FERTILIZER TECHNOLOGY UPDATE

- New Fertilizer products

Yuncong Li
TREC-Homestead

Apopka, FL, February 29, 2012

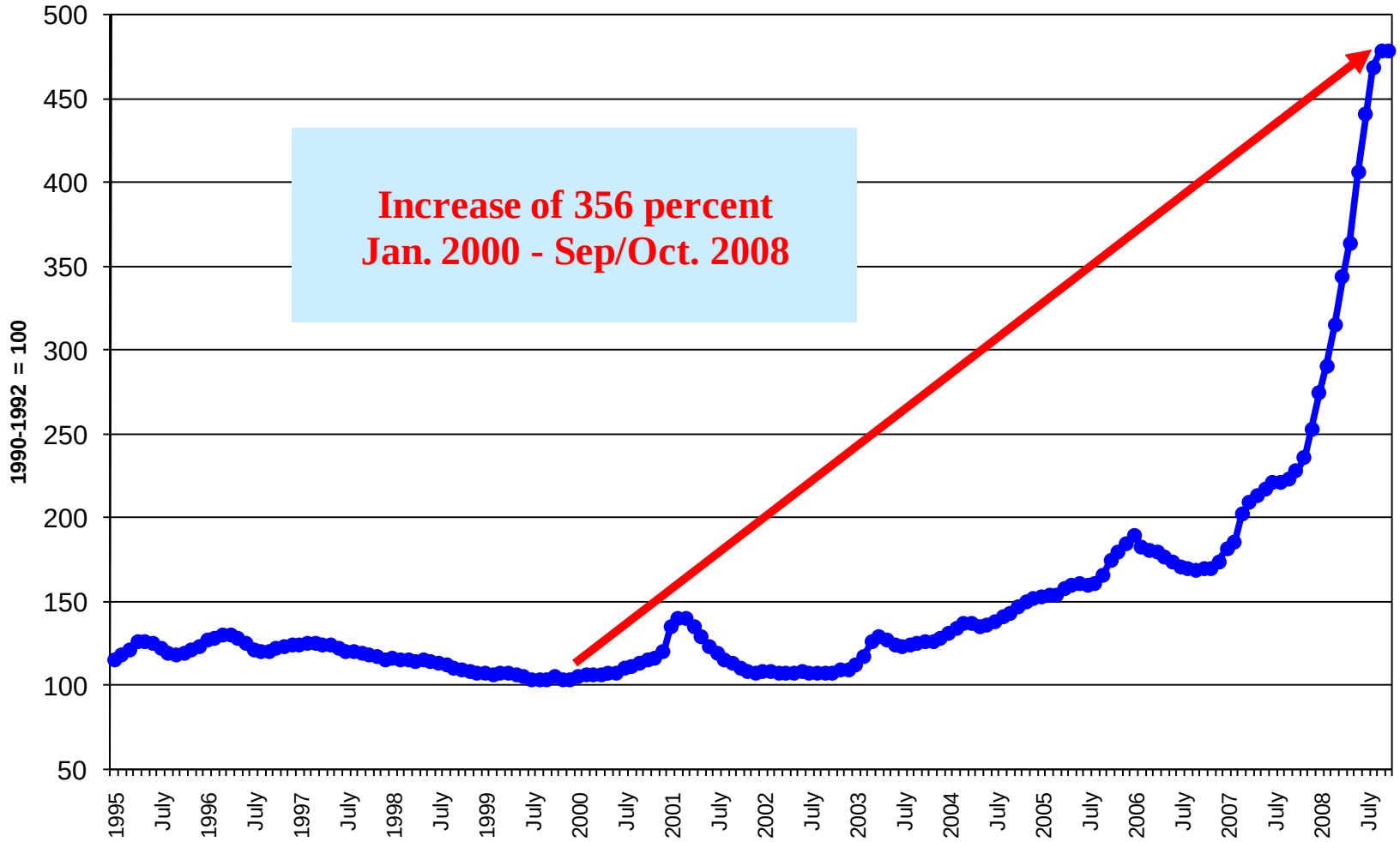
Outline

- Problems with fertilizer production and use
- Nano fertilizers
- Slow release fertilizers
- Liquid fertilizers
- Bio-fertilizers/organic fertilizer
- Zero-P fertilizers/dry granular fertilizers
- Magical/mysterious products

Problems with fertilizer production and use:

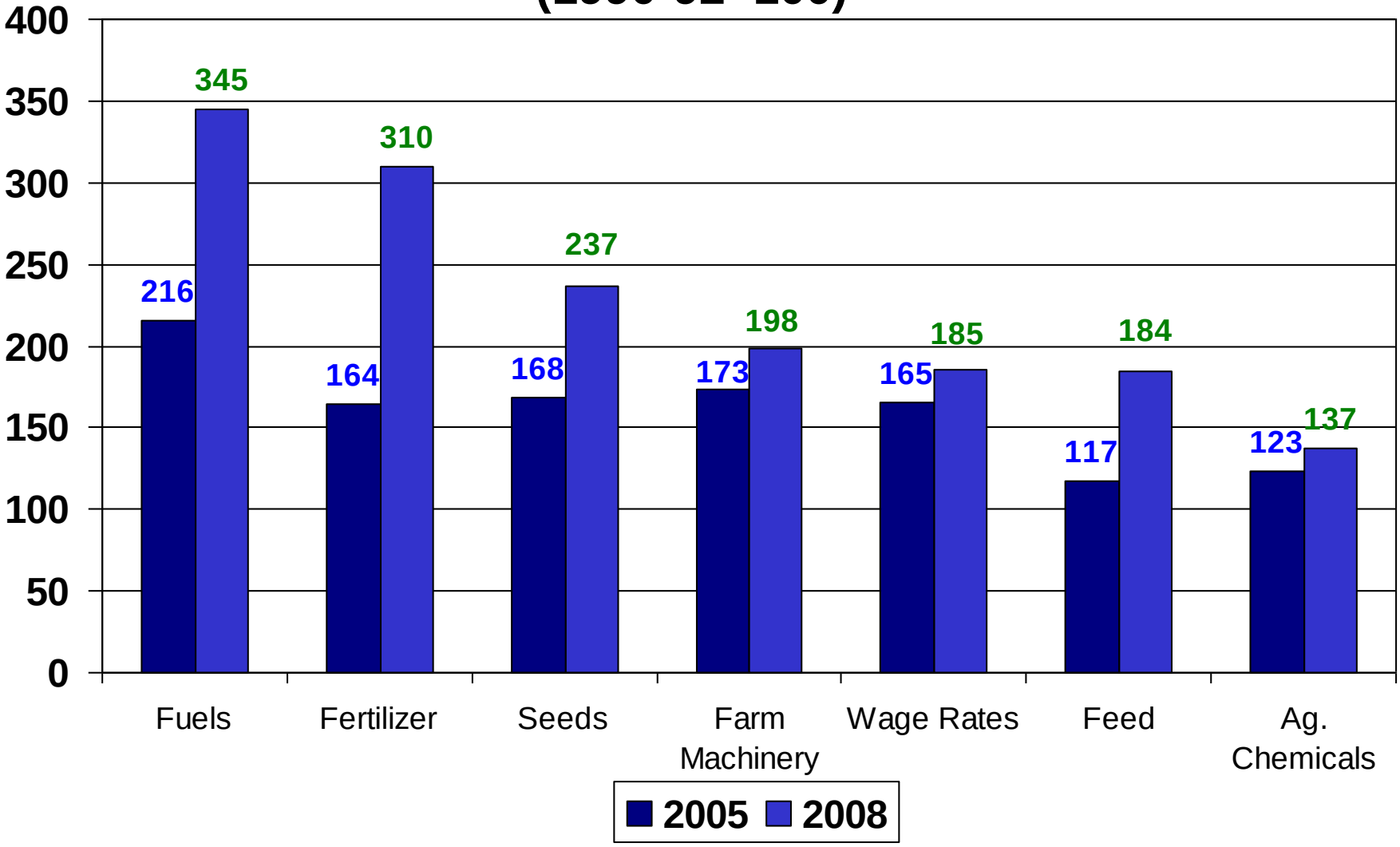
- Total use & price are continuously increasing
- Use efficiency is still low
- Pressure is coming from regulation/environmental concerns

Fertilizer Prices



Source: National Agricultural Statistics Service, USDA.

Input Prices Index Paid by Farmers 2005-2008 (1990-92=100)

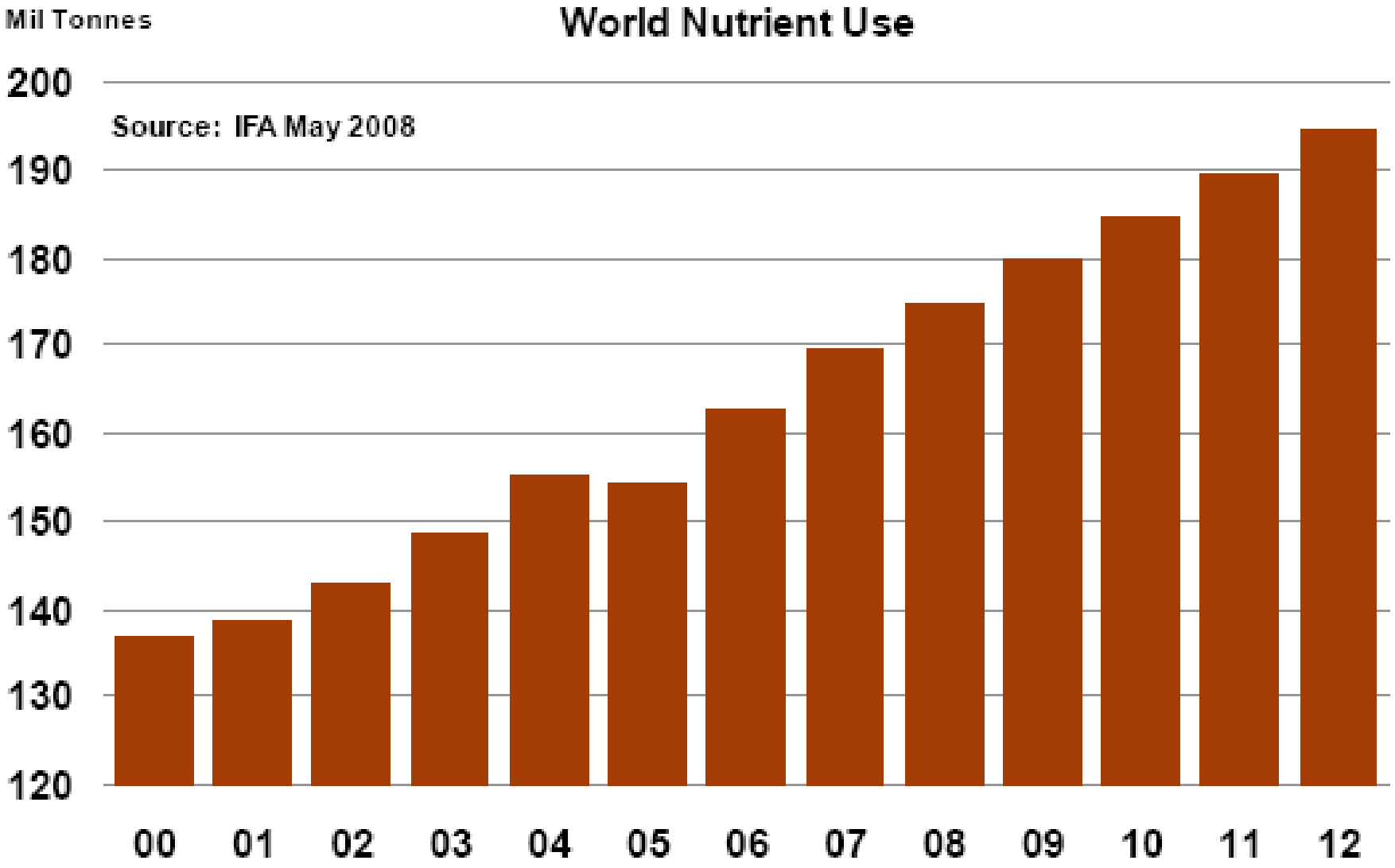


Source: Economic Research Service/USDA

The Fertilizer Institute:

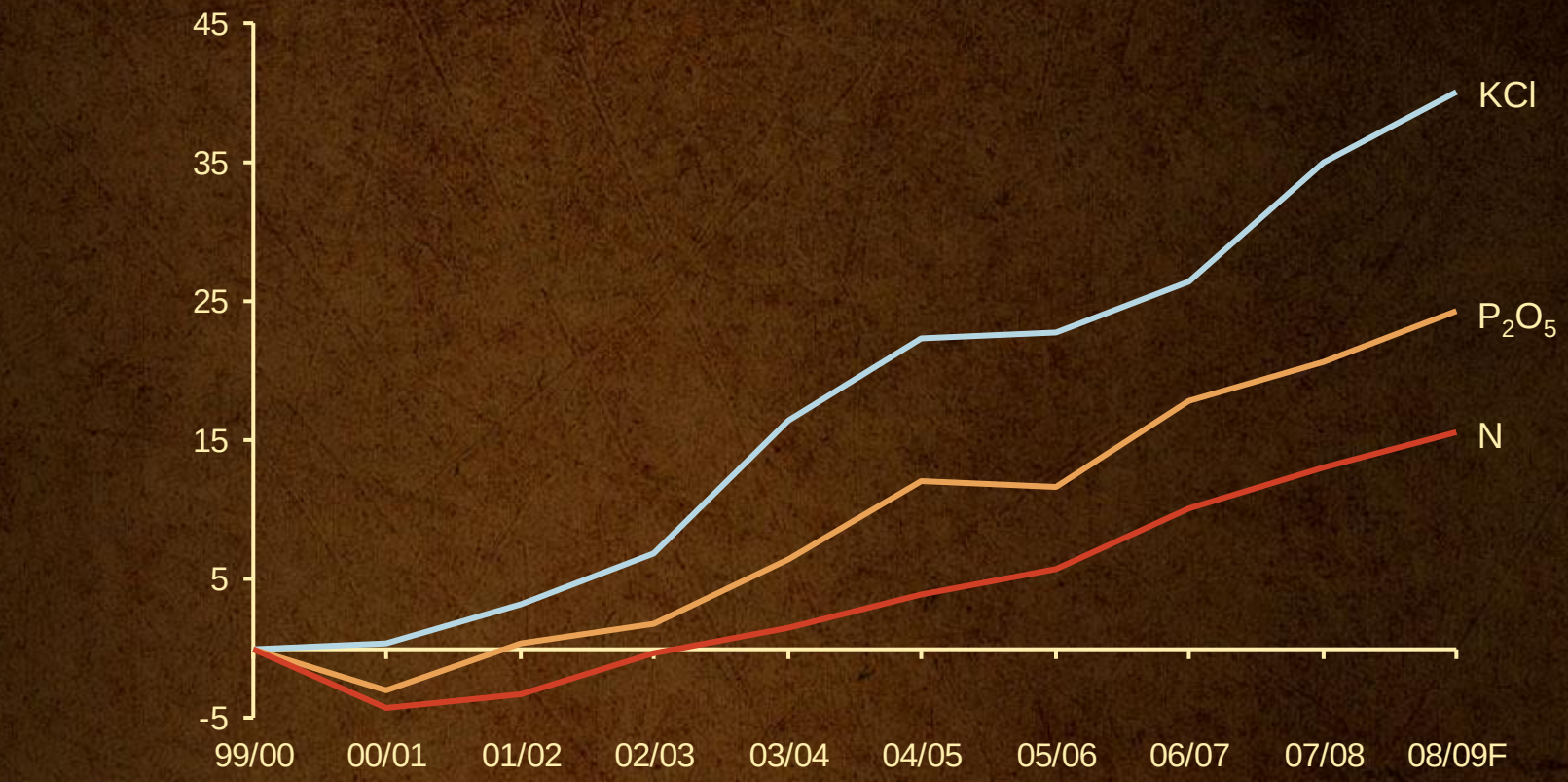
- Increase global demands:

  11%N, 13%P, 17%K (2001-2006)
- Ethanol production needs more fertilizers
- High transportation costs
- Values of US Dollar falls


Mil Tonnes
World Nutrient Use
200
190
180
170
160
150
140
130
120
Source: IFA May 2008
00
01
02
03
04
05
06
07
08
09
10
11
12

World Fertilizer Consumption Growth

Increasing Global Demand for the Three Primary Nutrients



Source: Fertecon, PotashCorp

PotashCorp
Helping Nature Provide

Top 10 Consuming Countries, '000 t 2006 data

	N
China	31,810
India	13,774
USA	11,970
Pakistan	2,650
Indonesia	2,350
Brazil	2,297
France	2,200
Canada	1,758
Germany	1,599
Turkey	1,407

	P_2O_5
China	11,958
India	5,537
USA	4,147
Brazil	3,149
Pakistan	969
Australia	867
Canada	635
Turkey	608
Viet Nam	600
Indonesia	570

	K_2O
China	5,600
USA	4,657
Brazil	3,460
India	2,335
Malaysia	1,005
Indonesia	802
France	731
Belarus	601
Poland	502
Germany	443

Source: http://www.fertilizer.org/ifa/Home-Page/STATISTICS

IPNI

The Fertilizer Institute:

- Increase global demands:

  11%N, 13%P, 17%K (2001-2006)
- Ethanol production needs more fertilizers
- High transportation costs
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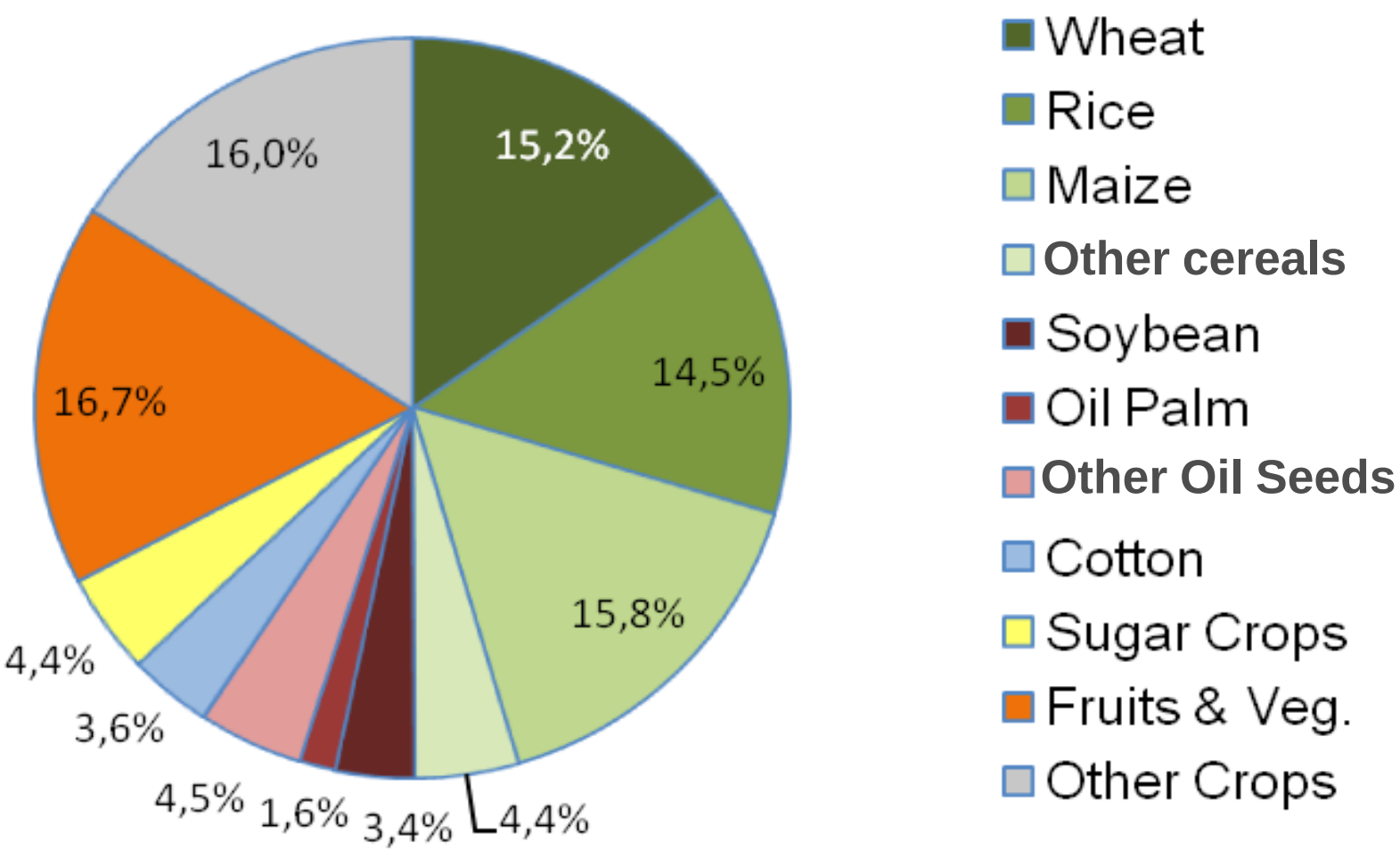
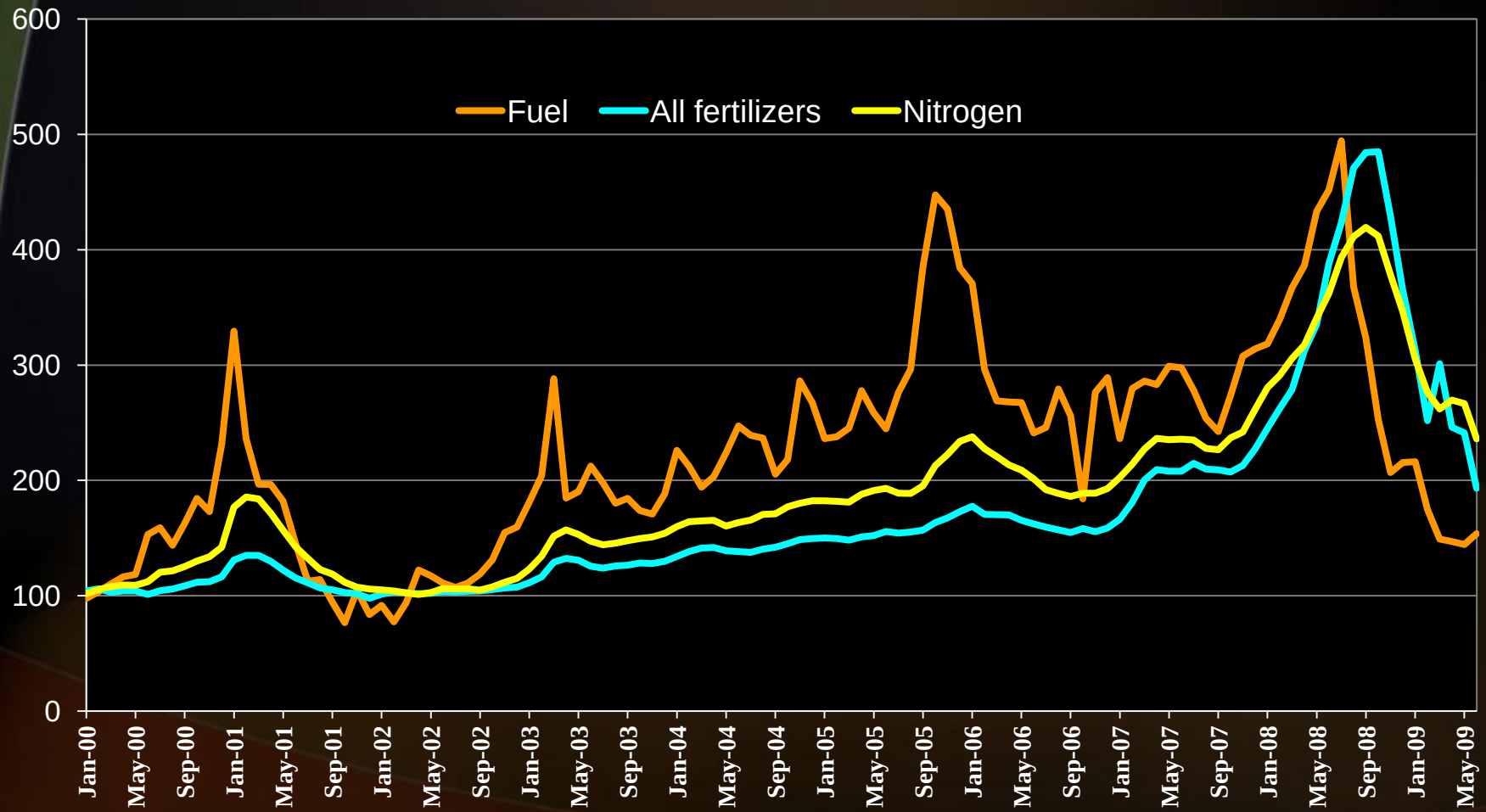
World Fertilizer Use by Crop Type
Estimates for 2006/07



Source : IFA

Fuel, All Fertilizers and Nitrogen Price Index

January 2000 – June 2009 (1982 = 100)



Source: The Bureau of Labor Statistics of the U.S. Department of Labor

Problems with fertilizer production and use:

- Total use & price are continuously increasing
- Use efficiency is still low
- Pressure is coming from regulation/environmental concerns

*N fertilizer **recovery efficiency** using on-farm measurements*

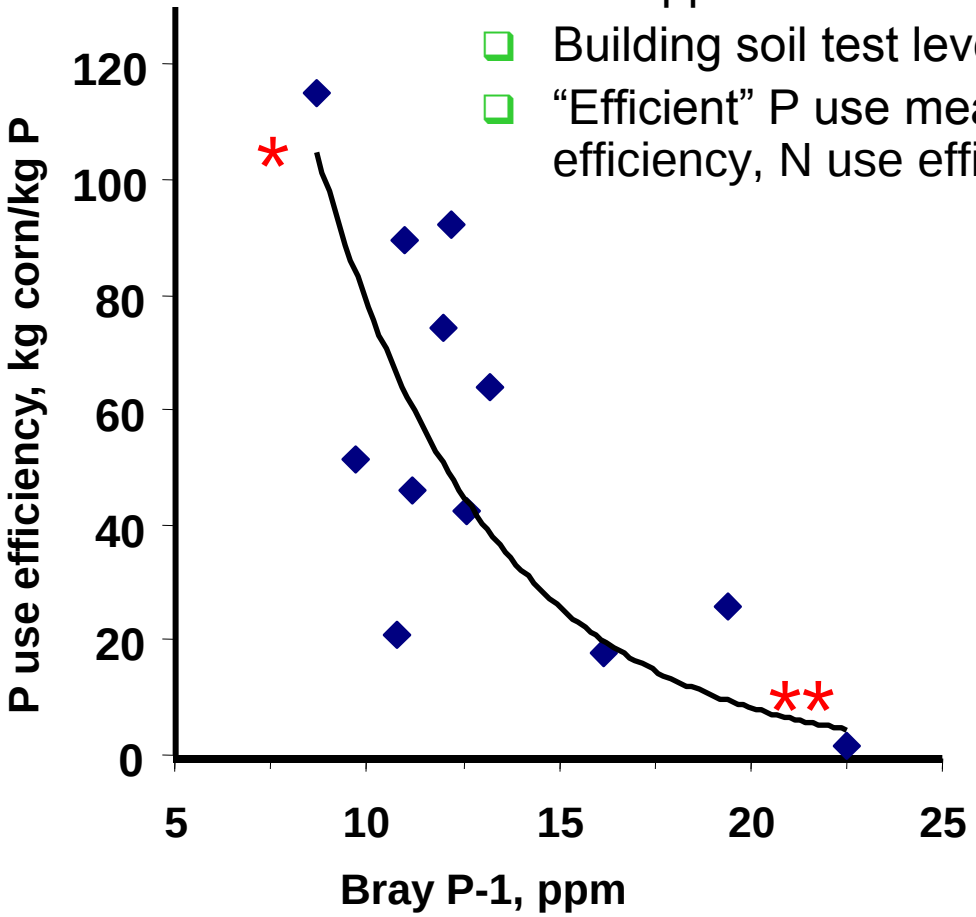
Opportunity for improvement

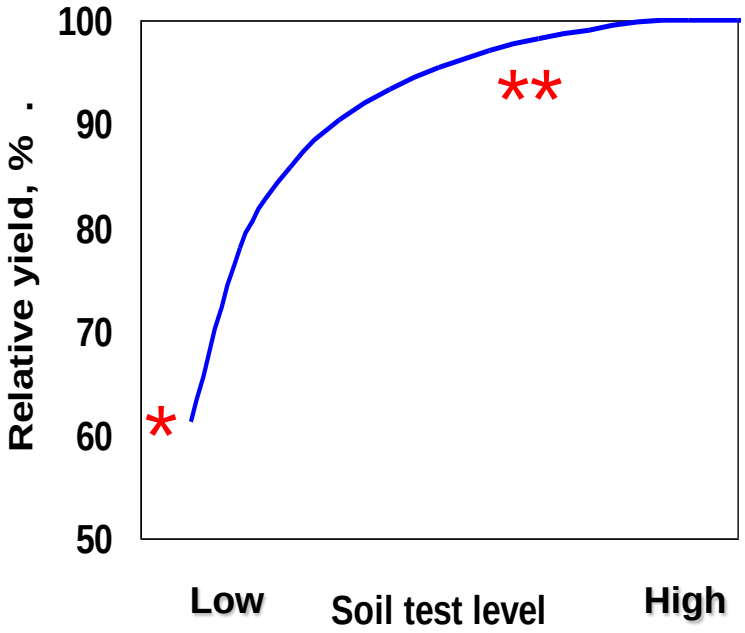
Crop	Region	Number of farms	Avg N rate, kg/ha	Recovery, %
Maize	NC USA	56	103	**37**
Rice	Asia-farmer	179	117 112	**31**
	Asia-researcher	179		**40**
Wheat	India-poor weather	23	145	**18**
	India-good weather	21	123	**49**

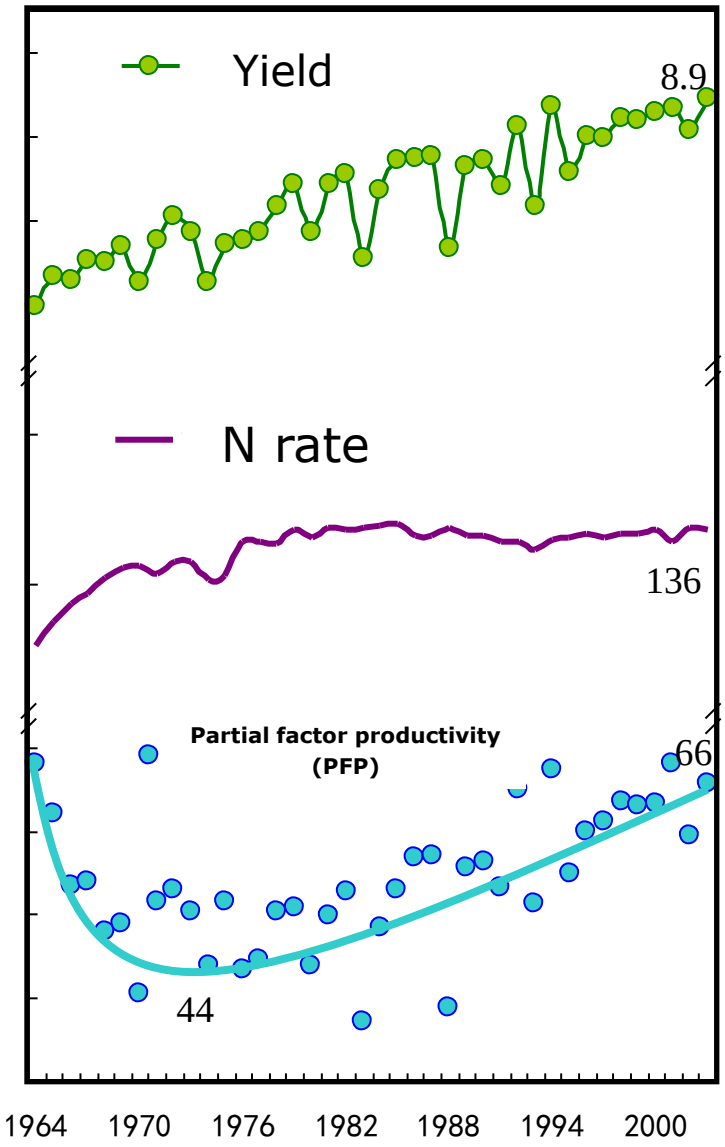
Cassman et al., 2002

The result of applying the definition of agronomic efficiency for N to P

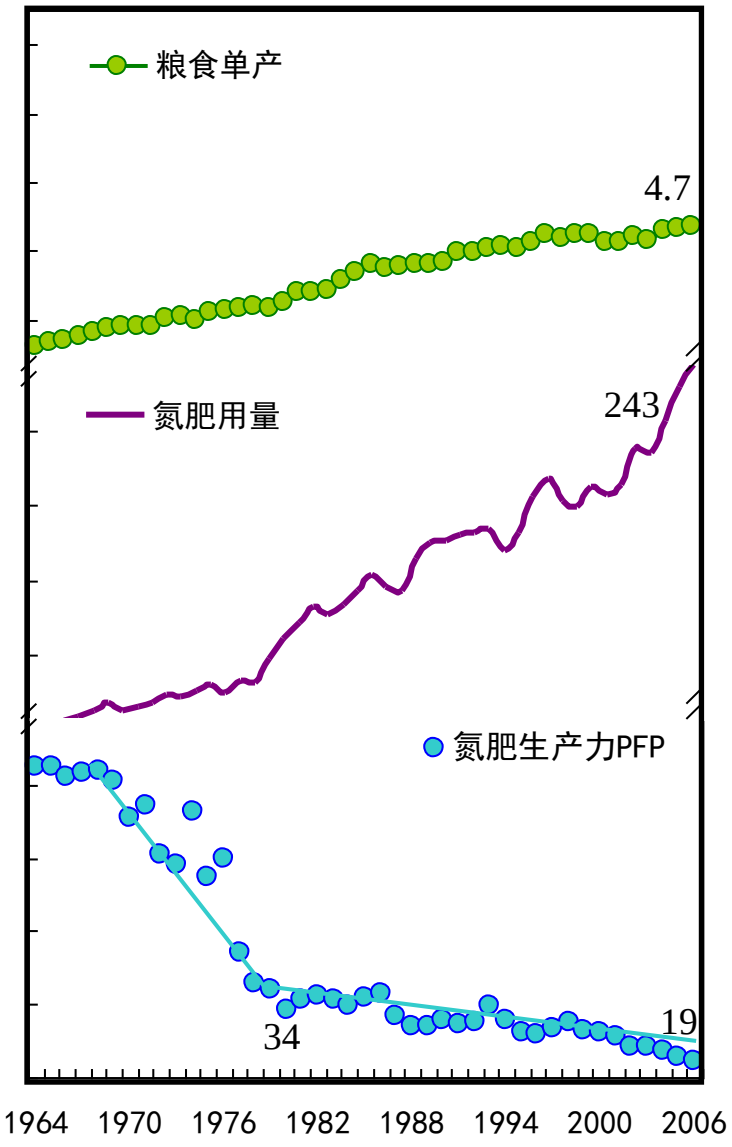
- The highest “efficiency” occurs when inadequate amounts are applied at low soil test levels
- Building soil test levels to optimum reduces “efficiency”
- “Efficient” P use means reduced profitability, water use efficiency, N use efficiency, and land use efficiency






Yield
8.9
N rate
136
Partial factor productivity
(PFP)
66
44
1964
1970
1976
1982
1988
1994
2000

USA


粮食单产
4.7
氮肥用量
243
氮肥生产力PFP
34
19
1964
1970
1976
1982
1988
1994
2000
2006

China

Problems with fertilizer production and use:

- Total use & price are continuously increasing
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New fertilizer technology

- New fertilizers
  - High use efficiency
  - Relatively low price
  - Minimal environmental impact
  - Renewable

ScienceDaily
Your source for the latest research news

Web address:
http://www.sciencedaily.com/releases/2008/08/080825103527.htm

Fertilizer Technology Used Worldwide, But Few New Products Since 1970s

ScienceDaily (Aug. 26, 2008) — About 75% of fertilizers and fertilizer technology used around the world today were developed or improved during the 1950s to 1970s by scientists and engineers at the Tennessee Valley Authority (TVA) in the United States, says John Shields, a former TVA official. Shields is now Interim Director of IFDC, An International Center for Soil Fertility and Agricultural Development, based in Muscle Shoals, Alabama.

"An investment of $41 million in fertilizer research through 1981 returned an incredible $57 billion to U.S. agriculture," Shields says. "That doesn't include benefits of the technology to the rest of the world."

But inadequate public funding caused closure of the TVA fertilizer research program in the early 1990s. Today,

TVA developed 75 percent of the fertilizers used worldwide today -- but research and development in fertilizer technology has almost ceased since the program closed in the early 1990s. (Credit: IFDC)

Calls for New Fertilizer Research

Dr. Norman Borlaug (1970 Nobel Laureate):

"I am concerned about the state of the fertilizer industry itself. With the price of energy increasing, we need to find cheaper, more effective ways to nourish food crops …… the fertilizer industry needs to do everything in its power to minimize that cost. Farmers are paying way too much for fertilizer products …… because much of the nutrients in applied fertilizers are never used by the crop. Nutrient losses to the environment are high with consequences for global warming and water pollution."

Calls for New Fertilizer Research

Peter McPherson, President of the National Association of State Universities and Land-Grant Colleges (NASULGC) :

"The world needs a major research effort to improve the effectiveness of fertilizer production and use. Fertilizer is a commodity industry and it is unlikely the industry alone will undertake the research. Some public investment is probably required."

Calls for New Fertilizer Research

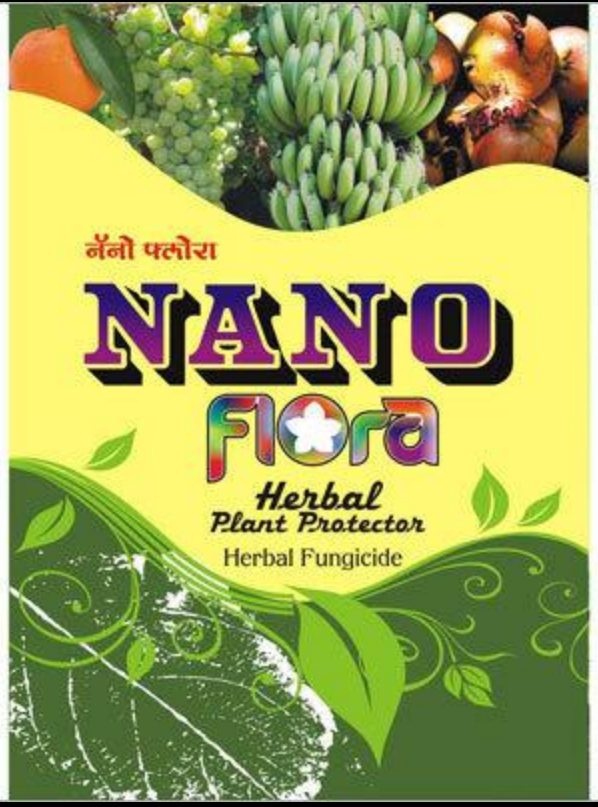
Dr. Norman Borlaug (served on the IFDC Board of Directors from 1994 to 2003):

"Work should begin now on the next generation of fertilizer products using advanced techniques such as nanotechnology and molecular biology, especially in conjunction with plant genetics research. 'Smart' fertilizer products that will release nutrients only at the time and in the amount needed should be developed."

Nano fertilizers

- Using Google Scholar:
  - 2070 articles
  - 60 patents

- There is no refereed article on nano fertilizer (using Agricola database)


नॅनो फ्लोरा
NANO
Flora
Herbal
Plant Protector
Herbal Fungicide

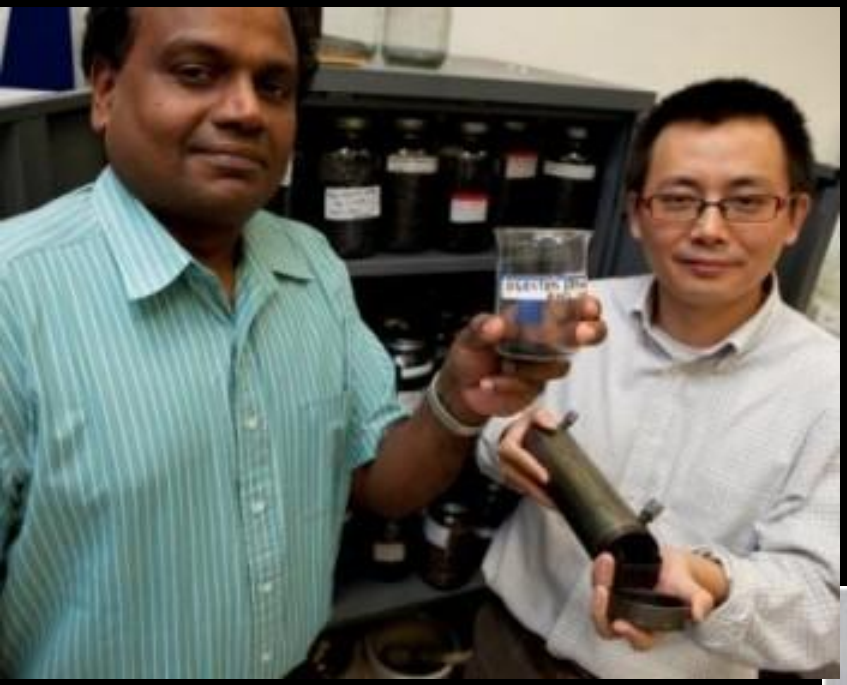

Uno Fortune Inc.
established 1993
Nano-5
Nano-5
Nano-5
Nano-5
Nano-5
3 IN 1 NATURAL MUCILAGE ORGANIC FERTILIZER®
Since 1994
plant growth, elimination of pests and diseases,
prevention of pests and diseases

Carbon Nanotubes Are Super Fertilizer

Carbon nanotubes (CNTs) were found to penetrate tomato seeds and affect their germination and growth rates. Analytical methods indicated that the CNTs are able to penetrate the thick seed coat and support water uptake inside seeds, a process which can affect seed germination and growth of tomato seedlings

- University of Arkansas

Credit: ACS/*ACS Nano (2009)*



P-enriched Biochar with nanotechnology

Dr. Bin Gao

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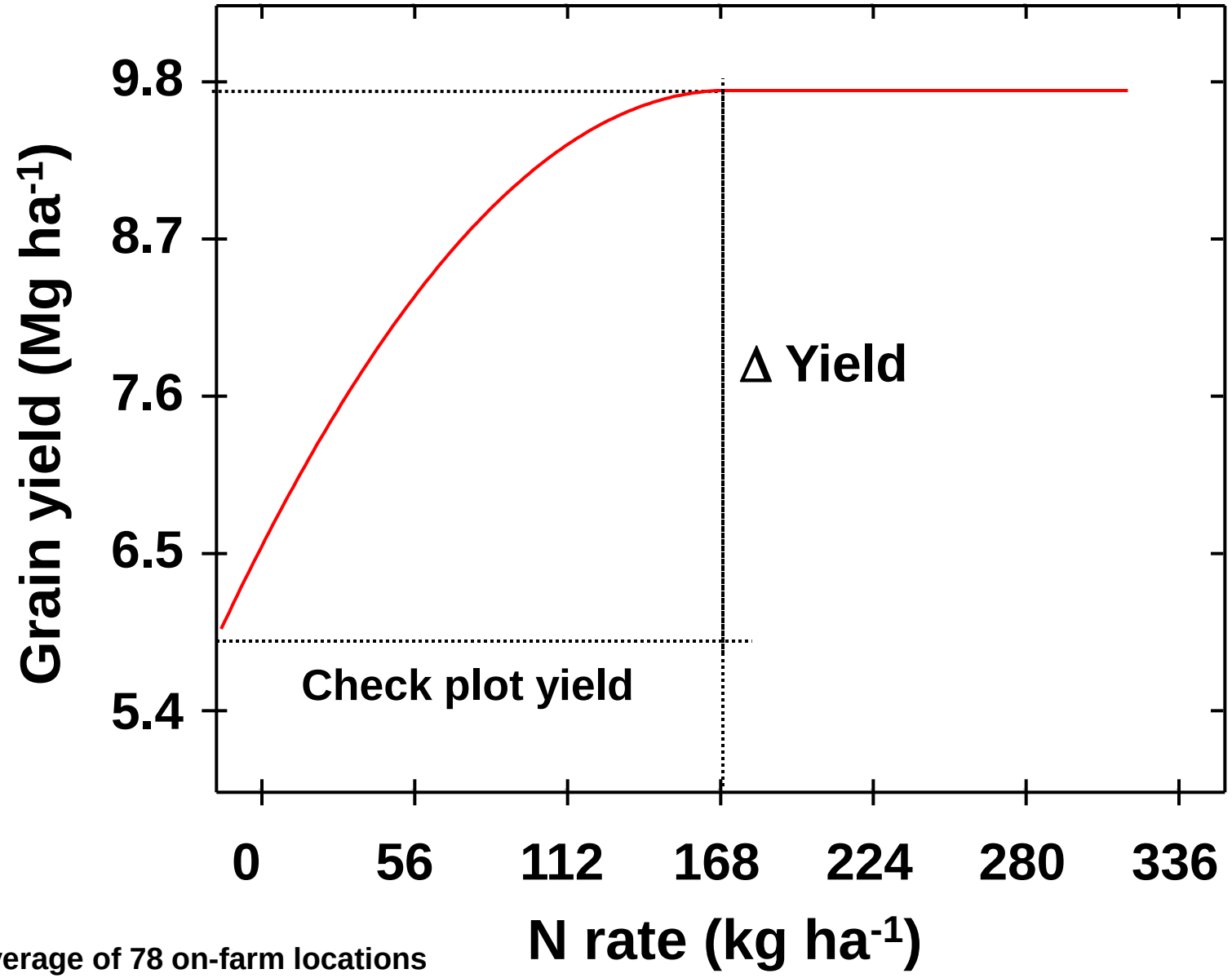
Technology and Biotechnology for Better Nitrogen Use Efficiency in Corn

Fred Below

Crop Physiology Laboratory
University of Illinois

Typical Corn Response to Fertilizer N



Average of 78 on-farm locations

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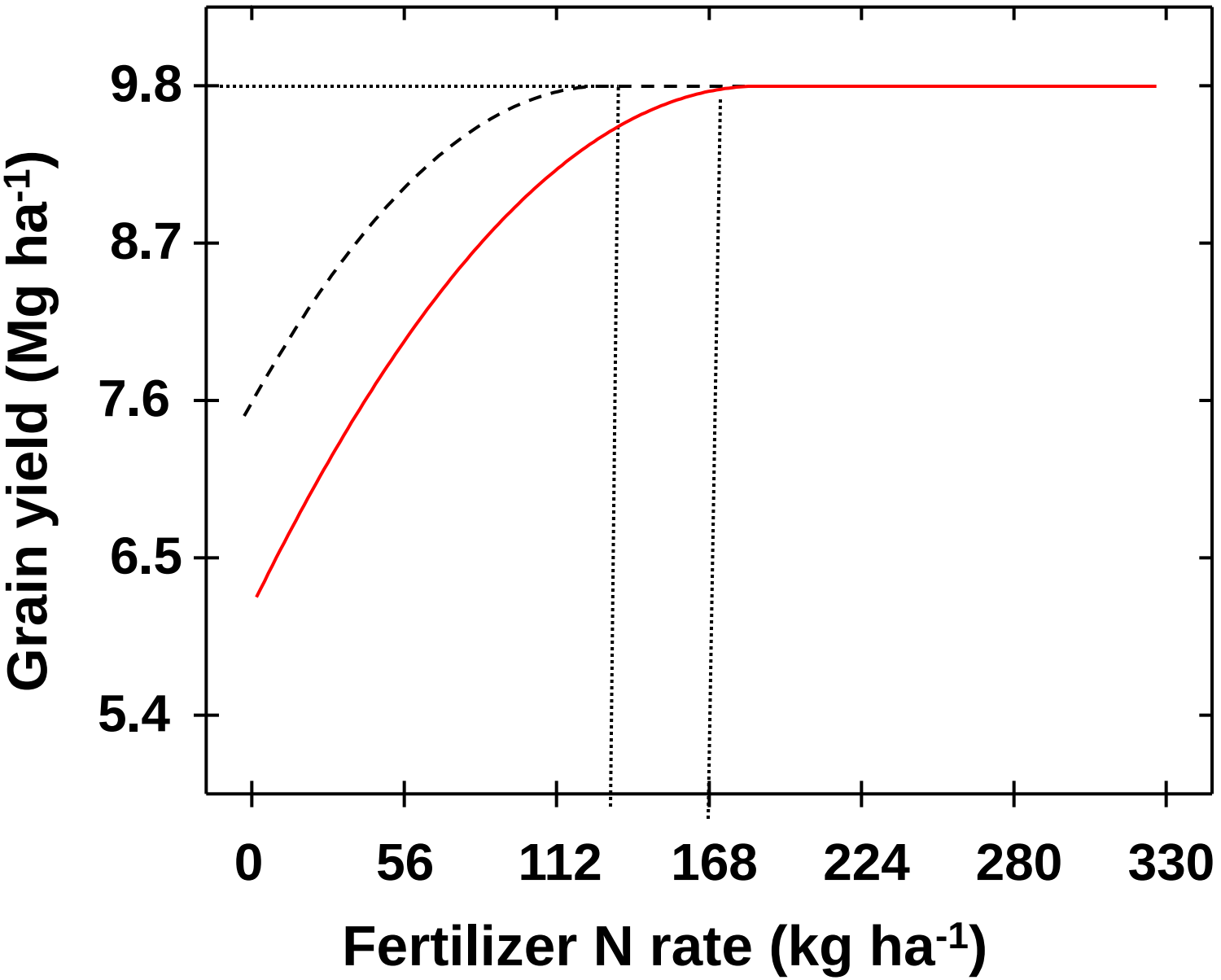
UNIVERSITY OF ILLINOIS

Same yield with lower N requirement



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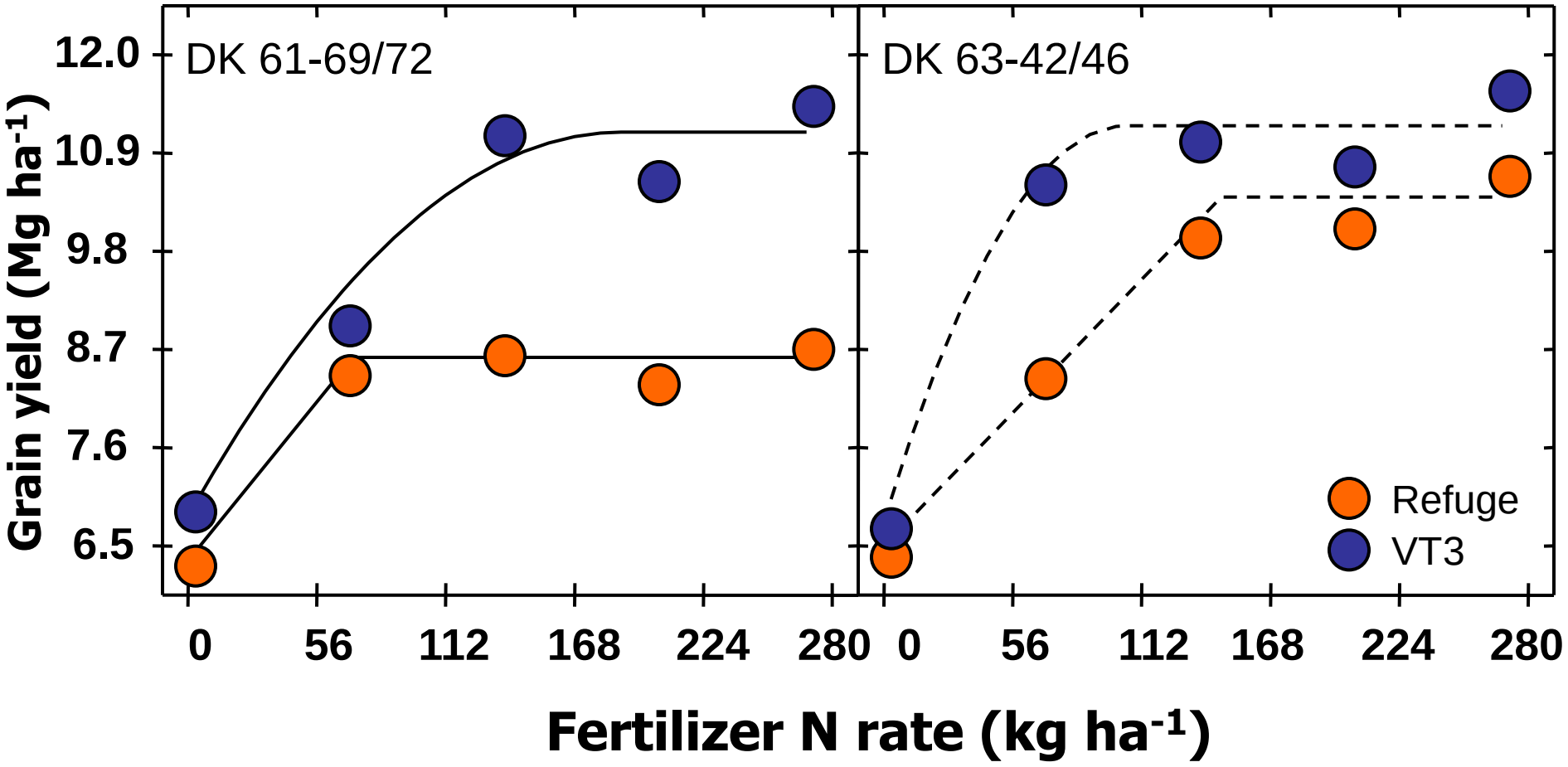
Nitrogen & Biotech Traits



Data from 2008

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Rootworm Bt on N use

Hybrid	NUE	Uptake	Utilization
	kg/kg N	%	kg/kg N
DK 61-69	25.9*	71*	36.4
DK 61-72	17.0	52	33.1
DK 63-42	31.7*	71*	44.6
DK 63-46	22.4	56	40.1

*different from non-RW counterpart P< 0.05

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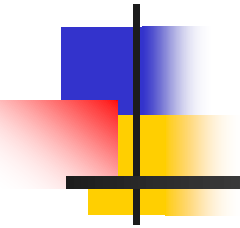
UNIVERSITY OF ILLINOIS

Need high P-efficient varieties in FL



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Slow- or Controlled-release fertilizers

Slow-release fertilizers/ Controlled-release

Water-soluble	Slow-release	Controlled-release
	Non-coated	Coated
		
Ammonium nitrate	Urea formaldehyde	Osmocote
Dissolves all at once	Slowly decomposes to soluble N	Nutrients "leak" through coating

Controlled-release fertilizer (CRF)

At soil temperatures under 25°C, a CRF must meet three criteria:

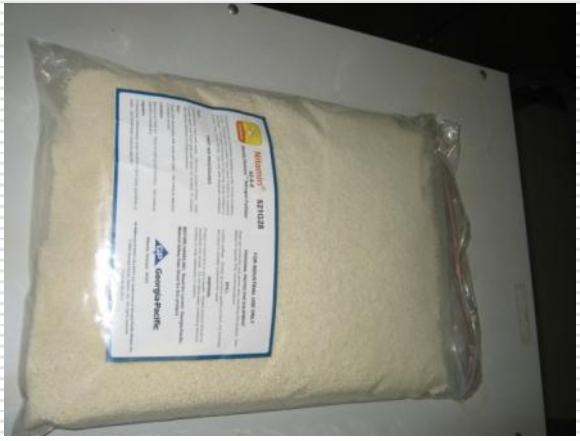
1) less than 15% of the CRF nutrients should be released in 24 hours,
2) less than 75% should be released in 28 days, and
3) at least 75% should be released by the stated release time (40–360 days).

Slow-release fertilizers:

- Urea-formaldehyde (UF) –38% N
- Isobutylidene diurea (IBDU) –32% N
- Crotonylidene diurea (CDU) –32.5% N

Slow-release fertilizers

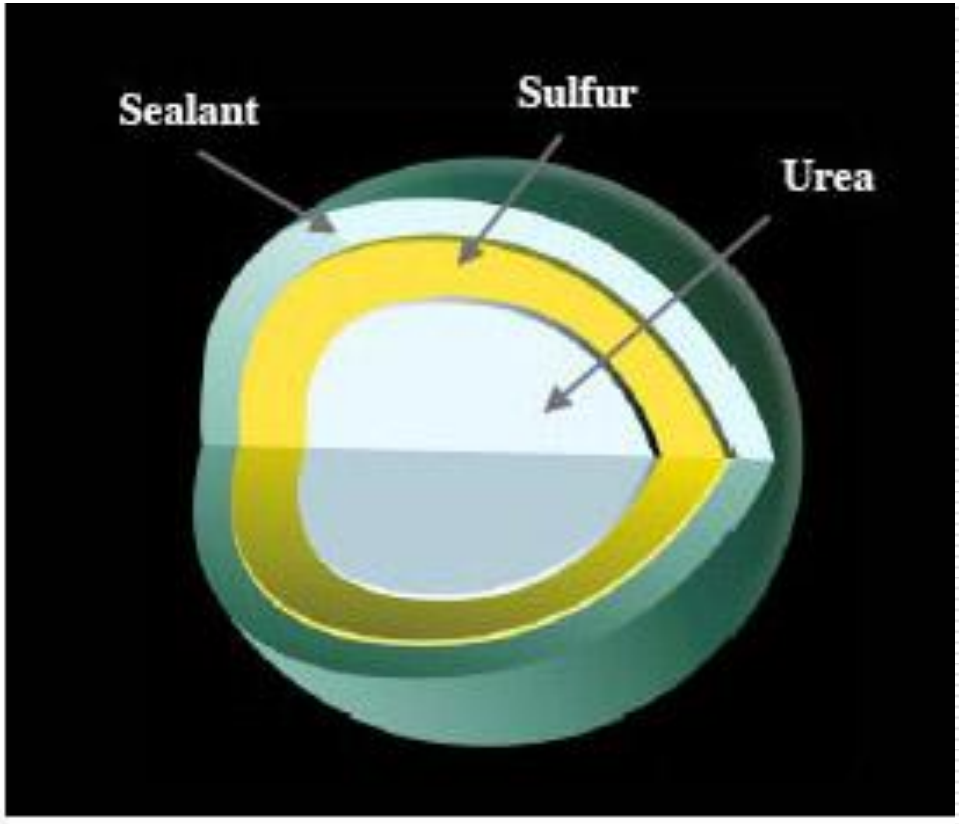
Nitamin 42G



RC 24-0-0

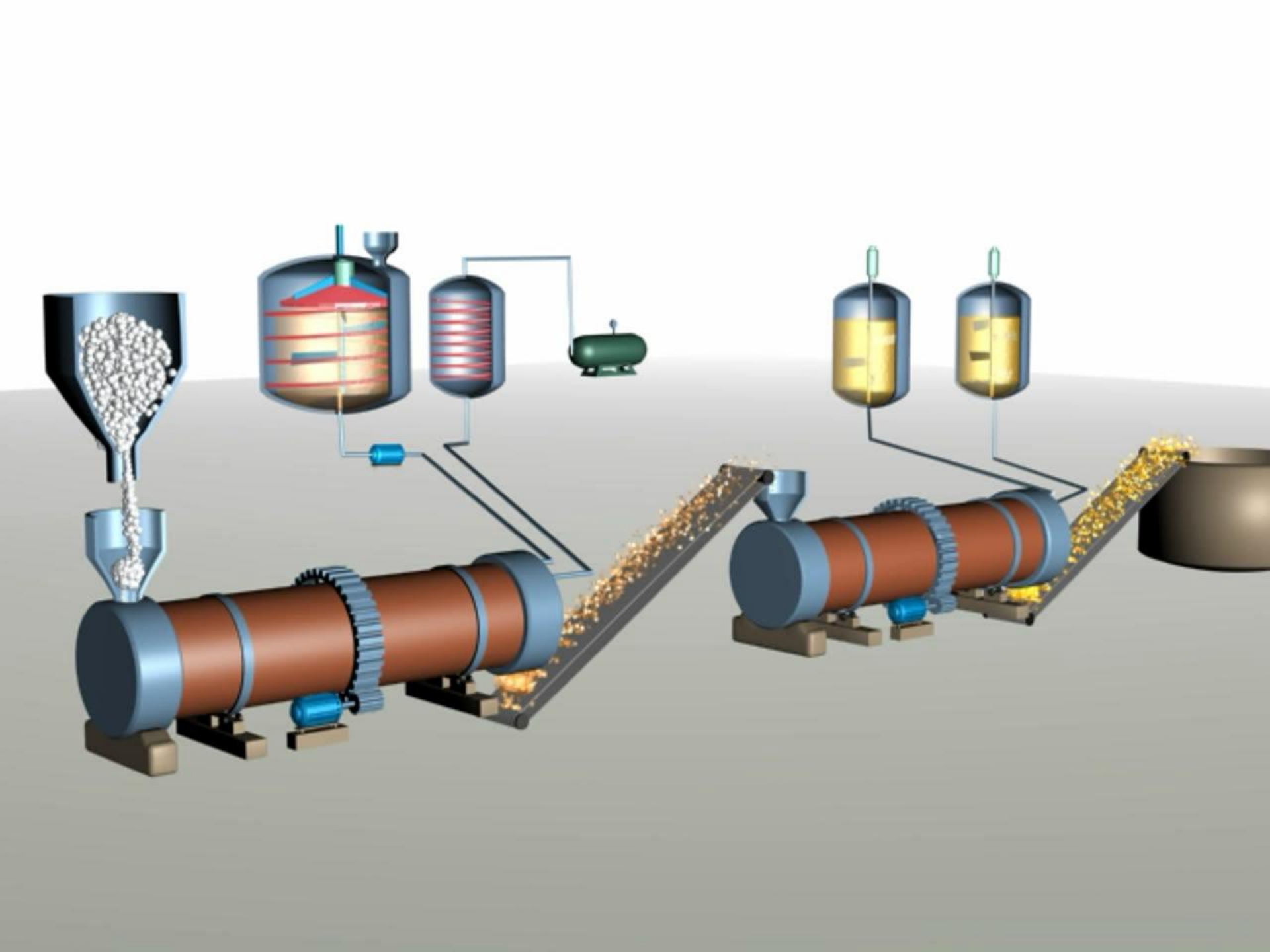
Nitamin 30L

Controlled-release fertilizers



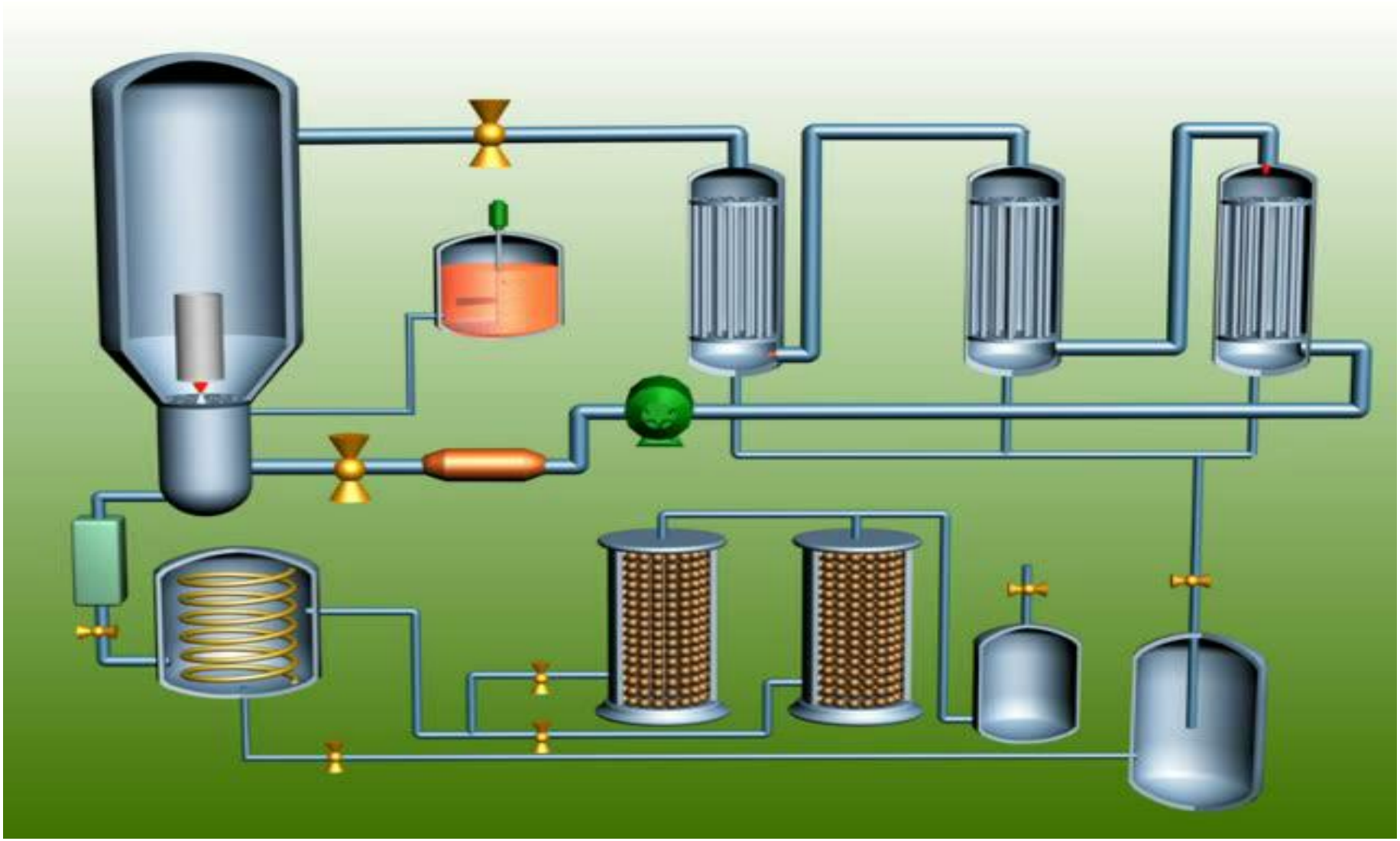
Coating Technology of CRFs

- Polymer (polyethylene, polyesters)
- Sulfur
- Sulfur plus polymer



Sulfur Coated Urea (SCU) Fertilizers

Schematic Diagram-The processing for Controlled-Release fertilizer (polymer coated fertilizer)

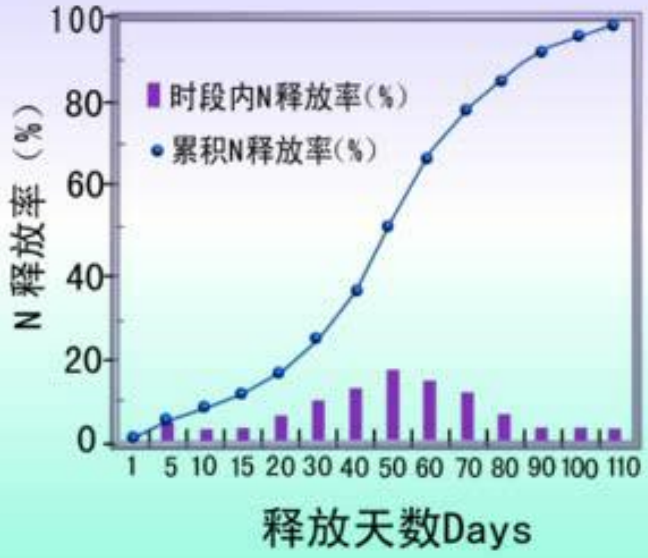


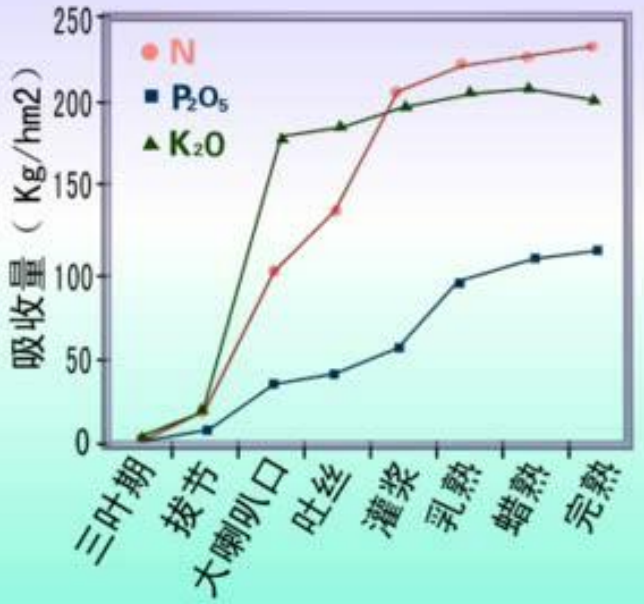
Polymer coated fertilizers

CRF-9 month-Brown

CRF-6 month-Pale-brown

4. Nutrient release from Controlled-Release fertilizer





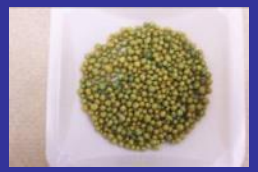
Edge of lawn burned by excess fertilize

Guaranteed not to burn

Why does a CRF burn plants?

- Release too quick
  - Poor quality of products
  - High temperature in FL

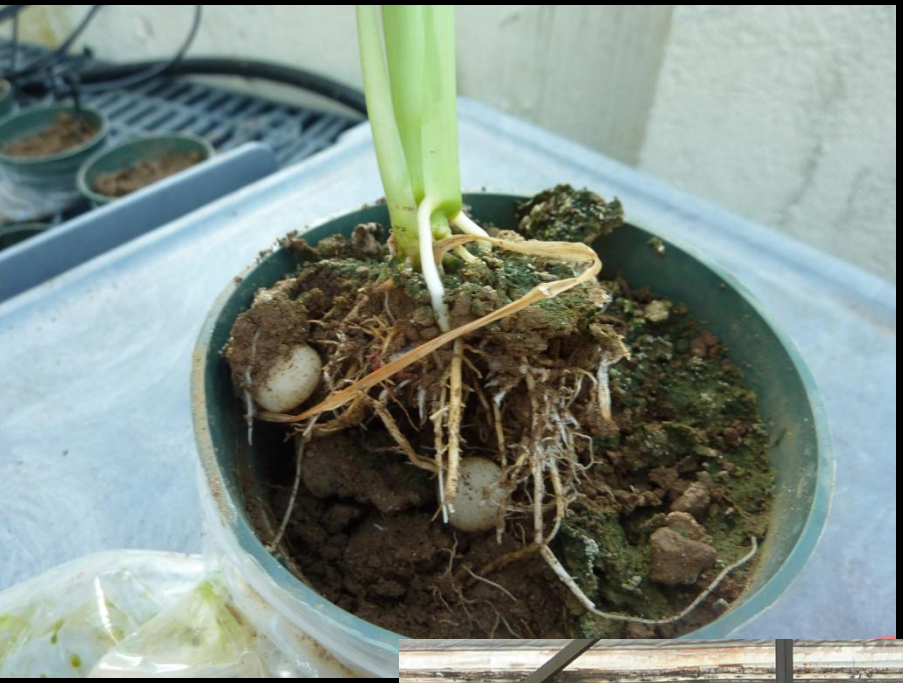
Main characteristics of the CRFs used

	Product	Stated NPK analysis	N derived from	Release claimed (days)	Release Tested (days)
	F1	18-6-8	AN, AP, PN	140	104
	F3	15-7-15	AN, AP, PN	90-120	84
	F4	20-8-10	AN, AP, PN	180	114
	F5	15-9-12	AN, AP, PN	120-150	114
	F6	16-6-11	AN, Mono-Ammonium Phosphate	150-180	168

Henry Mayer et al. 2011

CRF research at our laboratory

Large size CRFs

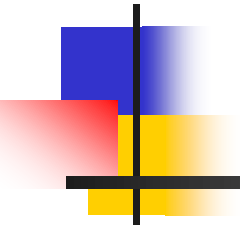



CRU3-4
CRU3-3
CRU3-2
CRU2-4
CRU2-3
CRU2-2
CRU1-3
U-4
U-2
U-1
CK

Polymers from agricultural wastes

Dr. Zhaohui Tong

Liquid fertilizers



UF News (January 17, 2012)

- **UF researchers discover 'green' pesticide effective against citrus pests**
- Discovered a key amino acid essential for human nutrition is also an effective insecticide against caterpillars that threaten the citrus industry.

KeyPlex®

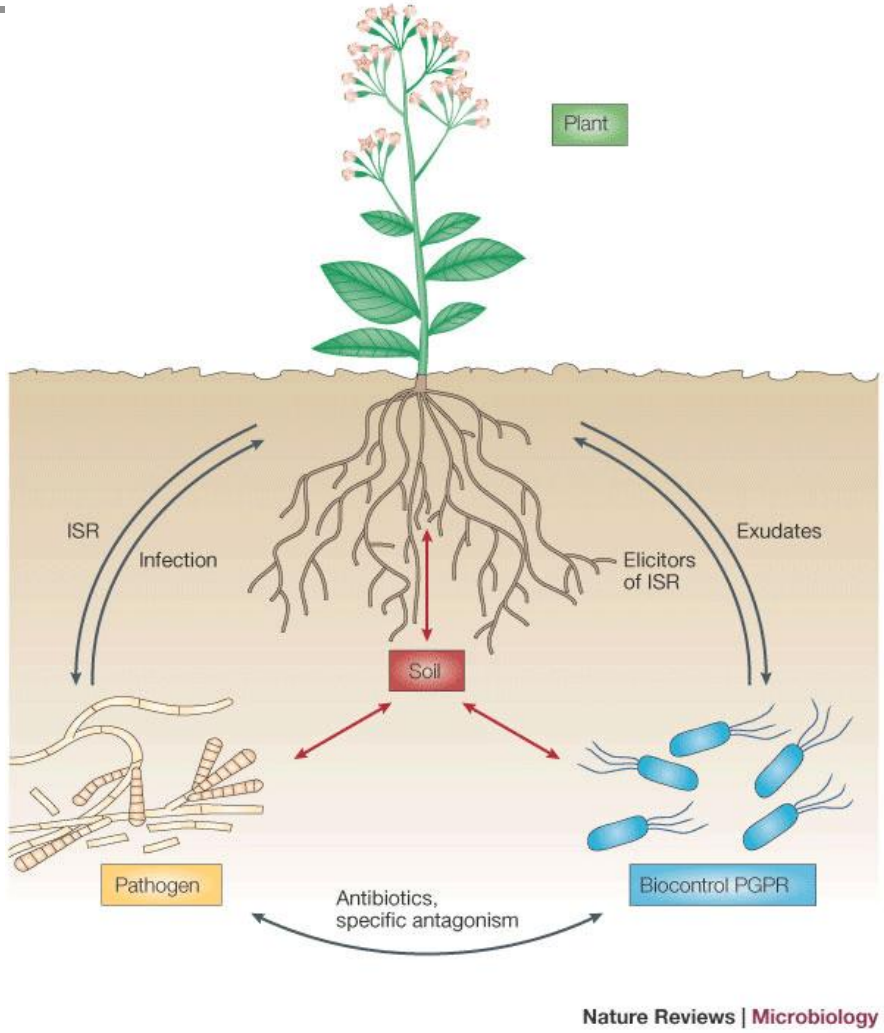
Amino Acid NPK fertilizer-TREC

Bio-fertilizers

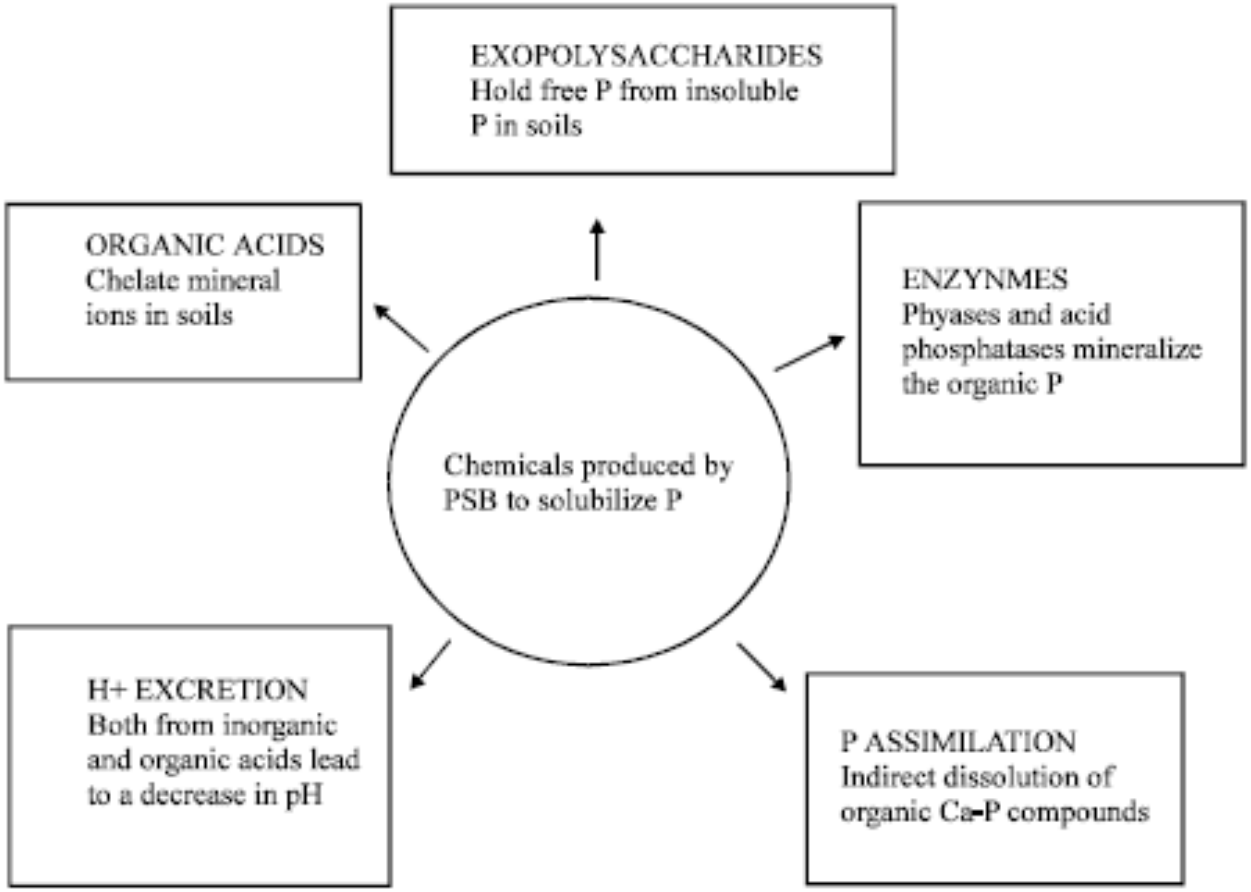
Dr. Bruce Schaffer

Plant Growth Promoting Rhizobacteria

Dr. Shouan Zhang

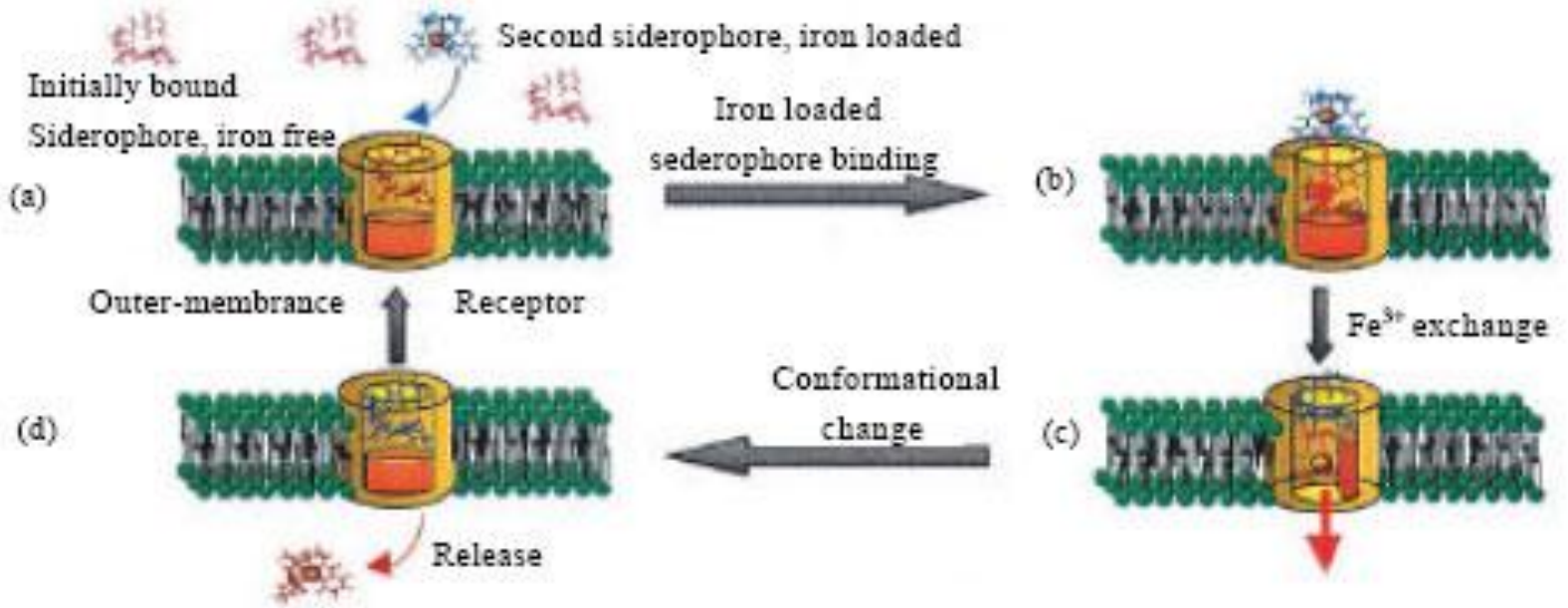


Phosphate-Solubilizing Bacteria



Mechanisms of P solubilization by phosphate solubilizing bacteria adoped from Ahemad & Khan 2011

Iron-Solubilizing Bacteria



The siderophore shuttle iron delivery mechanism. Adopted from Stintizi *et al*. (2002)

Summary

- The best approach to improve fertilizer use efficiency is to invent new fertilizers and to breed new varieties.

- It is time for breakthrough of new type of Fertilizers because of high fertilizer price and tight regulations.

Thank you!


University of Florida
CIVIUM IN MORIBUS REI PUBLICAE SALUS
IN GOD WE TRUST
1853
UNIVERSITY OF
FLORIDA
IFAS EXTENSION