




Growing Our Own Nitrogen:
Results from 12 On-Farm Trials in MA & VT

Becky Maden, UVM

Katie Campbell-Nelson, UMass

Ryan Karb, Many Hands Farm Corps, MA

December 14th, NEVFC, Manchester, NH






Why Bother Growing Nitrogen?

On-Farm N Production

- Reduces the need for blended fertilizers, composts, and manures
- Less imports onto farm, more sustainable
- Saves money on purchased soil amendments
- Increases soil health

Vermont's Clean Water Act
Required Agricultural Practices (RAPs)

Effective July 1, 2017

"…improve the quality of Vermont's waters by reducing and eliminating cropland erosion, sediment losses, and nutrient losses"

Phosphorus is the nutrient of most concern- if soil P is over 20 ppm, farmers must reduce P applications.

Plant Nutrient Regulations in Massachusetts

December 5th, 2015

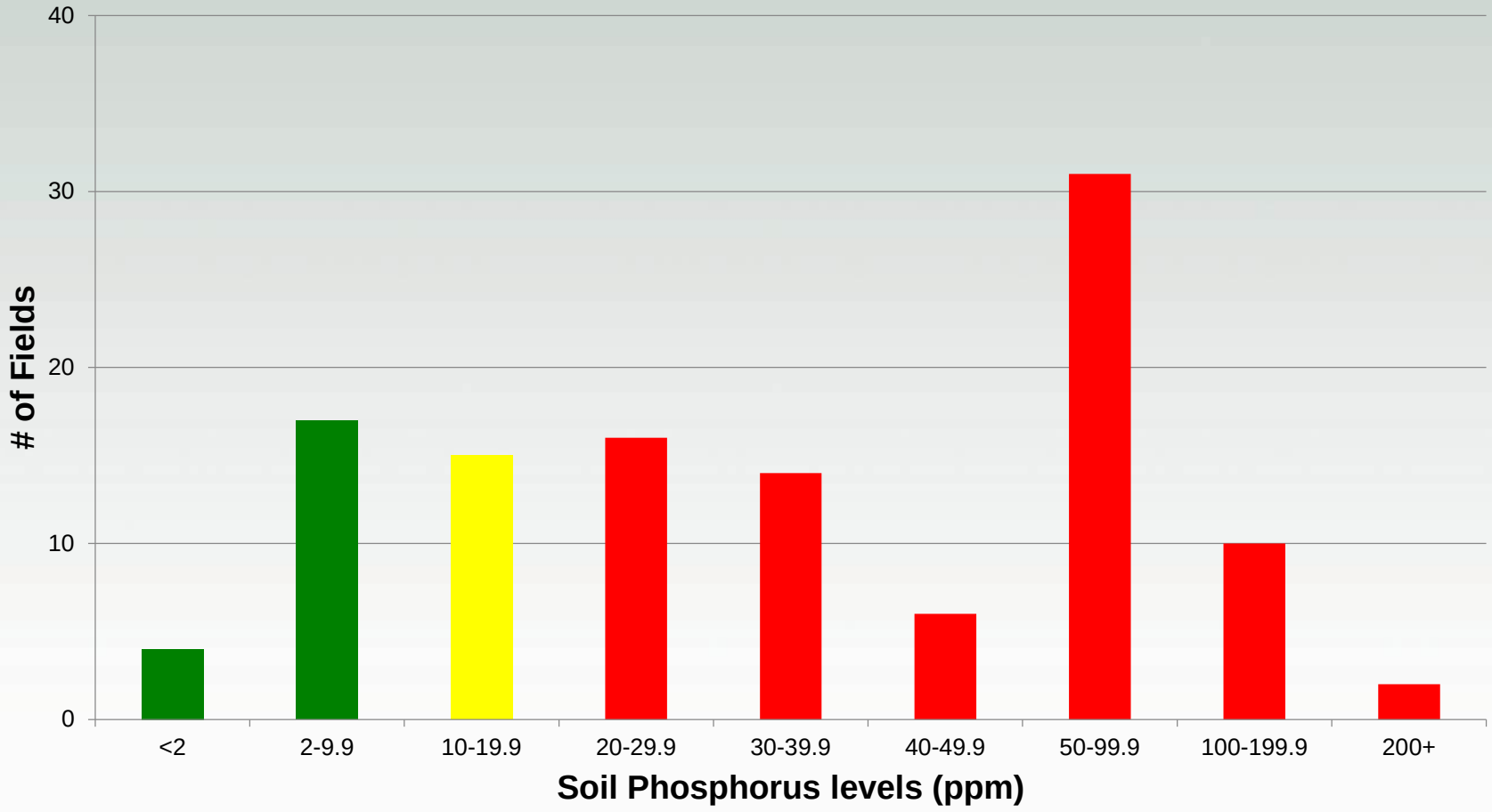
- Specify WHEN plant nutrients may be applied and LOCATIONS in which plant nutrients shall not be applied

- General requirements include:
  - Follow UMass guidelines for nutrient management

MDAR
MASSACHUSETTS DEPARTMENT OF AGRICULTURAL RESOURCES

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Soil Phosphorus Levels on 11 Commercial Vermont Vegetable Farms

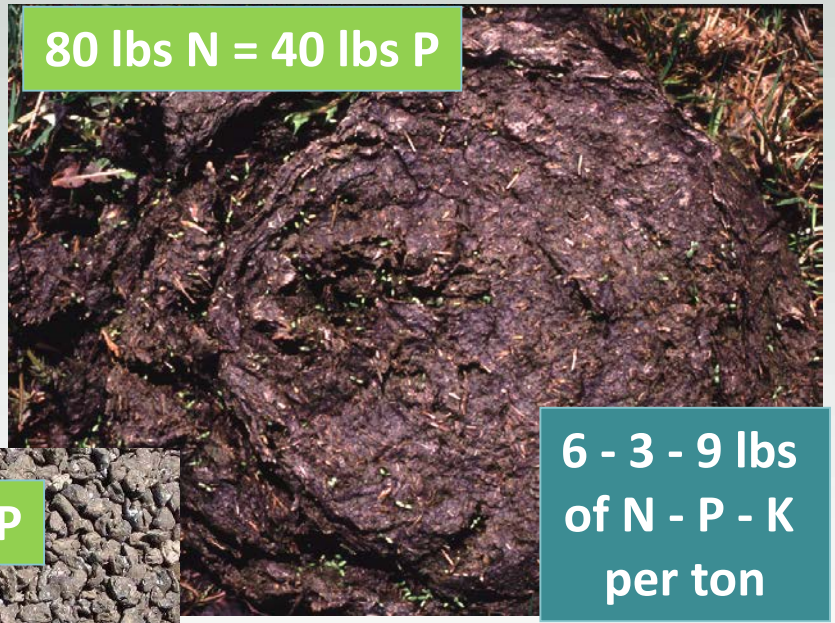


UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Using compost or manure to meet N leads to soil phosphorus accumulation on vegetable farms

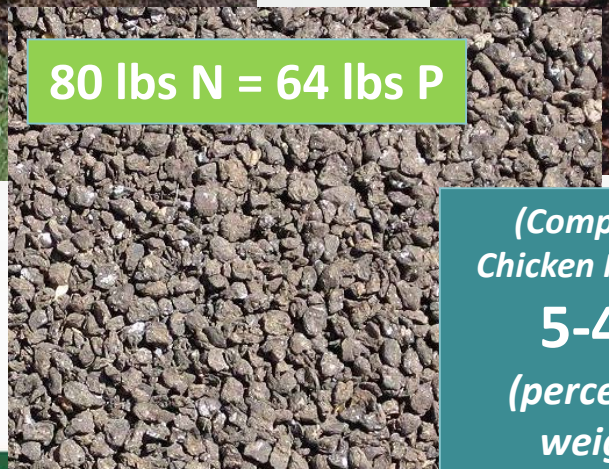
80 lbs N = 50 lbs P

3- 2- 10 lbs of N - P - K per ton



80 lbs N = 40 lbs P

6 - 3 - 9 lbs of N - P - K per ton



80 lbs N = 64 lbs P

(Composted Chicken Manure)

5-4-3

(percent by weight)

*Adapted from "Using Manure and Compost as Nutrient Sources for Fruit and Vegetable Crops" Univ. of MN Extension – Numbers vary widely based on manure and compost used.

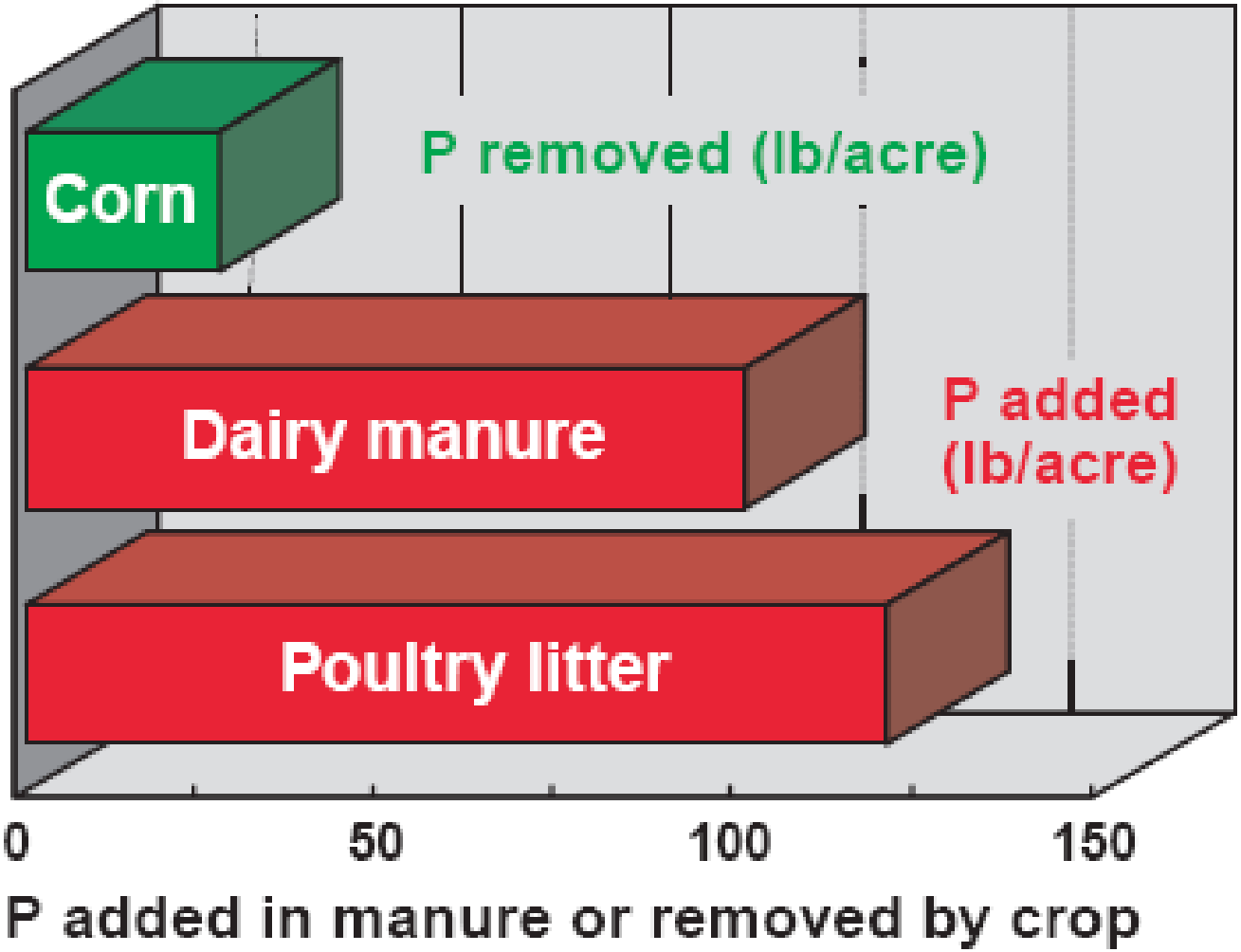
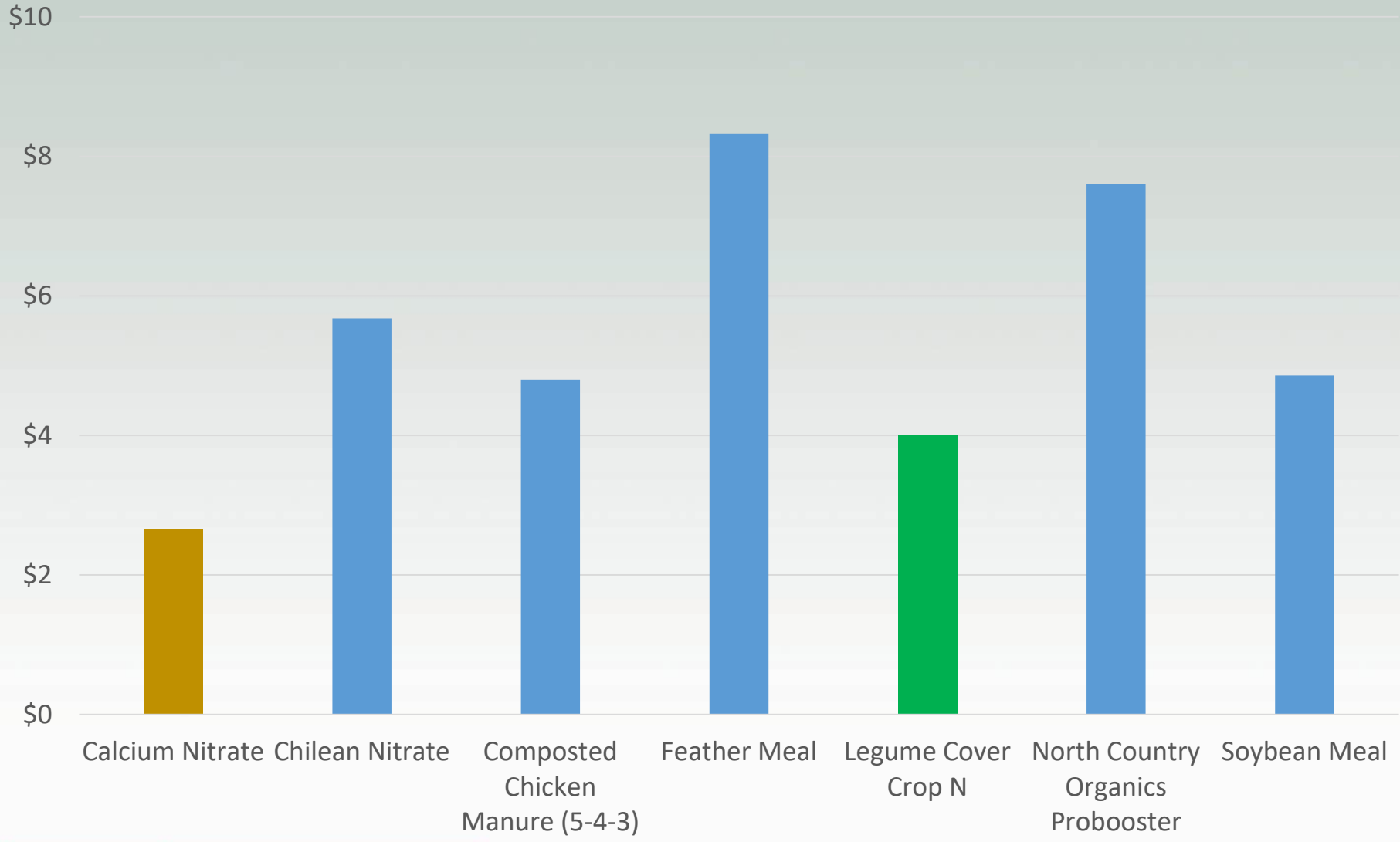


Figure 5. Applying manure to meet crop N needs (about 200 lb available N/acre) adds much more P than corn crop needs.

Legume Cover Crops

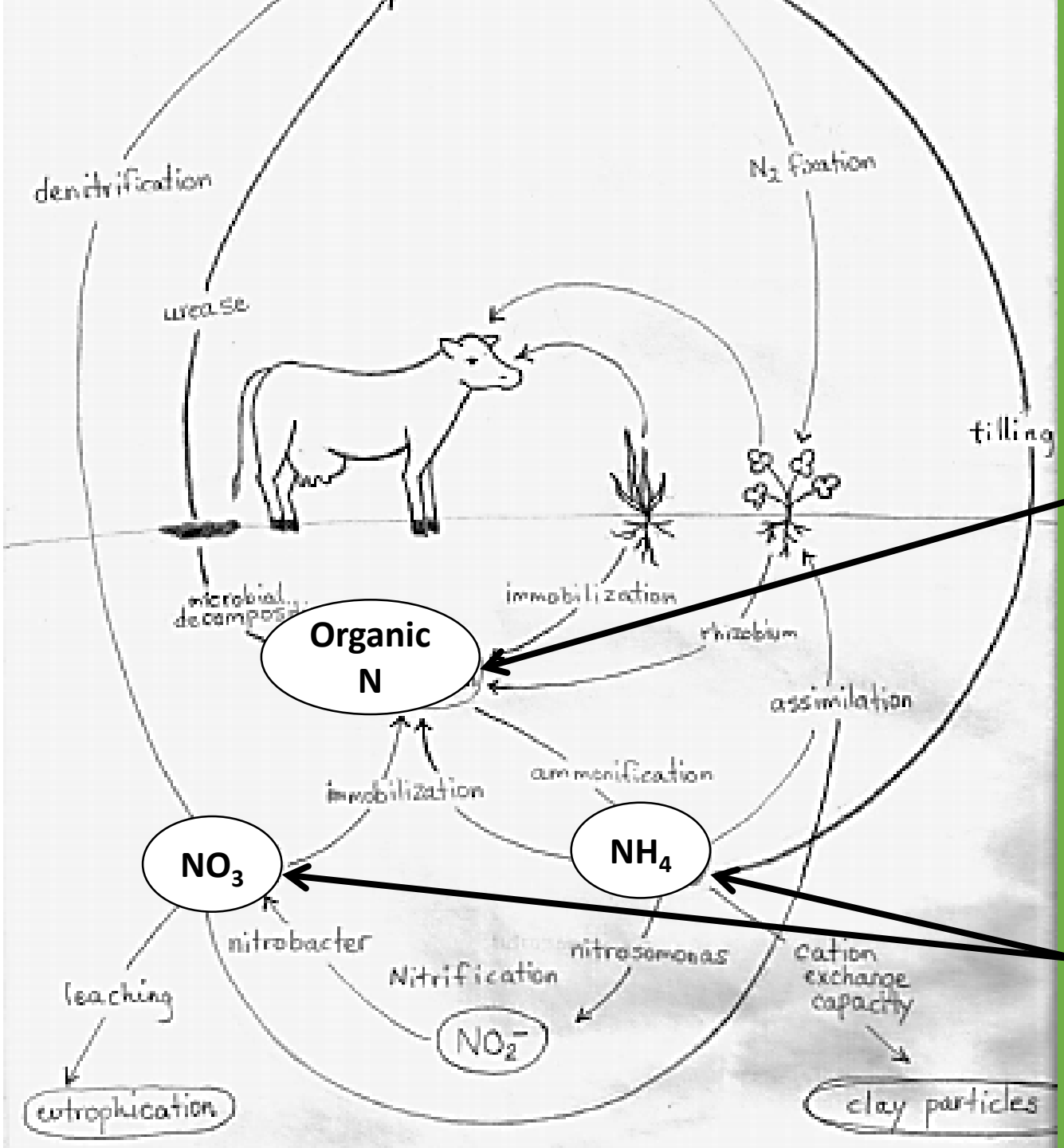
- Source of N with no additional P
- Cost-benefit varies based on variety, seed cost, seeding rate, region, termination time, etc.
- Likely to be cost effective for most organic growers compared to other sources of N.

Estimated Costs per pound N



What we thought we knew

The Nitrogen Cycle

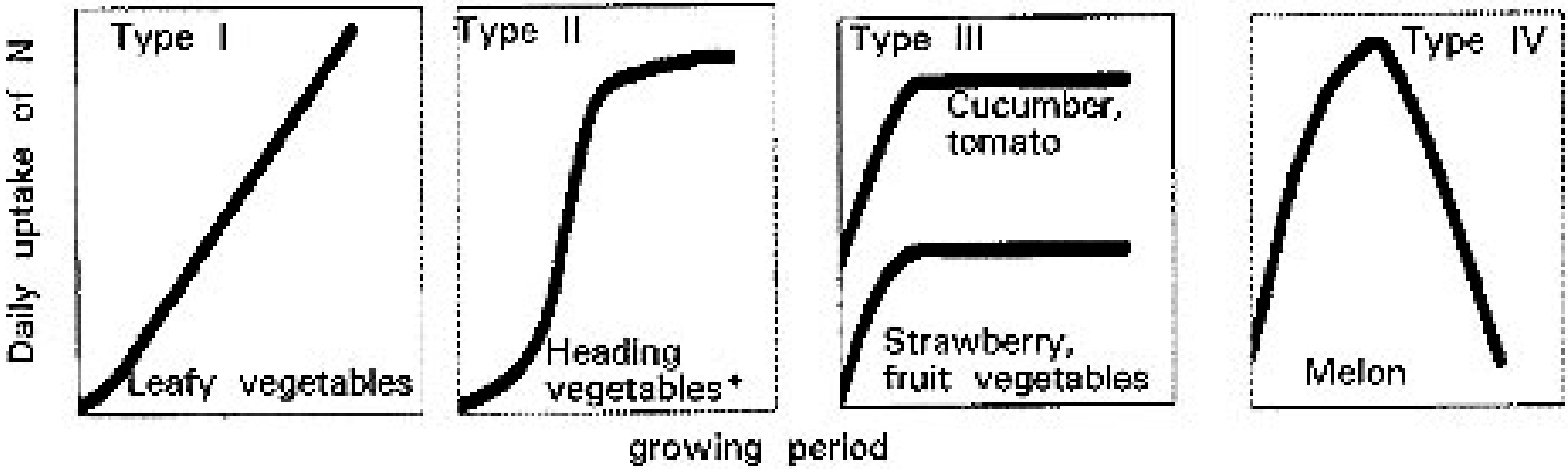


Release Rates

Slow

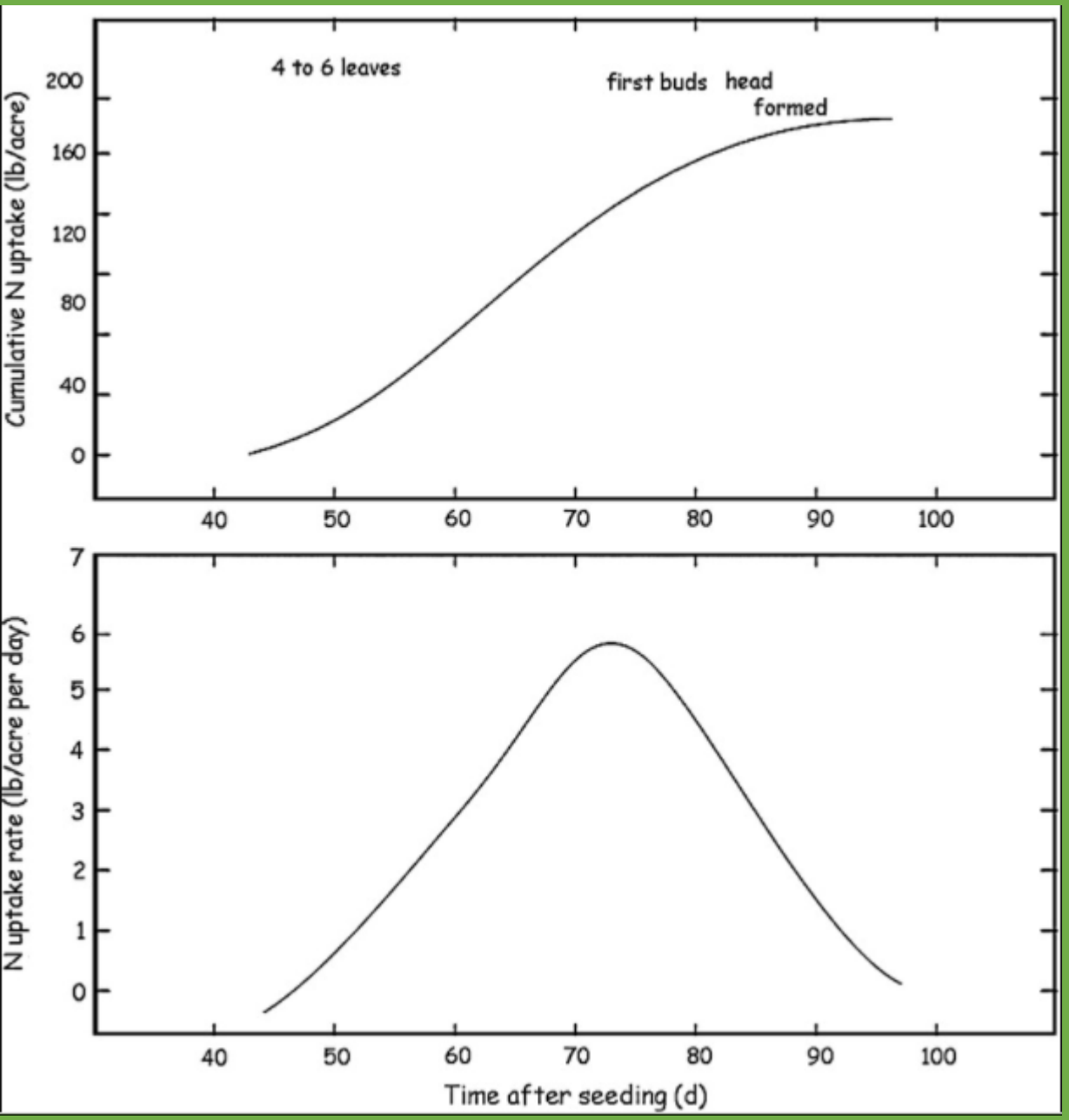
Quick

Nitrogen use curves



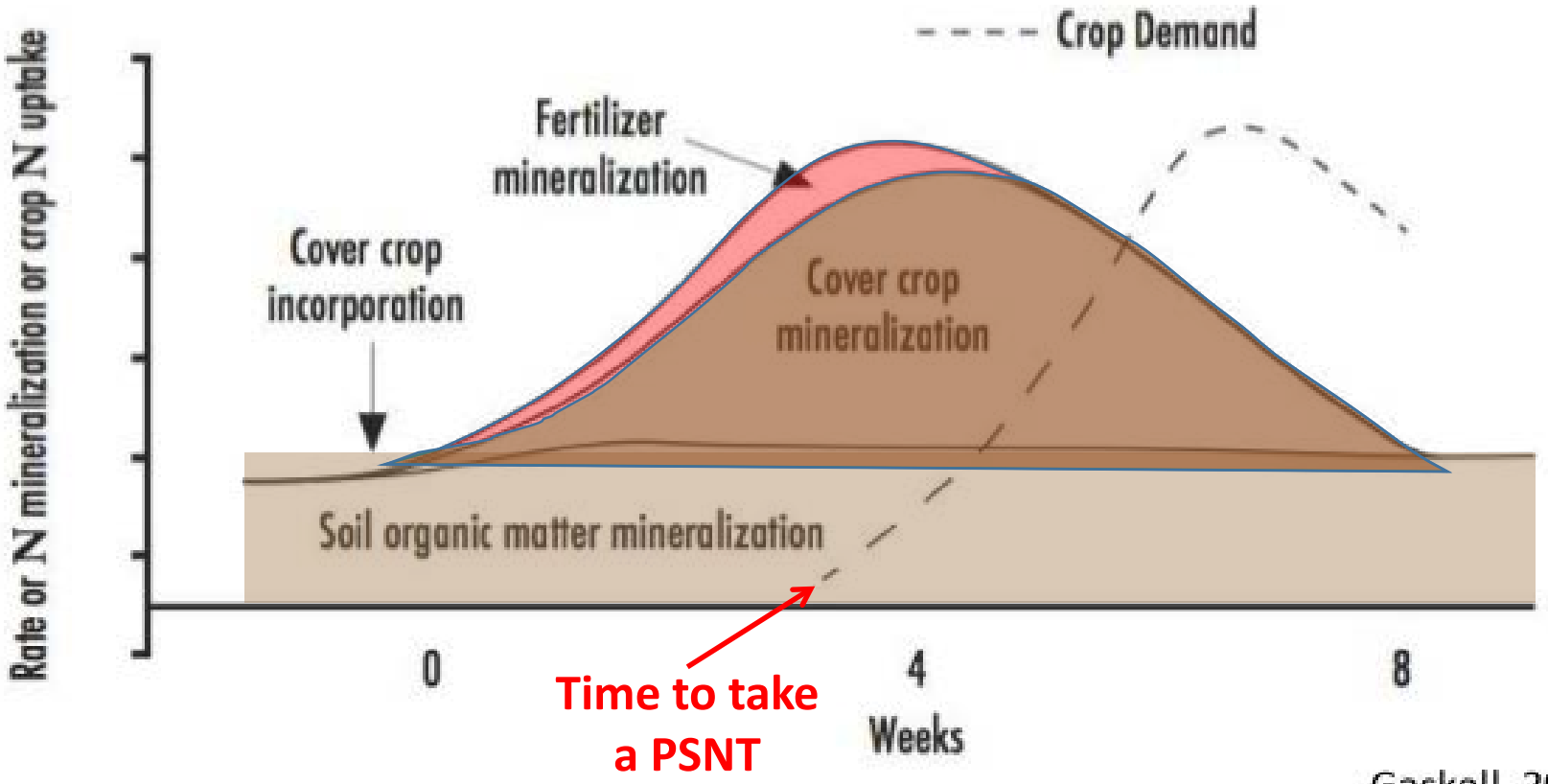
Source: Redrawn after Kato (2000)

* i.e. leaf vegetables which form a head, such as cabbage



Phases of broccoli crop nitrogen (N) uptake rate (lb/acre per day) and cumulative N uptake in lb/acre (1 lb/acre = 1.1209 kg·ha^{-1}) compared with broccoli biomass accumulation in ton/acre (1 ton/acre = 2.2417 mg·ha^{-1}) (Sullivan et al., 1999).

Figure 1. Timing of nitrogen mineralization from soil organic matter, cover crop residue, and organic fertilizer in relation to crop nitrogen uptake.



Gaskell, 2006

Estimating Nitrogen availability

New England Vegetable Management Guide: https://nevegetable.org/

PNW 636 • November 2012

ESTIMATING PLANT-AVAILABLE NITROGEN RELEASE FROM COVER CROPS

D.M. Sullivan and N.D. Andrews

HIGHLIGHTS

- Legume cover crops provide up to 100 lb PAN/a. To maximize PAN contribution from legumes, kill the cover crop at bud stage (early May).
- Cereal cover crops immobilize up to 50 lb PAN/a. To minimize PAN immobilization from cereals, kill the cover crop during the early stem elongation (jointing) growth stage (early April).
- Legume/cereal cover crop mixtures provide a wide range of PAN contributions, depending on legume content. When cover crop dry matter is 75 percent from cereals + 25 percent from legumes, PAN is usually near zero.
- A laboratory analysis for cover crop total N as a percentage in dry matter (DM) is a good predictor of a cover crop's capacity to release PAN for the summer crop.
  - When cover crops contain a low N percentage (less than 1.5 percent N in DM), they provide
- PAN from legume cover crops is usually much less expensive than PAN from organic fertilizers.
- Values for cover crop PAN listed here are most applicable to winter cover crop/summer vegetable crop rotations in western Oregon and Washington.

Dan M. Sullivan, Extension soil scientist, and Nick D. Andrews, small farms Extension agent; both of Oregon State University

A Pacific Northwest Extension Publication
Oregon State University • Washington State University • University of Idaho

Most Plant Available Nitrogen is released 4-6 weeks after cover crop kill.

Divide the total estimated N content of your green manure by 2 if you are plowing it down and the weather is expected to be warm with adequate rain (based on seasonal averages, or, if you're feeling lucky, on astrological predictions). Divide by 4 (conservative estimate) if you are leaving the green manure on the surface in a no-till system or if you are cropping during a cold or very wet season.

CULTIVATING HEALTHY COMMUNITIES






Growing Our Own Nitrogen:
Results from On-Farm Trials in VT

Becky Maden, University of Vermont Extension

December 14th, NEVFC, Manchester, NH

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Understanding Nitrate in Vermont

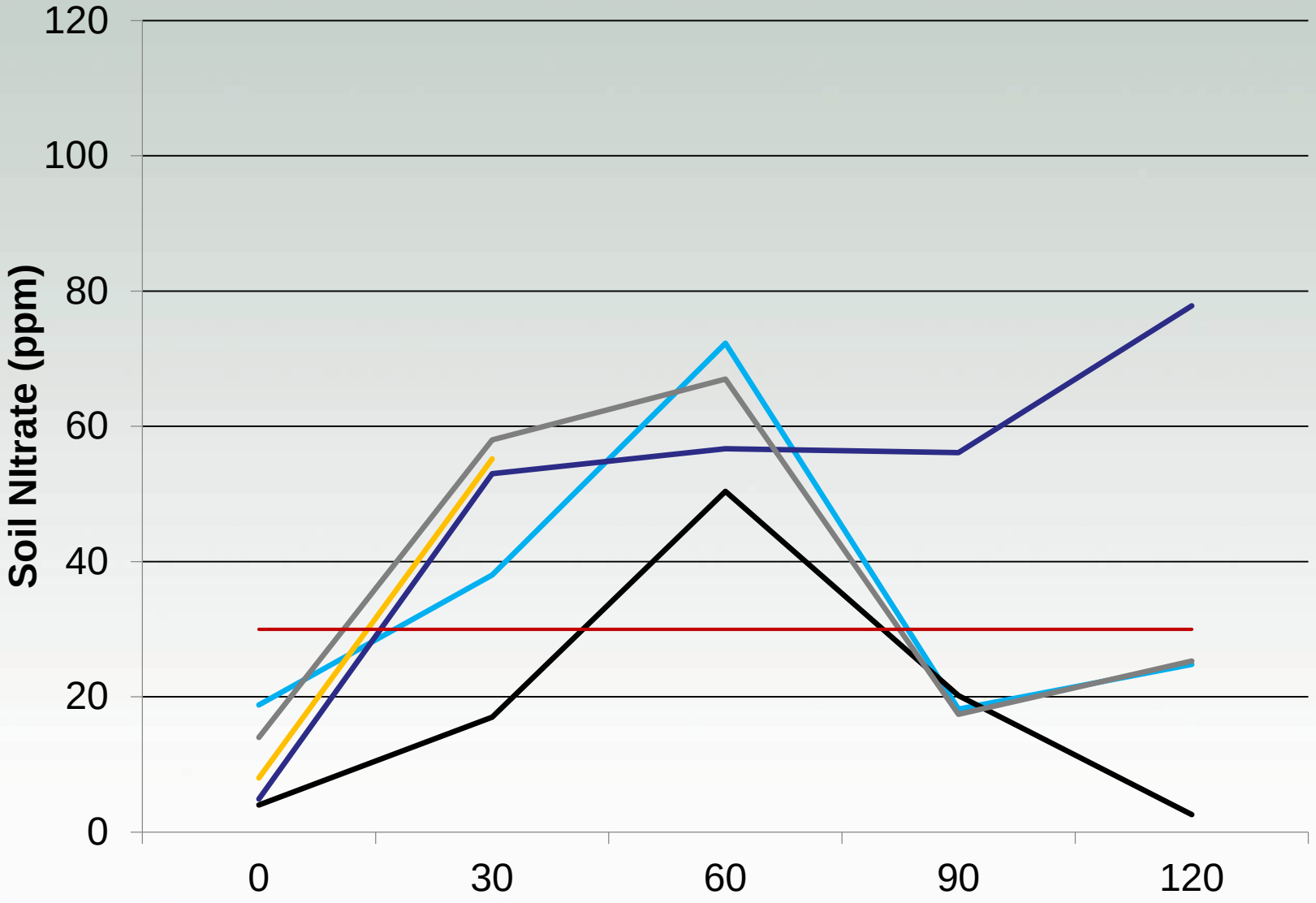
Our research questions

- Can we rely on the nitrate produced by legumes for cash crops?
- Timing and duration of nitrate availability from legume cover crops for cash crop uptake?
- Best time (date) to incorporate legume cover crop for maximum N availability?
- Compare common legume cover crops
- Best time to take a PSNT for veg crops?
- Cost/ benefit analysis of N provided by legume cover crops?

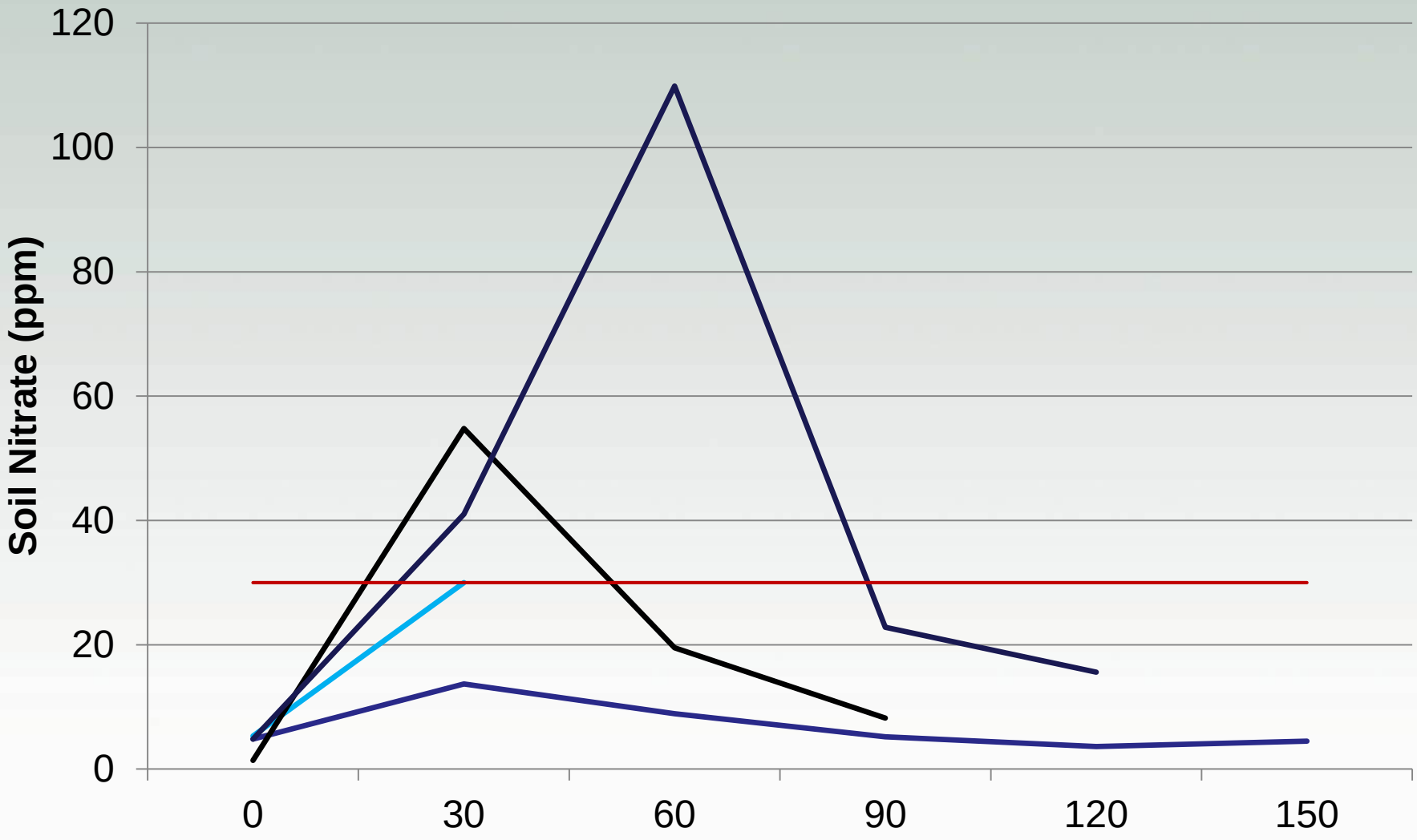
2016 Background Study

- Landscape scan of 11 VT veg farms
- Farmers sampled 6 different legume cover crops already seeded on the farms
  - *Farmers maintained usual practices including fertilization and irrigation.*
- Monthly PSNT samples from pre-incorporation through October

Soil Nitrate Levels Following Oat Pea Cover Crop



Soil Nitrate Levels Following Rye Vetch Cover Crop



UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Findings…

- Fall planted Rye Vetch and spring planted Oat Pea release max plant available nitrogen (PAN) 4-6 weeks after incorporation
- Seeding legume with grain helps sustain nitrate levels
- Annual rainfall and temperature **major** factor in nitrate availability

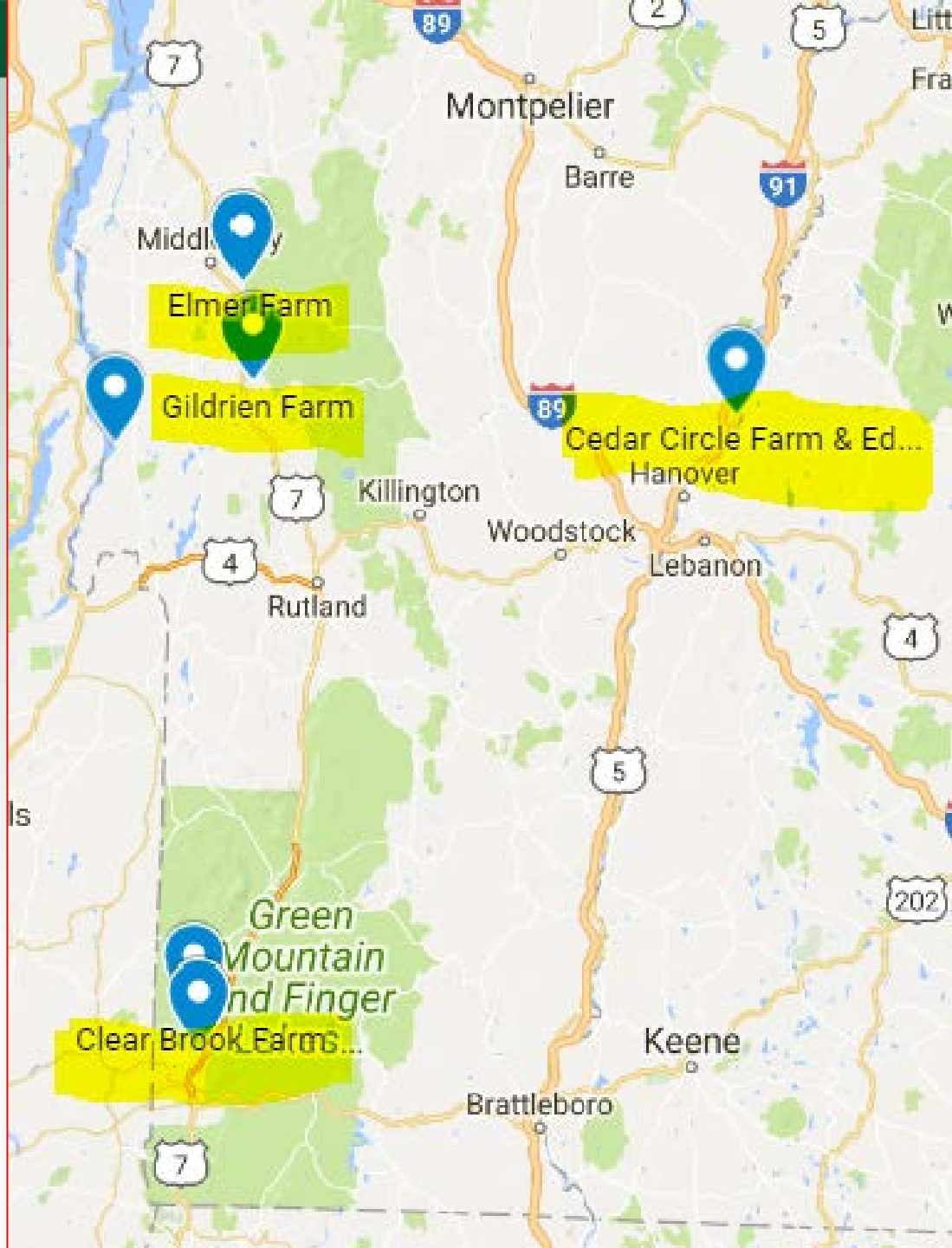
UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Two Year On-Farm Trial (2017-2019)

- 4-6 commercial vegetable farms
- ¼- ½ acre blocks
- Spring: Oat Pea (120# Peas, 20# oats), seeded April 22 (+/- 1 week)
- Fall: Rye Vetch (70# Rye, 20# vetch), seeded September 15 (+/- 1 week)
- Cash crop= Transplanted sweet corn, var. Montauk

2017 Trial Farms in VT

- *All Commercial, Organic Vegetable Farms*
- *3 in Addison County*
- *2 in Bennington County*
- *1 in Orange County*



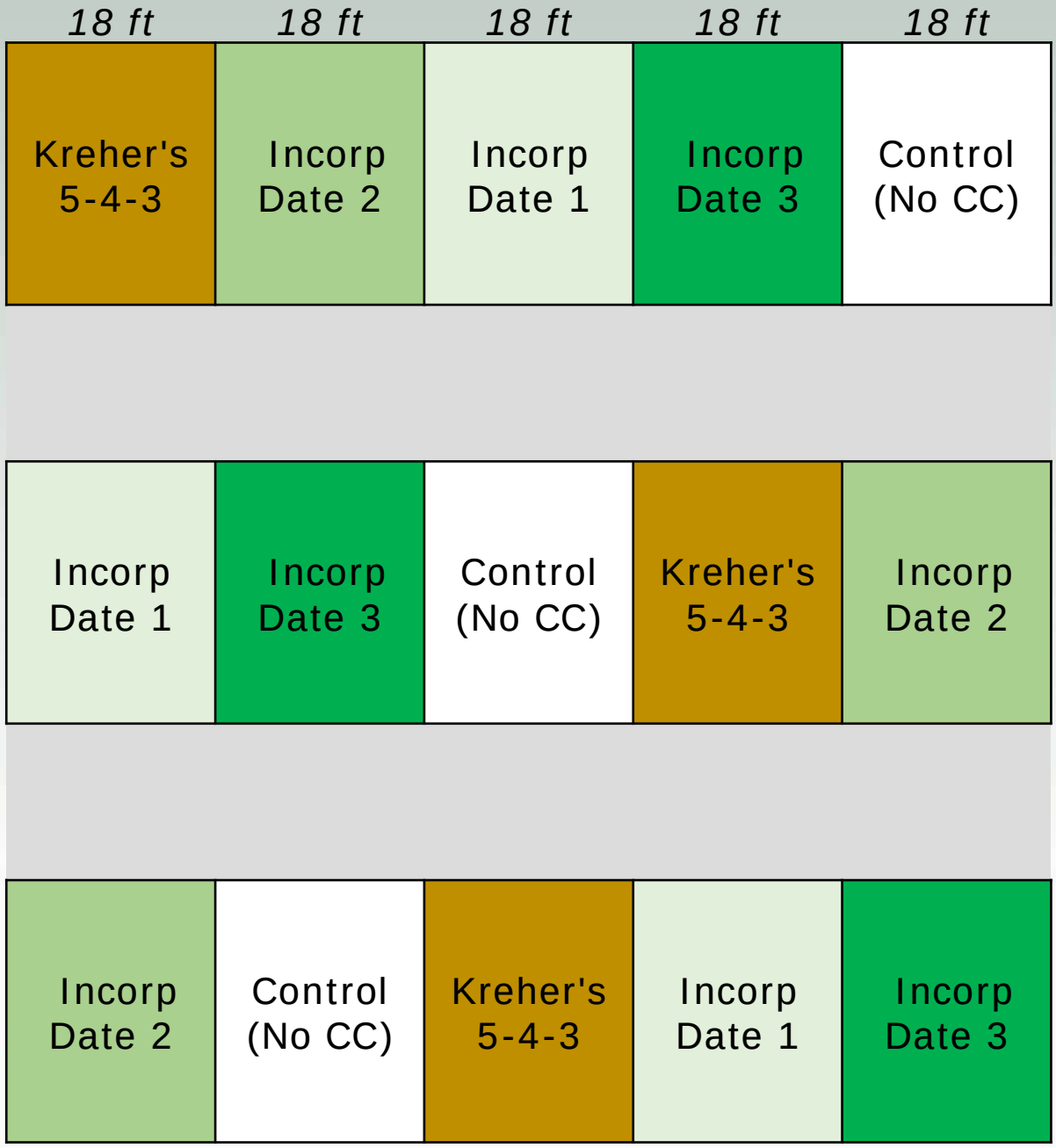
UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Trial Layout

Replicated Complete Block Design

Treatments:

- 3 Incorporation dates
- Grower Standard (Kreher’s 5-4-3) 100 lbs N/ Acre
- Control (no cover crop, no additional N)
- *All blocks amended with P and K to match 5-4-3 rates*



UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Trial Timeline

- **April 2017** Seed Oat Pea Cover Crop
- **May-September** Collect PSNTs every other week
- **June** Collect biomass and incorporate cover crops
- **June** Transplant sweet corn
- **September** Harvest sweet corn
- **September** Collect yield data and end of season stalk nitrate tests
- **September** Seed rye vetch for 2018 plots

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

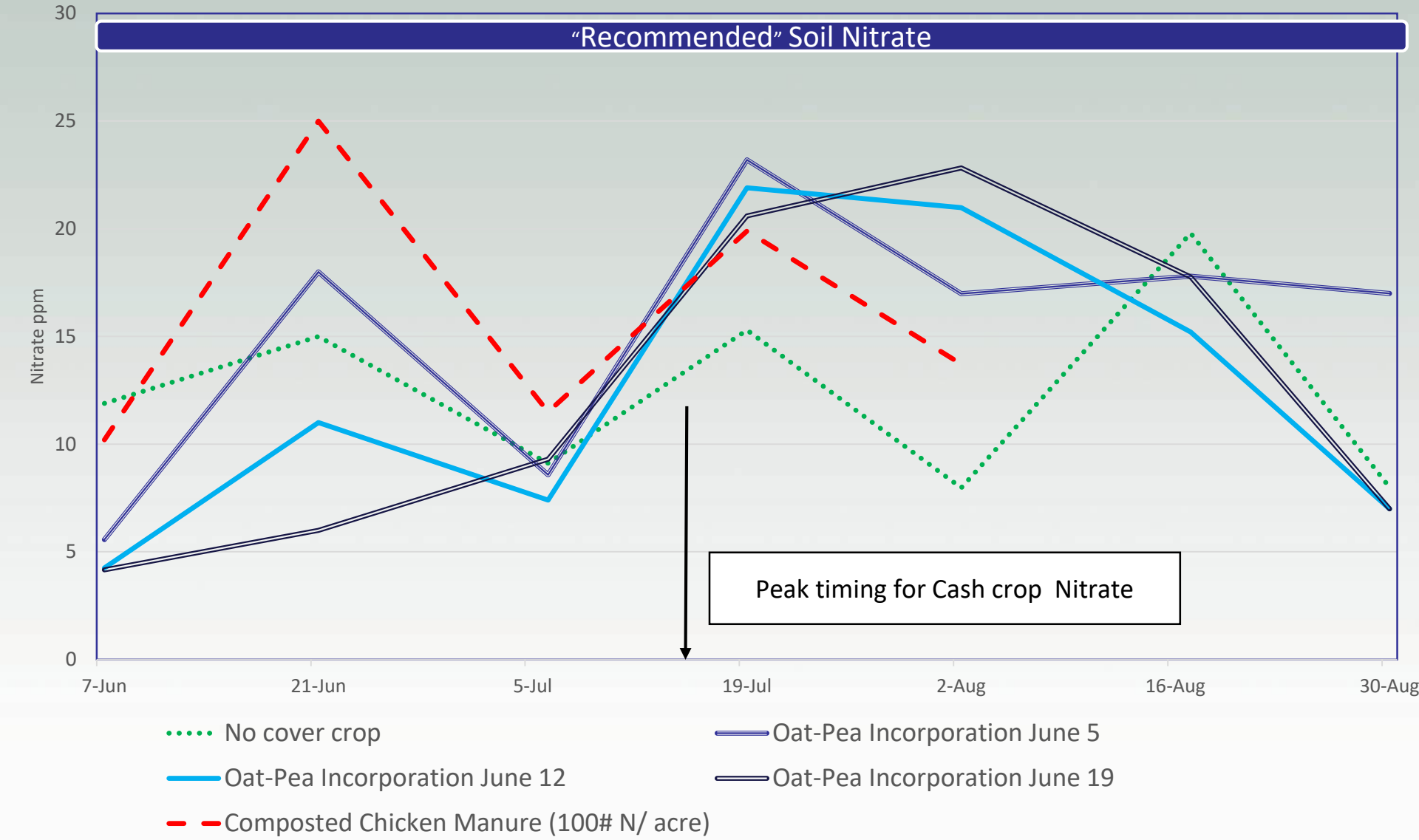
Data Collected

- **Soil Nitrate (PSNT)** every other week for 6 weeks
- **% Cover** of cover crop
- **Weed species and density**
- **Biomass of cover crop** before incorporation
- **Data Loggers** soil temperature and soil moisture
- **End of season cornstalk nitrate test**
- **Sweet corn yield**

UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

Preliminary Results…from one farm

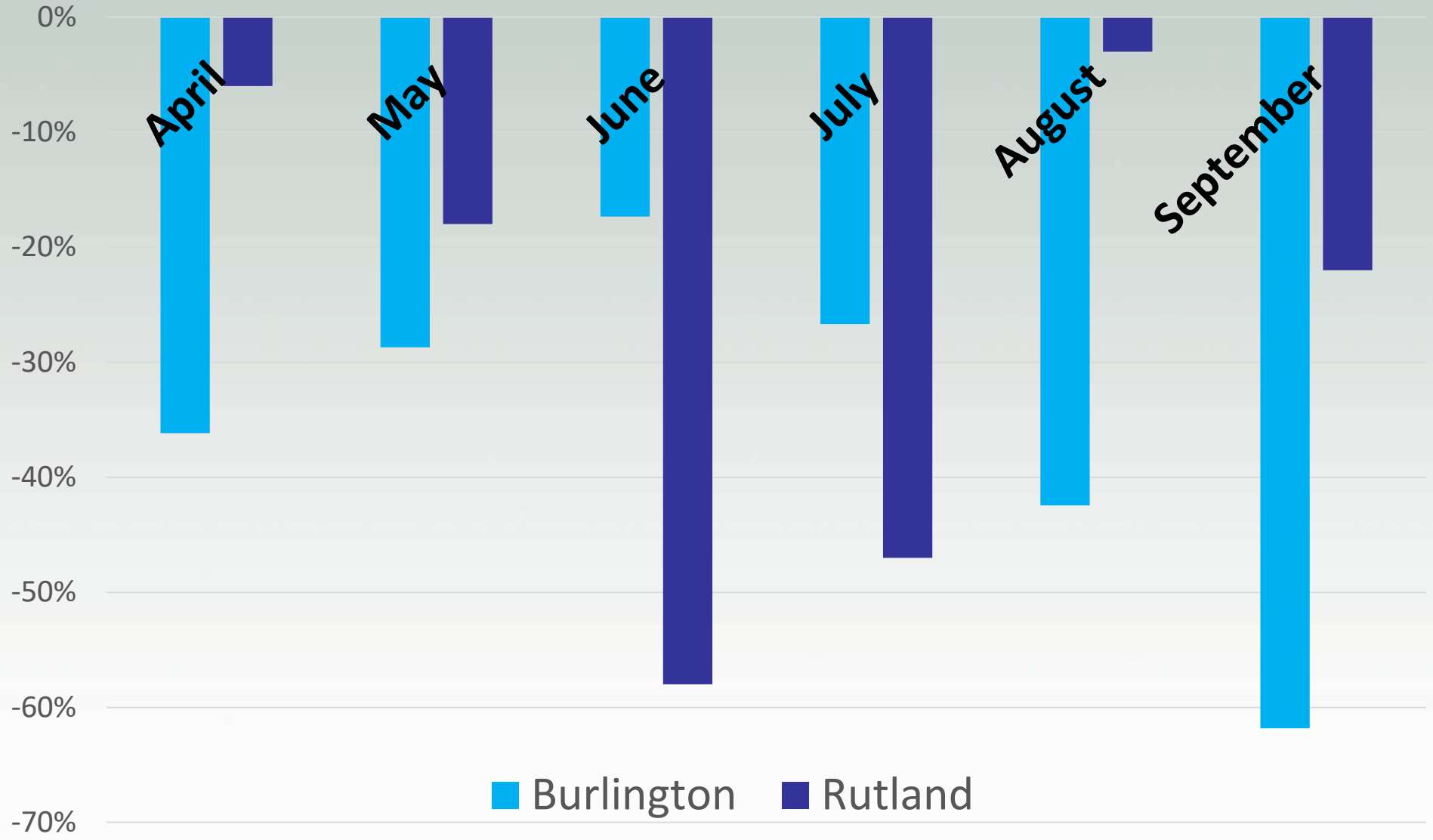


UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Variables in an on-farm trial

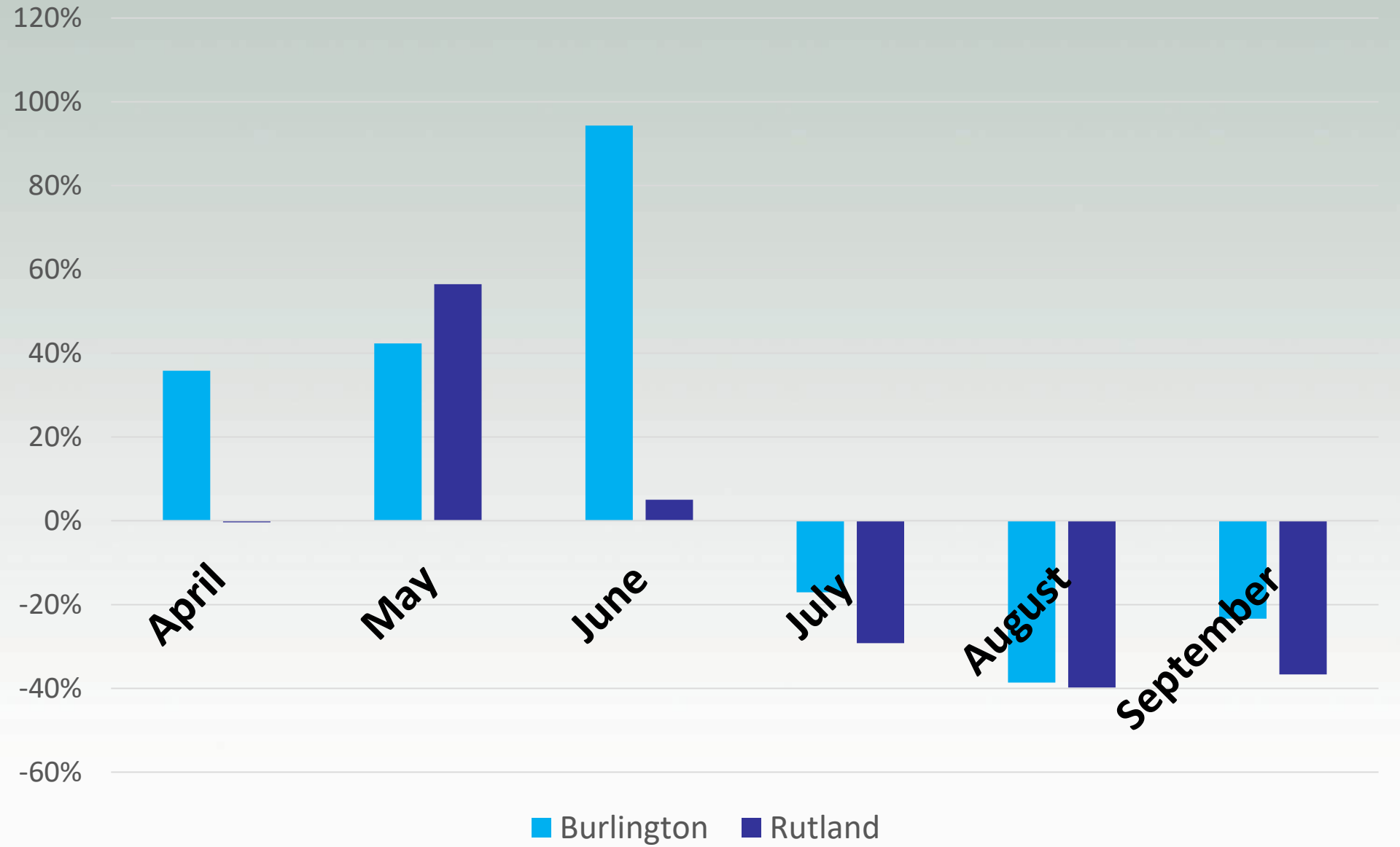
- Available equipment for seeding, incorporation, planting, and cultivating
- Soil type and soil chemistry
- Farmer practices
- Farmer needs
- Weather—temperature and rainfall

2016 Percent Deviation from Average Rainfall



UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2017 Percent Deviation from Average Rainfall



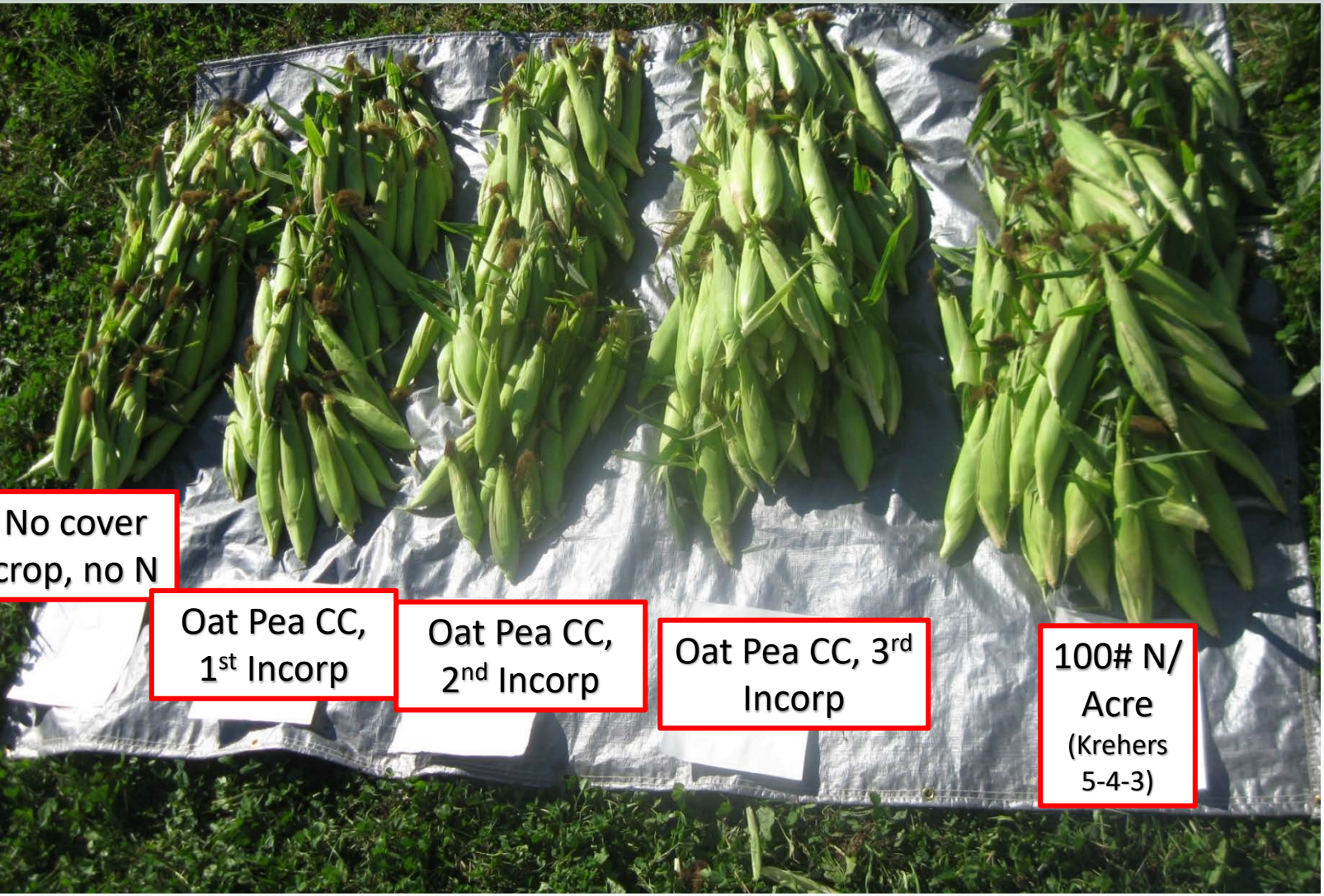
UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Preliminary Findings

- Overall crop quality and cash crop yield was best in plots with Kreher's 5-4-3
- Next best was third (last) incorporation (June 19)
- Control and first incorporation were both very poor cash crops
- Pea oat cover crop alone does not provide enough N for marketable sweet corn yields

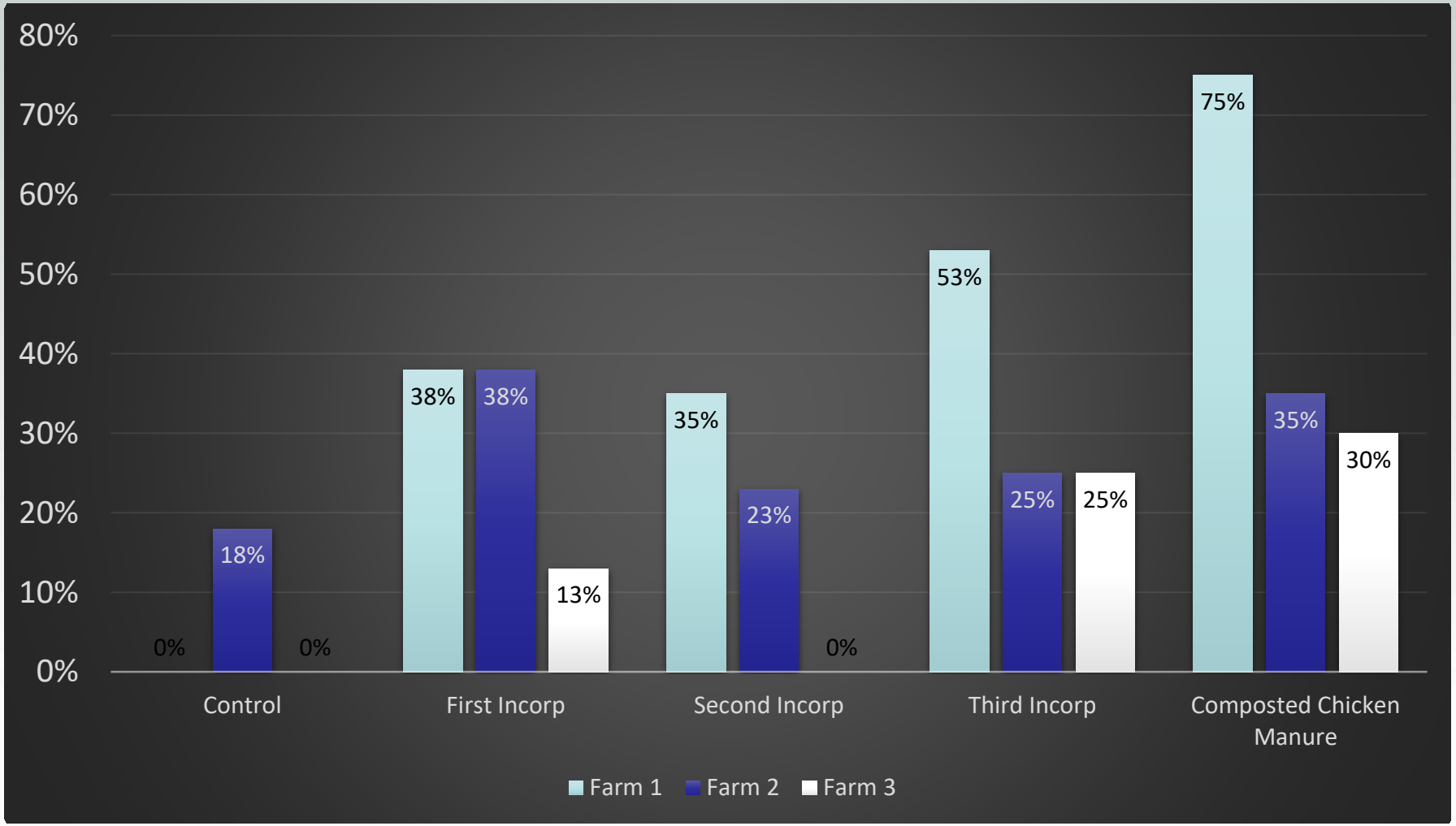
DATA CURRENTLY UNDER ANALYSIS—STAY TUNED!

Sweet Corn Yield



UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Percent Marketable Ears



UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Management Take Homes

- Incorporate 4-6 weeks before peak cash crop N need.
- Take a PSNT 4-5 weeks after CC incorporation
  - sidedress if recommended
- Don’t skimp on P and K when counting on legume N
- Incorporated cover crop residue helps with soil tilth after heavy rain (especially on clay)
- Weather events change nitrate availability. Pay attention and be ready to sidedress after heavy rains during peak crop need

Ongoing questions…

- How to manage variables associated with on farm research
- How to engage farmer participation
- What does the PSNT really tell us??
- What data/ management recommendations will be most useful to farmers from this research?
- When do cash crops really need the N?

Thank you Farmers!

Cedar Circle Farm
Clearbrook Farm
Elmer Farm
Gildrien Farm
Mighty Food Farm
Singing Cedars Farmstead

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

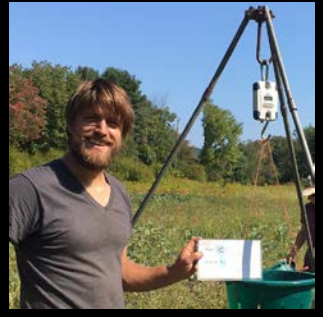
Thank you funders!

- Vermont Specialty Crop Block Grant Program
- University of Vermont Extension
- New England Vegetable and Berry Growers' Association Research Fund
- Vermont Vegetable and Berry Growers' Association Research Fund

Contact: Becky Maden
University of Vermont Extension
Rebecca.Maden@uvm.edu

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES






Growing Our Own Nitrogen:
Results from On-Farm Trials in MA

Katie Campbell-Nelson, UMass
Ryan Karb, Many Hands Farm Corps, MA

December 14th, NEVFC, Manchester, NH

UMass Extension

Goals

- Measure when nitrogen is being released by cover crops in relation to cash crop growth stages on different farms.

- Reduce nitrogen and phosphorus fertilizer use.

UMass Extension

Methods

Three treatments

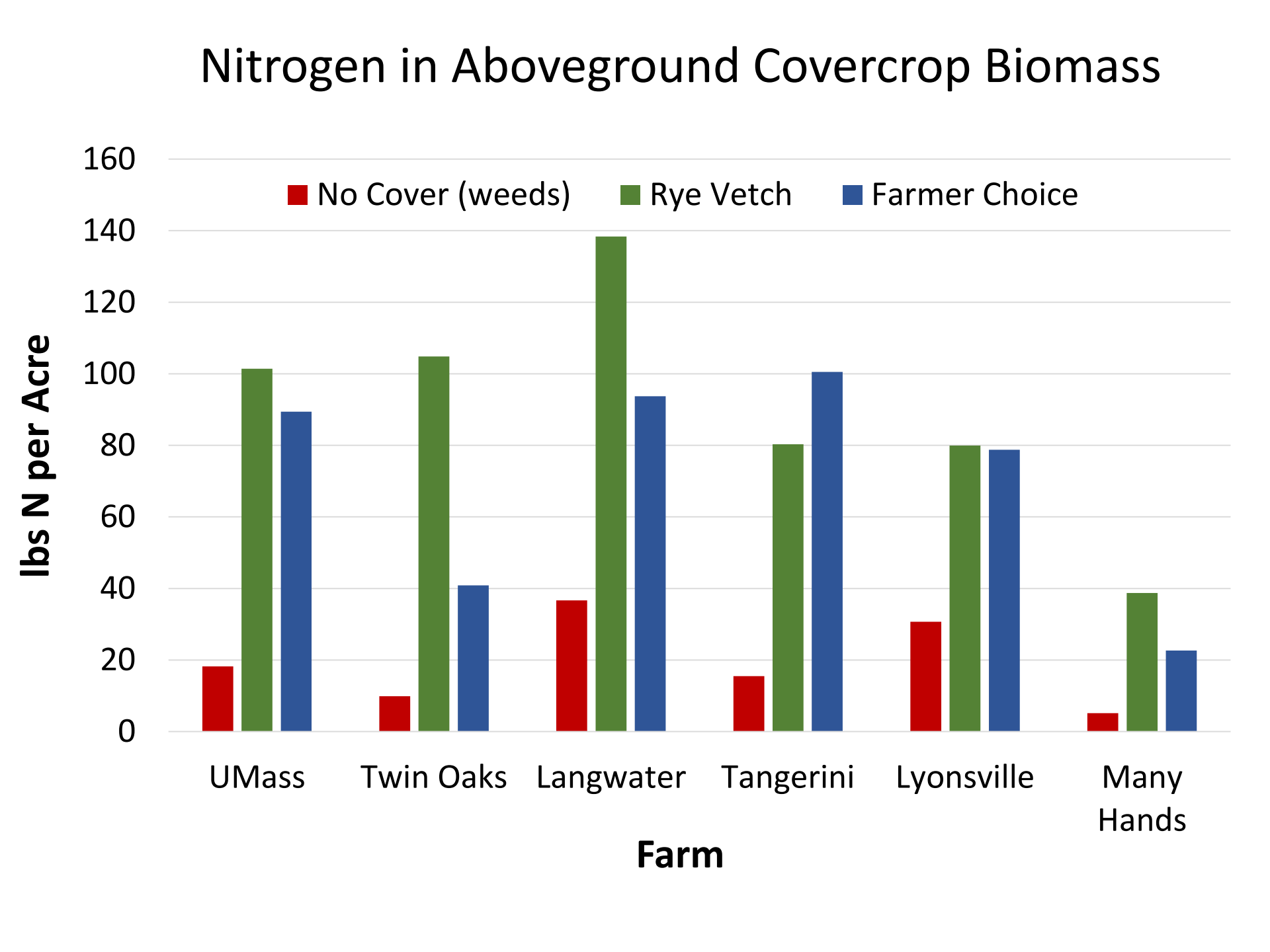
1. No Cover Crop
2. Rye (70lbs/A) and Vetch (20lbs/A)
3. Farmer Choice
    - **With and without 60lbsN/Ac after incorporation**

Timeline

- **Sept. 2016:** Plant cover crops.
- **Sept. 2016 – May 2017:** Collect % cover data monthly.
- **May 2017:** Collect above ground biomass and incorporate cover crops.
- **May – July:** collect soil nitrate every 2 weeks up to 8 weeks after incorporation.
- **Two weeks after incorporation:** apply additional 60lbsN/ac to split plots.
- **Four Weeks after incorporation:** Plant cash crop
- **End of season 2017:** Collect yield data.

What we know now

UMass Extension

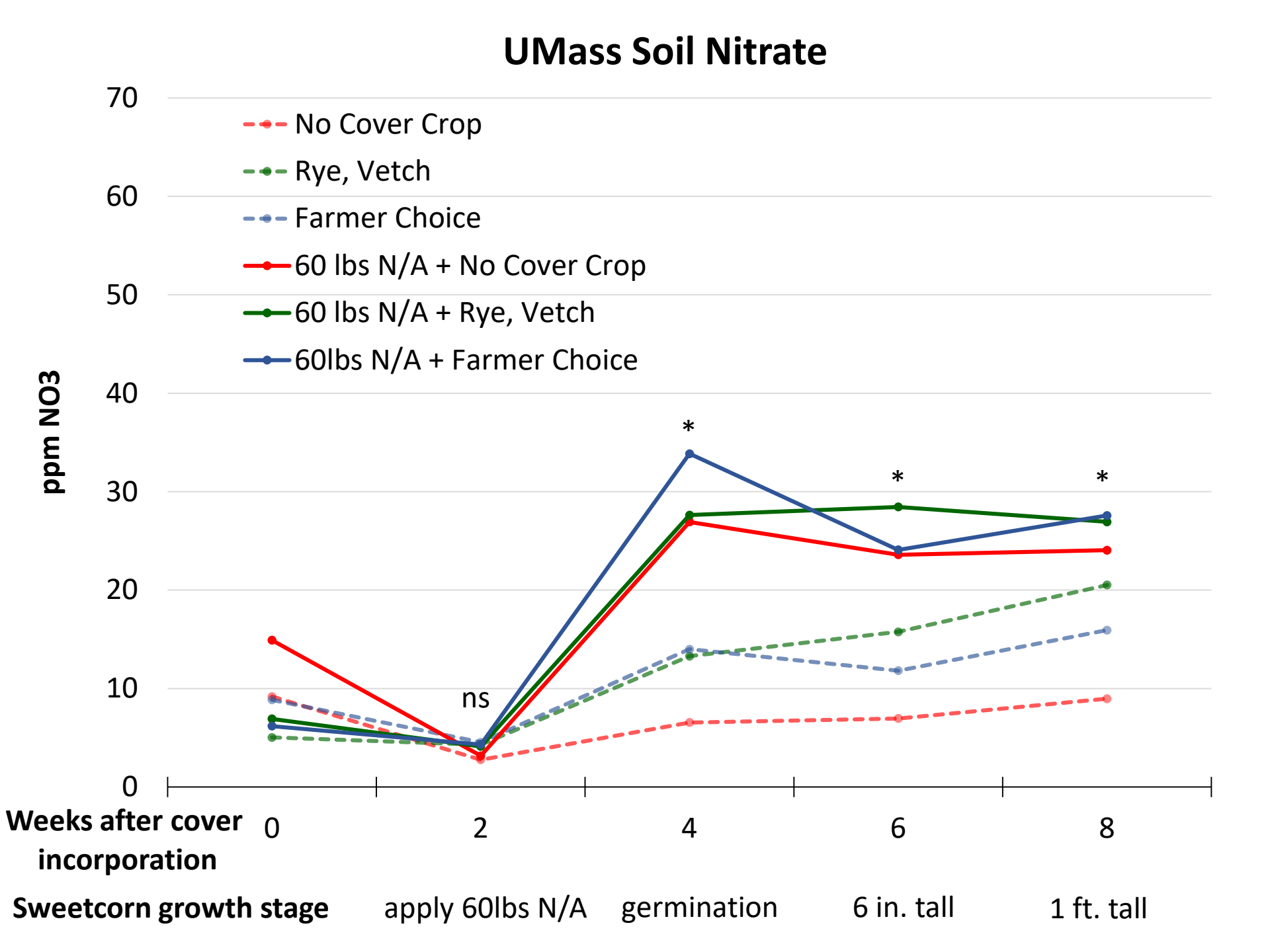

Nitrogen in Aboveground Covercrop Biomass
160
140
120
100
80
60
40
20
0
No Cover (weeds)
Rye Vetch
Farmer Choice
lbs N per Acre
UMass
Twin Oaks
Langwater
Tangerini
Lyonsville
Many Hands
Farm

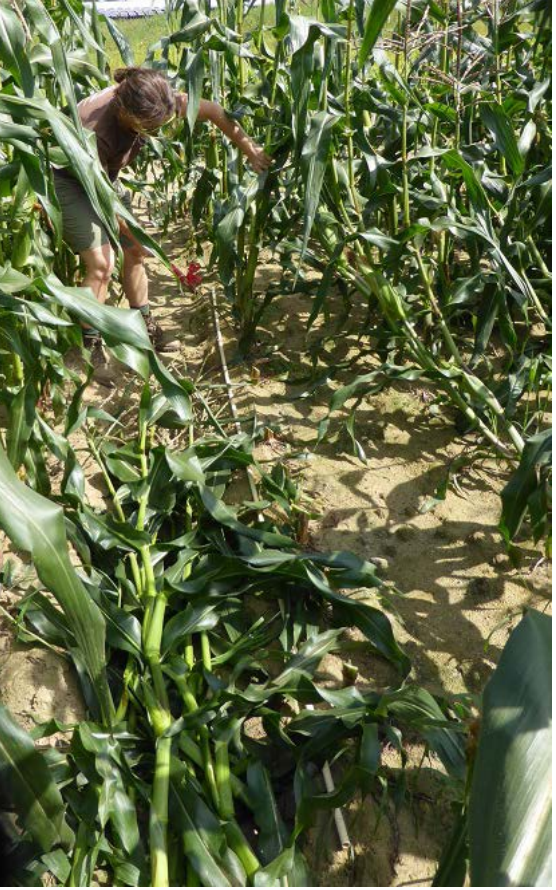
$ Value of N per acre from Cover Crops

	No Cover (weeds)	Rye Vetch $90/Ac	Farmer Choice
$4.00/Lb N organic Chilean Nitrate	$21 - 147	$155 - 553	$91-375
$0.85/lb N conventional Urea	$4-26	$33-118	$19-85

Farmer Choice cover crop seed cost = $51 – 308/acre

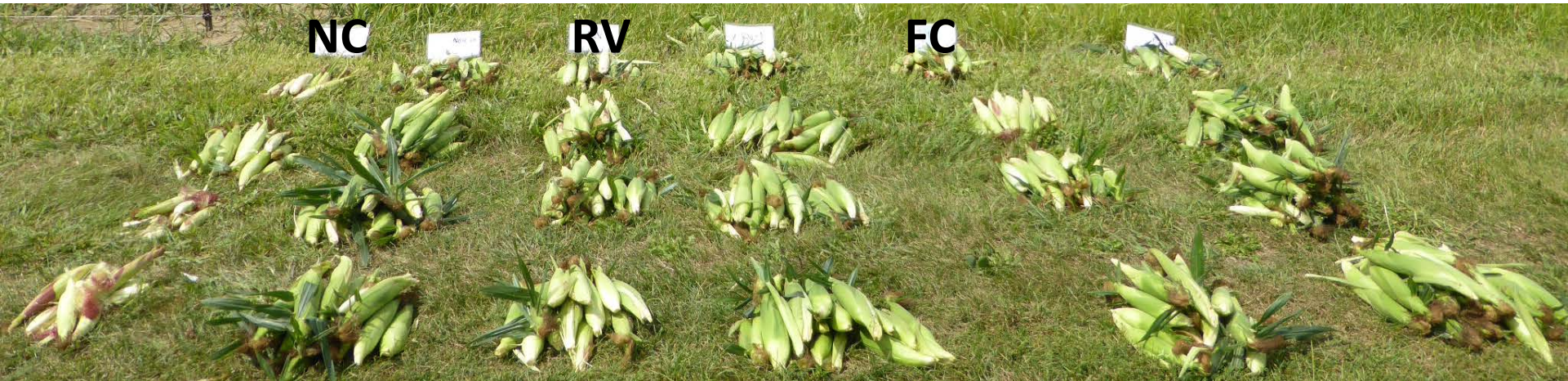
Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
UMass	Rye (60), Vetch (20), Tillage Radish (5) $ 96	Sweet corn (100-130)	1.7 (20)	Winooski silt loam	flail mow, moldboard plow

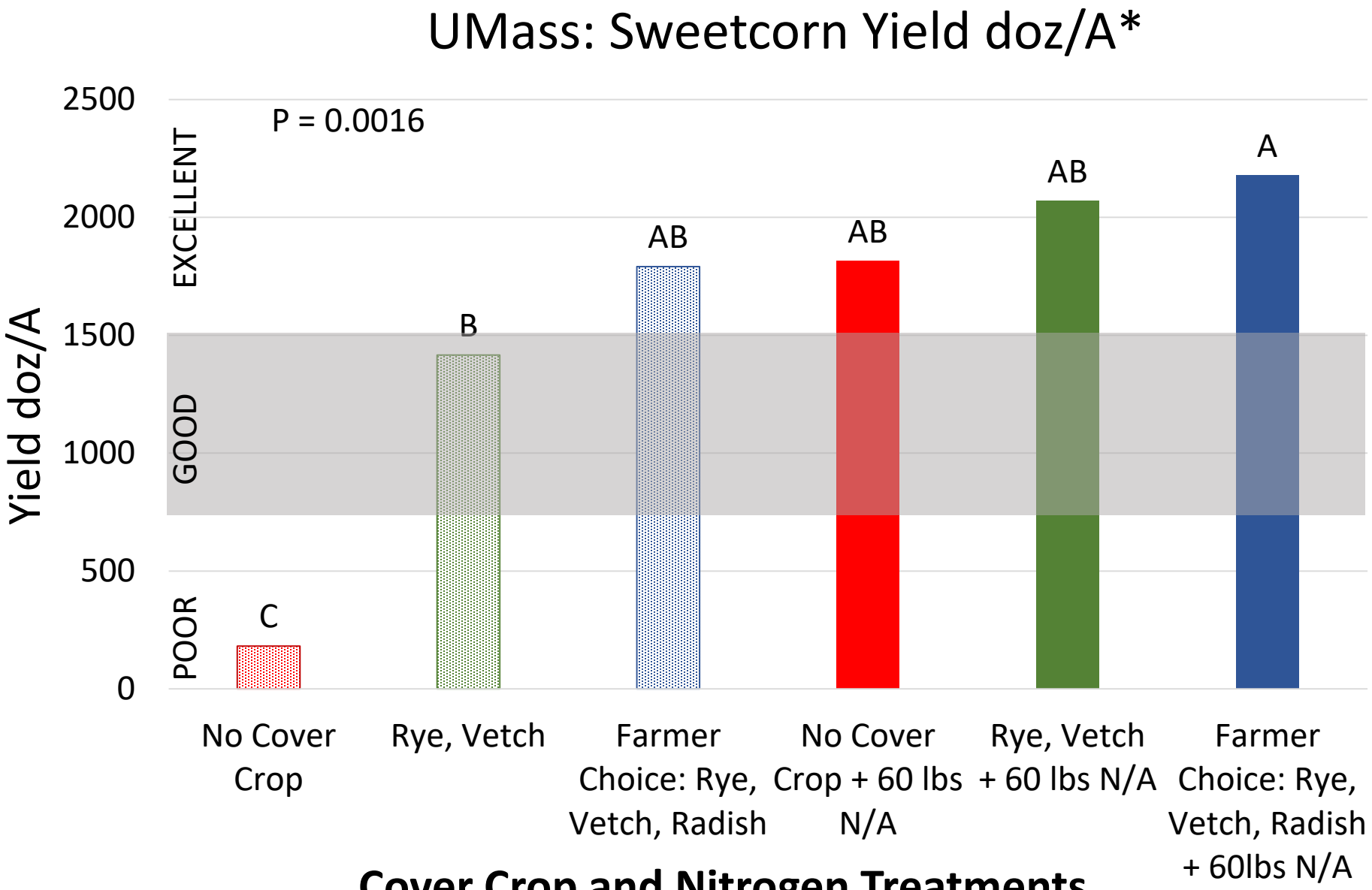

UMass Soil Nitrate
70
60
50
40
30
20
10
0
ppm NO3
No Cover Crop
Rye, Vetch
Farmer Choice
60 lbs N/A + No Cover Crop
60 lbs N/A + Rye, Vetch
60lbs N/A + Farmer Choice
*
*
*
ns
Weeks after cover incorporation
0
2
4
6
8
Sweetcorn growth stage
apply 60lbs N/A
germination
6 in. tall
1 ft. tall



UMass Yield

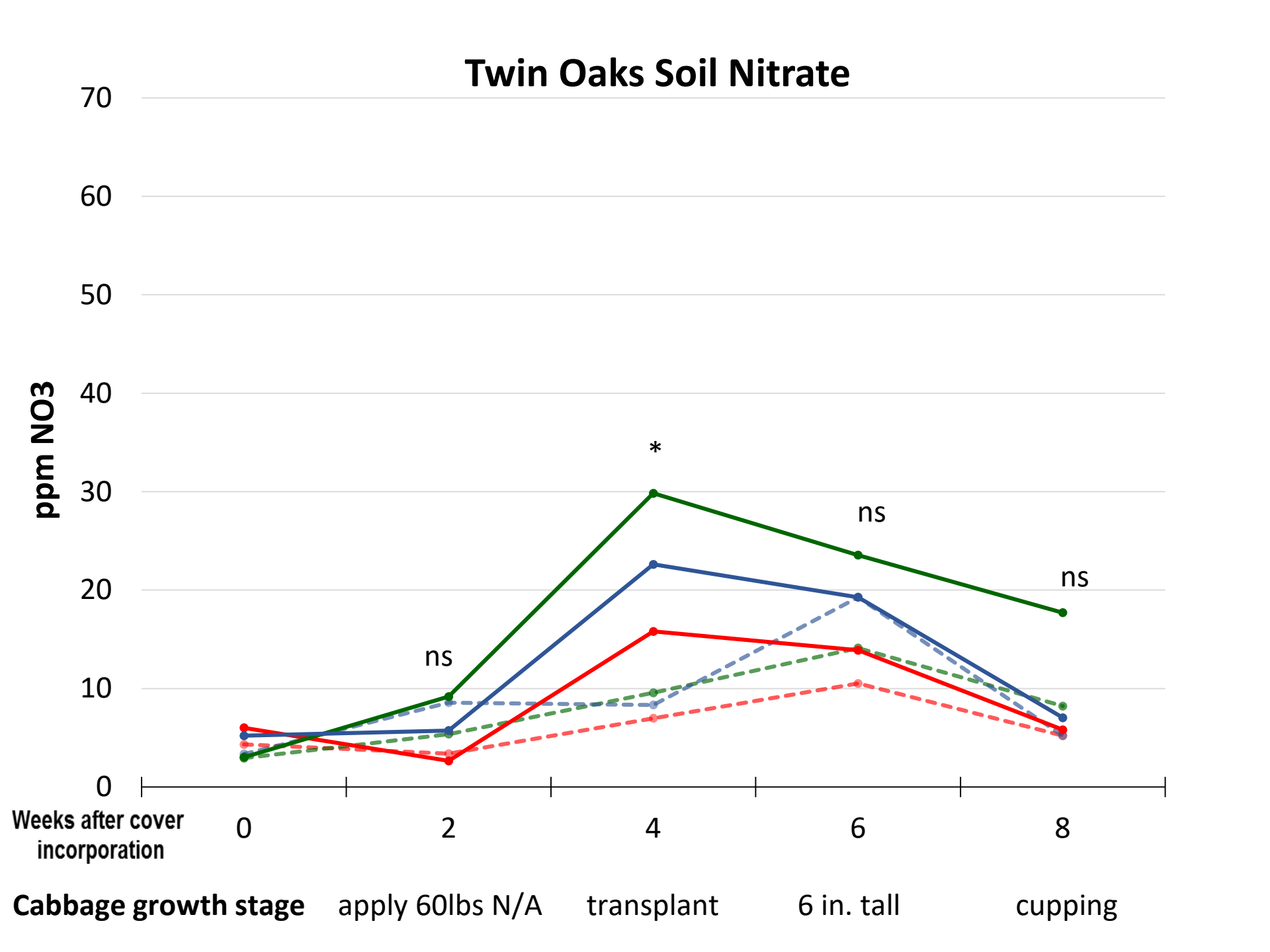
NC + N **RV + N** **FC + N**



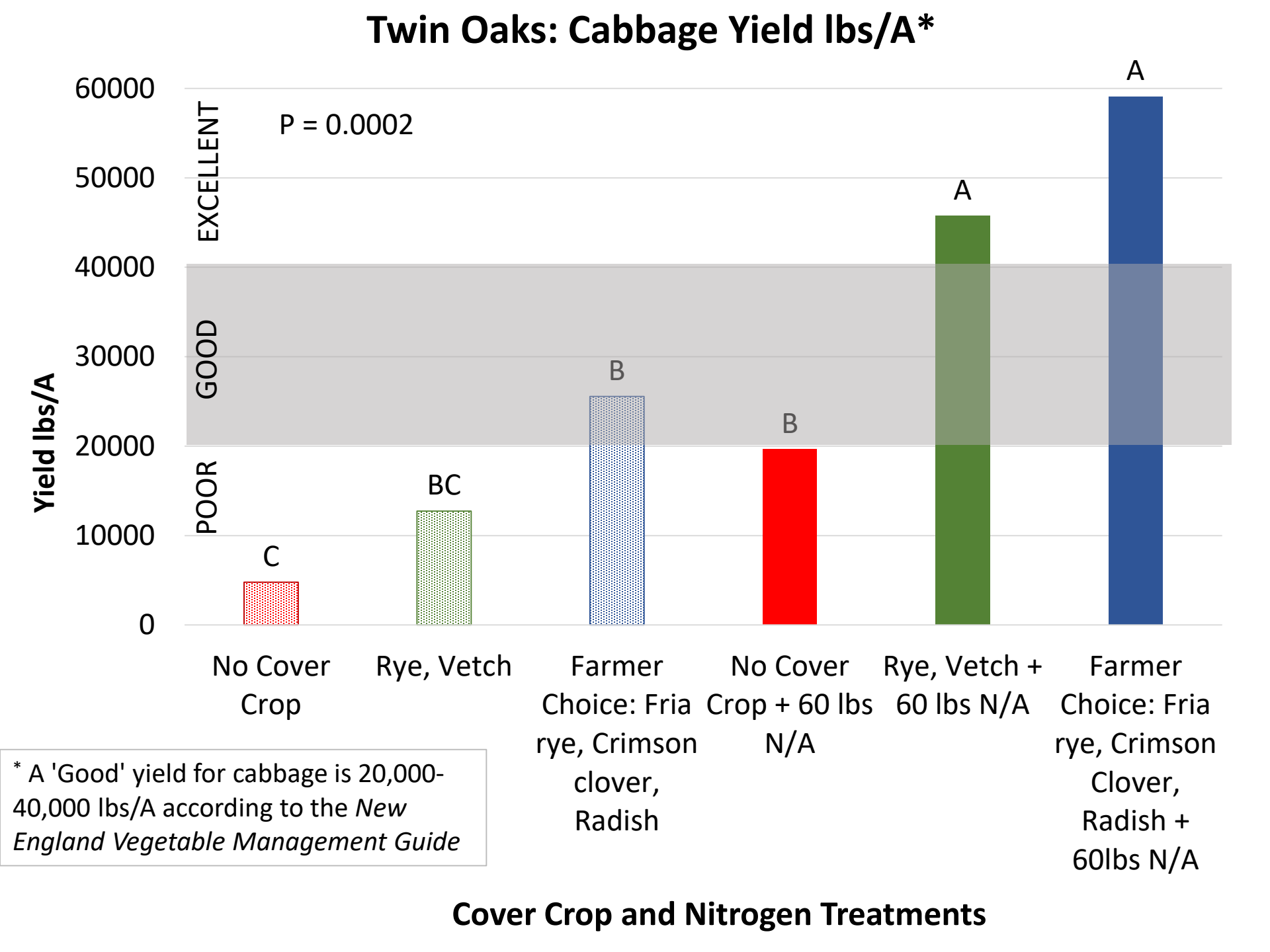


* A 'Good' yield for sweetcorn is 750-1,500 doz/A and for cabbage is 20,000-40,000 lbs/A according to the New England Vegetable Management Guide.

Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
Twin Oaks	Fria annual rye (6), Crimson Clover (4), Tillage Radish (10) $51	Cabbage (160)	2.2 (28)	Deerfield loamy fine sand	rotary mow, moldboard plow

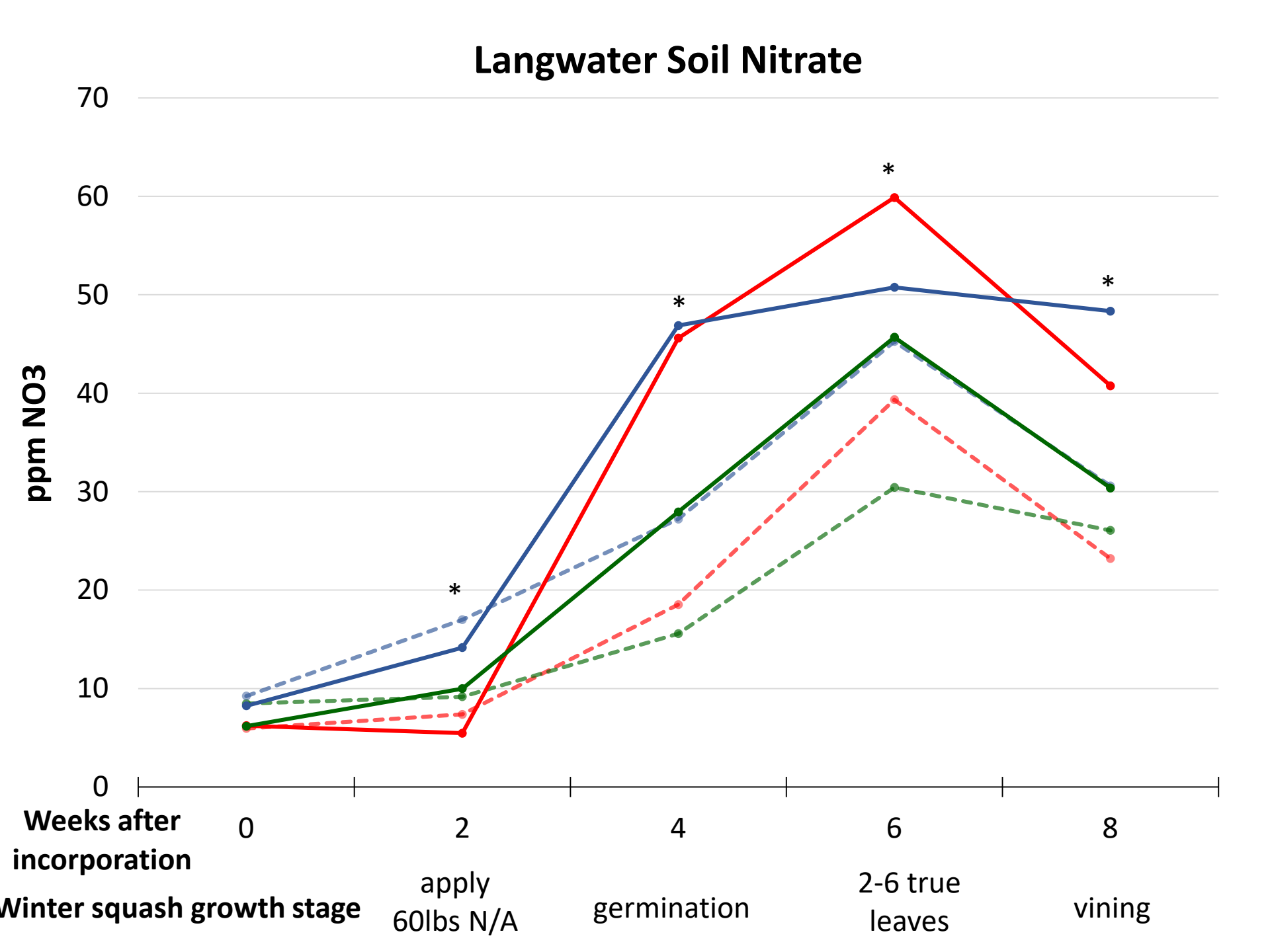

Twin Oaks Soil Nitrate
70
60
50
40
30
20
10
0
ppm NO3
*
ns
ns
ns
Weeks after cover incorporation
0
2
4
6
8
Cabbage growth stage
apply 60lbs N/A
transplant
6 in. tall
cupping

Twin Oaks Yield



* A 'Good' yield for cabbage is 20,000-40,000 lbs/A according to the *New England Vegetable Management Guide*

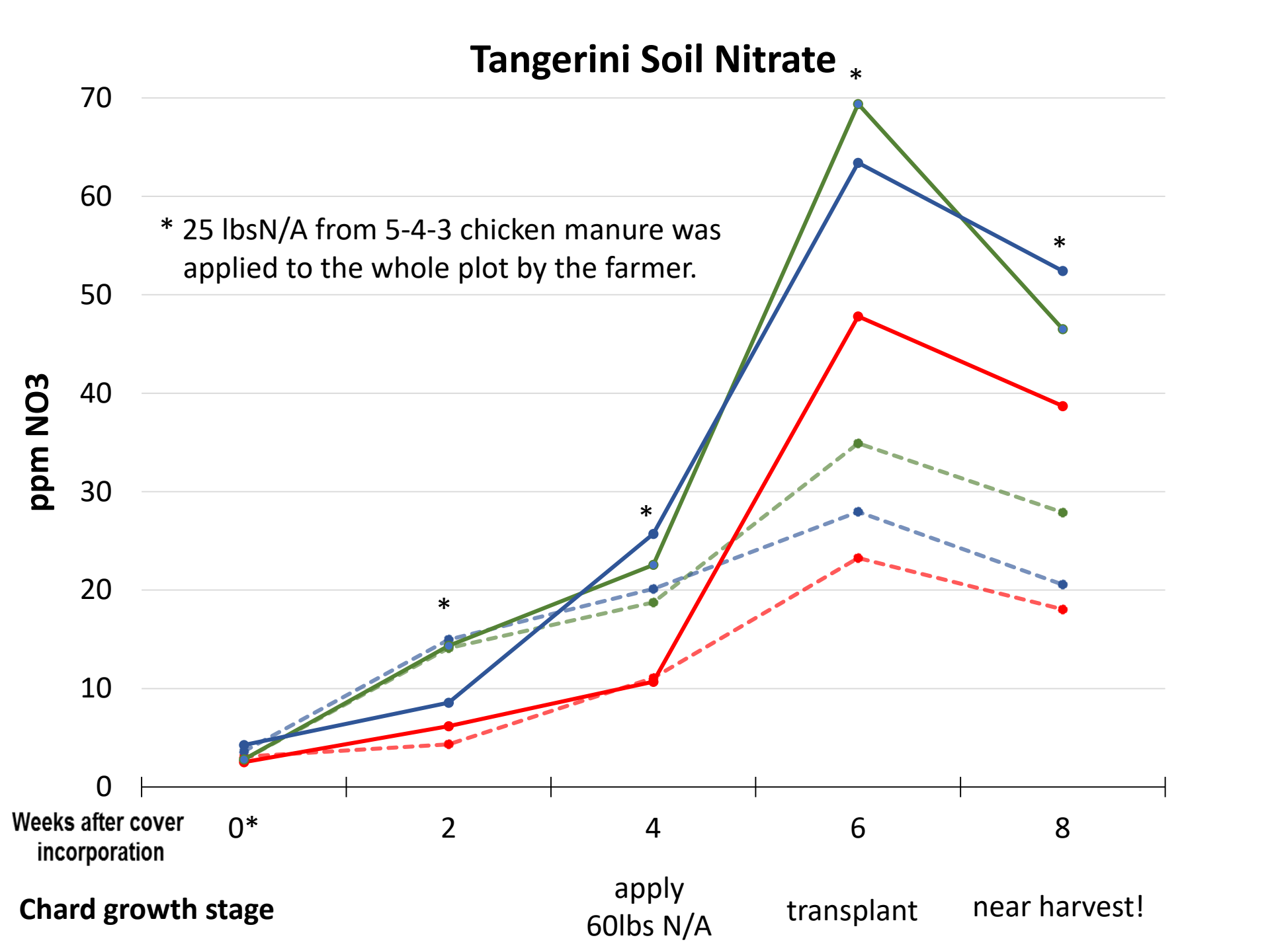
Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
Langwater	Oat (90), Pea (50), Vetch (40) $308	Winter Squash (110-140)	6.8 (105)	Charlton-Paxton fine sandy loam	flail mow, chisel plow, disc harrow


Langwater Soil Nitrate
70
60
50
40
30
20
10
0
ppm NO3
*
*
*
*
Weeks after incorporation
0
2
4
6
8
Winter squash growth stage
apply 60lbs N/A
germination
2-6 true leaves
vining

Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
Tangerini	Oat (90), Crimson clover (15), Vetch (18) $205	Chard (105-130)	3.4 (30)	Merrimac fine sandy loam	flail mow, rototill, perfecta

May 26, 2017

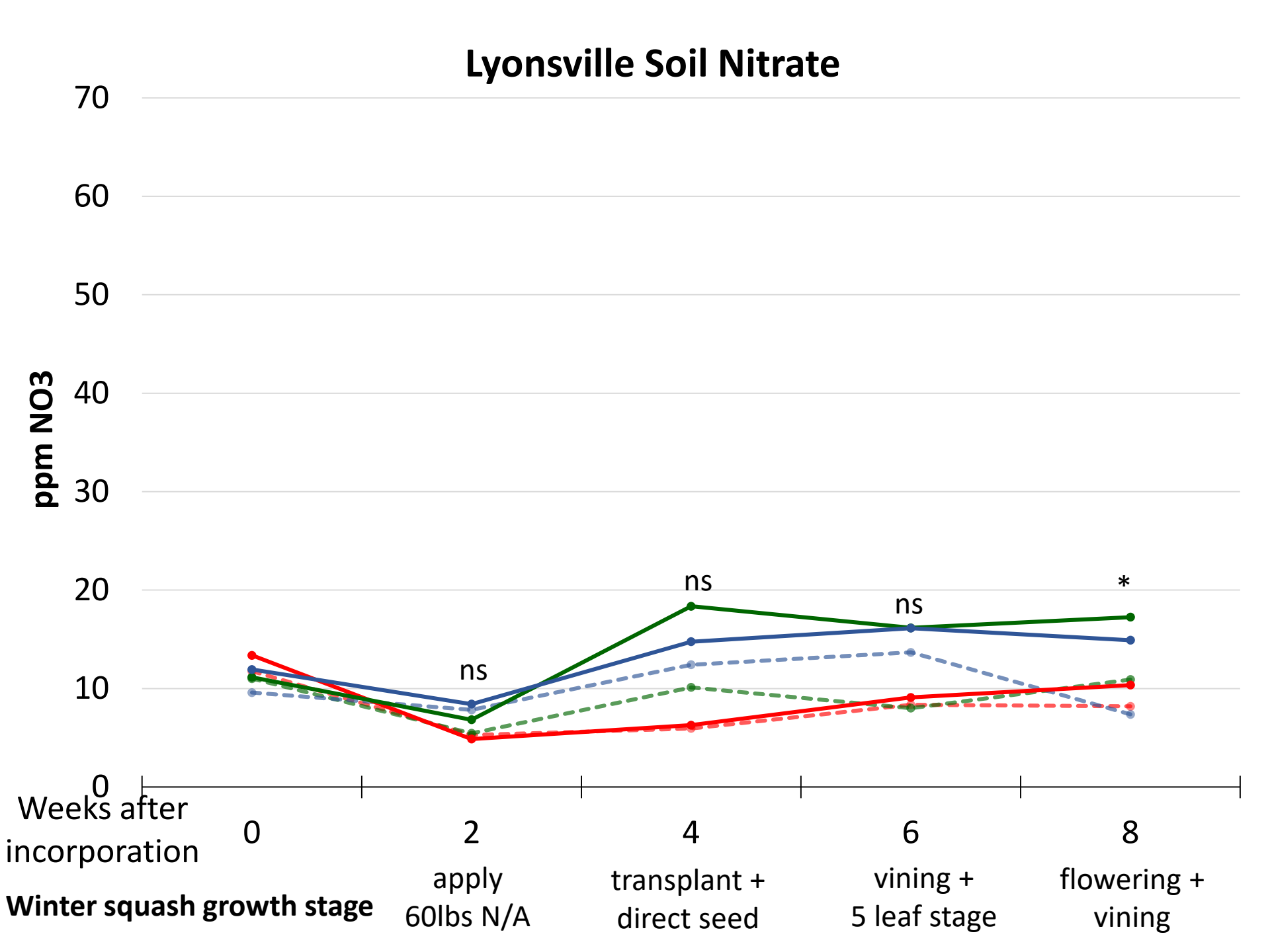
FC


Tangerini Soil Nitrate
* 25 lbsN/A from 5-4-3 chicken manure was applied to the whole plot by the farmer.
ppm NO3
70
60
50
40
30
20
10
0
*
*
*
Weeks after cover incorporation
0*
2
4
6
8
Chard growth stage
apply 60lbs N/A
transplant
near harvest!

Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
Lyonsville	Fria rye (15), Crimson clover (15), Vetch (18) $136	Winter Squash (110-140)	2.9 (25)	Occum fine sandy loam	rotary mow, plow, disc

April 12, 2017

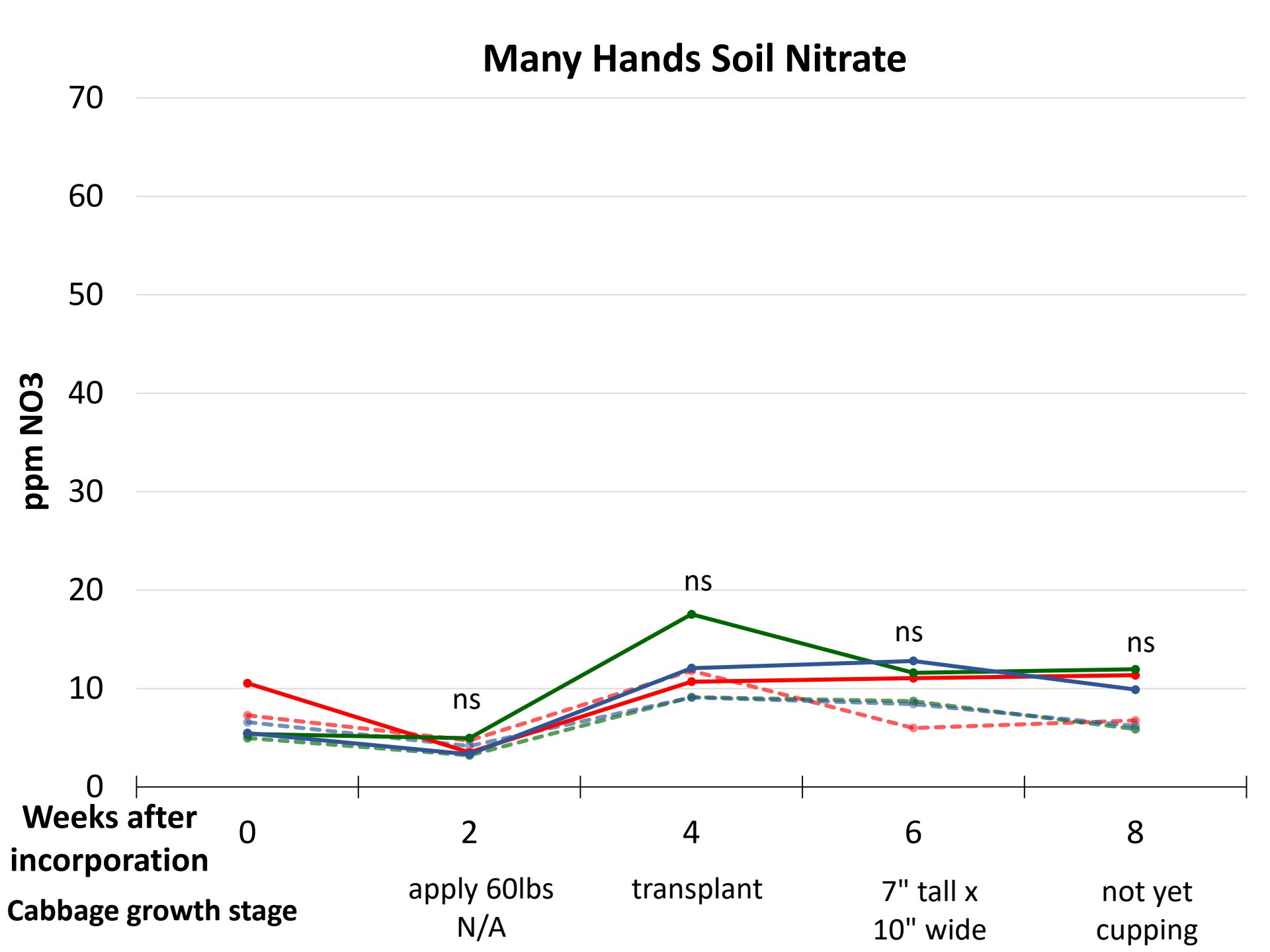
FC


Lyonsville Soil Nitrate
70
60
50
40
30
20
10
0
ppm NO3
ns
ns
ns
*
Weeks after incorporation
0
2
4
6
8
Winter squash growth stage
apply 60lbs N/A
transplant + direct seed
vining + 5 leaf stage
flowering + vining

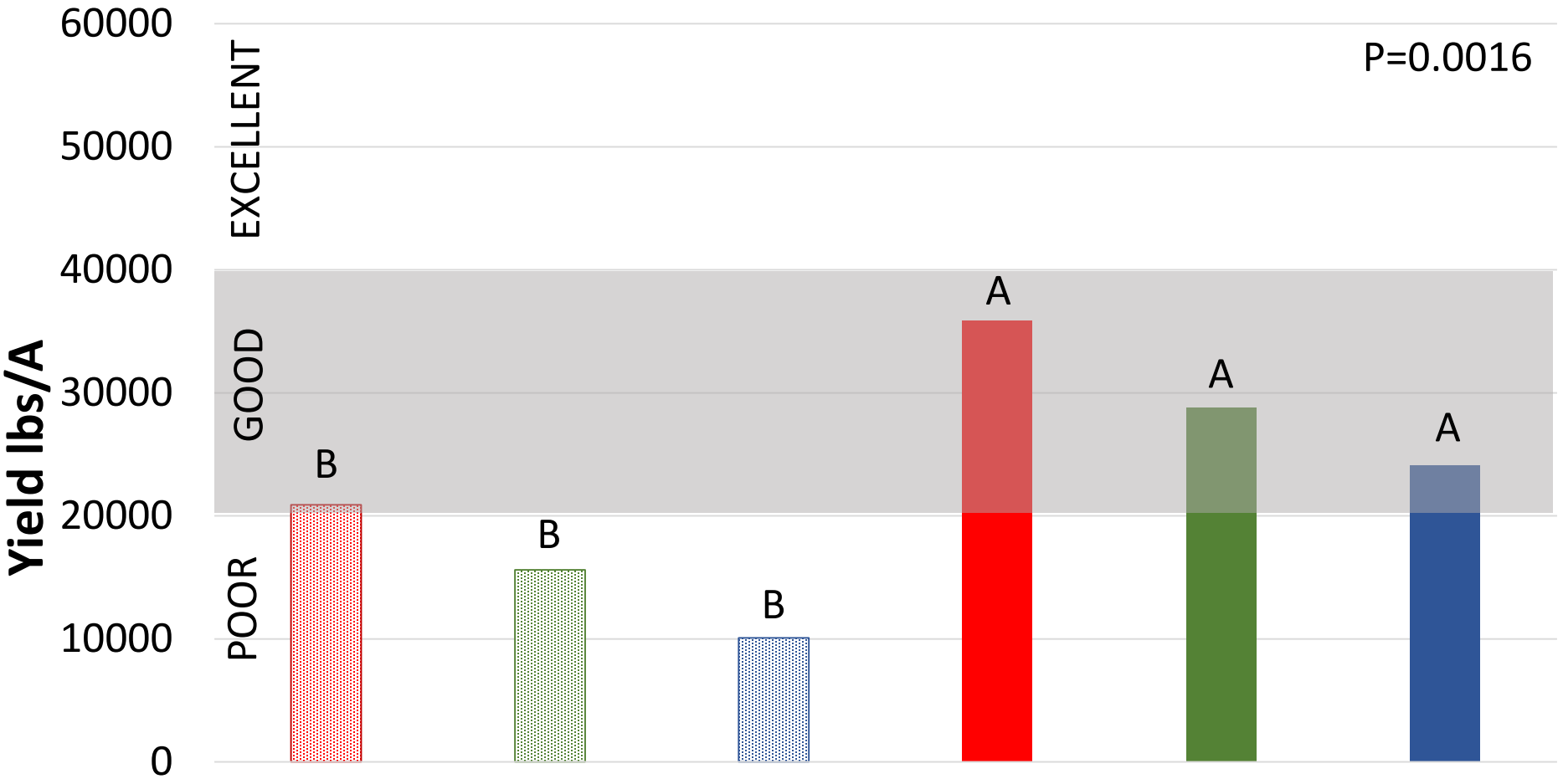
Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
Many Hands	Summer 2016 seeded: Sorghum Sudan (90) $234 Spring 2017 Seeded: Oat (100), Pea (100) $251	Cabbage (160)	**6.2 (5)**	Pootatuck fine sandy loam	disced twice

Farm	Farmer Choice (lbs/acre) and $/acre	Cash Crop and N needs (lbs/acre)	Fall 2016 % SOM and (ppm NO_3)	Soil Type	Method of incorporation
Langwater	Oat (90), Pea (50), Vetch (40) $308	Winter Squash (110-140)	**6.8 (105)**	Charlton-Paxton fine sandy loam	flail mow, chisel plow, disc harrow
Many Hands	Summer 2016 seeded: Sorghum Sudan (90) $234 Spring 2017 Seeded: Oat (100), Pea (100) $251	Cabbage (160)	**6.2 (5)**	Pootatuck fine sandy loam	disced twice

Langwater vs. Many Hands


Many Hands Soil Nitrate
70
60
50
40
30
20
10
0
ppm NO3
ns
ns
ns
ns
Weeks after incorporation
0
2
4
6
8
Cabbage growth stage
apply 60lbs N/A
transplant
7" tall x 10" wide
not yet cupping

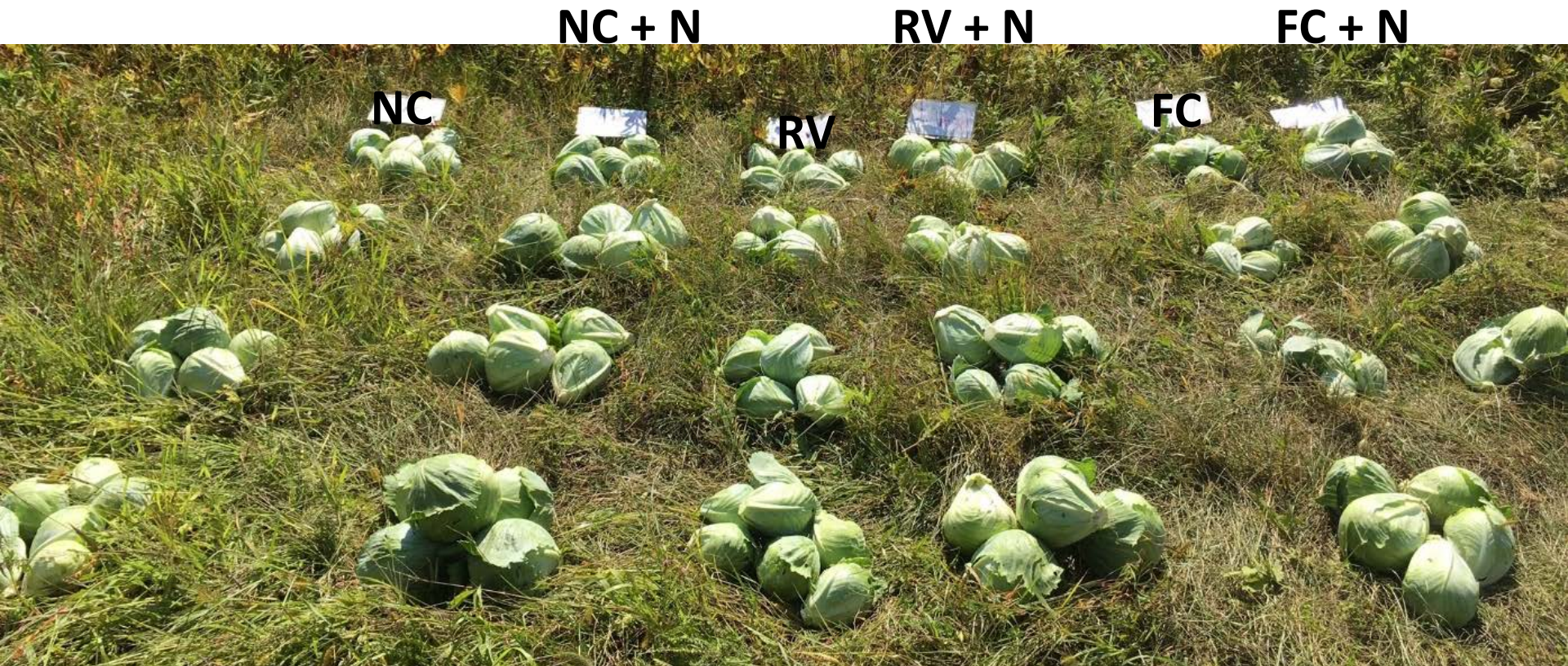
Many Hands: Cabbage Yield lbs/A



* A 'Good' yield for cabbage is 20,000-40,000 lbs/A according to the *New England Vegetable Management Guide 2016-2017.*

Cover Crop and Nitrogen Treatments

Many Hands Yield



Farmer Adaptations

- Transplants 4 weeks after incorporation.
- Direct seed 2 weeks after incorporation.
- Experiment with less nitrogen fertilizer.
- Take more soil Nitrate tests

Plant tillage radish at 10lbs/Ac for weed control

Start growing crimson clover

Thanks!

- ***Thanks to Farmers:*** *Steve Chiarizo, Laura and Charlie Tangerini, Edwin and Joe Matuszko, Andrew Lawson, Kevin O'Dwyer and crew, Ryan Karb, and Maria Topitzer.*

- ***Thanks to staff and advisors:*** *Genevieve Higgins, Michele Meder, Julie Stultz-Fine, Samantha Glaze Corcoran, and Masoud Hashemi, Kate Parsons, Paul Peckham*

UMass Extension

NORTHEAST SARE Sustainable Agriculture Research & Education

NEW ENGLAND VEGETABLE & BERRY GROWER'S ASSOC.