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DETECTING NITROGEN VARIABILITY AT EARLY GROWTH STAGES OF WHEAT BY ACTIVE FLUORESCENCE AND NDVI

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Abstract. *Low efficiency in the use of nitrogen fertilizer, has been reported around the world which often times result in high production costs and environmental damage. Today, unmanned aerial vehicles (UAV) cameras are being used to obtain conditions of crops, and can cover large areas in a short time. The objectives of this study were (i) to investigate N-variability in wheat at early growth stages using induced fluorescence indices, NDVI measured by active sensor and NDVI obtained by digital imagery; and (ii) understand the relationship among the various indices in explaining N-variability. The experiment was conducted in a greenhouse, and the experimental block design consisted of six replications. The treatments were composed of five levels of nitrogen (0, 25, 50, 87.5 and 150% of N recommended in Hoagland solution). Wheat seeds were planted in 30 pots with 6 kg of silica sand. The first application of N treatments was applied to the pots with 300 ml of water with different N levels at three days after emergence (DAE). Second application of N treatments was performed at 15 DAE. Sensor measurements were acquired at 24 and 28 DAE. The four sensors used in this study were Mutiplex3 (FORCE-A, Orsay, France); NDVI by Trimble Greenseeker handheld; and NDVI estimated from images obtained with two cameras (Gopro Hero4 InfraRed and Canon SX280 InfraBlue). Considering the results we conclude that nitrogen balance index estimated from fluorescence and NDVI by Greenseeker as well as NDVI obtained by digital images of GoPro camera with Red-IR filter have potential for fast and easy detection of nitrogen variability at early growth stages of wheat crop. Field research should be carried with wheat and other crops to enable the use of NDVI obtained from photographic equipment embedded in drones, to diagnose nitrogen deficiency and recommend fertilizer application in varying rates in real time.*

Keywords. *Fertilizer efficiency, N-deficiency, Vegetation Index, Image InfraRed.*

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Introduction

Low efficiency in the use of nitrogen fertilizer has been reported around the world which often result in high production costs and environmental damage. Commercially available crop canopy sensors based on reflectance are capable of detecting nitrogen deficiency (Longchamps and Khosla, 2014). Today, unmanned aerial vehicles (UAV) cameras are being used to obtain conditions of crops, and can cover large areas in a short time. Our hypothesis is that low price photographic instruments and their easy accessibility can be used to obtain the Normalized Difference Vegetation Index (NDVI) for discrimination of N-variability in crops. The objectives of this study were (i) to investigate N-variability in wheat at early growth stages using induced fluorescence indices, NDVI measured by active sensor and NDVI obtained by digital imagery; and (ii) understand the relationship among the various indices in explaining N-variability.

Materials and Methods

The experiment was conducted in a greenhouse at the Colorado State University, USA. The experimental block design consisted of six replications. The treatments were composed of five levels of nitrogen (0, 25, 50, 87.5 and 150% of recommended N, applied as Hoagland solution) (Hoagland and Arnon, 1950), as shown in Table1.

Table 1. Nutrient treatments used for experiment (Hoagland Solution).

Ingredients	Stock solution (g/L Water)	Nitrogen (%)				
		150	87,5	50	25	0
		ml/L				
KH_2PO_4 (pH to 6.0 with 3M KOH)	136.09	1	1	1	1	1
KNO_3	101.11	7.50	4.38	2.5	1.25	-
$Ca(NO_3)_2$ x $4H_2O$	236.16	7.50	4.38	2.5	1.25	-
$MgSO_4$ x $7H_2O$	247.47	2	2	2	2	2
KCL	74.56	5	5	5	5	5
$CaCl_2$ x $2H_2O$	147.02	5	5	5	5	5
Minours	*	1	1	1	1	1
Fe-EDTA	**	1	1	1	1	1

*Minors: micronutrients. Stock solution was prepared by H3BO3 (2.86 g/L), $MnCl_2$ x $4H_2O$ (1.81 g/L), $ZnCL_2$ x $7H_2O$ (0.1g/L), $CuCl_2$ (0.04g/L) and H $_2$MoO4.H_2O (0.02g/L) **Fe-EDTA: Ferric ethylenediaminetetra acetic acid. Stock solution was prepared by $FeSO_2$ x $7H_2O$ (24.9g/L), EDTA-Na (33.2g/L) and NAOH 1N (89ml/L)

Wheat seeds were planted in 30 pots with 6 kg of silica sand. The first application of N treatments was applied to the pots with 300 ml of water with different N levels at three days after emergence (DAE). Second application of N treatments was performed at 15 DAE.

Sensor measurements were acquired at 24 and 28 DAE. The four sensors used in this study were Mutiplex3 (FORCE-A, Orsay, France); NDVI by Trimble Greenseeker handheld; and NDVI estimated from images obtained with two cameras (Gopro Hero4 InfraRed and Canon SX280 InfraBlue). The nitrogen balance index estimated by fluorescence (NBI-Rm) was calculated with far-red fluorescence induced by Ultra-violet (UV) divided by red fluorescence induced by red. The Normalized Difference Vegetation Index by Greenseeker (NDVI-GS) was obtained by direct reading, and Normalized Difference Vegetation Index by Gopro digital image-NDVI Red (NDVI-GP) or by Canon-NDVI Blue (NDVI-CA) was calculated using Photo Monitor Plugin using free software Figii ImageJ. Regression analysis was performed to assess the precision of sensors indices, and to investigate the relationship among them.

Results

The NBI-Rm, NDVI-GS and NDVI-GP showed quadratic response to the nitrogen levels with R^2 values of 0.95, 0.94 and 0.89, respectively, as shown in Figure 1.

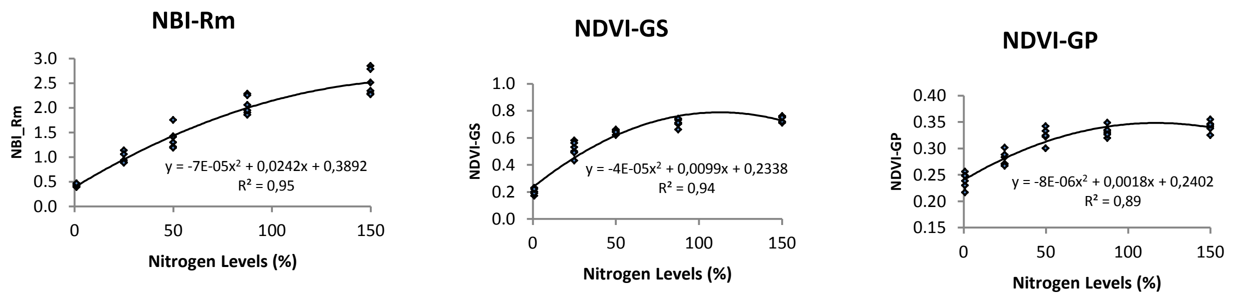

Fig 1. Estimates of the three vegetative indices, NBI-Rm, NDVI-GS and NDVI-GP as a function of various levels of applied nitrogen.

The Figure 2 depicts the correlation between the sensors used in the study. The NBI-Rm showed exponential response to the NDVI-GS and NDVI-GP with R^2 of 0.95 and 0.87, respectively, and NDVI-GS showed linear regression response to the NDVI-GP with $R^2 = 0.89$. The NDVI-Blue had no significant correlation with the nitrogen levels, and others sensors.

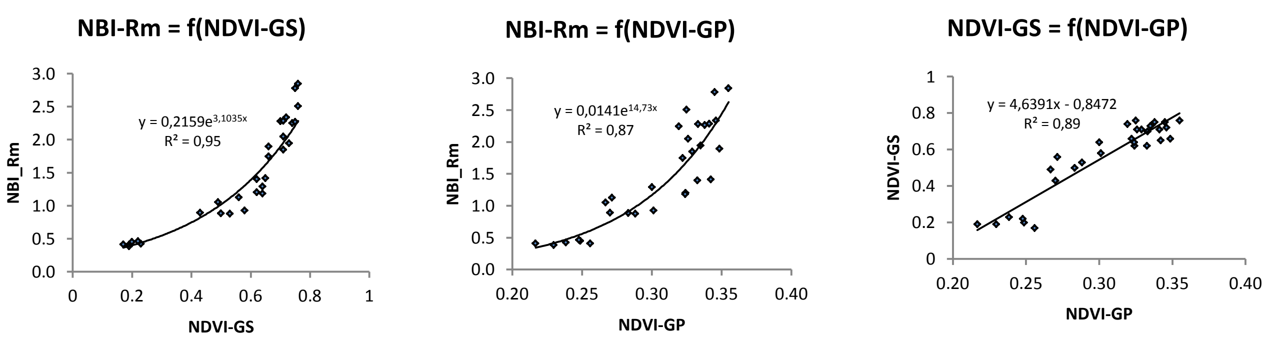

Fig 2. Correlation between the sensors used in the study.

Conclusion

Considering the results observed in this study we conclude that nitrogen balance index estimated from fluorescence and NDVI by Greenseeker as well as NDVI obtained by digital images of GoPro camera with Red-IR filter have potential for fast and easy detection of nitrogen variability at early growth stages of wheat crop. Field research should be carried with wheat and other crops to enable the use of NDVI obtained from photographic equipment embedded in drones, to diagnose nitrogen deficiency and recommend fertilizer application in varying rates in real time.

References

Hoagland, D.R. & D.I. Arnon. (1950) The water-culture method for growing plants without soil. California Agricultural Experiment Station Circular 347:1-32.

Longchamps, L., & Khosla, R. (2014) Early Detection of Nitrogen Variability in Maize Using Fluorescence. Agronomy Journal, 106(2), 511-518.