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SALINITY STRESS

Water Relations and Transpiration of Quinoa (*Chenopodium quinoa* Willd.) Under Salinity and Soil Drying

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Abstract

Drought and salinity are the two major factors limiting crop growth and production in arid and semi-arid regions. The separate and combined effects of salinity and progressive drought in quinoa (*Chenopodium quinoa* Willd.) were studied in a greenhouse experiment. Stomatal conductance (g_s), leaf water potential (Ψ_l), shoot and root abscisic acid concentration ([ABA]) and transpiration rate were measured in full irrigation (FI; around 95 % of water holding capacity (WHC)) and progressive drought (PD) treatments using the irrigation water with five salinity levels (0, 10, 20, 30 and 40 dS m^{-1}); the treatments are referred to as FI_0, FI_{10}, FI_{20}, FI_{30}, FI_{40}; PD_0, PD_{10}, PD_{20}, PD_{30}, PD_{40}, respectively. The measurements were carried out over 9 days of continuous drought. The results showed that increasing salinity levels decreased the total soil water potential (Ψ_T) and consequently decreased g_s and Ψ_l values in both FI and PD. During the drought period, the xylem [ABA] extracted from the shoots increased faster than that extracted from the roots. A reduction in Ψ_T, caused by salinity and soil drying, reduced transpiration and increased apparent root resistance (R) to water uptake, especially in PD_0 and PD_{40} during the last days of the drought period. The reasons for the increase in apparent root resistance are discussed. At the end of the drought period, the minimum value of relative available soil water (RAW) was reached in PD_0. Under non-saline conditions, Ψ_l decreased sharply when RAW reached 0.42 or lower, but under the saline conditions of PD_{10} and PD_{20}, the threshold values of RAW were 0.67 and 0.96, respectively. In conclusion, due to the additive effect of osmotic and matric potential during soil drying on soil water availability, quinoa should be re-irrigated at higher RAW in salt-affected soils, i.e. before the soil water content reaches the critical threshold level causing the drop in Ψ_l resulting in stomatal closure.

Introduction

One third of the global land is situated in arid and semi-arid regions (Flowers et al. 1986). Low precipitation, high evapotranspiration rates and low quality water resources are major problems in these regions. Twenty per cent of the soil in arid and semi-arid regions, corresponding to 6 % of the global land, are saline soils (Flowers et al. 1986). Soils are classified as saline when the saturated electrical conductivity (EC_e) is 4 dS m^{-1} or more, which is equivalent to approximately 40 mM NaCl, and generates an osmotic potential of approximately −0.2 MPa (USDA-ARS 2008). Plants could be damaged due to osmotic stress imposed externally, by high ion concentrations in the soil, or internally, when excess salt uptake results in high salt accumulation in the intercellular spaces. Thus, plant adaptation to salinity could be of three distinct types: (i) osmotic stress tolerance to high ion concentrations in soil and intercellular spaces, (ii) Na^+ or Cl^- exclusion, and (iii) tissue tolerance to

