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Performance of traits in a high CO_2 world – Examples from the AGFACE project

For the AGFACE team: Sabine Tausz-Posch

Traits for the future - Background

FACT:
Current pre-breeding research focuses on the contribution of traits to enhance field performance and end-product outcome

In low-rainfall agriculture current traits in focus include, e.g.:

- ❑ Tillering
- ❑ Transpiration efficiency
- ❑ Water soluble carbohydrates
- ❑ High early vigour
- ❑ Root systems etc.

Atmospheric CO_2:

- ❑ Rising atmospheric CO_2 instantaneously alters photosynthetic CO_2 fixation (A) and stomatal conductance (g_s)
- ❑ Effects on growth, water relations and productivity

AGFACE:

How will selected traits perform in a high CO_2 world?

Results will be passed on to pre-breeders and can become selection targets for breeding efforts

Trait: Tillering capacity

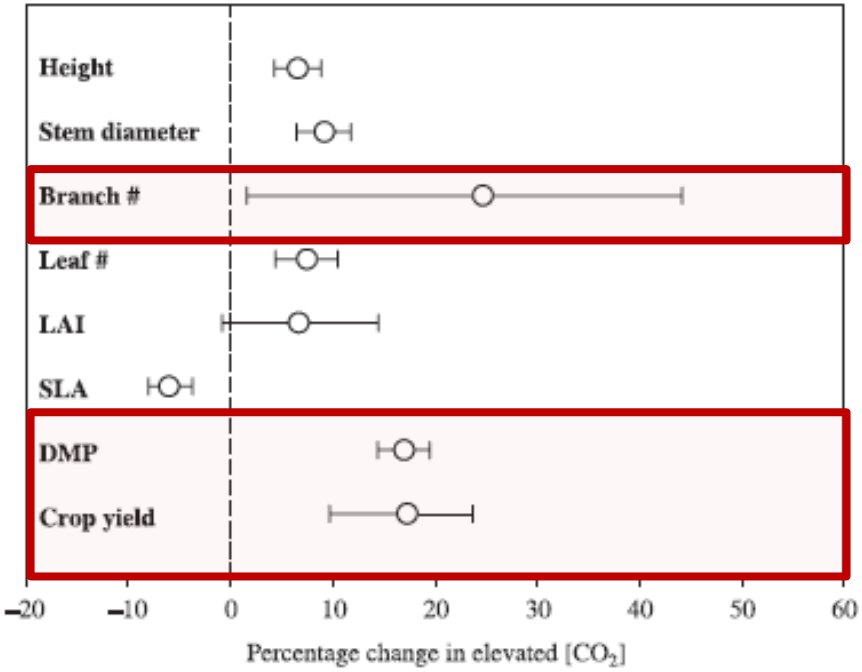
RESTRICTED TILLERING:

- Advantage under terminal drought conditions (Duggan et al. 2005)
- Mitchell et al. 2013 J. Exp. Bot.: Tin (tiller inhibition) lines had up to 51% fewer screenings and up to 11% more yield under terminal drought

Source: http://www.csiro.au

HOWEVER:

- Elevated CO_2 promotes growth and yield
- Effect linked to increased biomass and tillers
- Effect less linked to other yield components (Ziska 2008)



Source: Ainsworth and Long (2004) New Phytol.

Trait: Tillering capacity

Research questions:

1. Does a freely tillering cultivar benefit more from elevated CO_2 in terms of growth and yield?
2. To what extent is the restricted tillering trait maintained under high CO_2? Can it benefit from additional CO_2 at all?

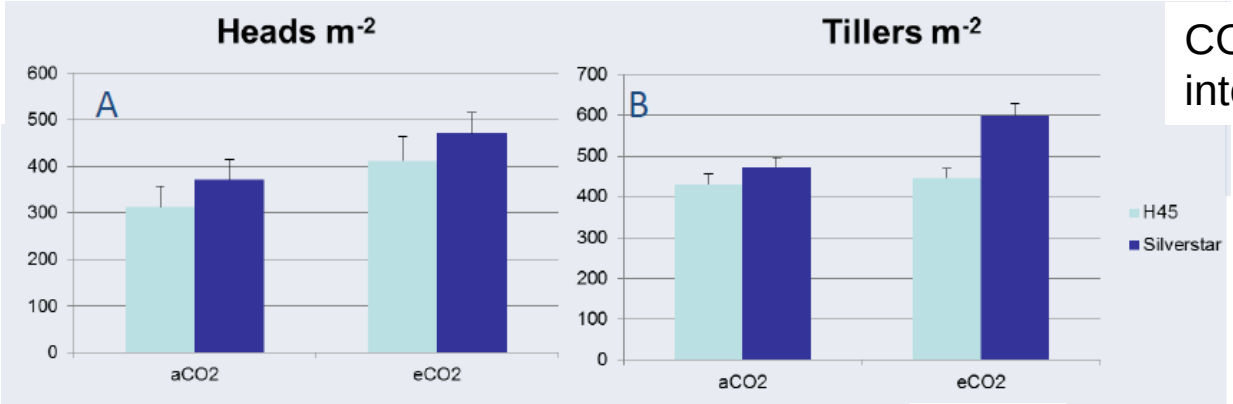
2009 and 2010 (commercial varieties):
Cv. **Silverstar:** a freely tillering variety
Cv. **H45:** a restricted tillering variety

2011 and 2012 (CSIRO tiller inhibition (tin) line):
Cv. **Silverstar**: a freely tillering variety
Cv. **Silverstar – tin line T65** (SSR T65): a restricted tillering line

H45 Silverstar

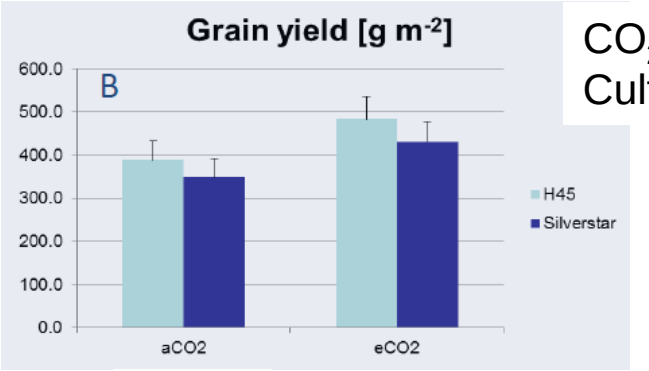
Tillering results: e.g. H45 vs. Silverstar

CO_2 effect
Cultivar effect



CO_2 x cultivar interaction

aCO_2 eCO_2 aCO_2 eCO_2



CO_2 effect
Cultivar effect

aCO_2 eCO_2

H45 = Silverstar =

Tillering: Conclusion

- Tillering increased under CO_2 enrichment in both free and inhibited tillering lines/cultivars
- The relative ranking in tillering (free vs. restricted) was maintained
- High tillering alone does not ensure greater benefits from the CO_2 fertilisation effect. The restricted tillering cultivar can compensate for smaller gains during vegetative growth through greater gains during spike development and grain filling

POSTER

Australian Grains Free Air CO_2 Enrichment (AGFACE) program

Elevated CO_2 stimulates yield of a restricted tillering and a freely tillering wheat cultivar to a similar extent

Sabine Tausz-Posch[1], Raymond W. Dempsey[1,*], Saman Seneweera[1,+], Robert M. Norton[3], Glenn J. Fitzgerald[2], Michael Tausz[1]
[1]University of Melbourne, [2]Department of Environment and Primary Industries, [3]International Plant Nutrition Institute
*present address: James Cook University +present address: University of Southern Queensland

POSTER

Australian Grains Free Air CO_2 Enrichment (AGFACE) program

Is the reduced-tillering trait (*tin*) beneficial under elevated CO_2 in four FACE environments?

Markus Löw*, S Tausz-Posch*, G Rebetzke§, F Dreccer#, S Chapman#, S Seneweera*, G Fitzgerald%, M Tausz‡
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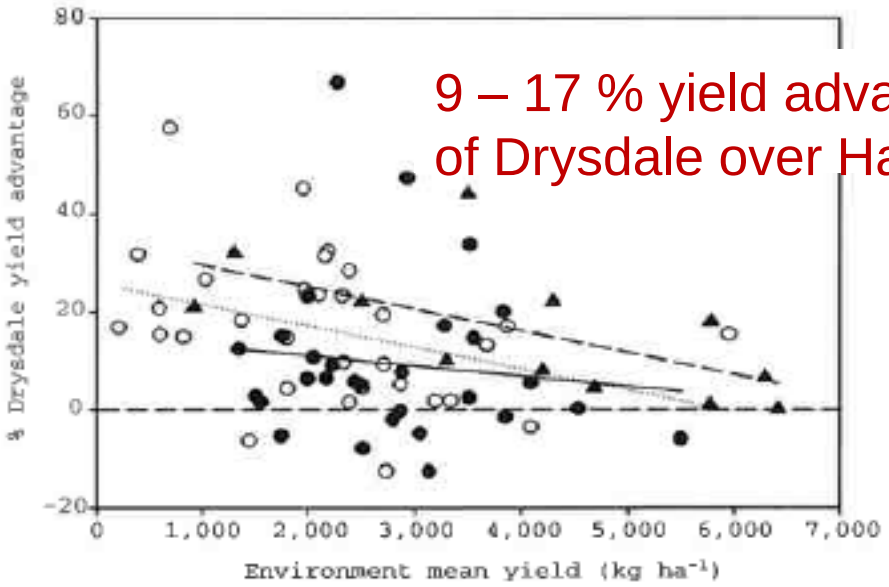
§#CSIRO Plant Industry, §Canberra / #Brisbane, %Department of Environment and Primary Industries, Horsham

Trait: Transpiration Efficiency

- Carbon gained per water lost
- Plants vary how efficient they exchange water for CO_2

cv. Drysdale - superior transpiration efficiency
cv. Hartog - low transpiration efficiency

Drysdale has lower $\Delta^{13}C$ than Hartog

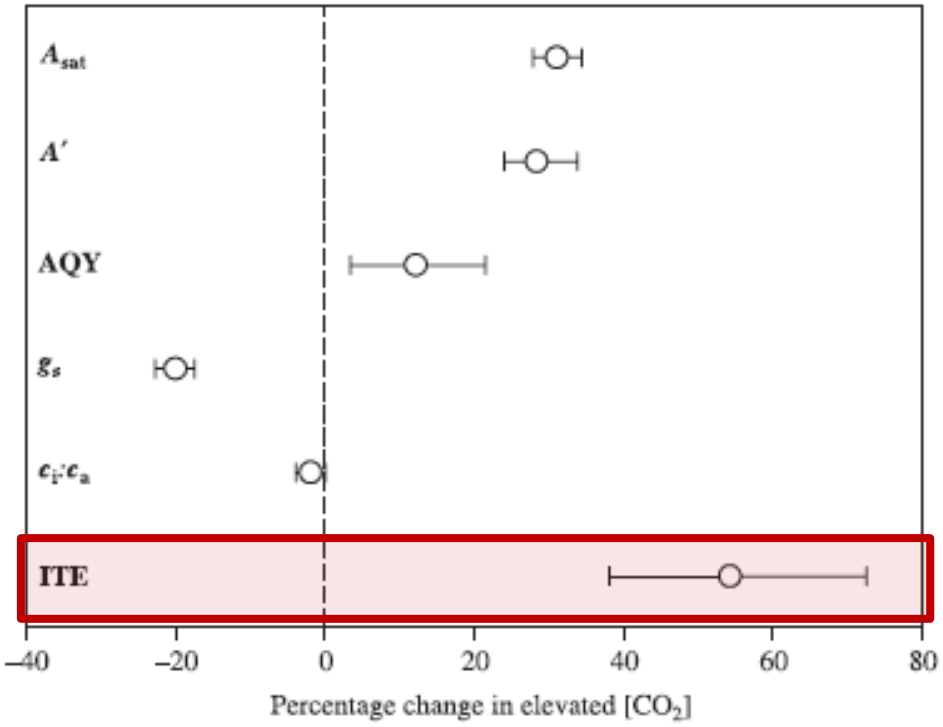


9 – 17 % yield advantage of Drysdale over Hartog

Rebetzke et al. (2009) Wheat: Science and Trade 215-249

Trait: Transpiration Efficiency

Transpiration efficiency (TE) increases under elevated CO_2



Ainsworth and Long 2004, New Phytologist
ITE = instantenous transpiration efficiency

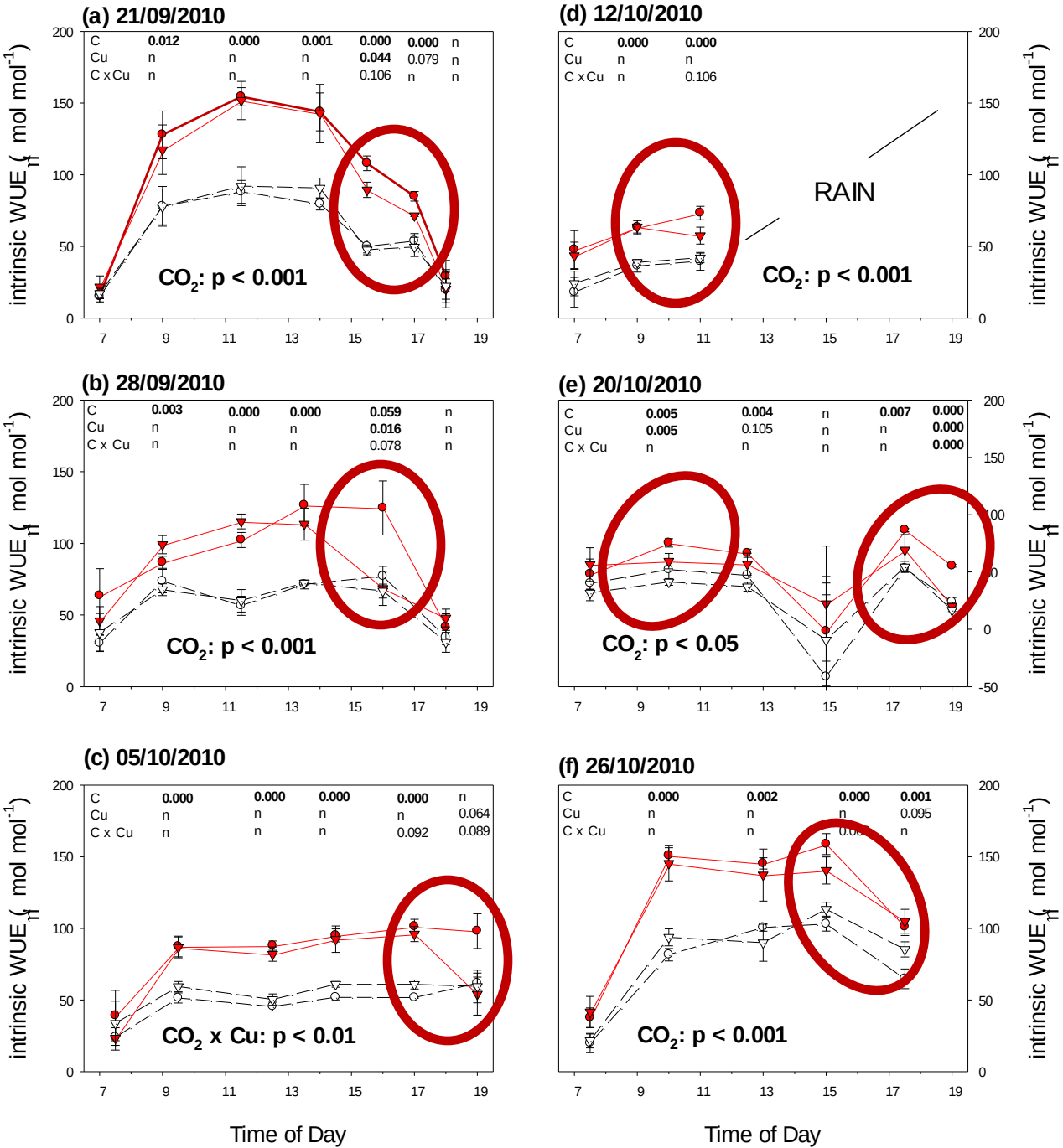
Research question:

Will a trait selection for superior TE efficiency still be beneficial under future elevated CO_2 ?

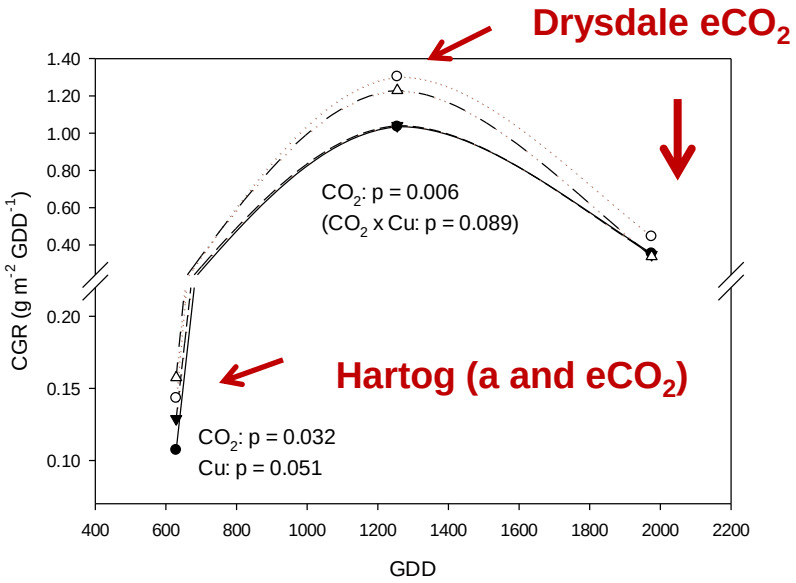
Intrinsic Transpiration Efficiency:

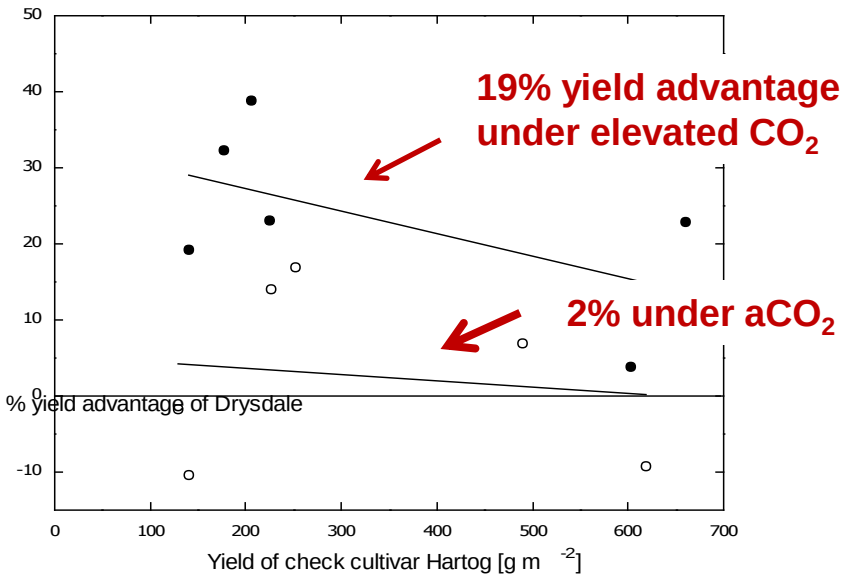
Hartog (▽,▼)
Drysdale (○,●)

ambient [CO_2]
elevated [CO_2]



What about Yield?





Conclusion:

- ❑ **The trait of superior transpiration efficiency is maintained under high CO_2**
- ❑ **Superior transpiration efficiency may become an advantage in environments where this is not evident under current CO_2**

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Australian Grains Free Air CO_2 Enrichment (AGFACE) program

Can the trait of superior transpiration efficiency be maintained in a high CO_2 world?

Sabine Tausz-Posch[1], Robert M. Norton[2], Saman Seneweera[1], Glenn J. Fitzgerald[3], Michael Tausz[1]

[1] The University of Melbourne, [2] International Plant Nutrition Institute, [3] Department of Environment and Primary Industries

More Traits

Water soluble carbohydrates (WSC)

- Experimental lines (CSIRO): SB003 low carbohydrate accumulation
  SB062 high carbohydrate accumulation
- WSC also in Silverstar / H45 poster and Silverstar / Silverstar tin poster

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Australian Grains Free Air CO_2 Enrichment (AGFACE) program

Is an increased carbohydrate-storage trait benefical under elevated CO_2?

Markus Löw*, S Tausz-Posch*, G Rebetzke§, F Dreccer#, S Chapman#, S Seneweera*, G Fitzgerald%, M Tausz‡

High early vigour and root traits

Yitpi and Scout (good early vigour, CSIRO transpiration efficiency gene)

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Putative nitrogen use efficiency of wheat cultivars in interaction with soil nitrogen and root traits under elevated CO_2

Helale Bahrami[1], Roger Armstrong[2], Glenn Fitzgerald[2], Michael Tausz[1], Sabine Tausz-Posch[1]

Heat and field peas

EFFECTS OF HEAT: High early vigour and root traits

Yitpi and Scout (good early vigour, CSIRO transpiration efficiency gene)

POSTER

Effects of elevated CO_2 and heat stress applied prior and after anthesis on the remobilisation of nitrogen and carbohydrate in wheat main stems

Allene Macabuhay[1], Glenn Fitzgerald[2], James Nuttall[2], Michael Tausz[1], Sabine Tausz-Posch[1]

FIELD PEAS:

- Traits such as for wheat are not available for peas
- Different types of field peas in regard to genotypic variability under elevated CO_2 were tested

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Elevated CO_2 increases yields of field peas and the N contribution for the subsequent crop

Maryse Bourgault[1], Glenn Fitzgerald[2], Jason Brand[2], Michael Tausz[1]

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