Irrigation Practice as it Affects Fertilizer Requirement, Quality and Yield of Sugar Beets[1]

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Approximately 85 percent of the sugar beet acreage in the United States is under irrigation. "Water turn" and "share holdings" rather than need frequently have controlled the time and quantity of water applied to the sugar beet crop. Since irrigation practice is so important in sugar beet culture and since the economical use of water is becoming increasingly important for all crops, it is desirable that growers become familiar with the effects of various irrigation practices on fertilizer requirements, quality and yield of sugar beets.

Results from experiments conducted in 1946 and 1947 (1)[3] at the Utah Agricultural Experiment Station showed marked differences in yield and quality of sugar beets among four irrigation treatments studied. The results of these experiments indicated the need for further study on the effect of irrigation practices as they affect fertilizer requirements, quality and yield of sugar beets. Such a study was made possible in 1948 through the cooperative efforts of the following organizations: Utah-Idaho Sugar Company; Amalgamated Sugar Company; Sugar Beet Development Foundation; Utah Agricultural Experiment Station, and the Bureau of Plant Industry, Soils and Agricultural Engineering of the U. S. Department of Agriculture.

Experimental Procedure

An experiment was designed to study the relationship of irrigation practice and soil fertility on yield and quality of sugar beets. This experiment was placed near Garland, Utah, on Millville sandy clay loam with a randomized split-plot design. Six irrigation regimes constituted the main plots. Superimposed on each irrigation plot were six fertilizer treatments. The irrigation treatments are symbolized and described as follows:

W_1—Moist all season (10 sprinkle irriagtions) .

W_2—Moist all season (9 furrow irrigations) .

W_3—No irrigation until July 20; moderately moist remainder of season (5 irrigations) .

W_4—Moderately dry all season (2 sprinkle and 4 furrow irrigations) .

W.—Moist until July 29; no irrigation thereafter (2 sprinkle and 1 furrow irrigations) .

W_6—Moist until August 14; no irrigation thereafter (2 sprinkle and 3 furrow irrigations) .

Commercial fertilizer was side-dressed four inches below the soil surface and six inches to the side of the row June 26. Manure was applied prior to seeding and disked into the soil.

Soil moisture conditions were followed by means of tensiometers and resistance blocks. It is evident from the resistance block readings shown

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[3] Numbers in parentheses refer to literature cited.

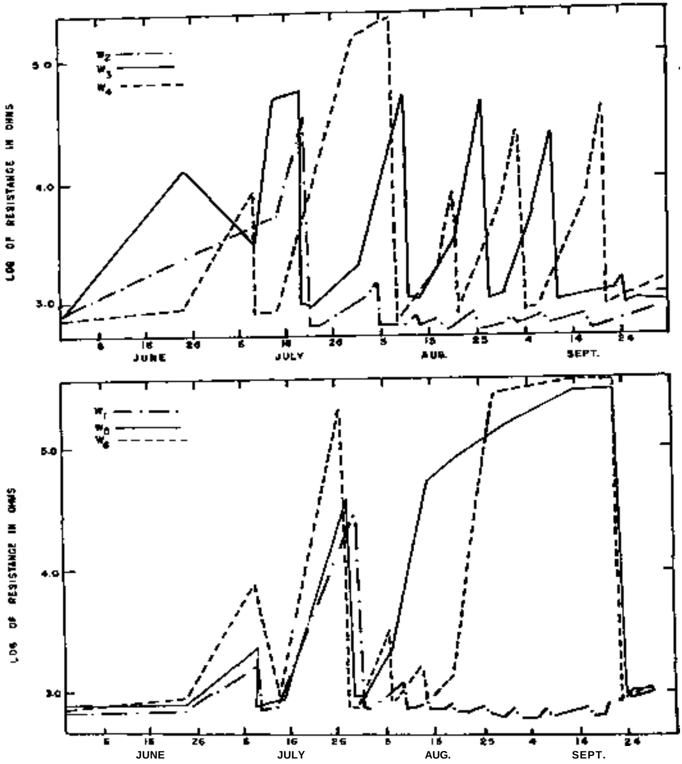
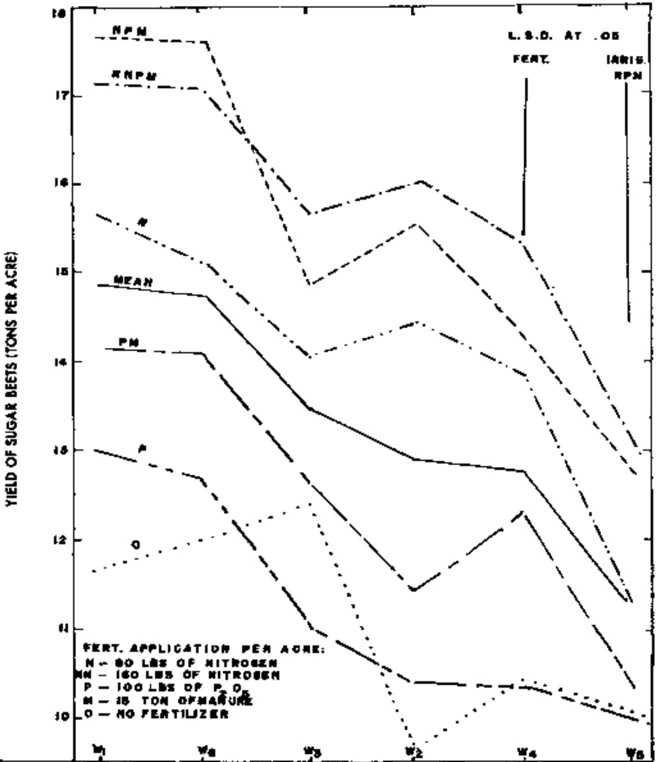


Figure 1. Seasonal soil moisture condition as indicated by resistance blocks.

graphically in Figure 1 that soil moisture conditions for treatments W_1 and W_2 were similar throughout the season. Likewise treatments W_3 and W_4 present a similar seasonal pattern. Treatments W_5 and W_6 were comparable except that the soil became relatively dry on treatment W_5 by August 15, while a similar condition was not reached on W_6 until August 25.



SOIL MOISTURE	MOIST ALL SEASON	MOIST TO AUG. 14 DRY	DRY TO JULY 20 MOD. MOIST	MOIST ALL SEASON	MOD. MOIST ALL SEASON	MOIST TO JULY 29 DRY
IRRIG.	10 SPRINKLE	2 SPRINKLE 3 FURROW	6 FURROW	9 FURROW	2 SPRINKLE 4 FURROW	2 SPRINKLE 1 FURROW
WATER (INCHES)	21.2	12.8	19.4	32.6	21.1	7.0

Figure 2. Yield in tons of sugar beets per acre for each of the irrigation and fertilizer treatments and for the mean of the fertilizer treatments.

Experimental Results

Yield of Sugar Beets and Method of Irrigation

The yield data for six irrigation treatments and six soil fertility treatments studied in this experiment are presented graphically in Figure 2.

It will be observed that plots kept moist all season by sprinkler irrigation (W_1) and those kept moist only until August 14 (W_6) gave the highest yields of beets. When an attempt was made to keep the soil relatively moist all season by furrow irrigation (W_2) yields were adversely affected, especially where commercial nitrogen fertilizer was not applied.

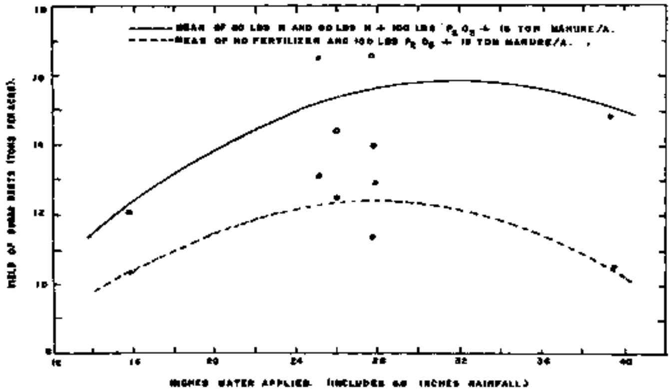


Figure 3. The relationship between the yield of sugar beets and the total depth of water applied (inches) for the mean yield of fertilizer treatments $N_1P_0M_0$ and $N_1P_1M_1$ and the mean yield of fertilizer treatments $N_0P_0M_0$ and $N_0P_1M_1$

The irrigation water required to keep the soil moist all season by sprinkling was approximately 21 inches while more than 30 inches was required by furrow irrigation. It would appear that 9 inches of excess irrigation water were lost by deep percolation under treatment W_2. That available nitrogen was also lost with this leaching effect is indicated by the fact that beet petioles from W_2 plots were lower in nitrate-nitrogen than were petioles from any of the other irrigation plots.

It will be noted that nearly as much irrigation water was required for moderately dry plots (W_3 and W_4) as for the moist plot (W_1), and yet yields tend to be consistently lower on the drier plots. It is probable that some water was lost by deep percolation from treatments W_3 and W_4, although insufficient evidence is available on this point.

Irrigation and Nitrogen Fertilization

The data *in* Figure 2 show that nitrogen fertilizer modifies the effect of irrigation treatment. This is particularly noticeable in a comparison of irrigation treatments W_2, W_3 and W_4. It will be observed that the three fertilizers resulting in yields above the mean contain nitrogen and that irrigation treatment W_2 tends to give a higher yield than treatments W_3 and W_4. On the other hand, the three fertilizers giving yields below the mean do not contain commercial nitrogen. When soils are low in available nitrogen or when fertilizers do not contain commercial nitrogen, irrigation

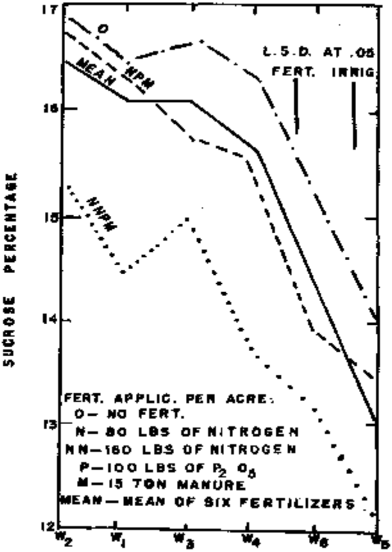


Figure 4. Sucrose percentage of sugar beets as influenced by irrigation practice.

treatment W_2 tends to result in yields lower than those obtained in treatments W_3 and W_4. This interaction between yields of beets from plots receiving no nitrogen vs. nitrogen x irrigation treatments is highly significant.

An analysis of the data on yield and total depth of water applied indicates a significant interaction of irrigation x nitrogen levels in the soil. This interaction is a linear effect which is highly significant and is shown by the relationship of the two curves in Figure 3. As the quantity of water and soil nitrogen are increased simultaneously, the distance between these two lines continue to increase. This tendency would undoubtedly change as aeration becomes **limiting.**

Time of Irrigation

Previous observations have indicated that young sugar beet plants are adversely affected by dry soil conditions. Furthermore, data were obtained during 1946 and 1947 which led to the assumption that sugar beets were not seriously affected by drought during the latter half of their growing period. Apparently this assumption was not well founded. The soil moisture condition under treatments W_5 and W_e are similar except that plots with treatment W_5 became relatively dry ten days earlier than those with treatment W_6 (see Figure 1). This apparently critical period resulted in a yield differential on moderately fertile soil of nearly 5 tons of beets.

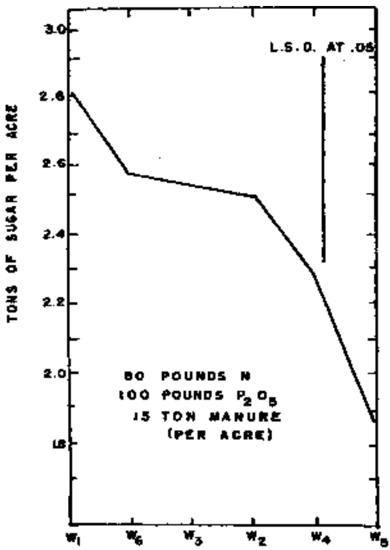


Figure 5. Yield of sugar as influenced by irrigation.

Irrigation Practice Affects Sucrose Percentage and Yield of Sugar

The data in Figure 4 clearly indicate that sugar beet soils should not remain dry for extended periods immediately preceding harvest. Late fall growth (stimulated by fall rains and an abundance of nitrate-nitrogen accumulated in the soil during the dry period, or nitrogen rapidly made available immediately after soil moistening), markedly depressed sucrose percentage. It will be observed that the sucrose percentage of beets grown under conditions of treatment W_5 was depressed more severely than those under conditions of treatment W_6, while beets from both of these plots were affected to a greater extent than those given treatments W_3 and W_4. Beets grown in plots which were kept moist all season (W_1 and W_2) tended to mature early and were generally higher in sucrose than those from plots which were dry for an extended period. Beets grown under treatment W_2 tended to be higher in sucrose than those under treatment W_1. This observation supports the previous conclusion that possibly some of the available soil nirogen was lost by deep percolation under treatment W_2.

The data in Figure 5 show that irrigation treatment W_1 which encouraged rapid continuous growth of beets with good yields and high sucrose percentage, gave highest yields of sugar. Although treatment W_6 encouraged high yields the extended dry period late in the season was detrimental to sucrose percentage. Treatment W_2 encouraged high sucrose but low yield of beets and hence only moderate gross sugar production. Irrigation treament W_5 depressed sucrose percentage and yield and therefore gave a low yield of gross sugar.

Discussion

It is evident from the data presented that there is a close relationship between irrigation practice and available soil nitrogen. The ideal irrigation practice for sugar beets, as indeed for all crops on normal non-saline soils, should result in a moist soil profile with the minimum of water. This is important, not only for the efficient use of water, but also for the conservation of soil nitrogen.

The fact that yields of sugar were greatest under sprinkler irrigation does not mean that this is the most practical method of irrigation. However, it does suggest that proper control of irrigation water is an important factor in sugar beet production. The idea held by many farmers and expressed by some field men that sprinkler irrigation will result in short, stubby, branching beet roots is not in agreement with facts obtained in this experiment.

It is difficult if not impossible to keep a sugar beet field moist by furrow irrigation without losing substantial quantities of water by deep percolation. It appears as though loss of irrigation water by deep percolation is accompanied by concomitant losses of available soil nitrogen. Excess irrigation water applied to soils already low in available soil nitrogen may bring a substantial depression in sugar beet yields.

Sugar beets appear to be sensitive to extremely dry soil conditions until about the middle of August in the Great Basin area. Evidence is too meager to make precise statements about the critical physiological periods of sugar beet growth as influenced by irrigation. However, since extended periods of drought preceding harvest result in substantial reductions in sucrose percentage it appears advisable to continue with moderate irrigations until shortly before harvest.

Final justification for a given field practice is not to be found in the yield of beets nor the sucrose percentage of beets, but rather in the product of these.

When sufficient evidence is available on the relationship between irrigation practice and available soil nitrogen it would appear that a given level of soil fertility will call for a rather definite irrigation practice in order to insure maximum sugar production.

Summary

1. Irrigation practice for sugar beets should be modified, not only to suit the texture of the soil, but the available supply of nitrogen.

2. The lower the available nitrogen supply of a soil the more seriously will excess irrigation water depress yields. The more abundant the available nitrogen supply in a soil the smaller the reduction in yield will be from excessive water application.

3. Experiments designed to study the effects of irrigation practice on yield and quality of sugar beets should not neglect the soil fertility status. Likewise, experiments designed to study soil fertility status should account for irrigation practice.

4. It is difficult to adequately furrow-irrigate a crop of sugar beets without losing some water and nitrogen by deep percolation. An attempt should be made to keep this loss to a minimum, especially on soils relatively low in available soil nitrogen.

5. Too little and too much irrigation water in relation to the available soil nitrogen are twin evils in sugar production.

Literature Cited

(1) Agron. Jour. 41:79-84. 1947.