Plant adaptation to elevated carbon dioxide: Using a lipidomic approach to identify alterations in lipid metabolism and signaling in *Arabidopsis thaliana*

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INTRODUCTION

Changes in the Levels of CO_2 in Earth Atmosphere

From the beginning of the industrial revolution, anthropogenic activities have caused the concentration of atmospheric CO_2 to increase from about 270 parts per million (ppm) to over 370 ppm today. Current estimates suggest that atmospheric CO_2 concentration will reach 550 ppm by the year 2050 and over 700 ppm by the end of the 21st century (Prentice et al., 2001).

Ecophysiological Responses Plant Systems to Elevated CO_2

- Photosynthesis is increased
- Stomatal conductance is decreased
- Water use efficiency is increased
- Elevated CO_2 can produce selective pressure on plant
- Populations

→Alterations of plant metabolism

Changes in Lipid Metabolism at Elevated CO_2 in Leaves (Ekman et al., 2007; Williams et al., 1998)

- Decrease in chloroplast lipid classes MGDG and PG
- Increase in PC and PE lipid classes
- Lower ratio 16:1trans to 16:0 in PG
- Lower ratio 16C:18C in PG
- Decrease in total fatty acids

Hypotheses

Preliminary data allow us to propose the following hypotheses :
(1) CO_2 treatment (380 or 700 ppm) during plant growth will affect the levels of specific lipid species.
(2) CO_2 exposure decreases lipid desaturation by lowering the activity of fatty acid desaturase 3 (Fad3).
(3) CO_2 reduces lipid signaling by phospholipase D (PLD).

METHODOLOGY

- Greenhouse experiment:
  - -15 genotypes of *Arabidopsis thaliana*
  - -2 treatments: 380 and 700 ppm CO_2
- -Sampling leaves at stage 6 (flower production) (Boyes et al., 2001)
- Lipid extraction
- Polar lipid profiling by ESI-MS/MS (> 140 polar lipids) (Devaiah et al. 2006)
- Data analysis

Abbreviations:
DGDG, digalactosyldiacylglycerol; ESI-MS/MS, electrospray ionization tandem mass spectrometry; MGDG, monogalactosyldiacylglycerol; PA, phosphatidic acid; PC, phosphatidylcholine; PE, phosphatidylethanolamine; PG, phosphatidylglycerol; PI, phosphatidylinositol; PS, phosphatidylserine.

RESULTS

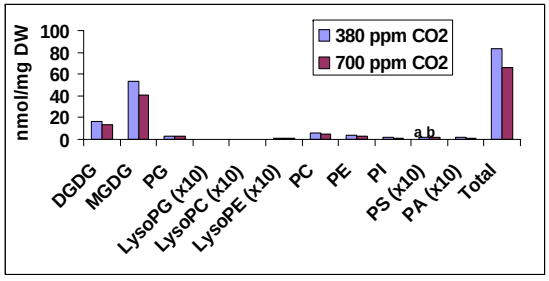

Fig. 1. Elevated CO_2 on levels of classes of lipids

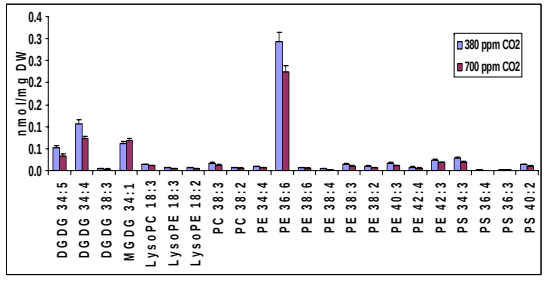

Fig. 2. Levels of lipid species significantly altered across the genotypes

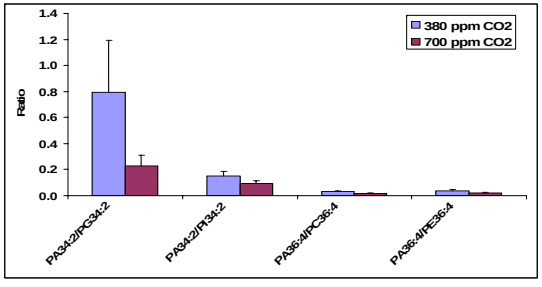

Fig. 3. Ratios of specific phospholipids reactants and products of PLD altered by CO_2 treatment (p>0.05).

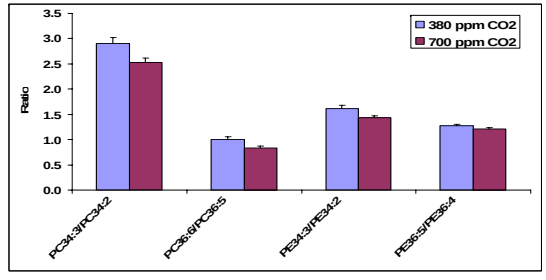

Fig. 4. Ratios of specific phospholipids reactants and products of Fad3 altered by CO_2 treatment (p>0.05).

CONCLUSIONS AND FUTURE WORKS

- CO_2 treatment (380 or 700 ppm) affects the levels of specific lipid species.
- Levels of particular lipid species are influenced by genotype and in-lab selection at elevated CO_2.
- Important enzymes in lipid metabolism (PLD, Fad3) are affected by CO_2 treatment as revealed by lipidomics analysis.
- A second growth chamber experiment was realized this summer for confirming the results of polar lipid profiling and the samples are currently being processed.

References:
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Williams et al. 1998. Plant, Cell and Environment 21: 927-936.

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