Sustained Veggie: A Preliminary Look at Continuous On-Orbit Food Production

Jess M. Bunchek[1,*], Matthew W. Romeyn[2], Aaron B. Curry[3]

[1]SURA/LASSO, Kennedy Space Center, FL, [2]NASA, Kennedy Space Center, FL, [3]AECOM/LASSO, Kennedy Space Center, FL

*Presenter contact: jess.m.bunchek@nasa.gov

Background

- The Veggie system on the International Space Station (ISS) intermittently supplements the crew diet with fresh, leafy green crops.
- For 120 days, Sustained Veggie assessed the potential of continuous on-orbit crop production.
- Crops grown in Veggie have been grown concurrently, but Sustained Veggie staggered plant initiation and harvest to provide more constantly available produce.
- The objective of this preliminary study was to compare two growth schemes to determine the methodology for required inputs, optimal yield, food safety, and crew considerations.

Materials & Methods

- 2 Veggie facilities: single-harvest (28 days after initiation; DAI) treatment in one facility vs multiple "cut-and-come-again" harvest (28, 42, 56 DAI) in second facility
- Crops selected from prior or planned Veggie on-orbit studies
  - 2 crops grown for first 56 days
    A: 'Amara' mustard B: 'Red Russian' kale
  - Rotated in 2 other crops for latter experiment half
    A: 'Shungiku' Asian green B: 'Extra dwarf' pak choi
- Staggered plant growth for continuous production: 1A/B plant pillows initiated in each facility on 0 DAI, 2A/B initiated 7 DAI, and 3A/B initiated 14 DAI **(Figure 1)**
- Data collected: plant yield and health metrics, microbial analysis for food safety
- Statistics (i.e. analysis of variance) conducted in R Version 3.5.1

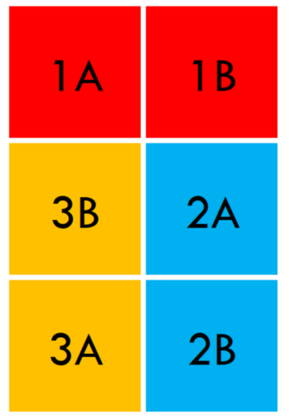

Figure 1. *Crop and pillow initiation layout.*

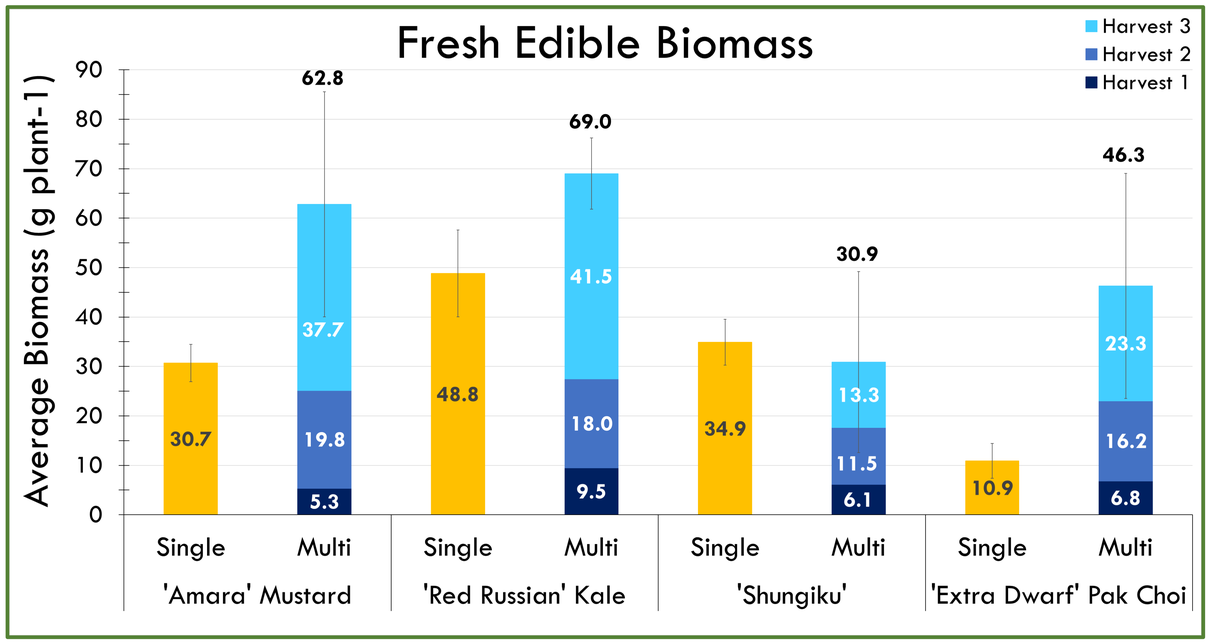

Figure 2. *Fresh edible biomass (g plant^{-1}) for single and multiple "multi" harvest treatments. For "multi," biomass shown for each harvest and overall plant (shown above standard error bars).*

Results

- **REQUIRED INPUTS**
  - Single harvest: 24 pillows (including 2 failed pillows)
  - Multiple harvest: 13 pillows (including 1 failed pillow)
- **OPTIMAL YIELD**
  - Average per plant fresh edible biomass higher in multiple-harvest than single harvest for all crops but shungiku **(Figure 2)**, but no harvest by crop interaction ($P > 0.05$)
- **FOOD SAFETY**
  - Microbial load was more dependent on system age rather than plant age.
    - Aerobic plate counts from 'Amara' and 'Red Russian' kale samples were lower than 'Shungiku' and 'Extra Dwarf' pak choi samples across both harvest methods.
- **CREW CONSIDERATIONS**
  - Continuous production schemes aimed for weekly harvests.
    - 1 week without yield in multiple-harvest treatment vs. 5 weeks in single-harvest

Figure 3

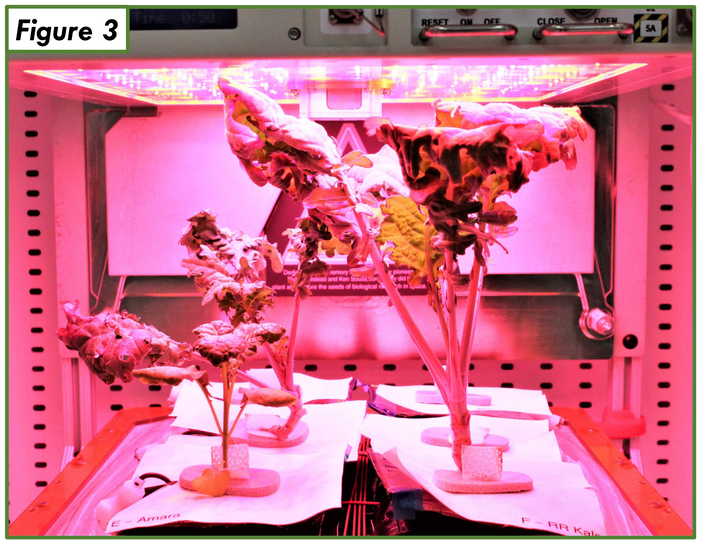

Figure 4

Figure 3. *Drastic height differences across growth stages caused shading of younger plants and plant competition.*

Figure 4. *'Extra dwarf' pak choi in multiple harvest displayed aging via nitrogen deficiency (yellowing older, lower leaves) and flowering.*

Figure 5. *Roots created thick mats on pillow bottoms in multiple-harvest treatment.*

Figure 5

Future Research & Acknowledgements

- Repeat study for microbiology, and test new crops and other layouts that could potentially reduce shading and plant competition **(Figure 3)**
- Mitigate plant stress and nutrient deficiencies **(Figure 4)**
- Develop protocol for crop failures and periodic root mat cleaning **(Figure 5)**

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