Rotations for the Northern Plains

Don Tanaka and Mark Liebig
USDA-ARS
Mandan, ND

Manitoba-North Dakota Zero Tillage Farmers Association
34th Annual Zero Till Workshop & Trade Show
10 January 2012

Overview

• Crop rotations in context

• Principles of sustainable crop sequencing

• Case study results from the Area IV SCD Cooperative Research Farm
Crop Rotations in the Northern Plains
Pre-European Settlement

• Mandan, Hidatsa, Arikara
  – Corn, bean, and squash (Three Sisters); sunflower, tobacco

• Strategies for success
  – Diversity
  – Recycling
  – Limited cultivation
  – Moisture conservation
  – Regional adaptation

Kirschenmann, 2010
Crop Rotations in the Northern Plains
Post-European Settlement
Crop Rotations in the Northern Plains

• Crop portfolio: Flax, spring wheat, barley, oat, corn, alfalfa, bromegrass, potato...
  – Moisture retention a significant issue.
  – Erosion; Fertility depletion

“Crop growing is hazardous in regions of limited rainfall... ...The country is better adapted to a mixed type of farming than to straight grain farming.” (Page 72)
Crop Rotations in the Northern Plains

- Spring wheat – fallow
  - Water-use efficiency ≤40%
  - Declining soil health

--- Weed and Residue Management Technology ---

- Opportunity/Flex crop rotations
- Annual sequencing
  - Fixed or dynamic
Crop Rotations in the Northern Plains

• **Fixed sequencing**
  – Limited flexibility to address challenges/opportunities
  – Can lead to weed, insect, and disease infestations over time

• **Dynamic sequencing**
  – Decisions made annually based on externalities as well as management goals
<table>
<thead>
<tr>
<th>From Hanson et al. (2007)</th>
<th><strong>Monoculture</strong></th>
<th><strong>Fixed-Sequence Rotations</strong></th>
<th><strong>Dynamic Cropping Systems</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop portfolio</strong></td>
<td>Single crop</td>
<td>Multiple crops; number</td>
<td>Multiple crops; number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dependent on regionally</td>
<td>dependent on regionally</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adapted species, economics,</td>
<td>adapted species, economics,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>farmer knowledge,</td>
<td>farmer knowledge,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>infrastructure</td>
<td>infrastructure</td>
</tr>
<tr>
<td><strong>Crop diversity</strong></td>
<td>N/A</td>
<td>Diversity dependent upon</td>
<td>Diversity inherently high</td>
</tr>
<tr>
<td></td>
<td></td>
<td>length of fixed sequence</td>
<td>due to annual variation in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>growing conditions and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>marketing opportunities,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>as well as changes in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>producer goals</td>
</tr>
<tr>
<td><strong>Crop sequencing</strong></td>
<td>N/A</td>
<td>None, although fixed-sequence</td>
<td>High. All crops, in essence,</td>
</tr>
<tr>
<td>flexibility</td>
<td></td>
<td>cropping systems that</td>
<td>are opportunity crops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>incorporate opportunity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>crops increase flexibility</td>
<td></td>
</tr>
<tr>
<td><strong>Biological and</strong></td>
<td>Basic knowledge</td>
<td>Some knowledge of crop</td>
<td>Extended knowledge of</td>
</tr>
<tr>
<td><strong>ecological</strong></td>
<td>of agronomy</td>
<td>interactions is necessary</td>
<td>complex, multi-year crop</td>
</tr>
<tr>
<td>knowledge</td>
<td></td>
<td></td>
<td>and crop by environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>interactions</td>
</tr>
<tr>
<td><strong>Management complexity</strong></td>
<td>Generally low,</td>
<td>Complexity variable</td>
<td>Complexity inherently high</td>
</tr>
<tr>
<td></td>
<td>though variable</td>
<td>depending on length of</td>
<td>due to annual variation in</td>
</tr>
<tr>
<td></td>
<td>depending on</td>
<td>fixed sequence and</td>
<td>growing conditions, markets,</td>
</tr>
<tr>
<td></td>
<td>crop type</td>
<td>diversity of crops grown</td>
<td>and producer goals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dynamic Cropping Systems

Develop crop portfolio

Assess short-term sequencing effects

Evaluate long-term viability
Objective

Illustrate crop rotation principles for field-scale grain production systems over a ten year period (2001-2010).
Location

- SW of Mandan, ND
- Area IV SCD Cooperative Research Farm (1984-present)
- Four quarter sections (F, G, H, I)
- Approximately 400 acres.
Soil and Landscape

- Evaluations were conducted on a nearly level (0-3% slope) Temvik-Wilton silt loam.
- The Temvik-Wilton series consists of very deep, well drained soils that formed in a silty loess mantle overlying glacial till.
- Fine-silty, mixed, superactive, frigid Typic and Pachic Haplustolls
Growing Season Precipitation

<table>
<thead>
<tr>
<th>Month</th>
<th>2001-2010</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>2.47</td>
<td>2.25</td>
</tr>
<tr>
<td>June</td>
<td>3.20</td>
<td>3.33</td>
</tr>
<tr>
<td>July</td>
<td>2.71</td>
<td>2.56</td>
</tr>
<tr>
<td>August</td>
<td>1.41</td>
<td>1.79</td>
</tr>
<tr>
<td>Total</td>
<td>9.79</td>
<td>9.93</td>
</tr>
</tbody>
</table>
Field Management

- No-till management
- 750, 7340 JD seeders
- Weed control via pre- and post-emergent herbicide
- N and P adjusted to crop need and residual fertility.
Cropping Systems

Cereal crop – Fallow

(2 yr system, G4 & G3)

26 yrs
Crop – Fallow System

Area G

G2

G3
spring wheat
13 a

G4
fallow
17.7 a

180 Seed Sources from Great Plains Region

GSA
Hackberry Provenience Test 1990

G5B Siberian Elm

Tree Breeding

240 Hybrid Poplar and Cottonwood Clones ('83)

1.1 a

1.3 a
Cropping Systems

Continuous spring wheat
(monoculture, I1)

26 yrs
Continuous Wheat

Area I

- I1
- I2
- I3
- I4
- I5
- I6
- I7

Rain Gauge

Weather Station

Dimensions:
- I1: 5.3 a
- I2: 11.4 a
- I3: 11.3 a
- I4: 11.2 a
- I5: 15.8 a
- I6: ~14 a
- I7: 44.3 a
- 11.4 a
- 11.3 a
- 22.0 a
- 27.0 a

Location:
NE ¼ Section 20 T138N R81W
Cropping Systems

Spring cereal - winter wheat - sunflower
(3 yr system; F3, F2, F4 and I4, I5, I6)
26 yrs
3 Year System

Area F

- F1
- F2: winter wheat 19.7 a
- F3: spring wheat 23 a
- F4: sunflower 18.9 a

- Weather Station
- Rain Gauge

Area I

- Weather Station
- Rain Gauge

<table>
<thead>
<tr>
<th></th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>I5</th>
<th>I6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>spring wheat</td>
<td>11.2 a</td>
<td>winter wheat</td>
<td>15.8 a</td>
<td>sunflower</td>
<td>~14 a</td>
</tr>
<tr>
<td>I7</td>
<td>44.3 a</td>
<td>11.4 a</td>
<td>11.3 a</td>
<td>22.0 a</td>
<td>27.0 a</td>
<td></td>
</tr>
</tbody>
</table>
Cropping Systems

Spring cereal - winter wheat - dry pea - corn - soybean

(5 yr system; H4, H2)

5 yrs
5 Year System

Area H

H1: 28.5 a

H2: 48.9 a
  - spring wheat: 5.2 a

H3: ~20 a

H4: 20.0 a
  - winter wheat: 5.0 a
  - corn: 5.0 a
  - soybean: 5.0 a
  - dry pea: 5.0 a

Weather Station:
- H1: 28.5 a
- H2: 48.9 a
- H3: ~20 a
- H4: 20.0 a

Plants:
- dry pea
- corn
- soybean
- spring wheat
- winter wheat
Cropping Systems

Dynamic Cropping System
(long-term systems; H1, H3, F5, F6, G2, I2, I3, I7)
10 yrs
Used spring wheat as indicator crop
10 yr (2001-2010)
Spring wheat average yield

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>Yield (bu/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-F</td>
<td>38.6</td>
</tr>
<tr>
<td>Continuous</td>
<td>34.4</td>
</tr>
<tr>
<td>3-yr system</td>
<td>32.0</td>
</tr>
<tr>
<td>5-yr system</td>
<td>32.9</td>
</tr>
<tr>
<td>Dynamic</td>
<td>38.3</td>
</tr>
</tbody>
</table>
Precipitation Use Efficiency

PUE = seed yield / precipitation
(from harvest of previous crop to the harvest of current crop)
Units: lbs/ac/inch of precipitation
PUE of each system

C-F: 100.7
Continuous: 136.2
3-yr system: 141.4
5-yr system: 138.1
Dynamic: 162.5

PUE (lb/ac/in)

36-41% increase to 62% increase

Cropping System
Summary

• Cropping systems need to be greater than 3-yr to take advantage of crop diversity.
Continuous spring wheat might produce yield as great as diverse cropping systems, but require greater management inputs.
Among continuous cropping options, Dynamic Cropping Systems provide opportunity for greatest diversity, yield stability, and precipitation use efficiency.
Acknowledgments

• Don Tanaka, Robert Kolberg, Marv Hatzenbuhler et al.

• Supervisors of the Area IV SCD Cooperative Research Farm
Thank You

Northern Great Plains Research Laboratory
USDA-ARS, Mandan, ND
http://www.mandan.ars.usda.gov/