School of Agriculture, Policy and Development

University of Reading

Combined effects of elevated [CO_2] and increased temperatures on cacao reproductive development

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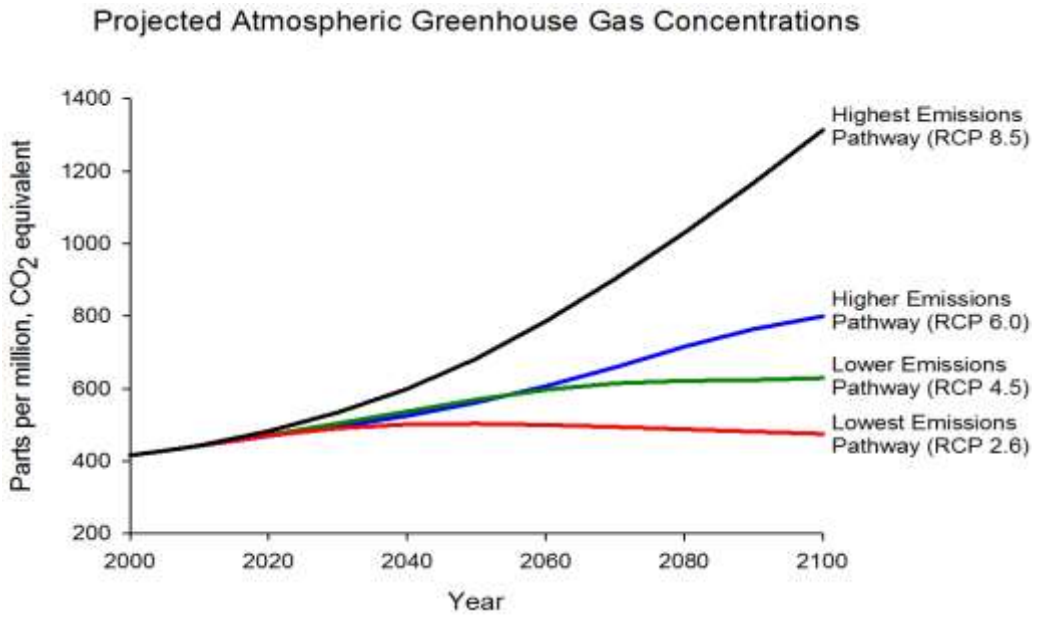
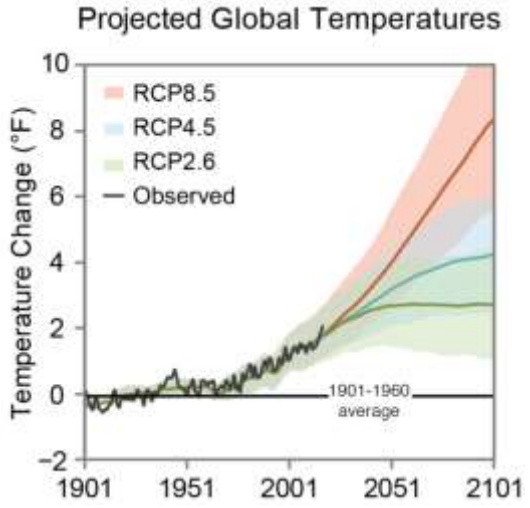
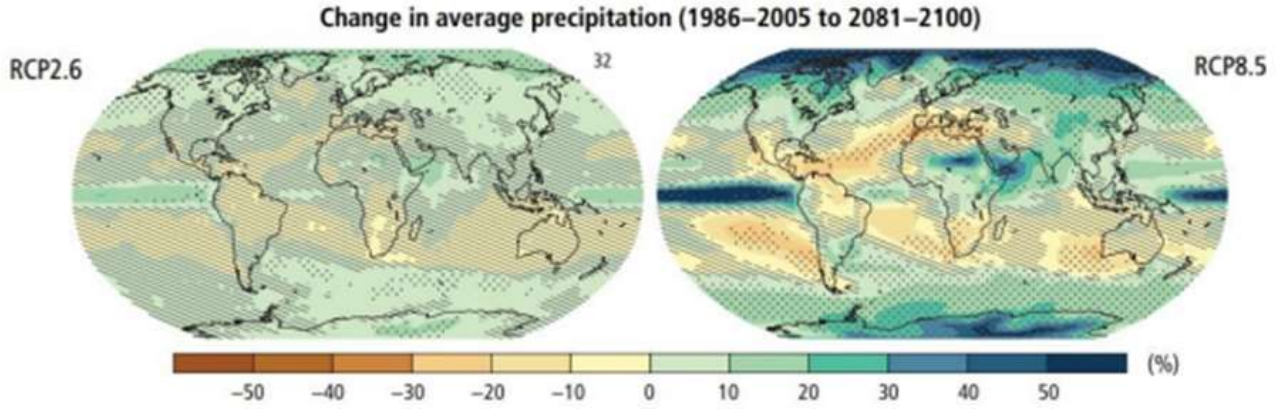
2022 International Symposium on Cocoa Research (ISCR)
Montpellier, France

A changing climate



- Increases in greenhouse gases, in particular CO_2 are contributing to changes in the worldwide climate
- Current CO_2: 415.31 ppm (https://www.co2.earth)
- Impacts on:
  - Global temperature
  - Precipitations patterns
  - Weather seasonal changes





Source: IPCC, 2014

Climate change and cacao

The potential effect of climate change on suitability of cacao cultivation is currently a big concern for many cacao regions around the world


Climate change could threaten cocoa production: Effects of 2015-16 El Niño-related drought on cocoa agroforests in Bahia, Brazil

Published: July 15, 2018 • https://doi.org/10.1371/journal.pone.0200454

Science of The Total Environment

Volume 556, 15 June 2016, Pages 231-241

Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation

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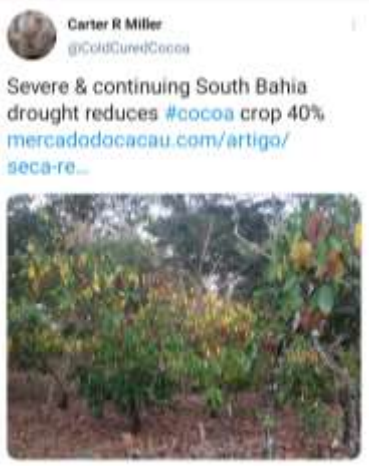
- Initial predictions suggested that climate change would negatively impact cacao areas.
- Recent models, reported that the physiological effect of future CO_2 enrichment might ameliorate the impact of increased temperature on net primary productivity (NPP). Yield or bean quality ?


Carter R Miller
@ColdCuredCocoa

Severe & continuing South Bahia drought reduces #cocoa crop 40% mercadodocacau.com/artigo/seca-re...


ENVIRONMENTAL RESEARCH LETTERS

LETTER

OPEN ACCESS

Cocoa plant productivity in West Africa under climate change: a modelling and experimental study

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Keywords: climate change, agriculture, Africa, cocoa

Research background in cacao

Source: Google images

Elevated CO_2

- Enhancement of photosynthesis and vegetative growth (short-term)
- Studies in cocoa since 2008 particularly in juvenile plants
- The effect can be modulated by other environmental factors
- Increase in crop water use efficiency

Temperature

- Most biological processes are temperature-sensitive
- Photosynthesis may be affected at temperatures above/below optimal
- Growth and development in cacao is dependent on the temperature

Understanding the combined effects is key to determining agricultural practices and providing data for climate models, as well as the exploration of genetic diversity in cacao to adapt to future scenarios.

Plant material and experimental setup

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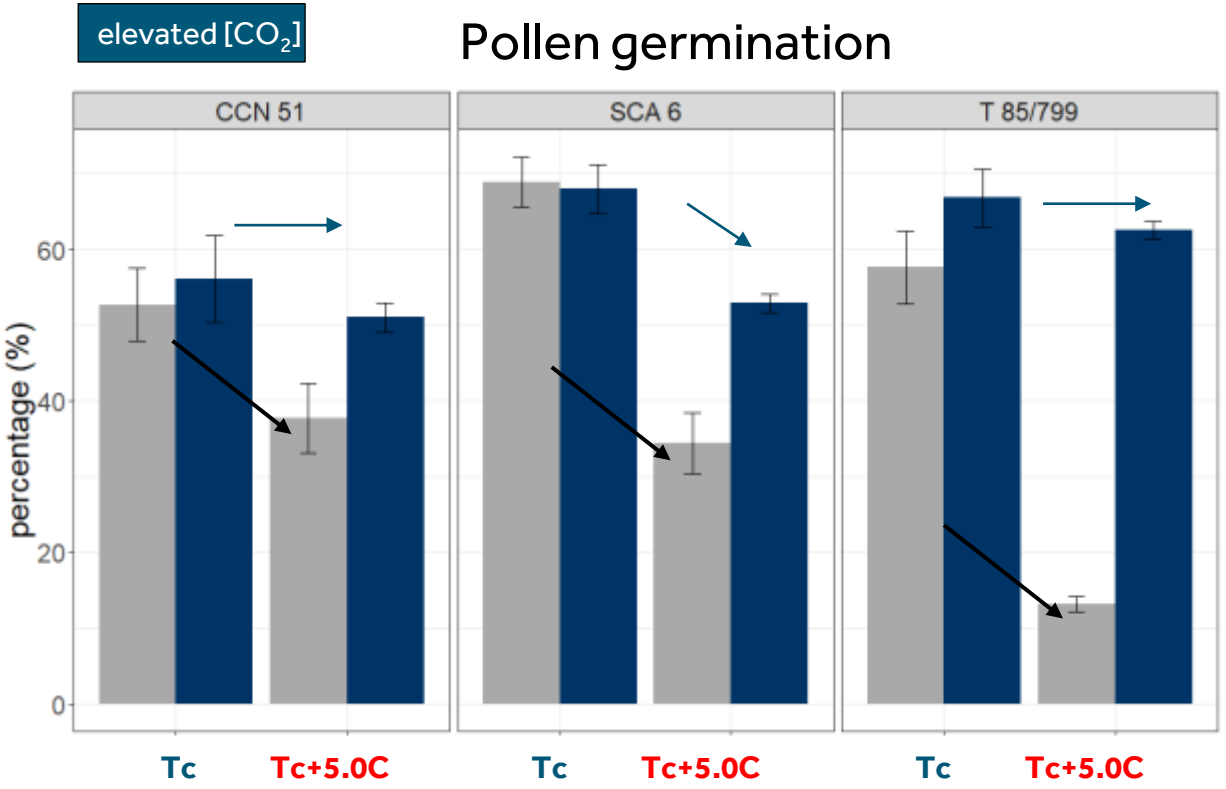
	ambient [CO_2] (~ 420 ppm)	elevated [CO_2] (~ 700 ppm)
Control (31/22°C) Tc		
Mid century (33.5/24.5°C) Tc+2.5C		
End of century (36/27°C) Tc+5.0C		

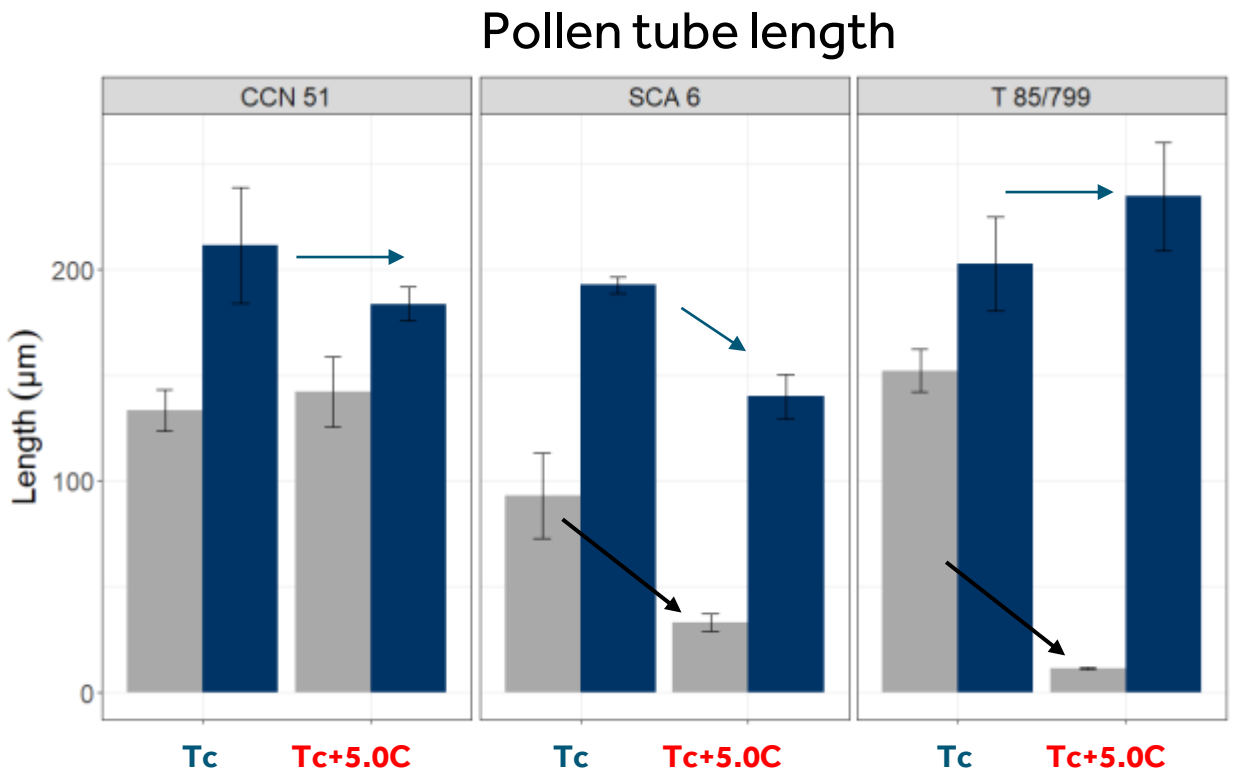
- Glasshouses study (~ 380 days)
- Cacao clones of 3 genotypes:
  - CCN 51
  - SCA 6
  - T85/799
- Six glasshouses: combination [CO_2] *temperature

Combined effects on pollen viability

ambient [CO_2]

elevated [CO_2]





- Genotypic differences on pollen germination and pollen tube length.
- Both parameters decreased with increasing temperatures (Tc+5.0°C).
- Germination and pollen tube length increased under elevated [CO_2]. CO_2 enrichment alleviated the negative effects of high temperature.

Effects on pollination and pod production

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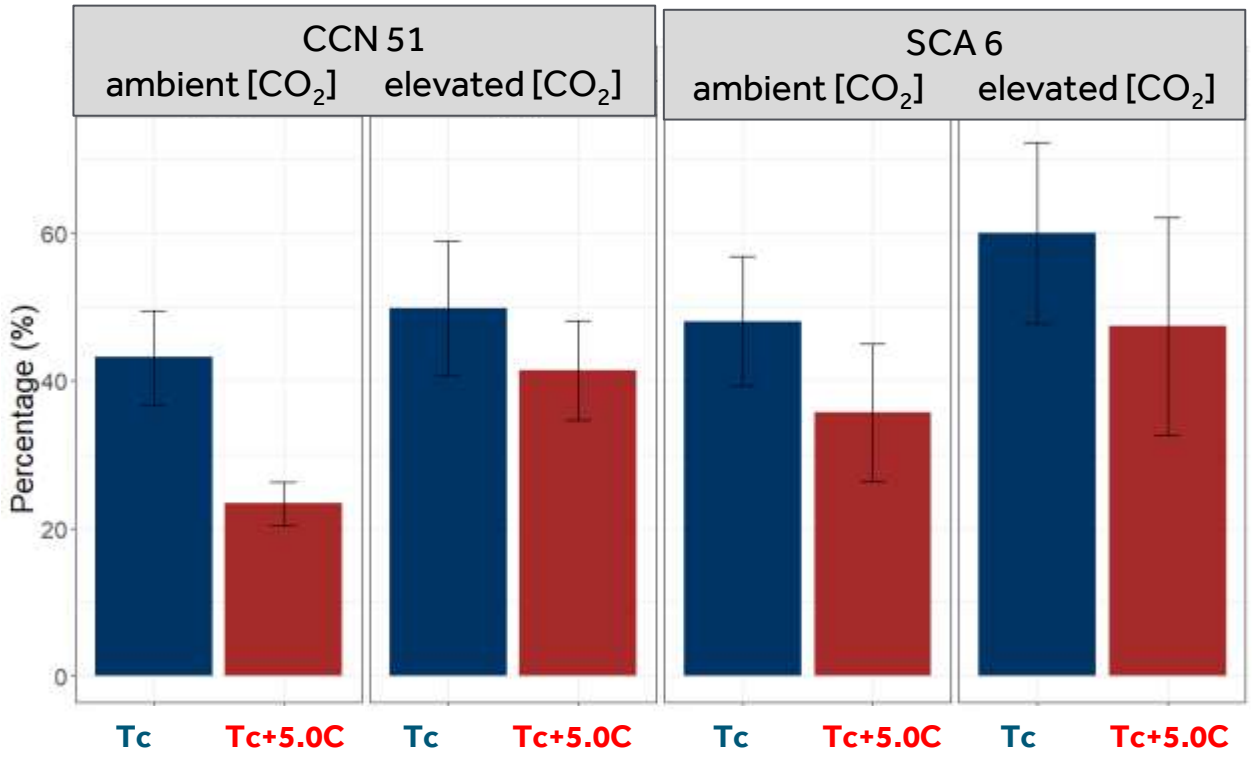
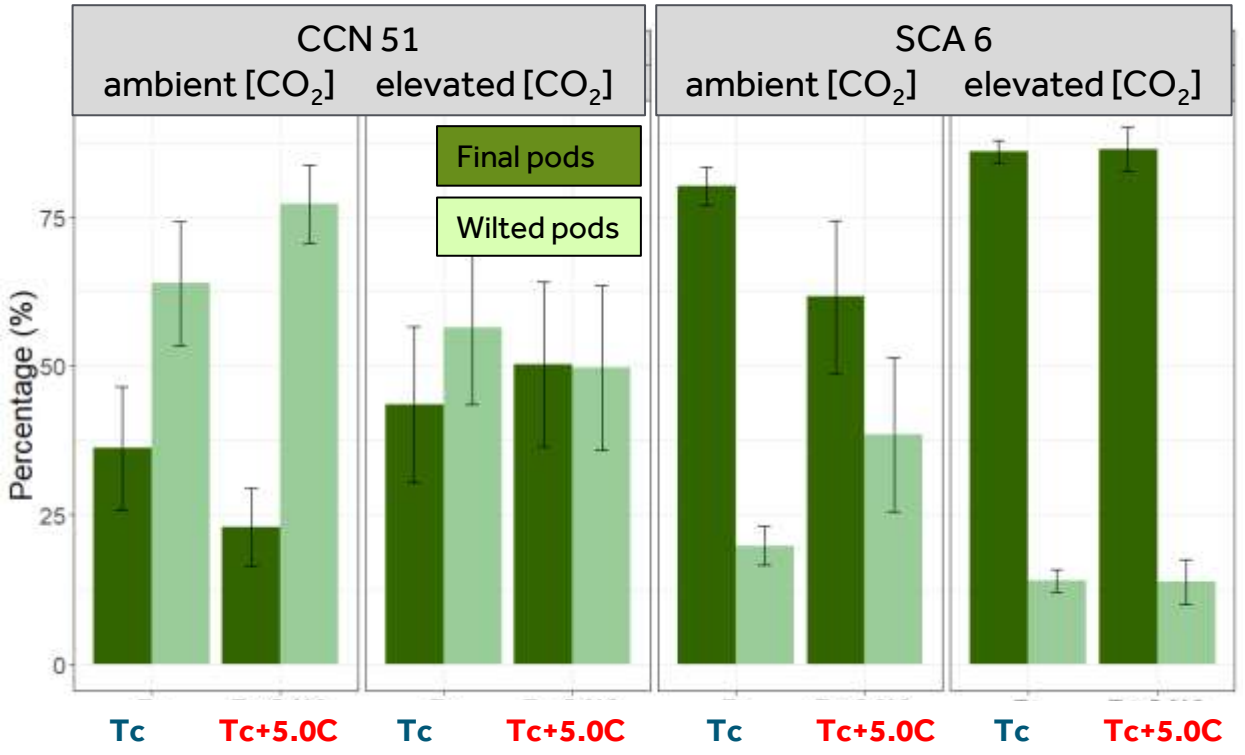
Pod set



Final pod production



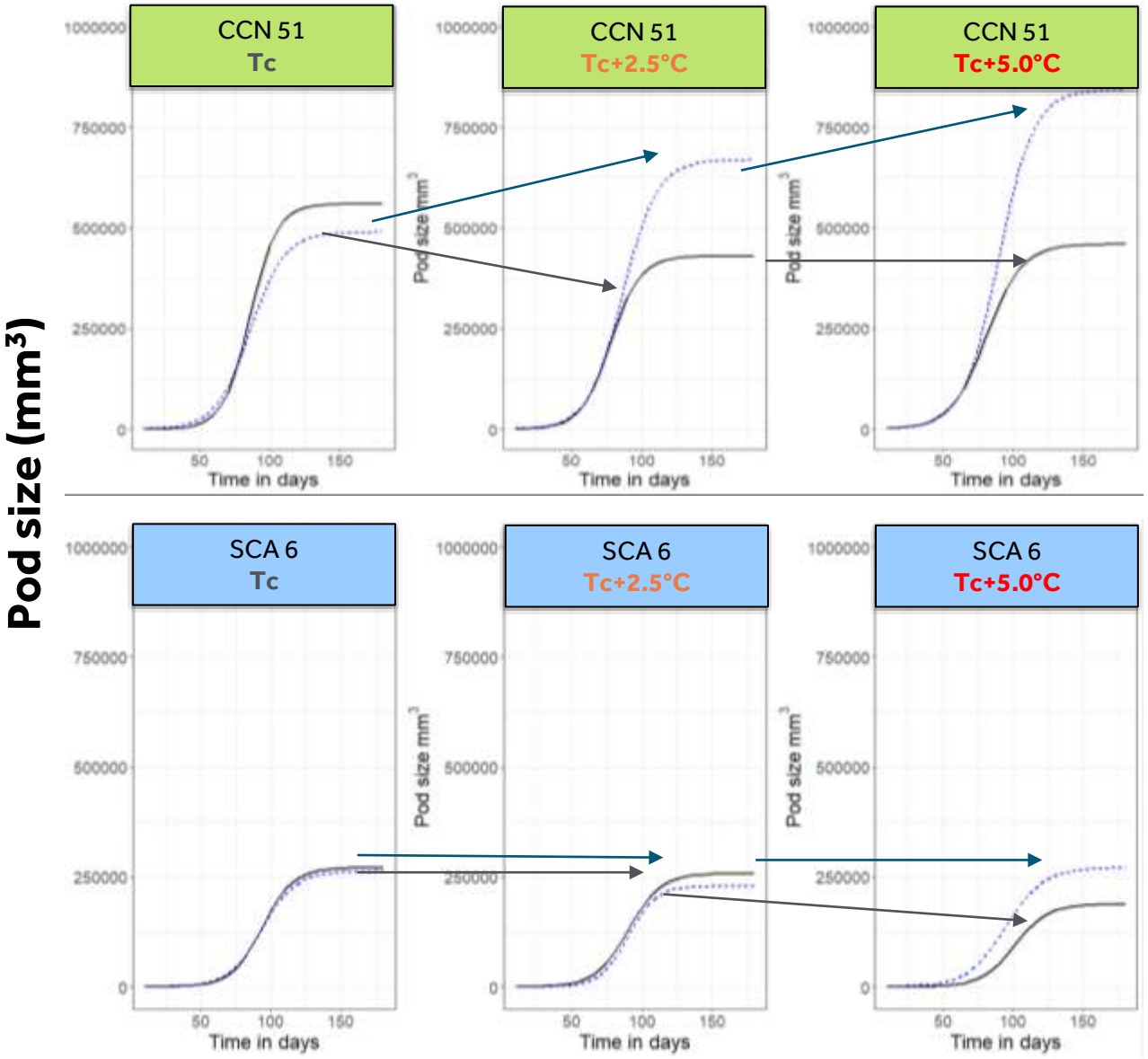
At a[CO_2], pollination declined under temperatures of ~36/27°C (more evident in CCN 51).

e[CO_2] enhanced pollination at each temperature treatment in both genotypes.

Final pod production declined with temperature increases under a[CO2].

However, e[CO2] seemed to compensate the elevated temperature effect (~36/27°C)

Effects on pod development



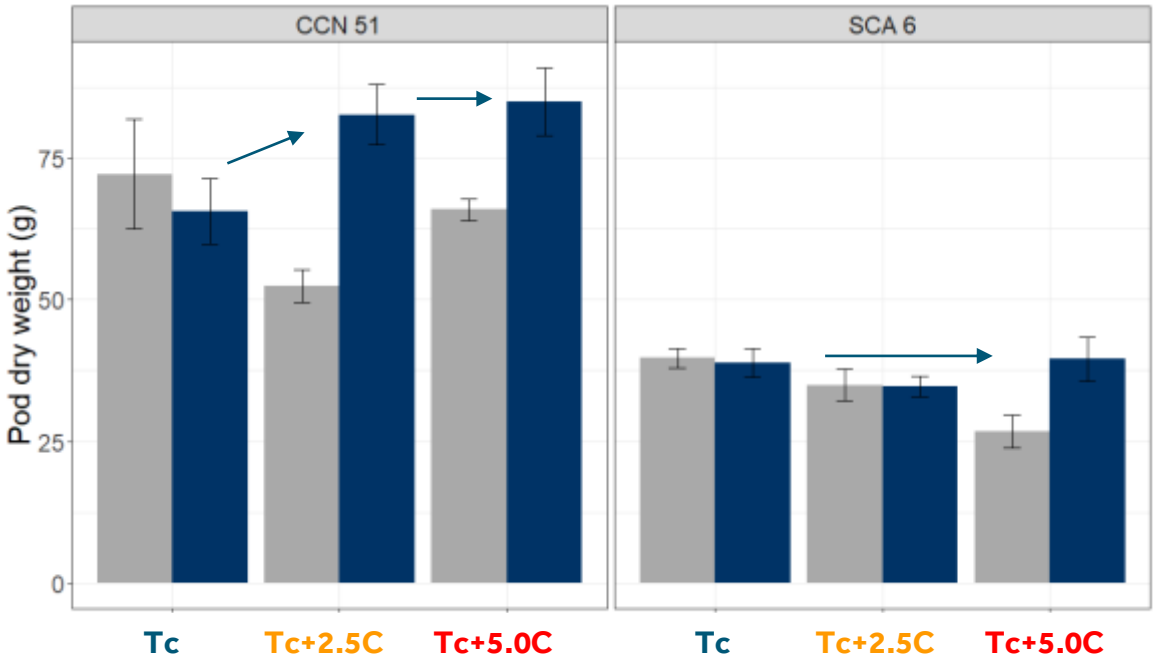
- Genotypic differences: Larger pods in CCN 51 compared to SCA 6
- Pod size declined with increasing temperature.
- Elevated [CO_2] compensated (SCA 6) or enhanced (CCN 51) pod size under the highest temperature.

Effects on pod and bean parameters

ambient [CO_2]

elevated [CO_2]

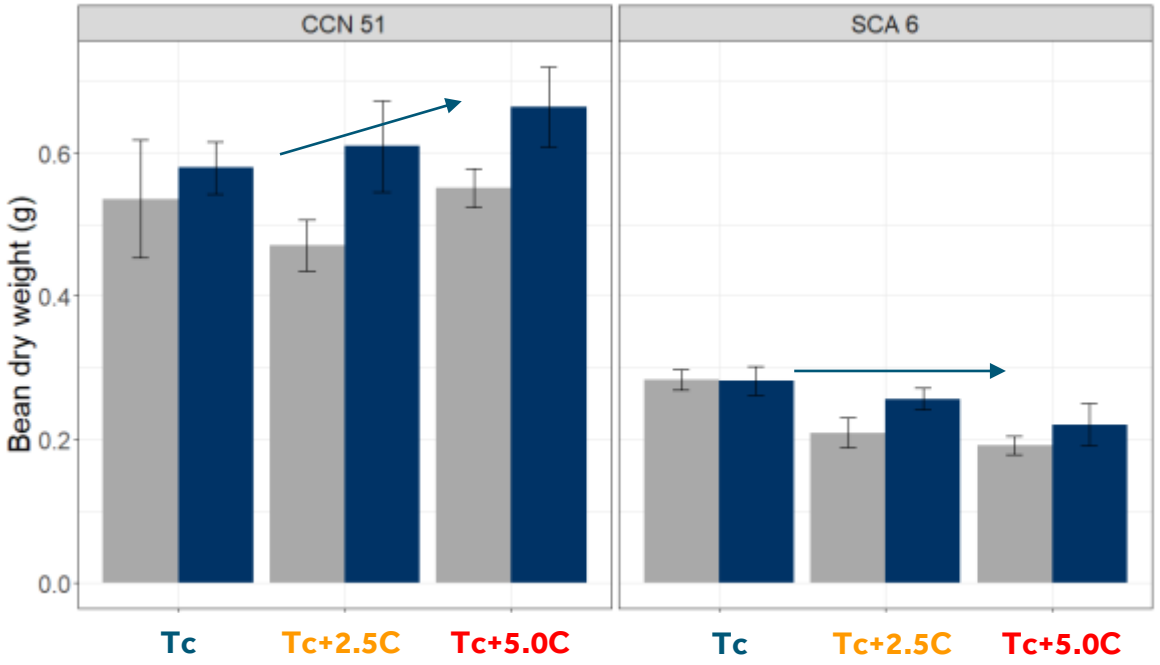
Pod dry weight



Genotypic response: CCN 51 > SCA 6

Positive effect of e[CO_2] under warming conditions: improving pod dry weight in CCN 51 and compensating in SCA 6

Individual bean dry weight



Genotypic response: CCN 51 > SCA 6

Positive effect of e[CO_2] is more evident above 31/22°C

Key conclusions

- Increases temperatures up to 5°C above current mean temperatures had negative effects on reproductive development.
- Elevated [CO_2] mitigates to a greater or lesser extent the negative effect of elevated temperatures. Long-term studies are needed.
- Genotypic differences in terms of sensitivity to warming conditions and responsiveness to the combined effect of elevated [CO_2]
  - ➢ Results suggest that there is an interesting scope for exploring and selecting materials to face a changing climate

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