Alkali Soil Reclamation Tests

experiments in Tulelake Basin show encouraging improvements in soil after treatment with gypsum

K. G. Baghott, Warren Schoonover, and James Quick

Results in the reclamation of alkali soils in the Tulelake Basin have demonstrated that bad alkali soils can be reclaimed—or improved—by the use of soil correctives, irrigation, and proper drainage.

A recent survey showed that some 2,400 acres of irrigated land in the Tulelake Basin were affected by a severe alkali condition. The survey also disclosed that an additional 2,600 acres of irrigated land were affected to a somewhat lesser degree by an alkali and high salt condition.

A large part of the area affected was homesteaded by veterans in 1949. Previous homesteaders in a nearby area had demonstrated that reclamation could be achieved over a period of years, provided suitable drainage was made possible. The 1949 homesteaders could not afford to wait for a period of up to ten years to grow crops, so they and the United States Bureau of Reclamation asked the University of California to work on the alkali reclamation and other problems peculiar to the Tulelake Basin.

An examination of the affected acres indicated that the soil contained some accumulation of salt—caused by poor drainage—together with a high percentage of sodium saturation on the clay. This was particularly true where slick spots—areas with high accumulations of alkali—existed. All soils proved to be calcareous—containing calcium carbonate—and had an impervious layer at depths of from 18″ to 24″, which without treatment prevented leaching. The soils are of basin deposition, with some peat at the surface, grading rapidly to a light diatomaceous—containing silica—material.

In March 1950, four experimental plots were located in the alkali area to determine the most rapid and economical means of reclaiming the soil. Treatments used consisted of the application of gypsum at the rate of 2, 4, 8, and 16 tons per acre and sulfur at 500, 1,000, and 2,000 pounds per acre. All treatments and checks were leached three times before planting.

The water was very slow in draining away during the first two irrigations but moved relatively rapidly in the 4-, 8-, and 16-ton gypsum applications after the third irrigation. Water penetration rate was considerably slower where the 2-ton gypsum application was made and did not seem to penetrate the check plots or where the sulfur was applied. Finally, the water on the sulfur and check plots evaporated, causing considerable cracking and an even higher accumulation of alkali and salts.

As soon as the plots had dried sufficiently, they were seeded to alfalfa, yellow-blossom sweet clover, alta fescue, tall wheatgrass, and Lemons alkaligrass. The plots were all seeded to a companion crop of oats to obtain shade for the soil to prevent cracking and drying. The oats

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Results of Applications of Gypsum and Sulfur to Alkali Soil in Tulelake Basin

Treatment*	Depth of sample inches	pH (1–5) before[1]	pH (1–5) after[2]	Salinity as conductance (millimhos/cm) before[1]	Salinity as conductance (millimhos/cm) after[2]	Per cent soluble sodium before[1]	Per cent soluble sodium after[2]	Per cent exchangeable sodium before[1]	Per cent exchangeable sodium after[2]
None	0–6	9.1	9.7	1.4	7.7	72	100	16	67
	6–12	9.6	9.7	3.8	6.8	89	100	49	69
2 tons	0–6	10.1	8.5	5.3	2.4	96	18	70	5
gypsum/acre	6–12	10.0	8.4	3.2	2.5	83	15	57	4
4 tons	0–6	9.9	8.5	5.6	1.8	100	11	64	3
gypsum/acre	6–12	9.6	8.6	3.7	1.5	82	19	54	4
8 tons	0–6	10.1	8.7	7.0	0.7	100	10	76	3
gypsum/acre	6–12	9.6	8.8	3.0	1.1	83	17	48	6
1 ton	0–6	9.2	9.1	5.5	4.7	90	74	76	70
sulfur/acre	6–12	9.6	9.0	3.8	3.2	81	80	47	42

[1] Before treatment—sampled March 1950.
[2] After treatment—sampled October 1952 (after 2 growing seasons).
* Treatments made March 1950.

Alkali reclamation tests plots in the Tulelake Basin. In the foreground is the untreated check plot. The plot at the upper left was treated with gypsum at the rate of 2 tons per acre. The plot at the upper right received sulfur at the rate of 500 pounds per acre. Photo taken third season after treatment.

VALENCIA

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on June 23, 1952, were: 1,056, 1,219, 1,654, 1,638, 2,215, 2,027, 1,121, and 1,183 grams for cultures Nos. one to eight. The fruit measurements of the Keen sour orange rootstocks showed: 2.24; 2.29; 2.36; 2.26, on Brazilian sour orange rootstock; 2.35; 2.44; 2.50; and 2.26 inches average diameter for cultures Nos. one to eight.

The illustration of Valencia orange fruit shows a comparison of the fruit sizes obtained in three of the cultures—Nos. one, six, and eight. The two fruits—shown to the left—from culture No. 1, the culture solution of which contained no calcium and high magnesium, averaged 70 grams fresh weight per fruit; the two fruits—center—from culture No. 6, the culture solution of which contained 82 ppm calcium and 144 ppm magnesium, averaged 172 grams fresh weight per fruit; whereas the two fruits—shown to the right—from culture No. 8, the culture solution of which contained high calcium and no magnesium, averaged 64 grams fresh weight per fruit.

The improvement in the root system as calcium in the nutrient solution was increased is seen in the illustration showing the root systems. The depressing effect on the fruit size and on the root condition of very low calcium or magnesium values is clearly shown by the illustrations.

As the calcium in the nutrient solution increased and the magnesium decreased, the fresh weight of the peel as a percentage of the fresh weight of the whole fruit—Keen sour orange rootstocks—shows changes: 35.06; 35.73; 29.24; 30.76, on Brazilian sour orange rootstock; 29.37; 29.92; 27.52; and 29.88% for cultures Nos. one to eight. The fruits from cultures Nos. one and two—those that received a nutrient solution low in calcium and high in magnesium—had the largest percentages of peel, and some of the fruit of culture No. one—no calcium, high magnesium—were somewhat misshapen and the peel pebbly. The fresh weight of the pulp of an average fruit from cultures Nos. one—lowest calcium, highest magnesium—to eight—highest calcium, lowest magnesium—was: 59.5, 59.9, 94.6, 76.8, 81.3, 87.4, 101.5, and 72.2 grams. Except for culture No. 3 and culture No. 8—highest calcium, no magnesium—a decrease in magnesium and an increase in calcium in the nutrient solution was accompanied by an increase in the fresh weight of the fruit pulp.

A. R. C. Haas is Plant Physiologist, University of California, Riverside.

Joseph N. Brusca is Senior Laboratory Technician, University of California, Riverside.

The above progress report is based on Research Project No. 1086.

ALKALI

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in several plots failed to germinate, but where the crop did germinate and come through the soil, it usually died before making but a slight growth.

Of the plants mentioned, yellow-blossom sweet clover, tall wheatgrass, and Lemons alkaligrass proved the most rapid in obtaining stands. The alfalfa and alta fescue—although somewhat slower in starting—eventually did a better job of growing than the others, the one exception being tall wheatgrass.

The first year, spotty stands of all five named plants were obtained on the 4-, 8-, and 16-ton gypsum plots. A sparse selection of plants appeared on the 2-ton gypsum plot and no plants germinated on the sulfur or check plots. The first year the plots were watered nine times and by the end of the season the rate of water penetration in the 4-, 8-, and 16-ton gypsum plots was very rapid and the rate of the 2-ton gypsum plot had increased appreciably. The sulfur and check plots had only a very slow water penetration rate, resulting in increased evaporation losses.

During the second season, the plots were all reseeded to Ladak alfalfa. Excellent stands were obtained in all gypsum-treated plots, but a stand could apparently not be obtained in the sulfur or check plots. Although the growth was slower in the 2-ton gypsum plot, a good stand was obtained, and during the third year the alfalfa growth on the 2-ton gypsum plots was as vigorous as the others. But even after three years of leaching on seven different plots, the sulfur applications up to 3,000 pounds per acre show no appreciable benefit. Gypsum and sulfuric acid appear to be much more economical than sulfur.

Field tests indicate that slick spots will respond more rapidly to applications of sulfuric acid than to equivalent amounts of calcium applied in the form of gypsum. Slick spots should be diked and leached several times prior to planting; otherwise, suitable forage-type cover cannot be obtained.

The table on page 10 shows results of the applications of gypsum and soil sulfur. Two growing seasons occurred between the tests. The figures show that the pH—relative acidity-alkalinity—was reduced considerably by the gypsum applications, and subsequent leaching of the salts is shown by the reduction of conductance values. This is particularly true in the 4- and 8-ton gypsum treatments and to a lesser degree in the 2-ton gypsum application.

On the check plots the salinity increased. This was apparently due to the accumulation of salts from the evaporated irrigation water. All gypsum treatments reduced the per cent soluble and exchangeable sodium, while the untreated plots showed evidence of the per cent sodium increasing.

Little effective reclamation was accomplished by the sulfur treatment. The pH values were lowered very slightly and the salinity reduced a little. No reduction was observed in either the exchangeable or soluble sodium of the soil. Practically no plant growth was obtained, even after three seasons on plots receiving the sulfur treatment, as shown in the illustration on page 10.

The tabulated figures are merely an indication of reclamation. In no instance has reclamation been possible in one year. Generally, at least two years are needed, and on the worst alkali soils, up to five or six years may be needed. Reclamation is only possible if there are adequate drains so that the salts can be removed by leaching.

K. G. Baghott is Farm Advisor, Siskiyou County, University of California.

Warren Schoonover is Extension Soils Specialist, University of California, Berkeley.

James Quick is Senior Laboratory Technician, University of California, Berkeley.

SULFUR

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less manganese deficiency symptoms on the leaves where sulfur has been added, but again this difference is of doubtful commercial importance.

Fruit Production

The final measure of any possible benefit from such treatments, as applied in these experiments, is their influence on yields. The tabulated yields—in four-year periods—show that the acidification of the soil by the use of sulfur in these experiments had no effect on fruit production.

Sulfur has other agricultural uses—such as in the reclamation of alkali soils—but where other nutrients are not limiting and where soil structure has not been greatly affected, the use of sulfur to increase soil acidity has been of no benefit in these experiments.

Winston W. Jones is Horticulturist, University of California, Riverside.

Clarence B. Cree is Principal Laboratory Technician, University of California, Riverside.

The above progress report is based on Research Project No. 594.