XPEST: plateforme de modélisation en ligne pour la création et le développement de modèles de nuisibilité

Jean-Noel Aubertot, Guillaume Robaldo, Marie-Anne Vedy-Zecchini, Emmanuelle Mestries

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Jean-Noël Aubertot, Guillaume Robaldo (CDD), Marie-Anne Vedy-Zecchini (M2), Emmanuelle Mestries (Terres Inovia)

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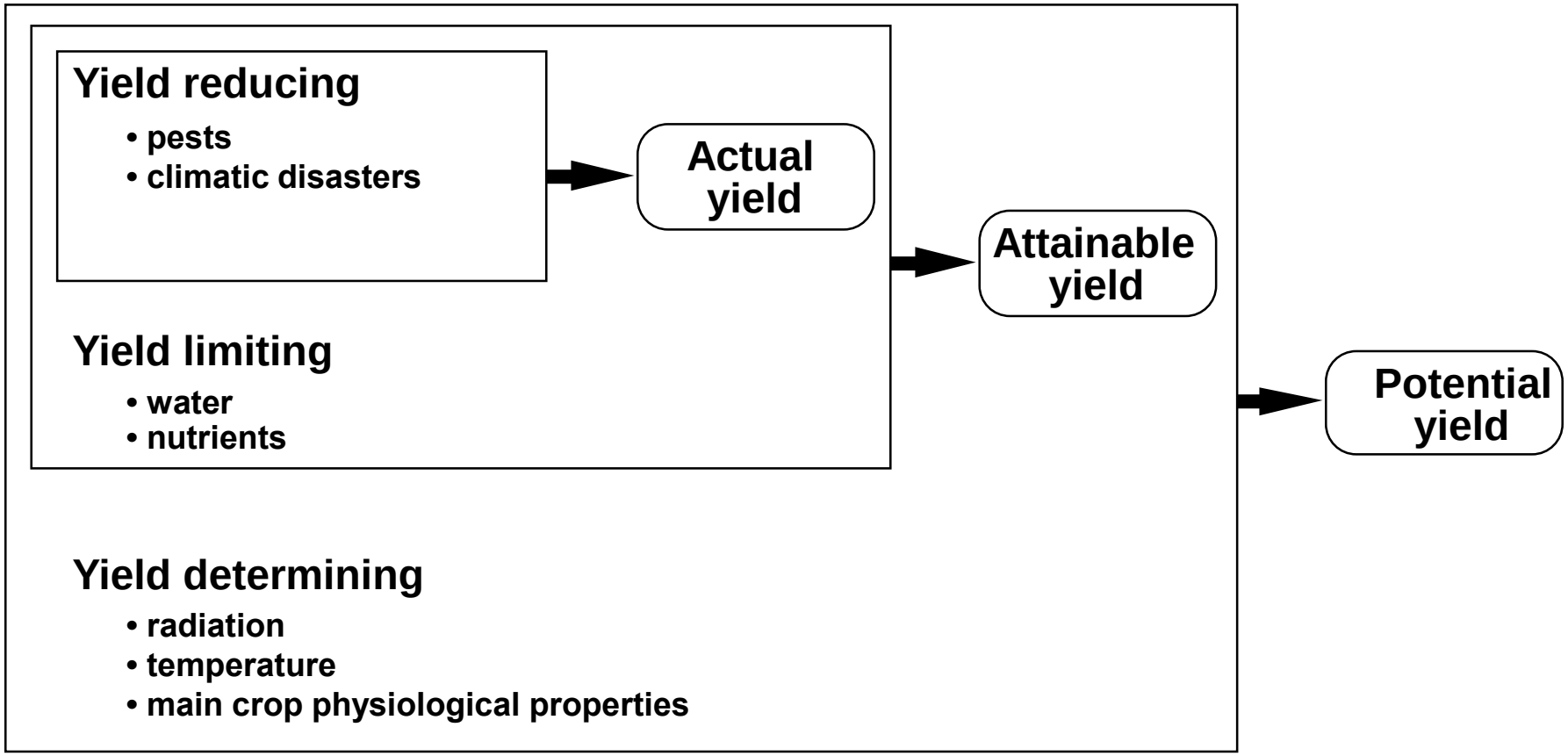
Arezki Zerourou, Marie-Hélène Charron-Moirez (AGIR)

Hélène Raynal, Eric Casellas, Nathalie Rousse (MIAT)

Pourquoi s’intéresser aux pertes de récolte ?

Yield defining factors



Zadoks, J.C., Schein, R.D., 1979. Epidemiology and Plant Disease Management. Oxford University Press, New York.

Rabbinge, R., 1993. The ecological background of food production. In: Chadwick D.J., Marsh, J. (Eds.), Crop Protection and Sustainable Agriculture. John Wiley and Sons, Chichester, UK, pp 2-29.

Yield loss assessment

$Yield_{loss} = Yield_{attainable} - Yield_{actual}$

$RelativeYield_{loss} = (Yield_{attainable} - Yield_{actual}) / Yield_{attainable}$

Yield loss modelling

2 main statistical approaches

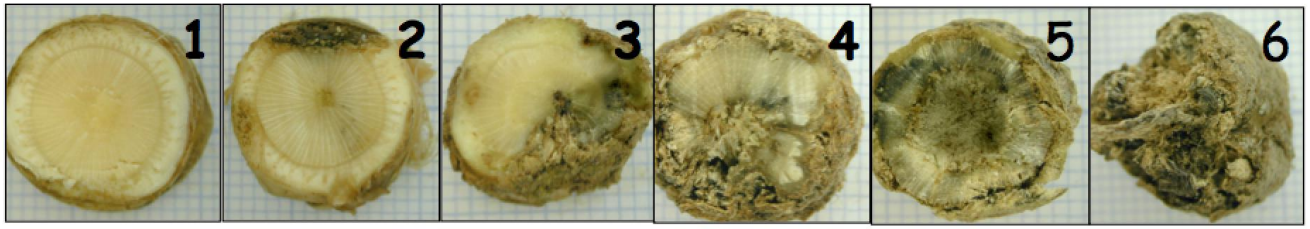
$Yield_{loss} = f(injury)$

$RYield_{loss} = f(injury)$

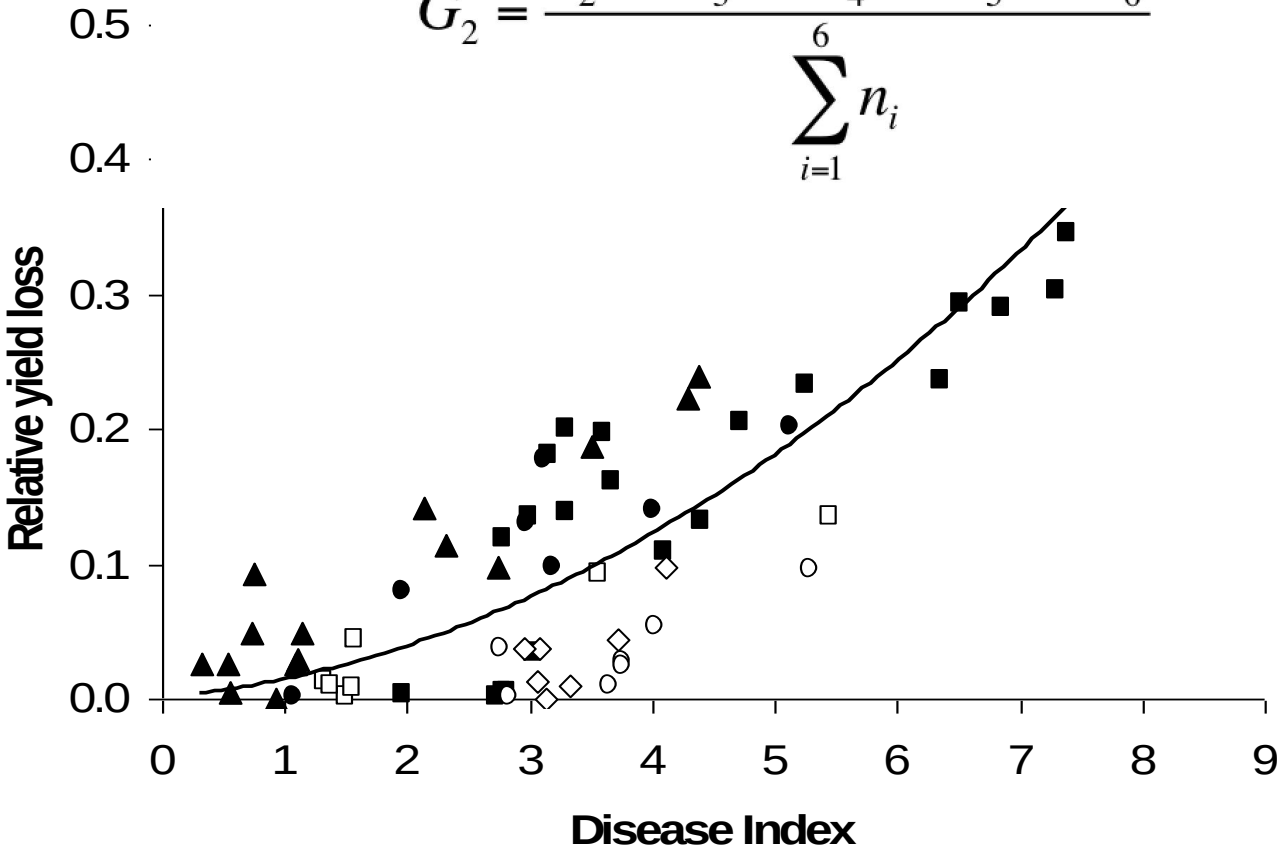
$Yield_{loss} = f(injury(t))$

$RYield_{loss} = f(injury(t))$

Dynamic modelling of damage functions associated to a crop model



$$G_2 = \frac{n_2 + 3n_3 + 5n_4 + 7n_5 + 9n_6}{\sum_{i=1}^{6} n_i}$$



Aubertot et al, 2004

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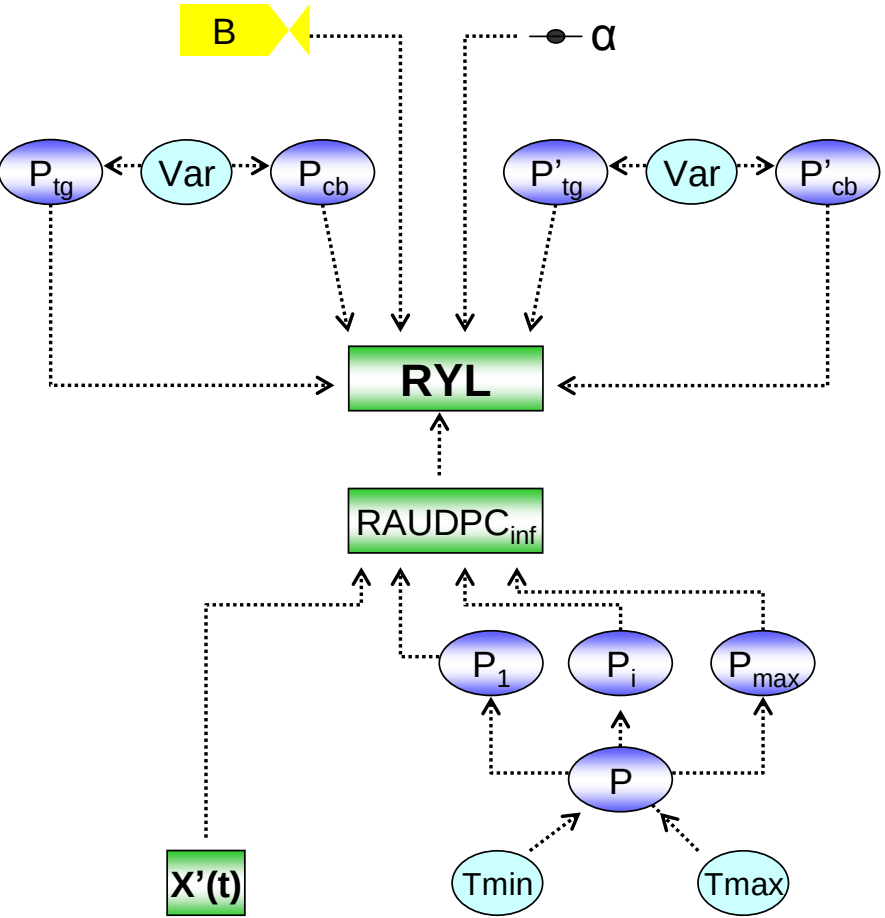
Dynamic modelling of damage functions associated to a crop model

Fonction de nuisibilité de P. infestans sur Pdt (Shtienberg et al.,1990)

$$RYL = 100\left(1-\left(1-\frac{\alpha\left(RAUDPC_{\inf}-RAUDPC_{ref}\right)}{B}\right)\left(\frac{P'_{cb}-P'_{tg}}{P_{cb}-P_{tg}}\right)\right)$$



$$RAUDPC = \frac{\sum_{i=1}^{i=n}\left(\frac{X_{i+1}+X_i}{2}\right)\left(P_{i+1}-P_i\right)}{P_{\max}-P_1}$$

B : taux de tubérisation

A : coefficient de réduction du taux de tubérisation

P : âge physiologique

X’(t) : destruction foliaire en pourcentage

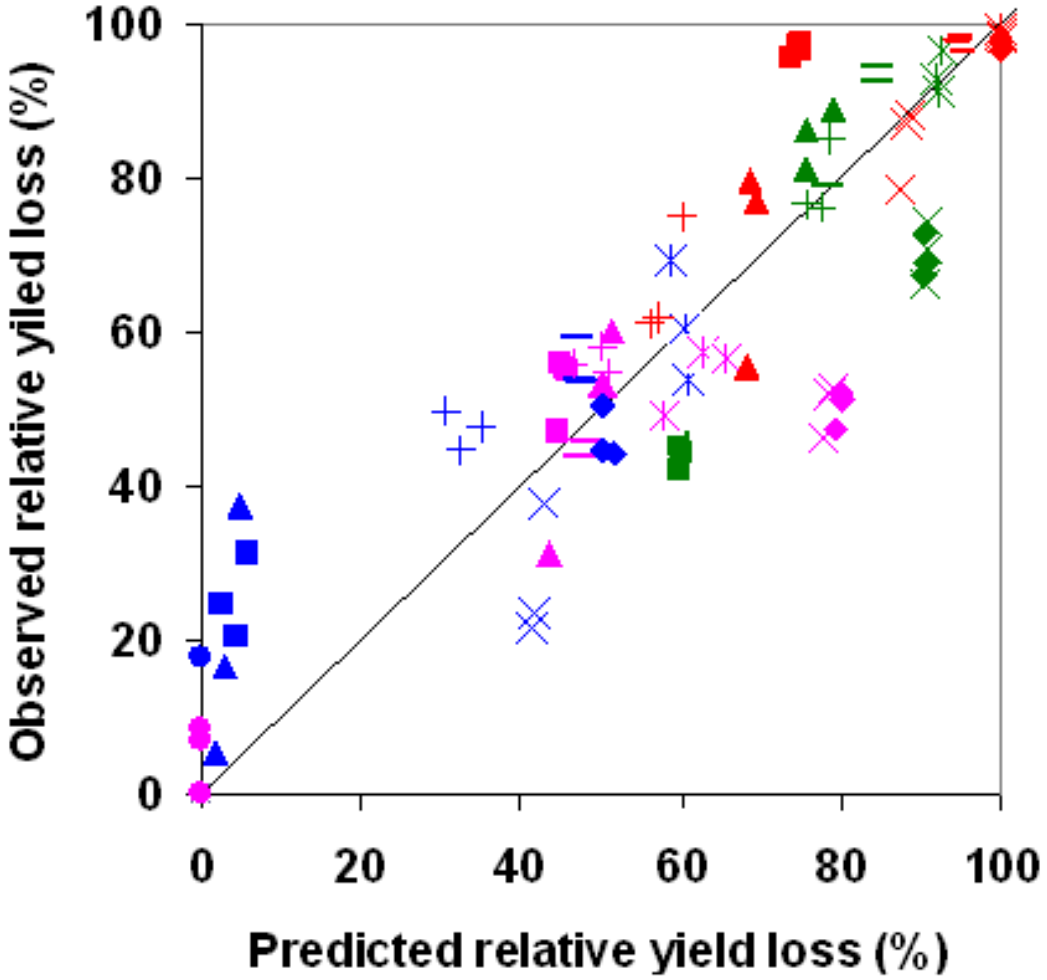
RYL : perte relative de rendement

Evaluation de la qualité prédictive de la fonction de nuisibilité de Shtienberg et al. (1990)

Efficiency = 0.80
RMSEP = 13.25 %
Bias = -0.36

☐ : Arka
* : Bintje
\- : Désirée
Δ : Eden
× : Inra 92T.114.76
¤ : Inra 92T.120.16
\+ : Naturella
◊ : Robijn.

- 2006
- 2007
- 2008
- 2009



Rakotonindraina et al, 2012

Yield loss assessment

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Dynamic modelling of damage functions associated to a crop model

Damage mechanisms

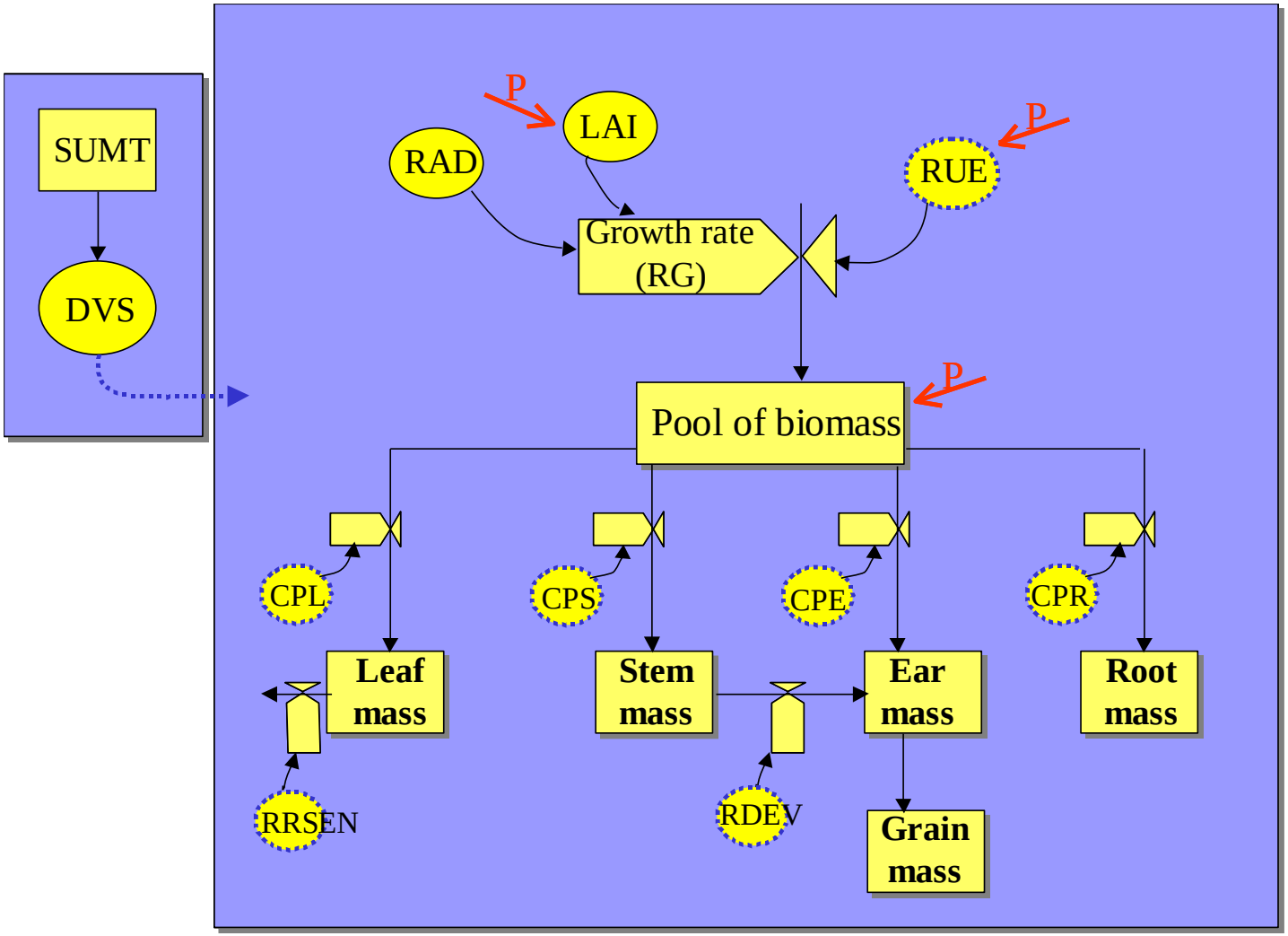
• Damage mechanism: physiological effect of injury on crop growth and yield. Can be incorporated in models to simulate yield losses.

Damage mechanism	**Physiological process/variable affected**	**Examples**
Assimilate sapper	Maintenance/pool of assimilates	Aphids, rusts, septoria blotch
Light stealer	Light interception/green LAI	Rusts, powdery mildew, septoria blotch
Assimilate rate reducer	Photosynthesis/RUE	Eyespot, sharp eyespot, fusarium stem rot, take-all, weeds, BYDV, aphids

Rabbinge, R., Vereijken, P.H., 1980. The effect of diseases or pests upon the host. Z. Pflkrankh. Pflschutz 87, 409-422.

Boote, K.J., Jones, J.W., Mishoe, J.W., Berger, R.D., 1983. Coupling pests to crop growth simulators to predict yield reductions. Phytopathology 73, 1581-1587.

Simplified flow chart of WHEATPEST



Willocquet L, Aubertot JN, Lebard S, Robert C, Lannou C, Savary S. 2008. Simulating multiple pest damage in varying winter wheat production situations. Field Crops Research, 107 (1), p.12-28.

Modelling Actual Yield

Disease	Injury localisation	Data input in the model
Take-all	Roots	Percentage of take-all disease on roots.
Fusarium Stem Rot	Roots, Stems	percentages of tillers with Fusarium stem rot symptoms.
Eyespot	Stems	percentages of tillers with eyespot
Sharp-eyespot	Stems	percentages of tillers with sharp eyespot symptoms
Septoria nodorum blotch	Leaves	Septoria nodorum blotch severity
Septoria tritici blotch	Leaves	Septoria tritici blotch severity
Brown rust	Leaves	Brown rust severity
Yellow rust	Leaves	Yellow rust severity
Powdery Mildew	Leaves	Powdery Mildew severity
Fusarium Head Blight	Ears	percentage of kernels with Fusarium head blight symptoms
Aphids	Affect overall performance	Number of aphids
Weeds	Affect overall performance	Dry biomass of weeds
Barley Yellow Dwarf Viruses	Affect overall performance	Percentages of plants with Barley Yellow dwarf Viruses symptoms

Biomass production

$$RG = RAD * RUE * (1 - e^{-kLAI})$$

RG: Rate of Growth ([RG]=$MT^{-1}L^{-2}$)

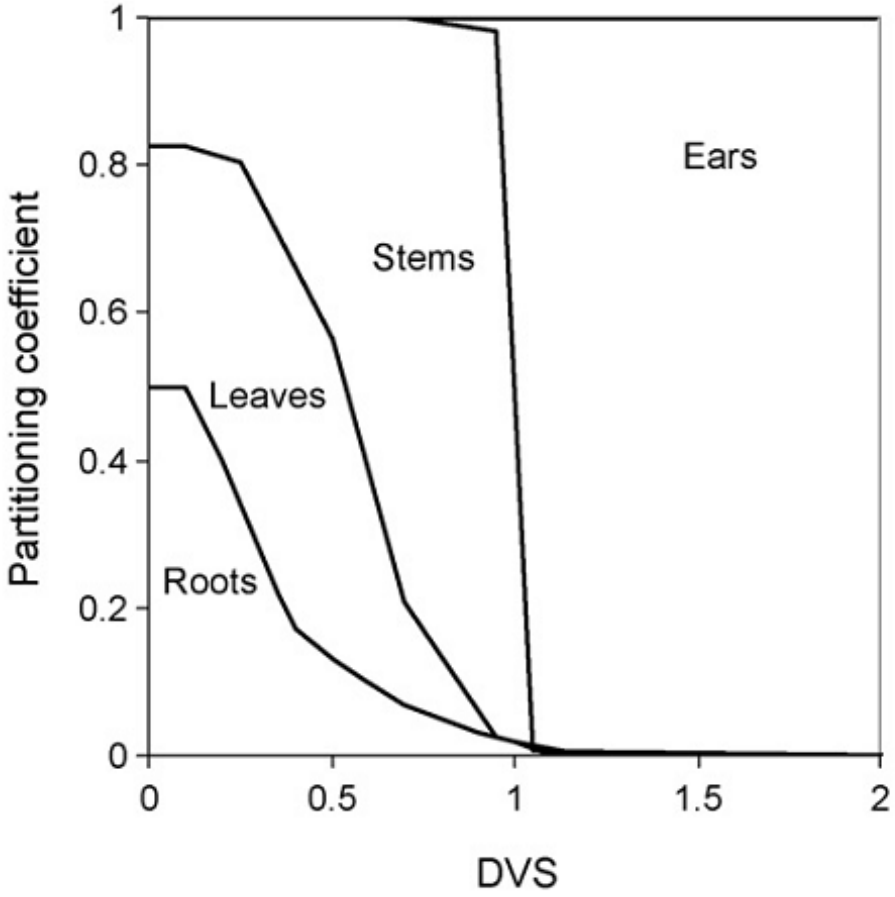
RAD: global RADiation ([RAD]=MT^{-3})

RUE: Radiation Use Efficiency ([RUE]=$T^{2}L^{-2}$)

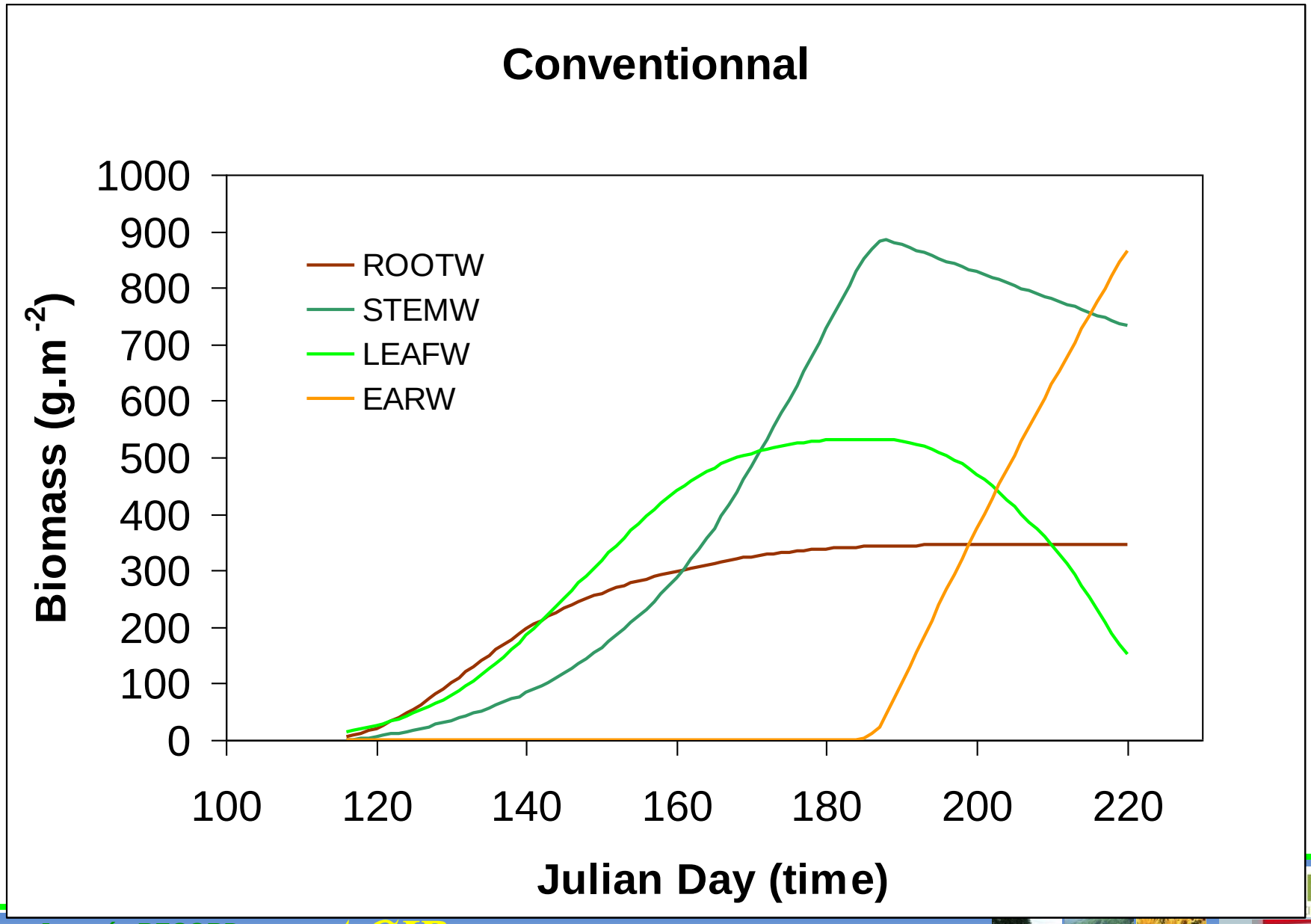
k: coefficient of light extinction ([k]=1)

LAI: Leaf Area Index ([LAI]=1)

Partitioning of assimilates to wheat organs as a function of development stage (DVS). Derived from Spitters et al (1989)



Output examples



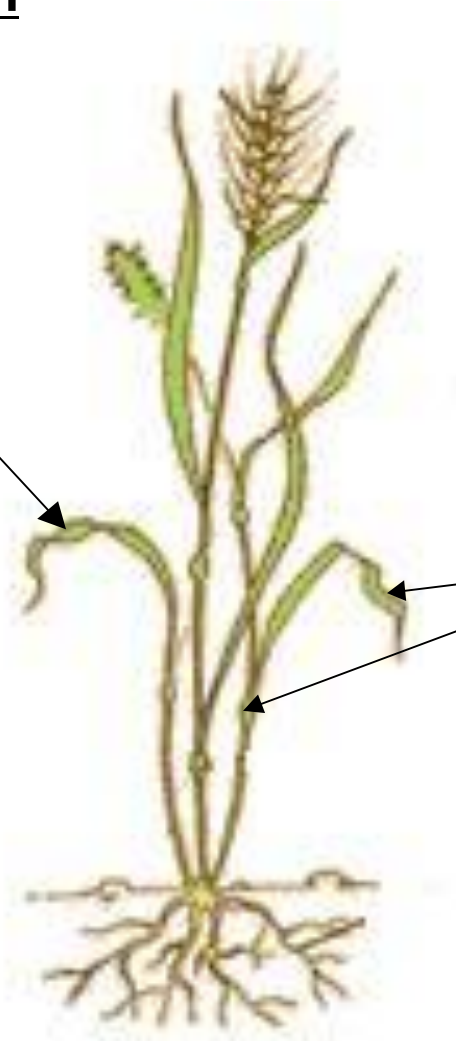
Leaf and Stem diseases

Septoria tritici, S nodorum

r

• elongate ovals lesions, running parallel to leaf veins +chlorotic halo around the lesions.

• black pycnidia (spore cases) in mature lesions.



Powdery mildew

• white fluffy mildew pustule
+ black spores at the end of vegetation

Modelling damage mechanisms: powdery mildew (*Blumeria graminis*)

$$LAI_{dis} = LAI\left(1 - x/100\right)^{\beta}$$

LAI_{dis}: reduced Leaf Area Index ([LAI_{dis}]=1)

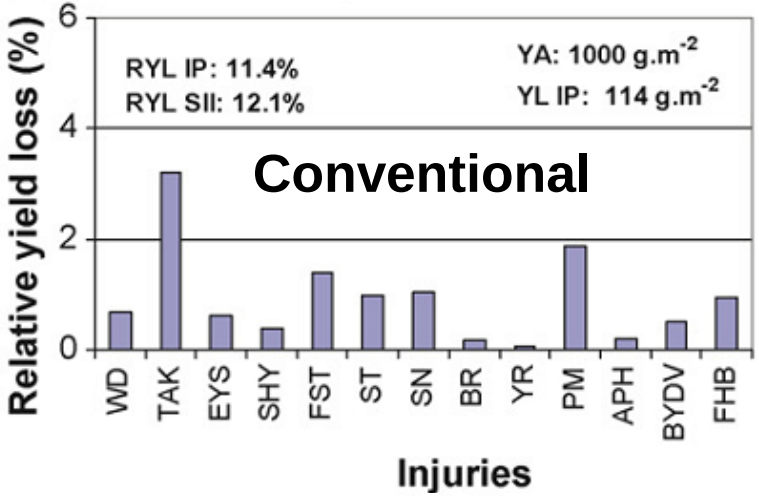
LAI: Leaf Area Index ([LAI]=1)

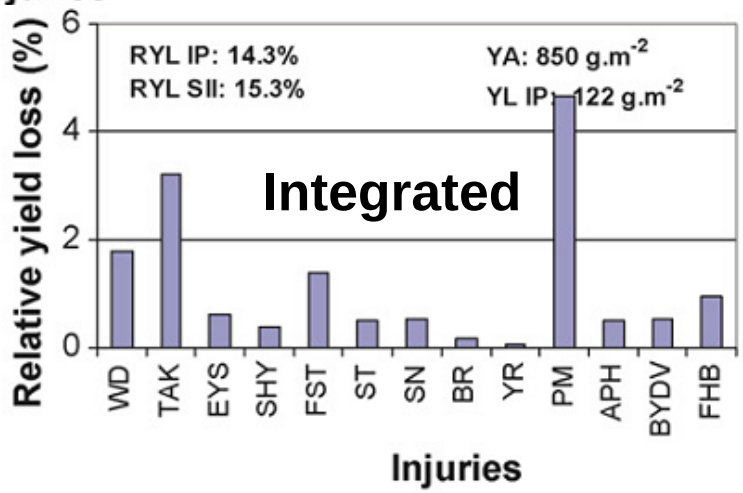
x: severity of the disease expressed in % ([x]=1)

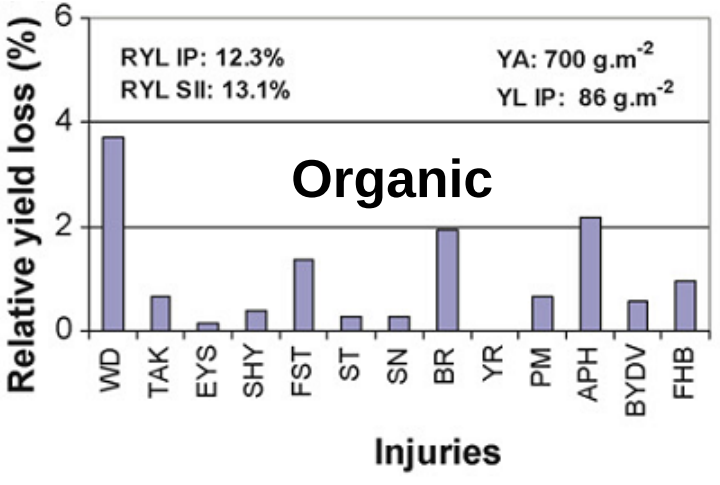
β: ratio of the virtual lesion area over the actual lesion area ([β]=1)

β=2.5 (Rabbinge et al, 1985)

Output examples

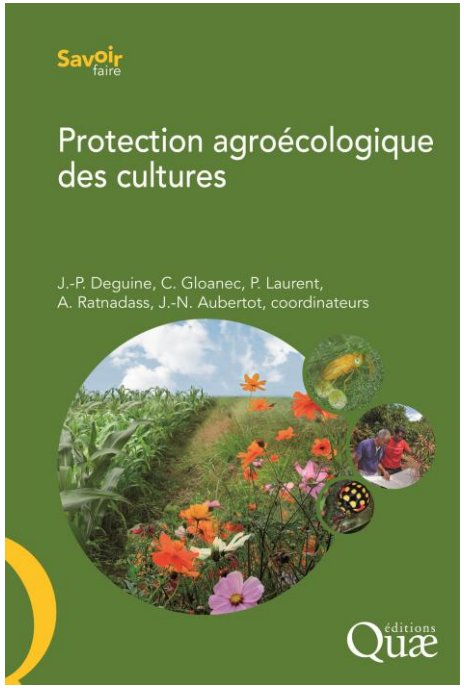






Objectifs de la plateforme XPEST

- Partager un cadre conceptuel générique
- Faciliter le développement de modèles de nuisibilité
- Faciliter l'utilisation et le partage de ces modèles
- Promouvoir les approches de R&D ayant trait aux profils de dégâts
- Contribuer à la formation pour la PAEC



Structure of the XPEST platform

Home page
- Description of the aims of the platform, its structure, and underlying concepts

- Links to specific webpages describing XPEST models

Modelling forge
From scratch or re-using available models or sub-models

Outputs stored in a database:
- models: online and downloadable R packages
- description of models with texts and pictures displayed in specific web pages

Simulation center
Using a XPEST model and uploading input variables

Outputs stored in a database:
- simulations: input variables, model (mathematical structure and parameters), output variables (data, online and downloadable graphs)

Accessibility

- Any web surfer

- XPEST modellers (required authorisation)

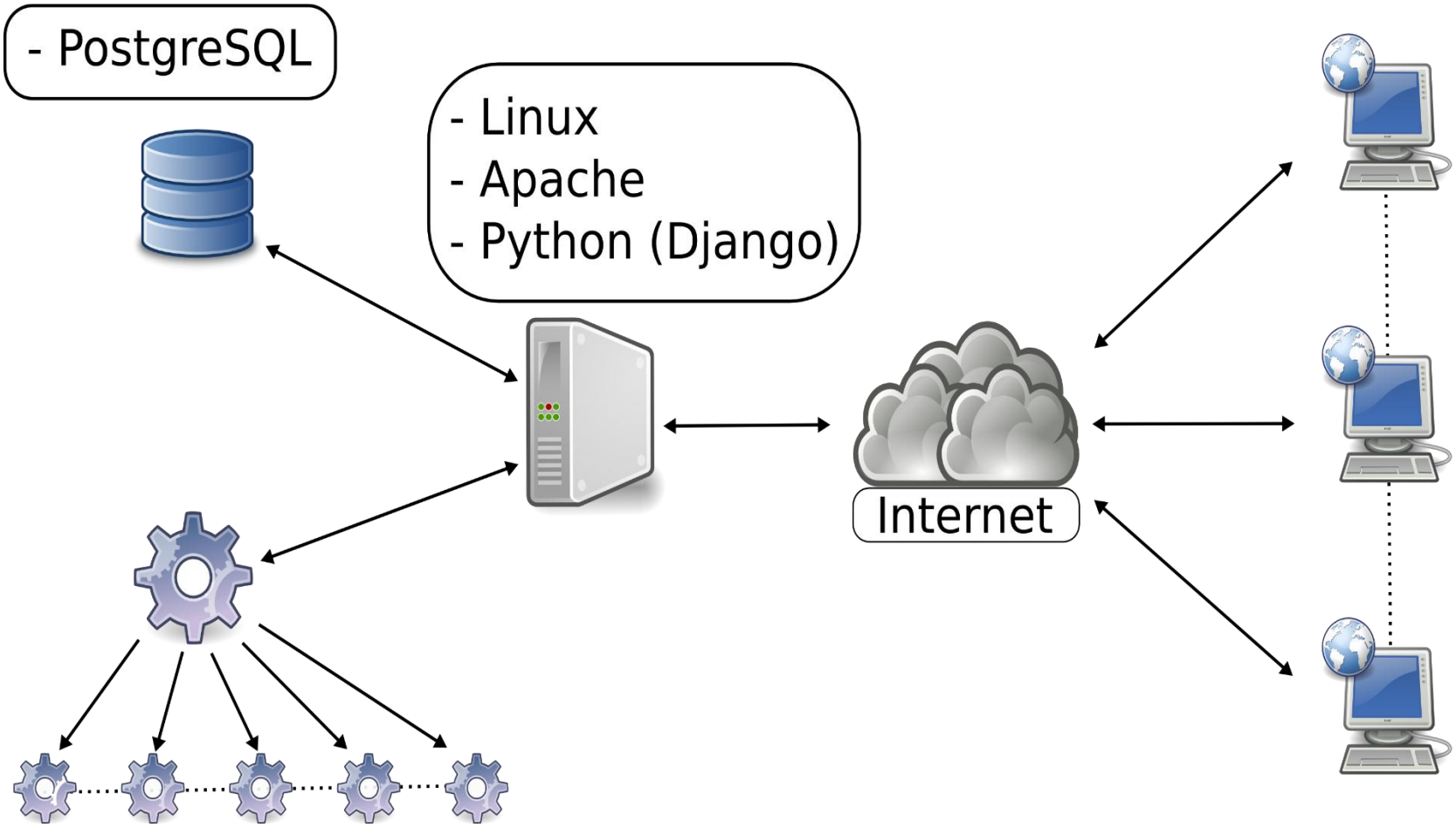
-XPEST administrators

- XPEST users (defined by XPEST modellers)

- XPEST modellers

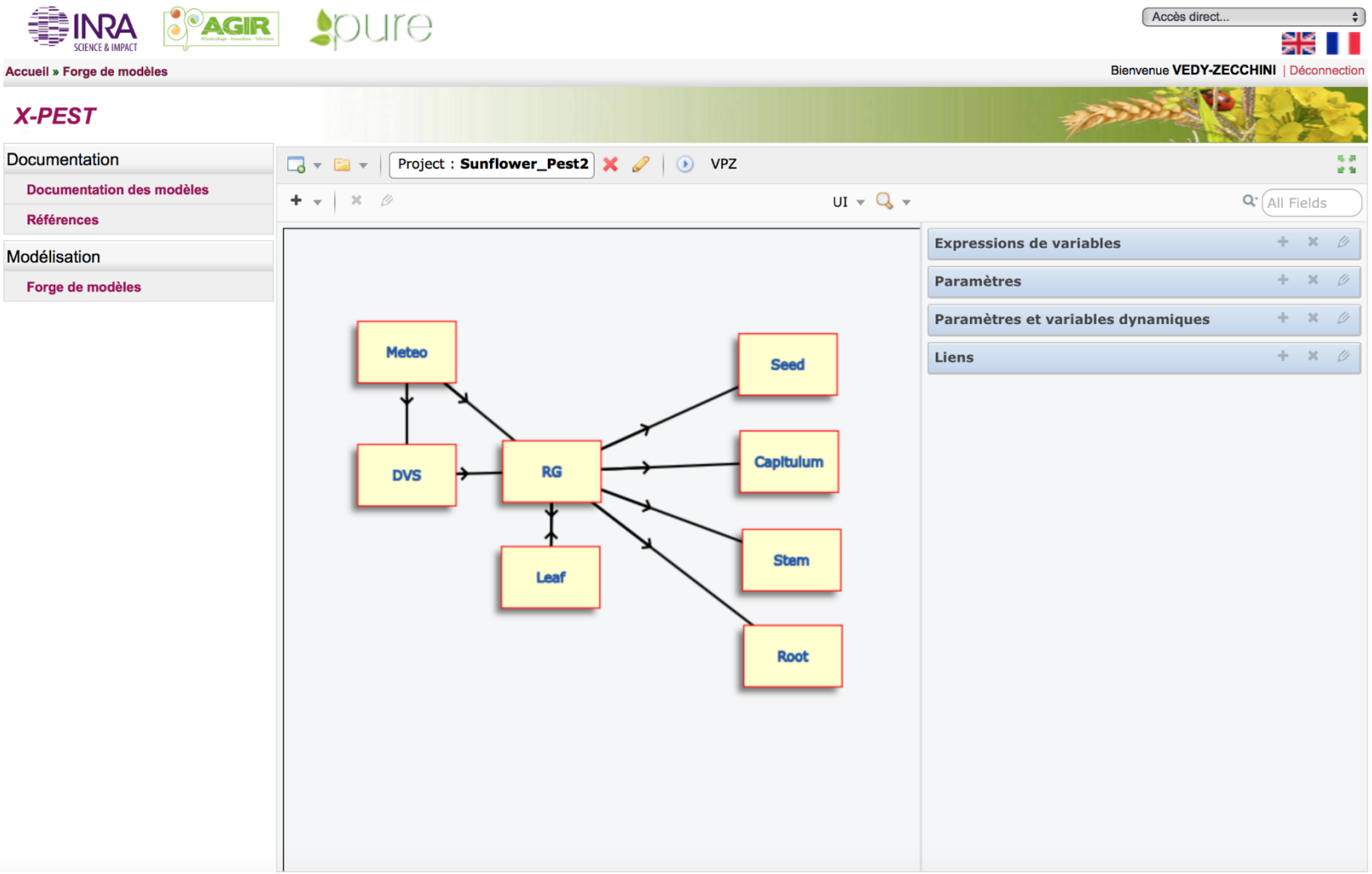
- XPEST administrators

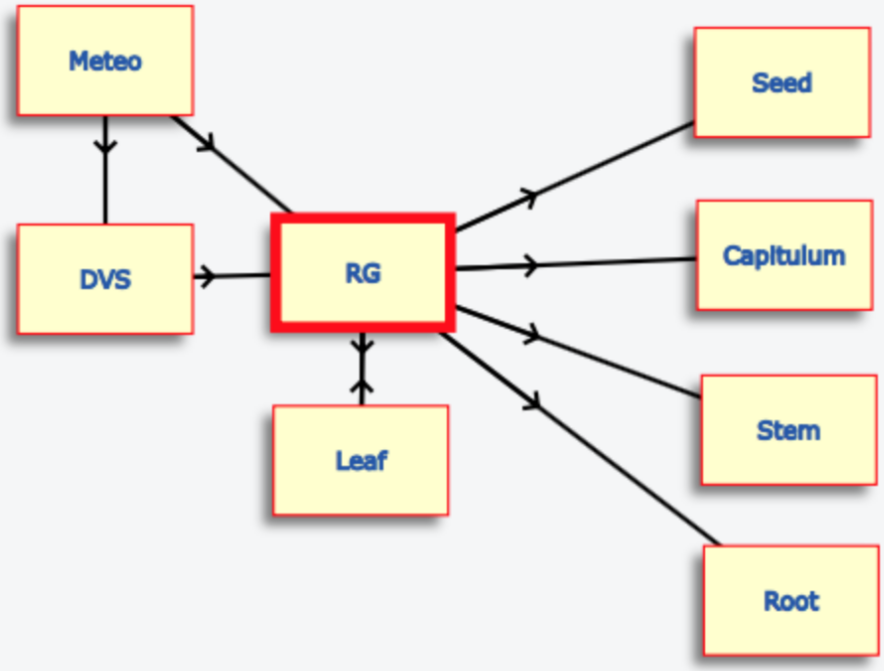
Architecture informatique de la plateforme XPEST



SUNFLOWERPEST V1.0

http://147.100.164.75/xpest


Accès direct...
Accueil » Forge de modèles
Bienvenue VEDY-ZECCHINI | Déconnection
X-PEST
Documentation
Documentation des modèles
Références
Modélisation
Forge de modèles
Project : Sunflower_Pest2
VPZ
UI
All Fields
Expressions de variables
Paramètres
Paramètres et variables dynamiques
Liens
Meteo
DVS
RG
Leaf
Seed
Capitulum
Stem
Root



Expressions de variables

Variable	Expression	Init.	Unité
RG	(ec*RAD*RUE*(1-exp(-k*LAI(-1))))*dt	1	g.m-2

Paramètres

Paramètre	Valeur	Unité
ec	0.48	Dimensionless
k	0.85	Dimensionless
dt	1	day

Paramètres et variables dynamiques

Variable	Fichier	Temps	Unité
RUE	RUE.txt	DVS	g.MJ-1

Liens

Variable	Modèle	Mode	Unité
RAD	ModelMeteo	synchrone	MJ.m-2.day-1
DVS	ModelDVS	synchrone	Dimensionless
LAI	ModelLeaf	asynchrone	m2.m-2

Edit equation **RG**

Variable: RG

Unité: g.m-2

Expression: (ec*RAD*RUE*(1-exp(-k*LAI(-1))))*dt

Valeur initiale

Description

Equation editor

7	8	9	/	VAR	log2	sqrt	min	&&	ll	sin	cos	tan
4	5	6	*	(	log	abs	max	<=	>=	sinh	cosh	tanh
1	2	3	-	)	ln	sign	sum	!=	==	asin	acos	atan
0	.	^	+	:?	exp	rint	avg	>	<	asinh	acosh	atanh

Cancel Save

Direct access...

Home » Modelling forge

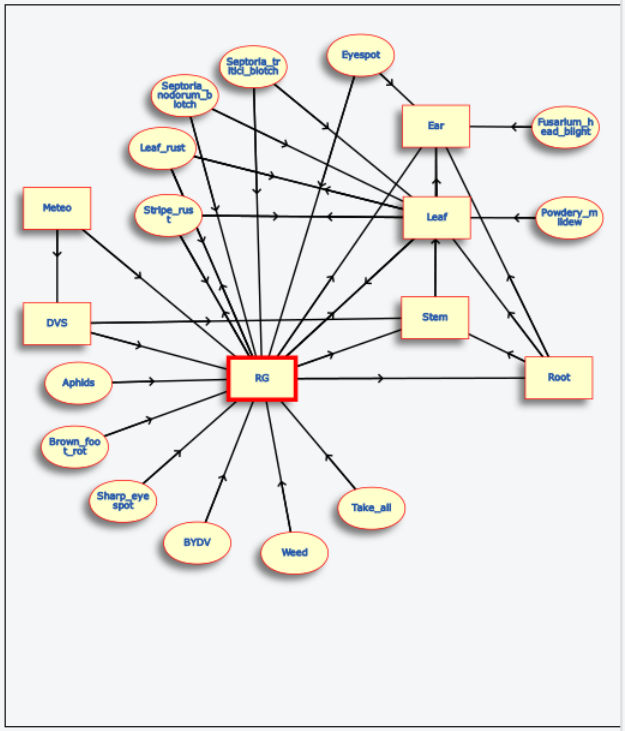
Welcome **admindj** | Logout | Administration

X-PEST

- Documentation
  - Model documentation
  - References
- Modelling
  - Modelling forge
- Simulation
  - Simulation center

Project : **Wheatpest** | VPZ

Model : **ModelRG** | UI | All Fields



Variable expressions

Variable	Expression	Init.	Unit
RG	RGATT*RF_ES*RF_SES*RF_WEED*RF_BFR*RF_BYDV*RF_TA*RF_SNDV*RF_STDV*RF_SR(-1)*RF_LR(-1)*RF_APH-RSAP	0	g.day-1.m-2
RGATT	RAD*RUE*(1-exp(-k*LAI))	0	g.day-1.m-2

Parameters

Parameter	Value	Unit
k	0.65	Dimensionless

Dynamic parameters and variables

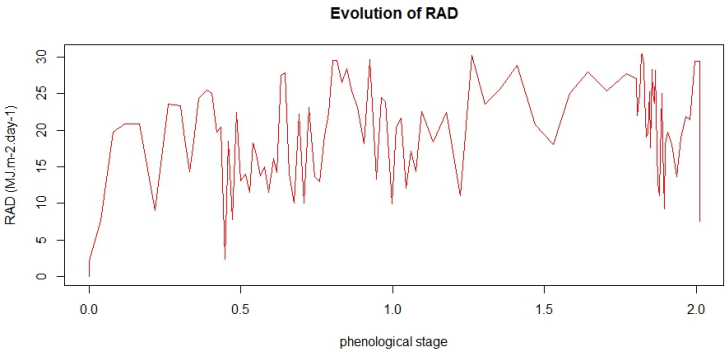
Variable	File	Time	Unit
RUE	RUE.txt	DVS	g.MJ-1

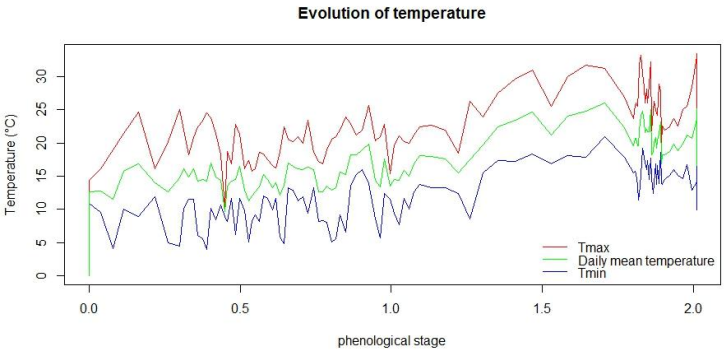
Links

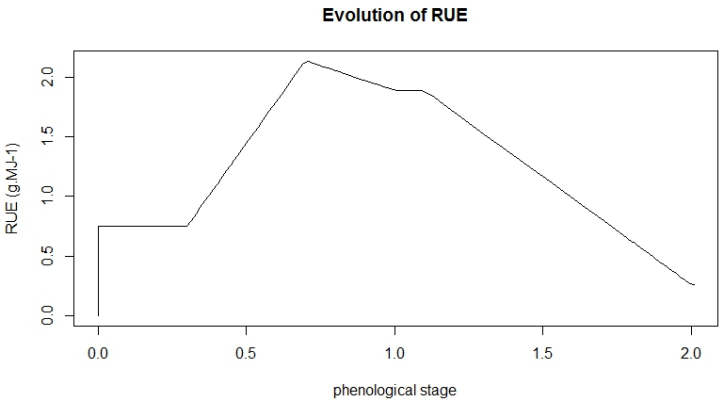
Variable	Model	Mode	Unit
LAI	Leaf	synchrone	m2.m-2
DVS	ModelDVS	synchrone	Dimensionless
RAD	ModelMeteo	synchrone	MJ.m-2.day-1
RF_APH	Aphids	synchrone	Dimensionless
RF_BFR	Brown_foot_rot	synchrone	Dimensionless
RF_BYDV	BYDV	synchrone	Dimensionless
RF_ES	Eyespot	synchrone	Dimensionless
RF_LR	Leaf_rust	asynchrone	Dimensionless
RF_SES	Sharp_eyespot	synchrone	Dimensionless
RF_SNDV	Septoria_nodorum_blotch	synchrone	Dimensionless
RF_SR	Stripe_rust	asynchrone	Dimensionless
RF_STDV	Septoria_tritici_blotch	synchrone	Dimensionless
RF_TA	Take_all	synchrone	Dimensionless

Premières simulations du modèle SUNFLOWERPEST (sans stress biotiques)

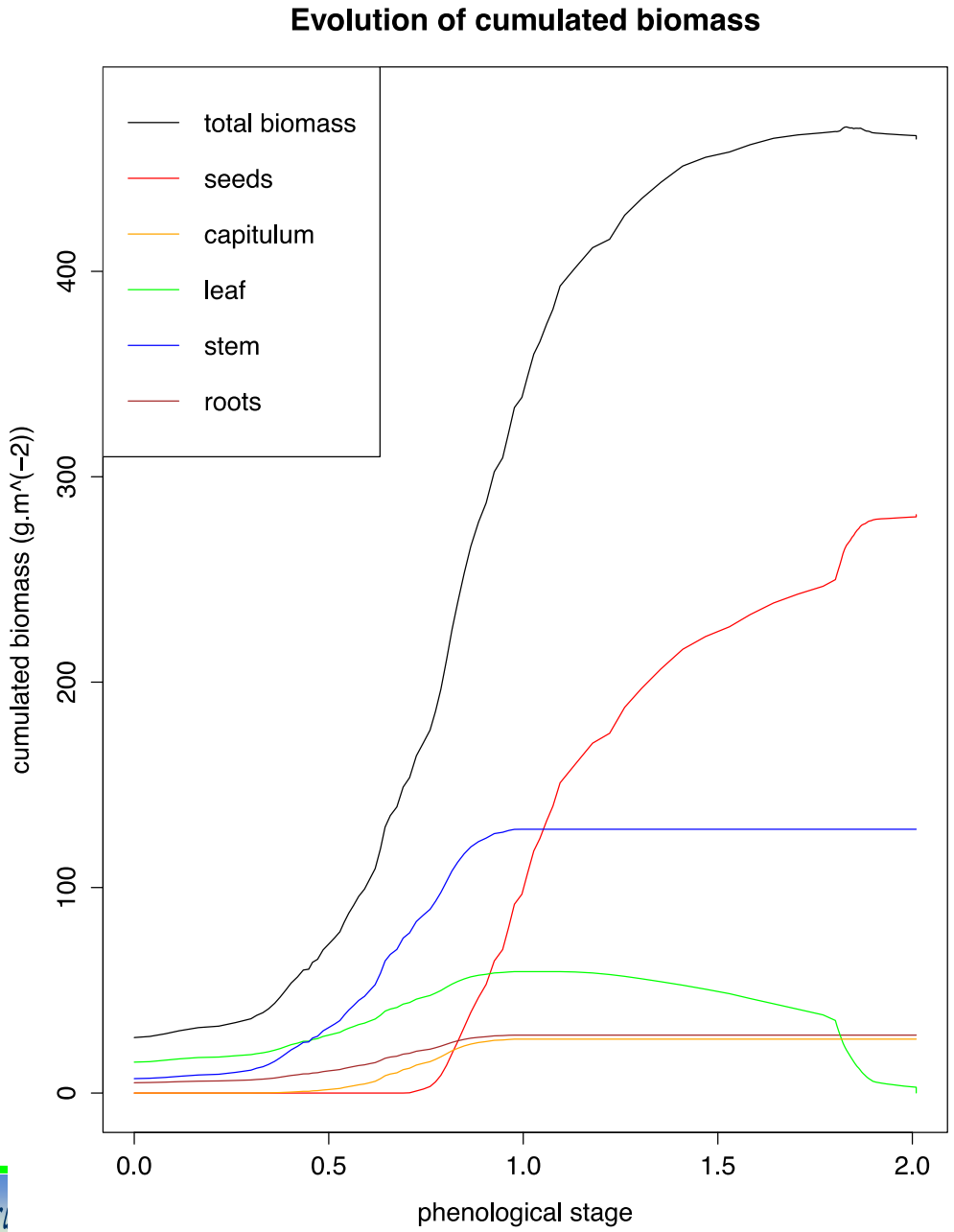
Variables d'entrée



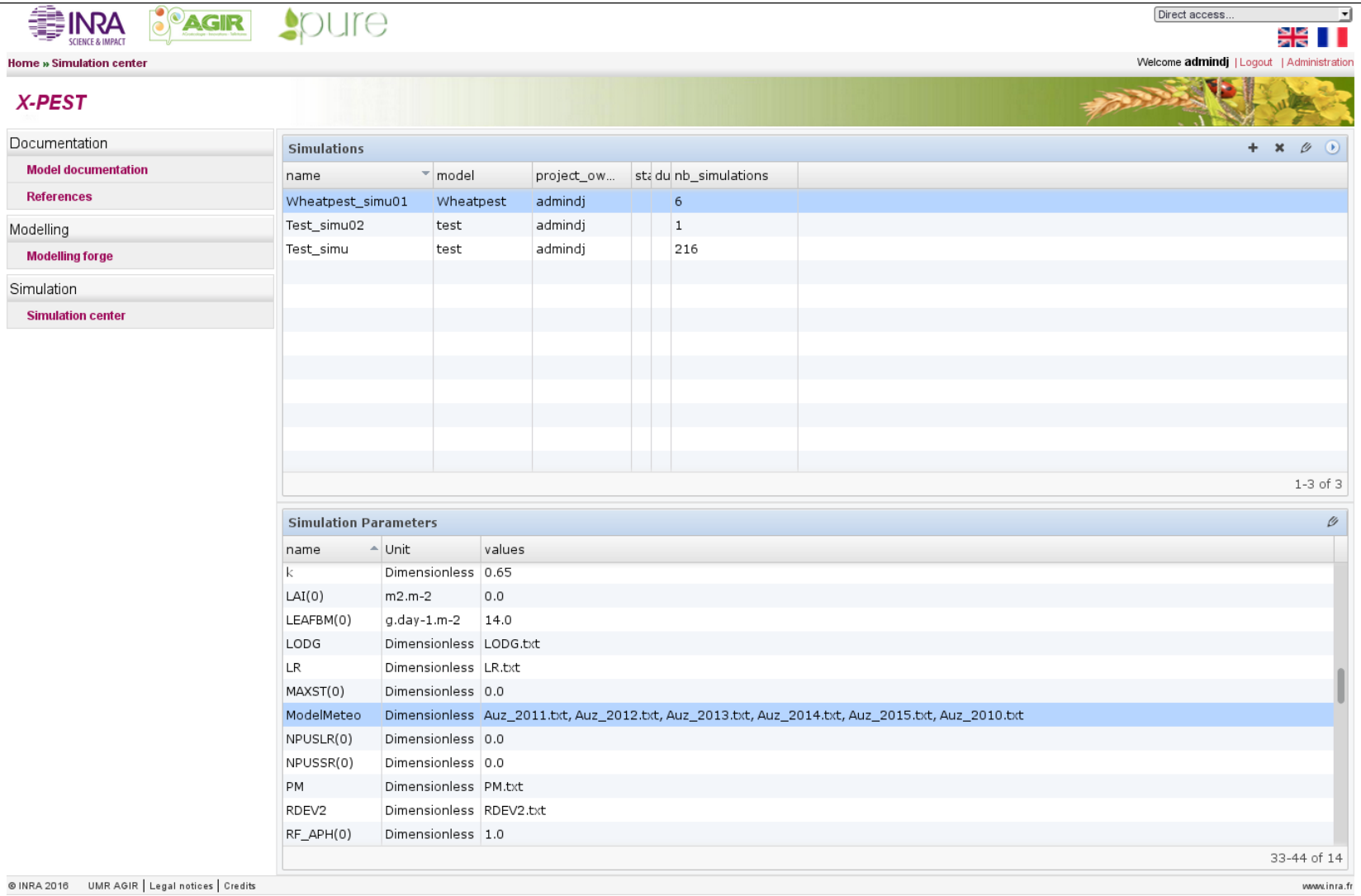




Variables de sortie



Centre de simulation (pas encore déployé)



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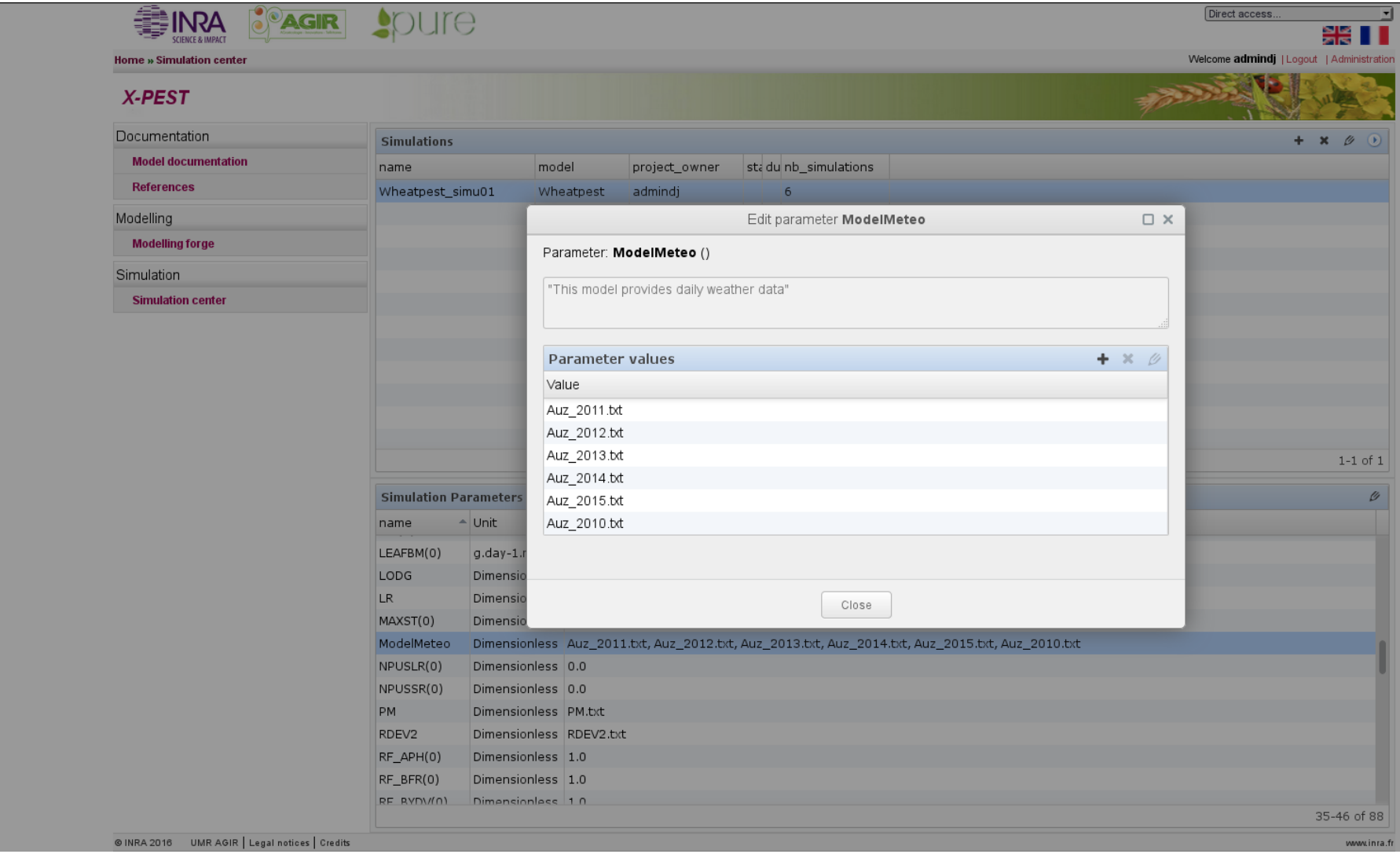

Perspectives

- finaliser le « centre de simulation » de la plateforme
- développement du modèle SUNFLOWERPEST (projet Promosol) dans le cadre de la thèse de MA Vedy-Zecchini
- implémentation de VINEYARDPEST(collaboration UMR SYSTEM)
- article en cours de rédaction pour le numéro spécial PURE de Crop Protection
- création d'un TD pour

GASCON

Gestion Agroécologique de la Santé des Cultures et des Organismes Nuisibles

- Installation de R-VLE sous d'autres OS qu'Unix bientôt possible ?