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Effects of light quality and nitrogen form on reproductive growth in hydroponic quinoa

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Abstract

Hydroponic grain production currently represents only a minor share compared to leafy vegetable cultivation. However, increasing climate change, soil degradation, and water scarcity underscore its potential role in future food security. In controlled environment agriculture, maximising reproductive biomass accumulation is essential to optimise resource-use efficiency and reduce operational costs per unit of yield.

We evaluated the effects of light quality and nitrogen form on generative growth in quinoa (*Chenopodium quinoa* Willd., 'Titicaca'). Plants were grown in deep water flow systems under blue-dominated LED and metal halide (MHL) lighting, combined with two nitrogen ratios (NO -N:NH +-N = 50:50 and 100:0) at a total N concentration of 3.0 mM. Additionally, two root zone salinity levels (0 and 150 mM NaCl) were applied to exploit quinoa's salt tolerance. Nutrient solutions were renewed every five days and regularly analyzed. Five destructive harvests were performed at six-day intervals over the 30-day experimental period to assess biomass partitioning, focusing on inflorescence and shoot dry mass (DM).

Shoot DM showed significant interactions between light and time ($p = 0.018$) and salinity and time ($p < 0.001$), whereas nitrogen ratio had no significant effect on the Shoot DM. In contrast, inflorescence DM was significantly influenced by the interaction between light and N ratio ($p = 0.005$). After 25 days, LED-50:50 (2.24 ± 0.51 g), LED-100:0 (1.92 ± 0.24 g), and MHL-50:50 (1.84 ± 0.49 g) treatments produced significantly higher inflorescence DM than MHL-100:0 (0.70 ± 0.17 g). This trend persisted at the final harvest, although not statistically significant ($p = 0.059$). However, the analysis of the inflorescence absolute growth rate confirmed a significantly higher growth performance ($p = 0.005$) for LED-50:50, LED-100:0, and MHL-50:50 over the entire observation period, independent of salinity.

These findings demonstrate that light quality and nitrogen form interactively influence reproductive growth in quinoa. While nitrogen form had no significant effect under LED lighting, ammonium supply significantly enhanced inflorescence growth under MHL. Optimising light spectra and nitrogen ratios may increase inflorescence mass and thus the yield in grain crops in controlled environment hydroponics, making it a viable option for the future of agriculture.

Keywords: Controlled environment farming, hydroponics, light quality, nitrogen form, quinoa

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