Acidification of California Soils

many pumped irrigation waters of State require large additions of acid to add appreciable amount to soil

L. D. Doneen

Making soil acid—acidification—by adding acid to the irrigation water has been advocated as a means of controlling potato scab; for neutralizing highly alkaline soils; the reclamation of saline soils; and the improvement of penetrability of water into the soil.

Large additions of acid would be required before the water is acid enough to add an appreciable amount to the soil.

Many of the waters pumped from California wells contain various quantities of salts which act as compounds that resist changes in the measurable acidity and alkalinity—the pH—of the water and are known as buffers.

Distilled water will absorb carbon dioxide from the atmosphere until an equilibrium—a balance or saturation—is reached according to the temperature and concentration of carbon dioxide in the air. As 0.5% of the carbon dioxide will form carbonic acid, distilled water is usually acid, with a pH between seven and six—pH7 is neutral—below this figure is acid and above alkaline.

Most of the pumped waters of California are alkaline with an equilibrium pH which falls between 7.5 and 8.5.

Sulfuric Acid

Sulfuric acid or any other strong acid added to water will increase the acidity of the water 10 times with each additional pH lowered. For example the pounds of sulfuric acid required to reduce neutral distilled water—pH7—to a lower pH is given in the accompanying table.

Reduction of neutral distilled water	Lbs. acid per acre foot water
pH to pH	
7 to 6 requires..........	.13
7 to 5 requires..........	1.30
7 to 4 requires..........	13.00
7 to 3 requires..........	130.00
7 to 2 requires..........	1300.00
7 to 1 requires..........	13000.00

The table indicates it will be necessary to keep the irrigation water in the lower ranges of pH to apply large quantities of acid to the soil through this medium.

Sulfuric acid is stable in water and atmospheric conditions have little or no influence on it, as compared to carbonic acid. This is a theoretical consideration, as most well waters contain a considerable amount of calcium, magnesium, and sodium carbonates and bicarbonates which act as buffers, and neutralize the acid. Assuming the water contains calcium carbonate and calcium bicarbonate—a form of soluble lime—the sulfuric acid will be neutralized by these carbonates—lime. The resulting product of this neutralization is calcium sulfate or gypsum water and carbon dioxide. The gypsum formed is a neutral salt and will not affect the pH.

The increased carbon dioxide will temporarily increase the carbonic acid, but with dissipation of the carbon dioxide to the atmosphere equilibrium will be reestablished and the pH of the water will not be lowered to any great extent. For each pound of sulfuric acid added there will be obtained about 1¾ pounds of gypsum until the carbonates of the water are all consumed. This usually occurs at about pH5. At this pH there is available 1.3 pounds of acid per acre foot of water regardless of the large quantity of acid applied to the water. This reaction would be similar for magnesium or sodium carbonates.

The buffering capacity of a water—the action of the buffer compounds—is approximately equivalent to its carbonate and bicarbonate content. For each milligram equivalent of bicarbonate it will require approximately 136 pounds of pure sulfuric acid per acre foot of water.

Most of the well water in California will have a carbonate content from one to eight milligram equivalents, with a few saline waters going much higher. The bulk of irrigation waters from wells will contain from two to five milligram equivalents of carbonate. This will require from 272 to 680 pounds of sulfuric acid to neutralize the carbonates in an acre foot of water.

The concentration of calcium—or magnesium or sodium—does not change but merely shifts from a carbonate to a sulfate form. As the sulfate is a heavier radical than carbonate and gypsum contains two molecules of water, the actual weight of gypsum is greater than the acid added. After the above reaction with acid has taken place the water has not been improved by bringing more calcium and magnesium into solution unless sufficient acid is added to reduce the pH below five so that the acid will be in solution to react with the carbonates in the soil and produce gypsum. Below pH5 the lowering of pH will be in accordance with the above table, as there will be little if any buffering of the acid in these lower ranges of pH.

Sulfur Dioxide

Sulfurous acid is produced by dissolving sulfur dioxide in water, and it is known only in solution.

The reactions in irrigation water with carbonates are similar to those of sulfuric acid. The molecular weight is less, and it requires only 111 pounds of sulfurous acid to the acre foot of water to neutralize one milligram equivalent of carbonate.

When sulfur dioxide is introduced in water from cylinders, it will require one pound to produce 1.28 pounds of sulfurous acid. Hence it would require about 87 pounds of sulfur dioxide to neutralize one milligram equivalent of carbonate.

Another source of sulfur dioxide is from the exhaust of diesel engines burning fuel high in sulfur. The maximum sulfur content of fuel oils is 1.5% but many fuel oils do not contain any appreciable quantity of sulfur.

A 100-horsepower diesel engine under full load will burn approximately 50 pounds of oil per hour. Assuming the oil contains the maximum of sulfur, 1.5%, and all of it is converted to sulfur dioxide and to sulfurous acid in the irrigation water, then the 0.75 pound of sulfur consumed in an hour would produce 1.92 pounds of sulfurous acid. If the engine pumps 2.5 cubic feet of water per second—1,175 gallons per minute—the acid produced per acre foot of water would be 9.2 pounds. This is about one twelfth the quantity of acid required to neutralize one milligram equivalent of carbonate.

Carbon Dioxide

Carbonic acid is known only in solution. It is formed by dissolving carbon dioxide in water. About 0.5% of the dissolved gas forms carbonic acid either in an ionized or in an un-ionized form. As this is considered a weak acid, much of it is in the un-ionized form.

Assuming a temperature of 68° F and an atmospheric content of .03% of car-

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CHICKENS

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The houses need to be cooled when the air temperature reaches 90° F if egg production is to be maintained and to prevent losses. Birds kept on wire are more susceptible to high air temperature than birds kept on the floor. Commercial poultry raisers cool their houses by using roof sprinklers. A mist spray is also used by some growers inside the house. This is for the purpose of cooling by evaporation. The efficiency of the cooling is increased by air movement.

Trials were conducted at Davis and in the Imperial Valley with evaporative coolers. It was found that the house could be effectively cooled by this method. The hens were more comfortable; laid a few more eggs than did hens in the uncooled houses. The expense of buying and operation should be paid for by increase in the number of eggs and/or the number of birds kept alive. In some years at Davis the expense seemed to be justified while in other years it did not.

The spray method of cooling poultry houses is to be recommended instead of the use of evaporative coolers. Further investigation is needed before unqualified recommendations can be made.

Wilbor O. Wilson is Assistant Professor of Poultry Husbandry and Assistant Poultry Husbandman in the Experiment Station, Davis.

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The experiments with evaporative coolers were conducted by Professor V. S. Asmundson of Poultry Husbandry, Davis, and J. R. Tavernetti, Associate Agricultural Engineer in the Experiment Station, Davis.

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which fail to set is complete. A delay in thinning of only a week to 10 days will reduce the increase in berry size a third or more.

Berry thinning must usually accompany the girdling of Thompson Seedless to avoid overcompactness of cluster. With the great increase in size of berry on girdled Thompson Seedless vines, clusters of 200 to 250 berries are large enough.

Cluster thinning consists in the removal of cluster after bloom—after the berries have set. It does not influence the number of berries on the retained clusters but does improve quality through greater uniformity of size and better coloring. Therefore it is useful on varieties that set well-filled clusters, such as Emperor, Malaga on light soils, and Rish Baba.

Irregular, oversized, and undersized clusters should be removed in order to produce uniform, nicely shaped, properly matured clusters.

The thinning should be carried out as soon as the berries have set—seven to 10 days after full bloom. The time of thinning is especially important in order to obtain the largest possible increase in the size of berry.

Under certain conditions Ribier may require only cluster thinning. Where Emperor produces clusters with long, straggly tips these should be cut off, which would be berry thinning. On some soils Emperor may set clusters that are too loose, and flower-cluster thinning would be appropriate.

Careful observation from year to year, however, should enable any grower to select the proper method of thinning. When the proper method of thinning is carried out skillfully, it not only improves quality, but actually increases the marketable crop.

Girdling

Girdling consists in removing a complete ring of bark about three-sixteenth inch wide from the trunk, arm or cane below the fruit it is intended to affect. As a result, the carbohydrates elaborated in the leaves will accumulate in the parts above the girdle, including the fruit, and will influence its development.

The effects to be achieved by girdling determine the time of girdling. Thus, if the girdling is to increase size of berry of Thompson Seedless, it must be done when the berries are beginning to grow most rapidly—one-eighth to three-sixteenth inches in diameter. If it is to hasten coloring and maturing it must be done at the beginning of ripening.

Properly timed and executed girdling accompanied by proper thinning has regularly increased the size of Thompson Seedless berries from 50% to 100%.

The berry size of seeded varieties such as Ribier and Malaga is influenced very little by girdling. The coloring of Red Malaga and Ribier can usually be hastened by girdling when the color first appears. The rate of ripening of most seeded varieties may be accelerated.

In the early producing sections the advance in coloring and maturity of Ribier and Red Malaga may be of great value. The girdling of these varieties is of questionable value elsewhere, since the color and maturity are normally advanced only a few days.

To obtain the best results, the vines must be carrying relatively light crops—not as heavy as girdled Thompson Seedless in the same area. A girdled Thompson Seedless vineyard should not carry more than two-thirds as much fruit as would be brought to normal maturity without girdling.

A. J. Winkler is Professor of Viticulture and Viticulturist in the Experiment Station, Davis.

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bon dioxide—and complete ionization of the carbonic acid—distilled water would have a pH of approximately 6.7. As it requires only .13 of a pound of sulfuric acid to change an acre foot of distilled water from pH of seven to six, the concentration of carbonic acid in distilled water under atmospheric conditions is extremely small.

If the atmosphere or the gas surrounding the water is made up entirely of carbon dioxide, then solubility of the gas will be much greater. At 68° F, 1,000 grams—2.2 pounds—of water will contain 1.688 grams—.17%—of carbon dioxide and with complete ionization of the carbonic acid it would reduce the pH to approximately 4.3. As ionization is not complete, it is questionable whether pH would be reduced below five.

The principal buffers in most of the California irrigation waters pumped from wells are the carbonate salts of calcium, magnesium and sodium. An equilibrium or balance is established between the carbonate, the bicarbonate of these salts, carbonic acid, and the carbon dioxide of the air. As these bases—calcium, magnesium and sodium—are strong and the carbonates are weak acids, the irrigation waters are usually alkaline with an equilibrium pH value between 7.5 and 8.5.

The addition of carbon dioxide by saturating the air in or around the water will increase the carbonic acid content and lower the pH of the water but it is necessary to maintain the carbon dioxide atmosphere over the water or the pH will gradually rise to its original value and in equilibrium with the carbon dioxide of the air.

A water in equilibrium with an atmosphere of 12% carbon dioxide will form sufficient carbonic acid to reduce the pH from one to 1½ units provided the water is near neutral and nearly complete ionization occurs. This represents less than one pound of free carbonic acid per acre foot of water.

High concentrations of acid in the irrigation water will be deleterious to concrete pipe and corrosive to irrigation equipment. Even though the water has sufficient buffering capacity to neutralize the acid, the temporary acidity will be sufficient to ruin irrigation equipment. It is good judgment not to add any acids or acid forming materials to water that will be run through irrigation equipment.

The above discussion indicates that with the high buffering capacity in many California irrigation waters, large additions of acid will be required before the water is acid enough to add an appreciable amount to the soil.

L. D. Doneen is Associate Irrigation Agronomist in the Experiment Station, Davis.