Indicators of nitrogen sufficiency for spring wheat grain protein

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Background

Farmers need to produce high protein hard red spring wheat that achieves market threshold levels such to obtain price premiums. But there is uncertainty in price premiums, weather conditions and yield potential of the crop.

Making high pre-seeding nitrogen (N) applications can raise protein, but brings economic, agronomic (lodging) and environmental risk.

Recent Manitoba, Canada studies have shown potential to increase wheat protein with mid and late season N applications.

The development of scouting aids to determine N sufficiency and predict response of yield or protein to in-season applied N would provide valuable guidance to agronomists and farmers.

The objective was to determine which tools had the strongest and most consistent relationship with final grain yield and protein content

Method

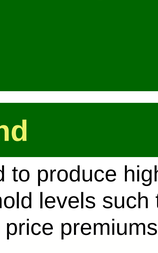
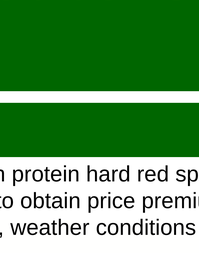
Small plot N response studies were conducted on hard red spring wheat at 8 locations across Manitoba, Canada between 2016-2017.[1]

A number of mid-season measurements were taken at various stages of crop development to determine N sufficiency for yield and protein. The stage deemed most practical to allow detection, interpretation and time for intervention was full flag leaf emergence or Zadoks growth stage 45.

Similarly on-farm-tests were conducted by Manitoba farmers using field equipment to evaluate a number of N fertilization strategies to increase protein in wheat[2].

Some of these same mid-season assessment tools were evaluated on-farm.

1) NDVI as measured with the hand-held Green Seeker unit. Values were scaled according the growing degree days after seeding (GDD base 5C).

2) Leaf chlorophyll measurement of fully developed leaves using the SPAD meter.

3) Flag leaf N content (%) by leaf sampling.

Results

- NDVI and SPAD indices used to predict grain yield were relatively reliable when combined across site-years and varieties (Table 1).
- For example, when measured at flag leaf timing NDVI had the best relationship with final grain yield, with an R^2 value of 0.6.
- Although the same indices showed potential to predict grain protein within a particular site-year for a particular variety, they lost that capability to predict protein content when combined across locations and varieties (Figures 1-8)

Table 1. Regression analyses of the relationship between various indices and wheat yield and protein combined across site-years and varieties.

Tool	Parameter	P-Value	R^2
NDVI/GDD	Yield	<0.0001	0.6031
	Protein	0.0206	0.0132
Flag Leaf N	Yield	<0.0001	0.1448
	Protein	<0.0001	0.1038
SPAD Index	Yield	<0.0001	0.31
	Protein	<0.0001	0.07
SPAD/GDD	Yield	<0.0001	0.6028
	Protein	0.0860	0.01

Figures 1-8. Linear relationships between yield and protein with NDVI (Fig 1-4) and Flag Leaf N (Fig 5-8) indices at flag leaf stage.

At one site combined across varieties, Brunkild 2016 (below)

Combined across all 8 site-years and varieties (below)

Fig 1

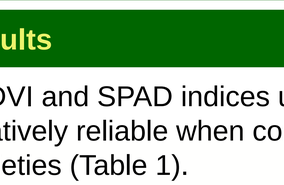


Fig 2

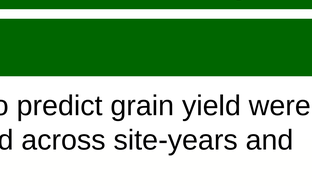


Fig 3

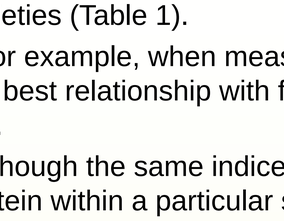


Fig 4

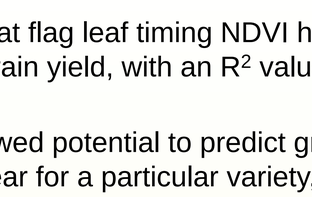


Fig 5

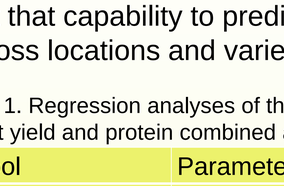


Fig 6

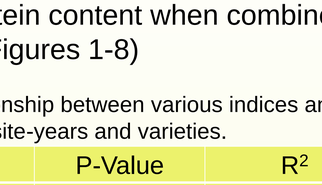


Fig 7

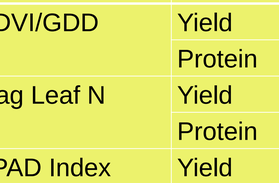
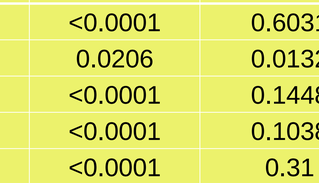


Fig 8



On farm test sites

NDVI and flag leaf N measures were recorded at 18 on-farm-tests where farmers used various N strategies to increase grain protein. The measured yield and protein is graphed in contrast to the linear relationships established from the small plot studies.

Figures 9-12. Estimated yield and protein from NDVI and Flag Leaf N (dotted lines) compared to field measures of yield (blue) and protein (red).

Fig 9

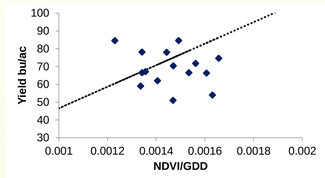


Fig 10

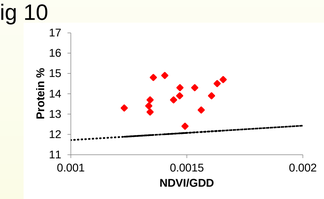


Fig 11

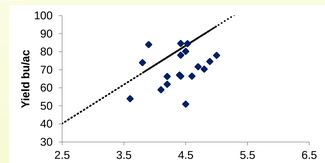
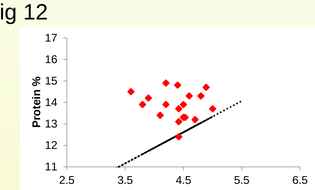


Fig 12



Vegetative indices of NDVI and Flag Leaf N provided marginal value in estimating yields across these 18 fields.

Estimation of grain protein was poor, generally underestimating the actual protein achieved.

Summary

- Vegetative indices have potential to be used as an indicator of grain yield potential and allow for in season intervention to meet N requirements and therefore, mitigate the risks of applying large amounts of N fertilizer at or before planting when crop potential is unknown.
- Grain protein content was much more difficult to predict. To warrant late season N applications targeted at protein increases we require the ability to predict absolute protein content before application to determine if expected grain protein content is likely below a target market threshold. However the tools we tested were not able to reliably predict absolute concentrations of grain protein across cultivars and site-years.
- Indices for yield and protein estimation performed poorer when compared in growers fields.

References

[1] Mangin A. and D. Flaten. 2018. http://www.mbwheatandbarley.ca/wp-content/uploads/2018/05/Mangin-Flaten-N-mgmt-for-HY-wheat-project-revised-technical-report-2018-03-31.pdf

[2] Heard, J. 2017. http://www.mbwheatandbarley.ca/wp-content/uploads/2014/11/OFT-summary-2017-FINAL.pdf