Spent Lime Rate Effects on Sugarbeet Yield and Quality (2004 and 2007)
Wheat and Soybean (2005 and 2006)

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Interest in spent lime (from the processing of sugarbeet) has increased in recent years in the Red River Valley. Two factors for the interest relate to reduced Aphanomyces cochlioides and the nutrient value as it relates to "sand syndrome" and other nutrient replacement from crop removal.

In 2004, five rates of spent lime from the ACSC Crookston plant were applied and sugarbeet grown. In the following years, other crops in the sugarbeet rotation were planted to determine beneficial or detrimental effects of spent lime application.

Materials and Methods

2004 – On May 10, 2004, spent lime rates of 0, 2.5, 5.0, 10.0 and 15.0 ton dry matter (TDM) per acre were applied to two series of plots in a randomized block design. One series of plots received no additional nitrogen (69 lb/A 0-4ft) and the other was brought up to the recommended nitrogen level (130 lb/A). Both series of plots received 70 lb/A P_20_5. Beta 3820 sugarbeet seed was planted in 22-inch rows on May 24. Plots were six rows wide and 35 ft in length. Plants were thinned to uniform populations of 35,600 plants per acre on June 22. all other cultural practices were applied to ensure maximum yield and quality. The trial was machine harvested on September 28 and quality determined at the ACSC Quality Laboratory, East Grand Forks, MN. In mid-October all plots in the trial were soil sampled to a depth of 0-6 and 6-24 inches and a complete soil analysis run.

2005 – The sugarbeet series receiving the recommended rate of N (130 lb/A) was planted to Knutson wheat on Mays 6, 2005. Eighty-five pounds of N was applied pre-plant as urea. No phosphorus fertilizer was applied. Weed control consisting of Bronate (0.8 pt/A) and Puma (0.5 pt/A was applied on May 31. Folicur fungicide was applied on June 23 for disease control. The wheat was harvested on August 23 and yield, test weight and protein content determined.

On the series receiving no additional N in 2004, two varieties of soybean differing in susceptibility to iron chlorosis were planted in 22-inch rows on May 17, 2005. The soybean varieties were Gold Country 923RR and Garst 0211RR, with the Garst variety supposedly being more chlorosis susceptible than the Gold County variety. Round-up herbicide was applied for weed control on June 20. The trial was harvested on September 29 and yield, protein and oil content determined.

In mid-October, all plots were again soil sampled to determine residual nutrients.

2006 – The spent lime series planted to soybean in 2005 was planted to Knutson spring wheat on May 15, 2006. Eighty pounds of N was spring applied as urea. No phosphorus fertilizer was applied. Weed control consisted of Bronate at 0.8 pt/A. The wheat was harvested on August 15 and yield, test weight and protein content determined.

On the series planted to spring wheat in 2005, Gold Country 426RR was planted for harvest on May 19, 2006. One row (not in harvest population) in each spent lime treatment was planted to NKSO1-T5, a variety which is highly susceptible to iron cholorosis (IDC) to determine if the various spent lime rates increased iron chlorosis compared to the check plots. Roundup herbicide was applied for weed control on May 19, and Warrior insecticide was applied for soybean aphid control on July 6. The trial was harvested on September 15 and yield, protein and oil content determined.

On October 4, all plots were again soil sampled to determine residual nutrients.

2007 – Crystal R434 sugarbeet seed was over planted in 22-inch rows on April 26, 2007, on both the spent lime series planted to wheat and soybean in 2006. The plots were thinned to a uniform population of 41,500 plants/A on June 5. The 3 spent lime rates with wheat in 2006 were adjusted to the recommended nitrogen rate (130 lb/A – 0-4ft) with urea for the 2007 sugarbeet crop. On the spent lime series with soybean in 2006, the residual NO_3-N in the top 24 inches was over 100 lb/A, with NO_3-N in the 24-48 inch soil profile ranging from 9-19 lb/A. as a nitrogen credit recommendation for crops following soybean is 30-40 lb/A, no additional nitrogen was added. (I don't know of any evidence to support this nitrogen credit from soybean sugarbeet exists). No additional P_20_5 or other plant nutrient was added. All other cultural practices were as recommended to ensure maximum yield and quality. The trial was mechanically harvested on September 22 and the quality parameters determined at the ACSC Quality Laboratory, East Grand Forks, MN.

On October 20, plots were soil sampled to determine residual nutrients.

Results – 2004

The chemical analysis of the spent lime used in the trial is shown in Table 1. The analysis of variance for the trial is shown in table 2. Nitrogen was the only treatment to influence the variables measured (Table 3). The increase in RSA and gross return are the result of an increase in yield (2.3 T/A).

The main effects of the lime treatments (area over nitrogen rate) are shown in table 4. The different rates of lime application had no effects on yield, quality or gross return.

The soil analysis of the various treatments after harvest at the 0-6 inch and 6-24 inch soil depth is shown in tables 5 & 6. The most noticeable feature is the significant increase in P level with the addition of the lime. The no lime treatment at both N levels had a mean P level of 9 ppm. At the 15.0 TDM treatment, the P level increased to a mean of 18.8 ppm. No significant change in soil pH was noted between the zero And 15.0 TDM lime treatments.

There were no differences in stand establishment between lime treatments.

Discussion 2004

According to the analysis of the lime used in this trial, there were 16.5, 33.0, 66.0, and 99.0 lb of N in the 2.5, 5.0, 10.0 and 15.0 TDM lime rates applied. Phosphorus wise, the lime contained 19, 38, 76, and 114 lbs respectively.

Because the trial already had 70 lb/A P_20_5 applied before the lime treatments were applied, no phosphorus response was expected. Conversely with N, one would have expected a response based on the chemical analysis of the % N in the lime and the two N regimes chosen on yield and quality (Table 7). None occurred and no increase in soil residual N (0-24 inches) was observed in the soil after sugarbeet harvest. The question then is "Where Is It?"

Results – 2005

The response of Knutson spring wheat to the various levels of spent lime applied in 2004 is shown in Table 8. No differences in yield, test weight, or protein content occurred between the various lime levels.

The two soybean varieties gave similar response across the lime rates (Tables 9 & 11). Lime rates, however, had significant effects on yield, oil and protein (Table 10). The 2.5 and 5.09 TDM/A rates had significantly higher yield than the check, 10.0 and 15.0 TDM lime rates; however, there was no significant difference between these three rates. The 2.5 and 5.0 TDM/A also had significantly higher protein than the check.

Soil phosphorus (P) level following wheat and soybeans compared to the 2004 levels at the various lime and nitrogen rates is shown in Table 12. While P levels are somewhat variable, there is still a trend to higher soil levels at the higher lime rates, even after the yields of wheat and soybean that were obtained in 2005.

Discussion – 2005

The lime treatments receiving wheat in 2005 had an average of 15 lb/A NO_3-N in the top 24 inches after sugarbeet in 2004. With the added 85 lb/A N, spring applied, it was anticipated that any of the nitrogen not recovered in the sugarbeet crop from the various lime rates may show up in increased yield and protein. This did not happen and we are still looking for the 99 lb/A of N that was applied with the 15.0 TDM spent lime application in 2004.

It was anticipated that the 10.0 and 15.0 TDM spent lime rates applied in 2004 may have deleterious affects on soybean yield and chlorosis. While mild chlorosis occurred at these rates early in the growing season, no chlorosis was visible in early August. Why the 2.5 and 5.0 TDM lime rates increased yield and protein as compared to the check is unknown.

Results – 2006

The response of Knutson spring wheat to the various levels of spent lime applied in 2004, and following soybean in 2005, is shown in Table 13. There were non-significant differences in yield and test weight. The spent lime rate of 2.5 TDM/A had significantly higher protein than the 0, 10 and 15 TDM/A lime rates.

The various spent lime rates had non-significant effects on soybean yield, oil content and protein, following 2005 wheat. (Table 14). While differences were non-significant, it should be noted that the 15 TDM spent lime rate was close to being significantly lower in yield than the other rates.

IDC visual ratings throughout the growing season of the variety Gold County 426RR showed no differences between lime rates. On the other hand, the single row IDC susceptible variety, visually had more chlorosis at the 3-5 tritoliate stages at the 10 and 15 TDM/A lime rate than at the check or other two lime rates. This visual difference disappeared by August 1.

Discussion – 2006

Spent lime rates applied in the spring of 2004 had no effects on either wheat of soybean yields in 2006 after three crop cycles (sugarbeet, wheat, soybean). Fears of the high spent lime rates affecting IDC and ultimately yield have not materialized.

A complete soil analysis of the 0 and 15 TDM/A spent lime rates (Table 15) shows little variation from that taken following sugarbeet in 2004, with exception of NO_3-N and chloride. Nitrogen levels following both wheat and soybean in 2006 were higher than anticipated, but relatively uniform across treatments. Why the Cl levels are higher is unknown.

Of significance is the level of soil phosphorus (P) following application of the 2004 spent lime rates through 3 crop cycles (Table 16). All rates continue to have higher soil P levels than the check plots, which is especially true of the 10 and 15 TDM/A lime rates. This is especially significant as no additional P fertilizer has been added to either the wheat or soybean crops in 2005 and 2006.

Results 2007

The results of the trial and the ANOVA are shown in Tables 17 and 18. Sugarbeet following the 2006 wheat crop had significantly higher RSA, yield and gross return than the sugarbeet following soybean (Table 19). Non significant effects were noted for the quality factors, RST, sugar % and LTM %.

All spent lime rats that were applied in 2004 significantly increased RSA, RST, sugar % and gross return compared to the check plot (Table 20). This was true whether the previous crop was wheat or soybean. The spent lime rates had non significant effects on yield and LTM %. A plausible explanation may relate to Aphanomyces cochliodes control or suppression with spent lime, as reported by Dr. Carol Windels. While no visible or measured differences were seen or made, this is only speculation.

The complete soil test results from the 0 and 15 TDM/A spent lime rates on the sugarbeet following both soybean and wheat in 2006 is shown in Table 21. With the exception of phosphorous (ppm), no large differences in soil nutrient levels existed between the 0 and 15 TDM/A lime rate.

Discussion 2007

Why the spent lime rates increased RSA, RST and sugar %, but not yield is unknown. It could be speculated that it may be related to no P_20_5 being added in the four years the trial was conducted, even though the fall 2006 soil test, along with research on the topic at the NWROC, indicated adequate phosphorous (Table 16). Also previous phosphorous research by the author has never shown a sugar % difference in the absence of an increase or decrease in yield.

Previous research by Dr. Alan Dexter and the author, has shown decreased yield of sugarbeet following soybean as compared to wheat. However, this reduction always had a corresponding decrease in sugar % which did not occur in this trial. One could speculate in this trial, that the nitrogen credit given to the soybean crop was invalid, and the reason for the decrease in yield was due to inadequate nitrogen, however, this is not supported by previous research or the fact that the sugar % between the previous crops was non significant.

As I have no way of explaining the differences noted, as well as never finding the 99 lb/s A of nitrogen that the initial analysis of the 15 TDM/A spent lime rate said it contained, I will use and blame it on a phrase coined by Dr. Albert Sims, soil scientist, "it's due to complex soil chemistry".

Four Year Summary

No negative effects from the application of up to 15 TDM/A spent lime were observed on sugarbeet, wheat or soybean. Soil test levels of phosphorous were significantly increased at the 15.0 TDM/A spent lime rate compared to the 0 level for all years of the trial (Table 22). Soil phosphorous levels were not measured for the 2.5, 5.0 and 10.0 spent lime rates in 2006 or 2007 (a mistake), but were in 2005 following 2004 sugarbeet and 2005 wheat and soybean (Table 12). If the increases noted there were maintained throughout the crop rotation in this trial would only be speculation. As no phosphorous fertilizer was applied in 2005, 2006 and 2007 to the crops grown in this trial, it is worth noting that the soil phosphorous test level was maintained and even slightly increased over this time frame. This raises the question, at least in the author's mind, as to recommendations for applying excess phosphorous fertilizer, above crops needs, to "build" soil phosphorous levels, or to statements made that applying only 3 gals/A 10-34-0 in-furrow in sugarbeet production, rather than broadcast application of 60-100 lb/A P_20_5 on soils testing low-medium in phosphorous, will have negative effects on subsequent soil phosphorous levels.

Comparing the complete soil test analysis over the four years of this trial, between the 0 and 15.0 TDM/A spent lime application, for all components except phosphorous, shows no major differences or negative effects.

Table 1. Chemical analysis of spent lime on a dry matter basis

Nutrient	(%)	Nutrient	(ppm)
Nitrogen	0.33	Zinc	36
Phosphorus	0.38	Iron	1492
Potassium	0.01	Manganese	126
Sulfur	1.00	Copper	12
Calcium	18.00	Boron	12
Magnesium	1.00		
Sodium	0.002	Percent Dry Matter	72.8%

Table 2. ANOVA[1]

Source	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return[2] ($/A)
Nitrogen Rate (Nr)	***	NS	***	NS	NS	***
Line	NS	NS	NS	NS	NS	NS
NR x Lime	NS	NS	NS	NS	NS	NS

1. NS, *, **, *** represent nonsignificant and significant levels of 0.05, 0.01 and 0.001 respectively.
2. Basis – ACSC November 15, 2004 – payment

Table 3. Main effects of nitrogen rate (ave over lime rates) on sugarbeet yield, quality and return, 2004

Nitrogen rate (lb/A[0-4 ft])	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return ($/A)
69	5805	296.4	20.1	15.56	1.11	607
130	6633	289.0	22.4	15.85	1.03	714
Stat. Sign.	***	NS	***	NS	NS	***

Table 4. Main effects of lime (ave over nitrogen rate) on sugarbeet yield, quality and return, 2004

Lime (TDM/A)	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return ($/A)
0	6238	293.2	21.3	15.69	1.03	663
2.5	6320	296.5	21.3	15.90	1.07	681
5.0	6249	290.7	21.5	15.62	1.08	659
10.0	6146	293.2	20.9	15.72	1.07	654
15.0	6143	290.0	21.2	15.62	1.11	655
Stat. Sign	NS	NS	NS	NS	NS	NS

Table 5. Soil analysis following sugarbeets receiving no applied N in 2004 and different spent lime rates

Depth	N appl	Lime T/A	Nitrate N lb/A	P ppm	K ppm,	C1 lb/A	S lb/A	B ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Mg ppm
0-6	0	0	7.7	8.7	119.0	3.7	17.3	2.0	0.53	7.6	4.7	0.54	928
0-6	0	2.5	7.7	11.0	130.7	4.0	12.7	1.9	0.64	8.0	4.8	0.57	850
0-6	0	5	6.3	12.7	132.3	6.0	18.7	2.0	0.60	8.1	4.6	0.57	930
0-6	0	10	5.3	13.0	121.0	2.7	16.0	1.9	0.62	8.1	4.8	0.56	873
0-6	0	15	7.0	19.3	126.3	5.0	36.7	1.9	0.65	10.1	4.9	0.59	936
$LSD_{.05}$			NS	2.81	NS	NS	13.3	NS	0.071	0.70	NS	NS	NS
6-24	0	0	11.0	3.0	76.0	6.0	48.0	1.3	0.30	9.4	1.7	0.60	1028
6-24	0	2.5	26.0	3.3	94.7	10.0	84.0	1.4	0.42	10.0	2.0	0.55	1036
6-24	0	5	10.0	3.7	91.7	6.0	82.0	1.3	0.37	9.9	2.0	0.59	1049
6-24	0	10	8.0	3.3	88.3	3.0	74.0	1.1	0.36	10.3	1.8	0.56	910
6-24	0	15	16.0	4.7	98.7	9.0	116.0	1.4	0.42	9.7	2.1	0.56	994
$LSD_{.05}$			14.8	0.8	22.6	NS	NS	NS	0.105	NS	0.37	NS	NS

Depth	N Appl	Lime T/A	ca ppm	NA ppm	OM %	Carb %	Salt mmho/ cm	Soil pH	CEC meq	% Base Saturation			
										%CA	%Mg	%K	%Na
0-6	0	0	4872	49.3	3.8	4.87	0.33	8.1	32.6	74.7	23.7	0.93	0.63
0-6	0	2.5	4965	37.0	3.8	3.90	0.39	8.1	32.4	76.6	21.9	1.07	0.50
0-6	0	5	5087	45.3	3.5	4.77	0.37	8.2	33.7	75.5	22.9	1.00	0.60
0-6	0	10	5169	32.0	3.6	4.77	0.39	8.1	33.6	77.0	21.7	0.90	0.40
0-6	0	15	5472	46.7	3.7	5.00	0.46	8.1	35.7	76.7	21.8	0.93	0.57
$LSD_{.05}$			376.2	NS	NS	0.92	0.10	NS	2.54	NS	NS	0.09	NS
6-24	0	0	4396	43.7	2.0	7.73	0.41	8.3	30.93	71.1	27.6	0.63	0.60
6-24	0	2.5	4444	31.7	2.7	3.80	0.37	8.2	31.23	71.2	27.6	0.77	0.47
6-24	0	5	4186	45.0	2.3	5.30	0.32	8.4	30.10	69.5	29.1	0.80	0.67
6-24	0	10	4122	36.7	2.2	4.33	0.31	8.3	28.57	72.0	26.6	0.80	0.57
6-24	0	15	4298	44.3	3.5	4.37	0.35	8.3	30.20	71.1	27.5	0.83	0.63
$LSD_{.05}$			230.2	NS	1.43	3.04	NS	0.15	2.01	NS	NS	0.18	0.19

Table 6. Soil analysis following sugarbeets receiving the recommended nitrogen rate (130 lb/A) in 2004 and different spent lime rates

Depth	N appl	Lime T/A	Nitrate N lb/A	P ppm	K ppm,	C1 lb/A	S lb/A	B ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Mg ppm
0-6	130	0	7.0	9.3	135.3	5.3	26.0	2.4	0.56	8.5	4.7	0.54	1101
0-6	130	2.5	6.0	9.3	117.0	4.0	39.3	1.9	0.58	8.4	4.9	0.59	947
0-6	130	5	9.7	11.3	124.0	17.0	40.7	2.1	0.60	8.6	5.6	0.54	1007
0-6	130	10	9.0	17.3	132.3	18.7	59.3	2.2	0.66	8.7	6.2	0.59	1020
0-6	130	15	7.7	18.3	117.7	4.0	64.7	2.2	0.61	9.0	5.0	0.57	1052
$LSD_{.05}$			NS	2.23	NS	NS	NS	NS	0.06	NS	1.36	NS	111.4
6-24	130	0	8.0	3.3	78.7	3.0	195.0	1.4	0.26	10.1	1.7	0.54	1232
6-24	130	2.5	5.0	3.0	82.0	3.0	30.0	1.1	0.27	9.5	1.6	0.55	964
6-24	130	5	7.0	3.3	88.3	5.0	54.0	1.2	0.33	9.9	1.9	0.58	1161
6-24	130	10	8.0	3.7	96.7	6.0	192.0	1.3	0.35	10.5	2.0	0.58	1258
6-24	130	15	7.0	5.0	85.7	5.0	66.0	1.2	0.32	10.0	1.7	0.55	1281
$LSD_{.05}$			NS	1.38	17.10	NS	NS	NS	NS	NS	NS	NS	NS

Depth	N Appl	Lime T/A	ca ppm	NA ppm	OM %	Carb %	Salt mmho/ cm	Soil pH	CEC meq	% Base Saturation			
										%Ca	%Mg	%K	%Na
0-6	130	0	5090	72.7	4.0	5.30	0.36	8.0	35.3	72.2	26.0	1.00	0.87
0-6	130	2.5	5041	48.0	3.7	4.67	0.40	8.2	33.6	75.2	23.3	0.87	0.60
0-6	130	5	5178	59.3	4.0	4.93	0.45	8.2	34.9	74.3	24.0	0.93	0.77
0-6	130	10	5239	73.0	3.5	5.50	0.58	8.2	35.4	74.2	23.9	0.97	0.87
0-6	130	15	5397	59.0	4.0	5.93	0.61	8.2	36.3	74.4	24.0	0.83	0.70
$LSD_{.05}$			236.7	NS	NS	0.59	NS	NS	1.78	1.63	1.41	NS	NS
6-24	130	0	4137	82.7	2.2	8.87	0.41	8.4	31.53	65.9	32.4	0.63	1.10
6-24	130	2.5	4344	30.3	1.9	7.00	0.43	8.3	30.10	72.3	26.6	0.73	0.43
6-24	130	5	4194	51.3	1.9	6.27	0.47	8.3	31.10	67.6	30.9	0.73	0.73
6-24	130	10	4242	73.0	2.2	5.63	0.53	8.4	32.23	65.8	32.5	0.77	0.97
6-24	130	15	4086	118.3	2.1	6.77	0.69	8.4	31.83	64.6	33.1	0.70	1.57
$LSD_{.05}$			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 7. The effect of spent lime on sugarbeet yield, quality and return at the two nitrogen rates used in 2004

Spent Lime (TDM/A)	N Level (lb/A – 0-4 ft)	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return ($/A)
0	69	5944	291.8	20.4	15.62	1.03	627
2.5	69	5880	294.9	19.9	15.84	1.10	630
5.0	69	5788	283.5	20.4	15.31	1.13	592
10.0	69	5540	285.7	19.4	15.45	1.16	571
15.0	69	5875	289.1	20.4	15.59	1.13	614
Stat. Sign.		NS	NS	NS	NS	NS	NS
0	130	6531	294.6	22.2	15.76	1.03	698
2.5	130	6760	298.2	22.7	15.94	1.03	731
5.0	130	6710	297.9	22.5	15.93	1.03	726
10.0	130	6751	300.7	22.4	16.00	0.97	737
15.0	130	6411	290.9	22.1	15.64	1.10	675
Stat. Sign.		NS	NS	NS	NS	NS	NS

Table 8. Wheat yield, test weight and protein following sugarbeet at different spent lime rates applied in 2004

Lime (TDM/A)	Yield (bu/A)	Test Weight (lb)	Protein (%)
0	70.1	58.4	14.3
2.5	70.1	58.1	14.1
5.0	72.3	58.4	14.1
10.0	69.5	58.3	14.1
15.0	70.1	58.1	14.1
Stat. Sign.	NS	NS	NS

Table 9. Main effects on soybean variety (ave. over lime rates) on yield, oil and protein, 2005

Variety	Yield (bu/A)	Oil (5)	Protein (%0
Gold Country 923RR	44.8	19.32	31.6
Garst 0211RR	44.0	19.72	30.6
LSD_{05}	NS	NS	NS

Table 10. main effects of lime rates (ave over varieties) on soybean yield, oil and protein, 2005

Lime (TDM/A)	Yield (bu/A)	Oil (%)	Protein (%)
0 (check)	42.2	19.88	30.02
2.5	47.3	19.16	32.18
5.0	45.6	19.30	31.78
10.0	43.0	19.95	30.04
15.0	43.9	19.31	31.60
LSD_{05}	3.3	0.60	1.5

Table 11. Soybean yield, oil and protein following sugarbeet at different spent lime rates applied in 2004

Variety	Lime Treatment (TDM/A)	Yield (bu/A)	Oil (%)	Protein (%)
Garst 0211RR	0	41.5	20.0	29.6
	2.5	48.5	19.6	31.3
	5.0	45.4	19.5	31.4
	10.0	42.1	20.1	29.7
	15.0	42.6	19.5	31.1
Gold Country 923RR	0	42.9	19.8	30.5
	2.5	46.0	18.8	33.1
	5.0	45.7	19.1	32.2
	10.0	43.8	19.8	30.4
	15.0	45.3	19.2	32.1

Table 12. Soil phosphorous levels following sugarbeet, wheat, and soybean at the various spent lime rates

Phosphorous levels (ppm)				
Lime (TDM/A	2004 Sugarbeet (130 N)	2005 Wheat	2004 Sugarbeet (69 N)	2005 Soybean
0	9.3	8.75	8.7	9.33
2.5	9.3	9.25	11.0	11.33
5.0	11.3	10.0	12.7	11.00
10.0	17.3	12.25	13.0	12.67
15.0	18.3	14.25	19.3	15.00

Table 13. Wheat yield, test weight and protein following soybean (2005) at different spent lime rates applied in 2004.

Spent Lime (TDM/A)	Yield (bu/A)	Test Weight (lb)	Pro9tei8n (%)
0	72.9	58.8	11.8
2.5	73.2	57.9	13.1
5.0	73.7	58.0	12.4
10.0	73.1	58.2	12.0
15.0	76.0	58.6	11.9
Stat. Sign	NS	NS	*
LSD_{05}	----	----	1.0

Table 14. Soybean yield, oil and protein following wheat (2005) at different spent lime rates applied in 2004.

Spent Lime (TDM/A)	Yield (bu/A)	Oil (%)	Protein (%)
0	49.2	20.03	32.53
2.5	50.2	20.10	32.45
5.0	49.3	19.95	32.70
10.0	48.2	20.13	32.18
15.0	46.8	20.10	32.35
Stat. Sign.	NS	NS	NS

Table 15. Complete soil test results from the 0 and 15 TDM/A spent lime rates applied in 2004 following wheat And soybean in 2006.

Soil test Results	Wheat		Soybean	
	Spent Lime (T/A)			
	0	15 T/A	0	15 T/A
N – lb/A (0-24")	65	87	102	100
P – ppm	9.75	17.25	9.50	15.75
K – ppm	143	142	138	136
Chloride (0-6") – lb/A	30.0	30.8	26.0	27.0
Chloride (6-24") – lb/A	89.0	74.2	80.1	82.0
Sulfur (0-6") – lb/A	23.0	20.5	57.0	64.0
Sulfur (6-24") – lb/A	283	214	302	223
Boron – ppm	1.97	1.75	2.01	1.85
Zinc – ppm	0.50	0.57	0.51	0.52
Iron – ppm	7.00	6.58	5.80	6.40
Manganese – ppm	2.65	2.80	3.05	3.00
Copper – ppm	0.64	0.64	0.59	0.62
Magnesium- ppm	941	799	905	962
Calcium- ppm	4699	4979	4608	5043
Sodium – ppm	66	52	88	88
OM - %	3.6	3.5	3.8	3.6
C_aCO_3 - %	5.52	5.30	5.28	5.68
Salts (0-6")-mmho/cm	0.44	0.45	0.65	0.93
Salts (6-24")-mmho/cm	0.85	0.51	1.23	1.21
pH	8.35	8.32	8.20	8.20
CEC - Meq	32.0	32.2	31.3	34.0

Table 16. Soil phosphorus levels sugarbeet (04) wheat (05,06) and soybean (05,06) at the various spent lime rates.

Spent lime Rate (TDM/A)	Bray Phosphorous Levels (ppm)					
	2004 Sugarbeet (130 n)	2004 Sugarbeet (69 N)	2005 Wheat	2006 Wheat	2005 Soybean	2006 Soybean
0	9.30	8.70	8.75	9.75	9.33	9.50
2.5	9.30	11.00	9.25	11.00	11.33	10.25
5.0	11.30	12.70	10.00	11.75	11.00	10.75
10.0	17.30	13.00	12.25	12.00	12.67	12.00
15.0	18.30	19.30	14.25	17.25	15.00	15.75

Table 17. ANOVA

	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return* ($/)
Previous Crops (C)	***	NS	***	NS	NS	**
Spent lime Rate (LR)	*	*	NS	**	NS	**
C x LR	NS	NS	NS	NS	NS	NS

* Basis – ACSC November 15, 2007 payment

Table 18. Effect of spent lime rates applied in 2004 on sugarbeet yield, quality and gross return following a wheat-soybean rotation

Previous Crop	Lime Rate (TDM/A)	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return* ($/)
Wheat	0	9390	303	31.0	16.48	1.33	1020
	2.5	9793	310	31.6	16.76	1.23	1093
	5.0	9910	318	31.1	17.18	1.27	1135
	10.0	9788	317	30.9	17.09	1.23	1116
	15.0	9775	312	31.3	16.86	1.27	1096
Soybean	0	8665	299	29.0	16.32	1.37	929
	2.5	9260	312	29.7	16.87	1.27	1039
	5.0	9212	319	28.9	17.09	1.17	1056
	10.0	9143	317	28.9	17.04	1.20	1041
	15.0	9161	312	29.4	16.81	1.20	1028

*Basis – ACSC November 15, 2007 payment

Table 19. main effect of crop (across lime rates)

Previous Crop	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return* ($/)
Wheat	9731	312.1	31.2	16.87	1.27	1092
Soybean	9088	311.7	29.2	16.83	1.24	1018
Stat. Sign.	***	NS	***	NS	NS	**

*Basis – ACSC November 15, 2007 payment

Table 20. Main effect of lime rate (across previous crop)

Lime Rate (TDM/A)	RSA (lb/A)	RST (lb/T)	Yield (T/A)	Sugar (%)	LTM (%)	Gross Return* ($/)
0	9027	301.0	30.0	16.40	1.35	974
2.5	9526	311.3	30.6	16.82	1.25	1066
5.0	9651	318.4	30.0	17.14	1.22	1095
10.0	9465	317.0	29.9	17.07	1.22	1079
15.0	9468	312.1	30.3	16.84	1.23	1062
LSD_{05}	306	8.8	NS	0.35	NS	63

*Basis – ACSC November 15, 2007 payment

Table 21. Complete soil test results from the 0 and 15 TDM/A spent lime rates applied in 2004 following sugarbeet and wheat and soybean in 2006.

Soil Test Results	Sugarbeet (07)			
	Wheat (06)		Spent Lime (T/A)	Soybean (06)
	0	15 T/A	0	15 T/A
N – lb/A (0-24”	26	25.0	35.5	33.2
P – ppm	10	16	10.5	13.67
K – ppm	168	188	173	177
Chloride (0-6”) – lb/A	55.3	55.8	58.8	60.2
Sulfur (0-6”) – lb/A	37.3	36.0	33.0	63.0
Boron – ppm	1.94	1.93	2.20	2.04
Zinc – ppm	0.63	0.70	0.67	0.66
Iron – ppm	9.40	8.52	8.35	9.00
Manganese –ppm	4.47	3.92	4.65	4.20
Copper – ppm	0.80	0.76	0.73	0.78
Magnesium – ppm	1067	1029	1079	1121
Calcium- ppm	6457	6907	6496	6789
Sodium – ppm	79.3	1290	148.5	149.5
OM – 5	3.3	3.4	3.6	3.3
C_aCO_3 - %	4.70	4.87	4.30	5.08
Salts (0-6”) –mmho/cm	0.48	0.50	0.50	0.62
pH	8.10	8.12	8.10	8.12
CEC - Meq	42.1	44.2	42.6	44.4

Table 22. Soil Phosphorous Levels (ppm) at the 0 and 15.0 TDM Spent Lime Rate and Crop Sequence 2004-2007

Soil Phosphorous (ppm)									
Spent Lime (TDM/A)	Sugarbeet (04)	Wheat (05)	Soybean (06)	Sugarbeet (07)	Sugarbeet (04)	Soybean (05)	Wheat (06)	Sugarbeet (07)	(All crops, All years)
	(130N)	----	----	----	(69N)	----	----	----	
0.0	9.30	8.75	9.75	10.00	8.70	9.33	9.50	10.50	9.48
15.0	18.30	14.25	17.25	16.00	19.30	15.00	15.75	13.67	16.19

2003 Phosphorous soil test = 9.00 ppm