Module 6 - Economic Benefits of Improving Soil Health

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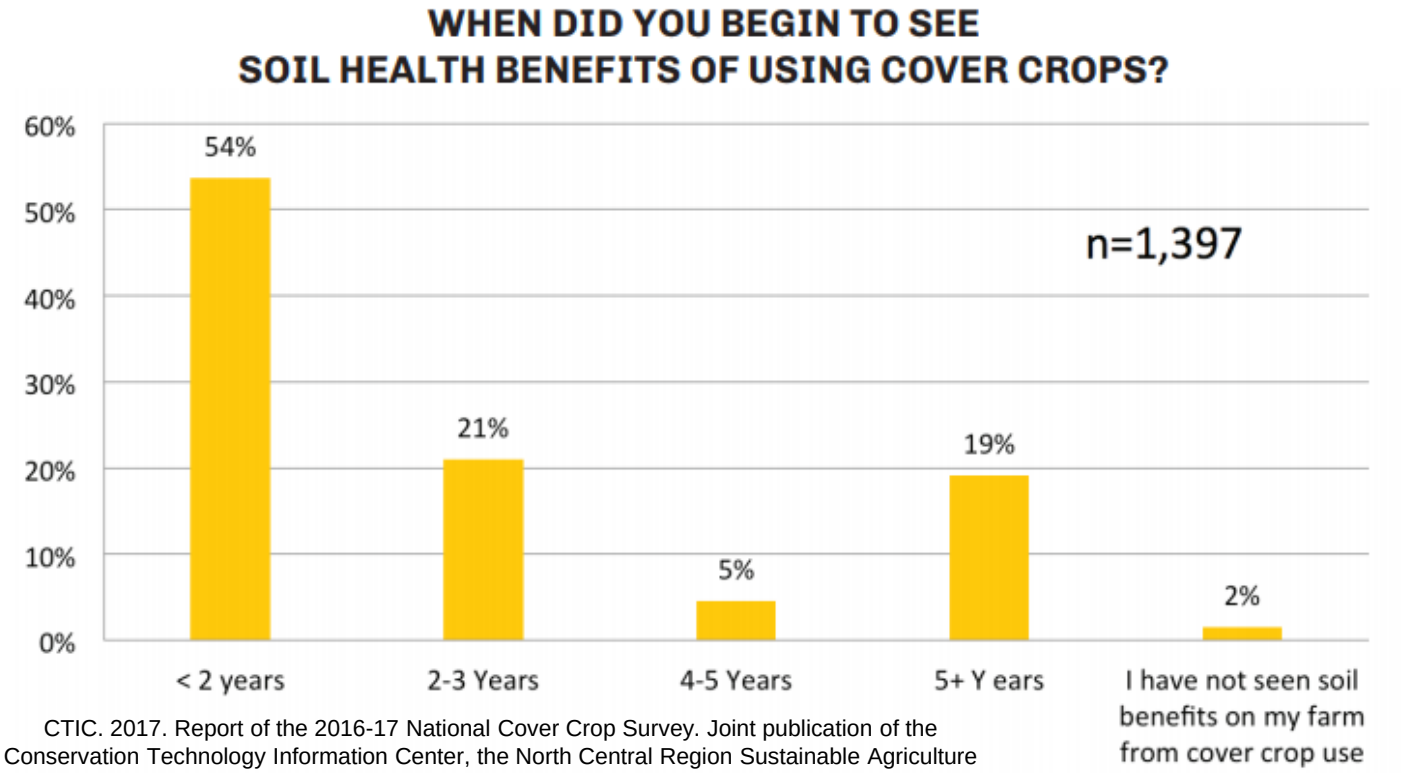
Perception of Cover Crop Benefits



CTIC. 2017. Report of the 2016-17 National Cover Crop Survey. Joint publication of the Conservation Technology Information Center, the North Central Region Sustainable Agriculture Research and Education Program, and the American Seed Trade Association. West Lafayette, IN.

It's both a long-term investment and something that our farmers see a benefit from.

Economics of Soil Health

- It is difficult to quantify and validate the value of improving soil health.
  - Assigning dollar values to soil health metrics can vary greatly.
- Two ways to view soil health economics:
  1. The impact of the conservation system in reducing operating expenses.
  2. The effect on improving the soil's biological, physical, and chemical attributes.

Soil Economics = Systems Approach

- The true economic value of soil is found in creating a system that finds a balance of:
  - Keeping soil in place.
  - Building a sustainable production system
  - Increasing output efficiently.
  - Reducing inputs required.
- It requires multiple steps and is a long-term investment.

**Source of Image: Iowa State - "The Economics of Soil Health", May 23, 2017.*

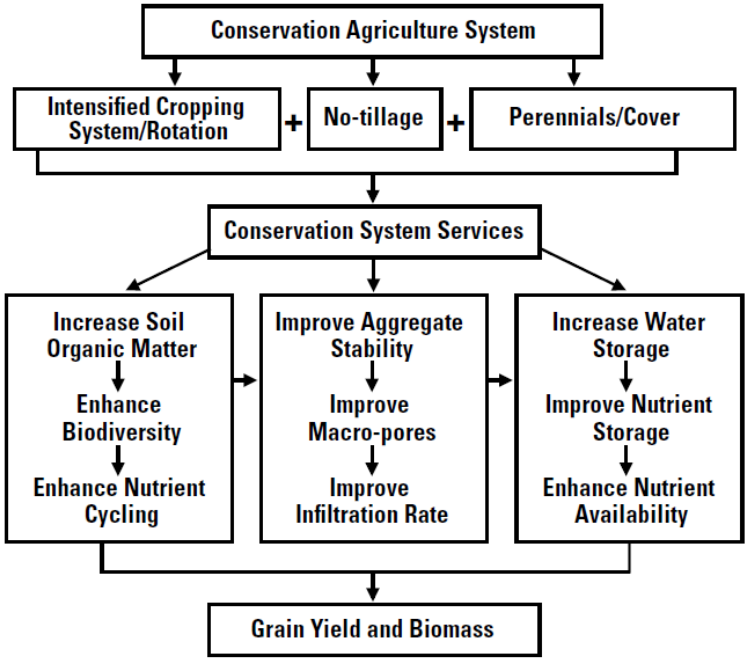


Figure 5. Systems approach for building soil health and productivity (Al-Kaisi, 2015).

Outline

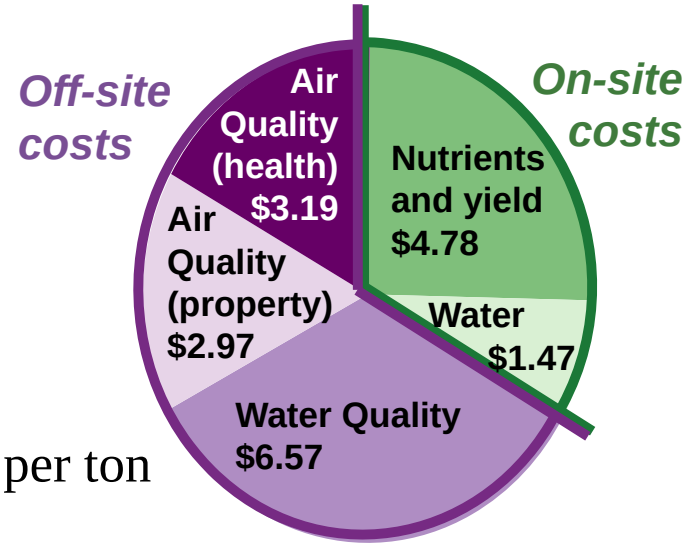
- Economic costs of erosion
- Value of nutrients
- Nitrogen loss and efficiency
- Impact on managing weeds
- Impacts on pest and disease
- Value of improved drainage
- Use for grazing

Economics of Soil Erosion

- Does soil have value? **Absolutely**.
- What is its economic value?
  - This is extremely and incredibly difficult to measure.
    - Numerous things must be considered:
      - Soil type – not all farms are alike
      - Water holding capacity
      - Yield potential
      - Other potential uses of the land

Example of estimated erosion costs on one field:

Erosion Affects Soil, Air and Water Quality and Profitability



$19 per ton soil

Source: NRCS & Soil Quality Inst., 2003

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Value of a Ton of Topsoil

- Most biological activity occurs in the top 3 inches.
- One million pounds, or 500 tons, of topsoil in the top 3 inches
- Average Value of Cropland = $5,000/Acre
- Soil Productivity Value: $2,500/500 = $5/Ton
  - Assumes half of the value is in productivity value.
  - Other half is value of location of the land itself.
- Soil Lost at T value = 4-5 ton/acre
  - T value = tolerable erosion levels
- Lost value per acre = $5/ton soil loss
  - Assume loss of 4-5 tons annually equates to losing $20 to $25 per acre.

**Source: Ohio State University; modified land values to fit Tennessee*

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Value of Nutrients

- How do you measure the value of nutrients in the soil?
  - Quite simple actually.
  - What is the impact of the lack of a nutrient on either the input needs for a crop and/or the impact on the output of the field?
  - Soil tests are needed to understand what nutrients are deficient.
- Nutrient availability is linked directly to what is available in the soil and what is added synthetically.
- The loss of organic matter directly impacts the availability of nutrients to a plant.
- Let's look at an example of valuing the organic matter as a nutrient source.

Value of Soil Organic Matter

- Assume that we have two soil types:
  1. Soil #1: Organic Matter of 2.0%
  2. Soil #2: Organic Matter of 3.5%
- Fertilizer applied is assumed to be manure to show that not only are macronutrients being added, but micronutrients as well.
- Manure can also be used to build organic matter.

Value of Soil Organic Matter

- One ton of soil = 2,000 lb. of soil minerals and organic matter
- Amount of organic matter per/one ton of 2,000 lb. of soil:
  - 2.0% O.M. = 0.020 x 2000 = 40 lb. of organic matter
  - 3.5% O.M. = 0.035 x 2000 = 70 lb. of organic matter
    - 3.5% O.M. is a good average that we can achieve due to heat and moisture levels in Tennessee.
- Value for 2.0% OM = 40 lb. x $0.10 = $4 per ton of soil loss for 3.5% OM= 70 lb. x $0.10 = $7 per ton of soil loss
- If soil loss is 5 tons/acre, then the total loss for the two soil types would equate to:
  - 2.0% = $4 per ton x 5 tons/acre soil loss = $20 per acre value
  - 3.5% = $7 per ton x 5 tons/acre soil loss = $35 per acre value

**Source: Dr. Mahdi Al-Kaisi, Iowa State Extension, "What is the Nutrient Value of Lost Organic Matter by Erosion?"*

Value of Soil Organic Matter: Another Example

- Assumptions: 2,000,000 pounds soil in top 6 inches per acre.
  - 1% organic matter = 20,000 lb.
- **Nutrients**:
  - Nitrogen: 1000 lb. x $0.37/ lb. of N = $370
  - Phosphorus: 100 lb. x $0.44/ lb. of P = $44
  - Potassium: 100 lb. X $0.29/ lb. of K = $29
  - Sulfur: 100 lb. x $0.31/ lb. of S = $31
  - Carbon: 10,000 lb. or 5 ton x $?/Ton = Unknown Value
  - **Value of 1% SOM Nutrients/Acre = $474**

**Source: Ohio State University Extension, Jim Hoorman, 2011. Modified with figures from UT Crop Budgets, 2018.*

Soil Organic Matter on Productivity

- Michigan State University Study:
  - For every 1% increase in soil organic matter, yields increase by 12%.

Crop	Yield	Yield Increase Bu. / acre	Price per bushel	Increased Income	Avg. Annual @ 0.10% OM / yr.
Soybeans	50	6	$7.85	$47.10	$4.71
Corn	165	19.8	$3.29	$65.14	$6.51

**Source: Warncke, D. 2007. Benefits of wheat in a rotation. Michigan State University Extension Crop advisory team alerts.* http://msue.anr.msu.edu/news/benefits_of_wheat_in_a_rotation

Nitrogen Loss and Efficiency

- Cover crops impact the nitrogen in the soil in many ways.
  - Cover crops can add back nitrogen through the use of legumes.
  - Cover crops are effective at limiting offsite movement of nitrate.
  - Potentially mineralizable nitrogen is impacted by the cover crop species planted.
  - Yield is impacted by the presence of additional N and other nutrients.

Nitrogen Losses

- Corn and wheat have a relatively high N requirement.
- Soil organic matter losses can have a direct impact on N management.
  - Soil organic matter is one place where N is stored in the soil.
- Increased tillage and applying N in only 1 to 2 applications leads to more leaching and loss of N.
- Soil organic matter breaks down with more tilling and soil disturbance.

Nitrogen Losses

- Although you can add either organic or inorganic N forms to soil, plants only take up inorganic N (that is, NO_3^--N and NH_4^+-N).
- One form isn't more important than the other and all N sources can be converted to NO_3^--N. Commercial N fertilizers, legumes, manures and crop residues are all initial sources of NO_3^--N and NH_4^+-N.
- Nitrate is always present in the soil solution and will move with the soil water.

*Source: Fernandez and Kaiser, Iowa State Extension Nutrient Management Specialists, 2018.

Nitrogen Losses: UT Study

- 6 different cover crop mixes were evaluated.
- Cereal Rye and Hairy Vetch resulted in the highest amount of inorganic N available to the plants.
- All plots with a multispecies cover crop mix had higher inorganic N concentrations available to the plants.
- By converting the chart from Mg/hectare, the yield for the Soil Health Mix equated to 67.8 bushels/acre.
- The next best yield was a Cereal Rye and Hairy Vetch crop mix with a yield of 58.0 bushels/acre.
- The control, with no cover crop, did not have a significantly lower yield than the other cover crop mixes, save the Soil Health Mix.

**Source: Chu, Jagadamma, Walker, Each, Buschermohle, and Duncan; University of Tennessee, 2017.*

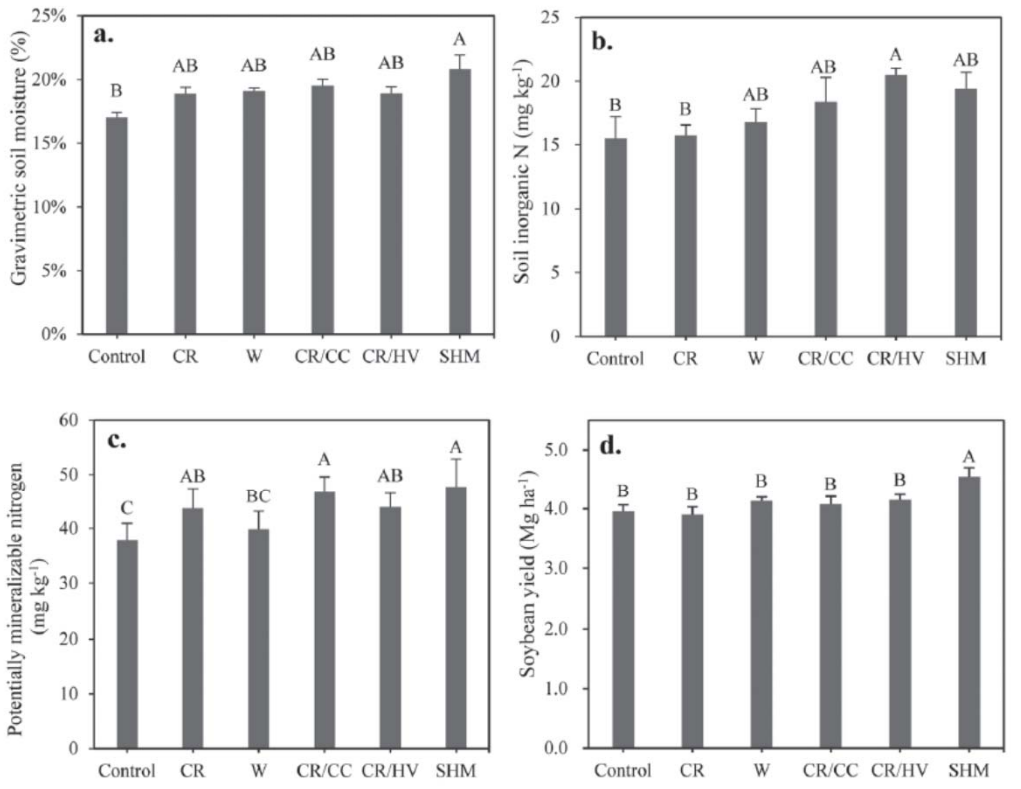


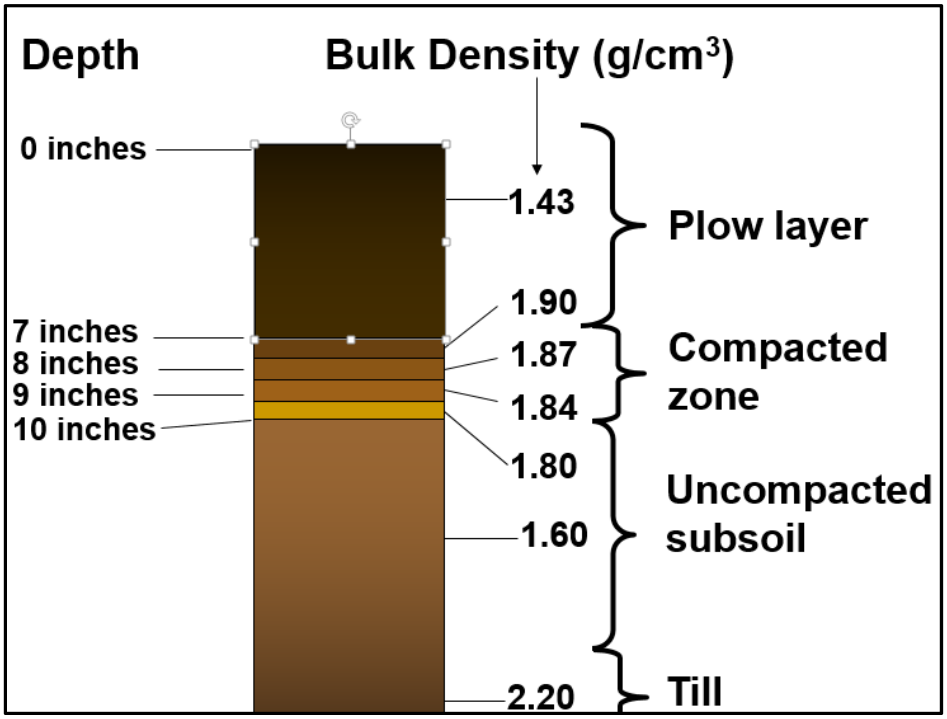
Fig. 1. Effect of cover crop treatments on (a) gravimetric soil moisture, (b) soil inorganic N, (c) potentially mineralizable N, and (d) soybean grain yield. CC, crimson clover; CR, cereal rye; HV, hairy vetch; SHM, soil health mix (cereal rye, whole oats, purple top turnips, daikon radish, and crimson clover); W, wheat. Different uppercase letters over the bars denote statistically different means at $P \leq 0.05$. Error bars represent standard error of the mean with $n = 4$.

Nitrogen Losses: Poor Soil Structure from Conventional Tillage Increases Losses in No-Till Corn

Soil N Losses from Poor Soil Structure: Conventional Tillage

- Volatilization: 5-50%
- Leaching: 20-40%
- Denitrification: 40-60%
- Soil Erosion: 0-100%

Note: It can take 3-5 years of using No-Till and cover crops to reduce losses.



*Source: Camp & Lund; Jim Hoorman, NRCS Soil Health Specialist

Nitrogen Efficiency

If a producer doubles their N use efficiency from 40% to 80%, how much less N might they have to buy if they purchase 180 lbs. of N fertilizer at $0.39 per pound?

- 180 lbs. of N x 40% = 72 lbs. of actual N used by plant
- 72 lbs. of N needed/80% or 0.80 = 90 lbs. of N fertilizer needed instead of 180 lbs. of N fertilizer needed. Also 180 lbs. N x (40%/80%) = 90 lbs. of N
- Producer saves buying 90 lbs. of N fertilizer (180 lbs. of N – 90 lbs. of N) x $0.39/lbs. of N = $35.10/Acre
- In reality, producers may give themselves a credit for N from cover crops, but they will not drastically reduce their N use as it is the lifeblood of their yield. **Soil analysis should always be considered**.

Soil Health and Nitrogen Efficiency

- According to the NRCS:

  Nitrogen Efficiency:

  – Conventional Tillage: 30-50%

  – Cover Crop + No-till: Goal is to increase to 80% or higher

  Phosphorus Efficiency:

  – Conventional Tillage: 10-50%

  – Cover Crop + No-till: Goal is to increase to 80% or higher

Value of Improved Drainage due to Cover Crops

- Cover crops allow the soil to retain moisture longer.
- In a dry year, this is a blessing.
- In a wet year, this can become a curse.
- We are going to look at the impact that cover crops have on water storing capabilities.

Water Storage Value

- Every 1% soil organic matters (SOM) holds 1 acre-inch of water
  - Crops need about 1 inch of water for optimal growth
- Value of an acre-inch of water = $12 (varies)
  - UT Crop Budgets value an acre-inch of irrigation at approx. $7
- Value of 6% SOM vs 2% SOM =

  4 acre-inches of water * $7/acre-inch=$28
- 0.1% SOM addition per year =

  0.1 acre-inch x $7/acre-inch = $0.70 per year

Value of Water Storage in Hot Dry Summers

- **Water needs for Corn based on soil temperature**:
  - 75°F – 1 Inch water/week
  - 85°F – 2 inch water/week
  - 95°F – 4 inch water/week
- **2X Water requirements for every 10°F increase**
  - 1” Rain = 8 bu. Corn, 6 bu. Wheat and 3.5 bu. soybeans
  - 22” water needed for 200 bu. Corn
  - Typical Ohio Rain = 19-23 inch/year in growing season
  - 1” Rain fully used:
    - Corn = 8 bu./ac. x $4 = $32/acre
    - Beans = 3.5 bu./ac. x $8 = $28/acre
    - Wheat = 6 bu./ac. x $5 = $30/acre
- **Heat and drought quickly increase yield losses!**

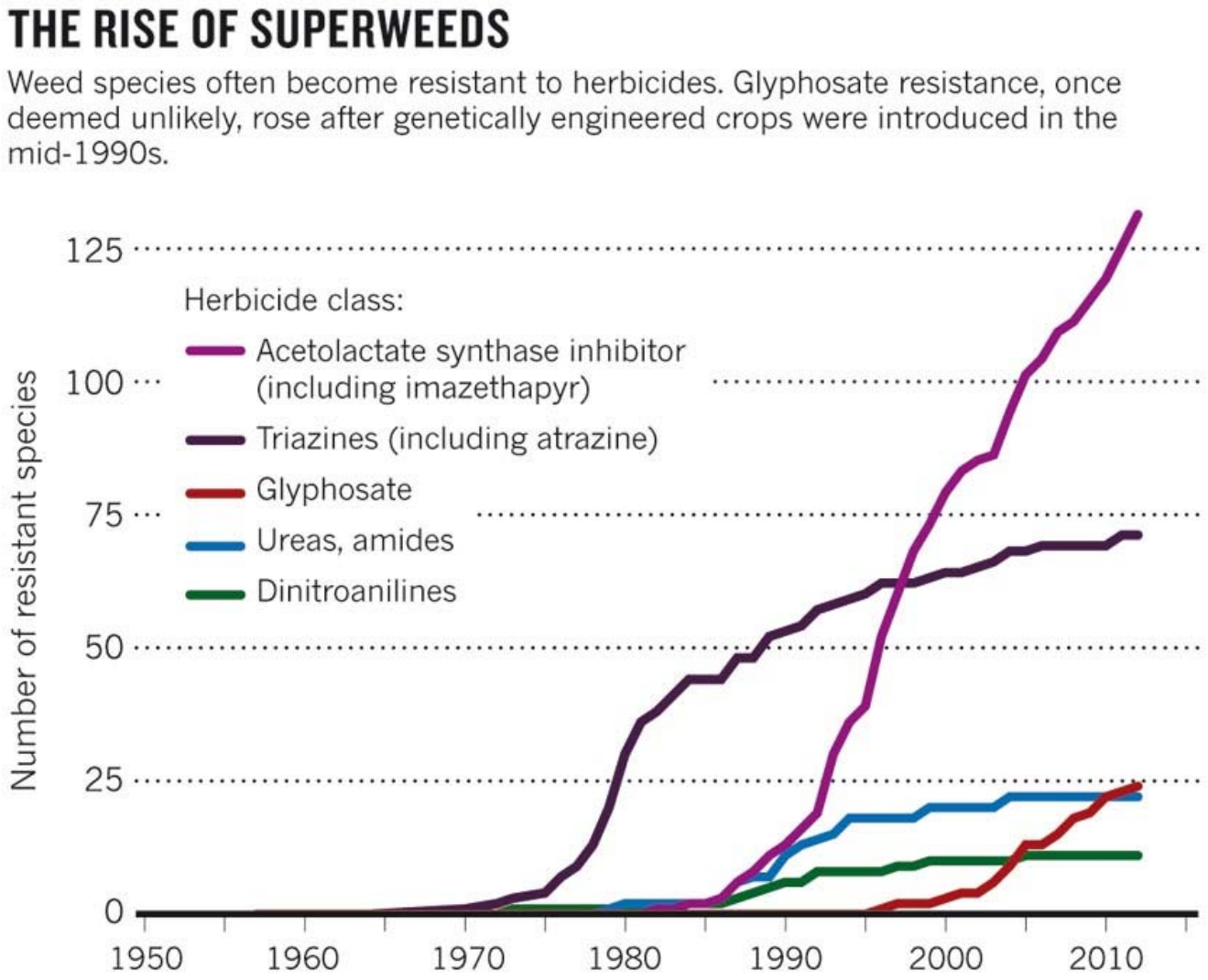
**Source: Elwynn Taylor, Iowa Ag. Climatologist*

Using Cover Crops to Combat Weeds

Resistance to herbicides is a big deal.

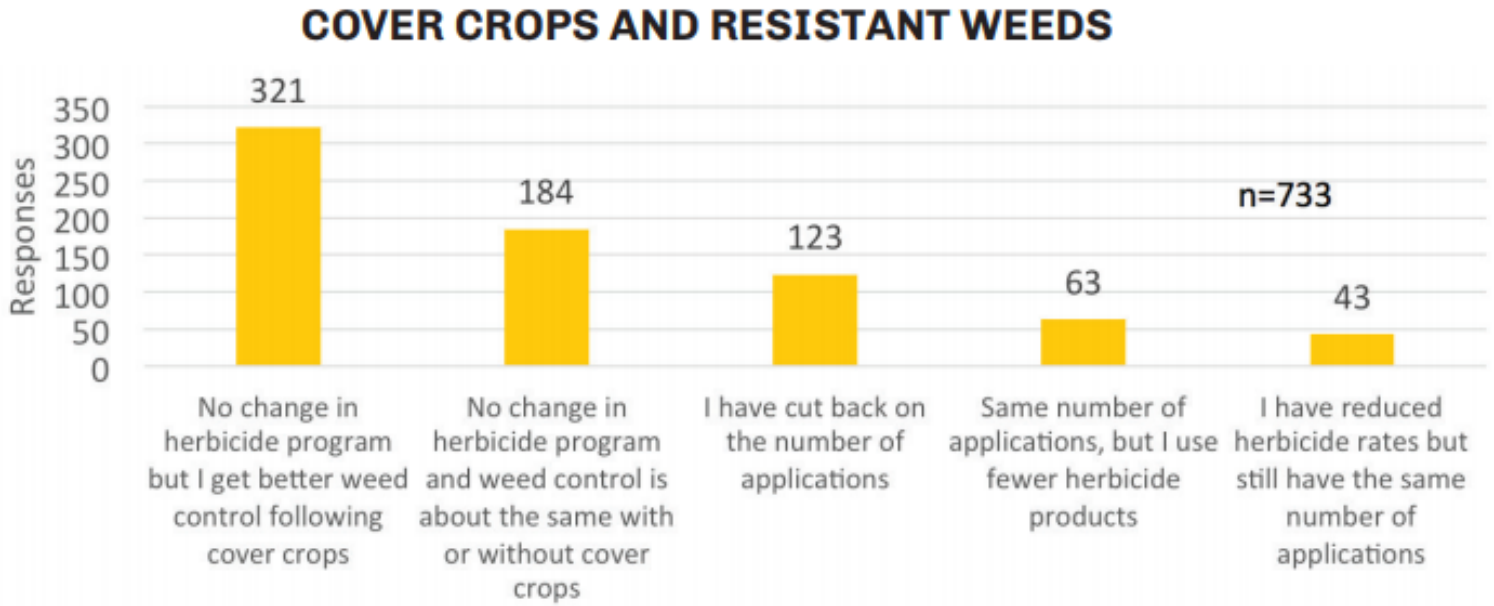
Cover crops are being looked at to better control or extend the life of some chemical technologies that we heavily rely upon for weed control.

ALS Example = Leadoff
Dinitroanlines Example = Prowl & Treflan



**Source: http://www.nature.com/news/increase-resistant-weeds-jpg-7.10318?article=1.12907*

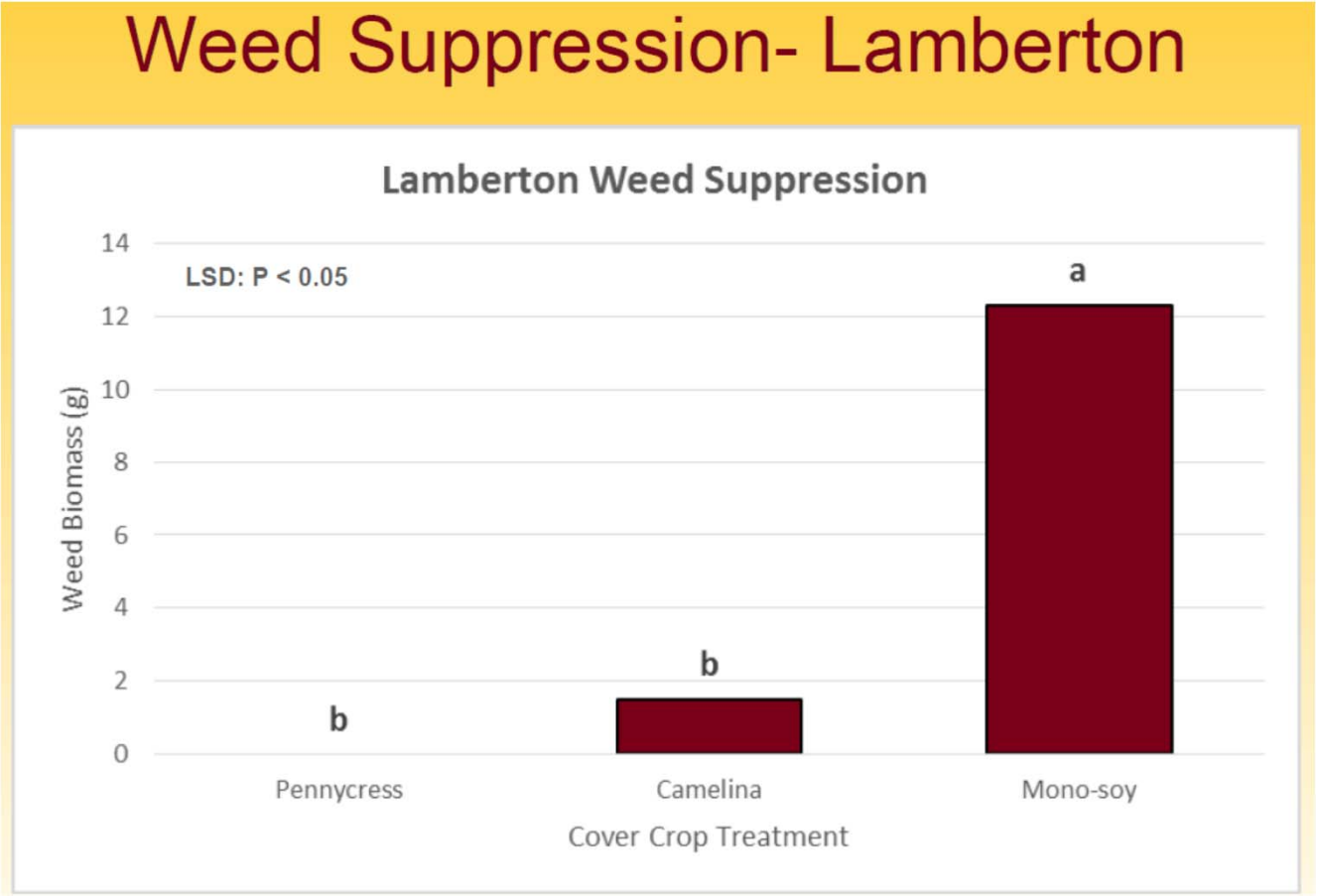
Producer Reported Benefits of Cover Crops



69% of survey participants stated they made NO change in their herbicide program due to cover crops.

Do cover crops reduce weed pressure?

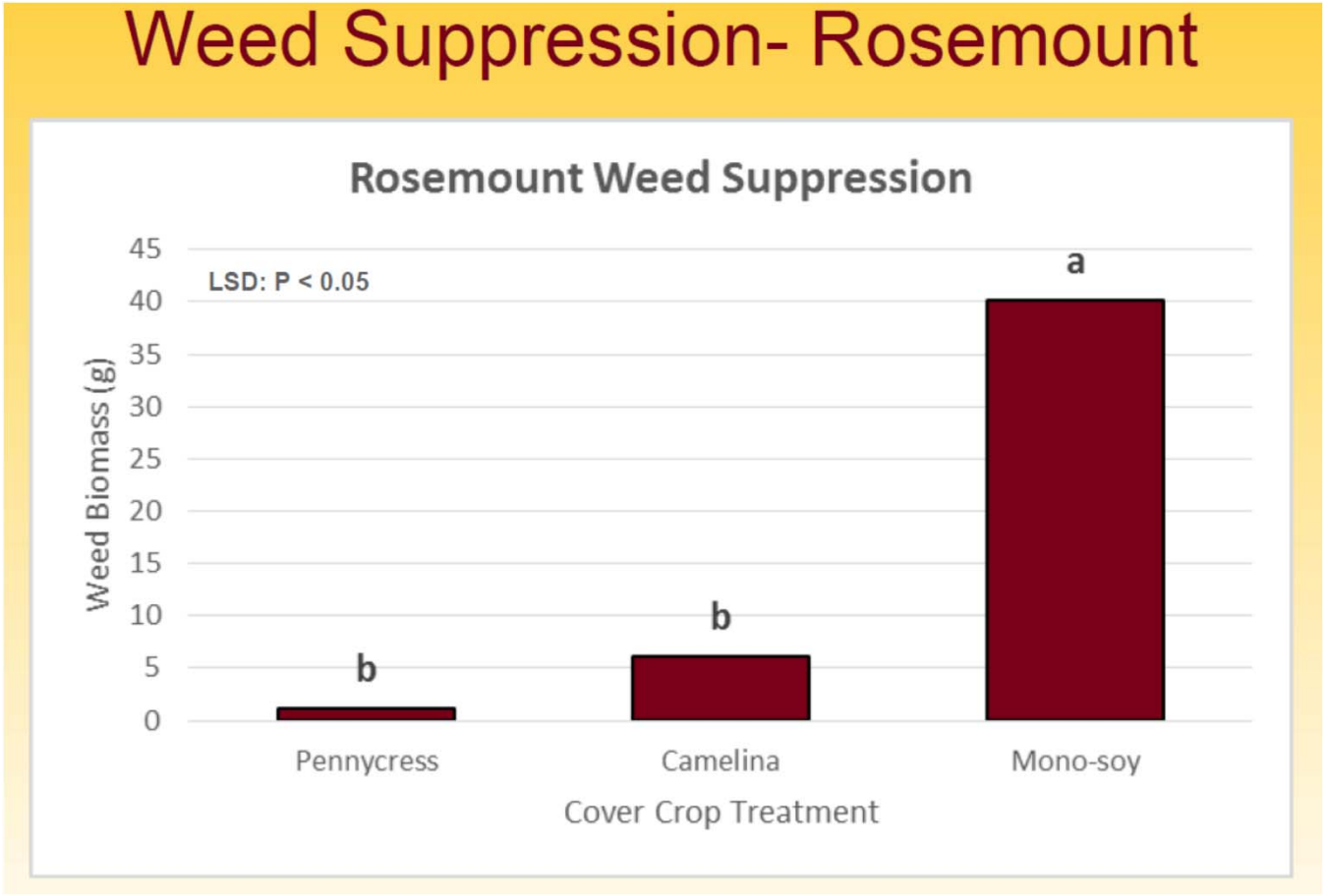
Reported 87% reduction in weed biomass between Camelina (brassicaceae) plots and soybean fields.



Source: Hoerning, et al.; University of Minnesota; Cover Crop ASA Presentation;2017.

Do cover crops reduce weed pressure?

Reported 85% reduction in weed biomass between camelina plots and soybean fields.



Source: Hoerning, et al.; University of Minnesota; Cover Crop ASA Presentation;2017.

Pennycress

Camelina

Economic Benefit of Reducing Weeds

- If farmers with no-till and cover crops reduce herbicide cost by approximately 33%:
  - $7-$12/A. savings
- Early weeds reduce crop yields 10%
  - 50 bu. soybeans x $8/Acre = $40
- Need high biomass cover crops to reduce weeds
  - Cereal Rye $18.90/ac.
  - Rapeseed $8.00/ac.
  - Sorghum Sudan $18.60/ac.
  - Cost of seeding $15/ac.

2016-2017 National Cover Crop Survey

About 19% (265) of the cover crop users strongly agreed and 28% (398) agreed with the statement, "Using cover crops has helped me reduce my overall crop inputs (fertilizer, insecticide, herbicide, etc.)." Twelve percent (171) disagreed, 4% (52) strongly disagreed, and 37% (522) were neutral. This level of neutral-and-below attitudes could signal a need for further research into the impacts of cover crops on the subsequent use of fertilizer and crop protection products, as well as a need for focused communication efforts.

- The result of this survey was very split among farmers with 47% saying that cover crops reduced inputs and the remaining 53% either disagreeing or being neutral on the statement.

- The use of cover crops can have an impact on burndown chemistry which may cause producers to incur additional costs.

Impacts on Pest and Disease

Positive: Soybean Cysts Nematodes (SCN)

1. 80-90% Reduction using cereal rye/annual rye
   a) 50 bu * 30% =15 bu * $8 = $120/acre
   b) Keep in mind that single species are not often implemented.

Increase natural pollinators is positive benefit from cover crops.

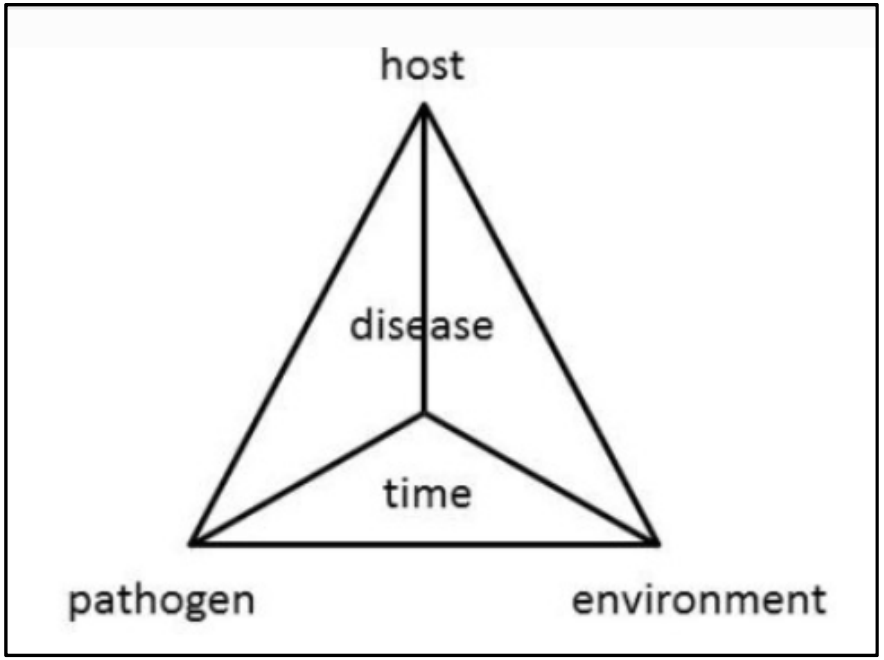
Negative: Slugs, Cutworm, Armyworm

**Source: NRCS, Economics of Improved Soil Function.*

Impacts on Pests and Diseases

- Improved water infiltration
- Reduced compaction
- Improved soil structure

Lead to better drainage: which improves the soil environment for less disease incidence and more predators of disease carrying insects.



Impact on Pests and Diseases

1. Cover crops will increase the need and value of insecticide seed treatments or other at-planting insecticide applications.
2. Cover crops can increase the need for a foliar insecticide application (i.e. pyrethroid) near planting to prevent problems with cutworms, three-cornered alfalfa hoppers, etc.
3. Problems can be reduced by terminating the cover several weeks in advance of planting.
    - Early termination reduces some benefits of cover crops such as weed suppression.
4. Pests, such as slugs, pose a challenge.
5. Multiple covers, multiple crops, multiple pests (varies by geography), multiple timing/methods of cover crop termination can be challenging to manage.

Grazing Economics

- Feed accounts for approximately 50% of all expenses in a cattle operation.
- Any chance we can get to reduce our feeding expense, we tend to add more to our bottom line.
- Grass is by far the cheapest feed source for cattle.
- We can use cover crops to extend our grazing season and reduce the amount of hay needed.

Economics of Extended Grazing Season

Hay Requirements / Storage and Feeding Loss Calculator		
Describe cattle being fed and length of feeding period in days		
	Alternative 1	**Alternative 2**
Number of head	50	50
Average weight (lbs.)	1200	1200
Percent body weight fed	2.00%	2.00%
Number of days fed	120	90
Describe the hay being fed		
Bale weight (lbs.)	750	750
Bale size (diameter x length)	4'x5'	4'x5'
Percent dry matter (%)	89.0%	89.0%
Price (value) per bale ($)	$35.00	$35.00
Price (value) per ton as fed ($)	$93.33	$93.33

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Animal Consumption and Cost Estimates

	Alternative 1	Alternative 2
Consumption per head on dry matter basis		
pounds per day	24.0	24.0
Consumption per head on as fed basis		
pounds per day	27.0	27.0
tons for feeding period	1.6	1.2
bales for feeding period	4.3	3.2
Total herd consumption for feeding period		
tons	81	61
bales	216	162
Cost* per head		
per day ($)	$1.26	$1.26
for feeding period ($)	$151.01	$113.26
Cost* for herd		
per day ($)	$62.92	$62.92
for feeding period ($)	$7,550.56	$5,662.92

Assuming a 25% reduction in hay fed results in a savings of $1,888, assuming 50 head.

Grazing Economics

- By getting additional value from the cover crop in the form of grazing you can see a net benefit in a shorter amount of time (i.e. increased SOM)

Costs

Cover Crop Before Corn		Grazing Infrastructure	
Cover Crop Seed ($/acre) - Winter Triticale, 20 lbs/acre, $0.31/lb Purple Top Turnip, 4 lbs/acre, $1.70/lb Spring Oats, 20 lbs/acre, $0.30/lb	$19.00	Fence ($/acre) [1/]	$49.17
Cover Crop Planting ($/acre)	$20.00	Watering Facilities ($/acre)[2/]	$71.52
Cover Crop Termination ($/acre)	$10.00		
Total Cost ($/acre)	$49.00	Total Cost	$120.69

Benefits

Cover Crop Before Corn	
Grazing Value ($/acre) – 2.7 AU/ac, 35 lb/AU/day forage demand, 42 days grazing, $80.00/ton forage value	$158.76

Source: NRCS, Economic Benefits of Improves Soil Function.

Fall Season Livestock Carrying Capacity for Annual Cover Crop Mixes

Dry Matter Tons/Acre		*Cow[2] Days of Grazing/Acre*
1.50	average stand	74
2.25	good stand	110
3.0	great stand	147

1. Assumes 70 percent utilization, 30 percent residual left standing or trampled on the soil surface.
2. Assumes a 1,300 pound beef cow that is not milking consuming 28.5 pounds of dry matter per day.

*Source: Jerry Lindquist, Michigan State University Extension, “Fall cover crop grazing basics”, July 2016.

Cover Crop Grazing: Things to Remember

- Death loss can be an issue with certain cover crop mixes.
- Bloat, nitrate toxicity, and other risks are a possibility.
- Supplement cattle with either a feed supplement and/or provide access to a good quality hay to prevent this.
- Providing plant species such as oats and other grasses along with the clover can help prevent bloat.

Conclusion

- The economic benefit of cover crops is shown by increased yields, reduced inputs, extended grazing seasons, etc.
- Cover crops have their challenges as well by way of a potential increase in pests, added establishment costs, and more time to manage them.
- Cover crops require a long-term approach to see the full benefit in both productivity and economics.
- Farmers need to consider the proposed benefit of cover crops along with the cost of implementing them into their operation.

Questions or Comments?

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