NRCS CONSERVATION INNOVATION GRANT

Final Report

Project Number: 69-3A75-17-274

Grantee Name: Clemson University

Project Title: “Utilizing Deep-rooted Cover Crops to Enhance Water Quality, Soil Health, and Farm Profits While Reducing Soil Compaction in Coastal Plain Region”

Project Director: Dr. Michael W. Marshall

Project Period: 9-21-17 to 9-30-22

Project Summary: Soils in the coastal plain region have extremely low water holding capacity due to their predominantly sandy texture with very low organic matter content. This results in deep water percolation which increases the potential for environmental degradation from nitrogen, phosphorus, and pesticide leaching. These fields are also susceptible to rain and irrigation-induced runoff, which can concentrate these chemicals into small collection points where they can enter surface or ground water where they will have adverse impacts on water quality. In addition, coarse textured soils in the southeast US have several chronic production problems including soil compaction, low water holding capacity, and low organic matter which limits yields and makes plants more susceptible to drought stress. Cover crops have been an economical solution for increasing positive soil attributes. The onset of production problems in southern U.S. including herbicide-resistant weeds and early season insect management in cotton are reducing farm profits and sustainability and/or threatening soil conservation practices. Cover crops have the potential to also mitigate these production issues facing growers. The results of this project clearly demonstrate the benefits of cover crops on soil physical and biological properties, water quality, run-off/erosion potential, and farm profitability.

Project Background: The use of cover crops is an increasingly popular sustainable farming practice that provides many benefits to the soil and subsequent cash crops. Cover crops increase residue cover and soil organic matter or soil humus, which provides greater water infiltration and available water holding capacity. This would enhance ground and surface water quality by reducing runoff and increasing soil water retention. In addition, cover crops improve soil physical and chemical properties, recycle nutrients, fix nitrogen with legumes, reduce soil compaction, improve field traffic-ability, reduce soil erosion, improve weeds, insects, and nematodes control, and increase crop yields.

Project Methods: EQIP eligible farmers were identified that were using already using the DRCC farming systems (cover crops) in South Carolina and Georgia during the project period. These demonstration fields (roughly 4-6 sites per year) were located at geographically diverse locations in both states and provided locations for field days and training workshops. Soil moisture sensors were installed in each demonstration field which monitored soil levels at different depths (Figure 1). Due to the lack of deep tillage equipment availability at demonstration sites, the sites were planted either cover crop (farmer choice) alongside a no-cover crop section.

Figure.1. Watermark sensors and mounting pole installed in the grower's demonstration fields with cellular data transmitter and solar panel.

Land preparation before cover crop planting consisted of tandem disk and drilling the cover crop seed afterwards. Cover crops were terminated each spring using the recommended herbicides and cash crops were planted.

Afterwards, field days and county/regional meetings were conducted in South Carolina and Georgia (see outputs). Benefits of these DRCC systems were disseminated to growers and interested clientele. In addition, training events were held for Extension agents and consultants at the field days where these individuals could further extend the knowledge to other growers in their respective counties or regions. Other delivery methods including emails and other methods were used.

To demonstrate the impact of DRCC on water quantity and quality, an environmental quality monitoring site was established at the Edisto Research and Education Center in Barnwell County located near Blackville, SC (Figure 2). The site was established in a six-acre field, which has been divided into six one-acre sections (~100 by 450ft) to allow us to compare two production systems [deep rooted rye cover crop vs the grower standard, no cover crop, where winter weeds were present during the winter months]. The field is under a center pivot irrigation system and can be irrigated as needed. A soil berm was constructed between adjacent plots to contain runoff within each plot. A ditch was built along the southern edge of the field to allow drainage of runoff water. At the outlet of each plot, a system to automatically measure runoff and to take water samples to evaluate runoff water quality was installed. To measure runoff hydrograph from each plot, a 9-inch stainless steel H-flume was installed. The water height on the flume is measured using an electronic water level sensor. An electronic wireless sensor network and Internet-of-Thing system were used to collect the data from the eTape, collect water samples during run-off events, and transmit the data to the internet in real time.

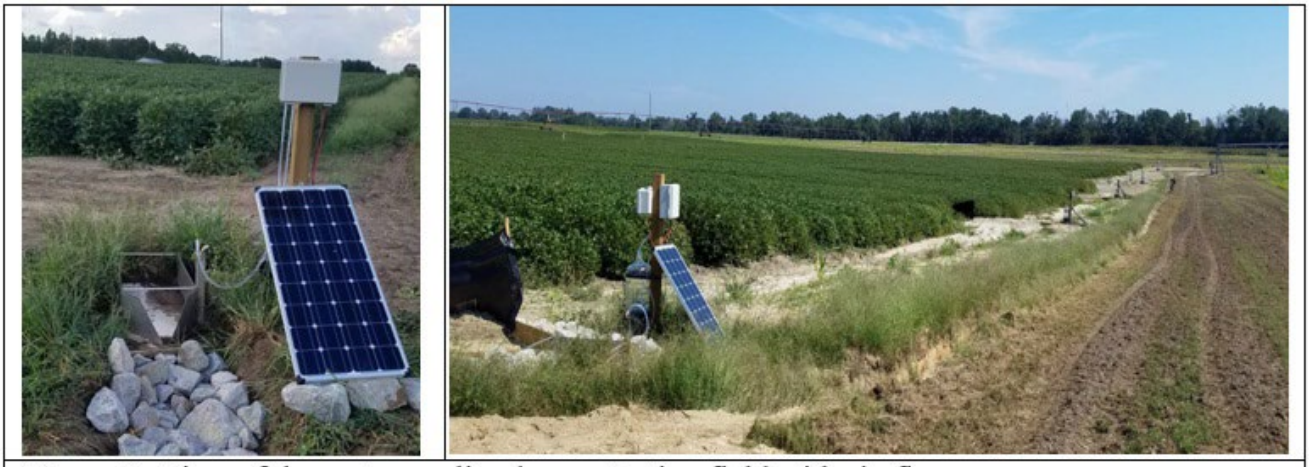

Figure 2. View of the water quality demonstration field with six flumes.

Project Results

1. To select 18 "EQIP eligible" growers in South Carolina and Georgia and establish six "Prototype Fields" per year (4 in SC and 2 in GA) to directly train growers in the use, benefits and effectiveness of DRCC systems.

For the duration of this project, we have worked with 7 growers (5 in SC, 2 in GA) each year (2018-2019, 2021-2022). Utilizing the same set of growers each year (as indicated in the objective 1), has allowed us to see the long-term benefits of the static demonstration sites and show the trend over time of the cover crop effects that we could not see moving to new sites each year (i.e., we would be starting over each time and the long-term benefits would not be as evident). With the extension, we will have approximately 35 demo site locations over the term of the grant (2018-2019, 2021-2022, 7 growers x 5 on-going demonstration sites).

2. Demonstrate and evaluate the effects of deep-rooted cover crop farming systems on water infiltration rate, water holding capacity, ground and surface water quality, pest suppression, crop yield, soil compaction, fuel consumption, and farm profits.

The water quality results from this project are presented in the results section (see Table 1). Infiltration rate and water holding capacity increased in the cover crop plots. In general, crop yields were higher in the cover crop plots. Soil compaction results were inconsistent because broadcast tillage before planting was not done due to lack of equipment availability from the grower. Fuel consumption was reduced due to fewer trips across the field (i.e., cover crop reduced pest occurrence thereby reducing need for pesticides). As a result of these savings, farm profitability was increased when utilizing cover crops.

3. To implement an aggressive training & outreach program in South Carolina and Georgia for crop consultants, technology providers, and county Extension agents to become the primary providers of the DRCC farming system for growers beyond the geographic and time limitations of this project.

The information gathered from this project was disseminated at numerous national, state, regional, and county level meetings/fields days/trainings in both states over the life of this project (see detailed outreach results section). Data from grower and Edisto REC demonstration sites showed positive benefits of cover crops and summer crop yield enhancement.

Project Outreach Results:

1. Delivered 7 in-person grower crop productions meetings conducted by Clemson Extension during 2018-2019.

2. Presented results from this CIG project on how cover crops aid in moisture retention in coastal plain soils at the Sandhill Research and Education Center Cover Crop Field Day (Apr 3, 2019).

3. Presented the status and results from CIG project at the CIG showcase event at the annual Soil and Water Conservation Meeting in Pittsburg, PA (July 28-Aug 1, 2019). https://www.swcs.org/static/media/cms/19_AC_Final_Program_398D7E1AD8A71.pdf.

4. Presented 2 posters on cover crops and moisture retention and weed suppression at the annual Soil and Water Conservation Meeting in Pittsburg, PA (July 28-Aug 1, 2019). https://www.swcs.org/static/media/cms/19_AC_Final_Program_398D7E1AD8A71.pdf.

5. Hosted Dr. Harbans Lal, USDA-NRCS for a tour of the University of Georgia-Tifton water quality monitoring site and grower demonstration sites in Georgia (Aug 6-Aug 9, 2019).

6. Presented results from the CIG project at the University of Georgia Southeast REC field day (Aug 14, 2019).

7. Presented results from the CIG project at the Soil Health Field Day at the Lamar Black's demonstration site in Georgia (Aug 21, 2019).

8. Demonstrated the water quality monitoring site and other CIG results at the Edisto REC annual field day (Sep 5, 2019).

9. Presented an USDA-NRCS Webinar "Applications for Internet of Things (IoT) for Improved Agricultural Operational Efficiency." This presentation discussed the overall project with focus on the technology developed during the demonstration project (10/2019).
   - Registrations (number of unique login email addresses)
     - Total – 151
     - USDA – 60
     - Private, University, Other government – 91
   - Estimated participation (includes USDA group logins) – 227
   - Number of states, territories, other represented – 46
   - CEUs / Training Certificates – 58 individuals documented Conservation Planner, Certified Crop Advisor, and other professional CEUs.

10. Delivered 6 Virtual Zoom grower crop productions meetings offered by Clemson Extension in the winter of 2020-2021:

11. Water quality samples from run-off demonstration sites (2018-2020) were analyzed and results presented to clientele during 2 Virtual Extension meetings.

12. Presented a poster titled "Evaluating the effects of Cover Crops on Runoff Water Quality" at the 2021 Soil and Water Conservation Society Annual Meeting. www.swcs.org/21AC.

13. Published a paper titled "Development of an Internet of Things (IoT) System for Measuring Agricultural Runoff Quantity and Quality." https://doi.org/10.4236/as.2021.125038.

14. Published a paper titled "Development and Application of Cell-Phone-Based Internet of Things (IoT) Systems for Soil Moisture Monitoring. https://doi.org/10.4236/as.2021.125035.

15. Published a paper title "Effect of Rye and Mix Cover Crops on Soil Water and Cotton Yield in a Humid Environment. https://doi.org/10.4236/ojss.2021.115015.

16. Delivered six virtual Zoom and in-person grower crop productions meetings conducted by Clemson Extension during 2021-2022.

17. A design for the low-cost soil moisture monitoring system was made available for growers and other interested parties. Our capability to mass produce these is limited, but it is an easy project for growers to tackle for their operations.

18. A portal for the soil moisture data collection for these demonstration sites was developed for the cooperators in the project. https://thingspeak.com/

Project Water Run-off and Quality Results: Cover crop had no effect on water quality in 2018 and 2019; however, water samples collected from the no cover crop areas in 2020 had higher calcium, magnesium, and sodium levels in the runoff water. These results demonstrate the long-term benefits of cover crops in capturing and storing crop nutrients. In the long-term, cover crops can reduce nutrient run-off and increase storage of soil nutrients and improve water quality (Table 1).

Table 1. Concentrations of total suspended solids (TSS) and crop nutrients in the runoff water from cover crops and control plots.

Treatment	TSS (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
			2018		
Cover	543	2.75	0.36	3.89	1.21
No cover	342	1.38	0.35	14.5	2.92
p>F	ns	ns	ns	ns	ns
			2019		
Cover	375	9.09	0.47	1.34	2.71
No cover	337	11.5	0.99	5.27	4.85
p>F	ns	ns	ns	ns	ns
			2020		
Cover	423	9.85b*	1.95b	0.78b	8.55
No cover	390	17.6a	4.35a	4.92a	11.7
p>F	ns	0.02	0.03	0.009	ns

*Mean values within the same column followed by different small letters are significantly different at $p<0.05$ within the treatments
Abbreviations: ns, non-significant; Ca, Calcium; Mg, Magnesium; Na, Sodium; and K, Potassium.

Project Challenges:
Some of the challenges encountered during the project centered around equipment functionality, particularly electronic parts that were permanently outside. For example, sensors would stop transmitting at grower sites and it would take several days to repair the problem. By the end of the project, most of the equipment problems were fixed, but it took much longer than anticipated at the beginning of the project. Continued "fine-tuning" of this technology along with better enclosure are needed before future implementation by growers.

Summary of Outputs:
This demonstration project clearly showed the benefits of cover crops as an enhancement for improved crop production. Our results were shared widely with stakeholders using in-person and other delivery methods at over 25 meetings/trainings across the two states over the life of the project as described in the results section reaching over 1,500 individual growers. In addition, results were presented at the international Soil and Water Conservation Society meetings in 2019 and 2021. In 2019, the project investigators were invited to present a USDA-NRCS webinar on the results of this project with over 200 participants. Several papers were published on-line from this project, the hyperlinks are included in the project results section.

Project Impact on Conservation:
Cover crops are an invaluable cultural practice that has numerous and long-lasting benefits in crop production. This demonstration project showed these benefits to regional and national audiences in the United States. Clearly, our project demonstrated that a farmer adopting cover crops on their operation will observe multiple benefits including soil improvement, reduced run-off/erosion potential, pest suppression, and increased profitably/sustainability. Given the relative low-cost (no-cost if considering the benefits previously described) of cover crops, implementation of this practices should be a “no-brainer” for farmers.