Cover Crops on Illinois Farms

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Abstract

Cover crop use is increasing on U.S. farms, but it remains low. The main reason for low adoption rates is the financial and management challenges of cover crops. Using a unique, field-level dataset from Illinois farms, we find that on average, cover crop fields have a lower operator and land return due to the additional seed, planting, and termination cost. Financial assistance is necessary for cover crop fields to be as profitable as non-cover crop fields. We also consider the carbon sequestration potential of cover crop fields using the Cool Farm Tool and estimate farmer carbon credit payments for cover crops.

INTRODUCTION

Cover crop use dates back thousands of years to ancient civilizations that incorporated cover crops into their rotation to replenish the soil. Throughout the nineteenth century, cover crops were used extensively and referred to as “green manure” for their fertility properties. With the introduction of synthetic nitrogen fertilizer and herbicides, cover crop use decreased, and from the 1960s to the 1980s, cover crop use was rare (Groff, 2015). Although cover crop use remains low today, cover crop acres are increasing over time. The most recent Census of Agriculture states that in 2017, cover crops in the United States totaled 15.4 million acres, representing 3.9% of all U.S. cropland, an increase of 5.1 million acres from the 2012 census (Zulauf and Brown, 2019). Financial incentives from federal and state governments along with private organizations are one reason for the increase in cover crop adoption (Wallander et al., 2021).

Cover crops have financial and management challenges. Research suggests that cover crops require three or more years to pay off without financial assistance or special agronomic circumstances (Myers, Weber, and Tellatin, 2019). Farmers incur costs from cover crop seed and planting, and they also incur termination costs with some cover crops. The farmer must consider the direct benefits such as an increase in yield, direct production costs, indirect benefits such as saving on nutrient application, opportunity cost, risk, and agricultural policy such as potential federal support for planting cover crops when making their cover crop decision (Bergtold et al., 2017). There is also the management challenge of selecting the cover crop seed or seed blend and deciding on the optimal planting and termination dates.

Cover crops provide societal environmental benefits, which is one reason the federal government provides incentives for cover crop adoption. Societal benefits occur through reduction of nitrate runoff, soil carbon sequestration, increasing microbial biodiversity, and reduced soil erosion (Bergtold et al., 2017; Sharma et al., 2018). Incentives exist through the United States Department of Agriculture’s (USDA’s) Natural Resources Conservation Service (NRCS). The NRCS programs offering incentives for cover crops are the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). The federal government also provides temporary assistance to farmers for planting cover crops through the USDA's Risk Management Agency (RMA) Pandemic Cover Crop Program (PCCP). This program provided a $5 per acre premium support to producers who insured their crop and planted a qualifying cover crop. In 2021, farmers received $59.5 million in premium subsidies for 12.2 million acres of cover crops (USDA RMA, 2022).

Although federal incentive opportunities exist, the challenge of limited funding to offset added costs related to cover crop planting and management remains an obstacle to scaling cover crop use. Discussions have emerged about more widespread incentives for cover crops, and possibilities exist for the next farm bill to address cover crop adoption. The objective of this article is to provide an evaluation of the cost and return of fields with and without cover crops. Several other studies evaluate the economics of cover crops and find that cover crops do not increase returns for farmers and can even decrease returns (Plastina et al., 2018; Mahama et al., 2016; Zhou et al., 2017). The dataset in this paper is a unique field-level panel dataset from Illinois that adds to the existing literature about the financial evaluation of cover crops. The Precision Conservation Management (PCM) differs from other studies because it is not survey data from farmers, and it is not experimental field trial data. The data is actual field-level data collected from central Illinois farmers who use cover crops on their fields, and the quality and accuracy of the data is ensured by the PCM specialists who assist farmers with inputting their data into the online system. The dataset is also unique because it is a panel dataset, so operator and land return and yield can be observed on the same cover crop fields through time.

PRECISION CONSERVATION MANAGEMENT

The data for this study come from PCM. PCM is a farmer service program led by the Illinois Corn Growers Association and Illinois Soybean Association in partnership with more than 30 entities, including other commodity associations, conservation groups, private foundations, supply chain providers, the Soil and Water Conservation Districts, and the NRCS. In an effort to address the goals of the Illinois Nutrient Loss Reduction Strategy, the mission of PCM is to help farmers make decisions about adopting on-farm conservation practices in a financially responsible way. Through PCM's regional specialists, PCM works one-on-one with nearly 400 Illinois farmers enrolled in its 32-county service area, representing over 350,000 acres of Illinois farmland. Figure 1 shows the service area PCM currently covers in Illinois. PCM also collects data on farms in Kentucky and Nebraska, but the focus of this analysis is Illinois.

PCM's precision conservation specialists help farmers report data through an online data collection platform. The precision conservation specialists offer one-on-one technical support for farmers, compile and review farm reports, and assess farm data to ensure quality and accuracy. The farmer reports all operations for each field enrolled in the PCM program. Any applications or field passes made on the field throughout the growing season, the amount and types of inputs applied, and yield are entered into the PCM system. The anonymized and aggregated data are used to provide reports to farmers to help them make business decisions about adopting conservation practices, focusing on financial and environmental comparisons.

PCM collects data about all inputs used, agricultural practices performed, and yields for each field but does not collect crop price or input cost data from the farmers. Instead, standard prices and costs are uniformly applied to all fields. Multiplying the field's yield by a standard yearly price results in revenue from crop sales that is the same across all farms. Multiplying actual input amounts by a standard input price provides the direct costs. These costs include seed, fertilizer, pesticide, drying, storage, and crop insurance. Assigning field passes a cost based on machinery cost estimates from the University of Illinois and summing the costs represents machinery-related power costs. Overhead costs are based on Illinois Farm Business Farm Management (FBFM) data and are the same for all farms. Subtracting costs from revenue results in operator and land return, a measure of return for farmland. Operator and land return does not include a land cost. Using the same costs and prices for all farmers removes the effect of farmer grain marketing skill, volume discounts on input purchases based on farm size, and negotiating skills from the data. The historical data change from year to year because as new farmers join the program, they share both current and historical production records.

The data is cleaned to select entries with representative typical practices that occur on central Illinois fields. A standard to remove outliers was applied to select Illinois fields with a corn-corn or corn-soybean rotation, as well as conventional or non-GMO seed with a yield between 100 and 300 bushels per acre, direct costs less than or equal to $500 per acre, and power costs less than or equal to $210 per acre from 2015 to 2020.

COVER CROP BENCHMARKS

Each field in the PCM dataset is classified into a cover crop benchmark based on the practices used on that field. The benchmarks are as follows:

- None: The field had no cover crop.
- Overwintering: The cover crop survives the winter and continues to grow in the spring until it is chemically or mechanically terminated.
- Winter terminal: The cover crop dies during the winter.

Many of the benefits of cover crops take time to accrue, so it is important to consider multiple years of data when looking at cover crop outcomes. Figure 2 shows the years of data for fields with cover crops from 2015–2021. There are 158 fields (15%) that have been planted in cover crops for three years or more. It also takes time for farmers to learn how to grow cover crops cost effectively. For the fields with cover crops, 67% of fields that use cover crops for one year continue using cover crops in the next year. For the fields without cover crops, 91% did not use cover crops the next year. Once a PCM farmer tries cover crops on a field, they are likely to continue to use cover crops on that field in the following year.

There are 1,033 cover crop fields in the PCM dataset. The cover crop fields represent 71,398 acres. Of the fields with a cover crop, there are 350 corn fields and 683 soybean fields. Figure 3 shows the percentage of cover crop observations by crop. Overwintering cover crops are planted on more soybean fields than corn fields, and winter terminal cover crops are planted on more corn fields than soybean fields. There are more soybean fields planted with cover crops than corn fields. This is likely due to the use of cereal rye, which was planted on 48% of cover crop field observations. When many farmers first start planting cover crops, they begin with planting cereal rye into corn stalks before planting soybeans (Schnitkey et al., 2018). Many of the PCM farmers are beginning cover crop users, so cereal rye is a common cover crop in the dataset, but other cover crops include annual rye grass, barley, clover, vetch, other legumes, oats, radishes, and mixtures of cover crops.

RESULTS FROM COVER CROPS ON CORN

Table 1 shows the average yield, productivity, costs, and returns for corn fields with high productivity soil from 2015–2021. Subtracting the average total non-land costs from the average gross revenue for each benchmark results in a range for the operator and land return. On average, the non-cover crop fields have higher operator and land return and yield than the cover crop fields, although some of the winter terminal cover crop fields have higher operator and land return than the non-cover crop fields. There is a cost to utilizing cover crops. Incentives exist to help defray some costs, but sometimes this does not cover the full cost of cover crop seed and planting, which ranges from $18 to $39 per acre in the PCM dataset. On average, the cover crop seed cost and cover crop planting cost add up to $25 per acre for overwintering cover crops and $29 per acre for winter terminal cover crops.

Farmers in the PCM dataset who are growing cover crops are typically receiving some financial assistance through PCM ranging from $5 to $35 per acre, which is not reflected in the operator and land return shown here. Another consideration is the estimated greenhouse gas emissions for the cover crop fields compared to the no cover crop fields. The cover crop fields are sequestering carbon dioxide equivalent (CO_2-eq), with a modeled net sequestration of 0.72 metric tons of CO_2-eq per acre determined using the Cool Farm Tool (release 1.0.0), representing a total emissions reduction of 1.02 metric tons of CO_2-eq if "no cover crop" is accepted as the baseline value and both emissions reductions and sequestration are acceptable assets. Farmers have potential to receive ecosystems payments for their fields, such as from agricultural carbon credit programs. Currently, agricultural carbon credit prices range from $10 to $20 per metric ton of CO_2-eq (Sellars et al., 2021). If a carbon credit is $20 per metric ton and the farmer is paid for CO_2-eq emissions reduced, then the farmer would receive $20 per acre for their cover crop fields. The financial assistance farmers are receiving from PCM can put them at or above their cover crop cost, and factoring in the carbon credit payment could have a farmer generating extra revenue just from planting cover crops.

Considering the averages over all years is a useful benchmark, but the variability from differences in weather and price affects the averages. Looking at the averages by year may be a more useful way to see an effect on yield or returns from cover crops. Table 2 shows the average yield and operator return by year for high productivity corn fields. For all years except 2016, fields with no cover crops have the highest average operator and land return. In 2016, winter terminal cover crops had the highest operator and land return. One explanation for winter terminal cover crop fields having the highest average operator and land return may be above-normal precipitation and temperatures. The winter of 2016 had much higher than normal temperatures and above normal precipitation in central and southeast Illinois (Geelhart, 2016). Most corn fields in the PCM dataset are in the fall nitrogen benchmark, which means the field receives 40% or more of its total nitrogen application in the fall. There are 31% of fields in the fall nitrogen benchmark, and other fields in the dataset may receive some nitrogen applied in the fall as well. A warm, wet winter is the perfect condition to lose fall-applied nitrogen. The cover crop could have helped retain nutrients on the field, increasing yield and preventing nitrogen losses.

The average corn yield for winter terminal cover crop fields in 2016 is only one bushel less than the fields with no cover crops. Winter terminal cover crops had a higher average yield than fields with no cover crops in 2015, but there are only four winter cover crop fields in the PCM dataset for 2015, so this may be a factor. On average, winter terminal cover crops appear to be more profitable than overwintering cover crops. This is likely because there is no termination cost for the winter terminal cover crops, so farmers do not have the cost of the herbicide or extra field pass to kill them.

RESULTS FROM COVER CROPS ON SOYBEANS

Table 3 shows the average yield, productivity, costs, and returns for soybean fields with high productivity soil from 2015–2021. Subtracting the average total non-land costs from the average gross revenue for each benchmark results in a range for the operator and land return.

As with the corn fields, on average, the non-cover crop soybean fields have higher operator and land return and yield than the cover crop fields, although some of the winter terminal cover crop fields have higher operator and land return than the non-cover crop fields. On average, the cover crop seed cost and cover crop planting cost add up to $23 per acre for overwintering cover crops and $29 per acre for winter terminal cover crops. Again, returns for the soybean fields do not factor in any cost share programs, which typically pay between $5 and $35 per acre for PCM farmers.

A big advantage of cover crop fields on soybeans is their high CO_2-eq sequestration potential. On average, cover crop soybean fields on high productivity soils sequester a net 1.76 metric tons of CO_2-eq per acre determined using the Cool Farm Tool (release 1.0.0), representing an emissions reduction of 1.48 metric tons of CO_2-eq if "no cover crop" is accepted as the baseline value and both emissions reductions and sequestration are acceptable assets. At a carbon credit price of $20 per credit, then the farmer would receive $30 per acre for their soybean cover crop fields. The cost of cover crop seed and planting ranges from $18 to $39 per acre, so receiving a carbon credit or ecosystems payment could cover all or most of the cost of planting cover crops.

Table 4 shows the average yield and operator and land return for high productivity soybean fields by year. On average, fields with no cover crops had higher yield and higher operator and land return for all years except in 2016 and 2017. In 2020, fields with no cover crops had the same yield as fields with winter terminal cover crops.

In 2016 and 2017, winter terminal cover crops had the highest average yield and operator and land return. In 2016, there were only two winter terminal soybean cover crop fields, so the sample is very small. In 2017, there were seven winter terminal soybean cover crop fields. These fields had slightly higher yields than the fields with no cover crops or with overwintering cover crops, and on average they had lower non-land costs than fields with overwintering cover crops. Again, this is likely due to the additional termination cost that overwintering fields incur. Winter terminal cover crops have higher average operator and land return and higher or the same yield than overwintering cover crops for almost every complete year in the dataset.

CONCLUSION

On average, the cover crop fields in the PCM dataset on high productivity fields have a lower operator and land return. Cover crop fields incur an additional seed and planting cost that ranges from $18 to $39 per acre, and there also could be additional termination costs depending on the cover crop. Without financial assistance, cover crops would have negative returns. Our study validates previous studies which also find that cover crop fields have lower returns than non-cover crop fields. Farmers can receive financial assistance that covers a portion of the cover crop cost, and carbon credit or ecosystems payments have potential to even generate revenue from planting cover crops. Cover crops on corn fields may be more competitive in years with warm, wet winters with higher chances of nitrogen losses. Most PCM farmers are new to cover crops, so they are still learning how to use them profitably. Many of the fields have not had very many years of cover crops, and it typically takes a few years to begin to see the benefits from cover crops. This paper provides evidence of the financial challenges farmers face when they begin adopting cover crops and shows the potential for increasing cover crop adoption with cost share support. Financial support is necessary for cover crop fields to be as profitable as non-cover crop fields. The PCM dataset is a unique and useful panel dataset for thinking about benchmarking, costs, returns, profitability, and sequestration potential of cover crops.

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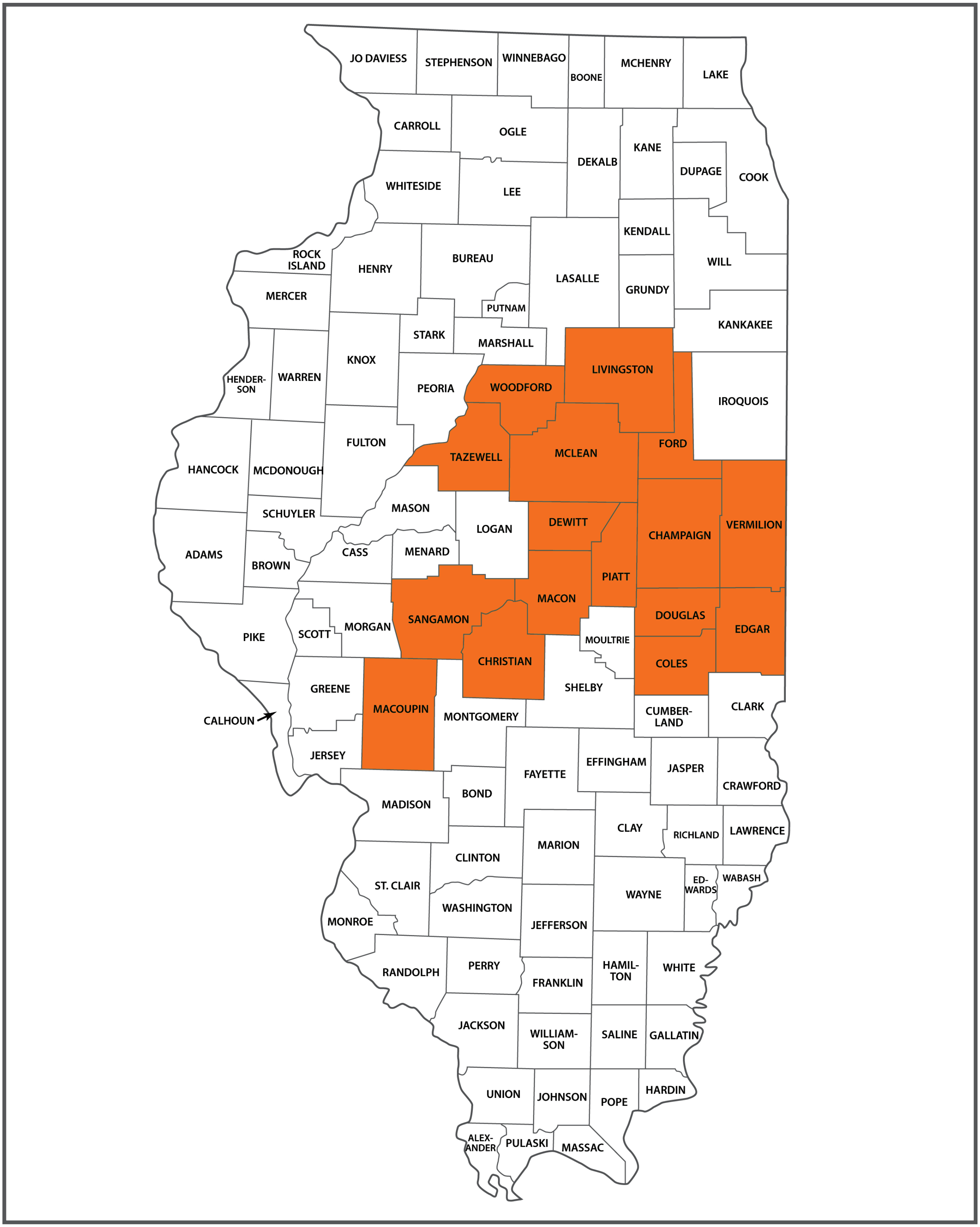

Figure 1. PCM service area

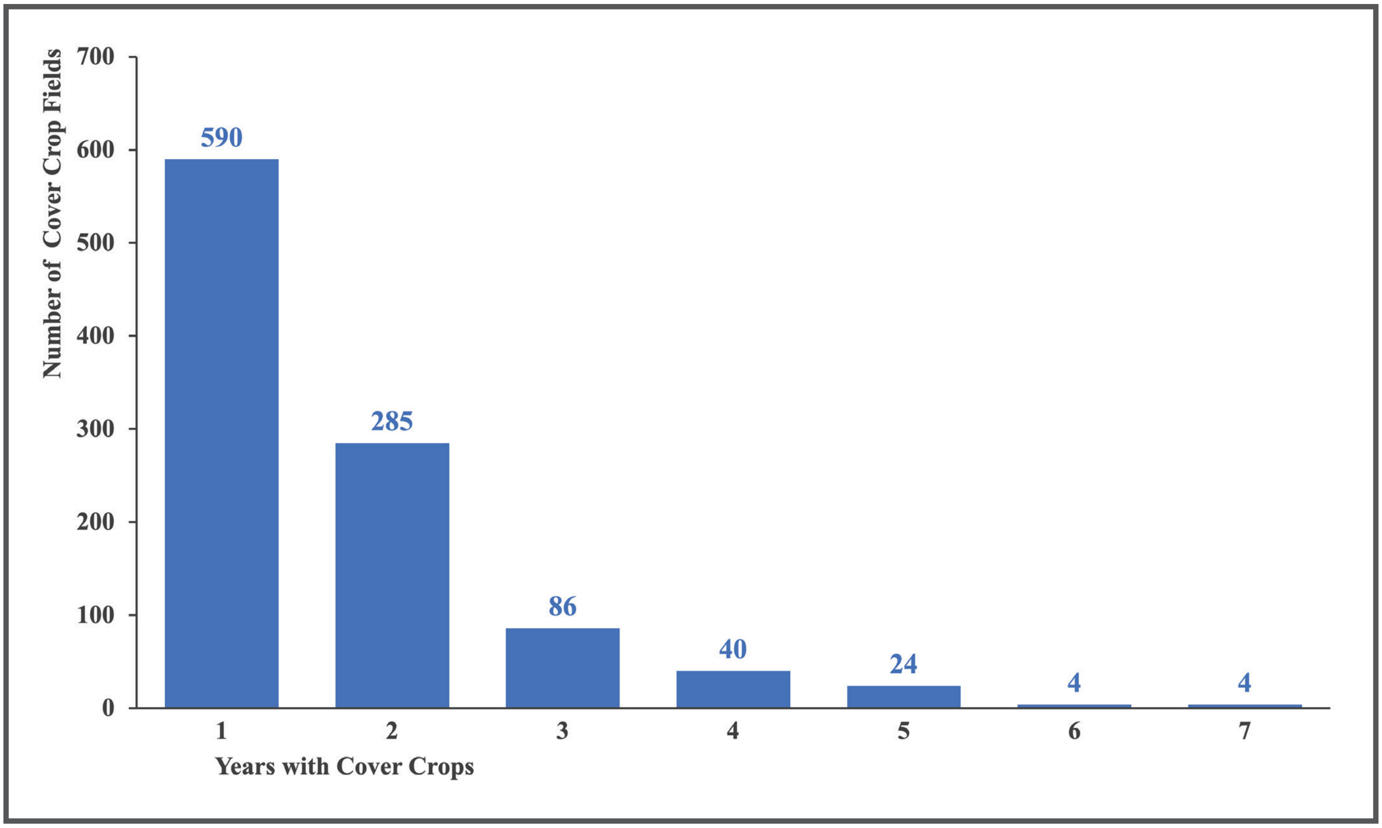

Figure 2. Cover crop fields, number of years with cover crops, 2015–2021

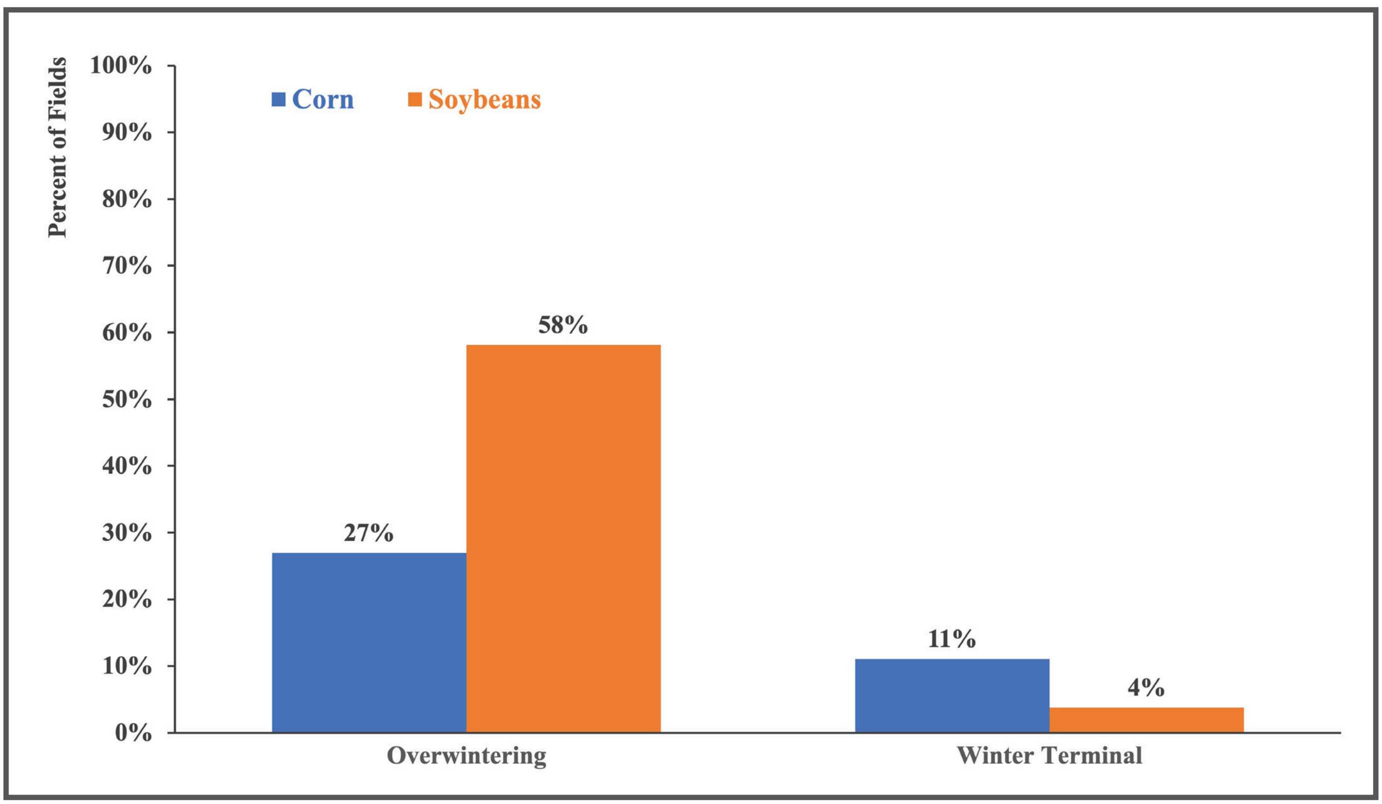

Figure 3. Percent of cover crop fields by benchmark, 2015–2021

Table 1. Averages for Corn (High Soil Productivity Rating), 2015–2021

	Overwintering	Winter Terminal	No Cover Crop
# of Observations	243	109	3523
Yield (bu/acre)	214	215	221
Soil Productivity Rating	139	139	140
Gross Revenue	$833	$834	$856
Cover Crop Seed	$13	$13	$0
Total Direct Cost[a]	$395	$374	$393
Cover Crop Planting	$12	$16	$0
Other Power Cost	$117	$106	$112
Total Power Cost	$129	$122	$112
Overhead Cost	$37	$37	$37
Total Non-Land Cost	$562	$533	$54
Operator and Land Return	$271	$301	$313
Estimated Soil Loss (tons/acre)	0.64	0.67	0.93
GHG Emissions (metric tons CO_2-eq/acre)	−0.72	−0.72	0.30

[a]Includes fertilizer, pesticide, seed, cover crop seed, drying, storage, and crop insurance.

Table 2. Averages by Year for Corn (High Soil Productivity Rating), 2015–2021

	Overwintering	Winter Terminal	No Cover Crop
Panel A: Yield			
2015	–	206	201
2016	222	223	224
2017	217	217	221
2018	225	222	234
2019	200	204	209
2020	210	208	217
2021	213	216	223
All Years	213	213	220
Panel B: Operator and Land Return			
2015	–	207	214
2016	204	267	251
2017	202	194	205
2018	255	313	324
2019	206	244	263
2020	266	269	313
2021	528	590	598
All Years	335	373	330

Table 3. Averages for Soybeans (High Soil Productivity Rating), 2015–2021

	Overwintering	Winter Terminal	No Cover Crop
# of Observations	588	28	3066
Yield (bu/acre)	68	68	70
Soil Productivity Rating	139	139	140
Gross Revenue	$666	$675	$686
Cover Crop Seed	$13	$13	$0
Total Direct Cost[a]	$158	$159	$151
Cover Crop Planting	$10	$16	$0
Other Power Cost	$90	$70	$84
Total Power Cost	$100	$86	$84
Overhead Cost	$31	$31	$31
Total Non-Land Cost	$290	$276	$266
Operator and Land Return	$376	$399	$420
Estimated Soil Loss (tons/acre)	0.96	1.03	1.29
GHG Emissions (metric tons CO_2-eq/acre)	–1.76	–1.76	–0.28

[a]Includes fertilizer, pesticide, seed, cover crop seed, drying, storage, and crop insurance.

Table 4. Averages by Year for Soybeans (High Soil Productivity Rating), 2015–2021			
	Overwintering	**Winter Terminal**	**No Cover Crop**
Panel A: Yield			
2015	66	–	67
2016	69	70	69
2017	67	69	67
2018	71	70	75
2019	62	62	64
2020	66	67	67
2021	70	70	73
All Years	67	68	69
Panel B: Operator and Land Return			
2015	369	–	379
2016	422	460	438
2017	337	398	375
2018	311	332	375
2019	278	316	327
2020	357	366	396
2021	550	553	621
All Years	408	412	409