

# Optimizing crop management

“Smart” application of fertilizer illustrates payoff in using analytical tools to enhance crop yields and improve the environment.

By Joseph Byrum

**The modern farm is becoming a proving ground for the value of data analytics.** For example, by looking at systems that optimize the management of fertilizer, or nitrogen, we can see that the reward for improved decision-making goes far beyond simple economics. Better run farms produce more food, contributing to global food security. Properly managed nitrogen also happens to be essential to improving the environment and water quality. In short, data analytics are key to a healthier and happier future for millions around the globe.

The environmental and food security challenges the world faces in the decades ahead are truly complex, and the job of data analytics is to make sense out of inherently complex systems, like those we find in agriculture.

When it comes to growing crops, no one field is the same as another. Natural factors such as soil quality and topography introduce unique characteristics that affect the rate of growth and health of plants grown



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therein. Plants also depend on sunlight and water for growth, so the weather introduces a random source of variability. And then there's the managed source of variation found in the application of fertilizer.

Whether the farmer has a small plot in Africa or a large growing operation in Iowa, there are always ways to do things smarter and more efficiently. The tools of operations research are capable of tackling each of the three main sources of variability to improve decision-making. The payoff in using analytical tools to optimize crop management is perhaps best revealed in exploring the application of nitrogen to enhance crop yields.

For plants like corn, nitrogen tends to be the most important factor for yield, but it is not so simple. Applying more nitrogen will not always produce better results. To the contrary, an overabundance of nitrogen is a known menace to the environment. This is why one-size-fits-all approaches to growing are becoming obsolete. We see the highest yields coming from customized approaches that use hard



Field monitoring documents changes that are naturally occurring within a field.

Source: Syngenta

data to select the best crop genetics, inputs and growing techniques that are a match for the field conditions and weather.

#### Achieving Optimization

Achieving that optimization requires better measurement, and this poses a practical dilemma. Farmers must invest in an array of remote sensors and related analytical tools to achieve the benefits of better management, yet some farmers prefer to stick to tried-and-true methods. They base how much nitrogen they will use this year on how much was used last year. They are more likely to invest more capital on a new tractor or combine – the value of this equipment is well known – than to spend on sensors and software that are unfamiliar to them.

The tools themselves hold the answer to whether such an investment makes economic sense. Sensors are an integral component of yield monitors that measure field performance against revenue. Simply put, more precise measurements enable farmers to make smarter, more accurate decisions that have an impact on their bottom line. Properly implemented sensor technologies are critical to achieving the data density required to ensure farmers have the economically actionable intelligence they need to improve their management practices. The marketing of these critical tools must be optimized to reflect the practical needs of farmers.

Remote sensors provide an objective assessment of a plant's health by measuring chlorophyll

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levels – the greener the plant, the healthier it is. Infrared detectors peer deeply into the plant to detect crop stress, such as the presence of pests, the lack of water and the lack of nutrients.

When combined with the technique of in-field reference strips, these sensors arm growers with the data they need to more precisely apply nitrogen. If the output of a field matches the yield of the reference strip, no more nitrogen is needed. Conversely, if output is down in comparison, more nitrogen may be needed.

Failure to apply nitrogen with precision causes significant harm. As much as nitrogen delivers a massive boost to corn yield, it has an even greater effect in promoting algae growth when fertilizer runoff hits a stream or lake.

Eutrophication is the term used to describe the resulting overabundance of nutrients in a body of water. While plankton and algae feast upon the bounty of nitrates, they also multiply rapidly and disrupt the ecosystem's balance. The algae that die end up consuming enough of the available oxygen that native fish suffocate.

In addition to this, nitrates making their way into the water supply raise significant human health concerns. The Environmental Protection Agency considers levels above 10 parts per million a hazard to drinking water, reflecting an elevated risk of various forms of cancer [1]. The situation is so serious in central Iowa that farmers have their livelihoods at risk in a lawsuit filed by the Des Moines Water Works over runoff.

### Complex Mathematical Challenge

The best way to get ahead of any such developments is to get nitrogen right in the first place, which is to say, by applying no more nitrogen than the plant can absorb. This is a complex mathematical challenge. Nitrogen is soluble in water, so it is swept away by moving water, whether by irrigation or a rainstorm. That means nitrogen levels change rapidly. The job of data analytics is to quantify a plant's response to varying nitrogen levels.

To know how much nutrient to apply to a plant requires an understanding of the plant's requirements and its ability to absorb them from

## Stanford team wins Syngenta Crop Challenge

Syngenta and the Analytics Society of INFORMS named Xiaocheng Li, Huaiyang Zhong and associate professors David Lobell and Stefano Ermon – a team from Stanford University – as the winners of the inaugural Syngenta Crop Challenge in Analytics.

The team was awarded a \$5,000 prize for its entry, "Hierarchy modeling of soybean variety yield and decision making for future planting plan," which modeled a system for predicting soybean seed variety selection.

"It has been a wonderful experience working with Syngenta on this project, and we are excited about the impact our work can have on improving crop yields and addressing food security challenges," says Xiaocheng Li. "Operations research and advanced analytics can contribute to variety development and evaluation, reducing costs and improved efficiency. Extracting useful insights from massive, unstructured data sets informed



A team from Stanford University won the inaugural Syngenta Crop Challenge in Analytics.

our findings and proves to us there is a lot of potential for modern operations research and computer science techniques in agriculture."

The Challenge tasked participants to develop a model that predicts the seed varieties farmers should plant next season to maximize yield. The inaugural competition aimed to address the challenge of global food

the soil, with the economic cost factors always kept in mind. Field experiments are used to test the effectiveness of different levels of nutrient application, but these tests must keep in mind that variability in the fertility of the soil must be factored in for the results to be accurate.

The analytics opportunity is to monitor in space and time in an effort to document the changes that are naturally occurring within a field. Statistical methods that rely on history alone are inadequate; experiments are necessary. For nitrogen optimization, treated sites and untreated sites would be established. Spatial statistics can be used to analyze covariance in the experimental sites, ultimately allowing the farmer to more precisely interpret the trends. Instead of guessing what is going on, he will know what is happening. By acting on solid information rather than intuition, his probability of success will increase because it will no longer be a matter of luck.

Farmers who have yet to explore the use of data analytics and sensor technologies are going

to have to dive into these technologies to stay competitive in the years ahead. The Iowa Soybean Association keeps track of the performance of nitrogen sensing in the field. Most farmers are reporting savings of between \$10 and \$20 per acre in reduced fertilizer costs [2]. In many cases, growers recoup the cost of sensors within a year or two.

At the same time, the industry also needs to step up to the challenge to implementing easy-to-use data analytics tools. That is a necessary step in fulfilling the promise of nitrogen optimization and contributing to global food security and a cleaner environment. **ORMS**

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## REFERENCES

1. <http://www.ncbi.nlm.nih.gov/pubmed/11338313>
2. <http://www.cals.uidaho.edu/edComm/pdf/BUL/BUL896.pdf>

security by fueling innovation among experts applying advanced analytics in biochemistry and agriculture.

“Global food security is one of the greatest challenges facing the next generation, and there is a significant need to engage a broader talent base into agriculture,” says Joseph Byrum, Syngenta head of soybean seeds product development and lead for the Syngenta Crop Challenge in Analytics Committee. “This competition clearly demonstrated that people outside and adjacent to the industry can make noteworthy contributions.”

The finalists made their presentations at the INFORMS Conference on Business Analytics & Operations Research in Orlando, Fla. Programs were evaluated based on the rigor and validity of the process used to determine seed varieties, the quality of the proposed solution and the finalists’ ability to clearly articulate the solution and its methodology.

The runner up, “Decision assist tool for seed variety selection to provide best yield in known soil and uncertain future weather conditions,” authored by Nataraju Vusirikala, Mehul Bansal and Prathap Siva Kishore Kommi, received a \$2,500 prize. The third place entry, “Balancing weather risk and crop yield for soybean variety selection,” authored by

Bhupesh Shetty, Ling Tong and Samuel Bure, received a \$1,000 prize.

“The submissions from the Syngenta Crop Challenge in Analytics represent best in class science,” Byrum adds. “What is striking is the overall professionalism, quality and effort that the finalists put into the presentations. The teams were clearly committed and had a deep connection to the challenge.”

Syngenta, a global agribusiness headquartered in Switzerland, donated the prize money from its 2015 Franz Edelman Award win in support of a commitment to run the Syngenta Crop Challenge for the next four years.

“Syngenta is a great example of a company using operations research to better both its own performance as well as to help better society,” says Melissa Moore, executive director of INFORMS. “In 2015 Syngenta won the Franz Edelman award for using operations research and analytics to make better breeding decisions to reduce the time and cost required to develop crops with high productivity. Their efforts, including the Crop Challenge in Analytics, are putting them at the forefront of utilizing operations research to transform the agriculture industry.”

*For more details about the Syngenta Crop Challenge and to register for the 2017 Challenge, visit [www.ideaconnection.com/syngenta-crop-challenge](http://www.ideaconnection.com/syngenta-crop-challenge).*