Sensitivity of hyperspectral bands to N concentration at different growth stages in winter wheat

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Abstract

Spectral indices are a precision tool to increase nutrient use efficiency by estimating N crop status. In this study, canopy hyperspectral reflectance (325 -1075 nm) were recorded at three different growth stages of winter wheat in two years. The objective was to assess the sensitivity of all possible two-bands (λ) combination in a normalized difference spectral index [$NDSI_{(\lambda1, \lambda2)} = (\lambda_1-\lambda_2)/(\lambda_1+\lambda_2)$] to crop N concentration at different growth stages. The results indicated that $NDSI_{(NIR,\ Red\text{-}Edge)}$ and $NDSI_{(510,\ 450)}$ were the most accurate indices to determine %N. Due to the early estimation, they could be used to adjust N fertilization.

Keywords: Crop N status, N fertilization, Remote sensing, vegetation indices

1. Introduction

Adjusting timing and spatial distribution of N fertilizer to crop demand is crucial to increase N use efficiency. Sensors could be used to better capture crop N status and estimate the response to N applications.

This study aimed to evaluate the estimation of crop %N by the normalized difference spectral index [$NDSI_{(\lambda1, \lambda2)} = (\lambda_1-\lambda_2)/(\lambda_1+\lambda_2)$] calculated with all possible two hyperspectral bands (λ) at different growth stages in winter wheat. The capability to adjust N fertilization has been studied.

2. Materials and methods

A field experiment with winter wheat (*Triticum aestivum* L.) was conducted in Central Spain during two years. Four different N treatments, from non-N-fertilized to over-fertilized, combined with two irrigation levels were established with four replications in 32 plots (22 x 22 m^2).

Crop %N was determined in wheat samples taken at three growth stages each year: mid-stem elongation, final stem elongation and flowering.

Canopy spectral reflectance was acquired as close as possible to crop samples collection with a FieldSpec® Hand-Held VNIR (Analytical Spectral Devices, Boulder, CO, USA) over 325-1075nm with 1nm spectral resolution.

The coefficients of determination (R^2) between all possible $NDSI_{(\lambda1, \lambda2)}$ and %N were calculated.

3. Results

The $NDSI_{(\lambda1, \lambda2)}$ that presented better R^2 at stem elongation were $NDSI_{(NIR,\ Red\text{-}Edge)}$ and $NDSI_{(510,\ 450)}$, whereas at flowering was only $NDSI_{(NIR,\ Red\text{-}Edge)}$ (Fig 1.).

Previous studies reported the correlation between N status and $NDSI_{(NIR,\ Red\text{-}Edge)}$, an index known as NDRE (Fitzgerald *et al*. 2006). This correlation occurred because reflectance at NIR is influenced by internal leaf structure and Red-Edge by chlorophyll concentration.

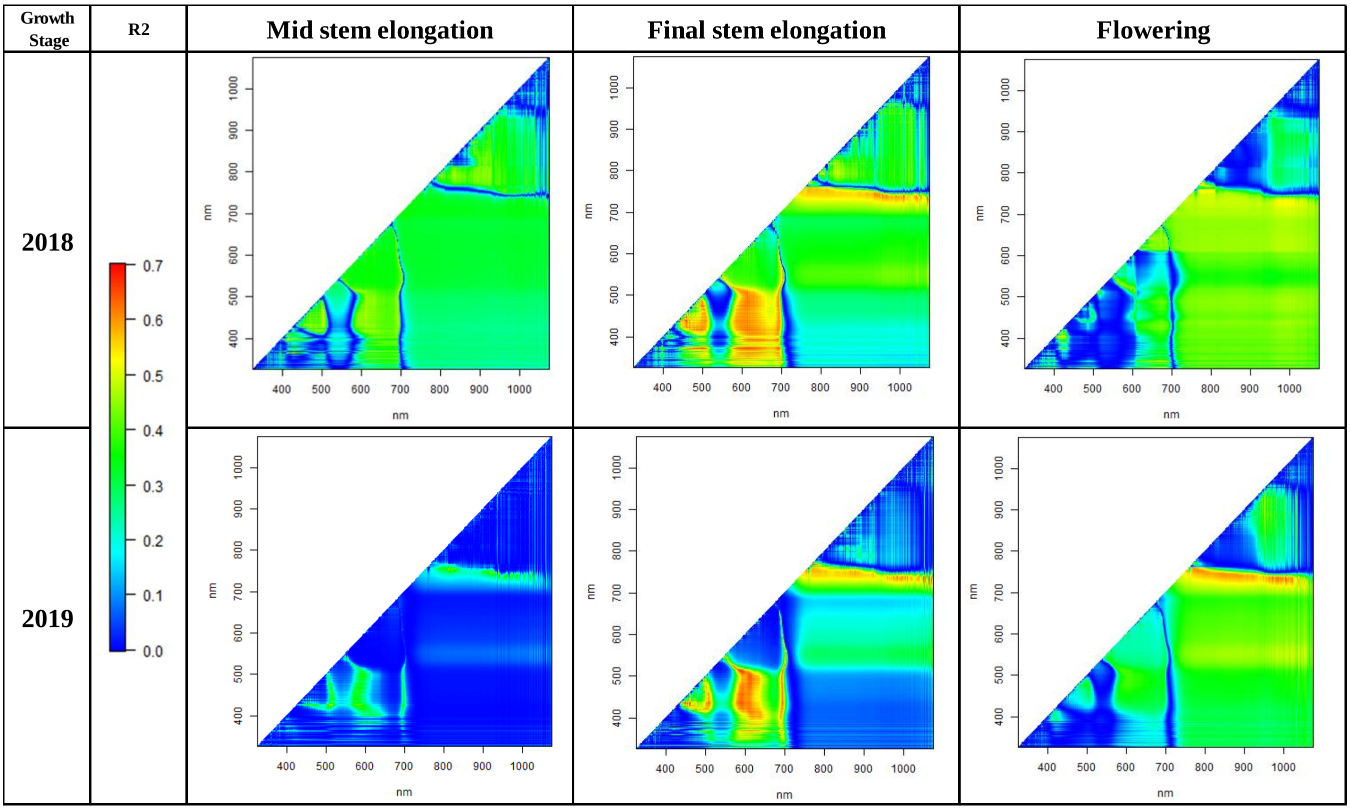

Fig. 1: R^2 between all possible NDSI and %N in 6 sampling dates.

$NDSI_{(510, 450)}$ displayed a good correlation because 510nm is into the chlorophyll reflectance region, and 450nm is related to the chlorophyll peak absorption, which can be used as reference until chlorophyll drops.

4. Conclusion

The normalized indices that best estimated wheat %N were $NDSI_{(NIR, Red\text{-}Edge)}$ and $NDSI_{(510, 450)}$. At final stem elongation, when maximum canopy cover was reached, the relationship was highly significant and could be used to adjust N fertilization.

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References

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