AHDB HORTICULTURE

Grower Summary

CP 143

Increasing crop yield and resource use efficiency via root-zone CO_2 enrichment

Final 2018

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the AHDB Horticulture office (hort.info.@ahdb.org.uk), quoting your AHDB Horticulture number, alternatively contact AHDB Horticulture at the address below.

AHDB Horticulture,
AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.

Project title:	Increasing crop yield and resource use efficiency via root-zone CO_2 enrichment
Project number:	CP 143
Project leader:	Ian Dodd
Report:	03/2019
Previous report:	02/2017
Key staff:	Estibaliz Leibar-Porcel, PhD student Martin McAinsh, co-supervisor
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 CO_2 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 CO_2 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 CO_2 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 CO_2 is released into the atmosphere (Figure 1), which is economically wasteful and releases a greenhouse gas to the atmosphere.

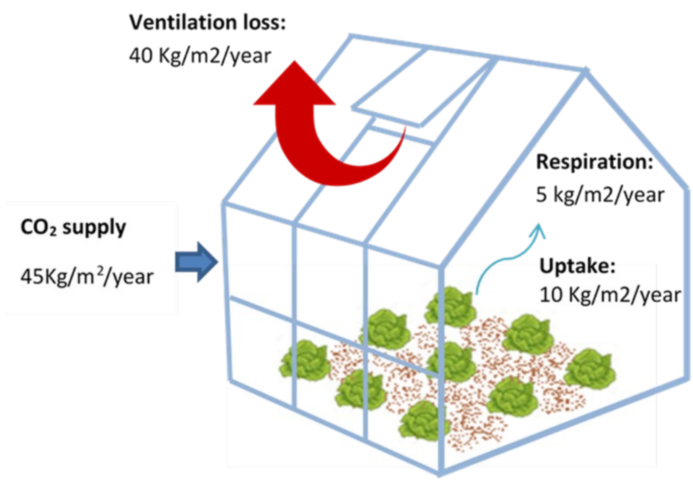

Figure 1. CO_2 balance model. a) General balance model when supplying 45 kg/ (m^2 year). *Modified from Wageningen University & Research, Business Unit Greenhouse Horticulture*

Sources of CO_2 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 CO_2 for enrichment. This practice has high-energy costs of £200,000 per annum for a 5 ha glasshouse (Pratt, 2011). CO_2 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 CO_2 enrichment, to improve crop production while minimising 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 CO_2 enrichment of soilless culture systems was beneficial.

Summary

Previous studies have shown that applying either bicarbonate hydroponically at low concentrations (5 mM HCO_3^-) or gaseous CO_2 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 CO_2 to the root-zone of semi-aeroponically grown lettuce (without altering the aerial CO_2 concentration) increased biomass by 10%. Therefore, root-zone CO_2 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 CO_2 enrichment of aeroponically grown lettuce increased shoot biomass (20%) compared to plants grown without root-zone CO_2 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 CO_2 enrichment.

Financial Benefits

Developing techniques to more effectively apply CO_2 will decrease the cost of supplying liquefied CO_2 or energy consumption (natural gas boilers) in commercial scale greenhouses.

Action Points

Understand that there are potential alternatives to the current practice of aerial CO_2 enrichment in greenhouses that decrease CO_2 usage and reduce pollution, while maintaining or increasing crop yields.