Digital Agriculture's Impact on Crop Inputs

Midwest Agriculture Conference

Bruce Erickson, PhD, Agronomy

PURDUE UNIVERSITY® | College of Agriculture

Quick Bio of Bruce Erickson

- Grew up on Iowa farm
- Iowa State University Agronomy B.S., 1983, M.S. 1996
- 1983-1996 Agronomist, Pioneer Hi-Bred (Corteva), southwest Iowa
- 2000 Purdue University Ph.D., Agronomy
- 2001-2004 Senior Technical Designer, Agri-Business Group, Indianapolis
- 2004-2011 Associate Director, Center for Commercial Agriculture, Purdue
  Top Farmer Crop Workshop, Site-Specific Management Center
- 2011-2013 Education Manager, American Society of Agronomy
  Certified Crop Adviser
- Director, Agronomy e-Learning, Clinical Prof of Digital Ag, Purdue Univ
  AGRY 105, Data Science for Agriculture

Early 1960s, Iowa

PURDUE UNIVERSITY

Precision Dealer Survey

- 24th Survey, first was 1997
- Collaboration of CropLife and Purdue
- Topics:
  - Technologies used by retailers in their business
  - Precision products and services offered to customers
  - Retailers’ estimation of farmer use of precision practices
  - Profitability, constraints to adoption

PURDUE UNIVERSITY | College of Agriculture

CropLife July 2024 Cover Story

COVER STORY

2024 *CropLife*/Purdue Precision Ag Survey

Charting a New Wave of Precision Agriculture

While adoption rates are picking up for many forms of precision technology, including artificial intelligence, there is still plenty of room to grow.

BY BRUCE ERICKSON and JAMES LOWENBERG-DEBOER

NEW FORMS OF DIGITAL TECHNOLOGY are making their presence known on farms and the businesses that support them, according to data from the 2024 Precision Agriculture Dealership Survey. These include new applications of automation, using UAVs/drones for input applications, and of course artificial intelligence (AI)—where everyone wants to play now! Who is using them, and why? Understanding their use and value can seem more complicated than our more familiar precision practices. In recent years we have reported mostly on long-time, foundational precision ag — yield monitors/mapping, GPS guided precision soil sampling, variable rate applications, satellite/aerial imagery, autoguidance, all originating in the 1990s. With many of the foundational technologies either maturing with widespread adoption or in a state of stagnation, for the 2024 survey we decided to focus more on the new and what is possibly headed our direction.

Adoption of the New

Many dealers have plans for these new technologies (**Figure 1**). About a third say they are currently offering crop inputs (such as a pesticide) applied with a UAV/drone — but fully half say they will be offering this in three years, a remarkable rise from three years ago. Robotics for soil sampling, crop scouting, and for crop weeding are only offered by a small percentage of dealers now, but more dealers plan to offer these in the future. Artificial intelligence that identifies weeds for spraying is offered by just 11% of dealers now, but a quarter say they will offer this service three years out.

Figure 1: Precision Technology Adoption Rates

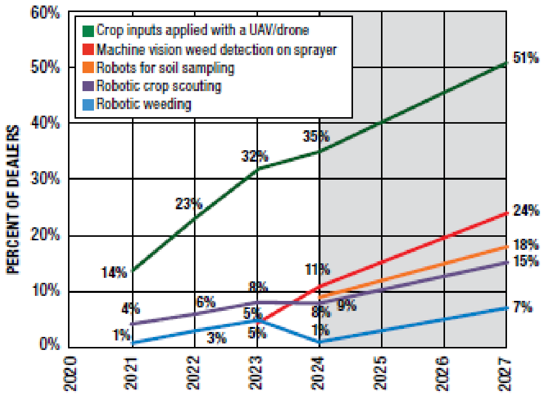


FIGURE 1: Dealer offerings of selected precision technologies over time. 2027 are projections.

Survey Methodology

The *CropLife*®/Purdue Precision Survey is the longest-running continuous study of precision farming adoption, conducted at least every other year since 1996. The 108 agricultural retailer input supplier respondents mostly from the Midwest included cooperatives, independent retailers, and those part of a regional or national chain. Those answering as a farm equipment dealer or consultant in the first question were not allowed to continue. The results reported are for dealers that identified as primarily working with field crops such as corn, soybeans, wheat, rice, cotton, milo, sugar beets, and forages. Dealers that work with specialty crops such as tree fruits and nuts, vegetables, berries, and grapes are analyzed separately. A full report detailing all of the 2024 results will be posted online later this year. The full report from the 2023 survey, and also previous years, can be accessed here: **https://ag.purdue.edu/digitalag/precision-agriculture-dealer-survey.html**

Comprehensive Review of Precision Ag Worldwide

Most downloaded in Agronomy Journal in 2021

Open Access for Anyone

Large Grain Farms Have Led Adoption of Precision Farming Around the World

Very Little Adoption on Non-Mechanized Farms

PURDUE UNIVERSITY | College of Agriculture

Published online May 23, 2019
REVIEW

Setting the Record Straight on Precision Agriculture Adoption

James Lowenberg-DeBoer and Bruce Erickson*

ABSTRACT

There is a perception that adoption of precision agriculture (PA) has been slow. This study reviews the public data on farm level use of PA in crop production worldwide. It examines adoption estimates for PA from completed surveys that utilized random sampling procedures, as well as estimates of adoption using other survey methods, with an objective to document the national or regional level adoption patterns of PA using existing data. The analysis indicates that Global Navigation Satellite Systems (GNSS) guidance and associated automated technologies like sprayer boom control and planter row or section shutoffs have been adopted as fast as any major agricultural technology in history. The main reason for the perception that PA adoption is slow is because PA is often associated with variable rate technology (VRT)—just one of many PA technologies, one of the first adopted by many farmers, but that now rarely exceeds 20% of farms. This level of adoption suggests that farmers like the idea of VRT, but are not convinced of its value. VRT adoption estimates for niche groups of farmers may exceed 50%. The biggest gap in PA adoption is for medium and small farms in the developing world that do not use motorized mechanization.

Core Ideas

- There is a perception that adoption of precision agriculture has been slow.
- Precision agriculture is not one technology but a toolkit from which farmers choose what they need.
- Global Navigation Satellite Systems guidance is being adopted rapidly.
- Variable rate technology adoption rarely exceeds 20% of farms.
- Use of precision agriculture technology on non-mechanized farms is almost nonexistent.

BECAUSE PRECISION AGRICULTURE (PA) is considered an approach that meets production and environmental goals simultaneously, both scientists and policymakers have been investigating techniques to overcome adoption barriers (Pierpaoli et al., 2013; Silva et al., 2015; Keskin and Sekerli, 2016; Paustian and Theuvsen, 2017; Kendall et al., 2017; and Thompson et al., 2018). For example, the World Agri-Tech Summit in London, UK, Oct. 17, 2018, had a session entitled, "Tackling Adoption Barriers: What Value is Digital Agriculture Bringing to the Farm"?, and in 2015 the UK Parliament Office of Science and Technology stated, "Precision farming uses technology to improve efficiency. It offers benefits for yields, profits and the environment. However, uptake by farmers has been slow" (POST, 2015:p. 1). The Italian Ministry of Agriculture, Food, and Forestry (2015) guidelines for PA make a similar comment. These reports suggest that there is an adoption barrier, which may or may not be accurate.

In spite of high profile reports, the data tells a different story. Some aspects of PA were adopted as quickly and as widely as any technology in history, while others have lagged behind for technical and economic reasons. The objective of this study is to set the record straight on PA adoption by reviewing the available data with an eye on data reliability and to hypothesize adoption trends. Because PA adoption data collection methods vary widely from country to country, there are limitations in making direct numerical comparisons. Consequently, the methodology is impressionistic comparison that looks at the big picture, rather than making quantitative comparisons. This study will be of interest to PA researchers and educators across all the disciplines involved, to agribusinesses involved in manufacturing and selling PA tools, and policymakers concerned about agricultural productivity and the environment.

The lack of a clear definition of PA makes tracking adoption more difficult. One aspect of this problem is how to distinguish PA from other terms describing agricultural technology (e.g.,

J. Lowenberg-DeBoer, Elizabeth Creak Chair of Agri-Tech Economics, Harper Adams Univ., Newport, Shropshire UK TF10 8NB; B. Erickson, Agronomy Education Distance & Outreach Director, Purdue Univ., West Lafayette, IN 47907. Received 14 Dec. 2018. Accepted 27 Feb. 2019. *Corresponding author (berickso@purdue.edu).

Abbreviations: ARMS, Agricultural Research Management Survey; DEFRA, Department of Food and Rural Affairs; EC, electrical conductivity; EMBRAPA, Brazilian Agricultural Research Corporation; GM, Genetically Modified; GNSS, Global Navigation Satellite Systems; GPS, global positioning system; GRDC, Grain Research and Development Corporation; ISPA, International Society of Precision Agriculture; INTA, National Institute for Agricultural Technology; KFMA, Kansas Farm Management Association; PA, Precision Agriculture; TAM, Technology Acceptance Model; VRT, Variable Rate Technology; WCA, World Census of Agriculture.

Published in Agron. J. 111:1–18 (2019)
doi:10.2134/agronj2018.12.0779
Available freely online through the author-supported open access option

Global Adoption of Precision Agriculture: An Update on Trends and Emerging Technologies

Jonathan McFadden[A], Bruce Erickson[B], James Lowenberg-DeBoer[C], Gabor Milics[D]
[A]USDA Economic Research Service, Washington, DC, USA 20250
[B]Purdue University, West Lafayette, IN, USA 47907
[C]Harper Adams University, Shropshire, Newport TF10 8NB, UK
[D]Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary

A paper from the Proceedings of the
16th International Conference on Precision Agriculture
21-24 July 2024
Manhattan, Kansas, United States

Abstract.

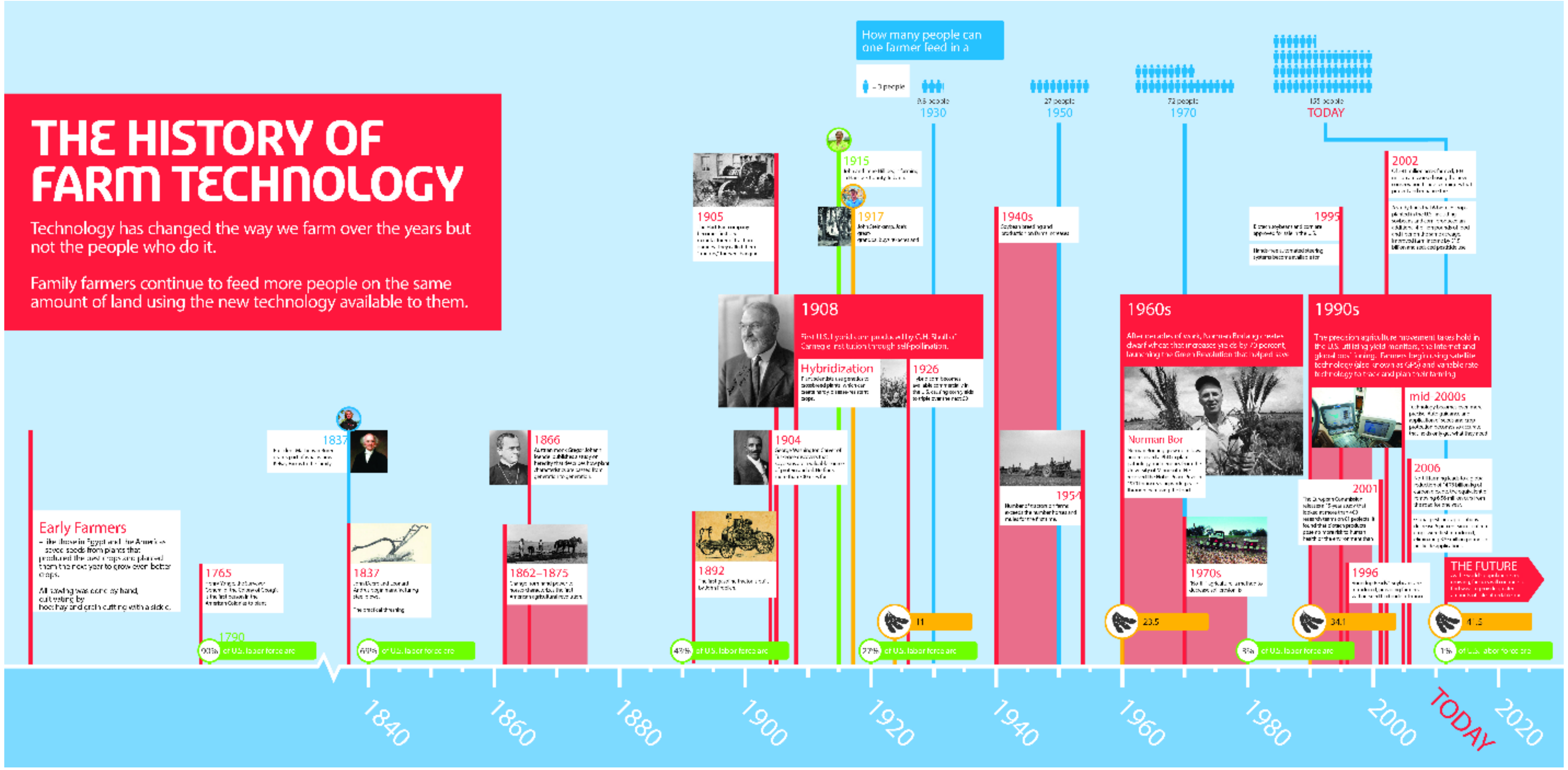
The adoption of precision agriculture (PA) varies greatly around the world according to region, crop, farm type and size, and other factors. This research provides an update on PA adoption and poses hypotheses on likely adoption patterns in the next decade. The major challenge with estimating PA adoption levels is that statistically robust PA adoption surveys are conducted in few countries worldwide. The availability of estimates from national statistical offices (NSOs) of 48 countries and other international sources was rigorously assessed. Survey results are reported from the Grains Research and Development Corporation (GRDC) of Australia, United States Department of Agriculture (USDA), the CropLife-Purdue Precision Dealer Survey, Denmark Statistics, the Hungarian Central Statistical Office, the United Kingdom Department for Environment, Food and Rural Affairs, Statistics Canada, Statistics Estonia, Statistics Portugal, Mexican National Institute of Statistics and Geography, and other organizations. Results are disparate, so summary statements are difficult. Global Navigation Satellite System (GNSS) guidance has been adopted rapidly worldwide on large, mechanized grain and oilseed farms. No survey results from any country, region, or crop show variable rate technology (VRT)

Update of Precision Ag Adoption Worldwide

https://www.ispag.org/Proceedings

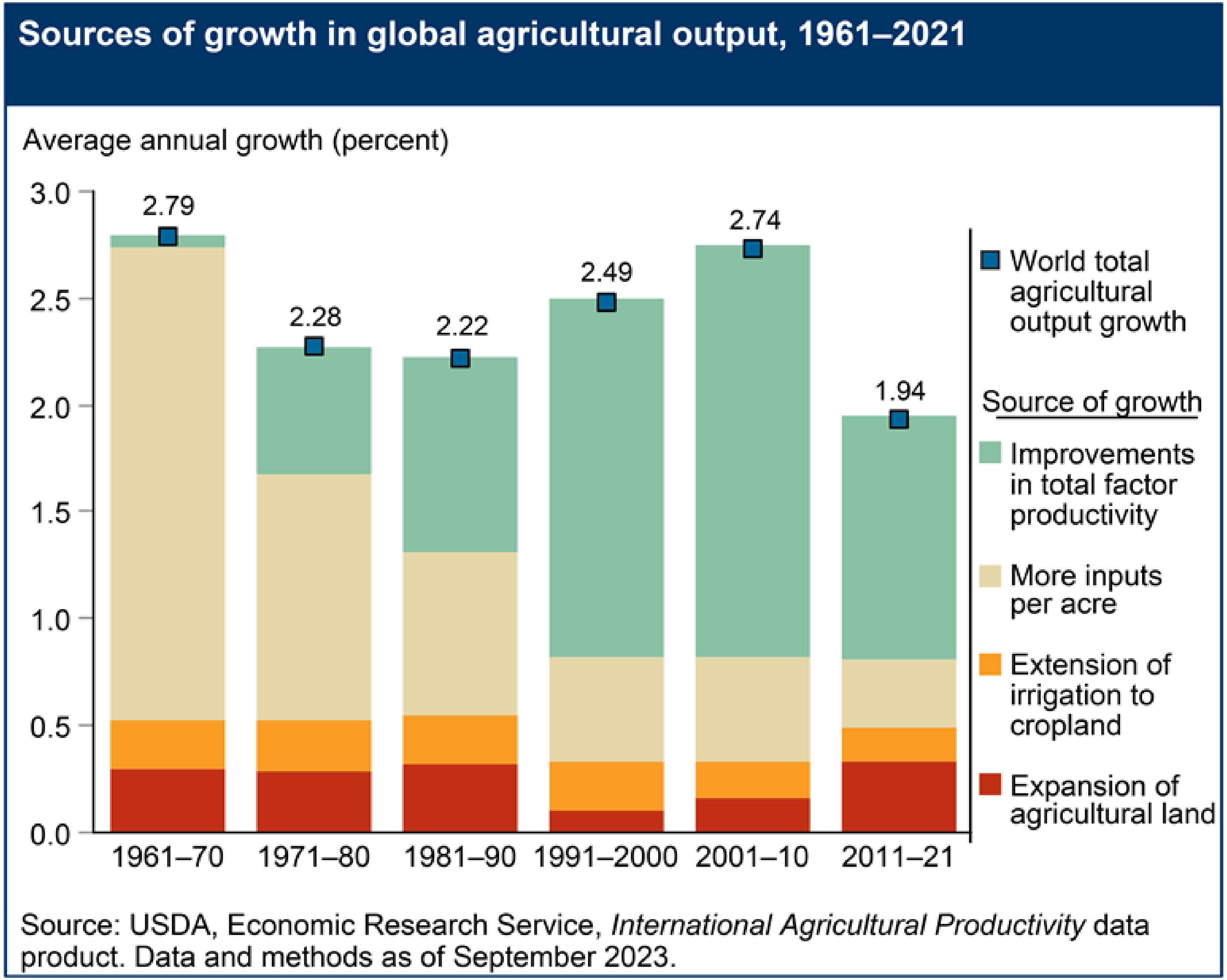
Eras of Agricultural Technology Advancements

- Mechanization
- Hybrids
- Fertilizers
- Chemicals
- Biotech
- Prec. Farming
- Automation



College of Agriculture

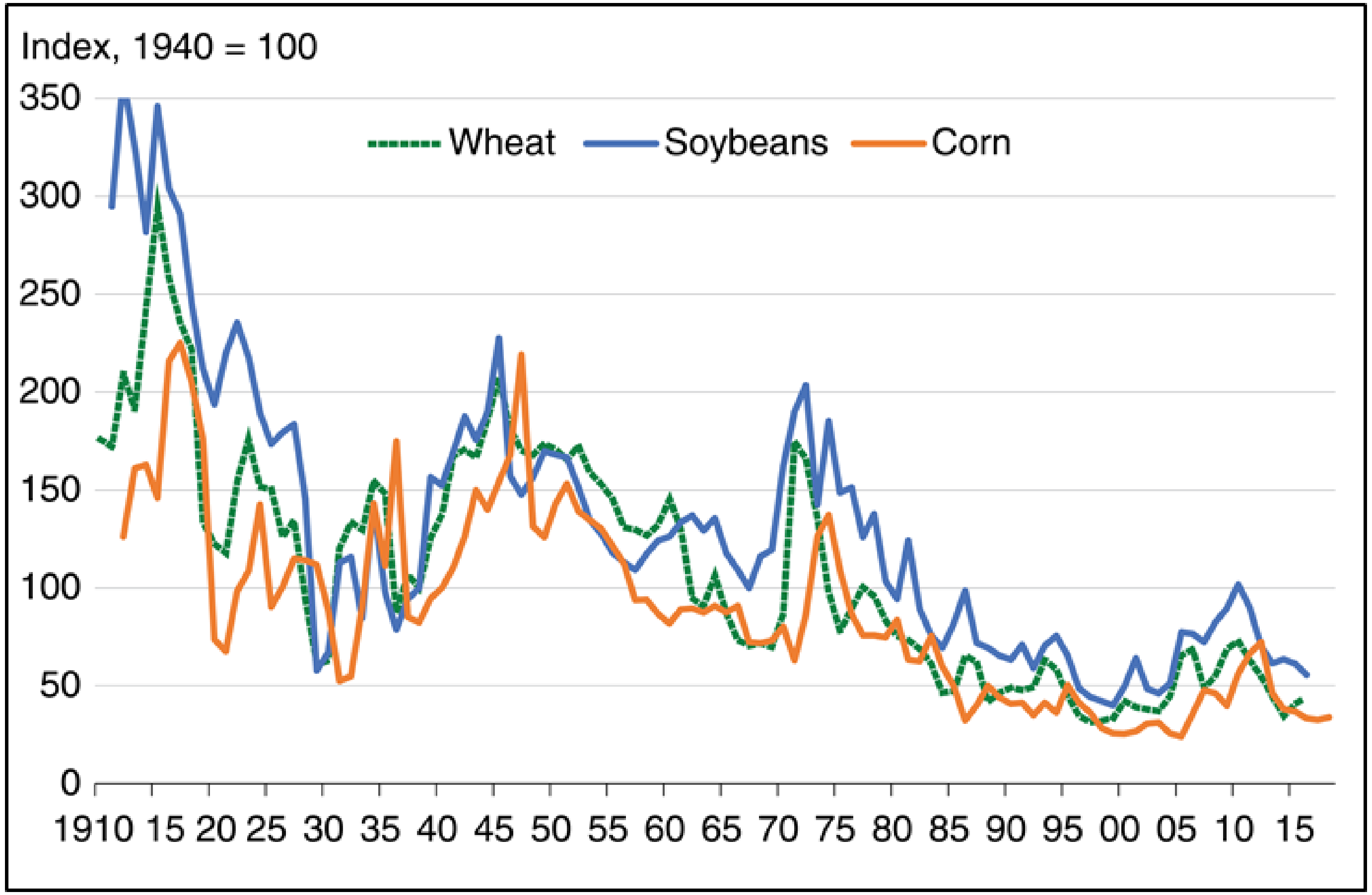
Trend in Agricultural Output—Less from Land Expansion and Inputs, More from Technical and Efficiency Change



PURDUE UNIVERSITY College of Agriculture

Technology Adoption Economics 101

- Benefits of new technology go to adopters—lowers their per-unit costs of production
- Those who do not adopt are put at a competitive disadvantage



Inflation adjusted wheat, soybean, and corn (maize) prices in the United States, 1912 to 2018 (USDA ERS, 2024).

https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=76964

Faster Adoption of Digital Agriculture:

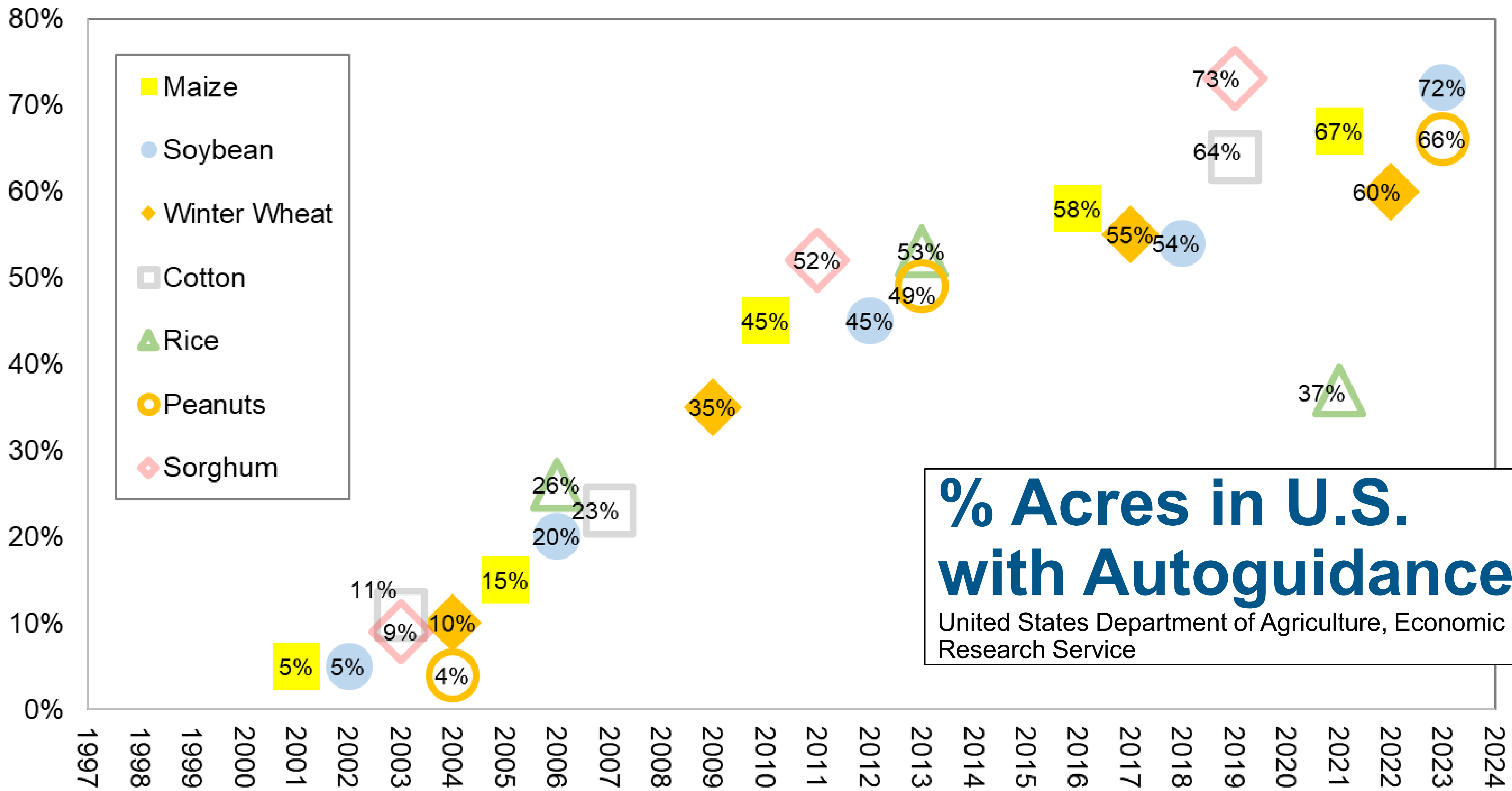
- Large grain and oilseed farms
- GPS guidance and section controllers
- Precision soil sampling (but not always continuing to VRT)
- Yield monitors (but not always continuing to maps, or using maps)

Slower Adoption of Digital Agriculture:

- Small farms, specialty farms, non-mechanized farms
- Remote sensing—whether satellite, aerial, or drone
- Vegetation or soil sensors
- Variable rate technology

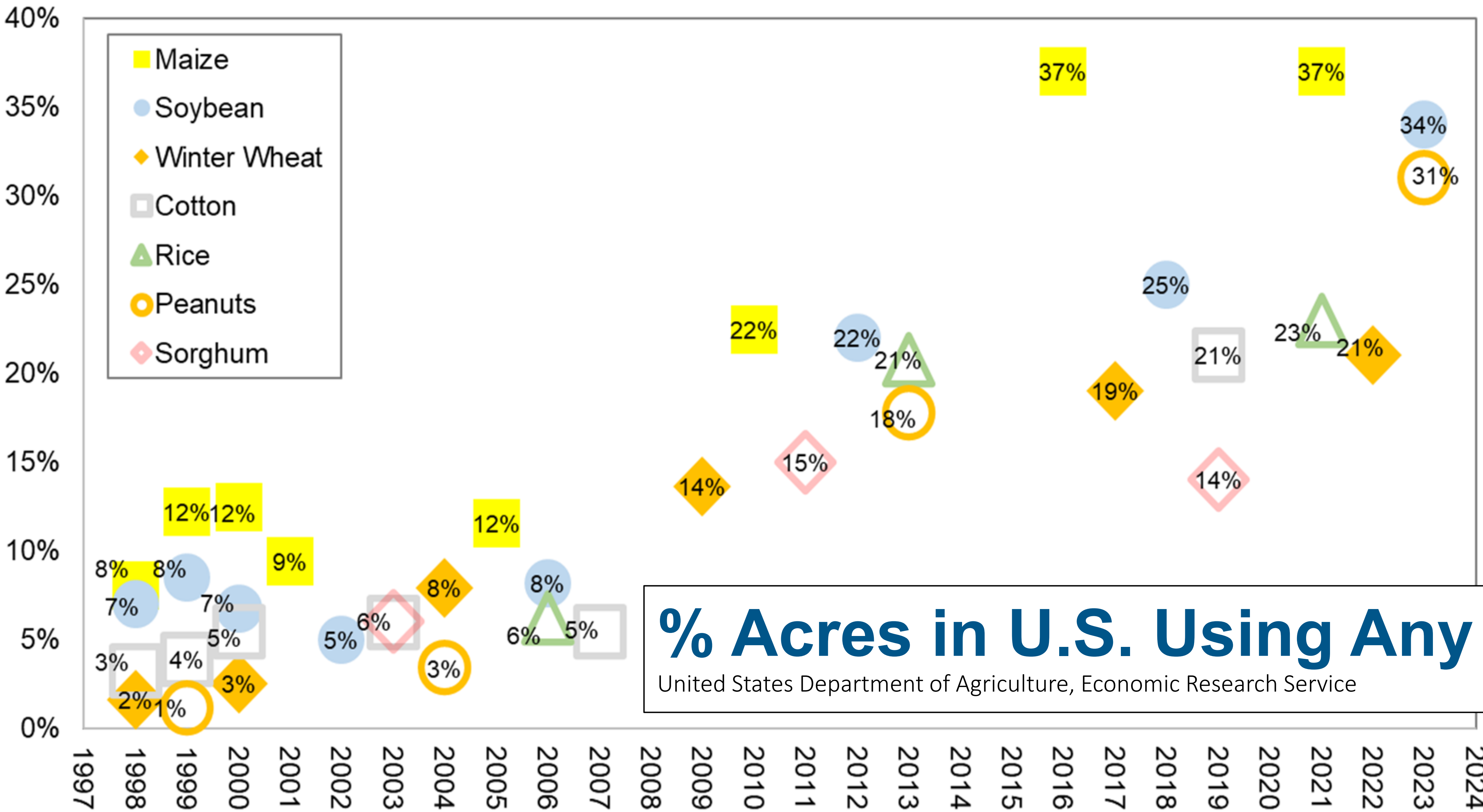
% Acres in U.S. with Autoguidance

United States Department of Agriculture, Economic Research Service



% Acres in U.S. Using Any VRT

United States Department of Agriculture, Economic Research Service

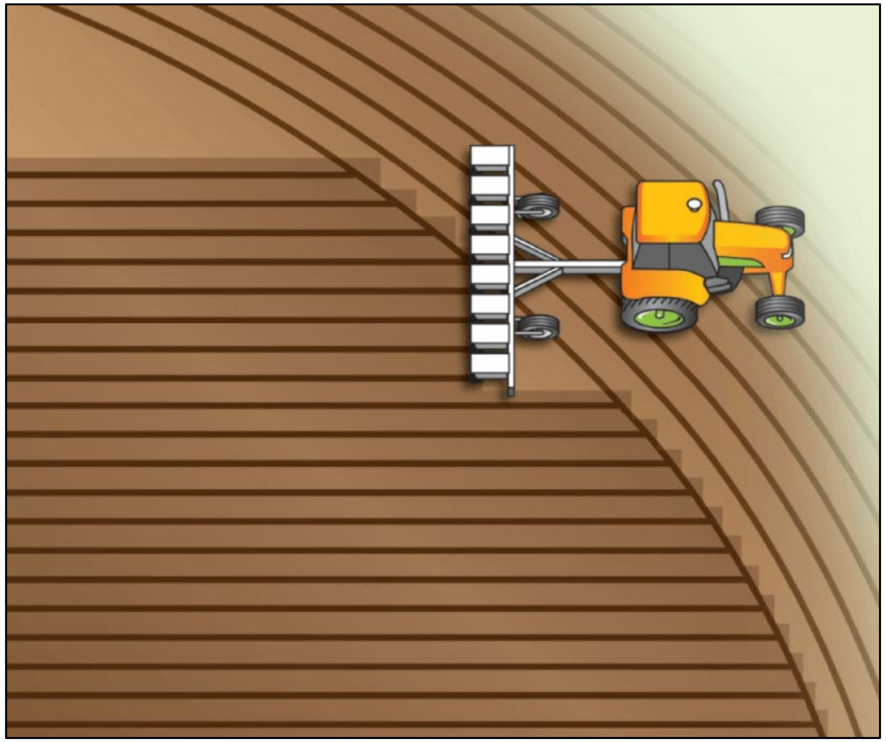


GPS Guidance

- Fewer overlaps and skips, more accomplished, less operator fatigue, helps when low visibility
- Return to same rows with accuracy

https://www.farmingahead.com.au/partners/partner-content/1429917/precision-agronomics-australia-leading-the-next-wave-of-precision-agriculture

Automation: Input Efficiency
Planter Shutoffs, Sprayer Nozzle and Section Controls



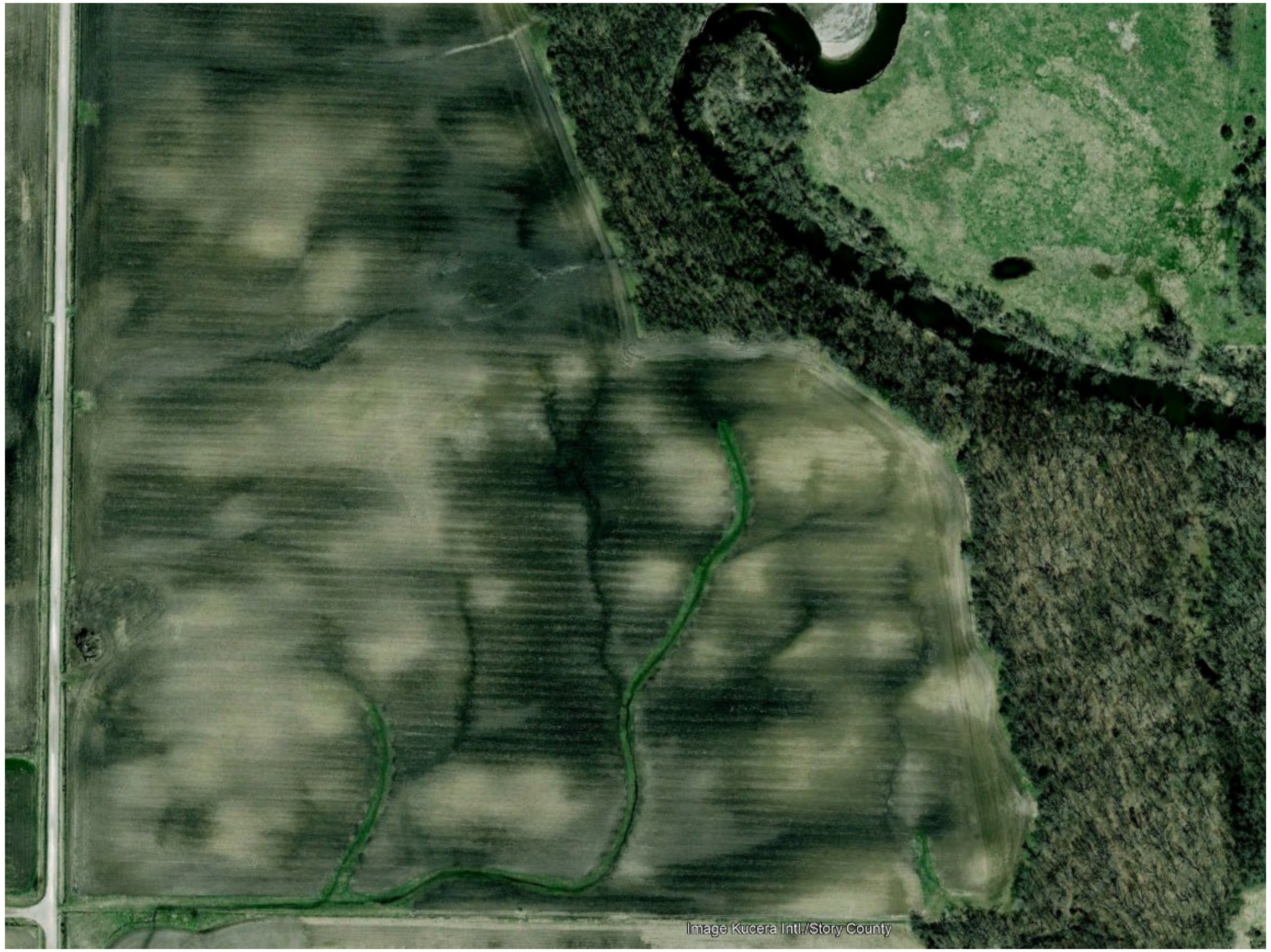
PURDUE UNIVERSITY | College of Agriculture

https://www.agleader.com/blog/ag-leader-section-control/

Variable Rate Technology is Appealing Concept

- **Lower Costs** by putting inputs exactly where needed
- **Increase Yields** by providing more optimum input environment across fields
- **Reduce Risks**—more yield stability

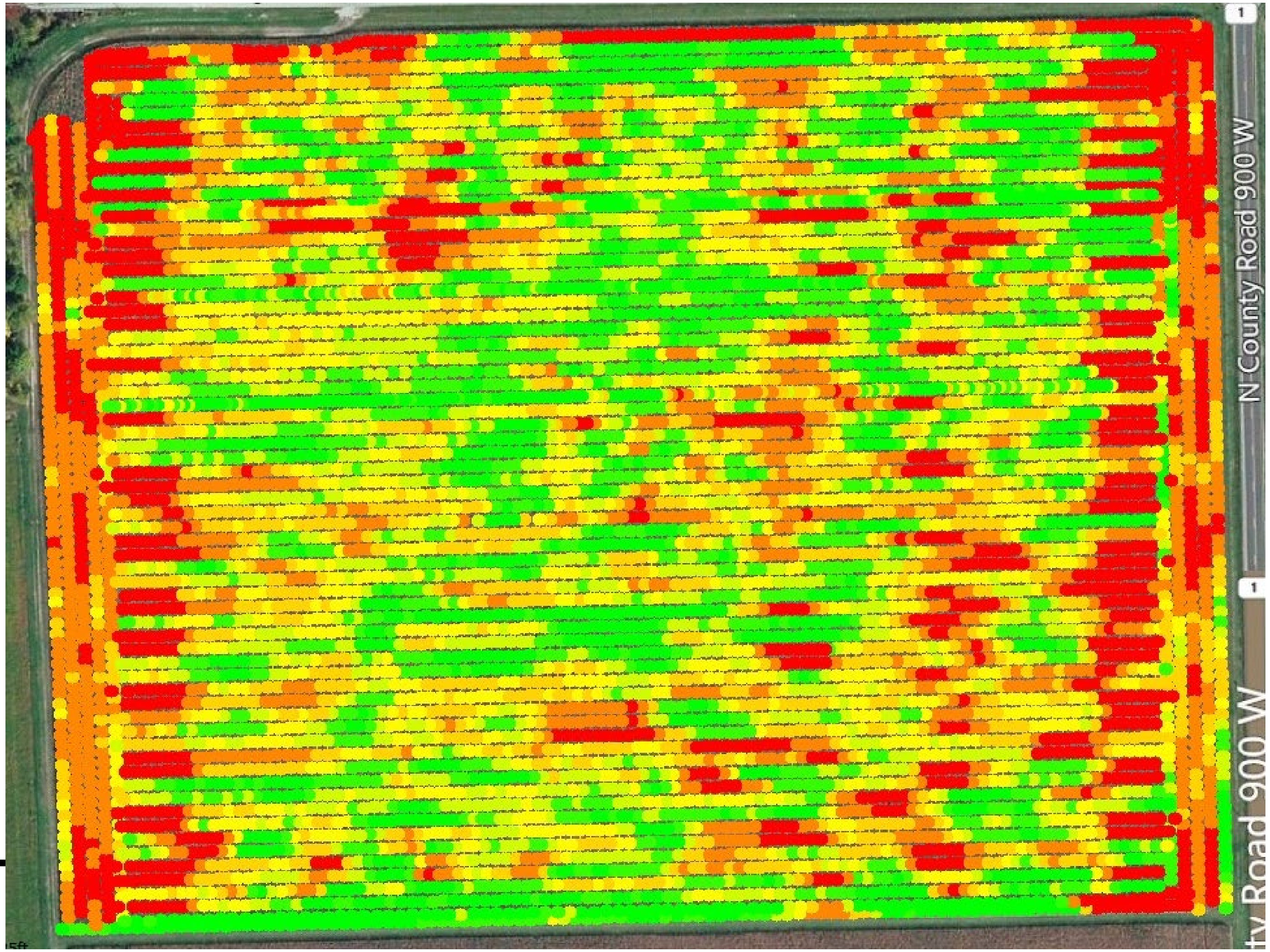
Cause/effect has often been difficult to determine



PURDUE UNIVERSITY | College of Agriculture

Google Earth, Story County, Iowa

Yield Map— Report Card of Genetics x Environment x Management

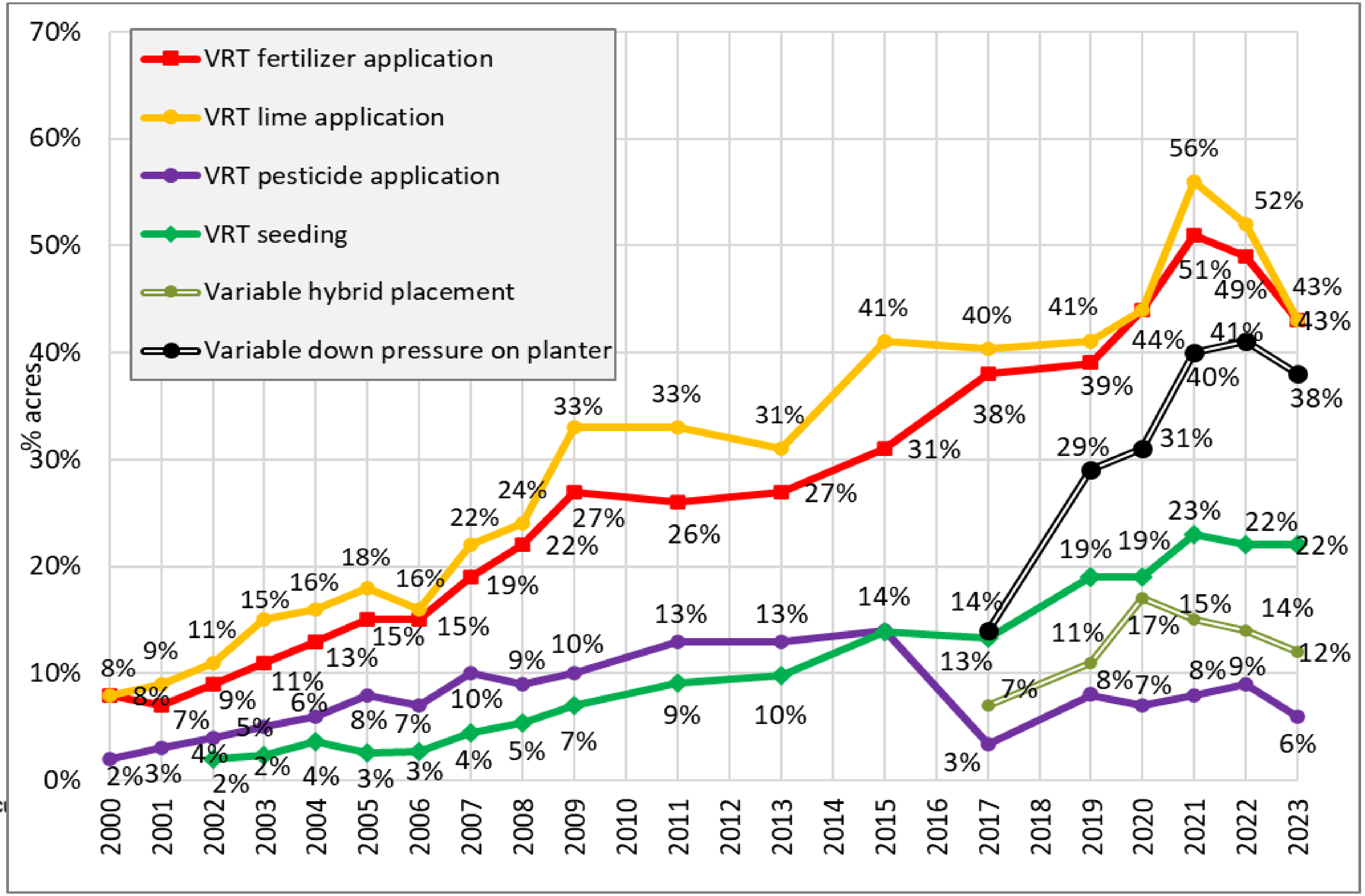


PURDUE UNIVERSITY College of Agriculture

Robert Nielsen, Purdue University

Farmer Adoption of VRT, % of Acres

After two decades, most farmers not doing VRT fertilizers, seeding, or pesticides



PURDUE UNIVERSITY
College of Agric

Most Precision Ag So Far Has Been Input Efficiency, Less in Increased Production

Crop Inputs and VRT:

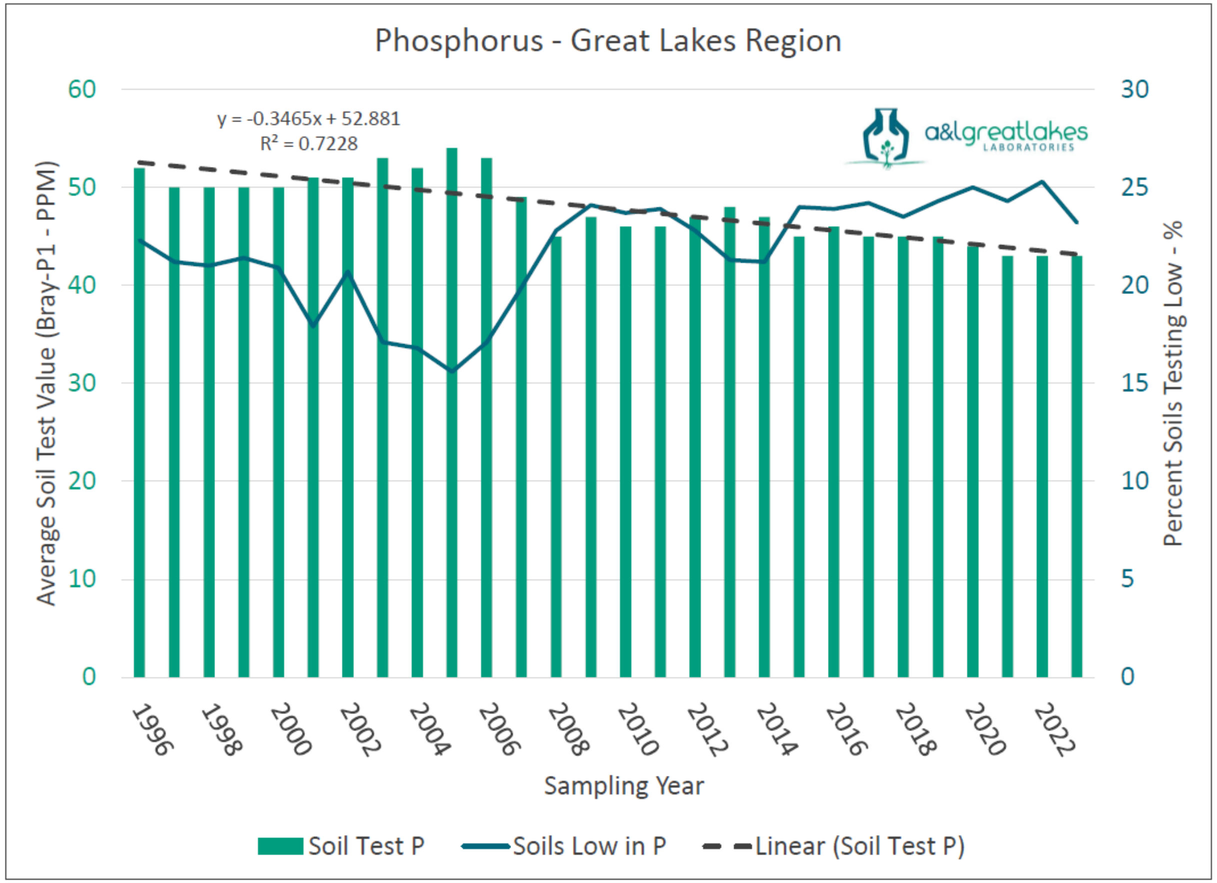
- For P, K, and lime, can’t get around overall need
- For N, Greenseeker was opportunity but little used
- For VRT seeding, modest changes to reduce seed and gain yields
- For pesticides, could cut inputs dramatically—but difficult to quantify

Precision Application of Fertilizers

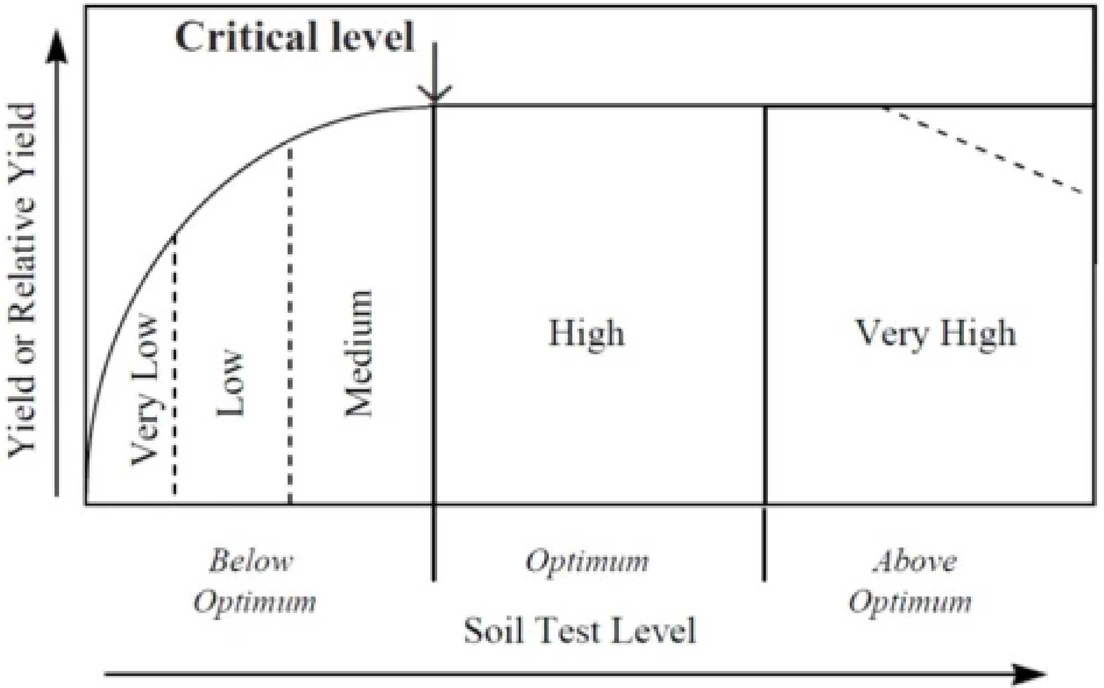
- Overall amounts over time cannot be substantially adjusted (possible exception: nitrogen)
- Possible disrupter: A technology to unlock huge amounts of nutrients in the soil unavailable to plants

  The amount of phosphorus available for plant uptake is very low compared to the total amount of phosphorus present in the soil. For example, total soil phosphorus may be 800 pounds per acre, but the plant available amount in soil solution might be 0.04 to 0.13 pounds per acre—Extension publication
- Efficiencies gained are relatively small

Test Summaries: Few Fields Low in P & K

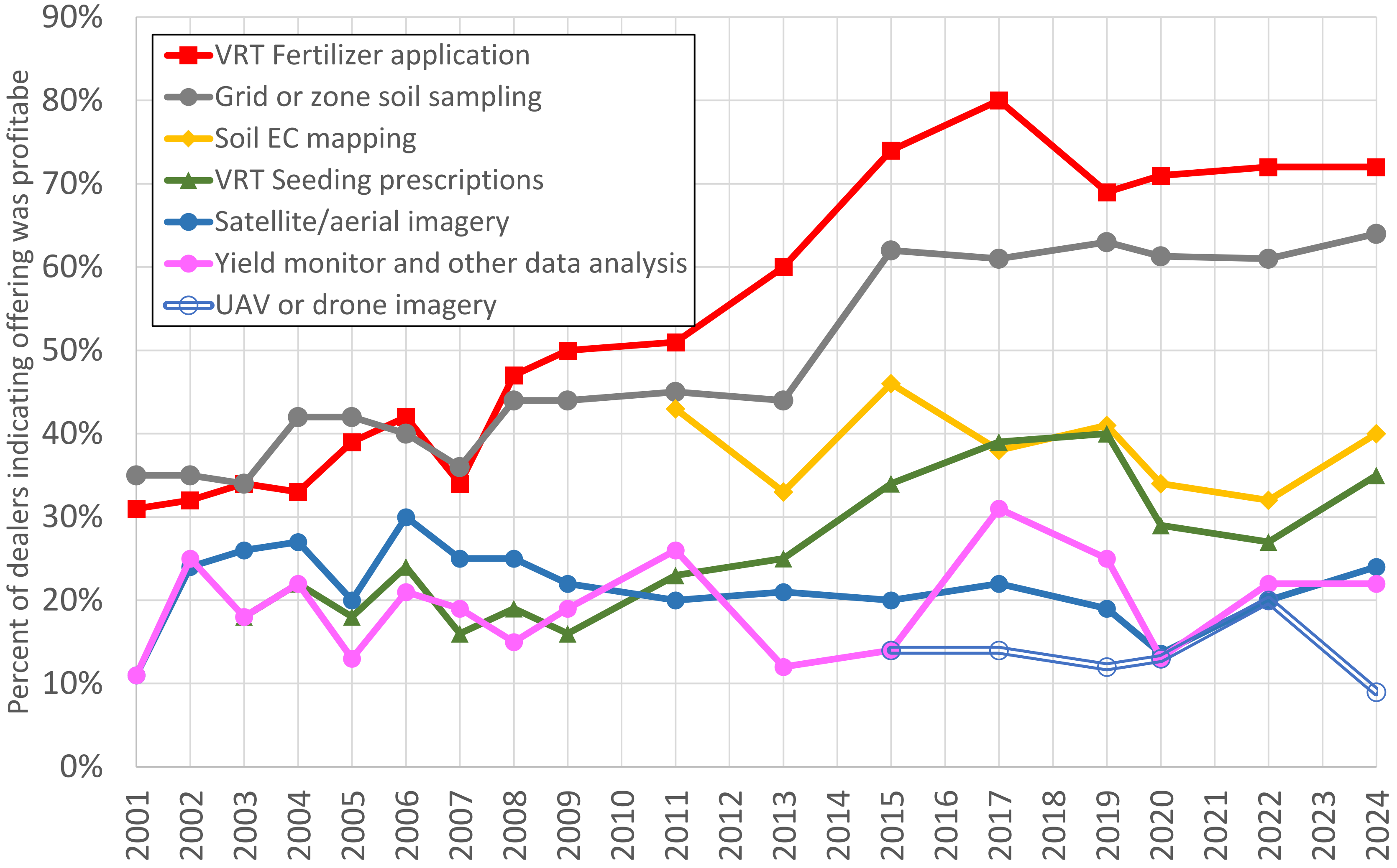


Actual soil test results



Conceptual response curve

Profitability Over Time, Field Crops Dealers

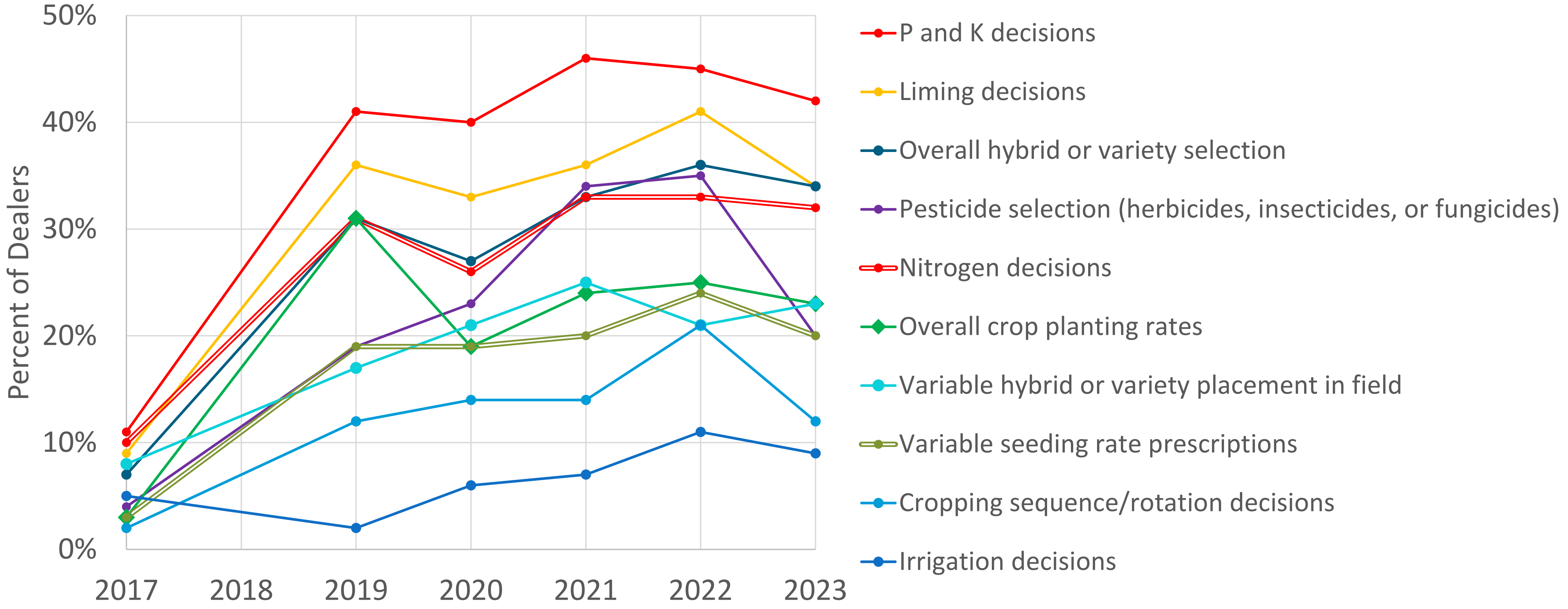


Fertilizer-related services consistently more profitable than imagery

2024 Purdue CropLife Precision Dealer Survey

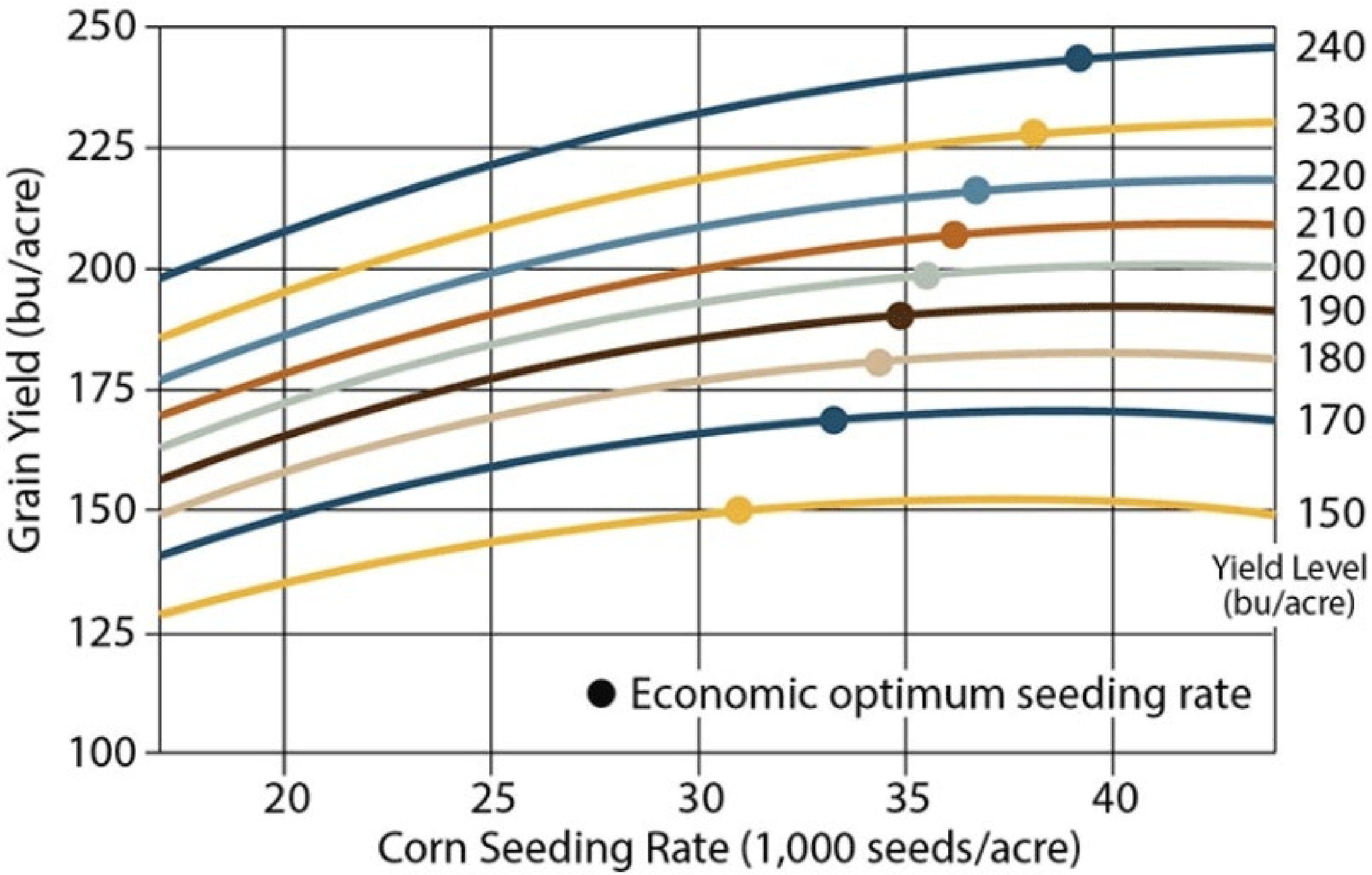
What Decisions Are Guided by Data?

Fertilizers and Lime Dominate



Precision Application of Seeds

- Overall amounts cannot be substantially adjusted
- Efficiencies gained from VRT are modest
- Possible long-range disrupter: new perennial grains such as kernza



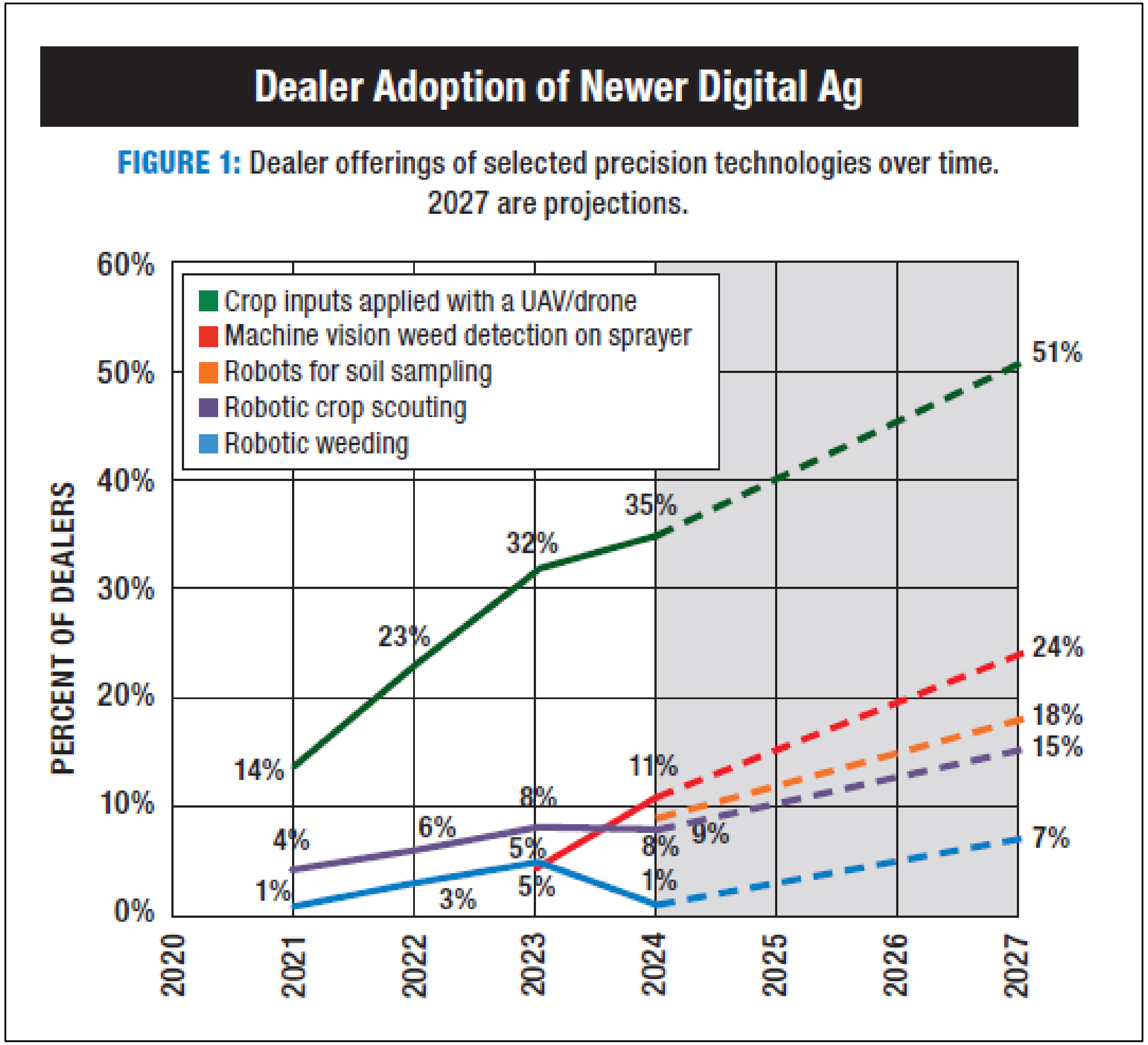
https://www.pioneer.com/us/agronomy/variable_rate_seeding.html

Precision Application of Pesticides

- Amounts can be substantially adjusted

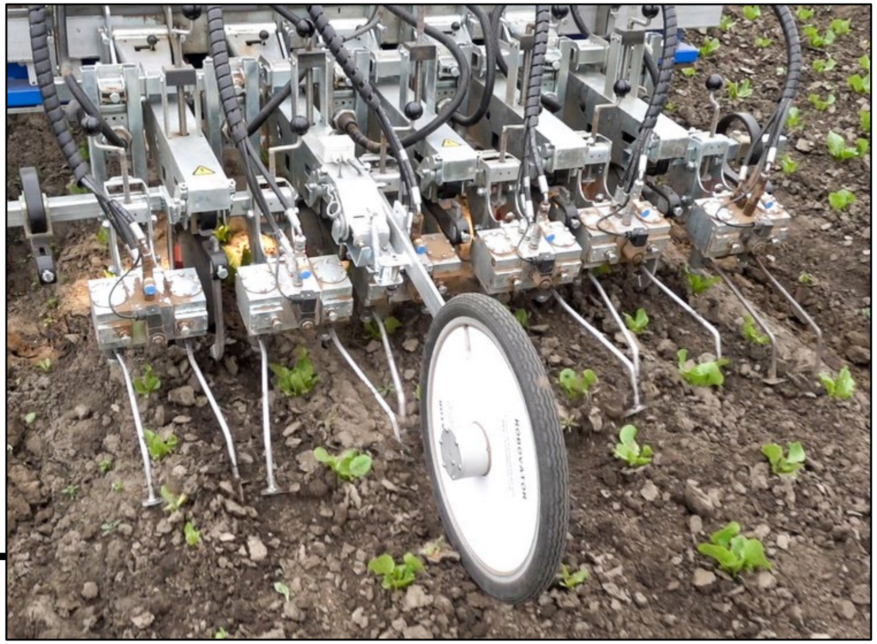
  Some weed management is cosmetic

- But very difficult to characterize some pests to know how and where to adjust
  - Perhaps Easiest: Weeds
  - Perhaps Most Difficult: Disease



Drone spraying

Automated weeding https://www.robovator.com/



PURDUE UNIVERSITY | College of Agriculture

2024 Purdue CropLife Precision Dealer Survey

Robotic Sprayers and Drones Are Challenging Traditional Methods

https://www.solinftec.com/en-us/alice-ai-solix-ag-robotics-2/

Table 1: The Business of UAV/Drone Applications for Agri-Dealers

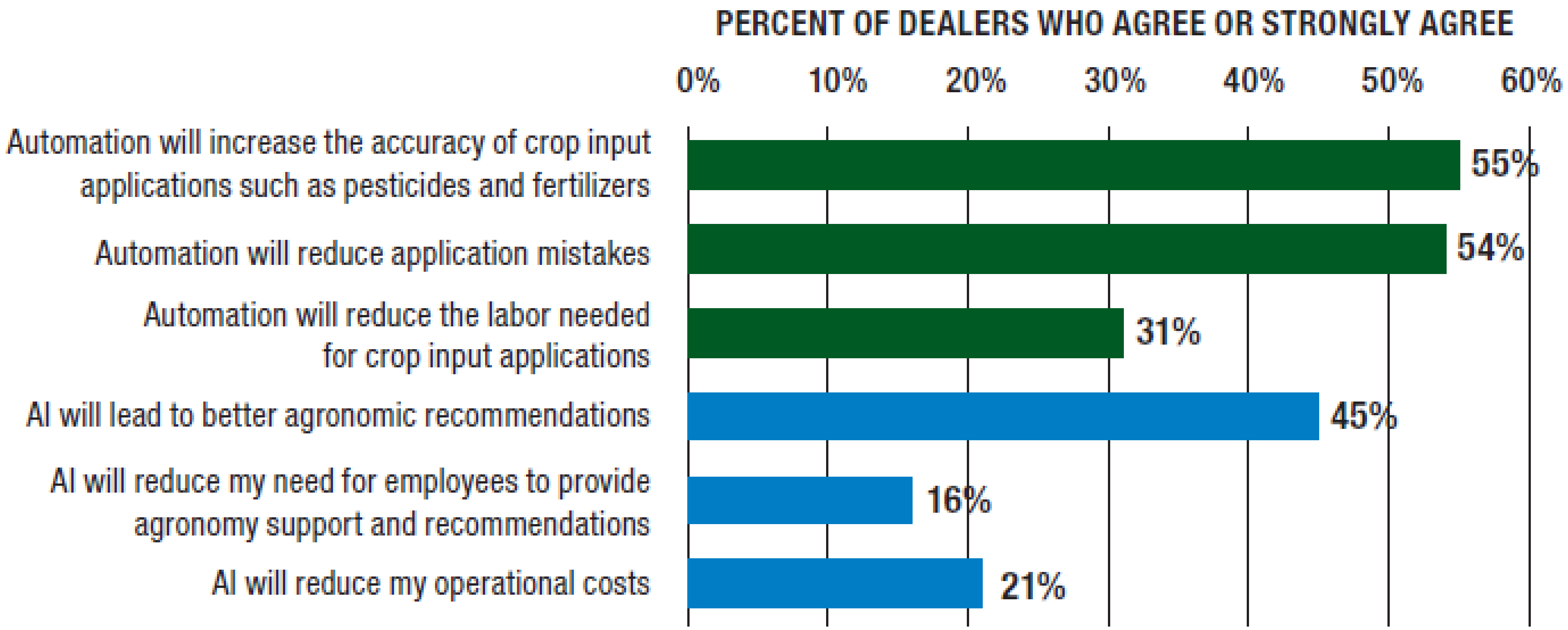
How UAV/drone services are procured by customers	Percent of dealers
Service provided to customers in-house:	27%
UAV/drone service to customers contracted to another company:	25%
Customers use UAV/drone companies not affiliated with us:	27%
Not aware of inputs applied via UAV/drone in my area:	20%
Operations of those offering UAV/drone applications in-house (25 respondents)	**Mean**
Number of UAV/drone crews per dealer	1.7
Workers per crew	2.2
Drones per crew	1.4
Investment to equip, license and train one crew	$62,000
Monthly variable cost per crew	$13,000

https://www.farmprogress.com/crop-protection/agricultural-drone-spraying-taking-off

2024 Purdue CropLife Precision Dealer Survey

How Automation and Artificial Intelligence Could Impact Business

FIGURE 2: Dealer attitudes about automation and artificial intelligence.



Barriers to Adopting Precision Ag in Last Decade

With a couple exceptions, these were always rated highest:

For Farmer Customers:

- The cost of precision services is greater than the benefits
- Farmers are interested, but pressure on farm income limits their use

For Dealers:

- It is difficult to find employees who can deliver precision services
- The equipment to provide precision services changes quickly, increasing my dealer costs
- The fees we can charge for precision services are not high enough to make PA profitable

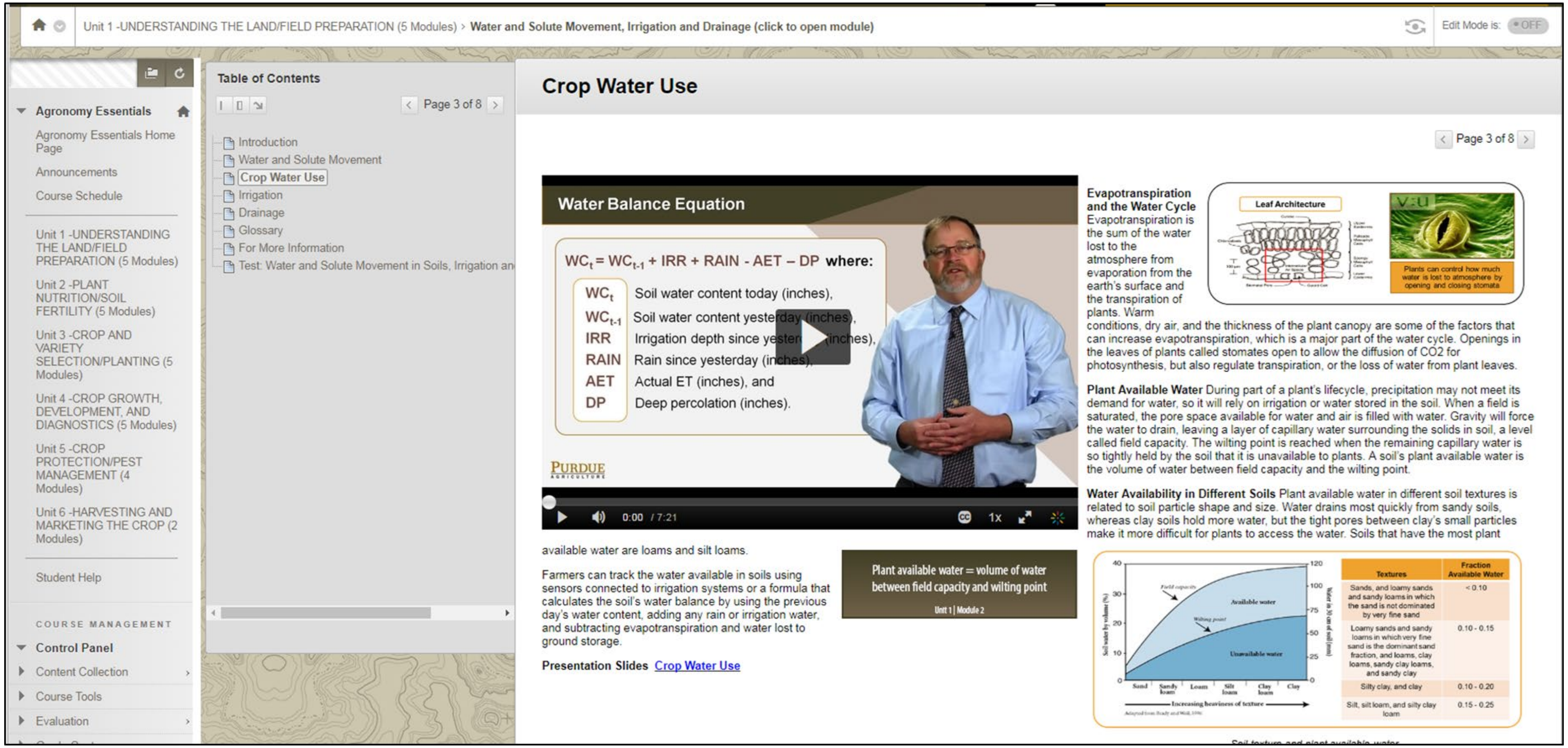
Agronomy e-Learning

Four courses for professionals. About 3000 course completions

Agronomy Essentials

Nutrient Management

Precision Agriculture




PURDUE UNIVERSITY
College of Agriculture
HOME
ABOUT
RESEARCH
EDUCATION
EXTENSION - OUTREACH
INTERNATIONAL OUTREACH
NEWS
RESOURCES
EVENTS
IDAAS SEARCH
College Home > Institute for Digital and Advanced Agricultural Systems
Institute for Digital and Advanced Agricultural Systems
Using data, science, and innovation to advance agriculture's future.

Questions and Comments

Supported by USDA National Institute of Food and Agriculture (NIFA) and the National Science Foundation (NSF) National AI Research Institutes Competitive Award no. 2023-67021-39829.