Electric-field nanobubbles for agriculture

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Niall J. English, from Chemical Engineering at University College Dublin, discusses how using electric-field-generated nanobubbles for agriculture is empowering fundamental progress

A fundamental challenge in crop and tillage agriculture lies in providing adequate levels of dissolved oxygen (DO) in the water supply whether via irrigation or spray-delivery methods for respective root-zone or stomatal delivery, with also CO^2 in the latter case. This is limited by Henry's Law, which governs thermodynamic gas solubility in liquids.

In ecosystems and the environment, lack of DO is a major reason for, inter alia, fish kills and water-body blight by algal blooms of cyanobacteria. However, in crop agriculture, escalating global population, coupled with persistent challenges engendered by climate change and dwindling natural resources, have heightened the urgency to revolutionise agricultural practices in a more sustainable manner.

Intensifying fertiliser usage in crop production is a perennial challenge concerning the limited uptake of applied nutrients by plants. In this vein, nitrogen-based fertilisers' recovery ratio in harvested crops can drop to as low as 40–50%, leading to the accumulation of residual fertilisers in soil and subsequent increase in surface runoff – accumulating inevitably in water bodies, e.g., leading to cyanobacteria. Furthermore, possible heavy-metal traces due to fertiliser consumption can negatively influence ecosystems and water quality.

Pioneering technologies for sustainable agriculture

With mounting demand for more sustainable food production, there has been a significant surge in the exploration of pioneering technologies aimed at achieving sustainable agriculture and mitigating environmental impacts. Organic farming—relying on organic fertilisers from crop residues and livestock manure—is an environmentally friendly agricultural system that emphasises natural pest control and minimises pollution from synthetic substances.

However, the slow release of plant-accessible nutrients from organic fertilisers remains a significant limitation: Organic crop production is up to 25% lower than that of conventional agriculture using chemical fertilisers, highlighting the need for research into expediting the organic fertiliser mineralisation.

In conventional farming, oxygen availability in the soil, essential for enhancing metabolism and microbial activity, relies primarily on air diffusion, which is often restricted, particularly in deeper layers. Therefore, an effective oxygen-delivery approach into the soil is yet another desideratum, among other things, in promoting the broader sustainability agenda in agriculture.

Novel water-gasification technologies

AquaB (AquaB Nanobubble Innovations Ltd), commercialises novel water- gasification technologies based upon its breakthrough low-energy nanobubble (NB)-generation approaches. It was established in 2020 as a spin-out company from UCD Chemical Engineering to commercialise the patented platform NB-generation technology lead-invented by Company Director Prof Niall English, who holds an ERC Advanced grant on NBs with broad applicability across disparate application areas.

Since 2020-21, AquaB has been developing TRL 4-8 NB generators, aided by its European Innovation Council (EIC) Accelerator Grant – and has been performing crop-agriculture trials since then, in both hydroponic and soil environments.

Enter nanobubbles for agriculture innovations

As part of the urgency in addressing food sustainability and security concerns and optimising crop productivity, NBs have emerged as one prominent subject of research within agricultural innovations, offering the promise of sustainable crop production. NBs are tiny gas bubbles on the nanometre (nm) scale. They may be thermodynamically metastable for up to many months, or sometimes even longer, and have enhanced gas-transfer properties and substantial industrial potential.

These NBs – shorter than the wavelength of light – are not visible to the naked eye and are orders of magnitude smaller in dimension than a human hair's width, as discussed in Prof English's recent audio-podcast course on NBs.

AquaB's method of generating NBs is based on static electric fields and electrostriction-based "sucking in" phenomena of gases into liquids – making "thick-skinned", or ultra-dense, NBs with enhanced longevity, e.g., long-time-maintained high DO in water. In recent agricultural studies, the catalytic effects of such oxygen and air NBs on plant growth have been documented – in particular, oxygen NBs.

Although significant progress has been made in leveraging NBs for crop cultivation, there is a need to explore the potential advantages of utilising air NBs as alternatives to more specialised gas variants, driven by economic and accessibility factors. Here, AquaB's low-energy electric-field approach offers many practical benefits. not least of which is the possibility of solar-powered NB generation.

AquaB rising to the agricultural challenge

The implementation of electric field- based air NBs (EF-ANBs) in irrigation presents a promising approach to enhance agricultural crop efficiency, concurrently promoting environmentally sustainable practices through reducing fertiliser usage, using a submersible AquaB NB generator, which can be easily retrofitted with a solar-panel/battery ensemble for placement in irrigation header tanks. UCD researchers investigated the impact of EF-ANBs on the germination and overall growth of agricultural crops in soil.

Results indicate a substantial enhancement in both germination rates and plant growth upon the application of EF-ANBs. Notably, the introduction of EF-ANBs led to a significant enhancement in the germination rate of lettuce and basil, increasing from approximately 20% to 96% and 16% to 53%, respectively, over two days.

Moreover, the presence of EF-ANBs facilitates superior hypocotyl elongation, exhibiting a 2.8- and a 1.6-fold increase in the elongation of lettuce and basil, respectively, over a six-day observation period. The enriched oxygen levels within the air NBs expedite aerobic respiration, amplifying electron leakage from the electron-transport chain and resulting in heightened reactive oxygen species (ROS) production, which plays a pivotal role in stimulating growth signalling.

Furthermore, the application of EF-ANBs in irrigation surpasses the impact of traditional fertilisers, demonstrating a robust catalytic effect on the shoot, stem, and root length, as well as the leaf count of lettuce plants. Considering these parameters, a single fertiliser treatment (at various concentrations) during EF-ANBs administration demonstrates superior plant growth compared to regular water combined with fertiliser.

The findings underscore the synergistic interaction between aerobic respiration and the generation of ROS in promoting plant growth, particularly in the context of reduced fertiliser levels facilitated by the presence of EF-ANBs. This promising correlation holds significant potential in establishing more sustainability for ever-increasing environmentally-conscious agriculture.

AquaB believes firmly that its industrially-proven field trials, with superior performance compared to rivals, e.g., in submersible NB generation is advancing its EIC- supported water management and treatment, (including for gut health in ruminant digestion). We see great potential for nanobubble technology to support the UN Sustainable Development Goal 2 – to achieve food security and promote sustainable agriculture – and to contribute to the EU’s laudable ‘Farm-to-Fork’ strategy for a fair, healthy and environmentally-friendly food system.

Please Note: This is a Commercial Profile

More About Stakeholder

AquaB Nanobubble Innovations Ltd and their electrostriction-based platform

AquaB Nanobubble Innovations Ltd is a University College Dublin (UCD) spin-out company incorporated in 2020 to commercialise nanobubble-generation technology lead-invented by Professor Niall English.