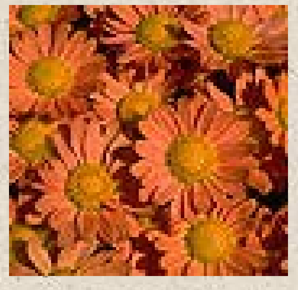
Monitoring Nutrition for Crops

Electrical conductivity
pH
Alkalinity
Cation exchange and Anion exchange capacities





Krishna Nemali, Ph.D.

Why should you monitor nutrients for plants?

$$

Nutrient deficiencies can cause moderate to severe crop loss

How to monitor Nutrition for greenhouse plants?

- Measure the concentration of fertilizer salts supplied to plants

  what we give plants

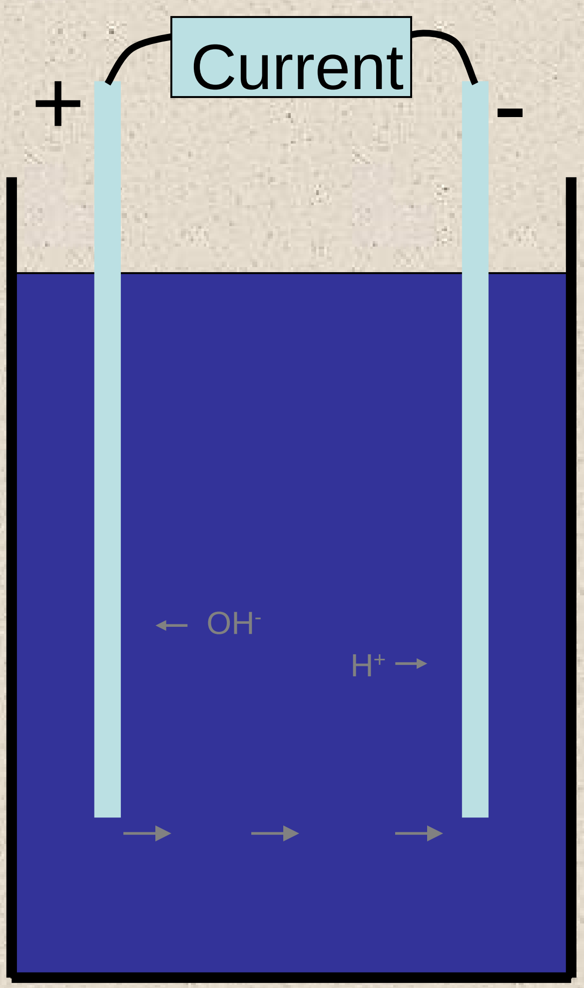
- Measure fertilizer salts in the root zone of plants

  what is available to plants

- Measure nutrients in the leaf / stem tissue

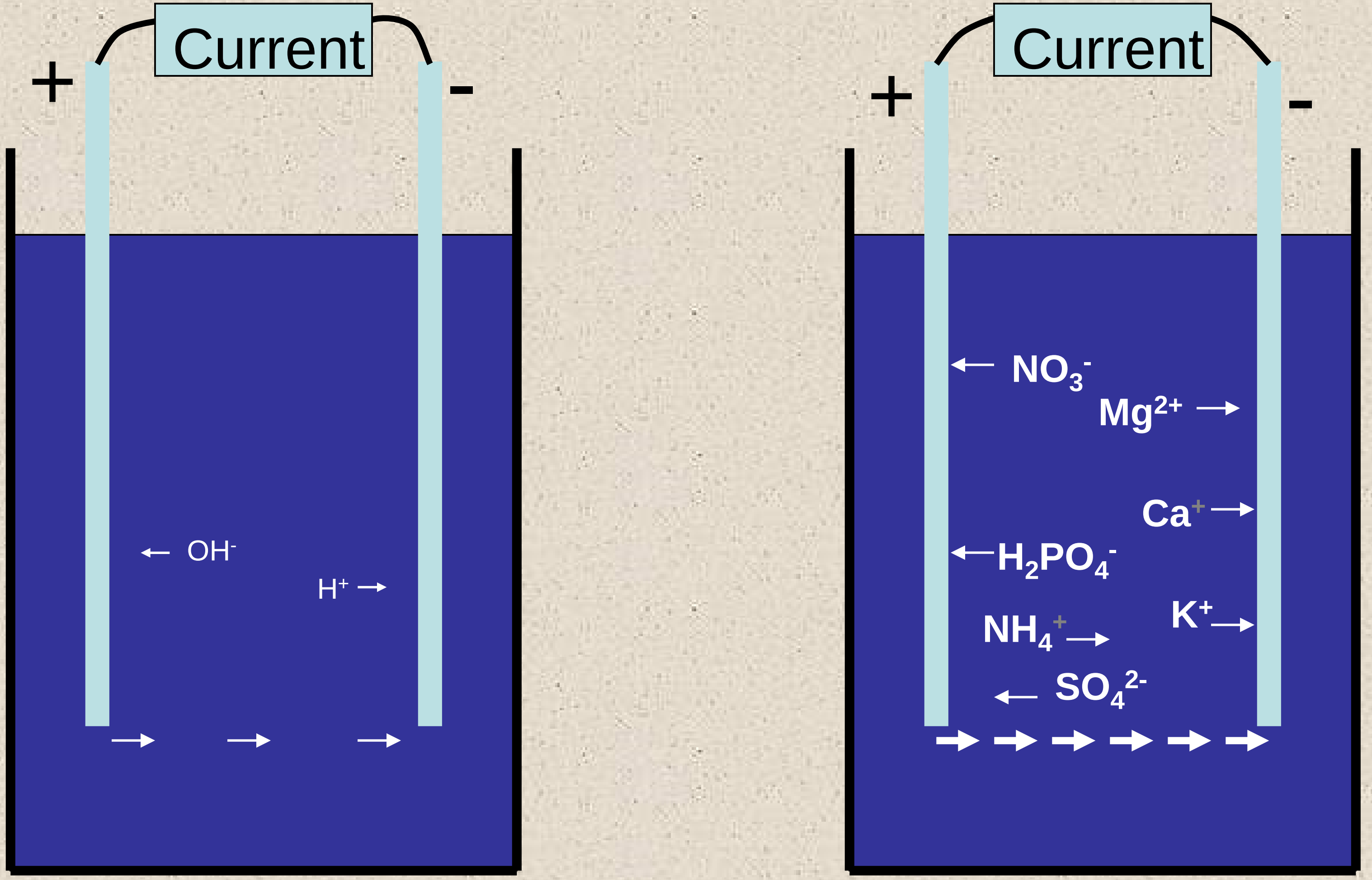
  what ends up in the plant

Electrical Conductivity (EC)



Is a measure of how well a fluid (water in the substrate) accommodates transport of electric charge.

Electrical Conductivity (EC)



Salts help conduct electricity

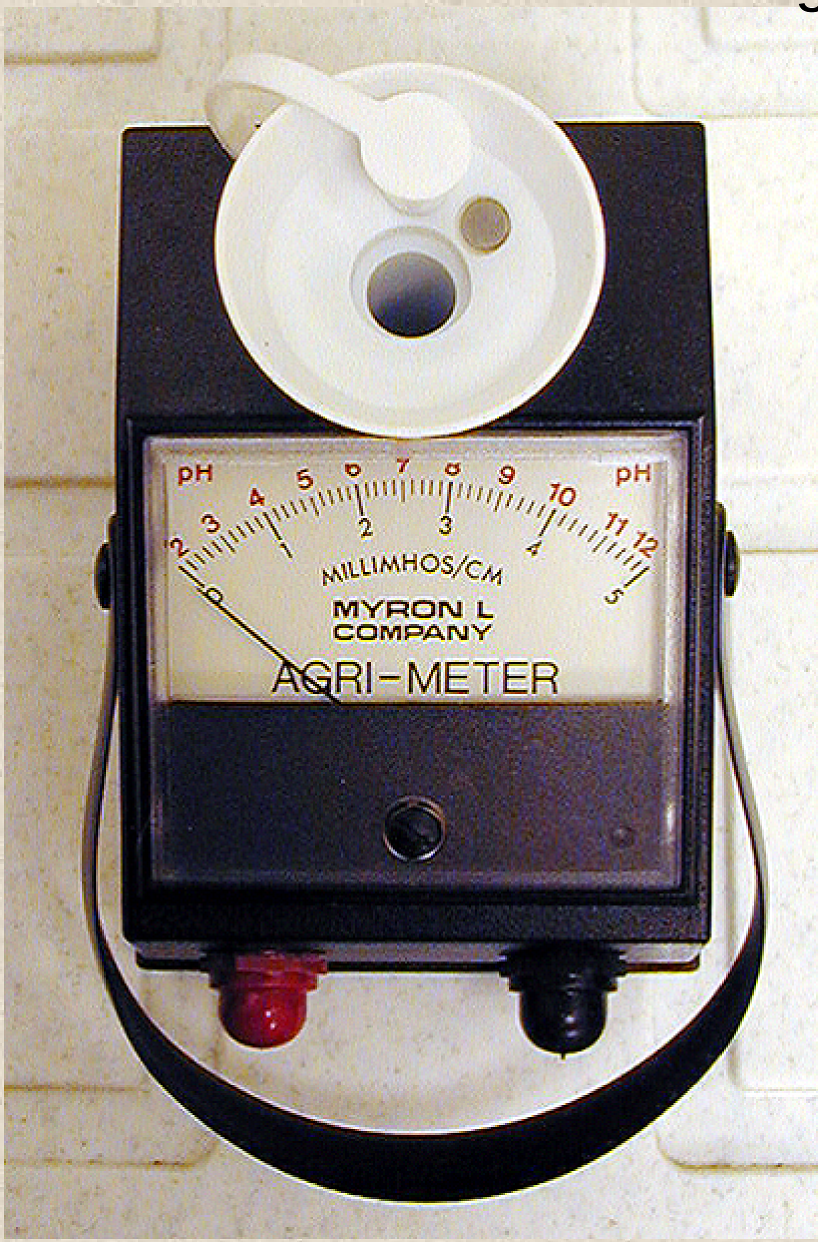
Electrical Conductivity (EC)

- A measure of the total amounts of salts (fertilizer or non-fertilizer) in the growing medium or solution
- A high EC indicates the presence of a lot of salts (fertilizer)
- Good indicator of the amount of N, P, K, Ca, Mg, and S

Electrical Conductivity Units

- Siemens (S) is used instead of Mhos
- 1m S/cm = 1 d S/m = 1,000 µ S/cm

Instruments for measuring electrical conductivity



How to monitor Nutrition for greenhouse plants?

- **Measure the concentration of fertilizer salts supplied to plants (what we give plants)**
- Measure fertilizer salts in the root zone of plants

  what is available to plants
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Calculating supplied fertilizer concentration (ppm) using EC

- Three things you need to know
  - the EC of your irrigation water
  - the EC of the fertilizer solution
  - the EC of a 100 ppm N fertilizer solution

A Little Math: calculating fertilizer concentration

1. EC of your irrigation water: 0.1 dS/m

2. EC of fertilizer solution: 1.3 dS/m

3. EC of fertilizer solution with 100 ppm N = 0.4 dS/m

Where do you get this information?

The EC of a 100 ppm N fertilizer solution

Ounces of Peters Professional 20-20-20 Per Gallon of Concentrate					
ppm	Injector Ratios				E.C.
Nitrogen	1:15	1:100	1:128	1:200	mmhos/cm
50	0.50	3.38	4.32	6.75	0.20
100	1.00	6.75	8.64	13.50	0.40
150	1.50	10.13	12.96	20.25	0.60
200	2.00	13.50	17.28	27.00	0.80
250	2.50	16.88	21.60	33.75	1.00
300	3.00	20.25	25.92	40.50	1.20
350	3.50	23.63	30.24	47.25	1.40
400	4.00	27.00	34.56	54.00	1.60

Step 1: Correct EC of the fertilizer solution by subtracting EC of the irrigation water.

Corrected EC of the fertilizer solution = 1.3 – 0.1 = 1.2 dS/m

Step 2: Calculate the fertilizer solution concentration (ppm):

Fertilizer concentration =100 x $EC_{fertilizer}$ / $EC_{100\ ppm\ N}$

= 100 x 1.2 / 0.4 = 100 x 3 = 300 ppm N

http://www.arches.uga.edu/~mvanier/Fertilizer/home.htm

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2. Concentration of fertilizer salts in the root zone (substrate EC)

Depends on :

- Substrate composition
- Fertilizer applications
- Irrigation water quality
- Irrigation method (leaching)
- Crop nutrient uptake

Substrate EC

A. **In-house tests**

- leachate collection method (pour-thru)
- direct estimation using probes

B. Growing medium analysis in the laboratory

(1:2 method, Saturated Media Extract or SME)

A. In-house tests: Pour-thru

Irrigate plants and allow water to equilibrate in the substrate

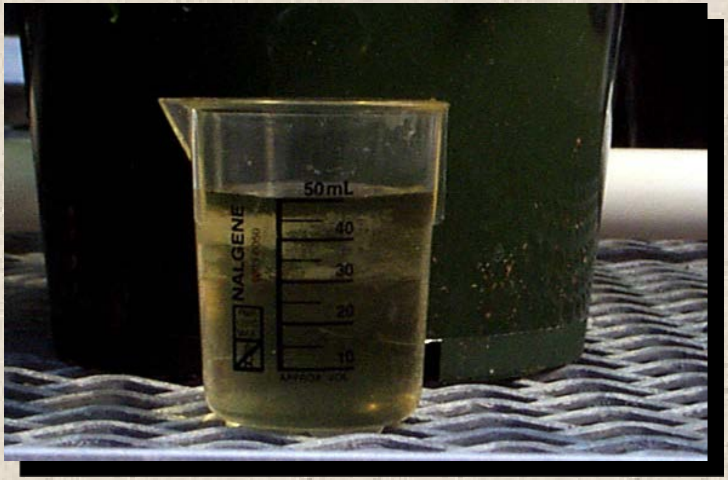
Place leachate collection cups at the bottom

Add water from the top of the substrate

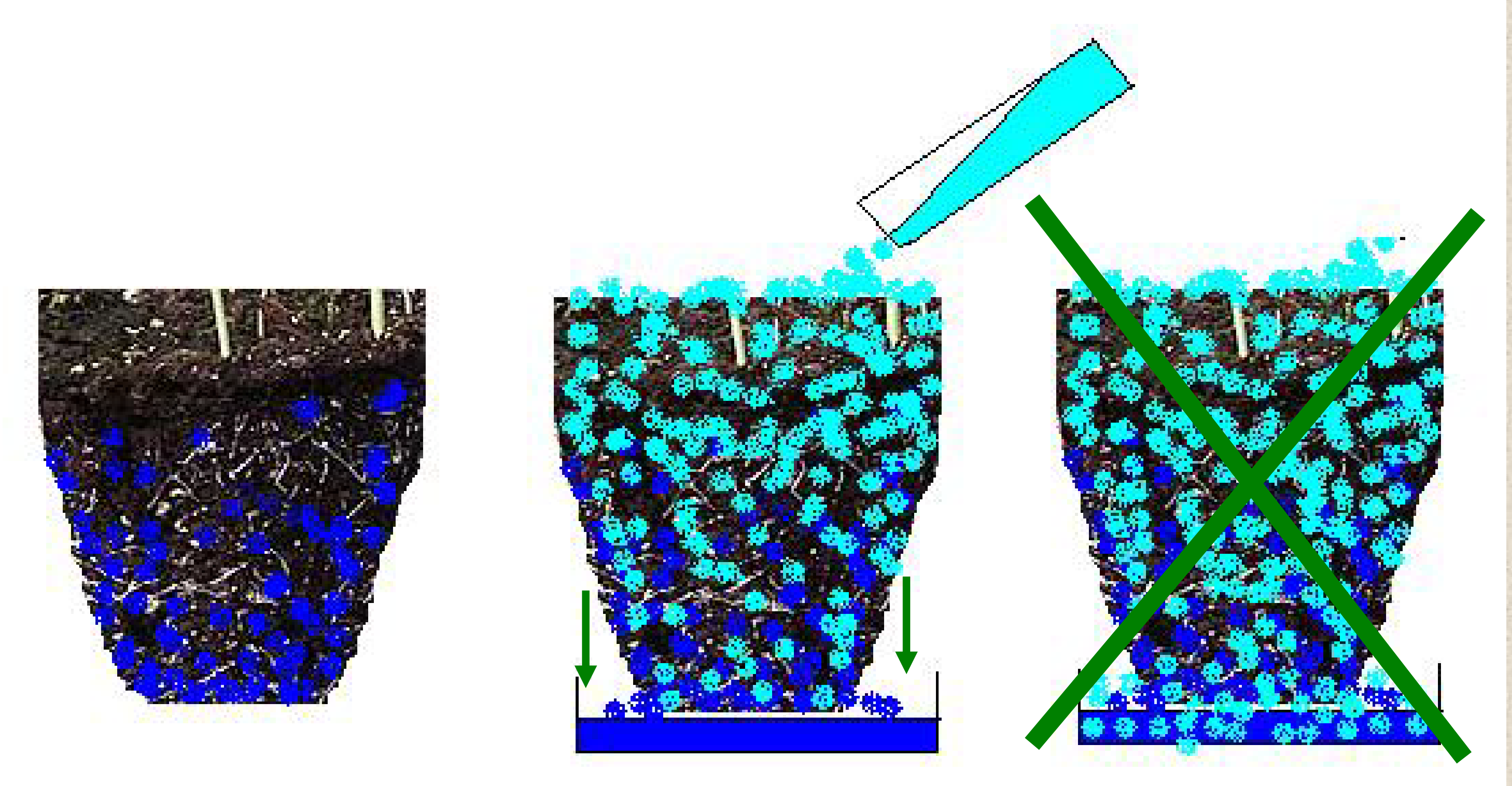
Collect the leachate from the cups into a beaker

Water Volumes for Pour-thru

Pot Size	ml	oz
4 inch	75	2.5
5 inch	75	2.5
6 inch	75	2.5
6.5 inch	100	3.5
1 Qt	75	2.5
4 Qt	150	5.0
12 Qt	350	12.0



Pour thru- do's and don'ts



Too much
water added

What kind of water to use?

- You can use your own water
- Make sure that water is applied evenly from the surface

A. In-house tests: Direct measurement

W.E.T. sensor

- Measures
  - Water
  - EC
  - Temperature

- Temperature-compensated

- Results comparable to pour-thru

Dynamax, $1,800

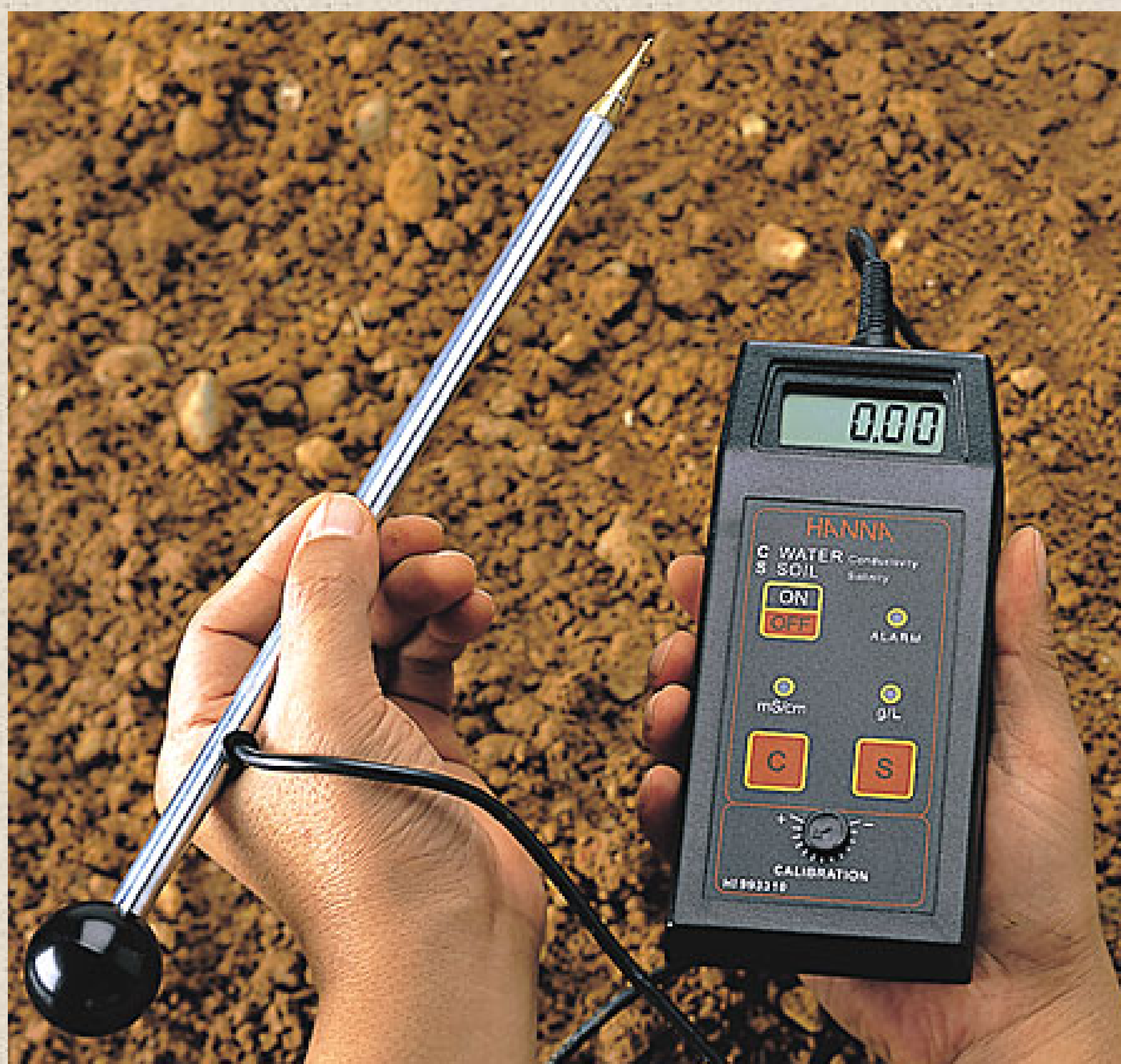
Field Scout soil EC meter

- Easy to use
- Quick
- Guidelines are being developed
- Temperature-compensated

$329, Spectrum Technologies

Hanna Soil EC meter

- Includes soil and solution probe
- Archaic units (g/L)
- **Not** temperature-compensated
- Not recommended



Various sources, $400

Calibration

- At least once a week. If you don't calibrate your meters, there is no need to collect any samples either.
- You will get bad information and **will** make the wrong decisions.

B. Growing medium analysis

Greenhouse Report

Soil, Plant and Water Laboratory

Grower Information	*Lab Information*	*County Information*
Client:	Completed: 02/08/2001 Printed: 02/08/2001	

Results

Lab		21502
Sample		1
pHw		5.00
SS	(mmhos)	2.450
Ca	(ppm)	242.1
K	(ppm)	87.12
Mg	(ppm)	78.33
NH4-N	(ppm)	1.000
NO3-N	(ppm)	170.0
P	(ppm)	16.97

EC Comparisons in different methods

1:2	SME	PourThru	Indication
0 to 0.3	0 to 0.8	0 to 1.0	Very Low
0.3 to 0.8	0.8 to 2.0	1.0 to 2.6	Low
0.8 to 1.3	2.0 to 3.5	2.6 to 4.6	Normal
1.3 to 1.8	3.5 to 5.0	4.6 to 6.5	High
1.8 to 2.3	5.0 to 6.0	6.6 to 7.8	Very High
> 2.3	> 6.0	> 7.8	Extreme

General guidelines for monitoring substrate EC

- Sample plants with different requirements separately
- Sample 5 pots or cell packs / 1000
- Randomly select plants
- Select plants from interior of bench
- Account for growth stages
  - establishment, active growth, and bloom

How to monitor Nutrition for greenhouse plants?

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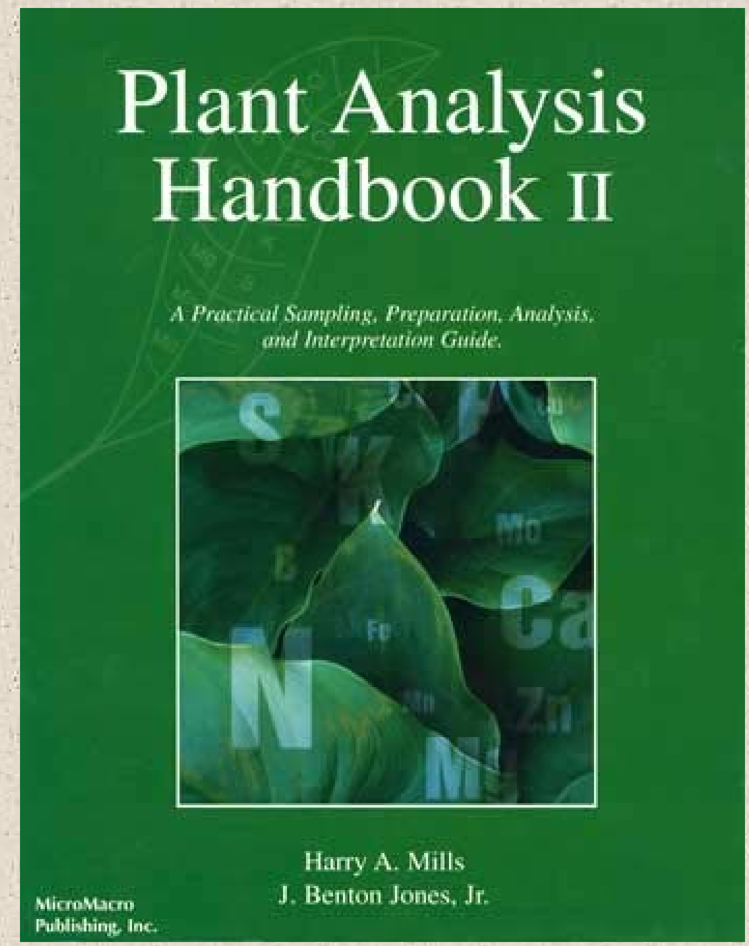
3. Tissue analysis

- Use a plant analysis handbook (ex: Micro-Macro Publishing, Inc., Athens, GA)



General guidelines: tissue nutrient concentrations

Macronutrients

N	P	K	Ca	Mg	S
%	%	%	%	%	%
2.5-4	0.4-1	2.5-4	1-2.5	0.25-1	0.2-0.7

Micronutrients

Fe	Mn	B	Cu	Zn	Mo
ppm	ppm	ppm	ppm	ppm	ppm
50-120	50-300	25-75	5-25	25-100	0.2-1

Plant Analysis report

PLANT ANALYSIS REPORT

GROWER:

DATE: 05/28/01

COUNTY:

KIT NUMBER:

LAB NUMBER: 2507

SAMPLE NUMBER: 1

CROP: Geranium

UNIVERSITY OF GEORGIA

COOPERATIVE EXTENSION SERVICE

ATHENS, GA. 30602

PERCENTAGE (%)						PARTS PER MILLION (PPM)					
N	P	K	CA	MG	S	MN	FE	AL	B	CU	ZN
3.78	0.46	4.20	1.79	0.76	0.40	230	319	81	33	8	36

RECOMMENDATIONS

pH or power of Hydrogen

- pH is negative logarithm of hydrogen ion concentration (very confusing!!)

- Let’s say that pH describes hydrogen ion concentration in the solution

- Low and high pH terms are a bit tricky….low pH actually has high H+ ions!!

a low pH of 1 [= -log (10^{-1})] has 10 times more hydrogen ions than pH of 2 [= -log (10^{-2})] and 100 times more hydrogen ions than a pH of 3 [=-log(10^{-3})])

- Why does hydrogen ions exist in water?

pH scale

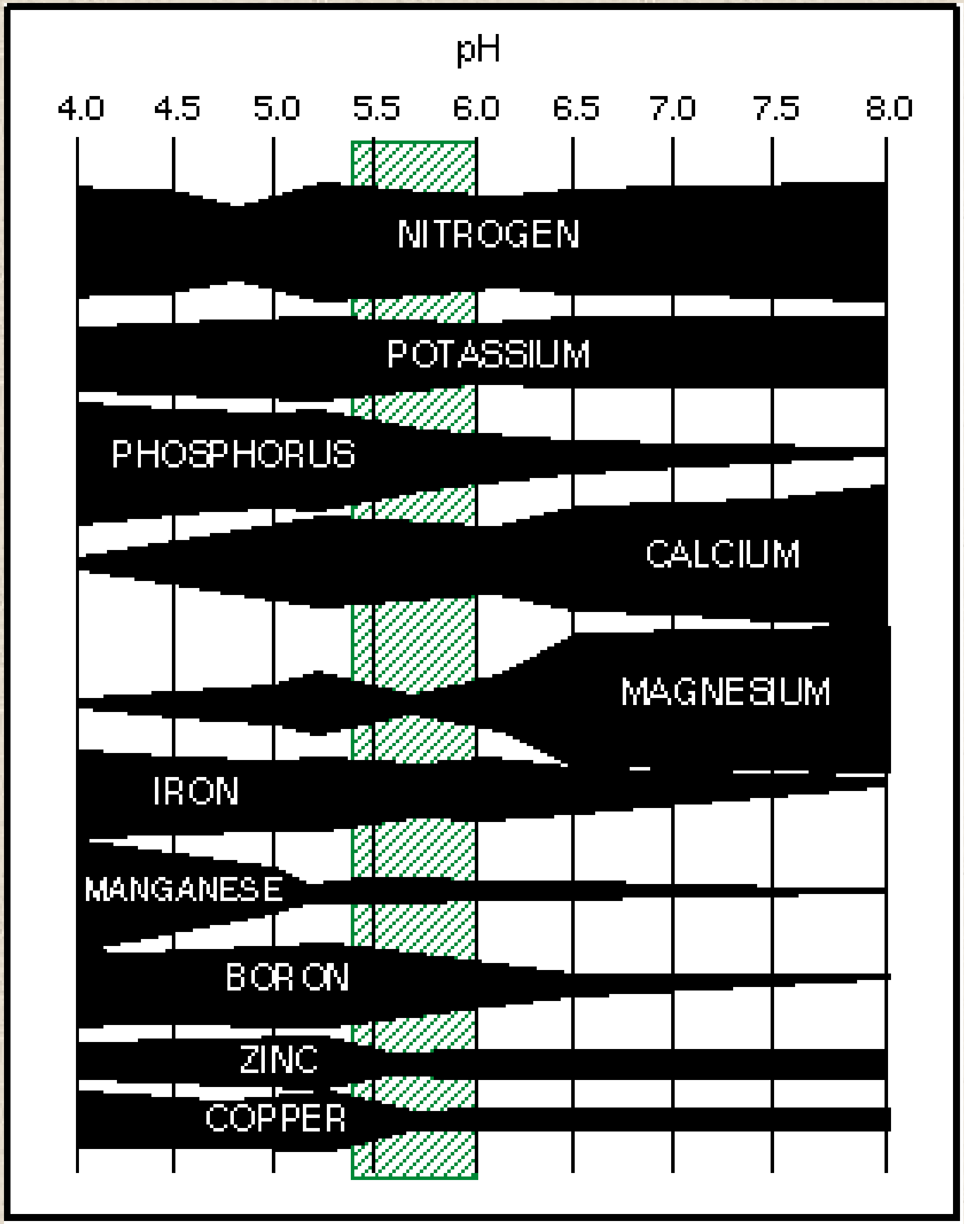
- There are more hydrogen ions under acidic conditions
- This is because an acid (ex: HCl easily dissociates into H+ and Cl- ions in water increasing H+ ion concentration)
- Another example (acidic fertilizer containing NH4+ ion)

  $NH_4^+ + H_2O = NH_4OH +$ **H^+**

Why does pH matter?

- Low pH increases solubility of positively charged ions
- An ion (ex: Fe, Mn, Zn) should be soluble or present in the solution for it to be taken by roots
- As pH decreases (more H+ ions in the solution), the positively charged ions that are adsorbed on the surface of the substrate will be increasingly exchanged with H+ ions.
- By exchange, positively charged ions like Fe, Mn and Zn will become available in the solution phase, while their spots on the substrate are taken by H+ ions
- Opposite effect at high pH. why?

pH of the substrate and nutrient availability



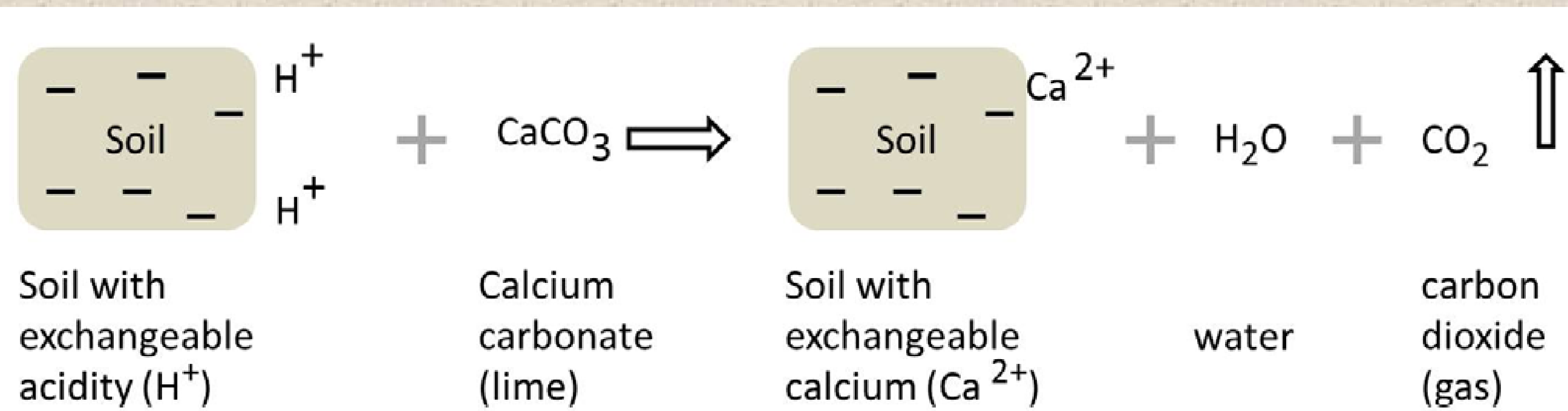
- Sometimes, nutrients are present in the substrate but may not be available to plants due to pH effect

- Adding more nutrients may not be helpful, monitoring pH is key

- pH is affected by the type of the substrate (peat and pine bark are acidic, vermiculite is basic while perlite and sand are neutral) and nitrogen form in the fertilizer

- In acidic substrates, add lime ($CaCO3$) to reduce low pH effect; to decrease pH add an acidic fertilizer

Courtesy: oregonstate.edu


Soil
H+
H+
+
CaCO3
Soil
Ca 2+
+
H2O
+
CO2
Soil with exchangeable acidity (H+)
Calcium carbonate (lime)
Soil with exchangeable calcium (Ca 2+)
water
carbon dioxide (gas)

Alkalinity of water

- Indicates the extent of carbonates and bicarbonates in the water (mg/L or meq /L)
- Important because alkalinity neutralizes acidic effect. In certain situations, irrigation water may contain high pH.
- Growers usually add dilute sulfuric acid to water for reducing pH
- However, if the water is also alkaline in addition to having high pH, the amount of acid needed for reducing pH will be higher
- Alkalinity is not same as alkaline (or sodic)!!

Cation exchange capacity (CEC)

- It is the ability of substrate to adsorb and release cations (positively charged ions, Ca, Mg, Al, Fe, Zn etc.)
- There are negatively charged sites on the substrate particles that attract and adsorb cations
- Materials like peat and pine bark have higher CEC than perlite or sand
- High CEC is better!!

- Generally substrates with higher CEC are better as they can hold more nutrients (when fertilizers are applied) and consistently supply them to plants

- Higher CEC is also good for buffering pH changes

- When you add fertilizer containing NH+ form of nitrogen, it will combine with water (H+ OH-) and releases more H+ ions in the solution while NH4+ combines with OH-.

- Thus pH is further lowered with an acidic fertilizer

- But if a substrate has high CEC, it will adsorb the added NH+ ions from the fertilizer on to the surface there by reducing the effect of NH4

Anion exchange capacity (AEC)

- It is the ability of substrate to adsorb and release anions (negatively charged ions, NO_3^-, PO_4^- etc.)
- AEC is very less in horticultural substrates as peat and pine bark particles are negatively charged
- This is why nitrates or phosphates, which are negatively charged ions, leach from horticultural substrates and causing environmental issues