Long Term Soil and Water Management in the High Tunnel

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Outline

- Introduction
- HT management practices in the Midwest
- Site preparation
- Water and irrigation management
- Fertility management
- Soil soluble salts management
- Conclusion

Site Selection and Preparation

- Site preparation is much like preparing a field for production (1-2 years in advance) – but you are planning out for several years
  - Removal of existing cover
  - Reduce weed seed bank
  - Cover crop
  - Soil test and amend as needed – compost, minerals, other amendments
  - Select well drained soils; provide for drainage if needed

Water and Irrigation Management

Compare and contrast water management in a high tunnel and in the field

Assess the Water Source

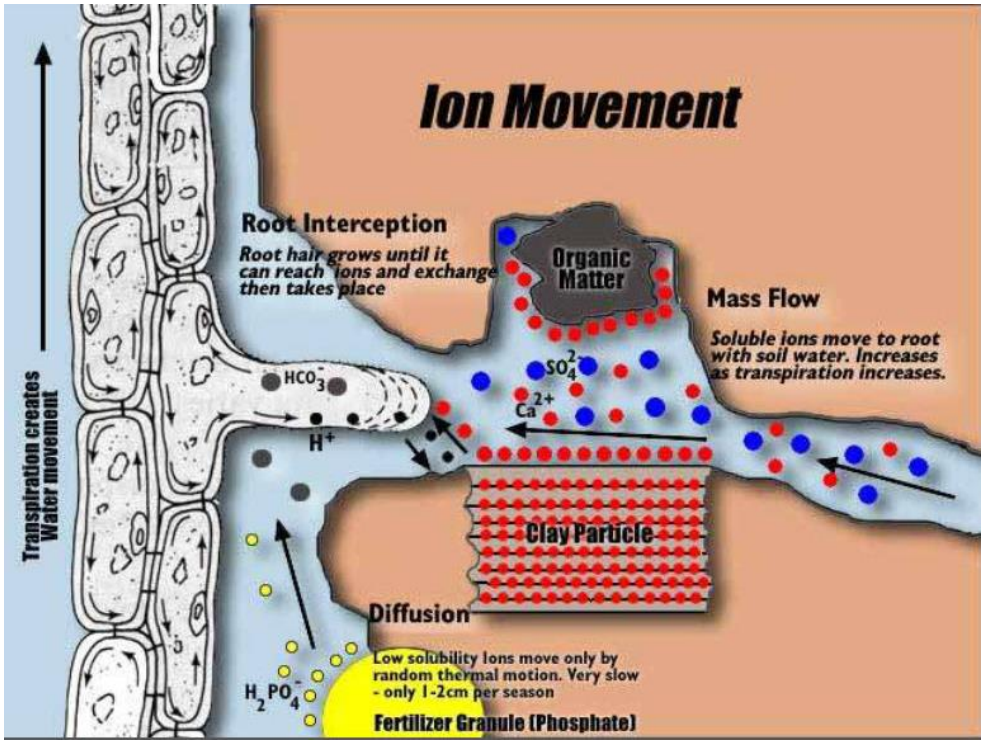
- Irrigation is necessary in the high tunnel
- Water quality is important, **especially for long term**
  - Alkalinity
  - Hardness
  - Pollutants
- Operation of drip irrigation systems – must have good quality water
- Issues related to salts buildup can be related to water quality

Soil Moisture and Irrigation

- Drip irrigation advantages
  - Efficient use of water
  - Great way to deliver soluble nutrients
  - Keeps plants dry
- Drip irrigation challenges
  - Important to know the system, and ensure adequate wetting depth for wide ranging root systems
  - May not provide sufficient water to leach away soil salts

Soil Fertility Management

- Fertility management is a balance of managing the following:
  - Physical characteristics
  - Chemical characteristics
  - Biological characteristics



Soil Fertility Management

- Why is the tunnel environment different than the field?
  - Raised beds and drip irrigation tend to concentrate root systems
  - Nutrients are delivered via fertigation, and are readily available and mobile
  - The nutritional status of the soil and the plant are dynamic and can change rapidly
  - Excess nutrients often remain in the rooting zone following a cropping cycle, and can accumulate

Fertility Management

- Successful fertility management in the high tunnel is related to several key components:
  - ***Soil Testing***. Soil testing to determine the nutrient availability (pH) and balance is perhaps even more important than it is in the field.
  - ***Compost***. Compost seems to be the most important soil fertility management tool for the high tunnel.
  - ***Rotations***. The variation in crops grown in the tunnel will influence whether cover crops are needed to maintain soil fertility and health.

Soil Testing

- Standard Field Soil Test
  - Conducted on a dry sample
  - Soil pH is tested on a separate sample.
  - Nitrate-nitrogen is not usually analyzed but can be if requested, which is a good idea for high tunnels.
  - The amount of K, Ca and Mg extracted are used to calculate an estimate of the total cation exchange capacity (CEC). The balance of the three elements is also calculated.
  - Phosphorus amount is estimated
  - Organic matter content is estimated
  - Micronutrients can be requested
  - Each lab will have an interpretation of the soil test

Soil Testing

- Saturated Media Extracts (SME) test (MU greenhouse media test)
  - Conducted on a saturated soil sample
  - total soluble salts as electrical conductivity
  - soluble nitrogen as nitrate and ammonium nitrogen.
  - In addition the P, K, Ca, Mg, Na and Cl in parts per million (ppm) are commonly reported.
  - The micronutrients Fe, Mn, Zn, Cu, B and Mo may also be reported if requested.
- For rapid growth conditions with frequent irrigation, ie conditions often found in a high tunnel, the SME provides a picture of available nutrients **at one moment in time**

Soil Testing

- Where is SME testing indicated?
  - Where nutrients applied as water-soluble fertilizers
    - Conventional greenhouse bench crops
  - Where nutrient content exceeds retention capacity
    - High proportion of “free salts”
  - Soils with accumulated nutrient salts
    - Irrigated desert soils
    - Long-term high tunnels

Soil Testing

- Startup high tunnel
  - Essentially same as open-field soil management
  - Routine field soil test most appropriate
  - Optimize pH, OM, major & micronutrient reserves

Soil Testing

- Established houses (1 + years)
  - Salt buildup can be a problem if not uncovered
    - Monitor total salt level to avoid desiccation damage
  - Open field soil N management does not apply
    - Monitor nitrate level to avoid over-fertilizing
  - Field soil test to address potential deficiencies
  - EC (SME) to monitor total nutrient salt buildup
  - Available nitrogen to address nitrate buildup

Soil Testing

- Continuously-covered houses, usually 3+ years
  - Saturated Media Extraction + Organic matter
    - Water soluble (nutrient intensity) mgt. system
    - UVM interpretation guidelines
  - N-P-K recommendations to adjust SME levels
    - UVM guidelines

Soil Testing

optimal soil nutrient levels

for greenhouse tomatoes or lettuce using the SME test

• pH	5.8 – 6.8
• nitrate-N	125 – 200 ppm
• P	8 – 13 ppm
• K	175 – 275 ppm
• Ca	> 250 ppm
• Mg	> 60 ppm
• soluble salts	1.5 – 3.0 (mmhos)

Adapted from: Greenhouse Tomatoes, Lettuce and Cucumbers. by S. H. Wittwer and S. Honma. 1979 . Michigan State Univ. Press.

Soil Testing

General interpretation guidelines for greenhouse growth media analyzed by the Saturated Media Extract Method.

	Low	Optimum	Very High
Soluble salts (dS/m)	0-.75	2.0-3.5	5.0+
Nitrate-N (ppm)	0-39	100-199	300+
Phosphorus (ppm)	0-2	6-10	19+
Potassium (ppm)	0-59	150-249	350+
Calcium (ppm)	0-79	200+	
Magnesium (ppm)	0-29	70+	

From: Recommended Test Procedures for Greenhouse Growth Media by Daryl Warnke, Michigan State University Extension. 2009.

Soil Testing – MU Soil Testing Laboratory

- Standard soil test
  - http://soilplantlab.missouri.edu/soil/trucksoil.aspx
  - Cost: $12.50 plus ; extra charge for micronutrients and nitrogen
- SME testing (Greenhouse media testing)
  - http://soilplantlab.missouri.edu/soil/greenhouse.aspx
  - Cost: $20 plus extra for micronutrients
- Compost testing
  - http://soilplantlab.missouri.edu/soil/compost.aspx
  - Cost: $40 for complete package

Soil Testing

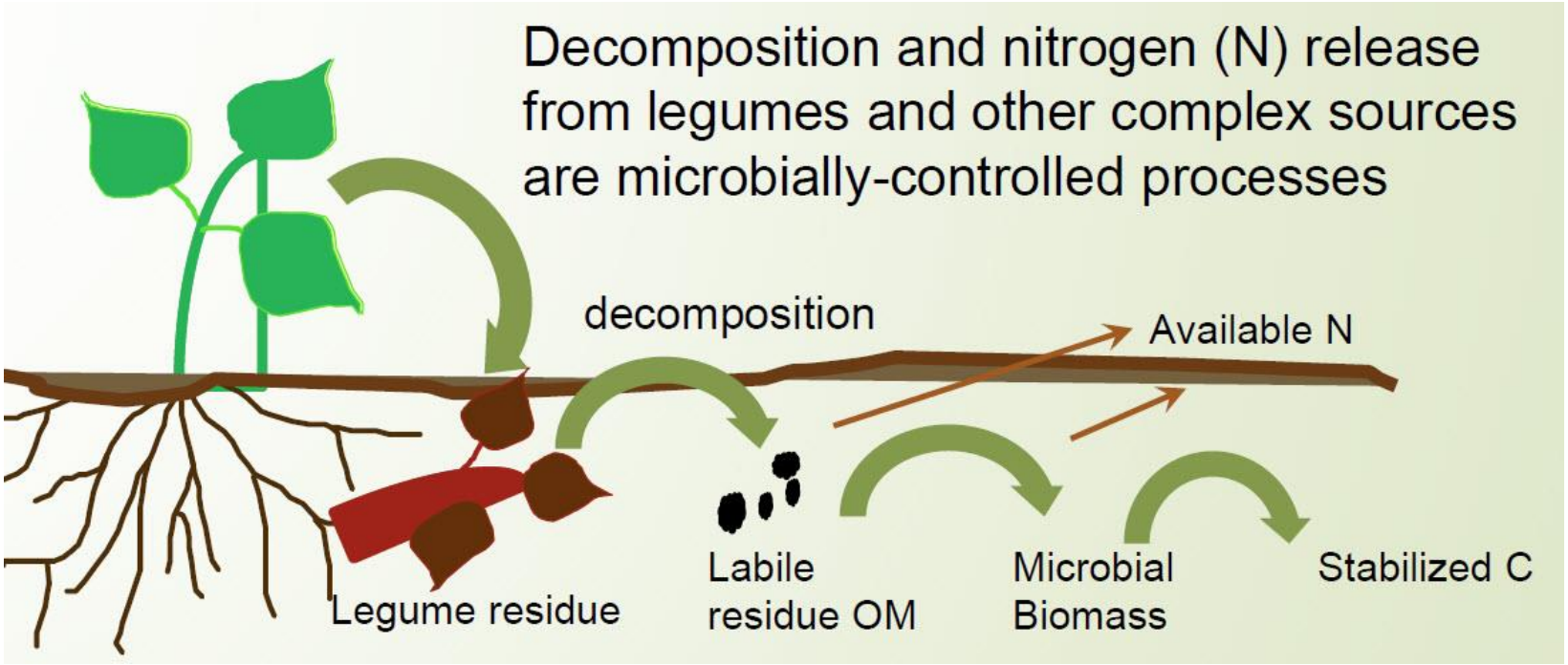
- Summary of high tunnel soil testing
  - For newer houses, routine field soil analysis with addition checks on EC and available nitrogen
  - Continuously covered high-EC houses can be effectively managed using SME testing system and field soil testing as indicated
  - Field soil and SME testing systems access greatly different pools for most nutrients and are reported on a different basis. Each requires discreet interpretation and recommendation systems.

Organic Matter

- Crop production is often focused on fertigation to provide water and soluble nutrients – “feed the plant”
- A better long term strategy is focusing on long term soil health – “feed the soil”
  - Soil organic matter management
  - Maintenance of the soil food web

Organic Matter in the High Tunnel

- What happens to organic matter in the high tunnel?



Source: http://www.conservationwebinars.net/webinars/soil-health-in-high-tunnel-production

Organic Matter

- Compost applications
  - Compost seems to be the most important soil fertility management tool for the high tunnel
  - Consider plant based compost rather than manures or manure compost; what about worm compost?
  - Consider a compost analysis to characterize the compost and to develop application rates
  - Annual recommended application rates vary - 12 to 40 gallons per 100 square feet = 26 to 86 cu yd/ acre or about 10 to 40 ton/acre

Crop Rotations

- Conflict between the need to rotate crops and economic realities
- Consider focusing on early and late plantings of cool season and warm season crops
- Effective rotations can take the place of cover cropping
- Crop family groups
  - lettuce and related leafy greens for baby leaf salad mix (multi harvest) or as heading crops (single harvest);
  - Brassicas for salad and cooking greens;
  - Solanaceous crops (tomato, pepper, eggplant);
  - Root crops (turnip, carrots, beets, radish) and
  - Cucurbits (cucumber, summer squash)

Cover Crops

- Cover crops
  - In general, once the structure is built, the production area is very valuable and the time between cash crops is short.
  - If a diverse crop rotation can be maintained, it is not essential to use tunnel cover crops.
  - If there is time in the schedule:
    - Buckwheat, Japanese millet or cowpeas are short term, warm season cover crops that break down quickly.
    - Oats can also be tilled in after a short time of grown and will grow in cool seasons
    - Use winter cover crops with caution, esp. for early plantings

Foliar Testing

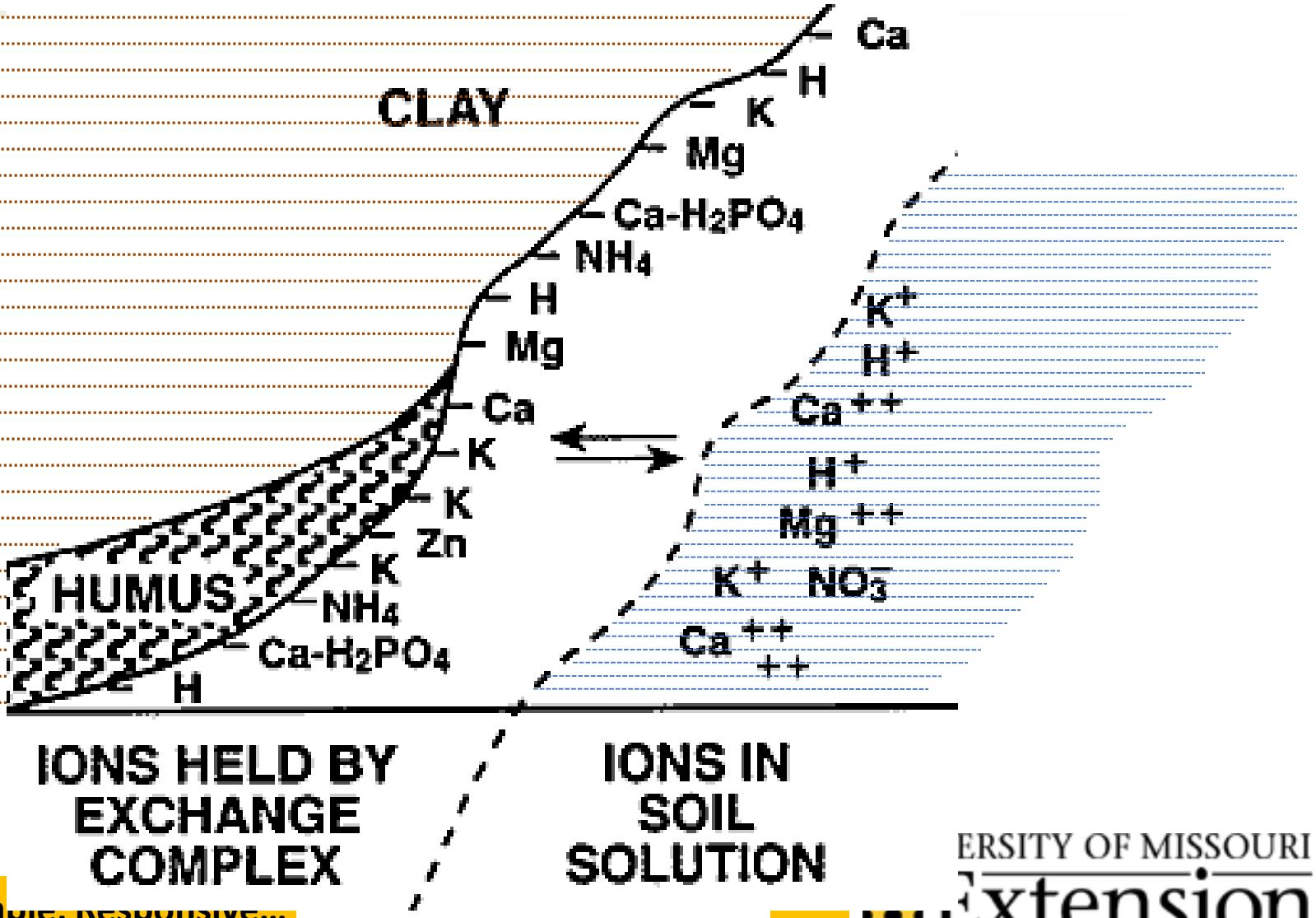
- Useful as a monitoring tool in the dynamic high tunnel environment
- Useful as a diagnostic tool in the event of issues

Magnesium deficiency

Soil Soluble Salt Levels

- What are soluble salts?
  - soluble forms of elements found in the soil - Ca++, Mg++, K+, Na+,NH4+, H+, HPO4-, SO4-, NO3-, Cl-
  - These forms move up and down in the soil profile in response to water movement
  - In the hight tunnel environment, soluble salts can accumulate in the rooting zone

Soil Soluble Salt Levels



Salinity in the High Tunnel

- High tunnel soils are similar to desert soils – no flushing rains!

50-80 lbs sodium/acre

700 lbs sodium/acre

Grower in Henderson or McLean county, photo courtesy of Dr. Tim Coolong, Univ. of Georgia

Source: http://www.conservationwebinars.net/webinars/soil-health-in-high-tunnel-production

Soil Soluble Salts Levels

Source: http://aggie-horticulture.tamu.edu/vegetable/problem-solvers/cucurbit-problem-solver/leaf-disorders/salt-injury

Plants affected by high salt concentrations often appear dark green in the early stages, but rapidly develop marginal yellowing and necrosis of older leaves.

Soil Soluble Salt Levels

- Soluble salt levels in high tunnels can be a problem
  - Many fertilizers and manures are high in potential salts; low quality water can contribute soluble salts
  - Faster mineralization in the high tunnel environment, especially under black plastic
  - Carryover of available nitrogen (Nitrate)
  - Enhanced evaporation “wicks” salts to the surface
  - No natural rainfall to wash (leach) excess nutrients
  - Irrigation usually not sufficient to leach excess salts

Soil Soluble Salt Levels

- Addressing high soil soluble salt levels
  - Monitor soluble salt levels in the soil
  - Place tunnels on soils that are well drained, to promote leaching
  - Avoid over application of nutrients
  - Use nutrients with low salt indices; limit use of animal manures
  - Use irrigation water that is low in salt levels
  - Consider using a sprinkler system to establish seedlings or maintain cover crops
  - Rotate into crops that are less sensitive to salts
  - Leach out salts

Soil Soluble Salt Levels

- Salt indices for common fertilizers

Salt Indexes of Various Fertilizers

Fertilizer	Salt Index
Ammonium Nitrate (34-0-0)	102
Sodium Nitrate (16-0-0)	100
Urea (45-0-0)	73
Ammonium Sulfate (21-0-0)	69
Calcium Nitrate	65
Diammonium Phosphate (18-46-0)	29
Monoammonium Phosphate (11-55-0)	27
Superphosphate (0-45-0)	10
Superphosphate (0-20-0)	8
Potassium Chloride (0-0-60)	116
Potassium Nitrate (14-0-47)	74
Potassium Sulfate (0-0-54)	46

Adapted from: Foth & Ellis, Soil Fertility 2nd Ed.

Soil Soluble Salt Levels

Plant response to salinity levels

The table below illustrates the effects of salinity level on various vegetable crops.

Salinity Level (mmhos/cm)	Effects
Less than 0.40	Negligible salinity; salt sensitive cultivars of beans and carrots my exhibit effects
0.40-0.80	Very slightly saline; 25-50% decrease in yields of carrots, onions, peppers, lettuce
0.81-1.20	Moderately saline; seedling injury possible; 25-50% decrease in yields of broccoli, potatoes
1.21-160	Saline; beets tolerant
1.61-3.20	Strongly saline
Greater than 3.2	Very strongly saline

*Adapted from the Agriculture Analytical Services Laboratory, The Pennsylvania State University; based on a 1:2 soil:water test.

Soil Soluble Salt Levels

- Leaching out salts
  - Movable tunnels to uncover production areas
  - Removal of plastic cover, in response to soil test report – at least 12” of rain needed to leach
  - Use of irrigation to leach salts
    - As a guideline, to leach salts away from the top 12” of soil:
      - 6” of water will leach away 50% of salts
      - 12” of water will leach away 80% of salts
      - 24” of water will leach away 90% of salts

Summary

- Develop a water and soil management plan
  - Test water source annually (or more)
  - Soil test annually, SME test at least annually (more often if indicated)
  - Apply compost, nutrients, and amendments as needed
  - Foliar testing is useful to monitor a fertility program and to diagnose issues
  - Use rotations and cover crops as possible
  - Monitor soil soluble salts levels
  - Keep records!!!!!

Any Questions?

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