



# **Grower Summary**

**Increasing crop yield and resource use efficiency  
via root-zone CO<sub>2</sub> enrichment**

**CP 143**

Annual report 2017

**Project title:** Increasing crop yield and resource use efficiency via root-zone CO<sub>2</sub> enrichment

**Project number:** CP 143

**Project leader:** Ian Dodd

**Report:** 09/2017

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**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** 30/12/2018

**(or expected completion date):**

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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



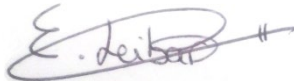
Date.....24/12 /17.....

Ms Estibaliz Leibar-Porcel

PhD Student

Lancaster University

Signature



Date        24/12/17

**Report authorised by:**

[Name]

[Position]

[Organisation]

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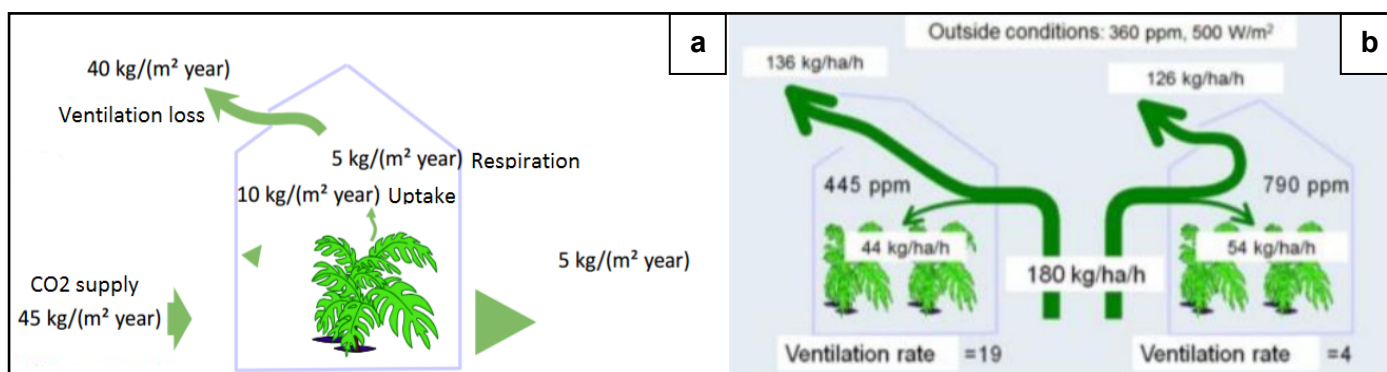
## GROWER SUMMARY

### Headline

Gaseous CO<sub>2</sub> 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<sub>2</sub> to the solution) increased shoot growth of lettuce and pepper by 10-20%.

### Background

Photosynthesis uses light energy to convert CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> is released into the atmosphere (Figure 1), which is economically wasteful and releases a greenhouse gas to the atmosphere.



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

Sources of CO<sub>2</sub> 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<sub>2</sub> 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](http://www.hdc.org.uk/sites/default/files/research_papers/PE%20003%20Final%202011_0.pdf)). CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> enrichment with soilless culture systems provided a viable alternative to aerial CO<sub>2</sub> enrichment.

## Summary

Previous studies have shown that applying either bicarbonate hydroponically at low concentrations (5 mM HCO<sub>3</sub><sup>-</sup>) or gaseous CO<sub>2</sub> 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<sub>2</sub> to the root-zone of semi-aeroponically grown lettuce (without altering the aerial CO<sub>2</sub> concentration) increased biomass by 10%. Therefore, root-zone CO<sub>2</sub> 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<sub>2</sub> increased dry biomass by 11%. Although gaseous root-zone CO<sub>2</sub> 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<sub>2</sub> will decrease the cost of supplying liquefied CO<sub>2</sub> 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<sub>2</sub> enrichment in greenhouses that decrease CO<sub>2</sub> usage and reduce pollution, while maintaining crop yields.