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pH and Alkalinity are Different©

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Often when I ask growers what the alkalinity of their irrigation water is, I get a response something like: "It's about 6.5." This might be a correct answer to the question: "What is the pH of your irrigation water", but it is not the correct answer to a question about alkalinity. The correct answer to a question about alkalinity will be a number in the range about 20 to 350. Let me explain.

Irrigation water is never absolutely pure H_2O. The water always has ions dissolved in it. These ions include such cations as sodium (Na^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}) and the anions chloride (Cl^-), sulphate (SO_4^{2-}), and bicarbonate (HCO_3^-). The concentrations of these ions and their relative proportions vary enormously amongst water supplies.

Thus rainwater caught in a dam in the higher-rainfall parts of the country will usually have low concentrations of all of these ions (and hence will have a low salinity). Its pH might be something like 6.9 and its bicarbonate concentration might be 20 $mg \cdot L^{-1}$.

In contrast, water pumped from deep underground in the drier parts of Australia could have the same pH (6.9), but could have a bicarbonate concentration of 250 $mg \cdot L^{-1}$ (and a salinity of perhaps 1200 $\mu S \cdot cm^{-1}$).

You will see soon why I pick on bicarbonate to illustrate the difference between these waters.

If the rainwater is used to irrigate a nursery crop whose nutrition is being provided by a fertiliser that releases acidity into the potting mix as it is used (as most fertilisers do), the potting mix will become steadily more acidic. That is, its pH will decrease.

If the underground water is used for the same purpose, despite its identical pH and the same acidity from the fertilisers, it will be found that the pH of the potting mix will steadily rise over time.

The difference in response of the potting mix is clearly not due to the pH of the irrigation water, as it is identical for the two water supplies. Rather, it is due to the difference in their levels of total alkalinity. The total alkalinity of a water supply is expressed as calcium carbonate equivalent ($mg \cdot L^{-1}$) and is calculated by multiplying the bicarbonate concentration in the water by 0.82.

For example, our rainwater with a bicarbonate concentration of 20 $mg \cdot L^{-1}$ has a total alkalinity of $20 \times 0.82 = 16$ $mg \cdot L^{-1}$ calcium carbonate (equivalent); our underground water with a bicarbonate concentration of 250 $mg \cdot L^{-1}$ will have a total alkalinity of $250 \times 0.82 = 205$ $mg \cdot L^{-1}$ calcium carbonate equivalent.

In practical terms, these numbers mean that every time 1 L of water is applied to a plant in a container, the rainwater will deliver 16 mg of lime (calcium carbonate) and the underground water will deliver 205 mg of lime. The underground water has delivered about 13 times more lime to the plant than has the rainwater.

A typical controlled-release fertilizer, whose nitrogen content has a higher proportion of ammonium (plus urea) than nitrate, will have a net acidifying effect on a potting mix. The acidity from the ammonium plus urea is greater than the alkalinity from the nitrate.

For example, for a container that holds 1 L of mix, the net amount of acidity can typically be enough to need 50 to 80 mg of lime to neutralise it. Irrigation water that is applied at the rate of, say, 2 L per week will, for the rainwater above, supply only about 32 mg of lime, so the net effect is that the potting mix pH slowly, but steadily, drops.

In contrast, the underground water will deliver 410 mg lime to the container, which is 330 to 360 mg more than can be neutralised by acidity from the fertilisers. The pH of the mix will rise, just as if lime had been topdressed onto the mix.

Many other examples could be given. They would all illustrate the fact that it is not the pH of irrigation water that determines its effect on potting mixes, but the total alkalinity of the water.

Every nursery must know the total alkalinity of each of the water sources it uses for irrigation. Water supply authorities can supply this information for reticulated supplies. You need to either send samples of other supplies to a laboratory for analysis or you can undertake the simple test yourself using a kit such as those sold at swimming pool supply shops.

I have repeatedly seen problems in nurseries that do not have this basic information and so make wrong decisions about fertilisers and other management practices. Here are some examples of actions that would be taken on the basis of the results of an alkalinity test of a water supply.

If the total alkalinity is low (less than about 40 $mg{\cdot}L^{-1}$) and it is known that the pH of the potting mix in containers becomes more acidic as the growing period progresses, a grower could either change fertilisers to one that is less acidifying, or include coarse dolomite (0.5-2 mm) in the mix to buffer against acidification, or make both changes.

If the total alkalinity is around 80 $mg{\cdot}L^{-1}$, potting mix pH should remain stable. But if it does drift unacceptably one way or the other, the fertiliser used can be changed to one that is better in tune with the water. One with more ammonium or urea would be used if pH has been drifting up, while one with a higher proportion of nitrate would be used if mix pH is drifting down.

For water supplies with total alkalinities in the 100 to about 150 $mg{\cdot}L^{-1}$, mix pH will generally rise unless a fertiliser with a high proportion of its nitrogen present as ammonium plus urea is used.

The higher the total alkalinity is above 150 $mg{\cdot}L^{-1}$, the greater will be the need to inject acid into the water. At what point you absolutely must do that will depend on the tolerance of your crop to high pH and on the length of the growing period. Starting off with the pH of the potting mix at about 5, or even a little lower, will extend the time until problems start to be seen, but in my experience any water with a total alkalinity of 200 $mg{\cdot}L^{-1}$ and higher must be acidified for successful use in a nursery. Management will usually be easier for those with water supplies with total alkalinities in the 150 to 200 $mg{\cdot}L^{-1}$ range if these are acidified.

The amount of acid to use should be enough to bring the total alkalinity down to about 80 $mg{\cdot}L^{-1}$. This can be done by guesswork or you can use a computer program to calculate it for you. I use one such program in my consulting.

Once you know what amount of acid is needed to bring the alkalinity to where you want it, in automated systems you can use the pH value of that acidified water to control acid injection. But the fundamental reading must still be the total alkalinity of the acidified water.

Sulphuric acid is the most practical acid to use. The (sulphate) sulphur provided would either be beneficial to your plants or at least not harmful. Nitric acid will often supply more nitrogen than is needed by your plants; this extra N will not allow you to hold back plants should you need to. The extra phosphorus provided if you use phosphoric acid will usually be too much for your plants and could lead to toxicities or interference with other nutrients. Hydrochloric acid must not be used as the extra chloride provided will increase the lushness of your plants, so making them more vulnerable to diseases, and/or it will burn leaf margins.

FURTHER READING

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Integrating a Tissue Culture Laboratory into a Nursery©

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INTRODUCTION

The successful introduction of many Australian native plants in tissue culture in commercial volumes has been full of pitfalls. Many papers have been published outlining research into the initiation and growth of native flowering plants but we are still to see large numbers of these plants in the commercial nursery and flower trade. Examples of plants such as *Ptilotus, Clianthus, Blandfordia,* and *Platycerium* are examples of native plants, which have been the subject of significant research, but we are yet to see any significant numbers of these plants available within the nursery and cut flower industries. Obviously, published research has not translated into commercial production of these plants.

There have also been some success stories with the introduction of some native plants into tissue culture production. *Anigozanthos*, *Asplenium*, and *Nephrolepis obliterata* 'Kimberley Queen'. However, there is clearly a major gulf between the small-scale success in a research project needed for publication and the development of reliable systems of commercial production in plant tissue culture.

This paper attempts to identify the operational issues in a plant tissue culture laboratory and how these can be integrated with commercial nursery production practices to ensure the successful commercial introduction of tissue-culture-produced lines into the commercial nursery and cut flower trade.

THE PLANT TISSUE CULTURE LABORATORY — FACTORS OF IMPORTANCE

The management of microbial contamination within the laboratory is the single most important factor in producing plants in the laboratory. A hygiene program must be implemented in all sections of the laboratory facilities to maintain freedom from contamination in cultures. Despite the title of this paper, I do not support the complete integration of a tissue culture laboratory within the physical confines of a nursery. The risk of microbial contamination increases dramatically if the laboratory is situated within the nursery.