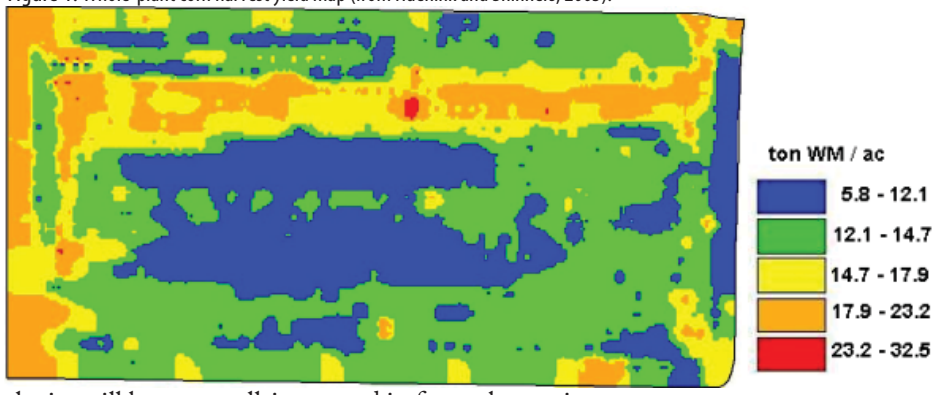
Advances in Yield Mapping Hay & Forage

Matthew Digman, U.S. Dairy Forage Research Center and Kevin Shinners, University of Wisconsin

Yield maps of forage crops will help identify problem areas, point out high and low yielding areas of fields, and provide a basis for matching lime, fertilizer, and other inputs with the yield potential of the field. A yield map is a valuable tool for establishing reasonable values for land rent or purchase. And, when combined with yield maps of the other crops in the cropping system, they can provide a reliable picture of the yield stability of the field. Yield stability is a key piece of information in building variable rate seeding maps.

In recent years, mass flow and moisture sensors allowing on-the-go mapping of hay and forage yields have been developed. Work has been done on windrowers, forage harvesters, and large square and round balers. Commercial implementation has generally been limited to the forage harvester and square baler. Widespread adoption has been slowed by the high cost, uncertainty of the payback period, and difficulty in accurately estimating hay and forage moisture which is needed to accurately determine dry matter (DM) yield. As sensor costs decrease and input costs increase, precision agriculture technologies will become well-integrated in forage harvesting systems.

Figure 1. Whole-plant corn harvest yield map (from Huenink and Shinners, 2003).



Yield Monitors and Mass Flow Sensors

Figure 2. Linear (right) and angle (left) sensor for measuring feed roll movement (Digman and Shinners, 2013).

Kevin Shinners has been working on forage mass flow sensors for more than a decade. Yields have been measured indirectly at the time of cutting by measuring conditioning roll force, roll displacement, and crop impact force on the swath-forming shields. Impact force was the most successful method applied on the windrower. These technologies have yet to be put into commercial production but they show promise, particularly the windrower because it covers such a large area of the field and can thereby produce a higher resolution yield map. Current commercial forage harvesters use a combination of feed roll displacement and speed (Figure 2).

Earlier work by Shinners measuring forage yield with a large square baler estimated mass flow by plunger force pulse width, bale displacement, bale velocity through the bale chamber, and bale weight on the bale chute. Individual bales were weighed directly with a "tipping" bale chute. This mechanism separates and weighs each bale as it passes over the center of a pivot. Although accurate bale weights are now possible, the computer software and hardware needed for commercial implementation are still in development.

Measuring Forage Moisture

Accurately measuring forage moisture at harvest, on-the-go, has been a real challenge for the machinery industry. An accurate measure of crop moisture is a key component of a reliable yield map. The three types of moisture sensors used on current machines include capacitance, near infra-red reflectance (NIR), and microwave. Each technology has strengths and limitations.

Capacitance sensors are generally lower cost but are calibrated at specific forage densities. Accuracy can suffer if the forage density is not close to that used in calibration. Near infra-red reflectance (NIR) technology has been used in forage testing labs for many years. Work by an industry and university consortium, including Kevin Shinners, has brought NIR technology from the lab to the forage harvester. NIR technology is quite accurate and recent developments allow real-time measurement of common forage components. The downside to NIR technology is the cost; it is more expensive than the other technologies. Microwave technologies show promise for forage harvest applications and have similar accuracy and costs to NIR. An advantage is greater penetration depth which allows more accurate measurement throughout the bale, however, it does not currently allow measurement of forage components as does NIR.

Forage yield maps along with all the benefits they provide are in our future. Better information about forage crop yield and quality will lead to better management decisions and, ultimately, better business decisions that will improve farm profitability and protect the environment.