Managing Greenhouse Tomato Irrigation and Nutrition

Richard J. McAvoy
Associate Professor and Extension Specialist
Greenhouse Crops

Proper management of irrigation and fertility are two key aspects of successful greenhouse tomato production. With the exception of ground-bed culture, all greenhouse tomato production systems depend exclusively on a constant supply of water soluble fertilizer. For this reason, management of irrigation and fertility are closely linked. Greenhouse tomato growers need to balance vegetative plant growth with fruit load. Both water and fertility can be used to control this balance.

In general, abundant water favors vegetative plant growth, while limited water stress will reduce growth and stimulate flower development. Don't withhold water from newly transplanted tomatoes; instead, irrigate frequently using small quantities. Adequate watering at initial transplant stimulates rooting into the new medium. Once flowering begins, reducing the available water will further stimulate flower development. Run the slab on the dry side until the fourth cluster begins to open and the bottom fruit begin to reach about 1 to 1¼ inches in diameter. Don't let the slab dry out, however. Once the fruit exceed this size, irrigate fully and avoid water stress. The actual quantity of water requirement at each stage will depend on plant size and weather conditions, especially total light.

To manage greenhouse tomato crop growth and tomato development with fertility, two aspects must be considered. The first involves the overall level of nutrients available to the plant as reflected by the electrical conductivity (EC) of the nutrient solution and the medium. Large plants, plants carrying heavy fruit loads and rapidly-growing plants (i.e. plants growing under conditions of high light and warm temperatures) require more total nutrients (higher levels) than small plants, plants with light fruit loads or slow-growing plants. Nutrient levels can also be used to control the rate of plant growth in an indirect way; through the effect of total salts on plant water status. As nutrient levels increase, EC increases and less water is available to the plant; a stress is imposed and growth slows. By modulating EC, the rate of tomato plant development can be controlled.

The second aspect of nutrition involves the balance of nutrients available to the plant. Nutrient balance controls the tendency for the plant to produce either vegetative or reproductive growth (i.e. leaves and stems v. flowers and fruits). Nutritional balance is usually represented by the ratio of potassium to nitrogen (K/N ratio). A K/N ratio that is close to 1 favors vegetative development over fruiting. However, a K/N ratio of 1.5 or higher favors fruiting. From transplant to flowering, use a K/N ratio of 1. Increase the K/N ratio to 1.3 to 1.4 from cluster 2 to 5. At cluster 6, increase the ratio to 1.5 or higher. If the rate of new growth slows and stems become thin as the fruit load increases, reduce the K/N ratio to the 1.3 to 1.4 range.

Maintaining the proper balance between vegetative growth and fruit load is the key to long-term productivity of the crop. Regulating this balance requires experience and skill. Growers with little experience in growing tomatoes in the greenhouse should follow the guidelines outlined herein and keep careful records as to how the crop responded to nutritional changes over time. This process will help growers gain the experience they need.

Tomatoes, like other green plants, require a number of essential elements for proper growth and fruit production. The essential macronutrients, which are supplied as fertilizer salts, are nitrogen, phosphorus, potassium, calcium, magnesium and sulfur. These elements are usually utilized by the plant as nitrate (NO_3^-) and ammonium (NH_4^+), phosphate ($H_2PO_4^-$), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and sulfate (SO_4^{2-}). Nitrogen is used in the largest quantities in terms of total atoms assimilated by the plant. It is a constituent of amino acids, the protein building blocks, and has a big influence on vegetative development and normal flower development. Nitrogen uptake increases rapidly during fruiting. Excessive uptake of the ammonical form of nitrogen usually produces soft, vegetative growth and tends to lower the pH in the growing medium. For this reason, limit NH_4 form nitrogen to no more than 10% of the total nitrogen.

Potassium is second in terms of total ion uptake. Potassium is important in fruit ripening and fruit quality. At harvest, 90% of the potassium in the plant can be found in the fruit. The ratio of potassium to nitrogen is important for controlling vegetative and reproductive growth. Calcium is third in terms of atoms accumulated, and deficiencies result in the common blossom-end-rot symptoms we often see on tomato fruit. Phosphorus is required in large amounts during seed formation. Early in development, phosphorus is important for good root formation and is supplied in large amounts at transplant in starter solutions with formulation like 9-45-15. Magnesium deficiencies show up as blotchy yellow patches on the lower leaves. Usually, deficiencies can be corrected before yields are affected. Of the micronutrients, only iron (Fe) is required in amounts higher than 1 ppm. Iron is usually supplied at rates ranging from 3 to 5 ppm.

In order to control nutrition, growers need to have a rapid and reliable method of monitoring the nutrient status of the cropping medium. The essential equipment includes a conductivity meter and a pH meter. For more detailed analysis, growers should send samples to a commercial lab. Conductivity (EC) is usually a good indicator of overall nutrient level in the growing medium. Medium pH affects individual nutrient availability. Therefore, as pH varies, the nutrient balance available to the crop will change.

In the greenhouse, tomatoes can be planted directly in the soil or in soilless substrates. Today, most tomato growers use some form of soilless culture. In general, soilless culture can be separated into two categories—inert substrates such as rockwool or perlite; or noninert substrates such as peat-lite mixes used in trough culture or upright and lay-flat bags.

The recommended nutrient levels differ for these two systems, however, the basic principles of nutrient management do not. First, the absolute quantity of nutrients a plant needs will increase as plant size and fruit load increase. Second, the optimal ratio or nutritional balance required by the crop will change as the crop develops. To get an idea of the general nutrient balance required by the crop, look at the total nutrients a plant removes from the nutrient solution over the production life of the plant and the relative ratio of these nutrients to each other [on a weight basis (Table 1)]. From these data you can see that the plants in this study used seven times more nitrogen (N) than phosphorus (P), 60% more potassium (K) than N, one-third more N than calcium (Ca) and five times more N than magnesium. Although the actual nutrient balance will vary during the crop, on average, nutrients should be supplied in roughly these ratios.

Of course, these numbers do not tell you when or how to adjust the nutrient levels in your management program. For this purpose, use the recommendations in Table 2 as a guide. Notice there are two sets of recommendations, one for inert growing

Table 1. Total fresh weight gain and nutrient quantities removed from solution by greenhouse tomatoes produced in a NFT (nutrient film technique) system.

Production Data and Nutrients	*Quantities per Plant*	*Nutrient Balance**
Spacing	4 $ft.^2$	
Total plant fresh weight	19 lbs.	
Total fruit weight	15 lbs.	
N uptake	0.59 oz.	
P uptake	0.08 oz.	7:1
K uptake	0.94 oz.	5:8
Ca uptake	0.44 oz.	4:3
Mg uptake	0.12 oz.	5:1

*Nitrogen relative to other nutrients by weight

media—in this case, rockwool—and the other for noninert media—in this case, peat-lite bags.

The actual concentration of each nutrient (especially N, K and Ca) can vary within a range of ± 20%. Generally, a nutrient solution EC of about 2.5 is recommended for plants in production, but the actual concentration you use may vary from 1.5 to 3.5, depending on the growing conditions, the fruit load on the plant and nutrient test results from the medium. Determining what is required and how the crop is doing comes with experience. One New England grower uses the schedule in Table 3 and does a pretty good job. However, I think the overall feed rates in this schedule are a little low, and the balance is poor relative to the stage of development.

The fertilizer schedule can be adjusted to alter both concentration and balance. Nutrient balance is usually adjusted with the stage of crop development, while nutrient concentration must be matched to plant size as well as weather conditions. It is possible to adjust concentration without affecting the K to N ratio. An example of such an adjustment appears in Table 4.

A complete feed can be formulated using several different fertilizer salts. Hydrosol, a 5-11-26 formulation, is a good fertilizer to start with since it contains micronutrients and magnesium in addition to N, P and K. A 4-18-38 formulation can be used in lieu of hydrosol. Calcium nitrate can be used to supply the necessary

Table 2. Recommended fertilizer rates (nutrient solution concentration in parts per million) for tomatoes cropped in peat-lite and rockwool systems.

Stage of Development	*N*	*P*	*K*	*Ca*	*Mg*	*Fe*	*EC*	*K/N Ratio*
Peat-lite Bags								
Planting to cluster 1	175	50	225	150	40	3	2.0	1.3
Clusters 1 to 4	215	50	320	120	60	3	2.4	1.5
Cluster 4 to finish	240	50	415	120	45	3	2.7	1.7
Rockwool Slabs								
Saturate slabs	210	46	190	240	80	2	2.3	0.9
Planting to cluster 1	240	46	240	240	80	2	2.6	1.0
Cluster 1 to 4	235	46	325	210	70	2	2.6	1.4
To cluster 10	240	46	370	190	60	2	2.6	1.5
After cluster 10	235	46	325	210	70	2	2.6	1.4

Table 3. Nutritional schedule used by a New England grower in peat-lite mix.

Stage of Development	*N*	*P*	*K*	*Ca*	*Mg*	*Fe*	*EC*	*K/N Ratio*
Planting to cluster 2	115	50	210	80	30	3	1.5	1.8
Clusters 2 to 4	150	50	210	130	45	3	1.8	1.4
Cluster 4 to finish	165	50	250	130	60	3	2.1	1.5

Table 4. Example of a nutrient solution adjusted to different concentrations (EC) while maintaining the same K/N ratio.							
NO_3N	*NH_4N*	*P*	*K*	*Ca*	*Mg*	*EC*	*K/N Ratio*
141	7	45	223	142	33	1.5	1.5
175	8	46	276	164	48	2.0	1.5
230	13	49	363	216	49	2.5	1.5

Table 5. Fertilizers and the N, P, K, Ca and Mg content at different rates. Use combinations of these fertilizers to get the nutrient ratio you desire.						
Fertilizer	*Concentration (oz./100 gal.)*	*N*	*P*	*K*	*Ca*	*Mg*
Hydrosol (5-11-26)	4	15	14	64		9
	12	45	42	193		28
	14	52	49	225		32
4-18-38	2	6	12	47		
	8	24	46	188		
	12	36	69	282		
Calcium nitrate	1	12			15	
	2	23			30	
	4	46			60	
	6	69			89	
Potassium nitrate	1	10		29		
	2	19		58		
	4	39		116		
	10	97		290		
Potassium sulfate	1			33		
	2			67		
Magnesium sulfate	1					7
	2					15
	4					29
Magnesium nitrate	1	7				7
	2	15				13
	4	30				27
Sodium nitrate	1	21				
	2	24				
	4	48				
Ammonium nitrate	0.5	12				
	1	25				

calcium and some additional nitrogen. Additional potassium can be supplied with potassium nitrate, monopotassium phosphate or potassium chloride. Ammonium nitrate or sodium nitrate can be used to augment nitrogen. Note that calcium nitrate cannot be mixed in the same stock solution with fertilizer salts contain

Table 6. Test levels in peat-lite are based on a 1:1.5 (soil to water) extraction method. Values from rockwool system are based on solution withdrawn from slab just prior to irrigation.

				(ppm)		
EC (mmhos/cm)	*pH*	*N*	*P*	*K*	*Ca*	*Mg*
			Peat-lite			
1-2.5	5.5-6.5	30-80	20-50	140-400	140-200	25-35
			Rockwool			
2.5-5.0	5.1-6.2	170-270	20-60	250-390	320-480	65-165

ing phosphorus or sulfur. Listed in Table 5 are the fertilizer salts, rates and levels of macronutrients they provide.

Iron chelate can be used to supplement iron (Fe) in the nutrient solution. One ounce per 100 gallons of a 10% Fe chelate will provide 7 ppm Fe.

Testing is an essential part of nutrient management. Use the values in Table 6 as target levels to be maintained in peat-lite and rockwool culture. The range of EC values in this table is fairly large. Typically, EC values would not vary more than 10% (+) from the EC values targeted at any particular stage of development.

To best manage the crop, growers must learn how to read the plant. Flower development, fruit set and fruit development are key indicators to watch. Stem thickness is another key indicator. Tomatoes produced with a well-balanced fertilizer program should have a thick stem with dark green foliage. The leaves should be closely spaced (not stretched), and the flower clusters should set fruit easily. Together, these indicators reveal the tendency for vegetative or reproductive development. The stem should be about one-half inch thick at a point six inches from the growing point. If the stem is thicker than this and the top leaves are thick and curl down, the plant is too vegetative. Decrease the nitrogen and increase the potassium level relative to the nitrogen level. If the stem is too thin, the plant is carrying too much fruit load. Increase nitrogen to increase vegetative development.