UNIVERSITY OF HOHENHEIM

Institute of Agricultural Sciences in the Tropics (Hans- Ruthenberg-Institute) Water stress Management (490g)

Effects of Light Quality and Nitrogen Form on Reproductive Growth in Hydroponic Quinoa

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Introduction

Controlled environment agriculture using hydroponics safely produces food unaffected by climate change, soil degradation, or fresh-water scarcity.
However, grain production, essential for human nutrition, in hydroponics remains a niche product.

We tested the effect of two light sources and nitrogen (N) forms (pure NO_3^- vs. 50:50 NO_3^--N:NH_4^+-N) on the biomass production of quinoa, with focus on the inflorescence, under saline and non-saline conditions in a deep-water hydroponic system.

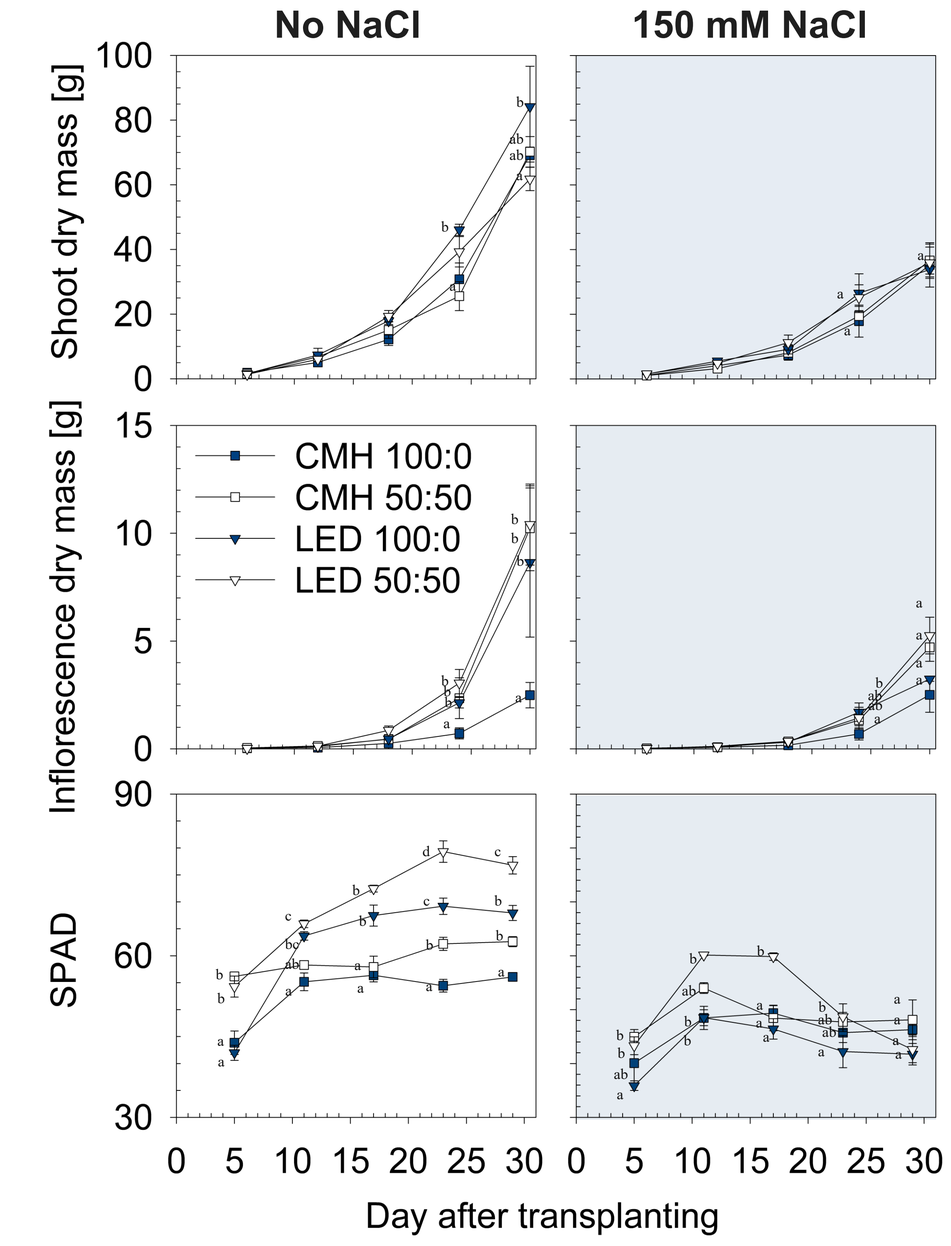
Our findings allow developing strategies to increase future quinoa yields.

Representative main inflorescences for non-saline treatments on the final day. Left: Ceramic metal halide (CMH) lamp, right: Light emitting diode (LED) lamp. 100:0, 50:50: Used NO_3^--N:NH_4^+-N ratio.

Conclusions

- **Without NaCl**, inflorescence biomass was significantly lower under CMH and pure NO_3^-
- **With NaCl**, NH_4^+ may be advantageous, potentially driven by higher chlorophyll concentrations during flower initiation
- **LEDs enhance inflorescence growth** in non-saline conditions with pure NO_3^-, but this effect diminishes under salinity, potentially due to increased Na^+uptake

Results and Discussion



Average (n=3) Shoot dry mass, inflorescence dry mass and SPAD development of the youngest fully developed leaf, separated by 0 mM NaCl (No NaCl) and 150 mM NaCl. CMH = Ceramic metal halide, LED = Light emitting diode lamp. 100:0, 50:50 referring to NO_3^-:NH_4^+-N ratios. Error bars = SE. Different letters show significant differences within the graph and measurement day.

- Significant effect of 150 mM NaCl on shoot and inflorescence dry mass
- **Shoot** dry mass differed up to 31% (no NaCl) and 8% (150 mM NaCl) on final day

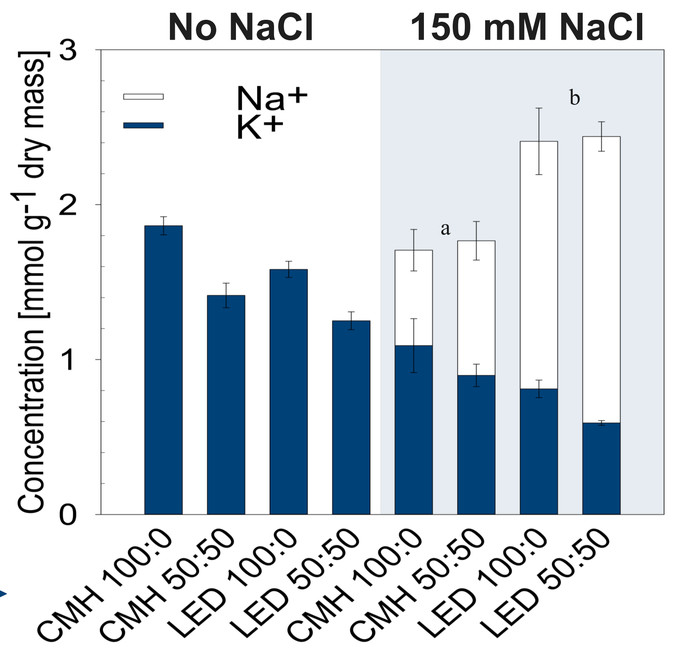
Inflorescence dry mass differed up to 123% (no NaCl) and 71% (150 mM NaCl) on final day

- **No NaCl**: Significantly lower dry mass under CMH and pure NO_3^-
- **150 mM NaCl**: Higher dry mass if NH_4^+ present (not significant)

Effect on SPAD (Chlorophyll indicator):
- **No NaCl**: Strong light and N form effect
- **150 mM NaCl**: NH_4^+ increased SPAD at the beginning

Effect on Na^+ & K^+ Uptake:
- Significantly higher Na^+ concentration in plants under LED
- Significant effect of light, N form, and NaCl (all $p<0.001$) on K^+ concentration

- Inflorescence biomass was more strongly affected by treatments than shoot biomass
- **No NaCl**: Lower inflorescence biomass under CMH and pure NO_3^- likely caused by high NO_3^- uptake, lower chlorophyll concentrations and reduced light intensity
- **150 mM NaCl**: Advantage of LED under non-saline conditions decreased, likely due to increased Na^+uptake



Average Na^+ & K^+ (n=3) concentrations analyzed in the total plant on the final day. CMH = Ceramic metal halide, LED = Light emitting diode lamp. 100:0, 50:50 referring to NO_3^- N:NH_4^+-N ratios. Error bars = SE. Different letters show significant differences between Na^+.

Materials and Methods

Quinoa 'Titicaca' was cultivated for 30 days (24.01.2026-23.02.2026) in deep-flow hydroponic systems. Each system consisted of six euro-boxes with circulating nutrient solution and was triplicated in acrylic glass enclosures placed in a greenhouse of the University of Hohenheim. VPD was maintained at 2.37 kPa during the 14 h of light day^{-1}.
Light was supplied by 4200K ceramic metal halide lamps (CMH) or 5700K light emitting diodes (LED), hanging at the same height. Total Nitrogen (N) (3.0 mM) in the nutrient solution was supplied either as NO_3^- as sole N form (100:0) or NO_3^--N and NH_4^+-N in equal shares (50:50). Nutrient solution contained either 0 mM NaCl or 150 mM NaCl. Nutrient solution was exchanged after experimental day ten every five days. Every six days three plants per treatment were harvested for partitioning and dry mass. Plant organs of the last harvest were analyzed on K^+ and Na^+. Before harvests SPAD was measured non-destructively using the KONICA MINOLTA 502-plus.

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