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# Evaluation of the STICS crop model within the INTERCROP EU project to simulate pea-barley intercropping systems.



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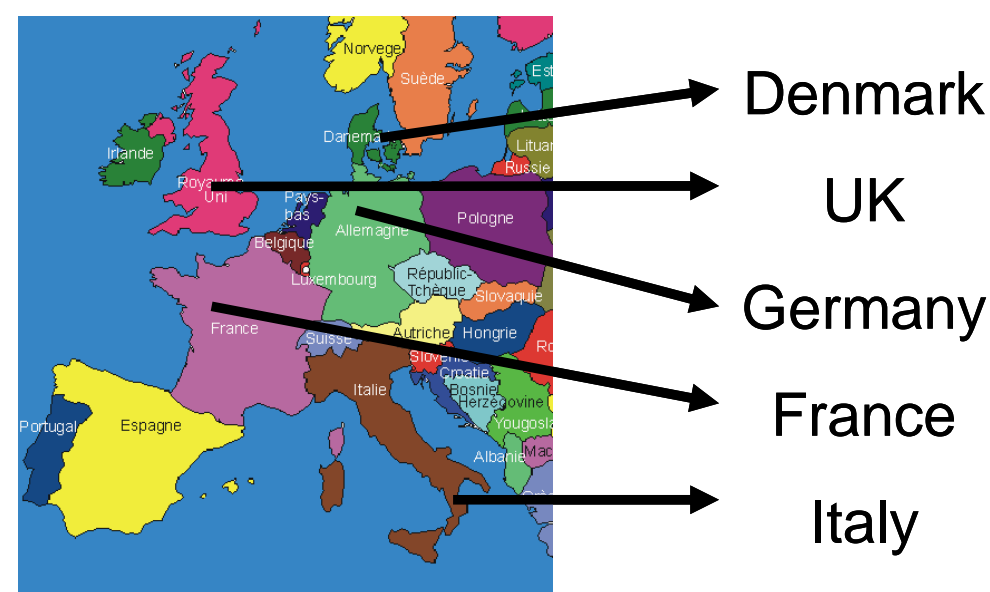
## Objectives

Evaluating a crop model to simulate intercropping systems

Testing agronomic strategies: comparing intercrops/sole crops and testing the influence of the sowing density

## Material and methods

Intercrop network: 5 sites



Model inputs

- Climate
- Soil
- Management: Sole pea (P), Sole barley (B), Additive P100%+B50%, Substitutive P50%+B50%

Model

improvements

- Adaptation for intercropping
- New N fixation formalisms



Model evaluation

- 8 experiments from the 5 site network (2003-2004)

Test agronomic strategies

- 3 sites (Denmark, UK, France)
  - 10 year climatic series
  - 12 density combinations = sowing densities x inter-row distances
- |              |       |
|--------------|-------|
| P100+B50 (A) | 6 cm  |
| P50+B50 (B)  | 12 cm |
| P50-B25 (C)  | 12 cm |
| P75-B75 (D)  | 24 cm |

Parameterization for sole crops of pea and barley (France, 2002 and 2003)

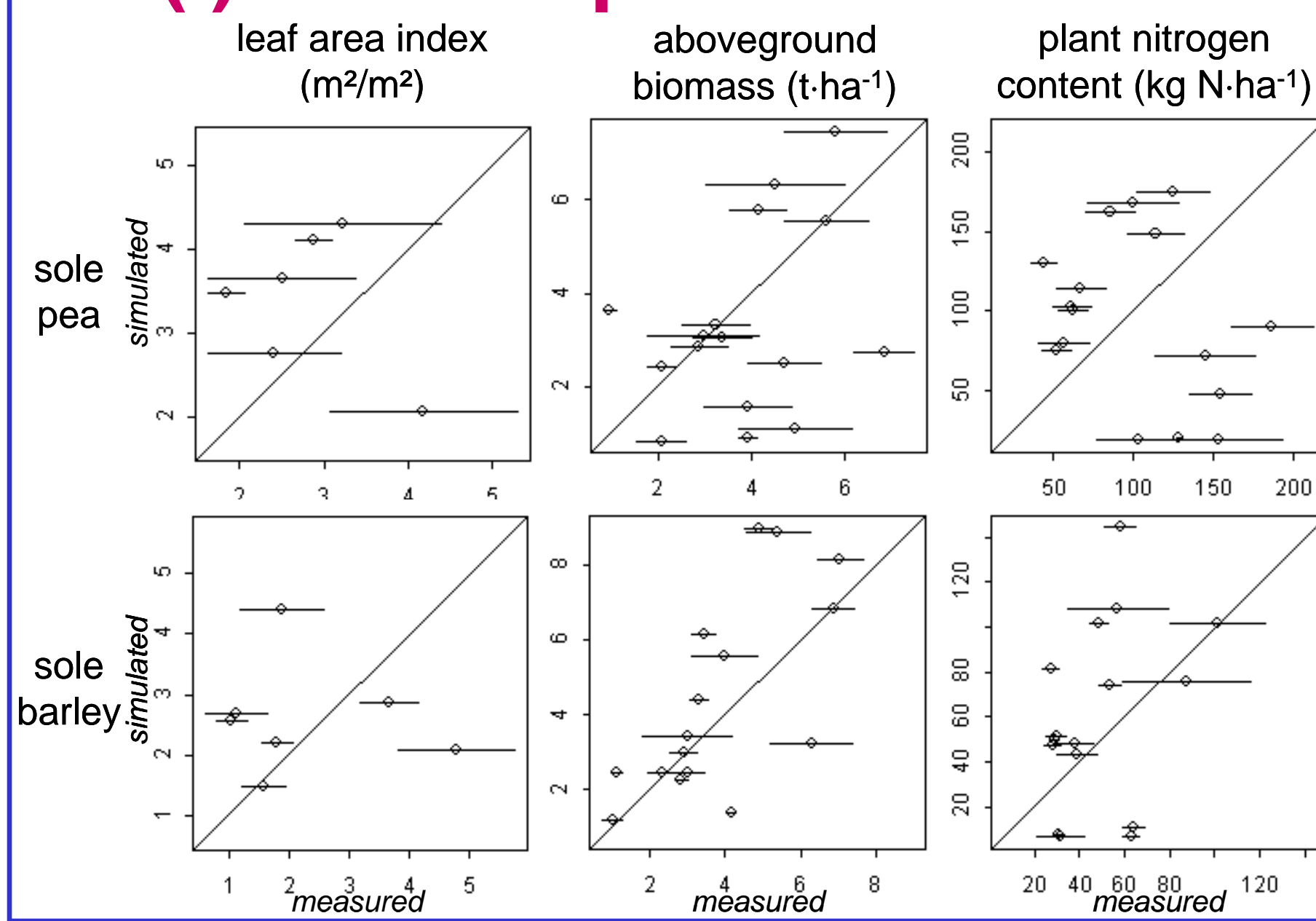
- Plant parameters

## 1- Model evaluation

## Results

## 2- Use of the model to test agronomic strategies

### (i) sole crops



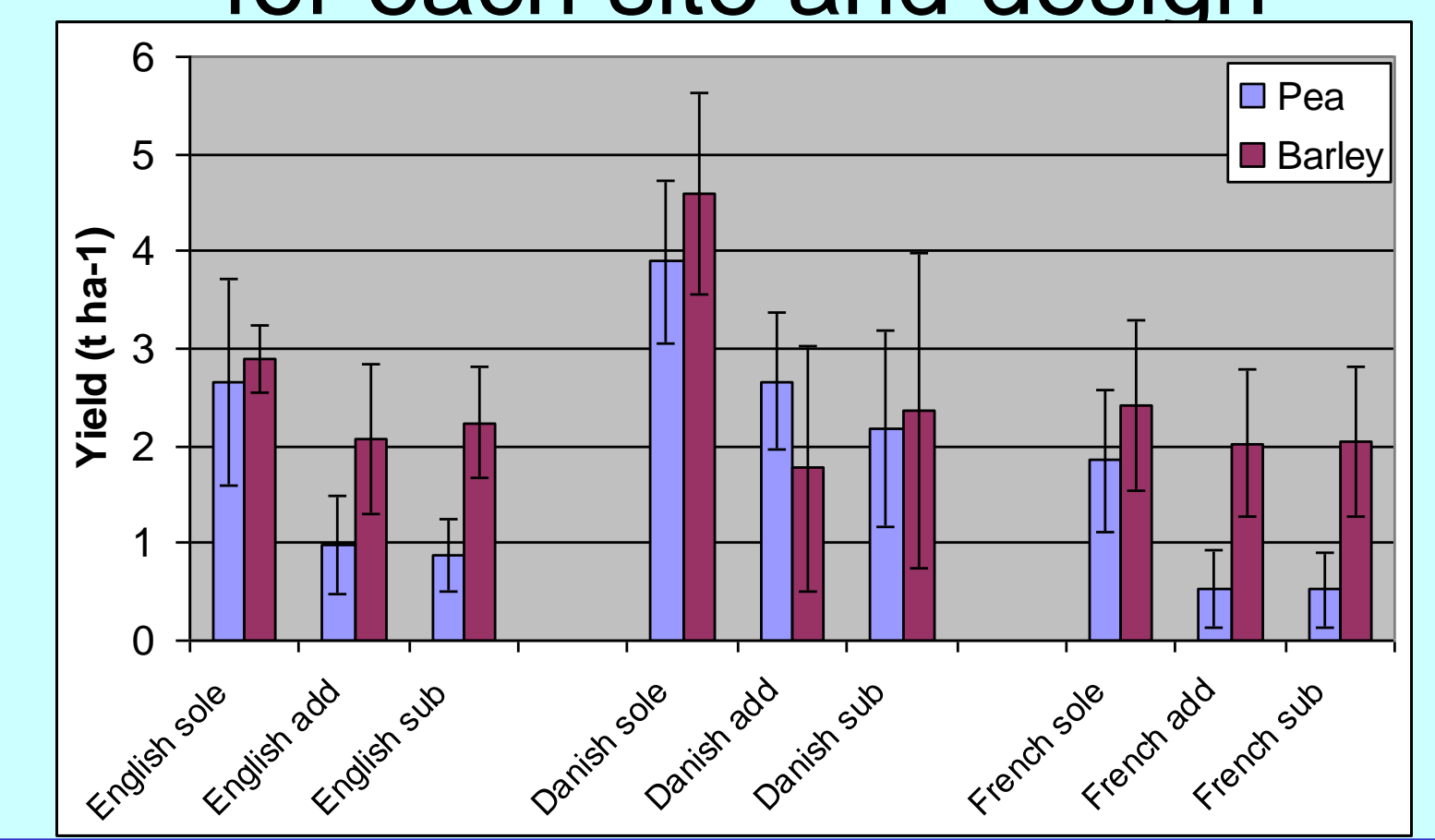
	Leaf area index (m <sup>2</sup> /m <sup>2</sup> )		Aboveground biomass (t·ha <sup>-1</sup> )		Plant nitrogen content (kg N·ha <sup>-1</sup> )	
	Mean of measurements	RMSE	Mean of measurements	RMSE	Mean of measurements	RMSE
Sole pea	2.84	1.37	3.88	2.07	103	76
Sole barley	2.26	1.66	3.85	1.95	49	39

### (i) What are the interests in terms of quantity, quality and stability of pea-barley intercrops compared to sole crops?

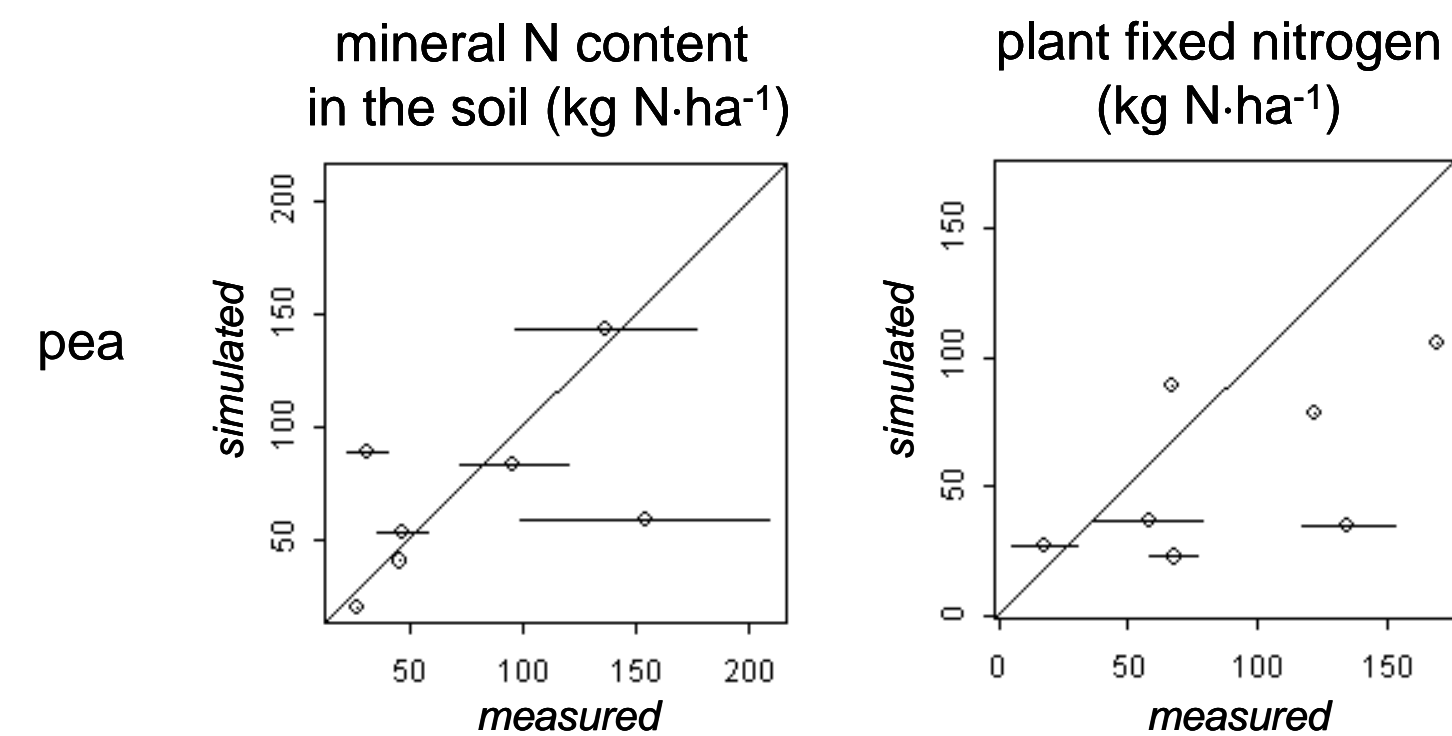
Pea: great difference between sole and intercrops: low competitiveness

Barley: slight advantage for substitutive design: lesser competition with pea

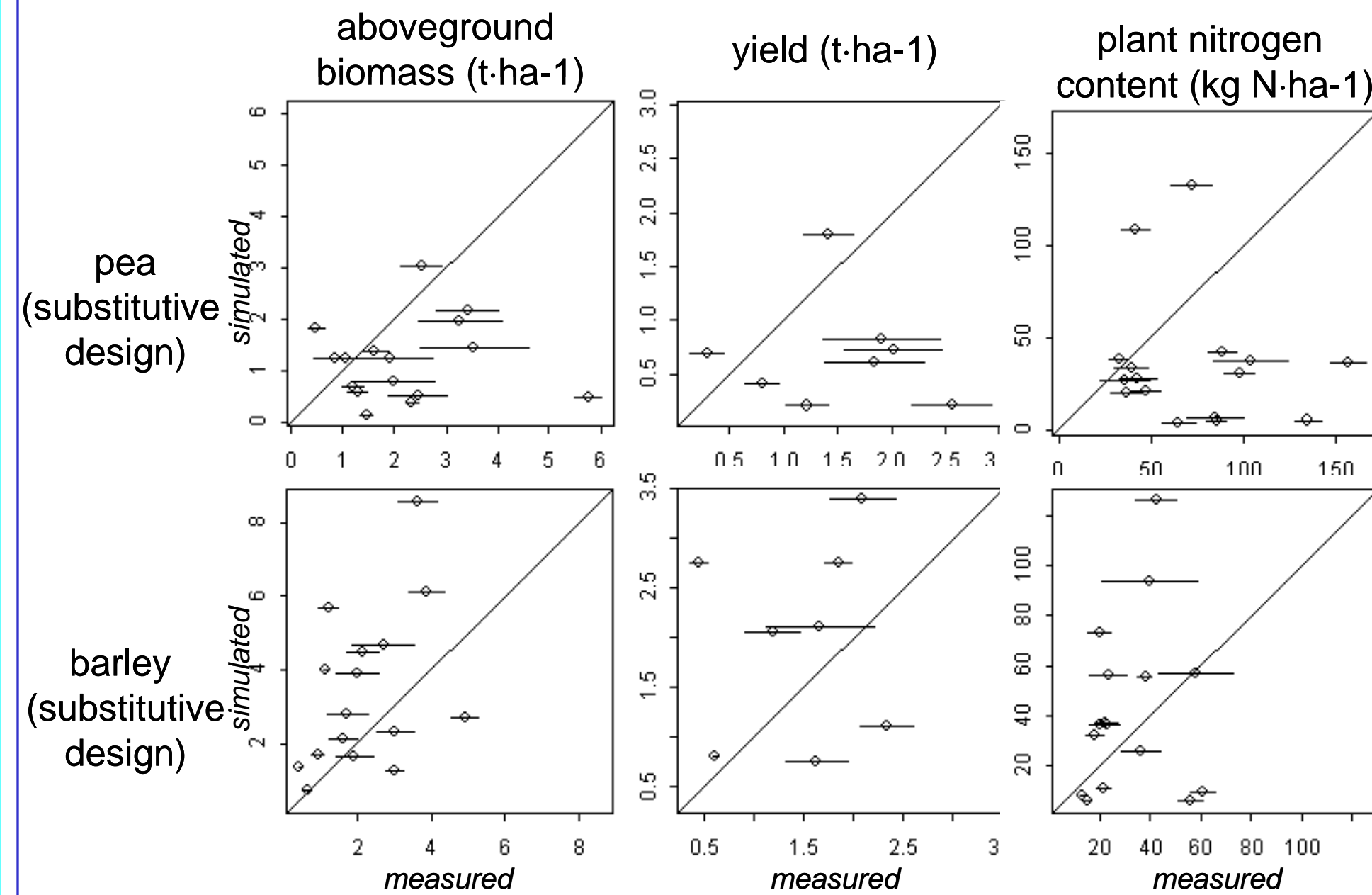
Mean yield over climatic series for each site and design



Pea biomass and plant N underestimated:  
Soil N content well estimated, but N fixation underestimated!



## (ii) Intercrops

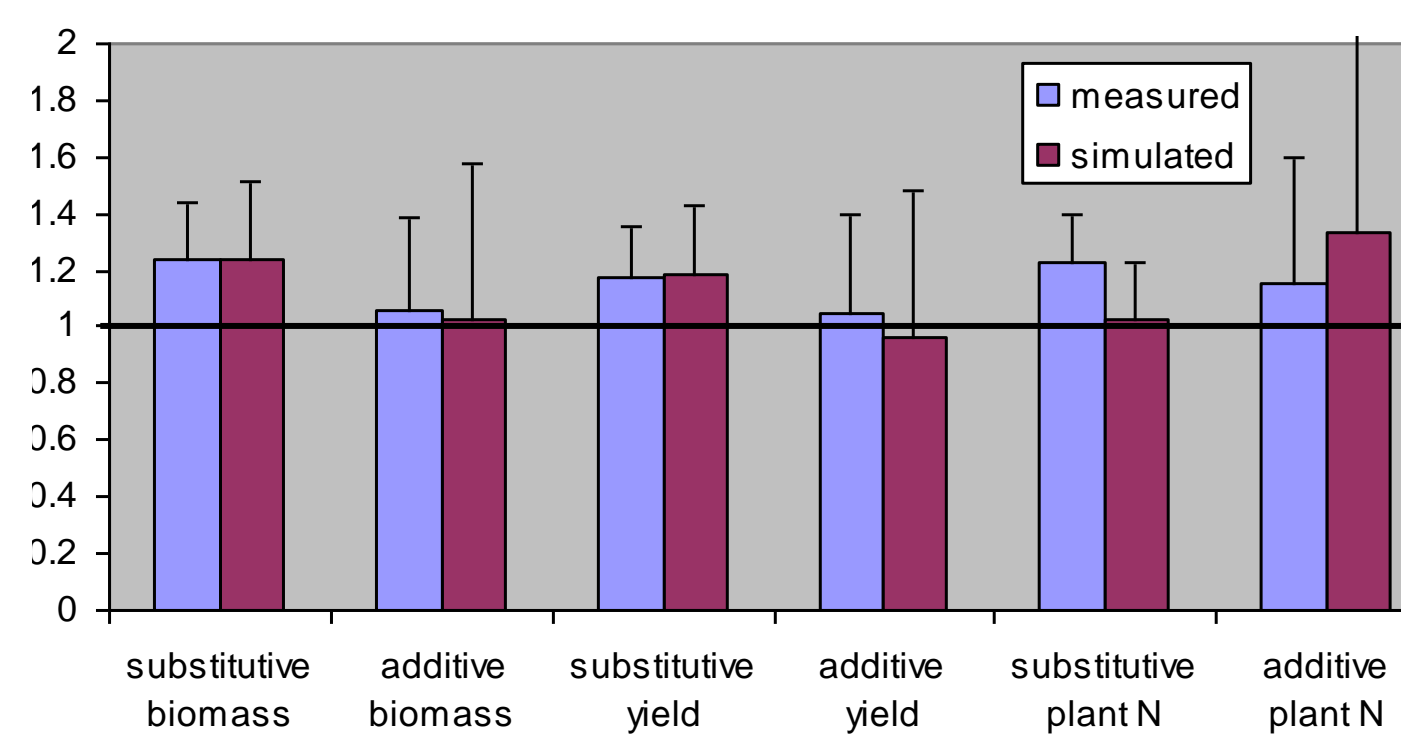


Pea: underestimation due to N fixation underestimation,

	Aboveground biomass (t·ha <sup>-1</sup> )		Yield (t·ha <sup>-1</sup> )		Plant nitrogen content (kg·ha <sup>-1</sup> )	
	Mean	RMSE	Mean	RMSE	Mean	RMSE
Substitutive pea	2.20	1.75	1.51	1.19	57	52
Substitutive barley	2.54	1.82	1.72	0.60	36	34

Barley: overestimation due to non-accounting for biotic stresses

Aboveground biomass, Yield and plant N LERs



- ◆ LERs > 1.0
- ◆ Simulated results more variables
- ◆ Substitutive design gives better results than additive one except for plant N
- ◆ Hierarchy between designs well reproduced by simulation

## Yield and Plant N LERs

location	LER	Yield		Plant N	
		Additive	Substitutive	Additive	Substitutive
England		1.09	1.10	0.99	0.97
Denmark		1.07	1.07	1.17	1.06
France		1.12	1.12	1.01	1.01
<b>All sites</b>		<b>1.09</b>	<b>1.10</b>	<b>1.04</b>	<b>1.00</b>

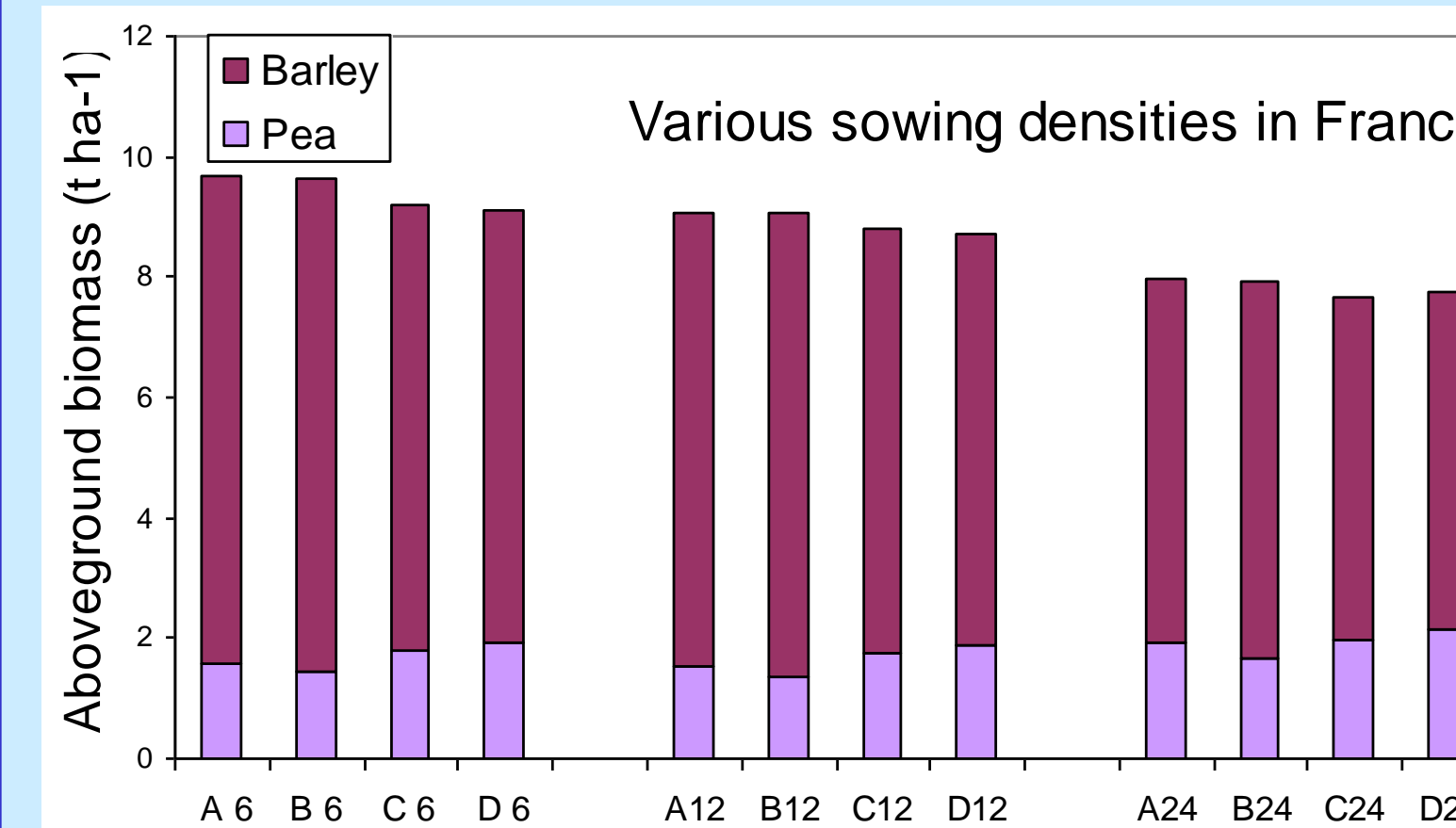
- ◆ Interest of intercropping is obvious in term of yield
- ◆ France location is the most appropriate
- ◆ Additive design in Denmark increases the relative accumulation of nitrogen

Production stability: biomass CV over climatic series

The stability  
◆ decreases at the species level  
◆ increases at the crop level

Coefficient of variation	Sole pea	Additive pea	Substitutive pea	Sole barley	Additive barley	Substitutive barley	Additive intercrop	Substitutive intercrop
England	0.23	0.46	0.30	0.11	0.34	0.24	0.16	0.15
Denmark	0.16	0.22	0.44	0.20	0.61	0.60	0.20	0.17
France	0.32	0.65	0.66	0.34	0.37	0.37	0.27	0.27
<b>All sites</b>	<b>0.30</b>	<b>0.65</b>	<b>0.66</b>	<b>0.36</b>	<b>0.42</b>	<b>0.41</b>	<b>0.27</b>	<b>0.27</b>

## (ii) Which is the influence of the sowing density on the pea-barley intercrop performances?



- ◆ The yield decreases when the inter-row increases whatever the sowing density. It mainly concerns barley.

## Variance analysis

Factor	Biomass	Plant nitrogen
Inter-row	4.7 10 <sup>-5</sup>	3.1 10 <sup>-2</sup>
Density	9.1 10 <sup>-1</sup>	1.5 10 <sup>-1</sup>
Interactions	1.0	1.0

Factor	Pea		Barley	
	Biomass	Plant nitrogen	Biomass	Plant nitrogen
Inter-row	3.4 10 <sup>-3</sup>	2.0 10 <sup>-7</sup>	2.6 10 <sup>-9</sup>	8.5 10 <sup>-2</sup>
Density	4.6 10 <sup>-4</sup>	2.5 10 <sup>-4</sup>	4.3 10 <sup>-2</sup>	6.4 10 <sup>-1</sup>
Interactions	0.987	0.979	0.996	0.999

- ◆ The inter-row factor is a better driver factor for choosing density than global density.
- ◆ Pea is much more sensitive to the density design than barley.

## Conclusion

The evaluation of the STICS intercrop/sole crop model within the INTERCROP EU project, showed that, if we can consider the model to be well adapted to intercrop simulation, it is not the case for organic farming in the sense that it does not account for biotic stresses (weeds and diseases). However, the relative values drew to the same results for simulation and observation, i.e. the global advantage of intercropping compared to sole crops.