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

Denmark
UK
Germany
France
Italy

Model inputs

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

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

- Plant parameters

Model improvements

- Adaptation for intercropping
- New N fixation formalisms

STICS

Model evaluation

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

Test agronomic strategies

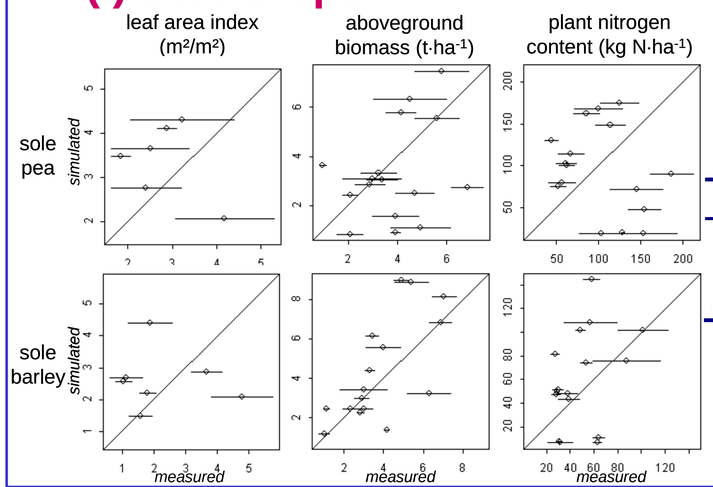
- 3 sites (Denmark, UK, France)
- 10 year climatic series
- 12 density combinations = sowing densities x inter-row distances

P100+B50 (A)		6 cm
P50+B50 (B)	X	12 cm
P50-B25 (C)		
P75-B75 (D)		24 cm

Results

1- Model evaluation

(i) sole crops



	Leaf area index (m²/m²)		Aboveground biomass (t·ha^{-1})		Plant nitrogen content (kg·ha^{-1})	
	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

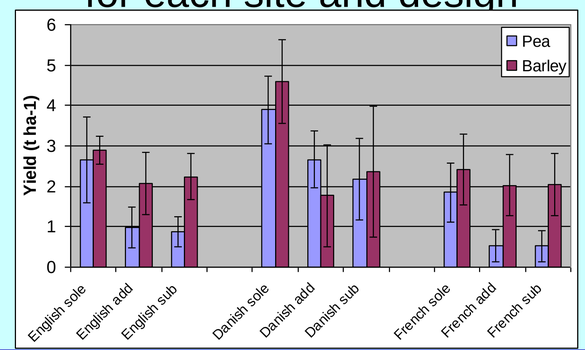
2- Use of the model to test agronomic strategies

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

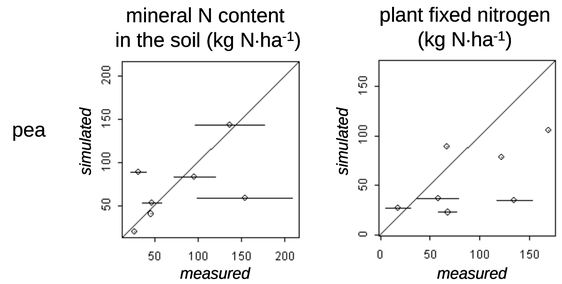
Pea: great difference between sole and intercrops: low competitiveness

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

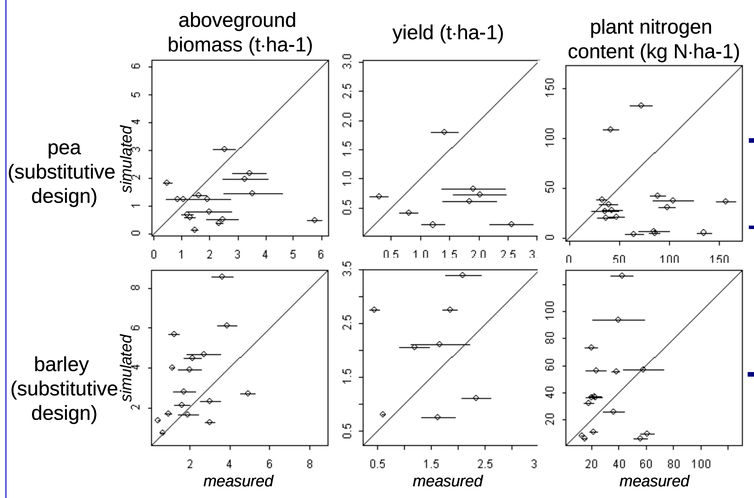
Mean yield over climatic series for each site and design



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



(ii) Intercrops



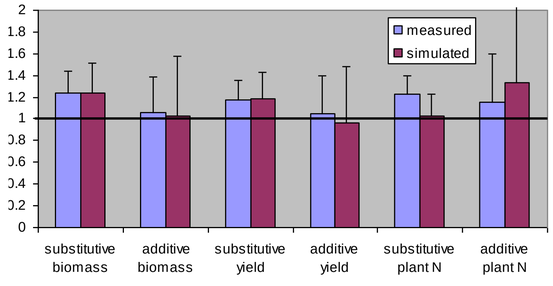
Pea: underestimation due to N fixation underestimation,

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

Barley: overestimation due to non-accounting for biotic stresses

♦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

Aboveground biomass,Yield and plant N LERs



Yield and Plant N LERs

LER		Yield		Plant N	
		Additive	Substitutive	Additive	Substitutive
location	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
All sites		1.09	1.10	1.04	1.00

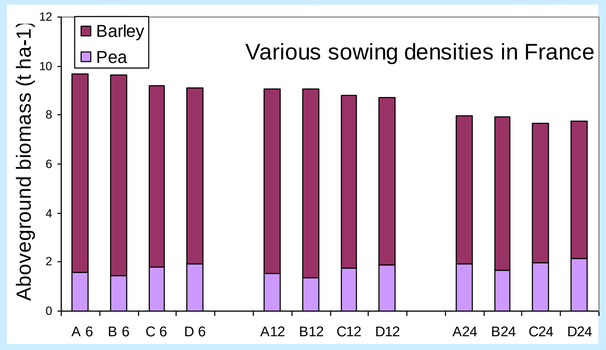
♦Interest of intercropping is obvious in term of yield
♦France location is the most appropriate
♦Additive design in Denmark increases the relative accumulation of nitrogen

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

Production stability: biomass CV over climatic series

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
All sites	0.30	0.65	0.66	0.36	0.42	0.41	0.27	0.27

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



♦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.

♦ 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 10-5	3.1 10-2
Density	9.1 10-1	1.5 10-1
Interactions	1.0	1.0

	Pea		Barley	
Factor	**Biomass**	**Plant nitrogen**	**Biomass**	**Plant nitrogen**
Inter-row	3.4 10-3	2.0 10-7	2.610-9	8.5 10-2
Density	4.6 10-4	2.5 10-4	4.3 10-2	6.4 10-1
Interactions	0.987	0.979	0.996	0.999

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.