Lime Effect on Soil Properties

studies made on the effect of massive lime applications on physical properties of five types of Sacramento Valley soils

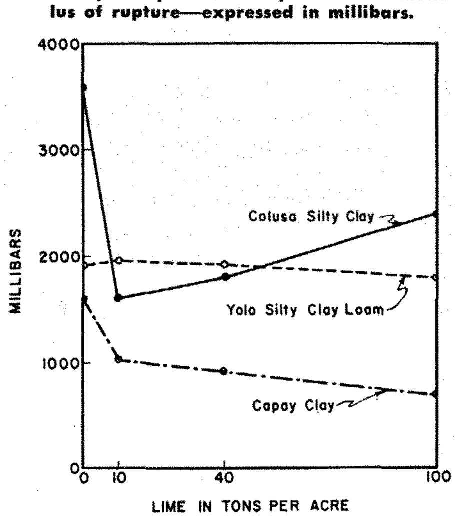
A. L. Brown, T. R. Nielsen, and E. Halevy

By-product lime—from beet sugar refineries—is used frequently in the Central Valley of California, to improve the physical condition of the soil, particularly for seedbed preparation. Lime is commonly applied to acid soils to decrease the acidity but the pH—relative acidity-alkalinity—of most of the Central Valley soils is neutral to slightly alkaline.

The beneficial effects of liming have been observed but experimental data have not been available to substantiate those observations. Consequently greenhouse and laboratory studies were designed to learn whether the beneficial effects on soil physical properties resulting from lime applications can be demonstrated and whether lime applications at the usual rates, or at rates representing the largest conceivable accumulations resulting from current liming practices, cause overliming injury or adverse nutritional effects on plants growing in those soils.

The application of excessive amounts of lime to soils—more than enough to bring them to a neutral reaction—causes adverse nutritional effects on subsequent crops in many areas in humid regions. The so-called overliming injuries are difficult to explain in detail. However, among the commonly listed factors causing reduced yields are: *1.* Minor or trace element deficiencies produced by overliming. The solubilities of iron, manganese, zinc, and copper are known to be reduced as soils become more alkaline. *2.* Phosphorus availability is reduced as soil pH is increased above 6.5. *3.* Boron nutrition of plants is adversely affected by excessive amounts of lime.

The force per square centimeter required to break a specially formed briquet of soil—modulus of rupture—expressed in millibars.



Five representative soils of the Sacramento Valley, which had not been limed previously, were chosen for study: Colusa silty clay, with a pH of 6.3; Yolo silty clay loam, pH 7.2; Yolo silty clay, pH 6.7; Sacramento clay, pH 5.4; and Capay clay, pH 7.0. Samples of each soil were thoroughly mixed with chemically pure calcium carbonate and sugar beet by-product lime at rates of 10, 40, and 100 tons per acre. One set of samples was then placed in 6″ flower pots, watered, and planted to barley. The other set of samples was placed in flower pots and watered repeatedly for a three month period to encourage chemical reaction between lime and soil before barley was planted. The barley was harvested after about six weeks and tomatoes planted.

Observations of the barley and tomato plants, during growth, and yield data showed essentially no effect of lime treatment on plant growth—except those plants in the Yolo soils—at all rates of lime with or without the three month incubation treatment. Phosphate deficiency symptoms appeared on tomato plants in the Yolo soils and yields of both the tomato and barley plants were reduced, except where sugar beet by-product lime was applied.

Phosphorus Content of Sugar Beet By-Product Lime Samples

Sample	Relative age of lime	% phosphorus (acid soluble)
1	24″ depth, 5 yrs. old	0.46
2	Surface, 5–7 yrs. old	0.33
3	New	0.39
4	New	0.42
5	Old	0.64
6	Old	0.25
7	New	0.23
8	New	0.06
9	Old	0.51
10	New	0.38
11	Old	0.54
12	New (1955)	0.51
13	New (1954)	0.46
14	Old	0.13
15	New	0.30
16	Lime used in greenhouse work	0.43
17	Old	0.39
18	New	0.39
19	Old (5 yrs.)	0.49
20	New	0.15
21	Old (15 yrs.)	0.23
22	Old (1950)	0.61
23	New	0.58
	Mean	0.38

Soil analyses indicated that the available phosphorus in the two Yolo soils was low. Consequently a small greenhouse experiment was set up with those two soils which included untreated soil, phosphorus applied as monocalcium phosphate, and phosphorus applied as an impurity in the beet lime. The results obtained confirmed the fact that the growth response in the two Yolo soils was a simple phosphate response.

Following the barley and tomato crops the soils were removed from the pots, air dried, screened, and samples taken for laboratory tests of the modulus of rupture. The modulus of rupture is the force per square centimeter required to break a specially formed briquet of soil. The values, usually expressed in millibars, are correlated with the crusting tendency or hardness of a soil.

The lime markedly reduced the modulus of rupture of the Colusa soil, did not change that of the Yolo silty clay loam, and produced an intermediate effect on the Capay soil. Ten tons of lime per acre were practically as effective as 40 or 100 tons. Results with the Sacramento soil were similar to the Colusa, and the Yolo silty clay behaved like the Capay.

The improvement in physical properties of some soils as measured by decrease in modulus of rupture might well be important under field conditions. Crusting should be less of a problem and the soils

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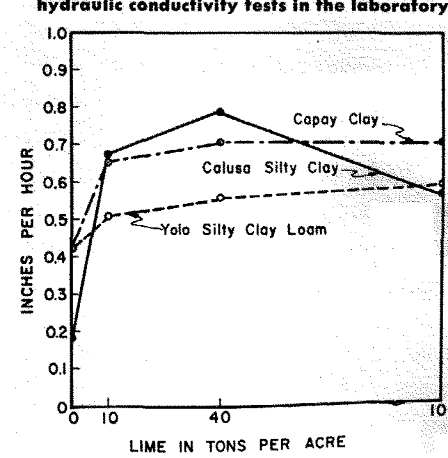
Permeability of three soils as determined by hydraulic conductivity tests in the laboratory.



tions occurred in all treatments including the check but the differences between the treatments did not appear significant.

The heads of Double Dwarf 38 are characteristically tight and compact. In the test field many heads were covered by the dense foliage, which made it almost impossible to apply liquid insecticides thoroughly to the heads. Furthermore, most of the larvae in the field were mature or nearly mature at the time of treating. Many of the larvae were leaving the plants to pupate. This factor alone undoubtedly accounted for much of the difference in numbers of larvae between the pre- and post-treatment counts of the check. The age of the larvae undoubtedly influenced the degree of control, because mature larvae are more tolerant of certain insecticides than are the younger larvae.

Excellent control of the corn earworm was obtained in the RS610 variety with DDT spray and dust—each 98.8%—followed closely by Phosdrin—97.1%—and Thiodan—95%. Guthion with 84.9% and Dylox with 89.1% gave the poorest control. The RS610 variety produces heads on stalks high above the foliage. The heads are loose and not as compact as those of Double Dwarf 38. While a much heavier infestation was in the RS610 field the larvae were mostly immature—first to third instars—at the time of treatment.

From these experiments it appears that DDT is highly effective in reducing numbers of corn earworm larvae in grain sorghum heads. However, spray applications of DDT result in significant residues on the grain at harvest. Although residues on threshed grain were extremely small in the dusted plots, Federal regulation prohibits any residue.

The results of these tests indicate that Phosdrin, Thiodan, and perhaps Dylox are materials that could be substituted for DDT. Dust formulations of these materials were not tested, but it is possible that dusts may prove to be superior to airplane spray applications in penetrating the grain sorghum heads.

To achieve maximum control, fields should be treated while the larvae are small and before extensive feeding damage has occurred in the heads. The presence of small larvae can be detected readily without removing the heads from the plant by jarring the heads over a pan.

Oscar G. Bacon is Associate Professor of Entomology, University of California, Davis.

Raymond Miskus is Laboratory Technician in Entomology, University of California, Berkeley.

Morton D. Morse is Farm Advisor, Butte County, University of California.

Robert L. Sailsbery is Farm Advisor, Glenn County, University of California.

W. D. Riley, Principal Laboratory Technician in Entomology, University of California, Davis, cooperated in the studies reported here.

LIME

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should be more friable and easy to cultivate. Power requirements for tillage should be reduced and seedbed preparation less difficult. No plant differences could be attributed to the changes in physical condition but greenhouse methods minimize the effect of physical condition on yield.

Samples of the same three soils—Colusa silty clay, Yolo silty clay loam, and Capay clay—were tested for hydraulic conductivity by the laboratory method of determining the flow of water through a column of soil to gain information on the permeability of soils. As was the case with modulus of rupture, some soils are affected more favorably than others by the addition of lime. The permeability of a soil is increased by the addition of lime, the first increment of 10 tons per acre being practically as effective as larger amounts. Hydraulic conductivity and modulus of rupture data indicate an improvement in the physical conditions of some soils.

Because the tomato plants showed an increase in growth, which could be attributed to the phosphate, the phosphorus content of 23 samples of sugar beet by-product lime—representing old and new production—was determined chemically.

Sugar beet lime may contain from 0.06% to 0.64% phosphorus or an average of 0.38% phosphorus. An application of 10 tons per acre of sugar beet lime may add to the soil some 12 to 128 pounds of phosphorus per acre or, expressed as phosphorus pentoxide, from 27.5 to 313 pounds per acre. Laboratory and greenhouse studies indicate that this phosphate is readily available.

It is evident that modulus of rupture and permeability of some soils can be improved by lime applications and other soils may be improved only slightly or show no change. At present, there is no test or measurement that can be readily utilized to determine which soils might be changed favorably by lime applications. While increased yields may not result from this improvement, cultivation and seedbed preparations may be somewhat easier. No adverse nutritional effects could be demonstrated.

Sugar beet by-product lime can not be considered a fertilizer and the response obtained in these studies might be nutritional rather than a result of physical improvement of the soil. The percentage of phosphate in sugar beet by-product lime varies—even from the same refinery—and there is no assurance that the lime will always contain a uniform concentration of phosphorus.

A. L. Brown is Specialist in Soils and Plant Nutrition, University of California, Davis.

T. R. Nielsen was Assistant Professor of Soils, University of California, Davis, when these studies were conducted.

E. Halevy was Senior Laboratory Technician in Soils, University of California, Davis, at the time of these studies.

DISTRICTS

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ness of district agricultural production to one or more of the external economic conditions.

Michael F. Brewer is Assistant Professor in Agricultural Economics, University of California, Berkeley.

The foregoing is based on a research project financed in part by the Water Resources Center of the University of California.

ALFALFA

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At such locations growers applied phosphate fertilizers, and yield responses were observed. The survey indicated also alfalfa fields where phosphorus application was not needed. Strip tests with superphosphate were tried in many such fields and—in no case—was a response to fertilization obtained.

Plant analysis shows real promise as a means of evaluating the phosphorus status of alfalfa fields and as a guide for the development of improved fertilization practices.

Samples of alfalfa plants for tissue analysis must be collected at the one-tenth bloom stage—the ideal time for hay harvest—or when one out of 10 plants is in bloom. In spring or fall the plants are in a growth stage comparable to the one-tenth bloom period when the small regrowth shoots, growing up from the plant crown, are $\frac{1}{4}''$–$\frac{1}{2}''$ in length. The soluble phosphate concentration in the midstem tissue will be too high in alfalfa plants sampled before the one-tenth bloom stage and, at more mature stages of growth, the phosphorus readings will be too low. The critical values reported in this article apply only to alfalfa plants in the one-tenth bloom stage of growth.

W. R. Sallee is Farm Advisor, Tulare County, University of California.

Albert Ulrich is Plant Physiologist in Soils and Plant Nutrition, University of California, Berkeley.

W. E. Martin is Extension Soils Specialist, University of California, Davis.

B. A. Krantz is Extension Soils Specialist, University of California, Davis.