



Optimizing Hydroponic Lettuce Growth Through Root-Zone Oxygenation and pH Management



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Introduction

- Limited growing season in New Hampshire (~160 days)
- Hydroponics enables year-round production
- Performance is constrained by:
 - pH imbalance
 - Low oxygen availability
 - Poor nutrient circulation

Research question

How do pH and oxygenation levels affect lettuce growth and system efficiency in deep-water culture (DWC) hydroponic systems?

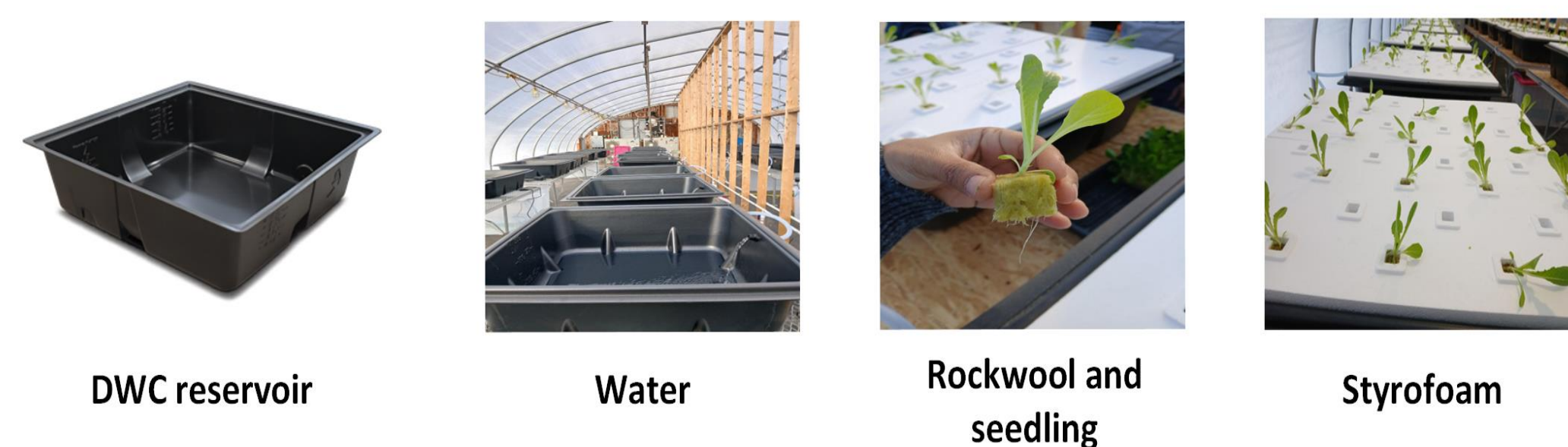
Objectives

1. Evaluate the effects of pH levels (6, 7, 8, and control) and oxygenation treatments (aeration, non-aeration, and recirculation) on DWC lettuce production.
2. Identify optimal management strategies to enhance lettuce growth, yield, and resource efficiency in DWC systems.

Hypothesis

Optimized pH and oxygen availability will significantly enhance lettuce growth and overall system performance.

Materials



Seed to harvest



Figure 1: DWC lettuce growth stages

Experimental design

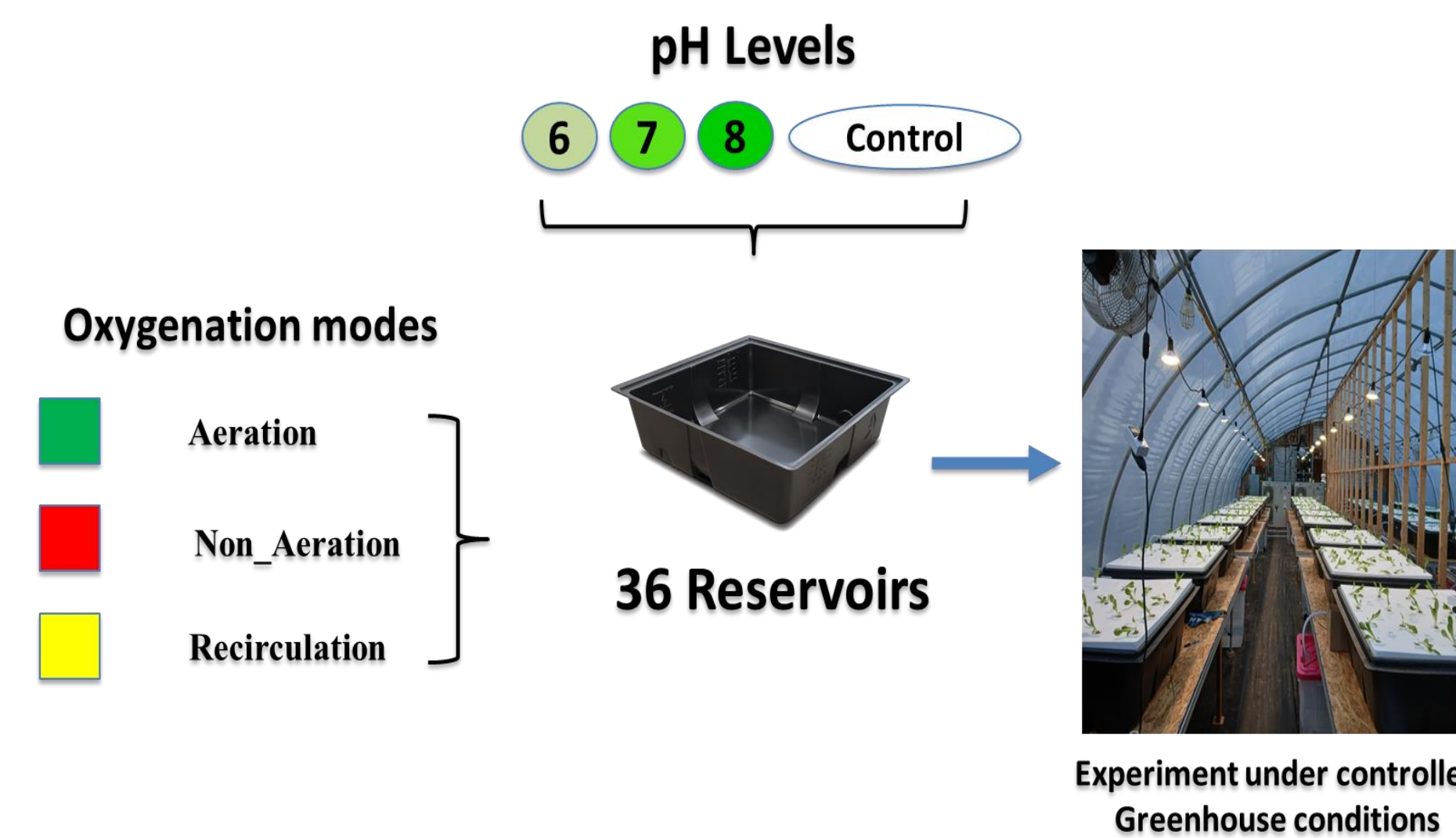


Figure 2: DWC experimental setup

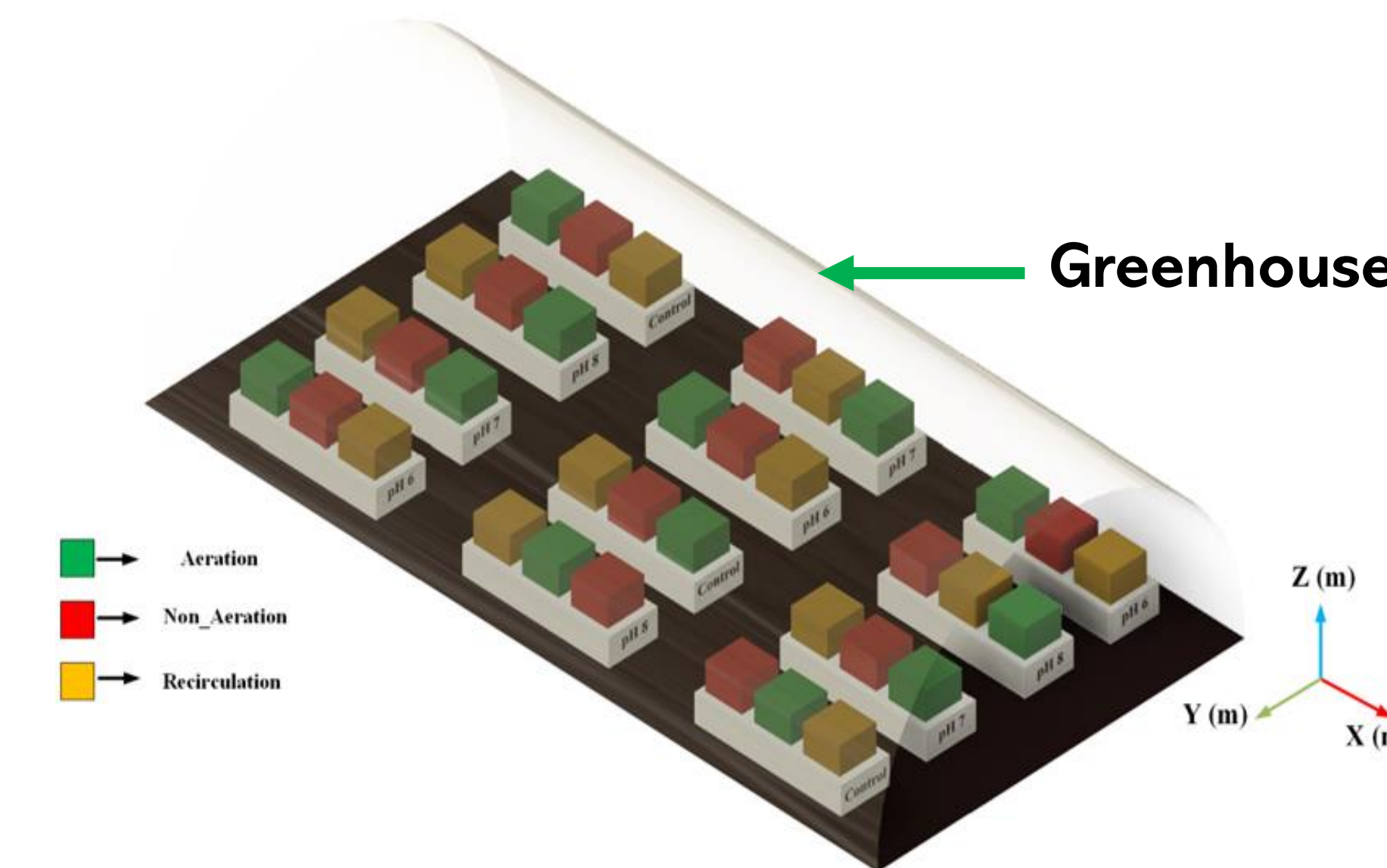


Figure 3: Experimental layout of the DWC system

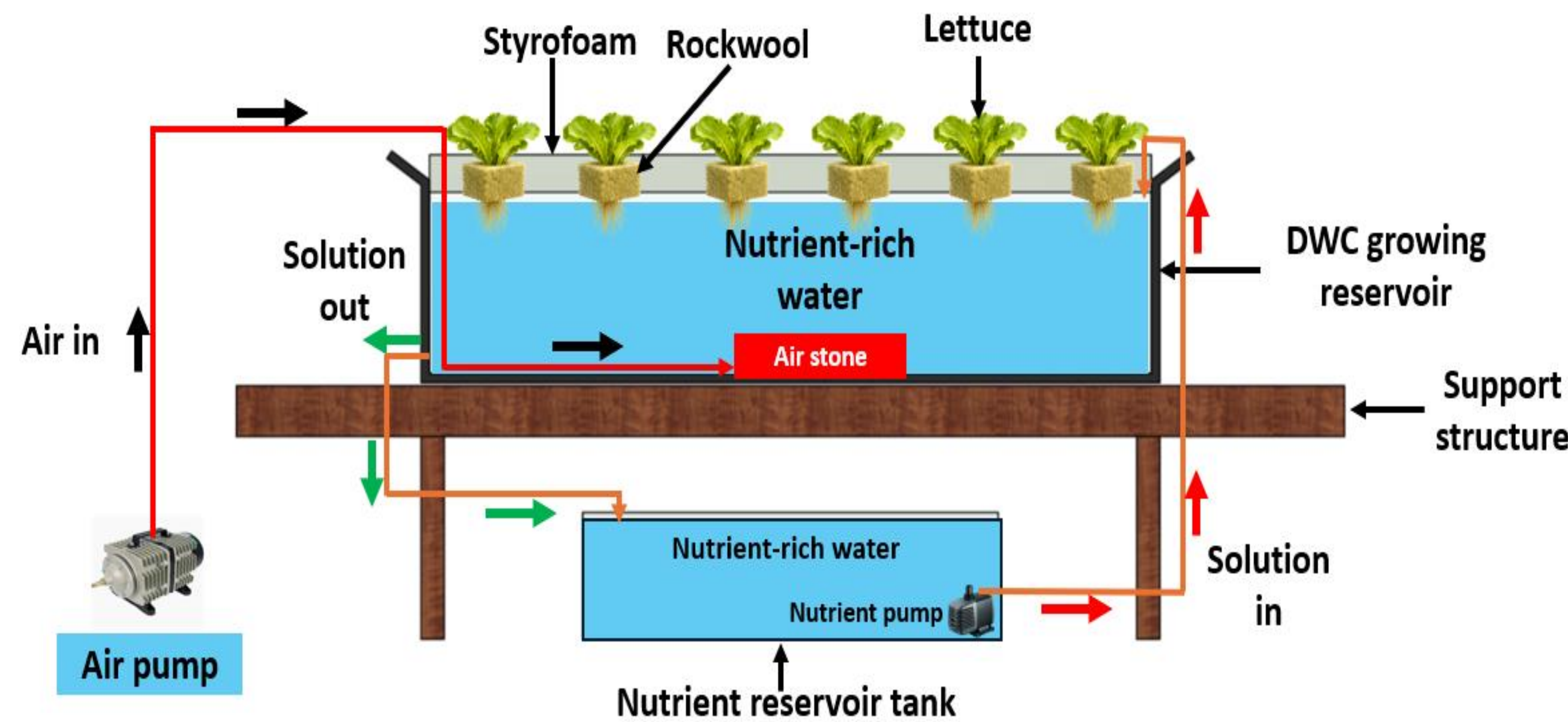


Figure 4: DWC system schematic

Effects of temperature, pH, and oxygenation on DWC lettuce growth

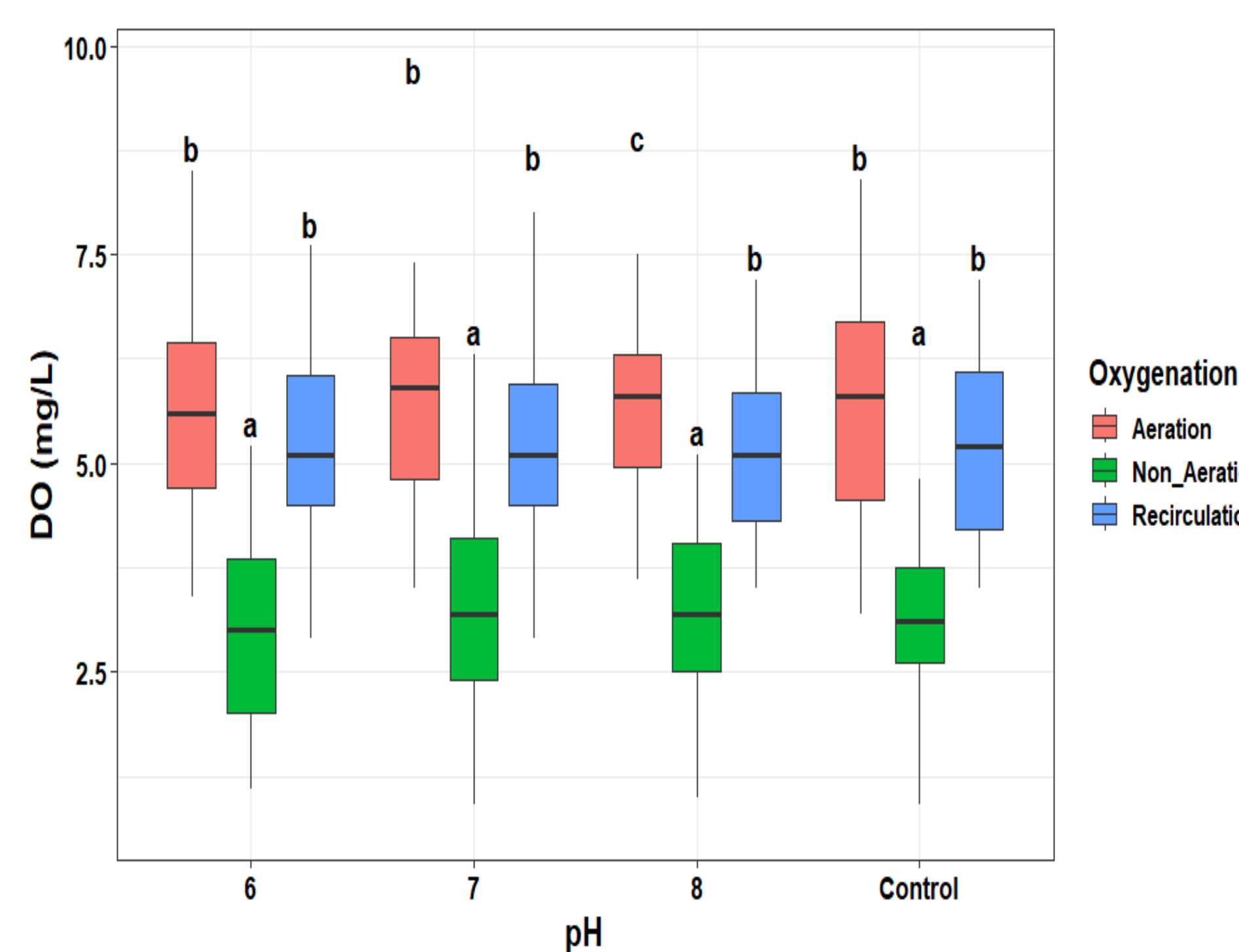


Figure 5: Effects of pH and oxygenation on dissolved oxygen concentration

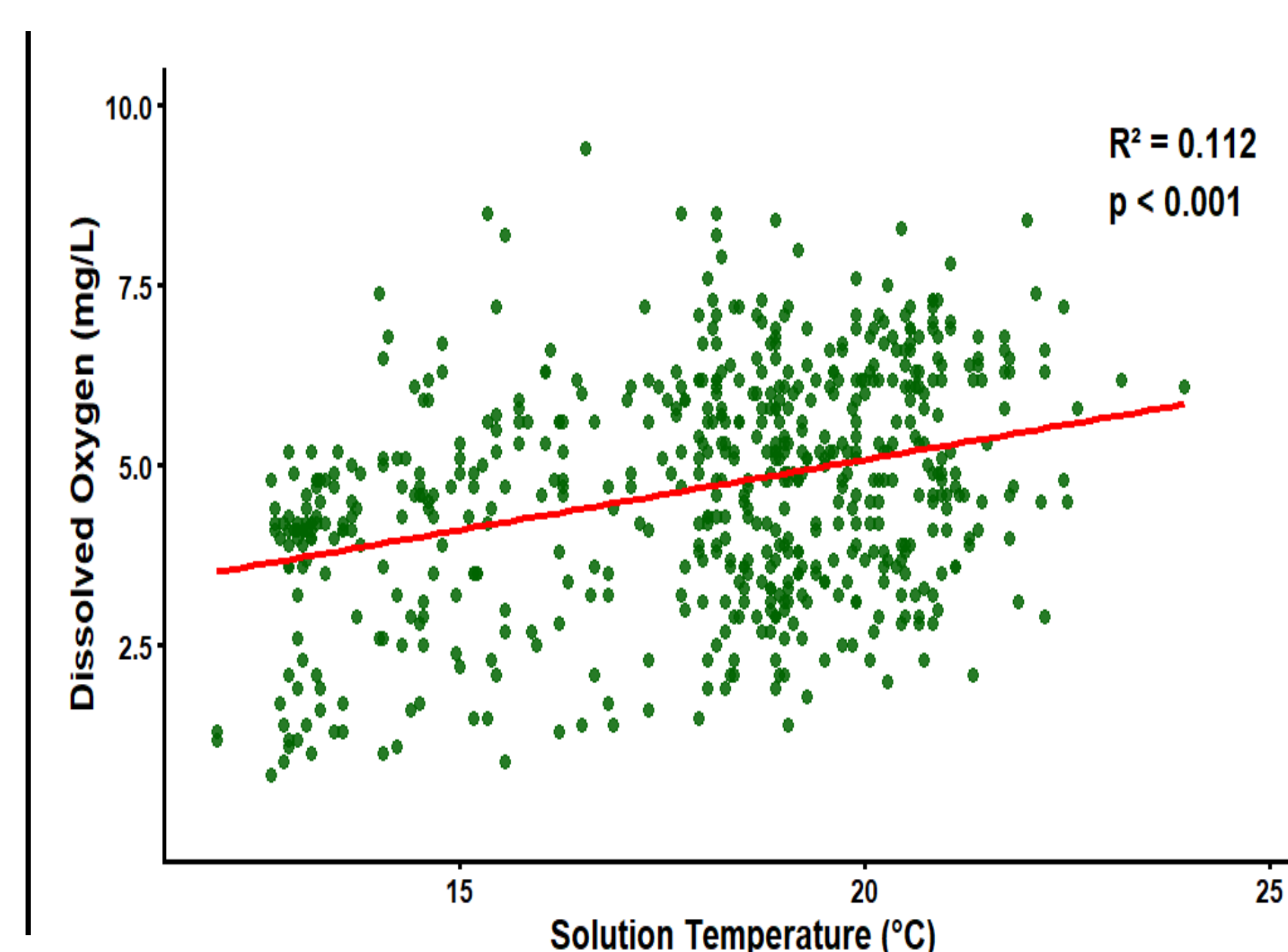


Figure 6: Effect of solution temperature on dissolved oxygen concentration

Growth response to pH and oxygen levels

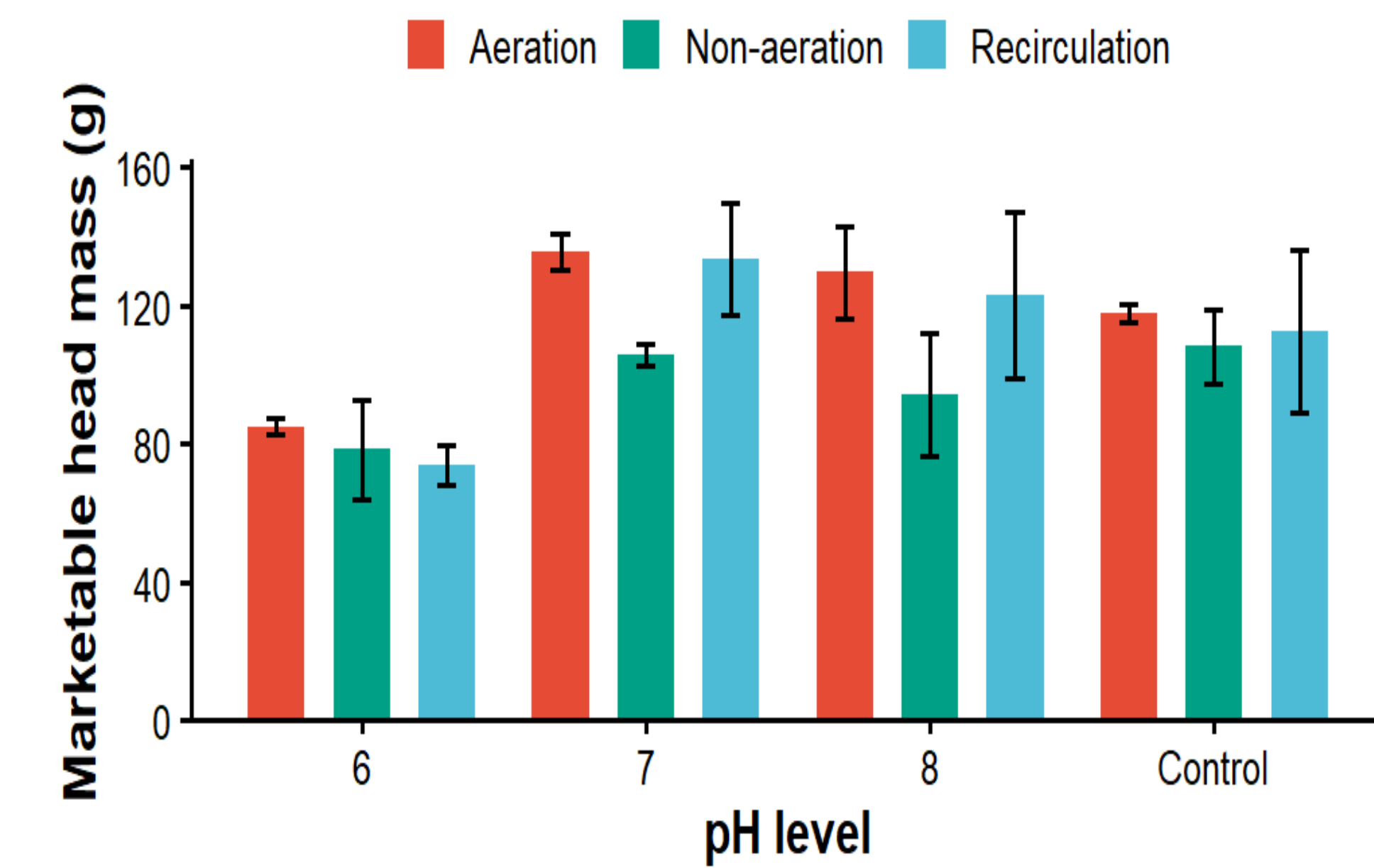


Figure 7: Effects of pH and oxygen on marketable head mass

Key findings

- Aeration & recirculation significantly increased lettuce yield across all pH levels.
- Optimal performance observed at pH 7 with aeration.
- Non-aeration consistently limited growth due to low dissolved oxygen levels.

SDG alignment

Aligned with UN SDG 2 (Zero hunger) and SDG 12 (Responsible consumption and production) by enabling year-round hydroponic crop production and improving resource-use efficiency.

Conclusion

- Optimizing pH (6–7) with aeration and recirculation enhances dissolved oxygen and significantly improves lettuce growth and yield in DWC systems.
- Oxygen availability is a critical limiting factor in hydroponic production.

Practical implications

- Improves year-round greenhouse productivity in cold climates.
- Reduces the risk of root-zone oxygen stress
- Provides actionable guidelines for hydroponic growers

References



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