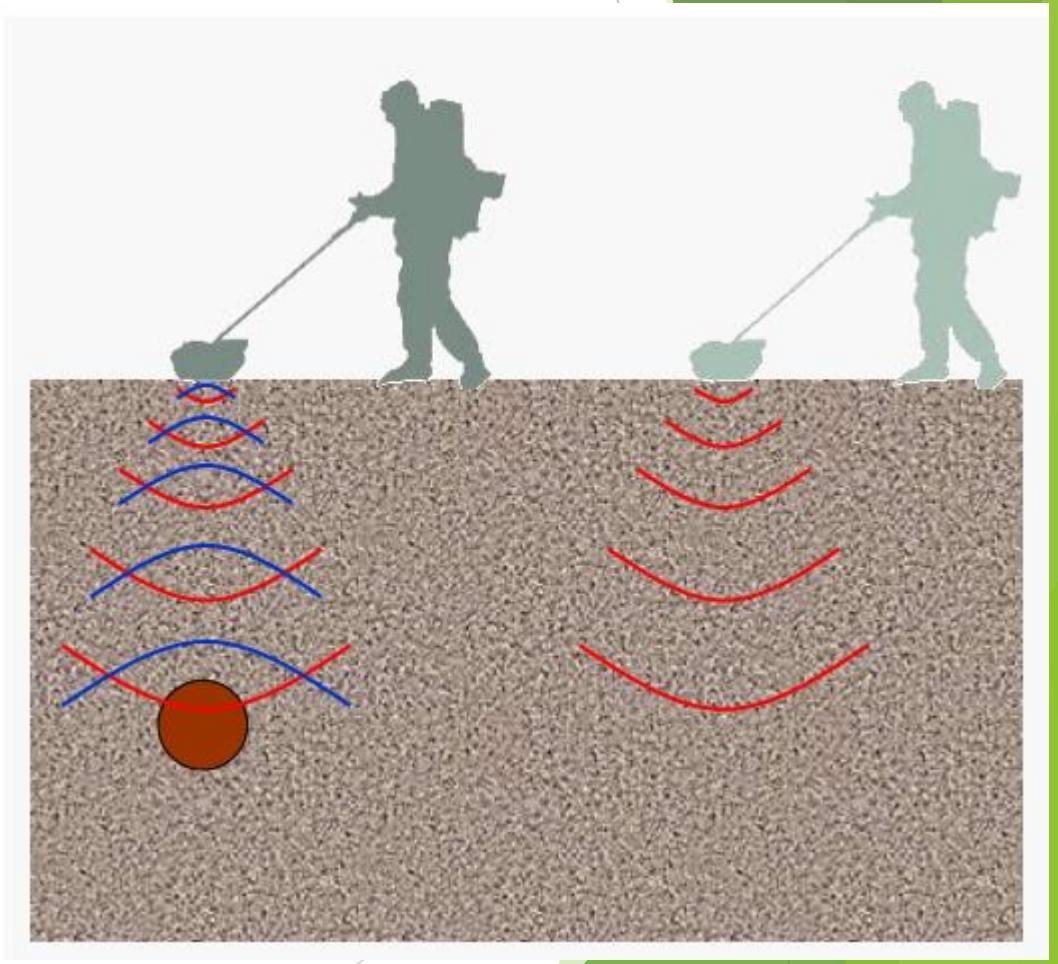
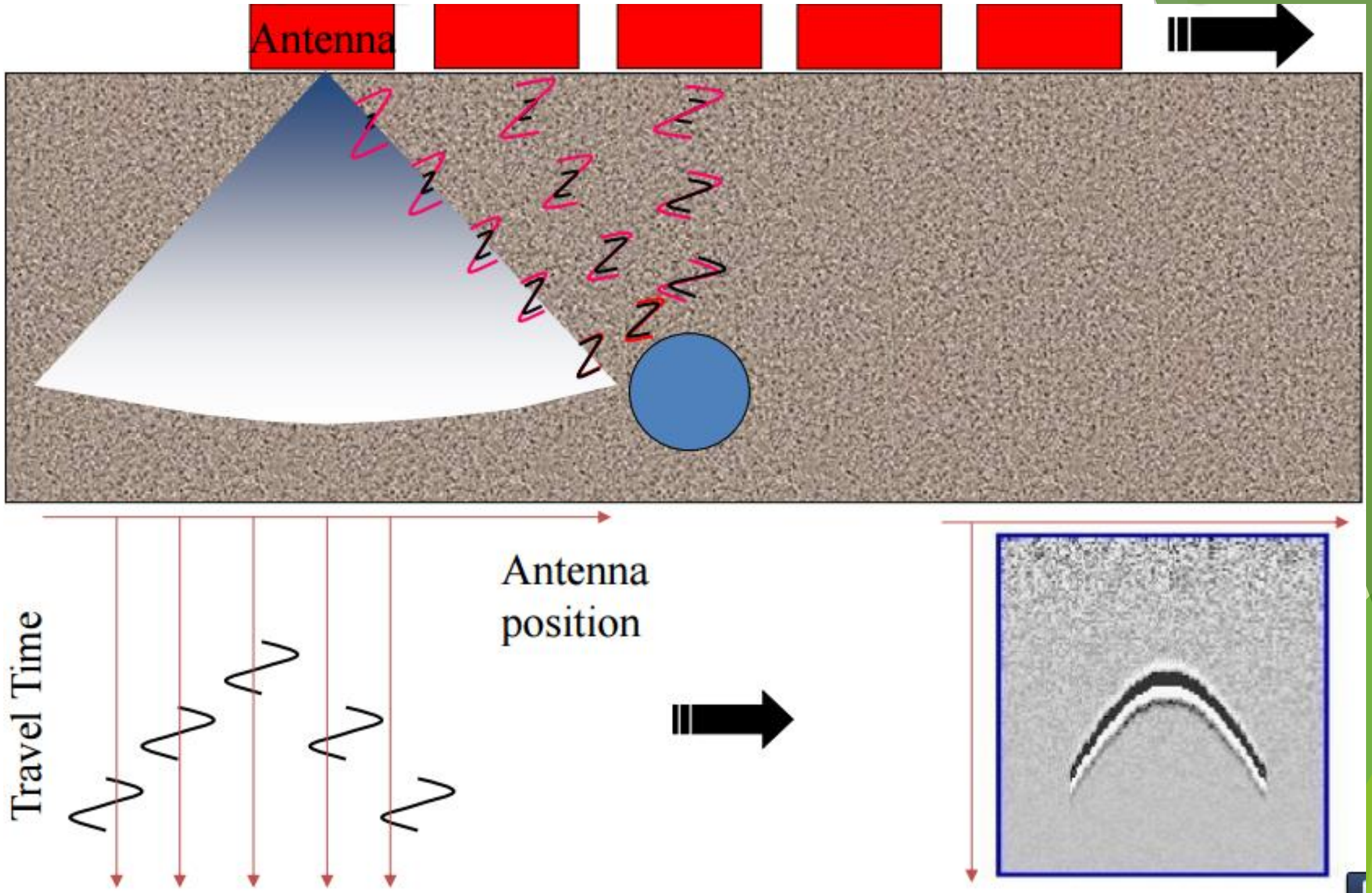
Application of ground penetrating radar: A case study for estimating root bulking rate in cassava (*Manihot esculenta* Crantz)

Alfredo Delgado, Dirk B. Hays, Hernán Ceballos, Alexandre Novo, Enrico Boi, Michael Gomez Selvaraj

Ground Penetrating Radar

- GPR transmits pulses of EM energy from a transmitting antenna
- Energy reflected by discontinuities is captured by a receiving antenna
- Information is captured as amplitude response at a given travel time




Antenna
Antenna position
Travel Time

Previous Works

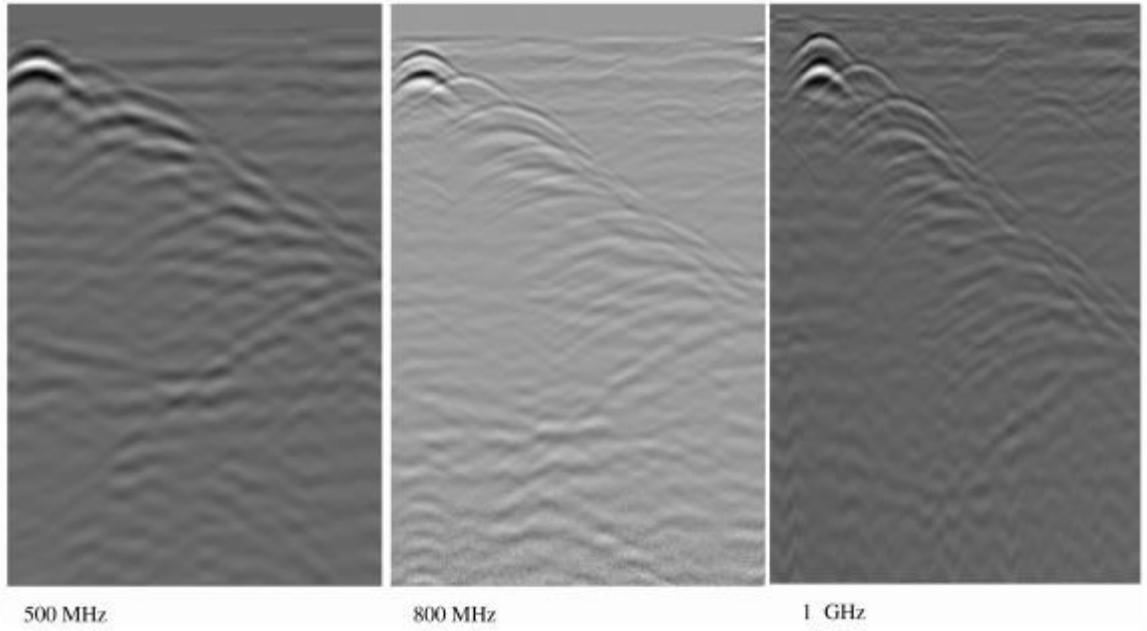
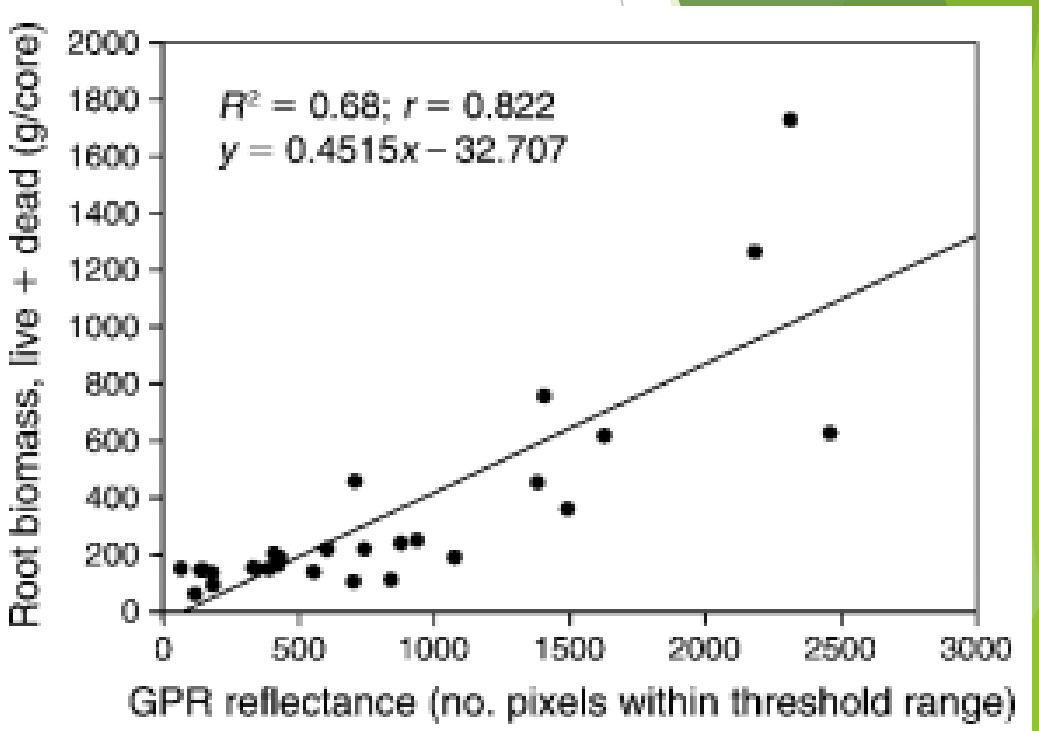


Figure 3. Radar profiles from three antennas (500 MHz, 800 MHz, 1 GHz) along a transect across the center of eight roots of similar size (5 cm diameter) buried in the sand pit at depths of 15–155 cm.



Detection of tree roots and determination of root diameters by ground penetrating radar under optimal conditions[†]

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EFFECT OF ELEVATED CO_2 ON COARSE-ROOT BIOMASS IN FLORIDA SCRUB DETECTED BY GROUND-PENETRATING RADAR

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GPR Potential in Roots and Tubers

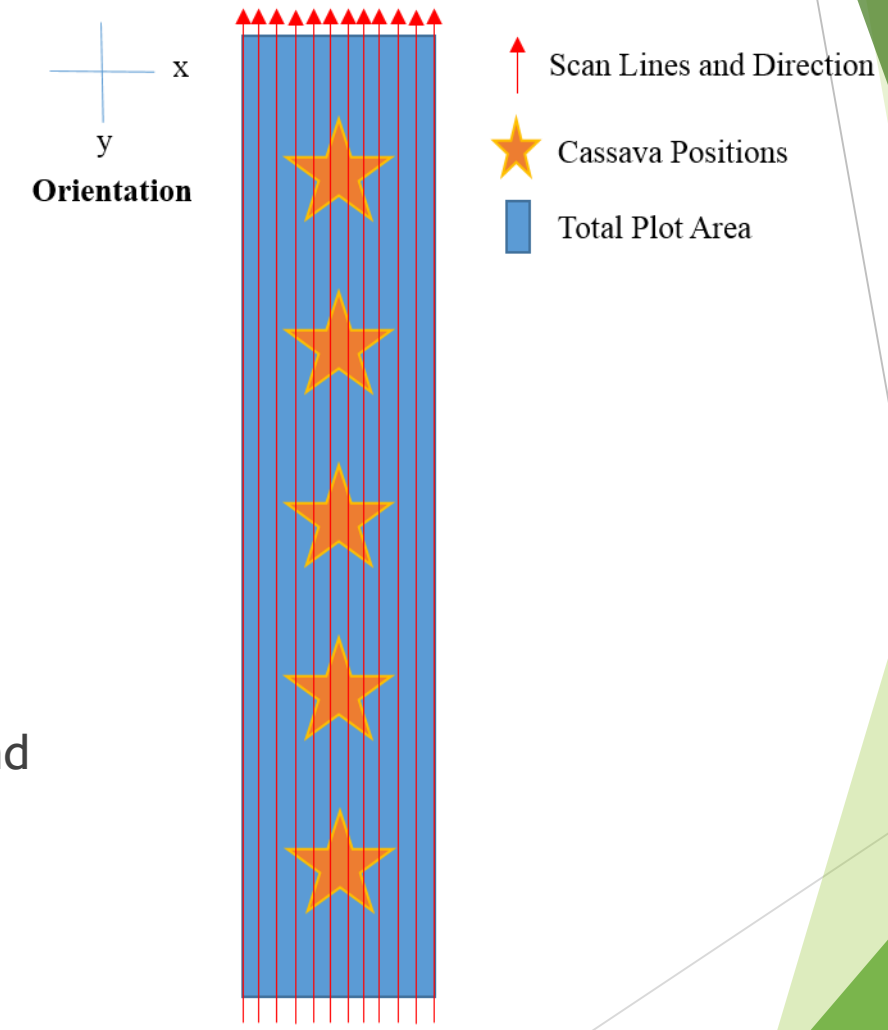
- Genetic Improvement
  - Non-destructive Phenotyping
  - Marker Assisted Selection

Research Question

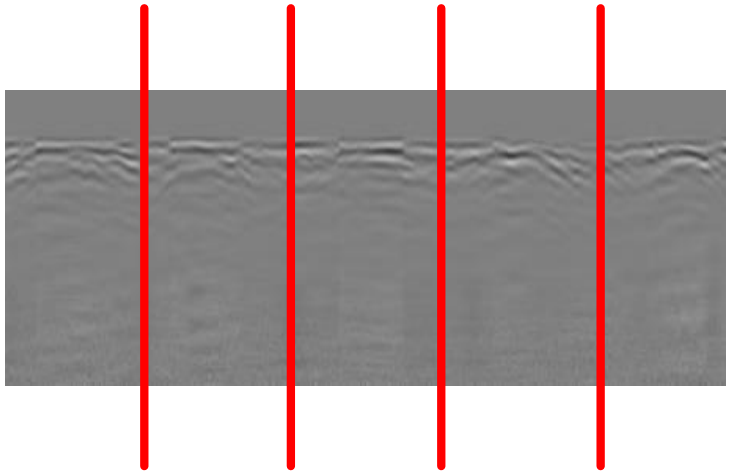
- Can early bulking in cassava be detected utilizing Ground penetrating Radar?

Trial Design

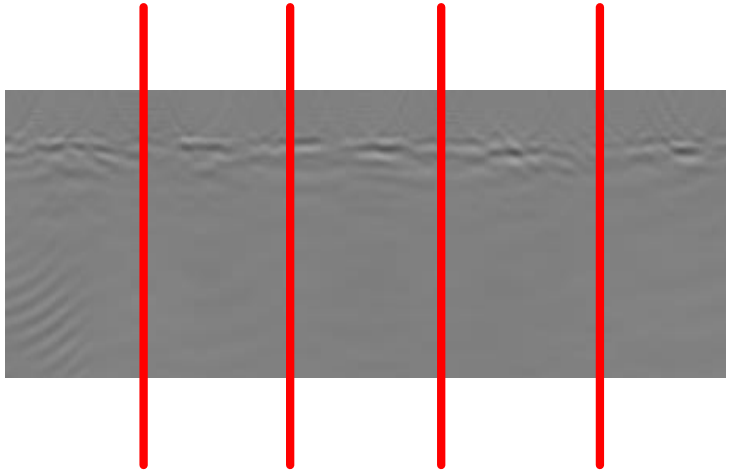
- 3 Varieties of Cassava
- 4 planting dates
  - 5 plants per planting date
- Data capture at 5 cm intervals
- Plants harvested and weighed (fresh weight and dry weight)



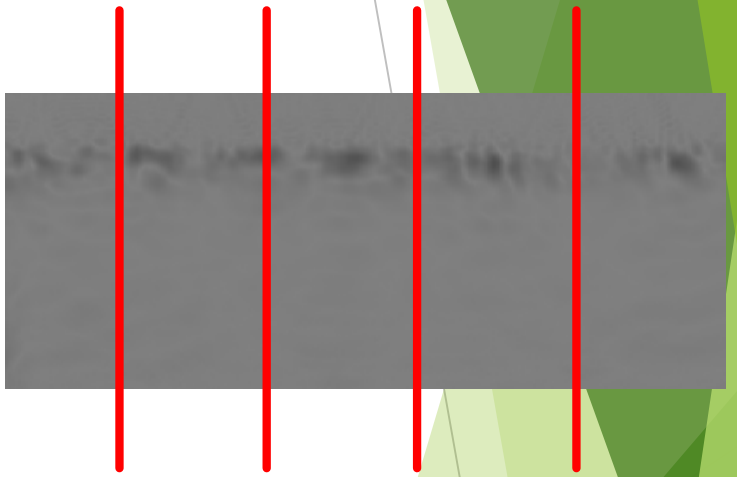
Data Pre-Processing



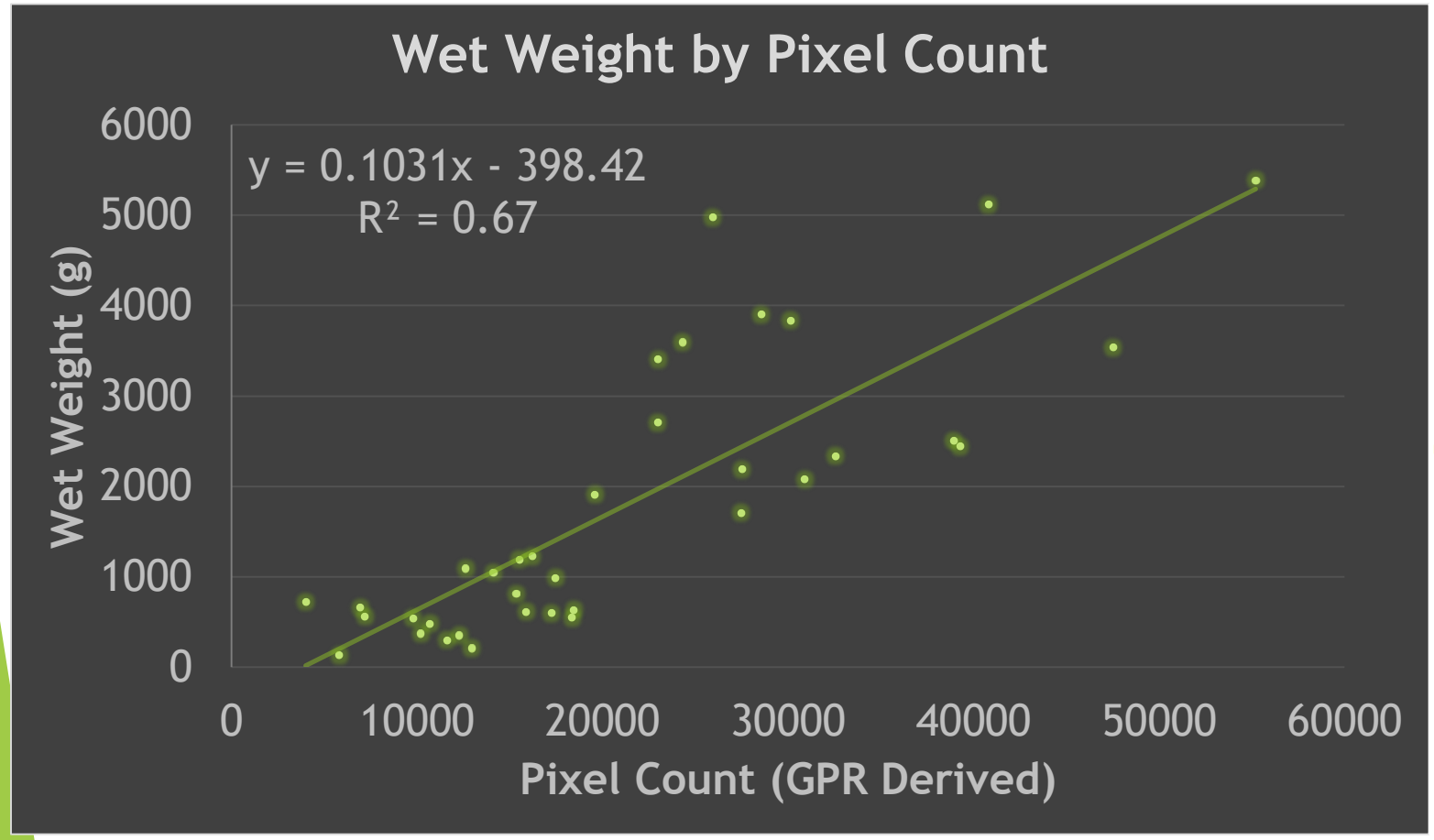
Filtered Data

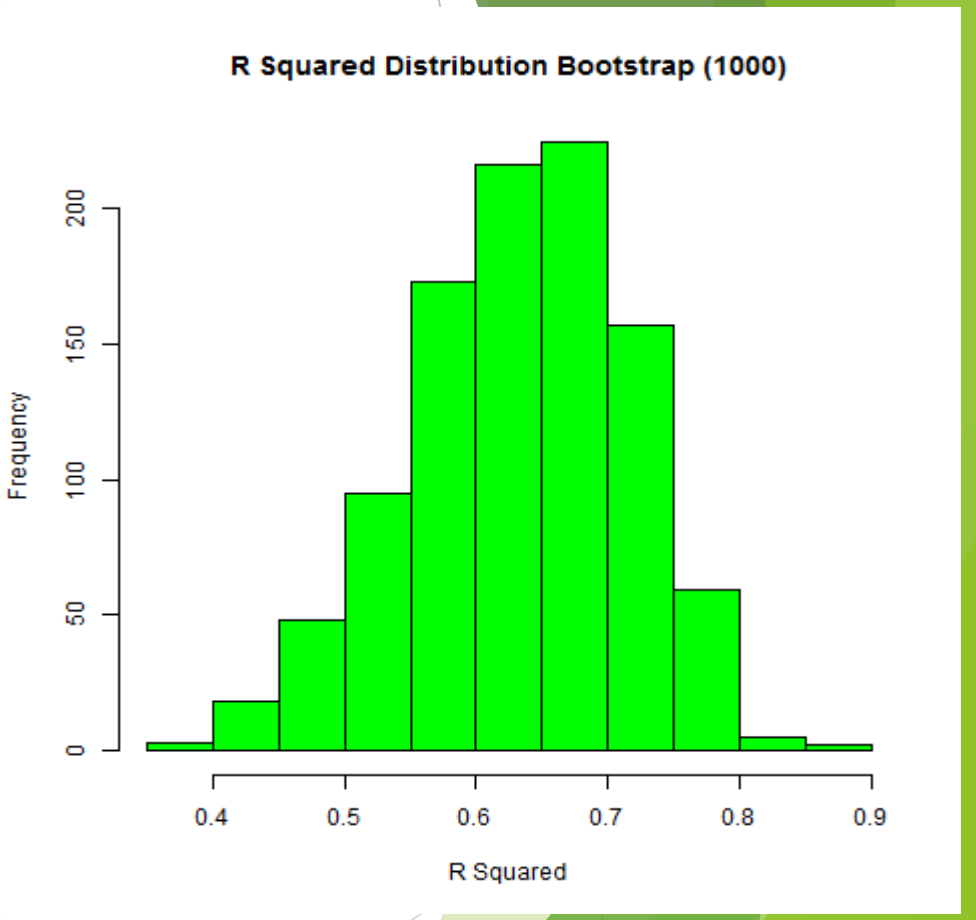


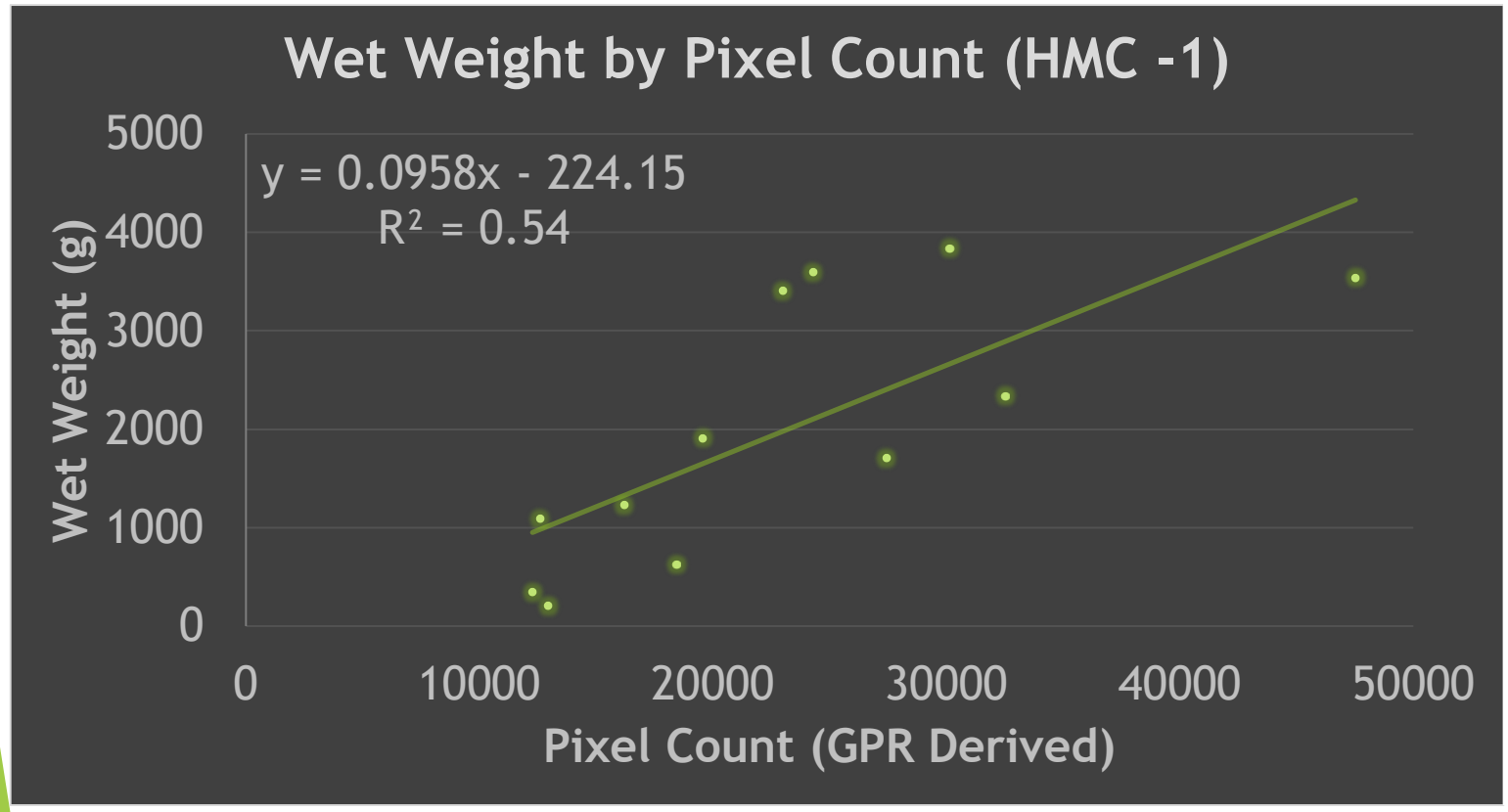
Data Migration

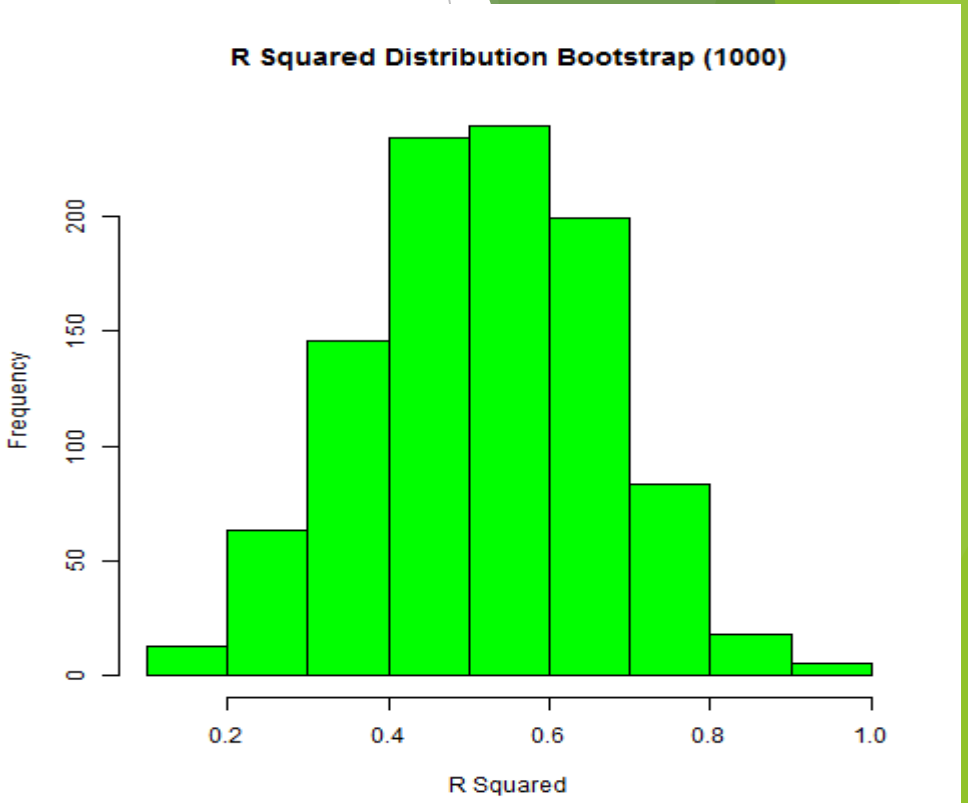


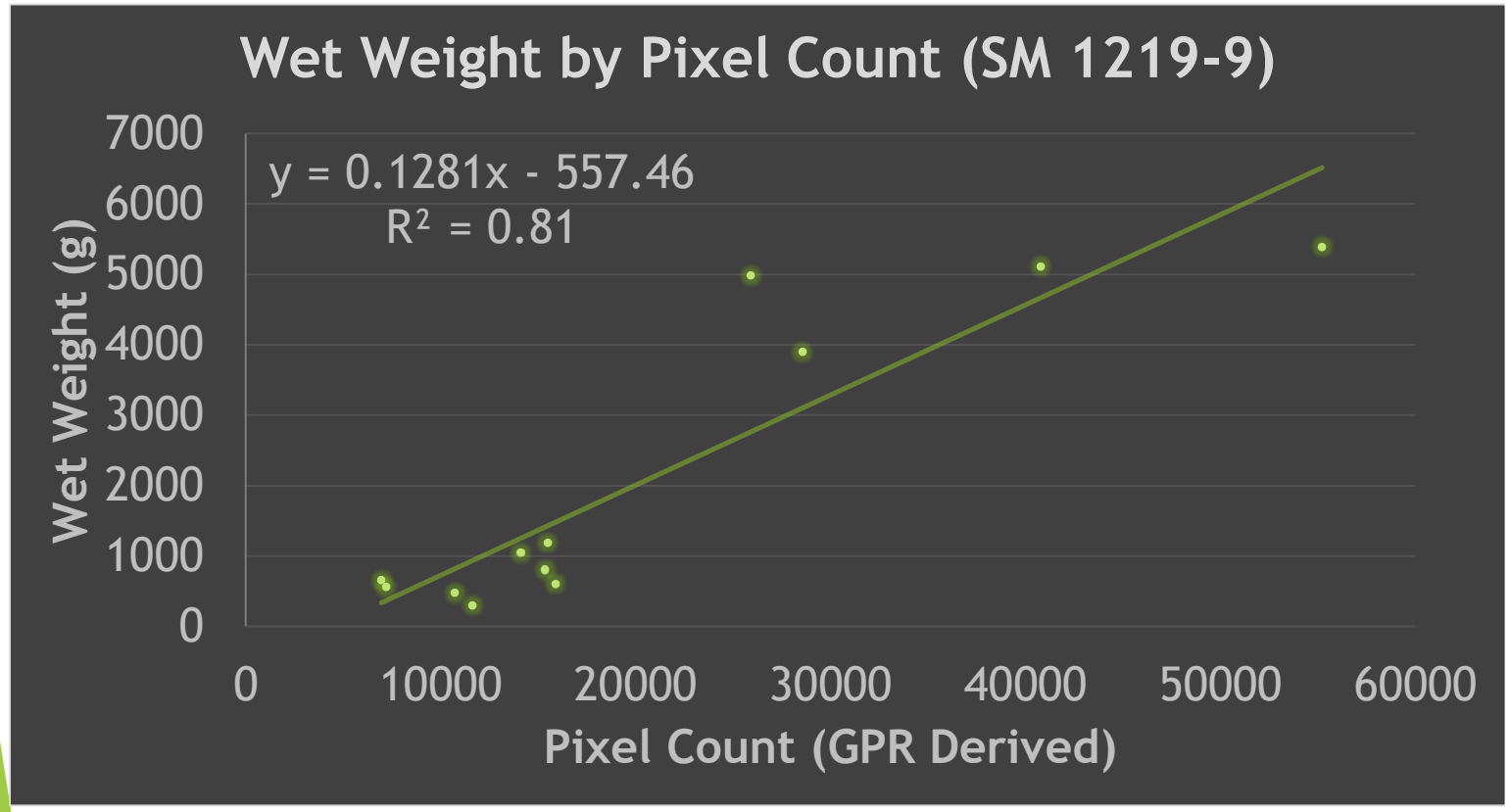
Hilbert Transform of Data

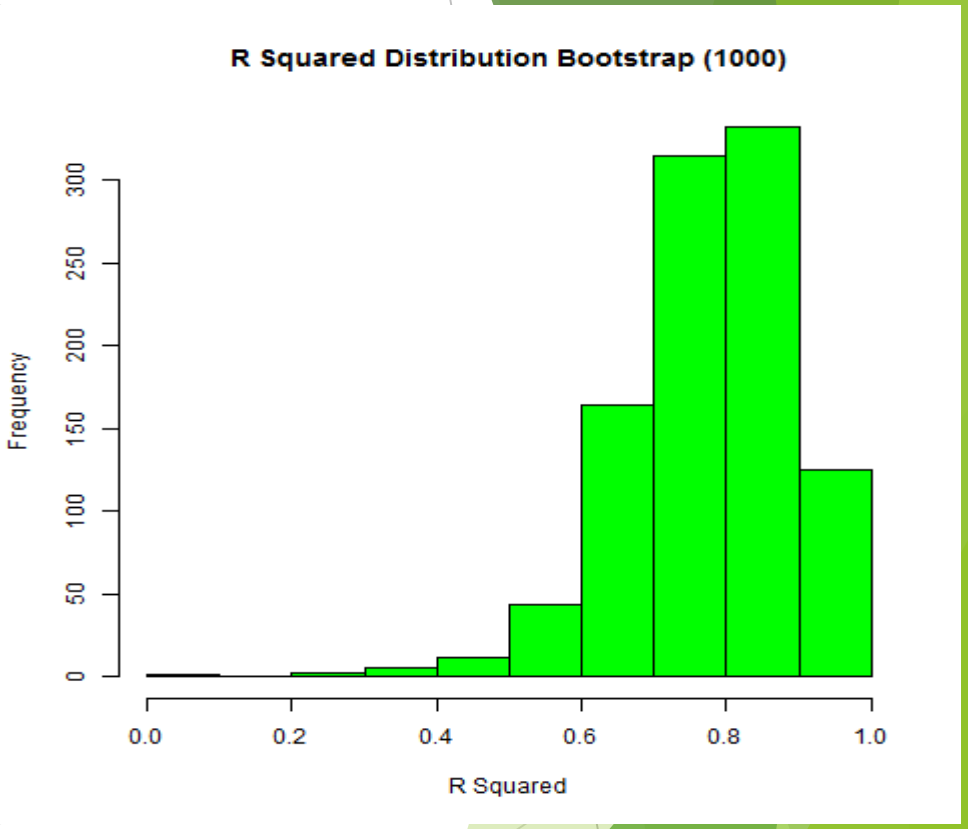

Wet Weight by Pixel Count
y = 0.1031x - 398.42
R² = 0.67
Wet Weight (g)
6000
5000
4000
3000
2000
1000
0
0
10000
20000
30000
40000
50000
60000
Pixel Count (GPR Derived)

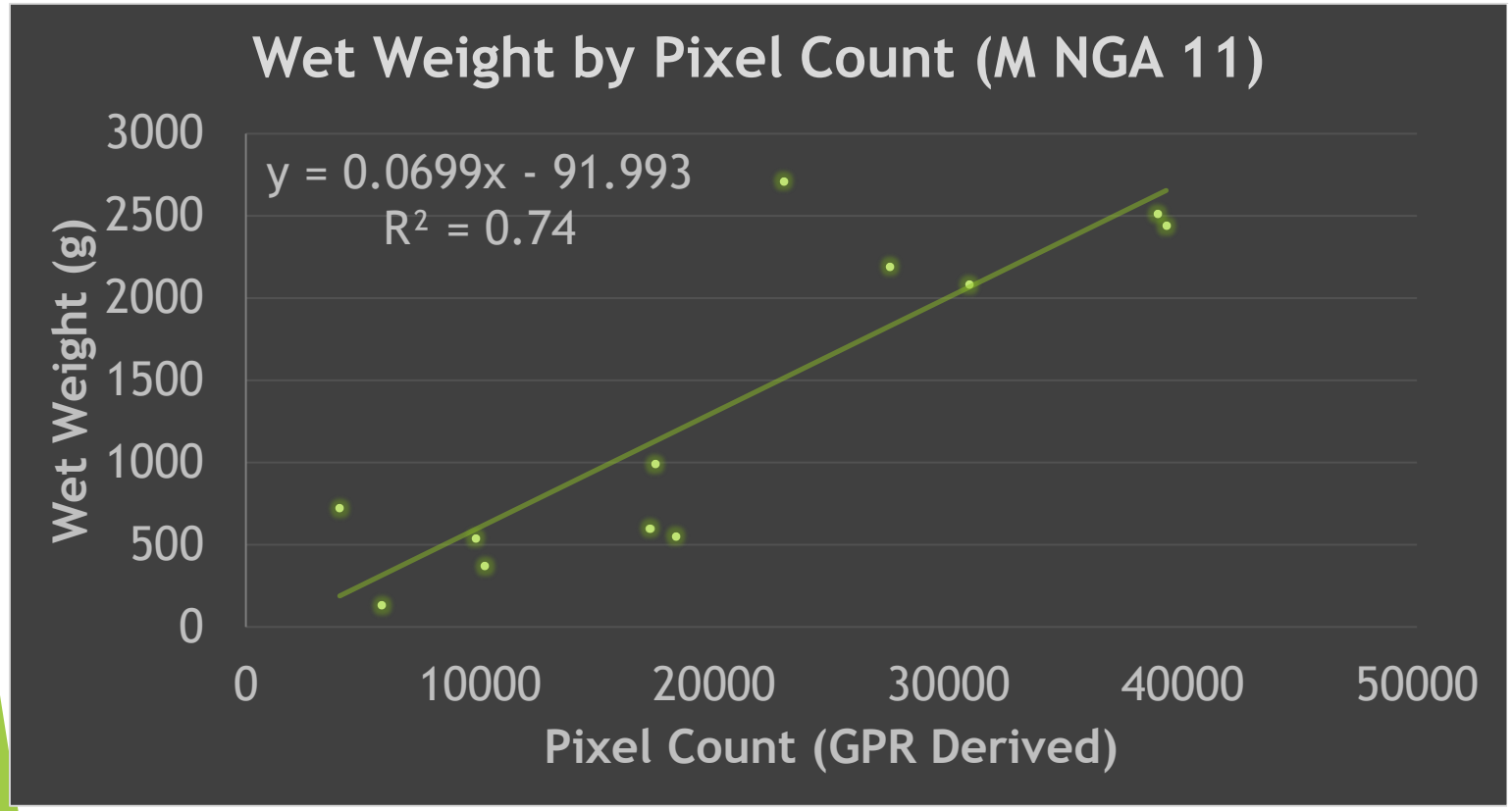

R Squared Distribution Bootstrap (1000)
Frequency
0
50
100
150
200
0.4
0.5
0.6
0.7
0.8
0.9
R Squared

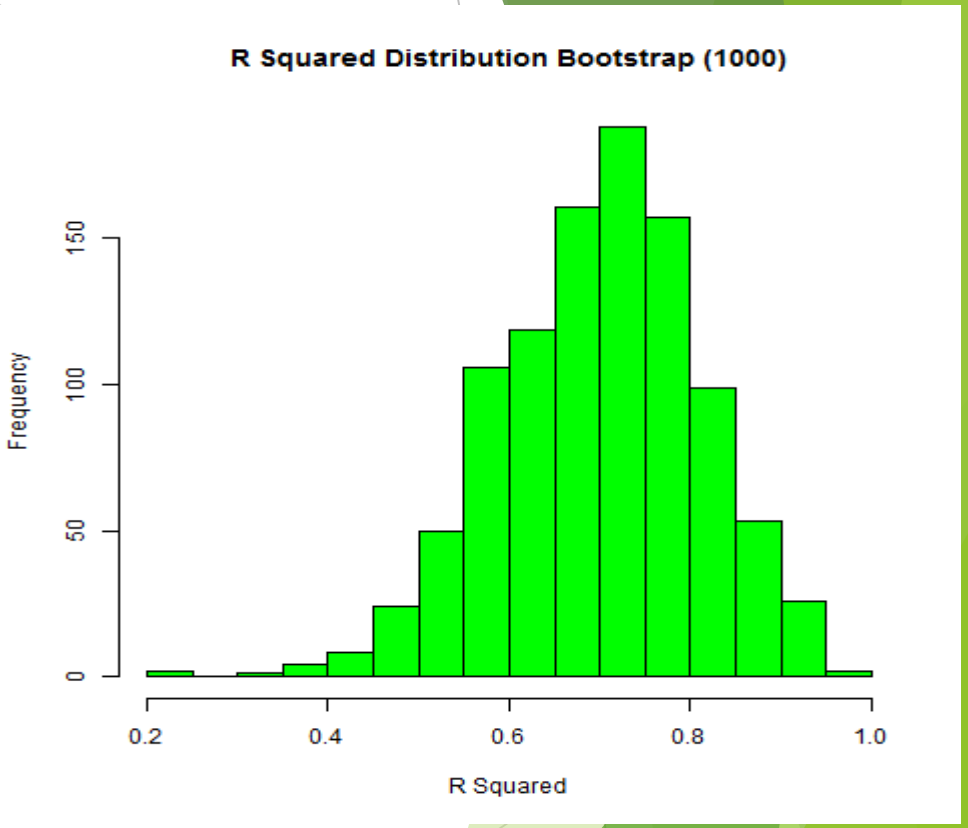

Wet Weight by Pixel Count (HMC -1)
y = 0.0958x - 224.15
R² = 0.54
Wet Weight (g)
5000
4000
3000
2000
1000
0
0
10000
20000
30000
40000
50000
Pixel Count (GPR Derived)

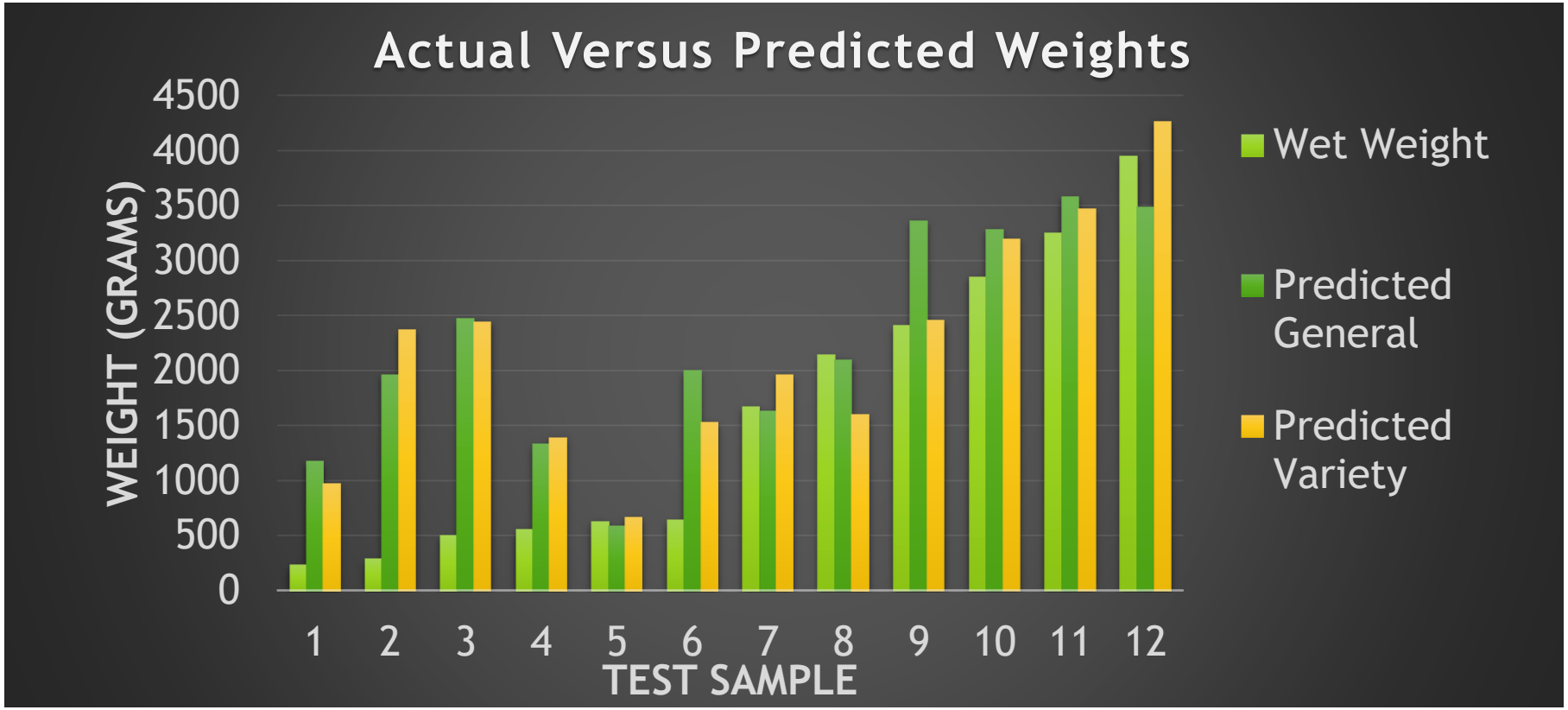

R Squared Distribution Bootstrap (1000)
Frequency
0
50
100
150
200
0.2
0.4
0.6
0.8
1.0
R Squared


Wet Weight by Pixel Count (SM 1219-9)
y = 0.1281x - 557.46
R² = 0.81
Wet Weight (g)
7000
6000
5000
4000
3000
2000
1000
0
0
10000
20000
30000
40000
50000
60000
Pixel Count (GPR Derived)

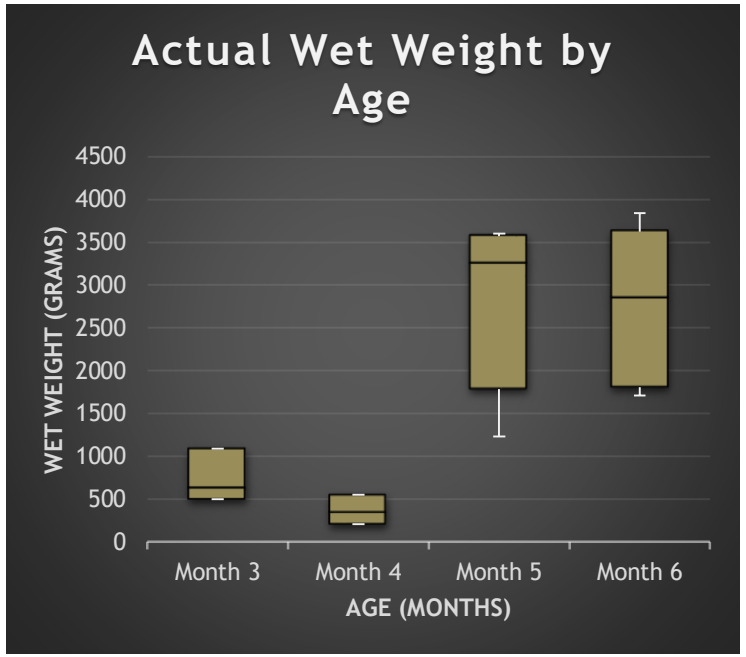

R Squared Distribution Bootstrap (1000)
Frequency
0
50
100
150
200
250
300
0.0
0.2
0.4
0.6
0.8
1.0
R Squared

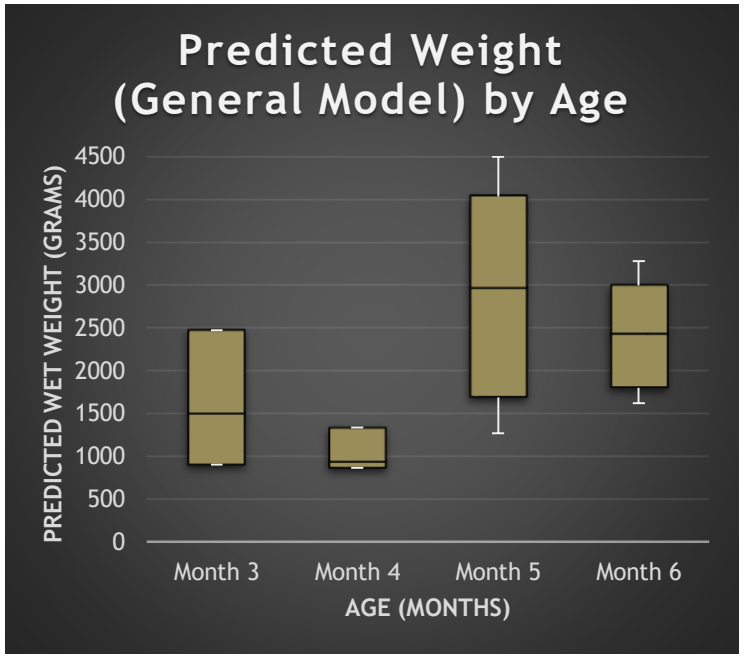

Wet Weight by Pixel Count (M NGA 11)
y = 0.0699x - 91.993
R² = 0.74
Wet Weight (g)
3000
2500
2000
1500
1000
500
0
0
10000
20000
30000
40000
50000
Pixel Count (GPR Derived)

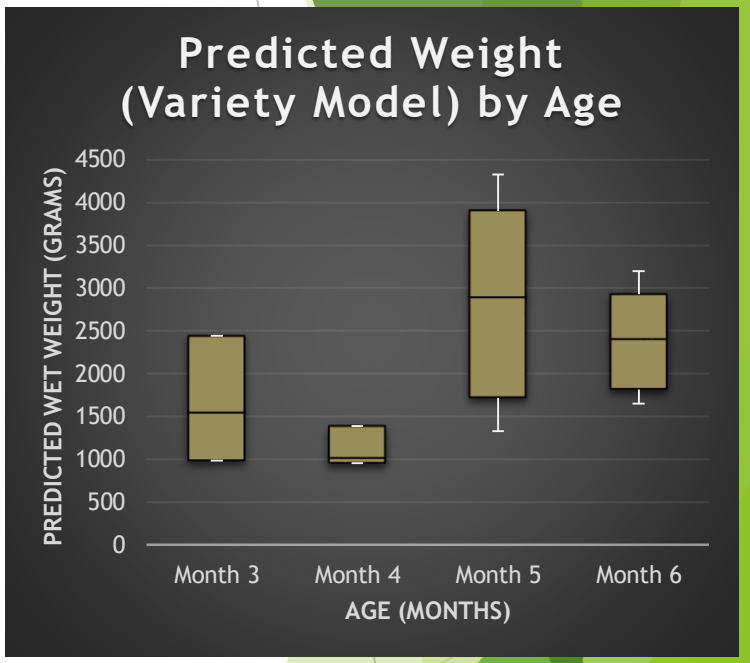

R Squared Distribution Bootstrap (1000)
Frequency
150
100
50
0
0.2
0.4
0.6
0.8
1.0
R Squared


Actual Versus Predicted Weights
WEIGHT (GRAMS)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
10
11
12
TEST SAMPLE
Wet Weight
Predicted General
Predicted Variety

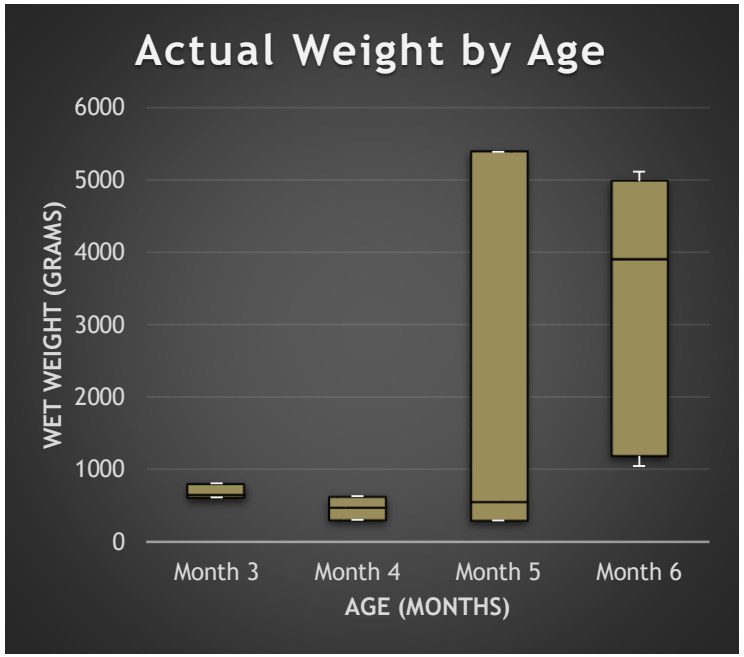
Variety HMC - 1

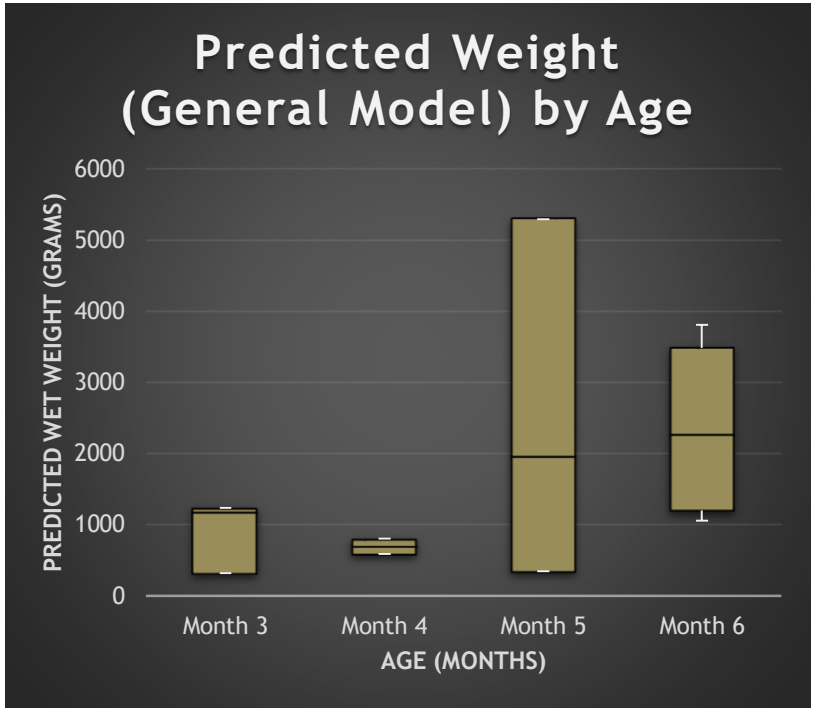


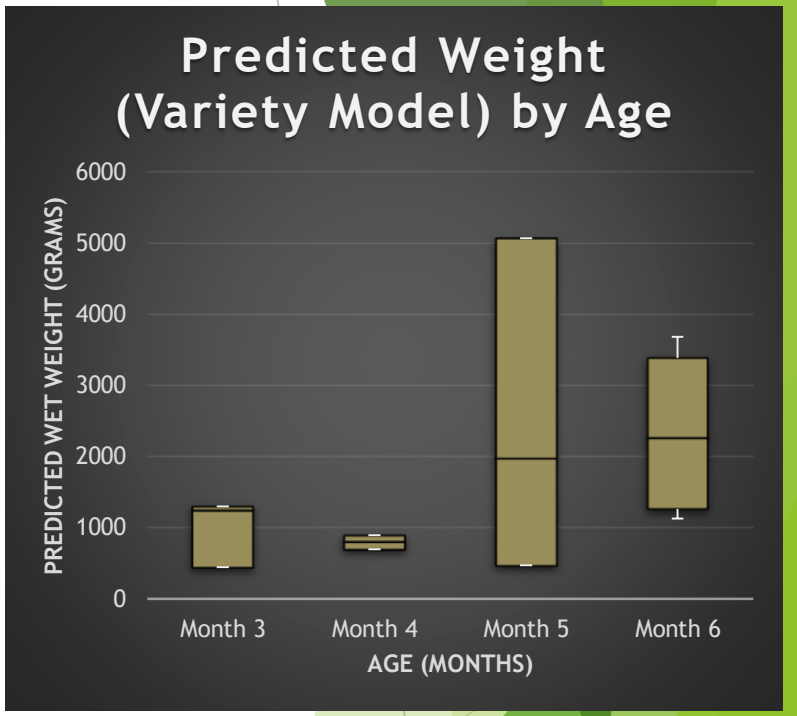




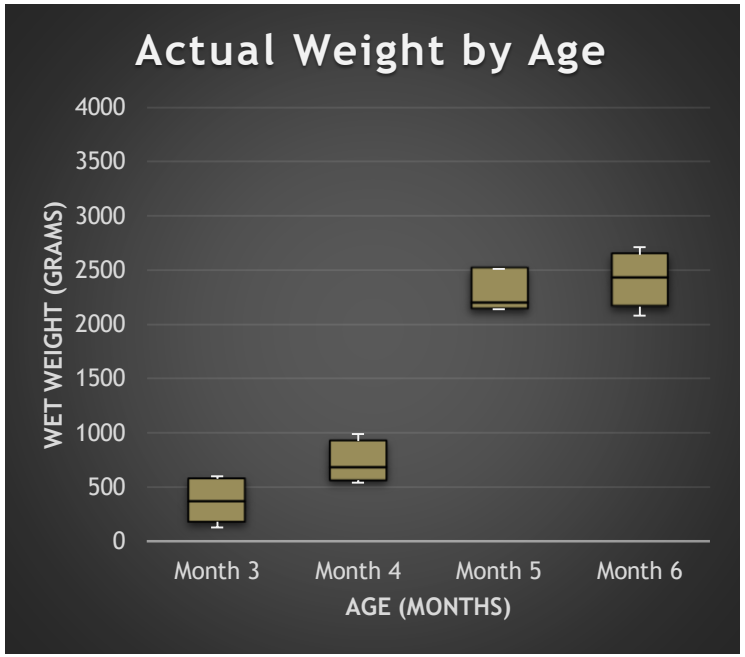
Variety SM 1219-9

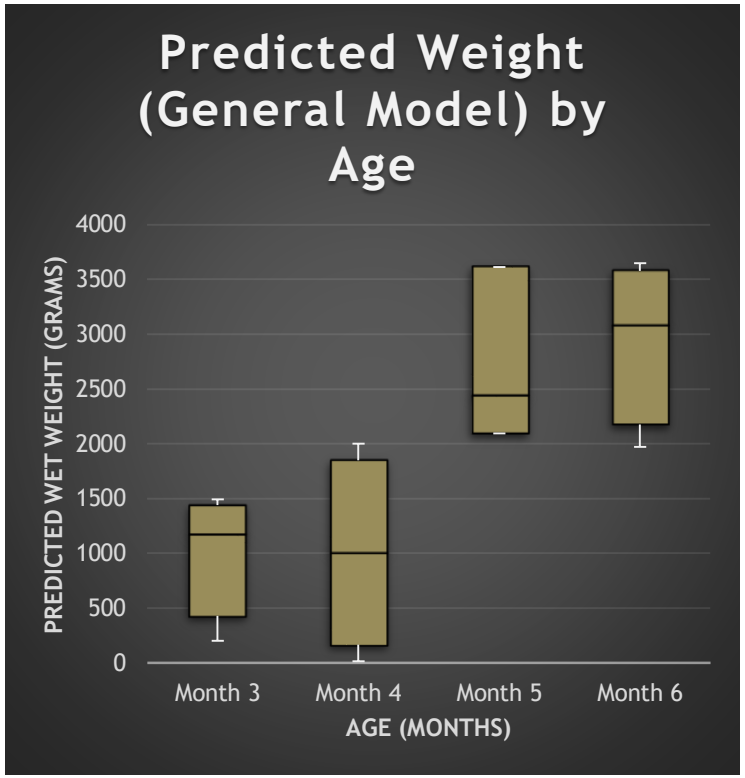


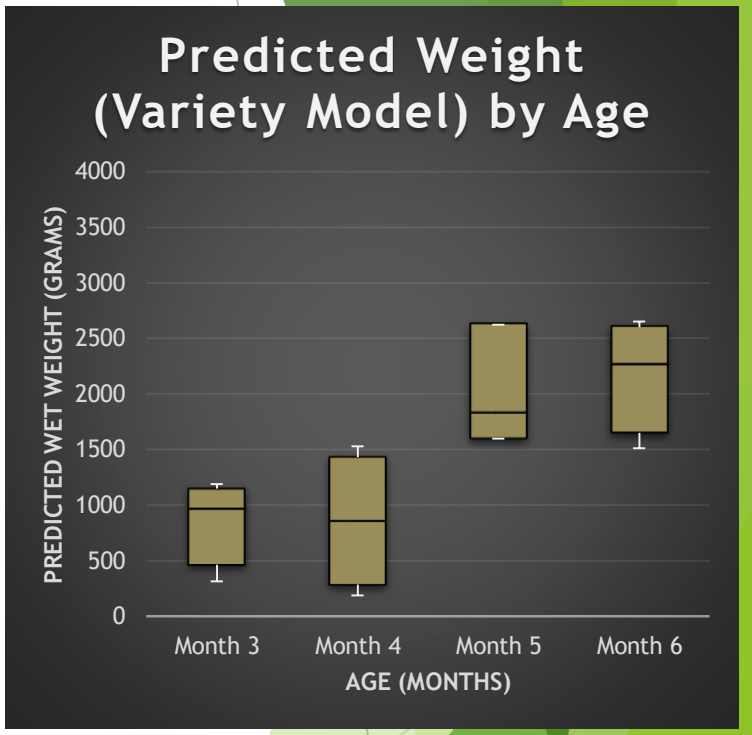




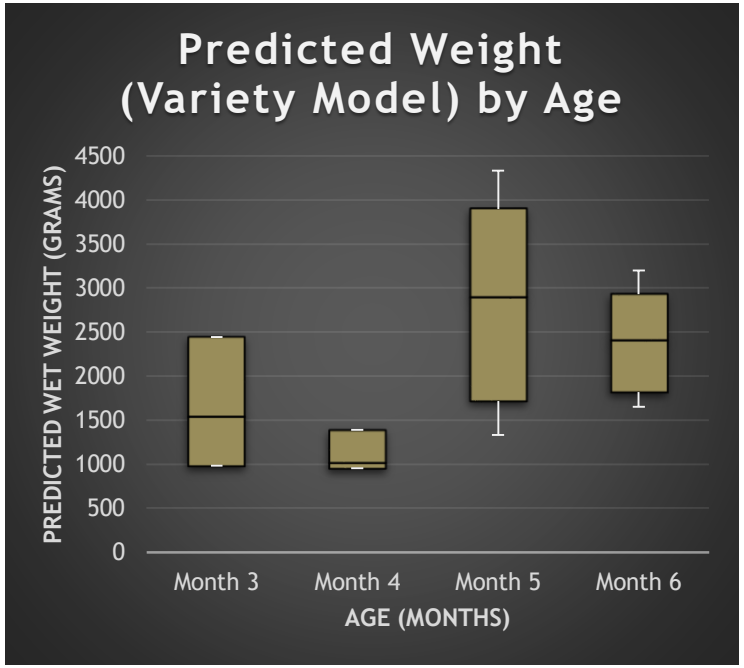
Variety M NGA 11

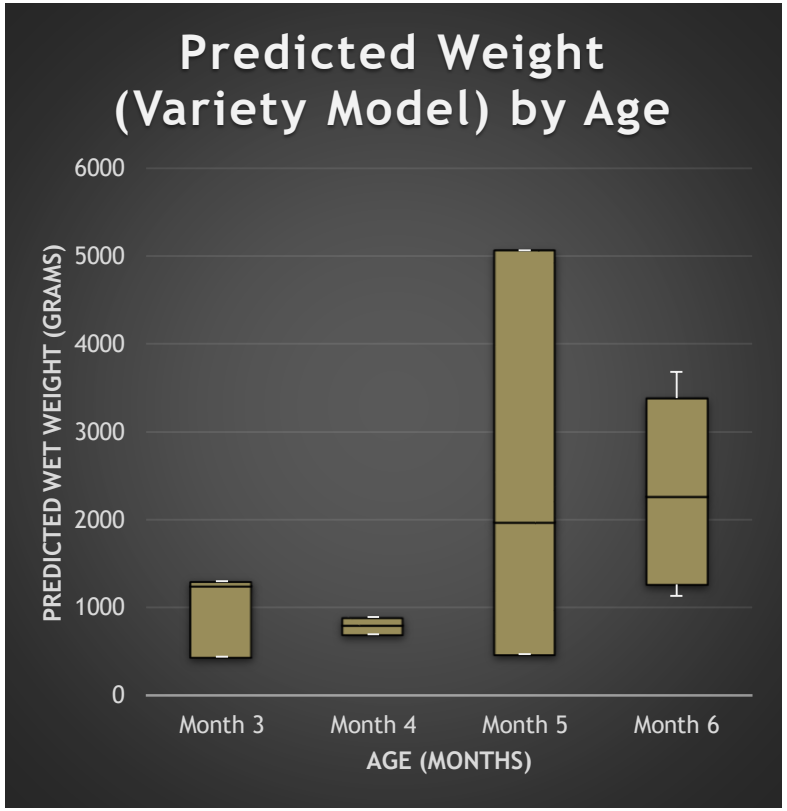


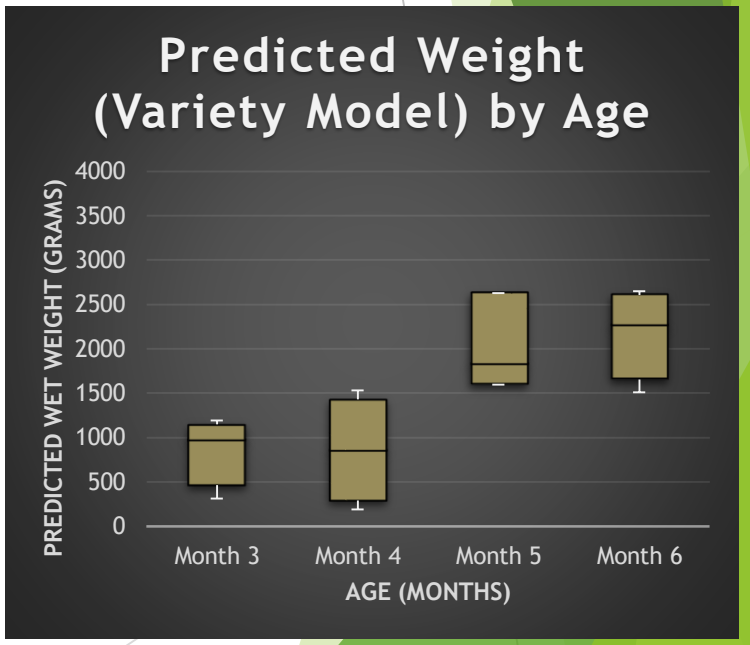




Root Bulking Rate Across Varieties







Discussions

- Equipment design
  - Field capabilities
  - Spatial Resolution
  - Signal Polarity
- Soil Conditions
  - Varying soil
  - Varying soil moisture
  - Objects in soils
- Plant Development
  - Root architecture variations

Acknowledgements

U.S. BORLAUG FELLOWS IN GLOBAL FOOD SECURITY PROGRAM

USAID FROM THE AMERICAN PEOPLE

PURDUE UNIVERSITY

CIMMYT International Maize and Wheat Improvement Center

TEXAS A&M UNIVERSITY

CIAT International Center for Tropical Agriculture
Since 1967 / Science to cultivate change

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Thank You! Any Questions?