Winter Oilseeds as “Cash” Cover Crops for Sustainable Crop Production

Russ Gesch, Frank Forcella, Carrie Eberle, Jane Johnson, and Matt Thom
USDA-Agricultural Research Service-NCSCRL
Morris, Minnesota, USA
• Threats to agriculture sustainability
• Sustainably intensified agriculture
• Dual cropping winter annual oilseeds with food and forage crops
• Ecosystem services provided by winter oilseeds
• Summary
Concerns Threatening Agriculture Sustainability

- Increased population growth – Food security
- Urbanization – Loss of productive lands
- Balancing food, feed, fiber and fuel production
- Climate change - Loss of resources
- Lack of diversity across the agricultural landscape
2011-2015 ~ 69 million acres of corn & 54 million acres of soybean annually

Acres of corn harvested for grain as percent harvested cropland acreage in 2012. From USDA-NASS
Effective Number of Crop Species

- 1 - 2 (Low Diversity)
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 12
- >12 (High Diversity)

Counts with <20% cropland

Cropping Diversity of Contiguous U.S.

By Gramig & Forcella
Issues Surrounding Loss of Diversity

Pest Resistance

Soil Erosion

Water Quality

The “Dead Zone” In the Gulf

CCD

Climate Change Source or Sink?

Data source: N.A. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, Louisiana State University. Funded by: NOAA, Center for Sponsored Coastal Ocean Research
Potential Solutions to Increase Sustainability and Add Diversity

• “Sustainably Intensified Agriculture”
  – Increasing production on existing arable lands while minimizing negative environmental impact and sustaining food production
    • Conventional – Improved crop genetics, increased but efficient use of inputs
    • Spatial – Strategic placement of cultivated and natural systems
    • Temporal – Increased number of crops in a given time period – includes double and relay cropping
Mono-crop

Missed opportunities for crop production

Large opportunities for nitrogen leaching

Heggenstaller et al. 2008, Agron. J.

Dual-crop

More opportunities for crop production

Reduced opportunities for nitrogen leaching

Heggenstaller et al. 2008, Agron. J.
Progress and perspectives with cover crops: Interpreting three years of farmer surveys on cover crops;

Authors: Rob Myers and Chad Watts

Top 8 cover crop benefits farmers want

1. Increased soil organic matter
2. Reduced soil erosion
3. Reduced soil compaction
4. Control weeds
5. Provide a N source
6. Scavenge N
7. Increase primary crop yields
8. Economic return

There were several others with lower priority to farmers
Challenges of Cover Crops for Upper Midwest

- Short growing seasons

- Cold and freezing tolerance
  - Very few options, especially for winter annuals

- Economics – direct return
Winter camelina (*Camelina sativa*) and pennycress (*Thlaspi arvense*)

- Good seed oil content: 32-42%
- Short life cycle
- Excellent winter survivability

1st week of May
Double and Relay Cropping Soybean with Camelina

Soybean relayed before bolting, late Apr/early May

Early June

Late June
1. Plant cover crop in corn
2. Harvest corn over cover crop
3. Cover crop lies dormant
4. Plant soybean into cover crop
5. Harvest cover over soybean
6. Summer crop grows
Establishment in Corn

- Planting methods
- Planting date and seeding rate
- Effect of residue after harvest
Dual Crop Winter Camelina and Soybean

Morris, MN 2010 and 2011

Seed yield (Mg ha⁻¹)

- **Camelina**
  - DC-Soy: 23 bu/a
  - Swath-DC-Soy: 27 bu/a
  - Relay-Soy-NR: 39 bu/a
  - Relay-Soy-YR: 42 bu/a
  - Mono-Soy: 50 bu/a

- **Soybean**

Oil yield (Gal acre⁻¹)

- **Camelina**
  - DC-Soy
  - Swath-DC-Soy
  - Relay-Soy-NR
  - Relay-Soy-YR
  - Mono-Soy

- **Soybean**

Dual crop treatments

Cropping treatment
## Economics – Dual Cropping with Camelina

<table>
<thead>
<tr>
<th>Cropping treatment</th>
<th>Total APV</th>
<th>Net APV</th>
<th>Total gross income</th>
<th>Net return</th>
<th>Breakeven camelina price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\text{acre}^{-1}$</td>
<td></td>
<td>$\text{lb}^{-1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double crop</td>
<td>542 c</td>
<td>266 b</td>
<td>467 c</td>
<td>190 b</td>
<td>0.45</td>
</tr>
<tr>
<td>Swath/Double crop</td>
<td>621 b</td>
<td>326 b</td>
<td>541 b</td>
<td>247 b</td>
<td>0.38</td>
</tr>
<tr>
<td>Relay/no glyphosate</td>
<td>750 a</td>
<td>482 a</td>
<td>650 a</td>
<td>383 a</td>
<td>0.26</td>
</tr>
<tr>
<td>Relay/use glyphosate</td>
<td>798 a</td>
<td>521 a</td>
<td>697 a</td>
<td>420 a</td>
<td>0.21</td>
</tr>
<tr>
<td>Full-season soybean</td>
<td>630 b</td>
<td>480 a</td>
<td>576 b</td>
<td>426 a</td>
<td>NA</td>
</tr>
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</table>

APV = Approximate processed value = Estimate of the total product value to an oilseed crusher.
## Growing Season Water Use

Precipitation + Soil Water Storage – 2010-2011

<table>
<thead>
<tr>
<th>Cropping Treatment</th>
<th>Season total</th>
<th>Water Use (inches)</th>
<th>WUE (lb/acre/inch)</th>
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<tr>
<td></td>
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<td>Camelina</td>
<td>Soybean</td>
</tr>
<tr>
<td><strong>Double Crop</strong></td>
<td>19.8 a</td>
<td>4.5</td>
<td>15.3 b</td>
</tr>
<tr>
<td><strong>Swath/double crop</strong></td>
<td>19.0 b</td>
<td>3.8</td>
<td>15.2 b</td>
</tr>
<tr>
<td><strong>Relay/use glyphosate</strong></td>
<td>19.1 ab</td>
<td>3.9</td>
<td>15.2 b</td>
</tr>
<tr>
<td><strong>Relay/no glyphosate</strong></td>
<td>19.4 ab</td>
<td>4.8</td>
<td>14.6 b</td>
</tr>
<tr>
<td><strong>Full-season soybean</strong></td>
<td>18.3 c</td>
<td>NA</td>
<td>18.3 a</td>
</tr>
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</table>

Growing Season Water Use

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<tr>
<td><strong>Full-season soybean</strong></td>
<td>18.3 c</td>
<td>NA</td>
<td>18.3 a</td>
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</table>
## Dual Cropping Camelina-Forage Sorghum (2012-2013)

<table>
<thead>
<tr>
<th>Cropping treatment</th>
<th>Morris, MN</th>
<th>Prosper, ND</th>
<th>Carrington, ND</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-Sorghum</td>
<td>3.2 c</td>
<td>2.1 c</td>
<td>0.9 c</td>
</tr>
<tr>
<td>Relay-Sorghum</td>
<td>4.6 b</td>
<td>4.4 bc</td>
<td>1.4 c</td>
</tr>
<tr>
<td>Sorghum-DSD</td>
<td>4.5 b</td>
<td>5.6 b</td>
<td>2.6 b</td>
</tr>
<tr>
<td>Sorghum-NSD</td>
<td>7.6 a</td>
<td>8.0 a</td>
<td>4.2 a</td>
</tr>
</tbody>
</table>

Annual Precip. inches: 26, 23, 20

*We have also successfully double cropped millet and sunflower following winter camelina*
Ecosystem Services Provided by Winter Annual Oilseed Crops
Retention of N & P in Cropping Systems and Water Quality

Cover crops = winter rye, tillage radish, winter camelina, and pennycress (no-till wheat & conv. till) - The primary crop is soybean
Pennycress

Planted (Winter Cover) -> Harvested

Soybean

Planted Harvested

August
September
October
November
December
January
February
March
April
May
June
July
August
September

Camelina

Planted (Winter Cover) -> Harvested

Soybean

Planted Harvested

Winter Rye

Planted (Winter Cover) -> Chemical Killed

Soybean

Planted Harvested

Tillage Radish

Planted Winter Killed

Soybean

Planted Harvested

No-till and Conventional-till Fallow

Planted

Soybean

Planted Harvested

Controls
Soil NO$_3$-N Content in Morris (0-12” depth)

### 29 October 2014

- Radish: c
- Winter Rye: bc
- Pennycress: bc
- Camelina: c
- Tilled: ab
- No-Till: a

### 17 April 2015

- Radish
- Winter Rye
- Pennycress
- Camelina
- Tilled
- No-Till
Biomass N Content

29 October 2014

<table>
<thead>
<tr>
<th>Plant</th>
<th>N (Lbs/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camelina</td>
<td>bc</td>
</tr>
<tr>
<td>Pennycress</td>
<td>c</td>
</tr>
<tr>
<td>Radish</td>
<td>ab</td>
</tr>
<tr>
<td>Rye</td>
<td>a</td>
</tr>
</tbody>
</table>

17 April 2015

<table>
<thead>
<tr>
<th>Plant</th>
<th>N (Lbs/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camelina</td>
<td>b</td>
</tr>
<tr>
<td>Pennycress</td>
<td>a</td>
</tr>
<tr>
<td>Rye</td>
<td>b</td>
</tr>
</tbody>
</table>
### Spring Water Erosion

#### Runoff Water Samples, 17 May 2015

<table>
<thead>
<tr>
<th>Rye</th>
<th>Pennycress</th>
<th>Camelina</th>
<th>No Till</th>
<th>Tilled</th>
<th>Radish</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="Image1" alt="Sample Image" /></td>
<td><img src="Image2" alt="Sample Image" /></td>
<td><img src="Image3" alt="Sample Image" /></td>
<td><img src="Image4" alt="Sample Image" /></td>
<td><img src="Image5" alt="Sample Image" /></td>
<td><img src="Image6" alt="Sample Image" /></td>
</tr>
</tbody>
</table>
Weed Control Provided by Winter Oilseeds

**Early June**

<table>
<thead>
<tr>
<th>Experiment site</th>
<th>Pennycress seeding rate</th>
<th>Weed biomass g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 lbs/acre</td>
<td>6 lbs/acre</td>
</tr>
<tr>
<td>Rosemount MN</td>
<td>97.7 a</td>
<td>4.4 b</td>
</tr>
<tr>
<td>Lamberton MN</td>
<td>38.9 a</td>
<td>6.3 b</td>
</tr>
<tr>
<td>Waseca MN</td>
<td>74.6 a</td>
<td>1.4 b</td>
</tr>
</tbody>
</table>

Honey bees are big business in Minnesota

132,000 hives and 8 million lbs of honey in 2014

Eagle Bend, MN
Trucks haul many thousands of transient colonies of honey bees back to Minnesota from the West and Gulf Coasts in spring. At that time there is little for the bees to eat.
Pennycress flowers attract honey bees and provide much needed nectar in early spring.

Camelina flowers attract bees and syrphid flies. Fly larvae voraciously eat soybean aphids.

Figure 2. Pennycress and winter camelina attract pollinators during anthesis. Bees, including honey bees and bumble bees, use these resources, as do syrphid flies. The “Other” category includes butterflies and beetles.
Camelina Cover Crops a Boon for Bees

November 25, 2015 | Posted in Cover Crops, Water Management

Source: USDA-Agricultural Research Service

Once considered a weed, camelina is finding favor in some parts of the country as a soil-protecting winter cover crop…

Link to article http://www.no-tillfarmer.com/articles/5246-camelina-cover-crops-a-boon-for-bees
Summary

• Winter oilseeds WC & PC can serve as cash cover crops while helping to diversify cropping systems
• Dual cropping winter oilseeds can fit in corn-soybean-small grain systems and is economically viable
• Dual cropping winter oilseeds is a way to sustainably intensify crop production and produce bioenergy without loss of food security.
• WC & PC as cover crops provide ecosystem services
  – Sequester N & P
  – Prevent soil erosion
  – Control weeds
  – Provide habitat and nutrition for pollinators and other beneficial insects