Cropping system diversification for yield, profit and environmental health

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IL: 15 Mha
60% in m/sb

IA: 14.6 Mha
66% in m/sb

IN: 9.4 Mha
50% in m/sb
Annual efflux of N into streams in Mississippi River drainage basin (1980-1996)

EXPLANATION
Yield, in kilograms per square kilometer per year
- Less than 200
- 201 to 500
- 501 to 1,000
- 1,001 to 1,800
- 1,801 to 3,050

Goolsby et al. 1999
Farm-scale crop diversity has declined over time,
So has landscape scale crop diversity
Data source: USDA-NASS, 2016
Some types of diversity in agroecosystems

• Crop species diversity
  – temporal
  – spatial

• Genetic diversity
  – individual: breeding, conservation
  – population: multi-lines

• Management diversity

• Non-crop species diversity

• Landscape-level diversity
Cropping system diversification: both spp. and mgt diversity

crop rotation, integrated crop-livestock production

agroforestry

intercropping
Potential ecosystem services from cropping system diversification

Diversity-productivity

Resource partitioning
- spatial, temporal
e.g. nutrient type, depth

Mutualisms

Soil health/quality

Multiple stresses for pest control

Tilman et al. 2006
Landscape-scale complementarity

potato/grain (N-poor/C-rich)

dairy (N-rich/C-poor)

Diversity partners

Mallory et al. (2010)
In order to escape build-up of late blight (Phytophora Infestans), Dutch potato producers must follow a 10+ yr rotation away from home field. Some are rotating themselves and equipment across the landscape.
No market? Make your own

Central IL farmer (E. Rund) added perennial bioenergy crops to farming operation

1. Researched production BMPs
2. Visited with other growers (EU)
3. Used BCAP to cover conversion
Increasing diversity on your farm

• Identify main objectives

• Identify resources

• Identify obstacles

• Start small

• Be creative!
How did we get here? Do we have a choice?
Marsden Farm study
(2002- present; Dr. Matt Liebman, PI)

**Central hypothesis:** cropping system diversification will promote development of ecosystem services over time, supplementing or eventually displacing role of synthetic inputs in promoting crop productivity and profitability
Experimental design

<table>
<thead>
<tr>
<th>rotation length</th>
<th>crop sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 yr</td>
<td>m-s</td>
</tr>
<tr>
<td>3 yr</td>
<td>m-s-o/r</td>
</tr>
<tr>
<td>4 yr</td>
<td>m-s-o/a-a</td>
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</tbody>
</table>
Crop management

• Maize and soybean:
  – cultivars: both GE and non-GE maize and sb cult. used after 2005; same genetic background
  – Seeds ha\(^{-1}\): m 79.5K, sb 395K
  – 76 cm row spacing

• Small grains
  – 3yr: triticale through ‘05, oat thereafter; 4yr: oat (IN09201) 2003-2011
  – drilled in early spring; underseeded with red clover (3) or alfalfa (4)

• Forage legumes
  – red clover: Cherokee; 13 kg seed ha\(^{-1}\); disked in as green manure
  – alfalfa: FSG 300LH; 17 kg seed ha\(^{-1}\); baled for forage
Soil fertility management

• 2 yr: NPK applied at maize planting based on soil test recommendations; sb: P&K sidedressed

• 3 & 4 yr:
  – Inorganic fertilizers: LSNT to guide sidedress N in maize phase; P & K from compost
  – Organic amendments:
    • forage legume residues disked in before maize
    • 8.3 Mg ha⁻¹ (dry wt.) composted beef manure added in October of each year to red clover (3) or established alfalfa (4)
Weed Management

• Rates and MOA based on weed community, population density and size of weeds in plots

• 2 yr: POST herbicide applications, full row width

• 3 & 4 yr:
  – POST herbicide banded over row (38 cm band) in m & sb
  – interrow cultivation in m & sb
  – no weed control in small grain or forage legume
System: P < 0.05
1df: (3 & 4) > 2, p = 0.03
4% greater
System: $P < 0.05$
1df: $(3 \& 4) > 2, p = 0.01$
11% greater
Soybean sudden death syndrome, 2010:

2 yr: 27-97% infected
3 & 4: < 9% infected

Photo: D. Sundberg
System: $P < 0.0001$

1df: $(3 \& 4) < 2$, $p < 0.0001$

~50\% \text{ less}
N fertilizer inputs (kg N ha$^{-1}$ yr$^{-1}$)

Rotation length (years)
- 2
- 3
- 4

System: $P < 0.001$
1df: (3 & 4) < 2, $p = 0.005$
*difference increased over time*
Herbicide inputs (kg a.i. ha\(^{-1}\) yr\(^{-1}\))

**System:** $P < 0.0001$

1df: (3 & 4) < 2, $p < 0.0001$

*difference increased over time*

Davis et al. 2012 PLOS ONE 7(10): e47149
Overall impact

Year 4 soybean

Year 3 oat/forage legume

Year 2 soybean

Year 1 corn

Overall impact

Month of the year

- Herbicide application
- Tillage or cultivation
- Row closure by canopy
- Mowing and forage removal

after Liebman and Staver, 2001
Disruption of weed life cycles

- **summer annual crop**
- **winter annual crop**
- **perennial/biennial crop**

Seasonal cycles:
- Summer annual (May to September)
- Winter annual (November to February)
- Perennial/biennial (March to April)
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