

Soil, Water and Nutrient Management in High Tunnels

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Soil Management

- ◆ Important measures of soil health
- ◆ Soil pH
- ◆ Organic matter content
- ◆ Cation Exchange Capacity (CEC)
- ◆ Soil type

Soil pH

- ◆ Maintain soil pH between 5.8 to 6.8.
- ◆ If soil becomes too acidic, add lime (either) calcitic or dolomitic to adjust pH up to 6.5-6.8. If too basic, add sulfur to adjust pH down to 6.5-6.8.

Organic matter

- ◆ Soil organic matter consists of a variety of components. These include, in varying proportions and many intermediate stages:
 - ◆ * raw plant residues and microorganisms (1 to 10 per cent)
 - ◆ * "active" organic fraction (10 to 40 per cent)
 - ◆ * resistant or stable organic matter (40 to 60 per cent) also referred to as humus.

Organic Matter

- ◆ The "active" and some of the resistant soil organic components, together with microorganisms (especially fungi) are involved in binding small soil particles into larger aggregates. Aggregation is important for good soil structure, aeration, water infiltration and resistance to erosion and crusting.

Organic matter

- ◆ The resistant or stable fraction of soil organic matter contributes mainly to nutrient holding capacity (cation exchange capacity) and soil color. This fraction of organic matter decomposes very slowly and therefore has less influence on soil fertility than the "active" organic fraction.

Soil Organic matter

- ◆ After harvesting each crop grown in the high tunnel and before establishing the next crop, recommend the addition of some type of organic matter (manures, compost, cover crops, etc) to maintain an organic matter content of 4 to 5%. Generally a layer 1" deep is broadcast on top of the soil and incorporated.

Organic Matter Content

- ◆ Because of higher temperatures (soil and air) in HT, organic matter decomposes faster in HT compared to soil in field (1.5 to 3.0%).

Cation Exchange Capacity

- ◆ The Cation Exchange Capacity (CEC) of a soil is the adsorption of cations (positive charged molecules - K, Mg, Ca) on the surface of soil particles that are negatively charged. The higher the CEC value, the more sites for cations to be adsorbed onto soil particles (mainly clay based soils).

CEC

- ◆ To maintain a balance of K, Mg and Ca in soil, the following cation ranges are recommended:
 - ◆ K - 3-5%
 - ◆ Mg - 10-12%
 - ◆ Ca - 65+%

Soil Type - Clays

- ◆ Clay and clay loam soils will hold more water than sandy types, but have much slower infiltration rates and can stay wet after heavy rains for several days. Clay and clay loam soils general have a higher Cation Exchange Capacity (CEC) than sandy types and have higher content of nutrients especially K, Mg and Ca. If clay soils are tilled when they are wet, compaction will occur that will last the entire growing season. Clay type soils also take longer to warm up in the spring.

Soil Type - Sandy

- ◆ Sandy soils on the other hand have very high water infiltration rates, hold virtually no water, dry relatively quick after a heavy rain, have low CEC values and low organic matter so that there is a lower content of K, Mg and Ca in the soil. Sandy soils warm relatively quick in the spring and tend to have less compaction problems

Wetting Patterns Based on Soil Type



Soil Health

- ♦ Soil health describes the capacity of a soil to be used productively without adversely affecting its future productivity, the ecosystem or the environment. Soil health emphasizes the integration of biological with chemical and physical measures of soil quality that affect farmers' profits and the environment.

Healthy Soil



Unhealthy Soil



Reducing soil pests with cover crop + adding organic matter



Rye and other grains



Water Sources

- ◆ Ponds - water filtration required
- ◆ Streams - water filtration required
- ◆ Wells - generally water filtration not necessary
- ◆ Public water systems - generally water filtration not necessary.

Sneezer Ceramic Filter



24" Sand Filters



TR-60 Swimming Pool Filters



High Purity Filter Sand



Water application

- ◆ Overhead irrigation - least efficient
- ◆ Sprinkler irrigation
- ◆ Drip irrigation - most efficient

When to apply water

- ◆ Based on EvapoTranspiration (ET) values - measure ET daily and replace lost water in 1-3 days.
- ◆ Soil moisture monitoring - measuring available soil moisture with tensiometers and replacing lost water every 1-3 days.
- ◆ Guess ??? - Eyeball plants or soil for water stress - not precise, could lead to disaster.

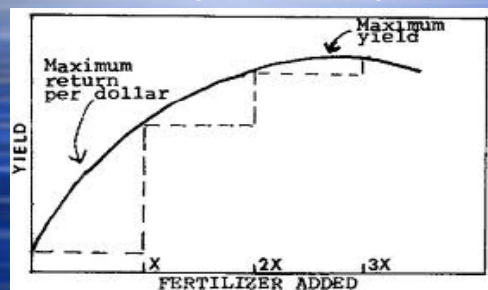
Evapotranspiration Pan



Tensiometer



Relationship between nutrient availability and crop yield



Nutrient Management

- ◆ Once pH, Ca or Mg problems are identified, recommendations are made to rectify these soil nutrient problems by the addition of lime (calcitic or dolomitic) or sulfur prior to planting the crop.
- ◆ Periodic plant tissue sampling will help determine if nutrients in the soil are being taken up by the plant or if there is some other pest problem mimicking nutrient problems.

Methods of adding nutrients to soil

- ◆ 1) Applying the nutrients in granular or liquid form over all the field (broadcast) prior to plowing. 2) Applying nutrients in bands 2" x 2" next to the crop at planting time (banding). 3) Side-dressing nutrients while the crop is developing but prior to crop maturity. 4) Fertigation – applying part or all required nutrients through the drip irrigation system prior to or after crop establishment.

Salinization

- ◆ The accumulation of soluble salts in soils, can be observed in the potting medium of house plants. The salt accumulates because of evaporative water loss from soil that is repeatedly supplied with water that contains dissolved salts, even if in low concentrations. Only pure water evaporates; the salts dissolved in the water do not.

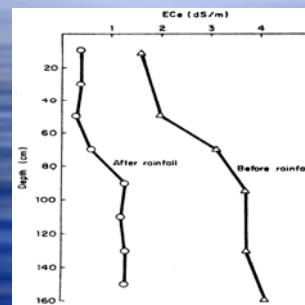
Multi-week trend of salt build-up and the effect of leaching cycles



Extreme salt buildup in soil



Effect of rainfall on leaching of salts on soil



Nitrogen

- ◆ Nitrogen compared to all the other nutrients acts like a growth regulator and will maintain plants in an active growth (vegetative) stage until all the nitrogen has been metabolized in the plant; thereby limiting reproductive growth and ultimate crop yield.

Nitrogen

- ◆ Plants generally respond to nitrogen when
 - 1) there is low organic matter in the soil,
 - 2) soil consists of a large percentage of sand, and
 - 3) cold, wet growing season similar to 2009.

How much N to apply?

- ◆ How much nitrogen should be applied for the crop to be grown? The crop nitrogen requirement equals the recommended rate of nitrogen application for that specific crop minus the contribution from the previous crop (residual N), minus the contribution from cover crops (especially legumes) planted in rotation, and minus the contribution from manures and composts.

Nitrogen Sources

- ◆ Nitrogen sources include; nitrogen materials, graded fertilizers (10-10-10 contains 10% nitrogen per 100 lbs. material), legume cover crops (hairy vetch produces the equivalent of 100 lbs. N/A when incorporated into the soil), animal manures, and organic composts (peanut hulls, mushroom compost, straw, etc.)

Nitrogen Materials

- ◆ Ammonium nitrate - 33.5% N
- ◆ Ammonium sulfate - 21.0% N
- ◆ Calcium nitrate - 15.5% N
- ◆ Potassium nitrate - 13.0% N
- ◆ Urea - 45.0% N
- ◆ N solution (11 lb/gal) - 32% N
- ◆ Anhydrous ammonia - 83% N

Inorganic N source

- ◆ When looking for an inorganic nitrogen source look for;
- ◆ the % nitrogen in the product,
- ◆ acid equivalent,
- ◆ salt index and
- ◆ solubility of the nitrogen material.

Inorganic N

- ◆ For example, urea contains 45% nitrogen but is moderately soluble in water compared to calcium nitrate that contains only 15.5% nitrogen but is twice as water soluble as urea.

What about other elements?

- ◆ Optimum levels of phosphorus in soil are 120 to 320 lbs./A of actual P. If soil test results indicate an optimum P level, a high phosphorus starter solution (12-48-8, 10-52-10, or 11-52-17) is recommended when transplanting vegetables in cold, wet soils. Extremely high levels of P in soil (800 lbs./A or more) can cause zinc deficiency in various crops.

What about other elements?

- ♦ Optimum potassium (K) level in soil is 3% to 5% saturation of CEC. Excess potassium can result in salt damage to roots and a lower availability to the plant of phosphorus, calcium and magnesium. The combination of low magnesium (less than 6% saturation of CEC) and excessive potassium can result in calcium deficiency problems in tomato, pepper, celery, cauliflower, melons and cucumbers.

What about micronutrients?

- ♦ Generally, there is more than an adequate supplies of manganese (Mn), boron (B), zinc (Zn), copper (Cu), iron (Fe) and molybdenum (Mo) in the soil. Addition of these micronutrients is generally not required if the soil pH is maintained in the optimum range (6.0 to 6.8) and there are no imbalance or deficiency of micronutrients in the soil.

Any Questions??

