Traits Identification to Improve Yield Potential and Nitrogen Use Efficiency in Wheat

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Introduction

Nitrogen (N) is critical to but expensive for growth and development of wheat. The ability to take advantage of existing and applied N determines nitrogen use efficiency (NUE), the capacity by which plant uptake and transport N into biomass and grains (Todeschini et al. 2015). This capacity can be dissected into the impact of N on grain number (GN) and kernel weight (KW), which together, make the ultimate sink-size in wheat. In this study, we evaluate these yield deterministic traits (GN and KW) through field-based phenotyping of representative Purdue-bred experimental lines.

Objectives

- Understand the responsiveness of GN and KW to N input.
- Identify interacting and non-interacting wheat germplasm to N input.

Methods

We grew 30 representative Purdue-bred experimental lines in split plot design (N as main plots and lines as sub-plots) under two contrasting N availability environments i.e., low N (< 45 lbs/acre) and high N (100 lbs/acre).

Figure 1. Experimental layout at Purdue ACRE Research Farm in West Lafayette, IN (Images taken 10/21/16 and 6/7/17)

Results

- Grain number showed a greater response (27.90%) than kernel weight (no change) to decreases in N input, meaning that deficiency in N causes the plant to produce grains (sink) with proportional size.
- KW was highly heritable (0.92 and 0.91) in both N environments with GN having heritability of 0.58 and 0.44, respectively per treatment.
- Under both high and low N environments, GN was correlated significantly with biomass (0.77, 0.90) and spikes per unit area (0.59, 0.69).

Table 1. N effects on yield and yield component traits over 30 representative lines of SRWW at low N (< 45 lbs/acre) and high N (100lbs/acre).

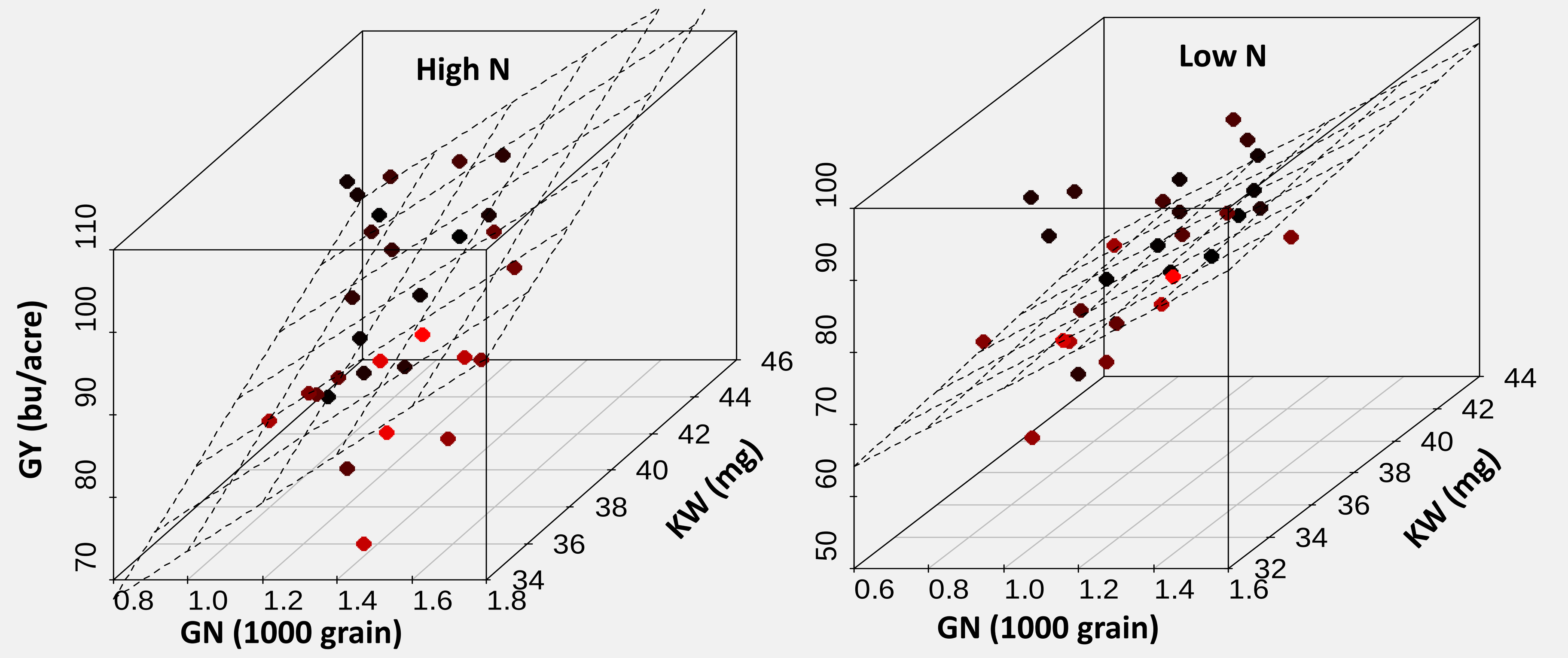
	Averages			Heritability	
Traits	High N	Low N	Change	High N	Low N
Grain yield (GY)	91***	78***	-14.30%	0.78	0.87
Biomass (BIO)	123*	105*	-14.60%	0.14	0.32
Spikes per unit area (SPUA)	55***	50***	-9.30%	0.63	0.78
Kernels per spike (KPS)	32***	27***	-15.60%	0.73	0.72
Grain number (GN)per unit area	1.3K***	1.0K*	-27.90%	0.58	0.44
Kernel weight (KW)	39***	39***	No change	0.92	0.91

Significant levels of 0.05*, 0.01**, and 0.001***.
Heritability estimated on the basis of plot mean.

Results

Table 2. Correlations among YLD, BIO, KPS, SPUA, thousand kernel weight (TKW), and GN at high N (100lbs/acre - upper right) and low N (< 45 lbs/acre - lower left). Significant levels of 0.05*, 0.01**, and 0.001***.

	YLD	BIO	KPS	SPUA	TKW	GN
YLD		0.32ns	0.03ns	0.18ns	0.07ns	0.33ns
BIO	0.48**		0.20ns	0.35ns	-0.27ns	0.77***
KPS	0.05ns	0.30ns		-0.34ns	-0.48**	0.33ns
SPUA	0.56**	0.46*	-0.40*		0.08ns	0.59***
TKW	-0.10ns	-0.13ns	-0.51**	0.19ns		-0.64***
GN	0.60***	0.90***	0.37*	0.69***	-0.32ns	



Variable	Estimate	P-value
(Intercept)	-17.63	0.686
GN	0.0292	0.00841**
KW	1.822	0.04288*

Variable	Estimate	P-value
(Intercept)	34.41	0.234
GN	0.0277	0.00054**
KW	0.4203	0.52154

Figure 2. Multiple regression $GY_i = \beta_0 + \beta_1 GN_i + \beta_2 KW_i + \varepsilon_i$ analysis evaluating GY in response to variation in GN and KW under two contrasting N environments. Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05.

- GN is highly significant under both environments, having an impact on yield with response to N availability.
- KW is relatively "fixed" across these experimental lines when source (N) is limiting.

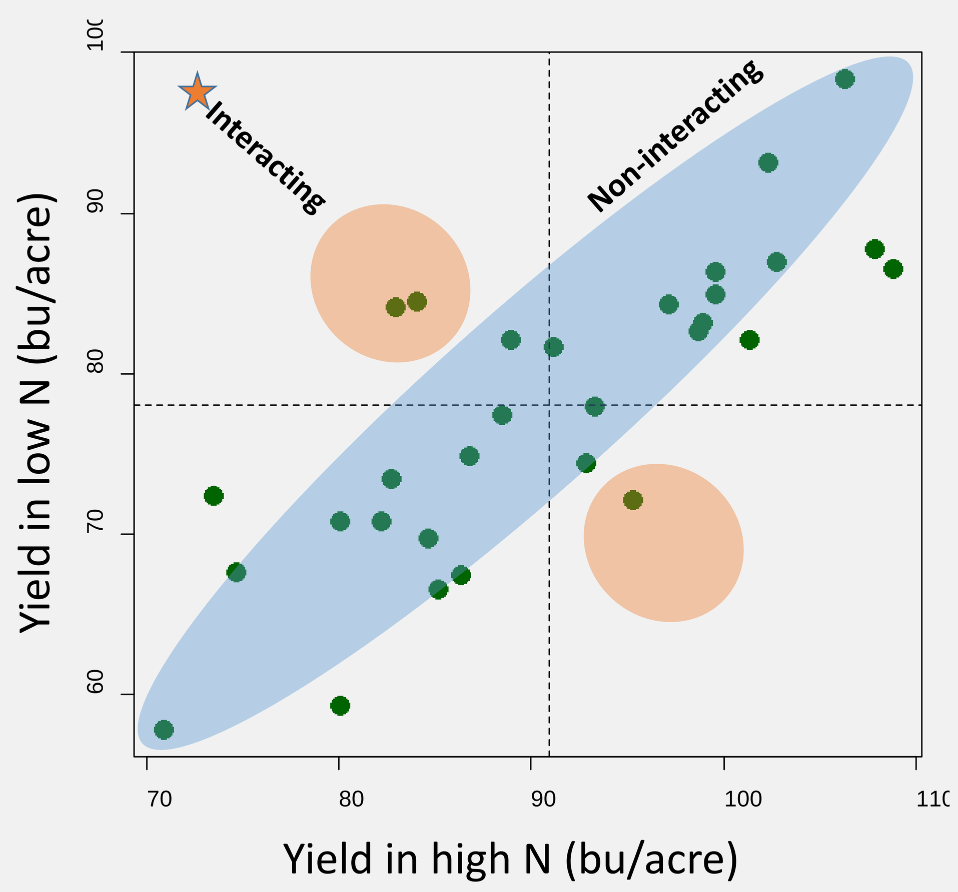


Figure 3: Yield of 30 breeding lines under low N and high N environments. All except three lines showed N non-interacting patterns. The three N interacting lines were 10565C1-1, 04719A1-16-1-1-47-4, and 10222A1-09-2, acknowledging that not all lines respond similarly to changes in N.

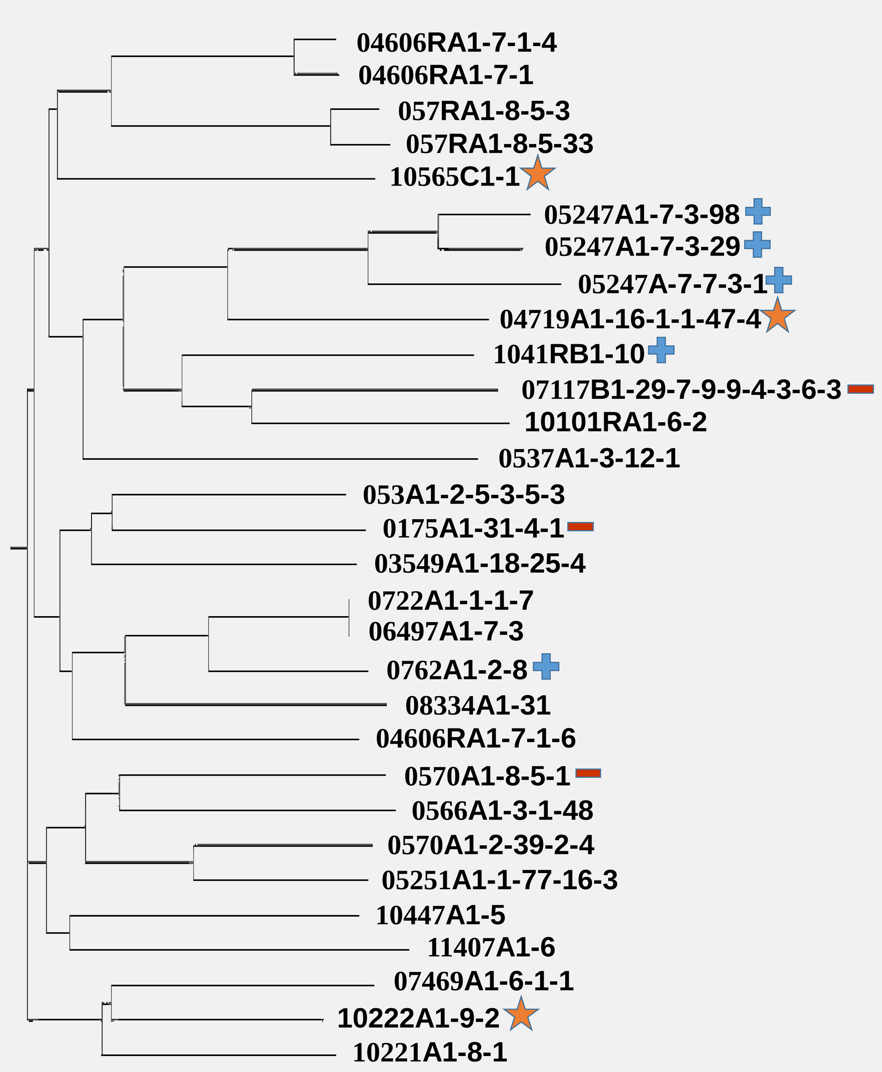


Figure 4. Cladogram representing 30 Purdue breeding lines.

References

Todeschini et al., 2015. Soil and Plant Nutrition, 75: 351-361.

Acknowledgment

Financial support from Purdue College of Agriculture is greatly appreciated. We are thankful to James Beaty, Jason Adams, and Eugene Glover for logistic support for planting and harvesting. Also, thankful for Dr. Shaun Casteel for providing fertilizer applications.