The Effect of Climate on Sugar Beet Yields In Western Montana

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The relationship of climate and its effect on the sugar beet crop has received attention and study by a number of workers in this country. As far as temperature is concerned, the sugar beet can grow in any state of the United States. In general, however, the sugar beet makes its best and most efficient growth as a crop plant in the United States within a zone lying between the summer temperature isotherms of 67° and 72° *F.* Wiley *(4)* called attention to this relationship and in 1901 mapped the potential belt of sugar beet culture in the United States. It is of interest to note that in the years that, followed this generalization the actual localization of the industry tallied rather closely with the predicted areas best suited for the sugar beet crop. Braudes and Coons (1)[2] expressed the opinion that summer temperatures affect the production and qualify of sugar beets less than does the water supply. Pierce et al *(2),* working under eastern Montana conditions, found an interesting but not highly significant correlation between June temperatures and acre yields of beets. Tavernetti *(3),* in making a study of beet growth and response to fertilizers, found that under California conditions the growth increment was small when minimum soil temperatures were less than 55° *F.*

In western Montana certain trends in weather and yield of beets have been observed, leading to the belief that yield might be associated with daily temperatures. To test this inferred relationship as a possible basis for predicting beet yields, a study was made of climatological data available for this western Montana area, and results of this study are reported herein.

The poorest beet crop in the 17 years the Missoula factory has operated was harvested in 1943. The sugar-per-acre yield was 700 pounds below the average of the preceding crops. A record amount of snow had fallen during the winter, with lower than average temperatures. The Spring was late, cold, and wet, the planting was delayed, and thinning and cultivating was later than normal. The results of this growing season led to a preliminary survey of the effects of weather on beet yields. All of the data available on length of growing season, annual precipitation, average annual maximum and minimum temperatures, and average mean temperature were studied in relation to the yield of beets and sucrose percentage for the 11-year period, 1933 to 1943 inclusive. This study was continued in 1944 and

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[2]Italic numbers in parentheses refer to literature cited.

1945, and after various analyses of the data had been made it became apparent that for the 13 years it would be necessary to begin with October weather data of each year for studies of effects on the beet yield of the subsequent year. This is reasonable, since weather after the first of October does have an influence on the following growing season. Moisture falling this quarter is carried over. If there is a warm Fall, bacterial action is stimulated and fertility of the land is increased. Also, an open Fall permits completion of Fall plowing operations which contributes appreciably to increased crop yields.

Temperature Effects

The effect of average daily mean temperatures on beet yield is most striking, as is shown in the graph in figure 1.

The highest annual mean temperature was 49.4° in 1940, and the lowest was 44.9° in 1948. This is a variation of only 4.5° in annual

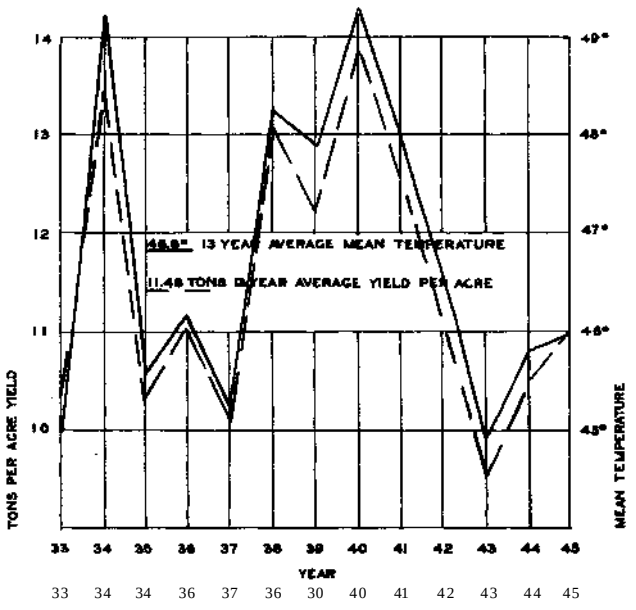

Figure 1.—Comparison of average sugar beet yields with the average of the annual mean temperatures for the 12-month period, October through September, 1933 to 1945.

mean during the entire 13-year period. As to beet yields, the highest tonnage produced was in 1940 with 13.96 tons beets per acre, and the lowest was in 1943 with 9.52 tons per acre. The variation in yield per acre for the 13 years was 4.44 tons. The relationship between annual mean temperature and beet yield is very apparent. In no year does the yield fluctuate widely from the annual average mean. Increases or decreases of 1° in annual mean temperature have a direct effect on the yield of beets. Thus each degree variation from the average is responsible for an increase or decrease of 1 ton of beets per year.

In breaking down this relationship of mean temperature to beet yields, the data were arranged in October through December, October through March, and October through June categories, in addition to the October through September grouping shown in figure 1. The resultant data indicated a sufficiently close correlation to permit the deduction as early as January that the first quarter average of daily mean temperature is usually following the same trend it will follow for the entire season. Further, by using the 6 months' average mean temperature reading of October through March, it is possible before the crop is planted to have a fairly reliable estimate of what the crop will yield. By using the 9 months daily average mean temperature, it should be possible to estimate yields within *1/2* ton per acre.

A similar study was made for temperature effects upon sucrose, and a negative relationship was obtained, as is shown in figure 2.

The graph in figure 2 shows that as a rule high mean temperatures were reflected in lower sucrose content, and low mean temperatures were generally productive of higher sucrose content in beers. From the graph, the year 1943 was an exception to this because of excessively high precipitation which affected adversely both tonnage yield and sucrose content in the beet.

Effect of Precipitation

Figure 3 is a comparison of sugar beet yields with total annual precipitation. This graph shows a very definite trend in the effect of precipitation on beet crops.

These data show that for the 13-year period better beet crops were produced when precipitation was above the 12.60-inch average annual rainfall; and further, that more than 16 inches of moisture per year had an adverse effect on. yield under western Montana conditions. Considering the fact that this area has an abundance of irrigation water, too much rainfall is more detrimental to crop growth than too little rainfall, because of increased weed growth and the deterrent effect on performance of timely cultural and other farming operations.

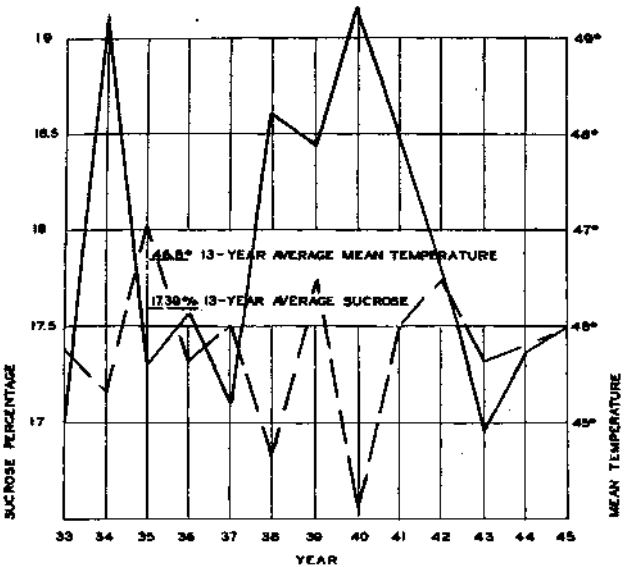

Figure 2.—Comparison of the average sucrose percentage with the average of the daily mean temperatures for the 12-month period. October through September, 1933 to 1045.

Estimating Yields by Using Mean Temperatures

Since the temperature-yield relationship seemed to be the most reliable, an attempt was made in early October of 1944 to estimate the yield of the erop on the basis of the mean temperature for the past 12 months. The estimate was 10.25 tons per acre, which was .25 tons short of the actual yield of 10.50 tons per acre. In July of 1945 a prediction of that year's crop was made. The figure of 11.00 tons per acre was obtained by using the mean temperature for the previous 9-month period. Adding to this another .50 ton to compensate for the increased yield because of the recently developed practice of side-dressing beets with nitrogen, the expected yield was 11.50 tons per acre. (About 1/3 of the acreage was side-dressed with nitrogen fertilizer, which we expected to increase the yield by 1 1/2 tons per acre, or 1/2 ton per acre for the entire acreage.) Early in October a final esti-

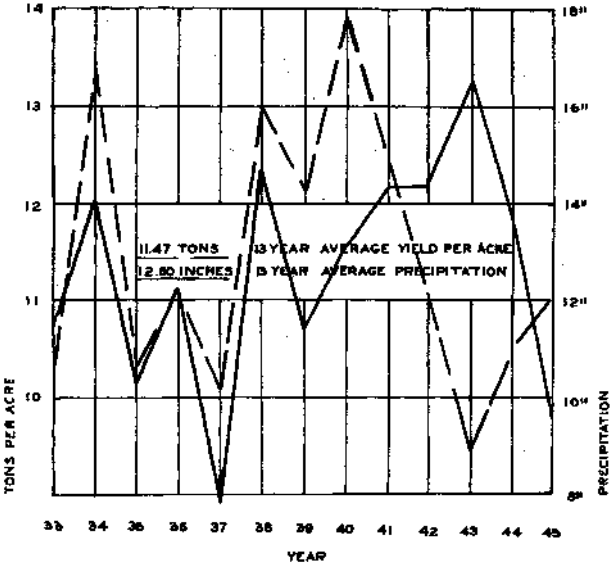

Figure 3.—A comparison of sugar beet yields with annual precipitation for the period October through September, 1933 to 1945.

mate was made on the basis of 12 mouths' elapsed annual mean temperatures. The yield estimate was 10.70 tons per acre, plus the .50 tons expected increase from the use of nitrogen, or 11.20 tons beets per acre. The actual yield was 11.02 tons per acre.

From the data obtained to date, it is felt that it may be possible in the future to predict the amount of additional nitrogen that will be needed by the sugar beet crop during the growing season. If a warm season is predicted, the amount of additional nitrogen required would be less, because soil bacteria would convert more nitrogenous organic matter into nitrates available to the plant. A cold season would demand additional nitrogen, side-dressed in an available form to meet the requirements of a normal crop of beets.

Summary

The average of October through September daily mean temperature readings in western Montana is closely related to beet yields, with each degree annual variation producing approximately 1 ton difference in beet yields.

Sucrose percentages arc generally lower when the annual mean temperature is high.

Annual rainfall is also associated with yield but not to the same extent as mean temperature.

An October 1 estimate of beet yields based on the annual mean temperature for 1944 was .25 tons short of the actual yield. By use of the average daily mean temperature from October through June, 1945, in early July it was possible to estimate the yield within .50 ton; and in early October, 1945, within .25 ton.

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