The Influence of Plant Population, Soil Moisture, and Nitrogen Fertilization on the Sugar Content and Yield of Sugar Beets

Jay L. Haddock

The average yield of sugar beets in the irrigated area of western United States is about 12 tons per acre. Additional information is needed relative to single factors and the interrelations of factors of plant growth which can be readily modified to increase yield and sugar content of sugar beets.

Previous investigations have shown that under certain conditions too much available soil nitrogen decreases the sugar percentage of the sugar beet (2, 11). On the other hand, reports (9) have indicated that large additions of nitrogen fertilizer do not adversely affect sugar content. A number of reports (1, 5, 7, 8, 10) from various sections of the irrigated west have shown the need for nitrogen fertilizers in the economical production of sugar beets. There are a few studies (6) which do not indicate the need of additional available soil nitrogen.

A study (3) of the interrelations of soil moisture, plant population, and soil fertility was conducted in Utah in 1946 and 1947. This study was made possible through the cooperative efforts of the following organizations: Utah-Idaho Sugar Company, Amalgamated Sugar Company, Sugar Beet Development Foundation, Utah Agricultural Experiment Station, a research grant by the Kennecott Copper Company through the Utah State Agricultural College, and the Bureau of Plant Industry, Soils, and Agricultural Engineering of the U. S. Dept. of Agriculture. That portion of the study which has to do with the influence of nitrogen fertilization on sugar content and yield of sugar beets is presented here.

Materials and Methods

This study was conducted on Millville fine sandy loam in 1946 and Millville silt loam in 1947. Both soils are well-drained. Manure was broadcast in the spring and disked in before seeding. Ammonium nitrate was side-dressed 4 inches below the soil surface the first of June, immediately before thinning. All plots were uniformly sprinkle-irrigated twice in 1946 and three times in 1947 before the moisture variables were initiated. Plots were arranged in a randomized split-plot design.

Each soil moisture and plant population plot was 100 feet long by 32, 40, or 48 feet wide, depending on variable row widths. Each fertilizer plot was four rows wide and 20 feet long. There were 9 replications for soil-moisture in 1946 and 10 in 1947, 12 replications for fertilizers in 1946 and 40 in 1947, 72 replications for plant population in 1946 and 20 in 1947, and 72 replications for nitrogen fertilization in 1947.

Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Dept. of Agriculture, in cooperation with the Utah Agricultural Experiment Station, Logan, Utah. Received for publication September 27, 1948. Published February, 1949.

Experimental Results

SOIL MOISTURE CONDITIONS

With certain simple devices recently developed, it is possible to follow changes in soil moisture conditions under the four irrigation practices. Two samples of 20 beets each were obtained from the study on sugar percentage and percentage purity; these samples were rasped at harvest time and quickly analyzed. Moisture samples were taken about two months after harvest.

Soil moisture conditions: Moisture treatment I—Soil kept continuously moist (below 15 cm water tension) from June 1, 1946, to the first of June, 1947.

W1—Soil kept continuously moist from planting (below 75 cm water tension) until the end of June, 1947.

W2—After June 26 soil moisture tension allowed to reach equivalent of wilting percentage at 12-inch depth.

W3—Soil moisture tension allowed to reach equivalent of wilting percentage at 24-inch depth.

Two samples of 20 beets each were obtained from each treatment for the study on sugar percentage and percentage purity. These samples were rasped at harvest time and quickly analyzed. Moisture samples were taken about two months after harvest.

The symbols used in the figures, which will be referred to subsequently, may be described as follows:

1. Soil moisture conditions:
   - Moisture treatment I: Soil kept continuously moist (below 75 cm water tension) from June 1, 1946, to the first of June, 1947.
   - W1: Soil kept continuously moist from planting (below 75 cm water tension) until the end of June, 1947.
   - W3: After June 26 soil moisture tension allowed to reach equivalent of wilting percentage at 24-inch depth.
   - W4: After June 26 soil moisture tension allowed to reach equivalent of wilting percentage at 36-inch depth.

2. Plant population, 1946 (all plants 12 inches apart in row):
   - 12 x 20 inch: Rows alternating 12 inches apart (32,750 plants per acre)
   - 24 inches: Rows 24 inches apart (26,135 plants per acre)
   - 24 inches: Rows 24 inches apart (21,780 plants per acre)

3. Plant population, 1947 (rows were 20 inches apart):
   - S1: Plants 12 inches apart in row (26,135 plants per acre)
   - S2: Plants 6 inches apart in row (52,270 plants per acre)

4. Fertilizers:
   - N0P0M0: No fertilizer
   - N0PoM1: 15 tons barnyard manure
   - N0P1M1: 15 tons manure, 100 pounds phosphoric acid per acre (treble superphosphate)
   - N1P1M1: 15 tons manure, 100 pounds phosphoric acid and 100 pounds nitrogen per acre (ammonium nitrate)
   - N2P0M1: 250 pounds phosphoric acid, 160 pounds nitrogen
   - N2P1M1: 15 tons manure, 250 pounds phosphoric acid, 160 pounds nitrogen
   - N2P2M0: 250 pounds phosphoric acid, 160 pounds nitrogen, ½ nutrient applied pre-thinning, ½ of the nitrogen applied post-thinning, one-half side-dressed July 13.

Experimental Results

SOIL MOISTURE CONDITIONS

With certain simple devices recently developed, it is possible to follow changes in soil moisture conditions under the four irrigation practices. Two samples of 20 beets each were obtained from each treatment for the study on sugar percentage and percentage purity; these samples were rasped at harvest time and quickly analyzed. Moisture samples were taken about two months after harvest.

The symbols used in the figures, which will be referred to subsequently, may be described as follows:

1. Soil moisture conditions:
   - Moisture treatment I: Soil kept continuously moist (below 75 cm water tension) from June 1, 1946, to the first of June, 1947.
   - W1: Soil kept continuously moist from planting (below 75 cm water tension) until the end of June, 1947.
   - W3: After June 26 soil moisture tension allowed to reach equivalent of wilting percentage at 24-inch depth.
   - W4: After June 26 soil moisture tension allowed to reach equivalent of wilting percentage at 36-inch depth.

2. Plant population, 1946 (all plants 12 inches apart in row):
   - 12 x 20 inch: Rows alternating 12 inches apart (32,750 plants per acre)
   - 24 inches: Rows 24 inches apart (26,135 plants per acre)
   - 24 inches: Rows 24 inches apart (21,780 plants per acre)

3. Plant population, 1947 (rows were 20 inches apart):
   - S1: Plants 12 inches apart in row (26,135 plants per acre)
   - S2: Plants 6 inches apart in row (52,270 plants per acre)

4. Fertilizers:
   - N0P0M0: No fertilizer
   - N0PoM1: 15 tons barnyard manure
   - N0P1M1: 15 tons manure, 100 pounds phosphoric acid per acre (treble superphosphate)
   - N1P1M1: 15 tons manure, 100 pounds phosphoric acid and 100 pounds nitrogen per acre (ammonium nitrate)
   - N2P0M1: 250 pounds phosphoric acid, 160 pounds nitrogen
   - N2P1M1: 15 tons manure, 250 pounds phosphoric acid, 160 pounds nitrogen
   - N2P2M0: 250 pounds phosphoric acid, 160 pounds nitrogen, ½ nutrient applied pre-thinning, ½ of the nitrogen applied post-thinning, one-half side-dressed July 13.