Irrigation and Fertilization

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Topics

- Irrigation
- Fertilization
- Transplanting
- Pruning & Training
- Pollination
- Harvest
- Containers
- Packing lines

Irrigation and Fertilization

- EC guidelines
- pH guidelines
- How to monitor
- Equipment suggestions
- Goals in fertilization program
  - Controlling growth

Why is EC important?

- High EC increases fruit quality
- EC too high keeps water from moving into the root
  - Drought
  - Overall lack of nutrients
  - Lack of calcium (BER)
- EC too low means not enough fertilizer present
  - Low fruit quality

Effect of EC on fruit quality

Characteristic	EC 2.6	EC 3.5
Fruit #	224	222
Fruit yield	12.7	11.9
Average fruit Weight	56	54
Coloring in days	4.4	4.1
Shelflife in days	17.5	19.2
EC fruit sap dS/m	5.8	6.2
Acid in fruit sap mmol/l	75	84
Refraction in fruit sap	4.8	5.0

EC Guidelines

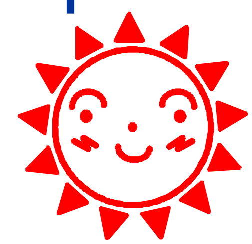
- Should be 1.0-3.0 millimhos/cm (or deciSiemen/m or mS/cm) or 1000-3000 micromhos
  - go to conversions at: www.ces.ncsu.edu/greenhouse_veg/ for other units
- Rockwool EC 1.5-2.0 millimhos/cm, but can be grown somewhat higher to improve fruit quality (BER less likely in hydroponics than soil).

How to Monitor in Containers

- Check fertilizer solution EC and pH at end of drip line with an extra bucket, especially after re-mixing
  - Make sure sample drippers are at same level as plant drippers
- Check drainage (leachate) using pour-through method (see NCSU Floriculture website) for peat & perlite
- Peat based mixes: can also use saturated media extraction (SME) on substrate

What You're Looking for!

- Amount of water draining out at each watering: 10-15% to avoid salt buildup and compensate for unevenness in drippers and 'hot spots'.



- EC and pH in drainage not more than 5-10% different from incoming
  - EC Much lower: plants 'hungry'
  - EC Much higher: danger of salt buildup
  - pH out of range: nutrients unavailable

Sensors to check EC and nutrients*

Soluble salt measurements of saturated media can be made by simply decanting a few drops of extract onto the cell of the Cardy Twin EC meter.

Conductivity cells. Dip-type must be deep enough in liquid to cover holes midway up the shaft. Cup-type can be put in the solution or filled with a small volume of liquid.

Fertilizer meters are specialized EC meters that can be calibrated for specific fertilizer formulations and read out in grams per liter. The meter on the right measures concentration for a single fertilizer while the larger meter on the left can measure two separate fertilizers and EC.

*Images provided by George Elliot. June 1999 article in Greenhouse Product news ‘Selecting the Right E.C. Meter’

pH-Tomatoes

- pH should be 5.6-5.8 for tomatoes in peat/pine bark bags (peat tends to be acidic)
  - 5.5-6.0 for rockwool slabs (must be pre-soaked before planting)
- Above 6.5, essential micronutrients and phosphorus become less available
  - At 7.0 tomato yield decreased 25%

pH-other crops

- Optimum for most crops at 6.0
- Low pH (below 6.2) makes lettuce or cucumbers susceptible to molybdenum deficiency
- May also need to correct alkalinity in irrigation water
  - Go to NCSU Floriculture site for conversions: http://www.ces.ncsu.edu/depts/hort/floriculture/hils/hil558.html

Types of pH meters

- Glass bulb
  - Stored wet, easily broken
  - Not recommended for saturated media extracts (SME)
- Ion Selective Field Effect Transistor (ISFET)
  - Stored dry, not easily broken
  - More expensive

Desirable pH meter features

- Rugged & portable-Cardy Twin or pH Pro
- Batteries & ac adapter
- Two-point calibration & auto-recognition are nice features
- Indication of stable reading
- Automatic temperature compensation

Other features in pH meters:

- Flat surface-good for small samples (liquid goes on surface)
- Reference and sample electrodes in same unit are more convenient than separate units
  - Refillable with potassium chloride (need to check reference and 'top off')
  - Non-refillable-gel which is not replaced

pH electrodes

ISFET (Ion selective field effect transistor) pH electrodes can be used to make measurements directly in saturated media slurries. This is a flat-surface pH electrode with non-refillable reference in a plastic body.

All you need to know about nutrition and fruit quality!*

- K:N ratios critical in tomatoes
  - Vegetative (up to first truss) requires 1.2:1 K:N
  - By Ninth flower truss, increase to 2.5:1
  - 70% of K moves into fruit
  - Insufficient K decreases flavor
- Lettuce K:N 1.7:1

* From Adams 1999 Plant Nutrition demystified and Ho and Adams 1995 Nutrient uptake and distribution in relation to crop quality

All you need to know about nutrition and fruit quality!*

- Generally N=200 mg/l and P 30 mg/l
  - Can reduce P to 10 after rooting completed
- Running at high or low EC requires careful monitoring!

All you need to know about nutrition and fruit quality!*

- Organic media requires more N than rockwool, because N may be tied up
- Form of N important-no more than 10% in ammonium form or will reduce calcium and get BER at 20% NH_4.
- High K reduces Ca and Mg availability

Irrigation amount determined by light integral

- For computerized watering:
  - Cucumber-150 ml/1MJ per plant
  - Tomato-120-130 ml/1MJ per plant
  - Pepper-100-120 ml/1MJ per plant
- Can also consider temperature, especially in summer
- Advantages: water conservation, less cracking

Aeration

- Oxygen must be at least 3 gm/l
- Decreases in hot weather
- In rockwool
  - aerate solution
  - increase watering frequency
- In peat
  - reduce watering at high temperature
  - add more iron (frequently deficient in water-logged peat)

To Steer Plants Between Generative and Vegetative Growth Using Irrigation and Fertilization: Reading the Plant!

Plant growth

Photosynthesis

- ✓ CO_2, Water and light
- ✓ Producing assimilate (Sugar)
- ✓ Organic material
- ✓ Building bricks
- ✓ Fruit, growing parts and root

Generative plant

- ✓ Fruit and flowers

Vegetative plant

- ✓ Growing points and root

Generative growth (fruiting)

- Reduce crop growth rate
  - Light irrigation
  - low relative humidity
  - high EC
- Reduce nitrogen supply or increase ratio of potassium to nitrogen

Read the plant*

	Generative plant	Vegetative plant
Fruits	Big Many Good shape Quick growing	Small Few Bad shape Slow growing
Cluster stalk	Thick and stiff Short and curved	Thin Long and bristly
Leaves	Vigorous and curled in top of plant* Short leaves Dark and stiff	Smooth in top of plant Long leaves Light green and many leaves
Flower	Near top of plant Quick opening of flower Short flowering period Dark yellow flowers	Far from top Slow flower opening Flowers stay open longer Pale, dull flowers

From presentation by Laust Dam at 2001 NCGVGA meeting

What do we want to record*

- ✓ **Climate in greenhouse and outside**
- ✓ **Water / irrigation**
- ✓ **Plant growth**
- ✓ **Energy consumption**

*From presentation by Laust Dam at 2001 NCGVGA meeting

Recording form*

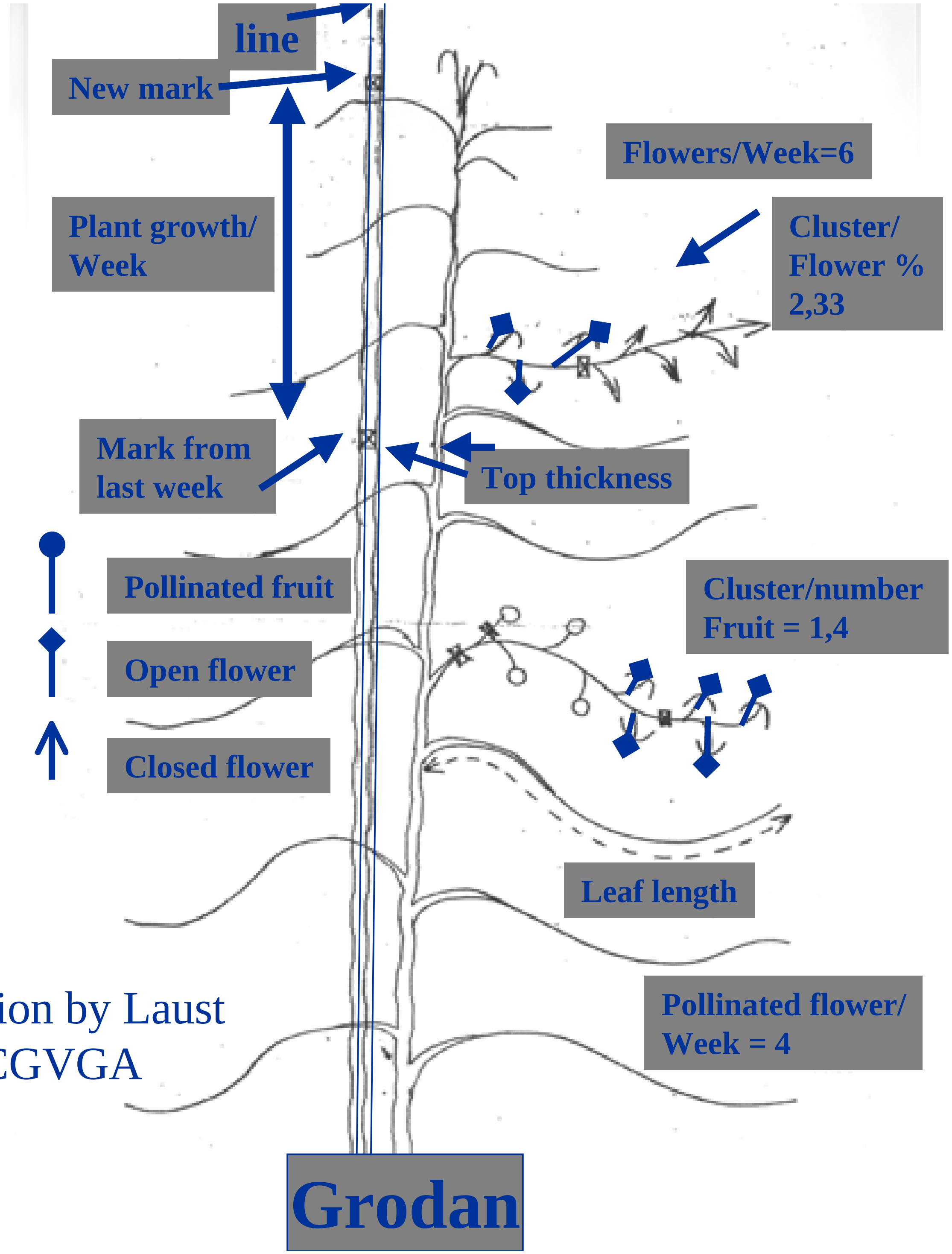
- **Climate**

1. Week No.
2. Radiation
3. Average temp. outside
4. Temp. set point (Day)
5. Temp. set point (night)
6. Temp. Increase with light
7. Pre-night Temp.
8. Average day temp.
9. Average night temp.
10. Average 24 hr. Temp.
11. Pipe temp. day
12. Pipe temp. Night
13. Humidity day
14. Humidity night
15. Delta X Day
16. Delta X night
17. CO_2 ppm

*From presentation by Laust Dam at 2001 NCGVGA meeting

- **Water / irrigation***
  1. Given water
  2. Given water (cum)
  3. Drain
  4. Water consumption
  5. Water consumption (Cum)
  6. EC – Drip
  7. EC – Slab
  8. pH – Drip
  9. pH – Slab
- **Plant recording**
  1. Plant growth
  2. Leaf length
  3. Top thickness
  4. Flowering truss
  5. Flowering speed
  6. Setting
  7. Harvest # truss and fruit
  8. Fruit load
  9. Yield
  10. Yield (Cum)
- **Energy consumption**

*From presentation by Laust Dam at 2001 NCGVGA meeting



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How to control a plant*

Control mechanism	Generative growth	Vegetative growth
Avg. Temp.	Lower	Higher
Temp. difference day/night	Higher	Lower
Day temp. to night temp.	Quick	Slow
Pipe temp.	High	low
Placing of growth pipe	Flowering truss	Ripening truss
CO2	More	Less
Humidity	Lower	Higher
E.C	Higher	Lower
Water content in slab	Low	High
Irrigation	Long but few	Short more frequent
Irrigation start	Late	Early
Irrigation stop	Early	Late

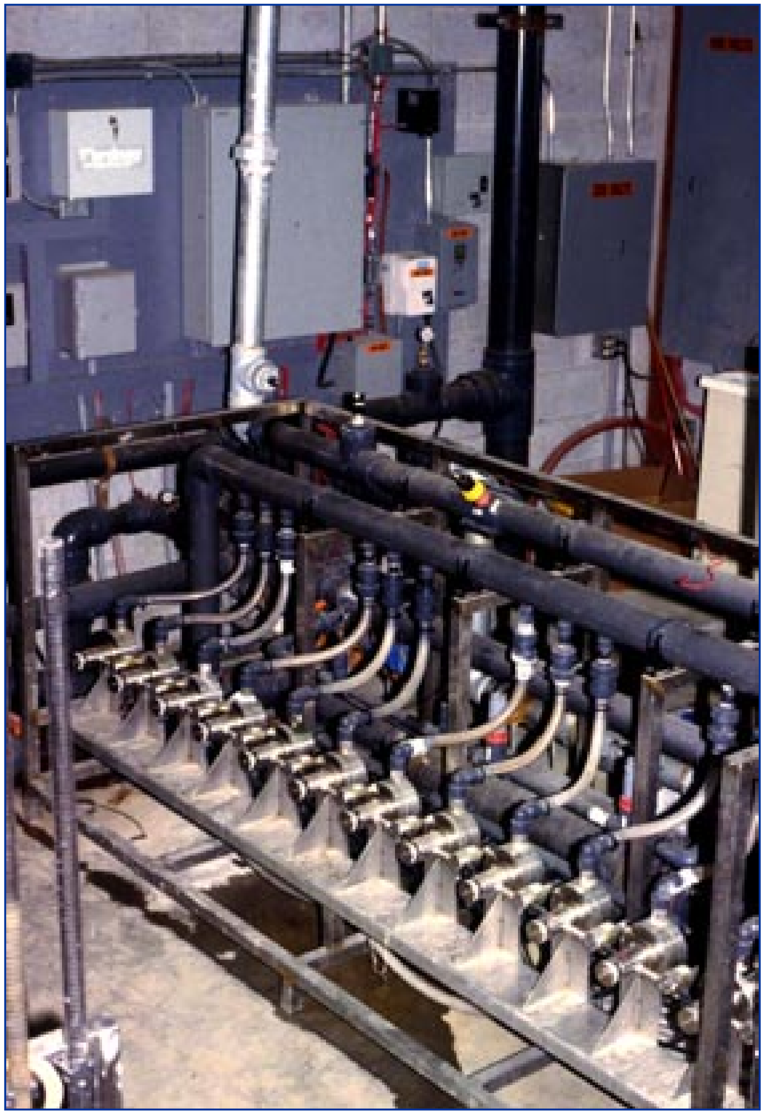
*From presentation by Laust Dam at 2001 NCGVGA meeting

Required Equipment

- Drip irrigation equipment
- Fertilizer injection equipment



Fertilization in a large Ontario Greenhouse



Computerized irrigation

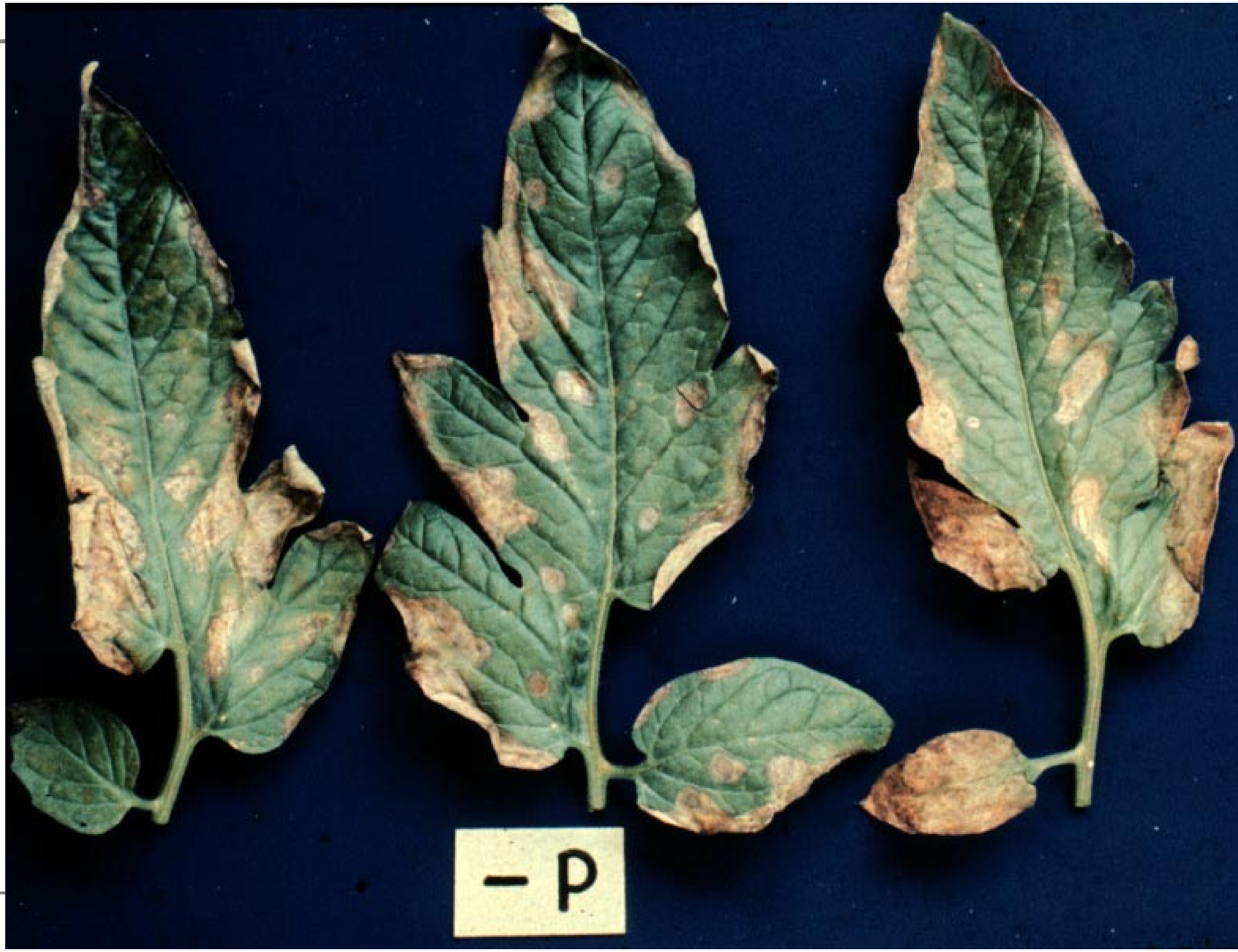
Greenhouse controllers come in all sizes!

? Deficiency

Nitrogen Deficiency

? Deficiency

Phosphorus Deficiency



? Deficiency

Mature leaf

Young leaf

Phosphorus Deficiency

Mature leaf

Young leaf

? Deficiency


Note interveinal chlorosis

Potassium Deficiency

Note interveinal chlorosis

? Deficiency

Magnesium Deficiency

Easily confused with spider mite damage!

? Deficiency

Leaves are brittle, and the mid-rib is often cracked

Boron Deficiency

Leaves are brittle, and the mid-rib is often cracked

? Deficiencies in tomato & cucumbers

Def 1

Def 2

Minor Element Deficiency

Copper (Cu)

Iron (Fe)

That’s all Folks!