AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD

Grower Summary

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

CP 143

Annual report 2017

Project title:	Increasing crop yield and resource use efficiency via root-zone CO_2 enrichment
Project number:	CP 143
Project leader:	Ian Dodd
Report:	09/2017
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):	30/12/2018

DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Professor Ian Dodd

Project leader

Lancaster University

Signature

Date………………24/12 /17...

Ms Estibaliz Leibar-Porcel

PhD Student

Lancaster University

Signature

Date 24/12/17

Report authorised by:

[Name]

[Position]

[Organisation]

Signature .... Date ....

GROWER SUMMARY

Headline

Gaseous CO_2 enrichment (1500 ppm) of the root-zone of aeroponically-grown plants increased lettuce biomass by 20%. 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

Photosynthesis uses light energy to convert CO_2 and water into sugars, which are required for growth and respiration. 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.

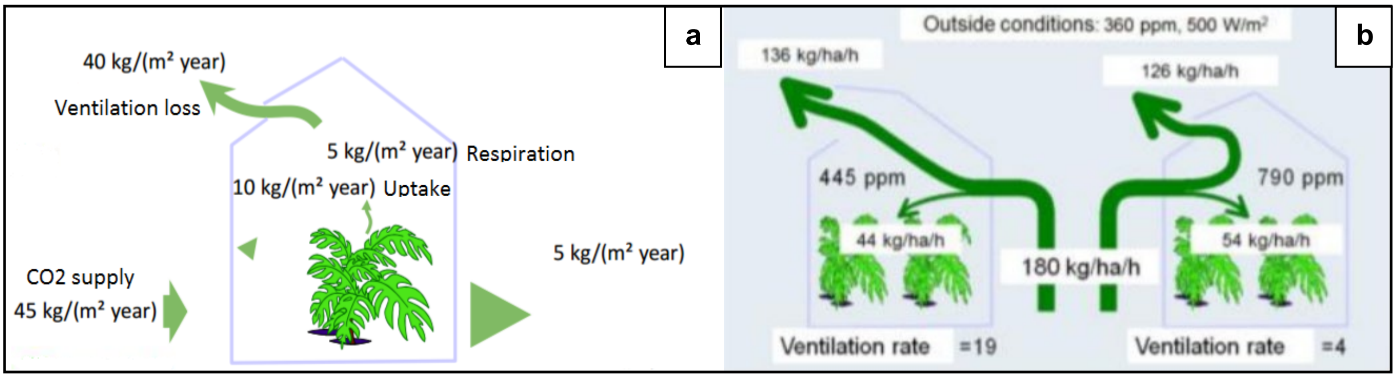

Figure 1. CO_2 balance model. a) General balance model when supplying 45 kg/ (m^2 year). b) CO_2 balance model when supplying 180Kg/ha/h CO_2 and different ventilation rates are applied with same outside conditions. *Wageningen University & Research, Business Unit Greenhouse Horticulture.*

Sources of CO_2 for enrichment include boiler, combined heat and power (CHP) and 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 (HDC 2011;

http://www.hdc.org.uk/sites/default/files/research_papers/PE%20003%20Final%202011_0.pdf). CO_2 gas 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, the cost-effectiveness and the environmental performance of tomato, lettuce and pepper production, by testing whether root-zone CO_2 enrichment with soilless culture systems provided a viable alternative to aerial CO_2 enrichment.

Summary

Previous studies have shown that applying either bicarbonate hydroponically at low concentrations (5 mM HCO_3^-) or gaseous CO_2 at high concentrations (2000-50,000 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.

In Year 1 of this project, 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%. In addition,, hydroponically grown tomato plants enriched with 1500 ppm root-zone CO_2 increased dry biomass by 11%. Although gaseous root-zone CO_2 enrichment is still undergoing additional research, some experiments showed greater biomass (7-10%) in aeroponically grown lettuce. However, these experiments need to be repeated to reach a final conclusion.

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

1. 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 crop yields.