PREDICTING PROTEIN WITH FLAG LEAF N? MADRAS CASE STUDY

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ABSTRACT

Low protein discounts reduce returns to hard red spring wheat producers. A survey of 48 irrigated commercial hard red spring wheat fields in central Oregon was conducted to relate flag leaf N and cultural practices to grain protein at harvest. Flag leaf N samples were collected based on published and unpublished small plot research but flag leaf N was not at all helpful in predicting protein in this survey of commercial fields. Potential pitfalls of applying the small plot research results to a commercial scale include the difficulty of collecting representative flag leaves at precisely the same growth stage in all fields, using different sample collection systems for flag leaves and grain protein from spatially variable fields, laboratory result variability, and possibly the broad spectrum of growing conditions and N status of the wheat. The survey did reveal some of the basic relations between yield, protein and available N for the production system. A fertilizer N per bushel ratio of 2.2 was associated with 14% grain protein at harvest. Using such a ratio may have potential for managing both early and late season N for hard red wheat protein enhancement.

INTRODUCTION

Higher prices for the hard red spring wheat (HRS) market class can increase returns to traditional soft white wheat producers if they can avoid low protein discounts. HRS protein in the higher rainfall or irrigated production area is typically low without either late season applied N or N applied in excess of that required for yield. An accurate pre-flowering prediction of protein at harvest would be useful for avoiding low protein discounts as it would help determine the need for corrective measures such as late season applied N. Flag leaf N was superior to earlier plant sampling for predicting hard red winter protein (1). Flag leaf N contents were found to be significantly associated with HRS protein and the protein increase resulting from specific rates of late season applied N (2,3). Both of these studies identified critical flag leaf N contents of 4.2-4.3% as the concentration above which little if any protein increase would be expected from an application of 40 lb/A of late season N. These small plot research studies have provided the data to support the general recommended use of flag leaf N testing for protein prediction. But the value of flag leaf N testing on a commercial scale has been more difficult to document. The objective of this paper was to evaluate flag leaf N testing on a commercial scale in the real world of irrigated HRS production.

METHODS

Protein from 48 producer fields of HRS in Central Oregon was examined in a survey conducted by the local Coop to evaluate cultural practices and flag leaf N testing and their relation to protein. Flag leaf % N from 35 fieldmen collected samples was determined in a commercial laboratory. Flag leaves were reported to be sampled at flag leaf emergence. Grain samples from the trucks from each field at harvest were sampled upon delivery to the elevator. Protein was determined on the grain samples by NIR. Yield, variety, planting date, leaf sampling date, N applied, irrigation method and previous crop were recorded. Pre-plant residual

N was available for only six fields in this survey. Regression was used to relate flag leaf N to protein as well as for other relationships of interest.

RESULTS AND DISCUSSION

Yecora Rojo was the most commonly used variety accounting for 85% of the fields surveyed. Previous crops included twelve small grain fields (winter wheat, spring wheat, or barley) eleven Bluegrass seed fields, nine carrot or garlic fields, nine sugarbeet fields, three Coriander fields, three fallowed fields, and one potato field.

The preplant N applied to each field ranged from 100 to 250 lb/A with a mean of 195 lb/A. Nine of the 48 fields were flood irrigated, the rest were under sprinklers. Flood irrigated fields averaged 13.0% and sprinkler fields averaged 13.5% protein. Reported yields ranged from 70 to 146 bu/A and averaged 105 bu/A. The survey included fields planted as early as March 1 and as late as April 27. The survey covered diverse cropping practices and growing conditions.

Flag leaf N ranged from 3.8 to 5.6 % with an average of 4.6%. Mean flag leaf N for small grain, grass seed, sugarbeet, and carrot/garlic crops were 4.69, 4.73, 4.75, and 4.91% respectively. Of these samples, only 2 of the 35 samples were reported to have flag leaf N below 4.2% at heading, the published critical level for affecting protein with 40 lb N/A applied at heading. Since additional N for protein enhancement was to be scheduled based on flag leaf N content, little late season N was applied. Only six fields received late season N and four of these had no flag leaf N data reported.

Protein ranged from 11.2 to 15.7% and averaged 13.2%, despite flag leaf N averaging 4.6%, well above the critical level reported in previous studies for flag leaf N at heading. Mean protein for the small grains, grass, sugarbeets, and carrots/garlic were 12.8, 12.5, 13.5, and 13.9 % respectively. These previous crop protein means generally reflect the residue C:N ratio, fertilization, and residual N carryover generally associated with them.

Flag leaf N was regressed against protein (Fig. 1), total grain protein, and yield but there was no significant relationship between them. Flag leaf N was a dismal failure in predicting protein at harvest in this survey despite small plot based research reports indicating good agreement between flag leaf N at heading and harvest ripe protein. It would be no surprise to find in a commercial scale evaluation a weaker relationship between flag leaf N and protein, given the controlled conditions in small research trials, the reduced variability associated with small plot

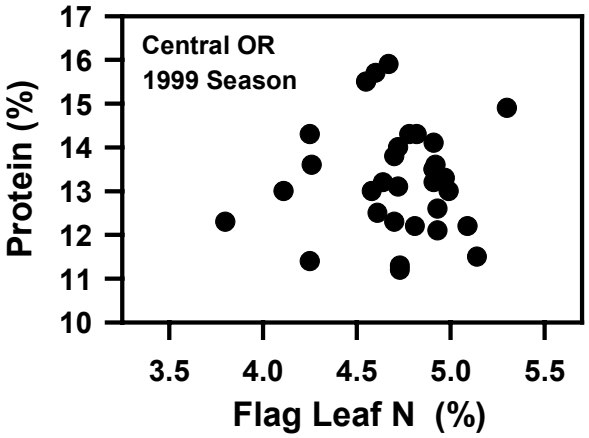

Figure 1. The HRS grain protein relation to flag leaf N in central Oregon for 35 commercial fields in 1999.

research, the relative ease of collecting representative leaf and grain samples, and the care given to the analyses in research programs. But to find no association at all between flag leaf N and protein in this survey was disheartening. It has shaken our confidence in the use of flag leaf N testing for protein prediction in the very commercial applications for which it was intended.

The survey data was further examined to reveal circumstances that could affect the flag leaf N protein relationship. There was a positive and weak but significant relation between flag leaf N and protein for the variety Express (r^2=52, n=6) which two growers used. But the relation for Yecora Rojo comprising 85% of the samples was not significant. In three of the sites, two fields or portions of fields with different previous crops were sampled together and reported as one, suggesting the possibility of variable flag leaf N or protein at the reported site. Such variability was particularly suspected at two of the sites where the previous crops were either grass/Coriander or grass/Carrots.

Flag leaf samples were reportedly collected at flag leaf emergence. Any deviation from sampling at a uniform growth stage would likely weaken the statistical relationship between flag leaf N and protein. It is difficult to know how uniform the flag leaf samples were in terms of timeliness of sampling and growth stage from the information provided. The days from planting to the date of sample collection were calculated for all fields from which flag leaves were collected. The number of days ranged from a low of 38 for an April 27 planting, the latest in the survey, to 108 for the earliest planting on March 1. The later the planting the fewer the days to the targeted growth stage and sampling date, as one would expect since heat units are accumulated more slowly early in the season (Fig. 2). There was a good linear correlation (r^2= 0.89) but even so there were some samples that deviated several days from the best fitted curve. For one planting date, the sampling date differed by 13 days, for another 11 days, and for another 10 days.

Given that there are only a few days separating flag leaf emergence and heading growth stages, it appears that a small number of samples were collected at somewhat different growth stages. Also, ten days difference in sampling for early planted wheat wouldn't make nearly as much difference in flag leaf N as with later plantings where there are fewer days between growth stages. The importance of sampling at uniform growth stages can't be over emphasized given the rapidly declining flag leaf N levels at succeeding growth stages. The days from planting relation

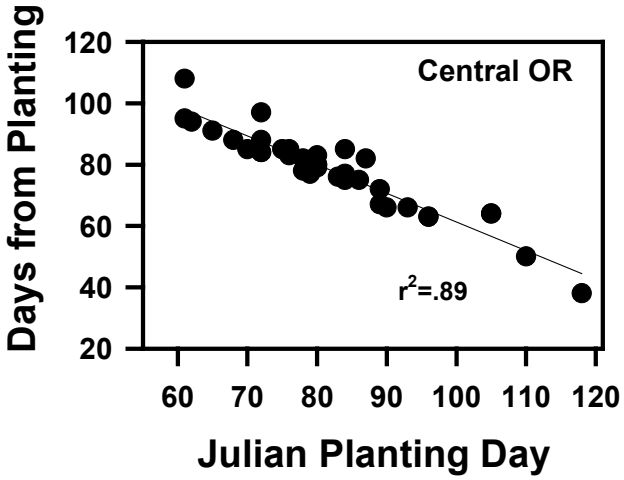

Figure 2. Days from planting that flag leaf samples were collected in 1999 as related to Julian date for planting in central OR.

for all but a few samples suggests that the samples were fairly uniform in their growth stage collection. In a practical sense, the data may point out the logistical challenge, during a time when several fields are approaching the target growth stage, for extensive sampling, by a limited number of samplers with other responsibilities.

The cited reports of flag leaf N involve flag leaf N at heading. Sampling in the survey appears to be earlier than the published reports, based on the coordinator's comments and corroborated with the mean flag leaf N levels for the survey. While it is likely that flag leaf N and protein in research trials are strongly correlated at flag leaf emergence, as they are reported to be at heading, the relation for flag leaf N and protein at flag leaf emergence has not been reported previously. Based on our experience, collecting flag leaves just after emergence rather than at heading would make a difference of from 0.2-0.5% higher N. Collecting leaf samples after heading would be even more misleading. Our experience suggests changes in flag leaf N of 1.7% between heading and flowering, assuming no additional N applied at heading.

While the flag leaf N data was disappointing, the survey data was instructive of basic yield, protein, and available N relations. Protein did not appear to be related to yield when all protein data were included (Fig. 3a). However, if the data were partitioned by protein into two data sets, data above and below 13% protein, significant yield protein relationships are revealed (Fig. 3b). The dividing protein value of 13% was chosen because HRS yields in our experience are limited by insufficient available N if protein does not reach at least 12.5%. Below 13% protein, yield

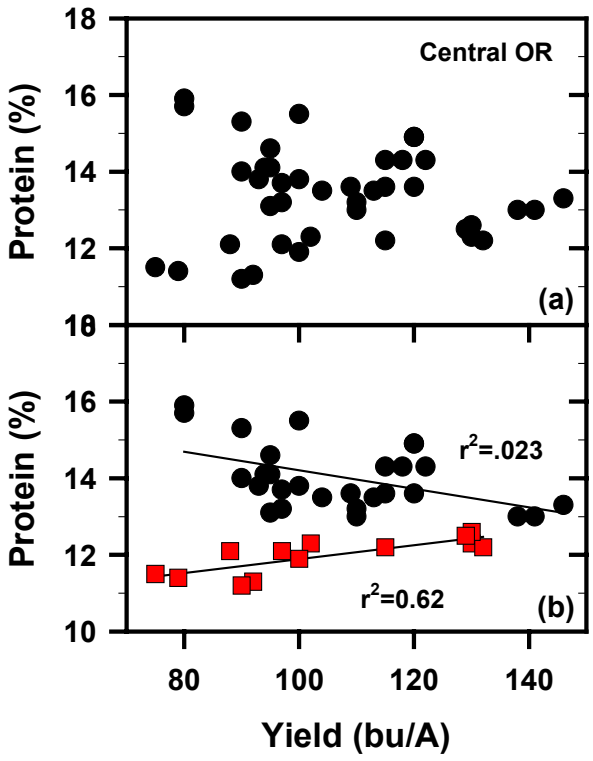

Figure 3. Protein relation to yield in central OR for (a) all the data and (b) for data divided at 13% protein.

and protein were positively and significantly related (r^2=0.62) as one might expect if both yield and protein were simultaneously increased with increasing available N.

In contrast, above 13% protein, protein and yield are negatively and significantly but more weakly correlated (r^2=0.23). The latter relation might be expected where the N requirement for yield is satisfied and yield is solely a function of the growing conditions and management provided. When yield is not limited by N, protein can be expected to decrease under higher yield conditions, conditions most conducive for grain filling, as protein deposited in the grain is diluted with higher starch content. The negative correlation of protein and yield points out the particular challenge of producing both high yields and high protein HRS.

The fertilizer N per bu ratio was calculated for each field within each partitioned data set. For protein above 13%, protein increased as the ratio increased (Fig. 4a) as one might expect

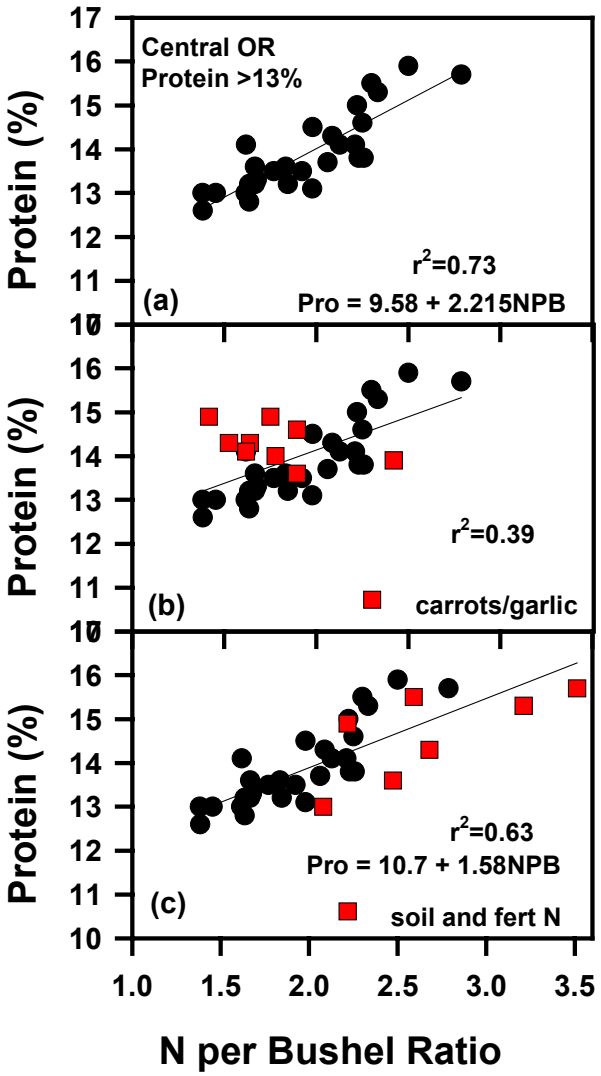

Figure 4. Protein as related to the calculated fertilizer N per bushel for central OR sites with over 13% protein where (a) all previous crops but carrot/garlic are included, (b) carrot/garlic sites are included, and (c) the N per bushel ratio was corrected for residual N at planting.

where yields are no longer increased with N but protein continues to increase. From this relation 14% protein was associated with a ratio of 2.2 lb N/bu. Residual soil N was not measured in most fields. There was no mineralizable N data to include. Including residual and mineralizable N sources would likely shift the best fit regression line to the right. Figure 4a does not include data for the sites involving previous crops of carrots or garlic. These crops are generally highly fertilized and result in considerable N carryover to subsequent crops. When the data for carrots and garlic are included in Fig. 4b it shows how confounded the data can be if residual N from crops with lower N utilization efficiency are not taken into consideration. Very limited residual N data were available, but where it was available, Fig 4c shows the improved fit when it is included in the ratio. For the <13% protein data, the protein and N/bu ratio relation was negative with almost no slope.

The protein vs N per bu relation in figure 4 integrates the effects of yields. Using this relation, adjusted for whatever significant N sources that can be included, may have potential for predicting the N required to support both high yield and high protein in the irrigated intermountain West. Yield estimates are already used for some wheat N recommendations. Data is needed from similar surveys elsewhere and research to corroborate this approach.

In summary, flag leaf N proved woefully inadequate for predicting protein of HRS grown in commercial fields of central Oregon, despite published and other small plot research indicating a good correlation. Information from this case study revealed the potential limitations of extending general N fertilizer recommendations for protein enhancement from small plot research to a commercial scale. The survey also provided useful information for future management of HRS for both high yield and high protein.

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