



Foliar Deposits and Stains from Irrigation Water¹

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Ground water used for irrigation often contains dissolved materials that can precipitate and create management problems with microirrigation or sprinkler irrigation systems that deliver water over the tops of plants. Particularly common is the precipitation of calcium and magnesium associated with ground water that comes from limestone deposits below the earth's surface. Limestone contains calcium and magnesium carbonates that are dissolved in association with carbon dioxide to produce bicarbonates (Johnson, 1972). An increase in pH or temperature, or reduction in pressure results in loss of carbon dioxide as a gas from bicarbonate in water. Consequently the calcium and magnesium precipitate with remaining carbonates. When ground water is pumped to the surface and discharged through an irrigation system, the temperature, pressure, and pH of the water often change. This can result in the precipitation of calcium or magnesium carbonates or other minerals to form scale on the inside surfaces of irrigation components (Pitts, et al. 1989). When overhead (sprinkler) irrigation is used, calcium and magnesium carbonates in the water can result in white scale-like deposits on plant foliage that decrease the quality of plant material (see Figure 1). A simple test for identifying carbonate scale is to dissolve it using vinegar. Carbonate minerals

dissolve and release carbon dioxide gas with a fizzing, hissing sound known as effervescence. In addition to scale-like deposits on foliage and irrigation components, irrigating with carbonate-laden water can result in an increased pH of the substrate.

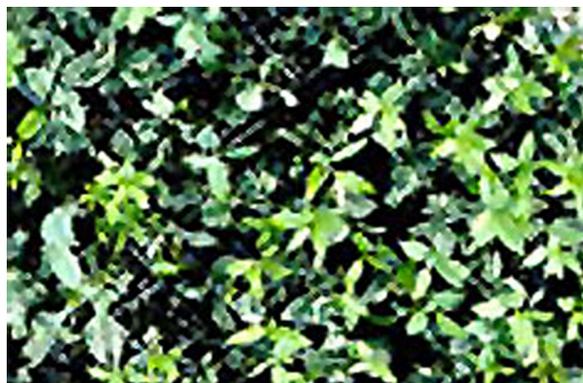


Figure 1. White Scale-Like Deposits on Plant Foliage

The terms "hardness" and "alkalinity" are often used to refer to the concentration of carbonates in water, although the two terms are not always synonymous. Hardness can be the result of carbonates or noncarbonates. Calcium and magnesium usually compose the carbonate hardness, while calcium sulfates or chlorides may compose the noncarbonate hardness (Johnson, 1972). For irrigation water, we assume that most of the calcium

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and magnesium is in the carbonate form, thus a measurement of the calcium and magnesium content is used to estimate water hardness. Hardness is estimated using the following equation: (ppm calcium x 2.5) + (ppm magnesium x 4.1) = ppm hardness where ppm indicates parts per million. For irrigation water with 20 and 10 ppm calcium and magnesium, respectively, the hardness will be $(20 \times 2.5) + (10 \times 4.1) = 91$ ppm. It should be pointed out that irrigation water with hardness above 100 ppm would often result in scale deposits.

Alkalinity is a measure of the acid neutralization potential of the water (Johnson, 1972). Neutralization is often the result of calcium and magnesium carbonates, so alkalinity and hardness terms are used synonymously. However, irrigation water can have alkalinity that is not due to calcium or magnesium carbonates. It is also important to realize that an irrigation water pH above 7.0 does not always mean the water has a high acid neutralization potential.

In addition to hardness and alkalinity values reported by labs, carbonates and bicarbonates may be measured directly and reported. The concentration of these compounds is also used to estimate the suitability of water for irrigation. As with hardness, an assumption is made that carbonates and bicarbonates in the water are associated with calcium and magnesium. However, carbonates and bicarbonates may be associated with potassium or sodium, particularly sodium in areas where salt-water intrusion has occurred. Consequently, the interpretation of your lab results is important because potassium and sodium bicarbonates are more soluble (less likely to clog irrigation systems) than calcium and magnesium carbonates.

Iron is another potential source of mineral deposits that can plug irrigation components or result in a metallic stain on the foliage. Iron is found in ground water as ferrous bicarbonate or ferrous sulfide. When exposed to air, soluble ferrous bicarbonate oxidizes to the insoluble or colloidal ferric hydroxide and precipitates. The result is commonly referred to as "red water," which is sometimes encountered in irrigation wells. Aeration could be used in collection basins to precipitate iron

so that water with minimal iron concentrations could be removed from the surface of the basin. Iron concentrations higher than about 0.3 ppm often result in orange/reddish staining (see Figure 2). Iron bacteria also oxidize the ferrous iron resulting in slime deposits in irrigation systems. Manganese will sometimes accompany iron in irrigation water, but usually in lower concentrations.



Figure 2. Orange-Reddish Staining Due to Iron Concentrations Higher than .3ppm

Acid has been used to lower the pH of irrigation water to enhance the solubility of calcium and magnesium carbonates. Sulfuric, hydrochloric, and phosphoric acids have all been used for injection, but care is required in handling acids and acid-resistant injection equipment is required. The amount of acid injected depends on the buffering capacity of irrigation water and concentration of the acid. One milliequivalent of acid completely neutralizes one milliequivalent of base (carbonate). If acid is injected on a continuous basis to prevent calcium and magnesium precipitates from forming, the injector should be adjusted until the pH of the irrigation water is just below 7.0. If the intent of the acid injection is to remove existing scale buildup within the irrigation system, the target pH will have to be lower. Lowering the irrigation water pH much below 7.0 may result in damage to exposed metal surfaces within the irrigation system. It may be possible to adjust the water pH at a location within the system where this potential corrosion problem can be avoided.

Alternatives to acid injection are scale inhibitors, such as chelating and sequestering agents that have been used with success by other industries. Many of these products contain some form of inorganic phosphate that can reduce or prevent precipitation of certain scale-forming minerals. These inorganic phosphates do not always stop mineral precipitation, but keep it in the sub-microscopic range by inhibiting its development. Probably the most commonly used scale inhibitor is sodium hexametaphosphate. Sodium hexametaphosphate is not only effective against alkaline scale, but also forms complexes with iron and manganese and can prevent deposition of these materials. Although the amount of phosphate required to prevent iron deposit depends on several factors, a general recommendation is 2 to 4 ppm of phosphate for each ppm of iron or manganese. Scale inhibitors will keep irrigation systems clean and at the same time minimize deposits forming on plant material.

Foliar residues and irrigation clogging commonly result from poor quality irrigation water. A comprehensive array of management strategies may be needed to minimize adverse effects of poor water quality. Some of these management strategies are listed below.

- Apply only the amount of water required by plants and reduce leaching
- Produce plants with short production time to minimize exposure to poor quality water
- Irrigate when evaporative loss is minimal
- Use microirrigation to avoid water on foliage
- Use water purification systems
- Mix poor quality and good quality water
- Use chemicals to treat water or inject acid

Additional water quality considerations are given in the *Best Management Practices Guide for Producing Container-Grown Plants* (Yeager, et al. 1997).

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