THE EFFECT OF FERTILIZER N, SPRING MOISTURE, AND RAINFALL ON THE YIELD AND PROTEIN CONTENT OF BARLEY IN ALBERTA

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Lethbridge is in the Dark Brown soil zone. It receives an average of 400-mm annual precipitation, about 1/3 of this falling during June and July. In this semi-arid region most dryland farmers have followed a 2-year rotation. After cropping, the soil is kept barren or summer-fallowed the following year.

In the past few years better moisture conservation, the use of higher levels of N fertilizers, and better chemical weed control practices have made recropping more popular. Wind erosion and dryland salinity related to improper or unnecessary summerfallowing have encouraged recropping.

Because cereal yields are dependent on soil-stored water in southern Alberta, we have advocated that farmers base their decision regarding the feasibility of recropping on the level of spring soil-stored moisture. Rules of thumb such as "If the soil is moist to a depth of 27 inches, then recrop" have evolved. Unfortunately, 27 inches of moist soil can contain a variable amount of water, depending on the texture and the moisture content of the "moist soil".

If sufficient moisture is present to justify recropping, the provincial soil testing laboratory suggests that farmers adjust to their N fertilizer recommendation, depending on the level of spring soil-stored water.

Critical levels of soil water to justify recropping and the degree to which fertilizer -N levels should be adjusted relative to soil moisture have not been established. This study was designed to quantify these relationships for spring barley (Hordeum vulgare L.).

Methods and Materials

In 1973 a field experiment was established in which 12-m x 12-m field plots were fall irrigated with 2.5 to 10 cm of water to simulate fall rainfall. Other plots were covered with PVC to exclude snowmelt and

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early spring rain or left unchanged. Soil-stored available moisture in the surface 120 cm has varied from 7 to 24 cm on June 1. This date was selected as the date to measure soil moisture since yields of barley seeded after that date are frequently reduced.

Six levels of N fertilizer, 0 to 180 kg/ha, have been split on each main plot in strips of 1.2-m by 12-m drilled in at right angles to the direction of seeding. The central 90 cm were harvested with a plot combine. Yield was determined and samples analysed for total N. Percent protein was calculated by multiplying %N of dry samples by 6.25.

The study was set up as a 6 x 6 factorial in 4 reps although only regression analysis of the actual measurements is presented. June - July precipitation varied from 41 to 157 mm during the 5-year study, representing the 95 to 25% probability levels of precipitation (more rain can be expected than these levels 95 to 25% of the time). This wide range in precipitation gives us confidence in the scope of data. Recropping for 2-6 years reduced soil test NO_3-N levels to very low values.

Results and Discussion

The yield of barley (Y) in kg/ha, as a function of available spring soil-stored water (W_S) in cm, June - July precipitation (Ppn) in mm and the N fertilizer level (N) in kg/ha was determined by regression analysis to be:

$$Y = 1899 + 258\ W_S - 6.18\ W_S^2 - 70.3\ Ppn + 0.441\ Ppn^2 + 1.78\ N - 0.0416\ N^2 - 0.141\ W_s\ Ppn + 0.249\ W_S\ N + 0.0703\ Ppn\ N + 0.000626\ W_S\ Ppn\ N$$

$$R = 0.944$$

The percent protein (P) is described as follows:

$$P = 20.79 - 0.732\ W_S + 0.0173\ W_S^2 - 0.0480\ Ppn + 2.18 \times 10^{-4}\ Ppn^2 + 0.0370\ N - 3.60 \times 10^{-5}\ N^2 + 4.52 \times 10^{-4}\ W_S\ Ppn + 1.04 \times 10^{-3}\ W_S\ N + 2.03 \times 10^{-4}\ Ppn\ N$$

$$R = 0.723$$

Yields of Barley

The barley yield was highly dependent upon the levels of available soil water, precipitation, and N fertilizer as shown by the high correlation coefficient for Equation (1) and as shown in Figure 1. One cm of soil

moisture increased barley yield by 160 to 230 kg/ha at the 5 cm W_S level and from 0 to 80 kg/ha at the 20 cm level, depending on the level of N fertilizer. Data is plotted at the 117 mm precipitation level which is the 64 year average or the 0.50 probability level.

Yields were 500 to 900 kg/ha lower at the 87 mm level (P = 0.70) and little response was obtained from more than 60 kg/ha. The 148-mm June - July precipitation (P = 0.30) resulted in yields 1600 to 1800 kg/ha higher than those obtained with normal precipitation (data not shown).

Protein Content of Barley

The protein content of the barley, as predicted by Equation (2), decreased with increasing soil moisture, and increased with the level of N fertilizer (Figure 1). Soil moisture had a considerably greater inverse effect on protein levels than did precipitation (data not shown). This is surprising and may be due in part to the low multiple correlation coefficient (0.723).

Optimum Fertilizer Levels

By equating the differential of the dollar return, with respect to N, to the cost of a kg of N fertilizer we can calculate the optimum economic level of N fertilizer. Using an example of \$0.0734/kg barley (\$1.60/bu) and \$0.845/kg N fertilizer (\$.22/lb) the optimum N fertilizer level was increased by 20 kg/ha with each 5 cm increase in available soil water (Figure 2). Although the optimum N level varied directly with the level of precipitation the effect of soil water on the optimum N level was relatively independent of the level of precipitation (data not shown).

Economics of Recropping

Equation (1) can also be used to evaluate the relative economics of recropping. The necessary recrop yield (Y_R) for a given summerfallow yield (Y_F), cost of recropping (C_R), cost of cropping for summerfallowed land (C_{CF}), cost of the summerfallowing operation (C_F), and price of barley (P) is :

$$Y_R = \frac{Y_F}{2} + \frac{(2\ (C_R) - C_{CF} - C_F)}{2\ (P)}$$

If we assume an average summerfallow barley yield of 2500 kg/ha (46.5 bu/ac), and the annual costs of summerfallow cropping fallowed land, and recropping to be \$18.26/ha, \$73.78/ha, and \$84.98/ha respectively, then:

$$Y_R = \frac{2500}{2} + \frac{(2\ (84.98) - 74.78 - 18.26)}{2\ (.0734)} = 1780 \text{ kg/ha}$$

(Economic data supplied by R. R. Zentner, Agriculture Canada Research Station, Lethbridge)

This barley recrop yield will be obtained with average Lethbridge June - July precipitation of 117 mm if 7.5 cm of available water is stored in the soil (Figure 3). If the producer wishes recropping to be profitable 6 years out of 10 (greater than 103 mm June - July precipitation), more than 10 cm of soil water must be present on June 1 before recropping should be practiced.

Producing Malting Quality Barley

The variety of barley used in this study (Galt) is not eligible for C. W. grades, but produces protein levels similiar to those of eligible varieties under similiar field conditions. Maltsters require barley with less than 13.5% protein. Equation (2) predicts this protein level will be achieved with fertilizer -N levels increasing from 0 to 180 kg/ha as the soil water level increased from 7.5 to 20 cm (Figure 4). Barley with less than 12.5% protein is normally used for malting, and very low fertilizer -N levels must be used to cbtain barley with this low a protein content at Lethbridge, Alberta.

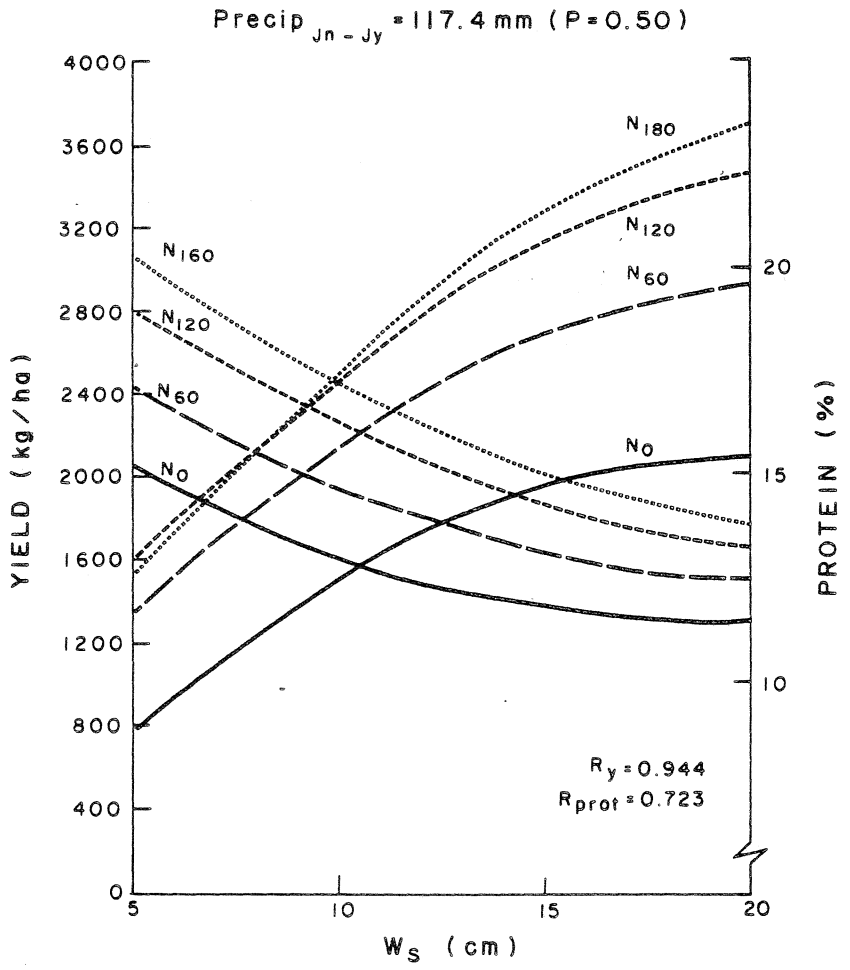

Figure 1: Increase in yield and decrease in protein content of barley as a function of available soil water at four fertilizer N levels (kg/ha), with an average (117mm) June - July precipitation.

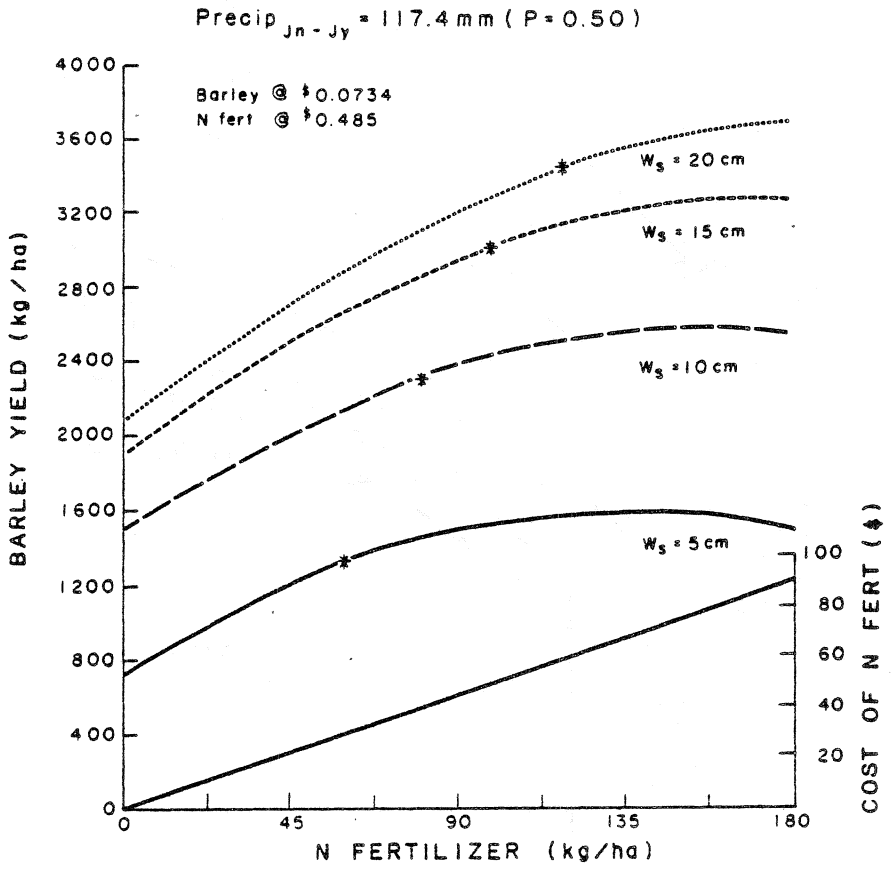

Figure 2: Effects of N fertilizer on barley yield at four levels of available soil water. Economic optimum N levels are indicated (*) for barley at $0.0734/kg ($1.60/bu) and N fertilizer at $0.485/kg (22¢/lb)

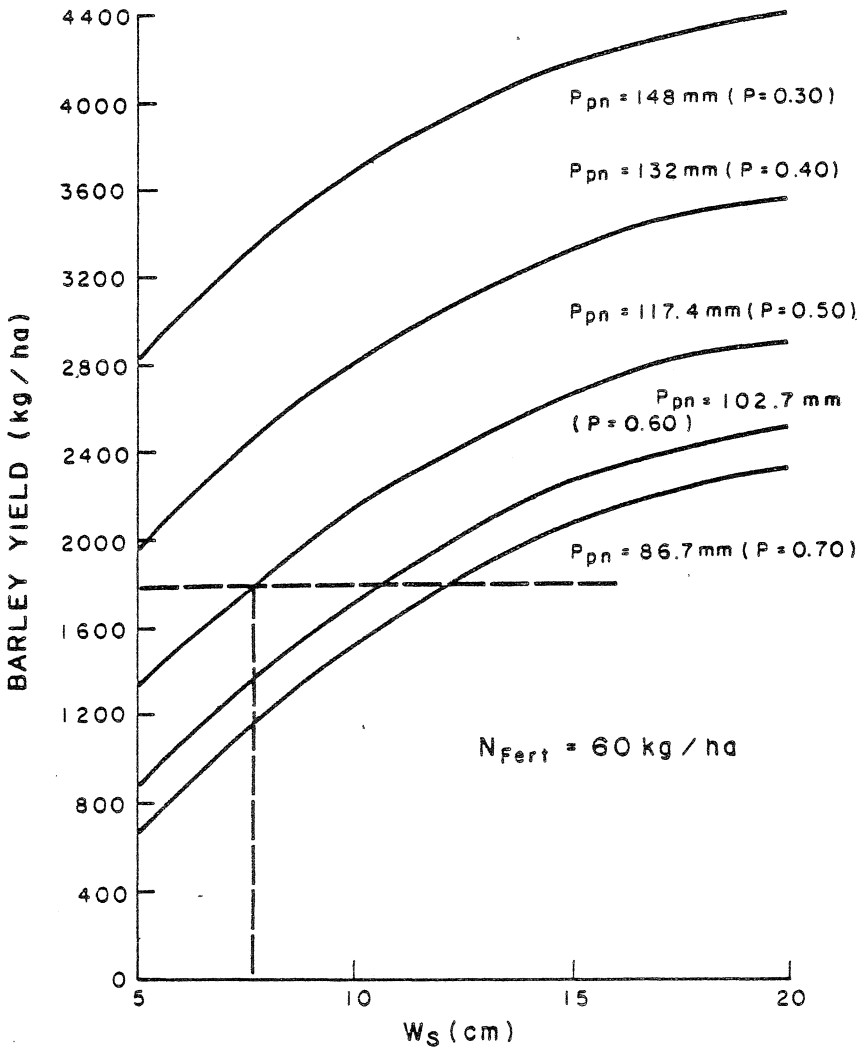

Figure 3: Effect of soil moisture on barley yield at five precipitation levels representing the probability of receiving more than the indicated precipitation level at Lethbridge, Alberta.

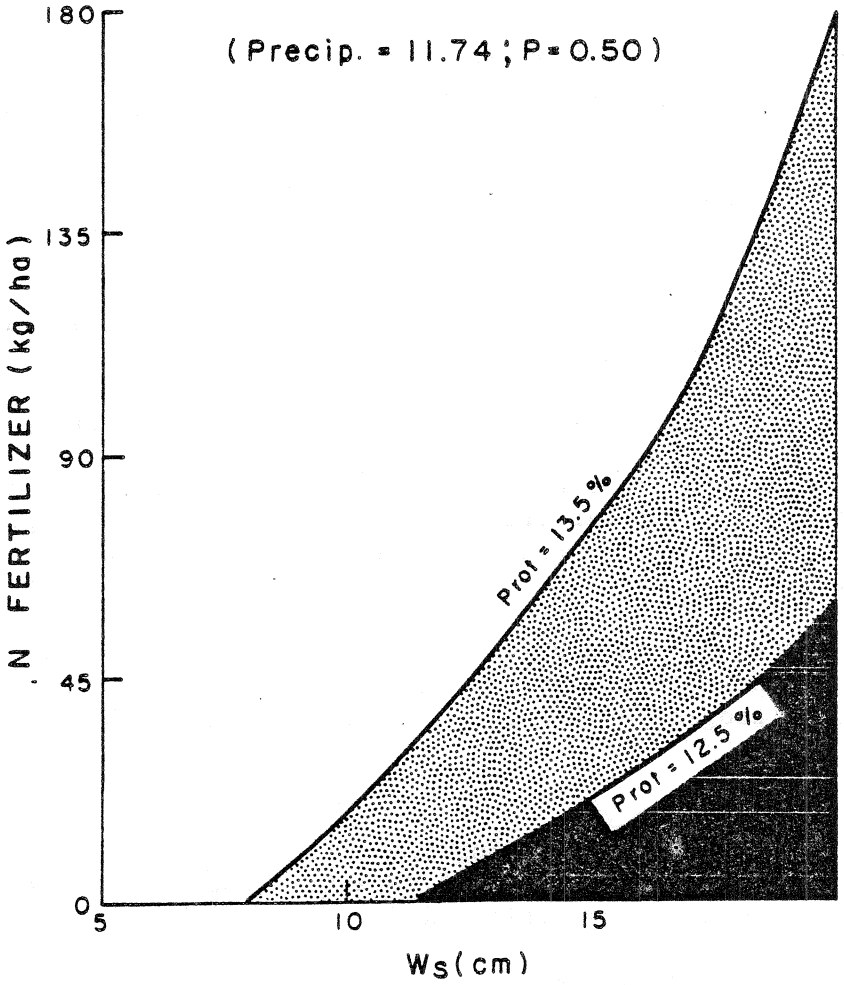

Figure 4: Effect of soil moisture and N fertilizer on the protein content of barley.