Irrigated Crop Management Effects On Productivity, Soil Nitrogen, and Soil Carbon

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Background Information:

- Conversion of Grassland to Cropland
  - conventional tillage (CT) practices
  - loss of soil organic matter (SOM)
  - release of carbon dioxide (CO_2) to the air
- Global Warming – Greenhouse Gases
  - CO_2 increased from 280 ppm (pre-industrial) to 370 ppm in 2000
  - Nitrous Oxide (N_2O) – increased from 275 ppb to 317 ppb in 2000
  - Methane (CH_4) – increased from 700 ppm to 1800 ppm in 2000
- Reduced-Till (RT) and No-Till (NT) Farming Systems
  - reduce SOM decomposition and reduce CO_2 emissions

Background Information:

- **Fertilization for Optimum Grain Yield and Economic Returns**
  - also maximizes crop residue production
  - enhances potential for SOC sequestration.
- **Nitrogen Fertilization**
  - may enhance residue decomposition and SOC sequestration
  - may increase residual soil NO_3-N available for leaching
  - increases nitrous oxide (N_2O) emissions
- **Limited Information Is Available Under Irrigated Conditions**
  - For RT and NT systems
  - N and Tillage affects on SOC sequestration

Research Objectives:

- Document the influence of N and tillage management on irrigated:
  - Corn yields
  - Corn residue production
  - Soil organic C (SOC) sequestration
  - Total Soil N (TSN)
  - NO_3-N leaching potential
  - N_2O emissions

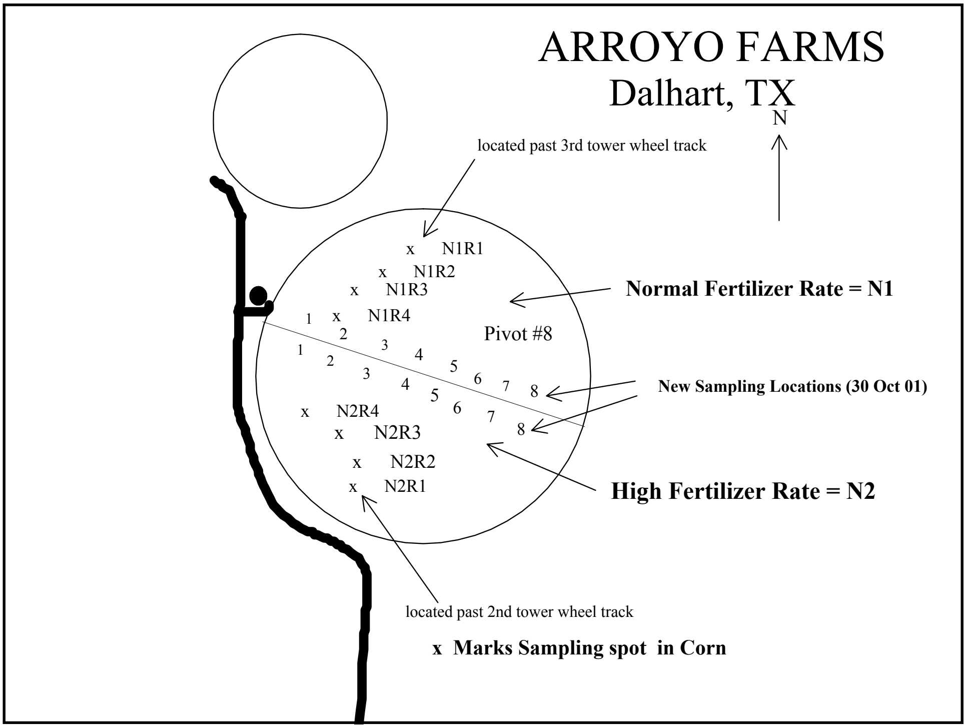
Research Sites and Environment:

- Locations and Soil Texture:
  - Dalhart, TX -- Dallam fine sandy loam soil
  - Texline, TX -- Conlen and Dumas clay loam soils
  - Fort Collins, CO – Fort Collins clay loam soil
- Cropping System: Continuous Corn
- Irrigation: Center Pivot (Texas) or Linear Move (Colorado)
- Tillage Systems
  - Texas sites used RT (disk/ripper implement)
  - Colorado site used NT system and CT system (disk, moldboard plow, mulcher, land leveler, etc.)
- N Treatments – Texas Sites
  - N1 (N fertilizer for >250 bu/a corn yield)
  - N2 (N1 rate plus additional liquid N applied to residue)
- N Treatments – Fort Collins Site
  - CT – four N rates from 0 to 180 lb N/a
  - NT – six N rates from 0 to 180 lb N/a

Texas Sites

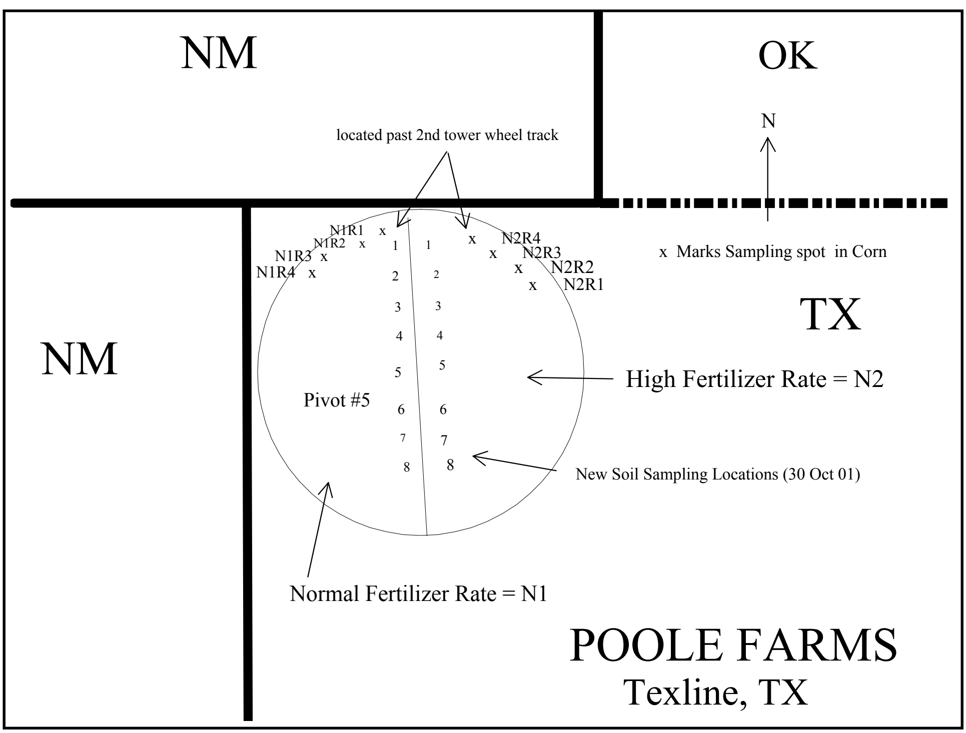

DMI Eco-Tiller used at
Dalhart, Nov. 1999


DMI Eco-Tiller Shank, tillage
about 12 to 15 inches deep


ARROYO FARMS
Dalhart, TX
N
located past 3rd tower wheel track
x N1R1
x N1R2
x N1R3
x N1R4
Normal Fertilizer Rate = N1
Pivot #8
1 2 3 4 5 6 7 8
1 2 3 4 5 6 7 8
New Sampling Locations (30 Oct 01)
x N2R4
x N2R3
x N2R2
x N2R1
High Fertilizer Rate = N2
located past 2nd tower wheel track
x Marks Sampling spot in Corn


Dalhart, Oct. 2001


Dalhart, Sept. 2002

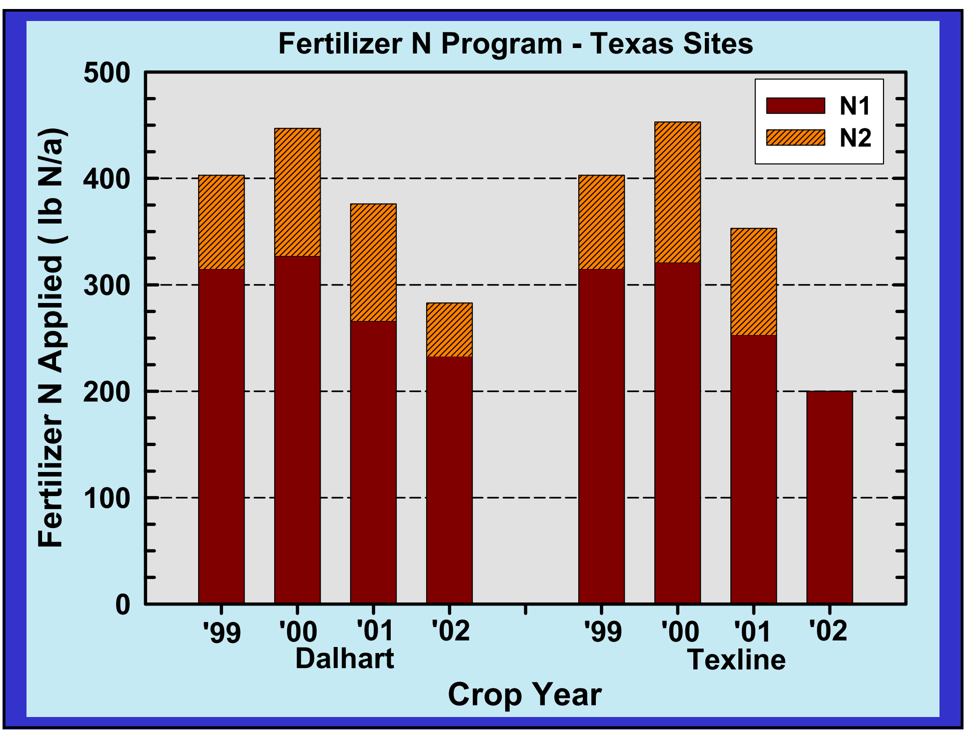

NM
OK
N
located past 2nd tower wheel track
N1R1
N1R2
N1R3
N1R4
N2R4
N2R3
N2R2
N2R1
x Marks Sampling spot in Corn
TX
NM
Pivot #5
High Fertilizer Rate = N2
New Soil Sampling Locations (30 Oct 01)
Normal Fertilizer Rate = N1
POOLE FARMS
Texline, TX

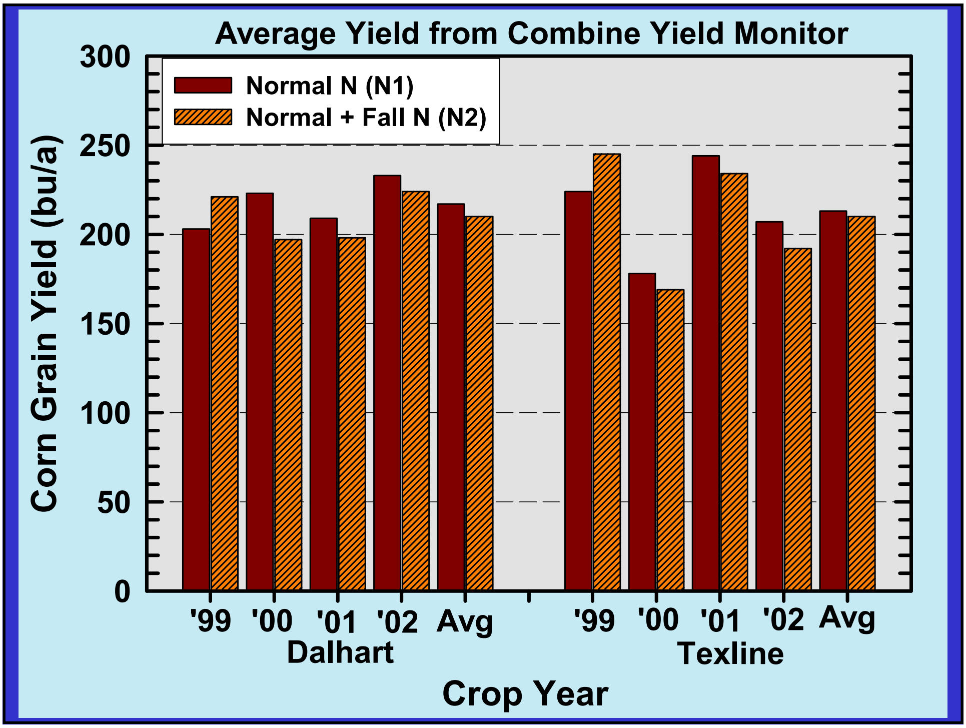

Texline, Nov. 2002, corn residue

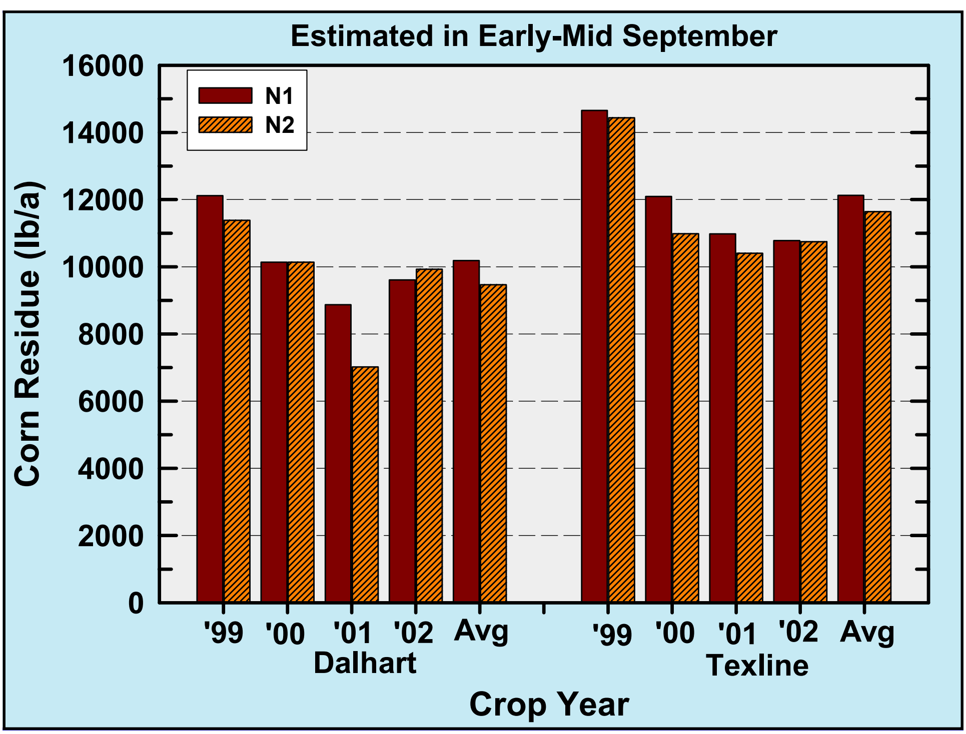

Texline, May 2000

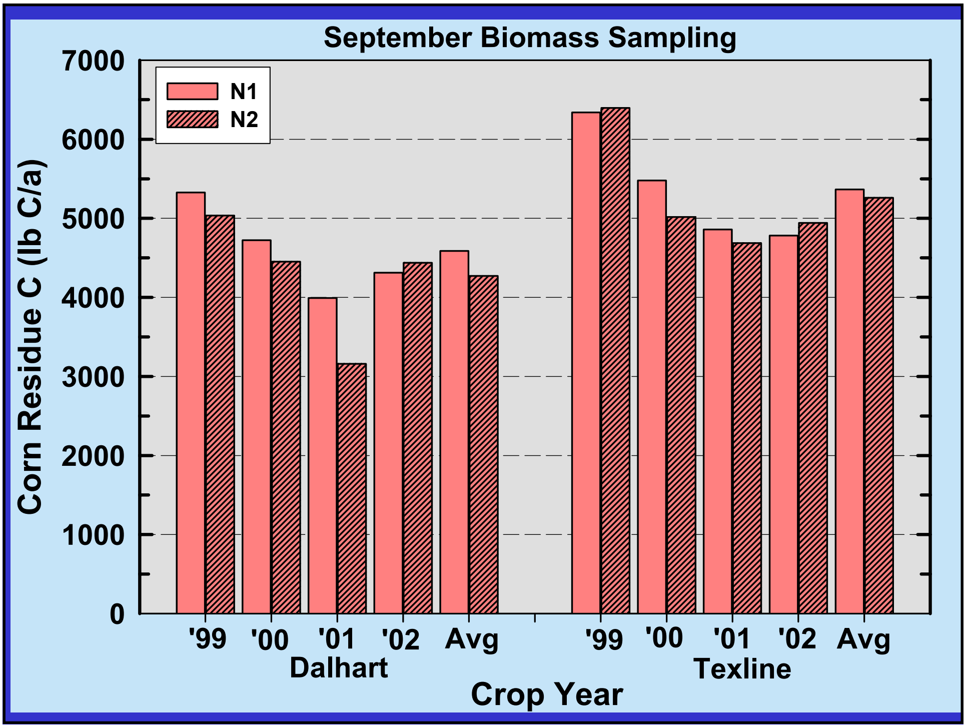
Texas Nitrogen Treatments

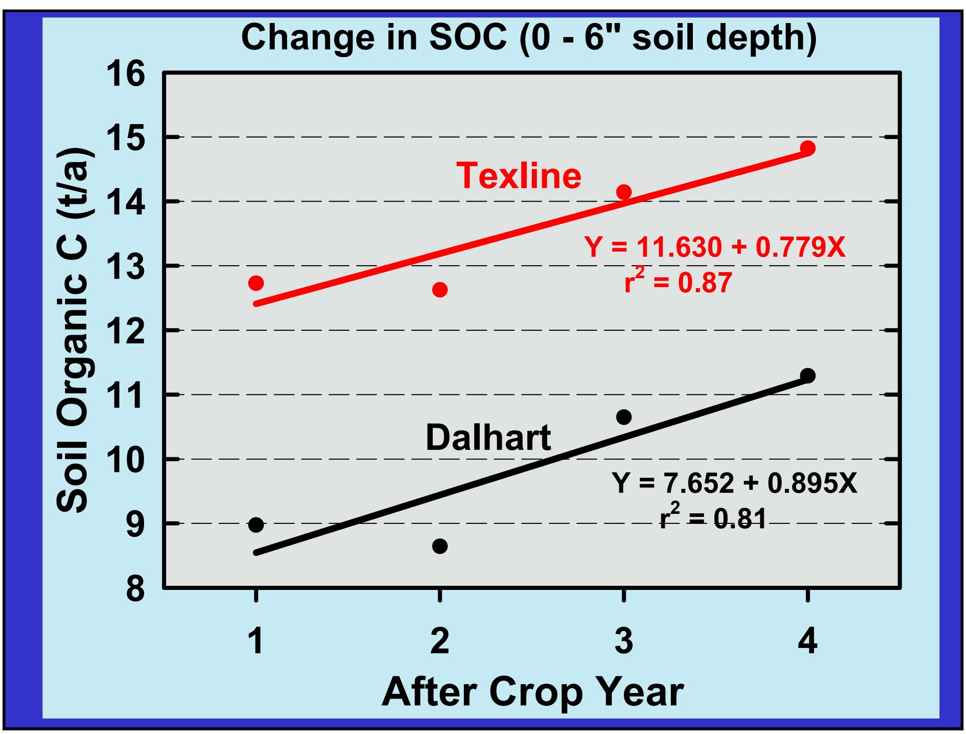
- N1 = normal N rate applied to achieve >250 bu/a corn yields. Desired yield goal is 300+ bu/a corn.
- N2 = normal N rate plus liquid N fertilizer applied to corn residues after harvest to aid residue decomposition.
- N Rates varied with year and location.
- Other nutrients were also applied.

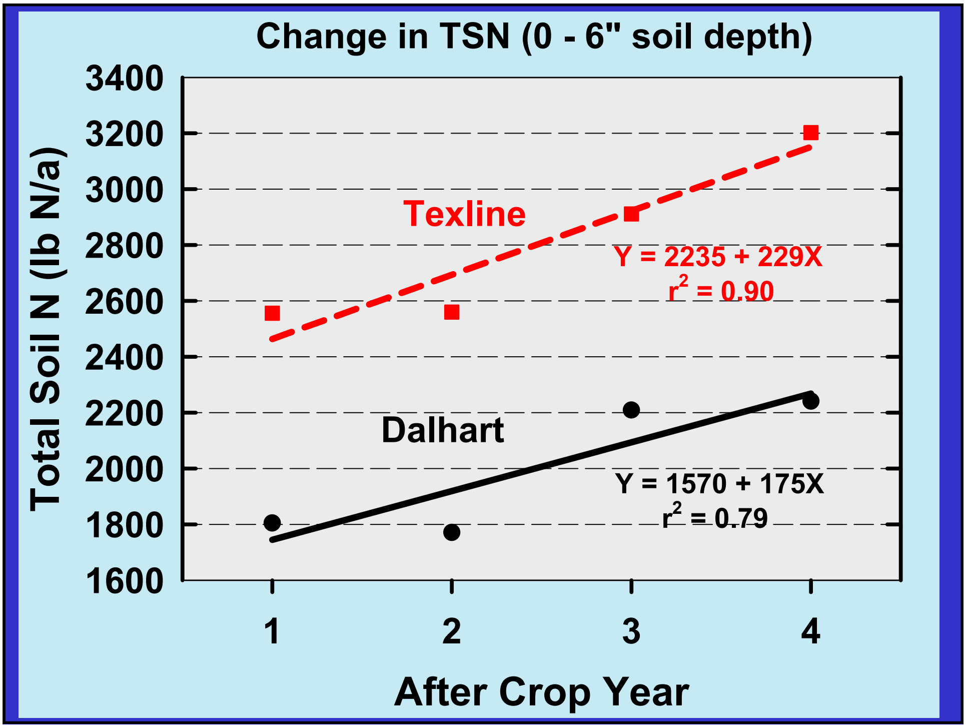



Average Yield from Combine Yield Monitor
Normal N (N1)
Normal + Fall N (N2)
Corn Grain Yield (bu/a)
300
250
200
150
100
50
0
'99
'00
'01
'02
Avg
Dalhart
'99
'00
'01
'02
Avg
Texline
Crop Year

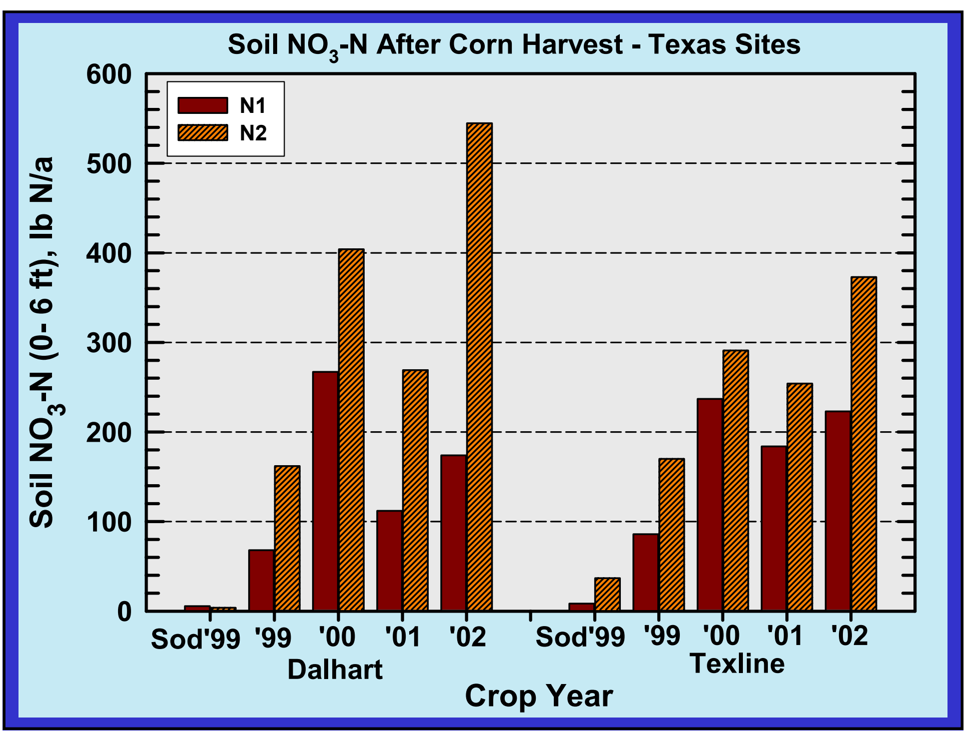

Estimated in Early-Mid September
N1
N2
Corn Residue (lb/a)
16000
14000
12000
10000
8000
6000
4000
2000
0
'99
'00
'01
'02
Avg
Dalhart
'99
'00
'01
'02
Avg
Texline
Crop Year


September Biomass Sampling
Corn Residue C (lb C/a)
7000
6000
5000
4000
3000
2000
1000
0
N1
N2
'99
'00
'01
'02
Avg
Dalhart
'99
'00
'01
'02
Avg
Texline
Crop Year


Change in SOC (0 - 6" soil depth)
Soil Organic C (t/a)
16
15
14
13
12
11
10
9
8
Texline
Y = 11.630 + 0.779X
r2 = 0.87
Dalhart
Y = 7.652 + 0.895X
r2 = 0.81
1
2
3
4
After Crop Year

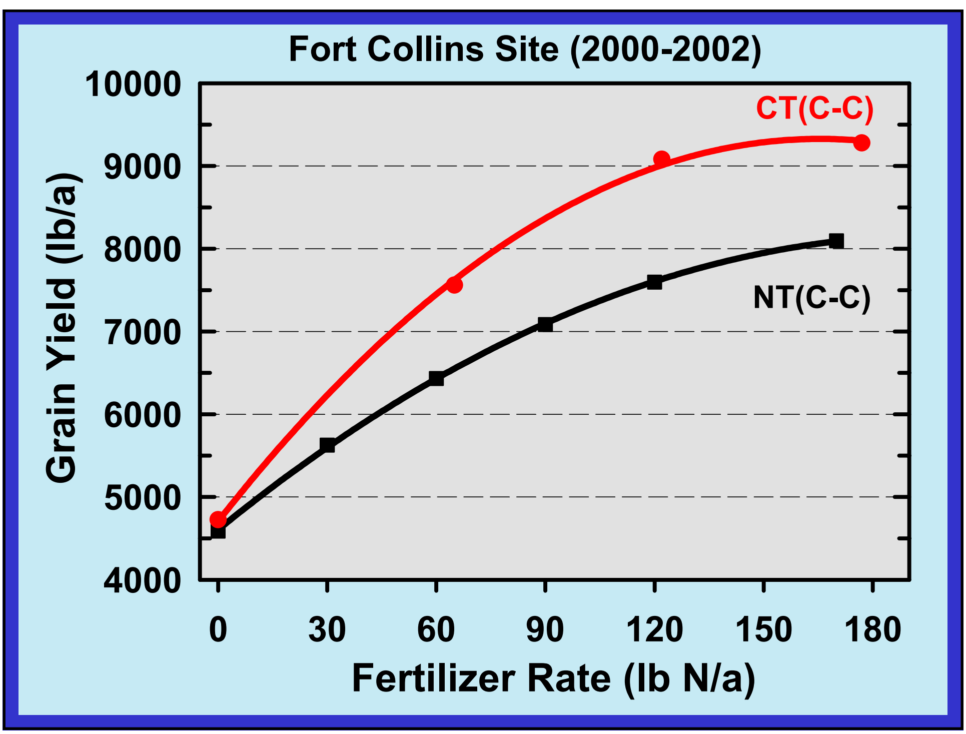


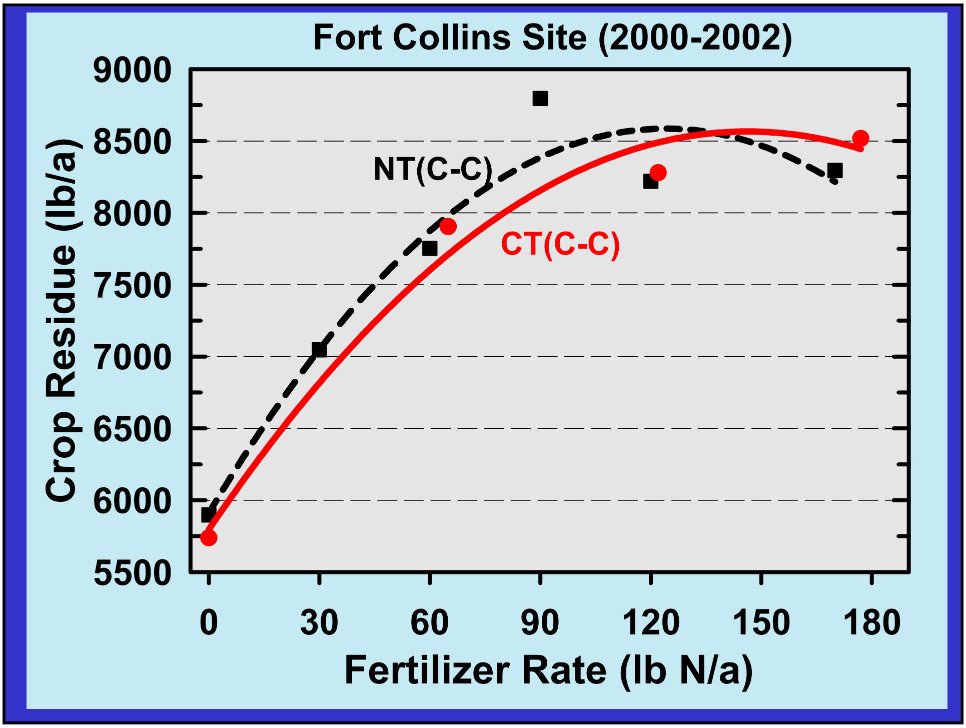
Change in TSN (0 - 6" soil depth)
Total Soil N (lb N/a)
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
Texline
Y = 2235 + 229X
r2 = 0.90
Dalhart
Y = 1570 + 175X
r2 = 0.79
1
2
3
4
After Crop Year

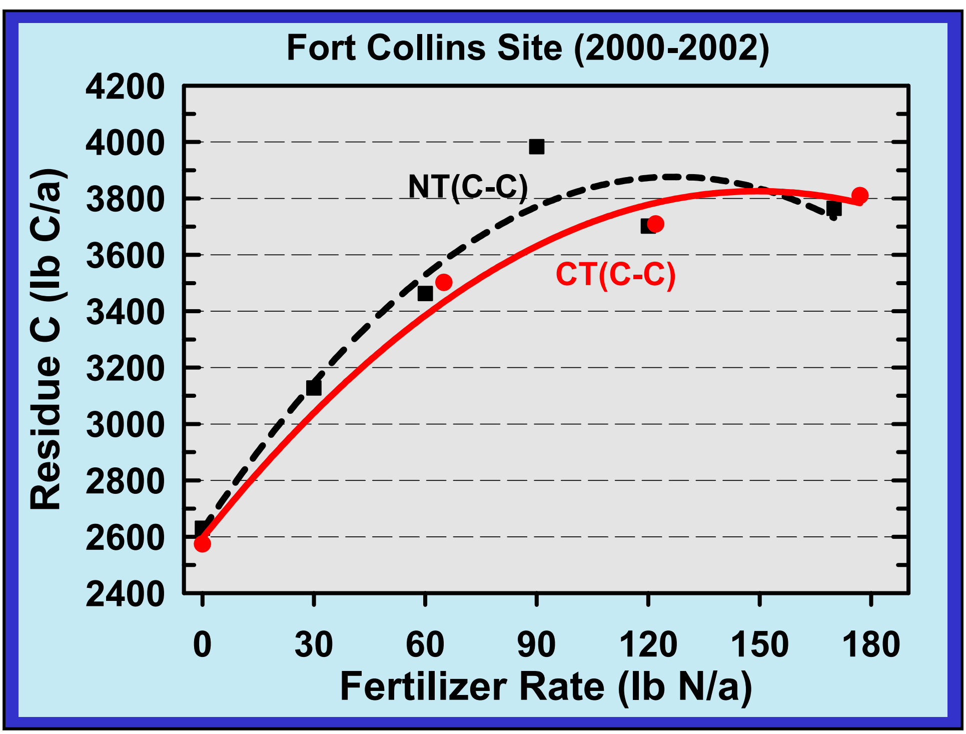


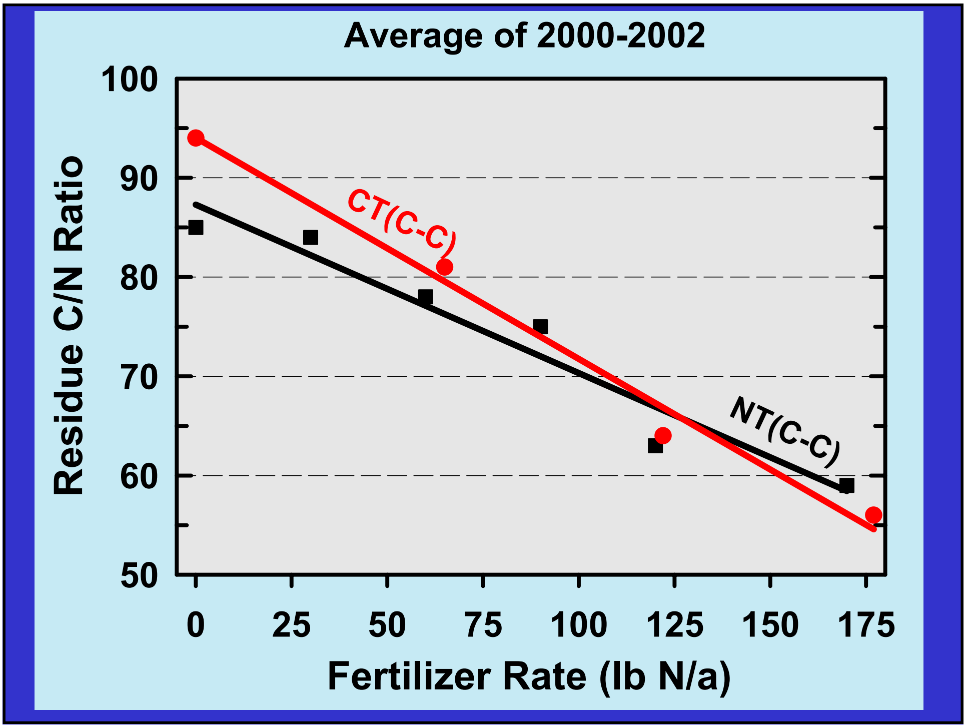
Soil NO3-N After Corn Harvest - Texas Sites
N1
N2
Soil NO3-N (0- 6 ft), lb N/a
600
500
400
300
200
100
0
Sod'99
'99
'00
'01
'02
Dalhart
Sod'99
'99
'00
'01
'02
Texline
Crop Year

Colorado Site

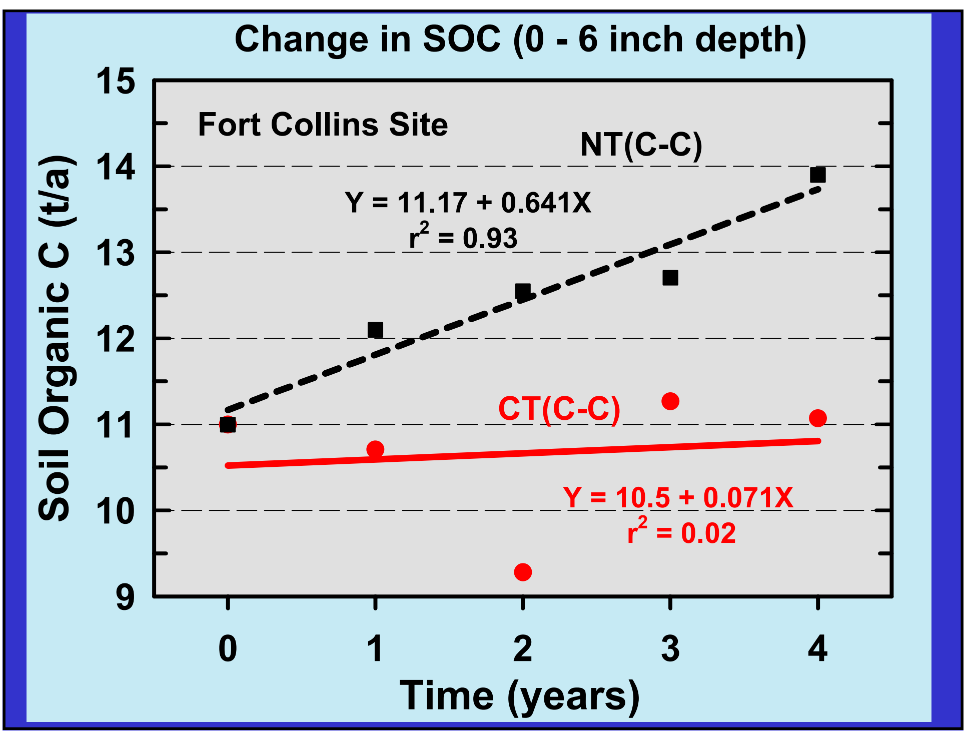

Fort Collins Site (2000-2002)
CT(C-C)
NT(C-C)
Grain Yield (lb/a)
10000
9000
8000
7000
6000
5000
4000
0
30
60
90
120
150
180
Fertilizer Rate (lb N/a)


Fort Collins Site (2000-2002)
Crop Residue (lb/a)
9000
8500
8000
7500
7000
6500
6000
5500
NT(C-C)
CT(C-C)
0
30
60
90
120
150
180
Fertilizer Rate (lb N/a)

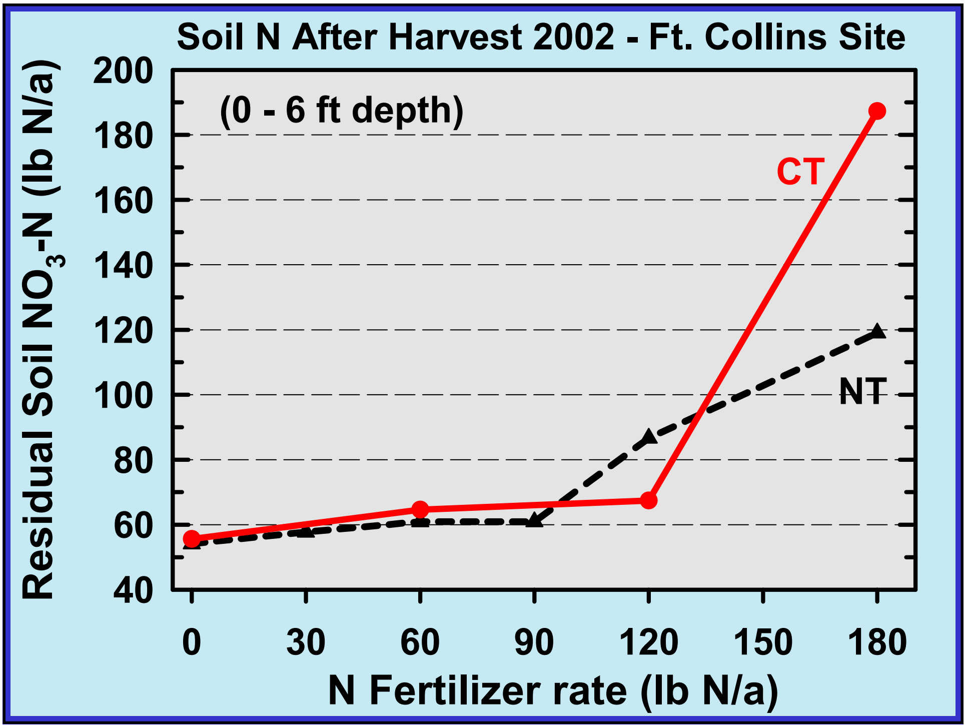

Fort Collins Site (2000-2002)
Residue C (lb C/a)
4200
4000
3800
3600
3400
3200
3000
2800
2600
2400
NT(C-C)
CT(C-C)
0
30
60
90
120
150
180
Fertilizer Rate (lb N/a)



Average of 2000-2002
Residue C/N Ratio
100
90
80
70
60
50
0
25
50
75
100
125
150
175
Fertilizer Rate (lb N/a)
CT(C-C)
NT(C-C)

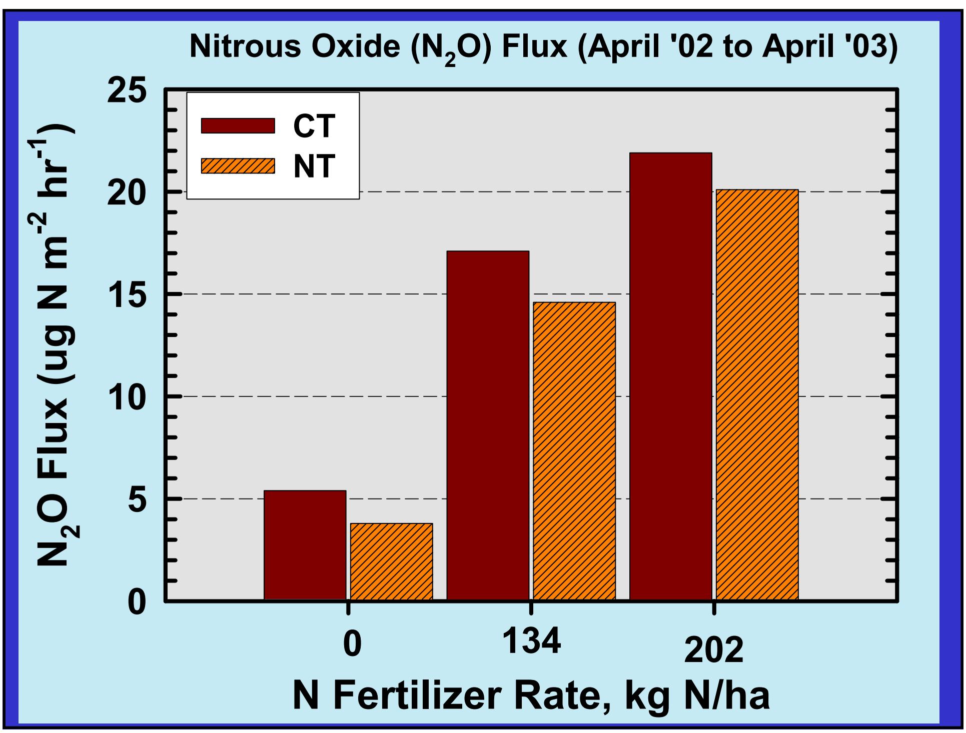


Change in SOC (0 - 6 inch depth)
Fort Collins Site
NT(C-C)
Y = 11.17 + 0.641X
r2 = 0.93
CT(C-C)
Y = 10.5 + 0.071X
r2 = 0.02
Soil Organic C (t/a)
15
14
13
12
11
10
9
0
1
2
3
4
Time (years)

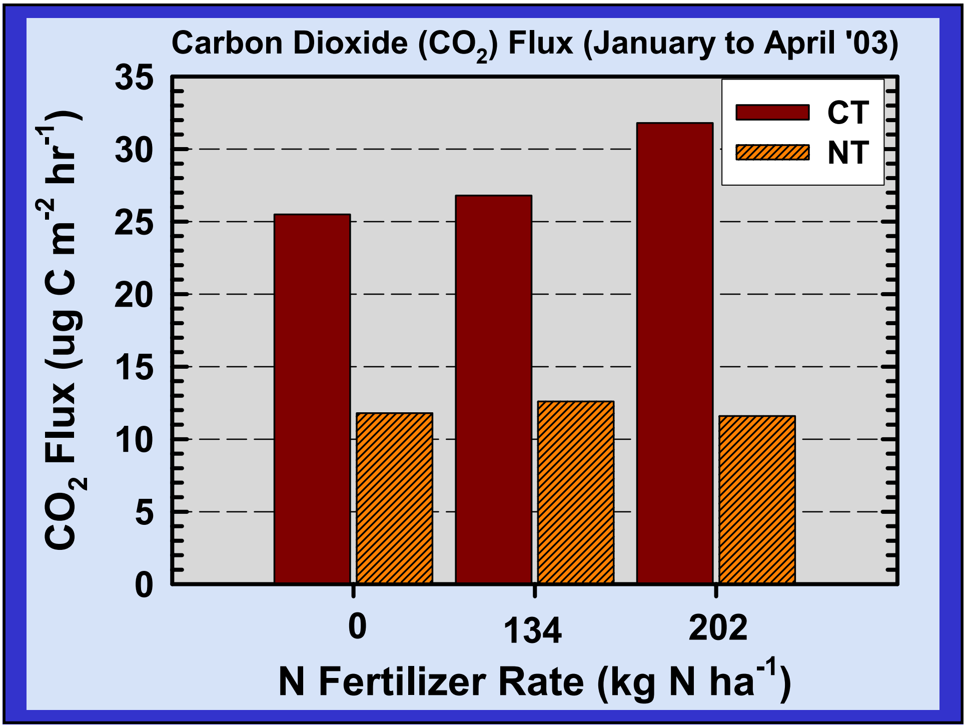


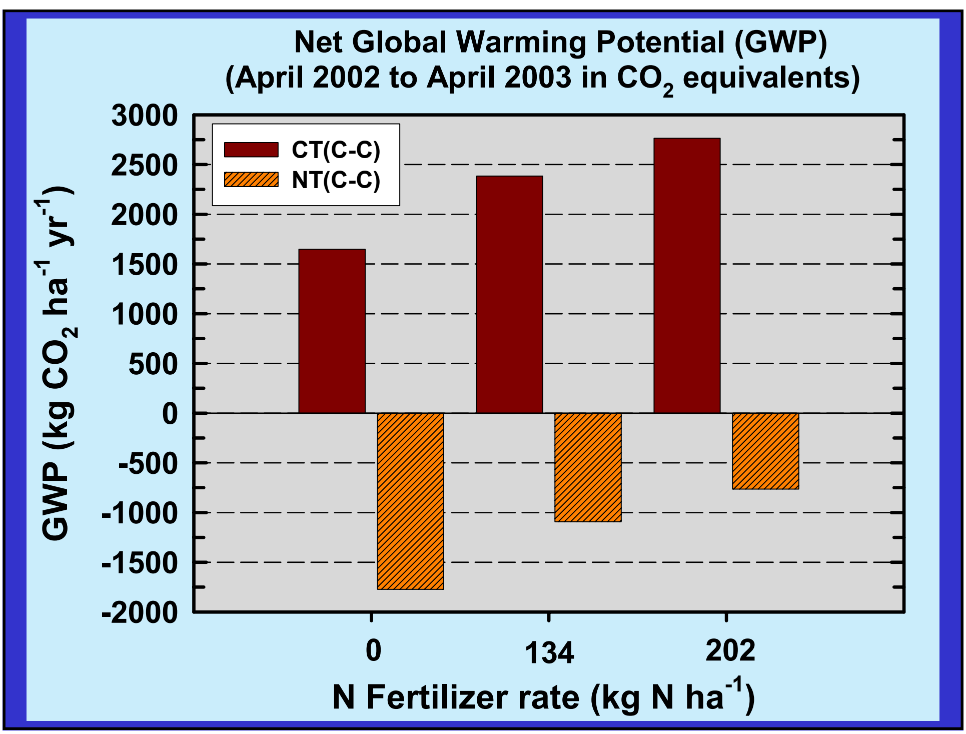
Greenhouse Gas Emissions and Global Warming Potential

Fort Collins, CO Site



Nitrous Oxide (N_2O) Flux (April '02 to April '03)
CT
NT
N_2O Flux (ug N m^{-2} hr^{-1})
0
5
10
15
20
25
0
134
202
N Fertilizer Rate, kg N/ha


Carbon Dioxide (CO_2) Flux (January to April '03)
CT
NT
CO_2 Flux (ug C m^{-2} hr^{-1})
35
30
25
20
15
10
5
0
0
134
202
N Fertilizer Rate (kg N ha^{-1})


Net Global Warming Potential (GWP)
(April 2002 to April 2003 in CO_2 equivalents)
CT(C-C)
NT(C-C)
GWP (kg CO_2 ha^{-1} yr^{-1})
3000
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
0
134
202
N Fertilizer rate (kg N ha^{-1})

Summary of Findings - Texas

- Applying liquid N to corn residue after harvest has not enhanced SOC sequestration after 4 corn crops, but did increase residual soil N levels.
- N1 fertilizer rate exceeded N needs for yield potential, therefore, excess N available for leaching.
- SOC – increased with each additional crop year in these RT irrigated systems.
- SOC in cropped area exceeds that in native sod.
- Changes in TSN follow same trends as SOC.

Summary of Findings - Colorado

- N fertilization is essential to optimize grain yield potential.
- Residue C returned to soil increased with increasing N rate in CT and NT systems.
- SOC increased each year in NT system but not in CT system.
- N rate has not influenced SOC sequestration significantly after only 4 corn crops.
- N_2O emissions increased with increasing N rate.
- GWP was decreased by converting from CT to NT, but increased with increasing N rate.

THANKS!!!

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FOR SUPPORTING
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