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Modèles qualitatifs : IPSIM, un outil pour une gestion intégrée des ennemis des cultures.

Jean-Noël Aubertot, UMR AGIR, Toulouse

30/11/2015

PLAN

1) Présentation de la problématique agronomique

2) Présentation de la problématique mathématique

3) Discussion

Jean-Noël Aubertot, UMR AGIR, Toulouse

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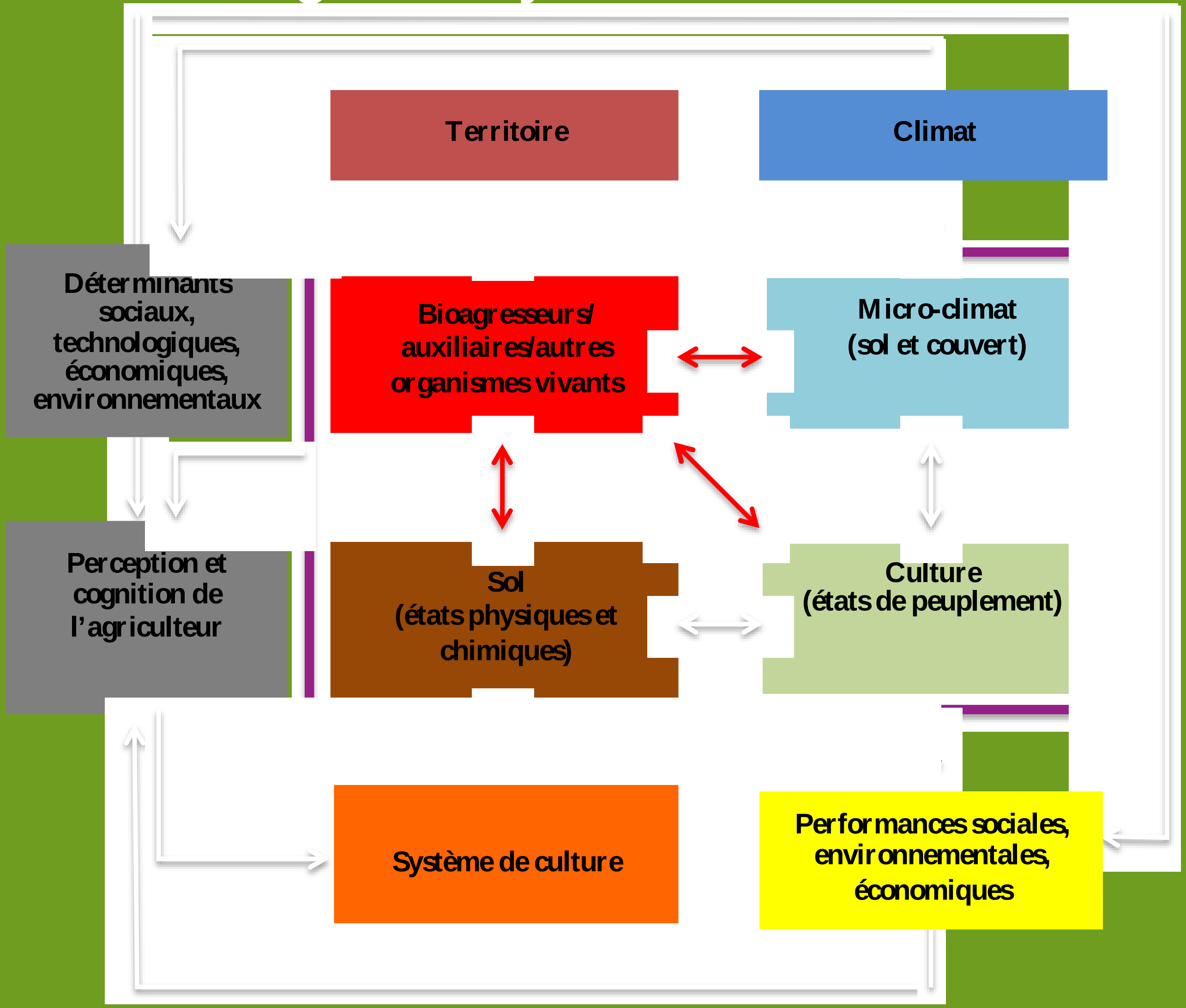
AGROECOLOGIE

Compréhension, grâce notamment aux concepts et méthodes de l’écologie, des mécanismes, processsus et régulations biologiques à l’œuvre dans les agro-écosystèmes appréhendés à différentes échelles, et valorisation des connaissances afférentes dans la conception et l’évaluation de systèmes techniques agricoles innovant.

T Doré (AgroParisTech)

Deguine JP, Atiama-Nurbe, Aubertot JN, Augusseau X, Atiama M, Jacquot M, Reynaud B. 2015. Agroecological management of cucurbit-infesting fruit fly: a review. Agronomy for Sustainable Management

Enjeux scientifiques : analyse et modélisation des régulations biologiques au sein des agroécosystèmes



Territoire

Climat

Déterminants sociaux, technologiques, économiques, environnementaux

Bioagresseurs/ auxiliaires/autres organismes vivants

Micro-climat (sol et couvert)

Perception et cognition de l'agriculteur

Sol (états physiques et chimiques)

Culture (états de peuplement)

Système de culture

Performances sociales, environnementales, économiques

Objectifs

La gestion agroécologique des bioagressions nécessite :

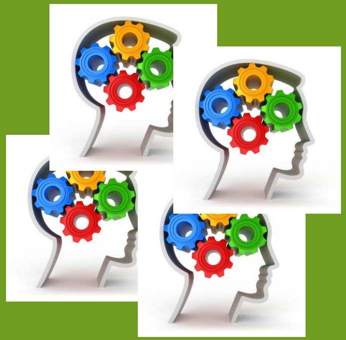
1)Une **production de connaissances** sur les effets du pédoclimat et des actions anthropiques sur les dynamiques biotiques *sensu lato*

2)Un renouvellement méthodologique pour **l'intégration** verticale et horizontale des méthodes de gestion des bioagressions

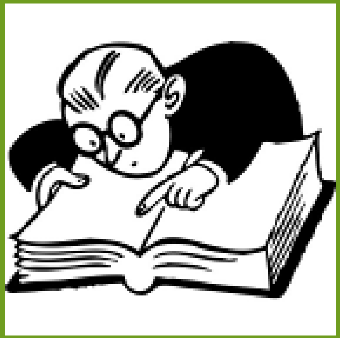
1)Un renouvellement méthodologique pour réduire le fossé entre production de connaissances académiques et **utilité agronomique**

Pas de jeux de données permettant de caractériser simultanément :

- -La situation de production
- -Les pratiques agricoles
- -Les profils de dégâts

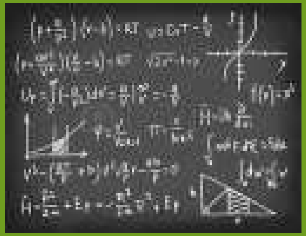


Expertises



Analyses bibliographiques

Intégration des connaissances



Modèles existants

Diagnostics en parcelles agricoles

Expérimentations

IPSIM-WHEAT (Injury Profile SIMulator), a hierarchical , aggregative and qualitative model to predict wheat injury profile as a function of cropping practices, soil, climate and field environment. PhD thesis defended February 7 2014.

Marie-Hélène ROBIN, EI Purpan

Jean-Noël AUBERTOT, UMR AGIR, Philippe DEBAEKE, UMR AGIR

BDD nationale essais blé : INRA, Arvalis, CA, GEVES, In Vivo, Bayer ; Cholez, 2011, Prix de la fondation Xavier Bernard de l'Académie d'Agriculture de France ; rés0Pest ; diagnostic en parcelles agricoles

Réseau PIC PMNET

INRA cirad

Cité des Sciences Vertes
Établissement Public

Réseau Mixte Technologique
Systèmes de Culture Innovants

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Rés0Pest

GRANDE CULTURE
GCHP2E

ÉCOPHYTO
RÉDUIRE ET AMÉLIORER L'UTILISATION DES PHYTOS

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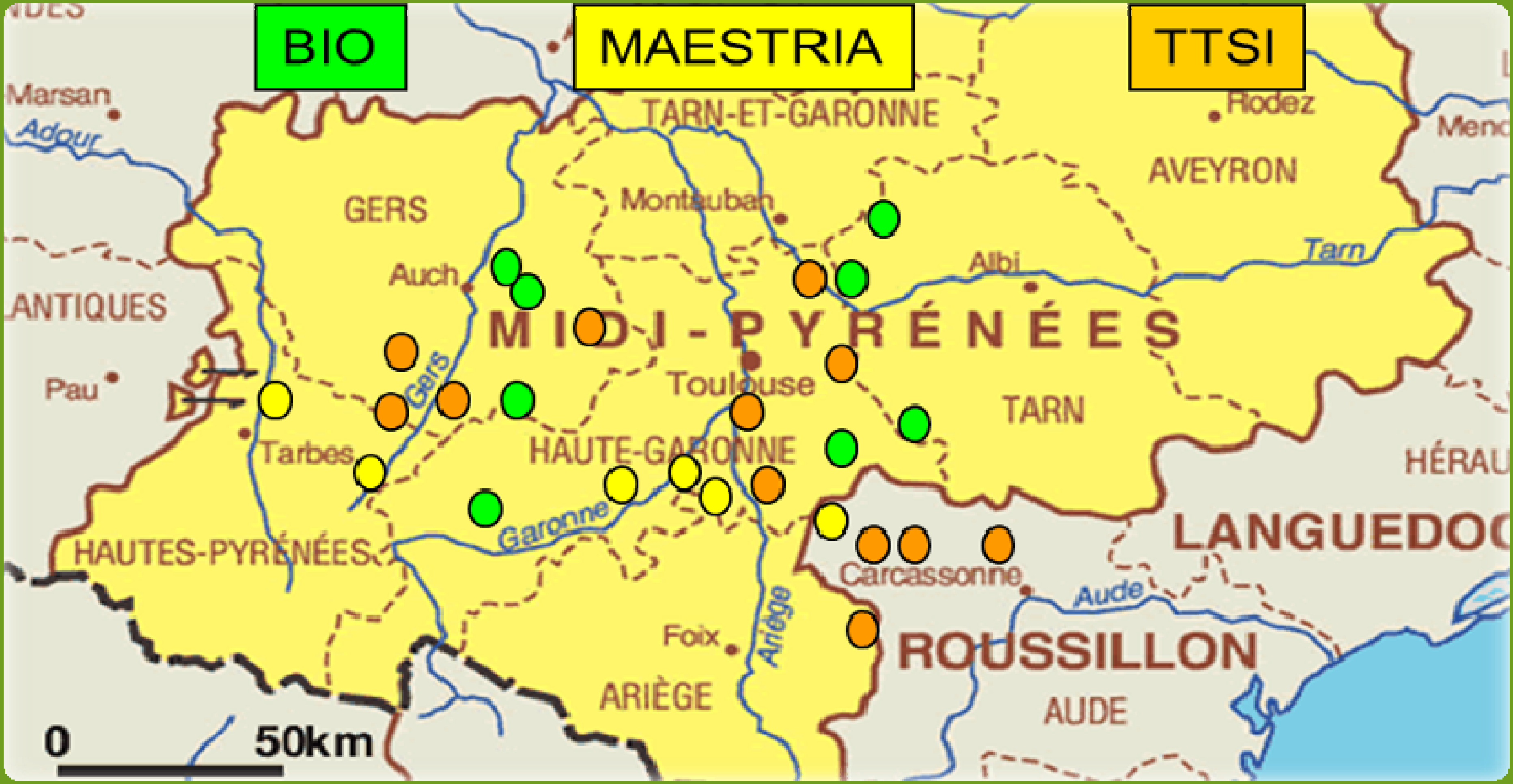
RÉPUBLIQUE FRANÇAISE

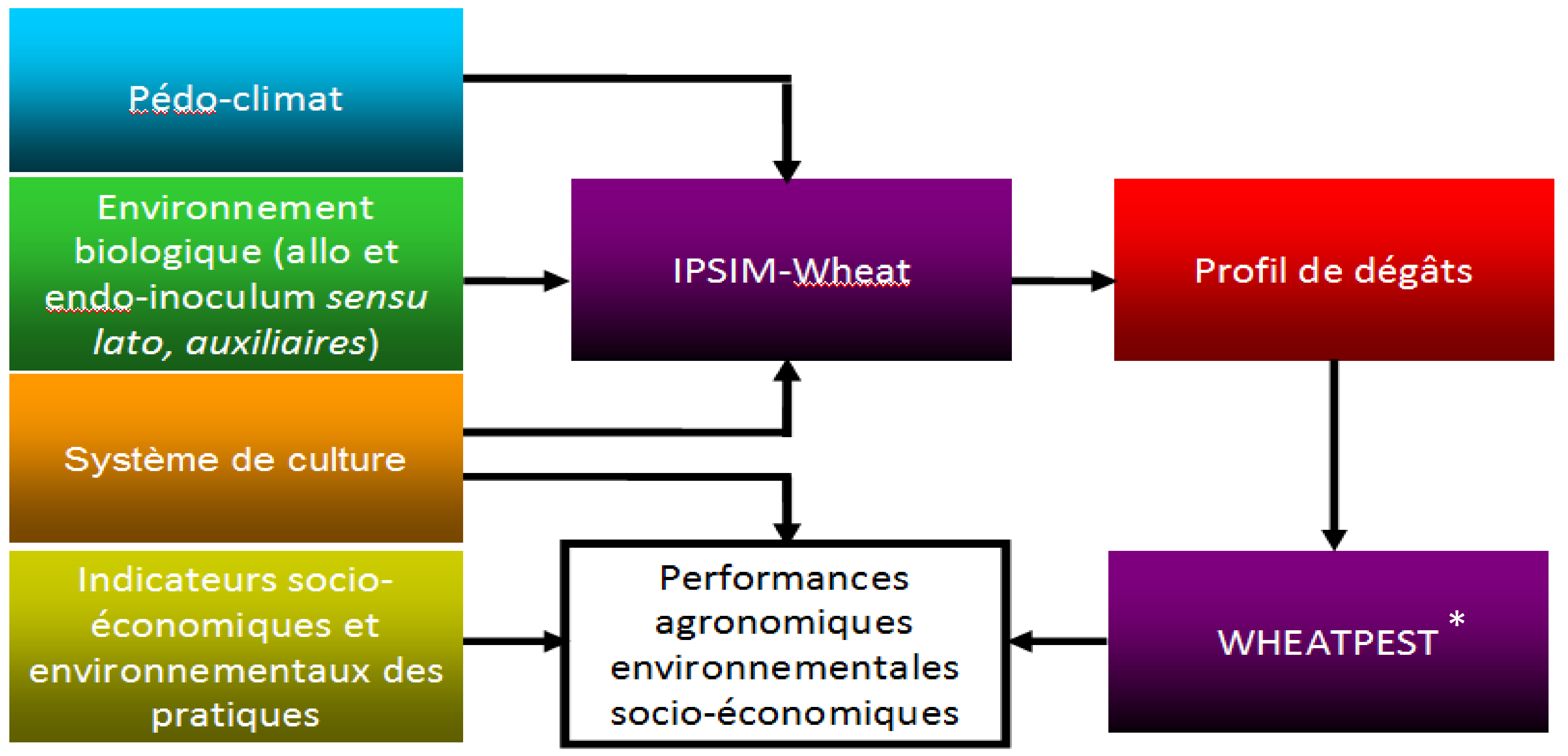
MINISTÈRE
DE L'AGRICULTURE
DE L'AGROALIMENTAIRE
ET DE LA FORÊT

ONEMA
Office national de l'eau
et des milieux aquatiques

Recueil de données idoines en parcelles agricoles en Midi-Pyrénnes



Stratégie de modélisation



Pédo-climat

Environnement biologique (allo et endo-inoculum *sensu lato, auxiliaires*)

Système de culture

Indicateurs socio-économiques et environnementaux des pratiques

IPSIM-Wheat

Profil de dégâts

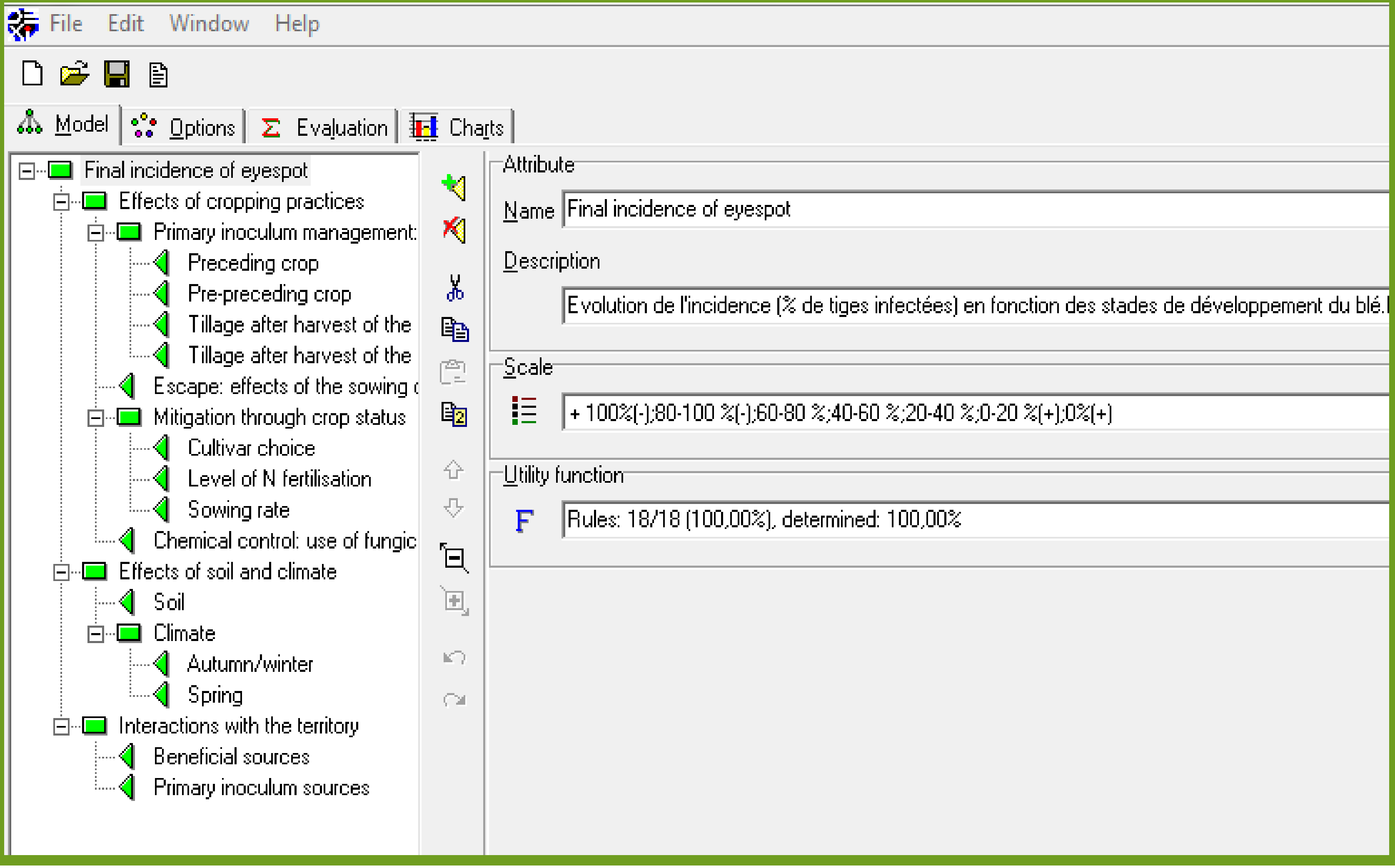
WHEATPEST *

Performances agronomiques environnementales socio-économiques

* Willocquet, L., Aubertot, J. N., Lebard, S., Robert, C., Lannou, C., and Savary, S. 2008. Simulating multiple pest damage in varying winter wheat production situations. Field Crops Reserach. 107:12-28.

EXEMPLE de développement du modèle IPSIM-Wheat Eyespot à l’aide du logiciel DEXi (comme MASC; Sadok et al, 2009; et DEXiPM; Lô-Pelzer et al, 2012

http://www-ai.ijs.si/MarkoBohanec/dexi.html



- Final incidence of eyespot
  - Effects of cropping practices
    - Primary inoculum management:
      - Preceding crop
      - Pre-preceding crop
      - Tillage after harvest of the
      - Tillage after harvest of the
    - Escape: effects of the sowing d
    - Mitigation through crop status
      - Cultivar choice
      - Level of N fertilisation
      - Sowing rate
    - Chemical control: use of fungic
  - Effects of soil and climate
    - Soil
    - Climate
      - Autumn/winter
      - Spring
  - Interactions with the territory
    - Beneficial sources
    - Primary inoculum sources

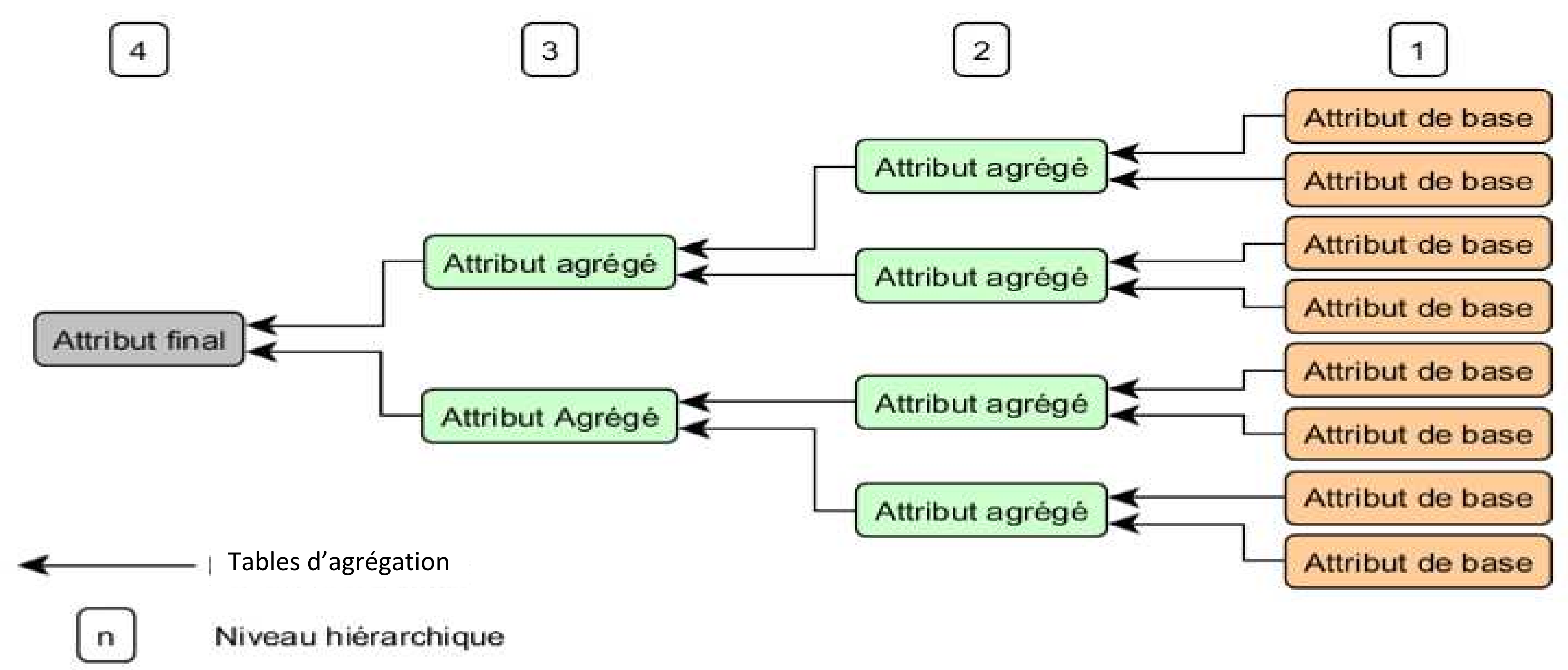
Name: Final incidence of eyespot

Description: Evolution de l'incidence (% de tiges infectées) en fonction des stades de développement du blé.

Scale: + 100%(-);80-100 %(-);60-80 %;40-60 %;20-40 %;0-20 %(+);0%(+)

Utility function: Rules: 18/18 (100,00%), determined: 100,00%

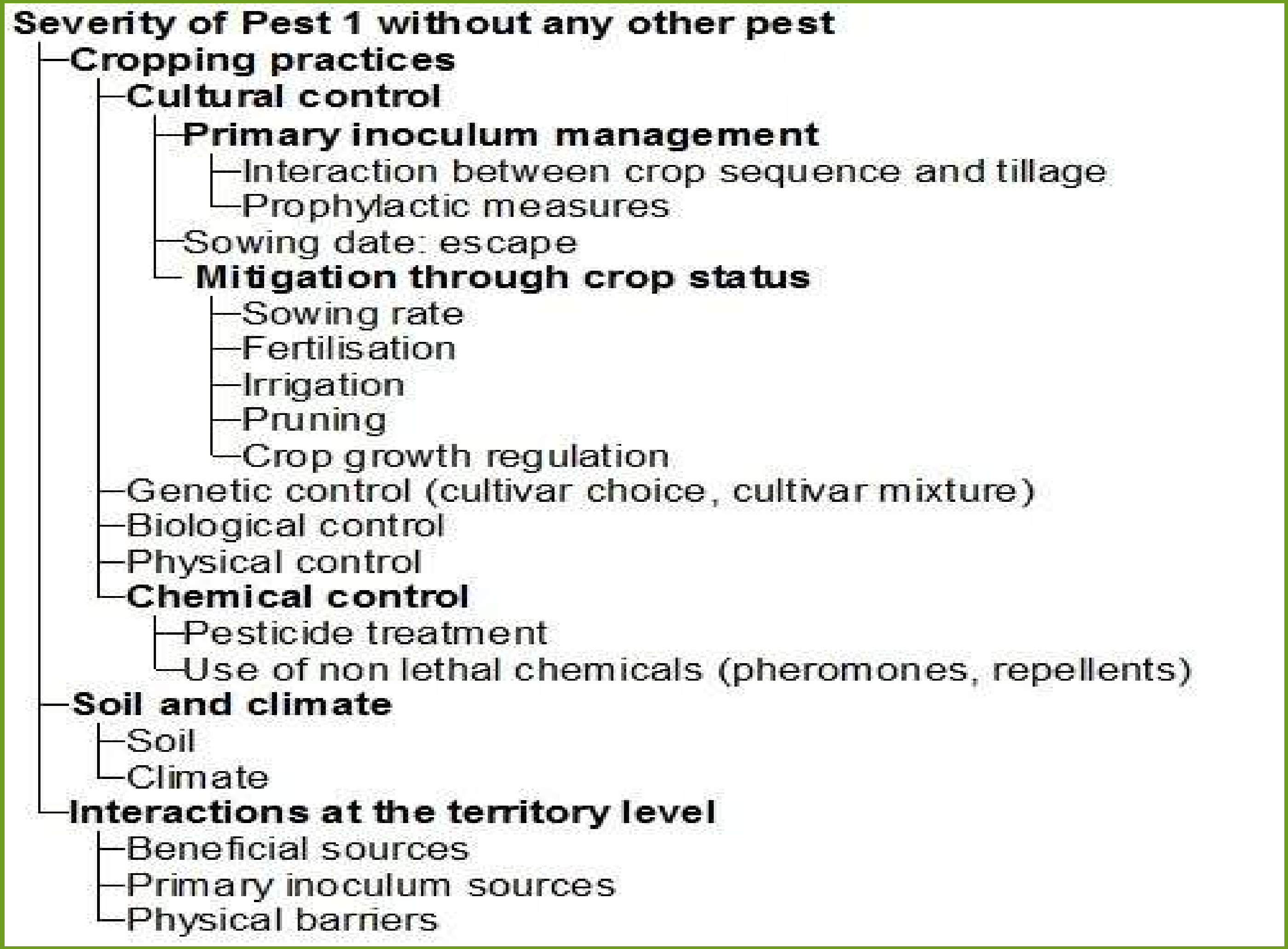
Réseaux hiérarchiques bayésiens déterministes (variables ordinales ou nominales)



Principe des tables d’agrégation : exemple d’une table d’agrégation déterministe de deux attributs binaires (des exemples réalistes suivront)

- Si la valeur de l’attribut sous-jacent 1 vaut X1 et que la valeur de l’attribut sous-jacent 2 vaut Y1, alors l’attribut agrégé vaut Z1
- Si la valeur de l’attribut sous-jacent 1 vaut X1 et que la valeur de l’attribut sous-jacent 2 vaut Y2, alors l’attribut agrégé vaut Z2
- Si la valeur de l’attribut sous-jacent 1 vaut X2 et que la valeur de l’attribut sous-jacent 2 vaut Y1, alors l’attribut agrégé vaut Z3
- Si la valeur de l’attribut sous-jacent 1 vaut X2 et que la valeur de l’attribut sous-jacent 2 vaut Y2, alors l’attribut agrégé vaut Z4

Structure générique de la plateforme IPSIM*



Severity of Pest 1 without any other pest
- **Cropping practices**
  - **Cultural control**
    - **Primary inoculum management**
      - Interaction between crop sequence and tillage
      - Prophylactic measures
    - Sowing date: escape
    - **Mitigation through crop status**
      - Sowing rate
      - Fertilisation
      - Irrigation
      - Pruning
      - Crop growth regulation
  - Genetic control (cultivar choice, cultivar mixture)
  - Biological control
  - Physical control
  - **Chemical control**
    - Pesticide treatment
    - Use of non lethal chemicals (pheromones, repellents)
- **Soil and climate**
  - Soil
  - Climate
- **Interactions at the territory level**
  - Beneficial sources
  - Primary inoculum sources
  - Physical barriers

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*Aubertot JN, Robin MH. 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, issue 9, e73202.

Application au cas du piétin-verse*

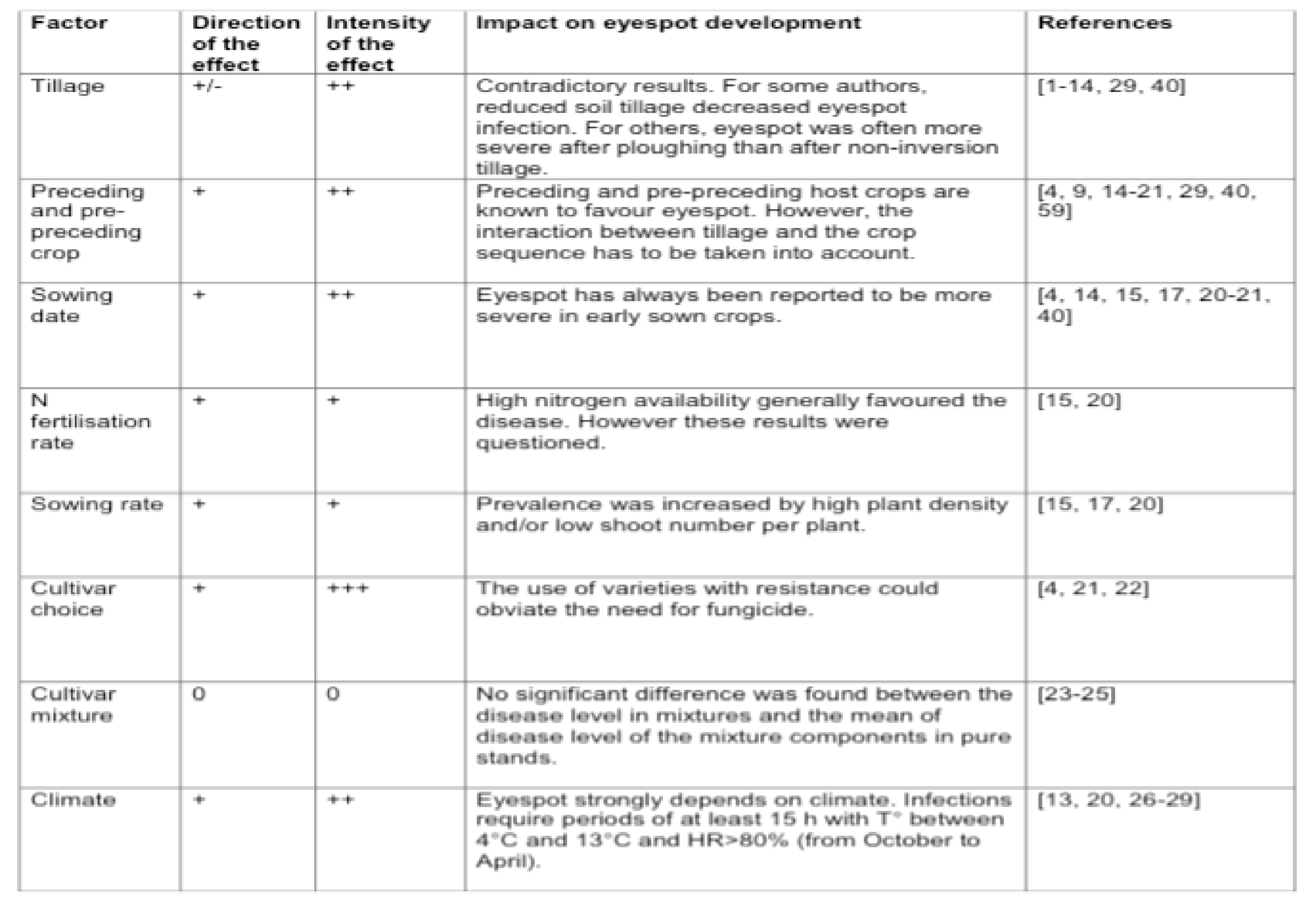
Attribute

- **Final incidence of eyespot**
  - **Effects of cropping practices**
    - **Primary inoculum management: interaction between crop sequence and tillage**
      - Preceding crop
      - Pre-preceding crop
      - Tillage after harvest of the previous crop
      - Tillage after harvest of the pre-previous crop
    - Escape: effects of the sowing date
    - **Mitigation through crop status**
      - Cultivar choice
      - Level of N fertilisation
      - Sowing rate
    - Chemical control: use of fungicide
  - **Effects of soil and climate**
    - Soil
    - **Climate**
      - Autumn/winter
      - Spring
  - **Interactions with the territory**
    - Beneficial sources
    - Primary inoculum sources

*Robin, M. H., Colbach N., Lucas P., Monfort F., Cholez C., Debaeke P., Aubertot J.N. 2013. Injury Profile SIMulator, a hierarchical aggregative modelling framework to predict an injury profile as a function of cropping practices,and abiotic and biotic environment. II. Proof of concept: design and evaluation of IPSIM-Wheat-Eyespot, a model that predicts eyespot injuries on winter wheat. PLOS ONE 8, Issue 10, e75829

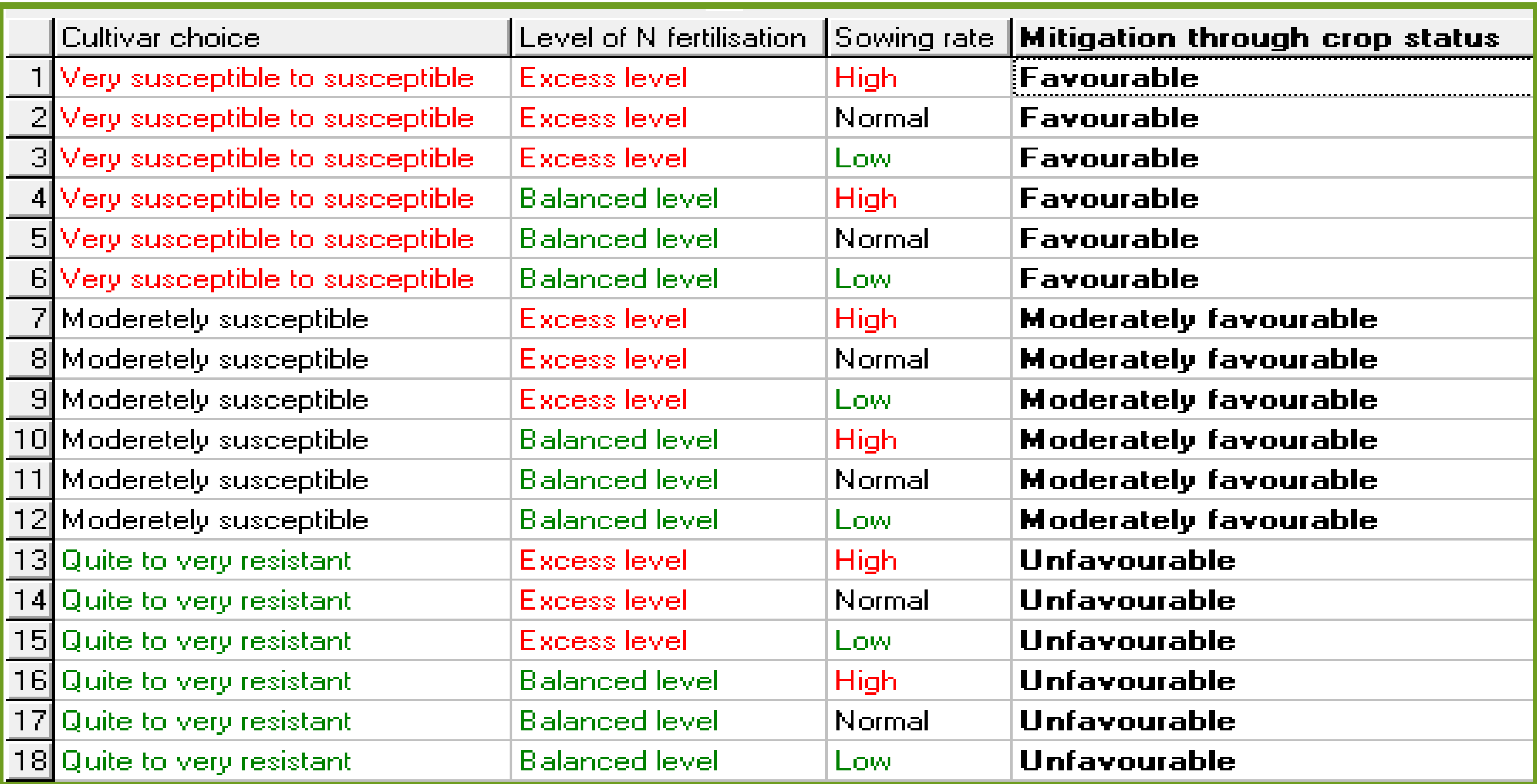
Attribute	Scale
Final incidence of eyespot	100%; 80-100 %; 60-80 %; 40-60 %; 20-40 %; *0-20 %*; *0%*
├**Effects of cropping practices**	Favourable; Moderately favourable; *Unfavourable*
│ ├**Primary inoculum management: interaction between crop sequence and tillage**	Favourable; Moderately favourable; *Unfavourable*
│ │ ├Preceding crop	Host; Risk amplifying non-host; *Non host*
│ │ ├Pre-preceding crop	Host; Risk amplifying non-host; *Non host*
│ │ ├Tillage after harvest of the previous crop	Non-inversion tillage; Inversion tillage
│ │ └Tillage after harvest of the pre-previous crop	Non-inversion tillage; Inversion tillage
│ ├Escape: effects of the sowing date	Early sowing; Normal sowing date; *Late sowing*
│ ├**Mitigation through crop status**	Favourable; Moderately favourable; *Unfavourable*
│ │ ├Cultivar choice	Very susceptible to susceptible; Moderetely susceptible; *Quite to very resistant*
│ │ ├Level of N fertilisation	Excess level; *Balanced level*
│ │ └Sowing rate	High; Normal; *Low*
│ └Chemical control: use of fungicide	None; *One*
├**Effects of soil and climate**	Very favourable; Favourable; *Unfavourable*
│ ├Soil	Favourable; *Neutral*
│ └**Climate**	Very favourable; Favourable; *Unfavourable*
│ ├Autumn/winter	Very favourable; Favourable; *Unfavourable*
│ └Spring	Very favourable; Favourable; *Unfavourable*
└**Interactions with the territory**	Favourable; *Neutral*
├Beneficial sources	Normal; *Important*
└Primary inoculum sources	Important; *Normal*

Robin, M. H., Colbach N., Lucas P., Monfort F., Cholez C., Debaeke P., Aubertot J.N. 2013. Injury Profile SIMulator, a hierarchical aggregative modelling framework to predict an injury profile as a function of cropping practices,and abiotic and biotic environment. II. Proof of concept: design and evaluation of IPSIM-Wheat-Eyespot, a model that predicts eyespot injuries on winter wheat. PLOS ONE 8, Issue 10, e75829



Factor	Direction of the effect	Intensity of the effect	Impact on eyespot development	References
Tillage	+/-	++	Contradictory results. For some authors, reduced soil tillage decreased eyespot infection. For others, eyespot was often more severe after ploughing than after non-inversion tillage.	[1-14, 29, 40]
Preceding and pre-preceding crop	+	++	Preceding and pre-preceding host crops are known to favour eyespot. However, the interaction between tillage and the crop sequence has to be taken into account.	[4, 9, 14-21, 29, 40, 59]
Sowing date	+	++	Eyespot has always been reported to be more severe in early sown crops.	[4, 14, 15, 17, 20-21, 40]
N fertilisation rate	+	+	High nitrogen availability generally favoured the disease. However these results were questioned.	[15, 20]
Sowing rate	+	+	Prevalence was increased by high plant density and/or low shoot number per plant.	[15, 17, 20]
Cultivar choice	+	+++	The use of varieties with resistance could obviate the need for fungicide.	[4, 21, 22]
Cultivar mixture	0	0	No significant difference was found between the disease level in mixtures and the mean of disease level of the mixture components in pure stands.	[23-25]
Climate	+	++	Eyespot strongly depends on climate. Infections require periods of at least 15 h with T° between 4°C and 13°C and HR>80% (from October to April).	[13, 20, 26-29]

Robin, M. H., Colbach N., Lucas P., Monfort F., Cholez C., Debaeke P., Aubertot J.N. 2013. Injury Profile SIMulator, a hierarchical aggregative modelling framework to predict an injury profile as a function of cropping practices,and abiotic and biotic environment. II. Proof of concept: design and evaluation of IPSIM-Wheat-Eyespot, a model that predicts eyespot injuries on winter wheat. PLOS ONE 8, Issue 10, e75829



	Cultivar choice	Level of N fertilisation	Sowing rate	**Mitigation through crop status**
1	Very susceptible to susceptible	Excess level	High	**Favourable**
2	Very susceptible to susceptible	Excess level	Normal	**Favourable**
3	Very susceptible to susceptible	Excess level	Low	**Favourable**
4	Very susceptible to susceptible	Balanced level	High	**Favourable**
5	Very susceptible to susceptible	Balanced level	Normal	**Favourable**
6	Very susceptible to susceptible	Balanced level	Low	**Favourable**
7	Moderetely susceptible	Excess level	High	**Moderately favourable**
8	Moderetely susceptible	Excess level	Normal	**Moderately favourable**
9	Moderetely susceptible	Excess level	Low	**Moderately favourable**
10	Moderetely susceptible	Balanced level	High	**Moderately favourable**
11	Moderetely susceptible	Balanced level	Normal	**Moderately favourable**
12	Moderetely susceptible	Balanced level	Low	**Moderately favourable**
13	Quite to very resistant	Excess level	High	**Unfavourable**
14	Quite to very resistant	Excess level	Normal	**Unfavourable**
15	Quite to very resistant	Excess level	Low	**Unfavourable**
16	Quite to very resistant	Balanced level	High	**Unfavourable**
17	Quite to very resistant	Balanced level	Normal	**Unfavourable**
18	Quite to very resistant	Balanced level	Low	**Unfavourable**

Robin, M. H., Colbach N., Lucas P., Monfort F., Cholez C., Debaeke P., Aubertot J.N. 2013. Injury Profile SIMulator, a hierarchical aggregative modelling framework to predict an injury profile as a function of cropping practices,and abiotic and biotic environment. II. Proof of concept: design and evaluation of IPSIM-Wheat-Eyespot, a model that predicts eyespot injuries on winter wheat. PLOS ONE 8, Issue 10, e75829

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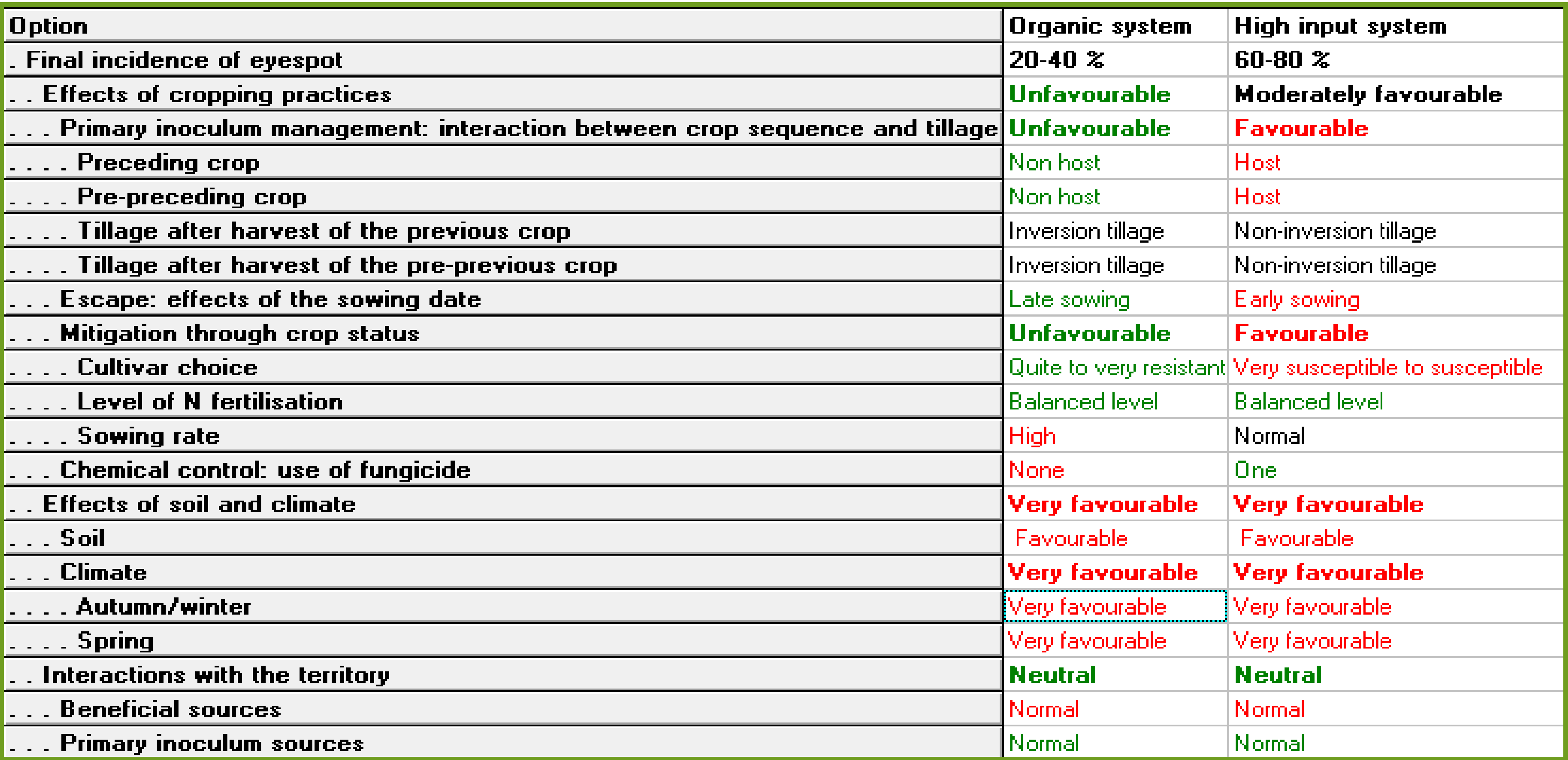

Option	Organic system	High input system
. Final incidence of eyespot	20-40 %	60-80 %
. . Effects of cropping practices	**Unfavourable**	**Moderately favourable**
. . . Primary inoculum management: interaction between crop sequence and tillage	**Unfavourable**	**Favourable**
. . . . Preceding crop	Non host	Host
. . . . Pre-preceding crop	Non host	Host
. . . . Tillage after harvest of the previous crop	Inversion tillage	Non-inversion tillage
. . . . Tillage after harvest of the pre-previous crop	Inversion tillage	Non-inversion tillage
. . . Escape: effects of the sowing date	Late sowing	Early sowing
. . . Mitigation through crop status	**Unfavourable**	**Favourable**
. . . . Cultivar choice	Quite to very resistant	Very susceptible to susceptible
. . . . Level of N fertilisation	Balanced level	Balanced level
. . . . Sowing rate	High	Normal
. . . Chemical control: use of fungicide	None	One
. . Effects of soil and climate	**Very favourable**	**Very favourable**
. . . Soil	Favourable	Favourable
. . . Climate	**Very favourable**	**Very favourable**
. . . . Autumn/winter	Very favourable	Very favourable
. . . . Spring	Very favourable	Very favourable
. . Interactions with the territory	**Neutral**	**Neutral**
. . . Beneficial sources	Normal	Normal
. . . Primary inoculum sources	Normal	Normal

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Profil de dégâts du blé : de nombreux organismes sont impliqués !

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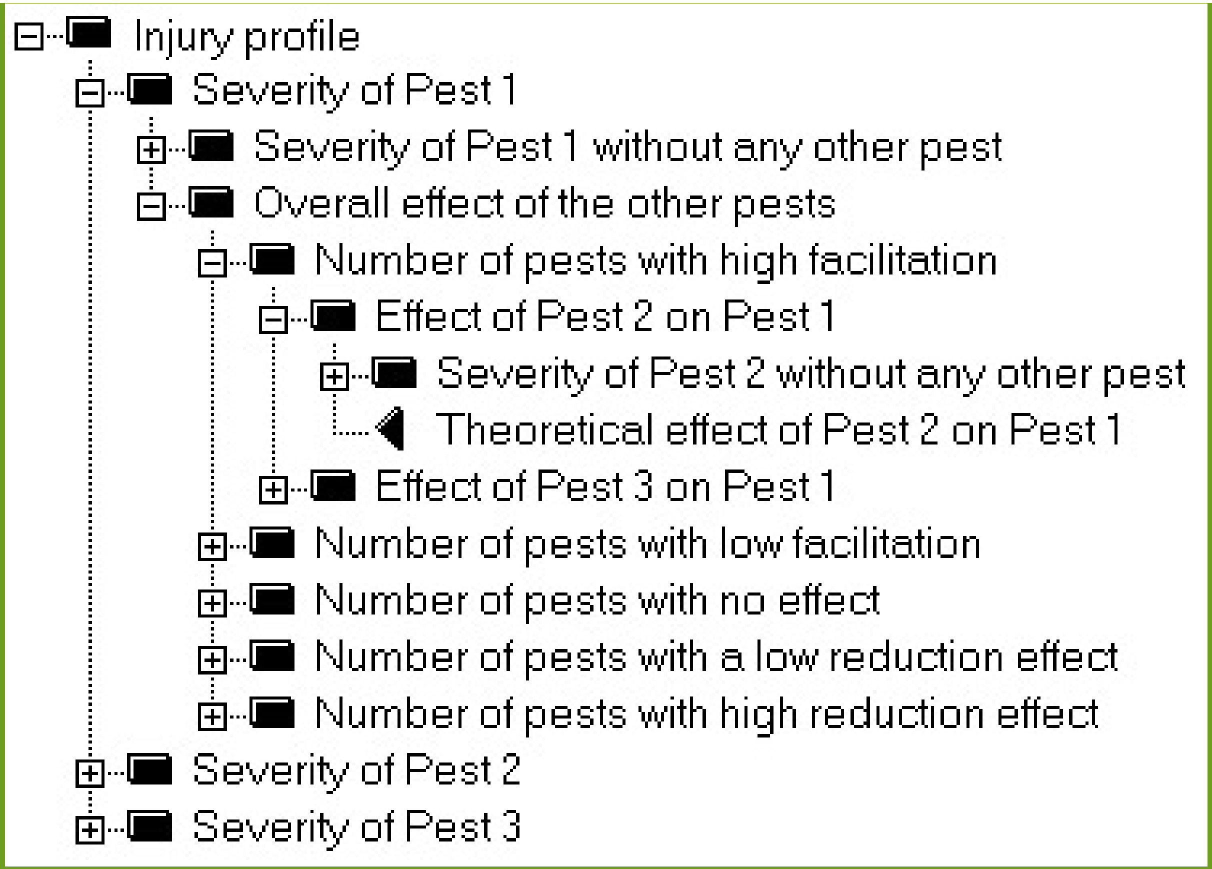

- ⊟ Injury profile
  - ⊟ Severity of Pest 1
    - ⊞ Severity of Pest 1 without any other pest
    - ⊟ Overall effect of the other pests
      - ⊟ Number of pests with high facilitation
        - ⊟ Effect of Pest 2 on Pest 1
          - ⊞ Severity of Pest 2 without any other pest
          - Theoretical effect of Pest 2 on Pest 1
        - ⊞ Effect of Pest 3 on Pest 1
      - ⊞ Number of pests with low facilitation
      - ⊞ Number of pests with no effect
      - ⊞ Number of pests with a low reduction effect
      - ⊞ Number of pests with high reduction effect
  - ⊞ Severity of Pest 2
  - ⊞ Severity of Pest 3

Overall output attributes of IPSIM: description of an Injury Profile (screenshot of the DEXi software). For the sake of simplicity, only 3 pests are represented in this figure. The severity of a given pest is first calculated independently by IPSIM as if no other pest was present. The aggregated severity of a given pest is then calculated by taking into account the combined effects of all other pests. This is done by considering the theoretical effect of one pest on another according to five levels: high facilitation, low facilitation, no effect, low reduction, high reduction.

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PLAN

1) Présentation de la problématique agronomique

2) Présentation de la problématique mathématique

3) Discussion

Jean-Noël Aubertot, UMR AGIR, Toulouse

- Les modèles IPSIM sont développés à partir d’analyses bibliographiques et de dires d’expertS
-Quid de leur qualité prédictive ?
-Utilisation de différentes données issus d’essais expérimentaux ou de diagnostics en parcelles agricoles pour évaluer la qualité prédictive

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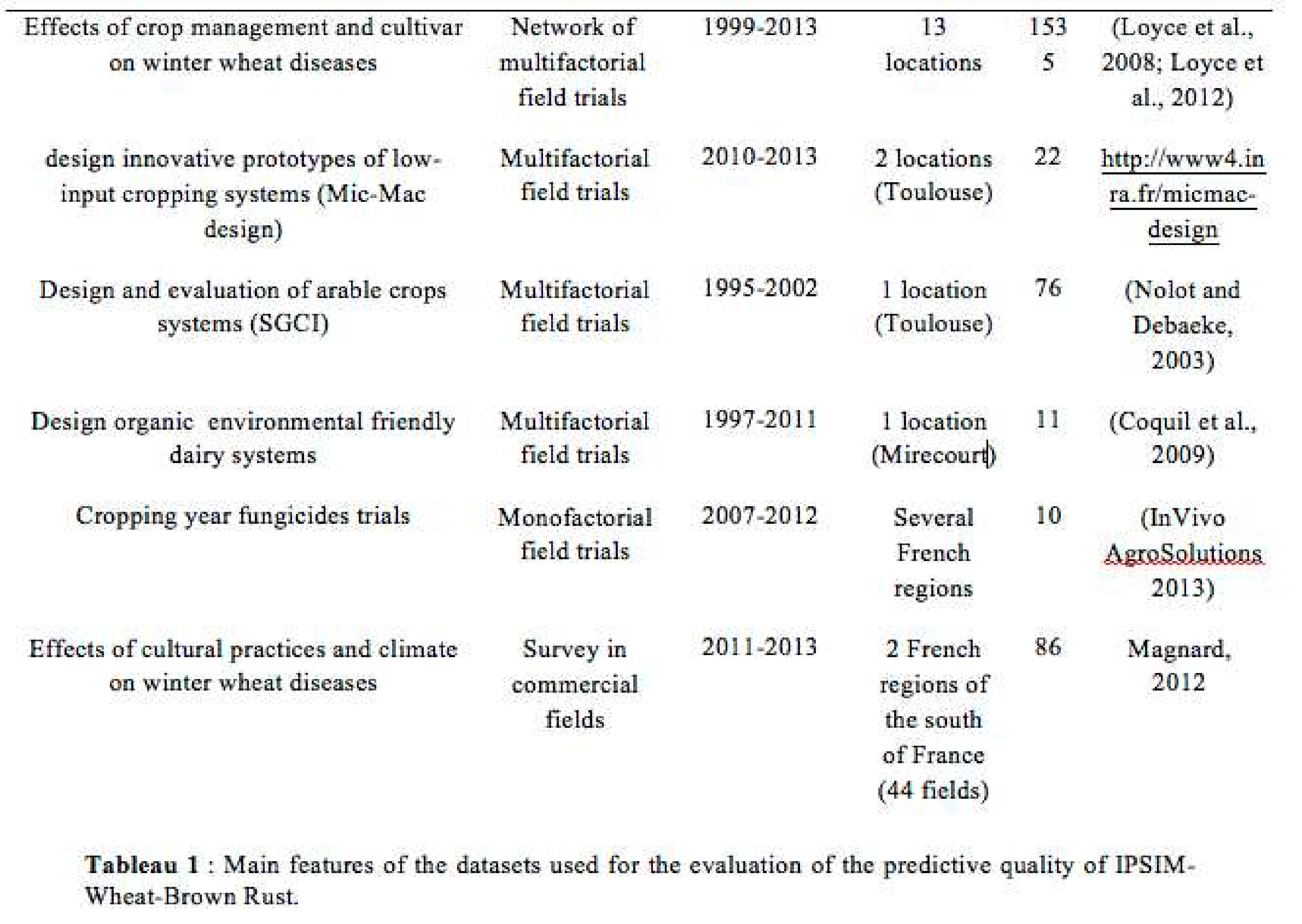


Effects of crop management and cultivar on winter wheat diseases	Network of multifactorial field trials	1999-2013	13 locations	1535	(Loyce et al., 2008; Loyce et al., 2012)
design innovative prototypes of low-input cropping systems (Mic-Mac design)	Multifactorial field trials	2010-2013	2 locations (Toulouse)	22	http://www4.inra.fr/micmac-design
Design and evaluation of arable crops systems (SGCI)	Multifactorial field trials	1995-2002	1 location (Toulouse)	76	(Nolot and Debaeke, 2003)
Design organic environmental friendly dairy systems	Multifactorial field trials	1997-2011	1 location (Mirecourt)	11	(Coquil et al., 2009)
Cropping year fungicides trials	Monofactorial field trials	2007-2012	Several French regions	10	(InVivo AgroSolutions 2013)
Effects of cultural practices and climate on winter wheat diseases	Survey in commercial fields	2011-2013	2 French regions of the south of France (44 fields)	86	Magnard, 2012

Tableau 1 : Main features of the datasets used for the evaluation of the predictive quality of IPSIM-Wheat-Brown Rust.

Robin MH, MO Bancal, M Launay, C Robert, I Sache, Magnard A, Felix I, Olivier A, Rolland B, Délos M, Aubertot JN. Design and evaluation of IPSIM-Wheat-Brown Rust, a model that predicts Brown Rust injuries on winter Wheat as a function of cropping practices, soil, weather, and field environment. Phytopathology. In preparation.

Deux voies possibles pour estimer la qualité prédictive des modèles IPSIM :

1)Transformer les variables de sorties des modèles IPSIM en variables quantitatives

2)Transformer les données observées sur les dégâts en variables ordinales en utilisant la même échelle que la variable de sortie du modèle DEXi

Transformation des variables de sorties des modèles IPSIM en variables quantitatives

Représentant d'une classe: moyenne des bornes de la classe.

Dans le cas de la rouille brune du blé, 5 classes de sévérité :

-0-5% -> transformation en 2.5%

-5-10% -> transformation en 7.5%

-10-20% -> transformation en 15%

-20-50% -> transformation en 35%

-50-100% -> transformation en 75%

Transformation des variables de sorties des modèles IPSIM en variables quantitatives

Avantage : on peut utiliser les méthodes classiques d’évaluation de la qualité prédictive des modèles (analyse des résidus et calcul de différents critères statistiques)

$$Bias = \frac{1}{n}\sum_{i=1}^{i=n}\left(Y_i^{obs} - Y_i^{sim}\right)$$

$$RMSEP = \sqrt{\frac{1}{n}\sum_{i=1}^{i=n}\left(Y_i^{obs} - Y_i^{sim}\right)^2}$$

$$EF = 1 - \frac{\sum_{i=1}^{i=n}\left(Y_i^{obs} - Y_i^{sim}\right)^2}{\sum_{i=1}^{i=n}\left(Y_i^{obs} - \overline{Y}\right)^2}$$

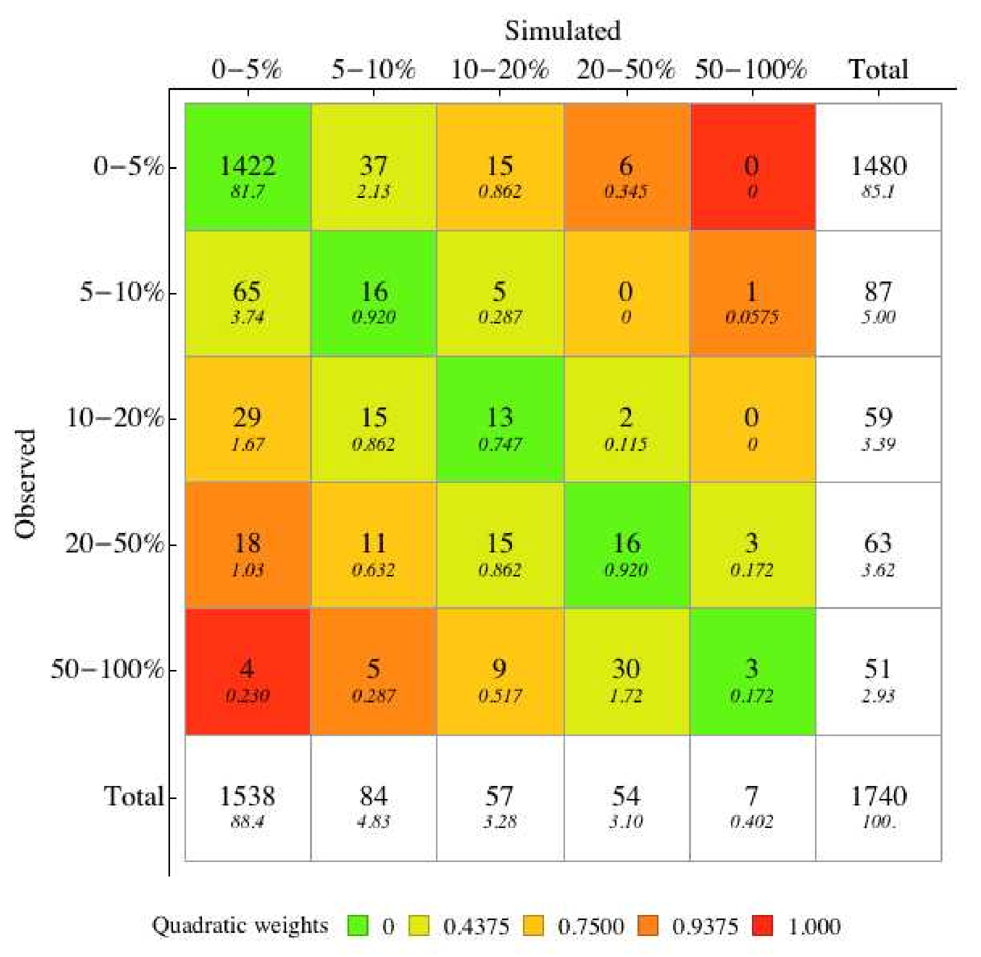
Bias = 0.84%

Efficience = 0.41

RMSEP=11%,

1940 sites-années, 19 régions, 15 années

Transformation des données observées sur les dégâts en variables ordinales ->matrice de confusion (code Mathematica)



	Simulated					
Observed	0–5%	5–10%	10–20%	20–50%	50–100%	Total
0–5%	1422 *81.7*	37 *2.13*	15 *0.862*	6 *0.345*	0 *0*	1480 *85.1*
5–10%	65 *3.74*	16 *0.920*	5 *0.287*	0 *0*	1 *0.0575*	87 *5.00*
10–20%	29 *1.67*	15 *0.862*	13 *0.747*	2 *0.115*	0 *0*	59 *3.39*
20–50%	18 *1.03*	11 *0.632*	15 *0.862*	16 *0.920*	3 *0.172*	63 *3.62*
50–100%	4 *0.230*	5 *0.287*	9 *0.517*	30 *1.72*	3 *0.172*	51 *2.93*
Total	1538 *88.4*	84 *4.83*	57 *3.28*	54 *3.10*	7 *0.402*	1740 *100.*

Quadratic weights 🟩 0 🟨 0.4375 🟨 0.7500 🟧 0.9375 🟥 1.000

Comment résumer les matrices de confusion ?

Précision

$$Accuracy = \frac{1}{n}\sum_{i=1}^{i=n_c} n_{ii}$$

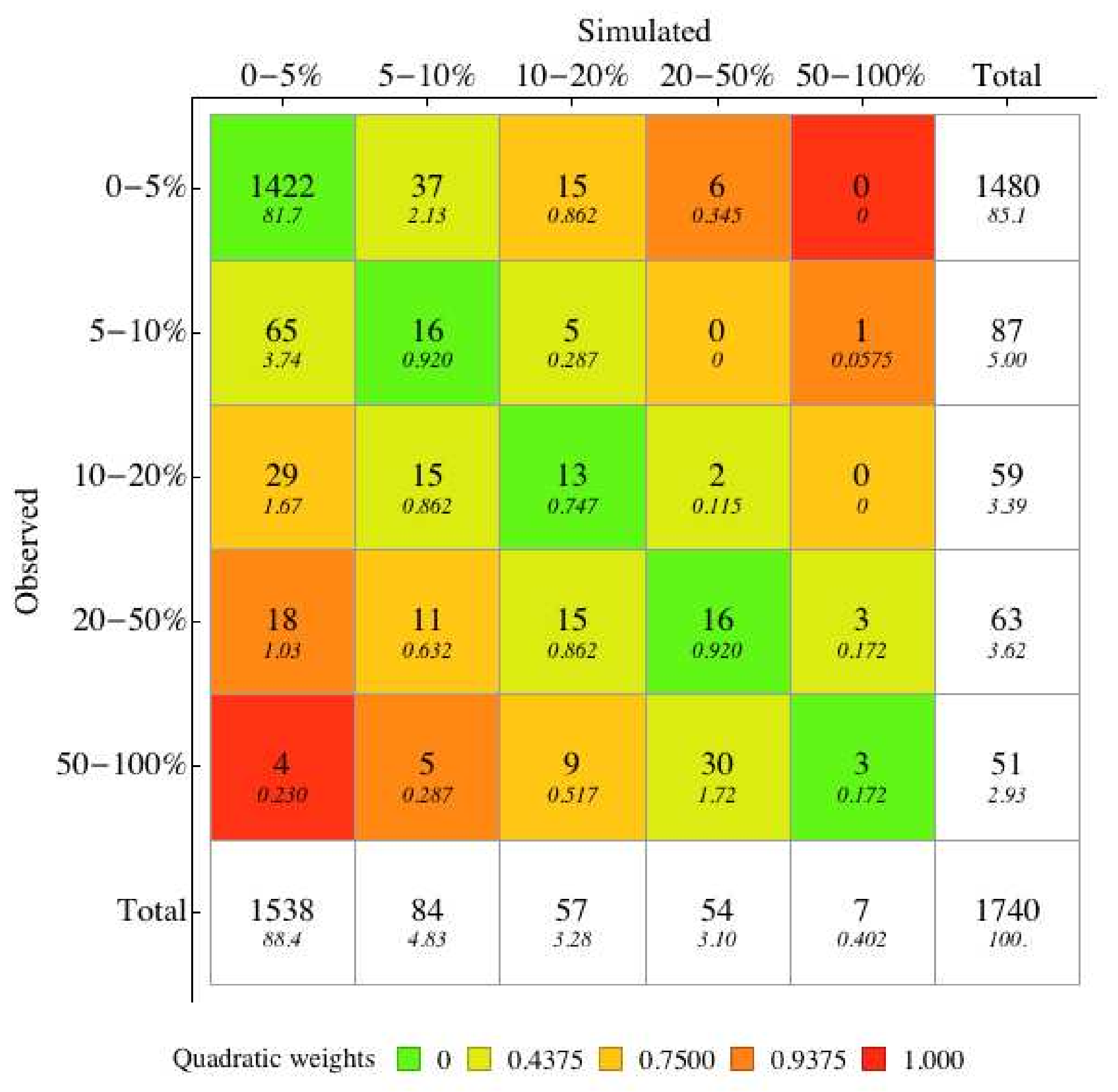
κ_w pondérés de Cohen

$$\kappa_w = \frac{\sum_i \sum_j w_{ij}\pi_{ij} - \sum_i \sum_j w_{ij}\pi_{i+}\pi_{+j}}{1 - \sum_i \sum_j w_{ij}\pi_{i+}\pi_{+j}}$$

(Spitzer et al, 1967, à partir de Cohen, 1960) avec :

$$\left\{w_{ij} = 1 - \frac{|i-j|}{c-1}\right\} \quad \text{and} \quad \left\{w_{ij} = 1 - \frac{(i-j)^2}{(c-1)^2}\right\}$$

Fleiss et Cohen (1973) ont montré que ce critère pouvait être interprété comme la proportion de variabilité expliquée (pondération quadratique).

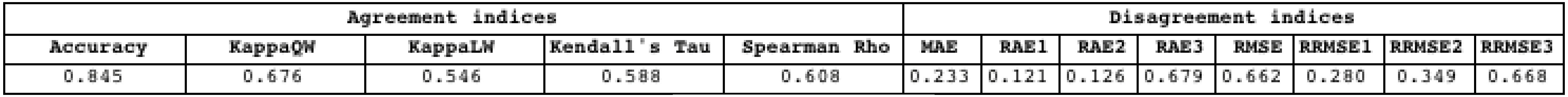


Simulated

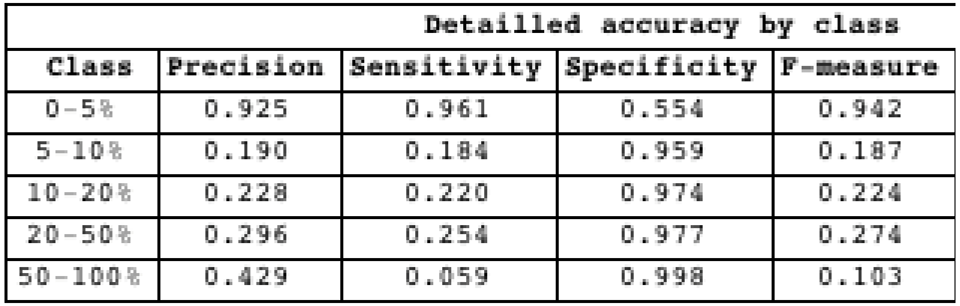
Observed	0–5%	5–10%	10–20%	20–50%	50–100%	Total
0–5%	1422 81.7	37 2.13	15 0.862	6 0.345	0 0	1480 85.1
5–10%	65 3.74	16 0.920	5 0.287	0 0	1 0.0575	87 5.00
10–20%	29 1.67	15 0.862	13 0.747	2 0.115	0 0	59 3.39
20–50%	18 1.03	11 0.632	15 0.862	16 0.920	3 0.172	63 3.62
50–100%	4 0.230	5 0.287	9 0.517	30 1.72	3 0.172	51 2.93
Total	1538 88.4	84 4.83	57 3.28	54 3.10	7 0.402	1740 100.

Quadratic weights 🟩 0 🟨 0.4375 🟧 0.7500 🟧 0.9375 🟥 1.000

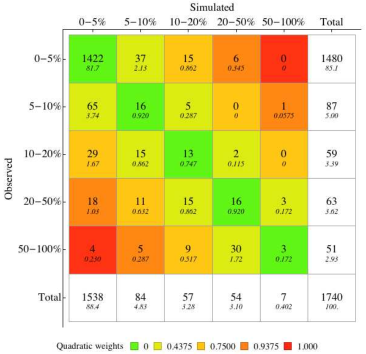
Comment résumer les matrices de confusion par des indicateurs (code Mathematica) ?



Agreement indices					Disagreement indices							
Accuracy	KappaQW	KappaLW	Kendall's Tau	Spearman Rho	MAE	RAE1	RAE2	RAE3	RMSE	RRMSE1	RRMSE2	RRMSE3
0.845	0.676	0.546	0.588	0.608	0.233	0.121	0.126	0.679	0.662	0.280	0.349	0.668



Detailled accuracy by class				
Class	Precision	Sensitivity	Specificity	F-measure
0-5%	0.925	0.961	0.554	0.942
5-10%	0.190	0.184	0.959	0.187
10-20%	0.228	0.220	0.974	0.224
20-50%	0.296	0.254	0.977	0.274
50-100%	0.429	0.059	0.998	0.103



Observed \ Simulated	0–5%	5–10%	10–20%	20–50%	50–100%	Total
0–5%	1422 81.7	37 2.13	15 0.862	6 0.345	0 0	1480 85.1
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Total	1538 88.4	84 4.83	57 3.28	54 3.10	7 0.402	1740 100.

Quadratic weights 🟩 0 🟨 0.4375 🟨 0.7500 🟧 0.9375 🟥 1.000

Pour mémoire :

la sensibilité = TP / (TP + FN) = TP / P

la spécificité = TN / (TN + FP) = TN / N

moyenne harmonique de la précision et de la sensibilité F-measure = 2TP/(2TP+FP+FN)

Comment améliorer la qualité prédictive des modèles IPSIM à l’aide des jeux de données disponibles ?

- Technique de validation croisée (en retirant les éventuelles corrélations d’espace et de temps)

- Adaptation de la méthode développée par Wallach et al (2001)* : chaque ligne de chaque table d’agrégation peut être considérée comme l’équivalent d’un paramètre d’un modèle quantitatif (Aubertot et Robin, 2013)

- Choix du critère à minimiser : k_{qw}

- Difficulté : temps de calcul (très !) limitants (e.g. 10^{68} nécessaires dans le cas d’IPSIM-Wheat-Brown Rust)

Wallach D, Goffinet B, Bergez JE, Debaeke P, Leenhardt D, Aubertot JN. 2001. Parameter estimation for crop models : a new approach and application to a corn model. Agronomy Journal 93 (4): 757-766

Description de l’algorithme d’optimisation envisagé

1) Calcul de k_{QW} sur l’ensemble des données avec le modèle IPSIM-Wheat-Brown Rust initial

2) Calcul des k_{QW} en modifiant une à une chacun des 134 lignes du modèle, identification de la ligne conduisant à la valeur la plus élevée de k_{QW} en validation croisée

3) Calcul des k_{QW} en modifiant 2 des 134 lignes du modèle, identification de la combinaison conduisant à la valeur la plus faible de k_{QW} en validation croisée

4) On répète jusqu’à ce que le critère k_{QW} diminue

Problème : on ne sait pas encore si cet algorithme peut boucler !

Collaboration Gauthier Quesnel (MIAT)

PLAN

1) Présentation de la problématique agronomique

2) Présentation de la problématique mathématique

3) Discussion

☹

- Lack of precision
- Subjectivity when defining aggregating tables
- No explicit representation of underlying mechanisms
- Static models
- Threshold effects when translating quantitative input variables into qualitative variables

☺

- Lack of precision
- Combination of expert knowledge, existing models and data
- Fair predictive quality considering that no calibration was performed
- Transparent
- Very easy to develop and to present
- Great for communicating and teaching
- Better vertical and horizontal integrations in IPM

Qualitative modelling to help design sustainable cropping systems less reliant on pesticides.
Aubertot JN, Avelino J, Boiffin J, Chabert A, Cros MJ, Dayde C, Debaeke P, Deguine JP,
Guichard L, Lescourret F, Mestries E, Navarrete M, Peyrard N, Robin MH, Sabbadin R,
Tchamitchian M. Numéro spécial PURE Crop Protection

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