Crop and Substrate Tests with Single Use Rooting "Pillows" for the VEGGIE Plant Growth Hardware

Gioia Massa[1], Gerard Newsham[2], Janicce Caro[2], Gary Stutte[2], Robert Morrow[3] and Raymond Wheeler[1]

1. Surface Systems Division, Mail Code NE-S-1, Kennedy Space Center, FL 32899
2. ESC Team QNA, Mail Code ESC-24, Kennedy Space Center, FL 32899
3. Orbital Technologies Corporation, 1212 Fourier Drive, Madison, WI 53717

Email addresses: gioia.massa@nasa.gov, gerard.newsham-1@nasa.gov, janicce.l.caro@nasa.gov, gary.w.stutte@nasa.gov, morrowr@orbitec.com, raymond.m.wheeler@nasa.gov

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VEGGIE is a small plant production chamber built by ORBITEC. This chamber can be collapsed for easy stowage and deployed in orbit. It is designed for gravity independent operation, and provides 0.17 m^2 of crop growth area with three primary subsystems: an LED light panel, extendable transparent Teflon bellows to enclose the plants, and a wicking reservoir. VEGGIE would provide the capability for astronauts to grow fresh foods for dietary supplementation.

Initial planting concepts tested with the VEGGIE included direct seeding or plug placement on the reservoir surface. These options had issues of salt accumulation and eventual toxicity if the reservoir was filled with nutrient solution, and hardware reuse was limited due to sanitation. In response a rooting packet or "pillow" concept was developed: single-use bags of media containing time release fertilizer with a wicking surface contacting the VEGGIE reservoir. Pillows being tested are small electrostatic bags with a Nitex nylon mesh side, each holding 100 mL of dry media. Six pillows fit in one VEGGIE unit; however pillow size could vary depending on crop selected. Seeds can be planted directly in pillows and planted pillows can be hydrated in space as desired.

Our goals were to define optimal media and crops for an ISS mission scenario. Plant tests in pillows were performed in a controlled environment chamber set to habitat-relevant conditions, and capillary reservoir analogs were utilized. Media tested within pillows included: a commercial peat-based potting mix, arcillite (calcined clay), perlite: vermiculite, and peat-based: arcillite blends. Testing included 15 types of leafy greens, snow pea, radish, and herbs. Media performance was crop dependent, but generally plants showed the greatest growth in the peat-based: arcillite mixes. Crops with the best performance in pillows were identified, and testing is underway with select leafy greens examining plant and microbial load response to repeated harvest. We plan to use findings from previous flight testing with media to evaluate the effects of capillary flow from the reservoir to pillows in μ-gravity. (This work was supported by NASA).

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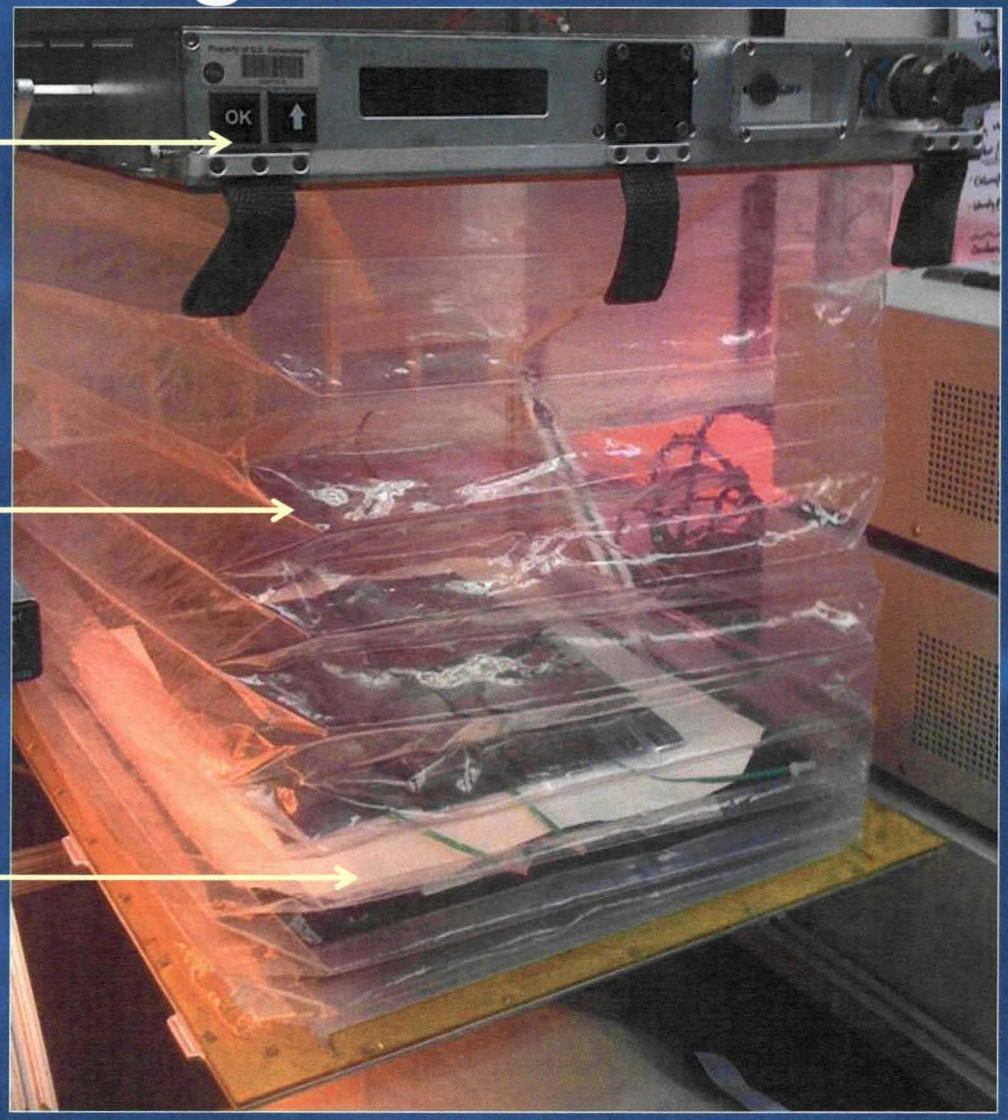
VEGGIE Vegetable Production Unit



Designed and built by Orbital Technologies Corporation (ORBITEC)

Initial Planting Tests

Planting directly over reservoir:

- •Stunted growth
- •Decline by 21 DAP
- •Stem girdling/collapse due to nutrient toxicity
- •Salt damage in roots
- •Water logging in roots

One Layer Nitex with 1X Hoagland

Two Layer Nitex with 1X Hoagland

Planting in blocks/plugs on reservoir:

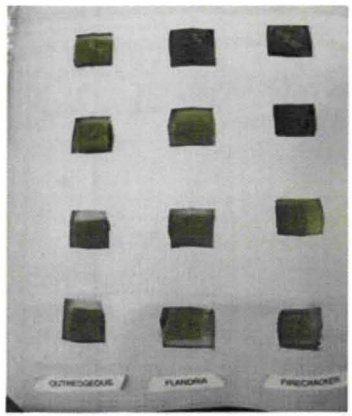
-in 1 X Hoagland solution:

- •Poor germinations
- •Salt build-up on plugs

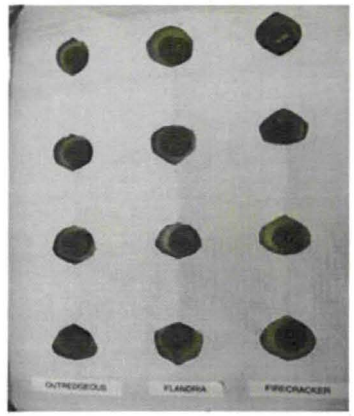
- In ½ X Hoagland solution:

- •Slow growth
- •Severe stunting
- •Wilting
- •Salt build-up

Rockwool blocks at 7 DAP with 1X Hoagland

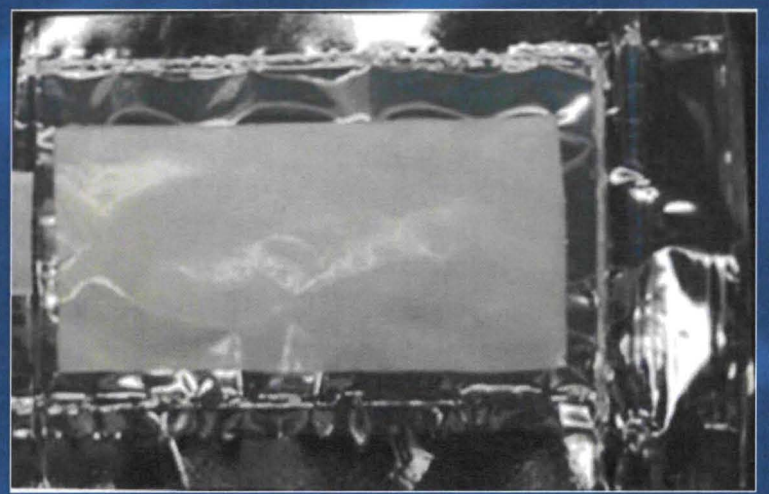


Oasis Plugs at 7 DAP with 1X Hoagland



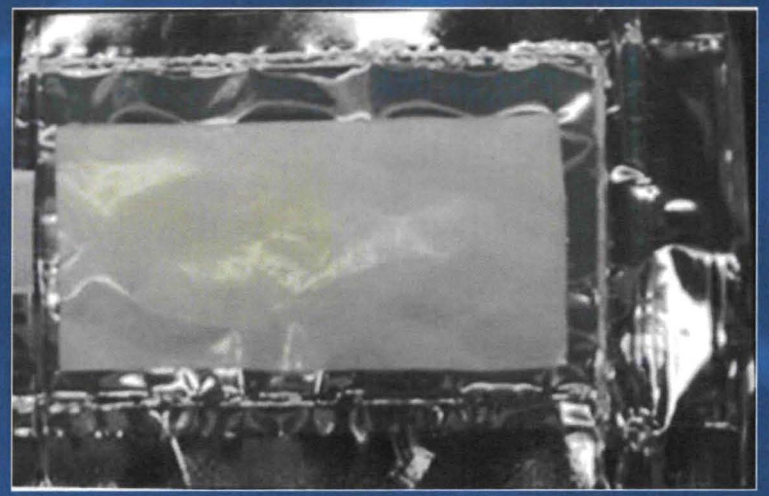
Pillow Concept

- Small bag
  - Resealable
  - Static shielding
- Wicking surface
  - Heat-welded Nitex (nylon) membrane
  - Allows passive wicking from reservoir
- Media Contained
  - Testing underway
- Fertilizer Contained
  - Time release
  - Nutricote 18-6-8 selected



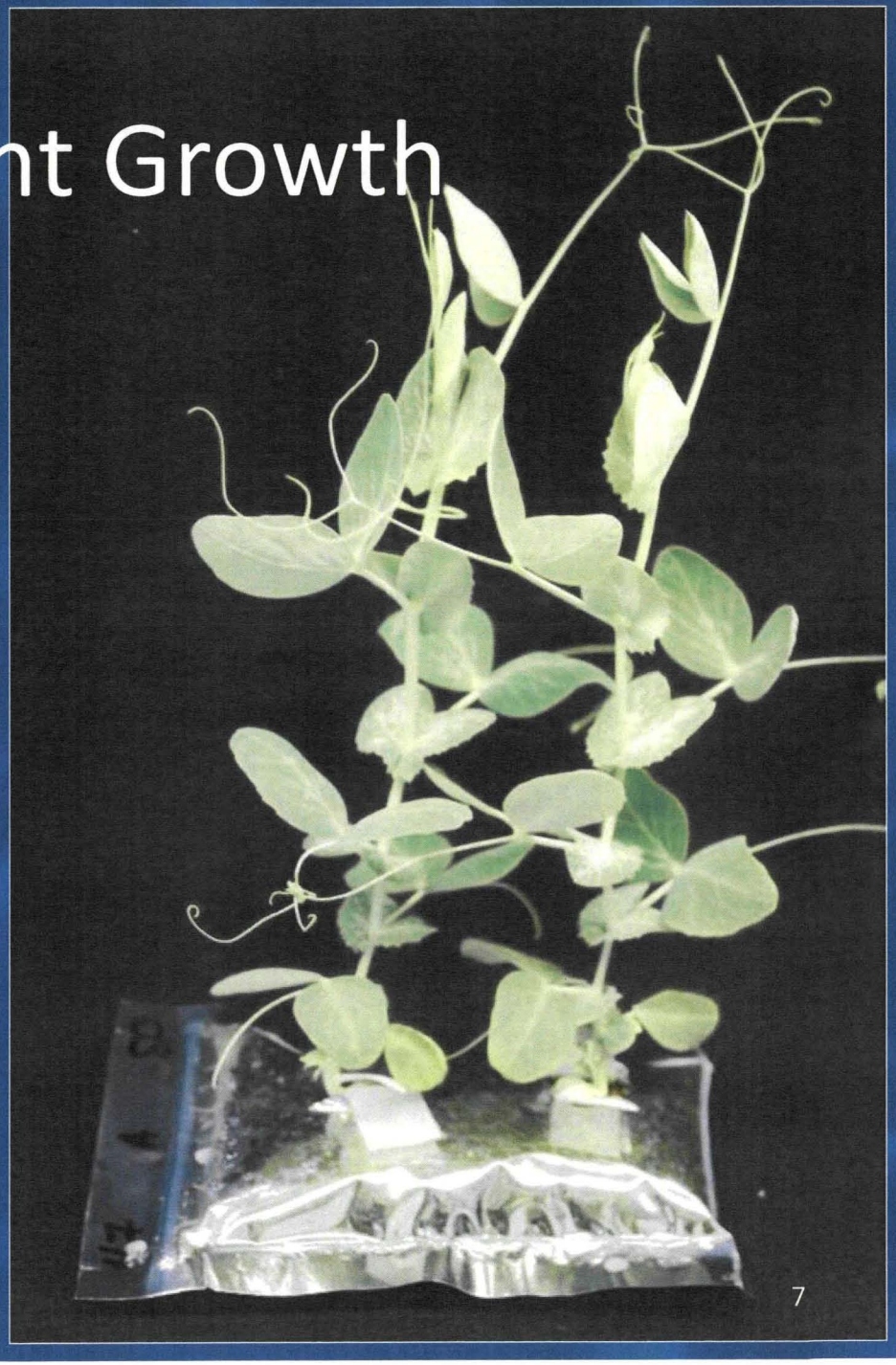
Pillow Concept (cont.)

- Plant seeds dry, in 1 g
  - Low launch mass
- Hydrate on orbit
- No energy requirement
- Minimal crew time
- Designed for single use
- Dispose after harvest
- Reduces sanitation requirements



Pillow Testing in Reservoir Analog

Pillow Plant Growth



Early Media Studies

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

Media and Cultivar Test #1

13 cultivars

- 'Outredgeous' lettuce
- 'Flandria' lettuce
- Mizuna
- 'Sierra' lettuce
- 'Oak leaf' lettuce
- 'Tender leaf' Vegetable Amaranth
- 'Bright lights' Swiss Chard
- 'Tokyo Bekana' Cabbage
- 'Sugar Pod II ' Snow Peas
- 'Spicy Globe' Basil
- 'Genovese' basil
- Common Chives
- Greek Oregano

5 types of media

- Fafard # 2 (commercial peat-based media)
- Arcillite (1-2mm)
- 1:1 Fafard # 2 : Arcillite
- 7:3 Fafard # 2 : Arcillite
- 1:1 Perlite : Vermiculite

- Reservoir analogs
- Walk-in growth chamber
- Temp. and RH (28°C, 70%)
- 16 h photoperiod
- Elevated CO_2 – 1200 ppm
- Grown for 36 Days

Multiple Species and Cultivars

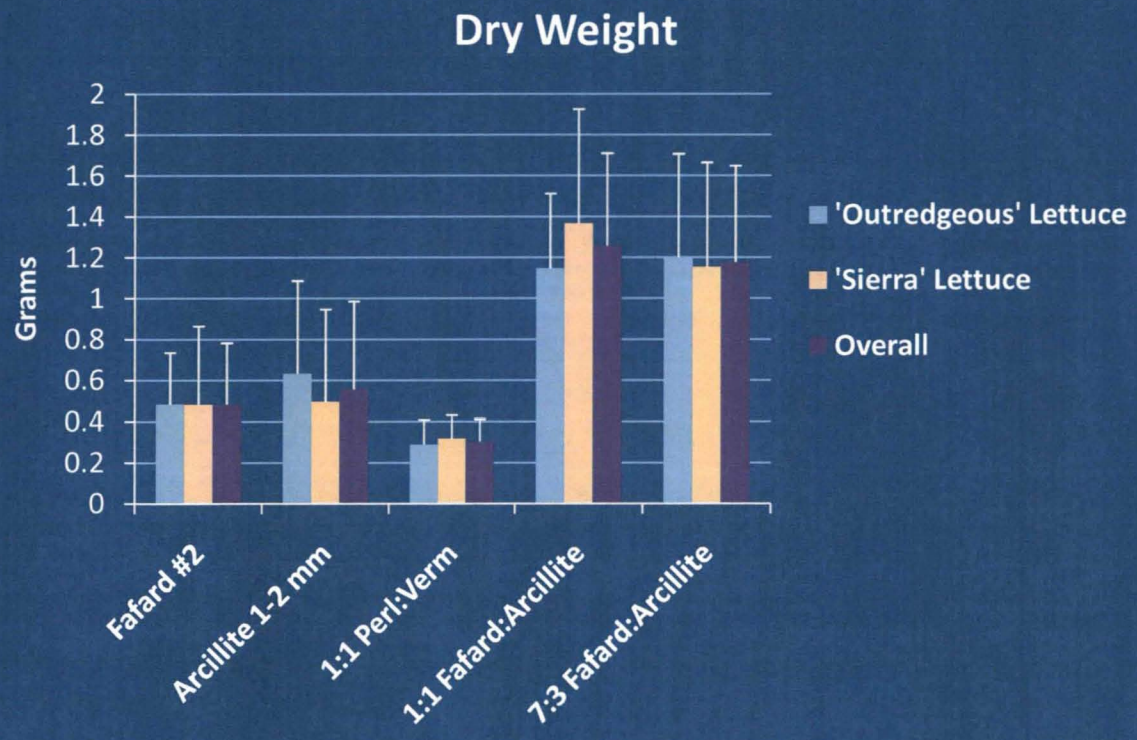
General Results – Cultivars and Media

Species/Cultivar Testing

- Best performance in pillows seen from cultivars of:
  - Snow Pea
  - Lettuce
  - Chinese Cabbage
  - Mizuna
  - Swiss Chard
  - Basil

Media Testing

- 1:1 and 7:3 mixes support best growth



Different Media Types

Root Response Varies with Species and Media

Second Test

Cultivars

- 'Sugar Pod II' Snowpea
- 'Tokyo Bekana' Chinese Cabbage
- 'Bright Lights' Swiss Chard
- 'Outredgeous' Lettuce
- 'Cherry Bomb II' Radish

Media

- Fafard # 2 (commercial peat-based media)
- Arcillite (1-2mm)
- 1:1 Fafard # 2 : Arcillite
- 7:3 Fafard # 2 : Arcillite

- Same environmental conditions
- All cultivars tested with all media
- Larger sample sizes
- Grown for 28 Days

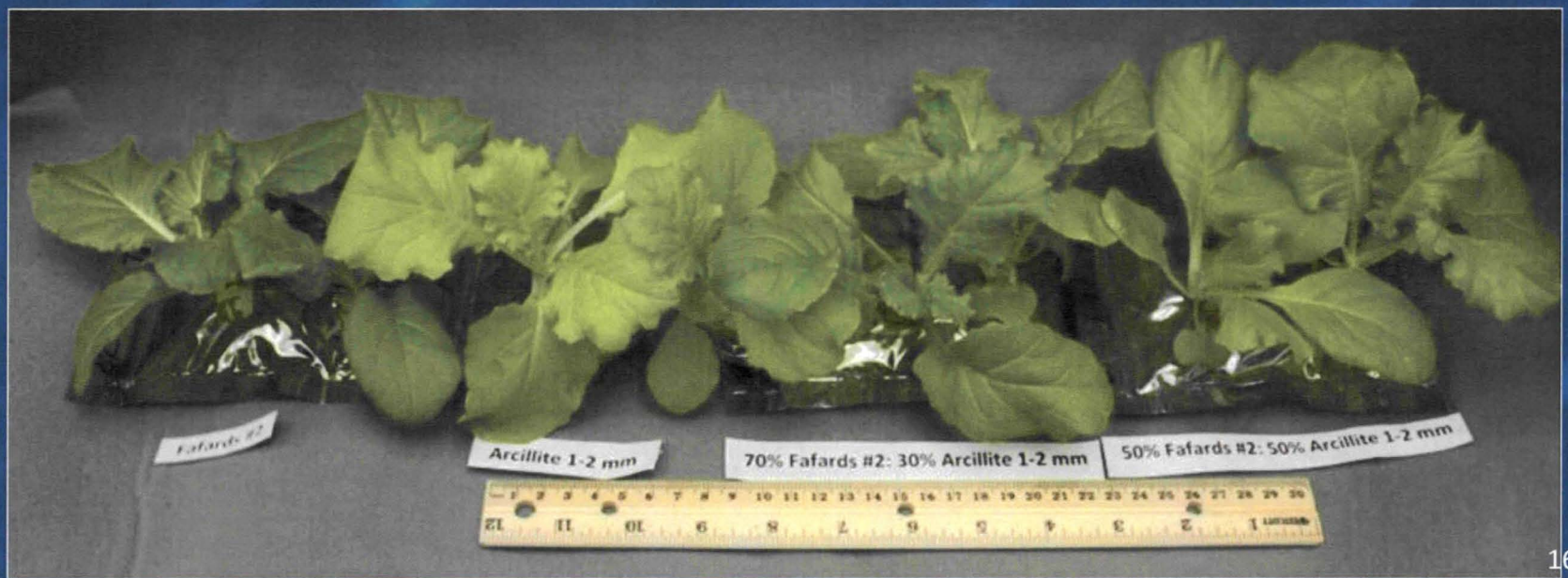
Space Competition

(28 DAP)

18 DAP

‘Outredgeous’ Lettuce

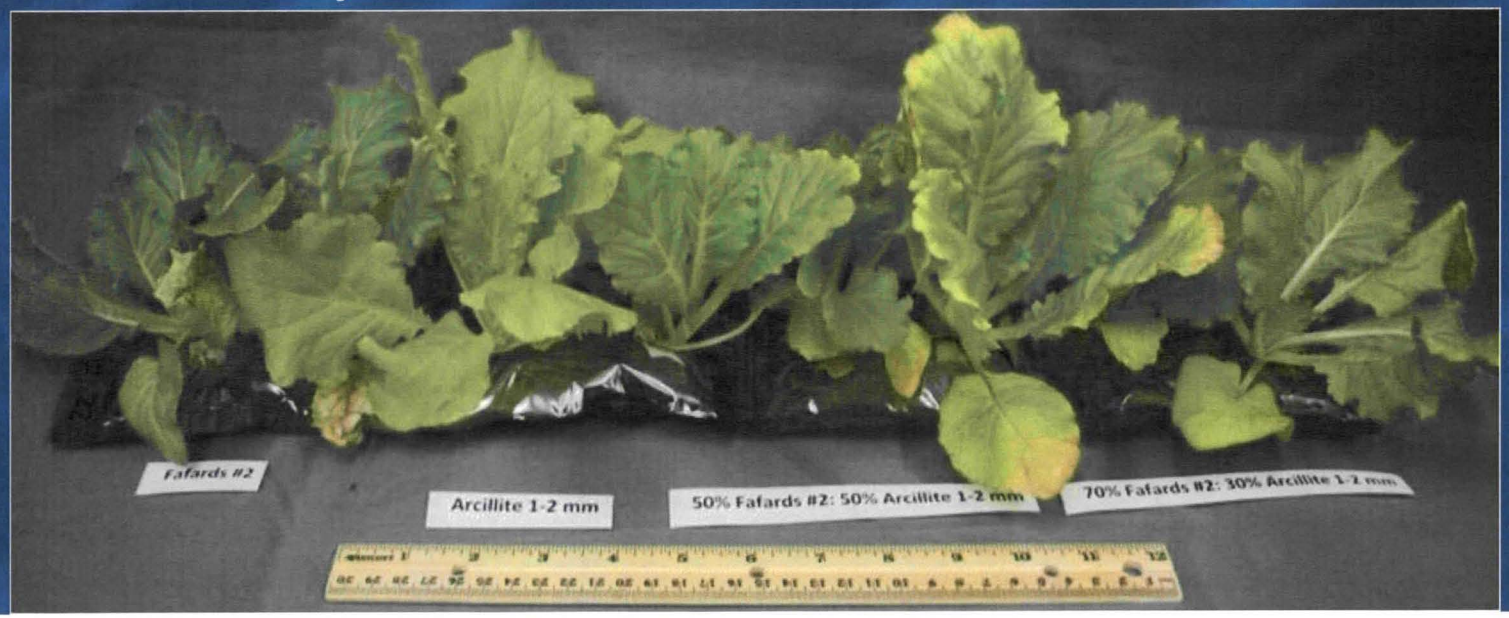
‘Tokyo Bekana’ Chinese Cabbage



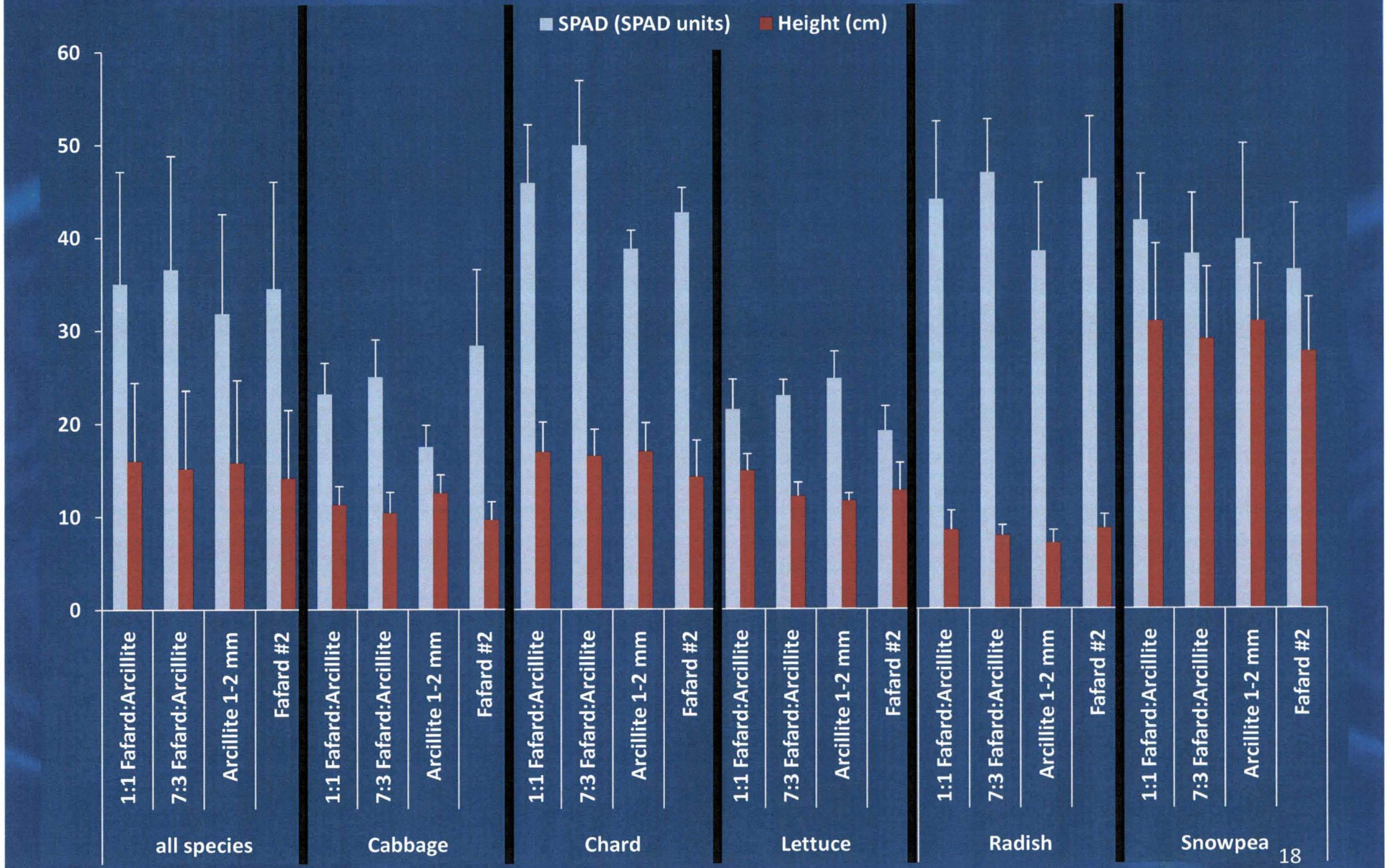
28 DAP

‘Outredgeous’ Lettuce

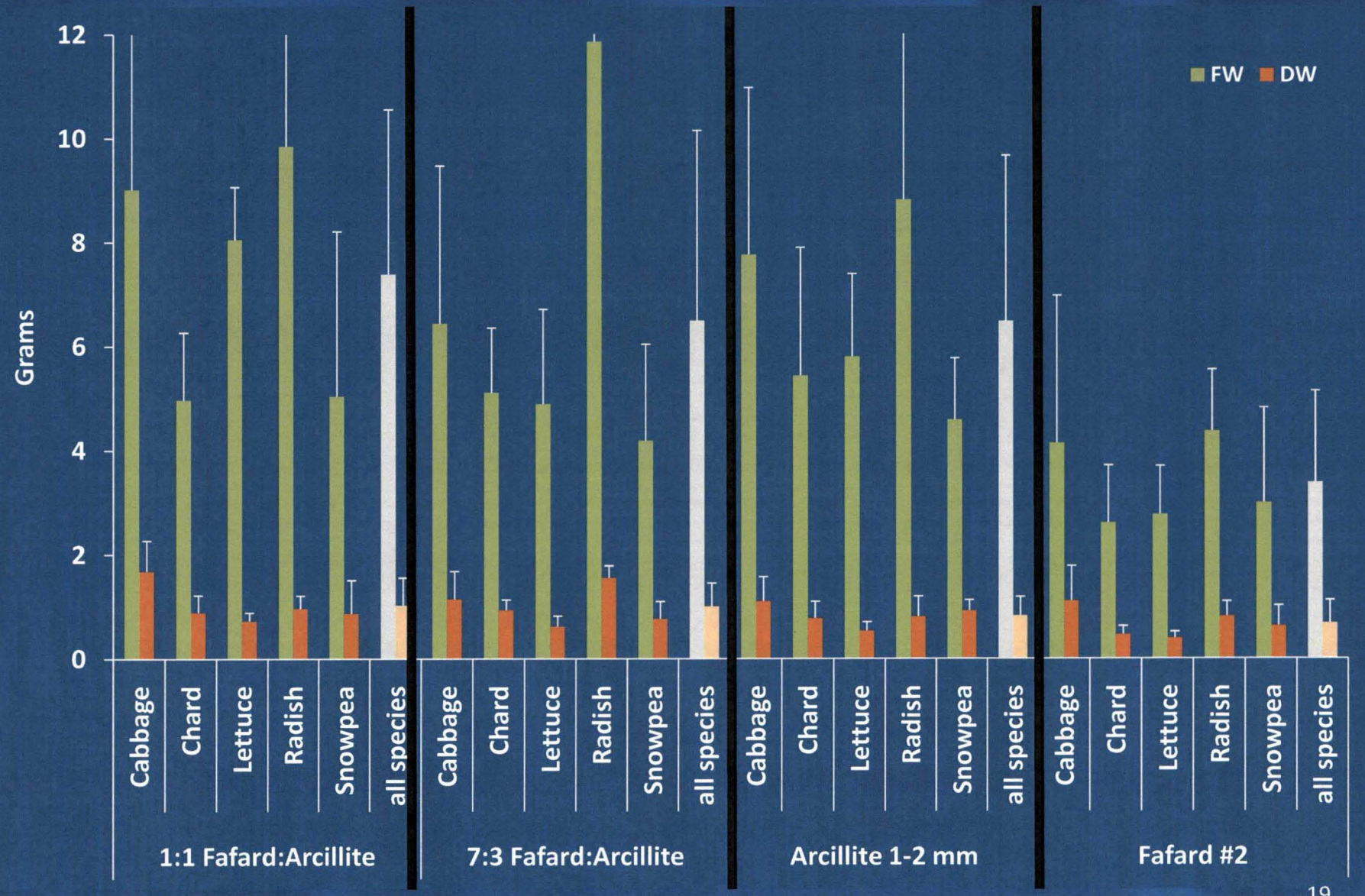
‘Tokyo Bekana’ Chinese Cabbage



SPAD and Height are cultivar-specific

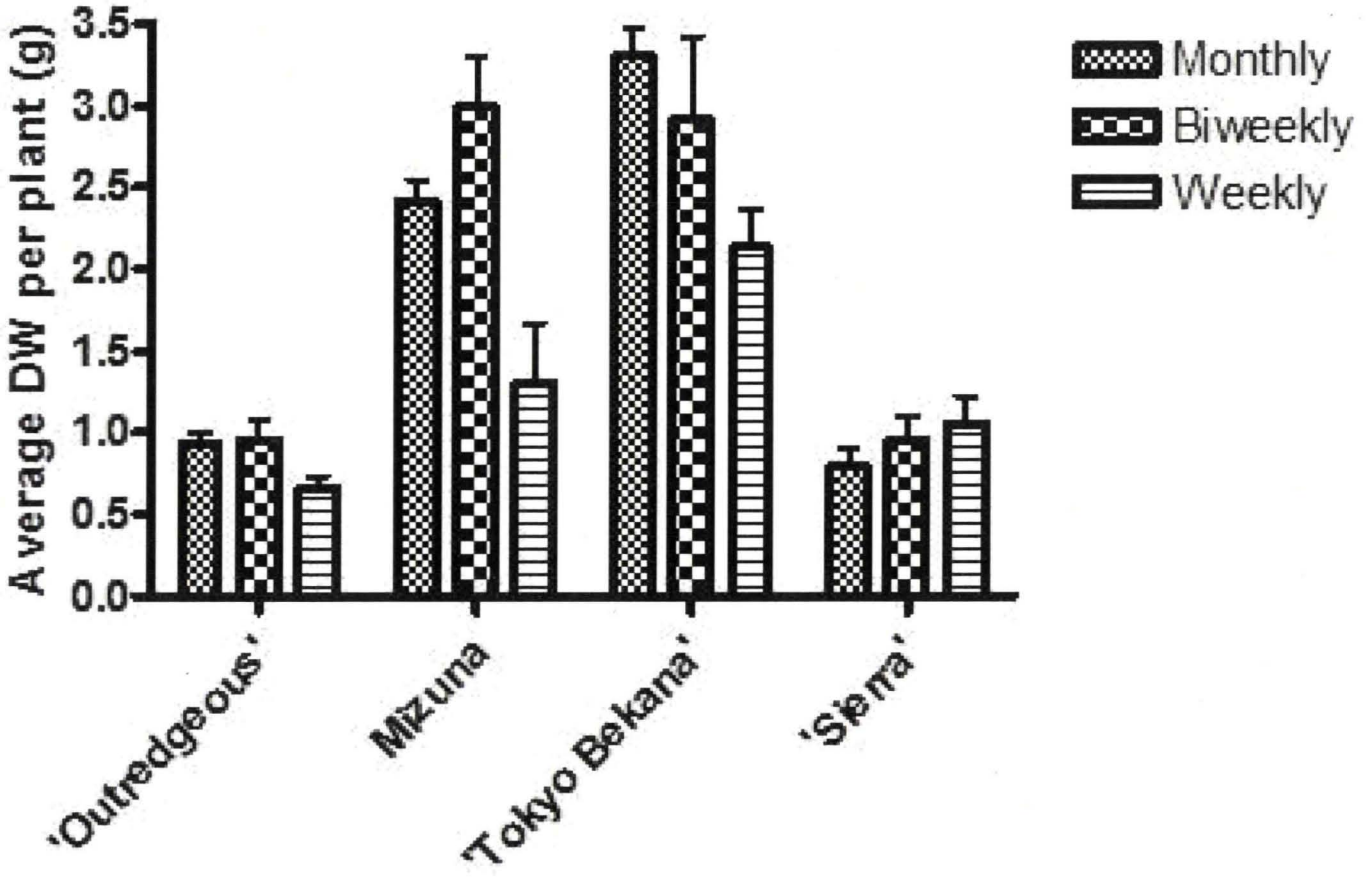


Effect of Media



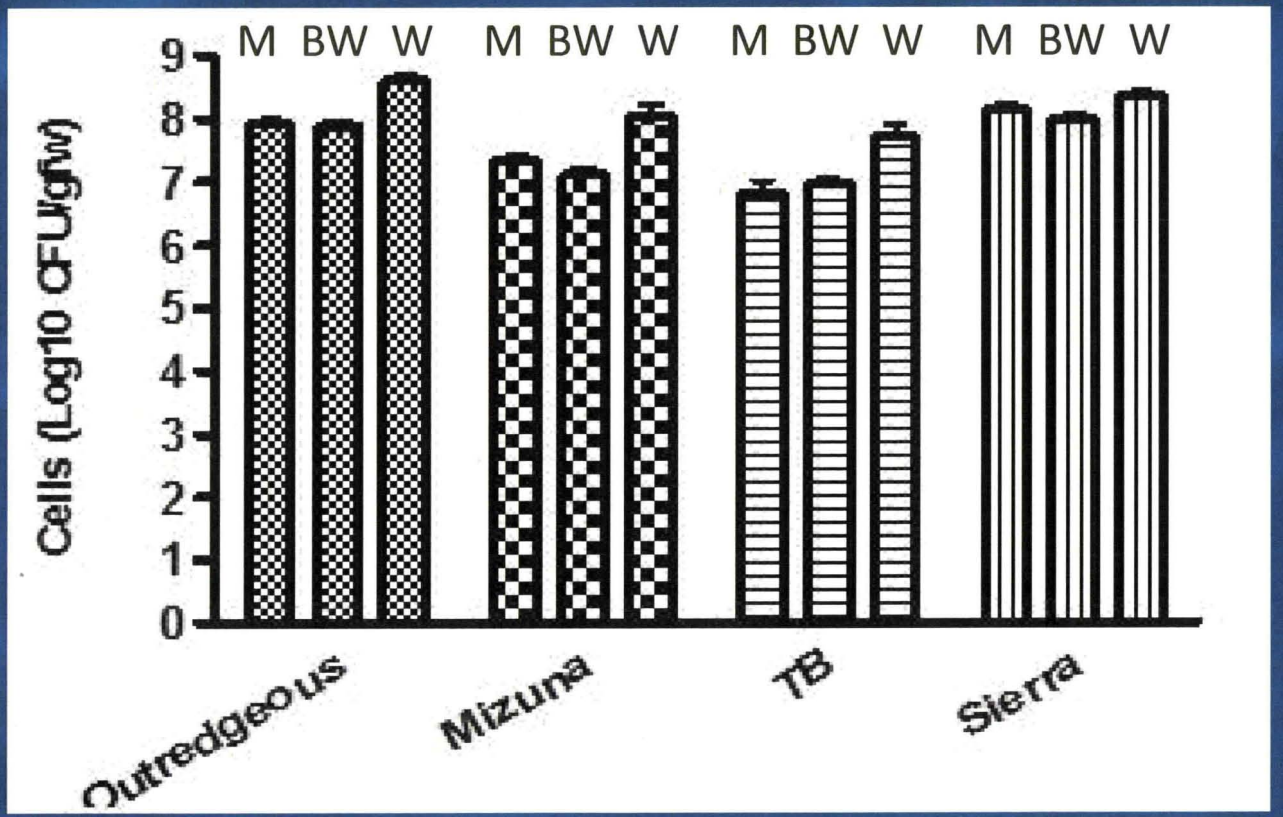
Next Steps

Harvest strategies



Next Steps

Harvest strategies and microbial load



Graph courtesy of Anthony Nguyen

Next Steps (cont.)

- Other media combinations
- Consideration of other factors:
  - Launch mass
  - Ease of rewetting
  - Uniformity
  - Storage
- Planting for microgravity

Media in Spaceflight – a few examples

- CHROMEX – Floro foam (Musgrave)
- PGBA – Agar and other media (Hohen)
- PTNDS – porous tubes (PT) - no media (Dreschel)
- SVET – Balkanine zeolite (Ivanova & Bingham)
- ASTROCULTURE- Arcillite with PT (Morrow)
- Balkanine-Arcillite comparison (Jones & Or)
- PESTO – Arcillite (1-2mm) with PT (Monje & Stutte)
- ORZS – multiple media, no plants (Bingham et al.)

Summary courtesy of Oscar Monje

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