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Improvements in Sugarbeet Growth with Amendments in Sandy Soils with a History of Poor Sugarbeet Performance

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Introduction

Some areas in the Red River Valley of Minnesota and North Dakota have experienced poor sugarbeet growth, especially in sandy soils with lower organic matter. These same areas appear to grow good yields of other crops, including corn, wheat and potatoes. A study was initiated in 2000 to determine probable causes and solutions to the problem. The first year, soil and 6-leaf beets at sites near Downer, MN and Galchutt, ND were sampled in transects from "poor" growing beets to " normal" growing beets. Differences were easily seen at the 6-8 leaf stage. A description of the poor growing beets and details of the transect sampling are reported in Franzen et al., 2000. The results of the transect sample analysis suggested that magnesium might be part of the nutritional problem. Results were not obtained in 2001 due to serious stand problems at both locations caused by environmental and soil physical factors. Research at University of Minnesota, Crookston, suggested that banded P fertilizer at planting may alleviate some of the poor growth (L. Smith and A. Sims, personal communication).

The objectives of the 2002 experiments were:

1. Study the effect of starter P application on sugarbeets within the poor growth soils.
2. To study the effect of liming materials and magnesium amendments on poor growth soils.

Methods

In the fall of 2001, plots were established at three locations; Galchutt, and Larimore, ND, and Downer, MN. Each location had experienced poor sugarbeet growth in the past. All three sites were relatively sandy and low in organic matter compared with the rest of the field. Details of the characteristics of each site are given in Table 1. A split plot experimental design was used, with lime and broadcast fertilizer amendments as main plots and with and without row starter at planting as split plots. Individual plots were twenty feet long and twenty two feet wide, split to twenty feet long and eleven feet wide sub plots. Lime and broadcast fertilizer amendments were as follows- Check; Dolomite, 2 ton/acre; Dolomite, 4 ton/acre; Sugarbeet spent lime, 2 ton/acre; Potassium magnesium sulfate (K-Mag) 100 lbs Mg/acre and 50 lbs Mg/acre; Magnesium sulfate (Epsom salts), 100 lb Mg/acre; Borate 48 (14% boron), 2 lb B/acre.

Dolomite was obtained from the Ag-Lime Sales, Inc. quarry south of St. Paul, MN. Fresh spent sugarbeet lime was obtained directly from the American Crystal Sugar factory at Moorhead, MN. Characteristics of lime and fertilizer amendments are given in Table 2. Lime treatments were applied in November, 2001, to the soil surface. These treatments were not incorporated. Analysis of the Ca and Mg content of the lime sources is given in Table 3. The Downer site was clean tilled wheat stubble prior to lime application. The Galchutt and Larimore sites were disked corn residue. The Galchutt and Larimore sites were protected by shelter belts. The Downer site was not protected by any wind erosion method during the winter of 2001-2002.

Potassium magnesium sulfate (K-Mag), magnesium sulfate (epsom salts), and boron treatments were applied in the spring of 2002. Urea was broadcast at a rate of 80 lb N/acre to all plots within a week of seeding at Downer and Galchutt, but seeding at Larimore was delayed due to rainfall until May 14. Rain during early and late May at Larimore may have contributed to lower plant N levels in portions of the plot with a coarser subsoil due to increased leaching out of the root zone.

At date of seeding, Larimore and Galchutt plots were field cultivated twice. Downer was seeded directly into the field, since the plots had been field cultivated three times in the early spring by the cooperator to try to stop soil blowing. 10-34-0 was applied directly in the seed furrow at a rate of 3 gal./acre, diluted 2-1 with water. Aphenomyces tolerant variety Crystal 952 was planted at 3 seeds/foot was used. Wind storms destroyed the stand at Downer just after plant emergence. Downer was replanted, but emergence was poor due to continued seed burying from persistent wind and emerged plants were destroyed by soil blowing. The plots at Downer were subsequently abandoned following a final soil sampling. At the two leaf stage, Larimore and Galchutt stands were thinned to 1.4 plants/foot of row. At the 6-8 leaf stage, twelve plants from the four interior rows were cut off at the soil surface, dried, weighed and ground for nutrient analysis. A vigorous fungicide application spray program was adhered to during June, July and August for Cercospora control. Cercospora control at both surviving sites was very good. Heavy rains at Galchutt initiated Rhizoctonia and Aphenomyces root diseases in late June. Plant stand counts were taken and plants wilted and dying were recorded. Soil samples were collected in June at each location and in August at Larimore and Galchutt. At harvest, 10 feet each of two rows were hand harvested from each plot and sent to the East Grand Forks Tare Laboratory for analysis. Dates for activities are recorded in Table 4.

Table 1. Site characteristics, 2001-2002 experiments on poor sugarbeet growth.

Site	Soil series	pH, mean/range	P, ppm	K ppm	Ca ppm	Mg ppm
Downer	Arvilla ls	8.2 8.1-8.3	7.6 (5-10)	35 (20-55)	3600 (1827-4452)	201 (95-414)
Galchutt	Mantador l	6.3 5.4-8.0	10.2 (2-18)	98 (45-165)	1044 (630-1827)	217 (137-315)
Larimore	Arvilla ls	5.9 (5.6-6.5)	36.2 (28-54)	159.4 (70-245)	711 (546-1092)	133 (95-160)

Table 2. Amendment characteristics from poor sugarbeet growth experiments, 2001-2002.

Amendment	**% H_2O**	**% CCE**	**% <200m**	**% 100-200m**	**% 100-60m**	**% 60-30m**	**% 30- 8m**	**% >8**	**% effectiveness**
Sugarbeet spent lime	28.35	86.3	98.2	1.0	0.4	0.4	0	0	100*
Dolomite	4.07	96.6	46.7	29.7	5.5	1.9	10.5	5.8	89.3**
Fertilizer	**%K**		**%Mg**		**%S**		**%B**		
Potassium magnesium sulfate (K-Mag)	22		11		22		0		
Magnesium sulfate	0		9.8		13		0		
Borate 48	0		0		0		14		

*Effectiveness, source weight spent lime = (100 % effectiveness)X (86.3 % CCE calcium carbonate equivalence) X (71.65 % solids) = 61.8 %

** Effectiveness, quarry weight dolomite = (89.3% effectiveness) X (96.6 % CCE) X 95.93 % solids = 82.8%

Table 3. Calcium and magnesium content of lime sources, dry basis.

Lime source	% Ca	% Mg
Sugarbeet spent lime	30.84	1.3
Dolomite	17.75	9.4

Table 4. Dates of activities for three locations.

Site	Lime application and fall sampling	Spring fertilizer application	Seeding	6-8 leaf sampling, soil sampling	Dying beet count	Fall soil sampling/harvest
Downer	10/31/2001	4/22	5/2 reseeded 5/28	abandoned/ 6/20	NA	abandoned
Galchutt	10/30/2001	4/22	5/3	5/28	7/23	9/16
Larimore	11/5/2001	4/23	5/14	6/3	NA	9/17

Results and Discussion

Visual differences in growth of sugarbeets were evident from the 6-leaf growth stage to harvest at Galchutt, but not at Larimore. These observations are reinforced measurements from the two sites.

At Larimore, boron (B) application significantly increased 6-leaf plant weight compared to lime treatments, but this increase did not translate into yield improvement or recoverable sugar increases (Table 5). Spatially within the plot, two of the B plots were in an area with noticably more robust growth regardless of treatment. Because of their location, and the resulting lack of differences in yield and quality at harvest, it is unlikely that the effect was due to boron application, but on location within the plots. This conclusion is supported in Table 6 by the lack of difference in B concentration due to treatment. If B was responsible for greater growth then an increase of B concentration would probably have been seen.

Starter treatments had no effect on plant weight, beet yield or recoverable sugar at Larimore or Galchutt. Plant weight was increased over the check at Galchutt with beet lime, both KMag rates and magnesium sulfate. The increase with magnesium sulfate is noteworthy in that it suggests that the increased early growth at least was not a consequence of K nutrition. Highest beet yields and recoverable sugar yields were obtained with the beet lime application and the 50 lb Mg KMag rate. Early plant P levels were increased with starter application at Galchutt (data not shown), but not plant P uptake.

Table 5. Early plant weight, final yield and recoverable sugar, Larimore and Galchutt.

Treatment	Larimore			Galchutt		
	6-leaf plant wt-g.	Yield ton/a	RSA lb/a	6-leaf plant wt-g.	Yield ton/a	RSA lb/a
Check	8.0 ab†	18.2	5290	15.4 b	8.5 b	1890 b
2 ton Dol.*	7.8 ab	18.7	5570	18.6 ab	13.2 ab	3040 ab
4 ton Dol.	6.0 b	16.4	4650	14.1 b	12.4 ab	3000 ab
2 ton B.L.	6.4 b	14.6	4400	21.1 a	18.5 a	4480 a
100 KMag	9.5 ab	19.2	5620	22.2 a	13.3 ab	3140 ab
100 MgSul	8.6 ab	15.7	4780	23.7 a	13.8 ab	3280 ab
2 lb B	11.1 a	16.5	4940	15.5 b	10.6a b	2580 b
50 K Mag	8.9 ab	18.6	5620	25.0 a	20.4 a	5150 a
LSD	5% 4.6	NS	NS	10% 7.2	5% 9.9	10% 2290

* Dol. is dolomite, B.L. is Sugarbeet spent lime, 100 KMag is 100 lb Mg/acre as potassium magnesium sulfate, 100 MgSul is 100 lb Mg/acre as magnesium sulfate, B is boron, 50 K Mag is 50 lb Mg as potassium magnesium sulfate.

†Values followed by the same letter are statistically similar. Values followed by a different letter are statistically different.

Table 6. Plant nutrient concentration and uptake, 6-leaf beets, Larimore.

Plant Nutrient Concentration, 6- leaf					
Treatment	% P	% Ca	% Mg	% K	B ppm
Check	0.49	0.82 ab	0.87	3.5	14.8
2 T/a Dol.	0.52	0.85 ab	0.99	3.8	15.8
4 T/a Dol.	0.56	0.99 a	1.00	3.8	14.7
2 T/a B.L.	0.51	0.83 ab	0.86	3.6	13.7
100 KMag	0.48	0.67 b	0.78	3.4	12.8
100 Mg Sul	0.53	0.72 b	0.84	3.8	14.5
2 B	0.44	0.71 b	0.80	3.2	15.2
50 KMag	0.48	0.71 b	0.79	3.4	13.5
Significance	NS	5% 0.21	NS	NS	NS
Plant nutrient uptake, g/12 plants					
Treatment	P	Ca	Mg	K	B
Check	0.039	0.065	0.071	0.29	0.0000119ab
2 T/a Dol.	0.039	0.065	0.075	0.28	0.0000120ab
4 T/a Dol.	0.031	0.059	0.060	0.22	0.0000086b
2 T/a B.L.	0.033	0.054	0.056	0.23	0.0000083b
100 KMag	0.044	0.063	0.074	0.32	0.0000119a
100 Mg Sul	0.044	0.062	0.072	0.32	0.0000123a
2 B	0.047	0.075	0.085	0.35	0.0000164a
50 KMag	0.040	0.061	0.068	0.29	0.0000114ab
Significance	NS	NS	NS	NS	LSD 10% 0.0000058

Plant Ca levels were highest at Larimore with the 4 ton Dolomite treatment, but did not translate into higher plant uptake. Boron levels were highest at Galchutt with B application, but it did not translate into higher B uptake. Magnesium and K uptake were higher at Galchutt with KMag treatment at the 50 lb Mg level, but this was not due to higher Mg and K levels in these treatments, but higher early growth.

Table 7. Plant nutrient concentration and uptake, 6-leaf beets, Galchutt.

Plant Nutrient Concentration, 6- leaf					
Treatment	% P	% Ca	% Mg	% K	B ppm
Check	0.45	0.92	1.40	4.9	31.0
2 T/a Dol.	0.47	0.94	1.50	5.1	28.2
4 T/a Dol.	0.44	0.87	1.41	4.9	26.8
2 T/a B.L.	0.45	0.99	1.42	5.0	27.0
100 KMag	0.44	0.82	1.37	5.6	26.8
100 Mg Sul	0.44	0.93	1.54	5.3	31.0
2 B	0.48	0.87	1.42	5.4	52.5
50 KMag	0.45	0.95	1.45	5.6	30.5
Significance	NS	NS	NS	NS	LSD 5% 12.7
Plant nutrient uptake, g/12 plants					
Treatment	P	Ca	Mg	K	B
Check	0.070	0.141	0.217 b	0.76 b	0.0000141
2 T/a Dol.	0.088	0.180	0.279 ab	0.90 ab	0.0000180
4 T/a Dol.	0.062	0.124	0.199 b	0.69 b	0.0000124
2 T/a B.L.	0.094	0.207	0.299 ab	1.05 ab	0.0000207
100 KMag	0.094	0.182	0.311 ab	1.25 ab	0.0000182
100 Mg Sul	0.108	0.222	0.371 a	1.27 ab	0.0000222
2 B	0.074	0.133	0.218 b	0.82 ab	0.0000133
50 KMag	0.113	0.177	0.362 a	1.39 a	0.0000237
Significance	NS	NS	LSD 10% 0.12	LSD 10% 0.61	NS

At Galchutt, there was certainly a positive effect from the lower rate of KMag and the beet lime treatments. Whether or not the effect was nutritional is somewhat up to question, considering that concentrations of nutrients in the plants were similar. However, the "6-leaf" stage of growth was an experiment mean. Given differences in dry weight at this early stage of growth, some of the differences no doubt came from differences in growth stage. Some of the higher weights coming from perhaps 8 leaf beets and some of the lower weights from smaller beets. This difference makes a large difference in plant nutrient concentration. All of the nutrients measured in this experiment would be expected to decrease in concentration with growth stage increases, so plant uptake might be a better measurement. If that is the case in this experiment, then KMag and beet lime effects would be related to Mg and K nutrition.

If Mg and K nutrition were the causes of the increased growth and yield caused by the lower rate of KMag and beet lime, then why didn't the dolomite treatment perform as good as beet lime, and why didn't the magnesium sulfate or the high rate of KMag perform similarly? The answer to the high rate KMag and magnesium sulfate question may be due to the high rates used and salt effects on germination. Because of observed differences between some treatments, a stand count was made prior to thinning at Galchutt. Results are shown in Table 8. Stand reduction was caused by the beet lime and heavier rates of magnesium amendments, as well as the B application. All of the treatments resisted root diseases compared to the check. It is not known if this response is due to nutritional factors in the sugarbeets, or some antigonistic effect on the disease organisms themselves.

Table 8. Stand counts, Galchutt prior to thinning, 5/28 and per cent dead and dying plants due to Rhizoctonia/Aphenomyces, 7/23.

Treatment	Stand count	% dead and dying
Check	76.0 a	22.0 b
2 ton/a Dolomite	76.5 a	6.6 a
4 ton/a Dolomite	78.5 a	7.2 a
2 ton/a Beet lime	69.2 b	5.8 a
100 lb Mg KMag	71.8 b	11.6 ab
100 lb Mg Mg Sul	74.7 b	9.1 ab
2 lb/a B	73.8 b	6.5 a
50 lb Mg KMag	80.8 a	7.8 a
Significance	LSD 5% 5.6	LSD 5% 13.3

General observations of poor growing areas of sugarbeets and summary remarks

The areas of poor sugarbeet growth have many problems. I called this project the "weird beet" project due to the large differences in growth and the distinctive upright, red-rimmed leaves at early stages of growth in some years. Others have called it "sand syndrome". From our work on these soils during the past three years it is clear that a major part of the problem is the poor physical condition of the soil. Low organic matter, high sand content with little resistance to crusting, blowing and dry weather. These soils need to be protected from blowing, need a residue cover and perhaps even a composted manure application or two to increase the organic component of the soil and avoid losing any more "topsoil" (to use the word loosely) than has already occurred. The two sites which were grown to maturity in 2002 were protected with both disked corn stalks and tree rows. Had the tree rows and residue not been in the field, it is unlikely that we would have any data to share this year. For growers considering applications of amendments to their own fields, they first need to address the physical condition of these soils before attempting to “solve” the problem by a simple application of amendments.

If these physical factors are addressed, then I think trying some amendments might be appropriate. If growers are not willing to address the soil side of this problem, then I think amendments are next to futile.

The amendments that made the biggest difference at Galchutt were lower rates of KMag (about 450 lbs/acre) and beet lime (2 tons/acre). Since this data comes from only one site in one year, no conclusive recommendations can be made. Some items to check before going through the more difficult and costly applications are - what is the soil K level in the poor growing area? It would not be uncommon for these areas to test 30-40 ppm K, which Moraghan (1978) has already shown are responsive levels to K fertilizer. Certainly a regular K application would be of considerable help in these areas. How high is the soil P level? At Galchutt and Larimore, soil P levels were medium to high, so starter P was not a factor in improving yields. However, other studies have shown benefits to P at low soil P levels. If low, then a starter P or broadcast P application would be appropriate. Sample the soil in these poor growing areas and the "good" areas separately and if nutritional “red flags” stand out, address them. But more than anything, look at the areas in a systems approach. It will be important for sustained better yields to treat these fragile areas with kid gloves and prevent wind erosion and crusting problems and soil dryness problems in the spring from reducing stand. That can only come with a change in tillage and soil management practices.

References

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