Effects of Root Zone Temperature on Nutrient Depletion Dynamics and Growth Performance of Hydroponically grown Tomato

Susanne Werner, Theresa Detering, Folkard Asch

University of Hohenheim, Hans – Ruthenberg Institute, Management of Crop Water Stress in the Tropics and Subtropics
Garbenstraße 13, 70599 Stuttgart

Introduction

A potential strategy to mitigate climate change induced water scarcity is greenhouse based hydroponic cultivation of crops. One important factor affecting the growth of hydroponically cultivated plants is the root zone temperature [RZT]. Earlier studies have shown, that approximately 25 °C constitutes the ideal RZT for tomato (*Solanum lycopersicum*). However, controlling temperature and humidity (vapor pressure deficit [VPD]) in greenhouses, particularly during the hot months of the year, is difficult, and often results in RZTs higher than optimal. In this context, both nutrient depletion and growth performance at elevated RZT were assessed to identify effective strategies for improving nutrient utilization.

Conclusions

- Elevated RZT negatively affects nutrient uptake and growth performances in dryer greenhouse conditions.
- In humid greenhouse conditions the Root Zone Temperature effect is diminished
- Increase RZT results in stress responses and compensatory stress adjustment mechanisms

Results and Discussion

Nutrient uptake

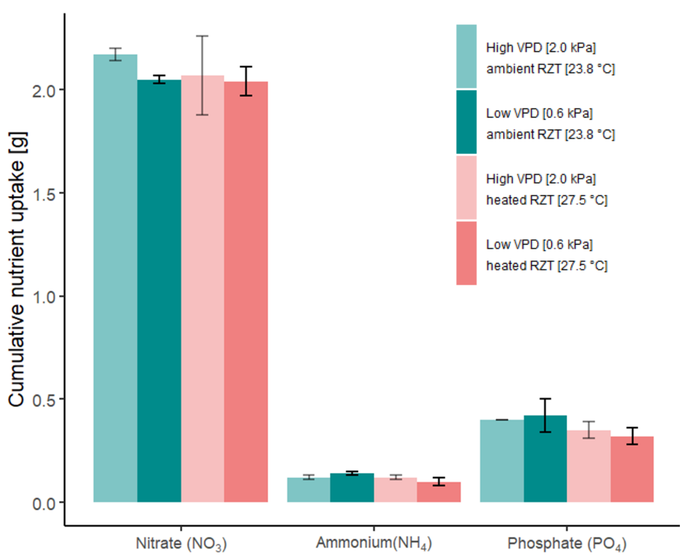

Figure 1: Total nutrient uptake per plant 31 days after transplanting affected by different root zone temperature [RZT] under different vapor pressure deficit [VPD] condition

- Plants grown under high VPD and ambient RZT exhibited the highest NO_3 uptake.
- NH_4 and PO_4 uptake was enhanced in plants grown in ambient RZT under low VPD conditions.

Higher RZT decreased nutrient uptake, leading to less efficient use of the nutrient solution and potentially lower yield.

Biomass & Leaf area

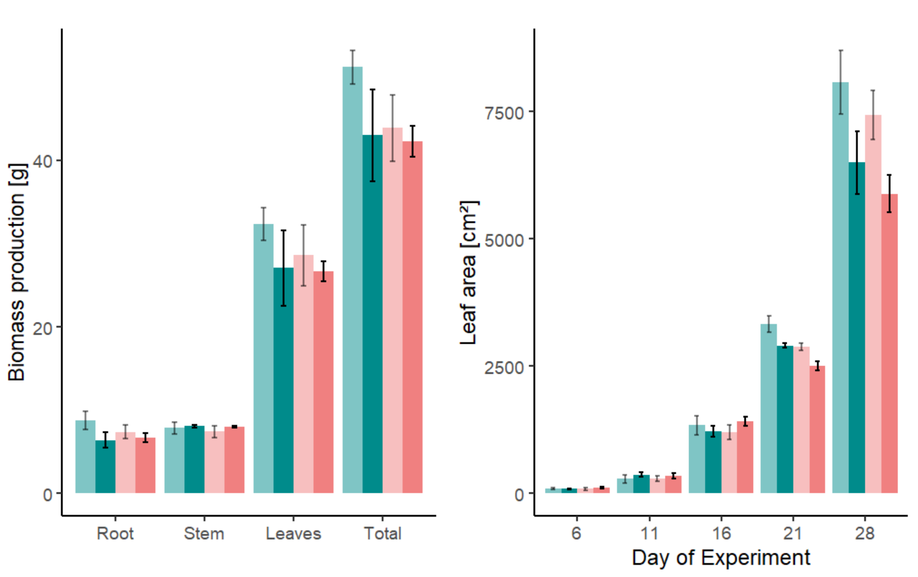

Figure 2: Biomass production per plant 31 days after transplanting, and leaf area development over the course of the experiment affected by different root zone temperatures [RZT] under different vapor pressure deficit [VPD] conditions

- Increased RZT decreased biomass production under high VPD condition.
- The least amount of biomass was allocated to leaves in elevated RZT and low VPD environment with a significant decrease in leaf area 21 days after the start of the experiment (24 % less compared to high VPD and ambient RZT).

Lower leaf biomass and leaf area adversely affect photosynthesis, fruit yield, and nutrient uptake. This leads to a decline in overall plant health, resulting in lower productivity and increased susceptibility to stress.

Chlorophyll

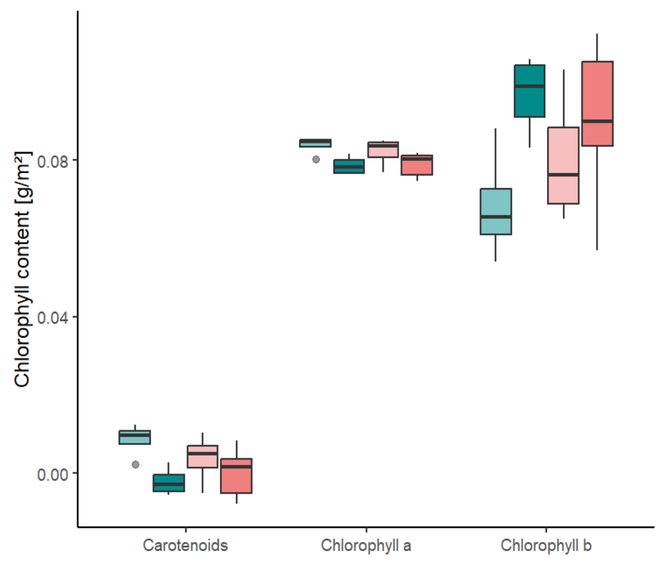

Figure 3: Chlorophyll content affected by different root zone temperature [RZT] under different vapor pressure deficit [VPD]

- Higher RZT in high VPD environment resulted in higher chlorophyll b content at the cost of carotenoids content.
- Under low VPD the elevated RZT affected the chlorophyll b content negatively but carotenoid content positively.

Increasing chlorophyll b content can enhance photosynthetic efficiency. However, a reduction in carotenoids may affect the plant's ability to manage light stress and increase its vulnerability to oxidative damage.

Materials and Methods

A hydroponic experiment was conducted in humidity controlled growth chambers at the Phytotechnikum research greenhouse at the University of Hohenheim (Stuttgart, Germany) from 20.02.2024 to 18.03.2024. Tomato plants variety *Saluoso* were exposed to elevated RZT (~27.5 °C) utilizing a deep water culture hydroponic system. The study involved daily measurements of nutrient levels in the solution to monitor nutrient depletion dynamics, along with destructive harvests at five to seven-day intervals to evaluate growth performance.

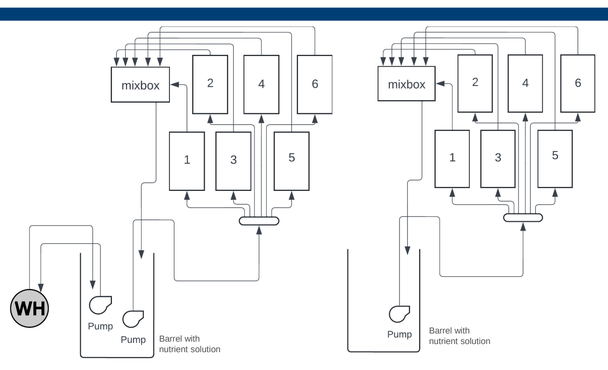

Figure 4: Schematic layout of a hydroponic set. Heated sets are connected to an aquarium heater/cooler [WH] to heat the nutrient solution during the day to ~27.5°C. Ambient sets have no water temperature control system connected, and the nutrient solution maintains a temperature of ~23.8°C during the day.