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**Growing Greenhouse Tomatoes & Greenhouse Cucumbers in Containers**

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**Trends in Greenhouse Tomato Yields:**

- ~1975 top commercial yields about 100 tons per acre per year (20 #/plant\*)
- ~1990 top commercial yields about 200 tons per acre per year (40 #/plant\*)
- ~2005 top commercial yields about 330 tons per acre per year (66 #/plant\*)

\*Based on 10,000 plants per acre.

Achieved through intense environmental & crop management techniques to maximize the productive potential of the plant

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**Environmental & Cultural Factors that are Critical to Crop Production**

- o Light - quantity, photoperiod, quality
- o Temperature -
- o Water -
- o Fertility -
- o VPD or humidity - (to control disease & water use)
- o Plant care
- o Interaction of all above = crop management

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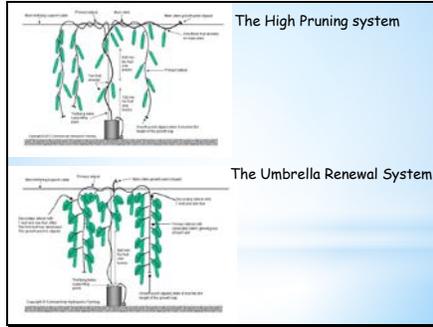
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**If you can't alter the light, then you have to adjust your management to optimize the light that is available**

Adjusting to the Light Environment:  
 Example - The Case of Limited Light

- o Plant Density - more area per plant
- o Fruit Load - carry fewer fruit
- o Temperature - run cooler temperatures
- o Irrigation - reduce quantity
- o Fertility - higher EC
- o VPD - maintain VPD above 0.03 psi to prevent disease (see <http://ohioline.osu.edu/> for fact sheet on VPD)

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**Plant Spacing: Provide More space in Light Limited Months**

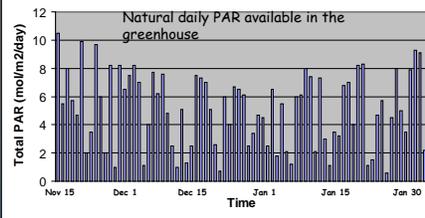


Adjust Plant Density to Optimize Fruit Quality (sq.ft./plant)

Season	Tomato	Cucumber
Light-limited	5-6	8
Light-abundant	4-5	6

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**Rule Two:**  
 Match Temperature to the Prevailing Light Environment  
 Temperature Controls The Rate of Plant Metabolism & Growth



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**The Short-Term Temperature Environment**

Adjust night temperature to the light condition of the preceding day

**Tomato**

- o During light-limited seasons:
  - o Run 60F following dark days
  - o Run 63F following bright days
- o During light-abundant seasons:
  - o Run 62F following dark days
  - o Run 65F following bright days

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**The Short-Term Temperature Environment**

Adjust night temperature to the light condition of the preceding day

**Cucumber**

- o During light-limited seasons:
  - o Run 62F following dark days
  - o Run 64F following bright days
- o During light-abundant seasons:
  - o Run 66F following dark days
  - o Run 70F following bright days

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**Grow-Tubes Boost Temperature in Localized Parts of the Plant to Boost Growth & Manage Disease**



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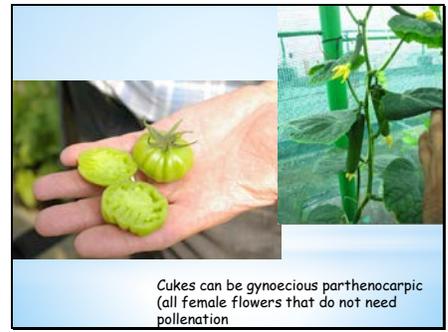
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Cucumber		
Planting Season	Leaves to 1 <sup>st</sup> fruit	Fruit on main stem
Winter planting (Dec, Jan, Feb)	10-12	3-4
Spring/Summer (Apr, May, Jun)	8-10	5-8
Late fall (Oct, Nov.)	10-12	3-4

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**'May-Check' in Tomato Fruit Set**

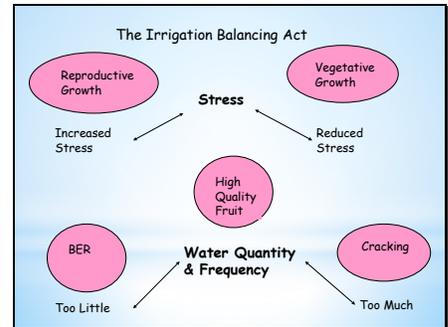
A drop in fruit set following heavy flowering & fruit set in March & April

Avoiding or reducing a drop off in production requires a total management approach: temperature, fruit load, fertility & water management

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Both Water & Fertility Can Influence the Tendency Toward Either Vegetative Growth or Reproductive (Flowering & Fruiting)

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**Irrigation: rules of thumb**

- o 8-10% dry down = Vegetative Growth
- o 17% dry down = reproductive growth
- o Adjust water stress throughout the day (wetter early, drier later)
- o Adjust water frequency to weather conditions & plant size
- o Frequent light irrigations are best
- o Avoid chronic over or under watering
- o Avoid daily extremes

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Cucumber under stress: similar symptoms can occur from water stress, stem rot, or excessive fruit load

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**Nutrient requirements are related to the stage of plant development & seasonal conditions**

- o Prior to first flower: run K:N ratio of 1:1 to build the vegetative plant structure
- o 1<sup>st</sup> cluster to 4<sup>th</sup>: run K:N ratio of 1.5:1
- o Mature fruit to ripening: run K:N ratio of 1.7:1
- o To boost vegetative growth at any time: increase nitrogen proportion especially ammonium (NH<sub>4</sub>) form

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Cucumber

Similar to tomato, fertilizer program is adjusted for three stages in production:

- Transplant to 4-6 leaf stage
- Normal feed
- Heavy fruiting

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Cucumber compared to Tomato

- Very high potassium requirement
- Very high magnesium requirement
- High calcium requirement

Typically use a 4-18-38 base formula supplemented with K<sub>2</sub>SO<sub>4</sub>, MKP (KH<sub>2</sub>PO<sub>4</sub>), calcium nitrate, potassium nitrate and ammonium nitrate.

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Nitrogen form: NH<sub>4</sub>:NO<sub>3</sub> ratio

- ◇ To boost vegetative growth at any time: increase nitrogen proportion especially ammonium (NH<sub>4</sub>) form
- ◇ Typically keep NH<sub>4</sub> to 10% of total N or less but can increase it more in the short term



Total fertility level

- ◇ In early Spring & Fall, higher EC (2.5-3.5)
- ◇ In Summer, lower EC (1.5-2.5)

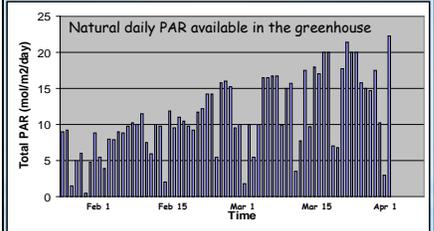
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**Matching Irrigation & Fertility with Environment**

- As light (& temperature) increase, water uptake also increases
- Irrigation frequency should increase
- Nutrient solution concentration should decrease

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**Rule Four: Match Irrigation & Fertility to Prevailing Light Environment**



Irrigation=daily adjustment  
Fertilization=seasonal or stage of development adjustment

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**Some General Rules**

- o Smaller the root volume - the less buffered it is to change (pH, EC)
- o Inert media are less buffered against change than Peat-lite & soil-based media
- o As buffering decreases, the need to more closely monitor & manage nutrition increases
- o Small root volumes, allow for better control of crop growth & development BUT only if you are able to monitor and manage closely

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**Use of Grafted Rootstock to Control Plant Vigor ....**

Grafted rootstock increases the POTENTIAL for Consistently Big Yields.

With Use of Rootstock like "Maxifort", growers can find the Challenge of 'Reining in Excessive Vigor' more of a Management issue than 'Avoiding Loss of Vigor'



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Cucumbers are also grafted but for disease resistance

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**Use Superior Root-Stock for Increased Vigor**



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**The most important factor of all is Grower Experience:**

**Learning to Read the Plant**

Identify problems early and make the Proper adjustments quickly

- o Leaves appear bright under low water stress & duller under moderate water stress
- o Thick stem (1/2" at 6" from the top; thicker = too vegetative, thinner = too much stress)
- o Leaves should be closely spaced, expand rapidly & deep green in color
- o Flowers & fruit should set easily

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*Nuts & bolts of building a fertilizer program*

- o Selecting fertilizers
- o Determining concentrations
- o Adjusting concentrations
- o Calculating ratios

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*General requirements:*

*Typical ranges for nutrients (ppm)*

**Tomato**

N (NO <sub>3</sub> /NH <sub>4</sub> )	P	K	Ca	S	Mg	Fe	K <sub>2</sub> O Ratio	EC
125-225 ppm N (5-10% NH <sub>4</sub> )	40-60	200-350	120-180	40-140	30-60	3-7	1:1 to 1.7:1	1.5-3.5

**Cucumber**

N (NO <sub>3</sub> /NH <sub>4</sub> )	P	K	Ca	S	Mg	Fe	K <sub>2</sub> O Ratio	EC
160-210 ppm N (7-14% NH <sub>4</sub> )	40-60	325-370	190-210	120-140	60-75	1-2	1.8:1 to 2.1:1	1.5-3.0

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*Comparing some basic formulations*

Fertilizer	N (NO <sub>3</sub> /NH <sub>4</sub> )	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca	S	Mg	Fe
%							
Hydro-Sol 5-11-26	5 (5/0)	11	26	--	4	3.1	0.3
JacK's 5-12-26	5 (5/0)	12	26	--	8.2	6.32	0.3
Chem-Gro 4-18-38	4 (3.5/0.5)	18	38	--	0.5	0.4	0.4
Flamtec 6-11-31	6 (6/0)	11	31	--	3.5	3	0.3
Flamtec 7-11-27	7 (6.48/0.52)	11	27	--	4.8	3.75	0.1

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*Example of a simple fertilizer program:*

EC=2.3 K<sub>2</sub>O/N ratio\*=1.6

Fertilizer	(oz/100 gal)	N (%NH <sub>4</sub> )	P	K	Ca	Mg	Fe
Hydrosol (5-11-26)	14	52	49	225	0	32	3
Calcium nitrate (15.5-0-0)	10	115 (6%)			149		
Potassium nitrate 13-0-44	3	30		82			
<b>Totals</b>		<b>198 (4%)</b>	<b>49</b>	<b>307</b>	<b>149</b>	<b>32</b>	<b>3</b>

\*K<sub>2</sub>O/N ratio=Total K/Total N=307/198

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*Example of a program with same K<sub>2</sub>O/N ratio but lower EC:*

EC=1.8 , K<sub>2</sub>O/N ratio=1.6

Fertilizer	(oz/100 gal)	N (%NH <sub>4</sub> )	P	K	Ca	Mg	Fe
Hydrosol (5-11-26)	11	41	39	177	0	25	2
Calcium nitrate (15.5-0-0)	7.5	87 (6%)			112		
Potassium nitrate 13-0-44	2	20		54			
Epsom salts	1					7	--
Fe-chelate (10%)	0.25						2
<b>Totals</b>		<b>148 (3.8%)</b>	<b>39</b>	<b>231</b>	<b>112</b>	<b>32</b>	<b>4</b>



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*Example of a program with same EC but lower K/N Ratio:*  
 EC=2.3 K/N ratio=1.3

Fertilizer	(oz/100 gal)	N (%N <sub>2</sub> H <sub>4</sub> )	P	K	Ca	Mg	Fe
HydroSol (5-11-26)	15	56(0%)	.53	241	0	35	3
Calcium nitrate (15.5-0-0)	10	115 (6%)			149		
Ammonium Nitrate 34-0-0	0.5	12 (50%)		0			
<b>Totals</b>		184 (7.5%)	.53	241	149	35	3

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*Example: same as original formulation using a different base formulation: EC=2.3, K/N ratio=1.6*

Fertilizer	(oz/100 gal)	N (%N <sub>2</sub> H <sub>4</sub> )	P	K	Ca	Mg	Fe
Chem-Gro (4-18-38)	11	33 (12%)	63	258	0	3	3
Calcium nitrate (15.5-0-0)	12	130 (6%)			179		
Potassium nitrate 13-0-44	1	10		27			
Epsom salts	6					44	
<b>Totals</b>		181 (7.2%)	63	286	179	48	3

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*Tomato nutrition programs used in different regions:*

Program	N (%N <sub>2</sub> H <sub>4</sub> )	P	K	Ca	S	Mg	Fe	K/N Ratio
Canada (closed)	165 (8.5%)	38	254	110	48	24	5	1.5/1
Canada (open)	240 (7%)	58	371	216	141	58	8	1.5/1
Arizona	144	62	199	165		50	2.5	1.4/1
Mississippi (spring)	171	48	304	180		48	3	1.8/1
Mississippi (summer)	132	36	228	135		36	2.25	1.8/1
Connecticut (spring)	200 (4%)	53	323	150	45	35	3	1.6/1
Connecticut (hot w/ tops thinning)	160 (7.5%)	42	220	120	56	43	3	1.4/1

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- How to use the look-up tables:*
1. Select the base fertilizer you are using (e.g. Hydro-Sol 5-11-26, Jack's 5-12-26, Chem-gro 4-18-38)
  2. Find the row that provides all of the 'P' (phosphorus) you need.
  3. Next 'Look up calcium nitrate' & find the row that provides all of the 'Ca' (calcium) you need.
  4. Sub-total by adding up all the nitrogen, all the P, all the K (potassium) etc.
  5. Calculate K/N ratio (total K divided by total N) – you can also estimate EC by totaling all of the nutrients together (total ppm), divide this number by 680 and then add the EC of your water.
  6. Add other fertilizers such as Epsom salts to supplement Mg (magnesium), potassium nitrate to increase potassium & nitrogen as needed.
  7. To increase plant vigor (increase nitrogen & lower K/N ratio), by increasing calcium nitrate or you can add a small amount of ammonium nitrate.
  8. To reduce plant vigor, increase the K/N ratio by increasing the base fertilizer or increasing potassium nitrate.