The Management Time Economics of On-the-go Sensing for Nitrogen Application

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Introduction

The possibility of real-time sensing to drive crop input application has been frequently discussed since the earliest days of computer controlled precision agriculture in the 1980s, but most commercial precision agriculture has been map based. That is to say that input applications have been determined with the help of soil tests, yields, and other spatial information. That may be changing. Several real-time sensor systems for nitrogen management are being marketed. This article examines how management time requirements affect the economics of real-time sensing.

One of the key constraints to precision agriculture in general and map based variable rate application in particular is the management time required. To interpret yield monitor data or to develop a recommendation map requires a skill and an attention to detail. Most commercial farmers did not enter that line of work to sit behind a computer; they became farmers because they wanted an outdoor, active life. The relatively slow adoption pattern of precision agriculture suggests that motivating farmers to spend time analyzing data requires higher levels of profits than most map based systems provide.

For U.S. ag retailers hiring skilled agronomists to analyze data and develop recommendation maps has been a continuing challenge. People with the required set of skills are rare and often have job opportunities that are better compensated or have better working conditions than a fertilizer dealership position. Until there is a critical mass of precision agriculture adoption, there is little incentive for people to develop the specialized skills needed.

Use of real-time sensing to drive variable rate application reduces the management time constraint to site-specific management. In effect, management becomes automated. Decisions that must be made by a human in map based systems are embodied in software rules that use the sensor data to control input application. If the algorithms driving the controller are not well understood by the user this is referred to as a “black box” approach.

This article examines the management time economics of real-time sensing, assuming that yield benefits and input savings at least cover the cost of operating the sensor and variable rate equipment. Each commercially available real-time sensor system makes its own claims about yield increases, input savings and costs of operation. The claims of some of the systems are supported by publicly available research. A comprehensive review of those claims would be a worthwhile effort, but to the best of my knowledge no one has yet undertaken such a review.

The focus of this article is on sensors mounted on application equipment. There are also several companies marketing handheld crop sensing units. Using such units a grower or crop consultant could take measurements at various sites in a field to come up with an application plan. This may be a good way to develop an application map, but it does not deal with the management time problem.

Soil Doctor®

The first commercial real-time soil sensor system was the Soil Doctor® (http://www.soildoctor.com/). It has been marketed since the mid1980s by Crop Technology Inc. Originally, it was used without global positioning systems (GPS), but in the 1990s the sensor and application technology were linked to GPS to provide maps of the sensor readings which would be used for other management decisions and as-applied maps of the input application. The company has been very zealous about protecting its patent rights and proprietary technology, so there has been little public scrutiny of the approach and results. Little public information about the algorithms used in the system is available.

The Soil Doctor® website reports on-farm test corn yield increases ranging from 3 to 11 bushels/acre, and reduction in nitrogen application from 10 lbs/acre to 78 lbs./acre. The gross value of yield increases and nitrogen rate reductions varies from $16/acre to $40/acre.

The net benefit of the Soil Doctor® approach to nitrogen management would depend on the acreage covered, the useful life of the equipment and other factors, but back of the envelop calculations suggest that the reported yields increases and input savings would probably cover the cost of equipment ownership. The purchase price of the equipment for an eight row applicator is around $12,000.

No public data is available on Soil Doctor® adoption, but the dot map on the website showing users suggests that adoption patterns have been similar to other precision agriculture technology. In spite of the potential profitability why has the Soil Doctor® not become standard practice?

One hypothesis is that while the Soil Doctor® solves one management time problem by using real-time sensing to determine application rates, it creates another management time problem by its zeal in protecting proprietary secrets. Because of CTI's litigious strategy few third party evaluations of the Soil Doctor® technology have been done. Very few university or other public sector researchers have tested the Soil Doctor®.

Another potential reason why adoption of the Soil Doctor® has been relatively slow is that this is a classic black box design. The algorithms used by the Soil Doctor® are proprietary. They have not been published. Even researchers studying this type of technology do not know the details. Trusting input application to a black box makes many growers nervous.

Farmers are largely on their own when they are trying to make a decision about this technology. They can look at the farmer testimonials on the Soil Doctor® website and farm Internet chat groups, but they must pull together this information themselves. They must decide which reports are credible and which should be taken with a grain of salt. They must usually test the technology on their own farm. Some farmers like doing this kind of research, but many would prefer to shorten the process by having third party information to start from.

N-Sensor

The Hydro N-Sensor was developed in Germany in the mid 1990s and first marketed in 1999. It is now marketed by the Norsk Hydro spin-off company Yara (http://www.sensoroffice.com/). The N-Sensor measures light reflected from the crop and software converts that to an application rate. The sensor is usually mounted on the tractor cab and adjusts nitrogen relative to some reference rate set by the operator.

Industry sources suggest that there are about 300 N-sensor units in use worldwide, mainly in northern Europe. The main markets are in Germany, Sweden, United Kingdom, Denmark and the Czech Republic. It is used mainly for wheat and other small grains. Some studies indicate a 3% to 13% yield increase and a14% reduction in overall nitrogen application. Some studies of the economics of the N-Sensor are available at http://www.agricon.de/de/index.htm (website all in German).

Because of perceived environmental benefits, the N-Sensor has been subsidized by some European governments. Regulatory limits on nitrogen application motivate growers to make the most of the nitrogen that they are allowed to use.

One of the criticisms of the N-sensor is that it uses only ambient light. It works best from midmorning to midafternoon on sunny days. Algorithms have been developed to compensate for low light cloudy conditions and early morning and late afternoon sun angles, but it cannot be used at night. Daytime operation may be adequate for the relatively small acreages in northern Europe, but it is a severe limitation for the larger scale farms in the Americas and Australia.

In terms of management time, the N-Sensor has automated the nitrogen application decision process. It is not necessary to consult an agronomist or carryout a separate step to develop an application recommendation map. Also the N-Sensor has been open to third party evaluation. It has been widely tested by public sector organizations in northern Europe, so growers and agribusinesses have information on which to base their decisions.

A criticism of the N-sensor voiced at the 4th European Precision Agriculture Conference in Berlin in 2003 was that the sensor did not take into account yield potential. Light reflected from a crop growing in a high yield area may show adequate nitrogen at the time of application, but the crop may run out of nitrogen before it is mature. In a lower yield area, reflected light at application might suggest a need for more N and over apply relative to the limited yield potential.

Incorporating a yield potential map into the N-Sensor algorithm may substantially increase its usefulness and only modestly increase the management time requirement. For those growers with yield monitor data a yield potential map could be created by cluster analysis of several years of yield maps. For those without yield monitors, yield potential maps might be estimated from satellite or aerial images images, soil maps or other data. For growers reluctant to invest the time and skill development efforts to create yield potential maps, this task could be outsourced by growers to crop consultants.

Greenseeker

The Green Seeker™ technology was developed about the same time as that of the N-Sensor, but it has only recently been commercialized. The technology was developed at Oklahoma State University in the mid 1990s. It was licensed to NTech, Ukiah, California, in 2001 (http://www.ntechindustries.com/). It uses an active light source to measure the ratio of red to near infrared light (NDVI) to determine nitrogen rates by comparing it to a nitrogen rich strip within the field.

GreenSeeker was originally marketed in winter wheat growing areas of the U.S. Great Plains. Data presented by Oklahoma State University researchers indicate a benefit of $16/acre to $38/acre when used in top dressing wheat.

According to Barry Pace, NTech, Des Moines, Iowa, a corn algorithm will be tested in the Corn Belt this year. Pace said that there are handheld GreenSeeker units are already being sold overseas. They are in use in Europe, Asia, Australia, and Latin America. He expects boom mounted Greenseeker units to be sold to users in Canada and Brazil this year.

"The active light source is a major advantage of the GreenSeeker," Pace said, "Because it provides its own light, the GreenSeeker can be used under low light conditions, including nighttime, in dust, and under heavy clouds."

In terms of management time, the GreenSeeker is similar to N-Sensor. It eliminates the need for a separate step to create recommendation maps. Because it was originally developed by a public university, the technology and initial testing are well documented. NTech has been open to third party involvement in testing the commercial version.

Conclusions:

Real-time sensors for site-specific input application seem to be claiming a market share. At least three companies are marketing systems for nitrogen application. From an economic point of view one of the key advantages of these systems is that they eliminate the need for a separate step to create recommendation maps and the management time that this step requires.

Constraints to widespread adoption of real-time sensors include:

- The systems based on reflectance (i.e. N-Sensor, GreenSeeker) must be used in growing crops. Many input application decisions, especially in Corn Belt cropping systems, must be made before the crop is planted. For example, in the Corn Belt relatively little nitrogen is applied in standing corn because of logistical problems, uncertainty about weather, soil compaction concerns, and crop damage caused by equipment operations. In theory at least the Soil Doctor® could be used preplant, but the marketing effort has been focused on the sidedress operation. There is a need for real-time sensors that work preplant.
- Skepticism that sensors can determine all the information needed to determine input rates. In many cases, yield potential, soil information and other data may be essential in setting the optimal rates. The three commercially available sensors discussed in this article use only sensor readings to determine rates.
- What should be the reference point for setting N rates? The N-Sensor requires the user to set a reference rate; this is often the rate from whole field recommendations or the average rate applied in recent years. The GreenSeeker uses a nitrogen rich strip within the field. Having such a nitrogen rich strip requires some advance planning and related management time.
- Need for round the clock operation – this is a key limitation for ambient light sensors, like the N-Sensor developed by Norsk Hydro. If an active light source

such as the one used by the Greenseeker could be integrated with the N-Sensor system, this could be alleviated.

- Third party evaluation has been limited by company policies and the shortage of public sector research funds. Company openness to testing and funding for third party testing will be essential in building confidence in this technology.

More Information:

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