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

# Vapor Pressure Deficit Influences Optimal Nitrate to Ammonium Ratio for Quinoa in Hydroponics

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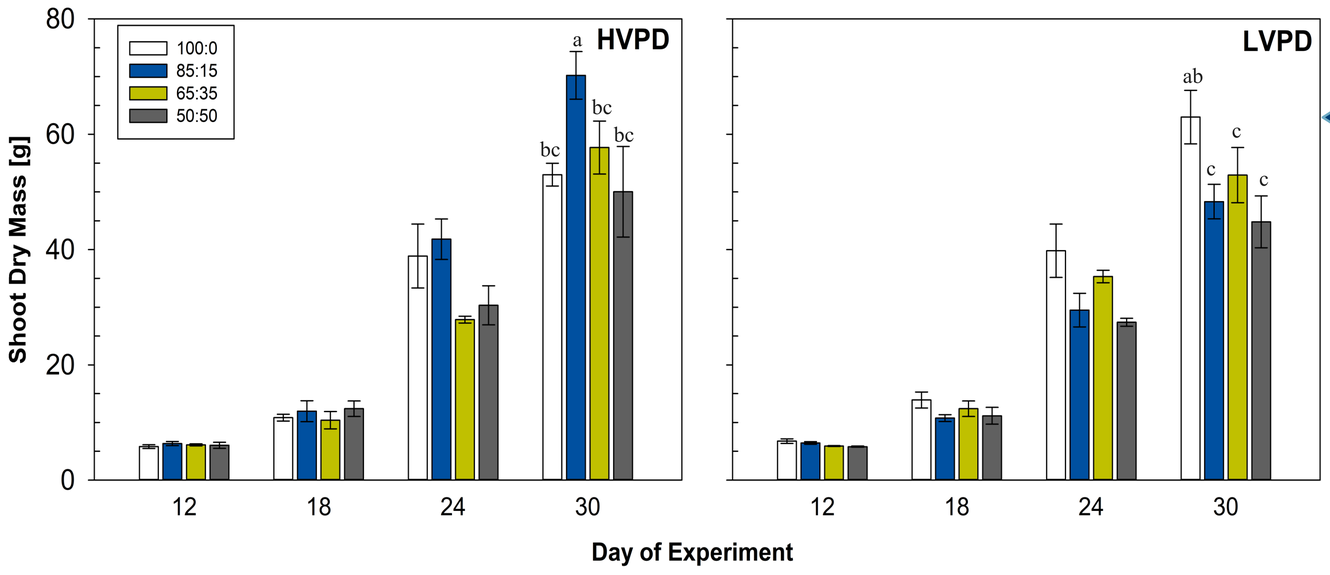
## Introduction

Increasing freshwater scarcity opens the way for alternative water sources for efficient water management. Treated wastewater presents a source for hydroponic food production, yet high ammonium ($NH_4^+$) concentration in the wastewater may limit plant growth. Greenhouse production often operates under low vapor pressure deficit (VPD) which constraints acropetal transport of nutrients. We studied the interactive effects of the nitrate-to-ammonium ratio under high and low VPD on the growth of quinoa cultivated for 30 days in a hydroponic system.

## Conclusions

- VPD influences the optimum $NO_3^-$-N:$NH_4^+$-N ratio for quinoa in hydroponics:
  - Low VPD (LVPD): Pure $NO_3^-$ optimal
  - High VPD (HVPD): 85:15 $NO_3^-$-N:$NH_4^+$-N ratio optimal
- Photosynthetic rate lower under low VPD in the presence of $NH_4^+$ than under high VPD
  - Might cause accumulation of toxic $NH_4^+$ in the cytoplasm
- Preference of quinoa for $NO_3^-$

## Results and Discussion

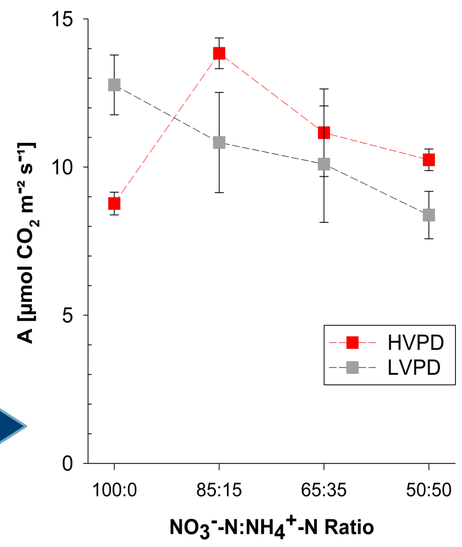



Shoot dry mass development for $NO_3^-$-N:$NH_4^+$-N ratios 100:0, 85:15, 65:35, 50:50, under high (HVPD) and low vapor pressure deficit (LVPD). n=3, day 30: n=6. Error bars show standard errors. Different letters show significant differences.

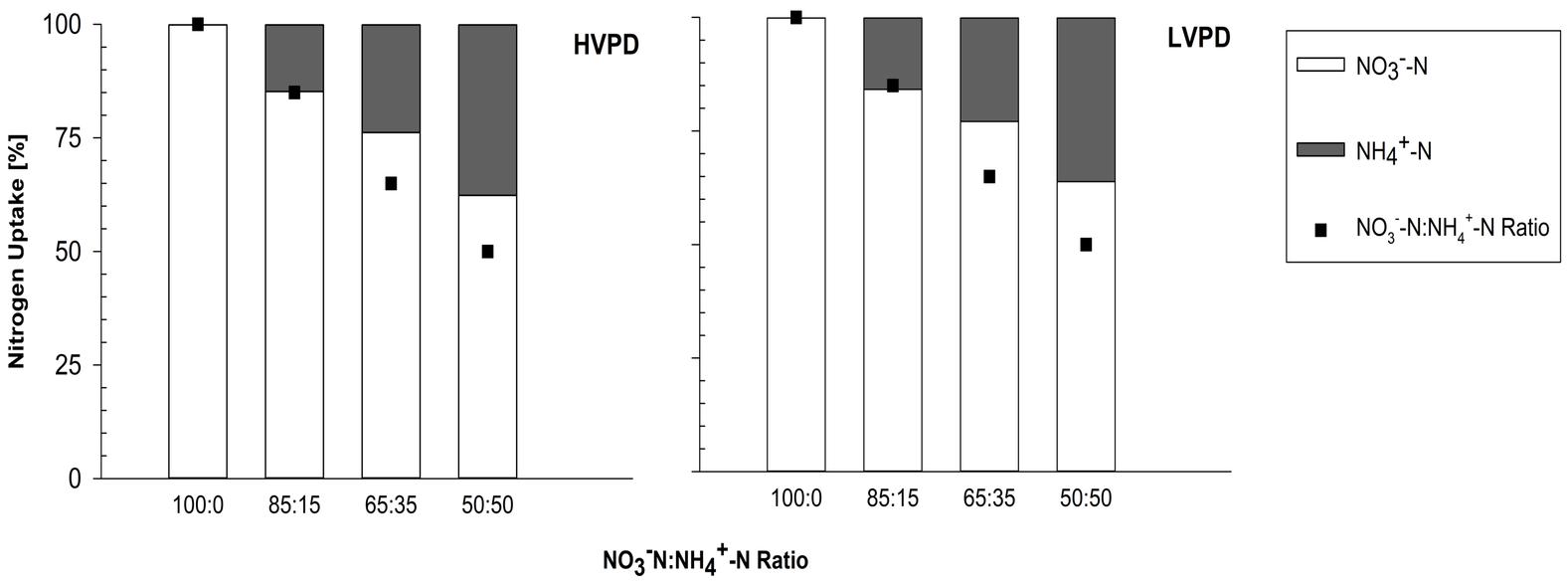
85:15 (high VPD) and 100:0 (low VPD) $NO_3^-$-N:$NH_4^+$-N ratio: Significantly higher biomass than other ratios on day 30

Lower photosynthetic rate under low VPD in $NH_4^+$ presence could lead to:

- Fewer carbon skeletons
- Disrupted GS/GOGAT cycle
- Accumulation of toxic $NH_4^+$




$CO_2$ assimilation rate, measured on youngest fully developed leaf, day 30, using ADCs' LCpro-SD. Error bars show standard errors.




$NO_3^-$-N:$NH_4^+$-N share on total nitrogen uptake for the four $NO_3^-$-N:$NH_4^+$-N ratios and high (HVPD) and low vapor pressure deficit (LVPD). Calculation done on nutrient solution analysis on $NO_3^-$-N and $NH_4^+$-N over 30-day experimental period. Black squares mark the supplied $NO_3^-$-N:$NH_4^+$-N ratio by the nutrient solution.

- No effect of VPD on the $NO_3^-$-N:$NH_4^+$-N uptake ratio
- Preference for $NO_3^-$
- Even with the 50:50 $NO_3^-$-N:$NH_4^+$-N treatment, $NO_3^-$-N accounted for 65% of the total nitrogen uptake

## Materials and Methods

Quinoa 'Titicaca' was cultivated for 30 days (01.07.2025-31.07.2025) in deep-flow hydroponic systems. Each system consisted of six euro-boxes with circulating nutrient solution and was replicated in triplicate acrylic glass enclosures placed in a greenhouse of the university of Hohenheim. VPD was controlled at either 4.0 ± 1.4 kPa (HVPD) or 1.2 ± 0.4 kPa (LVPD) during daytime using humidifiers/dehumidifiers. Artificial light was supplied by ceramic metal halide lamps 16 h $day^{-1}$. $NO_3^-$-N:$NH_4^+$-N ratios (100:0, 85:15, 65:35, 50:50) were maintained at 3.03 mM via stock solution addition every three days, pH was held at 5.3–6.3. Nutrient solution samples were taken daily for analysis. Every six days, three plants per treatment were harvested following assimilation rate measurements.

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