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Stronger greens

When drought meets salinity, seaweed extracts bolstered with antioxidants fight back on both fronts.

Daniel Velasco-Clares¹, Eloy Navarro-Leon², Maria Jose Izquierdo-Ramos², Begona Blasco², Juan Manuel Ruiz²

¹ PROMISOL, S.A., C/Cervantes s/n, 25100 Almacelles, Spain.

² Department of Plant Physiology, Faculty of Sciences, University of Granada, 18071 Granada, Spain.

Contact e-mail: daniel.velasco.clares@gmail.com

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INTRODUCTION

Abiotic stresses pose a growing challenge to global agriculture, particularly when they occur simultaneously, as they intensify oxidative damage through excessive reactive oxygen species (ROS) production.

In this study, lettuce plants were exposed to water and salt stress, both individually and in combination, to assess the effectiveness of a biostimulant containing antioxidant compounds and metabolism-eliciting agents: *A. nodosum* extract, proline, salicylic acid menadione sodium bisulfite and tocopherol.

Formulated with an alkaline extract of marine algae, proline, and a blend of key antioxidants, the treatment enhanced plant defences, reduced ROS, and mitigated oxidative damage.

Notably, its efficacy was most pronounced under combined stress for antioxidant enzyme activity, water use efficiency and ion selectivity.

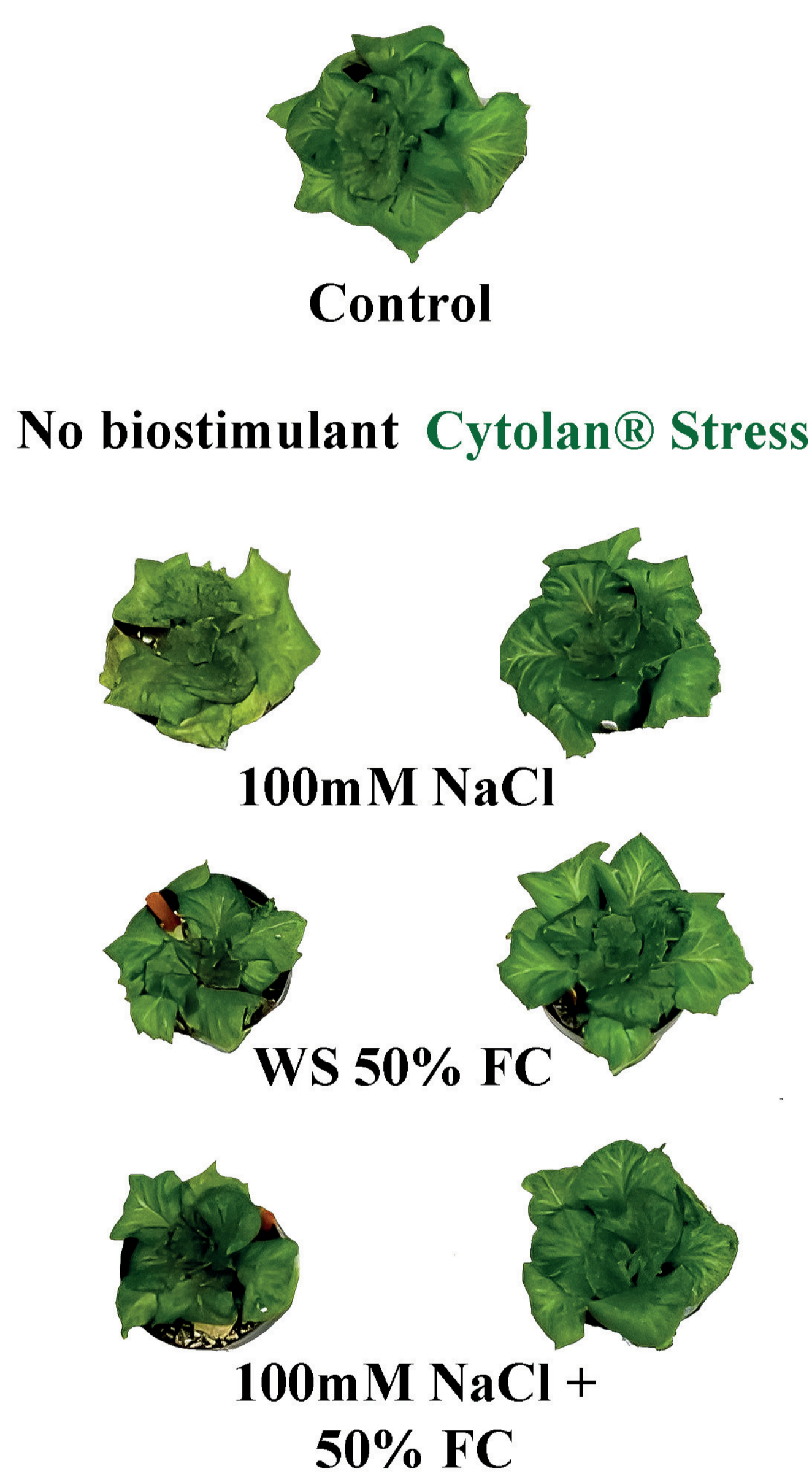
METHODS

Lettuce plants (*Lactuca sativa* cv. Maravilla de Verano) were cultivated for 45 days in nursery trays before transfer to a controlled growth chamber. Plants were grown in perlite with a modified Hoagland nutrient solution and subjected to water (50% field capacity, FC) and salt stresses (100mM), separately and in combination.

A biostimulant (Cytolan® Stress = Cyt) containing antioxidant compounds (tocopherol, ascorbate) and metabolism stimulating agents (salicylic acid and menadione sodium bisulfite) was applied as a foliar treatment at a previously optimised dose of 300ml/hl. The total applications were three: 7 days after transplanting, and 2 more applications separated by 15 days.

The experimental design followed a randomized complete block arrangement with eight plants per treatment. Physiological, biochemical, and antioxidant parameters were analyzed 10 days post-stress induction. Measurements included leaf area, chlorophyll fluorescence, gas exchange, electrolyte leakage, enzymatic and non-enzymatic antioxidant activity, and ion concentrations. Statistical analysis was performed using ANOVA, with Fisher's LSD test to compare treatment means at a 95% confidence level.

RESULTS

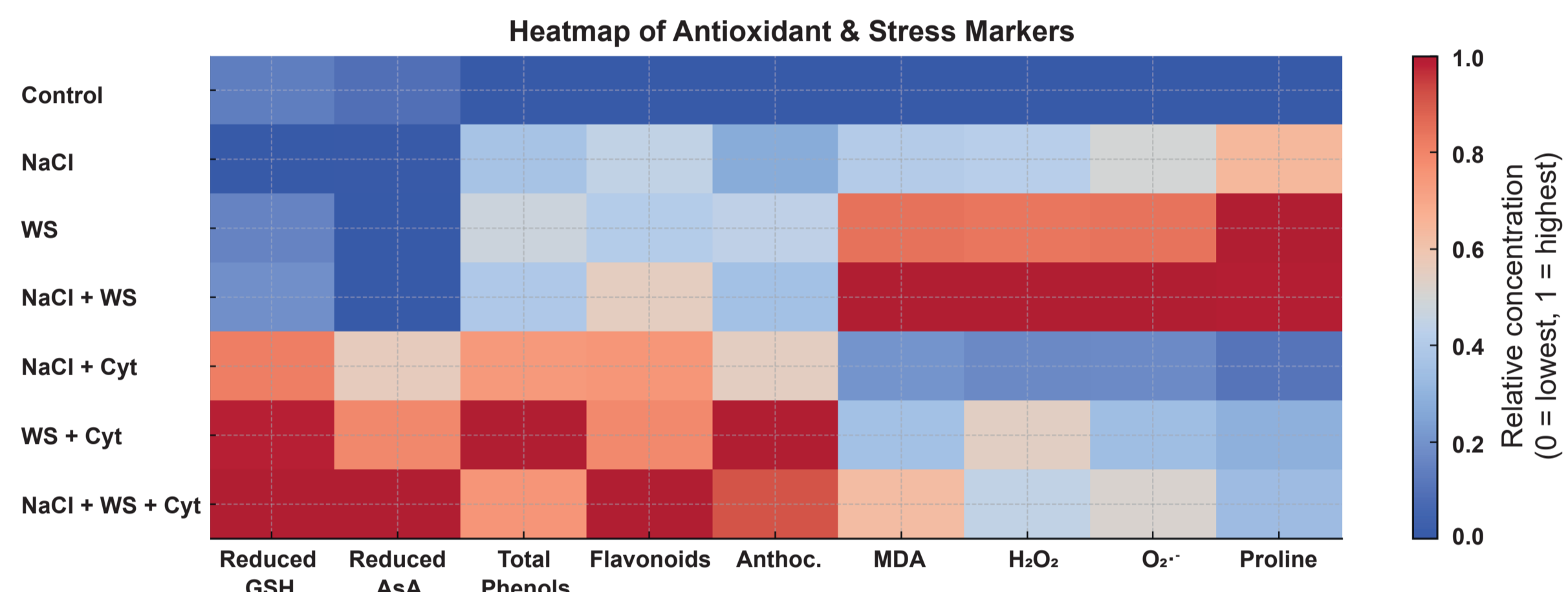


Picture 1.- Images of the state of the plants before sampling. The onset of stresses started 50 days after germination and lasted until 10 days after the third and last foliar application of the biostimulant. At this time, the plants were sampled for physico-chemical analysis.

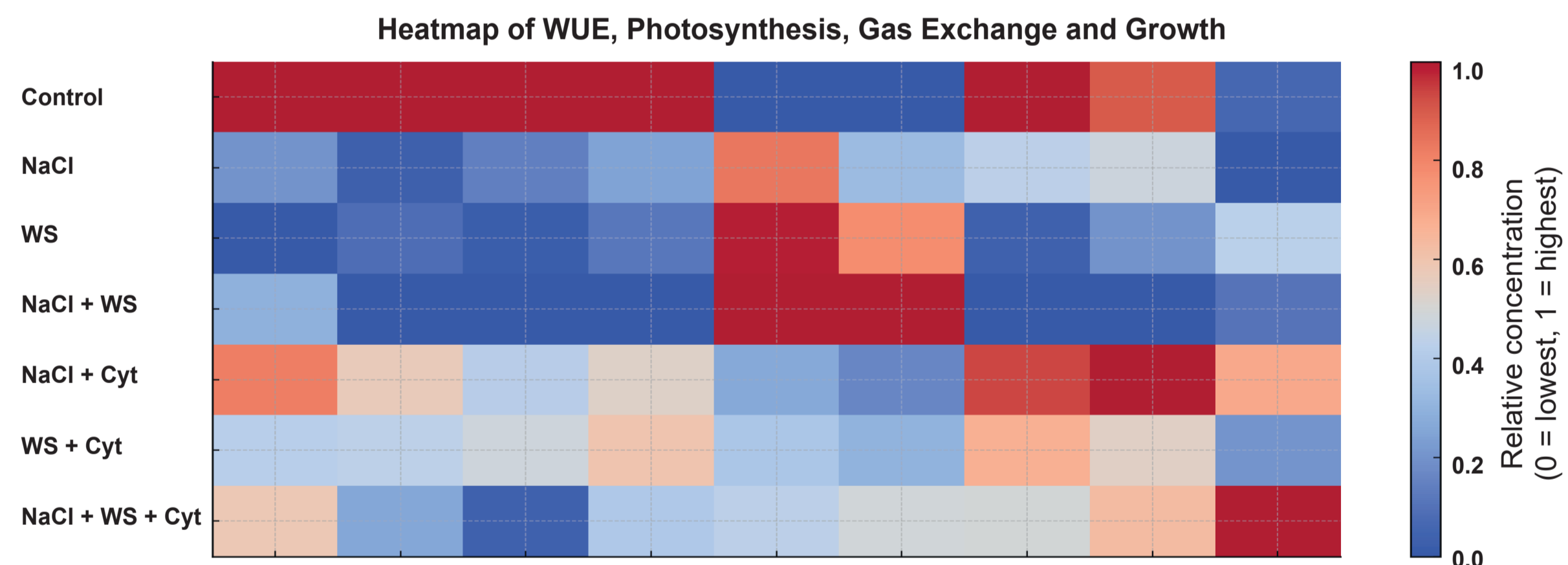
The combined application of NaCl and WS significantly affected lettuce growth, oxidative stress, photosynthesis and ion accumulation. The use of Cytolan® Stress significantly improved plant resistance under these extreme conditions.

Its action was mainly manifested through improvements in membrane stability, the glutathione-ascorbate cycle, photosynthesis protection and ion selectivity.

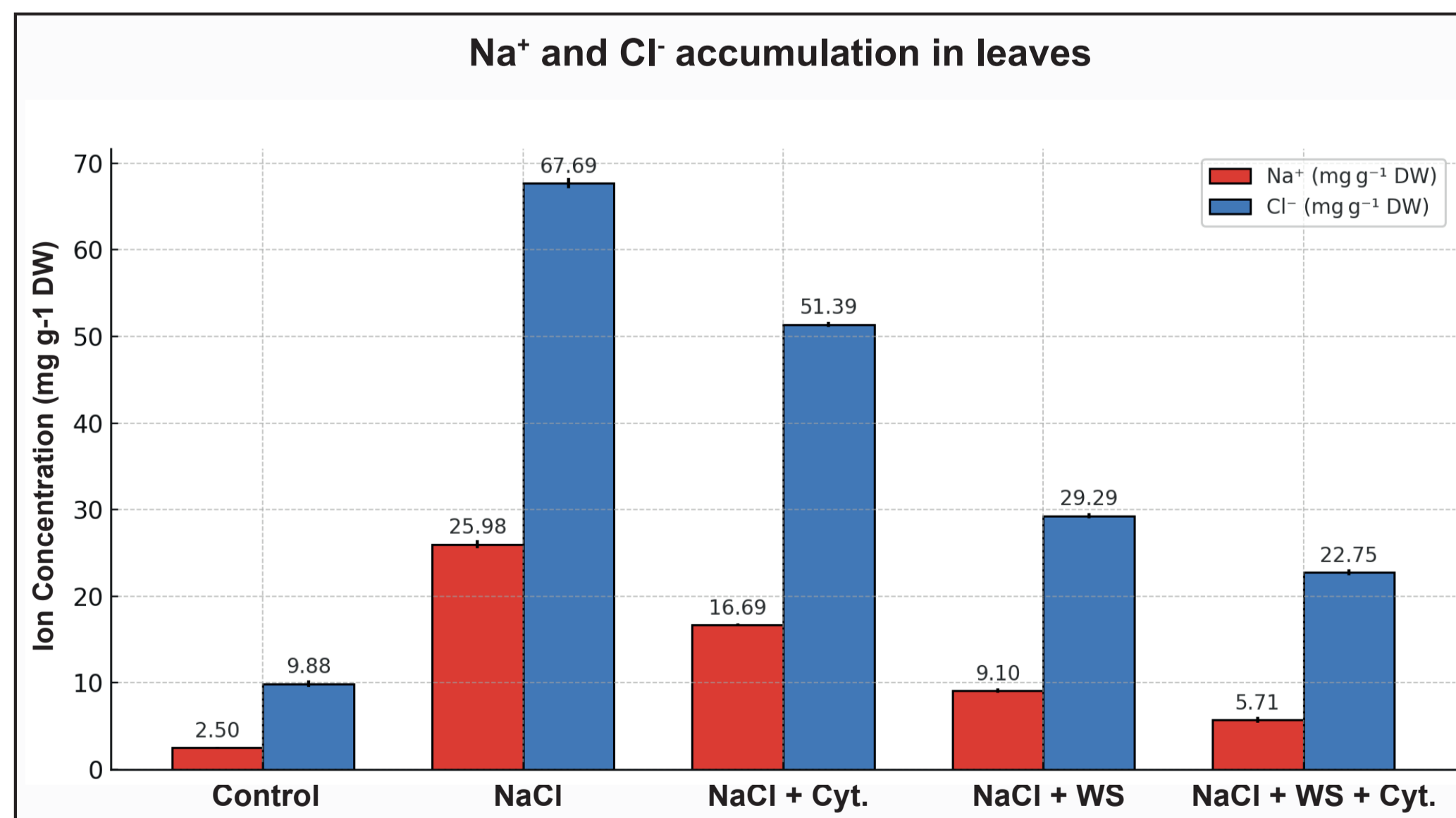
We were also able to confirm its **positive effect on flavonoids and anthocyanins**, substances that occur naturally in plants and have an antioxidant function.



Picture 2.- The biostimulant maximised the concentration of reduced glutathione (GSH), reduced ascorbate (AsA) and flavonoids under combined stress, while significantly increasing the concentration of anthocyanins. At the same time, the stress markers malondialdehyde (MDA), H₂O₂, O₂⁻ and proline remained at a reduced concentration.



Picture 3.- The biostimulant stands out in the combined stress situation, with a high relative water content (RWC) value and maximum water use efficiency (WUE). Photosynthetic performance (PI(ABS)) in NaCl+WS+Cyt is favoured by reduced stomatal resistance (r). *A*, carbon assimilation rate; *E*, transpiration rate; *Ci*, intercellular CO₂; *DW*, dry weight.



Picture 4.- Under combined stress, minimal accumulation of sodium and chlorine ions was recorded in leaves, suggesting improved ionic selectivity in terms of nutrient assimilation.

CONCLUSION

Emphasizing antioxidant metabolism is emerging as a viable approach to address the impact of concurrent abiotic stresses. Notably, **the integration of antioxidants with promoters of antioxidant metabolism appears to be a robust strategy**. Due to their low effective concentrations, these substances can be incorporated into existing fertilizers or biostimulants to amplify their benefits.

FUTURE WORK

- Validation under heat stress conditions separately and in combination with water and/or salt stress.
- Search for methods of encapsulating ingredients to control their release and increase the shelf life of the product.