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Winter Wheat Response to Available Nitrogen and Water

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Nitrogen (N) is the most common nutrient limiting yield of wheat and other crops in Montana. Deficiency symptoms are frequently characterized by general chlorosis (yellowing) of leaves and a reduction in overall plant vigor and growth. In winter wheat, deficiency symptoms most often appear in the early to late spring depending on the level of severity. Once present, symptoms become more severe through vegetative growth stages. At flowering, N deficient plants will be shorter, contain fewer fillers and smaller heads than healthy plants. Ultimately, grain yield is reduced and the grain protein is low.

Nitrogen typically represents a grower's largest fertilizer cost input. Current fertilizer N recommendations are based on an average relationship between N requirements (NR) and estimated yield potential [NR (lbs/acre) = Yield potential (bu/acre) x 2.51]. The recommendation assumes 2.5 lbs N/acre are needed to produce each bushel of grain. However, in reality, this relation varies with location, growing season, management, yield potential and variety selection. Since yield potential is most closely associated with available water (stored soil water + growing season precipitation), we were interested in determining the affects of available water supply on available N requirements and winter wheat yield potential.

Field experiments were conducted on a Yegen sandy loam in southcentral Montana during 1986-87 and 1987-88, or the 1987 and 1988 seasons, respectively. A single irrigation-line or line-source sprinkler irrigation system, was used to establish a water gradient in the field to simulate a wide range of rainfall conditions. Stripped at right angles to the irrigation-line were seven fertilizer N levels (0, 40, 80, 120, 160, 200, and 240 lbs N/acre). 'Redwin' winter wheat was seeded in 12 inch rows at 85 lbs/acre. Nitrogen was applied at seeding in a band 3 inches below and to the side of the seedrow. Sufficient P and K were applied to maintain adequate levels.

Available N was defined as the sum of fertilizer N applied + soil nitrate-N (0-48 inch depth). Available water was the sum of net soil water loss (0-48 inch depth) plus precipitation received between April 1 (approximate beginning of spring regrowth) and the hard dough stage. Economic return from N was computed as the product of yield and unit grain price ($3.50/bu), minus the product of available N level and material N cost ($0.20/lb). Soil N was assumed to be equal to fertilizer N in terms of its contribution to yield and cost of production.

As expected, available water increased wheat yield potential, but the response to water was much different for the two growing seasons (Figure 1). Yield response to water and maximum yields were much greater in 1987 than 1988 due to cooler, more seasonable, air temperatures during grainfill (anthesis to maturity). The 1988 season was characterized by an intense and prolonged heat-wave during grainfill. Temperatures during this growth stage averaged 73.5°F (mean of daily maximum and minimum) in 1988, or 8.5°F higher than in 1987. High temperatures at anthesis can lead to floret sterility and fewer kernels per head. After anthesis, high temperatures reduce kernel weight by hastening maturity and shortening the duration of grainfill. The net effect is to reduce wheat yield response to water and yield potential during years of high heat stress. With irrigated wheat production, farmers typically view high temperatures in combination with drought as a signal to apply additional water. The results of this study illustrate that large, economical yield responses to water are not as likely to occur under such conditions.

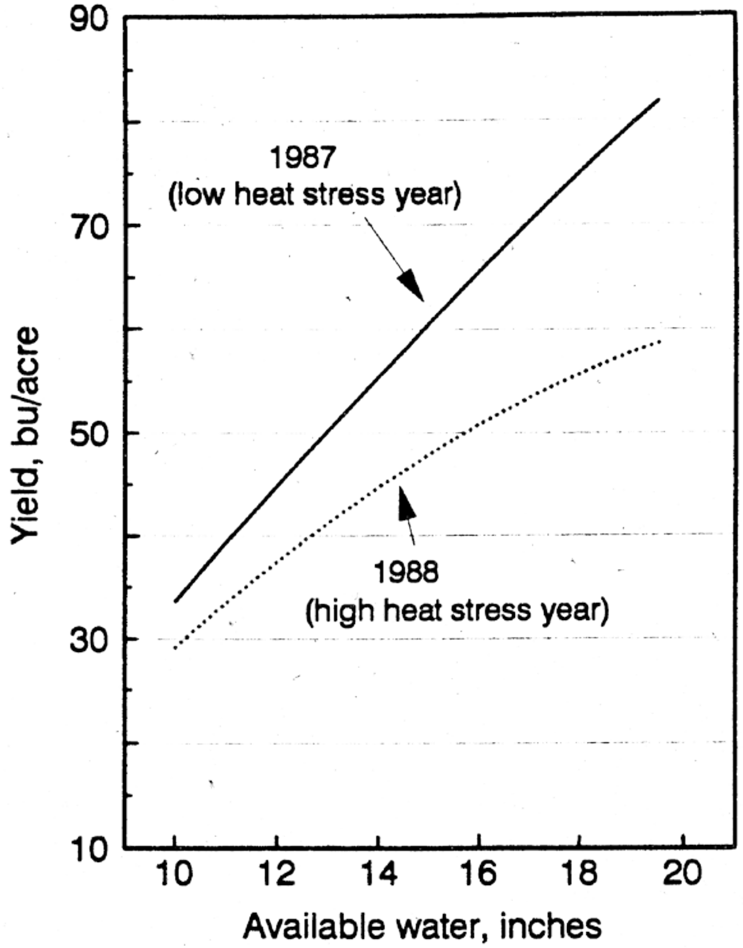

Figure 1. Winter wheat yield potential as affected by changes in available water.

Yield and available N relations were affected by water and differing heat stress conditions (Figure 2). Yield response to fertilizer N was greater in 1987 than 1988 at similar water levels. The larger N response in 1987, particularly under high moisture conditions, was a result of lower indigenous soil N levels and the higher yield potential.

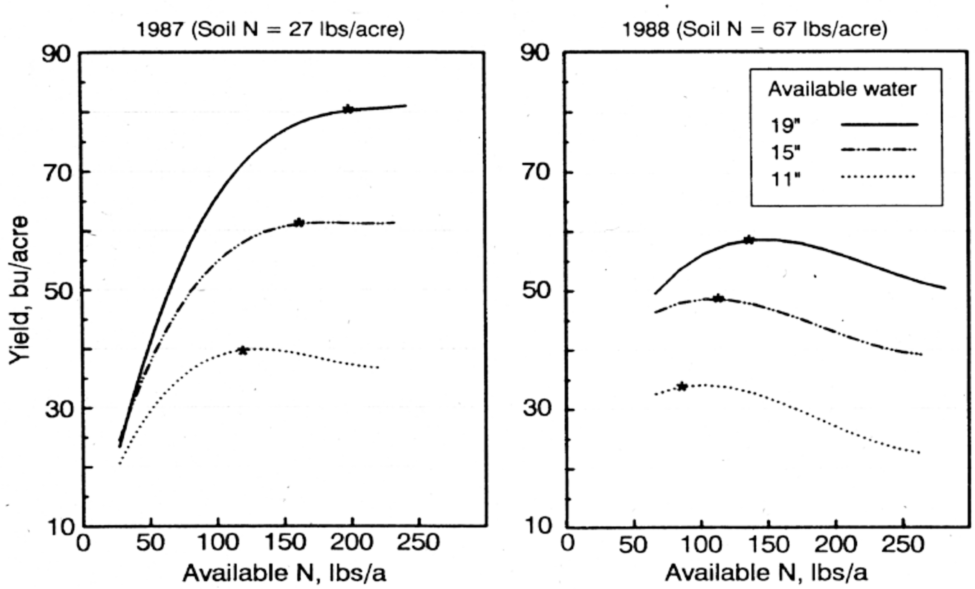

Figure 2. Winter wheat yield in 1987 and 1988 as affected by available N and water

level (*=maximum economic return from N).

Excess N fertility is sometimes blamed for reduced wheat yield. In our study, significant yield reductions from high fertilizer N levels occurred in 1988. During this season, high N fertility reduced yield at all moisture levels. These N-induced yield reductions appeared to be associated more with the heat-stress conditions of this season than drought stress. In general, soil water content and wheat water use were not affected by N fertility above I 10 IN available N/acre. In 1987, a low heat stress season, only small yield reductions from N occurred and only under low available water conditions (i.e., 11 inches).

Maximum economic yield and optimum N levels (ONL were defined as the point along the yield-N curves (Figure 2) where increases in N no longer paid for themselves through higher yield, or where dollars returned from N was maximized. As expected, ONL increased with available water, but due to the lower yield potential, N requirements in 1988 were 73% of the 1987 levels (Figure 3). The ONL-available water curves for 1987 and 1988 may be viewed as a picture of winter wheat N requirements during seasons with 'favorable' and 'severe' environmental conditions, respectively. Though seasonal differences in N requirements and associated N costs appeared large, a satisfactory compromise strategy of N application can be developed by averaging the results from the two seasons. Using this approach, sufficient fertilizer N should be applied to achieve 90 lbs available N/acre where 10 inches of available water is expected during the growing season. If water conditions improve, N application is increased 15 lbs/acre per 2 inch increase in available water. The resulting line lies approximately midway between the 1987 and 1988 ONL-available water curves. In addition, the economic return from N using this strategy is within 2% of the maximum under favorable (1987) and severe (1988) conditions.

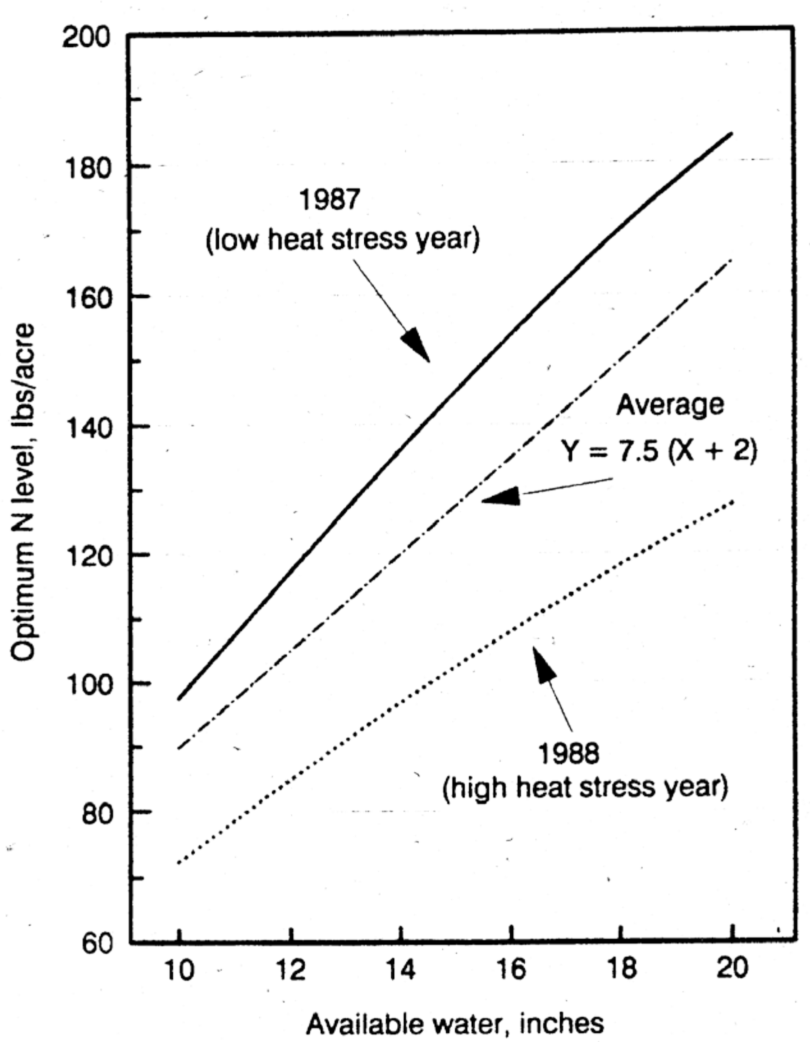

Figure 3. Available N requirements for maximum winter wheat yield, or optimum N level, as affected by changes in available water.

Fertilizer Facts

- The effect of supplemental water on winter wheat yield is greater under low heat stress than high heat stress.
- Estimates of available water and residual soil test nitrate-N must be used to calculate N fertilizer requirements.
- Optimum N level (ONL, lbs/acre) for winter wheat increase with available water (AW, inches) according to the relationship ONL 7.5 (AW + 2).

(*Edited by Jeff Jacobsen, Extension Soil Scientist)*