

Managing water and oxygen for optimum rooting



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Oxygen supply to roots

- Oxygen supply to roots is essential for root growth and plant health
- Root zone low oxygen (hypoxia) occurs at $\approx < 3$ mg/L
 - Decrease metabolism and nutrient uptake
 - Root death
 - Wilting
- Low oxygen and high substrate moisture increases the risk of root pathogens



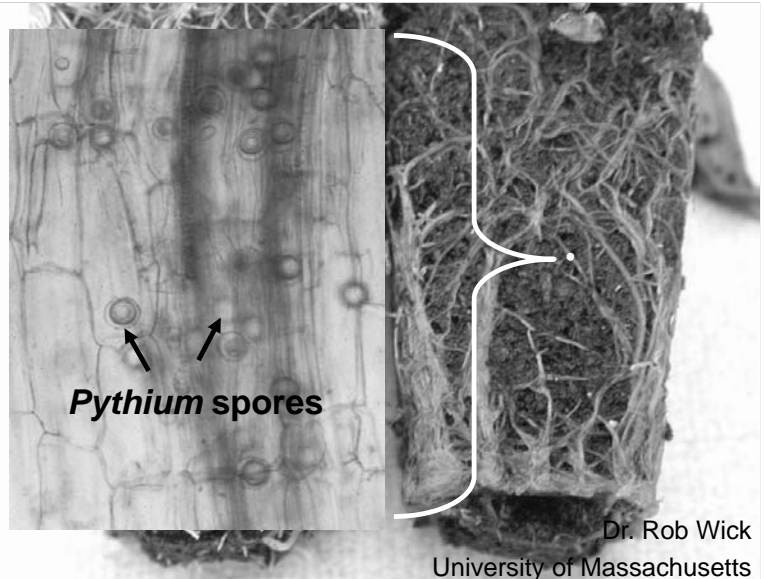
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Overwatering leads to disease

Root rot in *Ipomoea* (sweet potato)



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Pythium spores

Dr. Rob Wick
University of Massachusetts

Overwatering delays rooting



Scaevola

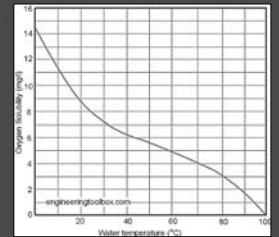
- A saturated substrate delays root growth after callus

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Oxygen in air and water

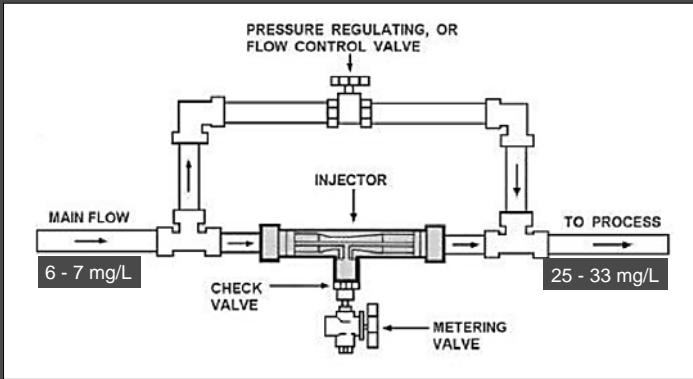
- Oxygen (O_2) is a gas present in the atmosphere at 271 mg/L at 1 atm & 25°C
- Dissolved oxygen (DO) is 8.3 mg/L at saturation at 1 atm & 25°C
- DO is less soluble at high temperature
- Oxygen diffuses 10,000 times more quickly through air than water

Temperature oxygen solubility



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Oxygen injecting technology



www.Mazzei.net, Technical bulletin No. 7

When does it make sense to oxygenate?

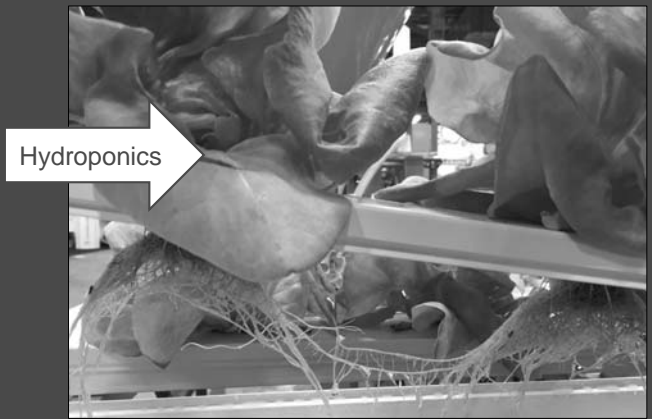


When does it make sense to oxygenate?

Water quality issues: iron, manganese, hydrogen sulfide



When does it make sense to oxygenate?



When does it make sense to oxygenate?

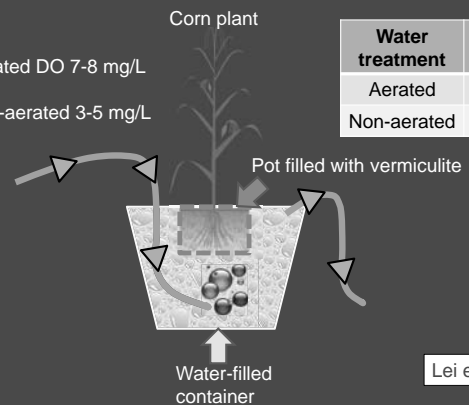
Completely water-logged conditions



Lei et al. (2015)

When does it make sense to oxygenate? Completely water-logged conditions

Water
(1) Aerated DO 7-8 mg/L
OR
(2) Non-aerated 3-5 mg/L



Water treatment	Corn ear weight (g/pot)
Aerated	34 grams
Non-aerated	17 grams

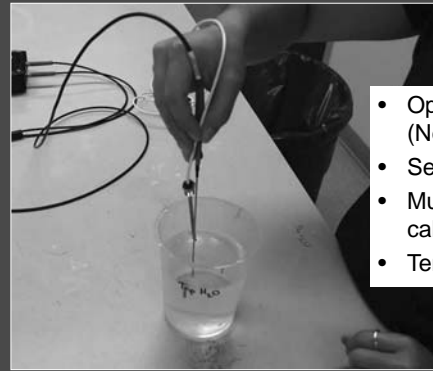
Lei et al. (2015)

Oxygen injecting technology



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Data collection: DO in solution



- Optical oxygen sensor (Neofox, Ocean Optics)
- Senses oxygen pressure
- Multi-point factory calibrated
- Temperature probe

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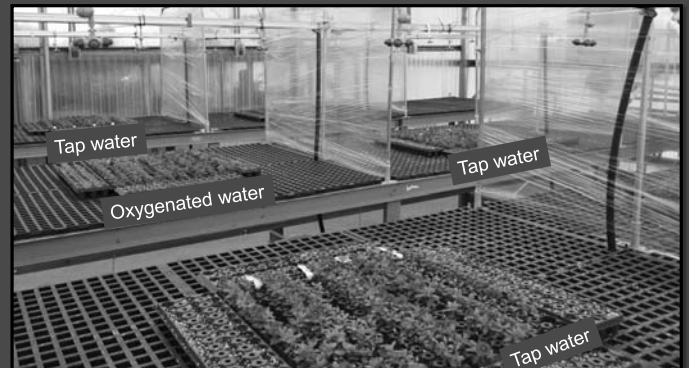
We can super-saturate water, and DO levels stay very high for several hours at 75°F

- Ambient tap water was not affected by time or water movement the average DO was 7.1 ± 0.5 mg/L

Water Type	Water Movement	Initial Time	Final Time 4.5 hr.
Oxygenated	Non-stirred	28.3 mg/L	26.5 mg/L
Oxygenated	Stirred (100 gal / hr)	26.8 mg/L	16.9 mg/L (37% decrease)

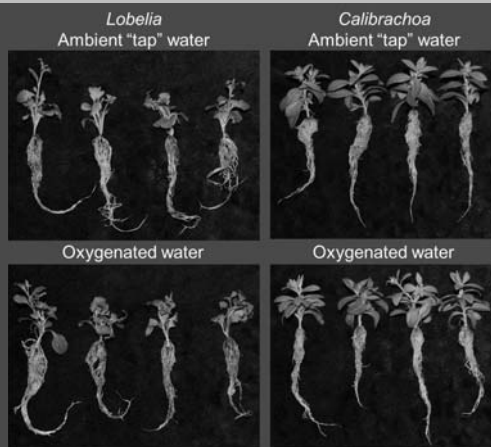
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Does oxygenation benefit plant propagation under mist?



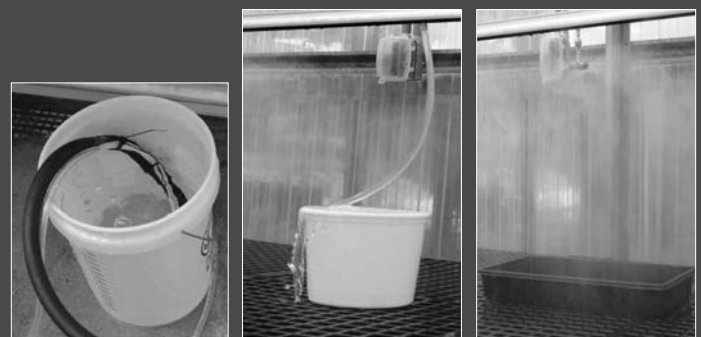
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There were no differences in plant growth with oxygenated compared to tap water for lobelia and calibrachoa



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DO was measured at different points in greenhouse irrigation



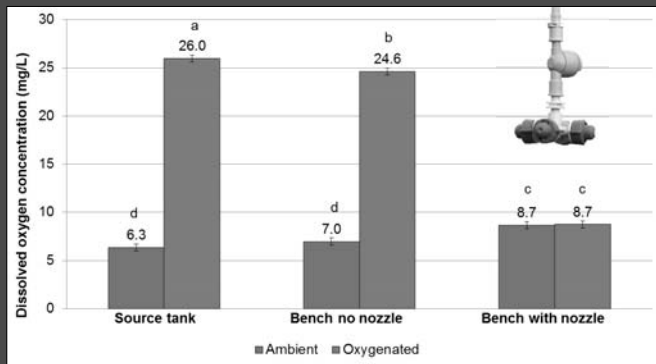
Source tank

Bench no nozzle

Bench nozzle

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Oxygen off-gassed when super-saturated water passed through a mist nozzle



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DO measured in irrigation water at a commercial operation was 98% of saturation after passing through a nozzle



Before Nozzle	After Nozzle
7.0 mg/L (74%)	8.6 mg/L (98%)

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Key findings

- Oxygenated water held in unpressurized containers remained super-saturated after a few hours
- There were no differences observed in root and plant growth for oxygenated water compared with ambient tap water during the propagation trial
- Water that passed through fine mist nozzles were brought to 100% DO saturation for oxygenated and tap water

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What happens when we irrigate plants with oxygenated vs. ambient water without using a fine breaker

Level	Water Type	Description
1	Tap	6.0 mg/L DO at 26°C
2	Oxygenated	27.7 mg/L DO at 26°C

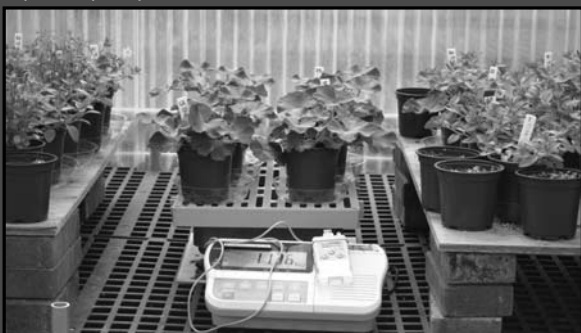
Level	Irrigation Delivery Method
1	Top watered
2	Subirrigated

Level	Plant Species
1	<i>Calibrachoa x hybrid</i> 'Aloha Kona Dark Red'
2	<i>Lobelia erinus</i> 'Bella Aqua'
3	<i>Pelargonium x hortorum</i> 'Patriot Red'

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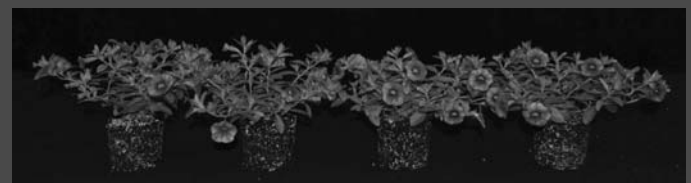
Plants were irrigated when the average of 6 pots dried to 45% of container capacity

- Randomized complete block design with four blocks and two replicate pots per block for each treatment combination



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There was an increase in root length and root dry mass for top watering compared to subirrigation for calibrachoa but no effect of oxygenation



Tap water Top watered Oxygenated Top watered Tap water Subirrigated Oxygenated Subirrigated

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Geraniums grew healthy and vigorous, and there were no treatment effects observed



Tap water Top watered Oxygenated Top watered Tap water Subirrigated Oxygenated Subirrigated

How does subirrigation with oxygenated or ambient water and different substrate moisture levels affect the growth of geranium?



Water Type	Description
Tap	6.0 mg/L DO at 26°C
Oxygenated	27.7 mg/L DO at 26°C

Substrate Moisture Level
High (80% of CC)
Medium (45% of CC)

There was a slight increase in root length and root dry mass for high moisture compared to medium moisture level for geranium



Tap water Medium moisture Oxygenated Medium moisture Tap water High moisture Oxygenated High moisture

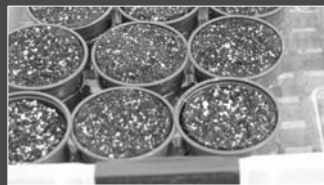
Can you increase DO the growing substrate by irrigating with oxygenated water compared to ambient water?

Water Type	Description
Tap	7 mg/L DO at 24°C
Oxygenated	29 mg/L DO at 24°C

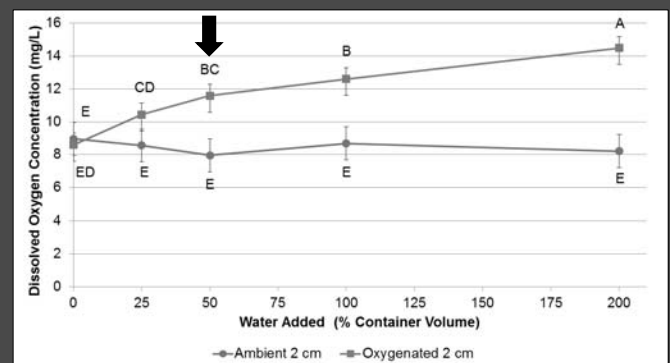
Percent container volume	Water Added to Pots in mL (10-in diameter)	Water Added to Pots in Percent of Container Capacity (4-in diameter)
0	0	0
25	106	44
50	212	87
100	425	175
200	850	350

Measuring dissolved oxygen in substrate

- Sub-irrigated & drained to container capacity
- Measured at 2 and 4-cm depth in substrate
 - Used a tooth pick to indent the substrate
 - Inserted the oxygen sensor
 - Equilibrated for 40 to 120 sec
 - Recorded temperature and DO



When a lot of oxygenated water was applied to pots the substrate-DO increased compared to ambient water



Conclusions

- Continued growth of transplants
 - Irrigating with oxygenated water did not benefit plant growth of three bedding plants compared to tap water
 - Treatment effects on plant growth were observed for calibrachoa, lobelia, and sub-group of geranium with medium and high substrate moisture level
 - High porosity in peat-based substrate provided adequate oxygen to roots by air-filled pores (19% at container capacity for 4-in pots)

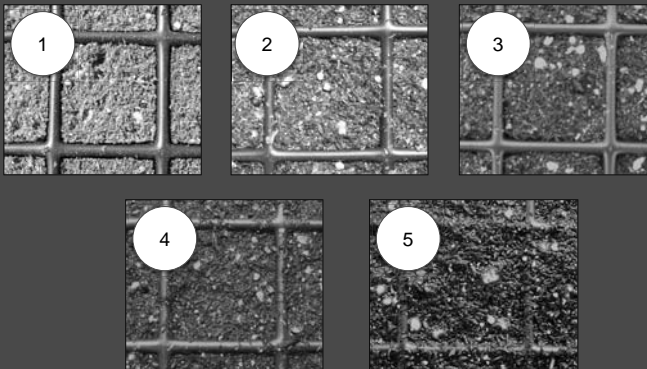
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Conclusions

- Continued growth of transplants
 - Hypoxic growing conditions were not observed and therefore oxygenated water did not enhance or negatively affect plant growth
 - Adding oxygenated water to an already saturated container substrate is not a recommended approach to irrigation management
 - In container substrate, the supply of water and oxygen must be adequate to support plant growth demands
 - Substrate with porosity
 - Irrigation management by not overwatering

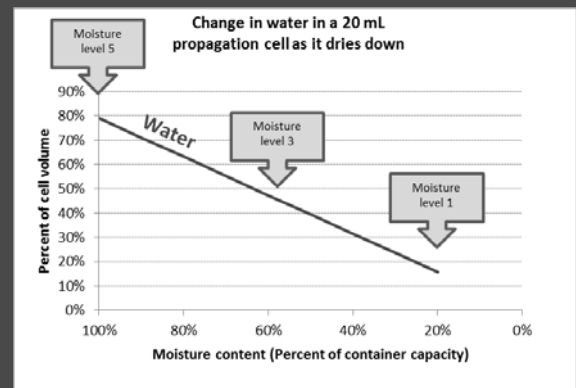
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1 to 5 moisture scale



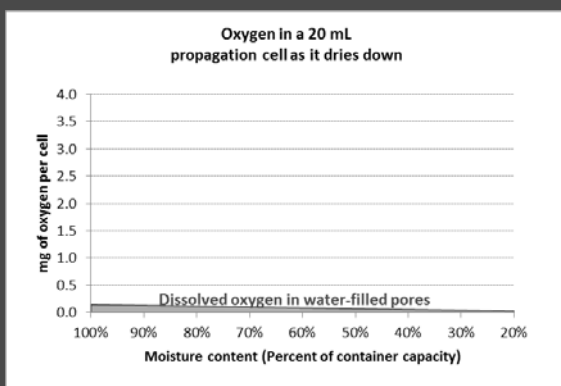
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Manage water with the moisture scale



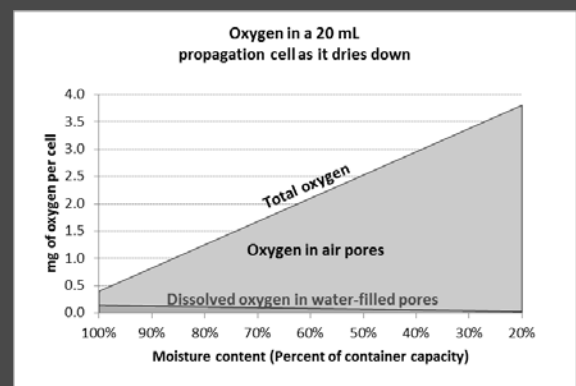
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There isn't much oxygen in water



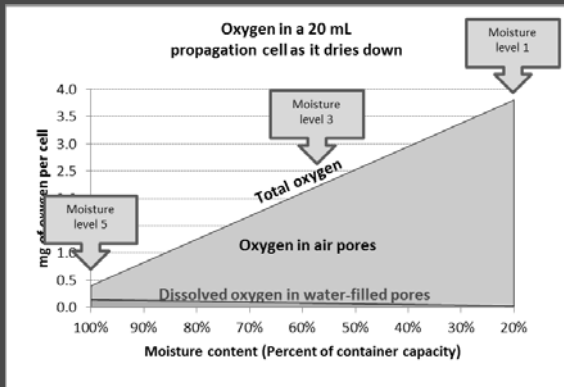
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Irrigation management



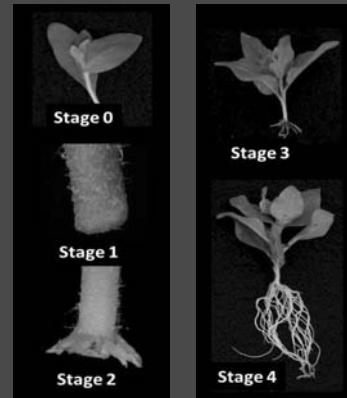
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Water management is air management



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Continue to study root environment on root growth and architecture



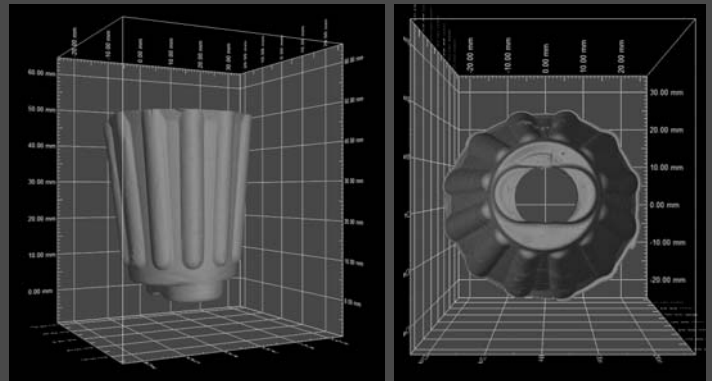
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Continue to study root environment on root growth and architecture



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How does container size and shape affect root growth?



Imaged by Ana Bohorquez at UF

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- Dr. Paul Fisher
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