Evaluating Benefits and Costs of Cover Crops in Cotton Production System in Northwest Louisiana

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Abstract

Cover crop adoption by producers as part of a production-cycle depends on their objectives regrading time management, cost-vs-benefits, and environmental obligations. A myriad of studies that examined the economics of cover crops found them to be often idiosyncratic, i.e., results depend on the region, weather patterns, soil type, and management practices. The studies determined that lack of long-term economic outlook for the incorporation of cover crops as one of the factors for their minimal adoption in many parts of the country. Thus, we aim to assess the economic impact of long-term adoption of cover crops as part of a production-cycle. Partial budgeting tool, CoverCropEconomics, is used to generate the overall costs and benefits. The data on agronomic variables, i.e., yield, organic matter, applied nitrogen, soil microbial counts, and among others are obtained from a 30-year cover-crop research conducted in Northwest Louisiana. The research reported a significant increase in yield for crops planted following cover crops. Additionally, research shows improvements in soil nitrogen and soil organic matter suggesting added profits to the farmer. Accounting for those economic and agronomic variables, overall long term net benefits of incorporating cover crops amount to 1,354 per acre, with majority of the benefits contribution through yield increase of cash crop. The results can be useful for conservation agencies to evaluate their current incentive payments toward cover crop adoption.

Introduction

The current paper quantifies the environmental and economic benefits and costs of incorporating cover crops into a continuous cotton system. The research was conducted at the Red River Research Station in Bossier City, LA. Production benefits in terms of yield were estimated, whereas the environmental benefits were left unquantified. Fully accounting the magnitude of environmental services cover crops produce such as reduced erosion, reduced nitrate leaching, enhanced habitat for wildlife, and other ecosystem services can benefit off-farm public. Such accounting can help to direct more effort toward promoting cover crops thorough extension programs and federal cost-assistance programs.

Literature indicates that substantial benefits can accrue from incorporating cover crops into cropping systems. Increased yield of the cash crop is the most direct benefit on the farm. Yield increase in corn and soybeans in fields with cover crops were higher by 3.1 percent and 4.3 percent respectively, than those without cover crops (SARE and CTIC 2014). Winter cover crop, hairy vetch increased cotton yields compared to cotton without a cover crop (Rothrock and Kendig 1991). Research has even concluded that careful timing of planting cover crops and killing them was very important to prevent yield reduction in corn (Ebelhar et al. 1984).

Research has shown that chemical use reduction through integration of cover crops into various cropping systems offer economic benefits on the farm and environmental benefits both on and off the farm (Lazarus and White 1984). Mitigation of nitrate leaching and surface runoff are two important environmental effects that reach beyond farm boundaries, and the effect of cover crops is as big as 70 percent (Wyland et al. 1996). Cover crops enhanced recycling of inorganic Nitrogen (N) by more than 50 percent and reduce nitrate leaching (Vyn et al. 1999; Weinert et al. 2002). In addition, cover crops build soil organic matter and improve weed control (Sainju et al. 2002; SARE and CTIC 2014).

On the other hand, several on-farm costs have been identified for cover crops. Such on-farm costs include costs associated with high seeding rates of cover crops that are hard to establish (Labarta et al. 2002), termination costs of cover crops that are hard to kill, residue management costs due to vigorous
growth of some cover crops (Griffin and Hesterman 1991; Vyn et al. 1999). These costs are considered a major factor in the economics of cover crops.

Knowledge of cover crop management practices, nutrient benefits, and economics could promote adoption (Snapp and Borden 2005). The perception that cove crops are costly and are tough to terminate are the top two principal barriers to adoption of cover crops as reported in the most recent national cover crops survey (SARE and CTIC 2014). Determining the overall agri-environmental situation of cover crops through measuring input use, yield impacts and quantifying on and off farm agronomic and environmental benefits and calculating long-term profitability outlook of production systems that incorporate cover crops will help producers better understand the use of cover crops. This research will shed some light on the key environmental benefits that are often left unquantified. The results can help producers and policy makers to work together to develop programs that can increase the adoption of cover crops into existing production systems.

Methods

Cover crop economics tool, an excel spreadsheet based economic assessment tool (Natural Resources Conservation Service 2015) is used to assess the benefits and costs of integrating cover crops into a cotton production system are estimated. The tool is a partial budgeting tool that helps producers and planners provide the overall costs and benefits of adding cover crops to their production system. The benefit category includes direct nutrient credits, which are the credits from reducing fertilizer use on the farm; chemical input use reduction, which results from reduced chemical application; yield increase; a potential benefit from improving moisture availability to the cash crop; reduced erosion; improved water retention capacity, and infiltration (Natural Resources Conservation Service 2015).

The tool uses user supplied information and provides both short-term net benefits and long-term net benefits of incorporating cover crops and their impact on the above-mentioned benefit categories. The environmental benefits of cover crops that are often unaccounted are now expressed in dollar terms. The tool incorporates financial tools such as Net Present Value to evaluate the long-term overall profitability outlook of the investment decision, which is to incorporate cover crops into a current production system. The economic variables that are included in the tool are reported in the table below.

Table1. Costs and benefits categories included in the Cover Crop Economics Tool

<table>
<thead>
<tr>
<th>Cost categories</th>
<th>Benefit categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover crop seed</td>
<td>Nutrient credits</td>
</tr>
<tr>
<td>Planting</td>
<td>Chemical inputs reduction</td>
</tr>
<tr>
<td>Termination</td>
<td>Yield increase</td>
</tr>
<tr>
<td>Management</td>
<td>Reduced erosion</td>
</tr>
<tr>
<td></td>
<td>Long term soil fertility improvement</td>
</tr>
<tr>
<td></td>
<td>Long term improved water storage and infiltration capacity of soils</td>
</tr>
</tbody>
</table>

Note: The cost and benefit categories are adopted from the tool description handout (Natural Resources Conservation Service 2015)
Data

The data for this analysis is obtained from a research conducted at the Red River Research Station, starting in 1959 until 1988, the study was conducted over a 30-year period (Millhollon and Melville 1991). For the purpose of this analysis, the data for the years 1984-1988 is used. Their results did not quantify the environmental benefits of the research, primarily due to lack of appropriate models at that time. The tool is used to conduct both short term and long term overall costs and benefits associated with incorporating cover crops into a production system.

The data from the results analyzed during the 1984-1988 study period are used to determine the overall costs and benefits of incorporating cover crops into the cotton system. The data reported from the original research are used as data-inputs for the decision tool. Data elements are described below.

**Planting:** Cover crops were planted each fall after cotton was harvested and the remaining stalks were shredded. Cover crop varieties planted include Austrian winter pea, common vetch, hairy vetch, berseem clover, oats, and rye. Cover crops were disked in mid-April of each year. Cotton was planted approximately 10 days after turning under the cover crops. Soil from each treatment plot was sampled at 0-6, 6-12, and 12-18 inch depths and analyzed for organic matter content and other nutrients. The effect of different cover crops on cotton yields have been recorded.

**Yield:** cotton yields were significantly higher in treatments with cover crops than those that received only fertilizer inputs and treatments that had no cover crop nor received any fertilizer inputs. The average cotton yields over the period 1984-1988 are presented in the table below.

**Soil characteristics:** Soil samples were collected at 0-6 inches, 6-12, and 12-18 inches depth. Soils were tested for phosphorus, potassium, calcium, Magnesium, organic matter, and pH. Soils from the plots without cover crops showed highest PH, and lowest organic matter content. The differences among soils in their nutrient content, and organic matter were similar between samples collected at 0-6 and 6-12 inches deep. At 12-18 inches, the differences in most of the analyzed variables among treatments were minimal. The organic matter results from this study are used as data inputs for the decision tool. For the cost and benefit analysis, results of hairy vetch treatment are analyzed. Hairy vetch is the most common winter cover crop suitable for production systems in Louisiana (Coreil 2016).

Table 2. Average Cotton yields for 1984-1988 and organic matter content in 1988 following cover crops at the red river research station (Millhollon and Melville 1991)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average cotton yield, lbs/acre</th>
<th>Organic matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austrian winter pea</td>
<td>2,121 c</td>
<td>0.40 abc</td>
</tr>
<tr>
<td>Hairy vetch</td>
<td>2,652 ab</td>
<td>0.54 a</td>
</tr>
<tr>
<td>Check</td>
<td>965 d</td>
<td>0.25 c</td>
</tr>
<tr>
<td>Common vetch</td>
<td>2,373 bc</td>
<td>0.56 a</td>
</tr>
<tr>
<td>Vetch + 40lbs of Nitrogen</td>
<td>2,683 a</td>
<td>0.49 ab</td>
</tr>
<tr>
<td>40lbs Nitrogen</td>
<td>2,137 c</td>
<td>0.30 bc</td>
</tr>
<tr>
<td>60 lbs Nitrogen</td>
<td>2,292 c</td>
<td>0.25 c</td>
</tr>
</tbody>
</table>

Note: Means within a column followed by the same alphabet are not significantly different (p <= 0.05)

**Benefit categories:** Fourteen different soil erosion benefit categories are described by the United States Department of Agriculture (USDA) (Hansen and Ribaudo 2008). The categories that are included in this analysis include soil productivity, reduced costs of removing sediments from irrigation channels. Several other categories such as improved catch rates for marine and fresh water fisheries seem relevant,
discussion with other experts in the field suggested that given the location of the research, the benefits of improving catch rates within the river basin are negligible. As a result, those benefit categories are not accounted in the analysis. Hansen and Ribaudo (2008) reported the value of soil productivity for the Delta states (Louisiana, Arkansas, and Mississippi) as $0.43/ton, estimated in 1990 dollars, which is $0.71/ton in 2015 dollars. Similarly, the value of reduced costs of removing sediments was valued at $0.12/ton in 2007 dollars ($0.14/ton in 2015 dollars). These estimates when combined with the annual soil loss per acre per year in Louisiana, which is 2.32 tons/acre/year (U.S. Department of Agriculture 2015) will enable to estimate soil erosion costs (savings) to Louisiana farmers in lost (improved) productivity each year.

Results

Short-term analysis results: The analysis used hairy vetch as the cover crop to carry out the overall economics. The cost categories account for the establishment and management costs of cover crop. The benefit categories account for nutrient credits, i.e., reduction in nitrogen, phosphorous, and potassium purchased, reduction in purchase of other inputs such as herbicide and fungicide, yield increase of cash crop following cover crop, off-site water quality damage prevention credit, and on-site erosion reduction credit. The immediate total costs and benefits of adding cover crops to the existing cash crop for each year per acre are $226 and $1,562, respectively, resulting in net benefits per acre of $1,335. In the revenues component, majority of the benefits amount to the yield increase of cash crop, followed by reduction in fertilizer input costs, and then on-site erosion reduction credits per acre and off-site water quality damage prevention credits per acre.

Long-term analysis results: The long-term analysis assumes continuous utilization of cover crops and captures additional benefits that may be realized over time. For the long-term analysis, a lifespan of 15 years is assumed, which indicates that cover crops will be part of the production system for the next 15 years. The long-term analysis utilizes financial principles to calculate the present value of net benefits. Default values are assumed for the number of years required to increase the soil organic matter by one percent. The default value in the model is 10 years. Accounting for the two benefit categories that are exclusive for the long-term analysis, the overall soil fertility benefit and water storage benefit. In comparison to the short-term analysis, total additional benefit in the long-term analysis increase by $13 per acre per year. The costs and benefits amortized over the life span are $227 and $1,569, respectively. As a result, the total net benefits per year per acre amount to $1,354.

Conclusion and Discussion

Introducing cover crop in an irrigated cotton system has a positive effect on cotton yield and soil organic matter. The cover crops economics tool provided meaningful monetary estimates of on-site erosion reduction credit, off-site water quality protection credit, and long-term increased soil water storage capacity credit. The results from the capital budgeting tool provided an initial understanding to the value of those credits that are often unquantified. With increased burden on agricultural community to protect off site water quality through on-site management practices, increase in farm revenues are a starting step to encourage more adoption of such management practices. Introduction of methods that can quantify value for beneficial aspects of management practices and develop incentive payments that comprehensively account for all of the benefit categories can encourage farmers from adoption of such practices.
Cover crop adoption that is associated with a range of benefits including reduced erosion, reduced nutrient loss to water, and increased carbon sequestration; information on monetary credits of benefits generated can be useful to determine cost-share and/or incentive payments. Federal conservation incentive programs should be designed in a way that can reward farmers for using cover crops taking into account both on-farm and off-farm impacts. Incentives can take the form of subsidy per unit decrease in soil erosion, subsidy per unit decrease in nutrient (nitrogen loss) to waterways, and subsidy for per unit decrease in greenhouse gas emissions. Although not quantified in the current analysis, cover cropping combined with other management practices has been proven effective in GHS mitigation through sequestering carbon in the soil (Coreil 2016), and direct and indirect reduction in GHS emissions associated with fertilizer application. Potential incentives for cover crops that intend to quantify GHG mitigation should account for production decisions such as changes in tillage practices, changes in rotation, and changes in nitrogen use, among others.

The national program that currently promotes cover crops has mostly relied on covering 70-90 percent of the production related costs, i.e., cost of seed, cost of planting operations, cost of termination (Coreil 2016). In most cases, that incentive amounts to $70 per acre. A recent change has increased the period of participation for farmers from three years to five years, i.e., cost-share assistance will be provided for five years for farmers interested to implement cover crops in their production system. Although such improvements in the process to promote cover crops can be useful, a comprehensive approach in developing incentive payments by accounting for the on-site and off-site benefits is needed. The incentive payment do not take into account the value of such benefits mostly due to lack of reliable models that generate monetary estimates of the benefits. Hence, our attempt to quantify these values based on on-farm research can serve as a starting point for reevaluating the cost-share program, at least at the state level. From the analysis, it is evident that producers would gain significantly through increase in cash crop yields, a direct benefit to the farmer. The analysis provides estimates for the soil erosion improvement and water quality improvement credits. These credits when added to the current incentive payments that cover planting and management costs would add an environmental component to the incentive payments. Although the credit estimates calculated in this paper are relatively small, they could represent a lower bound of benefits that are directly attributable to cover crops. Currently, Dr. Daniel Fromme, co-author on this papers, is conducting research evaluating cover crops in both corn and cotton production systems in Louisiana collaborating with Louisiana Natural resources Conservation Service. The results from the research are expected to provide information that could be used to update the estimates provided in this paper.

Agricultural producers understand the agronomic and environmental benefits, necessary equipment, technology, and knowledge of cover crops to include cover cropping as part of their cropping system. Designing a cost-share structure that recognizes cover crop benefits including agronomic and environmental benefits can serve as a catalyst to adoption and increase cropping systems resilience in the face of climate challenges. Role of nonrevenue tools that are also considered significant for cover crop adoption (SARE and CTIC 2014) must be explicitly addressed if revenue based policies are to be effective; however, this on-site and off-site agronomic and environmental benefits information for cover crops estimated in this paper should be a valuable contribution to the policy debate.
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