Precision Agriculture: Supporting Global Food Security

By Steve Phillips

The global population is expected to surpass 9 billion people by 2050, and food security challenges are at the forefront of every discussion regarding agricultural production. According to most estimates, food production will have to increase 50 to 70% to meet global demand. The fertilizer industry will need to be a world leader in meeting this challenge as fertilizers are currently responsible for 50% of food production and will likely be even more important in the future. Success can be best achieved using the evolving tools, technologies and information management strategies found in precision agriculture (PA).

No single agricultural technology or farming practice can be viewed as a "silver bullet" for increasing food security, but rather the "stacking" of all technologies is where the real benefit lies. Combining PA, existing nutrient management strategies (e.g., 4R Nutrient Management, Integrated Soil Fertility Management) and effective combinations of other high priority technologies (i.e., no-till farming, improved crop protection, irrigation) have been reported to have the potential to result in as much as 67% increases in global crop yields (Rosegrant et al., 2014).

The historical corn yield trend in the U.S. is an example of how stacking technologies can lead to sustained yield increases. From 1965 to 2013, U.S. corn grain yields have steadily increased by 1.8 bu/A/yr. However, underlying this trend is a stream of technological innovations that include improved soil management and fertility, genetic improvements, integrated pest management, and precision technologies (**Figure 1**). The question is what will be the next innovative practice, not just for U.S. corn, but for food production worldwide, that will increase yields? A good guess would be PA. Precision agriculture is a rapidly growing industry and more and more farmers are taking advantage of the technologies to more effectively manage their operations. It's important to note that PA is much more than tools and technologies. It is better defined as whole farm management focused on maximizing the use of information to make decisions and optimizing inputs and preserving resources. Precision agriculture has the potential to create more knowledgeable farmers than ever before.

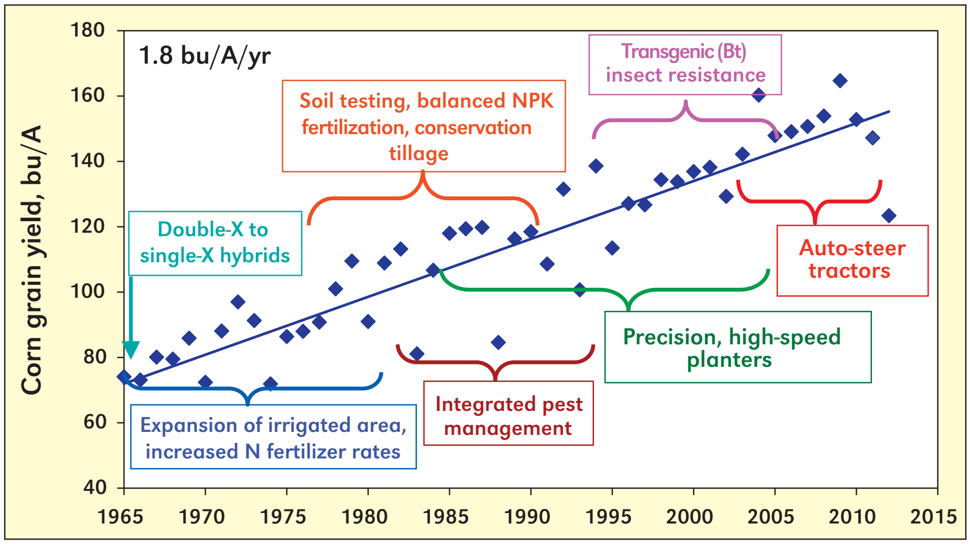


Figure 1. U.S. average corn yields (1965 to 2012) and the stream of technological advancements supporting productivity (modified with permission. Cassman et al., 2006).

Engaging the Mobile Device

One of the ways farmers are becoming more knowledgeable is through the use of mobile device technology. The trending popularity in mobile device technology for agriculture has increased markedly over the past couple of years and is projected to continue, with an expected 1.25 billion people owning a mobile device (smartphone or tablet) by the end of 2014. There are many reasons why the use of mobile device technologies in agriculture is growing rapidly. The most obvious reason is that many people already have one. Anytime a tool that users are already familiar with can be used to enhance farm management, adoption will be rapid. Another driver for adoption is the recent explosion in agricultural applications (apps) for mobile devices that make it possible for users to have access to more information than ever before. Functions and uses of various agricultural apps include news, weather, and market updates, identification tools for weeds, pests, and nutrient deficiencies, input calculators for seed, chemicals, and fertilizer, and comprehensive scouting tools.

Abbreviations and Notes: N = nitrogen; P = phosphorus; K = potassium.

Tackling Variability

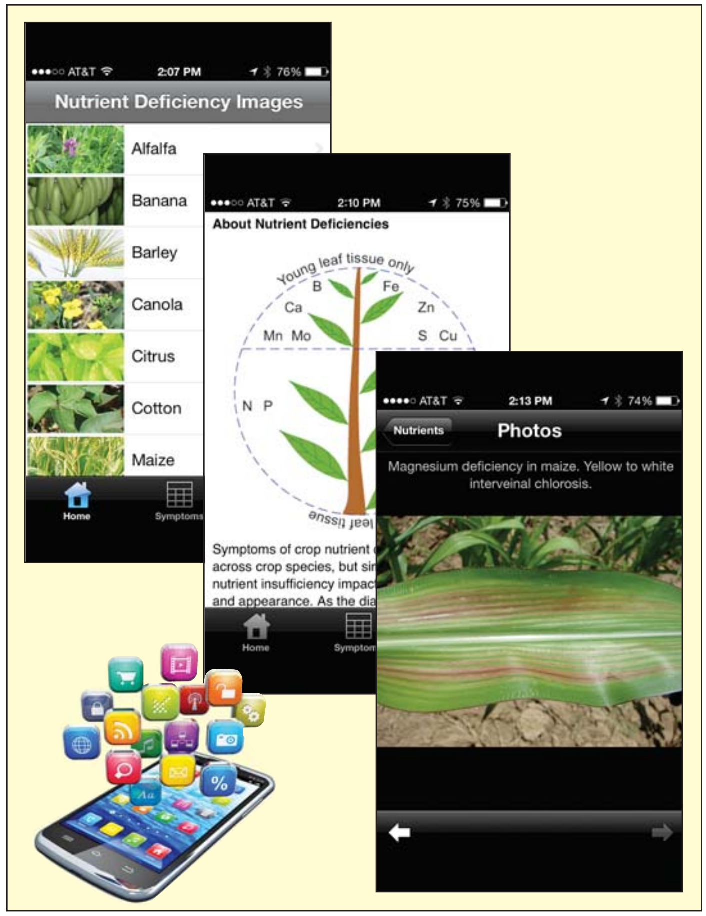
For decades, one of the key drivers for the development and adoption of PA technologies has been nutrient management. Current estimates are that approximately 70% of fertilizer dealers and ag. retailers in the Midwest U.S. are equipped to provide variable rates of fertilizer and lime, with the numbers expected to reach 80% by 2016 (Holland et al., 2013). Seventy percent also offer GPS-based soil sampling, while nearly 50% will provide satellite or other aerial imagery for management zone delineation. Redistributing fertilizers based on soil and crop variability optimizes production by minimizing over- and under-application of nutrients. Most variable-rate nutrient applications are map-based, relying on either a grid or zone soil sampling strategy. So rather than a single fertilizer recommendation for the entire field, as would be the case using a composite soil sample, multiple recommendations are made within the field according to the fertility needs of the various management zones. Another map-based approach is to use yield maps to make variable-rate fertilizer applications based on nutrient removal estimates for the previous crop. This nutrient balancing approach can be an effective method for maintenance of soil nutrients, but is generally not preferred over a soil-test based approach.

Another technology used to make variable-rate nutrient applications, particularly for N, is crop canopy sensors. The basic function of all forms of these sensors is to measure reflected light from the crop and use that information to determine the crop nutrient requirements by utilizing N rate algorithms that incorporate a variety of site-specific information depending on the sensor system being used. The reliance on these algorithms has resulted in slow commercial adoption rates despite well-documented success in both small- and large-scale research and demonstration studies. The use of crop sensors has begun to increase more rapidly in the past few years, particularly in the U.S. and Europe. Reasons for the increase now as opposed to when sensors first became commercially available a decade ago have to do with various factors. First, the N rate algorithms are well established and cover a variety of crops and geographies. Second, is the opportunity to utilize the tool for more applications including weed pressure mapping and variable-rate herbicide sprays, variable-rate plant growth regulator and defoliant applications, and estimating disease and insect stress and damage spatially throughout the field.

One of the misconceptions about PA is that it is only an option for the large-scale, high-profitability farming systems found in developed nations. In reality, spatial and temporal variability exists in smallholder systems and allowing these factors to contribute to the mismanagement of resources creates an even greater risk to these producers. The ability to incorporate spatial and temporal information into the decision-making process in the developing world is of tremendous value, possibly even more so than in developed nations. Several precision nutrient management strategies exist and are being used successfully in smallholder systems including leaf color charts, omission plots, handheld crop sensors, and web-based decision support software packages.

Another practice rapidly gaining popularity is variable hybrid planting. Just as in the case of spatial variability of soil nutrients, not all areas of the field have the same production potential with regard to hybrid or variety performance. The most popular hybrids are often the highest yielding in seed trials. However, these trials are typically conducted under optimum conditions and many of the high performers have very low tolerance for less than optimum conditions that are found spatially distributed in many agricultural fields. Other hybrids that don't have as high of a yield potential are better suited to handle these stressed conditions. So in practice, the higher yielding hybrid will be planted in the best parts of the field, while the more durable, lower yielding hybrid will be planted in the problem areas. Varying seeding rates based on spatial variability has also shown to be a profitable practice. Zones of a field with low production potential often do not have the capacity to support the seeding rates recommended for optimum yield. In these areas, seeding rates can be reduced to more closely match the yield potential in that area and increase whole farm profitability.

Water is yet another agricultural input that is more commonly being managed using variable-rate techniques. Irrigation amounts, timings, and spatial distribution can be effectively managed using precision technologies. Variable water requirements can be determined using soil moisture sensors or



Adoption of agricultural applications within mobile device technology have the advantage of familiarity and accessibility.

weather and plant-based evapotranspiration models. Irrigation timing becomes more precise by using real-time information and variable-rate distribution systems, (whether pivot, lateral, or drip) and result in more efficient use of water resources. Precision drainage can also be used to control soil profile moisture throughout the growing season. Keeping with the increasing trend of agricultural application technologies, water management is more commonly being done through mobile device platforms. One example of an irrigation-scheduling app uses real-time weather and crop development data to estimate moisture deficits and farmers are notified of a need to irrigate with a recommended amount via text message.

Improving Technologies

The most rapidly growing adoption trends in U.S. PA over the past five years involve data integration and equipment technologies. The increasing availability and capacity of wireless data transfer has resulted in easier integration of outside data such as weather, higher utilization of GPS-based logistics for equipment management, and overall improvements in decision-making. The process of transforming data into information that can lead to a knowledgeable management decision is faster and easier than ever before. Compatibility of tools has also increased markedly over the past few years resulting in very rapid adoption of equipment technologies, specifically automated guidance and sprayer boom section controls.

GPS-based manual guidance technologies have been popular for a decade or so, but in the past four to five years the use of automated guidance has surged tremendously. While manual

Decision support tools integrate the numerous site factors used in making decisions about nutrient management practices.

systems still relied on the operator to guide the equipment along the GPS-targeted path, automated systems have taken the controls out of the hands of the farmer and use mechanical navigation. Automated guidance results in greater accuracy of each pass across the field, as well as increased operator comfort. Also adding to the accuracy and precision of agricultural input placement is automatic section control (ASC) technology. Automatic section control is not a variable-rate approach, but rather a technology that allows multiple sections of the implement to be turned on or off as needed. This technology allows the operator to significantly minimize overlap and skips as the application is made. Whether applying chemicals or fertilizers, the ability to precisely target applications has a positive effect not only on profitability, but also on environmental quality by minimizing over-application and potential off-site movement. Using ASC on planters also has economic value by optimizing plant population in the field by improving the precision of row spacing and eliminating double seeding.

Looking to the future of PA technologies, one that is generating a great deal of interest among numerous stakeholders is the use of unmanned aerial vehicles (UAVs). UAVs, or drones, are small, self-propelled aircraft that can be used to collect high-resolution data from fields rapidly and inexpensively. The aircraft is equipped with a data collection device ranging from something as simple as a digital camera to very high-tech multi-spectral and thermal imaging sensors. There are several benefits to using UAVs; however, much more research is needed before this technology finds its way into commercial use. One of the major obstacles to adoption will be the rules and regulations surrounding their use. Despite the possible challenges moving this technology into mainstream agriculture, there is as much excitement surrounding UAVs as anything in PA right now.

Summary

Meeting the food production challenges for a growing population is a daunting, but not impossible task. It will require focus, cooperation and a combining of technologies across several disciplines of agriculture and society. Implementing PA technologies within the context of 4R Nutrient Stewardship—supporting the fundamental practices of applying the right nutrient source at the right rate, at the right time, and in the right place—is an efficient and effective way to help meet the environmental, economic and social goals of sustainable agricultural systems. BC

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