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

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***Abstract* - This work is devoted to the evaluation and utilization of the STICS intercrop/sole crop model taking into account the European environmental variability within an organic farming framework. The model ability to simulate intercropping systems was evaluated on the network of the INTERCROP EU project experiments. We first realized the difficulty to simulate relevant absolute production values in spite of a satisfactorily phase of parameterisation in conventional farming experiments. We attributed most of the discrepancies between simulations and measurements to the non accounting of biotic stresses. However, the relative values and in particular the Land Equivalent Ratios draw to the same results for simulation and observation, i.e. the global advantage of intercropping compared to sole crops. Those conclusions caused us to think that the use of the model to test technical strategies was worthwhile. Among the different strategies we tested with the model, one showed that intercropping was very interesting in term of stability, and an other showed that the inter-row factor was a better driver factor for choosing density design than global density.** [1]

## Introduction

Given the complexity of intercropping systems, models can be especially helpful to analyse them comprehensively and to test agronomic strategies. Hence a special issue was devoted to modelling in the INTERCROP FP5 EU project which aimed at promoting pea-barley intercrop as a relevant cropping system for organic farming throughout several European countries (Denmark, France, England, Germany and Italy). The first phase of the work consisted in setting up the STICS crop model (Brisson *et al.*, 2002) from a first intercrop version (Brisson *et al.*, 2004) and ecophysiological experiments conducted in conventional conditions in Angers, France (Corre-Hellou and Crozat, 2005). During this first phase a few new physiological concepts were introduced in the model and a thoroughly parameterization of both species was performed on sole crop trials (Corre-Hellou *et al.*, 2006). This paper focuses on the second phase, devoted to the evaluation and utilization of the STICS intercrop/sole crop model taking into account the European environmental variability within an organic farming framework.

## Analysis of the model agronomic results

The model ability to simulate intercropping systems was evaluated on the network of the INTERCROP experiments. The agronomic and physical framework consisted in 9 pedoclimatic situations spread over Europe. For each sites, three cropping systems were studied : sole crop of pea (100% pea), sole crop of barley (100% barley), additive pea-barley intercrop (100% pea and 50% barley), and substitutive pea-barley intercrop (50% pea and 50% barley). The STICS input data concerned climate, soil and crop management, organised in appropriate input files. In order to evaluate the model, some analytical key crop variables were measured in the fields in 4 replicates such as LAI, biomass, yield and plant nitrogen content. When looking at analytical results, we first realized the difficulty to simulate relevant absolute production values in spite of a satisfactorily phase of parameterisation in Angers in conventional farming. We attributed most of the discrepancies between simulations and measurements to the non accounting of biotic stresses. Consequently, knowing that the conditions of simulation are different from the actual condition of growing within the organic intercropping network of the project, this modelling study could not be considered a validation of the model. In spite of those rather pessimistic conclusions on the ability of the model to simulate correct absolute values, the relative values and in particular the Land Equivalent Ratios draw to the same results for simulation and observation, i.e. the global advantage of intercropping compared to sole crops (Fig. 1).

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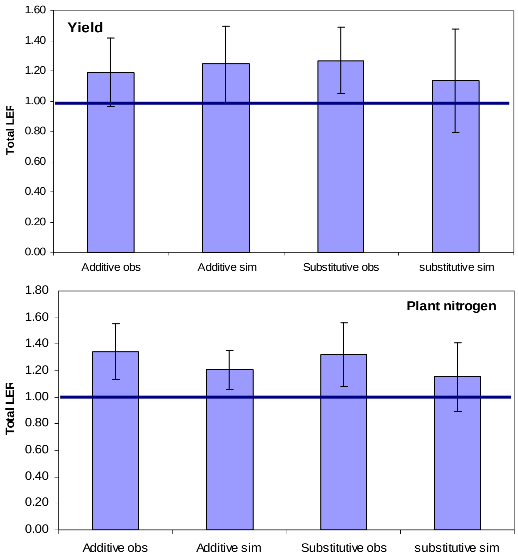


*Figure 1: Comparison of measured and simulated LER for yield and plant nitrogen content throughout the years and locations*

## Use of the model to test agronomic strategies

Then the model was used to investigate various technical intercrop strategies (choice of sowing dates and plant densities, position in the rotation…). In order to reach some generality of the responses through statistical analysis, we used climatic series of around 10 years, on the French, the English and the Danish sites. To illustrate this approach, we detail in this paper the two following questions addressed to the model: What are the interests in terms of quantity, quality and stability of pea-barley intercrops compared to sole crops? Which is the influence of the sowing density on the pea-barley intercrop performances?

To answer the first question, we realized the four types of simulations corresponding to the INTERCROP project experimental design (sole pea crop, sole barley crop, additive pea-barley intercrop and substitutive pea-barley intercrop) but over the climatic series. In order to estimate the stability of intercropping we calculated the coefficient of variation of the produced biomass over the climatic series. The results (Table 1) showed a decrease in the production stability at the species level (except for barley in France and in Denmark) while it is clearly an improvement at the crop level as if the intercrop system allows compensation in the specific reaction to the year to year climatic variability.

**Table 1.** Biomass over year statistics.

| Coefficient of variation | Sole pea | Additive pea | Substitutive pea | Sole barley |
|---|---|---|---|---|
| France | 0.24 | 0.42 | 0.42 | 0.20 |
| England | 0.15 | 0.25 | 0.21 | 0.09 |
| Denmark | 0.11 | 0.34 | 0.29 | 0.18 |

| Coefficient of variation | Additive barley | Substitutive barley | Additive intercrop | Substitutive intercrop |
|---|---|---|---|---|
| France | 0.18 | 0.18 | 0.21 | 0.21 |
| England | 0.19 | 0.16 | 0.14 | 0.12 |
| Denmark | 0.17 | 0.18 | 0.08 | 0.10 |

To answer the second question, we tested both the inter-row and the in-between plants on the raw distances in order to identify the most interesting combination. The simulation results showed that the inter-row factor was a better driver factor for choosing density design than global density.

## 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. The use of the model to test agronomic strategies, on different pedoclimatic situations, showed that the strategies to get the best agricultural results can be different according to locations and output objectives: pea or barley, grain or forage utilisation.

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