NURSERY PAPERS
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Water test interpretation

BACKGROUND

Quality water is one of the critical requirements to grow quality plants. Water quality can not only impact plant health but affect soil, growing media, irrigation equipment, nursery activities. The properties of surface, underground and drainage water can vary.

Good quality water for nursery production contains:

- inorganic ions and compounds in the correct amounts and ratios
- low levels of suspended solids, water moulds and bacteria.

Regular water testing forms part of best management practice in nursery irrigation.

One of the most important things to test is the inorganic or chemical components of irrigation water.

WHY TEST

Water, media and nutrition are interrelated. Plant growth depends on nutrients, which depends on your media and the quality of your irrigation water. So, whether you're relying on fertigation or controlled release fertiliser, you need to work out the nutritional program in line with your water analysis.

If you don't know the quality of your irrigation water and how it interacts with fertilisers and media, you might inadvertently inhibit plant growth.

WHEN TO TEST

It's important to test regularly and keep good records. The data provides a base for informed crop management decisions.

If you're a production nursery recycling your irrigation water, you should:

- undertake full water analysis annually
- test pH and electrical conductivity (EC) at least every six months.

The information gained from these tests can show:

- changes in water quality early, so you can take corrective action before issues arise
- which nutrients are available in useful amounts and may help reduce fertiliser use.

TESTING EQUIPMENT

We recommend using a photometer to check nutrient levels in your irrigation water, especially if you are recycling your water.

A photometer can:

- improve nutrient management
- reduce nutrient loss to environment
- record release water quality to show you're meeting your legal obligations.

While the establishment cost can be around $500 – $2,000+, this equipment makes testing quicker, easier and cheaper than sending samples to a laboratory for analysis.

HOW TO TAKE WATER SAMPLES

It's important that samples accurately reflect the irrigation water quality.

For instance, the water quality at the edge of a dam can vary significantly from that at a foot valve, 60cm under the surface of the water in the middle of the dam. So, collect your sample close to the foot valve.

If you're using a testing facility, make sure you follow their guidelines around sample volume and storage.

Always take your samples from the same place so you can compare results over time.

If you treat water, test the quality afterwards so you know if the treatment has been effective in meeting the water quality parameters you're looking for. Take these samples from an irrigation line in a growing area.

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WHAT DO THE RESULTS MEAN?

There are 14 main results that are important to understand.

1. pH

This is the measure of how acidic or alkaline the sample is. It is a measure of the hydrogen ions in solution. Hydrogen ions play a part in most chemical reactions in water and media. Their concentration also influences the solubility and availability of nutrients. A pH that is too high (>7.5) can result in nutrient deficiencies, and a pH that is too low (<5) may result in micronutrient toxicities and injury to the root system.

For effective use of chlorine as a water disinfectant, the pH needs to be below 7.5.

2. Electrical Conductivity (EC)

EC is a measure of the total salts in the water. This test does not identify which salts are present, only the total amount. EC is shown as deciSiemens per metre (dS/m), milliSiemens per centimetre (mS/cm), or microSiemens per centimetre (μS/cm). (1dS/m is equal to 1mS/cm or 1,000μS/cm.)

As the conductivity number rises, symptoms such as slow growth, leaf and root burning, and death may occur. Some plants are more sensitive to salt content than others.

We recommend that irrigation water has an EC of less than 0.6 dS/m before fertiliser is added. You may be able to use water with a higher reading if the salt content is from required nutrients. This may also allow you to reduce the amount of these nutrients you add via fertiliser.

3. Alkalinity

This is a measure of bicarbonates (HCO_3), carbonates (CO_3) and hydroxides (OH) in irrigation water that have acid neutralising effects. Alkalinity is usually shown as mg/L $CaCO_3$ but can also be reported in milliequivalents (meq) or parts per million (ppm).

One way to think of alkalinity in irrigation water is as 'liquid lime'. If water has a high alkalinity, it has the potential to increase growing media pH over time because 'liquid lime' is being applied every time you irrigate.

Water with a high pH will not always equate to high alkalinity. The higher the alkalinity the harder it will be to alter the pH of the water.

4. Hardness

Hardness is a measure of the combined content of (mainly) Calcium and Magnesium, dissolved in water. Water hardness is generally associated with high alkalinity, but not always.

5. Nitrate (NO_3) and Phosphate (PO_4)

These levels in your water are the main indicators of nutrients leaching from your production system or other farmed areas. They can be a significant source of nutrients for your crops – so, if you are recycling your water, it's good to know their quantities.

Results for nitrate up to 30mg/L will have no real impact on your plants, but if the result is 100mg/L or higher, take this into account in your nutrition program.

Phosphate results under 4.5 mg/L should not cause problems. However, results greater than 15 mg/L could interfere with the uptake of other nutrients, and phosphorus may not be necessary in your nutrition program. (To convert a phosphate result to phosphorus, divide by 3.)

6. Potassium (K)

Potassium levels up to 15mg/L are considered acceptable in irrigation water. Higher levels can be tolerated if they are 2% – 5% of the total dissolved cations (ions with a positive charge) in the sample. Cations include Ca, Mg, K and Na and you'll need to account for these in your nutrition program.

7. Calcium (Ca)

Calcium at levels below 60mg/L will lead to deficiencies unless calcium is part of your nutrition program. Levels exceeding a ratio of Ca:Mg of 2:1 can lead to magnesium deficiency.

8. Magnesium (Mg)

At 25 – 50 mg/L magnesium is suitable for plant production. Magnesium can become deficient in plants if Ca levels are too high. Maintain a ratio of Ca:Mg of 2:1.

9. Iron (Fe)

Keep iron below 0.2 mg/L. High iron levels can stain and damage foliage and clog irrigation components, especially drip systems.

10. Copper (Cu)

Copper levels below 0.2 mg/L should not cause issues. Higher levels could cause toxicity in sensitive plants, especially at low media pH levels.

11. Zinc (Zn)

Zinc at less than 0.3 mg/L should not cause issues. Levels above 1 mg/L could cause toxicity in sensitive plants, especially at low media pH levels.

12. Manganese (Mn)

Less than 0.1 mg/L of manganese should not cause issues. 0.1–2 mg/L is not usually toxic to plants but may form bacterial slime in pipes and fittings.

13. Boron (B)

Boron levels less than 0.3 mg/L should not cause issues. Boron tolerances and toxicities vary in plants. Some, like Poinsettia, showing toxicity symptoms at 0.5 mg/L.

14. Sodium (Na)

Less than 60 mg/L of sodium is fine for most plants. As sodium levels increase, you will need to increase the rates of calcium, magnesium and potassium in your nutrition program to avoid deficiencies. Results over 100 mg/L will cause increasing issues.

TEST	SUITABILITY RANGE
pH	• <5 Corrosive, phytotoxic, expect nutritional problems later in crop cycle if pH not corrected • 5.5 – 7 Ideal range • >7 Increasing deposits and blockages. Problems with chlorine disinfestation, nutrient imbalances in plants. • (pH needs to be considered with alkalinity to determine the ability of irrigation water to alter growing media pH)
Alkalinity ($CaCO_3$)	• <40 mg/L $CaCO_3$ suits most situations and will have little effect on pH • >125 mg/L $CaCO_3$ will cause the pH levels to rise in longer crop cycles • >500 mg/L will produce severe problems and is not recommended • Ability of water to neutralise acids. Used to describe water samples testing above pH 8.5, which are normally associated with high bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}) levels.
Hardness ($CaCO_3$)	• 0 – 100 mg/L soft water • 100 – 300 mg/L hard • >300 mg/L very hard • The amount of Calcium and Magnesium ions dissolved in the water sample, usually shown as mg/L of $CaCO_3$
Bicarbonate (HCO_3)	• <90 mg/L suitable • 90 – 200 mg/L increasing problems with plant growth, container staining, and irrigation equipment blockages • >500 mg/L unsuitable for nursery irrigation
EC (dS/m)	• 0.0 – 0.3 good for salt sensitive crops • 0.3 – 0.6 low to medium tolerance (Results above 0.6 dS/m will see reduced growth and/or marginal leaf burn (older leaves) in sensitive plants, in sub irrigation, or low leaching situations) • >1. 0 high tolerance crops • (If a high EC result is from plant nutrients, then this may be acceptable.)
Nitrate (NO_3)	• 10 – 30 mg/L is suitable • >100mg/L are problematic if not taken into consideration with nutrition programs. • Particularly important for water recycling systems. (For N value of NO_3 multiply by 0.225)
Phosphorus (P)	• 1 mg/L upper limit for phosphorus sensitive plants • 1.5 mg/L upper limit for plants already supplied with P at moderate levels in fertiliser • (If the parameter shown is Phosphate (PO_4), then divide the value by 3 to get P value)
Potassium (K)	• 5 – 15 mg/L suitable. • Adjust K if recycling water. K should be 2-5% of cations – (Ca, Mg, K, Na)
Ammonium (NH_4)	• High levels, >10mg/L, can lead to direct toxicity and contribute to downward pH drift in growing media
Calcium (Ca)	• 40 – 70 mg/L suitable • High levels can interfere with Magnesium availability. Low levels lead to deficiency unless supplemented in nutrition program. Ca:Mg ratio of 2:1 is ideal.
Magnesium (Mg)	• 15 – 25 mg/L suitable
Sulphur (S)	• <33 mg/L suitable
Sulphate (SO_4)	• <100 mg/L suitable
Chloride (Cl)	• <70 – 90 mg/L suitable • >200 mg/L tip and marginal burning of leaves, especially in low leaching situations • >400 mg/L not suitable for nursery irrigation
Iron (Fe)	• <0.2 mg/L no problems • 0.3 – 1.5 mg/L iron bacteria may develop and form blockages in drip irrigation • 1.0 – 4.0 mg/L iron deposits will block irrigation equipment, will stain and damage foliage • >4.0 mg/L very difficult to treat
Copper (Cu)	• <0.02 mg/L is generally suitable • >0.05 mg/L is becoming excessive for indoor irrigation systems • >0.2 mg/L may kill plants and is not recommended
Zinc (Zn)	• <2 mg/L is suitable for irrigation of most plants
Manganese (Mn)	• 0.1 mg/L maximum concentration for irrigation • >1.5 mg/L will clog irrigation equipment

TEST	SUITABILITY RANGE
Boron (B)	• <0.3 mg/L is suitable for most plants • >0.3 mg/L is unsuitable
Aluminium (Al)	• <1 mg/L suitable • 5 mg/L maximum concentration for plants • Can cause foliage damage and bind Phosphorus in high concentrations
Total dissolved solids (TDS)	• A measure of combined organic and inorganic substances • >500mg/L is considered unsuitable
Sodium (Na)	• <60 mg/L suitable for most crops • >100 mg/L unsuitable for many crops
Sodium adsorption Ratio (SAR)	• <3 is suitable • 3 to 7 gives increasing problems of nutrient deficiencies, by tying up calcium, magnesium and potassium ions • >7 is unsuitable

Note: Not all parameters occur in all water quality tests
1 milligram/Litre = 1 part per million (1mg/L=1ppm)
1dS/m=1mS/cm=1000QS/cm=1mmho/cm
milliequivalents (meq) (1 meq/L Alkalinity = 50 ppm (mg/L) $CaCO_3$ (Calcium Carbonate) or 61 ppm (mg/L) HCO_3
Adapted from Irrigation Water Test Interpretation NGIQ 2015, Water Management in Container Nurseries NGIA 2007, Managing water in plant nurseries. 3rd Ed.2021, DPI NSW, and Understanding Irrigation Water Test Results and Their Implications on Nursery and Greenhouse Crop Management, 2014,University of Kentucky

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Spectrum Analytic. Guide to interpreting irrigation water analysis. ***https://www.spectrumanalytic.com/support/library/pdf/guide_to_interpreting_irrigation_water_analysis.pdf***

Agriculture and Natural Resources Publications. Understanding Irrigation Water Test Results and Their Implications on Nursery and Greenhouse Crop Management. ***https://uknowledge.uky.edu/anr_reports/160***

FURTHER READING

GIA: Nursery Papers, November 2020. ***Water management for production nurseries***.

GIA: Nursery Paper, May 2014 Issue no.4. ***The Importance of Suitable Sources of Irrigation Water to Nursery Businesses***.

Nursery levy at work: Water Disinfestation. ***A Comparison of Proven Water Disinfestation Systems for Production Nurseries***.

Irrigation toolbox Calculators: ***https://nurseryproductionfms.com.au/irrigation-toolbox-calculators/***

GIA E-News 2022. How healthy is your irrigation water source? – ***https://www.greenlifeindustry.com.au/communications-centre-content/media-releases-1/2021/how-healthy-is-your-irrigation-water-source***

NGIQ 2010. Selecting Water Testing Equipment – ***https://nurseryproductionfms.com.au/download/selecting-water-testing-equipment-2010-2/***

MORE INFORMATION, LINKS AND FURTHER RESOURCES

Past editions of nursery papers are available online on the Greenlife Industry Australia website:
https://www.greenlifeindustry.com.au/communications-centre?category=nursery-papers

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