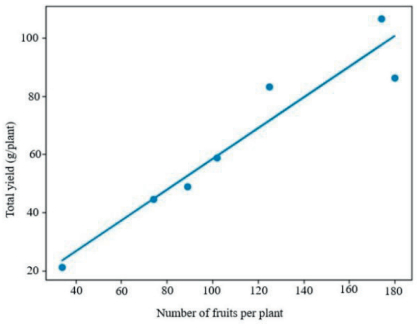

Figure 2. Relationship between number of fruits per plant and total yield in *Lonicera caerulea* L.

The coefficient of variation (CV) was high for both fruit number and total yield, indicating substantial biological variability among individual plants, whereas the low CV for average fruit weight reflected good morphological stability. A strong positive correlation was observed between fruit number and total yield ($r = 0.956$), while the correlation between fruit weight and total yield was weak and biologically negligible ($r = -0.117$). A moderate negative relationship was detected between fruit number and average fruit weight ($r = -0.395$), indicating a tendency toward reduced fruit mass at higher fruit loads. Each additional fruit contributed, on average, approximately 0.53 g to total yield per plant, and fruit number explained 91.4% ($R^2 = 0.914$) of the total yield variation. Overall, yield variation was primarily driven by fruit number rather than individual fruit weight, indicating that fruit load was the main determinant of productivity in the fifth year of cultivation.

The coefficient of variation calculated for total production indicates acceptable uniformity of the crop, characteristic of plantations at biological maturity, according to observations in the literature on blueberry crops (Qi et al., 2025). Correlation analysis revealed a significant positive relationship between the number of fruits and the total mass of production, suggesting that variation in production is mainly determined by fruit load, and variation in the individual mass of the fruit has a much smaller impact on total production (Jorquera-Fontena et al., 2017).

An increase in fruit number was associated with an almost proportional increase in total yield, whereas average fruit weight showed limited variation and therefore had a negligible influence on yield formation. From a biological perspective, higher productivity resulted primarily from increased fruit load rather than from an increase in individual fruit size.

The results obtained confirm previous observations regarding the importance of fruit number as a determining factor of total production in Siberian blueberry (*Lonicera caerulea* L.). The moderate variability of fruit load and the stability of fruit mass are consistent with studies by Qi et al. (2025), who highlighted that in mature plants, variations in total production are mainly explained by fluctuations in fruit number, rather than by changes in average fruit mass.

On the other hand, Jorquera-Fontena et al. (2017) highlighted that the relationship between morphological dimensions of fruits and their weight can vary depending on the species and growing conditions, and in the case of Siberian blueberry, the stability of individual mass suggests a potential for selection to maintain fruit quality, even under intensive production conditions.

2. Fruit morphometric characteristics

In addition to yield-related traits, fruit morphometric characteristics were evaluated on a sample of 35 fruits. Individual characteristics of blueberry fruits (1-35): height, diameter, and mass, with the means of each parameter indicated by dotted lines, were graphically represented in Figure 3.

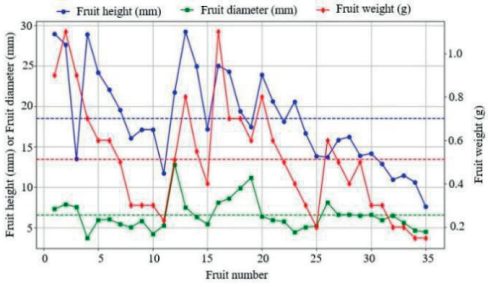

Figure 3. Individual characteristics of blueberry fruits: height, diameter, and mass

Following the analysis of the 35 blueberry fruits, significant variability in the measured

morphometric characters is observed, namely the height, diameter, and mass of the fruit. The height of the fruits presents values ranging between 7.61 mm and 29.2 mm, with the majority of the fruits falling within the range of 15-25 mm, which indicates a relatively uniform development of the analyzed population, with the exception of some less developed fruits.

The diameter of the fruits varies between 3.73 mm and 12.8 mm, with most values being concentrated around the range of 5–7 mm. The presence of fruits with a larger diameter is observed, which can be considered better developed from a morphological point of view, suggesting potential superior quality.

The mass of the fruits ranges between 0.15 g and 1.1 g, with the most common values being between 0.3 g and 0.8 g. Fruits with reduced mass generally correspond to smaller sizes, while fruits with greater mass are associated with high values of diameter and height.

Overall, a direct relationship is observed between fruit size and mass, with diameter having a more pronounced influence on mass than height. The variability recorded can be explained by differences in maturity, fruit position on the plant, or environmental conditions, confirming the non-uniform character of the development of the analyzed fruits (Jorquera-Fontena et al., 2017; Lobos & Hancock, 2015; Malodobry et al., 2013).

Statistical analysis of fruit morphometric traits revealed moderate to high variability among the analyzed samples, are presented in Table 2.

Table 2. Descriptive statistics of fruit morphometric characteristics (n = 35)

Parameter	Medie	SD	Min.	Max.	CV (%)
Fruit height (mm)	18.48	5.77	7.61	29.20	31.20
Fruit diameter (mm)	6.52	1.91	3.73	12.80	29.28
Fruit weight (g)	0.511	0.257	0.15	1.10	50.28

To quantify the relationships between fruit morphometric parameters, simple linear regression was applied between individual mass and fruit height, individual mass and fruit diameter, as well as between diameter and height, allowing the evaluation of the influence of each character on fruit mass and shape.

In Figure 4 it is shown between fruit height and individual fruit weight in *Lonicera caerulea* L. (n = 35).

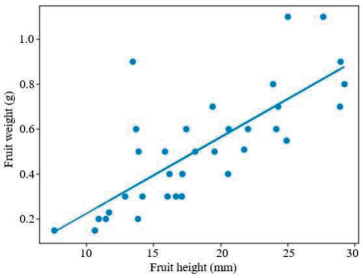

Figure 4. Linear regression between fruit height and individual fruit weight

The regression equation is:

$$Fruit\ weight\ (g) = -0.117 + 0.034 \times Fruit\ height\ (mm)$$

It is therefore observed that each additional millimeter in fruit height corresponds, on average, to an increase of ~0.034 g in mass. The coefficient of determination $R^2 = 0.582$ suggests that 58.2% of the variation in fruit mass is explained by height, which highlights its major role in determining individual mass. The negative intercept has no direct biological relevance, being only a statistical consequence.

Therefore, fruit height is an important predictor of individual mass in *Lonicera caerulea* L., highlighting that longitudinal growth contributes significantly to mass accumulation. Data on longitudinal and transverse dimensions of blueberry fruits demonstrate that some morphological dimensions may be differently correlated with the actual weight of the fruits (Wan et al., 2024).

In Figure 5 it is shown a linear regression between fruit diameter and individual fruit weight in *Lonicera caerulea* L. (n = 35).

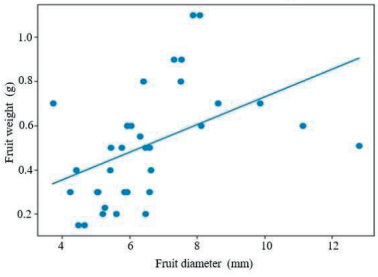

Figure 5. Linear regression between fruit diameter and individual fruit weight

The regression equation is:

$$Fruit\ weight\ (g) = 0.103 + 0.063 \times Fruit\ diameter\ (mm)$$

A moderate positive relationship was observed (R^2 = 0.216), indicating that fruit diameter contributes to fruit mass but explains a limited proportion of weight variability.

The regression analysis revealed a positive linear relationship between fruit diameter and individual fruit weight (R^2 = 0.216), indicating that radial growth contributes to fruit mass. However, the relatively low coefficient of determination suggests that diameter alone explains only a limited proportion of weight variability among fruits. In contrast, fruit height exhibited a substantially stronger relationship with fruit weight (R^2 = 0.582), demonstrating a higher predictive capacity for mass accumulation. This marked difference highlights fruit elongation as the primary morphological driver of fruit weight in the studied material.

The stronger association between fruit height and mass may reflect species-specific growth patterns in *Lonicera caerulea* L., where longitudinal cell expansion and berry elongation play a dominant role during fruit development. Similar findings have been reported in other elongated berry species, where fruit length has been shown to be a better predictor of fresh weight than diameter, due to asymmetric growth dynamics and differential cell division along the longitudinal axis (Jorquera-Fontena et al., 2017; Wan et al., 2024). The relatively weaker influence of diameter suggests that radial expansion occurs to a lesser extent or contributes less consistently to total fruit biomass.

In Figure 6 it is shown a linear regression between fruit height and individual fruit diameter in *Lonicera caerulea* L. (n = 35).

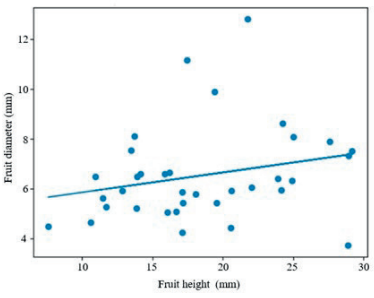

Figure 6. Linear regression between fruit height and individual fruit diameter

The regression equation is:

$$Fruit\ diameter\ (mm) = 5.051 + 0.080 \times Fruit\ height\ (mm)$$

The very low R^2 value (R^2 = 0.058) indicates that only ~6% of the variation in fruit diameter is explained by height variation. The relationship is very weak, although the slope is positive. Biologically, this result shows that fruit height and diameter are relatively independent characters: longitudinal growth does not automatically imply radial growth. This is typical for *Lonicera caerulea* L., a species with elongated fruits, where shape is determined more genetically than by proportional growth.

Pearson correlations between the analyzed parameters show that fruit mass is more closely related to height (r = 0.763, strongly positive correlation) than to diameter (r = 0.465, moderate correlation), suggesting that more elongated fruits tend to be heavier, and diameter influences mass to a lesser extent. Height and diameter have a weak positive correlation (r = 0.241), indicating that fruit shape varies independently to some extent.

From a physiological perspective, the dominance of fruit height over diameter in explaining fruit weight may be related to vascular architecture and the distribution of assimilates. Longitudinal growth potentially allows for a more efficient allocation of photoassimilates along the fruit axis, resulting in greater mass accumulation without proportional increases in diameter (Wan et al., 2024; Boyarskikh, 2017). In addition, environmental and genetic variability among fruits may further modulate radial growth, thus reducing the explanatory power of diameter-based models (Starast et al., 2017; Lobos & Hancock, 2015; Lyrene, 1994).

The moderate relationship observed between fruit diameter and mass should not be ignored, as it still indicates a positive contribution to fruit weight. However, when considered in isolation, diameter appears insufficient as a reliable predictor of yield-related traits. These results highlight the importance of multivariate approaches when evaluating fruit quality parameters, especially in breeding and selection programs aimed at improving fruit size and uniformity (Truță et al., 2013; Xu et al., 2025).

The relatively high variability observed between individual fruits may also reflect differences in

plant vigor, fruit position, and environmental conditions. As the fruits analyzed came from multiple plants, interplant variability likely contributed to the dispersion of morphological traits. However, the consistent superiority of fruit height as a predictor of mass in the data set underscores the robustness of this relationship.
From an applied perspective, the results have practical implications for cultivar evaluation and agronomic management. Selection strategies focused on increasing fruit elongation, rather than diameter alone, may be more effective in improving individual fruit weight and overall yield. Furthermore, fruit height could serve as a rapid, non-destructive indicator of fruit mass in field assessments and phenotypic screening.

CONCLUSIONS

Fruit height was identified as the main morphological determinant of fruit weight in *Lonicera caerulea* L., and can be used as a rapid and non-destructive indicator of fruit quality.
Fruit weight is explained to a greater extent by fruit height than by diameter, which highlights the dominant role of fruit elongation in mass accumulation.
Fruit diameter showed a positive relationship with fruit mass, but its predictive capacity was limited compared to that of height.
Fruit shape proved stable, with a low correlation between morphological axes, supporting the importance of height as a distinct morphometric parameter.
The results obtained provide relevant information for cultivar evaluation, fruit shape-oriented breeding programs, and agronomic assessment of marketable yield under open-field conditions.

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