Promoting Sustainable and Resilient Farming Practices

CO_2 irrigation: what role does it play in sustainable productivity?

When it comes to improving productivity in agriculture, food producers are facing a series of challenges demanding new methods and innovations. On the one hand, there is the need to meet growing demand, particularly on the continents of Asia, South America and Africa. But at the same time, longstanding agriculture methods are being forced to adapt to regulations and targets that aim to reduce emissions, improve the efficient use of land, water and fertilisers.

And with this there has been renewed interest in the method of CO_2 irrigation. With improvements in smart irrigation technology the use of this gas in agriculture has become more accessible to a generation of farmers facing new challenges when sustainably increasing yield in their crops.

Carbonic irrigation can contribute to a cleaner future by improving soil health, as it helps to maintain optimal pH levels in the soil, enhances nutrient availability and promotes better soil structure and microbial activity.

But what does the research say about this method, what are the constraints in its application, and which food producers have the potential to benefit the most?

CO_2 irrigation: how it works

Improved growth from CO_2 irrigation is due to a combination of different mechanisms. Firstly, CO_2 can reduce water and soil pH, improving the uptake of nutrients. Secondly, root growth and quality are also enhanced by reducing ethylene inhibition, while the increased CO_2 through both the root, and its subsequent presence in the ambient atmosphere has positive effects on photosynthesis as well as plant hormones and enzyme balances.[1]

These mechanisms are enhanced in particular environments and with certain crops. Research shows that the method is particularly effective in controlled greenhouse environments and hydroponic 'soilless crop' systems where CO_2 and irrigation levels can be closely monitored. Tomatoes, cucumbers, leafy greens, strawberries, herbs, rice, wheat, and flowering plants are responsive to increased levels of CO_2 and the use of carbonic irrigation methods have returned significantly increased yields.[2]

CO_2 irrigation has been used in open crop systems and is used in arid systems where water efficiency is of concern, as well as in alkaline soils. For example, a 2022 study from Spain showed the benefits of carbonic irrigation methods in calcareous soils when growing tempranillo grapes for wine production.[3]

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[1] S. Guri. O. Marfá. R. Savé. J. Casado. (1999). Effect of carbonic irrigation on the production of a pepper crop. VIII National Congress of Horticultural Sciences. Murcia, Spain.

[2] Craig A. Storlie, J. R. Heckman. (1996). Soil, plant, and canopy responses to carbonated irrigation water, , HortTechnology.

[3] Lampreave, M.; Mateos, A.; Valls, J.; Nadal, M.; Sánchez-Ortiz, A. (2022) Carbonated irrigation assessment of grapevine growth, nutrient absorption, and sugar accumulation in a tempranillo (Vitis vinifera L.) Vineyard. Agriculture, 12, 792. https://doi.org/10.3390/agriculture12060792

What does the research say on increased yield?

There is a longstanding body of research dating back to the 1980s that describes significant yield increases in a variety of crops including cotton, cucumber and tomato. A landmark 1993 research review found a mean increase yield of 2.3% across the different crops.[4] But the research has also emphasised that such growth responses are dependent on environmental and soil conditions.

Increased yield is likely in soil and water that has a higher pH than alkali soils[5], while other factors such as the use of polyethylene mulch as well as the frequency and duration of irrigation improved the growth response to carbonic irrigation.

Research has demonstrated that carbonic irrigation can significantly increase yields in specific crops under certain environmental conditions. While its commercial use is still emerging, it has shown great promise in hydroponic systems and in regions with high aridity, water scarcity, and alkaline soils. Irrigation water acidification using captured CO_2 has also been demonstrated as an alternative to traditional acidification systems in water.[6]

A 2022 study carried out showed promising results using CO_2 treated water using micro nano bubble technology (MNB) for vegetable cultivation in China, Southeast Asia and India.[7]

Over an eight-week period, the vegetable group treated with CO_2 enriched water showed increased nutrient content, root development and growth levels consistent with past studies, including research carried out by Air Products' Lead Agricultural Engineer, Dr Sonia Guri, on green peppers.

What do food producers need to know?

Effective use of CO_2 irrigation requires an understanding of crop type, soil and growing conditions. For producers working in soilless culture or open crop systems, the use of carbon enriched water has a longstanding body of research in improving yield. Research shows that it is also becoming a viable alternative to synthetic fertilizers and chemicals used in more traditional farming, improving nutrient uptake and overcoming challenges in certain growing conditions.

[4] Enoch HZ, Olesen JM. (1993). Plant response to irrigation with water enriched with carbon dioxide. New Phytol. 1993 Oct;125(2):249-258. doi: 10.1111/j.1469-8137.1993.tb03880.x. PMID: 33874496.

[5] Craig A. Storlie, J. R. Heckman. (1996). Soil, plant, and canopy responses to carbonated irrigation water. HortTechnology

[6] Adolfo Donoso Meneses – Agricultural Engineer. (2020)- Irrigation water acidification using captured CO_2; An option to traditional acidification systems. M.Sc. https://www.worldagexpo.com/ wp-content/uploads/sites/2/2020/11/Soil-acidification-r.-1.0.pdf

[7] Khan, P., Wang, H., Gao, W. et al. (2022). Effects of micro-nano bubble with CO_2 treated water on the growth of Amaranth green (Amaranthus viridis). Environ Sci Pollut Res 29, 72033–72044 (2022). https://doi.org/10.1007/s11356-022-20896-6

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