Grower Summary

CP 143

Increasing crop yield and resource use efficiency via root-zone CO₂ enrichment

Final 2018
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Further information

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AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.
Project title: Increasing crop yield and resource use efficiency via root-zone CO₂ enrichment

Project number: CP 143

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Report: 03/2019

Previous report: 02/2017

Key staff: Estibaliz Leibar-Porcel, PhD student
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Location of project: Lancaster University

Industry Representative: Philip Morley, British Tomatoes Growers' Association

Date project commenced: 1/10/2015

Date project completed (or expected completion date): 31/12/2018
GROWER SUMMARY

Headlines

- Gaseous CO₂ enrichment (1500 ppm) of the root-zone of aeroponically-grown lettuce increased biomass by up to 19-25%, with variation according to the environmental conditions and lettuce cultivar
- Bicarbonate application (1-5 mM) to hydroponic solutions (which releases CO₂ to the solution) increased shoot growth of lettuce and pepper by 10-20%

Background

Biomass accumulation is the difference between the photosynthesis rate and respiration rate. Greenhouse operators often inject extra CO₂ into the aerial environment to increase photosynthesis and biomass accumulation. However, when the humidity or the temperature is very high, the greenhouse is vented and CO₂ is released into the atmosphere (Figure 1), which is economically wasteful and releases a greenhouse gas to the atmosphere.

Figure 1. CO₂ balance model. a) General balance model when supplying 45 kg/ (m² year). Modified from Wageningen University & Research, Business Unit Greenhouse Horticulture

Sources of CO₂ for enrichment include boiler, combined heat, power (CHP), burner exhaust gases, and liquefied pure gas. Flue gases from natural gas boilers are widely used in the UK as a source of CO₂ for enrichment. This practice has high-energy costs of £200,000 per annum for a 5 ha glasshouse (Pratt, 2011). CO₂ is a “greenhouse gas” that contributes to global warming and climate change. Despite the efforts of growers to minimize spending and maximize production through technical improvements, it is necessary to consider other
systems such as localized root-zone CO₂ enrichment, to improve crop production while minimizing environmental emissions.

This project focused on improving resource use efficiency and the environmental performance of tomato, lettuce and pepper production, by testing whether root-zone CO₂ enrichment of soilless culture systems was beneficial.

Summary

Previous studies have shown that applying either bicarbonate hydroponically at low concentrations (5 mM HCO₃⁻) or gaseous CO₂ at high concentrations (2,000-50,000 ppm) to the roots increased growth of some crops such as tomatoes or lettuce. Also, initial studies carried out at Lancaster University by a previous AHDB-funded PhD student indicated that applying 700 ppm CO₂ to the root-zone of semi-aeroponically grown lettuce (without altering the aerial CO₂ concentration) increased biomass by 10%. Therefore, root-zone CO₂ enrichment in greenhouses may provide an alternative technique to increase yield.

Initial studies identified that applying low concentrations of bicarbonate (1-5 mM) to the nutrient solution of hydroponically grown pepper and lettuce increased shoot biomass by 10% compared to those plants that did not receive bicarbonate. In addition, root-zone CO₂ enrichment of aeroponically grown lettuce increased shoot biomass (20%) compared to plants grown without root-zone CO₂ enrichment. However, the response is variable depending on the experimental conditions and the lettuce variety used. Due to time constraints in this project, further work is required to fully understand how other environmental variables (e.g. temperature, light) affect plant responses to root-zone CO₂ enrichment.

Financial Benefits

Developing techniques to more effectively apply CO₂ will decrease the cost of supplying liquefied CO₂ or energy consumption (natural gas boilers) in commercial scale greenhouses.

Action Points

Understand that there are potential alternatives to the current practice of aerial CO₂ enrichment in greenhouses that decrease CO₂ usage and reduce pollution, while maintaining or increasing crop yields.