Variable Rate Nutrition through Field Insite™
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Introduction

Remote sensing is the act of detection and/or identification of an object, series of objects, or landscape without having the sensor in direct contact with the object (Elachi, 1987). The most common forms include color and color infrared aerial photography, multi-band satellite imaging, radar sensing, or ground-based detectors. Remote sensing has been used to varying degrees since the 1950’s, when aerial images were used to detect diseases in wheat. More recent examples in the literature show potential for sensing a number of characteristics of interest to agronomists and producers, including crop biophysical characteristics (Mass, 1988; Clevers, 1997; Vaesen et al., 2001), soil properties (Huete et al. 1985; Bruce et al. 1999), land cover (Markham and Townshend, 1981; Lillesand and Kiefer, 1994; Jensen, 2000), and crop husbandry practices (Biard and Baret, 1997; Colpitts, 1998; Bannari et al., 2000; Daughtry, 2001; Gowda et al., 2001). However, there have been various limitations associated with adoption of remote sensing and variable rate fertilizer application, including cost, equipment capability, agronomic considerations, and grower and/or agronomist skill set requirements. In July of 2005, The Mosaic Company launched a commercial agronomic software tool called Field Insite™. Field Insite™ is a web-based geographic information system (GIS) tool that provides functionality for mapping, record keeping, satellite-derived crop management zones and yield potential maps, and generation of variable rate prescription maps. The default variable rate prescription tool utilizes crop demand for nutrients and soil nutrient supply capability to generate a variable rate fertilizer prescription that can be downloaded directly to a variable rate controller for application. The tool also allows the user to utilize numerous layers of information to refine recommendations beyond the default model provided.

Background

The Field Insite™ tool began as a joint project with Cargill Inc., NASA, the USDA, and Geosys in the early 1990’s to examine the potential for remote sensed information to be used for merchandising intelligence. More specifically, crop acreage and crop yield potential over large areas were of interest. As a result of this project, the technology and algorithms were successfully established to accurately estimate yield and crop acreages. However, the technology was cost-prohibitive relative to the benefits gained. It was deemed that by adding personnel to various geographies around the world, estimates of yield and crop acreage could be accurately garnered without the expense of repeated collection of images many images. However, the project attracted interest from Cargill Crop Nutrition. Although they weren’t interested in using remote sensing technology to look at large areas, they felt that the knowledge of the yield potential of a single pixel representing a 15m x 15m was of interest agronomically. They felt that if the yield potential of a specific area of the crop was known, that specific area could be managed independently of the rest of the field, and that agronomic and production gains could be realized as a result. When layered with other agronomic information, yield potential maps have significantly more agronomic value than a yield map alone. There was similar thinking in the literature as well. For example, Blackmer and White (1998) stated “Information generated by remote sensing, soil testing, and plant analysis greatly increases the value of the yield measurements. As methodology for its use becomes more established, GIS should provide unprecedented capacity to analyze all of this information in systematic searches for trends across sites to establish a defensible basis for recommendations to improve N management during corn production.”

Again, remote sensing of crop biophysical characteristics alone could not account for all of the variability of crop yield and nutrient management. Instead, remote sensing needs to be combined with other agronomic diagnostic and interpretive tools in order to best make nutrient recommendations for maximum
economic and sustainable crop production. Therefore, Cargill Crop Nutrition developed a software tool that incorporates remote sensed yield potential and agronomic interpretation of soil nutrient supply, nutrient availability and crop nutrient demand to develop a variable rate nutrient prescription. This prescription can be loaded into modern application controllers and applied using GPS positioning and variable rate applicator technology.

Tools

Field Insite™ is a web-based GIS tool that utilizes geographical information combined with agronomic assumptions and measurements to create information for knowledge-based decisions. As such, there are a number of tools available to the user for a single field.

Mapping and Recordkeeping

In order for the software to utilize various geographic layers, field boundaries must be established. This can be done by developing a geo-referenced polygon by driving around the perimeter of the field with a GPS unit and a data-capturing tool to capture the information. This information can then be uploaded into the software for use by the program. Another, more simple alternative is to draw the field boundary right in the software itself. High-resolution (1-2 m) background images are provided as a layer to aid the user in navigating to and tracing field boundaries. The user can simply navigate to a specific area using legal location, postal code, or municipal district and trace around the area to be identified. Once the boundary is established, various types of information can be associated with the field boundary. For examples, characteristics such as field name and related information, soil information, and husbandry information such as planting, pesticide applications, harvest, and soil sample information can all be captured within the software.

Satellite Derived Management Zones

The satellite derived management zones tool (SaMZ) utilizes numerous remotely sensed images (6-15) captured in the peak of crop biomass over a number of years and crops. All of these images are combined and analyzed to develop a geo-referenced map of two to ten management zones within the field. Each of these zones corresponds to an area in the field that responds similarly from year to year within the zone, but is distinctly different from the other zones derived within the field. Because these measurement span a number of years, differences due to crop types, weather patterns, and crop husbandry are averaged into the map, and the result is a map of crop differences that is not related to a specific environmental condition. Because the map is derived from a number of years and crops, specific yield estimation is not provided. However, yield goals, sampling strategies, and variable rate fertilization prescriptions can be based upon the zones derived by the SaMZ tool.

Yield Potential Maps

Conversely to SaMZ, the satellite derived yield potential map (YPM) develops a model of yield potential for a single image captured at the peak of biomass. The YPM estimates the yield potential of each pixel on the image independently, such that a yield map similar in appearance to a harvester yield map is developed. Actual yields are calculated and displayed. This tool allows historical images to be analyzed, so yield data collection from numerous years is facilitated without having to use a harvester mounted yield monitor. This information can then be used to establish yield goals based on specific environmental conditions, sampling strategies, and variable rate fertilization strategies.

Organic Matter Mapping

Utilizing images of bare soil surfaces captured remotely, the Field Insite™ tool develops a map of the soil organic matter contents for each pixel in the field. Soil wetness models and soil color are used for this estimation. Soil organic matter maps can then be used to direct sampling strategies and to estimate variability in soil supply of nutrients from mineralization.
Variable Rate Nutrients

The variable rate nutrients (VRN) tool allows the user to utilize various layers of information to develop a variable rate prescription for plant nutrients that can be downloaded in the appropriate format to a variable rate controller for field application. The default tool estimates crop demand for nutrients (based on SaMZ or YPM yield goals, crop type, and crop nutrient usage) for each pixel on the field image. The soil supply is then estimated. Soil supply is calculated from organic matter maps, nutrient mineralization estimates from organic matter, soil residual nutrient (from soil sampling), and other sources of nutrients (irrigation water, top dress applications, starter fertilizers, etc) for each pixel on the field image. The difference between crop demand and soil supply is then calculated for each pixel, and the difference is made up with fertilizer. Essentially, a nutrient balance is calculated for each pixel in the field, the amount of fertilizer needed to meet crop demand is calculated, and a variable rate prescription map is developed. The economics of the variable rate prescription map is calculated and can be compared to the grower’s flat rate alternative for planning. All planning can occur with zero cost to the grower. There is no charge to the grower until a prescription map is downloaded. Therefore, accurate nutrient application planning scenarios can be evaluated before there is any cost to the grower.
References


