On-Farm Study Researches Novozymes Fermentation Spent Residuals

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The Novozymes enzyme-manufacturing facility in Blair, Neb. produces enzymes through aerobic fermentation of non-pathogenic and non-toxigenic microorganisms. The process generates a solid byproduct consisting of lime-stabilized spent microbial biomass (LSSMB) (Figure 1).

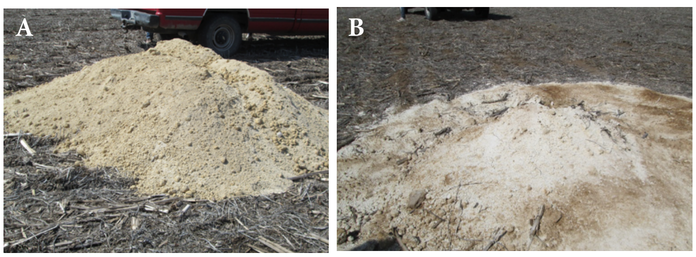

Figure 1. (A) Freshly delivered lime-stabilized spent microbial biomass (LSSMB). (B) Remnants of LSSMB pile delivered in the fall of 2012 and remaining in the spring of 2013. The surface crusted over, shedding rainwater, and protecting the underlying material.

To evaluate potential agricultural use of this byproduct, field research was conducted with LSSMB applied in the fall of 2012 or spring of 2013 at three sites in Washington County, Neb. and one site near Mondamin, Iowa. The effects on the 2013 corn crop and residual effects on the 2014 corn or soybean crop were determined. All fields were rainfed and no-till in a corn-soybean rotation. Corn, which followed a 2012 soybean crop, was planted at all locations in 2013. In 2014, two sites had corn and two sites had soybean.

The spent microbial biomass was evaluated for nutrient and heavy metal content; nitrogen (N) fertilizer equivalent (first and residual-year crop N availability); liming value; and effect on corn and soybean yield.

Treatments included combinations of an LSSMB application rate of 2.23 or 4.46 tons per acre on a wet weight basis; fertilizer N applied with LSSMB at 0 and 36 lb per acre N; and LSSMB applied either in the fall or spring.

In addition, six N rate treatments in 36 lb per acre increments ranging from 0 to 180 lb per acre with no LSSMB were applied for corn trials in the spring of 2013 and again in 2014.

Research Results

No problems of heavy metals for land application were detected from analyses of LSSMB samples. Nitrogen content ranged from 1.9% to 2.1% on a dry weight basis. Content of P2O5 ranged from 0.75% to 0.87%. Contents of K2O and S were about 0.15% and 0.2%, respectively, on dry weight basis. However, the product tested had about 50% water content.

Corn yield increased with N application at two of the four sites in 2013 and at both sites in 2014 (Figures 2 and 3). The mean fertilizer N substitution values for the LSSMB in 2013 was 4.5 and 4.4 lb N per ton applied in 2013 and 2014, respectively, and equal to 11% of the N applied in the LSSMB per year. This was less N release than expected. It may be that the high pH of the LSSMB, and possibly unreacted calcium oxide in conjunction with the organic N, inhibited microbial breakdown.

The LSSMB liming value varied greatly, with neutralizing values on a calicium carbonate equivalent basis of 12, 18, and 31% for three samplings of LSSMB. These values should be near the effective calcium carbonate equivalent (ECCE) because fine particle sizes in the product (<0.25 mm or <60 mesh) should give high reactivity. For comparison, agricultural lime is commonly about 60% ECCE. Following the 2013 corn harvest, soil pH in the 0- to 4-inch depth was increased on average by about 0.1 pH unit per ton per acre of LSSMB applied.

Corn and soybean yield was not negatively affected where LSSMB was applied at planned rates, but no positive effect on yield was observed beyond that associated with N contribution to corn.

The LSSMB stored well throughout the winter in a stockpile. A surface crust formed that shed water and prevented the pile from eroding (Figure 1). Normal application rates had no negative effect on crop growth, but quite excessive rates, such as where a stockpile site was not well cleaned, could inhibit crop emergence due to crusting (Figure 4). If LSSMB remains intact as small lumps during application,

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the lumps crust over and are slow to disperse and react with the soil.

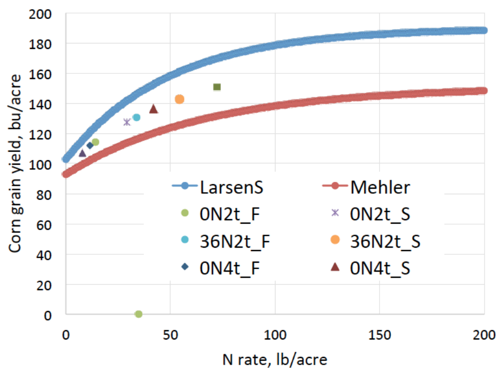

Figure 2. Corn grain yield response to applied N for two trials in 2013 and the average fertilizer N substitution effects of LSSMB applied at 2.23 or 4.46 wet t/ac in the fall (F) of 2012 or spring (S) of 2013 with 0 or 36 lb/ac fertilizer N.

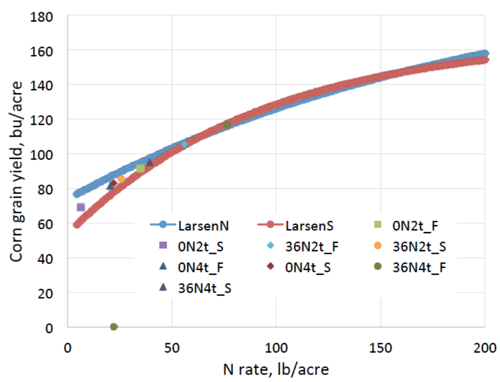

Figure 3. Corn grain yield response to applied N for two trials in 2014 and the average residual-year fertilizer N substitution value of LSSMB applied at 2.23 or 4.46 wet t/ac in the fall (F) of 2012 or spring (S) of 2013 with 0 or 36 lb/ac fertilizer N.

Conclusions

Several conclusions are drawn from this study.

- Land application of LSSMB up to 5 tons per acre on an as-is (wet) basis presents no problems to crop production if soil pH is 7 or lower.
- Nutrients applied with each ton of LSSMB, as is, include about 20, 8, 1.5, and 2 lb of N, P_2O_5, K_2O, and S.
- The nutrients, except K, are in organic form and microbial activity is needed to decompose the organic matter to release most nutrients.
- On average, about 22% of the N applied in LSSMB was available during the growth of two crops with 11% availability in each year for no-till situations.
- Nitrogen availability was greater with fall compared with spring application in the second year for these no-till situations.
- Availability of other nutrients in LSSMB was not determined, but
  - percent P and S availability is expected to be similar to N availability;
  - potassium, however, is expected to be released more rapidly, likely with 80% to 90% of it available to the first crop.
- The liming value of LSSMB varied considerably across three samples. The liming value of applied product needs to be determined from analysis of a representative sample or by subsequent soil sampling.
- The liming effectiveness of the LSSMB, per ton dry material and $CaCO_3$-equivalent applied, is expected to be more reactive than agricultural lime because of fine particle size and CaO used for LSSMB stabilization.
- To maximize LSSMB effectiveness a broadcast application with enough throwing force for lumps to shatter on impact is needed.
- Incorporation of LSSMB by tillage is likely to enhance first-year effects but not long-term effects.
- LSSMB stores well in stockpiles with surface crusting that sheds water and prevents erosion from the pile.
- Stockpiles need to be cleaned up as excessive LSSMB amounts can crust over and inhibit crop emergence.
- LSSMB is suitable for land application.

Figure 4. Corn grew well in the LSSMB highest rate plot applications. However, when remnants of a stockpile were not well cleaned up, crusting of material left on the soil surface prevented good seedling emergence and early growth.

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