THE INTERNATIONAL SOCIETY OF PRECISION AGRICULTURE PRESENTS THE
13th INTERNATIONAL CONFERENCE ON
PRECISION AGRICULTURE
July 31-August 4, 2016 • St. Louis, Missouri USA

WINTER WHEAT GENOTYPE EFFECT ON CANOPY REFLECTANCE: IMPLICATIONS FOR USING NDVI FOR IN-SEASON NITROGEN TOPDRESSING RECOMMENDATIONS

Stanisław M. Samborski[a], Dariusz Gozdowski[b], Olga S. Walsh[c], David. W. Lamb[d], Michał Stępień[a], Edward. S. Gacek[d], and Tadeusz Drzazga[f]

a Agronomy Dep., Warsaw Univ. of Life Sciences, Nowoursynowska Street 159, 02-776 Warsaw, Poland

b Dep. of Experimental Design and Bioinformatics, Warsaw Univ. of Life Sciences, Nowoursynowska 159, 02-776 Warsaw, Poland

c Univ. of Idaho, SW Idaho Research and Extension Center, 29603 U of I Lane, Parma, ID 83660-6590

d Precision Agriculture Research Group, Univ. of New England, Armidale, NSW, Australia

e Research Centre for Cultivar Testing, 63-022 Słupia Wielka, Poland

f Małopolska Plant Breeding Company, Unit Nasiona Kobierzyc, Sportowa Street 21, 55-040 Kobierzyce, Poland

A paper from the Proceedings of the
13th International Conference on Precision Agriculture
July 31 – August 4, 2016
St. Louis, Missouri, USA

Abstract. Active optical sensors (AOSs) measure crop reflectance at specific wavelengths and calculate vegetation indices (VIs) that are used to prescribe variable N fertilization. Visual observations of winter wheat (Triticum aestivum L.) plant greenness and density suggest that VI values may be genotype specific. Some sensor systems use correction coefficients to eliminate the effect of genotype on VI values. This study was conducted to assess the effects of winter wheat cultivars and growing conditions on canopy reflectance, as measured by red or amber normalized difference vegetative indices (NDVIs) derived from AOSs. Variations in NDVI values among three wheat cultivars were measured at three growth stages (Zadoks 31, 37, and 65) during 3 yr at three sites in Poland. GreenSeeker Model 505 (Trimble Navigation Limited, Sunnyvale, CA, USA) and Crop Circle ACS-210 (Holland Scientific, Lincoln, NE, USA) sensors were utilized to measure red and amber NDVIs, respectively. Significant ($p < 0.05$) differences in both forms of NDVI associated with wheat genotypes were observed across years and sites at Zadoks 31, the time when canopy sensing and N fertilization decisions are often made. Lack of a genotype × site interaction for both red and amber NDVIs and the presence of a significant genotype × year interaction suggested that (i) canopy greenness and density of the same genotype measured at the same growth stage are likely to be stable across different growing conditions, and (ii) NDVI values for a particular genotype tend to vary more across years than across sites. Red and amber NDVI values were significantly different for the same genotype, at the same growth stage, across years. This suggests that a genotype-specific calibration should not be blindly applied from one season to the next, even if at the same growth stage, and this in turn supports the suggestion that in situ reference or virtual strips could mitigate the effect of genotype variability when prescribing variable-rate fertilizer. Because developing temporally variable correction coefficients is not practical, we strongly recommend that an in situ calibration (based on in-field or a virtual reference strip) is utilized to normalize NDVI across genotypes, years, and sites.

Keywords. Winter wheat, genotypes, vegetation indices, active optical sensors

Winter Wheat Genotype Effect on Canopy Reflectance: Implications for Using NDVI for In-Season Nitrogen Topdressing Recommendations

Active optical sensor (AOS) data can be utilized to optimize variable N fertilization applications in a range of agricultural crops, including wheat. The acquired radiance values are expressed as ratio-based vegetation indices (VIs). Visual observations of plant greenness (indirect measures of chlorophyll content) and density suggest that VIs may be genotype specific. Contradictory results have been reported in the literature with regard to variations in optical sensor measurements associated with wheat cultivars. No systematic research has been conducted to understand how winter wheat genotype may interact with growing conditions (e.g., air temperature, rainfall, soil type) to affect the NDVI values. The objective of this study was to evaluate the effect of winter wheat genotype and growing conditions on red and amber NDVI values obtained throughout the growing season.

Genotypic variation of both types of NDVI values generally diminished across measurement dates starting from stem elongation to flowering. Genotype significantly influenced the values of both forms of NDVI in all nine site-years but only at growth stage Zadoks 30 to 32. The effect of genotype on the absolute values of both red and amber NDVI was inconsistent across years. The year x site interaction indicated that site-specific growing environments for NDVI development were significantly

affected by weather conditions in a different way across years. A significant year x genotype interaction was also observed for the earlier two measurement dates for both forms of NDVI. This means that genotypes across years had different relative red NDVI and amber NDVI values, but the absolute values for several genotypes could have been the same. The significance of a genotype x year interaction also means that genotype ranking in terms of the VIs for the same growth stage across the growing seasons is different. This finding could limit the versatility of winter wheat cultivar-specific calibration coefficients across growing seasons. The nonsignificant effect of genotype x site interaction on both VIs indicates that very similar red and amber NDVI values could be obtained for the same genotypes grown at different locations. Red and amber NDVI values were significantly different for the same genotype, at the same growth stage, across years. This suggests that a genotype-specific calibration should not be blindly applied from one season to the next, even if at the same growth stage, and this in turn supports the suggestion that in situ reference or virtual strips could mitigate the effect of genotype variability when prescribing variable-rate fertilizer.

Conclusions

The genotype-specific differences in both red and amber NDVI in winter wheat were not consistent and diminished throughout the growing season. A consistent influence of genotype on both types of NDVI was observed at Zadoks 30 to 32—the growth stages at which topdress N fertilization decisions are made by the majority of growers. This conclusion points to two possible alternatives to applying NDVI as the basis for in-season topdressing recommendations. Either an in situ calibration must be performed (using in-field reference or virtual reference strips) or temporally variable correction coefficients must be used to normalize NDVI across genotypes, years, and sites.

In practice, the development of the genotype based calibration coefficients would be constrained by the fact that new winter wheat cultivars are being released annually and several growing seasons' data would be necessary to produce robust calibration coefficients. We conclude that references must be utilized to make sound nutrient management decisions based on in-season NDVI measurements.

Acknowledgements

We thank James Wilson, SoilEssentials Ltd., Dr. Jan Szatyłowicz. This research was supported by the Polish Ministry of Science and Higher Education, Project NN 310 089036, 2009–2012.