Food and Crop Research Activities
Kennedy Space Center, FL

June 2005

Ray Wheeler
Crop Research at NASA-KSC

KSC's Crop Research Began in Hangar L ca. 1985
for the CELSS Program

Biomass Production Chamber, Hangar L

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Biomass Production Chamber Studies
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Crop testing in smaller growth chambers

Historical Timeline of Advanced Life Support Research at Kennedy Space Center

<table>
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<tr>
<th>External Reviews / Advisory Panels*</th>
<th>AIBS Panels (3)</th>
<th>Zero-Base</th>
<th>NRC Panel</th>
<th>STWG</th>
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Crop Tests
(Lab Scale)
~0.5-2.0 m³

Breadboard
Integrated
Testing in BPC
20 m³

Resource
Recovery
(Lab Scale)

Nutrient
Water Delivery
Lighting
Porous Tubes

Resource Recovery
Cellulase
Yeast
Sodium Recycling with Plants

Integrated Nutrient
Soybean
Lettuce
Tomato

Preliminary Tests

Aquaculture

Crop Testing / Bioreactor Effluent

Effluent Tolerance

Composting

Bioreactors

Yeast

Fixed Film Reactors

Table西瓜

Intermediate CSTs

Greywater
Processing

Lab CSTs

Wheat NFT

Soybean NFT

Effluent Recycled

* In addition to annual RTOP and Program Reviews
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Current Crop Research Activities:
- ALS Technology Development Proposal / Technical Task Agreements
  - Environmental Responses of ALS Crops
  - Cultivar Comparison / Selection
  - Mixed vs. Monoculture
- NRA Grants
  - PESTO / ISS Flight Experiment (Gary Stutte)
  - RASTA / VOCA (Gary Stutte)
  - WONDER Flight Experiment (Howard Levine)
- National Research Council (Hyeon-Hye Kim)
  - Plant Growth Under LED lighting
- Graduate Student Research Program
  - Cornell, Univ. Florida, Univ. Arkansas, Texas Tech.

TTA Progress:

Environmental Response Tests*

Light: μmol m^2 s^-1 :
150, 300, 450
CO₂ (ppm) :
400, 1200, 4000
Temp. (°C) :
22, 25, 28

Target Crops:
1) Lettuce, Radish, Onion
2) Tomato, Pepper
3) Strawberry

* Underlined values indicate conditions typical for open chambers in space cabin
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TTA Progress: Environmental Response Tests

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TTA Progress
Cultivar comparisons:

- Lettuce: Waldmanns' Green, Ostinata, Fiandra, (Red Sails, Eruption, Outredgeous)
- Onion: Kinka, Krunch, Choho, Choetsu, Guardman, Pacific Pearl, Evergreen Hardy White, Deep Purple
- Radish: Cabernet, Fireball, Cherriette, Giant White Glove, Cherry Belle, Sora, Cherry Bomb II, Vintage
- Tomato: MicroTina, Florida Pette, Red Robin
- Pepper: Triton, Hanging Fruit Basket, False Alarm

(underlined indicates the cultivar chosen for further testing)
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**TTA Progress:**
*Mixed vs. Monocultures*

- Allelopathy
- Nutrient Competition
- Canopy Competition

**Monoculture**

**Mixed Plantings**

⇒ No differences noted to date

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**LED Lighting Studies**

Green Light for Human Vision and Better Canopy Penetration

**Stomatal Responses to Spectra**
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- RASTA / VOCA Project:
  
  - Team: Gary Stutte (PI), Ignacio Eraso, Sylvia Anderson
  
  - Originally a flight experiment to study effects of volatile organic compounds (VOCs) in closed flight chambers on plant growth (RASTA).
  
  - Transitioned to a Ground-Based project to study volatile organic compounds produced in closed systems, and their effects on plants growth (VOCA)

  ⇒ Development of a “SMAC” scale for plants

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RASTA / VOCA...Exposure and Collection Chambers

Target VOCs:

- Ethylene (10^{-4} SMAC)
- Ethanol (10^{-2} SMAC)
- Methanol (10^{-1} SMAC)
- Toluene (>0 SMAC)
- Acetone (>0 SMAC)
LADA Microbial Risk Assessment
Jay Garland, co-Investigator
(Gail Bingham, Principal Investigator)

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• Food Analysis and Testing

  – Proximate Composition
    • Protein, Fat, CHO, Ash, (Dietary Fiber)
  – Elemental Composition
  – Antinutrients
    • Nitrate, Phytic Acid, Oxalic Acid
  – Antioxidants
    • Vit. E and C, Anthocyanins, Lycopene, Polyphenols
  – Sensory Evaluations
    • Taste Test Panels at JSC
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- Crop Production Activities (existing in black and proposed in red)
  - Environmental Testing with
    - Continue Lettuce, Radish, Onion, Tomato, and Pepper
    - Initiate Strawberry Testing
    - Initiate Pressure Response Testing at Univ. of Guelph
  - Cultivar Selection
    - Complete strawberry testing
    - Initiate GMO Strategy and Development
  - Mixed / Monoculture
    - Continue Lettuce-Onion-Radish / Tomato-Pepper
    - Initiate Long-Duration, Sustained Production Trials
  - Continue LED Testing
    - Design and Develop Solar Light Capture / Delivery Systems
  - Continue Food Quality and Sensory
  - Continue VOC Response Testing / Plant SMAC
  - Initiate VPU Development
  - Support Psychological Response Studies (Human/Plant)
    - Terrestrial Analogues, e.g., McMurdo Station, Antarctica
  - Initiate Crop Radiation Response Studies
  - Initiate Integrated Crop, Wastewater, Solid Waste Testing
  - Initiate Planetary Surface Chamber Design and Development
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Meetings / Presentations for 2004:

- Intl. Conference on Environmental Systems
- Habituation Society
- Plant Growth Regulator Society of America
- American Society for Horticultural Science
- Intl. Controlled Environment Working Group (NCR-101)
- Int. Society of Horticultural Science
- Agronomy Society of America
- Committee on Space Research (COSPAR)
- International ALS Working Group
- American Society for Gravitational and Space Biology

Crop Research with KSC Authors for 2004/2005:


