Kansas Farms' Sequence of Information-intensive Precision Agriculture Technology Adoption in Bundles

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Beginning in the fall of 2015, Kansas Farm Management Association (KFMA) members were surveyed regarding their adoption of precision agricultural technologies. Of the 358 responses, 348 responded to either having adopted or not adopted information-intensive precision technologies. The three information-intensive technologies included 1) yield monitor (YM) with or without GPS 2) variable rate application of inputs (VR), and 3) precision soil sampling (PSS) (see Table 1 for description of technology). Combinations of these three technologies in addition to a possible "no technology adopted" response resulted in eight categories of technology or bundles. Each year, farms were classified as having one of these eight possible bundles of precision agriculture technology. Figure 1 shows the level of adoption of the different technology bundles by year. As illustrated in the figure, adoption of precision agricultural technologies has increased over the past 17 years, with the use of yield monitors and YM, PSS, and VR as the two primary bundles being adopted.

Table 1 Brief description of technologies

Technology	Description use in survey
Yield monitor (YM)	Yield monitors estimate the grain harvested by sensing the grain moisture content and flow rate through the clean grain elevator either with or without GPS.
Variable rate application (VR)	Use of automatic rate controllers to apply crop inputs such as fertilizer, lime, or seed to match conditions (yield potential, soil test) at some sub-field scale.
Precision soil sampling (PSS)	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.

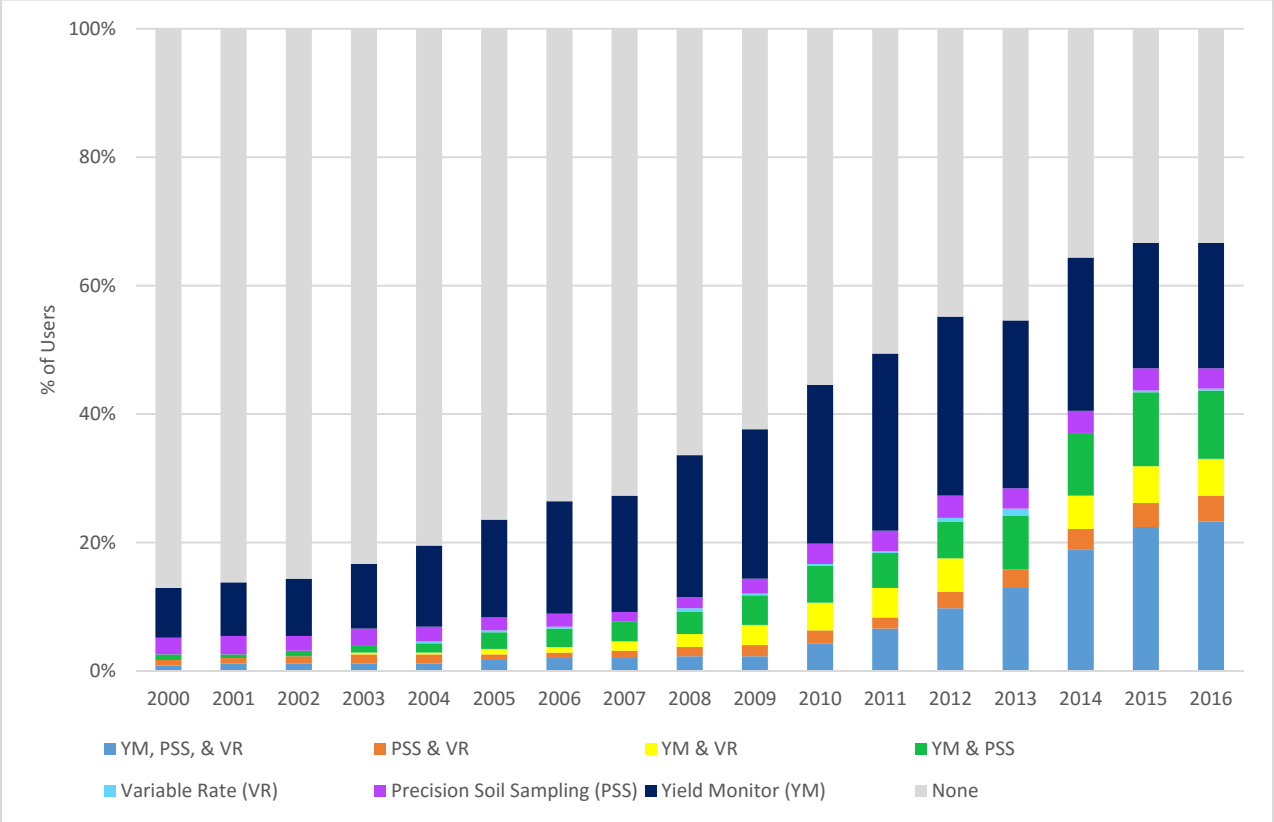

Figure 1. Precision Ag Technology Usage (Adopters & Non-Adopters): 2000 – 2016 N=348

The probability of transitioning from one bundle of precision agricultural technology to any other bundle was estimated over a 17-year time period from 2000 to 2016. Each of the 348 farms contributed 16 observations over the 17 years. Probabilities were estimated to indicate the likelihood that a farmer would stay with the same bundle of practices or transition to a different bundle in a given year. The underlying assumption of these models is that the state of the world in the current year is only a function of the previous year.

The probability of transitioning from adoption of one bundle of precision agricultural practices to another bundle was estimated for all farms that were in the KFMA database for all years from 2000 to 2015 (Table 2). Results indicate that farms tend to remain with the same bundle of technology, however

transitions between bundles were observed. For example, the values in each row show that farms moved from using the given technology (in the row) to another technology use category or stayed in the same category (in the columns). Consider the bundle of YM and PSS in row 6 of Table 2. The likelihood that farms keep using YM and PSS from year to year is approximately 89%; however, the likelihood of farms adding variable rate technology (VR) to this bundle of precision agricultural practices is approximately 11%.

Table 2. Transition probabilities between bundles of information-intensive precision agriculture technologies, 2000-2016 N=358

	none	PSS	PSS VR	VR	YM	YM PSS	YM PSS VR	YM VR
none	0.942	0.008	0.003	0.002	0.038	0.001	0.003	0.003
PSS	0.014	0.822	0.041	0	0	0.116	0.007	0
PSS VR	0.011	0	0.935	0	0	0	0.054	0
VR	0	0	0	0.533	0	0	0	0.467
YM	0.008	0	0	0	0.903	0.037	0.025	0.026
YM PSS	0	0	0.004	0	0.004	0.886	0.105	0
YM PSS VR	0	0	0	0	0	0.003	0.993	0.003
YM VR	0.119	0	0	0	0.008	0	0.102	0.771

In all cases, farms tended to remain with the given level of technology adopted in the previous year. For instance, when a farm had only YM in the previous year there was 90% likelihood that the farm would only have YM in the current time period. However, when a farm with only yield monitor in the previous year adds another technology, then most of the time farms adopted PSS followed by VR or a combination of VR and PSS.

However only about half of the farms that used only VR technology in the previous year still used only that technology the following year. The other half (47%) of the time, those farms with only VR added YM. The behavior of farms using the YM and VR bundle is interesting. Only about three-

fourths of the time did these farms remain with the current bundle. Twelve percent of the time farmers with the YM and VR combination transition to no precision agriculture technology in the next time period. Ten percent of the time these farms with yield monitors and variable rate add precision soil sampling, the most persistent combination of technologies.

The behavior of non-adopters, or those that had no precision agriculture technology in the previous year is also interesting. For a farm that had none of the bundles analyzed, the probability that the farm would have multiple technologies bundles (YM and VR, YM and PSS, PSS and VR, or YM, PSS, and VR) in the following year was very slight, with all probabilities below half of one percent. For these non-adopter farms, the probability of adopting an individual technology was greater than the probability of adopting a bundle of technologies but these probabilities were still small. When farms transition from no technology, they are most likely to adopt YM and to a lesser extent PSS. However, the least likely movement from no technology was a combination of YM and PSS. For farms that had no technology bundle in the previous year, the probability of still having no precision agriculture technology the next year was much higher, at 94%, second only to the probability of farms that had all three bundles (YM, PSS, and VR) in the previous year would still have all three technology bundles the following year. These results suggest that farms inhabiting either end of the adoption spectrum (i.e. those with no technology bundles and those with all three information-intensive technologies) behave differently than those farms that have adopted only one or two technologies – they are more steadfast in their stance towards technology adoption. We are hopeful that further insights into farm decision-making regarding technology adoption can be made by examining this unique data set.