EVALUATION OF SUGAR BEET LIME (PCC) AS A LIMING SOURCE FOR CORRECTING SOIL ACIDITY

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*The term **PCC** (precipitated calcium carbonate) is used throughout this report and refers to sugar beet, factory, or waste lime.*

Justification: The use of sugar beet lime has increased in past years due to benefits such as reduced disease incidence and potentially supplementing fertilizer applications for crops. However, more soil in areas of fields in Western Minnesota has become more acidic recently increasing the need for a local source of lime. There has been very little lime research in Minnesota in the last 20 years and the benefits of liming to an optimal pH have not been assessed. If sugar beet lime is used as a liming source the additional nutrients such as phosphorus or potassium may additionally have added benefits resulting in greater yield. A study funded by the Minnesota Soybean Research and Promotion council is underway focused on evaluating how lime materials change soil pH and the overall value of lime applications to crops. I am utilizing sugar beet lime in a few of the locations and one area that I need to address with whether the beet lime is increasing the uptake of nutrients such as phosphorus where any increases of yield from the lime may be confounded with increased nutrient availability over the five years of study at each location.

In western Minnesota PCC is being used as a lime source but I have not found much information regarding pH correction with this product. While PCC is not always applied to correct pH, the impacts on soil pH still are important to know how quickly soil acidity can be corrected and how pH is affected by multiple rates of PCC looking not only at the year of application but future years where crop yield may be more impacted. Since PCC contains other nutrients one challenge with comparing PCC to other lime sources is determining potential effects due to pH change versus the uptake of other beneficial nutrients that may be in the PCC. Plant tissue analysis can help to sort out potential effects of nutrients applied with the PCC compared to impacts related to pH change alone.

Application of PCC as a liming source is occurring in Western MN. The liming studies established are put in place to focus on the economics of liming in different areas of Minnesota to determine whether lime pays over five cropping years. Additionally, any P or K in PCC may provide a benefit to crops, but having more longer-term data would have great value as benefits from lime or PCC may occur 1 to 2 years or more following application.

The use of sugar beet lime has increased in areas due to benefits for disease suppression (Windels et al., 2006) and potential nutrient benefits (Sims et al., 2010). Sugar beet lime also contains calcium carbonate which is a source of lime that can be utilized to adjust soil pH. Current Minnesota lime recommendations suggest maintaining a soil pH of at least 6.0 for most crops (Kaiser and Rosen, 2023). Some soils in central and Western Minnesota are becoming more acid where lime should be applied and more research on the impact of sugar beet lime on modifying soil pH should be studied. Since been lime contains more than just calcium carbonate, any trials to assess the impact of lime on pH change and subsequent yield increases to the crop can be confounded by the addition of other nutrients. Additional soil and plant tissue sampling can be beneficial to help determine whether potential benefits are due to a change in soil pH or other nutrients contained in sugar beet lime.

Objectives:

1. Compare soil pH change from precipitated calcium carbonate (PCC) compared to traditional lime sources.
2. Evaluate nutrient uptake in crops following PCC application.

Table 1. Summary of soil test data collected prior to initial treatment application at two locations in Minnesota. Samples were collected from the 0-6 and 6-18” depths and are a composite of 8 separate cores collected from each split-split plot and averaged for each location.

Start Year	Location	Soil Type	0-6” Soil Test[/1]			pH		Sikora Buffer	
			P	K	OM	0-6”	6-18”	reg	1:3
			--ppm--		-%-			---ppm----	
2024	Sandborn	Normania	58	184	3.1	5.2	5.8	6.3	na
2025	Nicollet	Cordova	17	177	6.3	6.3	--	6.8	na

/1: P, Bray-P1 phosphorus; K, ammonium acetate K; pH, soil pH; OM, organic matter; SO_4-S, sulfate-S extracted by mono-calcium phosphate.

Materials and Methods: Lime rate trials were established at 2 locations (Table 1) in southern Minnesota (2 additional trials will be established in spring 2026). At each site six rates of lime (including a non-limed control) will be applied as ag lime sourced from a Minnesota quarry, pelletized lime, and PCC sourced from the Southern MN beet sugar cooperative (A summary of pertinent lime analyses are given in Table 2). Lime will be applied in the spring and crop yield will be measured over a period of five growing seasons. Soil samples will be collected from all plots before lime application and each fall post-harvest to assess pH change over time. For the sites with PCC application, plant samples will be taken at the early reproductive stages for corn and soybean (R2) by sampling either the leaf opposite and below the ear for corn or the uppermost fully developed trifoliate in soybean. Samples will be dried, ground, and analyzed for major macro- (nitrogen is not measured) and micro-nutrients. Grain samples will additionally be collected and analyzed for nutrient concentration.

Table 2. Summary of measured variables for the lime materials used in the study. The effective calcium carbonate equivalency (ECCE) is the value calculated for the lime at the time of application and can vary based on the moisture concentration of the material.

		Nutrient Concentration[/2]						
Source	ECCE	Ca[/1]	Mg[/1]	P	K	B	Cu	Zn
	Lb/ton			--------------------------ppm-----------------------				
Quarry Lime	1503	158460	99400	--	--	--	--	--
Pell Lime	1847	499630	1380	--	--	--	--	--
PCC	1381	309631	15872	3739	875	13.4	17.8	34.5

[1/]Values are calculated in ppm. ppm/10,000 = %.

[2/]Calcium and Magnesium concentration was measured on all materials. Additional nutrients were measured on the PCC material.

Table 3. Summary of limestone source and rate impacts on corn or soybean grain yield.

Location	Source	Total ENP Rate – 5yr						Avg
		0	1000	2000	3000	4000	5000	
		--------------------bushels per acre (13 or 15.5%)--------------------						
Sandborn	Lime	206	216	234	203	214	210	214
Corn 2024	Pell Lime	210	196	196	216	215	215	208
	Annual Pell	209	217	206	225	198	205	210
		206	216	234	203	214	210	
Sandborn	Lime	63.0	67.2	67.3	60.2	69.2	64.7	65.3
SB 2025	Pell Lime	69.4	66.5	69.2	61.9	67.2	66.2	66.7
	PCC	66.6	67.0	65.0	67.4	71.6	70.1	67.9
		66.3	66.9	67.2	63.2	69.3	67.0	
Nicollet	Lime	263	254	279	255	271	274	266
Corn 2025	Pell Lime	265	271	268	266	228	259	260
	PCC**	269	276	249	297	294	256	274
		266	267	265	273	265	263	

**Denotes where a significant source by rate interaction occurred

SB=Soybean

2025 Data Summary

I am providing a general summary of results through the 2025 growing season. These are long-term studies so I will not include conclusions in this report as it is too early in most cases to conclude effects of the treatments.

Crop yield data starting in 2024 is listed in Table 3. To date 2 years of data have been collected at Sandborn and one year of data is collected from Nicollet. Lime was applied in the spring of 2024 at Sandborn and spring of 2025 at Nicollet. There was a lot of random variation in yield across the trials which led to some issues determining significant effects with 1 year of data. Over time I can analyze the data across years for individual crops to determine whether the lime sources impacted yield. There was no indication of a yield response in either corn or soybean at the Sandborn site. At Nicollet there was a significant interaction between lime source and rate for the PCC treatments possibly indicating some increase in yield with PCC. However, there was no general increase in yield as the rate of PCC increased. Corn grain yield was highest with the 3000 and 4000 lb ENP rates but a relatively low yield with 2000. I have attempted to clean up the data by looking at spatial patterns in the random variability due to soil properties across the stie but that has not cleared up the variation enough to find significant responses.

Plant tissue data was used to assess the availability of nutrients specifically from the PCC. Using the values in Table 2, applications of 1000 lbs ENP per acre would supply 5.4 lb P and 1.3 lb K (12.4 lbs P_2O_5 and 1.6 lbs K_2O). The highest application rate (5000 lb ENP per acre) would supply roughly enough P to cover what is removed in an average corn crop. Past research has shown that applications of PCC can increase soil test P but no increase in crop yield. However, much of this work was conducted on high pH soils so it is likely that any calcium bound P would have very little solubility in high pH soils that are already high in Ca. Leaf tissue P concentration data are given in Table 4. The only significant response occurred for the soybean crop grown at Nicollet in 2024 where leaf tissue P concentration was higher with PCC compared to the other two sources. However, there was no effect of application rate on leaf P concentration. Leaf K concentration was affected by rate at Sandborn in 2024 and Nicollet in 2025, but the general effect was a decrease in leaf K concentration with increasing rate of lime (Table 5). This decrease in concentration was likely a result of increasing amounts of Ca applied that can affect the uptake of K. Leaf Zn and S were also measured but the data are not shown. The only significant increase in Leaf Zn and S was due to the application of PCC at Sandborn in 2024.

Grain P and K concentration data are summarized in Tables 6 and 7, respectively. There was no effect of lime source or rate on the concentration of P or K in corn or soybean grain in 2024 or 2025.

Fall post-harvest soil test data are summarized in Tables 8, and 9, respectively. Only soil pH was measured in the fall of 2024 from the Sandborn study, and I could not determine soil P and K concentration at that site that year. The data in Tables 8 and 9 summarize only the Fall 2025 data. Soil samples were collected in the fall of 2024 from Sandborn but only pH was analyzed at that time. Soil phosphorus was greater with PCC at the Sandborn site. Soil test P trended greater at Nicollet but the variation in soil test across the sites was high ranging from 10 to 20 ppm across the site. There was some weak evidence of a yield increase with PCC at Nicollet which could be a result of the phosphorus applied. There was no increase in soil test K at Sandborn, but the soil test K was slightly greater with PCC applied at Nicollet. A summary of the change in soil pH is included in Figure 1. All three sources showed a similar increase in pH when applied at the same ENP rate. Soil pH change was greater at Sandborn where the lime had more time to react. A slower change in soil pH is expected as most lime materials are not ground fine enough to change soil pH rapidly.

Table 4. Summary of limestone source and rate impacts on corn ear leaf or soybean uppermost fully developed trifoliate phosphorus concentration collected at R2 from 2 fields in Minnesota.

		Total ENP Rate – 5yr						
Location	Source	0	1000	2000	3000	4000	5000	Avg
				--------------------- (% P)---------------------				
Sandborn	Lime	0.29	0.31	0.33	0.31	0.29	0.30	0.30b
Corn 2024	Pell Lime	0.32	0.33	0.30	0.34	0.31	0.31	0.31b
	PCC	0.35	0.34	0.34	0.36	0.34	0.34	0.34a
		0.32	0.33	0.32	0.34	0.31	0.32	
Nicollet	Lime	0.27	0.29	0.28	0.29	0.30	0.30	0.29
Corn 2025	Pell Lime	0.28	0.29	0.29	0.29	0.29	0.29	0.29
	PCC	0.27	0.29	0.28	0.29	0.30	0.28	0.28
		0.28	0.29	0.28	0.29	0.29	0.29	
Sandborn	Lime	0.63	0.51	0.57	0.60	0.60	0.56	0.58
Corn 2025	Pell Lime	0.58	0.51	0.53	0.58	0.65	0.56	0.57
	PCC	0.51	0.56	0.64	0.56	0.49	0.63	0.57
		0.57	0.52	0.58	0.58	0.58	0.58	

**Denotes where a significant source by rate interaction occurred

Table 5. Summary of limestone source and rate impacts on corn ear leaf or soybean uppermost fully developed trifoliate potassium concentration collected at R2 from 2 fields in Minnesota.

		Total ENP Rate – 5yr						
Location	Source	0	1000	2000	3000	4000	5000	Avg
				--------------------- (% K)---------------------				
Sandborn	Lime	1.98	1.88	1.90	2.00	1.93	1.89	1.93
Corn 2024	Pell Lime	2.04	2.04	1.95	2.03	1.98	1.96	2.00
	PCC	2.06	1.95	1.96	1.97	1.86	1.85	1.94
		2.03a	1.96bc	1.94ab	2.00a	1.92bc	1.90c	
Nicollet	Lime	1.28	1.31	1.28	1.26	1.21	1.32	1.28
Corn 2025	Pell Lime	1.36	1.33	1.28	1.28	1.26	1.30	1.30
	PCC	1.50	1.41	1.30	1.38	1.37	1.37	1.39
		1.38	1.35	1.29	1.31	1.28	1.33	
Sandborn	Lime	2.22	2.13	2.08	2.12	2.23	2.10	2.15a
Corn 2025	Pell Lime	2.06	2.10	2.28	2.09	2.02	2.19	2.12a
	PCC	2.20	2.12	2.14	2.12	1.84	1.99	2.07b
		2.16a	2.11a	2.17a	2.11a	2.03b	2.09ab	

*Denotes where a significant source by rate interaction occurred

Table 6. Summary of limestone source and rate impacts on corn or soybean grain phosphorus concentration collected from 2 fields in Minnesota.

		Total ENP Rate – 5yr						
Location	Source	0	1000	2000	3000	4000	5000	Avg
				--------------------- (% P)---------------------				
Sandborn	Lime	0.30	0.27	0.26	0.27	0.26	0.27	0.30b
Corn 2024	Pell Lime	0.29	0.27	0.29	0.27	0.26	0.27	0.31b
	PCC	0.28	0.27	0.27	0.26	0.27	0.27	0.34a
		0.29a	0.27b	0.27b	0.27b	0.26b	0.27b	
Nicollet	Lime	0.24	0.24	0.24	0.22	0.22	0.23	0.23
Corn 2025	Pell Lime	0.24	0.23	0.24	0.24	0.23	0.23	0.23
	PCC	0.21	0.23	0.24	0.23	0.22	0.24	0.23
		0.23	0.24	0.24	0.23	0.23	0.23	
Sandborn	Lime	0.55	0.55	0.51	0.52	0.52	0.52	0.53
Corn 2025	Pell Lime	0.51	0.51	0.53	0.52	0.50	0.52	0.52
	PCC	0.50	0.52	0.53	0.53	0.51	0.55	0.52
		0.52	0.53	0.53	0.52	0.51	0.53	

**Denotes where a significant source by rate interaction occurred

Table 7. Summary of limestone source and rate impacts on corn or soybean grain potassium concentration collected from 2 fields in Minnesota.

		Total ENP Rate – 5yr						
Location	Source	0	1000	2000	3000	4000	5000	Avg
		-------------------- (% K)--------------------						
Sandborn	Lime	0.38	0.34	0.34	0.34	0.34	0.35	0.35
Corn 2024	Pell Lime	0.37	0.34	0.39	0.36	0.35	0.35	0.36
	PCC	0.36	0.35	0.35	0.34	0.35	0.35	0.35
		0.37	0.34	0.36	0.35	0.35	0.35	
Nicollet	Lime	0.21	0.22	0.22	0.20	0.20	0.20	0.21
Corn 2025	Pell Lime	0.22	0.20	0.21	0.20	0.20	0.22	0.21
	PCC	0.19	0.21	0.22	0.21	0.20	0.21	0.21
		0.21	0.21	0.21	0.21	0.20	0.21	
Sandborn	Lime	1.26	1.25	1.17	1.17	1.15	1.18	1.20
Corn 2025	Pell Lime	1.18	1.17	1.22	1.19	1.13	1.19	1.18
	PCC	1.20	1.18	1.18	1.18	1.15	1.19	1.18
		1.21	1.20	1.19	1.18	1.14	1.18	

**Denotes where a significant source by rate interaction occurred

Table 8. Summary of limestone source and rate impacts on fall 2025 0-6” soil test phosphorus (Bray-P1) concentration from 2 fields in Minnesota.

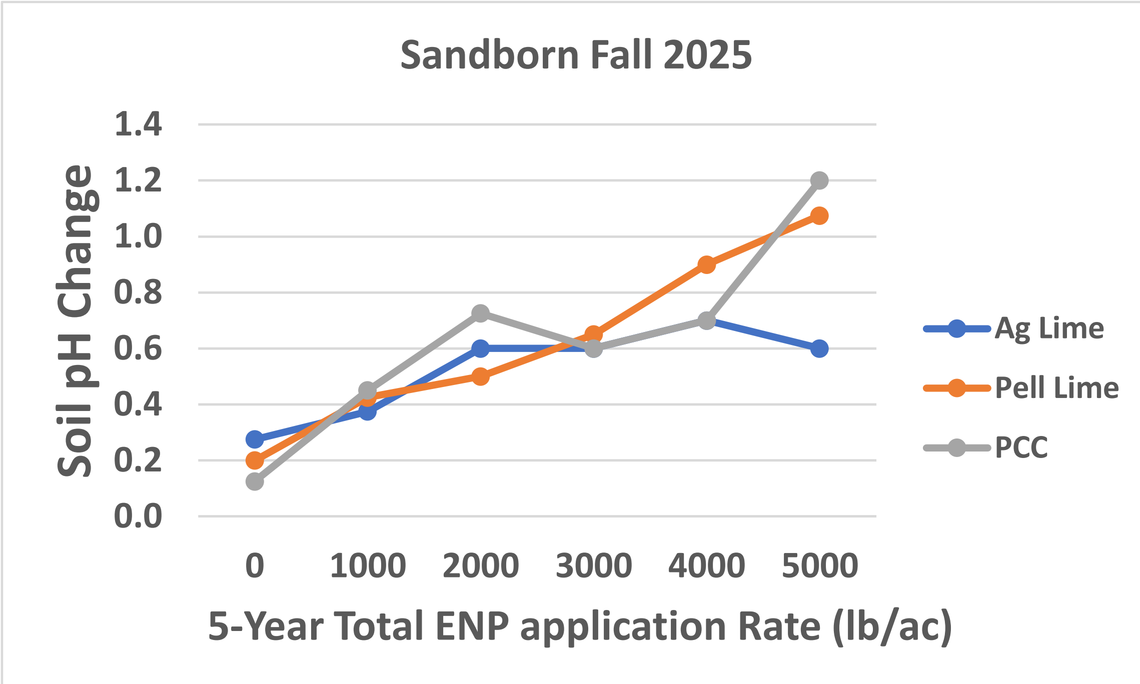
		Total ENP Rate – 5yr						
Location	Source	0	1000	2000	3000	4000	5000	Avg
		-------------------- (ppm P)--------------------						
Nicollet	Lime	11	11	12	12	10	13	11
Corn 2025	Pell Lime	11	12	12	11	10	12	11
	PCC	15	13	14	12	16	16	14
		12	12	12	12	12	14	
Sandborn	Lime	50	51	46	56	41	50	46b
Corn 2025	Pell Lime	59	55	49	55	46	59	45b
	PCC	47	53	48	60	51	50	56a
		52	53	48	57	46	53	

**Denotes where a significant source by rate interaction occurred

Table 9. Summary of limestone source and rate impacts on fall 2025 0-6” soil test potassium (ammonium acetate) concentration from 2 fields in Minnesota.

		Total ENP Rate – 5yr						
Location	Source	0	1000	2000	3000	4000	5000	Avg
		-------------------- (ppm K)--------------------						
Nicollet	Lime	144	150	141	145	142	152	145b
Corn 2025	Pell Lime	146	140	138	133	148	148	142b
	PCC	150	147	146	148	151	155	149a
		146a	145a	142b	142b	147a	151a	
Sandborn	Lime	155	162	138	164	138	160	153
Corn 2025	Pell Lime	163	157	149	150	143	182	157
	PCC	140	147	144	151	136	128	141
		153	155	144	155	139	157	

**Denotes where a significant source by rate interaction occurred



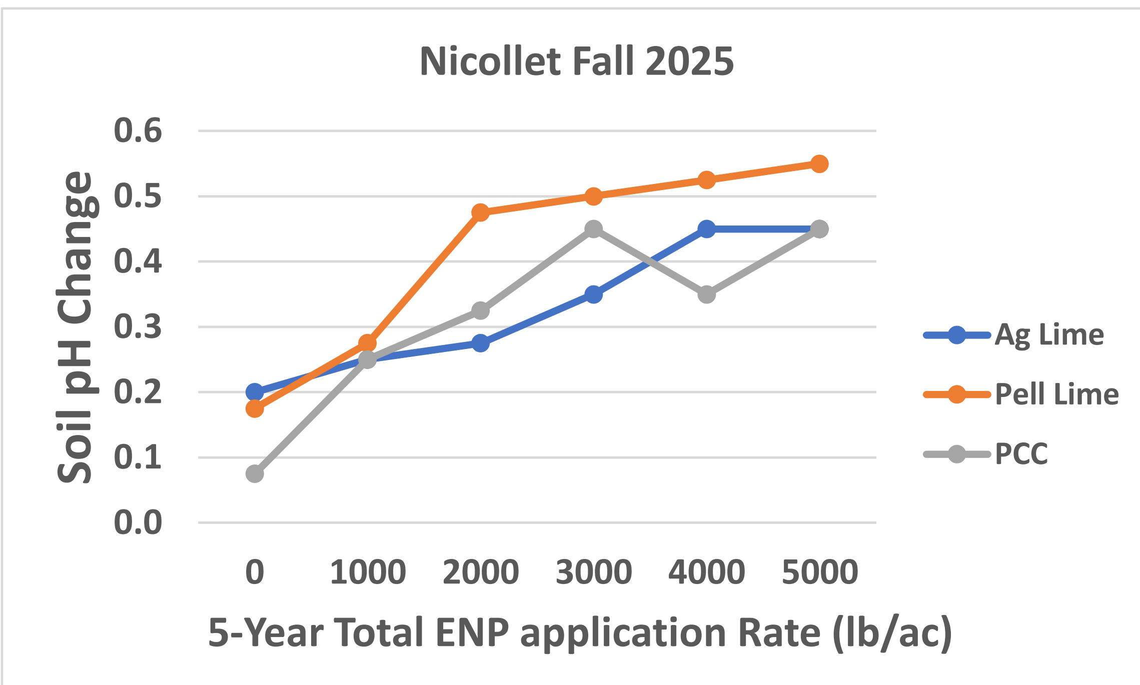


Figure 1. Summary of change in 0-6” soil water pH from initial lime application through the fall of 2025.

Acknowledgments

The authors would like to thank the research crews at the Southern Minnesota Beet Sugar Cooperative, the Department of Soil, Water, and Climate Field Crew, and the research staff at the Northwest Research and Outreach Center for their work with this study. I would also like to thank both Southern Minnesota Beet Sugar Cooperative and American Crystal Sugar Co. for providing the quality analysis for this research, and the Sugar beet Research and Education Board of Minnesota and North Dakota for providing funding for this project.

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