Quantifying the Environmental Benefits of Kernza

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Environmental impacts of cropping systems

Perennial Crop

Crop production

Natural enemies

Climate and air quality

Carbon sequestration

Water quality

Pollinator resources

Habitat and biodiversity

Water quantity

after Foley et al., 2005
Nitrate Leaching and Groundwater

Nitrogen Fertilizer

Unsaturated Zone

Nitrogen Leaching

Groundwater
3-10
10

Well water
NO₃ (ppm)

Minnesota Nitrate Issues
• 13% of wells exceeded safe drinking limit statewide
• 30% in central sand plains

Prepared by the Minnesota Department of Health, October 21, 2014
Nitrate Leaching and Groundwater

Irrigation boosts potatoes, but Park Rapids pays more for water

Dan Gunderson · Park Rapids, Minn. · Feb 13, 2014

Tainted drinking water is costing Minnesota taxpayers millions

Randall's water emergency is the latest sign of an environmental problem in Minnesota. Nitrogen fertilizer is leaching into groundwater from farm fields, contaminating wells and costing taxpayers millions of dollars a year.

By Tony Kennedy Star Tribune · APRIL 29, 2015 — 12:24PM
Nitrate Leaching and Groundwater

Nitrogen Fertilizer

Unsaturated Zone

Nitrogen Leaching

Groundwater
Nitrate Leaching and Groundwater

Nitrogen Fertilizer

Unsaturated Zone

Nitrogen Leaching

Groundwater
Nitrate Leaching and Groundwater

Nitrogen fertilizer

Corn

Perennial Crops
- Kernza
- Switchgrass

Plant uptake

Lysimeters (50 cm)

Moisture Sensors (50 & 100 cm)

Modeled Nitrate Leaching

Groundwater
Kernza and water quality

2013

Soil water nitrate (mg l⁻¹)

- Corn (160 kg N/ha)
- Kernza (160 kg N/ha)
- Switchgrass (160 kg N/ha)

Jungers et al., in prep
Kernza and water quality

Jungers et al., in prep
Kernza and water quality

Soil moisture (m³ m⁻³) over time for different crops:
- Corn
- Kernza
- Switchgrass

Jungers et al., in prep
Kernza and water quality

40 acre Kernza planting in an instrumented wellhead protection area. Land owned by Lincoln-Pipestone Rural Water Supply and was previously farmed in corn and soybean.
Kernza and GHG mitigation

Objective: Determine the GHG footprint of Kernza

Experiments

• Stand maintenance: inter-row cultivation/disturbance
• Grazing
• Legume intercropping and N fertilization
Kernza and GHG mitigation

Measurements
- Crop yield & growth parameters
- Belowground biomass
- Labile C pool
- Microbial activity
Kernza and GHG mitigation

Measurements
• Soil GHG emissions
Kernza and GHG mitigation

Time since chamber closure (seconds) vs. $\text{N}_2\text{O}$ (ppm)

- alf
- IWG−alf
- IWG−con
- IWG−org
Slope of N$_2$O emissions over time for different conditions:

- alf
- IWG-alf
- IWG-con
- IWG-org

**Legend:**
- Fertilized June 1

**Dates:**
- Jun 05
- Jun 12
- Jun 19
- Jun 26
Kernza production and GHG mitigation

Objectives: Use ‘DayCent’ to simulate Kernza yield and C dynamics

Data inputs
- Land cover: CDL
- Soil: SSURGO
- Climate: DayMet
Kernza production and GHG mitigation

Simulate annual row crop production and GHG emissions

2010 Minnesota Counties
Kernza production and GHG mitigation

Simulate Kernza production and GHG emissions where annual crops are underyielding.
## Kernza production and GHG mitigation

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Area Affected</th>
<th>Total Kernza Production</th>
<th>Difference in Annual Crop Production</th>
<th>Difference in Economic Value</th>
<th>Difference in GHG mitigation</th>
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</thead>
<tbody>
<tr>
<td>Replace all annual crop land that yields 10% less than county average</td>
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<tr>
<td>Replace all annual crop land grown within 100 meters of surface waters</td>
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<tr>
<td>Replace all annual crop land in wellhead protection areas</td>
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</tbody>
</table>
Questions
Acknowledgments

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- The University of Minnesota Forever Green Initiative
- SARE
- Ceres Trust Fund
Modeling Kernza GHG mitigation

Objectives: Parameterize ‘DayCent’ crop and carbon simulation model

R squared = 0.85; P value < 0.001

Aboveground Biomass Calibration using 9 site-years of data.

Validation using 21 site-years of data.
Objectives: Parameterize ‘DayCent’ crop and carbon simulation model

• Aboveground biomass
• Belowground biomass
• Soil moisture
• Soil C dynamics
Annual crops

Nitrogen Fertilizer

Nitrate leaching

Nitrate leached to groundwater

Groundwater

Reduced nitrate in groundwater

Low nitrate leaching

Nitrate in drinking water

Well nitrate contamination

Kernza perennial grain

Nitrate leached to groundwater

Reduced nitrate in well and drinking water

Nitrate leached to groundwater

Nitrate in drinking water