Yield and Quality of Sugar Beets as Affected by Cropping Systems

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Cropping systems influence yield and quality of sugar beets primarily by affecting the soil's nutrient supplying power and physical properties, and the plant diseases and pests transmitted by the soil. Before the advent of inexpensive commercial fertilizers, the effect of a cropping system on the nutrient supplying capacity was very important. Now, however, all necessary nutrients can be supplied through the use of commercial fertilizers and the other effects of cropping systems need to be evaluated.

Many previous rotation experiments measured the combined effects of the rotation on yield and did not attempt to determine the various factors which affected the yield. In the Morrow rotation plots of Illinois the yield of the continuous corn rotation without nitrogen fertilizer was 22 bushels per acre as compared with 109 bushels per acre for the three-year rotation with a legume before corn. However, recently the experiment was modified and this yield difference was overcome in one year by a heavy application of nitrogen fertilizer (1)[2]. The beneficial effects of alfalfa on succeeding crops have been observed by agronomists (3, 4, 6) on irrigated western soils. Gardner and Robertson (3), however, showed that the major effect of alfalfa on succeeding crops was to increase available nitrogen.

The soils of Imperial Valley are alluvial soils, low in organic matter and nitrogen, and poor in physical structure. To maintain or improve these factors, alfalfa, sesbania (an annual summer legume) and steer manure are commonly used in cropping systems. A field experiment was initiated in 1956 to evaluate the effectiveness of these cropping systems for improving physical properties and increasing soil nitrogen. Only the effect of the cropping systems on the supply of soil nitrogen and its effect on the sugar beet crop are discussed in this paper.

Methods and Materials

The experiment was conducted on a Holtville silty clay, stratified phase, at the Southwestern Irrigation Field Station located in the Imperial Valley near Brawley, California. The plot area had not been manured or planted to alfalfa for over 10 years. In the upper 8 inches of soil the organic matter content

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[2] Numbers in parentheses refer to literature cited.

was about 1% and the nitrogen content about 0.065%. Although phosphate is not limiting to plant growth on this soil, 240 pounds of P_2O_5 per acre were applied in 1956 and 80 pounds of P_2O_5 per acre in 1958.

The experimental design used was a split-plot randomized block with four replications. The cropping systems used as main plots for the first two years of the study are given in Table 1. In the third year of the experiment the entire area was plowed and planted to US 75 sugar beets in September, 1958. Each cropping system main plot was subdivided into 6 subplots which received the following rates of nitrogen: 0, 60, 120, 180, 300, and 420 pounds per acre. The nitrogen was applied as ammonium nitrate, one third at planting and two thirds at thinning time.

Table 1.—Description of the cropping system treatments used prior to the uniform sugar beet crop planted in September, 1958.

Treatment No.	1956 - 57	1957 - 58
1	Sugar beets (0 lb N)	Barley (0 lb N)
2	Sugar beets (160 lb N)	Barley (80 lb N)
3	Sugar beets (320 lb N)	Barley (160 lb N)
4	Alfalfa	Alfalfa
5	Sugar beets (160 lb N) Sesbania[1]	Barley (80 lb N) Sesbania[1]
6	Sugar beets (160 lb N) + 10 tons manure	Barley (80 lb N) + 10 tons manure

[1] Sesbania *(Sesbania macrocarpa)* is a legume and was grown as a summer green manure crop.

At harvest, June 1959, a 15- to 20-beet sample was taken from each plot to determine sucrose percentage and purity. Sucrose percentage was determined with a saccharimeter using a method of the Association of Official Agricultural Chemists (2). Total soluble solids for calculating purity were determined with a Brix spindle hydrometer on an aqueous extract of the sugar beet pulp.

Results and Discussion

Cropping systems influenced yield and quality of sugar beets by their effect on the nitrogen-supplying ability of the soil during the cropping season. Large amounts of nitrogenous organic matter were added to the soil by cropping systems that included alfalfa (Treatment No. 4), sesbania, (Treatment No. 5) or steer manure (Treatment No. 6). The other systems added only inorganic fertilizer nitrogen (Treatment No. 2 and 3) or no nitrogen (Treatment No. 1). Figure 1 shows how the yield and quality of the sugar beets from all of the cropping systems varied as the rate of nitrogen fertilization increased.

With no additional fertilizer nitrogen, treatments 4, 5 and 6, which added organic matter to the soil, produced marked increases in yield over treatments 1, 2 and 3, which added relatively little organic matter to the soil. The yield of sugar beets from

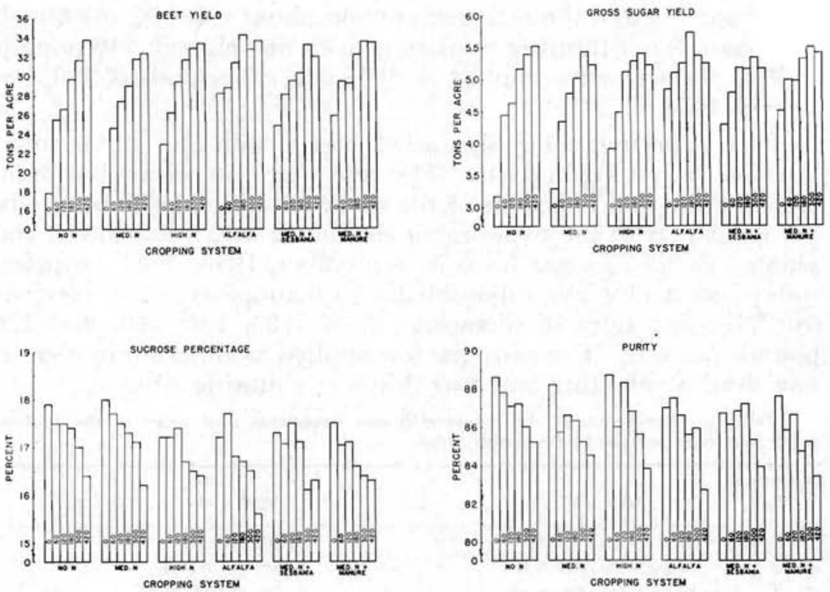

Figure 1.—The effect of different cropping systems on yield and quality of sugar beets in Imperial Valley during the 1958-59 season. Cropping systems designations from left to right refer to treatments 1-6 in Table 1. The LSD at the 5% level of significance is 2.5 tons/acre for yield of beets, 0.42 tons/acre for gross sugar, 1.52% for sucrose percentage, and 2.5% for purity.

the alfalfa treatment was 58% higher than that from the treatment that had received no nitrogen during the preceding two years. The sesbania and manure treatments resulted in a 33 and 45% higher yield, respectively, than the no-nitrogen treatment. The cropping system that had received a high rate of inorganic nitrogen fertilizer (Treatment No. 3) during the preceding two years resulted in a 23% increase in yield.

When additional nitrogen was supplied in the form of fertilizer to the 1958-59 sugar beet crop, the differences in yield among the different cropping systems were decreased. At the 180 pound per acre rate of nitrogen fertilization, the alfalfa treatment yielded only 15% more sugar beets than treatment 1. The yields of the other treatments at this rate of fertilization were not significantly different from each other or from treatment 1 at the 5% level. When 420 pounds of nitrogen per acre were used, the yields of all treatments were practically the same. Only 180 pounds of nitrogen per acre were required to maximize the yields with the alfalfa treatment but 420 pounds of nitrogen per acre were needed to produce the maximum yield in treatment 1.

The cropping system that resulted in the highest yields of sugar beets tended to produce the lowest sucrose percentage and purity. Also, as the amount of nitrogen fertilizer applied was increased the sucrose percentage and purity decreased. Loomis and Ulrich (5) showed that nitrogen nutrition affects the quality of sugar beets. Ample nitrogen throughout the season depresses sucrose percentage whereas beets deficient in nitrogen have a high sucrose content. The results of this experiment indicate that cropping systems 4, 5, and 6 supplied additional nitrogen to the beets. At the higher rates of nitrogen fertilization this additional nitrogen tended to inhibit sugar yield, and depress sucrose percentage and purity.

The nitrogen status of sugar beets throughout the season can be followed very closely by measuring the nitrate concentration in the beet petioles (7). Results of the analysis of sugar beet petiole samples from the alfalfa system and the no-nitrogen system are shown in Figure 2. The availability of additional nitrogen to the sugar beets from the alfalfa system resulted in more nitrate at all dates for comparable nitrogen fertilizer levels. Depletion of petiole nitrate concentrations to the 1000 ppm critical level was delayed approximately one month at each nitrogen rate by the alfalfa cropping system.

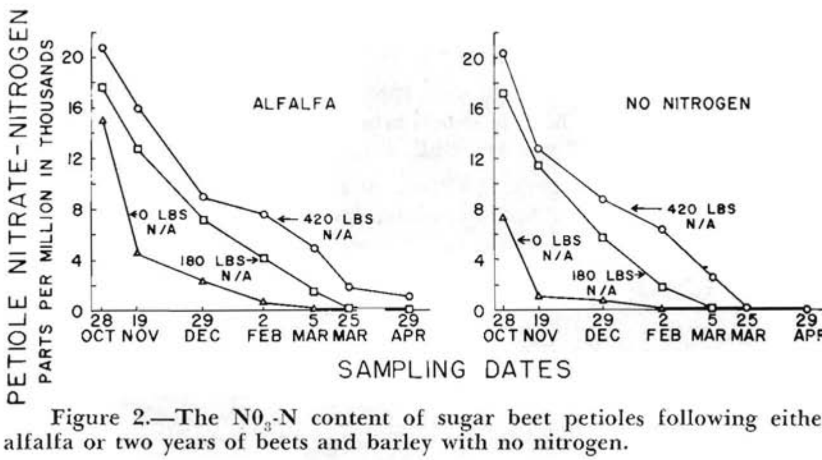

Figure 2.—The NO_3-N content of sugar beet petioles following either alfalfa or two years of beets and barley with no nitrogen.

Summary

From these results it may be concluded that cropping systems influence yield and quality of sugar beets on Holtville silty clay by their influence on the availability and supply of soil nitrogen. The cropping systems which added nitrogenous organic matter or had residual nitrogen from high fertilizer applications in-

creased the supply of available soil nitrogen and increased sugar beet yields, especially at low rates of applied nitrogen. However, these differences in yield due to cropping systms were overcome by the application of additional nitrogen fertilizer. At 420 pounds of nitrogen per acre there was no significant difference in yield for any cropping system. This indicates that the benefits from alfalfa, sesbania or steer manure were mainly due to the addition of nitrogen to this soil. The nitrogen from these organic sources had no apparent advantage over inorganic fertilizer nitrogen. Furthermore, any benefits from these treatments other than nitrogen, were not reflected in yield or quality of sugar beets.

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