Active canopy sensors for the detection of non-responsive areas to nitrogen application in wheat

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Abstract.

Active canopy sensors offer accurate measurements of crop growth status that have been used in real time to estimate nitrogen (N) requirements. NDVI can be used to determine the absolute amount of fertilizer requirement, or simply to distribute within the field an average rate defined by decision models using other diagnostics. The objective of this work was to evaluate the capacity of active canopy sensors to determine yield and N application requirements within a site at jointing stage (Feeks 6 or Zadoks 31), and in particular the capacity to detect non-responsive areas of the field. For this purpose a set of 6 large nitrogen response field experiments were conducted at contrasting sites where canopy readings were acquired with Cropcircle CS-45, and complimentary information (leaf area, biomass, and nitrogen absorption) was obtained. In addition two fields were surveyed with a commercial canopy sensor (Cropscanner) and check/not-limiting plot pairs at different locations with contrasting NDVI readings were installed. Sensor readings correlated well with biophysical measurements and were good predictors of yield for treatments with and without fertilization after canopy readings. When grouping the plots by NDVI at the time of top dress, N response curves showed different optimum application rates according to NDVI readings. Sites or locations with medium NDVI presented response to larger rates of N, while sites or locations with either low or high NDVI presented response to lower rates of N. At the field level, similar trends were observed. Low NDVI areas show the greatest promise in N savings and return to variable rate technology use. Even when absolute requirements seem difficult to estimate for each location, sensors provide an objective evaluation of crop status across the field at the time of measurement that allows for the distribution of N across the field.

Keywords. *NDVI, wheat, barley, nitrogen, active canopy sensor.*

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Introduction

Active canopy sensors offer accurate measurements of crop growth status that have been used in real time to estimate nitrogen (N) requirements (Shanahan, et al. 2008). NDVI can be used to determine the absolute amount of fertilizer requirement (Barker, et al. 2010), or simply to distribute within the field an average rate defined by decision models using other diagnostics (Holland, et al. 2013). The objective of this work was to evaluate the capacity of active canopy sensors to determine yield and N application requirements within a site at jointing stage (Feeks 6 or Zadoks 30), and in particular the capacity to detect non-responsive areas of the field.

Materials and methods

A set of 6 large nitrogen response field experiments were conducted at contrasting sites where canopy readings were acquired with Cropcircle CS-45, GreenSeeker, and complimentary information (leaf area, biomass, and nitrogen absorption) was obtained. N fertilization treatments (0, 40, 80 kgN ha^{-1}) were applied at planting, Zadoks 22 (Z22), and Zadoks 30 (Z30, time of top dress). In addition two fields were surveyed with a commercial canopy sensor (Cropscanner) and check/not-limiting plot pairs at different locations with contrasting NDVI readings were installed.

Results

Sensor readings correlated well with biophysical measurements (Fig 1a) and were good predictors of yield for treatments without fertilization after canopy readings (Fig 1b). Between Z30-33 NDVI showed better capacity to differentiate between treatments in the experiment and therefore was a good predictor of future grain yield. NDVI at Z30 was also a good predictor of grain yield for fertilized plots at Z30 (Fig 2a), providing the opportunity to identify optimal N application rates at each NDVI level. When grouping the plots by NDVI at the time of top dress, N response curves showed different optimum application rates (total applied N) according to NDVI readings (Fig 2b).

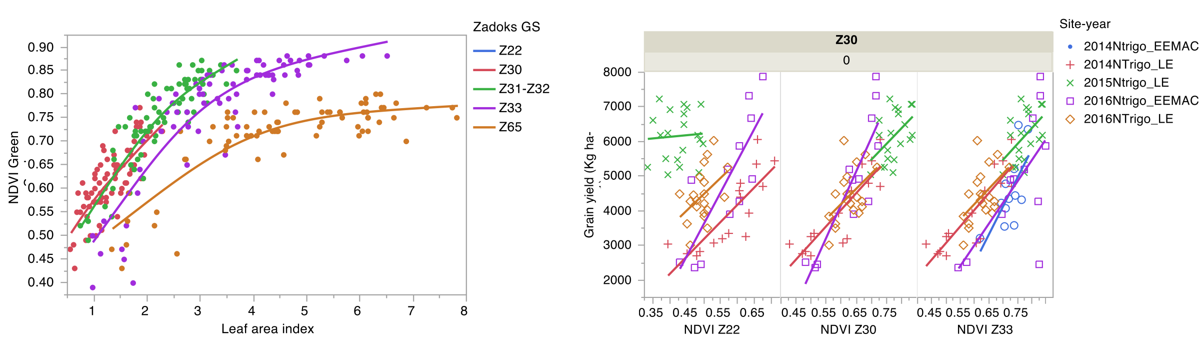

Fig 1. NDVI association with leaf area index for different growth stages in 2014 at site LE (a); and yield vs. NDVI at different growth stages for the five site-years receiving no N at Z30 (b).

Plots with the largest NDVI at the time of top dress (i.e. 0.76-0.84 group) resulting from sites with high mineralized N or previous applied N had the smallest EONR (Economically optimal

Nitrogen Rate) (Fig 2, insert). Plots with middle range values of NDVI, had the largest EONR. And in the other extreme, with decreasing NDVI below middle range values, EONR tended to decrease, probably due to impaired yield potential of the crop. However in these experiments extremely low NDVI values were not observed. While these results conform to previously observed application models (e.g. Raun, et al. 2005, Holland, et al. 2013), here they were obtained with standard response curve fitting procedures for obtaining EONR (Cerrato, et al. 1990). At the field level, similar trends were observed. Low NDVI areas show the greatest promise in N savings and return to variable rate technology use.

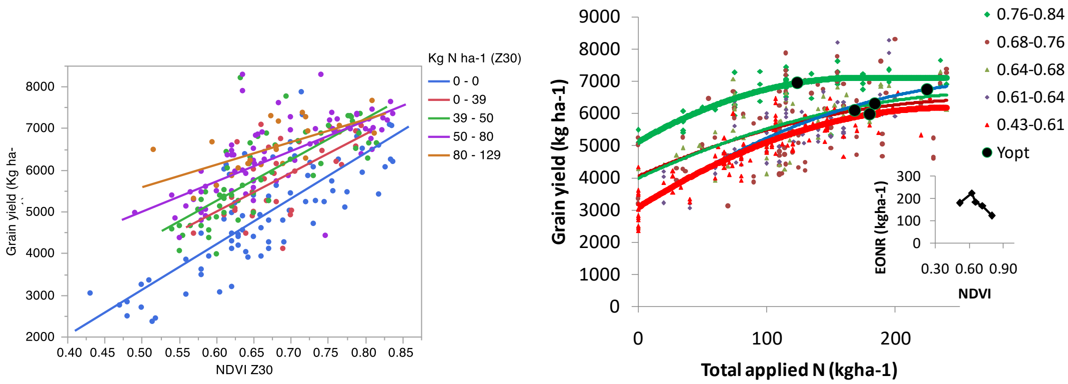

Fig 2. Grain yield observed in all site-years for the N treatments applied after measuring NDVI at the time of top dress (Z30) (a); and EONR obtained from response curves of grain yield to total N applied for different categories of NDVI observed at the time of top dress (Z30) (b).

Conclusion

Locations presenting either high or low NDVI showed the least response to N, with the greater decrease in rates in areas of extreme low NDVI (usually not observed in large numbers in plot experiments). These areas show the greatest promise in N savings and return to variable rate technology use. Even when absolute requirements seem difficult to estimate for each location, sensors provide an objective evaluation of crop status across the field at the time of measurement that allows for the distribution of N across the field.

Acknowledgements

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