USING WHEAT CANOPY COLOR TO VARY NITROGEN APPLICATION RATE

G.J. Schwab, L.W. Murdock, T. Sombaugh, J. James, and D. Call

BACKGROUND:

A technological improvement for the detection of N nutritional stress involves using spectral reflectance of red and near infrared colors from the crop canopy, on-the-go, to determine the fertilization rate. A variable rate nitrogen application system, called the GreenSeeker system, has been developed by Oklahoma State University and is now commercially available. Liquid nitrogen is applied through a set of three stacked nozzles. Each set of nozzles has a remote sensor on the leading side of the tool bar to control nitrogen application rate which is dependant on the greenness of the crop canopy. The exciting feature of this technology is that the sensors and the applicator are coupled so that fertilization decisions are made in real time and based on the current condition of the crop. Using this technology it is possible to fertilize each 6 square feet independently at a top speed of 15 mph. Years of research have gone into developing the algorithms that control the nitrogen applications. Field scale tests began in Oklahoma in 2002 on 17 fields in replicated strips. Compared to flat rate of nitrogen the variable rate application increased yields by 5 bu/ac and decreased overall nitrogen rates by 10 lb/ac. Complimentary research in Virginia using the same system over a two-year period has shown a yield increase of up to 8 bu/ac with a 15 lbs N/ac reduction in fertilizer.

METHODS:

A 20 foot plot sprayer manufactured by Ntech Industries, Inc. (Ukiah, CA) equipped with 8 red normalized difference vegetative index (red NDVI) sensors each of which electronically control three stacked nozzles capable of delivering from 1 to 7 times a base rate of fertilizer was utilized for this study. Study sites were located in Caldwell, Trigg, and Woodford Counties plots ranged from 200 – 1600 feet in length depending on the location. The study tested four different algorithms (prediction equations) for N requirement. Treatments were: 1) a flat rate of 40 and 70 lbs N/acre split (Fig. 1) applied at Feekes 3 and 6, respectively, 2) a flat rate of 40 lbs N/acre at Feekes 3 followed by a variable rate (Oklahoma algorithm) applied at Feekes 6, 3) a variable rate applied at both Feekes 3 and Feekes 6 growth stages (Virginia algorithm), and 4) a flat rate of the average applied in treatment #3. A high N strip (120 lbs N/a) was also established at Feekes 3 for comparison purposes.

The Oklahoma algorithm's applied the highest rate of nitrogen to the lightest green areas (lowest NDVI) of the field and incremented downward to 0 lbs N/acre at the point where the canopy color was equal to the color of the high N strip (Fig. 2). For the Virginia algorithm, the Feekes 3 N application was based on tiller density. The areas with very thin stands (<50 tillers/sq ft) received 58 lbs N/a, areas where tiller density was between 50 and 100 tillers/sq ft received 31 lbs N/a, and the areas where tiller density was greater than 100 tillers/sq ft received 0 lbs N/a at this early application time. At the Feekes 6 stage, the Virginia algorithm calls for relatively low N applications where NDVI is low and increasing amounts of N up the average and then decreasing rates (Fig.3). The field

average rates of N for the Virginia algorithm treatment was 33 lbs N/a at Feekes 3, and 38 lbs N/a at Feekes 6. These average rates were applied as a flat rate for the fourth treatment (Fig. 4).

Whole plot yield was determined using a plot combine in Caldwell Co. Grain yield was determined at the other two locations by using combines equipped with yield monitors. Whole plot yields were verified with a weigh wagon.

RESULTS:

Unfortunately, the Caldwell and Trigg Co sites had severe disease pressure which dramatically reduced yield. At these two sites, N application treatment did not affect grain yield. Thankfully there was very little disease pressure at the Woodford Co site.

Average plot yield is listed in Table 1 for the Woodford Co site. The farmer practice was the highest yielding treatment, but it also received the highest rate of nitrogen fertilizer. Using the Oklahoma algorithm to vary the N rate saved 34 lbs N/a and produced yields statistically equal to the farmer practice treatment. By spatially varying the N rate, wheat yield was increased by about 3.5 bu/a when compared to a uniform application at the same N rate (trt 2 vs. trt 3.). The economic returns (gross income minus N costs) were very similar for the two variable rate treatments and the presently recommended flat rate treatment (Table 1).

CONCLUSIONS:

Results reported in this paper are for the first year of the study, and might not be observed with different growing conditions in future years. The results, however, indicate the GreenSeeker technology can aid in N management decisions by giving farmers the confidence they need to decrease their overall N application. This technology also enables farmers to capitalize on within field N supply variability which may further improve nitrogen use efficiency. Additional sites and algorithms will be evaluated in the 2004-2005 growing season.

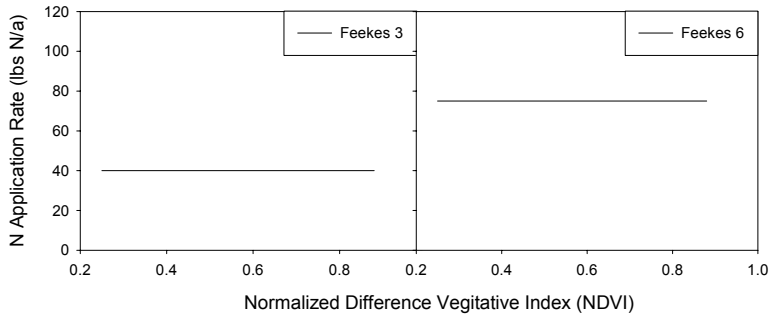

FIGURE 1. NITROGEN APPLICATION RATE AT FEEKES 3 AND FEEKES 6 FOR FARMER PRACTICE (TREATMENT 1) FOR THE WOODFORD CO SITE

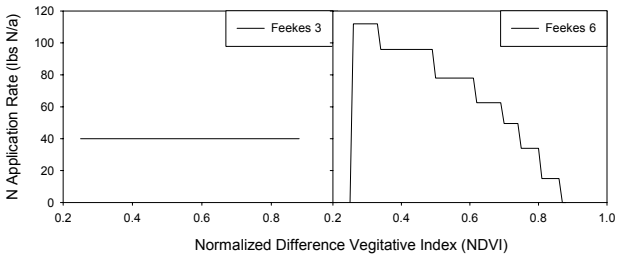

FIGURE 2. NITROGEN APPLICATION RATE AT FEEKES 3 AND FEEKES 6 FOR THE OKLAHOMA ALGORITHM FOR THE WOODFORD CO SITE (TREATMENT 2)

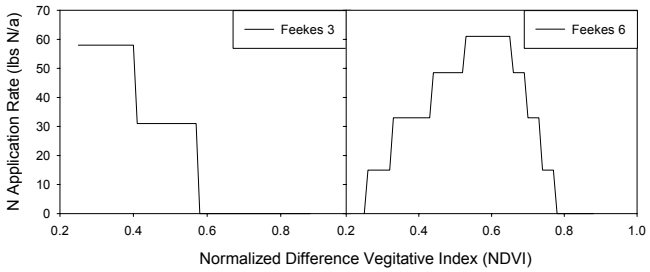

FIGURE 3. NITROGEN APPLICATION RATE AT FEEKES 3 AND FEEKES 6 FOR THE VIRGINIA ALGORITHM FOR THE WOODFORD CO SITE (TREATMENT 3)

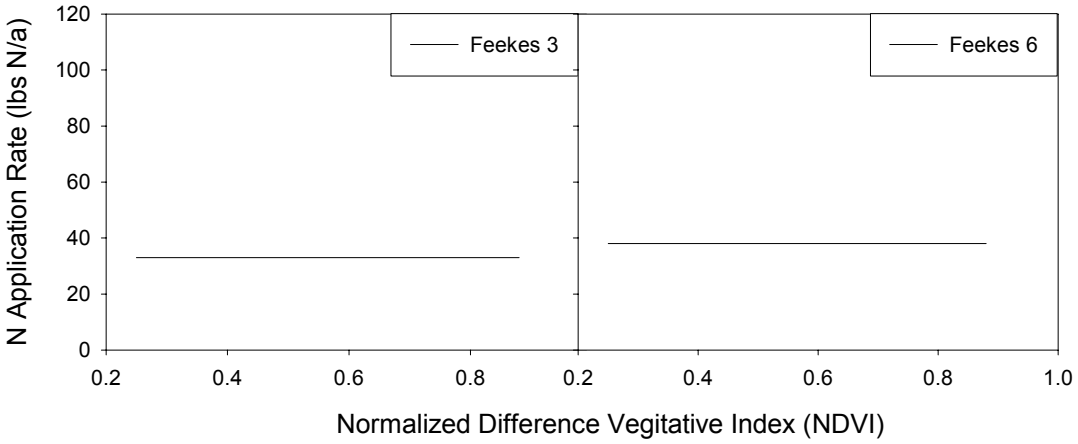

FIGURE 4. NITROGEN APPLICATION RATE AT FEEKES 3 AND FEEKES 6 FOR FLAT RATE OF THE VIRGINIA ALGORITHM FOR THE WOODFORD CO SITE (TREATMENT 4)

TABLE 1. TOTAL N APPLICATION RATE USED FOR EACH TREATMENT AND AVERAGE TREATMENT YIELD AT THE WOODFORD CO. SITE 2003-2004

Treatment	Nitrogen (lbs/ac)			Yield	Returns to N
	Feekes 3	Feekes 6	Total	Bu/ac	$/Ac*
Flat Rate (BMP)	40	75	115	64.3	164
VA Variable	33	39	72	58.6	158
VA Average Flat	33	38	71	54.9	146
OK Variable	40	41	81	61.7	165
			LSD (0.10)	3.3	
			C.V.	4.3	

*N = $0.25/lb Wheat = $3/bu