NUTRIENT PARTITIONING AND STOICHIOMETRY IN SOYBEAN: A SYNTHESIS-ANALYSIS

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INTRODUCTION

Total plant N uptake, N harvest index (**NHI**) and N concentration in seeds (**%N_{seed}**) may explain seed yield generation in crops.

In soybean, NHI and grain harvest index (**HI**) may also vary as a function of **%N_{seed}** and by the %N present in the stover fraction (%N_{stover}). This approach has been summarized algebraically in an equation proposed by Sinclair (1998):

Eq. 1

$$NHI = \frac{\%N_{seed} \times HI}{[HI \times (\%N_{seed} - \%N_{stover}) + \%N_{stover}]}$$

OBJECTIVES

1) Provide evidence about the effect of NHI and %N_{seed} on yield-to-N uptake relationship;
2) Implement Sinclair's equation (Eq. 1) for NHI:HI relationship and extend it to P and K; and
3) Study the influence of seed:stover ratio on the relationship of N with P, and K uptake.

MATERIALS AND METHODS

-Biomass was sampled at R7 for Argentina (ARG) and Kansas (KS), and at R8 for Indiana (IN).
-Database included: **1)** seed yield (dry basis), **2)** %N, %P and %K in seeds and stover, and **3)** seed, stover, and total biomass.
-A curve following **Eq. 1** was fitted using the NLIN procedure of SAS software to estimate parameters of %$Nutrient_{seed}$ and %$Nutrient_{stover}$ for each nutrient.

Table 1: Sites, years, plant density, genotypes, and main characteristics for each data set.

Data set	Site	Year	Water supply	Plant density	Genotype			Main characteristics
					Number	Release year	MG	
Pampas Region, ARG	5	2009-2011	Rainfed	30 (16 – 53)	6	2005-2009	III, IV, V	No nutrient limitations
Kansas, US	2	2014	Rainfed Irrigated	30 (16 – 49)	1	2008	IV	Row spacing, inoculation, plant density, fertilization strategy
Indiana, US	1	2011-2012	Rainfed	38 (12 – 60)	9	2002, 2004, 2005, 2007, 2008, 2011	II, III	Varieties, biomass and nutrient uptake and partitioning

Plant density expressed in plants m^{-2}, range indicated in parenthesis.

RESULTS

Objective 1

-Average seed yield for pooled data was 3.4 Mg ha^{-1}. Average HI was 0.40 and presented similar values across data sets.
-Residuals of **Fig. 1A** were calculated and regressed against both NHI and %N_{seed} **(Fig. 1B)**.
-There was a positive linear relationship between NHI and the residuals ($p<0.01$**) but not between the residuals and %N_{seed} (data not shown).

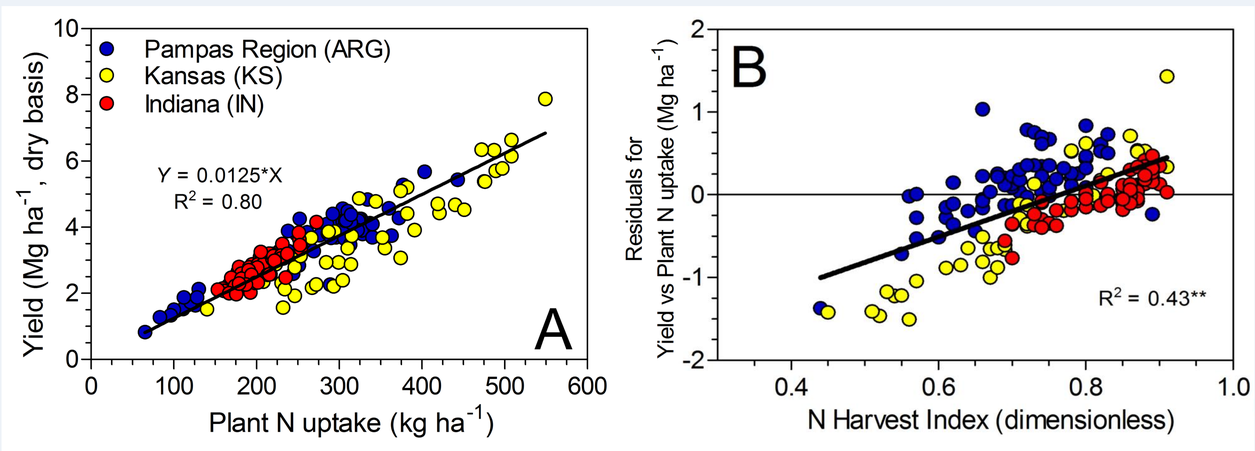

Fig. 1: Relationship between seed yield and plant N uptake (n = 167), **(A)**. Relationship between residuals of the linear model fitted in **(A)** and N harvest index **(B)** for each data set analyzed. ARG (n = 68), KS (n = 45) and IN (n = 54).

RESULTS (continuation)

Objective 2

- For the fitted curve %N_{seed} was 5.89 and 1.28 g 100 g^{-1} for %N_{stover}, **(Fig. 3A)**.
- Data from P showed a similar trend when PHI and HI (**Fig. 3B**), while KHI fitted a model **(Fig. 3C)** that tended to be more linear than NHI and PHI (close to the 1:1 ratio).

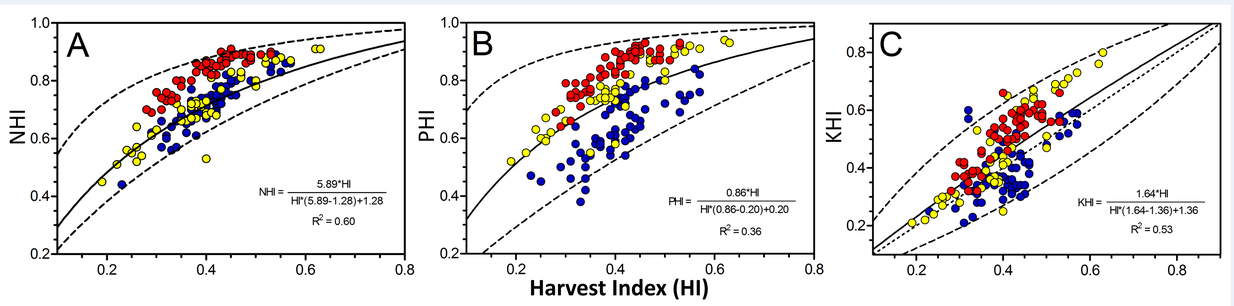

Fig. 2: Relationship between N harvest index (NHI) **(A)**, P harvest index (PHI) **(B)** and K harvest index (KHI) **(C)** and harvest index (HI) for the metadata (n = 167). Solid line represents the fitted model of Eq. 1 and the dashed lines represent the 95% CI. Dotted line in Fig. 2C represents the 1:1 ratio when parameters of the Eq. 1 are equals.

Img. 1: Experiment overview at Kansas (US; growing season 2014) under rainfed and irrigated conditions. Fertilizer, row spacing and seed population was evaluated in this location.

Objective 3

- Variation in plant N-to-P uptake residuals was primarily explained by changes in %P_{stover} (R^2 = 0.38; **Fig. 3A)**.
- For %K_{stover} and %K_{seed}, residuals were both statistically significant ($p<0.001$) but changes in %K_{stover} explained most of the variation of N:K relationship (R^2 = 0.57; **Fig. 3B**).

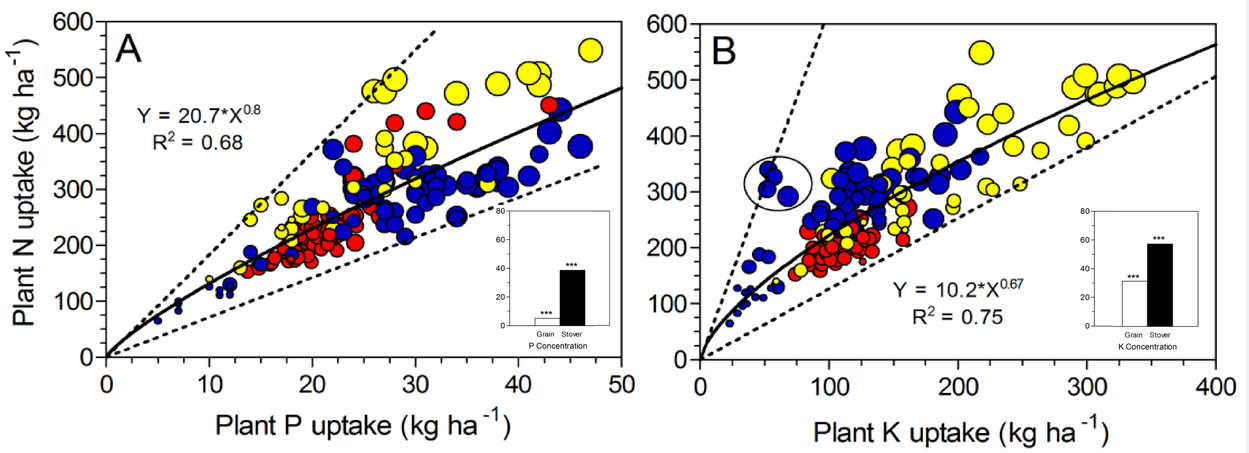

Fig. 3: Plant N uptake as a function of plant P **(A)** and K uptake **(B)**. Bubble sizes represent different ranges of seed yield. Percentage of variance (R^2) provided by both linear regression between residuals of Fig. 3A as a function of seed and stover P and K concentration (insets in Fig. 3A and 3B).

CONCLUSIONS

- *NHI was the main variable explaining variation for yield-to-uptake for N.*
- *The NHI:HI relationship adequately modeled by Sinclair's equation, followed by P and with a more linear fit for K.*
- *Plant N uptake was strongly related to P and K uptake, with stover concentration accounting for a large proportion of the variation on the nutrient ratios; implying that the vegetative plant fraction can act either as storage or supply.*

REFERENCES

Sinclair, T.R., 1998. Historical Changes in Harvest Index and Crop Nitrogen Accumulation. Crop Sci. 38, 638–643.