Preparation for the Proof of Concept Flight of the Veggie Plant Growth Chamber

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Structure

- Veggie overview
- Background testing
  - Rooting “pillow” development
  - Media selection
  - Crop testing
- VEG-01 hardware verification test
- Acknowledgements

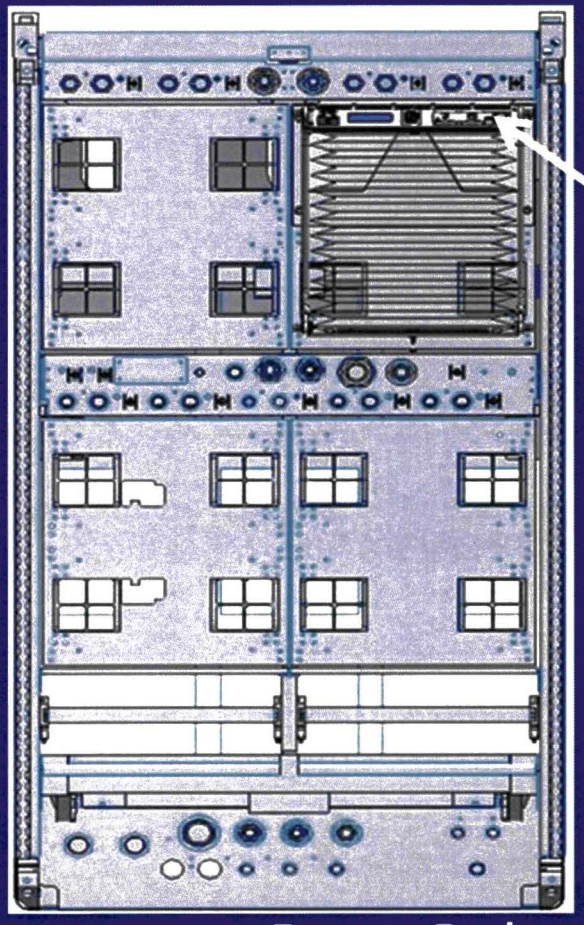
Veggie Background

- Conceived by ORBITEC in 1996
- 1st generation developed under Phase I And Phase II NASA SBIR to ORBITEC (2003-2004)
- 2nd generation developed through Innovative Partnership Program (IPP) between ORBITEC and KSC (2010)
- ORBITEC currently building/testing flight hardware (contract from 2011)
- Flight to ISS scheduled for SpaceX-3 in 2013

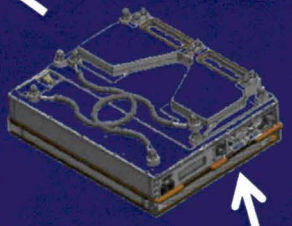
Veggie Attributes

- Small Vegetable Production System – 0.17 m^2 growing area
- Compact stowage, low launch mass
- Low energy usage –lights and fans
- Minimal crew time
- Separate components allow for reuse or replacement
- Goals: Research toward Food Production, Crew Recreation, Education and Outreach

Veggie Concept

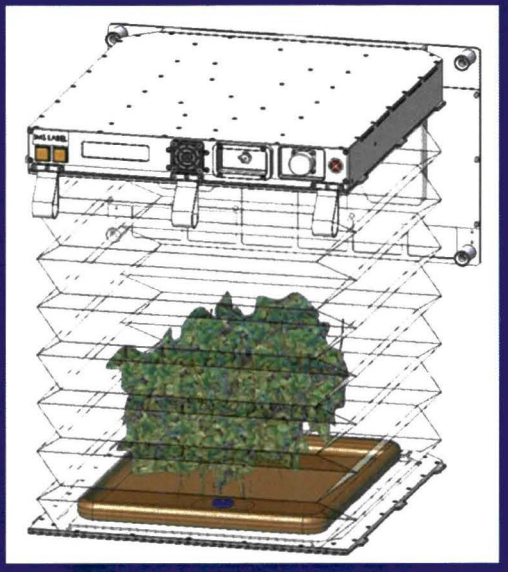


Express Rack



Veggie unit

Cargo Transfer Bag (CTB)



An easily stowable, simple, low resource plant growth system capable of supporting plant growth for improving crew habitability.

Stows in small volume, but provides large growth volume

Images courtesy of ORBITEC

Veggie

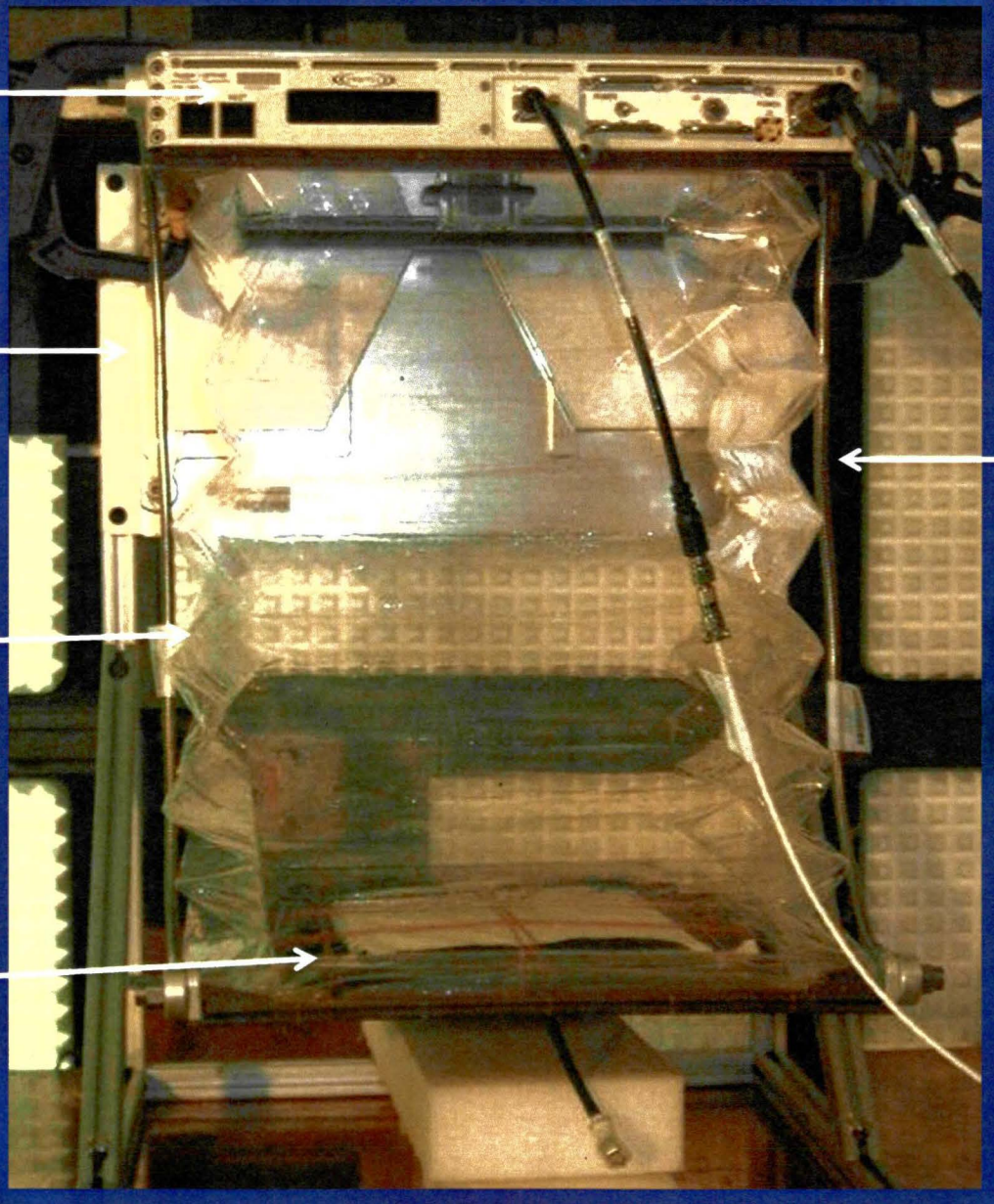


Image courtesy of Felix Joe

Designed and built by Orbital Technologies Corporation (ORBITEC)

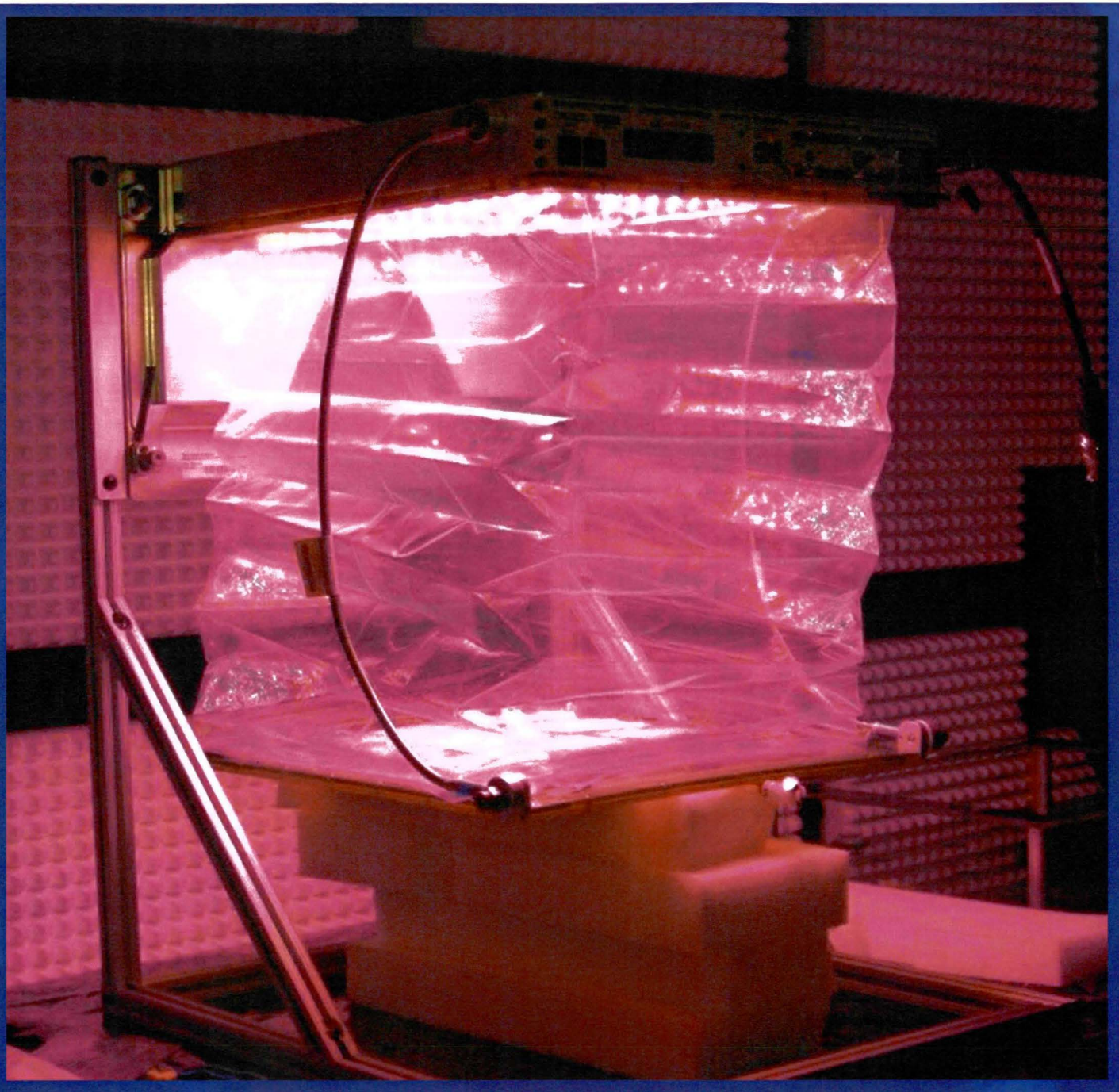


Image courtesy of Felix Joe

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Veggie Unit Testing

- ORBITEC and NASA currently performing ground functional and acceptance tests on first unit.
- Checking hardware and software specifications
- Thermal properties, lighting, off-gassing, electrical, vibration, acoustics, etc. of Veggie and components checked at nominal and extreme conditions
- Any issues found are addressed and unit is refurbished
- Second unit under construction

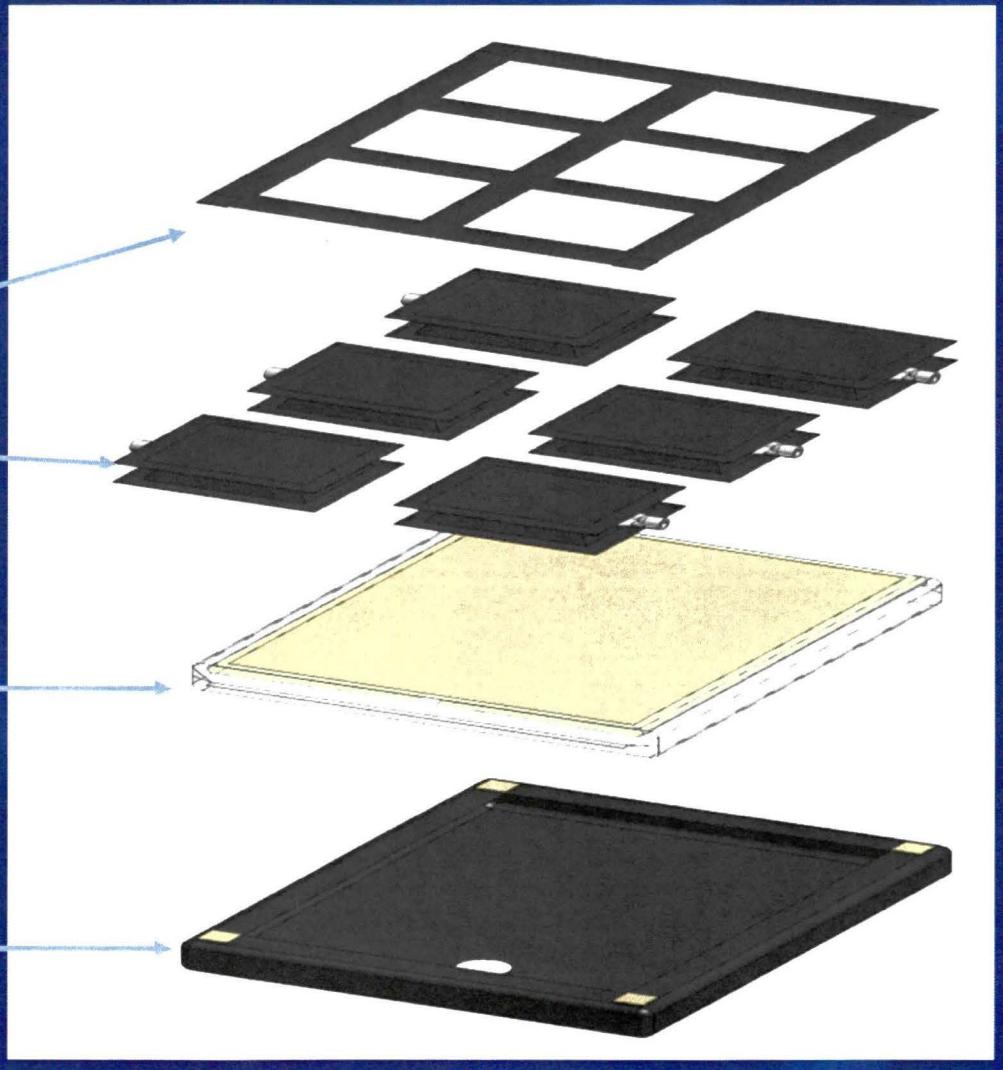
Rooting Pillow Concept

- Different sizes for variety of plant types (1, 2, 3, 6)
- Media and fertilizer containment
- Plant seeds dry, in 1 g
  - Low launch mass
- Hydrate on orbit
- No energy required
  - Passive wicking from reservoir
- Minimal crew time
- Designed for single use
  - Dispose after harvest
- Reduces sanitation requirements

Prototype flight pillow courtesy of ORBITEC

Root Mat Assembly

Exploded view



Schematic courtesy of ORBITEC

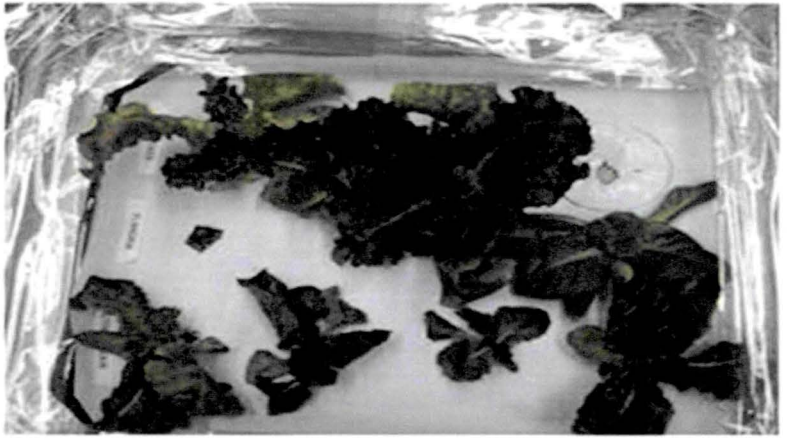
Before Pillows—Direct & Plug Planting

One Layer Nitex

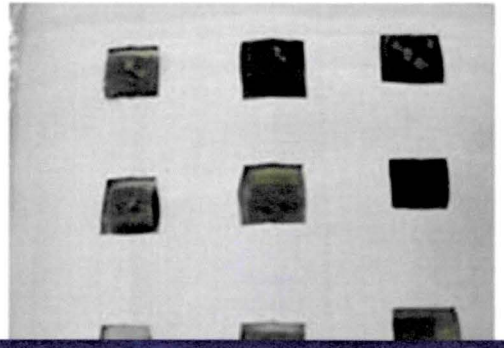
with 1X Hoagland

Two Layer Nitex

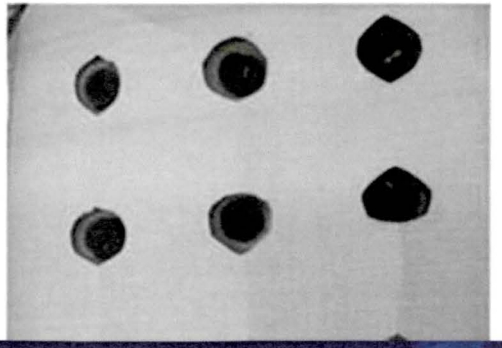
with 1X Hoagland



Rockwool blocks at 7 DAP with 1X Hoagland

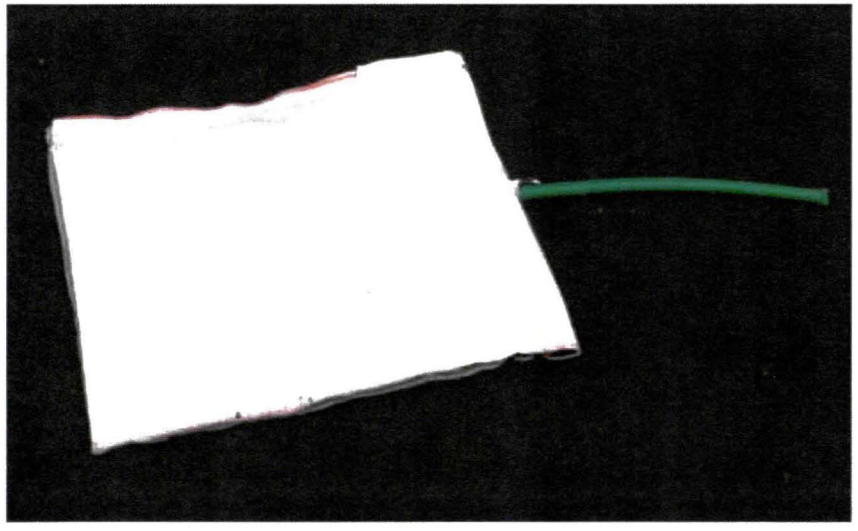


Oasis Plugs at 7 DAP with 1X Hoagland

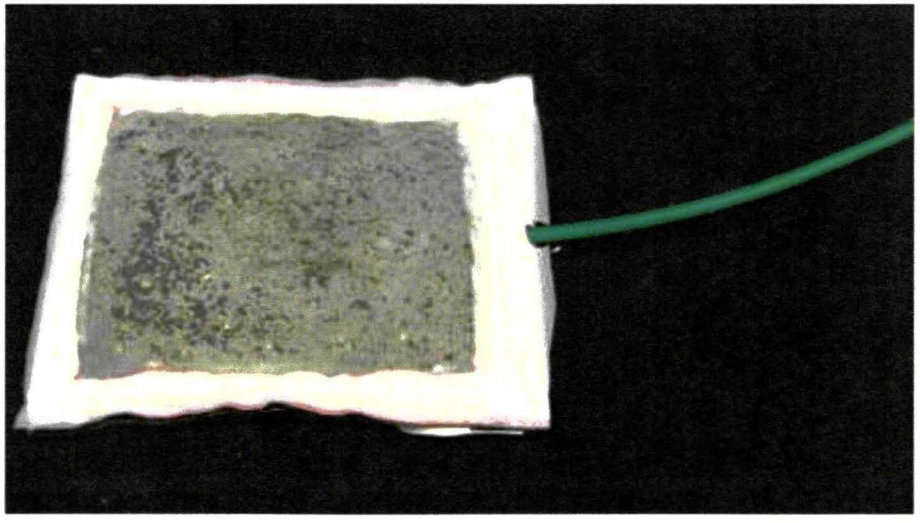


Early Pillows

Upper surface of Rooting Pillow with top sealed

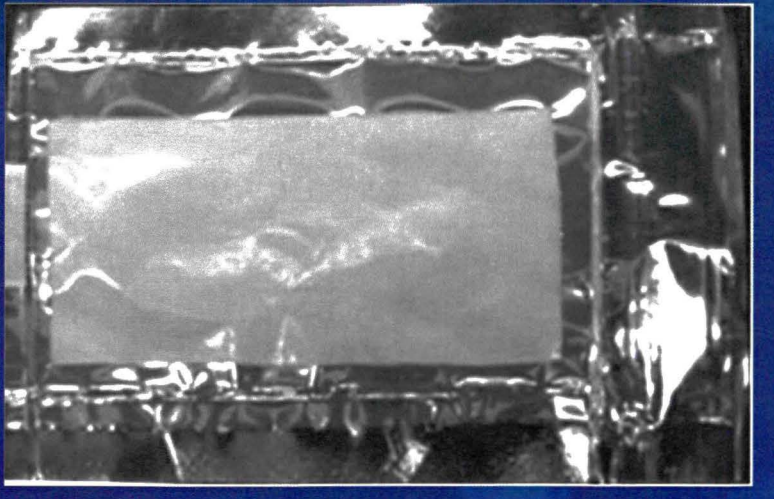


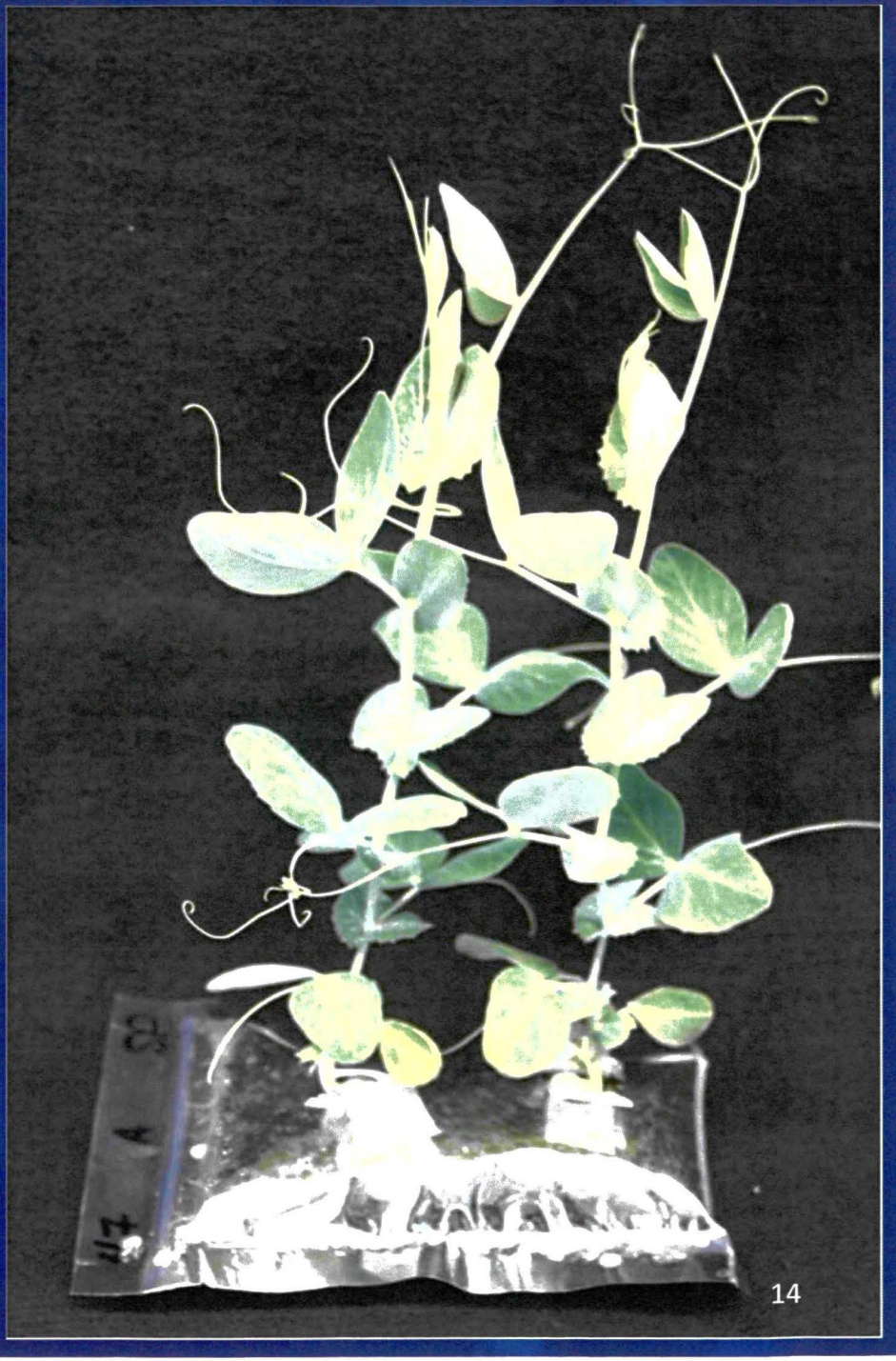
Lower Surface with Nitex barrier to contain media



Analog Pillow Testing

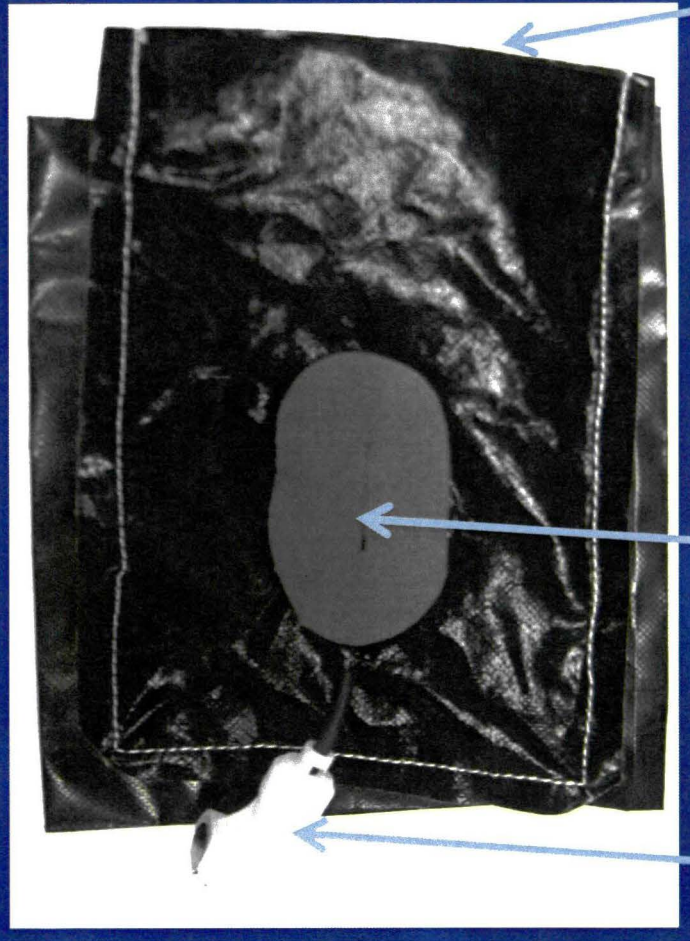
- Small bag
  - Resealable, Static shielding
- Wicking surface
  - Heat-welded Nitex (nylon) membrane
  - Allows passive wicking from analog reservoir





Anatomy of a Flight Pillow

Opaque flight-approved material body

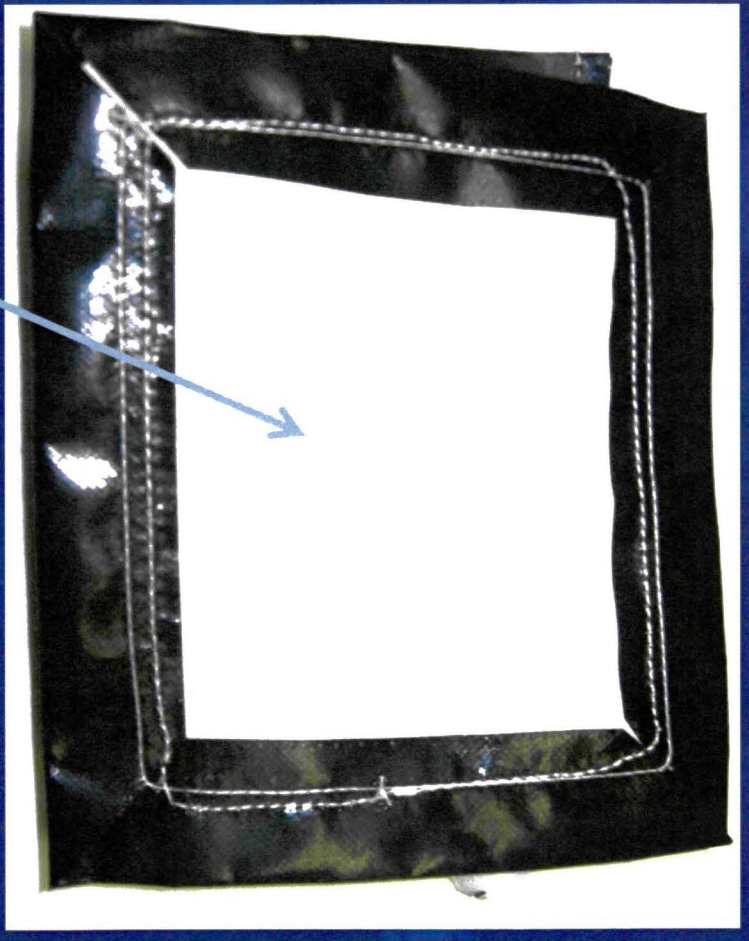


Open end for filling

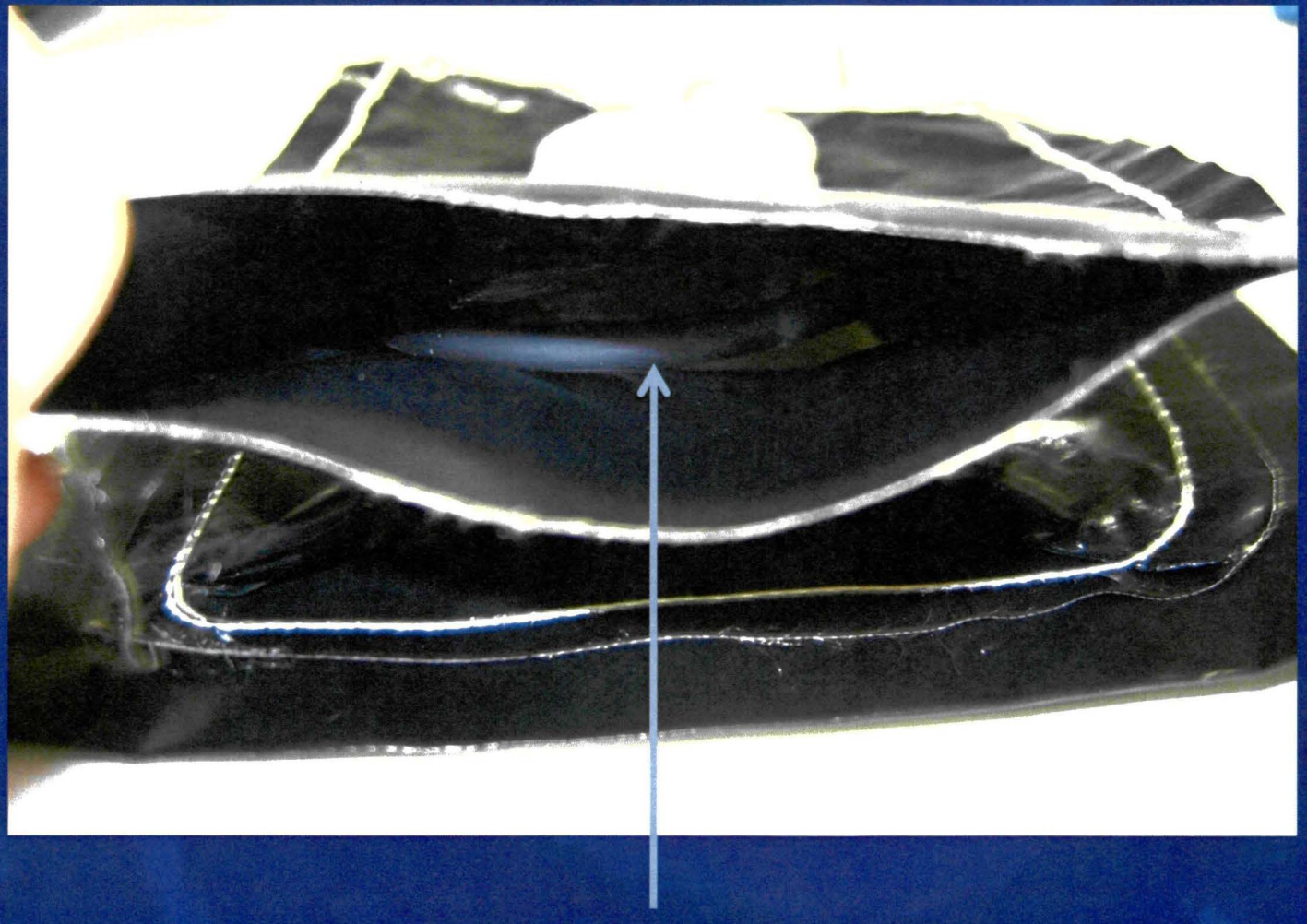
Wicking fabric

Slot for wicks/seeds

Quick disconnect for priming

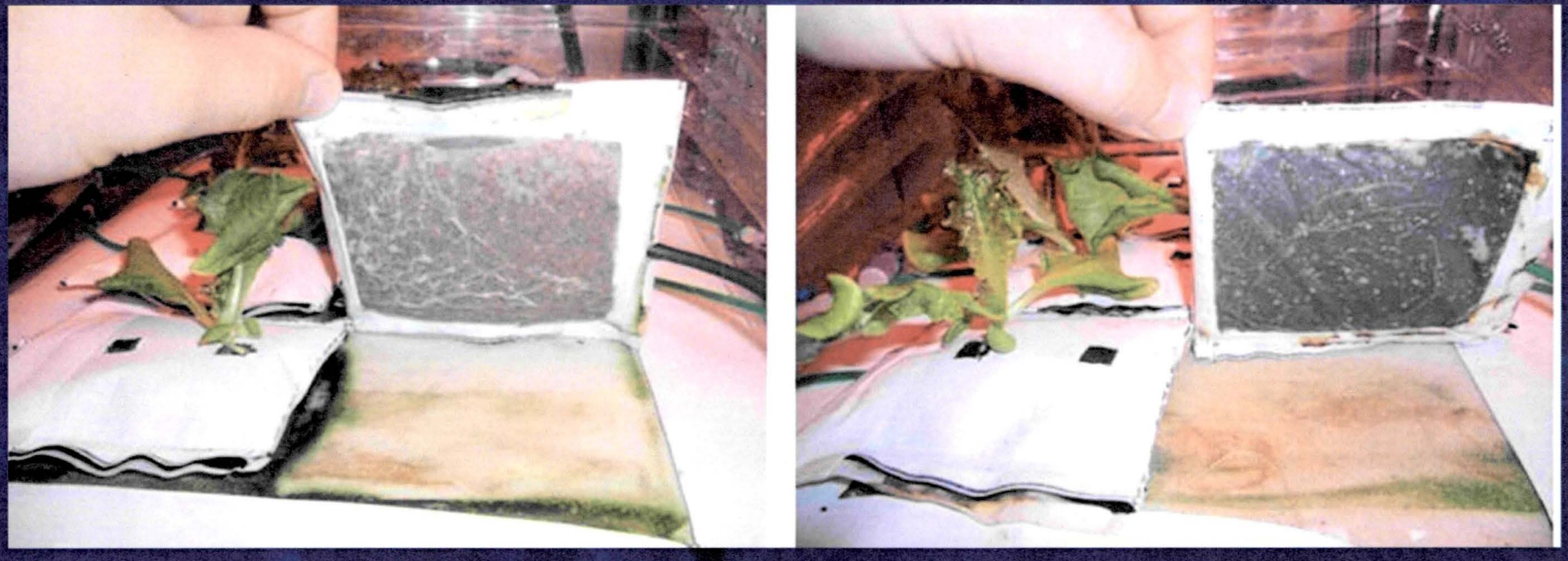


Flight Pillow (continued)



Internal irrigation ring for priming

Early Media Studies

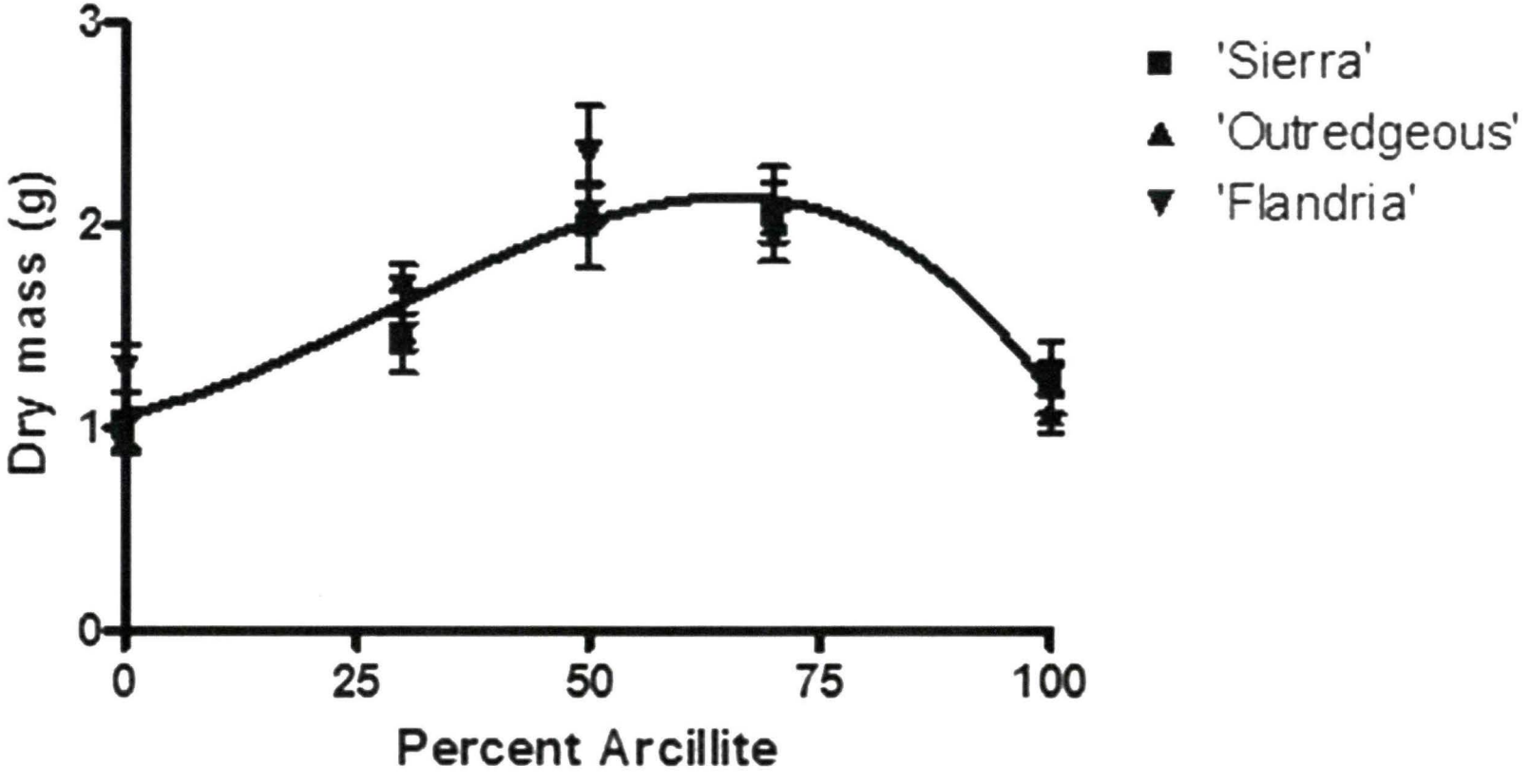


Relatively equal root growth and shoot yields in both peat-based and arcillite media

Lettuce media response spectrum

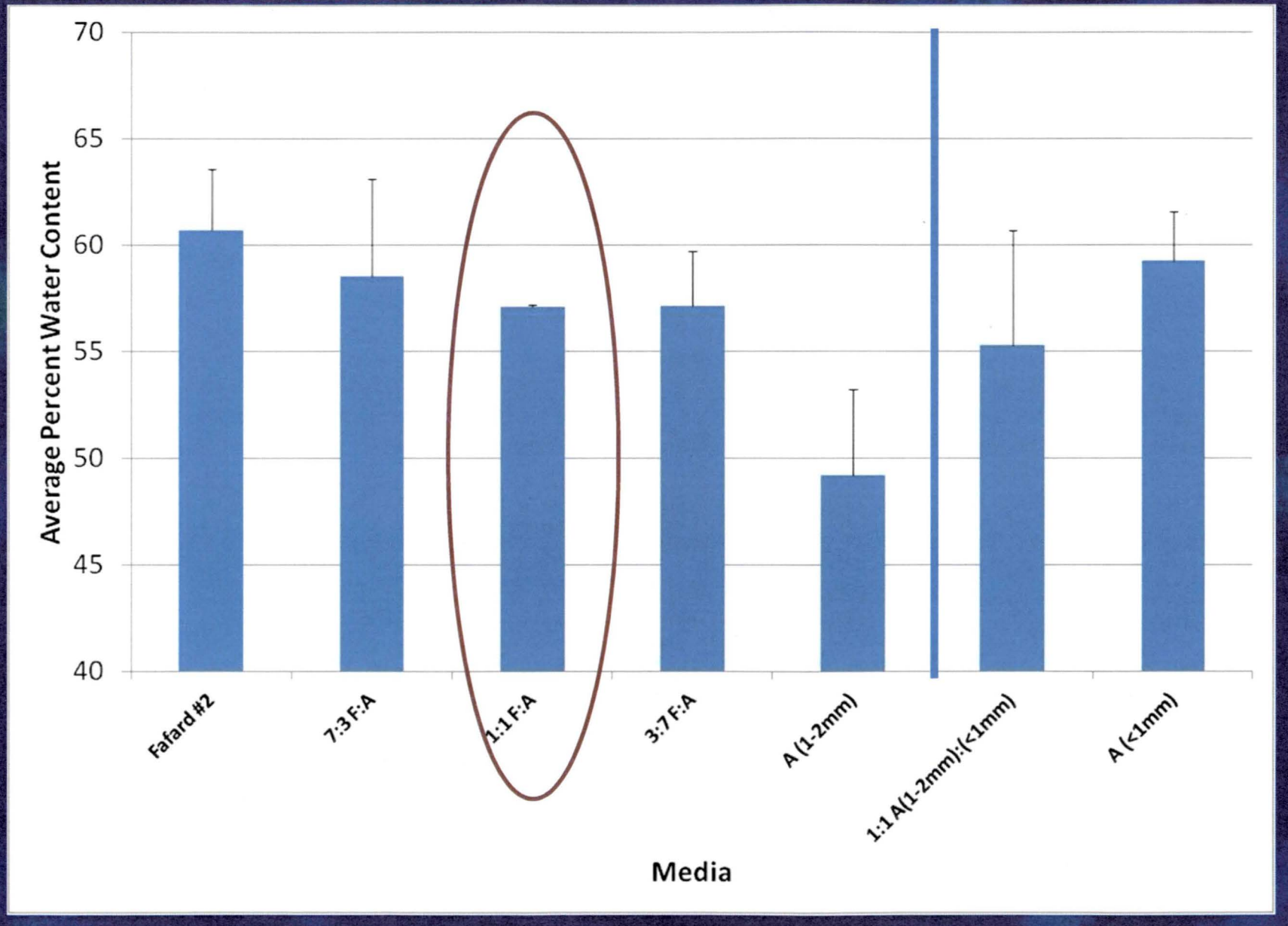
100% Arcillite ⟷ **100% Fafard #2**

Lettuce Yield

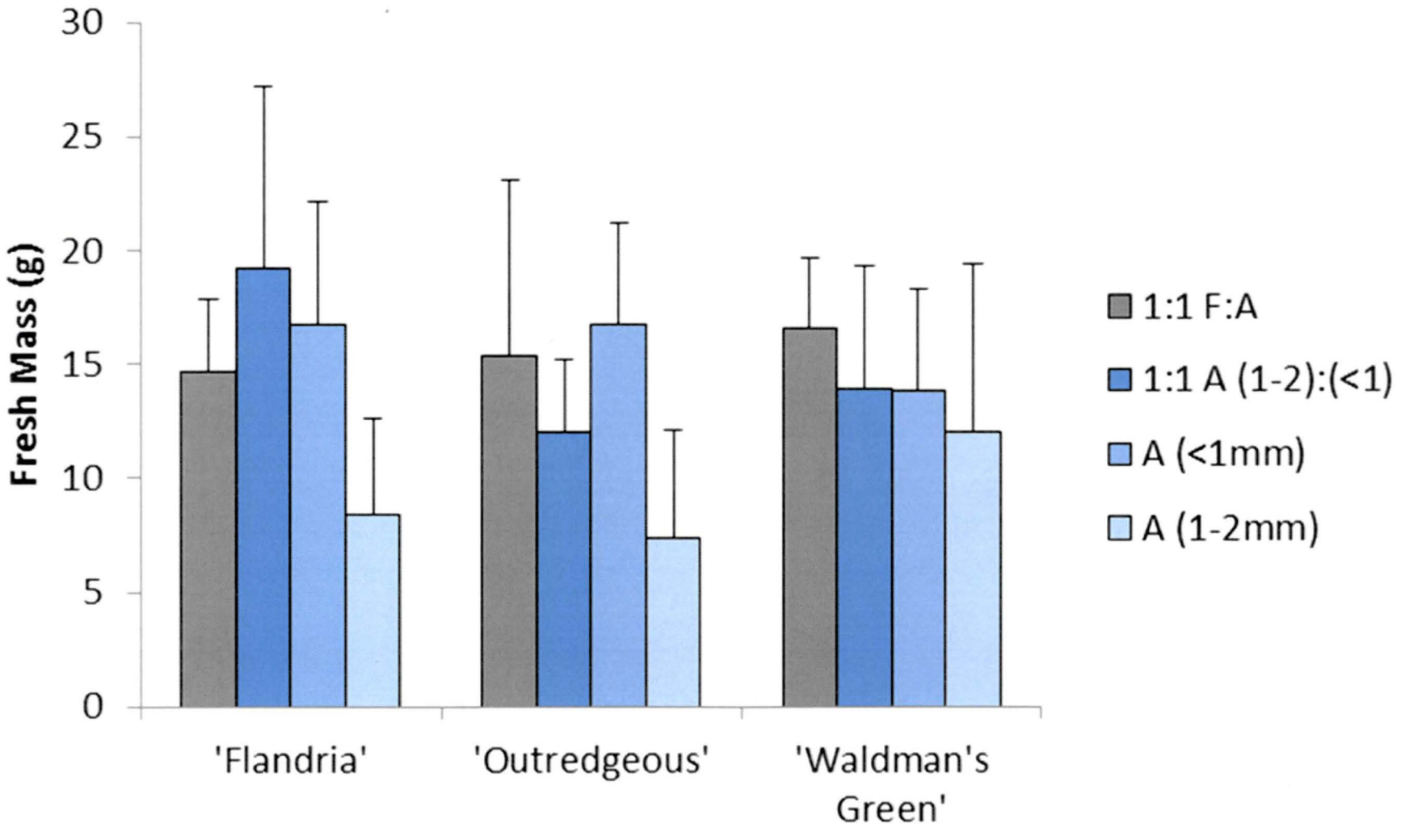


$r^2 = 0.6885$

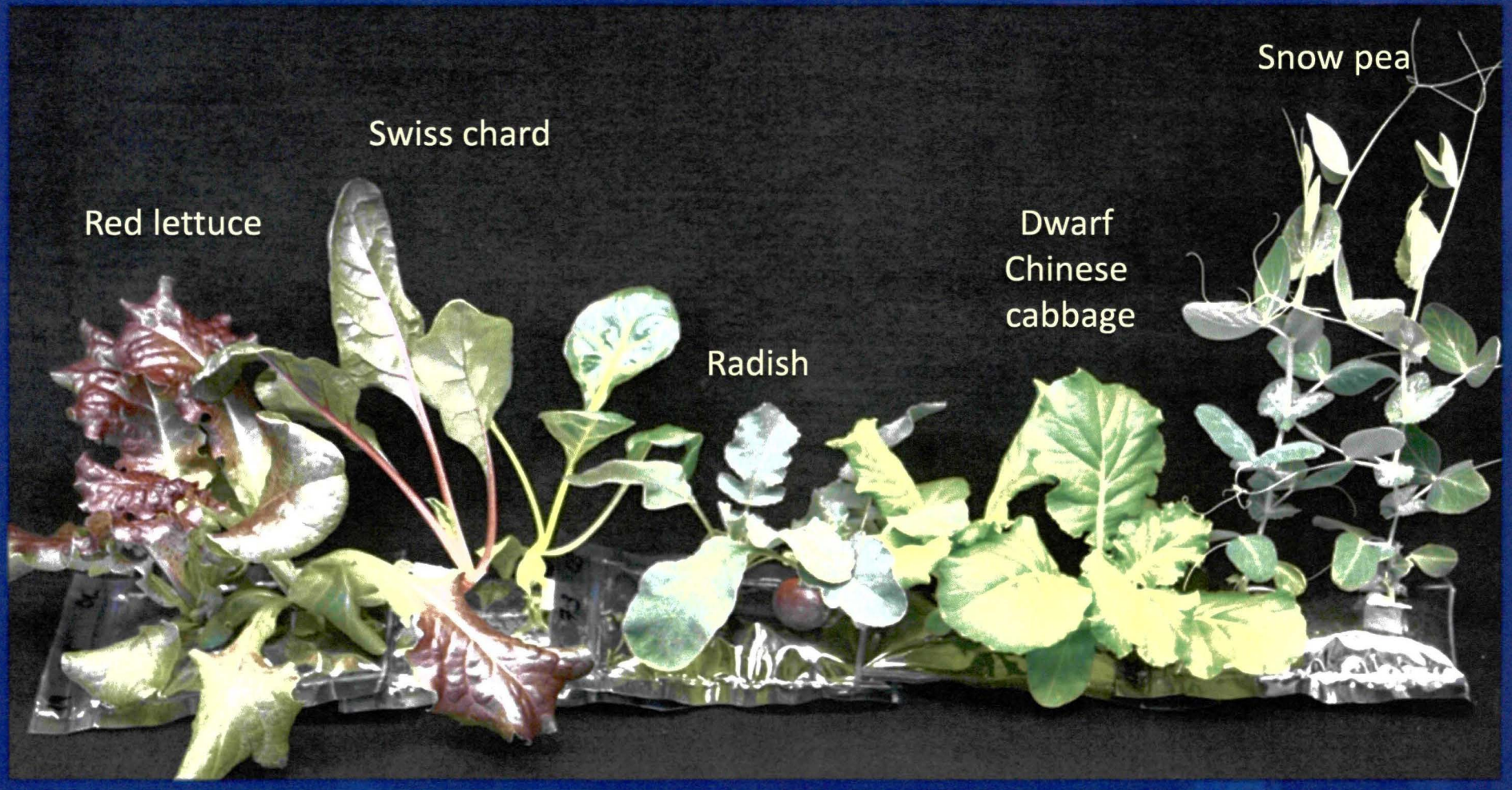
Water content of media



Lettuce Yields on Different Growth Media



Examples of crops tested in pillows



Initial Selection Factors

- Rapid growth
- Reliable germination
- Low microbial levels
- Palatability / acceptability
- Attractiveness
- Antioxidants

'Outredgeous' red leaf lettuce

VEG-01
Hardware Verification Test - Goals

- Demonstrate hardware function on ISS
- Test procedures for Veggie operation
- Demonstrate plant pillow concept
- Compare two media combinations for root and plant growth
- Look at microbial growth on plants, in pillows, and on surfaces
  - Food safety
- Assess plant productivity and health
- Generate data for future Veggie researchers

VEG-01
Hardware Verification Test - Setup

- Six pillows
- Two media types – arcillite of <1mm and arcillite 1:1 <1mm:1-2mm
- Lettuce – *Lactuca sativa* cv. 'Outredgeous'
- Water
  - Current plan is to use stored water from water processing system
- Tool set
- Sample return: eight swabs, all plants, two pillows

Planned Crew Operations

- Activation
  - Veggie installation and programming
  - Reservoir filling
  - Pillow priming
- Daily checks and refilling water every third day
- Wick separation
- Plant thinning
- Harvesting and sampling
- Hardware sanitizing

Microbiology

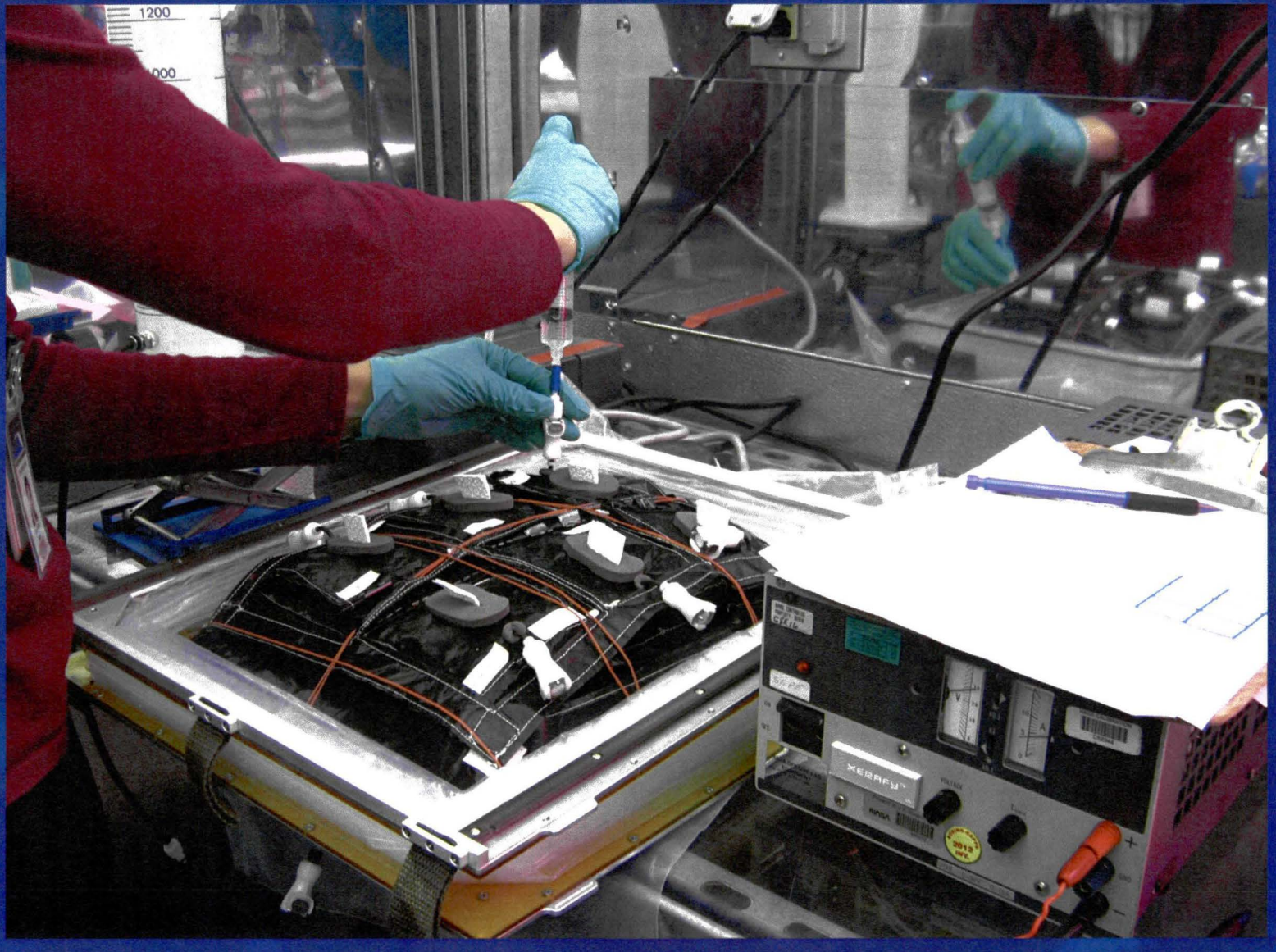
- Species selection
  - Low microbial levels
- Pre-flight sanitation
  - Seed sanitizing
  - Media and materials

- In flight procedures to minimize contamination
- Sample Return: swabs, plants, pillows
  - Heterotrophic Plate Counts
  - Yeast and Mold
  - Specific Screens: *E. coli* and coliforms, *S. aureus*, *Pseudomonas*, *Salmonella*
  - Isolate and ID microbes from plates

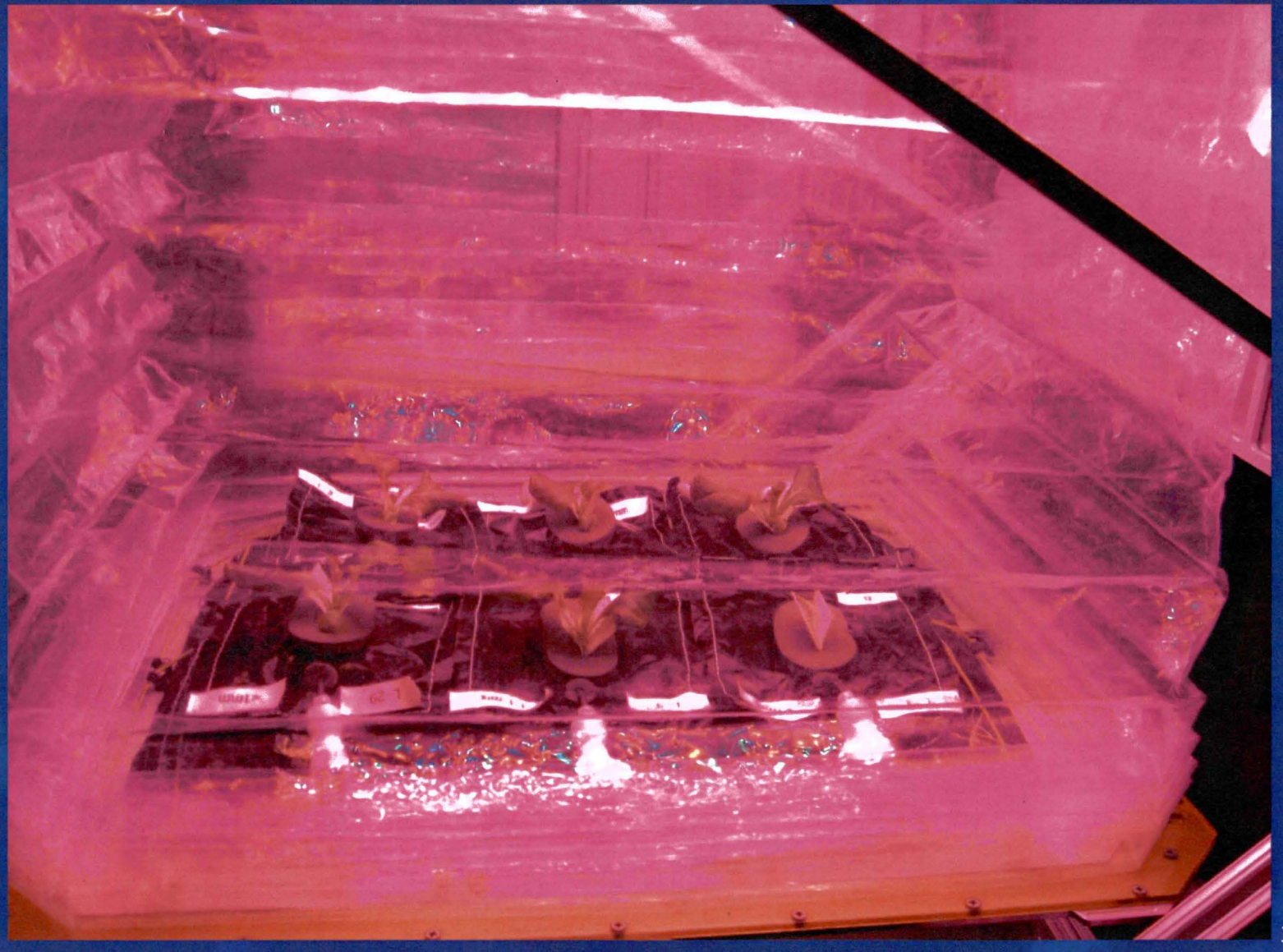
VEG-01 – Additional Aspects

- Launch on SpaceX-3 – sample return on SpaceX-4
- Additional sample processing: plant mass, ATP levels, nutrient analysis, root distribution
- Temperature and RH monitored via data logger
- Additional pillow sets for crew use:
  - Set 2: Ornamental plants
  - Set 3: Lettuce for consumption pending microbiology
- Edible produce sanitizing for microgravity
  - Collaboration with Microcide, Inc.

VEG-01 SVT



SVT Plants



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