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The DIRECT4AG Project, Part 3: Technology for Cover Crop Establishment

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As combines continue to roll across Midwestern farm fields, the machines serve up reminders about the vast technological advancements in modern farming (see e.g., Castillo, June 3, 2024; Farm Progress, February 15, 2024). There are also reminders that technology for conservation practices and sustainable farming systems has not advanced at the same pace or to a similar degree, presenting opportunities for research and development. The DIRECT^{4}AG project seeks to facilitate the adoption of emerging agricultural advancements that create value for the farmer, while also facilitating productive and sustainable farming practices (*farmdoc daily*, October 21, 2024; October 14, 2024). This third article in the series reviews collaborative efforts with other research projects to test effective ways to implement cover crops into commercial agricultural systems.

Background

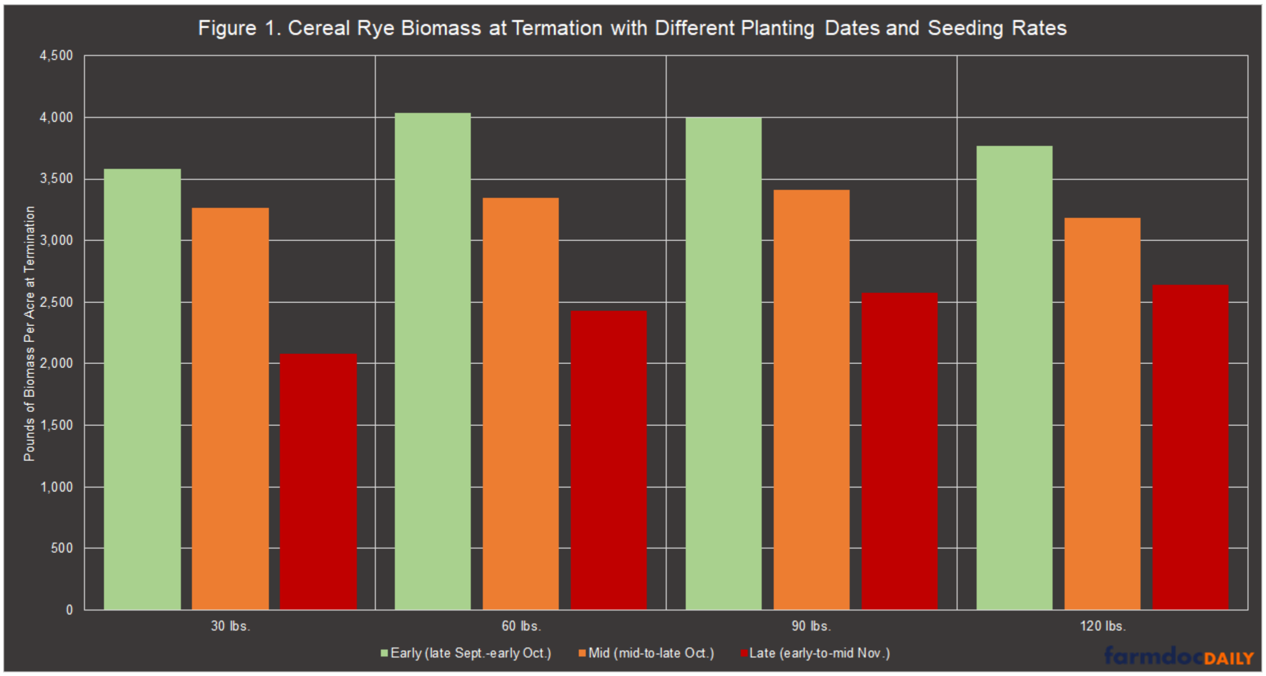
From mechanization to automation, roughly one hundred years separates the precursors of both; before there were tractors, inventors mounted an internal combustion engine on a "wagon frame with wheels" in 1889, spurring others to push innovation that led to building the first successful gasoline engine tractor by Charles Hart and Charles Parr, in 1901 (Cochrane, 1993, at 108). Tractors took off during and after the "fiery cauldron of World War I" helped along by Henry Ford and Farmall's first general purpose tractor with power takeoff in 1924 (Wik, 1964, at 81; Olmstead and Rhode, 2001; Cochrane, 1993). Fast forward nearly 100 years when, in 1983, President Reagan first permitted civilian use of global positioning systems (GPS) which contributed to the development of equipment and methods for variable rate fertilizer application and the first grain yield monitors in 1992-1993, and with them, the advent of precision and digital agriculture (Lowenberg-DeBoer and Erickson, 2019; McFadden, Njuki, and Griffin, February 2023). Precision, and now digital, agriculture offer important opportunities to help farmers advance sustainability goals and successfully adopt or manage conservation practices in the reality of complex and variable agricultural ecosystems (see e.g., Basso, 2003; de Paul Obade, Lal, and Chen, 2013; Donat et al., 2022). Into this long history of technological advancement, DIRECT^{4}AG is working to assist advancements for conservation practices such as cover crops.

Discussion

The timing of planting a cover crop is an important factor in maximizing the practice's effectiveness for soil health and nutrient loss reduction benefits. Sufficient time for establishment is needed in the fall to reduce winter kill and ensure robust spring growth. Researchers continue to develop a better understanding of these factors, including work on a minimum GDD threshold for successful cover crop establishment (Crespo et al., 2024). As with any growing plant, it is important to get cover crops seeded early when moisture and heat units are available. This timing can, however, conflict with harvesting the cash crop and be further complicated by unpredictable fall weather. Here again, a major practical challenge for implementing cover crops and an area of opportunity for advancements through research, development, and demonstration.

The Midwest Cover Crop Field Guide (Midwest Cover Crops Council, 2021) provides cover crop profiles for 40 different potential cover crop species. Each offers a different combination of benefits and challenges. Many of these will only reach their maximum potential if planted prior to the main crop harvest. According to the 2017 Census of Agriculture (USDA-NASS, 2017), 50-60% of acreage planted to cover crops is seeded with Cereal Rye (Secale cereale). This percentage may vary depending on the region, as cereal rye is particularly popular in the Midwest and Northeast, where it is valued for its winter hardiness, soil erosion prevention, and weed suppression. Most notably its ability to germinate quickly in challenging and cool soil conditions. It is the least likely-to-fail cover crop species when farmers are faced with late post-harvest seeding.

Solving the cover crop planting and timing problem is a prerequisite for accessing the full range of cover crop species options. Extensive research on the implications of planting dates for cover crops includes a rigorous experimental design to investigate planting date, seeding rates, and termination before soybean planting at different locations in Illinois. With funding from the Illinois Soybean Association, the effort recognizes that farmers need data to help them make decisions when managing cover crops. Figure 1 presents a compilation of the findings from this research at the Belleville Research Center, Orr, Monmouth, and Ewing field sites comparing different seeding rates from three different establishment time frames. The biomass numbers were pooled over two termination timings for all sites: (1) when the rye reached 18-to-24 inches in height; and (2) when the rye was fully headed.



One of the clearest results from the study is also intuitive: September and October cereal rye planting dates performed better than November planting. Although the exact "optimum" planting date would vary by year, an increasing amount of data supports early planting dates for cereal rye. Of course, it can be difficult to achieve an early cover crop planting date when it coincides with the harvest of the main crop.

Working on this pinch point, researchers at the University of Illinois are experimenting with robot and drone cover crop seeding (I-FARM). The use of emerging technological advances can offer innovative solutions for on-farm operations. Robot and drone planting of cover crops offers increased flexibility because they can be deployed prior to the harvest of the main crop. The robot currently in use can autonomously navigate between corn rows seeding multiple rows with each pass. The seed tank on the robots can hold approximately 90 pounds of seed. The broadcast seeder is below the canopy which ensures more seed reaches the soil as compared to aerial seeding by drone or manned aircraft. This seeding efficiency can provide equivalent results with lower seeding rates and a cost savings to the farmer. Figure 2 provides a visual comparison of cereal rye biomass in the spring of 2023 as between robot-seeded into standing corn (September 1, 2022) and drilled after harvest (November 3, 2022).

Figure 2. Visual biomass comparison (Spring 2023). Top row robot seeded into standing corn (September 1); bottom row drilled after harvest (November 3).

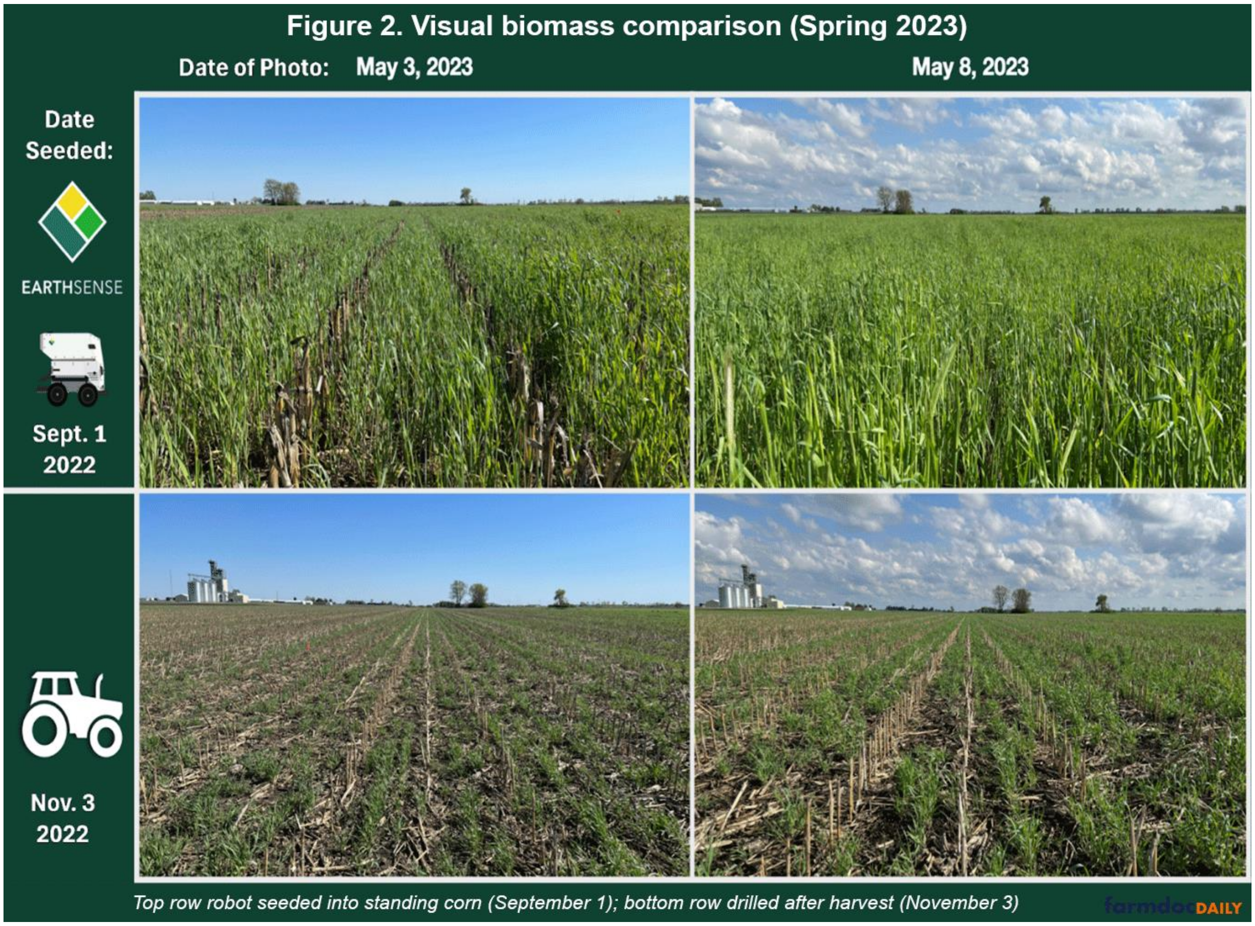


Figure 2. Visual biomass comparison (Spring 2023)

Top row robot seeded into standing corn (September 1); bottom row drilled after harvest (November 3)

For narrow rows and soybean fields, drones provide another new seeding option. Currently available, large, multi-rotor spraying/spreading drones can carry up to 110 pounds of seed per load. The number of acres per hour that can be spread will be directly related to the seed size and weight of the cover crop species being used. Cereal rye seed is large and heavy, choosing a mix or smaller seeded species will increase the drone efficiency to a potentially large extent. Drone application is ideal for small irregularly shaped fields. With drones and robots, the efficiency improves with the ability to use and deploy swarms of devices into a field at once.

This problem is not unique to Illinois, or even the Midwest, and DIRECT^{4}AG is collaborating with the Innovated Cover-crop Opportunity, Verification, and Economy stimulating technology for underserved farmers using Robotics (iCOVER) project. The project researches how autonomous robotics and other technologies could be applied to enable the adoption of cover crops in a variety of agricultural systems. To date, iCOVER includes field sites in Illinois, but also across the Midwest with representation in Indiana, Iowa, and Missouri, as well as field sites in Alabama; the latter sites represent a unique opportunity to explore the use of cover crops with a wider variety of cash crops and the engagement of smallholder farmers.

Concluding Thoughts

Advancements in agricultural technology present important opportunities to help advance conservation practices and goals for sustainable farming. The argument embedded in the DIRECT^{4}AG project is that realizing the potential in those opportunities will require collaborations in research, development, and demonstration that seek to apply technological innovations to the specific complexities and challenges of conservation. The articles in this series have reviewed the progress of the USDA-funded project as it seeks to develop an adaptable and functional hub for translational sciences applied to best practices for improving production and sustainability for farmers. As further progress is made and results are available, this series will be updated.

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