Alkali Soil Reclamation

most carbon dioxide added to irrigation water is lost into atmosphere and as reclaiming agent

Warren R. Schoonover and J. C. Martin

Use of carbon dioxide in irrigation water had no significant effect toward the reclamation of black alkali soil in the cases of two Tulare County irrigation systems studied.

Many alkali soils can be reclaimed merely through the use of sufficient water under conditions of good drainage. Other soils require some type of treatment which will effectively supply soluble calcium to replace the sodium combined with the clay.

Alkali soils have one or both of two different chemical characteristics. The so-called white alkali soils contain only soluble salts—of a type which can be washed out readily—but the black alkali soils contain sodium combined with the clay which produces sodium carbonate. This type of alkali dissolves organic matter, yielding dark colored solutions which give these soils their name.

It is difficult and sometimes impossible to wash black alkali from the soil. The remedy is to make available some soluble calcium which will replace the sodium attached to the clay or which will neutralize the sodium carbonate.

Many alkali soils have been reclaimed through the effects of carbon dioxide, a theoretically cheap source of acid. However, acids are effective in reclaiming alkali soils only to the extent that they make calcium or magnesium—or both—available by dissolving it from insoluble sources usually present in alkali soils.

If plants—of any kind—can be induced to grow on an alkali spot, reclamation will start, provided the soil contains a source of calcium. The roots of the plants give off carbon dioxide which dissolves in the soil moisture and brings some calcium into solution. This calcium replaces sodium, leaving it in a soluble form which can be leached from the soil provided the drainage is adequate. Thousands of acres have been reclaimed by such a natural process.

The tops of a green manure crop—which are turned under—are of some benefit but most of the carbon dioxide produced by decay processes in the surface soil is lost to the atmosphere and is without effect. However, most of that produced deep in the soil through the decay of roots can be captured and is effective for alkali soil reclamation. The roots of a good cover crop might easily contain 1,000 or more pounds of carbon per acre. The carbon dioxide produced from this amount of carbon has a potential acidity equivalent to more than 2,700 pounds of sulfur or nearly four tons of sulfuric acid.

Because of the great power of carbon dioxide produced by roots and by decaying organic matter attempts have been made to introduce carbon dioxide into alkali soils by other procedures. One procedure has been to take exhaust gases—predominantly, carbon dioxide—from engines or from the burning of natural gas or diesel fuel through some

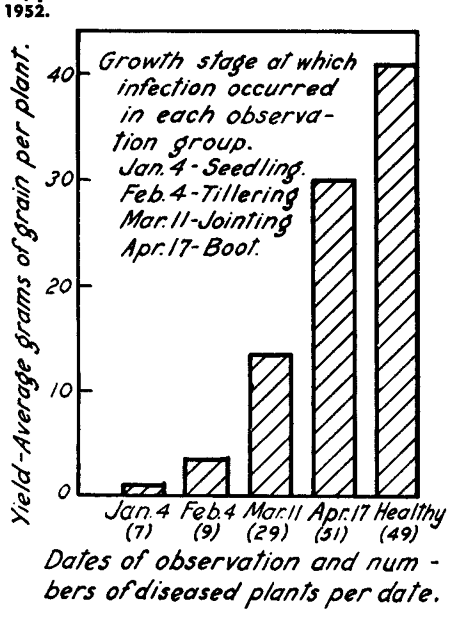
Concluded on page 14

---

stages of growth but as heading occurs there is considerable recovery.

The oat varieties, California Red and Coast Black, and the barleys, Tennessee Winter, and Club Mariout rate as extremely susceptible. When infected in the seedling stage these varieties are so severely dwarfed—often by three quarters—that they rarely produce heads.

Correlation between growth stage of the plant when infected with yellow dwarf and ultimate yield of grain of the barley variety, Atlas 46, planted November 1951 and harvested June 1952.



Field observations indicate that the three most common California wheat varieties—Baart 46, White Federation 38, and Ramona 50—are highly susceptible. Sonora 37 appears to be most tolerant of the California wheats.

Effect on Yield

The three principal California barley varieties, Atlas 46, California Mariout and Club Mariout were planted experimentally in November 1951. Yellow dwarf was uniformly distributed by January to the extent of 3% to 4%. By February the incidence had increased to 15%, by mid-March to 23%, and by April 17 to 50%.

Plants of each variety were grouped at harvest according to the date the disease was first observed. Composite samples were threshed and the average weight in grams of grain per plant was calculated for each variety for each observation date.

There was a direct correlation between time of infection and ultimate yield of barley. Grain yields of all three varieties when infected in the seedling stage were reduced over 95%. Yields of Atlas 46 and California Mariout when infected at jointing were cut by approximately 70% and that of the more susceptible Club Mariout over 90%. With late infection in the heading stage all showed approximately the same order of reduction—15% to 25%.

To determine the effect of seedling infection on wheat yields, 24 plants of each of three varieties, Baart 38, White Federation 38 and Ramona 50 were inoculated in the greenhouse and transplanted to the field. A comparable number of non-inoculated checks were put out at the same time. Yields in grams of grain per plant were as follows: Baart 38, 6.6 grams per healthy plant, 0.8 grams per diseased plant; White Federation 38, 9.0 grams as against 0.7 grams; and Ramona 50, 6.1 grams as against 1.2 grams.

John W. Oswald is Associate Professor of Plant Pathology, University of California, Davis.

Byron R. Houston is Associate Professor of Plant Pathology, University of California, Davis.

C. W. Schaller, Assistant Professor of Agronomy, University of California, Davis, co-operated.

SORTER

Continued from page 8

wear was discernible at the end of the test.

Because lemon damage prior to storage is reflected in high storage losses through rot and mildew the possibility of mechanical injury to the fruit in the photoelectric sorter was evaluated by a standard dye test and by a storage test.

In the dye test, fruit is immersed in a special dye solution which adheres only to those parts of the fruit from which oil has been expressed by bruising or abrasion. Several lemons of each color class were subjected to this test after they had been run through the machine 25 times. No damage was discerned by a trained observer.

The storage test was performed in a packing house where, customarily, the fruit was sorted into four color categories—Yellow, Silver, Light Green, and Dark Green. Accordingly the machine was adjusted to duplicate this procedure and fruit from eight different orchards was sorted and stored with samples of hand-sorted fruit from the same lots. The boxes were inter-stacked to ensure identical storage conditions. At the end of the standard storage period, the fruit was carefully inspected by a fruit physiologist to determine the percentage affected by rot or mildew. There was no significant difference in spoilage between the machine-sorted and the hand-sorted fruit.

Sorting Accuracy

As a part of the storage test the machine-sorted and the hand-sorted lemons that had failed to reach full maturity during the storage period were counted. In each case, the quantity of immature fruit was less than 0.02% of the total—a commercially insignificant fraction.

A further test was performed to determine the consistency with which the machine would place a particular lemon in a given color category. Sixteen fruits—representing approximately equal gradations in the total color range—were selected by visual comparison. This fruit was machine-sorted 25 times. From a practical standpoint, the precision of measurement was approximately equal to that attained in manual sorting.

Because the accuracy of manual sorting is adequate for commercial purposes, it is questionable that even a minor investment in apparatus would be justified solely on the basis of increased precision. The real problem is one of reducing labor costs to a minimum while maintaining the approximate accuracy level of hand sorting.

Color sorting of lemons is one of a sequence of operations—picking, loading, hauling, unloading, dumping, washing, culling, waxing, color sorting, and storage—and if one is interrupted for a protracted period, all of them must cease.

Lemon-sorting apparatus—with an annual use factor of about 30%—would have far greater utilization than most agricultural machines. Therefore, low operating expense rather than low first cost is the important consideration.

It might be practicable to construct a machine to handle the flow of fruit received at a packing house—usually at the rate of about 40 lemons per second—but the advisability of this procedure would be questionable. It would seem better to divide the flow among two or more machines so that a temporary failure of one would not interrupt the operation of the entire receiving line.

A sorting rate of 4 to 5 lemons per second was used in the experimental photoelectric sorter, although it may become commercially necessary to increase the capacity of the machine.

J. B. Powers is Lecturer in Agricultural Engineering, University of California, Davis.

J. T. Gunn is Assistant Specialist in Agricultural Engineering, University of California, Davis.

F. C. Jacob is Assistant Specialist in Agricultural Engineering, University of California, Davis.

ALKALI

Continued from page 7

sort of a venturi tube by means of which the gases are introduced into the irrigation water.

Carbon dioxide can be dissolved in water and some of it will form carbonic acid which is capable of bringing calcium from the soil into solution as calcium bicarbonate. Carbonic acid produced from carbon dioxide in this manner would be a cheap source of acid—if it could be captured and gotten into the soil. One gallon of diesel oil which costs about 10¢ contains about six pounds of carbon. This quantity has an acid producing potential equivalent to 16 pounds of sulfur, costing about 40¢, or equivalent to about 50 pounds of concentrated sulfuric acid, costing about 85¢.

A laboratory experiment was set up to test the effectiveness of carbon dioxide charged water in reclaiming a Fresno fine sandy loam alkali soil. A one-to-five equilibrium water extract was made with water containing 72 ppm—parts per million—of dissolved carbon dioxide.

The net result of the laboratory test was to bring into solution, calcium and magnesium—in excess of that dissolved by untreated water—equivalent to ¾ of a ton of gypsum per acre foot of soil. If such a result could be accomplished in the field, the operation would be economical.

The concentration of 72 ppm of carbon dioxide in an acre foot of water—from exhaust gases of diesel oil, for example—could be achieved only if all the carbon dioxide, possible of production from the carbon in about 10 gallons of diesel oil were captured in solution. However that would be extremely difficult to accomplish because carbon dioxide is a gas which dissolves freely in water only under pressure. The amount of carbon dioxide retained in water flowing in a ditch is very small.

To test the efficiency of introducing carbon dioxide from oil burners into irrigation water, experiments were conducted with water from two wells in Tulare County. In one experiment exhaust gases from diesel fuel burned at the rate of 1.75 gallons per hour were introduced into a stream of water pumped from a well at the rate of 850 gallons per minute. The fuel used should have produced enough carbon dioxide to supply 100 ppm in the water. In a second—and parallel—experiment the fuel burning rate was three gallons per hour and the pumping rate was 1,900 gallons per minute, which should give a carbon dioxide concentration of about 70 ppm.

Water samples were taken at both pumps before and after treatment, and at various distances from the pumps in the distribution ditches. Chemical analyses indicated that from 10% to 20% of the possible carbon dioxide from the fuel was absorbed on various days at Well No. 1 and about 30% at Well No. 2. In both cases, approximately half of the carbon dioxide which was absorbed at the point of treatment merely changed sodium carbonate in the water to sodium bicarbonate. Such a change is of minor importance for improving the quality of the water.

The pH—relative acidity-alkalinity—of the water was reduced, in Well No. 1 from 8.4 to 7.3 and in Well No. 2 from 8.2 to 7.1—still slightly alkaline, but because the pH of water is usually changed easily, no importance is attached to this downward shift. Such a shift results from changing the carbonate to bicarbonate but when the soil irrigated with this water dries out there is a tendency for the bicarbonate to be converted back to the carbonate. The so-called sodium percentage, which is an important criterion in judging water quality, is unchanged.

The remaining carbon dioxide dissolved in the water could bring calcium or magnesium—or both—into solution if it were still present as the water enters the soil. However, as the water flowed along in the ditch, the carbon dioxide was gradually lost to the at-