Towards control of Ascochyta Blight in pea/wheat intercrops using qualitative modeling Centre Occitanie-Toulouse

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Introduction

Ascochyta blight, mainly caused by *Didymella pinodes* is one of the most damaging aerial diseases on pea crops. Today, chemical control is the main method used to contain the disease. However, it leads to environmental pollution, can generate biodiversity loss in agricultural systems, and can lead to resistance in targeted populations, Intercropping (species mixtures of two or more crops in the same field at the same time, or relayed ; Willey, 1979) could enhance the control of Ascochyta blight due to the presence of non-host species that act as physical barriers to inoculum dispersal, or to the modification of the canopy microclimate or plant receptivity (Schoeny et al, 2009; Fernández-Aparicio, et al, 2010). However, the effects of crop management on disease development are difficult to handle. Modeling is a powerful tool that can help improve disease control allowing the representation of relationships between factors such as cropping practices, soil, weather, crop characteristics and field environment. For this purpose, we proposed a qualitative and aggregative model to predict Ascochyta blight severity in pea/wheat intercrops based on a modeling method named Injury Profile SIMulator (IPSIM) (Aubertot & Robin, 2013).

IPSIM method

IPSIM is based on qualitative hierarchical multi-attribute decision modeling (Aubertot & Robin, 2013). This method is composed of four successive steps presented in Figure 1. In first step, we identified and organized the attributes based on expert knowledge and scientific literature. In second step, qualitative scales are defined from nominal or ordinal values. Attribute values in red, black and green are favorable, neutral and unfavorable to Ascochyta blight development, respectively. In third step, we built aggregative tables for each aggregated attribute, A set of IF-THEN rules defines the value of the considered attribute as a function of the values of its immediate descendants attributes in the model., The evaluation consists in comparing observed and simulated classes of *Didymella pinodes* severity using an independent dataset covering a wide range of production situations. In addition, in order to run the qualitative model, it is necessary to design a converter that will transform nominal input variables, or quantitative input variables into ordinal variables such as required by the IPSIM method,

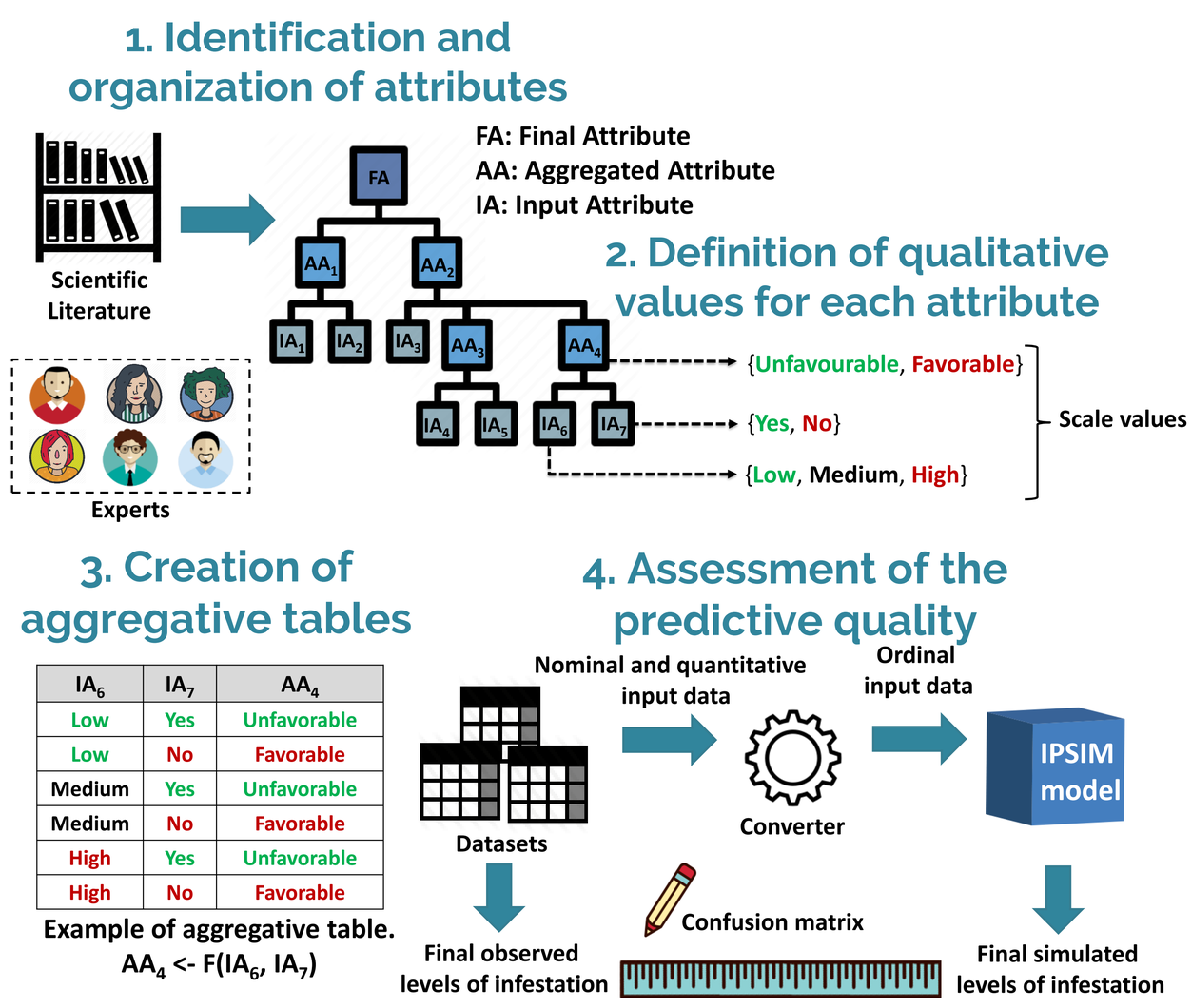

Figure 1. Steps of Injury Profile SIMulator (IPSIM) method

Preliminary results

Attribute	Scale
D.pinodes severity on pea/wheat intercrops	Extreme; High; Moderate; Low; *Very low*
├─Cropping practices	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Preventive measures	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ ├─Chemical control	*Yes*; No
│ │ ├─Sowing date	Early; Normal; *Late*
│ │ └─Risk for seed transmision	*Absence*; Presence
│ ├─Impact of intercropping	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ ├─Competition	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ │ ├─Cultivar choice for wheat	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ │ │ ├─Cereal canopy height	*Short*; Average; High
│ │ │ │ └─Tillering ability	*High*; Moderate; Low
│ │ │ ├─Cultivar choice for pea	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ │ │ ├─Pea canopy height	*High*; Average; Short
│ │ │ │ ├─Resistance to lodging	*High*; Moderate; Low
│ │ │ │ └─Foliage type	conventional; *Semi-leafless*
│ │ │ └─Available N by the end of winter	High; Moderate; *Low*
│ │ └─Pea density in the mixture	Pea sole crop; IC-P/W density equal to the recommended sowing dose; *IC P/W density lower than recommended sowing dose*; *IC P/W density much lower than recommended sowing dose*
│ └─Curative chemicals	*Yes*; No
├─Weather conditions	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Weather from emergence to the end of winter	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ ├─Temperature	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ ├─Relative Humidity	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ └─Rainfall	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Weather from end the winter to flowering	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ ├─Temperature	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ ├─Relative Humidity	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ │ └─Rainfall	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ └─Weather from flowering to seed filling	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Temperature	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Relative Humidity	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Rainfall	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ ├─Dew	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
│ └─Irrigation	Favorable to D.pinodes; Moderately favorable to D.pinodes; *Unfavorable to D.pinodes*
└─Interactions with landscape: Stubble management	*Efficient*; Quite efficient; Unefficient
├─Shredding	*Yes*; No
├─Exportation	*Yes*; No
└─Tillage	*Ploughing*; Superficial tillage; No tillage

Figure 2. Aggregative hierarchical tree of attributes and qualitative scales of IPSIM-Pea/Wheat-Ascochyta blight

IPSIM-Pea/Wheat-Ascochyta blight is composed of 37 attributes (25 input attributes, and 12 aggregated including the output attribute Ascochyta blight severity) (Figure 2), 48 scale values and 459 rules. We considered 15, 4 and 17 attributes from weather, landscape and cropping practices, respectively,

Discussion

Before using the model to support farmers with technical advises, we need to be confident with its quality of prediction. Currently, we are building a dataset from French experimental crops (provided by research centers) in order to evaluate IPSIM-Pea/Wheat-Ascochyta blight. The originality of the approach is to make us of any source of knowledge available: published technical and scientific papers, expert knowledge, existing quantitative simulation models (to create the required converter), and data from experiments or observations in commercial fields. This approach permits to easily create models helping the management of agroecosystems involving complex interactions and less dependent to pesticides, such as the ones with species mixtures.

References

Aubertot, J.-N., & Robin, M.-H. (2013). Injury Profile SIMulator, a qualitative aggregative modelling framework to predict crop injury profile as a function of cropping practices, and the abiotic and biotic environment. I. Conceptual bases. PLoS One, 8(9), e73202.
Fernández-Aparicio, M., Amri, M., Kharrat, M., & Rubiales, D. (2010). Intercropping reduces Mycosphaerella pinodes severity and delays upward progress on the pea plant. Crop Protection, 29(7), 744–750.
Schoeny, A., Jumel, S., Rouault, F., Lemarchand, E., Tivoli, B. (2009). Effect and underlying mechanisms of pea-cereal intercropping on the epidemic development of ascochyta blight. european Journal of plant pathology, 126 (3), 317-331
Willey, R. W. (1979). Intercropping: Its Importance and Research Needs. Agronomy and Research Approaches.

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