

Effects of light source and vapor pressure deficit on quinoa (*Chenopodium quinoa* L.) grown in saline hydroponics

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Introduction

Salinity limits plant growth through osmotic stress, ion toxicity, and nutrient imbalances. In hydroponic greenhouse systems, vapor pressure deficit (VPD) regulates transpiration and thereby influences nutrient uptake. Energy-efficient white LEDs are increasingly used in controlled-environment agriculture, but their performance under combined atmospheric and root-zone stress is still poorly understood.

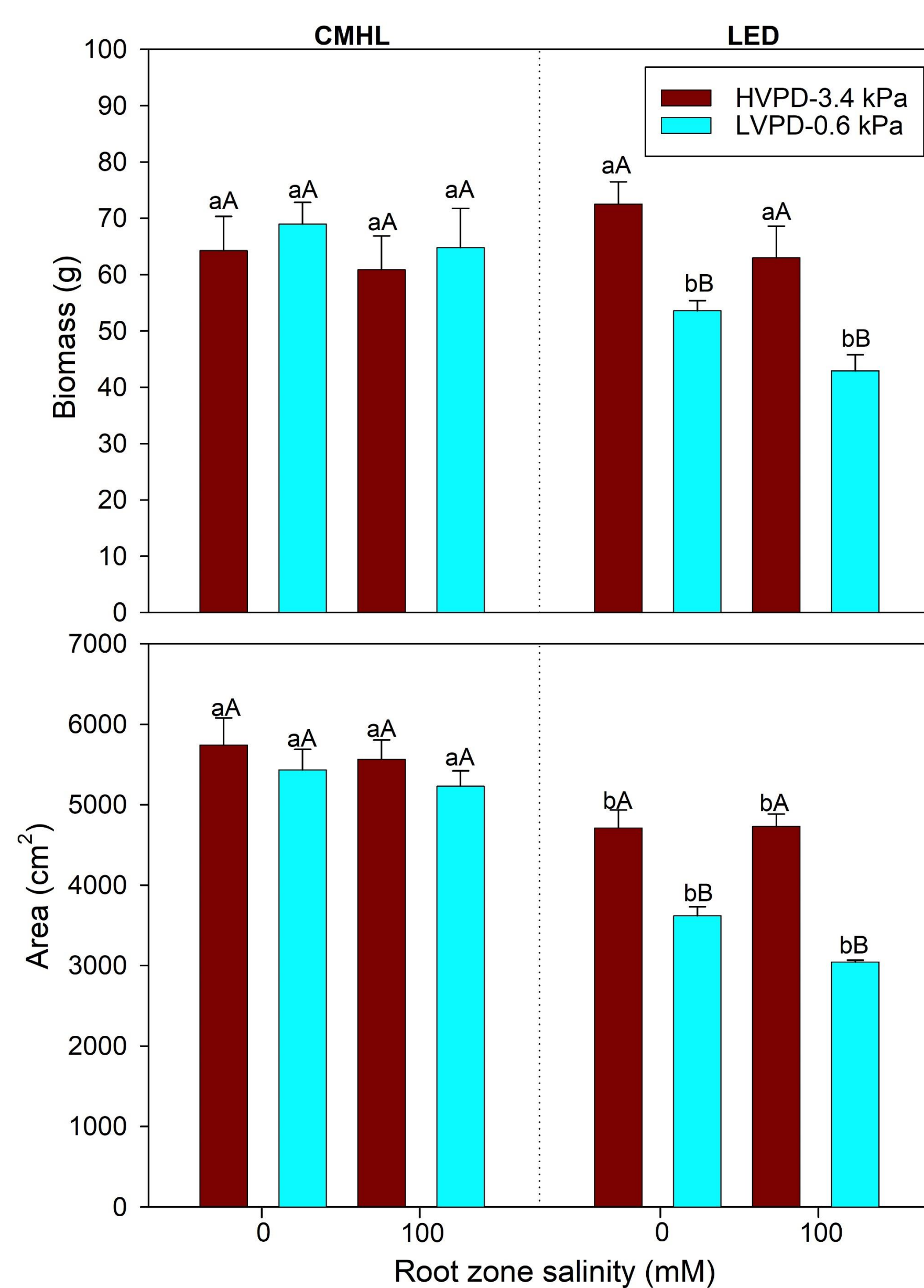


VPD Growth Chamber

Conclusions

- LED maintained biomass comparable to CMHL under high VPD.
- Quinoa tolerated 100 mM NaCl under high VPD.
- LED produced a smaller, more compact canopy.
- K⁺ uptake under LED was comparable to CMHL at high VPD.
- Lower ET under LED was associated with reduced Na⁺ uptake under salinity.

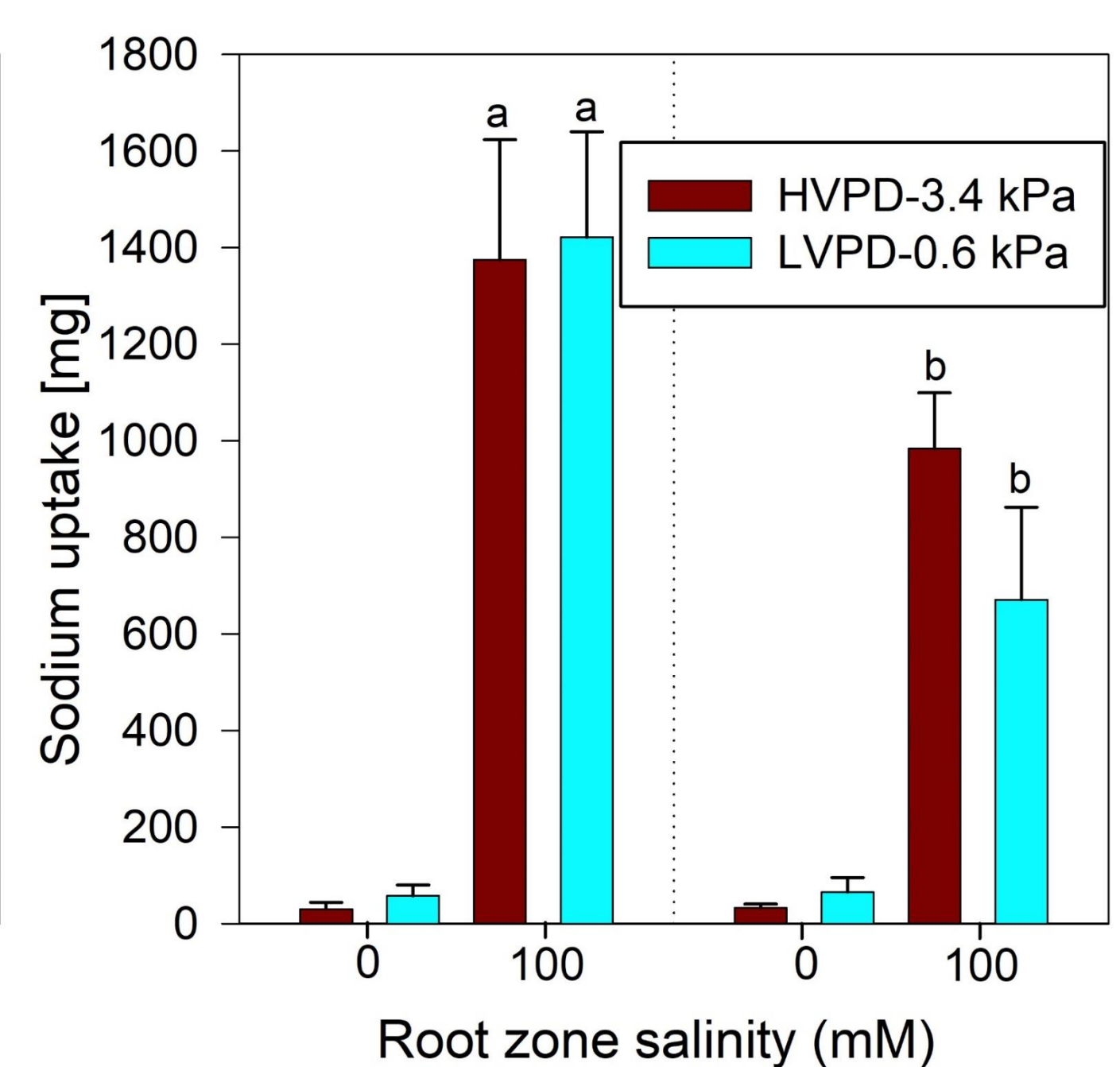
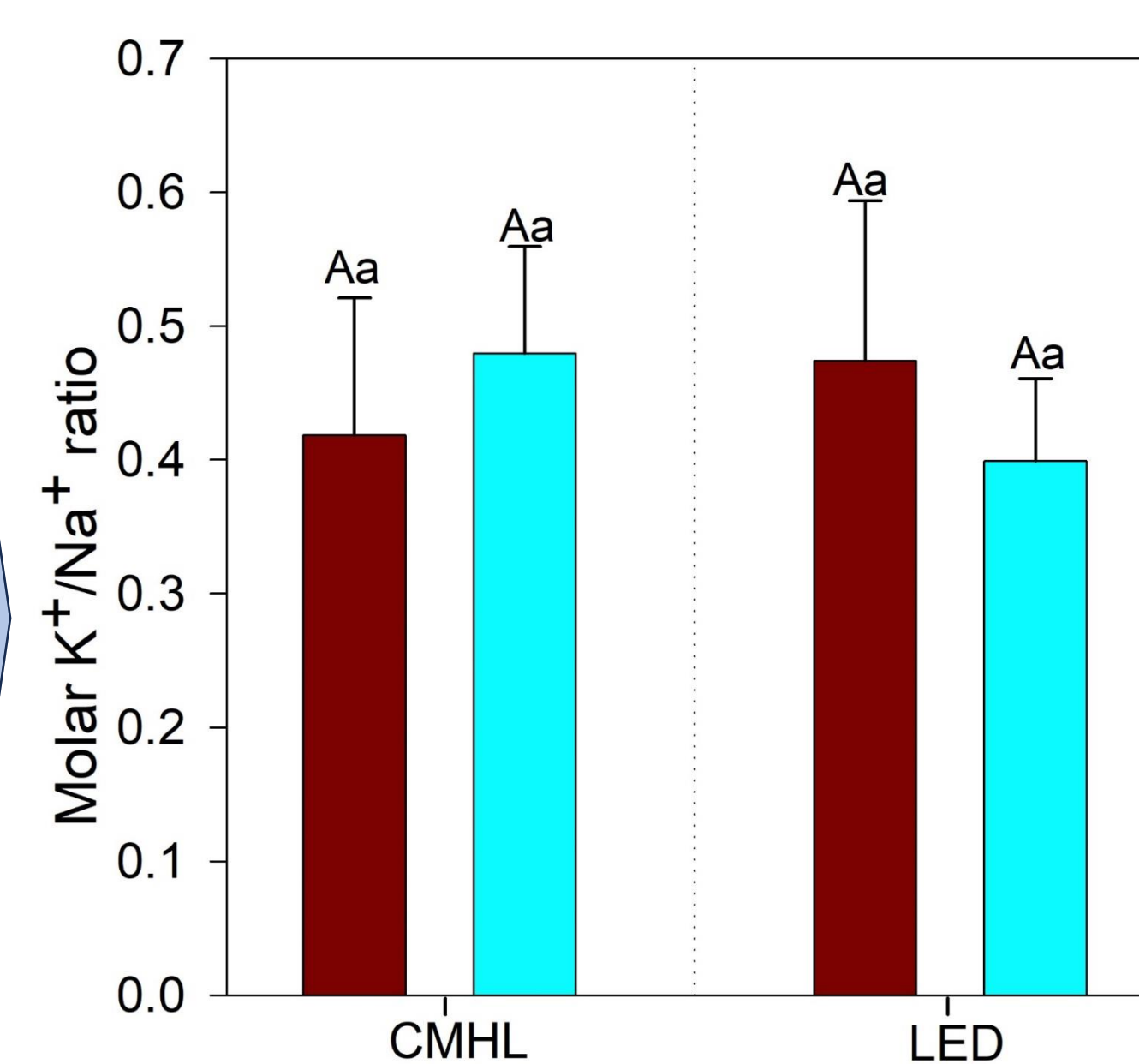
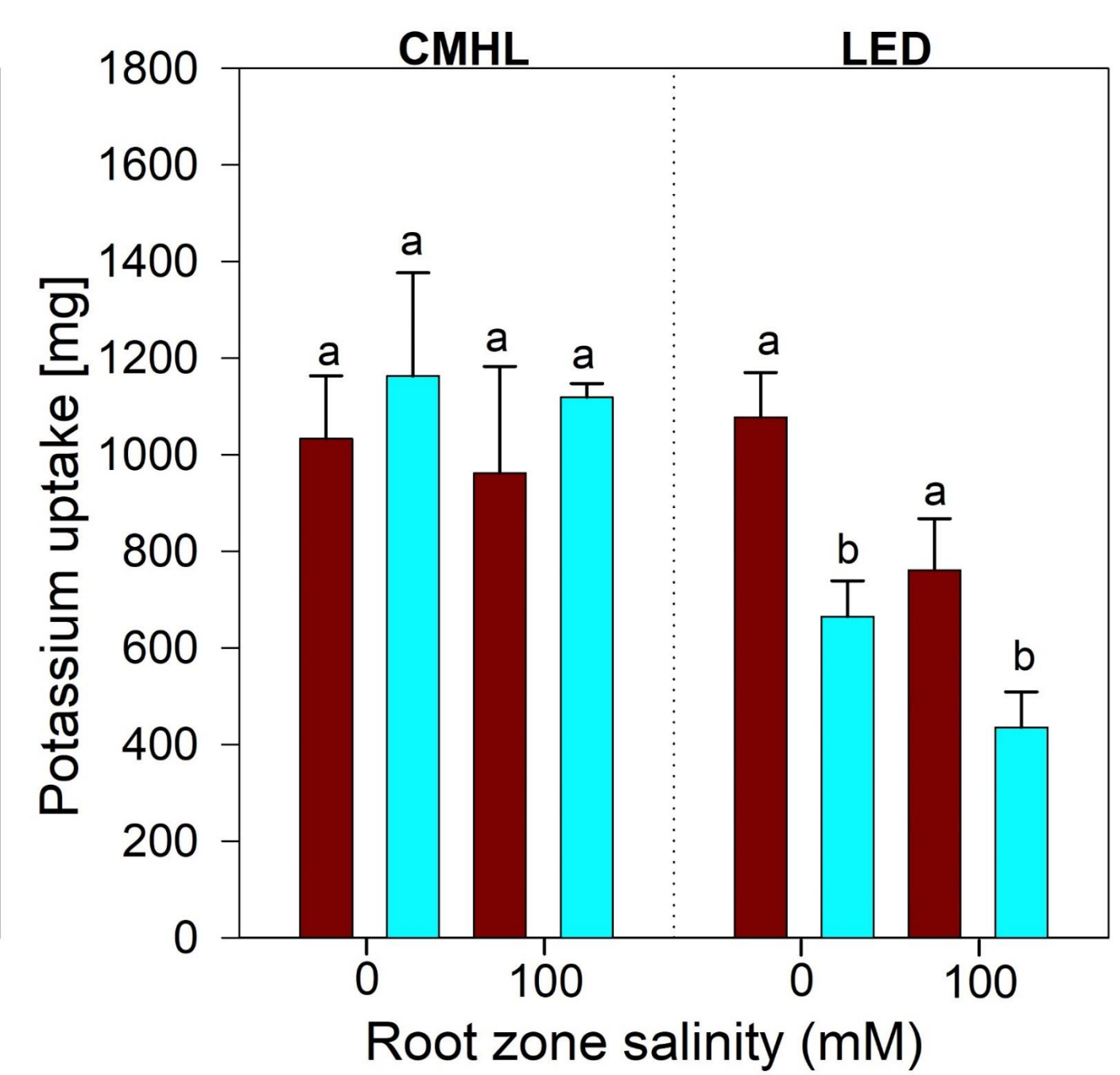
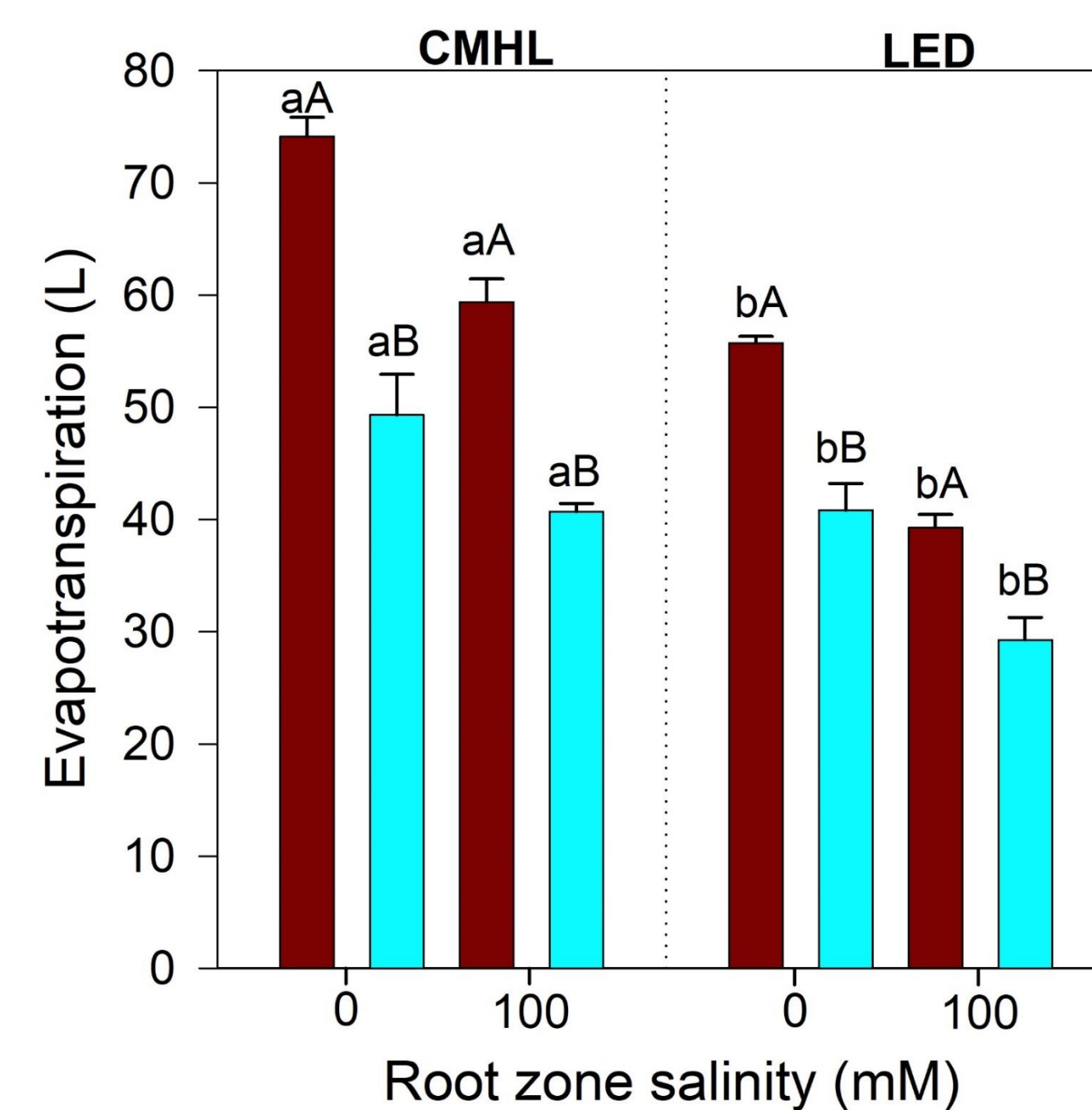
Results and Discussion



- High VPD increased biomass and leaf area under LED.
- LED reduced leaf area compared with CMHL.
- At high VPD, salinity had no effect on biomass or leaf area.

- LED reduced evapotranspiration and Na⁺ uptake compared with CMHL.
- Low VPD strongly reduced K⁺ uptake under LED.
- Whole-plant K⁺/Na⁺ ratio remained similar under LED and CMHL at both VPD levels.

Total plant dry weight and leaf area of 63 days old quinoa plants grown hydroponically under two light sources, two root-zone salinity levels, and two VPD regimes.



Cumulative evapotranspiration and total Na⁺ and K⁺ uptake at 0 and 100 mM NaCl, and whole-plant molar K⁺/Na⁺ ratio at 100 mM NaCl, of quinoa grown under LED and CMHL at two VPD regimes.

- LED maintained biomass despite a smaller leaf area at high VPD.
- LED produced a more compact canopy than CMHL.
- Low VPD reduced growth under LED, especially under salinity.

- Reduced transpiration under LED limited ion uptake, particularly K⁺ under low VPD.
- LED affected total ion uptake more than whole plant K⁺/Na⁺ ratio.
- Lower Na⁺ uptake under LED likely reflected reduced transpirational ion transport rather than improved salt exclusion.

Materials and Methods

Quinoa (*Chenopodium quinoa* cv. Vikinga) was grown in a hydroponic set-up in VPD-regulated growth chambers at the Phytotechnikum of the University of Hohenheim, Germany. Five-week-old seedlings were transplanted into an INTEGAR-based nutrient solution and grown under two light sources, white LED and ceramic metal halide lamps (CMHL). Two VPD levels (0.6 and 3.4 kPa) and two root-zone salinity levels (0 and 100 mM NaCl) were applied for 28 days. Evapotranspiration was recorded daily by replenishing the consumed water. At harvest, leaf area was measured and dry biomass was determined after drying plant material at 65°C for 72 h. Dried samples were analyzed for Na⁺ and K⁺ using a flame photometer, and molar K⁺/Na⁺ ratios were calculated.

