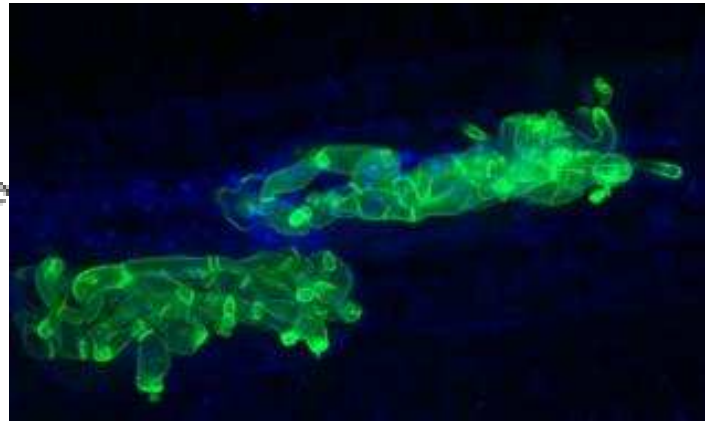
ICAP: Interactions Céréales-Agents Pathogènes

Problématique: comprendre les interactions à l'échelle moléculaire
pour construire des résistances plus durables des céréales aux champignons phytopathogènes

Magnaporthe oryzae



Pyriculariose

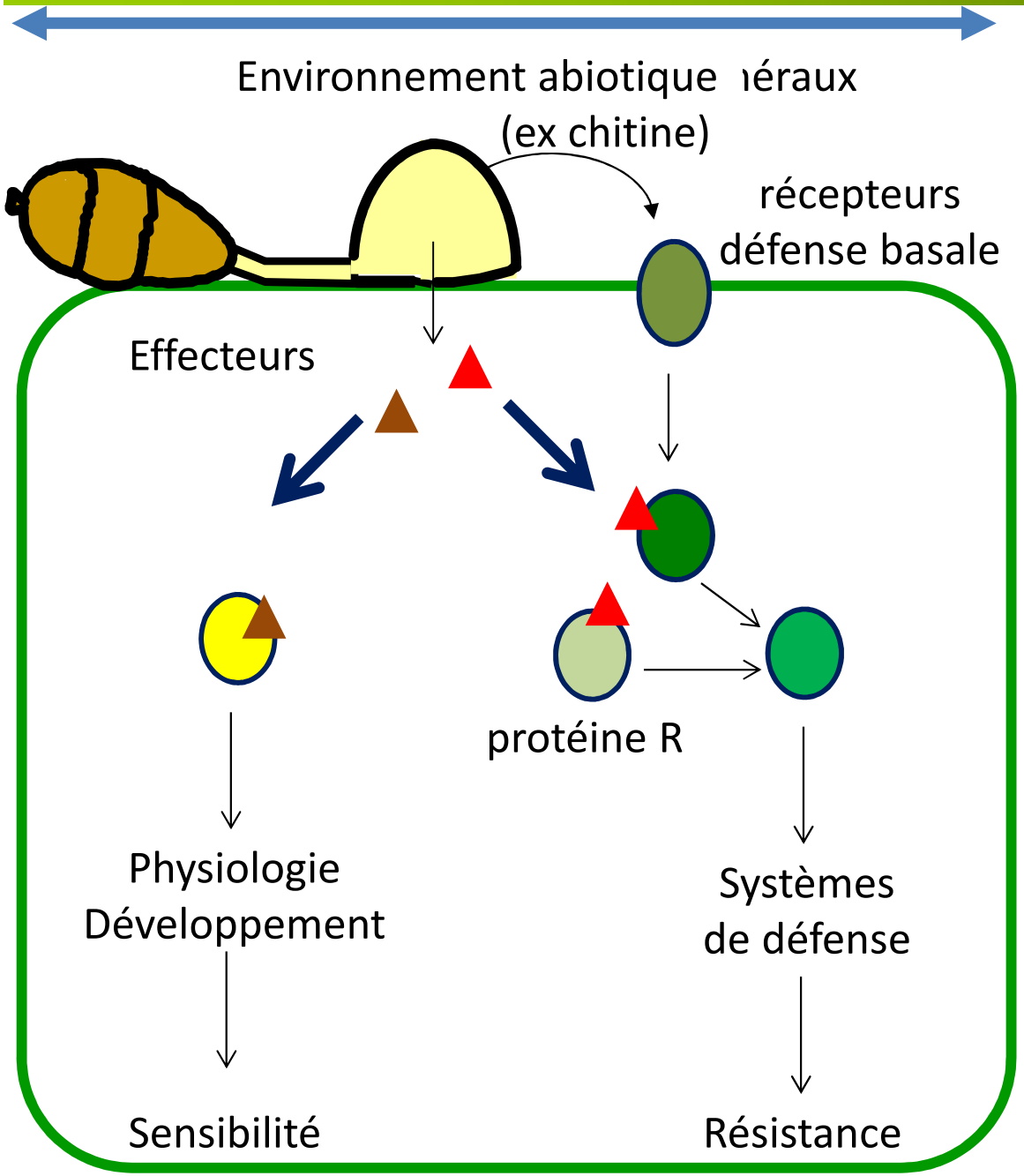
La pyriculariose

Principale maladie du riz
Emergent sur blé en Amérique du Sud

Un couple modèle pour l'étude des interactions

apports à un système d'importance économique
connaissances transférables à d'autres céréales

ICAP: Contexte et questions scientifiques



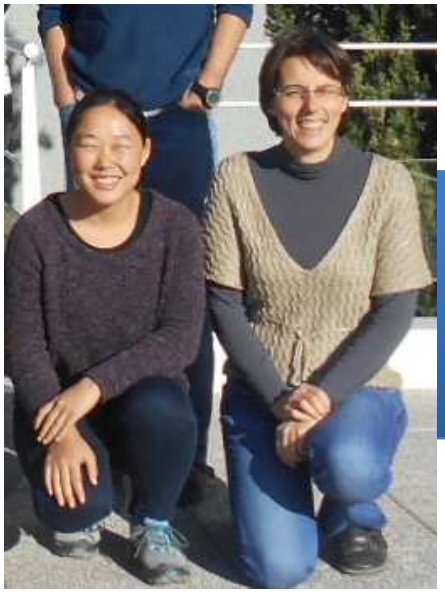
Comment le pouvoir pathogène se construit-il?

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?

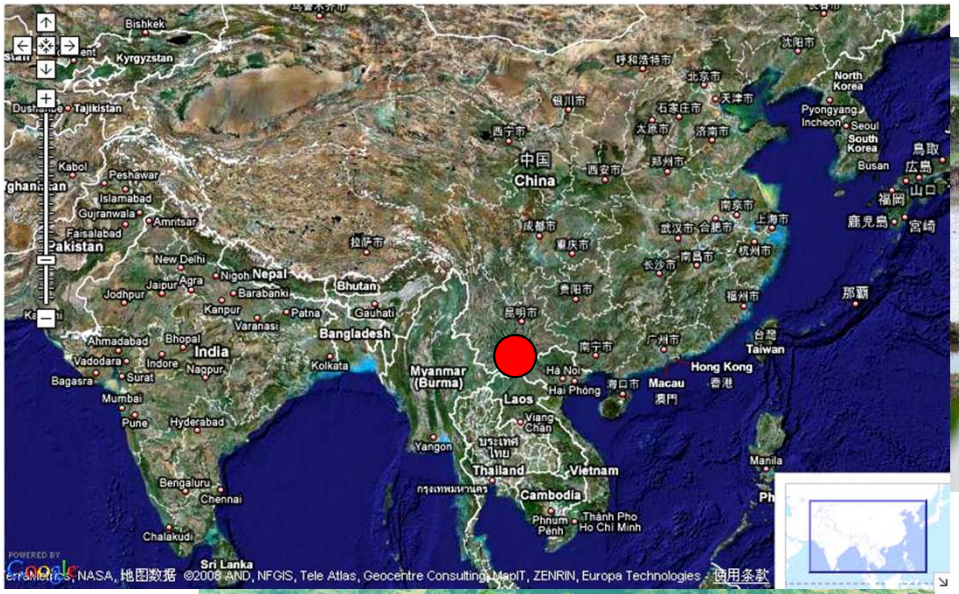
Axe 3: Effets de l'environnement abiotique
Comment l'environnement affecte-t-il le fonctionnement de ces systèmes?

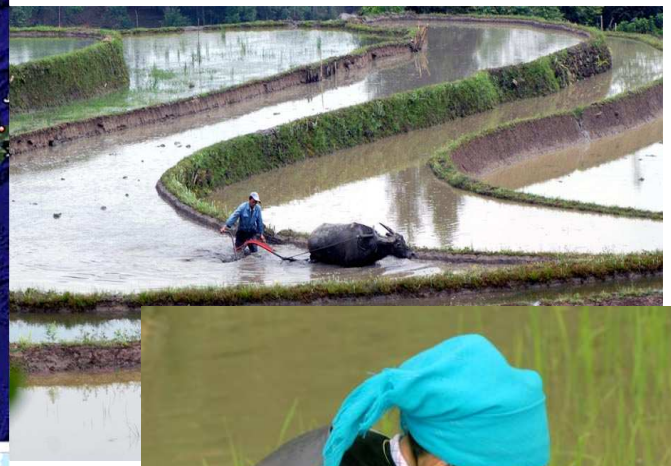
Survey of the Durability of YuanyangTerrace



Jingjing Liao, Isabelle Meusnier, Huichuan Huang, Xiahong He, Youyong Zhu, Elisabeth Fournier, Didier Tharreau, Thomas Kroj, Jean-Benoit Morel

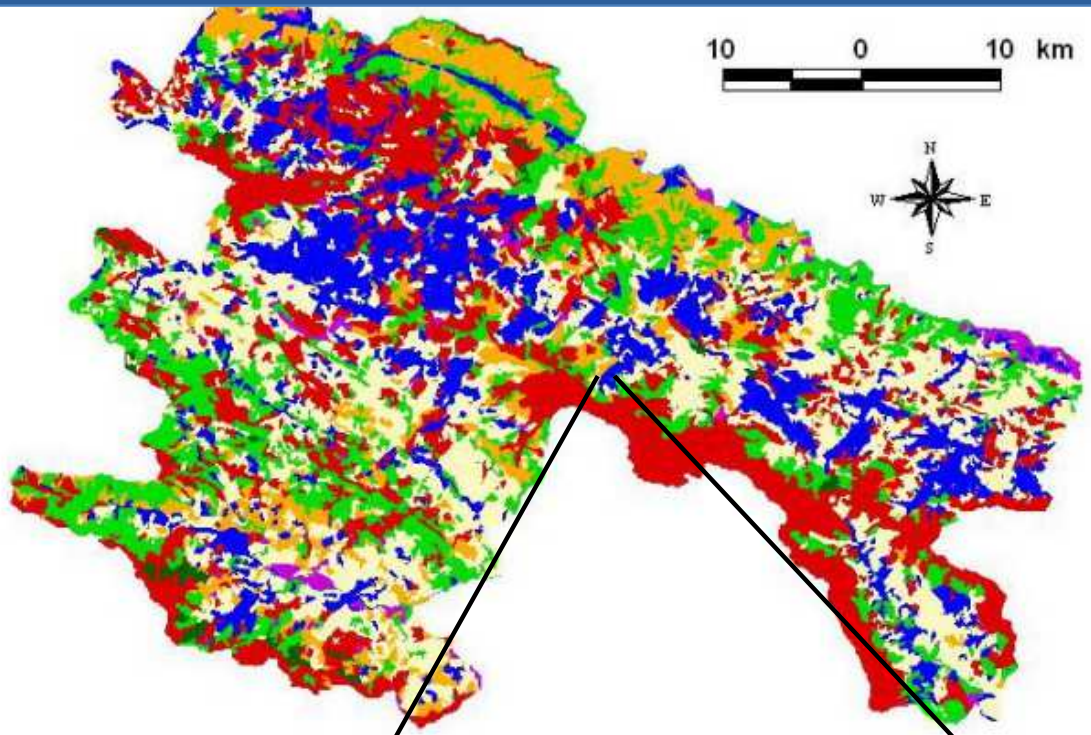
The yuanyang terraces, Yunnan





~ 6500 hectares
Acuce genotype for more than 110 years
Yield ~ 5-7 t/ha
Traditional varieties
No chemical fertilizer
High microbial diversity in the soil
No fungicide
Area close to diversity center of *M. oryzae*

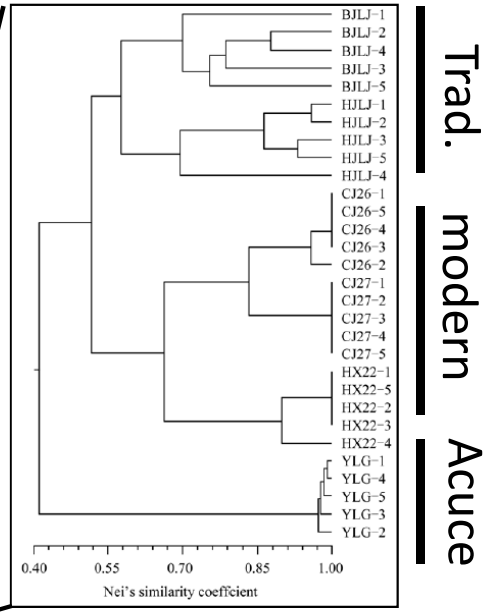
The yuanyang terraces: diversity at all levels



Cao et al, 2012

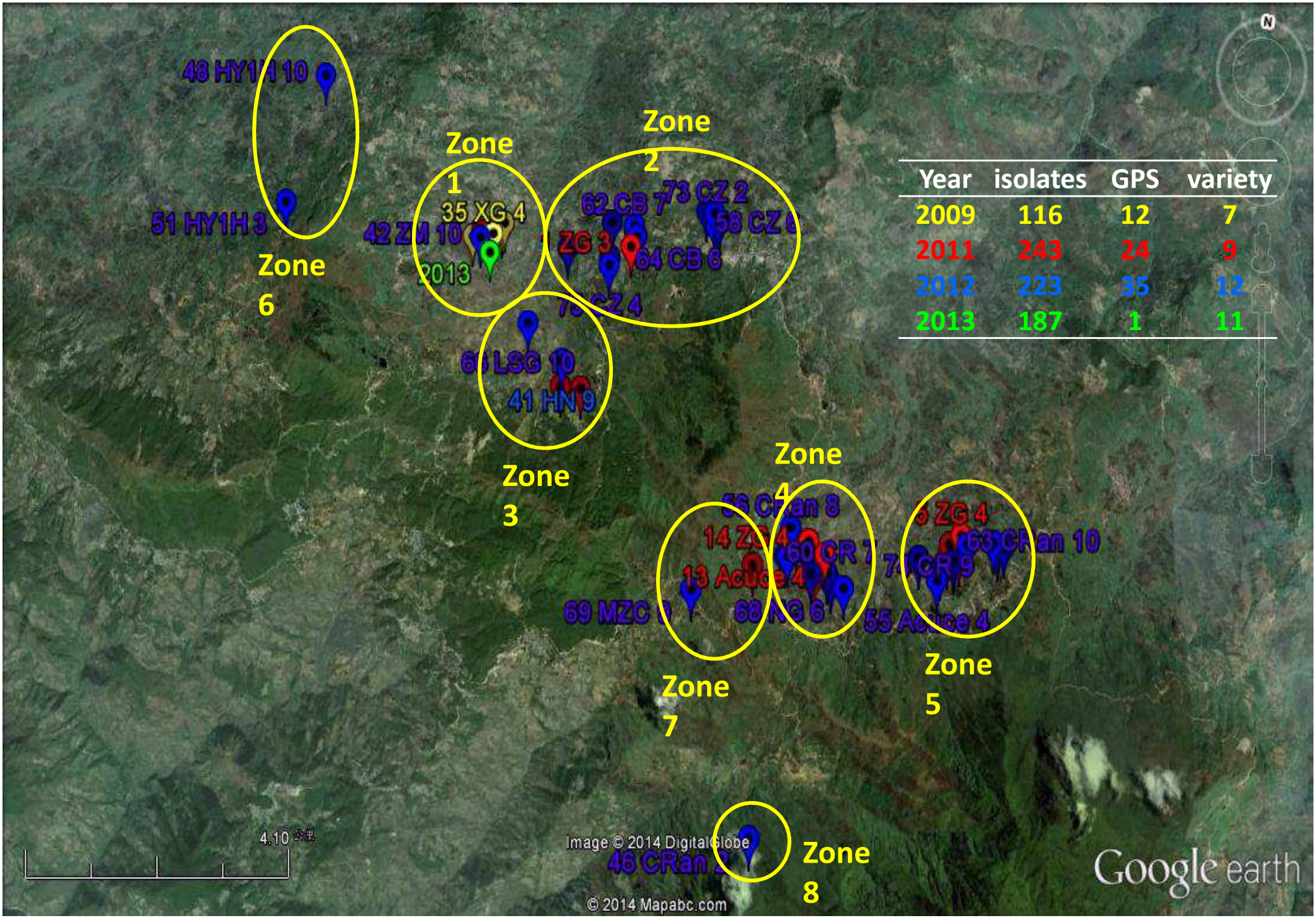
- Pasture land
- Shrub land
- Dry land
- Residents
- Sparse woods
- Paddy field
- Water area
- Forested land
- Garden plots

Gao et al, 2012



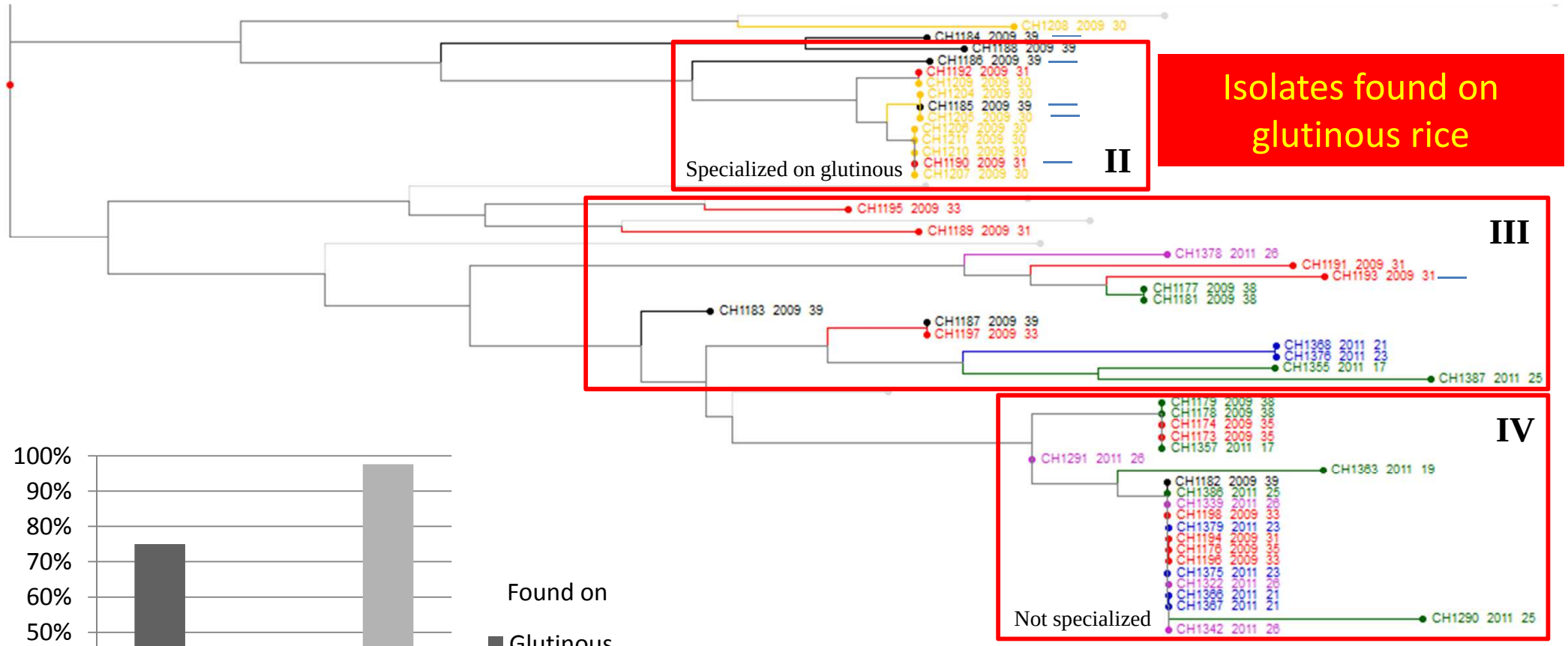
> 30 varieties
Mixtures
Glutinous and non-glutinous

Sampling *Magnaporthe* in Yuanyang terraces



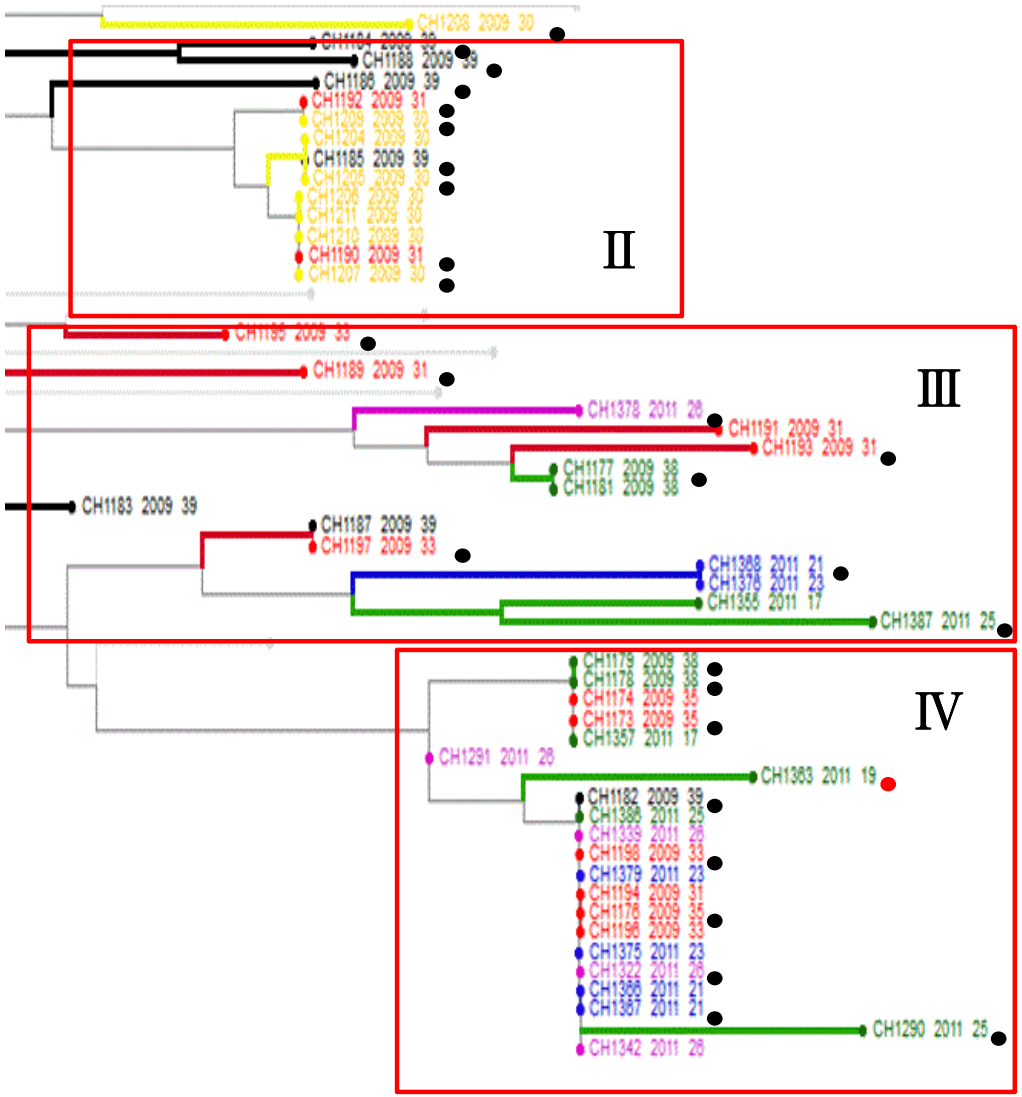
Year	isolates	GPS	variety
2009	116	12	7
2011	243	24	9
2012	223	35	12
2013	187	1	11

Microsatellite analysis of 54 YYT isolates and 10 reference isolates



Isolates within one group can infect several hosts
Almost no group III and IV isolates found on glutinous
Most isolates of group II are found on glutinous

Group Ⅱ isolates show reduced virulence on Non-Glutinous rice



	Glutinous		Non-Glutinous			
	HPN	NG	XG	LJG	AZG	Acuce
CH1184	S	S	R	R	R	R
CH1188	S	S	R	R	R	S
CH1186	S	S	R	R	R	R
CH1192	S	S	R	R	R	R
CH1209	S	S	S	S	R	S
CH1185	S	S	R	R	S	R
CH1205	S	S	R	R	R	R
CH1190	S	S	R	R	R	R
CH1207	S	S	R	R	R	R
CH1195	S	S	S	S	R	R
CH1189	S	S	S	S	S	S
CH1378	S	R	S	S	S	S
CH1193	S	S	S	S	S	S
CH1177	S	S	S	S	S	S
CH1197	S	S	S	S	S	S
CH1368	S	S	S	S	S	S
CH1387	S	S	S	S	S	S
CH1179	S	R	S	S	S	S
CH1178	R	R	S	S	S	S
CH1173	S	S	S	S	S	S
CH1383	S	R	S	S	S	S
CH1182	S	S	S	S	S	S
CH1198	S	S	S	S	S	S
CH1176	S	S	S	S	S	S
CH1322	S	R	S	S	S	S
CH1367	S	R	S	S	S	S
CH1290	S	R	S	S	S	S

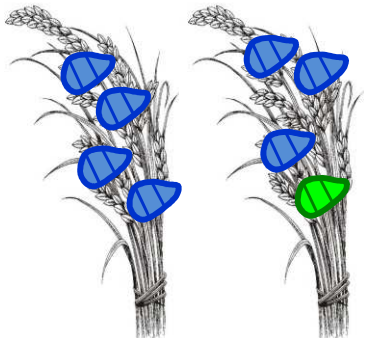
Group II isolates resemble specialists
Group III and IV isolates seem generalists
Glutinous rice is a universal host

Unbalanced situation between glutinous and non-glutinous rice

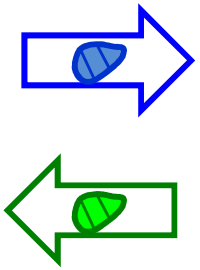
	HPN	NG	XG	LJG	AZG	Acuce
CH1184	S	S	R	R	R	R
CH1188	S	S	R	R	R	S
CH1186	S	S	R	R	R	R
CH1192	S	S	R	R	R	R
CH1209	S	S	S	S	R	S
CH1185	S	S	R	R	S	R
CH1205	S	S	R	R	R	R
CH1190	S	S	R	R	R	R
CH1207	S	S	R	R	R	R
CH1195	S	S	S	S	R	R
CH1189	S	S	S	S	S	S
CH1378	S	R	S	S	S	S
CH1193	S	S	S	S	S	S
CH1177	S	S	S	S	S	S
CH1197	S	S	S	S	S	S
CH1355	S	S	S	S	S	S
CH1387	S	S	S	S	S	S
CH1179	S	R	S	S	S	S
CH1178	R	R	S	S	S	S
CH1173	S	S	S	S	S	S
CH1383	S	R	S	S	S	S
CH1182	S	S	S	S	S	S
CH1198	S	S	S	S	S	S
CH1176	S	S	S	S	S	S
CH1322	S	R	S	S	S	S
CH1367	S	R	S	S	S	S
CH1290	S	R	S	S	S	S

why do group II isolates are not virulent on non-glutinous rice?

Glutinous rice

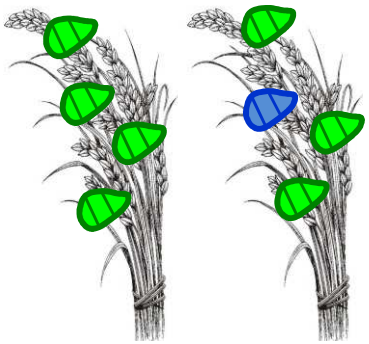


difficult

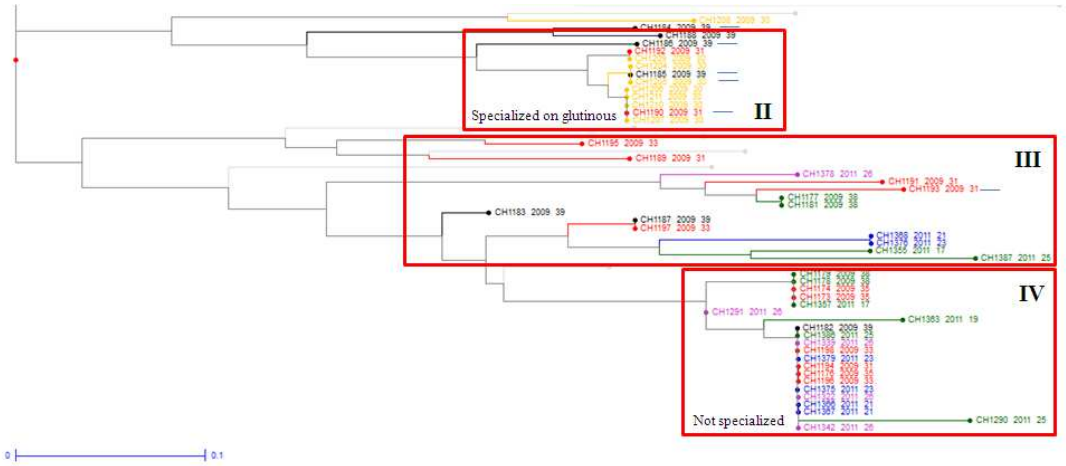


possible but…

Non-Glutinous rice



why so few non-group II isolates on glutinous rice?

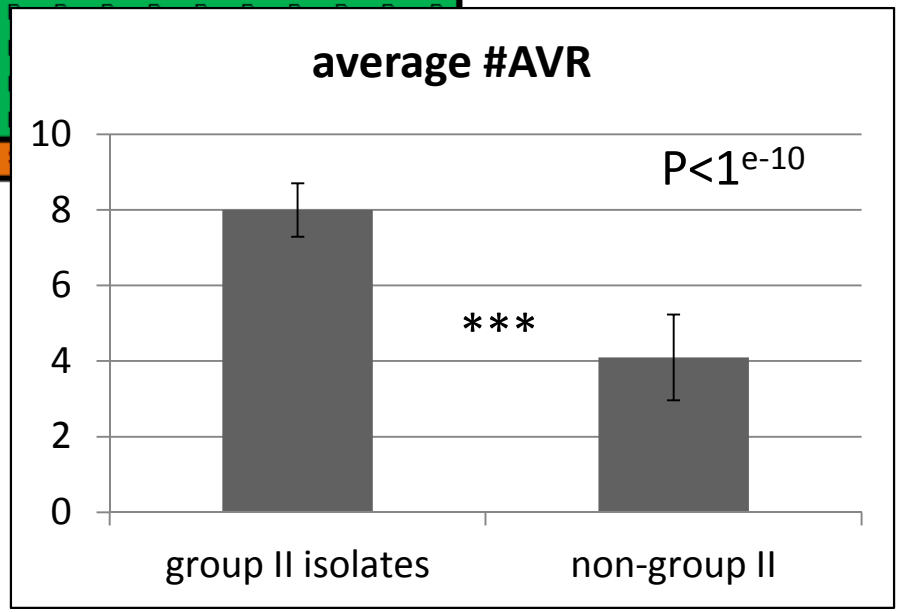


Group Ⅱ isolates possess many *Avr-genes*

	Group II isolates									Non-Group II isolates																				
	CH1184	CH1188	CH1186	CH1192	CH1209	CH1185	CH1205	CH1190	CH1207	CH1208	CH1180	CH1358	CH1195	CH1189	CH1378	CH1193	CH1177	CH1197	CH1368	CH1387	CH1179	CH1178	CH1173	CH1383	CH1182	CH1198	CH1176	CH1322	CH1367	CH1290
a+19	R	R	R	R	S	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
R-CO39	R	R	R	R	S	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
ta	R	R	S	S	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
1	R	R	R	R	R	R	R	R	R	S	S	S	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3	S	R	R	R	S	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
i+ks	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
ks	R	R	R	R	R	R	R	R	R	S	S	S	S	S	R	S	S	S	S	S	R	R	S	S	S	R	R	R	R	S
kp	R	S	R	R		R			R	S	S	S	R	S	R	S	S	S	S	S	S	S	S	S	R	S	S	R	S	S
km	R	R	R	R	R	R	R	R	R	S	S	R	R	R	S	S	S	S	R	S	S	S	S	S	R	S	S	S	S	S
kh	R	R	R	R	R	R	R	R	R	S	S	R	R	S	S	S	S	R	R	R	R	S	S	R	S	S	R	R	S	S
k	R	R	R	R	R	R	R	R	R	S	S	S	R	S	S	S	S	S	S	S	R	R	S	S	R	R	R	R	R	S
z+sh	S	S	S	S	S	R	S	S	S	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
z	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
zt	R	R	R	R	R	R	R	R	R	R	R	R	S	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
b	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
9	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
33	R	R	S	R	R	S	R	S	R	S	S	R	S	S	S	S	S	R	R	R										
2=z5	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	S	S	R										
ta[2]	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R										
t	R	R	R	R	R	R	R	R	R	S	R	R	S	S	R	R	R	R	R	S										
f	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	S	R	S	S	S										

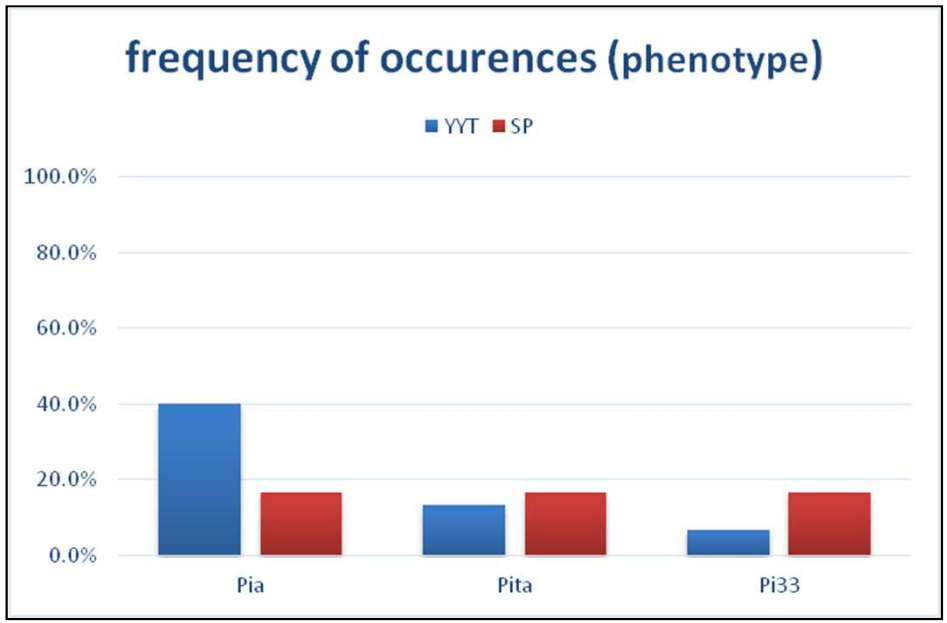
14 R-genes tested

10 R-genes different between group II and other

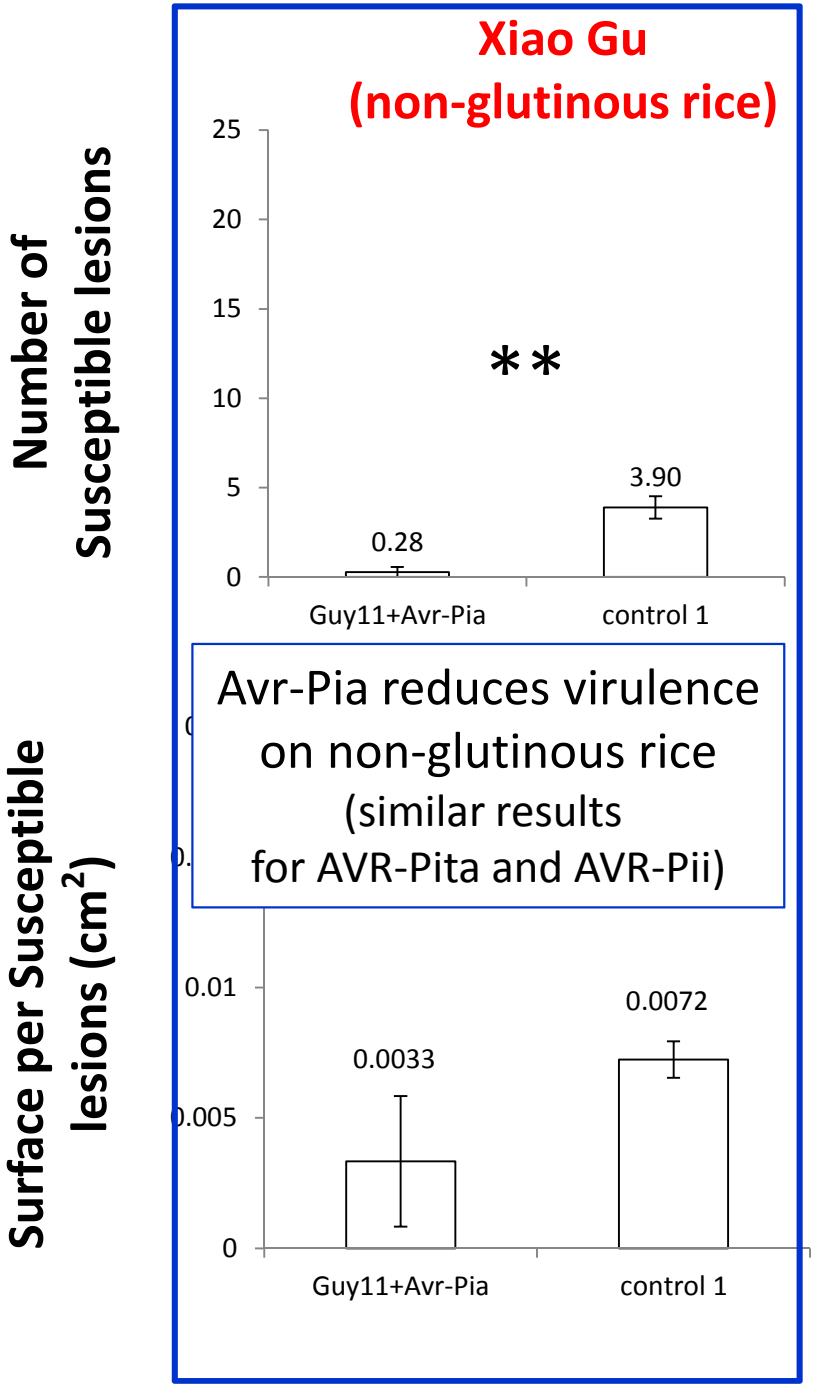


R-genes deployed in Yuanyang terraces

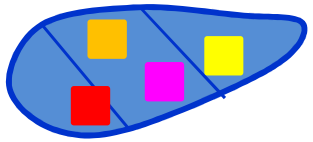
-22 R-genes found in more than 50 varieties
-Pik, Pi-ta, Pib and Pi-a found with high frequencies



Transgenic isolates



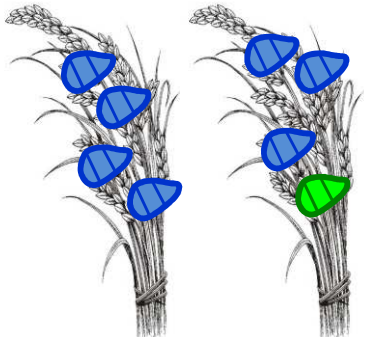
Unbalanced situation between glutinous and non-glutinous rice

AVR genes 

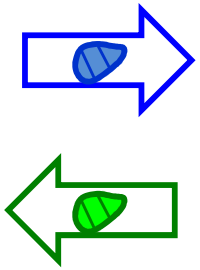
Probably because of R-AVR interactions
since group II isolates have a large AVR complement

why do group II isolates are not aggressive on non-glutinous rice?

Glutinous rice

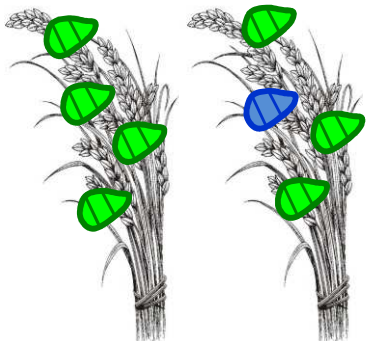


difficult



possible but…

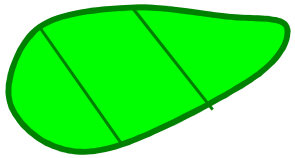
Non-Glutinous rice



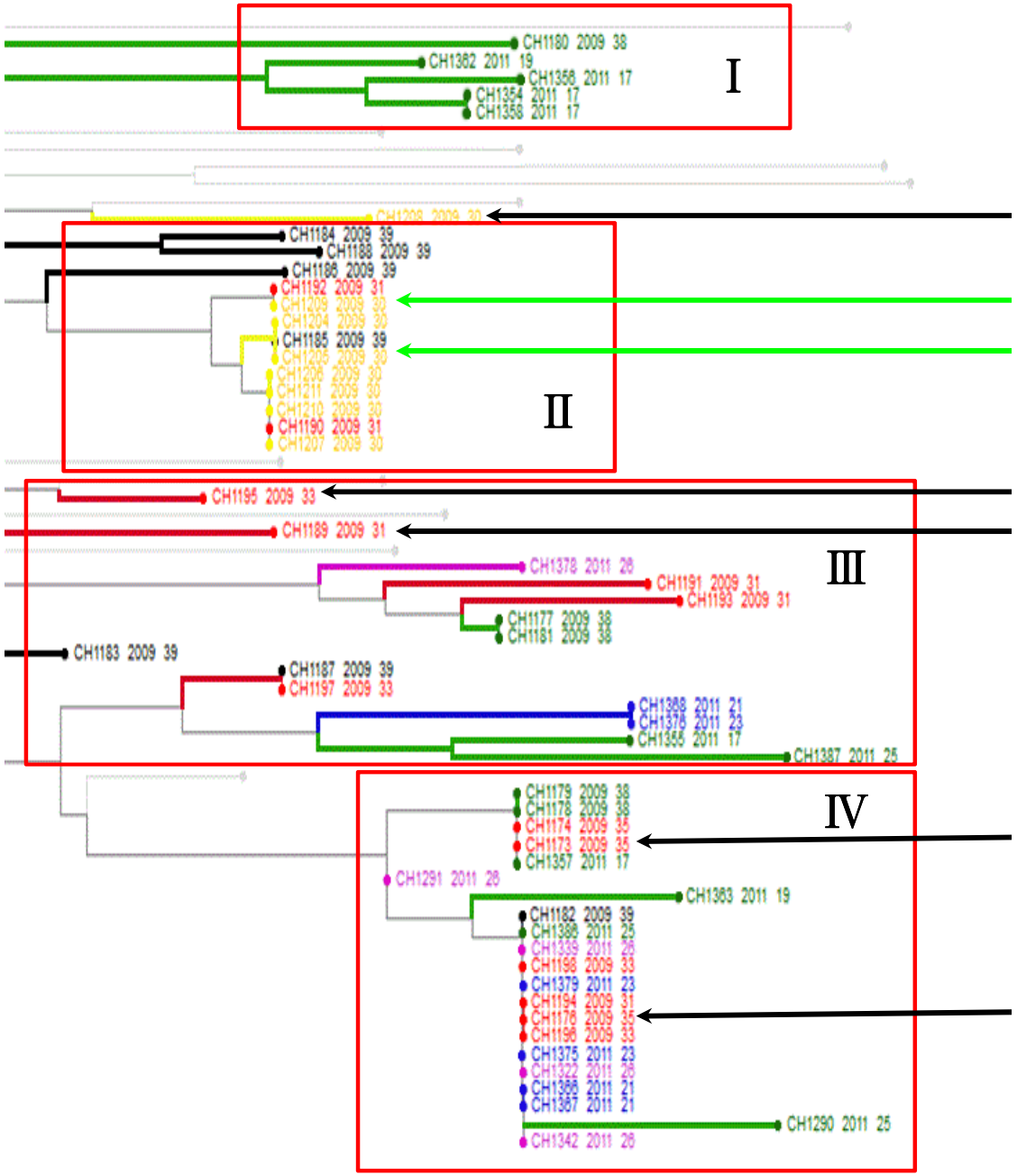
R genes

why so few non-group II isolates on glutinous rice?

HYP: A large AVR/Effector complement is required on glutinous rice



Selection of isolate showing increasing number of AVR genes



CH1208: Avr-gene: 2

CH1209: Avr-gene: 7

CH1205: Avr-gene: 9

CH1195: Avr-gene: 3

CH1189: Avr-gene: 1

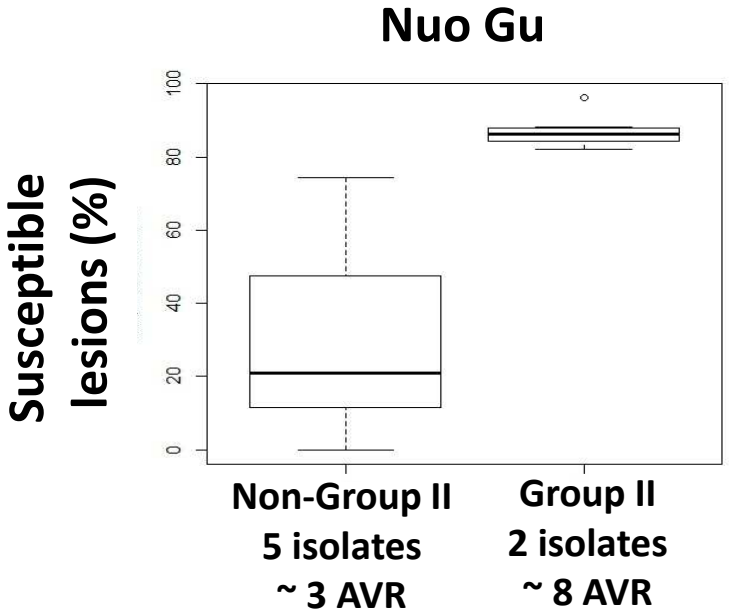
CH1173: Avr-gene: 4

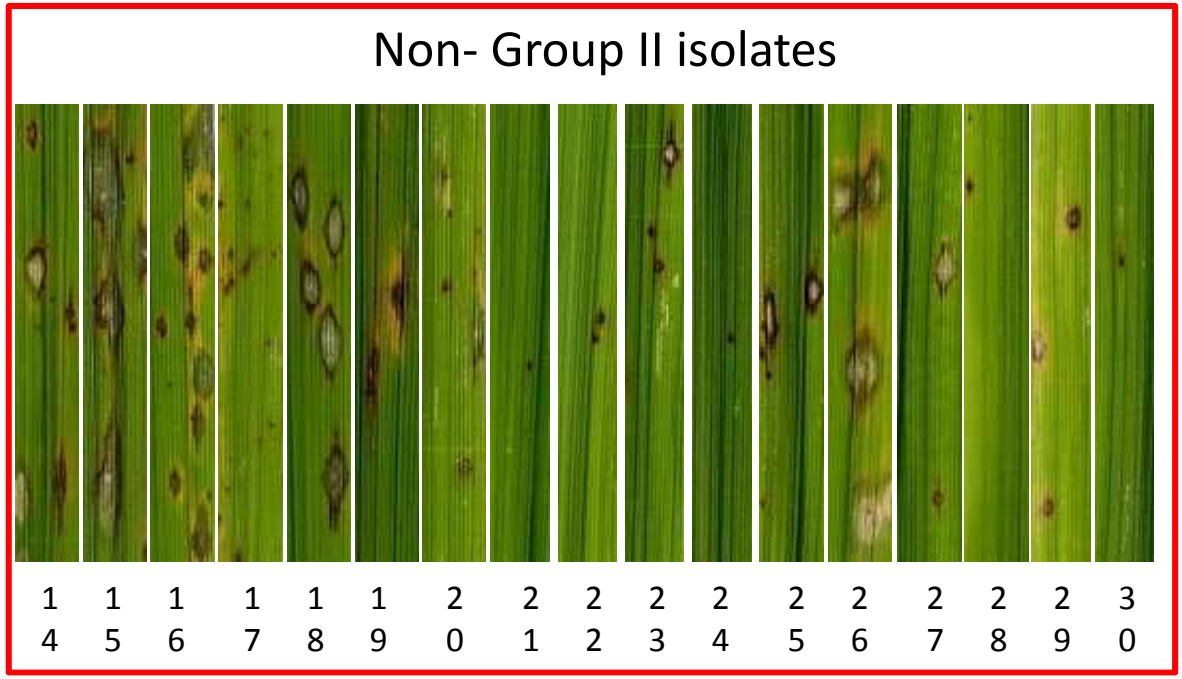
CH1176: Avr-gene: 5

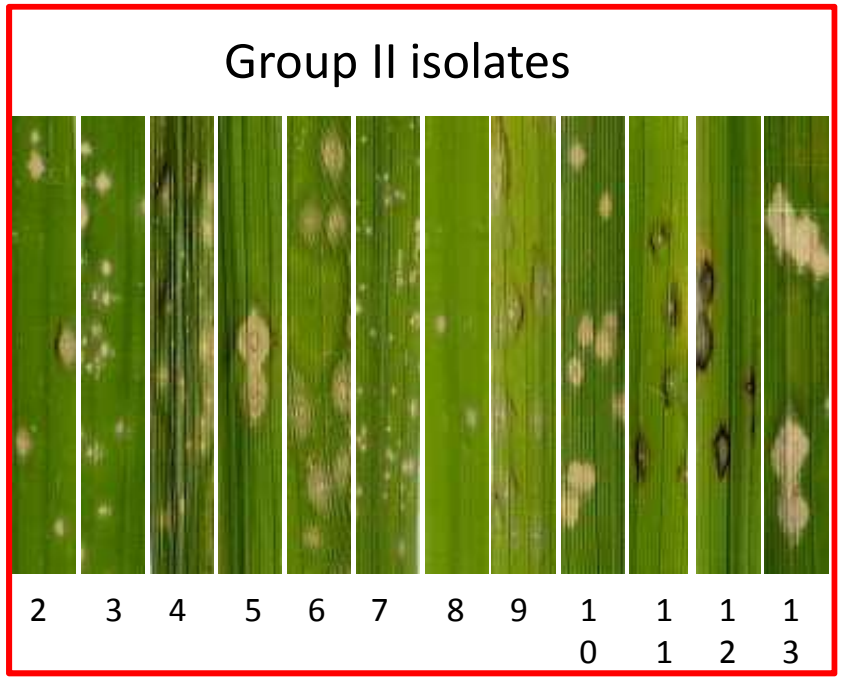
Glutinous rice:
Huangpinuo
Nuogu

Non-Glutinous rice:
Maratelli
Nipponbare

AVR number and disease severity on glutinous rice

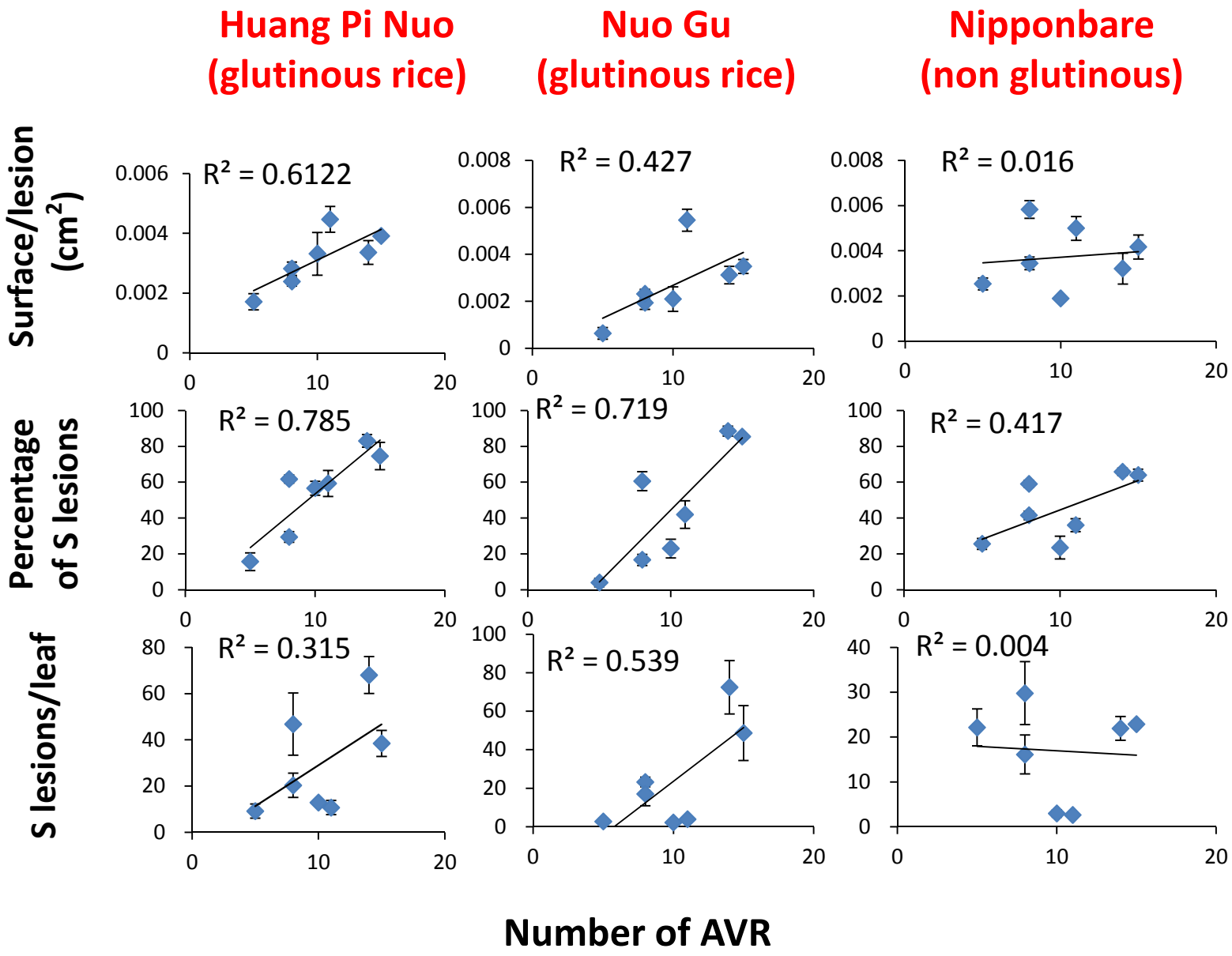






Same results with Huangpinuo

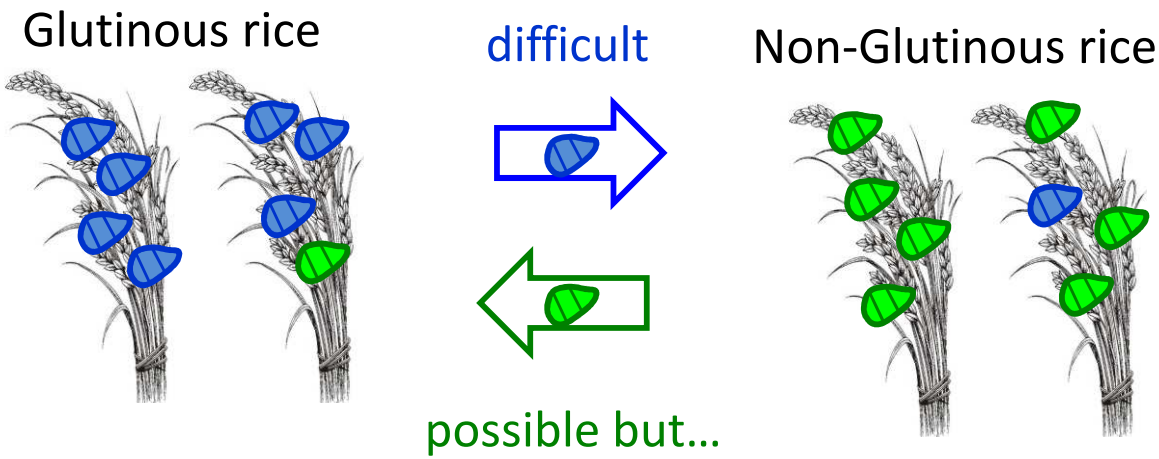
AVR complement and fitness



Unbalanced situation between glutinous and non-glutinous rice

Probably because of R-AVR interactions
since group II isolates have a large AVR complement

why do group II isolates are not aggressive on non-glutinous rice?



why so few non-group II isolates on glutinous rice?

Probably because a large AVR/effector complement is required on glutinous rice

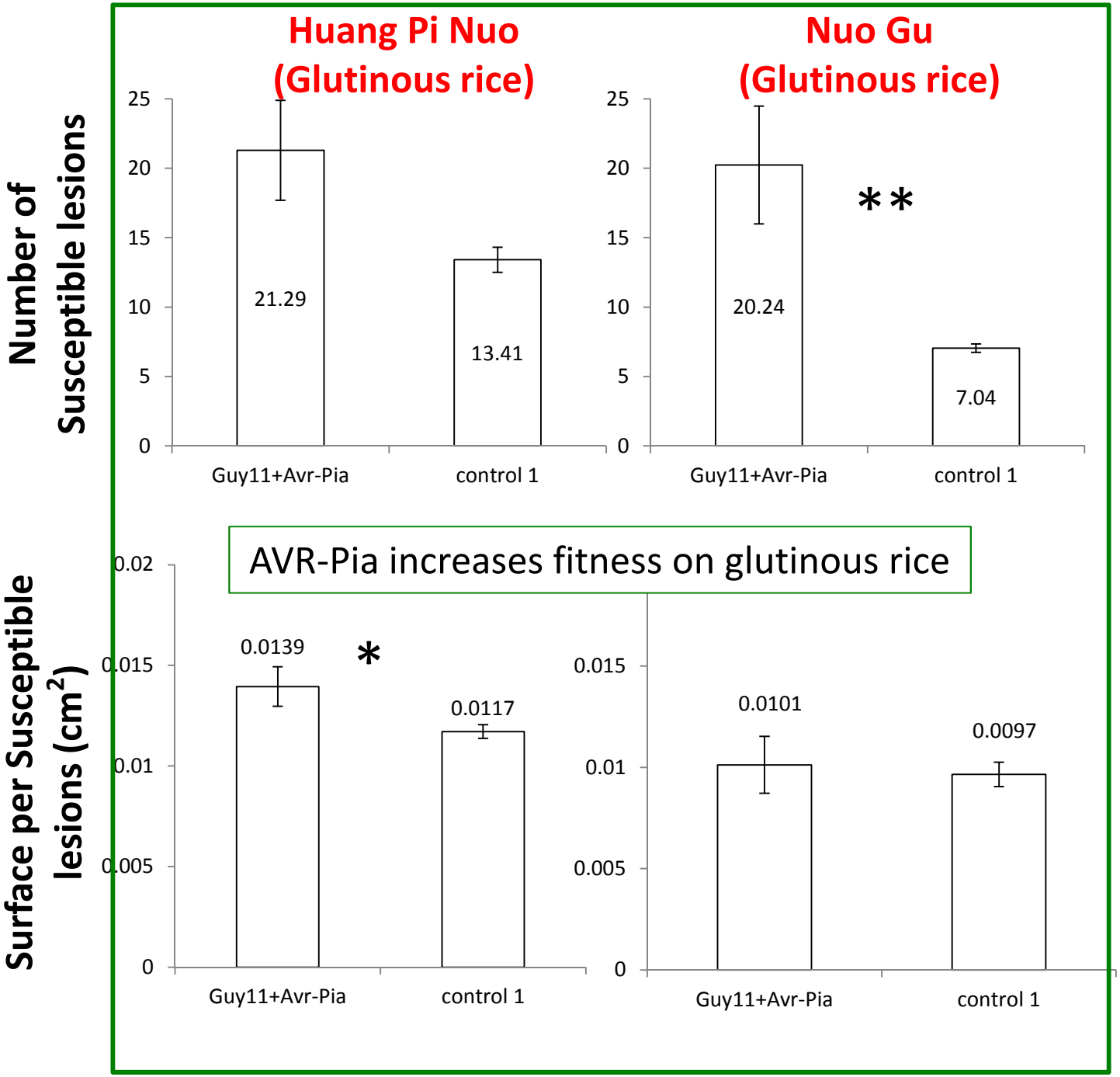
Which *AVR-gene* is the most important one?

	group II									Non-group II																					
	CH1185	CH1205	CH1190	CH1207	CH1192	CH1184	CH1188	CH1186	CH1209	CH1208	CH1322	CH1378	CH1179	CH1182	CH1176	CH1358	CH1178	CH1198	CH1367	CH1368	CH1383	CH1195	CH1177	CH1387	CH1173	CH1290	CH1180	CH1193	CH1197	CH1189
a	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
all k	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	S	R	S	S	S	S	R	R
3	R	R	R	R	R	S	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
zt	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	S
1	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	S
ta	R	R	R	S	S	R	R	S	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
33	S	R	S	R	R	R	R	S	R	S	R	S	R	R	R	R	R	R	R	R	R	S	S	R	R	R	S	S	R	S
2	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	S	S
t	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	S	S	R	S	R	R	R	R	R	S
f	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	S	R	S	R	S	S	S	S	S	S	S

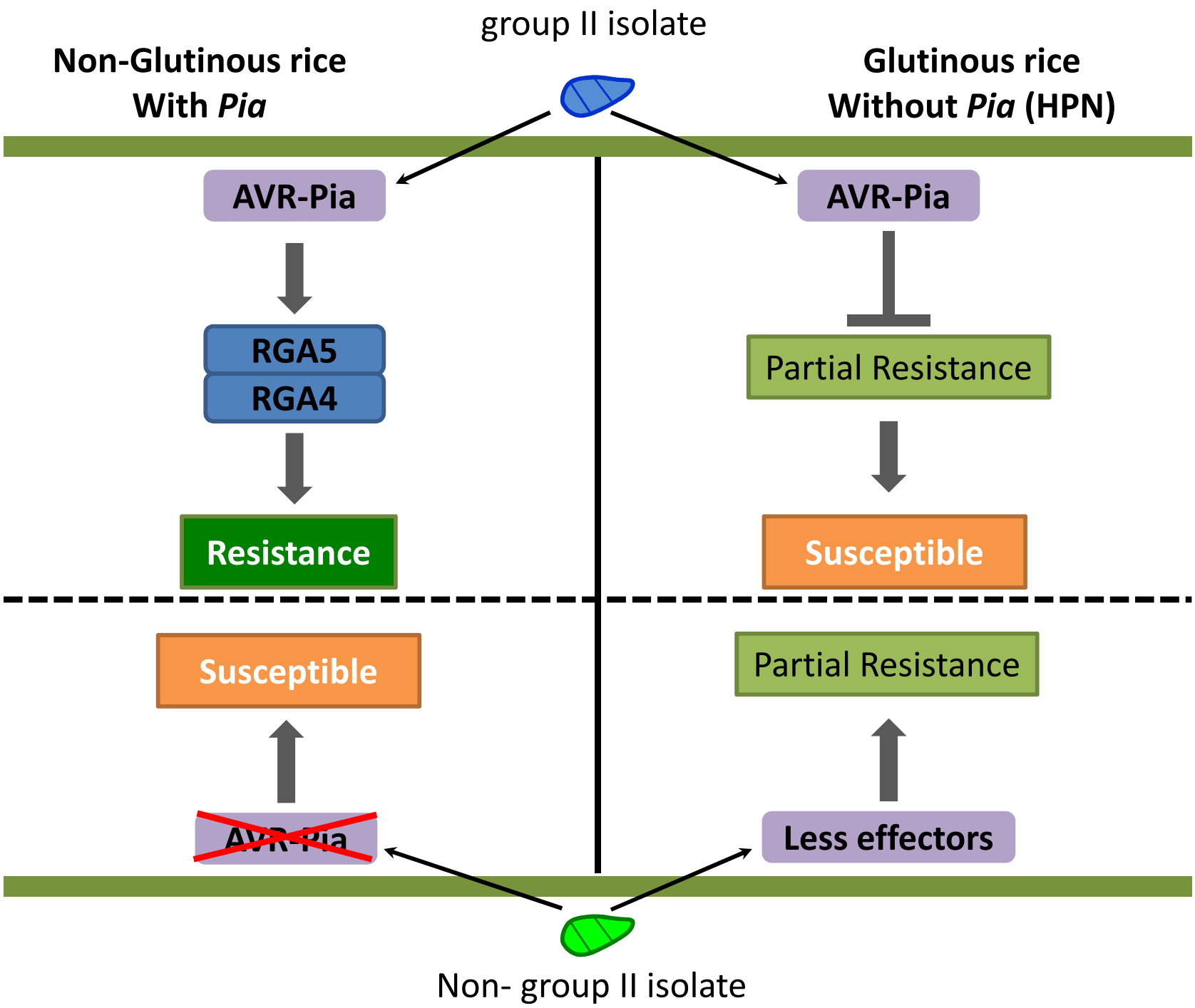
Usual suspect: Effector (as detexted by AVR activity) present in most Group II isolates but mostly absent from non-group II isolates (VIR)

AVR-Pia
AVR-Pi3
AVR-Pi1

Effect of AVR-Pia on fitness



How did *AVR-Pia* make Group Ⅱ isolates more virulent on Glutinous rice?



Conclusions and prospects

- Effector complement shapes adaptation to host

- Hypothesis: glutinous rice has a type of resistance that forces adapted isolates to keep/acquire Effectors

Thank you