Kernza: a Perennial Grain and Forage Crop with Multiple Uses

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Ecological intensification of agroecosystems

Biodiversity

Low

High

Low

High

“Perenniality”
Continuous ground cover

- Native grasslands
- Perennial polycultures
- Perennial monocultures
- Crop-forage long rotations
- Cover crops
- Short crop rotations
- Intercropping annuals
- Annual monocultures

Continuous ground cover

- Low Biodiversity
- High Biodiversity
Perennials

- Ecosystem services:
  - Erosion control
  - Nutrient leaching reduction
  - Carbon fixation

- Multiple agricultural uses:
  - Pastures for grazing
  - Forages for feed
  - Biomass for energy
  - Perennial grains
Kernza intermediate wheatgrass
FOOD WRITER'S DIARY

Could perennial grains be the next climate-saving superstars?

Behold Kernza: Could this wheat save the planet?

FOOD FOR THOUGHT

Can This Breakfast Cereal Help Save The Planet?

Kernza: The wheat ecologists dream about
Dual-use management in IWG cropping systems
• What do Kernza farmers say?
• Dual use: grain and forage
  • What is the forage nutritive value?
  • Grazing impacts on grain yield?
  • Can cattle be fed Kernza crop residue?
• Weed suppression with Kernza
• Intercropping with legumes
  • Which legume species?
  • Which varieties?
  • Which management?
Farmer Perspectives on Growing Kernza

Lanker et al., 2019

- 10 semi-structured, on-farm interviews with Kernza growers
- Summer 2017, U.S Midwest (MN, WI, IA, IL, OH)
- Ages: 30 to 80 years old
- Crops: Diversified row crops, some w/ livestock, some grass seed
- 4 Organic, 3 Conventional (except Kernza), 3 Mixed
- Farm acreage: 160 to 10,000; Kernza acreage: 1 to 38
- Kernza start date: Fall 2011 to fall 2016
Motivations - “I guess I was just interested in something new, looking to try something different.”

- Sense of innovation
- Personal connection to Kernza social network
- Environmental consciousness
- Interest in niche markets
- Some level of criticism of the dominant system

Management - “we don’t know much about the management.”

- Lack of agronomic management information
- Planting: diverse methods, late dates
- Harvest grain: 3 Combine, 4 swathing
- Limited inputs (some fertilizer)
- Weeds: perennials; Cutting/mowing

Lanker et al., 2019
Farmers’ questions and challenges

• Establishment (seeding, density, spacing)
  - “nobody knows much about thow to establish this.”
• What’s a ‘good stand’
  - ‘Should I terminate this? Is this an adequate stand?’
• Obtaining seed on time
  - “the seed not coming ‘til late. Just everything happened too late....”
• Forage value
  - “If I had cattle and I could feed it ...”
• Weed management
  - “pretty much squeezes everything else out.”
  - “quickly become a weedy mess.”
• How to keep Kernza productive over years
  - “it became sodbound”
• Economics, processing & markets
  - “what would the market price for it be right now?”

Lanker et al., 2019
Kernza
A Perennial Grain and Forage Crop with Multiple Uses

Dorothy & John Priske
Fountain Prairie Farm
Fall River, WI
John and Dorothy Priske’s farm

John and Dorothy Priske’s Fountain Prairie Farm
W1901 State Road 16, Fall River, WI, 53932

First organic perennial grain polyculture commercial field: Kernza-clover with cattle grazing
<table>
<thead>
<tr>
<th>Paddock 1: Red clover frost seeded</th>
<th>Paddock 3: Red clover frost seeded</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 acres</td>
<td>2.6 acres</td>
</tr>
<tr>
<td>Paddock 2: Red clover drilled in fall</td>
<td>Paddock 4: Red clover drilled in fall</td>
</tr>
<tr>
<td>1.2 acres</td>
<td>2.6 acres</td>
</tr>
<tr>
<td>12.3 acres total</td>
<td>2.4 acres</td>
</tr>
</tbody>
</table>

← North

<table>
<thead>
<tr>
<th>Paddock 5: Red clover frost seeded</th>
<th>Paddock 6: Red clover drilled in fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4 acres</td>
<td>2.4 acres</td>
</tr>
</tbody>
</table>
Field preparation: On improved pasture being used for grazing and migratory bird habitat.
Moldboard plowing Aug. 25, 2017; tandem disc Sep. 8, tandem disc Sep. 11, Cultipack Sep 11.


Red clover (variety Red Wing) planting (2 planting date treatments):
Sep 13, 2017: Drilled with 1590 grain drill-small box, setting 6: 7 lbs PLS/acre
March 10, 2018: In the paddocks not planted to red clover in the fall, frost seeded at 11.5 lbs PLS/acre with conical broadcast seeder
<table>
<thead>
<tr>
<th>Kg/ha</th>
<th>Summer (8/14)</th>
<th>Fall (10/12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWG forage</td>
<td>4100</td>
<td>1100</td>
</tr>
<tr>
<td>Red clover forage</td>
<td>800</td>
<td>700</td>
</tr>
<tr>
<td>Weeds</td>
<td>500</td>
<td>65</td>
</tr>
</tbody>
</table>

Summer Hay: 97 bales of 682 lb average = 66,154 lb
Hay nutritive value: CP: 9.6%; ADF: 51%; NDF: 77%; NDFD: 23%; RFV: 59

Kernza grain: estimated in quadrats: 450 kg/ha; after combine harvest and cleaning: 484 kg total (100 kg/ha)
Forage value of Kernza intermediate wheatgrass in monoculture vs mixture with red clover

- Lancaster, WI, USA
- Arlington, WI, USA
- First production year

Favre et al., in review
Dual-use management

Spring forage harvest

Grain/straw harvest

Fall forage harvest

Vegetation

1. Kernza monoculture
2. Kernza – red clover

Sampling: Quadrat harvest at the soil level
Planting: August 15 - Sept 20
Spring grazing: Before stem elongation (May 1)
Grain harvest: ~Aug 1
<table>
<thead>
<tr>
<th>Planting</th>
<th>Forage</th>
<th>Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept</td>
<td>Oct</td>
<td>[...]</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>May</td>
</tr>
<tr>
<td>Oct</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Grain harvest: ~Aug 1**
Fall grazing: Mid-October
Forage and grain yields – 1st year, Wi

Favre et al., in review
# Forage nutritive value – 1st year, Wi

<table>
<thead>
<tr>
<th>Material</th>
<th>Season</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>Summer</td>
<td>Fall</td>
</tr>
<tr>
<td><strong>NDF (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IWG monoculture</td>
<td>46</td>
<td>ef</td>
<td>70</td>
<td>ab</td>
</tr>
<tr>
<td>IWG/clover mixture</td>
<td>-</td>
<td></td>
<td>64</td>
<td>bc</td>
</tr>
<tr>
<td><strong>ADF (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IWG monoculture</td>
<td>25</td>
<td>d</td>
<td>43</td>
<td>ab</td>
</tr>
<tr>
<td>IWG/clover mixture</td>
<td>-</td>
<td></td>
<td>41</td>
<td>b</td>
</tr>
<tr>
<td><strong>CP (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IWG monoculture</td>
<td>23</td>
<td>a</td>
<td>5</td>
<td>f</td>
</tr>
<tr>
<td>IWG/clover mixture</td>
<td>-</td>
<td></td>
<td>9</td>
<td>e</td>
</tr>
<tr>
<td><strong>ttNDFD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IWG monoculture</td>
<td>0.53</td>
<td>a</td>
<td>0.41</td>
<td>b</td>
</tr>
</tbody>
</table>

Favre et al., in review
Relative forage quality

- Spring
- Summer
- Fall
- Annual

- Monoculture
- Mixture

Lactating dairy cow
Stocker calf
Lactating beef cow, heifer
Dry cow

Favre et al., in review
Grazing impacts on Kernza grain yield

NCR-SARE grant – UW, UMN, TLI

- Lancaster, WI
- Morris, MN
Treatments

Vegetation (2 treatments):
   a) Kernza monoculture
   b) Kernza + legume intercrop

Grazing (4 treatments):
   a) Spring grazing
   b) Fall grazing
   c) Spring and fall grazing
   d) No grazing

Grain harvest from every plot
Grain yield vs grazing timing

Favre et al., in prep.
Lodging vs grazing timing

Favre et al., in prep.
Forage yield vs grazing timing

![Bar graph showing total utilized forage (kg ha⁻¹) for Wisconsin and Minnesota in different grazing periods:]

- **Control**: Wisconsin (B) vs. Minnesota (a)
- **Spring**: Wisconsin (AB) vs. Minnesota (a)
- **Fall**: Wisconsin (AB) vs. Minnesota (a)
- **Spring + Fall**: Wisconsin (A) vs. Minnesota (a)

Favre et al., in prep.
Beef cattle performance in a feeding trial with Kernza crop residue

<table>
<thead>
<tr>
<th></th>
<th>100% grass-alfalfa haylage</th>
<th>50% Kernza crop residue + 50% haylage</th>
<th>p-value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow final body weight</td>
<td>kg</td>
<td>769</td>
<td>739</td>
<td>0.05</td>
</tr>
<tr>
<td>Average daily gains</td>
<td>kg day⁻¹</td>
<td>0.92</td>
<td>0.45</td>
<td>0.02</td>
</tr>
<tr>
<td>Dry Matter intake</td>
<td>g kg BW⁻¹</td>
<td>28.7</td>
<td>21.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Increase in Body Condition Score</td>
<td>-</td>
<td>0.3</td>
<td>0.1</td>
<td>0.05</td>
</tr>
<tr>
<td>Calf birth weight</td>
<td>kg</td>
<td>40.8</td>
<td>39.5</td>
<td>0.55</td>
</tr>
<tr>
<td>Calf weaning weight</td>
<td>kg</td>
<td>203</td>
<td>211.2</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Favre et al., in prep.
Dual-use Intermediate wheatgrass cropping systems effectively suppress weeds over three production years

Zimbric, Stoltenberg, and Picasso, in prep.
Weed community composition (first year)

Shepherd’s purse

![Graph showing weed species cover in 2016](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAEAAAAAcCAYAAAAAmz9AAAACXBIWXMAAA7DAAAPwAAC+AAAlAAAB1JREFUSMهنK/7KAAAAASUVORK5CYII=

*CAPBP, THLAR, OTHER*
Weed community composition (second and third year)

Dandelion

White cockle

Annual fleabane

![Graph showing weed density over time and weed species]
Results: Weed biomass

![Graph showing weed shoot dry biomass over years 2016 to 2018. The biomass decreases over time.]
Results: IWG aboveground biomass

![Graph showing IWG aboveground biomass over years with different nitrogen inputs](image-url)
Results: IWG grain yield

![Graph showing IWG grain yield over years with data points and trend lines for different nitrogen levels.](image-url)
Kernza Grain Yields in the US

1st year: ~500 – 1000 kg ha\(^{-1}\) (450-900 lb ac\(^{-1}\))
2nd year: ~3–650 kg ha\(^{-1}\) (3-580 lb ac\(^{-1}\))
Kernza Forage Yield in the US

1st year: ~ 4 – 12 Mg ha\(^{-1}\) (3.5 - 11 Ton ac\(^{-1}\))
2nd year: ~ 2.5– 9 Mg ha\(^{-1}\) (2.2 - 8 Ton ac\(^{-1}\))
Bushel weight of Kernza ~ 20 lb/bu

<table>
<thead>
<tr>
<th>Grain</th>
<th>Test weight (g/L)</th>
<th>lb/cu ft</th>
<th>Bushel weight (lb/bu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-Min</td>
<td>161*</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>K-Mean</td>
<td>241*</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>K-Max</td>
<td>283*</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>Grass</td>
<td>179</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Oats</td>
<td>412</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>Barley</td>
<td>617</td>
<td>39</td>
<td>48</td>
</tr>
<tr>
<td>Wheat</td>
<td>771</td>
<td>48</td>
<td>60</td>
</tr>
</tbody>
</table>

* Data from Arlington, Wisconsin 2017 AK1 and AK2
Factors: 1 bushel is a volume of 1.24 cubic foot; 1 g/L = 0.0624 lb/cubic foot
Intercropping legumes with Kernza
Experimental design

Locations: Arlington and Sturgeon Bay, WI
Seeds from Cycle 4 IWG – TLI, 11 kg ha\(^{-1}\)
5 replications

Main plot factor: Row Spacing
- 38 cm
- 57 cm

Sub-plot factor: IWG cropping system
- IWG monoculture – weedy
- IWG monoculture – weed free
- IWG monoculture + 45 kg N ha\(^{-1}\)
- IWG monoculture + 90 kg N ha\(^{-1}\)
- IWG + Alfalfa
- IWG + Red Clover
- IWG + Kura Clover
- IWG + Berseem Clover
- IWG + Soybean
Red clover
*Trifolium pratense*

Kura clover
*Trifolium ambiguum*

Alfalfa (Lucerne)
*Medicago sativa*
Zimbric et al., in prep.
Alfalfa varieties for Kernza intercropping

Brandon Schlautman et al.
Planting date of Kernza and legume

Kernza grain yield first year (kg/ha)

- Red clover fall
- Red clover spring

R² = 0.904
R² = 0.6808

Planting date
Invitation – on farm research

On-farm comparisons of Kernza grain yield, total biomass yield, and changes in soil nitrogen in two intercropping treatments:

1) Kernza intercropped with alfalfa, and
2) Kernza intercropped with another perennial legume best fit for the growing conditions of the on-farm participant.

This experiment will be conducted in partnership with two farmers per state associated with each institution.

Based on discussions with the on-farm participants, legumes currently being considered for intercropping in addition to alfalfa include red clover, birdsfoot trefoil, and sainfoin.

SARE project (UMN, UW, TLI)
Thank you!