Evaluation of Various Furrow Irrigation Methods for Corn Production in Nebraska
Committee:

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Tom Loynachan, Member

Ken Moore, Member
Background

- David Nelson
- Holdrege, Nebraska
- Farmer
- 1000 acres
- Gravity and Pivot Irrigated
Phelps County, Nebraska

- Located in South Central Nebraska
- Irrigated Cropland
  - Center pivot and gravity irrigation
  - Surface and subsurface water
  - Corn and soybean production
- Severe Drought 2000-2006
Lake McConaughy

- Largest lake in Nebraska
  - Capacity – 1,900,400 acre feet
  - November 15, 2007 – 30% full
  - Inflows last 5 years at historic lows
    - Mountain snowmelt below average
    - Increase in irrigation development upstream
Density of Registered Irrigation Wells in Nebraska
August 2005

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University of Nebraska-Lincoln

Mark Berbach, Water Levels Coordinator, CSD
Nebraska NRD Districts
Water Restrictions

- Tri-Basin NRD – No new wells or irrigated acres
- LRNRD - No new irrigation wells or irrigated acres
  - Allocation of pumping
    - 33-36 inches per 3 year period

Surface Water

- Lake McConaughy
- 2006: 8.4 inches
- 10 week delivery period
Site Location

- Location – 9 mi north and 5 mi west of Holdrege
- 1% slope
- Holdrege silt loam soil
  - Easily worked and takes water readily
  - High natural fertility
  - Organic matter level – 2.8%
- Annual precipitation – 23 inches
  - 13.5 inches from May 1 to Sept. 1
- Irrigation source – Surface water
Two Experiments

- Every Furrow Method
  - No water application until soil moisture reached target levels
  - Treatment levels – 0.5 FC, 0.7 FC, 0.9 FC

- Every Furrow Compared to Every Other Furrow
  - Water applied when soil moisture reached 75% FC

- Randomized Complete Block Design
  - Replicated 3 times
  - 8 rows per plot
  - 30” row spacing
  - Row length – 2640 feet
Reasons for Study

- Commonly known that furrow irrigation is less efficient than center pivot irrigation.
- Many field’s shape prevent pivot irrigation.
- Restricted water allocation’s are forcing farmers to implement strategies that will reduce water application on furrow irrigated fields.
Objectives of the Study

Evaluation of Different Irrigation Methods On:

- Yield
- Applied amount of water
- Economic return
- Residual soil nitrate
Soil Moisture Measurements

- Gypsum blocks
  - Gypsum cast around 2 stainless steel electrodes
  - Resistance of electrodes in the porous block is proportional to its water content

- Gypsum blocks installed
  - 6”, 18”, 30” 42” depths
  - Installed in the row between corn plants
  - One block per hole
Delmhorst Moisture Meter

- Soil moisture levels read during growing season
  - Once a week early growth stage
  - Twice a week after 11 leaf growth stage
- **Planting**
  - Pioneer hybrid 34A18
    - Contains Rootworm gene
    - Planted April 17
    - 31,000 seeds/acre

- **Herbicide and Fertilizer**
  - Lumax applied pre-plant
  - 170 lbs. of (32-0-0) applied pre-plant
  - Spirit herbicide applied post plant
- **Irrigation**
  - Water is pumped from electric motor at canal
  - Flow meter at turnout
  - 12 hour sets
  - Adjust flow to reach bottom end of field after 9 hours
  - Each row of treatment adjusted for equal flow
Harvest

- Eight row plots harvested on Sept. 14th
- Weighed at local feedyard
  - Yields adjusted to 15.5% moisture
Nitrate Measurements

- **Stalk Nitrate**
  12-15 random stalks cut 12” above the ground in 8” segments

- **Crude Protein**
  Three cups of grain were taken from combine bin

- **Soil Nitrate**
  7 soil cores at a depth of 0-36” were taken after harvest

Testing done at Ward Laboratory in Kearney, NE
Results

Experiment I

Every Row Irrigation Methods
Yield

- **Bu/Ac**
- **Ave. Yld.**
- 0.5 FC: 232.6
- 0.7 FC: 232.9
- 0.9 FC: 236
Water Applied

![Water Applied Diagram](attachment:image.png)

- 0.5 FC: 11.1 Acre/Inch
- 0.7 FC: 16.9 Acre/Inch
- 0.9 FC: 34.4 Acre/Inch
Irrigation Costs

Water Costs $/Acre

- Hook-up charge
- Electricity used
- Water applied

Treatment Levels

- 0.5 FC: 7.13, 6.55
- 0.7 FC: 7.13, 9.99
- 0.9 FC: 7.13, 20.28, 100.28
Treatment level influence on water costs, yield, gross income, and net income for Experiment 1.

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Water Costs/acre</th>
<th>Yield (bu/acre)</th>
<th>Gross Income/acre</th>
<th>Other Costs (acre)</th>
<th>Net Income/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 FC</td>
<td>46.0 a*</td>
<td>232.6 a</td>
<td>697.9 a</td>
<td>477 a</td>
<td>174.9 a</td>
</tr>
<tr>
<td>0.7 FC</td>
<td>66.4 b</td>
<td>232.9 a</td>
<td>698.7 a</td>
<td>477 a</td>
<td>155.3 b</td>
</tr>
<tr>
<td>0.9 FC</td>
<td>127.7 c</td>
<td>236.0 a</td>
<td>707.9 a</td>
<td>477 a</td>
<td>103.2 c</td>
</tr>
</tbody>
</table>

*Means with the same letter within each column are not significantly different at P ≤ 0.05.

FC, field capacity

Water costs is the total of the hook-up charge, electricity used, and $/inch of water used. Other costs were calculated at $202/acre seed and chemicals, $100/acre machinery, $30/acre labor, and $145/acre land (Duffy & Smith, 2007). Gross income for each irrigation treatment was calculated by multiplying treatment yield by $3/bushel.
Effect of irrigation levels in corn height, diameter for Experiment 1 in 2006.

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Stalk Height (in)</th>
<th>Stalk Diameter (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 FC</td>
<td>114.0 a*</td>
<td>1.1 a</td>
</tr>
<tr>
<td>0.7 FC</td>
<td>131.0 b</td>
<td>1.4 b</td>
</tr>
<tr>
<td>0.9 FC</td>
<td>130.0 b</td>
<td>1.2 ab</td>
</tr>
</tbody>
</table>

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FC, field capacity
Treatment level on residual lbs. of soil nitrogen, stalk nitrate, and % of crude protein in grain for Experiment 1.

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>lb/acre of Soil Nitrogen</th>
<th>Stalk Nitrate ppm</th>
<th>% Crude Protein Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 FC</td>
<td>22.0 a*</td>
<td>3169 a</td>
<td>9.3 a</td>
</tr>
<tr>
<td>0.7 FC</td>
<td>24.7 a</td>
<td>1240 ab</td>
<td>9.2 a</td>
</tr>
<tr>
<td>0.9 FC</td>
<td>29.3 a</td>
<td>837 b</td>
<td>9.2 a</td>
</tr>
</tbody>
</table>

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FC, field capacity
Soil Moisture at 18” Depth

18 Inch Soil Depth

Date

Inches of Soil Moisture

T90

T70

T50
Soil Moisture at 30” Depth

30 Inch Soil Depth

Inches of Soil Moisture

Date


T90  T70  T50
Soil Moisture at 42” Depth

42 Inch Soil Depth

Date


Inches of Soil Moisture

T90  T70  T50
Comparison of Irrigation Scheduling

Week of Irrigation

Water Application (Inches)

0.5 FC
0.7 FC
0.9 FC
ET

Week of Irrigation
Results

Experiment II

Every Furrow Irrigation Compared to Every Other Furrow
Yield

![Bar Chart]

- **Bu/Ac.**
  - **EOF**: 233
  - **EF**: 231.7

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231
231.5
232
232.5
233
233.5

EOF
EF
Water Applied

![Bar graph showing water applied in Acre/Inch for treatments EOF and EF.]

- Treatment EOF: 14.5
- Treatment EF: 17.8

The bar graph illustrates the difference in water applied between the two treatments.
Water Costs

<table>
<thead>
<tr>
<th>Treatment Levels</th>
<th>Hook-up charge</th>
<th>Electricity used</th>
<th>Water applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOF</td>
<td>7.13</td>
<td>8.55</td>
<td>42.27</td>
</tr>
<tr>
<td>EF</td>
<td>7.13</td>
<td>10.48</td>
<td>51.89</td>
</tr>
</tbody>
</table>
Irrigation methods influence on amount of water, water costs, yield, gross income, and net income for Experiment II in 2006.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water Costs $/ac</th>
<th>Yield bu/ac</th>
<th>Gross Income $/ac</th>
<th>Other Costs $/ac</th>
<th>Net Income $/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF</td>
<td>69.5 a</td>
<td>231.7 a</td>
<td>695.2 a</td>
<td>477.0 a</td>
<td>148.7 b</td>
</tr>
<tr>
<td>EOF</td>
<td>57.5 b</td>
<td>233.0 a</td>
<td>699.0 a</td>
<td>477.0 a</td>
<td>164.5 a</td>
</tr>
</tbody>
</table>

*Means with the same letter within each column are not significantly different as P ≤ 0.05.

EF, every furrow; EOF, every other furrow

Water costs is the total of the hook-up charge, electricity used, and $/inch of water used. Other costs were calculated at $202/acre seed and chemicals, $100/acre machinery, $30/acre labor, and $145/acre land (Duffy & Smith, 2007). Gross income for each irrigation treatment was calculated by multiplying treatment yield by $3/bushel.
Effect irrigation method on corn height and diameter for Experiment II in 2006.

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>Stalk Height (in)</th>
<th>Stalk Diameter (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF</td>
<td>131.0 a*</td>
<td>1.3 a</td>
</tr>
<tr>
<td>EOF</td>
<td>122.0 b</td>
<td>1.3 a</td>
</tr>
</tbody>
</table>

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EF, every furrow; EOF, every other furrow
Irrigation methods influence on residual lbs. of soil nitrate-nitrogen, stalk nitrate-nitrogen, and % of crude protein in the grain for Experiment II in 2006.

<table>
<thead>
<tr>
<th>Treatment Level</th>
<th>lbs of Soil Nitrogen</th>
<th>Stalk Nitrate ppm</th>
<th>% Crude Protein Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF</td>
<td>22.3 a*</td>
<td>1602.3 a</td>
<td>9.3 a</td>
</tr>
<tr>
<td>EOF</td>
<td>49.0 b</td>
<td>3503.7 b</td>
<td>9.3 a</td>
</tr>
</tbody>
</table>

*Means with the same letter within each column are not significantly different at P ≤ 0.05.

EF, every furrow; EOF, every other furrow
Soil Moisture at 6” Depth

Date
Soil Moisture (Inches)
Soil Moisture at 18” Depth

![Soil Moisture Graph](image)
Soil Moisture at 30” Depth

Soil Moisture (Inches)

Time

EOF

EF
Soil Moisture at 42” Depth

- **Soil Moisture (Inches)**
- **Time**
  - 18-May
  - 25-May
  - 1-Jun
  - 8-Jun
  - 15-Jun
  - 22-Jun
  - 29-Jun
  - 6-Jul
  - 13-Jul
  - 20-Jul
  - 27-Jul
  - 3-Aug
  - 10-Aug
  - 17-Aug
  - 24-Aug
  - 31-Aug
  - 7-Sep

Graph showing soil moisture levels from May to September, with data points for different dates.
# Comparison of Irrigation Scheduling

<table>
<thead>
<tr>
<th>Week of Irrigation</th>
<th>EOF</th>
<th>EF</th>
<th>ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>2</td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>3</td>
<td>a</td>
<td>b</td>
<td>c</td>
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<tr>
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<td>b</td>
<td>c</td>
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<tr>
<td>5</td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>6</td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>7</td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>8</td>
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<td>c</td>
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<td>9</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Legend:**
- EOF
- EF
- ET

**Note:**
- Different letters indicate significant differences.
Conclusions

- **Experiment 1: Every Furrow Irrigation**
  - Benefits of allowing soil moisture to be depleted to 50% FC before irrigation:
    - No significant difference in yield
    - Less water applied
    - Increase in economic return compared to other treatments
Experiment II: Every Other Furrow Irrigation Compared to Every Furrow

- No significant difference in yield between the treatments
- Application of water was 19% less for EOF than EF
- EOF had a higher economic return
- EOF decreased nitrogen leaching
- EOF methods allow for more rainfall storage