Barley Response to Water and Nitrogen Levels

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ABSTRACT

Results from one year's data show that yields of more than five tons per acre are feasible for Fiesta, Gustoe and NKX-1558 barley cultivars. The cultivar Barcott is a shorter season variety; yields were reduced by approximately one ton per acre, compared to the other cultivars. Additional data needs to be collected to verify the amounts of water and nitrogen required for obtaining optimum production.

INTRODUCTION

Management of water and nitrogen are crucial for optimum yields. Often excessive amounts of water and nitrogen fertilizer have been applied to insure optimum crop production because they were low in cost and/or readily available. However, with increasing demands on water resources and higher energy and fertilizer costs, a farm manager needs more information to determine the relationship between yield and water and nitrogen. Also, new pollution laws require that groundwater resources not be contaminated. Therefore, greater application efficiencies must be obtained.

Water and nitrogen are the two most important inputs affecting yields that Arizona farm managers can control. A crop water- nitrogen production function will provide an important management tool.

Crop water production functions have been developed for over 35 different crops; they typically show that yields will increase linearly up to a maximum and then decrease curvilinearly. Yield normally increases curvilinearly to incremental nitrogen applications. If nitrogen deficiencies occur, yields can vary greatly, depending on the time of initial deficiency and the stage of plant growth when the deficiency occurred.

Excess nitrogen applications can cause curvilinear yield decreases. However, the water production function and the nitrogen production function cannot be put together to determine the interrelationships between different water and nitrogen amounts.

MATERIALS AND METHODS

A self-moving lateral sprinkler irrigation system was modified to accurately apply the various levels of water and nitrogen. A central composite rotatable statistical design with 2 variables, water and nitrogen, is used in this experiment. This statistical design can determine the crop response function (yield) for the two variables, water and nitrogen. The water levels vary from 50% to 150% water applied (W.A.) and the nitrogen levels vary for 33% to 167% nitrogen (N) applied per acre. Optimum application of water and nitrogen is considered to be 100%. The

optimum level of water was determined by using a neutron probe to schedule irrigation amounts so that an adequate moisture level was maintained. Tissue analysis was used to verify that adequate levels of nitrogen were maintained in plant tissue.

Figure 1 shows a typical production function of 2 variables, water and nitrogen. As noted in this figure, the center point (100% W.A. and 100% N) is replicated 5 times.

The water and nitrogen rates specified in this design are:

TREATMENT	% W.A.	% N
1	50	100
2	65	53
3	65	147
4	100	33
5	100	100
6	100	100
7	100	100
8	100	100
9	100	100
10	100	167
11	135	53
12	135	147
13	150	100

Water applied in this experiment is defined as not only the unit or amount of water used on a given area for transpiration, the building of plant tissues, and evaporation from adjacent soils, but also that amount of water necessary to keep the total soluble salts in the soil at a desirable level and maintain an adequate yield.

A total of nine different levels of water and nitrogen combinations are defined by this statistical design with the center treatment replicated 5 times. This gives a total of 13 areas where different levels of water and nitrogen are applied. Each of these 13 water and nitrogen plots are 40 feet in length. The 13 plots were randomized down the crop row.

The different amounts of water applied is accomplished by using nozzles of different orifice size. Thus, the nozzles used in the 150% W.A. plots apply 3 times the amount of water as the nozzles used in the 50% W.A. plots. The amount of water applied during each irrigation is determined by measuring the time required to travel a selected distance. The different nitrogen application rates are accomplished by using different size orifices in each plot to meter the nitrogen into the irrigation water. Water samples are collected each time the nitrogen is injected to verify that the correct rate of nitrogen is being applied. The amount of nitrogen applied per application varies from 10 to 60 pounds per acre by changing the machine travel speed from 100% to 15%. High nitrogen applications result in high water applications since both are controlled by the machine travel speed. The nitrogen fertilizer applied in the irrigation water raises the total soluble salts about 100 ppm.

The experiment is located on the University of Arizona Yuma Mesa Experiment Station. The soil is a Superstition sand series. The infiltration rate of the soil is quite high, approaching 3 inches per hour, and the available water is low, less than one inch per foot. The irrigation water used in this study is Colorado River water having an average total soluble salt content of about 1000 ppm. The nitrogen source used to fertilize the plots is liquid ammonium nitrate. The use of this source allows us to determine the nitrate level in the water when nitrogen fertilizer is injected. Thus we could verify that the proper amount of nitrogen is applied to each plot.

Four cultivars of barley were planted on December 16, 1986 at a rate of 110-120 pounds per acre with a small plot grain drill to simulate normal planting procedures. All plots were irrigated with the uniform spray bar to accomplish uniform germination and initial plant growth. The four barley cultivars selected were Gustoe, Barcott, Fiesta and NKX-1558. These varieties were selected because they are full season cultivars and are representative of what is commercially available. All cultivars were planted in the same fields and received the same irrigation, nitrogen and cultural management. After uniform germination the variable spray bars were used to irrigate the barley varieties until maturity. During the germination period, 1.6 inches of water was applied. At the time of converting to the variable spray bar, nitrogen applications of about 10 pounds per acre were made bi-weekly until mid-February and the application of about 25 pounds per acre were made weekly until the first of April for the 100% nitrogen treatment. After germination and until mid-April only two irrigations per week were applied. From mid-April until May 13 three irrigations per week were applied. The total amount of water applied to the 100% treatment was 29.6 inches which includes the 1.6 inches of germination water. The amount of nitrogen applied to the 100% treatment was 210 pounds per acre. All four cultivars were harvested on June 5, 1987. The plot size of each treatment and cultivar was 3 1/2 feet by 30 feet.

RESULTS AND DISCUSSION

Results are shown in Table 1 for the four barley cultivars. Plant heights were measured just prior to harvesting. Typically plant heights increased with incremental amounts of water and nitrogen. There was not a tendency for plant lodging with increased water and nitrogen applications for the barley varieties as we had previously experienced with wheat cultivars. However, the Gustoe barley cultivar did have an 80% lodging in the treatment where 39.4 inches of water and 310 pounds of nitrogen were applied. Bushel weights for each treatment and cultivar were measured and are presented in Table 1. No consistent trends of bushel weights were determined from the effect of varying water and nitrogen amounts. The protein values for each cultivar and treatment were not available at the time this report was prepared.

The yields in tons/acre are shown for the four cultivars in Table 1. The yields presented here were adjusted to 10% moisture and represent clean grain weights. Yields increased with incremental water applications for all cultivars. Yield did increase for the Barcott and Fiesta cultivars when increasing nitrogen applications from 70 to 210 pounds/acre (Treatments 4 and 5, respectively). Yield also increased for all cultivars except for the NKX-1558 cultivar at the high water application of 39.4 inches when nitrogen levels were increased from 110 to 310 pounds/acre.

The yield data collected from each cultivar were fitted by regression to a quadratic equation. This quadratic equation is used to predict the yield for all levels within the range of water and nitrogen applications used in this study. The yield contours in tons/acre are shown in Figure 2 for the Gustoe cultivar. The equation used to predict these contours is:

$$Y = -4.324 + 0.483W + 0.0003N - 0.0071W^2 - 0.00002N^2 + 0.0003WN$$

R = 0.98** LOFF = 4.98ns F = 30.7** STD ERROR = 0.3 tons/acre

**99% confidence interval LOFF=lack of fit f ns=no significance

Where: Y = yield in tons/acre
W = water application in inches
N = nitrogen application in pounds/acre.

This equation is valid for the water application range of 15.6 to 43.6 inches and for the nitrogen application range of 70 to 350 pounds/acre. Erroneous yield values could result if water and nitrogen application values outside of this range are used.

As noted in Figure 2 the barley yield increases were primarily due to water in the range of 15 to 30 inches of water because the yield contour lines are nearly vertical. At higher water applications 30 to 45 inches the yield contours become curvilinear and indicate a maximum yield. A maximum yield of 5.7 tons/acre was determined from the quadratic equation for the Gustoe cultivar when applying 40 inches of water and 310 pounds/acre nitrogen.

Similar yield trends were observed for the other cultivars. The Barcott cultivar maximum yields were about one ton/acre less than the other varieties. Barcott is a shorter season cultivar and it matured about 3 weeks ahead of the other cultivars.

The same water and nitrogen management system that we developed for wheat cultivars was also used to manage the barley cultivars. Early observations suggest that we may not have applied enough water during the tillering stage of growth. We feel that this delayed growth, thus requiring additional amounts of water and nitrogen to be applied before the barley cultivars matured. We would speculate that about 30 inches of water needs to be applied with consumptive use estimated at around 25 inches of water. The barley cultivars planted did not respond to the higher nitrogen levels that we imposed. Even at the minimum nitrogen application of 70 pounds/acre we did not see visual nitrogen deficiency symptoms as we had observed in similar plots of wheat cultivars. These same experiments will be continued so that we can better define the best water-nitrogen management techniques for maximum production.

TABLE 1. Summary of Barley Results

Treatment	Inches Water Applied*	Pounds Nitrogen Applied	Plant Height Inches	Bushel Weight Pounds	Yield Tons/A
			BARCOTT		
1	15.6	210	16a**	46.0a	1.9a
2	19.8	110	19 b	48.5 d	2.7 c
3	19.8	310	15a	47.5 b	2.3 b
4	29.6	70	21 c	47.5 b	3.5 de
5	29.6	210	23 d	48.0 cd	3.9 f
6	29.6	350	24 d	48.5 d	3.8 ef
7	39.4	110	21 c	47.0 b	3.4 d
8	39.4	310	23 d	47.0 b	3.8 ef
9	43.6	210	24 d	46.0a	4.1 f
			FIESTA		
1	15.6	210	15a	49.0 b	2.2a
2	19.8	110	16ab	48.0a	2.8a
3	19.8	310	16ab	48.5ab	2.6a
4	29.6	70	18 b	51.0 d	4.0 b
5	29.6	210	24 de	50.8 d	4.7 c
6	29.6	350	25 ef	51.0 d	4.3 bc
7	39.4	110	21 c	51.0 d	4.1 bc
8	39.4	310	27 f	50.0 c	5.0 d
9	43.6	210	23 cd	51.0 d	5.0 d
			GUSTOE		
1	15.6	210	16a	48.0ab	1.8a
2	19.8	110	18 b	48.5ab	2.7 c
3	19.8	310	18 b	47.0a	2.1 b
4	29.6	70	22 c	49.0 bc	4.5 d
5	29.6	210	25 de	50.7 d	4.7 d
6	29.6	350	26 ef	50.0 cd	4.7 d
7	39.4	110	22 c	50.0 cd	4.5 d
8	39.4	310	27 f	49.5 bcd	5.0 e
9	43.6	210	26 e	49.5 bcd	5.4 f
			NKX-1558		
1	15.6	210	19a	47.0 c	1.6a
2	19.8	110	21ab	45.5a	2.9 b
3	19.8	310	21a	46.0ab	2.6 b
4	29.6	70	25 b	47.0 c	4.5 c
5	29.6	210	28 c	47.0 cd	4.5 c
6	29.6	350	28 c	45.5a	4.5 c
7	39.4	110	28 c	47.0 c	4.8 cd
8	39.4	310	30 cd	46.5 bc	4.4 c
9	43.6	210	22 cd	47.0 c	5.1 d

*Includes 1.6 inches of germination water.
**Means followed by the same letter are not significantly different at the 5% level.

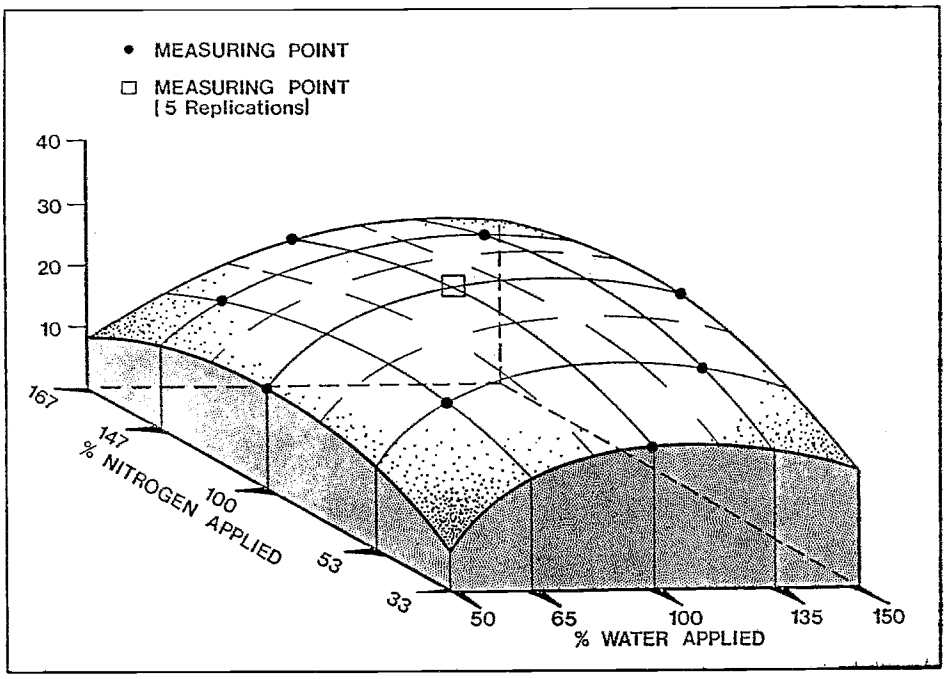

FIGURE 1: Production Function of 2 Variables- Water and Nitrogen.

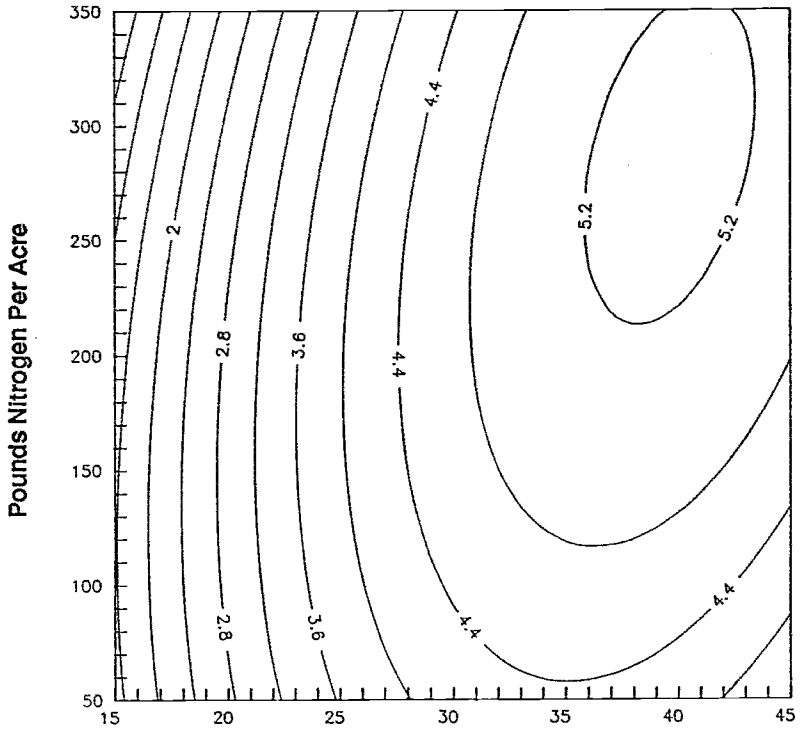

FIGURE 2: 1987 Gustoe Barley Yields In Tons/Acre