Effective Manganese Management for Corn and Soybean in Glyphosate-Dominant Cropping Systems

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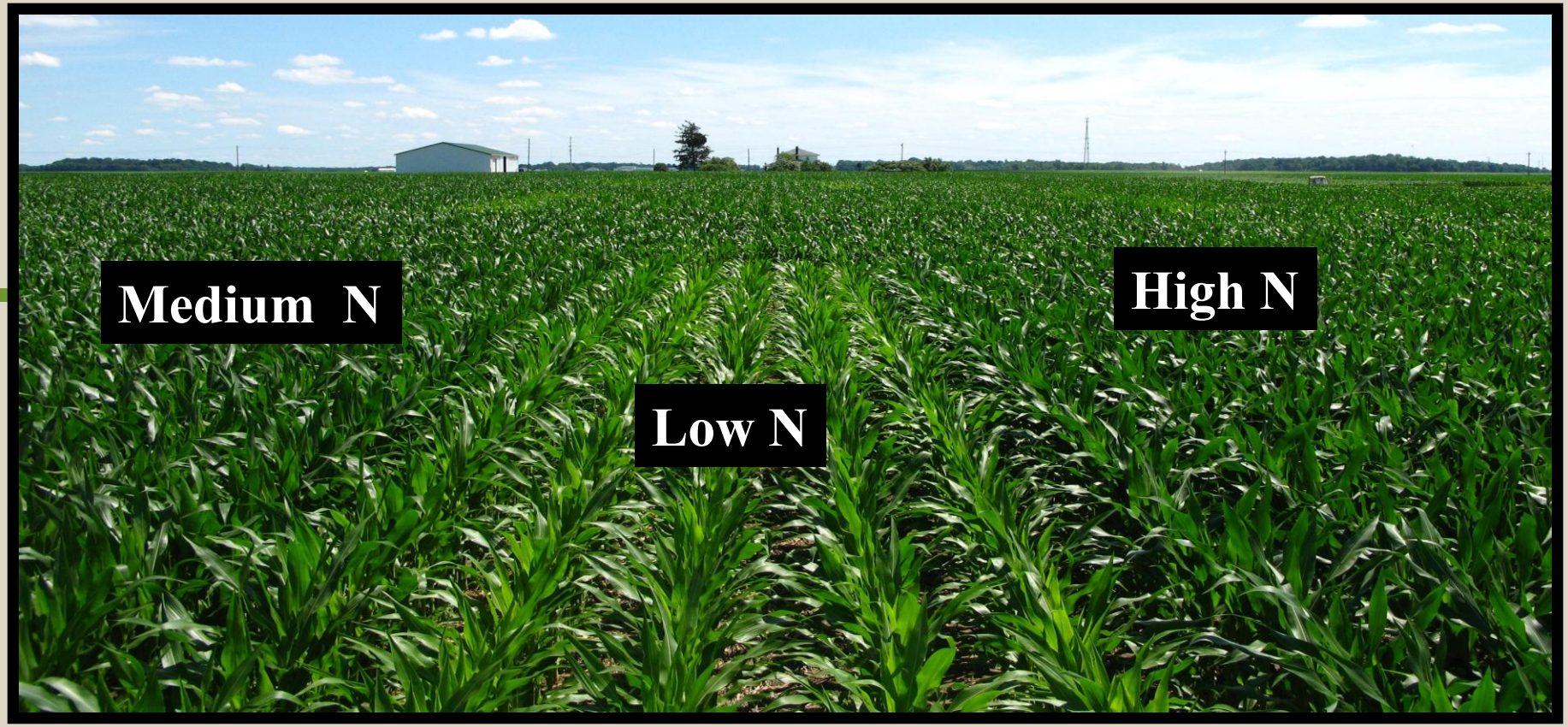
PURDUE UNIVERSITY

Purdue Agronomy
crop, soil, and environmental sciences

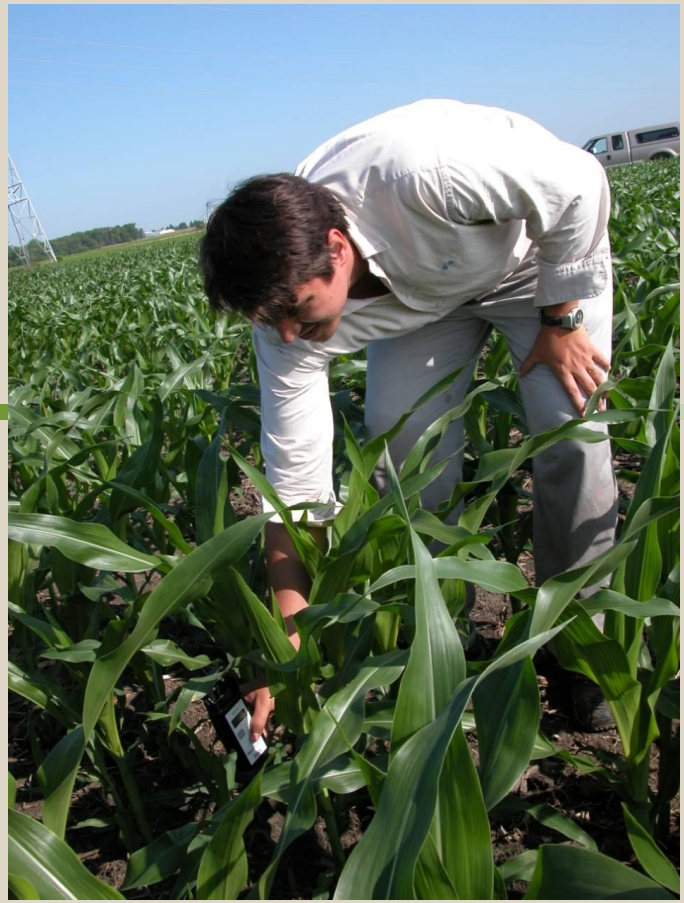
Role of plant manganese

- Chlorophyll formation & function
- Structural lipids/fatty acids
- Lignin, phenols, phytoalexins
- Transport and utilization of fixed N

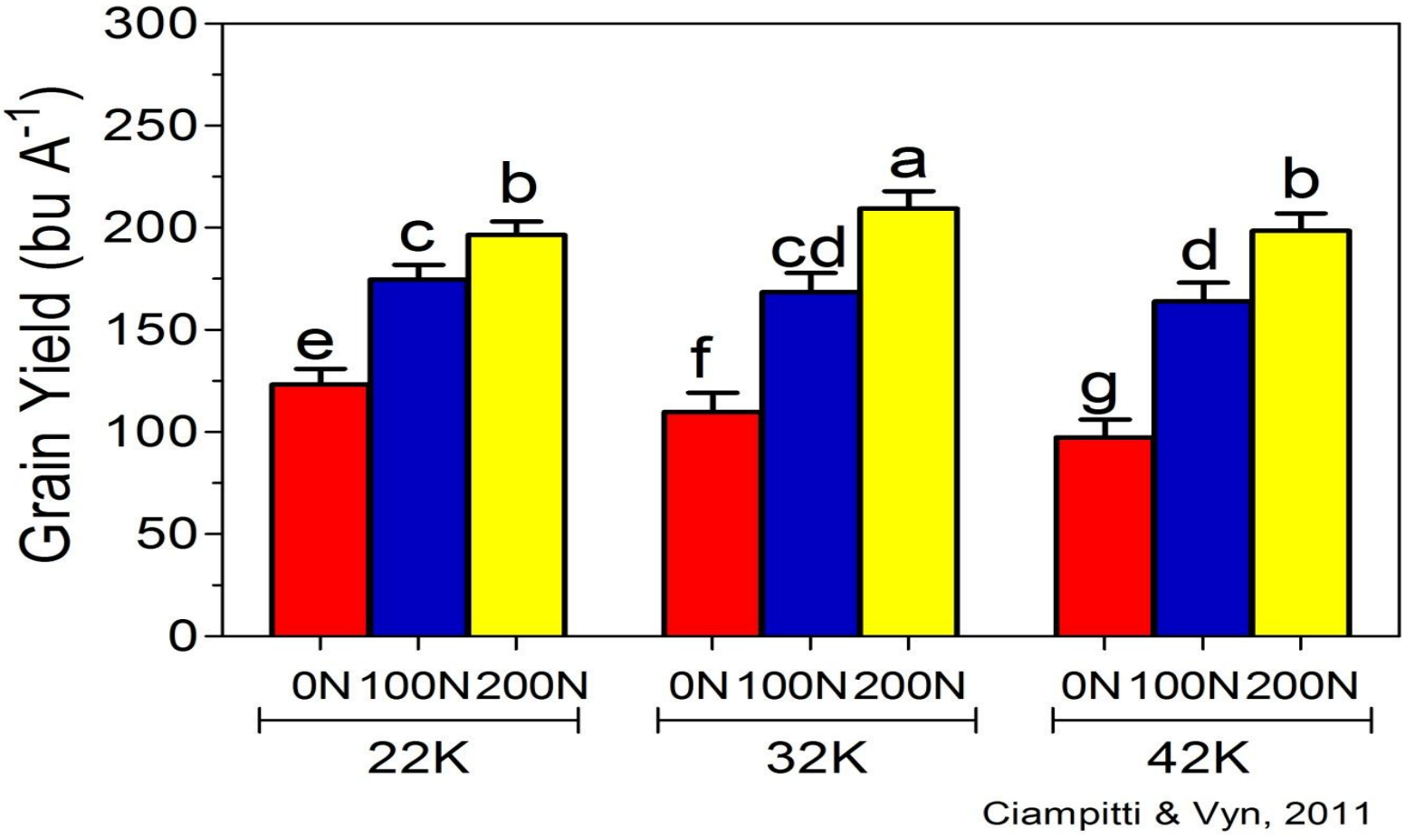
Plant Density and Nitrogen Rate Relationships with Grain Yield and NUE



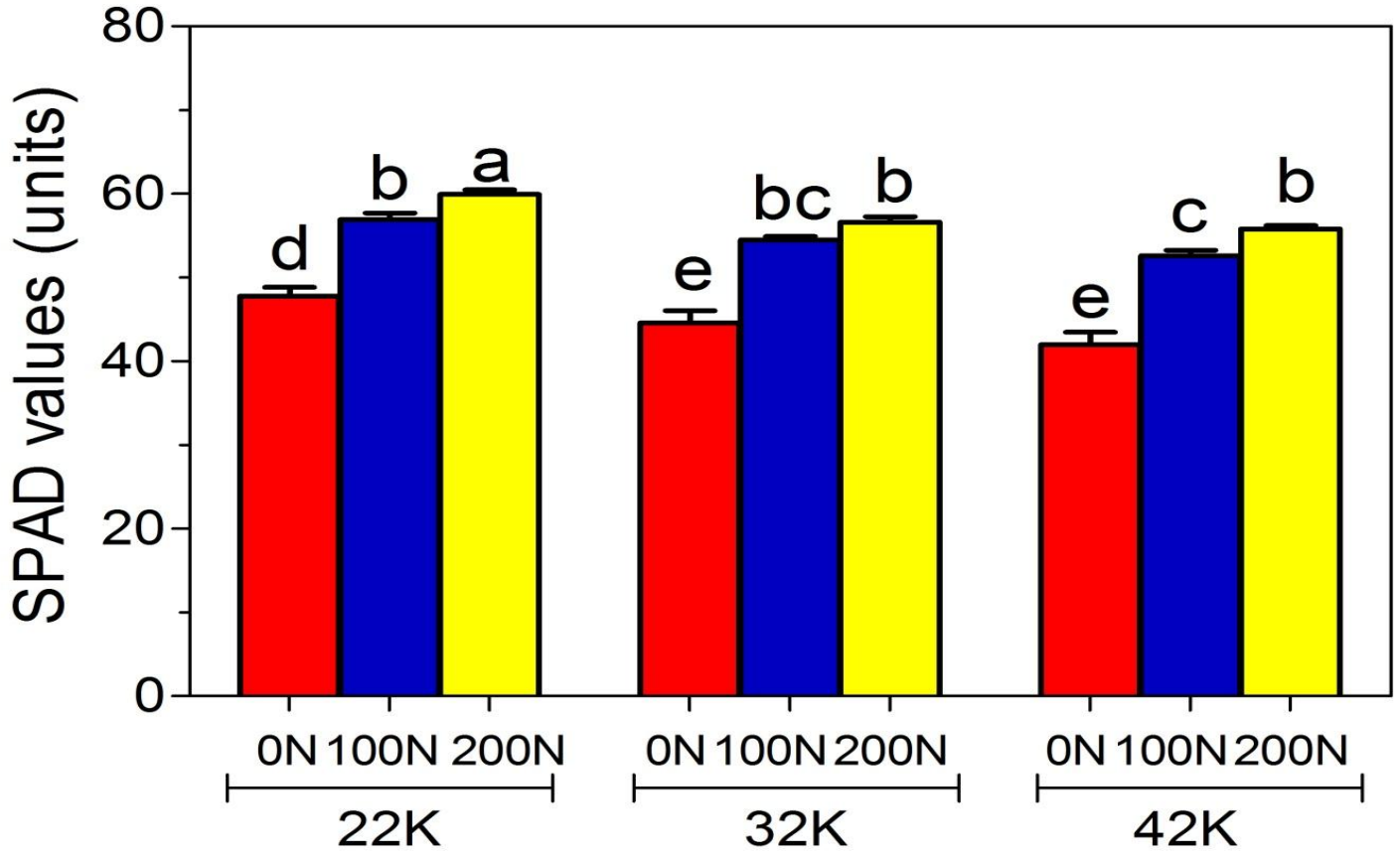
Ph.D. Graduate Student Training



Plant Density and N Rate Impacts on Grain Yield (average of 2 hybrids, 2 locations and 2010-2011)



Plant Density and N Rate Impact on Leaf Chlorophyll at RI stage
(mean of 2 hybrids, 2 locations and 2 years)



Ciampitti & Vyn, 2011

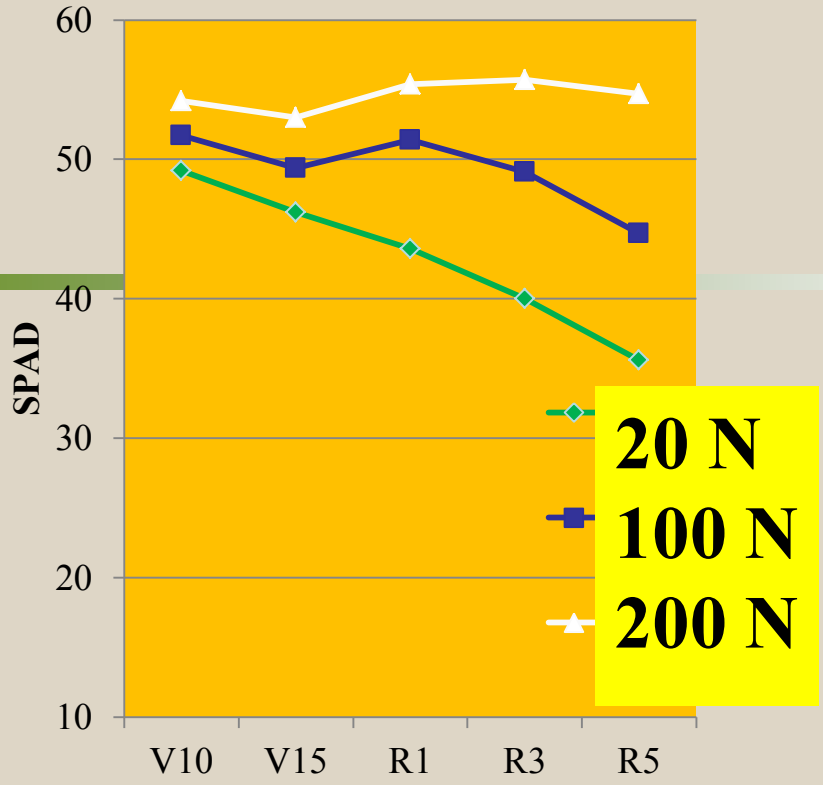
Photosynthetic Measurements

Li-Cor 6400XT

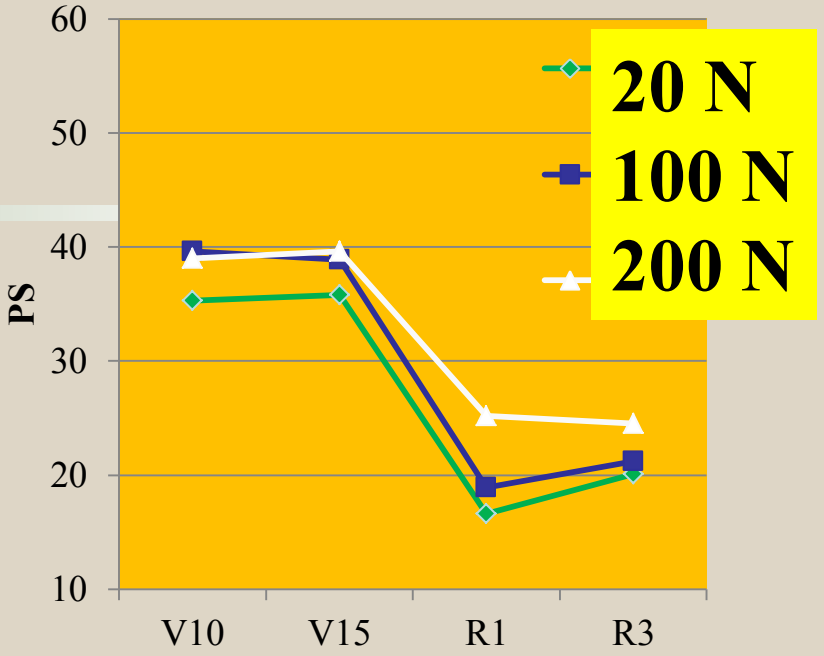
Dow AgroSciences™

N Rate Effects on SPAD and Photosynthesis Rate at High Density (mean of hybrids at 42,000 ppa in 2011)

Leaf SPAD

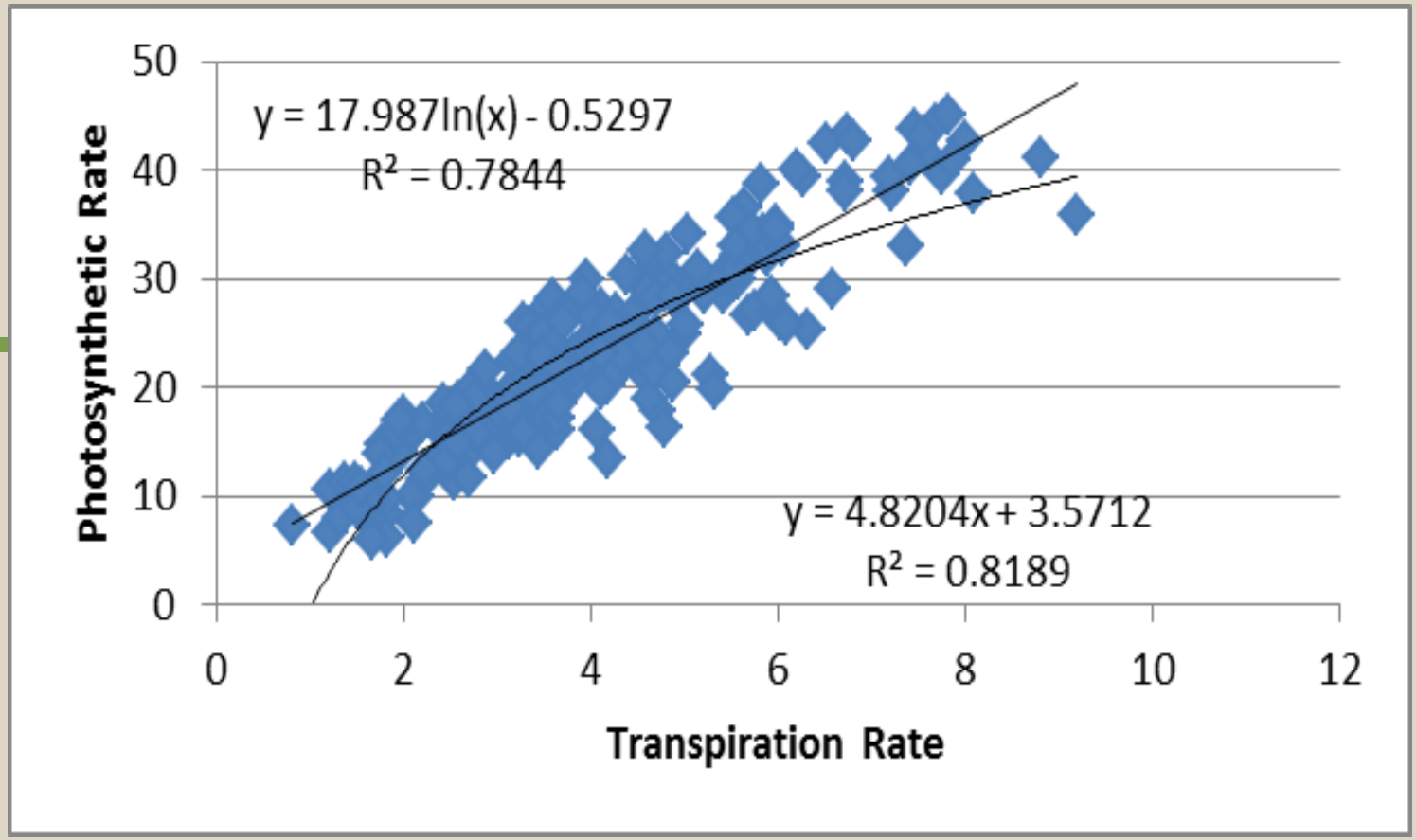


Leaf Photosynthesis



Corn Stage of Development

Photosynthesis is strongly dependent on Water Transpiration Rate



Sidedress UAN and Instinct™ Application

INDIANA CORN Marketing Council

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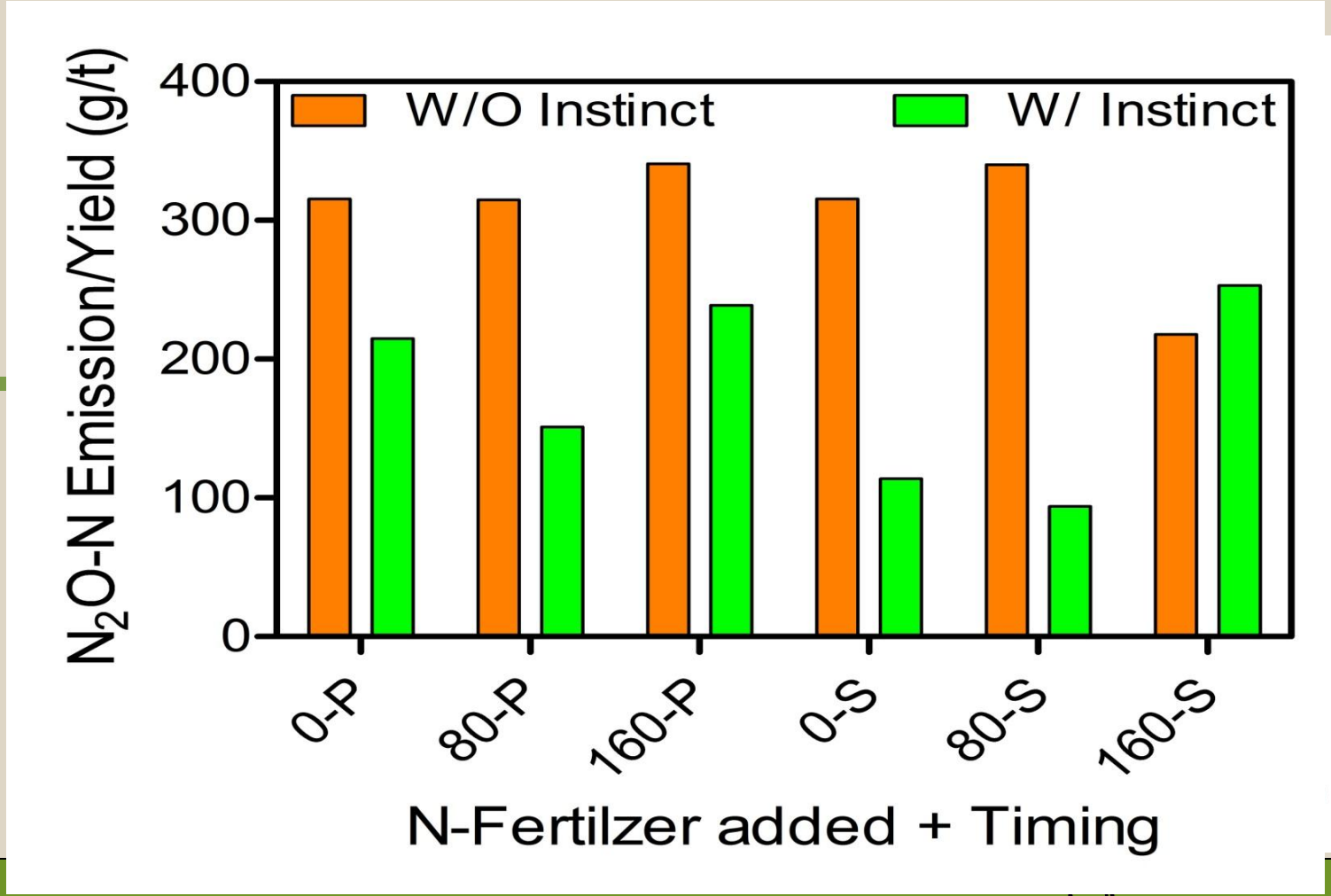
Nitrous Oxide Emissions per Unit Yield in 2010



Mn deficiency of soybean is <u>not</u> a new problem!

SOIL SCIENCE SOCIETY PROCEEDINGS 1946

IT has been known for a number of years that manganese is essential for normal plant growth. Response to manganese has been reported on oats, wheat, cowpeas, soybeans, spinach, sudan grass, onions, potatoes, and tomatoes (1, 4, 5, 6, 8, 9, 10, 12).[3] In 1914, Conner (3) reported the partial depletion of total manganese in Indiana soils. The analysis of a composite sample of 31 soils indicated the manganese content of the surface horizon of cropped soils had dropped to one half that in the virgin soils in a period of 60 to 80 years of cropping. In 1932, he (4) reported that oats responded to manganese fertilization on a dark silty clay loam; and in 1933, he (5) recommended the use of manganese sulfate on near-neutral dark sandy soils and mucks of Indiana.

The purpose of this investigation was to make a preliminary survey of manganese deficiency in northern Indiana and to determine the response of soybeans when fertilized with manganese and other minor elements.

MATERIALS AND METHODS

A field experiment was conducted on a Maumee loam in

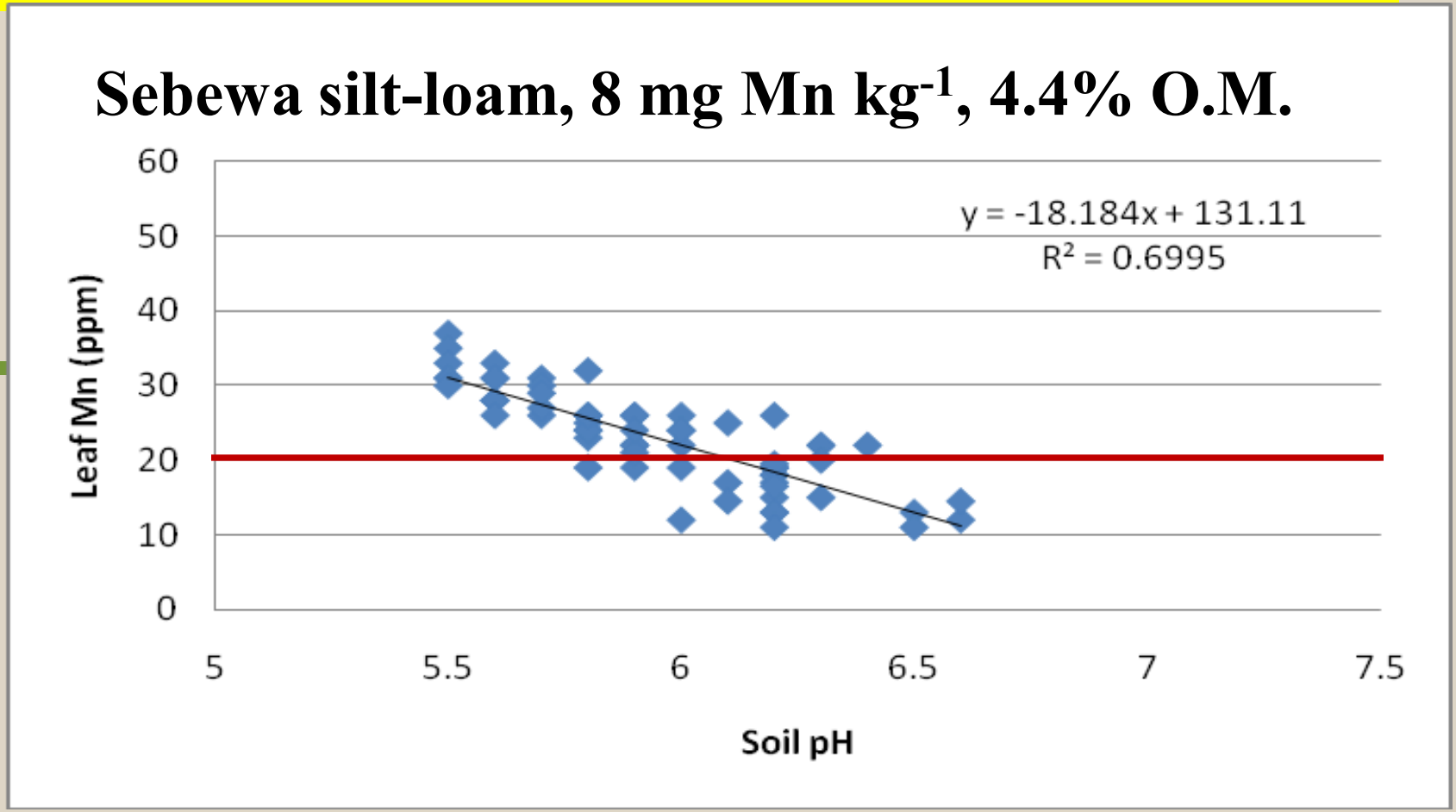
RESULTS

In Table 1 the average plant weight of soybeans when treated with the minor element mixture of 400 pounds of Es-Min-El (140 pounds $MnSO_4$, 100 pounds $CuSO_4$, 36 pounds $Fe_2(SO_4)_3$, and 4 pounds of borax) per acre was 7.5 grams, or an increase of 5.0 grams over the untreated plants. When copper, zinc, iron, and borax (without manganese) were

TABLE 1.—*Summary of plant weight, manganese content, and yield of soybeans grown on soil with various levels of manganese.*

Manganese treatment in lbs. per acre	Plant weight in grams per per plant*	Mn content of soybean plant*		Yield, bu. per acre†
		P.p.m.	Mgm. per plant	
Manganese sulfate‡				
0	2.8	12.0	0.034	16.7
18	5.7	13.6	0.078	21.2
35	6.7	15.3	0.103	29.0
71	7.9	29.1	0.230	34.1
142	8.1	68.3	0.553	34.8
284	6.3	73.0	0.460	34.6
568	6.6	219	1.445	32.7

High pH reduces Mn availability



Yanbing Xia, Tony J. Vyn, and Jim Camberato - 2009

Chelate?

Chelate comes from the Greek word chela, meaning "crab's claw.

Mn antagonism of glyphosate efficacy on velvetleaf control

Bernards et al., 2003; slide courtesy of Ron Gehl, MSU

Mn antagonism of glyphosate efficacy on velvetleaf control

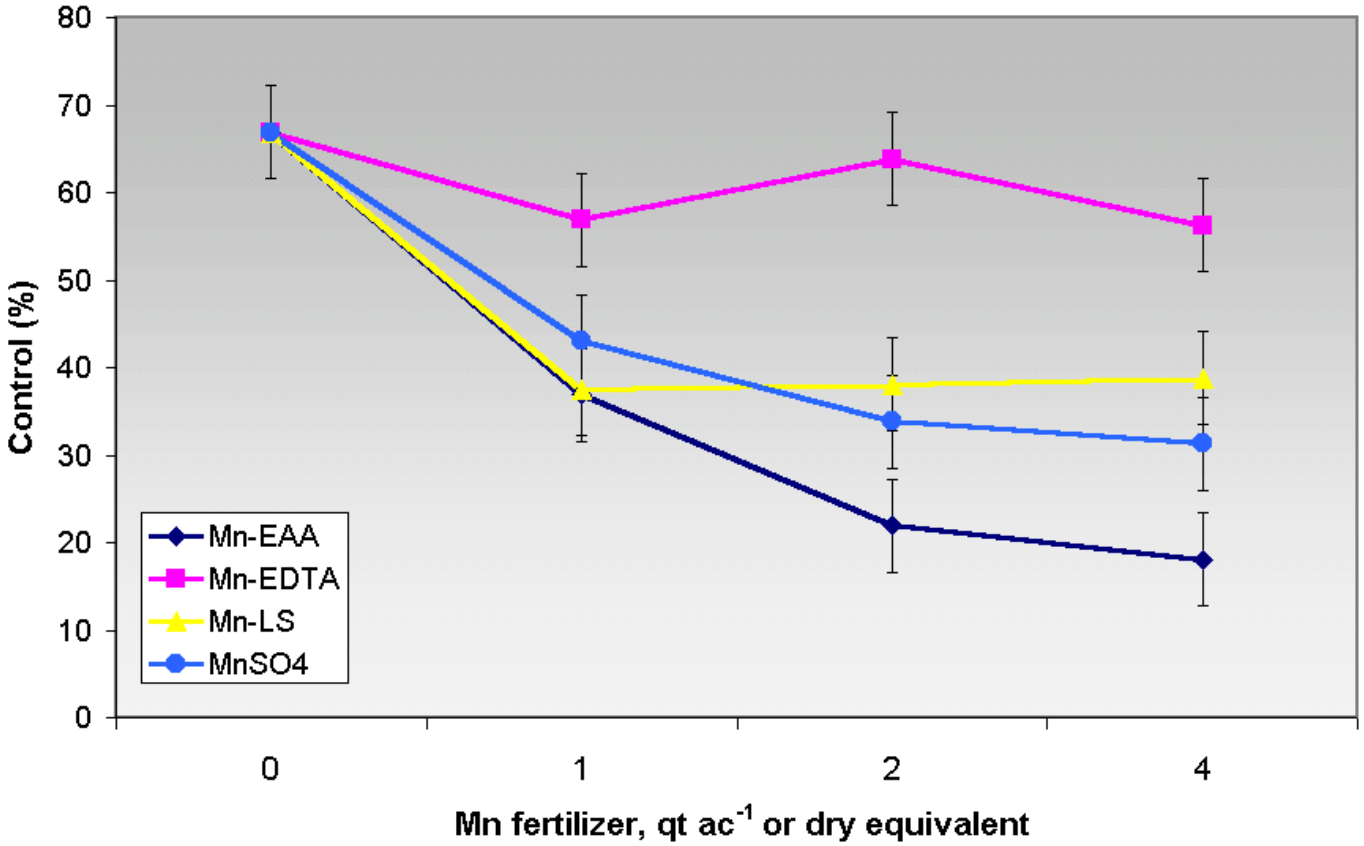


Figure 4. Velvetleaf control 14 days after treatment with glyphosate-Mn fertilizer tankmixes at three Mn fertilizer concentrations. "0" is efficacy of glyphosate without Mn. Data represent the averages of +/- AMS treatments. Error bars represent the standard error, p=0.05.

Bernards et al., 2003; slide courtesy of Ron Gehl, MSU

PURDUE UNIVERSITY

PURDUE EXTENSION WEED SCIENCE

www.btny.purdue.edu/weedscience/

Jim Camberato

Kiersten Wise and Bill Johnson

Purdue Extension

Glyphosate – Manganese Interactions and Impacts on Crop Production: The Controversy

We have been getting many phone calls concerning the recent No-Till Farmer article 'Are We Shooting Ourselves in the Foot with the Silver Bullet?' (http://fhrfarms1.com/notillglyphosate.pdf). In this article based on an interview with Dr. Don Huber (retired plant pathologist from Purdue University), it is alleged that the non-judicious use of glyphosate has induced micronutrient deficiencies which have led to more plant disease. In our opinion the doomsday scenario painted by this article is greatly exaggerated. A more balanced assessment of the non-target effects of glyphosate is available in the article 'Glyphosate Manganese Interactions in Roundup Ready Soybeans' (http://www.weeds.iastate.edu/mgmt/2010/glymn.pdf) written by Dr. Bob Hartzler (weed scientist at Iowa State University). The extent of glyphosate and glyphosate-resistant crops on the manganese (Mn) nutrition of soybeans is not agreed upon, nor fully understood. We are concerned that the article in No-Till Farmer encourages growers to make drastic changes to their fertility, weed, and disease management programs out of fear, not understanding. We suggest the following approach to managing Mn deficiency in soybeans.

http://www.btny.purdue.edu/weedscience/2010/GlyphosateMn.pdf

Research Objectives (2009-2012)

- **Objective 1:** **To help farmers better understand soil, environment, and soybean management factors reducing micronutrient availability.**

- **Objective 2:** **To assist farmers in determining optimum mode for micronutrient supplementation in RR soybeans for Mn and Zn individually and combined, or when both are mixed with other micronutrients.**

Foliar micronutrient products applied to soybean in 2009-2010

White County

Pinney (PPAC), Wanatah

Control versus Second Foliar Mn Application

Leaf Symptoms and Sampling 4 Times/year

Soybean Yield Response (bu/acre) to Single Foliar Mn Application at Four Glyphosate Intensities (2008-2011)

Glyphosate Treatment	No Foliar Mn	With Foliar Mn
Control	44.0	47.5
Pre Glyphosate	48.1	50.3
Pre + Post Glyphosate	46.5	49.8
Pre + 2 Post Glyphosate	47.4	50.4

Note: All treatments followed Roundup-Ready corn with 0, 1 or 2 glyphosate applications. Location is Wanatah, IN (PPAC)

Corn Yield Response (bu/acre) to Foliar Mn Applications to Prior Soybean at Four Glyphosate Intensities (2011)

Glyphosate Treatment in Corn (Odd years 07-11)	Glyphosate Treatment In Soybean (Even years 2008-2010)	Mn Treatment in Prior Soybean No Foliar Mn	Mn Treatment in Prior Soybean With Foliar Mn
Control	Control	189	188
	Pre Glyphosate	191	198
	Pre + Post Glyphosate	200	198
Post glyphosate	Control	198	193
	Pre Glyphosate	197	198
	Pre + Post Glyphosate	197	201

Note: All treatments followed Roundup-Ready soybean with 0, 1 or 2 Glyphosate applications. Location is Wanatah, IN (PPAC)

Soybean Yield Response to Foliar Nutrient Products and Rates (Wanatah, IN, 2009)

Treatment	Mn Rate (per acre)	Yield (bu/acre)	Δ Yield (%)
Control (no Mn)	----	14.5e	0
Mn powder at V4	0.25 lb	30.2c	108.3
Mn powder at V4	0.50 lb	30.5c	110.1
Mn powder at V4	1.0 lb	36.3ab	150.3
Mn powder at V4	2.0 lb	37.6a	159.3
Mn EDTA at V4	32 oz	27.5dc	89.5
Mn EDTA at V4	64 oz	23.1d	59.1
Manni-Plex for Beans at V4	60 oz	30.4c	109.6
Manni-Plex for Beans at V4	120 oz	31.7bc	118.6
Mn powder at V4 and R1	0.50 lb	29.2c	101.6
Mn powder at V4 and R1	1.0 lb	36.2ab	149.9
Mn powder at V4 and R1	2.0 lb	36.7ab	153.3
Mn powder at V4 and R1	4.0 lb	38.8a	167.4

Soybean Leaf Nutrient Response to Glyphosate and Foliar Nutrients (Wanatah, July 29, 2010)

Treatments	Foliar Nutrient Rate/ac	Zn (ppm)	Mn (ppm)
Main			
Glyphosate at June-25	22 oz	53.4	45.6
Glyphosate at June-25 + July-9	22 oz	50.7	48.3
Sub-treatment (mean of Main Tr.)			
Control (no micronutrient)	0	47.3	38.4
Mn #1 (EDTA Mn)	32 oz	46.3	39.5
Zn #1 low rate (super Tel Zn)	0.25 lb Zn	45.6	39.8
Zn #2 high rate (super Tel Zn	0.50 lb Zn	45.3	37.8
Mn+Zn #1	32oz Mn + 0.25lb Zn	44.8	37.4
MnZnNBo #1 (Manni-Plex)	60 oz	46.9	38.2
Zn #2 high rate (applied twice)	0.50 + 0.50 lb Zn	60.3	69.0
MnZn #2 (applied twice)	(32oz Mn + 0.25lb Zn) x2	86.4	76.2
MnZnNBo #2 (applied twice)	60 oz + 60 oz	46.5	65.2

Soybean Seed Response to Glyphosate and Foliar Nutrients (Wanatah, 2010)

Treatments	Foliar Nutrient Rate/ac	Mn (ppm)	Yield bu/ac)
Main			
Glyphosate at June-25	22 oz	21.8	52.6
Glyphosate at June-25 + July-9	22 oz	20.3	53.7
Sub-treatment			
Control (no micronutrient)	0	20	52.7
Mn #1 (EDTA Mn)	32 oz	21	55.1
Zn #1 low rate (Super Tel Zn)	0.25 lb	22	54.1
Zn #2 high rate (Super Tel Zn	0.50 lb	20	52.8
Mn+Zn #1	32oz Mn + 0.25lb Zn	21	53.6
MnZnNBo #1 (Manni-Plex)	60 oz	21.5	52.6
Zn #2 high rate (applied twice)	0.50 + 0.50	21	53.2
MnZn #2 (applied twice)	(32oz Mn + 0.25lb Zn)x2	21.5	51.5
MnZnNBo #2 (applied twice)	60 oz + 60 oz	21.5	52.9

Soybean Seed Response to Glyphosate and Foliar Nutrients (Wanatah, 2011)

Treatments	Foliar Nutrient Rate/ac	Yield bu/ac)
Main		
Glyphosate on July 14	22 oz	44.5
Glyphosate on July 30	22 oz	44.9
Sub-treatment		
Control (no micronutrient)	0	40.3 c
EDTA Mn #1	32 oz	42.8 bc
Pro Mn Low rate	38 oz	44.6 ab
Pro Mn High rate	76 oz	44.6 ab
MnZnNBo #1 (Manni-Plex)	60 oz	44.8 ab
EDTA Mn (applied twice)	32 oz + 32 oz	45.7 a
Pro Mn low rate (applied twice)	38 oz + 38 oz	46.4 a
Pro Mn high rate (applied twice)	76 oz + 76 oz	47.0 a
Manni-Plex (applied twice)	60 oz + 60 oz	45.7 a

Tentative Mn Recommendations in Glyphosate-Resistant Soybean

1. Post-emergence glyphosate applications aren't inherently negative for soybean leaf or seed nutrient concentrations.
2. Glyphosate application intensity doesn't seem to affect soybean yield or relative response to foliar micronutrient applications.
3. Soil pH, rain (moisture), and soil micronutrient concentrations are bigger factors in trifoliate leaf and final seed nutrient concentrations.

Tentative Mn Recommendations in Glyphosate-Resistant Soybean (cont.)

4. Starter-band Mn by itself is not effective, and soil banded application should only occur with multi-nutrient starters (especially with acid-forming fertilizers).

5. Timing for foliar Mn applications is very important (ASAP after leaf deficiency symptoms), but positive yield response is not guaranteed due to soil nutrient and moisture fluctuations as soybean growth continues.

6. Double foliar applications maintain optimum leaf Mn and Zn concentrations post flowering, but don't necessarily boost yield. Aim for lower cost Mn and Zn sources if higher rates are required.

Acknowledgments

Funding:

Indiana Soybean Alliance (2007-2010)

Fluid Fertilizer Foundation (2009…..)

Purdue University Mary Rice Farm Fund (2011)

In-kind (a) Laboratory Analyses: Waters Ag Laboratory
Western Laboratories
Olsen's Laboratory

(b) Nutrients (Brandt Consolidated, Inc.,
Tetra Micronutrients, and others)

Equipment: John Deere Cropping Systems Unit

Soybean Seed: Pioneer Hi-Bred, Int.

Thanks!

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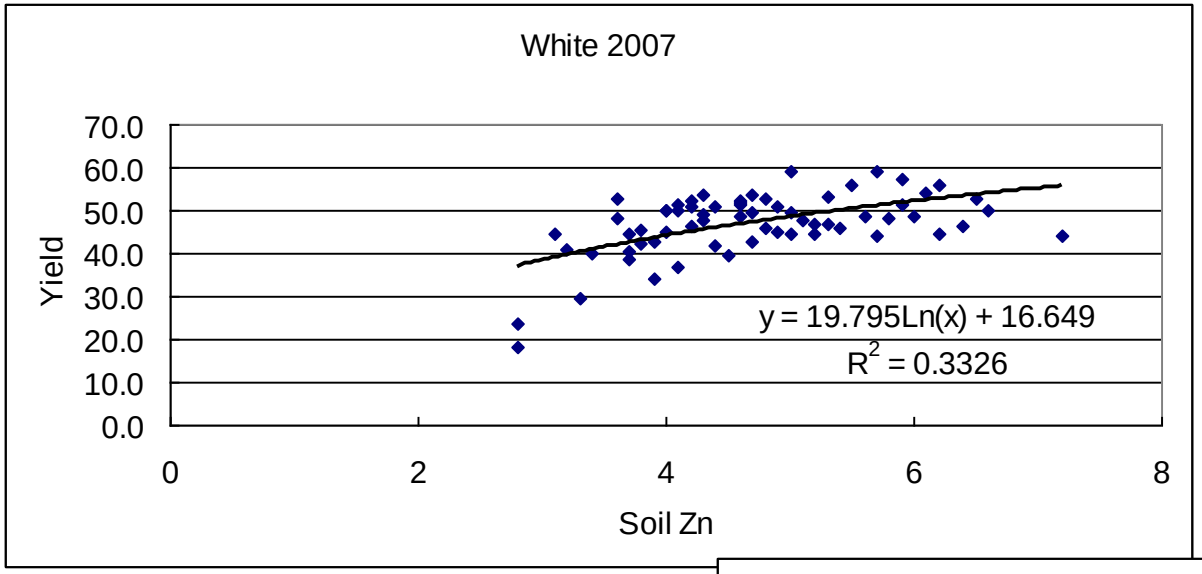
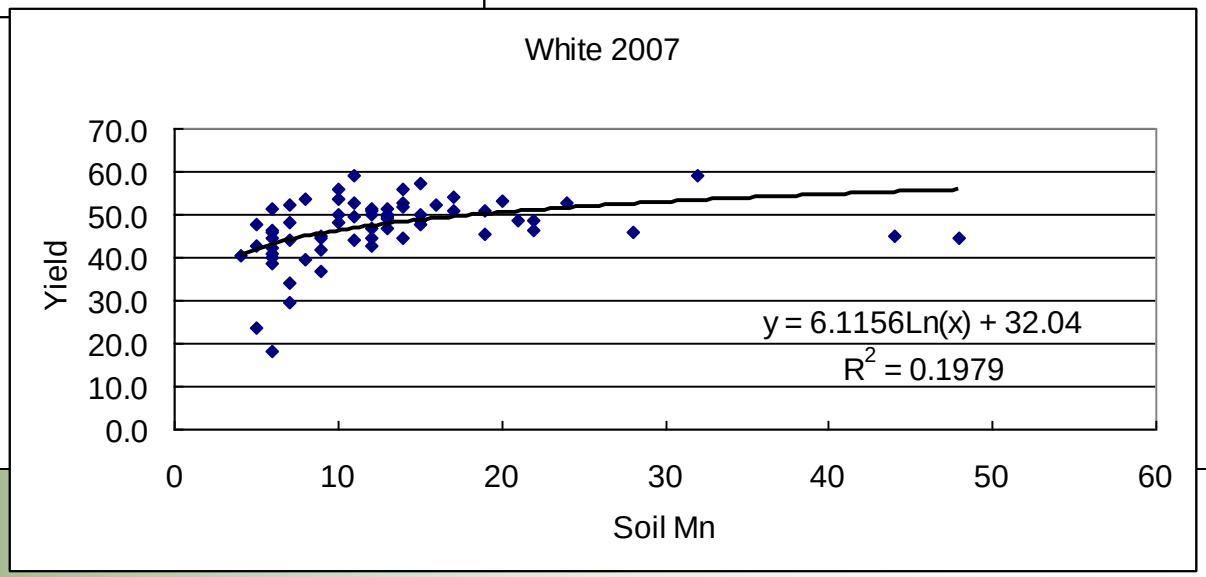
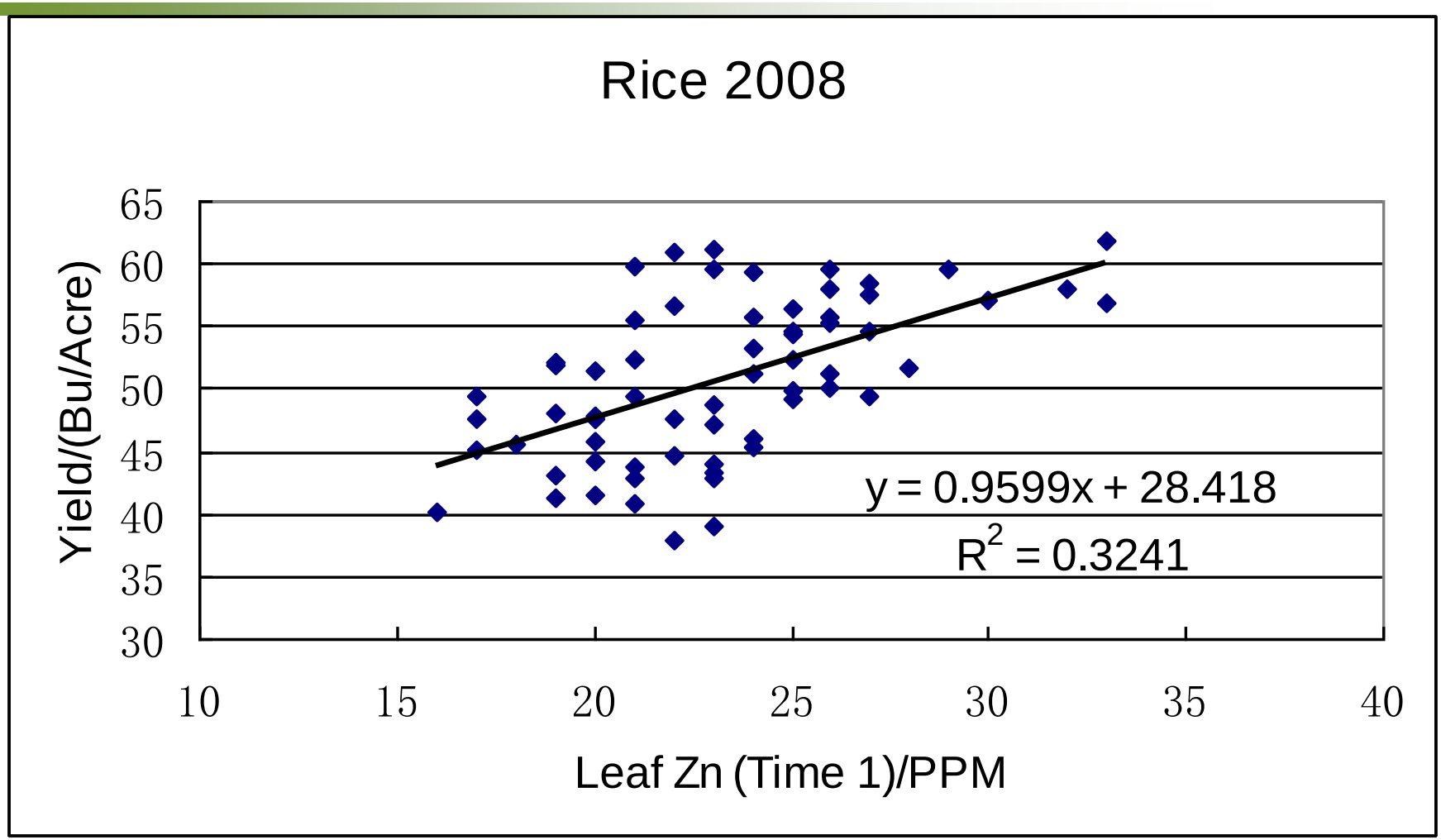
Questions?
Photo courtesy of Ron Gehl,
MSU

Soybean Yield Response to Soil Zn versus Mn (White County, 2007)





Relationship of Soybean Yield to Leaf Zn (Rice, 2008)



2008 Soybean Yield Response (bu/acre) to Single versus Double Foliar Mn Application after Glyphosate

Glyphosate Treatment	Single Foliar Mn	Double Foliar Mn
Control	2.6	3.1
Pre Glyphosate	1.7	3.5
Pre + Post Glyphosate	0	4.8
Pre + 2 Post Glyphosate	0	2.2

Note: All treatments had single post application of glyphosate to prior corn in 2007. Location is Wanatah, IN (PPAC)

Florida Registration No. 076-0860

CLAWEL®

0-0-0

GUARANTEED ANALYSIS

Manganese (Mn) 5.0%

Water Soluble Mn 5.0%

Derived from Manganese Glucoheptonate

Manganese

GENERAL RECOMMENDATIONS

For use in a balanced fertility program for all crops requiring manganese

The addition of other micronutrient salts such as sulfates and oxides in liquid and dry fertilizers in conjunction with this chelated material may cause a displacement of chelating agent. It is advisable to use all micronutrients in chelated form.

FOLIAR APPLICATION: Use 2-3 pints ClawEl MANGANESE per acre per application through

AERIAL APPLICATION: Use 2-3 pints ClawEl MANGANESE per acre per application with at

0-0-0

GUARANTEED ANALYSIS

Manganese (Mn) 5.0%

Water Soluble Mn 5.0%

Derived from Manganese Glucoheptonate

fertilizer and agitate

4. Add correct amount of ClawEl
5. Agitate adequately to mix

CAUTION: Check compatibility with ortho-phosphates, high potash suspensions, and chemical mixtures.

of a particular product expressed or implied, extends to the use of this product contrary to label conditions, or under conditions not reasonably foreseeable to the seller; and buyer assumes the risk of any such use.

Packed 2x2½ Gals..

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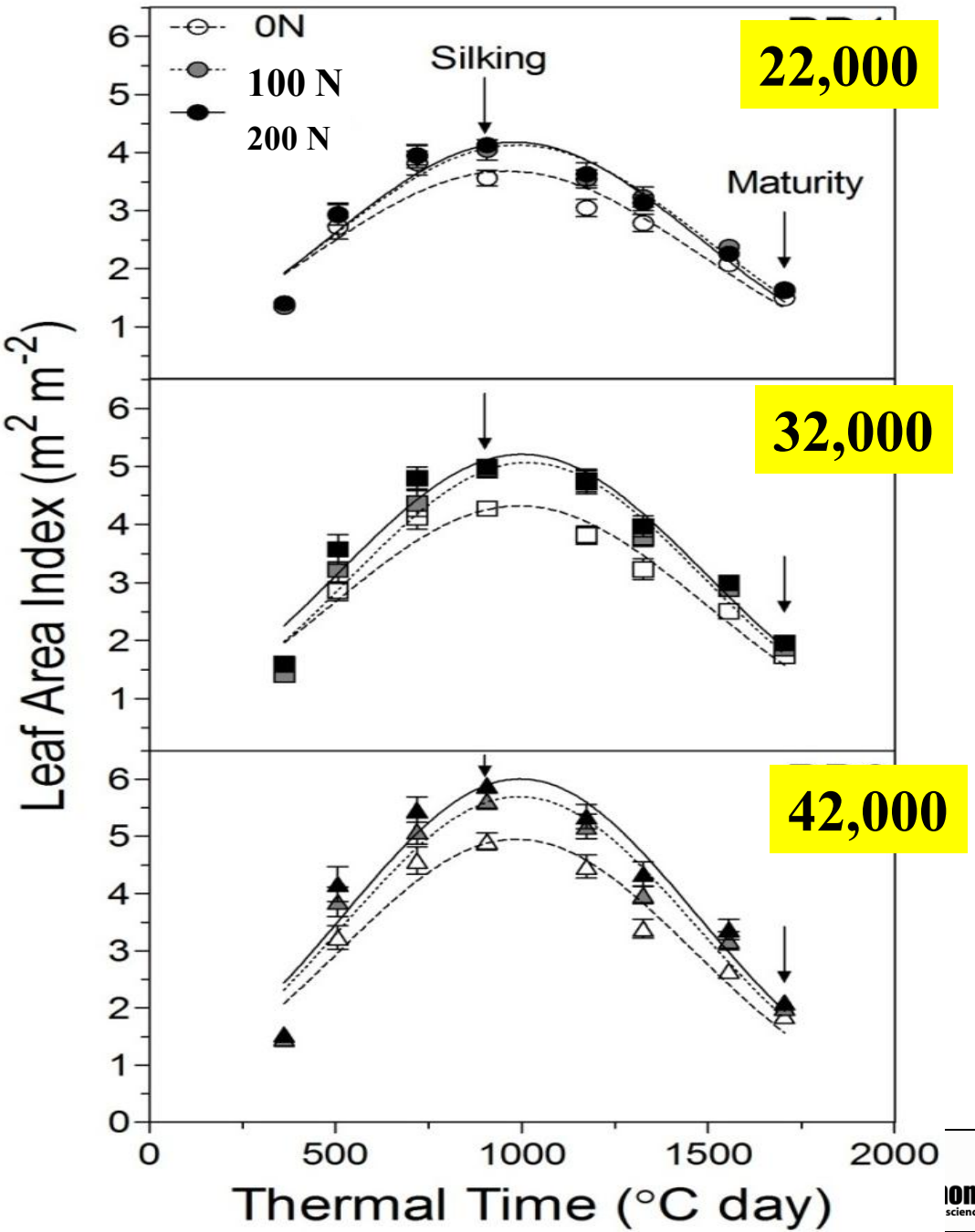
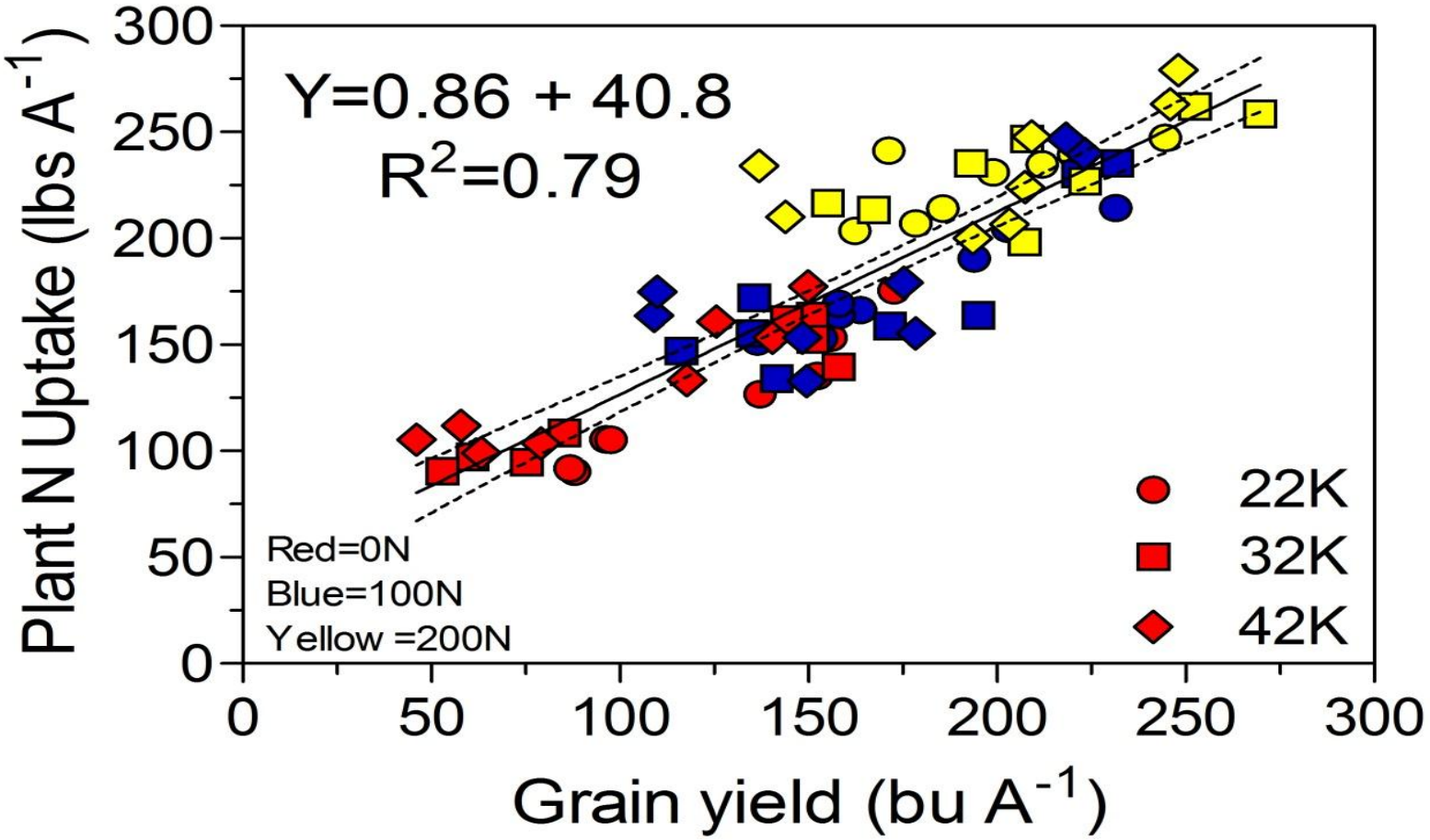
WARNING; Keep out of reach of children!
Dispose of container in accordance with local, state & federal regulations

Leaf area over time in response to population and N rates (2010-2011)



Relationship of Grain Yield to Plant N Uptake (per acre) for 3 Densities and 3 N Rates (treatment means of 2 hybrids & 2 locations; 2010-2011)



Ciampitti & Vyn, 2011