Growing Beyond Earth
Students Exploring Plant Varieties for Future Space Exploration

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Growing Beyond Earth supported through NASA CP4SMPVC+ Grant No. NNX16AM32G
Veggie on ISS and in the classroom
Goals and objectives

• Improve STEM instruction
• Increase & sustain youth and public engagement in STEM
• Better serve groups historically underrepresented in STEM fields
• Inform current and future NASA plant research
GBE Partners

• NASA Exploration Research and Technology Programs

• Miami-Dade County Public School (MDCPS)
How do we start the school year?

Jointly-led (FTBG & NASA), mandatory professional development workshop for all participating teachers

- NASA content on growing plants in space
- Teachers receive continuing education credits through MDCPS and Texas State University
- Schools receive all necessary materials and experimental protocols
What we ask the students and teachers to do?

- Planting of selected seeds and randomization of varieties
- Daily observations of plants and water needs
Recording data of weekly measurements

Filling a pre-designed google spreadsheet with weekly data

<table>
<thead>
<tr>
<th>Number of leaves</th>
<th>Plant height (cm)</th>
<th>Plant width (cm, left to right)</th>
<th>Plant depth (cm, front to back)</th>
<th>Plant health</th>
<th>Total fresh mass (g)</th>
<th>Edible fresh mass (g)</th>
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<tbody>
<tr>
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</table>
Classroom implementation

Why do teacher and students like to participate?

- Optional, school year long engagement
- Flexible design and support from project staff
- “Real-world” STEM experience
- Data are being used by NASA scientists
- Serves many diverse students
  - 90% students underrepresented in STEM fields
  - Approximately 3600 students participated in 2016-2017
  - 51 high schools and 75 middle schools are participating in 2017-2018
Outcomes for students and teachers

**Students**
- Strengthen research skills
- Improve attitudes towards STEM
- Increase botany knowledge
- Experience meaningful collaboration
- Build leadership skills
- Increase girls confidence in succeeding in science coursework

**Teachers**
- GBE teachers provide unique experience to their students
- Strengthen their own research skills
- Strengthen their botany skills
# The First 3 Years (2015 -2018)

## High School

<table>
<thead>
<tr>
<th>Pre-pilot</th>
<th>Pilot year</th>
<th>Year 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety study/Cut-and-come-again harvest</td>
<td>Tomatoes and Peppers</td>
<td>Variety study on Asian leafy greens</td>
</tr>
<tr>
<td>Data only/Presentations for top 12</td>
<td>Research proposal/Presentations for top 12</td>
<td>Execute research proposals/Poster presentation at Student Symposium</td>
</tr>
</tbody>
</table>

## Middle School

<table>
<thead>
<tr>
<th>Pre-pilot</th>
<th>Pilot year</th>
<th>Year 1</th>
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</thead>
<tbody>
<tr>
<td>Variety study</td>
<td>Variety study and fertilizer/Cut-and-come-again harvest</td>
<td>Variety study on Asian leafy greens</td>
</tr>
<tr>
<td>Data only</td>
<td>Science article for a popular science journal</td>
<td>Research poster/Optional Symposium participation</td>
</tr>
</tbody>
</table>
So far tested!

- Over the past two years, 94 varieties have been tested
- Leafy greens, herbs, medicinal plants, tomatoes and peppers
- Seeds chosen by Fairchild scientists
- Diverse seed suppliers
NASA Veggie use of Fairchild Data
Crop Variety Testing

• Data compiled, averaged, compared:
  – Shortest days until germination
  – Greatest number of leaves
  – Greatest edible biomass
  – Smallest plant size
  – Best health

• Smaller standard deviation given preference

• Crops ranked into best and runner up candidates for further testing in NASA facilities
Promising New Veggie Candidates

- Dragoon lettuce
- Extra Dwarf Pak Choi
- Petite Snap Green Peas
- Dill
- Ice Plant
- Large Leaf Tong Ho Shungiku
- Borage
- Garland Round Leaf Shungiku
- Cressida
- Fine Leaf Basil
Other Research Translating from Fairchild Challenge to NASA

• **Cut-and-come-again harvesting**
  – In spring 2016, Fairchild High School students tested cut-and-come-again repetitive harvesting compared to terminal harvest.

• **Student data showed more than double the amount of produce from the same inputs.**
• **NASA’s Veggie team began cut-and-come-again with ‘Outredgeous’ lettuce and ‘Tokyo Bekana’ Chinese cabbage in the Veg-03 test starting Oct. 2016.**
Other Research Translating from Fairchild Challenge to NASA

- **Multiple Cropping**
  - All tests have been using multiple crops in the growth chamber.
  - Veg-01 and Veg-03 A, B, and C tests were monocultures.
  - Veg-03 D, E, and F are using three crops modeled after how Fairchild Challenge students have grown their crops.
Future projects:
- Growing substrate
- Light pollution
- Light spectrum
- Light intensity
- Photoperiod
- Fertilizer
- Failure testing
Thank you!

- Researchers and Scientists at Kennedy Space Center
- Staff, Volunteers and Students at Fairchild Tropical Botanic Garden
- Dr. Catherine Raymond at Raymond Consulting
- Florikan
- NASA grant NNX16AM32G