The Pioneer Grant Program

The 2016 Pioneer Grant Program aims to reduce nutrient and/or sediment contaminant loads to the Maryland portion of the Chesapeake Bay and Maryland Coastal Bays from any nonpoint source: agriculture, urban or suburban stormwater, air, and septic by seeking proposals that focus on new techniques, information, or programs that increase the rate at which load reductions can occur.

Chesapeake Bay Foundation

Evaluating the Potential of Variable Rate Fertilizer Application Technology to Improve Nitrogen Fertilizer Use Efficiency

2004-2008

Project Track: New Information

Research Question: What are some potential environmental and economic benefits to using variable rate fertilizer application technology?

Research Results: The focus of this project was to evaluate the potential environmental and economic benefits for using variable rate fertilizer application technology (VRT) in growing field corn. This VRT technology targets fertilizer to high yield areas in a crop field and away from low yield areas, which should increase fertilizer efficiency and decrease fertilizer losses to the environment. Through this pilot program, CBF worked with farmers, university and agricultural scientists, and industry representatives to assess the effectiveness of VRT in Maryland. Variable rate technology has applicability in Maryland. Some refinements in the delivery system must be made before the technology can be successfully applied by farmers on a practical scale.

PROJECT PARTNERS

Chesapeake Bay Foundation

Evaluating the Potential of Variable Rate Fertilizer Application Technology to Improve Nitrogen Fertilizer Use Efficiency

2004-2008

Summary of Project

Over the course of the project, we gained valuable information which helped us to modify the design to adapt to needs and opportunities that we identified. There were four key areas that we have had to address over the course of the project:

a. Examining mapping technologies to determine which provided useful information on variability within a crop field;
b. Fertilizer delivery systems in the field (fertilizer application equipment);
c. Application equipment interaction with computer mapping and prescription software; and
d. Ground-truth actual results in the field.

Project Design Summary

Five crop fields were tested each of the two field crop seasons covered by the project (2005 and 2007). The fields were selected based upon field variability, availability of historic harvest data, and sufficient field size (>30 acres). Field variability maps were generated utilizing three different data sources (listed below under 'Mapping Technologies'). Using these field variability maps, soil samples were taken from each of the different zones (zones indicating high, medium and low yield potential) in an attempt to identify the underlying physical or chemical conditions that may have caused the field variability. Corn was planted and sidedress fertilizer was applied according to prescription maps that were generated based upon the variable rate maps. Fertilizer was dribble applied as UNA solution using a sprayer with a 60' boom. The corn crop was sampled during the growing season for leaf chlorophyll, earleaf nitrogen (N) concentration, and end-of-season corn stalk nitrate concentrations from each of the predicted yield zones in each field. At harvest, the crop yield was assessed using combines with yield monitors to compare actual yields with predicted yields. All field testing was done on actual farm fields working with local farmers. CBF staff coordinated the interaction between the farmers, the university researchers, and industry representatives to ensure that the mapping, fertilizer application, and ground-truthing occurred in a smooth and timely manner. (The complete project design for each growing season is included in the attached full project reports for each season.)

Mapping Technology

Over the course of the project we tested three variable mapping technologies:

1. Satellite Imagery - In year one, we utilized a satellite mapping technology showing field variability that was developed by Mosaic Corporation and which has been shown to be useful in research in mid-western states. Careful evaluation by extensive ground-truthing of the satellite maps failed to find consistent data to show that the variability indicated on the maps represented useful information related to crop yield potential. Pre-sidedress soil nitrate tests showed that there was no clear pattern between Mosaic's map of five different

yield zones and soil nitrate concentration. Also, neither soil texture nor soil organic matter showed consistent differences across the predicted (Mosaic) yield zones.

2. Precision Harvest data – Historic yield monitor data of corn harvests from each of the test fields from the previous 3-5 years was used to generate field variability maps. Fertilizer prescription maps were then generated based on these harvest data maps. Our results indicate that historic yield data did not generate useful variability rate prescriptions. Our tissue samples indicated that this was because there was no correlation between yield and stalk nitrate concentration, indicating that in these fields yield was not strictly related to the amount of N fertilizer applied.
3. Remote Sensing Imagery – Multispectral aerial imagery was acquired for each crop field by using a Duncan camera operated from a small airplane flying over the fields. Our results show that remote sensing of the corn canopy acquired when the plants are only about one foot tall is strongly correlated to yields. Of the three systems tested, the remote sensing shows the greatest reliability and most benefits for generating variable rate fertilizer applications.

Fertilizer Delivery Systems and Prescription Mapping Software Interaction

This project tested two sprayer systems for variable rate application. The first was an International Harvester sprayer which was modified by project cooperator, Southern States who also worked with technical consultants to be able to meet our variable rate application needs. This sprayer did not produce precise enough results to meet realistic variable rate fertilizer delivery in the field. The variation between the prescribed fertilizer rates and the actual applied rates was as great as 12-15 gallons per acre which was too great to provide any agronomic, economic, or environmental benefits.

The second system that was tested was a John Deere sprayer fitted with special nozzles designed to control flow volume based on pressure. The spray nozzles were tested and found to be relatively accurate and consistent. Nonetheless, in the field this system had problems as well. The in-field applied fertilizer rates did not match well with prescribed rates because there was a problem with the prescription maps not interacting well with the Apex software in the John Deere sprayer rig.

Summary of Project Conclusions

This project produced several useful findings:

1. There is enough field variability in Maryland crop fields to make variable rate application of fertilizer a beneficial practice.
2. Not all variable rate mapping technologies are well suited to Maryland field crop conditions. Aerial multispectral imagery was the most effective technology to determine useful field variability for variable rate application of fertilizer. Neither the satellite imagery nor the historical yield data variable rate maps provided consistently useful information.
3. Field equipment (sprayers outfitted with special variable rate nozzles) was successful at applying the rate loaded into the system, thus we can conclude the equipment is available. However, there were problems with the equipment interacting with the prescription map software that need to be resolved.

Variable rate technology has applicability in Maryland. Some refinements in the delivery system must be made before the technology can be successfully applied by farmers on a practical scale. As a follow up to this project the University of Maryland (with CBF's support) has applied for and received a two-year Conservation Innovation Grant (CIG) from Maryland NRCS to refine the system

and to work with NRCS on developing appropriate incentives to encourage farmers to utilize variable rate fertilizer application.

Project Evaluation

This project's biggest success was the interaction of the diverse collaborators. The inclusion of farmers, farm consulting and application services, university researchers, and the Chesapeake Bay Foundation staff gave us a realistic sense of what is required to make a technology useful to a farmer in the field. Using field scale farm fields under real time and weather constraints provided a dose of reality as to the need to have all the bugs worked out of a new technology before promoting it as a useful tool for farmers. The farmers were exposed to new technology and to a scientific way of evaluating the technology (random, replicated strips across whole fields). The farmers shared their constraints and needs and asked useful questions concerning the fertilizer application. The farmers also learned that in several cases they were applying more fertilizer than was benefiting them – at some cost. For CBF and the university researchers it was useful to understand first hand the limitations of farm consultants' abilities to adapt new technology without considerable experience with the technology first.

The biggest project challenge was effectively coordinating the efforts of all the collaborators smoothly. By relying on industry to provide equipment (for fertilizer application and remote sensing imagery) and carry out activities effectively and in a timely way, we learned about missed schedules, unfortunate delays, and inability to make rapid adjustments to equipment problems. Farmers needed to have their fields planted at optimal times, but also working around their already busy schedules.

Transferability and Sustainability

This project has developed sufficient information to determine that the VRT could be beneficial to farmers and the environment in the Chesapeake Bay region. We also learned that the technology is not field-ready for farmers. The University of Maryland has received a two-year CIG grant to further refine the system to make sure that it is fully field tested and ready before recommendations are made to farmers to use it. Certain pieces of the system are already useful (the aerial multispectral imagery) and can provide benefits to farmers without being tied to the variable rate application technology which is not quite ready.

By working with a CIG grant from NRCS the project collaborators will be able to work directly with NRCS to develop NRCS policy that appropriately encourages use of this technology when it is fully field ready. This will allow the technology to be introduced to farmers with incentives so that they can become familiar with the benefits so that in the future no incentives are needed to encourage use of the technology.

Monitoring and Maintenance

The project was designed to monitor each part of the technology system and the system as a whole. We have identified the parts of the system that are functional and those parts that need refinement.

The CIG grant that the University of Maryland was awarded by NRCS will continue the project to refine the system to be fully field ready and farmer friendly.

Community Involvement and Outreach Activities

The project brought together farmers, agricultural industry, the Chesapeake Bay Foundation and the University of Maryland researchers. The collaboration between these partners greatly enhanced communication between different sectors that have not interacted quite so intensively before.

Partnerships

CBF – project coordination, project conception and design

University of Maryland – project conception and design, data gathering and analysis

Southern States – project design and providing equipment and modifying it to meet the needs of the project

Mosaic Inc. – providing satellite mapping technology and developing variable rate maps and prescriptions for test fields

John Deere – providing sprayer equipment and technician; providing aerial remote imagery of test fields

Farmer collaborators – providing farm fields for study; providing historic yield data, and yield monitor data for corn crops in study years

Accounting of Expenditures

CBT Funds: $100,000
Rauch Foundation/Environmental Defense: $80,000
Mosaic/Cargill: $14,000
CBF: $16,120
Total Funds: $210,120