

SIMS, ALBERT L.<sup>1</sup>, CAROL E. WINDELS<sup>1</sup> and CARL A. BRADLEY<sup>2</sup>, <sup>1</sup>University of Minnesota, Northwest Research and Outreach Center, 2900 University Avenue, Crookston, MN 56716 and <sup>2</sup>North Dakota State University, Walster Hall, Box 5012, Fargo, ND 58105-5012.  
**Field applications of sugar factory spent lime: Effects on soil phosphorus**

### ABSTRACT

Spent lime generated during the purification process of raw sugar beet juice historically has been stockpiled near the factory sites. The seven sugar beet processing factories in Minnesota and North Dakota generate approximately 454,000 Mg (500,000 tons) of spent lime annually on a dry weight basis. In recent years, field application of spent lime has been shown to reduce the incidence of *Aphanomyces* root rot in sugar beet, a disease increasing in prevalence in sugar beet producing regions. In Minnesota and North Dakota, some growers field apply spent lime for a number of reasons, including a perception that more calcium is needed in these mostly calcareous soils, improved productivity of other crops in rotation with sugar beet, and reduced root disease in sugar beet. In many cases the scientific evidence for the improved production due to the application of spent lime has not been documented. The effect of spent lime on *Aphanomyces* root rot in sugar beet is currently undergoing intensive study.

Spent lime is the result of precipitation of calcium carbonates and many impurities from the raw sugar beet juice. Laboratory analysis of spent lime indicates a significant phosphorus component. However, it has been speculated that this P is chemically tied up as calcium phosphate and is not soluble, and thus not available to a growing crop once applied to the soil. As in the spent lime is not known, but some have speculated it is tied up as calcium phosphates and would not be available to a growing crop once applied to the soil. Our objectives were to: 1) determine the variability of spent lime P content from various sugar beet processing factories, and; 2) determine the effect of field applied spent lime on soil test P levels.

Objective 1: Spent lime was collected from each of the seven sugar beet processing factories in Minnesota and North Dakota (American Crystal at Drayton, East Grand Forks, Crookston, Hillsboro, and Moorhead; Minn-Dak Farmers Cooperative; and Southern Minnesota Beet Sugar Cooperative). Three sub samples of spent lime were collected on three dates: November 17, 2004; January 19, 2005; and March 17, 2005 from each factory—representing the early, mid-term, and late-term sugar beet processing season. Spent lime was collected just as it was expelled from the factory proper, and before it was hauled to the stockpile. The spent lime samples were brought to the University of Minnesota's Northwest Research and Outreach Center where they were dried, digested, and analyzed for total P concentration.

The P content in the spent lime from the various sugar beet processing factories ranged from 3470 to 7073 mg P kg<sup>-1</sup> over the three sampling dates. There was variation among sampling dates from a single factory as well as variation across factories. When averaged across all sampling dates, the two P content extremes appeared in spent lime from the Drayton factory, average of 3827 mg P kg<sup>-1</sup>; and from the Moorhead factory, average of 5627 mg P kg<sup>-1</sup>. Averages of spent lime at the other factories were 4259 (Crookston), 5135 (East Grand Forks), 5404 (Hillsboro), 4952 (Minn-Dak), and 5580 (So. Minn) mg P kg<sup>-1</sup>. The field application of 10 Mg spent lime ha<sup>-1</sup> (4.5 ton A<sup>-1</sup>) would range from the equivalent of 89 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Drayton) to 131 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Moorhead).

Objective 2: Spent lime was field applied to two experimental locations separated by a distance of 150 km, near Breckenridge, Minnesota and Hillsboro, North Dakota. At each location, four experiments were established; each with four replications of five spent lime application rates. At Hillsboro, spent lime rates of 0, 7, 15, 29, and 44 (dry weight basis) Mg ha<sup>-1</sup> (0, 5, 10, 20, and 30 wet tons A<sup>-1</sup>) were broadcast on the soil surface of appropriate plots in October 2003. At Breckenridge, spent lime rates of 0, 6, 12, 18, and 24 (dry weight basis) Mg ha<sup>-1</sup> (0, 5, 10, 15, and 20 wet tons A<sup>-1</sup>) were broadcast on the soil surface of appropriate plots in April 2004. Spent lime was weighed into a front mounted bucket of a Bobcat loader. As the Bobcat backed through the plots, people used hoes and shovels to pull the spent lime from the buckets. Each experimental area was located in a commercial field with a history of *Aphanomyces* root rot in sugar beet. At each location, corners of each experiment were geographically located using GPS technology and strategically placed buried metal disks. The farmer-cooperator did all tillage, fertilizing, crop planting and harvesting, and pest control exactly as the surrounding commercial field. The first growing season (2004) hard red spring wheat was planted at Breckenridge and corn was planted at Hillsboro. In 2005, sugar beet was planted to one experiment at each location and the other three experiments were managed by the farmer-cooperator. Hard red spring wheat was planted again at Breckenridge. However, soil conditions were too wet at Hillsboro to plant any crop and the site, except for the sugar beet plots, remained fallow throughout the entire 2005 growing season.

We intended to collect soil samples from each plot at both locations immediately after the crop was harvested, but before any tillage operations took place. At Breckenridge, soils were sampled in August 2004 and 2005 after the wheat was harvested. At Hillsboro, soil conditions after corn harvest were too wet to obtain a representative sample. The first soil samples were collected in early May 2005 at Hillsboro. The second soil samples were collected in August 2005 because there was no crop planted, except the sugar beet plots, and the soils were dry enough to sample. Ten soil cores, 1.9 cm in diameter and 15 cm deep, were collected and combined from each plot after dividing each core into two depth segments representing 0 – 7.5 cm and 7.5 – 15 cm depth increments. Soils were air dried, ground, and analyzed for soil test P levels using the NaHCO<sub>3</sub> (Olsen) method. Statistical analysis was done using Proc Mixed procedure using 16 replications.

The application of spent lime to the field had a significant and linear effect on the soil test P levels in those fields. One growing season after the spent lime was applied the 0 – 7.5 cm soil test P level increased 0.84 mg P kg<sup>-1</sup> and 0.75 mg P kg<sup>-1</sup> for each 1 Mg (dry) ha<sup>-1</sup> spent lime applied at Hillsboro and Breckenridge, respectively. There was little effect of spent lime in the soil test P level in the 7.5 – 15 cm soil depth. After two growing seasons, the response to spent lime differed between the two locations primarily because the Breckenridge farmer-cooperator applied 45 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> fertilizer in the spring of 2005. At Hillsboro, the soil test P levels increased 0.40 mg P kg<sup>-1</sup> for each increase of 1 Mg ha<sup>-1</sup> spent lime applied. But at Breckenridge, soil test P levels had a curvilinear response to applied spent lime rates. Soil test levels increased nearly 20 mg P kg<sup>-1</sup> through the 18 Mg ha<sup>-1</sup> spent lime rate with no further increase at the highest spent lime rate.

These field trials were designed to examine the effects of spent lime on sugar beet root disease; they were not designed to evaluate soil fertilizer management. Never the less, the data clearly indicate that soil test P levels are highly responsive to the application of spent lime. Soil tests are used under normal management strategies to develop an index of soil P availability and

P fertilizer application recommendations to the following crop. The responsiveness of the soil test P levels to the field application of spent lime suggests that at least a portion of the P in the spent lime may be available to a growing crop. Unfortunately, this hypothesis cannot be tested in this experiment for two reasons: 1) The fields selected for these experiments have been managed to build and maintain a high to very high soil test P level and crops would not be expected to respond to the application of P from any source; and 2) the grower-cooperators fertilize the experimental areas along with the surrounding commercial field so the addition of P fertilizer to the experimental area is not controlled. But, the data that was collected do suggest the potential for a P fertilizer credit attributed to the field application of spent lime. To do that, however, will probably require a P analysis of the spent lime that is applied since there can be considerable P content variation in this material depending on where and when it is obtained.