INFLUENCE OF VARIOUS PRECIPITATED CALCIUM CARBONATE (PCC) "SPENT LIME" RATES ON SUGARBEET PRODUCTION, ROTATIONAL CROPS AND SOIL CHARACTERISTICS.

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Introduction

The quality of lime is defined as its effective neutralizing power (ENP). This value can be calculated for any liming material by using the efficiency factors and the calcium carbonate equivalents (CCE) for the lime in question. The rate of reaction is affected by particle size. The finer the lime, the faster it will neutralize soil acidity. Lime too coarsely ground will be very slow in raising the soil pH. Lime particle size is based on the percentage of materials that pass through 8, 20, 60, and 100 mesh screens. The higher the CCE, the more neutralizing ability the lime has, therefore, helping maintain the optimum nutrient availability to plants. Liming also enhances nitrogen fixation and improves soil structure and soil tilth.

Precipitated calcium carbonate (PCC) or "spent lime" is a valuable resource for the growers in Michigan. Historically, PCC has simply been stock piled on site at each of the four factories in Michigan. As a result, large piles of this material are present at each factory site. Today, on a typical year, Michigan Sugar Company produces 154,000 tons of lime with 220,000 tons being used by the growers, thus aiding in the reduction of Michigan Sugar Company's PCC surplus that has accumulated the past 100 years. In 2012, Michigan Sugar Company initiated a project to study the effects of PCC on sugarbeets, rotational crops, and soil fertility. Three trials were established each year during 2012, 2013 and 2014 for a total of nine trials. PCC was applied at rates of 0, 2, 4, 6, 8 and 12 tons per acre in the fall and incorporated into the soil and sugarbeets were planted the following spring. Tissue samples were taken each year to track nutritional levels in the sugarbeets. Soils were also evaluated each year for pH levels and other parameters.

Research Objectives

The objectives of this research are to:

1. Determine the outcomes of PCC application on soil basis of certain nutrients.
2. Determine the variability in potential nutrient composition of PCC.
3. Determine the effects of PCC application on beet yield, beet growth, beet quality, and nutrient uptake.

The principal goals of this research are to expand management practices for application of PCC, explicate fundamental of disease suppression, reutilize nutrients in a cost-effective and environmentally sound means, and reduce stock piles of PCC at the four sugarbeet processing factories in Michigan.

Materials and Methods

Soil samples were taken and submitted to Michigan State University for analysis in each plot (total of 36) for every location during the three years. Soil samples were collected at a depth of six-eight inches prior to lime applications and during the summer the following year. PCC was applied by a hand spreader at rates of 0, 2, 4, 6, 8 and 12 tons per acre in the fall and incorporated in the soil with a rotary tiller and sugarbeets were planted the following spring. Individual plots were six (22 inch) rows wide and 50 feet long. Normal farming practices were used during each growing season. Each fall, the center middle four rows were harvested for yield and sugar analysis. Sugar analysis was processed at Michigan Agricultural Research Laboratory (MARL) in Carrolton, MI. PCC applied at Michigan Sugar Company's trials had the following physical and chemical properties, Table 1.

Table 1. Quality Analyses for Factory Lime, Bay City, MI

<table>
<tr><th colspan="4">Typical Analysis</th></tr>
<tr><td colspan="2">Calcium</td><td colspan="2">35%</td></tr>
<tr><td colspan="2">Magnesium</td><td colspan="2">0.95%</td></tr>
<tr><td colspan="2">Moisture</td><td colspan="2">31.8%</td></tr>
<tr><td colspan="2">Total Neutralizing Power (TNP)</td><td colspan="2">84.3%</td></tr>
<tr><td colspan="2">Effective Neutralizing Power (ENP)</td><td colspan="2">1677 (lb/T)</td></tr>
<tr><td colspan="2">Calcium Carbonate Equiv. (CCE)</td><td colspan="2">84.3%</td></tr>
<tr><td colspan="2">Neutralizing Value (NV)</td><td colspan="2">84.3%</td></tr>
<tr><td colspan="2">Effective Calcium Carbonate (ECC)</td><td colspan="2">83.9%</td></tr>
<tr><th colspan="4">% Passing: Mesh Sieve</th></tr>
<tr><td>8 Sieve</td><td>20 Sieve</td><td>60 Sieve</td><td>100 Sieve</td></tr>
<tr><td>100%</td><td>99.6%</td><td>99.1%</td><td>98.7%</td></tr>
</table>

The treatments were replicated six times and were arranged in a randomized complete block design and analyzed with ARM software written by Gylling Data Management, Inc. Data analysis for field data were transformed when appropriate, and subjected to analysis of variance. If significant ($P = 0.05$), means were separated by Least Significant Difference (LSD).

Rotational crops were planted into the plot area in years two and three and each trial will be completed after the fourth year when sugarbeets will again be planted. Tissue samples were taken each year in July and submitted to A & L Laboratory Inc. to determine nutritional levels in sugarbeets and rotational crops. Sugarbeet emergence, final stand, vigor, yield and quality were obtained in 2012, 2013, and 2014.

Results and Discussion

PCC is a by-product of the sugarbeet factories during the sugar purification process. It is produced by utilizing high temperatures to extract calcium carbonate limestone to form two components, calcium oxide and carbon dioxide. These two components are inserted into the thick juice during sugarbeet processing, which they are reformed as calcium carbonate. When the calcium carbonate reforms it affixes and adsorbs many of the impurities in the juice and precipitates out from the juice. The precipitate forms a solid lime product that needs to be removed, thus leaving behind the thin juice from which sugar is extracted.

Proper use of lime is one of the most important management strategies in crop production. Lime is relatively inexpensive in relation to fertilizer nutrients and should be the first soil amendment considered in crop production.

The fall of the year, depending on the weather, will make a good opportunity to start a liming program. First, do not try and guess if your soil needs lime. Take the time and take some soil samples before applying lime. Soil pH is a good indicator in telling us if lime is needed.

Sugarbeets do not grow well in acidic soils below pH 6.5. Soil test results will provide the current pH level of soils and whether liming should be considered. Sugarbeet growers often employ factory PCC for adjusting soil pH. In addition to soil pH adjustments, other benefits for PCC application may include 1) improving soil structure, 2) accessing quantities of unavailable P, K and other micronutrients due to pH adjustments, and 3) reducing the pressure of seedling damping off diseases like Aphanomyces (Carol E. Windels[1]).

After three years of testing (nine trials), PCC applications increased sugarbeet yields at each location, Fig.1. The 12 ton treatments had the highest yields followed by 8 tons, 4 tons, 6 tons, 2 tons and the untreated check. Manganese in the sugarbeet petioles was the only nutrient negatively affected by lime applications, Fig.2. Sugarbeet petioles from the untreated plots had an average of 22.5 ppm Mn compared to 13.4 ppm Mn in the 12 tons treatments. Sugarbeet stand followed the same trend as yield, with higher PCC rates having more sugarbeets per plot, Fig.3. Dead beet counts showed a slight numerical advantage to the PCC treatments, but differences were not significant and disease levels were low.

As expected, after lime application, soil analysis showed higher pH and calcium levels. Two other changes found were, the Cation Exchange Capacity (CEC) increased at eight of nine locations and Mn increased at six of nine locations. All other changes were not consistent over locations. The pH averaged 7.45 at the nine locations before lime applications. The pH decreased 0.32 with no lime application and the highest increase in pH was 0.43 with 12 tons applied per acre, Fig.4.

In yield results for sugarbeets, at nine trial locations, there was a significant advantage to all rates of lime over no lime application in tons per acre, Recoverable Sugar per Acre (RWSA) (Fig.5) and net dollars per acre (Fig.6). Stand beets per 100 feet of row was the lowest with no lime applied and was significantly better at the four higher rates of lime. Lime application treatments did have the largest increase in stands at the two locations where seedling disease was noticeable. Most of our trial locations have not had significant seedling disease, but one location in 2013 has been the worst and shows the potential advantage of lime application for better emergence.

<u>Summary and Conclusions</u>

The results of nine locations over three years show a significant increase from all rates of lime compared to the untreated in net dollar/acre, sugar/acre, and tons/acre. The three higher rates of lime had a significant increase in beet stand. Application of lime increased the stand at locations where there was noticeable seedling damping-off diseases. Lime applications increased soil pH, CEC, calcium, and manganese was higher at six of nine locations. All rates of lime caused lower manganese levels in sugarbeet petioles. Zinc levels were lower at the higher lime rates and potassium was higher with all rates of PCC.

[1] Windels, C.E., Brantner, J.R., Sims, A.L., and Bradley, C.A. 2008. Long-term effects of a single application of spent lime on sugarbeet, Aphanomyces root rot, rotation crops, and antagonistic microorganisms. 2007 Sugarbeet Res. Ext. Rept. 38:251-262.

Fig.1. Sugarbeet Tons/Acre with Factory Lime Applications (Averaged over 3 Years).

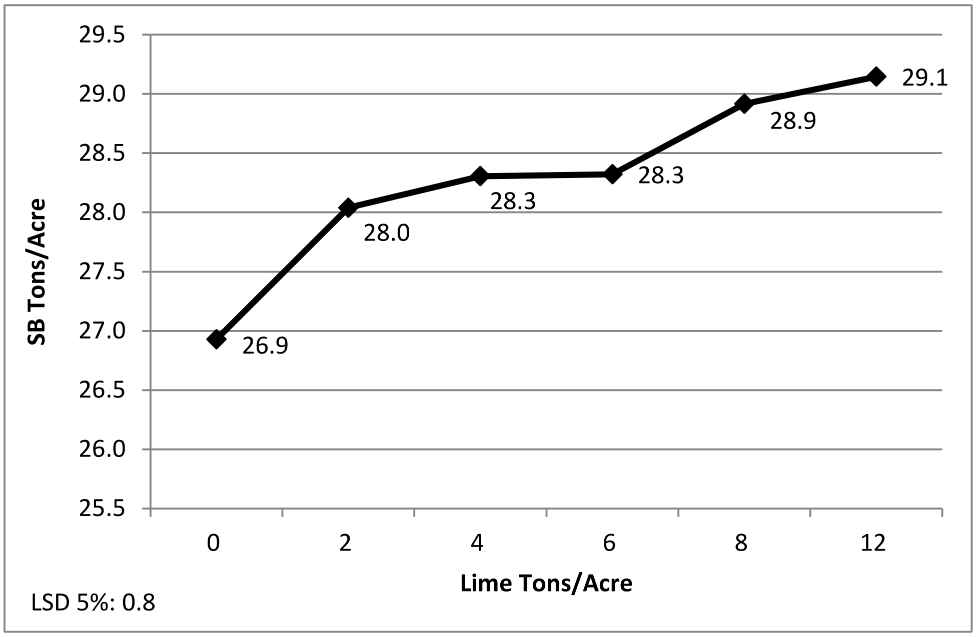

Fig. 2. Effect of Factory Lime on Sugarbeet Petiole Manganese Content, ppm (Averaged over 3 Years).

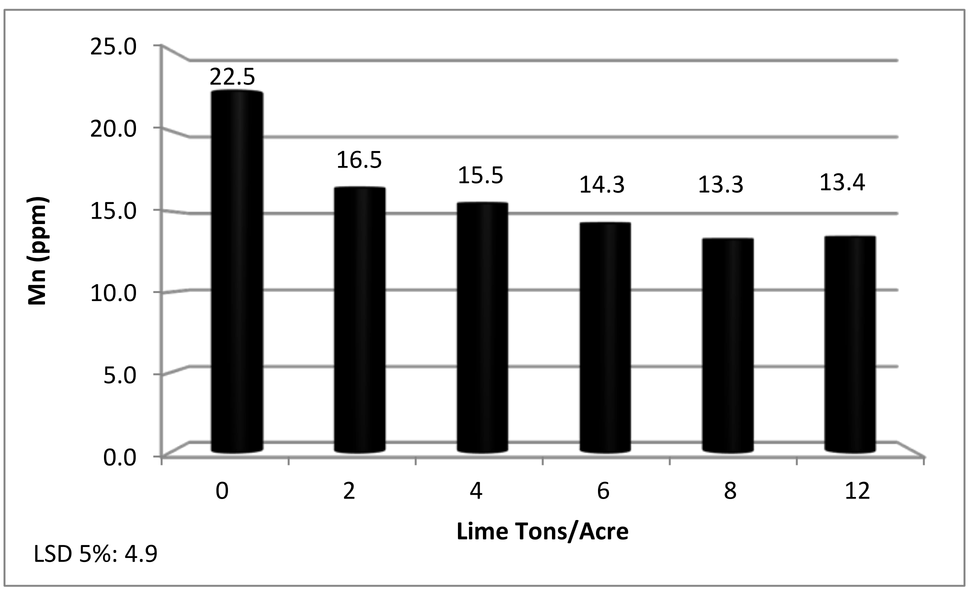

Fig. 3. Effect of Factory Lime on Sugarbeet Emergence (Averaged over 3 Years).

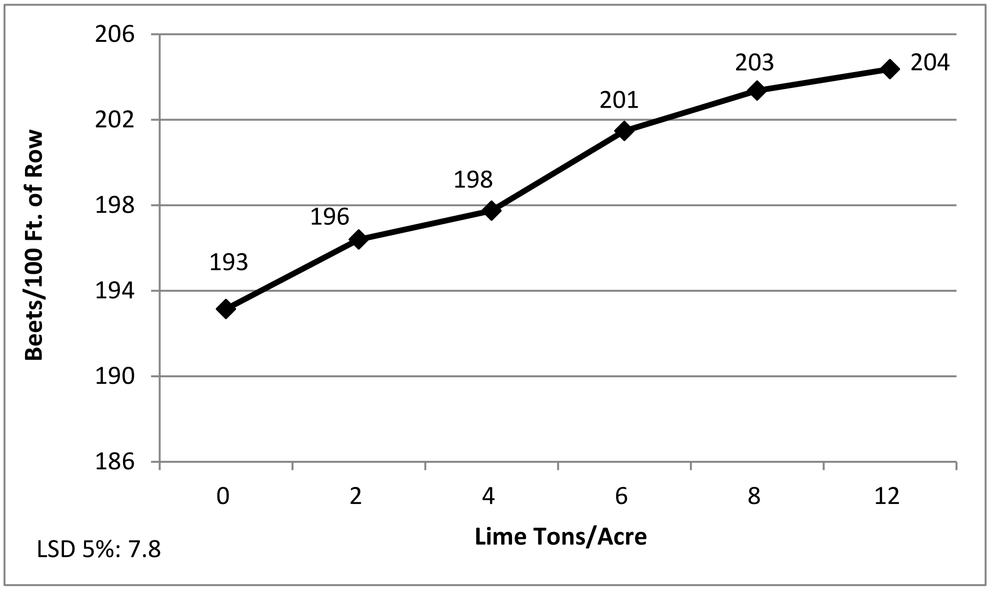

Fig. 4. The pH Averaged at the 9 Locations Before and After Lime Applications.

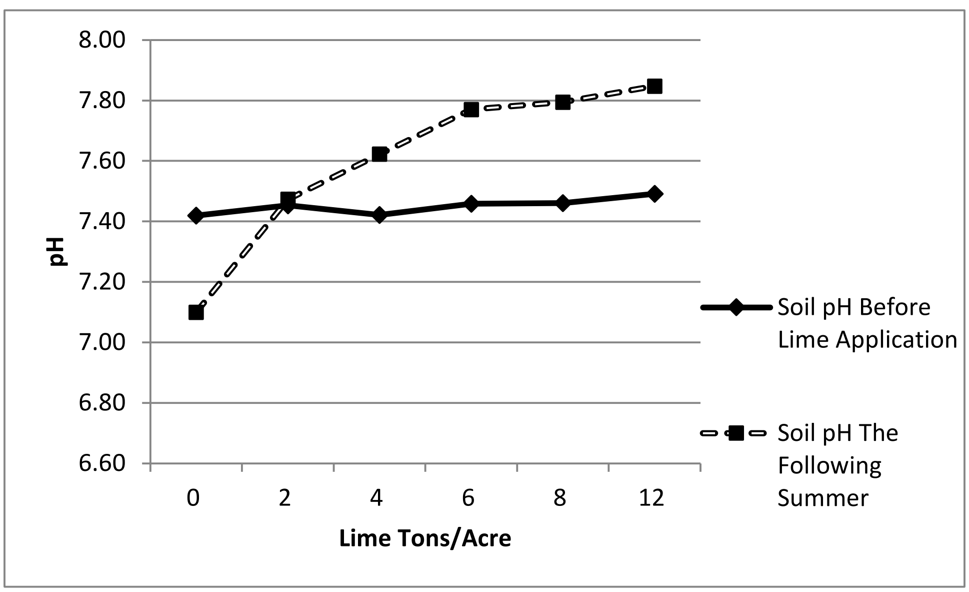

Fig. 5. The RWSA Averaged (Over 3 Years).

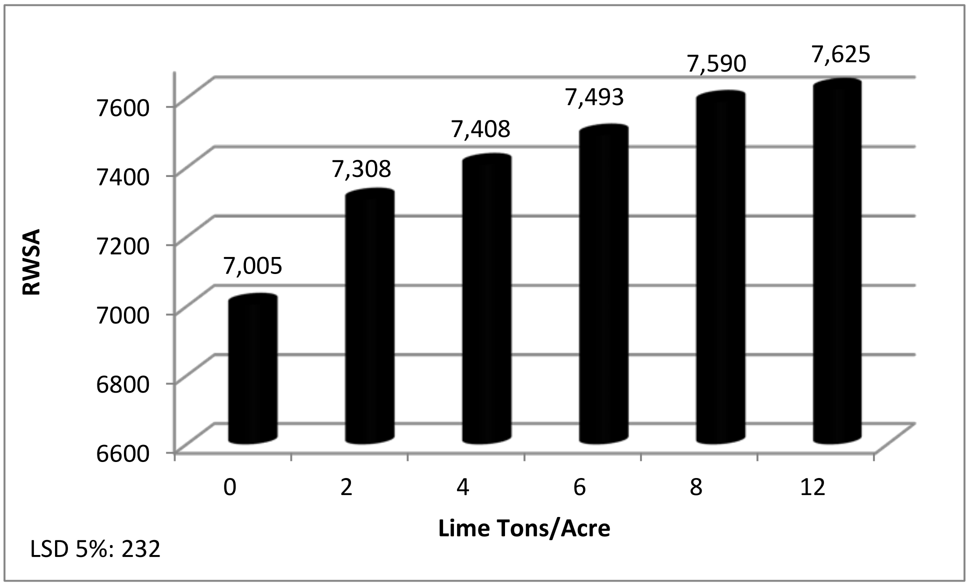

Fig. 6. Effect of Factory Lime Applications on Grower Income (Averaged over 3 Years).