Nutrition for Greenhouse Tomatoes

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Greenhouse tomato crop growth and tomato development can be controlled through mineral nutrition. There are two aspects of crop nutrition which the grower must consider. One aspect of nutrition involves the overall level of nutrients available to the plant. 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 than do 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, electrical conductivity (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 vs. flowers and fruits). 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 in this article and keep careful records as to how the crop responds to nutritional changes over time. This process will help growers gain the experience they need.

Tomatoes, like other green plants, require all of the basic 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 absorbed as nitrate (NO_3), phosphate (H_2PO_4), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}) and sulfate (SO_4).

Nitrogen is used in the largest quantities in terms of total atoms absorbed by the plant. It is a constituent of amino acids, protein building blocks, and has a big influence on vegetative development and normal flower development. Nitrogen uptake increases rapidly during fruiting.

Potassium is second in terms of amounts absorbed. 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, magnesium and sulfur are absorbed in lesser amounts. Phosphorus is required in larger 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 three to 10 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 the 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: production using inert substrates such as rockwool or perlite, and noninert media 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. There are many common features to nutrient management that growers should be aware of. 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 (Table 1). From these numbers, 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.

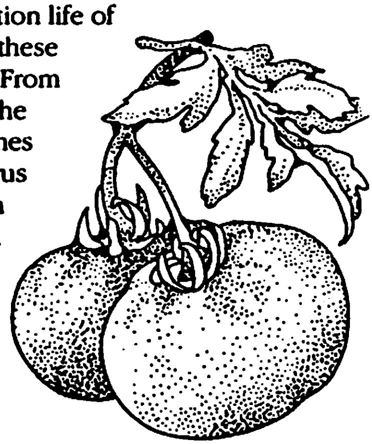

Table 1.
Total fresh weight gain and nutrient quantities removed from solution by greenhouse tomatoes produced in a nft (nutrient film technique) system.

Nutrients and Production Data	*Amount Per Plant*	*Nutrients Ratios: N Relative to Other Nutrients*
Spacing	4 ft^2	
Total fresh weight	19 lbs	
Total fruit weight	15 lbs	
N uptake	16.72 grams	
P uptake	2.32 grams	1:0.14
K uptake	26.73 grams	1:1.60
Ca uptake	12.57 grams	1:0.75
Mg uptake	3.5 grams	1:0.21

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 media (in this case rockwool), and the other for non-inert media (in this case peat-lite bags).

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

	Peat-lite Bags (ppm)						
Stage of Development	*N*	*P*	*K*	*Ca*	*Mg*	*Fe*	*B*
Planting to 1st cluster	150-200	50	225-300	80	30	3	0.5
1st to 4th cluster	200-225	50	300-340	80	30	3-5	0.5
4th to finish	225-300	50	340-500	80	30	3-10	0.5

Stage of Development	*Rockwool Slabs (ppm)* N	*P*	*K*	*Ca*	*Mg*	*Fe*	*B*
Saturating slabs	200	62	250	250	36	0.8	0.1
4 to 6 weeks	235	62	370	190	36	0.8	0.1
Normal feed	200	62	370	190	36	0.8	0.1
Heavy fruit load	200	62	390	190	36	0.8	0.1

You will also notice that the ranges recommended are quite broad. The actual amount plants require will depend on the growing conditions and the fruit load on the plant. 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. I think the overall feed rates in this schedule are a little low and the calcium and magnesium levels may be too high at the end of the crop, but they work for him.

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

Stage of Development	*Peat-lite Bags (ppm)* N	*P*	*K*	*Ca*	*Mg*	*Fe*	*B*
Planting to 2nd cluster	115	50	210	80	30	3	0.5
2nd to 4th cluster	150	50	210	130	45	3	0.5
4th to finish	165	50	250	130	60	3	0.5

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. Calcium nitrate can be used to supply the necessary calcium and some additional nitrogen. Additional potassium can be supplied with potassium nitrate or potassium chloride. Ammonium nitrate or sodium nitrate can be used to augment nitrogen. Note that calcium nitrate can not be mixed in the same stock solution with fertilizer salts containing phosphorus or sulfur. Listed in Table 4 are the fertilizer salts, rates and levels of macronutrients they provide.

Table 4.
Fertilizers and the N, P, K, Ca, and Mg content at different rates. Use combinations of these fertilizers to get the nutrient ratio you want.

Fertilizer	*Rate (oz/100 Gallons)*	*N*	*P*	*K*	*Ca*	*Mg*
Hydrosol (5-11-26)	13	50	48	210	–	30
Calcium nitrate (15.5-0-0)	5.3	62	–	–	80	–
Potassium nitrate (13-0-44)	1	9.7	–	29	–	–
	2	19.4	–	58	–	–
	4	38.8	–	116	–	–
	10	97	–	290	–	–
Ammonium nitrate (34% N)	1	25.3	–	–	–	–
	2	50.5	–	–	–	–
	4	101	–	–	–	–
Sodium nitrate (16% N)	1	11.9	–	–	–	–
	2	23.9	–	–	–	–
	4	47.8	–	–	–	–
Magnesium sulfate (10% MG)	2	–	–	–	–	15

Testing is an essential part of nutrient management. Use the values in Table 5 as target levels to be maintained in peat-lite and rockwool culture.

To best manage the crop, growers must learn how to "read" the plant. Tomatoes produced with a well-balanced feed 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. Flower development, fruit set and

Table 5.
Test levels in Peat-lite and rockwool.[1]

EC (mhos/cm)	pH	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
			Peat-lite			
1-2.5	5.5-6.5	30-80	20-50	140-400	140-200	25-35
			Rockwool			
1.5-3	5.5-6.5	200	50	360	185	45

[1]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.

fruit development are key indicators to watch, stem thickness is another key indicator. 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.