Fertigation

Chemigation

Jim Schepers
(retired)
Center-Pivot Fertigation
Self-Contained Fertigation Unit
Anti-Siphon Devices

Figure 3. Detail of an anti-siphon device (drawn by Dale Baker)
Chemical Safeguards

• Essential components
  back-flow restriction
  electric inter-lock
  supply tank over-flow protection
  flow meter

• Over-application of N if pivot stalls but continues to apply water

• Double-check calibration and periodically verify application rate
Uniformity of Water Application

- Poor water uniformity in water application results in poor uniformity of N application
- Rotation speed not adjusted for area being watered / pressure changes
- Improper nozzle sizes
- Non-uniform pressures (regulators)
- Canopy interference problems
Irrigation Design Flaws

Corner unit “ON”
Irrigation Design Flaws

Nozzle in canopy
More uniform water distribution - Hopefully
Uniformity Concerns:
(May Turn Into Huge Yield Concerns)

End-gun “OFF”
June 21 - longest day of the year

~July 19 - maximum photosynthesis

Optimum Daylight & Temperature
Imagery or sensor readings to assess N adequacy.

Sufficiency Index

Seasonal N Uptake - %
Nozzle Considerations

- Closely spaced nozzles result in greater uniformity *(operate under lower pressures)*
- Large droplet size is preferred
- Fine particles result in greater evaporation
- Insure adequate overlap of spray patterns
- Check for plugged nozzles
- Need for pressure regulators
Drop-Nozzles

Reduced drift and evaporation
Variable Rate Irrigation
Water Application Efficiency

**LOSSES**

- Low-Angle Impact Sprinkler: ~15%
- Spray Heads: 8%
- LEPA*: 2%

*LEPA – Low Energy Precision Application*
N Loss Potential

• Greater losses when:

  High pH water (salty)
  High temperatures
  Low humidity
  Windy conditions
  High pressures (small particle size)
N Application Rate

- High N concentrations in water can “shock” corn plants
- Might need to fertigate even if soil contains adequate supply of water
- Commonly used N application rates:
  - 20# N / 1-inch
  - 30# N / 1.5-inches
- Ammonium Thiosul (12-0-0-26) has some therapeutic value

88 ppm N
Example: Soil NO$_3$-N (silt loam)

Residual Soil N (60 lb / ac-ft)
(3.6 million lb / ac-ft)

ADD Water

50% Porosity

Field Capacity

~25 % by vol

60 lb NO$_3$-N / ac-ft

60 lb NO$_3$-N in 0.68 million lb water
(226,512 lb / ac-in)

~16.7 lb NO$_3$-N / million lb soil (ppm)

88 ppm NO$_3$-N in soil water
Need to Fertigate  ?? ?? ?? 

- Imagery can show spatial patterns, but need to be verified as to the cause
- Leaf N concentration decreases as plant matures
- DRIS analysis (tissue testing) can help evaluate other nutrient imbalances
- Consider growth stage and N uptake pattern
“Zero” N

Early symptom

Mexico - April, 2008
Young leaves
Landsat

~60-ft resolution

1-ft resolution

September 1, 2003
Seed Production

2-ft spatial resolution

August 20, 2005
Color Infrared

Irrigated Corn
2.5 ac Grid Sampling

~300-ft resolution

1 point / 2.5 ac
0.5-ac Grid Sampling

150-ft resolution

2 points / ac
Yield Monitor

~12-ft resolution

100 points / ac
Aerial Photograph

~1-ft resolution

~40,000 points / ac
Timing of N Applications

• Anticipate growth stages with critical N needs and future requirements

• Late-season N applications are likely to be ineffective

• Cool and wet soils have reduced mineralization

• Warm wet soils can have high denitrification losses
Rows of Kernels

- 20 rows
- 18 rows
- 16 rows
- 14 rows
- 12 rows
Rows of Kernels

20
18
16
14
12
Early N
Planting

When?
How much?
How much early?
In season?

Sensor based
In-season N

N uptake

Early N
Planting V6 V9 Tasseling
1993

Percent of Total Uptake at Silking

- Cu
- Cl
- Mn
- Ca
- Mg
- S
- Zn
- K
- P
- N
- Dry matter

0 20 40 60 80 100

Percent of Total Uptake at Silking
N Form and Problems

• Volatile losses of anhydrous ammonia is higher than UAN (raises pH)
• 32% UAN can "salt-out" under cold conditions
• Anhydrous ammonia will increase pH and cause precipitation of Ca and Mg salts
• Little direct foliar uptake of UAN
• P in DAP stays in surface soil
Plant Response Time

• Measure SPAD meter changes within 3 days
• Visually see canopy changes within a week
• Severe N deficiencies cannot be corrected with fertigation
• Modest N stresses at specific growth stages can reduce yield potential
$\text{acidic}$ 7 $\text{basic}$

\[ \text{pH} \]

$\text{NH}_3 + \text{H}_2\text{O} = \text{NH}_4\text{OH}$

$\text{H}^+ \quad \text{OH}^- \quad \text{SO}_4^{2-} \quad \text{CO}_3^{2-}$

UAN pH $\sim 7$
Some Useful Things to Know

0.228 lb N/acre-inch/ppm nitrate-N

~450 gal/min = 1 acre-inch/hr

~27,300 gal/acre-inch

1 gal/hr x 2.133 = ml/min

Density of 32% UAN = 11.06 lb/gal
32% UAN contains 3.54 lb N/gal
Salts out @ 32° F

Density of 28% UAN = 10.65 lb/gal
28% UAN contains 3.0 lb N/gal
Salts out @ 5° F
Don’t Overlook the Freebies in Water!

Nitrate

\[
\text{lbs N/acre} = \text{(inches)} \times \text{(ppm)} \times 0.227
\]

or

\[
\text{Kg N/ha} = \text{(mm)} \times \text{(ppm)} \times 0.01
\]

Cations . . . . (Na, Ca, Mg)
Irrigation with High Nitrate Water

Fertigation

30 mg/L NO$_3$-N water

3.0 kg N/ha-cm
6.6 lb N/acre-inch
Sample Calculation

- Apply 20 lb N as UAN per acre on 130-ac field with 900 gal/min in 1.0” water application

\[
\frac{20 \text{ lb N/ac}}{3.0 \text{ lb N/gal}} = 6.67 \text{ gal/ac}
\]

\[
6.67 \text{ gal/ac} \times 130 \text{ ac} = 867 \text{ gal UAN/field}
\]

\[
27,300 \text{ gal/ac-in} \times 130 \text{ ac} = 3,549,000 \text{ gal}
\]

\[
\frac{3,549,000 \text{ gal/field}}{900 \text{ gal/min} \times 60 \text{ min/hr}} = 65.7 \text{ hr}
\]

\[
\frac{867 \text{ gal UAN/field}}{65.7 \text{ hr/field}} = 13.2 \text{ gal/hr}
\]

\[
13.2 \text{ gal/hr} \times \frac{\text{hr}}{60 \text{ min}} \times 128 \text{ oz/gal} = 28.16 \text{ oz/min}
\]

\[
28.16 \text{ oz/min} \times 29.51 \text{ ml/oz} = 831 \text{ ml/min}
\]
Don’t Irrigate ???

Have access to high-clearance sprayer

Think about crop sensors
Missouri - 2008

Crop Canopy Sensors
Hannibal, MO - 2008

50 kg/ha preplant

2008 Studies
Six fields
$14-119/acre benefit

2009 Studies
21 fields
Averaged $23/acre benefit
Histogram

Frequency

Cumulative %

CI_{red-edge}
Appropriate Early-Season N

Excess N

Problems

Courtesy: Fred Below
Thank You

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