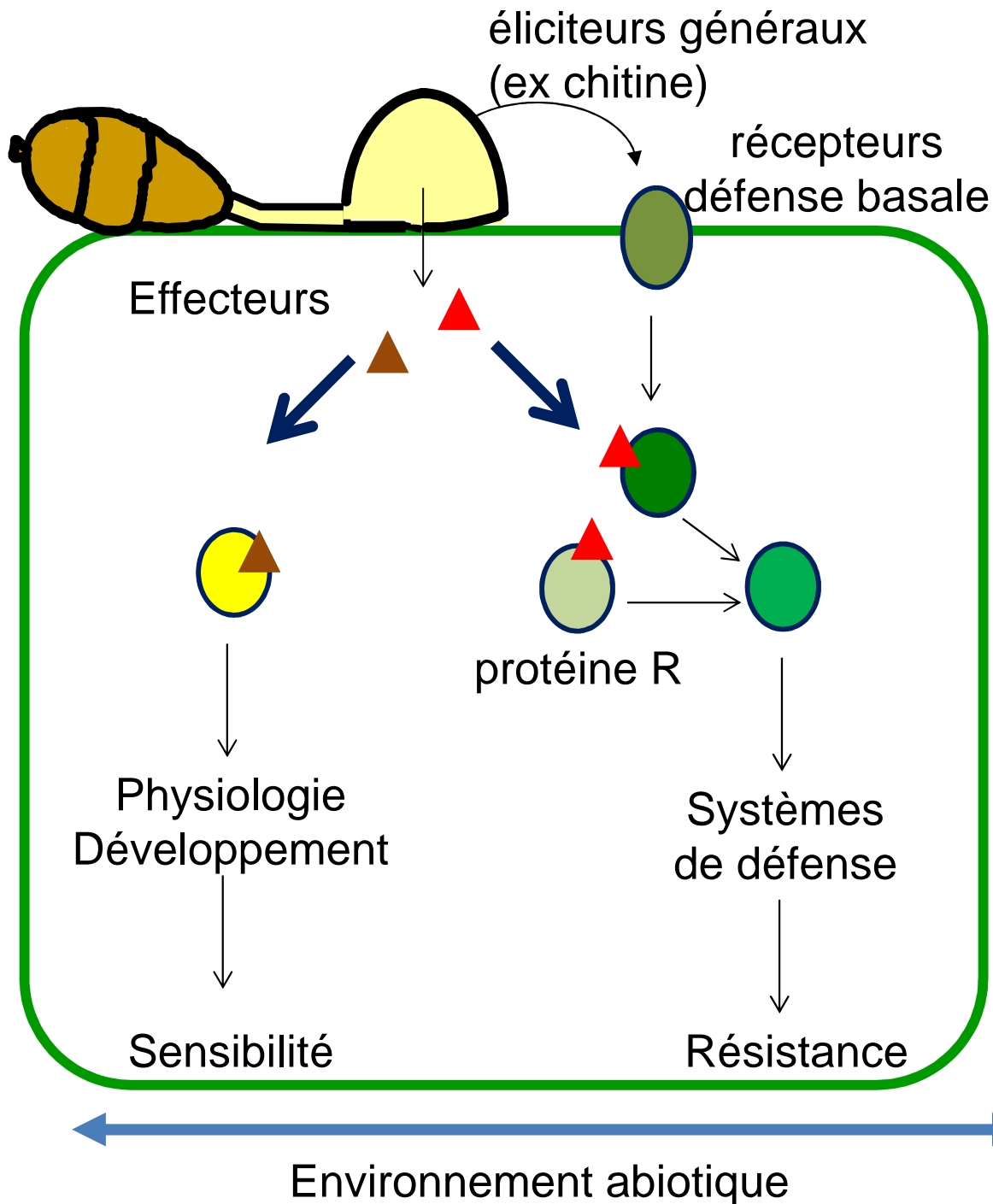




**Biologie et génétique des interactions plantes-parasites (BGPI)
INRA-CIRAD-SupAgro, Montpellier.**

*Exemples de transferts de connaissances du
riz au blé
pour l'amélioration de la résistance*



Comment le pouvoir pathogène se construit-il?

Axe 1: Effecteurs et cibles

- Quels effecteurs fongiques?
- Quelle contribution à l'agressivité?
- Quelles fonctions dans la plante?

Axe 2: Mécanismes de résistance

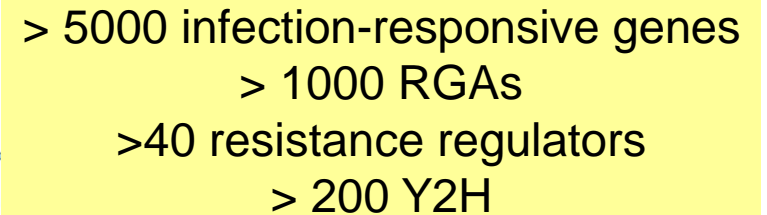
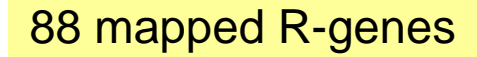
- Comment les effecteurs sont-ils reconnus?
- Quels régulateurs en aval?

Axe 3: Effets de l'environnement abiotique

Comment l'environnement affecte-t-il le fonctionnement de ces systèmes?

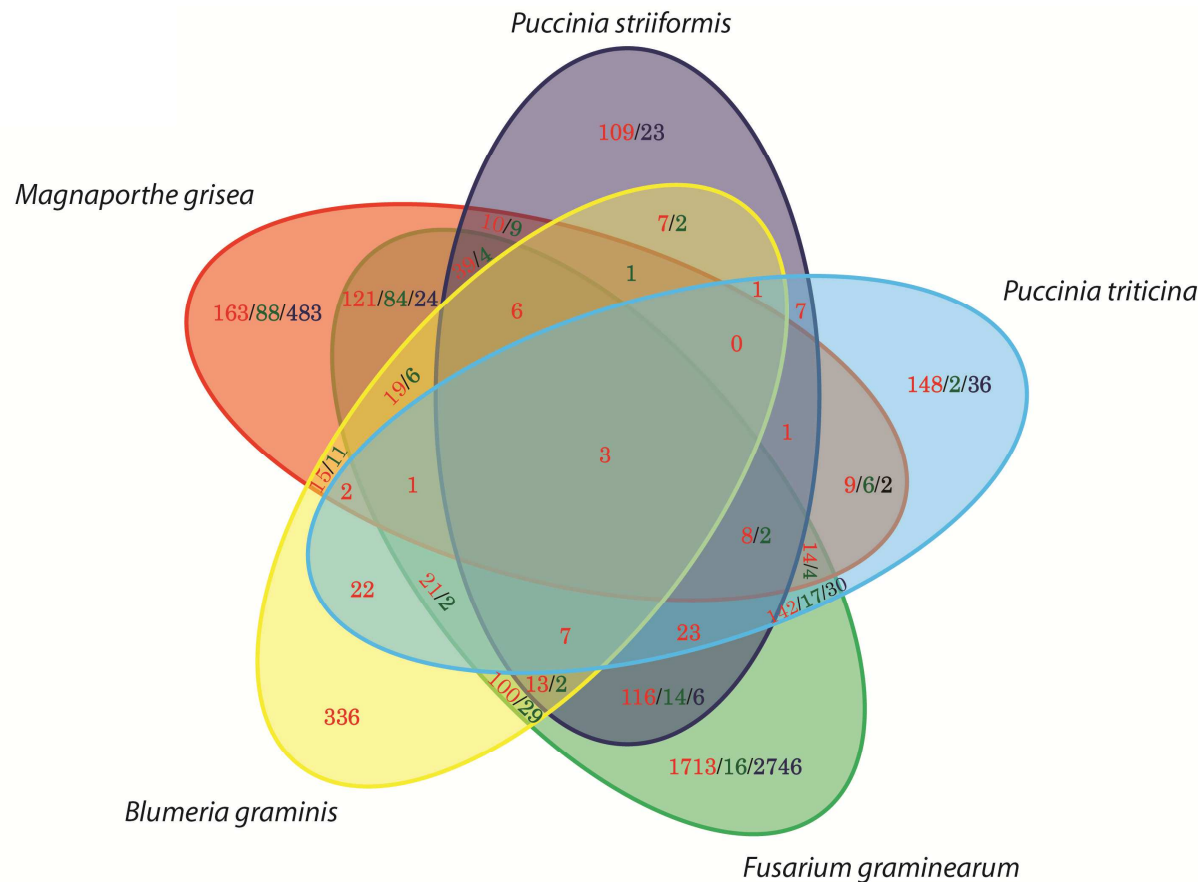
Transfert de savoir-faire

Ballini et al, MPMI 2008; Vergne et al, 2008



Archipelago wheat

Wheat affymetrix data



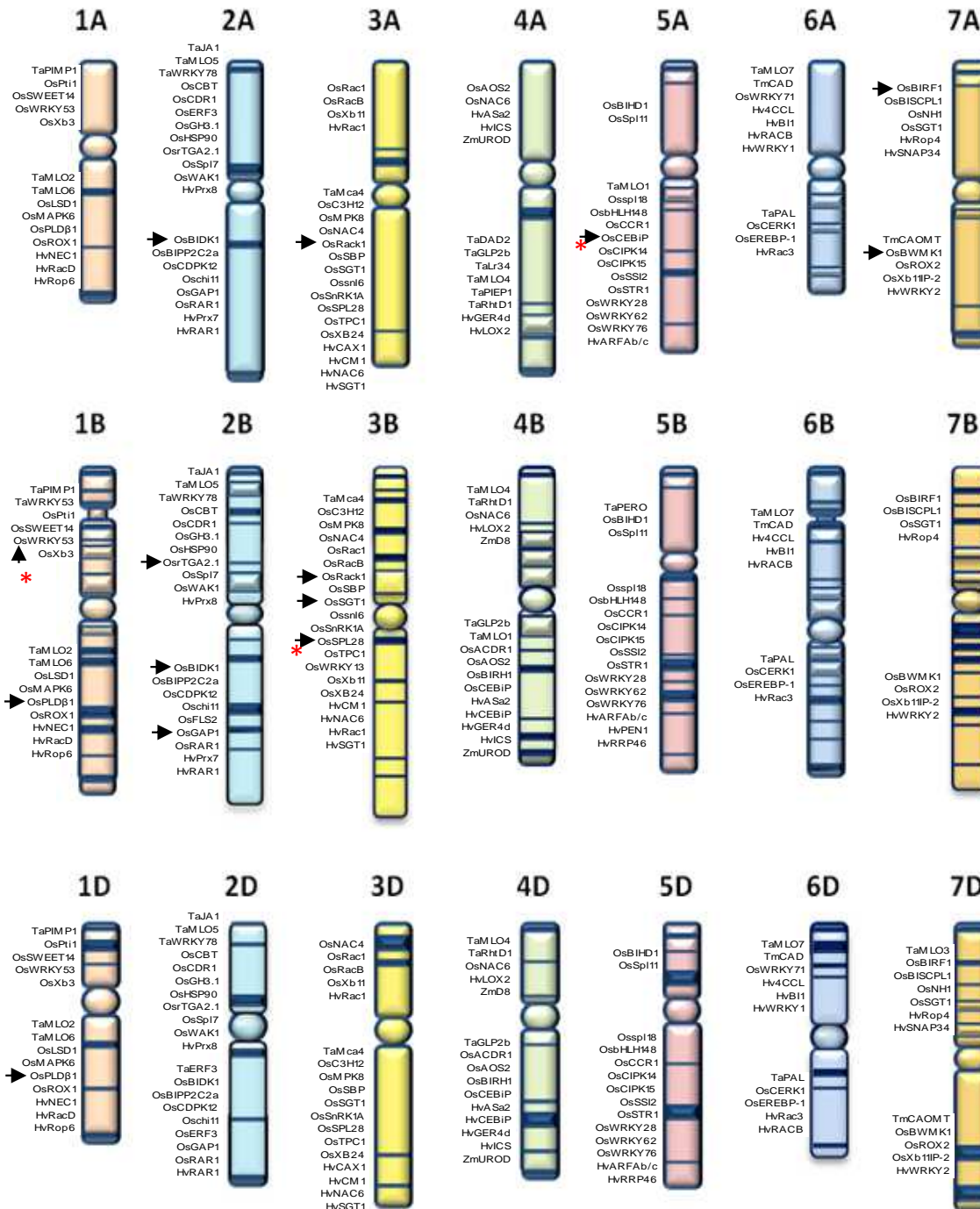
Published regulators converted into Affymetrix probes

Genes	
Triticum	28
Rice	101
Barley	28
Maize	4
total	161

- 6800 wheat genes differentially expressed during infection
- **179 genes likely involved in basal defense** (response to several fungi)
- One TF responds to all fungi; wheat transgenic in progress (Collab Biogemma)

Gobbato et al, submitted

Physical and genetical position of the cereal disease regulators



	Genes	Anchored on genome
Triticum	28	25
Rice	101	85
Barley	28	25
Maize	4	4
total	161	139 (86%)

+ Genetic position of SNPs corresponding to 25 published disease regulators (confirms *in silico* mapping)

Association genetics in wheat using disease regulators

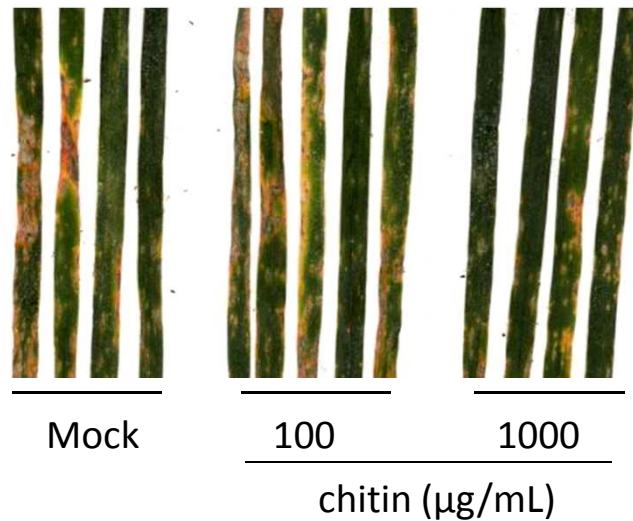
Table 2. Genetic association between disease regulators candidates and FHB resistance

Original rice accession	Rice alias	Function	EST TIGR	SNP and mapping position	FHB resistance evaluation ¹	
					Field, 2008 (3 traits)	Nethouse, 2010 (6 traits)
Os10g38060	OsPLD β 1	Phospholipase D	TA78332_4565	1 SNP mapped on 1B	0	0
Os02g22130	OsGAP1	GTPase-activating protein	TA74523_4565	1 SNP mapped on 1D	0	0
Os05g27730	OsWRKY53	Transcription factor	TA72784_4565	1 mapped on 2B	0	0
				2 mapped on 1B	0	5
					0	5
					0	1
Os01g50770	SPL28	adaptor complexes medium subunit	TA78791_4565	3 mapped on 3B	0	0
					0	0
Os01g49290	Rack1	Guanine nucleotide-binding protein	TA53975_4565	1 mapped on 3B	0	0
				1 mapped on 3A	0	0
Os07g48820	rTGA2.1	Transcription factor	TA61854_4565	2 mapped on 2B	0	0
					0	0
Os06g49430	BWMK1	MAP kinase	TA68380_4565	1 mapped on 7A	0	0
					0	0
Os03g04110	CEBiP	Chitin-binding protein	TA57258_4565	2 mapped on 5A	3	0
					2	0
					0	0
Os04g54200	OsBIDK1	diacylglycerol kinase	TA67450_4565	2 mapped on 2B	0	0
					0	0
Os02g50930	OsBIRF1	RING-H2 finger protein	CD889510_4565	1 mapped on 2A	0	0
				1 mapped on 7A	0	0
Os01g43540	OsSGT1	co-chaperone	TA59812_4565	2 mapped on 3B	1	1
					2	1

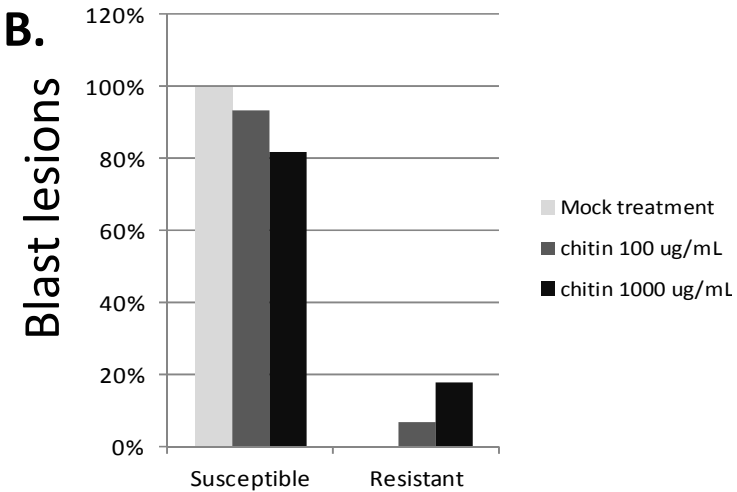
1: The values represent the number of significant associations ($P < 0.01$) found between the SNP and the 3 or 6 disease resistance traits evaluated.

Defense induction in wheat by chitin

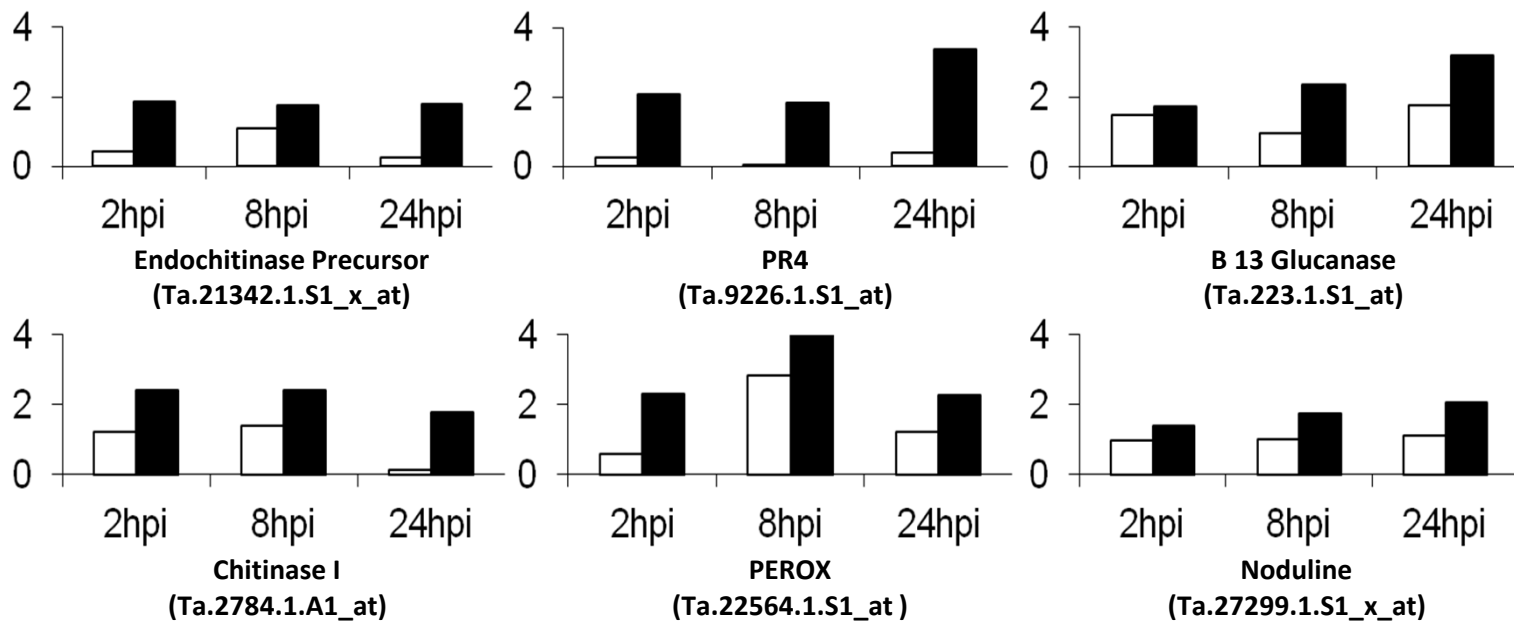
A.



B.



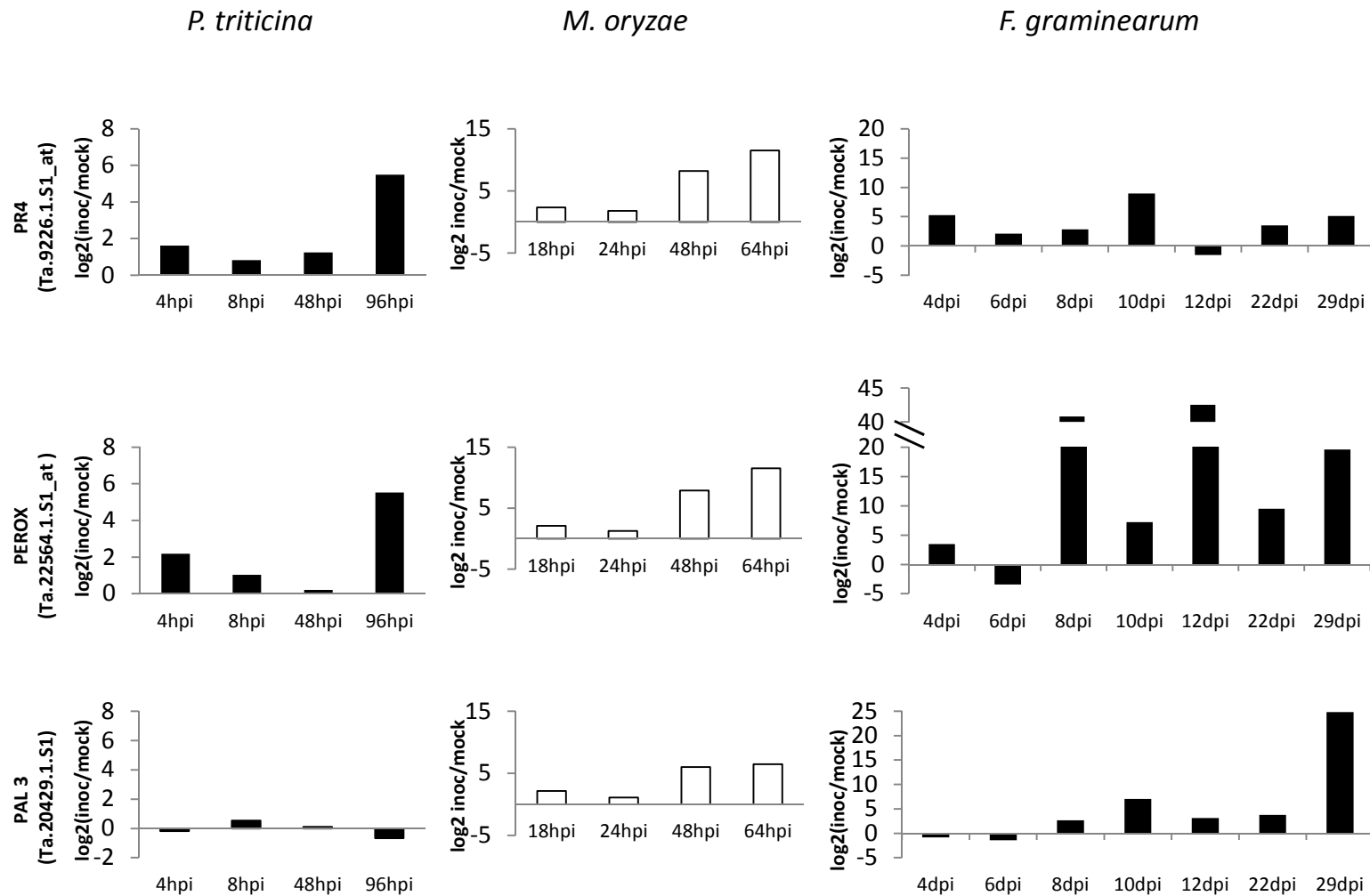
C.



Selected chitin-regulated wheat genes

probeset_id	Annotation	Log10 Ratio (Chitin vs Mock)		P-value		Number of fungi that regulate expression	homolog known to be involved in disease resistance		Rice homolog known to be regulated by chitin (Kaku et al 2006)
		2 hat	8 hat	2 hat	8 hat		Wheat or Barley	Rice	
Pathogenesis-related									
Ta.223.1.S1_at	Beta-1,3-glucanase.	1.44	2.37	0.125	0.007	5			no
Ta.30501.1.S1_at	Chitinase II.	1.59	2.22	0.022	0.004	4			no
Ta.21342.1.S1_x_at	Endochitinase precursor.	2.07	1.95	0.097	0.021	4	chi11		yes
Ta.169.1.S1_x_at	Germin-like protein precursor.	1.31	2.06	0.041	0.024	3	HvGER4d		yes
Ta.27477.1.S1_at	Oxalate oxidase GF-2.8 precursor (Germin GF-2.8)	-1.23	1.22	0.175	0.044	2	TaOXOX		nd
Ta.97.2.S1_x_at	TaPERO (peroxidase)	1.70	2.71	0.072	0.006	4	TaPERO		nd
Ta.22564.1.S1_at	peroxidase precursor, putative, expressed	2.63	3.11	0.025	0.002	3	HvPrx8		no
Ta.959.1.S1_at	Thaumatococin-like protein.	0.42	1.75	0.272	0.019	4			no
Ta.3133.1.S1_x_at	WIR1A protein.	1.63	2.96	0.098	0.019	4			nd
Secondary metabolism									
Ta.7022.1.S1_s_at	Phenylalanine ammonia-lyase (EC 4.3.1.5).	2.82	1.89	0.021	0.140	3	TaPAL		no
Ta.28562.1.A1_at	Cinnamyl alcohol dehydrogenase (EC 1.1.1.195) (CAD)	1.34	0.46	0.037	0.323	3	TmCAD		yes
Transcription									
Ta.4725.1.S1_at	TaWRKY53	0.98	2.58	0.128	0.002	1	TaWRKY53	OsWRKY53	no
TaAffx.23458.1.S1_at	WRKY28	0.73	2.95	0.463	0.007	1		OsWRKY28	yes
Ta.4678.1.S1_x_at	WRKY71, expressed	0.94	2.20	0.171	0.002	1	HvWRKY1	OsWRKY71	no
Ta.8614.1.S1_at	WRKY45 transcription factor.	-0.86	-1.50	0.043	0.016	2		OsWRKY45	no
Transporters									
Ta.19898.1.S1_s_at	white-brown complex homolog protein 16	-1.17	-0.21	0.001	0.460	0		STR1	nd
Ta.3869.1.S1_at	Putative histidine amino acid transporter	2.58	0.89	0.007	0.054	4			no
Ta.27329.1.S1_at	Putative sugar transporter.	1.58	0.99	0.018	0.002	4			no
Miscellaneous									
Ta.4936.1.S1_at	CAMK_KIN1/SNF1/Nim1_like.4	0.00	1.05	0.981	0.010	0		OsCIPK15	no
Ta.14898.1.S1_at	OsWAK25 - OsWAK receptor-like protein kinase, expre	1.09	0.45	0.038	0.123	1	WAK25	WAK25	yes
TaAffx.12271.1.S1_at	Ankyrin-like protein	0.99	1.74	0.050	0.016	2		OsNPR4	no
Ta.7991.1.S1_x_at	C2 domain-containing protein-like	1.10	0.64	0.035	0.015	0	OsGAP1	OsGAP1	yes
Ta.21335.2.A1_x_at	Luminal-binding protein 3 precursor (BiP3)	1.47	0.50	0.043	0.037	1		BiP3	no
Ta.29930.1.S1_at	SNAP-34./SNAP1	1.01	1.48	0.093	0.000	1	HVSNAP34		yes

Identification of chitin responsive genes



Transfert de concepts et d'approches

Defense genes and preformed defense

Moroberekan

Nipponbare

Maratelli

Sariceltik



Vergne et al. BMC Plant Biology 2010, 10:206
<http://www.biomedcentral.com/1471-2229/10/206>



RESEARCH ARTICLE

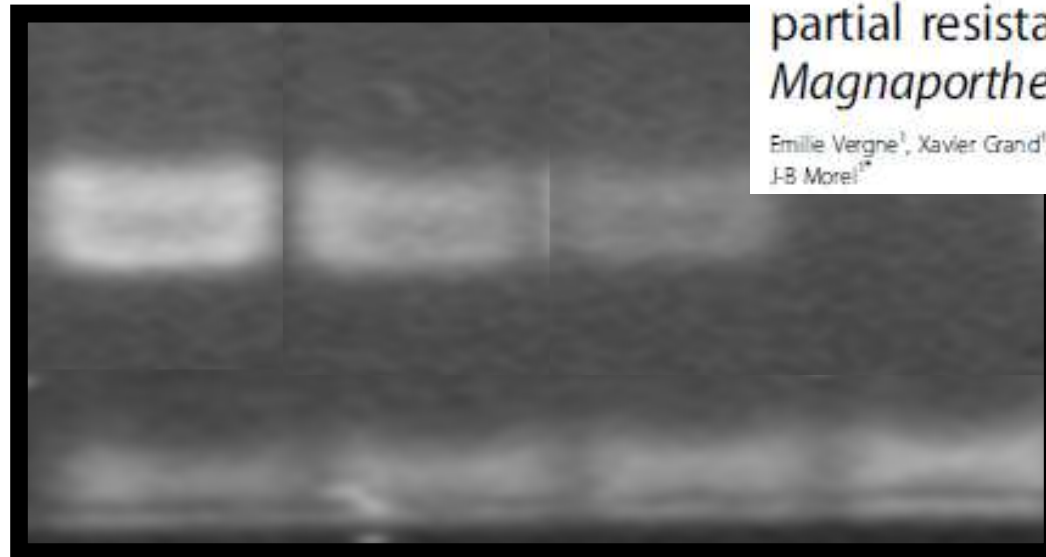
Open Access

Preformed expression of defense is a hallmark of partial resistance to rice blast fungal pathogen *Magnaporthe oryzae*

Emilie Vergne¹, Xavier Grand¹, Elsa Ballini², Véronique Chalvon¹, P Saindrenan³, D Tharreau⁴, J-L Nottéghem², J-B Morel^{1*}

PR3
(CHI)

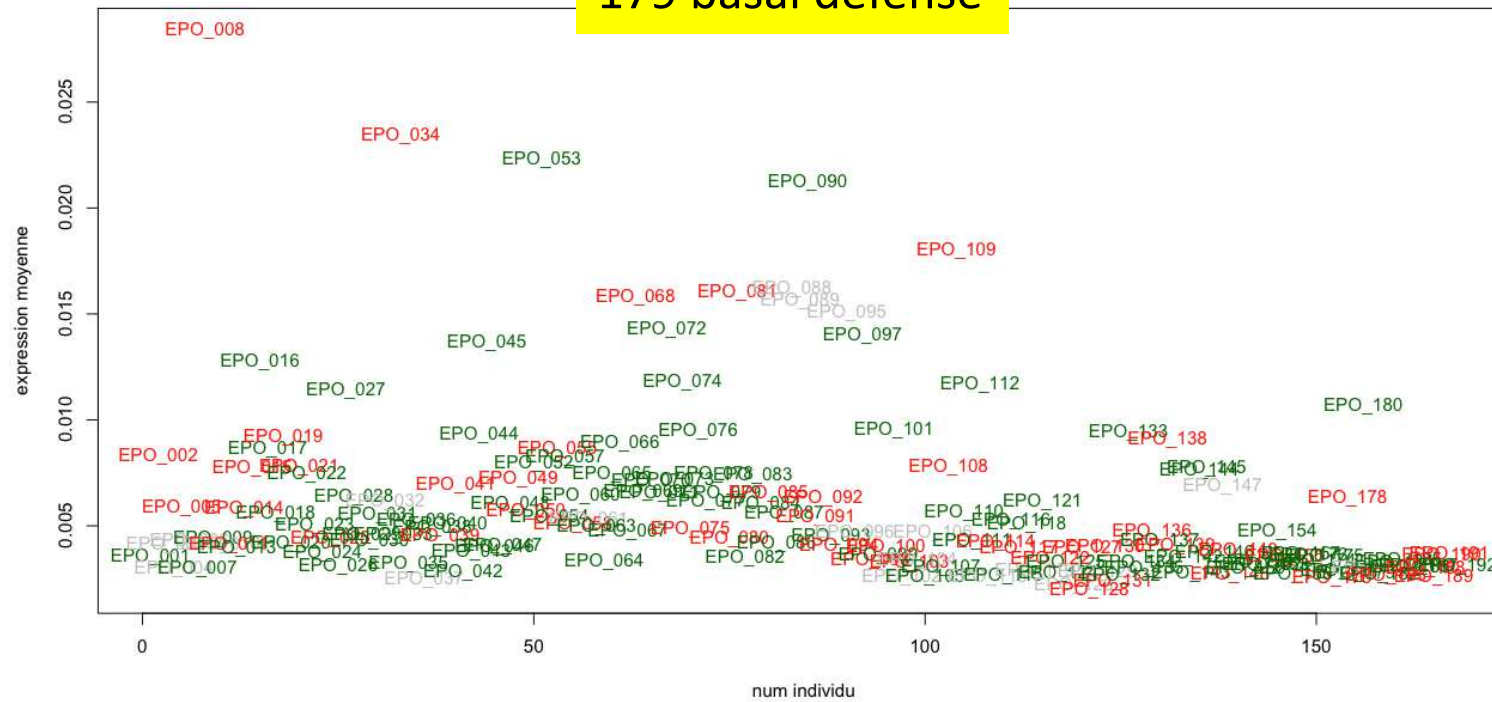
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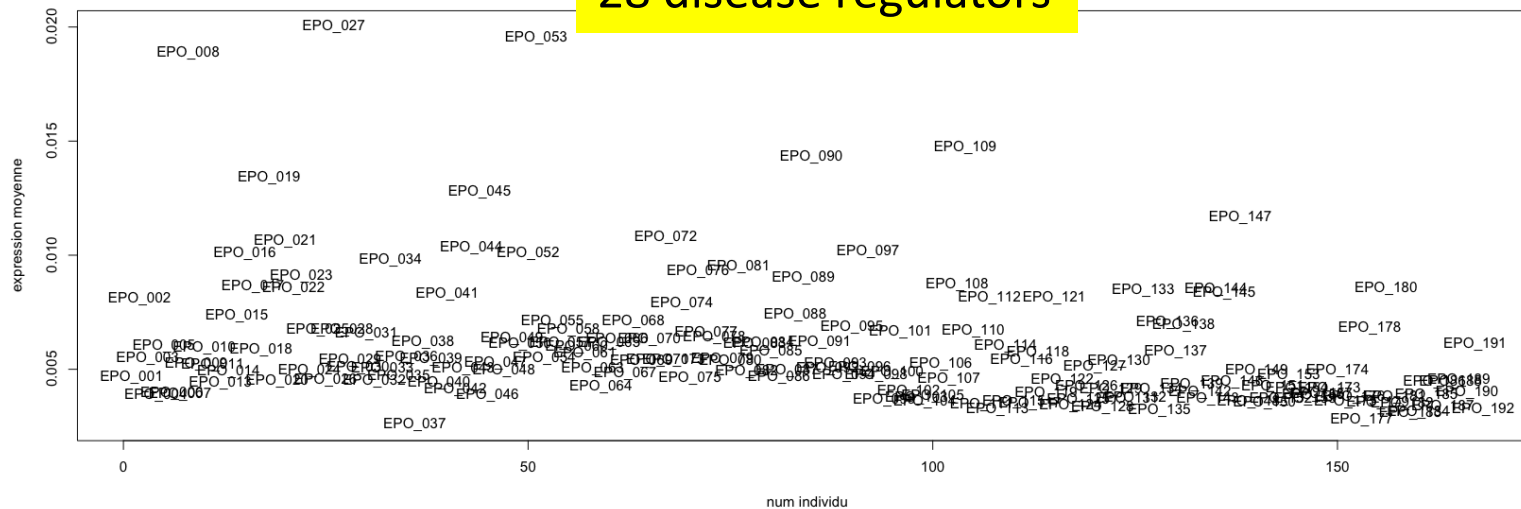
Preformed defense system

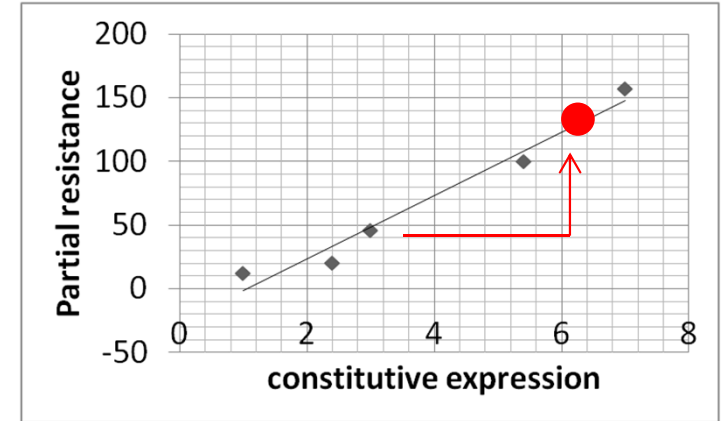
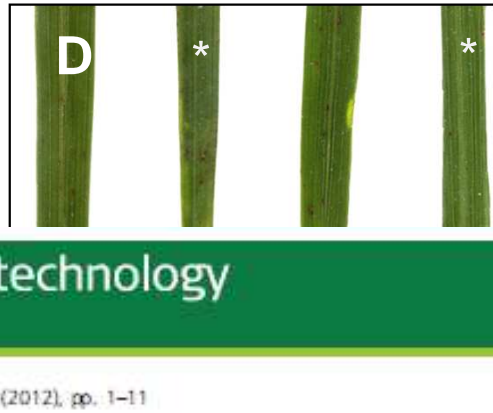
Defense gene expression in durum wheat EPO population

179 basal defense



28 disease regulators



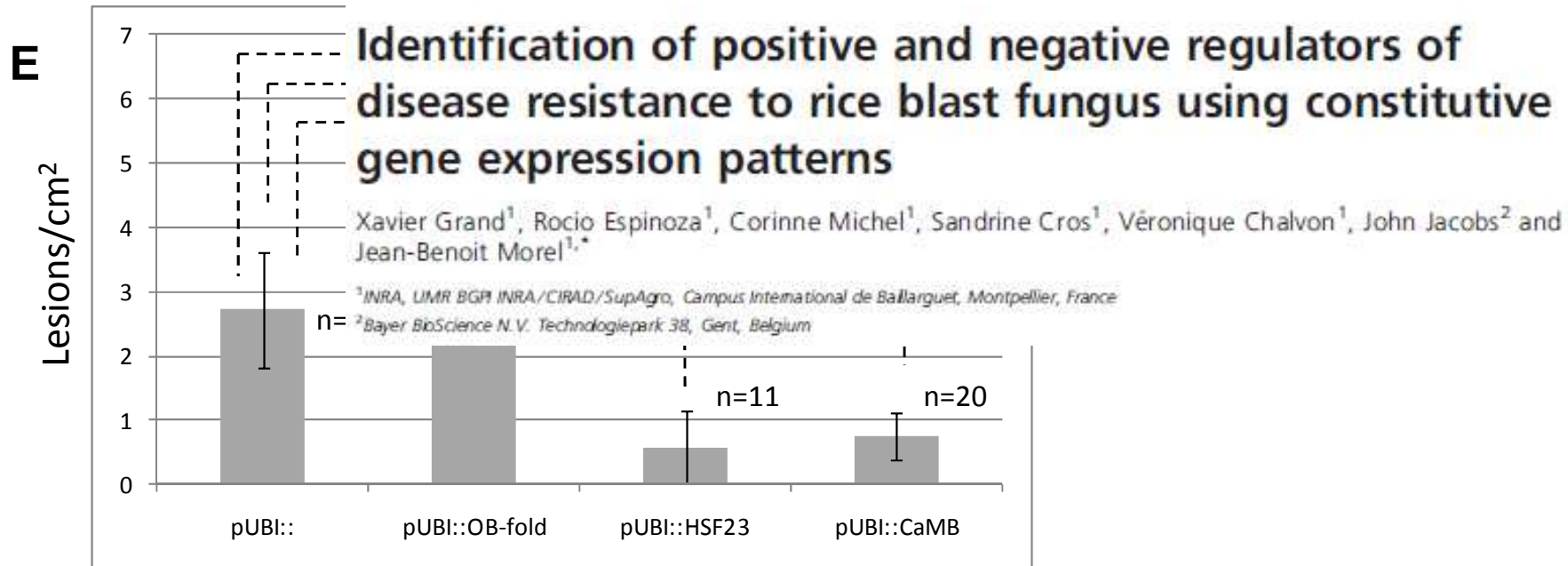


Plant Biotechnology Journal

aab SEB
Association of Arabidopsis Biologists Society for Experimental Biology

Plant Biotechnology Journal (2012), pp. 1–11

doi: 10.1111/j.1467-7652.2012.00703.x



Exploiting available data in wheat (Panel Biotech)

Fusarium disease data

Microarray before and after infection

Correlation analysis
(disease index X gene expression)

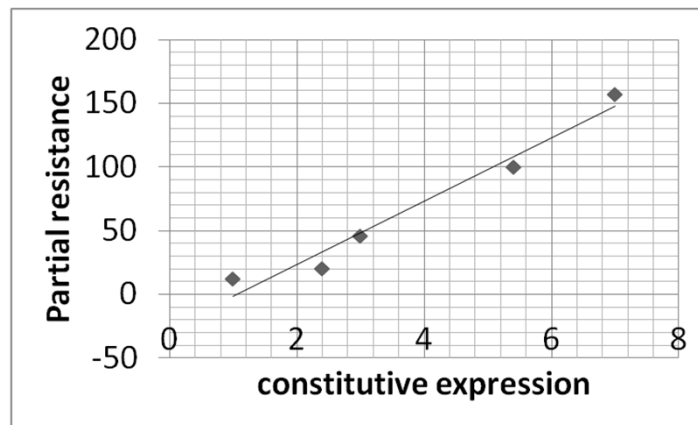


365 wheat ID

Rice information
(Archipelago+ unpublished)

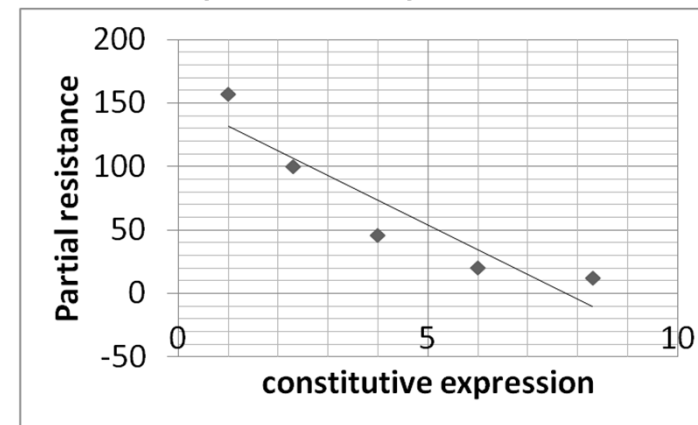


Defense gene
(positive regulator)



Over-expression

Susceptibility gene
(negative regulator)

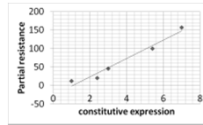


RNAi



Evaluation of resistance

Modification of preformed defense in wheat



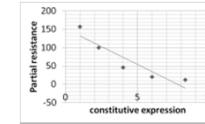
Candidate Defense gene
(the more R,
the more constitutively expressed)

OE-new PR

NS-new PR



OE in rice slightly more R



Candidate Susceptibility gene
(the more S,
the more constitutively expressed)

RNAi-new S

NS new S

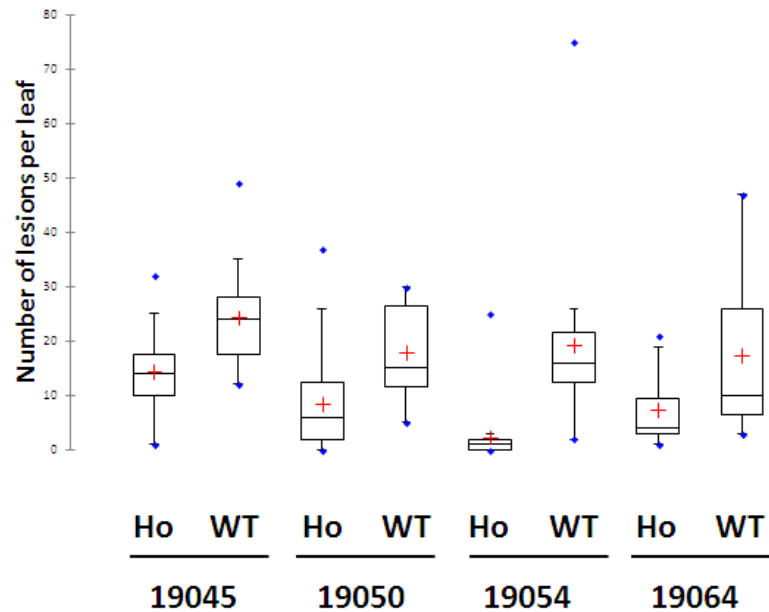


KO in rice under analysis

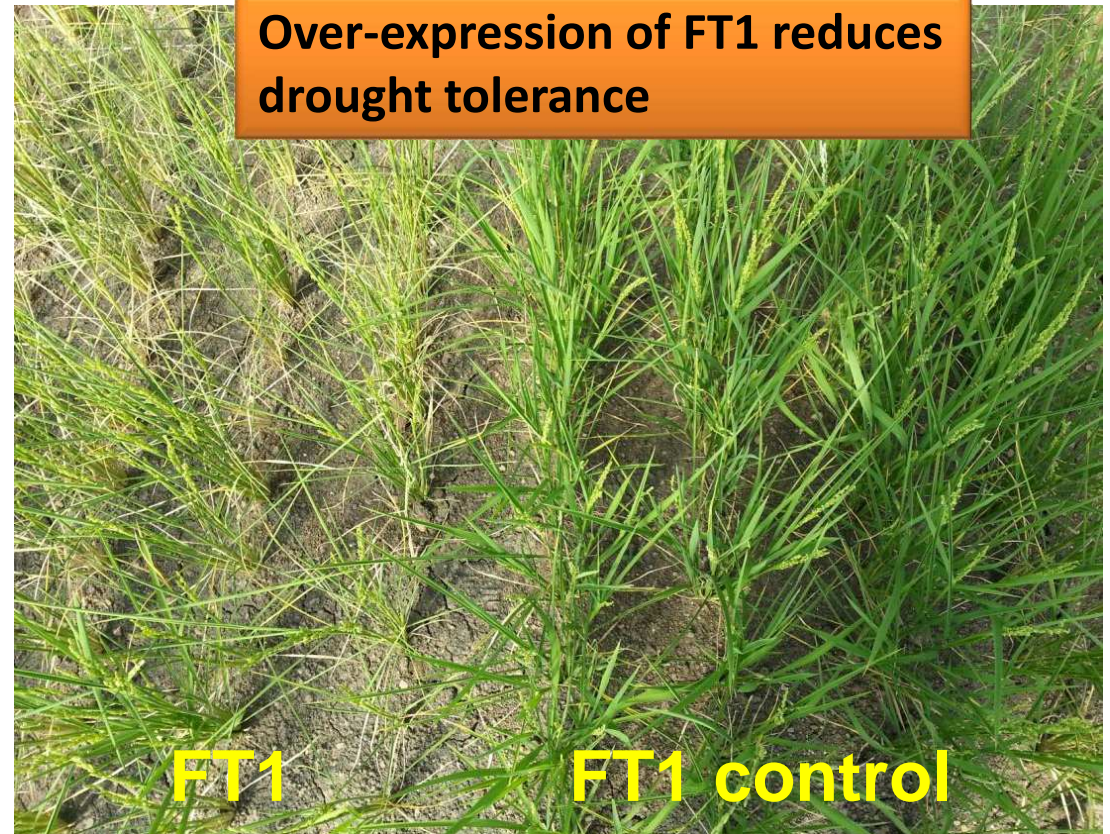
M. oryzae BR88, 7 dpi

Transfert de fonctions

Drought evaluation in the field of NAC lines



Over-expression of FT1 increases blast resistance

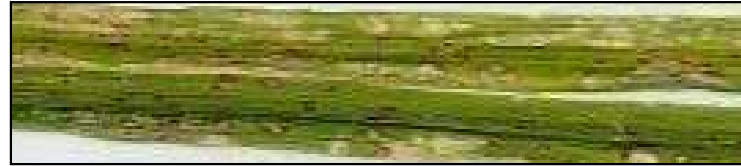


FT 2 RNAi rice plants are more tolerant to drought and blast

RNAi plants

controls

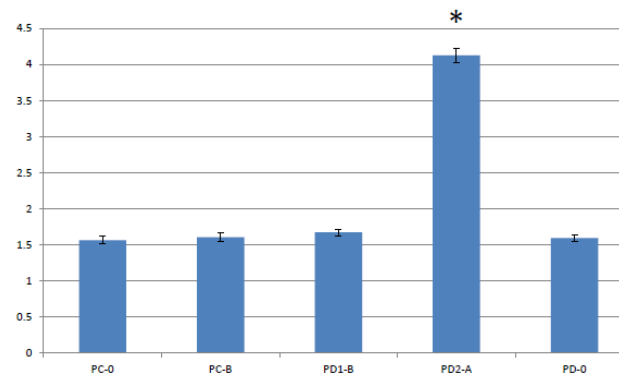
Blast



Drought in
the field (CIAT)



Yield (g/plant)
under drought
in the field



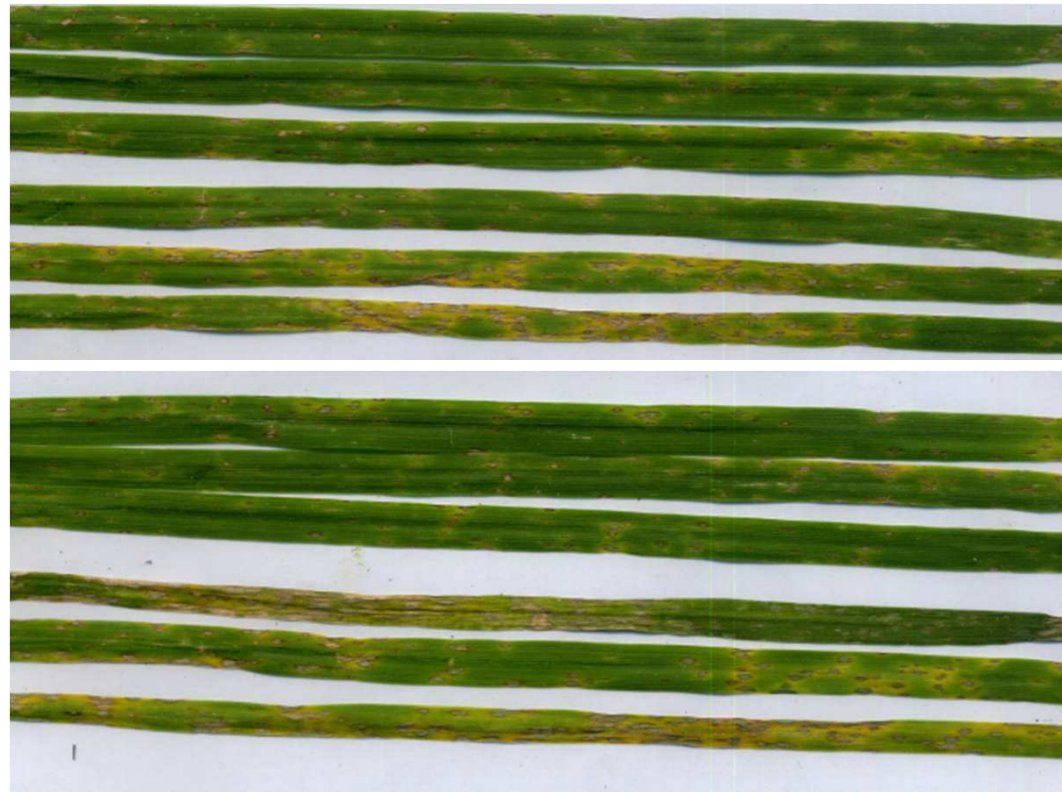
FT2 RNAi wheat plants are more resistant to blast

RNAi 1 FT2

control 1

RNAi 2 FT2

control 2



Transfert to wheat

Function	Origin	Rice	wheat
Receptor	Basal defense rice	OE more R to blast	No effect of OE on blast resistance?
Transcription factor 1	Basal defense rice	OE more R to blast but S to drought	No effect of OE on blast resistance?
Transporter	Basal defense rice and wheat	KO more resistant to blast?	OE in progress
Transcription factor	Basal defense wheat/chitin	NA	OE in progress
New PR gene	Preformed defense rice	OE slightly more R to blast	OE more R to blast
New S gene	Preformed defense wheat	ND	RNAi plants are more R to blast
Transcription factor 2	Development	RNAi are more R to blast, more tolerant to drought, have higher yield under non stress condition	RNAi are more R to blast

The ICAP group in Montpellier

