Overview and Value of Digital Technologies for North American Soybean Producers

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Abstract. *In the current state of digital agriculture, many digital technologies and services are offered to assist North American soybean producers. Opportunities for capturing and analyzing information related to soybean production methods are made available through the adoption of these technologies. However, often it is difficult for producers to know which digital tools and services are available to them or understand the value they can provide. The objective of this study was to assimilate and categorize current digital technologies available to producers today, understand how they are being used, and potential value they can provide.*

Over 100 currently available digital technologies were sorted into six categories that included: Data Warehousing, Production Benchmarking, Production Analysis, In-Season Monitoring, Crop Modeling, and Recommendations. Categorizing these technologies provided; 1) a clearer understanding of technology implementation, 2) an alignment of a digital technology to a producer's intended use if adopted, and 3) insight to producers considering these digital technologies.

A producer survey was also administered along with interviews of agriculture technology experts, and results were then summarized and analyzed. Survey results indicated that 70% of producers are confident that their data is valuable and 91% are actively using technology in soybean production. Many survey responses indicated concerns about the potential added value, data management logistics, and disconnects between technology providers and end users. Results of this study provide insight for soybean producers on the implementation and use of current and future digital technologies.

Keywords. *Digital Agriculture, Data, Soybeans, Technology, Precision Ag.*

Introduction

Since the mid-1990s, there has been significant adoption of precision agriculture technologies in farm operations. However, "agriculture is just embarking on the fringe of data management in which machine and agronomic data are being collected and stored on the web using servers or cloud technology" (Fulton, 2013). This evolution in data collection has led to the creation of innovative digital tools and services that can be used to draw site-specific information and new learnings from cropping fields with unprecedented ease. Despite this rapid development, the reasoning behind actual adoption of data collection tools and the value provided by these tools has not been made clear. Companies are making strides to change that as they continue to develop digital tools and help growers analyze data. According to the 2017 Precision Agriculture Dealership Survey, only 13% of dealers do not help customers with their farm-level data (Erickson, 2017). In addition, from the same Precision Ag Dealership Survey, dealers were asked to estimate their market area for a variety of technologies (Erickson, 2017). Cloud storage of farm data is currently estimated at 14% and expected to increase to 32% by 2020. Data analysis services, such as those considered in this study, are estimated at 13% now and are anticipated to increase to 30% by 2020 (Erickson, 2017). A wide variety of digital technologies are offered to producers today, making it difficult to identify the types of digital tools and services that provide real value to soybean producers. According to AgFunder's mid-year report for 2016, $1.75B was invested in ag technology (Burwood-Taylor, 2016), proving that these investments in digital tools and services are valuable but questions about implementation of those tools remain. With both large-scale agricultural companies and start-ups pushing the use of data and digital tools, producers are faced with a challenge: how to understand and successfully utilize digital technologies on the market.

For this project, the term "digital technologies" were defined as ag data tools that require the use of producer data to provide products and recommendations alongside other similar information. A variety of digital technologies that aid in collecting and analyzing data for producers were evaluated. The digital technologies and associated information were organized and thereby reported within six categories as defined below:

- Data Warehousing - Cloud storage for any type of data. Tools that allow producers to have a centralized location to store data. Data sharing and organization may or may not be functionality provided by a platform.
- Production Benchmarking - Ability for producers to benchmark themselves against other similar farms. These tools provide comparative insights regarding agronomic response, yield, costs, profit margins and possibly other aspects.
- Production Analysis - Platforms where producers can analyze their production data (agronomic, machine, imagery, etc.) and information permitting insights to support decisions.
- In-Season Monitoring - Facilitate in-season monitoring of crop health, development, and stress during the growing season. These tools may harness imagery or organize/simplify scouting notes to identify problem areas quickly.
- Crop Modeling - Includes crop modeling to estimate crop needs (e.g. nutrients) and crop development providing information to support in-season decisions or provide information such as yield estimates.
- Recommendations - Most platforms providing recommendation capabilities can link producers to trusted consultants and advisors so they can support the recommendation process.

The main objectives of the study were three-fold: provide a clearer understanding of technology adoption and limitations, consider alignment of a digital tool to a producer's intended use if adopted, and give insight to producers considering the adoption of digital technologies in each of the six categories.

Materials and Methods

Four primary methods were used to gain information for the purpose of evaluating current digital tools and services. These included a producer survey, company research, focus group workshop, and ag technology expert interviews.

Producer Survey

A producer survey was conducted in an attempt to understand the producer perspective on the value of digital technologies within soybean production. It must be noted that the producers asked to complete the survey were those that have already invested in precision agriculture technologies and are performing variable-rate fertilizer and/or seeding on their farms. These producers were viewed as a group that have already been using their farm data to inform plans and their business, or have been evaluating the use of digital technologies on their farm. The survey was administered through the Qualtrics online survey platform and featured 31 questions regarding demographics, decision-making, technology, and data/digital tools.

Company Research

Company research was completed using online sources, print materials, and other media outlets to research available digital tools and services. Each of the provided tools/services were placed into one or more of the six categories. General descriptions, capabilities, and solutions to producers were collected and a decision matrix of more than 100 companies.

Focus Group Workshop

The workshop portion of the study featured speakers from both industry and academia who presented information about digital technologies. More than 30 workshop participants gained valuable knowledge about the current state of digital ag technology, ongoing research to establish value, and the future of digital ag technologies. The research team utilized the event as an opportunity to open dialogue about the current tools available, as well as to gather feedback using Slido as a presentation/question-and-answer tool. Participants were asked questions similar to those included on the producer survey, as well as additional questions regarding limitations, tools most relevant to soybean production, and ways that producers, industry professionals and future professionals can be better educated about available tools and their value.

Ag Technology Expert Interviews

Information was also gathered via interviews with four noted agricultural technology experts. Each of the expert participants were asked about the current value, any foreseen future value/potential, and the limitations to adoption for each of the six categories.

Results and Discussion

Farmer Survey

While many solutions are being presented to producers, the value of adoption for each tool is not being clearly and accurately conveyed. Combining industry perceptions about the usefulness of digital tools and services with grower opinions of value provides a better understanding of how these tools and services can be used to support soybean production.

When producers were surveyed about the per acre value that technology provides, 51% selected “greater than $15/acre”, 16% estimated “$10-15/acre”, 28% answered “$5-10/acre”, and the remaining 5.7% chose “$2.50-5/acre”. While “less than $2.50/acre” was an option, no respondents selected it, which highlights their belief that agricultural technologies are valuable (Figure 1). With the exception of production benchmarking, the majority of producers did find some level of value in each category. In terms of future value, producers saw the most potential in increasing efficiency, followed by cost savings, increased production, and finally sustainability. In addition,

54% stated they had “high” with 15% “very high” expectations that sharing their data provides value.

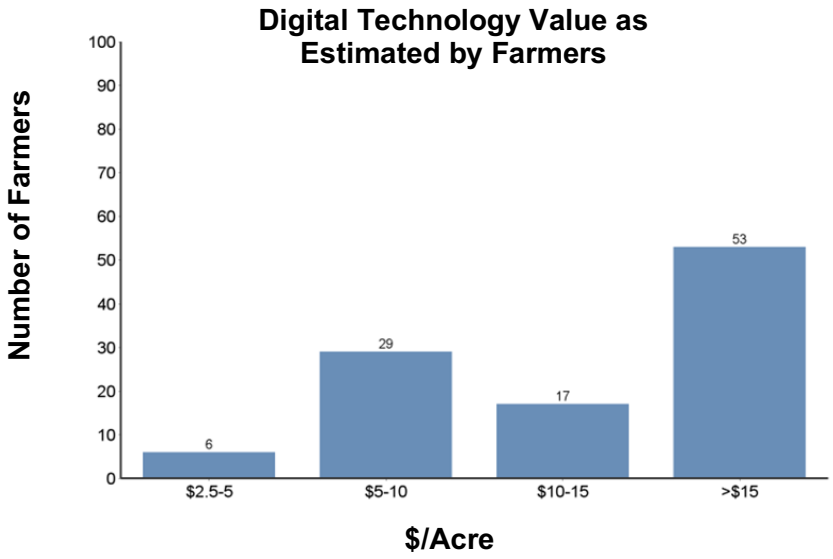

Figure 1. Value per acre of precision technologies as estimated by producers completing the survey.

Surveyed producers were given the opportunity to note the additional value and benefits digital technologies provide towards soybean production. Comments included that imagery is helpful to identify soil health areas, better decisions can be made for the following year, rainfall estimation tools can be used for efficiency gains in irrigation system controls/monitoring, there is a “peace of mind” value in a “game of moving variables”, real time data is available, tracking applications and different tests year-round is useful, and that using digital tools to understand needs of soybean crop results in raising a better quality soybean.

In addition to the value of digital technologies, surveyed participants were asked questions about data layers, how they manage their data, how technology assists in decision making, and many others. Farmers were also asked to identify the categories of digital tools or services that provided value to them. Data warehousing and recommendation tools were most valuable (Figure 2). While producers had the ability to answer "no" and "unsure" to any individual category, almost all categories presented at least some value to producers.

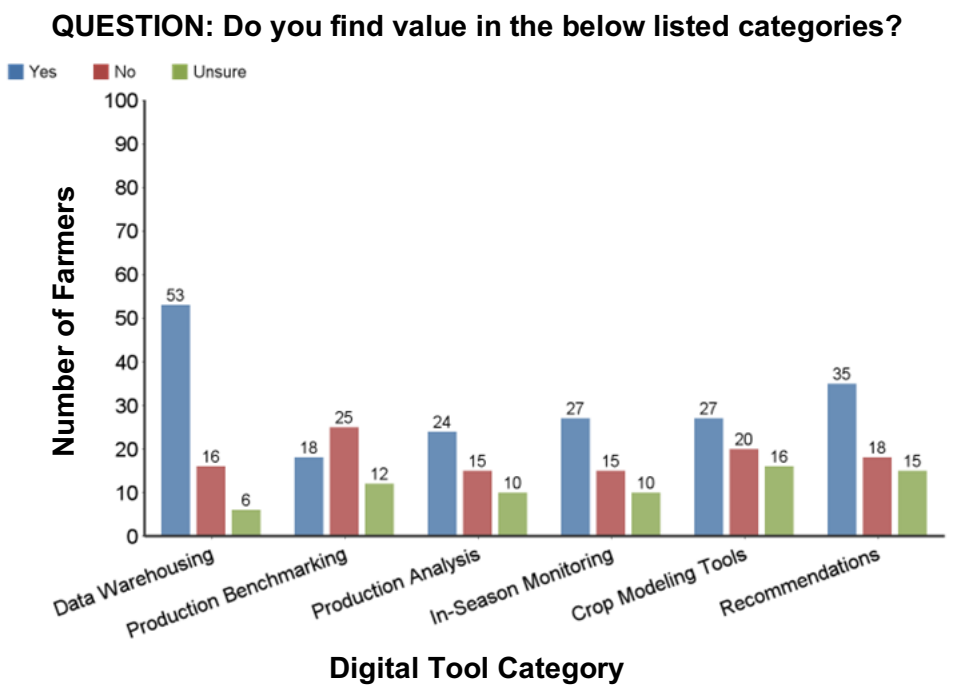

Figure 2. Farmer perceived value by digital technology category.

The producer survey indicated that the greatest potential for digital technologies on their farm was improving farm efficiency as related to input management. Cost savings and improved production efficiency as related to crop inputs and machinery management were also noted as potential value of using digital technologies. However, currently available digital technologies provide limited value for farm sustainability measurements and reporting. In the state of the industry at this time, the real monetary value is provided by ag technology and not digital agriculture tools. 75% of the producers surveyed place the value at more than $15/acre, but many specified that this value stems from the precision ag technologies (autosteer, VRA fertilizer, autoswath, etc.) they have implemented within their farm operation. Beyond the ag technology, producers recognize that their data holds actionable information, but a lack of robust digital ag tools and services limit the translation of that information to true value. 50% of producers find value in data warehousing and recommendations tools. 92% of producers are sharing data today, with 66% sharing with two or more people (seed representatives, consultants, university/extension, retailers, etc.). The most common data recipients were seed representatives and agronomic consultants, with whom more than 60% of producers share data. Nearly 70% of producers have “high” or “very high” expectations that this data sharing is valuable.

While it is evident that there are improvements to be made, active use of technology does exist in soybean production today. 77% of producers indicated that they are viewing variety results online (and 67% with a smartphone or tablet), 88% are using prescription maps, 96% are using data collected as a direct input for management decisions, and 91% are using some type of digital tool or service.

Company Research

The following summarizes results by individual category in an attempt to highlight the value or return on investment each could provide soybean producers.

Data Warehousing (35 companies identified)

The first category of data tools summarized was data warehousing. The biggest benefit noted

was the importance of having a centralized location for all data. This warehouse should have easy access and the ability to share data accurately while still maintaining ownership and security. These tools are the foundation or "backbone" to all other categories, as there is no aspect of data collection where storage and organization does not take place. The days of multiple thumb drives are on the decline and the need for data to be viewed by analytical software and the push for actionable decisions is becoming more and more significant. Currently, the biggest limitations for this suite of tools are a lack of understanding about the value sharing of data, and inconsistencies between the types of data across various platforms. These tools are being underutilized, and though the value may not be able to be monetized five years from now, it will be derived from having data organized as the industry continues to evolve.

Production Benchmarking (15 companies identified)

Production benchmarking was another data tool and service category analyzed. Described as a "next frontier" in bringing profitability to each acre on the farm, there is value in production benchmarking, but also a series of limitations to its usefulness. It is important to understand that not all benchmarking is equal. Factors such as geographical proximity, data quality, and financial multipliers may not be comparable across all operations. If an operation can identify a high-quality, reputable, and comparable dataset to benchmark against, the value of these tools and services greatly increases. Farmers can utilize production benchmarking as a way to discover production inefficiencies that can be corrected to increase overall profits. The ability to compare one operation to another allows for a better understanding of the changes that could be implemented to make the operation more successful. Production benchmarking provides value for comparing across operations, but it is also valuable for comparing previous cropping years within a single operation. This allows for comparisons to be made on inputs, yields, sale prices, etc. Especially valuable is the ability to combine production benchmarking with other production analysis tools and services.

Production Analysis (32 companies identified)

Another critical type of digital tools and services studied was production analysis. A huge feature of production analysis tools is the ability to discover the profitability or ROI of every acre in a field. These tools are often fairly easy to use for those new to the precision agriculture space and also work well with existing data. The most value in this category is achieved when tools are used in conjunction with those in other categories such as production benchmarking, in-season monitoring, and crop modeling. Computers can analyze and sort data faster than humans ever could and use the information to optimize cropping input decisions for maximum efficiency. Several of these tools also offer the ability to view different layers of data side-by-side on mobile devices. The biggest limitations of these tools include the low amount of value they provide without input from other data sources, finding a platform that will analyze data in the way producers desire it, and the ability to sort and collect data to maintain its quality. Strides are being made in the industry in order to streamline multiple data sources into one space for analysis.

In-season Monitoring (19 companies identified)

In-season monitoring was identified as being valuable, though perhaps not as much so as other digital tools or services. Some limitations included reduced accuracy in field boundaries and other datasets, difficulty retrieving data from scouting platforms, and the speed at which decisions can be made from scouting data. In fact, much of the value in in-season monitoring was noted as "future value" due to rapid changes in technology and development. While currently, the value of in-season monitoring did not score as highly with producers and experts, there seems to be a "potential value" aspect as better and/or more organized scouting options with GIS capabilities become available. The value of in-season monitoring is still rather low, but better than it has ever been with increases in imagery resolution, increases in GIS/GPS technology, additional sensors being installed and used to collect data, and an increase in internet connectivity in traditionally isolated areas. As these technologies improve, the value of in-season monitoring is expected to increase.

Crop Modeling (6 companies identified)

Crop modeling was identified as holding the least value at the present time, but potentially having a greater value in the future as algorithms begin to mature and improve. At this point, crop modeling tools present a general understanding of factors influencing a crop and may give producers some awareness of what to look out for in terms of preventative maintenance. However, they usually do not give enough accurate information to make confident decisions. Nitrogen models are one area within this category that has perhaps provided most value to producers. A major limitation is that producers already have access to more telling UAV or satellite imagery and weather data that is more specific to their operation. To increase the value of these tools in the future, more inputs and their impact on economics will need to be added to the software. Another difficulty is that there are huge spatial differences even across states and that there are so many other limiting factors (rainfall, soil conditions, mineralization, etc.).

Recommendations (13 companies identified)

The final digital tool and service category identified and analyzed was recommendations. The value of recommendation tools and services ranked highly, especially with the assistance of trusted advisors and when paired with crop modeling. Farmers often need assistance making decisions, and turn to crop advisors for help. Services that link producers to advisors is a way to "assemble the team" which gives producers resources in options, science, and agronomy to help support the decisions they are making. This process is especially valuable to producers who don't have a nearby trusted advisor in their area, but still need recommendations. As with any of the tools or services this study analyzed, there comes certain limitations. Challenges from producer and expert surveys included the need to develop a trusting relationship between a producer and an advisor, recommendation e-tools that lack "boots on the ground" experience, and the possibility of bad recommendations coming from a cloud based service that is not local to the growing area. As these limitations are corrected for, the value of recommendation tools and services would likely increase.

Focus Group Workshop

A primary concern expressed by the focus group were the roadblocks that prevent data from being simply managed and accessed. When asked about the limitations of existing digital ag technologies, 35% of participants selected "ease of use." However, making digital tools easy to use is not a straightforward task, especially when incoming data is very diverse in terms of content, file structure and formatting.

Another commonly mentioned issue that hinders digital technology usability is the lack of interoperability and the burden of moving data around for use in decision making. When asked if digital tools that provide data warehousing would provide value, 87% of participants indicated "yes."

One participant noted, "There isn't any one way to view all your information. The question is how do we use [digital tools] together to our best ability." Once the agricultural community finds solutions to the logistical problems of data management, these digital tools will be able to translate data into valuable information.

Ag Technology Expert Interviews

A clear message from the focus group of ag technology experts was that data is not going away within agriculture, indicating the shift or evolution of digital agriculture. It was continually noted that education is key to understanding which digital tools and services are useful, and that data collected through precision agriculture technologies is necessary to make improvements to possible agronomic decisions on farms. Another message was that too few people take the time to work with producers' data in way to clearly define the value it can bring to the producer. It was felt that data does hold value and producers need to be able to identify this and use it.

Disconnects between producers' opinions of value and those of the ag technology experts were

identified in all six categories. Analyses from the survey indicated that this disconnect has been the limiting value of digital tools. The experts expressed that producers want tools that are easy to use and interoperable between software and hardware platforms, but noted that the industry is not providing those needs today. Data warehousing was identified as the most valuable, while crop modeling tools are too limited to provide true value to a farm.

Conclusions

By comparing the value of the six digital tool categories as told by surveyed producers and the value reported by ag tech experts, a disconnect was identified. According to producers, data warehousing tools were labeled most valuable followed by recommendation tools. Crop modeling and in-season monitoring tools were tied for value level, with production analysis and production benchmarking being least valuable. Ag tech experts indicated that data warehousing is the most valuable digital tool or service, but production benchmarking was one of the least valuable. A category of interest is crop modeling. While producers noted crop modeling tools and services have some value, the ag tech experts disagreed due to many limiting factors that could make crop modeling results inaccurate.

Additionally, producers are asking for digital technologies that are easy to use and are interoperable between software and hardware platforms. Many of the digital technologies evaluated offered "bells and whistles" but were not addressing these base level concerns. Hundreds of companies are offering digital technologies to producers, but the disconnect between producers and industry is limiting the value of these tools. Once the ag tech community finds solutions to the logistical problems of data management, these tools will be able to translate data into information that can bring further value to producers.

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