Fertilizing for Wheat Yield and Quality

By T.S. Murrell

Data from Colorado on dryland winter wheat showed significant yield increases to nitrogen (N) in 10 of 19 site-years. Significant protein increases occurred in 17 of 19 site-years, or about 90 percent of the time. Under irrigated conditions, yield increases may be achieved more frequently.

As recommendations are created for N and phosphorus (P) management for wheat, it is important that the impacts on protein be considered.

An example of the combined responses of hard red spring wheat yield and protein content to N fertilization is shown in **Figure 1**. Irrigated yield response to N was curved, and protein response was linear. Gross revenue (**Figure 2**) was a function of both yield and price increases from higher protein content. Costs included in this calculation were: soil sampling ($0.45/A), fertilizer N ($0.15/lb N), broadcast application ($3.27/A), harvesting ($0.10/bu), hauling ($0.16/bu), and grain handling ($0.07/bu). Net crop price was a step function, since price was assumed to increase ($0.05/bu) for higher protein or decrease ($0.07/bu) for lower protein every 0.25 percent relative to the $2.88/bu base price for 14 percent protein wheat. A min-

Protein is a valuable quality component of wheat. Higher protein content in hard red wheats can translate to better flours and, most importantly for the farmer, higher commodity prices. Proper fertilization is a critical management strategy for higher protein wheat.

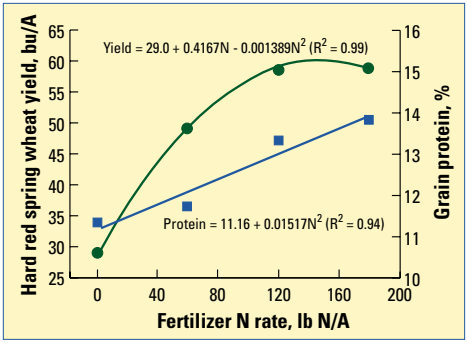

Figure 1. Irrigated spring wheat yield and protein response to N fertilization in 1995 at Bozeman, MT, no late-season N applied.
(Westcott, M. 1998. How to get higher spring wheat protein more efficiently. MontGuide MT9806ag. Montana State University Cooperative Extension Service, Bozeman. Available online at http:/www.montana.edu/wwwpb/pubs/mt9806.html).

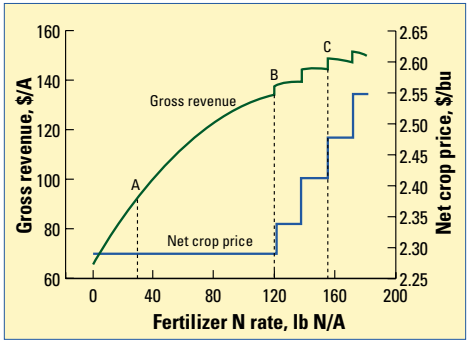

Figure 2. Gross revenue and crop prices at various N rates for the data in Figure 1. Line C denotes the optimum rate of N. Line A denotes the N rate where added revenue is great enough to pay for all fertilization costs at the optimum rate. Line B is the N rate producing revenue great enough to cover total costs of production, excluding irrigation expenses.

imum price of $2.62/bu was used. This was the lowest price available for low protein spring wheat at the time this article was written and included a loan-deficiency payment (LDP).

TABLE 1. Comparison of net gains to net losses in N response regions defined in **Figure 3**.

Region	Cumulative net losses from incremental increases in N rate	Net gain from price increase	Net gain + cumulative net losses	N rate at end of region where price increase occurred, lb N/A
	$/A			
1	-2.92	51.56	48.64	127
2	-0.33	2.01	1.77	138
3	-1.97	2.01	0.04	155
4	-3.54	1.85	-1.69	171
5	-3.34	0.00	-3.34	—

Jumps in gross revenue complicated calculations of optimum rate. Optimum rate is usually defined as the rate at which an increment of fertilizer produces a response equal in value to its cost. Such a definition assumes N response behaves in a classical manner, as in **Figure 1**. Nitrogen rates higher than optimum would result in yield increases too small to cover additional N costs. However, in this case, increasing N beyond such a point ($ return/$ invested = 1) resulted in increased crop prices due to higher protein content (**Figure 3**). The benefit of an increased price had to be weighed against the losses in marginal returns incurred before the price increase was encountered. Responses to N were divided into five regions. Region 1 was characterized by steadily decreasing marginal returns and a jump in crop price. The ratio of incremental income to incremental cost was 1 or above for this region. The first increment of fertilizer resulted in marginal returns less than 1 since it incurred all sampling and application costs in addition to an incremental N cost. Regions 2-4 were all characterized by marginal returns less than 1 followed by a price increase. Region 5 was marked only by declining marginal returns.

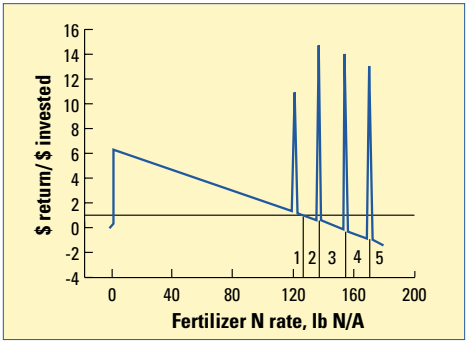

Figure 3. Marginal returns ($ return/$ invested) at incremental N rates. A reference line for a ratio of 1 is provided. Sharp features represent increases in overall crop price from protein improvement.

For each region, cumulative net losses were compared to net gain from the price increase (**Table 1**). If net losses were less than the net gain, then the additional N was considered profitable. Such comparisons in **Table 1** result in an optimum rate of 155 lb N/A, which generated gross revenue of $150/A. Beyond this rate, losses were too great to be recovered by an increased price. If an optimum rate had been calculated assuming a fixed protein content of 14 percent, the recommendation would have been 129 lb N/A which would have generated gross revenue of $140/A. Not accounting for price increases from protein would have resulted in an N recommendation of 26 lb N/A less and would have lowered gross revenue by $10/A.

Aiming for higher protein content in wheat incurs certain risks. The prices associated with various protein percentages vary by year and are based on factors related to weather and crop conditions that affect supply and demand of higher protein wheats.

Research is being conducted in the U.S. and Canada to determine factors important for estimating whether premiums or deductions are likely to occur within a given year. Also, late applications of N, such as those investigated in Montana, may allow producers to target higher protein when better estimates of market conditions are available.

(continued on page 20)

tional random samples, for a total for 40 samples. Plotting a semi-variogram, you can determine whether the sampling points are close enough together to assume spatial correlation between points. If the plot shows points are not correlated, accurate interpolation between points is not possible and they should be treated as independent values. BC

Dr. Reetz is PPI Midwest Director, located at Monticello, Illinois. E-mail: hreetz@ppi-far.org.

This work is a part of the technology development and evaluation under the Site-Specific Crop and Soil Management Systems project sponsored by the Foundation for Agronomic Research and PPI with major support from the United Soybean Board, the Illinois Council for Food and Agricultural Research (C-FAR), and co-sponsorship from a wide range of other partners.

Fertilizing for Wheat... *(continued from page 17)*

Environmental risks are also present. Fertilizing for higher yields when moisture becomes limiting can lead to higher residual N left in the soil profile. Soil testing to determine the quantity of N present at the start of the next growing season is critical to using N effectively.

Balanced fertility is important to environmental protection as well as profits. Paying attention to all nutrient needs is central to profitable wheat production. As an example, data in **Tables 2** and **3** show the impact of a fertility program that includes both N and P. These data show that N and P work together to increase yield, protein content, selling price, and returns. Although returns to fertilization were good, returns to total costs were negative for both the fertilized and unfertilized cases. Under current low crop prices and depressed economic times, fertilization may not guarantee positive returns, but proper fertilization can minimize losses. A recent survey by PPI found that 34 to 90 percent of the soil samples tested in major wheat producing states were medium or below in P. Rectifying deficiencies of nutrients, such as P, is necessary for increasing production and gross revenue.

TABLE 2. Response of the Hi-Line hard red spring wheat variety to N and P fertilization (five-year average), G.R. Carlson, unpublished.

Variety	Treatment	Yield, bu/A	Protein, %
Hi-line	66-33-0	42.58	14.31
Hi-line	unfertilized	24.41	10.97
Increase from fertilizer		+18.71	+3.34

TABLE 3. Economic impact of N and P fertilization on the Hi-Line hard red spring wheat variety, G.R. Carlson, unpublished (prices used are same as for **Figure 2**).

Treatment	Selling price $/bu	Total costs	Return to fertilization costs $/A	Return to total costs
66-33-0	2.93	128.16	28.93	-17.45
Unfertilized	2.62	109.85	0.00	-53.95
Difference	+0.31	+18.31		+36.50

One of the major concerns of dryland wheat production has been financing a fertilization program. Margins in such systems are narrow. Producers often struggle to get loans for needed fertilizer. Balanced fertility that targets higher protein may help producers find much needed revenue that will widen profit margins and further develop an upward cycle of land improvement and profitability. BC

Dr. Murrell is PPI Northcentral Director, Woodbury, Minnesota. E-mail: smurrell@ppi-far.org.