Cover Crops: Opportunities and Challenges to Realizing Ecosystem Services in Organic Agriculture

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USDA-ARS, Cornell University
• Subsidies, foundation support, funding programs.
• Web-based tools, custom seeding services, specialized equipment
  • Seed companies (customized mixes, research).
  • Germplasm curators/breeders, NRCS
Cover crops: multi-functional tools

Agroecosystem Services

- Hairy Vetch
- Cereal Rye
- Oats
- Red Clover
- Winter Wheat
- Forage Radish

Cover Crops

- Nitrogen Fixation
- Nutrient Scavenging/Retention
- Habitat for Beneficial Organisms
- Organic Matter
- Weed Suppression
- Insect Pests
- Erosion Control
- Crop Productivity
- Nutrient Use Efficiency
- Conserve Water
Are we realizing the potential of cover crops?

What are the primary limiting factors?

1. Information on management
2. Reliable sources of seed
3. Germplasm
4. Variability in performance
Information on management

DANGER
DUE TO
MISINFORMATION

1+1=3
Need for regionally specific decision support tools
Seed: reliable sources in sufficient quantities
(Certified organic vs. untreated)

- “Almost every year we run out of cereal rye in our region. Worse during dry years because cereal rye seed is produced in rain fed systems.”

- Cost of certified seed (production and cleaning)
Germplasm Improvements (breeding and screening)

Traits of interest

- Winter hardiness
- Drought tolerance
- Rapid emergence/growth
- High biomass production
- Nitrogen fixation
- Hard seed
Variability in performance

**Establishment**
(Seedbed prep., machinery, timing, soil conditions)

**Growth and Development**
(Drought/flooding, fertility, weeds, composition)

**Termination**
- Tillage
- Roller-crimpers
- Mowing
Legume and legume/cereal biomass production

(2008 to 2010; 9 site years GA & NC)
Salinas Organic Cropping Systems (SOCS) Experiment
Need long-term cover crop data (SOCS experiment)

Years of Data

Tons per Hectare

10
8
6
1 2 3 4 5 6 7 8

1 2 3 4 5 6 7 8
Farming Systems Project
(USDA-ARS, Beltsville)

ORGANIC, 2-YEAR  Corn-rye-Soybean-hairy vetch
ORGANIC, 3-YEAR  Corn-rye-Soybean-Wheat/hairy vetch

• Moldboard plow, poultry litter used to supplement N needs
• All rotation entry points present each year
Long-term cover crop biomass

Biomass (kg ha⁻¹)

Time (years)

2-yr rotation

3-yr rotation
Greenhouse gas emissions (CO$_2$eq)

Energy use (MJ)

Hoffman et al.
Legume performance is critical to the sustainability of organic agriculture

Mineral fertilizers
  • Slower release rates
  • Lower energy use
  • Renewable resource

Animal waste
  • No new P
  • No transport costs
  • Low volatility
Factors driving the magnitude and duration of agro-ecosystem services

Cover Crops

- Planting Methods
- Site-specific Mgmt.
- Nutrient Inputs
- Genetics
- Species Composition
- Weediness
- Seed Costs
- Methods of Termination
- Seeding Rate
- Timing of Mgmt.
Factors driving the magnitude and duration of agro-ecosystem services
Establishment methods
Cover Crop Interseeding
Aerial seeding crimson clover into soybeans
(Bill Mason Farm, Eastern Shore MD)
Charlie Martin’s high-boy interseeder
Delivers cover crop seed in standing corn at any time
Penn State 3-way cover crop interseeder
Grazing and harvesting opportunities
Cover crop mixtures
Cereal rye and hairy vetch monoculture and mixture biomass

North Farm 2012

South Farm 2012
- HV
- CR
- Tot

North Farm 2013

South Farm 2013

Biomass, Mg ha\(^{-1}\)

Hairy Vetch:Cereal Rye Sown

Poffenbarger et al.
Meta-analysis

Conclusions

• Hairy vetch-cereal rye mixture vs. monocultures

• > biomass
• = N content

• Cover crop proportion, amount of seed applied, and number of GDD we all drivers

Poffenbarger et al.
Cereal rye and hairy vetch monoculture and mixture N content

North Farm 2012

South Farm 2012

North Farm 2013

South Farm 2013

Poffenbarger et al.
Period of greatest N uptake begins at six-leaf stage
Nitrogen release over time

No-till

Tillage

N released (kg ha⁻¹)

No 28 52 70 90 109 131

0 50 100 150 200 250 300

Time (days)

Poffenbarger et al.
Soil mineral N level will influence growth of a mixture

High Nitrogen Level

Low Nitrogen Level

Courtesy of Charlie White
Effect of cover crops on N₂O emissions

kg N lost as N₂O vs. kg PAN from applied poultry litter

- Hairy Vetch
- Mixture
- Cereal Rye
- Bare Ground

Davis et al.
Whole system integration
There is currently a lot of momentum around utilizing cover crops in organic agriculture.

Cover crops are multi-functional tools that provide a wide range of services.

However, there are a number of factors that are limiting producers from realizing the maximum benefits from cover crops (information gaps, seed availability, suitable germplasm, and inconsistencies in performance).

There are numerous management and cultural strategies that can be utilized to increase their performance including:

- Improved methods of establishment and termination
- Use of multi-species mixtures
- More knowledge on how soil management influences cover crop performance
- Cover crop breeding programs

While there are numerous strategies for improving cover crop performance, a whole cropping systems approach is required.