IRRIGATION AND WATER QUALITY

To ensure the efficient and safe use of water for any horticultural venture, it is essential that an accurate chemical analysis of the water is obtained from a certified laboratory. A simple analysis can fore-warn of any potential problems and give confidence in an investment dependent upon supplies of clean water.

Water quality should be evaluated before using a new water supply or purchasing a property that is dependent upon a water supply of unknown quality. An analysis is especially critical in known problem areas. For existing water supplies, re-analysis should be performed from time-to-time, especially in dry seasons and when deep drilling has occurred in the area.

Chemical factors affecting the suitability of a water supply for irrigation relate to the presence of a number of potentially undesirable or hazardous features. These include:

- dissolved salts
- chemical toxicities
- problems with the irrigation system used
- the level of sodium and its effect on soil structure

Dissolved Salts

Irrigation water, whether taken from a river or from bores or wells, contains dissolved salts. This is in contrast to rainwater which is essentially free of these salts. Much of the water applied to soil or growing media will be taken up by the crop and transpired, leaving a portion of the salts behind in the root zone. If the water contains high levels (>1000ppm) of dissolved salts these will slowly accumulate, increasing the likelihood of problems associated with the factors listed above.

Water containing high levels of sodium salts is referred to as being saline. Irrigation waters are considered to have a high salinity hazard when they have an electrical conductivity greater than 1500 mS/cm (150 mS/m).

Highly saline water may injure plants in four ways:

- excess salinity can cause moisture stress within the plant, by increasing the osmotic pressure of the soil solution. This retards the plant’s ability to take up water and, in severe cases, will lead to wilting.
- certain chemical components (for example, sodium, chloride and boron) can have a toxic effect on the plant.
- nutrient availability can change due to changes in the soil pH and associated solubility or antagonisms among nutrients.
- soil permeability may decrease due to the loss of soil structure caused by the disintegration (deflocculation) of soil aggregates (especially deflocculation of clays by sodium).

High salinity generally results in the stunting of plants. All plant parts (leaves, stems and fruits) remain smaller than normal.

Soil salinity can be lowered only by thorough leaching. To leach a soil, water in excess of the amount needed to saturate the soil must be applied either at each irrigation, or at regular intervals while the crop is growing. The excess water carries the accumulated salts into the sub-soil, away from the primary root zone.

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Chemical Toxicities

Chemical ions in irrigation water may be beneficial or toxic to plants depending upon the specific ion, its concentration, the sensitivity of the plant to that ion, the volume of water applied and the method of irrigation used.

Traces of potassium and nitrate are seldom toxic to plants, but their presence does suggest contamination of the water supply from leaching of run-off from nearby land. High levels of nitrate may be beneficial and should be taken into account when formulating liquid feed programmes. However, some species, grapes for example, are sensitive and failure to consider nitrate contribution from water may produce crops with shortened storage shelf life. The presence of nitrate-nitrogen at high levels (>10ppm) poses a health hazard if the water is used for domestic supply or for stock.

Excess boron can be toxic to plants. Toxic levels of boron in irrigation water results in necrotic spots on the plant leaf, especially near the leaf edge. Other symptoms may include leaf puckering, deformed roots and, at extreme levels, plant death. Kiwifruit are especially susceptible. As a rule of thumb, if the boron concentration in the irrigation water is below 0.75 ppm, the water is satisfactory for most crops.

Chloride in high concentrations will inhibit plant growth, and is specifically toxic to some plants. Trees, vines and woody ornamentals are sensitive to chloride. Symptoms such as leaf burn, leaf drop, or stem dieback may appear at chloride concentrations of between 70 and 140 ppm. Tolerance varies from species to species.

Many plants are sensitive to excessive sodium absorbed through roots (e.g. Sandersonia). The sodium absorption ratio (SAR) of water is related to the amount of sodium present relative to the levels of calcium and magnesium. Waters with a sodium absorption ratio below 3 seldom present a problem. As the ratio increases from 3 to 9 problems are likely to increase. An SAR above 9 will almost always cause severe problems. Plants vary widely in their tolerance, and each species should be considered separately.

Sodium Absorption Ratio (SAR)

When the concentrations are given in mg/L

$$SAR = \frac{Na/22.99}{\sqrt{\left(\frac{Ca}{40.078} + \frac{Mg}{24.305}\right)}}$$

If the irrigation water contains high levels of free bicarbonate ions (greater than 60 ppm, equivalent to a Total Alkalinity greater than 50ppm $CaCO_3$), as well as sodium, then an adverse increase in the soil pH may occur over a period of time. If both ions accumulate in the soil, the soil's pH may rise to levels in the range of 8.4 to 9.0. This will lessen the availability, and lead to deficiencies, of elements like zinc, iron and manganese.

Soil testing is a useful means to monitor and detect this effect. Zinc toxicity is another potential problem. This may arise when an acidic water contacts galvanised piping in the reticulation system (e.g. down a borehole). Zinc from the pipe surface will dissolve and be carried to the root zone of the plants. The problem may not always be apparent from a water analysis as the pipes are usually purged before taking the sample.

A low pH and alkalinity for the water should alert the user to the possibility of zinc levels building up while the system is not pumping. If the water is then pumped directly to the plants, rather than into a holding tank where the zinc will be diluted, very high zinc levels can be introduced into the root zones.

Contamination of irrigation water supplies with herbicides is another potential problem.

Irrigation system problems

Some features of the water may affect the performance of the irrigation equipment. The presence of iron in the water can result in deposits of iron oxides blocking fine irrigation capillaries, sprinkler heads, and pump components. Iron in the water can lead to the formation of a brownish slime, produced by “iron bacteria”, which will also block irrigation equipment, etc. High manganese levels can produce a black sludge which has a similar effect. Both elements can often be removed by oxidation (e.g. by aeration or ozone) to insoluble forms, followed by filtration. Manganese is more difficult to remove than iron.

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High levels of undissolved minerals in the water may be abrasive and promote premature wear of pumps. A highly corrosive water may aggravate the latter.

Most water suitable for surface irrigation may be safely used for overhead sprinkler irrigation. However, there are several other considerations.

Leaf burn may occur when irrigation waters containing more than 70 ppm of sodium or more than 100 ppm of chloride, are applied overhead. This is most likely when the rate of evaporation is high, under such conditions as low humidity, high temperatures and winds. The build-up of toxic levels on leaves between sprinkler rotations may be avoided by irrigation intermittently or only at night.

Elevated levels of bicarbonate ions in the water may result in the formation of unattractive white calcium carbonate deposits on plants, once again especially under conditions of rapid evaporation. This is unsightly and may affect the marketability of the fruit. Iron (and, to a lesser extent, manganese) in the water system can cause brown staining on leaves and fruit. Decomposing leaf material in contact with fruit can cause a water stain following overhead irrigation (or rain!)

Trickle irrigation is one of the most economic means of irrigating crops, but results in only restricted areas being irrigated. Problems discussed above (e.g. salt build up, pH changes), along with leaching of desired nutrients, will be accelerated when the water requirements of the crop are being applied to only perhaps 10% of the soil surface. Such problems are diminished with the broader application systems (e.g. overhead, sprinklers).

Trickle irrigation may also suffer from blockages developing at the aperture of the trickle tubes. When water ceases to flow, evaporation at the aperture may occur, with the dissolved salts concentrating in solution and finally forming a solid deposit which blocks the tubes. If the water contains high levels of calcium and bicarbonate then calcium carbonate will form. This needs dilute acid to solubilise it to clear the blockage.

Soil Structure & Sodium

Excessive levels of sodium in the soil can destroy its structure. Sodium deflocculates the soil, resulting in a soil which dries into large hard clods separated by a few wide, deep cracks. A deflocculated soil has very undesirable physical properties, for example, decreased water permeability.

The structure of many irrigated soils will become unstable when exchangeable sodium exceeds 15 percent of the soil's total cation exchange capacity. The sodium hazard involved depends on both the sodium level and the sodium absorption ratio, problems increasing when the SAR exceeds 6. If irrigation water contains a high level of sodium, soil testing will reveal any build-up of sodium in the soil.

The exchangeable sodium percentage can be lowered by adding gypsum to the soil.

Water Sampling

Water samples for the assessment of a water's suitability for irrigation are simple to take, but several precautions should be observed. At least 500ml of sample is required.

If a Hill Labs Kit is used, do not pre-rinse any of the provided bottles as they may contain preservatives. When sampling well or bore water, always take samples as close to the source as possible, and only after the pump has been operating long enough to thoroughly flush the lines. Never take samples from irrigation ditches where water has not been flowing.

Surface water should be sampled from the running stream as near the intake as possible.

Samples should be sent to the laboratory as quickly as possible, along with details as to the source of the water, any specific problems and intended use of the water.

Please note: The information in this document covers a wide variety of situations and should be used solely as a guideline for interpretation. Assistance from a qualified horticultural adviser with experience in the crop being grown should be obtained if there are any questions about the suitability of a water supply for a particular crop.