Cover Crop Economics

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Introduction

Cover crops are an added input that cost money to plant, grow, and terminate. Everyone wonders whether that investment in growing cover crops is worthwhile, whether it pays, and how long does it take to recoup the investment? This fact sheet will give some general economic guidelines and general information on what cover crops may accomplish for our soil, air, and water resources.

There are several ways that cover crops pay for themselves. The economic benefits may be immediate or long-term. Some of these benefits are additive, others are harder to define. Farmers, gardeners, and homeowners often ask themselves: How much can I afford to pay for cover crop seed and still get a return on my investment?

Scenario 1: Cost of Tillage versus Cost of Cover Crop Seed

One way of improving soil health is to convert to no-till and start using cover crops. If conventional tillage is eliminated, use the money saved from doing conventional tillage to plant cover crops. Table 1 shows some common costs for tillage operations. On average, farmers are spending around $30 to $45 per acre per year to perform several tillage operations. As a first step, spend the money saved tillage to pay for cover crop seed and planting cosst; no more than the actual costs of performing tillage each year. If planting costs are around $15 per acre, farmers should be spending no more than $15 to $30 per acre in cover crop seed cost or $30 to $45 for cover crop seed and planting costs.

Table One: Cost of Tillage Operations/Acre

Chisel Plow	$14/A
Disk Tandem	$13/A
Field Cultivate	$11/A
Plow	$17/A
Soil Finishing Tools	$11/A
Subsoil	$18/A

Ohio Farm Custom Rates 2010

Tillage is a destructive process; it burns up soil organic matter and ruins soil structure. However, it does release many soil nutrients (often excessively and inefficiently) through oxidation. The benefit of the cover crops; is that in addition to conserving and building up soil organic matter levels, it increases water infiltration, increases water storage, and improves nutrient efficiency. Cover crops and no-till also decrease soil erosion and nutrient runoff. The benefits to cover crops may be difficult to quantify, but the long-term effects are invaluable over time.

Scenario Two: Nitrogen Fertilizer Value of Legume Cover Crops

For legume cover crops, it is often easier to quantify the benefits. In general, the seed costs are higher ranging from $.80 to $2.00 per pound of seed and total costs range from $18 to $69 per acre. However, legumes fix nitrogen and at $.50 per pound for nitrogen fertilizer, most legume cover crops are producing 100 to 200 pounds of nitrogen which is valued at $50 to $100 per acre in nitrogen fertilizer. See Table 2 on Legume Cover Crop Economics.

Table Two: Legume Cover Crop Economics

Cover Crop	Total Cost/Acre	Pounds of N	Value of N	Total N $	Net Gain
Cowpeas	$46-54	120-150	$.50	$60-75	$6-$29
Winter peas	$34-$69	120-150	$.50	$60-75	($9) -$41
Red Clover	$41-$45	100-120	$.50	$50-60	$5-$19
Sweet clover	$30-45	100-200	$.50	$50-$100	$5-$70
Crimson Clover	$18-25	100-150	$.50	$50-$75	$25-$50
Hairy Vetch	$49-$54	100-200	$.50	$50-$100	($4)-$51

Scenario Three: Value of Soil Organic Matter (SOM)

One simple way of valuing soil organic matter (SOM) is to value the nutrients stored in the SOM. Every one percent SOM has roughly 1,000 pounds of nitrogen (N) and about 100 pounds of phosphorus (P), potassium (K), and sulfur (S). The value of these nutrients is estimated to be about $670 for every 1% SOM. See Table 3 on Value of Soil Organic Matter. Of course, SOM is worth more than just its fertilizer value, but this method give an easy way of recognizing and valuing SOM accumulations in the soil. On average, a cover crop in a no-till system can add 0.10 to 0.15% SOM per year through the addition of an extra set of roots. These roots will require some additional nitrogen and nutrients to fully stabilize the SOM, but these nutrients are also slowly made available to the plants over time. Using the $670 per acre for every 1% SOM, the addition of 0.10 to 0.15% SOM on a yearly basis is worth $67 to $100 per acre per year. Grasses tend to add more carbon or soil organic matter than legumes which add more nitrogen. A healthy mixture of grass, legume, and other cover crops help to balance the nutrient availability.

Table 3: Valuing Soil Organic Matter

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Value of Soil Organic Matter

Assumptions: 2,000,000 pounds soil in top 6 inches
1% organic matter = 20,000#

Nutrients:

Nitrogen:	1000# * $0.50/#N	=	$500
Phosphorous:	100# * $0.70/#P	=	$ 70
Potassium:	100# * $0.50/#K	=	$ 50
Sulfur:	100# * $0.50/#S	=	$ 50
Carbon:	10,000# or 5 ton * $?/Ton	=	$ 0

Value of 1% SOM Nutrients/Acre = $670

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Original Jim Kinsella/ Terry Taylor(2006)/revised Jim Hoorman (2011)

One of the benefits of cover crops is in reducing soil erosion and preventing sediment loading by surface water to creeks, streams, rivers and lakes. By keeping live plants growing on the soil year round, the live plant roots protect the soil from being lost. Economists struggle to put a value on a ton of top soil that is either saved or preserved. The following is a simplified way of valuing topsoil and the economic benefits of cover crops in preserving the soil.

Scenario Four: Value of Reduced Sediment and Soil Erosion

Assume agricultural farmland is selling for $10,000 per acre of land. The land as a physical entity at a certain location has value but the soil also has value for agricultural production of food and crops. Let assume that the top three inches of the top soil has the majority of the value and that 50 percent of the value of the land is associated with the topsoil. So 50 percent of $10,000 is $5,000 for the top 3 inches of soil and there is roughly 500 tons of topsoil in this top 3 inches. The value of a ton of top soil is then about $10 per ton of soil ($5,000/500 ton= $10/ton of topsoil). Cover crops and no-till reduce the soil erosion to almost zero. The NRCS tolerable annual soil loss is around 4 to 5 tons of top soil per year. At $10 value for each ton of top soil, cover crops and no-till are saving farmers roughly $40 to $50 per acre per year in preserved topsoil. As a side note, the acceptable loss for topsoil should be zero and not 4-5 tons per year. It takes 500 years to build 1 inch of topsoil which at 5 tons of soil loss per year, it may be eroded in 30 years. Topsoil is too valuable to be indiscriminately lost to surface water when it costs additional money to clean the water and to dredge our rivers and lakes of sediment. Soil is meant to be kept on the land and as a society we do not put enough value on the price of top soil and keeping it intact on the land.

Scenario Five: Value of Increased Soil Productivity

A Michigan State University study showed that every one percent increase in SOM resulted in a 12% yield increase. Assuming that baseline yields are 200 bushel corn, 60 bushel soybeans, initial SOM levels are 2.5%, and corn is selling for $4 and soybeans for $10 per bushel. If SOM levels increase by 1% point from 2.5 to 3.5% SOM, corn yields are expected to increase by 12% or from 200 to 224 bushels per acre with a 24 bushel increase @ $4 per bushel or $96 per acre. For soybeans, a 12% increase in yield from 60 bushels to 67.8 bushels or 7.8 bushels @ $10 per bushel or $78 per acre. Assuming an increase in SOM of 0.1 to 0.15 per year, the value for corn is $9.60 to $14.40 per year and for soybeans the value is $7.80 to $11.70 per year.

Scenario Six: Soil Compaction Costs

Severe soil compaction may reduce crop yields by as much as 30% resulting in a yield loss. Yield reductions from soil compaction have been documented to last 10 to 30 years. Using baseline yields of 200 bushel corn and $4 per bushel for corn, a 30% yield loss is equal to 60 corn bushels valued at $4 or $240 per acre. For soybeans, baseline yields of 60 bushel soybeans and $10 per bushel, a 30% yield loss is equal to 18 soybean bushels valued at $10 or $180 per acre. However, in normal situations, soil compaction is not quite this severe.

Ohio State University soil compaction data on a Hoytville clay soil show that typical yield losses for soil compaction are 3% for corn and 10% for soybeans. Using our baseline yields, a 3% point loss on 200 bushel corn is 6 bushels times $4 per bushel or $24 per acre. For soybeans, a 10% yield loss on 60 bushel soybeans equals 6 bushels times $10 per bushel or $60 per acre. Investing in cover crops is a worthwhile investment if the cover crops can improve soil structure, increase water infiltration, and improve soil compaction and ultimately restore or even increase crop yields.

The cost of soil compaction on corn and nitrogen fertilizer applications can be significantly higher. For example, denitrification of nitrogen fertilizer can be as high as 40-60% loss under flooded conditions on clay soils. If a farmer is applying 150 to 200 pounds of nitrogen per acre valued at $0.50 per pound, a 40% loss (60-80#, $30-40) and a 60% loss (75-120#, $37.50 -$60), is highly significant on a per acre basis. Cover crops may significantly reduce the losses from denitrification by improving soil structure, improving water infiltration, improving drainage, decreasing soil compaction, and increasing soil aeration to reduce the negative effects of denitrification.

Scenario Seven: Drainage Efficiency

Cover crops and no-till (ECO Farming) improve soil structure and improve drainage efficiency by increasing water infiltration. Farmers in Northwest Ohio have installed enough subsurface to go to the moon and back three times. Systematic tile and subsurface drainage has traditionally been installed on 40 to 50 foot spacing. Drainage is critical to improve rooting depth and healthy plants, since most plant roots (excluding wetland species and grain crops like rice) do not grow in saturated soils. Some farmers are now installing new subsurface drainage systems at 25 to 30 foot spacing between drainage lines to improve drainage and increase crop yields. The decreased drainage spacing and increased installation of tile by splitting drainage lines has been implemented because soil compaction has increased and soil structure has declined. More drains placed closer together has resulted in improved drainage and improved soil productivity.

However, perhaps farmers have another option to improve soil productivity by improving soil structure naturally by increasing live roots in the soil, adding soil organic matter, and increasing water infiltration through the usage of cover crops. Let's use a simple example. On average, farmers pay $800 to $1000/acre for subsurface drainage. Most farmers know you pay for drainage every 20 years either through reduced yields (30 to 40%) from lack of drainage or from the cost of installing subsurface drainage.

What if farmers kept the $800 to $1000 in a bank or financial investment and collected 2-3% interest on the principal per year. To improve soil health and improve water infiltration from macropores, spend the interest on cover crop seed which would be around $20-30/acre. At the end of 20 years, a farmer should still have his principal investment but also, improved soil productivity from increased soil organic matter, improved water infiltration, improved drainage, and higher crop yields. For the cover crop system to work, cover crops need to be used every year and there must be adequate drainage already installed to remove excess water. Cover crops and no-till by themselves will not improve drainage unless there is an outlet for excess water to be removed from the root zone.

Scenario Eight: Increased Value due to Soil Moisture

The value of soil organic matter in the soil is evident during a dry summer or a drought. Depending on soil structure, a sandy soil can hold 0.5 to 1 acre inch of water for each additional percent of SOM, while a clay or loamy soil may hold 0.8 to 1.9 acre-inches of water for each percentage increase in SOM. For every inch of rainfall, the increase in corn yield is about 8 bushels per acre, for wheat xx to x bushels per acre, and xx to xx for soybeans. One inch of additional water storage in corn is worth 8 bushel @ $4 or $32 per acre, for wheat x bushels @ $5 or XX per acre, for soybeans, x bushels @ $10 or XX per acre.

SOM and surface residue also reduces evaporation and reduces the temperature of the soil and the requirements for soil water. The amount of water in the soil needed to produce a crop doubles for every ten degree Fahrenheit increase in soil temperature. For example, for corn production: at 75 degrees Fahrenheit – 1 Inch water is required per week; at 85 degrees Fahrenheit – 2 inch water/week is needed and at 95 degrees Fahrenheit – 4 inch water/week is needed. On bare soil, the soil temperature may be 20-30 degrees warmer than soils with higher amounts of surface residue and growing plants which shade and cool the soil.

Scenario Nine: Average Yield and Income Increases

The Conservation Technology Innovation Center (CTIC) conducted a comprehensive survey of cover crop and no-till users in 2012-2013. In the 2012 year of a major drought in the Midwest, corn plus cover crops yielded 11 bushels more than conventional @ $7/bushel or $77/Acre. Soybean plus cover crops yielded 5 bushels more than conventional @ 15/bushels or $75/Acre.

In 2013 (with good moisture in the Midwest), corn plus cover crops yielded 5 bushels more than conventional @ $4/bushel or $20/Acre. Soybean plus cover crops yielded 2 bushels more than conventional @ 10/bushel or $20/Acre. Cover crops, no-till, and soil health pay dividends, especially in dry years when crop prices are generally high.

Table 4: Change in Corn Yields & Net Income from 2012 Drought, David Robison's farm.

Cover Crop Management, Seed and Application Expenses	**Corn Yield Bu/Acre**	**Corn Yield Change Bu/Acre**	**Total Income**	**Net Revenue after Seed, Application Costs, Herbicide**	**Net Income**
check (no cover crop, No-till, replicated 3X)	**105.24**	0	$ 605.13	$605.13	**$0.00**
Annual Ryegrass + Crimson Clover + Radish ($44.87/A)	**120.31**	15.07	$ 691.78	$646.91	**$41.78**
Winter Cereal Rye ($32.48/A)	**126.86**	21.62	$ 729.45	$696.97	**$91.84**
Oats + Radish ($64.75)	**138.79**	33.55	$ 798.04	$733.29	**$128.16**
Annual Ryegrass Blend ($29)	**134.27**	29.03	$ 772.05	$743.05	**$137.92**
Annual Ryegrass + Crimson Clover	**136.41**	31.17	$ 784.36	$750.76	**$145.63**
Crimson Clover + Radish ($56)	**153.99**	48.75	$ 885.44	$829.44	**$224.31**
Oats + Rye +Turnips ($74.90)	**164.37**	59.13	$ 945.13	$870.23	**$265.10**
Austrian Winter Peas + Radish ($55.65)	**164.82**	59.64	$ 947.72	$892.07	**$286.94**

Corn Price = $5.75 in this example.

On David Brandt's farm in Central Ohio, with 30 years no-till and 15 years cover crops, in 2012 and a severe drought; Dave's corn yielded 149.9 Bu/A and soybeans yielded 49.5 Bu/A compared to his neighbors conventional tillage fields that yielded 80-95 Bu/A corn and 32-35 Bu/A soybeans. The economic difference at $7 corn and $15 soybeans is 55-70 corn bushels or $385 to $490 per acre on corn and15-18 bushels or $225 to$270 per acre in additional income on soybeans. A common saying is that rain makes grain but increased soil moisture due to higher SOM levels and more stored soil water also equals higher yields, and the benefits during a drought year are even greater due to higher crop prices and higher profit margins.

Scenario Ten: Forage Value of Cover Crops

A number of cover crops including oats, cereal rye, annual ryegrass, triticale, and Sorghum Sudan grass can be harvested as forages for livestock feed. For example, 4-5 wets tons of cereal rye or 3-4 dry tons of forage harvested in the spring is worth $100/ton or $300 to$400. Seed costs (2-3 bushels @ $12 plus drilling cost $24) are $60 plus the cost of harvesting forage ($40 per ton) results in a net income of $40 to $45 per ton or $120 to $180 per acre.

Scenario Eleven: Manure Nutrient Absorption Value

Cover crops especially grasses and brassicas are good at absorbing and recycling manure nutrients and leftover unused fertilizer in the soil profile. The grass plant total biomass typically absorbs a maximum of 0.5% nitrogen (N) and 0.2% phosphorus (P). Maximum phosphorus accumulation for grasses is 18 to 25 pounds per acre typically.

Table 5: Value of Manure Absorbed by Cover Crops
Swine Manure: 95% Water 5% solids
Manure Nutrient Analysis: 18(N)-16(P)-14(K)/1000 gallons

Uptake: At 5,000 gallons/A = 90#N-80#P-70#K $72
At 10,000 gallons/A = 180#N-160#P-140#K $101

Dairy Manure: 98% water 2% solids
Manure Nutrient Analysis: 20#N-15#P -15#K /1000 gallons

Uptake: At 5,000 gallons/A = 100#N -75#P -75#K $77
At 10,000 gallons/A = 200#N -150#P -150#K $149

*Absorb 70% N in manure, maximum 20# P
Cover crops absorb maximum 0.5% N and 0.2% P
N=$.50, P=$.60, K=$.40 per pound

Scenario Twelve: Cover Crops Grown for Seed Production

Some cover crops can be grown for seed production if the seed is not registered. Typical yields for cereal rye is winter cereal rye is 30-60 bushels/A @ $12 per bushel or an income of $360 to $720 per acre. Seed, planting, and herbicide cost equal $49/A plus $30 for harvesting leave a net income of $280 - $640/Acre. The most successful farmers have achieved yields of 80 to 90 bushels per acre with intensive management. Another example is Cowpeas which produce 30-35 bushels per acre or 1,500 to 1,750 pounds @ $.80 per pound equal to $1200 to $1400 per acre total income minus seed, planting, and harvesting costs ($100/Acre).

Scenario Thirteen: Reductions in Weed Costs

On average, farmers lose 30% of their production to weeds, insects, and diseases each year, and this number has held steady for fifty years or more. Farmers promote weed seed germination by tilling the soil. Tillage buries and protects the weeds seeds and when farmers re-till the soil, they replant the seed. Weed seeds can survive 30 to 50 years in the weed bank in the soil. If weed seed is left on the soil surface, weather and natural predators reduce the weed seed viability. Weeds exist in the ecosystem because they are the first colonizers of the soil when the soil is disturbed.

Farmers have a number of options to fight weeds. Weeds can be physically removed through hoeing, pulling them out, and even grazing. Another method is to chemically kill them with herbicides, but many weeds have started to adapt to this strategy by becoming chemically resistant. Another option is to compete with the weeds for sunlight and nutrients by growing cover crops to reduce weed seed production. Winter cereal rye and radish release natural chemicals that typically prevent weed seeds from germinating. Farmers who use no-till and cover crops generally have reduce their herbicide cost by one-third which is a savings of $7-$12/A. Early weeds reduce crop yields by 10% and on 200 bushel corn @ $4/Acre that equals $80/A and on 60 bushel soybeans @ $10/Acre that equals $60/A.

Scenario Fourteen: Reduction in Insect Pests

In soybeans, grass cover crops like cereal rye and annual ryegrass have been shown to reduce soybean cyst nematodes (SCN) by 80-90%. Assuming a maximum reduction of 30% due to a SCN infestation, and a baseline yield of 60 bushels per acre, the maximum reduction is 18 bushels of soybeans @ $10 or $180 per acre. So by using cereal rye or annual ryegrass, a farmer could potentially save $0 to $180 per acre. Another economic benefit of cover crops is the value of natural pollinators which has been estimated to be worth $ 5 billion dollars annually in the USA and if that benefit is spread over 350 million acres of crop land in the USA, that is worth $14 per acre.

There are some potential negative consequences of growing cover crops. Initially; slugs, cutworm, and armyworm populations may be higher until beneficial insect predators become established. *Carabidae* beetles or black ground beetles and lightning bugs are natural predators of soft body insects and eat their weight in insects daily. *Carabidae* beetles also consume weed seed. Many cover crops may be an alternative food source for slugs and harmful insect larva and may serve as an alternative host to protect corn from damage, allowing the corn to outgrow the insect larva damage.

In South Dakota, Dwayne Beck has documented that by using cover crops with continuous no-till for over ten years, the experimental farm has stopped applying insecticides and fungicides for both corn and soybeans. Researchers at South Dakota State University have documented over one billion predators exist on this farm per acre due to improved management of the ecosystem resulting in no need for insecticides and fungicides. Many common insect pest infestations have been so severely reduced in South Dakota on this farm that chemical forms of insect control have been eliminated. Crop yields are 25 to 35 bushels of corn higher on dryland, netting $100 to $140 more net income per acre not counting the reduced costs in pesticides (herbicides, insecticides, and fungicides).

Scenario Fifteen: Controlling Diseases

Many corn and soybean diseases thrive under saturated soil conditions or when excess water exists in the soil profile. Cover crops improve soil structure, improve water infiltration, and increase drainage so that the excess water is drained away from the crop roots, improving crop production. Common soybean diseases include *Phytopthora, Phythium, Fusarium*, and *Rhizoctonia. Sclertina* or white mold is another common soybean disease. Using a baseline yield of 60 bushels soybeans @ $10 per bushel; common losses for these diseases are 20% loss for *Phytophthora* (12 bushel, $120/A), 5-10% loss for *Phythium* (3-6 bushel, $30-$60/A), 10% loss for *Fusarium* (6 bushel, $60 per acre) and 2-5% loss for *Rhizoctonia* (1.2-3 bushel, $12-$30/A). *Sclertina* or white mold thrives with less biological activity and is actually preserved in the soil profile with tillage with common losses of 2-4 bushel per acre or $20-$40/A.

Annual yield reductions due to pests (weeds, insects, and diseases) of 30% for all crops including corn, soybean, wheat, and forages have been documented since the 1940's. Using a baseline yield of 200 bushel corn and 60 bushel soybeans, a 30 % reduction is equal to 60 bushel corn (@$4 or $240/A) and 18 bushel soybeans (@ $10 or$180/A). If cover crops improve the resiliency of these crops to pest infestation, considerable savings may be realized by growing cover crops.

Scenario Sixteen: Nutrient Losses and Soil Erosion

The biggest benefit to a good winter cover crops may be in reductions in soil erosion (90%), reduction in sediment loading to surface water (75%), decreases in nutrient runoff (50%), and reduction in pathogen loading (60%) that researchers have documented. These numbers are maximum reductions and theses reductions depend on growing a dense cover crop that survives the winter. However, these numbers also point out the importance of having a live crop on the soil surface to protect the soil from adverse weather events that occur on a regular basis. In addition, cover crops may reduce flooding potential (25% to 35%) by increasing water infiltration, storing water in the soil profile through the addition of SOM, and by slowly releasing water to surface outlets, resulting in reduced flooding damage. Cost estimates of the reduction in soil erosion, sediment, nutrient runoff, and pathogens with growing cover crops are quite variable and difficult to calculate but they may result in significant savings.

Summary

Cover crops offer many economic benefits that are seldom totally accounted for by farmers, agronomic consultants, university personnel, or government agencies. While it is difficult to add up all the benefits of cover crops, this fact sheet attempts to quantify some of the potential economic savings of using cover crops and no-till in an ecological system. Benefits include nitrogen fixation, increased soil organic matter levels, increased soil productivity, improved soil structure and decreased soil compaction, improved water infiltration and water storage, increased drainage and reduced flooding, decreased soil erosion and sediment losses, reduced nutrient runoff, improved resiliency to drought, reduced pests (weeds, insects, and diseases), and the potential to grow cover crops for forage, seed production, and the potential to absorb and recycle excess manure and fertilizer nutrients in the soil.

References

Altieri, M. A., Nicholls, C. I., & Fritz, M. A. (2005). In *Manage insects on your farm: a guide to ecological strategies*. Beltsville: Sustainable Agriculture Network.

Hoorman, JJ. (2013) ECO Farming in the 21st Century: Improving Agricultural Efficiency and Crop Production, In: Manitoba- North Dakota Zero Tillage Farmers Association, 35th Annual Zero Till Workshop. pg. 22-26.

Hoorman, JJ, (2015a) Paper on Ecological Farming (ECO Farming): Improving agricultural nutrient efficiency. Editor Reviewed, National No-till Conference, Cincinnati, Ohio,Vol 23, 5 pgs.

Hoorman, JJ (2015b) Understanding How Tillage Impacts Soil Structure and Soil Compaction, National No-till Conference, Cincinnati, Ohio, Vol 23, 5 pgs.

Hoorman, JJ and Young CE, (2015) Using Ecological (ECO Farming) Systems to Suppress Agricultural Pests**,** National No-till Conference, Cincinnati, Ohio, Vol 23, 5 pgs.

Hoorman, JJ and Islam, KR. (2010) Understanding Soil Microbes and Nutrient Recycling, Ohio State University Fact Sheet, SAG-16-10.

Hoorman, JJ, Islam KR, Sundermeier, AP, and Reeder, RC. (2009) Using Cover Crops to Convert to No-till, Ohio State University Fact Sheet, SAG-11-09.

Hoorman, JJ, Islam KR, and Sundermeier, AP. (2009) Sustainable Crop Rotations Using Cover Crops, Ohio State University Fact Sheet, SAG-09-09.

Hoorman, JJ, Reeder, RC, and Sa, JCM. (2011) Biology of Soil Compaction (Revised and Updated, Journal of No-till, Volume 9, No. 2. Pg 583-587.

Managing Cover Crops Profitably, 3rd ed., (2007) Editor: Andy Clark, Sustainable Agriculture Research and Education, (SARE), Handbook Series Book 9.

Midwest Cover Crops Council (2014) Midwest Cover Crops Field Guide, 2nd ed., ID-433, www.mccc.edu.