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Long-Term Effects of Lime on Soil pH In Some Acidic Soils of Northern Idaho

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Increased information in recent years indicates a need for lime on the acidic agricultural soils of northern Idaho. Some of the earliest information is contained in the 1981 University of Idaho publication CIS 629, *Implications of Acidification of Farmland in Northern Idaho*. That publication pointed out that lime inevitably will be needed to counteract the effects of acid-forming nitrogen fertilizers on most agricultural soils of northern Idaho. A later publication (CIS 811, *The Relationship of Soil pH and Crop Yields in Northern Idaho*) showed a relationship between acidic soil pHs and the yields of major crops, with yields declining with increasing acidity. Information on lime application rates and quality of liming materials is available in CIS 787, *Liming Materials*.

Growers and dealers frequently ask, "How long will an application of lime last in the soil?" They also ask, "How effective is the lime in changing the soil pH?" These and other questions can be answered at least partially by information collected from large demonstration plots conducted in northern Idaho from 1986 through 1990.

Methods

In summer 1986, four sets of large demonstration plots were set up to evaluate the use of lime on northern Idaho agricultural soils:

Site 1 — Kendrick, Nez Perce County
Site 2 — Genesee, Nez Perce County
Site 3 — Reubens, Lewis County
Site 4 — Moscow, Latah County

Lime applications and pH measurement

Lime was applied at each site in September 1986. At sites 1, 2 and 3 the lime application rate was about 2 tons per acre. Due to misadjustment of a borrowed spreader at site 4, the lime application rate was about 6 tons per acre. An unlimed plot, located adjacent to each limed plot, served as an untreated check.

After discing once or twice to incorporate the lime, winter wheat was planted at each site. Discing probably incorporated the lime only to a depth of about 3 inches. Soil samples were taken before lime application and each spring through 1990. Samples were taken from depths of 0 to 3 inches, 3 to 6 inches, 6 to 9 inches and 9 to 12 inches. Samples were analyzed for soil pH by the University of Idaho Analytical Services Laboratory using a glass electrode in a water saturated paste.

At site 1, a strip of alfalfa also was treated with lime. The established alfalfa did not permit incorporation of the lime into the soil; thus, reaction of the lime with the soil was dependent on the lime's movement into the soil with precipitation. Soil sampling in the alfalfa did not begin until May 1988, nearly 2 years after the lime was applied. An adjacent, unlimed strip of alfalfa was sampled as the unlimed check.

Soils

Each plot was 4 to 5 acres in size, with each site having two or three replications. Because of the large plot size, each plot included several soil types. All sites had a silt loam surface texture with 13 to 17 percent clay. The soil organic matter content (0- to 12-inch depth) was as follows:

Site 1	2.3 to 3.3%
Site 2	2.7 to 3.1%
Site 3	2.8 to 3.4%
Site 4	2.5 to 2.6%
Site 1 (alfalfa)	2.8 to 2.9%

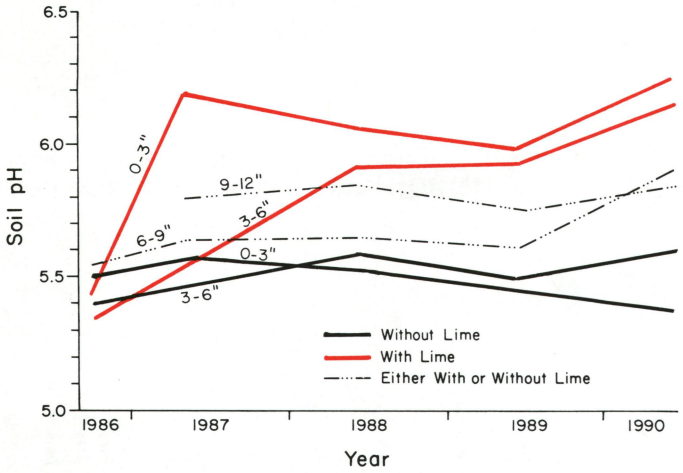

Fig. 1. Soil pH at site 1 for various depths, with and without lime, from demonstration trials in northern Idaho (Kendrick).

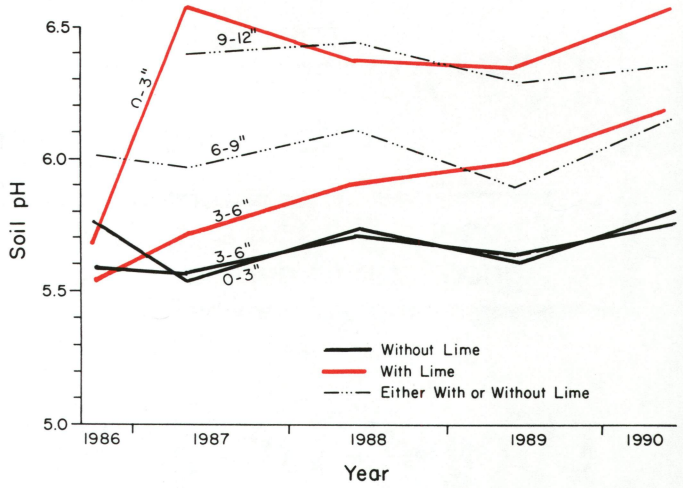

Fig. 2. Soil pH at site 2 for various depths, with and without lime, from demonstration trials in northern Idaho (Genesee).

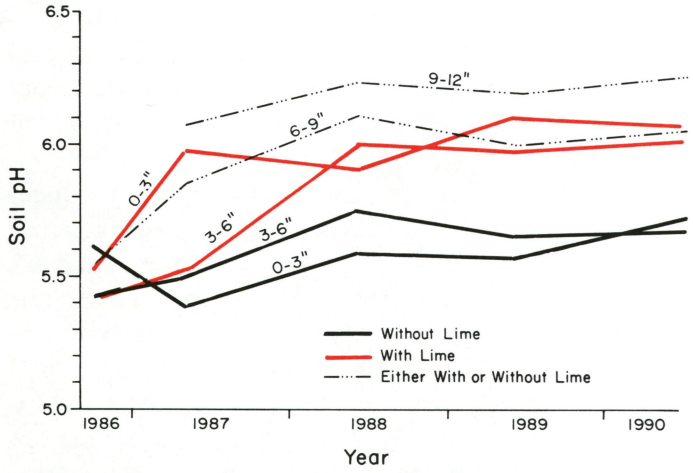

Fig. 3. Soil pH at site 3 for various depths, with and without lime, from demonstration trials in northern Idaho (Reubens).

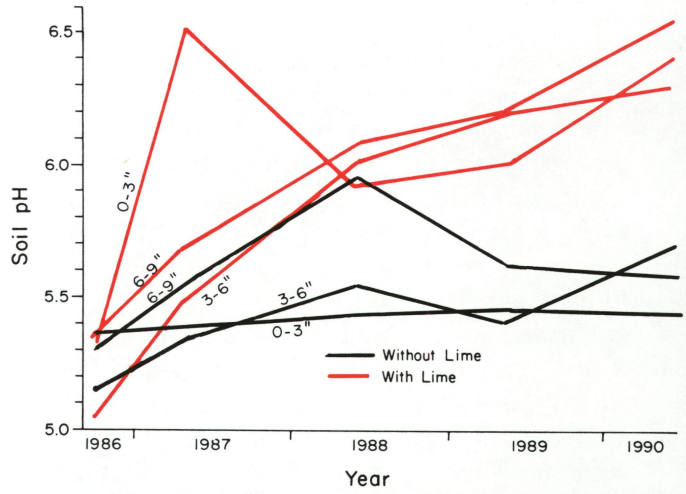

Fig. 4. Soil pH at site 4 for various depths, with and without lime, from demonstration trials in northern Idaho (Moscow).

Liming material

The lime used in the trials was a high-quality liming material with a calcium carbonate equivalent (CCE) of 98 percent. However, the limestone rock was not ground finely enough to be a high-quality agricultural liming material. The percentages of liming material passing 10-, 20-, 40- and 100-mesh sieves were 93, 67, 56 and 43 percent, respectively. The coarseness of the lime reduces its reaction speed in the soil but provides a longer-term benefit.

Results

Site 1 — Before lime application, the soil pHs were 5.5, 5.4 and 5.6 in the 0- to 3-inch, 3- to 6-inch and 6- to 9-inch depths, respectively (Fig. 1). The 9- to 12-inch layer was not sampled in 1986, but based on samples taken in subsequent years it appears the soil pH in the 9- to 12-inch layer was 5.7 to 5.8 at the beginning of the trials and remained at that level all 4 years.

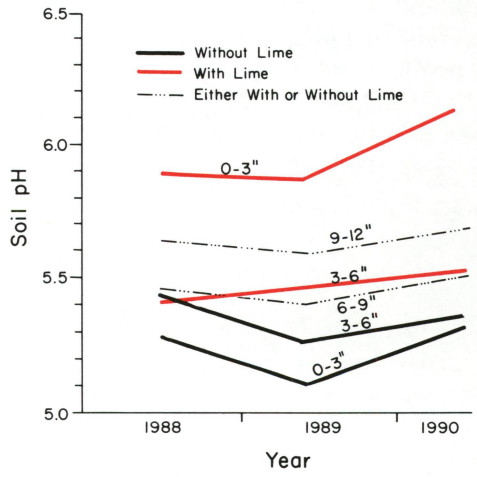

Fig. 5. Soil pH at site 1 (alfalfa) for various depths, with and without lime, from lime demonstration trials in northern Idaho (Kendrick).

In spring 1987, 8 months after lime application, the pH in the 0- to 3-inch layer had increased by 0.7, from 5.5 to 6.2. The pH in the 3- to 6-inch and deeper layers changed slightly or not at all. Between 1987 and 1989, the pH in the 0- to 3-inch layer appeared to drop slowly. It then increased slightly to pH 6.3 in 1990. The 3- to 6-inch layer steadily increased in pH, indicating the lime was reacting to this depth in the soil. There was no apparent change in the pH in the 6- to 9-inch layer. Nearly all the pH values (except for the 0- to 3-inch layer without lime) appeared to be slightly higher in 1990 than in 1989.

Site 2 — Before lime application, the soil pHs were 5.7, 5.6 and 6.0 in the 0- to 3-inch, 3- to 6-inch and 6- to 9-inch layers, respectively (Fig. 2). The 9- to 12-inch layer probably had a pH near 6.4.

Eight months after lime application, the pH of the 0- to 3-inch layer had increased by 0.9 due to the lime — from 5.7 to 6.6. The pH in the 3- to 6-inch layer may have increased slightly (by 0.1) at this sampling. In subsequent years the 0- to 3-inch layer seemed to level off at about 6.4 to 6.5 and the 3- to 6-inch layer continued to increase steadily. There is no indication of an increase in the 6- to 9-inch layer. As in site 1, there was an apparent increase of 0.15 to 0.2 pH units in all samples from 1989 to 1990.

Site 3 — Before lime application, the pHs were 5.6, 5.4 and 5.6 in the 0- to 3-inch, 3- to 6-inch and 6- to 9-inch layers, respectively (Fig. 3). The 9- to 12-inch layer had a pH near 6.1.

In spring 1987, 8 months after lime application, the pH in the 0- to 3-inch layer increased 0.4 to pH 6.0, while the 0- to 3-inch layer in the unlimed plot decreased 0.2, to about 5.4. The pH in the 6- to 9-inch layer increased, but probably not due to lime. In spring 1988, nearly 2 years after lime application, the 3- to 6-inch layer had a pH near that of the 0- to 3-inch layer. Both layers maintained this level (near pH 6.0) in the 1990 sampling. The 6- to 9-inch layer continued to increase in pH until 1988 then leveled off near 6.0 in 1990. Because the 6- to 9-inch layer in both the unlimed and limed plots had the same pH, it appears that there is no benefit from the lime at this depth after nearly 4 years. The 9- to 12-inch layer had a pH near 6.1 to 6.2 at all samplings.

Site 4 — Before lime application, the pHs were 5.4, 5.1 and 5.4 in the 0- to 3-inch, 3- to 6-inch and 6- to 9-inch layers, respectively (Fig. 4). With the addition of lime at a rate of 6 tons per acre, by spring 1987 the 0- to 3-inch layer had increased in pH by 1.1 units to 6.5. The pH of the 3- to 6-inch layer appeared to have increased slightly, but apparently so did the pH of the 3- to 6-inch layer in the unlimed plot. The pH of the 6- to 9-inch layers in both the limed and unlimed plots also increased in 1987 and again in 1988. Thus, it appears that there is no pH change due to lime in the 3- to 6-inch layer in 1987 or in the 6- to 9-inch layer in 1987 or 1988. In 1989 and 1990, the lime obviously had influenced the pH in the 6- to 9-inch layer because all layers down to 9 inches had about the same pH, ranging from 6.3 to 6.5.

Site 1 (alfalfa) — In 1988, nearly 2 years after the lime was applied, the pH of the limed 0- to 3-inch layer was about 0.6 units higher than the pH of the unlimed strip (Fig. 5). The 3- to 6-inch layers, both limed and unlimed, had about the same pHs in 1988, but in 1989 the limed strip had a slightly higher pH (0.2), possibly due to the effect of the lime. All layers — both limed and unlimed — seemed to have a slightly higher pH in 1990 than in previous years.

Conclusions

The results of this study do not necessarily pertain to all northern Idaho soils but are specific to the fields and sites on which the trials were run. Nevertheless, similar results probably can be obtained on similar soils under similar conditions.

1. The acidic pH problem in northern Idaho agricultural soils is most severe in the top 6 inches of soil, with the 3- to 6-inch layer having the most acidic pH.
2. The pH in the 9- to 12-inch and deeper layers is near 6.0 or higher and thus has been little affected by the acidification problem.
3. After nearly 4 years, an application of 2 tons per acre of coarse lime did not affect the soil pH in the 6- to 9-inch layer. At a rate of 6 tons per acre, the coarse lime did influence the soil pH at this depth.
4. Two tons of coarse lime raised the soil pH by 0.5 to 0.9 in the 0- to 3-inch layer in the first year. An application of 6 tons per acre of coarse lime raised the soil pH in the top 6 inches of soil in the first year and in the 6- to 9-inch layer in the third year.
5. Three years after 2 tons of lime was applied to alfalfa and not incorporated, only a slight increase in soil pH in the 3- to 6-inch layer could be attributed to the lime. In the second year, there was a significant benefit in the 0- to 3-inch layer.
6. An increase in pH in the surface 6 inches was maintained for at least 4 years and probably will continue for at least 8 more years.

Acknowledgments

This project was run by the University of Idaho College of Agriculture in cooperation with the USDA Soil Conservation Service (SCS), USDA Bureau of Indian Affairs (BIA), Nez Perce Tribe and Idaho Division of Environmental Quality (DEQ). The SCS provided financial support for sample analysis and personnel to help with plot sampling, staking and harvesting. The BIA and DEQ provided financial assistance to purchase and spread the lime. Jack Kauffman, commercial lime applicator from Lake Oswega, Oregon, provided a large spreader truck to apply the lime. Lime from the Nez Perce Tribal Enterprise was delivered to the sites from a quarry on Mission Creek, near Lapwai, Idaho. The tribe also provided personnel to help sample, stake and harvest the plots. The grower cooperators provided a front-end loader to load the lime on the spreader truck. County Extension agricultural agents in the three counties where plots were located assisted in locating plots and keeping in touch with growers as harvest approached and as other operations were needed. Four grower cooperators provided land, crop and equipment for the trials: Dale Silflow, Kendrick; Barry Holben, Genesee; Del Lunders, Reubens; and Leo Greenwalt, Moscow.

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