Modelling, designing better yield for wheat of the future

Senthold Asseng

Chair Digital Agriculture
Director Hans Eisenmann-Forum for Agricultural Sciences
Technical University Munich

+ AgMIP-Wheat Team

AgMIP

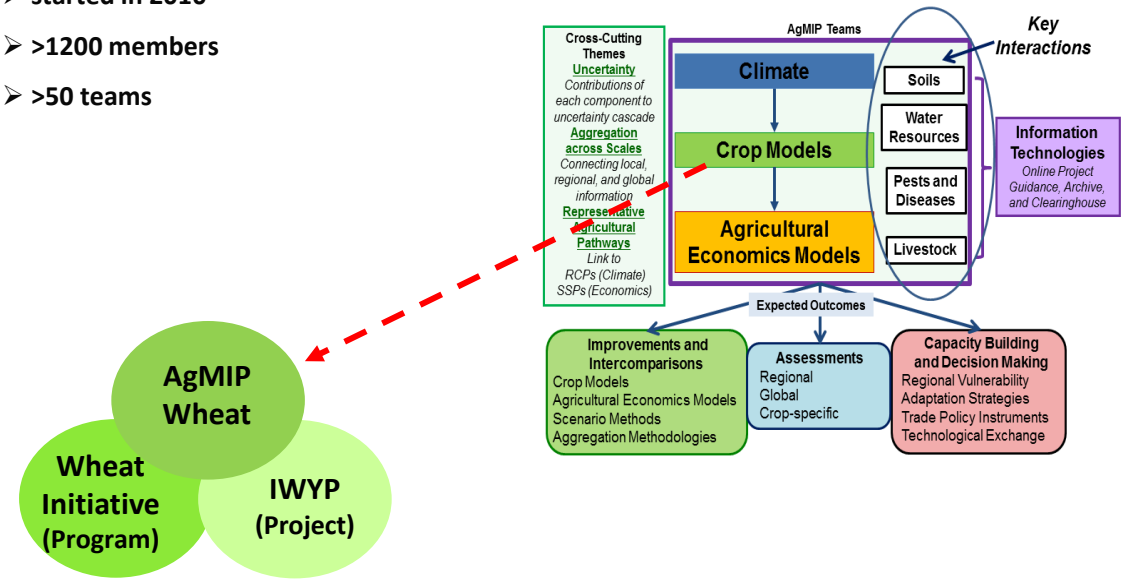
Agricultural Model Intercomparison and Improvement Project

AgMIP is a distributed program:

- **model intercomparison and future climate change impacts**
- **multiple climate, crop & agricultural economics modeling groups around the world**
- **started in 2010**
- **>1200 members**
- **>50 teams**

Rosenzweig et al., 2013 AFM

www.agmip.org

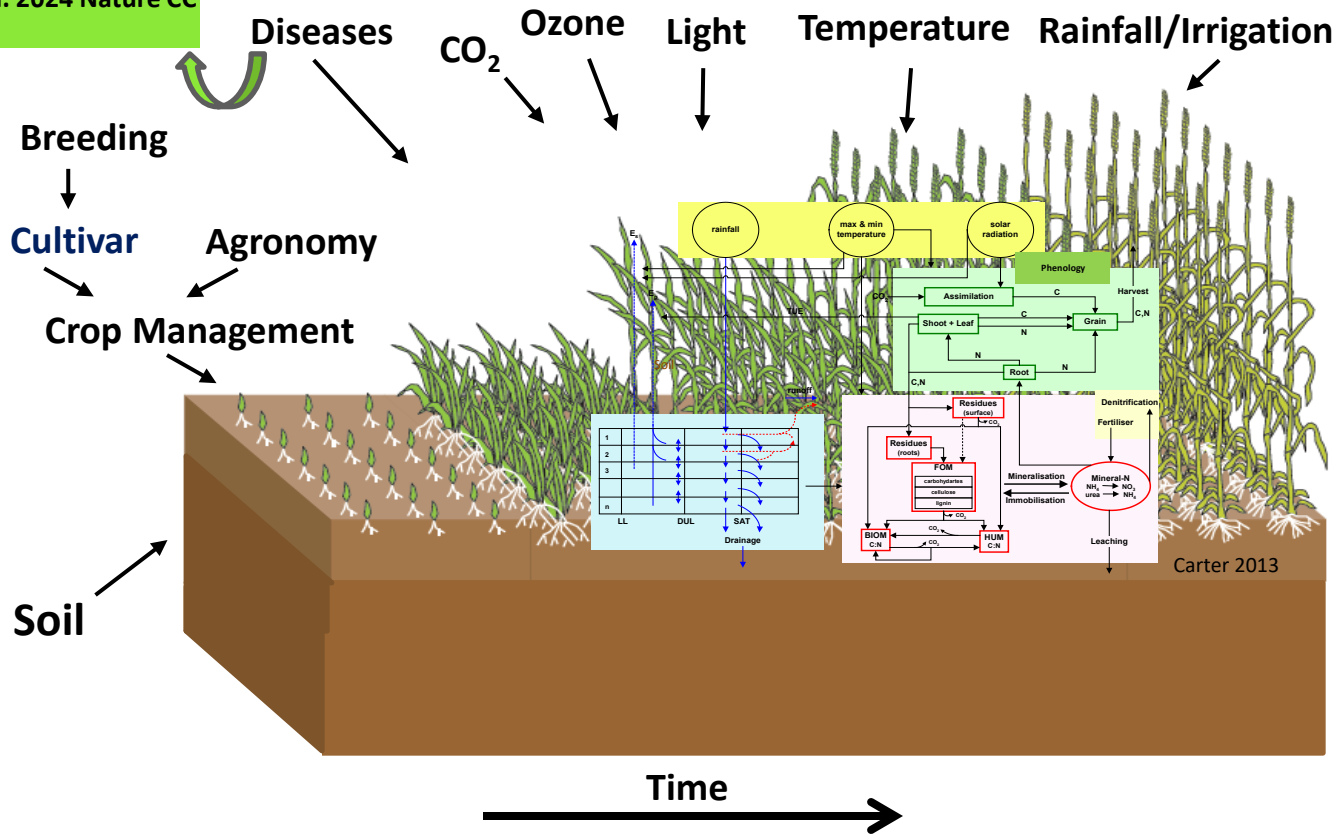


Mission

…to significantly improve agricultural models … for assessing the sustainability of agricultural systems, including impacts of climate change … the goal is to create a next-generation knowledge platform for agricultural modeling worldwide.

Modeling (Wheat) Cropping Systems

Pequeno et al. 2024 Nature CC
wheat blast



Multi-model ensembles

➢ **Multi-model ensemble median is a better predictor than any single model !**

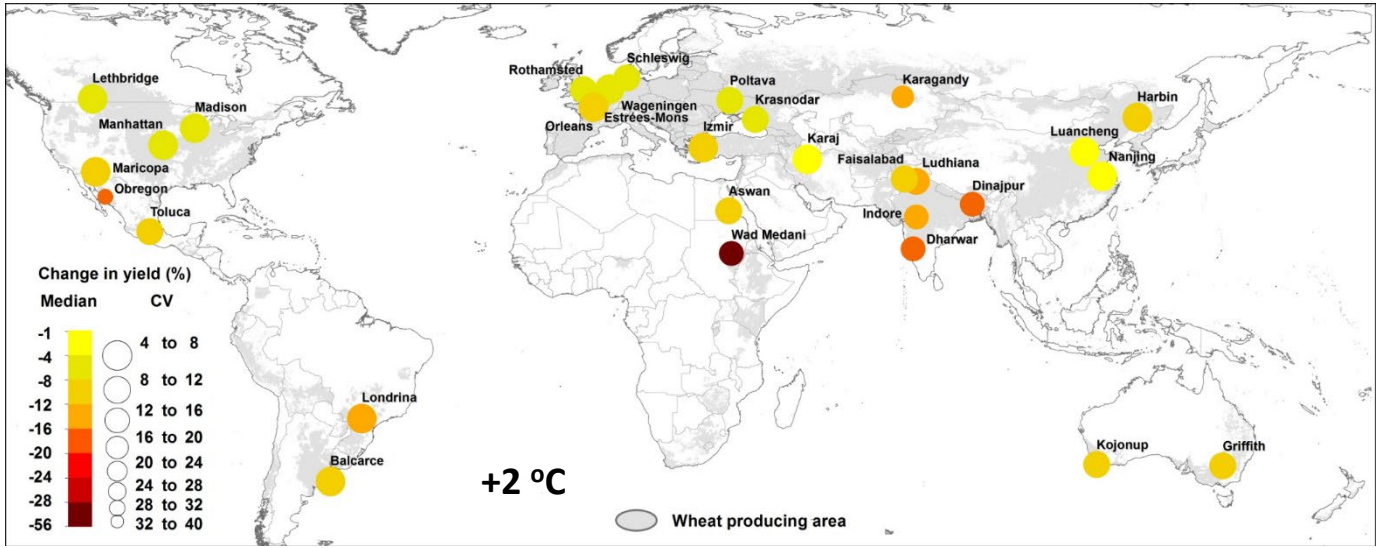
- **Wheat yields --- *Asseng et al. 2013 Nature CC***
- **Wheat yields (heat stress) --- *Asseng et al. 2015 Nature CC***
- **Wheat variables --- *Martre et al. 2014 GCB***
- **Wheat grain protein --- Asseng et al. 2019 GCB**
- **Maize yields --- *Bassu et al. 2014 GCB***
- **Rice yields --- *Li et al. 2014 GCB***
- **Potato yields --- *Fleisher et al. 2016 GCB***
- ***Statistical explanation* --- *Wallach et al. 2018 GCB***

Attribution of Impact Uncertainty*: *Wang et al. 2024 Nature Food

Climate change impact

Wheat Yield decline with increasing temperature

30 model ensemble median (& mean of 30 years)

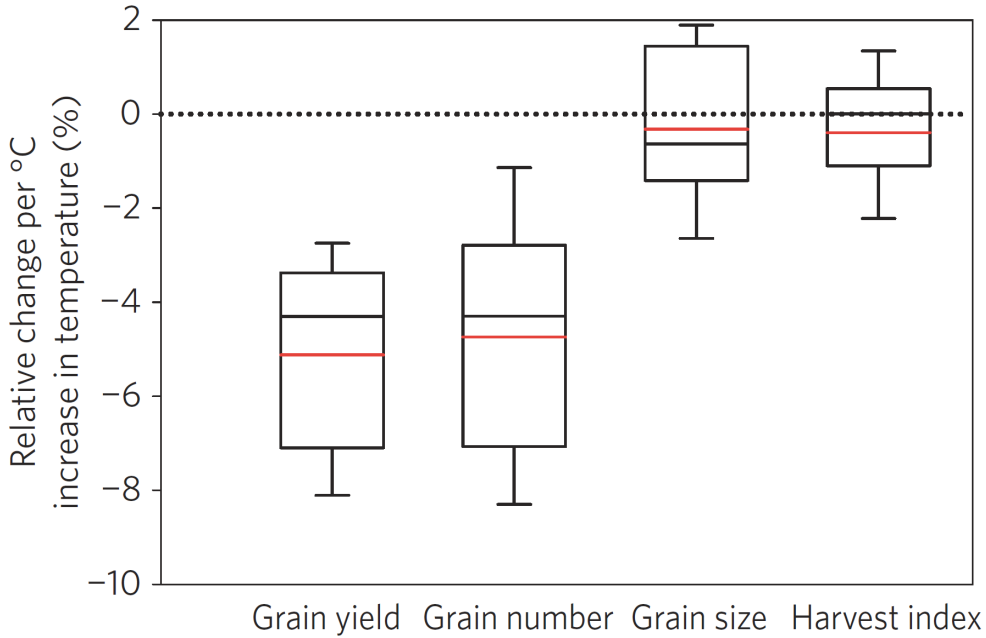


➢ **6% decline in global wheat production for <u>each</u> degree in temperature**

Asseng et al. 2015 Nature CC

Global temperature impact on yield components

Multi-model ensemble median (of 30 models) with average of 30-year & 30 locations



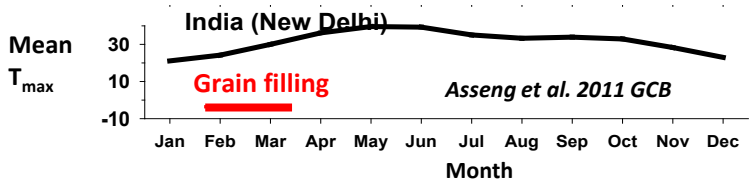
Asseng et al. 2015 Nature CC

Proposed adaptation:

Delay anthesis + increased grain filling rate

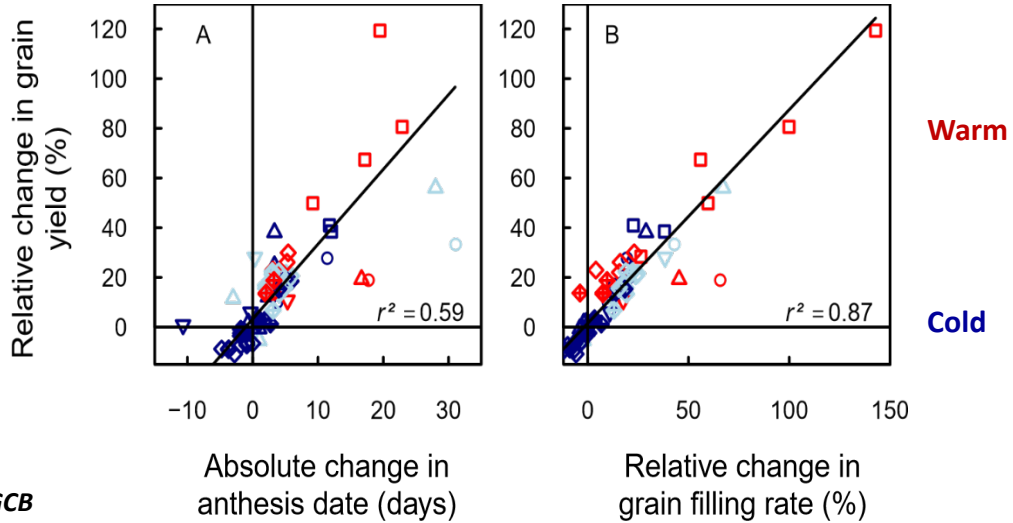
Adaptation to temperature

Field observations from 4 experiments



Proposed adaptation to increased temperature:

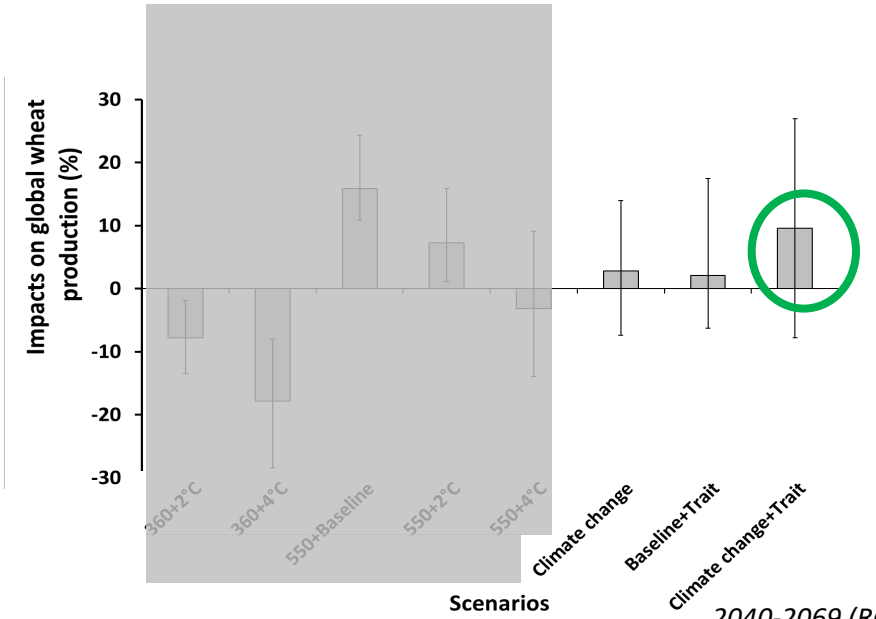
- **Delay anthesis + increased grain filling rate,** ***Asseng et al. 2015 Nature CC***
- **Does exist,** ***Asseng et al. 2019 GCB***



Asseng et al. 2019 GCB

Climate change impact (2050) on grain yield production at global scale (temperature, CO_2, rain)

Median of 32 (18 with N) models



Delayed anthesis + increased grain filling rate

Error bars: 25th and 75th %iles across 32 crop models and 5 GCMs together

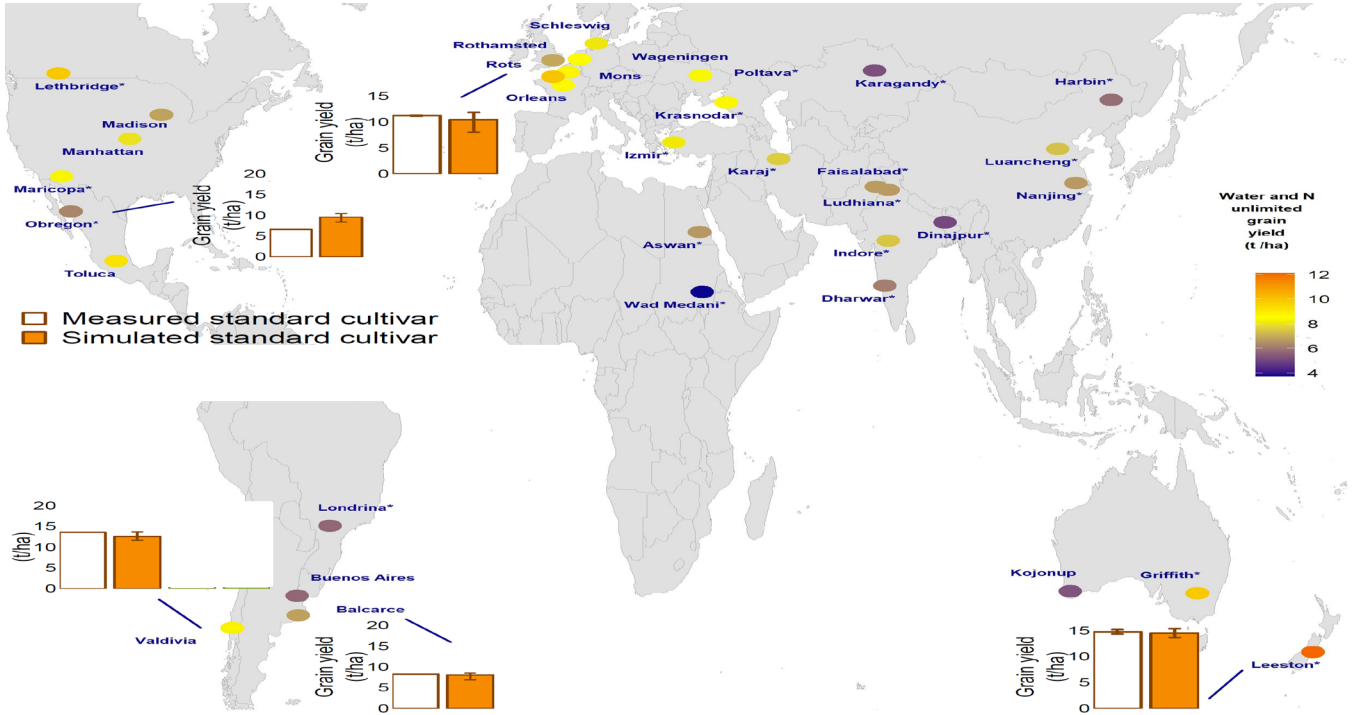
2040-2069 (RCP8.5, 5 GCMs)

Asseng et al. 2019 GCB

Simulation of a high yield trait combination

Asseng et al. 2021 Crop Science: Model-Driven Multidisciplinary Global Research…

Simulation of a high yields



Dueri et al. 2023 EB

Martre et al. 2024 Nature Plants

Identifying high-yield traits for simulation

Yield potential traits

Radiation use efficiency
$r^2 = 0.63$ *** **(+34 %)**

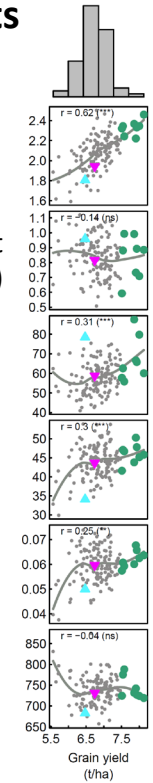
Light extinction coefficient
$r^2 = -0.20$ * **(+10%)**

Fruiting efficiency
$r^2 = 0.30$*** **(-5%)**

Average grain dry mass
$r^2 = 0.32$*** **(+16%)**

Grain filling rate
$r^2 = 0.26$** **(+21%)**

Grain filling duration
$r^2 = 0.002^{ns}$ **(-4%)**



Phenotypic correlations with yield in the HiBAP panel

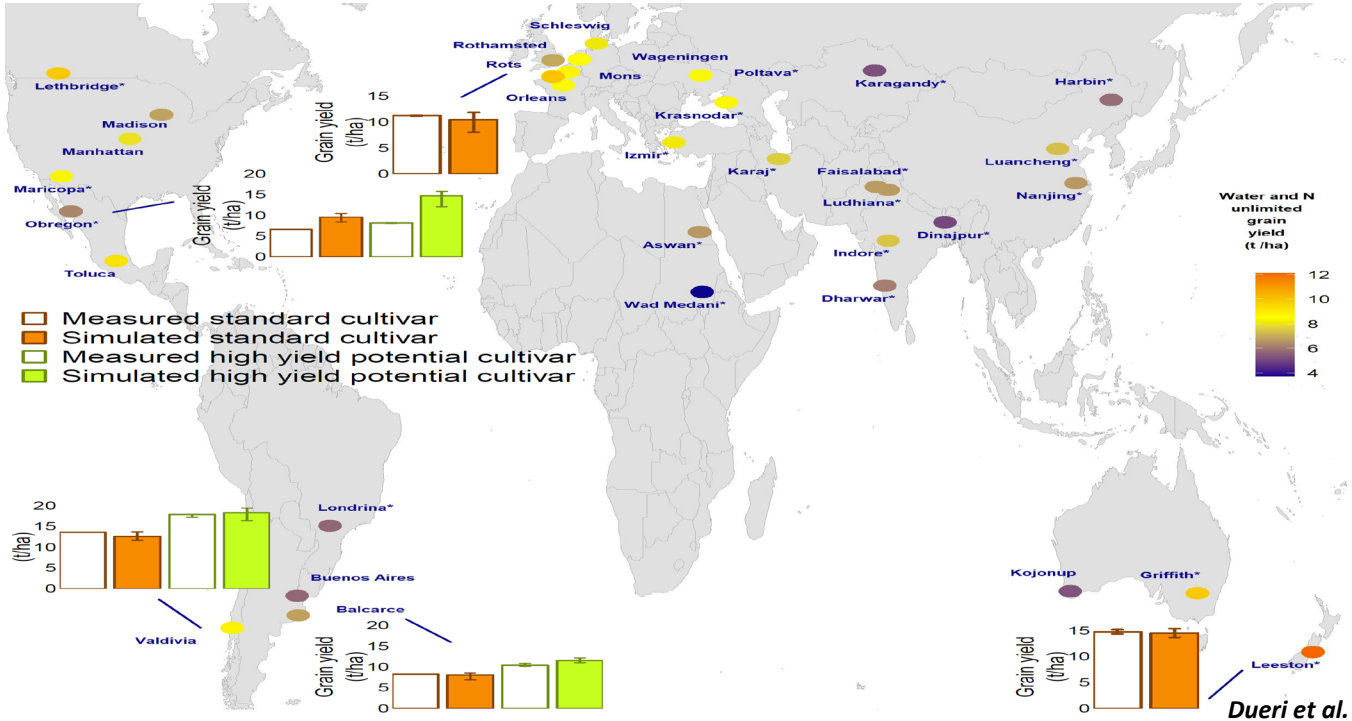
(*Molero et al. 2019 Plant Biotechnol*)

Included these traits into crop models

1. **Tested traits with measurements**
2. **Explored global trait impact**

Martre et al. 2024 Nature Plants

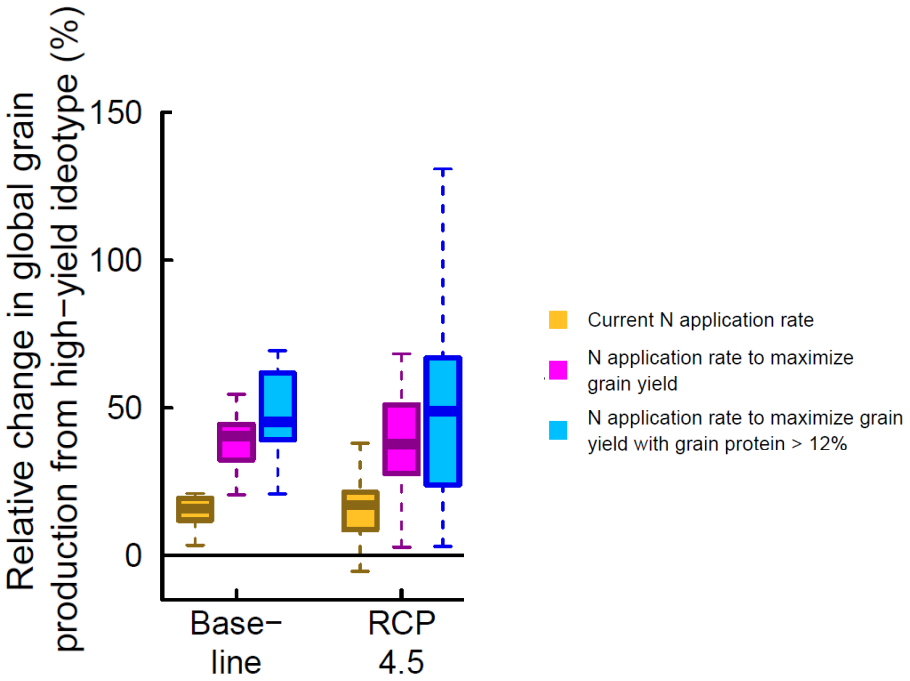
Testing simulation with high-yield trait



Dueri et al. 2023 EB

Martre et al. 2024 Nature Plants

Simulation of high-yield trait impact



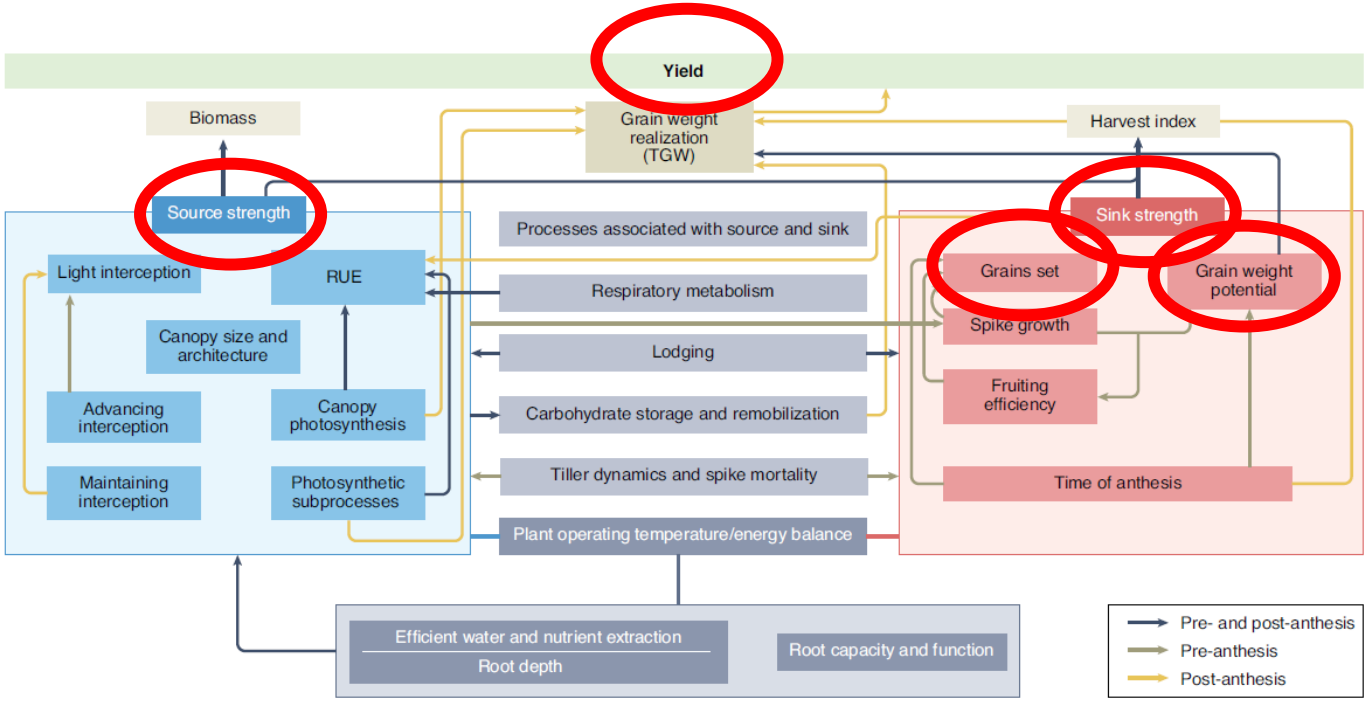
- **High-yield traits increased yield by 16%**
- **To achieve the full yield potential (up to 52%) – much more N is needed**

Martre et al. 2024 Nature Plants

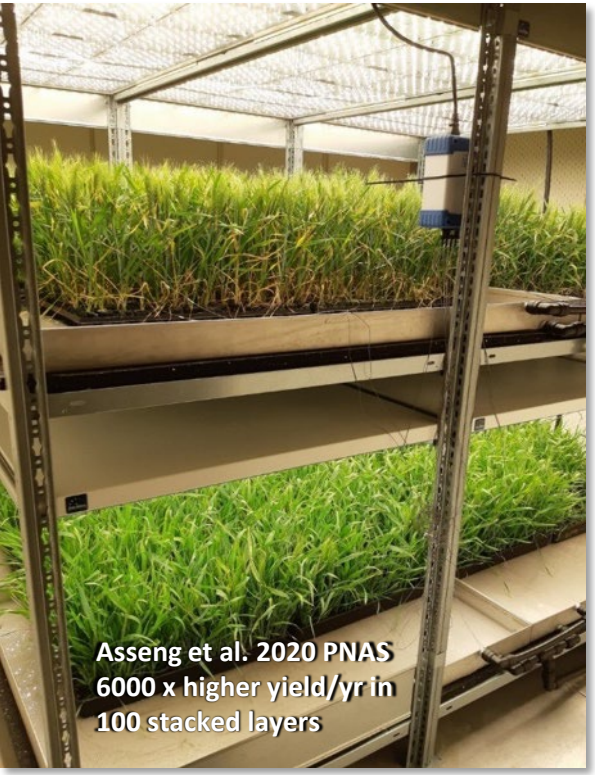
Next:

Model testing and exploring source-sink interaction

Reynolds et al. 2022 Nature Food: Wiring diagram…



Summary



Crop modeling:

1. To explore G x E x M interactions
2. To explore the impact of traits on yield
3. Next: source / sink --- working with experimentalists is key

senthold.asseng@tum.de