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Project Title: Remote Sensing Applications in the Optimization of Cotton Nitrogen Fertilization

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Executive Summary:

Various experiments involving investigations in utilizing remote sensing techniques to improve fertilizer nitrogen use efficiency in cotton production were completed. Relationships were established between cotton leaf and canopy reflectance and tissue nitrogen status. Wavelengths near 550 nm and 700 have been shown to provide the most reliable information with regards to nitrogen status, given all other nutrients are not limiting. Numerous leaf scans were taken from varying fertilizer nitrogen field plots and were used in neural network modeling. Strong relationships were established between plant height and NDVI measurements derived from multispectral imagery indicating its utility in evaluating growth rate differences. Leaf pigment concentration was very dependent on nitrogen nutritional status and a good relationship between chlorophyll a content and tissue nitrogen concentration was established. NDVI values were heavily dependent on the quantity of green biomass or groundcover and were influenced little by leaf nitrogen status within a given sampling date or physiological stage of growth. Specifically, leaf tissue nitrogen concentration was greatest at squaring and progressively declined through peak bloom while NDVI values were low at squaring and increased with increasing cotton growth. Variable rate nitrogen fertilization was successfully applied in 1998 and 1999. Utilization of multiple soil factors and bare soil imagery resulted in yield increases of 30 lb lint/acre in 1998 and 39 lb lint/acre in 1999. Fertilization based on residual available soil nitrogen near planting resulted in a decline in yield, thus emphasizing how numerous factors such as soil texture and moisture supply influence response to nitrogen.

The results of our first two years of work on this project indicate that plant nitrogen status can be accurately predicted from leaf reflectance using neural networks. We conducted research that approached the problem from two different points of view (as a classifcation problem and as a regression problem) and have developed a variety of neural network ensemble architectures to address both problems. Experiments testing the effectivenss of these ensembles has been conducted with both greenhouse and field data collected over a period of three years. We have found neural network ensembles result in improved performance compared to traditional methods such as linear regression analysis and curve fitting. Since leaf reflectance changes in response to nitrogen stress are quite subtle and are often accompanied by background noise, the traditional methods appear to be inadequate for modelling the complex relationship between leaf reflectance and nitrogen concentration. Our best results to date have been obtained using a set of four features extracted from reflectance spectra with an ensemble of feed-forward, back-propagation neural networks. One important result from this study is that exclusion of the *D* features from the original feature set improved prediction accuracy. Since the *D* features are extracted from far more spectral bands than the *X* or *M* features, this finding provided a way to reduce the number of spectral channels required for the prediction of cotton nitrogen status. One potential problem with the *X* and *M* features is the need of a reference for the ratio analysis. However, it may be possible to use the lowest and greatest sensor values as a reference. In addition, the classifier combination methods developed in this study may also be used to improve the accuracy of prediction of cotton nitrogen status from the imagery data.