IMPROVED NITROGEN AND IRRIGATION EFFICIENCY FOR SUGAR BEET PRODUCTION

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Summary

Management alternatives for reducing N fertilizer and irrigation water application rates were tested for furrow irrigated sugar beets in replicated half acre plots. A moderate N fertilizer rate and a reduced N fertilizer rate were tested under conventional furrow irrigation (continuous) and surge irrigation. The moderately fertilized and continuously irrigated sugar beets had the highest beet yield. There was no significant difference in sugar yield between the beets that were moderately fertilized and either continuously or surge irrigated. The reduced fertilizer beets had significantly lower sugar yields, whether they were continuously or surge irrigated.

Introduction

Previous small plot research at the Malheur Experiment Station has demonstrated the effectiveness of using greatly reduced nitrogen fertilizer inputs for optimum sugar beet production.

Surge irrigation is a tool that can be used to improve the water application efficiency of furrow irrigation. In surge irrigation, water is applied to an irrigation furrow intermittently during an irrigation set, whereas in continuous-flow (or conventional) irrigation, water is applied to the furrow during the entire irrigation set. With surge irrigation, an automated switching valve, commonly referred to as a surge valve, is used to repeatedly cycle water from one half of the field to the other half. Total water application can be reduced substantially with the use of surge irrigation. Previous research at the Malheur Experiment Station with wheat, onions, and potatoes has demonstrated the effectiveness of surge irrigation in reducing water applications while maintaining crop yield and quality equivalent to conventional furrow irrigation.

The reduced water applications with surge irrigation could result in a reduction of nitrate leaching and adjustment in N fertilizer practices. This trial compared sugar beet production with moderate and reduced N inputs under either conventional furrow irrigation or surge irrigation in field scale plots. Plots were 0.5 acres each with 600-foot long irrigation runs. The intent was to investigate the interaction between reduced nitrogen fertilizer and reduced water inputs on crop yield and quality.

Procedures

The 1995 trial was conducted on a Greenleaf silt loam previously planted to potatoes at the Malheur Experiment Station. The field was leveled and bedded into 44-inch centers in the spring of 1996. A soil sample taken from the top foot on May 1, 1995 showed a pH of 7.6, 1.4 percent organic matter, 19 meq per 100 g of soil cation exchange capacity, 4 ppm nitrate-N, 7 ppm ammonium-N, 14 ppm phosphorus, 178 ppm potassium, 1748 ppm calcium, 256 ppm magnesium, 340 ppm sodium, 0.7 ppm zinc, 4.4 ppm iron, 4.1 ppm manganese, 0.7 ppm copper, 13 ppm sulfate-S, and 0.7 ppm boron.

Sugar beet seed (cv PM-9, Hilleshog) was planted on April 11 in two rows 22 inches apart on each bed. Counter insecticide at 6 oz/1,000 ft of row (1.2 oz/1,000 ft of row) was applied in a band over the seed row. Spring ground work had dried the field and two soaking irrigations were used for seed germination and emergence.

The experimental design had the irrigation and nitrogen fertilizer treatments arranged in a randomized complete block factorial design replicated three times. The plots were 20 rows wide and 600 feet long. The treatments consisted of two fertility levels and two irrigation methods (Table 1). Fertility levels consisted of either fertilizing for a total N supply (soil NO_3-N + NH_4-N in the 0 to 3 foot depth plus fertilizer N) of 200 lb N/ac, or fertilizing for a total N supply of 128 lb N/ac (reduced level). The amount of fertilizer to be applied to each plot was based on late March soil samples. Each plot was sampled in one foot increments to six feet in three locations corresponding to the top, middle and bottom of the plot. The fertilizer was applied as water-run urea on June 7.

Gated pipe was arranged to permit all 12 plots to be irrigated simultaneously. A Waterman Model LVC-5 surge valve automatically oscillated water from three of the surge irrigation plots to the other three surge irrigation plots. The valves on the gated pipe were adjusted to deliver the same flow rate to all furrows in the surge and conventional irrigation systems.

Four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200, Irrometer Co., Riverside, CA) were installed at the 10-inch depth and four GMS were installed at the 20-inch depth in the top, middle, and bottom of one conventionally irrigated plot and in the top, middle, and bottom of one surge irrigated plot in the field center. The GMS were installed in line with the plants. The GMS were read at 8 AM five times per week from July 5 to September 17. Irrigations were started when the average soil water potential at the 10-inch depth dried to -75 kPa. The surge plots and the conventional furrow irrigation plots were irrigated separately as needed to maintain the soil water potential wetter than -75 kPa.

Petiole samples were collected from plants in the top, middle, and bottom of each plot on July 17, July 31, and August 28 and analyzed for nitrate. Eight beets in the top, middle, and bottom of each plot were harvested for nitrogen analysis on October 15. The beets were separated into beets, crowns, and tops. Tops and crowns were oven dried, and weighed. Beets were shredded, weighed, oven dried and weighed. All dried samples were ground and analyzed for nitrogen content. Beets from 40 feet of the middle two rows in the top, middle, and bottom of each plot were harvested and weighed on October 17. A 10 beet subsample was sent to the Amalgamated Sugar Company lab in Nyssa for quality analyses. After harvest, the soil from each plot was sampled in one foot increments to six feet in the top, middle, and bottom of the plot.

The available N balances were calculated by subtracting the post harvest accounted nitrogen (crop N uptake plus available soil N after harvest) from the nitrogen supply (available soil N in spring plus fertilizer N plus N from irrigation water plus N from organic matter mineralization).

Treatment differences in beet yield, beet quality, or petiole nitrate were compared using analysis of variance and the protected least significant difference test at the five percent level, LSD(0.05).

Results and Discussion

Conventional furrow irrigated plots required 11 irrigations totaling 259 hours, and surge irrigated plots required 13 irrigations totaling 331 hours in order to maintain the soil water potential at the 10-inch depth wetter than -75 kPa. The actual duration of water applications with surge irrigation would be half of that for conventional irrigation. Actual water applications were 259 hours for conventional irrigation and 166 hours for surge irrigation (a 36 percent reduction in applied water).

Despite the higher number of irrigations, soil water potential at the 10-inch depth averaged drier in the surge irrigated plots during the season than in the conventionally irrigated plots. The season long average soil water potential at the 10-inch depth for the surge plots was -62 kPa, and for the conventionally irrigated plots was -48 kPa. Soil water potential at the 20-inch depth remained drier during the season in the surge plots than in the conventional plots. The season long average soil water potential at the 20-inch depth for the surge plots was -85 kPa, and for the conventionally irrigated plots was -48 kPa.

Petiole nitrate was significantly lower for the reduced nitrogen beets than for the beets receiving 200 lb N/ac on July 17 and August 28 (Table 1). Irrigation method did not have an effect on petiole nitrate.

The moderately fertilized and continuously irrigated beets had the highest beet yield. (Table 2). There was no significant difference in sugar yield between the moderately fertilized, continuously irrigated beets and the moderately fertilized, surge irrigated beets. The conventionally irrigated, reduced fertilizer beets had among the lowest beet yield and sugar yield. The differences between treatments in beet sugar content, pulp nitrate, conductivity, and extractable sugar were significant but small. Beet sugar content was high, and pulp nitrate and beet conductivity were low for all treatments.

The soil N balance was not influenced by the treatments (Table 3). The N balances were all positive suggesting a substantial N contribution from organic matter mineralization. Total available nitrogen supply in growers' fields would normally be about 320 lbs nitrogen per acre based on soil nitrate, soil ammonium, and nitrogen fertilizer. The sugar beets in a typical grower's field would yield 30 tons per acre with 16 1/2 percent sugar, resulting in 4.5 tons per acre of recoverable sugar.

Table 1. Effect of nitrogen fertilizer rate and irrigation method on sugar beet petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, OR, 1996.

Irrigation type	N supply*	Petiole nitrate		
	lb N/ac	July 17	July 31	August 28
		------ ppm ------		
Continuous	200	1,683	707	273
Continuous	128	317	193	88
Surge	200	1,600	763	223
Surge	128	333	237	78
$LSD_{0.05}$		688	ns	89

*Soil NO_3 -N + NH_4-N in 0-3' depth plus fertilizer N

Table 2. Influence of reduced N application and surge irrigation on sugar beet yield and sugar yield. Malheur Experiment Station, Oregon State University, Ontario, OR, 1996.

Irrigation type	N supply*	Beet yield	Beet sugar content	pulp nitrate	Conductivity	Extractable sugar	Recoverable sugar yield
	lb N/ac	t/ac	%	ppm	µmhos	%	t/ac
Continuous	200	32.0	18.1	163.4	0.73	95.68	5.26
Continuous	128	27.7	18.5	171.1	0.67	95.73	4.65
Surge	200	29.2	18.3	161.7	0.71	95.71	4.86
Surge	128	28.6	18.4	167.1	0.67	95.72	4.78
LSD (0.05)		2.6	0.4	7.5	0.06	0.05	0.41

*Soil NO_3-N + NH_4-N in 0-3' depth plus fertilizer N

Table 3. Influence of reduced N application and surge irrigation on the available nitrogen accounting. Malheur Experiment Station, Oregon State University, Ontario, OR, 1996.

Irrigation type	N rate*	N supply		Fall nitrogen accounting			Balance**
		Pre-plant soil available N (0-3')	Fertilizer N	Fall soil available N (0-3')	Plant N recovery	Accounted N	
	lb N/ac	---------- lb/ac ----------					
Continuous	200	167.9	32	71.6	282.3	353.9	154.0
Continuous	128	133.3	0	63.6	234.5	298.1	164.7
Surge	200	173.0	27	59.2	284.8	344.1	144.0
Surge	128	144.0	0	60.9	230.8	291.8	147.8
$LSD_{0.05}$				ns	49.7	50.9	ns

*Soil NO_3 -N + NH_4-N in 0-3' depth plus fertilizer N

** based on the difference between N supplies and fall N accounting.