SUGAR BEET PRODUCTION ON SANDY SOILS: THE NEED FOR NON-TRADITIONAL NUTRIENTS

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Most fertilizer programs in sugar beet production in Minnesota and North Dakota focus on nitrogen and phosphorus, and, in some cases, potassium. In recent years, sugar beet grown on sandy soils along the beach ridges in NW Minnesota has shown a variety of visual symptoms that resemble nutrient deficiencies. Soil test and plant tissue analysis suggest deficiencies in one or more of the following nutrients; sulfur (S), sodium (Na), boron (B), manganese (Mn), iron (Fe) or a variety of other possibilities. Reports suggest about 15,000 acres are potentially affected by these symptoms (verbal communication with Al Cattanach)

Sulfur and Na are considered macronutrients and B, Mn, and Fe are considered micronutrients because of the relative quantities in which these nutrients are absorbed by the sugar beet crop. Under typical sugar beet growing conditions there is little emphasis on these nutrients because their release from the soil organic matter and naturally occurring soil minerals is sufficient to meet the sugar beet needs. However, on sandy soils with low organic matter (< 2%) this may not always be the case and deficiencies may appear. Draycott and Christenson (2003) reported that sugar beet can become deficient in several micronutrients, but is most responsive to the application of B, Mn, and Fe fertilizers when the soil availability of these nutrients is low. Boron and Mn deficiencies are probably most frequent and subsequently are the most studied of all the micronutrient important to the sugar beet production.

It is difficult to predict where and when deficiencies of these nutrients will occur. Soil tests methods are available for some of these nutrients and, under some situations, are valuable in predicting the likelihood the sugar beet crop will respond to the application of fertilizer. Since availability of these nutrients is dependent on their release from soil organic matter and soil minerals and are taken up in small quantities, especially micronutrients, the likelihood of a deficiency occurring can be dependent on weather conditions. Deficiencies are more frequent when the weather is cold, excessively wet, or dry.

Objectives

1) Determine the effects of applying fertilizers containing sulfur (SO_4-S), sodium (Na), or micronutrients boron (B), manganese (Mn), copper (Cu), zinc (Zn), or iron (Fe) on sugar beet yield and quality when grown on sandy, low organic matter soils along the eastern edge of the Red River Valley.

Materials and Methods

Two field site locations were selected for this experiment in 2007, one about 20 miles north-east of the Northwest Research and Outreach Center near Dorothy Minnesota (referred to as the Dorothy site) and one 10 miles east of Donaldson Minnesota (referred to as the Donaldson site). Soil at the Donaldson site was a Poppleton fine-sandy loam (mixed, frigid Aquic Udipsamments) and at the Dorothy site Rosewood fine-sandy loam (mixed, frigid, Typic Calciaquoll)

The experimental design was a randomized complete block with four blocks or replications. The entire field was fertilized for nitrogen, phosphorus and potassium by either the cooperator during their normal field fertilization process or by us using hand broadcast methods of recommended rates based on soil test. Fourteen treatments were imposed that included a Control (no added fertilizer), B (soil), B (early foliar), B (late foliar), B (early and late foliar), Mn (soil), Mn (early foliar), Mn Chelate (early foliar), Fe (soil), Fe (early foliar), Fe (seed 1 lb.), Fe Chelate (seed 2 lbs.) , Sodium Chloride (NaCl) (soil), and a combination of Copper (Cu) and Zinc (Zn) (soil). All soil applied fertilizers were broadcast and incorporated prior to sugar beet plant. The fertilizer materials used for the soil applied treatments were 2 lbs B A^{-1} (granular borate-15%B) and 10 lbs A^{-1} each of Mn ($MnSO_4$), Fe ($FeSO_4$), Zn ($ZnSO_4$), and Cu ($CuSO_4$), and 150 lbs Na A^{-1} (NaCl). Foliar applied fertilizer was applied at the 6-leaf sugar beet growth stage (early) or the 12-leaf growth stage (late). Foliar fertilizer sources were Solubar (B), $MnSO_4$, Mn Chelate, and $FeSO_4$ at the 1 lb rate of B and ½ lb rates of Mn and Fe. The seed applied Fe fertilizer source was an Fe Chelate (Soygreen) applied at 2 rates in contact with the seed at planting.

Fertilizer treatments were applied and sugar beet (VDH 46531) planted on April 24th and 27th at the Donaldson and Dorothy sites, respectively. Sugar beet was over seeded and thinned to 175 beets per 100 ft of row population after all seedlings were emerged and reasonably assured of survival. Herbicides, insecticides and fungicides were applied as needed.

On September 24 and 26th the middle two rows of each plot were harvested with a plot beet lifter from the Donaldson and Dorothy sites, respectively. Harvested beets were weighed and 10 randomly selected beets were placed in a tare bag and sent to the American Crystal Sugar Quality Laboratory in East Grand Forks for determination of tare and sugar and impurity concentrations. Data were used to calculate root yield, root quality (lbs of sucrose ton^{-1}), and Loss to Molasses (LTM). Concentrations of Na, potassium and amino nitrogen were used to calculate LTM.

Data were analyzed using Proc GLM in SAS 9.1 and Fishers protected LSDs used to determine mean separation. Alpha levels of both 0.05 was used to determine significance if the main ANOVA showed main treatment significance.

Results and Discussion

Soil conditions at planting were nearly ideal at both locations. Though both sites experienced periods of drought stress throughout the growing season, timely rainfall events and reserve soil moisture satisfactorily sustained the sugar beet crop.

In selecting each these sites, consultation with the grower cooperator and soil tests were conducted of the specific experimental area under consideration. Soil test results at the Donaldson site suggested the sugar beet crop might respond to the application of chloride (Cl), B, Mn, Cu, and Na. At Dorothy, soil test results suggest the sugar beet crop might respond to the application of Cl, B, Zn, Mn, Cu, Na, and possibly Fe. Though Cl was not included as a treatment at either location, the NaCl used to supply the Na treatment supplied about 225 lbs Cl A^{-1}.

Both locations had extreme plot-to-plot variability, but for different reasons. At the Donaldson site, there were undulating ridges and valleys that were each 2 to 4 sugar beet rows wide and ran parallel with the sugar beet rows. This characteristic was not apparent at the time the site was selected nor when it was tilled and planted. These ridges and valleys tended to go through all four replications of the trial. Sugar beets on the ridges tended to grow faster than those in the valleys, but none of the sugar beets grew exceptionally well. The sugar beet crop did not close canopy until very late in the season thus requiring additional herbicide applications to control new weed growth. At the Dorothy site, strong winds damaged or killed a significant number of sugar beets when they were very small. Nevertheless, these beets also tended to grow slowly and irregularly. As a result there was substantial variability at both locations that precluded detecting a significant sugar beet response to any of the treatments (Table 1 and 2). The exception was a significant increase in LTM associated with the NaCl treatment at the Donaldson site. Interestingly, at the Dorothy site there was a highly visible increase in sugar beet top growth associated with the NaCl treatment early in the growing season (early June). However, this visual growth difference was not evident after about three weeks.

It was apparent that sugar beet growth and production were hindered at both locations, though the actual yields at the Donaldson were quite good considering the way the plants looked throughout the growing season. No visual nutrient deficiency symptoms were observed at either location. A laboratory screening by Dr. Carol Windels lab confirmed the presence of Aphanomyces at the Dorothy site, but much less so at Donaldson site, but it could not be confirmed that this was causing the poor growth at the Dorothy site. At this point I cannot confirm that a micronutrient fertilizer program would contribute to the production of sugar beet at either of these locations. The control treatment had the greatest sugar beet root yield and total recoverable sucrose at the Donaldson site. At the Dorothy site, the NaCl treatment produced the greatest root yield and total recoverable sucrose. But, neither of these treatments was significantly different than any other treatment used in the experiments.

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References

Draycott, A.P. and D.R. Christenson. 2003. Nutrients for Sugar Beet Production. CABI Publishing, Cambridge, MA.

Table 1. 2007 Sugar beet root yield and quality parameter responses to various micronutrient and non-traditional fertilizer treatments 10 miles east of Donaldson Minnesota (Donaldson site).

Treatment	Root Yield	Root Quality	Revcoverable Sucrose	Loss to Molasses
	Ton/A	lbs sucrose/ton	lbs. A^{-1}	%
Control	24.6	300	7372	0.97
B (soil)	23.6	302	7135	0.99
B (foliar-early)	22.2	295	6553	1.01
B (foliar-late)	24.6	290	7030	1.00
B (foliar-both)	22.2	303	6661	1.01
Mn (soil)	22.3	298	6627	1.01
Mn (foliar)	24.0	302	7234	1.00
Mn (foliar-chelate	20.0	301	5988	1.02
Fe (soil)	20.4	302	6152	0.98
Fe (foliar)	22.4	296	6617	1.00
Fe (seed -1 lb.)	19.6	297	6378	1.00
Fe (seed – 2 lb.)	21.4	307	6018	0.99
NaCl	22.5	388	6462	1.20
Zn/Cu	22.0	295	6404	1.05
Avg	22.3	298	6624	1.02
$LSD_{(0.05)}$	ns	ns	ns	0.08

Table 2. 2007 Sugar beet root yield and quality parameter responses to various micronutrient and non-traditional fertilizer treatments 20 miles north-east of Crookston Minnesota (Dorothy site).

Treatment	Root Yield	Root Quality	Revcoverable Sucrose	Loss to Molasses
	Ton/A	lbs sucrose/ton	lbs. A^{-1}	%
Control	15.8	283	4494	0.75
B (soil)	17.0	288	4919	0.70
B (foliar-early)	17.6	287	5068	0.71
B (foliar-late)	15.1	282	4274	0.72
B (foliar-both)	15.2	288	4407	0.66
Mn (soil)	15.2	282	4274	0.72
Mn (foliar)	16.4	289	4749	0.68
Mn (foliar-chelate	16.4	290	4767	0.72
Fe (soil)	15.8	281	4452	0.76
Fe (foliar)	16.9	280	4738	0.73
Fe (seed -1 lb.)	16.8	285	4784	0.74
Fe (seed – 2 lb.)	16.8	280	4712	0.76
NaCl	18.8	291	5466	0.80
Zn/Cu	15.9	276	4393	0.79
Avg	16.4	285	4678	0.73
$LSD_{(0.05)}$	ns	ns	ns	ns