Australian Grains Free Air CO_2 Enrichment (AGFACE) program

AGFACE results: Pests and diseases

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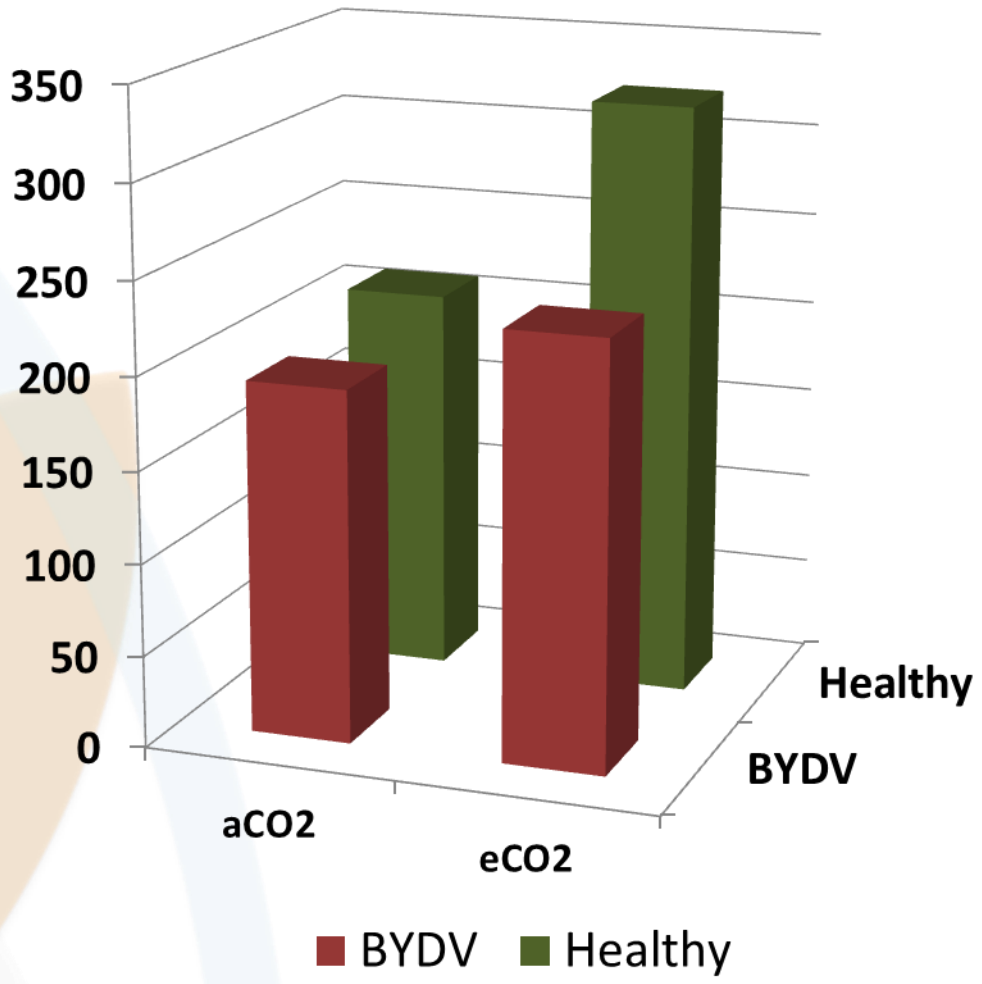
AGFACE is a collaborative research program led by the Department of Environment and Primary Industries Victoria and the University of Melbourne, with core funding support from the Grains Research and Development Corporation and the Australian Government Department of Agriculture.

Yield losses due to eCO2 and BYDV

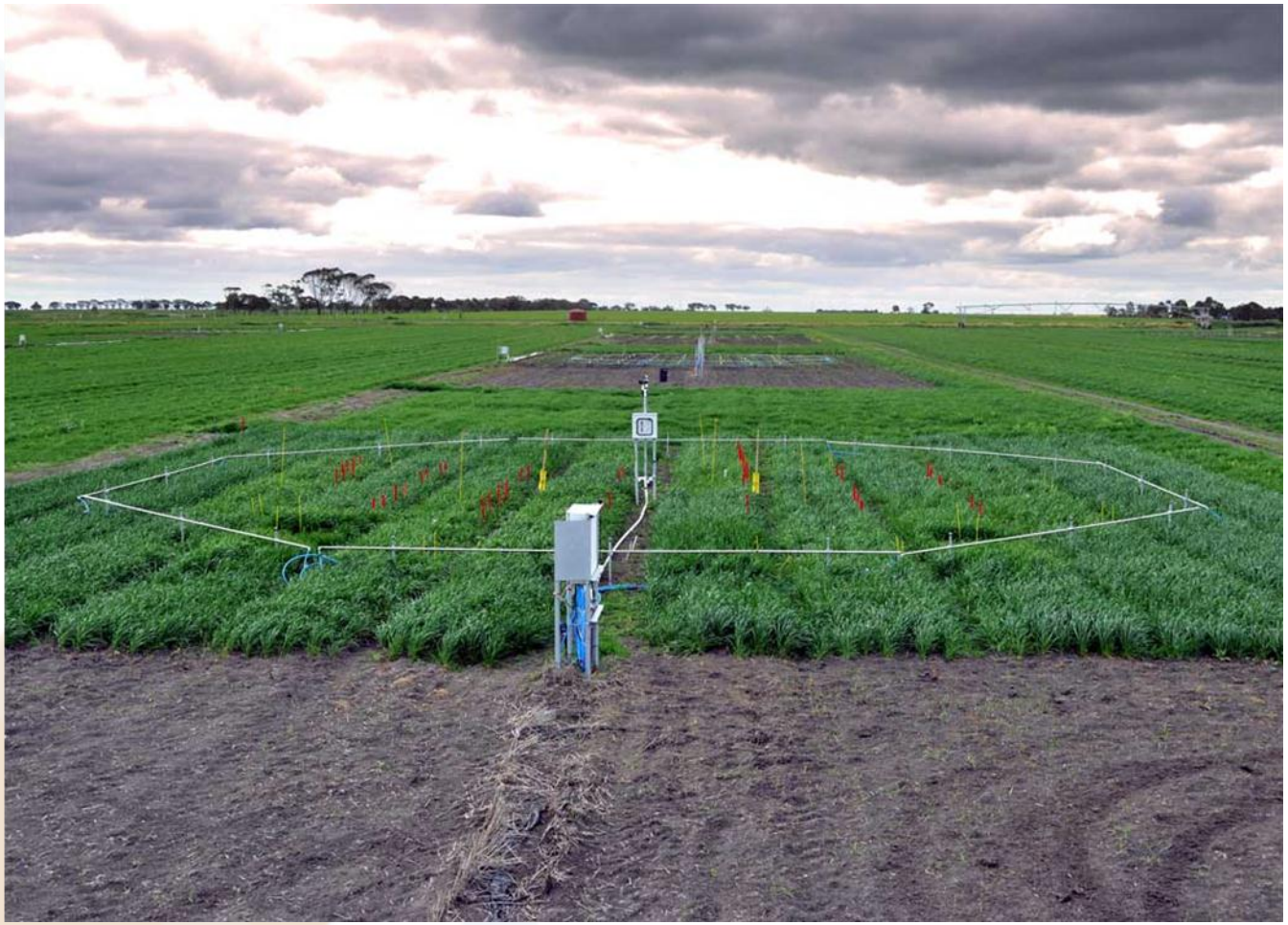
eCO2 = 28.5 % yield decrease due to BYDV

aCO2 = 8.6%



FACE 2013 data

Horsham AG FACE



Soil FACE

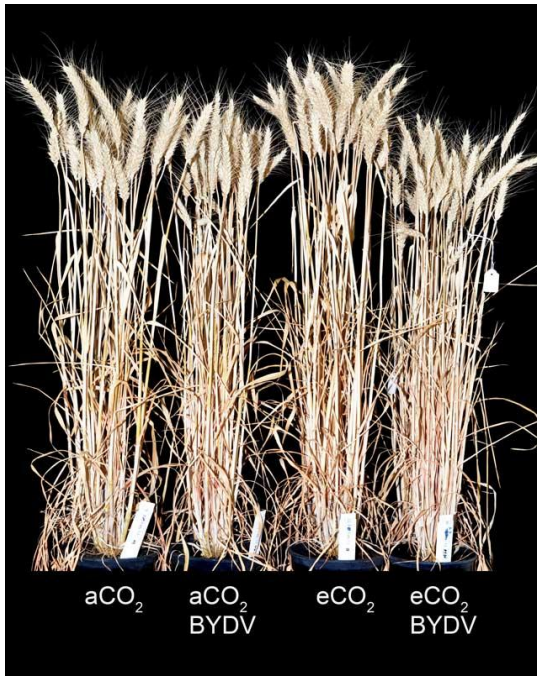
Elevated CO_2

Ambient CO_2

Effects of climate, wheat

Rising CO_2

- Higher crop yield under elevated CO_2
- Greater water-use efficiency due to partial closing of stomata under high CO_2
- Changes to C:N ratio
- Increased waxes
- Increased surface area, altered microclimate
- Diminished frost tolerance



Rising temperature

- Reduced biomass, including yield.
- Could counteract the positive effect of elevated CO_2 in some cv.

Changes in farming practices?

Effects of climate change on wheat

and

pests and diseases in wheat largely unknown

Rhopalosiphum padi

The bird cherry-oat aphid (Homoptera: Aphididae)

Widely distributed

Principal vector **of Barley *yellow dwarf virus* (BYDV)**

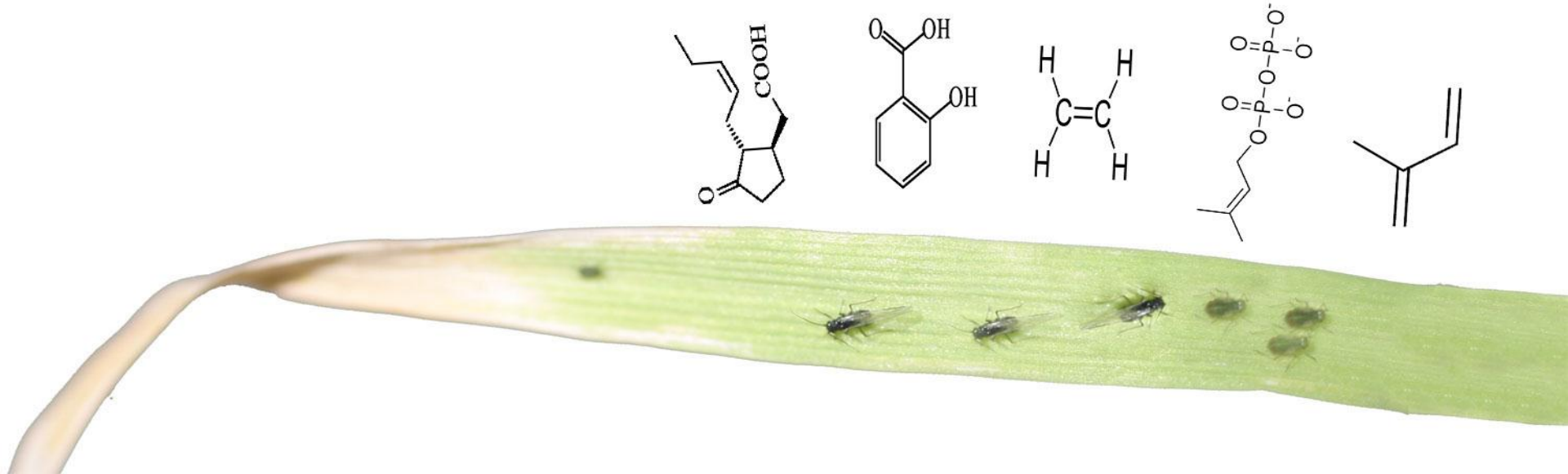
Many genotypes in Australia
(based on mitochondrial markers)

Asexual reproduction

- Population
- Feeding behaviour
- BYDV transmission/acquisition (virus spread)

Impact of eCO_2 and BYDV on wheat physiology and chemistry

- Determination of chemical components in plant tissue: soluble carbohydrates, C:N ratio, aminoacids.
- Morphological data: plant height, number of leaves, number of tillers.
- Virus testing: virus titer determination (BYDV - PAV)



R. padi biology under CO_2

R. padi

Growth chambers

Two CO_2 Levels
- Ambient 380 ppm
- Elevated 650ppm

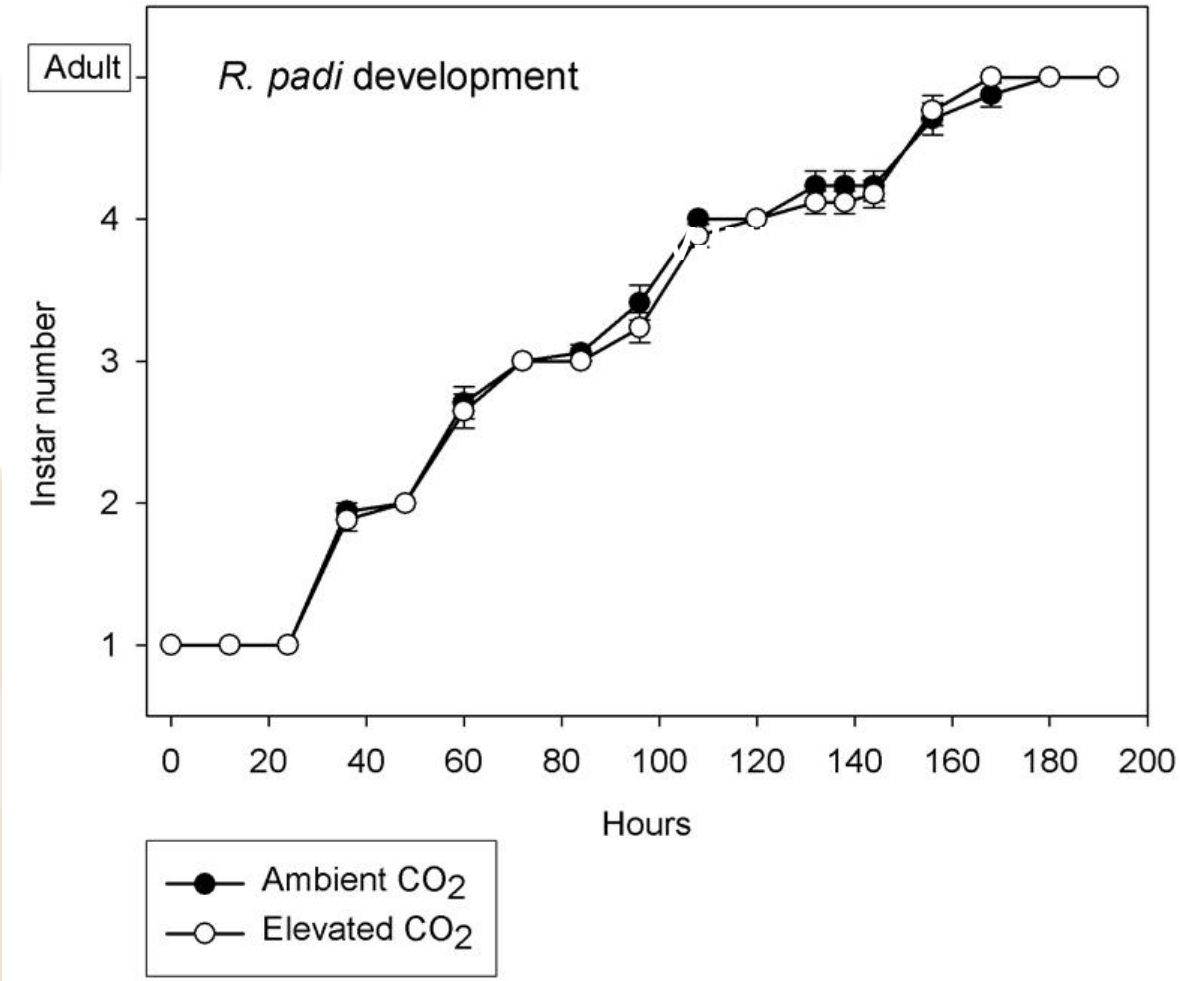
Clip cages

Healthy and BYDY

Development

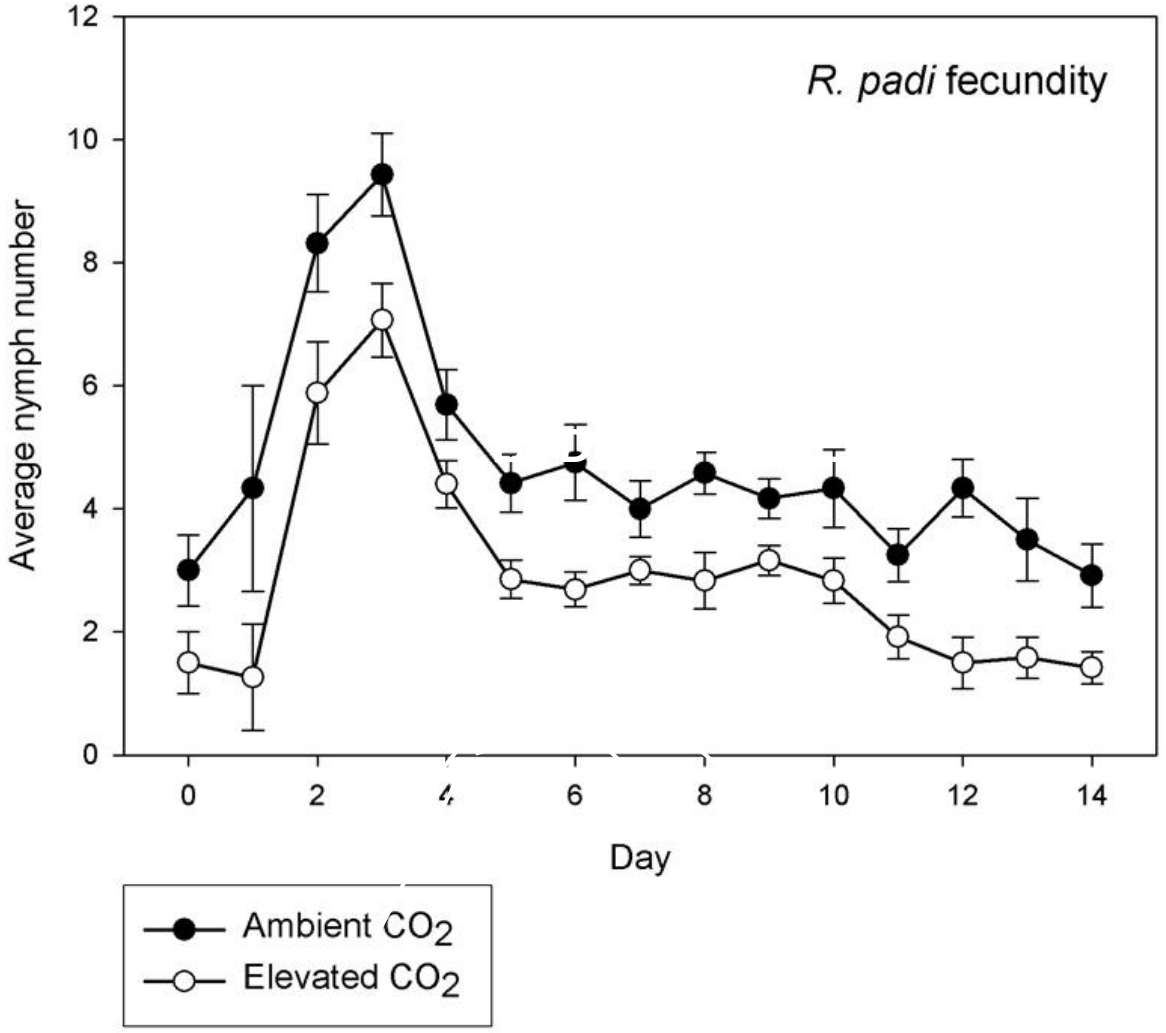
Aphid development unaffected by elevated CO_2

Both on Healthy and BYDV infected plants



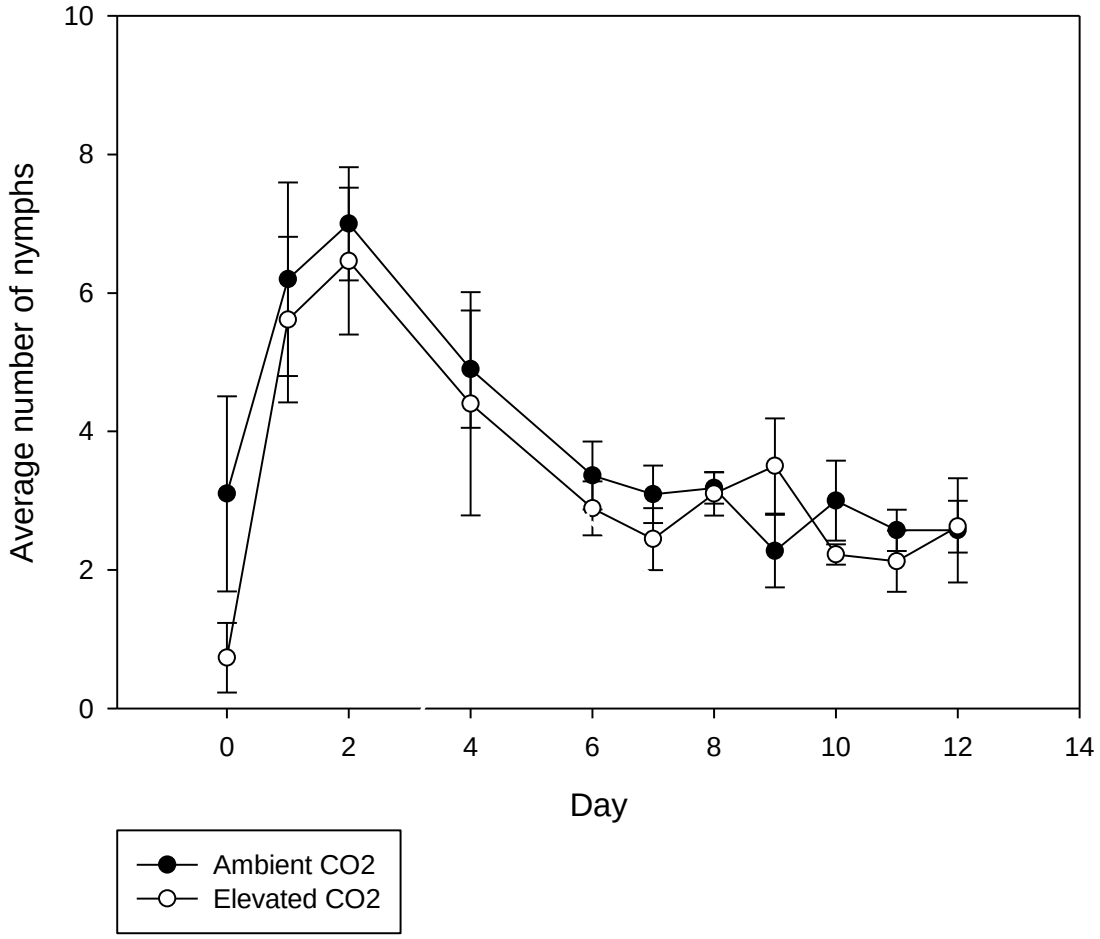
Fecundity

Healthy plants grown in eCO_2 caused a significant reduction in aphid fecundity

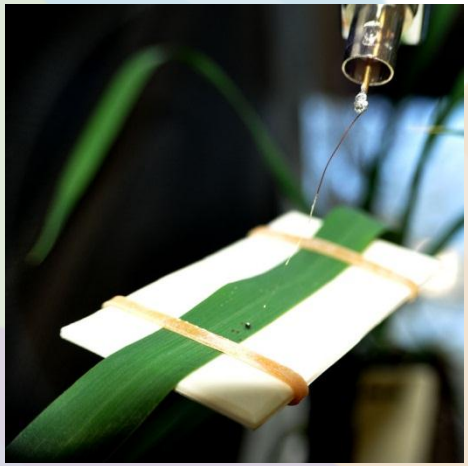


Fecundity, BYDV infected plants

Virus-infected plants grown in eCO_2 did not affect aphid fecundity



Electrical Penetration Graph



R. padi connected to EPG monitor

R. padi feeding under eCO_2

R. padi

Two CO_2 Levels
- Ambient
- Elevated 650ppm

8 hours monitoring

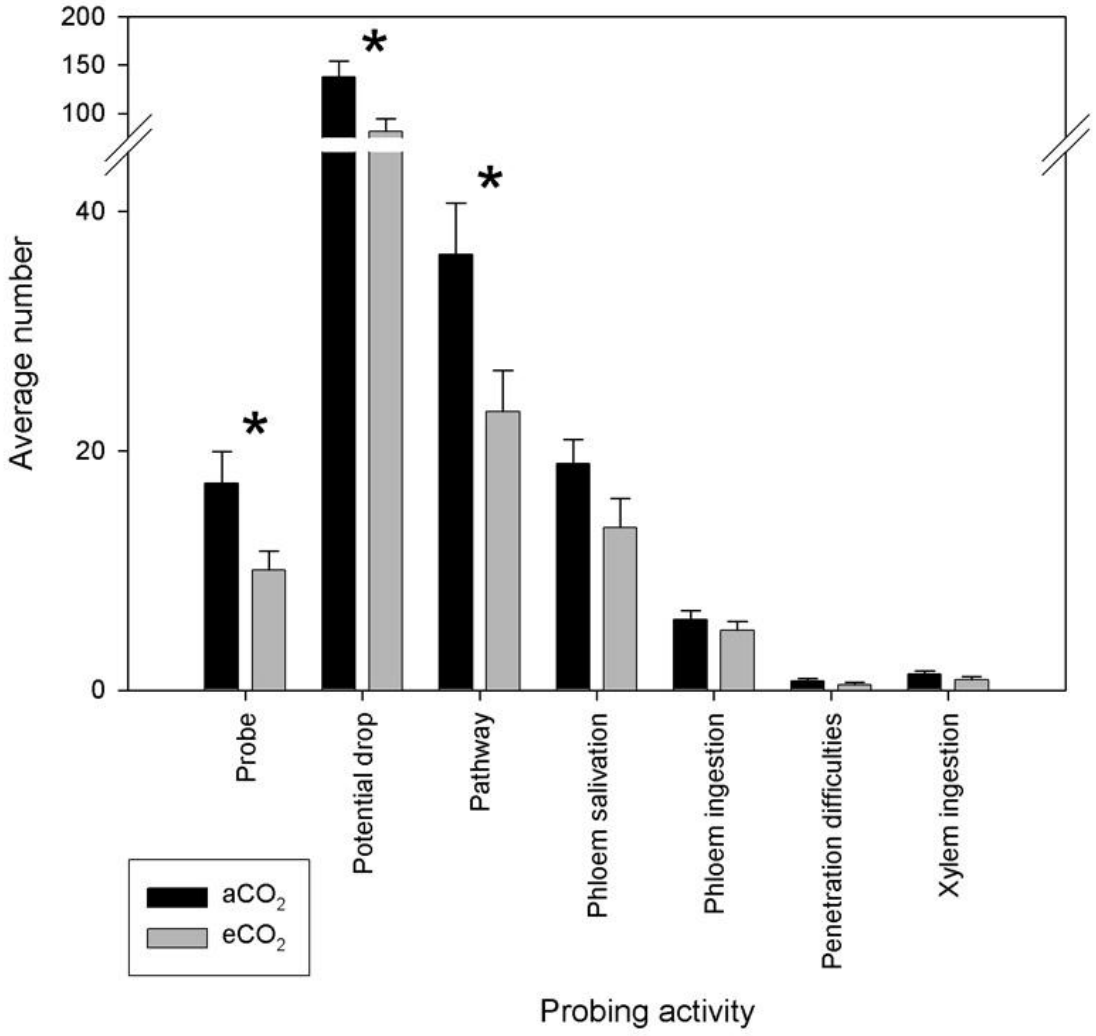
22 insect/wheat plant combinations for each treatment

Feeding behaviour, Healthy

Healthy plants, aCO_2 and eCO_2

Reduced number of:

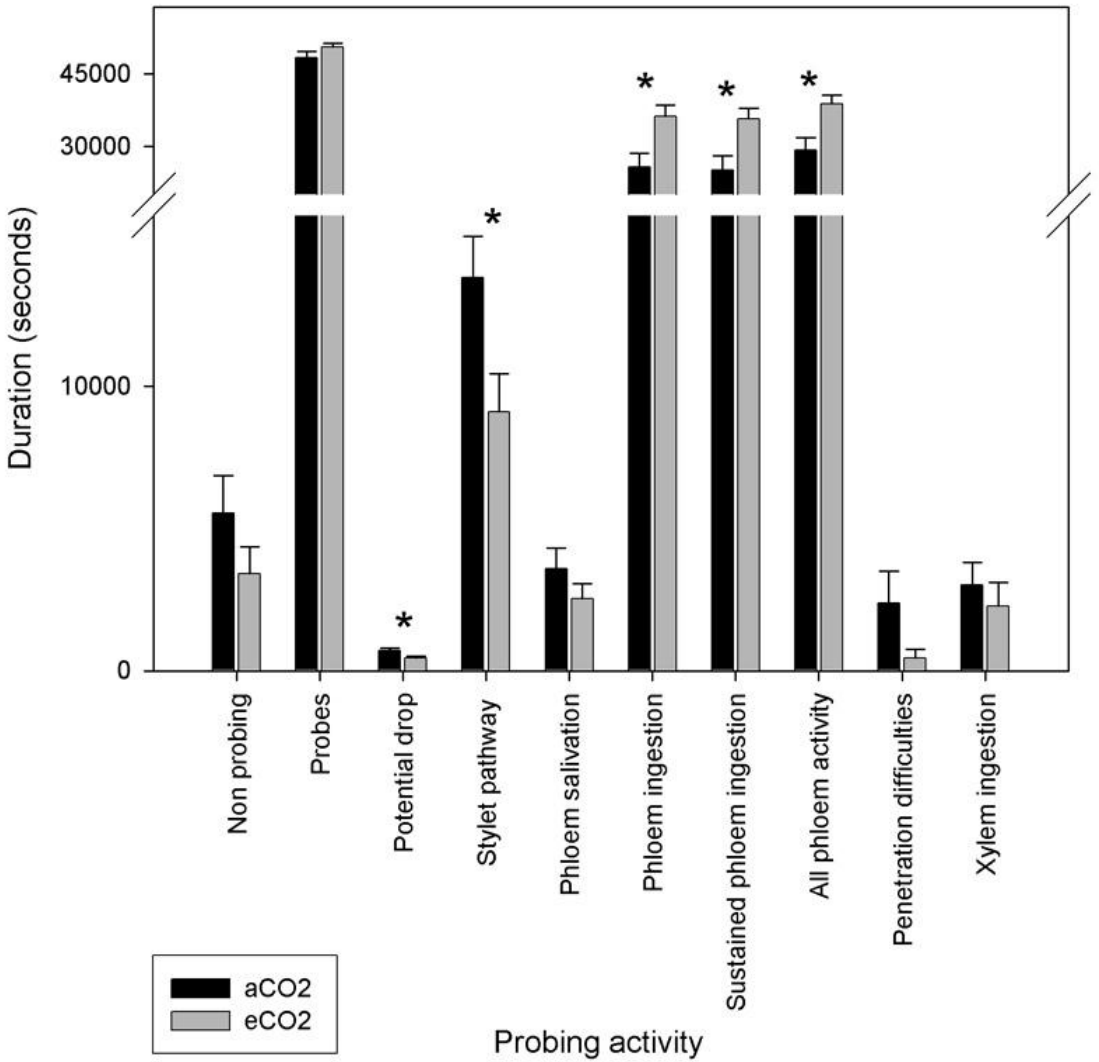
- probes
- potential drops
- pathways



Feeding behaviour, Healthy

Healthy plants, aCO_2 and eCO_2

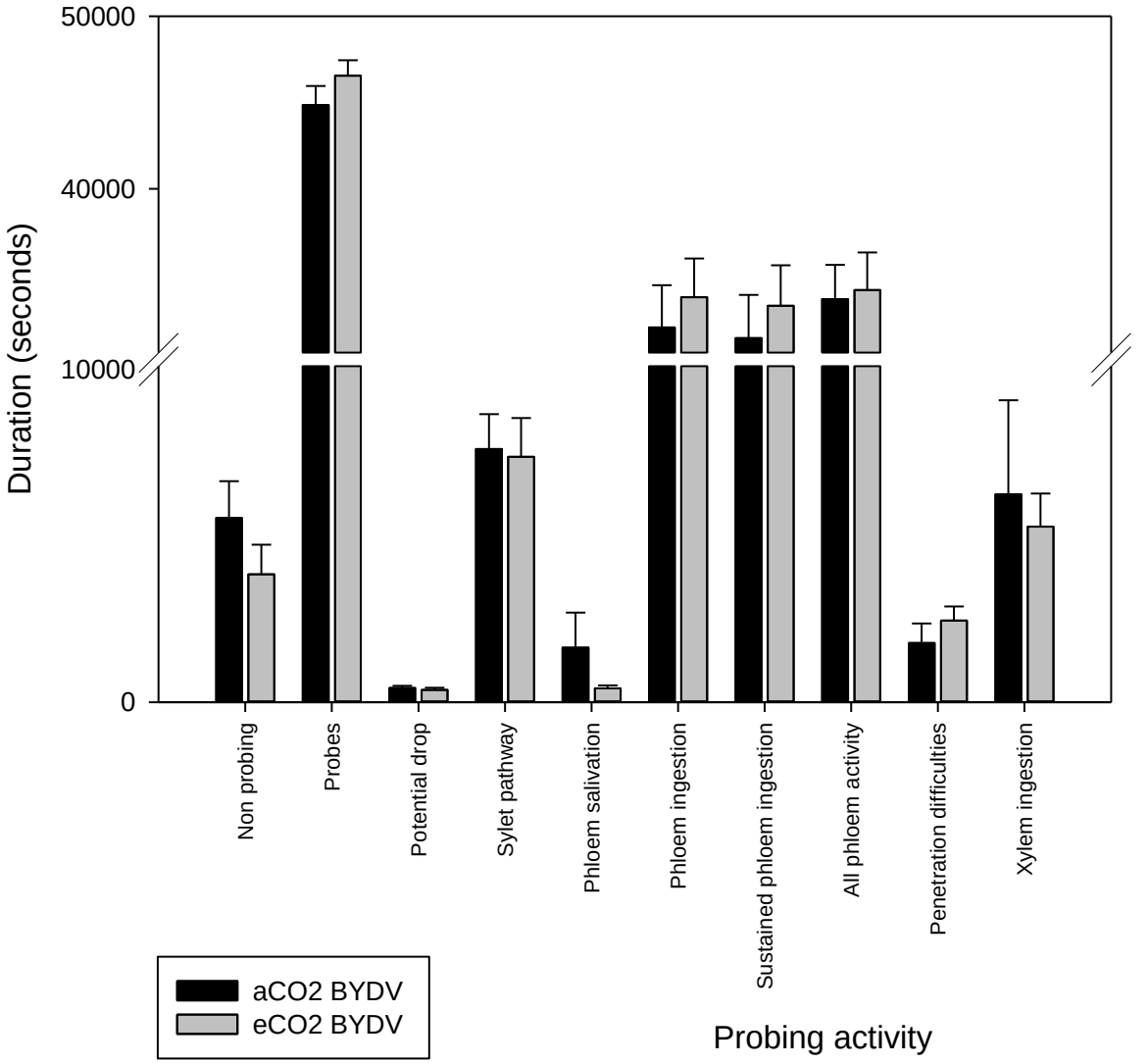
Increased feeding time - potential compensation for low N levels



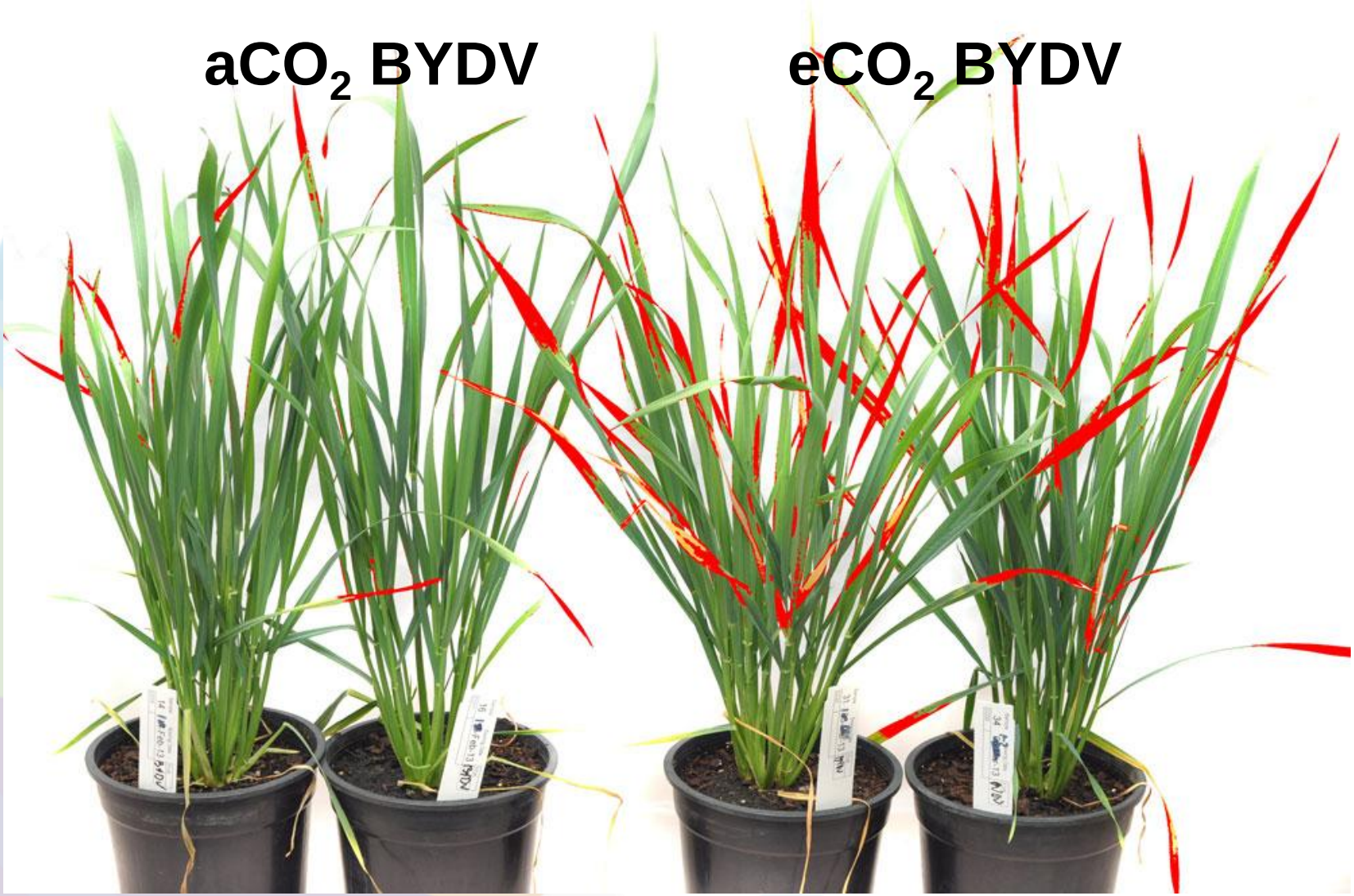
Feeding behaviour, BYDV plants

BYDV plants, aCO_2 and eCO_2

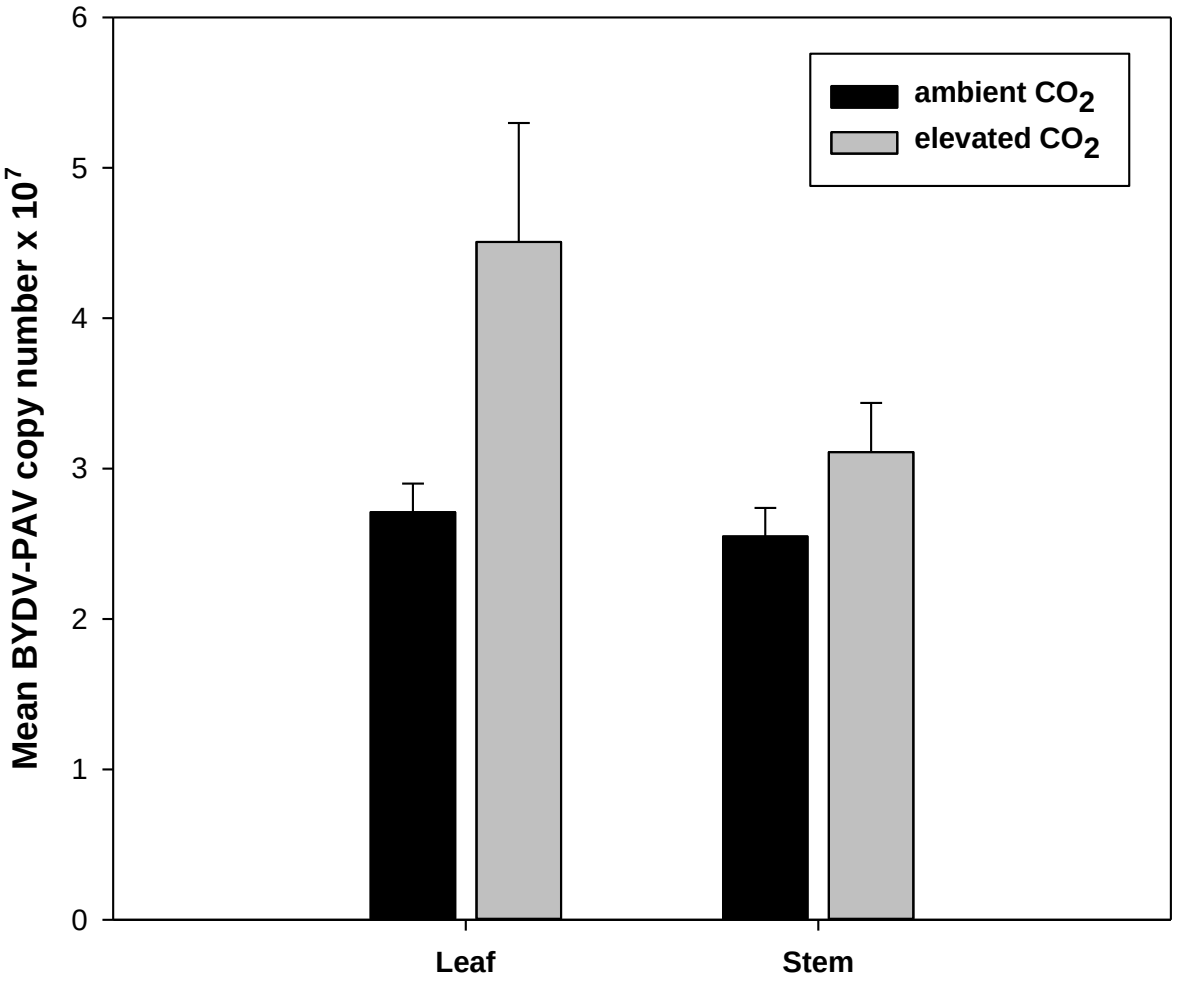
- No effect of CO_2
- Overall, less activity than healthy plants due to higher N content of infected plants



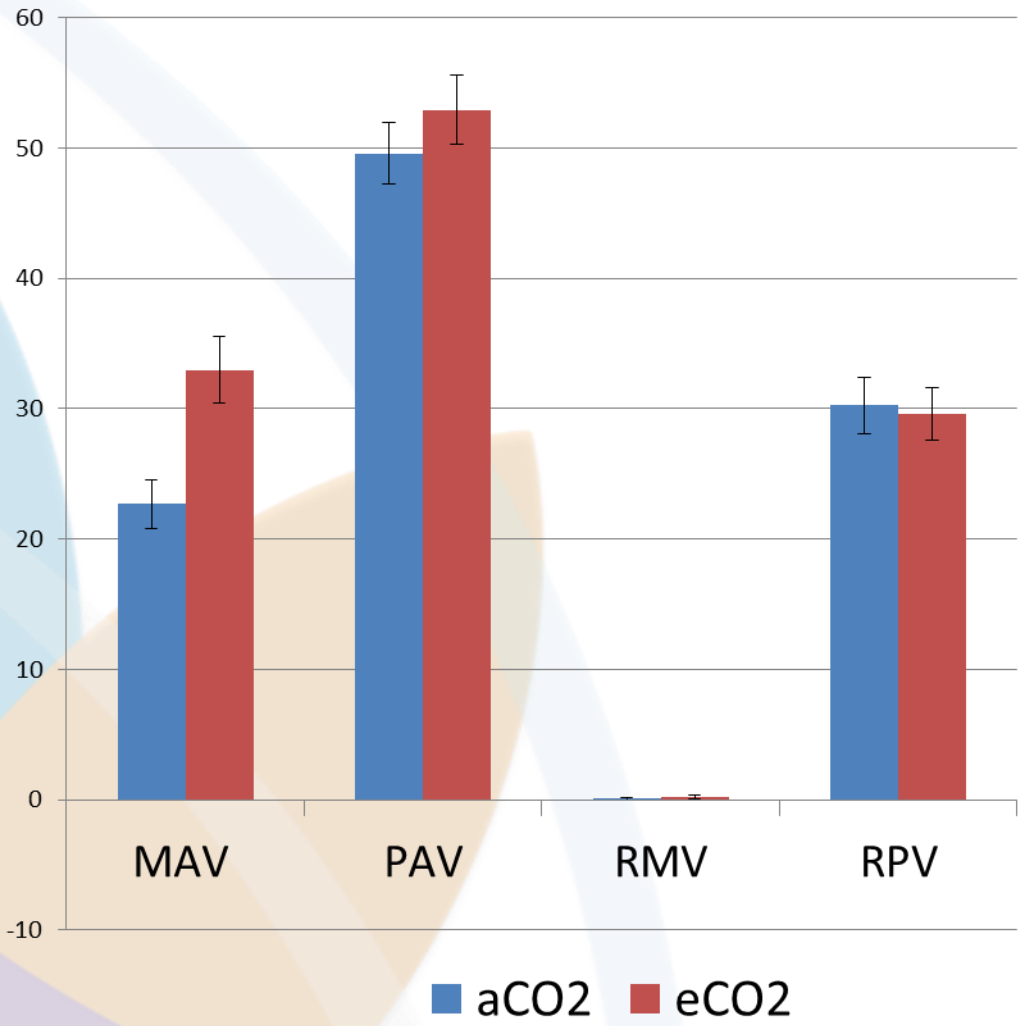
BYDV



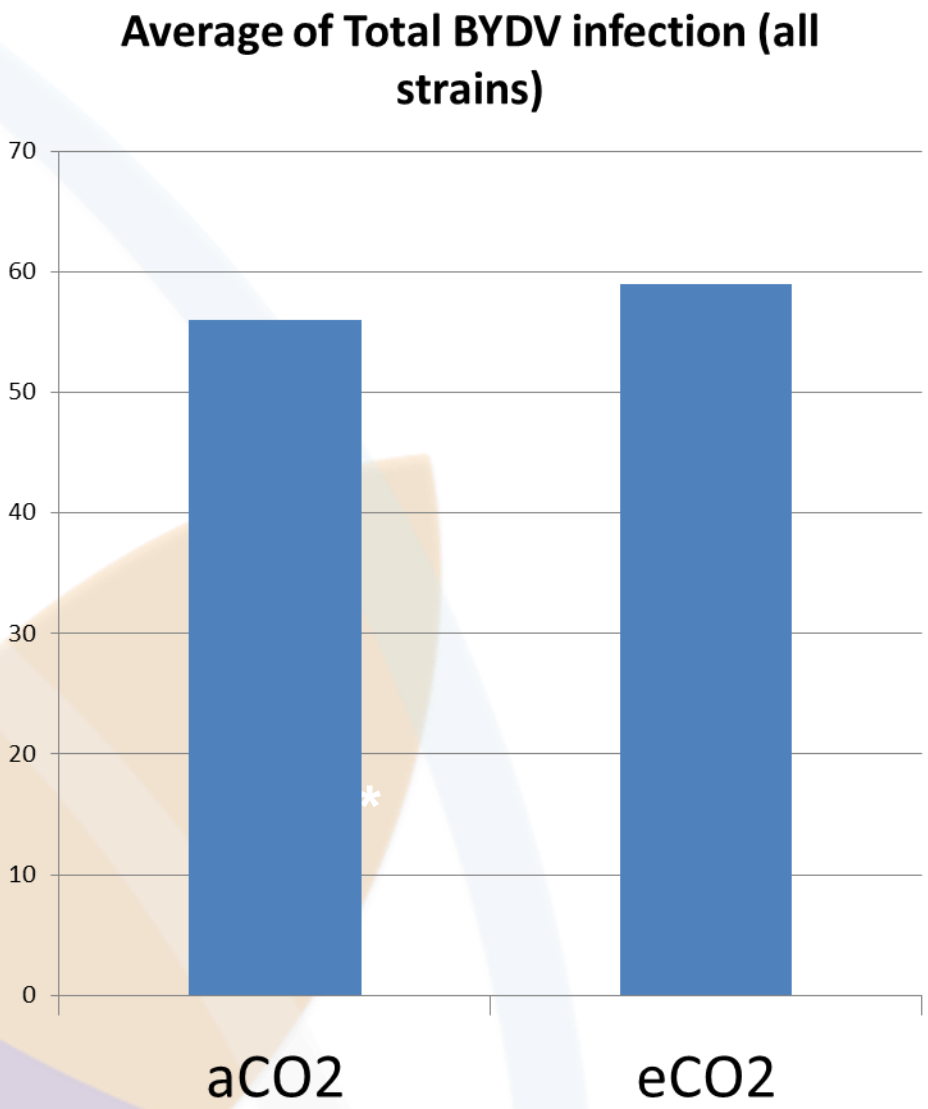
BYDV titer


Mean BYDV-PAV copy number x 10^7
6
5
4
3
2
1
0
ambient CO_2
elevated CO_2
Leaf
Stem

FACE BYDV infection



FACE BYDV infection



Conclusions

Exposed to elevated CO_2

- Higher crop yield, healthy plants
- 28.5 % yield decrease due to BYDV infection under elevated CO2, compared to 8.6% under ambient conditions
- Early BYDV symptoms development, higher BYDV concentration
- Changes to C:N ratio
- Negative effect on fecundity of *R. padi* (C:N), less aphids, healthy wheat
- No effect on fecundity, BYDV infected wheat
- Extended feeding, greater damage
- Shorter salivation period – shorter BYDV inoculation
- Higher overall BYDV incidence

Posters

* *

The effect of elevated temperature on the titre of *barley yellow dwarf virus*-PAV in wheat

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BYDV-PAV temperature experiment

- The titre of BYDV-PAV in wheat grown at current and future predicted (+5° C) temperatures for the Wimmera district in Victoria was measured using a normalised one-step multiplex RT-qPCR assay.
- Symptom expression and physical measurements were also recorded.
- **At elevated temperature:**
  - **BYDV-PAV titre was higher and peaked earlier.**
  - **Symptoms occurred earlier.**
  - **Plants were more vigorous and matured faster.**

Narelle Nancarrow

Rebecca Vandegeer, Michael Tausz and Kevin Powell

- Symptom expression and biochemical defence in *Barley yellow dwarf virus*-infected wheat grown under elevated CO_2
- Comparison of a susceptible and a 'resistant' cultivar of wheat
- Preliminary results of growth and antioxidant defence compounds
  - Greater biomass response to eCO_2 by resistant cv.
  - BYDV+aphid treatment associated with changes to antioxidants

Wheat Stripe Rust (Puccinia striiformis)

One of the most important diseases of wheat nationally and internationally

Well documented epidemiology of the disease

Aim

Investigate the effect of elevated CO2 on disease progress in susceptible and partially resistant wheat in the FACE.

Crown rot- Fusarium pseudograminearum

Reduces Victorian wheat production by approximately $5 million per year

Incidence of symptom severity (stem browning and white heads)

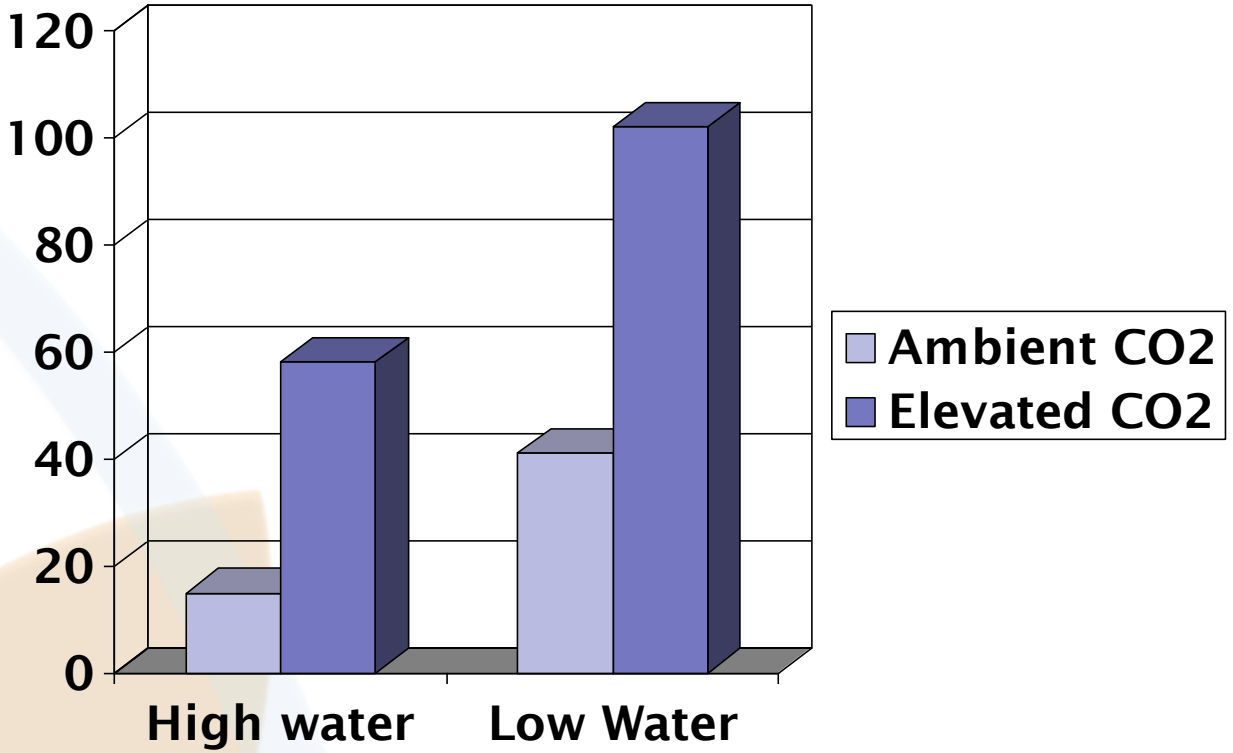
Influence of CO2 on life cycle of the pathogen

Tamaroi (susceptible) and 2-49 (partially resistant) seed was inoculated with *F. pseudograminearum* 03-0078 and randomly sown.

White head and stem browning symptoms were measured. Q-PCR was used to quantify fungal biomass

Crown rot results

Effect of irrigation and elevated CO_2 on the level of *Fusarium pseudograminearum* DNA (pg DNA/g soil) in plots of durum wheat (cv. Tamaroi) infected with *Fusarium pseudograminearum* in 2007



White head" symptoms were significantly reduced in the susceptible variety under eCO2

Length of stem browning was significantly higher under elevated CO2 at low watering than ambient

This correlated to Q-PCR results measuring fungal biomass which showed increased fungal biomass in Tamaroi compared to ambient treatment.

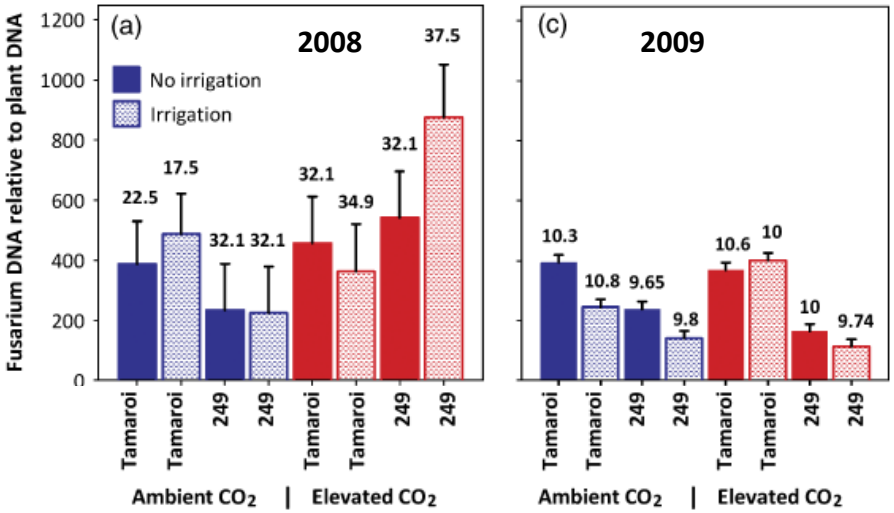
Increased pathogen inoculum at high CO_2

Inoculum production: pathogen biomass relative to wheat biomass

Quantitative PCR

Fusarium DNA 18s & TRI5 gene

Wheat DNA actin binding protein



Variety: Tamaroi Higher

CO_2: High higher in 2009

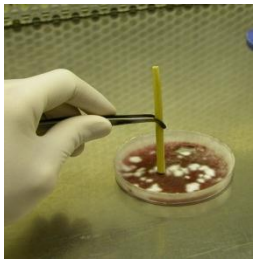
CO_2*variety*water

Inoculum fitness:

2008 FACE: 473 isolates

2009 FACE: 348 isolates

Wheat straw colonisation



CO_2 effect: not significant

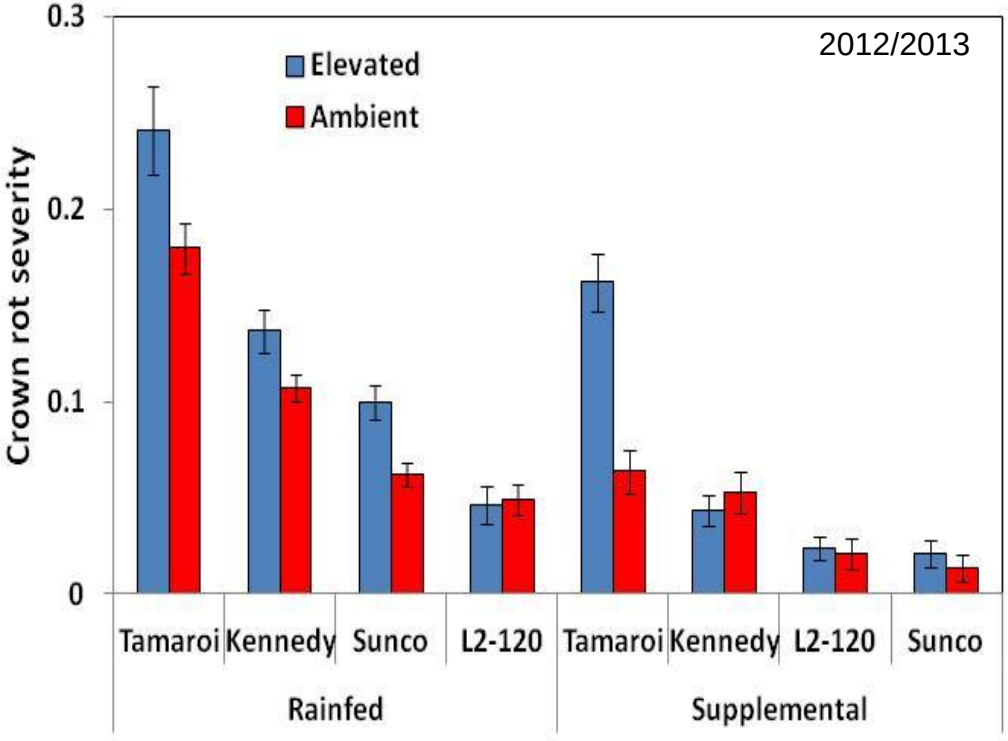
Melloy *et al.*, 2010 Global Change Biology 16: 3363-3373

Higher inoculum at high CO_2

Potential varietal influence on inoculum production

Saprophytic fitness of the inoculum does not change at high CO

Crown rot resistance at elevated CO2



- eCO_2 had significant effect on the proportion of stem browning

- Significant CO_2*variety*irrigation interaction indicating varieties will behave differently under irrigation at each CO_2 level

- Generally, the proportion of stem browning was significantly higher at elevated CO_2 and for the susceptible variety Tamaroi

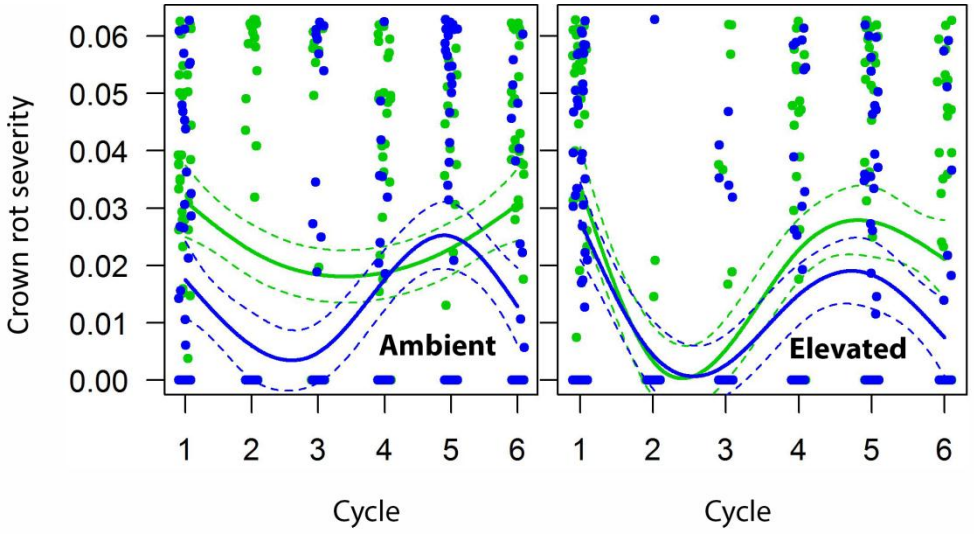
- Disease level on partially resistant line [L2-120] not affected by CO_2

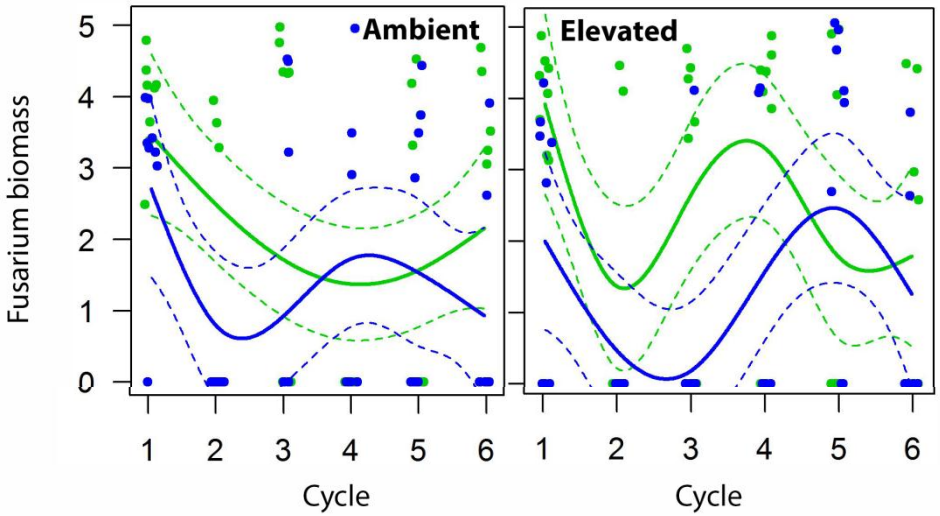
Overall, the results suggests that crown rot severity will increase with rising CO_2 both as a result of direct physiological effects and from increased drought stress

Pathogen dynamics on partially resistant [249] and susceptible [Tamaroi] wheat at elevated CO2

•CR severity in cycle 1 higher for Tamaroi than 249,and at eCO2 and aCO2.

•Dynamics of CR severity different for Tamaroi and 249 at aCO2 but similar at eCO2





•There was no difference between wheat lines or CO2 levels in the initial pathogen biomass

•Wheat lines behave differently at the two CO2 levels

•Pathogen biomass generally higher in Tamaroi and the difference was clear at elevated CO2 in the first four cycles

Changing *Fusarium* ecology at high CO_2

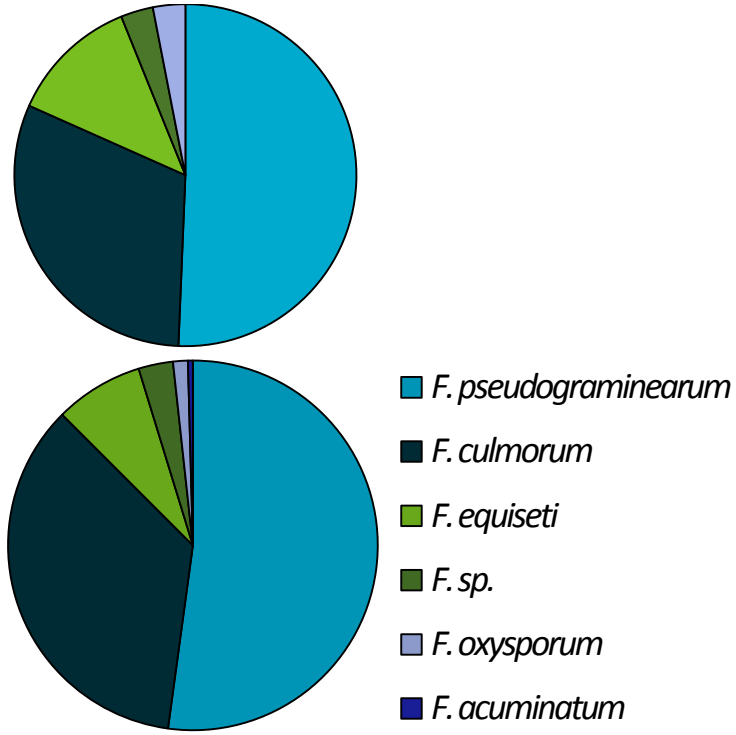
Relative frequency of Fusarium species on wheat straw

Initial 2008 FACE population

Population after 5 cropping cycles

Ambient CO_2

Elevated CO_2



Initially: No difference between ambient & elevated CO_2

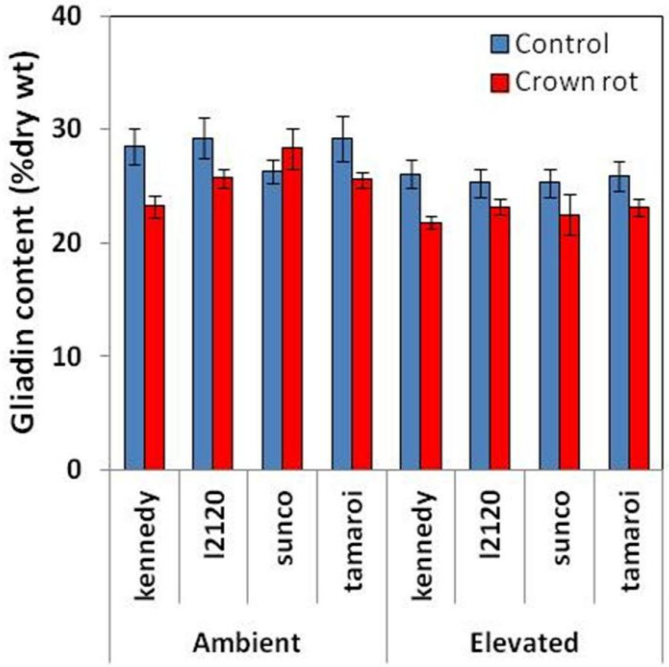
After 5 cycles: increased frequency of strong saprophytic species

Reduced *F. culmorum* frequency at elevated CO_2

Grain quality at high CO_2 & CR

Changing amino acids & protein composition

- Increased levels of 14 amino acids at high CO2/CR
- 5% reduction in protein
- 13% decrease in gliadin
- No change in globulin & Albumin



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