# Research prioritization for robust U.S. agriculture: How would you invest?

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**Indiana CCA Conf, Dec. 14, 2022**

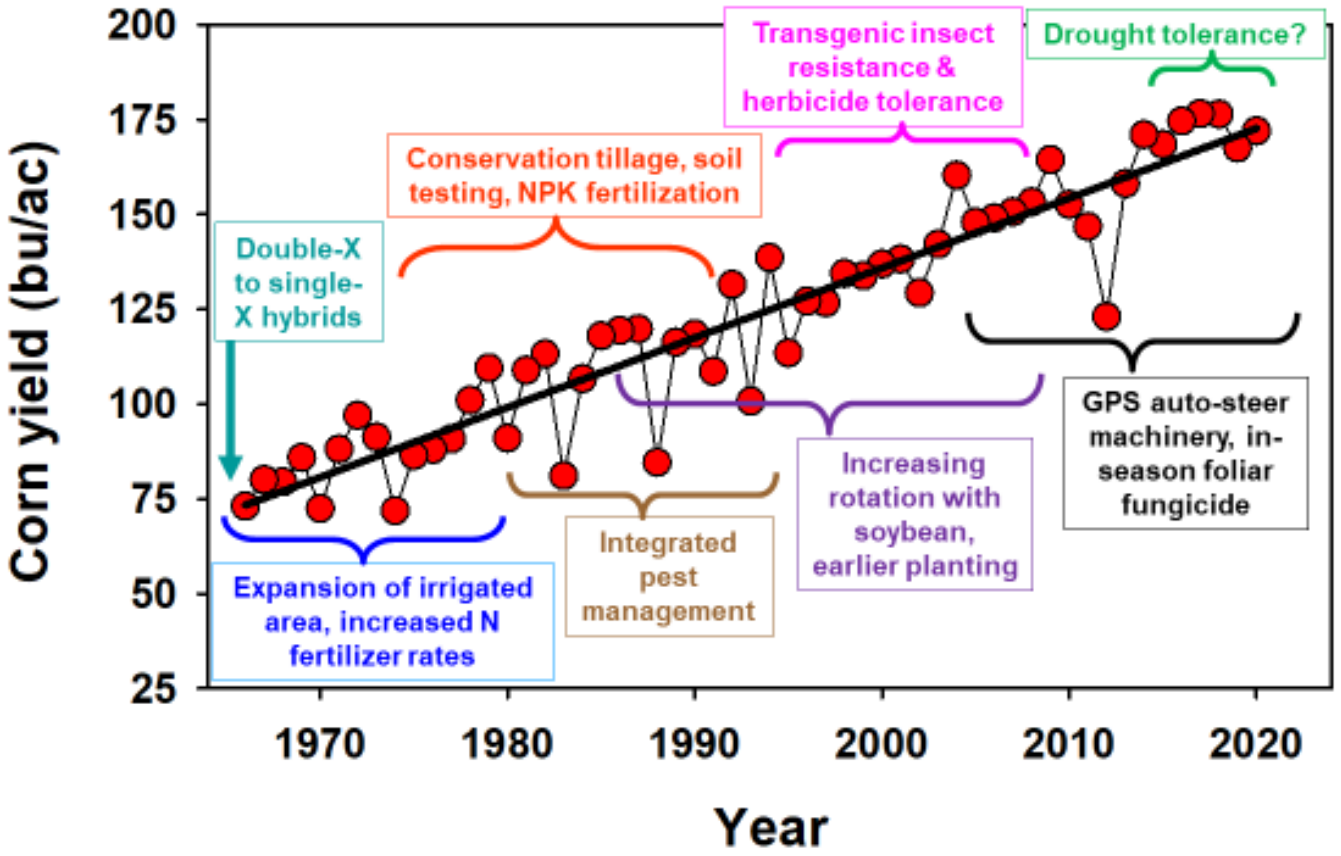
University of Nebraska Lincoln

# U.S. Agriculture, 2022

- **Most productive, efficient, and resource-conserving food production systems in the world (by a long shot!)**
- **Largest exporter of agricultural products that are essential components of food security for billions**
- **Total value of ag exports was $177 billion in 2021 (about 7% of total U.S. goods and services value)**

# In an uncertain and competitive world, how can we ensure that U.S. agriculture maintains its current premier position in global agriculture?

**Figure 1. Corn yield trends in the USA from 1966-2020, and the technological innovations that contributed to yield increases. Rate of gain is 1.8 bushels per year ($r^2 = 0.94$)** From: Cassman et al. Crops and Soils Magazine: https://doi.org/10.1002/crso.20133




**Answer:**

Adequate investment in research and development in both public- and private sectors focused on continuous improvement and consumer demands

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# Two stories we have witnessed first-hand!

- ***First story***: How the US automobile industry lost its preeminence after global dominance in the 1950s and 1960s due to more rapid innovation in other countries
  - First Japan and Germany, then more recently China
  - In 2021: China produced 26.1M vs 9.1M in the U.S

- ***Second story***: My first visit to elite corn research facilities and farms in China (1996). Biggest constraint: poor hybrids (thin stems, disease/insect susceptible at plant densities needed for high yields) What did China do? It bought Syngenta and massively increased investment in agricultural R &D in genetics, agronomy, computer science

*Feature: Agricultural Research and Productivity* June 06, 2022

# Investment in U.S. Public Agricultural Research and Development Has Fallen by a Third Over Past Two Decades, Lags Major Trade Competitors

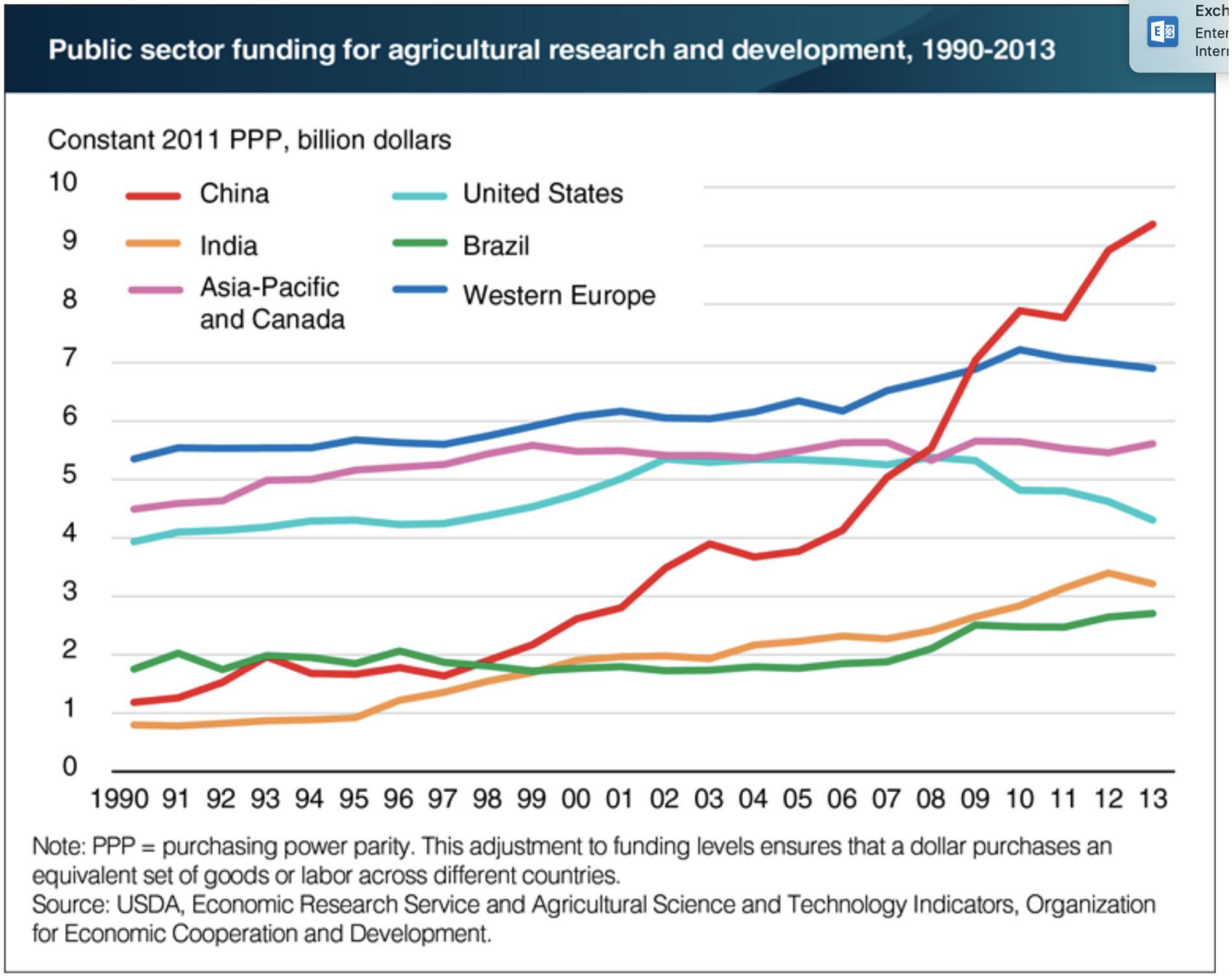
by Kelly P. Nelson and Keith Fuglie

In the United States, public agricultural research and development (R&D), which includes any agricultural R&D conducted at universities or Government laboratories regardless of funding source, is supported through Federal-State partnerships. These partnerships provide an important complement to business R&D, providing scientific and technological innovations that raise U.S. agri-food system productivity.

**Highlights:**

- U.S. public agricultural R&D expenditures, when adjusted for the rising cost of conducting research

# We are very concerned about current trends



# Our Prediction:

- If current trends in R & D spending do not change, U.S. agriculture will lose its premier global position within 25 years, just as it did for automobile production from 1970-1995.
- With adequate and wise strategic investment in public-sector ag research and development, there is no question U.S. agriculture can continue to thrive as the most competitive, resource-conserving, and productive food production systems in the world….

**So, if you were the U.S. ag research czar, what would you invest in?**

# U.S. Research Czar Survey

**Audience survey about agricultural R & D priorities:**

- **Which crops and cropping systems ?**
- **What are the most (and least) important research issues considering all constraints to more efficient, productive, and profitable crop production?**
- **Specifically for soil fertility and plant nutrition, what are the most important research issues?**

# "RESEARCH PRIORITIZATION IN U.S. AGRICULTURE " SURVEY

Dr. Ken Cassman

Dr. Tony Vyn

***To participate in the survey, use your cell phone and text your code selection to 765-560-4177 .***

PURDUE UNIVERSITY Extension

** Note that this number is the long-time Purdue number for the Hotseat Survey tool and that no record of your responses or your cell phone number is retained in the system. The survey is completely autonomous.*

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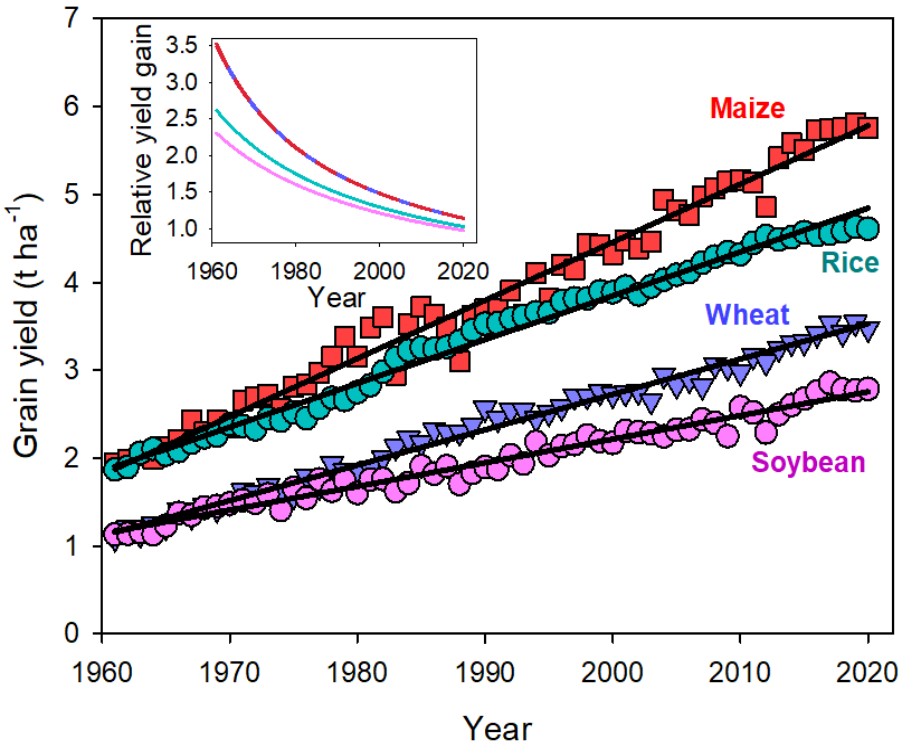
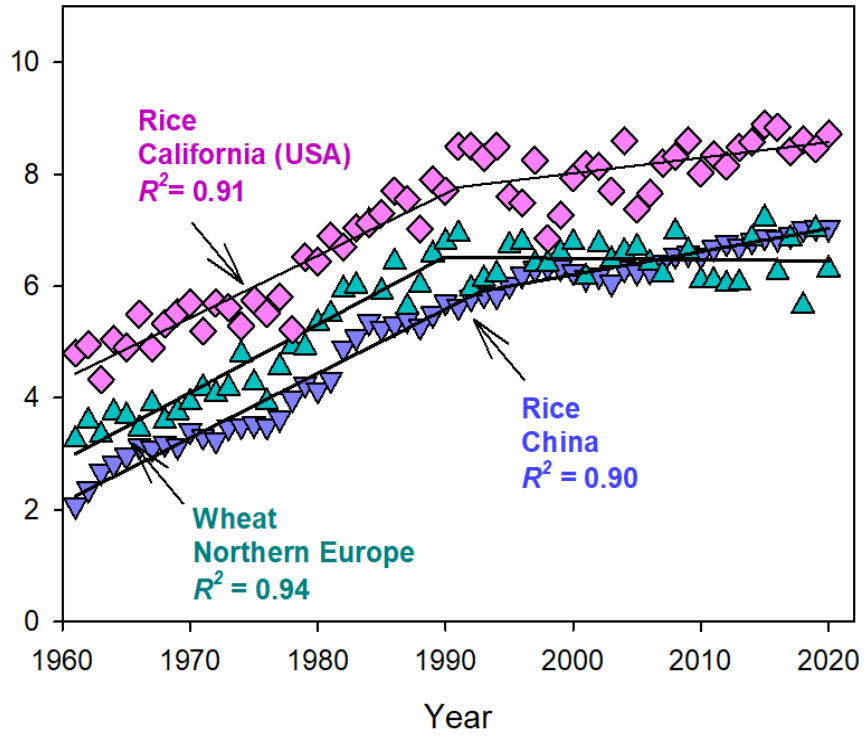
# The following slides gives our perspective on research priorities for agriculture

## Yield increases of major food crops are slowing, 1960-2020




Modified from: Grassini and Cassman. 2020. *Nature Sustainability*

**But increased production cannot come via massive expansion of crop production area at the expense of natural ecosystems, such as rain forests, wetlands, and grassland savannah**

# Cutting virgin rain forest in Brazil

# "Sustainable intensification" is the path forward because:

- **Need for enormous increase in the amount of food required for human population of nearly 10 billion by mid-century (even with plausible change in diets in developed countries and reduced food loss/waste)**
- **Limited supply of arable land and water**
- **Need to meet food production requirements on existing land to avoid further loss of natural ecosystems**
  - **Avoids land conversion and associated GHG emissions and soil degradation**
  - **Maintains natural ecosystems to provide habitat for biodiversity and other essential ecosystem services**

# Working definition of “sustainable intensification”

**Achieving greater crop yields on existing cropland while maintaining or improving soil health and profit, conserving natural resources, and avoiding negative environmental outcomes.**

**(scale neutral)**

# We believe research prioritization depends on scale

**Two competing narratives, Global versus Local?**

- **Globalized food system (current?): Few barriers to international food trade, which emphasizes comparative advantage of countries with favorable soils, climate, and infrastructure that support yields, input requirements, input use efficiencies, and costs**
- **Local/regional food systems: Focus on food sovereignty, food self-sufficiency, diversity, meso-scale environmental quality (e.g. watershed), environmental justice, and soil health among other objectives**

**Either approach could achieve global food security, but if the goal is SI to achieve adequate human food supply on existing cropland area, viable options are constrained by existing cropland area and estimated food demand for nearly 10B within 28 years**

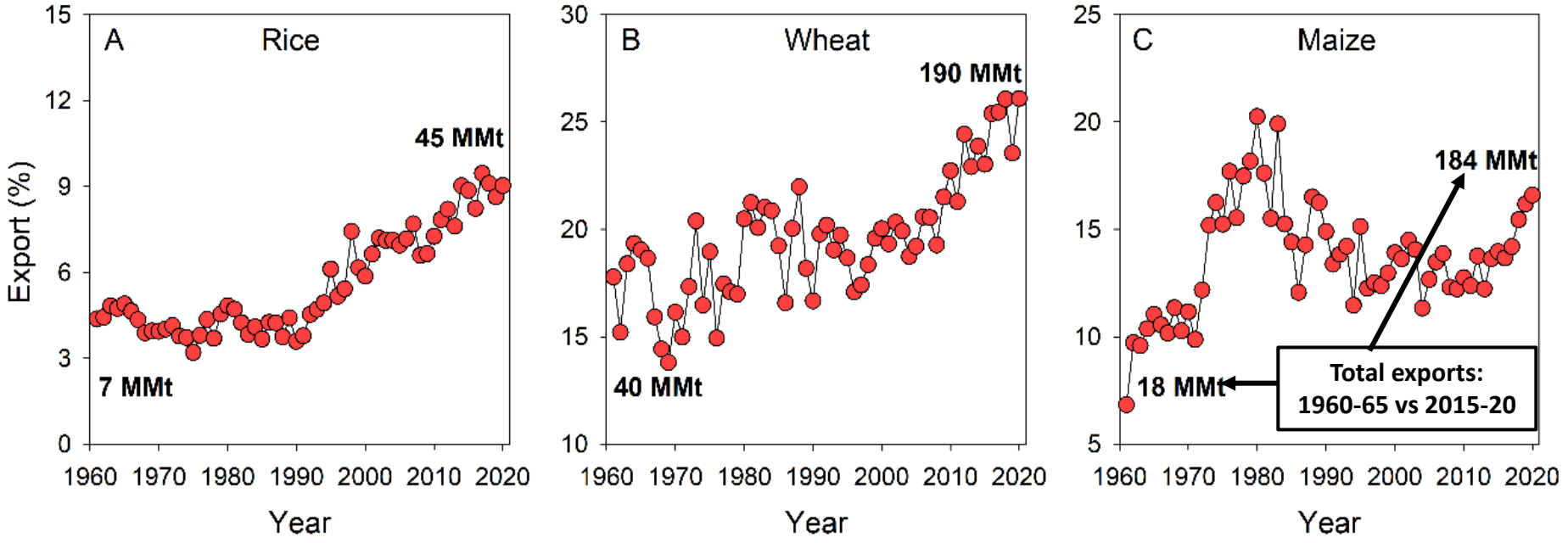
**Highest priority crops and cropping systems for research on sustainable intensification differ depending on expected structure of future global food system**

# So, what is most likely structure of our global food system in 2050?

- Plausible pathways must produce sufficient quantities of food that people wish to eat, at affordable prices, and with minimum risk due to the weather and also protect soils, natural resources, and environmental quality
- Clearly defined metrics are available to track progress towards required production quantities (Yield) with acceptable risk (variation in yield), as well as metrics for progress towards conservation of energy, water, and nutrients (including nitrogen and phosphorus)

# Plausible pathways: Power of Momentum

**Exports as a percentage of total global grain production, 1960-2020.**
**Source: FAOSTAT (https://www.fao.org/faostat/en/#data/QCL)**




**Most countries must import one or more staple food crop because they do not have favorable soils and climate to produce them. Hence global food system is essential for global food security and conservation of natural resources**

# What is most likely future food system scenario?

**Continued globalization with increasing reliance exports of major staple crops to produce sufficient quantities of calories, protein, and vegetable oil to meet demand in global markets. Why?**

- **Current major staple food crops produce more calories, protein, and vegetable oil per unit land, water, nutrients, and energy than other food crops**
- **They store well over long periods and have high energy density compared to other food crops, which makes them less expensive to transport**
- **They can be used for both human and livestock feed**

**No other crops or cropping systems have plausible pathways to produce sufficient food with acceptable risk within 28 years (relevant time frame to address climate change)**

# Conclusions

- Both globalized and local/regional global food systems can achieve global food security, but they require vastly different amounts of arable land and resources.
- Most likely future food system is more globalized than today
- Local/regionally oriented food systems have not been shown to supply sufficient food at affordable prices on existing cropland for current 8B today, or 10B by mid-century
- Research prioritization for sustainable intensification to ensure robust U.S. agriculture and global food security must focus on crops and cropping systems with plausible pathways to get there within a 28-yr time frame
- Prioritization amongst R & D for a globalized food system can be quantified by clear metrics that constrain potential options

# Conclusions

**And crop producers, crop consultants, ag industry professionals, and others who help improve crop and livestock production need more proactive engagement in the public-sector research prioritization process!**

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