



Find the full report at www.ers.usda.gov/publications/err-economic-research-report/err217

Farm Profits and Adoption of Precision Agriculture

David Schimmelpfennig

What Is the Issue?

How and whether farm managers decide to adopt new technologies is complex, but most account for the full costs and benefits of the proposed investment. Precision agriculture (PA) technologies require a significant investment of capital and time, but may offer cost savings and higher yields through more precise management of inputs. Until the early 2000s, the adoption rate of different PA technologies varied up to 22 percent across major U.S. field crops. After that time, adoption of some technologies began to outpace others. Yield mapping via Global Positioning System (GPS) grew faster for corn and soybeans than for other crops, while adoption of soil mapping varied substantially across crops. Tractor guidance systems have grown faster than variable-rate input application for all major field crops over the last 10 years.

This study investigates recent trends in PA adoption, the production practices and farm characteristics associated with adoption, and whether adoption is associated with greater profitability.

What Did the Study Find?

This report examines adoption rates for three types of PA technologies: (1) GPS-based mapping systems (including yield monitors and soil/yield mapping); (2) guidance or auto-steer systems; and (3) variable-rate technology (VRT) for applying inputs.

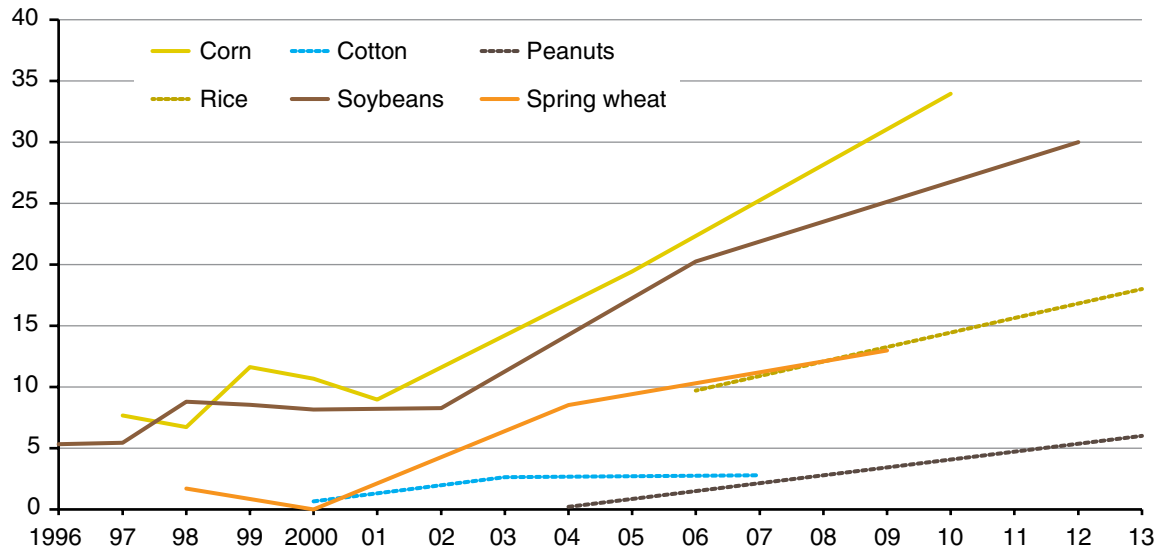
- **Adoption rates vary significantly across PA technologies:** Yield monitors that produce the data for GPS-based mapping are the most widely adopted, used on about half of all corn (2010) and soybean (2012) farms, while guidance or auto-steer systems are used on about a third of those farms and GPS-based yield mapping on a quarter. Soil mapping using GPS coordinates and VRT are used on 16 to 26 percent of these farms.
- **The largest corn farms, over 2,900 acres, have double the PA adoption rates of all farms:** 70-80 percent of large farms use mapping, about 80 percent use guidance systems, and 30-40 percent use VRT.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

- The share of all corn and soybean *acres* on which PA technologies are used tends to be higher than the share of *farms*, implying that larger farms are more likely to adopt these technologies. Yield mapping is used on about 40 percent of U.S. corn and soybean acres, GPS soil maps on about 30 percent, guidance on over 50 percent, and VRT on 28-34 percent of acres.
- **PA technology adoption and farm size both influence production costs on corn farms:**
 - Hired labor costs are 60 to 70 percent lower with any of the three PA technologies on small corn farms (140-400 cropland acres), while hired labor costs are higher on large farms that have adopted precision mapping and guidance. The additional use of hired labor on larger farms may be for information management and field operation specialists that can help implement PA technologies. Larger farms have higher expenses for other inputs that these specialists can help control using PA. Custom service expenses are higher with mapping and guidance on both large and small corn farms under all three PA technologies. However, custom operation costs are five times larger, in percentage terms, on small farms than on large farms.
- **Statistical analysis finds that several production inputs and practices are associated, both positively and negatively, with adoption of PA technologies on corn farms:**
 - Non-GPS-based soil testing increases the adoption of all three PA technologies.
 - Higher levels of unpaid labor and higher yield goals, representing the farmer’s self-reported yield potential, have a negative effect on PA adoption. Unpaid labor is a large, fixed overhead expense that may reduce the flexibility to adopt PA technologies. When yield goals are higher, farmers may already be close to the production potential for their land, whereas farmers with lower yield goals may be using the technologies to try to raise yields on land known to be less productive.
 - A bigger stock of machinery on corn farms has a negative effect on VRT adoption, possibly because of higher overhead costs, and less flexibility in taking on new capital outlays.
- **All three technologies have small positive impacts on both net returns (including overhead expenses) and operating profits for a U.S. corn farm of average size:**
 - GPS mapping shows the largest estimated impact among PA technologies, with an increase in operating profit of almost 3 percent on corn farms. The impact of mapping on net returns is almost 2 percent.
 - Guidance systems raise operating profit on corn farms by an estimated 2.5 percent and net returns by 1.5 percent.
 - Variable-rate technology (VRT) raises both operating profit and net returns on corn farms by an estimated 1.1 percent.
- **Corn and soybeans have had higher shares of acreage using yield mapping than other crops, but use of yield maps has increased for peanuts, rice, and spring wheat as well.**

Adoption of yield mapping (by crop)

Percent of crop planted acres



Source: USDA, Economic Research Service estimates using data from the Agricultural Resource Management Survey (ARMS) Phase II.

How Was the Study Conducted?

This study uses national data on U.S. field crop production between 1996 and 2013 (the latest available) from the Agricultural Resource Management Survey (ARMS) of field crop producers, jointly administered by USDA's National Agricultural Statistics Service (NASS) and ERS. The survey data allow examination of detailed field-level production and financial information for a large sample of farms. Use of three PA technologies—information mapping, guidance systems, and VRT—is examined for each farm. An econometric model is estimated that controls for selection bias since large corn farms tend to be both more profitable and early technology adopters.