DEVELOPMENT OF A NITROGEN REQUIREMENT ALGORITHM USING GROUND-BASED ACTIVE REMOTE SENSORS IN IRRIGATED MAIZE

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ABSTRACT

A study was conducted using the two most prominent ground-based active remote sensors (NTech's GreenSeeker™ red and Holland Scientific's Crop Circle™ amber) to begin the development of an N recommendation algorithm for each sensor for use at the V12 maize growth stage under semi-arid climatic conditions. Each sensor's NDVI N recommendation algorithm calculated unbiased N recommendations suggesting that the methodology of algorithm development is valid.

Keywords: N recommendation algorithm; NDVI; Nitrogen Management

INTRODUCTION

Studies have shown that normalized difference vegetation index (NDVI) from ground-based active remote sensors is highly related with leaf N content in maize (*Zea mays*). Remotely sensed NDVI imagery can provide valuable information about in-field N variability in maize and significant linear relationships between sensor NDVI and maize grain yield have been found suggesting that an N recommendation algorithm based on NDVI could optimize N application. Therefore, a study was conducted using the two most prominent ground-based active sensors (NTech's GreenSeeker™ red and Holland Scientific's Crop Circle™ amber) to begin the development of an N recommendation algorithm for each sensor for use at the V12 maize growth stage under semi-arid climatic conditions.

MATERIALS AND METHODS

Our NDVI based N estimation algorithms for the amber and red sensors were created by using the maize growth stage V12 NDVI readings from 0, 50, 100 and

175 kg ha^{-1} N plots. To create the algorithms a wide range of NDVI response indices (RI) were created by dividing the NDVI of an N applied plot by the NDVI of a 0 kg ha^{-1} plot. The calculated RI values were then plotted against the N application rate difference that created that RI (50, 100 or 175 kg ha^{-1}). The overall idea with this algorithm is that a RI can be based on N application differences. If we know the difference in N application rates and the resulting RI this information can be plotted and an N prediction equation can be formulated through linear regression. This process was repeated for all possible RI values across 50, 100, and 175 kg ha^{-1} N application rates. The intercept for the regression equation was set at 1.0 because this is the lower limit of the RI (at 1.0 no N is needed). After algorithm development, validation was required. Therefore, a test for N prediction bias was performed. A 95% confidence interval was calculated for each algorithm N recommendation and 100 "bootstrapped" (with replacement) random samples were created for each N application plot. If the algorithms are unbiased we would expect to see approximately 95% of the random bootstrapped samples fit in the 95% confidence interval.

RESULTS

An RI was calculated over a range of N application differences (175, 100 and 50 kg ha^{-1}) and then was regressed over the N application difference that created that particular RI. This regression was then used to calculate an N recommendation quadratic equation that predicts crop N need for the amber and red NDVI sensors. The resulting N recommendation algorithms for each active sensor are as follows:

Amber Sensor:

$$\text{N Rate (kg ha}^{-1}\text{)} = (114.1 \times (NDVI_{Reference} / NDVI_{Target})^2) - (118.1 \times (NDVI_{Reference} / NDVI_{Target}))$$

Red Sensor:

$$\text{N Rate (kg ha}^{-1}\text{)} = (135.3 \times (NDVI_{Reference} / NDVI_{Target})^2) - (134.8 \times (NDVI_{Reference} / NDVI_{Target}))$$

The premise for the algorithm methodology we used was that RI is directly related to N differences in the crop. The RI can therefore be used to predict the amount of N it would take to make up this difference, which can be used as the N recommendation. Both the amber and red NDVI algorithms presented above were unbiased based on the confidence interval fitting process. A very high percentage of the bootstrapped N recommendations fit within the 95% confidence intervals of the actual N recommendations.

CONCLUSIONS

The amber and red N recommendation algorithms developed in this study both proved to be unbiased in their N recommendations. This suggests that the NDVI N algorithm development methodology presented in this paper is sound and should be researched further to determine their accuracy over a larger data base that includes more spatial and temporal variability. The amount of variability in the RI portion of the equation is a concern and further testing is needed to determine how the recommendation equations are affected by this variability.