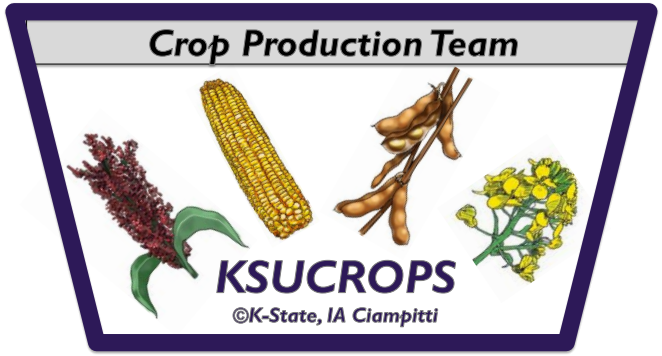
Proceedings of the 2nd Annual Nitrogen: Minnesota's' Grand Challenge & Compelling Opportunity Conference

Nitrogen Use Efficiency for OLD vs. MODERN Corn Hybrids

Ignacio Ciampitti, Cropping Systems Specialist
K-State Research & Extension
ciampitti@ksu.edu, 785-410-9354
@KSUCROPS (TWITTER)

K-STATE Research and Extension



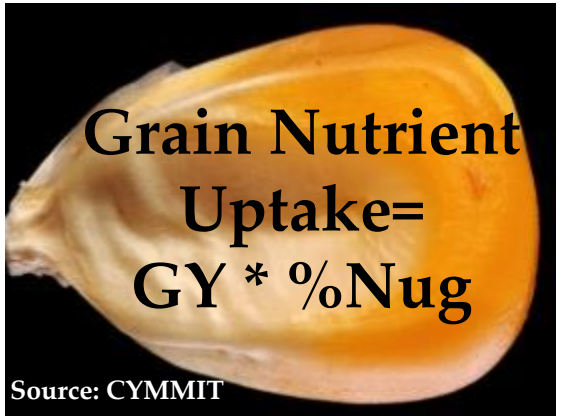
Kansas State University

Unraveling the Physiological Puzzle of Maize Yield Formation and Plant Nutrient Uptake Processes

Total Plant BM

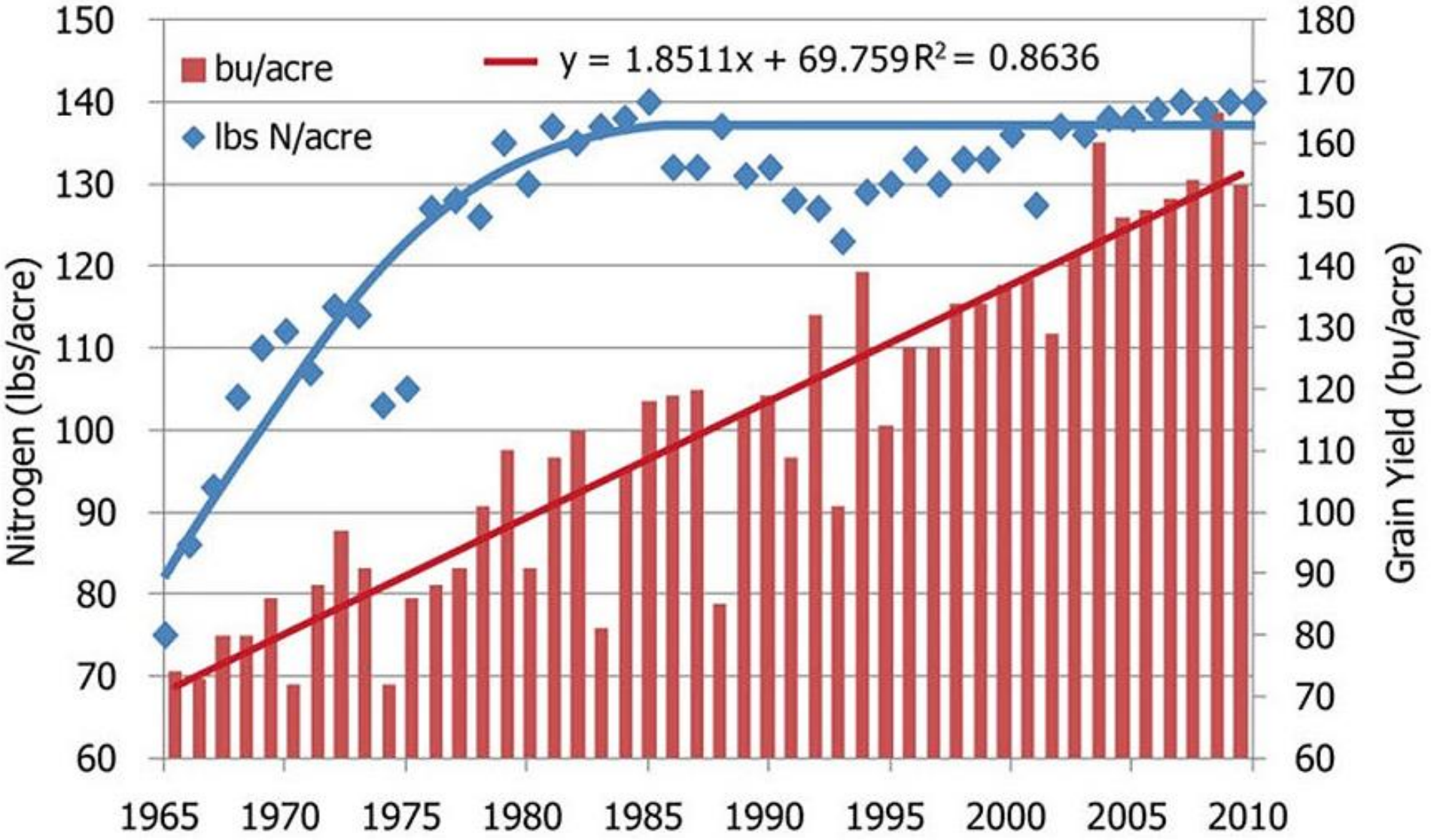
Nutrient Uptake

Nutrient HI



Grain HI

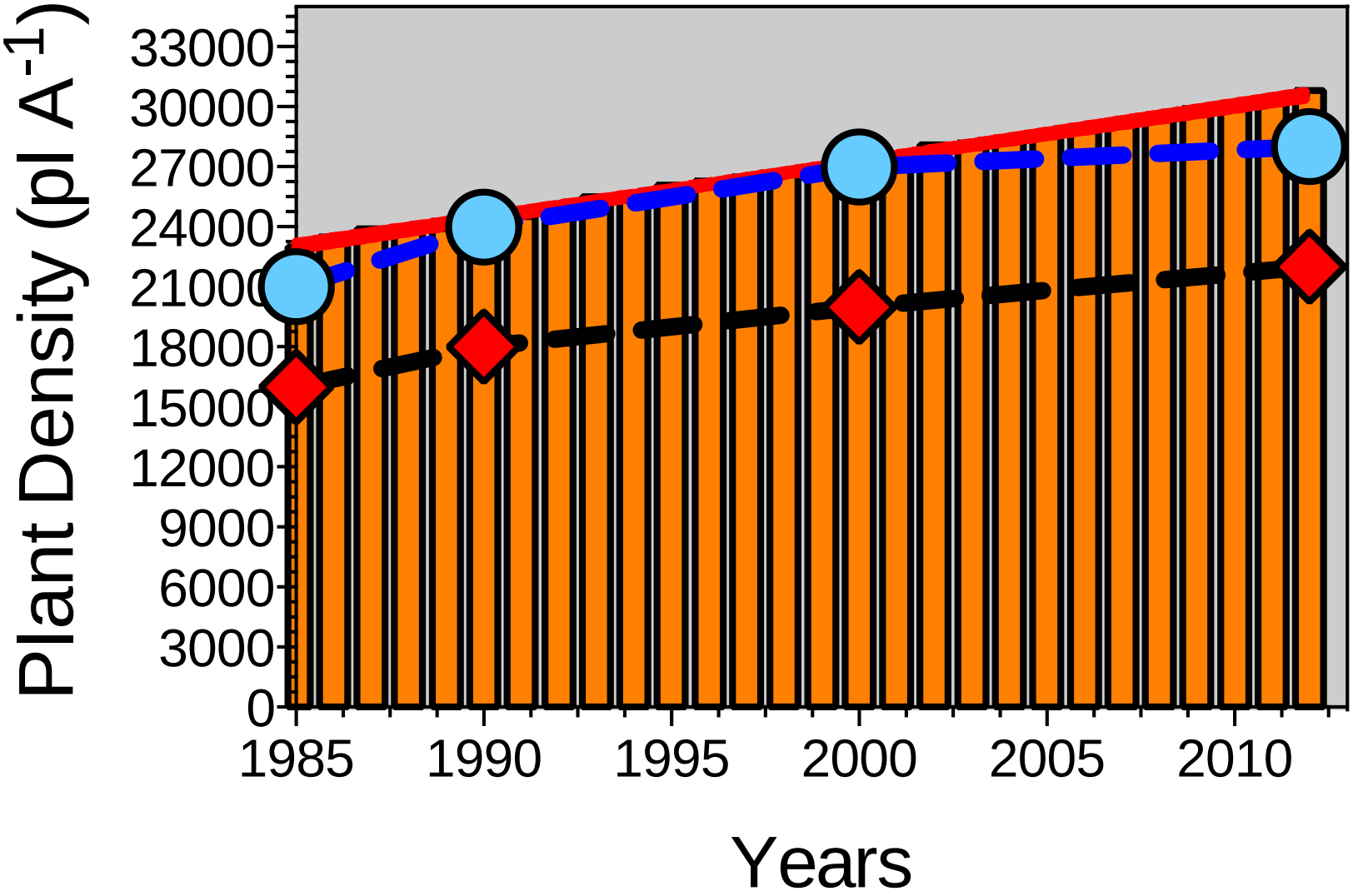
Historical N and Grain Yield Changes



USDA Source; Pioneer Website

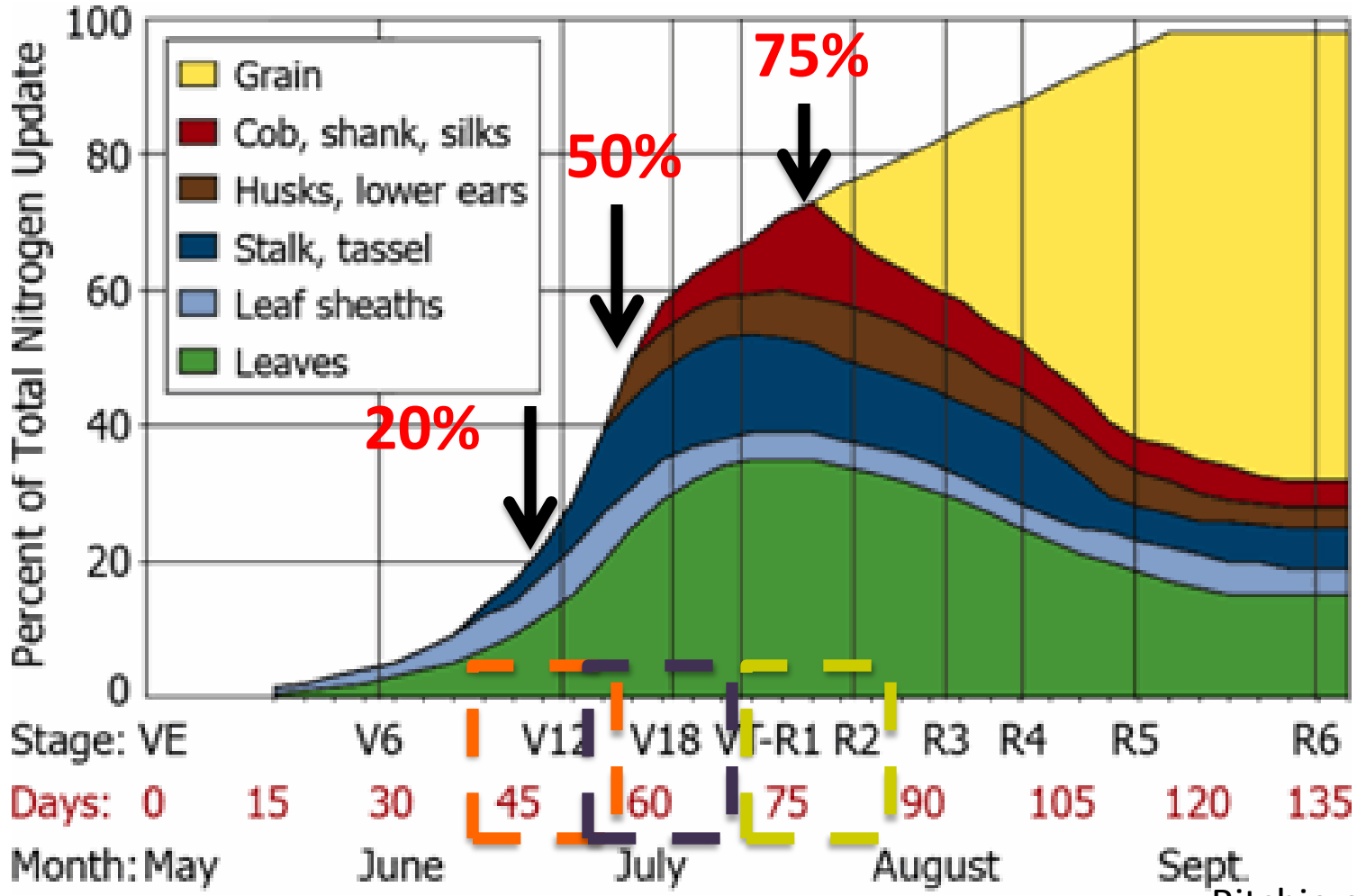
Historical Plant Density Changes

(Corn Trends from 1983-2012)



Kansas Corn dryland **US country average vs. Kansas Corn Irrigated**

Plant Nitrogen Uptake Dynamics in Corn



Ritchie et al., 2005

25-30% of total plant N uptake coming from post-flowering period.

Study of physiological changes over time: Plant N Uptake - Scientific Knowledge Gaps.

GAP #1: Study of the grain yield and plant N uptake relationship

GAP #2: Investigation of the association between plant biomass and N partition to the grain

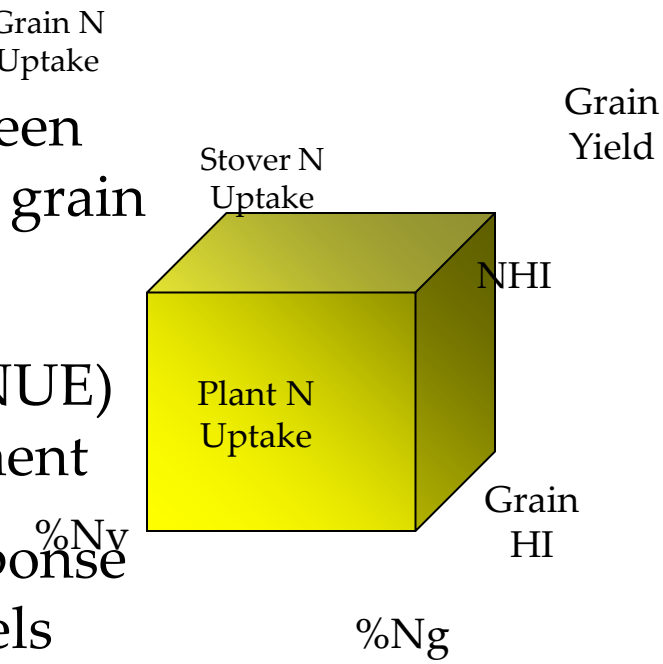
GAP #3: Evaluation of the N Use efficiency (NUE) through its N Internal (NIE) component

GAP #4: Quantification of the grain yield response and N uptake at different N rate levels

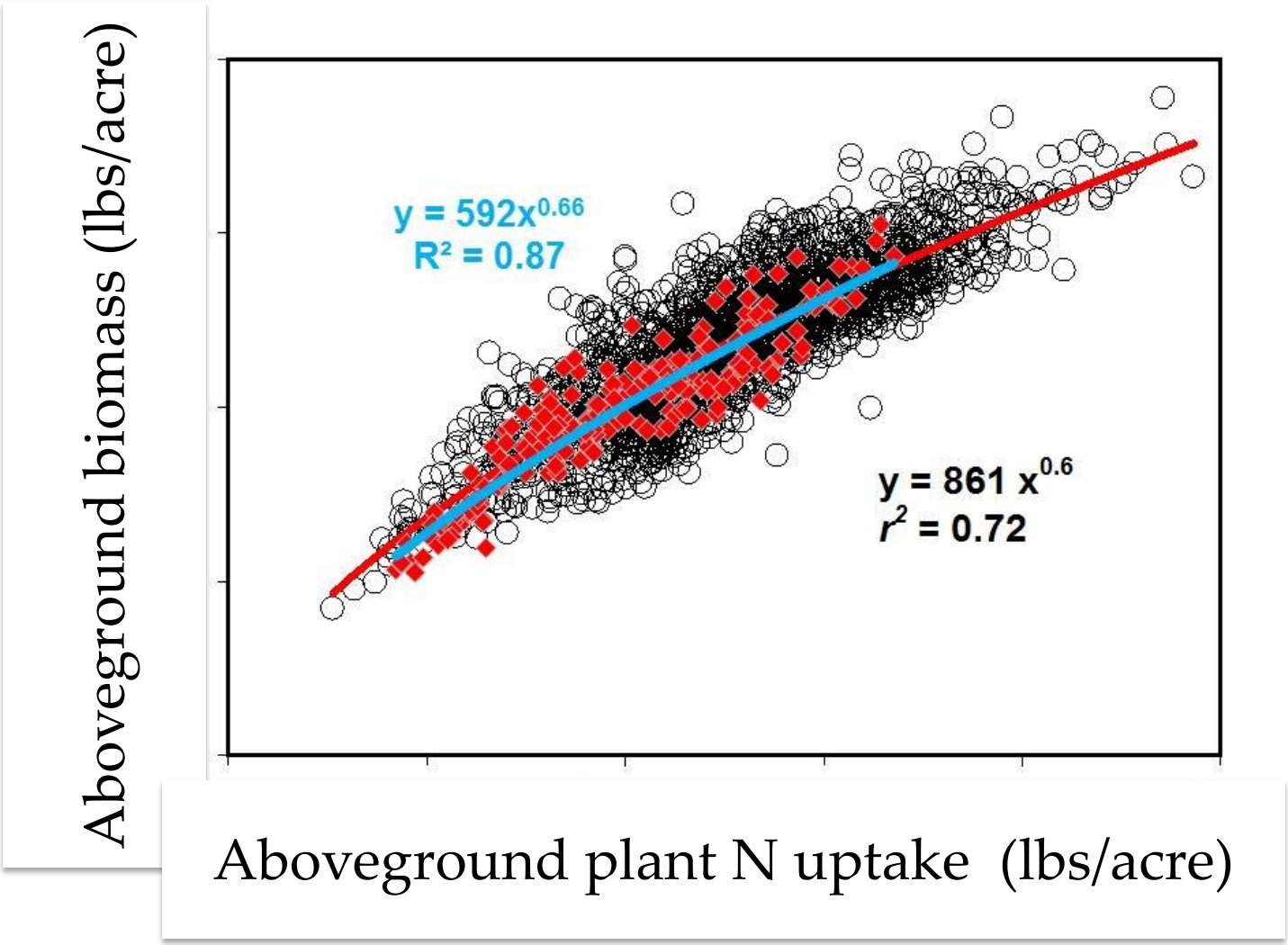
GAP #5: Is high-yielding corn related to NPK ratios?

GAP #6: Are grain nutrient removal values constant?

GAP #7: Post-flowering N uptake changes



Relationship between aboveground biomass and accumulated N at physiological maturity



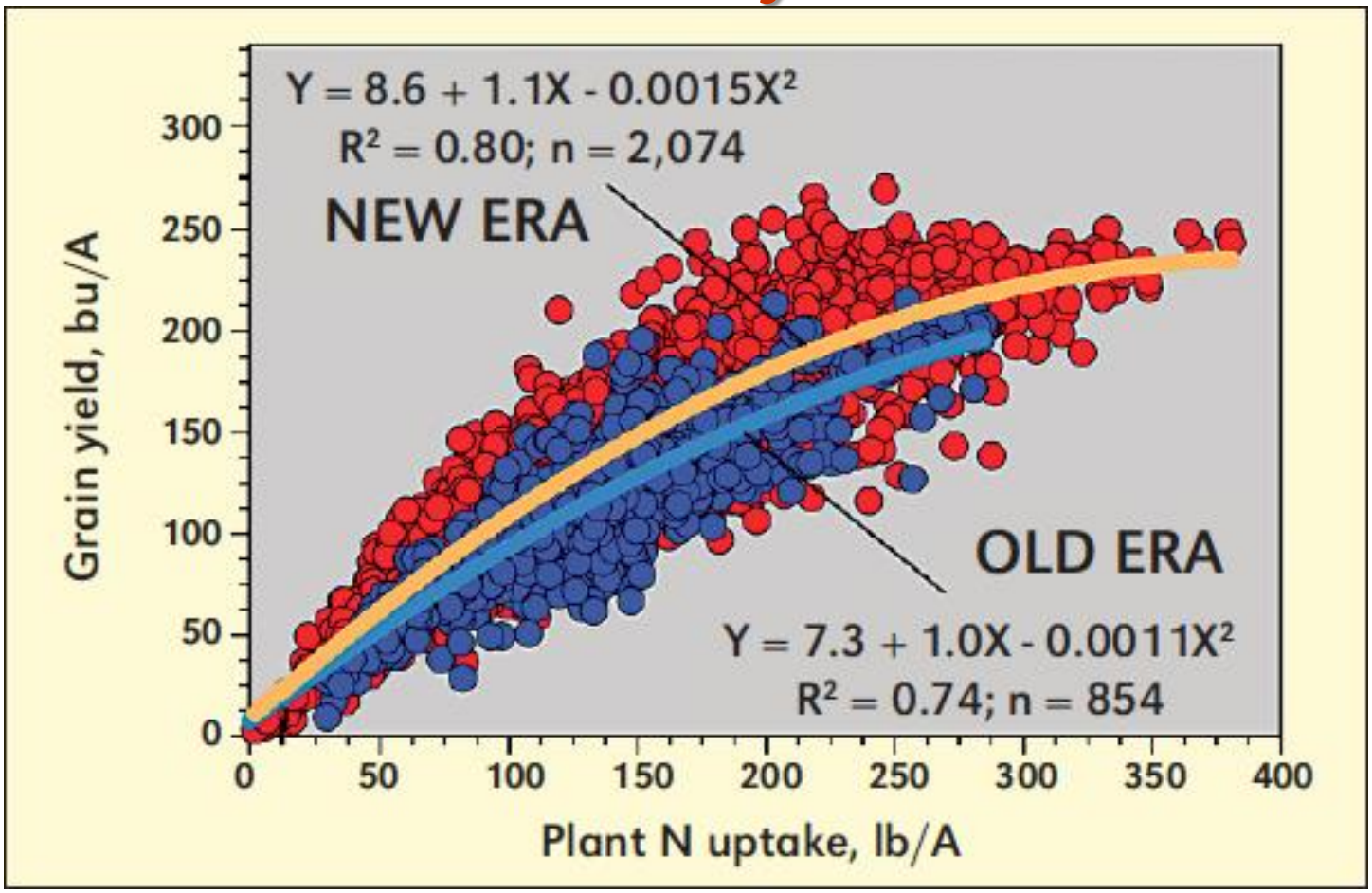
Setiyono et al., 2010; Wortmann et al., 2009; 2011

Gap #1: Relationship between Yield and N uptake

Review Paper: 100 reports (~3000 treatment means)

Hybrid Era (1940-1990 vs. 1991-2011)

Community-Level

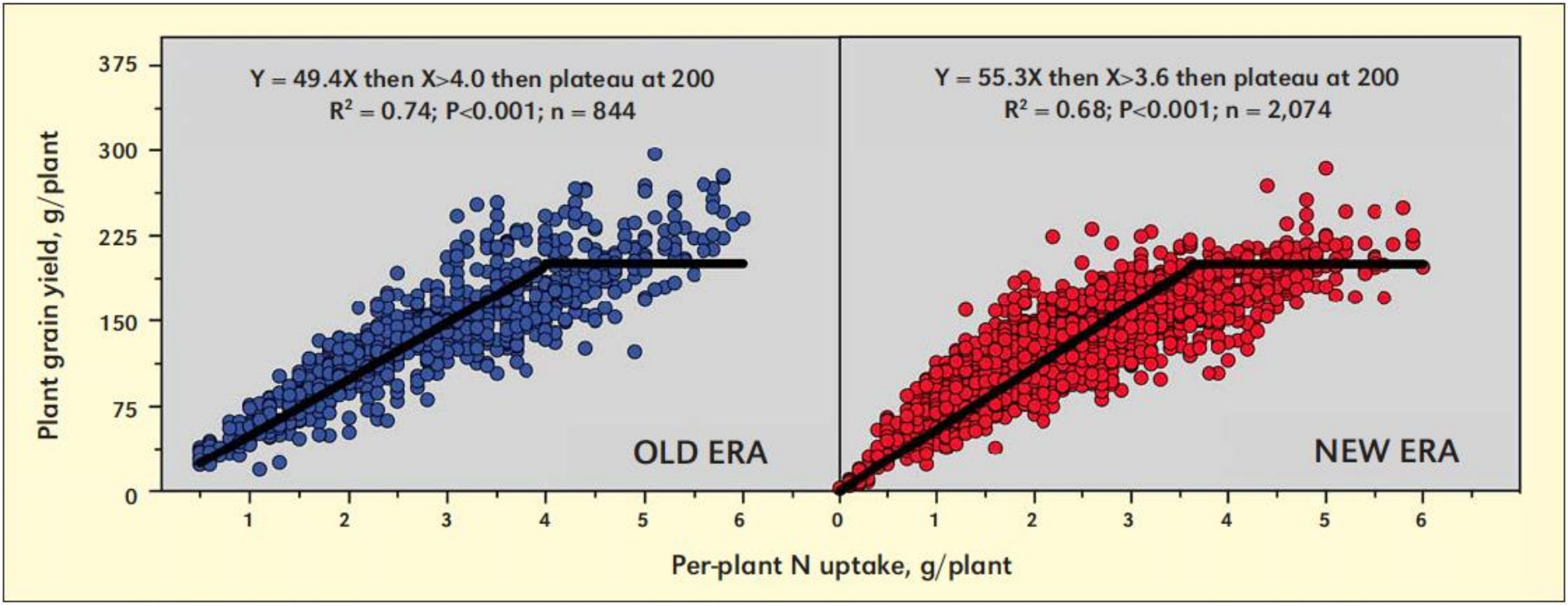


Ciampitti and Vyn (2012, Review Paper, Field Crops Research 133, 48-67)

Gap #1: Relationship between Yield and N uptake

Review Paper: 100 reports (~3000 treatment means)
Hybrid Era (1940-1990 vs. 1991-2011)

Plant-Level, adjusted by plant density

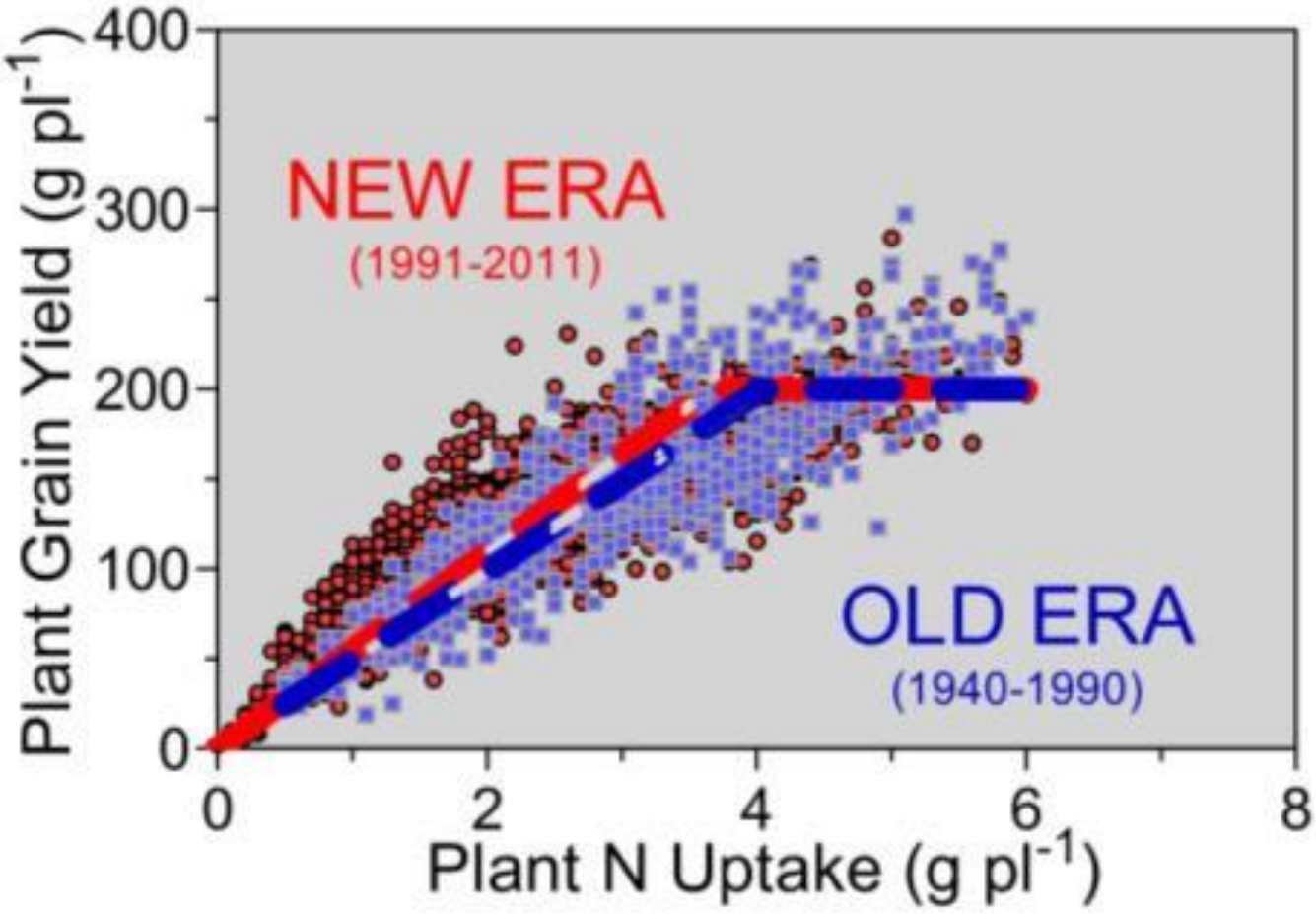


Ciampitti and Vyn (2012, Review Paper, Field Crops Research 133, 48-67)

Gap #1: Relationship between Yield and N uptake

Review Paper: 100 reports (~3000 treatment means)
Hybrid Era (1940-1990 vs. 1991-2011)

Plant-Level

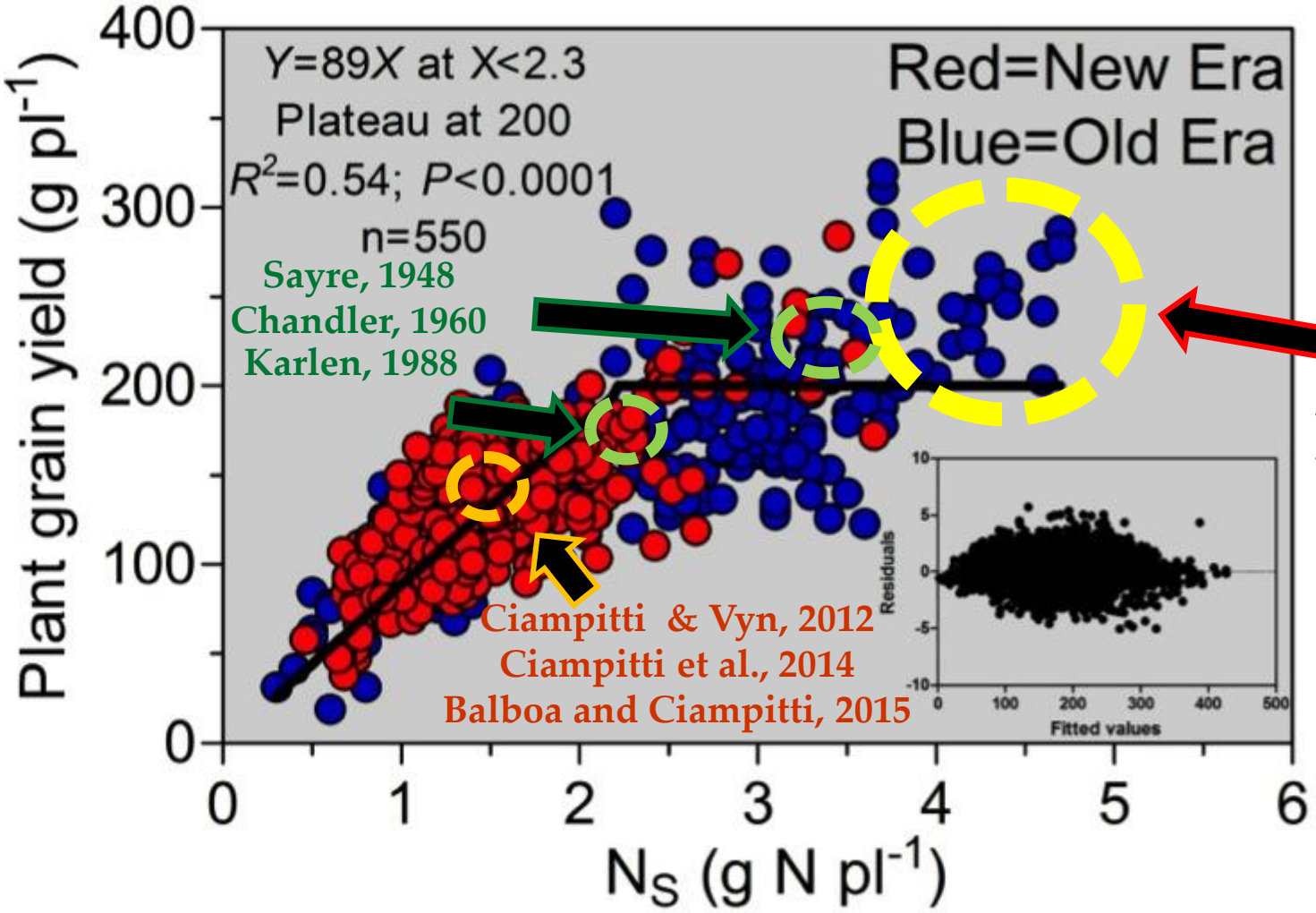


Grain yield vs. plant N uptake relationship was very similar for both OLD vs. NEW corn hybrids.

NEW ERA presented a slightly greater efficiency (higher slope) and lower N uptake to reach maximum YIELD (but similar plateau for maximum YIELD and N uptake).

Ciampitti and Vyn (2012, Review Paper, Field Crops Research 133, 48-67)

FLOWERING: Plant-scale Vegetative N vs. Grain Yield



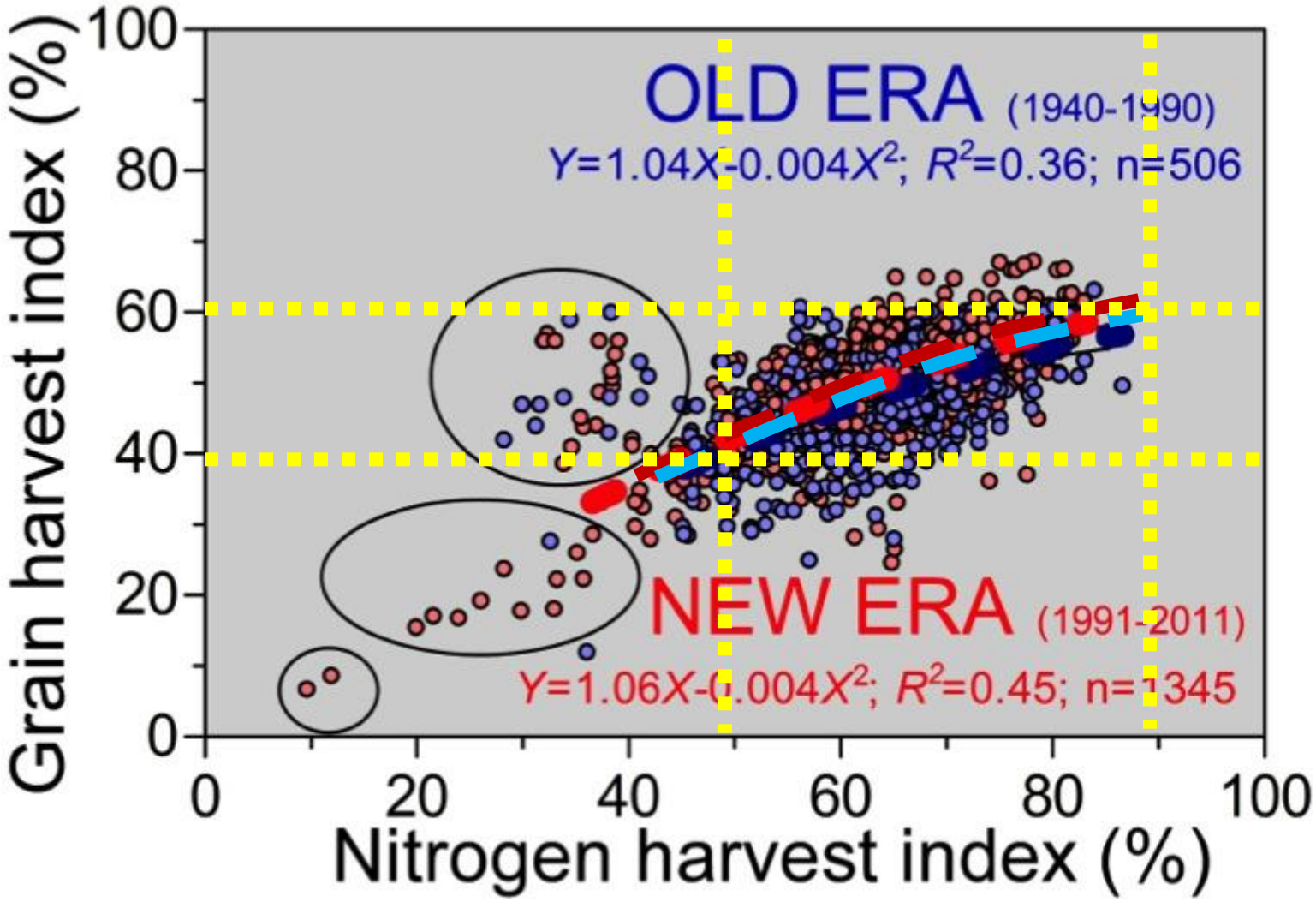
Prolific and Semi-Prolific Materials

Vegetative N status was tightly related to the final per-plant grain yield achieved at maturity.

CIAMPITTI & VYN, 2012

Gap #2: Dry Matter and N Partitioning at Maturity

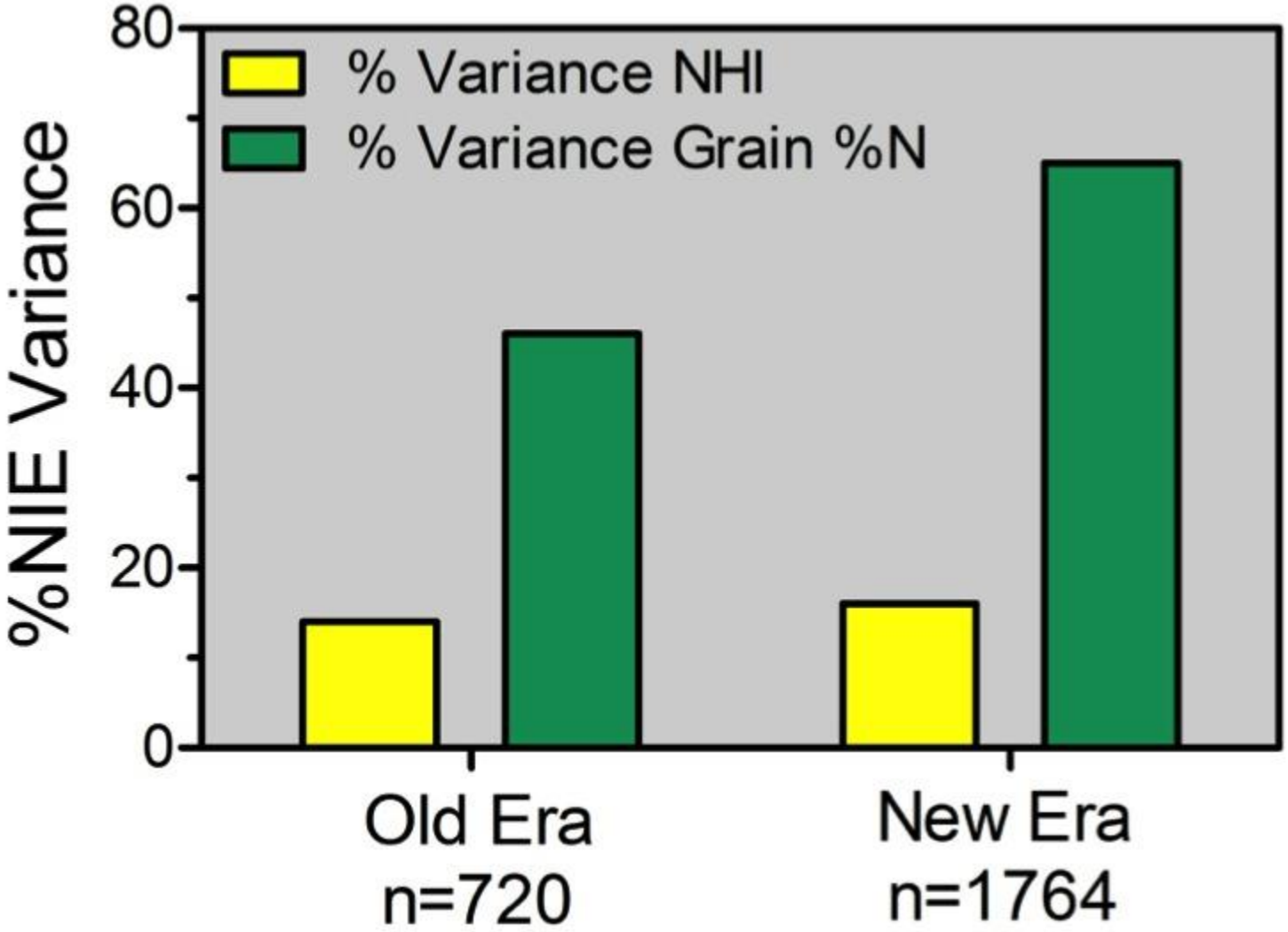
Review Paper: Hybrid Era (1940-1990 vs. 1991-2011)



Ciampitti and Vyn (2012, Review Paper, Field Crops Research 133, 48-67)

Gap #3: Era Effects on NIE and Grain N Concentration

Review Paper: Hybrid Era (1940-1990 vs. 1991-2011)



$$\frac{\text{NIE}}{\text{Grain Yield}} = \frac{}{\text{N uptake}}$$

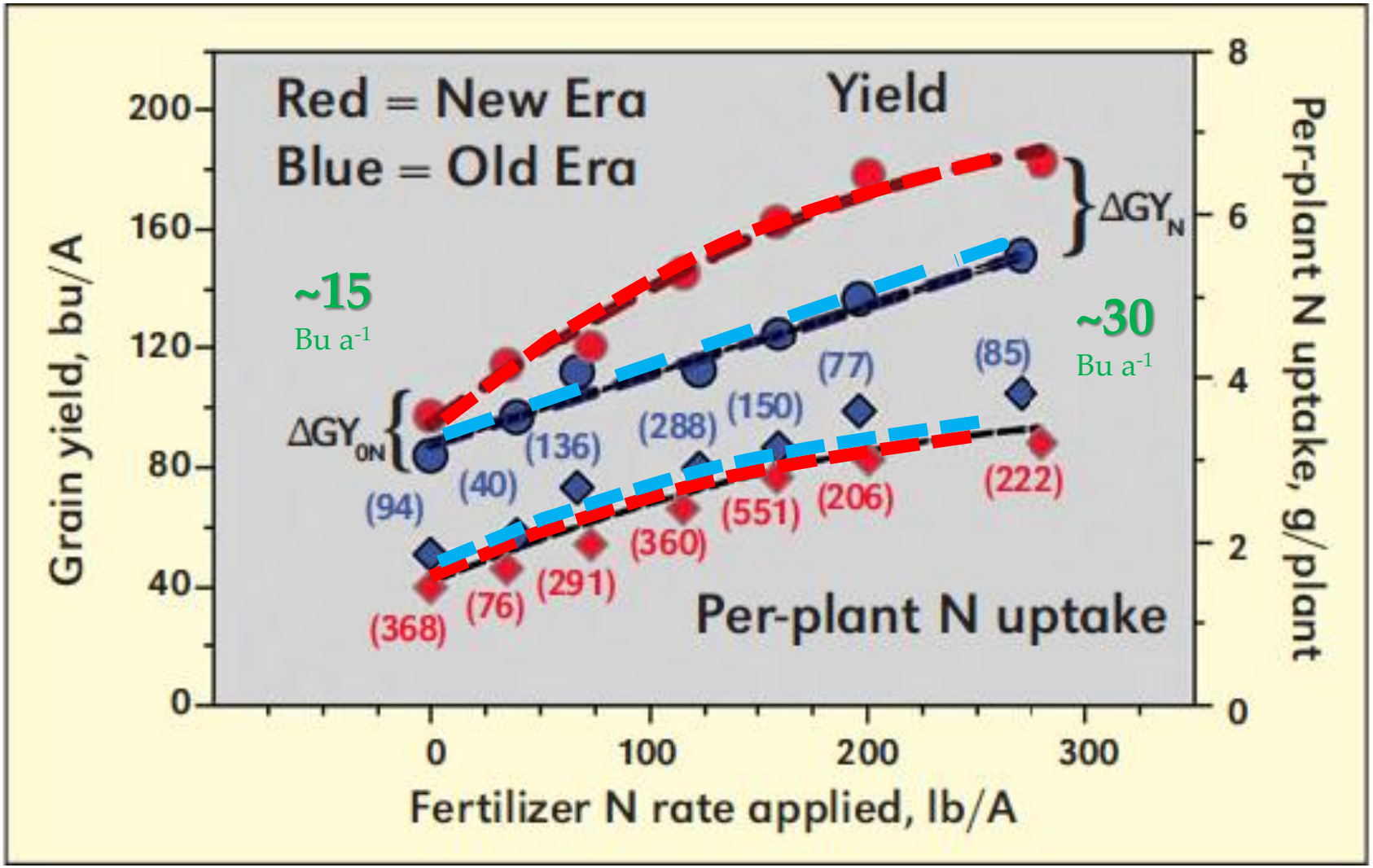
$$\downarrow$$

$$\underline{\text{NIE}} = \text{1-Grain \%N} - \text{2- NHI}$$

Ciampitti and Vyn (2012, Review Paper, Field Crops Research 133, 48-67)

Gap #4: Yield and Plant N Uptake versus N rate

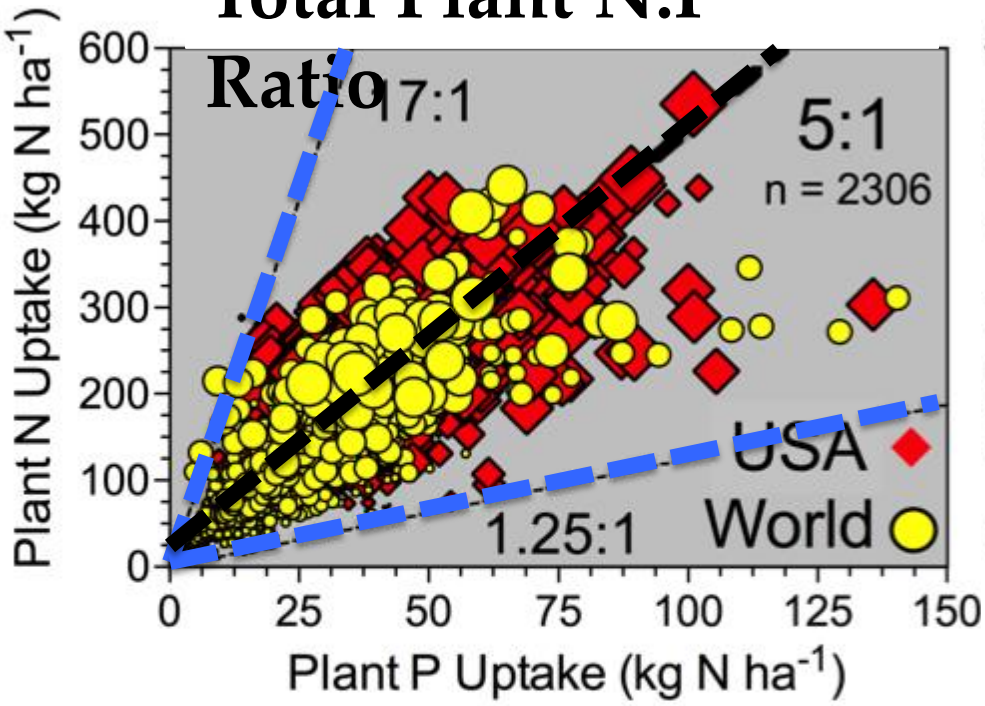
Review Paper: Hybrid Era (1940-1990 vs. 1991-2011)



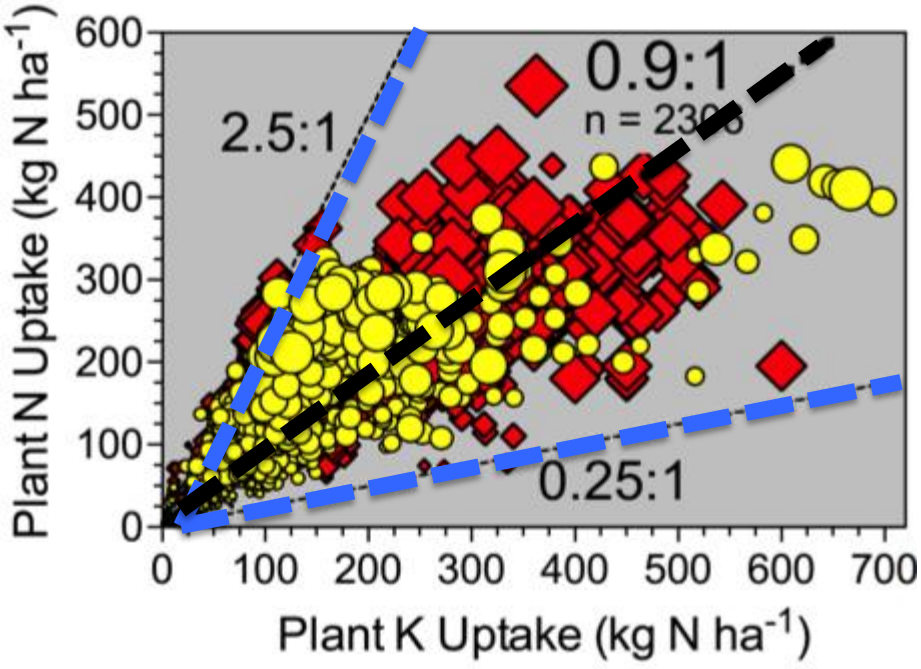
Ciampitti and Vyn (2012, Review Paper, Field Crops Research 133, 48-67)

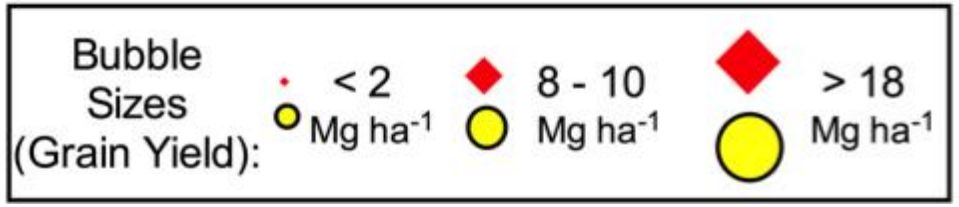
GAP #5: Is high-yielding corn related to balanced nutrition?

Total Plant N:P Ratio



Total Plant N:K Ratio

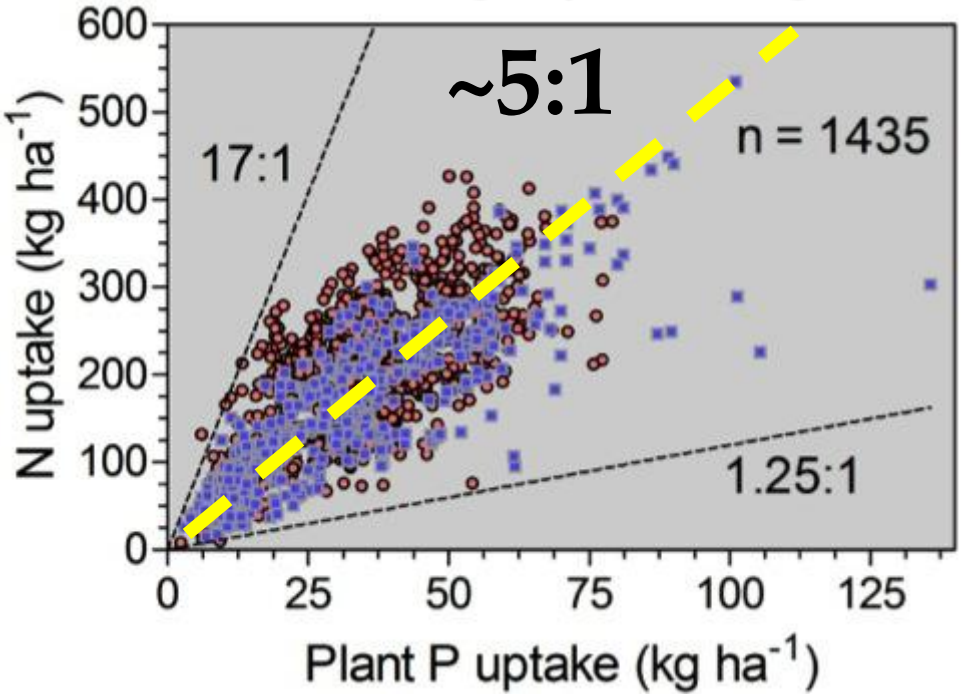




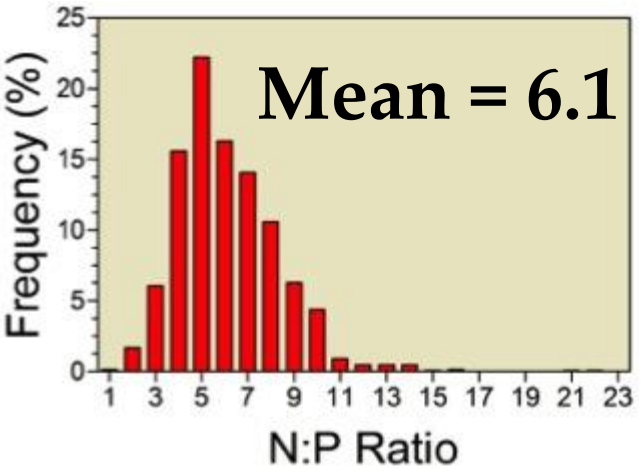
2006-12 yrs	USA (150 bu/a)	WORLD (80 bu/a)
Data Points	253	341
NP	4.9	5.3
NK	1.1	1.3

GAP #5: Higher yields requires a more balanced nutrition, NP (5:1) and NK ratios (1:1), and more nutrients.

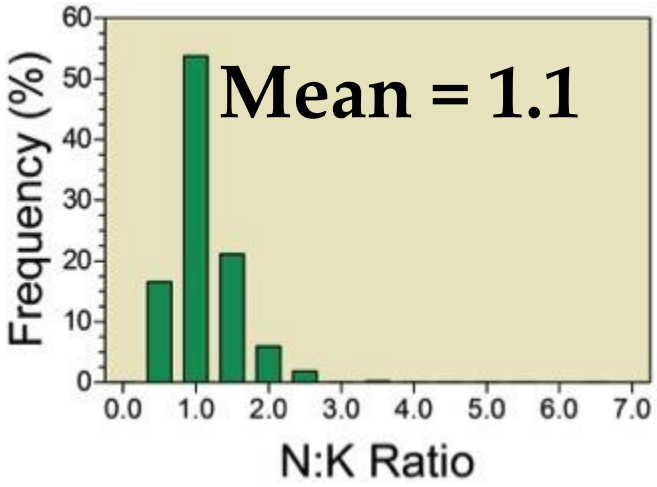
GAP #5: Is high-yielding corn related to balanced nutrition?

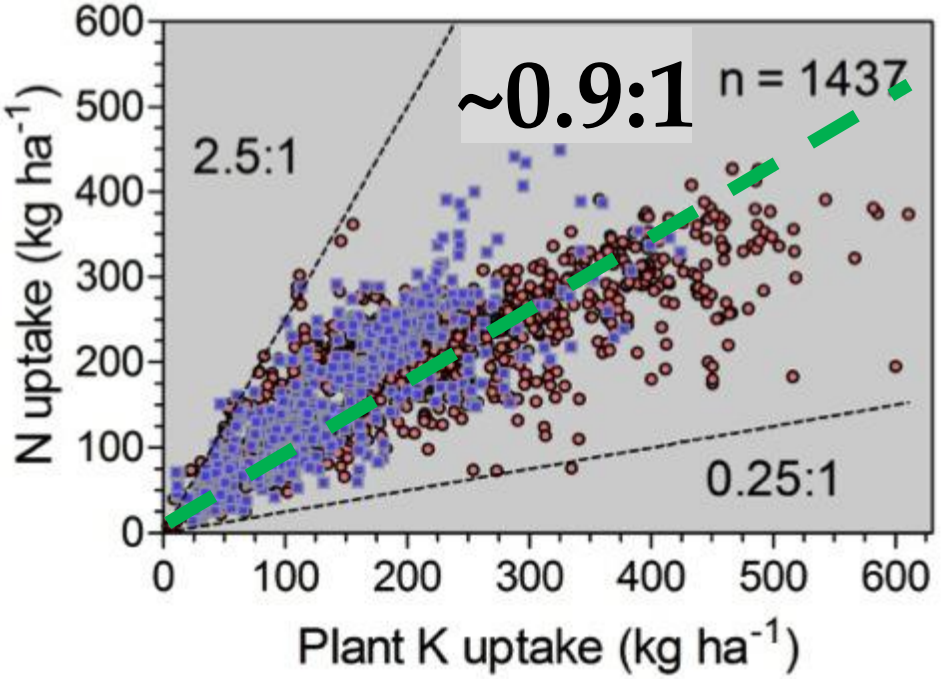


N:P Ratio : $\frac{\text{N uptake}}{\text{P uptake}}$



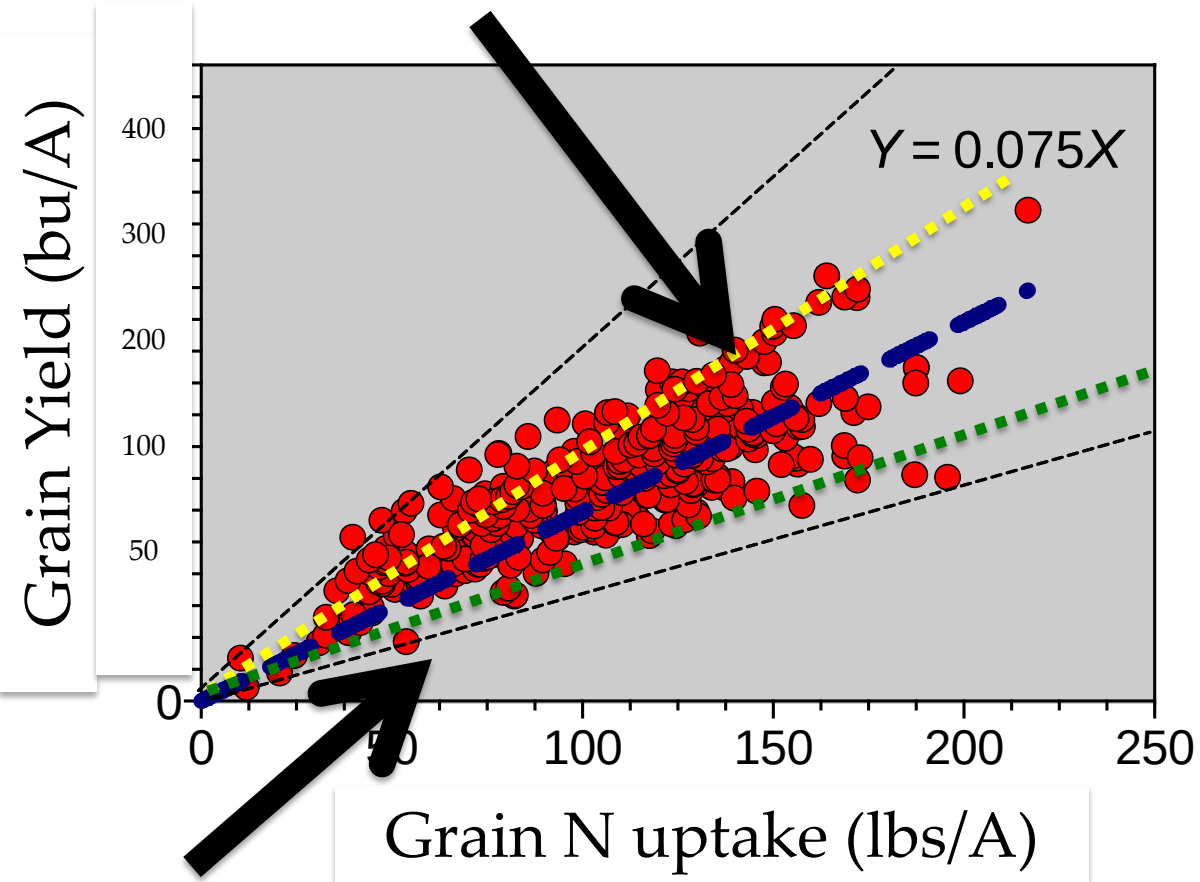
N:K Ratio : $\frac{\text{N uptake}}{\text{K uptake}}$





GAP #6: Grain Nutrient Removal Coefficients?

N-limiting factor
(dilution process)



Yield is limited
(accumulation process)

Non-Stress Factors, N REMOVAL
(from FITTED LINE):

	N removal
GY, bu a^{-1}	100/ 200/ 300
NU, lbs a^{-1}	90/ 180/ 230

IF N is limiting, N REMOVAL:

	N removal
GY, bu a^{-1}	150/ 300/ 400
NU, lbs a^{-1}	90/ 180/ 230

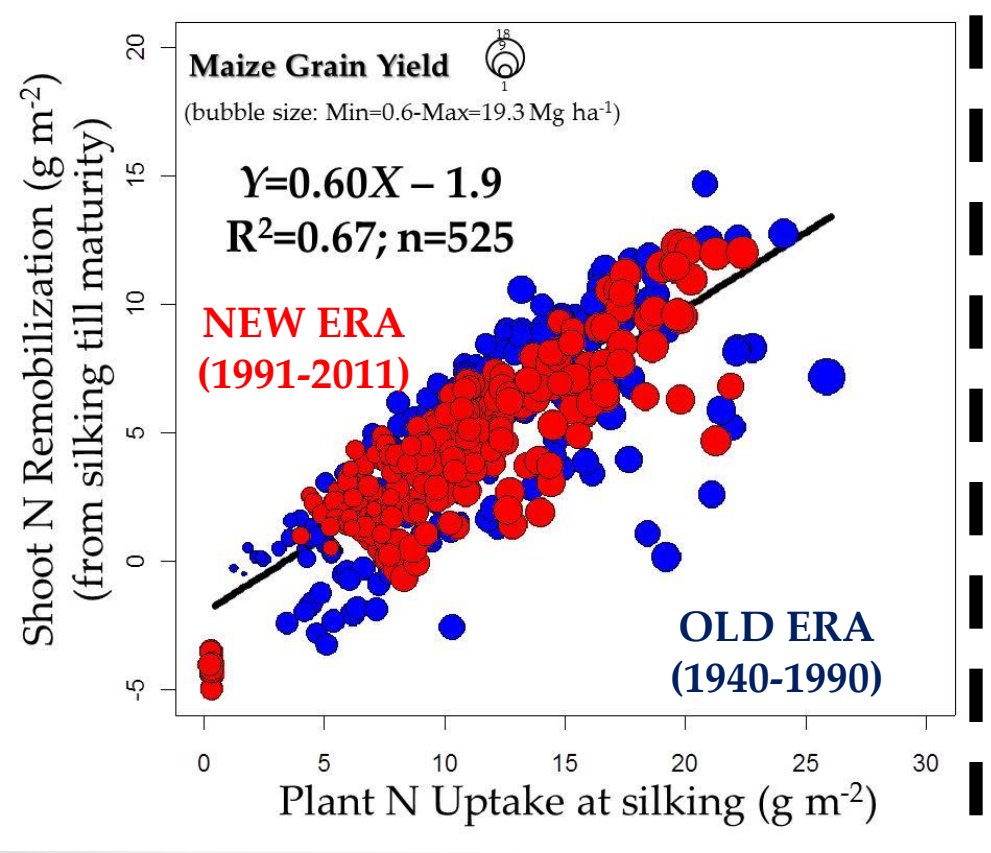
IF Yield is limited, N REMOVAL:

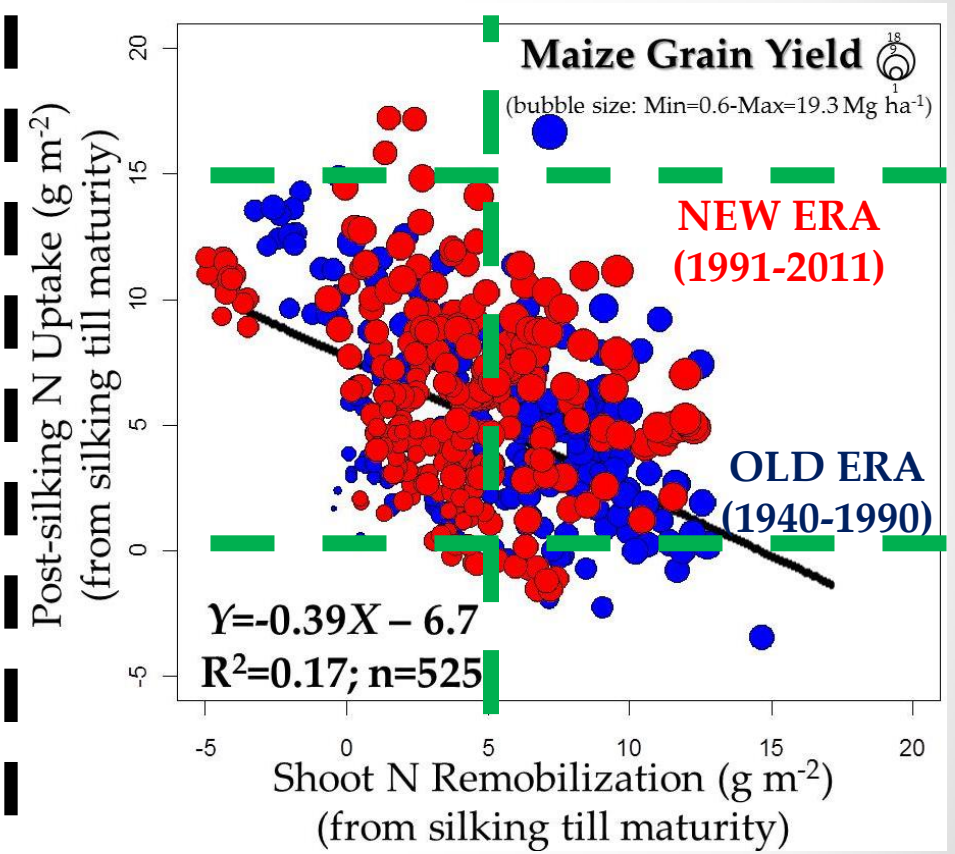
	N removal
GY, bu a^{-1}	80/ 165/ 210
NU, lbs a^{-1}	90/ 180/ 230

GAP #7: Post-Flowering N Uptake

Effects on vegetative and reproductive N uptake versus the reproductive shoot N remobilization?

Review Investigation

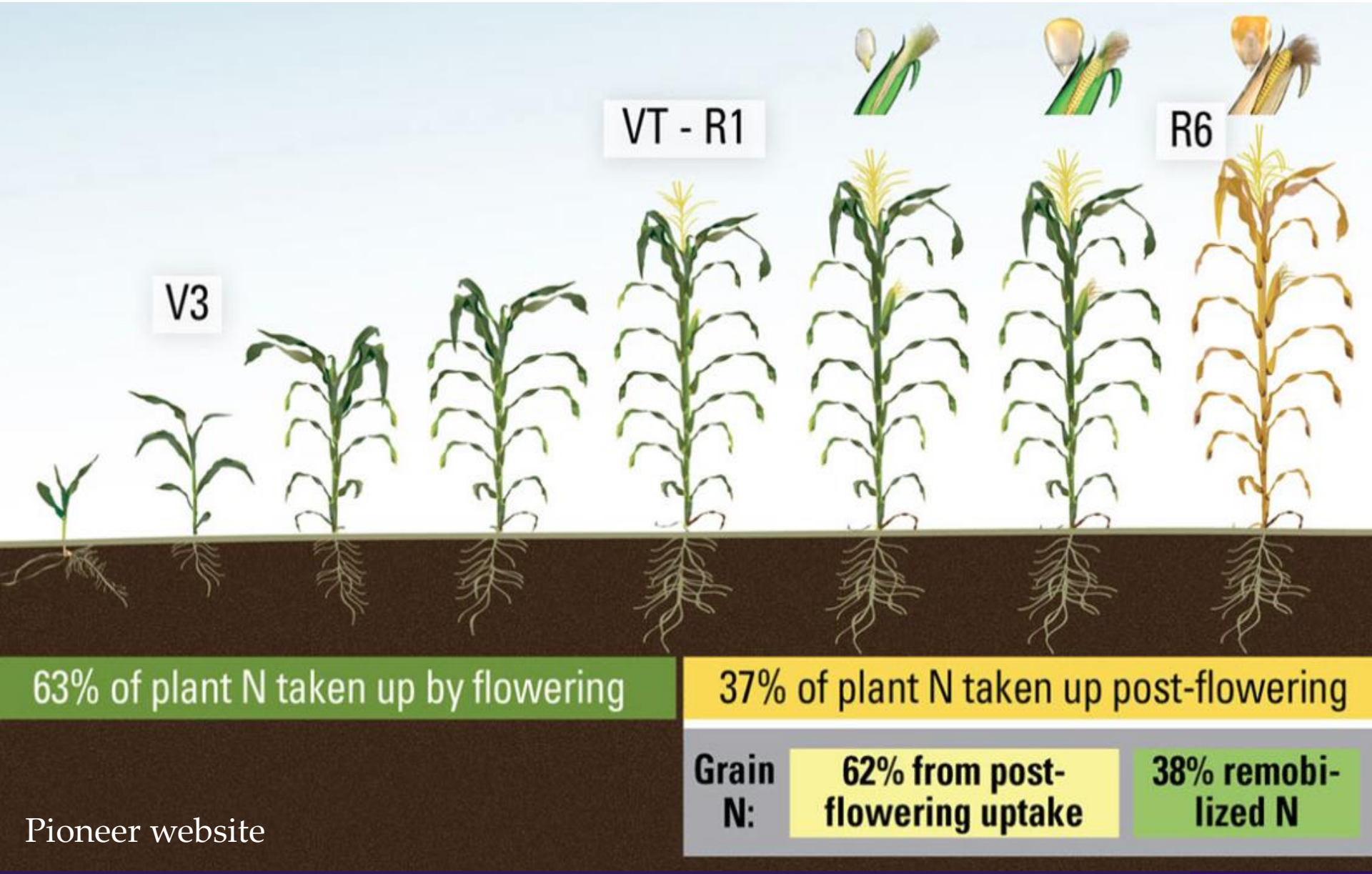




GAP #7: Shoot N remobilization was more associated with vegetative rather than with reproductive N uptake (≠ trends).

GAP #7: Post-Flowering N Uptake

Plant Nitrogen Uptake Dynamics in Corn



Pioneer website

Conclusions: Most Striking Findings

- **GAP #1:** On per-plant basis, nutrient uptake at maturity had not changed between Eras despite changes in modern hybrids.
- **GAP #2:** Nutrient harvest indices followed very closely the dry mass partitioning (grain vs. stover).
- **GAP #3:** Improvements in NUE were primarily resulted from nutrient dilution in the grain fraction of the plant.
- **GAP #4:** Improvement in historical yield were also accompanied by greater fertilizer N response.
- **GAP #5:** N:P and N:K balanced ratios => high-yielding corn.
- **GAP #6:** Grain nutrient removal varied with the yield production scenario (not a constant factor).
- **GAP #7:** Greater post-flowering N uptake for MODERN corn hybrids.

General Conclusions

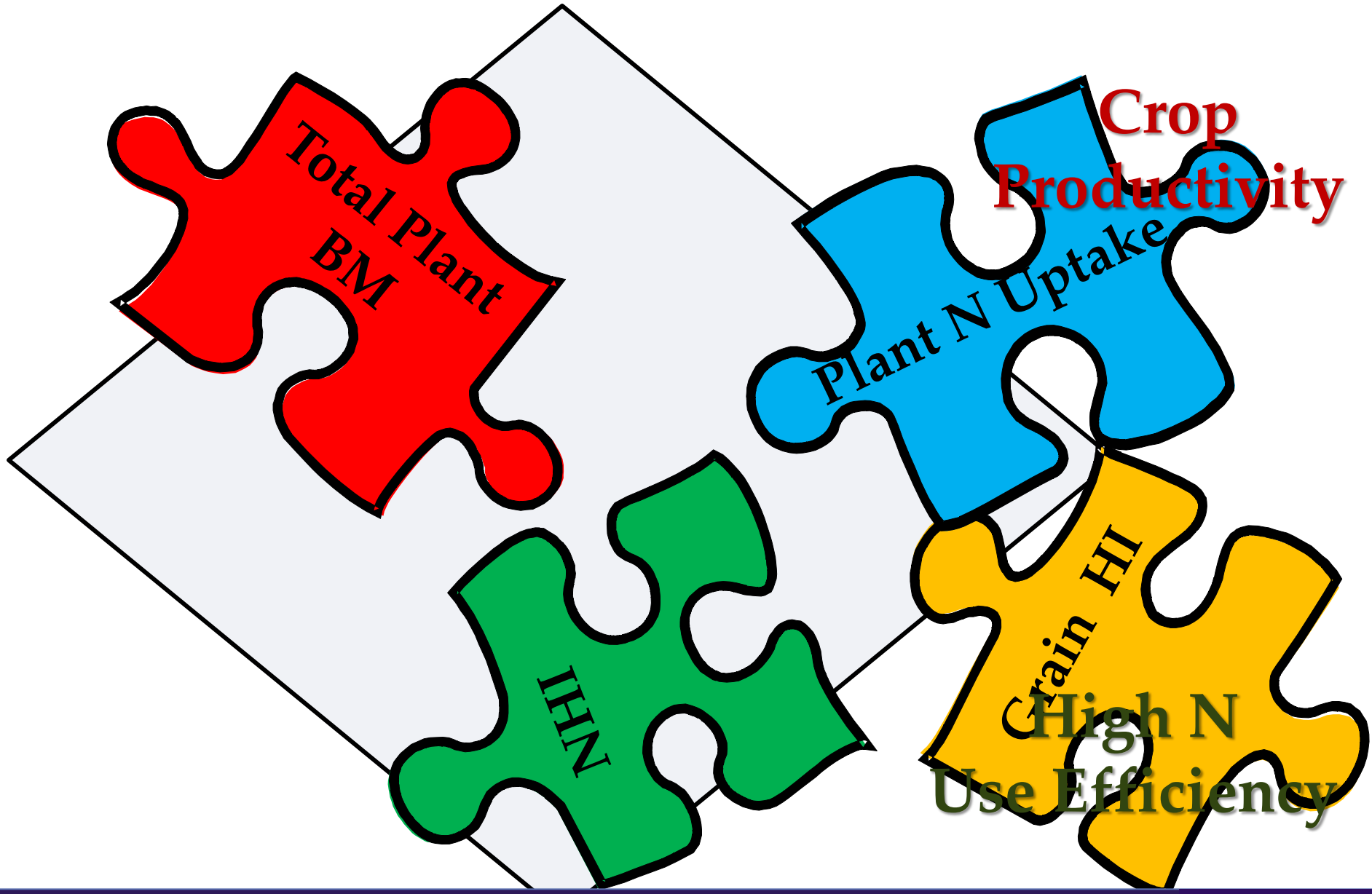
- From the REVIEW analysis:
  - i) newer hybrids presented greater tolerance to N deficiency and responsiveness as the N rate applied increased as compared to older materials.

  - ii) superior NUE (also NIE) for newer materials can be explained by a lowering grain %N as compared to older genotypes.

- Implications on the MANAGEMENT side:
  - i) As plant density increases, then dependency on N supply (soil + fertilizer) is much higher.

  - ii) greater post-silking N uptake is reflected to a greater N demand coming after flowering, increasing N dependency for high-yielding corn productivity.

In the Path of finding the solution for the Puzzle



QUESTIONS

THANKS!

KANSAS CORN COMMISSION

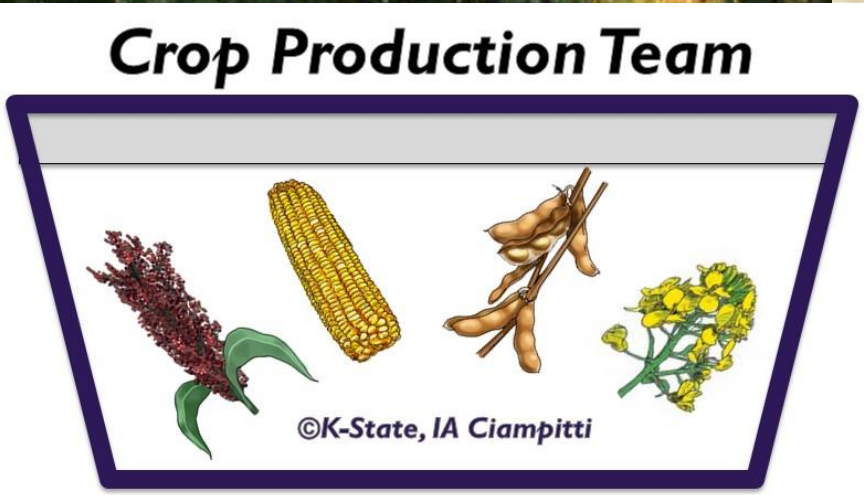
K-STATE Research and Extension

Ignacio A. Ciampitti, K-State Univ
Crop Production Specialist
ciampitti@ksu.edu, 785-410-9354

@KSUCROPS

/KSUCROPS

Crop Production Team



KSUCROPS