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Potential Payoffs of Precision Farming

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Recent *farmdoc daily* articles discussed the importance of new technologies to crop agriculture (March 5, 2021), the value and role of information in the adoption of these technologies (March 12, 2021) and (March 18, 2021), and the adoption of precision agriculture technologies (March 26, 2021). In this article, we continue this theme by discussing potential payoffs of precision farming from the producer, value chain, and environmental perspectives. Upcoming articles will discuss automation and robotics, and gaps in the skills pertaining to the adoption of new technologies in production agriculture.

Potential Payoffs for the Producer

Cost Reduction/Efficiency Improvement Increases

The improved measurement of soil characteristics and weather patterns that is part of precision farming has the most direct and obvious payoff in terms of cost reductions and efficiency increases from more accurate use of inputs such as fertilizer, seed, chemicals, and other inputs and the systematic measurement of the impacts of these inputs on yield and profitability. In essence, precision farming is one step closer to the manufacturing mentality of production agriculture. Precision farming combined with creative ways to schedule and sequence machinery use including 24 hour-per-day operations, moving equipment among sites, and deployment based on weather patterns has the potential to increase machinery utilization and lower per acre machinery and equipment costs as well.

Value Enhanced Differentiated Products

Part of production agriculture is expected to move from commodity to differentiated product production. One dimension of that differentiation may be the production process itself. For example, the use of chemicals during only certain stages of the plant growth process. For some markets such as organic, products cannot be produced using inorganic chemicals, and some processors and food companies want to trace the sourcing of crop products to specific locations or fields with detailed documentation of production processes. With more specificity required in the raw material to meet qualified supplier requirements, increased measurement and monitoring of both the growth process and the end product will be important for quality control and compliance. In fact, precision farming in its broader context of measuring, monitoring, and controlling the plant growth process is expected to have more payoff in

differentiated product production than in commodity product production because it has the potential to not only lower cost but to simultaneously enhance revenue by producing a higher valued product.

Span of Control

A key concern in crop operations is the perceived and, in many cases, real limit on size of operation because of the difficulty of monitoring progress and performance on large geographically dispersed acreages. The fundamental argument is that if plant growth processes can only be monitored by people with unique skills and those individuals are costly or expensive to train, the monitoring process limits the span of control to what one individual (or at least a few individuals) can oversee personally. If electronic monitoring systems can be developed (whether it be machinery operations or the growth process of the crop or the level of infestation of insects or weeds), fewer human resources are needed for this task and generally larger scale is possible. An analogy is the transformation from the labor-intensive corn processing or feed milling plants of the past to the electronically controlled and monitored plants and mills of today with computer-based monitoring and control systems and fewer employees producing significantly more output. Crop production can and will move more and more in that direction with improved electronic monitoring and control systems, which expands the span of control.

Reduced Downtime and Better Capacity Utilization

A critical determinant of productivity in crop production is timely operations, getting the planting completed in a timely fashion for optimal growth and harvest completed before harsh winter weather occurs. Delays due to unanticipated breakdowns can be very costly. Telematics that inform preventative maintenance can be very useful in reducing the prospects of a breakdown and GPS guidance can extend the hours of operating during the critical planting and harvesting seasons. Precision planting technology which enables more accurate seed placement at higher travel speeds increases the number of acres that can be planted per hour. In some cases, higher accomplishment rates and extended hours of operation per day can enable farmers to operate more acres with the same equipment or the same number of acres with a smaller machinery line.

Risk Reduction

No matter how good they are, people can and do make mistakes. Precision agriculture technology combined with automation reduces the chances of a mistake. GPS based auto- guidance combined with row shut-off technology reduces overlap in chemical or seed application. Seed monitors reduce the chances of skips or other inaccuracies in seed placement. Yield monitors provide the data for more accurate selection of fertility and chemical programs, which combined with variable rate application technology, reduce the risk of making an incorrect variety or weed control selection in subsequent years. And more timely planting and harvesting using precision farming technologies reduces the risk of yield reductions from unpredictable weather events.

Landlord/Supplier and Buyer Relationships

One of the most important business relationships a farmer has is with the land owners who rent him/her their property. Keeping the land owner (or the management company that has been retained by the landowner to oversee this arrangement) informed of the farming activities that are occurring on their property, the progress of the growing crop, and the management and cultural practices that are being used by the operator to maintain or improve the productivity of the property strengthens and deepens this critical relationship. The data and information generated through use of precision farming tools and techniques enhances communication with the land owner/farm manager well beyond the pictures and phone calls typically used in the past. Communication with other suppliers such as lenders and agronomic input and farm equipment suppliers is also enhanced by the additional detail that can be provided to solve problems. In a similar vein, data/information useful to more effectively communicate with buyers concerning crop progress and/or production practices or problems can also enhance the “preferred supplier” relationship that most farmers want to have with their product purchasers.

Enhanced Property Value

Finally, a longer-term payoff of adopting precision farming practices is improved productivity and soil health, and thus value of the land. Farm land values are heavily dependent on productivity as reflected

by yield, and in today's and tomorrow's agriculture yield is more and more impacted by data driven investments in land improvements. In the past these improvements have been primarily in the form of investments in drainage, land clearing, terraces and contour tillage, waterways, etc., but in recent years they have included the adoption of management practices that improve fundamental characteristics of the soil such as microbial activity, water-holding capacity, acidity, organic matter, compaction, soil tilth, etc. The use of management practices informed by improved sensing technology and data analytics that document the long-term yield response of 4R (right source, right rate, right time, right place) applications of agronomic inputs, soil conserving tillage techniques, cover crops, lime application, etc., have demonstrated the productivity benefits of improved soil health. Just to illustrate, one of the most common and well-recognized data driven precision agriculture soil health investments is variable rate lime applications to increase soil pH which enhances root growth and nutrient uptake.

Summary of Payoffs to Producers

So how specifically does this show up in a direct payoff to farmers? One way to think about and actually document the payoff is to measure the additional value of farmland that results from using precision agriculture tools and techniques. A common way of measuring farmland productivity in the Midwest is the CSR (Corn Suitability Rating), a soil productivity index driven primarily by fundamental soil characteristics (texture, tilth, water-holding capacity, etc.) or soil types, and less so by current and past farming practices. Precision agriculture documentation can help us understand how more informed data driven decisions on tillage, fertility, chemical use, seed selection, and planting and harvesting operations can enhance the natural productivity of the soil (compared to properties with the same CSR rating where these practices are not used), thus creating additional value that can be captured not only by higher yields and profitability during the years the owner is farming the land, but also in the value of that land when it is eventually sold or a higher rental rate when rented to a tenant. In essence, land farmed with precision farming practices has the potential to be more productive over a lifetime and consequently has higher value (i.e., it is worth more to the property owner as well as to society).

Potential Payoffs for the Value Chain

Food Safety

One of the most difficult risks for a food processing firm to manage is the potential of contamination of raw materials. And for a branded-product food company, a food safety scare can be disastrous. The improved measurement and monitoring of soil preparation, growth, harvesting, storage and handling, and processing processes that have the potential to be part of precision farming in the future will enable trace-back from end-user through the production/distribution chain which is the only secure method of guaranteeing food safety. If food safety concerns continue to increase and consumers demand more documentation that food products are in fact safe, precision farming has the potential to become one of the most effective ways of providing that documentation and reducing the risk of food contamination.

Sustainability

A growing number of food processors and retailers are responding to the "sustainability" concerns of their customers by requiring their suppliers to meet what they have specified as sustainability criteria, and document their sustainability practices. Some food retailers have or are considering adding a "sustainability" label to their food products much like the nutrition label that they currently carry. These "trust your food" initiatives are expected to expand. Precision farming provides the capability to execute and document the sustainability practices increasingly required to be a "qualified supplier" in a more demanding supply chain.

Traceability

Not unrelated to the increasing concerns of food consumers about food safety and sustainability is the issue of traceability and the chain of custody. If there is a food safety issue or contamination of a food product, consumers as well as food companies and government officials are eager to quickly uncover the source and take mitigating action. Tracking and tracing at the farm gate level to uncover sources of contaminant is significantly enhanced with precision farming tools that have recorded the use of specific agronomic and production practices. Likewise, similar documentation can be used to verify that

sustainability criteria have been met, or what adjustments might be needed to maintain “qualified supplier” status.

Potential Payoffs for the Environment

Reduced Fertilizer and Chemical Leaching and Runoff

More precise applications of fertilizer and insect and weed control in terms of location, timing, and amount to better match plant needs should reduce leaching and runoff into ground and surface water and the resulting deterioration of water quality. Undoubtedly, this potential exists, but what if the precision farming recommendations are for the highest application rates on the soils closest to a stream or waterway or with a shallow water table and heavy rains occur shortly after application. Precision farming has the potential to reduce environmental degradation of water sources, but we need to monitor and measure this phenomenon to be sure we are obtaining the expected results.

Conserving Irrigation Water

In some locations in the U.S., particularly in the Southern Plains, the availability of water for irrigation purposes is declining because utilization and draw-downs exceed recharge rates for underground as well as surface water sources. Use of precision farming technology to manage irrigation systems by applying water at the needed amount at the right location and at the right time has been shown to significantly increase efficiency and effectiveness of irrigation, and thus conserve increasingly scarce water resources.

Comprehensive Nutrient Management

In many states and locales, concerns about soil and water (or even air) degradation in rural areas has resulted in pressures to regulate and restrict the application of inorganic and organic (manure and animal waste) fertilizer. Some states/locales are contemplating or requiring comprehensive nutrient management plans to reduce the environmental footprint of crop production. Precision farming tools and technologies can be very effective in developing and implementing those plans that in many cases will not only reduce the potential of environmental degradation, but also lower costs by more efficiently and effectively using fertilizer (including animal waste) inputs.

Concluding Comments

This article discussed the possible payoffs for the agricultural producer, for the value chain, and for the environment associated with the further adoption of precision agriculture. As we develop technologies and tools to expand the toolkit for precision farming and digitization systems and platforms to enhance farmer’s profit margins as well as create value for the value chain and society as a whole, the farming sector will be increasingly transformed from “growing stuff” to biological manufacturing. Readers are encouraged to check out the Lowenberg-DeBoer and Erickson (2019) and Thompson et al. (2019) articles for more details pertaining to the benefits accruing to agricultural producers from the adoption of precision agriculture technologies.

Upcoming articles will discuss automation and robotics, and gaps in skills pertaining to the adoption of new technologies in production agriculture. The automation and robotics article will discuss how agriculture fits into general trends in adoption and will provide examples of technologies that are either starting to be adopted or that are expected to be adopted in the near future. Adopting precision agriculture technologies and robotics will require additional management skills. The article pertaining to the gap in skills will address these potential skill gaps and indicate whether it would be better to internalize the skills or contract for these skills.

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