Impacts of Regenerative Ag on Water Storage and Soil Health

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Texas Groundwater Summit
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Texas A&M AgriLife Research

Texas Tech University
Agricultural Sciences & Natural Resources
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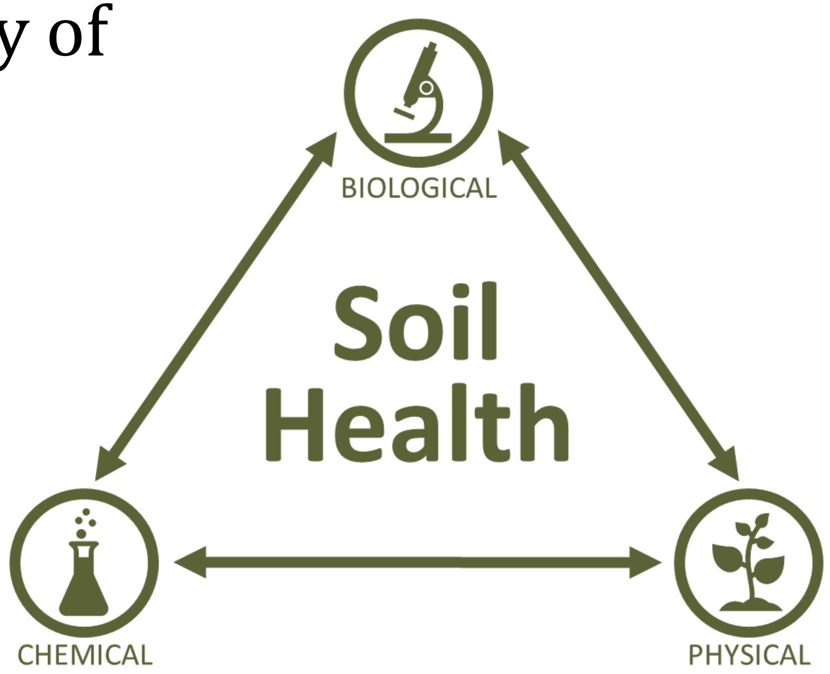
Introduction

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



Introduction

NRCS Soil Health Management -

- Manage more by disturbing soil less
- Keep the soil covered as much as possible
- Keep a living root growing throughout the year
- Diversify soil biota with plant diversity

Common soil health management practices on the THP -

Reduced or no-tillage | Cover crops | Crop rotations

Research Program

Demonstrate and quantify the improvements in soil chemical, physical, and biological properties (soil health) following the long-term adoption of conservation management in agricultural production systems

The Southern High Plains climate

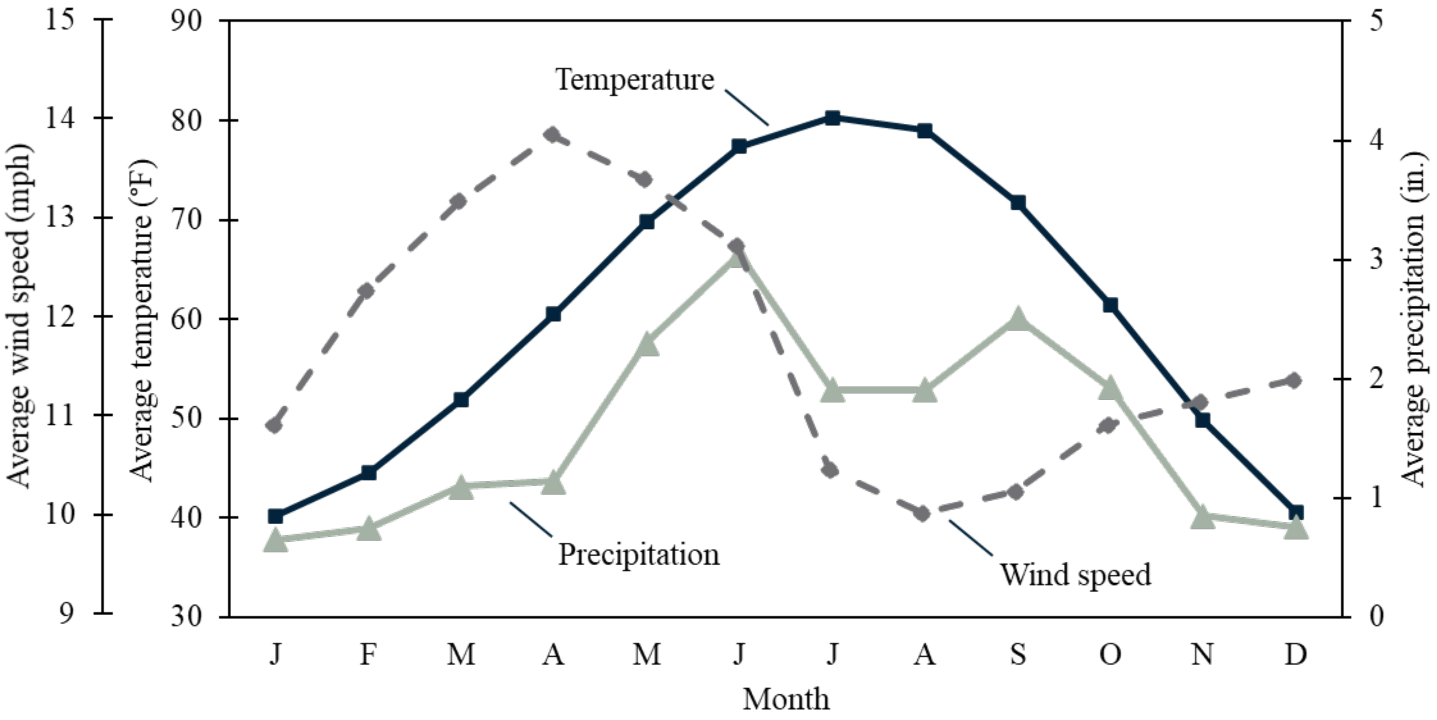
55 – 63°C

12.3 mph

16 – 22 inch

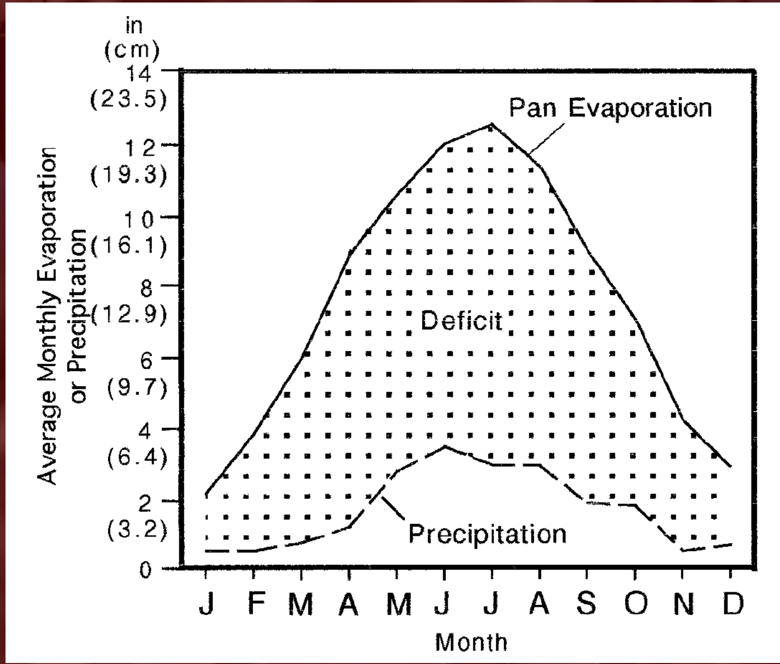
195 – 255 days/y

Climate in Lamesa, TX



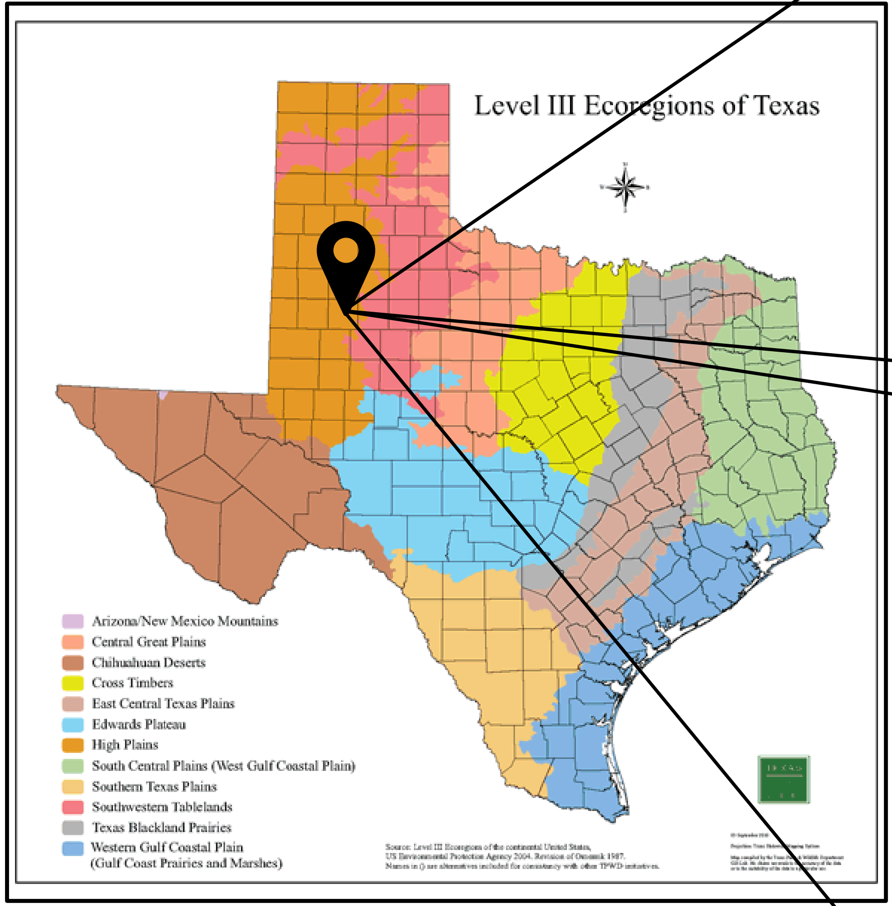
Potential evapotranspiration (PET)

- Average annual PET exceeds precipitation by 2-3 times



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

Long-term sites



<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)

Amarillo fine sandy loam

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

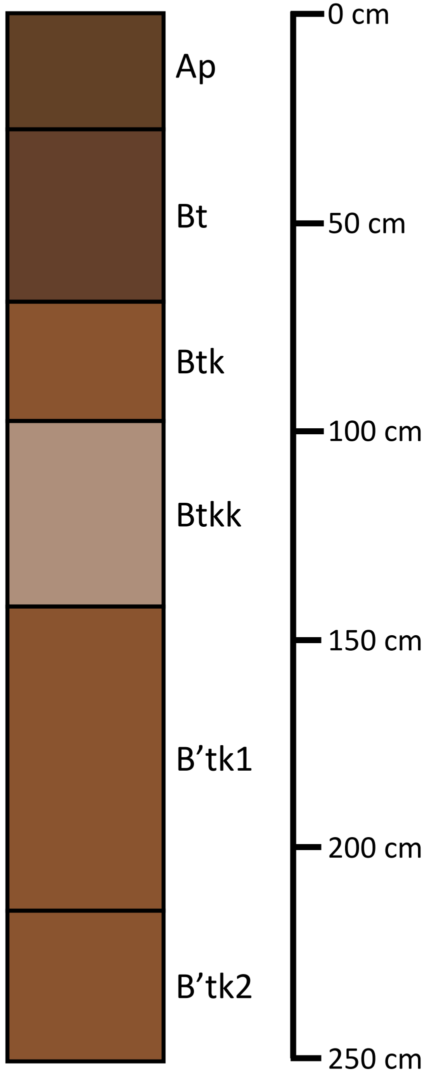
Primary uses: rangeland and agricultural production

Fine-loamy, mixed, superactive, thermic Aridic Paleustalf

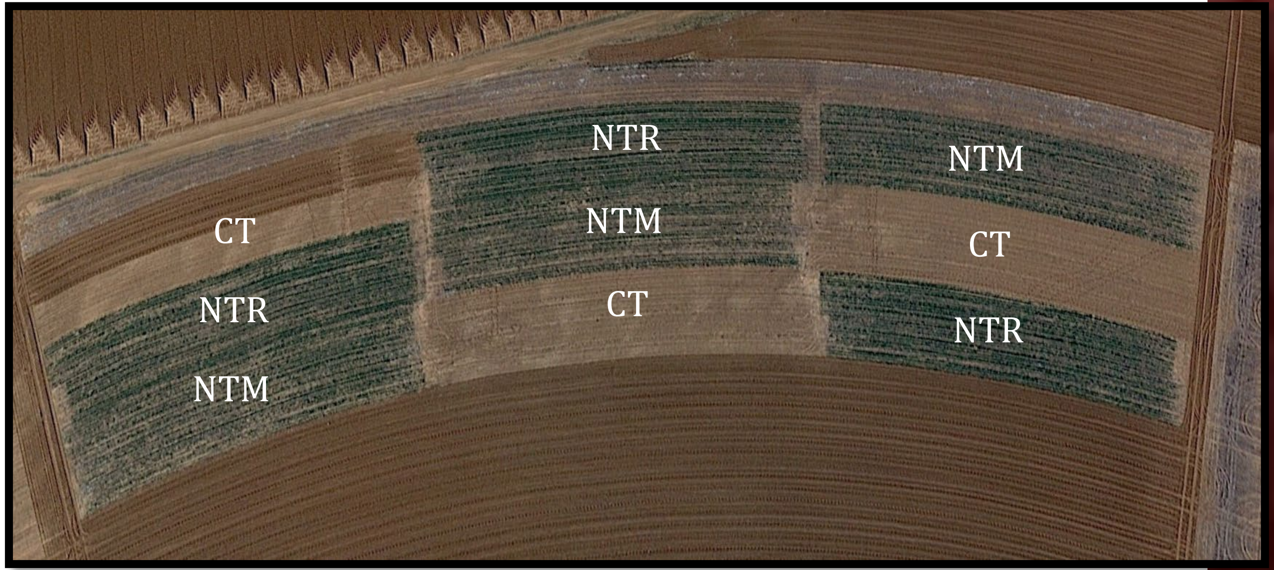
Sand - 80%, Silt - 9%, and Clay - 11%

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}

Typical Amarillo profile



The experimental design



Research plot design at Ag-CARES in Lamesa, TX

Evaluated systems

Continuous cotton systems – (est. 1998)

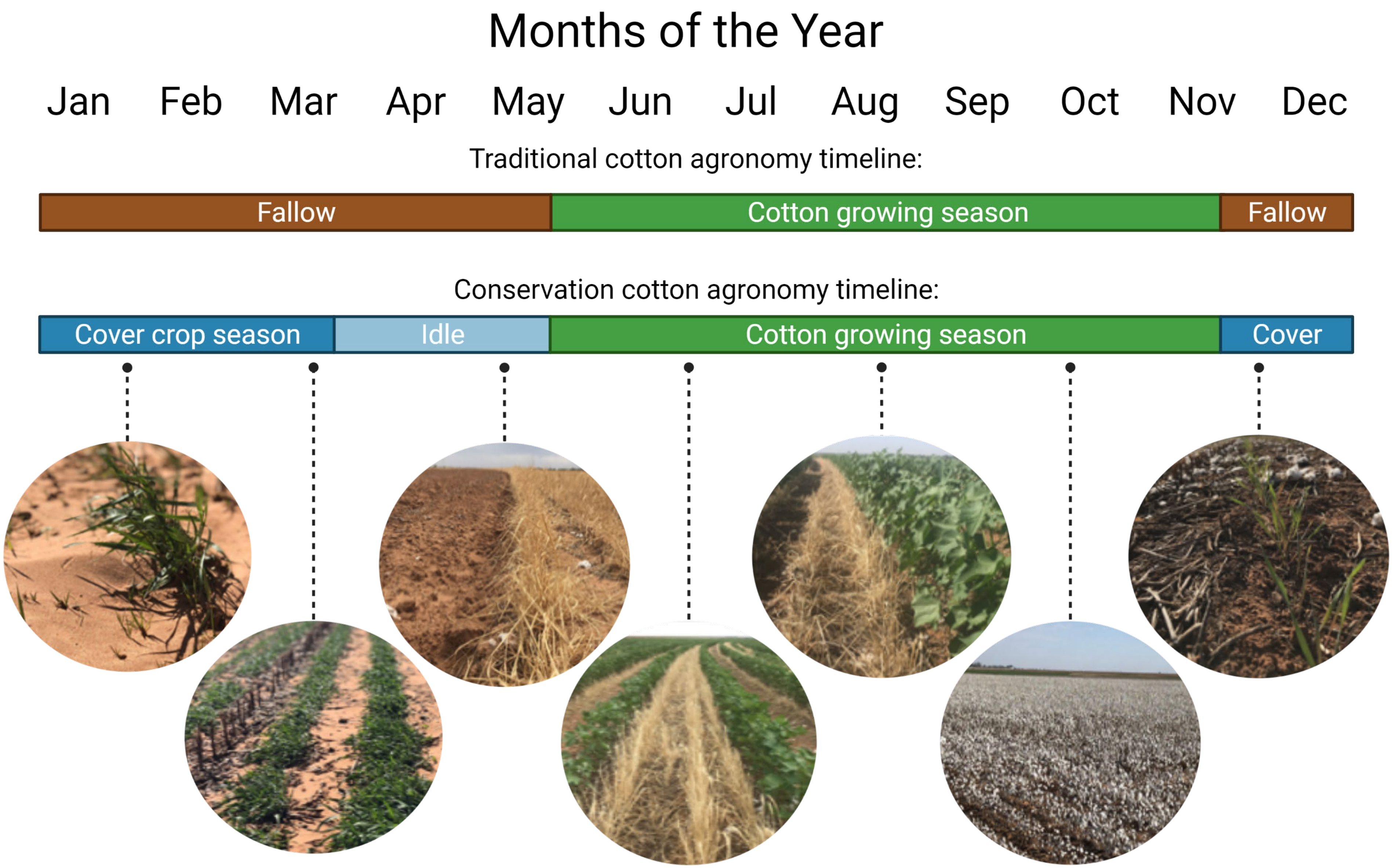
- Conventional tillage, winter fallow (CT)
- No-tillage, Rye cover (R-NT), 30 lb/acre
- No-tillage, Mixed cover (M-NT), 30 lb/acre
  - Rye (50%)
  - Austrian Winter Pea (33%)
  - Hairy Vetch (10%)
  - Radish (7%)
    - by weight
  - Established in November 2014
  - NRCS recommended mixture

Native Systems (NAT)

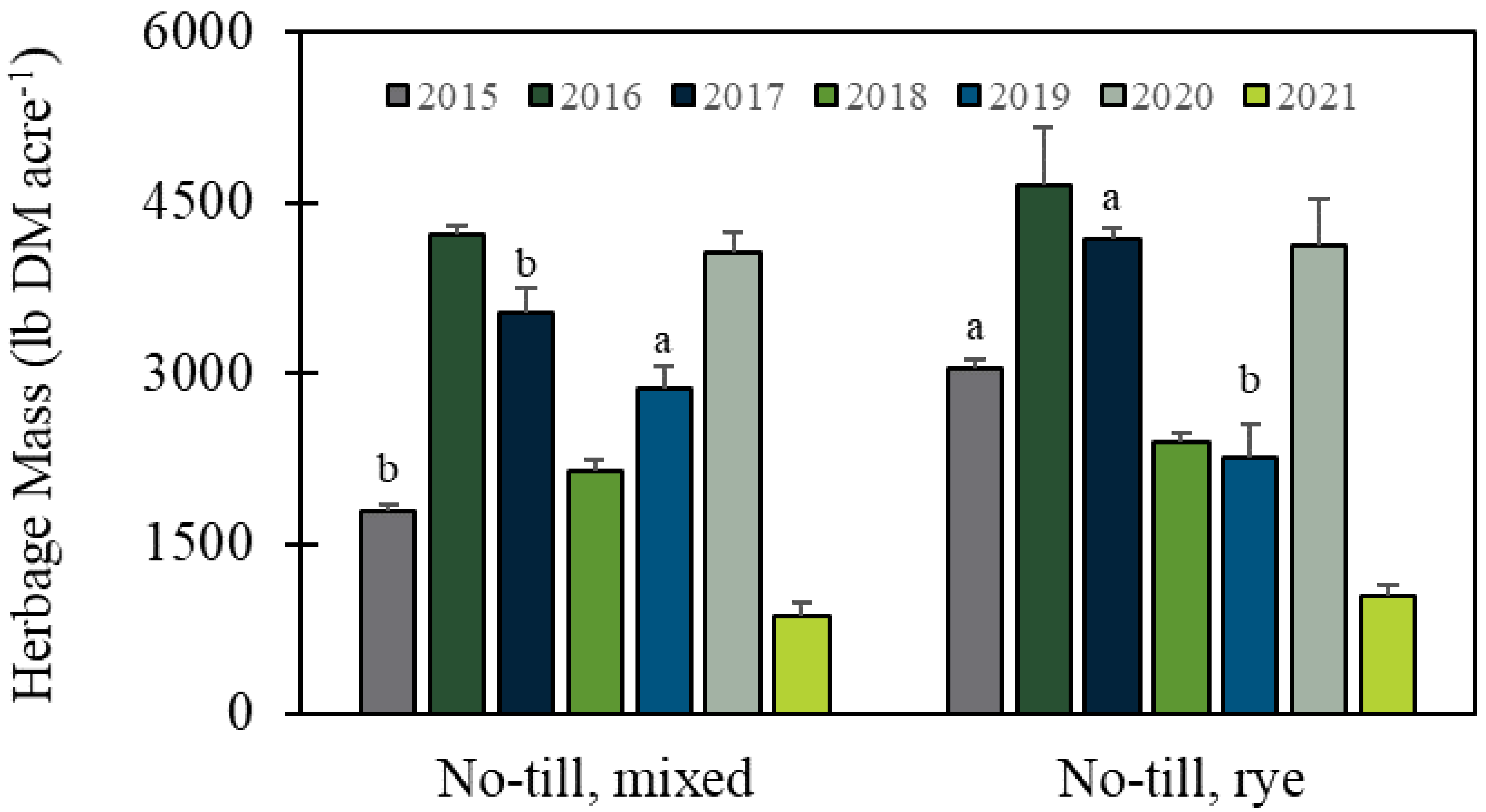
  - Rangeland - historical record indicates it unplowed at least 80 years

RCBD with three replications

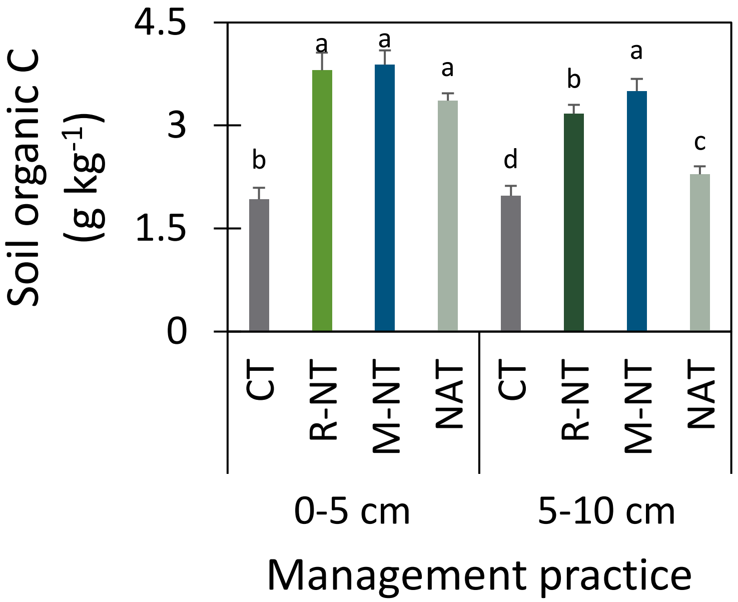
Cotton agronomy timeline

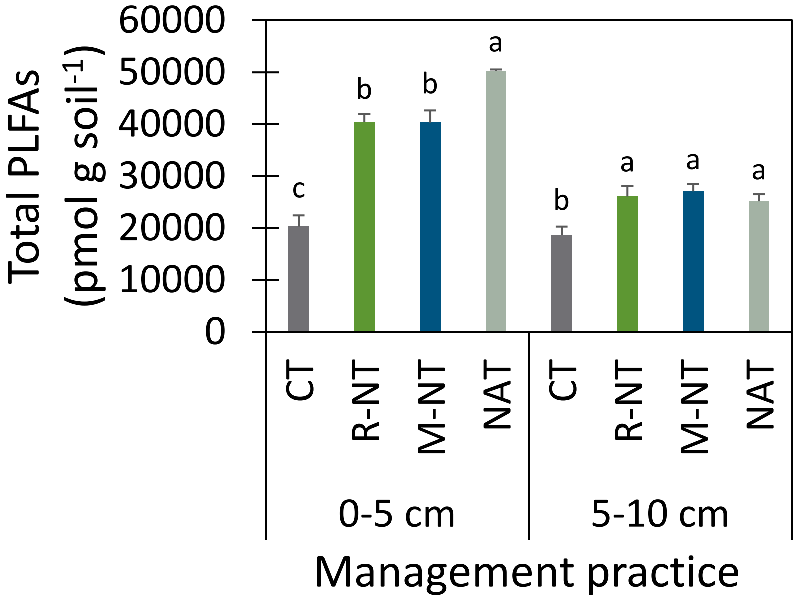


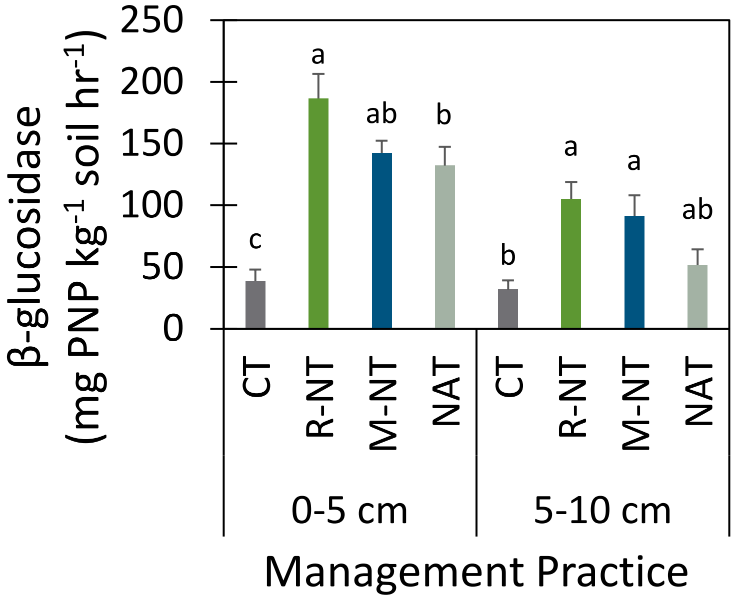
Cover crop biomass

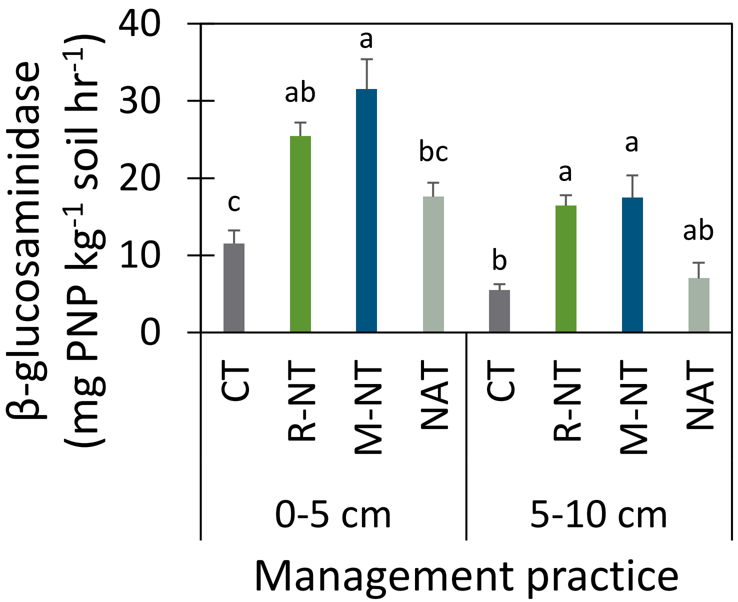


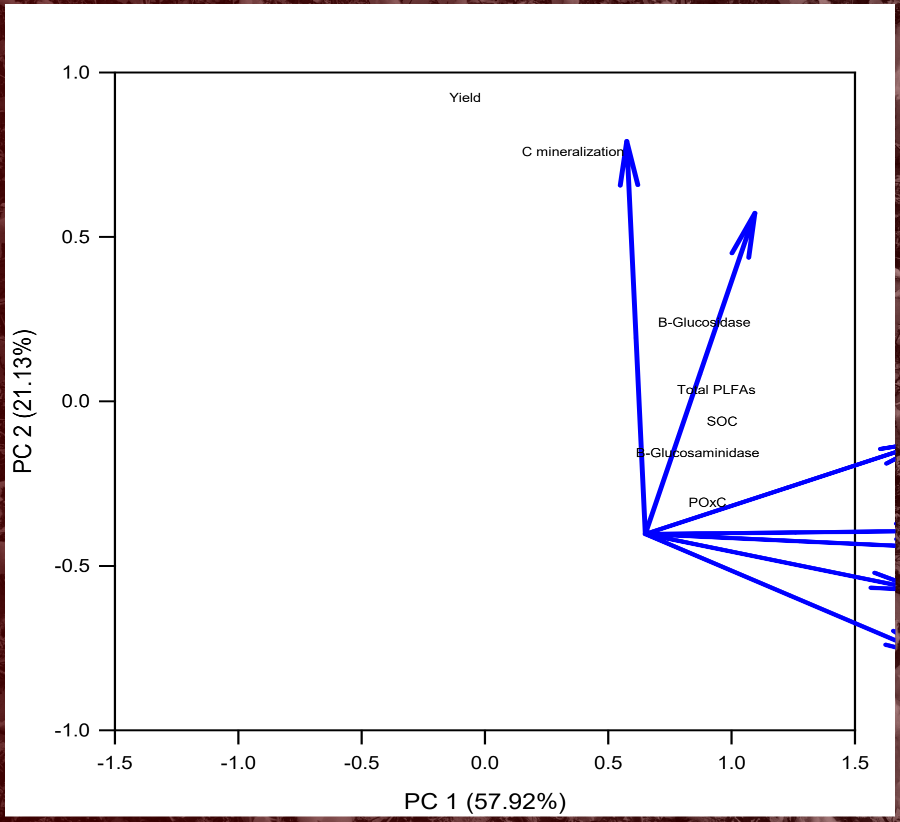
Soil health


Soil organic C
(g kg-1)
4.5
3
1.5
0
b a a a d b a c
CT R-NT M-NT NAT CT R-NT M-NT NAT
0-5 cm
5-10 cm
Management practice

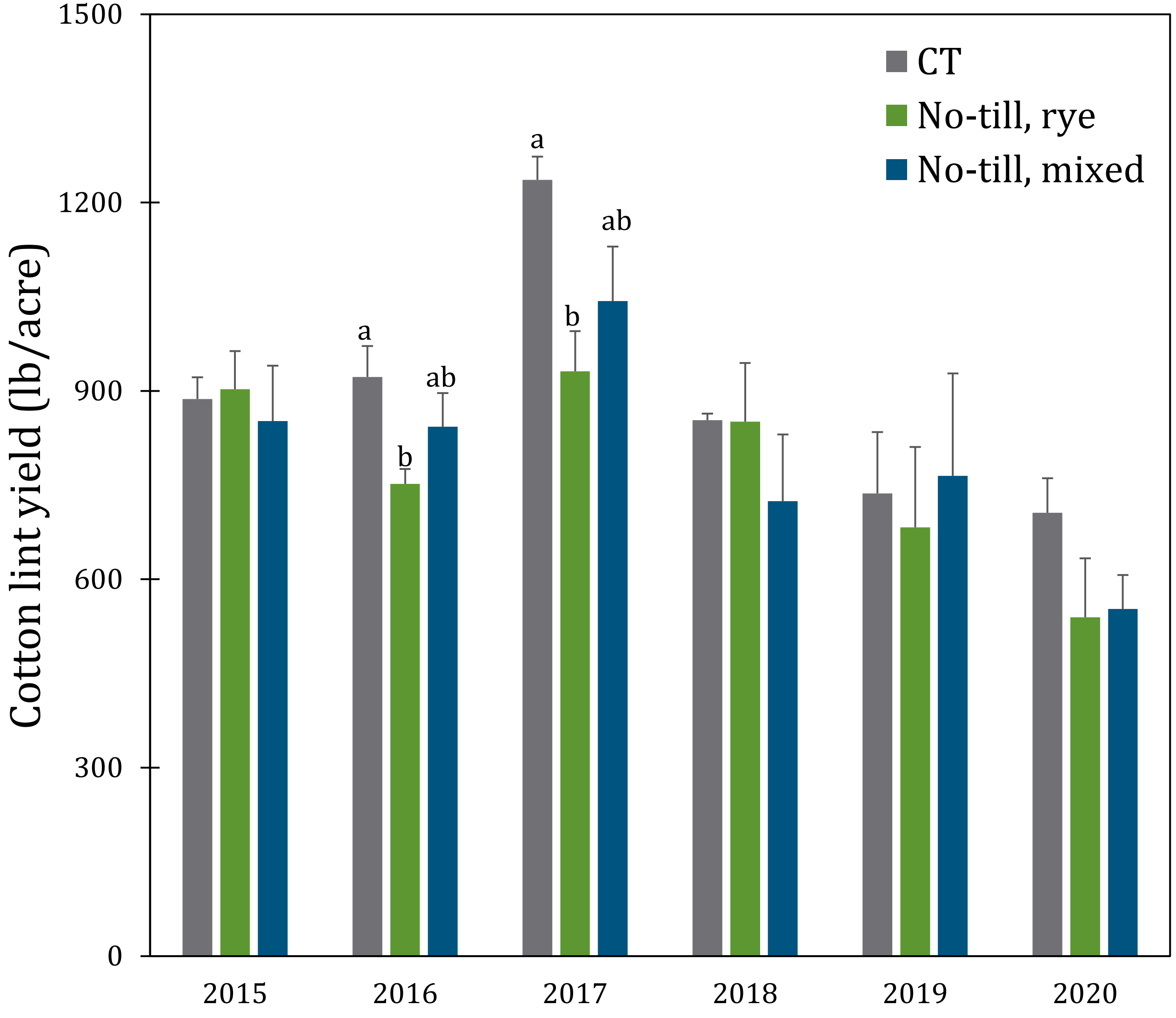

Total PLFAs
(pmol g soil-1)
60000
50000
40000
30000
20000
10000
0
c b b a b a a a
CT R-NT M-NT NAT CT R-NT M-NT NAT
0-5 cm
5-10 cm
Management practice


β-glucosidase
(mg PNP kg-1 soil hr-1)
250
200
150
100
50
0
c a ab b b a a ab
CT R-NT M-NT NAT CT R-NT M-NT NAT
0-5 cm
5-10 cm
Management Practice


β-glucosaminidase
(mg PNP kg-1 soil hr-1)
40
30
20
10
0
c ab a bc b a a ab
CT R-NT M-NT NAT CT R-NT M-NT NAT
0-5 cm
5-10 cm
Management practice


Yield
C mineralization
B-Glucosidase
Total PLFAs
SOC
B-Glucosaminidase
POxC
PC 2 (21.13%)
PC 1 (57.92%)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5

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?

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

Cotton water use efficiency

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2015-2017

	Water use efficiency		
	2015	2016	2017
Cropping system	lb lint A^{-1} in^{-1}		
Conventional tillage, winter fallow	33.0	38.0	58.9
No-tillage rye cover	33.6	31.0	44.4
No-tillage mixed species cover	31.7	34.7	49.7
P-value	*0.641*	*0.780*	*0.063*

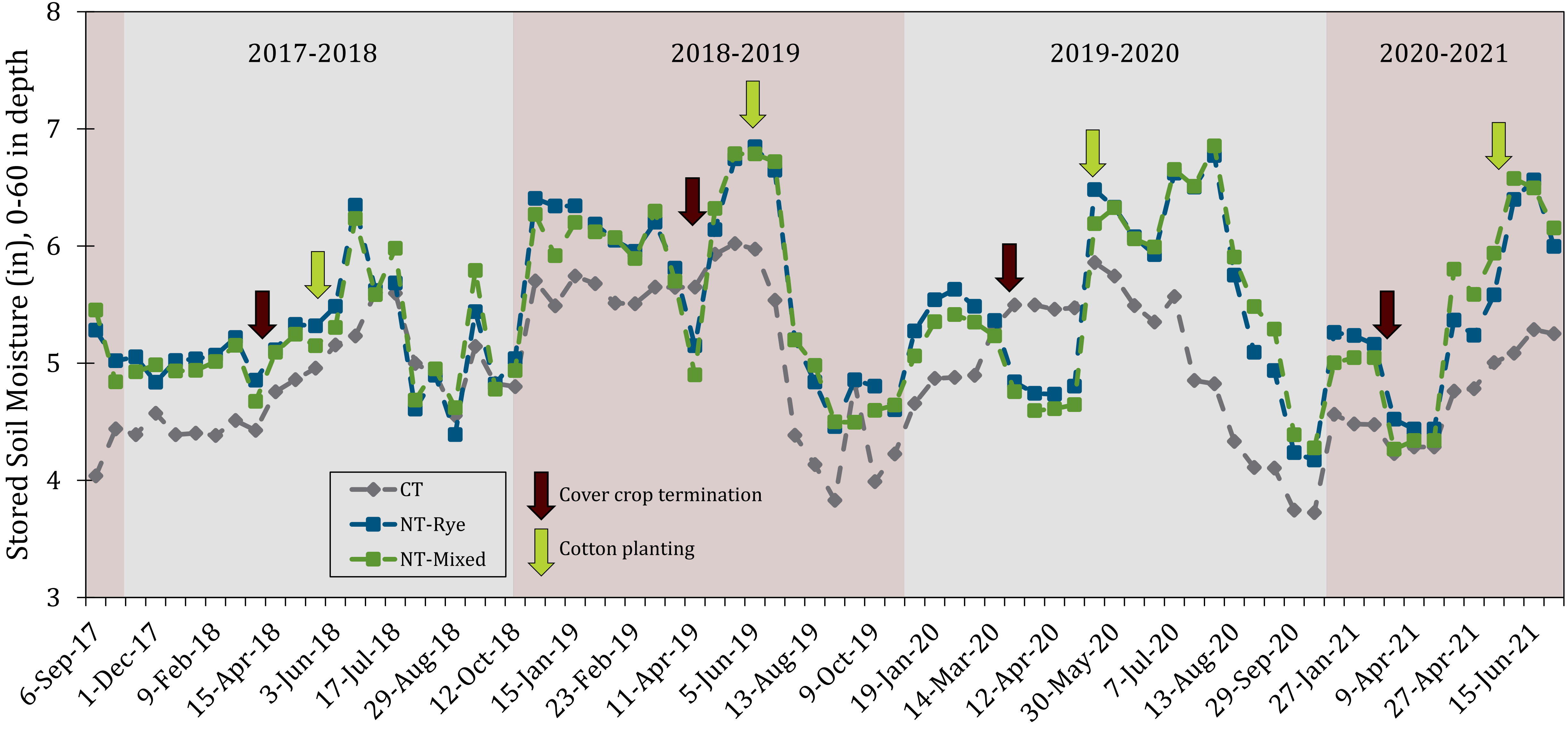
Burke et al., 2021, *Soil Till. Res., 208*, 104869.

2018-2020

	Water use efficiency		
	2018	2019	2020
Cropping system	lb lint A^{-1} in^{-1}		
Conventional tillage, winter fallow	54.6	37.0	43.7
No-tillage rye cover	55.9	33.5	32.9
No-tillage mixed species cover	47.7	37.5	34.8
P-value	*0.258*	*0.780*	*0.141*

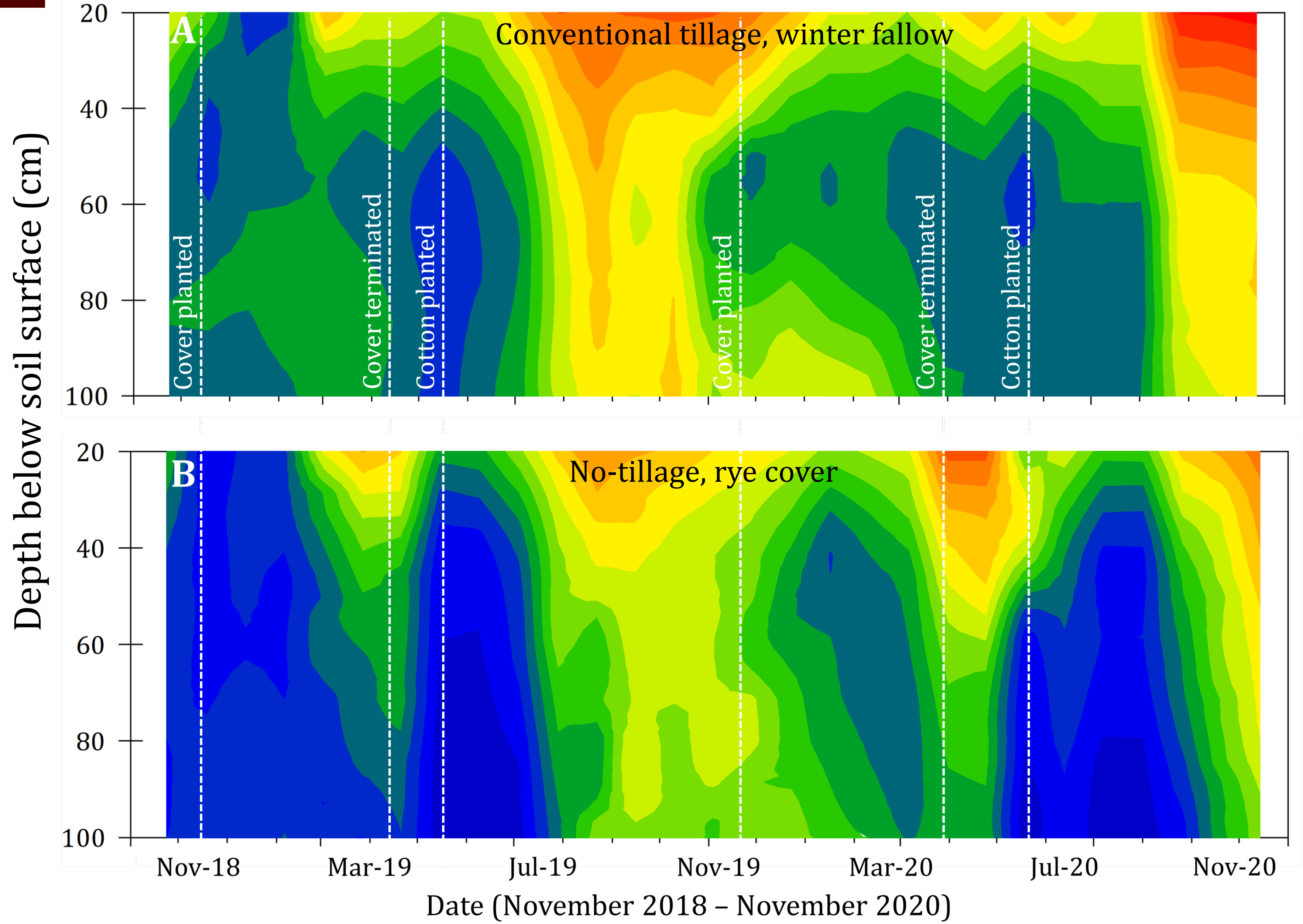
Burke et al., 2022, *Agronomy, 12*, 1306.

Soil water



Stored Soil Moisture (in), 0-60 in depth
2017-2018
2018-2019
2019-2020
2020-2021
CT
NT-Rye
NT-Mixed
Cover crop termination
Cotton planting
8
7
6
5
4
3
6-Sep-17
1-Dec-17
9-Feb-18
15-Apr-18
3-Jun-18
17-Jul-18
29-Aug-18
12-Oct-18
15-Jan-19
23-Feb-19
11-Apr-19
5-Jun-19
13-Aug-19
9-Oct-19
19-Jan-20
14-Mar-20
12-Apr-20
30-May-20
7-Jul-20
13-Aug-20
29-Sep-20
27-Jan-21
9-Apr-21
27-Apr-21
15-Jun-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: N management

Cropping System	Nitrogen fertilization strategies			
	FP	PPN	PEN	PHSN
	Lint Yield (lb/a)			
CC	723	787 (8.9%)	715 (-1.1%)	683 (-5.5%)
CCRC	806	938 (16.4%)	964 (19.6%)	856 (6.2%)
CWR	1134	1032 (-9.0%)	1117 (-1.5%)	1064 (-6.2%)

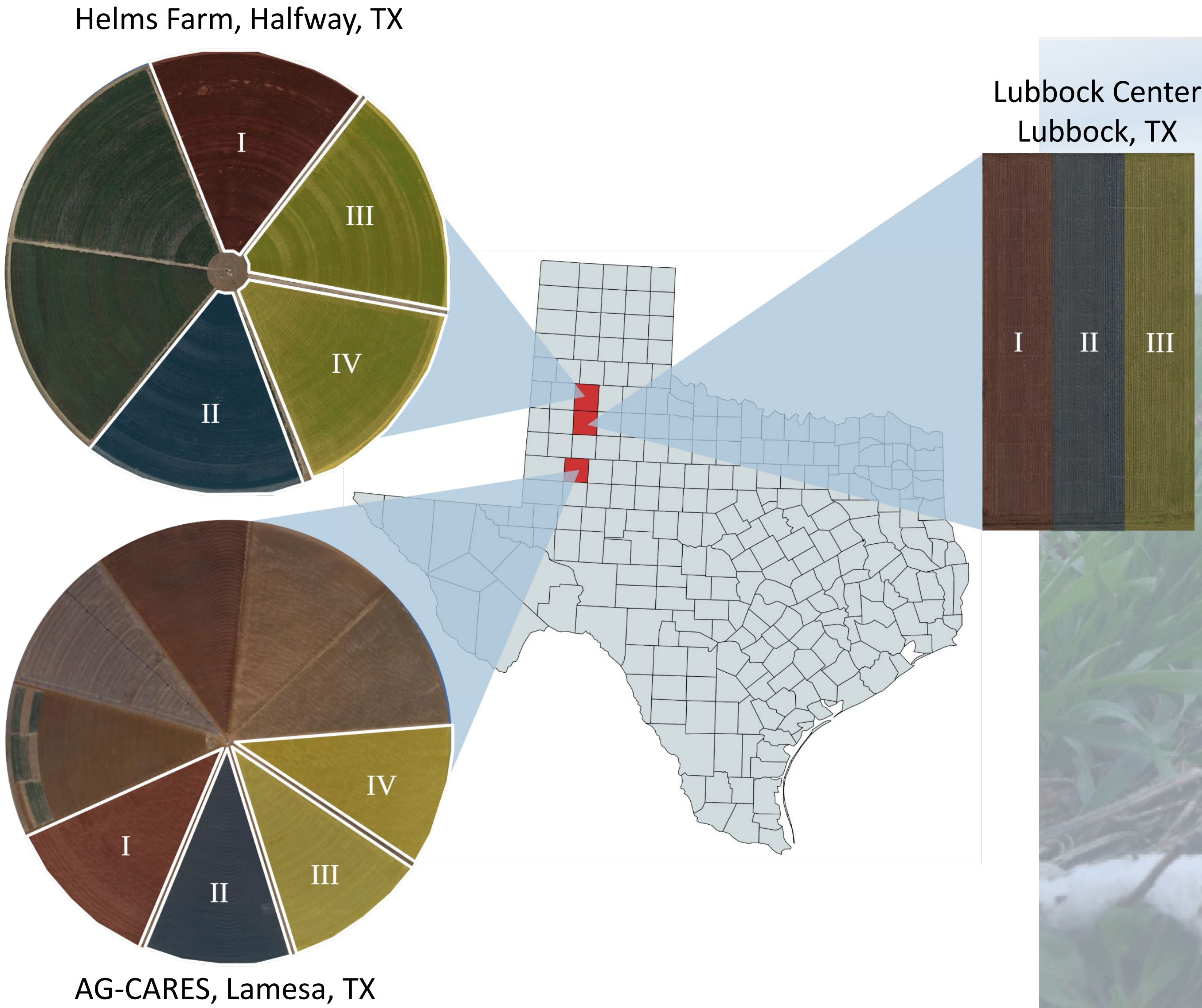
Fertilization strategies:

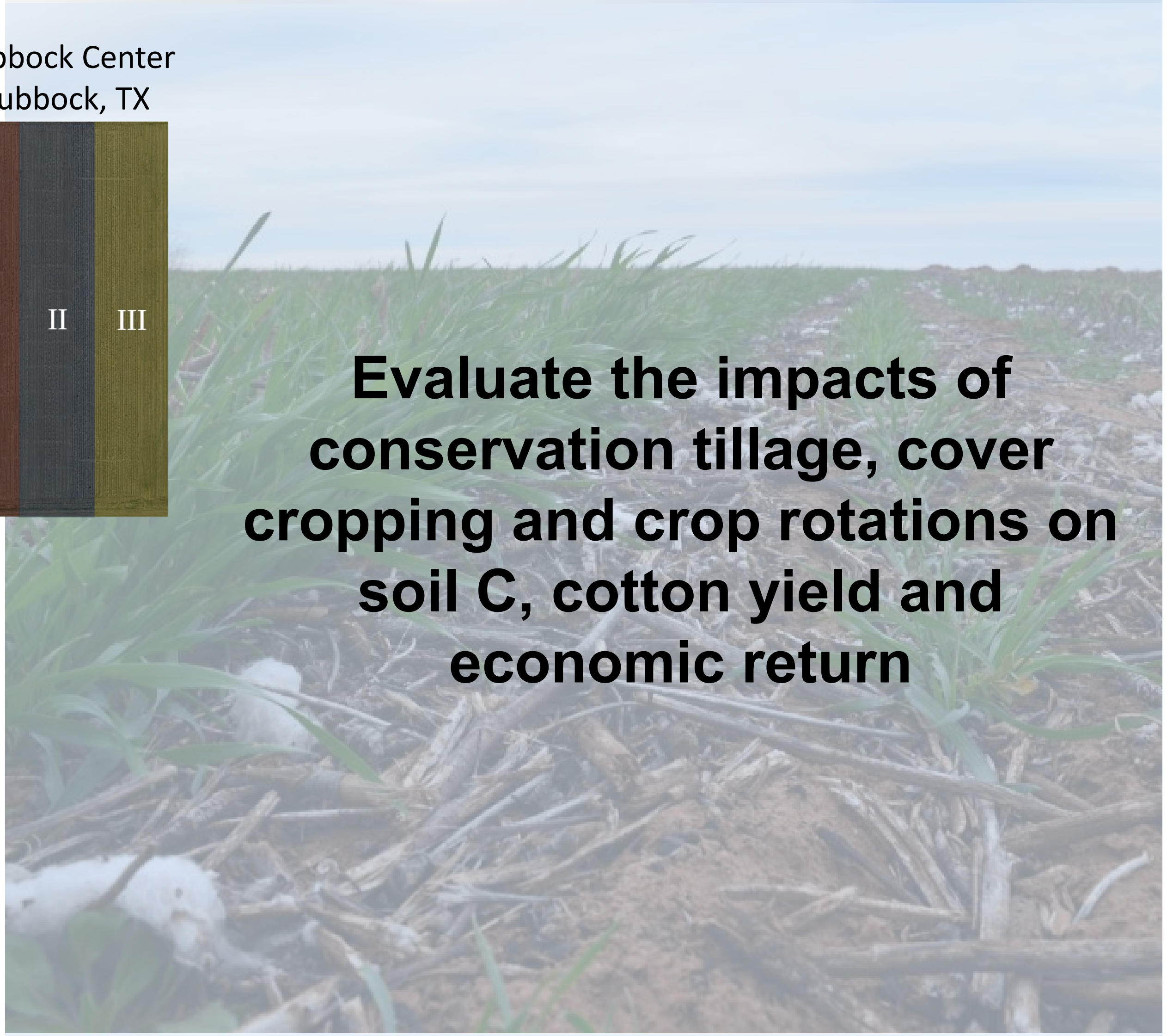
- FP = farmers practices (120 lb N/a)
- PPN = FP + 30 lb N/a preplant
- PEN = FP + 30 lb N/a post emerg. + 2 wks
- PHSN = FP + 30 lb N/a pinhead square + 2 wks

Cropping systems:

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

Carbon and Cotton Systems





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

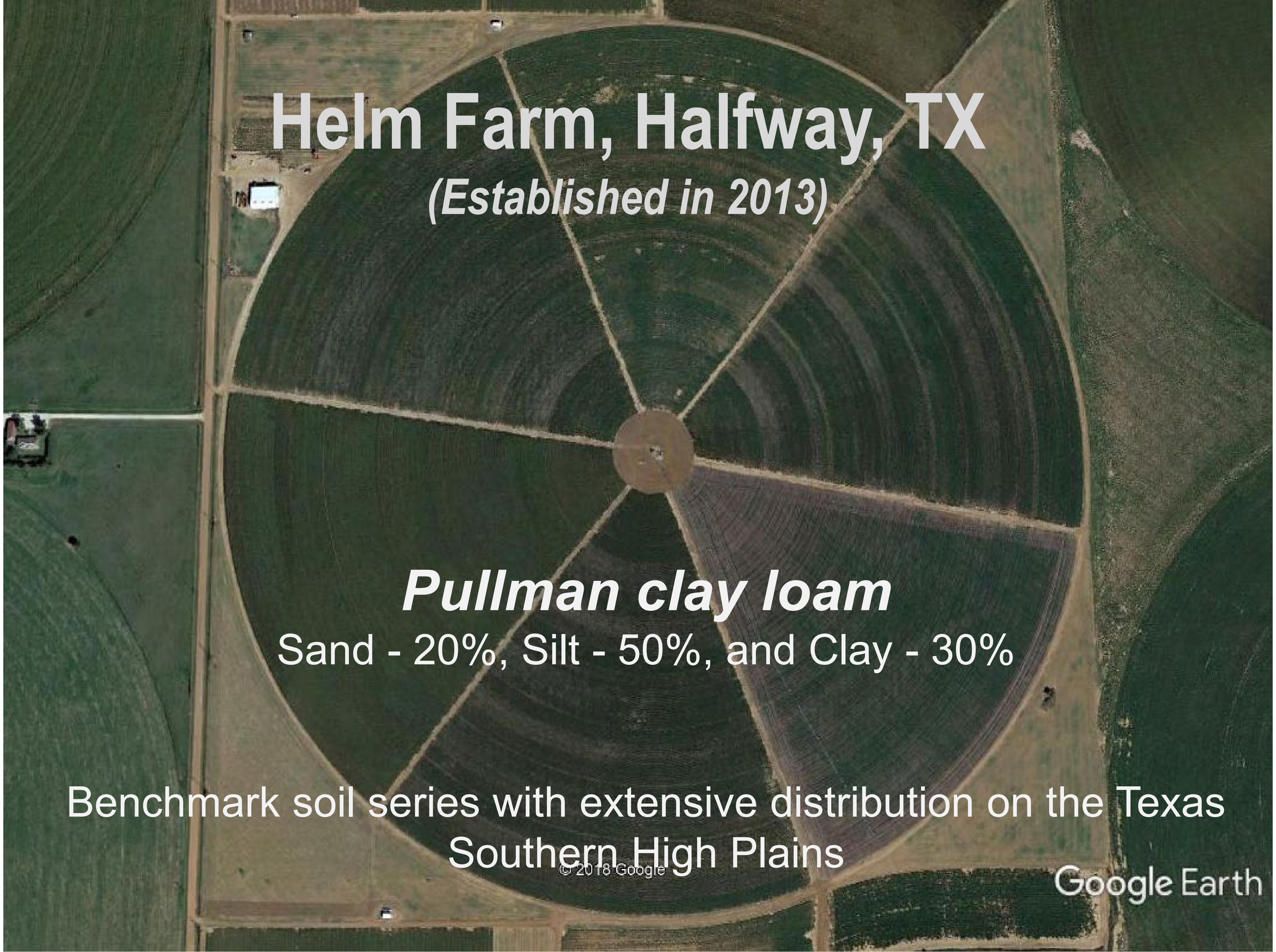
Helm Farm, Halfway, TX

(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



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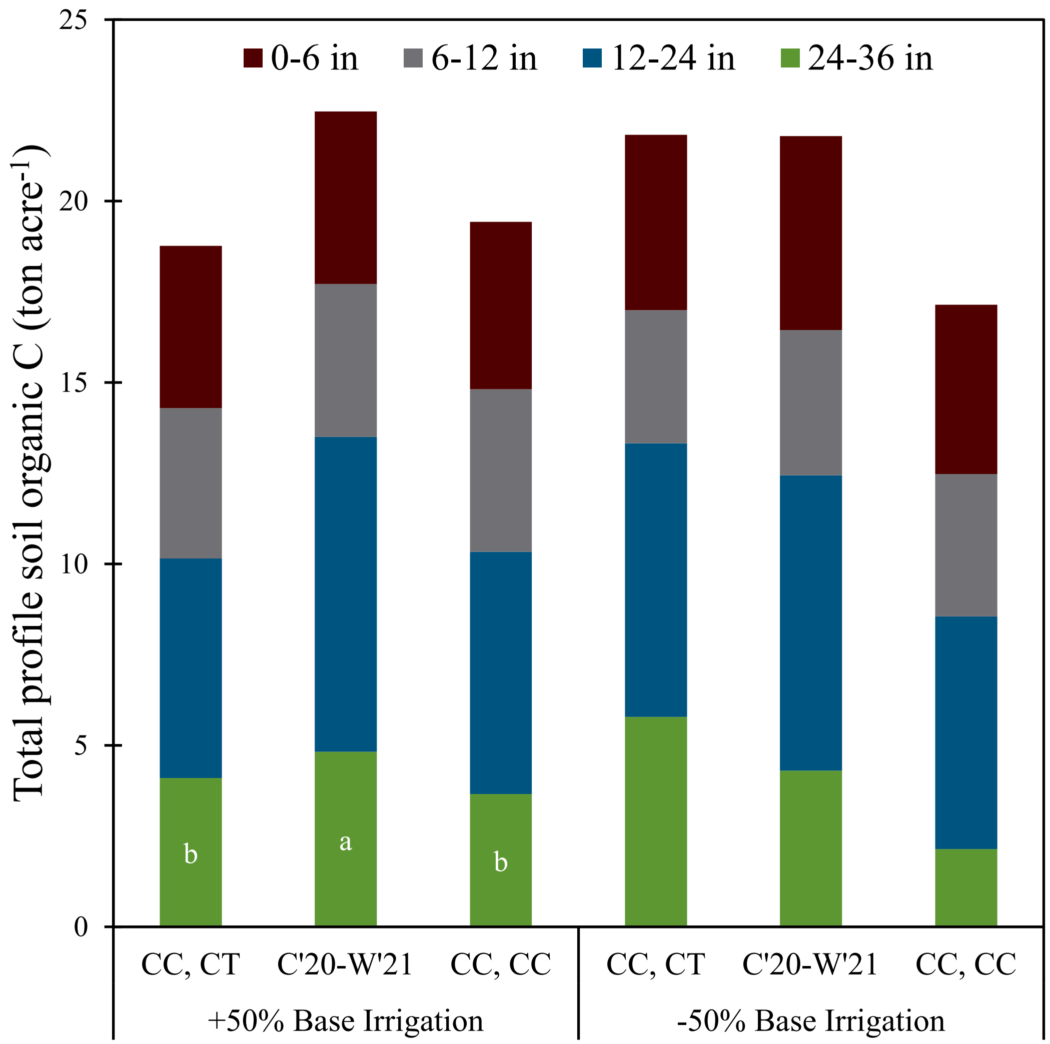
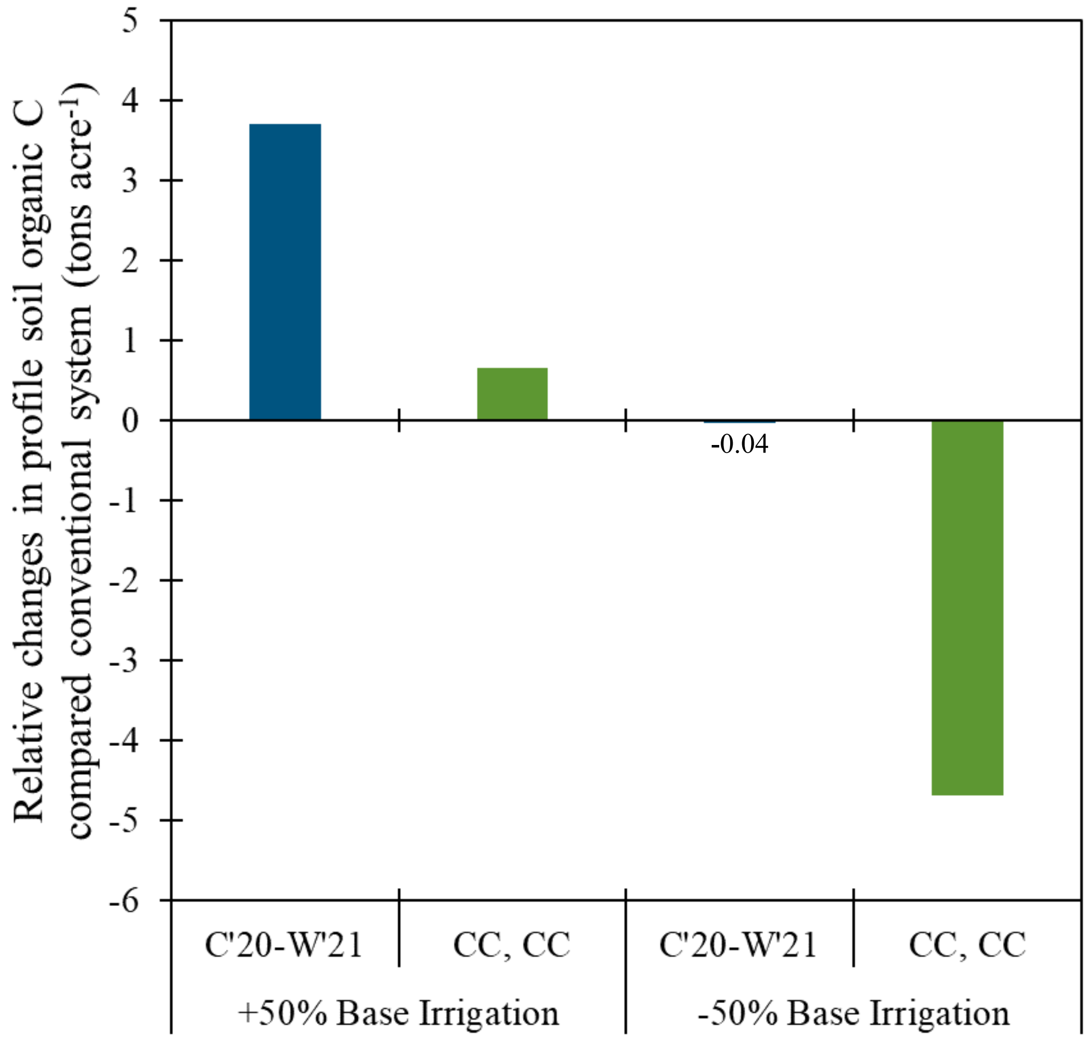
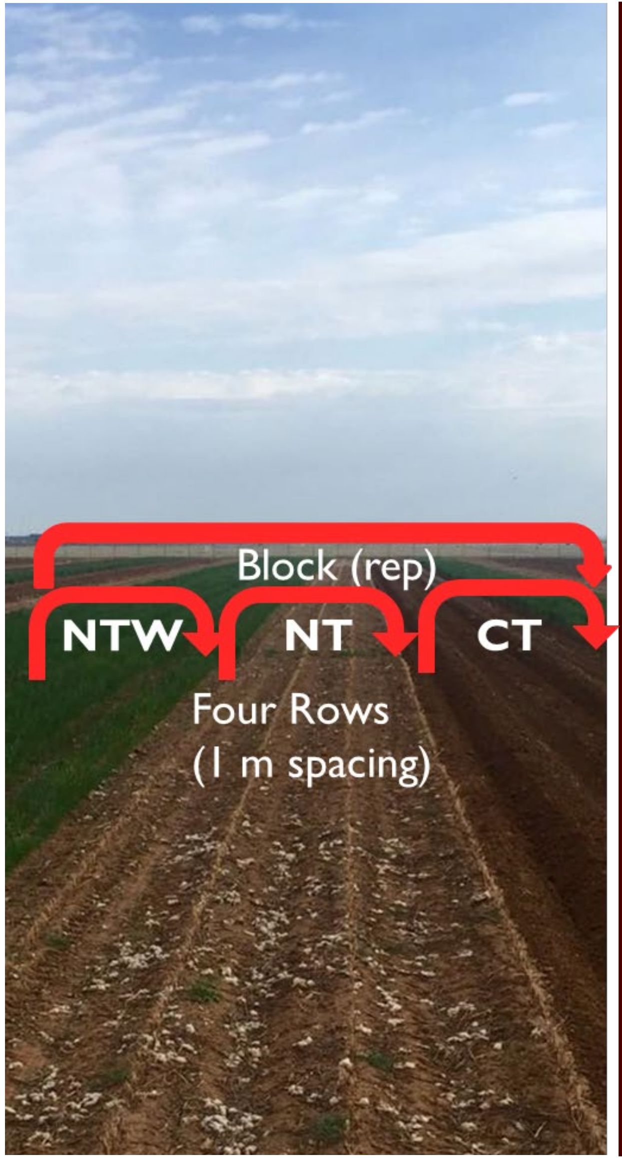
Soil Organic C (Helm Farm, est. 2013)

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



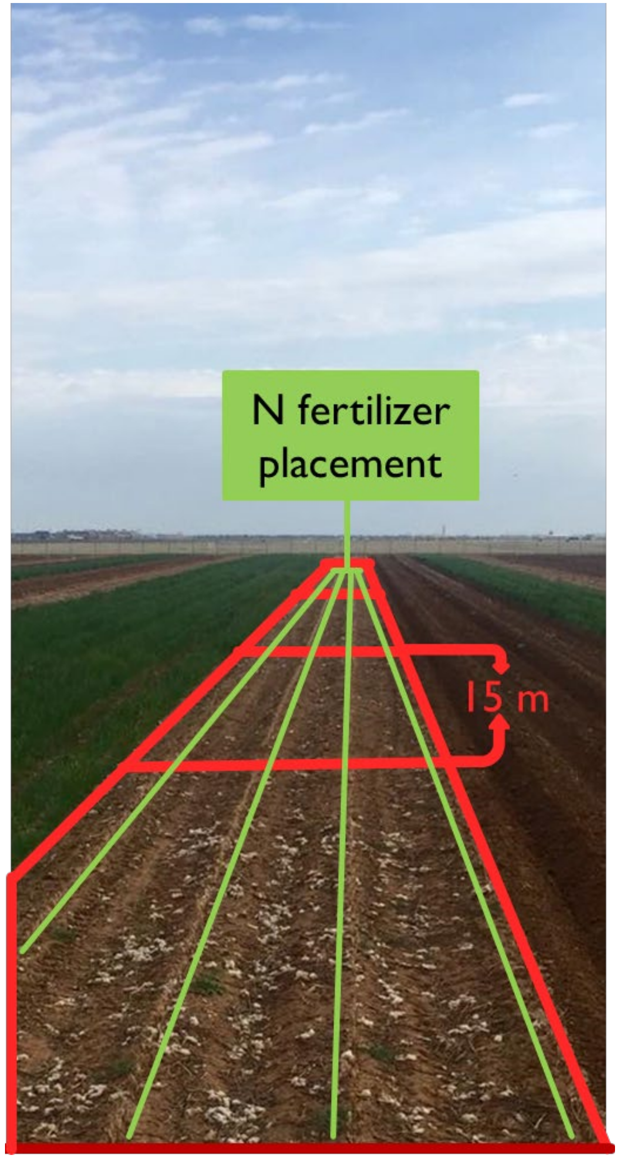




Research Center, Lubbock, TX

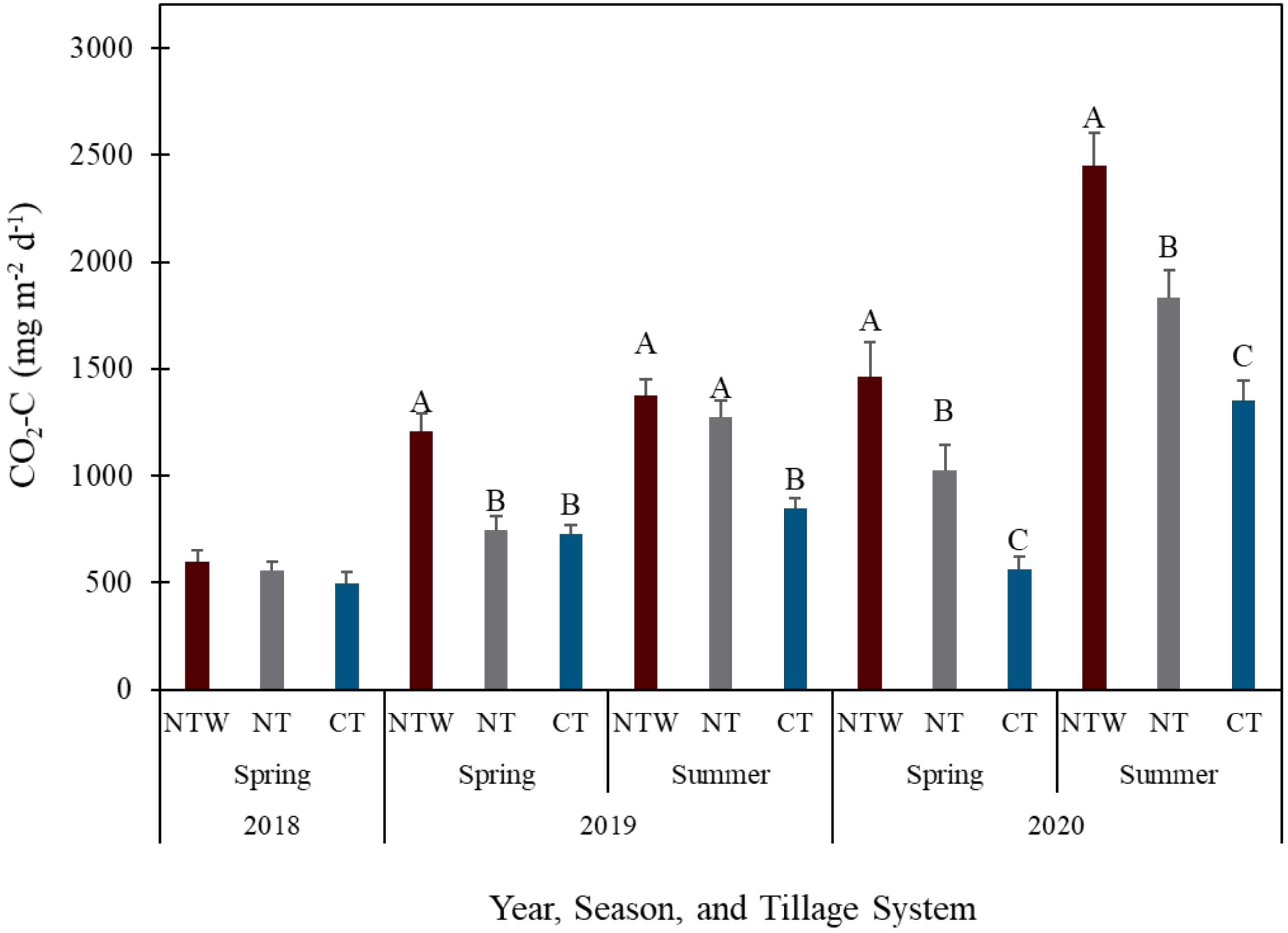
Est. 2015, Acuff loam

- Cover crops and no-tillage systems implemented in November of 2015
  - Site had been under conventional tillage for at least 60 years
- Study design – Split Plot (3 reps)
- Main plot: tillage systems
  - No-tillage with a winter wheat cover crop (NTW)
  - No-tillage winter fallow (NT)
  - Conventional tillage winter fallow (CT)
- Split Plot: nitrogen (N) treatments
  - 100% pre-plant (PP)
  - 40% pre-plant 60% side-dressed (SPLIT)
  - No-N control



Lubbock Research Center, Lubbock, TX

Est. 2015, Acuff loam



Conventional tillage CO_2-C emissions

- 0.87 tons C acre^{-1}

No-tillage with wheat cover net C flux

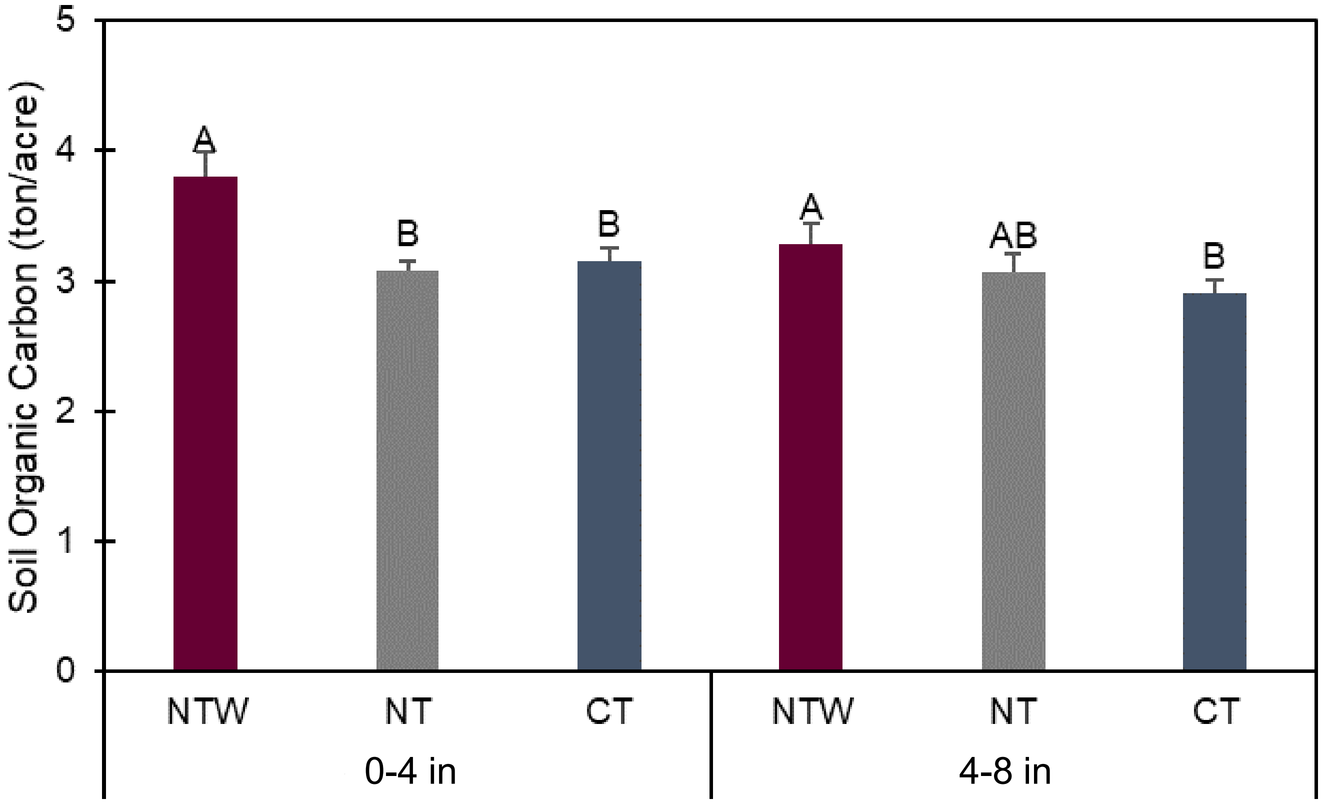
- 0.67 tons C acre^{-1}

Average decrease in CO_2-C emissions with the inclusion of wheat cover with no-tillage

- 22%
- 379 lb C acre^{-1}

Lubbock Research Center, Lubbock, TX

Est. 2015, Acuff loam

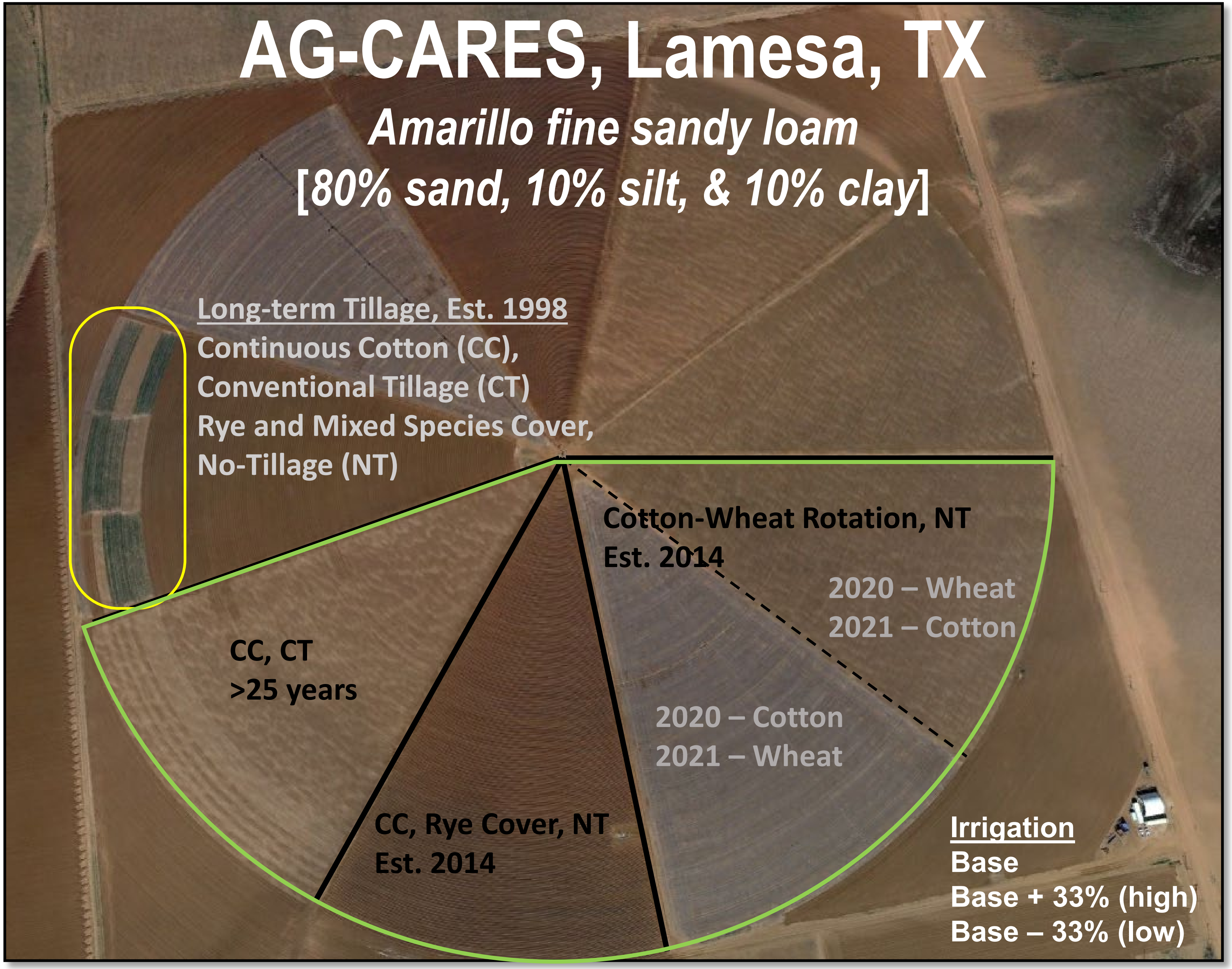


TEXAS A&M AGRILIFE RESEARCH

Texas A&M AgriLife Research

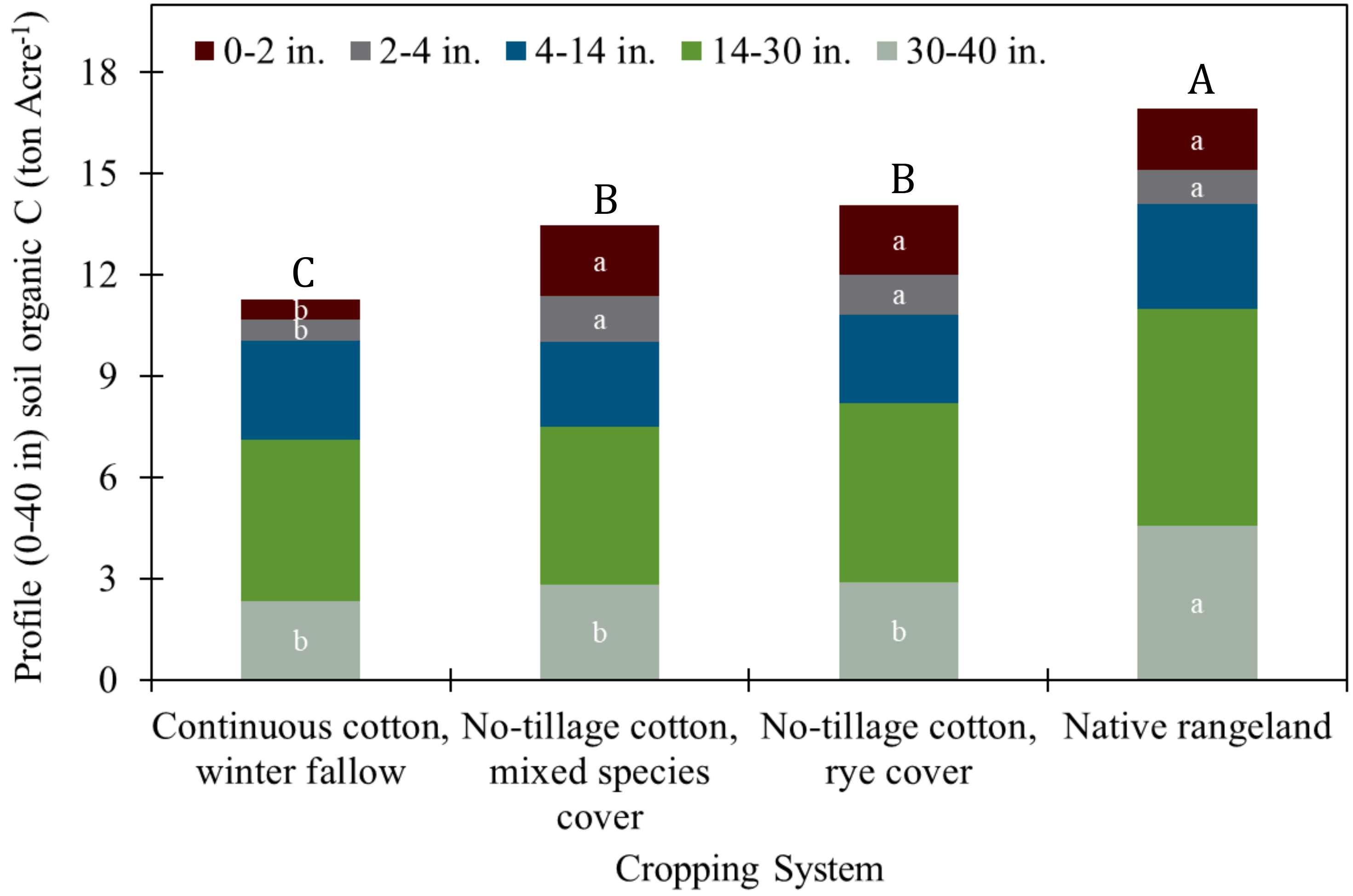
AG-CARES, Lamesa, TX

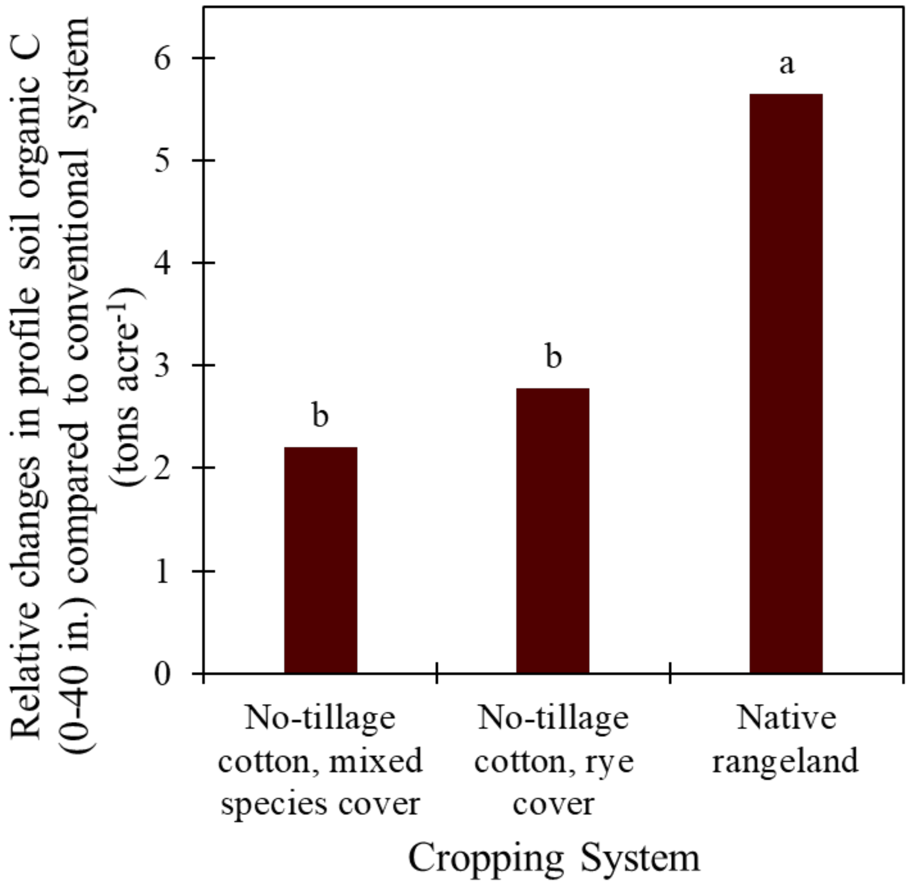
Amarillo fine sandy loam
[80% sand, 10% silt, & 10% clay]



Soil organic C (AG-CARES, est. 1998)

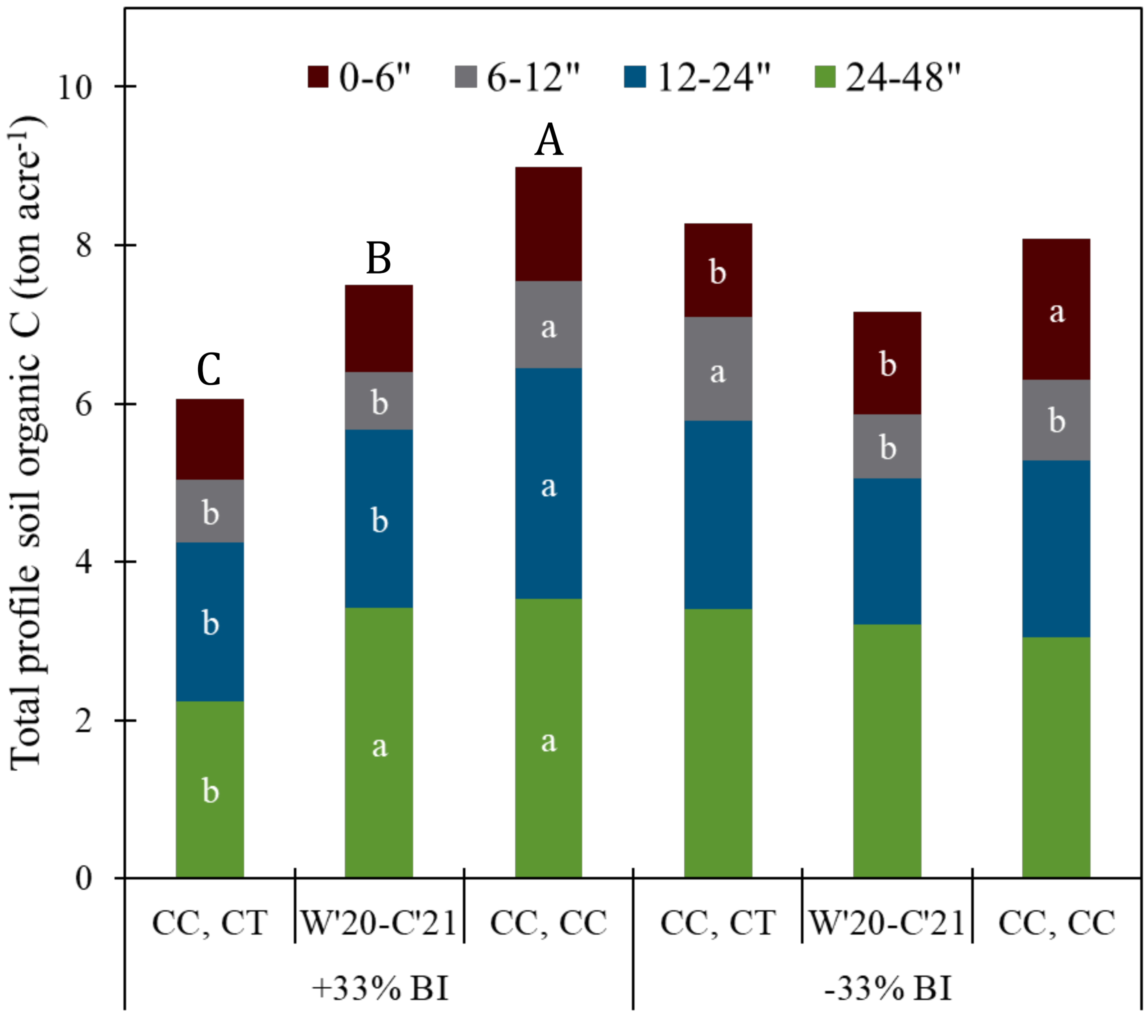
*Samples collected in year 20 of the study

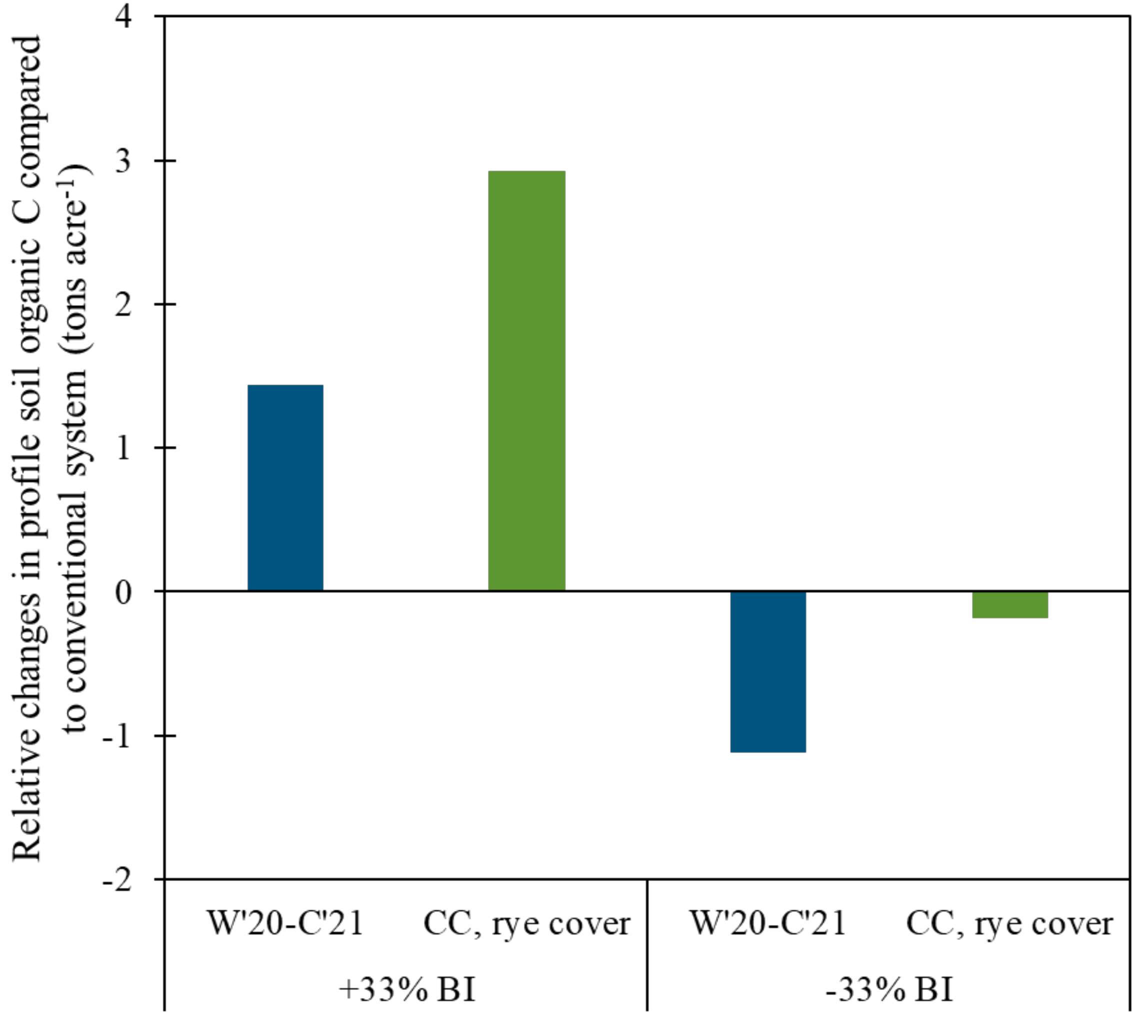




Soil organic C (AG-CARES, est. 2014)

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

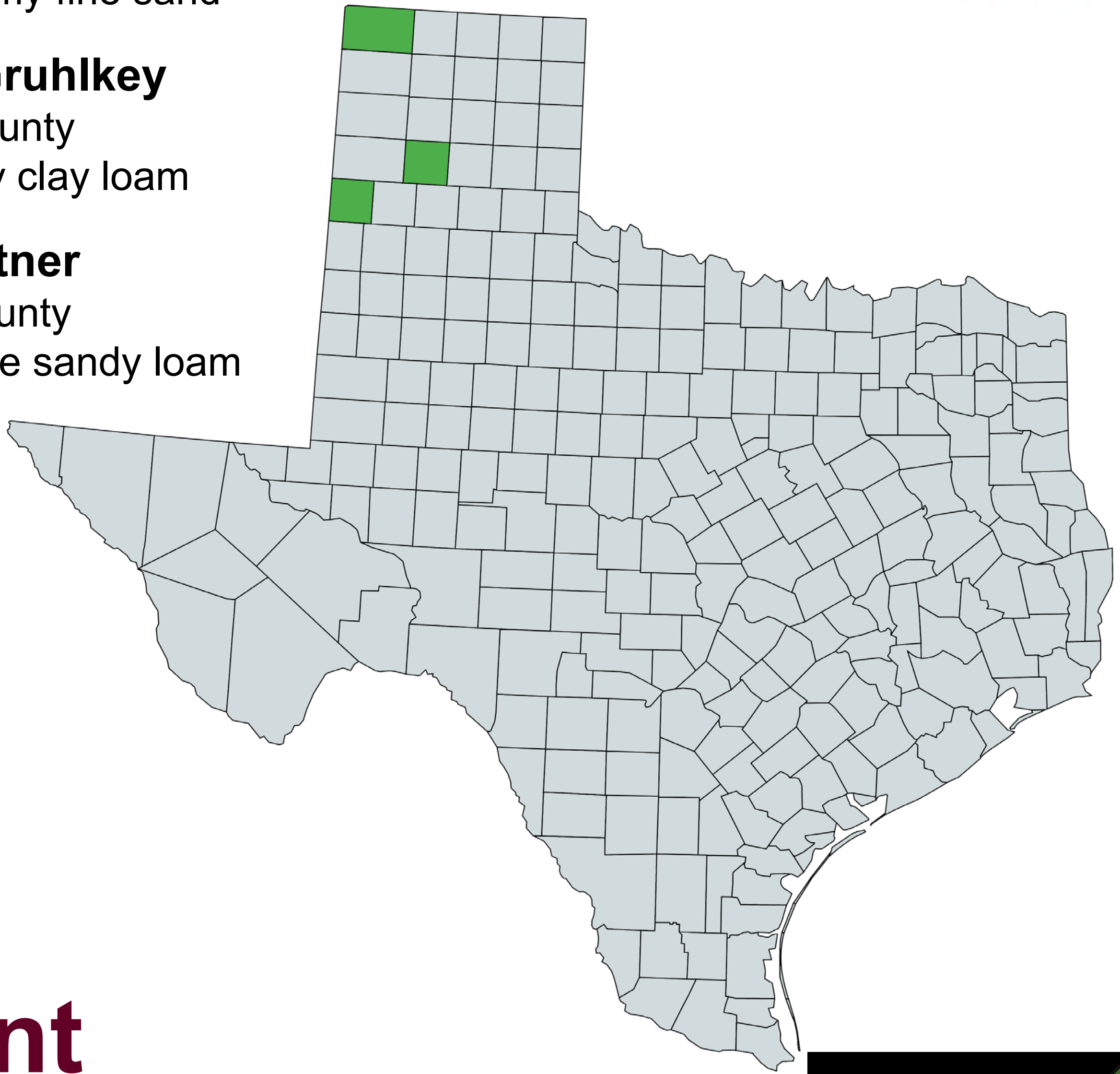




Steve and Zach Yoder
Dallam County
Dallam loamy fine sand

Braden Gruhlkey
Randall County
Pantex silty clay loam

Kelly Kettner
Parmer County
Amarillo fine sandy loam



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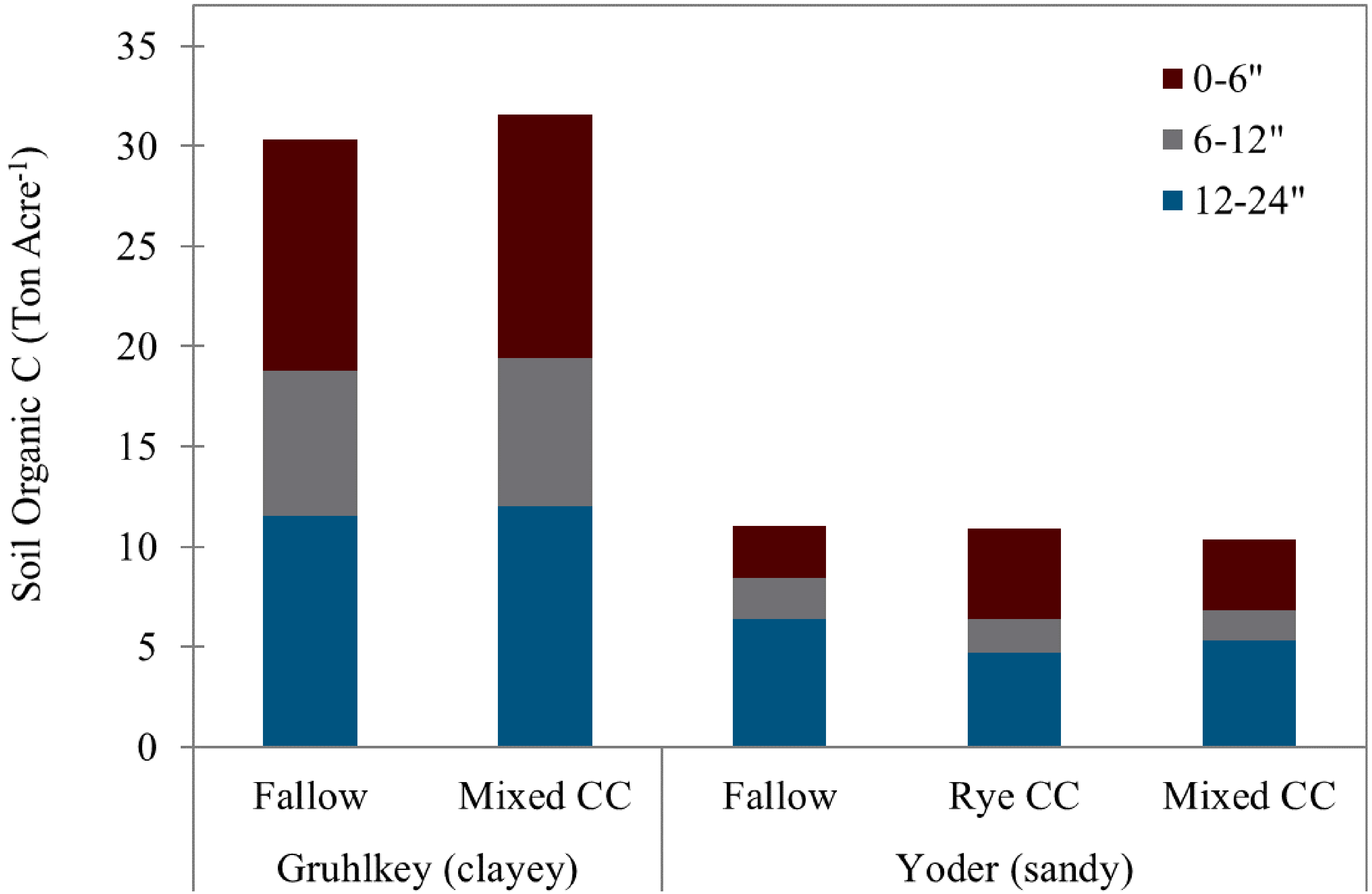
Conservation Management Corn Systems

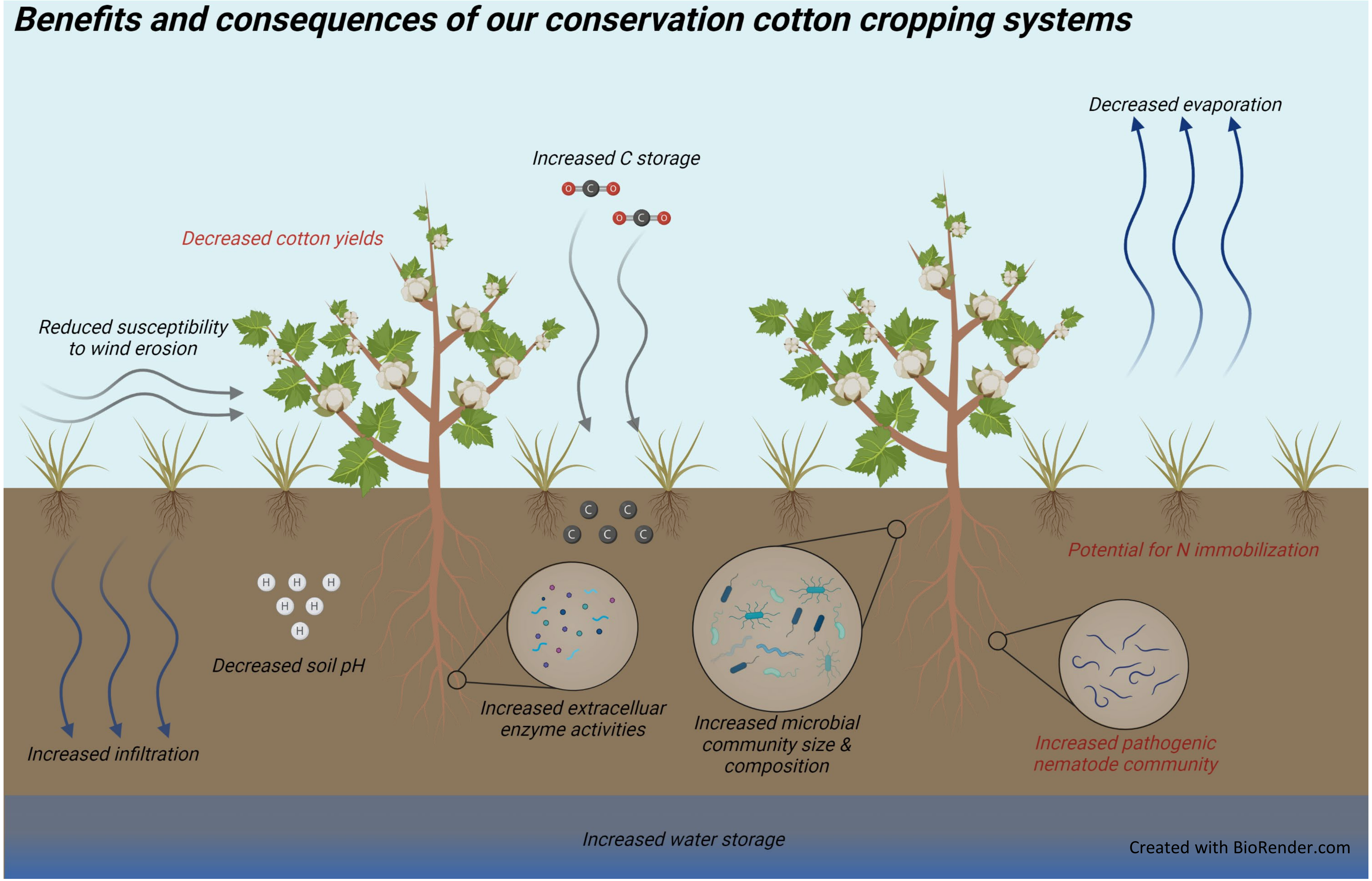
Texas Corn Producers

Soil Organic C (est. 2017)

Samples collected in April 2020



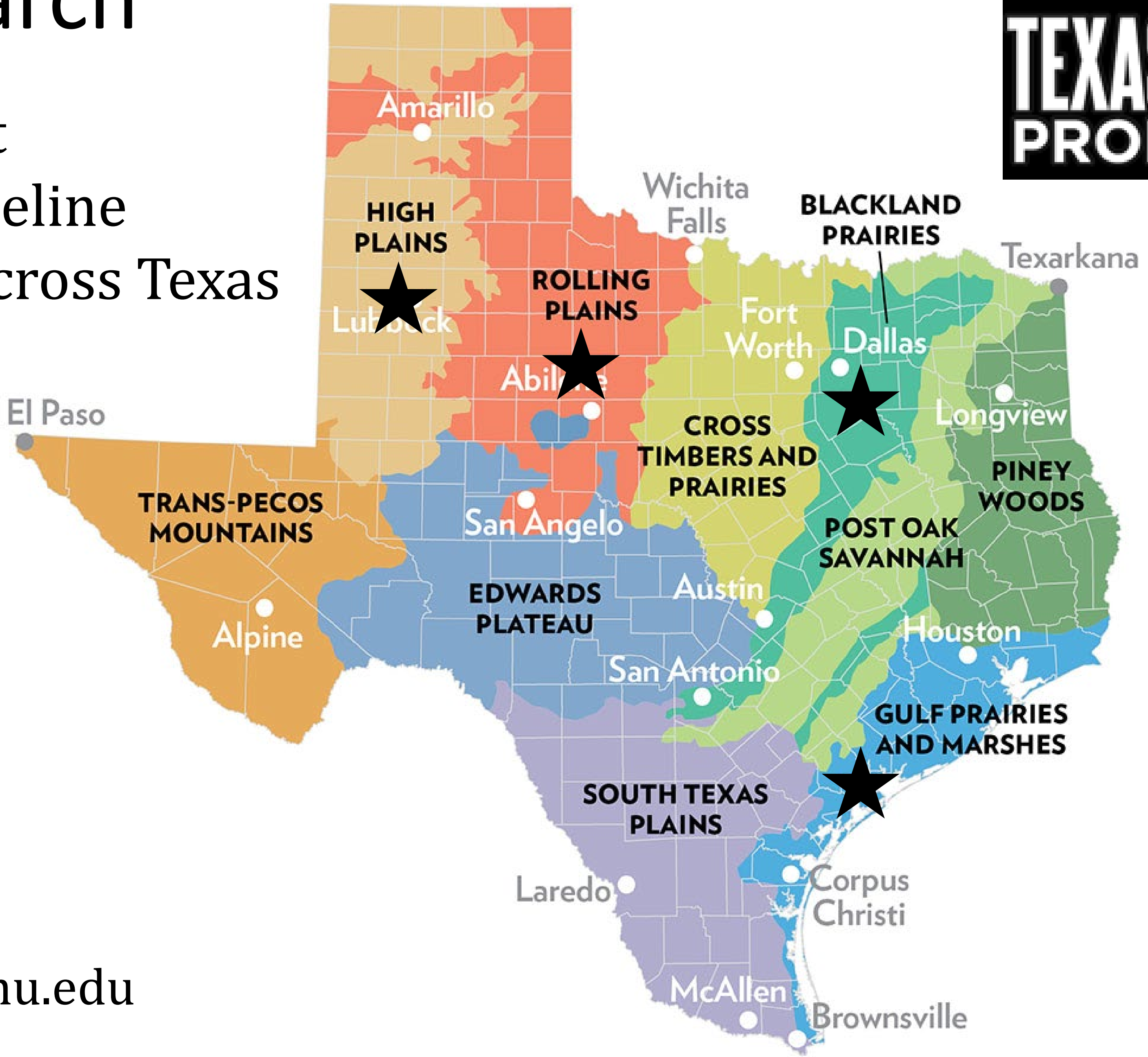
Summary



Benefits and consequences of our conservation cotton cropping systems
Decreased evaporation
Increased C storage
Decreased cotton yields
Reduced susceptibility to wind erosion
Potential for N immobilization
Decreased soil pH
Increased extracelluar enzyme activities
Increased microbial community size & composition
Increased pathogenic nematode community
Increased infiltration
Increased water storage
Created with BioRender.com

2022 Research

Project aimed at establishing baseline carbon values across Texas



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TEXAS CORN PRODUCERS

SORGHUM CHECKOFF

cotton

TEXAS A&M AGRILIFE RESEARCH

TEXAS A&M AGRILIFE EXTENSION

Sustainable Agricultural Intensification and Enhancement Through the Utilization of Regenerative Agricultural Management Practices

Texas Water Resources Institute — make every drop count | Texas A&M AgriLife Research | Texas A&M AgriLife Extension | ATM | OSU | TT | WT | Kansas State University

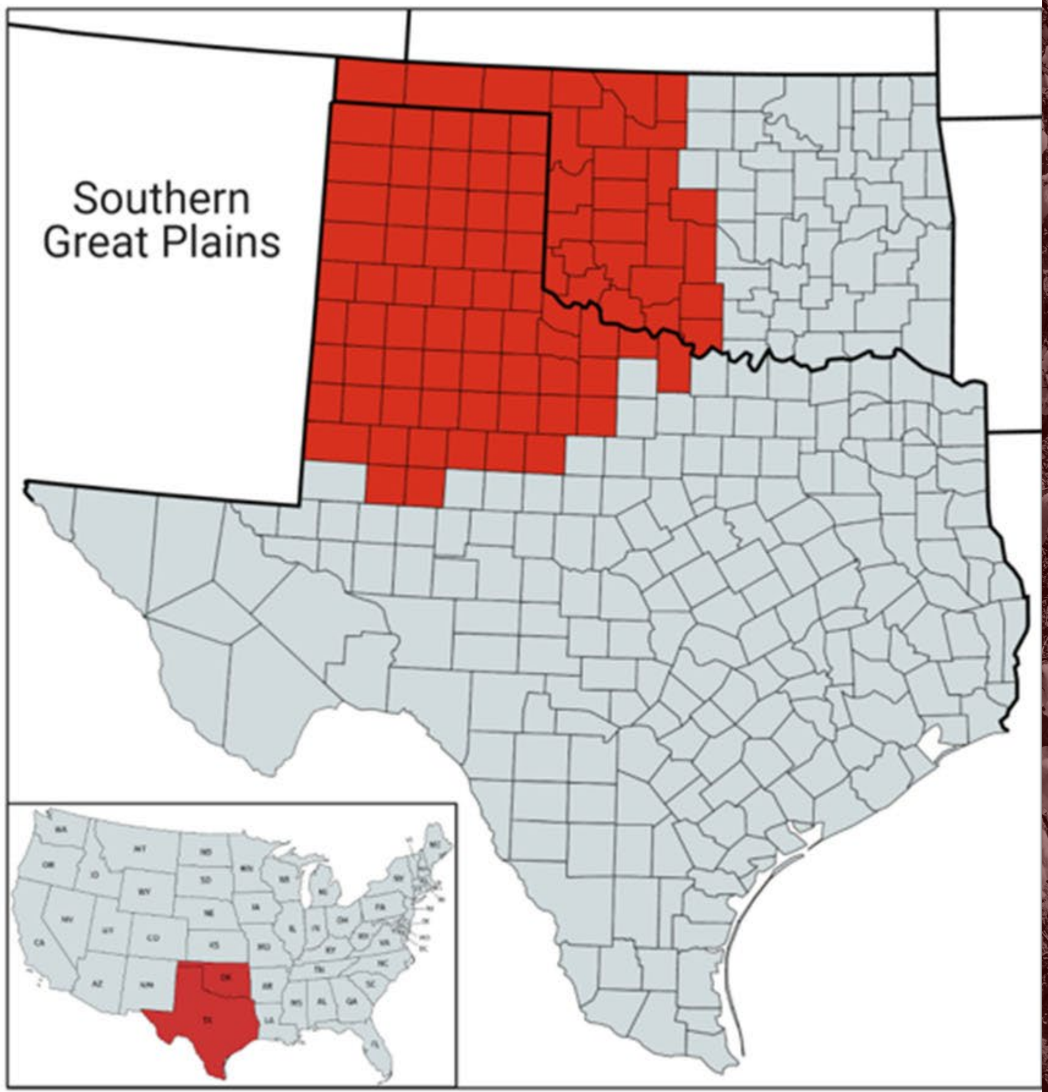
USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Regenerative Ag Systems

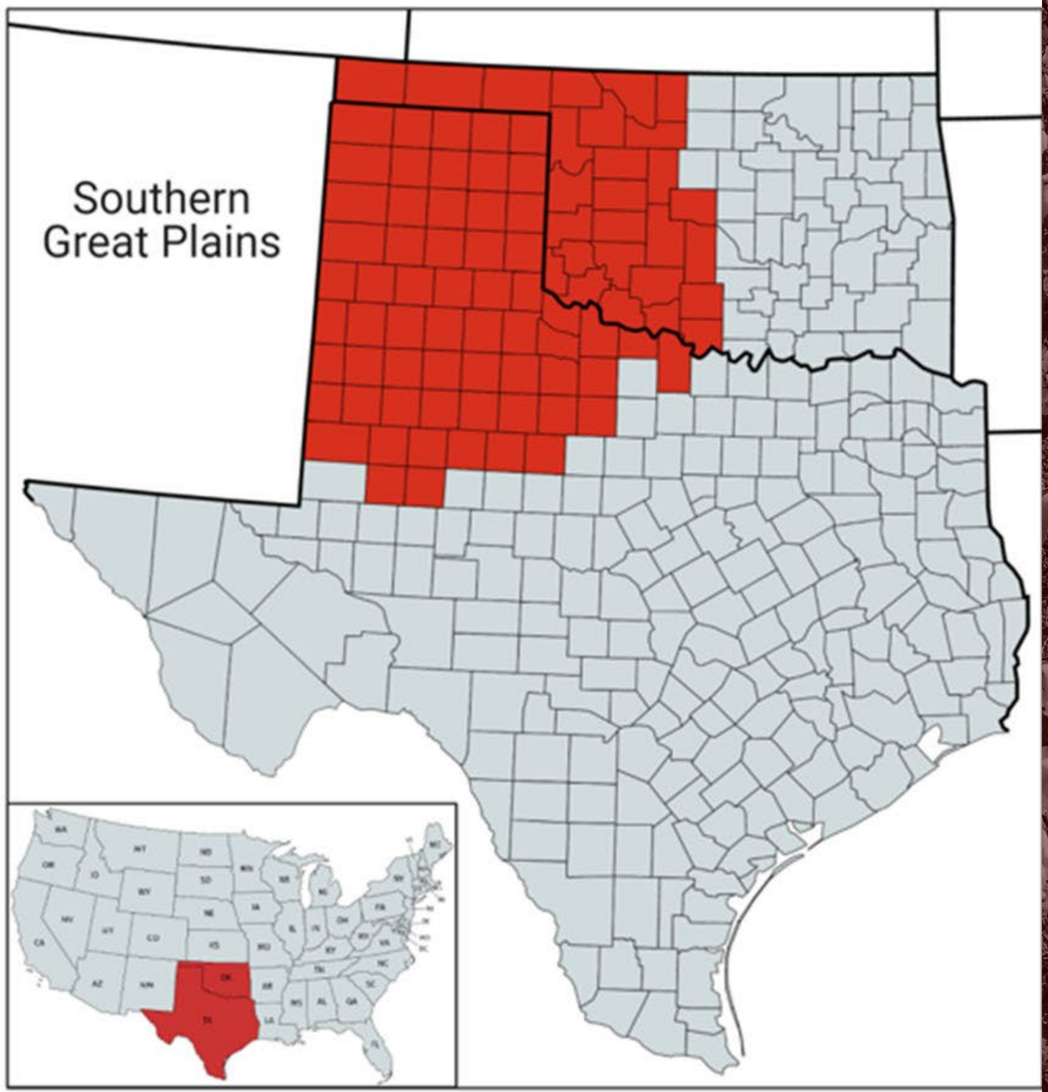
- Our project goal is to intensify agricultural production in an environmentally sustainable manner that enhances the agronomic, economic, and community resiliency in the Southern Great Plains.

- We will achieve this by successfully demonstrating the benefits of integration of *regenerative agricultural practices* and providing training on emerging technologies to increase C sequestration, reduce greenhouse gas (GHG) emissions, mitigate climate change impacts, diversify producer income, conserve scarce water, and enhance rural economies.



Regenerative Ag Systems

- Practices include reduced tillage, crop rotations, cover cropping, and grazing
- Practices aim to increase crop and livestock production resiliency and sustainability while reducing negative environmental impacts
- Regenerative agriculture in semi-arid environments can be defined as intensification of production systems through implementation of conservation practices (e.g. reduced tillage, cover crops, and livestock) to increase economic and environmental resiliency and sustainability



TEXAS A&M AGRILIFE RESEARCH

Regenerative Ag Systems

To address project goals, the key objectives are to:

1. identify adoption barriers of regenerative practices and pathways to overcome them;
2. increase understanding of field level processes, effects, and optimization of agricultural intensification using regenerative practices;
3. quantify the watershed/regional scale effects of regenerative practice adoption;
4. evaluate economics of regenerative practice adoption at farm and regional scales;
5. enhance adoption via dissemination of knowledge gained from Obj. 1-4.

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THANK YOU

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TEXAS TECH UNIVERSITY
Department *of* Plant & Soil Science™