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Department of Agricultural and Consumer Economics, University of Illinois Urbana-Champaign

Introducing the Cover Crop Decision Support Tool

Jonathan Coppess

Department of Agricultural and Consumer Economics
University of Illinois

Christopher Navarro, Sandeep Puthanveetil Satheesan, Vara Veera Gowtham Naraharisetty

National Center for Supercomputing Applications
University of Illinois

Rabin Bhattarai, Rishabh Gupta

Department of Agricultural and Biological Engineering
University of Illinois

Shalamar Armstrong

Department of Agronomy
Purdue University

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Today, October 1, 2020, the Gardner Agricultural Policy program, the *farmdoc* project, and the National Center for Supercomputing Applications (NCSA) are officially launching the Cover Crop Analyzer, a decision support tool designed to help Illinois farmers manage cover crops in their fields. The tool can be accessed here or through the *farmdoc* website. The project has been generously funded by the Illinois Nutrient Research & Education Council (NREC), as well as receiving seed funding from the McKnight Foundation and the University of Illinois. Additional features for the tool are currently under development and will be forthcoming thanks to funding from the Walton Family Foundation. This article reviews the tool and provides background information for users.

Background

Nitrate-nitrogen is one of the major nonpoint source pollutants in Illinois, as in other parts of the Midwest, and agriculture is one of the main sources of nitrate-nitrogen in water bodies. This nutrient loss to waterways has significant implications for water quality from local drinking water to the hypoxia in the Gulf of Mexico. The Science Assessment to the Illinois Nutrient Loss Reduction Strategy (INLRS) and

substantial research indicates that fertilizer applications on tile-drained corn and soybean fields are a major contributor to nutrient loads, with fall-applied fertilizers being the most susceptible to loss (INLRS Science Assessment, 2015; Kladivko et al., 2004; Fausey et al., 1995; Keeney and Duluca, 1993; Randall and Vetsch, 2005).

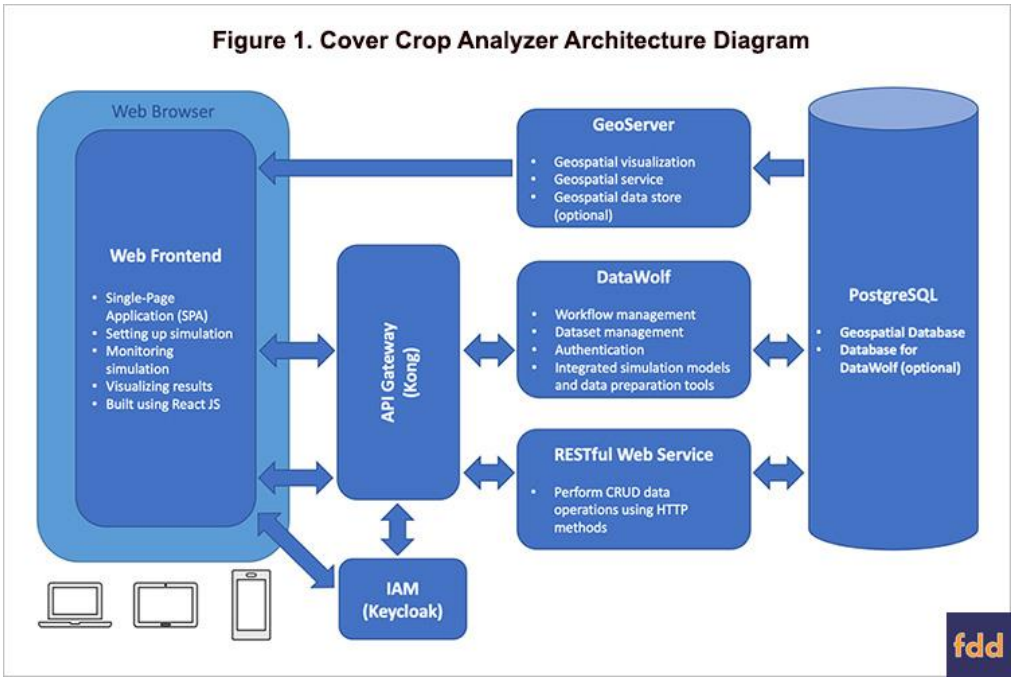
One method of reducing nutrient losses from fall application is by use of winter cover crops in place of a conventional, bare fallow method which reduces carbon and soil organic matter stocks and leaves unused additions of inorganic nitrogen more vulnerable to losses (Drinkwater and Snapp, 2007; Kaspar et al., 2007; Lacey and Armstrong, 2014; Lacey and Armstrong, 2015; Malone et al., 2014; Snapp et al., 2005). Cover crops can be an effective in-field strategy for reducing nutrient loss and helping achieve the INLRS, but farmer adoption has to-date been a significant challenge (Cover Crop Survey, 2016).

Discussion

Because a cover crop is generally established around harvest and terminated around planting, it necessarily adds risk and management complexity to the farm. Adding the practice also adds cost to the operation. For these reasons, we undertook the project to begin providing farmers (and researchers) with a web-based tool that could help with adoption and management decisions. Having learned from experience the value of online tools to farmer decision making, we sought to apply the concept to cover crops.

The basic framework for tool development is to visualize the outputs from scientific model-based simulations in a usable, understandable and easily accessible web application (Satheesan et al., 2019). The cover crop tool uses the Decision Support System for Agrotechnology Transfer (DSSAT), which is an open source modeling program for dynamic crop growth simulation for over 42 crops (Hoogenboom et al., 2019a; Hoogenboom et al., 2019b; Jones et al., 2003). Figure 1 shows the high-level architecture of the Cover Crop Analyzer that is based on a paper on the underlying framework that was presented at the Practice and Experience in Advanced Research Computing (PEARC) 2019 conference (Satheesan et al., 2019).

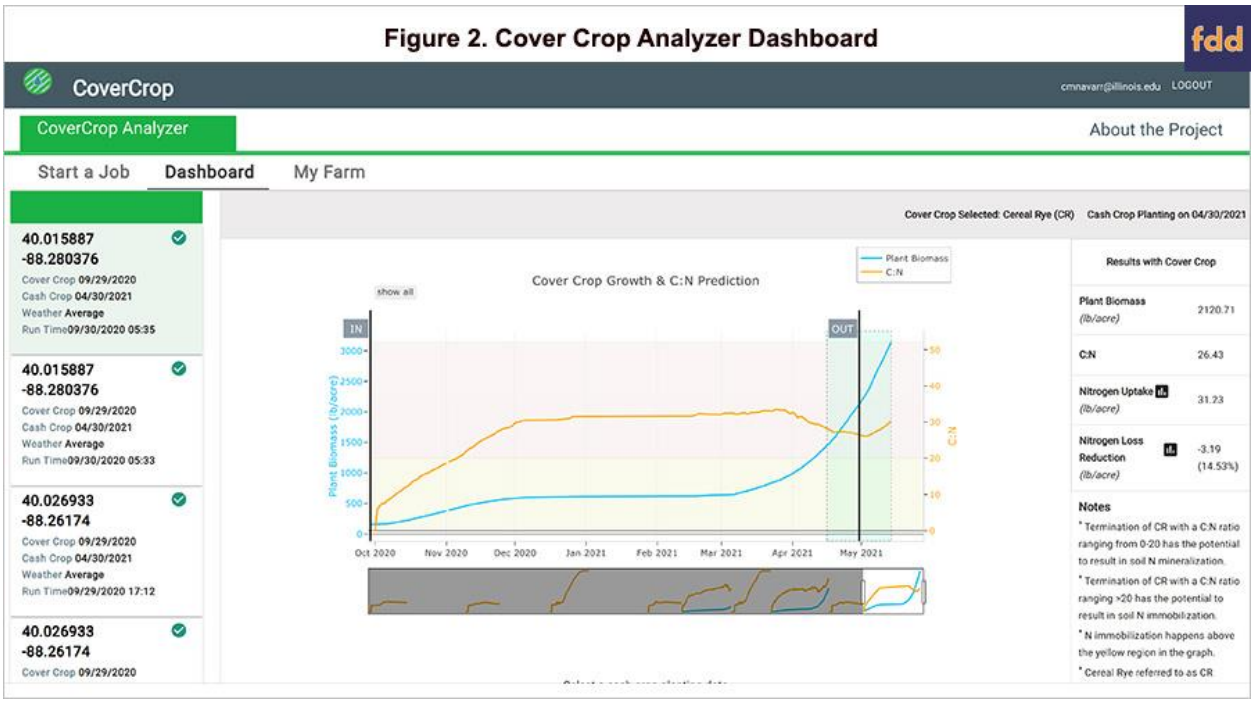
Figure 1. Cover Crop Analyzer Architecture Diagram



The tool uses publicly available weather data from the Illinois State Water Survey and soils data from USDA's SSURGO soil survey database for each field in Illinois using the Farm Service Agency Common Land Units (2008) obtained via Ag-Analytics.Org (Woodard 2016a; Woodard 2016b). The tool also uses cropping history from USDA's cropland data layer and a default set of management practices (seed population, fertilizer, etc.) developed by the project team based on historic regional data for Illinois.

The initial version of the tool will simulate cereal rye growth as a cover crop in the selected field. If previous years are selected for simulation, the tool will run actual weather data. If a future year is selected, the user has the option for a weather pattern built from historic weather. The options are the average for temperature, precipitation, etc. for the previous ten years, or options for the warmest, coldest, wettest or driest years in the previous ten years. The tool simulates cover crop growth and soil nitrogen dynamics for the field. It visualizes the outputs of the model simulation in a dashboard. The primary data visualized is the total biomass in the field for the cover crop, as well as the carbon-to-nitrogen (C:N) ratio. Combined, these two provide the farmer with a better understanding of the cover crop dynamics in the field, helping to manage termination and management (planting, fertilizer, etc.) of the cash crop. For example, total biomass in the field could impact planting, while the C:N ratio can impact decomposition and field nitrogen dynamics (Nevis et al., 2019; Ruffatti et al., 2019). The tool provides additional visualization of soil and plant nitrogen dynamics, including for total nitrogen taken up by the cover crop and estimated nitrogen loss reduction due to the cover crop. Figure 2 is a screenshot of the tool dashboard.

Figure 2. Cover Crop Analyzer Dashboard



Using the dashboard, the farmer is able to get simulated results of cereal rye growing as a cover crop in the farmer's actual field (based on CLU, SSURGO and weather). At different dates within a two-week window of expected planting for the cash crop, the farmer is able to compare potential biomass in the field, C:N ratio in that biomass, nitrogen uptake and nitrogen loss reduction. Farmers can provide more specific information for their fields, including cropping history and management programs to improve the results.

Concluding Thoughts

A project such as this depends entirely on a team effort. From the College of ACES, much of the experimental work using DSSAT was led by Dr. Rabin Bhattarai and Rishabh Gupta, including revisions to the model to simulate cereal rye as well as validation and calibration. The research software team from NCSA includes Dr. Jong Lee, Christopher Navarro, Sandeep Puthanveetil Satheesan, Vara Veera Gowtham Naraharisetty, Lisa Gatzke and Shannon Bradley and they worked on the design, development, and initial testing of the Cover Crop Analyzer web application. Dr. Shalamar Armstrong with Purdue University provided cover crop field trial data for model calibration and validation, as well as extensive knowledge, wisdom and insights on cover cropping practices and agronomic issues. Along with Dr. Armstrong, Corey Lacey has also provided valuable insights and knowledge about cover crops and the data collected from their field trials. Lowell Gentry at the University of Illinois, Oladapo Adeoye Adeyemi and Dr. Amir Sadeghpour at Southern Illinois University, along with Corey Lacey, volunteered to help test the tool before its release and provided vital feedback for the final stages of development.

Today's launch represents merely the first step, or beta version, of the tool. Project development continues with a future release adding a modeled simulation of the decomposition of the cover crop in the field during the cash crop growing season. This functionality has been funded by the Walton Family Foundation. Future releases will include improvements, along with additional functionality and features that include improving the weather data and modeling as well as additional cover crops. The project is also interested in expanding beyond Illinois. One final note of appreciation to the Illinois Nutrient Research & Education Council for funding and technical advice on this project, as well as the project team that has done such great work. The ultimate goal of this project is to prove out the potential for web-based tools for farmers and for increasing adoption of cover crops, but also as a potential example of a method for advancing the demonstration and translation of agricultural research, helping move more of it from the laboratories and field trials into the farmer's hands and fields.

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