Choosing the Best Vegetation Index for Use in Nitrogen Use Efficiency Selection in Winter Wheat

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INTRODUCTION

- Nitrogen use efficient (NUE) crops are needed due to environmental impacts and high nitrogen (N) costs.
- Traditional phenotyping methods for NUE are labor intensive and destructive.
- Canopy spectral reflectance (CSR) can be used as a proxy for physical sampling.
    - Data is collected in a short time period with low labor requirements.
    - Measurements are non destructive and repeatable.

OBJECTIVES

- Examine relationship between vegetation indices and measures of plant productivity for use in NUE phenotyping.
- Test ability of vegetation indices to discriminate genotypes.

MATERIALS

Plant Material

Hard Winter Wheat Association Mapping Panel

- 299 genotypes
- 2 check genotypes

Located near Ithaca, NE in 2012 and 2013

- Split plot augmented design
    - Whole plot: two nitrogen treatments 44 and 88 kg ha^{-1} residual + applied
    - Subplot: 299 genotypes arranged in incomplete blocks of 20 entries plus 2 check plots
- Two replications
- Plot size: 4 rows, 3m long with 30.5 cm spacing.

Equipment

- A two inter-calibrated Ocean Optics USB2000+VIS-NIR spectrometer system developed by CALMIT was used to measure downwelling and upwelling radiation simultaneously.
- Spectral Resolution: 0.4 nm; 350.02 to 1011 nm.

Measures of Plant Productivity

- Anthesis biomass: 2 x 30cm row
- Anthesis and maturity date: Julian date
- Plant height: cm
- Grain weight: g/ m^2
- Grain N yield = (grain yield) x (N concentration

METHODS

- 2012
    - CSR measured at 4 point measurements in center two rows of plot.
    - Data recorded in first replication of trial.
- 2013
    - CSR measured by continuous scanning of center two rows of plot.
    - Data recorded in both replications of trial.

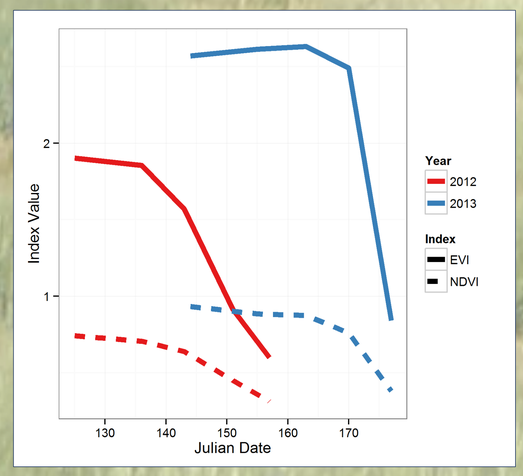
Vegetation Indices

All vegetation indices calculated in T3 database (http://triticeaetoolbox.org/) according to formula shown in Table 1.

Table 1: Vegetation indices used

Acryonym	Index	Formula	Reference
NDVI	Normalized difference vegetation index	$\frac{R_{890}-R_{670}}{R_{890}+R_{670}}$	Rouse et al. (1973)
NDVIg	Green normalized difference vegetation index	$\frac{R_{750}-R_{550}}{R_{750}-R_{550}}$	Gitelson et al. (1996)
EVI	Enhanced vegetation index	$2.5(R_{NIR}-R_{RED})/(R_{NIR}+6R_{RED}-7.5R_{BLUE}+1)$	Huete et al. (2002)
CI	Chlorophyll index	$\left(\frac{R_{NIR}}{R_{GREEN}}\right)-1$	Gitelson et al. (2003,2005)

Figure 1. EVI and NDVI season curves for check genotype Jagger in 2012 (red) and 2013 (blue).



RESULTS

Figure 2. Entry mean heritability of VI and plant productivity parameters in 2012 (red) and 2013 (blue).

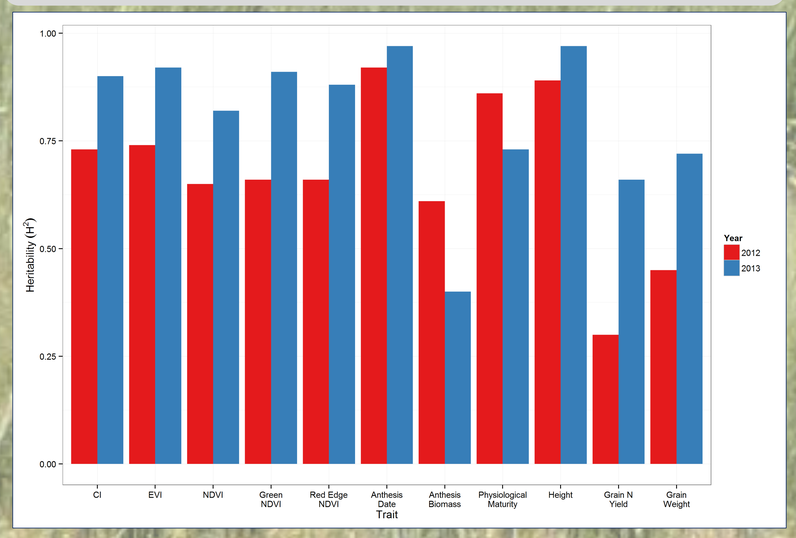


Figure 3. EVI, NDVIg, Anthesis Biomass, and Grain N Yield in 2012 regressed on 2013 values.

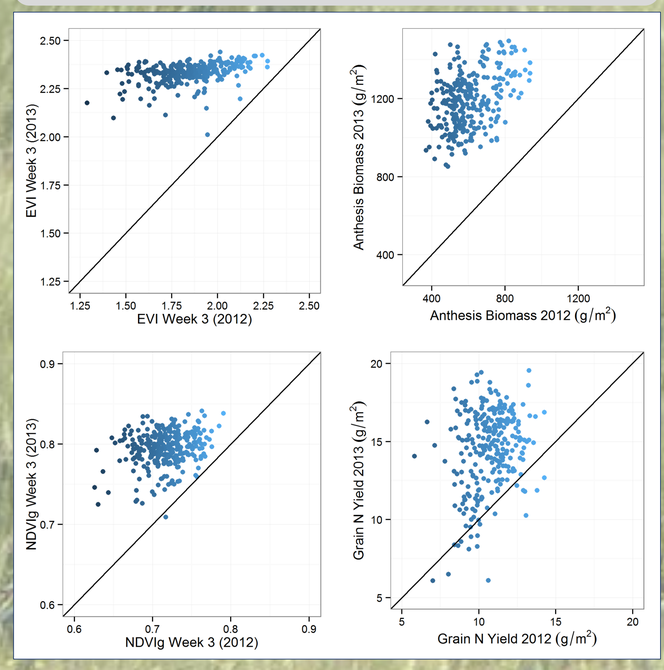
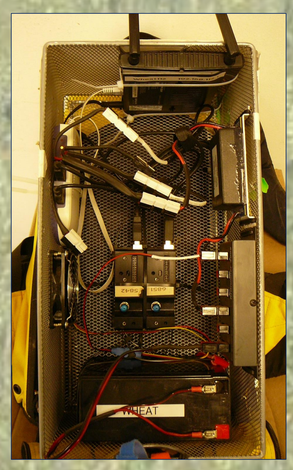


Table 2: Correlations of VI in 2012 and 2013 at Week 3 with plant productivity measures (N=278)

	Year	Anthesis Date	Anthesis Biomass	Plant Height	Grain N Yield	Grain Weight	Maturity Date
CI†	2012	0.591***	0.533***	0.372***	0.437***	0.480***	0.634***
EVI	2012	0.722***	0.656***	0.572***	0.344***	0.426***	0.737***
NDVI	2012	0.659***	0.611***	0.548***	0.363***	0.430***	0.681***
NDVIg	2012	0.603***	0.551***	0.429***	0.436***	0.484***	0.642***
NDVIre	2012	0.652***	0.605***	0.553***	0.361***	0.427***	0.670***
CI	2013	0.067ns	0.044ns	-0.229***	0.434***	0.481***	0.247***
EVI	2013	0.283***	0.212**	0.150**	0.127*	0.150**	0.365***
NDVI	2013	0.222**	0.132*	-0.099ns	0.287***	0.348***	0.373***
NDVIg	2013	0.060ns	0.022ns	-0.216**	0.434***	0.484***	0.257***
NDVIre	2013	0.200**	0.126*	-0.078ns	0.304***	0.357***	0.126***

†Pearson r *= p< 0.05, ** = p< 0.01 *** = p< 0.001



CONCLUSIONS

- The most predictive VI differed in the two years due to environmental effects.
    - Yield limiting environment (2012): EVI had the highest heritability and had high correlations with plant productivity parameters.
    - Optimal yield environment (2013): VI had highly heritability but were less sensitive to genotype differences. Alternative VI or analysis methods are needed.

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ACKNOWLEDGEMENTS: Research supported by USDA-NIFA Triticeae-CAP grant (2011-68002-30029)

STATISTICS: SAS Institute (2010). Cary, NC. SAS Version 9.3
GRAPHICS: R Core Team (2013). Vienna, Austria. URL http://www.R-project.org/.