Planning for Flexibility in Effective Vegetable Crop Rotations

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Outline

- Introductory comments
- What we learned from the farmers
- Tools for crop rotation planning
- Basics of a planning procedure
- Managing pests and weeds with rotation
Crop rotation defined by NOP

The practice of alternating the annual crops grown on a specific field in a planned pattern or sequence in successive crop years so that crops of the same species or family are not grown repeatedly without interruption on the same field.
Crop rotation is always a good idea
- Critical for managing disease
- Nutrients
- Weeds
- Building soil quality
- [Insects]
Crop rotation can be incredibly complicated

- Large variation in acreage among crops
- Some crops are in the ground more than one year
- Multiple plantings of some crops
- Some crops can only be grown on certain fields
- Cover crops between cash crops
NEON: Northeast Organic Network

- Rotation planner project was part of NEON
- Large, 3 year, regional collaborative project funded by USDA.
- Researchers, farmers, farmer organizations, non-profits.
Started by asking expert farmers how they plan crop rotations

- 12 peer nominated exemplary farmers
- Put them in a room for 3 days
- Formal information extraction process
  - DACUM = Develop A Curriculum
  - Originally devised for developing training manuals for industry

The New England Small Farm Institute
- Sue Ellen Johnson, Eric Toensmeier
The farmers
None of the 12 farmers develop long term rotation plans
– Forward planning horizon is 12 to 18 months

They have a crop mix – amounts of each crop that they want to grow

They look at each field (bed) history, field characteristics, and place the most appropriate crop on that spot.

They usually have a plan for the next cover crop and the next cash crop after that
The reason:
Long-term plans always get derailed

- Weather conditions may delay planting or wipe out a crop and necessitate a substitute crop
- Market conditions change
- Labor supply may not be as expected
However...

Some did their ad hoc placement within the context of a larger scheme

– Drew Norman: 2-3 years in vegetables, then a 2-3 years in hay
Some other farms studied by NEON used general rotation schemes as well

- Eric and Anne Nordell in N PA
- Have 12 half-acre strips. Sequence repeats 3 times
- Ad hoc placement of crops within strips.
Crop Rotation on Organic Farms: a Planning Manual

CH 1. Introduction (CLM)
CH 2. How expert farmers manage crop rotations (SEJ)
CH 3. Biological and physical processes in crop rotation (Various)
CH 4. Example crop rotations (SEJ)
CH 5. A crop rotation planning procedure (CLM)
CH 6. Crop rotation during transition from conventional agriculture (CLM)
CH 7. Crop rotation and intercropping (CLM and Kim Stoner)
Reference Tables
Appendix tables

- Crop characteristics
- Crop sequence problems and opportunities
- Sources of inoculum for crop diseases
- Weed characteristics relevant to crop rotation
- Crop diseases hosted by weeds
- Method for creating a field map in Excel
<table>
<thead>
<tr>
<th>Following:</th>
<th>Pea</th>
<th>Lettuce</th>
<th>Potato</th>
<th>Tomato</th>
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</thead>
<tbody>
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<td>XXXX</td>
<td>D, C-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce</td>
<td>D</td>
<td>XXXX</td>
<td>D</td>
<td>D, C-</td>
</tr>
<tr>
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<td>D, I</td>
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<td></td>
</tr>
</tbody>
</table>

D, I, W, C, N, S
Crop Rotation on Organic Farms: a Planning Manual

- Purchase book: PALS Publishing
  http://palspublishing.cals.cornell.edu/

- Free download:
  http://www.sare.org/Learning-Center/Books/Crop-Rotation-on-Organic-Farms
Planning procedure

Purpose is not to tell the farmer what to do

Purpose is

- to help farmer organize information
- to make decisions in an orderly series of steps
- to facilitate checking for problems

Goal: let anyone develop a plan that is as good as a really smart, experienced grower would produce.
Step 1 – Rotation goals

- Choose rotation goals
- Prioritize goals
  - Avoid soil-borne disease
  - Grow N-fixing cover crops
  - Suppress weeds
Step 2 – Do I want a general plan?

“Simple” operation

- Rest years
- Low variation in acreage among crops
- Few crops
- One cash crop/year
- Minor variation in soils, topography etc.

Focus on a general plan

“Complex” operation

- Continuous cropping
- High variation in acreage among crops
- Many crops
- Multiple cropping
- Much variation in soils, topography etc.

Focus on crop sequencing
Write down the crop mix

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
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<tbody>
<tr>
<td>Turnips</td>
<td>20</td>
</tr>
<tr>
<td>Beets</td>
<td>10</td>
</tr>
<tr>
<td>Carrots</td>
<td>30</td>
</tr>
<tr>
<td>Peas</td>
<td>20</td>
</tr>
<tr>
<td>Broccoli</td>
<td>20</td>
</tr>
</tbody>
</table>
Check family return times

Nightshades have 10 A out of 30 A in production.

30/10 = 3

On average, a field will have a nightshade one year out of every 3 years

Disease risk!

Try for return times of at least 4 years for all families (except grasses)

<table>
<thead>
<tr>
<th>Plant Family</th>
<th>Return Times</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Onion</td>
<td>3</td>
<td>Lilly</td>
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<tr>
<td>Potato</td>
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<tr>
<td>Tomato</td>
<td>3</td>
<td>Nightsh.</td>
</tr>
<tr>
<td>Lettuce</td>
<td>6</td>
<td>Aster</td>
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<tr>
<td>Pepper</td>
<td>2</td>
<td>Nightsh.</td>
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<tr>
<td>W. squash</td>
<td>4</td>
<td>Cucurb.</td>
</tr>
<tr>
<td>S. squash</td>
<td>4</td>
<td>Cucurb.</td>
</tr>
<tr>
<td>Brassicas</td>
<td>6</td>
<td>Brassica</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td></td>
</tr>
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</table>
Make a crop rotation planning map

- Equal area planning units
- Identify characteristics of each unit
Make a table

For each management unit:
- List critical characteristics
- Crops for last 3 years
## Example planning table

<table>
<thead>
<tr>
<th>MU</th>
<th>Char</th>
<th>Three summers ago</th>
<th>Two winters ago</th>
<th>Two summers ago</th>
<th>Last winter</th>
<th>Last summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>early</td>
<td>Kohlrabi/buckwheat</td>
<td>Oat</td>
<td>Pea/Sorgh-sud</td>
<td>Oat</td>
<td>Carrot</td>
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<tr>
<td>10</td>
<td>early</td>
<td>Beet 5/buckwheat</td>
<td>Oat</td>
<td>Pea/Sorgh-sud</td>
<td>Oat</td>
<td>Carrot</td>
</tr>
<tr>
<td>11</td>
<td>Pepper</td>
<td></td>
<td>Oat</td>
<td>S. Squash</td>
<td>Oat</td>
<td>Pea/Sorgh-sud</td>
</tr>
<tr>
<td>12</td>
<td>Pepper</td>
<td></td>
<td>Oat</td>
<td>S. Squash</td>
<td>Oat</td>
<td>Pea/Sorgh-sud</td>
</tr>
</tbody>
</table>
Sort the management units

1. put MU’s with similar *critical* field conditions together
2. put MU’s with similar histories together
Plan future crop sequences – write crops onto the planning sheet

- Next summer
  - Cash crops already in the ground
  - Families that are close to the maximum allowable return time
  - High value crops that require special field conditions
  - Other valuable crops that grow anywhere
  - Less valuable crops that require special conditions
  - Less valuable crops that grow anywhere
### Section 1

<table>
<thead>
<tr>
<th></th>
<th>1st Peas</th>
<th>1st Peas</th>
<th>1st Peas</th>
<th>1st Peas</th>
<th>2nd Peas</th>
<th>2nd Peas</th>
<th>2nd Peas</th>
<th>5.8 bu/bed</th>
<th>44.8 bu</th>
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### Section 2

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<th>3rd Peas</th>
<th>3rd Peas</th>
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<th>44.8 bu</th>
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<td>CURRENT PLANTING</td>
<td>DATE</td>
<td>SECOND PLANTING</td>
<td>DATE</td>
<td>COVER CROP</td>
<td>DATE</td>
<td></td>
<td></td>
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<td>Lettuce 15</td>
<td>23-Jul</td>
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<tr>
<td>3 Total</td>
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<td>2nd Peas</td>
<td>2-Apr</td>
<td>Lettuce 17</td>
<td>6-Aug</td>
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<td>30-Jul</td>
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<td>Spinach 21</td>
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<td>3 Total</td>
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<tr>
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<td>23-Apr</td>
<td>Lettuce 21</td>
<td>3-Sep</td>
<td>none</td>
<td></td>
<td></td>
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<td>Scallion 2</td>
<td>23-Apr</td>
<td>Lettuce 21</td>
<td>3-Sep</td>
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<td>3rd Peas</td>
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<td>Lettuce 21</td>
<td>3-Sep</td>
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<td>3rd Peas</td>
<td>9-Apr</td>
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<td>3rd Peas</td>
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<td>Lettuce 20</td>
<td>27-Aug</td>
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<td>3rd Peas</td>
<td>9-Apr</td>
<td>Lettuce 20</td>
<td>27-Aug</td>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Future years

- Check next summer’s crop, mix
- Plan two summers from now
- Now go back and fill in cover crops between next summer and 2 summers from now
Put plans on maps and walk

- Put the plans on maps, one map per year
- Take the maps to the field – take notes
  - “Farm the land in your head”
- What could go wrong?
  - Note contingency plans!
An ecological perspective on rotation and pest management

- **Annual crops**
  - First year of ecological succession
  - Crop is at outbreak density & abundance

- Annual plants in nature escape by being unpredictable in space and time

- If we grow the same species repeatedly, in a field
  - then it isn’t unpredictable
  - And it gets hammered

- Meanwhile weeds are moving in to drive succession forward
Rotation can’t solve all problems

<table>
<thead>
<tr>
<th>Pest</th>
<th>agent</th>
<th>Rotation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato bacterial spot</td>
<td>Xanthomonas campestris pv. vesicatoria</td>
<td>Y (1-3)</td>
<td>seed borne</td>
</tr>
<tr>
<td>Club root</td>
<td>Plasmodiophora brassicae</td>
<td>Y (7)</td>
<td>weeds</td>
</tr>
<tr>
<td>Damping off</td>
<td>Pythium spp.</td>
<td>N</td>
<td>saprobe</td>
</tr>
<tr>
<td>Late blight</td>
<td>Phytophthora infestans</td>
<td>N</td>
<td>wind blown</td>
</tr>
<tr>
<td>Corn root worm</td>
<td>Diabrotica spp.</td>
<td>Y</td>
<td>life cycle</td>
</tr>
<tr>
<td>Imported cabbageworm</td>
<td>Pieris rapae</td>
<td>N</td>
<td>good flyer</td>
</tr>
</tbody>
</table>
Crop rotation for weed control

- Multi-year tactics.
- Often involves manipulation of the weed seed bank.
- Requires integration with tillage practices.
Tilled fallow

- Tillage promotes weed seed germination.
  - Firm seed bed
- Then shallowly till again to kill weeds
- Repeat.
- Plant
Follow weedy crops with crops that are easy to keep weeded. This allows depletion of the seed bank built up in the previous year.

![Weed Seedbank, System 1, Entry Point 2](chart)

- **Lambsquarters**
- **Pigweed**
- **Chickweed**
- **Total Weeds**

Weed Seeds per Square Foot

- 2005
- 2006
- 2007
- 2008
Rotate between crops with different seasonality

Spring planted

Early summer planted

Mid-summer planted
Work cover crops into the rotation

- Sow heavy for best weed suppression.
- Winter cover can suppress quackgrass

Rye and hairy vetch
Avoid cover crops that cause weed problems

Example: hairy vetch can be a bad weed in wheat.
Rotate annuals with sod crops

- Repeated mowing depletes perennial weeds
- Annuals can’t reproduce so seed bank declines
Conclusions – lots of aspects to good rotation planning

- Several ways to use the book
- Reference
  - Basic principles and concepts of crop rotation
  - Look up information
- Inspiration – what do other farmers do
- Systematic planning too
Contact information

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- Cornell university
- Ithaca NY 14853