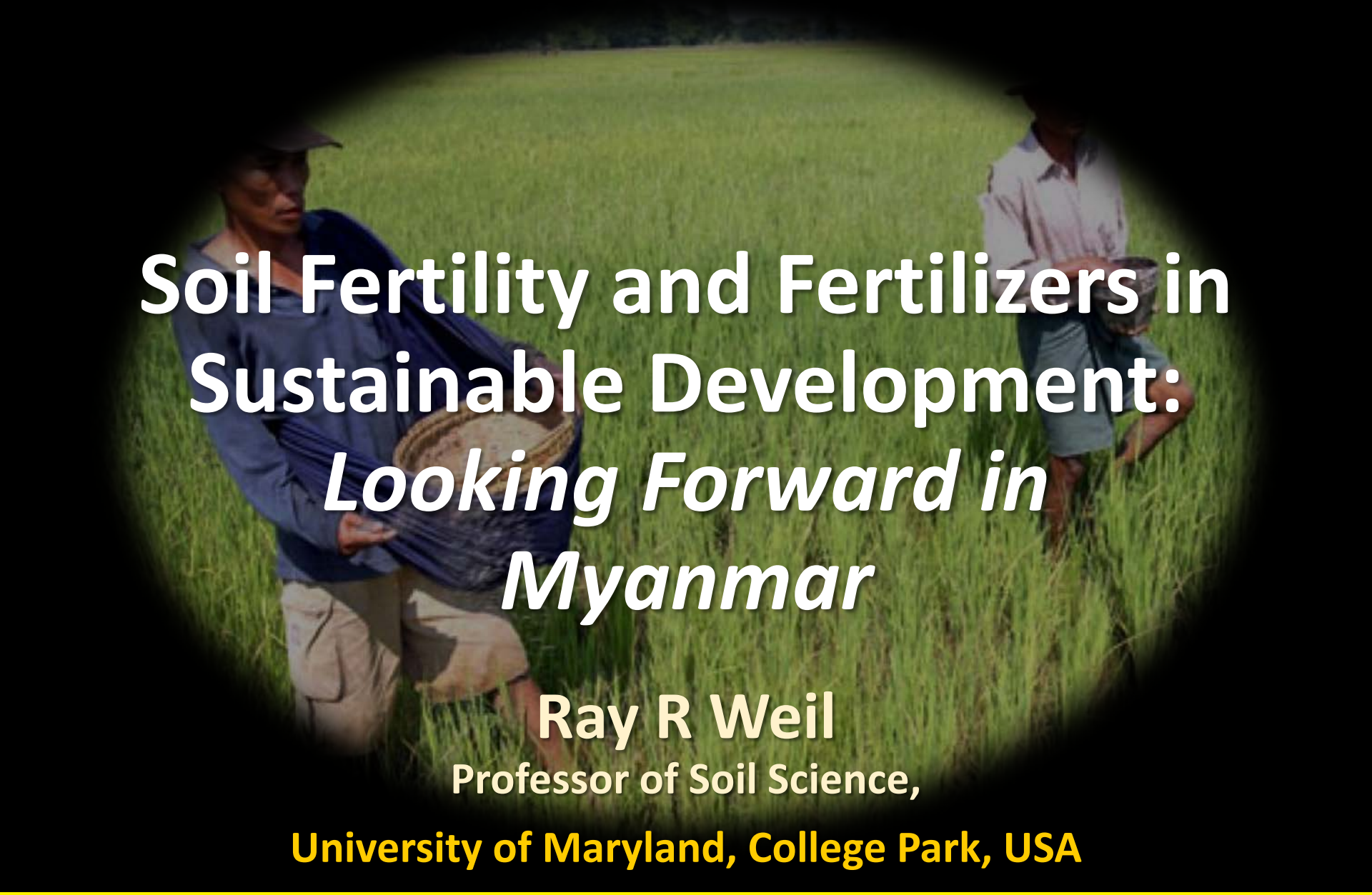

Soil Fertility and Fertilizers in Sustainable Development: *Looking Forward in Myanmar*

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DEPARTMENT OF
ENVIRONMENTAL SCIENCE
& TECHNOLOGY

w w w . e n s t . u m d . e d u

Photo credit: MM Times

Fertilizer needs to be considered in the context of the whole system:

- Food security and human nutrition
- Farmers and rural livelihoods
- Landscapes and natural resources
- The soil-plant-microbe community

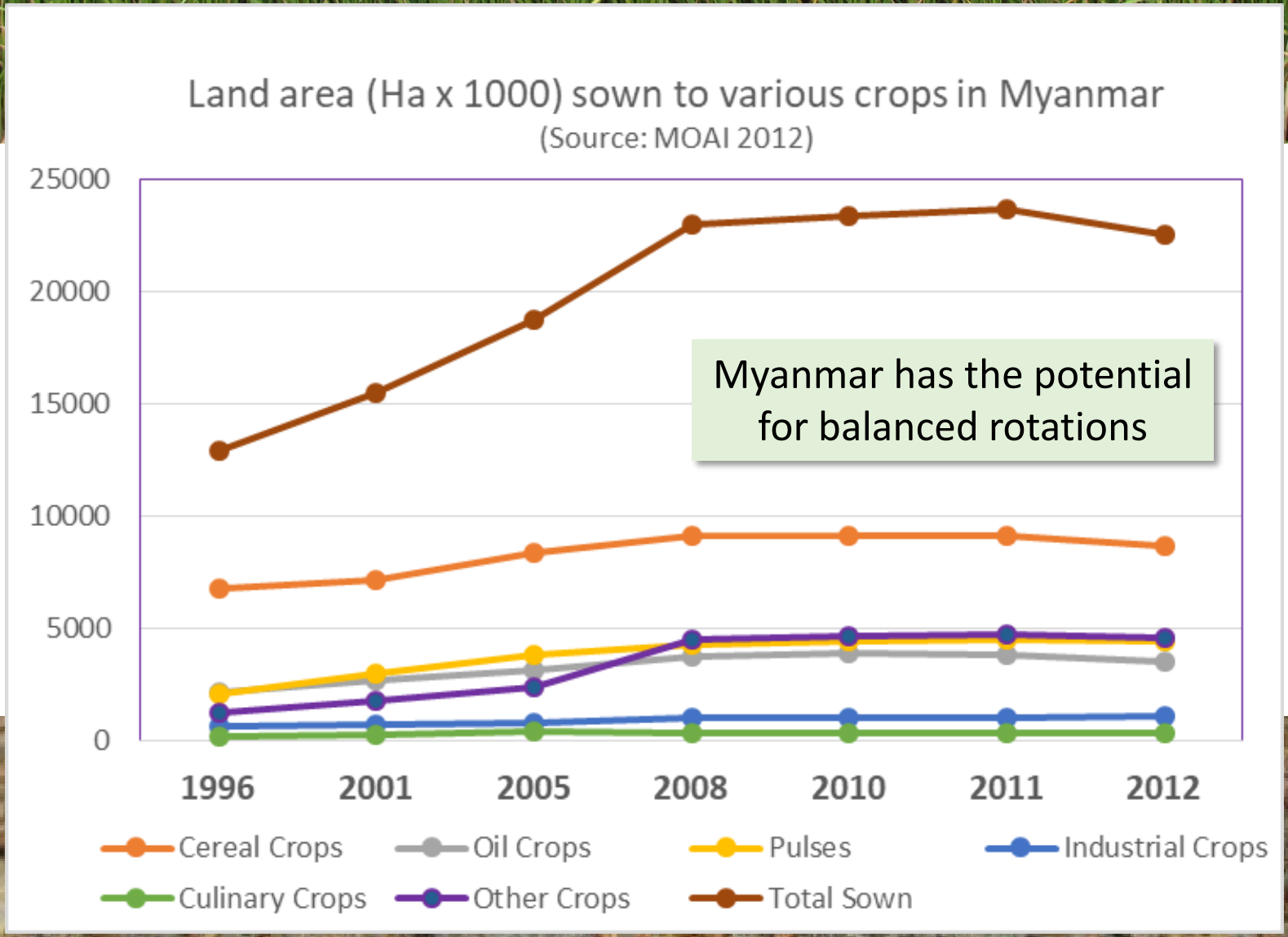
Soil – Plant – Microbe Community

- Fertilizers should support the living soil system
- Plants excrete signaling compounds to recruit favorable bacteria, fungi and even nematodes.
- Plant nutrition in soil depends microbial processes.
- Plant science should aim to improve rhizosphere function.

In here, fertilizer directly feeds the plants…

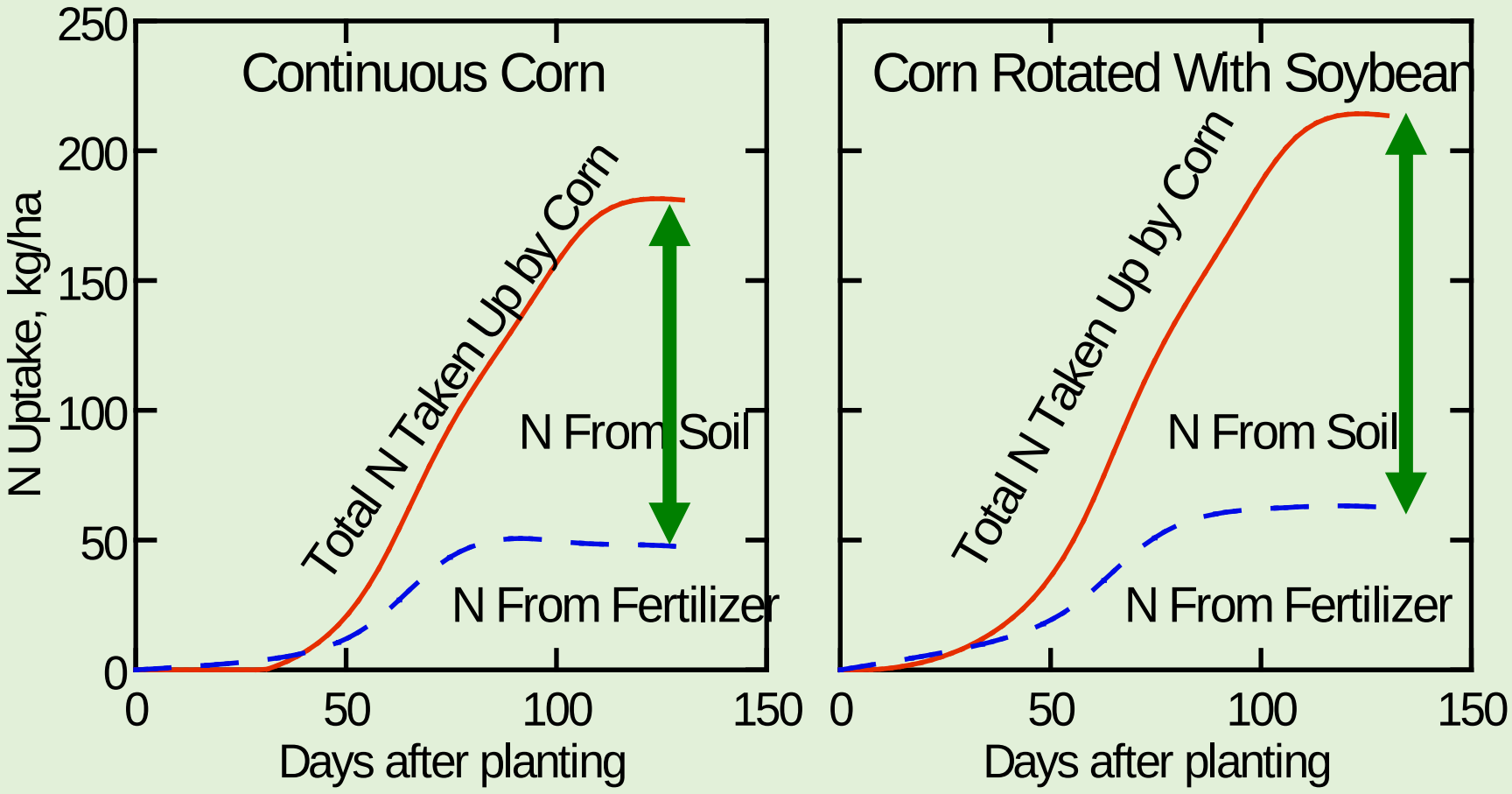

Out here, fertilizer mainly feeds the soil and the soil feeds the plants…

Cereal – legume rotations diversify the soil food web and almost always out-perform continuous single cropping.

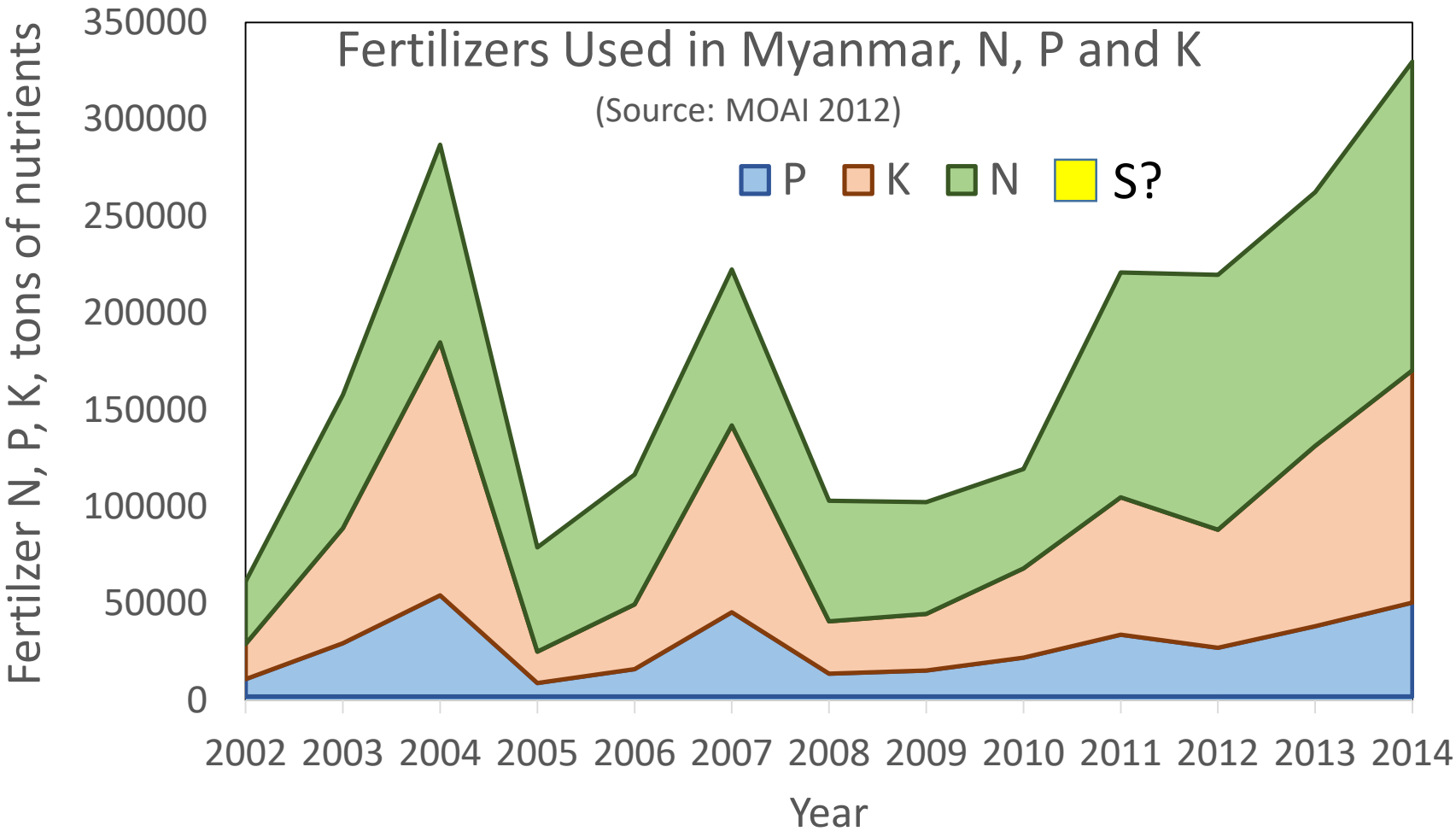


Mineralization of soil organic matter is almost always the greatest source of N

N-15 isotope research shows SOM as main N Source...



From Omay, et al. 1998. SSSAJ 62:1596-1603.



~320,000 tons / ~ 25 Million ha ≈ 13 kg /ha ???

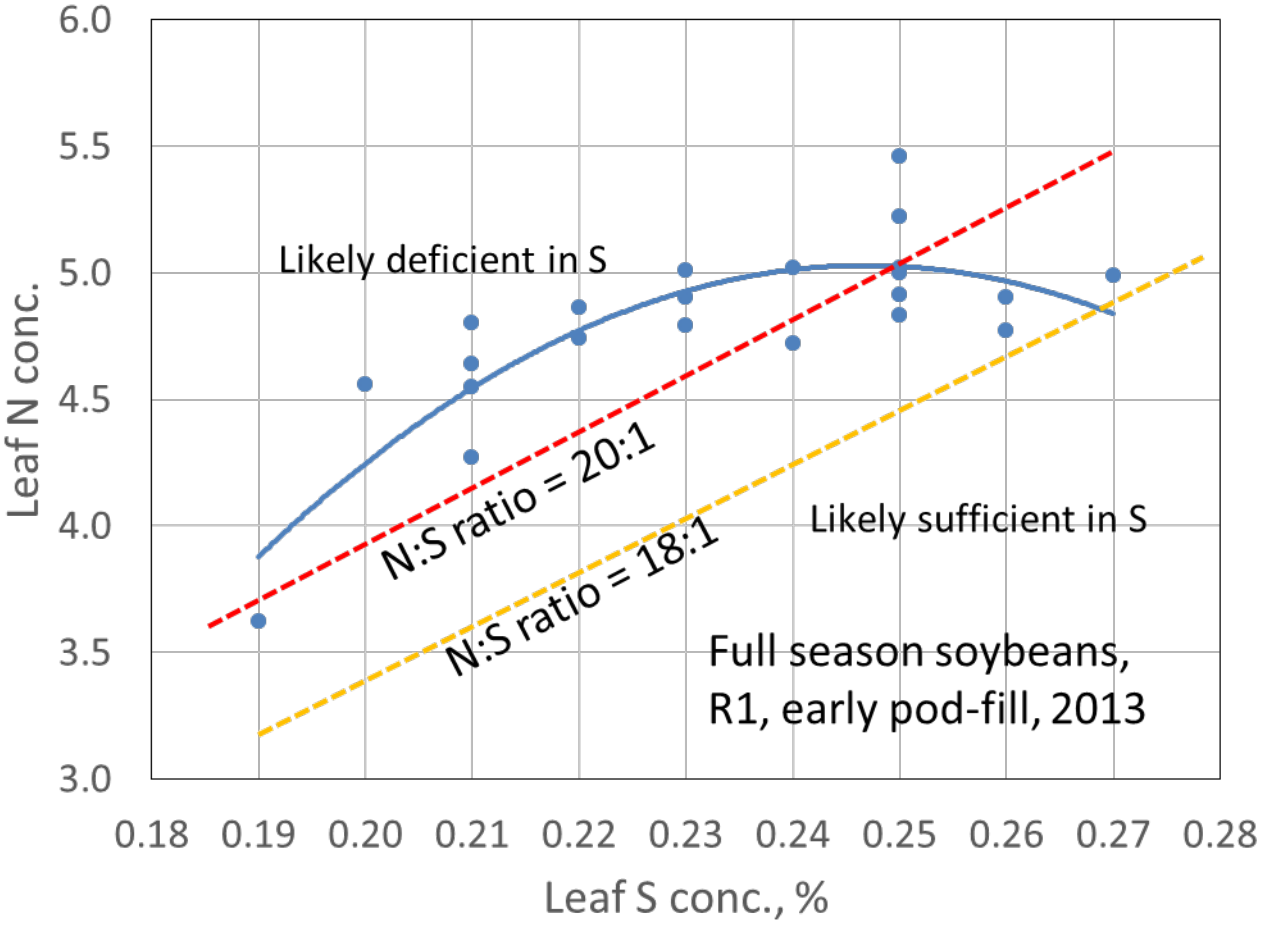
Fertilizer use in Nay Pyi Taw District in 2013 (Survey of 652 households)

Land Holding Area (Hectare)	Average Fertilizer Use Rate (kg/ Ha)	Paddy Yield (MT/Ha)	Partial Factor Productivity of Fertilizer (kg/kg)
0.2 – 2.02	213.1	4.5	21.2
2.14 – 4.05	214.4	4.3	20.1
4.17 – 6.07	253.4	4.7	18.5
6.48 – 17	258.6	4.4	17.0
Survey mean	**234.9**	**4.5**	**19.2**

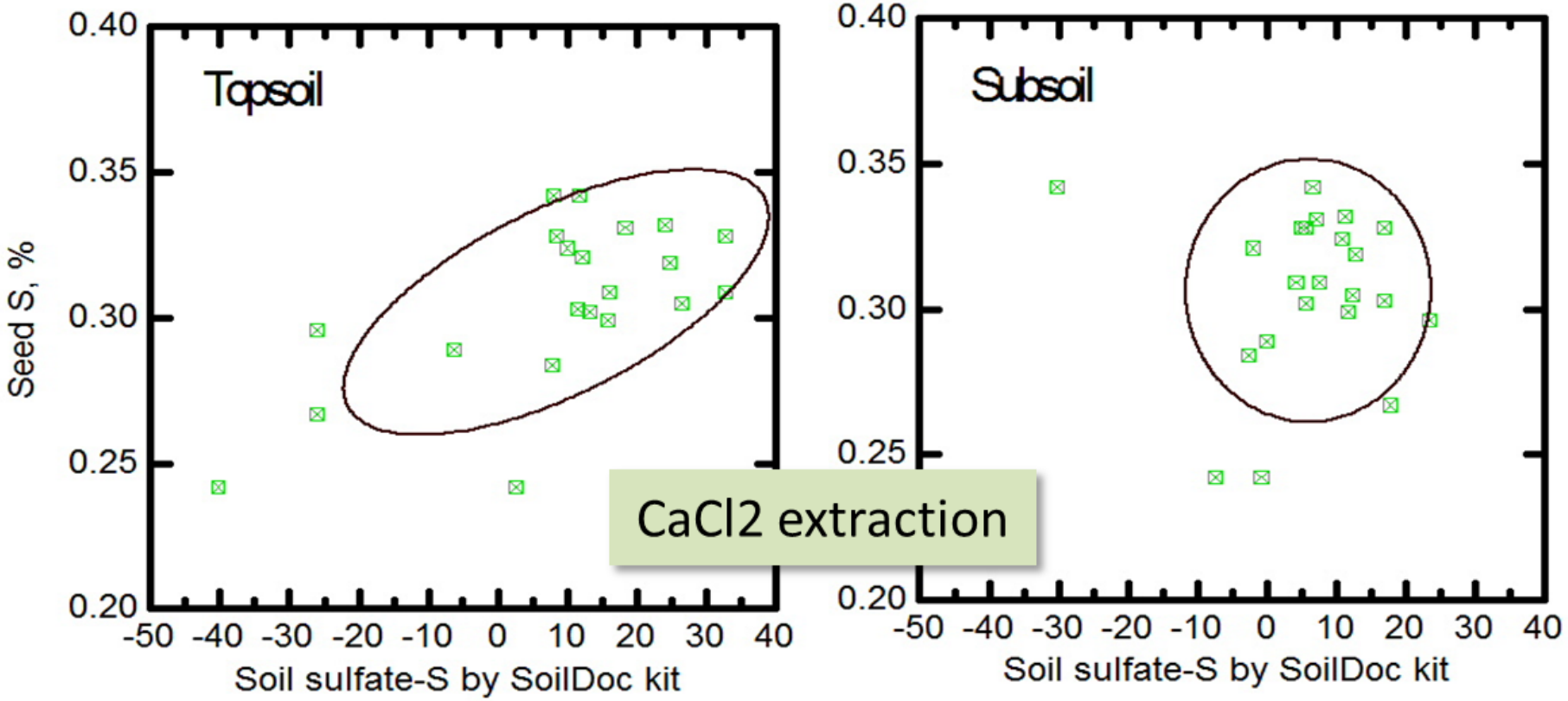
"Huge difference between the macro and micro data on fertilizer utilization indicates the possibility of illegal fertilizer import or unregistered fertilizer marketing in Myanmar."
Lwin, et al. 2013. Role of Fertilizer Policy in Transforming Agriculture of Myanmar. Dept. Agric. Econ., Yezin Agric. Univ.

Managing soil sulfur to increase protein quality (and yields) – especially of legumes & pulses

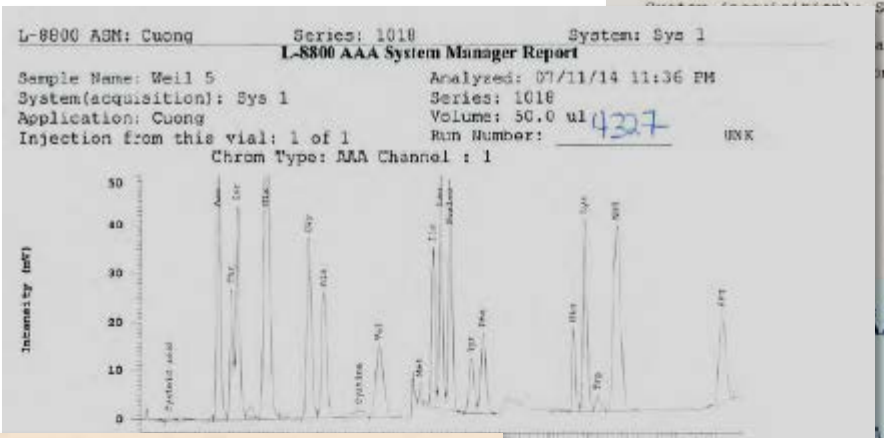
Initial survey of farmer fields in Maryland

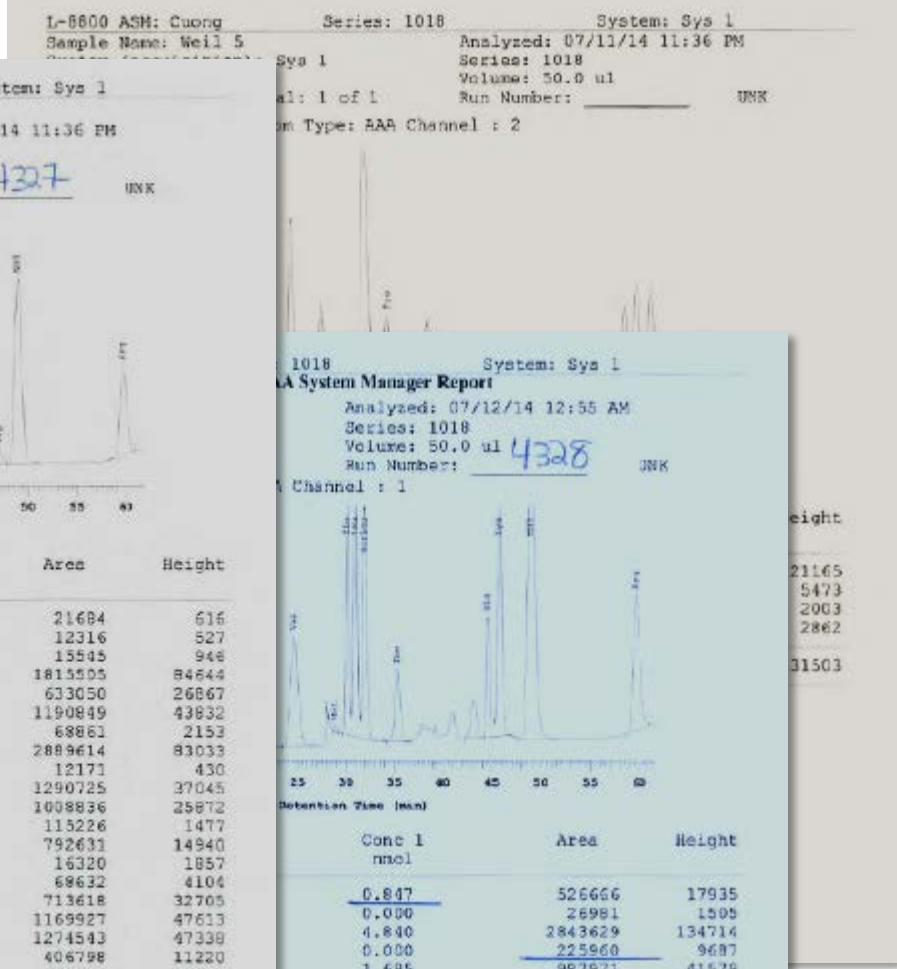


New $CaCl_2$ extraction test on soils sampled in April-May:
S status of crop predicted better from test on topsoil than subsoil



Printout for a single sample, Amino acid profile.



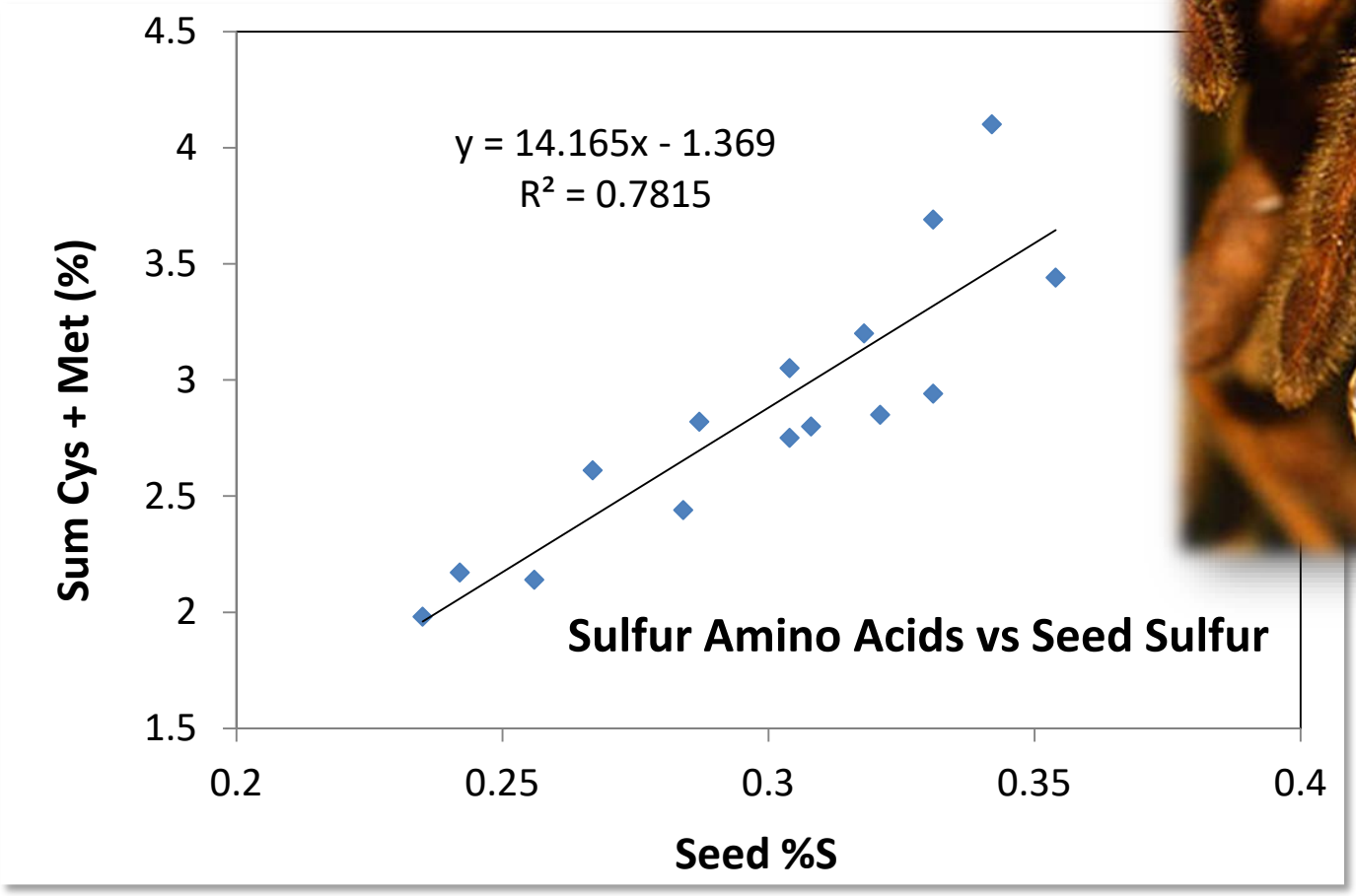


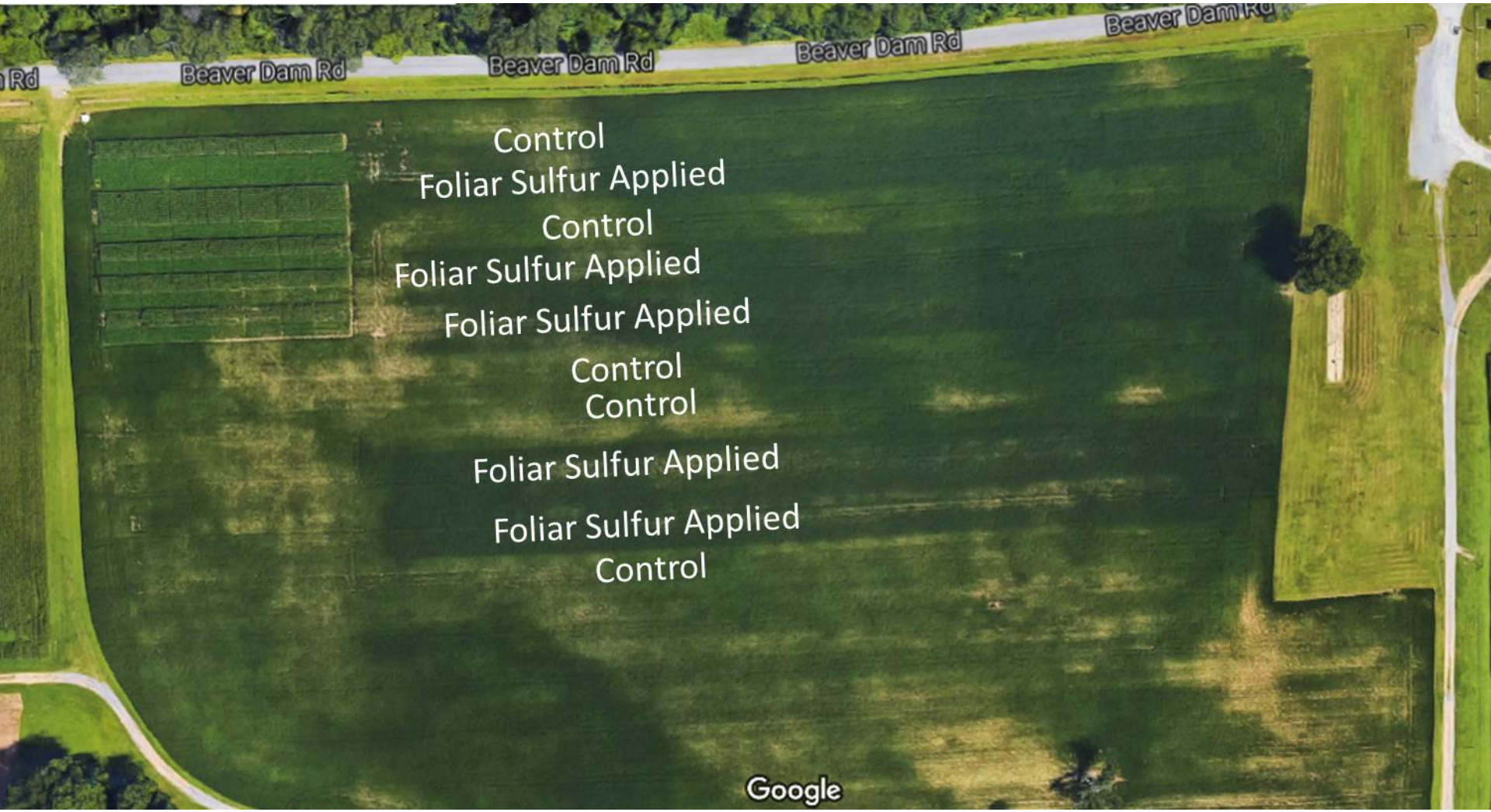
Weil 5

Run # =	4327	Mass Hydrolyzed=	2.06 mg
Internal std. =	2.030	Final Vol =	5 ml

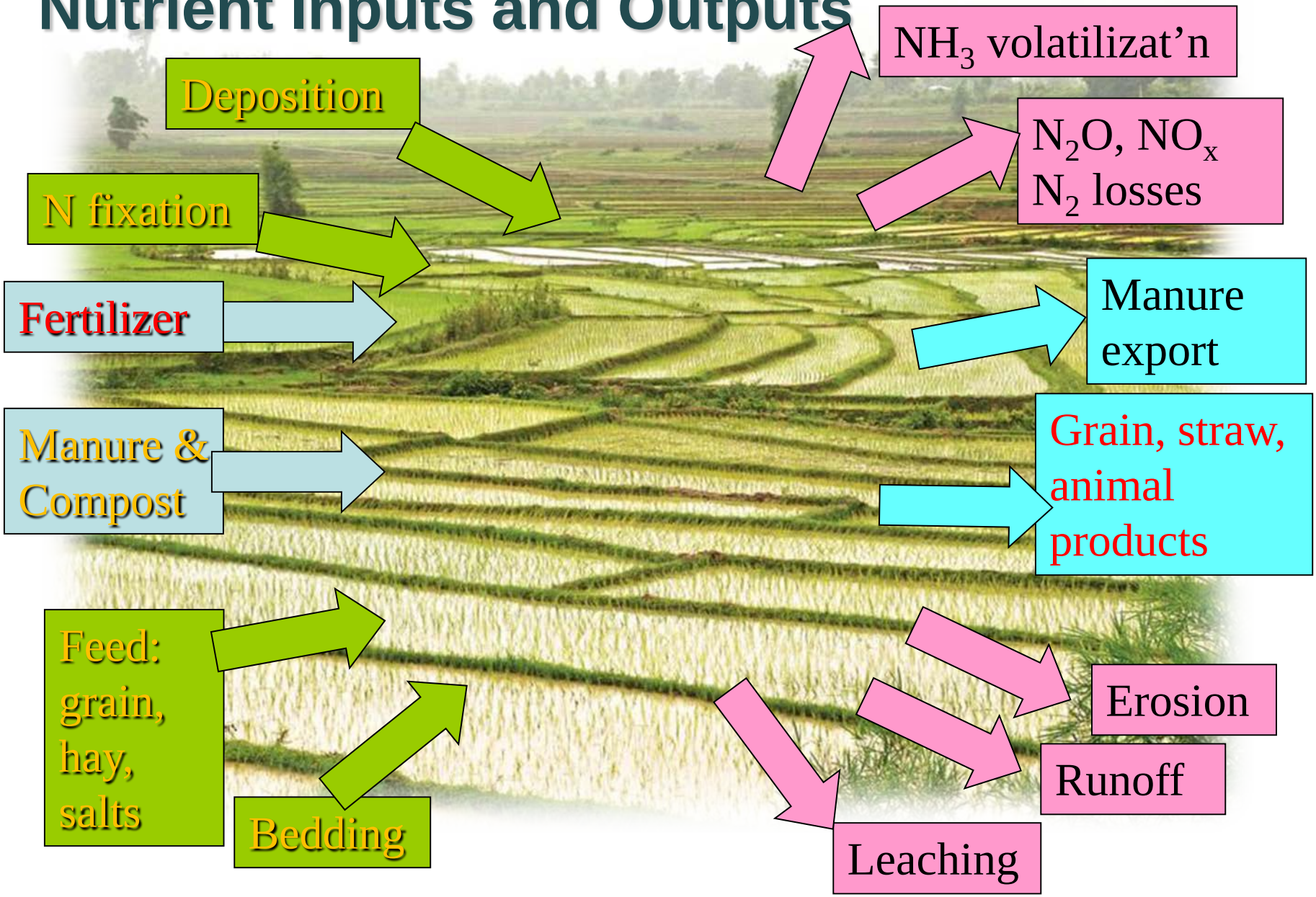
Amino Acid	nm/inj	nm/50ul	µgr/50ul	mole %	weight %	um/mg	%(w/w)
Asx	3.090	3.04	0.350	11.71	12.02	0.148	1.701
Thr	1.080	1.06	0.108	4.09	3.69	0.052	0.522
Ser	1.738	1.71	0.149	6.59	5.12	0.083	0.724
Glx	4.631	4.56	0.589	17.55	20.20	0.221	2.859
Pro	1.559	1.54	0.149	5.91	5.12	0.075	0.724
Gly	2.086	2.06	0.117	7.91	4.03	0.100	0.570
Ala	1.592	1.57	0.112	6.03	3.83	0.076	0.541
Val	1.232	1.21	0.120	4.67	4.13	0.059	0.584
Ile	1.145	1.13	0.128	4.34	4.38	0.055	0.620
Leu	1.908	1.88	0.213	7.23	7.30	0.091	1.033
Tyr	0.692	0.68	0.111	2.62	3.82	0.033	0.540
Phe	1.032	1.02	0.150	3.91	5.13	0.049	0.727
His	0.588	0.58	0.079	2.23	2.72	0.028	0.386
Lys	1.611	1.59	0.203	6.11	6.98	0.077	0.988
Arg	1.648	1.62	0.254	6.25	8.70	0.079	1.231
Cysteic acid	0.510	0.50	0.052	1.93	1.78	0.024	0.251
Met sulfone	0.242	0.24	0.031	0.92	1.07	0.012	0.152
TOTAL		25.99	2.92				
Total mg			0.292				
% Protein			14.15				14.15

Total S in seed correlates closely with percent of protein in essential S-containing amino acids

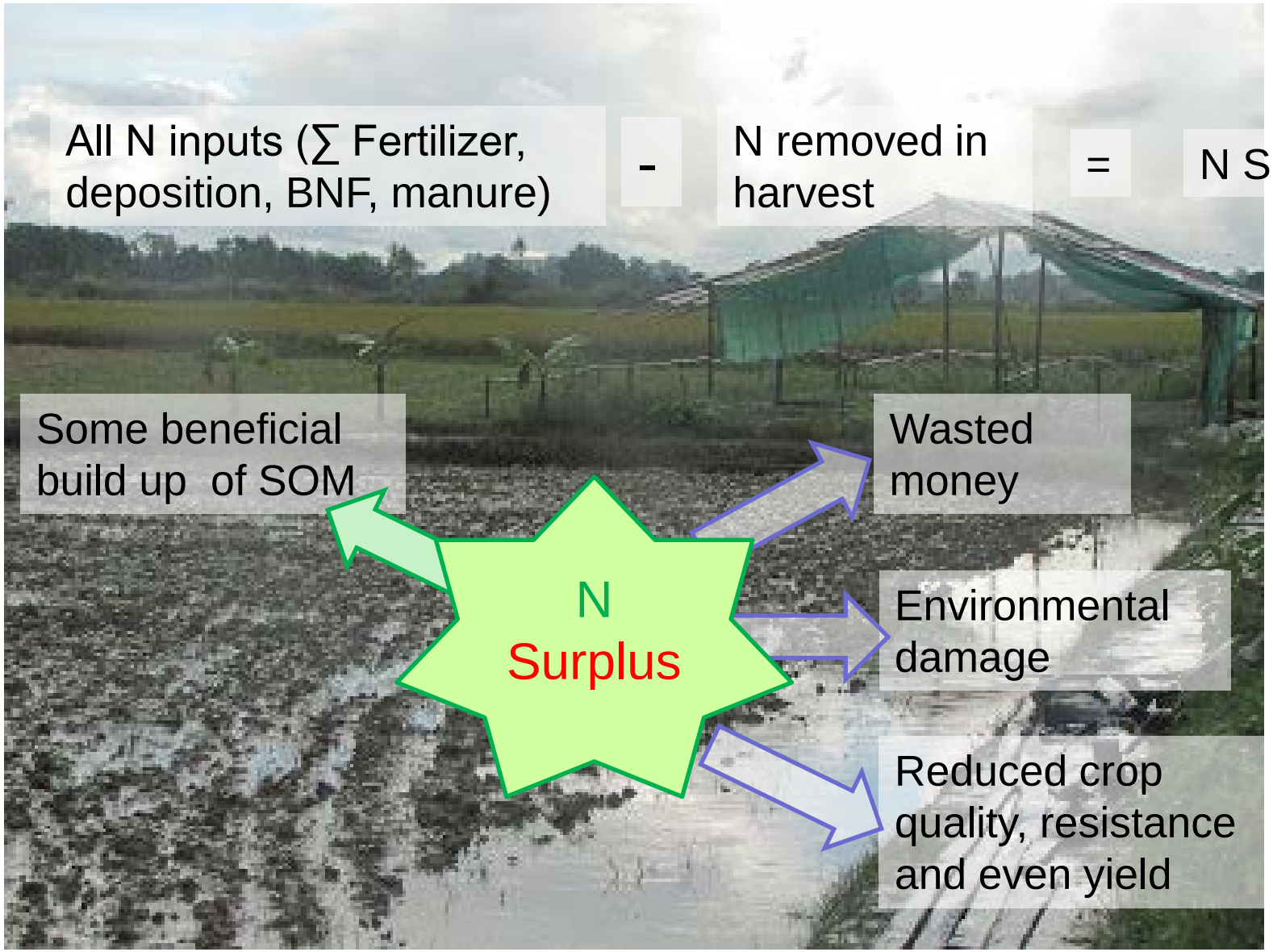



Beaver Dam Rd
Beaver Dam Rd
Beaver Dam Rd
Beaver Dam Rd
Control
Foliar Sulfur Applied
Control
Foliar Sulfur Applied
Foliar Sulfur Applied
Control
Control
Foliar Sulfur Applied
Foliar Sulfur Applied
Control
Google

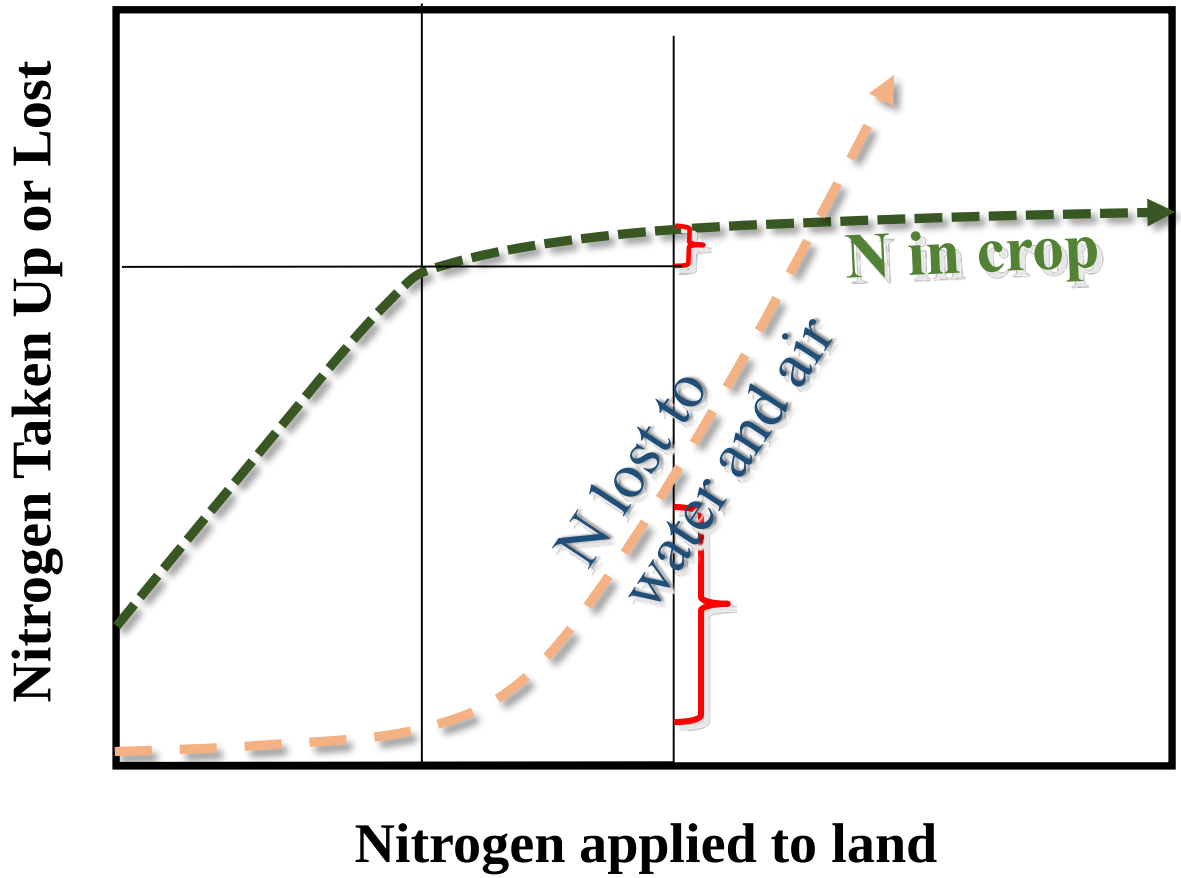
Farmer Should Aim to Balance Nutrient Inputs and Outputs



Aim to Minimize Nutrient Surplus



Trade-off between yield and pollution in fertilizing crops with N



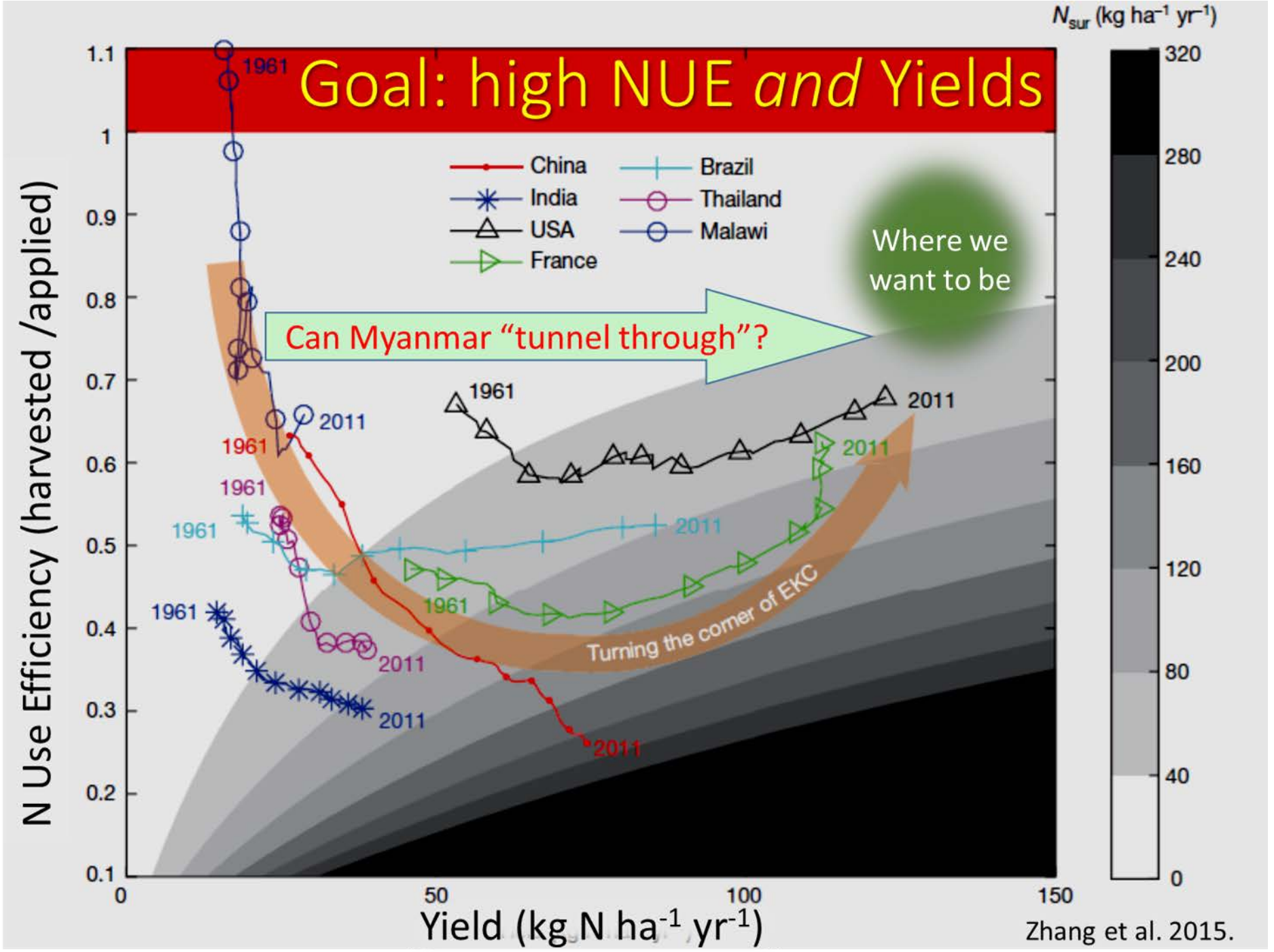
Conflict between economic and environmental goals may not be necessary.

Should fertilizer use *push* yield growth?

- Leads to low NUE

Or should yield increases *pull* fertilizer use?

- Can lead to high NUE and yields

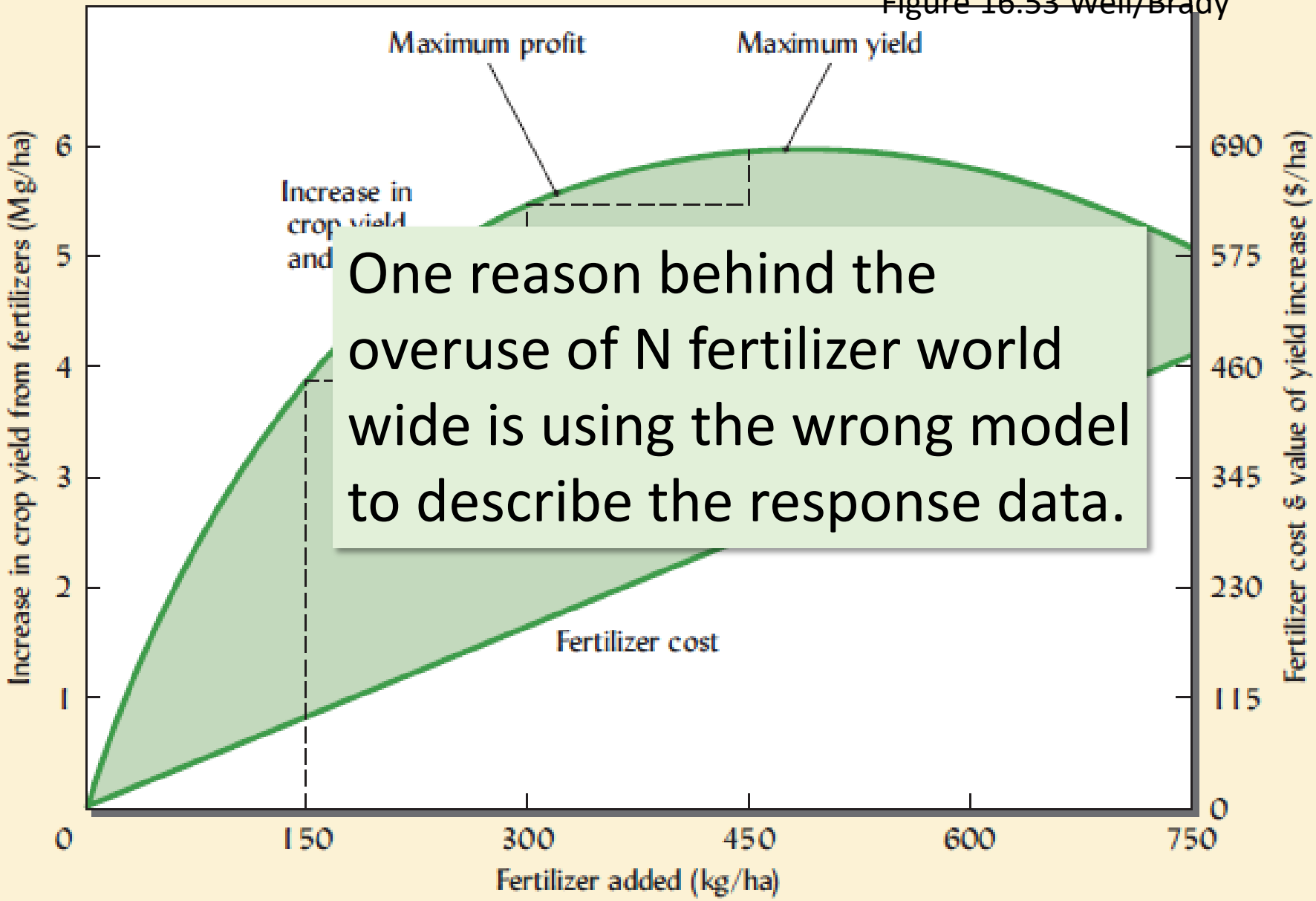


Zhang et al. 2015.

Improving nitrogen-use efficiency (NUE)

- Increases crop productivity
- Increases profitability
- Decreases environmental degradation.
- Indicator for Sustainable Development Goals

Figure 16.53 Weil/Brady

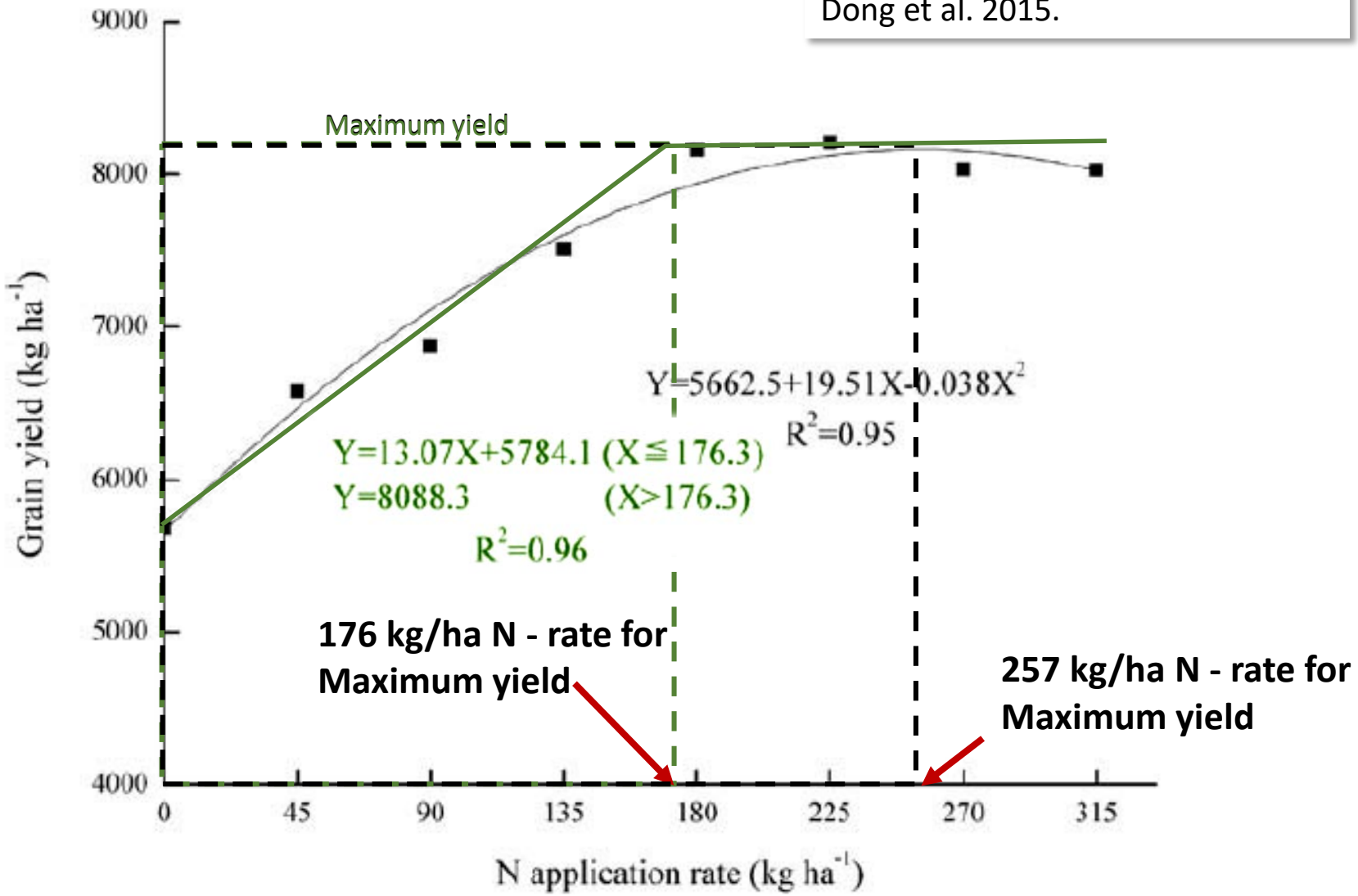


One reason behind the overuse of N fertilizer world wide is using the wrong model to describe the response data.

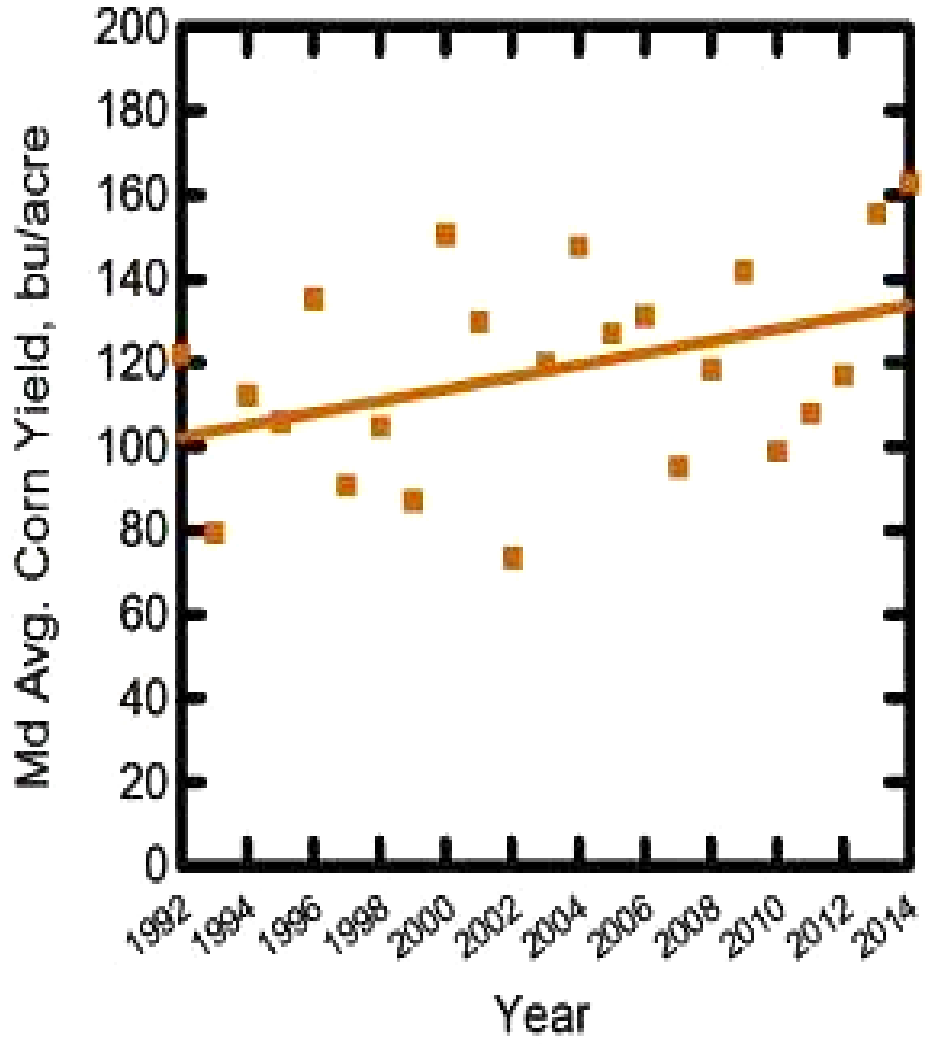
Cerrato, M.E., and A.M. Blackmer. 1990. Comparison of models for describing corn yield response to nitrogen fertilizer. Agron J 98:138-143.

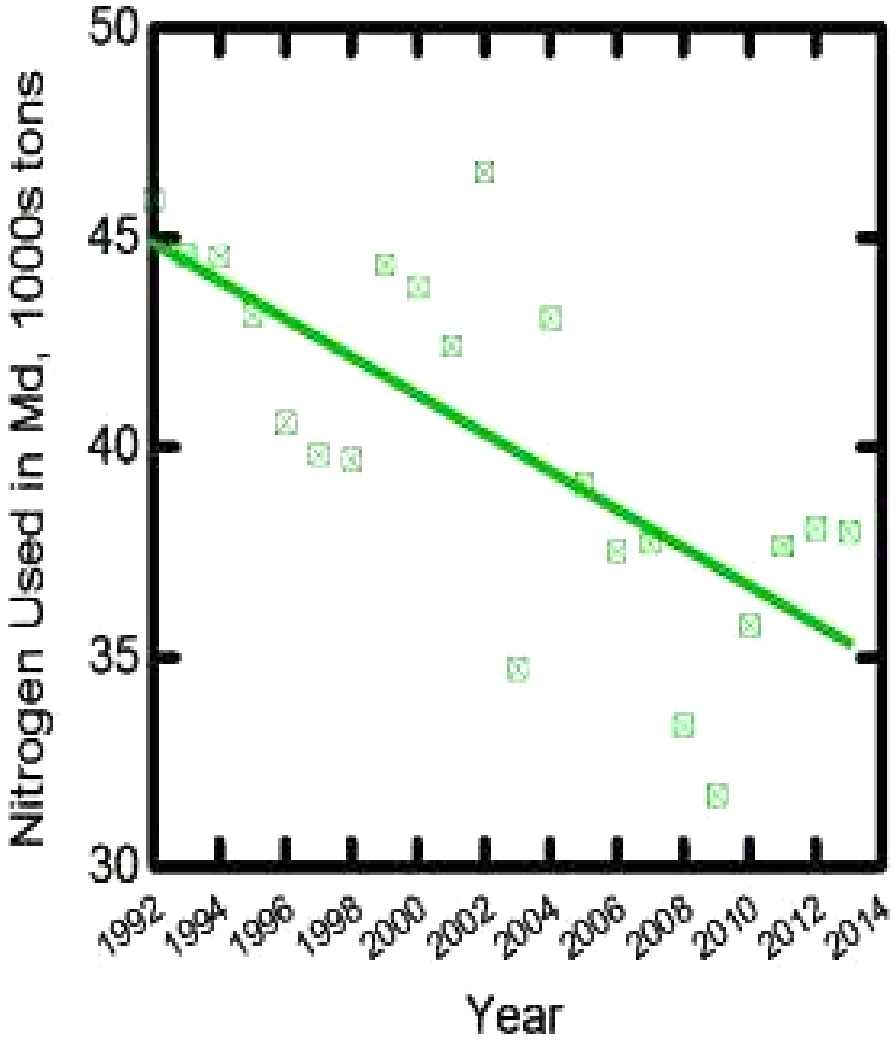
Linear plateau model maximum yield N rate for rice

Means of 12 replications over 3 years in Zhejiang Province, China. Dong et al. 2015.



Corn Yield and Nitrogen Use Trends in Maryland





To minimize ammonia N volatilization losses:

1. Farmers avoid broadcasting or spraying urea on the soil surface.
2. They incorporate the urea by dribbling instead of spraying

An early (~1985) Maryland farmer adoption of dribbling Urea Ammonium Nitrate (UAN) Solution (instead of spraying) for split application to maize.

A more advanced GPS-controlled variable-rate machine for dribbling Urea Ammonium Nitrate (UAN) Solution.
Note the no-till system with cover crop residue.

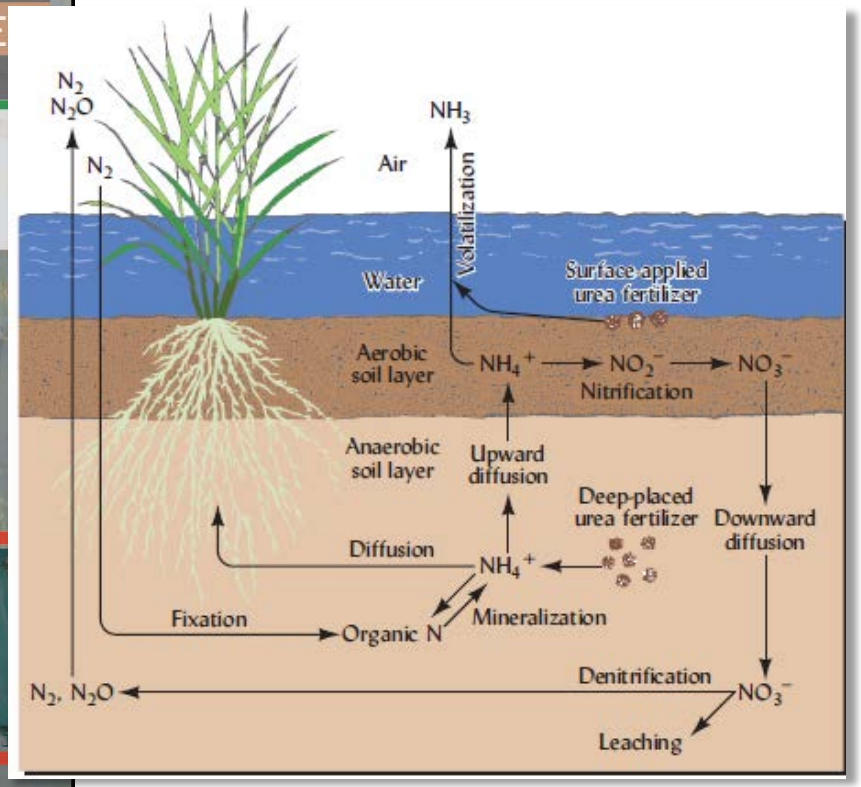
In the USA farmers and ag companies are often ahead of the researchers.

Urea Deep Placement Technology

*An **elegant, simple solution** for a complex ecological problem: Increases NUE.*

A REFERENCE GUIDE

IFDC



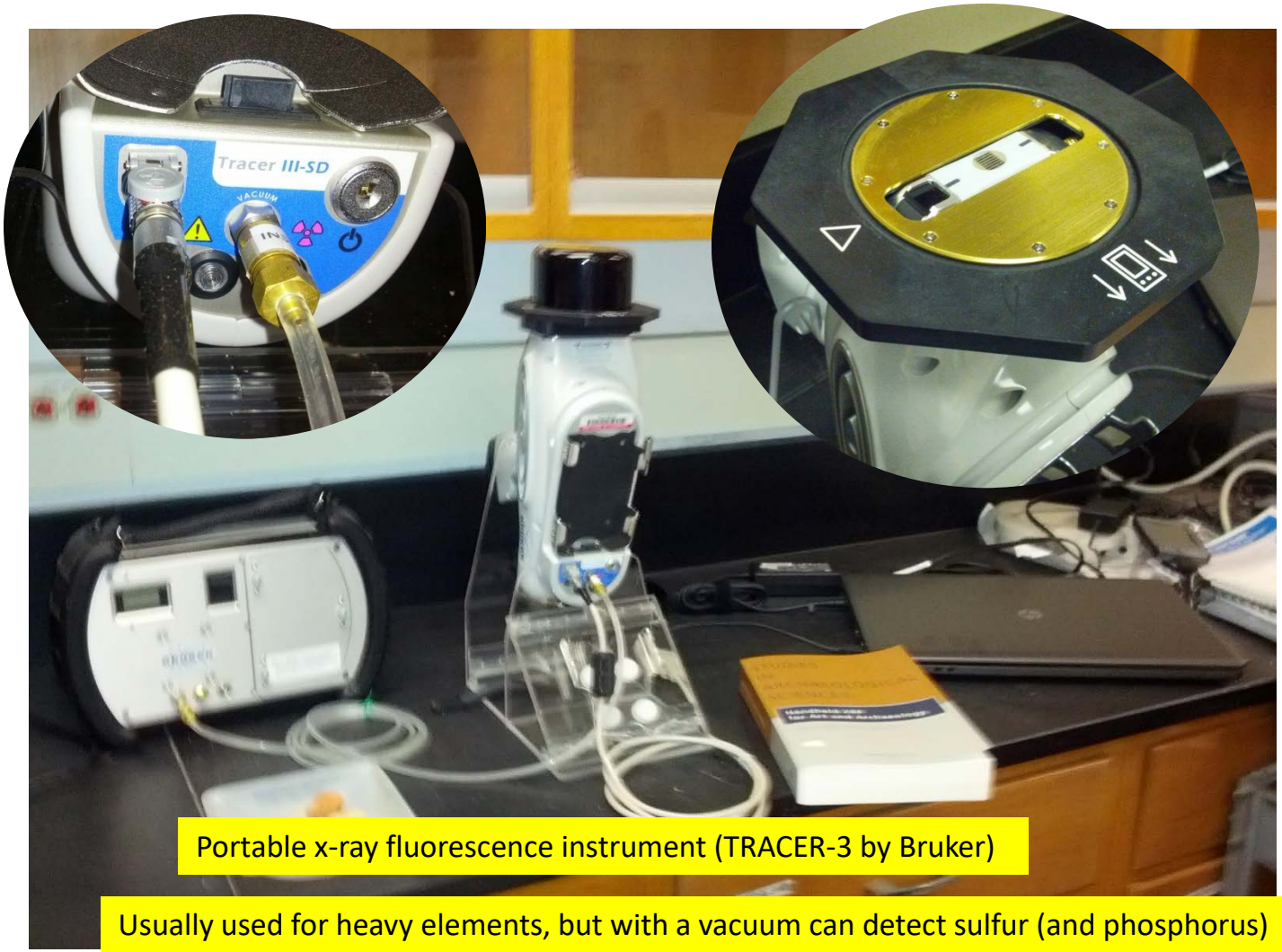
The Challenge of Bottom → Up vs. Top → Down Innovation

Farmer groups often tell me:
"Explain to me what needs to be done—we'll figure out how to do it"

Thank you
and
best wishes for
a productive
conference!

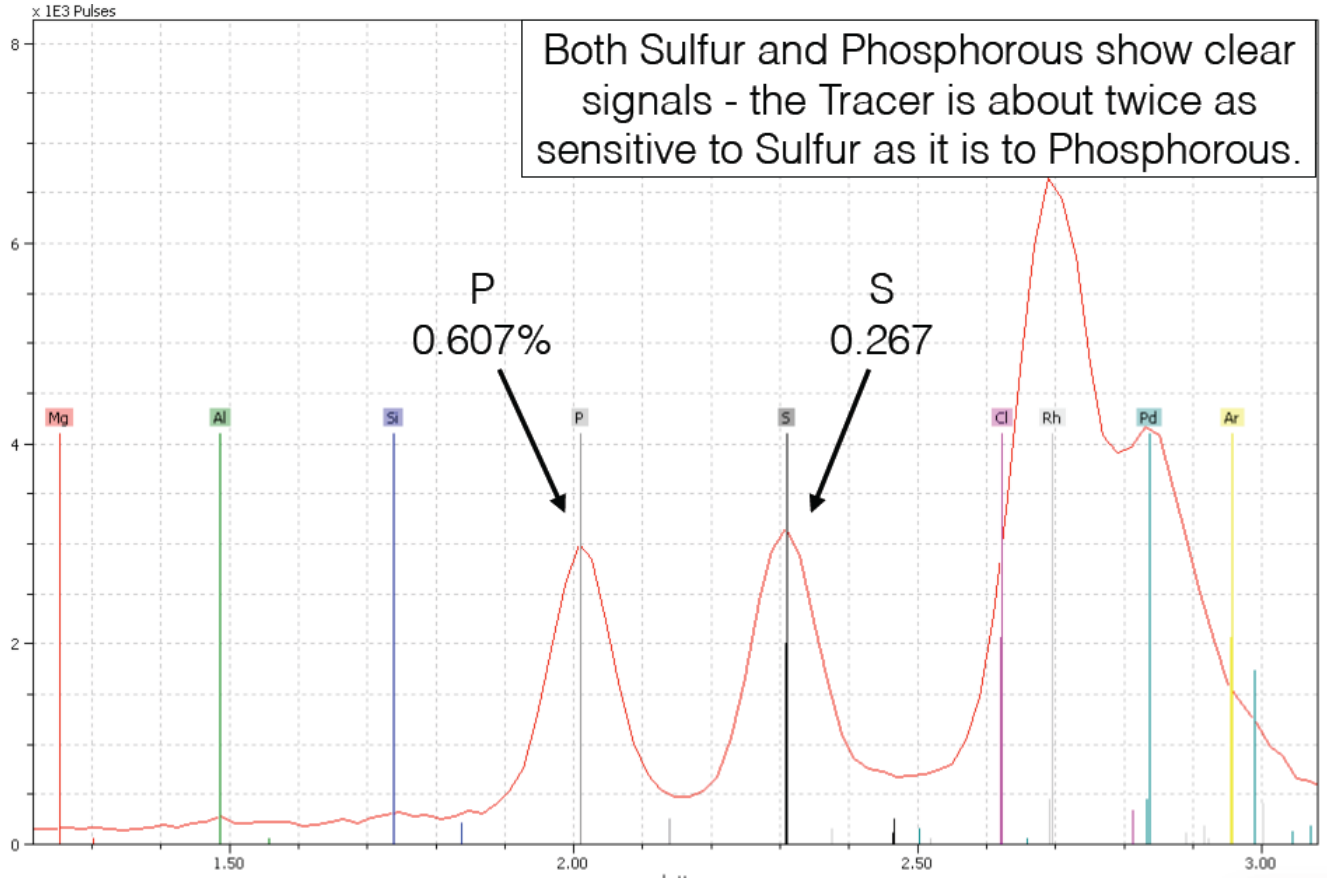
Four key areas to be addressed:

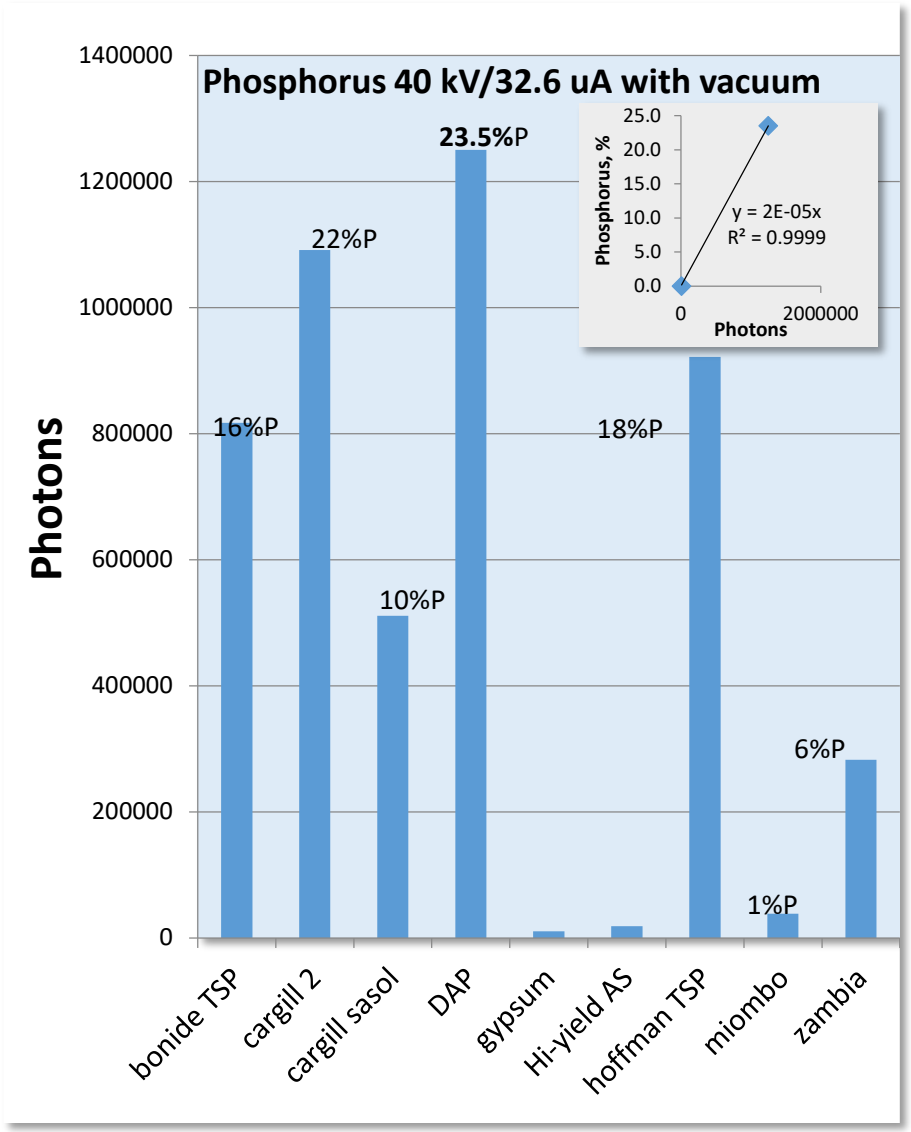
- Managing nutrients in soils and crops
- Fertilizer recommendations
- Environmental impacts of fertilizer use
- Assessing fertilizer quality

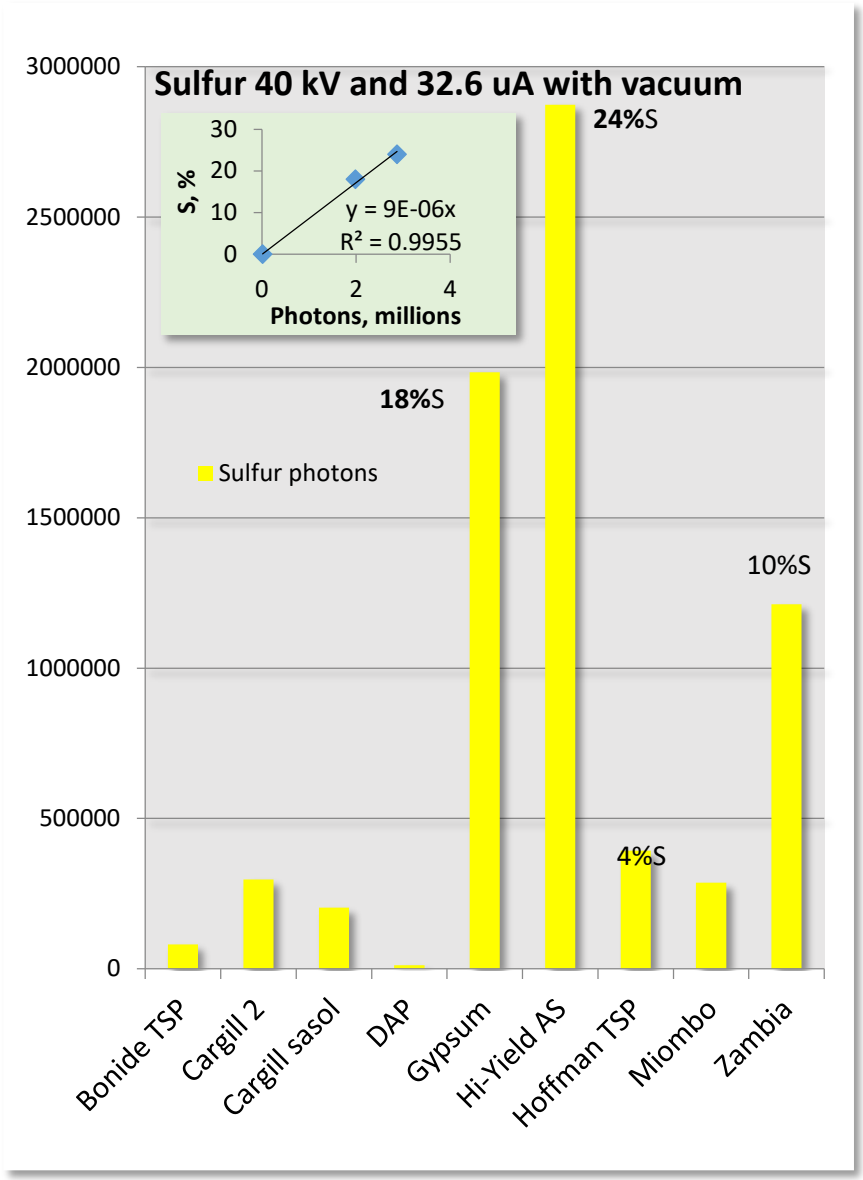


Portable x-ray fluorescence instrument (TRACER-3 by Bruker)

Usually used for heavy elements, but with a vacuum can detect sulfur (and phosphorus)


x 1E3 Pulses
8
6
4
2
0
Both Sulfur and Phosphorous show clear signals - the Tracer is about twice as sensitive to Sulfur as it is to Phosphorous.
P
0.607%
S
0.267
Mg
Al
Si
P
S
Cl
Rh
Pd
Ar
1.50
2.00
2.50
3.00


Phosphorus 40 kV/32.6 uA with vacuum
Photons
1400000
1200000
1000000
800000
600000
400000
200000
0
16%P
22%P
10%P
23.5%P
18%P
1%P
6%P
bonide TSP
cargill 2
cargill sasol
DAP
gypsum
Hi-yield AS
hoffman TSP
miombo
zambia
Phosphorus, %
25.0
20.0
15.0
10.0
5.0
0.0
0
2000000
Photons
y = 2E-05x
R² = 0.9999


Sulfur 40 kV and 32.6 uA with vacuum
3000000
2500000
2000000
1500000
1000000
500000
0
18%S
24%S
4%S
10%S
Sulfur photons
Bonide TSP
Cargill 2
Cargill sasol
DAP
Gypsum
Hi-Yield AS
Hoffman TSP
Miombo
Zambia
S, %
30
20
10
0
0
2
4
Photons, millions
y = 9E-06x
R² = 0.9955