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# Rethinking Manure Management with 360Rain: Expanding Application Windows and Improving Nutrient Use Efficiency

*LPELC Educational Webinar Series*
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Andrew Klopfenstein
**Food, Agricultural and Biological Engineering**

Department of Food, Agricultural and Biological Engineering

The Ohio State University
College of Food, Agricultural, and Environmental Sciences

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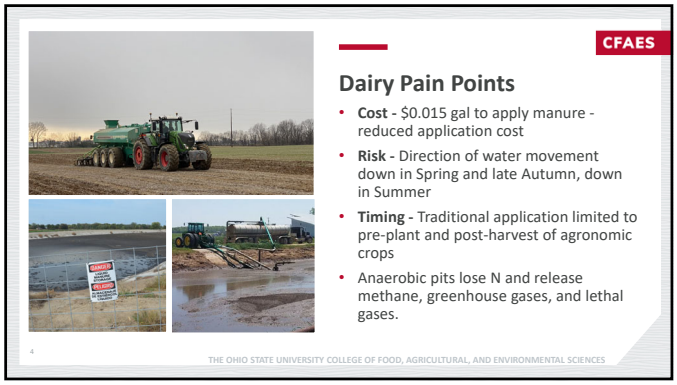


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6

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360 RAIN Specifications
3,000 ft of 3 in HDPE hose (~200 gal/min at 120 psi)
60 ft/80 ft boom with 12/16 drops on 60 in centers for 30 in spacing (20 in machine available with drops every 40 in)
24 hp diesel engine with 300 gal tank (0.5 gal/hr)
56 VDC brushless motors for propulsion system
12 VDC for control system
Base station 240-480 volts (1/3 phase)
Ground speed of 0.05 to 0.45 mph (1-8 in/s)
GVW 24,000 lbs with liquid
GVW 12,800 lbs empty
7
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7


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360 RAIN Specifications
Inputs: 4 analog (pressure) or 6 digital (flow) sensors
Outputs: 9 relays for control of products
0.75 in orifice at manifold with hydraulic squeeze system for row selection for inbound or outbound travel
Wet band 15 in
Manure manifold with impeller system
Injected nutrients for in-season applications
Solids injection system coming 2027
Local RTK system provided for planter passes and application passes
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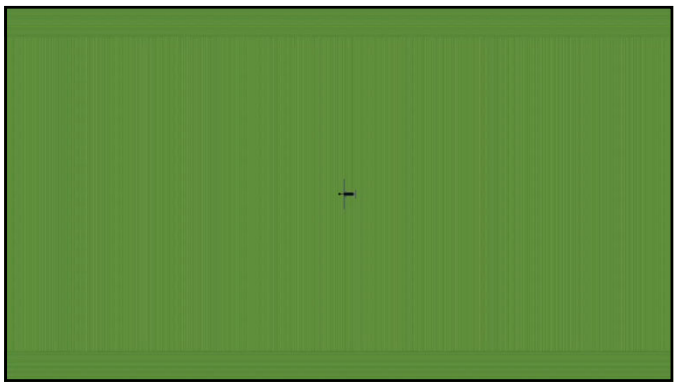

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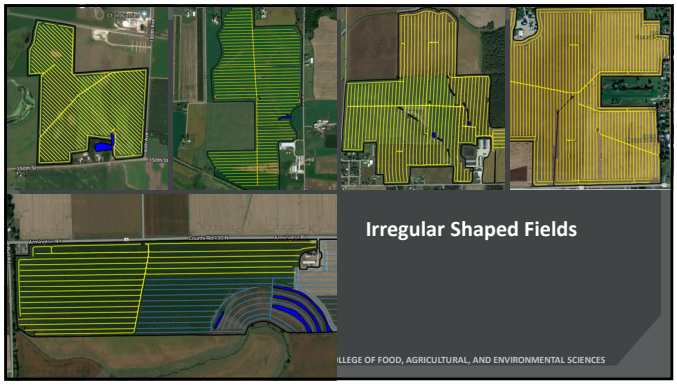


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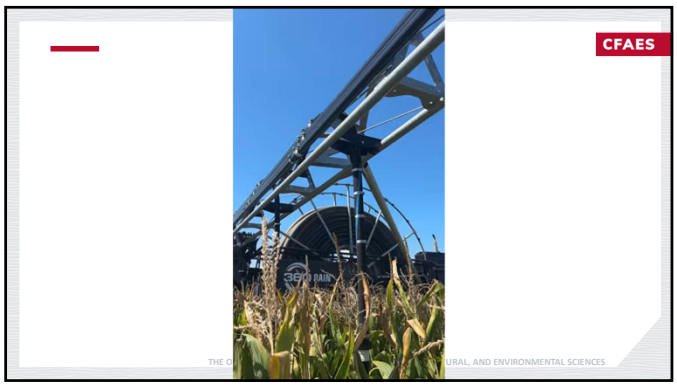


12

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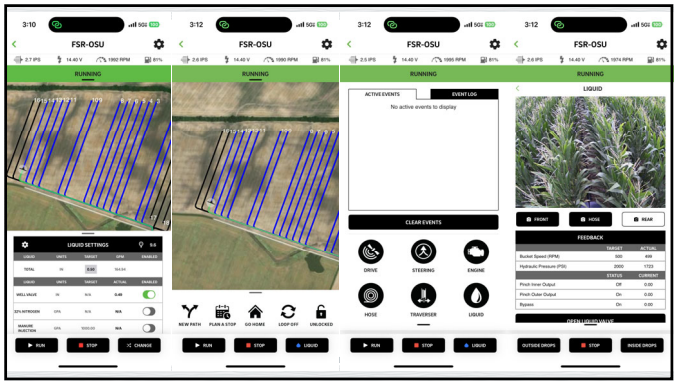


13

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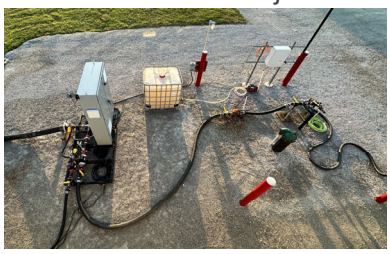
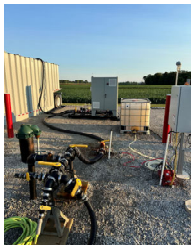
## 360 RAIN Nutrient Injection





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14

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## 360 RAIN Coverage (Example system)

| Gallons of Water to Cover Field | | | | | |
|---|---|---|---|---|---|
| Inches Applied | Field Size (acres) | | | | |
| | 40 | 80 | 120 | 160 | 200 |
| 0.2 | 217,234 | 434,469 | 651,703 | 868,937 | 1,086,171 |
| 0.3 | 325,851 | 651,703 | 977,554 | 1,303,406 | 1,629,257 |
| 0.4 | 434,469 | 868,937 | 1,303,406 | 1,737,874 | 2,172,343 |
| 0.5 | 543,086 | 1,086,171 | 1,629,257 | 2,172,343 | 2,715,429 |
| Rate (GPM) | | 200 | Pressure (psi) | | 120 |

| Gallons of Injected Manure to Cover Field | | | | | |
|---|---|---|---|---|---|
| Inches Applied | Field Size (acres) | | | | |
| | 40 | 80 | 120 | 160 | 200 |
| 0.2 | 54,309 | 108,617 | 162,926 | 217,234 | 271,543 |
| 0.3 | 81,463 | 162,926 | 244,389 | 325,851 | 407,314 |
| 0.4 | 108,617 | 217,234 | 325,851 | 434,469 | 543,086 |
| 0.5 | 135,771 | 271,543 | 407,314 | 543,086 | 678,857 |
| Manure Rate (GPM) | | 50 | Total Rate (GPM) | | 200 |

| Typical Days to Cover Field | | | | | |
|---|---|---|---|---|---|
| Inches Applied | Field Size (acres) | | | | |
| | 40 | 80 | 120 | 160 | 200 |
| 0.2 | 0.8 | 1.5 | 2.3 | 3.0 | 3.8 |
| 0.3 | 1.1 | 2.3 | 3.4 | 4.5 | 5.7 |
| 0.4 | 1.5 | 3.0 | 4.5 | 6.0 | 7.5 |
| 0.5 | 1.9 | 3.8 | 5.7 | 7.5 | 9.4 |
| Rate (GPM) | | 200 | Pressure (psi) | | 120 |

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15

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## Research Venues & Methods

- **ISU Brent Renner Farm:** Randomized strips with five treatments as
  - Fall manure injected (traditional manure injection) 3000 gpa manure
  - Spring manure injected (traditional manure injection) 3000 gpa manure
  - Spring split manure applications with 360 RAIN 3000 gpa manure
  - In-season split manure applications with 360 RAIN plus irrigation 3000 gpa manure
  - Spring UAN and side dress application. Equivalent N of 3000 gpa manure
- **OSU Beck's Site:**
  - Paired sub-watersheds instrumented for both surface water and subsurface tile drainage monitoring
  - Conventional commercial fertilizer application in accordance with the Tri-State Fertilizer recommendations
  - In-season nutrient management using the HCRI and Tri-State Fertilizer recommendations.
- **OSU Field 7 MCAC Site:** RCBD strip trial design with treatments that include
  - Commercial fertilizer application (N and P)
  - In-season nutrient management (N and P) using the HCRI
  - In-season nutrient management (N and P) using the HCRI and 67.7% Tri-State rates.

16

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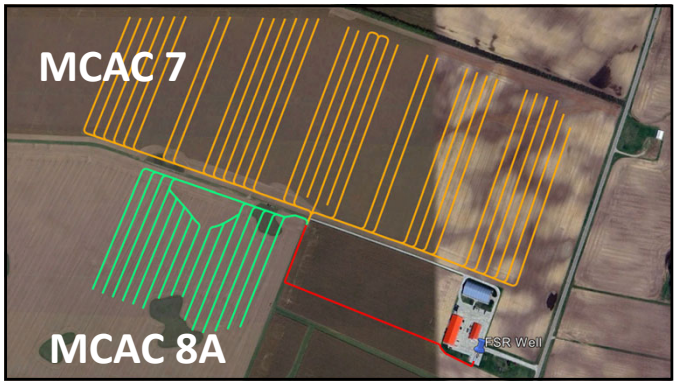
16




17


18

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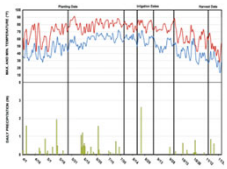
## Yield Trials CIG (Corn) – Beck's Hybrids 2023

WEATHER INFORMATION



| Treatments | Water Applied (in) | Moisture (%) | Yield (bu/ac) |
|---|---|---|---|
| Irrigated | 1.47 | 20.1 | 226 |
| Non-irrigated | 0 | 18.9 | 218 |

Growing Season Weather Summary

| | APR | MAY | JUN | JUL | AUG | SEP | Total |
|---|---|---|---|---|---|---|---|
| Precip (in.) | 3.51 | 3.31 | 5.08 | 3.56 | 2.61 | 0.45 | 18.52 |
| Cumulative GDDs | 217 | 607 | 1118 | 1825 | 2425 | 2887 | 2887 |

- Started watering 8/3/2023 and completed 5 passes
- Not having the rain unit in June/July made a large difference in this study

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19

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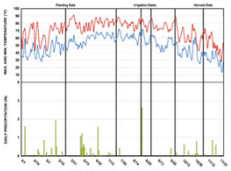
## Yield Trials Sandbox (Corn) – MCAC Field 8A 2023

WEATHER INFORMATION



| Treatments | Water Applied (in) | Nitrogen (lb/ac) | Moisture (%) | Yield (bu/ac) |
|---|---|---|---|---|
| 1 | 1.31 | 220 | 23.6 | 246 a |
| 2 | 1.31 | 170 | 24.0 | 245 a |
| 3 | 1.31 | 120 | 23.9 | 220 c |
| 4 | 0 | 220 | 22.3 | 235 b |
| 5 | 0 | 170 | 22.5 | 238 b |
| 6 | 0 | 120 | 22.8 | 210 d |
| Treatment Means with the same letter are not significantly different according to Fisher's Protected Least Significant Differences (LSD) test at alpha = 0.1. | | | | LSD: 5<br>CV: 2.6% |

Growing Season Weather Summary

| | APR | MAY | JUN | JUL | AUG | SEP | Total |
|---|---|---|---|---|---|---|---|
| Precip (in.) | 3.51 | 3.31 | 5.08 | 3.56 | 2.61 | 0.45 | 18.52 |
| Cumulative GDDs | 217 | 607 | 1118 | 1825 | 2425 | 2887 | 2887 |

- Started watering 7/24/2023 and completed 4 passes
- Not having the rain unit in June/July made a large difference in this study

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20


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## Outlook 2024

- MCAC Field 7 (Corn) - CIG
  - 5.5 in of water via irrigation
    - 11 applications
  - Completed 30/45 GPA of 28% N depending on treatments over multiple passes
  - Yield check A vs B strips (med CPU)
    - 182 bu/ac vs 211 bu/ac
    - 2033 gr vs 2328 gr
- MCAC Field 8A (Soybeans) - Sandbox
  - 4.5 in of water via irrigation
    - 6 applications of 0.75 inch per pass
- Beck's Field West 1A (Soybeans) - CIG
  - No irrigation applied this season

21

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21

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8/28/2024
8/28/2024
Low CPU
131 bu/ac
70 bu/ac
High CPU
195 bu/ac
170 bu/ac
Soybeans
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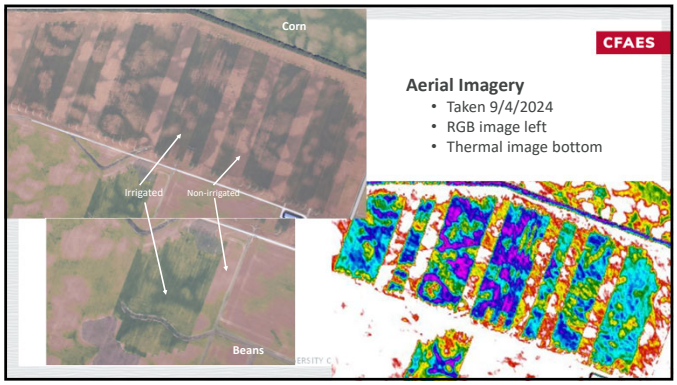
22


Corn
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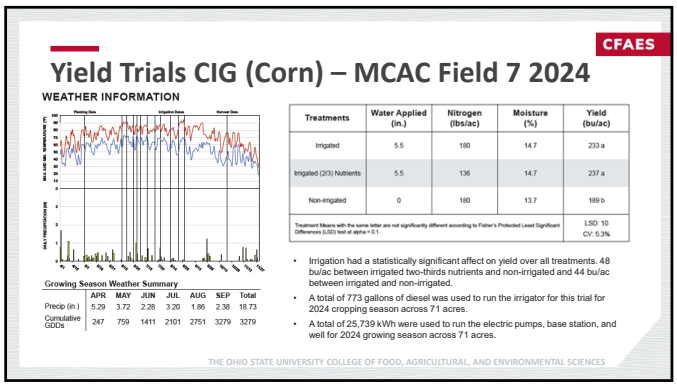
Aerial Imagery
• Taken 9/4/2024
• RGB image left
• Thermal image bottom
Irrigated
Non-irrigated
Beans

23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Yield Trials CIG (Corn) – MCAC Field 7 2024
WEATHER INFORMATION
Growing Season Weather Summary
APR MAY JUN JUL AUG SEP Total
Precip (in.) 5.29 3.72 2.28 3.20 1.86 2.38 18.73
Cumulative GDDs 247 759 1411 2101 2751 3279 3279
Treatments | Water Applied (in.) | Nitrogen (lbs/ac) | Moisture (%) | Yield (bu/ac)
Irrigated 5.5 180 14.7 233 a
Irrigated (2/3) Nutrients 5.5 136 14.7 237 a
Non-irrigated 0 180 13.7 189 b
LSD: 10
CV: 5.3%
• Irrigation had a statistically significant affect on yield over all treatments. 48 bu/ac between irrigated two-thirds nutrients and non-irrigated and 44 bu/ac between irrigated and non-irrigated.
• A total of 773 gallons of diesel was used to run the irrigator for this trial for 2024 cropping season across 71 acres.
• A total of 25,739 kWh were used to run the electric pumps, base station, and well for 2024 growing season across 71 acres.
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24

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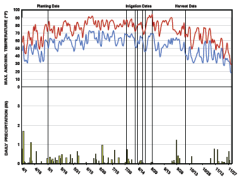
## Yield Trials Sandbox (Soybeans) – MCAC Field 8A

WEATHER INFORMATION



| Treatments | Water Applied (in.) | Moisture (%) | Yield (bu/ac) |
|---|---|---|---|
| Irrigated | 4.5 | 9.3 | 86 a |
| Non-irrigated | 0 | 9.4 | 50 b |
| Treatment Means with the same letter are not significantly different according to Fisher's Protected Least Significant Differences (LSD) test at alpha = 0.1. | | | LSD: 6<br>CV: 4.0% |

Growing Season Weather Summary

| | APR | MAY | JUN | JUL | AUG | SEP | Total |
|---|---|---|---|---|---|---|---|
| Precip (in.) | 5.29 | 3.72 | 2.28 | 3.20 | 1.86 | 2.38 | 18.73 |
| Cumulative GDDs | 247 | 759 | 1411 | 2101 | 2751 | 3279 | 3279 |

- Irrigation had a statistically significant affect on yield over non-irrigated.
- A total of 211 gallons of diesel was used to run the irrigator for this trial for 2024 cropping season across 11 acres.
- A total of 3,475 kWh were used to run the electric pumps, base station, and well for 2024 growing season across 11 acres.

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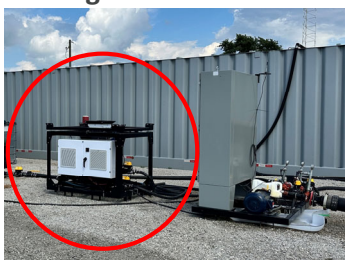
25

## Coming in 2027…



26

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## Coming in 2027…

27

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28

29

30

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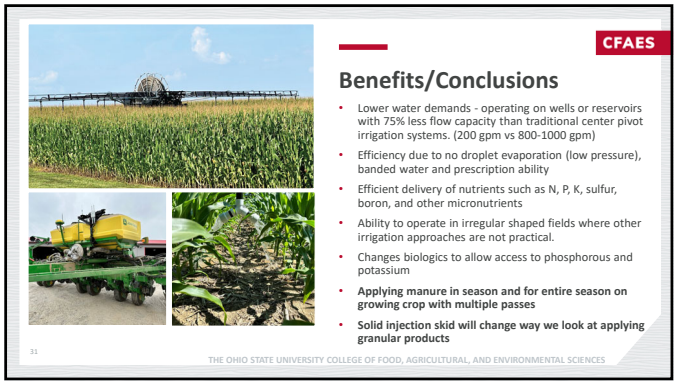
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Benefits/Conclusions
Lower water demands - operating on wells or reservoirs with 75% less flow capacity than traditional center pivot irrigation systems. (200 gpm vs 800-1000 gpm)
Efficiency due to no droplet evaporation (low pressure), banded water and prescription ability
Efficient delivery of nutrients such as N, P, K, sulfur, boron, and other micronutrients
Ability to operate in irregular shaped fields where other irrigation approaches are not practical.
Changes biologics to allow access to phosphorous and potassium
Applying manure in season and for entire season on growing crop with multiple passes
Solid injection skid will change way we look at applying granular products
31
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31


High Clearance Robotic Irrigator for In-Season Nutrient Management
Natural Resources Conservation Service
Conservation Innovation Grant (NR233A750013C037)
Ohio Department of Agriculture
H2Ohio Grant
USDA
NRCS
United States Department of Agriculture
Natural Resources Conservation Service
CONSERVATION INNOVATION GRANTS
IOWA STATE UNIVERSITY
Ohio Department of Agriculture
H2Ohio

32


Thank you to our project collaborators!
360 YIELD CENTER
BECKS
Molly Carey
Agricultural Center
ROOTED
SERVICE
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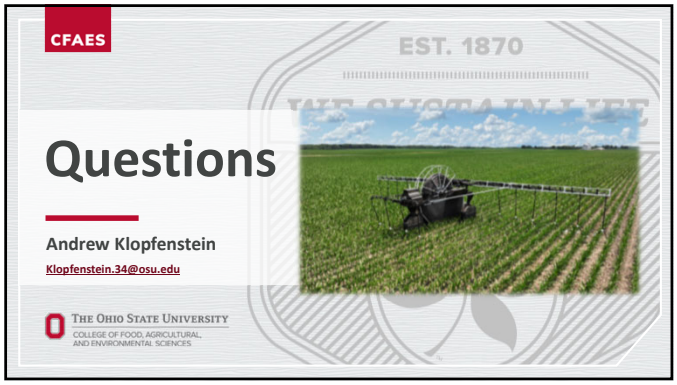
IOWA STATE UNIVERSITY
Extension and Outreach

33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Questions
Andrew Klopfenstein
Klopfenstein.34@osu.edu
The Ohio State University
College of Food, Agricultural, and Environmental Sciences

34