



THE GROWER'S GUIDE TO NANOBUBBLE OXYGENATION

- ✓ HEALTHY ROOTS
- ✓ CLEANER SYSTEMS
- ✓ OPTIMAL WATER QUALITY



How Agrona Nanobubble Generators Improve Irrigation, Root Health, and Plant Performance

Unlock the potential of your irrigation water with Nanobubble oxygenation. This guide explains how oxygen-rich water improves root health, nutrient uptake, and system efficiency, supporting stronger plants and cleaner, more reliable irrigation systems. Inside, you'll find practical strategies, science-backed insights, and grower-focused solutions to optimize water quality, plant growth, and operational performance.



WHAT'S INSIDE

The Grower's Challenge	2.
Why Oxygen Matters More Than Ever	3.
What Are Nanobubbles?	4.
How Do Nanobubbles Work in Irrigation and Root Zones?	5.
Agronomic Benefits of Oxygenated Water	6.
How Nanobubbles Improve Irrigation Systems	8.
Economic and Environmental Advantages	9.
Oxygenation Solutions Comparison	10.
Applications Across Crops and Systems	11.
Practical Implementation Guide	12.
Our Customers	14.
Technical Appendix	15.

THE GROWER'S CHALLENGE

Irrigation water is the foundation of every growing system. It carries nutrients, supports root respiration, and directly influences plant growth and yield. One critical but often overlooked factor in water management is dissolved oxygen (DO).



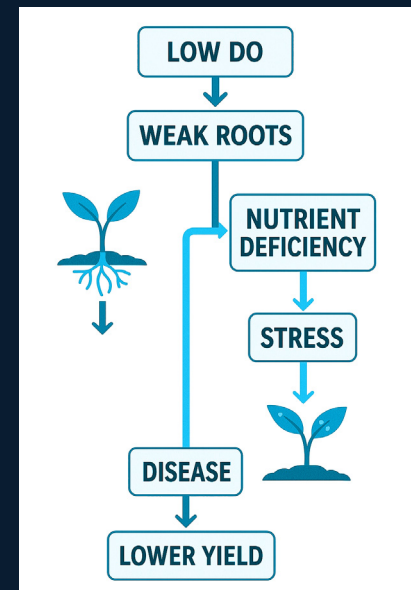
Without sufficient oxygen, roots cannot function efficiently, leading to:

- Reduced nutrient uptake and slower growth
- Weak root systems and lower stress tolerance
- Higher risk of root pathogens like Pythium, Fusarium, and Phytophthora
- Biofilm formation and clogged irrigation lines

At the same time, growers face additional pressures:

- Rising fertilizer, chemical, and energy costs
- Sustainability regulations requiring reduced chemical inputs
- Market demand for higher yields and better-quality crops
- The need for reliable, low-maintenance irrigation systems

These challenges make it clear, oxygen in irrigation water is not optional, it is essential. Without it, the full potential of crops cannot be reached.



WHY OXYGEN MATTERS MORE THAN EVER

Oxygen is the invisible fuel that powers plant roots

Roots use oxygen in cellular respiration to produce ATP, the energy required for:



Nutrient uptake



Water absorption



Stress resilience



Growth & development



When water is rich in dissolved oxygen:

- Roots are active and efficient
- Nutrients are absorbed more effectively
- Plants resist stress and recover faster
- Crop cycles accelerate
- Yield and quality improve, including taste, texture, and shelf life

High-quality irrigation water with stable oxygen levels is now more important than ever. Growers need solutions that deliver oxygen efficiently and reliably to optimize root function and plant performance.

WHAT ARE NANOBUBBLES?



Nanobubbles are extremely small gas bubbles suspended in water, typically around 75 nanometers in diameter. Invisible to the naked eye, their small size gives them unique physical and chemical properties.

Key Properties of Nanobubbles:

- ✓ **Very small size** - allows uniform circulation in water
- ✓ **High surface area** - maximizes contact between gas and water, enhancing oxygen transfer.
- ✓ **Strong surface charge** - prevents bubbles from merging, keeping them stable.
- ✓ **Brownian motion** - constant tiny movement keeps nanobubbles suspended and evenly distributed
- ✓ **High gas solubility** - oxygen dissolves efficiently and remains available for roots.



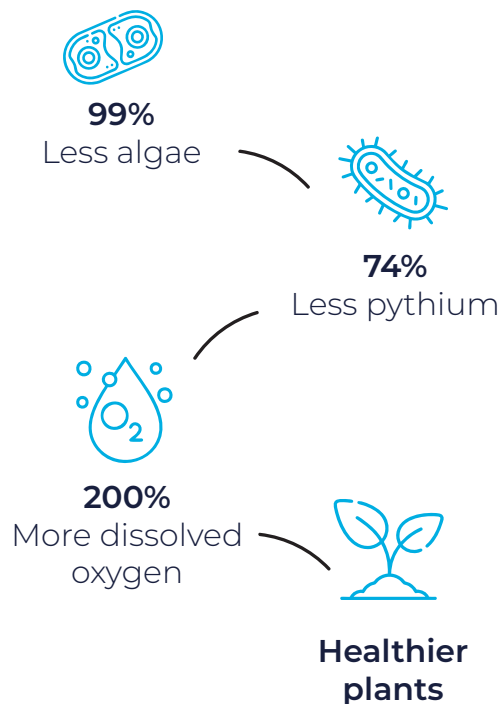
HOW DO NANOBUBBLES WORK IN IRRIGATION AND ROOT ZONE?

Nanobubbles leverage their unique properties to improve oxygen delivery, water quality, and microbial balance in ways conventional methods cannot. Unlike normal bubbles, which rise quickly and disappear, nanobubbles are stable and long-lasting, maintaining high dissolved oxygen throughout the irrigation system.

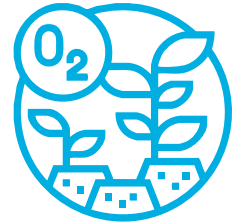
Mechanisms of Action:

- ✓ **Continuous Oxygen Delivery**
Maintains consistent DO in the system and root zone, supporting energy production, nutrient uptake, and water absorption.
- ✓ **Uniform Distribution**
Brownian motion ensures oxygen reaches all parts of soil, substrate, or hydroponic systems. Prevents depletion in stagnant or dense zones.
- ✓ **Pathogen Suppression**
Generates reactive oxygen species (ROS) that naturally inhibit harmful fungi and bacteria.
- ✓ **Support for Beneficial Microbes**
Encourages organisms like Bacillus, Trichoderma, and mycorrhizal fungi, enhancing nutrient cycling and root health.
- ✓ **Improved Water Quality and System Performance**
Reduces biofilm, sediment, and clogs in pipes and drippers while supporting uniform nutrient delivery in fertigation and recirculating systems.

Nanobubbles turn water into a functional growth tool: roots stay oxygenated, nutrient uptake is optimized, crops are more resilient, and irrigation systems operate more reliably.



AGRONOMIC BENEFITS OF OXYGENATED WATER



Efficient oxygen delivery to the root zone unlocks agronomic benefits that directly impact plant health, growth, and yield.

Key Benefits:

1.

Stronger Root Respiration

- ✓ Oxygen fuels cellular respiration, producing energy for nutrient and water uptake.
- ✓ Roots grow longer and more branched, improving overall plant stability and access to nutrients.

2.

Improved Nutrient Uptake and Fertilizer Efficiency

- ✓ Well-oxygenated roots absorb nutrients more effectively.
- ✓ Fertilizers are utilized more efficiently, reducing waste and input costs.

3.

Faster Growth and Shorter Crop Cycles

- ✓ Increased energy production accelerates root and shoot development.
- ✓ Crops reach maturity faster, allowing for more production cycles per year.

4.

Higher Quality and Yield

- ✓ Healthier roots support stronger, more uniform plants.
- ✓ Fruits, vegetables, and flowers show better taste, texture, firmness, and shelf life.

5.

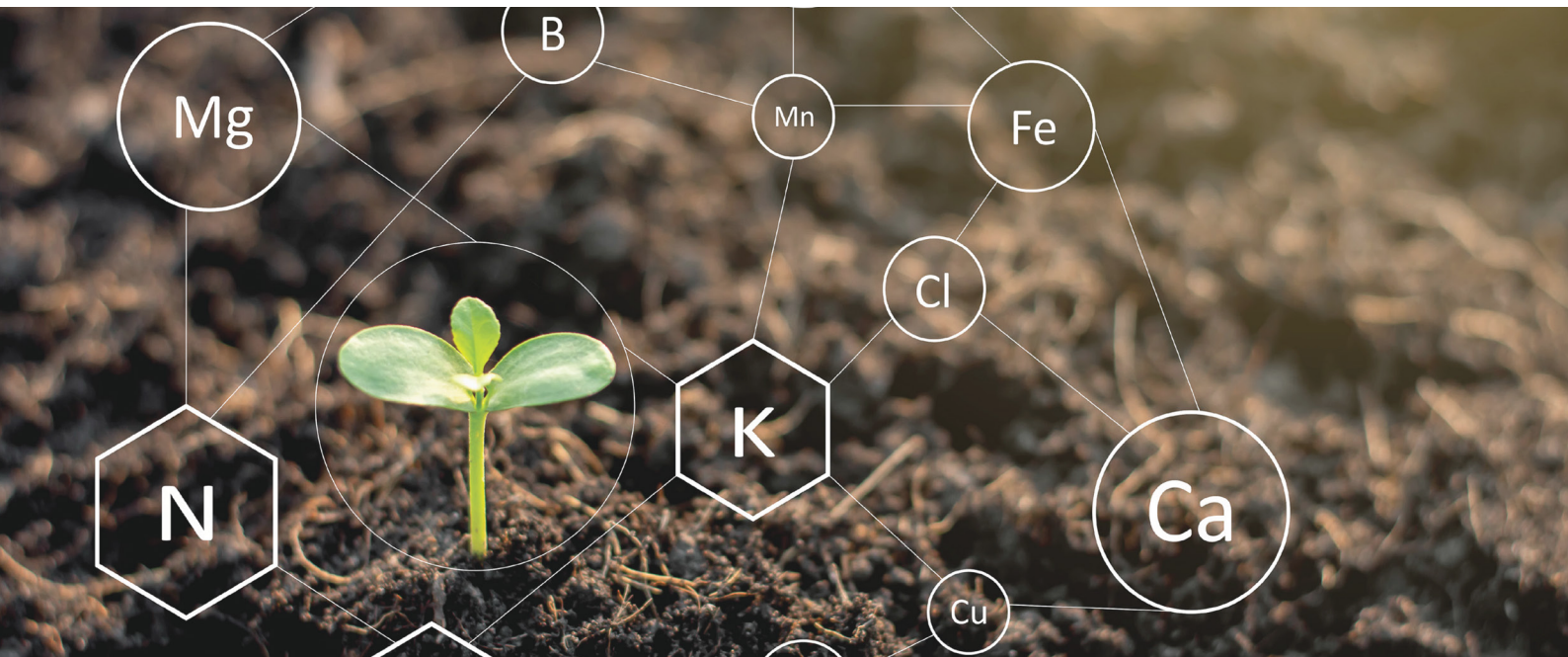
Greater Stress Resilience

- ✓ Oxygen-rich roots cope better with heat, drought, or salinity.
- ✓ Plants are less vulnerable to nutrient deficiencies and environmental stress.

6.

Natural Disease Suppression

- ✓ High oxygen levels discourage harmful pathogens.
- ✓ Beneficial microbes such as Bacillus, Trichoderma, and mycorrhizal fungi thrive, improving nutrient cycling and root health.



HOW NANOBUBBLES IMPROVE IRRIGATION SYSTEMS

Beyond plant health, Nanobubbles improve irrigation infrastructure and water management.

System Benefits of Nanobubbles

1. Cleaner Irrigation Lines

- ✓ Reduce the formation of biofilm, algae, and other organic deposits.
- ✓ Minimize clogs in drippers, sprinklers, and pipelines.
- ✓ Lower maintenance and downtime.

2. Uniform Water and Nutrient Distribution

- ✓ Brownian motion distributes oxygen and nutrients evenly.
- ✓ Supports consistent nutrient delivery to all plants

3. Compatibility with All Irrigation Types

- ✓ Surface irrigation, drip systems, sprinklers, hydroponic recirculation, DWC, NFT, aeroponics and vertical farming setups, fog/mist systems

4. Enhanced Reliability and Reduced Maintenance

- ✓ Less chemical buildup and biofilm means pumps, valves, and filters require fewer cleanings.
- ✓ Stable oxygen levels improve water quality, reducing the risk of root stress or disease spread through the system.



ECONOMIC AND ENVIRONMENTAL ADVANTAGES

Oxygenated water delivered through nanobubbles improves plant performance, system efficiency, and sustainability.

Reduced Crop Losses

- Healthier roots and reduced disease incidence decrease crop losses.
- More consistent plant growth ensures reliable production and higher yield per square meter.

Low Maintenance and Input Costs

- Cleaner irrigation lines reduce flushing, water waste and energy use.
- Pumps and filtration systems run more efficiently.

Faster Crop Cycles and Higher Turnover

- Enhanced root activity and growth speed up crop cycles.
- Growers can produce more cycles per year, increasing overall productivity and revenue.

Enhanced Crop Quality and Market Value

- Strong, uniform plants improve taste, texture, and shelf life.
- Higher-quality crops achieve better prices in the market.

Reduced Chemical Dependence and Sustainable Production

- Less reliance on fungicides or oxidants improves sustainability.
- Supports natural soil and root microbiology for healthier plants.

By improving both plant performance and system efficiency, nanobubbles deliver measurable economic returns and support sustainable production practices. Growers can reduce input costs, increase yield and quality, and operate in a more environmentally responsible way.

OXYGENATION SOLUTIONS COMPARISON

Traditional oxygenation methods often struggle to deliver stable dissolved oxygen (DO), especially in warm or complex systems.

Conventional Methods:

Diffusers, air stones, disk aerators, high-flow mixers, Venturi or inline air injection, ozone, UV, and hydrogen peroxide.

These methods can temporarily increase oxygen or disinfect water, but their efficiency is limited, DO levels fluctuate, and continuous monitoring and maintenance are required.

Limitations:

- DO fluctuates and drops quickly
- Low oxygen transfer efficiency, especially in warm water
- Continuous monitoring required
- Limited pathogen control and microbial support
- High energy and maintenance costs



Essential Parameters:

- Optimal DO for most crops is 15–25 ppm
- Warmer water holds less oxygen, making effective oxygenation crucial
- Energy-intensive solutions like chillers may improve DO but increase operational costs

Flexible Integration Options:

Nanobubble technology can operate independently or in combination with conventional methods to enhance system performance. It integrates into existing irrigation systems without major modifications and is compatible with all irrigation types.

APPLICATIONS ACROSS CROPS AND SYSTEMS

Nanobubbles are highly versatile and can benefit almost every irrigation and crop production system.

Water System Type	Grower Segments	Water Challenges	Nanobubble Benefits
Surface Irrigation	Cereals, ornamentals, traditional field crops	Uneven moisture, oxygen depletion near roots, poor nutrient mobility	Root oxygenation, healthier roots, improved nutrient uptake, reduced crop loss, higher yields and quality
Sprinkler Irrigation	Orchards, cereals, turf, landscaping	Low oxygen transfer, nozzle clogging, non-uniform soil aeration	Improved water quality, enhanced root oxygenation, reduced clogging, better crop resilience
Drip and Micro-Irrigation	High-value row crops, vineyards, berry crops, plasticulture vegetables	Emitter clogging, uneven wetting, localized oxygen depletion	Clean lines, oxygenated root zone, improved soil microbiome, more uniform growth, reduced chemical use
Controlled Environment Systems (CES)	Greenhouses, vertical farms, hydroponics, aeroponics, seedling propagation	Biofilm buildup, oxygen depletion, pathogen spread, nutrient imbalance	Continuous oxygenation, pathogen suppression, improved nutrient uptake, stronger growth, faster and uniform plant development
Other Systems	Seepage/sub-irrigation, hydro-sprinklers, foggers for cooling	Localized oxygen depletion, pathogen accumulation, inefficient water use	Enhanced dissolved oxygen, pathogen suppression, improved root health, reduced chemical inputs, better water efficiency

Nanobubbles are not limited to one type of grower or crop. They provide a system-wide improvement, from root health to water management and pathogen control. By selecting the right Nanobubble setup for each system, growers can optimize both plant performance and irrigation efficiency.

PRACTICAL IMPLEMENTATION GUIDE

Integrating Nanobubbles enhances oxygenation, root health, and system reliability.

Implementation Steps:

Step 1.

System Assessment

- ✓ Measure dissolved oxygen (DO) in tanks, lines, or substrate solutions.
- ✓ Inspect water system hygiene, noting biofilm, sediment, or algae.
- ✓ Evaluate crop needs: root sensitivity, density, and growth stage.

Step 2.

Generator Integration

- ✓ Install at the main tank, recirculating loop, inline with irrigation lines, near fertigation points, or multiple strategic locations to ensure uniform oxygen distribution throughout the system.
- ✓ Compatible with all major irrigation types: surface, drip, sprinkler, hydroponic recirculation, DWC, NFT, aeroponics, vertical farming, and fog systems.
- ✓ Smart Integration: optional sensors, automated valves, and timers for multi-tank or silo setups, Plug-and-Play connection to main controllers, fertigation systems, or AI irrigation management for precision dosing.

Step 3.

Monitoring and Evaluation

- ✓ Track DO and ORP (oxidation-reduction potential) for water quality.
- ✓ Inspect drippers, tanks, and lines for biofilm and cleanliness improvements.
- ✓ Compare crop performance and chemical use before and after integration.

Step 4.

Optimization

- ✓ Adjust generator output based on flow, tank size, crop type, and growth stage.
- ✓ Fine-tune multi-tank or silo setups for consistent oxygen distribution.
- ✓ Use smart features for automatic DO regulation and timed tank switching.

Agrona Trial / Rental Program

Experience nanobubble technology before committing to a full purchase

- Flexible trial durations, short-term or longer-term options tailored to grower needs.
- Evaluate system performance, crop response, and ROI.
- Monitor root health, biofilm reduction, and nutrient efficiency under real conditions.
- Flexible setup allows switching between multiple tanks or silos, with automatic timers for continuous testing.
- Plug & play design ensures easy installation and removal for temporary trials.



OUR CUSTOMERS

Agrona Nanobubble systems are already supporting growers across the world. From high-tech greenhouses to open-field farms and propagation nurseries, our customers see measurable benefits in root health, crop performance, and irrigation reliability.



📍 Agrona Tec.
Leeuwenhoekstraat 56
2652 XL Berkel en Rodenrijs,
The Netherlands

✉ info@agrona.nl
☎ +31 (0)10 76 15 757
🔗 www.agronagroup.com

TECHNICAL APPENDIX

Core Technical Specifications

Agrona Nanobubble Generator

- Nanobubble Size: 50 – 75 nm
- Available Capacities: 20 / 25 / 40 / 60 m³/h
(Custom capacities available up to 100 m³/h)
- Oxygen Transfer Efficiency: > 97%
- Power Consumption: Low, varies by model (see datasheet)
- Operating Temperature Range: 5 – 60 °C
- Corrosion-Resistant: Suitable for both freshwater and saltwater applications
- Installation: Plug & Play inline setup
- Integrated Digital Controller: On/Off function with programmable timer



Optional Smart Features

Real-Time DO Monitoring Sensor

- Automatically adjusts oxygenation based on actual dissolved oxygen levels.)

Automatic Valve System

- Connect up to four different tanks or silos.
- Programmable timer allows automatic flow switching between tanks.

System Capabilities

- Continuous oxygenation with stable dissolved oxygen.
- Supports multiple irrigation or recirculation loops simultaneously.
- Optimized for fertigation integration in hydroponics, DWC, NFT, aeroponics, and open-field irrigation.
- Energy-efficient, low-maintenance, and scalable to different farm sizes.



Visit our website
for more information
about the Nanobubble

Take the Next Step with Nanobubble Oxygenation

Unlock the Potential of Your Irrigation System



Seamlessly integrate advanced oxygenation into existing irrigation and fertigation setups.



Enhance root health, nutrient uptake, and overall crop performance.



Support sustainable, efficient, and resilient cultivation practices.



+31 (0)10 76 15 757



info@agrana.nl



www.agronagroup.com