Texas Plant & Soil Lab

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Making Better Crops For Growers Around The World.

ASK THE PLANT®
BETTER CROPS WITH LOWER COSTS.

TOMATOES

PLANT NUTRITION & SAMPLING NOTES - 1

Noel Garcia, CCA

The most important aspect of tomato production (field, greenhouse or hydroponic) is balanced nutrition. Tomato plants, particularly modern hybrid cultivars, have the potential to be extremely high yielding with the right nutrients being furnished to the plants at the right time and in the right amounts. This increase in yield and quality potential results in a huge increase in the amount of nutrients taken up by the plant to support these yields and vigorous plant growth in all environments including controlled growing environments such as greenhouses. Tomato plant nutrition is one factor which is continually changing with the use of new cultivars, systems and methods of production. There is no one 'ideal' nutrient program for field, greenhouse or hydroponic tomato crops, as each crop is different and requires continual monitoring of the nutritional status of the plants.

One major advantage of a hydroponic crop is that it allows very precise control and monitoring of tomato plant nutrition. Growers can gauge nutrient uptake with regular solution or leachate analysis and with computerized records, patterns of nutrient uptake, adjustments, and resulting yields can be plotted and used for reference in future crops.

Recirculating hydroponic systems are a useful tool to examine nutrient uptake in tomato crops, and much research has been done on this subject. However, every grower's situation is different, and the uptake of each element varies depending on a number of factors. For this reason, growers need to know both the basics of tomato nutrition and how this applies to their particular cropping situation. Use of regular nutritional analysis should be part of any commercial tomato production operation so that decisions are based on what the current crop requires at the present time, not just following a set program for crop production commercialized by a chemical company or university.

While the average tomato fruit is well over 90 percent water at harvest, certain nutrients are essential for fruit growth and quality. Tomatoes require balanced additions of **Nitrogen** (**N**), **Phosphorus** (**P**), high amounts of **Calcium** (**Ca**) and often extremely high levels of **Potassium** (**K**) if fruit quality is to be maximized. Large amounts of Phosphorus are required for seed formation, growth, fruiting and fruit quality. The inability to make Phosphorus available for rapid uptake can be a significant limiting factor to these aspects of plant development. A fruiting tomato plant absorbs proportionately more Phosphorus than a non-fruiting or vegetative plant. Nutrient additions must be periodically adjusted to maintain high yields and quality. The adjustments should be based on nutrient removal and stage of tomato growth and fruiting.

In tomatoes, the requirement for Potassium is about the same as for Nitrogen in the early crop stages (from seedling until initial fruit development). After this, the requirement for Potassium keeps increasing with fruit load while Nitrogen levels off. While Nitrogen is important and is used in large quantities for vegetative growth, Potassium is the predominant cat-ion in tomato fruit and has major effects on fruit quality. Excess Nitrogen can result in plants with extremely vigorous vine growth but little fruit production. (Refer to TPSL©'s ***Nitrogen Carbon Ratio*** paper). Too much Nitrogen delays fruiting, and increases disease susceptibility. Most multi-fruiting crops such as tomatoes use less than 20% of the Nitrogen requirement before fruit set. Extra Nitrogen should be applied in small increments as fruit is developing. The ***ASK THE PLANT***© petiole test is the best guide for when and how much Nitrogen to use.

The majority of the Potassium absorbed by the plants during the active fruiting stage ends up in the fruit. This is why ratios of Potassium need to be maintained at higher levels during the fruiting stages than during the vegetative and flowering stages. Thus, as crop load on the plant increases, so does the requirement and absorption of Potassium which will become part of the fruit tissue. If Potassium becomes deficient during the fruiting phase of a tomato crop, both yield and fruit quality will suffer greatly. Potassium is directly related to fruit quality, particularly the acidity and flavor of the fruit, firmness, ripening disorders, color and shelf life. As such, it is vital to maintain high levels during development.

Despite the importance of Potassium during fruit development, levels of Nitrogen also need to be maintained particularly during the pre-flowering stage. It has been shown that adequate levels of Nitrogen before initiation of the first bloom was of crucial importance in determining yield.

Studies have also found that hydroponically-grown tomato plants growing under optimal conditions, carrying high fruit loads, can take up 140 - 230 mg of Potassium per day. Similar figures for Nitrogen are in the range of 80 - 110 mg per plant per day and 22 - 35 mg per plant per day of Phosphorus. The Potassium requirement of a fruiting tomato plant is highest about the time the ninth truss is in flower; this is when high fruit loading is occurring and when Potassium depletion in many systems becomes most common when levels are insufficient. Fruit deficient in Potassium have a lower overall flavor and shelf life quality and can also suffer from ripening disorders such as blotchy ripening, gray wall, cloud, lack of good coloration and can be described as 'watery' and lacking flavor.

Calcium is another mineral essential for fruit growth and development. The supply of Calcium is more critical during the phase when there is rapid visible size increase as it is required for the formation of new cells and for strong cell structure. A lack of Calcium transportation into the fruit can rapidly result in the development of **Blossom End Rot** (**BER**). **Boron** (**B**) also plays a major role in combating BER. Since Boron is the transport element in the plant, the deficiency of it is sometimes is the major culprit behind BER even when Calcium is applied to plants. Strive to maintain Boron at range of 60-100 ppm as measured by the petiole test.

Crops growing under higher light levels have been shown to take up much greater quantities of Potassium. It is highly likely that different cultivars also have different uptake rates. Growers need to work through a process of determining the best ratios of Potassium to Nitrogen at these different growth stages for their own production systems under different seasonal conditions. This information, however, can form the basis of a "starter" nutrient formulation for a tomato crop with adjustments made in the Potassium to Nitrogen (K:N) ratio as crop growth progresses.

Lack of **Magnesium** (**Mg**) may appreciably reduce fruit production and in very severe cases, present as chlorosis in the leaves (as do several other nutrient deficiencies). Magnesium is a part of organic acids, chlorophyll, pectin and other organic compounds. Magnesium deficiency (otherwise plant-unavailable) can be found in sandy soils, soils with high Potassium, soils with high pH, and those with poor drainage and structure.

Soil pH –

Tomatoes require a slightly acid soil. University studies indicate a range of soil pH of 5.8 to 6.8. A more limited range of about 6.1 to about 6.6 pH is suggested. Water quality should be closely checked. High pH (over 7.0) water can be high in bicarbonates which will raise the pH of the soil and cause many other problems.

ASK THE PLANT® Petiole Analysis –

While there is data available from a number of studies on nutrient uptake rates in tomato crops, this can provide only a rough model or estimate of what is actually happening in a grower's present crop. This is because the variables which effect nutrient uptake, such as soil or growing media chemistry, cultivar, light, temperature, humidity, stage of growth, æration and crop health, differ considerably between growing systems. It is often just not applicable to take crop nutrient uptake data from another area or climate and apply it to a crop grown in a different area due to at least the differences in light and temperature levels.

In this situation, a grower's best tool is crop logging nutrient analysis, which can be used to make adjustments as required and ensure deficiencies do not occur. Also, visually discerning some plant nutritional deficiencies is impossible and a petiole analysis is required. Here are examples of two different tomato nutrient problems:

The plant on the left suffers from lack of Nitrogen, while the one on the right lacks Sulfur.
Could you correctly diagnose these problems in the field?

Nutrient Solution Analysis (Hydroponics) –

The solution analysis (TPSL©'s Hydroponic Suitability Water Test) report will give the amount of each element in ppm (parts per million). EC and pH will also be given, and additional testing parameters such as total alkalinity, acidity, **Molybdenum** (**Mo**), **Cobalt** (**Co**) and total hardness. Ideally, the data on the hydroponic suitability analysis report should be compared back to the levels of each element that the original formulation contained. So, if a nutrient formulation was created that has 150 ppm N, and the analysis of the solution after a few weeks in use came back with a level of 145 ppm N, then this indicates the initial level was approximately what the crop has required and taken.

Micronutrients –

Easily overlooked and misidentified micronutrient deficiencies (including **Zinc** (**Zn**), **Iron** (**Fe**), **Manganese** (**Mn**), **Copper** (**Cu**), **Boron** (**B**), **Sulfur** (**S**) and **Molybdenum** (**Mo**)) together with trace elements are wide spread and are limiting crop yields and quality, along with dozens of other controllable factors. Micronutrient deficiencies are common especially in very sandy soils, in high pH soils, or in instances when nutrient imbalances occur due to excess major elements, such as nitrogen or phosphorous. Micronutrients should be monitored regularly with ***ASK THE PLANT***© petiole tests to avoid deficiencies or toxicities. It has been well documented by much research that balanced nutrition of not only macro but micronutrients have been successful in suppressing plant disease.

- ***Boron (B):*** Its primary function is related to cell wall formation (associated with BER) and Calcium and Potassium transport within the plant. Boron-deficient plants may be stunted with poor sugar transport (poor quality), flower retention (poor fruit set), poor fruit-set, poor quality and poor pollen formation. Boron also assists tomato plants in resisting several common diseases. Boron deficiency in soils, especially those with low Organic Matter or high Calcium content, is very common.
- ***Copper (Cu):*** Is necessary for carbohydrate and nitrogen metabolism; inadequate copper results in stunting of plants. Required for lignin synthesis which is needed for cell wall strength and prevention of wilting. Copper also plays an essential rôle in combating a number of fungal diseases.
- ***Iron (Fe):*** Is involved in the production of chlorophyll. Iron is a component of many enzymes associated with energy transfer, nitrogen reduction and fixation, and lignin formation.
- ***Manganese (Mn):*** Is necessary in photosynthesis, nitrogen metabolism and to form other compounds required for plant metabolism. It is needed to combat certain diseases.
- ***Zinc (Zn):*** Is essential component of various enzyme systems for energy production, protein synthesis, and growth regulation. Zinc deficient plants also exhibit delayed maturity.
- ***Molybdenum (Mo):*** Is involved in enzyme systems relating to nitrogen fixation by bacteria. Nitrogen metabolism, protein synthesis and sulfur metabolism are also affected by molybdenum. Molybdenum has a significant effect on pollen formation, so fruit is affected.
- ***Sulfur (S):*** Tomatoes have one of the highest demands for Sulfur of any crop. Sulfur is a major component of protein, amino acids and other compounds that give tomatoes flavor and aid in the uptake of Nitrogen by the plant. Sulfur deficiency results in a watery, tasteless fruit and in extreme cases, the leaves will turn chlorotic. Additionally, Sulfur is very effective in controlling many diseases and insects.
- ***Silicon (Si):*** While not an essential micronutrient, research indicates that Silicon does several things: 1) It reinforces and hardens cell walls to make the plant more rigid. 2) This additional physical strength allows the plant to better able withstand disease and insect pressures. 3) It can attenuate **Aluminum** (**Al**) toxicity (usually only seen in some acid soils). 4) It can reduce Sodium toxicity. 5) Under certain conditions, it can dramatically increase the continent of certain minerals and nutrient compounds, particularly when there is Sodium present.
- ***Cobalt (Co):*** In trace amounts has been shown to enhance flowering and fruiting, and improving uptake of the major nutrients, N, P and K in tomatoes.

Additions of micronutrients to the soil should be made initially based on a soil test, then during the growing season, with ***ASK THE PLANT***© analysis-based recommendations. Monitoring the micronutrient concentration in a nutrient solution is also important in order to avoid their excess accumulation or deficiency. Foliar spray of nutrients is an extremely effective method of application.

This type of monitoring is important in rapidly growing crops with a heavy fruit load, where Potassium can become stripped from the root zone solution at each feed if not supplied at the correct rate in the soil or solution. Regular leachate analysis of the solution draining from the growing container at a mid-day feed may reveal any nutritional problems with the original feed formula.

Other factors which need to be checked on the analysis report are accumulation of any trace elements, particularly those which are known to be present in the water supply and any **Sodium (Na)** accumulation in recirculating systems, as this will determine when the nutrient solution needs to be dumped and replaced.

The rôle of ***ASK THE PLANT***® Tomato Petiole Analysis is different from that of the solution or soil analysis. Growers will often have a petiole analysis carried out to determine what is happening inside the plant with regard to nutrition. Often, certain elements may be in sufficient quantities in the soil or nutrient solution, but some external or internal plant factor is limiting uptake and distribution to plant tissues. One example of this is Calcium where the distribution of this element in plant tissues such as the tips of leaves and fruit, can be highly dependent on environmental conditions, rather than the level of Calcium in the soil or nutrient solution.
Petiole analysis is a vital tool for diagnosing mineral deficiencies or toxicities in crops, as it will forecast 7 to 21 days in advance what the plant will be deficient or toxic in before the visual symptoms occur—many of which may look similar and need confirmation with petiole sampling and testing.

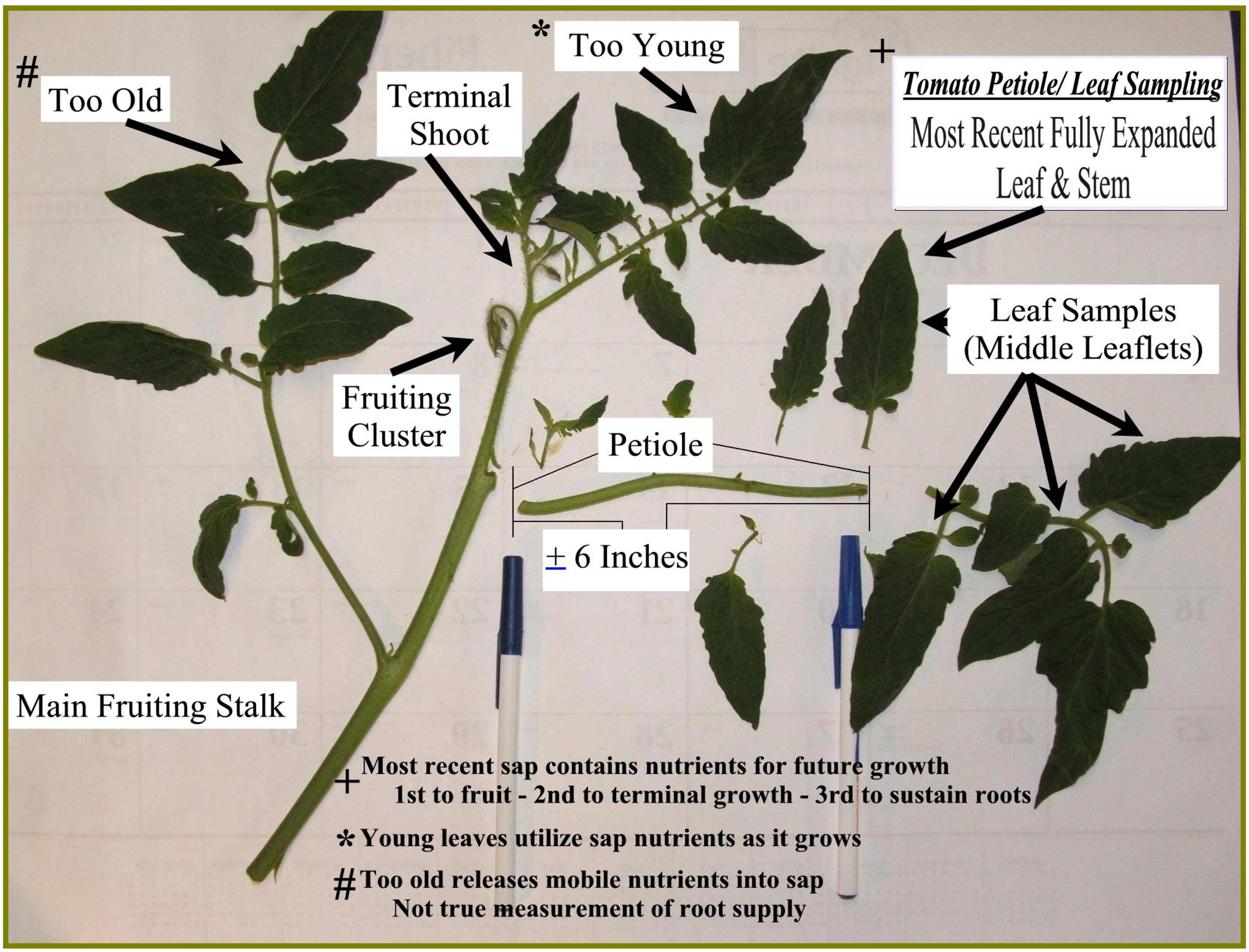
What ASK THE PLANT® Exhaustive Petiole Testing For Tomatoes Includes -

♦ NO_3 ♦ PO_4 ♦ K ♦ Ca ♦ Mg ♦ Na
♦ Zn ♦ Fe ♦ Mn ♦ Cu ♦ B ♦ S ♦ Si ♦ Co ♦Mo

…in an exclusive color-coded report, together with functions and ratings. Your report is E-mailed to you typically in 24 hours after the receipt of your sample. ***These analyses are also available for the fruit.***

ASK THE PLANT® *Tomato Petiole Sampling Procedure –*

Tomato petiole samples must be properly collected, carefully handled and submitted with as much information as possible given in the Plant Submittal Form. Because nutrient concentrations throughout a plant vary, the correct plant part must be sampled, and it must be at the proper stage of growth. Improperly collected petiole samples can produce unreliable results and lead to incorrect interpretations. The most recently mature or fully expanded leaf is the best indicator sample for all growth stages of tomato. This is generally the 4th or 5th leaf/stem from the top of the plant. Twenty to twenty-five petioles are required for a good sample. Rinse the samples thoroughly with drinking water (spring water), dry, and place inside a clean ***paper*** bag to send to the lab. Do not use a plastic or zip-lock bag – samples need to breathe while in transit.



Summary –

Nutrient uptake ratios change significantly throughout the tomato cropping cycle and are also influenced by environmental factors such as temperature, humidity and light levels. Balanced nutrition plays a major rôle in determining both yields and fruit quality, and a well monitored and regularly adjusted nutrient program can also result in cost savings by preventing fertilizer wastage. Growers who will monitor, adjust and fine-tune plant nutrition are at an advantage in terms of economy, yield *and* quality whether field, greenhouse and particularly hydroponic tomato production, and increasing numbers of producers are focusing more on developing this skill.