Improving Nutrient Use Efficiency with 4R Nutrient Stewardship

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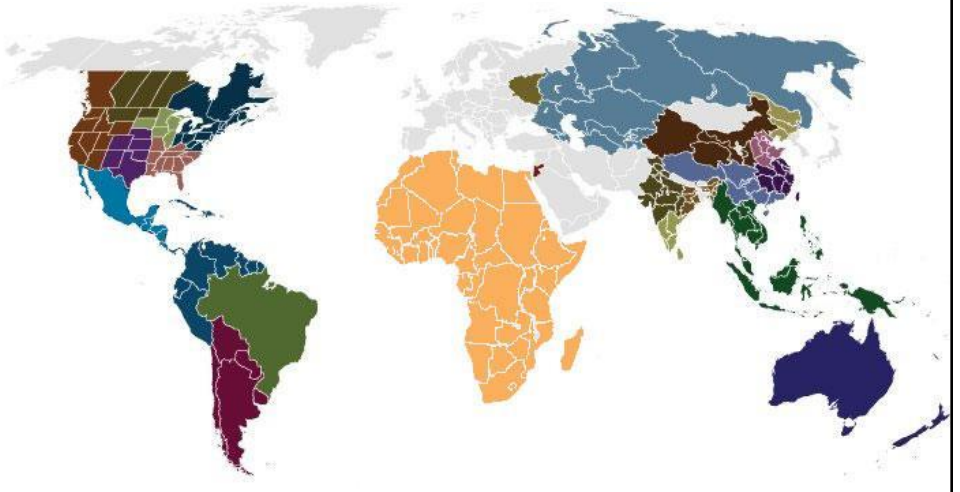
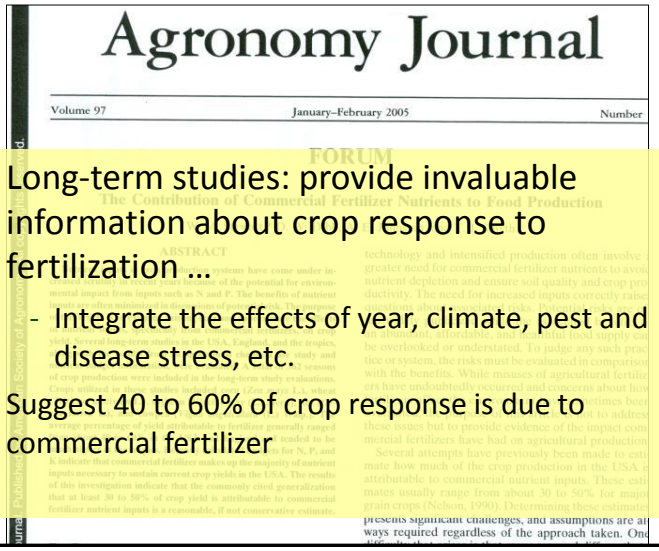
IPNI Mission

"to develop and promote scientific information about the responsible management of plant nutrition for the benefit of the human family."



In 2012 IPNI had 140 R&D projects
75% supporting increasing crop yields, or intensification

Food Security and Fertilizer Use?


Agronomy Journal

Volume 97 January–February 2005 Number

FORUM

The Contribution of Commercial Fertilizer Nutrients to Food Production

ABSTRACT

- Long-term studies: provide invaluable information about crop response to fertilization …
  - Integrate the effects of year, climate, pest and disease stress, etc.
- Suggest 40 to 60% of crop response is due to commercial fertilizer

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What is 4R?

4 nutrient stewardship

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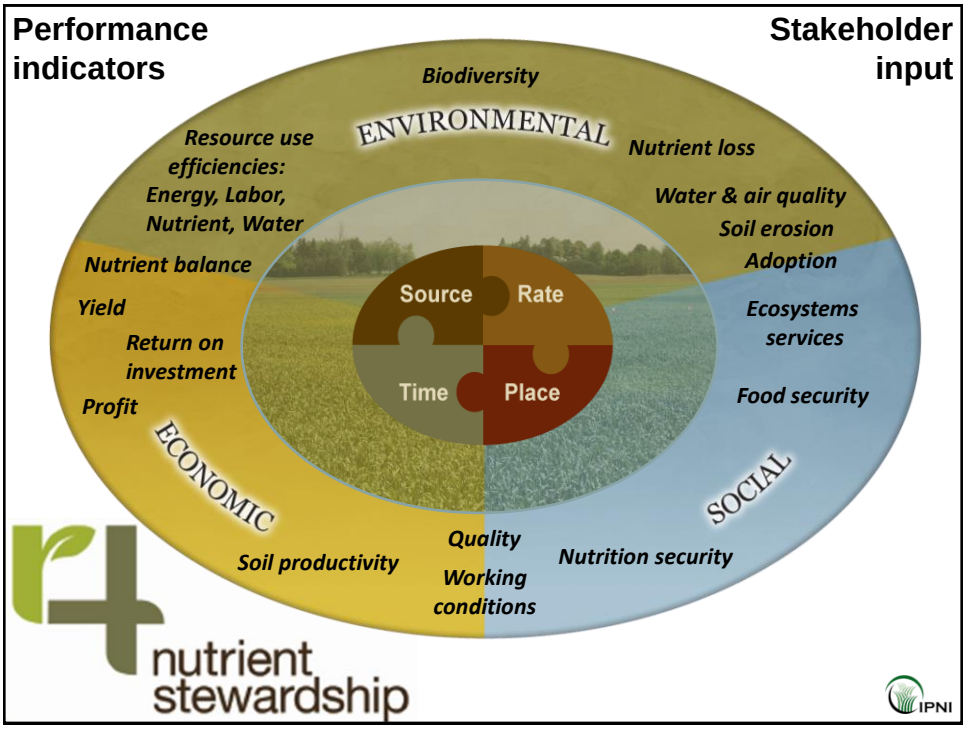

Source, rate, time, and place describe any nutrient application




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2. 4R technologies and practices

Right Source

Scientific Principle:

- Ensure a **balanced supply** of plant-available nutrients, utilizing all available sources (organic and inorganic).

Practices:

- Credit nutrients from manures and composts
- Credit nutrients from previous crops
- Assess use of enhanced-efficiency sources
  - Inhibitors of urease and nitrification
  - Coated fertilizers

Access to a range of fertilizer products is often a major challenge for small holders

Balanced nutrition And FUE in China

Reference	Crop	Treatment	
		N	NPK
		N recovery by crop,%	
Zhu, 1994	Barley	28	51
Jin, 2001	Wheat (11 yrs)	31	70
	Corn (5 yrs)	35	66

IPNI field validation of NE maize Northeast & Northcentral China

Year	Treatment	n	Grain yield (t/ha)	Fertilizer rate (kg/ha)			Profit
				N	P_2O_5	K_2O	(USD/ha)
2010	FP*	138	8.6	225	53	40	2364
	NE	**138**	8.7	**138**	**50**	**63**	**2433**
2011	FP	185	10.0	222	64	44	2978
	NE	**185**	**10.6**	**161**	**49**	**61**	**3097**
2012	FP	138	10.6	235	67	59	3285
	NE	**138**	**10.9**	**167**	**63**	**74**	**3477**

*FP – farmers practice
NE – Nutrient Expert

Xu et al., 2013

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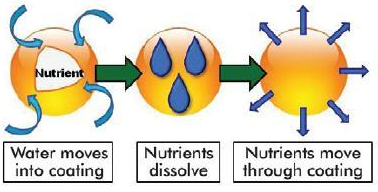
Slow & Controlled Release Fertilizers

1. Synthetic organic compounds containing N
   - urea-formaldehydes, IBDU, triazones, etc.
2. Physical coating or barrier around soluble N fertilizer
   - Sulfur-coated or polymer-coated urea.
3. Stabilized materials
   - urease and nitrification inhibitors

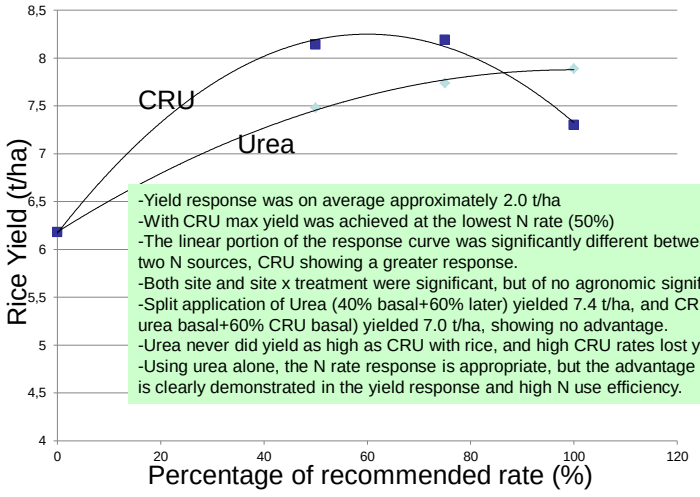
N-Serve

AGROTAIN



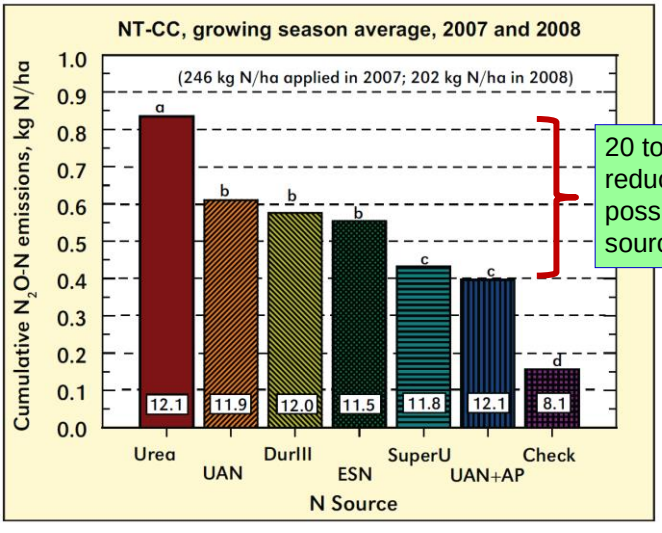
Rice Response

Six site years of data, China - 2009-10



-Yield response was on average approximately 2.0 t/ha
-With CRU max yield was achieved at the lowest N rate (50%)
-The linear portion of the response curve was significantly different between the two N sources, CRU showing a greater response.
-Both site and site x treatment were significant, but of no agronomic significance.
-Split application of Urea (40% basal+60% later) yielded 7.4 t/ha, and CRU (40% urea basal+60% CRU basal) yielded 7.0 t/ha, showing no advantage.
-Urea never did yield as high as CRU with rice, and high CRU rates lost yield.
-Using urea alone, the N rate response is appropriate, but the advantage of CRU is clearly demonstrated in the yield response and high N use efficiency.

Nitrogen Rate and Source Effects on N_2O Emissions in No-till Continuous Corn



20 to 50 % reduction possible with N source selection

Halvorson et al. 2009. Better Crops 93(1):16-18

Right Rate

Scientific Principle:

- Assess soil nutrient supply and plant demand for nutrients.

Practices:

- Soil testing
- Deletion plots
- Balance crop removal with inputs
- Determine crop yield potential
- Assess fertilizer:crop price ratios

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How to make "science-based" fertilizer recommendations for farmers?

- Soil testing has always been the standard approach to making fertilizer recommendations.
- Soil testing allows us to achieve 'site-specific nutrient management' (SSNM) on any given field.
- SSNM helped us avoid the known over- or under application which occurs when we use a blanket recommendation.
- Only problem is…getting soil testing done on small-holder farms

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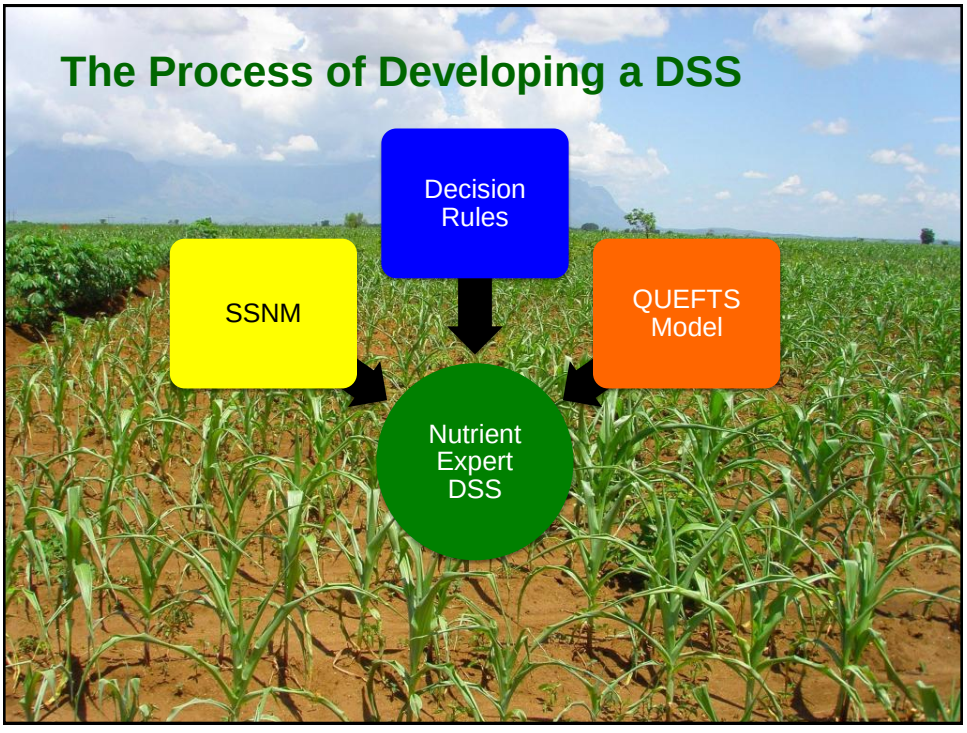
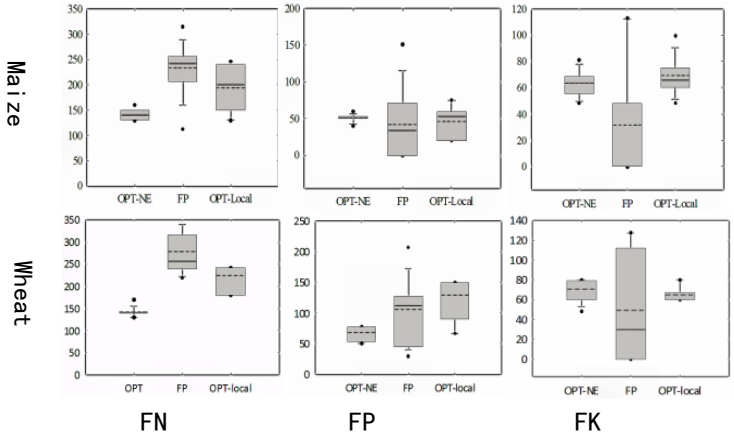
IPNI Supports Site-Specific Nutrient Management (SSNM)

- **SOIL BASED:** Rely mainly on soil testing, classical, destructive, and more static
- **PLANT BASED:** Rely mainly on plants as indicators, new, non-destructive, and more dynamic



China - Nutrient Expert impact on Fertilizer N recommendations

- Summer maize: N saved by -24~131kgN/ha, average 94kg/ha(40.1%)
- Winter wheat: N saved by 95-177kg N/ha, average 135kg/ha(48.3%)



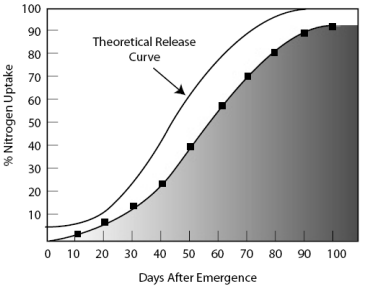
Right Time

Scientific Principle:

- Assess the timing of crop uptake, soil nutrient supply, weather, loss risks and field operation logistics.

Practices:

- Split-application for increased FUE
- At a commercial scale, split application must fit in with planting operations and crop development



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Effects of level, time, and splitting of urea on the yield of irrigated direct seeded rice. George Ghobrial, 1980, Plant + Soil

*"As compared to other treatments of time of urea application, topdressing of urea at maximum tillering **and** panicle initiation stages significantly improved nitrogen use efficiency by promoting production of more panicles per unit land area, and increasing grain weight."*

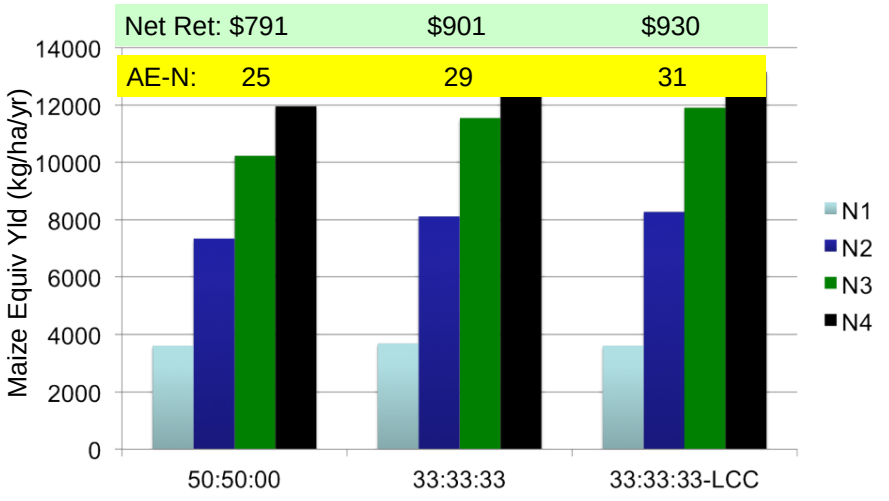
So why do so few farmers in China not split N application?

- High residual soil N levels…considerable IPNI research has shown there is no advantage when the soil already has sufficient N supply to meet the crop needs for split application.
- LABOUR...LABOUR…LABOUR



Maize-Wheat in Karanataka

Maize equivalent yields – kg/ha/yr



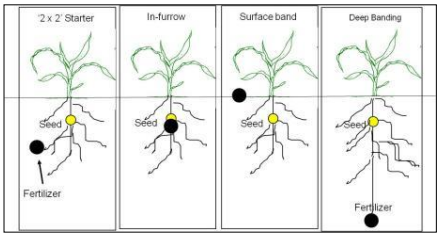
Right Place

Scientific Principle:

- Place nutrients where they are accessible to the crop.

Practices:

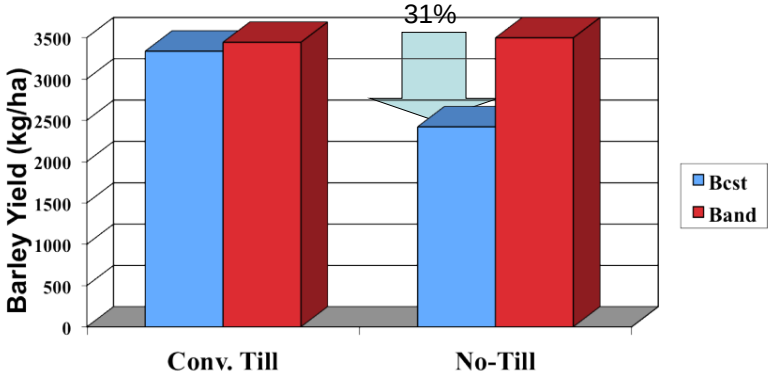
- Site-specific sensing technologies
- Starter placement near seedlings



Fertilizer Placement is Critical in Semi-Arid Agriculture…Canada, Australia, S.America

Tillage Effect on Fertilizer N Placement Response

Spring Barley – Alberta, CANADA



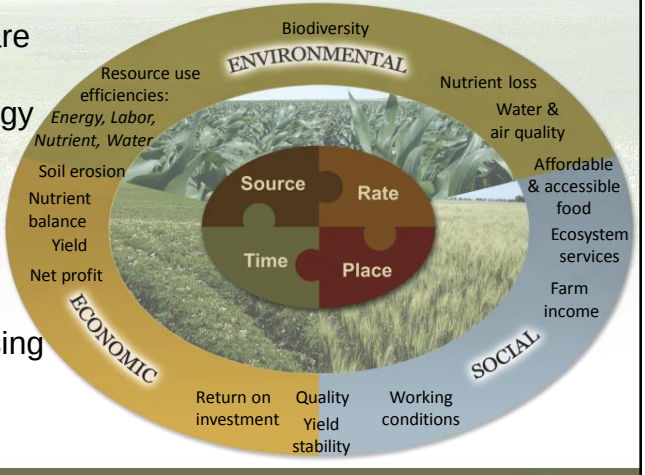
65 N – Malhi, 1991

Improving FUE with Placement

- On nutrient deficient soils, placement can play an important role in improving yield and NUE.
- On nutrient surplus soils, placement is of little significance.
- Placement of fertilizer is a challenge in small holder farms

4R Nutrient Stewardship to close the Yield Gap

- Achieving future food security will require increased yields
- Local solutions are required
- Current technology exits to capture significant yield increases
- Combining technologies is critical to increasing success



4R PLANT NUTRITION

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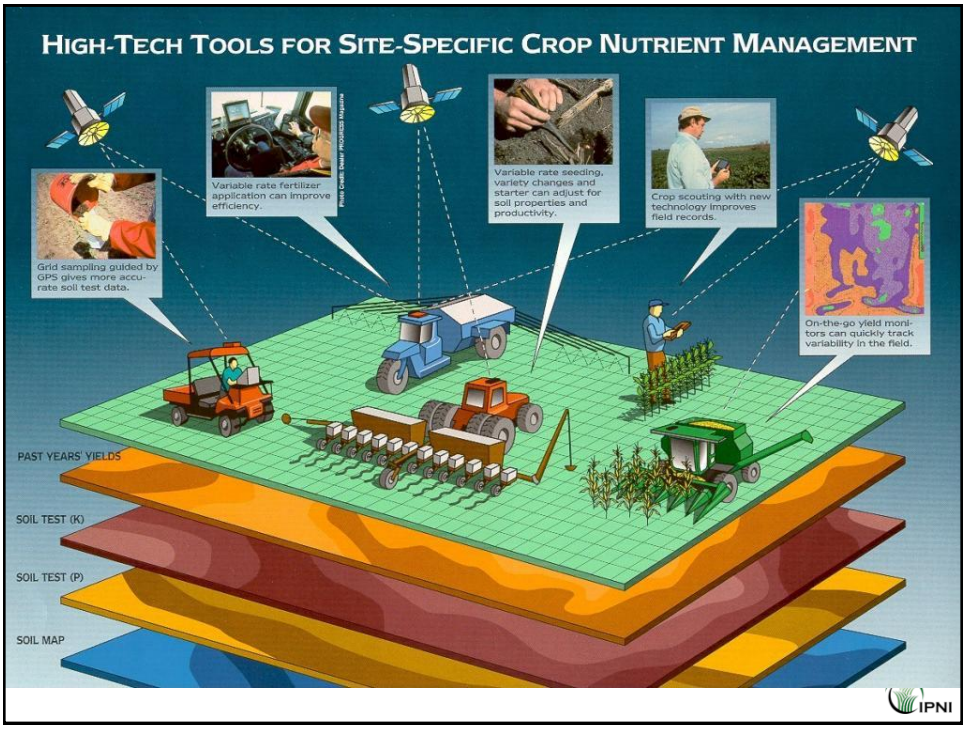


Precision Farming Tool Adoption in North America – 2013 Survey Results

Increasing returns or reducing costs is the dealer priority to adoption of PF tools/services

Tools used by Dealers:

- Light bars and auto steering being used by 60-65%
- Soil sensors or GreenSeeker technology, <10%
- GPS enabled sprayer booms, 53%

Tools requested by farmers:

- Variable rate fertilizer application, 75%
- Soil sampling with GPS, 78%
- Variable rate lime application, 67%

} Most profitable

- Variable rate pesticide application, 45%
- Satellite/aerial imagery, 65%

CropLife & Purdue Univ., 2013

Precision Farming Tool Adoption in North America – 2013 Survey Results

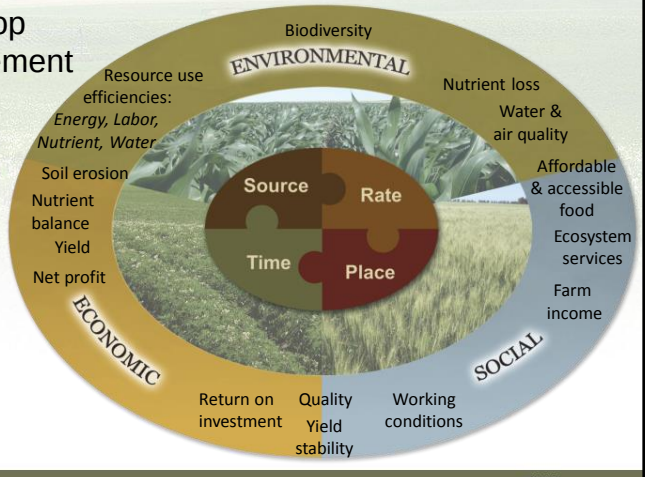
Barriers to Adoption continue to exist:

- The equipment required changes quickly
- Finding employees qualified to deliver the service
- Demonstrating value to the grower…?
- Cost of equipment
- Cost of employees to deliver the service

CropLife & Purdue Univ., 2013

The 4Rs influence many performance indicators

- social, economic and environmental performance
- influenced by crop and soil management as well
- whole system outcomes

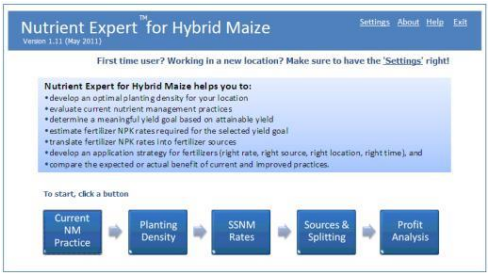


4R PLANT NUTRITION

nutrient stewardship

Making 4R Nutrient Stewardship Work in China

4R nutrient stewardship =



- Nutrient Expert Decision Support System software provides the opportunity to integrate the 4R principles into a fertilizer recommendation.
- This has proven particularly successful where soil testing infrastructure is weak, expensive or not timely for multiple cropping systems.

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Nutrient Expert recommendation:

- tailored to location-specific conditions
- consistent with 4R approach

Name and/or location: Here; Site A Field size: 1 ha

Current yield: 110 cavan (FW) 5.3 t/ha (15.5% MC)

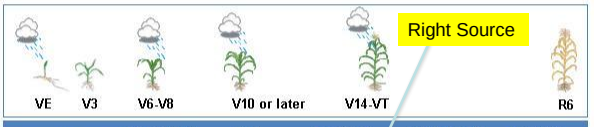
Growing environment: Favorable rainfed

Recommended alternative practice for hybrid maize

Yield goal: 165 cavan (FW) 8.0 t/ha (15.5% MC)

Planting density: 69,444 plants/ha

Distance between rows: 60 cm Distance between plants: 24 cm



Right Source

Growth stage	Days after planting	Soil moisture	Fertilizer sources	Weight of full bag (kg)	Amount (bags)
Basal	0	sufficient	14-14-14	50	6.5
			Urea	50	0
			MOP	50	0.5
V6	25	sufficient	Urea	50	2.5
V10	35	sufficient	Urea	50	2

Right Time

Other sources of nutrients:

Crop residue (maize): high

Organic fertilizer: 0 t

Fertilizer rates are adjusted to field size

Right Rate

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Complicated vs Complex Challenges

- Developing more appropriate, science-based nutrient recommendations in China is really a “complicated” challenge for the Chinese agriculture industry.

- More importantly, the “complex” challenge is developing an agriculture system where growing food grains allows a farmer to make a good living!

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Thank you