



GROWING BEYOND EARTH

A PARTNERSHIP BETWEEN FAIRCHILD TROPICAL BOTANIC GARDEN & NASA

Growing Beyond Earth Students Exploring Plant Varieties for Future Space Exploration

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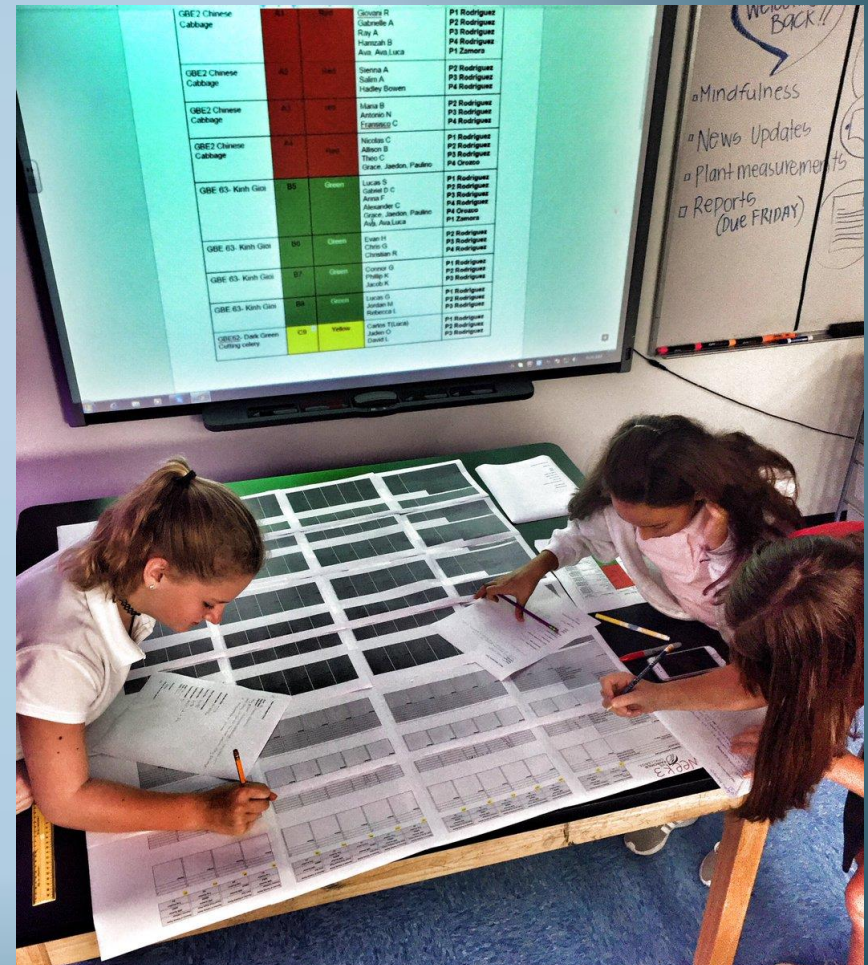
Growing Beyond Earth supported through NASA CP4SMPVC+ Grant No. NNX16AM32G

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

Number of leaves	Plant height (cm)	Plant width (cm, left to right)	Plant depth (cm, front to back)	Plant health	Total fresh mass (g)	Edible fresh mass (g)
14	15.6	14.8	9.8	good	39.1	20.3
13	21	12.8	11.2	good	28.6	16.2
19	13.5	26.8	12.3	good	35.4	29.3
				dead		
12	12.5	10.3	8.1	fair	16.5	11.3
				dead		
15	9.2	13.5	10.3	good	20.2	18.8
20	10.3	16.8	12.6	good	23.7	21.1
16	10.6	18	13	good	26.6	20.1
14	14.3	14.6	20.7	good	42.6	35.3
19	15.2	17.3	20.6	good	32.9	21.5
17	12.7	15.6	11.3	fair	22.2	18.6
				dead		
15	6.8	18.3	7.8	fair	17.8	17.2
22	13.2	11.6	10.6	good	23.6	19.6
11	10.3	13.9	9.4	fair	1.2	3.6

twitter.com/growbeyondearth

Mater Chemistry
@ChemistryMater

Follow

One of the peppers took a leap off a plant today. It was tasty. @GrowBeyondEarth @FairchdChallenge



RETWEETS 4 LIKES 9

9:32 AM - 29 Nov 2016

AUC Fairchild
@archiefairchild

Follow

seems like we have a little friend who's been eating our tomatoes! 🌱 @GrowBeyondEarth



RETWEETS 1 LIKES 3

10:58 PM - 25 Nov 2016

VinelandGreenStudies
@VinelandK8Green

Follow

Very sad trying to measure these dried out leaves! They suffered over the long weekend 😞 @VinelandK8 @GrowBeyondEarth @FairchdChallenge



RETWEETS 3 LIKES 7

8:02 AM - 14 Nov 2016

North Miami Middle
@North_Miami_MS

Follow

Meet the Young Scientists @North_Miami_MS who are on @growbeyondearth Tropical Fairchild Project #journeytomars #Botany



RETWEETS 2 LIKES 3

AE
@aporzio925

Follow

Harvest day and sharing the bounty with our littles @HDMcMillan @GrowBeyondEarth



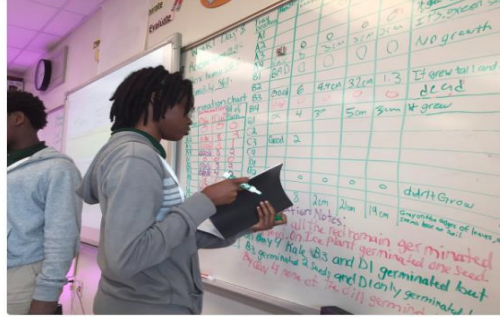
RETWEETS 2 LIKES 2

3:49 AM - 21 Oct 2016

Mandarin Lakes K-8
@MandarinK8

Follow

Week 2 @FairchdChallenge @GrowBeyondEarth @sosa720



Plant	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
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26	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0
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36	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0
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39	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0
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51	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0
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56	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0
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72	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0
93	0	0	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0
98	0	0	0	0	0	0	0	0	0	0
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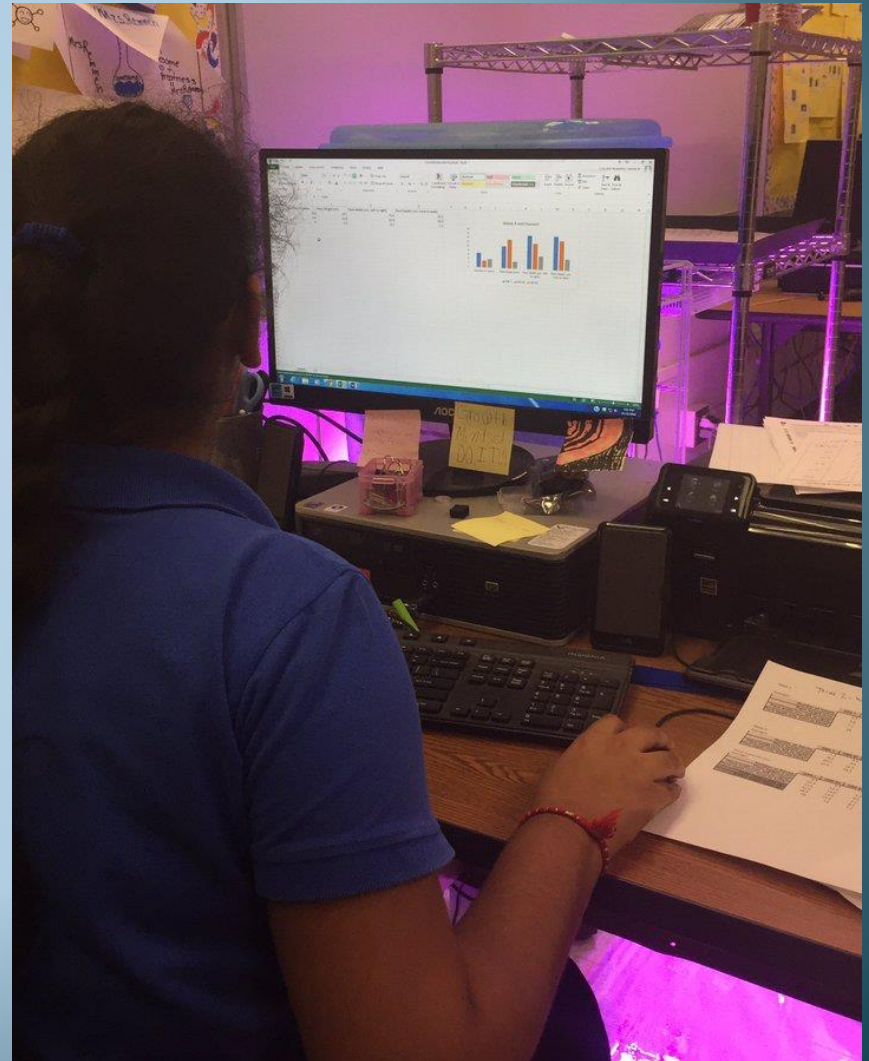
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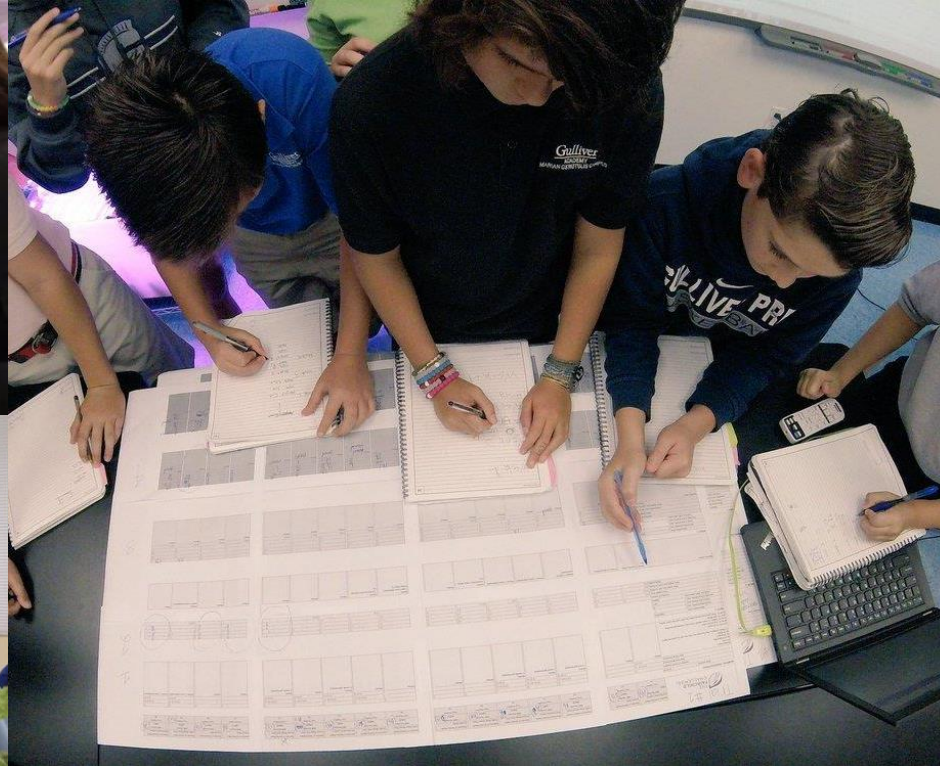
12:37 AM - 6 Nov 2016

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

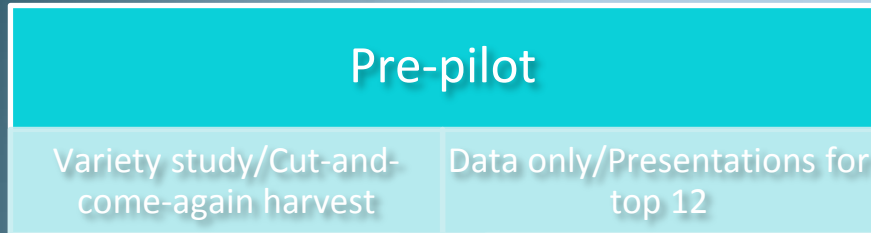
- Strengthen research skills
- Improve attitudes towards STEM
- Increase botany knowledge
- Experience meaningful collaboration
- Build leadership skills
- Increase girls confidence in succeeding in science coursework

Teachers

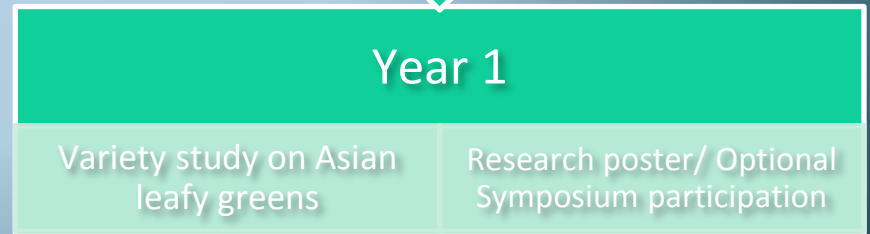
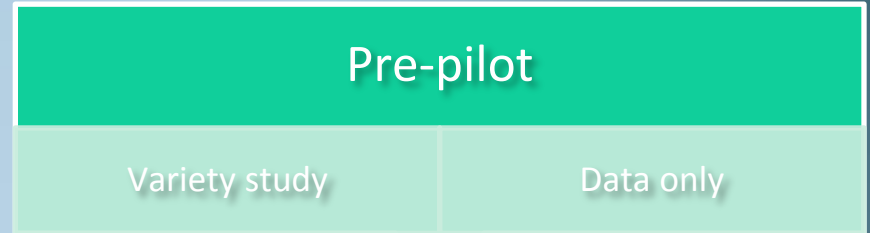
- GBE teachers provide unique experience to their students
- Strengthen their own research skills
- Strengthen their botany skills

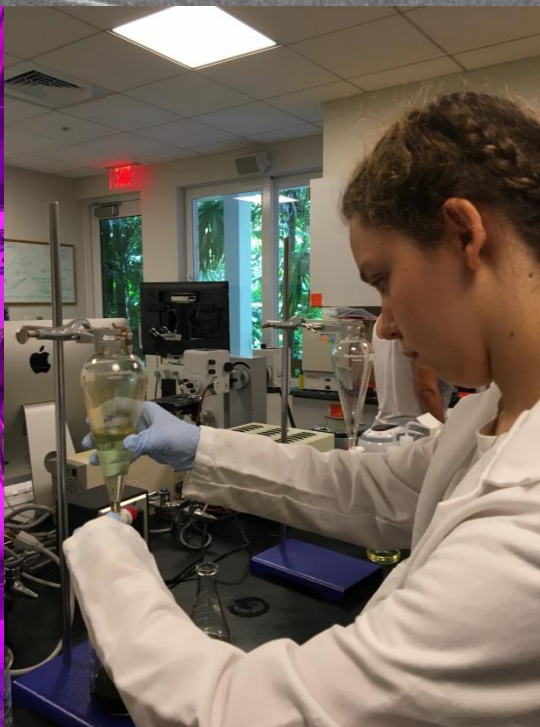
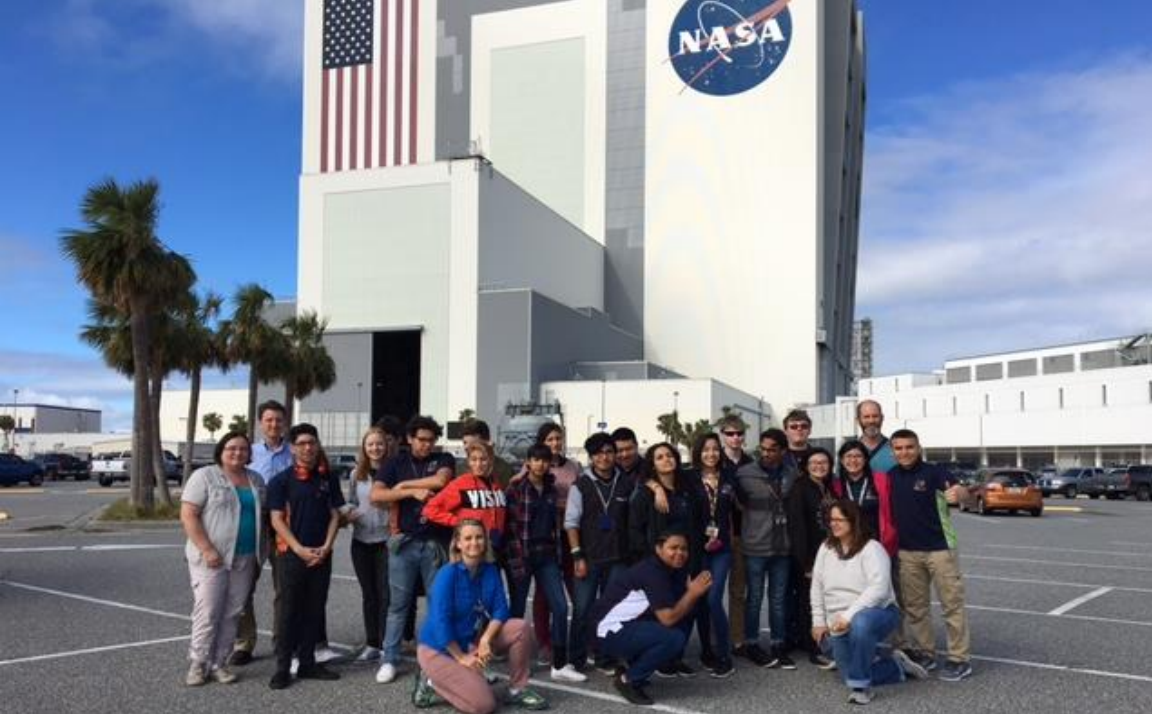
The First 3 Years (2015 -2018)

High School



Middle School

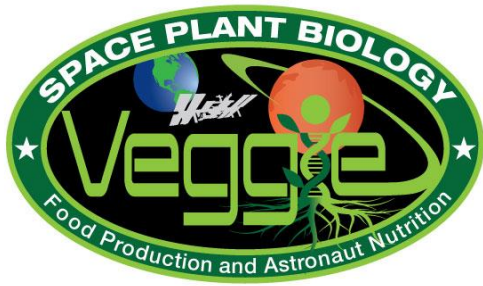




So far tested!

- 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.



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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