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Optical Sensor Based Strategies for Improving N Use Efficiency in Developing Countries

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Spatial Variability

- **Plant nutrient content of agricultural soils varies spatially due to changes in:**
  - ✓ Genesis
  - ✓ Topography
  - ✓ Cropping History
  - ✓ Fertilization History
  - ✓ Resource availability etc.

Lack of recognition of spatial nutrient variability among agricultural holdings has given rise to "one fits all" strategies of nutrient management in various countries

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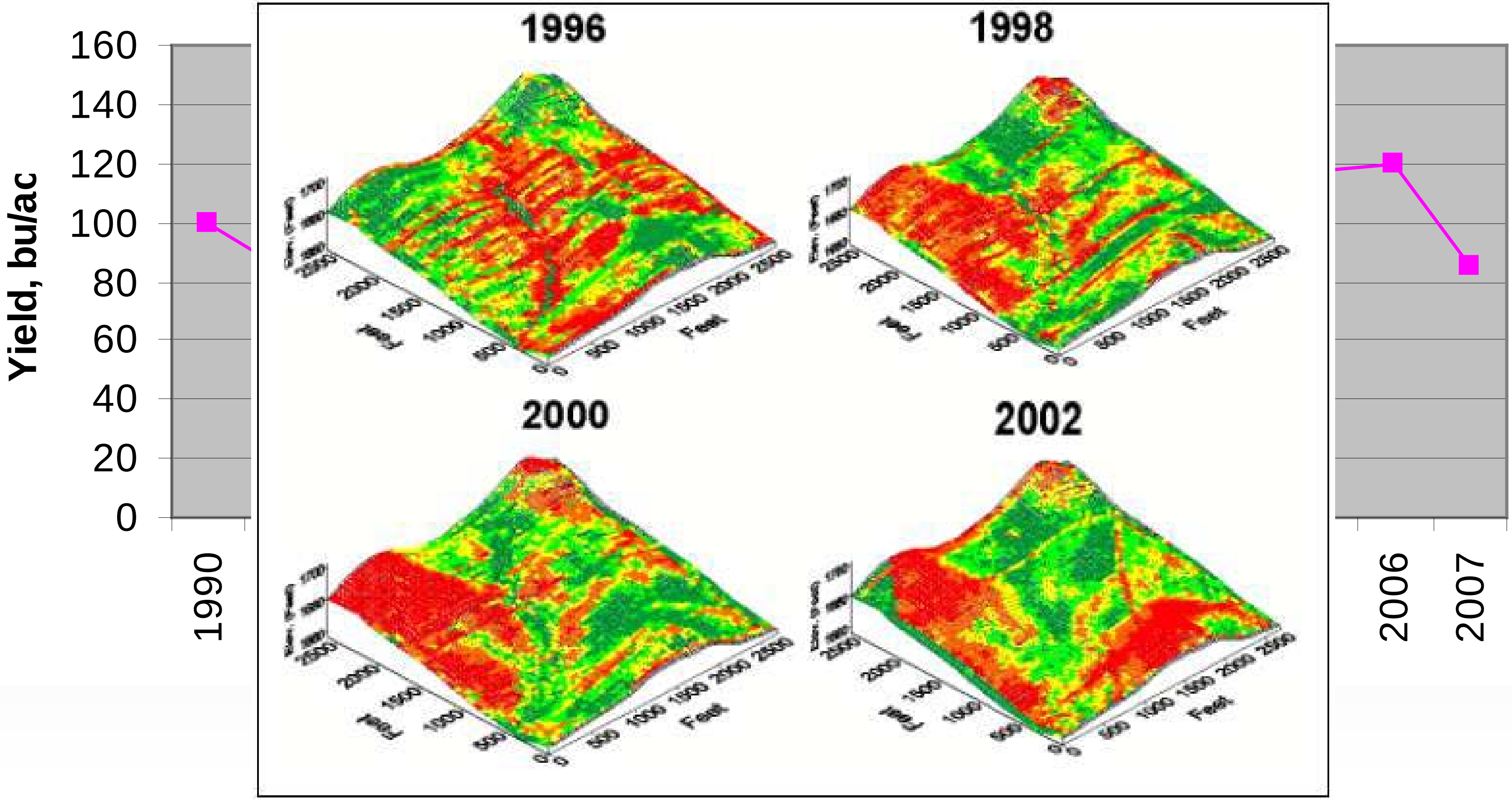
Spatial Variability

Generalized nutrient recommendation over large areas, without recognizing variability, leads to under and over-fertilization

- Consequences are apparent in:
  - Falling productivity
  - Low nutrient use efficiency
  - Multi-nutrient deficiency
  - High extent of nutrient mining

Proper assessment and management of spatial nutrient variability can ensure efficient and effective fertilizer use with reduced environmental impact

Temporal Variability



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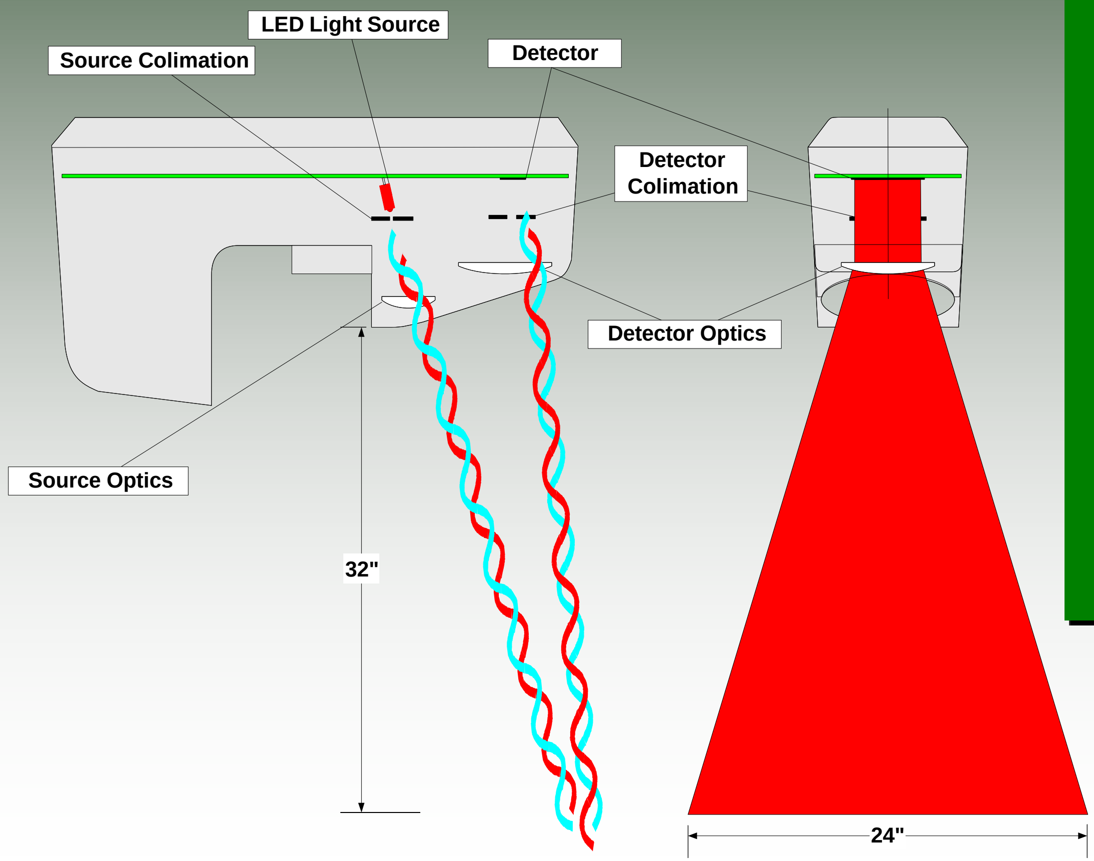
Real-time N management

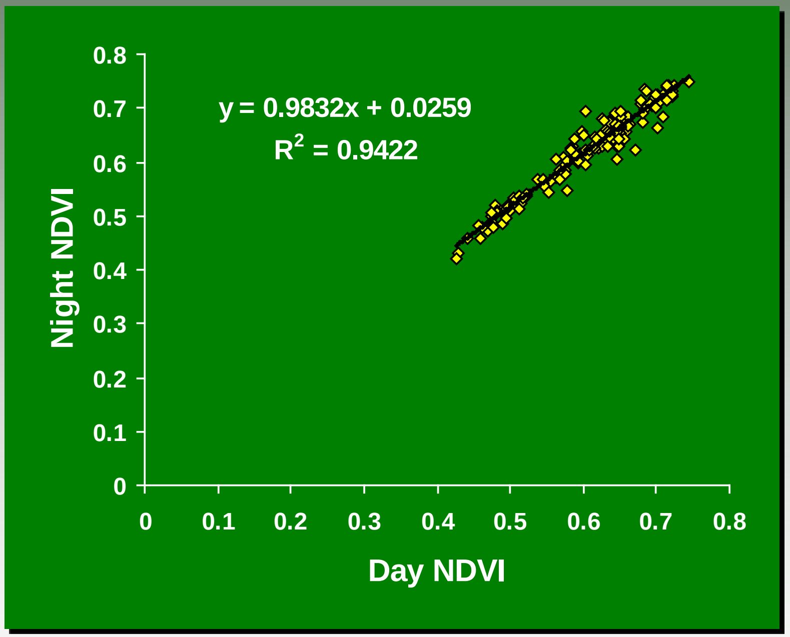
Leaf color charts

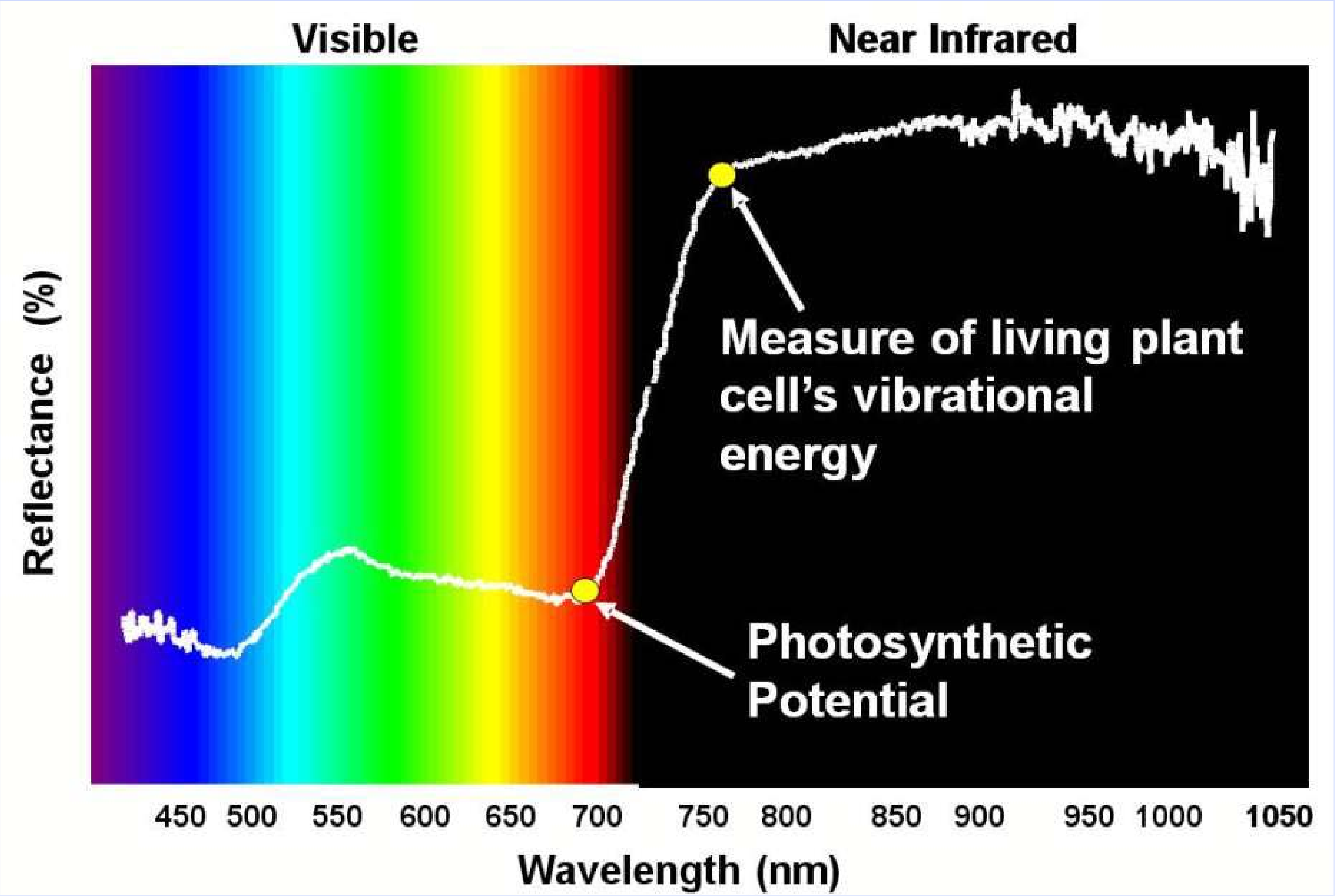
Chlorophyll meters

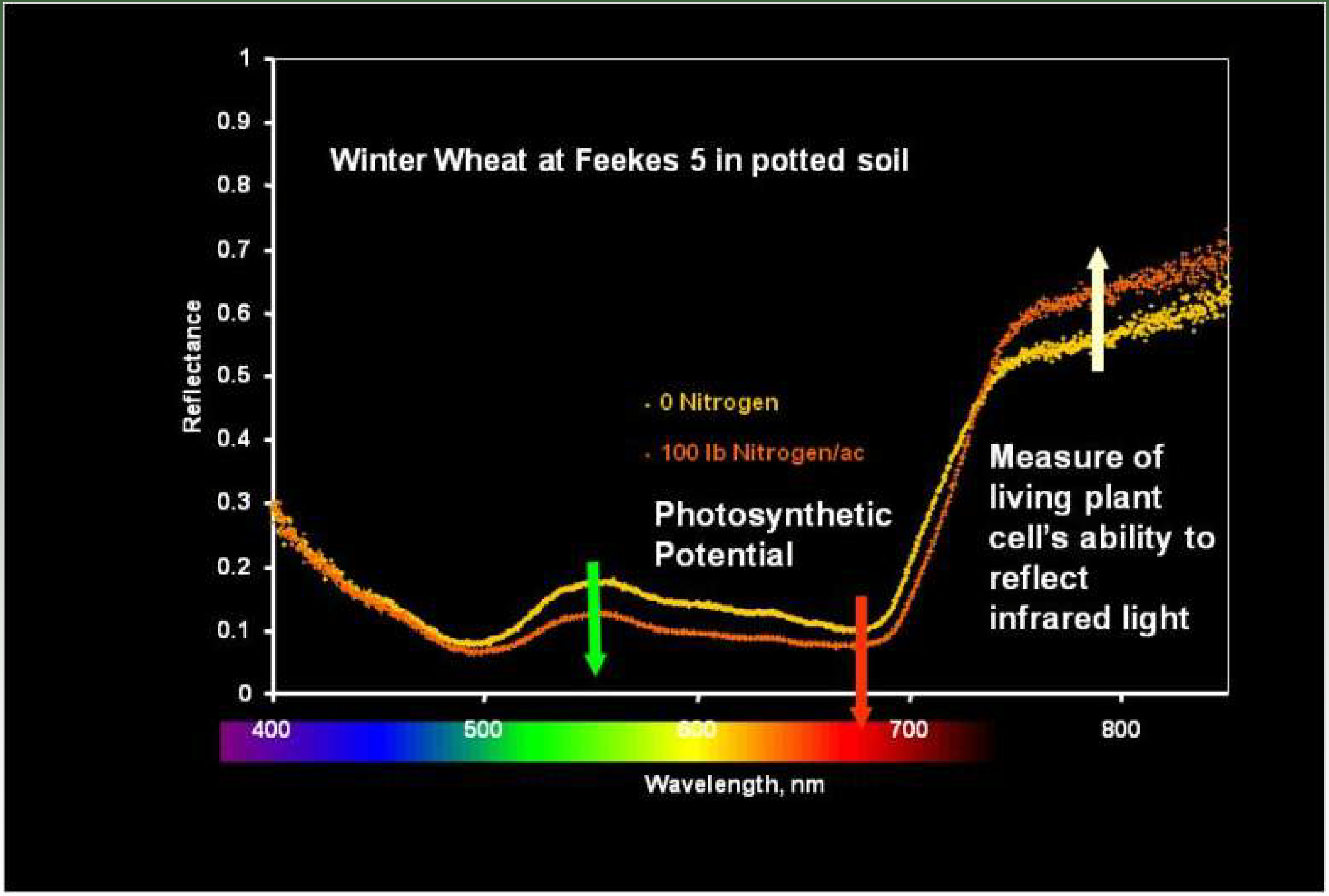
Optical sensors

GreenSeeker Sensors






Visible
Near Infrared
Measure of living plant cell's vibrational energy
Photosynthetic Potential
Reflectance (%)
450 500 550 600 650 700 750 800 850 900 950 1000 1050
Wavelength (nm)



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Developing a Sensor-Based Program

Identify a decision support tool for determining midseason N rate requirement of rice.

Input section:

Provide the following information here

Output section:

Get the N fertilizer recommendation ***instantly***

Sensor Based N Rate Calculator, Rice 2009

DATA ENTRY	
Max yield, bu/ac	320
Planting Date	23-Apr-09
Sensing Date	29-Jun-09
NDVI, N Rich Strip	0.78
NDVI, Farmer's practice	0.767
NUE expected	0.5

RESULTS	
Response Index	1.19
Days, planting to sensing	66
Potential yield (0-N), bu/ac	223
Potential yield (+ N), bu/ac	266
Fertilizer N, lb N/ac	46

Note:

NRS (Nitrogen Rich Strip) - Reference Strip

FP (Farmer's Practice)

NDVI (normalized difference vegetation index)

Max yield set to 2 times the average yield in the area

Rough rice: 45 lbs/bu

Rice grain N = 1.2%

PROCEDURE:

1. Farmer is asked to Establish the Maximum Yield Achievable, For that Year (YPMAX)
2. Sense the N Rich Strip (NRS)
3. Sense a strip parallel to the NRS (Farmer's Practice or FP)
4. Determine how many days from planting to sensing
5. Compute INSEY (NDVI/days from planting to sensing)
6. Predict yield
7. Predict grain N uptake in FP
8. Predict grain N uptake in FP based on RI
9. N rate = (grain N uptake in FP based on RI - grain N uptake in FP)/expected NUE

Contributors: Brenda Tubana, Dustin Harrell, and Timothy Walker

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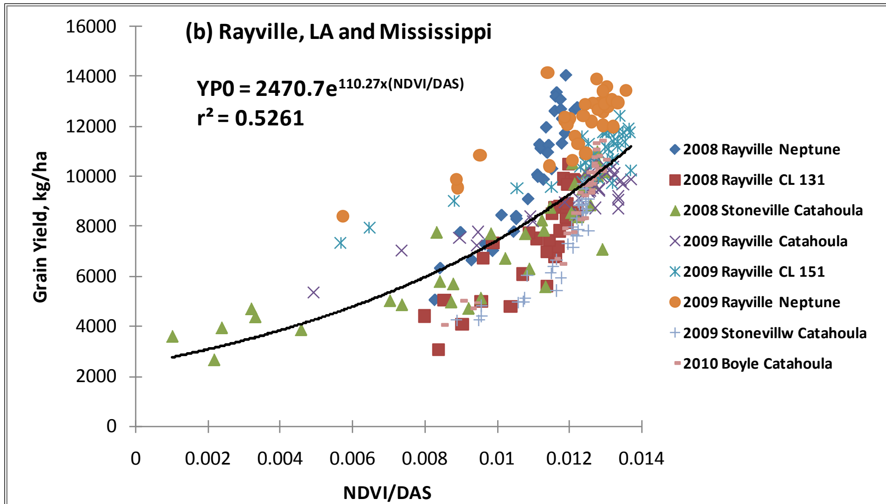
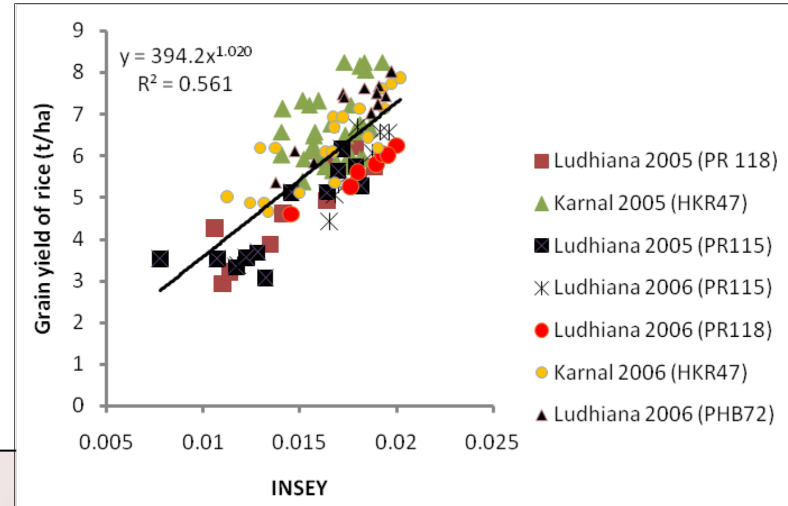
Calibration

- Establish sensor-based model for predicting rice grain yield potential





Calibration

- Identify sensing scheme to minimize water reflectance interference on sensor readings.






Validation

- Evaluate the performance of sensor-based N decision tool against the commonly applied flat N rate

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Evaluation of GreenSeeker based N management in rice

Treat-ment	Fertilizer N applied (kg N/ha) at DAT							Grain yield (t/ha)	AE (kg grain / kg N applied)
	0	7	21	28	42	49	Total		
1	20		40		28*		88	6.23	27.1
2	20		60		12*		92	6.83	32.3
3	30		30		32*		92	5.63	19.4
4	30		50		14*		94	6.28	25.8
5	40		40		24*		104	6.34	24.0
6		20		40		29*	89	5.97	23.8
7		20		60		19*	99	6.59	27.7
8		30		30		32*	92	5.66	19.7
9		30		50		17*	97	6.25	24.7
10		40		40		20*	100	6.50	26.5
Recom.	40		40		40		120	6.19	19.5
No-N							0	3.85	-
LSD (p=0.05)								0.774	

* GreenSeeker guided N dose

Fertilizer N management in rice: application of GreenSeeker (GS) optical sensor guided corrective fertilizer dose

Fertilizer N application (kg N/ha)				**Grain yield (t/ha)**			
Basal	21DAT	42 DAT (GS guided)*	Total	2006	2007	2008	2008
				PR118	PR118	PAU201	PHB71
0	0	0	0	3.85	4.05	4.16	3.42
40	40	40	120	6.19	5.01	6.86	6.16
30	30	32	92	5.63			
30	30	23	83		4.74		
30	30	48	108			6.59	
30	30	49	109				6.09
L.S.D. (p=0.05)				0.774	0.337	0.488	0.488

Technology Transfer

GreenSeeker Pocket Sensor

Conclusions

- Site-specific N management using GreenSeeker optical sensors is possible in both large and small land holdings
- Developing a sensor-based system requires:
  - Calibration
  - Validation
  - Technology Transfer
- Extensive research is limited, but results from developing countries are promising