Precision Agriculture Technology for Forages

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The concept of Precision Agriculture (PA) or Site Specific Crop Management (SSCM) has been in development for nearly 20 years. Historically, operations have been conducted on an "entire field" basis, or in some cases an "entire farm." With advancements in Global Positioning System (GPS), Geographical Information Systems (GIS), Variable-Rate Technology (VRT), and sensors, farmers can assess spatial variability within the cropping system and vary input rates to maximize profit.

GPS technology has been available for civilian use since 1996. This system consists of a group of 24 satellites that orbit the earth twice per day. These satellites are placed in such a way that, at minimum, four satellites can be seen from anywhere on the globe at one time. The GPS satellites have extremely accurate (and expensive) atomic clocks on board. Each satellite broadcasts a signal which includes the time it left the satellite to be collected by the GPS receivers on the earth's surface. The amount of time taken for the signal to travel to the receiver gives a distance between the receiver and the satellite. Errors are introduced into the GPS signal due to atmospheric conditions, proximity of buildings (signal bouncing), the proximity of the satellites to one-another (farther apart is better), and clock errors. These errors can be removed by differential correction where a second stationary GPS receiver is placed in a nearby location with known coordinates. A correction signal is broadcast from the stationary GPS receiver to the 'roaming' receiver. Having the correction GPS receiver close to the 'roaming' GPS receiver increases the accuracy of the location coordinates. An accurate method of geo-locating (i.e., knowing exactly where something was done on the earth's surface) field measurements is important to defining and ultimately managing field variability.

With the latitude and longitude (X, Y) being provided by the GPS receiver, the next step in SSCM is taking a measurement at these coordinates to obtain a Z value. There are a broad range of sensors available to generate these Z values that apply to forage crops including yield, soil properties, and plant health sensors. Most forage harvesters have a yield sensor which measures feedroll displacement. This measurement correlates the gap created by material passing under the feedroll at the throat of the machine to total mass of the crop passing through the machine. Measuring the yield of a crop provides a response "Z" variable for assessing variability due to inputs or soil parameters.

Another useful sensor for forages is a reflectance based sensor, available in active and passive varieties, to identify plant health. Active reflectance sensors direct a light at the plant, which is usually at a near infrared wavelength (NIR) and not visible to the human eye. A sensor measures light reflected off the plant. Passive reflectance sensors measure plant reflectance and rely solely on sunlight as the source. These sensors utilize vegetative indices, such as Normalized Difference Vegetative Index (NDVI), to correlate light reflected off a plant to plant health and growth vigor.

Soil property measurements are a vital part of SSCM. Inherent variability of soil types, water holding capacities, and fertility within fields lends well to SSCM. The first soil measurement to include in a SSCM scheme is geo-locating soil fertility by sampling the field on a grid. This can identify areas within the field that need more nutrients added and other areas that might not benefit from any additional fertilizers. Soil electrical conductivity can also be measured. These measurements can identify topsoil depth, pH, salt concentrations, and water holding capacity within the field. Finally, soil moisture sensors can be placed in the field during the growing cycle to manage water applications and optimize water usage.

Once we have our Z variables measured, a GIS software package is used to visually represent these values for the identification of any trends within the field. GIS software utilizes the X and Y locations of the measurements to project the location on a flat surface (i.e., a map). The Z values measured are usually represented by a color range. Interpolation methods are used to predict unknown values that lie between points that were measured. High and low performance areas within the field can then be identified using the yield data and comparisons can be made to soil property data to identify the cause of the low performing areas.

Once the variability within the field has been defined, VRT can be used to optimize inputs to the field. A prescription map is generated from the GIS software based on the Z variables measured. A lot of research is being conducted currently to identify the best Z variables for prescription map generation. These prescription maps are then loaded into a field computer on the applicator. Spreader trucks vary the material gate opening size and feed belt speed to vary the rate of dry nutrient application. Sprayers either utilize direct injection or varying on/off times of solenoid valves to vary the application rate of liquid fertilizers. An additional benefit of having these control mechanisms on application machines allows for the fertilizer stream to be stopped when traveling into an area that has already been covered. This reduces overlap which in turn reduces input costs. "As applied" maps can also be generated by these machines for comparison to yield maps in the future.

Significant changes to crop management practices have occurred in the past several years due to the implementation of GPS, GIS, VRT, sensing technologies and SSCM. Rather than whole field management, producers can now assess variability and manage at a much smaller unit of area. Future advancements could provide a means of not only managing field variability but also management of plant growth variability throughout the growing season. It is an exciting time for agriculture!