Irrigating Greenhouse Crops

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Overview

- Water Needs
  - Plant factors
  - Environmental factors
- Production Impacts
  - Growing media
  - Containers
  - Greenhouse
- Irrigation Considerations
  - Manual
  - Automated

Why is Irrigation so Challenging?

- Plants have different water requirements
- Changing environmental conditions
- Different container sizes
- Different types of containers
- Different media
- Plant canopies
- Location of plant in greenhouse
- Variability of irrigation systems
- Irrigation uniformity and efficiency

Plant Water Needs

- Herbaceous plants can be 70-95% water
- Woody plants 45-50% water

Why is Water a Concern?

Transpiration	• Cooling • Uptake of CO_2 (stomata open)
Turgor Pressure	• Plant stability • Cell enlargement
Metabolic Activities	• Solvent for various chemicals • Proton source
Photosynthesis	• Reactant
Transport	• Water, sugars, nutrients

Why is Water a Concern?

- Growing media
  - Maintain good properties
    - Water holding ability
  - Nutrient movement
- Fertilizer salt build up
  - Leaching

Plant Factors

- Plant size/age of plant
  - Rooting depth
- Leaf area/ canopy
  - Number of leaves
  - Size of leaves

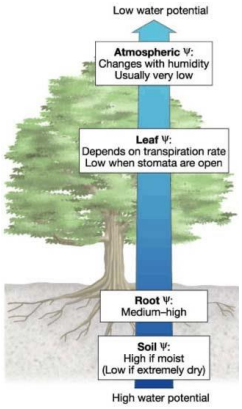
Plant Canopy

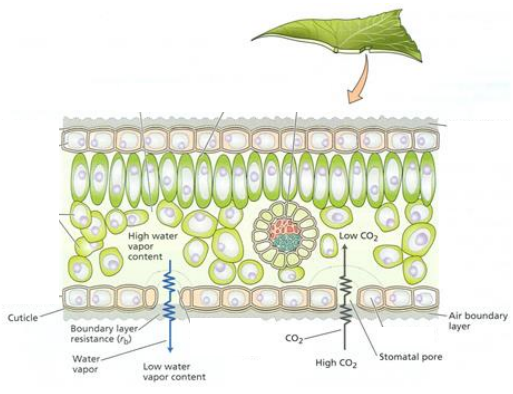
Plant Factors

- Plant size/age of plant
  - Rooting depth
- Leaf area/ canopy
  - Number of leaves
  - Size of leaves
- Transpiration rate
- Availability of water

Environmental Factors

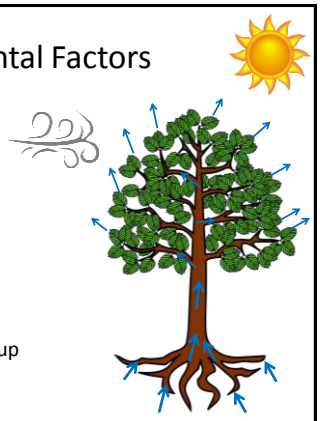
- Water potential gradient
  - Influenced by humidity
- Vapor pressure gradient
  - Difference in vapor pressure between air inside leaf and air outside
  - Drives transpiration
  - Influenced by temperature





Environmental Factors

- Solar radiation
- Wind
- Temperature
- Relative humidity (amount of water vapor in the air)
  - goes down as temperature goes up



Production Impacts

- Growing Media
- Containers
- Greenhouse Environment

Growing Media

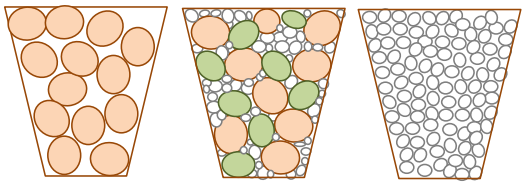
- Anchor the plant
- Lightweight
- Hold water and nutrients
- Provide aeration

Impact of Growing Media

- Variability in:
  - Size and distribution of particles, pore space, bulk density
  - Water holding capacity
  - Infiltration
  - Drainage

Particles and Pore Space

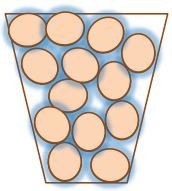
- Particle size and distribution determines pore space
- Pore space determines amount of water and air in the media



Porosity

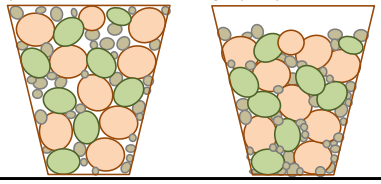
- **Total Porosity**– Total volume of pore space available
- **Air filled porosity**: Volume of a media filled with air after a fully saturated media drains due to gravity
  - Aka – "air space"

Water Holding Capacity- Volume of media filled with water a fully saturated media drains due to gravity
  - Available and unavailable water remains
  - Container Capacity



Bulk Density

- Weight of the dried media per volume of media particles (g/cm^3 or g/mL)
- Varies based on the density of the actual particles
  - Impacts "lightness" of media
- Can vary from container to container depends on how pots are filled
  - Compaction can increase bulk density
  - Compaction reduces water holding capacity

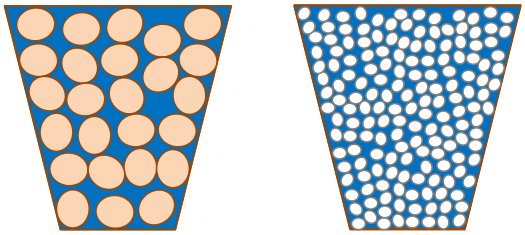


Infiltration and Drainage

- **Infiltration rate**- rate at which water enters the media
- **Water storage and drainage**:
  - 3 primary forces acting on water in media
    - Gravity
    - Adhesion – leads to absorption of water on media particles
    - Cohesion – what causes water molecules to be attracted to each other

Impact of Growing Media

- Larger particles provide drainage
- Finer textures hold more water



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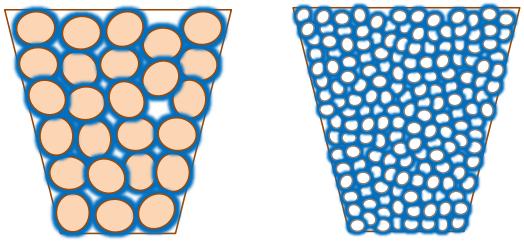

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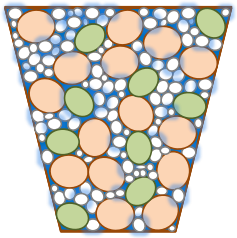
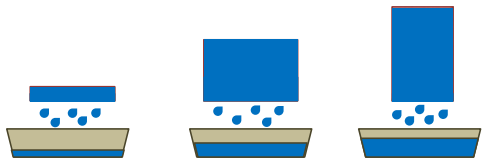


Media Components

*Hydrophobic
**Not hydrophobic

Container Impacts

- Sponge comparison



Container Impacts

- Zone of saturation
- Depends on media NOT container

Container Type

- Plastic
- Biodegradable
- Compostable

Plastic

Paper Pulp

Coir Fiber

Rice Hull

Peat

Container Type

- Pots with porous sidewalls can have higher water requirements
  - Can be 1.5-2.5x higher than plastic pots!

Paper Pulp

Coir Fiber

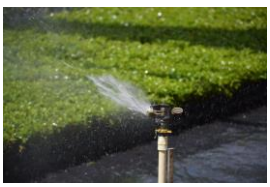
Peat

Greenhouse Impacts

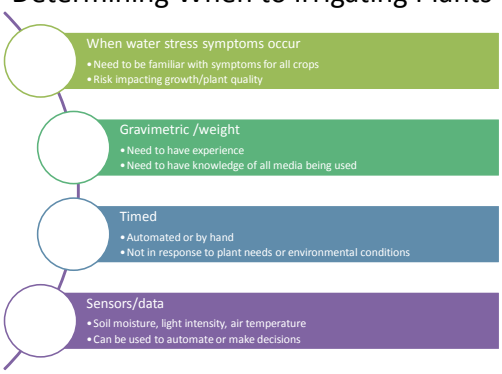
- Interference
- Air movement

Irrigation in Greenhouse Production

- Traditionally based on the idea that it is better to err on the side of too much
- Results:
  - Frequent irrigation
  - Over-irrigation
  - Fertilizer leaching



Determining When to Irrigating Plants



Manual Watering

Pros

- Less initial investment in equipment
- Grower looks at every plant and can adjust per plant needs

Cons

- Requires experience to be done well
- Labor intensive
- Can be wasteful
- Can be inefficient
- Uniformity depends on applicator
- Wetting of foliage can be problematic

Manual Watering

Manual Watering Best Practices

- Don't rely on looking – pick up a plant!
- Position of the watering wand
  - Close to media surface
- Water pressure – gentle stream
- Be consistent!
  - Have a count
- Check for thorough wetting of media

Automated Irrigation

Pros

- Reduced labor
- Reduced potential for human error
- More compatible with recycling water
- More consistent
- Depending on systems can control based on measured parameters

Cons

- Higher initial equipment investment
- Technology can require adjustment of existing systems

Automated Irrigation

- Drip
- Ebb-and-Flood Systems or capillary mats
- Overhead
- Boom

Drip Irrigation

- Pressure compensated emitters
- Spray stakes
- Drip line

Drip Irrigation

Pros

- Directed applications
- Efficient
- Foliage remains dry
- Can vary volume by emitter or time

Cons

- Can need to adjust emitter/time/amount of tubing per crop
- On ground can be a tripping issue
- What to do with tubes when plants pulled

Ebb-and-Flood

- Floor
- Table

Photo Credit: Doug Cox

Ebb-and-Flood

Pros

- Container size and placement easily changed
- Uniform applications
- Foliage remains dry
- Water recycled

Cons

- Floors require alteration of existing structure
- Contain and treat water
- Water spread diseases

Overhead Sprinkler

Overhead Sprinkler

Pros

- Container size and placement easily changed
- Spray pattern can be adjusted

Cons

- Much water can be lost between plants
- Wetting of foliage
- Can be impacted by greenhouse structures
- If not designed well can have uniformity issues

Boom

- Directed spray

Boom

- Mist

Pros

- Technology allows for high level of control
- Directed applications

Cons

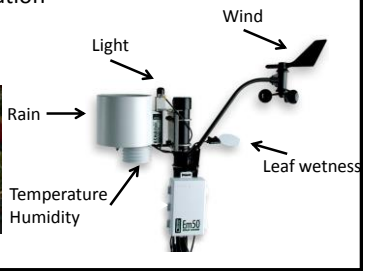
- Cost
- Can require changes in infrastructure
- Some wetting of foliage

Mist/Fog

- Propagation/plugs
- Fine mist created by fan

Weather Station Sensors

- Estimate evapotranspiration



Soil moisture sensors

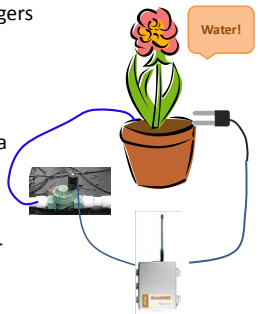
- Tensiometers – measure soil suction (indicates how easy it is for plants to remove water from media)

- Capacitance probes – measure actual water content

- Placement important: root zone

Sensor Controlled Irrigation

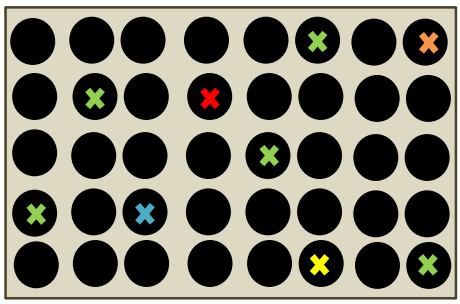
- When connected to data loggers or computers data can be collected continuously
- Automate irrigation
  - Application of water only when the media is below a setpoint
  - More efficient irrigation applications
  - In response to plant water needs



Sensors

- Placement of sensors is important
- Representative/average data

Sensors



Consequences of Poor Water Management

- Over-irrigation
  - Water loss
  - Nutrient leaching
  - Additional fertilizer applications
- Runoff
  - Environmental impact
  - Laws and regulations
- $$

http://smart-farms.net/our-approach/water-management

Consequences of Poor Water Management

- Reduction in plant quality/health
  - Over-irrigation:
    - Root rot, algal growth, nutrient deficiencies
  - Under-irrigation:
    - Wilt, reduced growth
    - Hydrophobic media, channeling
  - Wet foliage:
    - foliar diseases

Increasing Irrigation Efficiency

- Group plants by water needs (high, medium, low water use)
- Consolidate plants

Increasing Irrigation Efficiency

- Basing Irrigation Decisions on:
  - Environmental conditions
  - Media water status
  - Changing plant needs
- Improving applications
  - Drip/micro
  - Cyclic
- Reduce leaching
  - Leaching fraction no more than 20%

Increasing Irrigation Efficiency

- Inspecting systems regularly
  - Irrigation audit
    - Uniformity is key
  - Reduce variability
  - Replace nozzles, check for nozzle uniformity
  - Check for clogs or build-up
  - Check height of overhead irrigation (too high = increase likelihood of drift)
  - Assess container spacing

Tips To Properly Water

- Don't rely on the appearance of the media surface
  - Drying begins at the surface
  - Check the roots and media

Tips To Properly Water

- Whenever possible apply water to the media not the foliage
  - Use a uniform gentle flow
  - Water slowly – allow time for infiltration
- Bring plants back to container capacity
- Allow some drying between irrigation events

Tips To Properly Water

- When (Not) to Water
  - Avoid watering when evapotranspiration is high (midday)
  - Avoid evening irrigation to avoid wet foliage
- Avoid dripping from overhead hanging baskets, especially with newly potted plants
- Water evenly – don't reach for that last pot
  - These plants usually end up underwatered

Consider Making Guidelines

- Make irrigation guidelines based on what information you have available
  - Visual – look of media (plant pulled out of pot)
  - Weight
  - Media water content
  - Evapotranspiration
- Cloudy vs sunny
- Summer vs winter
- Humid vs dry

Conclusions

Plant Impacts	• Age, genus, transpiration rate • Leaf area/plant canopy
Environmental Considerations	• Change on a day to day basis • Drive transpiration
Production Impacts	• Growing media components: WHC, drainage • Container size and type • Greenhouse structures

Conclusions

When to Irrigate	• Stress symptoms, weight, timed, based on information • Experience
Manual Irrigation	• Someone looks at every plant • Variability by applicator
Automated Irrigation	• Reduced labor, generally increased efficiency and uniformity • Cost, technology

Conclusions

Improving Efficiency	• Inspect irrigation system • Uniformity is key • Avoid watering non-plant areas
Improve Applications	• Cyclic applications • Directed applications • Group plants by water requirements
Irrigation Tips	• When pots feel light not when it looks dry • No matter what type of irrigation – be consistent!

Questions?