Irrigation and Fertility Studies on Sugar Beets at Logan, Utah

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Introduction

The combination of irrigation treatment and fertilizer application which will produce maximum sugar beet yields and quality is a major concern to growers as well as to processors of sugar beets. This paper is a discussion of factors which affect yield and quality of beets in the light of results obtained during 1952 from a crop rotation experiment being conducted at the Greenville Farm at Logan, Utah. The data presented herein will indicate how the yield, sugar percentage, and purity percentage are related to the soil fertility conditions and irrigation treatments.

Four fertilizer treatments were involved as follows: 0 = no fertilizer; P=100 pounds of P_2O_5; N = 80 pounds of nitrogen; NP=100 pounds of P_2O_5 and 80 pounds of nitrogen.

The irrigation consisted of two methods—furrow and sprinkler, described as "F" and "S" respectively; each having four moisture levels. The driest level designated as 1 was too dry for optimum production, and the wettest designated as 4 was maintained in a very moist soil condition. The other levels were spaced between these two extremes which were designed to bracket the optimum growing conditions.

The problem of management of the irrigation water made it impractical to maintain exactly the same moisture conditions in furrow as in the sprinkler plots. Hence, the data presented relative to the amount of irrigation water used will be in terms of the actual amount of water applied including rainfall plus any net moisture removed from the soil during the growing season. These data on total water used by the sugar beet crop are plotted on the abscissa of the figure.

Results

The relationships between fertilizer and irrigation treatment as measured by yield are shown in Figure 1, as measured by sugar percentage in Figure 2, and as measured by purity percentage in Figure 3.

Block diagrams have been chosen for this presentation because of the ability to show important trends and general relationships which often times are not evident from other methods of analysis.

The abscissa to the left shows the fertility condition whereas the abscissa to the right portrays water management. The vertical ordinates in the three figures represent yield, sugar percentage, and purity percentage, respectively.

[1] The data in this paper were obtained at the Utah Agricultural Experiment Station under Project W-9 with the 11 western states, Hawaii, and the Soil and Water Conservation Branch of the Agricultural Research Services, USDA, cooperating.

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Yield

The most noticeable trend in yield is the decided increase with increased water. A plateau is reached in the yield with about 18 irrigations at 1.1 inches per irrigation or a total water application, including rainfall and soil moisture depletion, of 25 inches of water, after which little benefit is received from added increments.

It is interesting to note that, in every case, the furrow plots, shown by the solid lines, received more water than the supposedly comparable sprinkler plots, shown by dotted lines. Analyzing yield in terms of moisture regime alone would lead one to the generality that furrow irrigation gave better yield than sprinkler irrigation. Observations in previous years lead to contrary conclusions. Sprinkler irrigation has been shown to be especially advantageous on the wetter plots. However, Figure 1 shows that, when considered in terms of actual water applied, both methods were comparable. The difference in yield observed between the two methods was owing to the frequency of irrigation and to the amount of water applied.

Fertility treatments produced an interesting effect on yield. Under dry conditions the yield response was principally to phosphorus. Phosphorus appeared to affect yields favorably at all soil moisture conditions while nitrogen appeared to have a favorable influence only under high soil moisture conditions. In previous years, phosphorus has shown little influence on yield, whereas nitrogen has given significant yield increases.

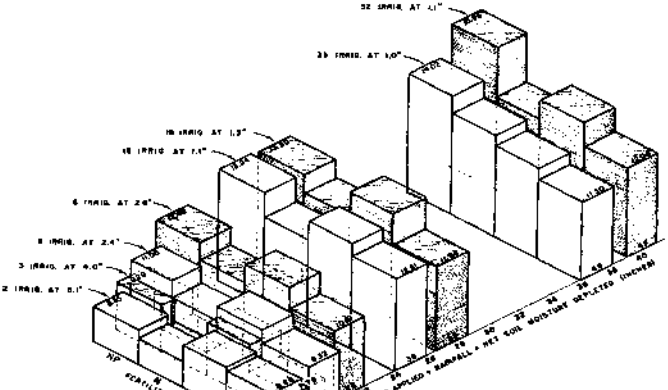

Figure 1.—Yield of sugar beets as **influenced** by **fertilization and irrigation treatment (1952).**

The minimum yield was obtained under the driest treatment with the maximum yield coming from ample water and ample fertilizer. The general trend from a minimum fertility and minimum water to a maximum yield with maximum fertility and maximum water is evident. The general trend and overall relationship as illustrated in the three-dimensional block diagram are informative.

Sugar **Percentage**

The most noticeable increase in sugar percentage portrayed in Figure 2 is with increased water. A plateau similar to the one in Figure 1 is reached after about 18 irrigations at 1.1 inches per hour, or total water use of 25 inches. Additional irrigations result in little if any increase in the sugar percentage. Previous studies have shown a consistent tendency for sucrose to increase with increasing amounts of irrigation water.

There appears to be a slightly beneficial effect in sucrose percentage for phosphorus fertilization while nitrogen has a depressing effect. It appears that phosphorus is slightly beneficial toward increasing sugar percentage after the plateau is reached.

A comparison of sprinkling and furrow irrigation from the viewpoint of sugar percentage as shown in Figure 2 leads to the same conclusions as were obtained from Figure 1, *i.e.*, the difference in the two methods of irrigation appears to be largely a difference in the amount of water applied. This is contrary to previous observations. Sprinkler irrigation has generally resulted in a slightly lower sucrose percentage even when similar quantities of water were used.

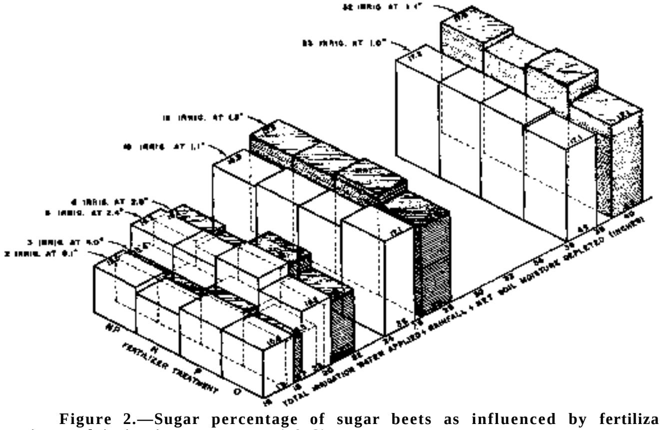

Figure 2.—Sugar percentage of sugar beets as influenced by fertilization and irrigation treatment (1952).

Percent Purity

The data *in* Figure 3 relating the percent purity of sugar beets to fertilizer and irrigation practice produces a picture comparable to that obtained in Figures 1 and 2. Twenty-five inches applied in 18 irrigations led to essentially a plateau where additional irrigation produced only slight increases in percent purity. It may be observed that phosphorus tended to influence percent purity favorably,, while nitrogen depressed it at low moisture levels and had no effect at high soil moisture levels. Phosphorus fertilizer alone tended to result *in* higher purities than when combined with nitrogen.

In 1952 the amount of irrigation water used was closely correlated with yield and **quality.**

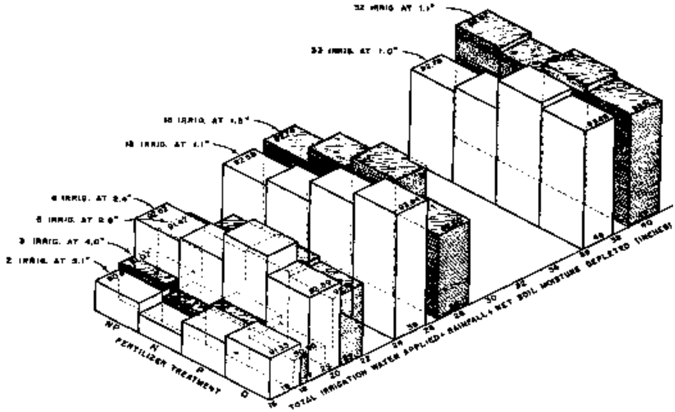

Figure 3.—Purity percentage as influenced by fertilization and irrigation treatment **(1952).**

Discussion and Summary

The yield and quality data obtained in 1952 are not typical of those for the area. What explanation suitably explains the results presented?

The normal sugar beet season from planting to harvest in Utah is from 180 to 190 days. In 1952 there was practically no spring weather. An abrupt break from winter to summer occurred the last ol April. The soil surface dried unfavorable to planting and delayed this operation nearly three weeks. Thinning was two to three weeks later than usual and the plants were actually about one month behind plants grown in more normal seasons at the same date. In addition, the harvesting season was about ten days ahead of the previous seasons.

The short season of approximately 160 days may account for low yields but how about the unusual response to fertilizers?

It has previously been proposed (l)[4] that the soil must provide 10 pounds of nitrogen for each ton of beets produced. It has also been suggested that typical soils in the Great Basin are able to supply from 100 to 160 pounds of nitrogen per acre. During short seasons when limitation of climate makes it possible to produce only 15 to 16 tons of beets, the soil is able to supply ample nitrogen for the crop. Under these conditions additional nitrogen fertilizer apparently does not contribute toward increased yields but may have an adverse affect on yield as well as on sucrose and purity percentages. Under conditions of high nitrogen supply, phosphorus fertilizer benefits yield and is favorable to high sucrose and purity.

This explanation appears to be borne out by the chemical composition of sugar beet petioles at harvest time. Whereas the petioles from the dry plots (IS, IF, 2S, and 2F) averaged about 1,500 p.p.m. nitrate-nitrogen at harvest time in 1950, petioles from the dry plots in 1952 averaged about 3,000 p.p.m. at harvest time. The phosphorus content of beet petioles in 1952 was only half the concentration observed in petioles in 1950. It is believed that these facts may partially help to explain the yield and quality response of sugar beets to irrigation and fertilizer treatments in 1952.

In 1952, nitrogen produced slight if any benefit. Certainly the benefit received would not justify the cost. On the other hand, phosphorus fertilization had a stimulating influence on all three quantities, but was most noticeable on yield.

A word of caution should be given with regard to the irrigation practice under wet soil conditions. In all cases, light applications of water were applied. Frequent irrigations should consist of light applications since the soil will only hold a limited amount of w'ater. Excessive downward movement of water beyond the root zone resulting in leaching of plant nutrients should be reduced to a minimum.

The three figures illustrate that for sugar beet production the difference between surface and sprinkler irrigation may be, in part at least, a difference in water control and management. The furrows are close enough and the roots deep enough during the latter portion of the season that both methods do a reasonably good job of storing water in the soil if there is good control. Local factors such as topography, water supply and depth of soil will determine which method is best suited to sugar beet culture on a particular farm; the choice being determined by which method will enable the best control of the water. Such factors as the need for germination and early irrigation, and the ability to apply light applications of water early in the season, will influence the choice of the method of irrigation, but a discussion of these factors is beyond the scope of this paper.

In previous years phosphorus fertilization has shown little if any benefit and nitrogen fertilizer has stimulated yield. The combination of both

[4] Numbers in parentheses refer to literature cited.

phosphorus and nitrogen has always given greater yields than either alone. This type of response depends upon the soil fertility conditions as well as climatic conditions under which the crop is grown.

It has also been observed in previous years that 80 pounds of nitrogen has increased yields, and also depressed sucrose percentage and purity of beets. This phenomenon was not manifest in 1952. An explanation for this lack of uniformity is the short season in 1952 and the fact that the low yield of beets did not place the heavy demand upon nitrogen fertilizer exhibited in previous years.

Literature Cited

(1) HADDOCK, JAY L.
1952. The nitrogen requirement of sugar beets. Proc. Araer. Soc. Sugar Beet Tech. pp. 159-165.