PERSYST, a cropping system model based on local expert knowledge

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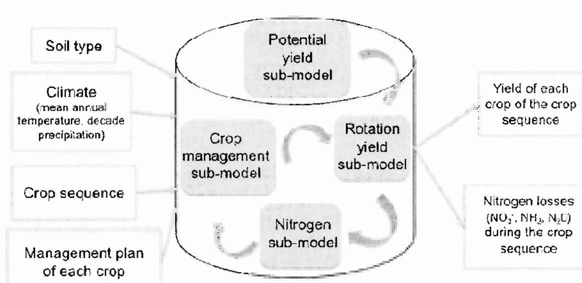
A large number of alternative cropping systems need to be investigated in order to identify the most suitable ones for a given set of objectives. Few crop models can be used to generate and assess cropping systems because they generally account for a limited number of production factors, and include a large number of parameters that are difficult to estimate. The cropping system model Persyst was developed to simulate the effect of crop sequence and crop management techniques on yield and nitrogen losses in the environment at a yearly time step. As Persyst is easy to parameterize from local expert knowledge, it could be implemented in different contexts by the model users themselves.

Model description

In Persyst, yield is calculated as a function of limiting and reducing factors (Van Ittersum and Rabbinge, 1997). Experts define a potential yield (i.e. when only climatic factors reduce yield) for each soil type of the study area. They also assess the yield reduction due to (i) the preceding crop effect, (ii) the frequency of crops affected by the same pests and diseases in the crop sequence, and (iii) soil physical and chemical fertility. This information is integrated in Persyst at the crop sequence level. The yield reduction is then corrected as a function of crop management techniques (sowing period, nitrogen fertilization, number of fungicides, insecticides and other pesticide applications). Nitrogen losses are assessed using the I_N indicator of the Indigo environmental assessment method (Bockstaller et al. 2008).

Figure 1: Model description



Methodology for parameter estimation

The main original feature of Persyst is the integration of local expert knowledge to estimate potential yields and percentages of yield reduction due to limiting factors.
Twelve experts (farmers' advisors and agricultural engineers) from Poitou-Charentes (Center-West of France) were asked to assess yield parameters. In the first part of the interview, experts were asked to (i) assess the potential yield of a given crop (ii) specify the main characteristics of the crop management systems and the preceding crop which provides this potential yield, (iii) express their assessments in deciles values to identify the variability in potential yield. Results provided by the individual expert were then discussed collectively and decision rules were designed to synthesize local knowledge (see results section).

This methodology combines several characteristics of the Delphi method (Pill, 1971) and of the techniques of elicitation of experts' judgments proposed in the SHELF (Sheffield Elicitation Framework) method (O'Hagan, 2001).

Results and discussion

Table 1 shows an example of results for wheat potential yields in two soil types derived from the expert interviews.

Table 1: Parameter assessment for wheat potential yields in two soil types, a shallow soil (limestone, 40 cm) and a deep soil (loamy soil, 100 cm) (Poitou-Charentes, France). Minimum (maximum) is the min (max) value given among all experts answers. Left table presents the results obtained from the individual step of interviews while results after collective discussion are presented in the right table.

Wheat potential yield	Shallow soil		Deep soil	
	1st decile	9th decile	1st decile	9th decile
Number of answers		*7*		*8*
Mean (q.ha-1)	55	71.4	77	95
STD (q.ha-1)	12.9	14.4	10.2	8.5
Minimum (q.ha-1)	40	55	60	80
Maximum (q.ha-1)	80	100	91	105

Shallow soil		Deep soil	
1st decile	9th decile	1st decile	9th decile
	5		*6*
53	69	77	96
5.7	5.5	6.9	5.8
45	60	65	90
60	75	85	105

In the second part of the individual step, experts were asked to assess the effect on yield of (i) a shift in the preceding crop, or (ii) a modification of the frequency of crops sensitive to the same soil-borne pathogens in the crop sequence. They were also asked about the effect of soil-borne pests and diseases, soil structure, delayed sowing date (and others factors) on yield. The third part of the interview dealt with the consequences of some crop management techniques (and their interactions) on yield. The aim was to identify modifications in the crop management plan that allow compensating partially or totally the reduction of yield and to quantify it. For each crop, Dexi software (Bohanec, 2008) was used to organize and implement in a generic way the main interactions between techniques (cultivar choice, sowing date and density, fertilization, crop protection, etc.) and their consequence on yield.

The collective step led us to adopt the following decision rules: (i) excluding extreme values when more than five responses were given, (ii) averaging of the remaining values. Finally, these rules led us to decrease the range of yield variation within responses for a same soil context, and the final values were accepted by all the experts.

Conclusion

The Persyst model and the methods used to elicit local experts' knowledge allow local parameter assessment as well as integration of additional knowledge. In the future, we plan to describe potential yield values using probability distributions (instead of point values) and to combine expert knowledge with several sources of experimental data (synthesized by meta-analysis).

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