



Improving Nutrient Use Efficiency

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Improving Nutrient Use Efficiency

- ❑ Interest in improved nutrient use has never been greater ...
 - ✓ driven by public belief of excessive use of nutrients and farmer concerns about high fertilizer prices and stagnant crop prices
- ❑ Efficiency can be defined in many ways and is easily misunderstood and misrepresented



Improving Nutrient Use Efficiency

- ❑ Definitions differ depending on perspective
 - ✓ Agronomic efficiency
 - ✓ Economic efficiency
 - ✓ Environmental efficiency
- ❑ Maximizing efficiency may not always be advisable or effective.
- ❑ As agronomic efficiency improves, economic, and environmental efficiency will also benefit



Common nutrient efficiency terms

Hypothetical example	N applied, kg/ha	Corn Yield, kg/ha	N uptake, kg/ha	
			Total	Grain
	None	6,000	110	60
	200	12,000	220	120

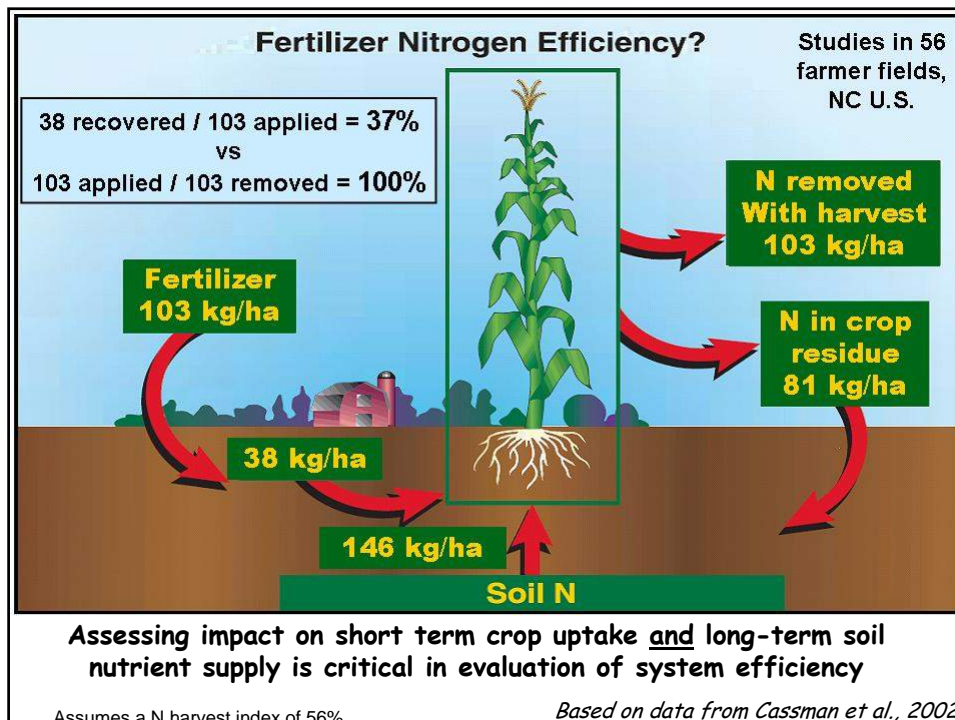
- ❑ **Partial Factor Productivity (kg/kg)** = crop yield per unit nutrient applied: $12,000/200 = 60 \text{ kg grain/kg N}$
- ❑ **Agronomic Efficiency (kg/kg)** = crop yield increase per unit nutrient applied: $(12,000-6,000)/200 = 30 \text{ kg grain/kg N}$
- ❑ **Crop Recovery Efficiency (%)** = increase in uptake by the plant per unit nutrient added, usually for the 1st crop following application: $(220-110)/200 = 55\%$
- ❑ **Crop Removal Efficiency (%)** = removal of nutrient in harvested crop as % of nutrient applied: $120/200 = 60\%$

After Mosier et al., 2004



Common nutrient efficiency terms

- Understanding the terminology and context in which it is used is critical to prevent misinterpretation and misunderstanding
- For example ... the same data can be used to estimate N fertilizer recovery at 37% or 100% ... which is correct?





Current Status of Nutrient Use Efficiency

- Recent review from researcher-managed experimental plots ... single-year fertilizer N recovery averaged
 - ✓ 65% for maize, 57% for wheat, and 46% for rice
- Farmer managed fields rarely exceed 50%
 - ✓ Best available information for on-farm ... ~20 to 30% under rainfed conditions and 30 to 40% under irrigation

Ladha et al. 2005



N fertilizer recovery from on-farm measurements under different cropping systems

Crop	Region	Farms	Average rate, kg N/ha	Fertilizer recovery*, % N
Maize	North Central U.S.	56	103	37
Rice	Asia-farmer practice	179	117	31
	Asia- SSNM	179	112	40
Wheat	India - poor weather	23	145	18
	India - good weather	21	123	49

* recovery is the proportion of applied N taken up the crop, calculated as the difference in total N uptake in above ground biomass at physiological maturity between fertilized plots and an unfertilized control.

Cassman et al. 2002



Nutrient use efficiency ...

- ❑ Most focus on use efficiency is on N, but P is also of interest...
- ❑ 1st year P recovery ranges from less than 10 to 30%, but long-term recovery is much higher



Apparent long-term recovery of fertilizer P

<u>Soil</u>	<u>Applied P₂O₅</u>	<u>No. of crops</u>	<u>Recovery of P₂O₅, %</u>
10 calcareous soils	511	8 GH	27
Calcareous clay	67	5 F	28
Sandy loam, pH 6.8	45	6 F	30
Loam	50	10.5 F	37
Silt loam, pH 7.1	67	6 F	41
48 non-calcareous soils	511	8 GH	45
		9 F	54
28 soils, pH 6.2-7.9	153	8 GH	74
4 soils, pH 6.7-7.6	229	19 GH	87
Sandy loam, non-calcareous	118	4 F	100

Fixen 1992



Nutrient use efficiency ...

- ❑ Little information available on K ... generally considered to have a higher 1st year crop recovery efficiency than N or P because it is immobile in most soils and not subject to gaseous losses
- ❑ Crop recovery efficiency ... 20 to 60%.



Optimizing Nutrient Use Efficiency

The fertilizer industry supports applying nutrients at the right rate, right time, and in the right place as a best management practice (BMP) for achieving optimum nutrient efficiency.



Right rate:

- ❑ Set realistic yield goals and apply nutrients to meet the target yield
 - ✓ Over- or under-application will reduce efficiency
- ❑ Soil testing - powerful tool for determining soil nutrient supply, but recommendations need good calibration data ...
 - ✓ not available in all regions
- ❑ Other tools ... omission plots



Nutrient omission plots

- ❑ Grain yield in nutrient omission plots indicate how much nutrient is supplied by the soil.



- ❑ Difference in grain yield between a fully fertilized plot and the omission plots indicates need for fertilizer.

Witt and Doberman 2002



Right time:

- ❑ Greater synchrony between crop demand and nutrient supply is necessary to improve nutrient use efficiency.
- ❑ Split applications vs. single application more effective
- ❑ Diagnostic tools for fine-tuning in-season N recommendations are effective
 - ✓ Tissue testing is well known, but other tools are available



Right time:



Chlorophyll meter



Leaf color chart

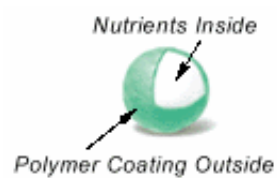


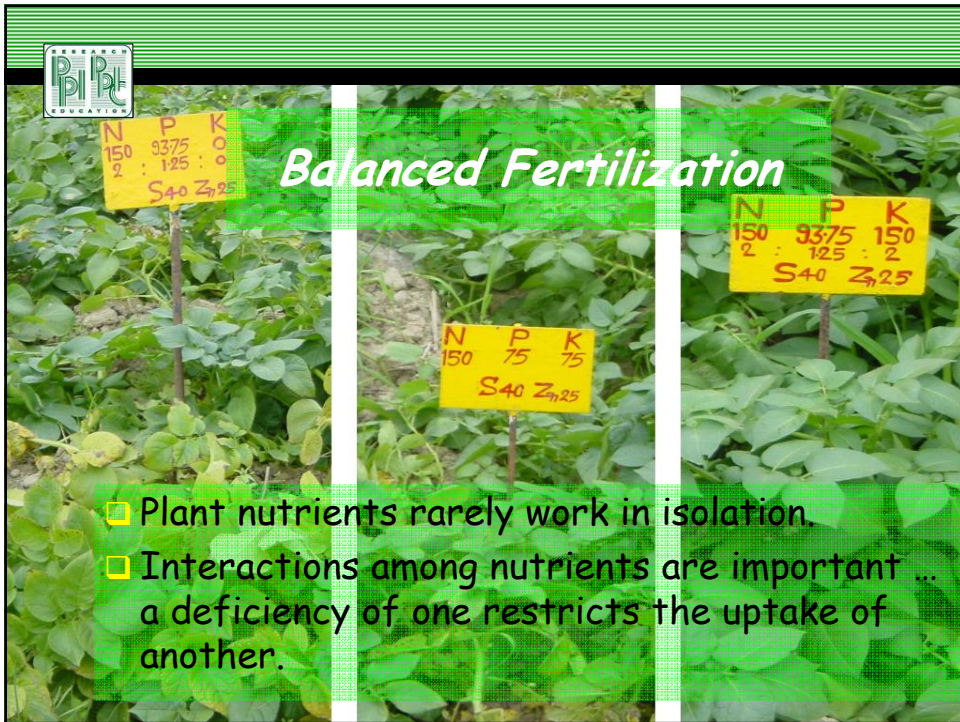
Right time:



Right time:

- ❑ N stabilizers (e.g. nitrapyrin, DCD, NBPT)
- ❑ Controlled release fertilizers
 - ✓ Most promising are polymer-coated fertilizers designed to release nutrients in a controlled manner







Effect of balanced fertilization on yield and N agronomic efficiency in India

	Yield, t/ha			AE, kg grain/kg N		
	Control	N	NPK	N	NPK	Inc.
Rice (summer)	3.03	3.45	6.27	10.5	81.0	69.5
Wheat	1.45	1.88	2.25	10.8	20.0	9.2
Sugarcane	47.2	59.0	81.4	78.7	227.7	150.0

40 kg N/ha applied on cereal crops and 150 kg N/ha applied on sugarcane

Prasad 1996

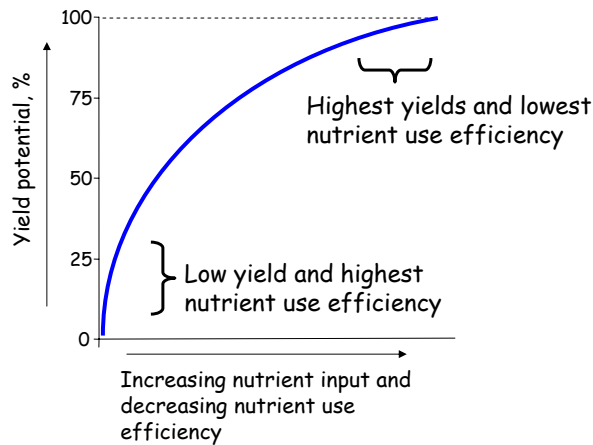


Efficiency vs. Effectiveness

- ❑ Improving nutrient efficiency is an appropriate goal ... effectiveness cannot be sacrificed for the sake of efficiency
- ❑ Higher efficiency can be achieved by sacrificing crop yield, but that would not be economically viable for the farmer or the environment
- ❑ For example ...



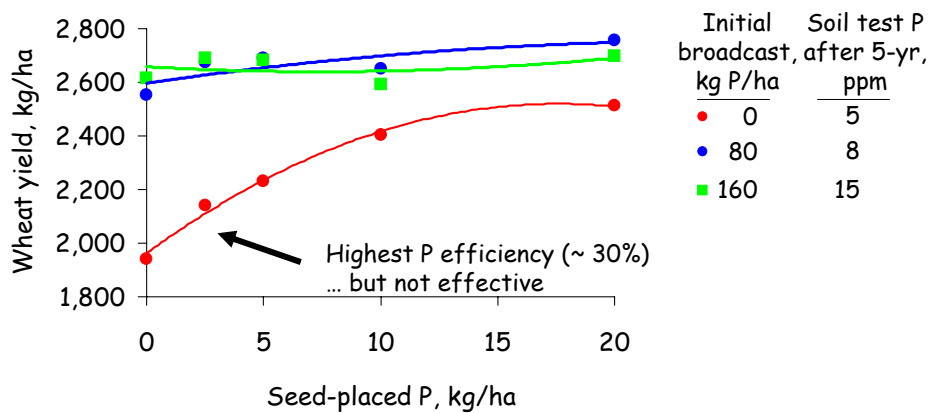
Relationship between yield response and nutrient use efficiency



Dibb 2000



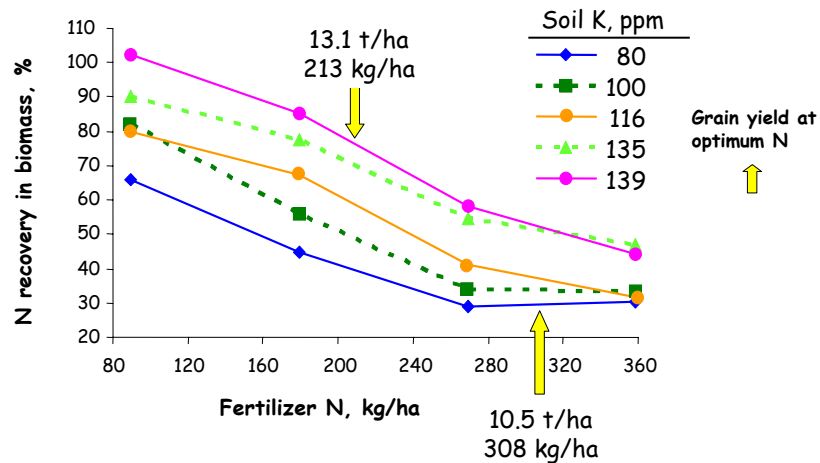
Relationship between P efficiency and wheat yield



Wagner et al. 1986



Adequate K Improves N Efficiency in Ohio Maize Study (4-year average)



Johnson et al. 1997



Conclusion

- Improving nutrient use efficiency is a worthy goal and fundamental challenge facing the fertilizer industry
- Opportunities are there and tools available to accomplish that task, but ... we must be cautious that improvements in efficiency do not come at the expense of the farmers economic viability or the environment



Conclusion

- Judicious application of fertilizer BMPs ...
right rate, right time, and right place ...
targeting high yields and nutrient
efficiency will benefit farmers, society,
and the environment