4. AMENDMENTS

Amendments are used for 2 main reasons:

1. Reduction of soil alkalinity

Soils with ESP values greater than 15 are classified as alkali soils and amendments should be applied to such soils. For grapes and tree crops, ESP levels should be below 10 (probably below 5 for some species) and amendments should be applied to maintain ESP below these levels.

2. Improvement in water penetration

Impaired water penetration can be caused by low salt water or by water having an unfavorable ratio of sodium and bicarbonate to calcium and magnesium (see Chapter 1). It must be remembered that poor water penetration can be caused by compacted soil, restrictive soil layers and soil crusting, all of which will be better remedied by mechanical means (ripping, harrowing) than by amendments. An actual need for amendments should exist before they are applied.

Amendment exert their benefit by increasing soluble calcium levels in the soil. Soluble calcium replaces sodium on the ex- change complex and provides for a looser, more friable soil (sodium tightens soils, calcium loosens soils). A reduction of sodium, by definition, means a reduction in soil alkalinity. Amendments fall into 2 broad categories.

A. Amendments containing calcium directly; this includes:

1. **Gymsum** (calcium sulfate) the most widely used soil amendment.
2. **Lime** (calcium carbonate) which is only an effective amendment if the soil is acid, since lime is only soluble in acid soils.
3. **Calcium polysulfide** or lime sulfur - primarily an acidifying amendment (see following).

B. Acidifying amendments that release calcium from lime (calcium carbonate)

In order for acidifying amendments to be effective, there must be lime in the soil - Acidifying amendments include:

1. **Sulfur** - sulfur is biologically converted in the soil to sulfuric acid; 1 ton of sulfur produces approximately 3.2 tons of sulfuric acid.
2. **Sulfuric acid**
3. **Sulfur dioxide (SO_2)** - usually added by burning sulfur to release SO_2 which is mixed with water to form sulfurous and sulfuric acid.
4. **Polysulfides** - the polysulfides are liquids and contain un- oxidized sulfur in the sulfide form. This sulfur is biologically converted to sulfuric acid. There are 2 polysulfide amendments in commercial use:

a) **Calcium potysulfide (CaS_5),** also called lime sulfur. 100 Ibs of this material will

produce 68 Ibs. of sulfuric acid. The calcium in the material is of direct benefit.

b) **Ammonium polysulfide $(NH_4)_2S_X$** - also called Nitro-Sul. The ammonium in the material also acts as an acidifying amendment (as well as nitrogen fertilizer); 100 Ibs of material will produce the equivalent of about 240 Ibs of sulfuric acid.

5. **Ammonium Thiosulfate $(NH4)_2S_2O_3$** - also called Thio-Sul (a liquid). The partially oxidized thiosulfate form of sulfur is biologically converted to sulfuric acid. The ammonium also acts as an acidifying amendment. 100 Ibs of material will produce the equivalent of 102 Ibs. of sulfuric acid.

Choice of Amendments for Reducing Soil Alkalinity

For reducing soil alkalinity, large amounts of amendments are needed, and either gypsum or sulfur, or in some cases sulfuric acid is used. A comparison of these 3 materials is given below:

Amendment	Tons required to equal 10 tons of 60% gypsum
60% gypsum	10
Sulfur	1.1
Sulfuric Acid	3.5

To determine the most economical amendment to apply, the costs of each must be known. Gypsum and sulfur are easily more economical than sulfuric acid on an equivalent cost basis, however sulfuric acid can out perform other amendments in the field. Gypsum is the most widely used amendment. Sulfur has the disadvantage of not being immediately active since it must undergo biological conversion to sulfuric acid. The rate of conversion depends on soil moisture and temperature and could take anywhere from a few weeks to over a year.

Sulfuric acid, although more expensive, has given excellent results in many situations and in test situations it has out performed both gypsum and sulfur on an amendment equivalent basis. Sulfuric acid goes to work immediately and it may be that its quick action on lime results in a larger percentage of lime being converted to gypsum (bicarbonate intermediates may not be allowed to react with the acid). Sulfuric acid has the disadvantage of being a hazardous material to apply.

Choice of Amendments for Improving Water Penetration

For the improvement of water penetration it should be kept in mind that many acid soils can have water penetration problems and that acidifying amendments are of no value on acid soils. Acidifying amendments are only effective if there is lime in the soil and can actually aggravate penetration problems on acid soils.

Lime is an excellent and economical amendment choice for improving water penetration of acid soils; 1 ton of lime has the amendment equivalent of 3 tons of 60% gypsum.

When it is desired to add amendments to the water, the choice is pretty well limited to the liquid acidifying amendments and SO_2 because of the low solubility of gypsum (and the virtual insolubility of lime). Gypsum can be added to water but it must be metered slowly and mixed thoroughly; few people are successfully adding gypsum to water.

When adding acidifying amendments to water, care should be taken not to allow the pH to drop much below 6.5 to prevent damage to irrigation lines and equipment. Neutralizing half the bicarbonate in a given water will usually drop the pH to the 6.5 range. It takes roughly 135 Ibs of sulfuric acid (or 45 Ibs of sulfur, burned to give SO_2) per acre foot of water to reduce the bicarbonate (or carbonate) concentration of a given water by 1 meq/l. For each meq/l that the bicarbonate content is lowered, Batons Gyp. Req. (see Chapter 1) is reduced by 164 Ibs.

Other amendments (e.g., lime sulfur) can have a corrosion hazard independent of acidity. Before running a given amendment through an irrigation system a knowledge of it's corrosion hazard should be obtained.

When water penetration problems occur on an acid soil, it is un- wise to add acidifying amendments to the water **unless** lime is first added to the soil. This combination - lime on the soil, acidifying amendments in the water - has been successfully used on acid soils and will probably see more use in the future. On neutral soils irrigated with a water that has a high pH_c (dissolves lime), lime is also a satisfactory amendment choice (for soil application).

The simultaneous addition of NH_3 and sulfuric acid to irrigation water has been successfully used in Arizona. Essentially ammonium sulfate is formed and the corrosion hazard of the acid is neutralized by the NH_3 ; volatilization loss of NH_3 is minimized or eliminated by the sulfuric acid. Proper metering and placement is important when using NH_3 with sulfuric acid but the method holds promise for those that attempt it in a diligent manner.

SO_2 generators have gained widespread popularity in the southern San Joaquín Valley of California in recent years and have been effective in improving water penetration. With both SO_2 and sulfuric acid, the amount that can be safely added (without excessive acidification of the water) is determined by the bicarbonate content of the water source - the higher the bicarbonate content, the more acid can be safely added.

Calcium nitrate - combination fertilizer and amendment

The amendment properties of calcium nitrate should be kept in mind when planning a fertilizer program for a crop on which water penetration is problem. Calcium nitrate contains 20% calcium and is an extremely soluble material. It is approximately 500 times more soluble than gypsum and because of this high solubility, 1 Ib of calcium from calcium nitrate is probably worth more than a pound of calcium from gypsum. Calcium nitrate is another weapon in the amendment arsenal of the fieldman. (Calcium ammonium nitrate, a liquid, is also available and can be a useful material).

Chemicals used in pest, disease and weed control that can also be amendments

There are three sulfur materials used in pest, disease and weed control that can also act as amendments. They are:

1. **Elemental sulfur**

   An old standby for mite and insect control is gaining renew- ed interest in some areas. On grapes, sulfur has been regularly used for mildew control for years.

2. **Lime sulfur**

   A widely used material for scale control at the turn of the century and also effective as a fungicide. Still recommended and used in some areas as both an insecticide and a fungicide.

3. **Sulfuric acid**

   Used for weed control; can be the best choice for weed control of certain crops, such as onions. Application is hazardous but there are, custom applicators that specialize in sulfuric acid application for weed control.

On calcareous soils where amendments can be beneficial, efforts should be made to integrate the above materials into the total farm management program. Because all of the above materials are acidifying, they will have the optimum amendment effect on calcareous soils. On non-calcareous soils they should be used with caution or used in conjunction with lime application to the soil to guard against excess soil acidity.

General References

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3. Branson, R.L. and M. Fireman. **Gypsum and other suitable amendments for soil improvement.** Univ. of Calif. Ext. Leaflet 2149, March 1980.