Alternative Approaches to Predicting Corn N Adequacy

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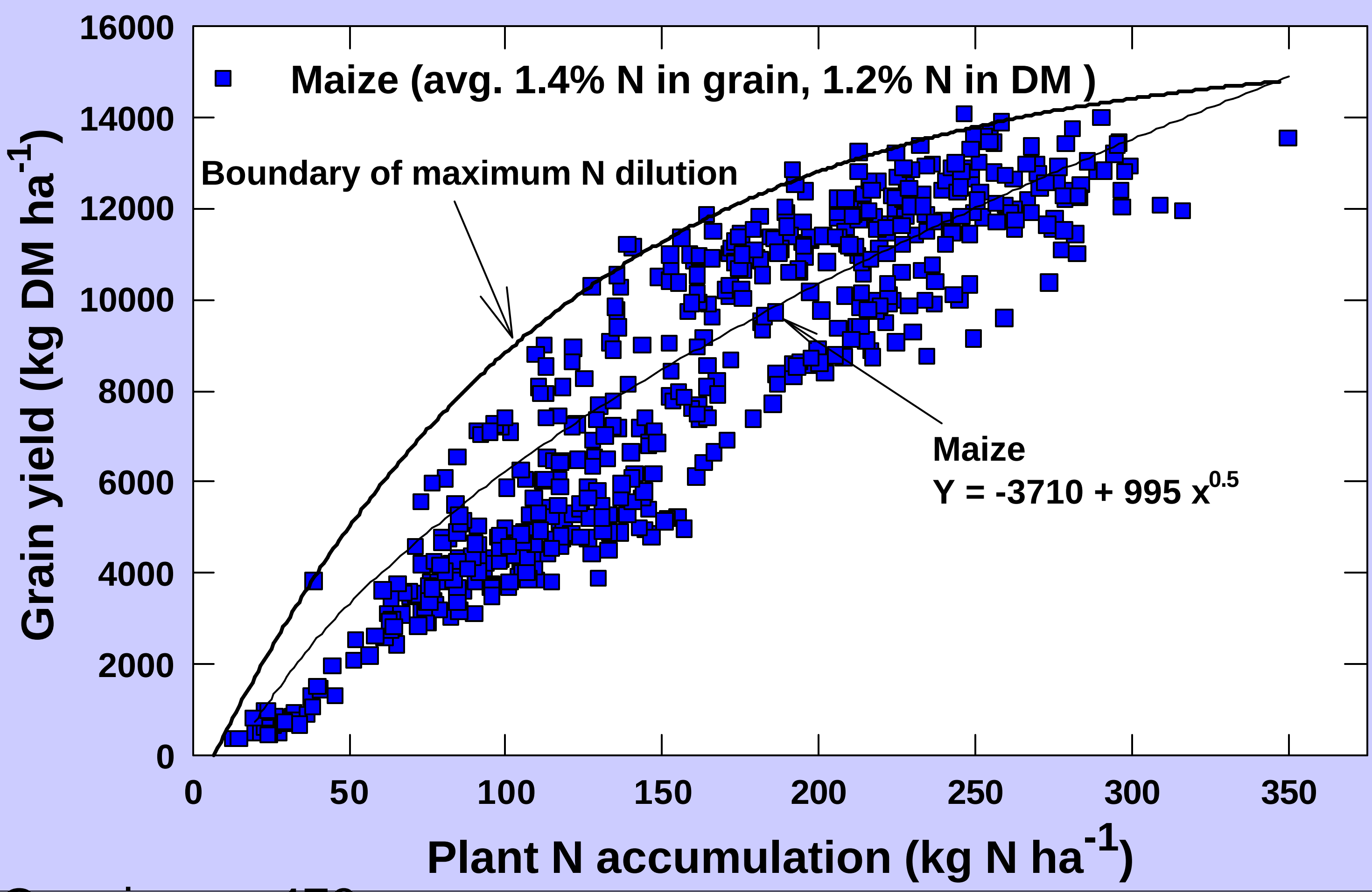
Problem Statement

- Nitrogen deficiency is difficult to diagnose because of the range in *internal N use efficiency* (IN) experienced during a given growing season.

IN = grain yield / total N uptake

- Critical plant or leaf N concentration, [N] = g N/g tissue, is subject to variations in both N uptake *and* dilution caused by changes in tissue weight with age, hybrid or seasonal/site dependent internal N use efficiency.

Corn Yield and N Uptake

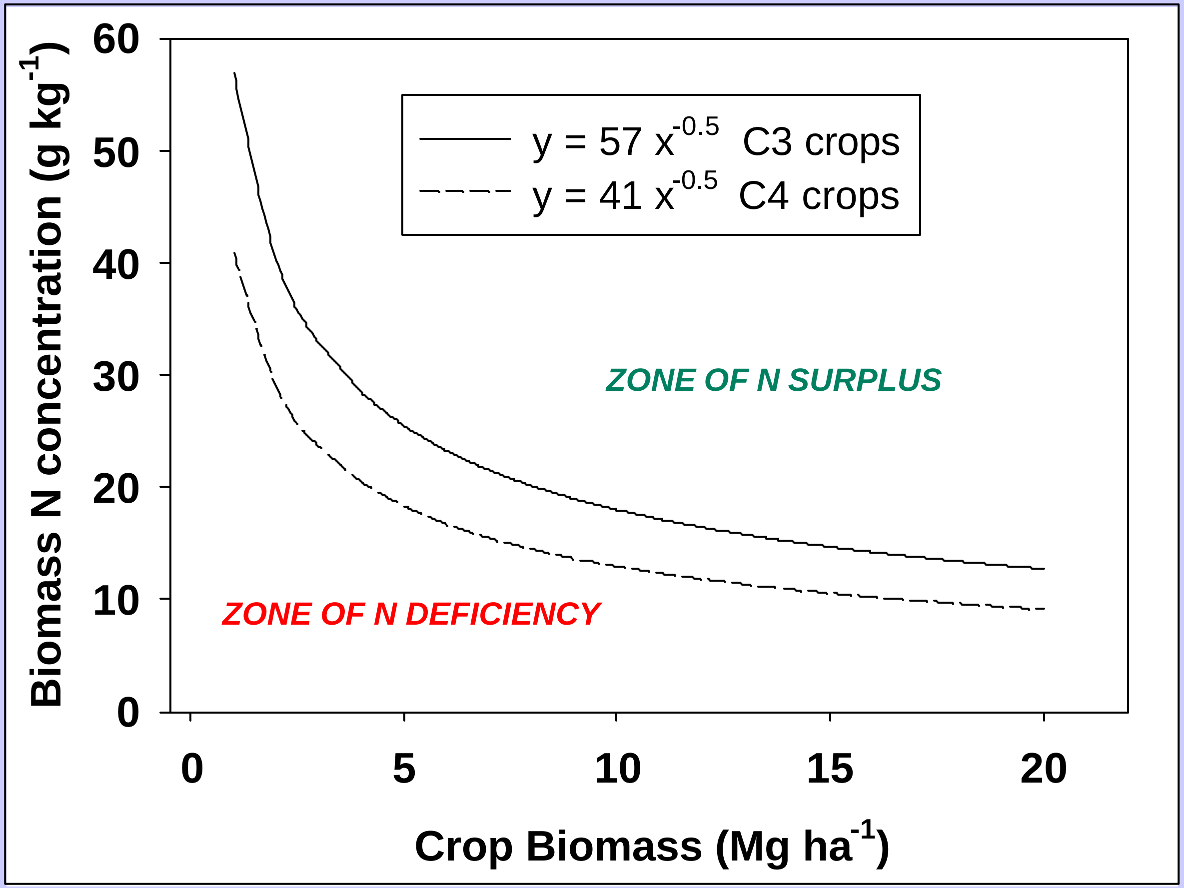


NC region, n=470

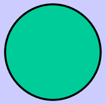
ARE THERE RELIABLE NITROGEN DIAGNOSTIC CRITERIA?

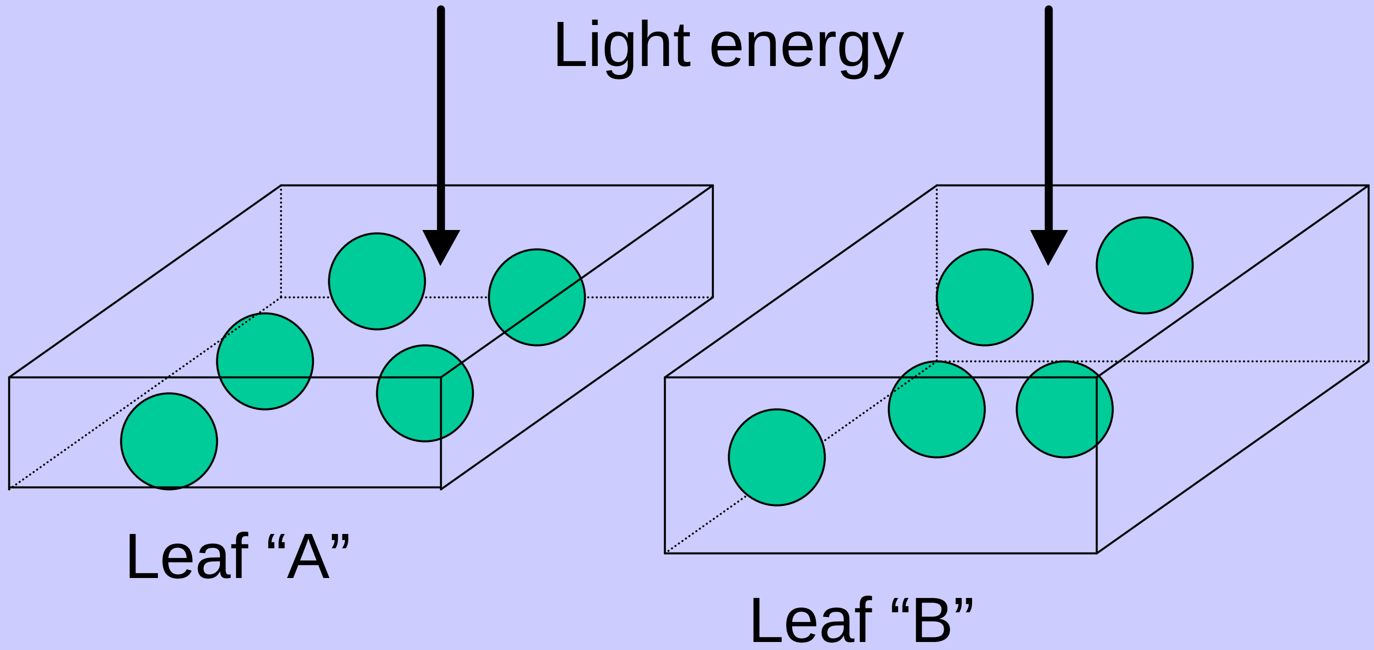
- Maize leaf photosynthesis and radiation use efficiency is optimized at a *canopy* leaf N content of 1.5 g N m^{-2} leaf.
  - Muchow and Sinclair. 1994. Crop Sci. 34:721-727
  - Lemaire (ed), Plenet and Grindlay. 1997. In “Diagnosis of the N Status of Crops”. Springer, Berlin.
- Biomass yield vs. N content has been shown to be a tightly conserved relationship within C4 and C3 species.
  - Greenwood et al. 1990. Ann. Bot. 66:425-436.
  - $\%N(C4)=4.1(DM)^{-0.5}$ $\%N(C3)=5.7(DM)^{-0.5}$

"GREENWOOD" CURVE

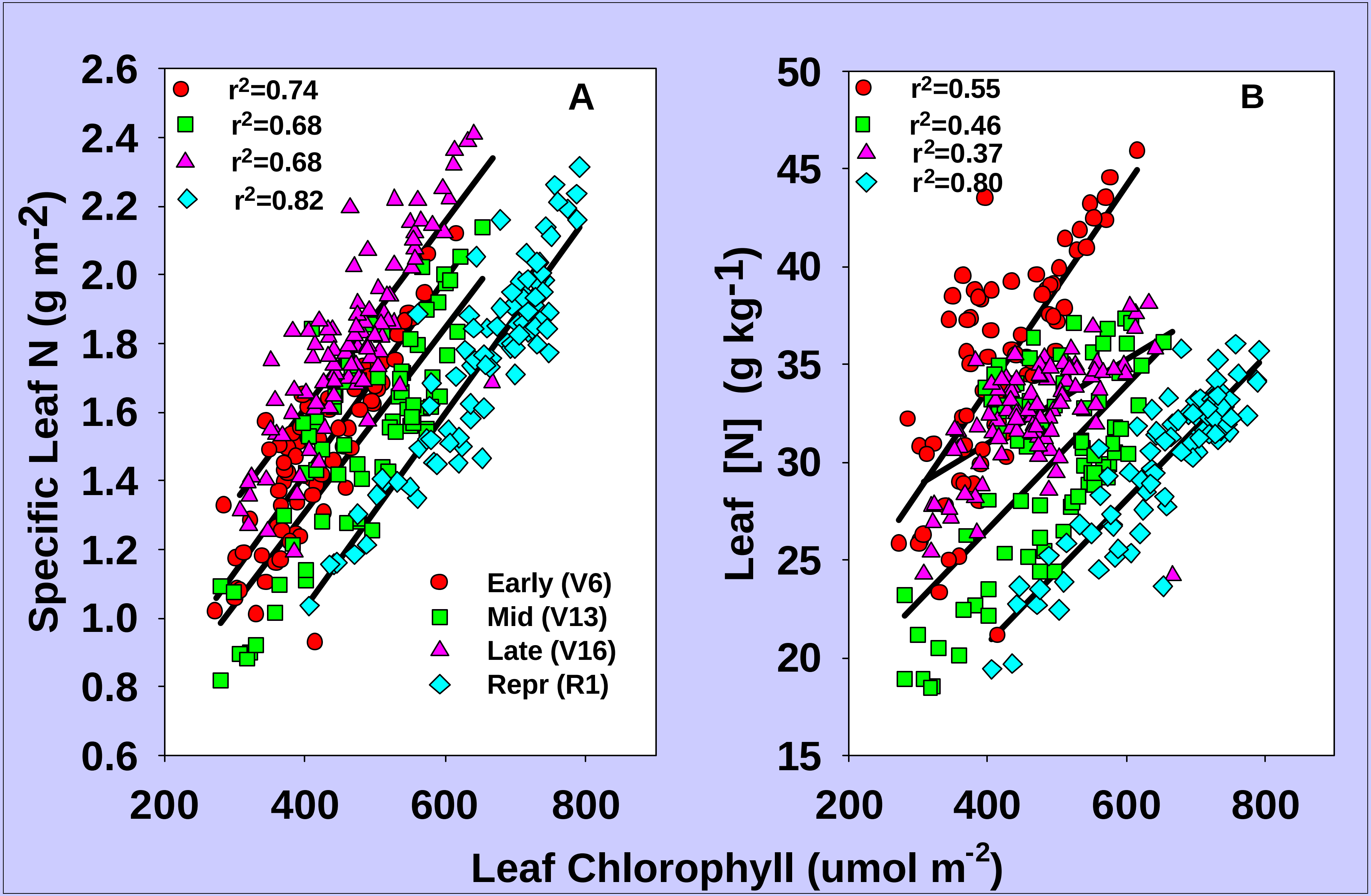


Greenwood et al. 1990. Ann. Bot. 66:425-436.

 N associated with Chlorophyll



Specific leaf weight (g/m^2)	A < B
N concentration (g N/g leaf)	A > B
Chl. concentration (umol/g leaf)	A > B
Specific leaf N (g N / m^2 leaf)	A = B
Specific Leaf Chl.(umol/m^2 leaf)	A = B
Radiation Use Efficiency (g / MJ)	*A = B*



Data from nine site-years and six hybrids

OBJECTIVES

- Compare differences among corn hybrids and population density in leaf development, leaf nitrogen and chlorophyll content in relation to N stress.
- Determine threshold diagnostic criteria for N sufficiency in maize.
- Test the ability to predict N sufficiency using “diagnostic leaf” measurements of specific leaf chlorophyll.

Materials and Methods

- **Experiment 1:**
  - **2 IRRIGATED SITES**
    - ***Mead, NE –Typic Argiudoll sicl, pc=Soybean***
    - ***Clay Center, NE – Typic Argialboll sil, pc=Maize***
  - **4 HYBRIDS (113 d RM) @ 28,000 pl acre^{-1}**
    - ***P-33A14-Bt P-33R88-Bt DK632 GH2581-Bt***
  - **4 NITROGEN RATES *0, 80, 160, 240 kg N ha^{-1}***

- **Experiment 2:**
  - **3 POPULATIONS *– 30, 37 and 44 thousand pl acre^{-1}***
  - **2 LEVELS OF FERTILITY MANAGEMENT**
    - **M1 - 138 kg N ha-1 (2 splits)**
    - **M2 - 298 kg N ha-1 (4 splits) + P and K**

Measurements

- **Destructive plant sampling @ 5 stages**
  - **V8, V15, R1, R4, R6**
    - ***45, 65, 78, 98, 135 dap (Mead, NE)***
    - ***51, 71, 85, 104, 142 dap (Clay Center, NE)***
  - **Parameters (1 m row)* (12 m row)†**
    - **LAI*** – *Leaf area index ($m^2 m^{-2}$)*
    - **SLW*** – *Specific leaf weight (g m^{-2})*
    - **SLN_{wp}*-** *Whole plant specific leaf N (g N m^{-2})*
    - **SLCHwp*** - *Whole plant spec.leaf chlorophyll (umol chl m^{-2} leaf)*
    - **LNla*** – *Leaf N / land area (g N m^{-2} land area)*
    - **TN*†** – *Total N uptake (g N m^{-2})*
    - **GY†** – *Grain Yield (12 m row)*
    - **SY†** – *Stover Yield (12 m row)*

"Diagnostic" leaf measurement

UEL-Uppermost expanded leaf
V8, V12, R1, R4

Ear Leaf
R1, R4

- SLW_{dl} g/m^2 leaf
- SLN_{dl} gN/m^2 leaf
- $SLCH_{dl}$ umol chl/m^2 leaf*

SPAD-502 Chlorophyll meter

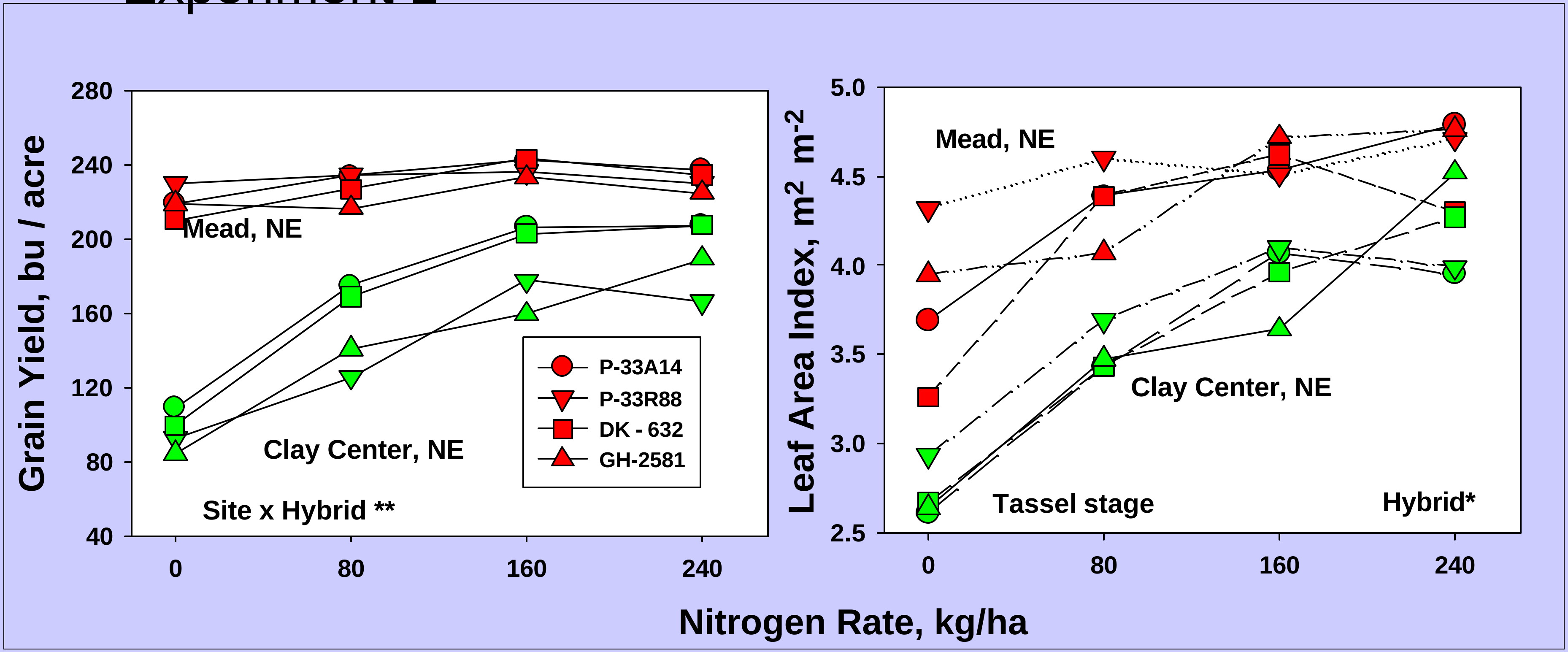
***Markwell, et al. 1995. Photosynthesis Res. 45:467-472.**

SPECIFIC LEAF WEIGHT

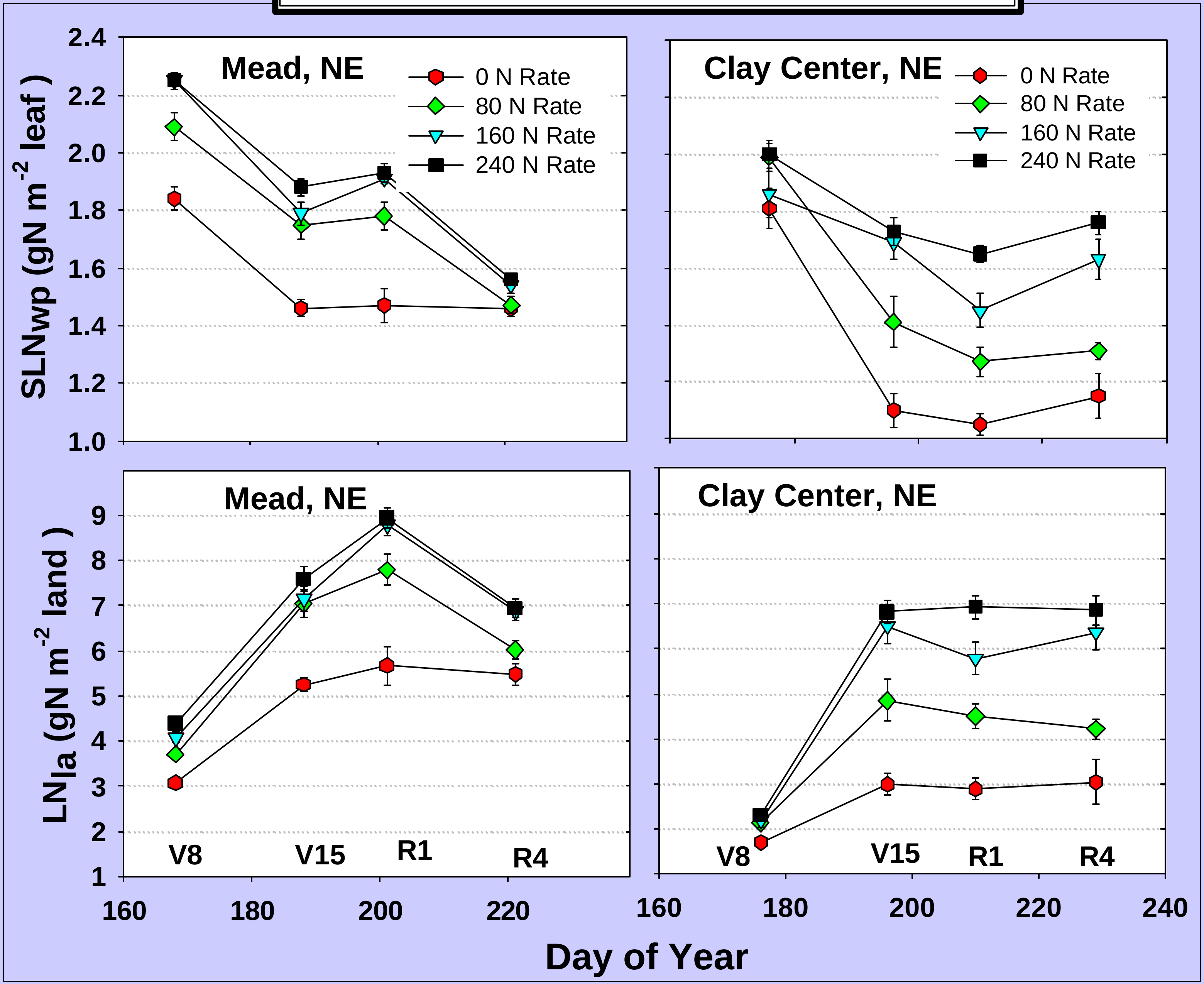
N RATE	LEAF STAGE						
	V8	**V15**	**R1-UEL**	**R1-Ear**	**R4-UEL**	**R4-Ear**	
kg N / ha	**------------------------------SLW$_{dl}$ (g m^{-2} leaf)------------------------------**						
0	48.00	50.34	54.07	56.57	66.32	58.37	**55.61**
80	48.78	52.21	55.42	57.83	66.09	56.86	**56.20**
160	50.10	51.68	53.51	58.60	66.56	59.03	**56.58**
240	50.57	51.70	56.41	59.31	69.35	57.90	**57.54**
	49.36	**51.48**	**54.85**	**58.07**	**67.08**	**58.04**	

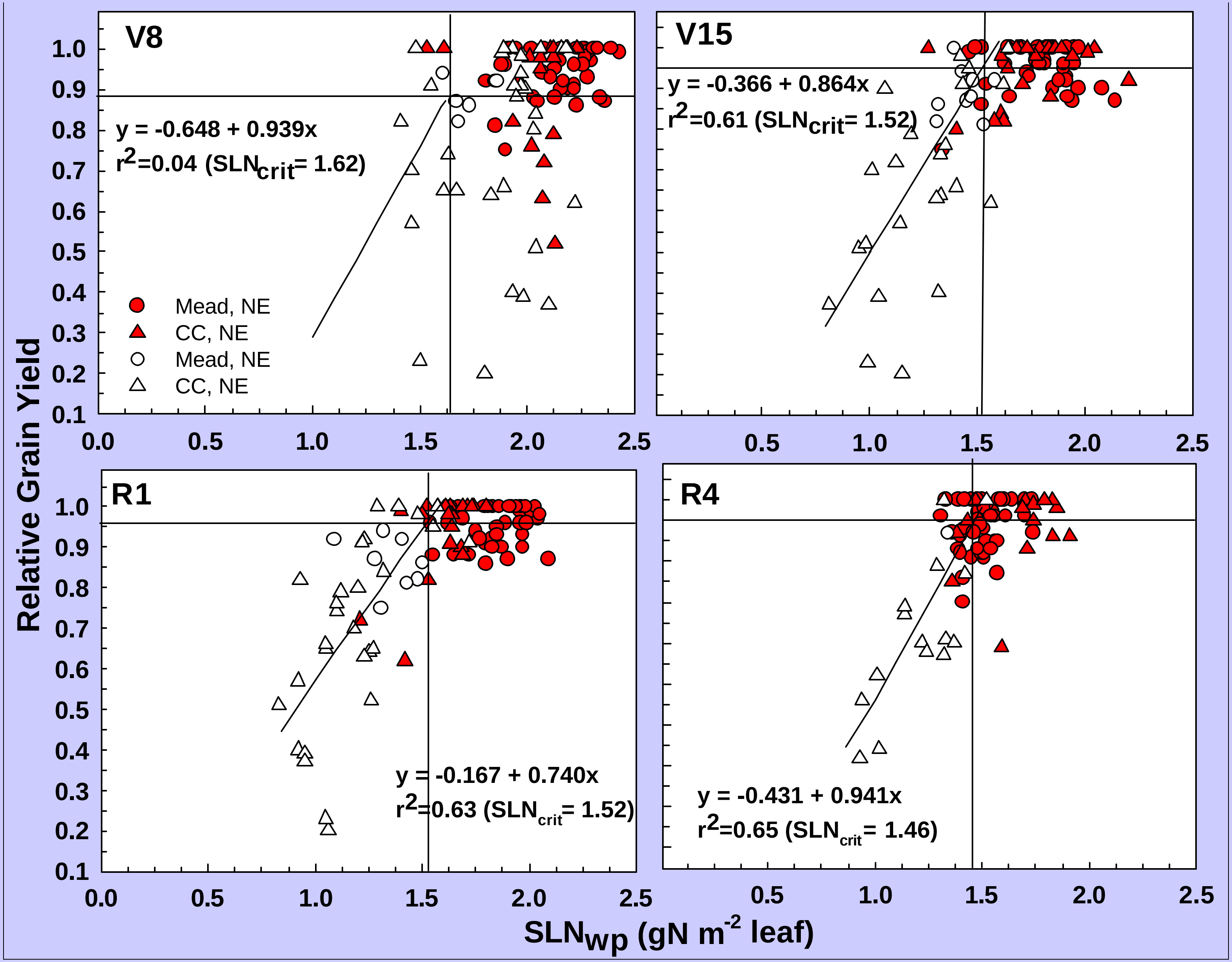
Hybrid Effects

Experiment 1

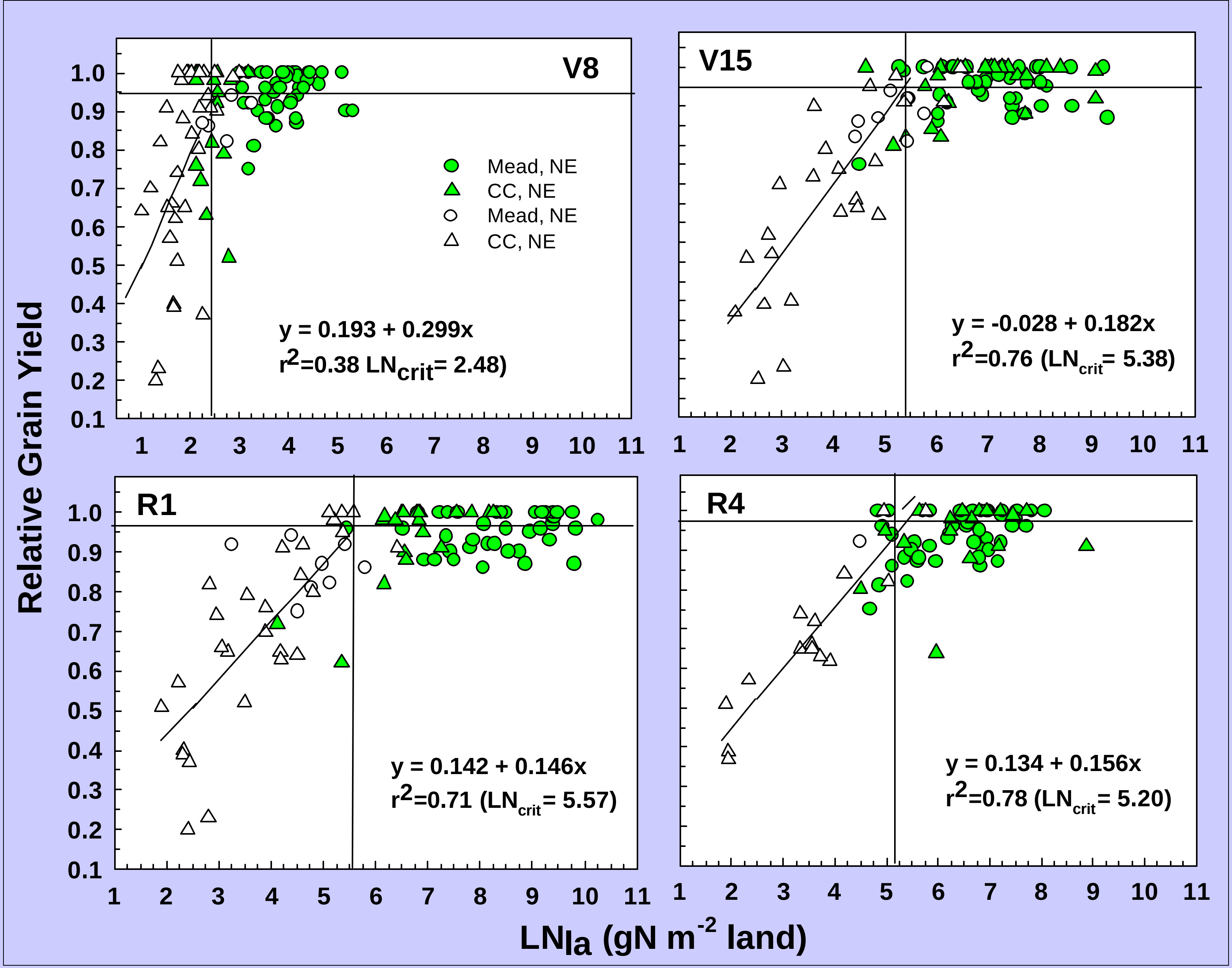


CHANGE IN LEAF NITROGEN

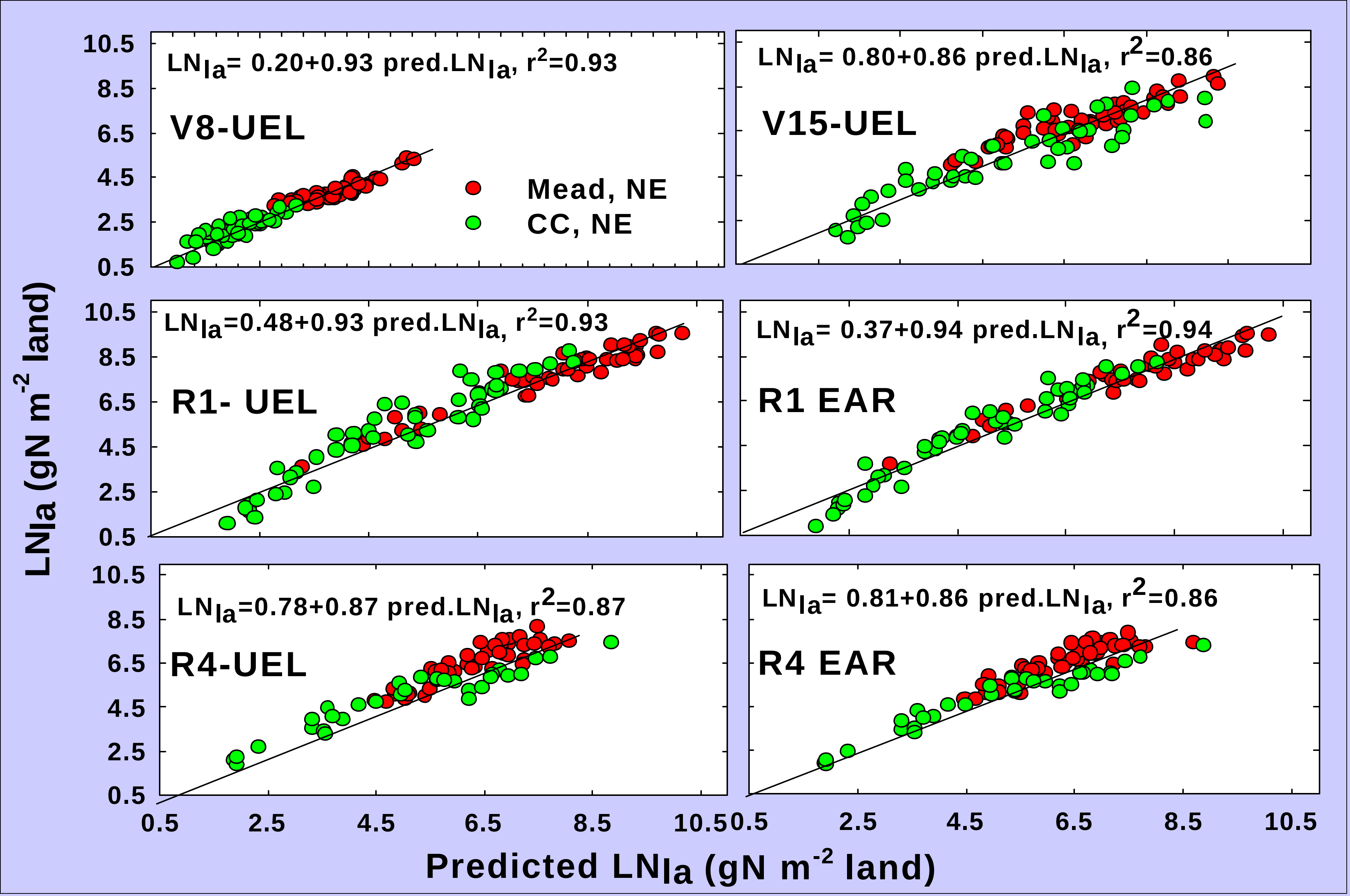




Regression (Linear Plateau) estimates of "threshold" values of whole plant SLN. Colored symbols are observations <u>on</u> or <u>above</u> the "Greenwood" curve.



Regression (Linear Plateau) estimates of “threshold” values of leaf N / land area. Colored symbols are observations on or above the Greenwood” curve.



Predicted $LN_{la} = a + b(SLCH_{dl}) + c(LAI)$. Line is 1:1

POPULATION EFFECTS

Stage	Popul. 1000pl acre^{-1}	Leaf Area Index m^{2} leaf m^{-2} land		Specific Leaf N g N m^{-2} leaf		Leaf N/land area g N m^{-2} land area	
		N management level[1]					
		M1	**M2**	**M1**	**M2**	**M1**	**M2**
V6	**30**	0.57	0.73	2.14	2.24	1.21	1.64
	37	0.95	1.20	2.16	2.19	2.05	2.63
	44	1.26	1.44	1.99	2.04	2.49	2.94
		Pop**		NS		Pop**, Man*	
V12	**30**	4.96	4.61	1.72	2.05	8.53	9.40
	37	5.57	5.74	1.66	1.94	9.24	10.60
	44	6.54	6.32	1.59	1.66	10.40	10.54
		Pop**		Man**		Man *	
VT	**30**	4.84	4.42	1.96	2.33	9.52	10.24
	37	5.67	5.97	2.09	2.05	11.84	12.18
	44	6.60	6.68	1.76	1.82	11.59	12.14
		Pop**		Pop x Man *		Pop x Man *	
Yield (bu/a)	**30**	225	229				
	37	233	248				
	44	231	232	Pop x Man**			

[1] M1 = 138 kg N ha^{-1} (split pre-plant and V6 stage)
M2 = 298 kg N ha^{-1} (split pre-plant, V6, V10 and V14 stage)

CONCLUSIONS

- Although differences in yield and leaf development were observed among hybrids, there was no direct effect of hybrid on leaf N and chlorophyll status.
- Both SLN_{wp} (g N m-2 leaf) and LN_{la} (g N m-2 land) are good diagnostic measures of maize N status.
- Grain yield was optimized at a whole plant specific leaf N $\geq$ 1.5 g N m^{-2} from mid to late vegetative stage and into reproductive stages. (Muchow and Sinclair)

CONCLUSIONS

- LN_{la} seems superior to SLN_{wp} as a predictor of N status at early vegetative growth stages. This suggests that LN_{la}, a population dependent diagnostic, more accurately reflects ecosystem N supply than individual whole plant SLN.

- Maize N status in our study also fit the “Greenwood” curve implying a consistent and conserved relationship between biomass yield and N content of C4 plants.

CONCLUSIONS

- Prediction of maize N status with nondestructive measurement of a diagnostic leaf (i.e. SPAD) will depend on specific calibrations for leaf stage, age and canopy density.

- The ability to nondestructively predict maize N status from diagnotic leaf measurement was improved when variation in LAI was removed.

CONCLUSIONS

- Remote sensing of canopy N status will most likely be improved when sensing devices that adequately measure canopy biomass and LAI are coupled to algorithms that relate canopy reflectance to SLN.