EFFECT OF SPENT LIME ON SUGAR PRODUCTION AND CROPS FOLLOWING SUGARBEET

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Introduction

Crushed limestone is used in the processing of sugarbeet at the factory to improve the sugar recovery. Traditionally this spent lime, after being filtered out of the process, has been stockpiled near the factory due to lack of a suitable use given the calcareous nature of most of the soils in the Red River Valley and southern Minnesota. The material has taken up many acres of space over the years the factories have operated in this region. Considering the amount of calcium carbonate already present in the soil profiles of the region, the addition of 2 to 8 tons of spent lime per acre should not have a significant effect on the physical or chemical nature of such alkaline soil.

Long term evaluation of spent lime application on the soil physical properties and crop production in the soils of the sugarbeet growing areas of the northern Great Plains was needed. The duration of a study established in the fall of 1996 near the East Grand Forks factory, was cut short during the flood of 1997 when the area was scraped to build a dike to protect the factory from the flood waters of the Red River. Observations of soybean herbicide carryover and the implementation of grid sampling for soil testing purposes in southern Minnesota led to the finding of acid soils areas in fields of the region. Application of spent lime was used to increase the pH of these areas to decrease the carryover period and allow sugarbeet to be grown in the normal crop rotation. Research trials established to determine the spent lime effect on herbicide carryover, also gave indication that a decrease in the infection of aphanomyces on sugarbeet was possibly occurring as well.

Materials and Methods:

An application of spent lime was made in the fall of 2001 at the rate of 2, 4 and 8 tons per acre on a beet field east of the factory in East Grand Forks. The material from the factory was hand spread and incorporated with fall tillage following beet harvest. The treatments were arranged in a randomized complete block design with six replications. Individual treatment plots measured 22 feet wide and 30 feet long. The research area was seeded to soybean in the spring of 2002. Excessive moisture conditions resulting from large precipitation events throughout the growing season causing severe damage to the crop. With the lack of pod formation on the soybean plant and limited forage mass at harvest time, a yield determination was not made. Soil samples were taken in October to a depth of 24 inches. In 2003 spring wheat was grown on the location and a grain harvest was obtained, but very wet soil conditions following harvest prevented soil samples from being taken for analyses. Sugarbeet was grown in 2004 and soil conditions allowed soil samples to be taken in the surface foot of the profile prior to harvest. Sugarbeet was harvested and quality analyses were determined. Primary tillage following harvest each year has been some type of disking and/or chiseling.

With the observation that the level of aphanomyces damage was increasing in the sugarbeet research location north of the Fargo airport, which has alkaline soil, spent lime rates of 3, 6 and 9 tons per acre were applied in October 2002. The treatments were applied similar to those established at East Grand Forks but with only four replications. Two varieties of sugarbeet, an aphanomyces susceptible (Beta 6447) and tolerant (Crystal 999) were planted on each treatment in 2003. Sugarbeet was harvested but wet soil conditions prevented soil samples from being taken. Spring wheat was seeded in 2004. Wheat harvest yields and soil samples were obtained in 2004. Primary tillage following harvest at this location has been similar to that at East Grand Forks.

The soil analyses were performed at the Soil Testing laboratory at North Dakota State University using standard accepted procedures. Sugar quality analysis was performed at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN.

Results and Discussion

The analyses data of spent lime used at both locations is given in Table 1. The material contains nutrients which are separated from the sugarbeet juice as the sucrose is recovered. The calcium carbonate equivalent is not reduced much from that of pure lime and thus is useful in raising the pH when applied to an acid soil. The nutrients contained are in forms available for plant uptake and use.

The soil chemical parameters in the top 6 inches at the East Grand Forks location are not significantly changed in a year's time, although there are trends for the soil test phosphorus to be increased and the potassium, chloride and sodium to decrease with increasing rate of spent lime (Table 2). This trend for soil test phosphorus is still present in the soil samples taken in 2004 (Table 3). The majority of the phosphorus is in the top three inches, but a significant increase occurred in the 3-6 inch increment with the 8 ton spent lime rate. The yield of wheat in 2003 (Table 7) and sugarbeet in 2004 (Table 4) are not significantly affected, although there is a trend for the wheat yield to decrease with increasing spent lime application. The net sucrose is significantly reduced with increasing spent lime, which also causes a reduction in the recoverable sugar per ton and gross return per acre, but the recoverable sugar per acre is not significantly affected. These crops showed no visual deficiency symptoms in the canopy during either year.

At the Fargo location, the increase in spent lime application resulted in a significant increase in recoverable sugar production with increasing spent lime application (Table 5). Most of the increase occurred with Beta 6447, the aphanomyces susceptible variety. The number of harvest beets is increased with increasing spent lime rates possibly indicating a decline in aphanomyces damage to the growing root. The difference in the sugarbeet effects at this location compared to the East Grand Forks location may be entirely disease suppression. The wheat yield in 2004 was not significantly affected by spent lime treatment, although there is a increase with increasing spent lime rate.

The analyses of soil samples taken in 2004 at the Fargo location (Table 6) show similar results to those of East Grand Forks. Soil phosphorus test levels significantly increase in the first two increments of the soil profile. Sulfate levels follow a similar trend.

Overall the results from the data collected at these two locations show very little detrimental affects from the application of spent lime. In fact there have been some positive results.

Table 1. Analyses data of spent lime used at East Grand Forks location in October 2001 and at Fargo location in November 2002.

Location	NO_3 N	P ppm	K ppm	pH	EC mmhos/cm	Zn ppm	Ca ppm	Mg ppm	Na ppm	CaCO3 Eq
EGF	121	258	190	9.6	0.73					90.2
	107	279	270	9.6	0.92					85.9
	121	276	200	9.6	0.76					87.2
	87	299	130	9.6	0.71					88.9
	145	302	240	9.7	0.72					87.2
	145	270	250	9.7	0.80					86.7
mean	121	280	213	9.6	0.77	ns	ns	ns	ns	87.6
Fargo	56	77	240	10.3		2.0	144000	5250	190	84.3
	68	77	240	10.3		2.1	161000	5460	360	83.5
	45	79	320	9.7		5.4	150000	5460	500	81.2
	53	79	420	9.9		5.3	150000	5460	340	85.1
mean	56	78	305	10.1		3.7	151250	5408	348	83.5

Table 2. Analyses of soil samples by depth from spent lime treatments at East Grand Forks location taken in August 2002.

Depth inches	Lime T/a	P ppm	K ppm	pH	EC mmhos/cm	OM %	SO_4 lb/a	Zn ppm	Fe ppm	Cu ppm	Cl ppm	Mg ppm	MN ppm	Na ppm	CEC
0-6	0	54	481	7.9	2.18	6.4	284	3.9	7.2	2.1	93	1598	10.5	462	35.0
	2	52	459	7.9	2.20	6.1	288	4.2	7.6	2.1	98	1658	8.9	471	33.8
	4	54	438	7.9	2.20	6.0	296	3.2	7.5	2.0	86	1597	8.7	441	36.6
	8	64	469	7.9	2.09	6.1	285	3.5	7.7	2.0	75	1514	10.4	414	37.0
Lsd (.05)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
6-12	0				2.96		336				112				-
	2				2.90		329				128				-
	4				2.74		321				98				-
	8				2.72		316				114				-
Lsd (.05)					ns		ns				ns				

Table 3. Analyses of soil samples by depth from spent lime treatments at East Grand Forks location taken in August 2004.

Depth inches	Lime T/a	P ppm	K ppm	pH	EC mmhos/cm	OM %	SO_4 lb/a	Zn ppm	Fe ppm	Cu ppm	Cl ppm	CEC
0-3	0	42	402	7.9	2.3	6.3	146	2.5	3.7	1.2	42	33.3
	2	44	387	7.9	1.8	6.6	137	2.5	3.5	1.2	29	30.5
	4	51	403	7.9	1.7	6.4	148	2.5	3.3	1.2	20	29.5
	8	56	390	7.9	1.8	6.4	134	2.5	3.4	1.3	49	31.8
Lsd (.05)		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3-6	0	17	233	8.0	3.2	6.8	185	2.7	3.5	1.2	46	-
	2	22	237	8.0	2.8	6.6	160	3.1	3.9	1.3	34	-
	4	25	231	8.0	2.8	6.4	179	2.7	3.2	1.8	39	-
	8	28	243	8.0	2.6	6.3	163	3.1	3.2	1.4	46	-
Lsd (.05)		9	ns	ns	ns	ns	ns	ns	ns	ns	ns	
6-12	0				3.2		364				114	
	2				2.9		352				94	
	4				3.2		358				90	
	8				3.0		356				89	
Lsd (.05)					ns		ns				ns	

Table 4. Effect of Spent Lime on sugarbeet root yields, sucrose percentage, recoverable sugar production, harvest population and gross $ return. East Grand Forks, MN. 2004.

TREATMENT	ROOT YIELD Tons/A	NET SUCROSE Percent	REC SUGAR Lbs/Acre	REC SUGAR Lbs/T	HARVEST BEETS /100 FT	GROSS RETURN $/T	GROSS RETURN $/A
Untreated Check	21.4	12.6	5413	253	198	22.5	485
2 Tons / A Spent lime	22.3	12.3	5465	246	190	21.0	467
4 Tons / A Spent lime	20.5	11.3	4666	227	186	16.8	348
8 Tons / A Spent lime	21.5	11.6	5031	233	182	18.2	396
LSD (.05)	ns	0.4	ns	17.0	ns	3.8	110

Table 5. Effect of spent lime application on Beta 6447 and Crystal 999 sugarbeet root yields, sucrose percentage, recoverable sugar production, harvest population and gross return. (September 23), north of Fargo Airport, Fargo, 2003.

LIME TREATMENT T/a	ROOT YIELD Tons/A	SUCROSE Percent	REC SUGAR Lbs/Acre	REC SUGAR Lbs/T	HARVEST BEETS /100 FT	GROSS RETURN $/T	GROSS RETURN $/A
Beta 6447							
0	22.0	17.0	6702	305	161	34.25	752
3	21.8	17.9	7060	325	164	38.76	840
6	21.5	17.9	7351	342	165	42.55	914
9	22.6	18.0	7594	336	171	41.11	929
LSD (.05)	ns	1.8	260	ns	ns	5.80	ns
Crystal 999							
0	23.5	17.4	7395	315	194	36.49	856
3	24.1	17.6	7720	320	188	37.58	906
6	24.4	17.9	8009	328	199	39.41	962
9	24.3	18.0	8004	329	201	39.66	963
LSD (.05)	ns	ns	ns	ns	ns	ns	ns
Spent Lime, Mean							
0	22.7	17.2	7048	310	178	35.37	804
3	22.9	17.7	7390	323	176	38.17	873
6	22.9	18.3	7680	335	182	40.98	938
9	23.5	18.2	7799	333	186	40.38	946
LSD (.05)	ns	0.8	611	18	9	3.99	105

Table 6. Analyses of soil samples by depth from spent lime treatments at north of Fargo airport location taken in August 2004.

Depth inches	Lime T/a	P ppm	K ppm	pH	EC mmhos/cm	OM %	SO_4 lb/a	Zn ppm	Fe ppm	Cu ppm	Cl ppm	CEC
0-3	0	12.3	488	8.1	0.68	5.2	7.8	0.6	6.9	1.4	8.5	29.6
	3	11.8	498	8.1	0.61	5.5	6.8	0.6	6.8	1.3	9.7	31.6
	6	14.3	430	8.1	0.59	5.4	30.5	0.5	6.5	1.3	6.8	33.4
	9	25.0	521	8.2	0.64	5.5	15.0	0.6	6.7	1.3	7.6	33.3
Lsd (.05)		6.2	ns	ns	0.06	ns	ns	ns	ns	ns	ns	1.9
3-6	0	6.3	270	8.0	0.60	4.2	8.5	0.4	7.7	1.4	4.3	-
	3	6.8	275	8.1	0.55	4.6	7.8	0.4	7.2	1.3	5.2	-
	6	5.3	279	8.0	0.59	5.0	10.8	0.3	7.5	1.4	4.9	-
	9	10.3	306	8.0	0.64	5.1	17.0	0.4	7.1	1.3	3.7	-
Lsd (.05)		2.8	ns	ns	ns	ns	ns	ns	ns	ns	ns	
6-12	0				0.63		21.8				7.4	
	3				0.58		16.5				4.3	
	6				0.63		23.8				5.7	
	9				0.70		27.8				2.9	
Lsd (.05)					ns		ns				3.5	

Table 7. Effect of Spent Lime on Wheat Yields (bu/a). East Grand Forks, MN, 2003 and Fargo, ND. 2004.

Treatment	EGF 2003	Treatment	Fargo 2004
Untreated Check	65.6	Untreated Check	40.2
2 Tons / A Spent Lime	57.5	3 Tons / A Spent Lime	44.0
4 Tons / A Spent Lime	60.4	6 Tons / A Spent Lime	44.0
8 Tons / A Spent Lime	54.8	9 Tons / A Spent Lime	45.3
LSD (.05)	ns		ns