Why Nanobubble Oxygenation is Key to Optimal Root Zone Health

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MOLEAER
ADVANCING NANOBUBBLE TECHNOLOGY

What's Inside

In practice, traditional technologies like bubblers or diffusers that aim to increase DO can leave a lot to be desired. They can be both ineffective and inefficient.

Now however, there is a new innovation available that has already changed how many controlled cultivation growers around the world approach maximizing root health and crop yield. The use of nanobubbles in irrigation water is an environmentally-friendly, chemical-free and cost-effective solution that more and more growers are already using worldwide to improve root zone health – in turn, significantly improving overall crop health and revenue over time.

Why Root Zone Health is Crucial for Business Success

The root zone is the essential link between a plant and its environment. It is heavily impacted by water quality, oxygen availability, pathogens and many other environmental factors. Due to its central role in plant growth, the health of a plant's root system has lasting effects on the crop and its yield potential.

Research has shown high-quality irrigation water with super-saturated levels of DO creates better root zone conditions for:

- Nutrient uptake
- Energy generation via ATP production
- Plant resilience & stress handling
- Increased Photosynthetic Capacity (Amax), and
- Water uptake efficiency

Root cells generate all their energy via cellular respiration. To respirate, root hair cells require ample oxygen from within the particles of the growth medium (soil/hydroponic), or within the flow of the Deep Water Culture (DWC) system. **Increasing oxygen in a stabilized and dissolved form creates ideal growing conditions within the rootzone.** However, providing enough oxygen and nanobubbles in a stabilized, dissolved form, that can reach the root surface in a meaningful concentration is very challenging.

If water is of sub-optimal quality, plant growth can be negatively impacted. The environmental stresses of poor water quality can also make plants more susceptible to infection from common pathogens such as:

Pythium

Fusarium

Pytophthora

Each of these fungi produce spores which enter the roots of greenhouse plants through tiny wounds or natural openings. Pythium and Phytophthora are closely related and cause root rot in infected plants. Fusarium causes blockage of plant cells, preventing them from transporting water and nutrients.

These pathogens are more prevalent in unfavorable conditions like hot weather, causing deterioration of root health and impaired nutrient uptake. The weakened plants and/or severe nutrient lockout caused by using irrigation water infected with these organisms commonly results in nutrient burn and curling throughout the canopy.

To deal with pathogens, some growers may resort to irrigating water with chemical oxidants, UV and ozone, and performing preventative root treatment with chemicals. This can be costly and is generally not considered to be environmentally sustainable. Incorrect dosing of these methods can damage the plants. In addition, both ozone and chemical treatments like hydrogen peroxide require careful management both in handling and application. Both are strong oxidants that can burn roots. They can also work against an integrated pest management system that relies on fostering beneficial organisms in the root zone.

It is well established that anoxic (low oxygen) conditions favor harmful bacteria, while a highly-oxygenated environment, created through the presence of nanobubbles, discourages disease pathogens from establishing sizable colonies. Highly-oxygenated water also allows beneficial organisms like mycorrhizae, Bacillus, Trichoderma and Streptomyces to thrive.

Root Zone Oxygenation Solutions

Finding the right water quality solution can be challenging for growers who work in complex environments. The most traditional approach has been aeration, simply mixing air and water, but conventional aeration methods all come with limited efficacy and serious challenges.

Traditional aeration options available on the market for increasing DO levels in irrigation water employ older equipment such as:

- Disk aerators in outdoor reservoirs
- Extreme agitation / high flow rate mixer
- Air stones
- Piping to suck air into irrigation water (Venturi)

When injecting air into water using any of these traditional aeration methods, the rate of oxygen transfer is typically very low and yields poor results. Complicating this is the fact that as water temperature increases, its capacity to hold DO decreases; when warmer water must be used to irrigate plants, the efficiency limitations of conventional aerators become even more pronounced. While chillers are frequently used to keep water cool and increase DO levels within an irrigation system, chilling water is both energy intensive and costly.

Specifically, growers have found that:

1. Diffusers and air stones, while inexpensive to deploy and use, provide minimal increases in DO levels. They are a hassle to keep clean, maintain, and are often noisy.

2. Venturi systems can achieve DO levels close to saturation; however, research shows that to maximize disease control and maximized crop yields, levels of 15-25 ppm oxygen are optimal for most crops.

This level of oxygenation can only be attained efficiently through the use of new technology.

Nanobubbles as a New Tool for Healthier Growth

Growers in the horticulture sector may not be aware that there is a new technology that provides unprecedented water oxygenation.

Proven, research-based nanobubble technology is disrupting and displacing outdated aeration technology.

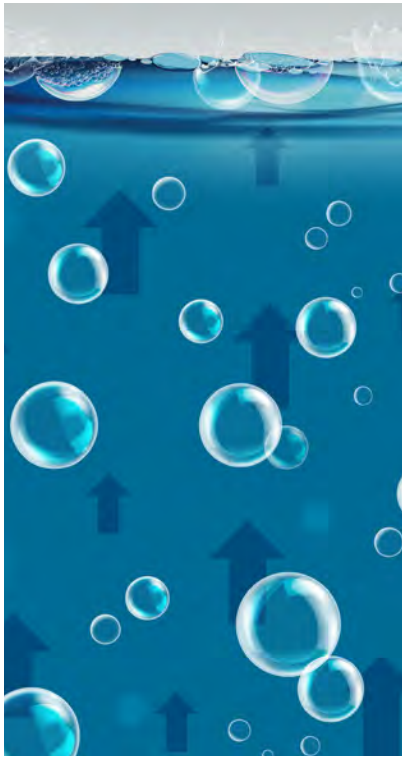
Progressive growers are increasingly investing in this technology to make significant gains in plant health (and also business health) under a favorable ROI timeline.

Nanobubbles are much more than just an aeration solution. They are a research-backed, field-proven innovation already being used by hundreds of growers around the world to boost DO levels in plant root zones — and improve many other conditions that impact plant yield.

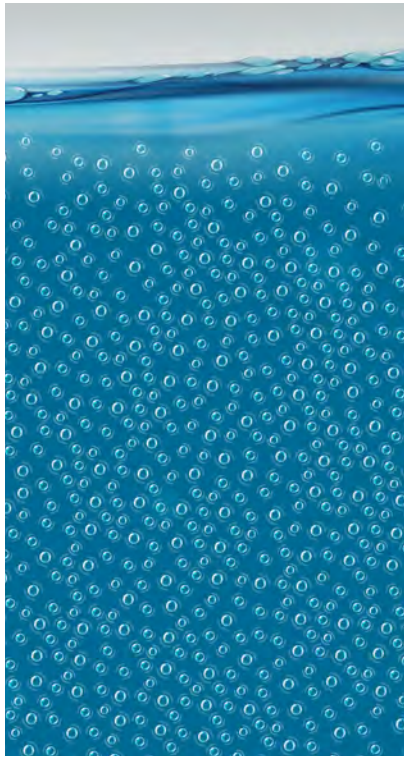
What is a Nanobubble?

Nanobubbles are bubbles that measure below 200 nanometers in diameter– roughly 2500 times smaller than a grain of salt. The most stable nanobubbles measure around 120 nm. Nanobubbles hover within a liquid, instead of rising to the surface and popping as larger bubbles do, making them constantly available for participation in physical, biological and chemical reactions.

Nanobubble		<200 nm
Microbubble		200 - 100,000 nm 500x nanobubble diameter
Ultrafine/fine bubble		100,000 - 3,000,000 nm 10,000x nanobubble diameter
Coarse bubble		3,000,000 nm



Larger Bubbles
Larger Bubbles rise to the surface and burst.



Nanobubbles
Nanobubbles are stable, neutrally buoyant, remain suspended and disperse in water.

How Do They Work?

Nanobubbles can remain suspended in water for months before dissolving. Over this long period of time, they travel randomly through water via Brownian motion and efficiently oxygenate the entire body of water that services plant roots. This is possible because nanobubbles have an equilibrium of surface tension, internal pressure and external pressure. This gives them neutral buoyancy, a strong negative surface charge, and a high transfer efficiency.

Nanobubbles **deliver more than 85% oxygen** transfer efficiency in irrigation water, maximizing oxygen utilization by plants.

In addition, nanobubbles also act like a chemical-free oxidant by producing hydroxyl radicals which lyse algal cells and reduce harmful pathogens and biofilms within irrigation systems. Oxidation is the process in which an electron is exchanged between molecules, which disrupts structures within the cells of pathogens, killing or inactivating them.

Numerous case studies have shown dramatic decreases in algae, biofilm and pathogens such as Pythium with nanobubble use.

How Do Nanobubbles Maximize DO (and Profit)?

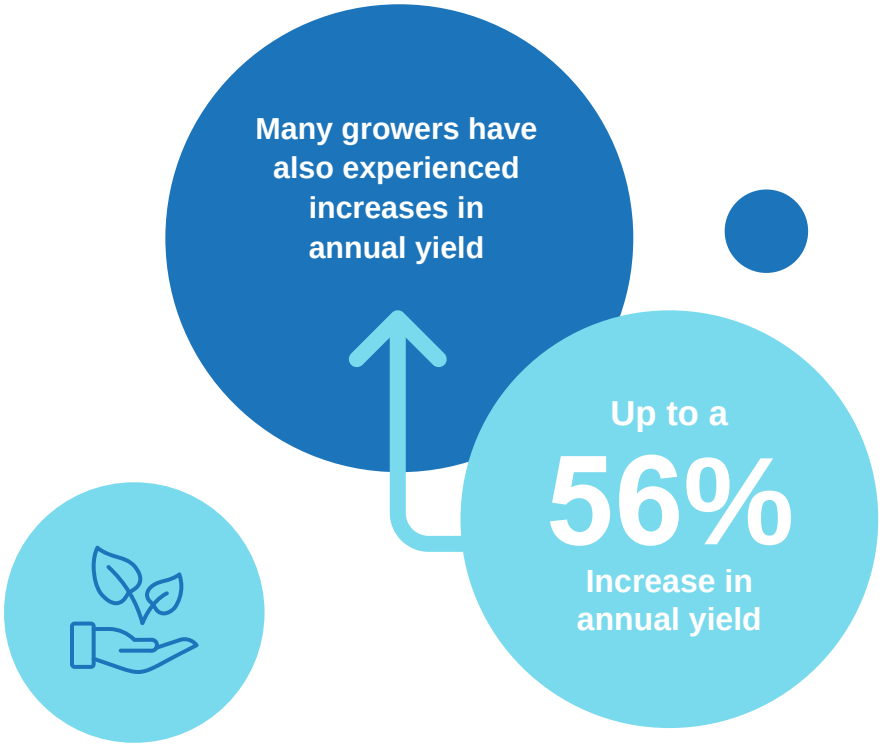
Because of their unique structure, nanobubbles efficiently enhance water in multiple stages of the plant growth cycle. Their long-term presence within water and their inherent ability to efficiently transfer and move oxygen around plant roots can reduce the cost of O2 usage and achieve a better level of water quality.

With the old aeration methods, growers were limited in the amount of DO they could achieve in their irrigation water. With nanobubbles, growers can achieve up to 300% more DO with nearly-perfect gas transfer and continuously-high DO transfer from water to roots. The cost of oxygen input is lower, and no additional resources are required (for example, ozone in older systems that offer limited DO generation).

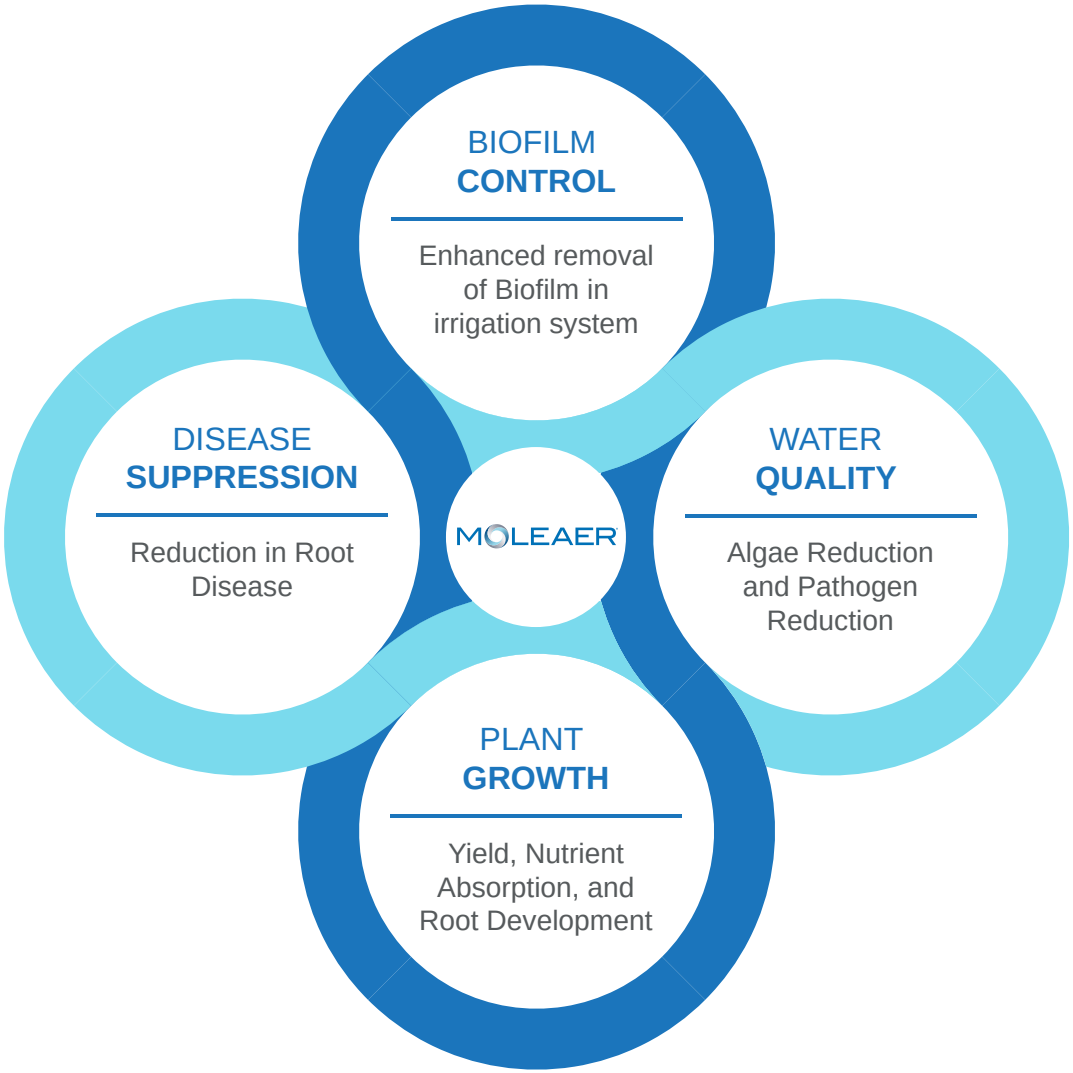
As a result, nanobubble-enriched water has been proven to improve water quality and soil mycology, root, and plant health while lowering treatment and oxygen costs. Many growers have also noted yield increases.

Healthier root systems with more surface area and protection from pathogens achieve more efficient nutrient uptake that can shorten cultivation time in certain crops and therefore generate more revenue for growers.

In terms of sustainability, nanobubble technology reduces the need for chillers (which require costly electricity) and preventative chemical treatments. This is a huge benefit for growers interested in reducing electricity usage and improving their operations' impact on the environment.



Benefits of Nanobubble Technology



Oxygenation Technology

- Super-Saturation Oxygen Enrichment in the Root Zone
- Stable and Uniform Dissolved Oxygen Levels Everywhere

Root Health

- Improved Root Development
- Reduction in Pythium and Root Disease

Nutrient Optimization

- Enhanced Nutrient Uptake and Utilization
- Improved Conversion of Organic Nutrients

Plant Growth

- Improved Vegetative Growth
- Improved Plant Vigor
- Increased adenosine triphosphate (ATP) and enzyme production

Environmental Tolerance

- Better Water Penetration & Retention in Soil
- Improved Plant Turgidity

Fast Installation and Fast Results

Another significant benefit of nanobubble technology is that it is easy to install, integrate and maintain within your existing irrigation system. There is no learning curve for growers, and integration is generally as simple as installing a new pump. With Moleaer's nanobubble technology, growers can even monitor water quality remotely online and receive text or email alerts.

Easy to integrate & maintain

Immediate impact on oxygen levels

Great for busy growers

After installation, the increase in DO around plant roots is almost immediate. This has been confirmed in research studies, which show that once nanobubble technology is running, target DO levels in nutrient mixing tanks and emitters are quickly achieved. Benefits to root health and yield potential begin to be gained almost immediately.

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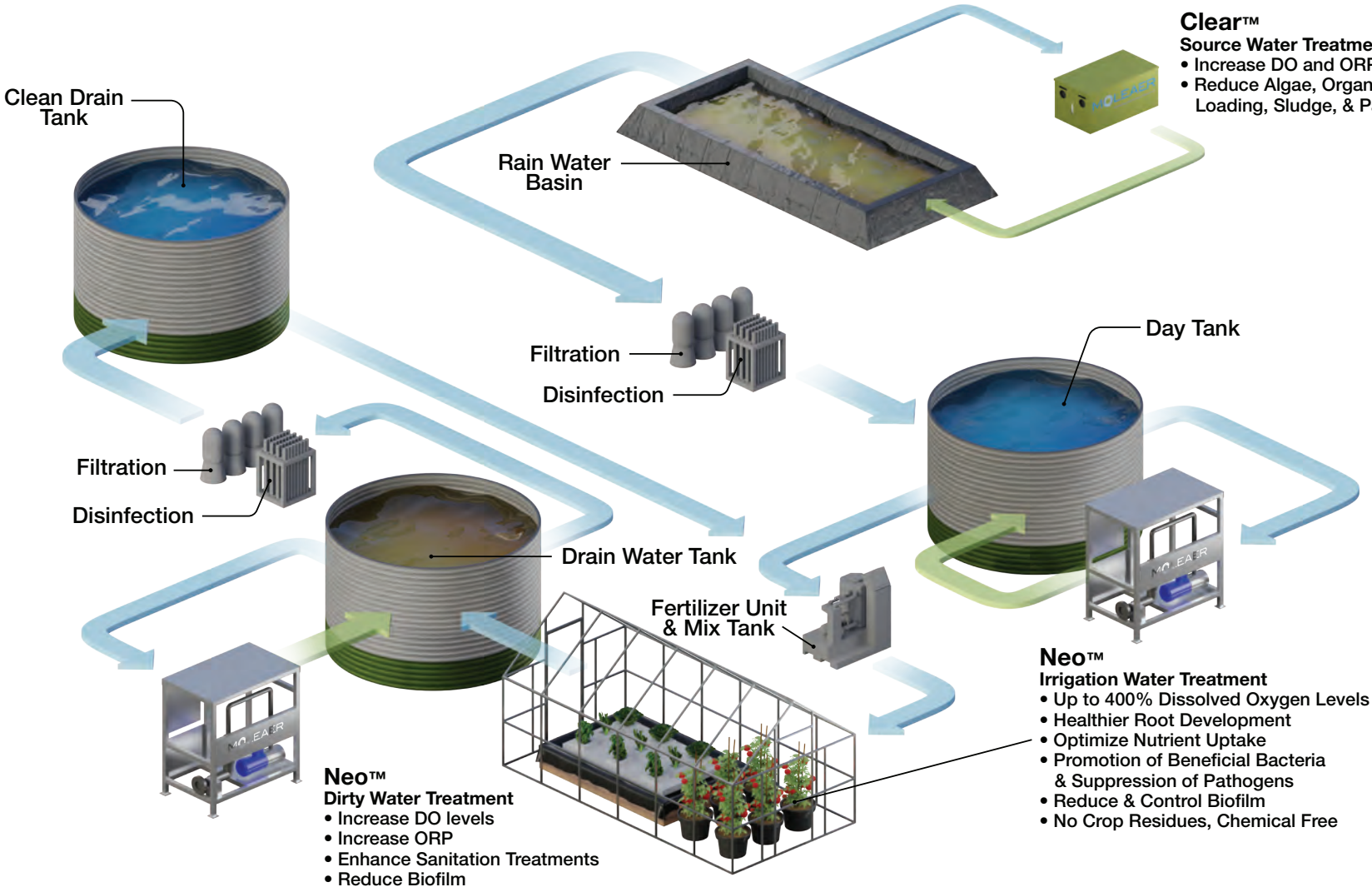
Irrigation Water Cycle in Greenhouse



Our Customers and Research Partners

Our Customers

Over 200 growers are currently using Moleaer technology to improve their operations.

Our Research Partners

Our experienced engineering and innovation team collaborate with scientists at world-renowned universities to validate and improve upon both existing and new applications of nanobubble technology. Our partners include:

Learn More About Nanobubbles

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