

Climate change and global wheat grain protein

Senthold Asseng

P. Martre, A. Maiorano, R.P. Rötter, G. O’Leary, G. Fitzgerald, C. Girousse, M.A. Baber, M.P. Reynolds, F. Giunta, R. Motzo, A.M.S. Kheir, P.J. Thorburn, K. Waha, A.C. Ruane, P.K. Aggarwal, M. Ahmed, J. Balkovic, B. Basso, C. Biernath, M. Bindi, D. Cammarano, A.J. Challinor, G. De Sanctis, B. Dumont, E. Eyshi Rezaei, E. Fereres, R. Ferrise, M. Garcia-Vila, Y. Gao, S. Gayler, G. Hoogenboom, R.C. Izaurralde, M. Jabloun, C.D. Jones, B.T. Kassie, K.C. Kersebaum, C. Klein, A.K. Koehler, B. Liu, S. Minoli, M. Montesino San Martin, C. Müller, S. Naresh Kumar, C. Nendel, J.E. Olesen, T. Palosuo, J.R. Porter, E. Priesack, D. Ripoche, M.A. Semenov, C. Stöckle, P. Stratonovitch, T. Streck, I. Supit, F. Tao, M. Van der Velde, D. Wallach, E. Wang, H. Webber, J. Wolf, P. Woli, Z. Zhang, and Y. Zhu, F. Ewert

Outline

- 1. Agricultural challenge**
- 2. AgMIP**
- 3. Estimates of climate change impact on yield**
- 4. Climate change impact on grain protein**

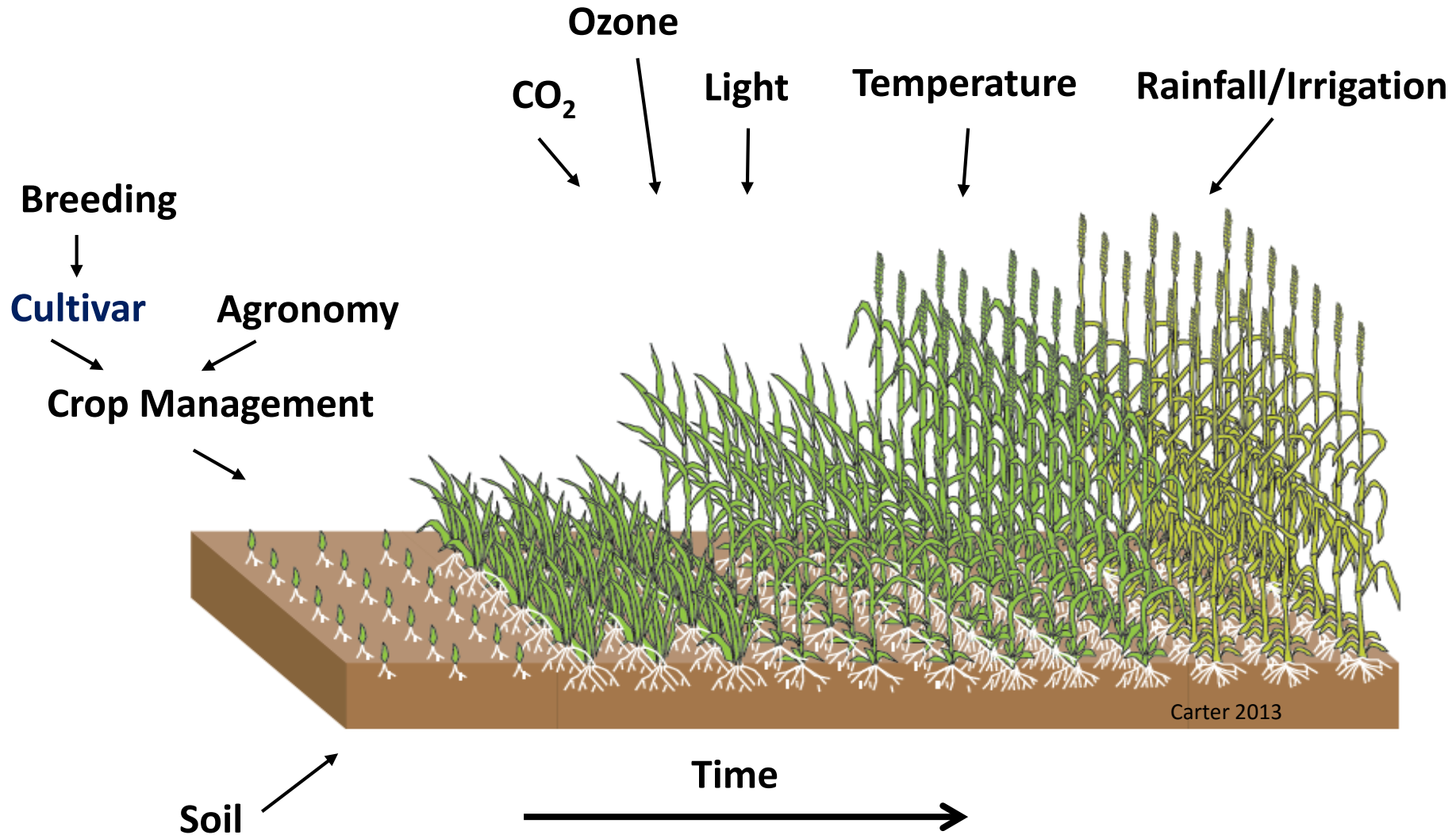
The Agricultural Challenge

- **Food Security - Increased demand**
- **Increase nutritional value**
- **Reduce environmental impact**

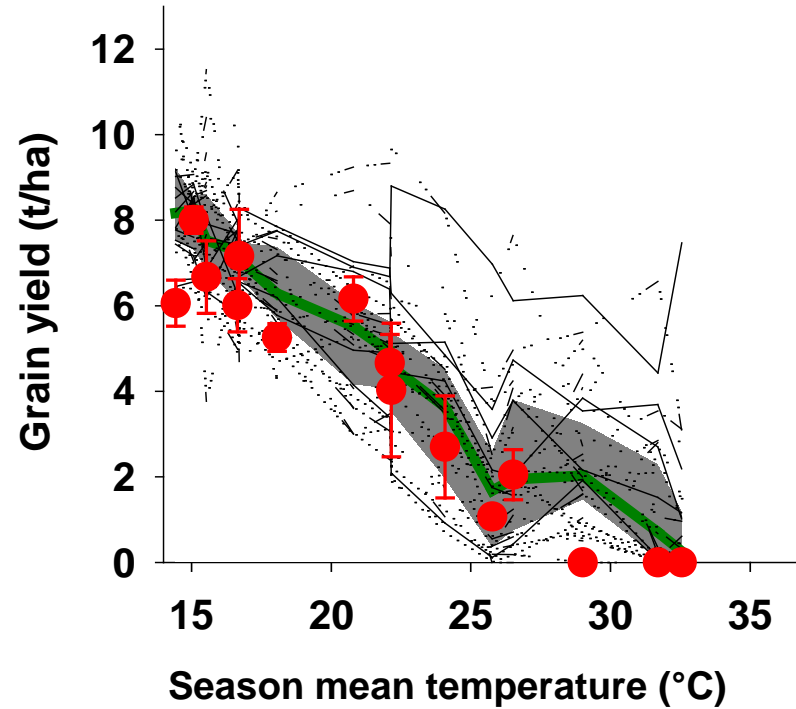
Climate Change

- **Temperature increased by 1.0 °C**
- **By 2050: Atmospheric CO₂ >500ppm**
- **By 2100:**
 - **More extremes (heat, droughts, rainfall).**
 - **Temperature +2 to 4 °C**

Modeling (Wheat) Cropping Systems



AgMIP - Multi-model ensembles



Asseng et al. 2015 Nature CC

AgMIP - Multi-model ensembles

- **Multi-model ensemble median is a better predictor than any single model !**
- **Wheat yields --- *Asseng et al. 2013 Nature CC***
- **Wheat yields (heat stress) --- *Asseng et al. 2015 Nature CC***
- **Wheat variables --- *Martre et al. 2014 GCB***
- **Maize yields --- *Bassu et al. 2014 GCB***
- **Rice yields --- *Li et al. 2014 GCB***
- **Potato yields --- *Fleisher et al. 2016 GCB***

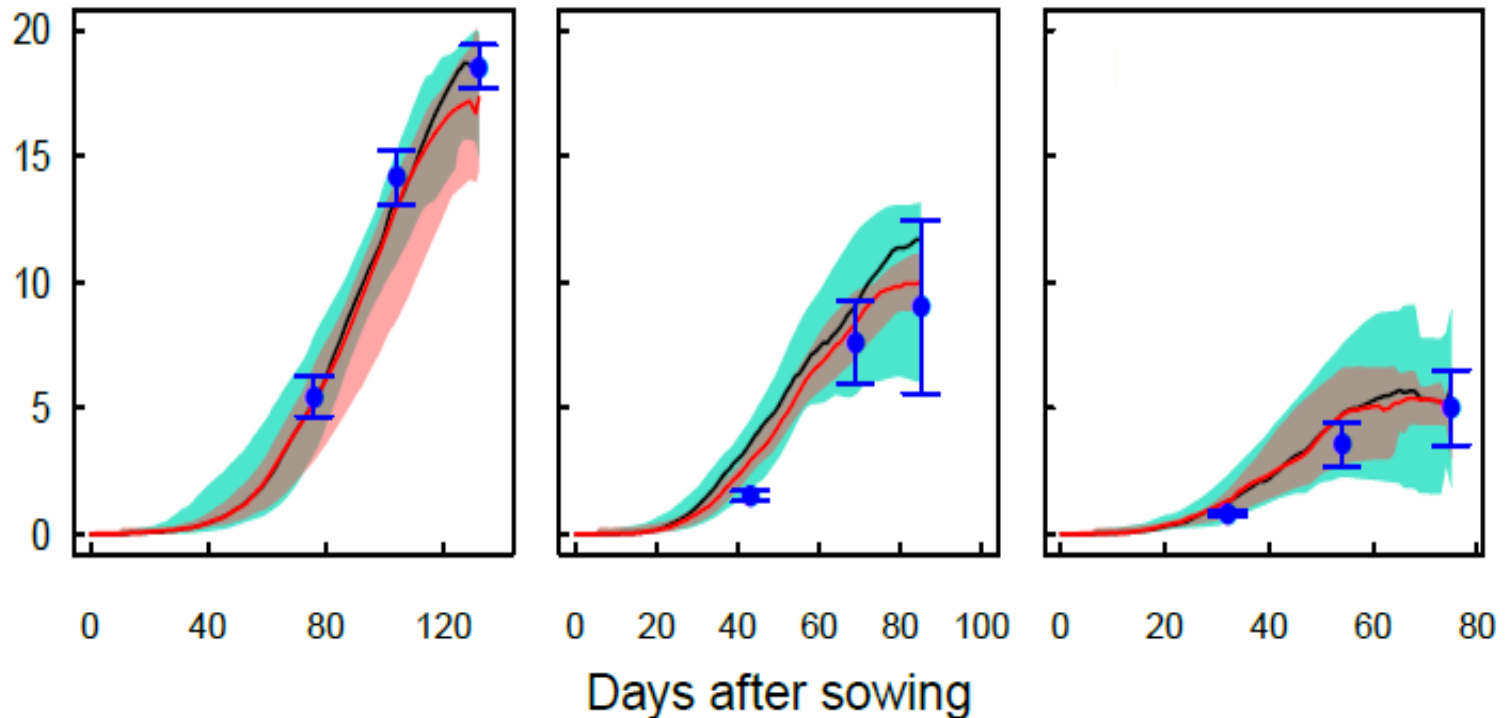
Improved models increase accuracy of simulations

Growing season mean T: **15°C**

22°C

27°C

Total biomass (t/ha)



Maiorano et al. 2016 FCR

Observed = symbols

Multi-model simulation = shades (red shade = improved models)

Multi-model simulation medians = lines

Multi-model ensembles to reduce uncertainty

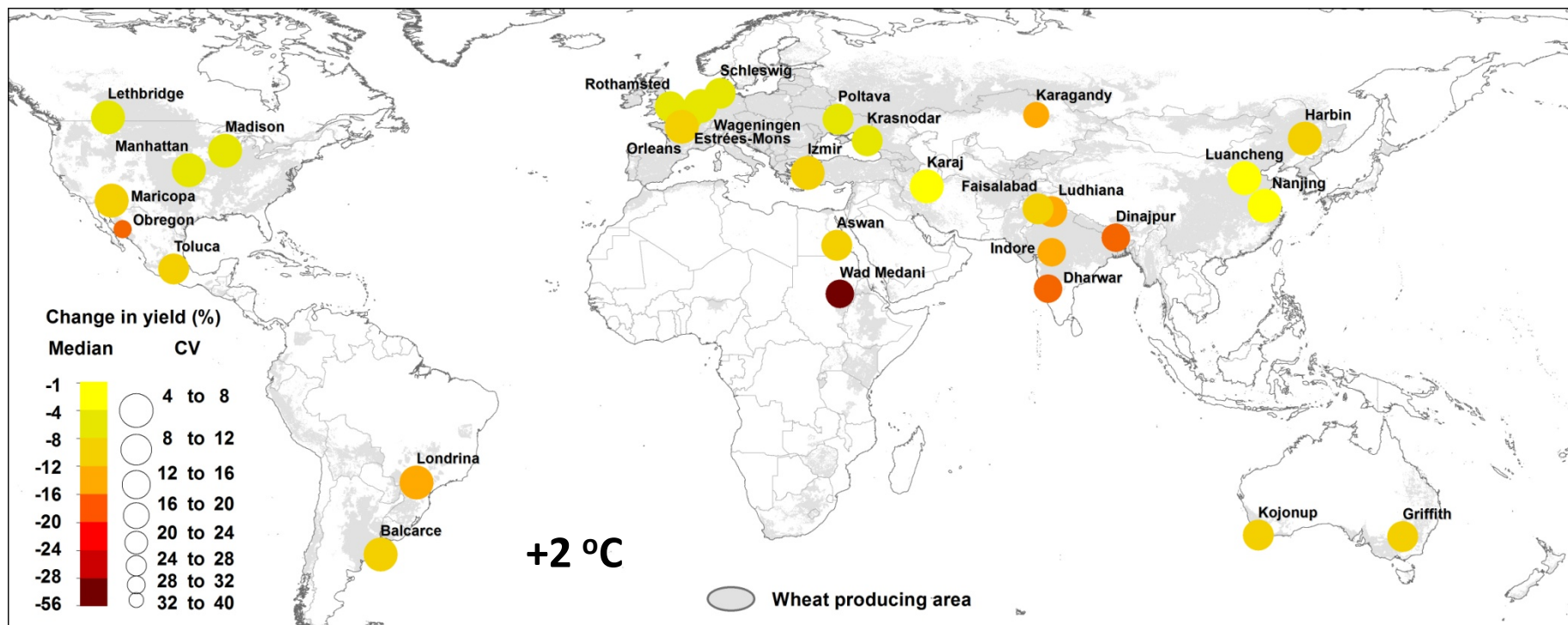
- *Model improvements reduce required number of models in multi-model ensembles*

Maiorano et al. 2016 FCR

Wang et al. 2017 Nature Plants

AgMIP - Wheat yield decline with increasing temperature

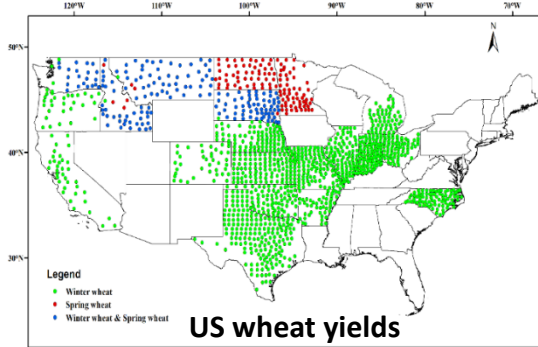
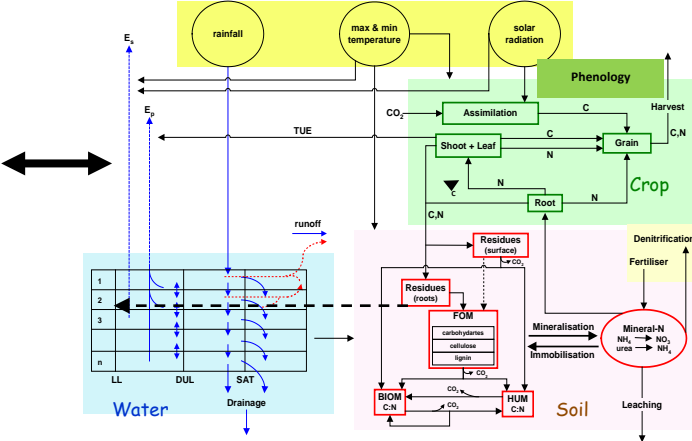
30 model ensemble median (& mean of 30 years)



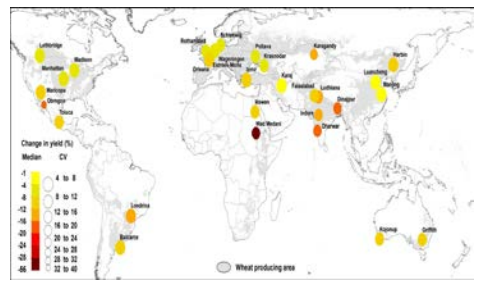
➤ 6% decline in global wheat production for each degree in global warming

Asseng et al. 2015 Nature CC

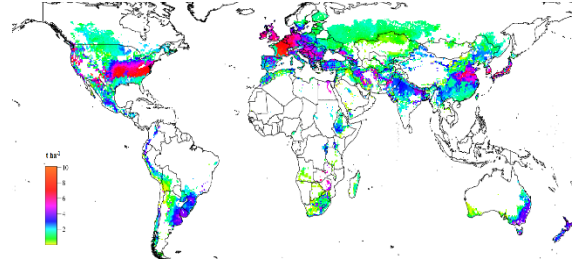
Different methods to estimate climate change impacts



Multi-model points

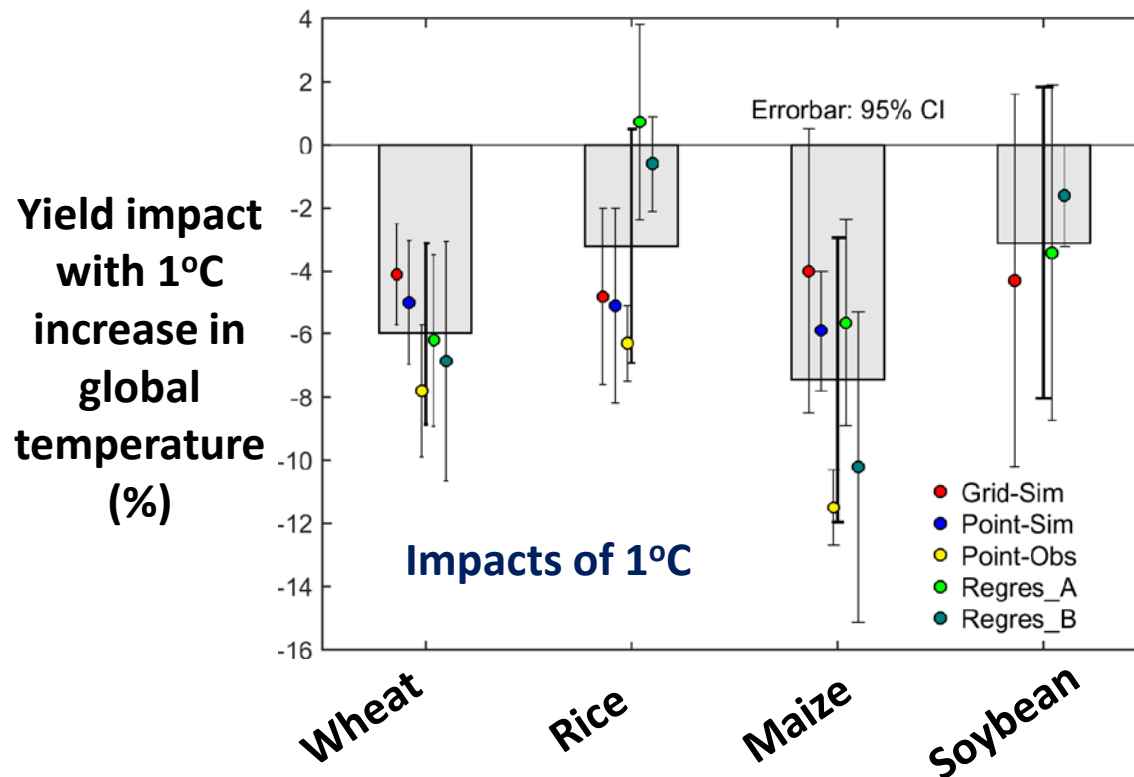


Global-gridded



Impact

Consistent impact estimates of global temperature increase on global yield, using 4 methods

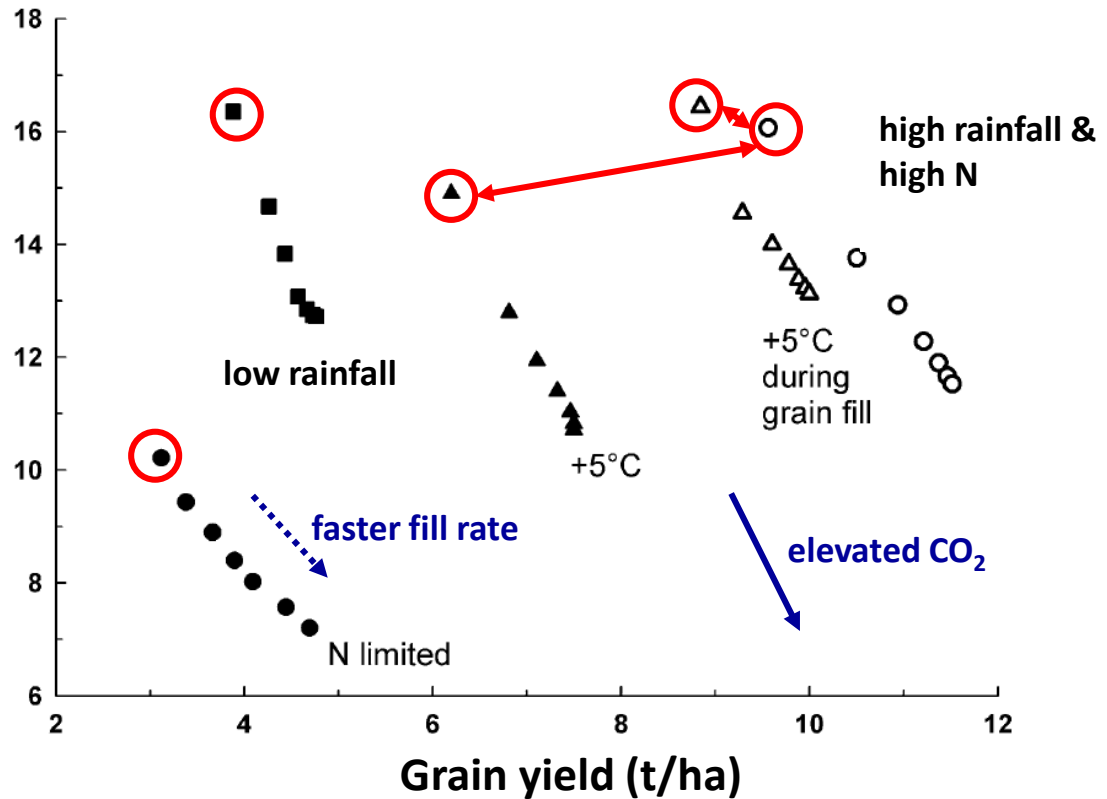


(For wheat: *Liu et al. 2016 Nature CC*)

Zhao et al. 2017 PNAS

Climate change impact on grain protein

Region-specific (local climate, projected change, soil, cultivar, crop management, adaptation)



The impact of climate change on grain protein is highly variable depending on local conditions together with specific changes in temperature, rainfall, atmospheric CO₂ concentration and possible adaptations.

Asseng et al. 2006 EJA