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Managing N application for desirable grain protein content in durum wheat using image processing and canopy reflectance

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Introduction

One of the major concerns for Arizona durum growers is to produce grains with high protein levels (>13%) to qualify for premium prices (Clarke, 2001). Optimizing N applications is highly needed to obtain adequate protein levels without affecting grain yield. A simple and rapid method for estimating crop yield at flowering stage and crop N status is required to make immediate N application decisions for increasing grain protein content (Ottman et al., 2000).

There are substantial literature reports to estimate crop N content using canopy reflectance through diverse indices. However, very few reports related canopy reflectance to the grain protein levels. Two studies conducted in bread wheat found that canopy reflectance was highly associated with leaf N and grain protein content (Wang *et al.*, 2004; Wright et al., 2004). Currently there are no reports on predicting crop yield and evaluating grain protein content in durum wheat using canopy reflectance indices in Arizona. This project investigated the potential of canopy reflectance and crop modeling for durum wheat yield and grain protein prediction.

Objectives

The objectives of this study were to use six common durum wheat varieties with low, medium, and high grain protein content:

1) To evaluate response of durum wheat varieties with different grain protein contents under three N rates.
2) To develop a simple and rapid method in which canopy reflectance and crop modeling are used to predict crop yield at flowering stage.

Materials and Methods

Six common durum wheat varieties (cv. Duraking, Topper, Kronos, Havasu, Orita, and Ocotillo) were planted on December 15, 2010 at Maricopa Ag Center. Five nitrogen rates were used in this project: 0, 65, 110, 165, and 240 lb/A (Table 1).

Biomass data were collected before each fertilizer application as well as at harvest to calibrate DSSAT crop growth models. Canopy reflectance indices were estimated using a spectroradiometer from 350 to 1050 nm (GER 1500, Spectra Vista Corp, New York) at flowering time. Normalized difference vegetative index [NDVI = (R900-R680)/(R900+R680)] was calculated from the canopy reflectance data to estimate yield and grain protein. The crop was harvested in June, 2011 for grain yield and protein content.

Results and discussion

A sudangrass cover crop was planted in the summer prior to the experiment to reduce soil N and variation in soil fertility. As a result, pre-plant soil samples showed that there was less than 5 ppm NO_3-N available for the wheat crop. Water test showed that there was about 20-30 lb/A N applied through irrigation water.

There were significant differences in grain yield and grain protein among N treatments (Table 2). N fertilizer up to 240 lb/A increased grain yield and protein content significantly. Grain yield among varieties was not significantly different when tested at each N treatment level. There were significant differences in protein content at N level of 65, 165, and 240 lb/A. At higher N level (165 and 240 lb/A), variety Duraking produced the highest grain yield with lowest protein content.

Using information on soil properties, weather data, crop management, and variety growth, DSSAT crop model predicted durum grain yield accurately (Figure 1). The model over-estimate crop yield under lower N rate, probably due to the fact that infested weeds in the lowest N rate treatment reduced crop yield. DSSAT predicted crop yield accurately in this study. The results indicate that DSSAT crop growth model can be used to estimate crop yield for the best N management practices.

Canopy reflectance index NDVI at flowering time had high determinant of coefficients (R^2) with crop yield and protein content (Figure 2). The results indicate the potential of using canopy reflectance index in durum wheat yield prediction and N management. In this study, crop yield had a positive relationship with grain protein when N fertilizer was applied from 0 to 165 lb/A (Figure 3). When 240 lb/A of N fertilizer were applied, the relationship between crop yield and grain protein was negative. The relationship between NDVI and grain yield/protein content needs to be further tested when crop yield is high.

In next year's study, we will continue to test if canopy reflectance indices can be used to predict crop yield and grain protein at flowering time. SPAD meter reading and leaf color chart will also be tested for the same purpose. The final goal of this research is to find approaches to a simple and rapid method to manage late N fertilizer to reach desirable grain protein content.

References

Clarke, J.M., 2001. In: Abecassis, J., Autran, J.C., Feillet, P. (Eds.), Durum Wheat, Semolina and Pasta Quality. Recent Achievements and New Trends. INRA, Paris, pp. 27–54.

Miyan S. and W. Anderson. 2003. Conference at the Australian Society of Agronomy Society.

Ottman, M.J., Doerge, T.A., Martin, E., 2000. Agron. J. 92, 1035–1041.

Wang Z.J., J.H. Wang, L.Y. Liu, W.J. Huang, C.J. Zhao, C.Z. Wang. 2004.. Field Crops Res. 90: 311-321.

Wright D.L., V.P. Rasmussen, R.D. Ramsey, D.J. Baker. 2004. GIScience Rem. Sensing 41: 287-300.

Table 1. N application rate at different growth stage

Growth stage (Date)	Nitrogen rate (lb/A)				
	N1	N2	N3	N4	N5
3-4leaf (1/18/2011)	0	15	30	55	80
Jointing (3/9/2011)	0	10	20	30	40
Flag leaf (3/24/2011)	0	20	30	40	60
Flowering (4/11/2011)	0	20	30	40	60
Total	**0**	**65**	**110**	**165**	**240**

Table 2. Grain yield, biomass, and grain protein content in six durum wheat cultivars grown under three nitrogen rates in the season 2009-2010.

Nitrogen Applied (lb/A)	Variety	Grain yield (lb/A)	Protein (%)
0	Duranking	1146 a	9.4 a
0	Topper	1645 a	9.6 a
0	Kronos	1433 a	8.6 a
0	Havasu	1734 a	8.7 a
0	Orita	1298 a	9.6 a
0	Ocotillo	1792 a	9.3 a
65	Duranking	3010 a	12.2 a
65	Topper	3345 a	12.4 a
65	Kronos	3370 a	11.3 b
65	Havasu	3266 a	11.8 ab
65	Orita	3226 a	11.5 b
65	Ocotillo	3063 a	12.3 a
110	Duranking	3946 a	12.7 a
110	Topper	4306 a	13.4 a
110	Kronos	4483 a	12.2 a
110	Havasu	4719 a	12.8 a
110	Orita	4556 a	12.6 a
110	Ocotillo	4288 a	13.2 a
165	Duranking	5985 a	12.7 c
165	Topper	5762 a	13.8 abc
165	Kronos	5934 a	13.9 ab
165	Havasu	5639 a	13.7 bc
165	Orita	6088 a	14.0 ab
165	Ocotillo	5585 a	14.8 a
240	Duranking	6611 a	14.4 b
240	Topper	6324 a	14.5 b
240	Kronos	5557 a	14.7 b
240	Havasu	6488 a	15.5 a
240	Orita	6524 a	15.1 ab
240	Ocotillo	6065 a	15.0 b

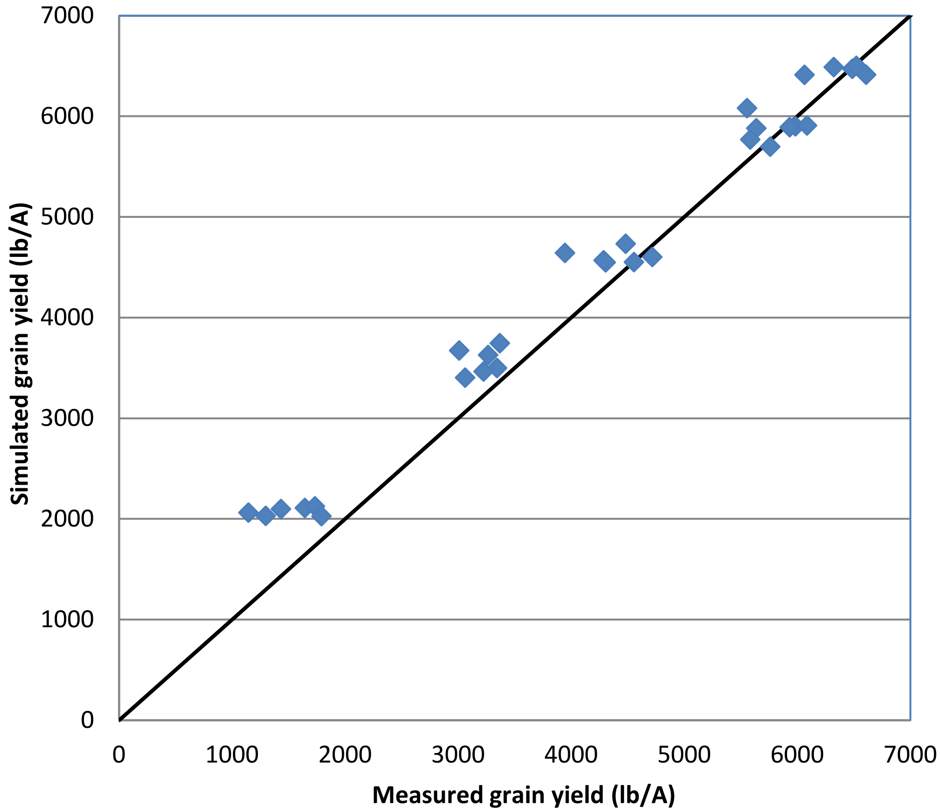

Figure 1. The relationship of measured grain yield and grain yield simulated by DSSAT crop growth model. The data points are means of grain yield or protein content from each treatment of six durum wheat variety under five N rates.

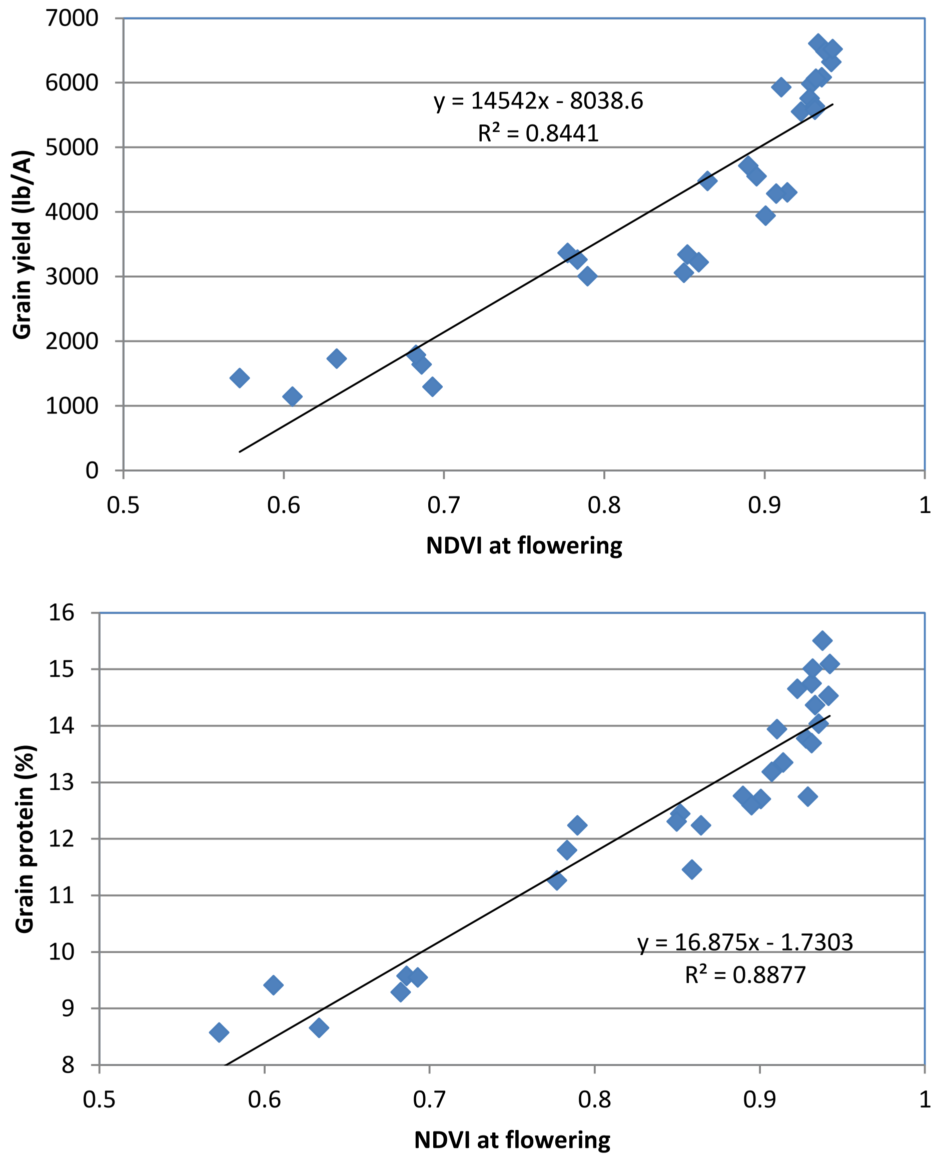

Figure 2. The relationship of NDVI at flowering time with grain yield (above) and grain protein content (below) at harvest. The data points are means of grain yield or protein content from each treatment of six durum wheat variety under five N rates.

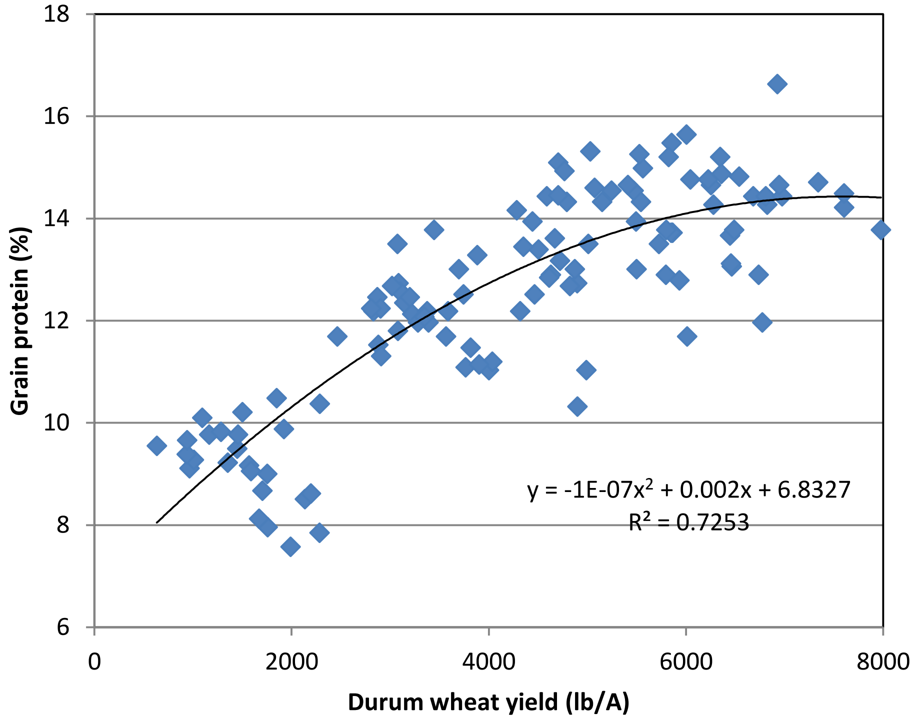

Figure 3. The relationship of grain yield and grain protein content in this study. The data points are grain yield and protein content of six durum wheat variety under five N rates.