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A User's Guide to High Tunnel Soil Testing

High tunnel soil testing has been provided at the University of Maine since 2010. Our testing system has developed through collaboration with other Universities in New England and has evolved over time. Yields in high tunnels can be several times greater than those possible in the open field, with much higher nutrient demand on the pool of available nutrients. Optimum test levels for N-P-K are therefore several times higher than those for open-field production. Recommendations are calculated to build soil levels to these much higher optimum ranges. Since management practices and cropping systems in high tunnels are so diverse, we have developed different testing options to better address this diversity and the range of soil properties that have resulted from it. However, having more than one testing option can cause confusion. This guide explains the basis and general utility of the available options and their best use, together or separately.

Basic High Tunnel Test

The Basic High Tunnel test is essentially the same as a routine Standard Field Soil test, with an added check on nutrient salt buildup and a direct check on plant-available nitrogen. The Field Soil test measures the soil's ability to supply nutrients over the entire growing season. This **Quantity** of available nutrients is identical to the test for open-field production and is the primary basis for making fertilizer recommendations. The basic high tunnel test offers tunnel-specific nutrient interpretation levels (low-medium-optimum) and adjusted fertilizer recommendations.

In covered production there is minimal loss of nitrogen to leaching or denitrification from saturated soils. Nitrate will carry over from one year to the next much more efficiently than in outside production, where it is usually monitored only <u>during</u> the growing season.

Covered production also leads to the buildup of water-soluble nutrient salts over time due to lack of normal rainfall, which naturally flush excess salts in outside production. Soluble salts are measured in the Basic test with a Saturated Media Extract (SME), using distilled water. The total dissolved salt level in the extract is measured by Electrical Conductivity (EC). Plants have increasing difficulty pulling in sufficient water as the salt level increases in the soil. Very high salt levels (EC > 4 in the SME) can cause water stress in the crop and, in extreme cases, root damage.

For many growers, the Basic High Tunnel test is all that is necessary to maximize production and monitor for common problems. This is especially true with newer tunnels that have been covered for only a few years or for older tunnels that have had excess salts recently flushed by natural rainfall or overhead irrigation.

Combined High Tunnel Test

This second option includes an additional report on the nutrient content in the SME. This is the same extraction used to measure the total nutrient salt level (EC) reported in the Basic High Tunnel test. When the EC level is high enough (typically > 1.0 – 1.5), there is sufficient nutrient content in this extract to provide useful supplemental information on soil fertility status. This is most appropriate for tunnels continuously covered for several years and/or aggressively amended. The nutrient content in the SME is measured and reported separately, with its own unique interpretation. This is the short-term, immediately available nutrient content in the soil water, which is also referred to as **Nutrient Intensity**. Soil pH and EC are measured only once and are identical in both reports.

To recap, the SME reports nutrient levels as concentration in the soil water. The field soil test reports concentration in the dry soil. The field soil test measures full season availability, the SME measures short-term availability. Because of these differences in nutrient pools and reporting basis, the numerical results often don't (and aren't expected to) agree with each other. The interpretation ranges for each test (low-medium-high) will be in general agreement for some nutrients and not for others. This will be explained in more detail below.

Salt Effect on Soil pH

One of the testing concerns with high EC is its effect on soil pH. Much of the nutrient salt load in soil water is composed of (+) charge ions (calcium, potassium, magnesium, sodium). These cations can cause a partial displacement of reserve acidity (aluminum and hydrogen) into the soil water, which disproportionately lowers the measured soil pH by up to 0.5-0.6 units. This is a common analytical problem in the western deserts, which have naturally high EC levels. This also occurs in high tunnel soils with EC levels above 1.0–1.5 in the SME. The soil pH level reported in both the Field Soil and SME reports has been corrected, where necessary, to compensate for EC level. This provides a more accurate picture of soil acidity or alkalinity. It also avoids the potential over-recommendation of lime, when needed.

Test Differences and the Importance of Organic Matter

Soil nitrate is the one nutrient that extracts equally well in both the Field Soil test and in the SME. Differences in the parts per million (ppm) numerical results are due to reporting basis (soil water vs dry soil). Lower organic matter soils, holding less water, tend to report higher nitrate levels in the SME than in the Field Soil test. Higher organic matter soils, holding more water, tend to report lower nitrate levels in the SME than in the Field Soil test.

Higher organic matter soils also tend to release more of the total amount of available phosphorus (P) and potassium (K) to the soil water than low organic matter soils. In those soils, Optimum P and K in the field soil report tend to also test High or Optimum in the SME. Low organic matter soils do not release much P to the soil water. It is common to have Above Optimum P level in the Field Soil test, but Low P in the SME. In our regional fertility tables, we recommend using a soluble P fertilizer at transplant time if the SME level is below 1 ppm. This is to encourage root growth early in the season, when P availability and root volume is limited – regardless of the full-season supply of P in the Field Soil test.

Soils release variable amounts of available K to the soil water, depending on organic matter level and also depending on soil texture. Loamy soils, with substantial clay content, tend to hold back more of the available K and release it more gradually to the soil water. When SME K levels are below 200 ppm, we recommend the addition of soluble K early in the season when root growth is still limited – especially for high-demand crops like tomatoes. Sandy soils tend to release more K to the soil water when Field Soil test K is Optimum. This can result in more K being taken up early, much of which can be lost to foliar pruning, resulting in possible K deficiency later in the season. For sandy soils, we recommend splitting the K application with ½ at planting and the remainder applied under drip lines or fertigated at first fruit set.

Calcium, Magnesium, Sulfur, and Micronutrients

Calcium and magnesium in the SME often do not agree with the Field Soil test levels. Because of their +2 ionic charge, Ca and Mg tend to be held very tightly on exchange sites with only gradual release to soil water. This can be overcome by applying water-soluble sources of each in your fertilizer regime. Gypsum (calcium sulfate) is the soluble source for calcium. Epsom salt (magnesium sulfate) is the soluble source for magnesium. Moderate applications of each will result in Optimum soil water levels in the SME report.

Sulfur relative levels between the two reports often follow those of nitrate and depend on organic matter level. Because almost all OMRI-approved potassium sources also contain sulfur, it is very common for sulfur test levels to test well Above Optimum in the Field Soil test and High in the SME. Despite the abundance of very high sulfur test levels, we have not seen any adverse effects on yield or quality in any crop or interference with the availability of other nutrients. Excess sulfur is relatively easy to flush with other excess nutrient salts.

Micronutrients are tightly held, either as exchangeable cations or complexed with organic matter. In most cases the Field Soil test is a better critical indicator of fertility level for these nutrients, which are needed in minute amounts. The metal micronutrients (copper, iron, manganese, and zinc) often test Low in the SME, when they are Medium or Optimum in the Field soil test.

Potential for Micronutrient Toxicity

Some micronutrients, when testing Above Optimum in the Field Soil test, can be a concern for potential toxicity to crop plants. In this case the SME can provide critical information. The micronutrient levels in the soil water measure what is in direct contact with plant roots, so the SME is often a better gauge of potential toxicity to plants. There have been a few cases of documented boron toxicity in high tunnel crops, including in tomato. Boron is often Above Optimum in the Field soil report. If it also tests High in the SME, then toxicity is a real concern. Concentrated sources, such as Borax (Sodium borate), must be used with extreme caution to avoid over-application. Boron is not tightly held and is relatively easy to remediate when flushing excess nutrient salts.

Basic copper sulfate is sometimes used as a fungicide in organic production. Copper toxicity often presents as foliar damage, but rarely builds to toxic levels in soil. Zinc can often test Above Optimum in the Field Soil report. If it tests as Optimum or lower in the SME, it is not a toxicity concern.