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 (CO₂) to the air
• Global Warming – Greenhouse Gases
  – CO₂ increased from 280 ppm (pre-industrial) to 370 ppm in 2000
  – Nitrous Oxide (N₂O) – increased from 275 ppb to 317 ppb in 2000
  – Methane (CH₄) – increased from 700 ppm to 1800 ppm in 2000
• Reduced-Till (RT) and No-Till (NT) Farming Systems
  – reduce SOM decomposition and reduce CO₂ 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$_2$O) 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$_2$O 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
DMI Eco-Tiller used at Dalhart, Nov. 1999

DMI Eco-Tiller Shank, tillage about 12 to 15 inches deep
ARROYO FARMS
Dalhart, TX

Normal Fertilizer Rate = N1
High Fertilizer Rate = N2

Pivot #8

New Sampling Locations (30 Oct 01)

x Marks Sampling spot in Corn

located past 3rd tower wheel track
located past 2nd tower wheel track

Dalhart, Oct. 2001
Dalhart, Sept. 2002

POOLE FARMS

Normal Fertilizer Rate = N1

High Fertilizer Rate = N2

Pivot #5

x Marks Sampling spot in Corn

located past 2nd tower wheel track

New Soil Sampling Locations (30 Oct 01)

POOLE FARMS
Texline, TX
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.

<table>
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<tr>
<th>Crop Year</th>
<th>N1</th>
<th>N2</th>
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<tr>
<td>'99 Dalhart</td>
<td>300</td>
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<td>'99 Texline</td>
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<tr>
<td>'02 Texline</td>
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</tbody>
</table>
Average Yield from Combine Yield Monitor

Crop Year

Corn Grain Yield (bu/a)

Normal N (N1)
Normal + Fall N (N2)

'99 '00 '01 '02 Avg '99 '00 '01 '02 Avg

Dalhart Texline

Estimated in Early-Mid September

Crop Year

Corn Residue (lb/a)

'99 '00 '01 '02 Avg '99 '01 '00 '02 Avg

Dalhart Texline

N1 N2
September Biomass Sampling

Crop Year

Corn Residue C (lb C/ha)

'99  '00  '01  '02  Avg  '99  '00  '01  '02  Avg

Dalhart  Texline

Change in SOC (0 - 6" soil depth)

Soil Organic C (t/ha)

Y = 7.652 + 0.895X

r^2 = 0.81

Texline

Y = 11.630 + 0.779X

r^2 = 0.87

Dalhart

After Crop Year

1  2  3  4
Change in TSN (0 - 6" soil depth)

Total Soil N (lb N/a)

Texline
$Y = 1570 + 175X$
$r^2 = 0.79$

Dalhart
$Y = 2235 + 229X$
$r^2 = 0.90$

Soil NO$_3$-N After Corn Harvest - Texas Sites
Colorado Site
Average of 2000-2002

Fertilizer Rate (lb N/a)

Residue C/N Ratio

Change in SOC (0 - 6 inch depth)

Soil Organic C (t/a)

Time (years)

Y = 11.17 + 0.641X
\( r^2 = 0.93 \)

Y = 10.5 + 0.071X
\( r^2 = 0.02 \)
Soil N After Harvest 2002 - Ft. Collins Site

N Fertilizer rate (lb N/a)

Residual Soil NO₃-N (lb N/a)

(0 - 6 ft depth)

Greenhouse Gas Emissions and Global Warming Potential

Fort Collins, CO Site
Nitrous Oxide ($N_2O$) Flux (April '02 to April '03)

N Fertilizer Rate, kg N/ha

CT

NT

0 134 202

$N_2O$ Flux (ug N m$^{-2}$ hr$^{-1}$)

0 5 10 15 20 25

N Fertilizer Rate, kg N/ha
Carbon Dioxide (CO₂) Flux (January to April '03)

N Fertilizer Rate (kg N ha⁻¹)

CO₂ Flux (µg C m⁻² hr⁻¹)

0 10 20 30 40

CT  NT

Net Global Warming Potential (GWP)
(April 2002 to April 2003 in CO₂ equivalents)

GWP (kg CO₂ ha⁻¹ yr⁻¹)

-2000 -1500 -1000 -500 0 500 1000 1500 2000 2500 3000

CT(C-C)  NT(C-C)

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.
- N 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\textsubscript{2}O 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
THESE PROJECTS