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Introducing an Update to the Cover Crop Decision Support Tool

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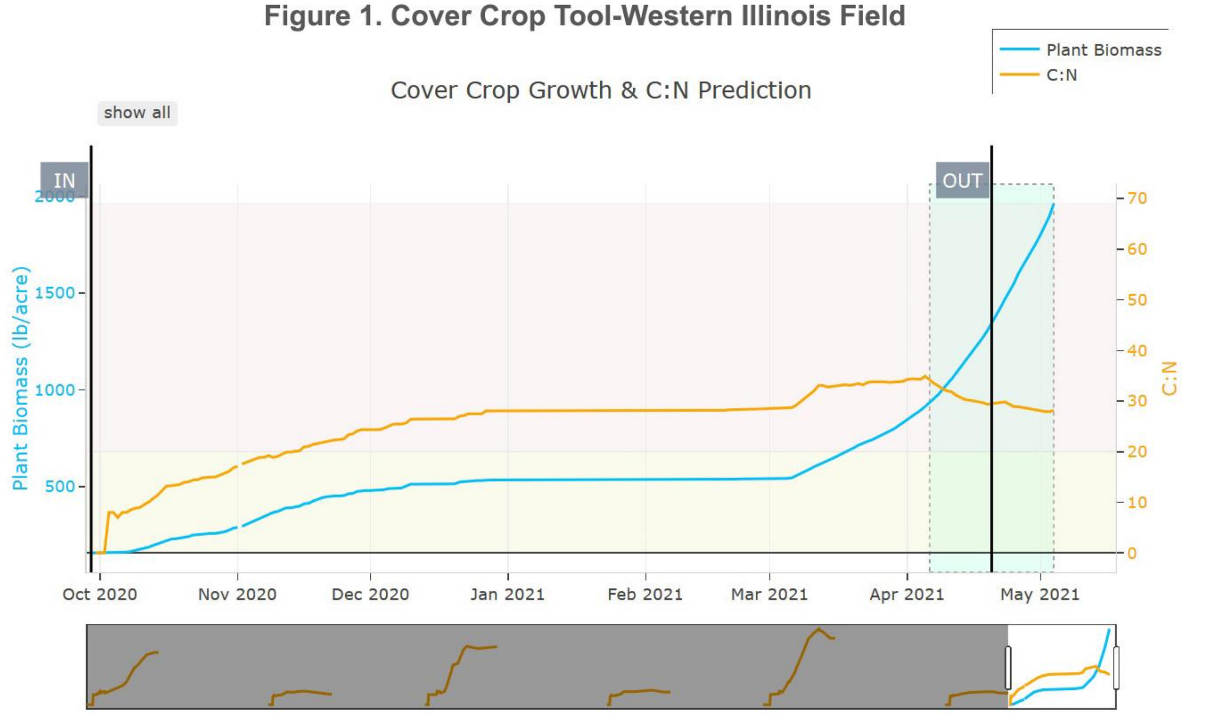
On October 1, 2020, the Gardner Agriculture Policy program and *farmdoc*, in conjunction with the National Center for Supercomputing Applications (NCSA) and researchers with Purdue University's Agronomy Department, released a first-of-its-kind, web-based decision support tool for cover crop management in Illinois fields (*farmdoc daily*, October 1, 2020). The project has been funded by the Illinois Nutrient Research & Education Council (NREC). The Walton Family Foundation provided funding to add additional functionality to the cover crop tool that simulates the decomposition of a terminated cover crop, building on research by Purdue University's Agronomy Department. Today's article discusses the recent release of this new functionality in the cover crop tool. Farmers, researchers and others interested in cover crops can access (and sign up for) the tool here: https://covercrop.ncsa.illinois.edu/.

Background

As previously discussed, widespread adoption of cover cropping practices in Illinois corn and soybean fields is a critical component of the Illinois Nutrient Loss Reduction Strategy but can add cost and risk to the farm operation (INLRS 2015; *farmdoc daily*, October 1, 2020; August 14, 2018; June 28, 2018; July 6, 2016). Winter cover crops can be an effective in-field strategy for reducing nutrient losses, while helping to improve water quality from local drinking water supplies to the Gulf of Mexico's hypoxia or dead zone (Drinkwater and Snapp, 2007; Kaspar et al., 2007; Lacey and Armstrong, 2014; Lacey and Armstrong, 2015; Malone et al., 2014; Snapp et al., 2005). The cover crop tool has been designed to help Illinois farmers with the decision to adopt cover cropping practices and contribute to their successful management of a cereal rye cover crop in their fields. It works by simulating the cereal rye growth in the actual Illinois field selected. It incorporates commercial cropping practices, soils data and weather data. The farmer receives visualized estimates for biomass, carbon-to-nitrogen ratio and nitrogen data (uptake, loss, reduction). These estimates can be factored in the farmer's adoption decision and management decisions, such as termination and planting of the cash crop. The tool offers an early effort at translating critical basic research into farmer decision making at the field level; much work remains to be completed. Figure 1 is a screenshot of a recent run of the tool for a field in western Illinois; cover crop established September 29, 2020, and expected cash crop planting date of April 20, 2021, under average weather conditions.

Figure 1. Cover Crop Tool-Western Illinois Field



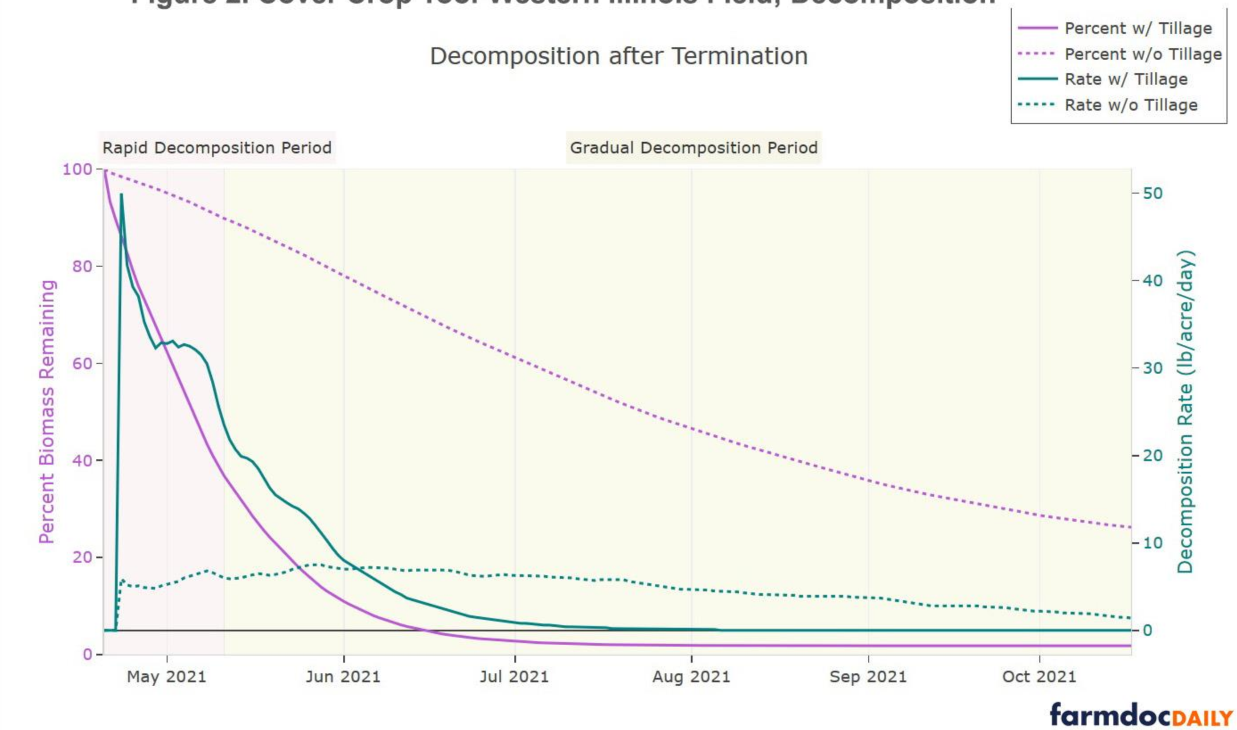
One example of advancing this important work involves research based on frequent farmer questions about the terminated cover crop; in particular, the need for better information about the terminated cover crop's impacts on the soils, nitrogen and subsequent cash crop. A team of researchers within Dr. Armstrong's Soil Ecosystem Nutrient Dynamics Lab (SEND) at Purdue's Agronomy Department have made progress on these questions (Nevins, Nakatsu and Armstrong 2018; Nevins, Lacey and Armstrong 2020). Their research on cover crop decomposition has been incorporated into the cover crop decision support tool by Illinois' NCSA, providing simulated estimates of the decomposing cover crop biomass in the field under projected weather conditions. That research and the updated version of the cover crop tool are discussed further below.

Discussion

Incorporating cover crops in the fallow period of the cash crop cycle—established around harvest of one cash crop and terminated around planting of the next cash crop—is well understood to increase soil organic carbon and reduce nitrogen losses through subsurface tile drainage (Nevins, Nakatsu and Armstrong 2018; Nevins, Lacey and Armstrong 2020). A significant concern for farmers and the source of much debate and work among researchers is the impact of a terminated cereal rye cover crop on the yields of a subsequent corn crop; a "conundrum . . . regarding the tradeoffs between ecosystem services derived from cover crops and the subsequent costs of potentially less cash crop productivity" (Nevins, Nakatsu and Armstrong 2018 (citing numerous sources)). Research using litter bag decomposition measurements was used in conjunction with soil sampling and other factors to analyze and better understand the impacts of cover crop decomposition.

Published research results for biomass decomposition were used to develop a model for decomposition that has now been incorporated into the cover crop tool. Figure 2 provides a screenshot of the decomposition outputs for the same western Illinois field. It incorporates the estimated biomass in the field (e.g. Figure 1) and the carbon-to-nitrogen ratio for that cover crop, coupled with expected weather conditions after termination to model decomposition. The tool visualizes this estimate as both the percentage of biomass remaining on the soil surface and the rate of decomposition for both tillage and without tillage (no-till) scenarios. In general, the tool provides these estimates over the rapid decomposition period during the first 21 days after termination and then the gradual decomposition after.

Figure 2. Cover Crop Tool-Western Illinois Field; Decomposition



The cover crop residue decomposition model is derived from experimental data and helps farmers to visualize the influence of in-field soil management on the dynamics and rate of residue decomposition after cover crop termination. The simulation above demonstrates the impact of spring tillage on the disappearance of residue on the soil surface and the rate or speed of residue decomposition. During the rapid decomposition period, there was a significantly lower peak in residue decomposition rate for the no-tillage system relative to the spring-tilled system, resulting in a linear decline in the mass of residue on the soil surface and 10% more residue on the surface at the harvest of the cash crop. On the other hand, the model predicts a large peak in residue decomposition rate for the spring tillage system that can be attributed to alterations in the size of the residue, increasing soil-to-residue contact due to mixing, and greater microbial activity due to oxygen influx. Thus, after termination, cover crop residue in the spring tillage system resulted in a dominant mass of surface residue disappearing from the soil surface by the month of July in an average weather scenario.

What is evident through the decomposition simulation are the implications of management and practice decisions. No-till management will result in slower decomposition and the greatest potential to increase soil organic matter. By comparison, residue disappearance is rapid in the spring tilled systems leading to the potential of more rapid nutrient and carbon release during the growing season. This rapid decomposition also results in very low potential for the increase in soil organic matter. The visualized information in the web-based tool helps a farmer to better understand these dynamics in their actual fields and under specific weather conditions. The purpose of this is to assist the farmer with the many complex decisions inherent in adopting and managing cover crops; enhanced information of the trade-offs in the adoption and management decisions for cover cropping with cereal rye.

Based on the decomposition model developed by the researchers, we updated the backend web service module of the web framework (Satheesan et al., 2019) with API calls for calculating decomposition data based on termination date, carbon to nitrogen (C:N) ratio, and biomass at termination date. This uses weather data obtained from the Illinois State Water Survey (Water and Atmospheric Resources Monitoring Program, 2021). We also added an endpoint to calculate the Cumulative Growing Degree Days (GDD) during the cover crop growth period. GDD are a measure of heat accumulation used to predict plant development rates. We used the following method to calculate GDD for any date *t*:

$GDD_t = max(GDD_{t-1}, GDD_{t-1} + T_{mean}, t)$, *where* T_{mean}, *is the mean temperature at date t and* $GDD_{t=0} = 0$.

The data obtained from these API calls were then used to generate visualizations on the web frontend. Visualizations for decomposition and growing degree days (GDD) were added to the Dashboard view of the Cover Crop Analyzer web application as shown in Figure 2. After simulating the cover crop growth in a field using DSSAT, the termination date, biomass at termination, and C:N ratio are passed to the web service to compute the decomposition and rate of decomposition graphs. In addition, users can use a slide bar on the Dashboard to adjust the termination date within a two-week window to see the effects of changing the termination date. Users can also visualize the growing degree days for the cover crop period by clicking the graph icon next to cumulative growing degree days in the Dashboard result table.

Conclusion

The decision to adopt a cover crop and incorporate it into the cash crop rotation can be a complex undertaking for a farmer. The overall cover crop decision support tool project is an effort to provide visualized information to the farmer to help with the myriad management decisions involved. The project also represents a critical experiment, in and of itself: the advancement of capabilities to harness data and technology for translating complex basic research for direct use in farm fields. The updated version of the tool demonstrates in particular how discrete functionalities can be designed from existing research, modeled and incorporated into the dashboard. Farmers and researchers are encouraged to try the tool out and to provide feedback. Future releases will build further upon this work. An additional goal of the project is to seek continuous inclusion of functionalities important to the adoption and management of cover crops.

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