Cover Crops in Organic Systems

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Hairy Vetch Seeding Dates and Rates

Rolled Cereal Rye for No-till Soybean

Red Clover Frost Seeding into Small Grains

Cover Crop Drill Interseeding
What are the two greatest challenges in organic crop production?

1. Effective weed management
2. Supplying enough nitrogen
Results from nationwide survey show organic farmers are willing to pay more for cover crops.

Knowledge intensive

- Most agricultural inputs have one purpose
- Managing for multiple benefits can be challenging
  - Narrow windows of time for field operations
  - Contingency plans and adaptive management

Hairy Vetch  Red Clover  Cereal Rye  Winter Wheat  Forage Radish

http://pubs.cas.psu.edu/FreePubs/PDFs/uc210.pdf and Joel Gruver
# Cover crop phenology

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tbody>
<tr>
<td>Hairy vetch</td>
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<tr>
<td>Red clover</td>
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<tr>
<td>Cereal rye</td>
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<tr>
<td>Winter wheat</td>
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<td>T</td>
<td></td>
<td></td>
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<td>T</td>
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<tr>
<td>Spring oats</td>
<td></td>
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<td>E</td>
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<tr>
<td>Forage radish</td>
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<td>E</td>
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</tr>
</tbody>
</table>

- **Hairy vetch**: Frost seeded in wheat, terminate in 2nd year
- **Red clover**: Winter-kill
- **Cereal rye**: Winter-kill
- **Winter wheat**: Winter-kill
- **Spring oats**: Winter-kill
- **Forage radish**: Winter-kill

**Images**

- **Hairy Vetch**
- **Red Clover**
- **Cereal Rye**
- **Winter Wheat**
- **Oats**
- **Forage Radish**
# Know your cover crop options

<table>
<thead>
<tr>
<th>Species, Life Cycle</th>
<th>Seeding Rate (lb/A)</th>
<th>Seed Cost (S/A)</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hairy vetch</strong></td>
<td>20–40</td>
<td>30.00–100.00</td>
<td>*Fixes 60–250 lb/A (avg.110) of N</td>
<td>*Slow establishment in early fall; little winter cover</td>
</tr>
<tr>
<td><em>Vicia villosa</em>, winter annual</td>
<td></td>
<td></td>
<td>*Cold tolerant and high yielding</td>
<td>*Late maturation in spring</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Relatively drought tolerant</td>
<td>*High P and K requirement for max. growth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Adapted to wide range of soil types</td>
<td>*Potentially weedy in small grains</td>
</tr>
<tr>
<td><strong>Red clover</strong></td>
<td>7–18</td>
<td>7.00–27.00</td>
<td>*Fixes 100–110 lb/A of N</td>
<td>*Winter hardiness and maturity of cultivars can differ</td>
</tr>
<tr>
<td><em>Trifolium pratense</em>, short-lived perennial</td>
<td></td>
<td></td>
<td>*Deep taproot</td>
<td>*Slow initial growth, high P and K requirement for max. growth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Adapted to wet soils, humid areas, and shade</td>
<td>*Pure-stand forage use causes bloat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Flexible; can be used as a forage (usually mixed with grass)</td>
<td>*Vulnerable to several pathogens and insects</td>
</tr>
<tr>
<td><strong>Cereal rye</strong></td>
<td>60–200</td>
<td>7.00–38.00</td>
<td>*Excellent scavenger of nutrients, esp. N</td>
<td>*Regrowth may occur if control is incomplete; difficult to manage when mature</td>
</tr>
<tr>
<td><em>Secale cereale</em>, winter annual</td>
<td></td>
<td></td>
<td>*Cold tolerant, late seeding possible, fast fall growth</td>
<td>*Possible crop suppression caused by allelopathy or nutrient immobilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Rapid growth aids weed suppression</td>
<td>*Potentially weedy in small grains</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Flexible; can be harvested for grain</td>
<td>*May harbor small grain insects and diseases</td>
</tr>
</tbody>
</table>

![Hairy Vetch](image1.png) ![Red Clover](image2.png) ![Winter Wheat](image3.png) ![Forage Radish](image4.png) ![Cereal Rye](image5.png) ![Oats](image6.png)
Weed management with cover crops

- **Direct effects**
  - Competition for resources
  - Allelopathy
  - Altered microenvironment
  - Physical suppression from mulch

- **Indirect effects**
  - Herbivores and pathogens
  - Management
Life cycle of an annual weed

**Micro-environment**
- Soil moisture
- Soil temperature

**Natural enemies***
- Seed predators
- Pathogens

**Physical Suppression**
- Mulch

**Allelopathy**
- Chemical inhibition

**Competition**
- Space
- Nutrients
- Light

**Control***
- Herbicides
- Mowing
- Termination

* Indirect effects
Hairy Vetch
Effective suppression of annual weeds

No hairy vetch  Hairy vetch
Hairy vetch project collaborators

- **USDA hardiness zone 5a to 8a**
  - Steven Mirsky, USDA-ARS BARC
  - Chris Reberg-Horton, NC State
  - Bill Curran, Penn State
  - John Spargo, Penn State
  - Masoud Hashemi, UMass

- **Analysis and writing**
  - Victoria Ackroyd, postdoc at USDA-ARS BARC
  - Stéphane Cordeau, visiting scientist from INRA, France
Hairy vetch seeding rate x date

- Tested effects of seeding rates and dates on biomass production
- 5 states: Massachusetts, New York, Pennsylvania, Maryland, and North Carolina
- Drill seeded into a tilled seedbed at multiple rates ranging from 5 to 45 lbs/a
- Same seed at all sites (Steve Groff); inoculated
- Biomass sampled at multiple times (conventional, intermediate, and 50% flowering)
Emily Reiss helping sample hairy vetch in NY on May 17, 2013
Why care about rates and dates?

- Major impact on cover crop performance, biomass production, and ecosystem services

- Using optimal practices can save farmers money and increase their satisfaction with cover crops
Wide range of biomass within and across sites; biomass production increased with decreasing latitude.
Optimizing seeding rates

Termination timing drives biomass and N supply

Hairy vetch seed ~ $3/lb

Compensatory effect

Reduce seeding rate when seeding early to save money in Maryland, but not in New York
Hairy vetch summary and next steps

- Hairy vetch seeding rate is more important in northern sites and when planting late

- Further examine relationship between seeding rates and dates and quantify compensatory effects

- Determine base temperature (optimization) and develop GDD model for biomass production

- Improve seeding rate and date recommendations, and create map of Northeast showing optimal dates
CSF Winter Cover Crop Planting Scheduler

Current Location:
Cornell University, Ithaca, NY
Lat/Lon: 42.45, -76.48
Change Location

Cover Crop
Rye

Probability of cover crop establishment before end of season (Rye)
Planting Date: 10/04

GDDs (base 42) from planting date (10/04) through end of season

Frost Seeding Red Clover in Small Grains
Frost seeding red clover into wheat is one of the easiest and cost effective ways to establish a legume cover crop before rotating to corn.
Impact of red clover cover crops

Greater corn yields with red clover

- Red clover nitrogen credit = 62 lb/A

[Graph showing corn yield vs. nitrogen fertilizer rate, with a higher yield for red clover cover crop compared to no cover crop.]
Consistent yield advantage beyond N

Fig. 1. Nitrogen response for the different cover crop treatments and the corresponding optimum N rate based on quadratic regression at the Northwest Research Station in 2007. Abbreviations: NC, no cover; RCNT, red clover no-till; RCT, red clover tilled.

Consistent yield advantage beyond N

(NC) \( y = -0.22x^2 + 65.51x + 3325.97; \) Opt. N = 146

(RCNT) \( y = -0.18x^2 + 55.32x + 4834.91; \) Opt. N = 150

(RCT) \( y = -0.17x^2 + 52.58x + 5366.19; \) Opt. N = 152
Survey of 1,415 farmers

http://www.ctic.org/media/CoverCrops/CTIC_04_Cover_Crops_report.pdf
Alternatives to post-harvest seeding

Aerial seeding red clover in soybean
COVER CROPS IN CORN

Where corn ground is not to go into winter grain, sowing a cover crop is always desirable. If successful it covers the soil and reduces winter washing and the leaching out of plant food. It also adds organic matter through its top and root growth and helps maintain soil condition. The cheapest, surest, and most generally satisfactory cover crop is domestic ryegrass sown at about 20 pounds to the acre. If sown before or right after the last cultivation, before the season normally becomes too dry, a good stand generally is secured. A cover crop is particularly valuable on washy slopes and where corn is to be followed by corn or potatoes.
European Inter-row cover crop seeder, photo from Matt Ryan, PSU
Drill interseeding cover crops into corn
On-farm trial in Central NY (July 7, 2013)
On-farm trial in Central NY (September 23, 2013)
Reduce nutrient losses when spreading manure and phosphorus loading by using legumes to provide nitrogen.
Dave Wilson’s Interseeding Mix ($60/a)

- **Red clover** (6 lb/a)
- **Hairy vetch** (8 lb/a)
- **Cereal rye** (30 lb/a)
- **Annual rye grass** (15 lb/a)
Planting date for NY corn was 6/19/15 and soybean was 6/5/15. Interseeded 7/31/15 at V5 stage of corn. Sampled cover crops in corn on 6/6/16 and soybean on 6/7/16.
Intercropping with cover crops

Table 9. Results of ANOVA and LSmeans to determine the effect of presence/absence of interseeded cover crops on August and October weed biomass and corn yield. Site refers to the three experimental sites New York (NY), Pennsylvania (PA), and Maryland (MD). Treatment refers to the ‘Medium Cover Crop’ (CC) and ‘Medium No Cover Crop’ (NCC) treatments, which were planted with corn at 7.41 plants m$^{-2}$, with and without interseeded cover crops, respectively. P-values refer to the F-test in the ANOVA. Similar letters next to means within a column indicate no significant difference ($a = 0.05$).

<table>
<thead>
<tr>
<th>Effect†</th>
<th>August weed biomass</th>
<th>October weed biomass</th>
<th>Corn grain yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site (S)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.02</td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>0.4</td>
<td>0.01</td>
<td>0.56</td>
</tr>
<tr>
<td>S × T</td>
<td>0.04</td>
<td>0.24</td>
<td>0.96</td>
</tr>
<tr>
<td>NY</td>
<td>–</td>
<td>1.88 b</td>
<td>1026 a</td>
</tr>
<tr>
<td>PA</td>
<td>–</td>
<td>62.18 a</td>
<td>745 b</td>
</tr>
<tr>
<td>MD</td>
<td>–</td>
<td>7.24 b</td>
<td>830 b</td>
</tr>
<tr>
<td>NCC</td>
<td>–</td>
<td>13.87 a</td>
<td>–</td>
</tr>
<tr>
<td>CC</td>
<td>–</td>
<td>6.42 b</td>
<td>–</td>
</tr>
</tbody>
</table>

Less than half the weed biomass in plot with interseeded cover crops compared to plots without
Sampled on
June 12, 2018

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Biomass (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Corn</td>
<td>7000</td>
</tr>
<tr>
<td>Corn with cover crop</td>
<td>4000</td>
</tr>
<tr>
<td>Corn without cover crop</td>
<td>6000</td>
</tr>
</tbody>
</table>

- Weeds
- Red Clover
- Hairy Vetch
- Cereal Rye
- Annual Ryegrass

**Note:** The biomass values are in kg/ha.
Organic No-till Soybean
Benefits from cover crop-based no-till

- Protect against soil erosion in late summer and early fall
- Improved soil health and infiltration
- Reduced labor and fuel requirements

Soybean growing in rolled-crimped cereal rye
Cover crop-based organic rotational no-till

Compared to traditional tilled organic corn-soybean-wheat:

- 27% less diesel fuel
- 31% less labor
- 13% less energy use
- 6% less GHG emissions

Roller-crimper in no-till soybean

I & J roller-crimper
(10.5-ft wide cylinder, 2625 lb water-filled weight)
Cover crop considerations

- Treat your cover crop like a cash crop
  - Seed early in fall, use a high rate and quality seed
- Rye reseeding can occur if too early or late
Bounce-back and reseeding

Rolled too early

Effective termination

Different approach

- Requires greater attention
  - Advanced planning
  - Adaptive management

- New equipment for rolling and no-till planting

- Different pests
  - Perennial and early weeds (e.g. common ragweed)
  - Seed corn maggot, true army worm, black cutworm
Crop selection

Improve performance by matching cover crops with cash crops

Soybean into winter cereal

- Aim to deplete soil N levels to starve weeds
- Too much N can cause winter cereals to lodge, making rolling difficult and giving weeds an advantage
Soil N immobilization from cereal cover crops can increase the relative competitive ability of legume crops.
Crop selection

Improve performance by matching cover crops with cash crops

Corn into hairy vetch

- Supplement manure or compost prior to vetch
- Mixtures of hairy vetch and rye will suppress more weeds
Cereal rye prior to soybean

Compared to a no cover crop control, will integrating a cereal rye cover crop prior to soybean improve:

- soil health
- weed suppression
- soybean yield
- profitability
Cereal Rye Treatments

**Plow down**: rye is incorporated at jointing

**Ryelage**: rye is harvested at boot stage

**Roll down**: rye is rolled prior to planting at 50% anthesis

**No cover**: No rye cover crop
Accumulated Precipitation (cm)

- Normal Accumulation
- 2015 Accumulation
- 2016 Accumulation
Biomass increased with termination date

Cereal Rye Biomass

Seeding dates:
- 2014: Oct 7
- 2015: Sep 18

Dry Weight (kg ha⁻¹)

<table>
<thead>
<tr>
<th>Year</th>
<th>Plow down</th>
<th>Ryelage</th>
<th>Roll down</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Early May</td>
<td>Mid May</td>
<td>Early June</td>
</tr>
<tr>
<td>2016</td>
<td>Late April</td>
<td>Early May</td>
<td>Late May</td>
</tr>
</tbody>
</table>
Higher in rolled rye compared to no rye

Soil Respiration

Measured in August both years
Greater water infiltration in rolled rye compared to no rye

Measured:
- 2015: August
- 2016: July, August
Weed biomass

Greater weeds in rolled rye, but low overall

Measured in early September both years

Biomass (kg ha\(^{-1}\))

- **No cover**
- **Plow down**
- **Ryelage**
- **Roll down**

The bar for **Roll down** is significantly higher compared to the others.
Treatments at harvest (October 8, 2015)

No cover  |  Plow down  |  Ryelage  |  Roll down
Treatments at harvest (October 19, 2016)

- No cover
- Plow down
- Ryelage
- Roll down
Lower yield in rolled rye in drought year

Crowley, KA, HM van Es, MI Gómez, and MR Ryan. Tradeoffs in cereal rye management strategies prior to organically managed soybean (In preparation for submission to Agronomy Journal)
Summary of results

- Profitability greatest in ‘Ryelage’
- Greater soil respiration, water infiltration, and surface soil moisture in ‘Roll down’ compared to ‘No cover crop’
- More weeds in ‘Roll down’
- Lowest costs in ‘No cover’ but lowest labor in ‘Roll down’
Know when to fold’em

- Avoid weedy fields, especially perennials
  - Mulch effective on annuals at low densities

- Change plans if cover crop stand is patchy or thin
  - Weeds will break through and cause problems
Wait for rain or harvest for grain!

- No sense in rolling cover crop if you can’t get soybean seed into the soil.

- Extra weight can help, but usually better to wait for rain to soften soil.

- Might be better to harvest for grain or ryelage.
Fitting into a crop rotations

- Need to establish cereal rye cover crop early
  - Early September is ideal
  - Not enough time after corn grain

- Following organic no-till soybean
  - Challenges with wheat for grain
  - Could be volunteer rye seedlings
  - Triticale for forage might be a good option
Red clover (frost seeded into triticale and harvested for forage)

Corn grain (interseeded cover crop at layby cultivation)

Triticale

Soybean (no-till planted into rolled cereal rye)

Red clover, hairy vetch, Italian ryegrass, cereal rye

Sorghum sudangrass and pearl millet

Cereal rye

Year 1

Summer

Spring

Fall

Year 2

Summer

Spring

Fall

Year 3

Summer

Spring

Fall

Year 4
Got 8,000 lb/a of biomass?

- Depends on soil weed seed bank

- Difficult to achieve and complicates planting and seed placement

- High-residue cultivation and high soybean planting rates (250,000 seeds/a) for supplemental weed suppression
Effect of planting rate on soybean yield

Yield reached a plateau at higher planting rates
Effect of planting rate on soybean yield

Yield reached a plateau at higher planting rates

Take advantage of asymptotic relationship for weed suppression
Higher planting rates can attain canopy closure earlier.
Weed suppression at different soybean planting rates

80,000 seeds a\(^{-1}\)

Large crabgrass
\((Digitaria\ sanguinalis)\)

315,000 seeds a\(^{-1}\)

80,000 seeds a\(^{-1}\)
Are high planting rates profitable?

Economic analyses for conventional soybean production are driven by:

- High cost of genetically-engineered seed, technology fees, and seed treatments
- Relatively inexpensive herbicides
- Low soybean market value: $12.50/bu
  (Average price in 2014, USDA-NASS)
Are high planting rates profitable?

Economic analyses for conventional soybean production are driven by:

- High cost of genetically-engineered seed, technology fees, and seed treatments
- Relatively inexpensive herbicides
- Low soybean market value: $12.50/bu
  (Average price in 2014, USDA-NASS)
- “Optimum economic seeding rates are often less than seeding rates that result in maximum yield because of the high costs of soybean seed.”
  (Cox and Cherney, 2011; De Bruin and Pedersen, 2008; Lee et al., 2008)
Partial profitability in organic no-till

Maximum partial return predicted at a planting rate of 260,000 to 290,000 seeds/acre

Soybean planting rate (seeds a$^{-1}$)

Partial return ($a^{-1}$)

Liebert & Ryan, Weed Tech., 2017
Maximum partial return predicted at a planting rate of 260,000 to 290,000 seeds/acre.
Planting soybean at double the recommended conventional rate appears to be appropriate for cover crop-based organic rotational no-till soybean.
Martens’ On-Farm Results 2013
Cover crop biomass

Cover crop biomass (lb/acre)

Cover crop termination
- May 30
- June 5

Barley
- May 30: 6,000
- June 5: 8,000

Cereal rye
- May 30: 8,000
- June 5: 8,000

Triticale
- May 30: 7,000
- June 5: 8,000

Differences indicated by letters:
- d, cd, ab, a, bc, ab
Weed biomass

Cover crop termination
- May 30
- June 5

Weed biomass (lb/acre)

Barley
- May 30: ab
- June 5: b

Cereal rye
- May 30: ab
- June 5: b

Triticale
- May 30: ab
- June 5: b
Soybean yield

![Graph showing soybean yield comparisons for Barley, Cereal rye, and Triticale with cover crop termination on May 30 and June 5.]

- **Barley**
  - May 30: [Soybean yield data]
  - June 5: [Soybean yield data]

- **Cereal rye**
  - May 30: [Soybean yield data]
  - June 5: [Soybean yield data]

- **Triticale**
  - May 30: [Soybean yield data]
  - June 5: [Soybean yield data]
Cereal rye (Aroostook) drilled at 3 bu/a on September 13

Soybean (Viking 1722N) planted at 300,000 seeds/a on June 2
Sarah Pethybridge (Rolled rye for white mold suppression in soybean and dry bean)
## Results from 2017 on-farm trial

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cover crop biomass (lb/a)</th>
<th>Injured seedlings (plants/a)</th>
<th>Established seedlings (plants/a)</th>
<th>Weed Biomass (lb/a)</th>
<th>Soybean yield (bu/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilled</td>
<td>0</td>
<td>2,489</td>
<td>90,854</td>
<td>686</td>
<td>43</td>
</tr>
<tr>
<td>No-Till</td>
<td>4,657</td>
<td>51,027</td>
<td>70,111</td>
<td>1,455</td>
<td>32</td>
</tr>
</tbody>
</table>

- Excessive rain in spring
- Difficulty planting through residue
- Seed corn maggot losses
- More than double the weeds
- Low soybean yields
Thank you

Visit our website:
scslabcu.wordpress.com
Winter annuals in rye cover crop - Central PA (April)

Oct. 15

Sept. 15
Ground cover on April 1 across rye seeding dates (2.5 bu/acre on 7.5 inch rows)

Effects of seeding and termination dates

Cereal rye biomass (kg/ha)

Termination dates
- May 20

Photographs taken on April 1

Cereal rye seeding date

Effects of seeding and termination dates

Delaying termination 1 day in the spring
= seeding 5 days earlier in the fall

Termination dates

- May 20
- May 30

Cereal rye biomass (kg/ha)

Photographs taken on April 1

Cereal rye seeding date

Effects of planting date on cereal rye

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biomass (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroostook</td>
<td>7259 a</td>
</tr>
<tr>
<td>Wheeler</td>
<td>6508 b</td>
</tr>
<tr>
<td>Rye/Hairy vetch</td>
<td>6876 ab</td>
</tr>
</tbody>
</table>

**Planting Date**

<table>
<thead>
<tr>
<th>Date</th>
<th>Biomass (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 25</td>
<td>7880 a</td>
</tr>
<tr>
<td>September 5</td>
<td>7904 a</td>
</tr>
<tr>
<td>September 15</td>
<td>7161 b</td>
</tr>
<tr>
<td>September 25</td>
<td>7016 b</td>
</tr>
<tr>
<td>October 5</td>
<td>6260 c</td>
</tr>
<tr>
<td>October 15</td>
<td>5066 d</td>
</tr>
</tbody>
</table>

**Termination Date**

<table>
<thead>
<tr>
<th>Date</th>
<th>Biomass (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1</td>
<td>4051 a</td>
</tr>
<tr>
<td>May 10</td>
<td>5809 b</td>
</tr>
<tr>
<td>May 20</td>
<td>7599 c</td>
</tr>
<tr>
<td>May 30</td>
<td>10,066 d</td>
</tr>
</tbody>
</table>

Effects of planting date on cereal rye

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biomass (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroostook</td>
<td>7259 a</td>
</tr>
<tr>
<td>Wheeler</td>
<td>6508 b</td>
</tr>
<tr>
<td>Rye/Hairy vetch</td>
<td>6876 ab</td>
</tr>
</tbody>
</table>

Although higher seeding rates did not increase cereal rye biomass, weed suppression was better

Increased biomass (and services) by about 50% when planting cereal rye in early September compared to mid-October.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Biomass (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 25</td>
<td>7880 a</td>
</tr>
<tr>
<td>September 5</td>
<td>7904 a</td>
</tr>
<tr>
<td>September 15</td>
<td>7161 b</td>
</tr>
<tr>
<td>September 25</td>
<td>7016 b</td>
</tr>
<tr>
<td>October 5</td>
<td>6260 c</td>
</tr>
<tr>
<td>October 15</td>
<td>5066 d</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Termination Date</th>
<th>Biomass (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1</td>
<td>4051 a</td>
</tr>
<tr>
<td>May 10</td>
<td>5809 b</td>
</tr>
<tr>
<td>May 20</td>
<td>7599 c</td>
</tr>
<tr>
<td>May 30</td>
<td>10,066 d</td>
</tr>
</tbody>
</table>

Questions?

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Jeff Liebert - jal485@cornell.edu