Precision Agriculture Technology Adoption and Obsolescence

Terry Griffin (twgriffin@ksu.edu), Noah Miller (njmill@ksu.edu), and Christian Torrez (torrez@ksu.edu)
- Kansas State University Department of Agricultural Economics
Ignacio Ciampitti (ciampitti@ksu.edu)- *Kansas State University Department of Agronomy*
Ajay Sharda (asharda@ksu.edu)- *Kansas State University Department of Biological and Agricultural Engineering*

Executive Summary

Kansas Farm Management Association (KFMA) farms were queried regarding their utilization of precision agricultural technologies. Preliminary results include the likelihood of using one technology given that the farm uses another technology. These analyses provide additional insights into how Kansas farms upgrade from obsolete technology to more advanced options.

Introduction

Over the past year, the KFMA databank was expanded to include farm-level adoption of precision agricultural technologies. This update to the June 2016 KFMA Research Article describes the sequence that Kansas farmers adopted technologies. This analysis builds upon the previous KFMA Research Report (Griffin, 2016) by updating adoption statistics with increased and reporting the likelihood of farms using a specific technology given that they are using another technology. These results will provide indication of the probability that a farm uses a specific technology given that another technology is already in the farm inventory.

Data and Methods

Beginning in the fall of 2015, the KFMA dataset was appended with farmers' adoption of precision agricultural technologies (see Appendix for definition of relevant technologies). The electronic KFMA databank includes detailed farm-level agronomic and financial information from 1973 to 2015. By August 2016, 358 farms reported their respective adoption and utilization of precision agricultural technologies including the year of adoption and abandonment if no longer in use. Of the 358 responses, 350 responded to either having adopted or not adopted precision technologies. In all, 299 farms reported adopting at least one of the technologies.

Proportion of Farms

The KFMA data provides useful information on the likelihood of farms to engage in adoption of technology given other technologies being utilized. The proportions presented in Table 1 and Table 3 show a farm's probability of adopting one technology given that another technology is being used on the farm in the same year. These technologies include precision soil sampling, variable rate application of fertilizer, variable rate seeding, yield monitor without GPS, yield monitor with GPS, GPS automated guidance, lightbar guidance, and automated section control. To allow tables to be readable, the technologies were split into two groups to be reported. The first group has the two yield monitor technologies (with and without GPS) and the three GPS guidance technologies (lighbar, automated guidance, and automated section control). The second group includes precision soil sampling and the two variable rate application technologies (fertility and seeding) compared to the 'yardsticks' of automated guidance and yield monitor with GPS.

The first column in Table 1 and Table 2 lists the technologies that are 'given', meaning that these are the technologies that are the basis for comparison. The top row lists the same technologies, but indicate the technology utilization 'given' that the other technology is being used on that farm. The values diagonally along the tables are blank since statistics on a technology given the same technology does not provide useful information. For example, for a farm that uses a combine yield monitor with GPS, the probability that the farm uses automated guidance is 97% (both Table 1 and Table 2 present this information). Farmers who use yield monitors without GPS are less likely to use section control and automated guidance than farmers who have GPS on their yield monitors (Table 1).

Farms that use variable rate application of fertilizer have 92% likelihood of using grid soil sampling while the probability of using variable rate seeding is 37% (Table 2). In other words, farms that use variable rate application of fertilizer are more likely to use grid soil sampling than variable rate seeding. For farms that have yield monitors with GPS, the probability of using variable rate seeding is 36%, while the probability of having automated guidance is 97%. Farms that have adopted yield monitor with GPS are therefore more likely to utilize automated guidance than variable rate seeding.

Table 1. Percent of farmers adopted a technology with respect to another technology.

	Probability of Adopting…				
Given …	Yield monitor	Yield monitor w/ GPS	Lightbar	Automated guidance	Section control
Yield monitor	-	55%	71%	86%	65%
Yield monitor w/ GPS	58%	-	69%	97%	87%
Lightbar	51%	48%	-	80%	58%
Automated guidance	54%	59%	69%	-	69%
Section control	57%	74%	70%	97%	-

Based on the information in Table 1 and Table 2, we can conclude that some technologies are preferred to others for farms given that other technology is being utilized. The proportion of farms adopting automated guidance was highest, ranging from 87% (for farms that had previously adopted grid soil sampling) to 98% (for farms that had previously adopted variable rate seeding) (Table 1). As we reported earlier, the adoption of automated technologies such as tractor guidance has much greater adoption than information technologies such as data collection (yield monitors, grid soil sampling) and sub-field decisions (variable rate applications of fertilizer and seeds). Since most KFMA farms utilize automated guidance while less than half utilize GPS yield monitors or variable rate applications, it logically follows that the proportion of farms adopting automated guidance given any other technology would be the highest values in the table. In addition, some sort of GPS is required to be utilized on the farm to make controller-driven variable rate applications and to collect site specific yield monitor data (i.e. GPS yield monitor). Since GPS is already being utilized on the farm, then it stands to reason that one of the major uses of GPS is for automated guidance. As opposed to automated guidance, variable rate seeding had much lower adoption rates, and lower proportions ranging from 24% (for farms that had adopted automated guidance) to 37% (for farms that had adopted variable rate fertilizer application. It seems intuitive that if a farm utilizes variable rate fertilizer then making use of variable rate seeding would be a natural technology to adopt.

Table 2. Proportion of Farms' Adoption of Precision Agriculture Technologies

	Probability of Adopting…				
Given…	Precision Soil Sampling	Variable Rate Fert.	Variable Rate Seed	Yield Monitor w/ GPS	Automated Guidance
Precision Soil Sampling	-	59%	30%	65%	87%
Variable Rate Fert	92%	-	37%	68%	92%
Variable Rate Seed	75%	60%	-	86%	98%
Yield Monitor (w/GPS)	69%	46%	36%	-	97%
Automated Guidance	55%	37%	24%	58%	-

To make decisions on variable rate fertilizer, site-specific information on soil fertility is needed. Three of the leading methods to obtain data sufficient for variable rate applications are on-the-go sensor based and map based from yield monitors (for nutrient replenishment based on grain nutrient removal) and precision soil sampling (for sufficiency, buildup, and maintenance) (see Ess et al. 2001 for overview of sensor-based versus map-based variable rate application systems). Therefore, from our data it is expected that farms utilizing variable rate fertility that either a GPS yield monitor (69%) or precision soil sampling (92%) was used to make prescription applications. Since the highest proportions given variable rate fertility is for precision soil sampling, it can be concluded that farms rely mostly on chemical analysis of soil samples rather than yield data as a proxy for nutrient removal especially when applying phosphorus and potassium.

Obsolescence and Sequential Adoption of Precision Agricultural Technologies

Data from the Kansas Farm Management Association (KFMA) provides insights into how farmers transition from one set of precision agricultural technology to another. Kansas farmers have adopted precision agricultural technology at similar rates as the rest of the United States. Detailed KFMA data from 358 farms indicated how some of the technologies were abandoned after having been used for several years.

Of the 10 precision agriculture technologies examined, six were abandoned by at least one farm that had used the technology (Table 3). Four technologies had relatively low abandonment rates (1 to 4% of total adopters) while two were more substantial. Specifically, yield monitor without GPS and lightbar guidance had relatively large proportions of farmers ceasing to use the technology at 41% and 28%, respectively. However, these particular technologies were also the two that were considered obsolete once more advanced technology became available.

These two technologies are representative of the major types of precision technology; embodied-knowledge and information-intensive technology. Yield monitors are the classic example of information-intensive technologies due to providing data but requiring additional management ability. Lightbar represents embodied-knowledge technology since the user does not have to have the same abilities as without the technology. Given that higher forms of these technologies are available, it seems intuitive that some farms abandoning yield monitors or lightbars may have upgraded. We examined whether this was the case.

For yield monitors without GPS, we expected yield monitor with GPS to be adopted by the next harvest season after ceasing to use the first technology. For farms that ceased to use lightbar guidance, we expected that automated guidance was either already in the farm inventory or was immediately adopted by the next season.

Of the 60 farms that ceased to use yield monitors without GPS, only six farms gave up yield monitors without adopting yield monitor with GPS by the next harvest. Of these six farms, three never adopted another yield monitor, and the other three adopted GPS yield monitors within six years after ceasing to use the initial yield monitor without GPS. Fifty-four farms adopted yield monitors with GPS by the next harvest season, i.e. within one year. Taking into consideration the number of farms that upgraded, six, or 4% of farms actually abandoned yield monitors.

Of the 57 farms that abandoned GPS lightbar guidance, 79% either already had GPS automated guidance on the farm or adopted by the next growing season. When the farms that upgraded from lightbar to automated guidance was taken into account, only 6% of farms that adopted lightbars abandoned any guidance technology. Of the farms that ceased to use LB, 12 were already using automated guidance on other equipment. Eight farms that ceased to use lightbars adopted automated guidance after at least a gap of two years. Thirty-three farms adopted automated guidance immediately after ceasing to use lightbar guidance. Two farms ceasing lightbar guidance abandoned guidance technology altogether.

The KFMA dataset accounted for farms that abandoned technology use so that current technology use could be reported. These data also provided the ability to determine how Kansas farms replaced or upgraded obsolete technology for more advanced capabilities. The proportion of farms that truly abandoned technology was similar across all technologies once upgrades were accounted for. Our results suggest that less than 6% of Kansas farmers who adopt precision agricultural technologies ever truly abandoned the technology.

Table 3 KFMA farms adopting, upgrading, and abandoning precision agriculture technology

	Number of Farms				% abandoned
Technology	adopt	abandon	upgrading	abandon (adjusted)**	
Yield Monitor without GPS	147	60	54	6	4
Lightbar Guidance	202	57	45	12	6
Grid Soil Sampling	149	6	NA	6	4
Variable Rate Fertility	94	3	NA	3	3
Yield Monitor with GPS	142	2	NA	2	1
Imagery	46	1	NA	1	2

Kansas Farm Management Association, Sample size = 358.
*NA = Not applicable to upgrade
**Adjusted accounts for farms that upgraded immediately to more advanced technology

Next steps

Building upon the results presented here, the sequential probabilities are being estimated. Rather than examine what technologies exist on the farm at the same time, it is important to understand the order, or sequence, that technologies are adopted. The characteristics of technology adopters will continue to be compared and contrasted to non-adopters. Given the long term KFMA databank, the characteristics of adopters could be determined immediately before adoption to determine which farms are likely to be the next users of spatial technologies. One goal of this long-term study is to evaluate the agronomic and financial impact of technology adoption on Kansas farms.

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K-State Agricultural Economics | 342 Waters Hall, Manhattan, KS 66506-4011 | (785) 532-1504 | fax: (785) 532-6925

Appendix

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.

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

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.

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.

Precision 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. Other precision soil sampling methods are included.

Variable Rate Fertility 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 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.