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Impact of Agrona Nanobubble Technology on Irrigation Water Quality, Root Zone Oxygen Availability and Tomato Biomass

LOCATION
Normec Groen Agro Control Delfgauw, Netherlands (climate controlled greenhouse and climate chamber)

UNIT TYPE
Agrona Nanobubble Generator

Independent Reserch by:

CROP
Tomato (variety Merlice, rootstock Maxifort)

TOTAL PLANTS
288 tomato plants (2 independent experiments: Trial 1, Trial 2)

DURATION
~11 weeks cultivation

VALIDATION PERIOD
2023-2025



THE CHALLENGE

As greenhouse growers increasingly rely on recirculated irrigation water, maintaining optimal water quality becomes essential for consistent crop performance. Disinfection can temporarily reduce bacterial populations but does not prevent biological regrowth during water storage. Earlier project measurements demonstrated increases in bacterial concentrations during storage, confirming that treated irrigation water can remain biologically active. This biological activity creates an ongoing oxygen demand. As microorganisms consume dissolved oxygen, less oxygen remains available to the root zone. This becomes particularly critical at higher substrate moisture levels, where oxygen diffusion is increasingly restricted. For growers, the challenge is therefore not simply to disinfect recirculated water, but to maintain sufficient oxygen availability throughout the irrigation process supporting a healthier root environment, efficient photosynthesis and consistent crop development.

The Solution

Agrona Nanobubble Technology was introduced to increase and stabilize oxygen availability in recirculating irrigation water. The system generates ultra-fine oxygen nanobubbles (~75 nm), enabling efficient and long-lasting oxygen transfer throughout the irrigation system.

Three irrigation treatments were compared:

- A Control (A): Basin rainwater + nutrients (no recirculation, no aeration)
- B Recirculated (B): 10% old drain water + 45% disinfected recirculation water + 45% basin rainwater + nutrients (no aeration)
- C Agrona (C): Same water mixture as B with Agrona Nanobubble oxygenation

METHODOLOGY AND DATA

The research was conducted under controlled greenhouse conditions using 288 tomato plants over approximately 11 weeks. Water temperature maintained at approximately 20°C. Measurements covered water quality, oxygen dynamics, root-zone oxygen availability and plant performance. All experiments were independently performed by Stichting Control in Food & Flowers and KWR Water Research Institute.

KEY RESULTS

- **3–6× HIGHER OXYGEN LEVELS**
  Higher oxygen saturation in irrigation water compared with non-aerated recirculated water (B).
- **+11.5% PHOTOSYNTHESIS EFFICIENCY**
  64.5% ⟶ 71.9% compared with non-aerated recirculated water (B).
- **+35.9% FRESH BIOMASS**
  59.07 ⟶ 80.27 g/plant compared with non-aerated recirculated water (B).
- **+31.1% DRY BIOMASS**
  5.14 ⟶ 6.74 g/plant compared with non-aerated recirculated water (B).

HIGHER OXYGEN SATURATION IN IRRIGATION WATER

3-6× higher oxygen saturation

Agrona Nanobubble Technology operated three times per day, with each aeration cycle lasting 15 minutes. Measurements in the daily nutrient-water storage tank showed substantially higher oxygen levels in the Agrona treatment (C) than in the non-aerated recirculated water treatment (B).

Agrona Nanobubble Technology operated three times per day, with each aeration cycle lasting 15 minutes. Measurements in the daily nutrient-water storage tank showed oxygen saturation levels of approximately 40-60% in the Agrona treatment (C), compared with approximately 10-15% in non-aerated recirculated water (B). Oxygen saturation in the Agrona treatment reached approximately 40-60%, compared with around 10-15% in the non-aerated recirculated water (B).

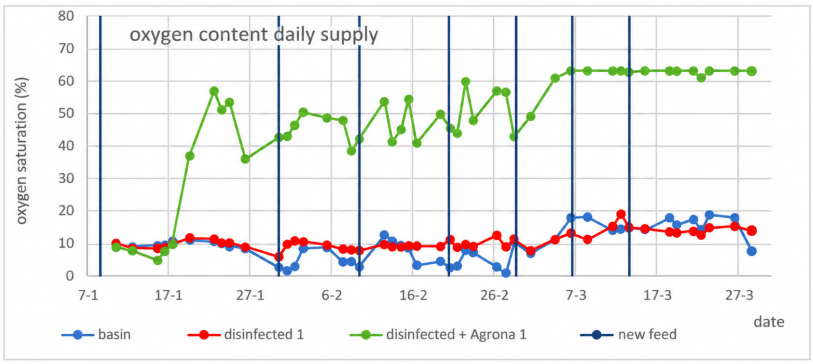


Figure 7: The oxygen content in the daily supply measured with the handheld meter for each treatment

(Reference: Figure 7, Impact of Water Quality on Tomato Plant Growth, April 18, 2025, Page 17).

These results demonstrate the substantial increase in oxygen availability achieved through Agrona nanobubble aeration. The high dissolved oxygen (DO) levels were maintained over an extended period.

OXYGEN CONSUMPTION AND WATER QUALITY

In addition to increasing oxygen availability, Agrona-treated irrigation water showed the lowest oxygen consumption among the tested treatments. Figure bellow illustrates oxygen consumption over the days following tank filling. The water mixtures were prepared on day 0, with nutrients added on day 2. Oxygen consumption initially decreased after mixing and subsequently fluctuated throughout the observation period. Despite these variations, the Agrona-aerated treatment (C) showed lower oxygen consumption than the other treatments, with values remaining close to zero during much of the observation period.

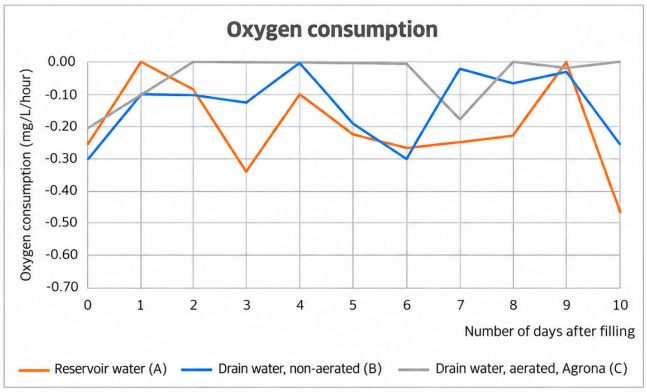


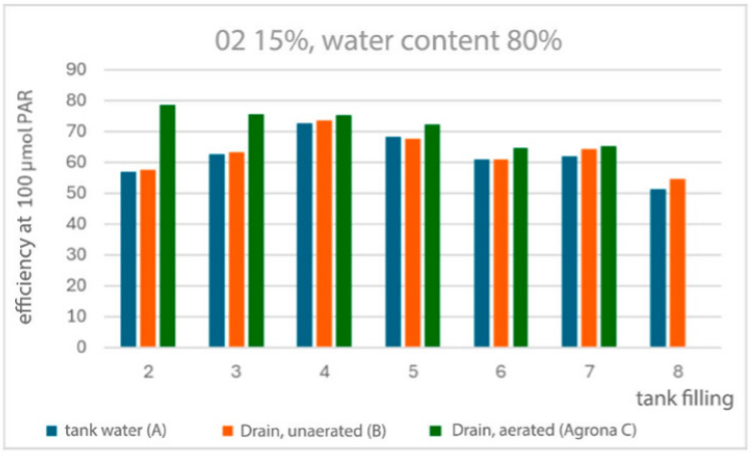
Figure 9: The average course of oxygen consumption at an initial concentration of 8 mg/L oxygen from the moment the tanks are filled.

(Reference: Figure 9, Impact of Water Quality on Tomato Plant Growth, April 18, 2025, Page 18).

Oxygen consumption is an indicator related to microbial activity and organic matter breakdown in water. These results demonstrate the influence of nanobubble aeration on oxygen consumption dynamics in recirculating irrigation water.

PHOTOSYNTHESIS EFFICIENCY

Highest measured efficiency under Agrona treatment.



(Reference: Figure 30, Climate Cell Trial 2: Impact of Water Quality on Tomato Plant Growth, November 14, 2025, Page 31).



Photosynthesis efficiency was calculated using comparable root-zone conditions of 15% oxygen and 80% moisture:

- Control (A): **63.8%**
- Recirculated (B): **64.5%**
- Agrona (C): **71.9%**

That represents:
+12.7% vs. Control (A)
+11.5% vs. Recirculated (B)

Nanobubble aerated treatment achieved up to 11.5% higher calculated photosynthesis efficiency compared with the recirculated treated water.

PLANT BIOMASS RESULTS

Agrona treatment produced the highest fresh and dry biomass.

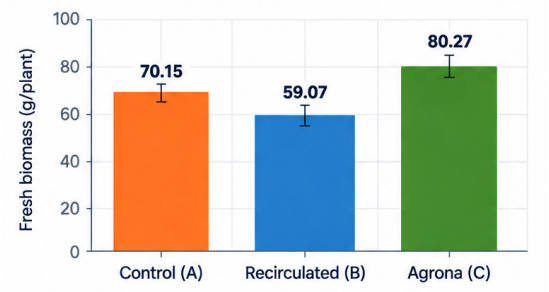
The average fresh and dry weight per plant and dry matter content of treatments A, B and C. Treatments differ significantly when they do not share the same letter.

Treatment	Avg. fresh weight (g/plant)	Avg. dry weight (g/plant)
Basin (A)	70.15	5.97
Disinfected (B)	59.07	5.14
Disinfected + aeration (C)	80.27	6.74

(Reference: Table 7, Climate Cell Trial 2: Impact of Water Quality on Tomato Plant Growth, November 14, 2025, Page 24).

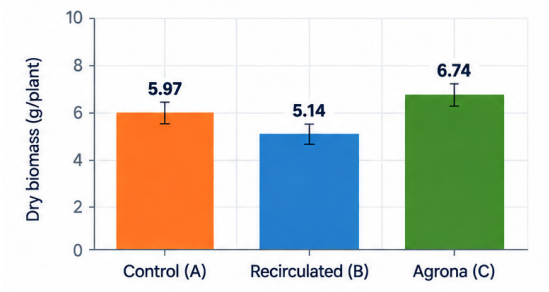
Fresh biomass: 80.27 g/plant with Agrona vs. 59.07 g/plant without aeration = +35.9%.
Dry biomass: 6.74 g/plant with Agrona vs. 5.14 g/plant without aeration = +31.1%.

Fresh biomass
(g per plant)



Agrona vs. Recirculated (B)
+35.9% Higher fresh biomass (80.27 vs. 59.07 g/plant)

Dry biomass
(g per plant)



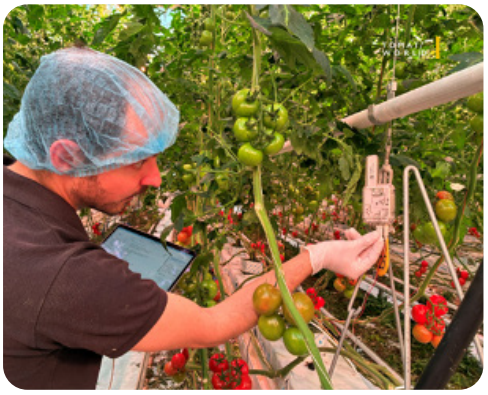
Agrona vs. Recirculated (B)
+31.1% Higher dry biomass (6.74 vs. 5.14 g/plant)

Compared with the basin water reference (A), Agrona produced +14.4% higher fresh biomass (70.15 → 80.27 g/plant) and +12.9% higher dry biomass (5.97 → 6.74 g/plant).

PLANT PERFORMANCE

The research clearly shows that oxygen rich irrigation water supports higher root zone oxygen availability, photosynthesis efficiency and plant biomass. Agrona nanobubbles consistently delivered the best overall results in tomato experiments.

- Higher oxygen saturation in recirculated irrigation water.
- Higher calculated photosynthesis efficiency.
- Higher average fresh biomass per plant.
- Higher average dry biomass per plant.



Source:
KWR Grenswaarden Waterkwaliteit climate cell experiments with tomato (Reports S20220001).
Results based on controlled research conditions.

SCIENTIFIC CONCLUSION

The independent tomato research demonstrates the benefits of Agrona Nanobubble Technology for increasing oxygen availability in recirculated irrigation water and supporting improved plant performance.
In addition to achieving higher oxygen levels, Agrona treated water recorded the lowest average oxygen consumption. Combined with the improvements in plant biomass and calculated photosynthesis efficiency, these results demonstrate the effectiveness of Agrona Nanobubble Technology as an advanced solution for oxygen optimization and improved irrigation water management.

WHAT THIS MEANS FOR TOMATO GROWERS

By combining increased oxygen availability with lower average oxygen consumption, Agrona offers growers an efficient tool for optimizing irrigation water management, complementing existing water treatment strategies and potentially reducing reliance on additional chemical interventions.

KEY BENEFITS

- Higher oxygen availability in recirculated irrigation water.
- Improved photosynthesis efficiency and stronger plant growth.
- Increased fresh and dry plant biomass.
- More effective oxygen management throughout the irrigation system.
- Reduced reliance on additional chemical water treatment interventions.
- Lower operating costs and more efficient water management.
- Easy integration into existing greenhouse systems.
- A practical solution for more sustainable tomato production.



Advanced nanobubble oxygen technology designed to improve water quality and plant performance across horticulture, agriculture, aquaculture and water treatment.

DISCOVER THE AGRONA DIFFERENCE

Explore what oxygen optimization could achieve in your greenhouse. Agrona Tec. can discuss your irrigation water, review your system configuration and help identify a suitable approach for on site evaluation.

- Free on-site water analysis and consultation
- Trial systems for short-term validation
- Flexible Rental Program for seasonal or pilot use

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