DEVELOPMENT OF INSITE VRN® AS AN EFFECTIVE NUTRIENT MANAGEMENT TOOL

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Abstract

Growers have significantly increased their yield levels in corn and wheat in the last 10 years. As yields increase, the amount of nutrients required has also increased to supply the crop with needed plant nutrition. Fertilizer application rates in excess of plant needs can increase the likelihood that the fertilizer may end up in ground water and streams. Mosaic developed a nutrient application tool, called InSite VRN, which more accurately positions the fertilizer where it is needed for maximum benefit and minimal environmental consequences. InSite VRN was developed to consider both the plant needs and the soil contribution. The program uses a "check book" approach toward making nutrient recommendations that can address variability in soils and management across states, fields, and within fields. Manure applications and appropriate nutrient credits are taken into account in writing the prescription. Nitrogen response curves were calculated from 4,000 sample sites over an eight-year period to validate that the site-specific applications achieved similar responses as determined by many years of university research. Within field variability is incorporated into existing university recommendations. A specific study in northwest Iowa showed a 24.8% reduction in nitrogen use while achieving a 3.1 bushel/acre increase in corn yield. Added revenue in this study was $17.02/acre. InSite VRN uses state of the art technologies and is adaptable to regional and updated university recommendations.

Introduction

Yield levels continue to climb for corn and wheat. Ten years ago a corn yield of 180-200 bushels was elusive. Today, 200-bushel corn is very common. The increased use of combine yield monitors has proven to growers that yields vary considerably across the field and yield levels approaching 300 bushels are possible in the highest performing areas. Higher nutrient availability will be required to achieve and maintain these increased yields. The additional nutrient will come from the soil as well as fertilizer and manure applications. An accurate estimate of organic matter mineralization will be the basis for achieving the appropriate supplemental nutrient applications. However, from an environmental standpoint, over application of nutrients can lead to excessive nitrogen leaching into ground water and streams.

Cargill Crop Nutrition (now Mosaic) began an investigation in 1992 to develop a site-specific tool that maintains or increases grower yields and profitability. At the same time, the goal was to address environmental concerns in a site-specific manner. The initial focus was on nitrogen application as other variable rate programs were commercially available for phosphorus and potassium. The final product needed to provide the flexibility to handle all nutrients and be able to be modified as new information became available. There were several goals for the project.

Goals of the project included:

1. Provide a site-specific approach in making nitrogen recommendations (environmental)
2. Maintain or improve grower yield levels (profitability)
3. Tool must be cost effective and self sustaining
4. Integrate new technology to incorporate both soil and plant factors simultaneously
5. Program must be flexible and adaptable
    a. Not dependent on combine yield monitor data or intense soil sampling, but be able to use either, or both, if available
    b. Minimal implementation investment needed at dealer or grower level
    c. Application of all forms of nutrients (N, P, K, blends)
    d. Adaptable to regional and updated university recommendations
6. Growers must be able to evaluate economics of individual fields prior to incurring costs
7. Improve grain or forage quality if possible

Experimental Procedure

Research fields were evaluated at five locations (western Nebraska, northwest Iowa, Southern Minnesota, northwest Indiana, and southern Ontario) from 1993 to 2000. Combine yield monitor maps were used to define five yield zones in each of the five locations. Five levels of nitrogen were evaluated in each yield zone. The nitrogen levels were replicated four times in each field. A total of 100 test sites were collected from each location each year for a total of 4,000 test sites.

Data collected from each sample site included:

1. Standard soil test measurements (N, P, K, OM, pH)
2. Leaf tissue samples readings at the 4-6 leaf stage
3. SPAD readings (1993-1994)
4. Grain sample quality measurements
5. Residual soil sample nitrogen readings
6. Grain yield from combine yield monitor
7. Soil compaction readings (1999-2000)
8. Bare soil and biomass satellite image data

Nitrogen response curves were generated at each of the sample sites (see figure 1). A patented, proprietary process was developed that integrates satellite image data into the recommendation and incorporates standard nutrient credits for previous crop, from organic matter mineralization, from manure application, from nitrates in irrigation water, and from other forms of fertilizer applied.

It was concluded from the data analysis following the 1993 and 1994 research that the initial hypothesis of being able to consistently raise the yield levels of the lower producing areas of the field was incorrect. The lower yielding areas of the field did not predictably respond to additional fertilizer applications. These areas were often low yielding as a result of poor drainage, inherently poor soil characteristics or other factors beyond the control of the grower. Analysis also suggested that the areas identified as higher yielding had a greater, and more consistent, response to higher nitrogen application rates.

Research from 1995 onward focused on reduction of nutrient application levels in the lower yielding areas that did not respond, and increase nutrient application in the higher yielding areas that responded favorably to increased inputs. Currently accepted university algorithms for crop removal rates were validated using InSite VRN over the next five years to ensure that the program supplied the appropriate amount of fertilizer to achieve a positive response. The InSite VRN program was commercialized in 2001 with applied acres increasing at a two- or three-fold rate since its release. Numerous enhancements have been made to the system since its initial release.

Commercial program – InSite VRN®

The program uses a "check book" approach toward making nutrient recommendations that can address variability in soils and management across states, fields, and within fields. It uses two historical satellite images with 30-meter resolution resampled to achieve a 5-meter resolution. One-meter resolution was evaluated but not adopted as the added cost did not provide significant economic benefit to the growers.

The first image is a bare soil image that measures soil brightness. Our research showed a very good correlation between soil brightness and soil organic matter (figure 2). The grower/soil test results provide the average organic matter level for the field. Organic matter level is distributed across the field based on soil brightness. Appropriate university defined mineralization calculations are used to allocate credits for nitrogen and phosphorus.

The second image is a multi-band image measures biomass (LAI) for the corn, wheat, barley or rice crop. The high correlation between biomass and grain yield for these crops allows the program to distribute yield across the field (figure 3). The grower supplies the 5-year crop average or his yield goal to complete the debit side of the checkbook.

The algorithm calculates the amount of fertilizer needed to achieve the desired yield goals and subtracts the appropriate credits. The program is designed to follow university recommendations for the area. The agronomy behind the recommendation is not changed, only the delivery of the recommendation.

InSite VRN Process

The process begins by defining the field boundaries. Accurate field boundaries are necessary prior to writing the prescription and completing the application, but are not necessary to evaluate the economic feasibility of the individual field. Economic feasibility studies for a field can be completed with hand drawn field boundaries, so no cost is incurred by the dealer or grower prior to the selection of fields for variable rate application.

A yield potential map is generated that displays yield distribution across the field based on biomass and yield goal defined by the grower. An organic matter distribution map is also available and has applications for variable rate herbicide application and variable rate seeding.

The nitrogen recommendation model is customized to individual dealerships, growers, and fields. Product to be used is selected with grower price per ton. Default levels are established for each region but can be changed on an individual basis. These default levels include: pounds of N per unit of yield goal, pounds of N released per percent of organic matter, average soil nitrate level, previous crop nitrogen credit. Planned starter, side dress and phosphate fertilizer nitrogen applications are specified. A minimum nitrogen application rate can be defined if grower is not comfortable going below a minimum or if application equipment does not have a bi-pass to allow for low application levels.

Phosphorus and potassium applications are derived using recommended university crop removal formulas and incorporating additional information that is available. Results from composite or zone sampling can be used or grid sample results can be incorporated into the program. Phosphorus and potassium credits are taken from manure and/or starter applications.

The program provides a summary of number of pounds of product applied and cost of the fertilizer in a flat rate application compared to the variable rate application (figure 4).

Benefits to Variable Rate Application

A two-year grower study was conducted in northwest Iowa to measure the effects of using variable rate application of nitrogen versus the standard flat rate in corn. Forty-three fields totaling 4,276 acres in five counties were evaluated. Total nitrogen applied was 212,167 less than the standard fertilizer application. This represents an average reduction of 49.6 lbs N/acre or 24.8%. Yield levels were increased an average of 3.1 bu/acre for the two-year study. Average fertilizer savings was $9.57/acre and the average revenue gain from increased grain yields was $7.45/acre. The overall increased revenue was $17.02/acre using VRN.

Comparisons between VRN yield potential maps and combine yield monitor maps were made to determine the frequency in which the VRN prescription applied the correct rate for the ultimate yield generated in the field. The correct rate was defined as plus or minus one half standard deviation. VRN applied the "correct" amount of fertilizer based on final yield 68-82% of the time. Standard flat rate applications were "correct" 15-33% of the time.

Vulnerability of the InSite VRN system

InSite VRN is not a silver bullet. It is only a tool that should be used as part of a total nutrient plan. It provides more accurate placement of nutrients where to reduce over fertilization and possible pollution in lower producing areas and to minimize under fertilization in higher yielding areas. It is very flexible and can be adapted as more knowledge is gained with soil and organic matter contributions, varietal responses, and environmental influences. Growers can evaluate the economics prior to investment.

Concerns have been raised regarding the use of VRN as a management tool. Some of these include:

1. Biomass image does not accurately measure yield potential. Much work has been done to validate the use of the biomass image. The correlation between LAI and yield is very

strong in selected crops, such as corn, wheat, barley, and rice. VRN does not currently work for soybeans or forages.

2. Use of satellite image is not the best source of a biomass image. Historic satellite images provide several benefits. Timing is not critical and planning can be done in the off-season to spread the workload. Unusually wet or dry years can be omitted from the image database. Yield monitor maps are not required, but can be used in place of the satellite image if there is confidence that the machines were well calibrated.
3. Bare soil image measures only surface organic matter. Organic matter values from grid soil sampling can be used if available. The system has an "overwrite" function that can be used if electro conductivity data is available.
4. VRN uses a mathematical model to control a living creature. The same is true with other nutrient management systems.
5. Recommendations are only as good as the user. Flexibility could be a disadvantage. Training and certification is required prior to issuing a license.
6. Equipment restrictions. While VRN can be used with all forms of fertilizer, applications cannot be made with ground driven pumps.
7. Inverse response years. It is possible that the areas that are identified as very low yielding areas (hill tops and shoulders) may be the best areas in years that receive very high and timely rainfall. The lower, higher yielding areas may receive too much moisture in those years. Farming is about averages and planning. Not many farmers plan for the unusual year.
8. Very small field sizes are more challenging when using VRN. Significant variation must exist to justify VRN. Small fields may be better to spread with a flat rate.
9. Growers must invest in controllers to accurately apply the prescription. Biggest challenge is grower applied anhydrous ammonia. Equipment is now available that reduces the variability of application rates by 20%. More sophisticated growers are willing to invest in the equipment or switch to other forms of nitrogen.

Conclusion

The InSite VRN application system is an effective method to variably apply fertilizer where it is needed. It involves dialogue with the grower so they are comfortable with the recommendation. Most growers recognize over-application of fertilizer, but they don't want to take the risk of the large, across-the-field cuts in rates. VRN allows the rates to be reduced gradually over time to demonstrate to the grower he is not losing profitability. Fields must have adequate variability to be cost effective. Our experience in the first four years of commercialization is that VRN is cost effective on 80-85% of the fields evaluated. Growers do not have to invest any money to determine if it is the right practice to follow.

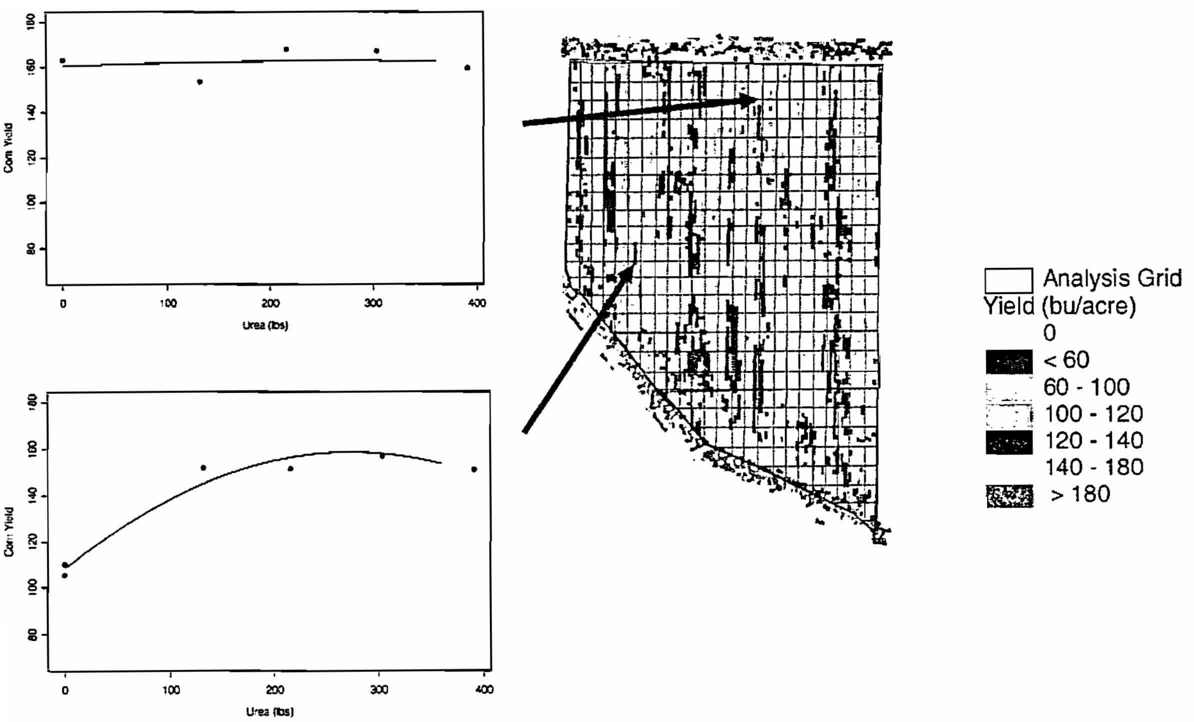

Figure 1: Nitrogen response curves

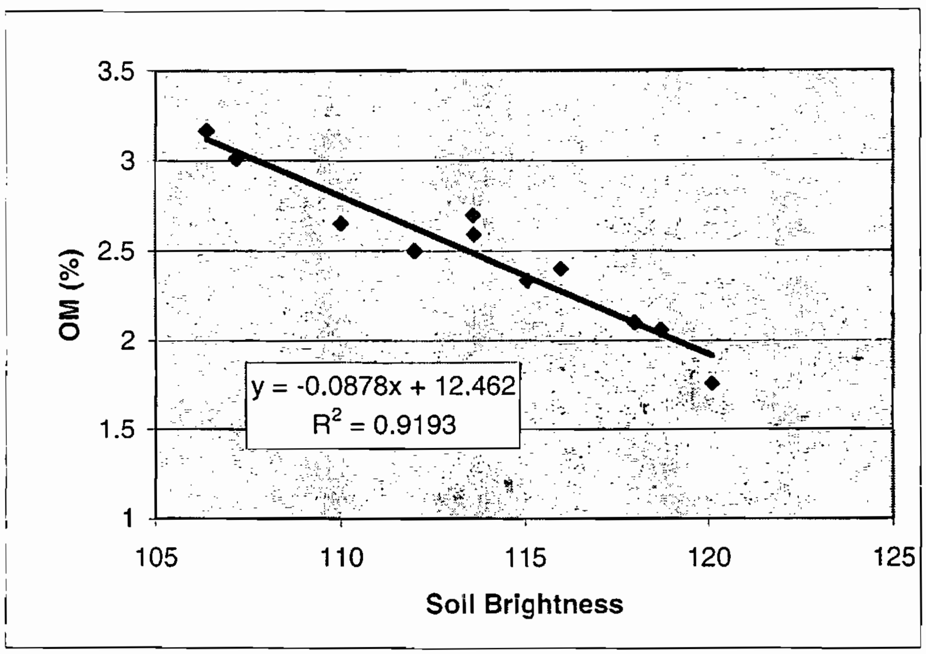

Figure 2: Organic matter in relation to soil brightness values. Holdrege, NE—1993-94.

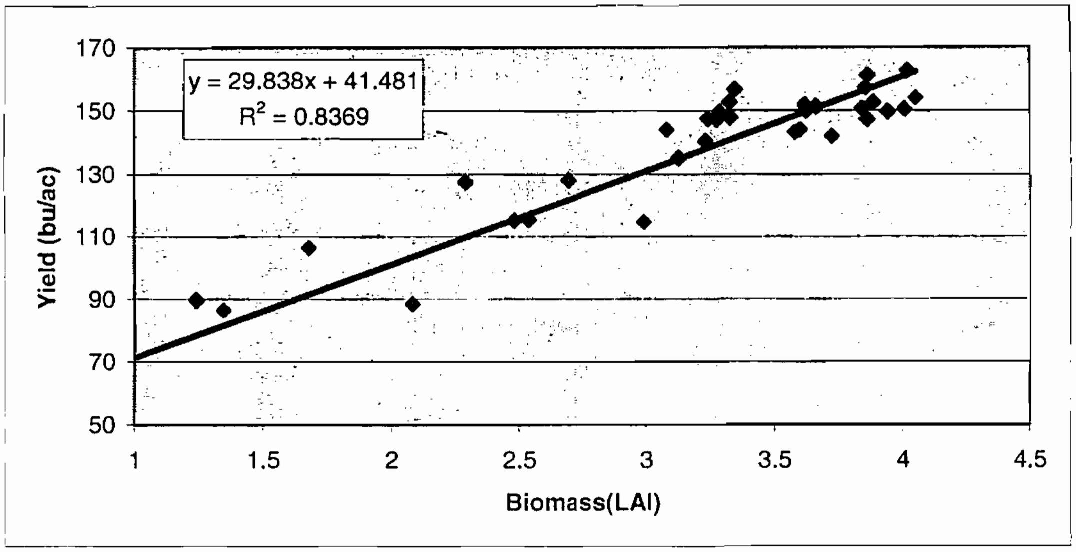

Figure 3: Yield in relation to biomass values. Blue Earth, MN—1993-94.

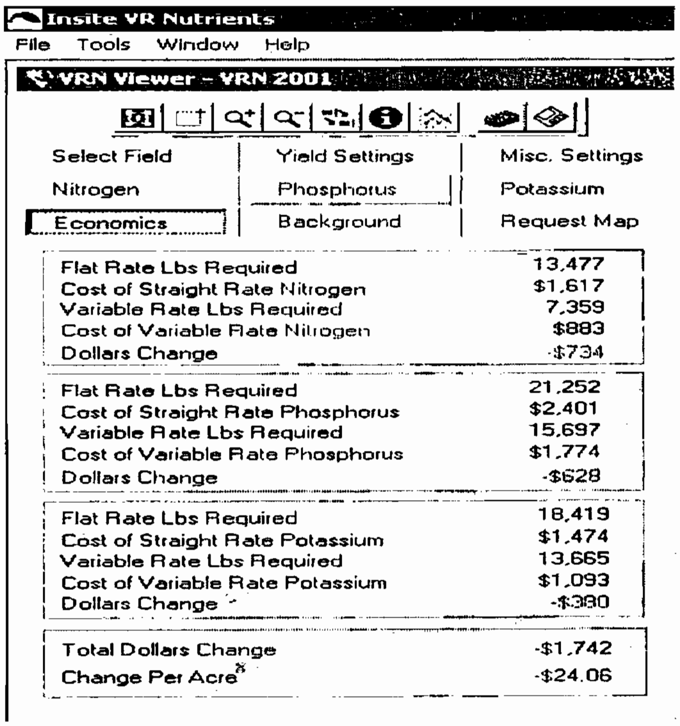

Figure 4: Economics of VRN application using variable rate N, P, & K.

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