



Abstract

Assessment of Cyanobacterial Biomass as Sustainable Agricultural Fertilizer: Soil Experiment with Plants in Pot [†]

Anabella Massa ^{1,2,3,4,5,*}, Joana Azevedo ⁵, Rui Azevedo ⁶, Edgar Pinto ^{2,6}, Anabela Costa ⁶, Vitor Vasconcelos ^{2,5,7}, Alexandre Campos ⁵ and Marisa Freitas ^{5,7}

- ¹ Instituto de Ciências Biomédicas Abel Salazar (ICBA), University of Porto, Rua Jorge de Viterbo Ferreira 228, 4050-313 Porto, Portugal
 - ² Faculdade de Ciências (FCUP), University of Porto, Rua do Campo Alegre S/N, 4169-007 Porto, Portugal; ecp@ess.ipp.pt (E.P.); vmvascon@fc.up.pt (V.V.)
 - ³ Universidad del País Vasco/Euskal Herriko Unibertsitatea (UPV/EHU), Barrio Sarriena, S/N, 48940 Leioa, Bizkaia, Spain
 - ⁴ Université de Pau et des Pays de l'Adour (UPPA), Avenue de l'Université, 64000 Pau, France
 - ⁵ Interdisciplinary Centre of Marine and Environmental Research (CIIMAR/CIMAR), University of Porto, Terminal de Cruzeiros de Leixões, Av. General Norton de Matos S/N, 4450-208 Matosinhos, Portugal; joana.azevedo@ciimar.up.pt (J.A.); acampos@ciimar.up.pt (A.C.); maf@ess.ipp.pt (M.F.)
 - ⁶ Faculdade de Farmácia, University of Porto, Rua do Campo Alegre S/N, 4169-007 Porto, Portugal; ruiazevedo43@gmail.com (R.A.); acosta@ff.up.pt (A.C.)
 - ⁷ CISA/Research Center in Environment and Health, Department of Environmental Health, School of Health, Polytechnic Institute of Porto, Rua Dr. António Bernardino de Almeida 400, 4200-072 Porto, Portugal
- * Correspondence: anabella.massa@gmail.com
- [†] Presented at the 7th Iberian Congress on Cyanotoxins/3rd Iberoamerican Congress on Cyanotoxins, Ponta Delgada, Portugal, 18–20 July 2022.
- ‡ Presenting author (poster).



Citation: Massa, A.; Azevedo, J.; Azevedo, R.; Pinto, E.; Costa, A.; Vasconcelos, V.; Campos, A.; Freitas, M. Assessment of Cyanobacterial Biomass as Sustainable Agricultural Fertilizer: Soil Experiment with Plants in Pot. *Biol. Life Sci. Forum* **2022**, *14*, 22. <https://doi.org/10.3390/blsf2022014022>

Academic Editor: Vitor Gonçalves

Published: 20 July 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: Providing food to the growing human population in a sustainable way is one of the greatest challenges of modern society. In this context, cyanobacterial biomass (CB) can function as a source of macronutrients to increase soil productivity. These organisms can be collected from the environment in considerable amounts, since they tend to grow in large blooms. However, some of these cyanobacterial strains produce toxins that need to be carefully monitored to avoid food accumulation. The objective of this work was to evaluate the possible use of toxic and non-toxic strains of CB as fertilizer supplement in the growth of economically relevant vegetables. One-month-old *Raphanus sativus* (radish) and *Spinacia oleracea* (spinach) plants were grown in pots in indoor controlled conditions. Six experimental conditions were set: (1) a control with no nutrient addition, (2) a recommended dose of a NK commercial fertilizer (CF), 0.6g of lyophilized CB of (3) a non-toxic strain of *Cylindrospermopsis raciborskii*, (4) a toxin-producing strain of *C. raciborskii*, (5) *Microcystis aeruginosa*, and (6) *Anabaena* sp. Several variables were estimated: in CB, this included the NPK dose addition, and in plants, the height, dry weight (dw) of the shoot and root, and the mineral content of plant edible parts. The mineral content in CB was estimated and compared with the recommended dose of CF, according to the information given by the fabricant label. We found no significative differences in N composition; nevertheless, there was a significative higher content in P and significative lower content in K in the CB. In the plants, we found no significative statistical differences between the treatments for the dw of radish root and spinach height. In spinach, the dw of the shoot in the *M. aeruginosa* treatment was significantly lower than the control, CF, and both the toxic and non-toxic *C. raciborskii* biomass. Additionally, in radish, the plant height and dw of the shoot *M. aeruginosa* treatment were significantly lower than in the toxic strain of *C. raciborskii* treatment. When analyzing mineral content in edible parts, we found that spinach treated with control and CF showed a higher content of Ca, Mo, N, P, and K, while in radish, the same two treatments plus the *C. raciborskii* toxic had higher Co and Fe content. *M. aeruginosa* amendment seems to impair shoot growth in both plant species. On the contrary, the toxic *C. raciborskii* CB seems to have a beneficial effect on growth and in mineral uptake on radish plants.

Keywords: radish; spinach; fertilizer; *Anabaena*; *Cylindrospermopsis*; *Microcystis*

Author Contributions: Conceptualization, A.M., J.A., M.F., A.C. (Alexandre Campos) and V.V.; methodology, A.M., J.A., M.F., A.C. (Anabela Costa), A.C. (Alexandre Campos), R.A. and E.P.; software, A.M., J.A. and R.A.; validation, A.M., J.A., R.A., E.P., M.F. and A.C. (Alexandre Campos); formal analysis, A.M. and J.A.; investigation, A.M., J.A., M.F. and A.C. (Alexandre Campos); resources, A.M., J.A., E.P., M.F., A.C. (Alexandre Campos) and V.V.; data curation, A.M., J.A. and R.A.; writing—original draft preparation, A.M., M.F. and A.C. (Alexandre Campos); writing—review and editing, J.A., M.F. and A.C. (Alexandre Campos); supervision, J.A., M.F. and A.C. (Alexandre Campos); project administration, A.C. (Alexandre Campos) and V.V.; funding acquisition, A.C. (Alexandre Campos) and V.V. All authors have read and agreed to the published version of the manuscript.

Funding: This work received funding from the European Union’s Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 823860.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: Many thanks to Nuno Vilas Boas, Diogo Lameirinhas Martins and Joana Costa Ferreira for helping us execute the experiment.

Conflicts of Interest: The authors declare no conflict of interest.