Rapid Onsite Soil Nitrate Testing for Farmers

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Nitrogen Fertilizer Decision-making

- Optimum N fertilizer for maximizing yields???

$$N_{fert} = N_{crop} – N_{smn} – N_{min}$$

- Today's Presentation
- Soil Nitrate Quick Test (SNQT)
  - Rapid
  - Onsite
  - No delay or high cost associated with laboratory analysis

What is the SNQT

- Onsite soil nitrate testing protocol
  - Extraction
  - Determination
- Developed and most recently modified by Hartz (2000)
  - Simple
  - Convenient
  - Universal
  - Cost effective

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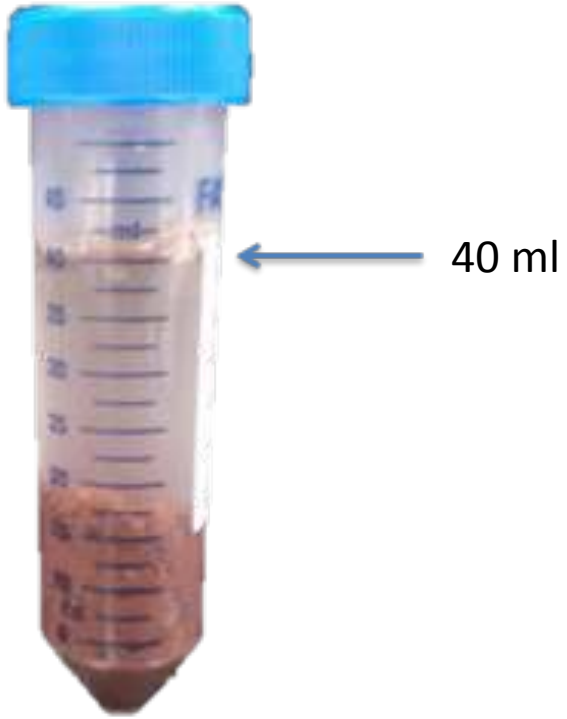
- 10 ml of soil (moist)



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- 10 ml of soil (moist)
- Shake by hand for 5 minutes

Tiziana Ruiz: NREM undergraduate student technician (Spring 2017)

Extraction

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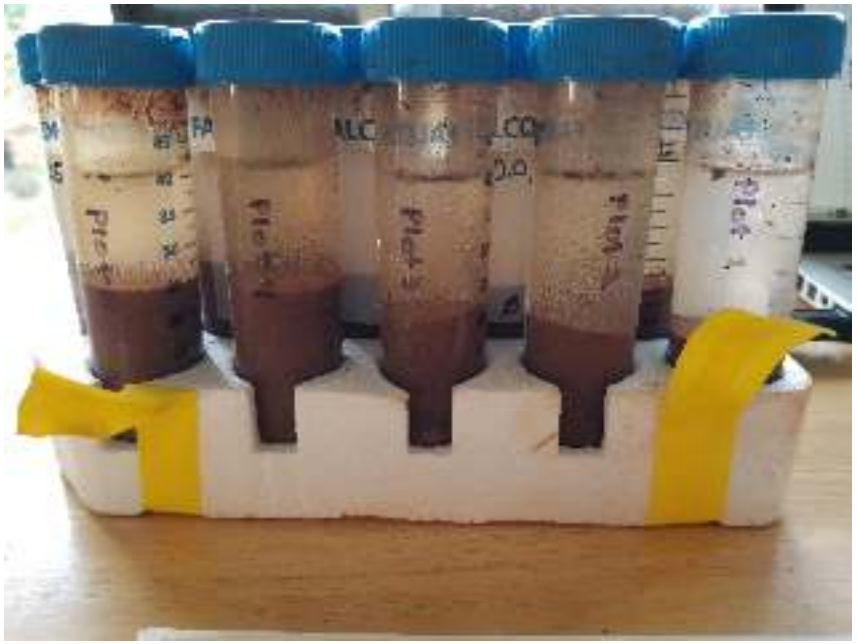
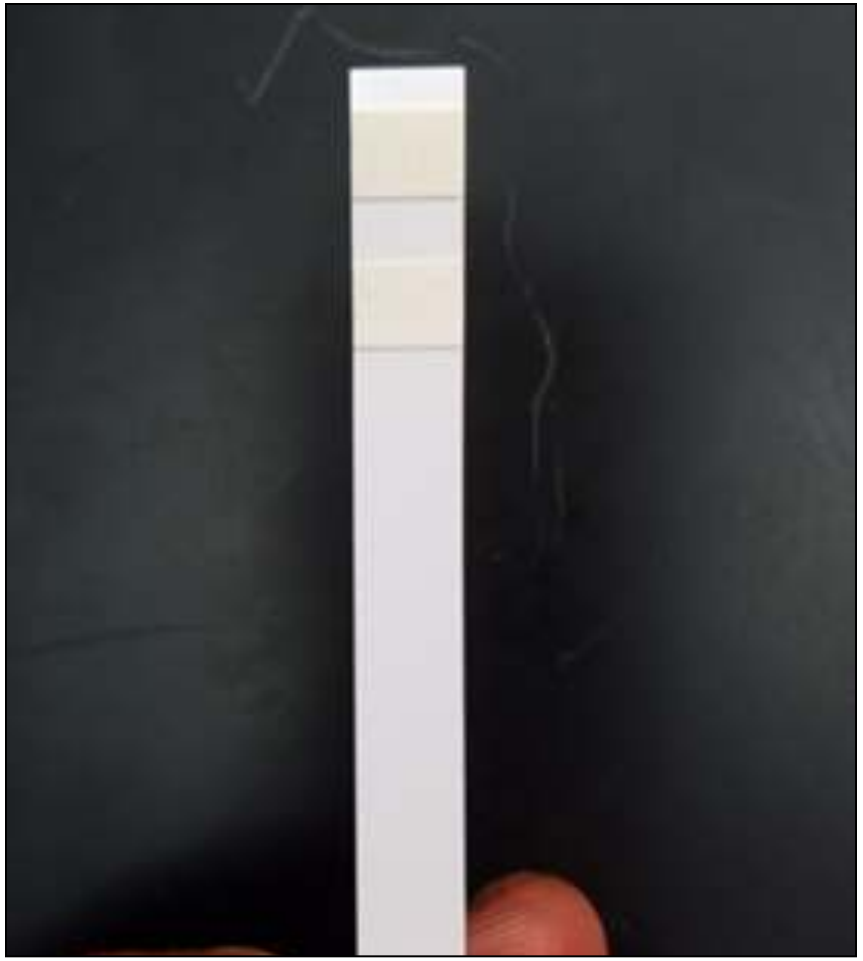
- 10 ml of soil (moist)
- Shake by hand for 5 minutes
- Wait for soil to settle out of solution
- Use clear solution zone at the top for nitrate determination



Determination

- Test strip
  - EMD Millipore Corporation, Billerica, MA
  - Dip into clear zone (2 sec)
- Colorimetric development
  - 60 seconds
- Determination
  - Quantitative (reflectoquant)
  - Semi-Quantitative (color chart)
- Interpretation
  - Reading is given in mg L^{-1} (NO_3^-)
  - Convert to mg kg^{-1} (NO_3-N)



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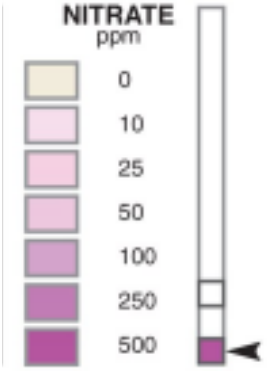
Test strip color development rxn

- Nitrate ions are reduced to Nitrite ions (Griess reagent)
- Nitrite form diazonium salt
- Diazonium salt reacts with N-(1-napthyl)-ethylene-diamine
- Forms a red-violet azo dye
- First applied to field soil testing back in 1979 in Wellesbourne England (Hunt et, al. 1979)

Nitrate Determination

- Semi-Quantitative
  - 1979
  - Use of standards to develop color chart
  - Test strip color development read visually



- Quantitative
  - Schaefer (1986) Australia
  - Reflectometer for blood glucose adapted levels modified to read nitrate concentration

Interpretation of test result

- Results given in mg L^{-1} (NO_3^-)
- As a PSNT Field calibrated thresholds in the literature have been developed for various vegetable crops
  - Reported in mg kg^{-1} (NO_3-N)
- Convert using dimensional analysis

Calculation

$$\text{Nitrate content [mg/kg]} = \frac{\text{Measured value [mg/l] x Vol. } CaCl_2 \text{ sol.[ml]}}{\text{Weight of sample [g]}}$$

- Need measures of:
  - Volume of extractant (ml)
  - Mass of soil sample (mg)
  - Mole fraction of nitrogen in an ion of nitrate.226

Correction factors

- Hartz (1994)
- Developed correction factors for soil samples of various soil texture and moisture content during time of sampling.

strip reading ÷ correction factor = PPM NO_3-N in dry soil

	Correction factor	
Soil texture	**Moist soil**	**Dry soil**
sand	2.3	2.6
loam	2.0	2.4
clay	1.7	2.2

Wahiawa soil series correction factor

Table 3.2. Empirically derived correction factor

Soil Moisture	Correction Factor
Dry	2.2
Wet	2.0
Very wet	1.7

Test strip reading (NO_3 mg L^{-1}) ÷ correction factor = NO_3-N mg kg^{-1}

My Research Activities

1. Assessed the accuracy of the SNQT in Hawaii Soils.
2. Field Calibrated SNQT results to crop performance and developed action thresholds for Napa cabbage grown on the Wahiawa series.
3. Characterized soil nitrate dynamics in relation to commercial N fertilizer practices for 6 different crops of selected brassicas on three different commercial farms.

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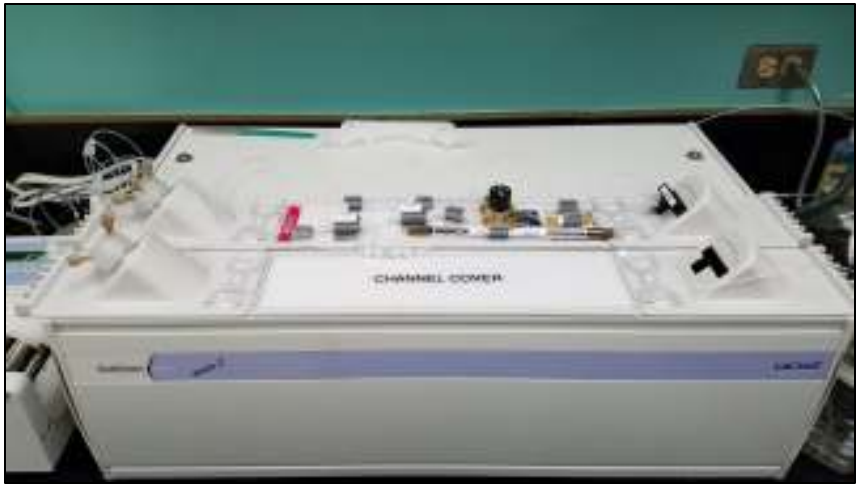
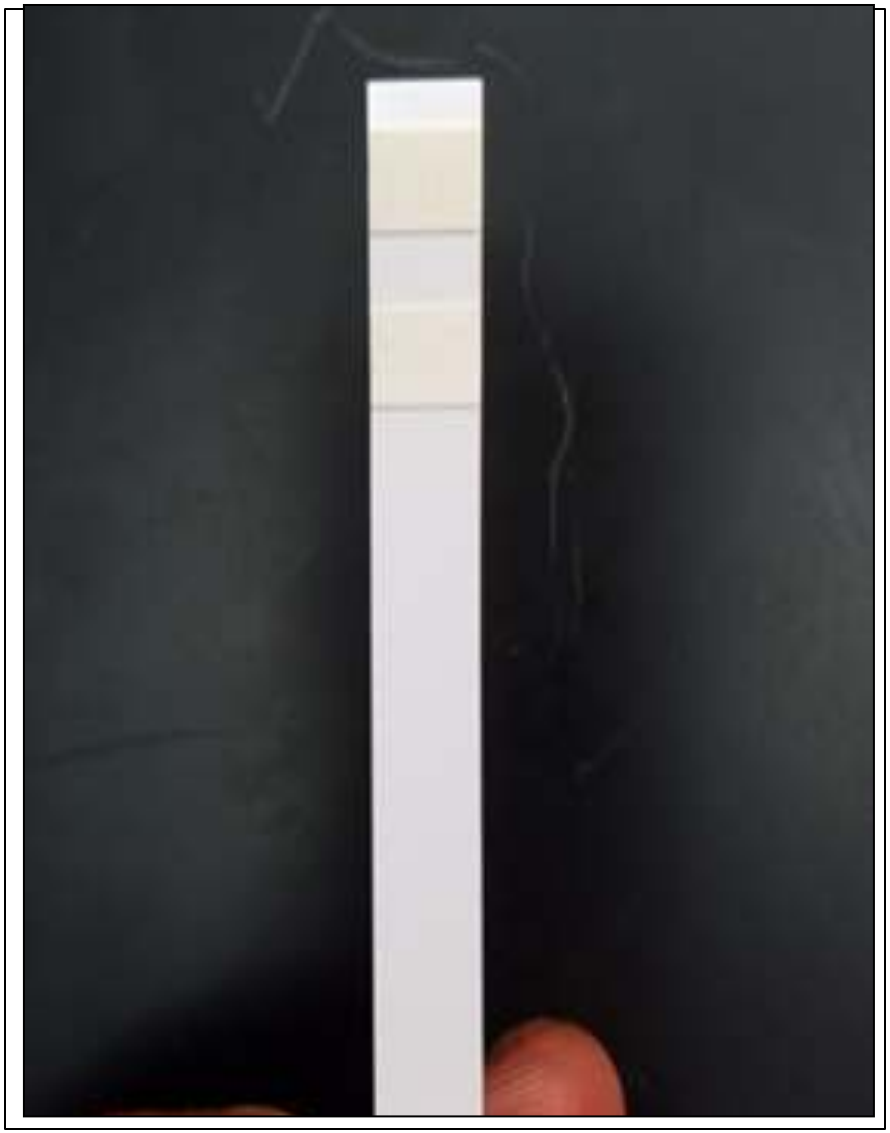
Range of Soil Types Present in Hawaii

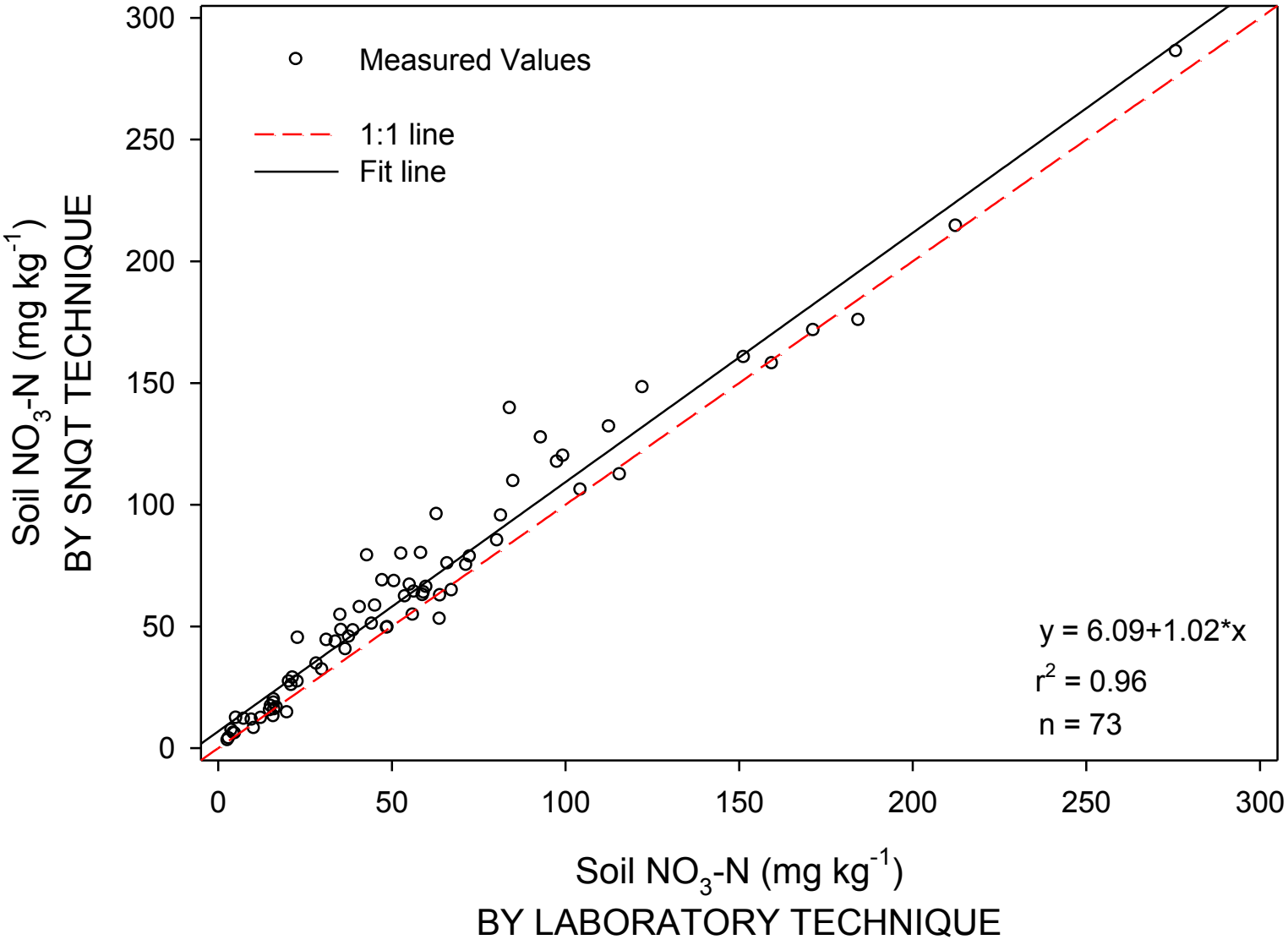
Ustox (n=56) | **Ustolls (n=3)** | **Cambids (n=4)** | **Ustands (n=3)** | **Udands (n=3)** | **Torrert (n=3)**

Compared Test Results of Two Methods





Results


Measured Values
1:1 line
Fit line
y = 6.09+1.02*x
r2 = 0.96
n = 73
Soil NO3-N (mg kg-1) BY SNQT TECHNIQUE
Soil NO3-N (mg kg-1) BY LABORATORY TECHNIQUE
0
50
100
150
200
250
300

Literature review

- Hartz (1994)
- Hartz (2000)
- Schmidhalter (2005)

- Conducted similar regressions between the two testing methods
- Similar coefficient of determination (r^2)
- SNQT slightly under estimated nitrate concentration

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Fertilizer Rate Experiment

- Poamoho Research Station
- Wahiawa soil series
- Napa cabbage

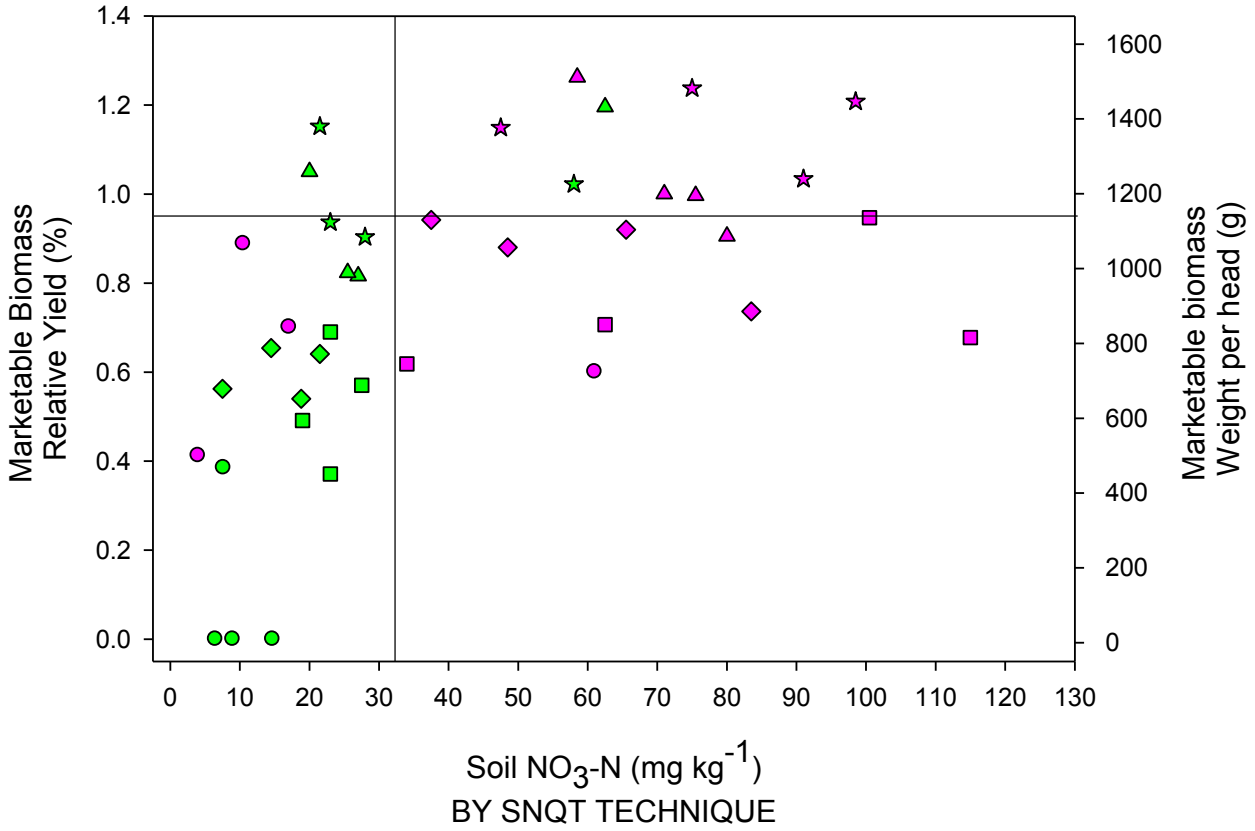
Data Collection

- Monitored weekly soil nitrate levels using the SNQT

Results

- SNQT most useful when used 2 weeks after planting for Napa cabbage

- Critical threshold 2 weeks after planting was 32- 38 mg kg^{-1}



Literature review

Previous studies have found the soil NO_3-N critical concentration to be roughly 20-25 mg kg^{-1}

- Iceberg and romaine lettuce in California soils (Breschini and Hartz, 2002)
- Sweet corn in New Jersey soils (Heckman et al., 1995)
- Fall cabbage in New Jersey, Deleware, and Conneticut (Heckman et al., 2002)
- Tomatoes in California (Krusekopf et al., 2002)

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Characterization of soil nitrate dynamics

Helemano Farm Site: Summer 2016
Wahiawa soil series (Ustox)
Crops: head cabbage, napa cabbage, broccoli

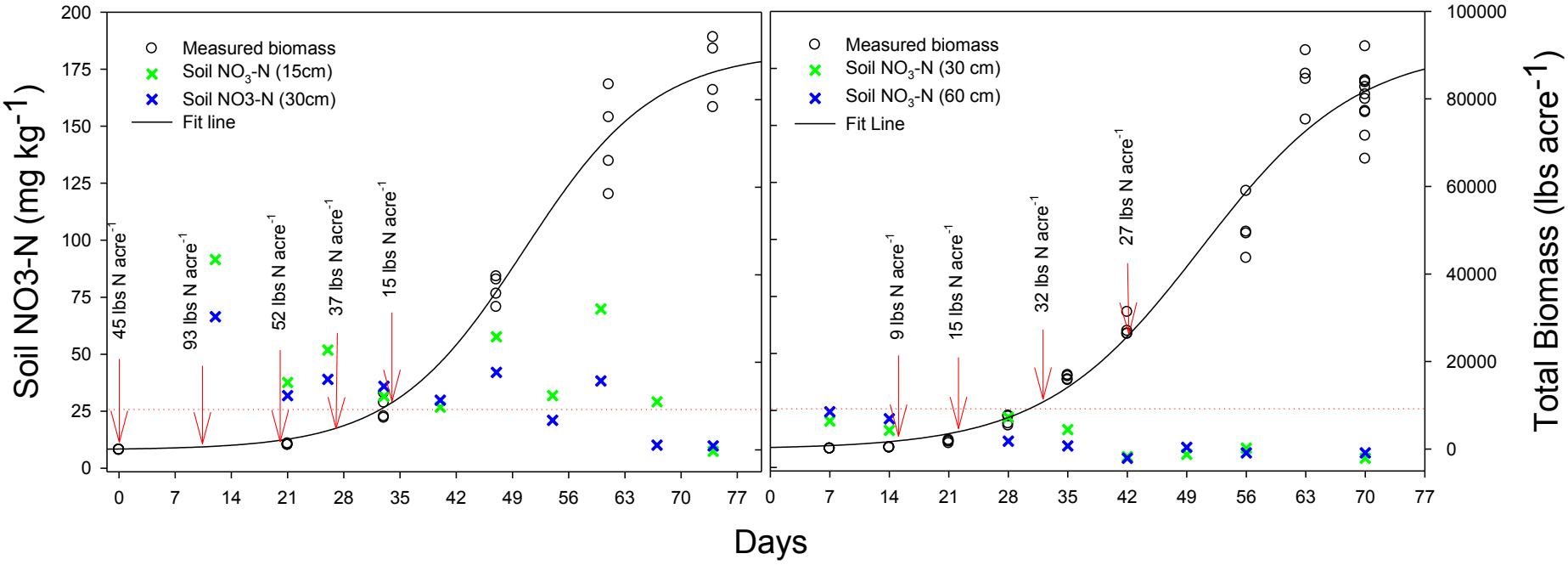
Waipio Farm Site: Fall 2016
Wahiawa soil series (Ustox)
Crops: head cabbage, napa cabbage

Ewa Plains Farm Site: Spring 2017
Hono'uli'uli soil series (Torrets)
Crops: head cabbage

Soil nitrate collection

- Soil nitrate levels collected weekly through out crop duration.
- Plotted in relation to crop N uptake

Impacts



- Farmer was able to make more informative N fertilizer decisions after we presented data on crop growth, N fertilizer inputs, and soil nitrate dynamics
- In the second round of head cabbage, the farmer greatly reduced N fertilizer and synchronized applications to the time of greatest demand
- No yield reduction

Conclusion

- SNQT seems like a promising N diagnostic tool for Hawaii farmers

- However…
- Hawaii has a diversity of soils and transfer of technology across sites and crops is not trivial
- There is still much R and D that must be done before the SNQT can be widely adopted in Hawaii

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Questions