Using Cover Crop Mixtures to Achieve Multiple Goals on the Farm

Penn State Cover Crop Cocktails Research
J. LaChance, M. Hunter, J. Hinds, C. White

Guidelines for cover crop mixtures:

1. **Weeds**: Have 1-2 species that provide fast ground-cover in the fall, then add species to achieve other goals
2. **Insects**: To support beneficial insects for pollination or biological control, manage mixtures to include flowers
3. **Nitrogen**: Combine a well-adapted legume with a low seeding rate of a winterhardy grass or brassica
4. **Overall**: Aim for balanced biomass from all species in the mix to benefit from a range of functions

Farmer use of mixtures aligns with ecological theory

Adapted from Hooper et al. 2005
Winter Cover Crop Mixtures in Pennsylvania

Cover Crop Mixtures in a Corn-Soy-Wheat Rotation for Organic Feed and Forage

An example with six cover crop species
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**3-Species Nitrogen Mix = 3sppN**

Goal: Supply and retain N

- **Red Clover**
  - 50% rate
- **Austrian Winter Pea**
  - 50% rate
- **Cereal Rye**
  - 20% rate

3 Species Nitrogen Mix (3sppN)
- Austrian Winter Pea (35#)
- Red Clover (6#)
- Cereal Rye (28#)

69lb, $51/A

**Goal:**
- Supply and retain N

**3-Species Weed Mix = 3sppW**

Goal: Suppress weeds and supply and retain N

- **Cereal Rye**
  - 50% rate
- **Oats**
  - 50% rate
- **Red Clover**
  - 50% rate

3 Species Weed (3sppW)
- Oats (50#)
- R.Clover (6#)
- Rye (71#)

127lb, $58/A

**Goal:**
- Supply and retain N

**4-Species Mix = 4spp**

Goal: Support pollinators & beneficial insects, suppress weeds and manage N

- **Canola**
  - 50% rate
- **Pea**
  - 50% rate
- **Red Clover**
  - 20% rate
- **Cereal Rye**
  - 20% rate

4 Species (4spp)
- Canola (9#)
- Pea (35#)
- R. Clover (6#)
- Rye (28#)

78lb, $77/A

**Goal:**
- Support pollinators & beneficial insects, suppress weeds and manage N
6-Species Mix = 6spp
Goal: The “Insurance” Mix

- Radish (4#)
- Winter Pea (1.8#)
- Oat (25#)
- Red Clover (3#)
- Canola (4#)
- Cereal Rye (28#)

82lb, $70/A

Adapted from Hooper et al. 2005

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Fall Cover Crop Biomass
Poor red clover establishment in cover crop mixtures

Dry Biomass (lbs per Acre)

- Pea
- Clover
- Canola
- Radish
- Oat
- Cereal Rye

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Spring Cover Crop Biomass
If planted after corn, then spring biomass is nearly 100% rye

Dry Biomass (lbs per Acre)

- Red Clover
- Pea
- Canola
- Cereal Rye
The Same “4 Species Mix” Varies by Farm

<table>
<thead>
<tr>
<th>Research Station</th>
<th>Farm 1</th>
<th>Farm 2</th>
<th>Farm 3</th>
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</thead>
<tbody>
<tr>
<td>Low N</td>
<td></td>
<td>Canola dominated</td>
<td></td>
</tr>
<tr>
<td>High N</td>
<td></td>
<td>Canola dominated</td>
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</tr>
<tr>
<td>High N</td>
<td></td>
<td>Canola dominated</td>
<td></td>
</tr>
<tr>
<td>Moderate N</td>
<td></td>
<td>Canola dominated</td>
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</tbody>
</table>

Can mixtures achieve multiple goals on the farm?
1. Weed suppression and management
2. Beneficial insects
3. Nitrogen management

Weed Management with Cover Crop Mixtures

Mitch Hunter
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Weed Management Goals:
• Keep weeds from setting seed
• Grow cover crops, not weeds
  – Get the benefits you paid for
• Bonus: Draw down the weed seedbank

Weed Management Questions:
• Which cover crops work best?
• Do mixtures help?
• How do cover crops suppress weeds?

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Canola Oat Radish 3SppN 4Spp

Spring Weed Biomass (lb/ac)

Yrs 1−2 Spring Weed Biomass by Treatment

Most cover crops controlled spring weeds

Results:
• Mixtures worked as well as the best monocultures
• Legumes were laggards
• Winterkilled can work
**Weed Take-Homes:**

- Many cover crop treatments can be effective
  - Watch out for slow-growing legumes on their own
  - Start from a weed-suppressive base, build out
- Winter-killed cover crops can suppress weeds through the spring
- Rapid fall growth is key
  - Focus on getting a good stand
- Manage tillage timing to draw down weed seedbank
Cover Crop Mixtures and their Influences on Beneficial Insects

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Beneficial Insects

• Provide valuable ecosystem services on farm.
  – Pollinate crops
  – Suppress pest insects
• Pollinators provide approximately $29 billion in pollination each year.
• Natural enemies provide estimated $4.6 billion in pest suppression service each year.

Insects and Cover Crops

• Plants represent a valuable resource to beneficial insects.
  – Food
    • Nectar, Pollen, Alt. Prey
  – Shelter
    • Egg laying sites, ground-dwellers
• Cover crops may support insects when insect prey numbers are low.
• Can we use cover crop mixtures to support beneficial insects?
Insects Have Preferences, Too!

- Insects exhibit preferences for specific floral resources
- Different insects may appear depending on plant characteristics:
  - Flower:
    - Shape
    - Size
    - Color
    - Smell
- More diverse mixtures may support a more diverse group of beneficial insects

Need to consider cover crop termination and crop establishment if a goal is to provision beneficial insects

- April
- May
- June
- July
- August
- Sept.

CC + Canola
CC + Red Clover
CC + Winter Pea
Pink Spotted Lady Beetle
Minute Pirate Bug

In rotations where cover crop mixtures must be terminated before flowering, are there alternative ways to use them to promote beneficial insects?

Conservation of Bees for Pollination Services

- A diverse group of wild bees visit canola plants in cover crop mixtures:
  - More frequent visits in the monoculture plots where floral density was highest

![Graph showing bee visits per 2 min.
Average no. bee visits per 2 min.
Monoculture: 4 Species Mix: 6 Species Mix]
What about our natural enemies?!

- Cover crops can be used as "insectary" strips

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**Can Mixes Be Tailored to Attract Specific Natural Enemies?**

<table>
<thead>
<tr>
<th></th>
<th>Buckwheat</th>
<th>Cowpea</th>
<th>Buckwheat-Cowpea Mixture</th>
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<tbody>
<tr>
<td><em>Nectar/pollen for beneficial insects</em></td>
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<td></td>
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<tr>
<td><em>Early extrafloral nectaries for beneficial insects</em></td>
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<tr>
<td><em>Floral nectar/pollen AND extrafloral nectar for beneficial insects</em></td>
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Would a biculture of buckwheat and cowpea provide combined benefits from both plant species? In progress, stay tuned......

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**Insect Take-Homes:**

Flower presence and flower density may be more important than cover crop diversity

- Compatibility with farm goals and crop:
  - Timing
    - Establishment, flowering, termination
  - Alternative
    - Insectary strips

- Mixture design:
  - Diversity of flower types
  - Be aware of potential crop pests in your system and if cover crop species will support them
Nitrogen Management with Cover Crop Mixtures

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Goals
• Prevent Nitrate Leaching
  “N retention”
• Supply N to the next cash crop

Behavior of Mixtures is Affected by Species Characteristics
• Grasses, Brassicas, Legumes
• Winterhardy vs. Winterkilled

Species Characteristics: Nitrogen Acquisition
• Grasses and brassicas only acquire N from the soil
• Legumes can acquire N from the atmosphere through N fixation

Cereal Rye
Forage Radish
Austrian Winter Pea
Nodules
Species Characteristics: Growth Period

- Cereal Rye (Winterhardy)
- Canola (Winterkilled)
- Oats (Winterkilled)
- Forage Radish

Species Characteristics Affect N Retention

- No cover crop or slow growing legume
- Winterkilled and/or fast growing legume
- Includes Winterhardy grass or brassica

On-Farm Results

- Frost seeded red clover allows significant nitrate leaching

Lancaster County Farm 2013 Photos
Nitrogen Supply: N is released from cover crop residues by microbial decomposition

C:N ratio of cover crop residues regulates N supply vs. N tie up

Corn Yield Declined with Increasing C:N Ratio of Cover Crop
Nitrogen Management with Cover Crop Mixtures Rule of Thumb

To balance N retention and supply, combine a well-adapted legume with a low seeding rate of a winterhardy grass or brassica

Can mixtures achieve multiple goals? Yes – but make a plan

Guidelines:
1. **Weeds**: Have 1-2 species that provide fast ground-cover in the fall, then add species to achieve other goals
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Making the most of cover crop mixtures

Identify the functions you want from the cover crop mixture
- Build organic matter
- Nitrogen fixation
- Nitrogen retention
- Weed suppression
- Beneficial insects
- Fall and/or spring forage production

Identify the planting window
- Late summer
- Early fall
- Late fall

Fine-tune for an even mixture on your farm
Thank you!

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