Attila Németh
Application of microalgae- and cyanobacteria-based biostimulant biomass to influence the growth and development of *pelargonium* under greenhouse cultivation conditions

**THESIS OF**

**DOCTORAL (PhD) DISSERTATION**

# ATTILA NÉMETH

**MOSONMAGYARÓVÁR**

**2026**

**SZÉCHENYI ISTVÁN UNIVERSITY**

**ALBERT KÁZMÉR FACULTY OF AGRICULTURAL AND FOOD SCIENCES IN MOSONMAGYARÓVÁR**

**DEPARTMENT OF PLANT SCIENCES**

**WITTMANN ANTAL MULTIDISCIPLINARY DOCTORAL SCHOOL OF PLANT, ANIMAL AND FOOD SCIENCES**

**HABERLANDT GOTTLIEB DOCTORAL PROGRAM FOR PLANT SCIENCE**

**DOCTORAL SCHOOL LEADER**

**PROF. DR. VARGA LÁSZLÓ, DSC**

**PROGRAM LEADER:**

**PROF. DR. GYULA PINKE DSC**

**SUPERVISOR(S):**

**DR. MOLNÁR ZOLTÁN PhD**

**ASSOCIATE PROFESSOR**

**DR. HORVÁTH NÁNDOR PhD**

**TITLE OF THE DISSERTATION:**

# APPLICATION OF MICROALGAE- AND CYANOBACTERIA-BASED BIOSTIMULANT BIOMASS TO INFLUENCE THE GROWTH AND DEVELOPMENT OF *PELARGONIUM* UNDER GREENHOUSE CULTIVATION CONDITIONS

SUBMITTED BY

**ATTILA NÉMETH**

MOSONMAGYARÓVÁR

2026

## Introduction

The increasing demand for sustainable horticultural production has intensified the search for alternatives to conventional agrochemical inputs. In ornamental plant cultivation, there is a growing need to enhance plant quality and growth while reducing the use of synthetic fertilizers and pesticides. In this context, biostimulants represent a promising approach, as they improve plant performance through physiological and biochemical processes rather than by directly supplying nutrients.

Microalgae- and cyanobacteria-based biomass products have gained particular attention due to their rich composition of bioactive compounds, including phytohormones, amino acids, vitamins, and antioxidants. These components may positively influence plant growth, root development, and stress tolerance. Although their beneficial effects have been demonstrated in several agricultural crops, their application in ornamental horticulture remains relatively underexplored.

*Pelargonium* is one of the most widely cultivated ornamental plant species with significant economic importance. The present study investigates the effects of biomass derived from *Chlorella vulgaris* and *Nostoc piscinale* on the growth and development of *Pelargonium* under greenhouse conditions. The aim is to evaluate their biostimulant potential and to contribute to the development of more sustainable ornamental plant production systems.

## Objective of the study

The objective of this study was to evaluate the effects of microalgae- and cyanobacteria-based biostimulant biomass on the growth and development of *Pelargonium* under greenhouse conditions. Particular emphasis was placed on the assessment of morphological parameters, growth dynamics, and treatment stability across multiple growing seasons.

Furthermore, the study aimed to determine the consistency of plant responses among different cultivars and to evaluate the reproducibility of treatment effects across years. Ultimately, the research intended to support the practical applicability of these biostimulants in sustainable ornamental plant production systems.

## Methodology

The experiment was conducted under greenhouse conditions over three consecutive growing seasons (2023–2025). Two biostimulant treatments were applied: one based on biomass derived from the microalga *Chlorella vulgaris* (T2) and the other from the cyanobacterium *Nostoc piscinale* (T1), alongside an untreated control.

The study included six commercially relevant *Pelargonium* cultivars arranged in a randomized experimental design with replicates. The experimental setup was repeated annually under comparable environmental and cultivation conditions.

Plants were subjected to repeated non-destructive measurements throughout the growing period to monitor growth dynamics. At the end of each cultivation cycle, destructive sampling was performed to assess final morphological parameters. Environmental conditions were continuously monitored to ensure experimental consistency.

Statistical analysis was performed using general linear models and mixed-effects models to evaluate treatment effects, year-to-year variability, and cultivar-specific responses. Model assumptions were verified to ensure the robustness and reliability of the results. In the 2025 endpoint samples, exploratory metabolite-level evaluation was also performed, including polyamine profiling and a targeted hormone- and phenolic-compound panel, which were interpreted descriptively and in a hypothesis-generating framework.

## Data collection and measurements

Data collection was carried out systematically over three consecutive growing seasons (2023–2025) under controlled greenhouse conditions. Both non-destructive and destructive measurements were applied to capture growth dynamics and final morphological characteristics of *Pelargonium* plants.

Non-destructive measurements were performed at regular intervals during the vegetation period. These included plant height, leaf number, and bud number, allowing continuous monitoring of growth dynamics. Measurements were conducted on the same individual plants to ensure consistency and enable longitudinal analysis.

At the end of each growing cycle, destructive sampling was carried out to obtain detailed morphological data. Parameters included fresh and dry aboveground biomass, root biomass, and root collar diameter. Dry mass was determined after oven-drying the samples to constant weight, while root systems were carefully cleaned prior to measurement.

Environmental parameters, including temperature and humidity, were continuously monitored throughout the experiments to ensure uniform growing conditions. All measurements were performed according to standardized protocols to minimize variability.

The collected data were organized into structured datasets suitable for statistical analysis, enabling comparisons across treatments, cultivars, and growing seasons.

## Result and Discussion

The application of microalgae- and cyanobacteria-based biomass treatments resulted in significant improvements in several key morphological parameters of *Pelargonium*. According to the general linear model, treatment effects were significant for all primary endpoint variables, including dry biomass, root biomass, root collar diameter, and plant height ($p < 0.001$).

The most pronounced effects were observed in parameters related to biomass accumulation and root development. Dry plant biomass increased by 19.2% (T1) and 33.1% (T2), while root biomass showed increases of 22.3% and 24.1% compared to the control. Root collar diameter also increased substantially (T1: +9.3%; T2: +17.0%), indicating improved structural stability of the plants.

In contrast, the effect on plant height was less pronounced, suggesting that the biostimulant treatments primarily enhanced biomass accumulation and root system development rather than shoot elongation.

The results of repeated, non-destructive measurements demonstrated that treatment effects were most clearly reflected in leaf number. Mixed-model analysis revealed a significant treatment effect ($F = 4.16$; $p = 0.016$) as well as a significant treatment × time interaction ($F = 4.73$; $p < 0.001$), indicating that treatment effects varied over time and became more pronounced in the later stages of the cultivation period. By day 42, leaf number increased by approximately 4.2–4.3% compared to the control.

Bud formation showed a positive but not consistently significant trend, while plant height exhibited only moderate treatment effects over time.

The significant treatment × cultivar interaction indicated that the magnitude of plant response was genotype-dependent. However, the direction of the treatment effect remained consistently positive across all cultivars. In contrast, the treatment × year interaction was not significant, suggesting that the observed effects were stable and reproducible across the three growing seasons.

Overall, the results demonstrate that microalgae- and cyanobacteria-based biostimulants can effectively enhance biomass production, root development, and structural plant quality in Pelargonium under greenhouse conditions. Exploratory endpoint metabolite analyses also indicated biologically interpretable differences between treated and control plants, not only at the level of polyamine patterns, but also in a targeted hormone- and phenolic-compound panel, supporting a more comprehensive physiological interpretation of the observed phenotypic responses.

## Conclusion

This study demonstrated that microalgae- and cyanobacteria-based biomass treatments significantly improved the growth and structural quality of

*Pelargonium* under greenhouse conditions. The most pronounced effects were observed in biomass accumulation and root development, with consistent positive responses across cultivars and years. These findings confirm the potential of such biostimulants as sustainable alternatives in ornamental horticulture, supporting improved plant performance and environmentally friendly production practices. The exploratory metabolite results further suggest that the observed phenotypic effects may be accompanied by coordinated biochemical shifts, although these findings should be interpreted as descriptive and hypothesis-generating rather than confirmatory.

## Novel Scientific Results of Doctoral Research

- The study demonstrated that the investigated microalgae- and cyanobacteria-based biomass treatments applied to *Pelargonium* under practical greenhouse conditions resulted in reproducible growth responses that differed from the control across three consecutive growing seasons.

- The study established that the effects of the treatments were primarily expressed in biomass accumulation and root-related structural parameters, while their influence on final plant height remained moderate.
- The study showed that the differences associated with the treatments in repeated, non-destructive growth measurements became more pronounced not in the early stages, but during the second half of the cultivation period.
- The study found that the magnitude of plant response exhibited strong cultivar dependency; however, the overall direction and relative ranking of treatment effects remained consistent across the examined growing seasons.
- The study demonstrated that exploratory endpoint metabolite analyses associated with the phenotypic results revealed biologically interpretable

differences between treated and control plants, including both polyamine patterns and a targeted hormone- and phenolic-compound panel, thereby providing a basis for future investigations into the underlying mechanisms of action.

## Publications


- **Németh, A.**, Horváth, N., Katona, S., & Molnár, Z. (2024). Review of biostimulant microalgae. *Acta Agronomica Óváriensis, 65*(1), 36–55. https://doi.org/10.17108/ActAgrOvar.2024.65.1.36
- **Németh, A.**, Horváth, N., Katona, S., Kerekes, G., & Molnár, Z. (2024). The use of biostimulant microalgae to influence the growth and development of ornamental plants. *BIO Web of Conferences, 125*, Article 03003. https://doi.org/10.1051/bioconf/202412503003
- **Németh, A.**, Kabato, W., Horváth, N., Fehér, N., & Molnár, Z. (2026). Microalgae-based biostimulants improve biomass production and root-linked

performance stability in *Pelargonium*: A three-year greenhouse study. *Plants, 15*, Article 803. https://doi.org/10.3390/plants15050803

- Kabato, W., Getnet, G. T., Sinore, T., **Németh, A.**, & Molnár, Z. (2025). Towards climate-smart agriculture: Strategies for sustainable agricultural production, food security, and greenhouse gas reduction. *Agronomy, 15*(3), Article 565. https://doi.org/10.3390/agronomy15030565
- Molnár, Z., Mutum, L., Kabato, W. S., **Németh, A.**, & Janda, T. (2023, November 16). Mikroalga biomassza kezelések hatása őszi búza kisparcellás kísérletben [Conference abstract].