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Economic Analysis of Cover Crops on Farms Participating in the Southeastern Minnesota Cover Crop and Soil Health Initiative[1]

By William Lazarus and Andrew Keller[2]

May 8, 2018

Contents

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[1] Funded under the Environment and Natural Resources Trust Fund (ENRTF), M.L. 2015, Chp. 76, Sec. 2, Subd. 04e

[2] Professor and Extension Economist, and Graduate Research Assistant, Department of Applied Economics, University of Minnesota.

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Introduction

The Minnesota Board of Water and Soil Resources received $253,000 from the Minnesota Environment and Natural Resources Trust fund in 2015 to accelerate the adoption of cover crops in order to reduce pollution runoff and sedimentation, improve water quality, and improve soil health in southeastern Minnesota through education, outreach, and research. Part of the funding ($100,000) was used to provide incentives for a group of participating producers to each plant cover crops on at least one field of their farm in the fall of 2016 and again in the fall of 2017. Thirteen producers participated and planted cover crops on a total of 1,050 acres. In return for the incentives, three of the producers hosted field days for other producers to learn from their experiences, and all of the producers supplied various kinds of data including data on the costs they incurred and the benefits they observed. Those costs and observed benefits are summarized in this report.

Everyone involved with the project has been keenly aware that two years is not a very long timeframe for evaluating cover crops. Past research has generally shown that it takes longer than two years for such practices to result in observable soil health changes. Nevertheless, two years was what the project funding allowed, and the information gained over even such a short period has been very helpful in expanding our knowledge base. We greatly appreciate the producers' willingness to share their information and insights.

Information Utilized in this Report

Three of the cooperating farms were visited in August, 2016 by the authors and Dean Thomas, Southeast SWCD Technical Support JPB Soil Health Technician. We attended a field day at another cooperating farm in September, 2016. The seeding costs for the cover crops were obtained from those four producers and seven of the other producers in the study group over the winter of 2016-17. We were unable to reach the other two of the 13 cooperating producers at that time. We attended field days at two of the farms in April and June of 2017. A mail questionnaire was sent to the producers in December, 2017 to ask for information on three main topics: 1) practices and costs of terminating the 2016 cover crops before planting the main crops in 2017, 2) how the cover crop affected practices, costs, benefits and/or drawbacks affecting the following main crop, and 3) practices and costs for seeding the 2017 cover crops. The questionnaire is included as an appendix to this report.

In addition, we reviewed the soil maps for the project fields on each of the farms. This was done in order to obtain the information required to run the RUSLE2 soil erosion estimating tool provided by USDA Natural Resources Conservation Service staff in order to gauge how much of an impact the cover crops may be have on soil erosion on the fields (Renard, Foster et al. 1997, USDA National Soil Erosion Research Lab 2015). We also summarized the soil organic matter estimates from soil tests taken from each of the project fields by BWSR staff in late 2016.

Below are general observations to add context to the budgets provided in a later section.

Crop and Livestock Enterprises and Tillage Systems

The cooperating farms are believed to be typical of southeastern Minnesota. However, they self-selected to participate and the size of the group is small, so it would be inappropriate to claim that they are representative of the area in a statistical sense. In terms of enterprises, the 13 farms included:

- One dairy operation with a rotation of corn silage and alfalfa hay
- Two operations with beef enterprises (one breeding herd and one with backgrounding animals)
- Four that grow canning peas along with corn grain and soybeans, including the farms with the beef enterprises
- Seven cash grain operations that only grow corn grain and soybeans
- One that grows corn grain, soybeans, and alfalfa

One way that the choice of crop and livestock enterprises in a farm operation affects cover crop economics is that the cover crop planting date can be much earlier following canning peas or corn silage than following soybeans or corn grain, if planted after harvest using ground equipment. For example, the one operation with canning peas and the beef herd planted a cover crop in early August, 2016 following the pea harvest. The earlier planting date allowed the use of cover crop species such as legumes that probably would not have grown successfully if planted after the soybeans or corn.

Another issue that came to the attention of the project team in 2017 was that the companies who were accepting the canning peas were reported to have notified the growers that small grain cover crops would not be allowed on fields to be planted to peas the following year, due to the risk of gluten contamination of the peas. Small grain cover crops would still be allowed following the peas, but that new rule will obviously limit the overall use of cover crops in the rotation.

The producer with backgrounding animals and a corn grain/soybean rotation planted a three-species cover crop mix after soybeans in 2016. The planting was successful, and he planned to graze part of his acreage in the spring. That grazing plan did not work out, however, because the cover crops were too mature by the time the animals were turned into the field so they refused to eat very much of it.

All of the producers used no-till or reduced tillage systems for planting their corn and soybeans. The canning peas are planted using conventional tillage.

Cover Crop Species, Seeding Rates, Timing, Seeding Methods, and Costs

Timing of Cover Crop Planting

The harvest timing of the main crop grown before the cover crop affects the choice of cover crop species and planting method. In 2016, four of the producers drilled their cover crops after a crop of canning peas, which allowed an August window for the cover crop planting (Table 1). The dairy producer planted the cover crop in September following corn silage while one other producer hired a custom applicator to fly on the cover crop on his entire field, and another producer used the aerial applicator for part of the field and broadcast the rest.

The other six producers planted their cover crops after a soybean or corn grain crop in a later time window. Four of these producers used drills while the other two broadcast the cover crop with a tillage tool or after one.

In 2017, eleven of the producers planted the cover crop after corn grain and four after soybeans. The dairy producer again followed corn silage, and one producer followed sweet corn. None of the producers followed canning peas in 2017.

The cover crop seeding and termination costs were tallied separately for fields that followed corn grain or soybeans in order to focus on the special challenges related to their harvest timing late in the fall. Termination costs were available for seven of the corn grain or soybeans on seven of the farms for the 2016-17 cover crops, and the ten farms were cover crops were seeded after these crops in 2017 (Table 2).

Cover Crop Species

The many potential cover crop species each have pros and cons, and each fits best in particular situations. The species planted by at least two of the cooperating producers are listed in Tables 3 and 4. Average seeding rates are shown in Table 5. Cereal rye was planted alone by four of the producers in 2016 and three in 2017. The numbers of species planted by the other producers was about equally divided between 2 and 3 species and 4 or more, but overall they narrowed the number of species in 2017.

Eleven species were planted by at least two producers in either 2016 or 2017. Several producers experimented with mixes containing a large number of species in 2016, so including those would have added 13 more species to the list shown. Three of the producers used more than one mix on different fields. Cereal rye was the most popular species planted. Eleven of the producers planted cereal rye in 2016 while one used annual ryegrass and one used wheat. All 13 planted cereal rye alone or in a mix in 2017. One producer planted both cereal rye and Aroostook rye in 2017. Both of them are lumped together as “cereal rye” in the table.

Table 1. Tally of cover crop species mixes and planting time windows on 13 cooperator farms, fall 2016 and fall 2017

	Number of species seeded in 2016				Number of species seeded in 2017			
Planting time window	1	2-3	4+	All	1	2-3	4+	All
Early planted								
Drill/planter	0	3	2	5	0	2	0	2
Aerial	0	0	1	1	0	0	1	1
Aerial & broadcast	0	1	0	1	0	0	0	0
Interseeded into corn & broadcast	0	0	0	0	0	1	0	1
All early planted	0	4	3	7	0	3	1	4
Late planted								
Drill/planter	2	0	2	4	2	1	1	4
Broadcast	2	0	0	2	1	2	2	5
All late planted	4	0	2	6	3	3	3	9
Either planting period								0
Drill/planter	2	3	4	9	2	3	1	6
Broadcast	2	0	0	2	1	2	2	5
Aerial	0	0	1	1	0	0	1	1
Aerial & broadcast	0	1	0	1	0	0	0	0
Interseeded into corn & broadcast	0	0	0	0	0	1	0	1
All planting periods & methods	4	4	5	13	3	6	4	13

Table 2. Tally of cover crop species mixes and planting methods following or aerially-seeded into corn grain or soybeans on 13 cooperator farms, fall 2016 and fall 2017 (This table includes only the 2016 farms for which termination cost data was available.)

	Number of species seeded in 2016				Number of species seeded in 2017			
Planted into corn grain or soybeans	1	2-3	4+	All	1	2-3	4+	All
Drill/planter	1		2	3	2	1	1	4
Broadcast	2			2	1	2	2	5
Aerial		1	1	2			1	1
All	**3**	**1**	**3**	**7**	**3**	**3**	**4**	**10**

Table 3. Cover crop species planted by at least two producers in 2016 and 2017

Species planted	Farms 2016	Farms 2017
Rye, Winter Cereal	11	13
Triticale	5	5
Rapeseed/Canola	4	4
Turnip	4	3
Radish, Oilseed or Forage	3	3
Ryegrass, Annual	3	1
Clover, Crimson	2	0
Pea, Field	2	0
Vetch, Hairy	2	3
Wheat	2	5
Oats	1	3

Table 4. Cover crop species planted after soybeans or corn grain by at least two producers in 2016 and 2017

Species planted	Farms 2016	Farms 2017
Rye, Winter Cereal	7	10
Rapeseed/Canola	4	4
Triticale	3	4
Ryegrass, Annual	2	0
Turnip	2	0
Wheat, Spring or Winter	2	5

Table 5. Seeding rates used in 2016 and 2017

	Number of species seeded in 2016				Number of species seeded in 2017			
Planting method	1	2-3	4+	All	1	2-3	4+	All
Drill/planter	74	79	76	77	117	66	82	89
Broadcast	82			82	90	86	81	84
Aerial or aerial & broadcast		87	59	73			58	58
Interseeded into corn						23		23
All planting methods	78	81	72	77	108	65	81	81

Seed Prices

Seed price is an important factor in overall cover crop cost. While variety, seed quality, and service are also important, the prices paid by the cooperating producers may be of interest. Some of the producers supplied us with prices by species while others just quoted a price for the mix or a cost per acre. Table 6 shows the average price per pound for the species planted by at least two producers in each year and reported to us. Seed costs averaged $25.58 per acre in 2016 and $20.24 per acre in 2017.

Table 6. Average prices paid for cover crop seed in 2016 and 2017

Species	2016	reports	2017	reports
	($/lb)	(farms)	($/lb)	(farms)
Cereal rye	$0.23	2	$0.17	5
Winter wheat			$0.29	2
Triticale	$0.37	2		
Rapeseed	$0.98	2	$1.02	2
Annual ryegrass	$0.70	2		

Seed Costs per Acre

The producers spent less on the cover crop seed in 2017 than in 2016, possibly due in part because of the later fall in 2017. The average seed cost was $25.00/acre in 2016 and $21.49 in 2017 (Table 7). We did not obtain a seed cost estimate in 2017 from the producer who used aerial application, which was a more expensive method in 2016 than ground application. That may have been one reason that the overall average seed cost per acre was less in 2017. Beyond that, the average cost increased for the producers planting one species, but that was overshadowed by a lower cost for the group planting four or more species.

Table 8 shows the seed costs just for the corn grain and soybean fields for 2016 and 2017. The 2016 costs for these crops averaged almost exactly the same amounts as the overall average - $25.07/acre compared with $25.00. In 2017, the corn grain and soybean field costs were slightly less than the overall average - $20.35/acre compared with $21.49.

National Surveys

Cover crops were planted on 10.3 million acres of U.S. cropland in 2012. This is 3.2 percent of the 315 million harvested acres reported in the 2012 Census of Agriculture (see tables 8 and 50 in (USDA National Agricultural Statistics Service. 2014)). Another agricultural census was conducted in 2017. When published, it should show how adoption of this important practice is changing over time.

The USDA National Agricultural Statistics Service and Economic Research Service conduct the Agricultural Resource Management Survey (ARMS). They collect data on crop production practices and costs and returns as well as whole-farm financial information. They follow a schedule where they survey the major crops usually once every five years. The recent crop surveys have included a section where they select one field at random for each farm and ask a set of detailed questions about that field.

The 2016 corn questionnaire asked about whether the previous crop planted in fall 2015 was a cover crop, and if so, "What was the seed cost per acre for the cover crop?" The results for that question have not been broken out in the published cost and return reports, but Dr. William McBride provided a tally for this report. There were not enough responses for Minnesota to provide a useful estimate, but 32 responses for the ARMS Heartland farm resource region averaged $12.81/acre for those reporting a cost (McBride 2018). Thirty one responses for the Northern Crescent region averaged $14.39/acre. The Heartland region includes southern and southwestern Minnesota along with Iowa, Illinois, Indiana, most of Missouri, and parts of South Dakota, Nebraska, Ohio, and Kentucky. The Northern Crescent includes central Minnesota and the states to the east through Pennsylvania, New Jersey, and the New England states (USDA Economic Research Service 2010). Those 2016 ARMS corn cover crop cost estimates are less than the corn and soybean averages for the project farms that are shown in Table 8. For example, the Heartland average of $12.81/acre is only half as much as the $25.07/acre 2016 overall average in Table 8.

Another source of cover crop seed costs is the 2017 CTIC Cover Crop Survey (Conservation Tillage Information Center 2017). The seed costs in that report are more difficult to interpret because they are provided only as ranges. Nearly half of the respondents paid $11 to $20/acre in 2016, with 25 percent paying $11 to $15 per acre and 22 percent paying $16 to $20. Smaller percentages paid more or less than those ranges.

The reasons for the higher average costs on our project farms may be partly due to the fact that the project farms followed species mixes and seeding rates detailed in a plan developed with the project technician following guidelines provided by the Midwest Cover Crop Council. The producers were encouraged to purchase quality cover crop seed from reputable commercial seed companies. Because the project budget provided incentives to the producers that covered most of the cover crop planting costs, the producers were not forced to scrimp on seed costs due to financial constraints. Information is not available on how many of the ARMS or CTIC respondents planted cheaper bin-run seed or seeded lower rates. This does beg the question of whether the benefits observed by the project producers and documented in this report are greater than the benefits of the ARMS and CTIC respondents who spent less on seed. The available data does not provide an answer to that question.

Total Seeding Costs with Equipment and Labor per Acre

The planting equipment and labor was valued using the actual custom rates or rental rates paid where they were used. Owned equipment was valued using the Iowa Custom Rate Survey. Equipment and labor costs averaged $18.94/acre in 2016 and $15.31/acre in 2017 (Table 9). The total cover crop establishment costs for seed, equipment, and labor averaged $43.93/acre in 2016 and $36.80/acre in 2017 (Table 10).

Table 7. Average cover crop seed costs/acre on cooperator farms, fall 2016 and fall 2017

Planting method	Number of species seeded in 2016, 12 farms			
	1	2-3	4+	All
Drill/planter	$10.04	$21.82	$35.40	$25.49
Broadcast	$18.00			$18.00
Aerial			$36.00	$36.00
Aerial & broadcast		$25.14		$25.14
All	$14.28	$22.68	$35.50	$25.00
	Number of species seeded in 2017, 11 farms			
	1	2-3	4+	All
Drill/planter	$20.93	$21.32	$21.37	$21.17
Broadcast	$18.75	$21.23	$20.42	$20.24
Aerial			$34.00	$34.00
All	$18.75	$21.23	$23.81	$21.49

Table 8. Average seed cost following or aerially-seeded into corn grain or soybeans by cover crop species mixes and planting method, fall 2016 and fall 2017

Planted into corn grain or soybeans	Number of species seeded in 2016, 7 farms			
	1	2-3	4+	All
Drill/planter	$11.62		$34.15	$26.64
Broadcast	$9.33			$9.33
Aerial & broadcast		$25.14	$36.00	$30.57
All	$10.48	$25.14	$34.77	$25.07
	Number of species seeded in 2017, 10 farms			
	1	2-3	4+	All
Drill/planter	$11.86		$19.94	$17.25
Broadcast	$17.75			$17.75
Aerial		$21.18	$34.00	$27.59
All	$15.78	$21.18	$24.63	$20.35

Table 9. Equipment and labor costs/acre on cooperator farms, fall 2016 and fall 2017

	Number of species seeded in 2016, 12 farms			
Planting method	1	2-3	4+	All
Drill/planter	$9.68	$17.35	$22.84	$18.27
Broadcast	$23.00			$23.00
Aerial			$17.00	$17.00
Aerial & broadcast		$18.55		$18.55
All	$16.77	$17.66	$21.81	$18.94
	Number of species in 2017, 11 farms			
	1	2-3	4+	All
Drill/planter	$15.35	$16.00	$15.00	$15.54
Broadcast	$13.55	$13.18	$14.65	$14.01
Aerial			$16.00	$16.00
All	$16.20	$14.63	$15.32	$15.31

Table 10. Average cover crop establishment costs/acre for seed, equipment, and labor, fall 2016 and fall 2017

	Number of species seeded in 2016, 12 farms			
	1	2-3	4+	All
Drill/planter	$19.71	$39.17	$58.23	$43.76
Broadcast	$41.00			$41.00
Aerial			$53.00	$53.00
Aerial & broadcast		$43.69		$43.69
All	$31.05	$40.34	$57.31	$43.93
	Number of species seeded in 2017, 11 farms			
	1	2-3	4+	All
Drill/planter	$36.28	$37.32	$36.37	$36.71
Broadcast	$32.30	$34.41	$35.07	$34.25
Aerial			$50.00	$50.00
All	$34.95	$35.86	$39.13	$36.80

Table 11. Average seed and planting cost following or aerially-seeded into corn grain or soybeans by cover crop species mixes and planting method, fall 2016 and fall 2017

	Number of species seeded in 2016, 7 farms			
Planted into corn grain or soybeans	1	2-3	4+	All
Drill/planter	$27.32		$49.56	$42.15
Broadcast	$24.32			$24.32
Aerial & broadcast		$43.69	$53.00	$48.34
All	$25.32	$43.69	$50.71	$38.82
	Number of species seeded in 2017, 10 farms			
	1	2-3	4+	All
Drill/planter	$36.28	$34.10	$36.37	$35.76
Broadcast	$32.30	$34.41	$35.07	$34.25
Aerial			$50.00	$50.00
All	$34.95	$35.86	$39.13	$36.80

Termination Timing and Costs and Extra Insecticide and Nitrogen

An issue discussed at recent field days is how far the cover crop needs to be terminated ahead of planting the main crop, especially in the case of corn following cereal rye and the possibility of an allelopathic effect. Extension guidelines suggest terminating 7 to 14 days ahead (Eberhart 2016), and there are specific requirements for EQIP funding and crop insurance (USDA NRCS). On the other hand, some producers at field days reported success planting corn into rye before terminating it.

Each producer terminated his cover crops in either April or May. The earliest termination date was April 12. The latest termination dates were May 12 (for a corn field) and around May 20 (for a bean field). The "average" termination date was April 30. The responses showed a wide range of the heights of cover crops, owing largely to the differing species used among the producers. The shortest crop at termination was 4 inches, while the tallest crop was 38 inches. The average height was 13 inches.

Five of the nine producers who planted corn into a cover crop this year waited at least 11 days between termination and planting, with an average wait of 15 days. The other four producers only waited between 2 and 6 days. Four of the producers followed the cover crop with soybeans. Three of them waited two weeks or more, while the fourth only waited three days. There did not seem to be any relationship between the wait time and yield of the corn crop, as discussed later.

Five of the producers in this survey required an additional terminating-round of herbicide for their cover crops—the other six producers were able to terminate the cover crops with the chemicals and rates that they were planning to use otherwise, since they were using notill or reduced tillage and so needed to apply a burndown chemical anyway. Each producer used glyphosate as their primary termination chemical. Three producers supplemented that with 2,4-D. Two added ammonium sulfate and three producers used a surfactant.

The overall 2016 cover crop cost for seed and planting equipment was $52.76/acre for those 11 producers who provided 2016 planting costs and 2017 termination cost data and who did not apply a separate termination chemical, insecticide, or extra nitrogen (Table 12). The producers who incurred a cost for a termination chemical spent less on planting, at $35.83/acre. The additional burndown chemicals and the extra equipment cost an average of $16.30/acre for those making an extra termination pass, bringing the total cost for seed, planting, and termination to $52.13, so it is interesting that there was not much difference in the total cost for those who applied an extra chemical and those who did not. The overall average cost for seed, planting, and termination for the 11 producers was $52.48/acre. Note that these costs are based on the 2016 planting costs, and for only 11 operations rather than the 12 operations included in Tables 8-10.

Two producers reported other costs related to the cover crops. One applied insecticide costing $5/acre. The other applied an extra 90 pounds of nitrogen to compensate for nitrogen tied up as the rye biomass breaks down. At a nitrogen price of, say, $0.35/lb, this would cost an additional $31.50/acre. This would be an added cost item that would need to be attributed to the cover crop. None of the other nine producers reported any changes in their rates. Adding the insecticide and extra nitrogen brings the overall cost for the seed, planting equipment, and termination to $55.79/acre.

Table 13 shows that the cover crops on the corn grain and soybean fields cost an average of $42.82/acre for seeding and termination, or around ten dollars/acre less than the overall average shown in Table 12, not including the insecticide that one producer applied. The insecticide on that one farm would increase the average by $0.72 per acre.

Table 12. Average cover crop costs/acre for seed, planting equipment and labor, termination, and insecticide on 11 cooperator farms seeded in fall 2016 and terminated in spring 2017

	Farms	Seed & planting	Termination	Seed, planting, & termination
Relied on normal notill burndown herbicide	6	$52.76		$52.76
Applied an extra herbicide application to terminate	5	$35.83	$16.30	$52.13
Overall average	11	$45.06	$7.42	$52.48
Overall average, including insecticide & N	11	$45.06	$10.73	$55.79
Corn yield increase required to cover the overall cost at $3/bushel		15 bu	4 bu	19 bu
Soybean yield increase required to cover the overall cost at $9/bushel		5.0 bu	1.1 bu	6.1 bu

The cover crop seeding costs were lower in 2017 than in 2016. We of course do now know what it will cost to terminate the 2017 cover crops in spring 2018, but Table 14 shows what the total costs will be if termination costs the same as in spring 2017.

Table 13. Average seed, planting and termination cost following or aerially-seeded into corn grain or soybeans by cover crop species mixes and planting method, fall 2016

	Number of species seeded in 2016, 7 farms			
Planted into corn grain or soybeans	1	2-3	4+	All
Drill/planter	$41.17		$49.56	$46.76
Broadcast	$31.40			$31.40
Aerial		$43.69	$53.00	$48.34
All late planted	$34.65	$43.69	$50.71	$42.82

Table 14. Average cover crop costs/acre for cover crops seeded in fall 2017 if termination and insecticide and extra nitrogen in spring 2018 costs the same as in spring 2017, 11 cooperator farms

	Farms	Seed & planting	Termi-nation	Seed, planting, & termination
Relied on normal notill burndown herbicide	6	$38.09		$38.09
Applied an extra herbicide application to terminate	5	$35.26	$16.31	$51.56
Overall average	11	$36.80	$7.41	$44.21
Overall average, including insecticide & N	11	$36.80	$10.73	$47.53
Corn yield increase required to cover the overall cost at $3/bushel		12 bu	4 bu	16 bu
Soybean yield increase required to cover the overall cost at $9/bushel		4.1 bu	1.1 bu	5.2 bu

Benefits and Other Considerations

Yield Impacts of the Cover Crops

A corn yield increase of around 19 bushels per acre would be required to cover the average cost of the cover crops at $3/bushel if no other benefits are achieved for the cover crops seeded in the fall of 2016 (Table 12). At a soybean price of $9/bushel, a 6.1-bushel soybean yield increase would suffice to cover the average cost.

At the lower 2017 seeding costs, the breakeven yield increases are lower if the termination costs turn out to be similar to last year – 16 bushels of corn or 5.2 bushels of soybeans (Table 14).

The 11 producers who returned our mail survey in December, 2017 reported a wide range of impacts on yields of the 2017 main crops following their cover crops. Three said that they did not have a way of comparing the yields because they did not have check strips or similar fields to compare against. Six of the others grew corn and three grew soybeans on those fields (two of them grew both corn and soybeans following the cover crops). Of the seven, three did not see a difference. Two of the others found yield increases. In the “lessons learned” category, the other one tried cutting corners on the burndown herbicide and ended up reducing the corn yield.

Another source of information on yield impacts is the national surveys that have been carried out for several years by the Conservation Tillage Information Center (CTIC) (Conservation Tillage Information Center 2017). They reported in their 2017 report that between 13 and 20 producers returned their survey from Minnesota.

We need several more years of data and data from more farms before we will feel comfortable saying anything very definitive about yield impacts. Our best estimate planning number for the corn and soybean yield impacts based on this one year of data from the project farms along with the CTIC survey results, we would assume a corn yield increase of four bushels/acre and a soybean yield increase of one bushel/acre.

Grazing or Harvesting Cover Crop Forage

As mentioned earlier, one cooperator has a cow-calf herd and was able to graze a cover crop in the fall of 2016 after it had been planted in August after canning peas. A mix of seven species was planted in one field and three species on another field on that farm. The cover crops produced lush growth estimated at 3,000 pounds of dry matter/acre by the time of a field day held there in late September. That field was grazed that fall, with the feed value estimated at $112/acre based on avoided hay or cornstalk grazing. That producer planted a seven-species cover crop mix on that field which cost more than average for the group, but the grazing value was more than enough to cover the establishment cost.

Another producer reported baling a cereal rye cover crop for hay in 2016 and selling it for around $40/acre. Mowing and baling would probably cost around half of that, but the net revenue would still cover much of the cover crop seed cost.

Differences in Visible Signs of Erosion or Runoff Sediment

Nine of the producers noted less erosion or runoff sediment on the demonstration field compared to similar fields that did not have cover crops.

Getting on the Field Earlier

Comments were made at field days to the effect that the mulch from the killed cover crop may sometimes support field equipment so as to get on the field earlier in the spring after wet conditions. Three of the producers responded that they were able to get on the field earlier. The others did not observe a difference.

If earlier access is possible in a given growing season, it is not entirely clear how to put an economic value on the extra working days. Yields might be increased due to more timely planting or other operations. Or, perhaps more acres could be covered with the equipment available. The extra days would be valuable in either of these cases, but it would depend on the situation.

Increased Soil Organic Matter

Soil tests taken in late 2016 on the project fields averaged 3.1 percent soil organic matter (SOM), with a range from 0.9 to 6.1 percent. The dairy producer in our group reported increases in SOM after cover crops, but that land also received dairy manure so it is difficult to know how much of the increase was due to the cover crops.

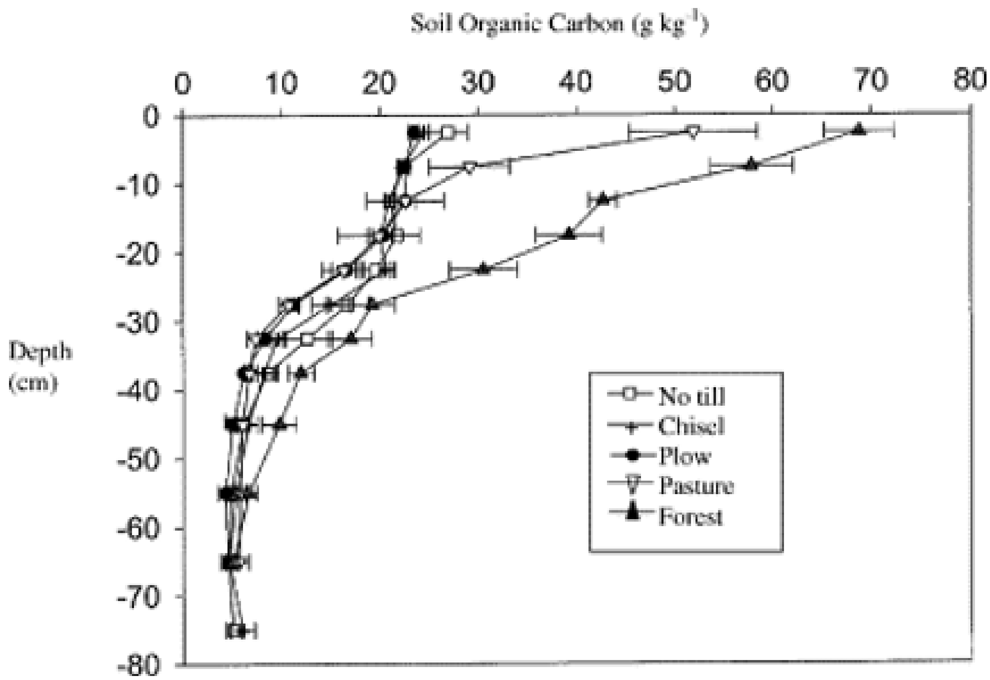
Another indication of the potential SOM increase is the difference between SOM after eight years under pasture compared to a corn-soybean rotation using three different tillage systems in eastern Ohio, shown in Figure 1. The SOM under pasture was around 5 percent near the surface compared with around 2.5 percent with the row crops. Since our producers are using notill or reduced tillage, it is interesting that there was little difference in the SOM under notill compared with tillage in that trial while a ten-year study in Alabama showed greater SOM under notill (Figure 2).

Soil organic matter has many potential benefits. We have only tried to put economic values on two of those potential benefits: extra mineralized nitrogen supplied to the main crop, and additional soil water holding capacity. The rule of thumb on nitrogen is that a 1 percent increase in SOM will mineralize over time to generate 20 pounds of nitrogen per year. One source for that number is a 1952 bulletin from Missouri that is cited in a recent NRCS cover crop economics decision tool (Unknown 1952, Cartwright and Kirwan 2018). The NRCS spreadsheet also assumes that a 1 percent increase in SOM holds 1 acre-inch of water.

The one year of soil tests available under our project does not establish how the SOM may have increased due to the project's two years of cover crops. Soil organic matter is mentioned here mainly as one factor that may help to explain the yield increases that were observed by the cooperating producers, as mentioned above.

It should be noted that the nitrogen contribution of the SOM referred to above is different from the nitrogen fixed by a legume cover crop grown in the immediately preceding year. It is also unclear how long the additional SOM contributed by a given year's cover crop will persist in the soil. The SOM that mineralizes and contributes nitrogen in a given year will not be there to contribute more in later years. Also, it is expected that the additional water holding capacity will be most valuable in drought years.

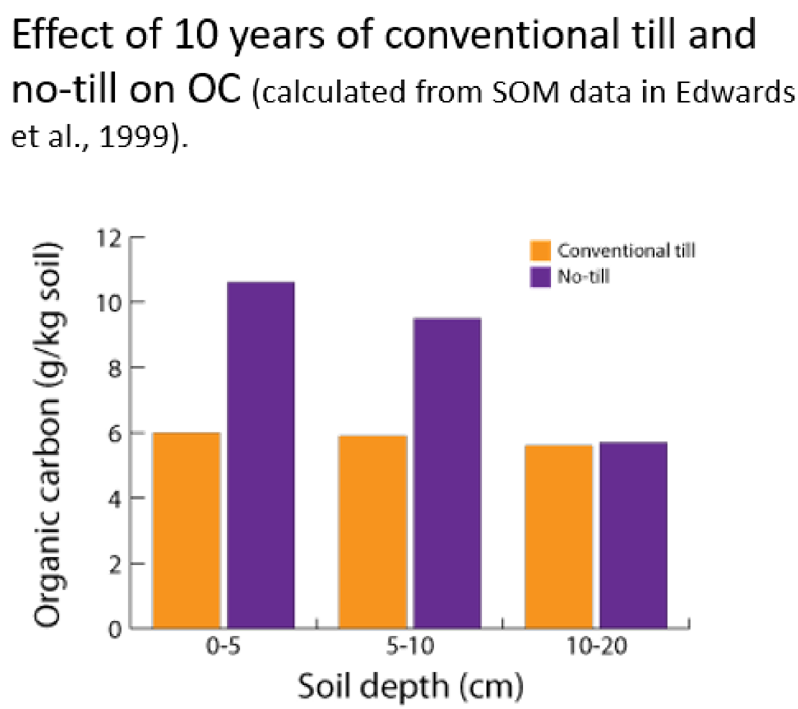
Figure 1.



Soil profile organic carbon concentration under plow till, chisel till, no till, pasture and forest.

Source: (Puget and Lal 2005)

Figure 2.



Source: (Edwards, Wood et al. 1992)

Reducing Soil Erosion

One of the main rationales for adopting cover crops is to minimize soil erosion. Water-related erosion is most likely to be a problem on sloping land, so the soil maps for the project fields were reviewed in order to identify areas with slopes that were steep enough and long enough to result in soil losses in excess of T values under the crop rotations and tillage systems in use on the farm (T stands for “soil-loss tolerance”).

RUSLE2 is the software that NRCS staff use to estimate water erosion rates for conservation planning purposes (Renard, Foster et al. 1997). RUSLE2 was used here to arrive at rough estimates of soil erosion on the project fields that might be expected with and without a cover crop. The estimates are considered “rough” because we did not utilize as much information as NRCS staff would normally use.

We reviewed the soil map for each field. The rule of thumb used by the NRCS for estimating soil erosion in a crop field using RUSLE2 is to consider the most restrictive soil that comprises at least 20 percent of the field. Soils are identified in the soil survey with letters denoting the slope. A “B” soil is between 2 and 6 percent slope while a “C” soil is between 6 and 12 percent and a “D” soil is between 12 and 20 percent. Our review of the soil maps suggested that two of the farms had at least one project field with at least 20 percent in the C slope category. Five other farms had fields with some C or D soils in the project fields but less than the 20 percent cutoff. The other six farms did not appear to have soils in the project fields that were steeper than the B category of 2 to 6 percent.

We focused mainly on the fields containing C or D slopes. We estimated slope steepness and slope length for representative areas of the fields using the MNTOPO web tool in lieu of actually walking the fields. RUSLE2 uses crop yields to estimate residues. We used crop yields from the producers themselves where we had that data, and default yields otherwise. We used default dates for the field operations.

The T value is five tons per acre for all of the soils we analyzed. Based on that five-ton benchmark, the fields in corn grain-soybean rotations and the corn silage-alfalfa rotation used on the dairy farm all had soil losses less than the T value whether or not they used cover crops, because the notill practices used on the corn and soybeans were sufficient. Two situations where it appeared that the cover crop made the difference between excessive erosion and tolerable erosion were fields where conventionally-tilled canning peas were grown on land with a C slope. The C slope area was more than the 20 percent cutoff in the one field, and less than 20 percent in the other. Terraces had been installed in the steeper field along with using the cover crops to keep the erosion in check.

A conclusion we draw from the RUSLE2 calculations is that when balancing the costs and benefits of cover crops, there may be situations where the only way an erosive crop like canning peas can be grown and still say within a tolerable soil loss is to plant a cover crop. One component of the economic value of the cover crop in that case would be the difference in profitability between the canning peas and whatever the next best alternative is, which would probably be a corn grain-soybean rotation in the case of the cooperator farms. We did pursue the calculation to the extent of actually comparing the profitability of those three crops.

While keeping within the T value is sufficient for conservation compliance, there are reasons to question whether it is too high. One concern is that T values are based on maintaining future soil productivity and do not consider water quality goals. Another issue is whether rainfall events have become more intense than when the T values were calculated in the 1980s. Finally, it is generally recognized that T values are higher than rates of soil formation and so include a certain amount of soil "mining" which may eventually exhaust the productive topsoil layer. The difference between the T value and the rate of soil formation depends on estimates of how much soil can be lost before yields would be reduced. Actually estimating the rate of soil formation is difficult, however. The logic behind T values and the formula used is presented in a 1982 publication by the American Society of Agronomy. (Skidmore 1982). I have made inquiries about the database of soil formation estimates that was used to calculate the T values currently included in the soil survey, but I have not so far been able to locate that database (Dobos 2018).

Other Benefits Noted by the Producers

The producers noted a number of other benefits of the cover crops. The benefits listed, in the producers' own words, included:

> "better stand"
> "soil temperature"
> "earthworm population"
> "soil structure"
> "less erosion in spring"
> "better soil health"
> "less compaction"
> "corn growth didn't vary"
> "organic matter"
> "ground warmer"
> "don't have to till"
> "wild life in spring"

A soybean disease that some producers are concerned about on southeastern Minnesota is white mold or sclerotinia. At one of my farm visits in 2016 one of the project producers expressed an opinion that cover crops reduce the likelihood of white mold because the mulch prevents soil from splashing up on the plant. A 2001 paper by Maloney and Grau describes the impact of a small grain cover crop on soybean yields in Wisconsin over the three-year period 1998-2000 (Maloney and Grau 2001). But, that paper is so old, and there has been nothing on this since then. I had pretty much dismissed the idea until another of the producers at the Owatonna meeting mentioned a 12-bushel yield advantage for cover crops in one year. He attributed that difference to reduced white mold.

Other potential benefits not specifically mentioned by the producers but which others have mentioned include reduced soil compaction, especially in the case of radish; increased water infiltration; and cooler summer soil temperatures.

On the downside, risks and potential costs of cover crops include slug damage to emerging corn. Several of the producers expressed different opinions about the roles of chopping corn heads and vertical tillage tools on the likelihood of slug damage and on erosion potential. Other concerns are whether the cover crop will reduce the yield of the following main crop in a dry year due to competition for moisture; delayed planting due to cooler spring soil temperatures under the cover crop; and difficulty getting seed coverage with notill equipment planting into a heavy cover crop mulch.

Summary and Concluding Thoughts

These results show that planting and terminating cover crops involved a significant cost for these producers. The yield impacts were a mixed bag, which is not surprising given the one-year time frame and the small group size. Other studies suggest that several more years of data is needed to get a fix on yield impacts. The ideal situation for profitable cover crop use is where it can be planted early after a short-season crop like canning peas and then can be grazed, but of course not that many farms have both of those enterprises. Cover crops clearly reduce soil erosion, although most of the cooperator farms did not appear to have major erosion issues because they were also using notill, reduced tillage, and/or terraces on their row crops. Increased soil organic matter is another likely benefit and may explain at least some of the yield improvements attributed to cover crops.

ACCESS TO EDUCATIONAL PROGRAMS AND MATERIALS:

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Appendix - Cover Crop Economics Questionnaire

Cover Crop and Soil Health Initiatives in Southeastern Minnesota

Please return in the stamped, self-addressed envelope to Andrew Keller, Department of Applied Economics, University of Minnesota. Thank you again for your participation. Please feel free to call us at 515-293-0486 or 612-625-8150 with any questions or concerns.

Farm/Producer Name: ____

1. **What are your typical crop rotations (for example, corn/soybeans or corn/corn)?**

   ____

<u>Questions about the cover crop you planted in the fall of 2016 and terminated last spring (2017):</u>

2. **When did you terminate it? (approximate date _____________)**
3. **What main crop did you plant on that field this year? (_____________)**
4. **How many days after termination did you plant your main crop? (__________days)**
5. **What was the height or growth stage when terminated? (_______________inches or stage)**
6. **Did the cover crop cause you to do extra tillage or use more herbicides than you would have used for the main crop without a cover crop?** *Circle Y/N.*

   YES **NO**

   If YES, how did you terminate the cover crop? *Briefly describe the process you used.*

   ____

7. **Describe what chemicals, if any, you used to terminate the cover crop and what they cost.**

Chemical names	Rates applied (per acre)	Units for the application rate	Cost / unit	Purchase units	Date purchased
1.					
2.					
3.					
4.					

8. **If you harvested hay or forage from the cover crop, complete the following table.**

Hay or forage yield (tons/acre)	**Moisture %**	**Value ($/ton)**	**Harvesting cost ($/acre)**

<u>Questions about the main crop you grew on the field this year</u>:

9. **Did you change your herbicide program to accommodate cover crop seeding?** *Circle Y/N.*

YES NO

If YES, what changes did you make? *Please explain.*

____

10. **What herbicides did you use on the main crop?** *Complete the table below.*

Chemical name	**Rate applied (per A)**	**Units for the application rate**
1.		
2.		
3.		
4.		
5.		

11. **Did you notice a difference in the yield of the main crop following the cover crop?** *Circle Y/N.*

YES NO

If YES, how much of a difference did you notice? ____________________bushels/acre

How did you measure that difference? *Check all that apply.*

_____ combine yield monitor

_____ counting and weighing wagon loads

_____ check strips in the field (how many strips or replications? ___________)

_____ comparing against other fields

_____ other (*explain*) ____

12. **Did you reduce or increase herbicide, insecticide, and/or fungicide inputs used for the main crop compared to fields that did not have a cover crop?** *Circle Y/N.*

INCREASE **DECREASE** **NO CHANGE**

If INCREASE, what extra chemicals did you have to apply, and what did they cost/acre, including chemical and application costs? *Complete the table below.*

Cash crop treated	Names of the extra chemicals applied	Cost of the extra chemicals and applications ($/acre)

If DECREASE, provide the estimated cost savings/acre, including chemical and application costs, for each category of chemical input. *Complete the table below.*

Cash crop that would have been treated	Names of the chemicals you were able to avoid using	Chemicals and application cost savings ($/acre)

13. **Did you adjust your nutrient application rates (up or down) due to the use of cover crops?** *Circle Y/N.*

YES **NO**

If YES, how much did you reduce the nitrogen application rate on the main crop?

________________________ lbs/A

14. **Did you notice any difference in visible signs of erosion or runoff sediment on the demonstration field compared to similar fields that did not have cover crops?** *Circle Y/N.*

YES **NO**

15. **Were you able to get on the field earlier in the spring because of the cover crop mulch supporting the equipment?**

YES **NO**

16. **What other benefits did you realize by using cover crops?** *Please explain.*

____

<u>Questions about the cover crop you planted this fall</u>:

17. **What cover crop species and varieties did you plant, and how much did they cost?**
Complete the table below with either individual seed species or seed mix information.

Species or Mix	Variety and Brand Name	Seed supplier	Seeding rate (lb/A)	Seed cost ($/lb) or Mix cost ($/lb)	Date Purchased
1.					
2.					
3.					
4					

18. **What seeding method did you use to plant the cover crop?** *Circle all that apply*.

Drill / planter	Broadcast	Aerial into standing crop	Interseed with ground equipment into standing crop	Other

19. **Describe the individual field operations involved in planting the cover crop.** *Complete the table*.

Type of planter, drill, etc.	Tractor or power unit	Date performed	If Custom: cost/acre	Fuel or other inputs you supplied	Est. cost/acre of owned equipment
1.					
2.					

20. **If interseeding with ground equipment, what was the crop stage or height?**

________________________inches/stage

21. Was the cover crop seeding successful this fall (2017) from what you can tell so far? *Circle Y/N.*

YES NO

22. Briefly explain what you consider important as you think of "success" of the seeding:

____

23. Did you harvest forage from the cover crop for sale or for use in your operation this fall? *Circle Y/N.*

YES NO

If YES, how much did it yield and what was the total amount of forage sold or used worth?
______________tons/acre at $_____________/ton

24. Are you planning to grow peas for canning in 2018? *Circle Y/N.*

YES NO

If YES, has the canning company placed any restrictions on planting peas following a cover crop that have affected your cover crop decisions? *Circle Y/N.*

YES NO

If YES, please explain ____

____

25. Please share any additional thoughts or concerns.