Super-Fine Limestone for Acid Soil Neutralization and Forage Production

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Summary

On the coarser textured Darco soil, limestone with an effective calcium carbonate equivalence of 100% (ECCE 100) increased soil pH and yield of legumes in two studies. On the Kirvin soil, pH levels in the 0- to 6-in. depth 2.6 years after limestone treatment were not significantly influenced by varying limestone ECCE values. Ryegrass yield followed a similar trend. However, clover yield was increased by ECCE 81 limestone compared with ECCE 62 material, but clover yield declined under the ECCE 100 limestone treatment.

Introduction

This research was initiated in the fall 1989. Concerns were expressed that agricultural-grade limestone may not be sufficiently reactive when surface-applied for winter pasture production. Agricultural-grade limestone is screened as fine as possible without introducing a drying phase to the process. Additional drying would increase the cost of limestone production. Concerns were also expressed that a more reactive, finer limestone material may not maintain a high soil pH compared with coarser material that reacted more slowly.

Materials and Methods

Two soil series were selected for this study. The Darco soil is sandy to 4 ft over a yellow clay subsoil. The Kirvin soil has a sandy surface to about 6 in. deep. This is underlaid by a red, gravelly, sandy clay loam subsoil.

Limestone effective calcium carbonate equivalence (ECCE) percentages of 62, 81, and 100 were selected for evaluation. These were applied at rates of 0, 1, 2, and 3 tons/A at each site. Three forage systems were used: 'Coastal' bermudagrass with no cool-season crop, Coastal bermudagrass overseeded with 'Marshall' ryegrass, and Coastal bermudagrass overseeded with 'Dixie' crimson and 'Yuchi' arrowleaf clovers.

These research sites were selected, sampled, and the limestone was applied in the fall of 1989. Collection of soil samples from each plot was initiated 1 week after the first rain on the limestone treatments. These samples were collected at increasing weekly intervals, i.e., 1, 2, 4, 8, etc., weeks. The cool-season forages were overseeded after limestone treatment and each succeeding October. Forages were harvested at timely intervals and sampled for dry matter and chemical analysis.

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is converted to nitrite and subsequently to nitrate by specific bacteria in the soil. The highest N fertilizer applications were made on the bermudagrass-ryegrass forage system. This system should have the lowest soil pH. Coastal bermudagrass grown without use of an overseeded cool-season annual forage received the lowest amount of N and should have the highest pH.

As expected, increasing limestone rates increased soil pH in both soils (Table 2). Two and one-half years after limestone treatment, the 3-ton/A rate on the Darco soil and the 2-ton/A rate on the Kirvin soil are maintaining soil pH at 6. These pH values are averages for the limestone rates across all ECCE levels and forage systems.

Limestone ECCE percentages of 81 and 100, averaged over lime rates, increased soil pH in the 0- to 6- and 6- to 12-in. depths of the Darco soil compared with the ECCE 62 material (Table 3). No statistically significant differences in pH existed 2.6 years after treatment in the 0- to 6-in. depth of the Kirvin soil.

Ryegrass production was increased in both soils by application of limestone (Table 4), but there was no yield difference among rates of application at an average ECCE of 81%. These results show that a pH of at least 5.6 is needed (see Table 2) on these soils to obtain optimum ryegrass yield.

Compared with the no-lime treatment, limestone application increased clover yield on both soils (Table 4). Increasing the lime rate magnified the yield on the Darco soil. Dry matter production was similar for all limestone treatments on the Kirvin soil although soil pH was increased from 5.57 to 6.37 by lime rates from 1 to 3 ton/A (see Table 2).

Increasing limestone ECCE caused a slight, but not statistically significant, increase in ryegrass yield on the Darco soil (Table 5). Ryegrass yields were unchanged by increasing ECCE of the limestone on the Kirvin soil for the 2- to 2.5-year period after limestone application. Soil pH levels were similar for all limestone ECCE percentages on the Kirvin soil (see Table 3). Ryegrass dry matter yield on the Kirvin soil was more than double that on the Darco. Clover yield was increased significantly by increasing limestone ECCE in both soils. Yields of Coastal bermudagrass were not affected by either limestone rate or limestone ECCE for as long as 2 years after limestone treatment (data not shown).

Table 2. Effect of limestone rate on soil pH† 2.6 years after limestone treatment.

Forage system	Darco soil 0-6 in.	Darco soil 6-12 in.	Kirvin soil 0-6 in.
	......pH......		
0	5.24 c*	4.86 b	5.46 c
1	5.58 b	5.09 a	5.57 c
2	5.78 ab	5.19 a	6.03 b
3	5.96 a	5.17 a	6.37 a

*Within a column, values followed by the same letter are not different statistically at the p = 0.05 level.
†Averaged across forage type and ECCE.

Table 3. Effect of limestone ECCE on soil pH† 2.6 years after limestone treatment.

Limestone ECCE	Darco soil 0-6 in.	Darco soil 6-12 in.	Kirvin soil 0-6 in.
%	......pH......		
62	5.54 b*	5.02 b	5.93 a
81	5.80 a	5.15 ab	5.91 a
100	5.99 a	5.30 a	6.02 a

*Within a column, values followed by the same letter are not different statistically at the p = 0.05 level.
†Averaged across forage type and limestone rate.

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Table 4. Ryegrass and clover dry matter production† influenced by limestone rate 2 to 2.5 years after limestone treatment.

Limestone rate, t/A	Darco soil Ryegrass	Darco soil Clover	Kirvin soil Ryegrass	Kirvin soil Clover
	......lb/A......			
0	2147 b*	865 d	6385 b	3457 b
1	2969 a	2379 c	7651 a	4553 a
2	3242 a	2684 b	7998 a	4724 a
3	2957 a	3059 a	7950 a	4469 a

*Within a column, values followed by the same letter are not different statistically at the p = 0.05 level.
†Yield averaged over limestone ECCE, 1992.

Table 5. Ryegrass and clover dry matter production† influenced by limestone ECCE 2 to 2.5 years after limestone treatment.

Limestone ECCE	Darco soil Ryegrass	Darco soil Clover	Kirvin soil Ryegrass	Kirvin soil Clover
%	......lb/A......			
62	2818 a*	2252 b	7810 a	4456 b
81	3086 a	2414 ab	7859 a	4817 a
100	3265 a	2857 a	7830 a	4472 b

*Within a column, values followed by the same letter are not different statistically at the p = 0.05 level.
†Yield averaged over limestone rate, 1992.

Both experiments were fertilized each fall and spring with 450 to 500 lb/A of a 0-20-20 blend containing 5% sulfur, 3% magnesium, 0.12% boron, and a trace of copper and zinc. The clover was not fertilized with nitrogen (N). Ryegrass was fertilized with 50 to 60 lb N/A for each cutting. Coastal bermudagrass was fertilized with 100 to 120 lb N/A for each cutting.

Results and Discussion

Soil pH affected by limestone ECCE in the surface 0- to 6-in. depth of the Darco and Kirvin soils is shown in Figures 1 and 2, respectively. These values are averaged over limestone rate and forage type. In general, soil pH increased through the cool-season months and decreased during the warm-season months. The decrease during the warm season may be due to soil acidification caused by nitrification of the ammonium forms of N fertilizer

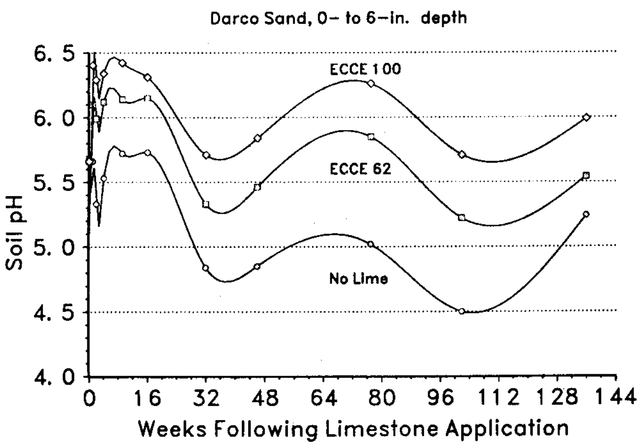

Figure 1. Effect of limestone ECCE on pH change in a Darco soil.

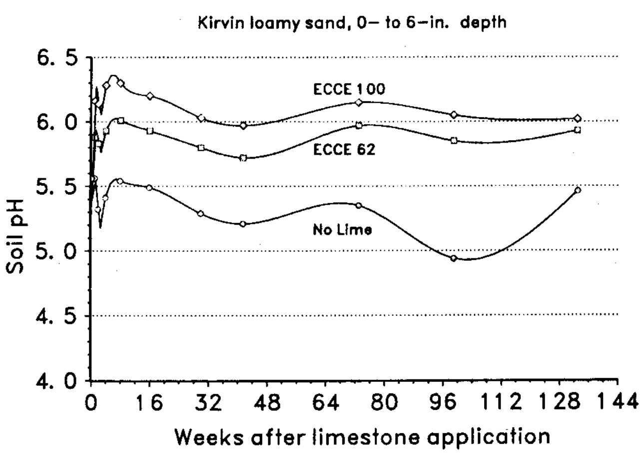

Figure 2. Effect of limestone ECCE on pH change in a Kirvin soil.

applied for Coastal bermudagrass production. The increased acidity occurs when a higher soil pH is desirable for germination and survival of legume seedlings. Limestone treatment of the soil, even with ECCE 100% limestone, did not prevent this pH decrease. Soil pH readjusted upward during the cool season, probably because of further reaction of the surface-applied limestone.

This seasonal change in soil pH is an important consideration when sampling soil to determine limestone needs. If the sample is collected in the summer, the limestone recommendation based on soil pH will be higher than if sampled in late winter, before N fertilizer is applied for warm-season grass production. Soil pH change by season was much more pronounced in the Darco soil (Fig. 1) than in the Kirvin soil (Fig. 2).

In the Darco soil at the 136-week sampling, soil pH in plots treated with ECCE 100 limestone was approximately 6.0. At the same sampling time, the ECCE 62 limestone maintained soil pH at 5.5. The initial pH of the soil was 5.7. The ECCE 100 limestone was maintaining soil pH at a level favorable for cool-season annual forage production.

In the Kirvin soil, pH change affected by ECCE 62 limestone was maintained near 5.9. This was 0.1 pH unit below the soil pH affected by ECCE 100 material at the 133-week sampling time. Soil pH influenced by ECCE 100 limestone was approximately 6.0 after 133 weeks.

Samples collected in June 1992 (week 136) show that the Coastal bermudagrass-ryegrass cropping system had the lowest soil pH for the 6- to 12-in. depth of the Darco soil (Table 1). Soil pH in the bermudagrass-ryegrass cropping system was lower but not statistically different from the bermudagrass-clover or bermudagrass forage systems in the 0- to 6-in. depth of the Darco soil. For the Kirvin soil, plots containing forage systems that included a cool-season annual overseeded into the bermudagrass had a lower soil pH than bermudagrass alone. Acid is formed in the soil when the ammonium form of N

Table 1. Effect of forage system on soil pH† 2.6 years after limestone treatment.

Forage system	Darco soil 0-6 in.	Darco soil 6-12 in.	Kirvin soil 0-6 in.
	.... pH	....	....
Coastal bermudagrass (Cb)	5.75 a*	5.22 a	6.10 a
Cb-clover	5.82 a	5.28 a	5.88 b
Cb-ryegrass	5.59 a	4.87 b	5.77 b

*Within a column, values followed by the same letter are not different statistically at the p = 0.05 level.

†Averaged across limestone rate and ECCE.