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?

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

Why is Water a Concern?

- Cooling
- Uptake of CO₂ (stomata open)
- Plant stability
- Cell enlargement
- Solvent for various chemicals
- Proton source
- Reactant
- Water, sugars, nutrients
Plant Factors

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

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

- 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/cm³ 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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Media Components

- Peat*: high WHC, lightweight
- Coir**: high WHC, lightweight
- Bark: varies with size; porosity, WHC, drainage
- Vermiculite: WHC, lightweight
- Perlite: drainage, lightweight
- Sand: drainage, high bulk density
- Rice hulls: drainage

*Hydrophobic
**Not hydrophobic

Container Impacts

- Sponge comparison
**Container Impacts**
- Zone of saturation
- Depends on media, NOT container

**Container Type**
- Plastic
- Biodegradable
- Compostable

**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**
- When water stress symptoms occur
  - Need to be familiar with symptoms for all crops
  - Risk impacting growth/plant quality
- Gravimetric/weight
  - Need to have experience
  - Need to have knowledge of all media being used
- Timed
  - Automated or by hand
  - Not in response to plant needs or environmental conditions
- Sensors/data
  - Soil moisture, light intensity, air temperature
  - Can be used to automate or make decisions
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 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

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Ebb-and-Flood

**Pros**
- Uniform applications
- Foliage remains dry
- Water recycled

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

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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

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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

Consequences of Poor Water Management

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

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?