The Nutrient Value of Irrigation Water

Most people don't consider water a source of nutrients and, if they are talking about animal nutrition, then they are correct. For plants, however, irrigation water can be a valuable source of secondary mineral nutrients. In fact, certain waters can contain all or a substantial portion of the calcium (Ca), magnesium (Mg) , and sulfur (S) needed for normal growth.

Before we go any further, let's have a quick review of mineral nutrition and water quality. Plants need 13 essential mineral nutrients: six macronutrients, which are needed in relatively greater quantities, and seven micronutrients which are required in minute amounts (Table 2). The quality of irrigation water is primarily determined by the type and concentration of dissolved salts. For our purposes here, a salt is defined as a chemical compound that dissolves into positively and negatively charged particles called ions in water. Too much of any salt can be harmful but, in the proper concentration, salts can be either beneficial or harmful depending on their chemical characteristics of the specific ions. As an example, ordinary table salt is composed of sodium chloride (NaCl) and, when mixed with water, dissolves into two ions (Na^+ and C1-) either of which is extremely toxic to plants. Young seedlings are only able to tolerate 50 parts per million (ppm) of sodium or 70 ppm of chloride.

Soluble fertilizers also are technically salts and supply essential plant nutrients. For example, potassium nitrate (KNO_3) is a soluble chemical which dissolves into two nutrient ions: potassium (K^+) and nitrate-nitrogen (NO_{3}-) **(Figure 4).** These dissolved ions are electrically-charged and so the total salt concentration of irrigation water can be determined by measuring its electrical conductivity (EC).

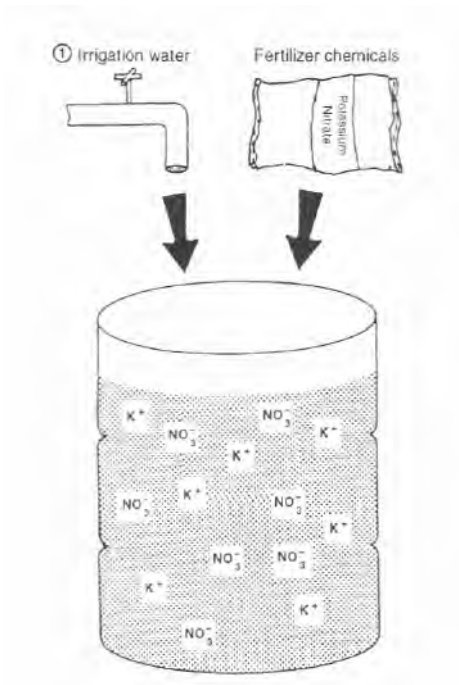

Figure 4. Fertilizers are salts which are used to supply mineral nutrients; for example, potassium nitrate (KNO_3) dissolves into charged nutrient ions (K^+ and NO_3-) which are taken up by plants.

The concentrations of soluble mineral nutrients in irrigation water vary considerably from nursery to nursery depending on the source of the water and the local geology. Because it has had less time to dissolve soluble minerals in the soil, irrigation water that is obtained from surface sources such as streams and ponds will usually have lower soluble salt levels than water from underground sources. Rain water is the purest natural source of irrigation water that is available to nurseries. When I was out in the Pacific Islands and far from any source of air pollution, I collected rain water from the roof and measured an EC of only 16 0/ cm - almost as pure as distilled water. For contrast, I also collected sea water and came up with a whopping EC reading of 50,000 µS/cm! Obviously, rain runoff would be a much better irrigation source than groundwater which can be contaminated with saltwater intrusion in maritime regions. Rain water is a poor source of mineral nutrients, however. In Hawaii, rain filters through young, pumice soils which do not contain many soluble minerals and so the irrigation water is very pure. The EC of irrigation water at a nursery in the hills of Hawaii was only 30 µS/cm **(Table** 2). This means that most if not all the calcium, magnesium, and sulfur must be supplied through fertilization. Actually, irrigation water can be too pure for good plant growth because it quickly leaches out the soluble nutrients from the soil or growing medium - this same thing happens in open growing compounds during periods of heavy rainfall.

Few forest and conservation nurseries rely on rainfall for irrigating, however, and so most irrigation water contains some dissolved salts. The water at many places in the semi-arid Western US is called "hard" because it contains a high levels of calcium and magnesium which cause scale to deposit on pipes and also leaves deposits

Table 2. Chemical analysis of irrigation water from forest and conservation nurseries compared to recommended mineral nutrient target concentrations

		Irrigation Water Analysis		
Essential Mineral Nutrients	**Target Levels**	**Hawaii Nursery**	**Colorado Nursery**	**California Nursery**
Macronutrients		***Parts per million***		
Total Nitrogen (N)	222	NT*	3	7
Nitrate-nitrogen (NO3)	156	NT*	3	5
Ammonium-nitrogen (NH4)	66	NT*	0	0
Phosphorus (P)	60	0	0	0
Potassium (K)	155	0	2	2
Calcium (Ca)	60	1	82	66
Magnesium (Mg)	40	1	14	113
Sulfate-sulfur (SO4)	63	NT*	43	315
Micronutrients		***Parts per million***		
Iron (Fe)	4.00	0.20	0	0
Manganese (Mn)	0.50	0	0	0.01
Zinc (Zn)	0.05	0	0	0.05
Copper (Cu)	0.02	0	0	0
Chloride (CI)	4.00	NT*	3.00	132.00
Molybdenum (Mo)	0.01	NT*	0	0
Boron (B)	0.50	0	0.06	1.00
Other Water Quality Factors Affecting Mineral Nutrient Uptake				
pH	5.5 to 6.5	5.7	6.9	8.1
Salinity (EC in mcmhos/cm)	1200 to 1800	30	470	1610

* = Not Tested

on other surfaces. Hard water inhibits the action of soap and so is softened for domestic purposes. Nurseries with moderately hard water are fortunate because it often supplies all or most of the calcium and magnesium requirement. On the other hand, soft water should never be used for irrigating plants because the added sodium and chloride ions are toxic.

Water from some irrigation wells can be too high in soluble salts as the analysis from the Sacramento Valley of California illustrates (Table 2). Although the calcium, magnesium, and sulfur levels are above the recommended levels, this nursery has had continual problems with direct toxicity from high chloride levels. Another problem is that high levels of some nutrient ions, for example calcium, can caused reduced availability of other nutrients including iron and phosphorus. Finally, note the high pH of the California water. The pH of water generally increases with the EC reading although the exact nature of the dissolved salts, especially carbonate and bicarbonates, have the major effect on the pH reading. Although pH is the most discussed aspect of irrigation water quality, it has a very minor influence and so should only be used as an indication that a more complete analysis is required.

The take-home message is that irrigation water should be tested during the nursery site selection process and periodically thereafter because water quality can change over time. Be sure to test for all the nutrient ions because the full range of mineral nutrients is not included in most standard water quality tests. This increases the cost of the analysis but this information is essential when formulating fertilizer programs.

Sources:

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1989. Seedling nutrition and irrigation, Vol. 4, The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: USDA, Forest Service. 119 p.