Texas A&M
AgriLife
Research

Regenerative Agriculture and Nutrient Management

Mid-Plains AG EXPO
Plainview, TX
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Farmer Concerns

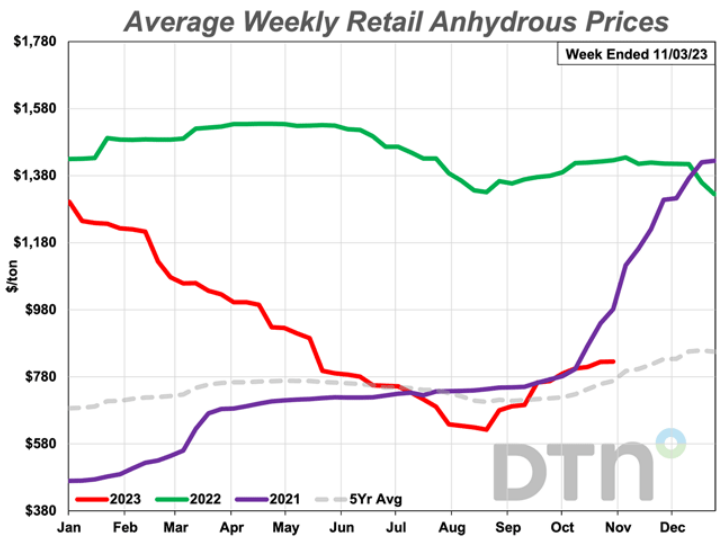
Environment

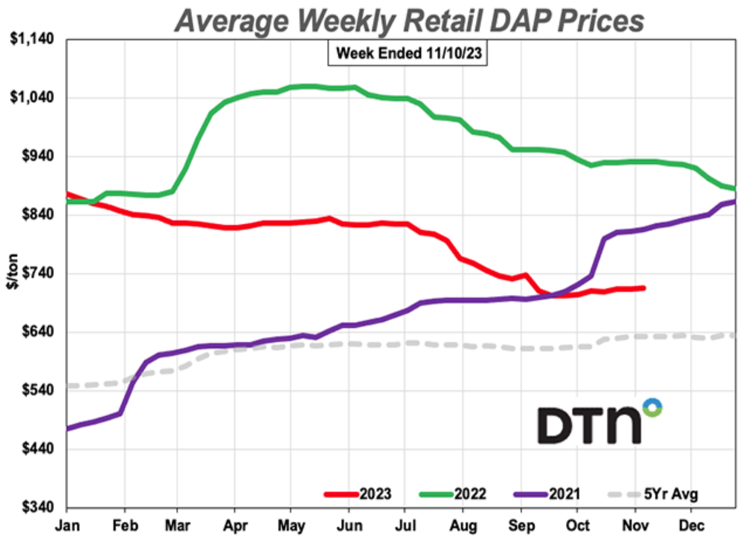
Instability of availability??

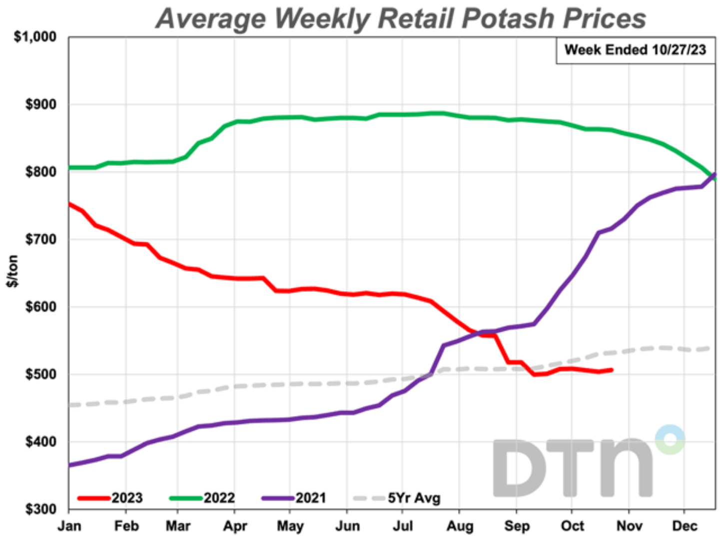
Costs

UAN-32: $0.90/lb N

Urea: $0.75/lb N


Average Weekly Retail Anhydrous Prices


Average Weekly Retail DAP Prices


Average Weekly Retail Potash Prices

Fertilizer Prices (2022 → 2023)

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Fertilizer	09/02/2022	11/01/2023	
Urea	$804/ton	$573/ton	29%
Anhydrous Ammonia	$1,364/ton	$830/ton	39%
UAN-32	$671/ton	$415/ton	38%
MAP	$1,022/ton	$802/ton	22%
DAP	$952/ton	$714/ton	25%
10-34-0	$866/ton	$613/ton	29%
0-0-60	$877/ton	$509/ton	42%

Our project goal is to intensify agricultural production in an environmentally sustainable manner that enhances agronomic, economic, and community resiliency in the Southern Great Plains.

Texas Water Resources Institute
make every drop count

Texas A&M AgriLife Research

Texas A&M AgriLife Extension

ATM

OSU

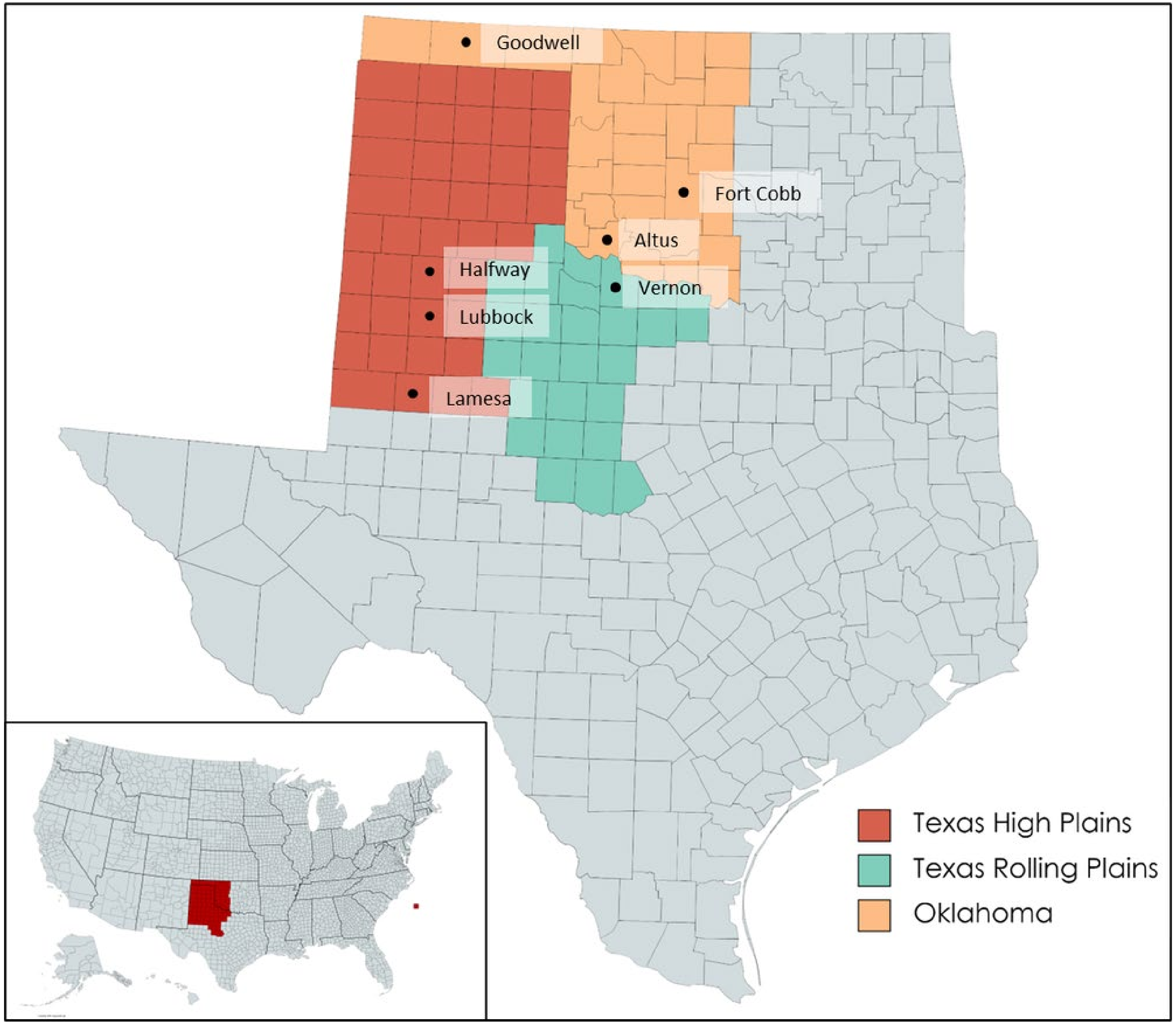
WT

Kansas State University

USDA Award Number: 2021-68012-35897

Project Overview

- The TX and OK components of the Southern Great Plains are one of the largest cotton and livestock production regions in the U.S. and vital to the economic, ecologic, and social facets of rural America
- Knowledge gaps exist when using regenerative agriculture in semi-arid agroecosystems, such as the Southern Great Plains
- Without a better understanding of regenerative agriculture, adoption will remain limited across the region, and the following will be inevitable:
  1. *depletion of water resources*
  2. *diminishing soil C storage*
  3. *net positive production of greenhouse gases*
  4. *increased contribution to climate change*
  5. *diminishing profit potential*



Regenerative Agriculture

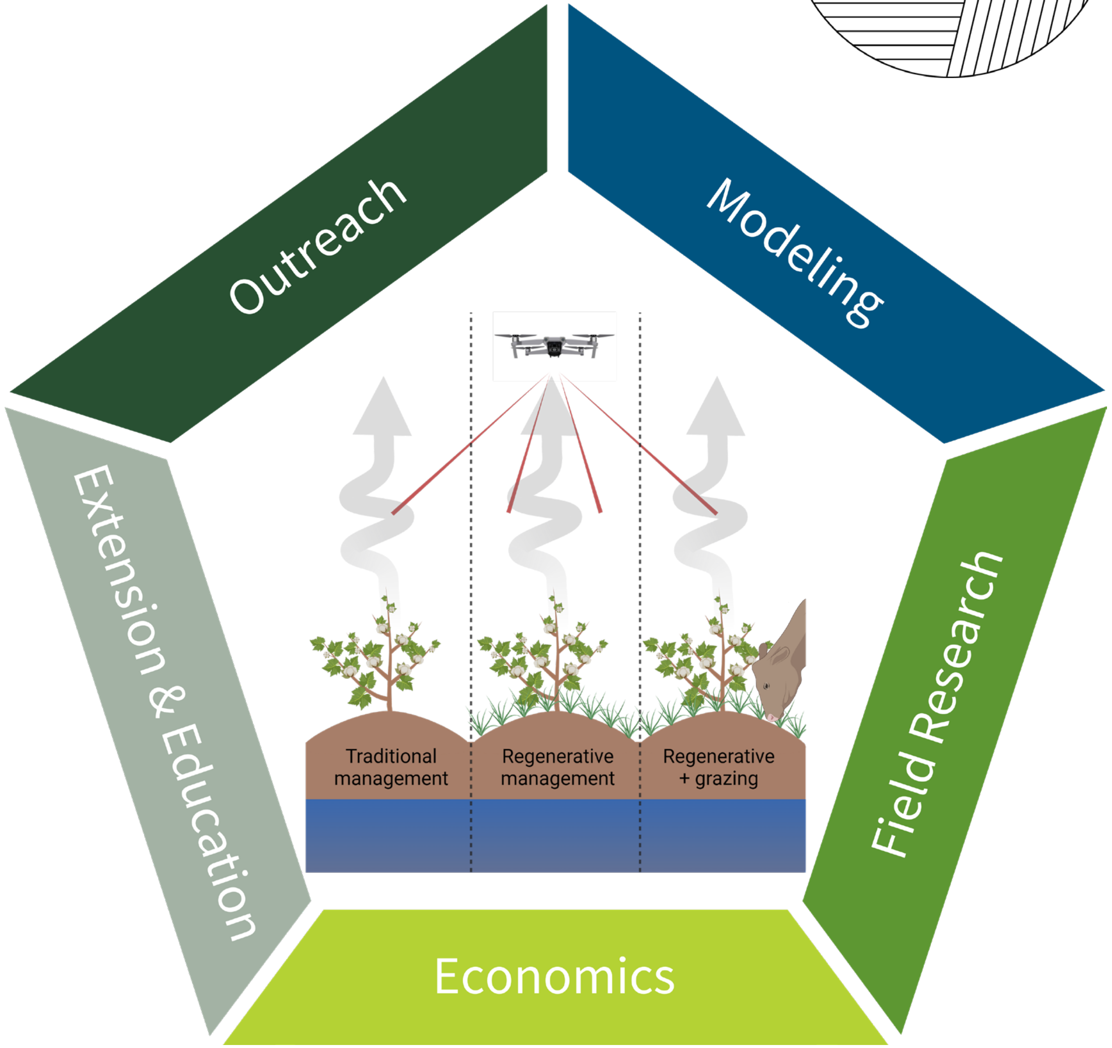
The continued capacity of agricultural systems to function in a changing climate that supports soil health, communities, economic output, environmental sustainability, and resilience to the outside threats of these outcomes. *–RegenAg Team*

Regenerative Agriculture (#RegenAg)

Southern Great Plains REGENAg

Objectives -

- Develop and deliver *Master Soil Steward Program*
- Utilize models to assess soil and water quality impacts of regenerative practices
- Evaluate regenerative agricultural practices
- Develop and deliver transdisciplinary graduate and undergraduate curriculum
- Create farm budgets and determine potential impacts on rural communities



Nitrogen

-ammonium (NH_4^+) & nitrate (NO_3^-)-

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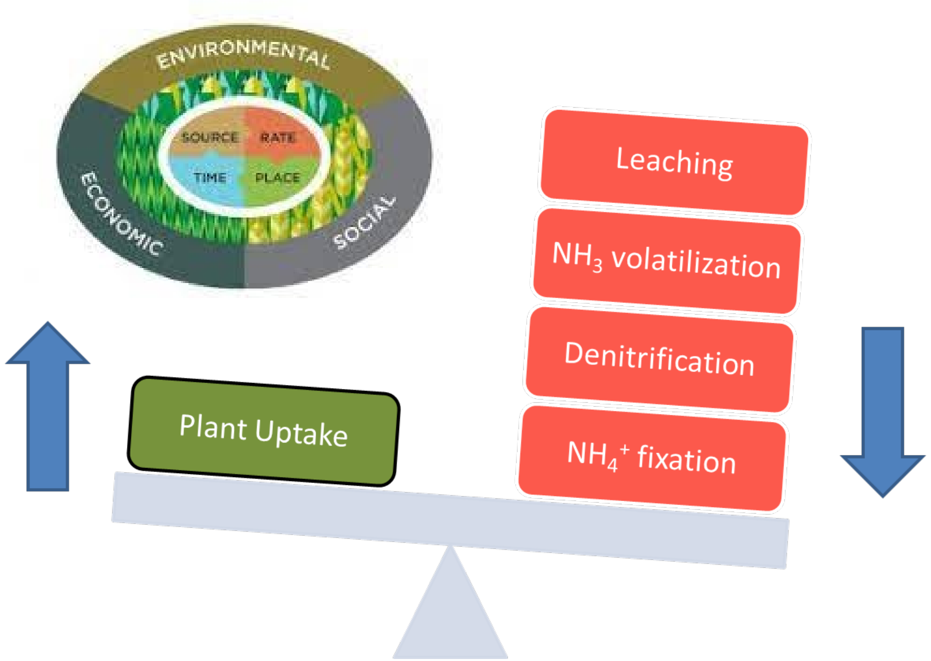
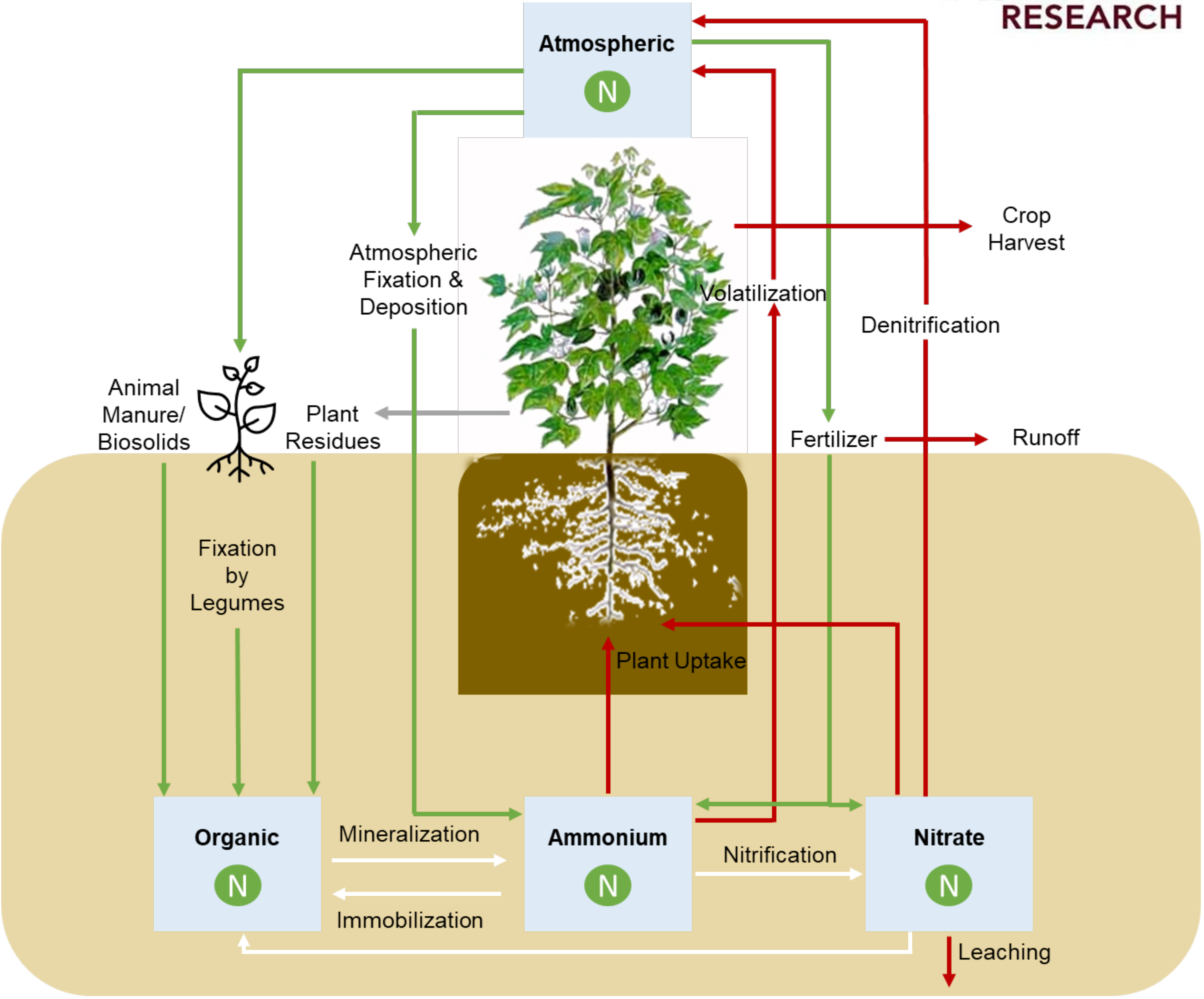
Nitrogen is the greatest limiting nutrient





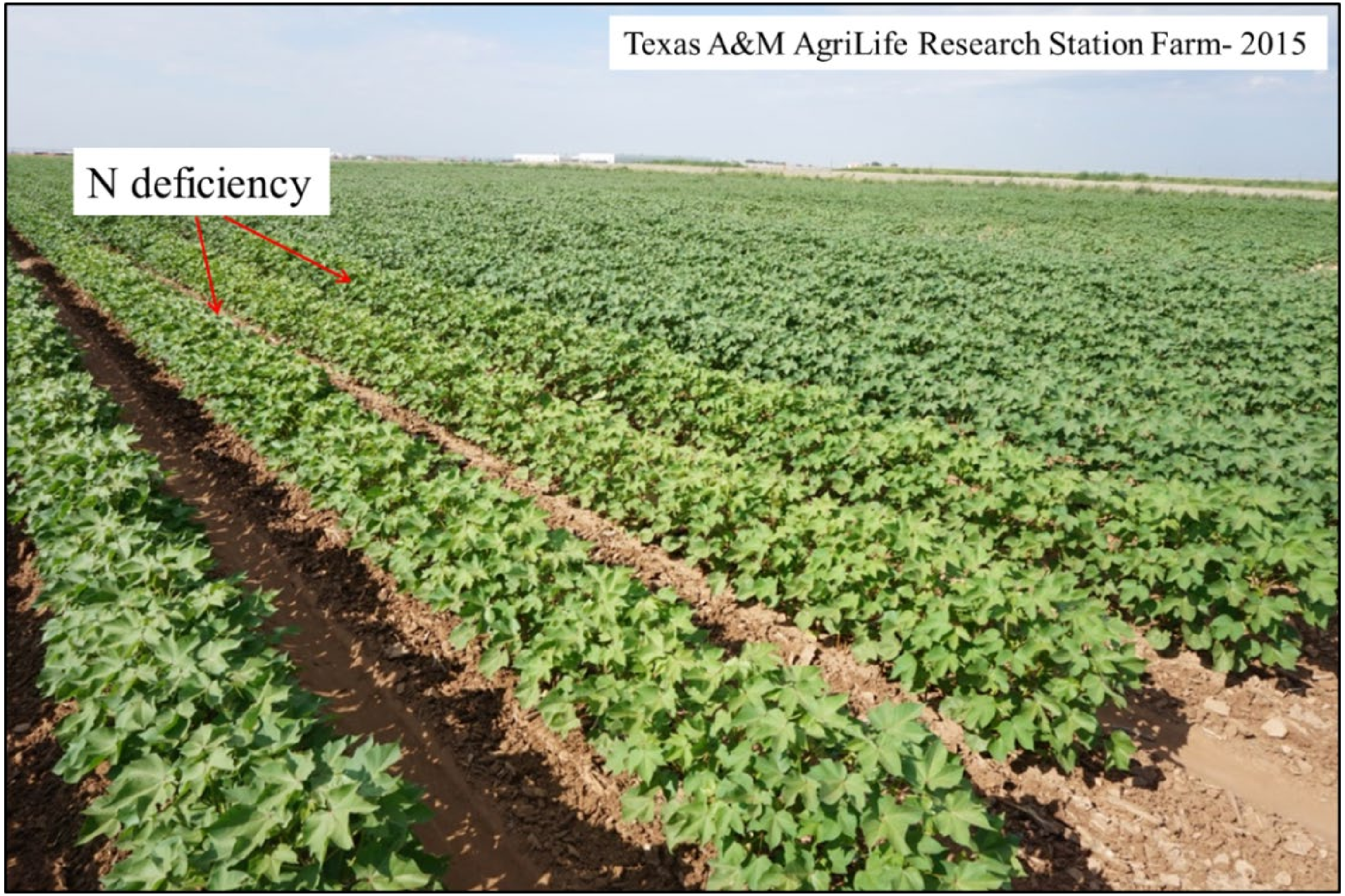
Nitrogen Requirements *(based on yield goal)*

1^{st} bale:

40 lb N/A/bale

2+ bales:

35-40 lb N/A/bale



Nitrogen Uptake

Source: Pabuayon et al. 2021

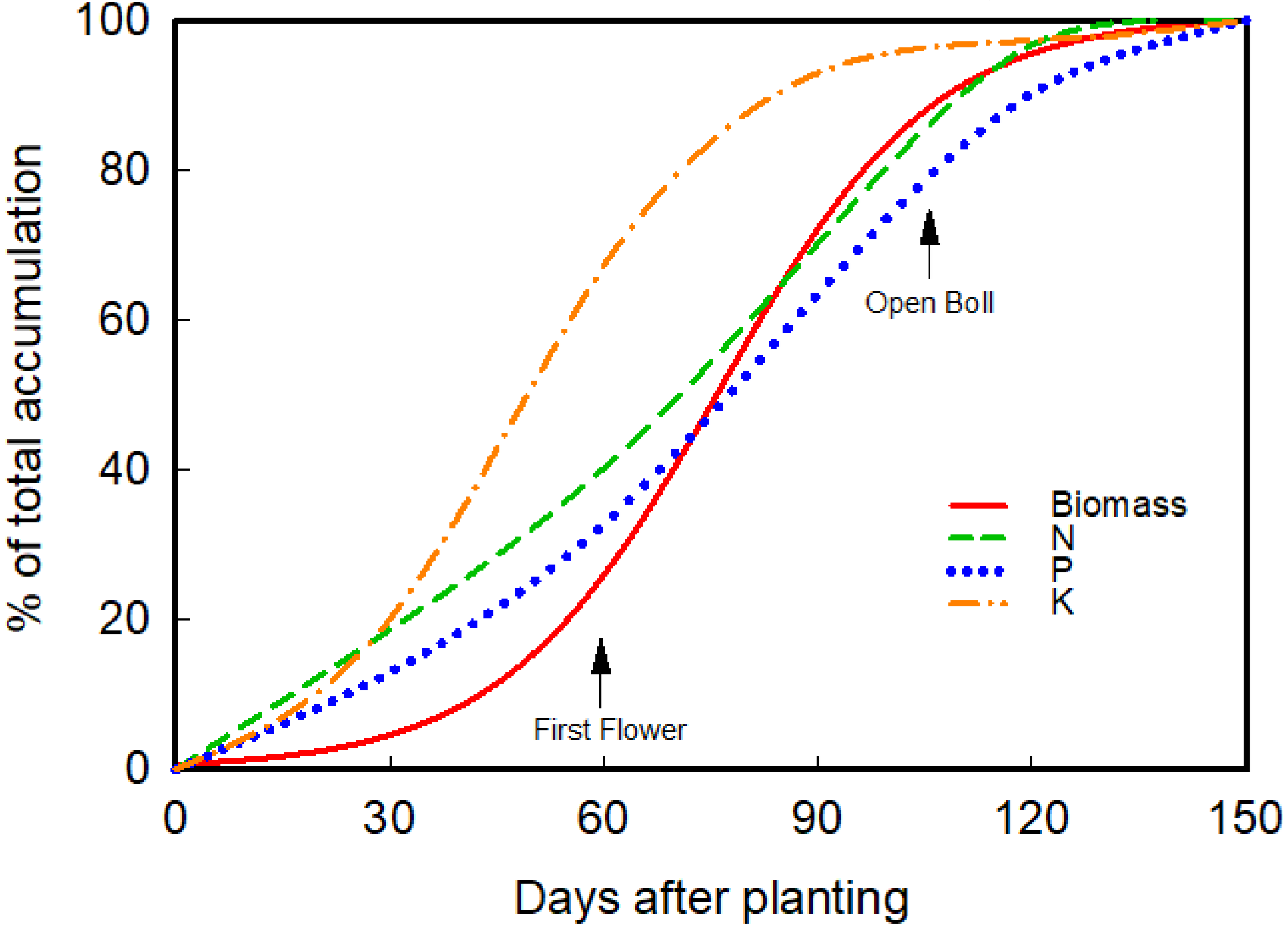
Macronutrient	**Nutrient uptake index** (lb nutrient per 100 lb lint yield)		Yield increase per unit of nutrient since the 1990s (%)
	Old Cultivars[a]	*Modern Cultivars*[b]	
N	20	12	73
P	2.5	1.3	92
K	15	10	61
Ca	9	7	26
Mg	2.6	2.0	30
S	2.7	2.2	23

[a] Values based on the report by Mullins and Burmester (1990)

[b] Values based on the mean two modern cotton cultivars (FM 958 and DP 1646)

Nitrogen Uptake

Source: Pabuayon et al. 2021



Mineralization and Immobilization

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Organic N ↔ Inorganic N
Equilibrium in soils
(Nitrogen cycling)

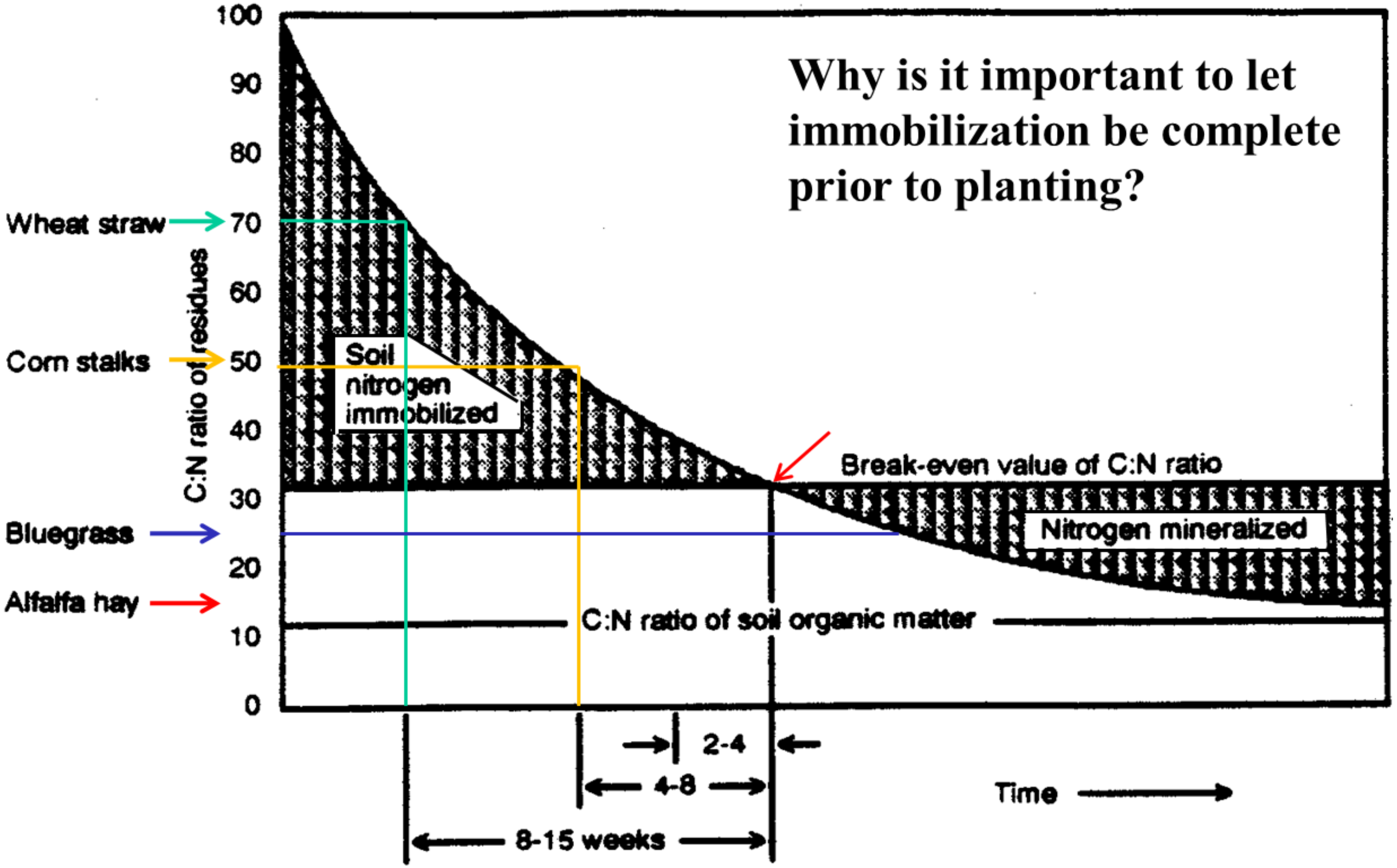
Mineralization – conversion of plant-unavailable organic N to plant-available inorganic N (NH_4^+); C:N < 30:1

Immobilization – conversion of plant-available inorganic N (NH_4^+, NO_3^-) to plant-unavailable organic N (**microbial tissues**); C:N > 30:1

Practical significance??

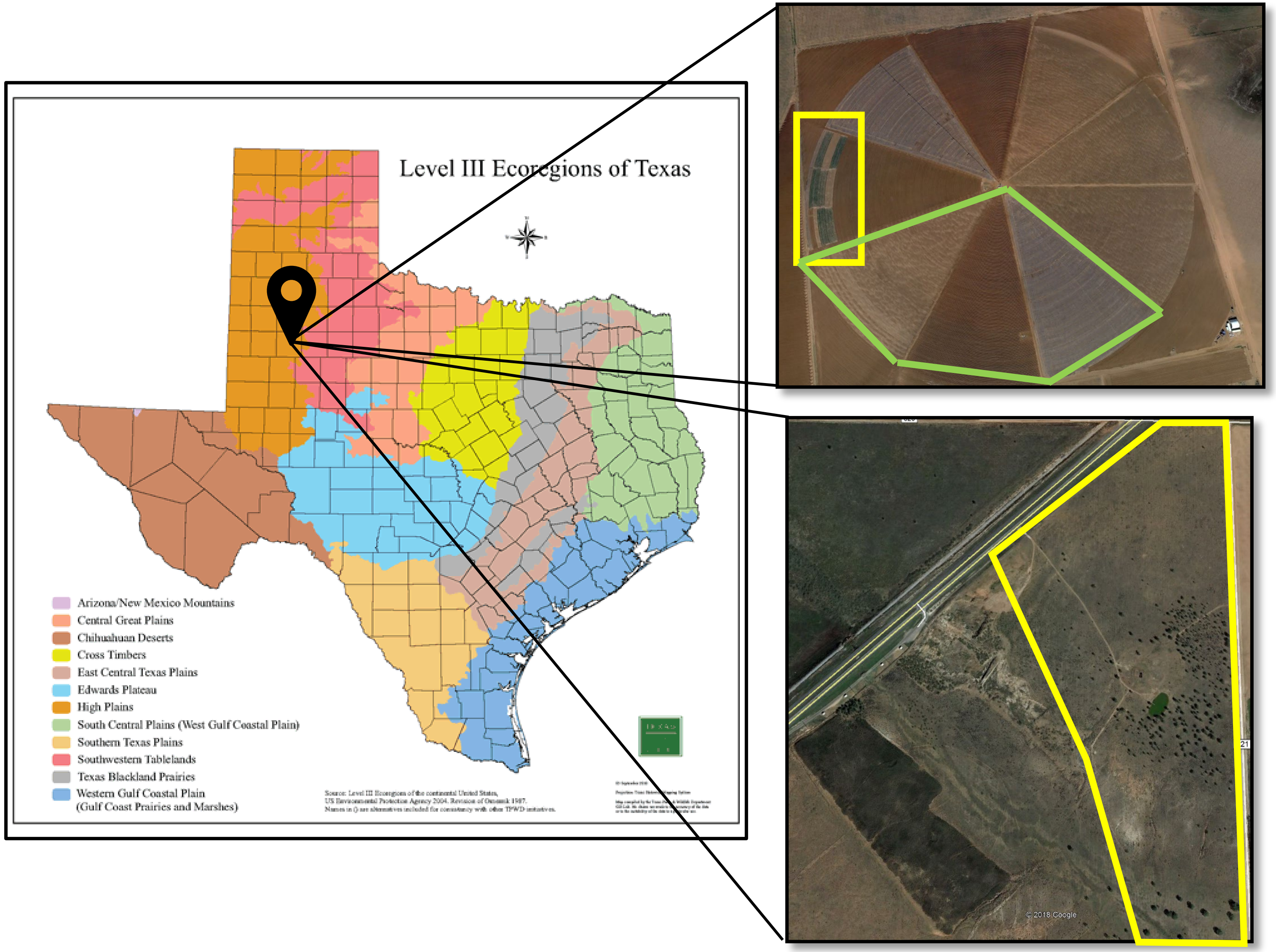
Determining Factor for Net N Mineralization or Immobilization

Time required for completion of N immobilization as affected by C:N ratio of crop residue



Why is it important to let immobilization be complete prior to planting?

Our sites



Cropping system location -

Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) - Lamesa, TX

Native system location -

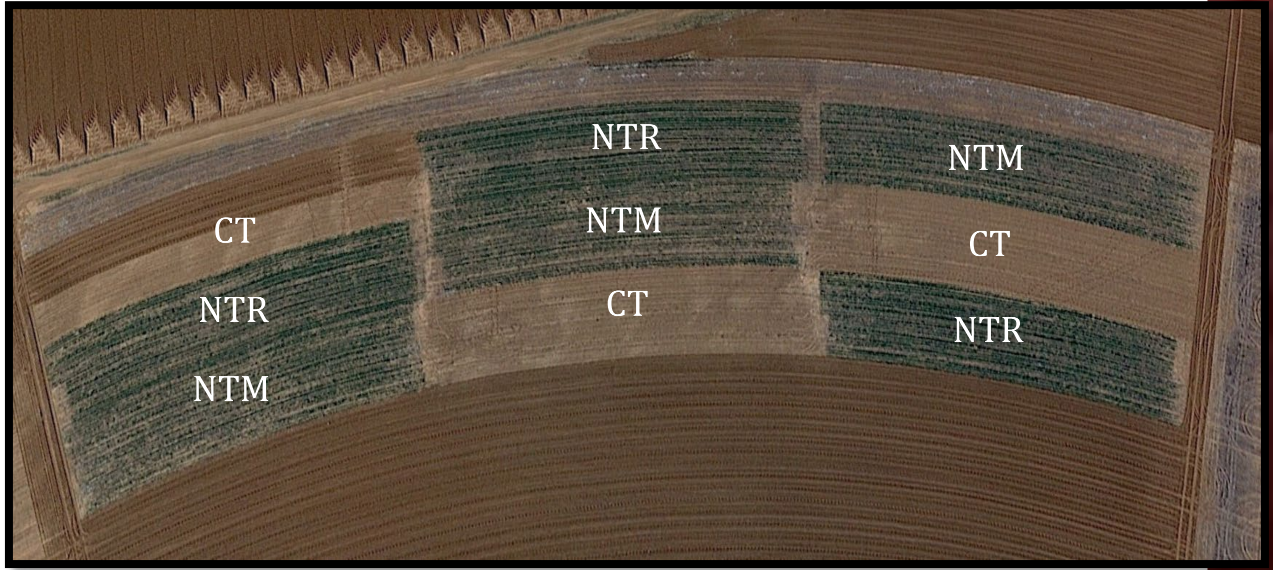
Wellman native range site – near Wellman, TX

Soil type at both sites:

- Amarillo fine sandy loam (fine-loamy, mixed, superactive, thermic Aridic Paleustalf)

80% sandy, 9% silt, and 11% clay

The experimental design



Research plot design at Ag-CARES in Lamesa, TX

Evaluated systems

Continuous cotton systems – (est. 1998)

- Conventional tillage, winter fallow (CT)
- No-tillage, Rye cover (R-NT), 40 lb ac.$^{-1}$
- No-tillage, Mixed cover (M-NT), 40 lb ac^{-1}
    - Rye (50%)
    - Austrian Winter Pea (33%)
    - Hairy Vetch (10%)
    - Radish (7%)
        - by weight
    - Established in November 2014
    - NRCS recommended mixture

Native Systems (NAT)

- Rangeland - historical record indicates it unplowed at least 80 years

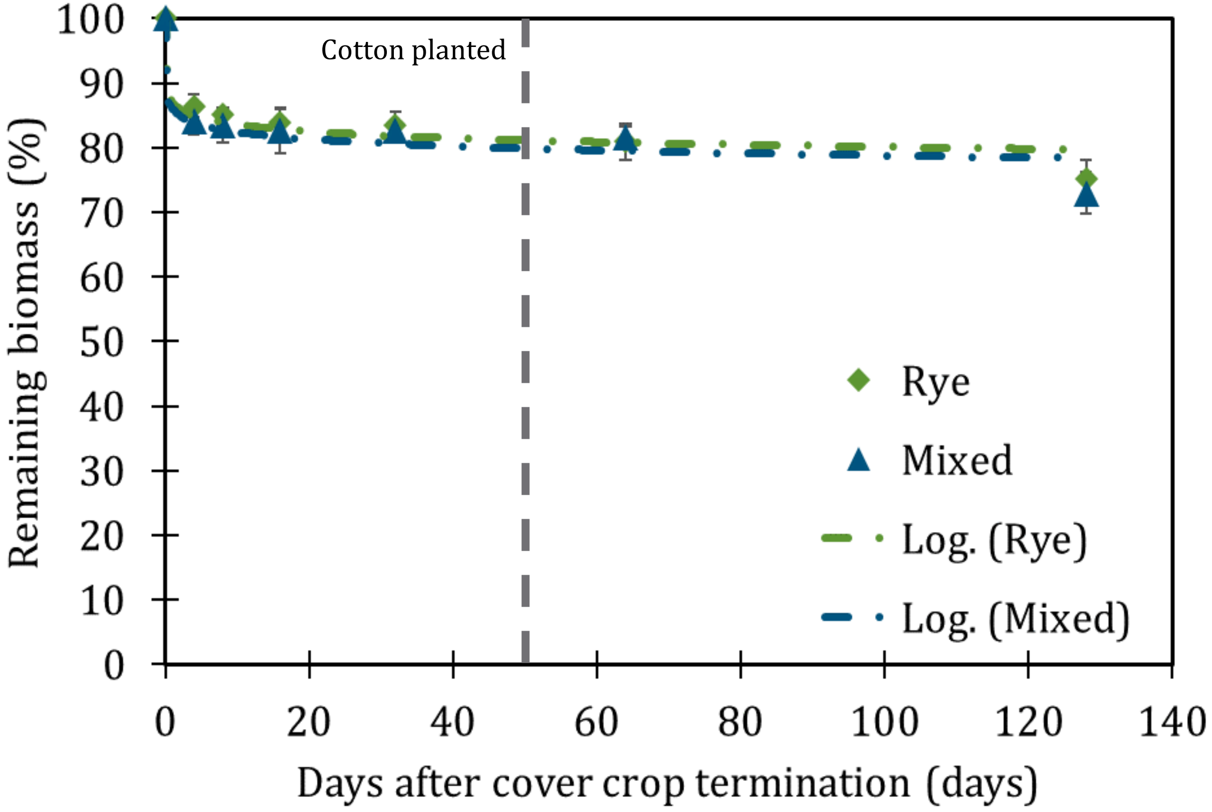
Depths: 0-2.5, 2.5-5, 5-12, 12-30, and 30-40”

The field methods

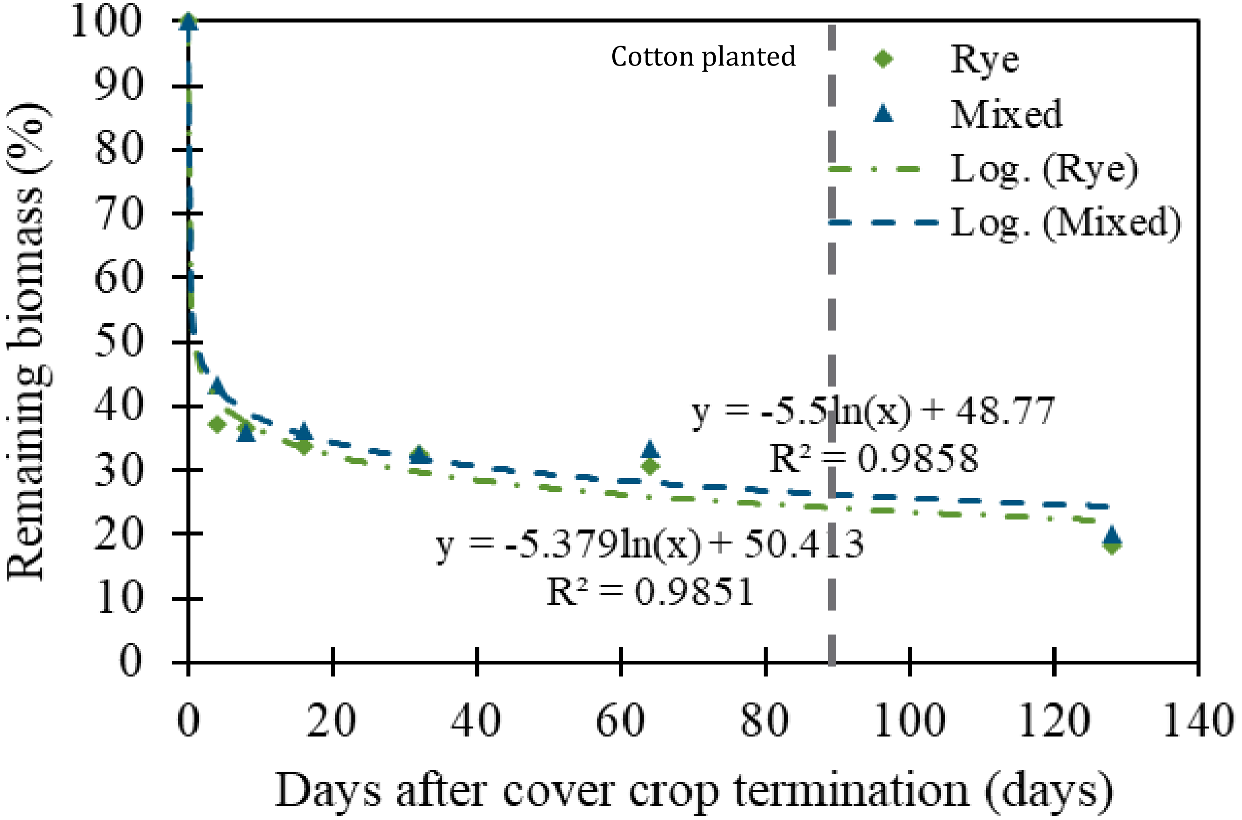
Biomass decomposition
75-mesh litterbags retrieved at 0, 4, 8, 16, 32, 64, and 128 days, *Heath, 1964*

Soil samples
Collected at 0-15 cm depth from directly beneath the litterbags

Cover crop biomass decomposition

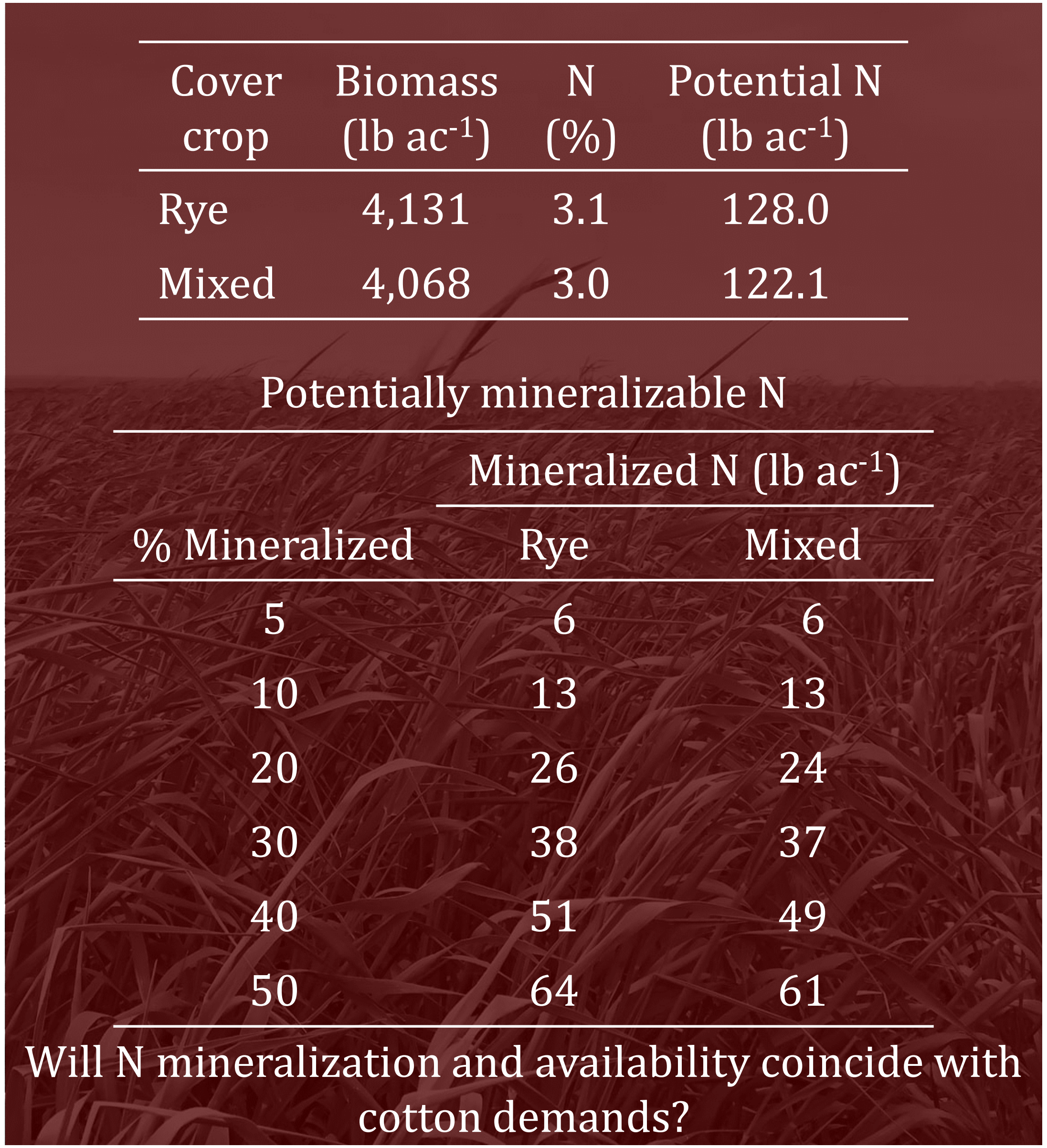


2020



2021

Biomass decomposition - 2020

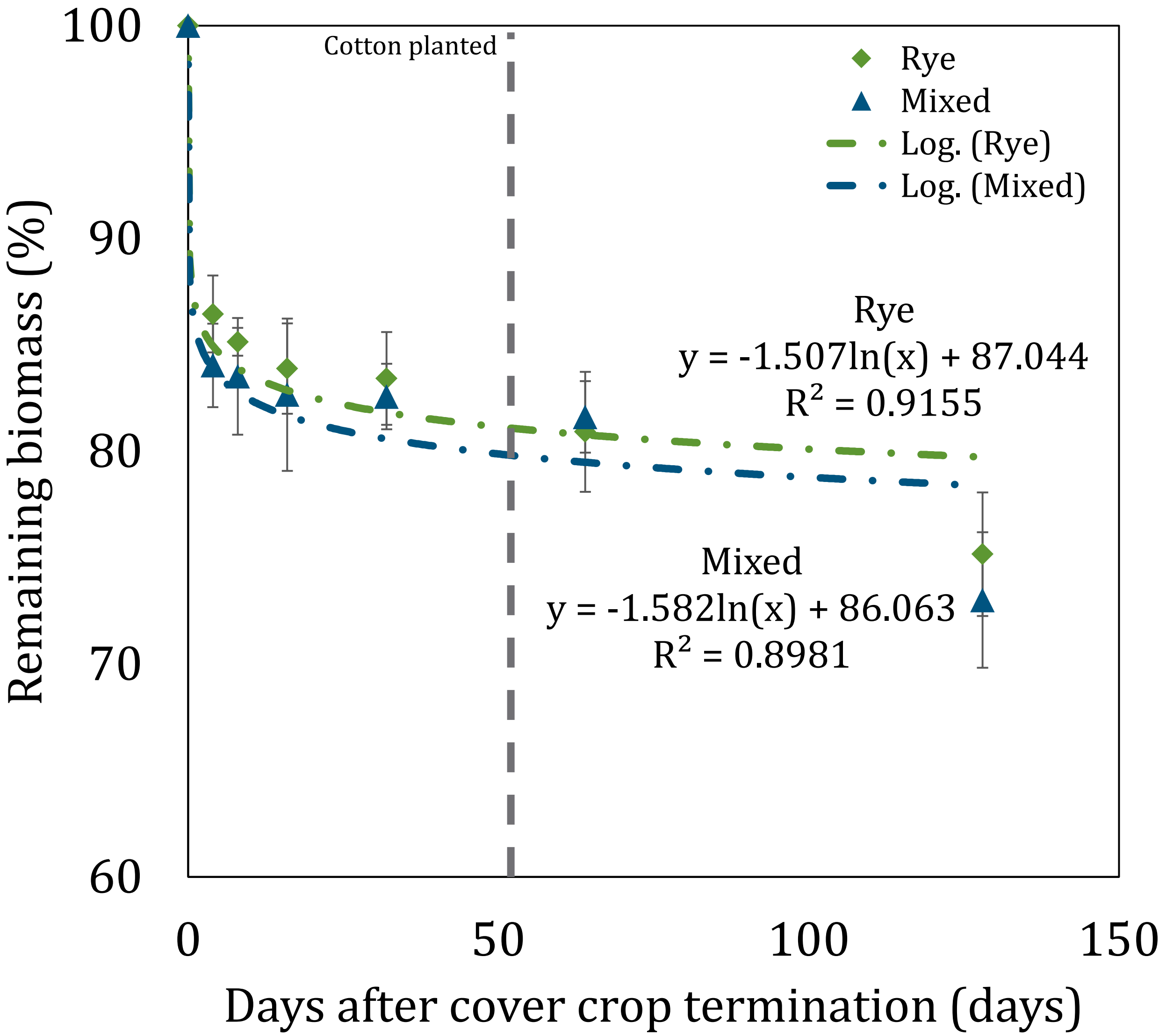


Cover crop	Biomass (lb ac^{-1})	N (%)	Potential N (lb ac^{-1})
Rye	4,131	3.1	128.0
Mixed	4,068	3.0	122.1

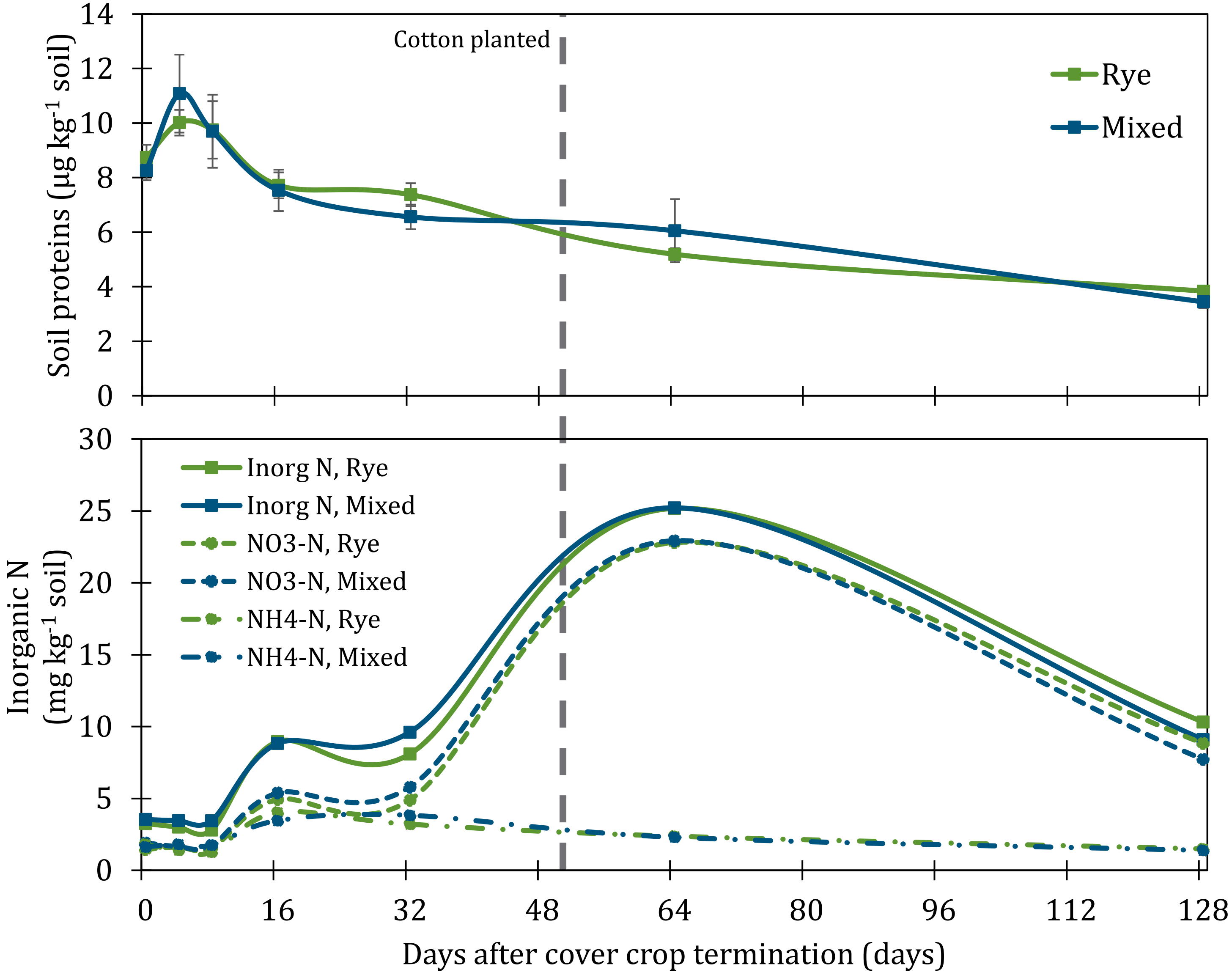
Potentially mineralizable N

	Mineralized N (lb ac^{-1})	
% Mineralized	Rye	Mixed
5	6	6
10	13	13
20	26	24
30	38	37
40	51	49
50	64	61

Will N mineralization and availability coincide with cotton demands?



Soil nitrogen dynamics



Soil proteins = organic N

- Increases in organic N result from decomposition of cover crop residues by soil microbes
- Those microbes will eventually make that N available to plants when they die or through mineralization, but the process is slow in semi-arid cropping regions with limited water

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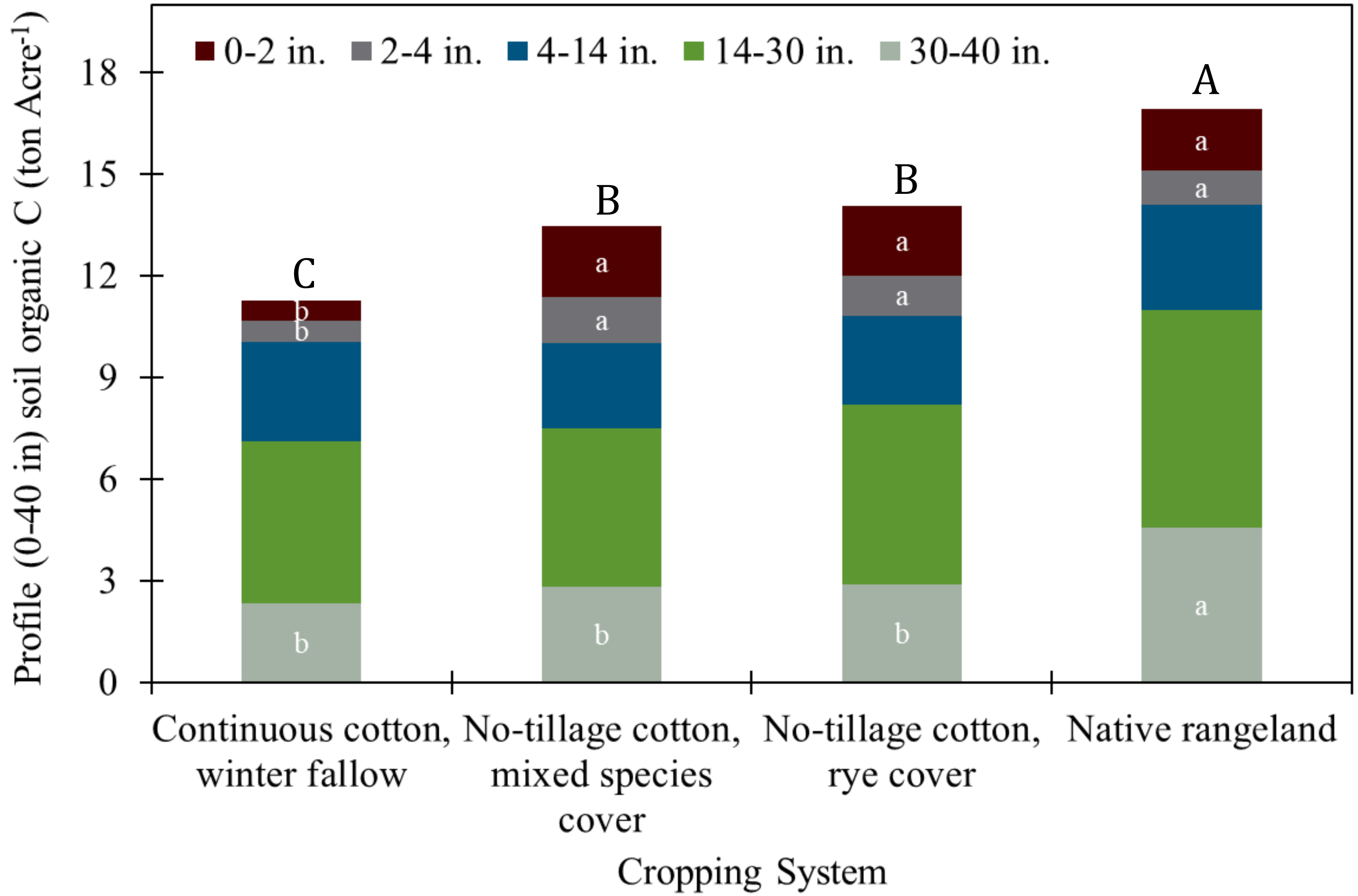
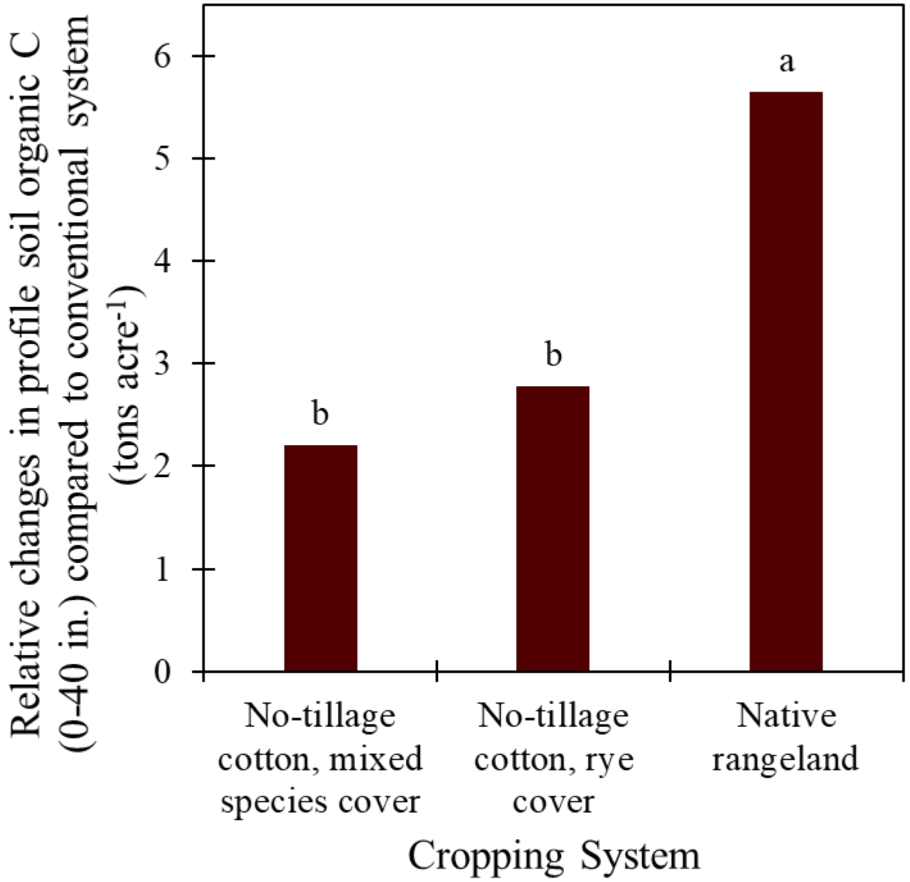
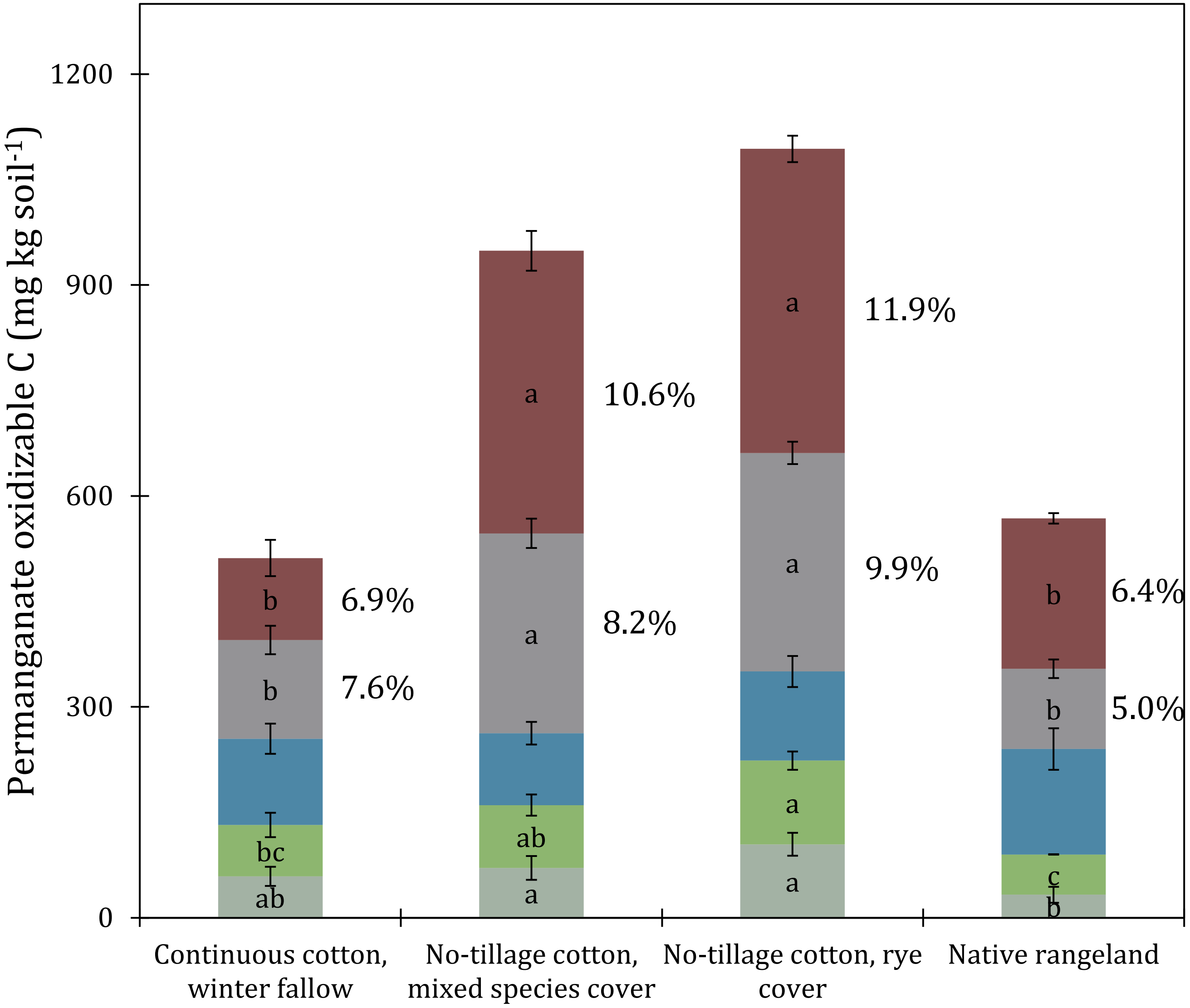
Soil organic carbon

*Samples collected in year 20 of the study

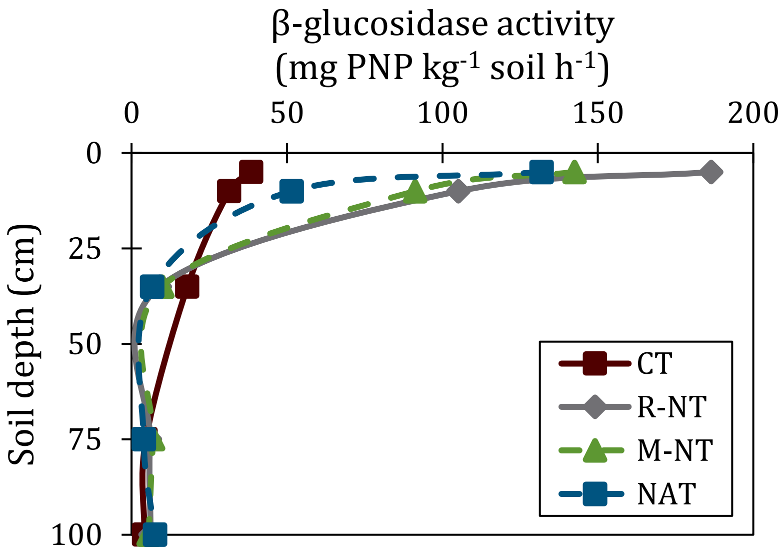




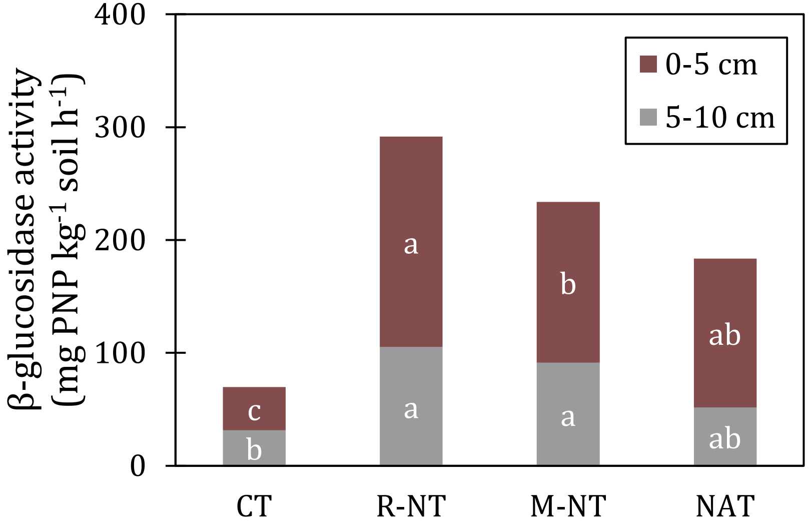
Permanganate oxidizable carbon

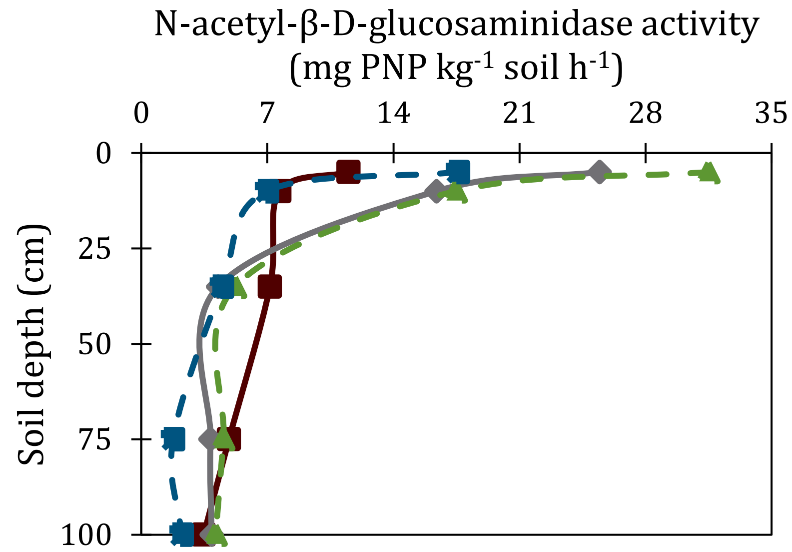


Enzyme activities

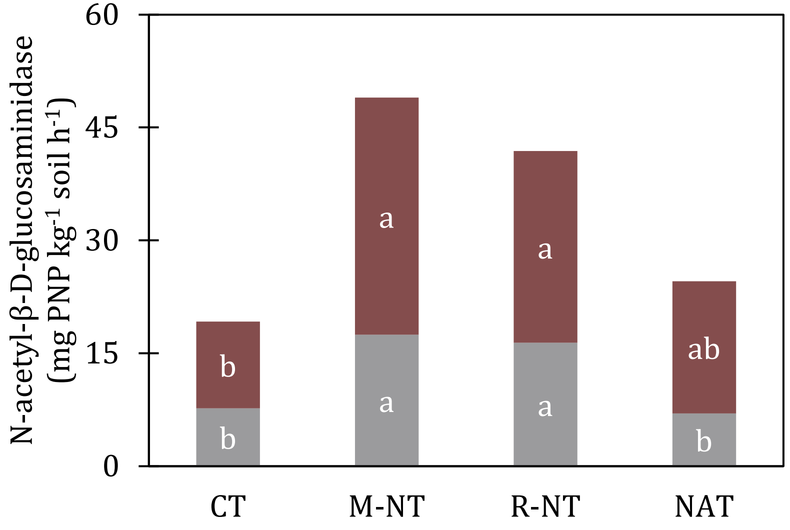


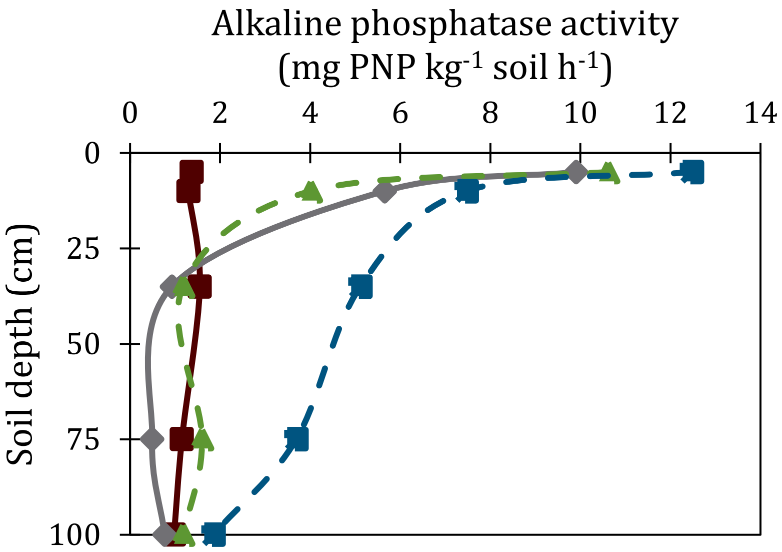
C cycling enzyme: Cellulose → Glucose



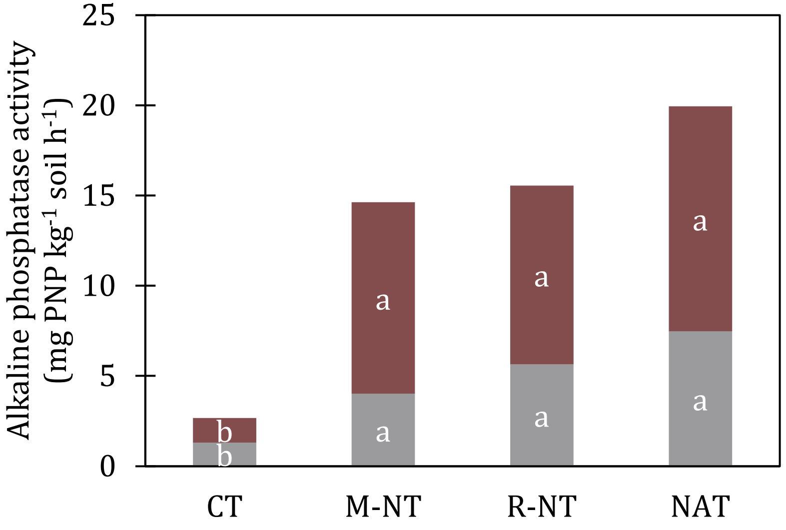


C & N cycling enzyme: Chitin → Amino sugars





P cycling enzyme: Phosphomonoesters → Phosphate



Microbial communities

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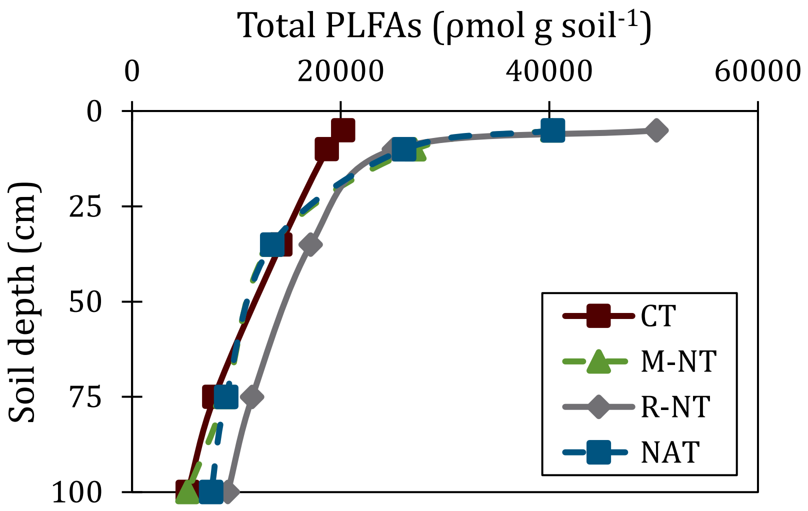
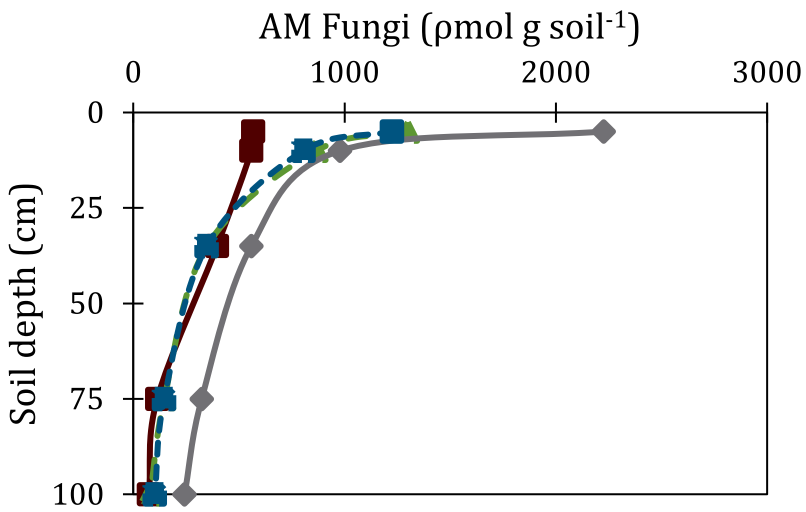
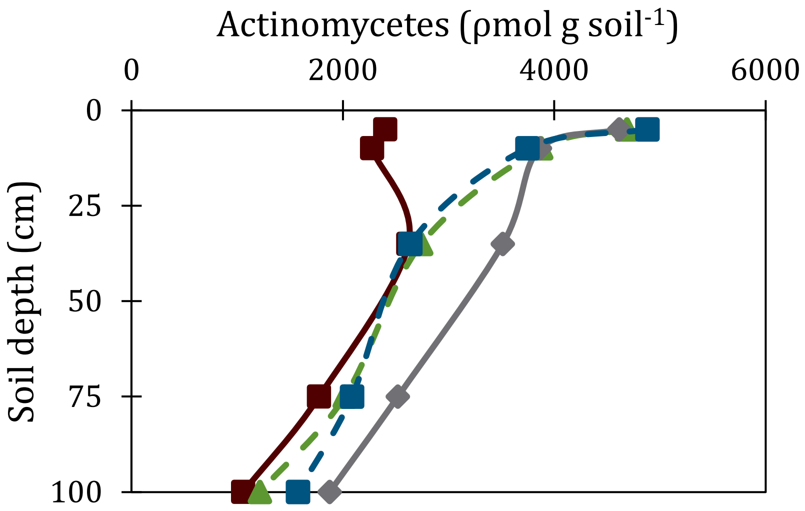
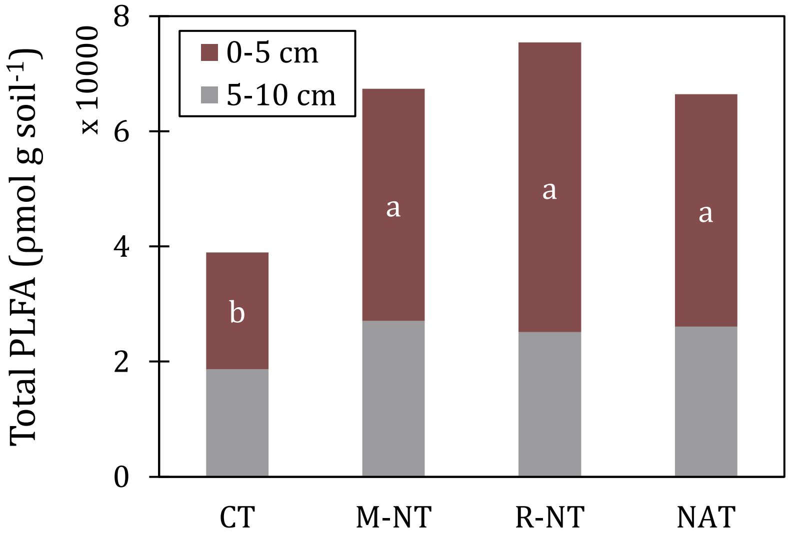
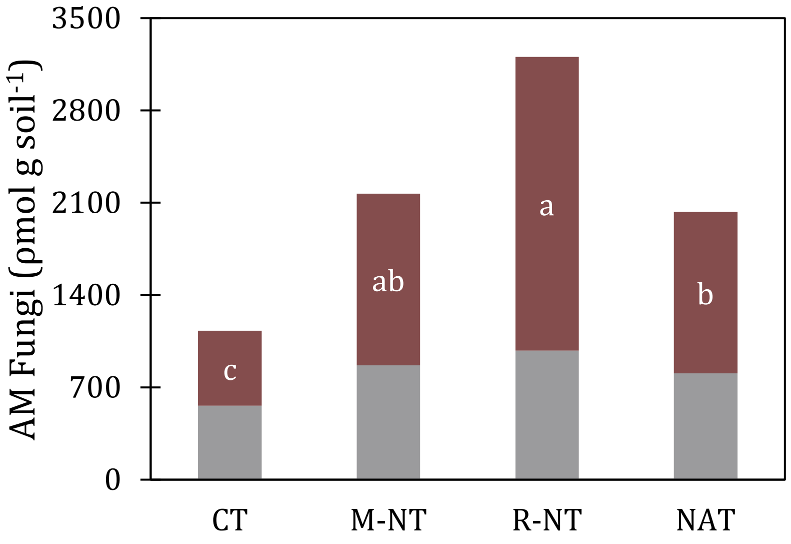
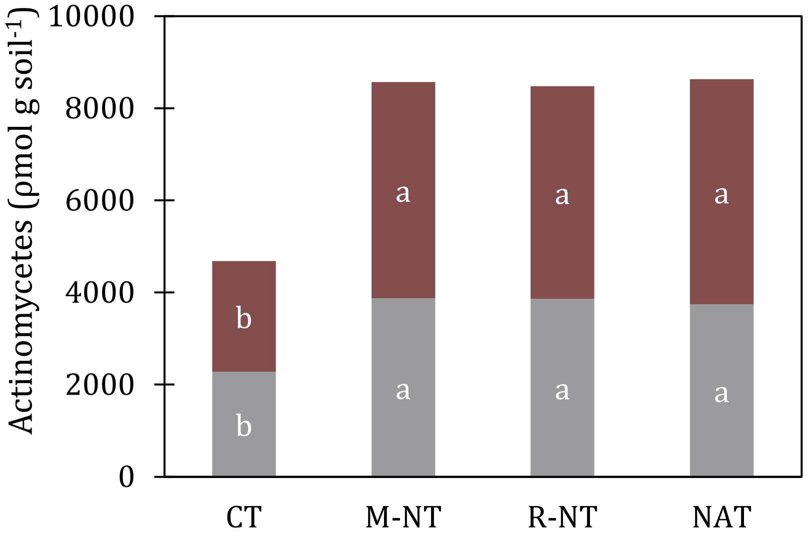






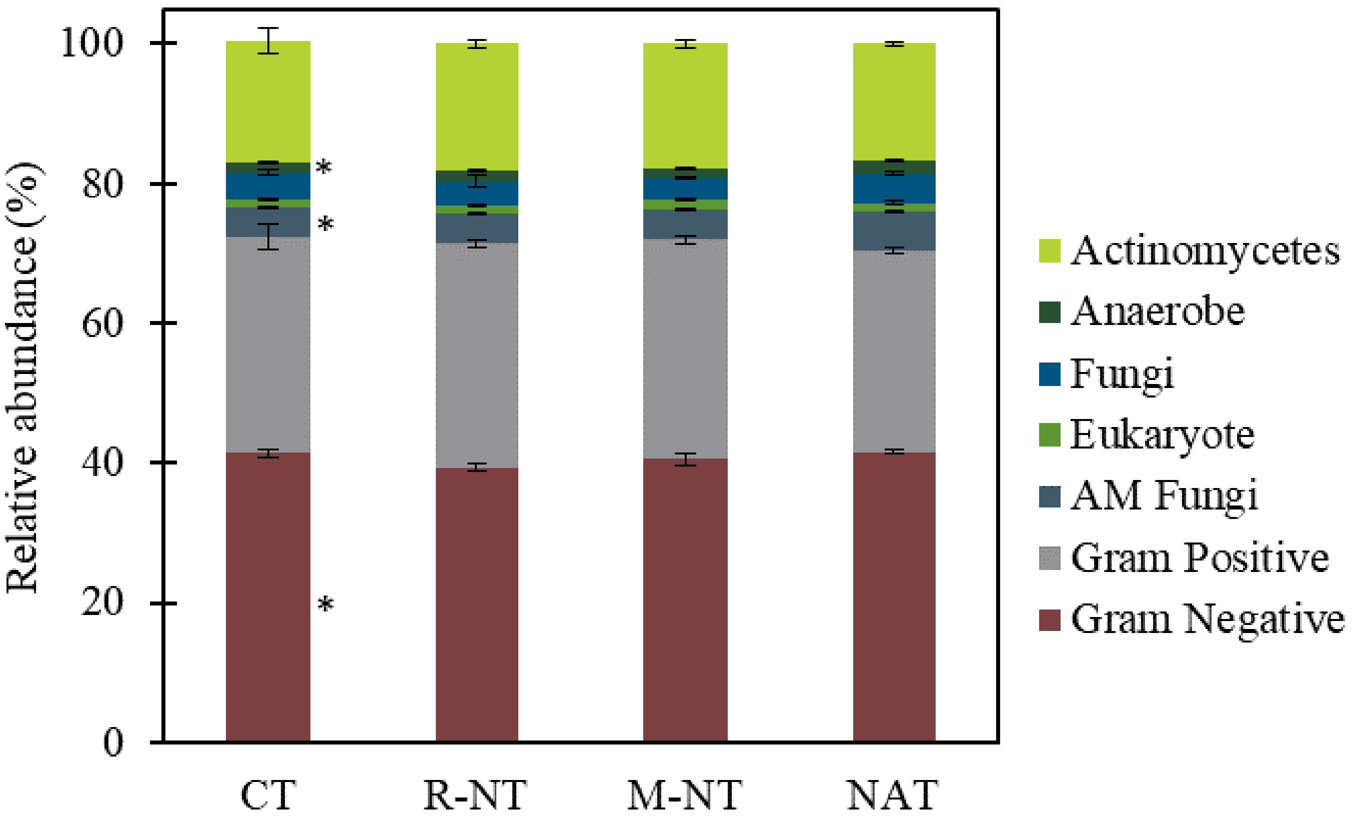






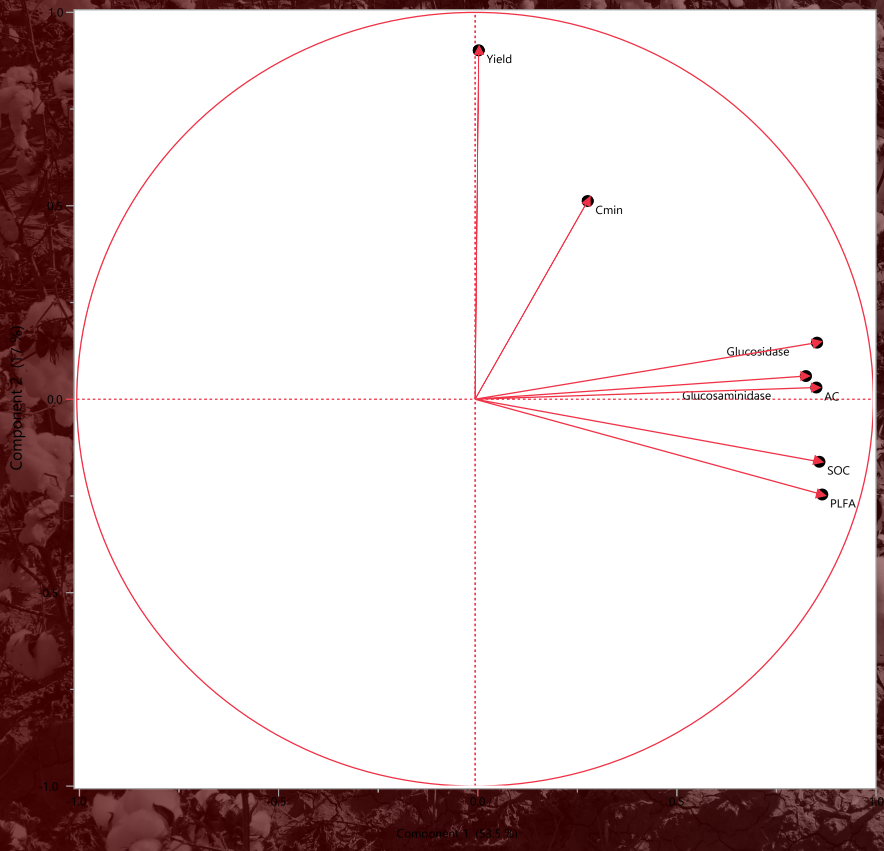
Microbial communities

Relative abundance of soil microbial community

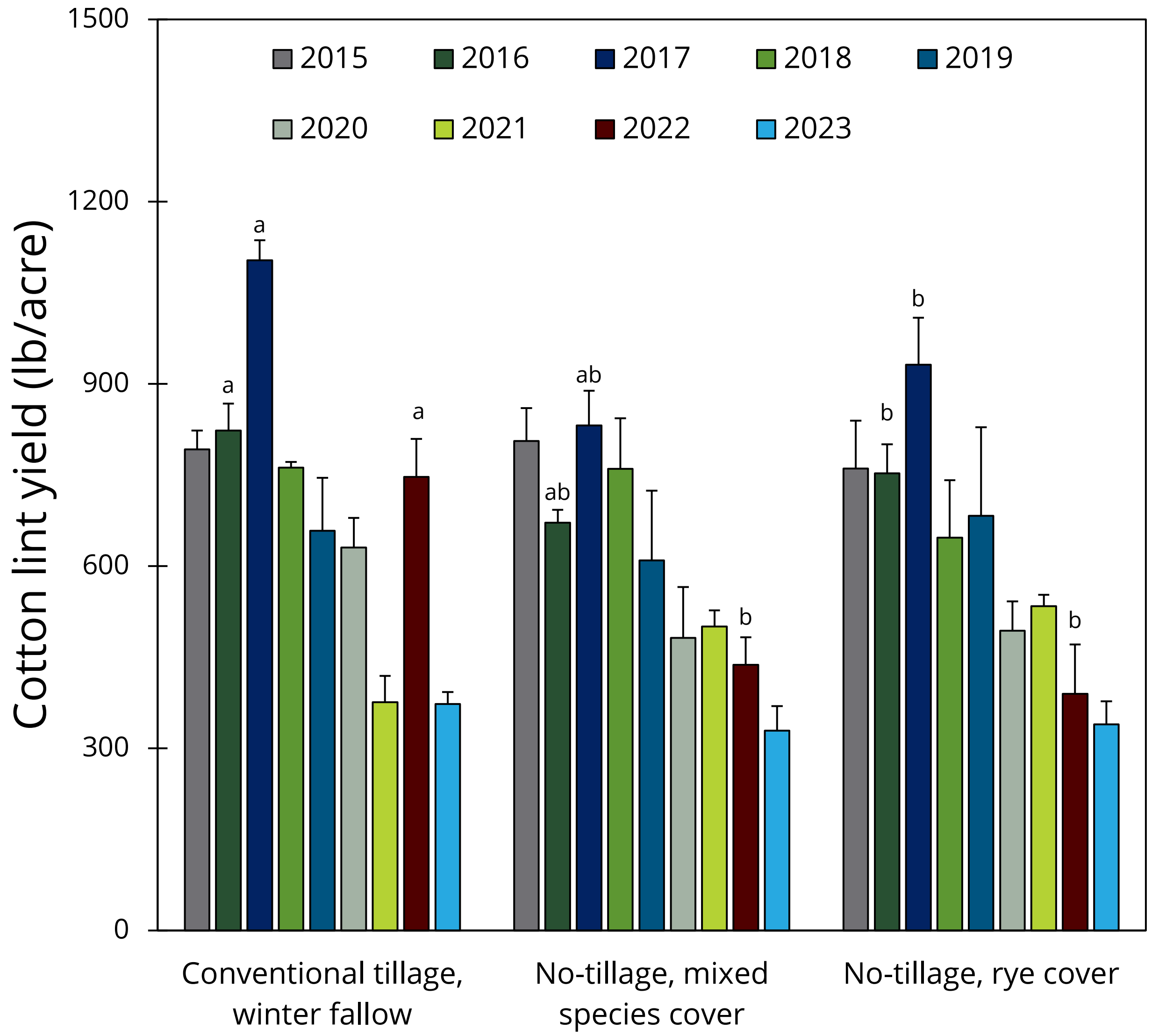


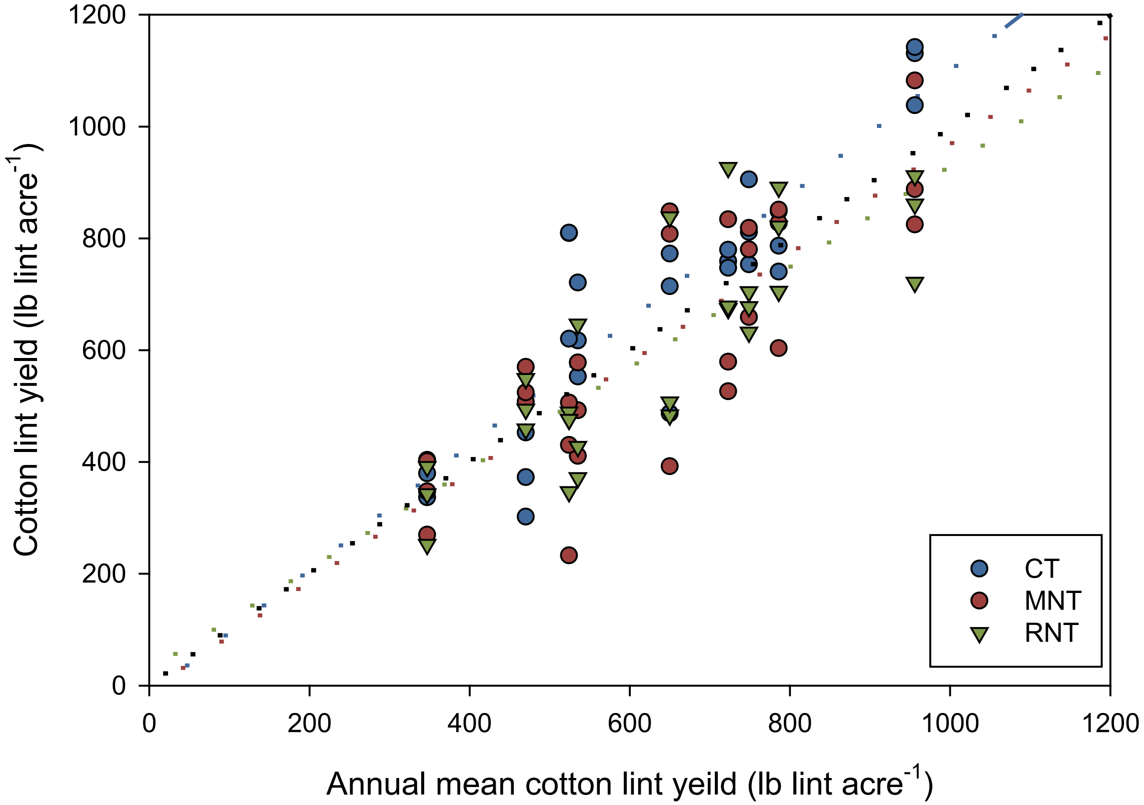
CT, conventional tillage winter fallow; R-NT, no-tillage rye cover; M-NT, no-tillage mixed species cover; NAT, native rangeland

Relationship between cotton yield and select biological indicators of soil health



Yield and stability





Treatment	$\widehat{\boldsymbol{\beta}}_1$	R^2
CT	1.120	0.771
MNT	0.978	0.659
RNT	0.903	0.696

> 1, more stable; = 1, stable; < 1, less stable

Soil Health and Nitrogen Management

AG-CARES, Lamesa, TX

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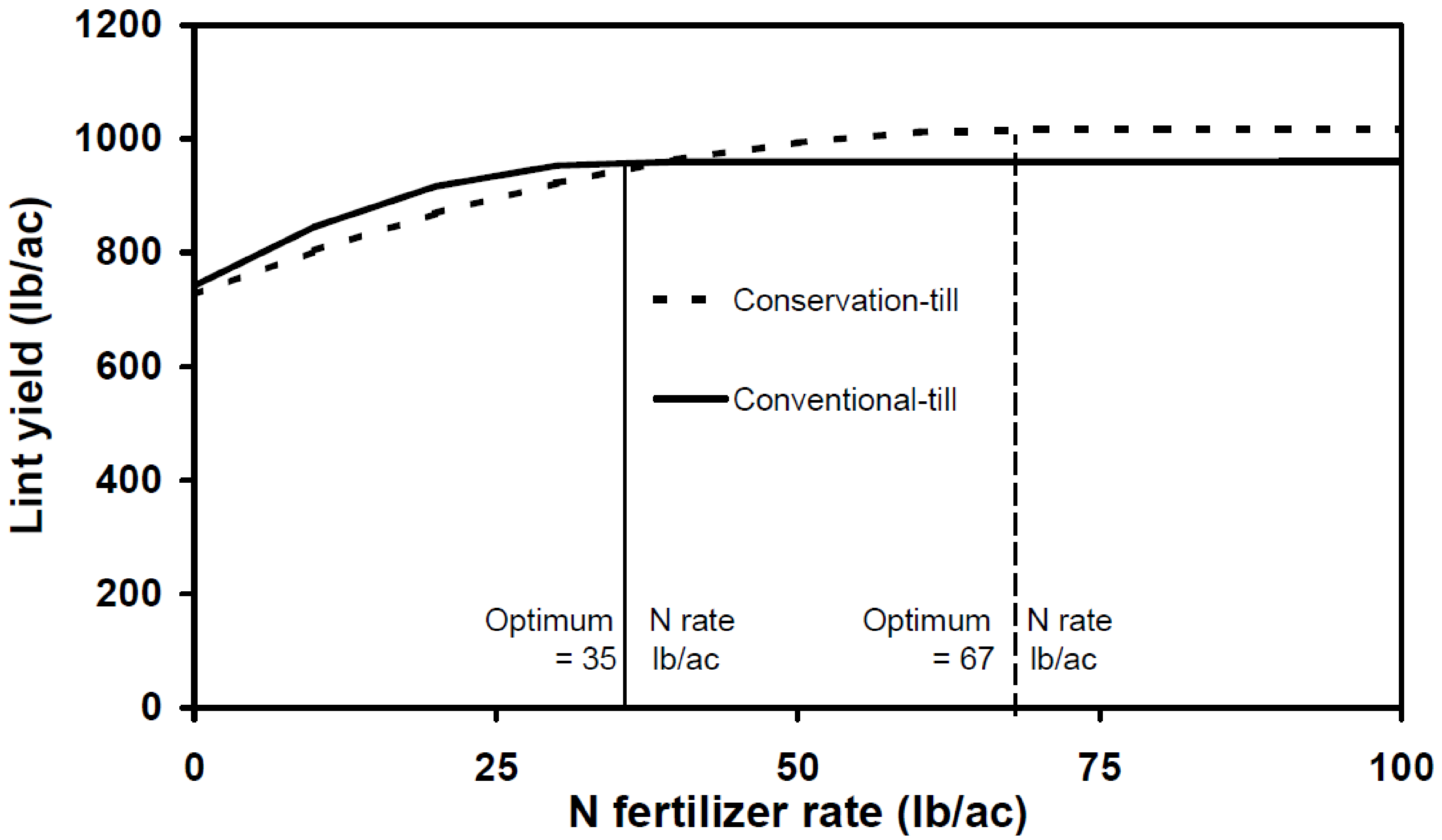


Source: Nutrient Management of Conservation-Till Cotton in Terminated-Wheat
K.F. Bronson, J.W. Keeling, R.K. Boman, J.D. Booker, and H.A. Torbert, April 2004

Soil Health and Nitrogen Management

AG-CARES, Lamesa, TX

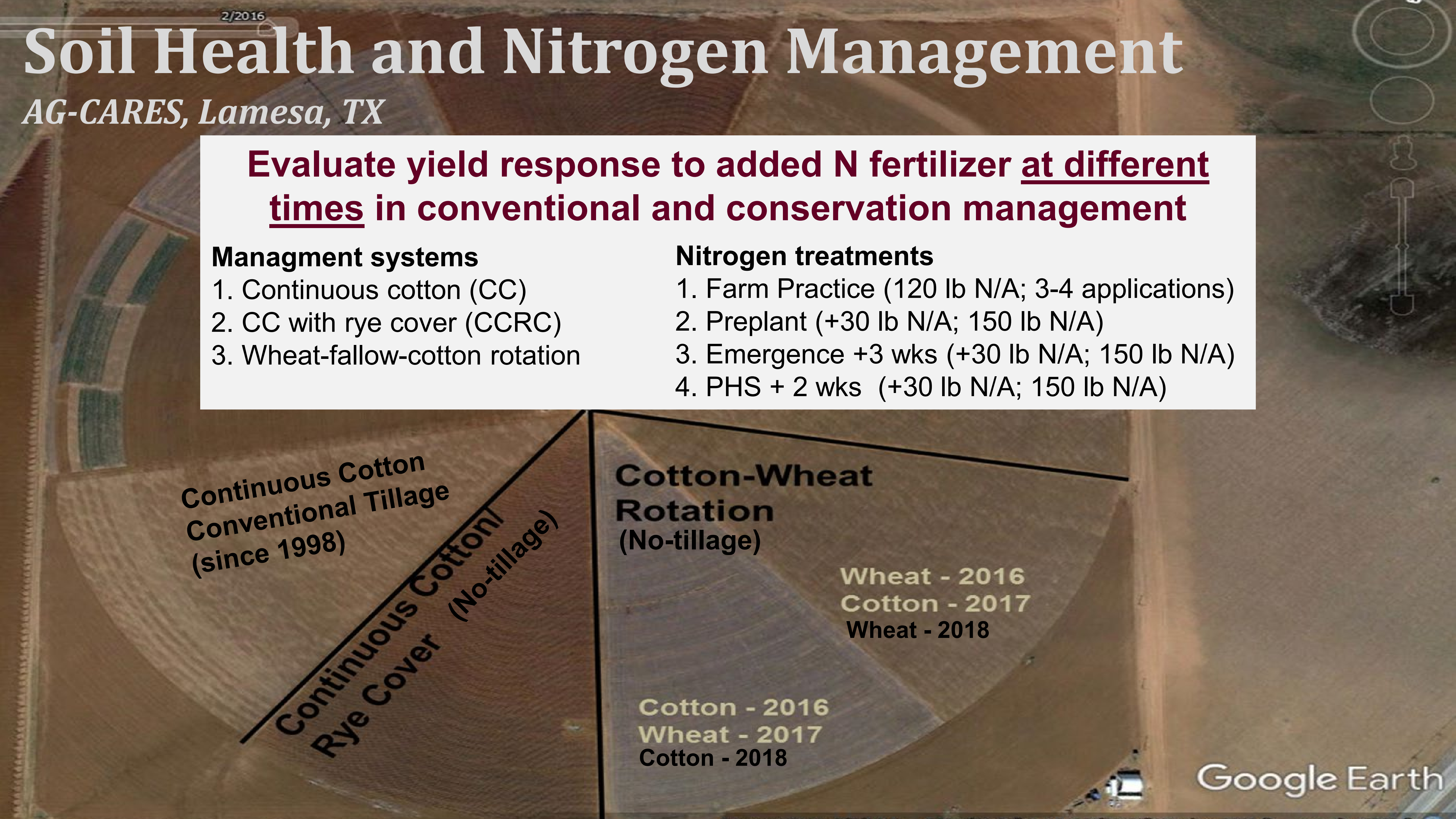
Evaluate yield response to added N fertilizer at different times in conventional and conservation management

Managment systems

1. Continuous cotton (CC)
2. CC with rye cover (CCRC)
3. Wheat-fallow-cotton rotation

Nitrogen treatments

1. Farm Practice (120 lb N/A; 3-4 applications)
2. Preplant (+30 lb N/A; 150 lb N/A)
3. Emergence +3 wks (+30 lb N/A; 150 lb N/A)
4. PHS + 2 wks (+30 lb N/A; 150 lb N/A)



Cotton Yield

2018-2020 averages

Cropping System	Nitrogen fertilization strategies				
	FP	**PPN**	**PEN**	**PHSN**	
	Lint yield (lint acre^{-1})				AVG
CC	723	787 (8.9%)	715 (-1.1%)	683 (-5.5%)	**727**
CCRC	806	938 (16.4%)	965 (19.6%)	857 (6.2%)	**891** (23.3%)
CWR	1,134	1,032 (-9.0%)	1,117 (-1.5%)	1,064 (-6.2%)	**1,087** (50.4%)
AVG	**888**	**919** (3.5%)	**932** (5.0%)	**868** (-2.2%)	

Fertilization strategies:

- FP = farmers practices (120 lb N A^{-1})
- PPN = FP + 30 lb N A^{-1} at preplant
- PEN = FP + 30 lb N A^{-1} at post emerg. + 2 wks
- PHSN = FP + 30 lb N A^{-1} at pinhead square + 2 wks

Cropping systems:

- CC = Continuous cotton, conventional tillage (>25 yrs)
- CCRC = Continuous cotton-Rye cover
- CWR = Cotton-Wheat rotation

Gross Margins

2018-2020 averages

Cropping System	Nitrogen fertilization strategies				
	FP	PPN	PEN	PHSN	
	Gross Margin ($ acre^{-1})				AVG
CC	434	489 (12.7%)	441 (1.6%)	420 (-3.3%)	**336**
CCRC	489	591 (20.7%)	608 (24.3%)	536 (9.5%)	**556** (65.5%)
CWR	609	575 (-5.6%)	610 (0.3%)	587 (-3.6%)	**595** (77.1%)
AVG	**511**	**552** (8.0%)	**553** (8.2%)	**514** (0.6%)	

Fertilization strategies:

- FP = farmers practices (120 lb N A^{-1})
- PPN = FP + 30 lb N A^{-1} at preplant
- PEN = FP + 30 lb N A^{-1} at post emerg. + 2 wks
- PHSN = FP + 30 lb N A^{-1} at pinhead square + 2 wks

Cropping systems:

- CC = Continuous cotton, conventional tillage (>25 yrs)
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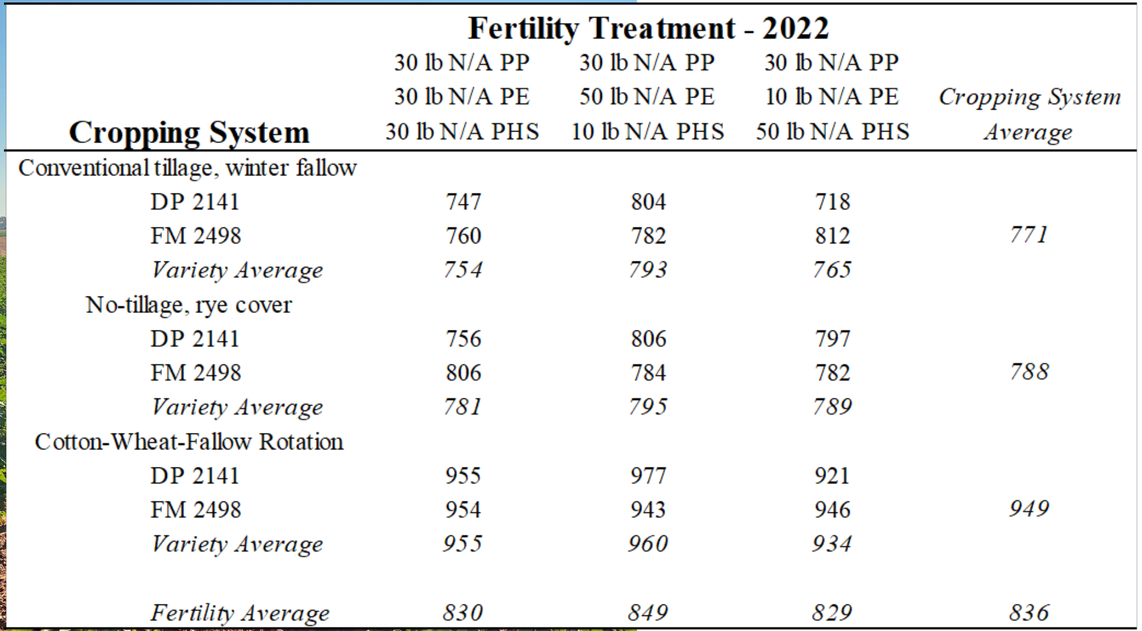
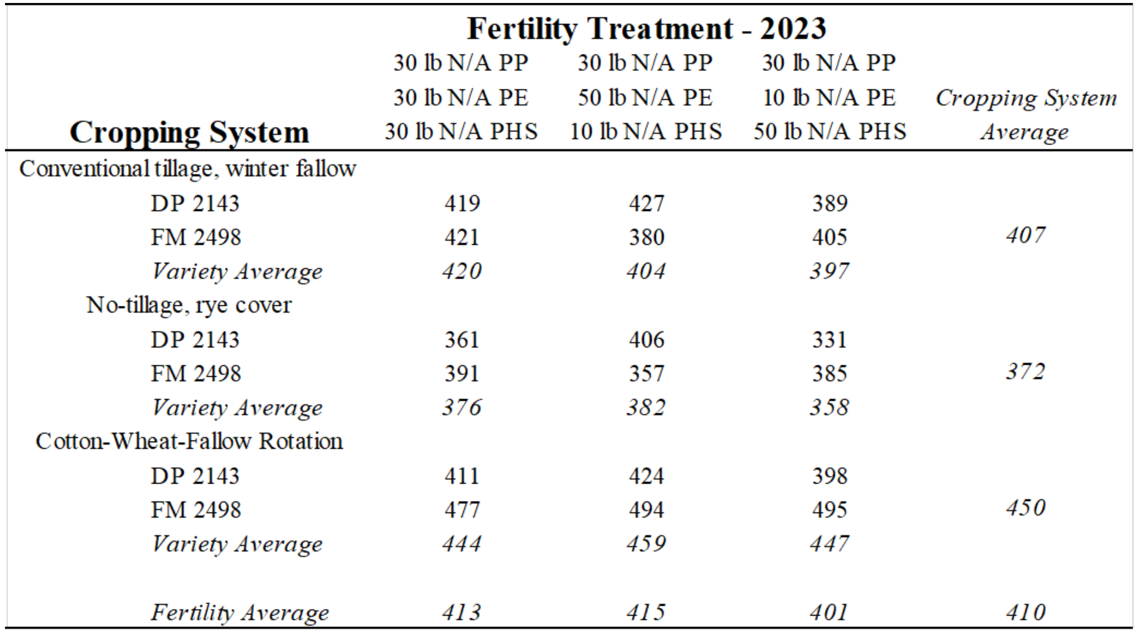
Nitrogen management (2022 - 2024)

Lewis et al.

AG-CARES, Lamesa, TX



Cropping System	**Fertility Treatment - 2022** 30 lb N/A PP 30 lb N/A PE 30 lb N/A PHS	 30 lb N/A PP 50 lb N/A PE 10 lb N/A PHS	 30 lb N/A PP 10 lb N/A PE 50 lb N/A PHS	*Cropping System Average*
Conventional tillage, winter fallow				
DP 2141	747	804	718	
FM 2498	760	782	812	*771*
Variety Average	*754*	*793*	*765*	
No-tillage, rye cover				
DP 2141	756	806	797	
FM 2498	806	784	782	*788*
Variety Average	*781*	*795*	*789*	
Cotton-Wheat-Fallow Rotation				
DP 2141	955	977	921	
FM 2498	954	943	946	*949*
Variety Average	*955*	*960*	*934*	
Fertility Average	*830*	*849*	*829*	*836*



Cropping System	**Fertility Treatment - 2023** 30 lb N/A PP 30 lb N/A PE 30 lb N/A PHS	 30 lb N/A PP 50 lb N/A PE 10 lb N/A PHS	 30 lb N/A PP 10 lb N/A PE 50 lb N/A PHS	*Cropping System Average*
Conventional tillage, winter fallow				
DP 2143	419	427	389	
FM 2498	421	380	405	*407*
Variety Average	*420*	*404*	*397*	
No-tillage, rye cover				
DP 2143	361	406	331	
FM 2498	391	357	385	*372*
Variety Average	*376*	*382*	*358*	
Cotton-Wheat-Fallow Rotation				
DP 2143	411	424	398	
FM 2498	477	494	495	*450*
Variety Average	*444*	*459*	*447*	
Fertility Average	*413*	*415*	*401*	*410*

Summary

- Cover crop biomass decomposition depends on herbage mass production and environmental conditions.
- Cover crop herbage mass can immobilize soil N early in the growing season.
- Supplemental N fertilization can offset immobilization and increase cotton lint yield.
- Cotton-wheat-fallow rotations may be a better alternative to cover crops in certain regions.

Nitrogen and Fertigation

Fertigation Frequency (SDI)

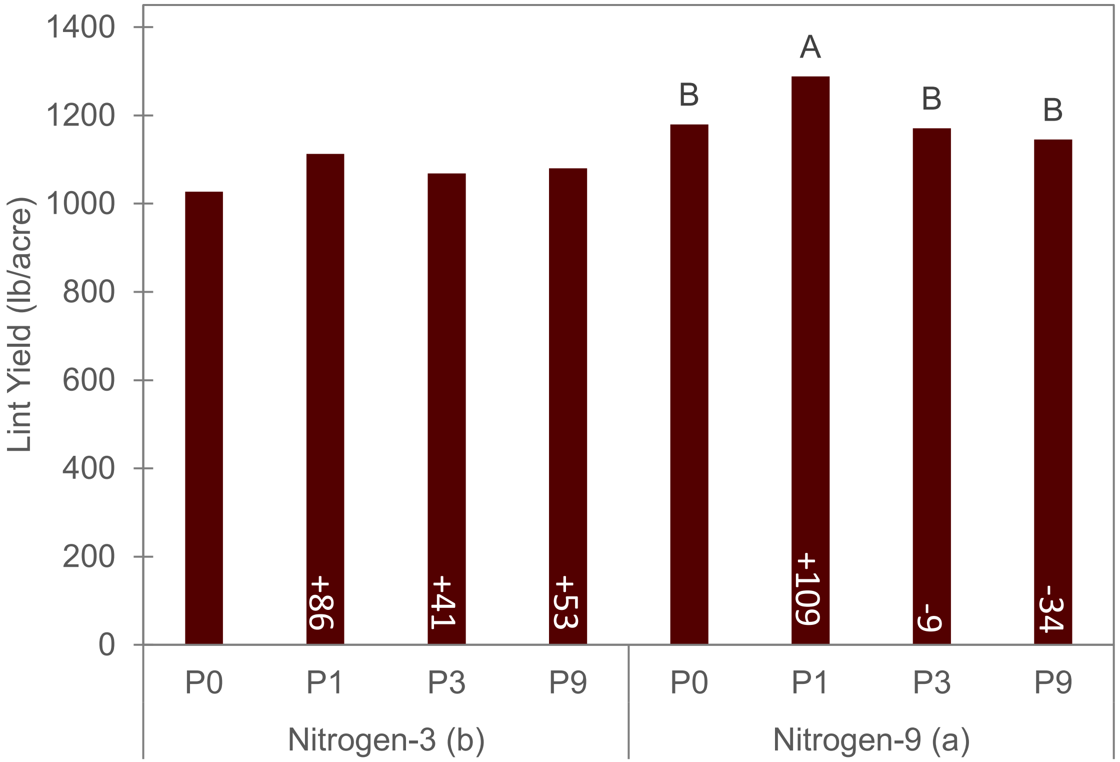
- Develop N and P fertigation strategies using SDI that optimize cotton lint yield and fertilizer return on investment.

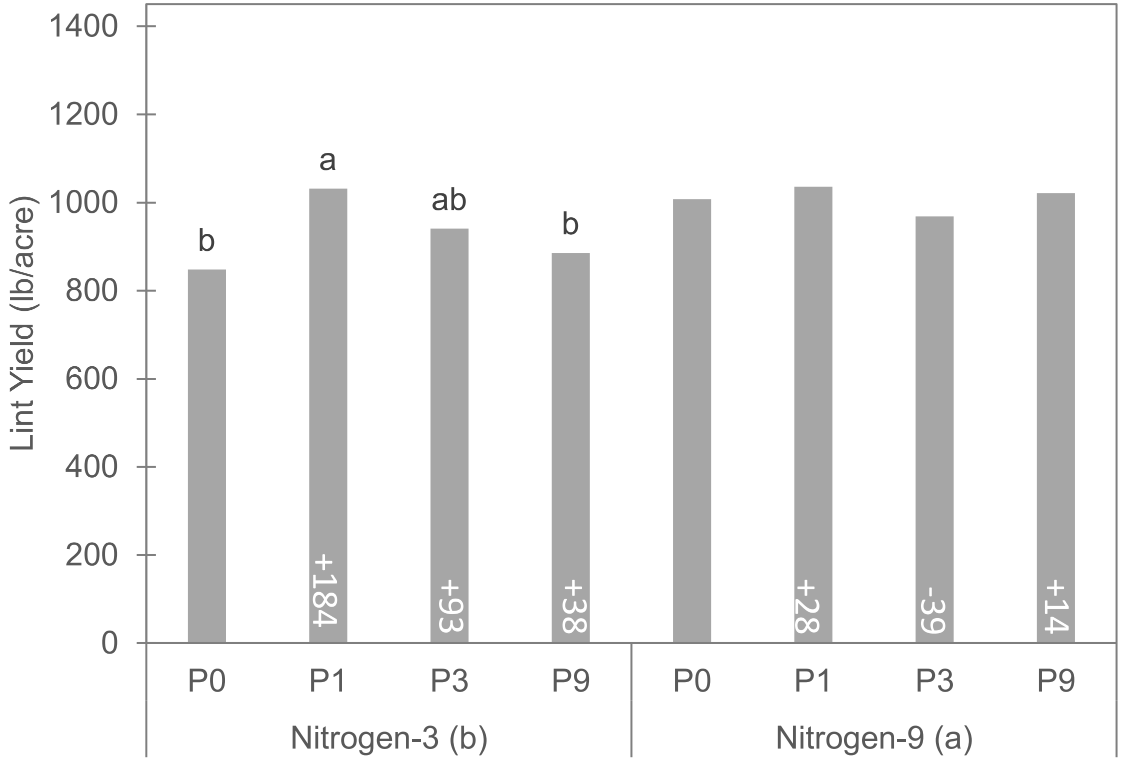
- More specifically, we will determine the number of fertilizer applications that results in the greatest nutrient uptake and yield when using SDI.

Applic Freq: 1		Applic Freq: 3		Applic Freq: 9	
2021	2022	2021	2022	2021	2022
9-May	7-Jun	9-May	7-Jun	9-May	7-Jun
				28-May	17-Jun
			24-Jun	18-Jun	24-Jun
				8-July	1-July
		20-July	8-July	20-July	8-July
				2-Aug	18-July
		11-Aug		11-Aug	29-July
				20-Aug	12-Aug
				30-Aug	26-Aug

Fertigation Frequency (SDI)

Lint yield (2021)


DP 2143


DP 2020

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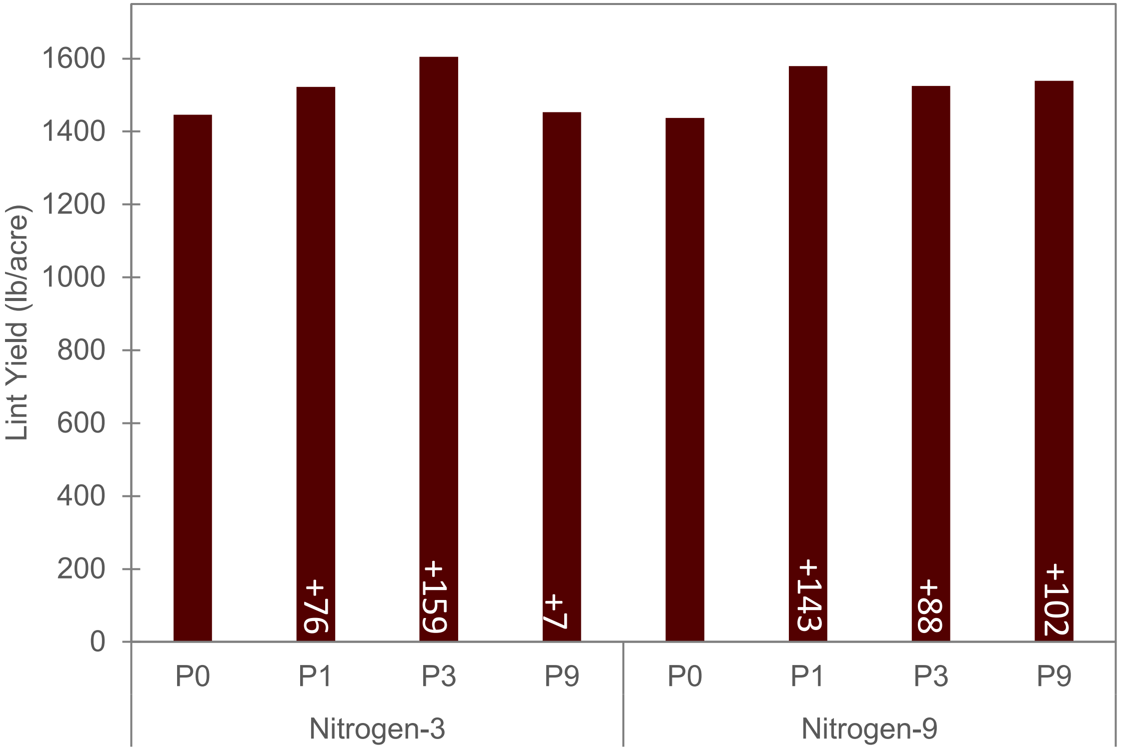
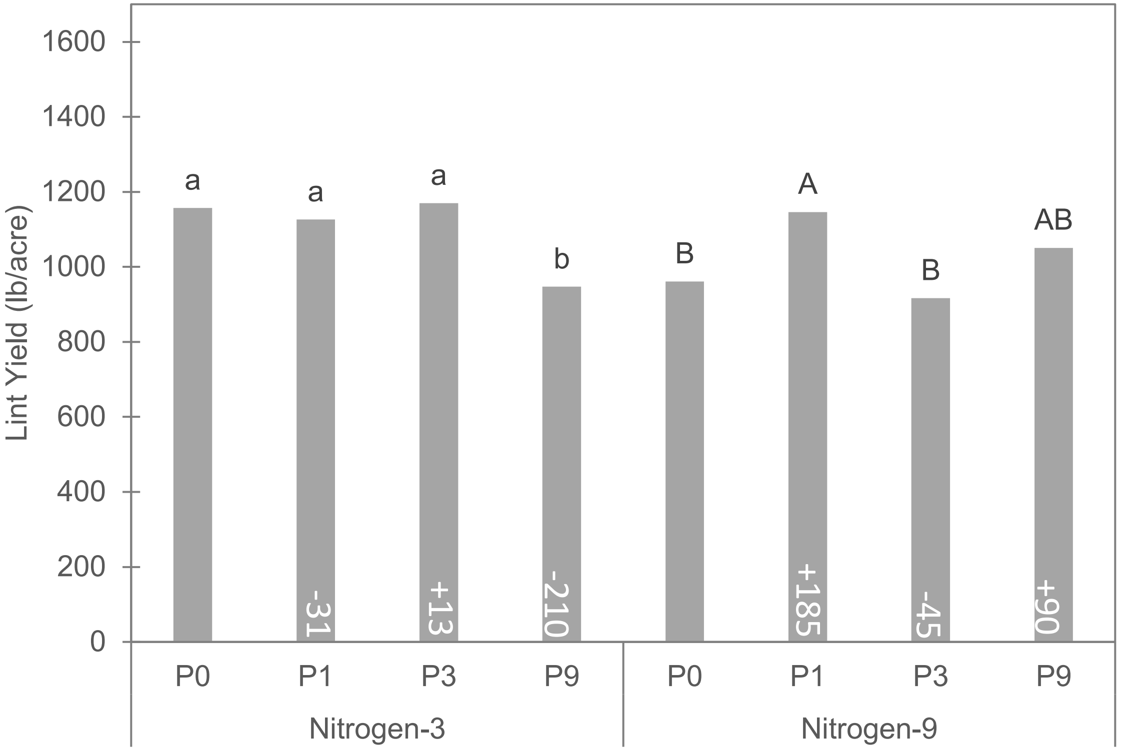
Fertigation Frequency (SDI)

Lint yield (2022)

DP 2143



DP 2020



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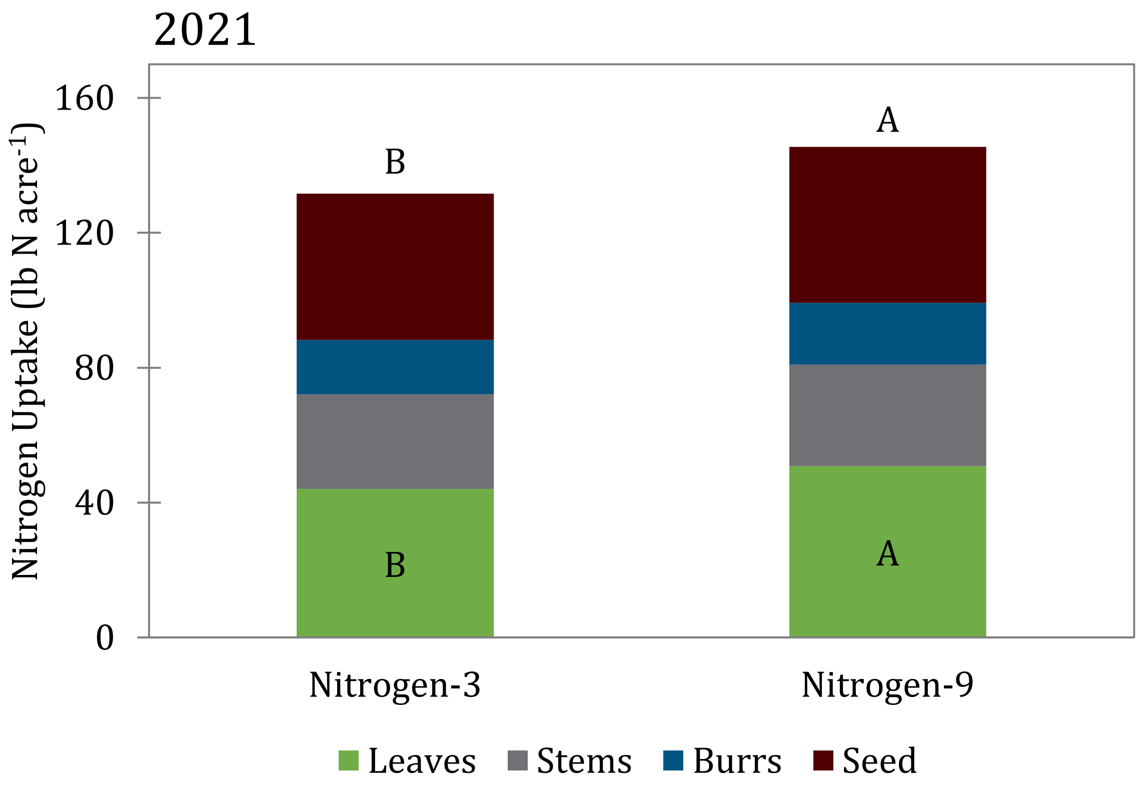
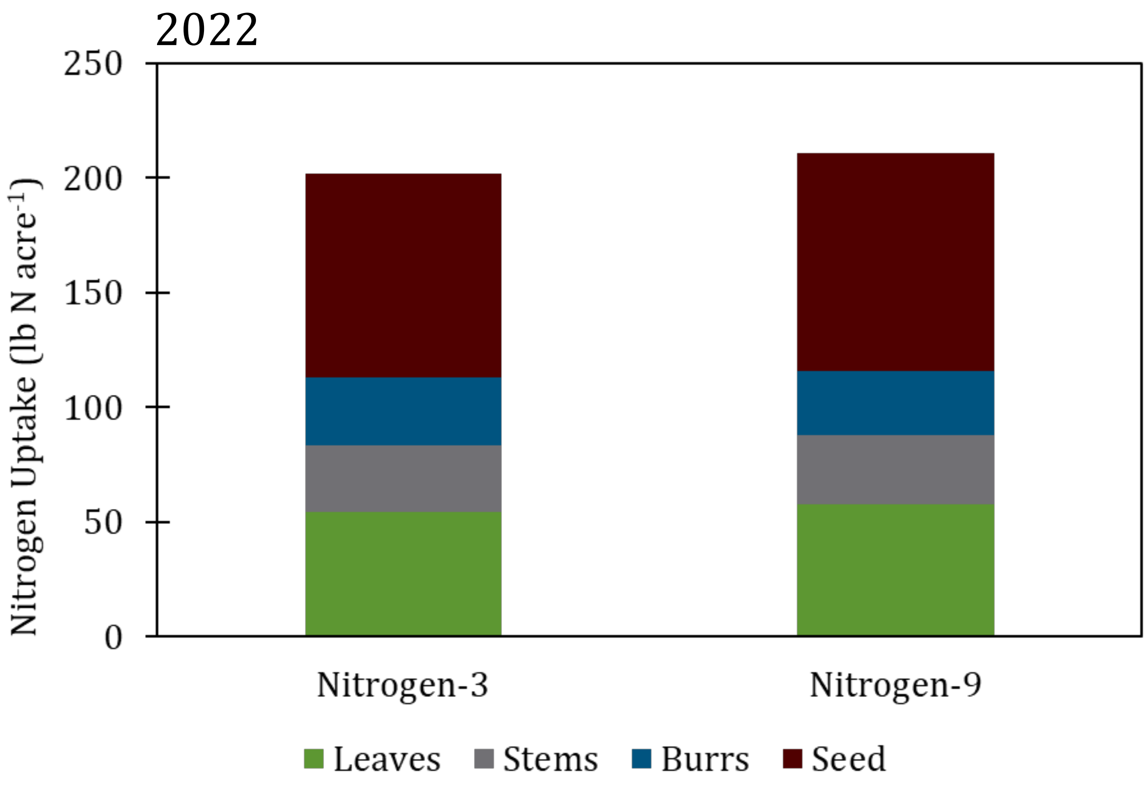
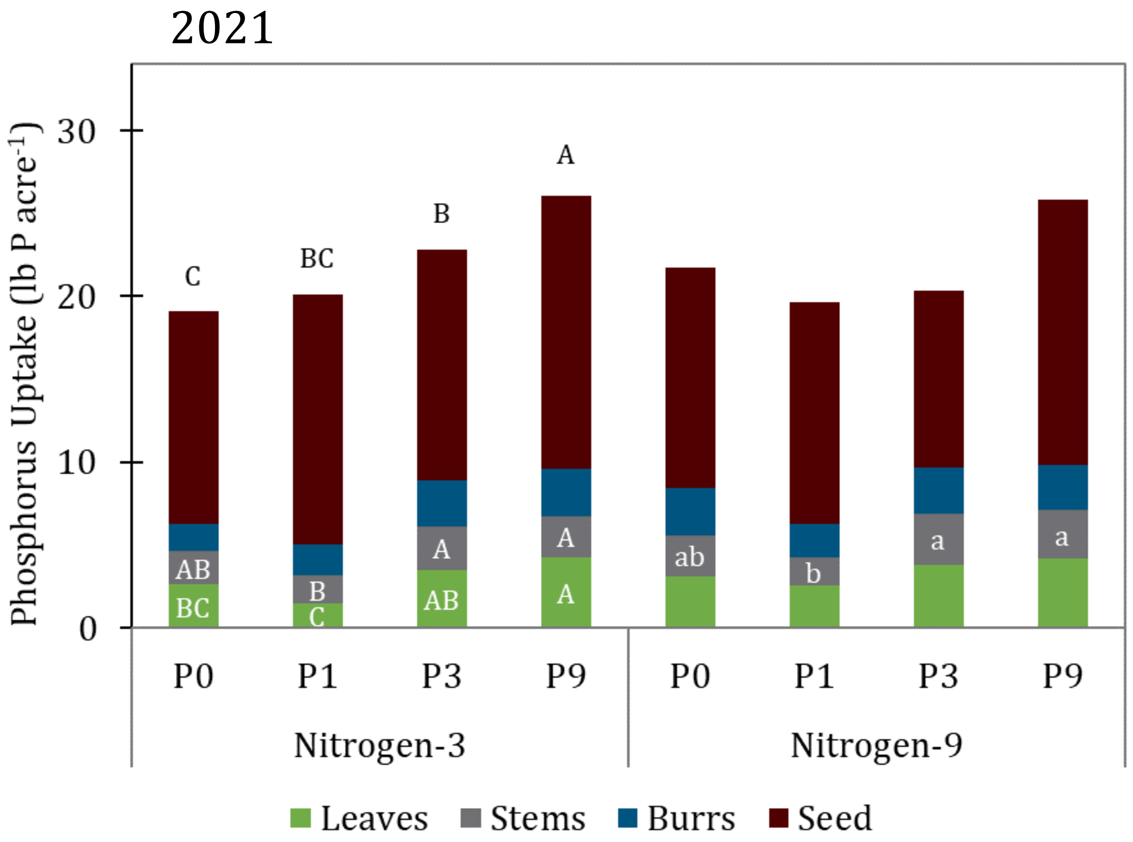
RESEARCH

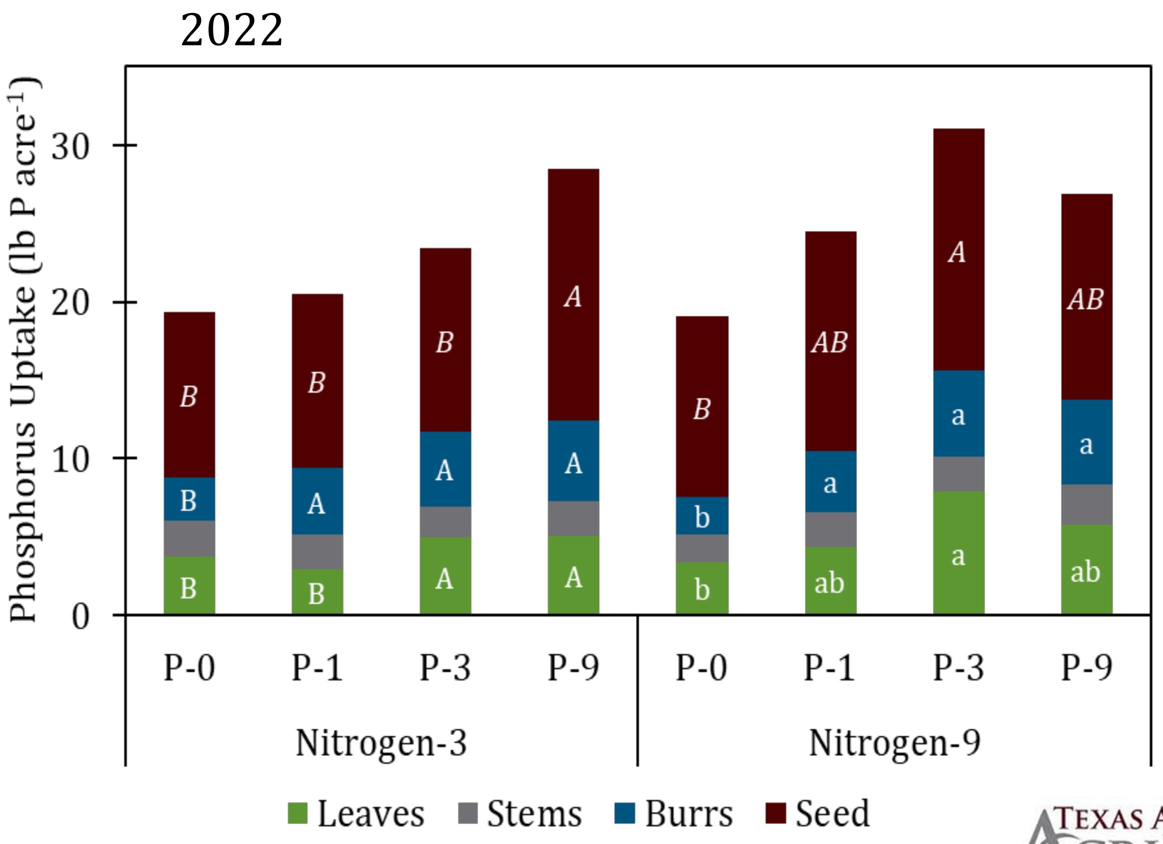
Nitrogen Uptake and Partitioning





Phosphorus Uptake and Partitioning





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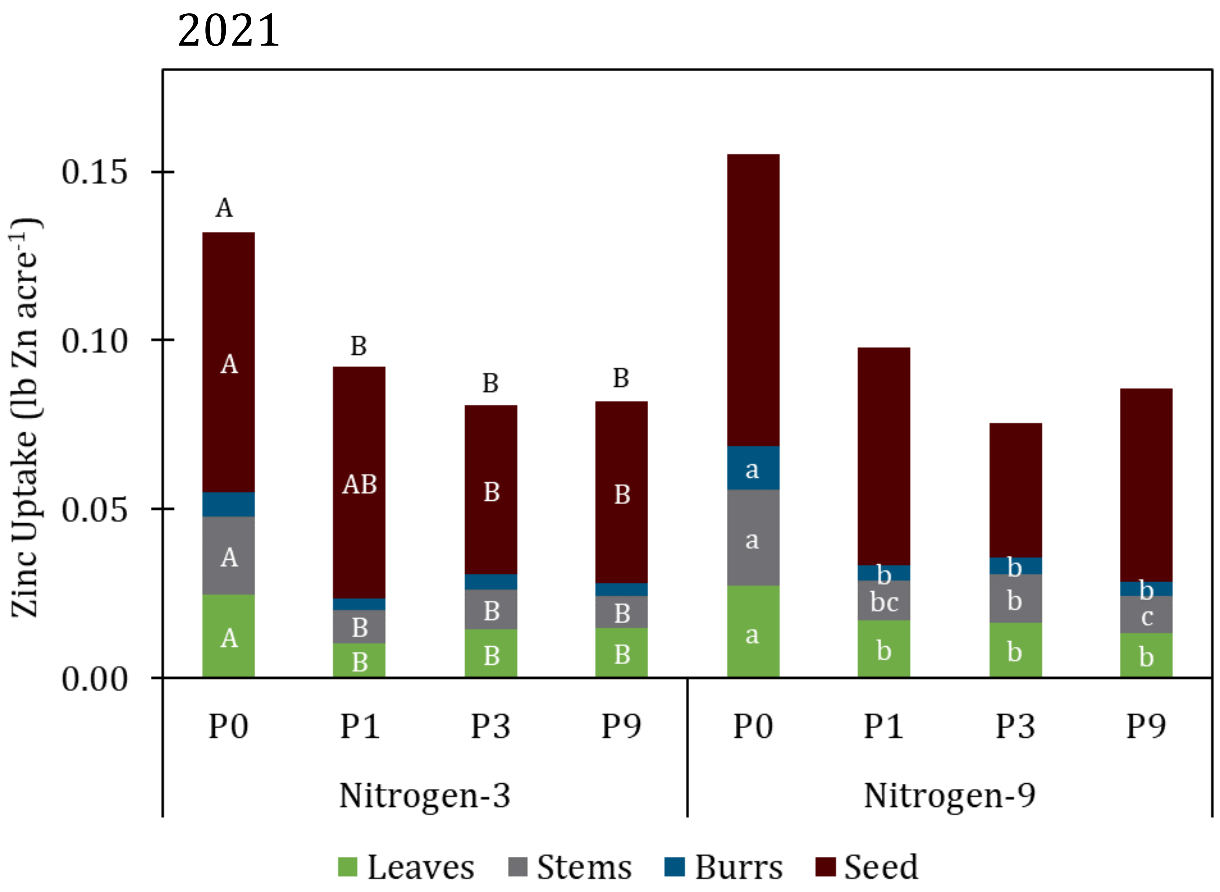
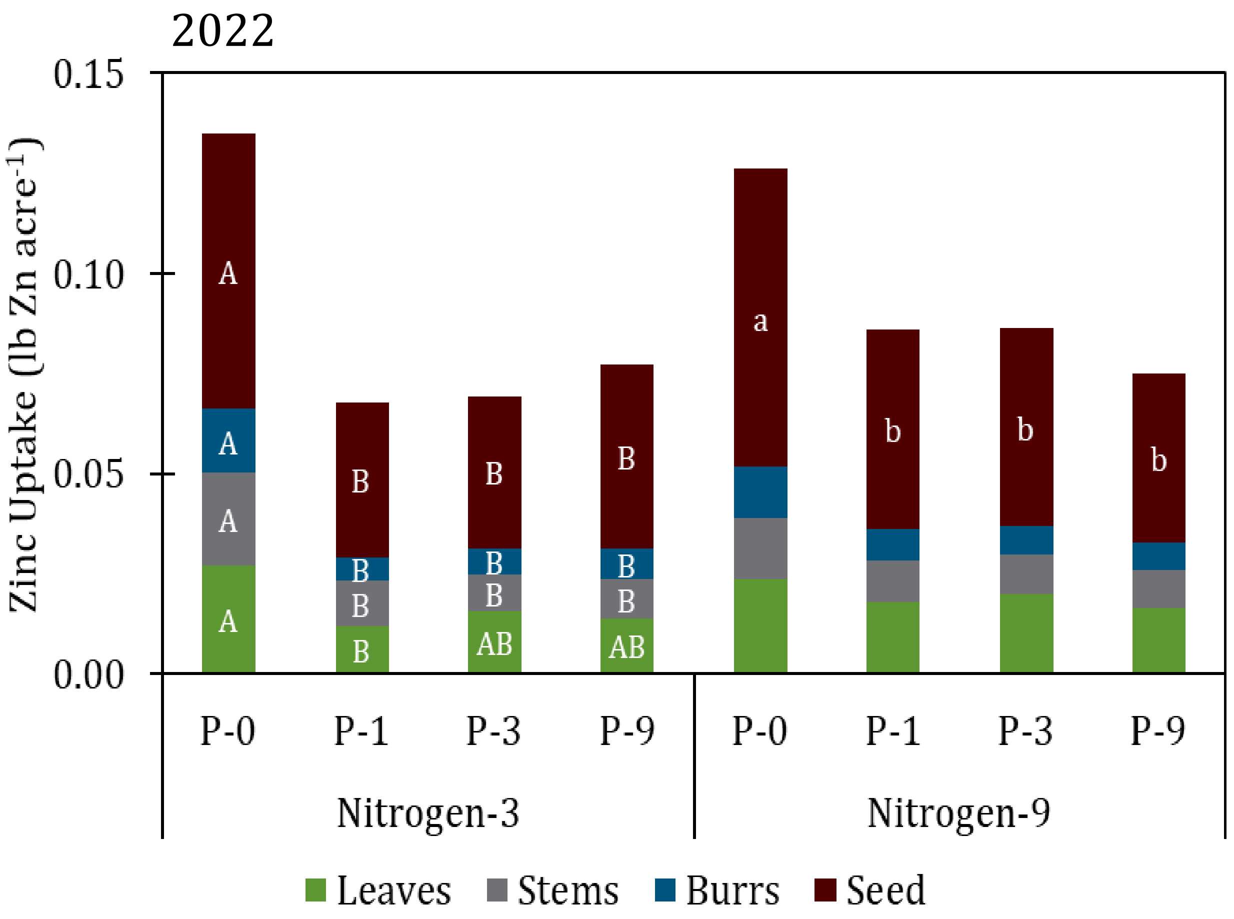
Zinc Uptake and Partitioning


2021


2022

Take-aways

- Nitrogen is needed earlier and at smaller rates than previously reported
  - 1st bale – 40 lb/acre
  - 2+ bales – 35-40 lb/acre

- Following a winter cover crop, a larger percentage of N should be applied earlier in season (contradicting Extension recommendations)

- Fertigation with subsurface drip
  - N should be applied in smaller doses more frequently
  - P should be applied in larger amounts less frequently

How to make more COST-efficient fertilizer decisions?

Carbon

Project goal and funding support

Project goal:

Establish soil organic carbon baseline levels across Texas corn, cotton, and sorghum cropping systems

TEXAS CORN PRODUCERS BOARD

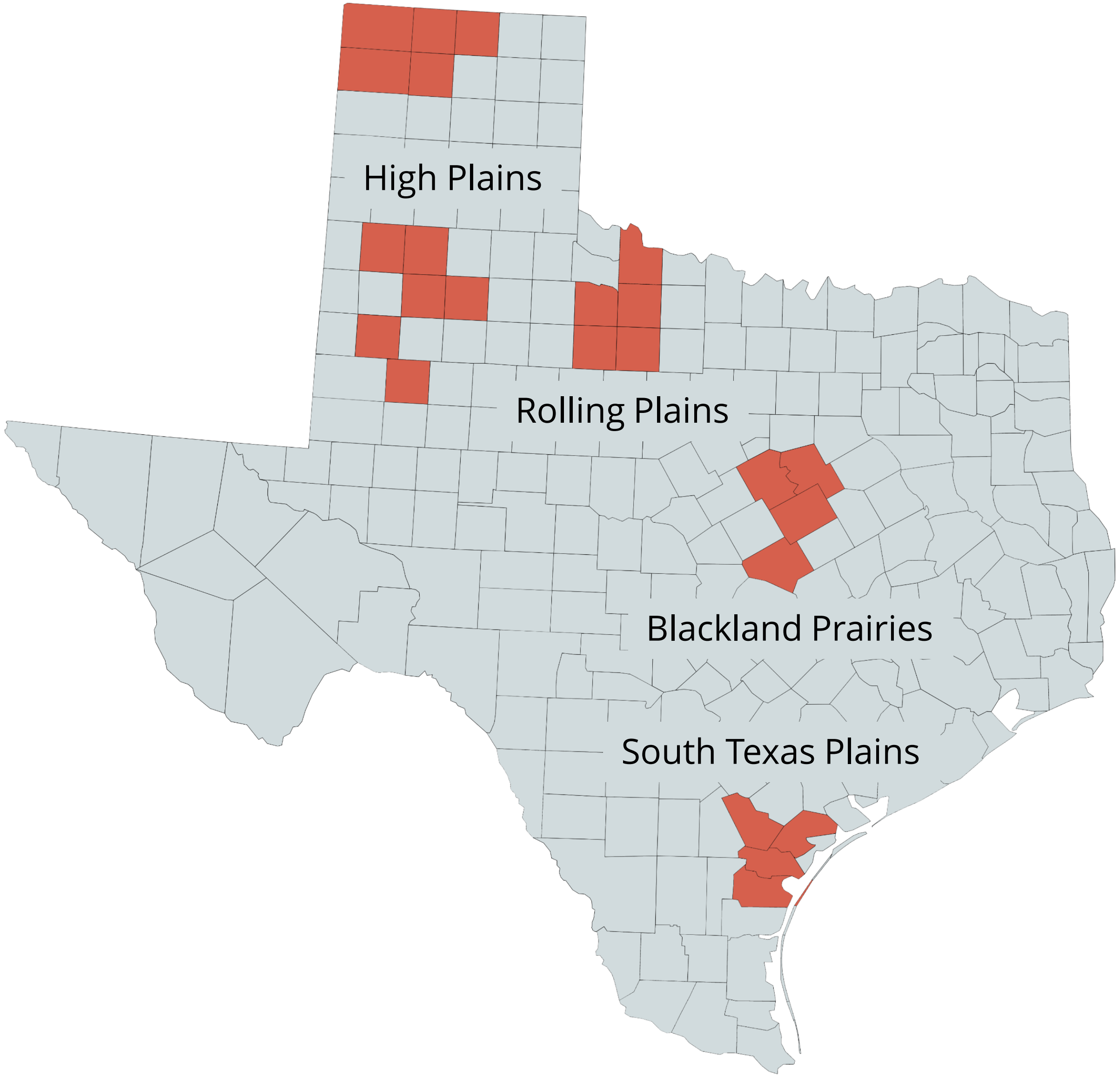
Cotton Incorporated

SORGHUM CHECKOFF

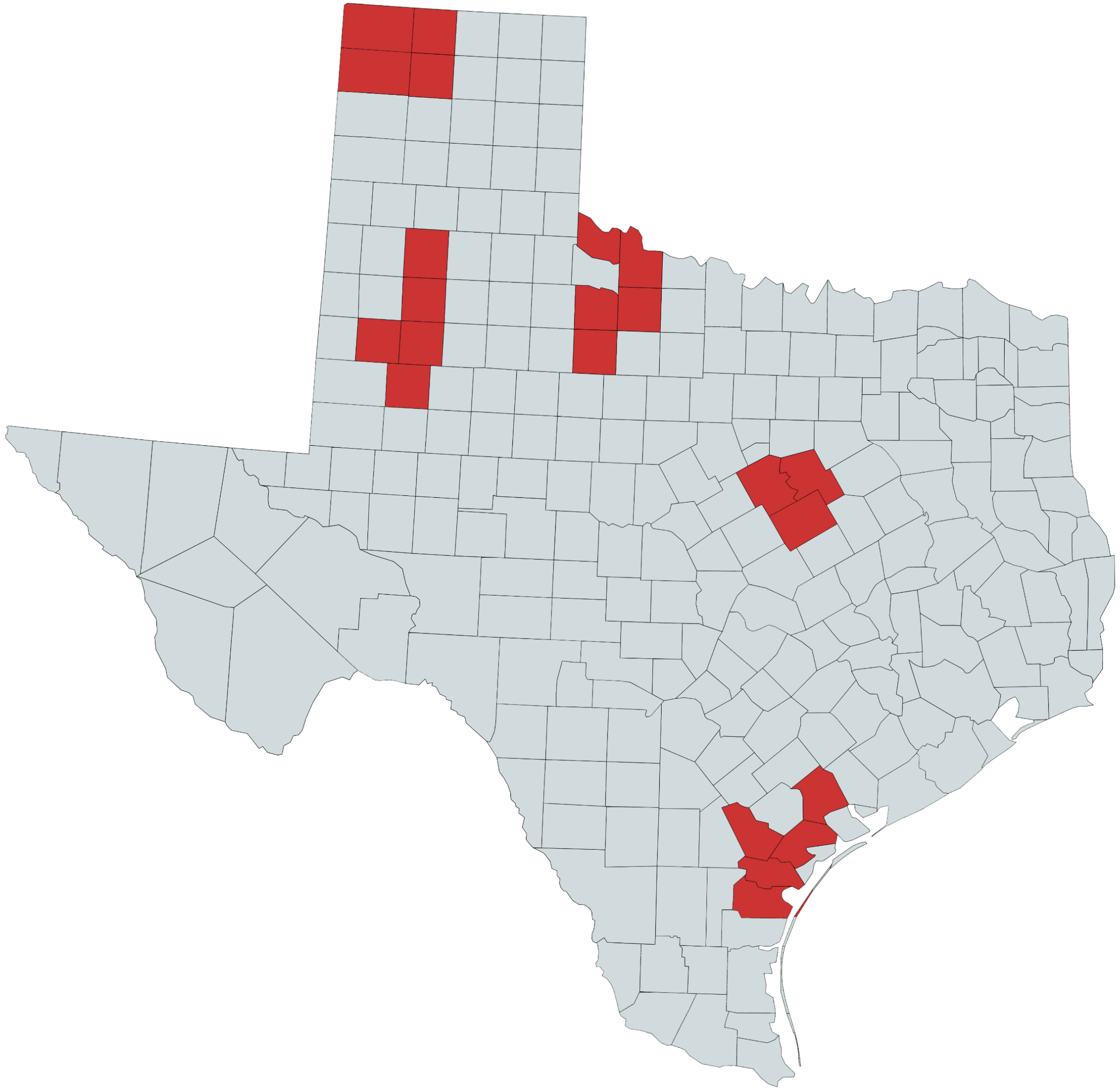
Targeted cropping systems

Cropping systems:

- Corn, cotton, and sorghum
- Conventional practices
- No-tillage
- Cover cropping
- Variable rate irrigation
- Livestock integration



Sampling plan



Region	Soil Series	Acres Represented
Northern High Plains	Conlen loam	501,717
	Dallam fine sandy loam	851,576
	Sherm silty clay loam	1,432,333
	Sunray loam	500,625
Southern High Plains	Amarillo fine sandy loam	3,054,075
	Olton clay loam	1,800,547
	Pullman clay loam	3,091,530
Gulf Coast	Edroy clay	73,281
	Orelia sandy clay loam	228,130
	Raymondville clay loam	235,577
	Victoria clay	784,257
Rolling Plains	Abilene clay loam	340,476
	Miles fine sandy loam	1,439,014
	Grandfield fine sandy loam	801,794
	Rowena clay loam	492,390
Blackland Prairies	Austin silty clay	351,412
	Branyon clay	436,764
	Frio silty clay	520,407
	Houston Black clay	1,415,510
Total acres represented by our sampling efforts		***18,412,723***

Methods and deliverables

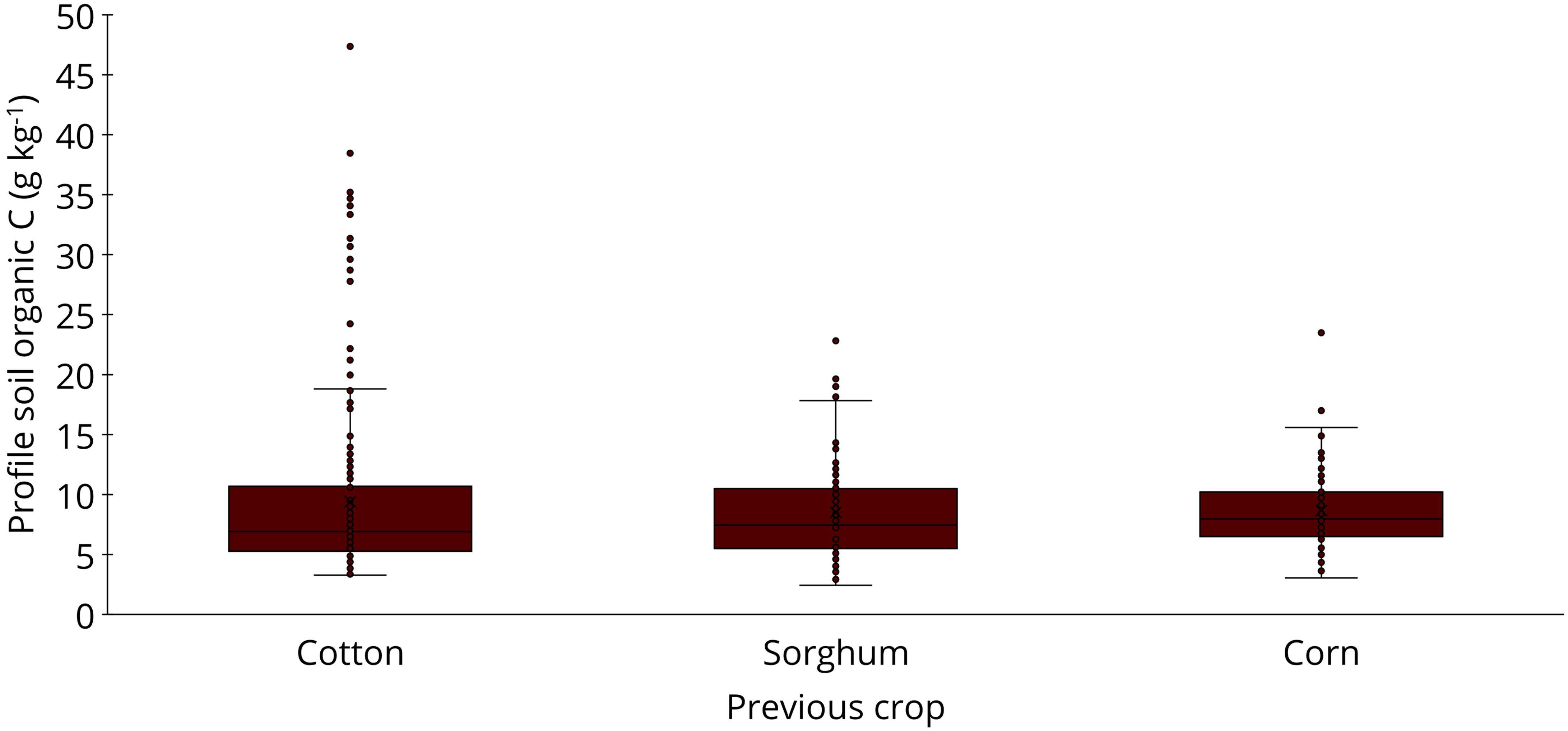
Soil sampling depths:

- 0-15, 15-30, 30-45, 45-60, 60-75, and 75-90 cm

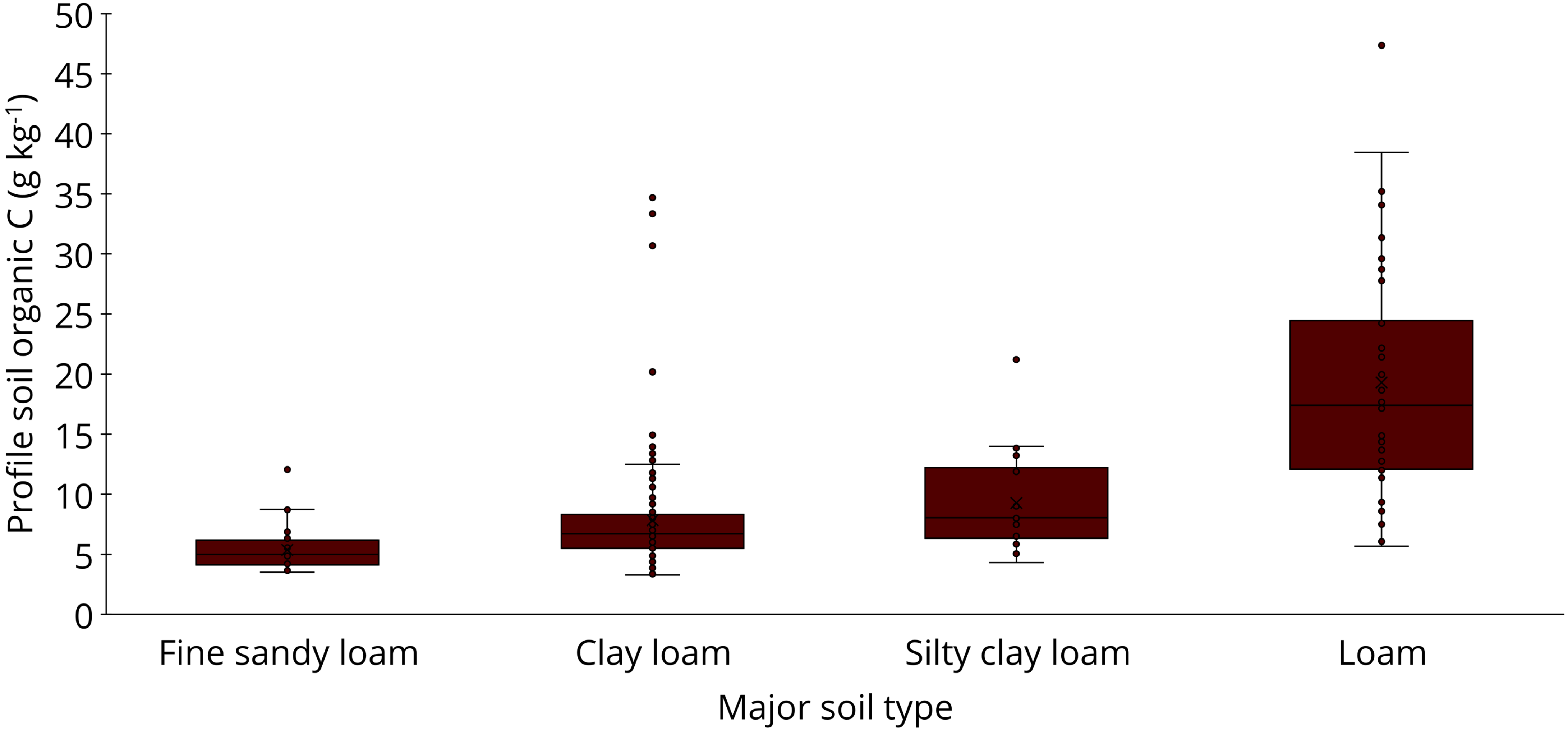
Deliverables:

- Soil organic carbon
- Bulk density
- Routine soil analysis (0-15cm)
- Soil texture
- Soil pH and salinity
- Soil inorganic nitrogen (NO_3^- and NH_4^+)

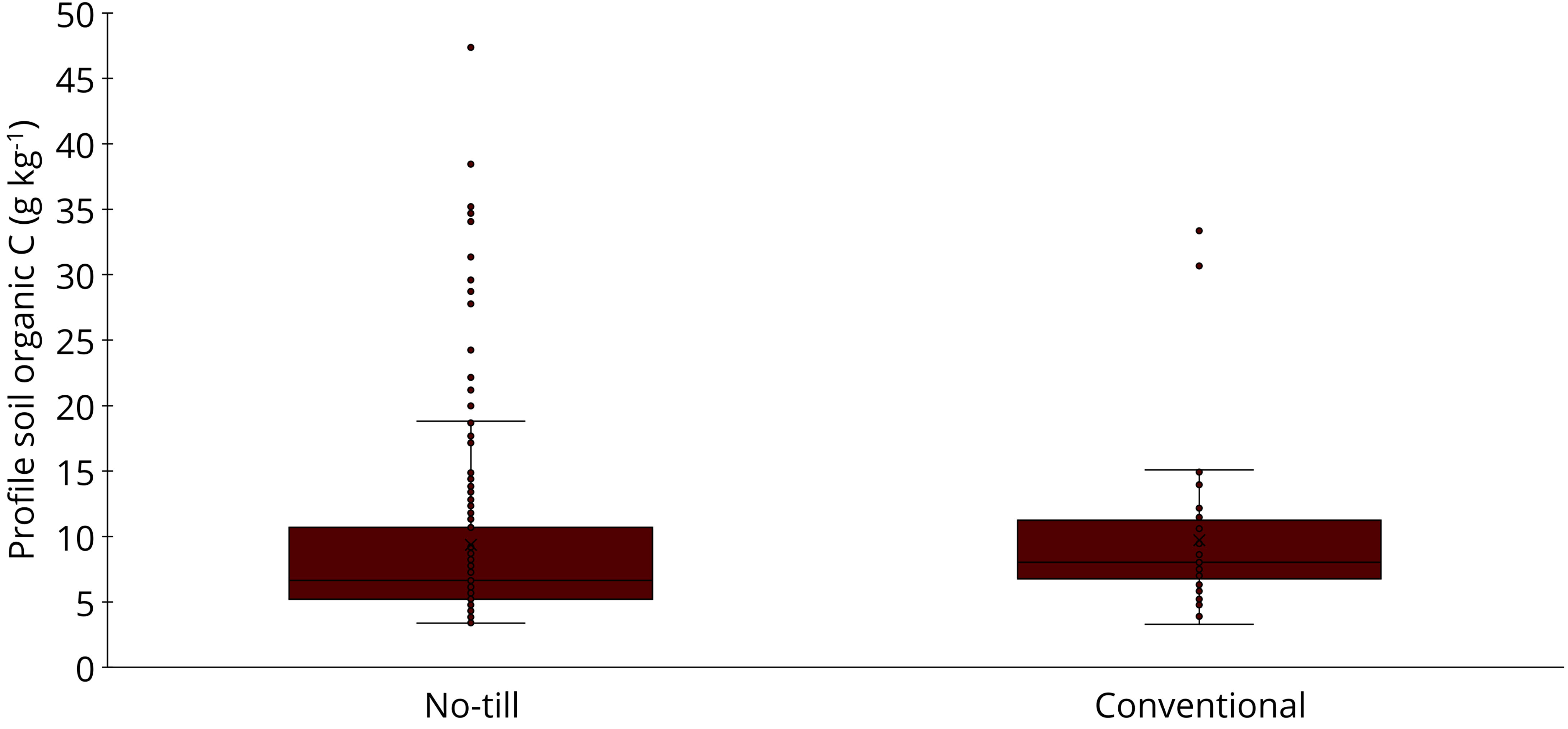
Soil organic carbon – Effect of cropping system



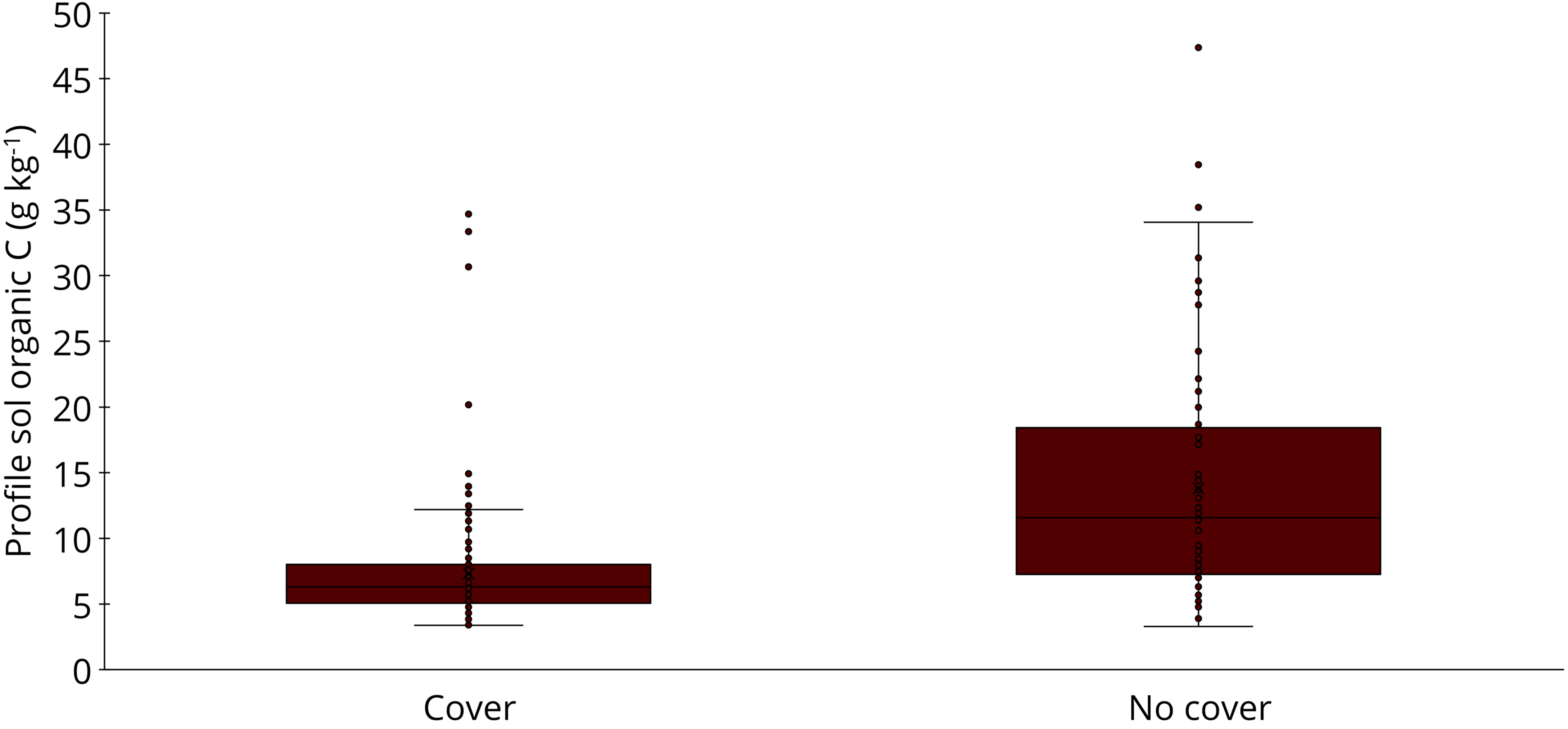
Soil organic C - Effect of soil type



Soil organic carbon – Effect of tillage



Soil organic carbon – Effect of cover crop



Project highlights

- Soil samples were collected from 72 farms across the Texas High Plains, Rolling Plains, Blackland Prairies, and Gulf Coast Plains, encompassing over 29.8 million acres of arable Texas.
- Soil carbon storage is primarily driven by soil texture with increased sequestration potential in more clayey soils.
- Conservation practices have a variable effect on carbon sequestration in the Texas High Plains.

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Additional Information -

txsoillab.com

Final Thoughts on Fertility

- Proactive strategies to increase fertilizer use efficiency
  - 4Rs of Nutrient Management
    Right *Source*
    Right *Rate*
    Right *Time*
    Right *Placement*
  - Fertilizer rates based on irrigation capacity, yield goals, and crop removal
  - Implementing conservation management may require adjustment of N fertilization
  - Read labels, do your own math, and keep it simple…

"Ever vigilant"