Mastering Moisture Management

For controlling greenhouse pests and diseases

Ryan Dickson, Ph.D.

State Specialist, Greenhouse Management and Technologies

University of New Hampshire Cooperative Extension

2017 Tri-State IPM Workshop Series

University of New Hampshire Cooperative Extension

Why is moisture management an important part of IPM?

The way moisture is managed affects…

- Spread of diseases
- Plant health
- Nutritional quality

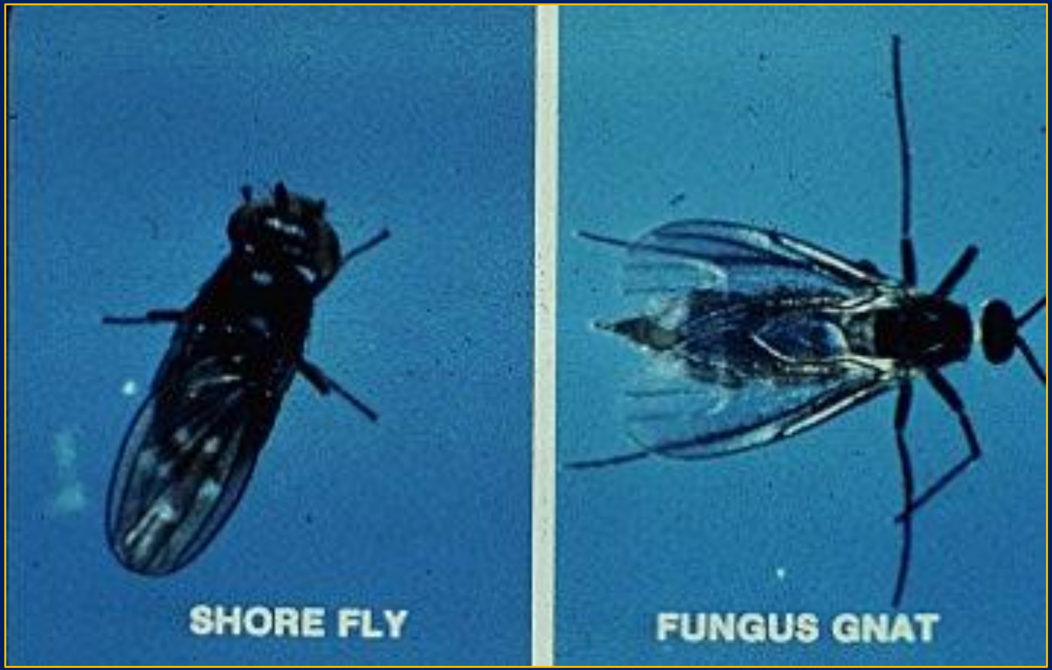
Adjust cultural practices to manage moisture for improved plant health and lower susceptibility to pests and diseases

Splashing water from overhead can help spread pathogens

Algae growth on substrate and floor

- Symptom of overwatering
- Algae harbors pests, disease, and is unattractive

Fungus gnats and shore flies



- Populations increase with overwatering
- Larvae feed on root tips, damage plants, spread disease

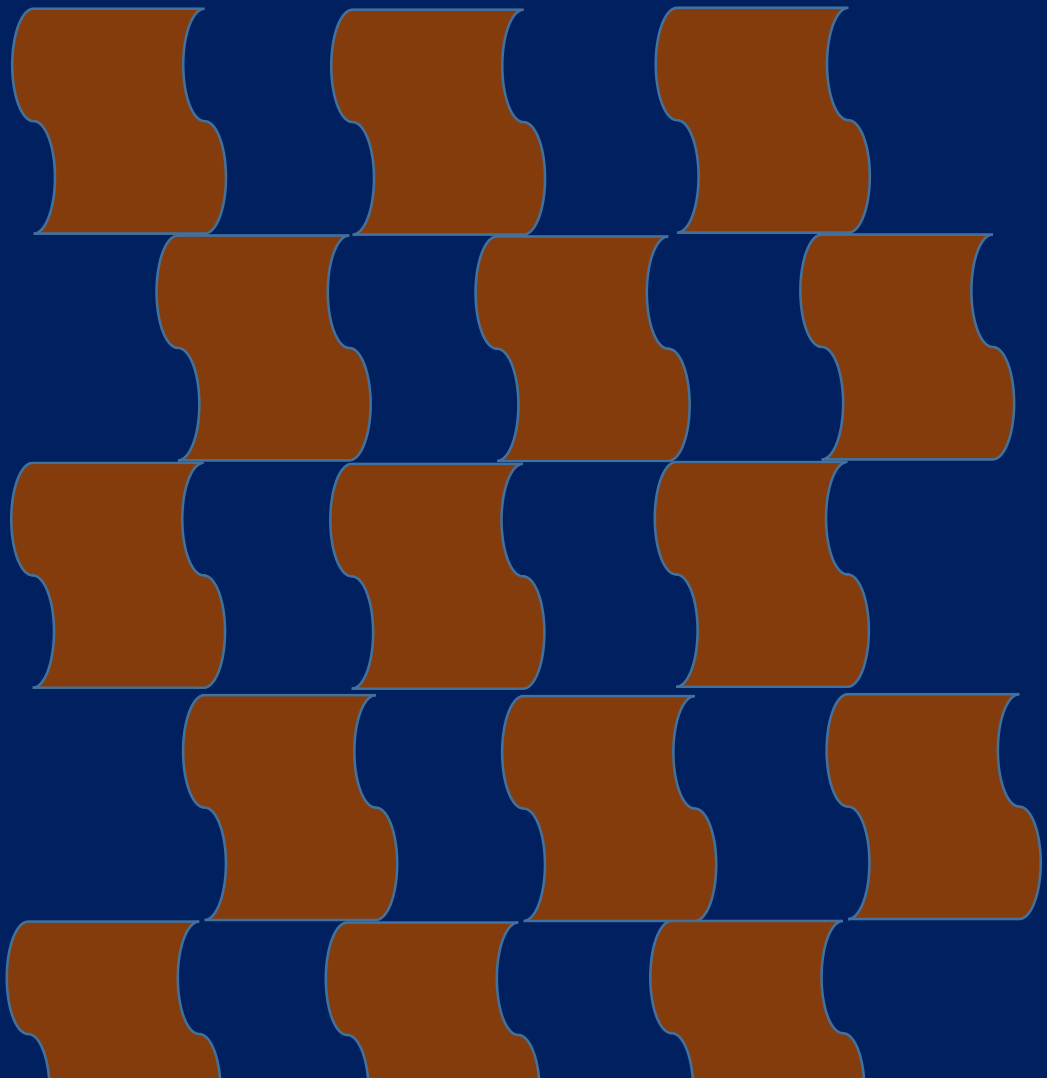
Where to look when fine-tuning moisture management?

1. Substrate type and container geometry

2. Irrigation practices

3. Water quality and treatment

Importance of air (oxygen) and water balance in the root zone



Roots need both air (oxygen) and water

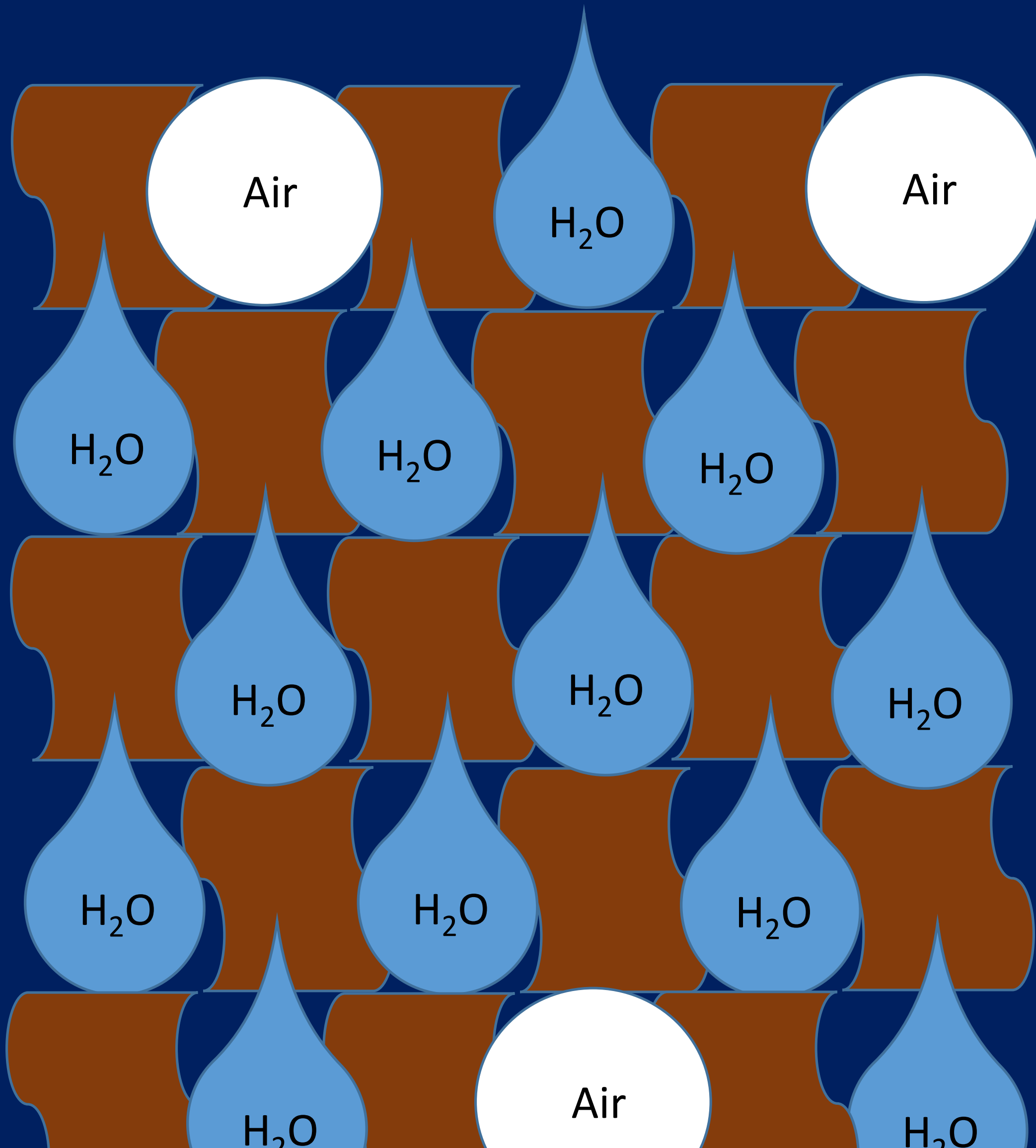
Oxygen needed for…

- Root respiration
- Pathogen resistance

Water needed for…

- Delivering nutrients
- Plant turgidity and growth

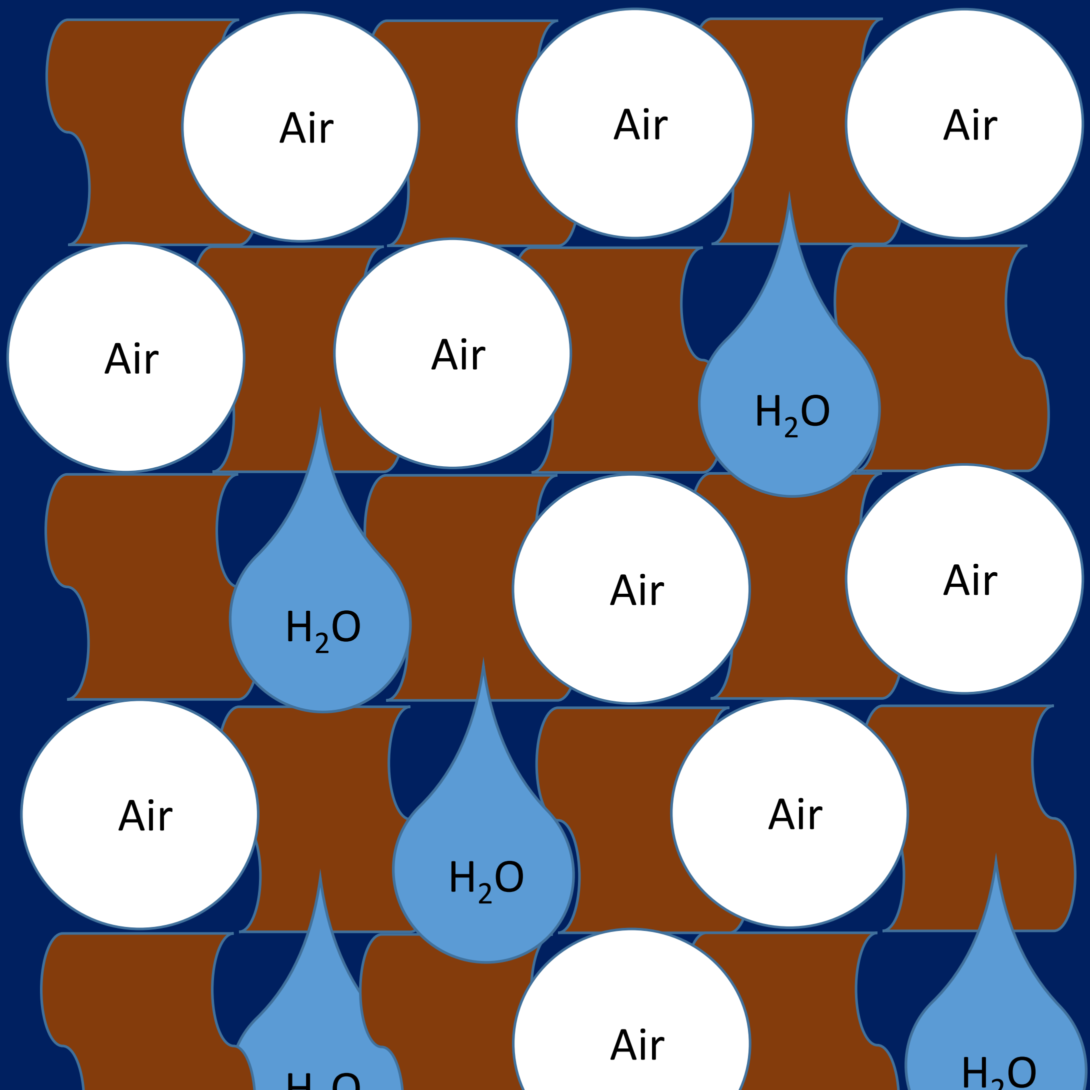
Importance of air (oxygen) and water balance in the root zone



Pore spaces filled mostly with water

- High nutrient availability, leaf expansion, and shoot growth
- Low oxygen for roots
- Occurs in dense media, after irrigating

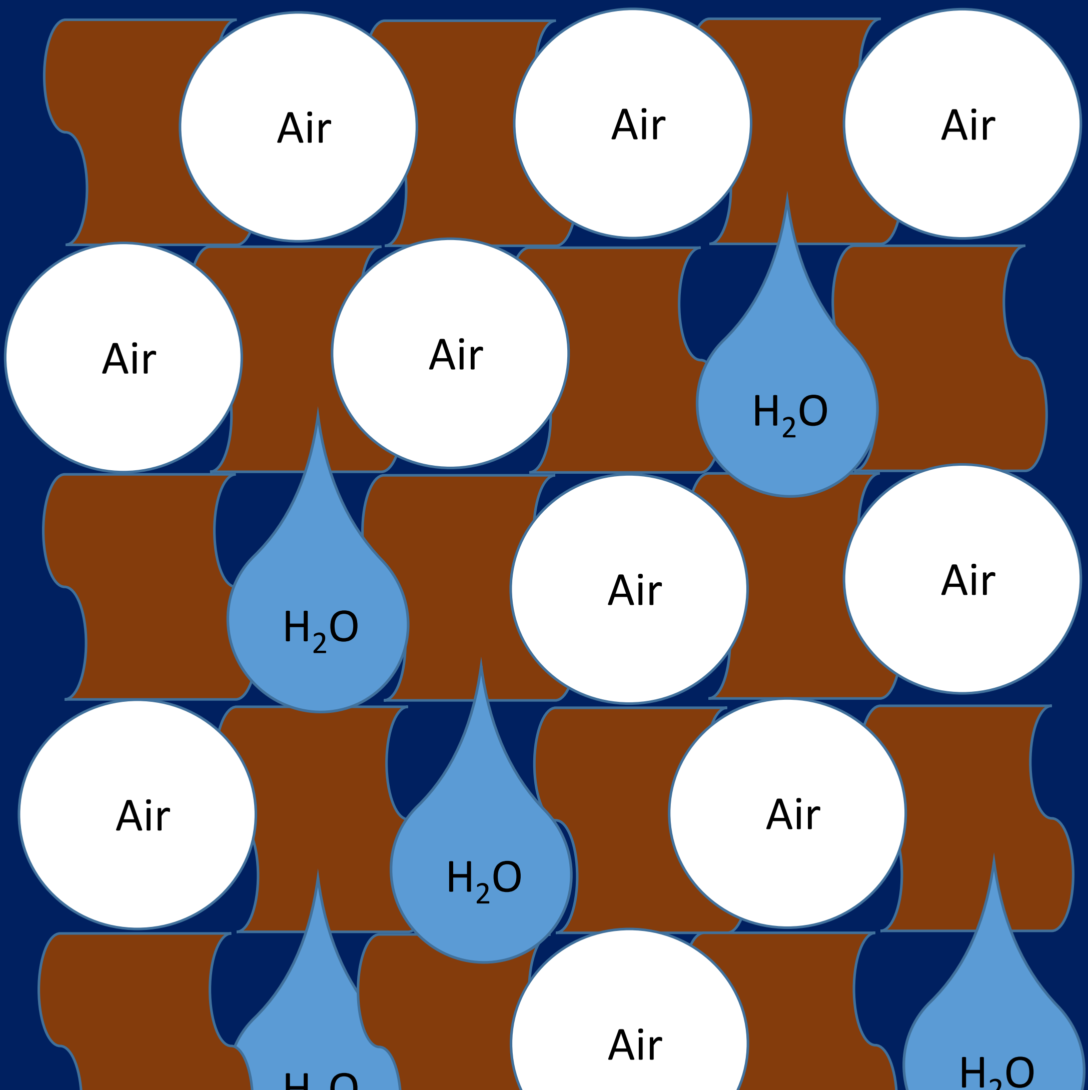
Importance of air (oxygen) and water balance in the root zone



Pore spaces filled more with air

- Oxygen for healthy root growth, root hairs
- Lower nutrient availability and water for transpiration
- Occurs in porous media, after drying

Key points for managing air (oxygen) and water balance

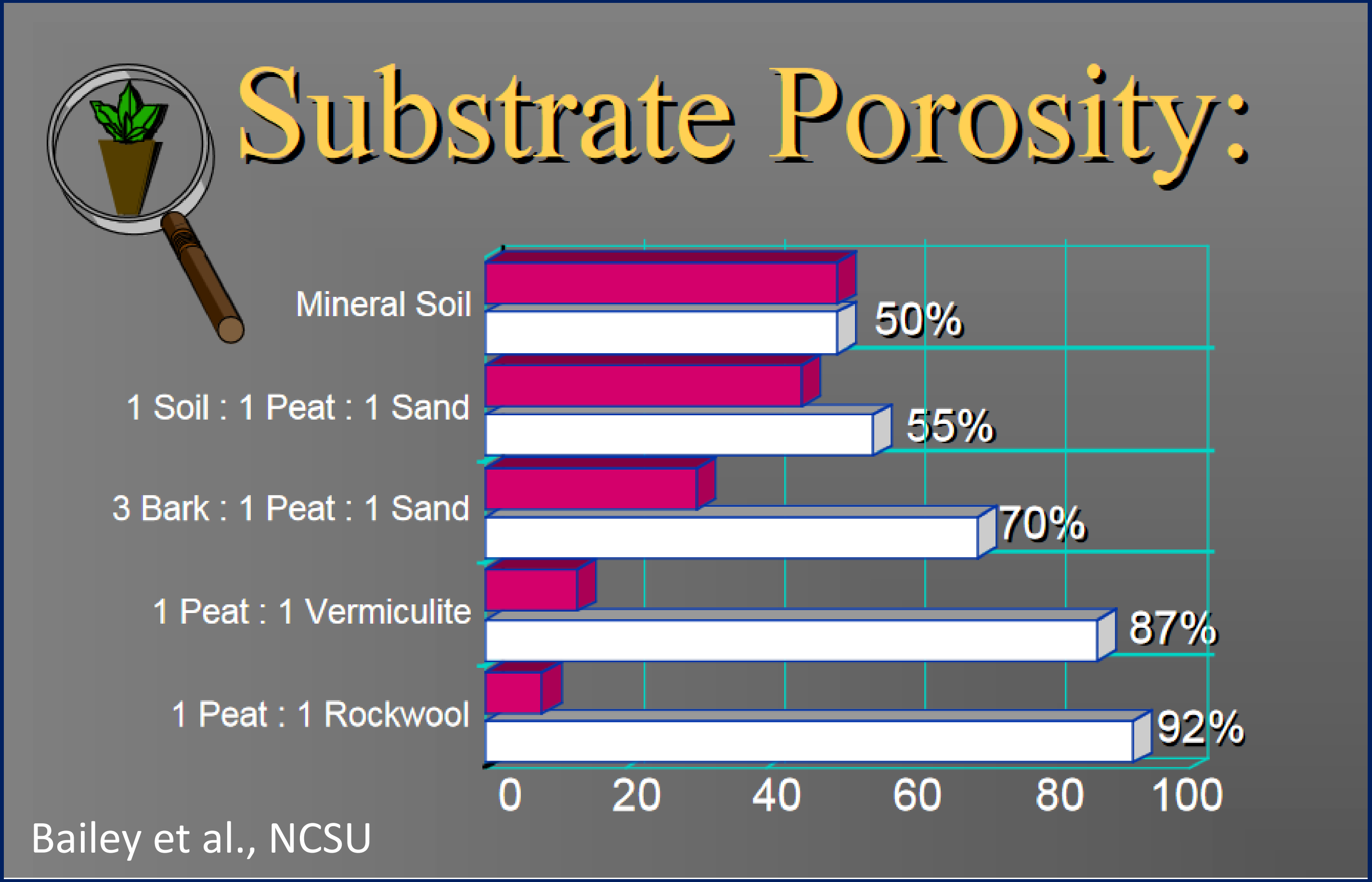


- Choose appropriate substrate and balance air-water
- Manage irrigation to balance water and aeration over time

Healthy roots are usually white and fibrous with lots of root hairs

- Trick is to balance air and water for healthy roots

Container substrates have a large amount of pore space by volume

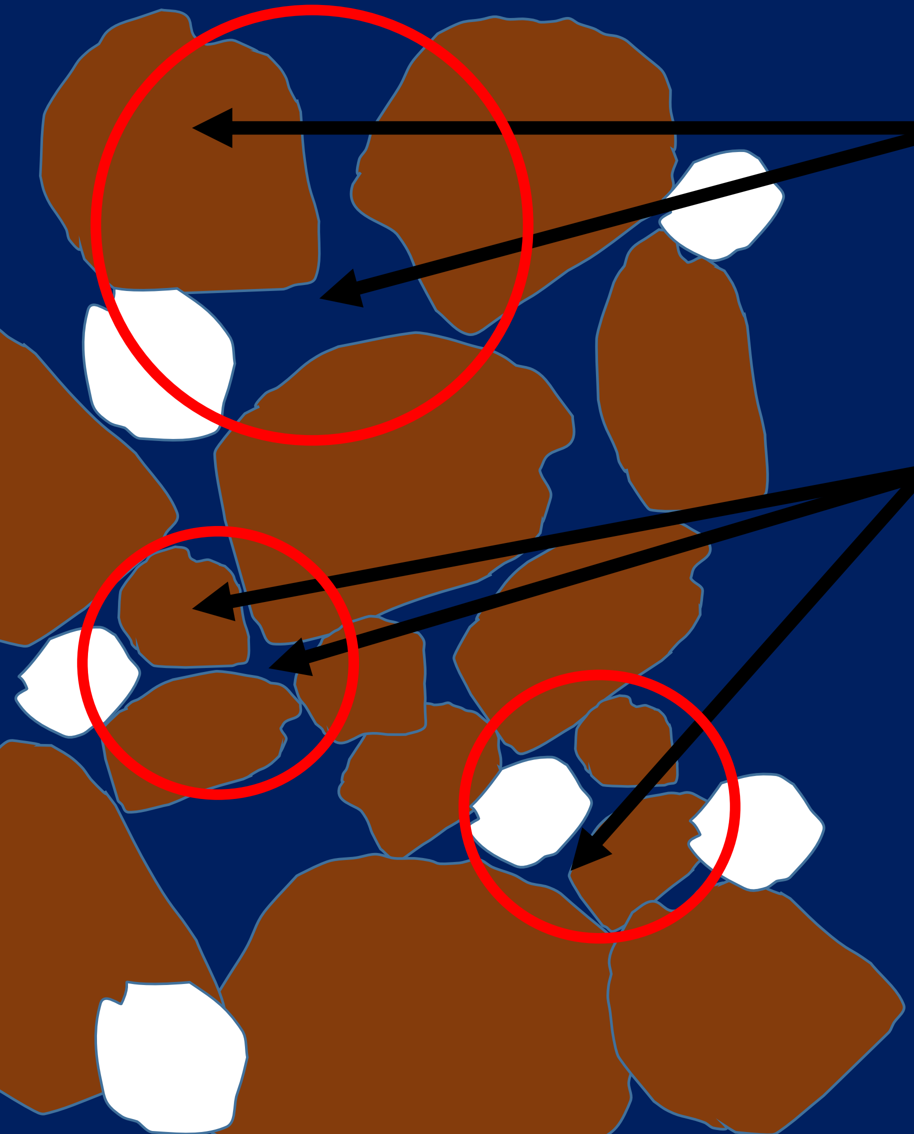


Pink
% solid particle

White
% pore space

- 80% to 90% pore space, can hold a lot of water or air

Substrate particle size also affects amount of pore space is filled with air and water



Large particles

Pore space holds more air

Small particles

Pore space holds more water

Need large and small particles for adequate aeration and water retention

Know particle size distribution when choosing the appropriate substrate

Particle grade	Diameter (mm)
Very coarse	>4.8
Coarse	2 – 4.8
Medium	0.5 – 2
Fine	0.15 – 0.5
Dust	<0.15

Contains mostly…

Propagating hard to root woody's and perennials, heavy irrigation

Know particle size distribution when choosing the appropriate substrate

Particle grade	Diameter (mm)
Very coarse	>4.8
Coarse	2 – 4.8
Medium	0.5 – 2
Fine	0.15 – 0.5
Dust	<0.15

Contains mostly…

Propagation and cases where heavy irrigation is needed

Know particle size distribution when choosing the appropriate substrate

Particle grade	Diameter (mm)
Very coarse	>4.8
Coarse	2 – 4.8
Medium	0.5 – 2
Fine	0.15 – 0.5
Dust	<0.15

Contains mostly…

Germination and growing seedling plugs

Know particle size distribution when choosing the appropriate substrate

Particle grade	Diameter (mm)
Very coarse	>4.8
Coarse	2 – 4.8
Medium	0.5 – 2
Fine	0.15 – 0.5
Dust	<0.15

Contains mostly…

Not recommended, substrate is "muck" (Fine, Dust)

Know particle size distribution when choosing the appropriate substrate

Particle grade	Diameter (mm)
Very coarse	>4.8
Coarse	2 – 4.8
Medium	0.5 – 2
Fine	0.15 – 0.5
Dust	<0.15

Approximately equal parts…

Provides adequate aeration and water, low settling and compaction

Look at your substrate bag for a "quick and dirty" estimate of porosity

Larger particles	Smaller particles
Peat moss or coconut coir (med-coarse fiber)	Peat moss or coconut coir (fine-med fiber)
Vermiculite (horticultural grade)	Vermiculite (fine grade)
Perlite	Sand
Bark	Calcined clay
Wood chips/fiber	Composts

- Large particle substrates are usually more porous, and therefore dry faster

Measure container substrate porosity on-site

- Free online protocols
- Test water and air porosity
- Containers and plug trays
- Guidelines


P. Fisher, UF

North Carolina State University
http://www.nurserycropscience.info/substrates/physical-properties/technical-pubs/bilderback2009measureafp-proc-sna.pdf

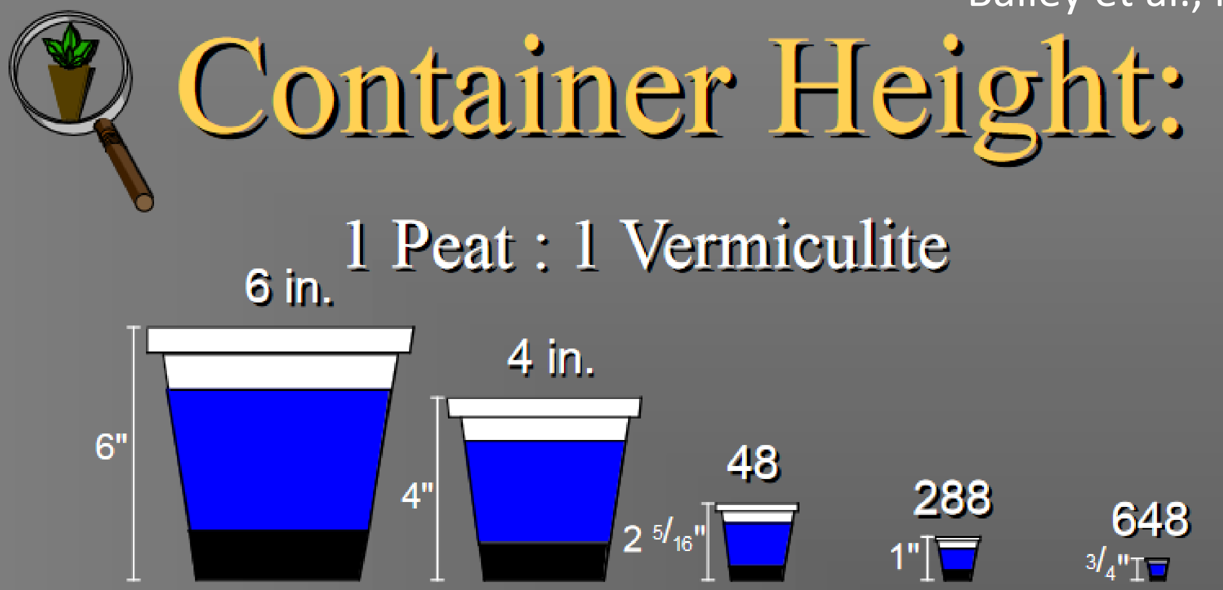
University of Florida
http://www.backpocketgrower.com%2farchive%2fS02_Porosity_Testing_for_Propagation_Substrates_in_Trays.pdf/RK=0/RS=8hKlMt1JuZDwU.BLyhQoJ1KQRWI-

Height of containers affects substrate air and water

Bailey et al., NCSU

Container Height:

1 Peat : 1 Vermiculite

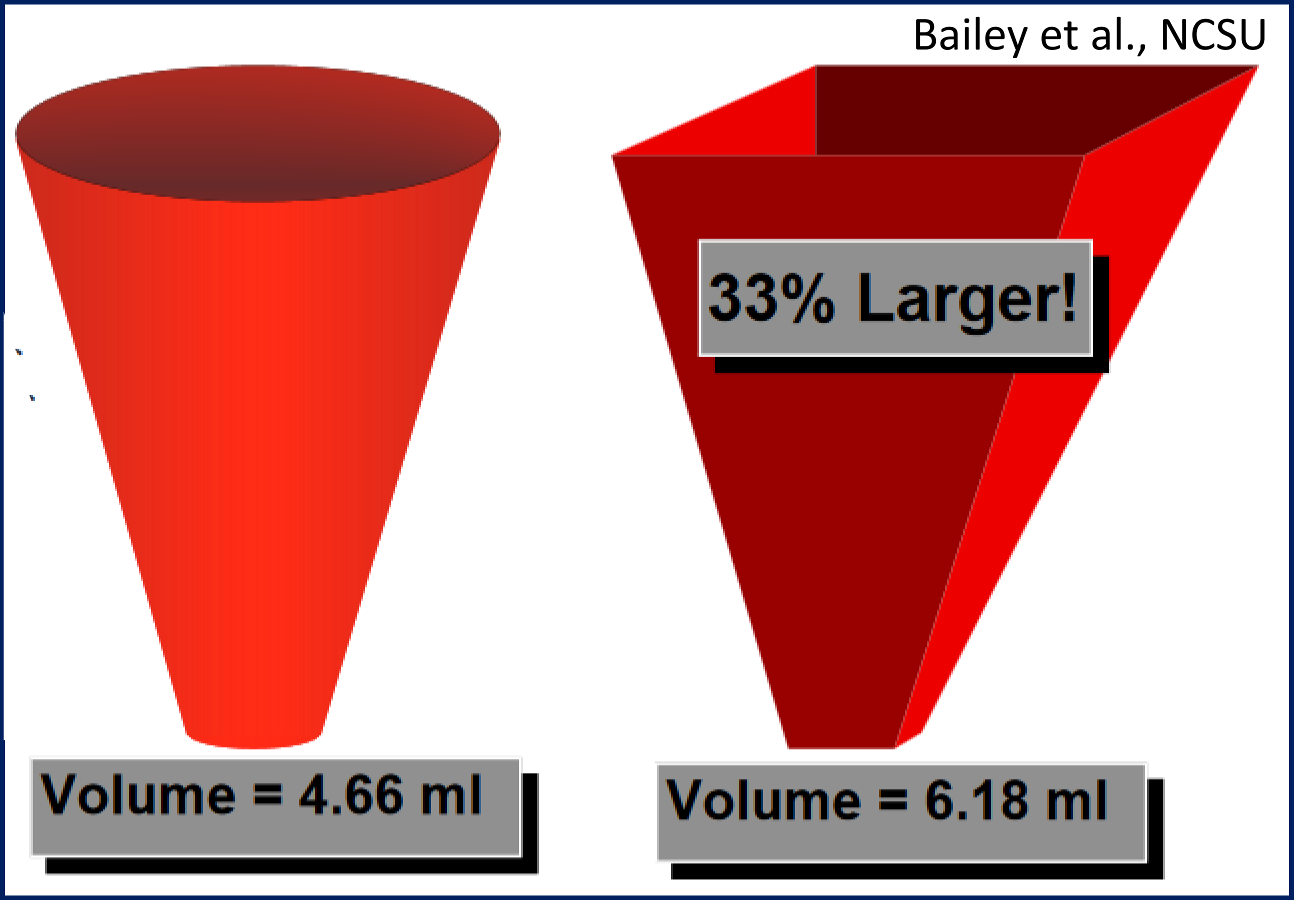


Air	20	13	8	3	0.5
Water	67	74	79	84	86.5
Solid	13	13	13	13	13

- 4-inch standard pots (taller) have better aeration compared to 4-inch azalea pots (shorter)

Cells in propagation or seedling trays are relatively tall to promote aeration

Square containers hold more substrate compared to round containers



- Square pots = greater volume for roots, water, and air
- Edges deflect roots for more branching less circling

Level of compaction affects air and water porosity

Bailey et al., NCSU

Compaction	Air space AS %	Unavailable water UW %	Available water AW %
light	9	21	58
medium	4	26	56
heavy	2	30	52

- Avoid compaction when filling pots
- Fine particles, clay, and sand compact over time

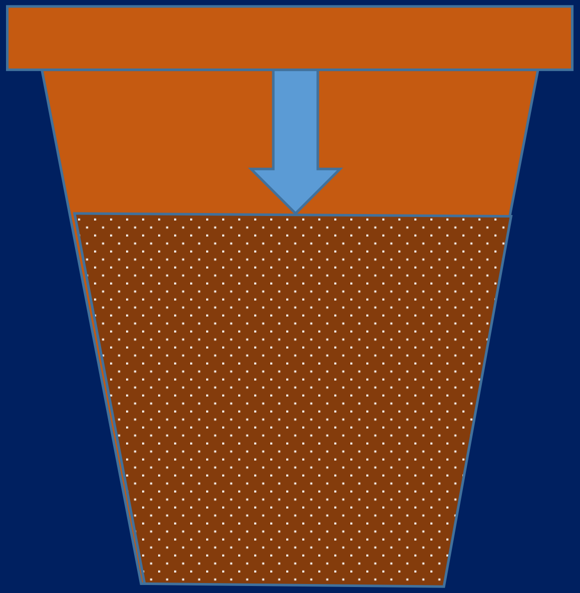
How compacted is your substrate at planting?

Compaction test

1. Fill container and irrigate to drain

2. Drop container twice from ~8 inch height

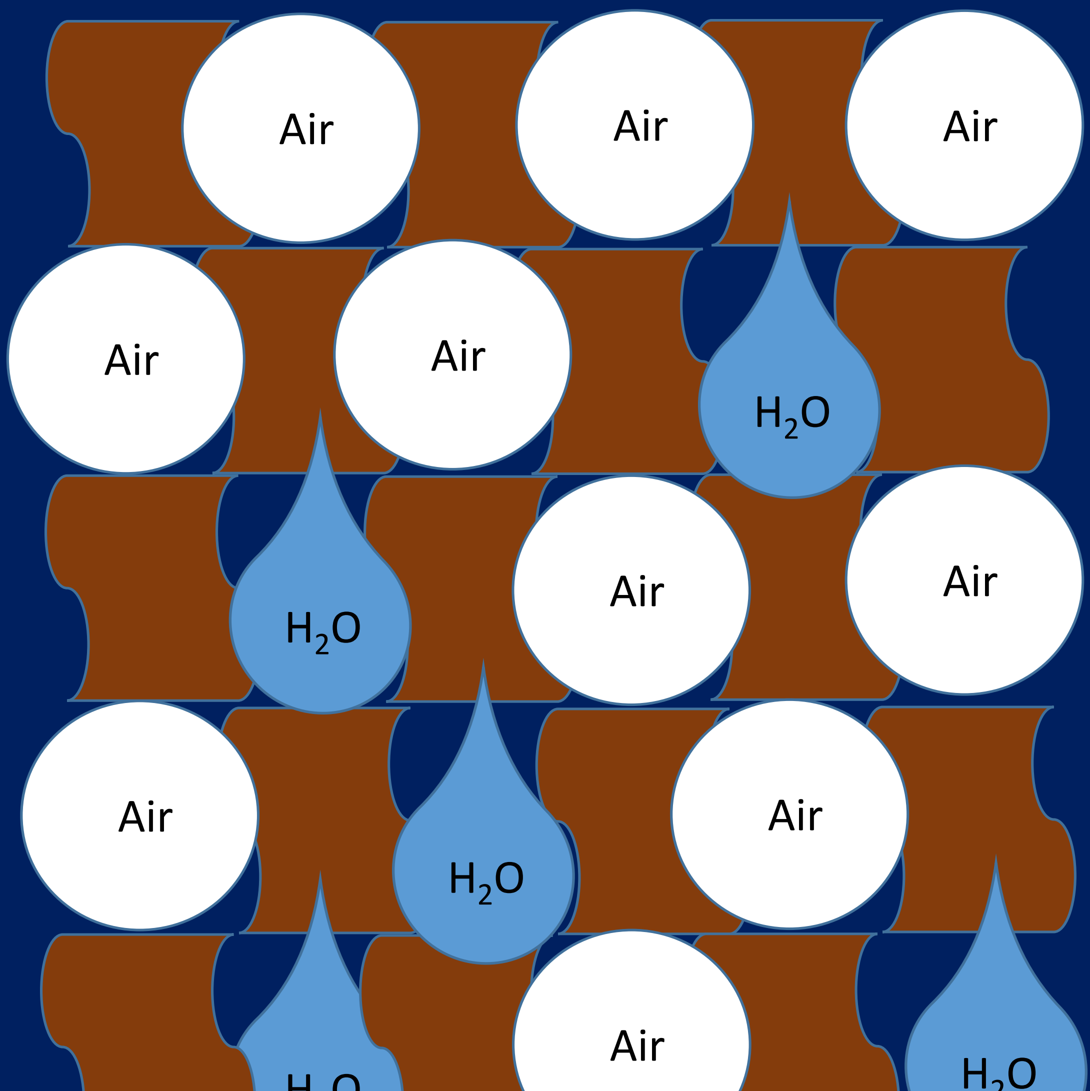
3. Measure drop in substrate as % of container height



<u>Container is under-filled:</u>
Drop >10% of container height

<u>Container is over-compacted:</u>
Drop <2% of container height

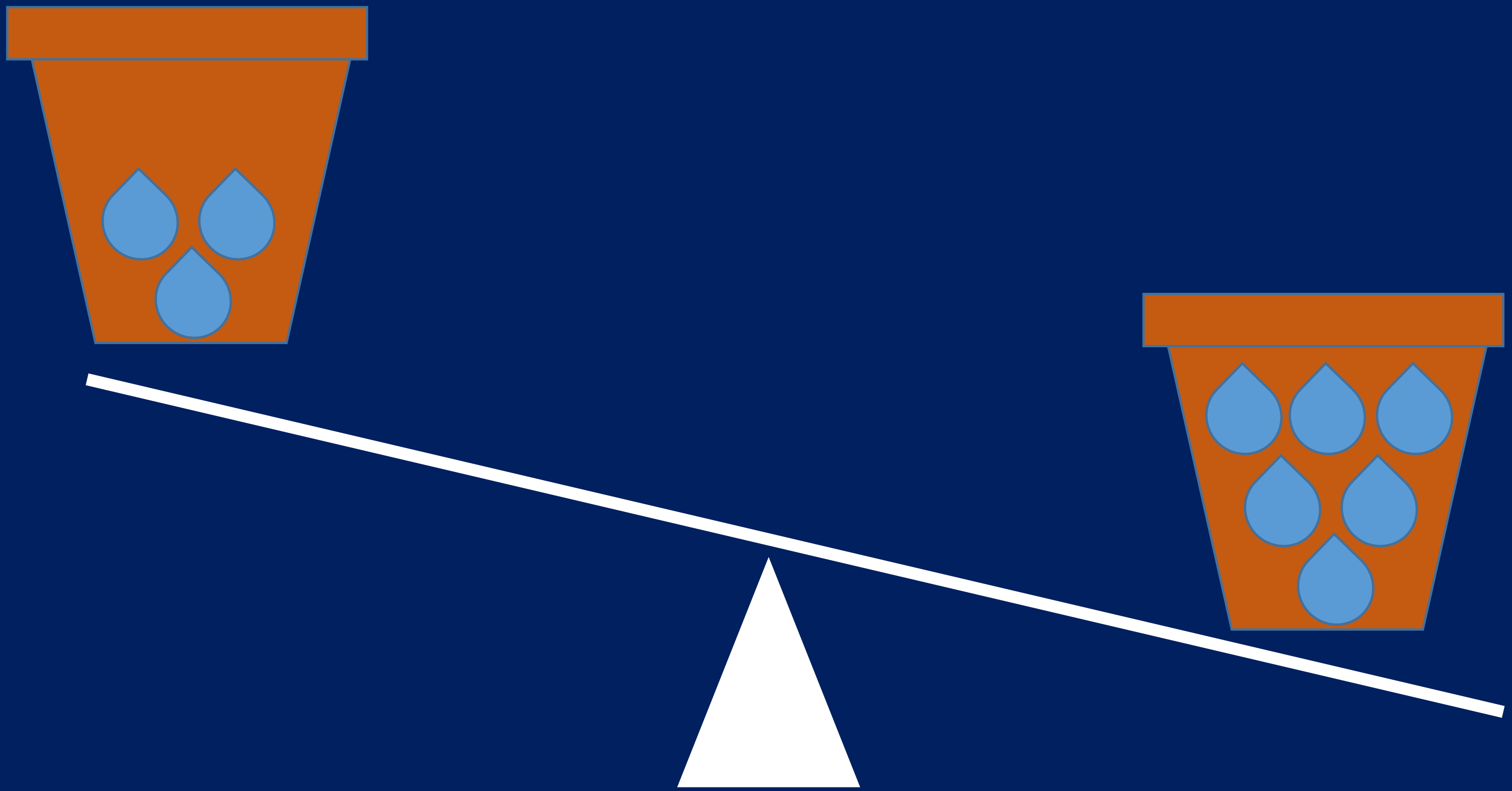
Key points for managing air (oxygen) and water balance



- Choose a substrate with appropriate air-water balance
- Manage irrigation to balance water and root aeration over time

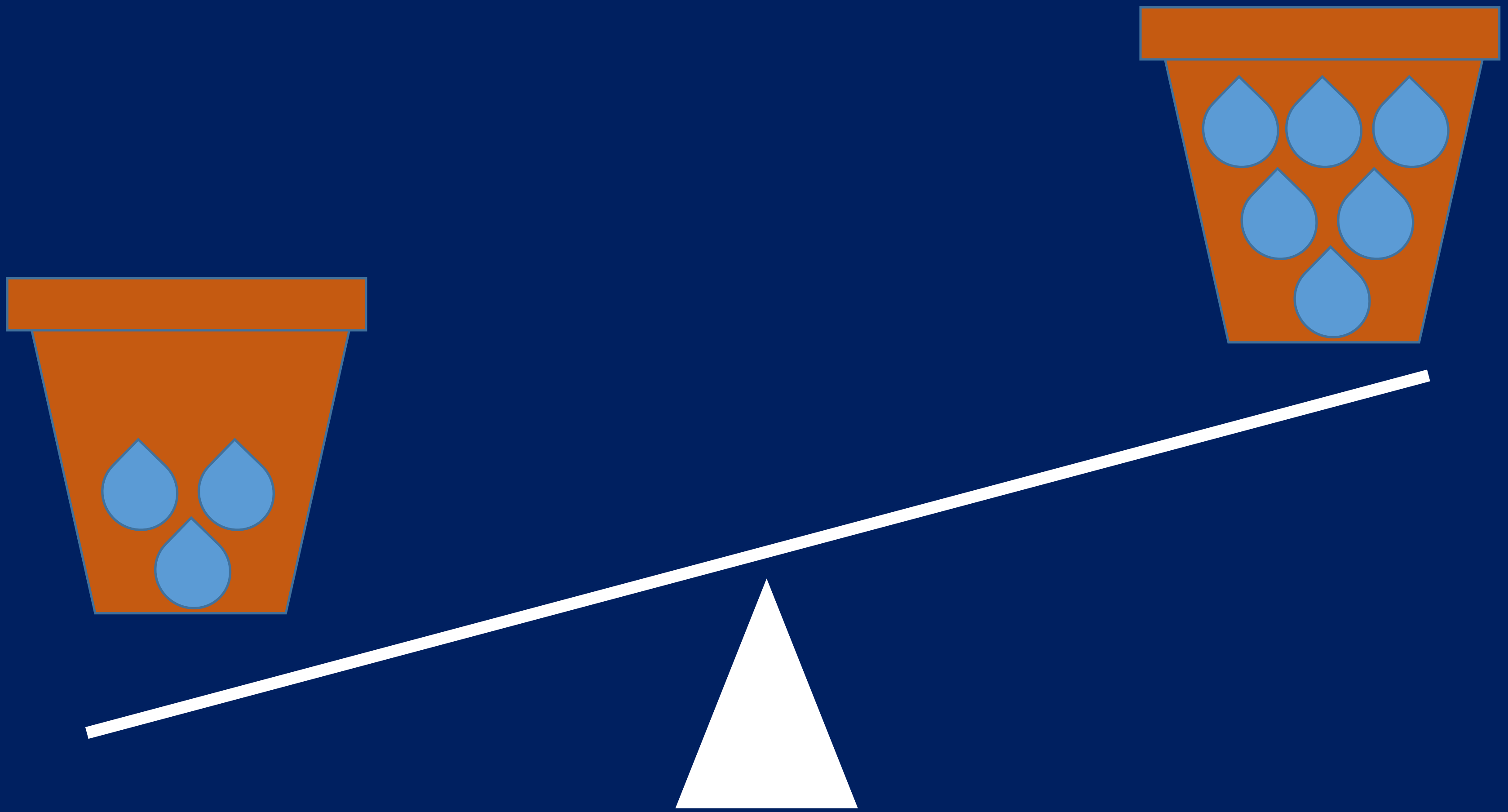
Irrigation: Balance air (oxygen) and water in the root zone

Substrate stays wet—Low aeration results in low oxygen, poor root health, greater disease susceptibility



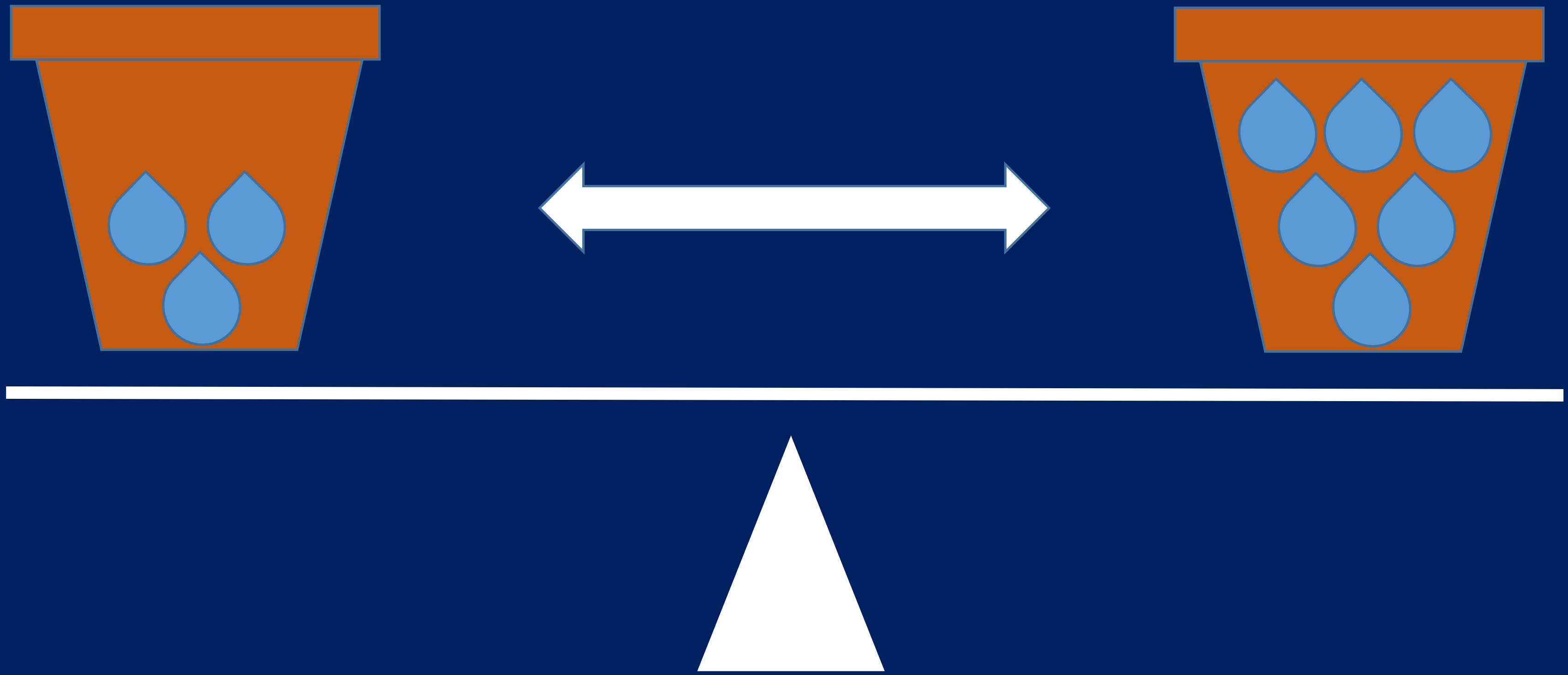
Irrigation: Balance air (oxygen) and water in the root zone

Substrate stays dry—High aeration results in water stress, limited root and shoot growth, burned roots (high salts)



Irrigation: Balance air (oxygen) and water in the root zone

Wet-dry irrigation cycles—Healthy root development, lowers disease susceptibility, toned growth



When to irrigate crops? It depends…

- Decisions are often subjective, differ between irrigators
- Based on climate, crop species, plant stage, canopy size
- Takes time and experience
- Monitor substrate moisture to improve irrigation

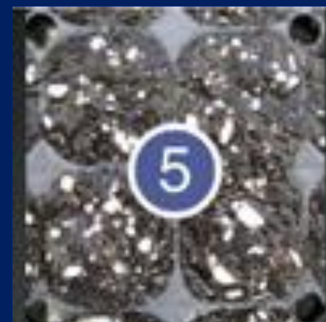
Monitor substrate moisture using the five-point moisture scale (Dr. Will Healy)

Define moisture based on 'look and feel' technique

Useful language to communicate irrigation strategy, train irrigators

<u>Example:</u>

Dry substrate to level 2 before irrigating to a level 4



Saturated

90-100% field capacity

50-70% field capacity

30-40% field capacity

~20% field capacity

http://floriculturealliance.org/archive/Will_Healy_Watering_Guide.pdf

Target moisture levels during finished crop production (Dr. Will Healy)

Crop species	Transplant	Root establishment	Shoot growth and flowering	Shipping
Geranium	3	4	3	3
New Guinea Impatiens	4	4	4	3
Fiesta Impatiens	4	4	4	3
Petunia	3	4	3	3
Verbena	4	3	4	3

- Most crops need between level 3 and 4
- Depends on species and stage of development

Target moisture levels during plug production (Dr. Will Healy)

Crop species	Germination (Stage 1)	1^{st} true leaf (Stage 2)	Growth (Stage 3)	Toning (Stage 4)
Pansy	**4**	**3**	**3**	**3**
Impatiens	**5**	**3**	**3**	**2**
Petunia	**4**	**4**	**3**	**2**
Verbena	**3**	**3**	**3**	**3**
Vinca	**4**	**3**	**3**	**3**

- Most crops need between level 2 and 4
- Depends on species and stage of development

Propagation: High moisture during cutting hydration and callusing

- Moisture level 4.5 to rehydrate and during callusing
- Moisture level 3 at root initiation and development

Irrigating based on container weight

Common irrigation strategy

Irrigate when several random containers feel "light"

Decisions are subjective, differs between irrigators

Simple gravimetric (weighing) technique to improve irrigation consistency

1. Weigh containers after irrigation and drain (field capacity)

2. Weigh same containers just before irrigation is needed (dry)

3. Standardized <u>weight</u> to signal irrigation

4. Periodically weigh 3-5 containers to determine when to irrigate

Good for large crops, same container size

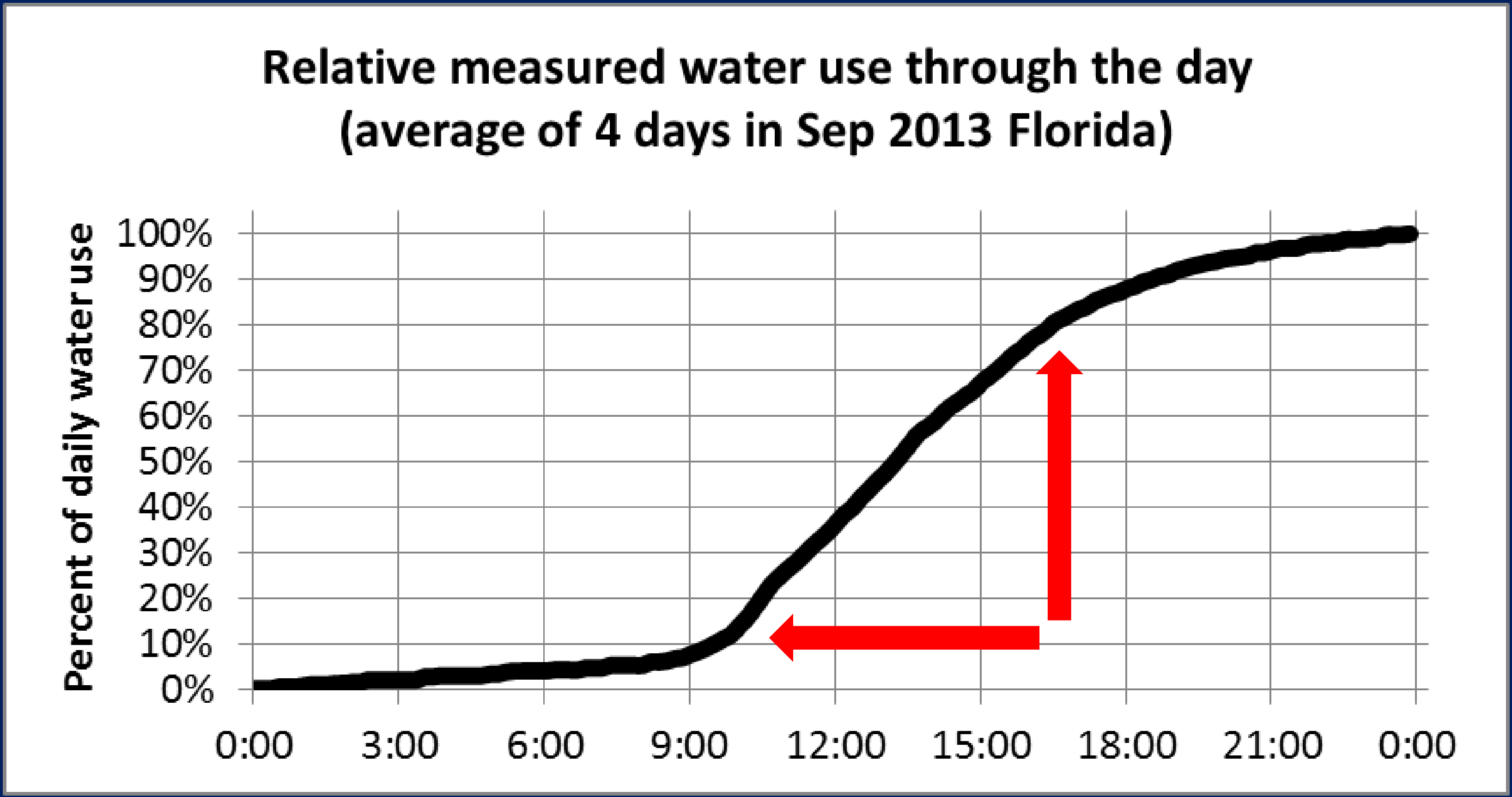
Train new irrigators

‘Get you calibrated’

Monitor moisture and control irrigation using soil moisture sensors

- New di-electric soil moisture sensors
- Calibrated to measure water volume per pot
- Trigger irrigation using environmental control computer
- Monitor irrigation practices remotely with wireless technology

Plants use relatively little water early and late in the day



- Plants used >70% of daily water requirement between 9am and 4pm

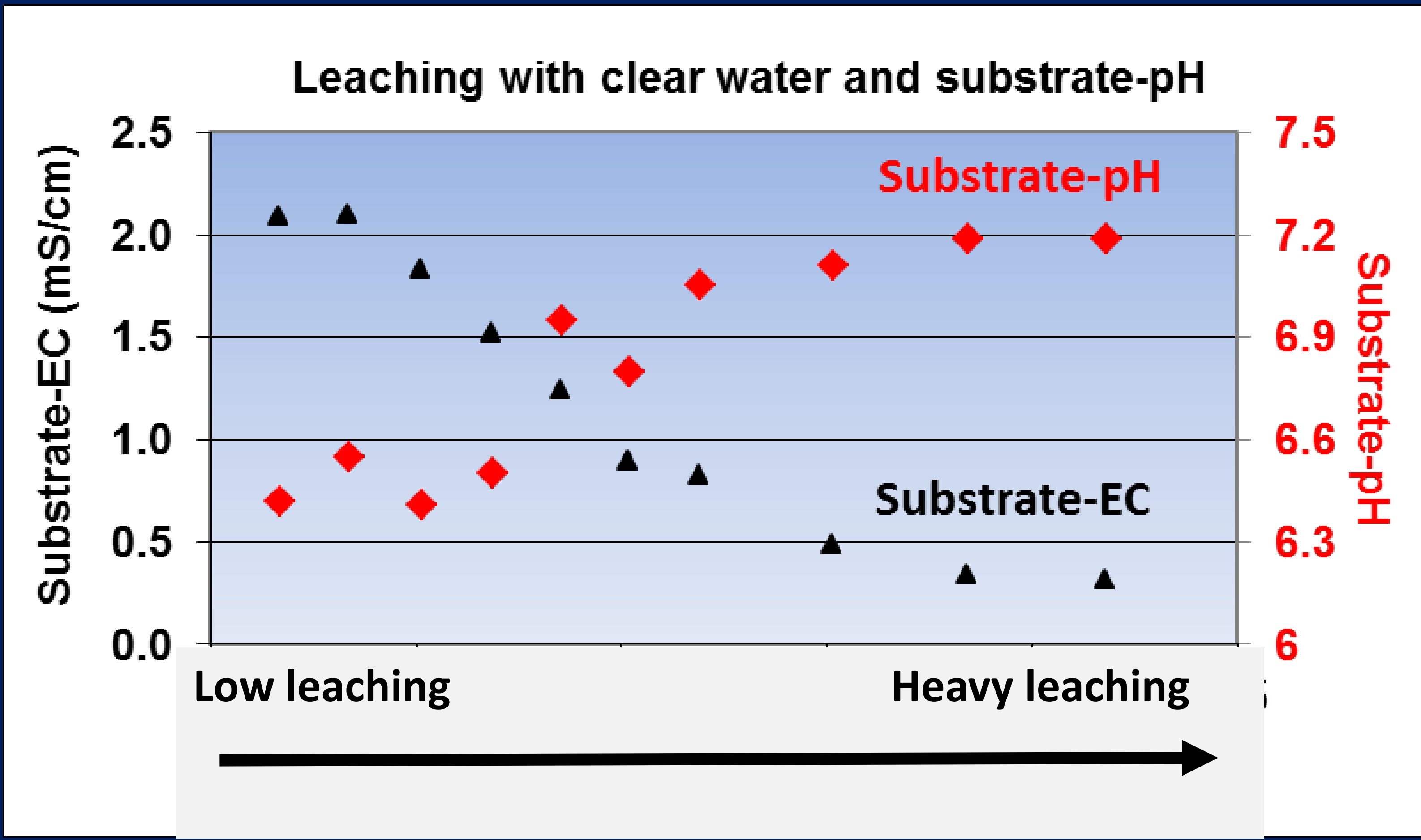
Test irrigation systems for uniformity in distributing water

- Check for clogged emitters and wet or dry spots
- Test uniformity by collecting water in buckets
- Check pots near flood floor drains
- Flush and clear lines of debris and biofilm before the season

Be aware of differences in greenhouse climate conditions

- Faster drying occurs near edges, fans, and heaters
- Slower drying occurs near cooling pads and in shade
- Check for differences in water pressure

Heavy leaching decreases substrate nutrients and raises substrate pH



- Low fertility increases disease susceptibility
- High pH favors *Thielaviopsis* root rot

Are you leaching too much?

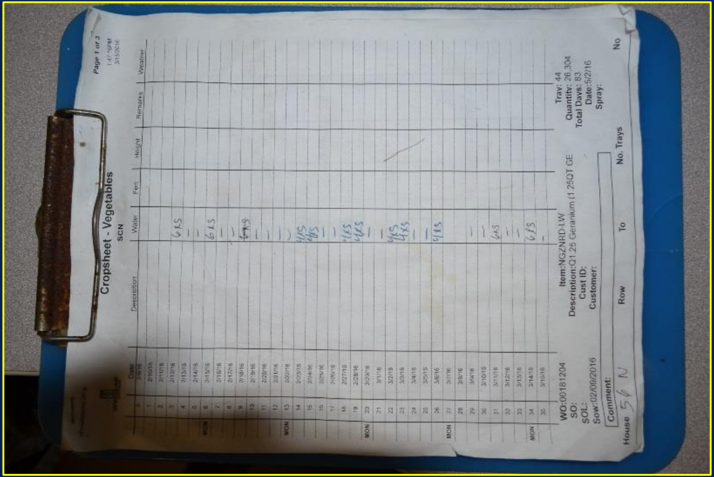
1. Collect water leached from random containers and trays
2. Divide leached water by volume applied per pot/tray to determine leaching fraction (10%-15% recommended)
3. Monitor substrate pH and EC (saturated media extract, PourThru, 2:1)
4. If leaching heavily, may need to increase fertilizer rates

Train staff members on irrigation and moisture management

Different ideas on when plants should be watered

Develop a training program that makes sense for your operation

Keep irrigation logs and monitor pH and EC



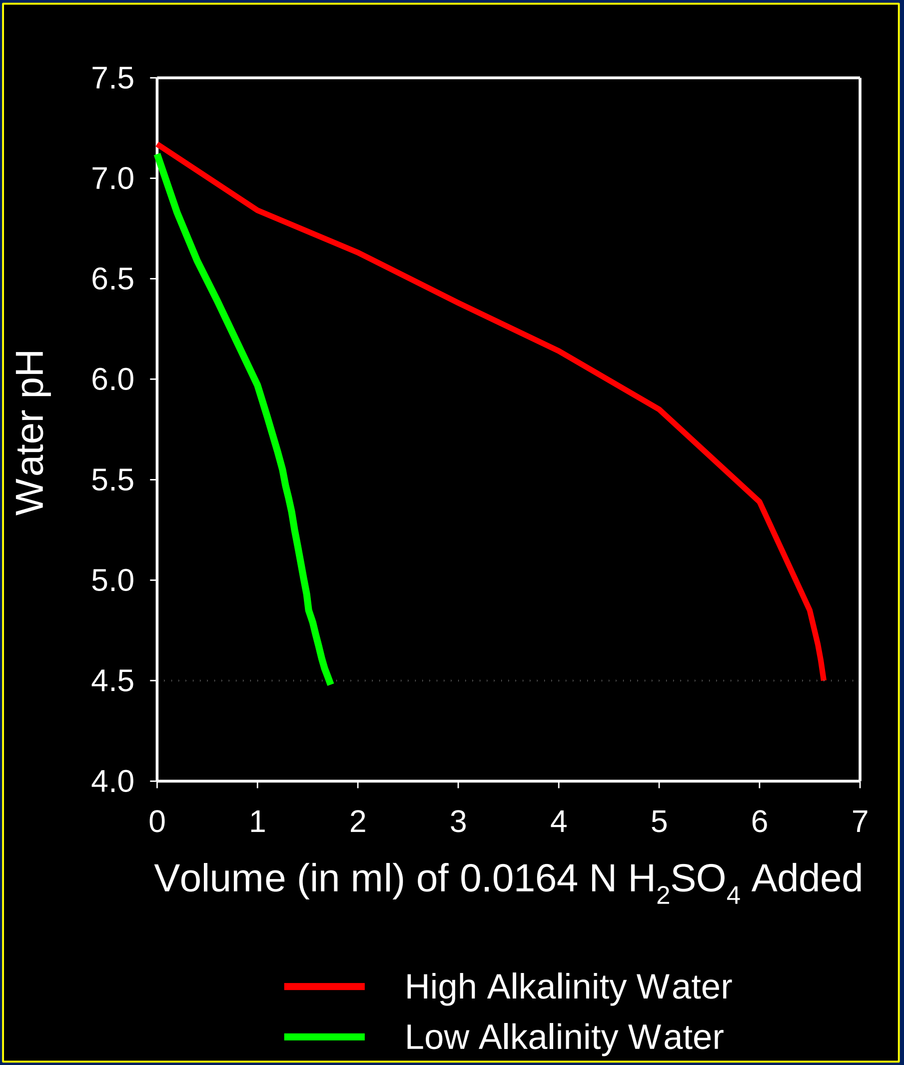
Where do you look when trying to improve moisture management?

1. Substrate type and container geometry

2. Irrigation practices

3. Water quality and treatment

High water alkalinity increases substrate-pH over time



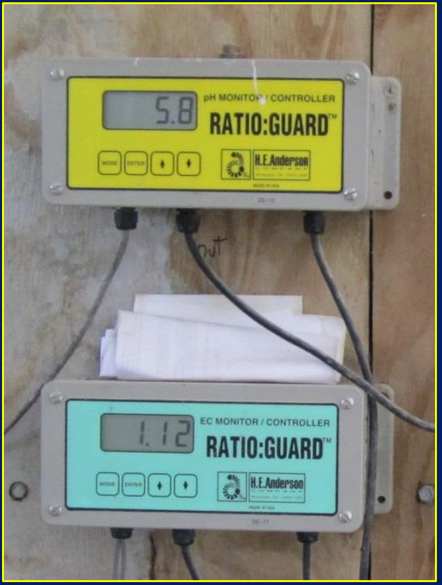
- Alkalinity can NOT be measured with a pH meter
- Can have a large effect on substrate-pH
- Often termed as bicarbonates
- Micronutrient imbalance
- May favor *Thielaviopsis* root rot

Alkalinity units

Milliequivalents Alkalinity (mEq/L)	ppm alkalinity ($CaCO_3$, or CCE)	ppm bicarbonate or HCO_3^-
1	50	61
2	100	122
3	150	183
4	200	244
5	250	305

Control alkalinity with mineral acid

- How much to add? Use online **AlkCalc** from University of New Hampshire

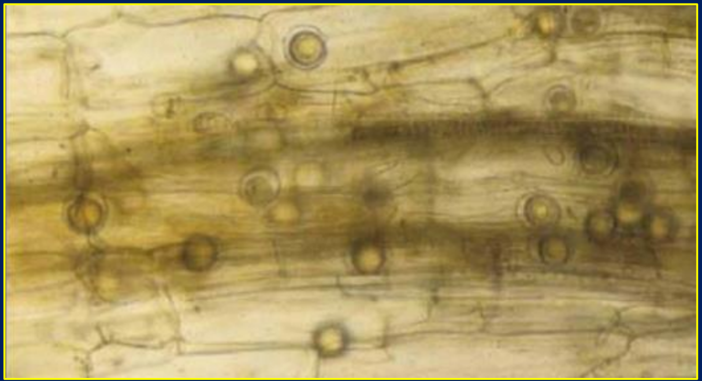


- Sulfuric (adds S)
- Phosphoric (adds P)
- Nitric (adds N)

- Bring water pH down to around 6 (~ 2 mEq/L or 100 ppm $CaCO_3$ for some alkaline water sources)

Treating irrigation water for pathogens and algae

- Water can be a source for pathogens and algae
- High microbial load can clog emitters
- Variety of treatment options, but no "one type fits all"
- Free online publication of water treatment technologies and cost from University of Florida



Free online publication on water treatment technology
http://hort.ifas.ufl.edu/yprc/resources/water/pdfs/Water%20Quality%20Series%20from%20GMPro.pdf

How do you know if you need to treat your irrigation water for microorganisms?

- Noticing increase in diseases such as *Pythium* root rot
- Clogged emitters and slime (usually aerobic non-pathogenic bacteria)
- Work with a testing lab and test water before and after treatment
- Not uncommon to have some level of pathogens

10,000 c.f.u./mL aerobic bacteria is a threshold for increased disease risk and clogging emitters

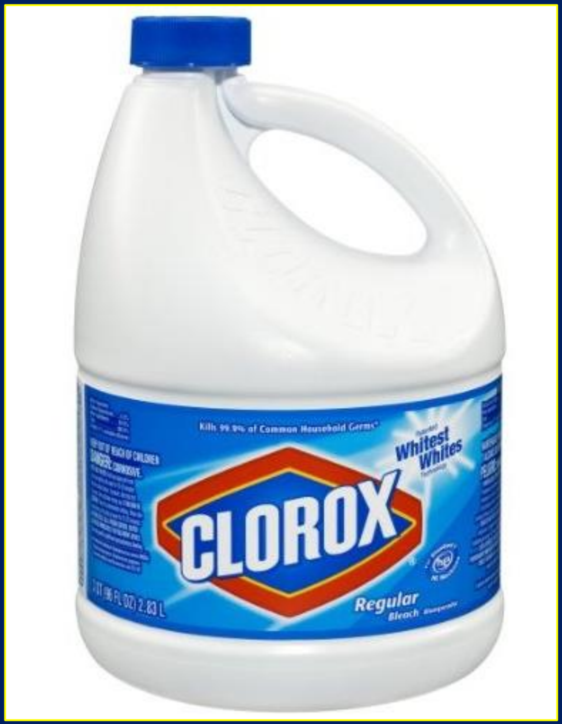
The "dirtiest" water usually comes from surface or pond and recycled water sources

- Contains more debris, algae, and potential pathogens
- Aerate and move pond water to reduce algae and duckweed
- Municipal sources usually have less microbial load and debris

Pond or recycled water treatment starts with filtering out particles and debris

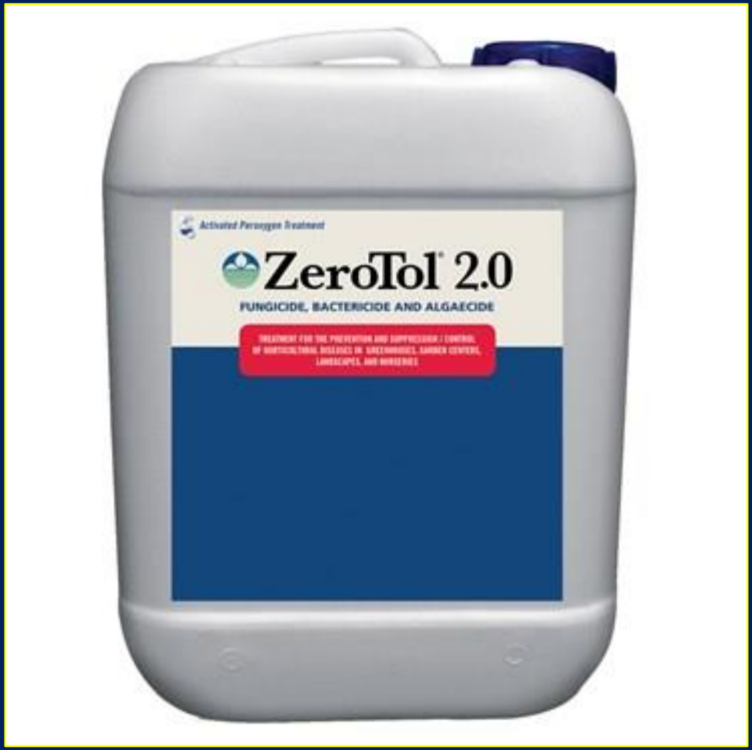
- Particles and debris hold pathogens and can also clog emitters
- Organic matter decreases efficacy of chemical treatment
- Most benefit from multi-stage filtration down to 5 to 50 microns
- Commercial labs can measure total suspended solids

Chlorine (calcium or sodium hypochlorite)



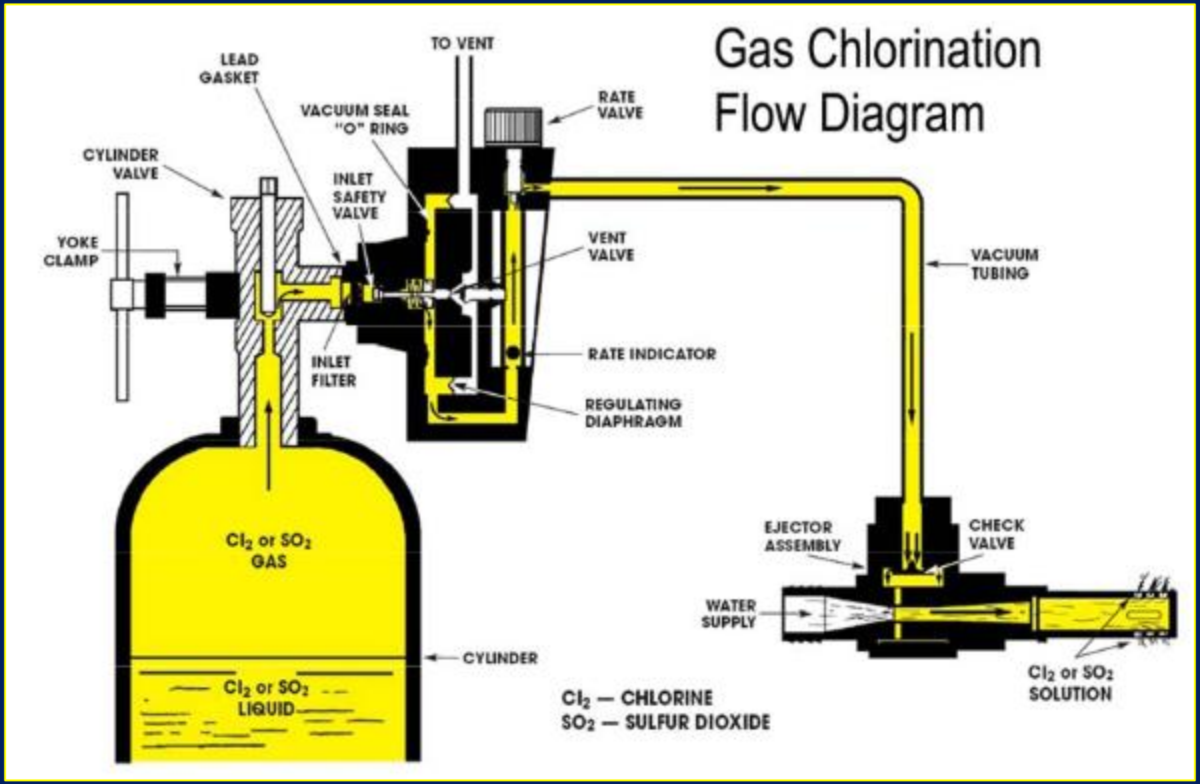
- Liquid or tablet dissolved to form hypohlorous or hypochlorite acid
- Inexpensive, commonly injected as "insurance"
- Filter out organic matter, keep pH below 6.8 (hypochlorous acid)
- Maintain 2ppm free chlorine, low residual activity

Peroxides and peroxyacetic acids



- Liquids are injected in-line, more expensive than chlorine
- Lower risk of phytotoxicity, safer for employees
- Easy to adjust injection rates depending on microbial load

Gas chlorination (Cl_2 or ClO_2 gas)



- Gas injected in-line, forms hypochlorous or hypochlorite acid
- Effective at 0.25ppm total chlorine, provides residual activity
- Gas is toxic, requires handling and safety training

Copper ionization

- Injects free copper (Cu^{2+}) as a sanitizing agent
- Less affected by organic matter, good for surface water
- Recent technology is more efficient, cost-effective
- Extra copper may lower solubility of some chelated micronutrients

Ozone (O_3) gas injection

- Forms reactive peroxygens/oxygen radicals, good residual activity
- High initial cost (>$10,000), low operating cost (electricity)
- Gas is toxic, special safety and handling training is required

Ultra-violet light (UV)

- UV-C (280 to 100nm) is effective, kills microbes and some viruses
- Filtration is necessary, UV light must “see” microbes
- Maintenance cost depends on pretreatment and electricity cost
- No residual activity

Thanks for attending

Thank also to our advisory group, collaborators, and sponsors

- Agdia, Inc.
- Applied Bionomics
- APS Press
- Biobest Biol. Systems
- Longfellow's Greenhouses
- OHP, Inc.
- Gardener's Supply
- Griffin Greenhouse Supply
- IPM Laboratories, Inc.
- Pleasant View Gardens
- D.S. Cole Growers
- Syngenta Bioline
- Univ. of VT, UNH, and UME Extension
- VT, ME, and NH Departments of Agriculture
- National Inst. Of Food and Agriculture, USDA
- Extension IPM Program

Contact me at:

Ryan Dickson, Ph.D.
State Specialist for Greenhouse Management and Technology
G54 Spaulding Hall, 38 Academic Way
Durham, NH 03824
Ryan.dickson@unh.edu
603-862-2520
https://extension.unh.edu/Agriculture/Greenhouse-Floriculture

University of New Hampshire Cooperative Extension