Adoption of Precision Agricultural Technology in Kansas

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http://www.agmanager.info/KFMA/Newsletters/Research/PrecisionAgAdoption.pdf

Executive Summary

In this study, Kansas Farm Management Association (KFMA) farms were queried regarding their utilization of ten precision agricultural technologies. Preliminary results indicate the level of adoption in Kansas. Additional analyses provide insights into the true farm management impact of precision agriculture.

Introduction

A recent study evaluated farm-level adoption of precision agricultural technologies. Although this study was unique in that the adoption is tied to farm-level analysis of whole farm productivity (forthcoming), at least one similar study was conducted that arrived at inconclusive results (Olson and Elisabeth, 2003). Olson and Elisabeth (2003) reported whole-farm impacts of precision agriculture adoption from Minnesota early in the infancy of these technologies. Their study attempted to evaluate technology impacts on profitability. They reported 59 of 212 farms surveyed used at least some precision technology in their operation. They suggested that the relatively small sample size was not adequate to discern relatively small expected differences between adopters and non-adopters during the time when even the most innovative farmers were still trying to find the best use of the technology.

Previous studies on technology adoption and profitability were disjointed, focusing on farm-level adoption in one study and the profitability of technology in other studies. Besides Olson and Elisabeth (2003), no studies were found that jointly determined the profitability of technology adoption. However, a series of studies evaluated differing aspects of precision agriculture adoption. Schimmelpfennig and Ebel (2016) use USDA data to report sequential adoption of combine yield monitors with and without GPS (Global Positioning Systems) along with variable rate technologies. They extend their study to examine the cost differences between adopters and non-adopters of precision technology. Lambert et al. (2015) evaluated cotton farmers' adoption of precision technology in bundles; and suggest that farmers have adopted technologies individually and in bundles. The most recognized study of precision agricultural technology adoption does not address farm-level but instead agricultural service providers (Erickson and Widmar, 2015). Their survey has been conducted annually or biannually since 1997 and reports the proportion of service providers using the same technologies examined here.

Data and Methods

During the fall and winter of 2015/2016, the Kansas Farm Management Association (KFMA) dataset was appended with farmers' use of precision agricultural technology (see Appendix for definition of relevant technologies). The KFMA databank includes detailed farm-level agronomic and financial information from 1973 to 2015. Even when considering only farms that were in the KFMA databank each year from 1973 to 2013, there were 425 farms. By June 2016, 348 farms reported their respective adoption and utilization of 10 precision agricultural technologies including the year of adoption and abandonment if no longer in use. Of the 348 responses, 341 responded to either having adopted or not adopted precision technologies. In all, 290 farms reported adopting at least one of the technologies. This preliminary analysis reports on the farms stating the use or nonuse of precision technology with emphasis on the 290 farms using precision agriculture.

Kansas Farmers' Adoption and Abandonment of Precision Agricultural Technologies

Adoption of Precision Technology

GPS-enabled guidance and section control have been readily adopted since commercialization occurred. Figure 1 shows the proportion of KFMA farms that are using the three technologies over time. In 2008, the number of farms using automated guidance surpassed the number of farms using lightbar guidance (Figure 1). Beginning in 2011, the utilization of lightbar guidance leveled off as automated guidance continued to be adopted by Kansas farms (Figure 1).

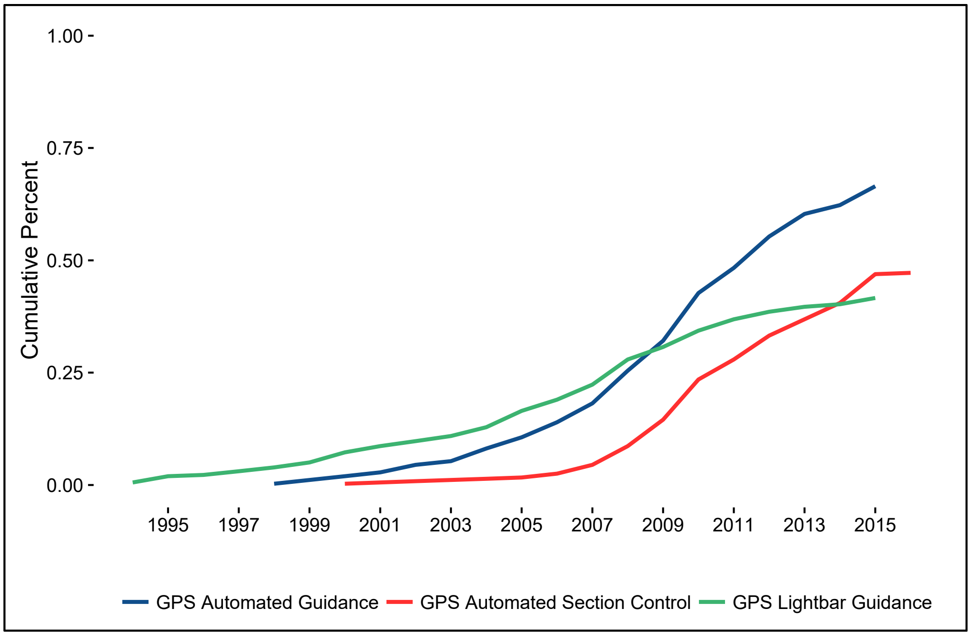

Figure 1. Percent of Kansas farms utilizing GPS guidance over time

Historically, the adoption of yield monitors was the yardstick with which precision agriculture was measured. Today nearly all new combines come equipped with yield monitors although this does not imply utilization at the farm level. Less than half of KFMA farms have adopted yield monitors which is consistent with USDA ARMS estimates (Figure 2). Unlike USDA ARMS survey, the KFMA data suggests relatively more yield monitors being associated with a GPS than without a GPS (Figure 2).

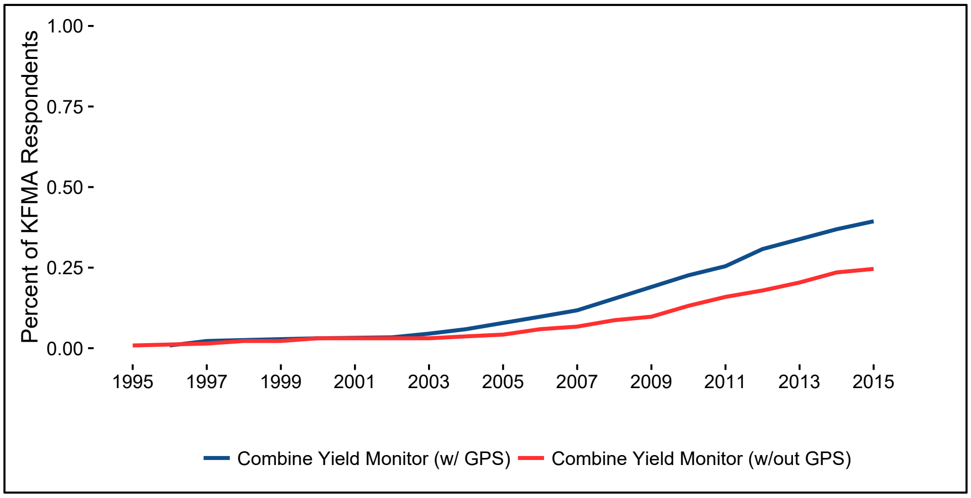

Figure 2. Percent of Kansas KFMA farms utilizing yield monitors

Kansas farms make use of grid soil sampling although adoption rates are still less than half of all farmers reporting to the KFMA study (Figure 3). Roughly one in four and one in five farms make use of variable rate technology for application of fertilizer and seeds, respectively (Figure 3). These results are consistent with USDA ARMS reports.

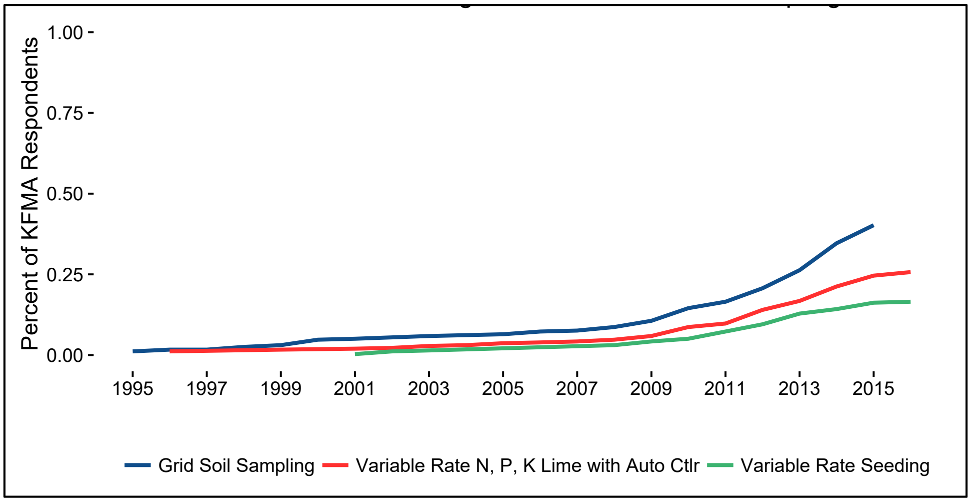

Figure 3. Percent Kansas KFMA farms utilizing grid sampling and variable rate application over time

Table 1 presents the number of farms adopting each of eight technologies. For instance, 228 farms have adopted automated GPS guidance (Table 1). Nearly half (46.6%) of Kansas farms utilize automated section control (Table 1). Only 17% of Kansas farms are using variable rate technology to apply seeds at site-specific rates (Table 1). Using both automated guidance and yield monitors as basis for comparison, the relative proportion of Kansas farms adopting the remaining technologies are presented (Table 1)

Table 1. Number of Kansas farms adopting precision agriculture technology

Technology	**Farms adopting**	**% of total (N=348)**	**as % of AGS (N=228)**	**as % of YM (N=136)**
GPS Automated Guidance	228	65.5	**100.0**	167.6
GPS Automated Section Control	162	46.6	71.1	119.1
GPS Lightbar Guidance	141	40.5	61.8	103.7
Grid Soil Sampling	140	40.2	61.4	102.9
Combine Yield Monitor (w/ GPS)	136	39.1	59.6	**100.0**
Auto Variable Rate N, P, K, Lime	87	25	38.2	64.0
Combine Yield Monitor (w/out GPS)	86	24.7	37.7	63.2
Variable Rate Seeding	58	16.7	25.4	42.6

Abandonment of Technology

Most farms that adopted precision agricultural technology did not abandon the technology except for obsolescence and replacement as expected. For instance, 58 farmers (40% of the total) abandoned combine yield monitors without a GPS (Table 2), most likely to replace with GPS-enabled yield monitor. Manual control GPS guidance, i.e. the lightbar, was expected to become obsolete with the introduction of automated control guidance; and 55 farmers or 28% of the total (Table 2) abandoned manual control technology for automated guidance. Two of the technologies were not abandoned including automated section control and variable rate seeding. For the remaining technologies, it was less clear whether the abandonment was for obsolescence reasons or if the technology were abandoned for performance reasons. The seven farms that abandoned grid soil sampling may have done so by replacing with on-the-go sensing or reverted back to sampling at field regions of greater than 5 acres. The two farms that abandoned GPS yield monitor may have given up on the technology or may have resulted from trading combines before the technology were more common place. Further analysis is necessary to address these uncertainties.

Table 2. Number of Kansas farms abandoning precision ag technology

	Adopters (farms)	Farms abandoned	% farms abandoning
Combine Yield Monitor (w/out GPS)	144	58	40.3
GPS Lightbar Guidance	196	55	28.1
Grid Soil Sampling	147	7	4.8
Auto Variable Rate N, P, K Lime	91	4	4.4
Combine Yield Monitor (w/ GPS)	138	2	1.4
GPS Automated Guidance	229	1	0.4
GPS Automated Section Control	162	0	0
Variable Rate Seeding	58	0	0

Farms that abandoned yield monitors without GPS, lightbar guidance, and grid soil sampling did so after a mean of 5 to 6 years of utilization (Table 3). The maximum number of years of yield monitor without GPS and grid soil sampling were nearly two decades at 20 and 21 years, respectively. Only a few farms have abandoned other technologies such as GPS yield monitors, automated guidance, and variable rate fertility. For each technology that has been abandoned, at least one farm abandoned the technology after the first or second year. It is expected that data technologies such as yield monitors, grid soil sampling, and variable rate application will take multiple years to realize any positive agronomic or financial results.

Table 3. Number of uses technologies utilized before abandonment

	Farms abandoning	Mean years	Min years	Max years
Combine Yield Monitor (w/out GPS)	58	6.2	2	20
GPS Lightbar Guidance	55	5.1	1	13
Grid Soil Sampling	7	5.7	1	21
Auto Variable Rate N, P, K Lime	4	1.3	1	2
Combine Yield Monitor (w/ GPS)	2	2.0	2	2

Next steps

Based on the preliminary results of the 348 farms, conditional probabilities are being estimated. These results will provide indication of the probability that a farm will adopt a specific technology given that another technology is already in the farm inventory. The characteristics of technology adopters will be compared and contrasted to non-adopters. Given the long term KFMA databank, the characteristics of adopters and non-adopters could be determined leading up to and immediately before the farm adopts technology. The study will ultimately evaluate the agronomic and financial impact of Kansas farmers' utilization of these precision technologies.

Acknowledgements

The authors wish to thank KFMA Economists who collected data from KFMA member farmers, Koren Roland with KMAR-105 for data processing, and Emily Carls for data entry from the precision agriculture technology instruments. Authors appreciate Christian Torrez for assisting with creating the graphs within the article. The K-State Research and Extension Precision Ag Team assisted with defining the survey instrument and deciding which technologies to query KFMA member farmers; and include Lucas Haag, Ajay Sharda, Brian McCornack, and Ignacio Ciampitti.

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Appendix A KFMA Precision Agriculture Definitions

Yield Monitor (without GPS)

Yield monitors estimate the grain harvested by sensing the grain moisture content and flow rate through the clean grain elevator.

Yield Monitor (with GPS)

Same as above except that the yield data are recorded along with GPS (Global Positioning System) location.

GPS lightbar guidance

Considered ‘manual’ rather than ‘automated’, the equipment operator must steer the equipment but with the visual aid of the ‘lightbar’ or on-screen display.

GPS Automated Guidance

Automated guidance used on at least one machine including tractors, combines, or other equipment. Any level of GPS accuracy is permissible including WAAS, Coast Guard correction, satellite subscription, RTK, CORS, VRS, or other. The main distinction is that steering for parallel or contour passes through the field are controlled automatically without the equipment operator making manual adjustments. Even with this technology, the equipment operator turns the equipment around near field boundaries.

GPS Automated Section Control

Automatic section control shuts off control section automatically on sub-field areas which have previously received input application or do not need any application; while keeping those control sections on where application is intended. A control section may be a single nozzle or row, pair of nozzles or rows, or a section consisting of multiple nozzles or row units. This technology is commonly used on sprayers and planters.

Grid Soil Sampling

Either soil sampling at less than 5 acres per sample or on pre-defined sub-field management zones. Grids can be square, rectangular, or other sub-field areas of less than 5 acres. Management zones may be based on soils, previous yield history, or a combination of prior information.

Variable Rate application of N, P, K, lime, or other crop nutrients (VRA, VRT)

Use of automatic rate controllers to apply crop inputs such as fertilizer or lime to match conditions (yield potential, soil test) at some sub-field scale.

Variable Rate Seeding (VRS)

Adjustment of the seeding rate to match conditions (yield potential) within a field. Seeds are planted at predetermined seed populations determined using crop and soil data layers within different areas of the field. The crop and soil data layers could include soil type, yield potential, slope, fertility, etc. which would define site-specific seeding rates. VRS technologies can vary the desired seeding rate for the whole planter as well as different seeding rates for any combination of planting rows.

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