Management Impacts on Soil Health

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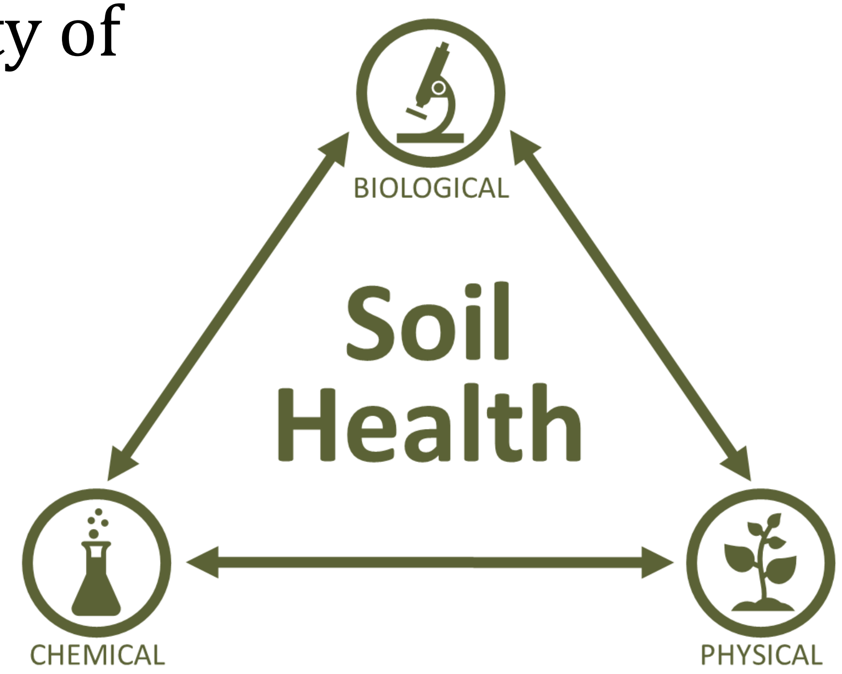
Texas A&M AgriLife Research

Oklahoma Master Irrigator Program
Guymon, OK
7 February 2023

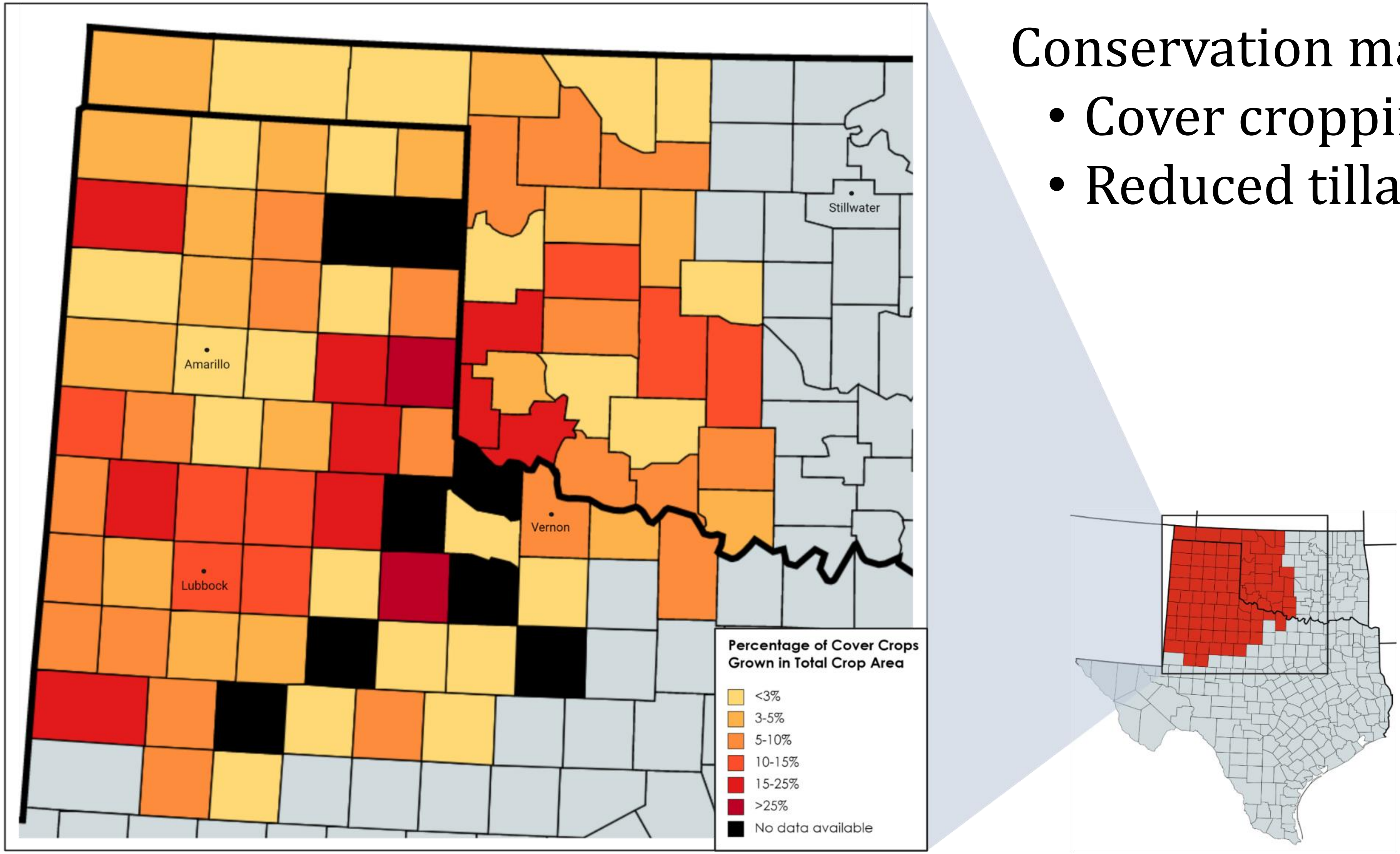
Introduction

Soil health is the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.



Includes both *inherent* and *dynamic* soil characteristics

Cover crop adoption on the Southern Plains



Conservation management:

- Cover cropping – 7.5%
- Reduced tillage – 54.4%

Values from 2017 Census of Agriculture

The Southern High Plains climate

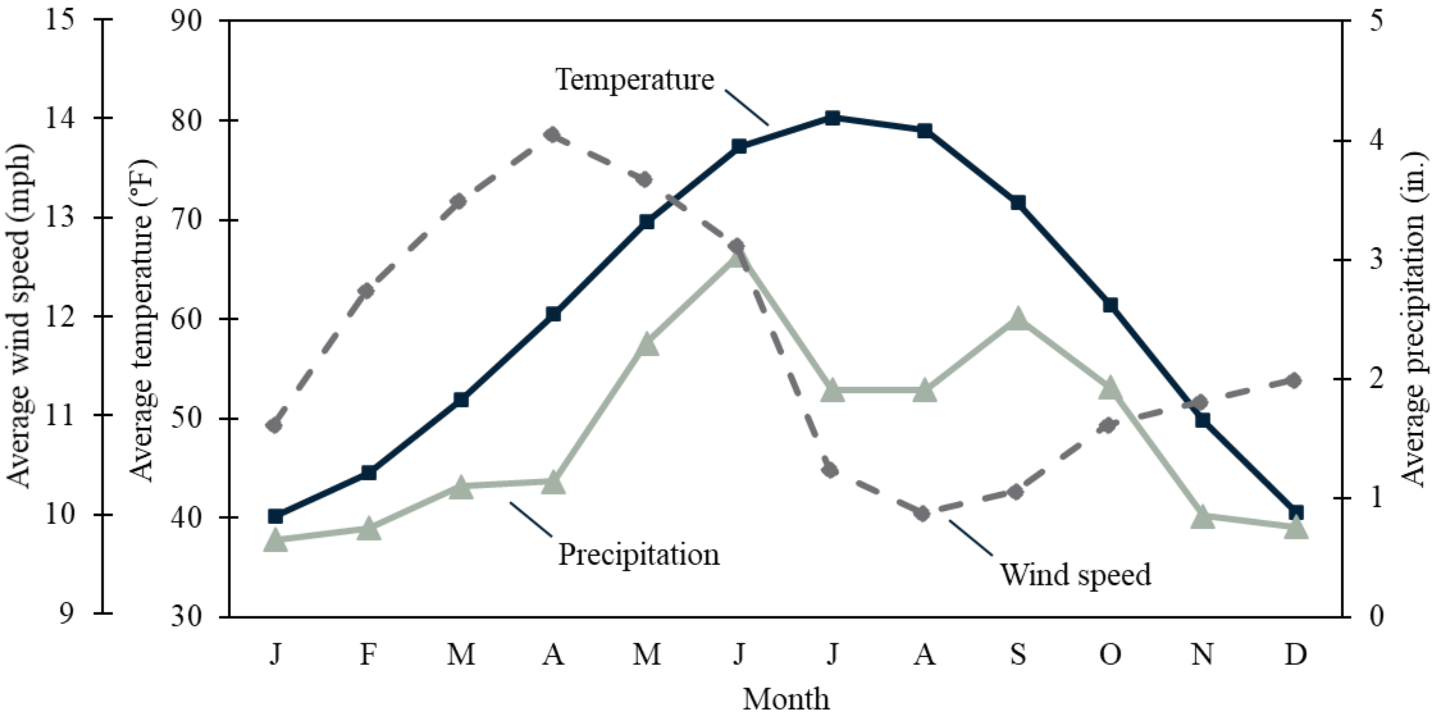
55 – 63°F

12.3 mph

16 – 22 inches

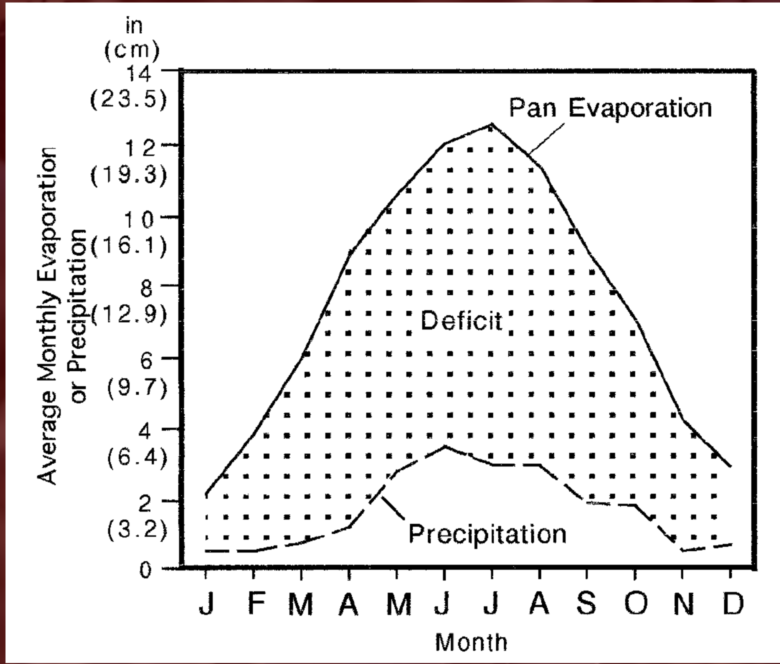
195 – 255 days y^{-1}

Climate in Lamesa, TX



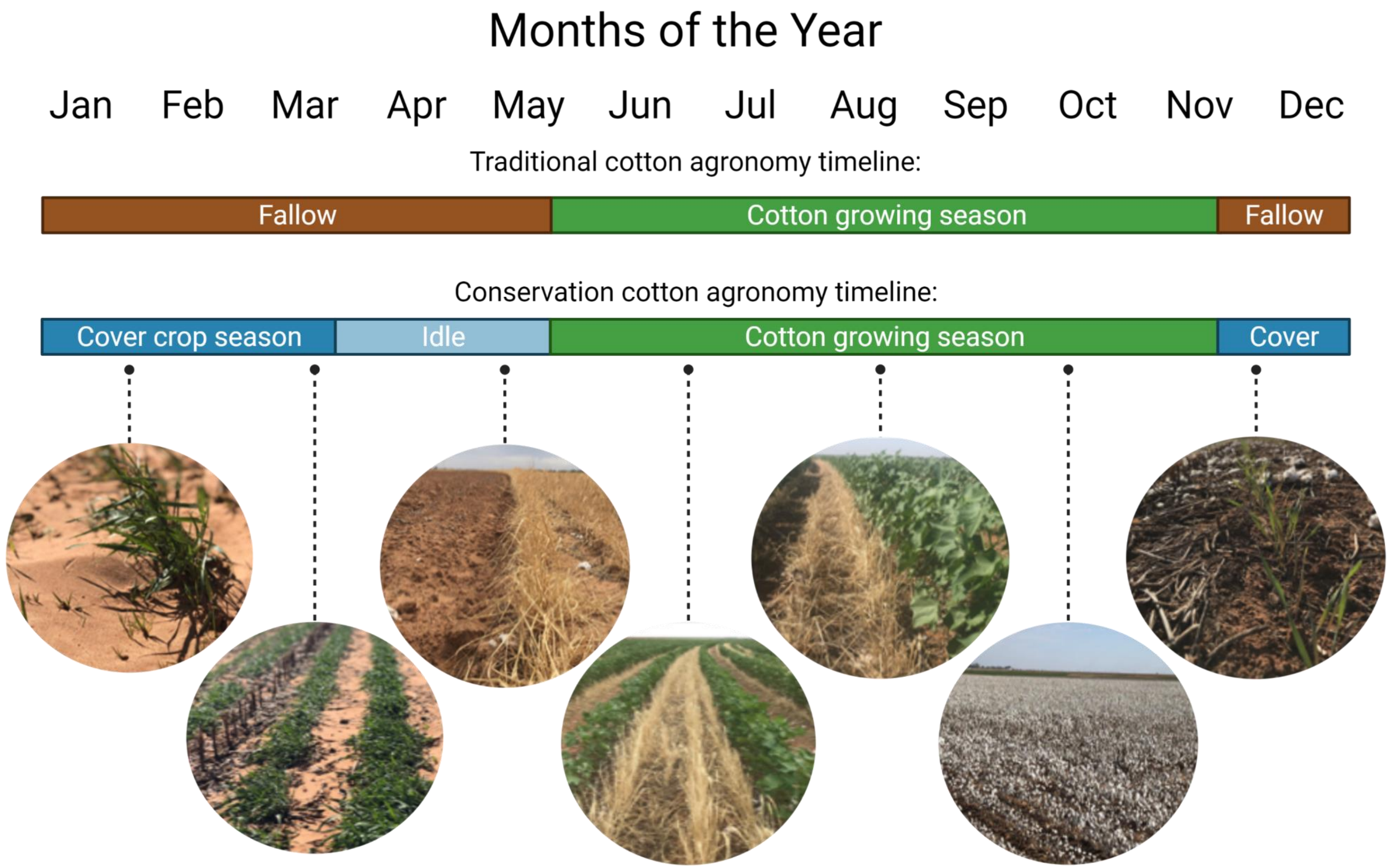
Potential evapotranspiration (PET)

- Average annual PET exceeds precipitation by 2-3 times



Gustovson and Holliday, 1999.
J. Sediment. Res. 69: 622-634.

Cotton agronomy timeline




Soil health in conservation
systems

Our sites

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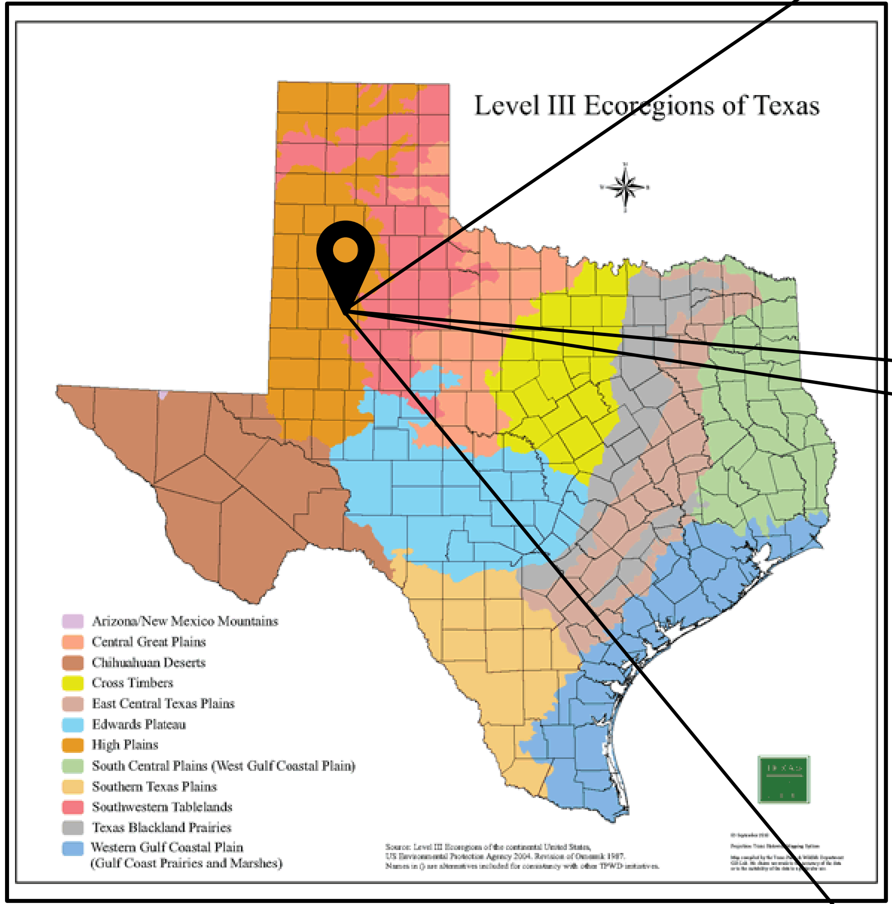


<u>Cropping system location -</u>
Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) - Lamesa, TX

<u>Native system location -</u>
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

Amarillo fine sandy loam

Fine-loamy, mixed, superactive, thermic Aridic Paleustalf

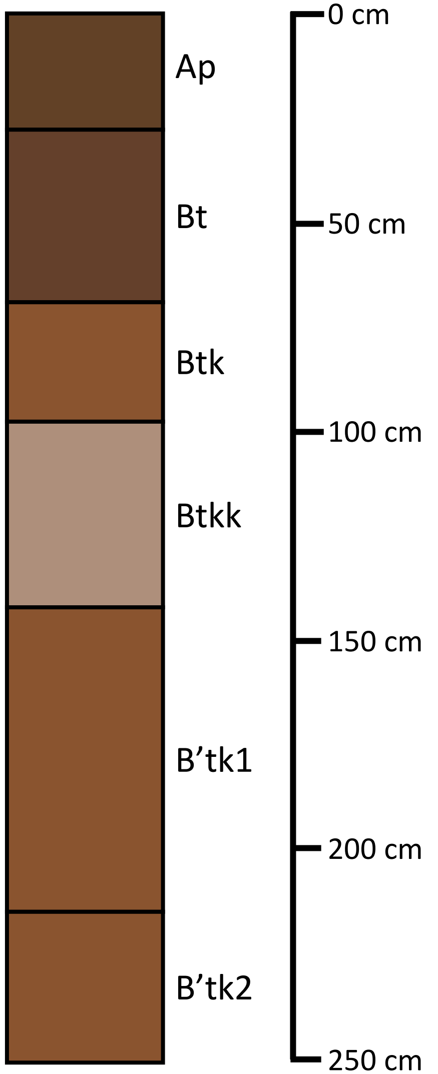
Sand - 80%, Silt - 9%, and Clay - 11%

CEC - 10 $cmol_c$ kg^{-1}
pH - 7.8 (7.2 in no-till with cover crop plots)
Soil organic C - 2.0 g kg^{-1}

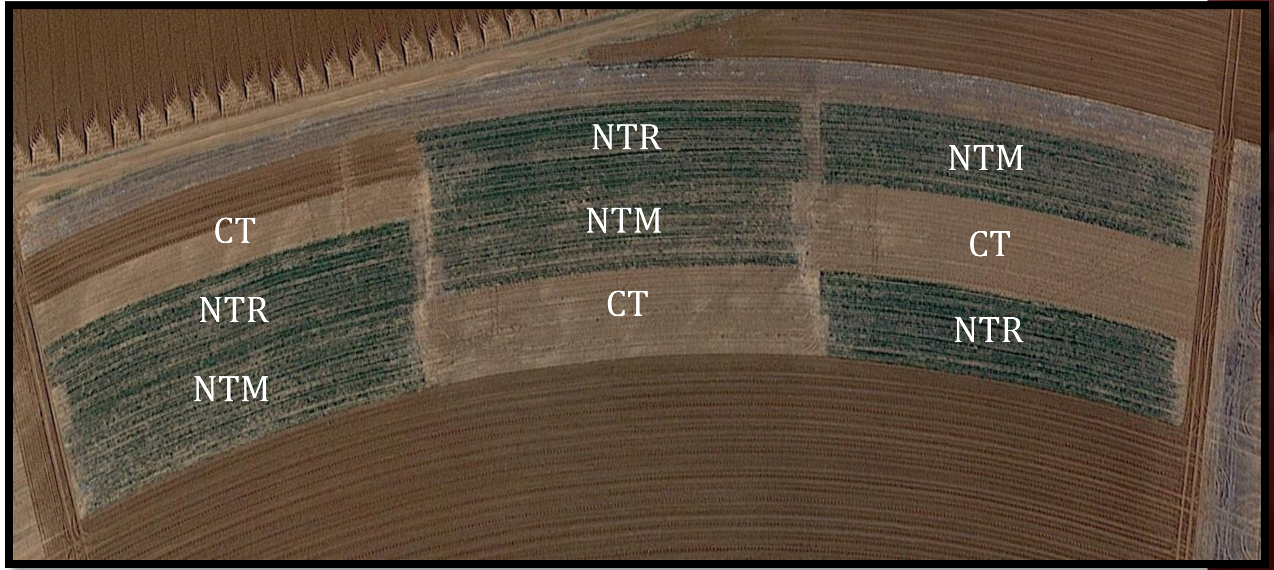
Primary uses: rangeland and agricultural production

Benchmark soil series with extensive distribution on the Texas Southern High Plains

Typical Amarillo profile



The experimental design



Research plot design at Ag-CARES in Lamesa, TX

Evaluated systems

Continuous cotton systems – (est. 1998)

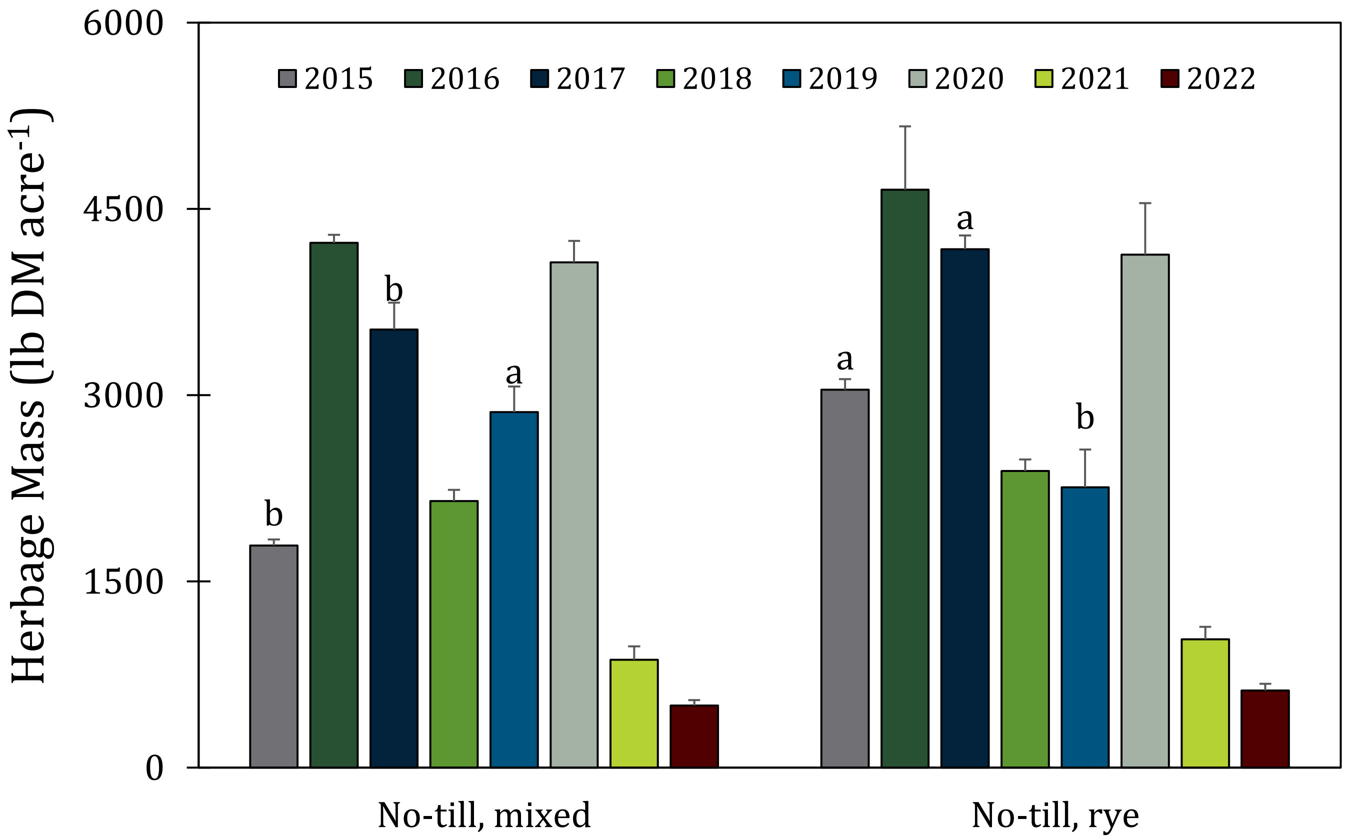
- Conventional tillage, winter fallow (CT)
- No-tillage, Rye cover (R-NT), 40 lb ac.$^{-1}$
- No-tillage, Mixed cover (M-NT), 40 lb ac^{-1}
  - Rye (50%)
  - Austrian Winter Pea (33%)
  - Hairy Vetch (10%)
  - Radish (7%)
    - by weight
  - Established in November 2014
  - NRCS recommended mixture

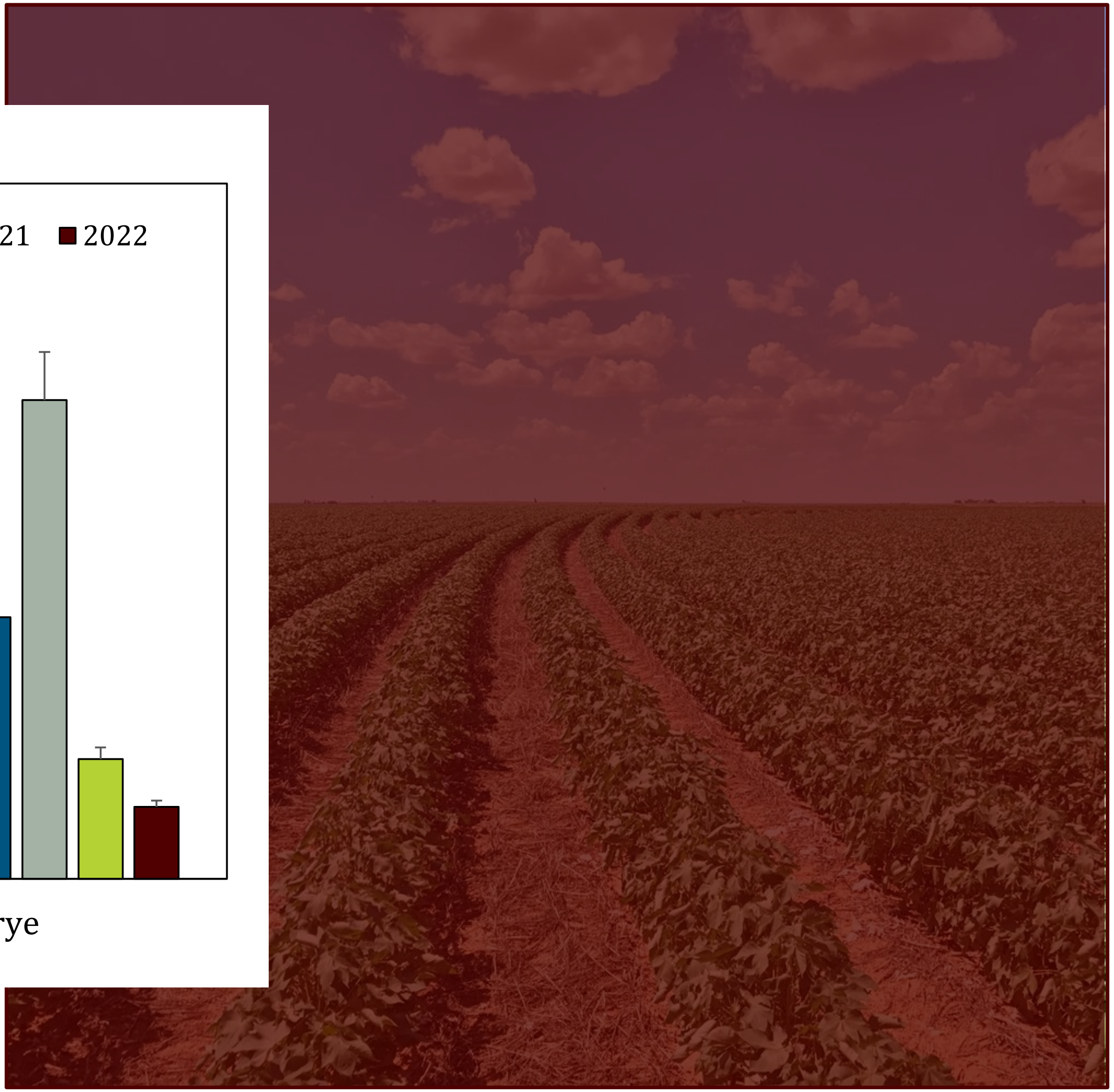
Native Systems (NAT)

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

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

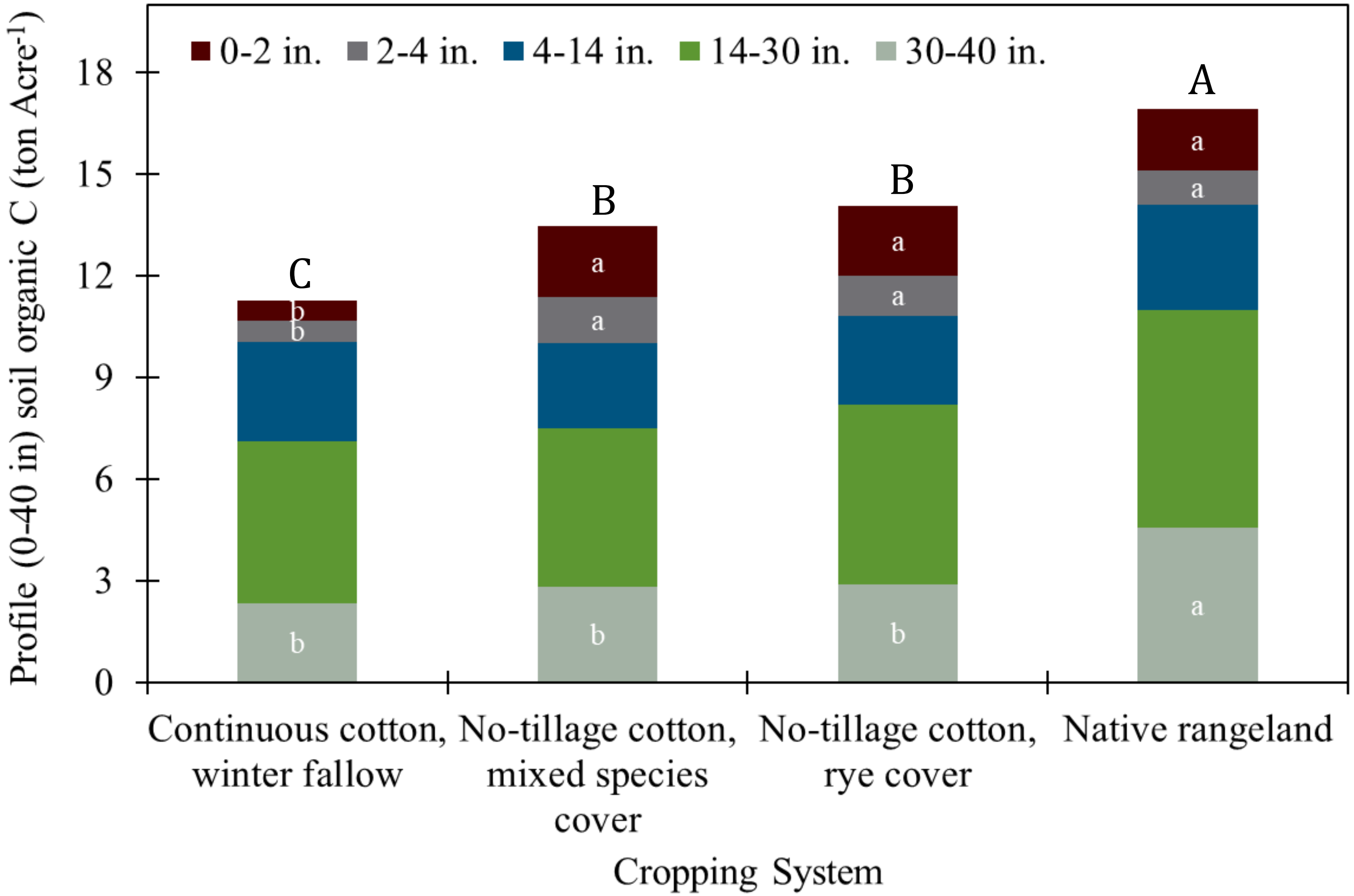
Cover crop biomass

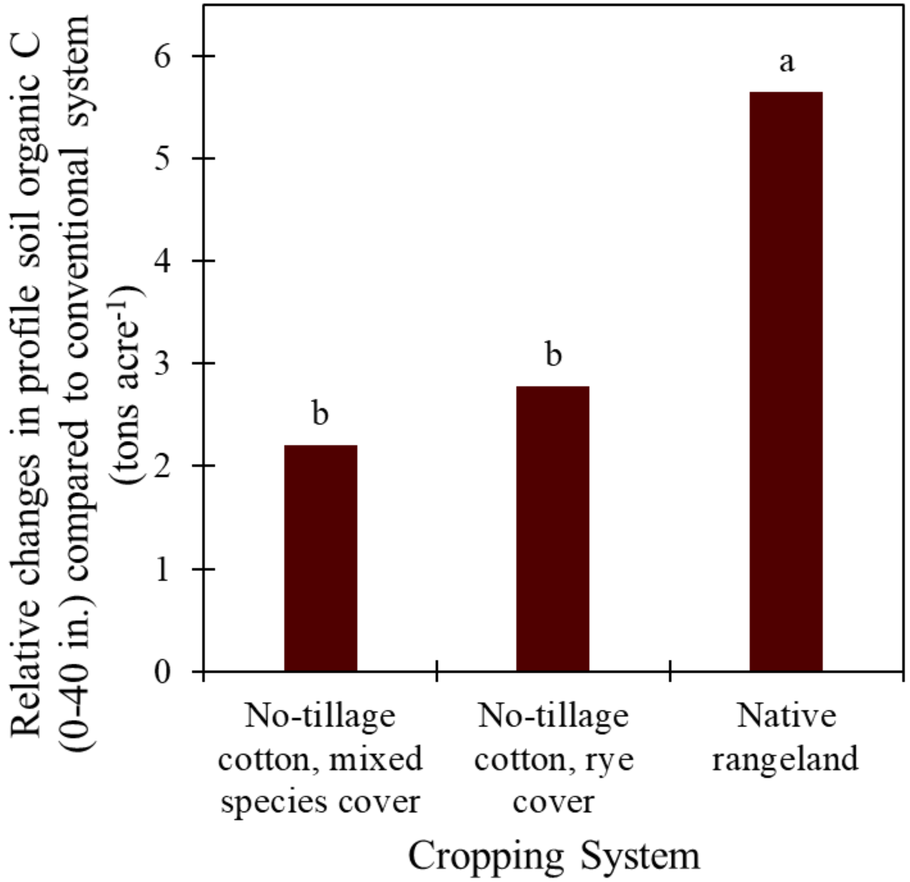




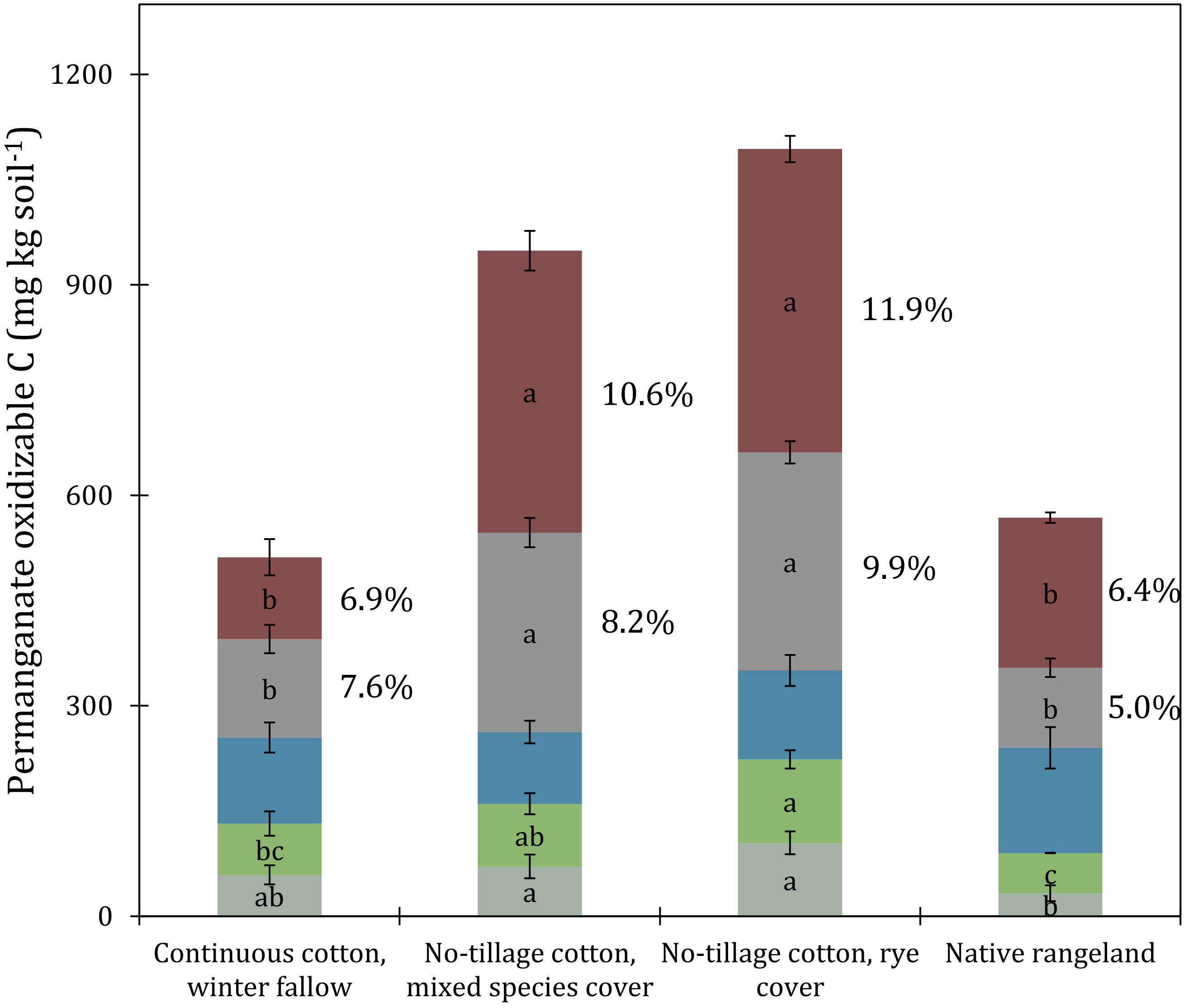
Soil organic carbon

*Samples collected in year 20 of the study

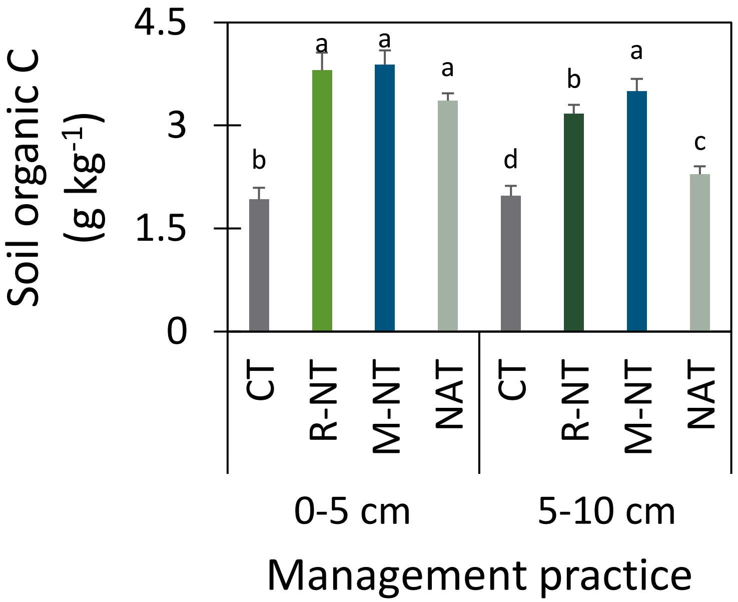


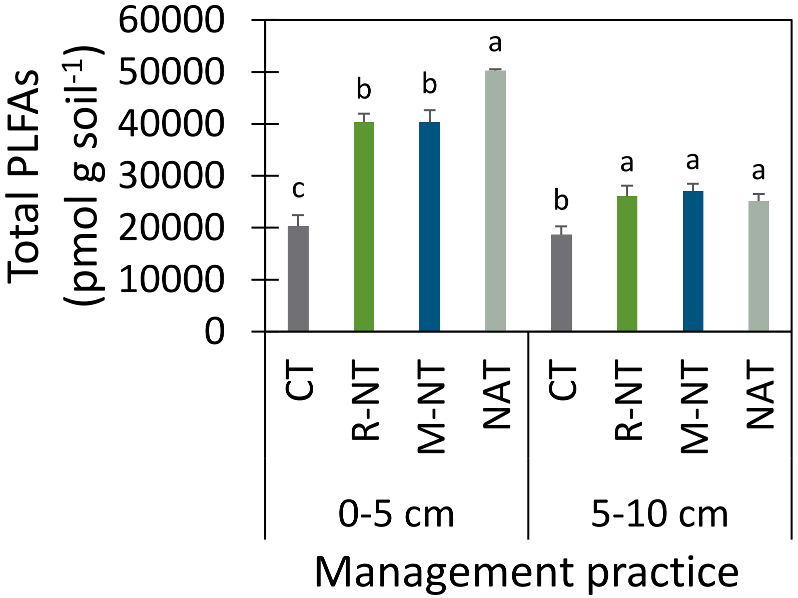


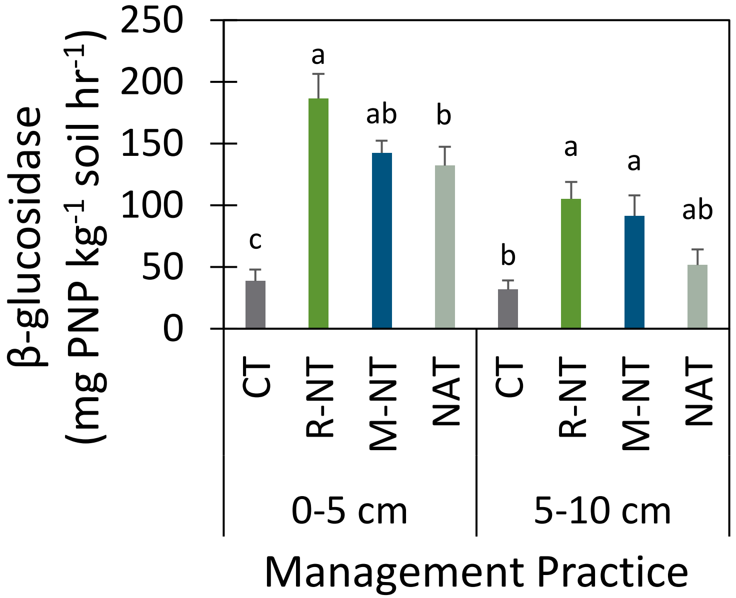
Permanganate oxidizable carbon

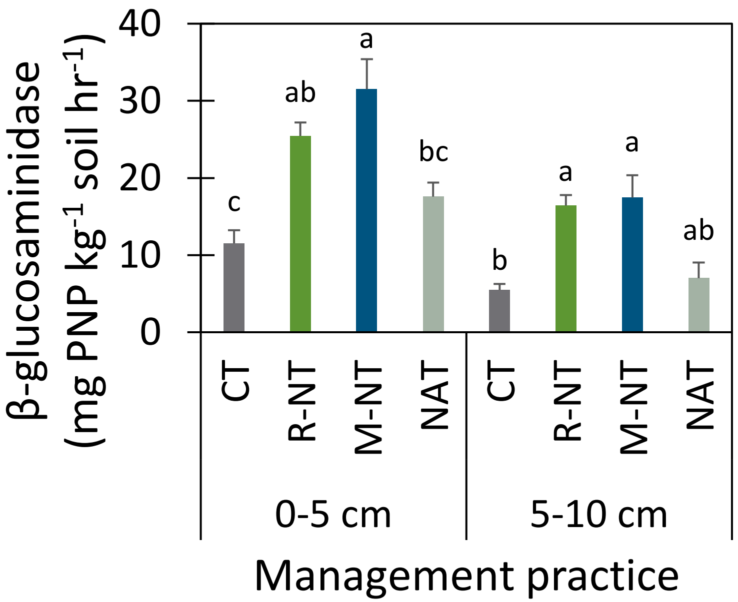


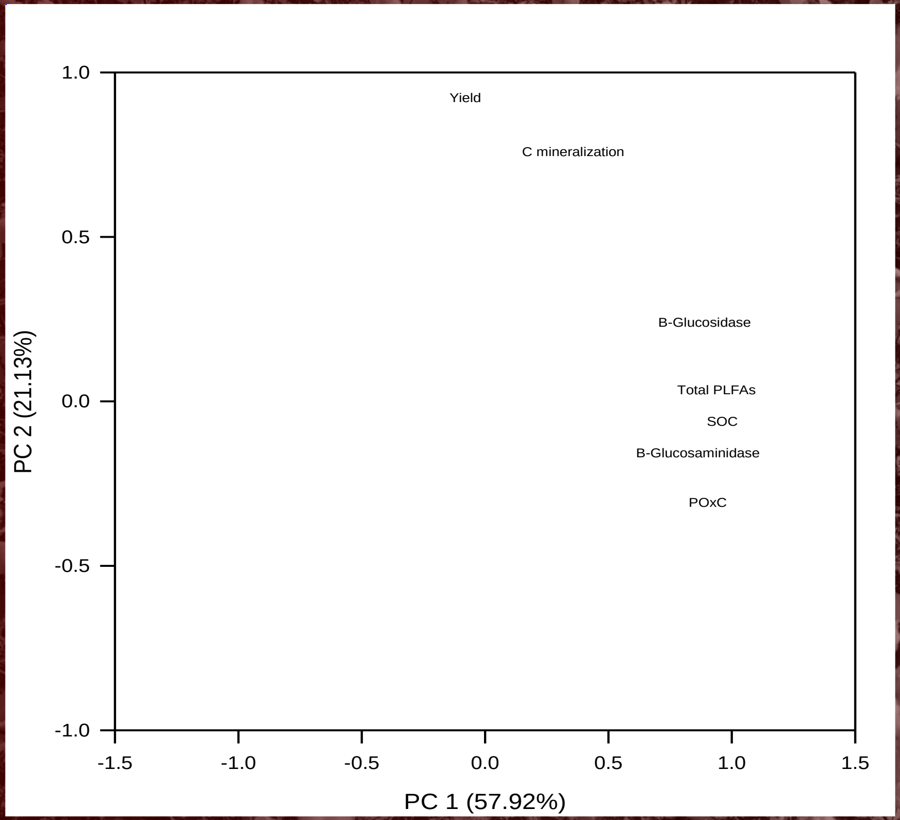
Soil health











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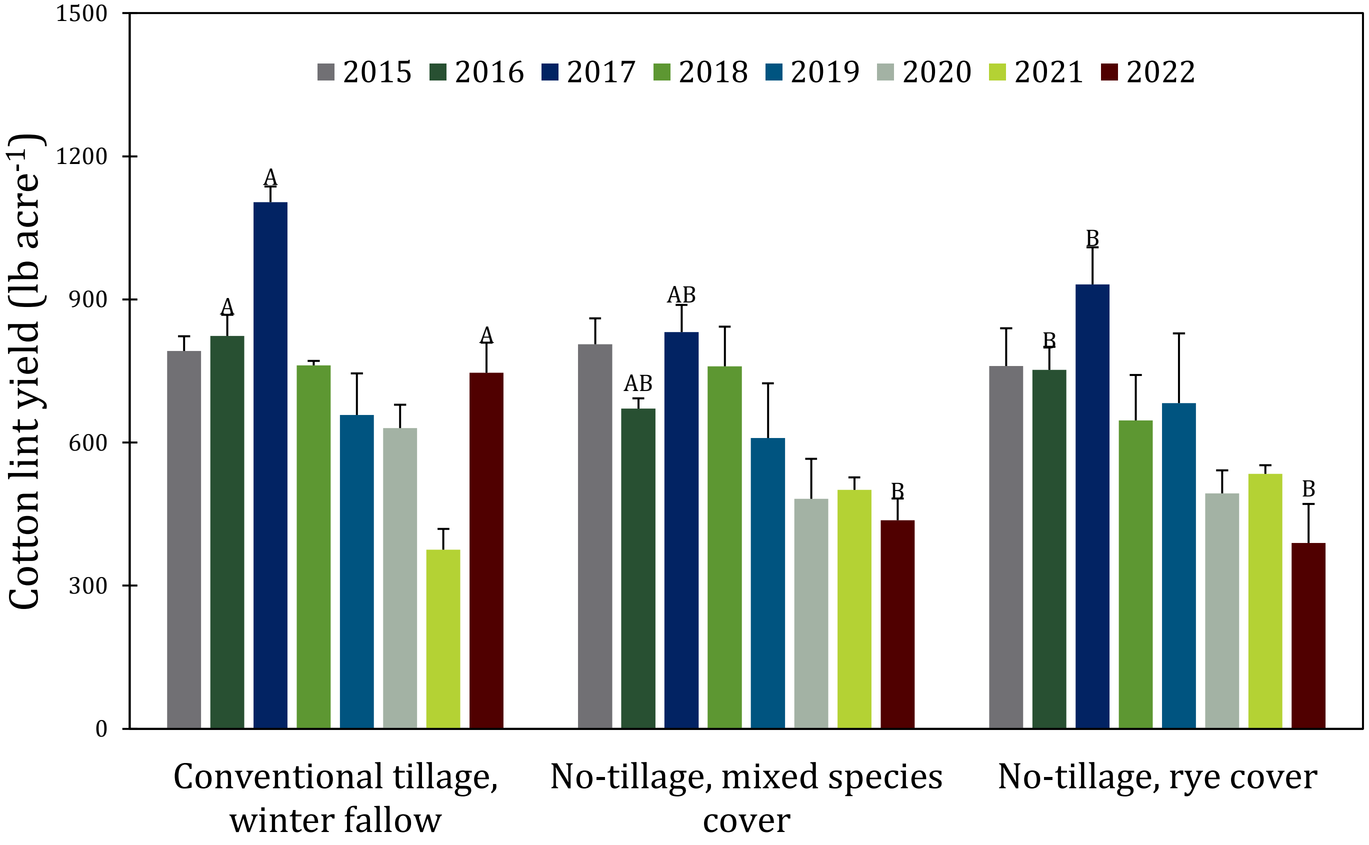
Cotton lint yield

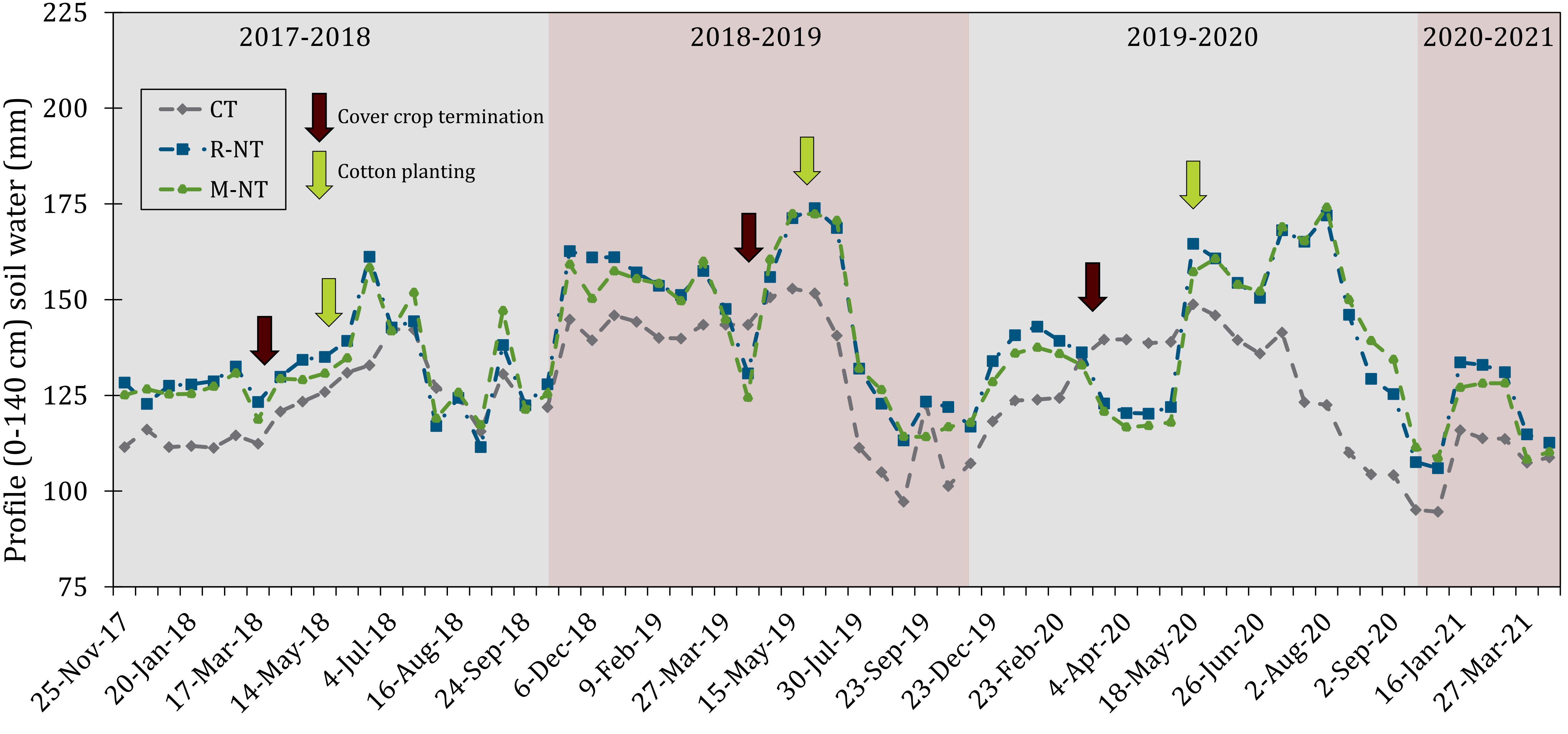


Conservation management has a variable effect on yield

What is causing the yield drag in some years?

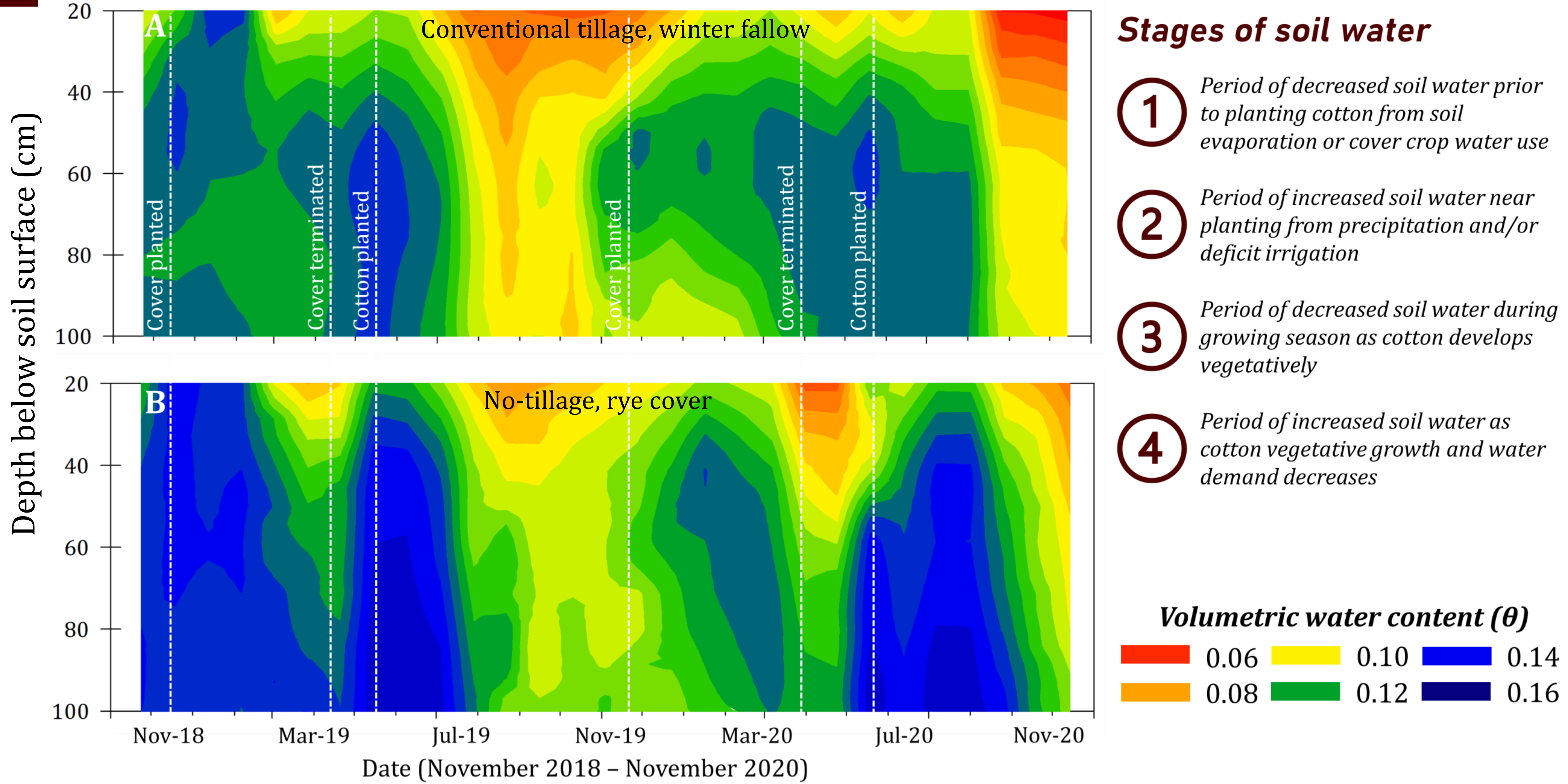
- Cover crop water usage?
- Nutrient immobilization?

Soil water



Profile (0-140 cm) soil water (mm)
225
200
175
150
125
100
75
2017-2018
2018-2019
2019-2020
2020-2021
CT
R-NT
M-NT
Cover crop termination
Cotton planting
25-Nov-17
20-Jan-18
17-Mar-18
14-May-18
4-Jul-18
16-Aug-18
24-Sep-18
6-Dec-18
9-Feb-19
27-Mar-19
15-May-19
30-Jul-19
23-Sep-19
23-Dec-19
23-Feb-20
4-Apr-20
18-May-20
26-Jun-20
2-Aug-20
2-Sep-20
16-Jan-21
27-Mar-21

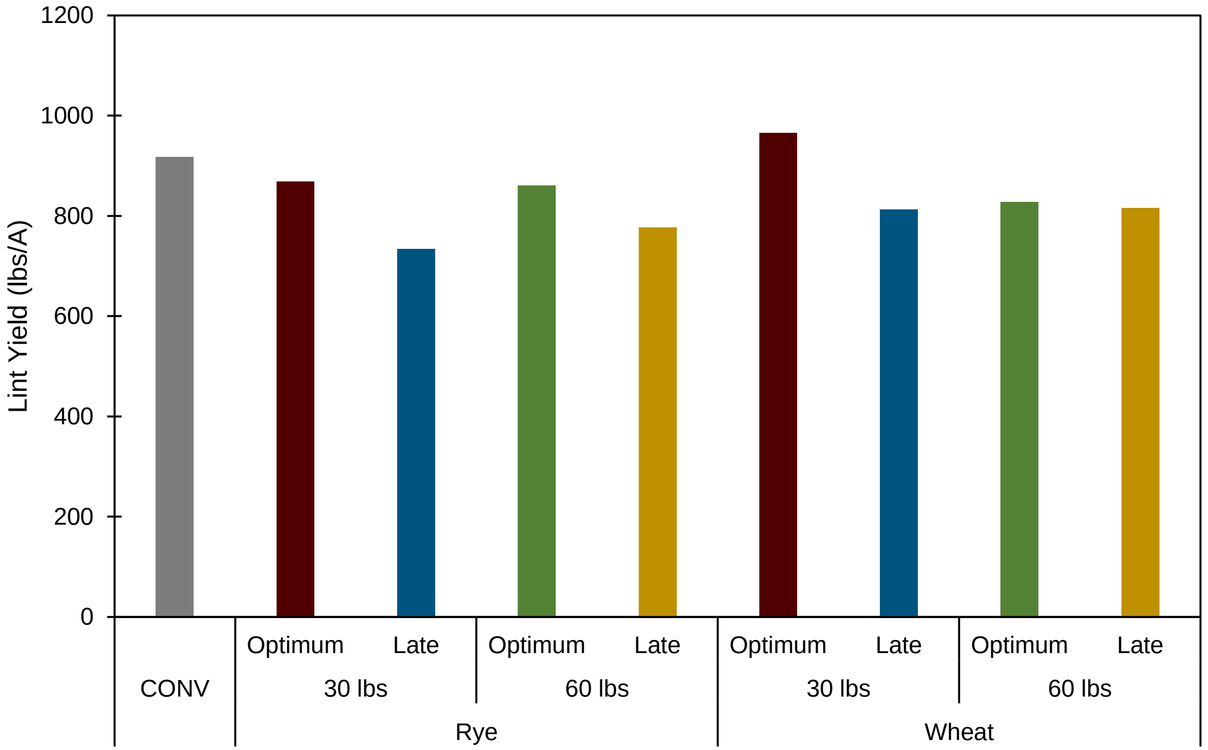
Soil water at depth

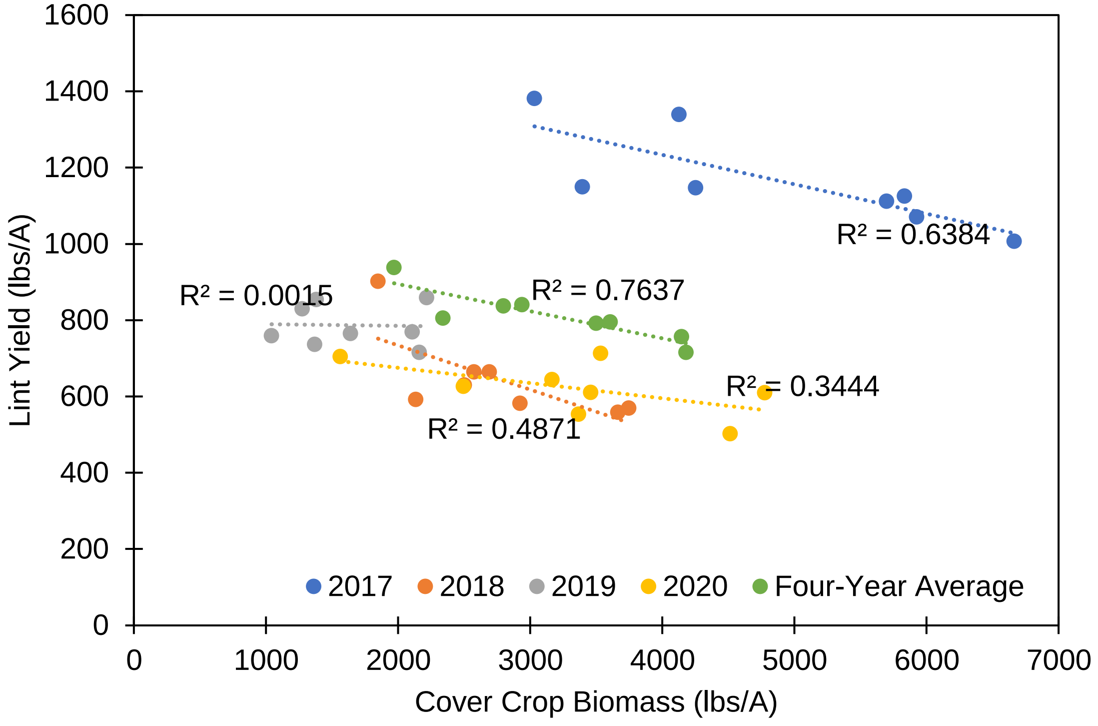


Stages of soil water

1. *Period of decreased soil water prior to planting cotton from soil evaporation or cover crop water use*
2. *Period of increased soil water near planting from precipitation and/or deficit irrigation*
3. *Period of decreased soil water during growing season as cotton develops vegetatively*
4. *Period of increased soil water as cotton vegetative growth and water demand decreases*

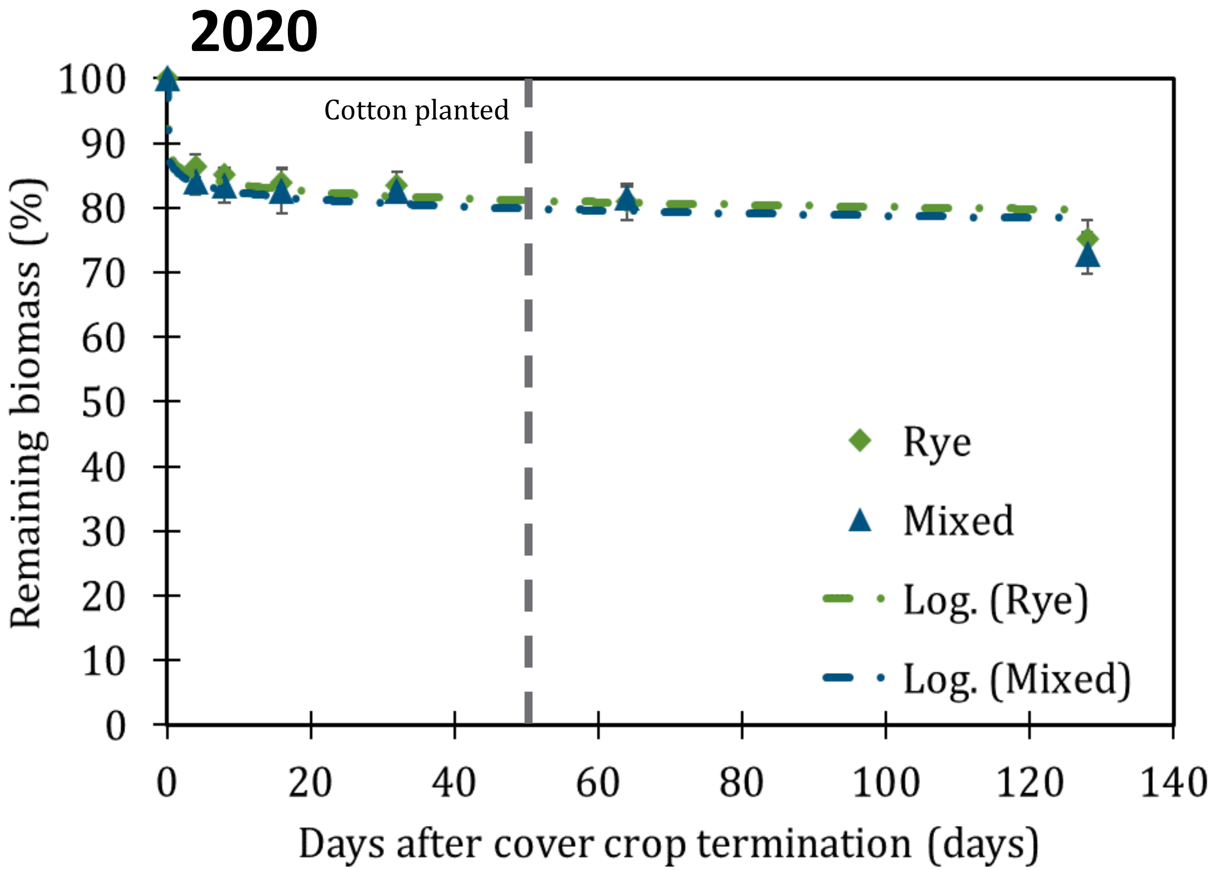
Overcoming yield reduction: termination time and seeding rate

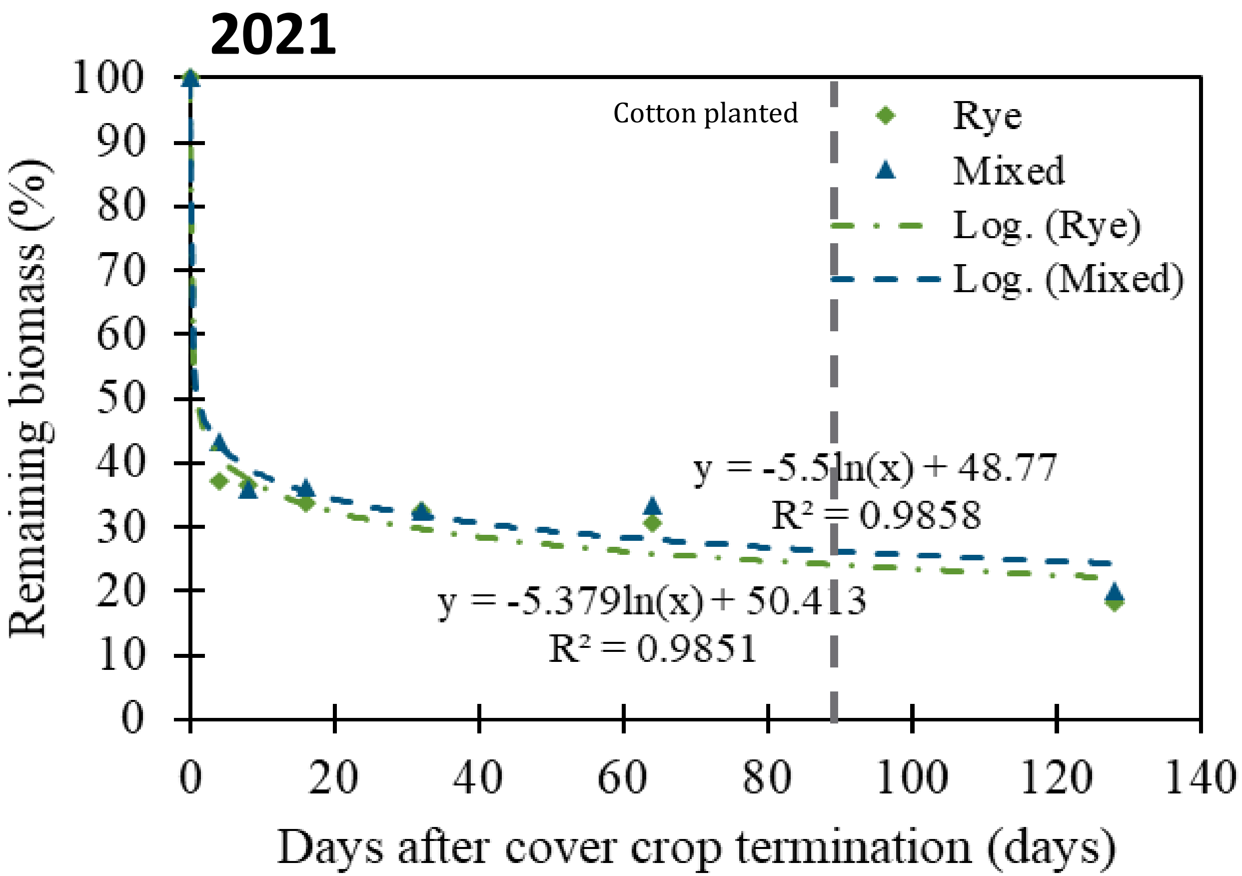




Earlier cover crop termination = less cover crop biomass = greater cotton lint yield

Cover crop biomass decomposition





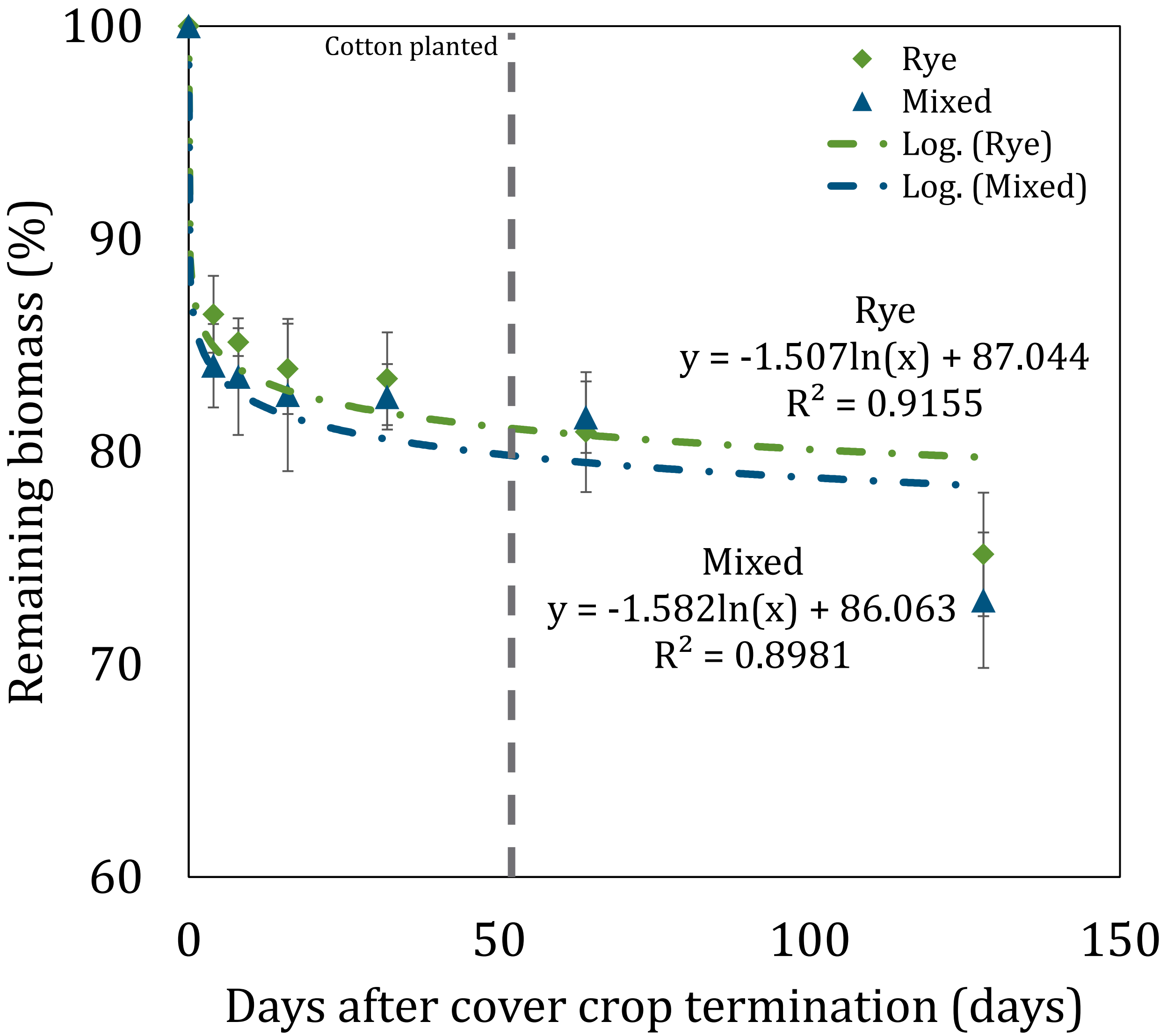
Biomass decomposition - 2020

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?

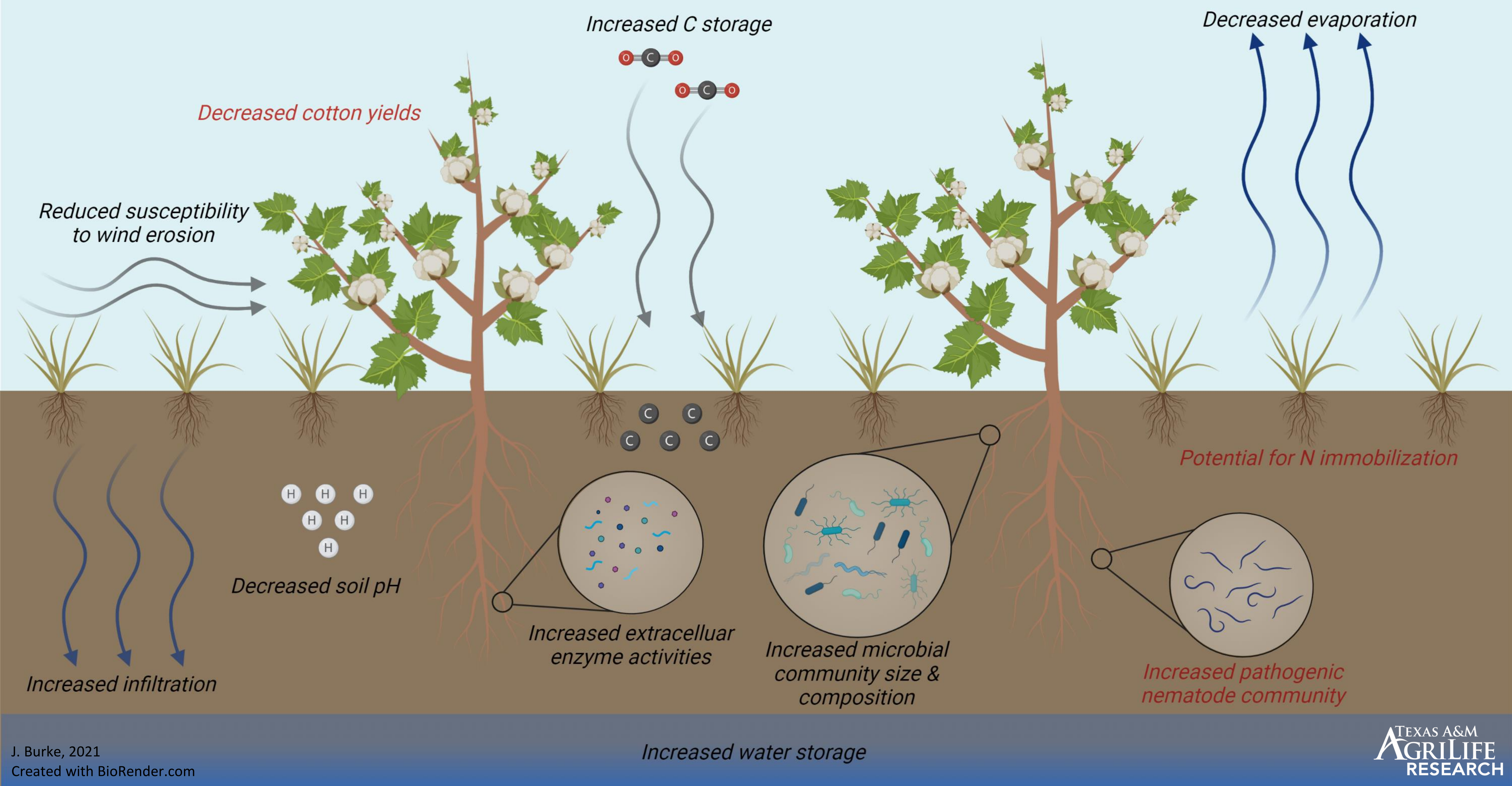


Economics

Management System	Input Cost*	Lint Revenue 2015	Lint Revenue 2016	Lint Revenue 2017	Gross Margin 2015	Gross Margin 2016	Gross Margin 2017	AVG
	----------------------------------			$/acre	-----------------------------			
Conv. Tillage	84	412	428	538	328	344	454	375
Rye, NT	45	419	349	428	374	304	383	354
Mixed, NT	72	396	391	468	323	319	395	345

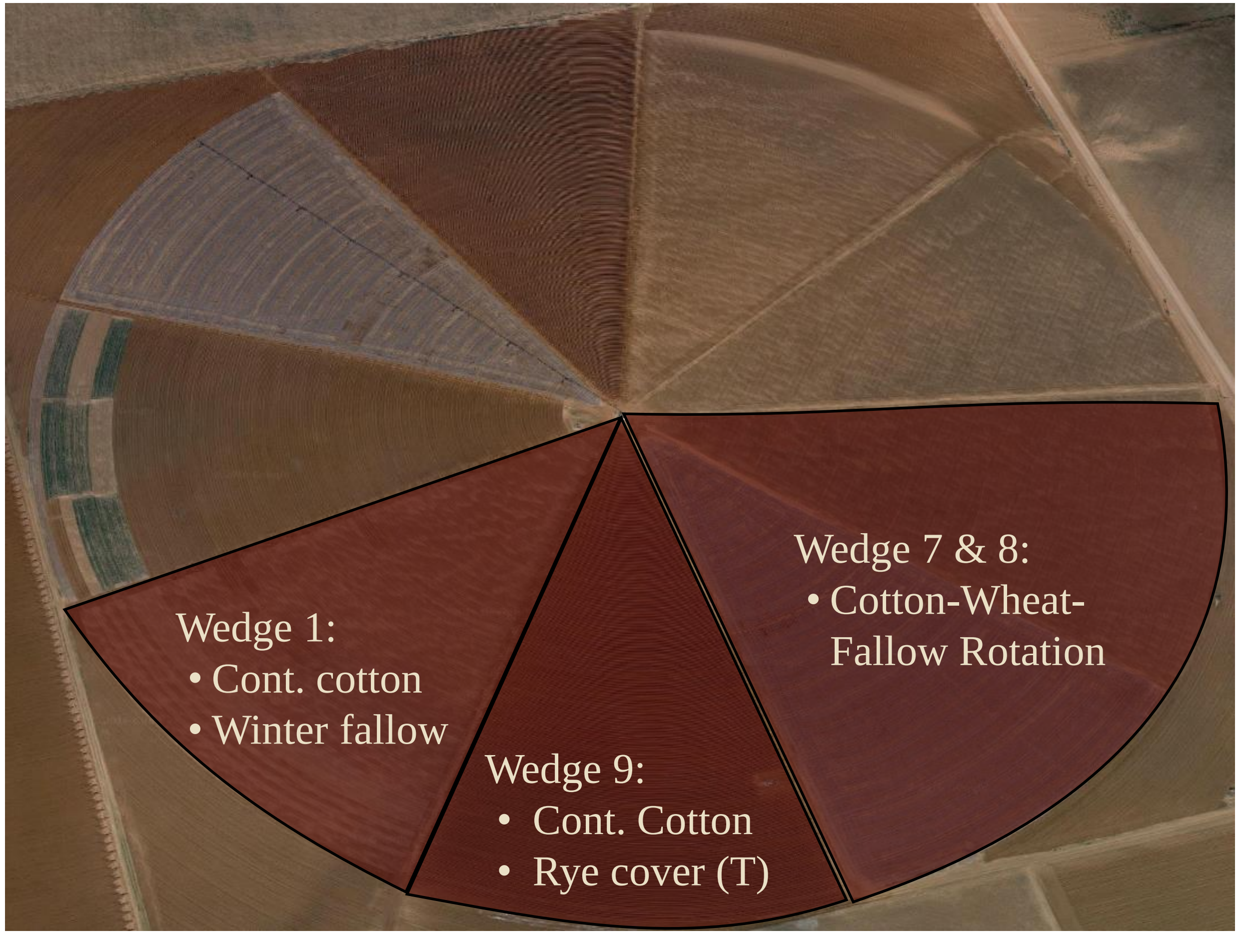
*No-tillage input costs included: seed, drilling, chemical termination, and in-season herbicide application. Conventional tillage input costs included: sand fighting (x2), cultivation (x2), rotary hoe, rodweeding, listing, and Treflan incorporation.

Benefits and consequences of our conservation cotton cropping systems



Nitrogen management

The experimental design



Nitrogen study plot design at Ag-CARES in Lamesa, TX

Treatments

- Cropping systems –
  - Conventional tillage, winter fallow (CC)
  - Continuous cotton with rye cover (CCRC)
  - Cotton-wheat-fallow rotation (CWR)
- Nitrogen applications –
  - Farmer's practice (120 lb N A^{-1}, FP)
  - FP + 30 lb N A^{-1} preplant (PPN)
  - FP + 30 lb N A^{-1} 2-3 weeks post emergence (POS)
  - FP + 30 lb N A^{-1} pinhead square + 2 weeks (PIN)

Cotton production

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%)	

2018-2020 averages

Fertilization strategies:

- FP = farmers practices (120 lb N A^{-1})
- PPN = FP + 20 lb N A^{-1} at preplant
- PEN = FP + 20 lb N A^{-1} at post emerg. + 2 wks
- PHSN = FP + 20 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

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%)	

2018-2020 averages

Fertilization strategies:

- FP = farmers practices (120 lb N A^{-1})
- PPN = FP + 20 lb N A^{-1} at preplant
- PEN = FP + 20 lb N A^{-1} at post emerg. + 2 wks
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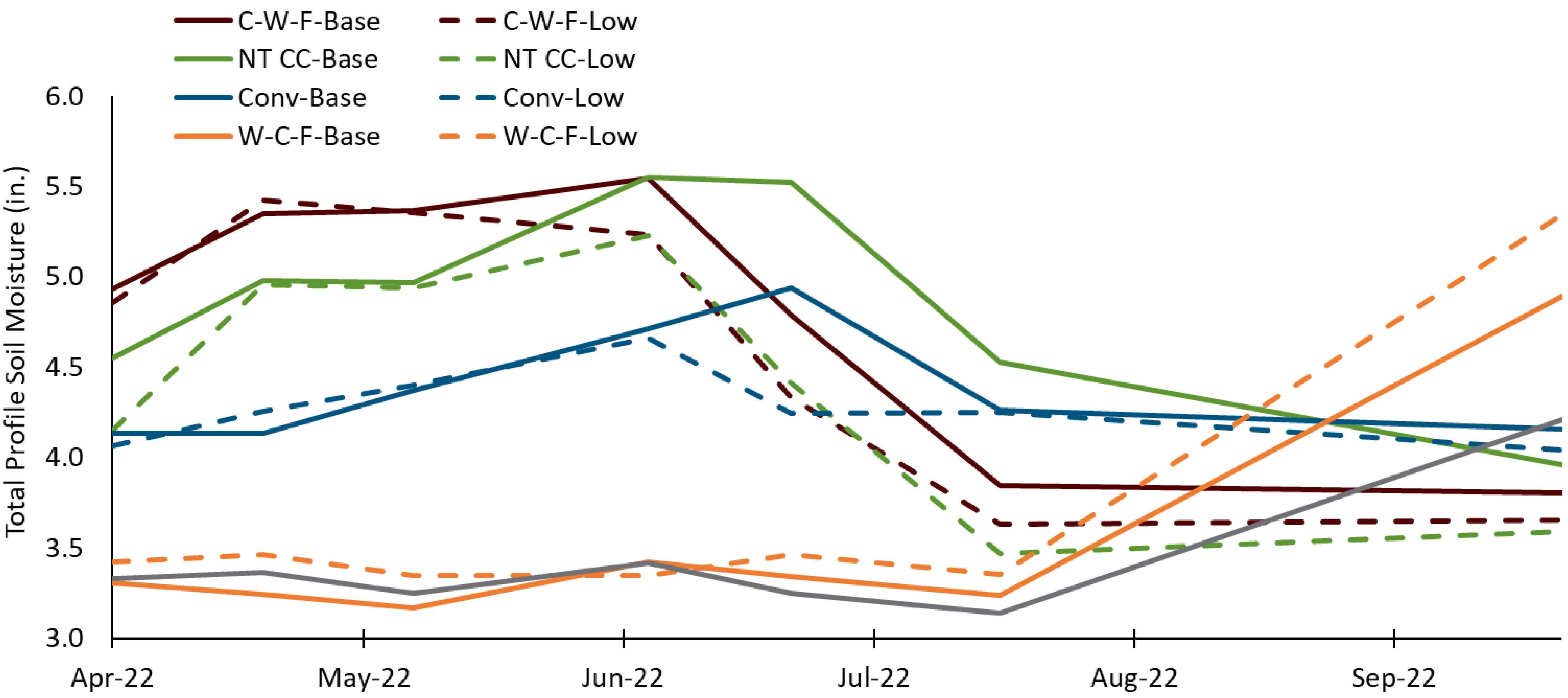
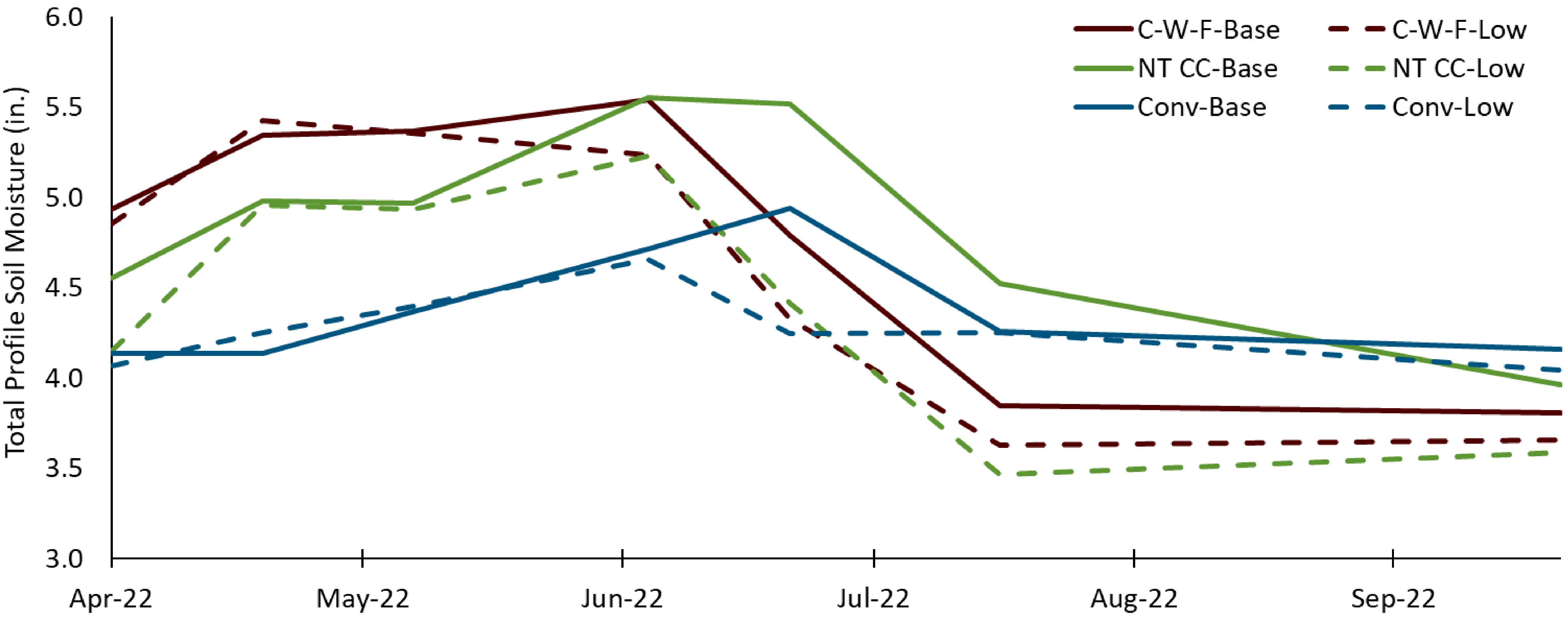
Soil water results

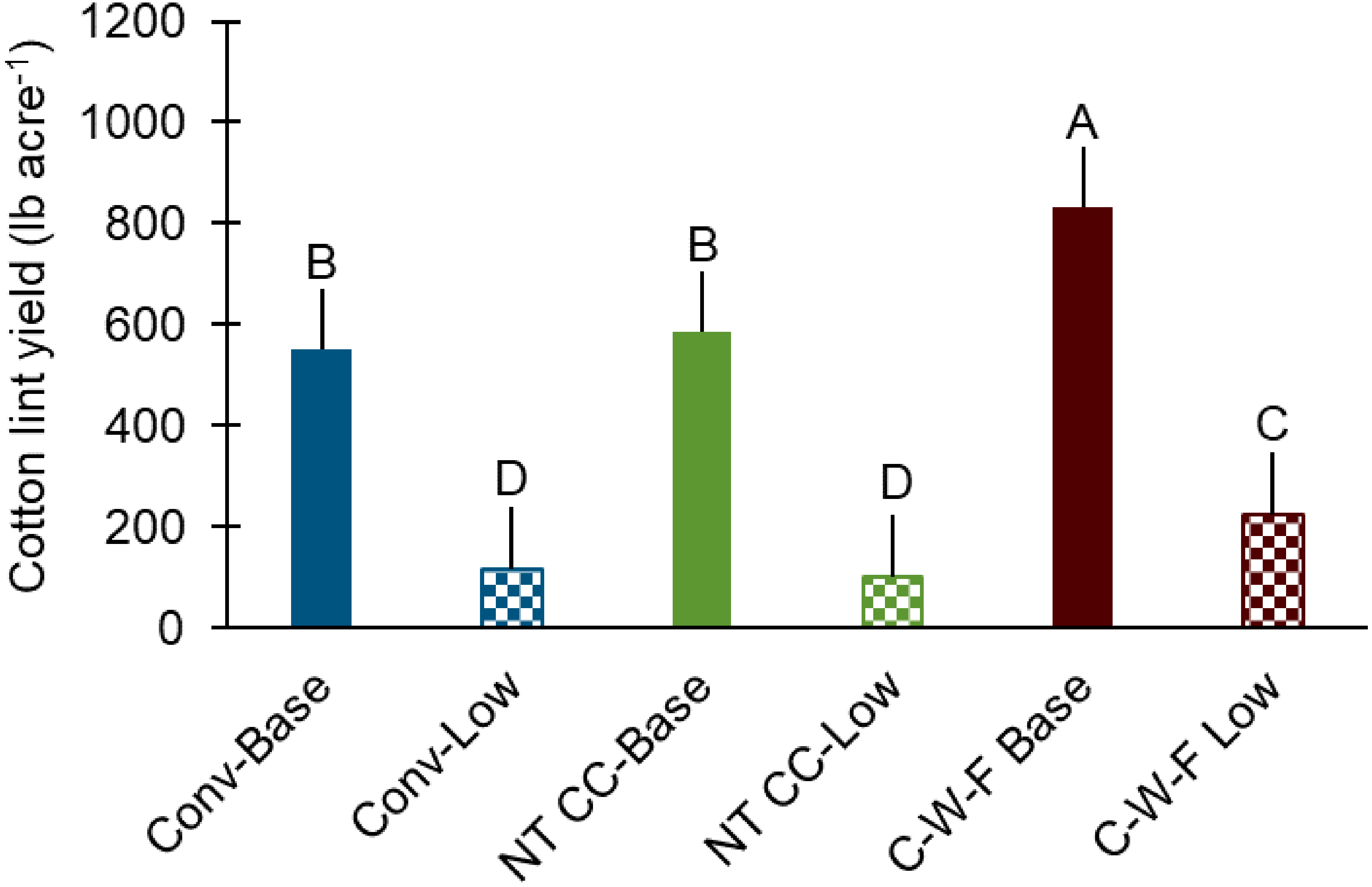


Soil water results



* = significant differences

Cotton lint yield



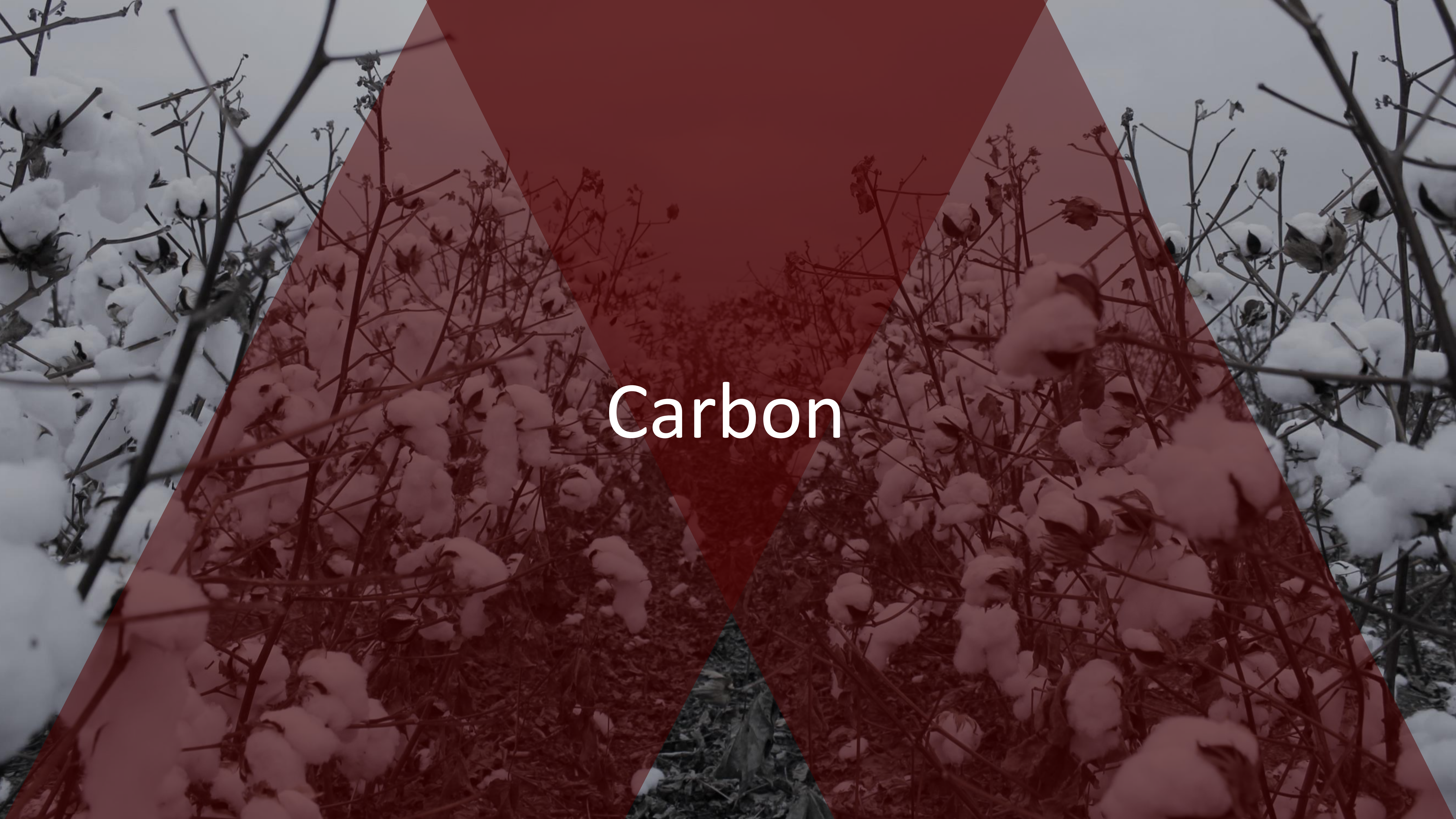
Summary & recommendations

Cotton following a cover crop benefits from additional N fertilization and added N fertilizer earlier in the growing season is most beneficial.

Cotton following wheat did not benefit from additional N fertilization to stimulate mineralization but did yield the greatest lint.

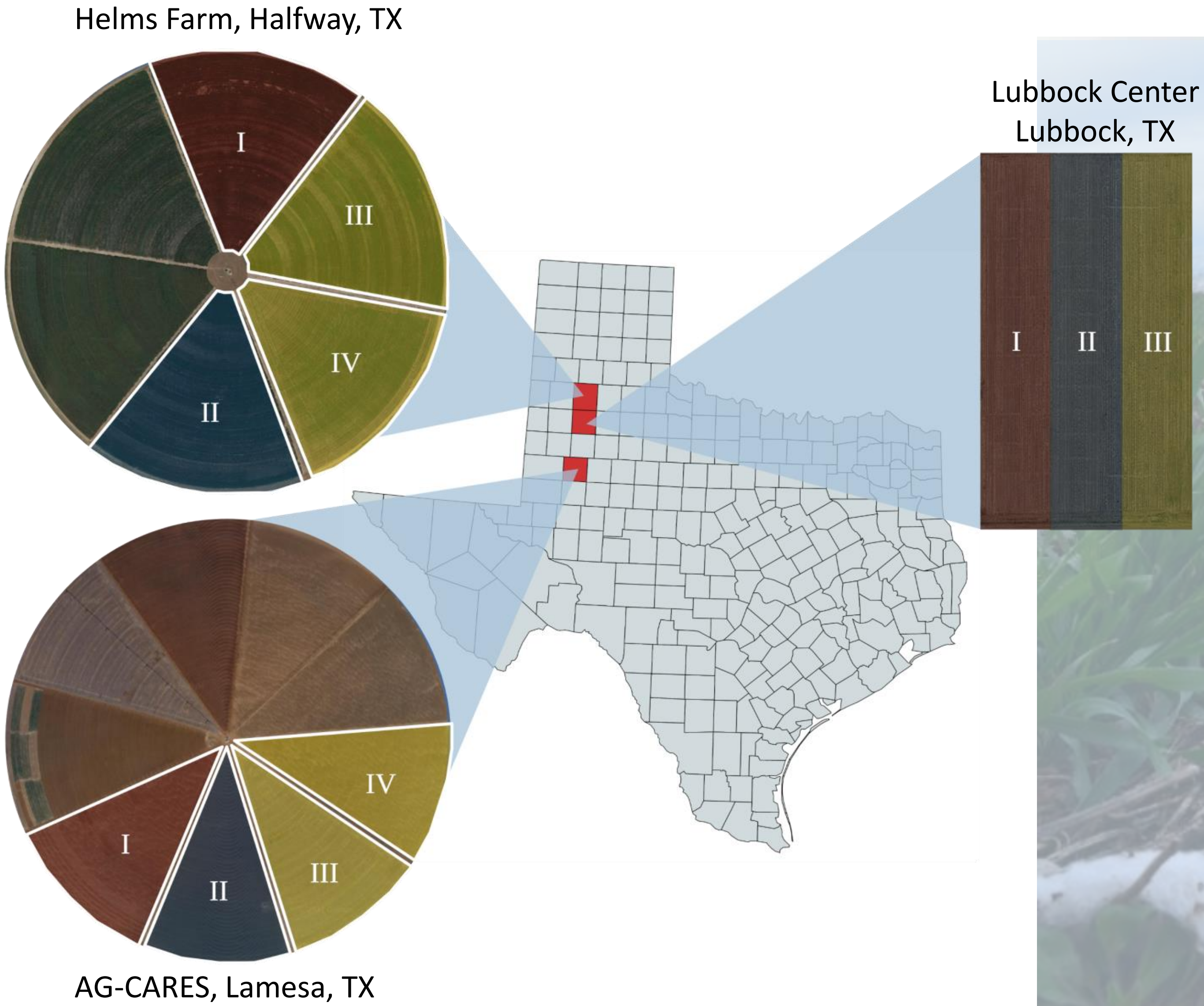
Partial budgets indicate no-tillage with cover crops or crop rotations are economical alternative to continuous cotton production on the High Plains.

Complete economic budgets are needed to understand the system. Current fertilizer prices may change the benefit of these production systems.



Carbon

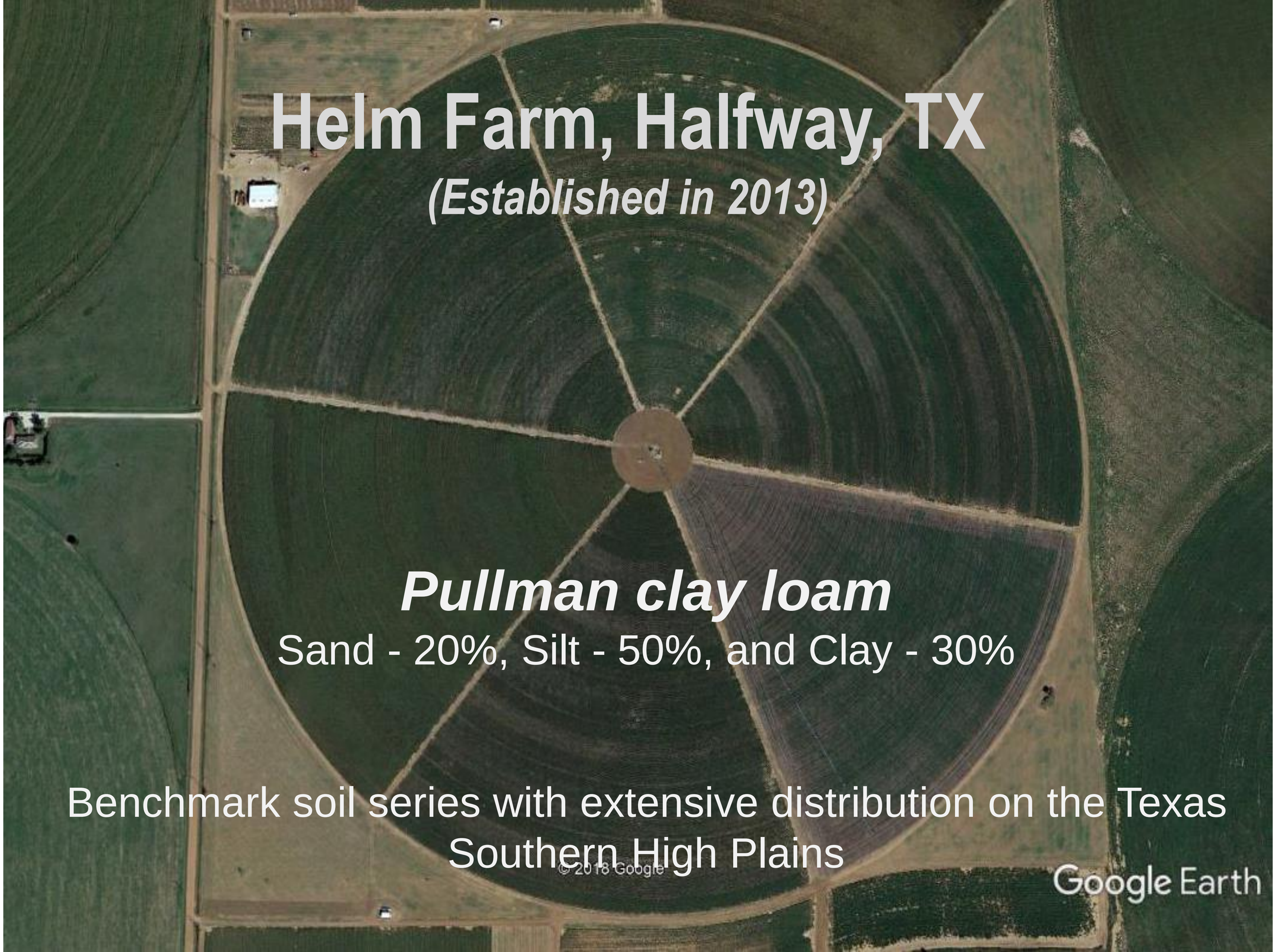
Carbon and cotton systems



Evaluate the impacts of conservation tillage, cover cropping and crop rotations on soil C, cotton yield and economic return

Helm Farm, Halfway, TX

(Established in 2013)



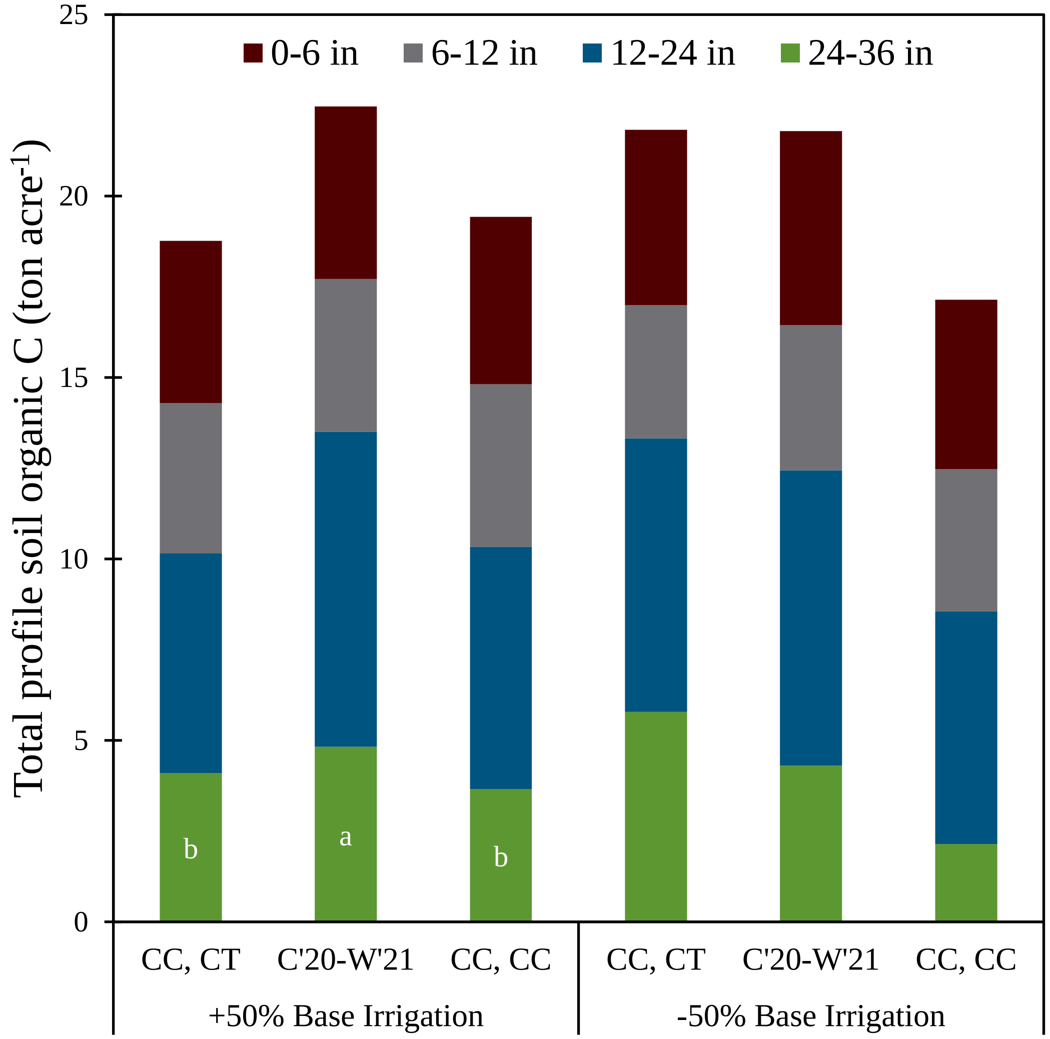
Pullman clay loam

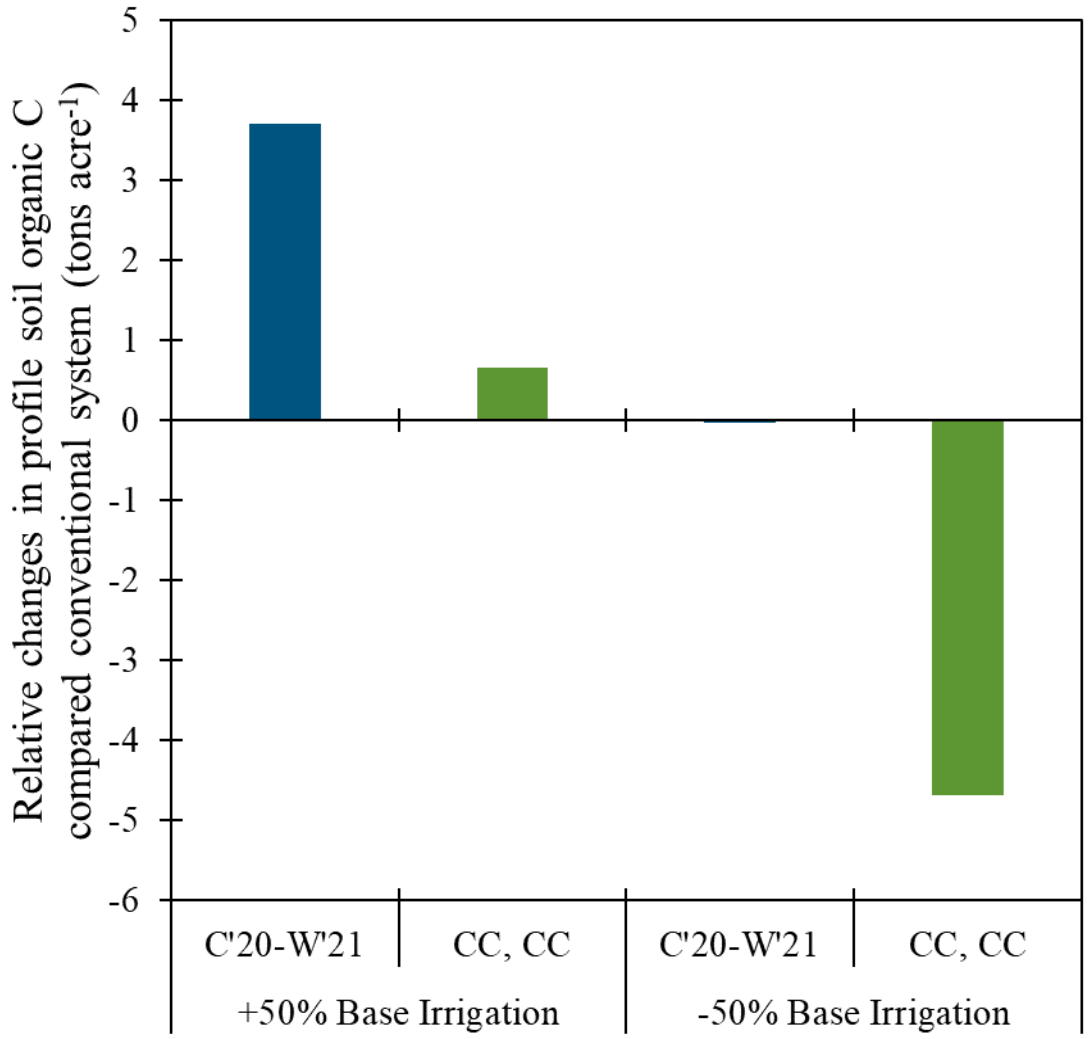
Sand - 20%, Silt - 50%, and Clay - 30%

Benchmark soil series with extensive distribution on the Texas Southern High Plains

Soil organic C (Helm Farm, est. 2013)

Soil samples collected prior to planting cotton in 2020 at 4 depths (0-6”, 6-12”, 12-24”, and 24-36”)





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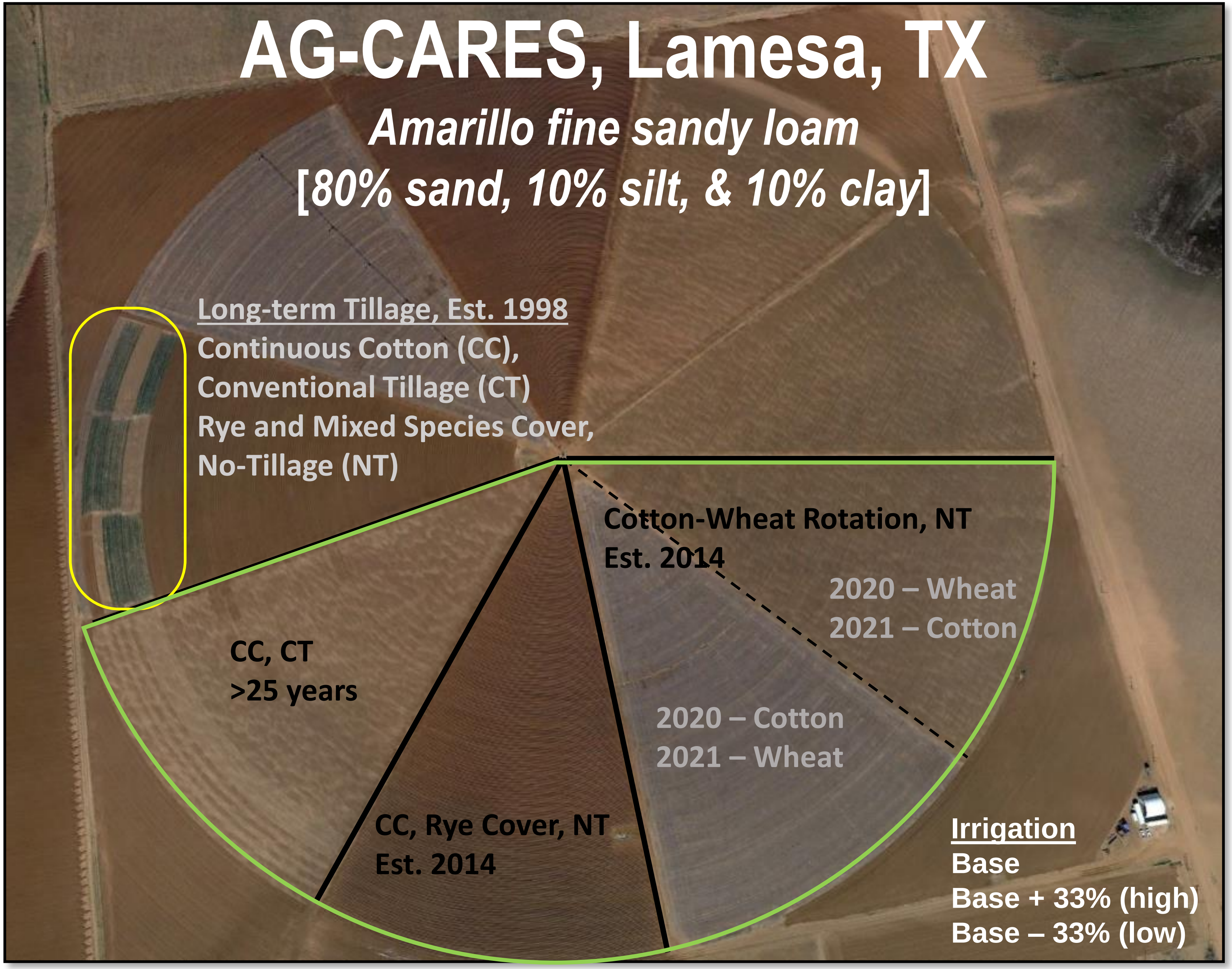
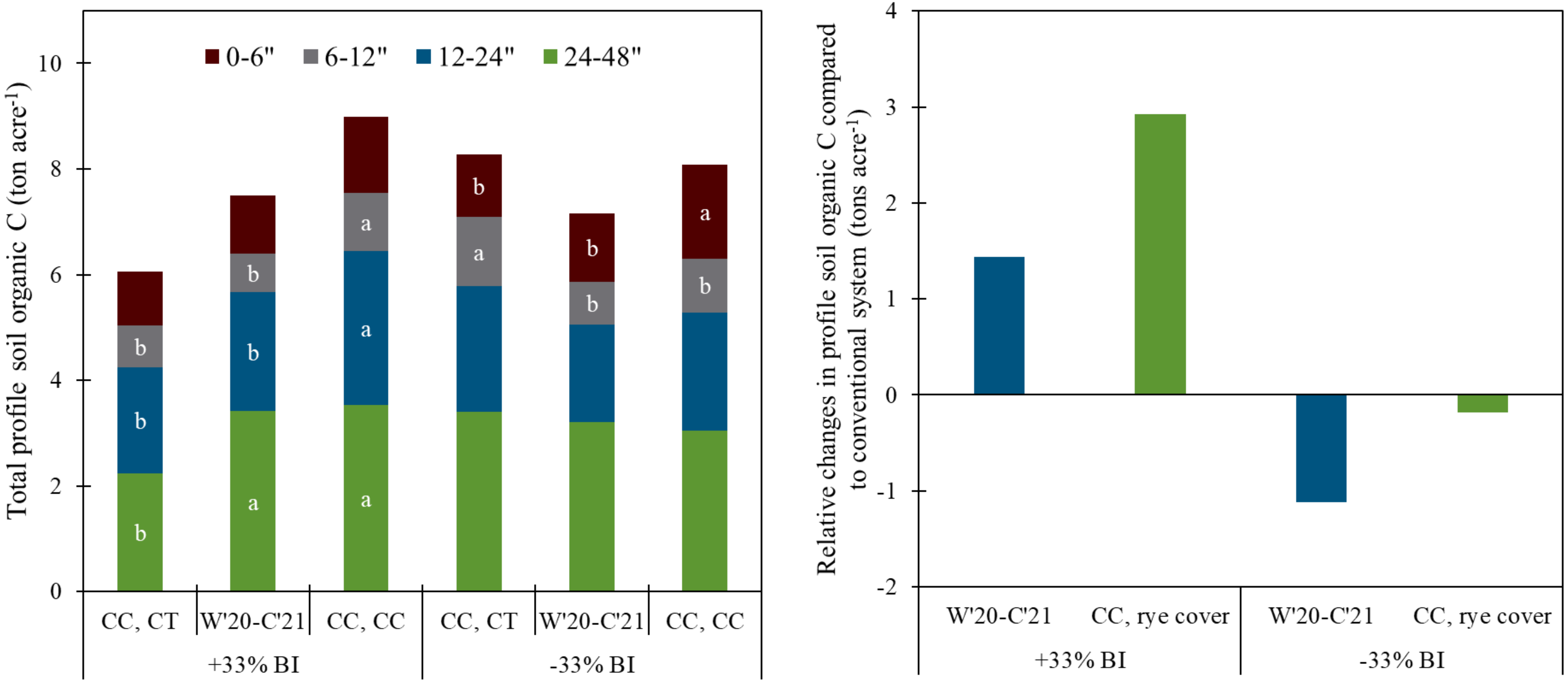


Soil organic C (AG-CARES, est. 2014)

Texas A&M AgriLife Research

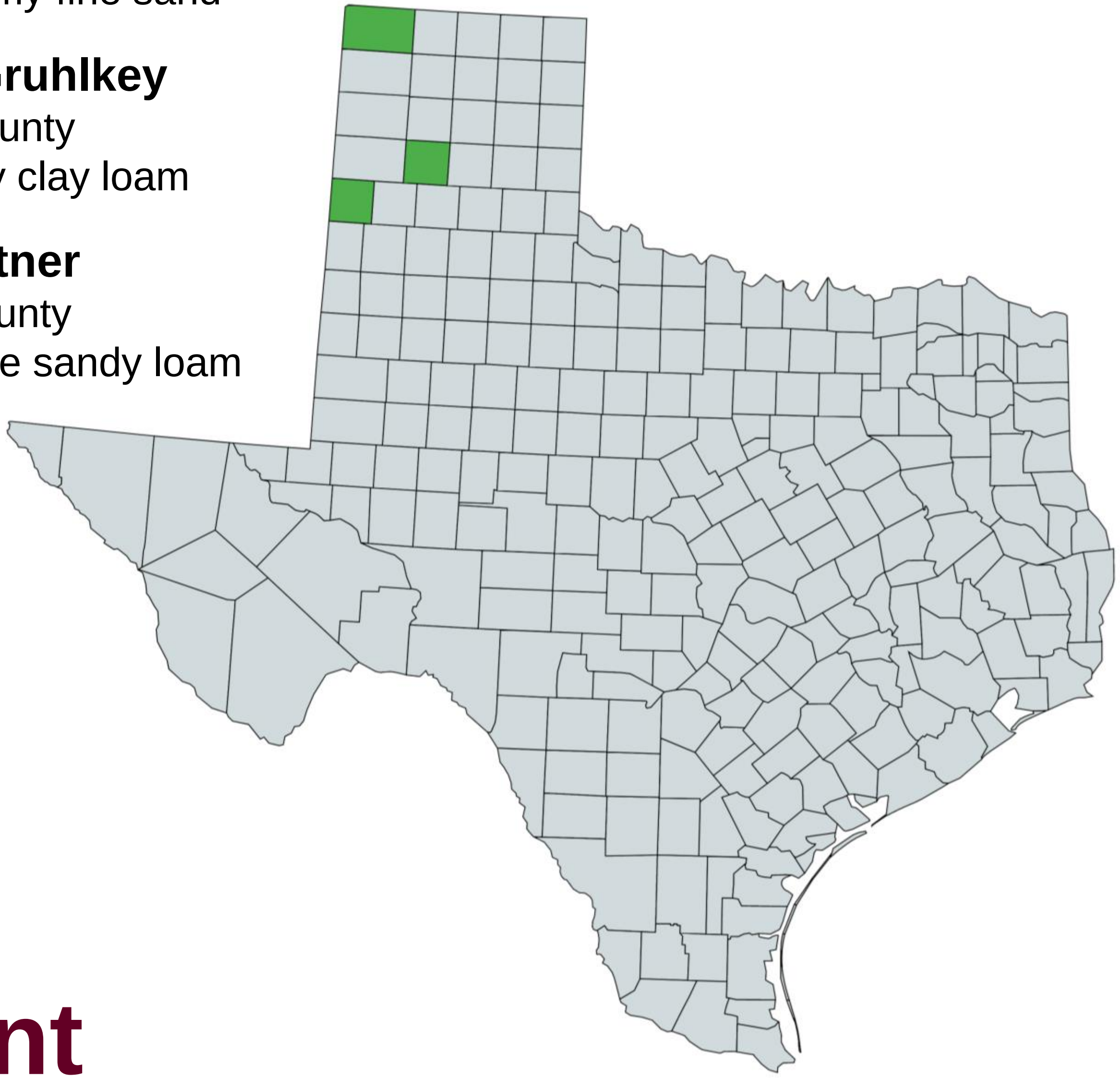
Soil samples collected prior to planting cotton in 2021 at 4 depths (0-6”, 6-12”, 12-24”, and 24-48”)



Steve and Zach Yoder
Dallam County
Dallam loamy fine sand

Braden Gruhlkey
Randall County
Pantex silty clay loam

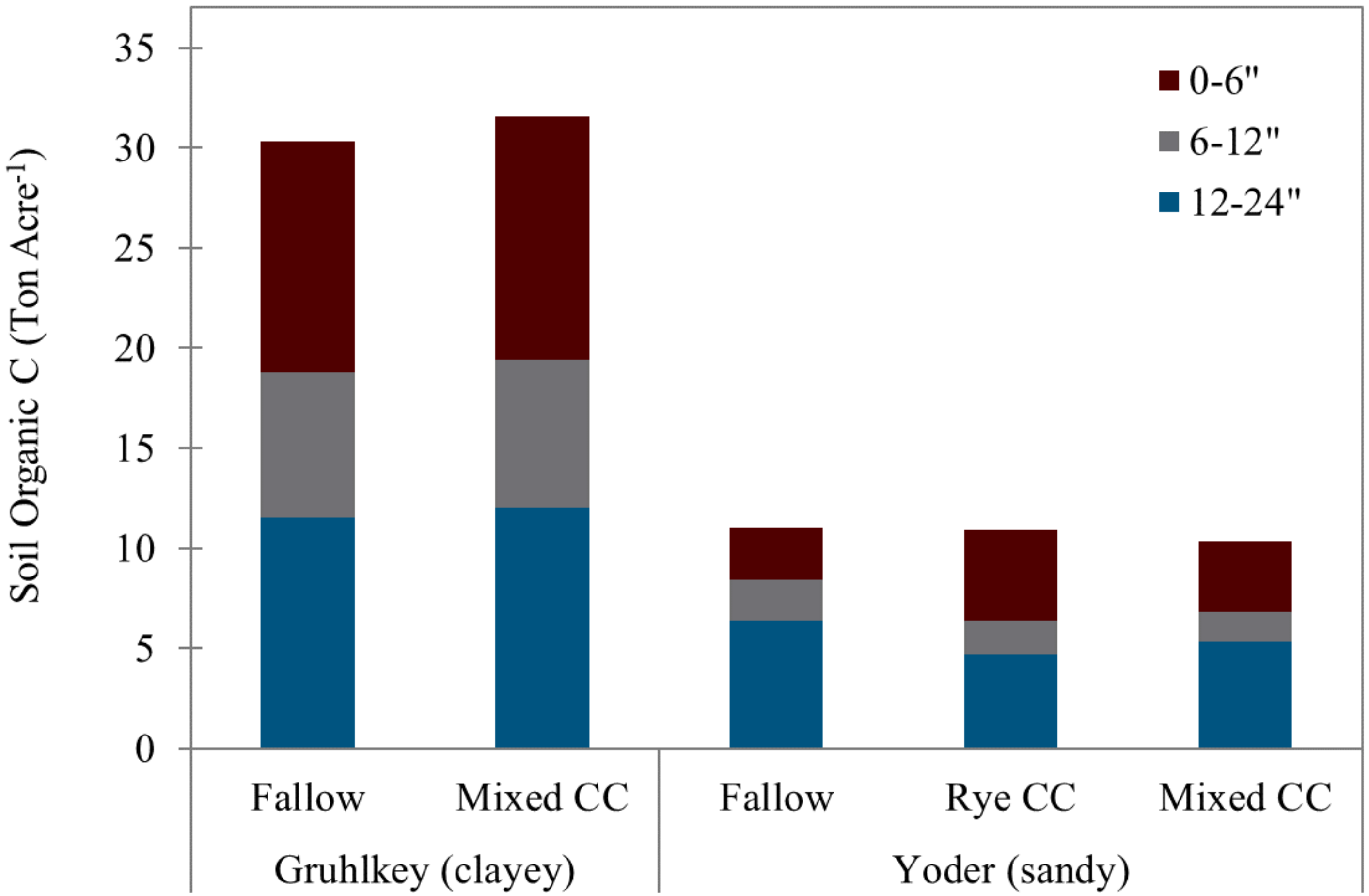
Kelly Kettner
Parmer County
Amarillo fine sandy loam



Conservation Management Corn Systems

Soil Organic C (est. 2017)

Samples collected in April 2020



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Summary

- Conservation management practices have a variable effect on soil C storage
- Soil texture and irrigation capacity have been identified as major drivers behind differences observed in soil C storage
- C storage is greater using cover crops in sandy soil and greater with rotation in clayey soil
- Potential to sequester 0.14 ton C/acre/year in sandy, semi-arid cotton system using cover crop and no-tillage (23-year system)
- While changes might be small, any amount of CO_2 kept in the soil and out of the atmosphere is going to be beneficial

Texas State Support Committee
Cotton Research and Promotion Program

TEXAS CORN PRODUCERS

THANK YOU

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