Science Societies

Data management and variability: Precision agriculture considerations for 4R management planning

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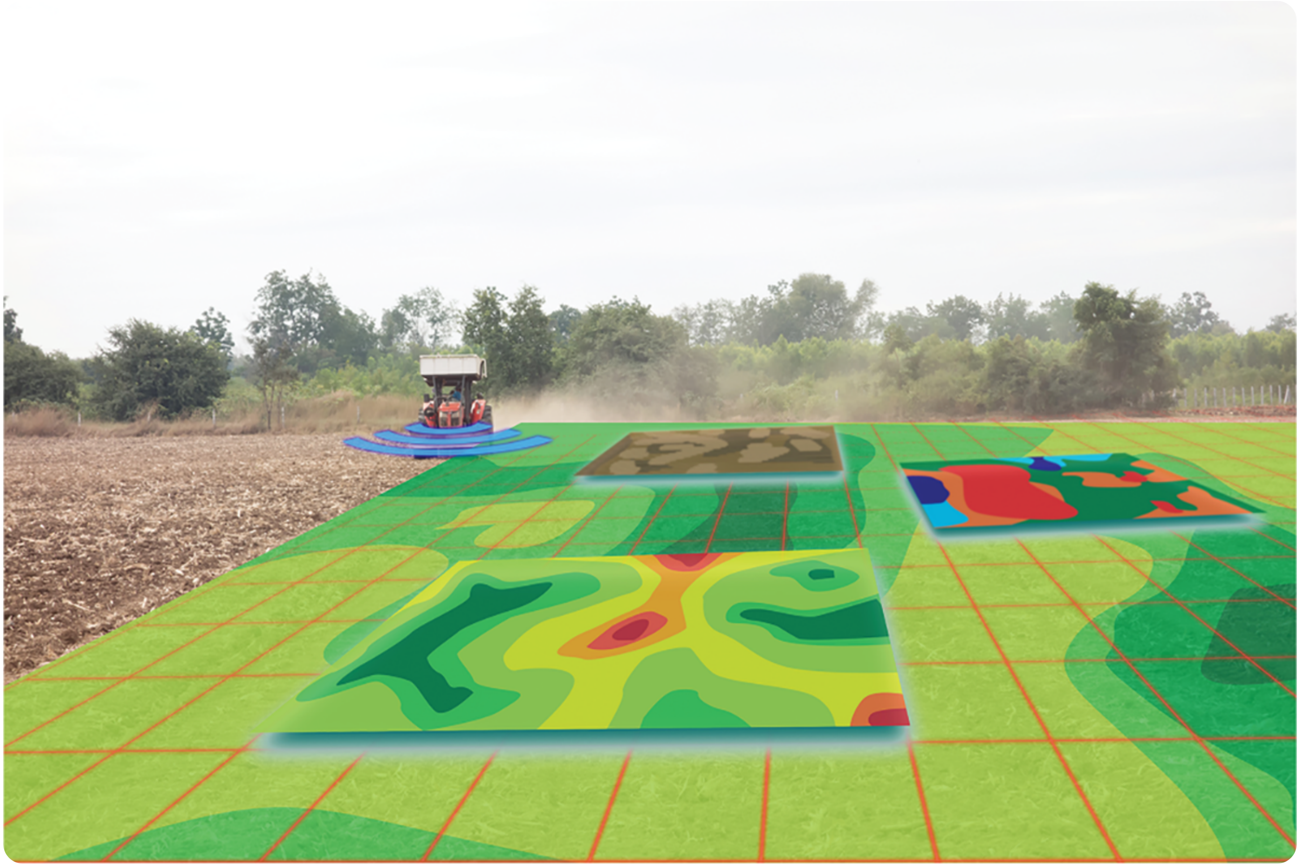

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> Precision agriculture plays a large role for crop advisers and farmers when developing 4R nutrient management plans. Combining temporal and spatial yield data can help farmers and consultants manage areas of fields or farms based on their differences from farm average yield and variability to improve nutrient use efficiency. The development of tools that use an increasing number of data layers together—beyond only yield maps—is needed to improve the interpretation and implementation of data-intensive precision agriculture.

For years, the term precision agriculture has been used to discuss various products, services, and technologies that aim to help farmers do more with less. The rate of adoption of these practices varies depending on the amount of data is needed or the technology's level of automation. According to a 2019 Kansas survey, data-heavy technology, such as variable-rate fertilizer application, was adopted at a much slower rate than automated practices like guidance and section control (Griffin & Yeager, **2019**).

With so many options, we are left with one question: what is precision ag? There are more than 27 definitions of precision agriculture with a variety of focuses.

The International Society for Precision Agriculture (ISPA) embarked on a year-long process with input from 46 precision agricultural experts and landed on the following definition:

“Precision agriculture is a management strategy that gathers, processes, and analyzes temporal, spatial, and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability, and sustainability of agricultural production” (ISPA, 2018).

Lowenberg-DeBoer and Erickson (2019) slightly modified this definition with the addition of *“…that uses electronic information and other technologies…”*.

Using this definition, precision agriculture plays a large role for crop advisers and farmers when developing 4R nutrient management plans. Whether it's variable-rate application, sidedressing, yield data collection, soil mapping, or equipment guidance, precision ag serves as the basis for a successful 4R strategy.

Precision Agriculture on the Farm—the Data Gap

The ISPA authors evaluated data sources from around the world to explore levels of precision agriculture adoption. In the United States, the USDA Agricultural Resource Management Survey (ARMS) is the main source for practice implementation data, and the survey is conducted by crop on a five-year cycle. Since 2007, precision agriculture survey data has been collected for corn (2016), rice (2013), peanuts (2013), soybean (2012), winter wheat (2009), and cotton (2007).

Across all the crops and years, the top two practices reported were the use of a global navigation satellite system and yield monitors (Lowenberg-DeBoer & Erickson, 2019). The challenge for precision agriculture implementation is transforming the information from these systems into useful data. In the 2016 survey, 68% reported using a yield monitor, yet only 45% reported that a yield map was created (Lowenberg-DeBoer &

Erickson, 2019). If data collected on yield monitors is not converted to yield maps, more advanced practices, like variable-rate fertilizer application, may also not be implemented.

Variable-rate application of nitrogen or phosphorus fertilizers is ranked as an advanced 4R nutrient stewardship practice, maximizing the use of nutrients applied by getting them in the right place at the right rate (Snyder, 2016; Bruulsema, 2017). In the 2016 corn survey, 20% of farmers reported using variable-rate fertilizer applications, representing 29% of the corn acres in the United States (Lowenberg-DeBoer & Erickson, 2019). Other surveys conducted with grain and cotton farmers, who farm more than 988 ac, reported as many as 73% of farmers who were using variable-rate fertilizer applications (Lowenberg-DeBoer & Erickson, 2019). The larger farm size surveyed in these projects likely impacted the higher percentage of variable-rate application implemented compared with the USDA-ARMS data. The most recent year of USDA-ARMS data on precision agriculture practices used in cotton production is from 2007; other researchers have conducted cotton grower surveys in 2009 and 2013 (Lowenberg-DeBoer & Erickson, 2019). In the 2007 USDA-ARMS survey, cotton growers only reported using variable-rate fertilizer applications on 5% of the planted area (Lowenberg-DeBoer & Erickson, 2019). The number of growers using variable-rate applications was reported as 22% in a 2009 survey and 25% in 2013 (Lowenberg-DeBoer & Erickson, 2019). These results are similar to the Kansas farm data that showed slower adoption for data-heavy technology and indicate there is significant opportunity for greater adoption of the practice.

Agricultural Service Provider Role in On-Farm Adoption

Source: United Soybean Board.

Agricultural service providers are filling the gaps to help farms use the data they are collecting and to optimize it for practices like variable-rate application. In 2019, 62% of agricultural service providers reported offering yield monitor and other data analysis services (Erickson & Lowenberg-DeBoer, 2019). Additionally, other services like grid- or zone-based soil sampling, soil electrical conductivity (EC) mapping, and grid- or zone-based plant tissue testing, all of which are part of a 4R strategy and build on yield map data to refine variable-rate recommendations, are widely available (Erickson &Lowenberg-DeBoer, 2019). Eighty-nine percent of agricultural service providers offer grid- or zone-based soil sampling, followed by grid- or zone-based plant tissue testing at 57%, and 33% offering soil EC mapping (Erickson & Lowenberg-DeBoer, 2019). Similarly, variable-rate fertilizer application services for fertilizer and lime continue to increase, with 81% offering variable-rate fertilizer applications and 70% offering variable-rate lime applications (Erickson &Lowenberg-DeBoer, 2019).

Farmers consistently recognize agricultural retailers and crop advisers as their trusted source for information on new technology and 4R practices. Investments by ag service providers in this technology are critical to the expansion of these practices—many of which provide economic and environmental benefits to farmers.

Addressing Spatial and Temporal Variability

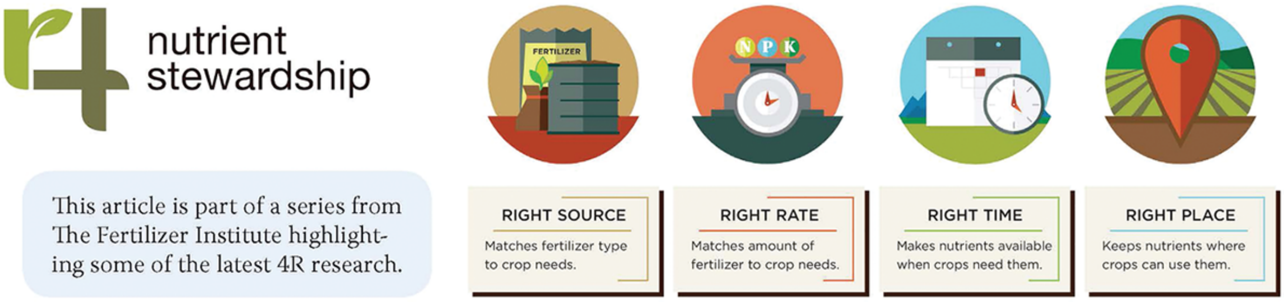
The first commercially successful grain yield monitors came on the market in 1992 (Lowenberg-DeBoer & Erickson, 2019). Thirty years of data can tell a powerful story, especially as more data layers like seeding rate, fertilizer applications, soil test results, and soil type maps are added. Having multiple years of data allows a farmer or adviser to examine the influence of field characteristics, management choices, and differences in weather conditions on crop yield.

Recent research used corn silage yield data from six different farms and 78 individual fields. Three years of data were used to map individual fields to 32.8- by 32.8-ft grid cells, analyzing them for spatial versus temporal impacts on yield (Kharel et al., 2019). Results showed corn silage yield varied substantially within an individual farm's set of fields and across all six farms (Kharel et al., 2019). Spatially, the data found that the variability within fields changed across the years with yields increasing from 2015 to 2017 (Kharel et al., 2019). Having additional data layers for weather with rainfall or temperature, or other management practices like fertilizer applications or seeding rates, would help the farmer and consultant gain insights on why different practices worked in different places.

The data were less variable spatially than temporally (Kharel et al., 2019). There was no relationship between the spatial and temporal variability, suggesting that both spatial and temporal variability need to be considered when developing management zones (Kharel et al., 2019). By understanding the lack of a relationship between spatial and temporal data and the high variably among the spatial or temporal data, the authors created four yield stability zones across the farms (Kharel et al., 2019). The four zones were Q1—above-average yield and below-average variability, Q2—above-average yield and above-average variability, Q3—below-average yield and above-average variability, and Q4—below-average yield and below-average variability. Creating similar management zones is one approach that could reduce the number of different specific management zones on the farm and allow for farmers and researchers to compare different practice combinations to the level of performance.

Conclusions

There are growth opportunities for data use and nutrient application sustainability. In a 2018 analysis of farmer data in Kansas, almost half of the farms in the database could potentially adopt precision agriculture practices that are more information intensive like variable-rate application of fertilizer (Griffin & Yeager, 2019). Combining temporal and spatial yield data can help farmers and consultants manage areas of fields or farms based on their differences from farm average yield and variability to improve nutrient use efficiency. The development of tools that use an increasing number of data layers together—beyond only yield maps—is needed to improve the interpretation and implementation of data-intensive precision agriculture.



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