Mitigation of Salinity-Induced Physiological Stress in Quinoa Using Organic and Mineral Amendments

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Abstract

Soil salinity limits crop production in arid regions. This study evaluated the physiological and growth responses of quinoa (*Chenopodium quinoa Willd., cv. Titicaca*) grown in saline–sodic soil under three salinity levels (4–12 dS·m⁻¹) and soil amendments including gypsum and spent mushroom compost (SMC). Salinity reduced chlorophyll content and biomass, particularly in the control, while SMC, alone or combined with gypsum, mitigated salt stress by improving membrane stability and plant growth.

Introduction

Soil salinity severely limits plant growth and productivity in arid and semi-arid regions by disrupting key morphological and physiological processes. Quinoa (*Chenopodium quinoa Willd.*), a salt-tolerant halophyte, is a promising crop for sustainable production in saline environments (Abbas et al., 2023). Improving saline–sodic soils through mineral and organic amendments is an effective approach to enhance soil quality and crop performance. This study assessed the effects of gypsum and spent mushroom compost (SMC) on physiological traits and growth of quinoa grown in saline–sodic soil. Results showed that amendment application improved plant physiological status and growth under salinity stress, highlighting gypsum and SMC as practical management options for quinoa cultivation in salt-affected soils.

Materials and methods

A pot experiment was conducted using quinoa (*Chenopodium quinoa Willd., cv. Titicaca*) grown in saline–sodic soil collected from the 0–25 cm layer in Ziar, Isfahan, Iran. Treatments included control, gypsum, spent mushroom compost (SMC), and gypsum + SMC. Organic amendments were applied to increase soil organic carbon by 0.5%, while gypsum was applied at 200 g pot^{-1} based on gypsum requirement. Soil salinity was adjusted to ~5 $dS \cdot m^{-1}$ by leaching, and plants were irrigated with saline water at three EC levels (4, 8, and 12 $dS \cdot m^{-1}$). Physiological traits were measured at flowering, and aboveground dry weight at maturity. Data were analyzed using two-way ANOVA and LSD tests ($p \leq 0.05$ and 0.01).

Results and discussion

Organic amendments (SMC and SMC + gypsum) produced the highest SPAD values across all salinity levels, indicating improved chlorophyll retention compared with the control and gypsum alone (Derbali et al., 2024; Figure 1). Electrolyte leakage increased with salinity, particularly in the control, but was significantly reduced by SMC-based treatments, reflecting enhanced membrane stability (El-Shamy et al., 2022; Figure 1). Although aboveground dry weight declined under increasing salinity, SMC and SMC + gypsum consistently maintained higher biomass than gypsum and control treatments (El Mouttaqi et al., 2023; Figure 1). Overall, these findings demonstrate that organic amendments, especially SMC combined with gypsum, effectively mitigate salinity-induced physiological stress in quinoa.

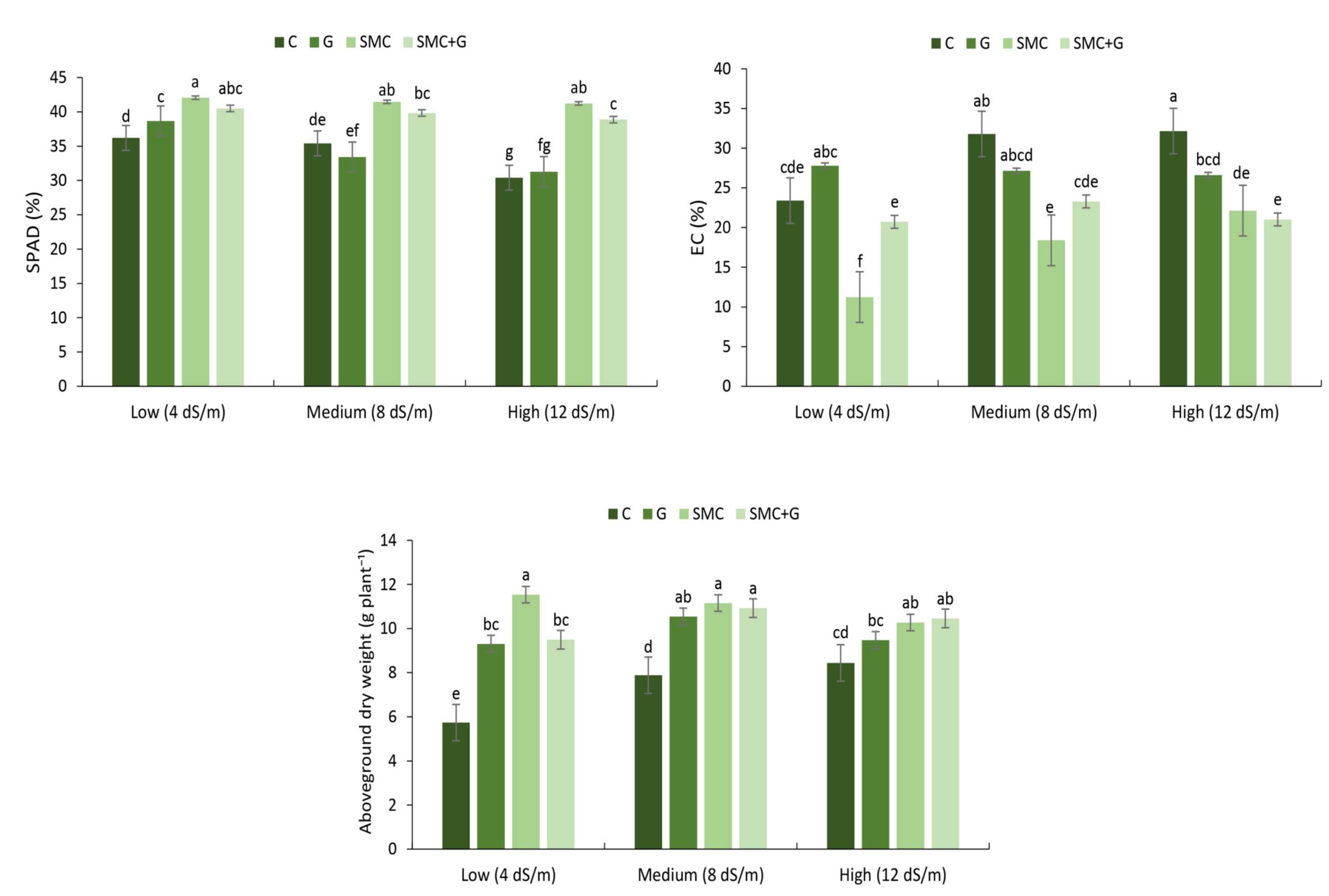

Figure 1. Effects of different soil amendments on SPAD index, electrolyte leakage (EL), and aboveground dry weight of quinoa under three salinity levels: low (4 dS m^{-1}), moderate (8 dS m^{-1}), and high (12 dS m^{-1}). Treatments included Control (C), Gypsum (G), Spent Mushroom Compost (SMC) and SMC+G. Different letters above the bars indicate statistically significant differences based on the LSD test ($p \leq 0.05$).

References

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