ORGANIC GREENHOUSE TOMATO NUTRITION

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Most organic greenhouse tomatoes are grown in soil amended with compost and organic fertilizers. Managing crop nutrition in this situation is like dealing with the proverbial 'black box' since nutrient availability can vary widely depending on the materials applied and the environmental conditions that affect microbial activity. This is in sharp contrast to conventional culture--hydroponic systems in particular--where the application and availability of nutrients can be monitored rather easily.

That said, in-ground or soil-based culture is highly buffered and can be rather forgiving in terms of nutrient management, since you only need to be 'in the ballpark' and then let soil microbes do the work. The flexibility provided by growing in a large volume of amended soil reduces the need to maintain precise levels of individual nutrients. However, that really doesn't justify 'flying blind' as many growers do--simply adding a lot of compost and hoping for good results.

Attention to soil fertility and plant nutrition are essential in order to obtain good yields of high quality fruit with organic production systems. Of course, management of environmental conditions and pests are also necessary to success.

Managing the nutrition of organic greenhouse tomatoes is best done through a combination of creating healthy soil conditions, monitoring soil nutrient status using the saturated media extract test, and monitoring crop uptake of nutrients using leaf analysis. Much of the information below comes from 'Growing Greenhouse Tomatoes in Soil and in Soilless Media' by A.X. Papadopoulos, Harrow Research Station, Ontario, Canada.

Soil physical condition. Greenhouse tomatoes grow best in a well-aerated soil with a high water-holding capacity, rich in nutrients and free of pathogens. The most suitable soil types are loams, sandy loams, and silty loams, with high organic-matter content. Other types can be used, with more difficulty and expense.

For example, light, sandy soils with low water-holding capacity and poor nutrient content may require extra irrigation, supplemental fertilization, and surface mulches to improve growing conditions. Heavier soils that are poorly drained with a structure easily damaged by cultivation can benefit from raised beds and a tile drainage system. Both light and heavy soils can be improved by adding organic matter.

Organic matter. Growers know that high levels of organic matter can enhance soil structure, improve the water-holding capacity of the soil, and serve as a reservoir of nutrients. Organic matter can be added to greenhouse soils as manure, compost, or peat.

The use of fresh manure is risky since it can result in the release of ammonia (especially with poultry manure) as well as the introduction of plant diseases and weed seeds. The organic standards prohibit the application of uncomposted manure less than 90 days prior to harvest of a crop that does not come in contact with soil. (If your greenhouse tomatoes are allowed to sprawl on the ground then the waiting period would be 120 days.)

Fresh or partially aged manure will provide more available nutrients to a crop than fully composted manure, which is a more slow-release source of nutrients. But relatively fresh manure, and even some composts can be high in soluble salts, so applying them in large quantity can have a negative effect on plant growth. Application of manure or compost that contains a lot of undecomposed straw, sawdust, leaves or other high carbon material can tie up nitrogen as it continues to break down in the soil. It's a good idea to test manure or compost before adding it to the greenhouse since the nutrient content, pH, soluble salts, and C:N ratios can be highly variable.

Only high-quality, mature compost should be used to amend the soil used to grow organic greenhouse tomatoes. Immature compost may have an unacceptable level of weed seeds or pathogens. If nutrient levels of N, P, or K are already very high in the greenhouse, then little or no compost should be added; instead, use peat to maintain soil organic matter levels and add individual nutrients using approved organic fertilizers.

Consider peat moss. Another source of organic matter is peat. Compared to manure or compost, peat is relatively inert, as it does not contribute nutrients, weed seeds or diseases. Coarse peat is acidic, with a pH of about 4, so in most cases it needs to be added in combination with about 8.5 lbs of ground limestone per loose cubic yard (17 lb per compressed yard) in order to neutralize its acidity. If nutrient levels are already high in a greenhouse soil, peat is a good option to add organic matter without additional nutrients. In new greenhouse situations, to supplement or replace compost additions, up to 5 cubic yards of loose peat (or 2.5 yards of compressed peat) per 1,000 square feet may be needed, depending on the condition of the soil.

Since soil organic matter decomposes rapidly under greenhouse conditions, an annual application of about 1 cubic yard of loose peat (or 0.5 cubic yard of compressed peat) per 1,000 square feet may be desirable. Broadcast peat and lime evenly, and incorporate thoroughly into the top foot or so of soil prior to making beds.

Nutrient needs. Although only 1% of the total plant fresh weight is made up of nutrients, fertilizer application is critical to optimize the growth and development of the crop, as well as the quantity and quality of the fruit. A greenhouse tomato crop absorbs major nutrients at about the following rates: potassium, 600 lb/acre; nitrogen, 330 lb/acre; magnesium 260 lb/acre; phosphorus, 45 lb/acre; and calcium, 40 lb/acre.

Nitrogen contributes more toward the vegetative components (leaves and stems) of the plant than the reproductive components (fruit). High rates of N induce vigorous vegetative growth to the detriment of fruit production. However, under hot and bright conditions, sufficient N must be available to allow the plant to continue growing and reach its maximum fruit production potential.

An excess of N is marked by strong thick stems, curled leaves in the head of the plant (bullishness), large clusters and flowers, and poor fruit set. A deficiency of N expresses itself in hard plants with thin heads, light green foliage, and pale yellow flowers.

Potassium influences fruit quality and is effective in hardening growth at high rates. Potassium levels are particularly important at planting time for growth control and later for the prevention of ripening disorders. The ratio between K and N is also important; the higher the ratio the slower the growth. Problems with fruit quality, such as blotchy ripening, boxy fruit, and even to some extent, green shoulder, are associated with low levels of potassium.

Phosphorus is important for early root growth, especially under cool soil conditions, and later it affects both vegetative growth and fruit set. Symptoms of P deficiency include a characteristic purple color of the veins and stem, thin growth, and poor cluster development. Phosphorus toxicity is uncommon. Phosphorus is stored well in soil but is easily leached in peat-based media.

Magnesium deficiency is commonly observed in greenhouse tomatoes, as yellowing between the leaf veins. However, it rarely results in yield reduction but as the leaf tissue breaks down it can create entry points for Botrytis and other diseases. Magnesium deficiency usually exists only in the plant, not in the soil, and is related to high-K availability or poor root development. Both these make it difficult for the plant to take in sufficient Mg, forcing the plant to move Mg from old leaves to the new. Magnesium deficiency is easily corrected by applying an organically approved epsom salts fertilizer (magnesium sulfate) through the drip or watering directly onto plant rows.

Calcium deficiency is usually expressed as blossom-end rot of the fruit and as dieback of the growing tips. In most cases the Ca deficiency is not in the soil but is induced. The most likely cause is water stress on the plant resulting from inadequate or uneven watering, frequent and large variations in relative humidity, or a high level of salts.

Calcium, magnesium, and potassium are believed to compete with each other, with a varying degree of success, for the same sites of absorption by the plant; it is useful to remember that increasing one of them affects the other two.

Other nutrients are rarely deficient in greenhouse tomatoes when growing in a naturally fertile soil with added compost or manure. A few of the more common problems are:

Iron deficiency is expressed as pale yellow young leaves. Indirect causes of iron deficiency may be soil pH that is too high, or root growth is poor due to anaerobic soil conditions as a result of overwatering. In many cases, improved soil aeration or drying corrects the problem. Soil applications and foliar sprays of iron salts or iron chelates are helpful, but it is better to eliminate the source of the problem.

Boron deficiency is expressed as brittleness of leaves, premature wilting, and, in acute form, as dieback of the growing tips. This deficiency can be corrected with foliar sprays of a Borax or Solubor solution, but the rate of application must be monitored carefully because excess B leads to toxicity that can cause severe plant damage.

Adding organic fertilizers. Prior to adding fertilizers, the saturated media extract (SME) test should be used to estimate nutrient availability in compost-amended soils. This test is available from most Land Grant University testing labs. It uses water to extract nutrients prior to measurement, and it's typically used for soilless mixes that are high in fertility and organic matter. A regular field soil test uses a weak acid to extract nutrients, and the results for fertile greenhouse soils are often 'off-the- charts'. In addition, the SME test analyzes for soluble salts (conductivity), nitrates, and ammonium.

The saturated media extract test should be used to test greenhouse soil early in the season, before the crop is planted. That way, organic fertilizers can be added and incorporated if needed. Once the crop is in place it may be difficult to add nutrients since so many organic materials are not particularly soluble so they don't go through the drip system very well.

The greenhouse soil should be tested before applying organically-approved fertilizers. If the soil is already highly amended with compost from previous years, take the SME test before adding any more. If the soil is known to be relatively low in fertility from prior year's experience, or if the house is new to production, incorporating bulk organic amendments such as compost and/or peat, then take the SME test. The tables below can be used to estimate the how much of what type of fertilizer to apply prior to planting.

Commonly used organic fertilizers include: calcitic or dolomitic limestone (for Ca, Mg); greensand, potassium sulfate (for K) or sul-po-mag (for K and Mg); rock phosphate or bone meal (for P); blood meal or Chilean nitrate (for N. Note that the organic standards allow Chilean to meet no more than 20% of a crop's N needs. For greenhouse tomato that would be an estimated 66 lb/acre, or the equivalent of about 9 lb Chilean per 1,000 sq ft.)

Plant meals such as alfalfa, peanut and/or soy are a source of N, P, K with a moderate rate of release. Check with your certification agency as to their allowability.

Trace elements are usually provided in sufficiency by compost and/or plant meals, but that can be supplemented using small amounts of natural materials (volcanic minerals such as Azomite). Some synthetic compounds (iron and zinc chelates, solubor for boron, etc.) are allowed under organic standards if a deficiency has been demonstrated by soil or tissue testing.

Table 1: Optimal soil test ranges for greenhouse tomatoes using the Saturate Media Extract(SME)test.

Available Nutrient or Measurement	
pH:	5.8 – 6.8
Nitrogen(as NO_3)	125-200 ppm
Phosphorus	8- 13 ppm
Potassium	175-275 ppm
Calcium	over 250 ppm
Magnesium	over 60 ppm
Soluble salts	1.50 – 3.00

Table 2: Estimated fertilizer rates to increase SME nutrient levels

Pounds/1,000 sq. ft needed to raise N approximately 10 ppm	
Chilean nitrate 16-0-0	3.2
Blood meal 12-0-0	4.2
Alfalfa meal 2.5-2-2	20.1
Pounds/1,000 sq. ft needed to raise P approximately 2 ppm	
Bone meal 0-15-0	26.6
Rock phosphate 0-3-0	133
Pounds/1,000 sq. ft needed to raise K approximately 20 ppm	
Sul-po-mag 0-0-22-11Mg	2.6
Potassium sulfate 0-0-52	1.1
Pounds lime/1,000 sq. ft needed to raise soil pH ~1 full unit	
Sandy loam	40
Loam	80
Clay loam or peat	120

(Tables 1&2 adapted from 'Greenhouse Tomatoes, Lettuce & Cucumbers, by S.H. Wittwer and S. Honma. Michigan State Univ. Press. 1979.)

Leaf analysis. Once the crop is growing and flowering, plant tissue samples can be taken to monitor nutrient status. Sampling at regular intervals is useful for monitoring nutrient levels in the crop and determining whether supplemental fertilization is needed. Some growers use leaf analysis only for diagnostic reasons, when they are trying to identify an apparent nutrient problem. I usually urge growers to take samples frequently: the cost is relatively low, usually $20-$30, so just a few pounds of tomatoes covers it, and the information is valuable.

It's a good idea to sample plants several times during the course of the growing season to monitor their nutrient status. Leaf tissue analysis should start as soon as the plants begin to flower, so that additional fertilizers can be applied in a timely fashion if needed. Take samples even if the crop looks good; having a record of leaf analysis and fertility practices over time helps diagnose problems when they occur.

Proper collection of leaves is essential to a good tissue sample, since nutrient levels vary among leaves of different ages. Select recently mature, fully expanded leaves from just below the last open flower cluster. Take at least eight to ten whole leaves from plants throughout the greenhouse to get a representative sample. Based on the results, apply soluble fertilizer as needed through the drip system, watered in by hand, or blended with a fresh application of compost spread along plant rows.

Table 3: Optimal nutrient ranges in greenhouse tomato leaves(dry wt.)

Macronutrients (%)			Micronutrients	
	Before fruiting	During fruiting		
N:	4.0-5.0	3.5-4.0	Fe:	50-200 ppm
P:	0.5-0.8	0.4-0.6	Zn:	25-60 ppm
K:	3.5-4.5	2.8-4.0	Mn:	50-125 ppm
Ca:	0.9-1.8	1.0-2.0	Cu:	8-20 ppm
Mg:	0.5-0.8	0.4-1.0	B:	35-60 ppm
S:	0.4-0.8	0.4-0.8	Mo:	1-5 ppm

(from Oregon State University Greenhouse Tomato Production Guide http://hort-devel-nwrec.hort.oregonstate.edu/tomatogh.html; similar ranges are recommended by North Carolina Dept of Agriculture http://www.ncagr.com/agronomi/pdffiles/gtomato.pdf)

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