VEGETATIVE RESPONSE OF *AMELANCHIER ALNIFOLIA* TO SPRING PRUNING UNDER TEMPERATE CONDITIONS: HORTICULTURAL IMPLICATIONS

Ruben BUDĂU[1#]

[1]University of Oradea, Department of Silviculture and Forest Engineering, 26 Magheru Boulevard, Oradea, Romania, Email: rbudau@uoradea.ro;

RESEARCH ARTICLE

Abstract

This study investigates the vegetative response of Amelanchier alnifolia Nutt. to spring pruning under temperate continental conditions in western Romania. Sixty mature plants (15 years old) were monitored during the 2025 growing season following uniform renewal pruning aimed at removing senescent and poorly positioned shoots. The experimental design focused on key vegetative parameters: shoot density, basal diameter, shoot length, and emission zone. Measurements were performed using precision horticultural tools, and data were analyzed statistically in Python using descriptive indicators and Pearson correlation coefficients.

Results revealed a strong regenerative capacity, with an average of 7.8 shoots per plant (range: 3–12; SD = 2.21) and mean shoot length of 46.1 cm (range: 21.4–63.7 cm; SD = 9.54). These findings indicate efficient activation of latent buds and redistribution of assimilates toward renewal shoots. Correlation analysis (r = 0.62, p < 0.01) demonstrated a positive relationship between shoot number and elongation vigor, confirming a coordinated regenerative mechanism. This trend aligns with previous reports on vegetative plasticity in Rosaceae species and highlights the adaptability of A. alnifolia to managed horticultural systems.

The integration of pruning practices and row orientation emerges as a critical strategy for optimizing canopy architecture, light interception, and fruit quality in sustainable orchards. Compared to other fruit-bearing shrubs, A. alnifolia exhibits a balanced ratio between regeneration and productivity, making it suitable for low-input systems. Overall, the study provides a robust scientific basis for refining canopy management and yield optimization strategies in emerging Amelanchier alnifolia plantations across temperate Europe.

Keywords: *Amelanchier alnifolia*, pruning, vegetative vigor, shoot performance, horticulture

#Corresponding author

INTRODUCTION

The diversification of perennial fruit crops in Europe has generated an increased interest in species capable of combining agronomic performance, ecological adaptability and high-value fruit production. Among them, *Amelanchier alnifolia* Nutt. (Saskatoon berry) stands out for its low temperature tolerance, drought resistance, and nutraceutical properties of the fruit (Mihovilović et al., 2020; Rop et al., 2012; Pluta, 2015).

Native to the Canadian prairie provinces, this species has considerable potential for integration into multifunctional agroforestry systems, contributing to increasing biodiversity and promoting agricultural sustainability (Budău et al., 2023; Musselman et al., 2014). Belonging to the Rosaceae family, *A. alnifolia* has a shrub habit, and fruiting is predominantly carried out on shoots of one year or older. In North America, the crop is well established commercially, and in Europe it is considered emerging for horticulture (Bieniek et al., 2019).

Fruits are rich in phenolic compounds, flavonoids, and anthocyanins, giving them antioxidant properties and health benefits (Rop et al., 2013; Gunawardana et al., 2016; Budău et al., 2022). In Romania, adaptation studies have shown high survival rates and vigorous vegetative development in the establishment phase (Budău, 2017), and yield research has confirmed productive performance under local pedoclimatic conditions (Budău & Enescu, 2022).

In addition to the agronomic benefits, *Amelanchier alnifolia* has significant economic and nutritional relevance. Its fruits are appreciated in the food industry for their high antioxidant content and potential for use in functional products, which responds to the growing demand for healthy food in Europe. The integration of this species into agroforestry systems contributes to reducing climate risks and diversifying farmers' incomes, which are essential for the transition to sustainable agriculture. Another feature is suitability to varied soils and tolerance to water stress, which recommends it for areas with limited water resources, strengthening its role in agricultural resilience strategies.

Vegetative growth in *A. alnifolia* determines the architecture of the canopy, the efficiency of light interception and the potential for long-term fruiting. Pruning interventions influence vegetative renewal by eliminating apical dominance, activating dormant buds, and redistributing assimilated buds (Zayan et al., 2016; Yang et al., 2010). Excessive vegetative vigor can compromise fruit quality and ripening uniformity, while insufficient renewal accelerates canopy senescence.

Despite the growing interest in this species, information on the behavior of shoots after pruning under European conditions is limited. The present study aims to quantify the growth parameters of vegetative shoots after spring pruning and interpret their implications for sustainable canopy management.

Beyond the agronomic and ecological benefits, *Amelanchier alnifolia* holds significant potential for economic diversification and functional food production. The species' adaptability to the temperate continental climate and its resilience to abiotic stressors positions it as a valuable element in climate-smart agriculture strategies. Its integration into agroforestry systems not only increases biodiversity but also contributes to carbon sequestration and improved soil health, in line with the European Union's sustainability objectives. Additionally, the growing consumer demand for antioxidant-rich fruits highlights the importance of developing effective canopy management practices for this species. These considerations establish a solid basis for investigating the dynamics of vegetative growth under felling regimes, as a foundation for optimizing orchard performance and ensuring long-term viability in European horticulture.

MATERIAL AND METHOD

The research was conducted in the experimental plantation of *Amelanchier alnifolia* located at Bărzani Farm, Arad County, western Romania. The geographical coordinates are 46°29′12.6″N, 22°08′22.9″E (Plot 1, 0.11 ha) and 46°28′56.6″N, 22°07′04.1″E (Plot 2, 0.63 ha), at an altitude of approximately 180 m (Budău & Enescu, 2022). The area is characterized by a temperate continental climate, with an average annual temperature of 10.3 °C, mean precipitation of 560–580 mm, and clay-illuvial chernozem soils with a pH of 6.4–6.8. The plantation was established using a spacing scheme of 3 m between rows × 1 m between plants, totaling 367 individuals in Plot 1 and 2,467 in Plot 2.

The choice of the experimental location was based on the pedoclimatic representativeness for western Romania, an area characterized by thermal variability and periods of water deficit. These conditions allow the assessment of the vegetative plasticity of the species in scenarios similar to those encountered in European commercial orchards. The instruments used were selected for the accuracy of the measurements, and the statistical analysis in Python ensures the reproducibility and transparency of data processing, according to international horticultural research standards.

Figure 1. **Measurements made with horticultural tape**

During the 2025 growing season, 60 mature plants (15 years old) were selected from Plot 1. In spring 2025, a uniform renewal pruning was applied, removing senescent shots and those with inadequate positioning. The plantation was not irrigated. For each plant, the following parameters were recorded:

- Total number of new shoots per plant.
- Basal diameter (mm).
- Shoot length (cm).
- Emission zone (%).

Measurements were performed using a horticultural tape (precision ±0.5 mm) and a Mitutoyo CD-6' ASX digital caliper (Figure 1).

Statistical analyses were conducted in Python 3.12 using the packages pandas, scipy, matplotlib, and seaborn. Descriptive indicators were calculated (mean, minimum, maximum, standard deviation, coefficient of variation – CV%). Correlations among parameters were determined using Pearson's coefficient (r), with significance levels at $p < 0.05$ and $p < 0.01$ (Table 1).

Table 1.
Descriptive statistics of vegetative parameters in Amelanchier alnifolia (2025)

Parameter	Mean	Median	Min	Max	SD	CV (%)
Shoots per plant	7.8	8	3	12	2.21	28.3
Shoot length (cm)	46.1	45.0	21.4	63.7	9.54	20.7

The choice of experimental methodology was based on the need to obtain reproducible and internationally comparable data. The use of high-precision measuring instruments, such as the digital shaker and horticultural tape recorder, ensures the accuracy of the vegetative parameters analyzed.

In addition, the integration of statistical analysis into the Python environment provides transparency and flexibility in data processing, complying with modern horticultural research standards.

This approach allows not only the correct interpretation of biological variability, but also the development of predictive models applicable in orchard management.

By combining experimental rigor with advanced digital tools, the study creates the premises for expanding research towards assessing the impact of agroecological practices on vegetative performance and fruit quality.

RESULTS AND DISCUSSIONS

The analysis of the results highlights the significant impact of spring pruning on the vegetative dynamics of *Amelanchier alnifolia*. This section presents the interpretation of the measured parameters, statistical correlations, and horticultural implications of observed regenerative behavior.

Understanding these mechanisms is essential for optimizing canopy architecture and developing sustainable orchard management strategies.

The results are discussed in relation to literature, to highlight the convergences and differences with other species of the Rosaceae family, as well as their relevance in the context of European horticulture.

The vegetative response of *Amelanchier alnifolia* demonstrated a strong regenerative capacity following spring pruning. The mean shoot density was 7.8 shoots per plant (SD = 2.21), with a range of 3–12 shoots per plant, confirming the activation of both latent axillary and adventitious buds.

Comparable compensatory dynamics have been reported in other perennial mixed-fruit shrubs, where pruning modifies resource allocation and hormonal gradients.

Shoot elongation exhibited considerable variability, ranging from 21.4 cm to 63.7 cm, with an average of 46.1 cm (SD = 9.54). This vigorous growth suggests efficient mobilization of assimilates toward renewal shoots, consistent with patterns described in the Saskatoon Berry Production Manual (2013), which attributes this behavior to the release of apical dominance and improved light penetration within the canopy.

Correlation analysis ($r = 0.62$, $p < 0.01$) revealed a positive association between shoot number and maximum shoot length (Figure 2), indicating that plants with a higher shoot density tend to exhibit greater elongation vigor.

This trend reflects a coordinated regenerative mechanism through which *A. alnifolia* redistributes assimilates among multiple growth axes while maintaining shoot vigor.

Similar correlations have been documented in other Rosaceae species, where balanced pruning promotes both shoot density and elongation potential (Pluta, 2015). These findings emphasize the physiological plasticity of *A. alnifolia*, supporting its adaptability to managed horticultural systems.

Looking ahead, future research should explore the combined impact of organic pruning and fertilization on vegetative dynamics and fruit quality, as well as the adaptation of mechanized harvesting technologies for this species. Also, the integration of phenological data into predictive models can support management decisions in the context of climate change, strengthening the position of *Amelanchier alnifolia* as a strategic species for European horticulture.

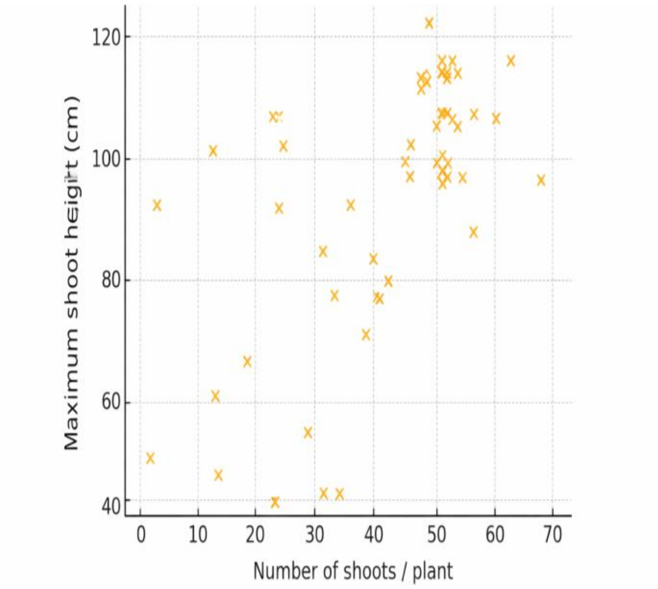

Figure 2. **Correlation between the number of shoots and the maximum shoot height**

The scatter plot (Figure 2) illustrates the relationship between the number of shoots per plant and their maximum height (cm) following the spring pruning (2025). The observed positive trend indicates an efficient internal allocation of resources within the canopy and confirms the regenerative plasticity of the species under the temperate continental climate of western Romania.

The obtained shoot density aligns with horticultural objectives aiming to maintain open canopy structures, which are favorable for light interception and fruit set.

Excessive shoot density in fruit-bearing shrubs can inhibit flowering through shade-induced suppression, while moderate densities support renewal and reproductive balance. These findings are consistent with previous acclimatization trials conducted in Romania, where *A. alnifolia* demonstrated sustained vigor both during establishment and in mature production phases (Budău, 2017; Budău & Enescu, 2022).

Overall, the results support the hypothesis that spring pruning facilitates efficient vegetative renewal in *A. alnifolia*, and that the species' high regenerative plasticity enables adaptive canopy management strategies that promote long-term horticultural performance in European temperate environments.

These findings not only confirm the regenerative plasticity of Amelanchier alnifolia but also underline its strategic role in sustainable orchard management. Maintaining moderate shoot density and balanced elongation vigor ensures optimal canopy architecture, improving light interception and air circulation-key factors for fruit quality and disease prevention. From a practical perspective, these results provide actionable guidelines for growers aiming to integrate A. alnifolia into low-input systems while preserving productivity and ecological resilience. Future research should expand on these observations by assessing the combined effects of pruning intensity, organic fertilization, and mechanization on both vegetative dynamics and fruit yield. Additionally, incorporating phenological data into predictive models will enhance decision-making under climate variability, reinforcing the species' potential as a cornerstone for climate-smart horticulture in temperate Europe.

CONCLUSIONS

Integrating experimental findings with existing literature, it can be concluded that spring pruning facilitates balanced vegetative renewal without compromising the plant's reproductive potential, providing an adaptive management model for emerging *Amelanchier alnifolia* orchards in continental Europe (Bieniek et al., 2019; Kuzmina & Toropova, 2020). This integrated approach reinforces the need to calibrate pruning practices and row orientation to maximize light interception and natural ventilation, thereby improving fruit quality—critical parameters for ecological and sustainable berry production systems (Reinhart et al., 2006).

Amelanchier alnifolia demonstrates strong regenerative capacity following spring pruning, characterized by moderate shoot density and vigorous elongation, consistent with previous findings on the species' vegetative plasticity (Mihovilović et al., 2020; Budău & Enescu, 2022). Positive correlations between shoot number, maximum height, and basal diameter confirm a coordinated regenerative mechanism, where internal resource redistribution is stimulated by pruning.

Compared to other fruit-bearing shrubs, *A. alnifolia* exhibits a balanced ratio between regeneration and productivity, making it suitable for low-input sustainable orchards (Musselman et al., 2014; Kumar et al., 2024). The integration of regular pruning and proper row orientation optimizes microclimatic conditions and fruit quality while reducing the incidence of fungal diseases (Gonzales et al., 2023).

Overall, these findings consolidate *Amelanchier alnifolia* as a promising horticultural species for temperate Europe, providing a solid scientific basis for refining canopy management and yield optimization strategies.

The results obtained confirm not only the vegetative plasticity of the *Amelanchier alnifolia* species, but also its strategic potential for the development of sustainable orchards in the temperate zones of Europe. The implementation of spring pruning, correlated with the optimal orientation of the rows, contributes to the improvement of the microclimate, the reduction of disease pressure and the increase of fruit quality. Beyond horticultural aspects, these findings have economic and ecological implications, supporting the integration of the species into multifunctional agroforestry systems. Future research should explore the interaction between cutting regimes, organic fertilization and adaptation of mechanized harvesting technologies, as well as the use of predictive models based on phenological data to optimize management decisions. Thus, *Amelanchier alnifolia* is emerging as a promising crop, capable of responding to climatic challenges and market requirements for functional food products.

REFERENCES

Bieniek, A., Markuszewski, B., Kopytowski, J., Pluta, S., & Markowski, J. (2019). Yielding and fruit quality of several cultivars and breeding clones of Amelanchier alnifolia grown in north-eastern Poland. Zemdirbyste-Agriculture, 106(4), 351–358. https://doi.org/10.13080/z-a.2019.106.045

Budău, R. (2017). Study on the acclimatization of Amelanchier alnifolia Nut. seminal descendants in the hilly area of Codru Moma Mountains from Romania. Annals of the University of Oradea, Fascicle: Environmental Protection, XXVIII, 53–62. PDF link

Budău, R., & Enescu, C. M. (2022). The yield of an 11-year-old Saskatoon berry plantation under Romanian conditions. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 50(2), 1245–1252. https://doi.org/10.15835/nbha50212745

Budău, R., Memete, A. R., Timofte, A., & Vicas, S. I. (2022). Phytochemical screening and antioxidant capacity of two berry cultivars, 'Ruben' and 'Duke', depending on their harvesting time. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Food Science and Technology,79(1). https://doi.org/10.15835/buasvmcn-fst:2022.000

Budău, R., Apăfăian, A., Caradaică, M., Bratu, I. A., Timofte, C. S. C., & Enescu, C. M. (2023). Expert-based assessment of agroforestry systems integrating Amelanchier alnifolia. Agroforest Systems, 97, 555–567. https://doi.org/10.3390/su152215724

Gonzales Alegría, R., Arévalo López, L., & Solís Leyva, R. (2023). Shade management and pruning in two coffee varieties vs. plant growth and leaf rust in the peruvian Amazon.

Gunawardana, S., Eberhart, K., Hartman, K., & Halaweish, F. T. (2016). Assessment of chemopreventive contents of native American Juneberries (Amelanchier alnifolia). Pharmaceutical Crops, 6(1), 13–21. https://doi.org/10.2174/2210290601606010013

Mihovilović, B., Habuš Jerčić, I., Prebeg, T., Tomaz, I., Pavičić, A., Barić, M., & Kereša, S. (2020). Light source and cytokinin type affect multiplication rate and chlorophyll content of Amelanchier alnifolia shoots in vitro. Journal of Central European Agriculture, 21(4), 826–838. https://doi.org/10.5513/JCEA01/21.4.2909

Kuzmina, T. V., & Toropova, E. Yu. (2020). Entomofauna of the crown of *Amelanchier alnifolia* (Nutt.) under conditions of the northern forest-steppe of the Ob region.

Kumar, A., Bhuj, B. D., & Dhar, S. (2024). New approaches of rootstocks in fruit production: a review. Open Access Journal of Botanical Insights, 2(1), 000109.

Musselman, R. C., Shepperd, W. D., Smith, F. W., & Asherin, L. A. (2014). Survival and growth of aspen and serviceberry planted on reclaimed surface mined land with landscape fabric and irrigation. Journal of the American Society of Mining and Reclamation, 3(1), 16–25.

Reinhart, K.O., Greene, E., & Callaway, R.M. (2006). Invasion through quantitative effects: Intense shade drives native decline and invasive success. Ecology, 87(1), 204–210. https://scholarworks.umt.edu/biosci_pubs/227

Rop, O., Řezníček, V., Mlček, J., Juríková, T., Sochor, J., Kizek, R., & Balík, J. (2012). Nutritional values of new Czech cultivars of Saskatoon berries (Amelanchier alnifolia Nutt.). Horticultural Science,39(3),123–128. https://doi.org/10.17221/194/2011-HORTSCI

Rop, O., Mlček, J., Juríková, T., Sochor, J., & Kizek, R. (2013). Antioxidant properties of Saskatoon berry (Amelanchier alnifolia Nutt.) fruits. Fruits, 68(5), 435–444. https://doi.org/10.1051/fruits/2013087

Yang, S., Xing, S., Liu, C., Du, Z., Wang, H., & Xu, Y. (2010). Effects of root pruning on vegetative growth and fruit quality of Zhanhuadongzao trees. Horticultural Science, 37(1), 14–21.

Zayan, M. A., Mikhael, G. B., & Okba, S. K. (2016). Treatments for improving tree growth, yield and fruit quality and for reducing double fruit and deep suture incidence in “Desert red” peach trees. International Journal of Horticultural Science, 22(3–4),7–19.