Biostimulants for Sustainable Hydroponic Lettuce Farming Under Saline Stress

Boran İkiz[1], Hayriye Y. Dasgan[1*], Sibel Balik[1], Sebnem Kusvuran[2], and Nazim S. Gruda[3]

[1] University of Cukurova, Adana, Türkiye
[2]Food and Agriculture Vocational School, Cankiri Karatekin University, Çankırı, Türkiye
[3] University of Bonn, Bonn, Germany and Academy of Sciences of Albania, Tirana, Albania.

*Corresponding author: dasgan@cu.edu.tr

Keywords: antioxidants; mineral content; nitrate; soilless cultivation; phenols; saline conditions; salinity.

Climate change is increasingly limiting the availability, quality, and distribution of high-quality water for agriculture due to shifting precipitation patterns, higher evaporation rates, extreme weather events, and rising salinity. Clean water is essential in vegetable cultivation, especially in greenhouse and soilless systems. However, water scarcity frequently necessitates the use of saline groundwater for irrigation. Salinity significantly challenges salt-sensitive vegetables like lettuce, particularly in a greenhouse. Hydroponics water quality ensures nutrient solution stability, enhances nutrient uptake, prevents contamination, regulates pH and electrical conductivity, and maintains system components. This study aimed to mitigate salt-induced damage in lettuce grown via the floating culture method under 50 mM NaCl salinity by applying biostimulants. Here, we examined lettuce's physiological, biochemical, and agronomical responses to salt stress after applying biostimulants such as amino acids, arbuscular mycorrhizal fungi, plant growth-promoting rhizobacteria (PGPR), fulvic acid, and chitosan. The experiment was conducted in a greenhouse with a randomized complete block design, and each treatment was replicated four times. Biostimulant applications alleviated salt's detrimental effects on plant weight, height, leaf number, and leaf area. Yield increases under saline water were from 33%-75%, using biostimulants. Biostimulants improved stomatal conductance (58–189%), chlorophyll content (4–10%), nutrient uptake (15–109%), and water status (9–107%). Biostimulants boost proline levels in lettuce, enhancing osmotic balance and reducing oxidative stress, lowering water potential, promoting water uptake, and restoring turgor. They regulated the reactive oxygen species by preventing metal auto-oxidation, reducing available electrons for ROS production, and enhancing antioxidant activity. The addition of biostimulants increased ascorbate peroxidase activity by 16–187%, catalase by 17–283%, and glutathione reductase by 16–78% in salt-stressed lettuce. Sodium bicarbonate activity only rose by 10% with fulvic acid. Malondialdehyde, a marker of cellular toxicity that rises under oxidative stress, was significantly reduced by 26–42%, mainly with vermicompost. Different biostimulants seem to have different pathways and different reaction levels in their activity. PGPR (1.0 ml L^{-1}), vermicompost (2 ml L^{-1}), and fulvic acid (40 mg L^{-1}) were particularly effective, enhancing growth, yield, phenol, and mineral content while reducing nitrate levels under saline conditions. Generally, they activated the antioxidative defense systems, offering a sustainable, cost-effective solution for mitigating salt stress in hydroponic lettuce cultivation. We are confident that hydroponic farmers will increasingly incorporate biostimulant products into regular practice. However, further research is essential to understand the mechanisms, optimal properties, concentrations, and synergistic combinations of biostimulants for soilless culture. This research will help maximize crop health, yield, and resilience in such systems.

For the complete publication, please see: İkiz, B., Dasgan, H.Y., Balik, S., Kusvuran, S., and NS Gruda 2024. The use of biostimulants as a key to sustainable hydroponic lettuce farming under saline water stress. BMC Plant Biol 24, 808 (2024). https://doi.org/10.1186/s12870-024-05520-8