One Step Closer to Mars with Aquaponics

A novel approach to sustainable agriculture.

Introduction — 2016-17 — Science Fair — 2017-18 — Extensions

Acknowledgements

Angela Detweiler and Brad Bebout (NASA Ames) both performed and analyzed the MinION sequencing runs, with the help of Mike Lee (USC) Miten Jain and Hugh Olsen (UCSC)

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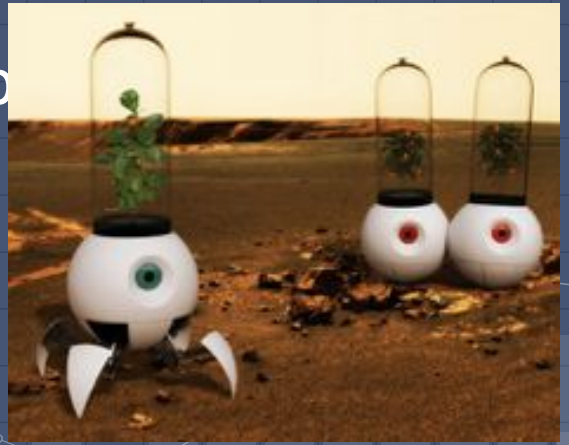
Meadow Park Students of 2016-2017 and SST students of 2017-2018

Ames Research Center

DonorsChoose.org

Why does NASA care?

- Food production is key to long term space travel
- Aquaponics can serve as a model for what could be used for long term space travel
- To develop the most efficient/most plant b system
- Large scale citizen science



Science in a Classroom Setting

- Over 55 middle school students
- More possible replication than in most labs in the same time frame
- Faster, and great data
- Citizen Science in our schools
- Follows Curriculum for students
- Unique Experience and Exposure for Students

Aquaponics 1.0

2016-2017

Introduction

2016-17

Science Fair

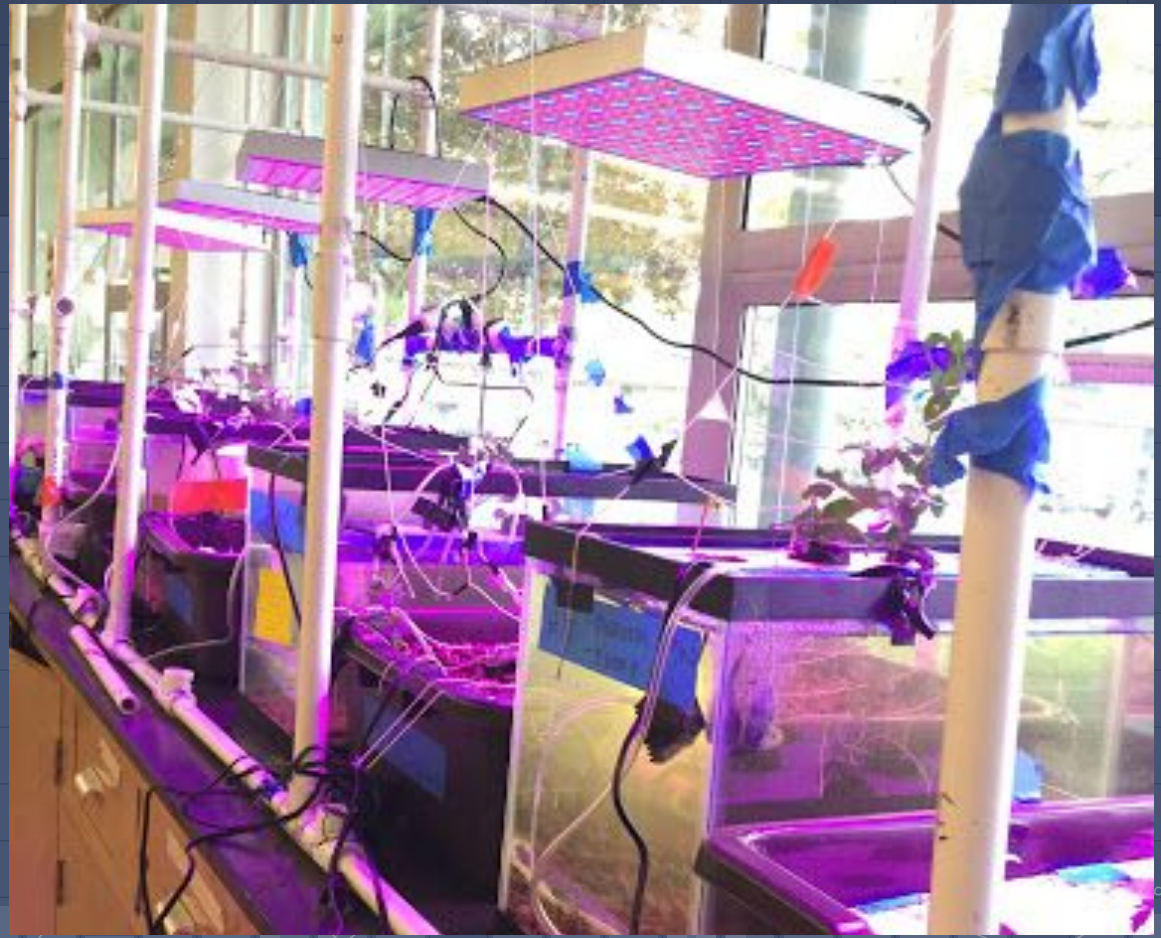
2017-18

Extensions

From the ground up, we engineered, maintained and analyzed 10 aquaponics systems.

- We engineered 10 different small scale aquaponic system
- We received funding from NASA, and funded the rest on our own
- Each system experimented with different variables
- We performed daily tasks
- We Analyzed and concluded our data
- Sent our genomics data to NASA, and ongoing analysis

2016-17



2016-17

Research Question

How do we create the most efficient aquaponics system with microbes that promote stable plant and fish growth with steady nutrient cycles?

2016-17

Variables and Hypothesis

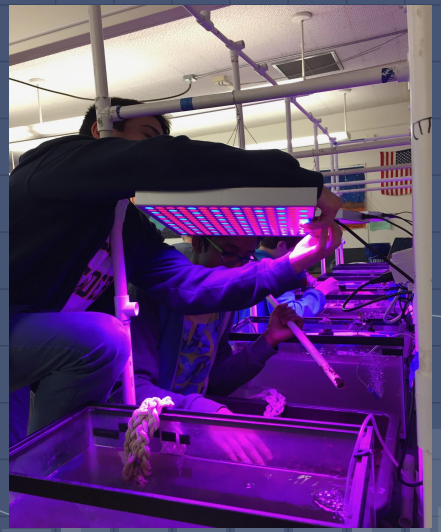
- Compared plant growth rate to many other variables
- IV: Plants, lighting, water circulation,
- DV: Plant growth (height, leaves)
- Constants: fish and water.
- Hypothesis: The addition of the EM-1 inoculant will lead to an increase in plant growth due to plant growth promoting bacteria.

2016-17

Original Experimental Setup

Three major structures:

- 10 gallon fish tank
  - Fancy and Comet Goldfish
  - Positive control plant group
- Plant bed
  - Experimental Plant Group
  - Media (three treatments)
- Light
- PVC pipe structure



2016-17

Original Experimental Procedure

- Floating bed construction
- Masking tape
- Basil, Tomatoes, Peas
- Daily: Nitrate, Nitrite, Ammonia, pH measurements, conditioning changes

2016-17

NASA used a MinION Sequencer to find genus

- Sent NASA water samples from tanks. 10 tanks and 3 time points
- Performed PCR in preparation

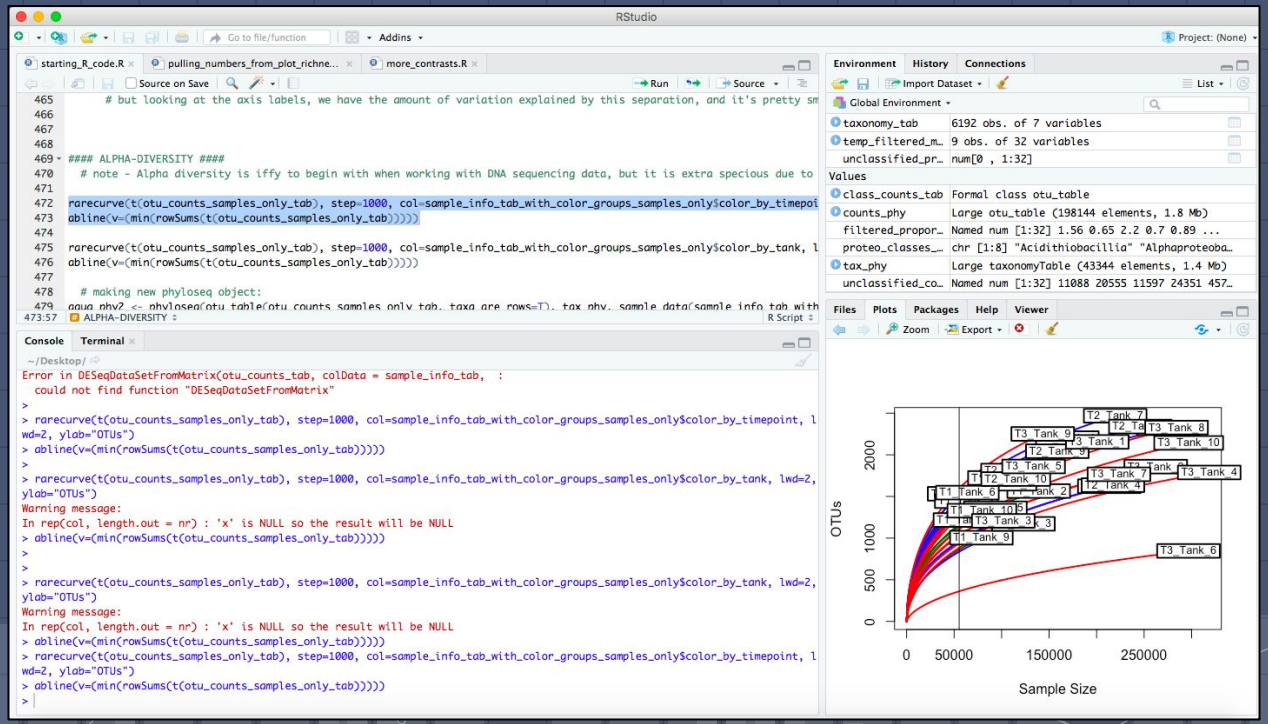
  for MinION

2016-17

Science Fair

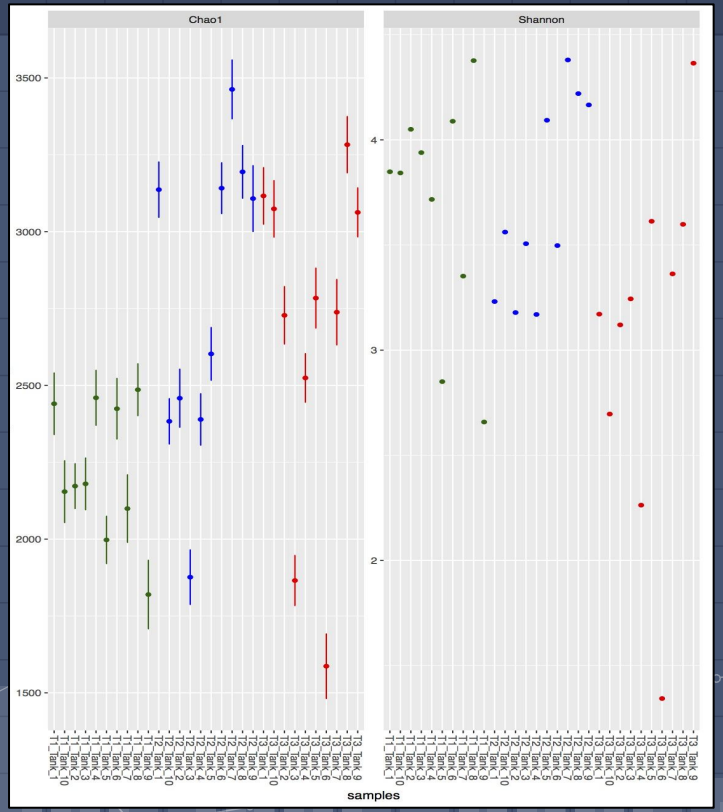
2017-18

Used R to processes large amounts of data

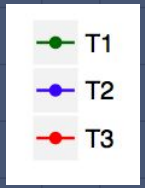


Science Fair

Data Analysis: Microbe Diversity



Biodiversity across at the family level using Shannon and Chao1

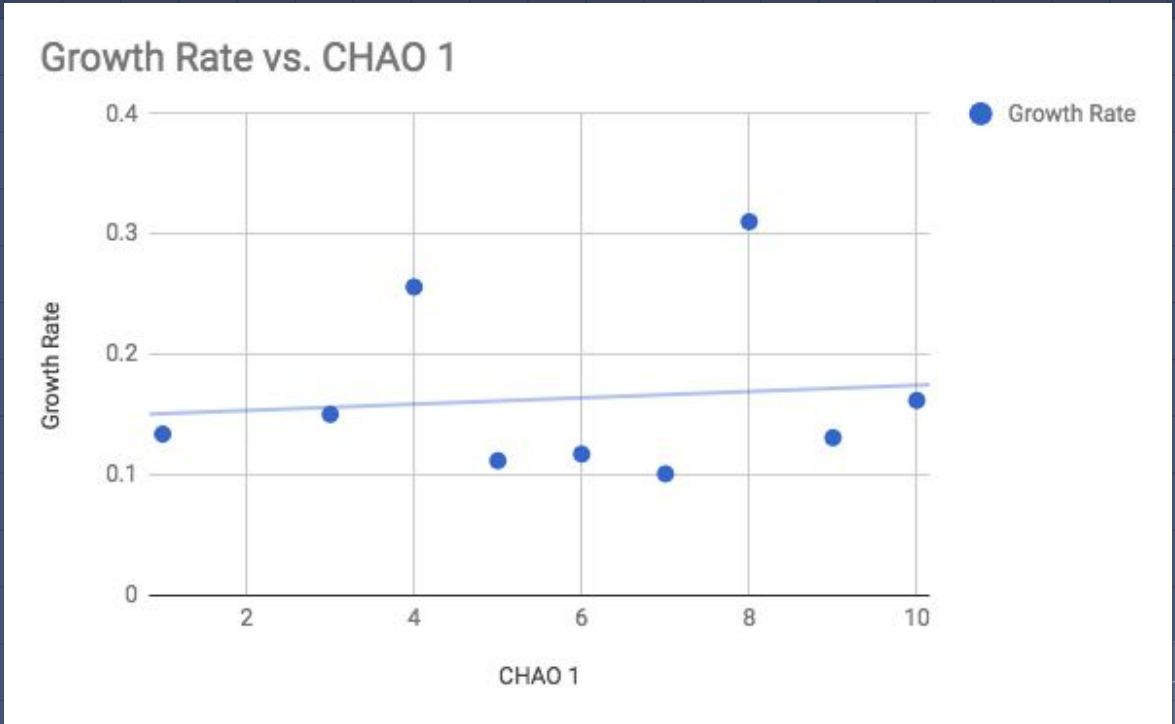


Science Fair

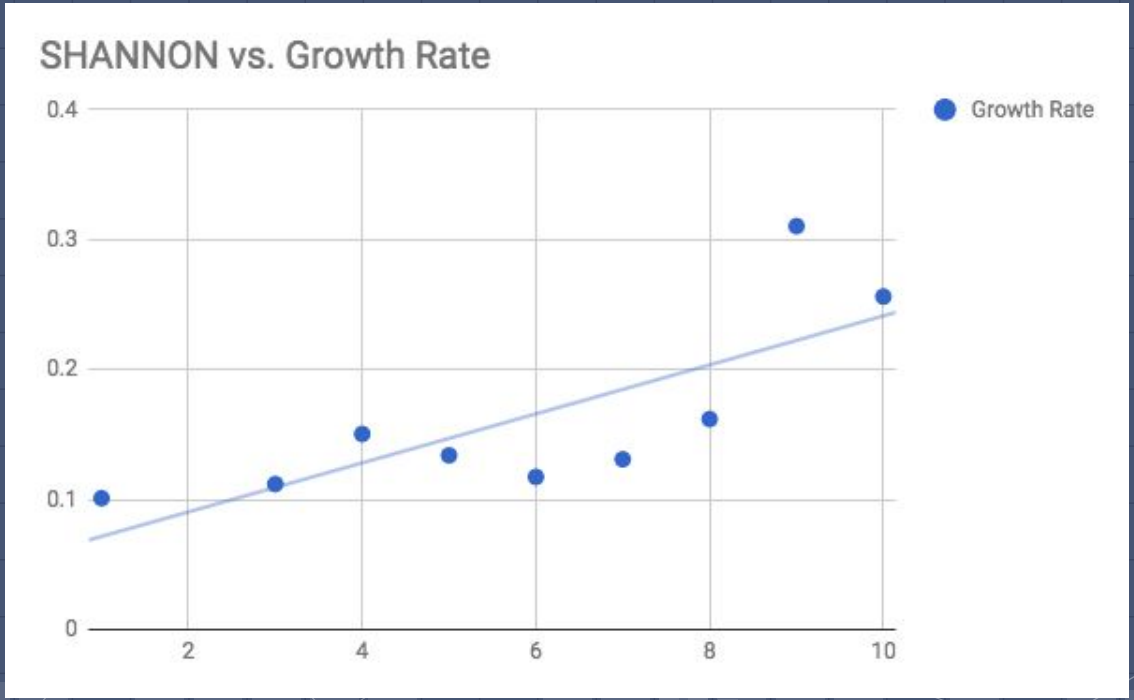
Data Analysis: Plant Growth

The following graphs exclude one tank because it was an extreme outlier that was skewing the data.

There is a slight positive correlation between growth rate and Chao 1 index values.



There is a positive correlation between growth rate and Shannon index values.



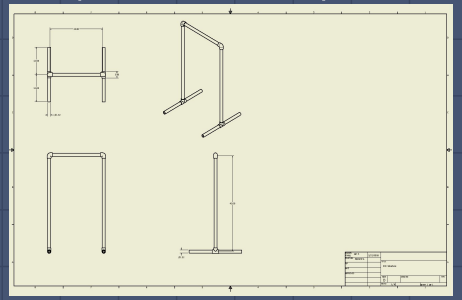
Conclusions and Future Extensions

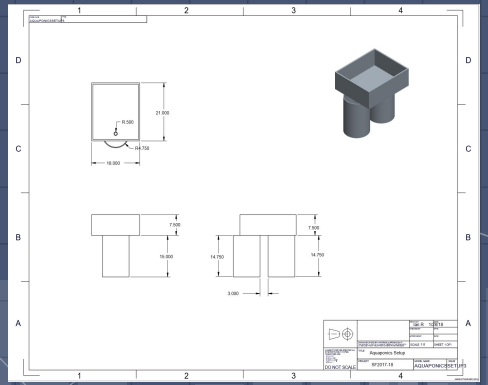
- What have we learned from this experiment?
- What will we learn in future experiments?

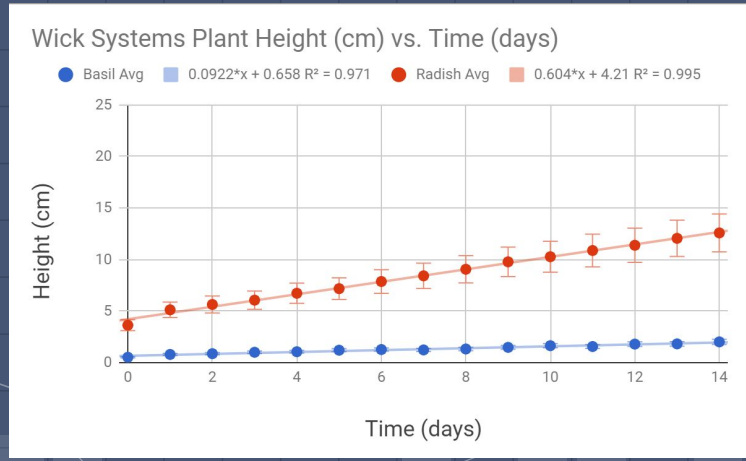
Science Fair: Optimizing Efficiency

- Each system has energy inputs and outputs
  - **Inputs:** Light, Nutrients, Water Cycling
  - **Outputs:** Fish and plant matter
- How to maximize system efficiency?
- Why is this an imminently needed question?
  - Growing **competition** in the aquaponics market will make energy a more important factor in profits
  - Limited resources in space travel

Setup: Building Hydroponic Systems, Analyzing Data



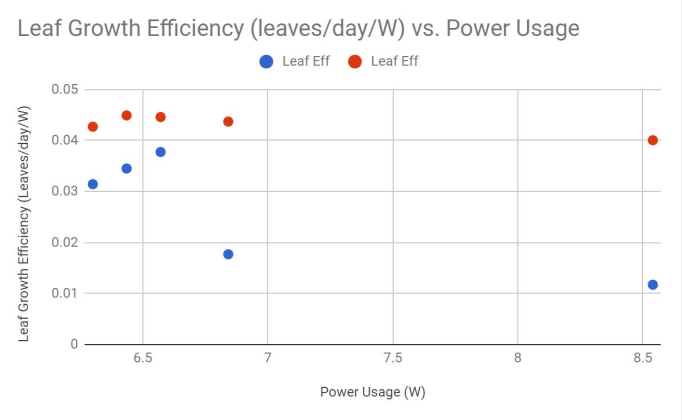


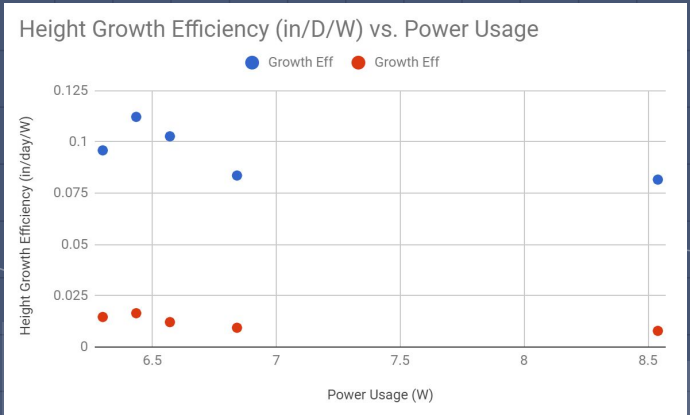


Science Fair

Data showed an efficiency peak

System	Wavelength (nm)
WICK	428.6
S2	422.8
S1	427.4
S3	428.9
S4	431.3





Conclusions and Future Extensions

- Extensions
  - Collecting more data to increase confidence in the notion that there's a peak
  - Growth yield vs. amount of wicking material
- Conclusion
  - A peak efficiency can be reached in aquaponic systems, but must be pinpointed through experimentation.

Aquaponics 2.0

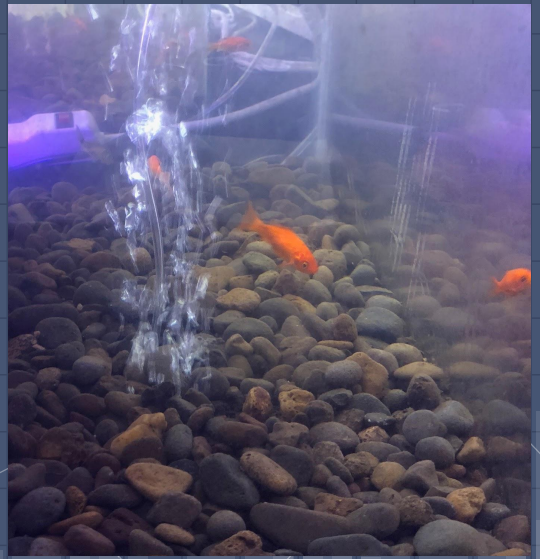
2017-2018

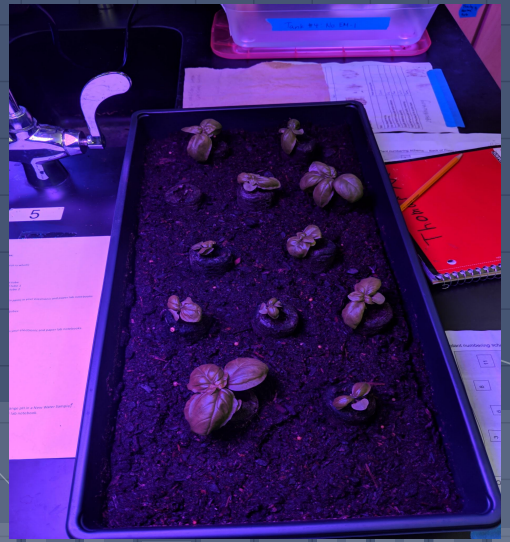
Introduction 2016-17 Science Fair 2017-18 Extensions

What changed?

This year's system:

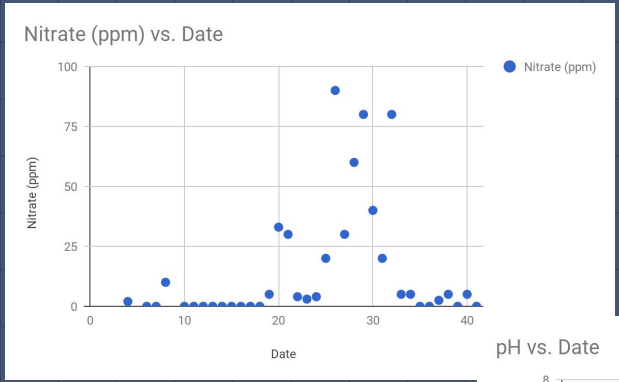
- EM1 (plant growth promoting bacteria) vs no EM1

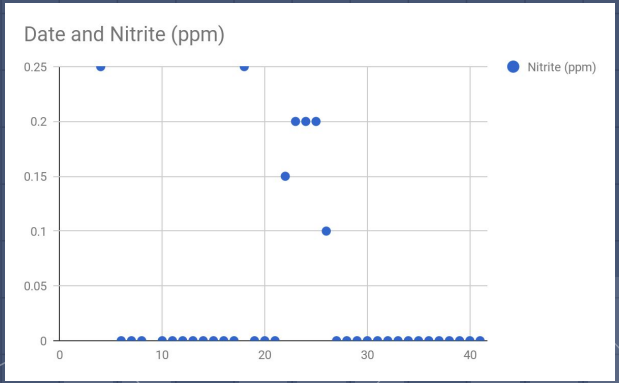


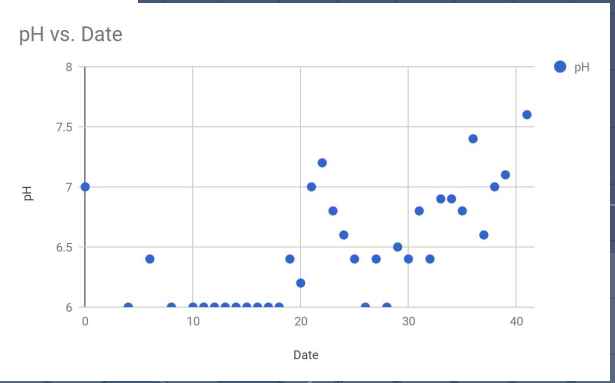


2017-18

Results: Tank 1: Ammonia, Nitrate, Nitrite, pH

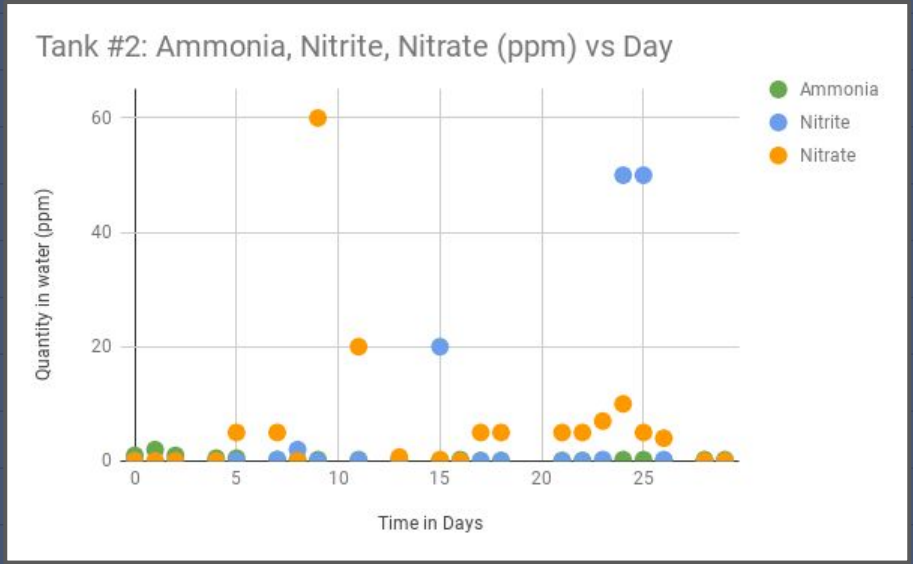


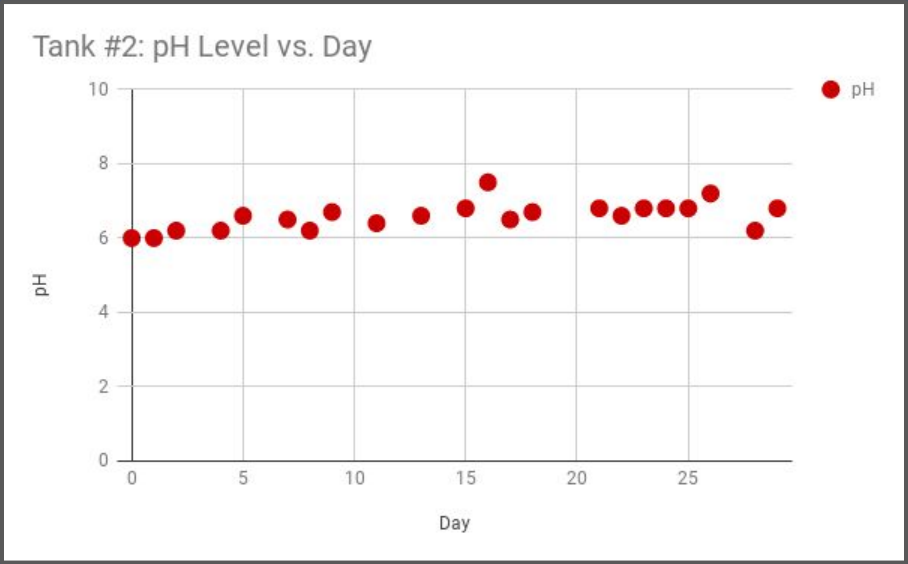




2017-18

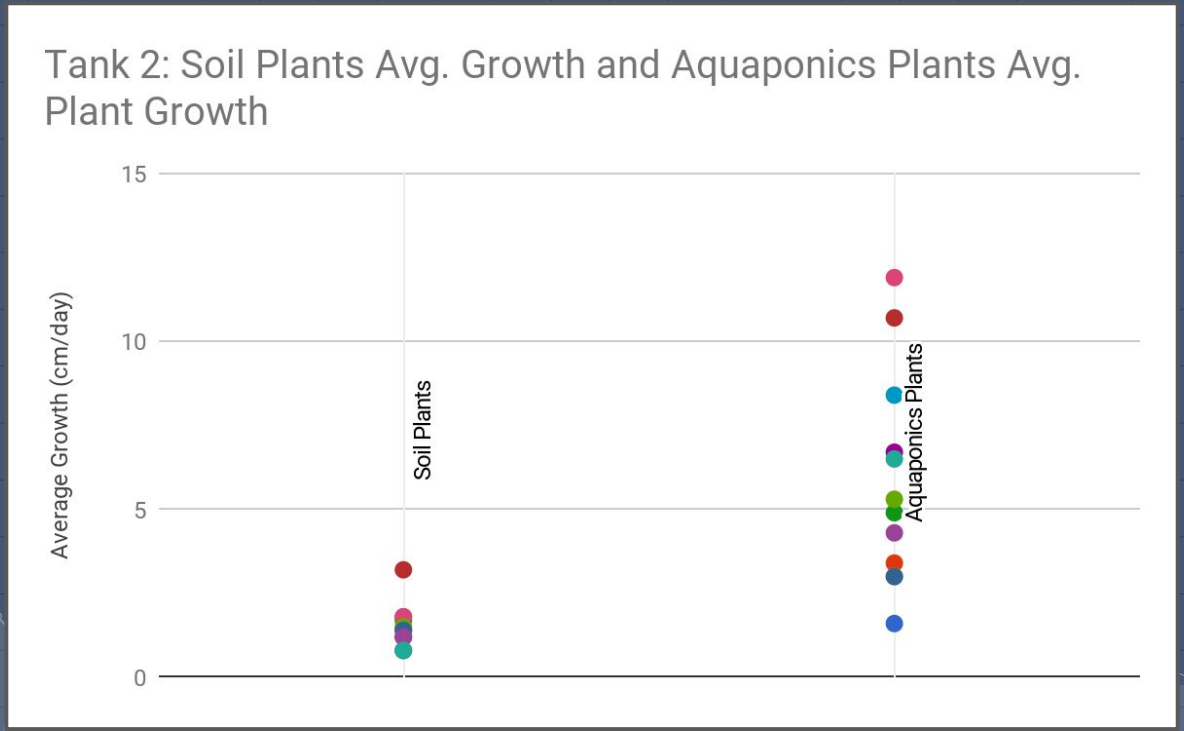
Results: Tank 2: Ammonia, Nitrite, Nitrate, pH





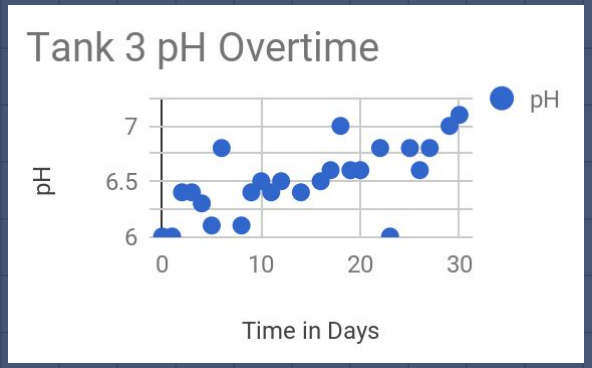
2017-18

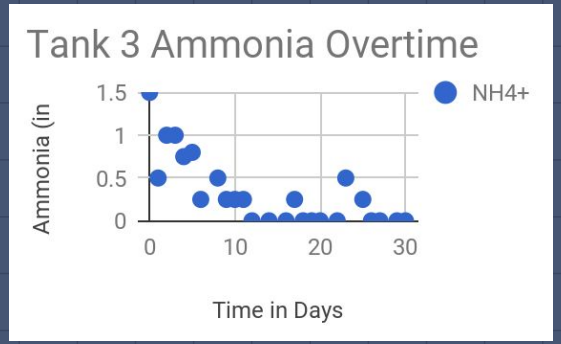
Results: Tank 2: Plant Growth Avg.

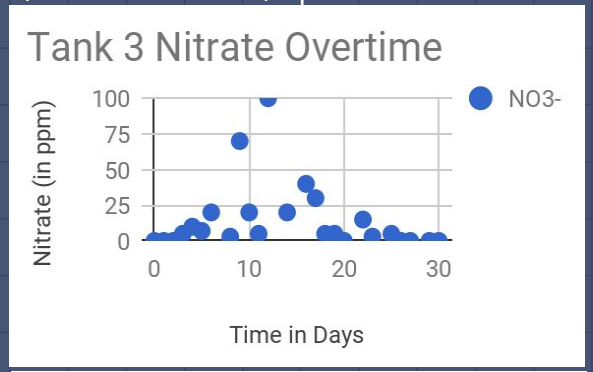


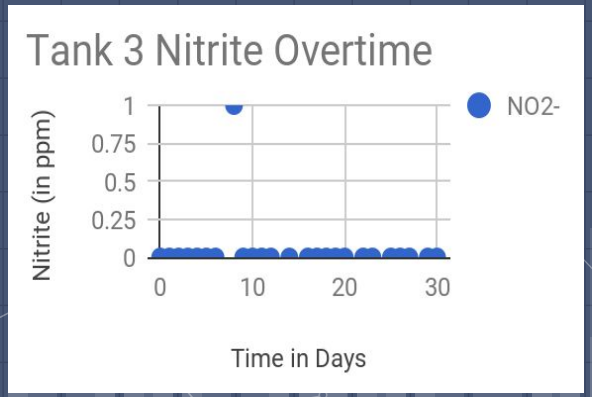
2017-18

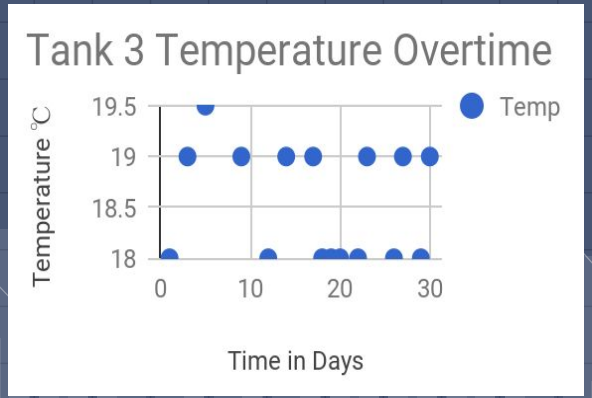
Results: Tank 3: Ammonia, Nitrate, Nitrite, pH

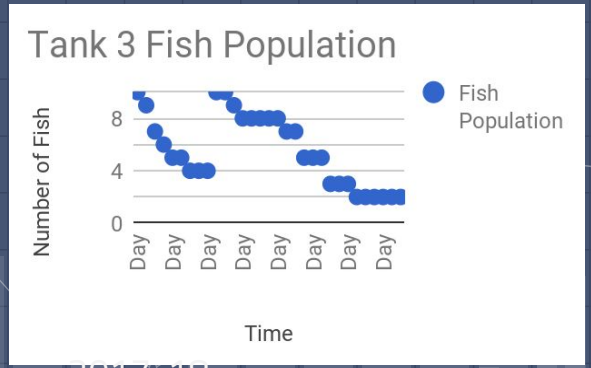






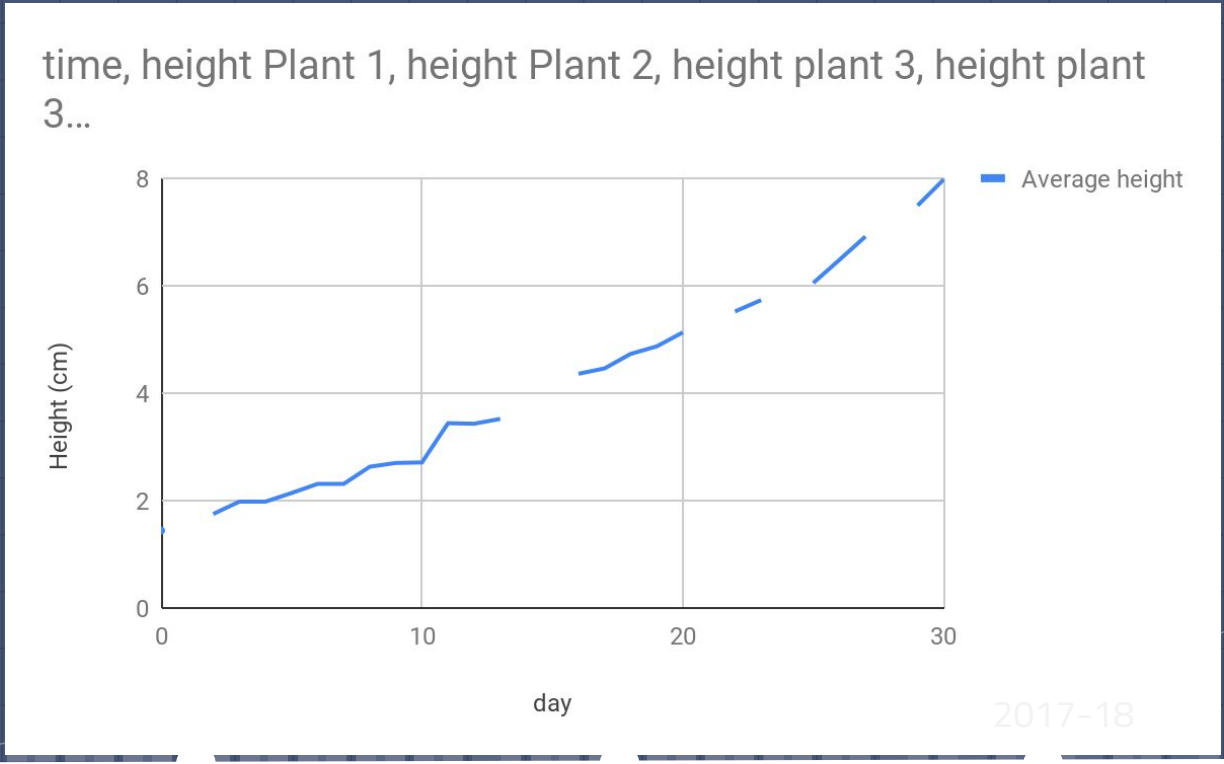




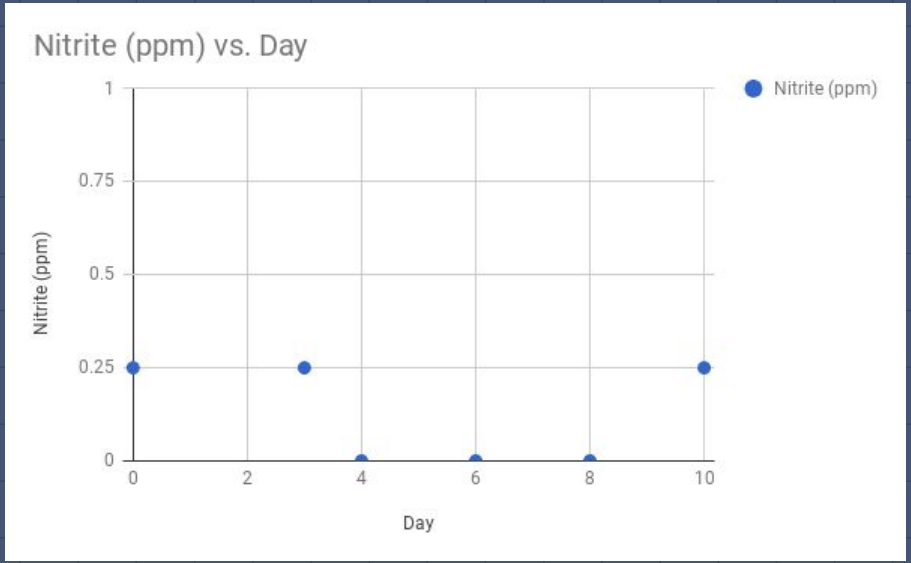


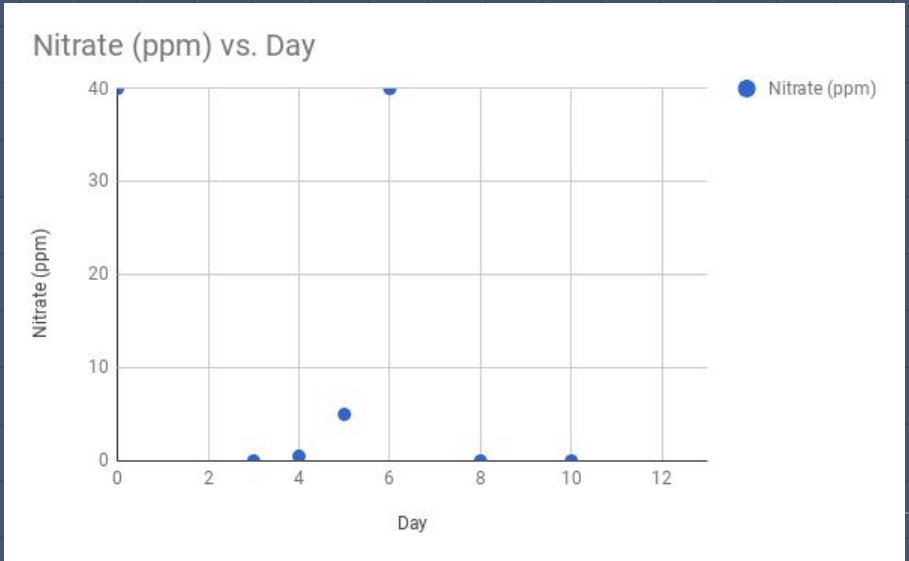
2017-18

Results: Tank 3: Plant Growth Avg.



Results: Tank 4: Nitrate and Nitrite





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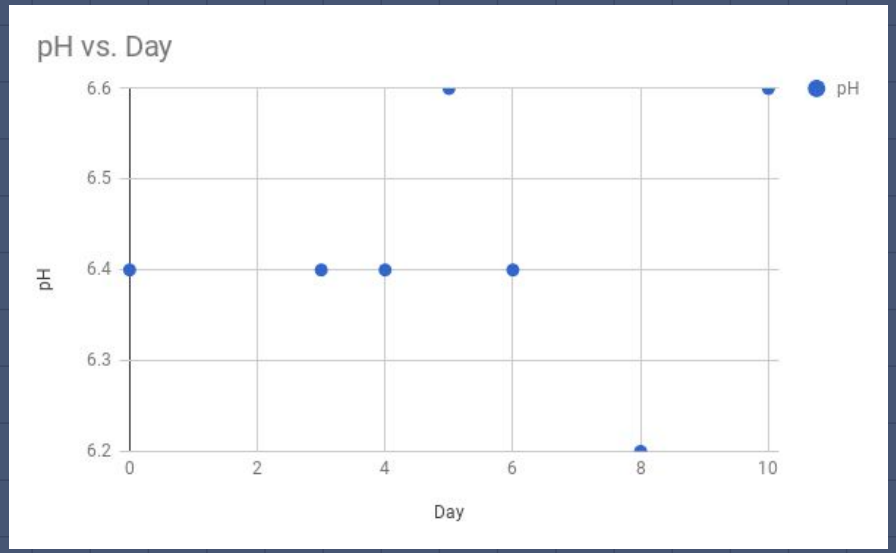
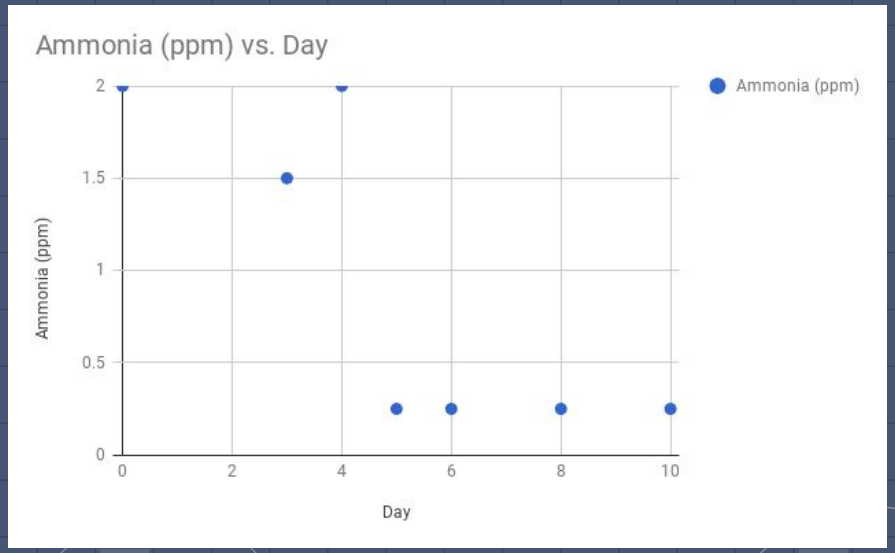
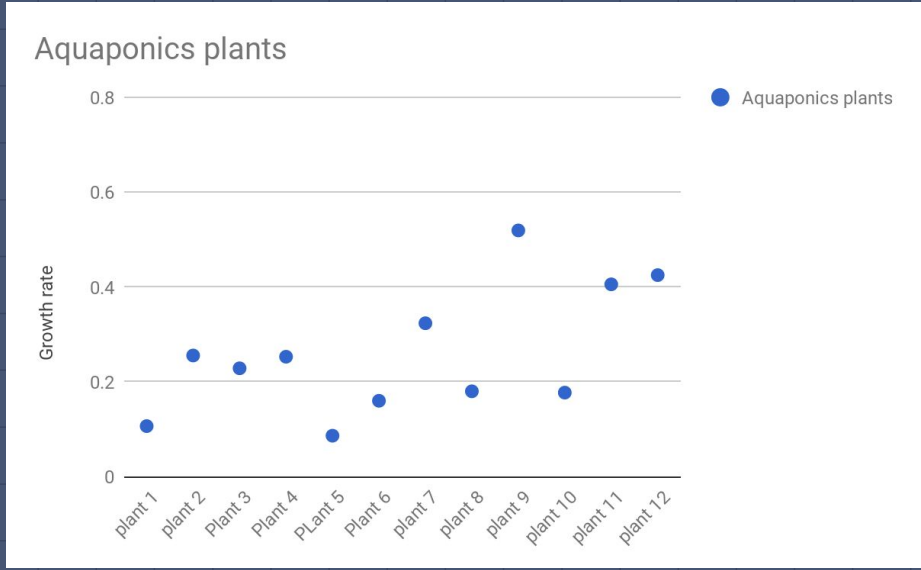
Results: Tank 4: Ammonia and pH

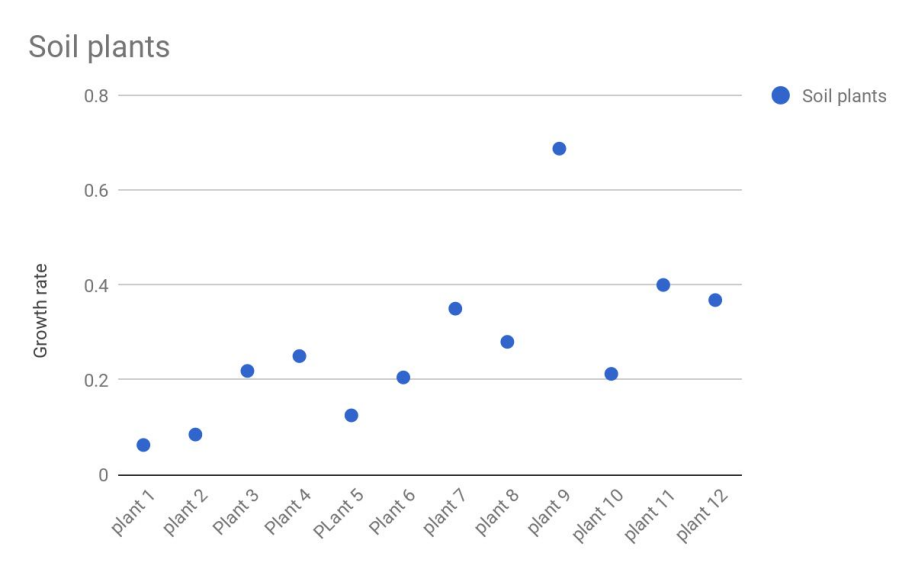




2017-18

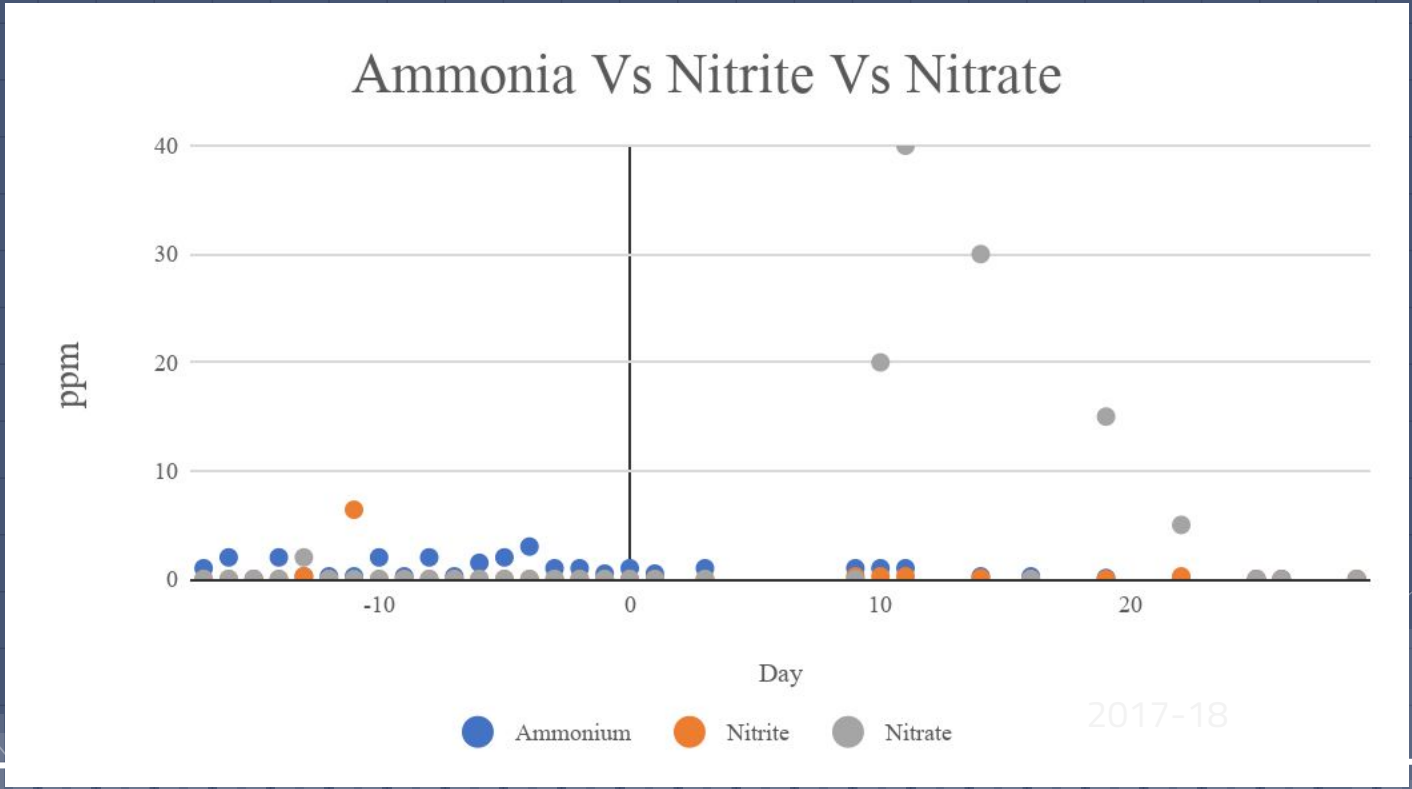
Results: Tank 4: Plant Growth Avg.





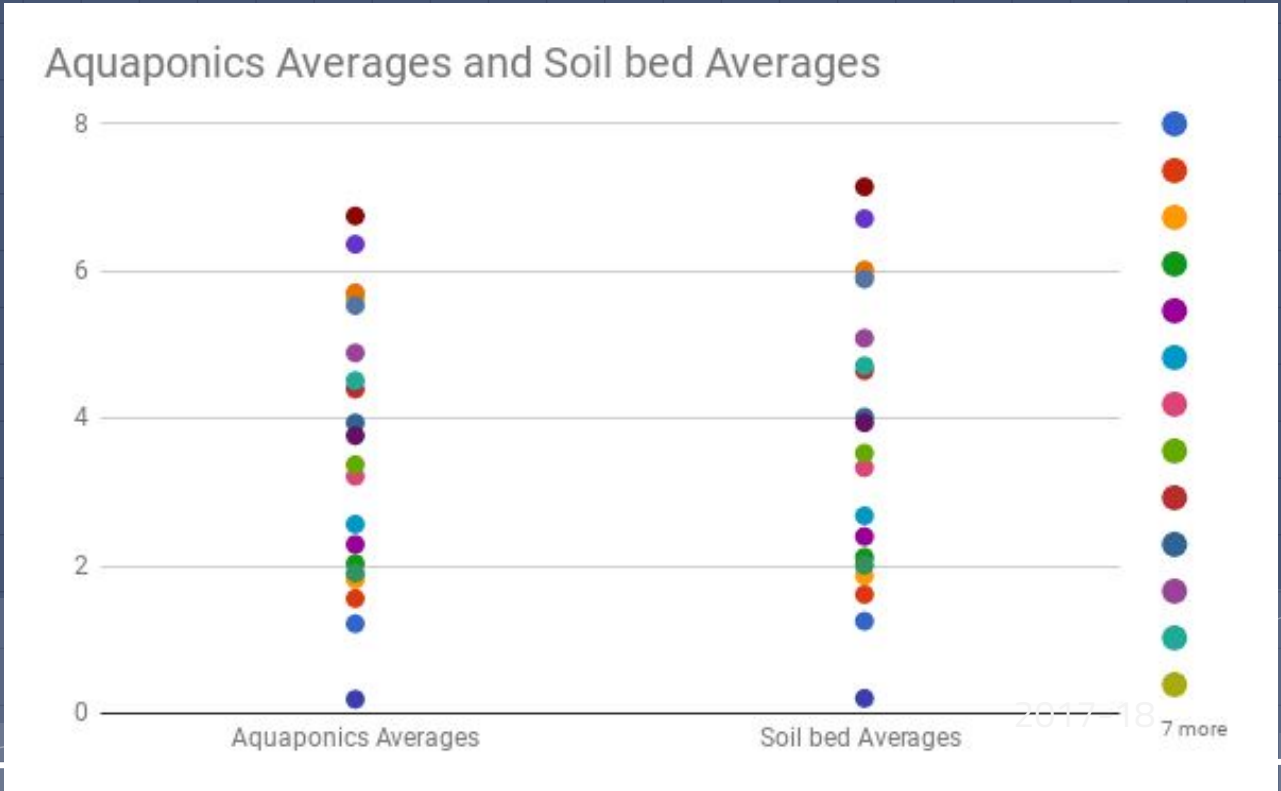
2017-18

Results: Tank 5: Ammonia, Nitrite, Nitrate

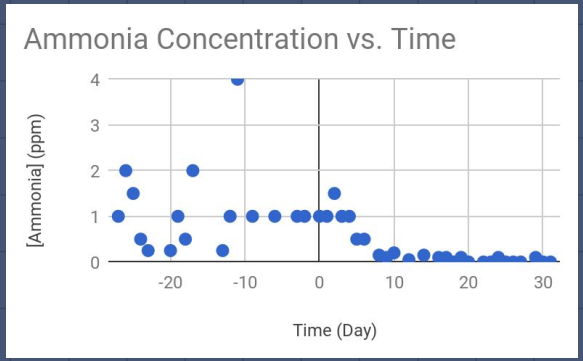


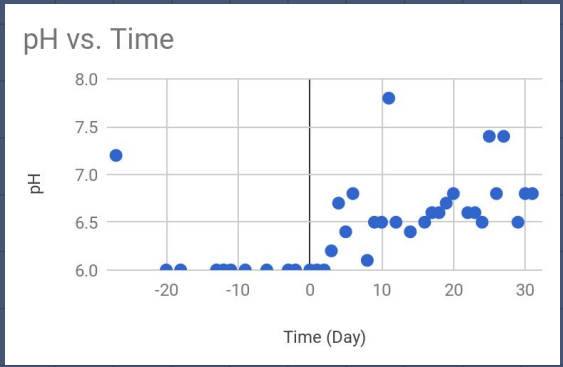
2017-18

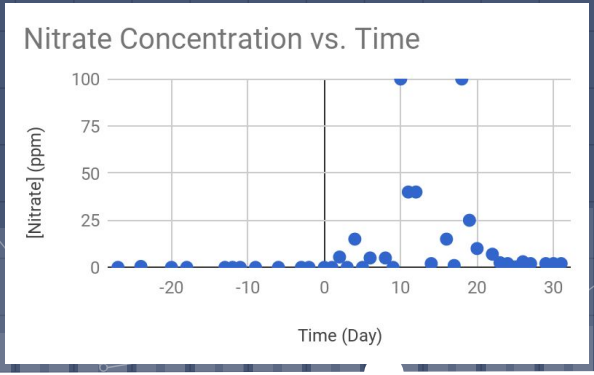
Results: Tank 5: Plant Growth Avg.

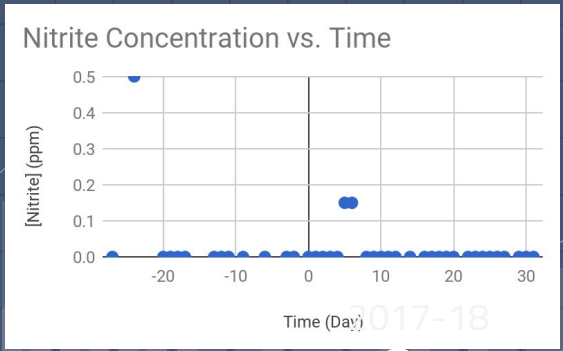


Results: Tank 6: Ammonia, Nitrate, Nitrite, pH

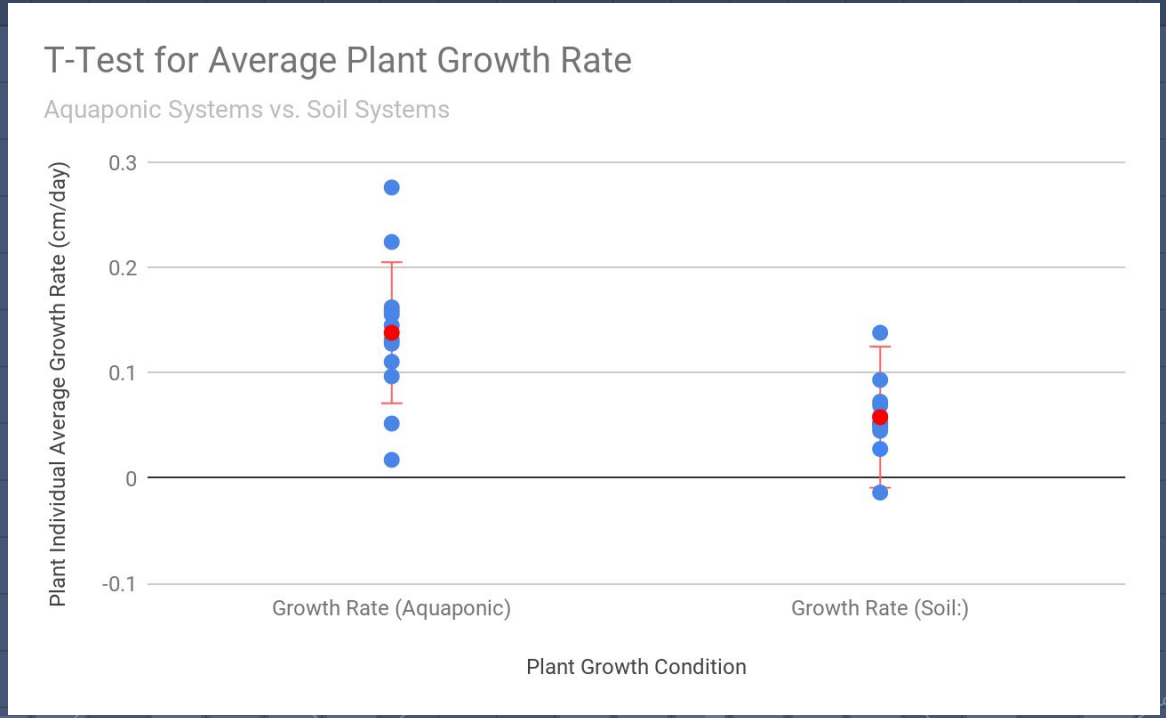






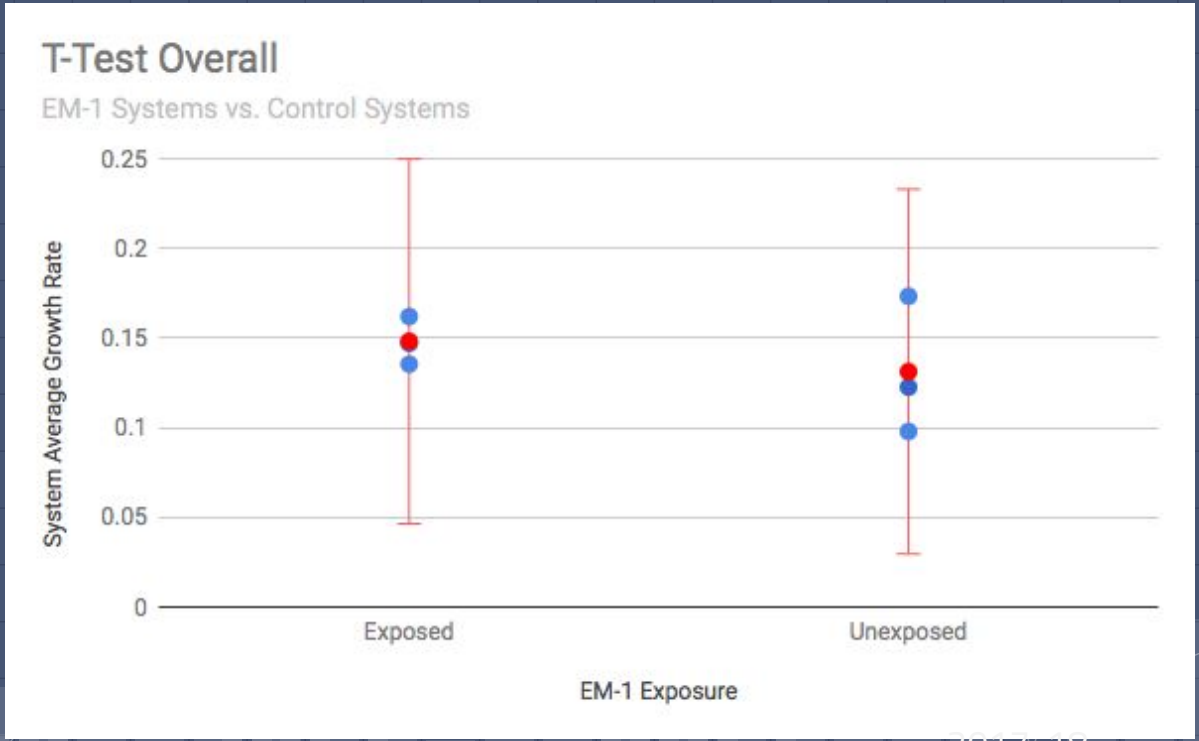


The growth rate of the aquaponics beds were bigger than the growth rate of the controlled plants in the soil beds



2017-18

The addition of EM-1 Plant Growth Promoting Bacteria had no impact on the average rate of plant growth



Future Questions

- What is the effect of basil on nitrate levels compared to other plants?
- What is the effect of feeder goldfish on nitrate levels compared to other fish?
- Does the temperature of the tank water affect the biochemical cycle?
- How will sample size effect significance tests on Em1 and no Em1?
- What is the significance tests results on temp, nitrate, and nitrite?

2017-18

Now what?

Introduction 2016-17 Science Fair 2017-18 Extensions

What will we accomplish in the near future?

- Continue setting up aquaponics tanks.
- We are also planning to publish a paper!

Spreading Aquaponics to Other Classrooms

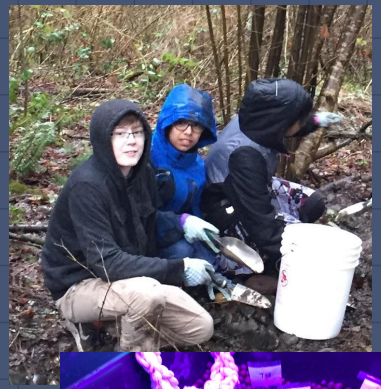
- Aquaponics changed the way we viewed science.
- We want to spread that experience!
- We have many ideas for spreading classroom aquaponics:
  - Making a class plan for this experiment.
  - Find ways to fund such experiments for other teachers.

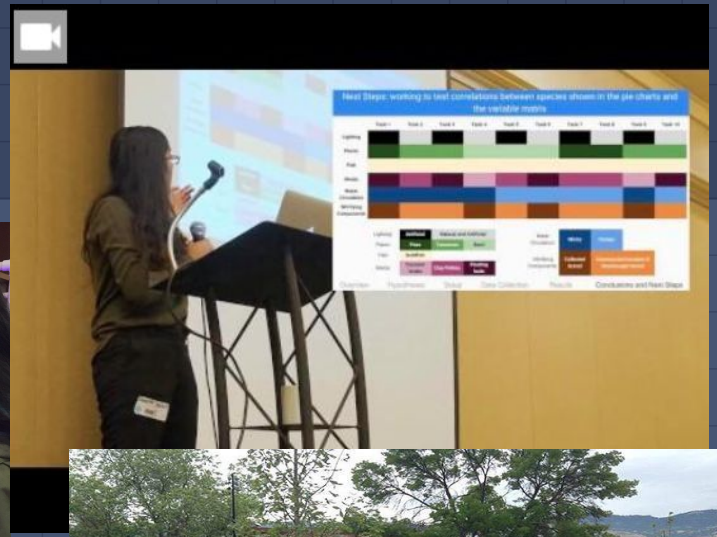
Diversifying Aquaponics Beyond the Classroom

- Aquaponics greenhouse (CSA).
- Bigger systems help us expand our knowledge much quicker.
- Give back to the community; food bank type organization.
- Fund the project so we can invest in better analytic tools.

COMMUNITY SUPPORTED AGRICULTURE

Questions?





Introduction 2016-17 Science Fair 2017-18 Extensions