OptimIA

OSU project update: Managing Nutrient Disorders of Hydroponic Leafy Greens

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Our tasks in OptimIA project at OSU

- Developing steady-state energy, water, and CO_2 input/output models for site-specific operational cost analyses (Objective 1B)
- Mitigating risks of lettuce tipburn (Objective 2C)
- Extension/outreach programming (Objective 3)
- Application of low pH for water-borne disease management in hydroponics (2018-2019 OSU project)

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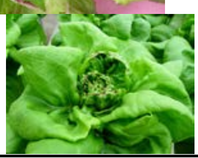
Understanding tipburn



- Browning of the edges or tips of leaves (*Do not confuse tipburn with edge-burn*)
- **Localized calcium (Ca) deficiency**
- Starting from **growing shoot tip**
- Seen **when the plant growth is *too* fast**
- Deficiency caused by **unbalanced Ca demand and supply**

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Tipburn Prevention Strategies

- Vertical downward airflow
  - Target air speed: 0.3-0.5 m/s on average (~1 mile/h)
- Reduce growth rate
  - Reduce daily light integral (DLI) by shading or lowering light intensity of supplemental lighting; lowering CO_2, temperature and other factors
- Humidity management
  - Low humidity during the day
  - High humidity during the night
- Foliar Ca application
  - ~1000 ppm Ca (chelated)

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Understanding tipburn

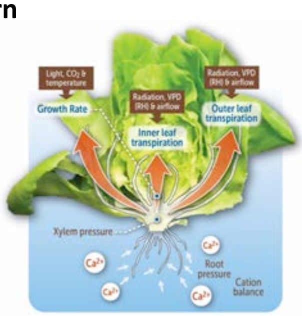
High risk of tipburn

Ca supply < Ca demand

- Transpiration
- Growth

Radiation, VPD, airflow, temperature , CO_2, EC, pH

✓ Measuring all factors by sensors?



Relational diagram of tipburn and factors

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Goal: Mitigating tipburn of lettuce in indoor farming

Developing methodology for **directly assessing microclimates** driving transpiration using **petri-dish evaporation pan**

- Direct measurement of potential evaporation (water loss)
- Applicable to small spaces
- Simple SOP to standardize
- Low costs (<$1)
- Indirect assessment of microclimates without expensive/bulky sensors

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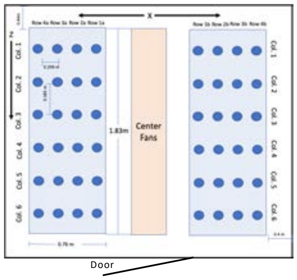
Example data – Petri-dish pan evaporation



G. Papio (2020, unpublished)

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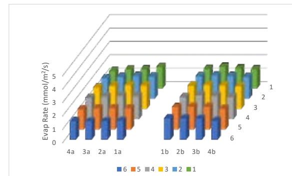
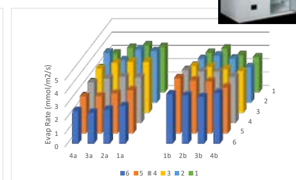
Example data – Petri-dish pan evaporation



Vertical air flow: 0.07-0.21 m/s
Air temp: 23 °C
VPD: 0.63 kPa
PPFD 225 µmol m^{-2} s^{-1}



Vertical air flow: 0.16-0.47 m/s
Air temp: 23 °C
VPD: 1.19 kPa
PPFD 225 µmol m^{-2} s^{-1}

G. Papio (2020, unpublished data)

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Our plans ahead

- Develop methodology to assess potential transpiration
- Develop methodology to assess potential growth rate
- Examine environmental conditions on lettuce transpiration, growth and tipburn
  - Examine effects of nighttime root pressure and transpiration
  - *In-situ* assessment of leaf conductance under varied light quality
- Define highly inductive and preventative conditions (tipburn)
  - Cultivar screening collaborating with seed companies and indoor farms
  - Help commercial farms and collaborators for assessing conditions
- Develop guidelines and low-cost methodologies to mitigate tipburn

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Growing leafy greens at low pH for disease management

OSU CEA program 2018/2019

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pH and plant and microbial growth

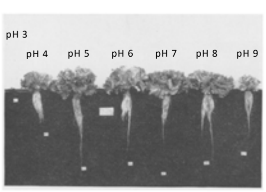

Fig. 2. Effect of external pH on the growth of lettuce. From left to right: pH 3, 4, 5, 6, 7, 8, and 9.

Lettuce plants under varied pH (Arnon and Johnson, 1942)

- Hydroponic nutrient solution pH is maintained at 5.5-6.5
- Oomycete pathogen growth can be reduced by lowering pH
- Low pH causes plant nutrient deficiency and yield reduction in hydroponics
- Some crops are uniquely tolerant to low pH
  - Basil ('Nufar' and 'Dolce Fresca') plants can grow in pH as low as 4.0 without yield penalty in DWC (Gillespie et al., 2020)

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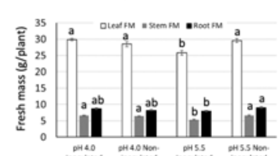
Application of low pH for water-borne disease management without causing nutrient disorders (2018/2019 OSU project)

Lowering pH to 4.0 protected basil plants from being infested by *Pythium aphanidermatum* without compromising yield



pH 4.0 Inoculated | pH 4.0 Non-inoculated | pH 5.5 Inoculated | pH 5.5 Non-inoculated

(Gillespie et al., 2020; HortScience)

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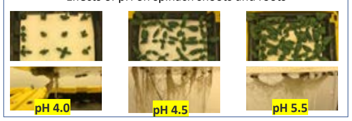
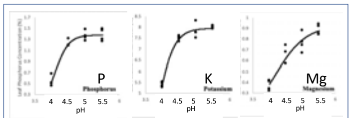
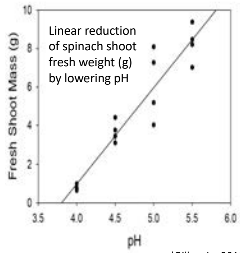
Spinach plants (baby leaf) reduce nutrient uptake and growth at lower pH





Examples of essential elements showing steep decline at low pH



(Gillespie, 2019)

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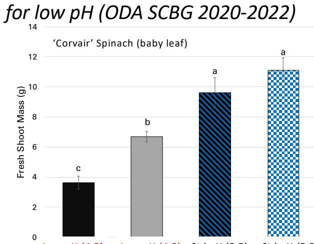
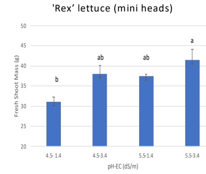
Increasing EC (3X all nutrients) can recover some yield under low pH (4.5) – *We will develop nutrient formula suitable for low pH (ODA SCBG 2020-2022)*





G. Papio (2019, unpublished data)

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Daniel Gillespie (MSc 2019)

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