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THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Nutrient delivery: Recirculation of nutrient solution

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Recirculation of nutrient solution

- An important practice for sustainable CEA crop production
- For good practices of recirculation, one needs to understand
  - Chemistry of hydroponic nutrient solution
  - Plant nutrient uptake
  - Optimization of nutrient solution formula
- Pre-mixed fertilizers are not suitable for recirculation
  - Multi-injection systems with flexible fertilizer mixing
  - Custom mix specific to crops and production environments
- **Goal: no or infrequent discharge of nutrient solution**

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Multi-injection system that allows flexible adjustments of nutrient solution

Eight injector system

Ten injector system

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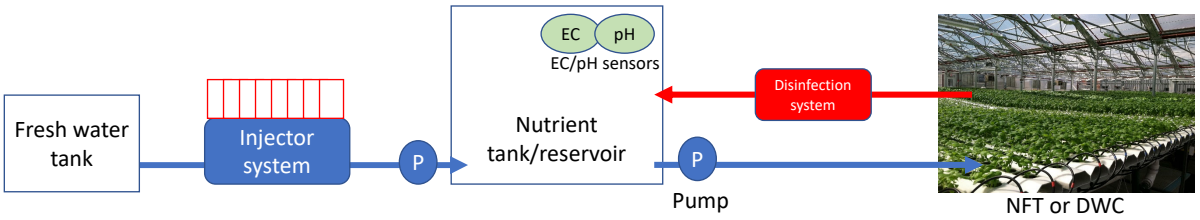
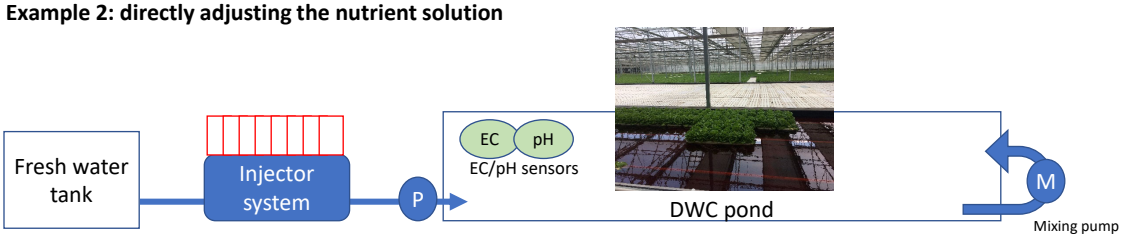
Nutrient recirculation systems – two examples

Example 1: having a separate reservoir to mix before circulating to the growing system



Example 2: directly adjusting the nutrient solution



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Disinfestation systems

- UV-radiation (UV-C)
- Ozone (O_3)
- Heat treatment (sterilization/pasteurization)
- Slow sand filtration

✓ UV, ozone, and heat treatment tend to make specific ions precipitate. (e.g., Fe by UV treatment, Mn by ozone treatment)
✓ Treatment must apply before adding fresh stock solution; then re-adjust the nutrient concentrations considering the loss by precipitation

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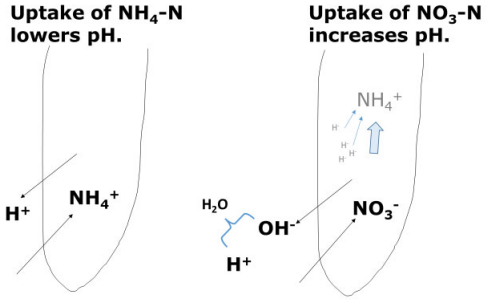
pH control

- Target pH 5.5-6.5 for most crops
- Dilute acid or base to adjust
- Optimizing cations and anions balance in the nutrient solution to minimize pH change
  - Nitrogen forms (NH_4-N to NO_3-N) have high impact on pH



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Nitrogen forms, NH_4^+:NO_3^- ratio

- In hydroponics or container production system using soilless media, NH_4^+ : NO_3^- ratio has significant effects on plant growth and solution pH.
- Most hydroponic formula use 0 – 25% NH_4-N (this means 100 – 75% NO_3-N).
- Some plant species exhibit an optimum NH_4^+ : NO_3^- ratio to enhance growth.
- Too high NH_4 uptake causes toxicity in plants.
- High concentration of NH_4^+ competes with other cations (Ca^{2+}, Mg^{2+}, K^+)

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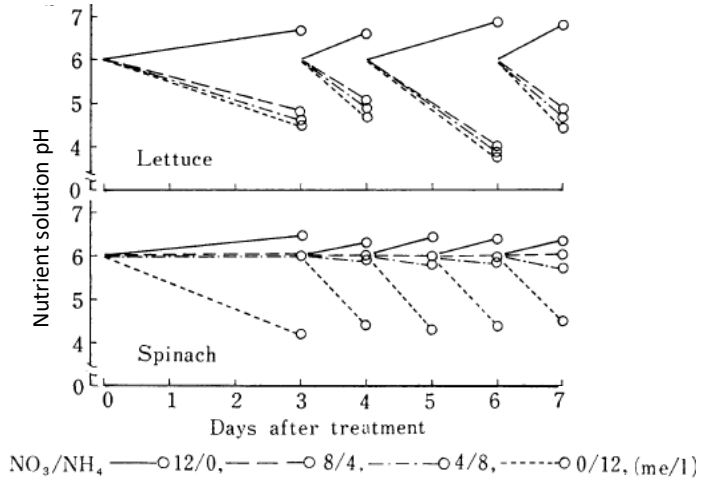
Changes in root-zone pH is affected by crop specific N-form preference and NH_4:NO_3 ratios



Effects of NO_3/NH_4 ratios on the change of nutrient solution pH

Ikeda and Osawa (1983)

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EC – Electrical Conductivity

- EC provides information on the general fertility level of the nutrient solution
- EC is controlled to maintain the total nutrient concentrations in hydroponics
- However, EC cannot tell individual elemental concentrations of nutrient solution
- Nutrient solution analysis (as often as weekly) is needed for managing recirculation
  - Based on the analysis, stock solution formula need to be adjusted; or injection program (for multi-head injectors) needs to be changed

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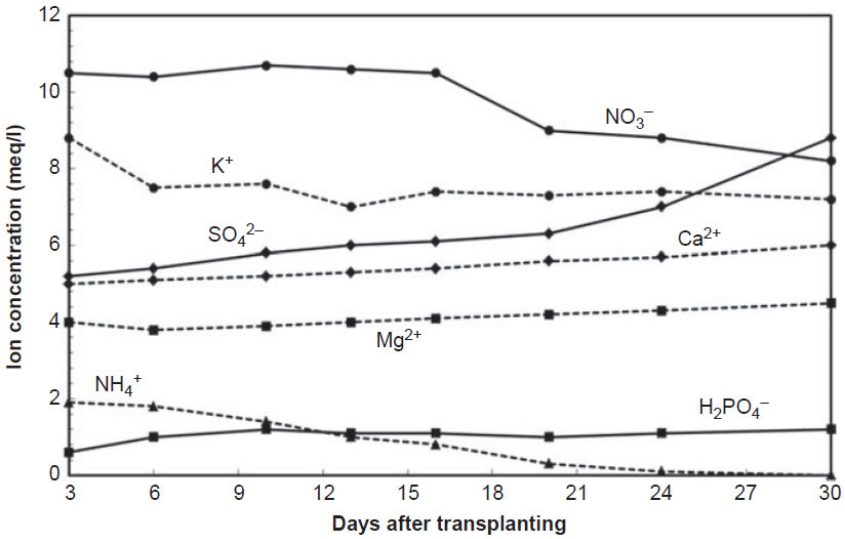

FIGURE 20.2

Changes in ionic concentration of the recirculated nutrient solutions controlled at a fixed EC (an example for lettuce).

Son et al. (2016)

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Upper limitation of Na and Cl in recirculation hydroponics

- Nutrient solution must be discharged as soon as Na^+ or Cl^- reaches crop-specific upper threshold concentration
  - ??? ppm Crop specific information is needed!
- When municipal water with high Na^+ and Cl^- is used, recirculation of nutrient solution is more challenging
  - Sodium < 50 ppm in source water
  - Chloride < 70 ppm in source water
- Select 'sodium-free' fertilizers
- Introduce a sodium removal system (if applicable)

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Thank you!

For questions, please contact:
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