Dirt, Fert and Squirt

(1) Supplying Essential Nutrients

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What are the most common nutritional problems?

- Too much fertilizer
- Not enough fertilizer

- pH too high
- pH too low

Nutrient level (EC) in a pot is like a bank

Deposits
- Irrigation water
- Water-soluble fertilizer
- Surface-applied fertilizer

Withdrawals
- Uptake by plant
- Salt layer at top of medium
- Leaching

Starting balance
- Media components
- Pre-plant charge

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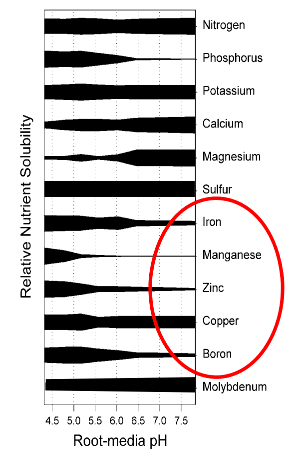
pH of the growing media (“Substrate-pH”) affects...

- Nutrient solubility
- Uptake by Plant
- Plant health
  too much → toxicity
  too little → deficiency



Many factors affect substrate-pH

BASIC Factors (Raise pH)	ACID Factors (Lower pH)
Lime	Substrate
Low fert	High fert
Nitrate NO_3^-	Ammonium NH_4^+
Alkalinity	Acid

Species: Petunia ↔ Geranium

pH balance

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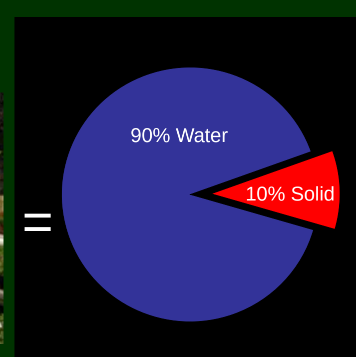
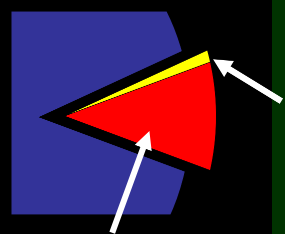


Essential Plant Nutrients



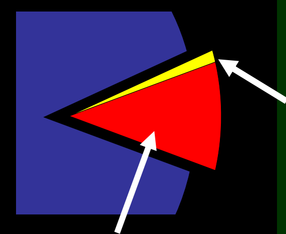
Carbon (C)
Hydrogen (H)
Oxygen (O)

Exercise:

a) Partner up with the person on your right. If there is no one to your right: good grief, just improvise.

a) Write down the 12 essential nutrients we normally provide in fertilizer. No more than 6 elements per partner. Yes, it's a race. Shout when you have them all.

Essential Plant Nutrients



Carbon (C)
Hydrogen (H)
Oxygen (O)

Fertilizer nutrients

Nitrogen	(N)
Phosphorus	(P)
Potassium	(K)
Calcium	(Ca)
Magnesium	(Mg)
Sulfur	(S)
Iron	(Fe)
Manganese	(Mn)
Zinc	(Zn)
Copper	(Cu)
Boron	(B)
Molybdenum	(Mo)

Generally not considered essential fertilizer nutrients

Sodium	(Na)
Chloride	(Cl)
Silicon	(Si)
Nickel	(Ni)

Typical Leaf Nutrient Concentrations
(Percentage of leaf dry weight)

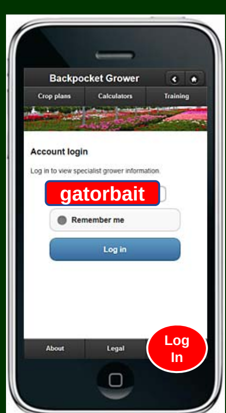
		Nutrient Percentage	
Nitrogen	(N)	4.0%	**Macronutrients**
Phosphorus	(P)	0.5%	
Potassium	(K)	4.0%	
Calcium	(Ca)	1.0%	
Magnesium	(Mg)	0.5%	
Sulfur	(S)	0.5%	
Iron	(Fe)	0.0200%	**Micronutrients**
Manganese	(Mn)	0.0200%	
Zinc	(Zn)	0.0030%	
Copper	(Cu)	0.0010%	
Boron	(B)	0.0060%	
Molybdenum	(Mo)	0.0001%	

ppm versus %

- 1 ppm (part per million)
  - = 1/1,000,000
  - = liquids: 1 mg/L (milligrams/liter) = 1 g/m^3
  - = solids: 1 mg/kg (milligrams/kilogram)
- 1% (per cent)
  - = 1/100
  - = 10,000 ppm

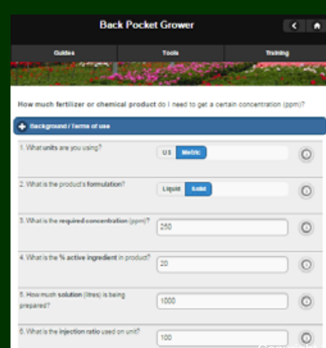
ppm calcs in Back Pocket Grower

- Go to backpocketgrower.com with your browser.
- Looks best on a mobile device.
- Log in (password for 2016 training account: gatorbait)



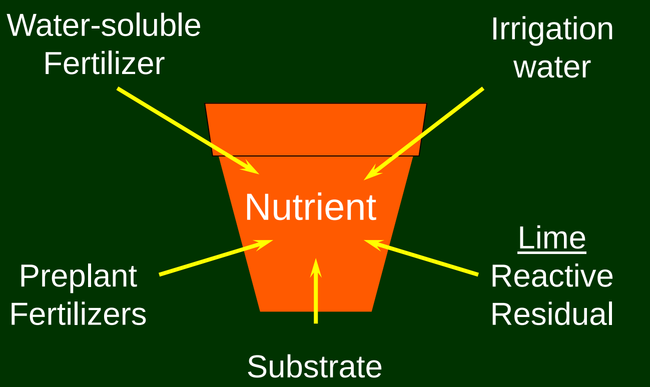
Exercise: BackPocketGrower.org

How much 20-10-20 to add to a 1000 L fertilizer stock tank with a 1:100 dilutor in order to get 250 ppm N?



Add 125 kg of product to 1000 liters

Essential nutrients can come from multiple sources



Nursery lab water tests

Nursery	Example 1	Example 2	Target ranges	
			Min	Max
pH	7.6	7.1	5.0	7.0
Alkalinity (ppm $CaCO_3$)	35	242	40	120
EC (mS/cm)	0.11	1.0	0.0	1.0
NO3-N (ppm)	0.9	0.0	0	10
P (ppm)	<0.1	0.3	0	20
K (ppm)	2	17	0	150
Ca (ppm)	4.1	167	0	150
Mg (ppm)	2.3	8	0	75
SO4-S (ppm)	11	180	0	120
Fe (ppm)	<0.1	0.0	0.00	2.0
B (ppm)	0.001	0.1	0.05	5.0
Na (ppm)	15	28	0	100
Cl (ppm)	5.7	57	0	70

For example, irrigation water provides nutrients & other ions

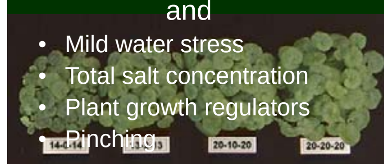
Example water soluble fertilizer plus irrigation water quality

mS/cm or ppm:	EC	HCO_3	N	P	K	Ca	Mg	S
Fertilizer	2.0	0	229	46	220	146	50	63
Irrigation water	1.0	242	0	0.3	17	167	8	180
Expected drip solution	3.0	242	229	46.3	237	313	58	243

Plant Nutrients and Growth Control

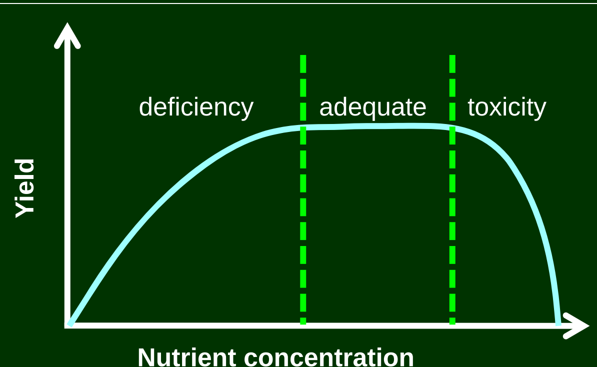
Used to control growth
- Nitrogen (N)
- Phosphorus (P)

and
- Mild water stress
- Total salt concentration
- Plant growth regulators
- Pinching



Not used to control growth

Effect of nutrient supply on crop yield



Deficiencies and Toxicities

- Too much or too little of a nutrient for healthy growth results in a toxicity or a deficiency
- Toxicities can occur from:
  - essential elements
  - other contaminants (e.g. Al, Na, pesticides)
- Symptoms vary:
  - mobility of the nutrient in plant tissue
  - how the nutrient is used in plant metabolism and growth

See http://www.ces.ncsu.edu/depts/hort/floriculture/def/ for deficiency symptoms of floriculture crops from NC State Univerrsity

Mobility of Nutrients

Mobile Nutrients
- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Magnesium (Mg)

Somewhat Mobile
- Sulfur (S)
- Molybdenum (Mo)

Immobile Nutrients
- Calcium (Ca)
- Iron (Fe)
- Manganese (Mn)
- Zinc (Zn)
- Copper (Cu)
- Boron (B)

Example of deficiency of an immobile nutrient: Iron

New leaves

Fe cannot be mobilized to growing point

Old leaves

Example of deficiency of a mobile nutrient: Nitrogen

New leaves

N

Old leaves

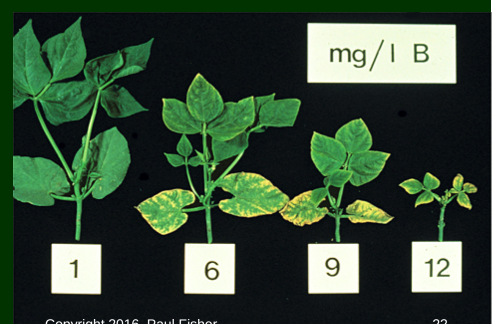
N-deficient Normal

Nutrient toxicities: tend to accumulate in older tissue because of leaf age

e.g. Boron toxicity

New leaves

Old leaves



Total salt concentration

- Electrical Conductivity (EC in mS/cm), or Total Dissolved Solids (TDS in ppm)
- 1 mS/cm = 1 dS/m = 100 mS/m
  = 1 mmho/cm = 1000 microS/cm
- 1 mS/cm of EC = approx. 700 ppm TDS (but this varies between meters)

In greenhouse production, mainly use EC units

- You need an EC meter to measure
  - EC of irrigation water (is the level of contaminants changing?)
  - EC of the substrate (are nutrients deficient, or are salts too high?)
  - EC of nutrient solution (is the dilutor/injector dosing the right amount of water soluble fertilizer?)

Interpreting EC in the substrate

- You can test substrate-EC with a plug squeeze, saturated paste, 1 soil:1.5 or 2 water, or pour-through test.
- For each type of test, the target EC level varies depending on how much dilution occurs during sample preparation.
- With a pour-through (onsite test), a typical range is
  – 1.0 to 2.5 mS/cm for young plants.
- With a Saturated Paste Extract (lab test), a typical range is
  – 0.75 to 1.9 for young plants

Nutrient level (EC) in a pot is like a bank

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- Irrigation water
- Water-soluble fertilizer
- Surface-applied fertilizer

Withdrawals
- Uptake by plant
- Salt layer at top of medium
- Leaching

Starting balance
- Media components
- Pre-plant charge

High EC can arise in two ways…

Deposits **greater than** **Withdrawals**

Starting balance
Initial nutrient charge is high

High EC: root rot

High EC: hard crispy or leathery leaves, less leaf expansion, chlorosis or necrosis in older leaves

Low EC can arise in two ways…

Deposits **less than** **Withdrawals**

Starting balance
Initial nutrient charge is low

Low EC: chlorosis, stunting

25 ppm N 150 ppm N

Low EC and Nitrogen deficiency

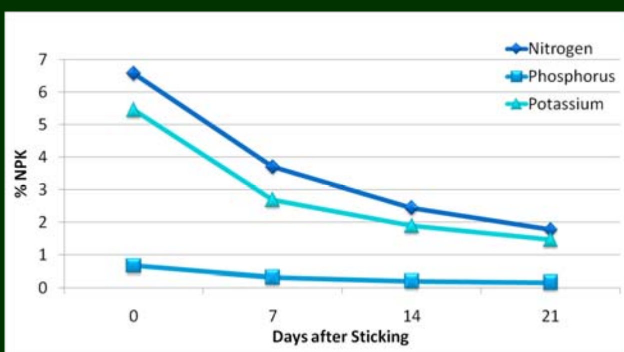
New leaves

N

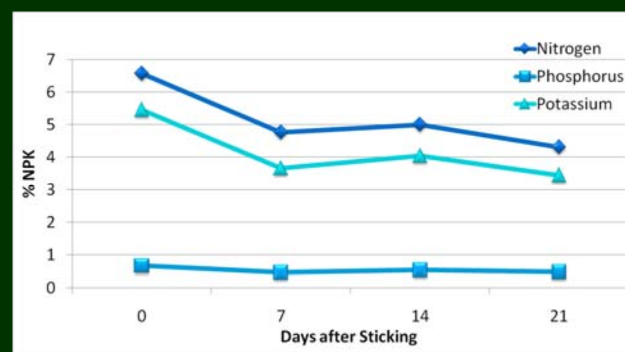
Old leaves

N-deficient Normal

% N P K in Petunia Tissue During Propagation (0 ppm N Applied)



% N P K in Petunia Tissue During Propagation (100 ppm N Applied)



Make sure adequate fertilizer in stock

Deficient (argyranthemum) during week 1 probably because of low nutrient reserve in cuttings.

Reported fertilizer type and concentration

- Calibrachoa and petunia crops
- More than one strategy!

Grower	ppm N By Week			
	1	2	3	4
A	200	200	200	200
B	0	200	170	200
C	150	200	200	150
D	0	300	300	300
E	0	0	150	150
F	0	0	1x150 2x300	1x150 2x300
G	0	0	200	200
H	100	100	100	100

Nutrition strategy during cutting propagation

Average ppm over 4 wks

N	76
P	4
K	65
Ca	61
Mg	17
S	21
Fe	2
Mn	0.4
Zn	0.4
Cu	0.3
B	0.2
Mo	0.05

Actual applied fertilizer solution from 8 leading propagators.

Nutrition strategy during cutting propagation

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N	76
P	4
K	65
Ca	61
Mg	17
S	21
Fe	2
Mn	0.4
Zn	0.4
Cu	0.3
B	0.2
Mo	0.05

17-5-17

N	76
P	10
K	63
Ca	13
Mg	4
S	0.0
Fe	0.5
Mn	0.2
Zn	0.2
Cu	0.1
B	0.1
Mo	0.04

- *Consider supplementing micronutrients.*
- *Also factor in water quality.*

Expected Irrigation EC

Formula	50 ppm N	100 ppm N	200 ppm N	400 ppm N
21-7-7	0.28	0.56	1.12	2.23
9-45-15	0.60	1.20	2.41	4.82
20-2-20	0.31	0.62	1.24	2.48
24-8-16	0.22	0.44	0.88	1.76
20-20-20	0.20	0.40	0.80	1.60
20-10-20	0.33	0.66	1.32	2.63
21-5-20	0.29	0.58	1.16	2.33
20-8-20	0.32	0.64	1.28	2.56
15-15-15	0.32	0.64	1.28	2.56
15-16-17	0.34	0.68	1.36	2.72
15-5-25	0.39	0.78	1.56	3.13
20-0-20-4 Ca	0.25	0.50	1.00	2.00
17-5-17-3 Ca-1Mg	0.32	0.64	1.28	2.56
15-3-16-3 Ca-2 Mg	0.35	0.70	1.40	2.80
15-5-15-5 Ca-2 Mg	0.39	0.78	1.56	3.13
13-2-13-6 Ca-3 Mg	0.34	0.68	1.36	2.72
14-0-14-6 Ca-3 Mg	0.34	0.69	1.38	2.76
15-0-15-11 Ca	0.37	0.74	1.48	2.96

Expected Irrigation EC

How to do it

EC (fertilizer) + EC (irrigation water) = EC (from the hose)

Example: 13-2-13 at 200 ppm N = 1.36 mS/cm
Irrigation water EC is 0.5 mS/cm

Measured Irrigation EC

How to do it

EC (from the hose) - EC (irrigation water) = Fertilizer EC

Example: 20-10-20 solution at EC of 1.8 mS/cm
Water EC = 0.5 mS/cm

Fertilizer EC Chart

Formula	50 ppm N	100 ppm N	200 ppm N	400 ppm N
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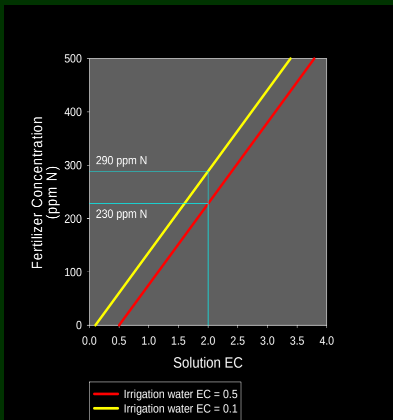
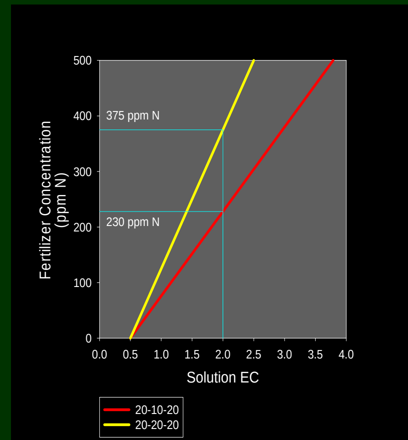
20-10-20 with 2 types of irrigation water

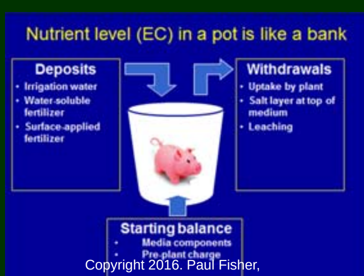


Same water with 2 types of fertilizer

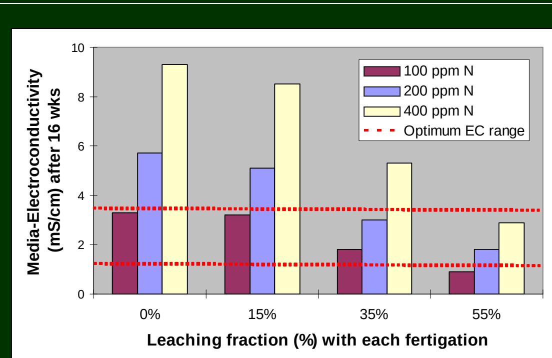


Interpreting EC: you move from (a) overhead sprinklers to (b) subirrigation or drip.

How will EC in the substrate change?



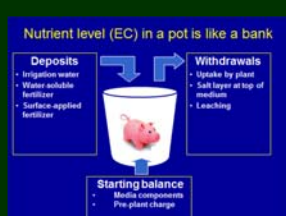
Fact: The more you leach (withdraw), the more fertilizer you must apply (deposit)



Yelanich and Biernbaum (Michigan State University)

Do you need to leach?

Only true if:



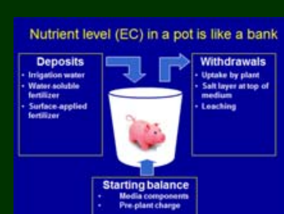
- Poor water quality
  - >50 ppm sodium or chloride in water
  - EC > 0.7 mS/cm
- Salt levels build up in the mix (EC > 2.5 mS/cm with a pour-through for young plants)
- Inefficient irrigation system

Should you "build up" a young plant early on by providing lots of fertilizer?

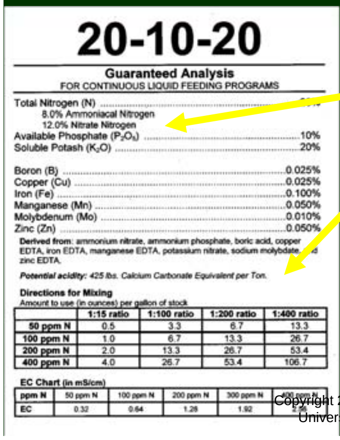
No: Match fertilizer concentration to rate of crop growth and nutrient uptake.

Fertilizer slowly built up over time

Fertilizer high rate from planting onwards



Reading a bag of blended fertilizer



20-10-20

Guaranteed Analysis
FOR CONTINUOUS LIQUID FEEDING PROGRAMS

Total Nitrogen (N) ....
8.0% Ammoniacal Nitrogen
12.0% Nitrate Nitrogen
Available Phosphate (P_2O_5) 10%
Soluble Potash (K_2O) 20%

Boron (B) 0.025%
Copper (Cu) 0.025%
Iron (Fe) 0.100%
Manganese (Mn) 0.050%
Molybdenum (Mo) 0.010%
Zinc (Zn) 0.050%

Derived from: ammonium nitrate, ammonium phosphate, boric acid, copper EDTA, iron EDTA, manganese EDTA, potassium nitrate, sodium molybdate, zinc EDTA.

Potential acidity: 425 lbs. Calcium Carbonate Equivalent per Ton.

Directions for Mixing
Amount to use (in ounces) per gallon of stock

	1:15 ratio	1:100 ratio	1:200 ratio	1:400 ratio
50 ppm N	0.5	3.3	6.7	13.3
100 ppm N	1.0	6.7	13.3	26.7
200 ppm N	2.0	13.3	26.7	53.4
400 ppm N	4.0	26.7	53.4	106.7

EC Chart (in mS/cm)

ppm N	50 ppm N	100 ppm N	200 ppm N	300 ppm N	400 ppm N
EC	0.32	0.64	1.28	1.92	[illegible]

- Fertilizer Formula
- Nitrogen Form
- pH Effect
- Macronutrients
- Micronutrients
- Applying Fertilizer
  - Mixing Rates
  - EC Chart

Coated Fertilizers

- Controlled-Released Fertilizers
  - Other names –
  Resin-coated, plastic coated, polymer coated

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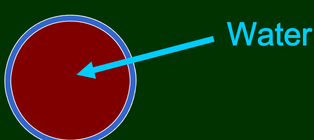

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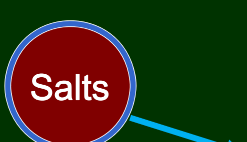

<u>Salt release based on:</u>
1) Substrate Temperature
2) Fertilizer release duration
3) Incorporation Rate

Difference between coated and water-soluble fertilizers?

<u>18-6-12 270-day formula</u>
•9.4% Nitrate N
•8.6% Ammoniacal N
•47% NH_4-N

Derived From:
Ammonium nitrate, ammonium phosphate, calcium phosphate, potassium nitrate, magnesium sulfate

Micronutrients

<u>20-10-20 water soluble</u>
•12% Nitrate N
•8% Ammoniacal N
•40% NH_4-N

Derived from:
Ammonium nitrate, ammonium phosphate, potassium nitrate, magnesium sulfate

Micronutrients

An example controlled-release fertilizer bag

17-11-10+2MgO+TE

5-6

16 °C	21 °C	26 °C
6-7 M	5-6 M	4-5 M

Guaranteed analysis

17%	**TOTAL NITROGEN (N)**
	6.5% nitrate nitrogen (NO_3-N)
	8.8% ammoniacal nitrogen (NH_4-N)
	1.7% urea nitrogen (Ur-N)
11%	**PHOSPHORUS PENTOXIDE (P_2O_5)**
	8.3% water soluble
10%	**POTASSIUM OXIDE (K_2O)**
	10% water soluble
2.0%	MAGNESIUM OXIDE (MgO)
0.02%	Boron (B)
0.037%	Copper (Cu)
0.33%	Iron (Fe) 0.06% chelated by EDTA
0.04%	Manganese (Mn)
0.015%	Molybdenum (Mo)
0.011%	Zinc (Zn)

Recommended application rates

	Light feeding	Normal feeding	Heavy feeding
Container Nursery Stock	2-2.5 g/l	3-3.5 g/l	4-4.5 g/l
Pot Plants	2-3 g/l	3-4 g/l	4-5 g/l
Bedding plants/Annuals	2-3 g/l	3-4.5 g/l	4-5.5 g/l

Take home message

- Provide all the essential nutrients in a moderate amount
- Use electrical conductivity or total dissolved solids as an onsite test
- Use complete nutrient analysis at a lab when problems arise