水質
台大生機系 方煒

水質
温室作物水份管理
最重要項目

水質重要項目
• pH 酸鹼度
  – Concentration of hydrogen ions
• Alkalinity 鹼度
  – Ability to neutralize acid
• Salinity 鹽度
  – Amount of dissolved charged solutes (not just NaCL)
• Specific Elements 特定元素

沈浸式 pH and EC meter 2 in one (Hanna公司產品)

插入式 EC meter (Spectrum公司產品)

pH
• 水分子經常性的解離成 H＋ and OH⁻ 離子又合成回水分子(H₂O)
• 純水: [H⁺] = [OH⁻]
什麼是 pH？

- pH = \(- \log_{10} [H^+]\) 溶液中氫離子濃度
- 範圍 0 to 14
- 中性 pH = 7 or \([H^+] = [OH^-] = 10^{-7}\)
- 鹼: pH > 7
- 酸: pH < 7

範圍 0 to 14
- 中性 pH = 7 or \([H^+] = [OH^-] = 10^{-7}\)
- 鹼: pH > 7
- 酸: pH < 7

大多數作物可接受的土壤酸鹼度 5.5 – 7.5

常見液體的 pH
- Citrus fruit 1.8 to 3.3
- Drinking water 6.5 – 8.0
- Ammonia 10.6–11.6
- Lye solution nearly 14.0

More Chemistry…

- Acid
  - Yields H+ when dissolved in water
- Strong Acids
  - HCl \(\rightarrow\) H+ + Cl-
  - H2SO4 \(\rightarrow\) 2H+ + SO4²⁻
  - HNO3 \(\rightarrow\) H+ + NO3⁻
- Weak Acids
  - Acetic acid (vinegar)
    \(\text{CH}_3\text{COOH} \leftrightarrow \text{H}^+ + \text{CH}_3\text{COO}^-\)
  - H₃PO₄ \(\rightarrow\) H+ + H₂PO₄⁻

- Base
  - Yields OH⁻ when dissolved in water
- Examples:
  - NaOH (lye)
  - CaCO₃
  - MgCO₃
  - Mg(HCO₃)₂

鹼度 Alkalinity

- Ability of water to neutralize acid due to dissolved carbonates in the water
- Alkalinity ≠ Alkaline
- Carbonates
  - CaCO₃ – limestone
  - Ca(HCO₃)₂ – calcium bicarbonate
  - MgCO₃ – magnesium carbonate
  - Mg(HCO₃)₂ – magnesium bicarbonate

Alkalinity

- Alkalinity establishes the buffering capacity of water
- Buffering – how resistant to pH change
- HCO₃⁻ + H⁺ \(\rightarrow\) H₂CO₃ \(\rightarrow\) H₂O + CO₂
- CO₃²⁻ + 2H⁺ \(\rightarrow\) H₂CO₃ \(\rightarrow\) H₂O + CO₂

By absorbing H⁺, the carbonate inhibits a change in pH when H⁺ is added.

鹼度為何重要

- Over time, irrigation with high alkalinity water will gradually absorb the available H⁺ ions in the media, resulting in a rise in media pH

H₂O + CO₂
鹼度為何重要
A rise in media pH can change nutrient availability and create nutritional problems in plants.
To lower pH, acid may have to be added to the media.

Acid is usually added through an injection system.
• Injectors add small amounts of a solution such as fertilizer or acid to water as water flows through the injector
• Use acid resistant pumps, containers, etc.
• Do not add acid to fertilizer concentrate - Must use twin-headed or separate injector.

Acid injection cont’d.
• When diluting the acid to make the solution to be used by the injector, ALWAYS add acid to water NOT the other way around!
• Wear appropriate safety equipment, especially eye protection!
• Retest irrigation water source regularly to see if alkalinity has changed.

Salinity or Soluble Salts
• Concentration of charged solutes – Na\(^+\), CO\(_2\)_3\(^2-\), Cl\(^-\), NO\(_3\)_3, Ca\(^{+2}\), Mg\(^{+2}\), H\(^+\), F\(^-\), others
• Measure electrical conductivity (EC)
  – Resistance (ohm, Ω) = 1/E.C.
  – E.C = 1/Ω = mho = siemen (S)
  – EC meters read 1 mS/cm = 1 dS/m
• Pure water has low conductivity
• Adding fertilizer to water, ↑ EC

Be careful when handling acids - they are very dangerous. Phosphoric is one of the safest to handle.
Monitoring soluble salts is done using an EC meter. EC meters can be hand held. They can also be part of an injector system.

Specific Elements
Some examples of specific elements that can influence water quality

- Nitrate – damaging to humans, but beneficial to plants
- Na⁺, Cl⁻ damaging in high levels
  - Prevent K⁺ uptake
- Heavy Metals (Zn, Mn, Fe, Cu)
  - Toxicity or prevent other nutrient uptake
- Boron – small amounts required
- F⁻, Li⁺ some plants sensitive
  - F⁻ added to municipal water supplies

Correcting high EC water

- Reverse osmosis
  - 95–99% of salts removed
  - Pressure applied to untreated water which forces water molecules across semi-permeable membrane leaving solutes behind
  - Cost-effective if energy source fairly cheap
    - $0.01-.02 per gallon
  - Brine water waste creates a disposal problem
Other solutions to high EC

- **Deionization**
  - Ion exchange resins remove anions and cations
  - Replaces bad ions with H⁺ and OH⁻
  - High purity water

- **Distillation**
  - Water purified by evaporation and condensation
  - Expensive
  - No horticultural value
  - Research value
廢水 vs. 純水
3.5 : 1
文心兰使用RO水做喷灌栽培
葉片（礦物含量）分析

水質分析

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Laboratory analysis: Phalaenopsis plant materials

Sample reference:  | Formula | Concentration | Formulation | Concentration | Formulation | Adequate range |
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**SUBSTRATUS CROP GUIDE Notes**

**DATE:** 28/05/2004  
**TO:** ANDY WANG  
**FROM:** JOHN THOMPSON  
**RE:** PHALAENOPSIS FERTILISER

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2006-01-14 1718pm at Dun Hwa