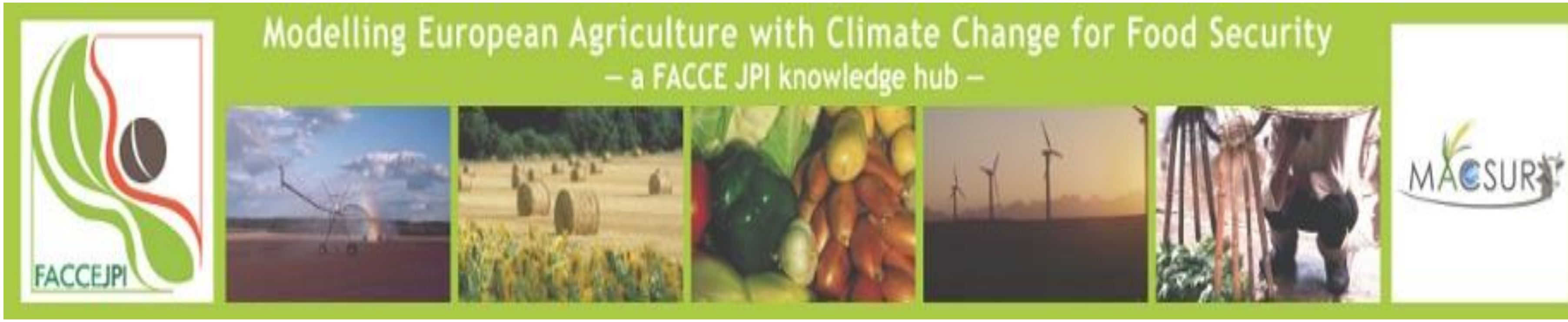

SIMULATING CROP ROTATIONS AND MANAGEMENT ACROSS CLIMATIC ZONES IN EUROPE – AN INTERCOMPARISON STUDY USING FIFTEEN MODELS

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zalf

MACSUR Conference 2015, Reading, UK, 8-9 April 2015

MACSUR

CropM WP1: Model inter-comparison and improvement

- WP leaders: K. Christian Kersebaum & Marco Bindi
- Objectives:
  - Identification of major cropping systems and model capabilities in Europe
  - Create a common protocol for model inter-comparisons and a methodological framework for multi-criteria model evaluation
  - Minimum requirements and classification of data sets depending on data quality and consistency to be used for calibration or validation
  - Performing model inter-comparisons to estimate ranges of model results for uncalibrated and calibrated runs
  - Identifying gaps and deficits of model approaches for their improvement
- Expected outputs:
  - Software and publication on data classification (submitted to EMS)
  - Protocoll and methodological framework for multi-criteria model evaluation
  - Model inter-comparison study on crop rotation effects vs. single year simulation
  - Improvement of crop models regarding their spectrum of crops and processes

ROTATIONEFFECT

Improving yield predictions by crop rotation modelling-?

Study design

5 agricultural datasets for crop rotations with different treatments (in total 303 seasons)

15 modelling teams

Simulating **rotation** and/or **single-years**

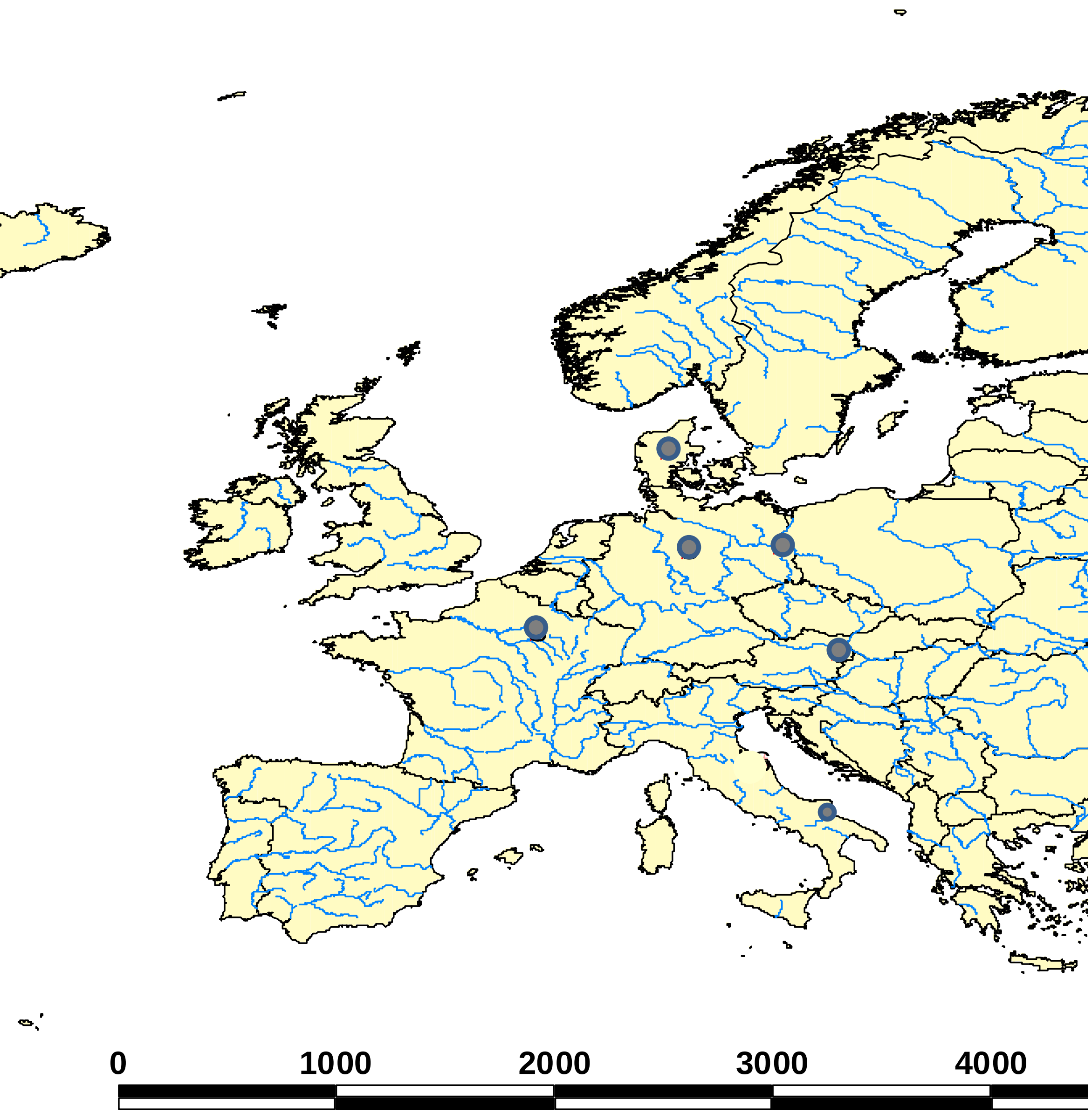
(Nmin & water content given for first year only)

Step 1:Model calibration on phenology/biomass of one treatment

Step 2: Model calibration with full data of one treatment

Focus on **yield**, biomass, N uptake, phenology, N-leaching, seapage water

Location of datasets



Agricultural datasets:

Thibie (FR)

Hirschstetten (AT)

Müncheberg (DE)

Braunschweig (DE)

Foulum (DK)

Foggia (I)

ROTATIONEFFECT: data

1) FACE experiment Braunschweig / GERMANY

6 year crop rotation (2000-2005)

Rotation: w. barley (WB), ryegrass (RyG, catchcrop), sugar beet (SBt), w. wheat (WW), w. barley, rye grass (catch crop), sugar beet, w. wheat

4 Treatments: CO_2: 374 and 550 ppm, 2 nitrogen treatments (100 and 50%) per CO_2 (6 years)

2) Müncheberg / GERMANY

6 year crop rotation (1992-1996), 4 x shifted by one year

Rotation: winter wheat (WW), winter barley (WB), winter rye (WR), oil radish (OR, catchcrop), sugar beet, winter wheat (WW), winter barley (WB)

2 Treatments: rainfed and irrigated x 4 years

ROTATIONEFFECT: data

3) Lysimeter Hirschstetten / AUSTRIA

7 year crop rotation (1998-2004)

Rotation: *mustard (MUS),* spr. wheat (SW), *mustard (MUS),* spring barley (SB), w. wheat (WW), *mustard (MUS),* potatoes (POT), *w. wheat (WW, green manure*), maize (MAZ), w. wheat (WW)

Treatments: 3 different soils

4) Foulum / DENMARK

11 year crop rotation (2002 – 2012)

Rotation/year	2002				2003				2004				2005				2006				2007				2008				2009				2010				2011				2012			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
2 plough			BAR				RAP					WHB				WHB				BAR				RAP				WHB						BAR		BAR				WHB				
3 plough			WHB				GRV 1 / BAR							GRV 2 / PEA		WHB				WHB				BAR						OAT		WHB				BAR						OAT		
4 plough			WHB				GRV 1 / BAR							GRV 2 / PEA		WHB				WHB				BAR						OAT		WHB				BAR						OAT		
2 No till			BAR				RAP					WHB				WHB				BAR				RAP				WHB						BAR		BAR				WHB				
3 No till			WHB				GRV 1 / BAR							GRV 2 / PEA		WHB				WHB				BAR						OAT		WHB				BAR						OAT		
4 No till			WHB				GRV 1 / BAR							GRV 2 / PEA		WHB				WHB				BAR						OAT		WHB				BAR						OAT		

Treatments: crop rotations, residue management and tillage

ROTATIONEFFECT:data

5) Thibie / FRANCE

12 year crop rotation (1991 – 2002)

12 Treatments: effects of catch crop establishment and reduced N

Rotation/year			1991				1992				1993				1994				1995				1996				1997		
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
1 PWS	catch crop	nitrogen low				WHB		PEA/DAC		WHB			RAD			SBt		BAR		PEA/RAD		WHB			RAD			SBT	
1 PWS		nitrogen low				WHB		PEA/DAC		WHB			RAD			SBt		BAR		PEA/RAD		WHB			RAD			SBT	
1 PWS	bare soil	Nitrogen high						PEA		WHB						SBt			PEA			WHB						SBT	
1 PWS		nitrogen low						PEA		WHB						SBt			PEA			WHB						SBT	
2 SPW	catch crop	nitrogen low			RAD			SBt		WHB		PEA/DAC		WHB			RAD			SBT		WHB		PEA/RAD		WHB			RAD
2 SPW		nitrogen low			RAD			SBt		WHB		PEA/DAC		WHB			RAD			SBT		WHB		PEA/RAD		WHB			RAD
2 SPW	bare soil	Nitrogen high						SBt			PEA			WHB						SBT				PEA		WHB			
2 SPW		nitrogen low						SBt			PEA			WHB						SBT				PEA		WHB			
3 WSP	catch crop	nitrogen low				WHB						SBt				PEA		WHB						SBt				PEA	
3 WSP		nitrogen low				WHB						SBt				PEA		WHB						SBt				PEA	
3 WSP	bare soil	Nitrogen high		DAC		WHB				RAD		SBt		WHB		PEA/RAD			WHB					SBt		BAR		PEA/RAD	
3 WSP		nitrogen low		DAC		WHB				RAD		SBt		WHB		PEA/RAD			WHB					SBt		BAR		PEA/RAD	

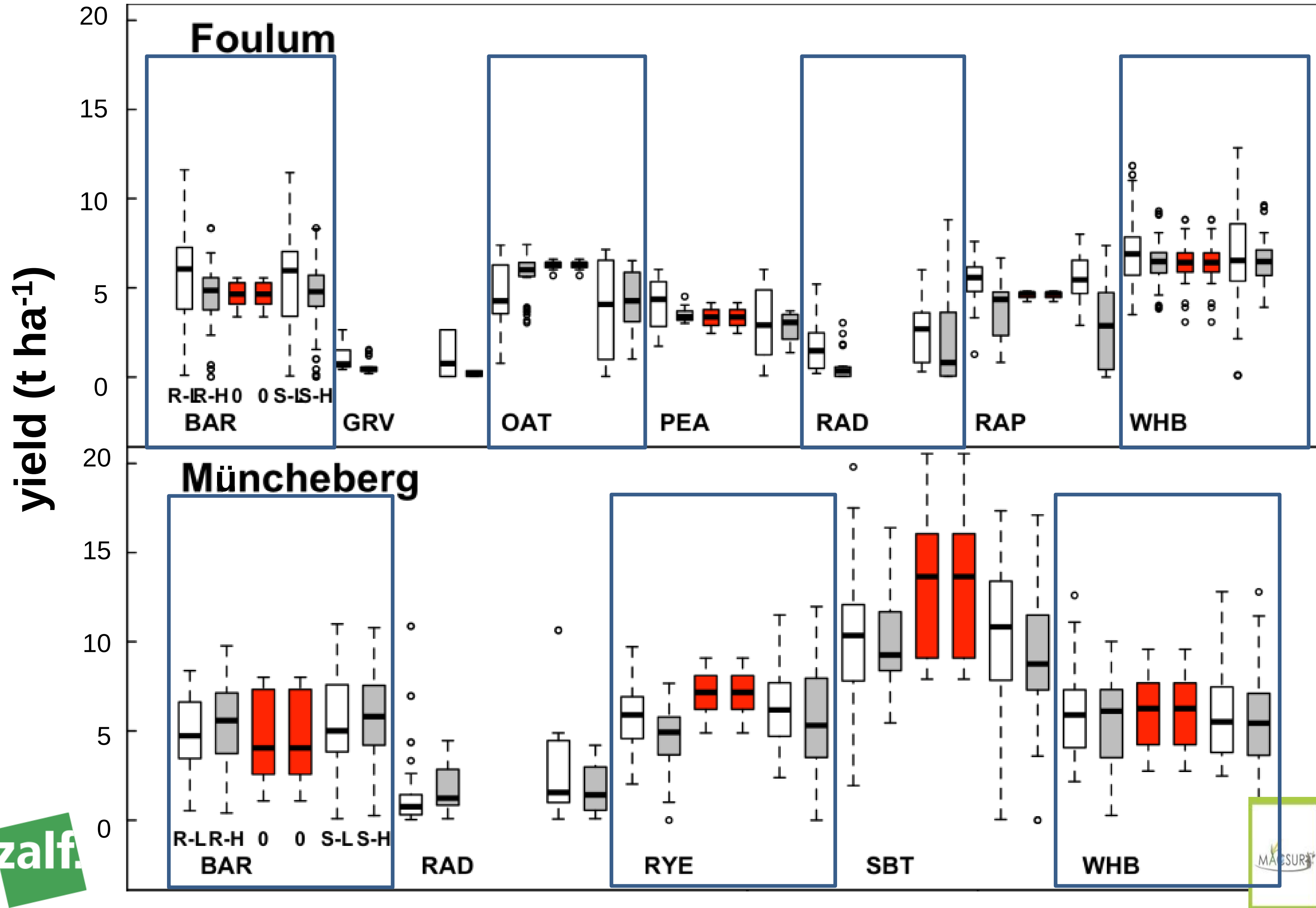
ROTATIONEFFECT: model applications

Results of 15 modelling teams

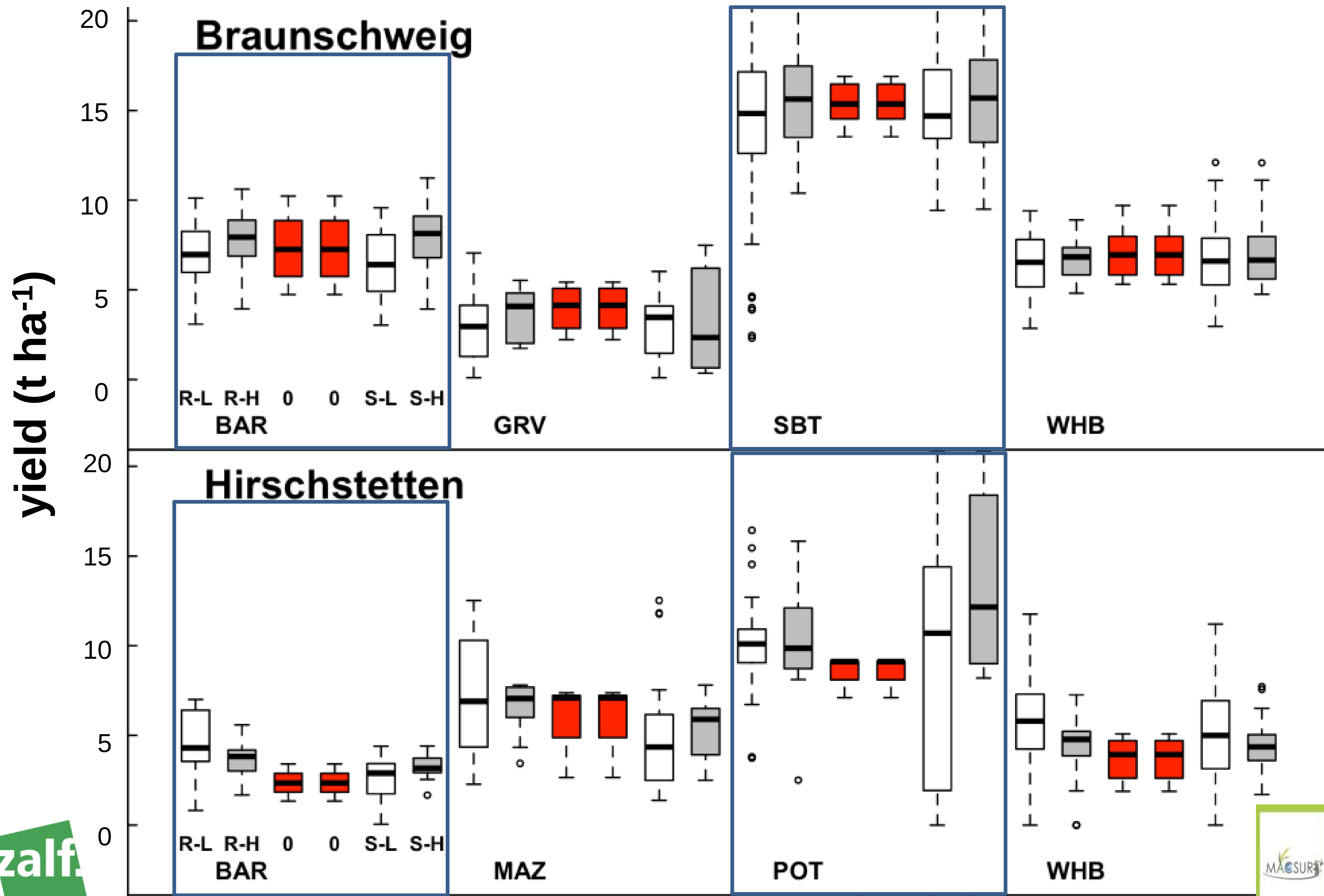
DSSAT 4.6
DSSAT
WOFOST
LPJmL
CROPSYST
Daisy
FASSET
SPACSYS
MONICA
Theseus
Simplace (Lintul5)
HERMES
SWIM
STICS
APSIM

Crop	#models ROTATION / SINGLE	#datasets	#observations (seasons)
MAIZE	6 / 7	1	3
WHEAT	9 / 12	5	96
BARLEY	9 / 11	5	37
RYE	9 / 9	1	12
OAT	6 / 7	1	8
SBEET	9 / 9	3	64
POTATO	6 / 6	1	3
RAPE	8 / 8	1	4
RADISH	4 / 4	3	42
PEA	7 / 9	2	52
GRASS	6 / 6	3	14

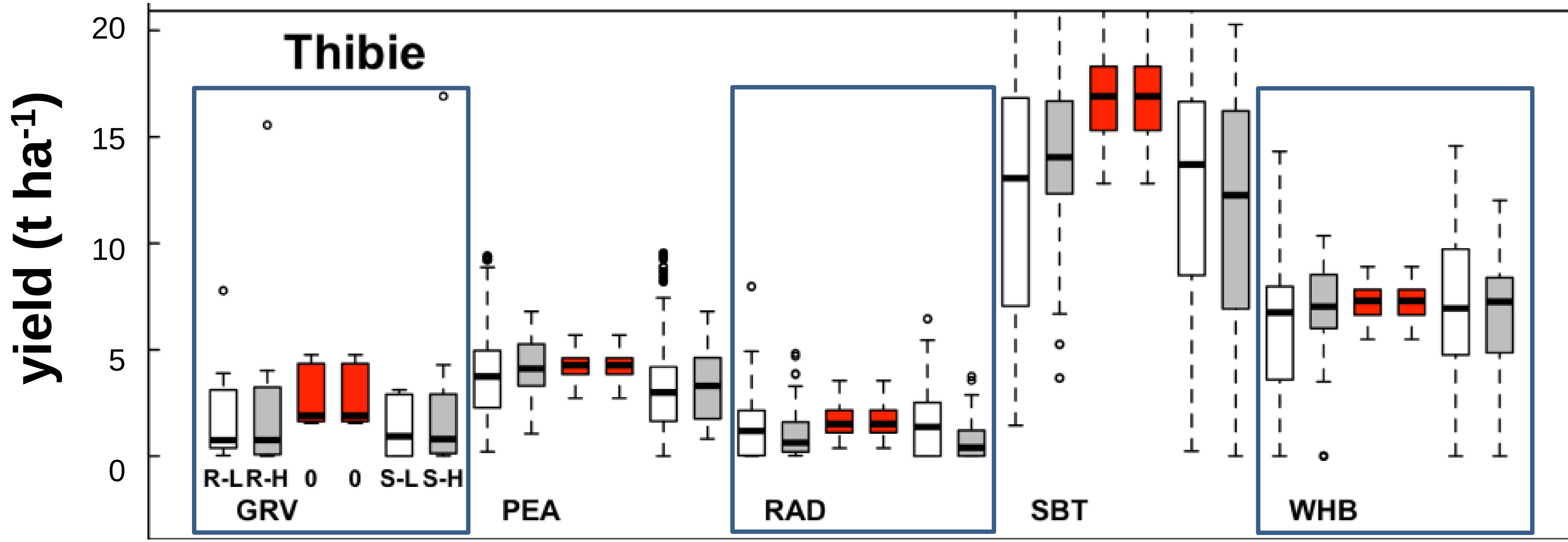
observed and simulated crop yields



observed and simulated crop yields

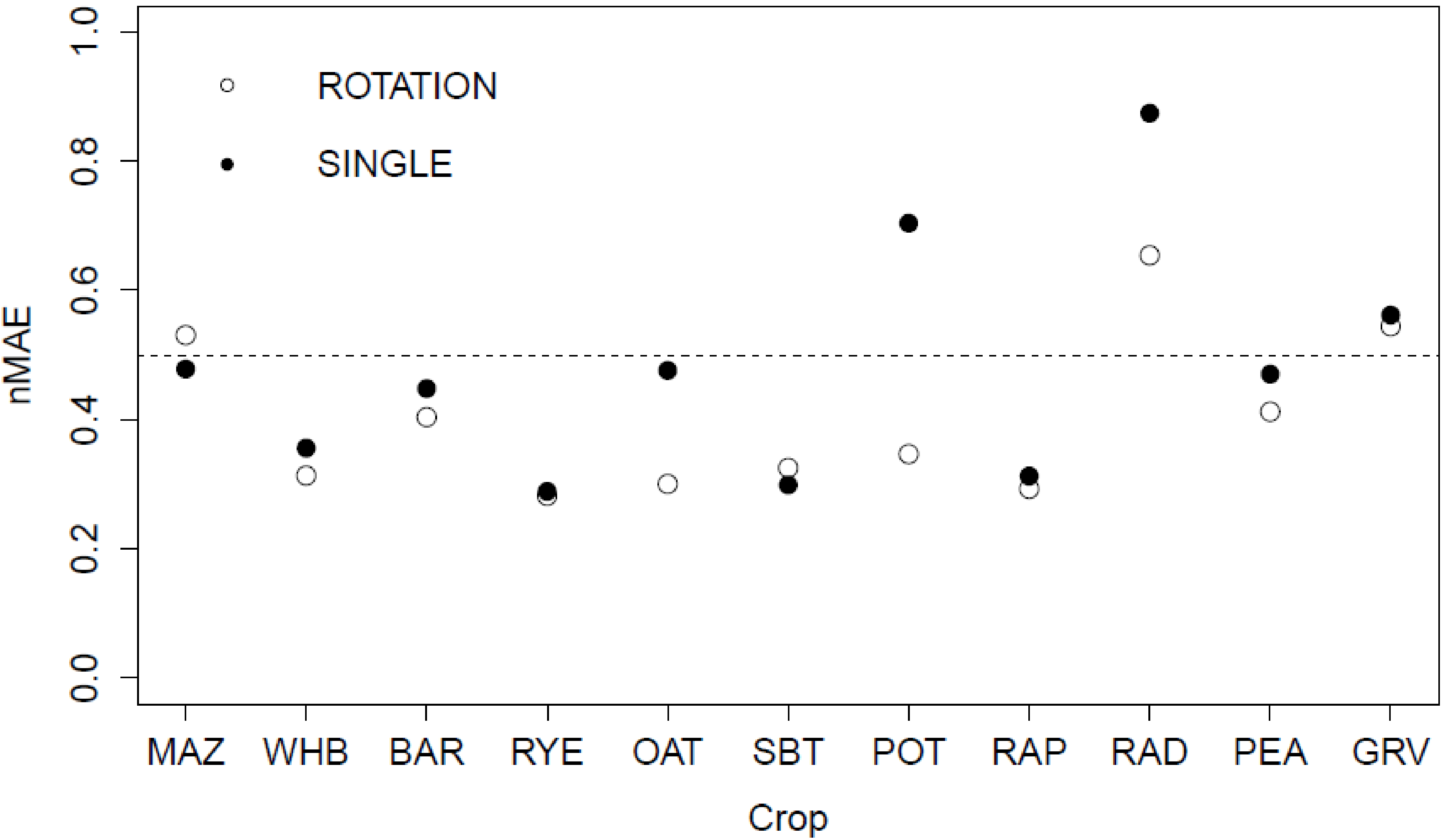


observed and simulated crop yields



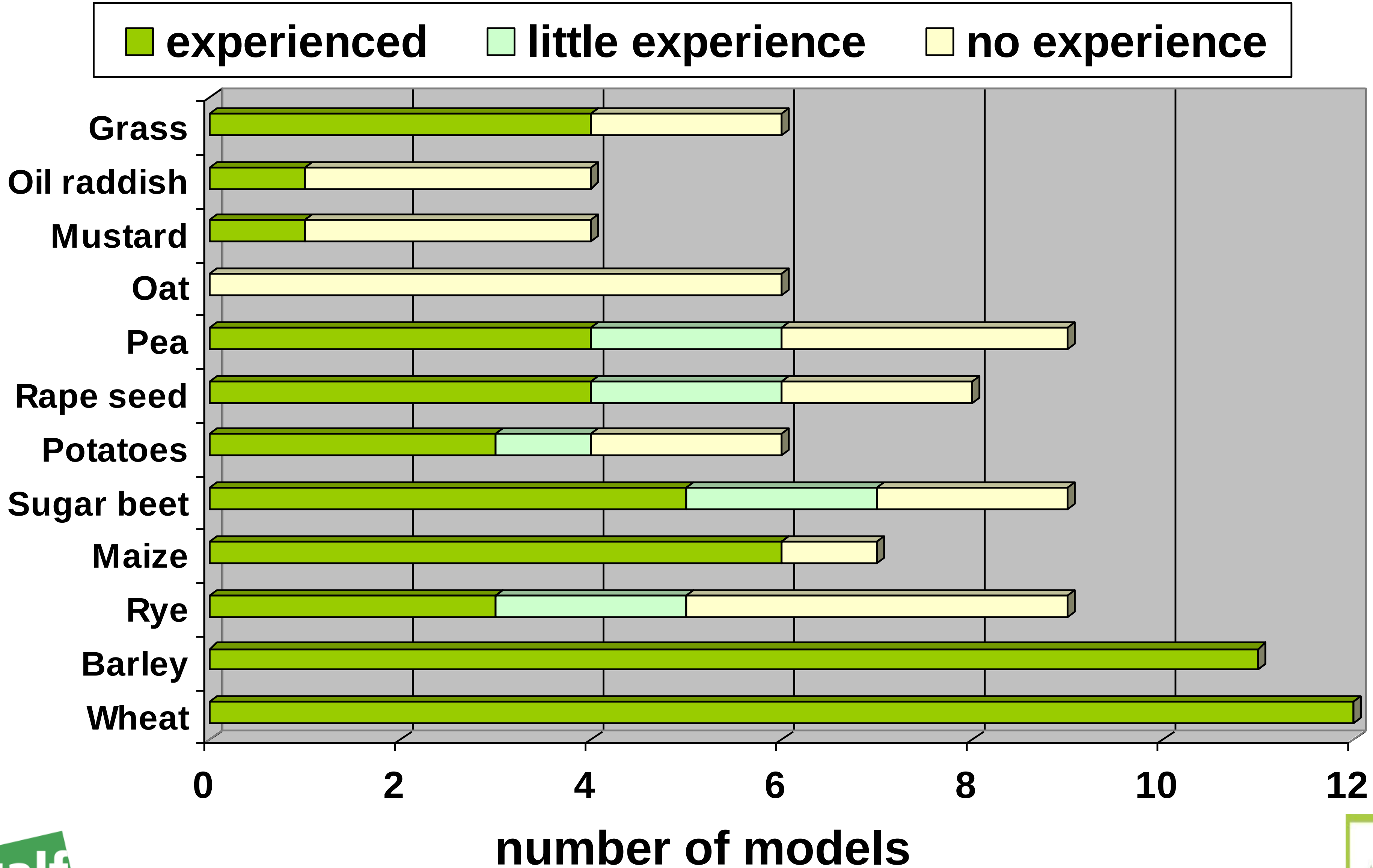
Across all sites, treatments and crops,
the ROTATION results was shown to perform slightly better compared to the SINGLE
but significantly only for one (IA) out of three indices

Rel. MAEs of rotation vs. single year simulation (uncal)

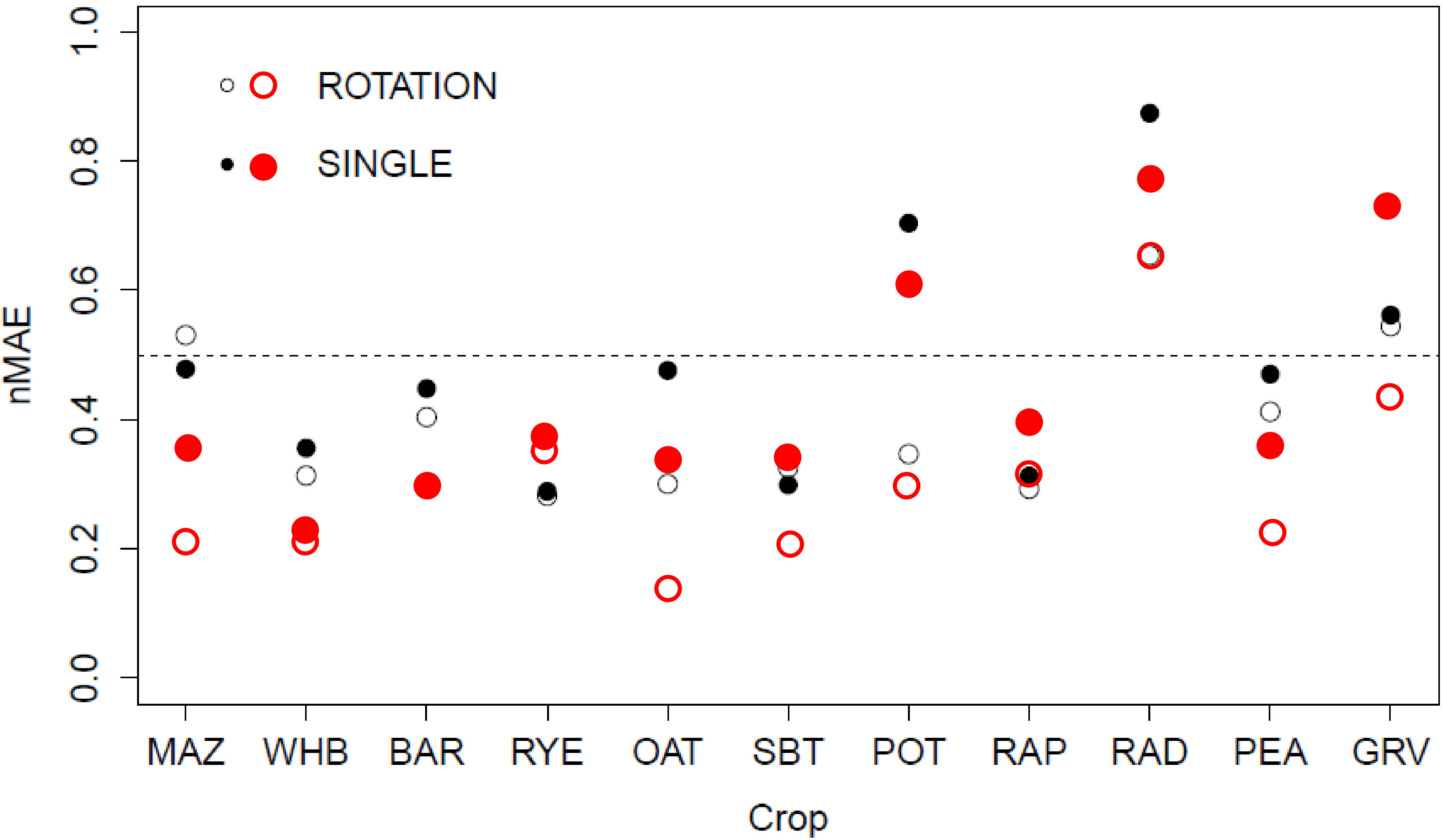


Crop specific performance is significantly better for ROTATION for nMAE and RMSE not for rRMSE for uncalibrated results

model experience regarding single crops

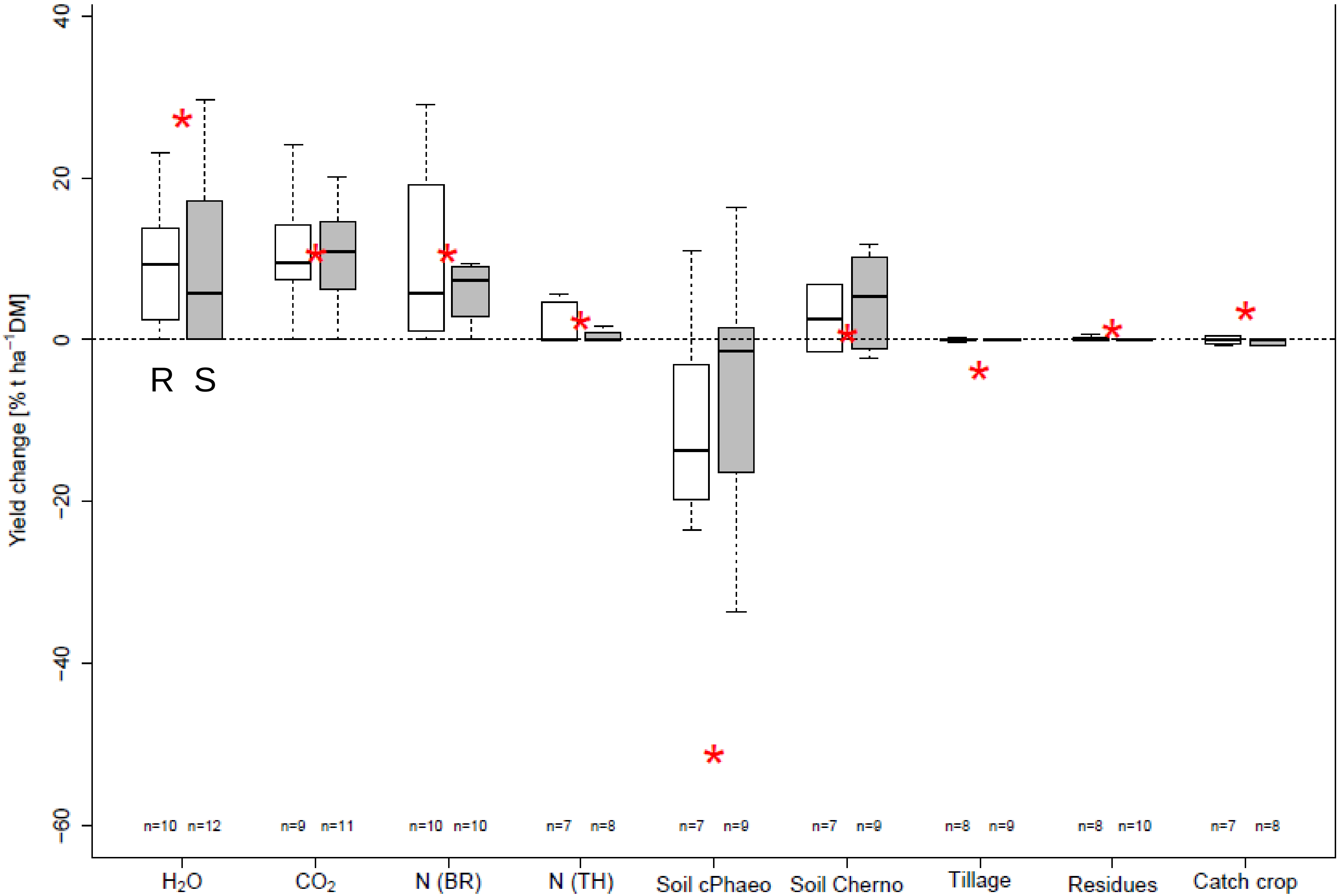


relative MAEs of rotation vs. single year simulation



Crop specific performance is significantly better for ROTATION for nMAE,RMSE and rRMSE for calibrated results

Yield responses to different treatments



Mediterranean site for crop rotation analysis

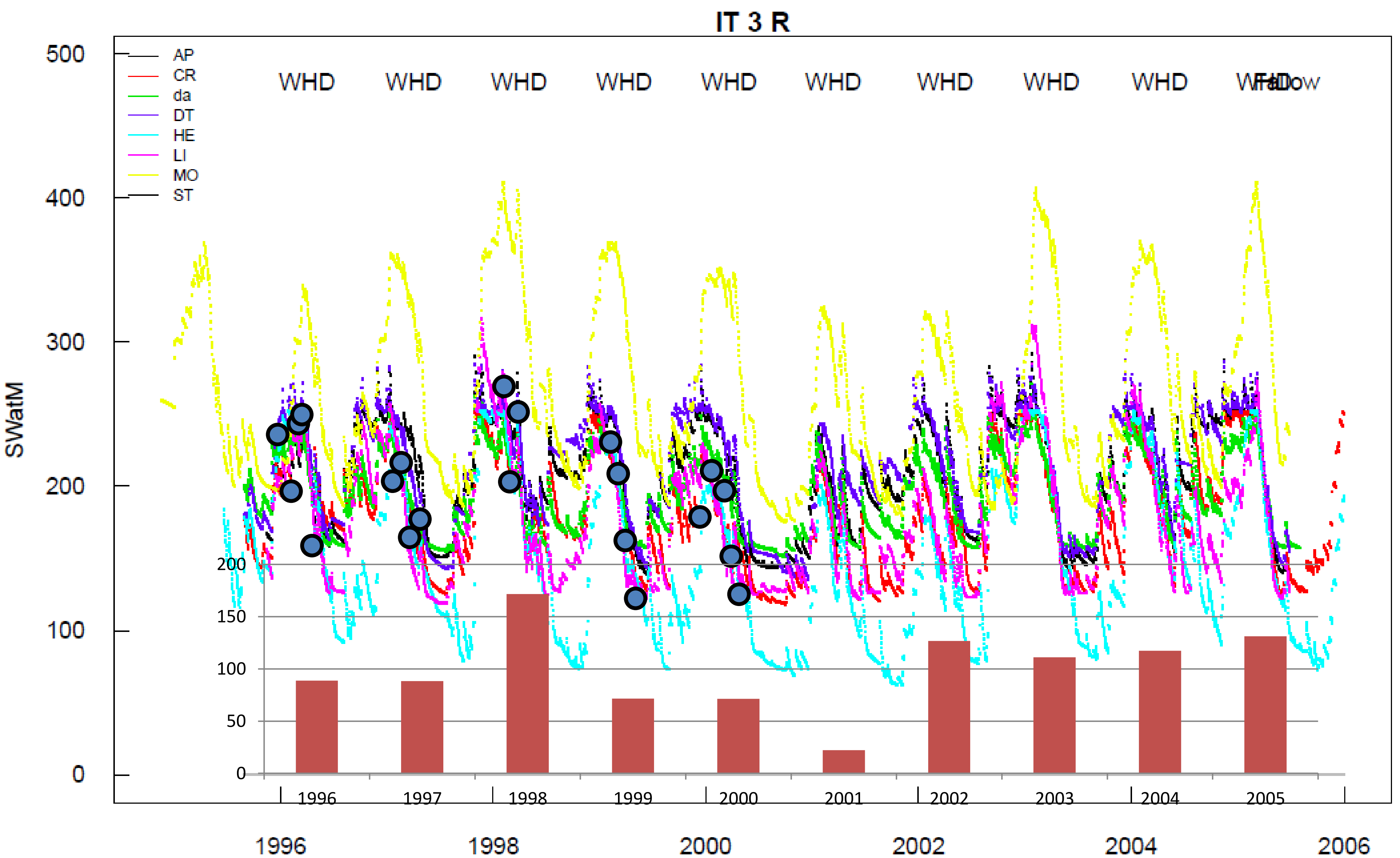
Location: Foggia/Italy

Crop rotation: 11 years durum wheat monoculture

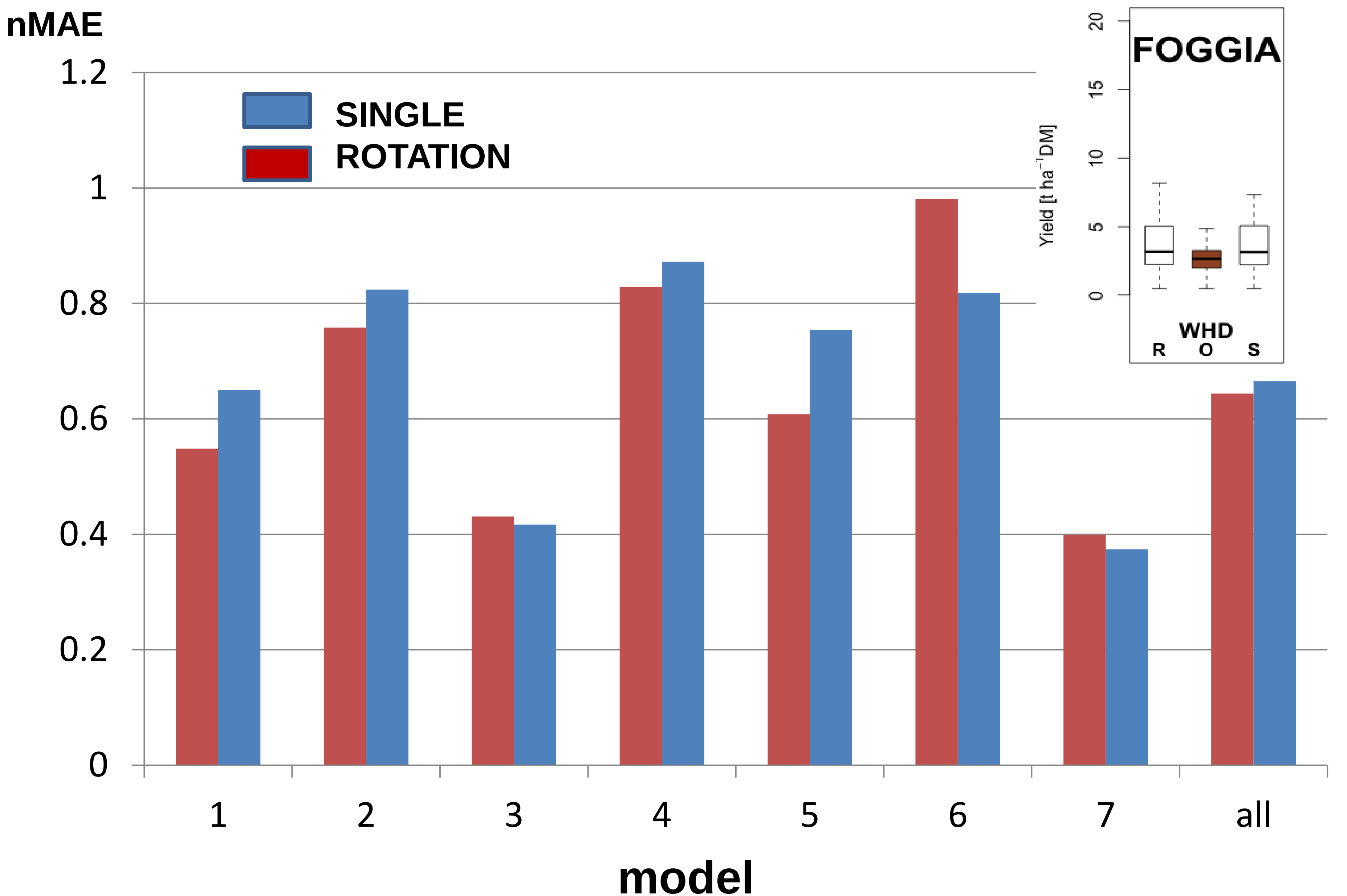
Treatments: 4 treatments with different nitrogen applications

(0, 50, 100, 150 kg N/ha) to straw/stubble in autumn

Soil water content at Foggia (0-60 cm)



nMAE of models with ROTATION and SINGLE mode at Foggia



conclusions

- Not all models are capable to run continuous crop rotations
- Continuous simulation via rotation does slightly improve the performance of yield prediction compared to year-by-year calculations for the uncalibrated models.
- Yield predictions of some crops show high uncertainties since they are not yet well parameterized.
- This may reduce quality of continuous runs and explains partly low differences between continuous and single-year runs.
- Calibration improved performance for specific crops and resulted in significantly better performance though continuous simulation.

conclusions

- Carry over effects were limited due to high nitrogen supply and water availability. Therefore, we selected an additional dry site for analysis.
- Model responses to CO_2 and N supply were similar to observed reactions, while response to water supply and soils was underestimated.
- Tillage and residue management showed no short term effects
- Although crop yields were mostly negatively affected by winter water deficit, the performance of the models in ROTATION mode was again only insignificantly better for the uncalibrated Mediterranean site regarding MAE and IA, but not for RMSE for the uncalibrated run.
- Continuous crop rotation is only beneficial if all crops in the rotation are adequately parametrerized and calibrated.

All models are wrong,
some models are useful G.E.P.Box, 1979

Thank you

for your attention

We greatly acknowledge the national fundings within the framework of the JPI FACCE knowledge hub MACSUR