Integrating Organic Amendments and Cover Crops into Organic Crop Rotations

Rob Wilson

IREC Director/Farm Advisor

University of California
Agriculture and Natural Resources | Research and Extension Center System

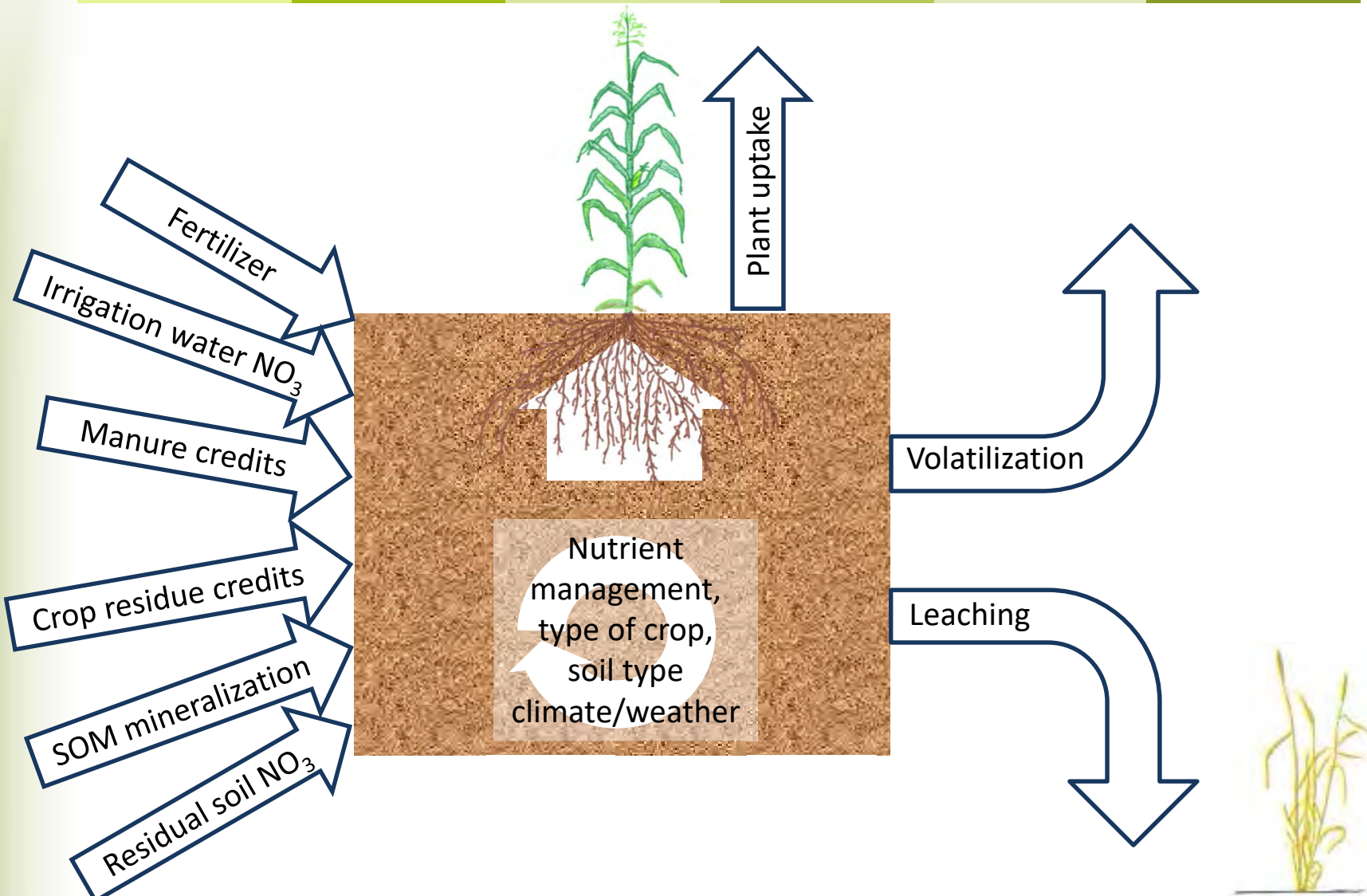
Organic Crop Production

- Benefits:
  - Specialty Markets and Price Premiums
- Challenges
  - How to supply the crop with adequate nutrients?
  - How to control weeds, insects, nematodes, and diseases?
  - How to produce a high-quality product that meets market demands?

Benefits of Organic Amendments and Cover Crops

- Improve soil structure and health
- Can help promote desirable soil bacteria and fungi
- Can sometimes suppress pests and diseases
- Improve soil fertility
  - Nitrogen is often the most limiting nutrient for vegetable, grain, and grass yields in the Klamath Basin

Input and output of N in agricultural fields



Common Misconception about Organic Amendments

- Nutrients in organic amendments and cover crops are more biologically active than nutrients in synthetic fertilizers? (FALSE!)
  - Plant available nutrients are the same for all fertilizer types
  - It is very important to understand how organic N is converted to mineralized N

Common Misconceptions about Cover Crops

- Grass cover crops often add plant available nitrogen to the system
  - FALSE: In most cases grass cover crops result in a net loss of plant available nitrogen the following growing season except for situations where high levels of nitrogen leached below the previous crops root zone
- Most of the nitrogen released from legume cover crops is from the roots
  - FALSE: Over 90% of the nitrogen in legume crops is contained in tops and the tops should be tilled back into the soil immediately to get the max benefit.

Using Cover Crops & Organic Amendments When Growing Organic Potatoes

Treatments

- Cover crops include:
  - Hairy vetch, Chickling vetch, Woolypod vetch, Berseem clover, Field Peas, Sorghum-sudangrass, Triticale, and Fallow
- Organic amendments include:
  - Composted chicken manure, steer manure, compost, soy meal, blood meal, fish meal, and combinations
- Conventional N fertilizer treatments to compare to organics

Site Information

- Studies conducted at IREC in fields with a cropping history of back-to-back cereal grains with low residual nitrogen levels
- Mucky silty clay loam soil
- UC Lab Test results
  - pH=6.3; Nitrates=17 ppm; OM=6.5%; OlsenP=38 ppm; K=249ppm

Five Trials

- Spring Dryland trial
- Spring Irrigated trial
- Mid-summer Irrigated trial
- Fall Irrigated trial
- Amendment trial

Spring Dryland Trial

- Planted: April 8, 2016
- Total Applied Water: 4.38 inches
- Harvest Date: June 21, 2016
- Cover crops were incorporated when the reached 50% to 100% flowering
- 74 days from planting to incorporation


FORD

Spring Dryland 4/21/2017

Spring Dryland Trial
May 17th

Spring Irrigated Trial

- Planted: April 20th, 2016 (12 days later than dryland)
- Total Applied Water: 11.74 inches (7.25 inches irrigation)
- Harvest Date: June 30, 2016 to July 6, 2016
- Cover crops were incorporated when the reached 50% to 100% flowering
- 71 & 77 days from planting to incorporation

Spring Irrigated Trial
May 17th

Mustards and Radish

- **Nemat Arugula**
  - High glucosinolate arugula that is excellent trap crop for root not nematodes
- **Caliente 199 Mustard**
  - Highest producing glucosinolate mustard for releasing isothiocyanate (ITC) for biofumigation
- **Defender oilseed radish**
  - Oilseed radish with higher than normal glucosinolate levels and good nematode trap crop for root not and lesion. Not daikon tillage type.

Nemat Arugula

Caliente 199 mustard

Defender oilseed radish

Defender oilseed radish

Field Peas and Vetch

- **Flex spring field pea**
  - Spring forage pea with good seedling vigor

- **Lana Woollypod Vetch, Hairy Vetch, Chickling Vetch**
  - Cool-season vetches. Lana is early maturing variety. Don't let vetches set seed.

Flex spring field peas

Lana woollypod vetch

Twin spring wheat

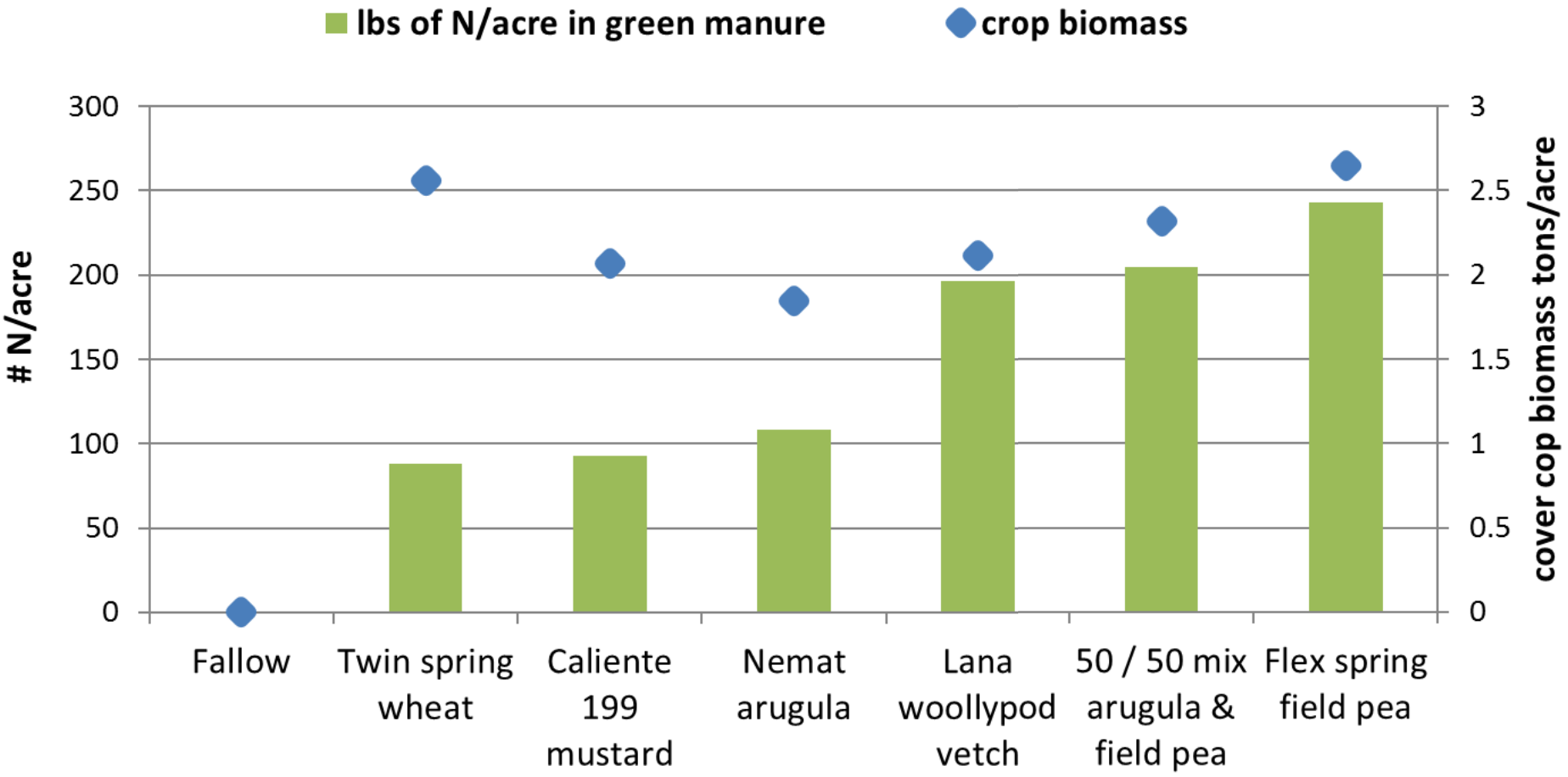
Mustard + field peas

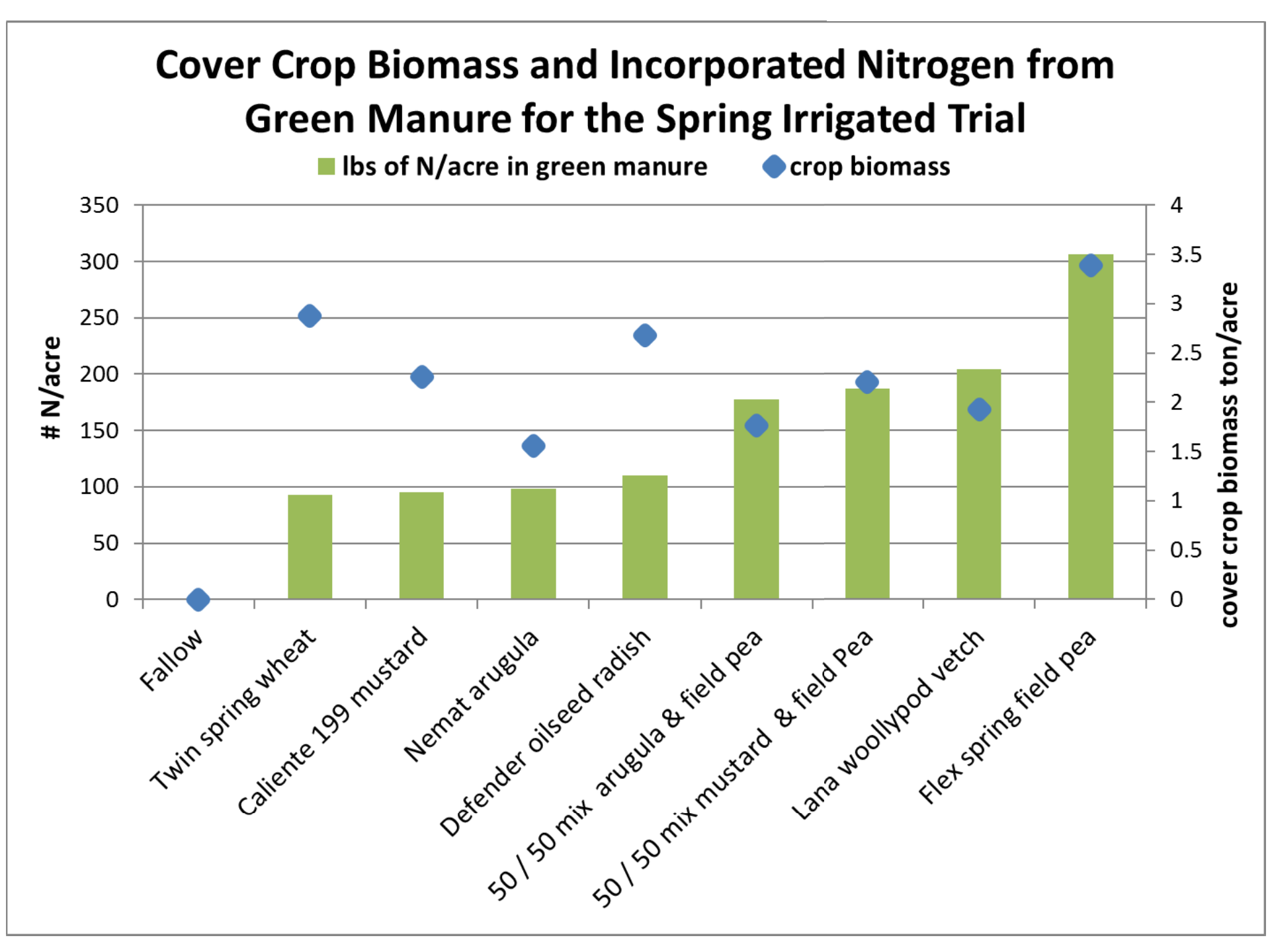
Very few weeds in spring trials due to timely tillage, cooler temperatures, rapid cover crop growth, and weed spectrum in the field!

Managed as a green-manure


Important to disk or rototill green residue into the soil shortly after chopping!

Cover Crop Biomass and Incorporated Nitrogen from Green Manure for the Spring Dryland Trial




Cover Crop Biomass and Incorporated Nitrogen from Green Manure for the Spring Irrigated Trial
lbs of N/acre in green manure
crop biomass
N/acre
cover crop biomass ton/acre
350
300
250
200
150
100
50
0
4
3.5
3
2.5
2
1.5
1
0.5
0
Fallow
Twin spring wheat
Caliente 199 mustard
Nemat arugula
Defender oilseed radish
50 / 50 mix arugula & field pea
50 / 50 mix mustard & field Pea
Lana woollypod vetch
Flex spring field pea

Spring trials were mowed or tilled as needed for the rest of the growing season.

Mid-Summer Irrigated Trial

- Planted: July 27th, 2016 after growing a spring twin crop for hay
- Total Applied Water: 6.2 inches (7.25 inches were applied in spring)
- Harvest Date: October 11th, 2016
- Cover crop incorporation occurred when temperatures became too low for significant growth to occur. Mustard was flowering.
- 76 days from planting to incorporation

Mid-summer trial
1 month after planting

Hello weeds!

Nitrogen deficiency

N deficiency amplified through the season!

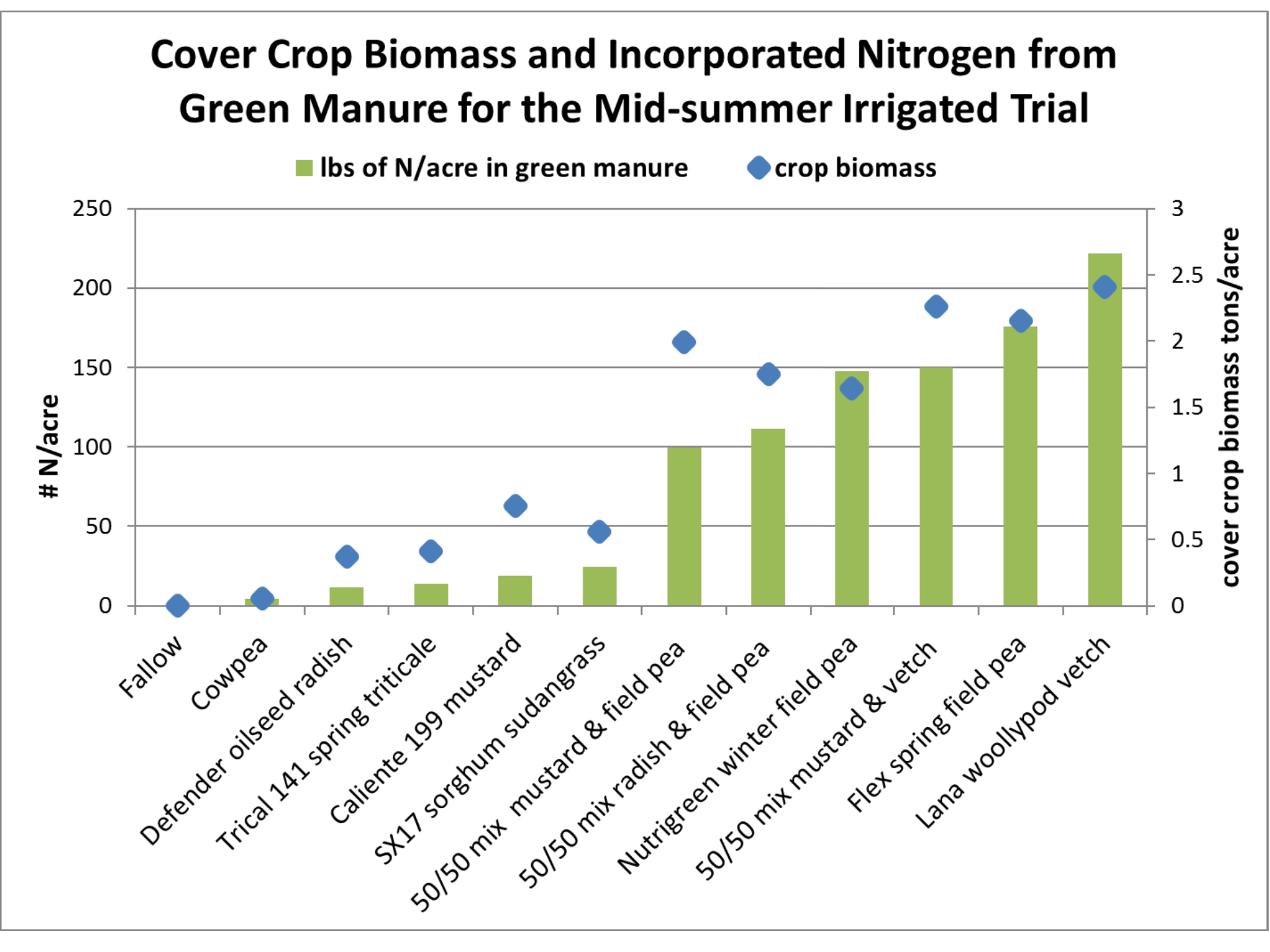
Peas did not share nitrogen with the mustard!

peas + mustard vs. mustard alone

SX17 sorghum-sudangrass

Trical 141 spring triticale

Cowpeas


Cover Crop Biomass and Incorporated Nitrogen from Green Manure for the Mid-summer Irrigated Trial
lbs of N/acre in green manure
crop biomass
N/acre
cover crop biomass tons/acre
250
200
150
100
50
0
3
2.5
2
1.5
1
0.5
0
Fallow
Cowpea
Defender oilseed radish
Trical 141 spring triticale
Caliente 199 mustard
SX17 sorghum sudangrass
50/50 mix mustard & field pea
50/50 mix radish & field pea
Nutrigreen winter field pea
50/50 mix mustard & vetch
Flex spring field pea
Lana woollypod vetch

Fall Irrigated Trial

- Planted: September 13th, 2016 after growing a spring wheat crop
- Total Applied Water: 2.1 inches in fall
- Harvest Date: May 2nd, 2017
- Cover crop incorporation occurred before flowering to allow at least 3 weeks before potato planting.

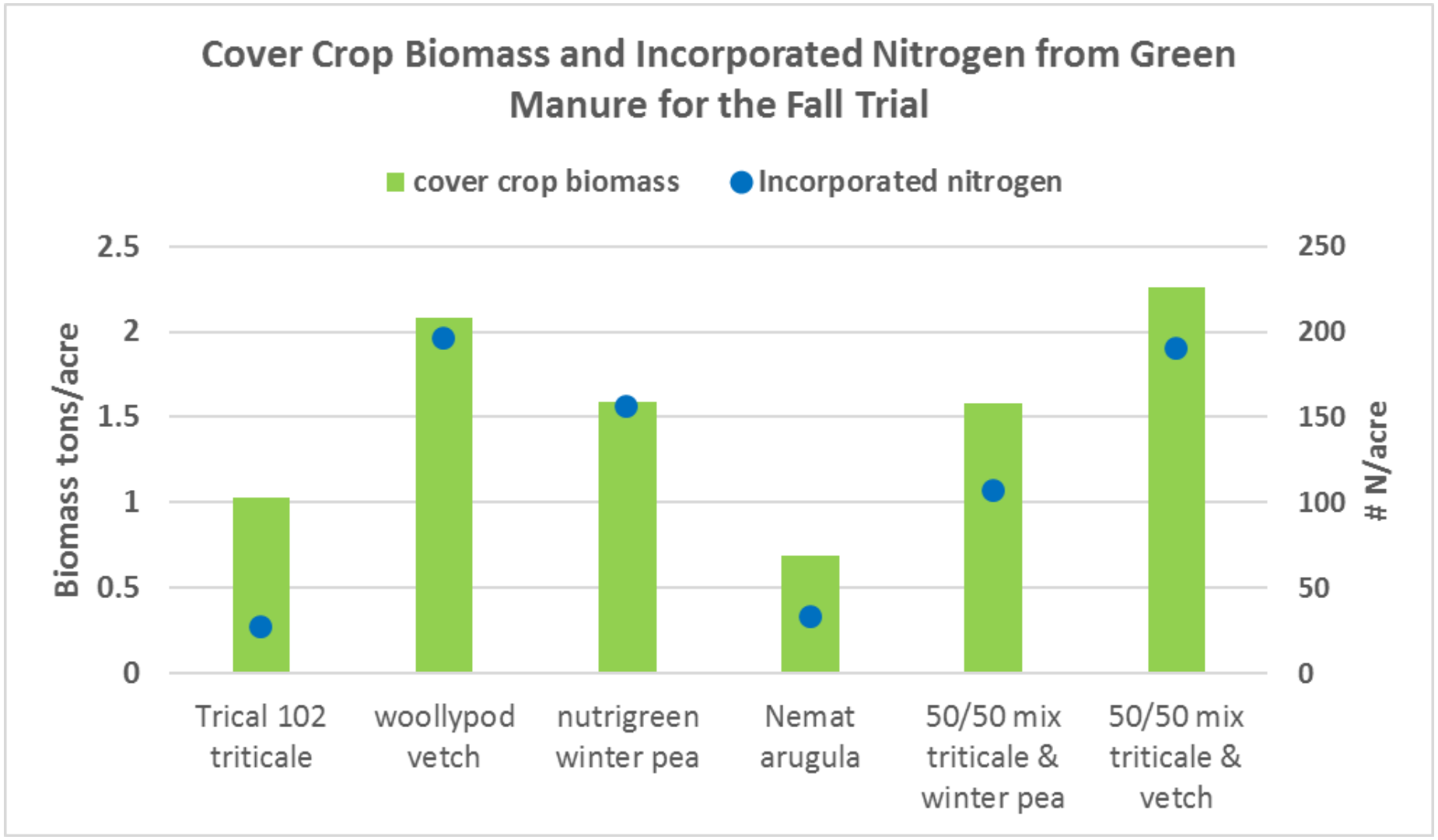
Fall Irrigated Trial
(1 month after planting)

triticale + hairy vetch & hairy vetch alone

triticale alone

Winter field peas

Arugula


Cover Crop Biomass and Incorporated Nitrogen from Green Manure for the Fall Trial
cover crop biomass
Incorporated nitrogen
Biomass tons/acre
N/acre
2.5
2
1.5
1
0.5
0
250
200
150
100
50
0
Trical 102 triticale
woollypod vetch
nutrigreen winter pea
Nemat arugula
50/50 mix triticale & winter pea
50/50 mix triticale & vetch

Cover Crop Summary

- Several legume cover crops generated at least 150 lbs N/A for future crops
- Field peas, hairy vetch, chickling vetch, and woollypod vetch performed well
- Don’t let vetches produce seed!!
- Allow time for cover crop to break down in the soil before planting the cash crop

Organic Amendments

- A lot of choices!
- Why are you applying them?
- If applying for nutrients, ask for a nutrient analysis and moisture content to determine the cost per lb of nutrient assuming 100% dry matter
- Don’t be afraid to ask if it is weed-free, disease-free, composted, etc.

Cost per lb of N

- Urea Fertilizer: $0.54
- Field Pea & Vetch Cover Crops: $0.73 – $0.97
  - Calculated Cover Crop Production Cost: $166 per acre
- Composted Chicken Manure: $1.85
- Compost & Composted Steer Manure: $2.00 -$3.00
- Blood Meal: $8.00
- Pre-made Liquid Compost Tea Blends: $15 - $20
- Soy Meal: $25 -$30

Nutrients in Amendments

- Composted Chicken Manure- 3.4 to 4.4% N
  - 3,400 to 4,400 lbs (2 tons) = 150 lbs N/A
  - 3% P and 3% K
- Dry Composted Steer Manure- 1% N
  - 15,900 lbs (8 tons) = 150 lbs N/A
  - 0.6% P and 1% K
- Manure/Green Waste Compost- 1.5% N
  - 10,000 (5 tons) = 150 lbs N/A
  - 1% P and 1.7% K

Composting

- C is respired, N is preserved
  ⇨ C/N ratio narrows
- Readily available material is decomposed, more recalcitrant material is left behind
  ⇨ Decomposition rate is lowered

Estimated availability of organic N in manures

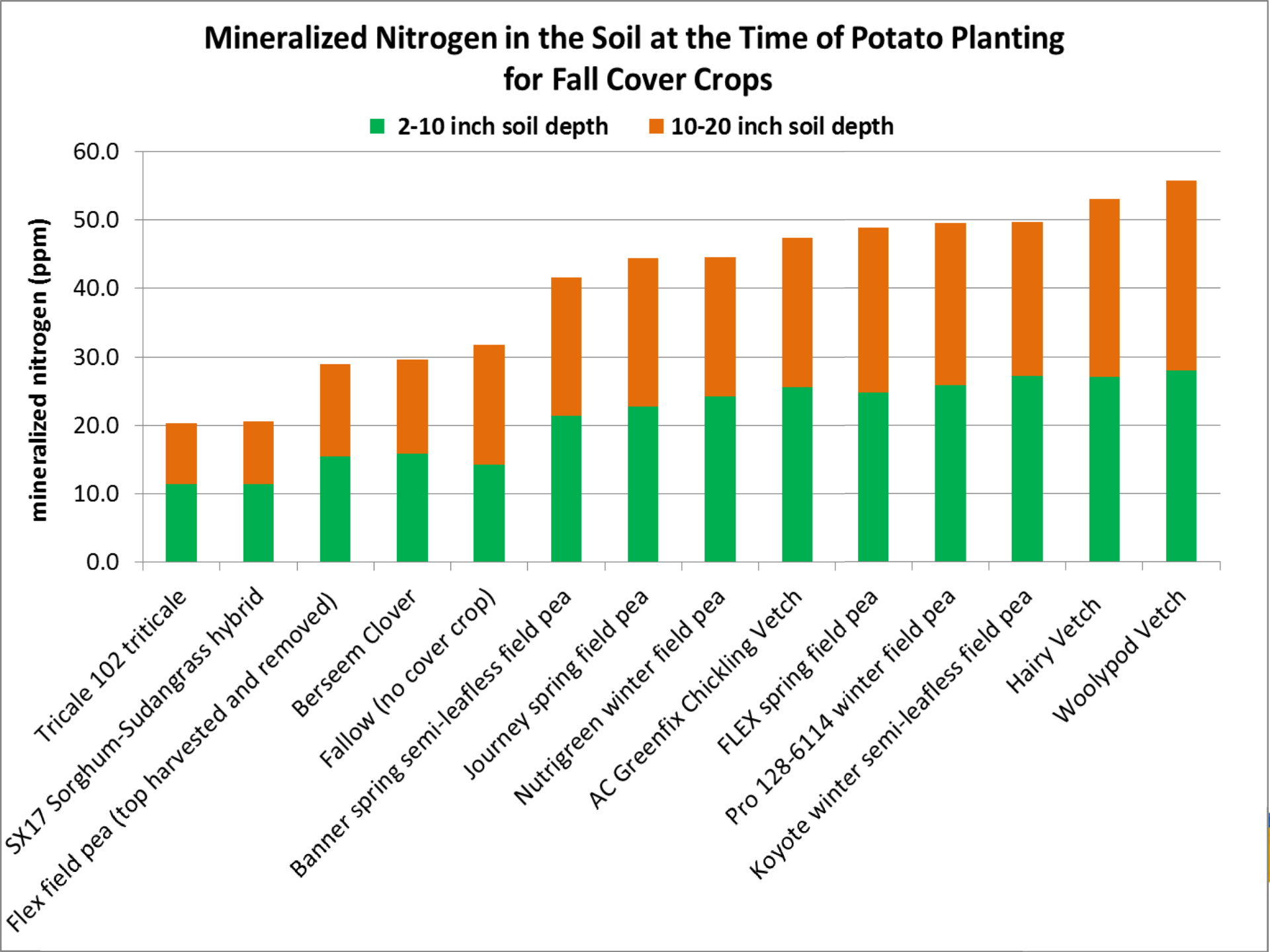
Manure type	% applied organic N mineralized		
	Initial 4-8 weeks	Year 1	Year 2
Dairy lagoon water	15-35	40-50	15
Dairy lagoon sludge and slurry; corral manure	10-20	20-30	15
Dairy mechanical screen solids	5-15	10-20	5
Aerobically composted cattle or horse manure (finished or mature)	0-7	0-10	5
Solid poultry manure	20-35	50	15

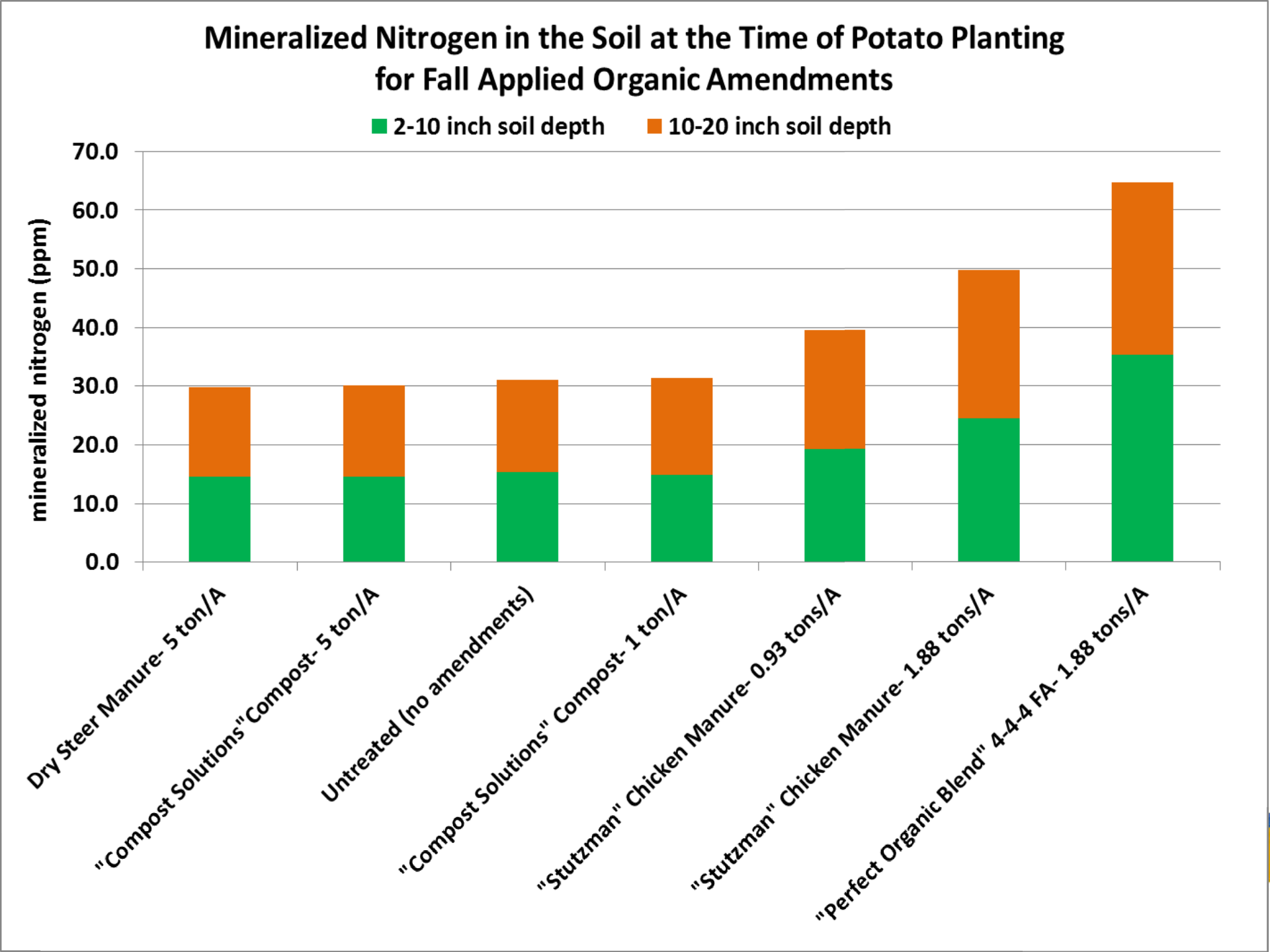
Pettygrove et al., 2009; Hartz et al, 2000; Gale et al., 2006

2015 Results

Influence of Cover Crops and Amendments on Russet Norkotah Potato Crop

Mineralized Nitrogen in the Soil at the Time of Potato Planting for Fall Cover Crops




Mineralized Nitrogen in the Soil at the Time of Potato Planting for Fall Applied Organic Amendments
2-10 inch soil depth
10-20 inch soil depth
mineralized nitrogen (ppm)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Dry Steer Manure- 5 ton/A
"Compost Solutions"Compost- 5 ton/A
Untreated (no amendments)
"Compost Solutions" Compost- 1 ton/A
"Stutzman" Chicken Manure- 0.93 tons/A
"Stutzman" Chicken Manure- 1.88 tons/A
"Perfect Organic Blend" 4-4-4 FA- 1.88 tons/A


No
Fertilizer


150 lb. N/A
Urea

University of California
Agriculture and Natural Resources | Research and Extension Center System


Hairy
Vetch

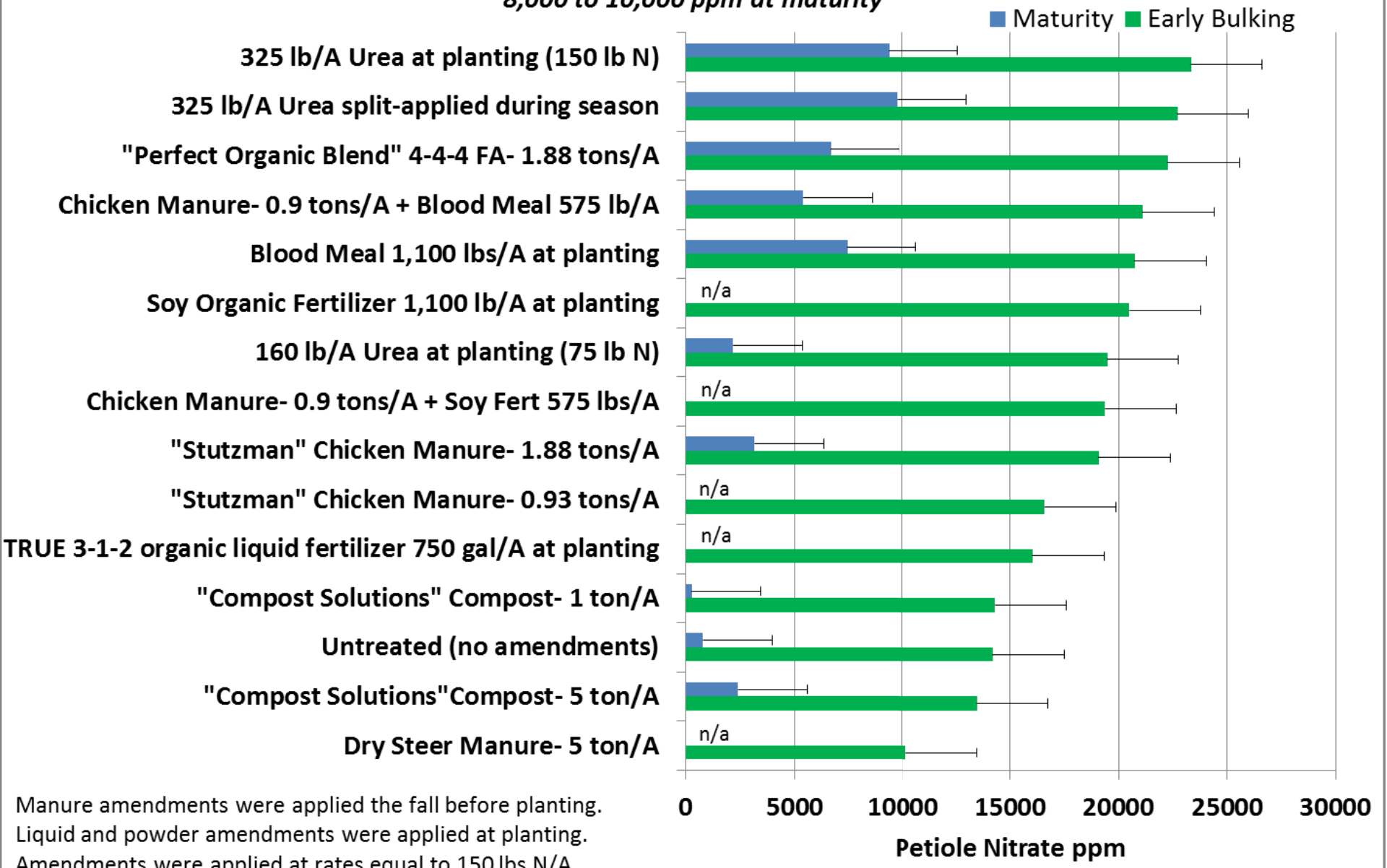

Woolypod
Vetch


"Stutzman"
Chicken Manure
150 lbs. N/A
In Fall


"Compost Solutions"
Compost
150 lbs. N/A
In Fall

Petiole Nitrate for Fall and Spring Applied Organic Amendments

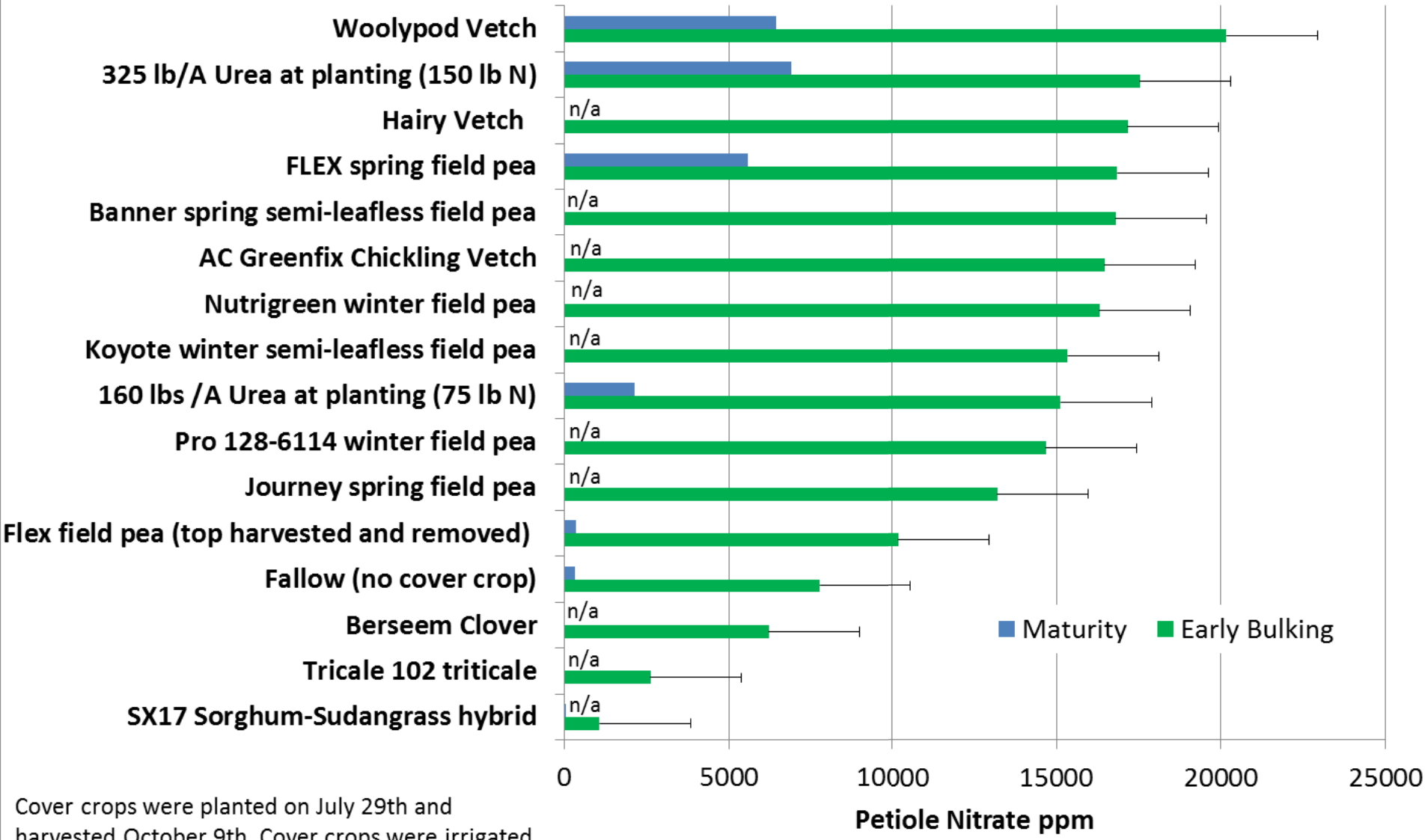
Recommended Petiole Nitrate for R. Norkotah is 17,000 - 19,000 ppm at early bulking and 8,000 to 10,000 ppm at maturity



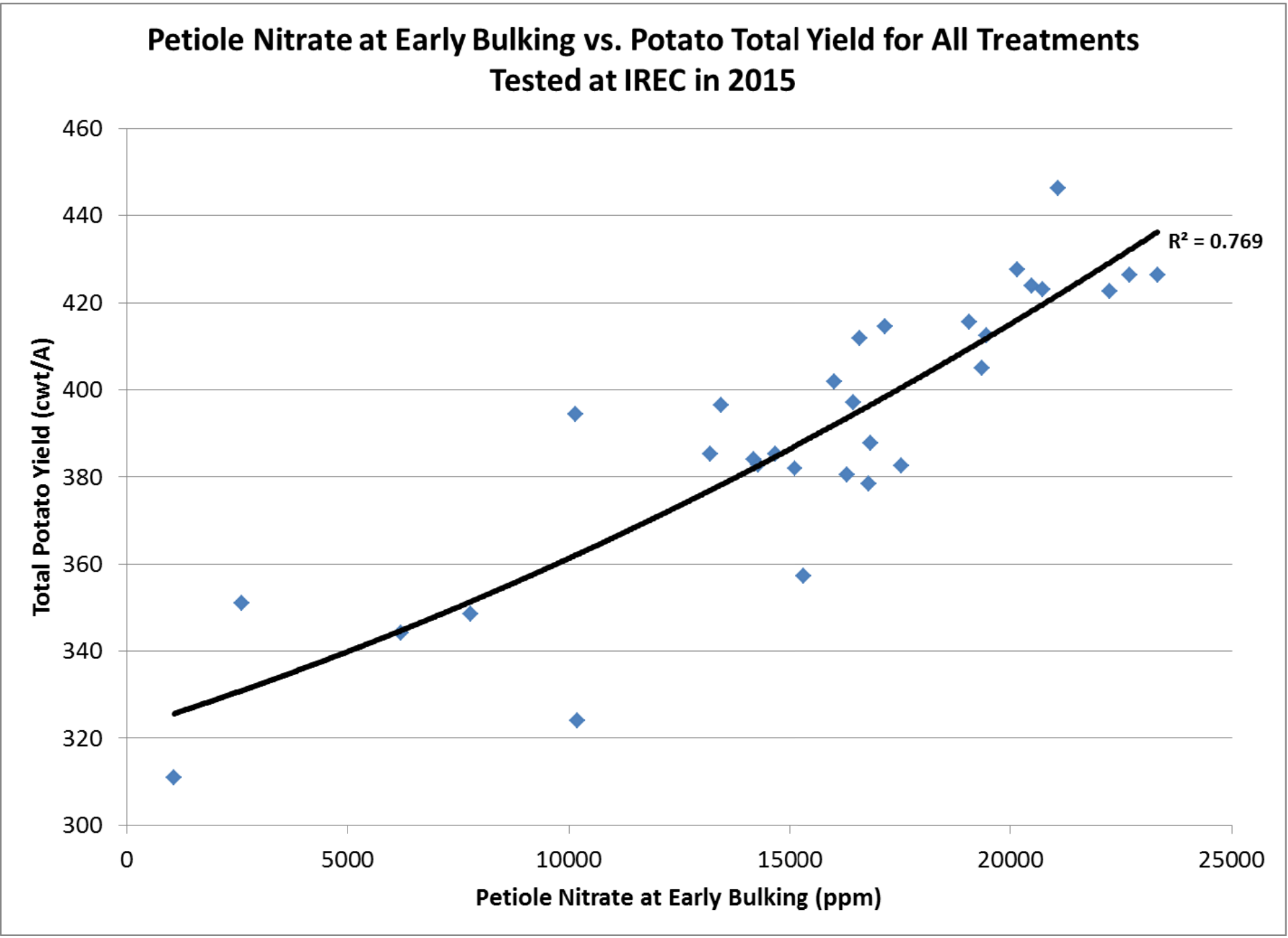
Manure amendments were applied the fall before planting.
Liquid and powder amendments were applied at planting.
Amendments were applied at rates equal to 150 lbs N/A.

Petiole Nitrate for Summer Planted Cover Crops

Recommended Petiole Nitrate for R. Norkotah is 17,000 - 19,000 ppm at early bulking and 8,000 to 10,000 ppm at maturity



Cover crops were planted on July 29th and harvested October 9th. Cover crops were irrigated to match crop ET.


Petiole Nitrate at Early Bulking vs. Potato Total Yield for All Treatments Tested at IREC in 2015
460
440
420
400
380
360
340
320
300
Total Potato Yield (cwt/A)
0
5000
10000
15000
20000
25000
Petiole Nitrate at Early Bulking (ppm)
R² = 0.769

Result Summary

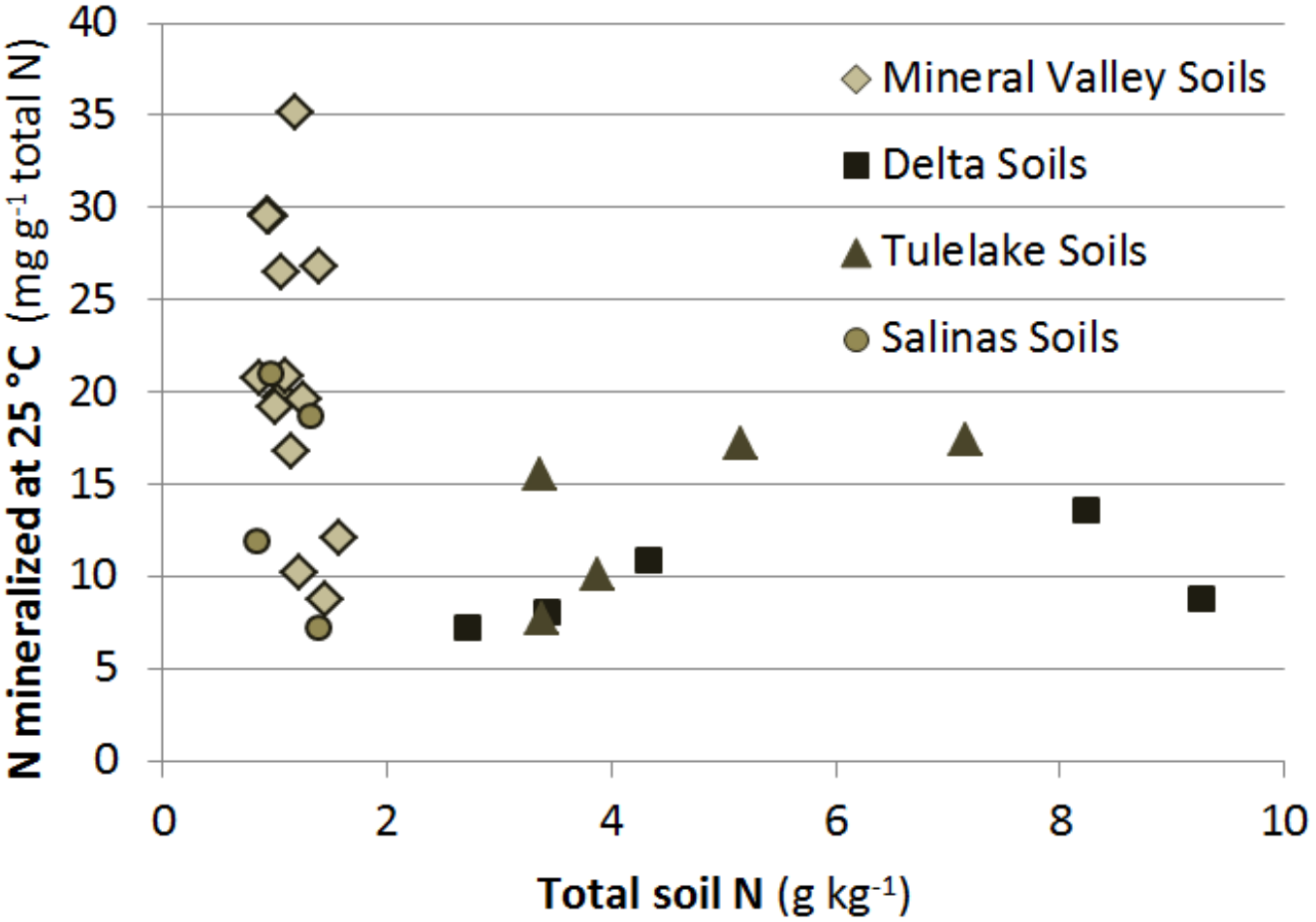
- Potato yields for cover crop and amendment treatments was highly correlated with nitrogen availability during the early growing season
- Nitrogen fixing cover crops such as field peas and vetch produced more than enough nitrogen to fertilize a Russet Norkotah crop
- Most of the nitrogen was in the cover crop tops! The tops must be incorporated to get the nitrogen benefit
- Composted chicken manure was the most cost-effective amendment

N Mineralization in Soils

- Soils are a huge reservoir of nutrients (3% organic matter soil has over 5000 lbs of stored N per acre)
- How much N is released and when it is released is the difficult question
- There are some quick calculations to approximate soil mineralization rates but for large scale agriculture they are often not accurate enough to base decisions on.

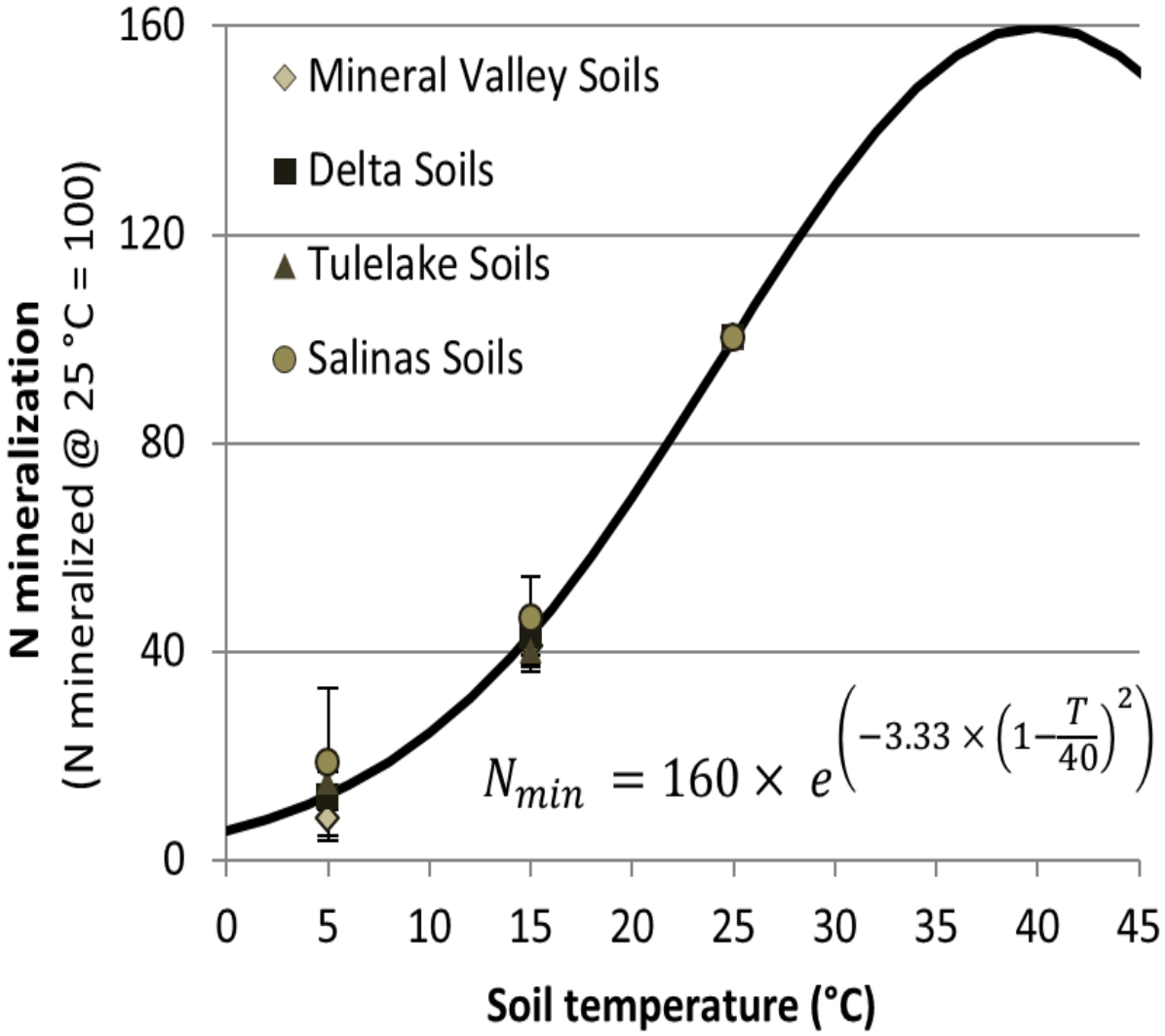
N mineralization from soil organic matter

- An estimated 1-3% of soil organic matter nitrogen is mineralized during growing season



Net N mineralization as a function of total soil N.

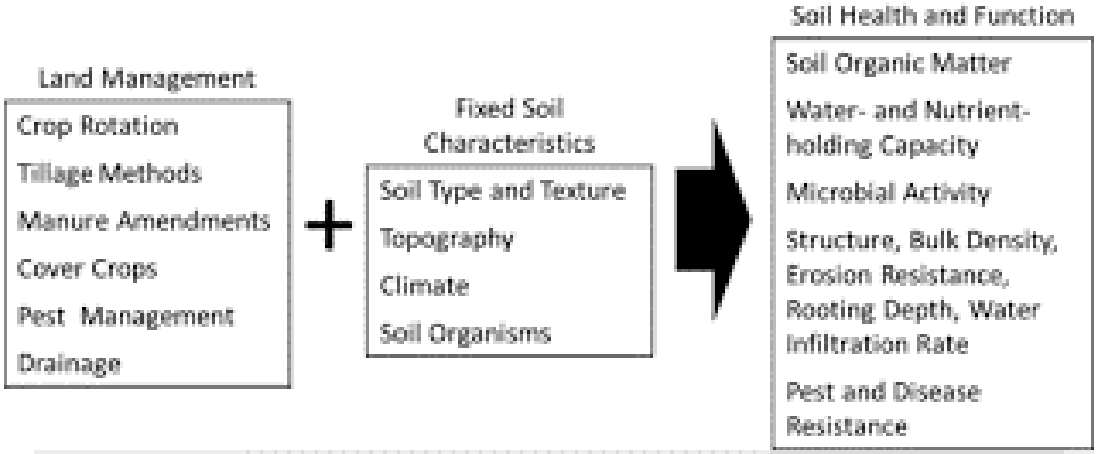
- Mineral soils had much more variability than Tulelake and Delta soils.
- Large differences in mineral soils is likely due to interactions with soil minerals and cropping history, and crop residues.
- Delta and Tulelake soils formed under water saturated conditions. In absence of oxygen decomposition is incomplete and organic matter accumulates. N mineralization per unit % soil N tends be lower in these soils and SOM is more stable.



Soil temperature response curve of N mineralization at 5(41F), 15(59F), and 25 (77F) degree Celsius

- Soil temperature had a strong effect on N mineralization.
- The temperature response curve differed little across all sites.

Factors Influencing Soil Health



- Very complex system with many interactions
- Develop an understanding of how crop management practices influence biological processes and the abiotic soil environment

Soil your Undies
(dirty drawers test)

Tea Bag Index


eat
me

Lessons I've Learned

- Site specific management is critical to success; a single management recipe rarely works on every site
- Develop a good understanding of crop development, crop nutrient needs, and how crop production practices influence soil health
- Conduct on-farm trials to test new practices and validate current practices when needed

Thank You

- California Potato Research Board (John Walker is president)
- Local PCAs and Ag. Businesses
- Grower cooperators
- Seed Suppliers
- Daniel Geissler & Lab, UC Davis Soil Science
- IREC Staff!!