Rice breeding for resistance to biotic stresses

RSC&RGDU
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Rice Gene Discovery Lab,
BIOTEC, THAILAND

NSTDA

BIOTEC
a member of NSTDA

ExcelRice

Rice Science Center

BIOTEC
a member of NSTDA

Rice Gene Discovery Lab

DNA Profiling Lab

DNA Technology Lab

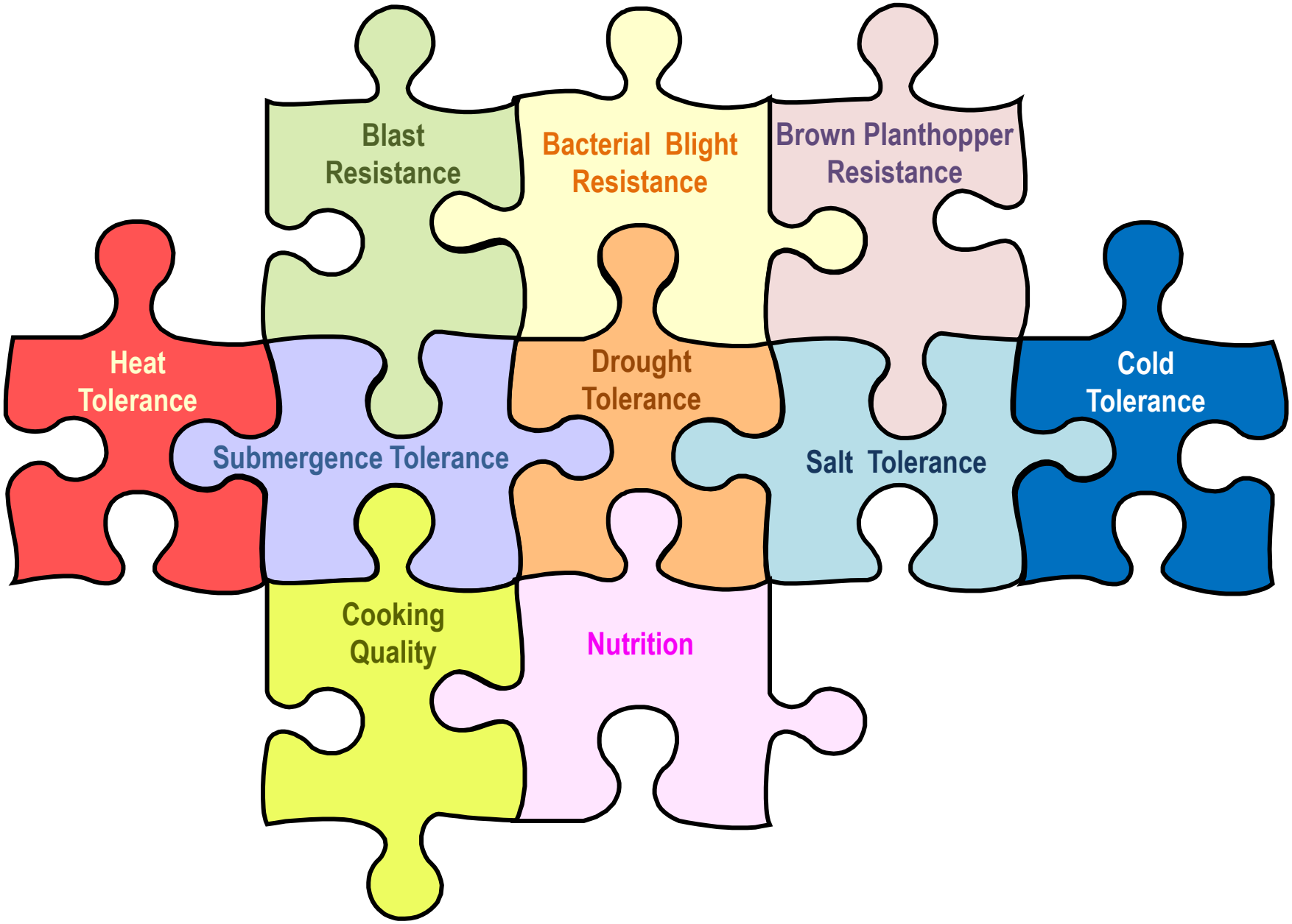
Our facilities

Seed storage

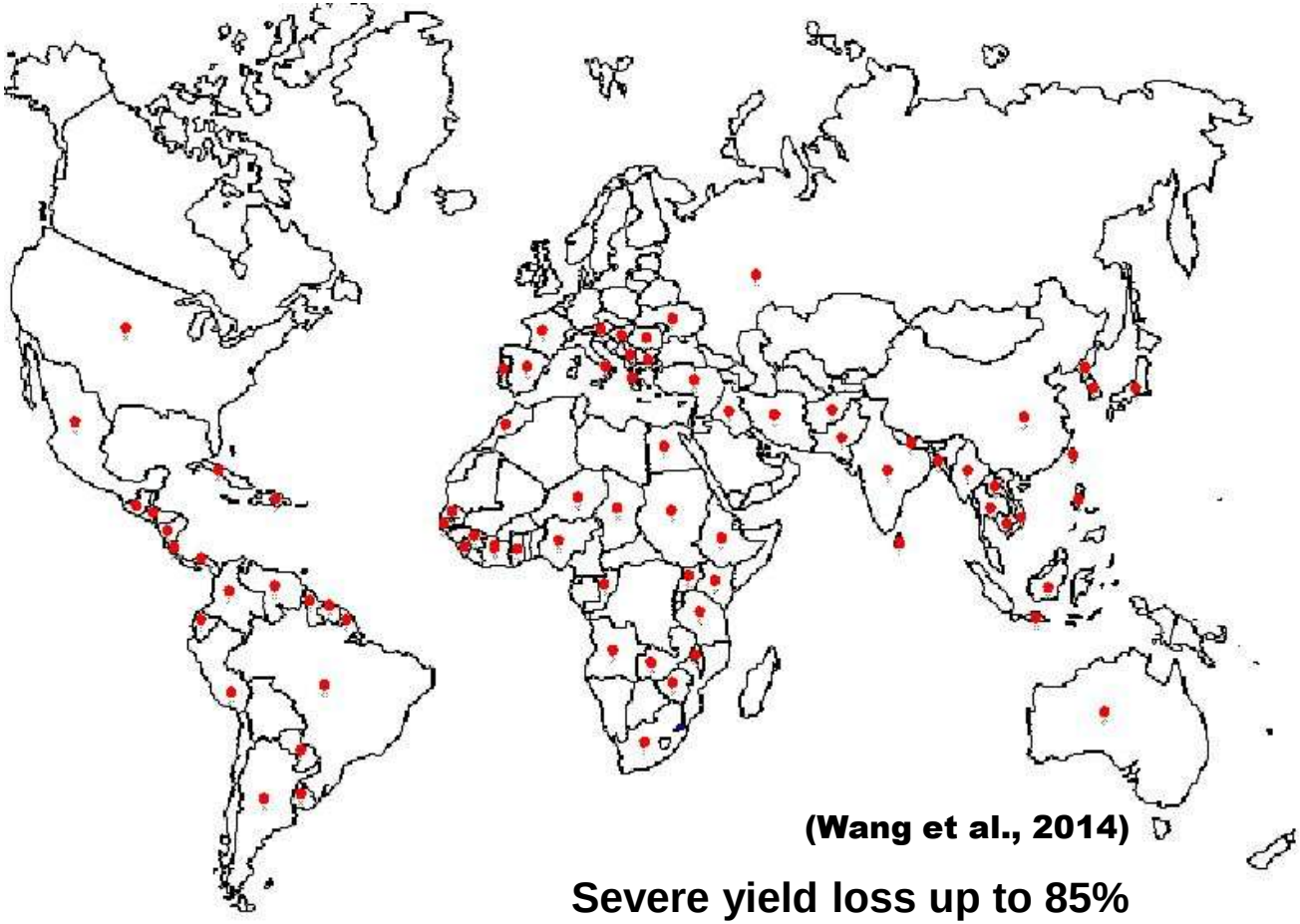
Greenhouses

Submergence screening pool

Rice Gene Discovery Lab & Rice Science Center



RICE BLAST DISEASE



(Wang et al., 2014)

Severe yield loss up to 85%

Teleomorph: *Magnaporthe grisea (Hebert) Barr*

Anamorph: *Pyricularia grisea* Sacc

RICE BLAST DISEASE

Leaf blast

Neck blast

Panicle blast

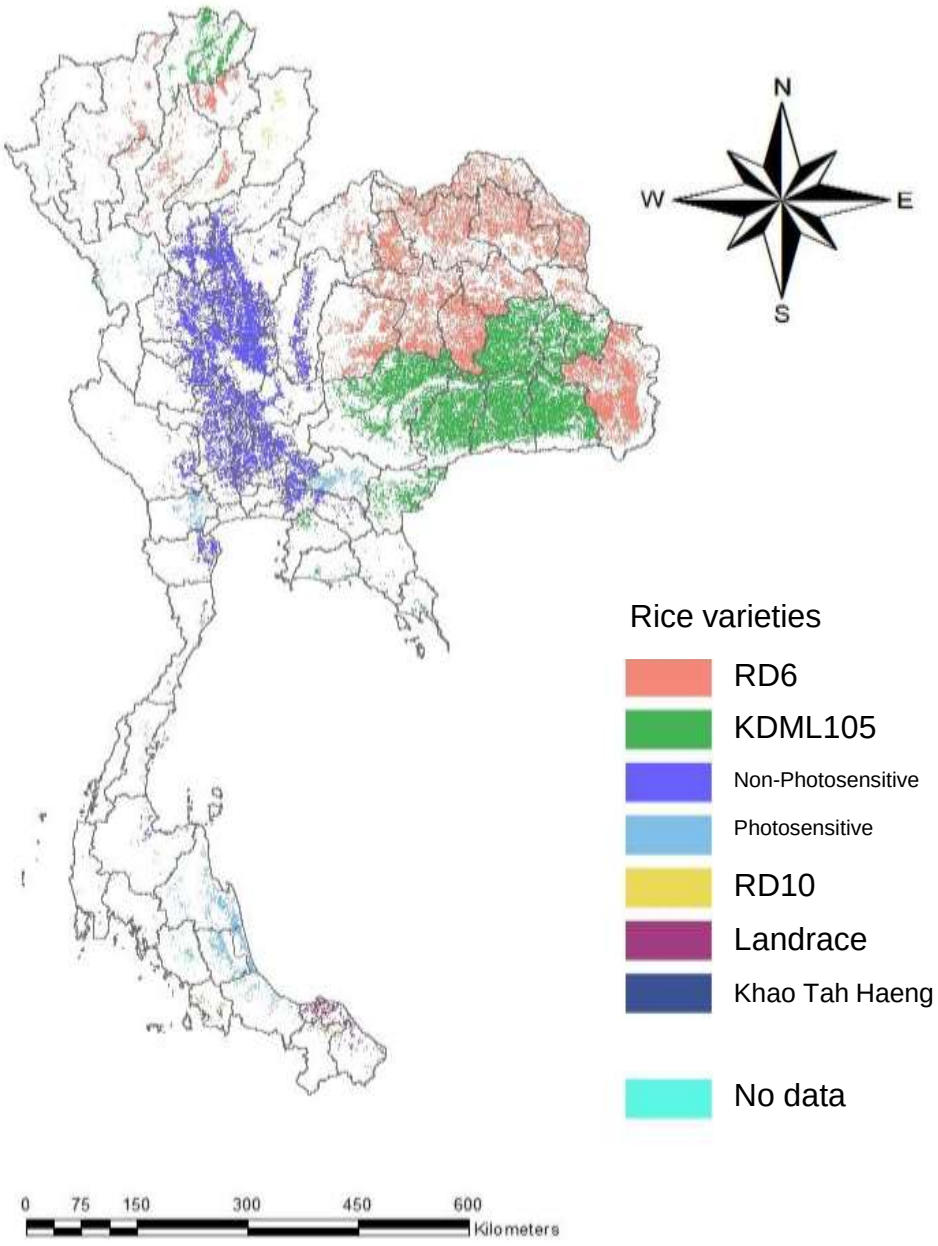
Sheath blast

Collar blast

Node blast

Rice Growing Areas

RICE BLAST DISEASE



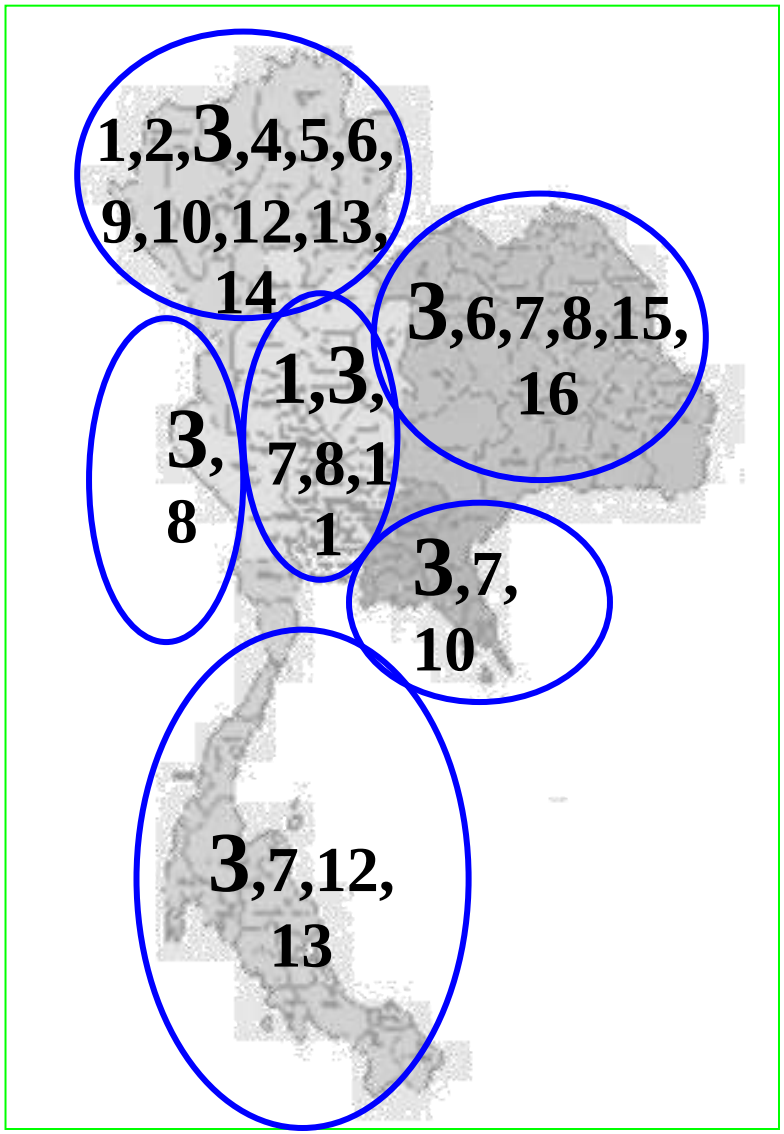
RD6

KDML105

Blast diversity in Thailand

RICE BLAST DISEASE

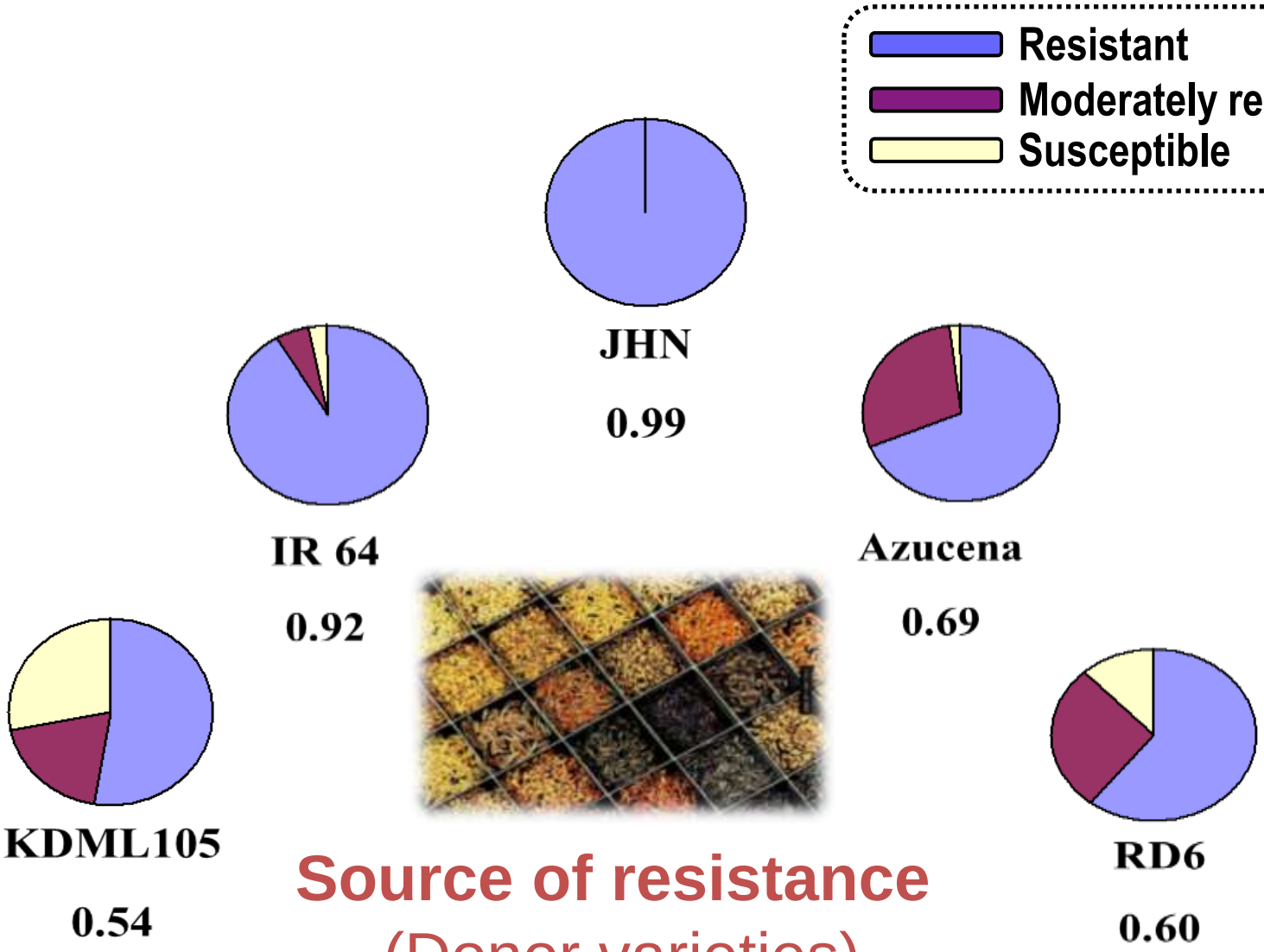
Genetic diversity and Mating type studies



Collection of blast fungus (Single spore isolation)

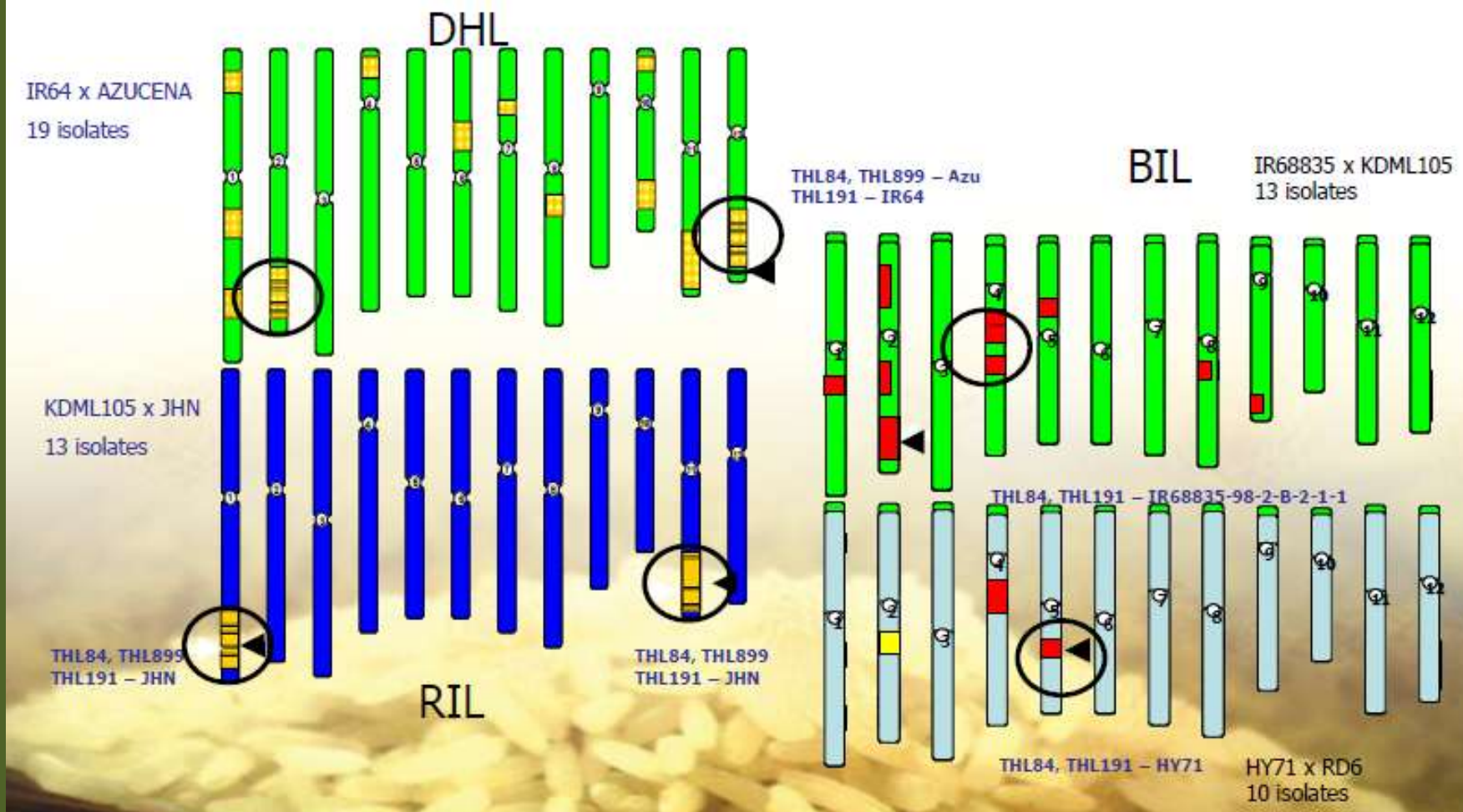
Region	Provinces	Isolates
Northeast	17	254
North	14	545
Central	14	158
South	10	101
East	5	54
West	2	16
Total	**62**	**1,128**

Breeding for Blast Resistance



Source of resistance
(Donor varieties)

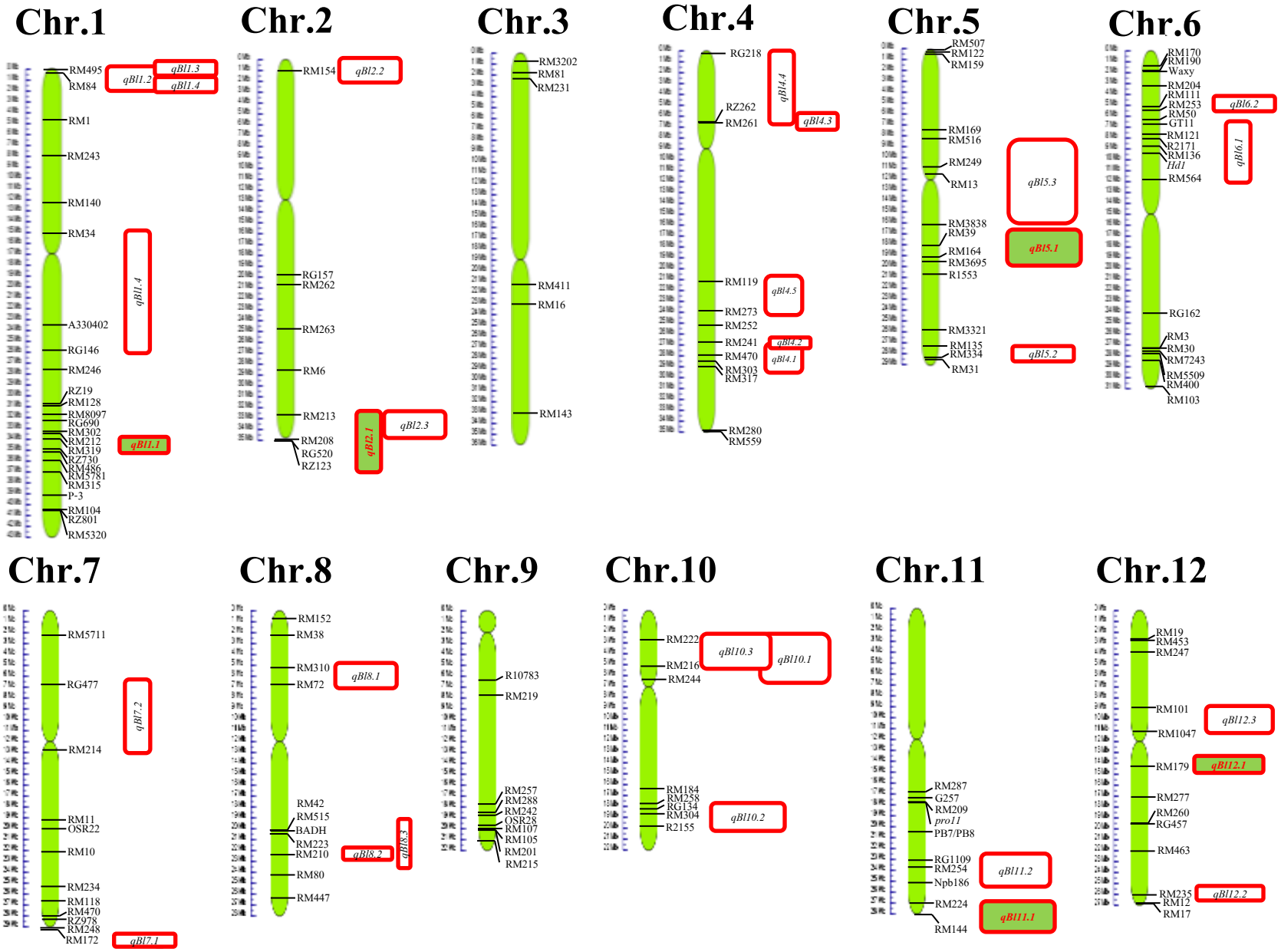
Targeted Resistance QTLs



RICE BLAST DISEASE

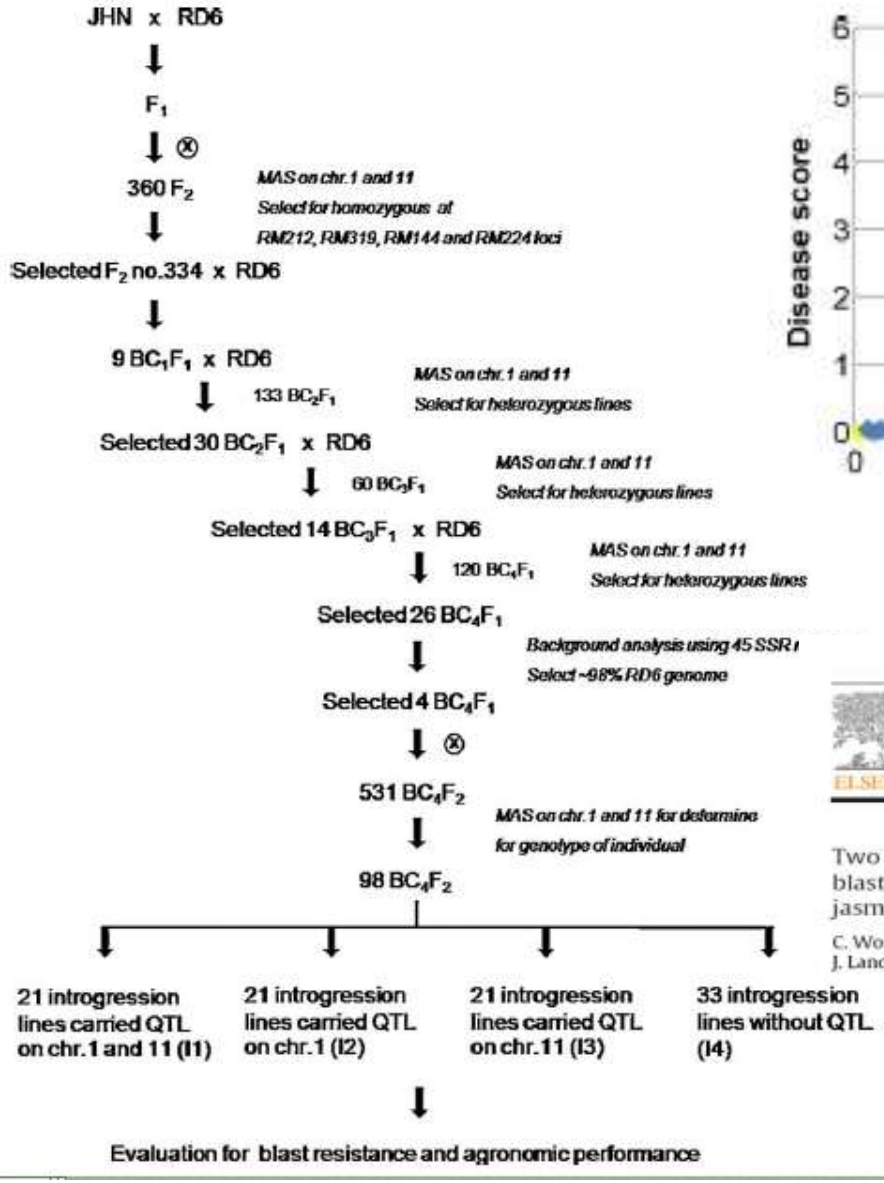
Blast Resistance QTLs

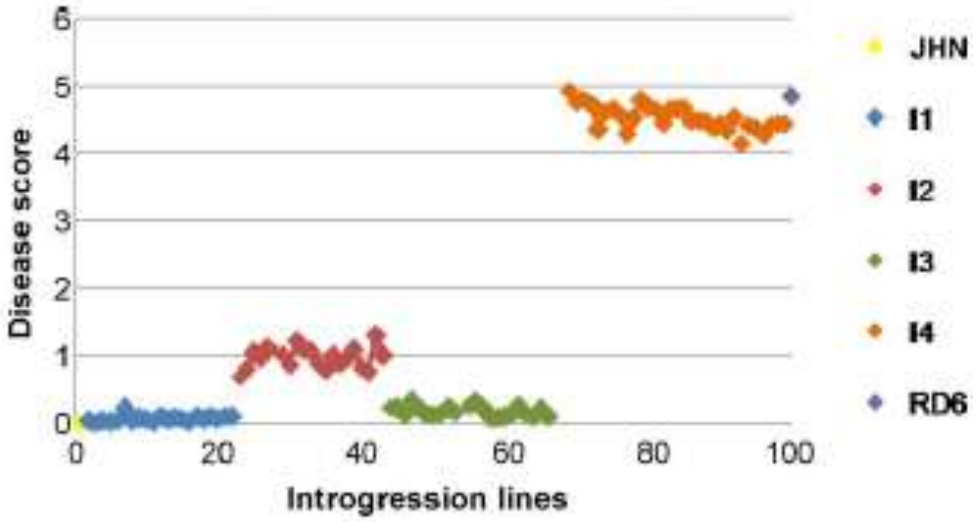
RICE BLAST DISEASE



Introgression of QTL for broad-spectrum resistance to blast disease into RD6

RICE BLAST DISEASE





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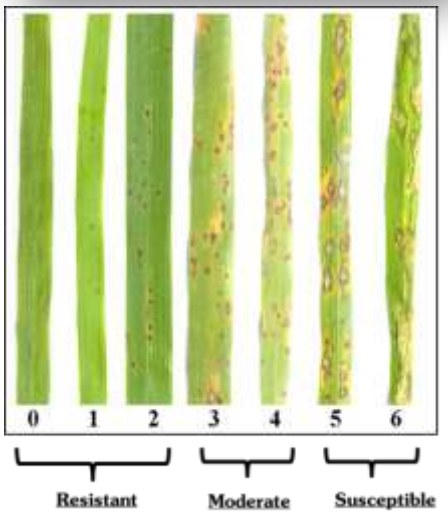
Field Crops Research
journal homepage: www.elsevier.com/locate/fcr

Two introgressed quantitative trait loci confer a broad-spectrum resistance to blast disease in the genetic background of the cultivar RD6 a Thai glutinous jasmine rice

C. Wongsaprom[a], P. Sirithunya[b], A. Vanavichit[c], G. Pantuwan[d], B. Jongdee[e], N. Sidhiwong[f], J. Lanceras-Siangliw[a], T. Toojinda[a,*]

RICE BLAST DISEASE

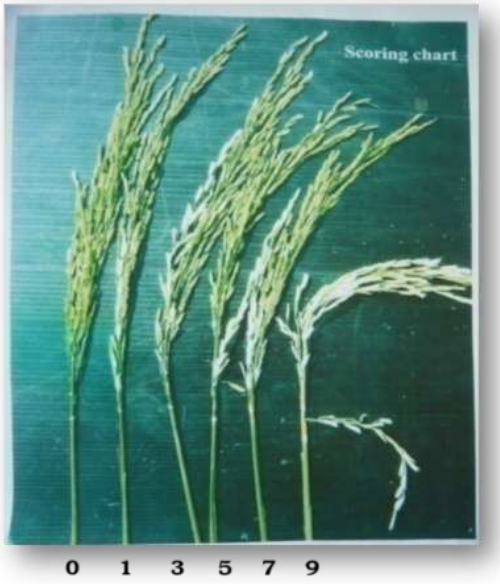
Validation of blast disease resistance



Leaf blast

RICE BLAST DISEASE

Validation of blast disease resistance



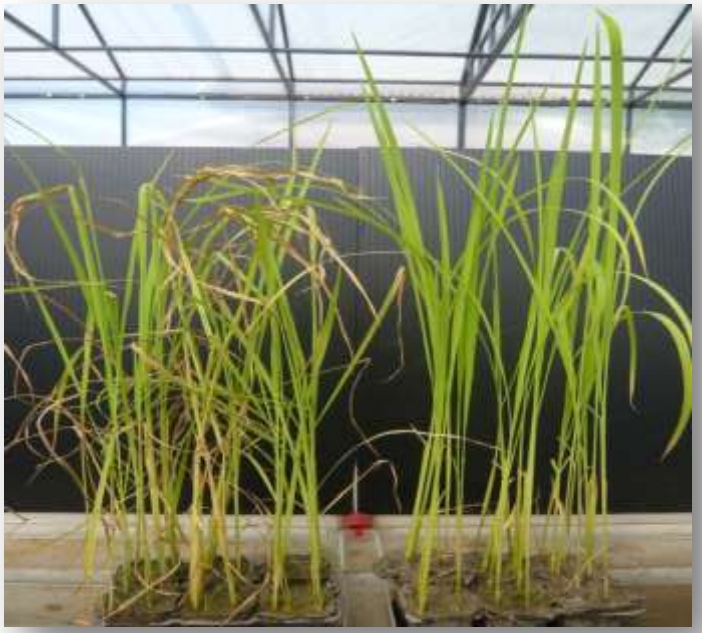
Neck blast

Improved varieties with blast resistance

RICE BLAST DISEASE

RD6

Thunyasirin
(RD6 + QBL1)



RD6

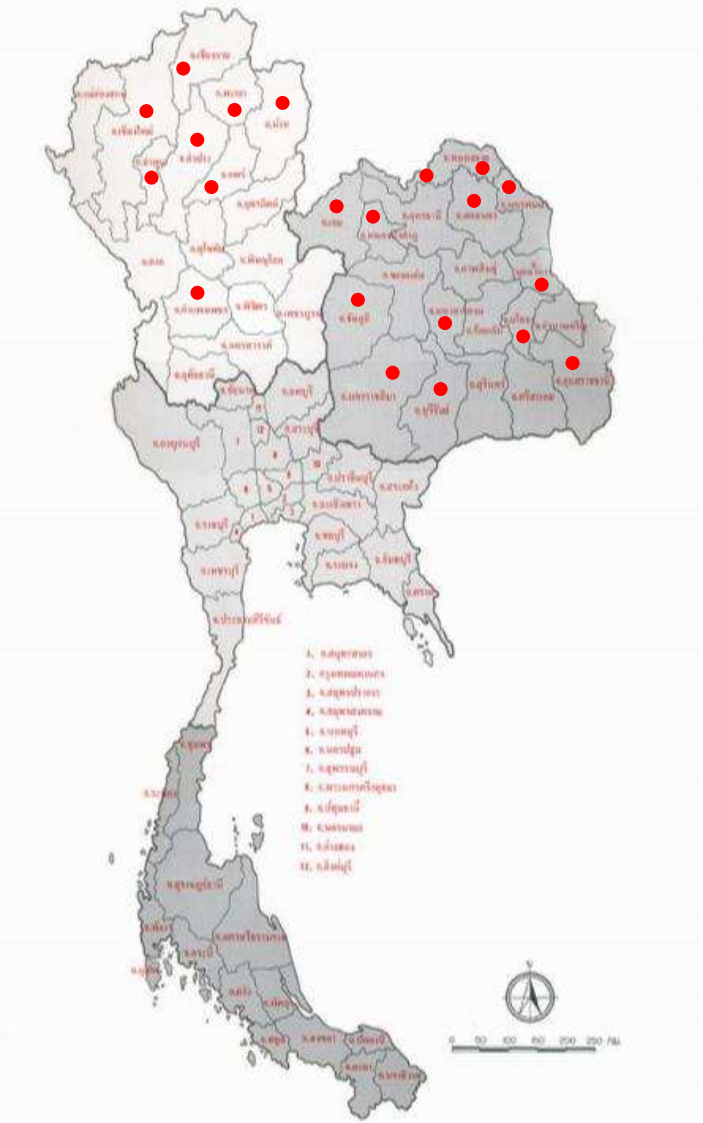
RD6
(+ QBL1 + QBL2
+ QBL11 + QBL12)

KDML105

KDML
(+ QBL1 + QBL11)

Thunyasirin (RD6 + QBL1) growing areas

RICE BLAST DISEASE



Released in 2008

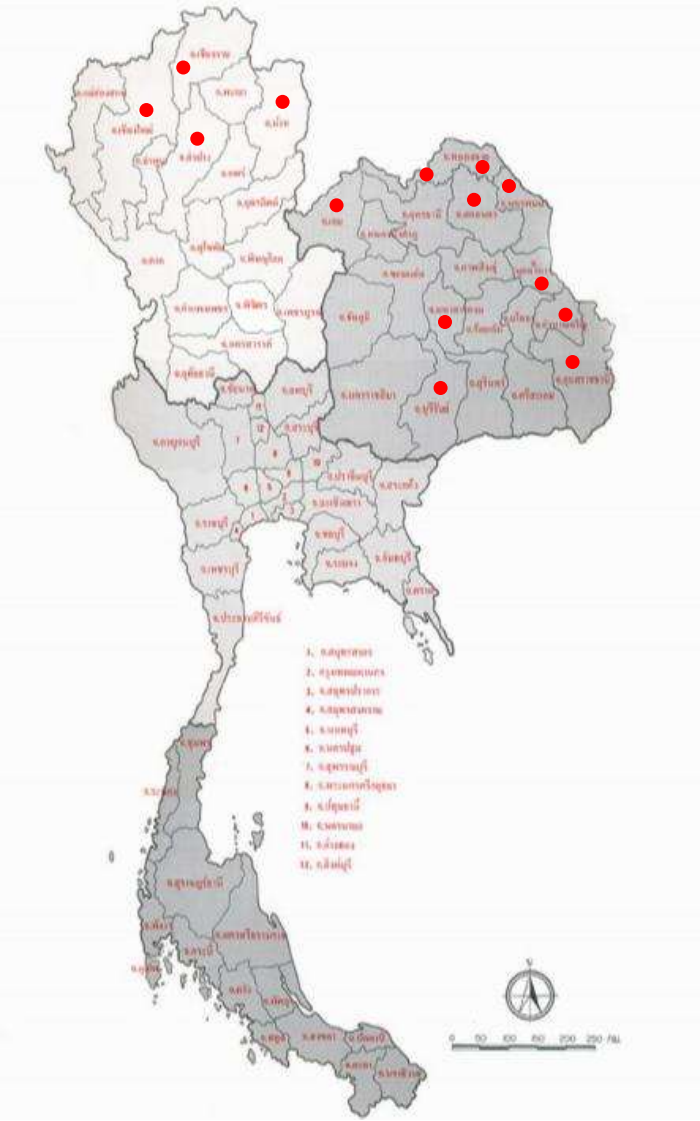
>1,800 families

>1,000 hectares

>31,315 tons

RD6 + QBL1+ QBL2+ QBL11+ QBL12 growing areas

RICE BLAST DISEASE



Released in 2012

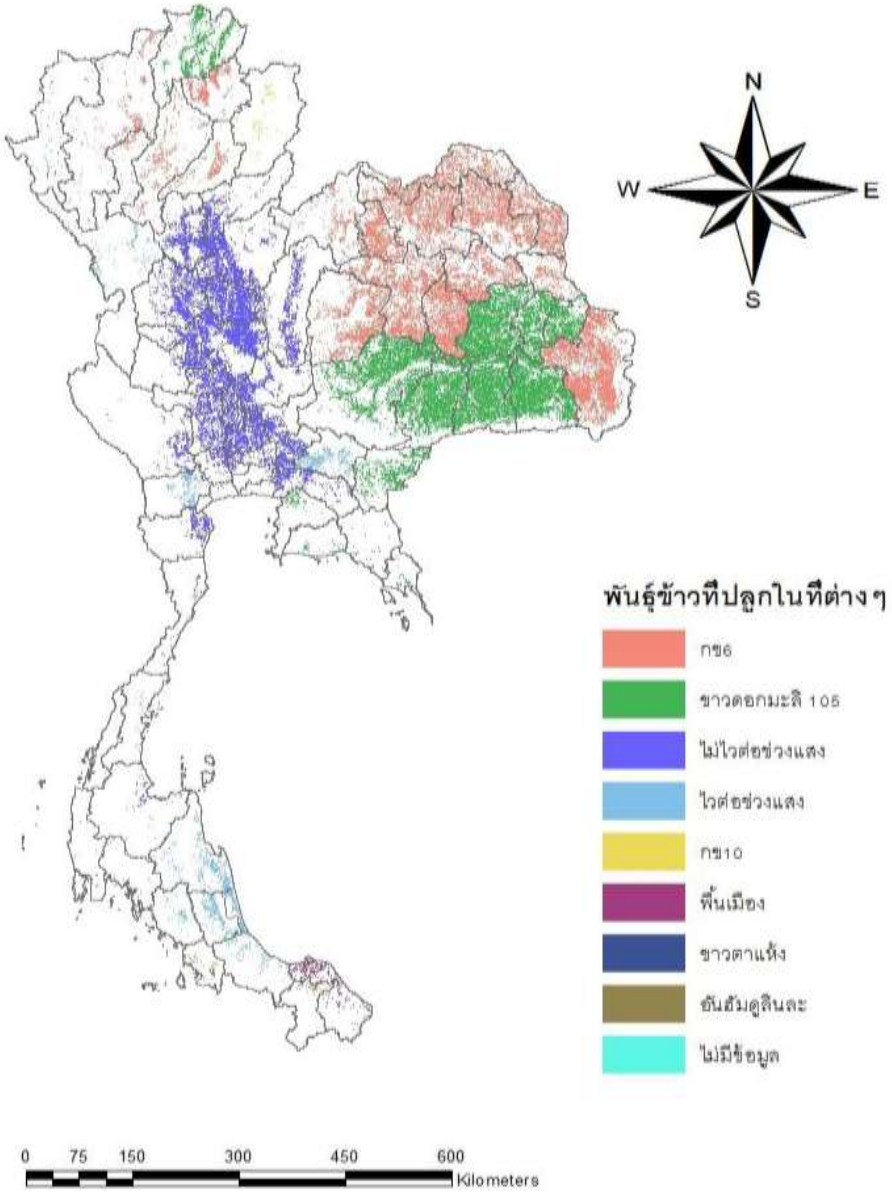
>565 families

>122 hectares

>484 tons

BACTERIAL BLIGHT

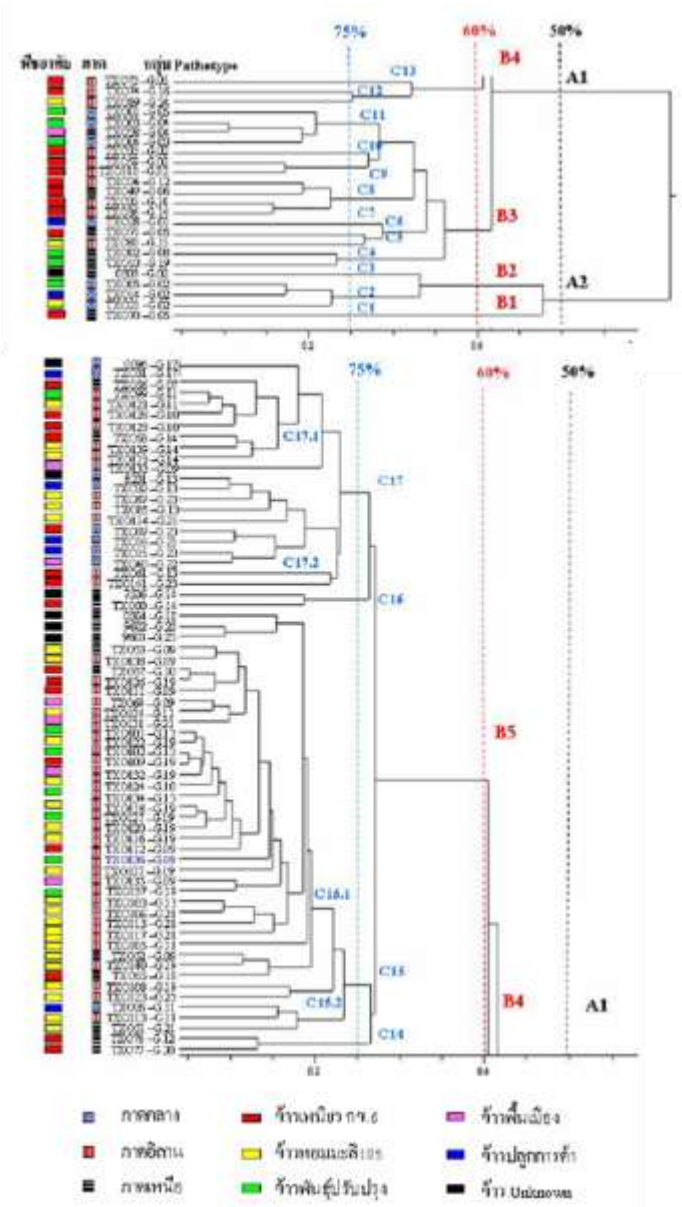
Rice Growing Areas



bacterial blight

Bacterial blight diversity in Thailand

BACTERIAL BLIGHT



90 isolates tested

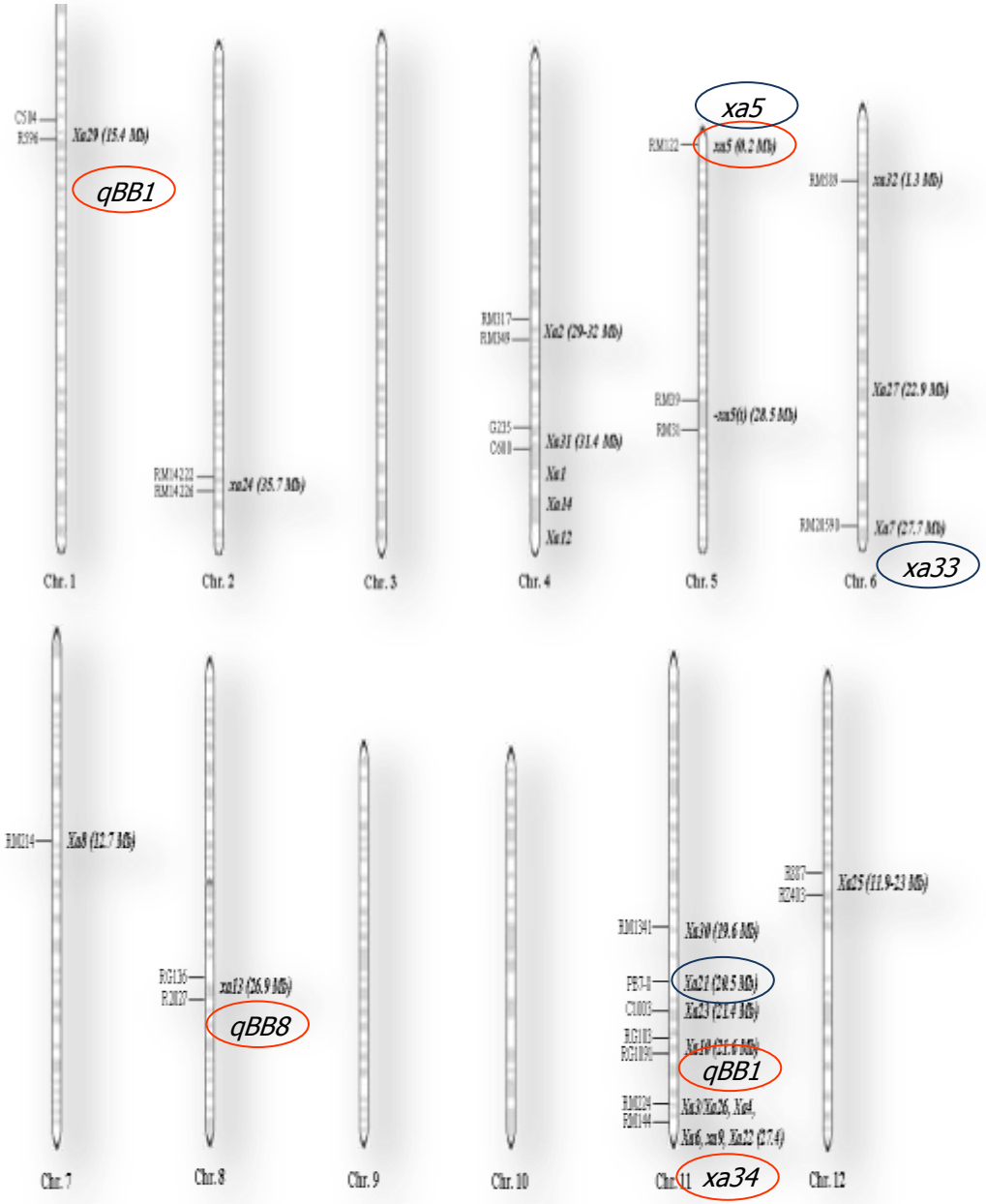
⬇

25 groups

Sangchai et al, 2010

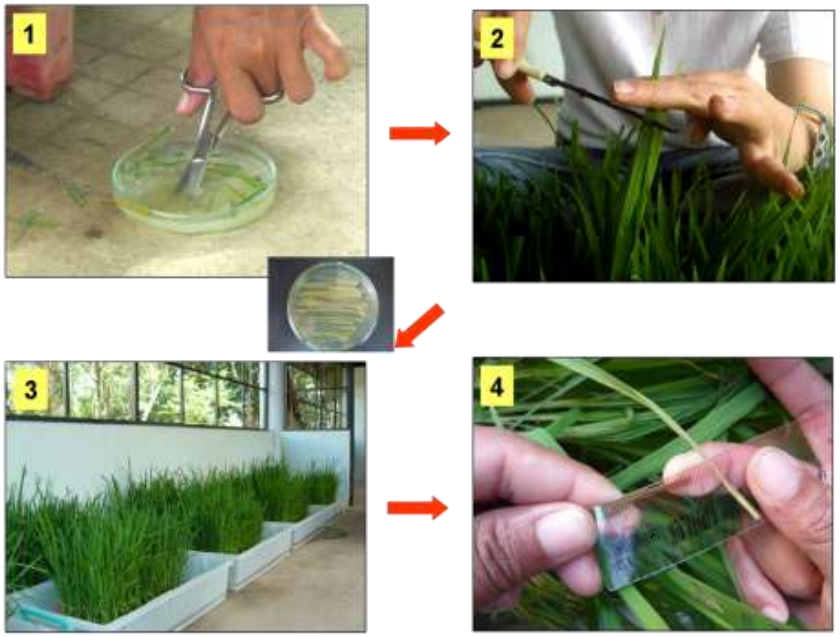
BACTERIAL BLIGHT

Bacterial blight resistance loci



BACTERIAL BLIGHT

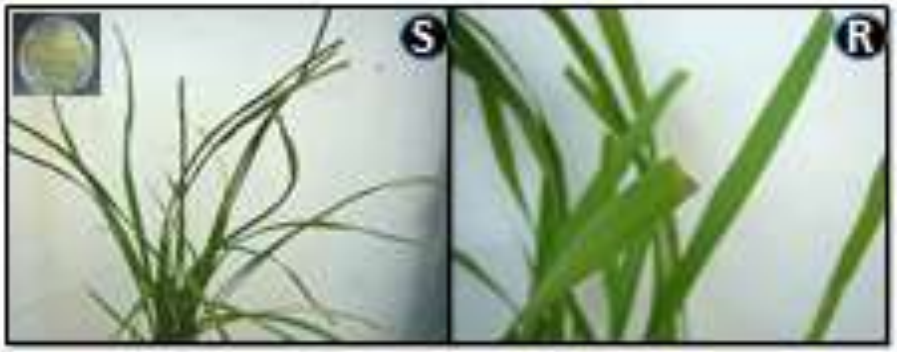
Validation of blight disease resistance



- 0 - 3 cm = ต้านทาน (R)
- >3.1- 6 cm = ต้านทานปานกลาง (MR)
- >6.1- 9 cm = อ่อนแอปานกลาง (MS)
- >9.1 cm = อ่อนแอ (S)

BACTERIAL BLIGHT

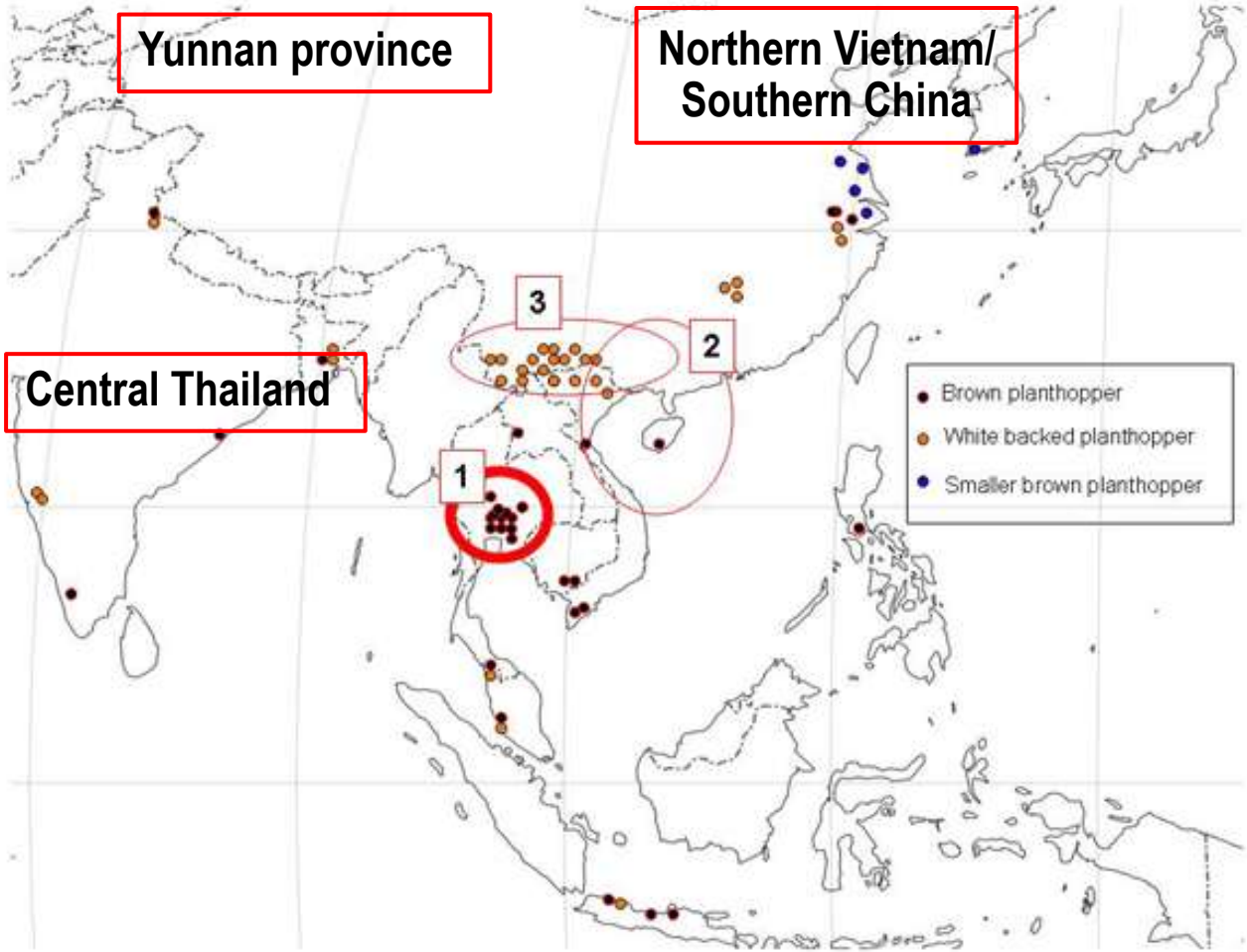
Improved varieties with blight resistance



RD6 **RD6** + QBL + QBB

BROWN PLANTHOPPER

Brown planthopper in Asia



BROWN PLANTHOPPER

Thailand's rice production loss by BPH

Year	US$ (million)
2009	275
2010	533
2012	450

$80 million spent in 2009

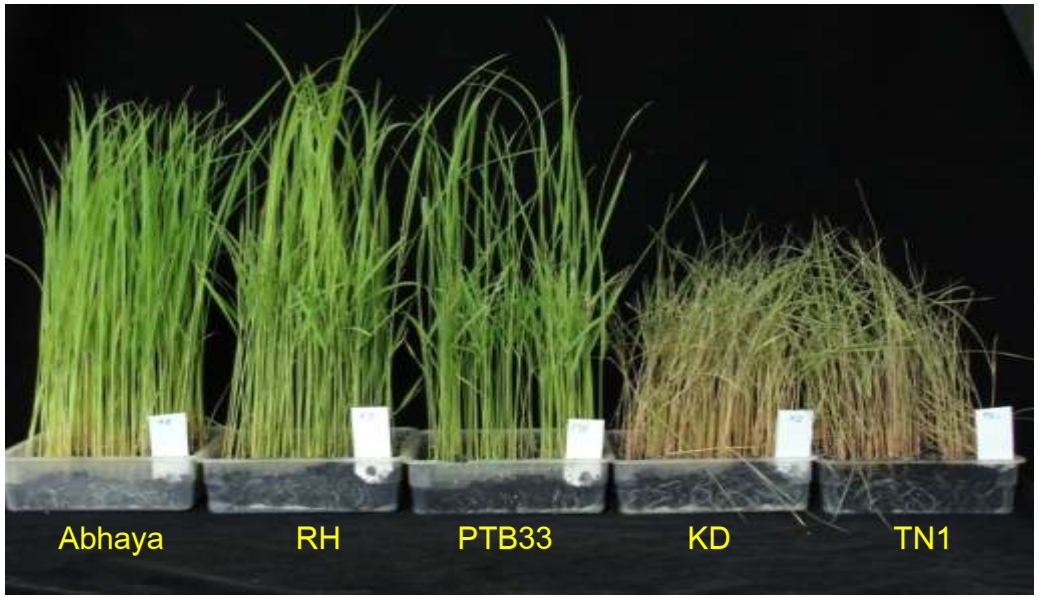
- **Compensation**
- **Campaigns**
- **Insecticides**

Screening for BPH resistance

BROWN PLANTHOPPER

BROWN PLANTHOPPER

Resistant varieties to BPH in Thailand



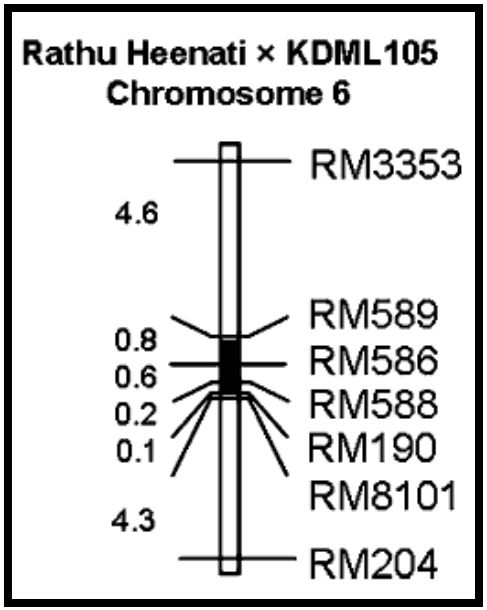
- **Rathu Heenati**
- **PTB33**
- **Abhaya**

Jairin et al, 2007, *Mol Breed*: 19,35

BROWN PLANTHOPPER

Source of brown planthopper resistance

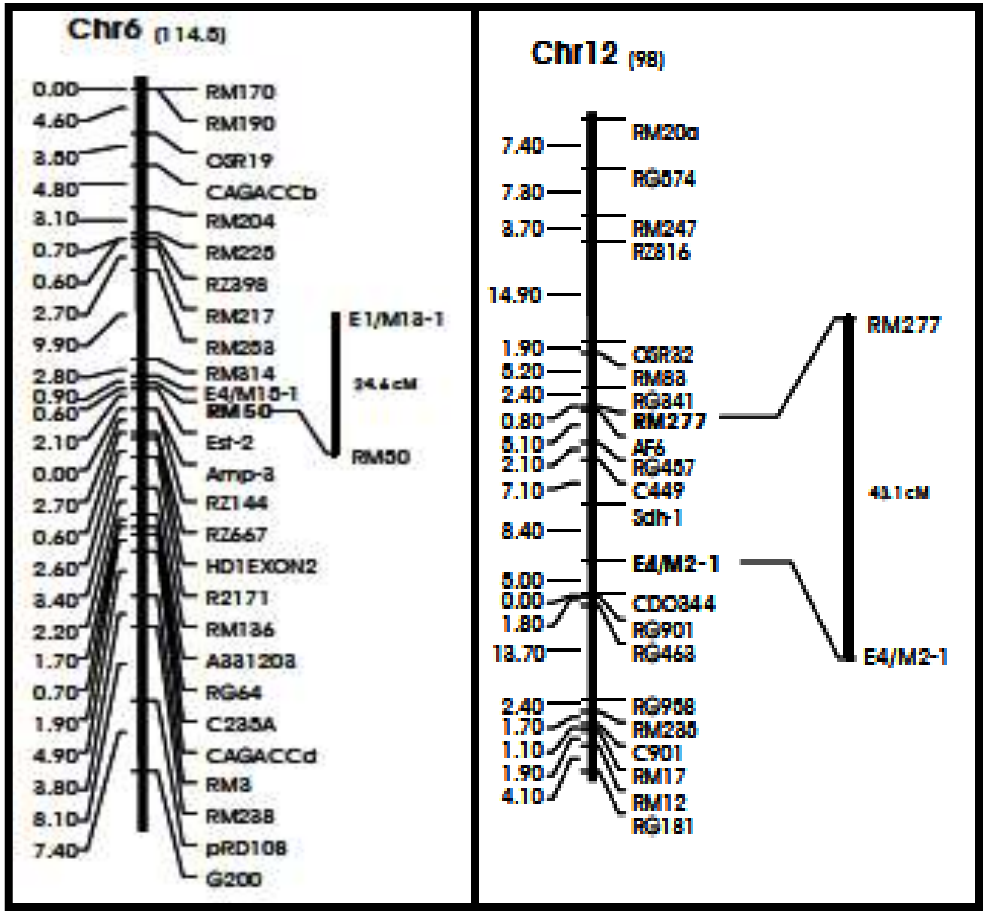
Bph3



Rathu Heenati

Qbph6

Qbph12



Abhaya

BROWN PLANTHOPPER

Breeding for BPH resistance

CNT + *Bph3*
(BC_4F_5)

X

CNT + QBph6 + QBph12
(BC_4F_5)

↓

F_1

↓⊗

F_2 ⇐ marker-assisted selection

↓⊗

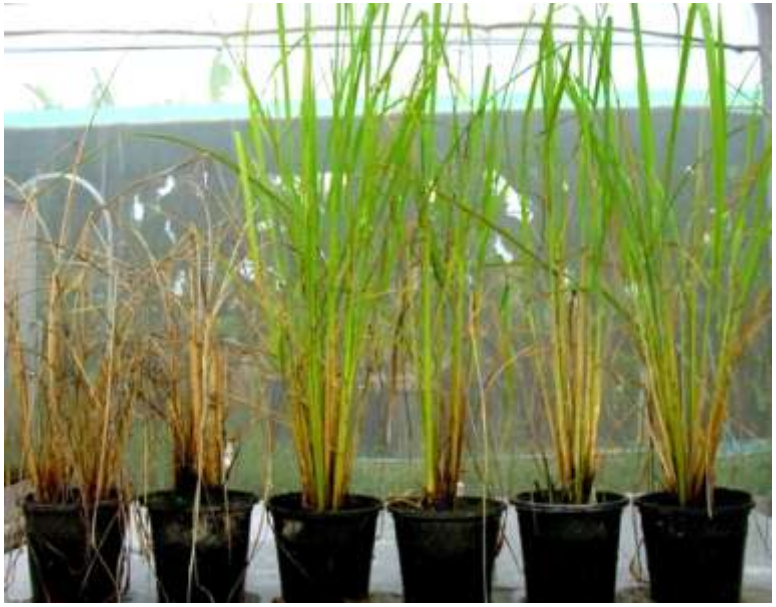
F_3 ⇐ phenotypic selection

Chainat 1

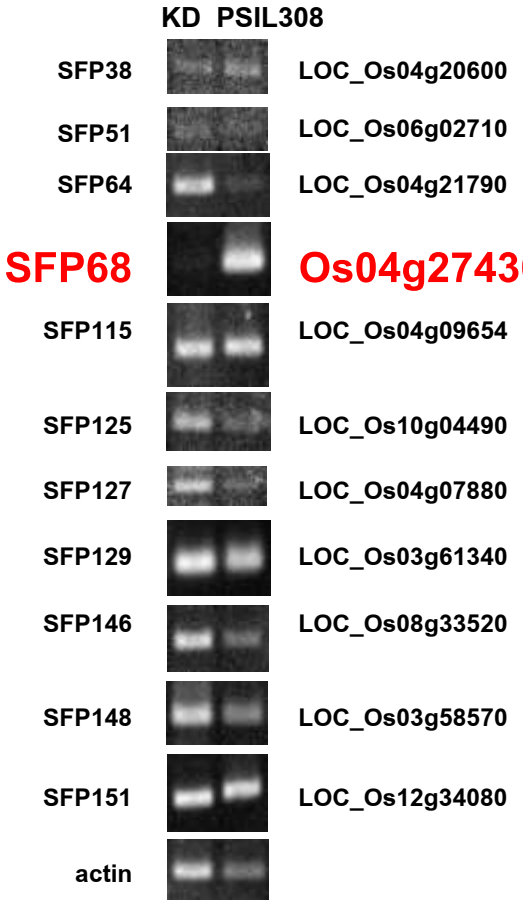
CNT-PYR (*Bph3* + QBph6 + QBph12)

BROWN PLANTHOPPER

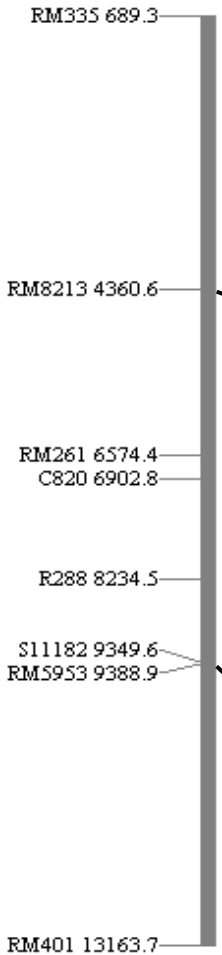
Genomic hybridization of microarray between KDML and introgression lines



KDML105 ⟷ Introgression lines



Identification of candidate genes in *Bph17(t)* region on chromosome 4



Matched MSU/TIGR Gene ID	gene annotation
LOC_Os04g03050	OsSub34 - Putative Subtilisin homologue, expressed
LOC_Os04g03100	OsSub35 - Putative Subtilisin homologue, expressed
LOC_Os04g04680	expressed protein
LOC_Os04g05400	expressed protein
LOC_Os04g05840	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g06320	retrotransposon, putative, centromere-specific, expressed
LOC_Os04g06734	expressed protein
LOC_Os04g06890	Not found
LOC_Os04g06910	expressed protein
LOC_Os04g06970	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g07410	Not found
LOC_Os04g07680	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g07880	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g08800	expressed protein
LOC_Os04g09654	O-methyltransferase, putative, expressed
LOC_Os04g10660	expressed protein
LOC_Os04g10740	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g11030	expressed protein
LOC_Os04g11350	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g11430	retrotransposon protein, putative, unclassified, expressed
LOC_Os04g11440	F-box protein interaction domain containing protein, expressed
LOC_Os04g11660	OsFBX119 - F-box domain containing protein, expressed
LOC_Os04g11780	resistance protein LR10, putative, expressed
LOC_Os04g12140	expressed protein
LOC_Os04g13050	expressed protein
LOC_Os04g13460	expressed protein
LOC_Os04g13590	expressed protein
LOC_Os04g14220	disease resistance protein RPM1, putative, expressed
LOC_Os04g14280	transposon protein, putative, CACTA, En/Spm sub-class, expressed
LOC_Os04g14320	hypothetical protein
LOC_Os04g14654	Sec1 family transport protein, putative, expressed
LOC_Os04g16878	uncharacterized protein ycf70, putative
LOC_Os04g20600	hypothetical protein
LOC_Os04g21820	OsWAK33 - OsWAK receptor-like protein OsWAK-RLP, expressed
LOC_Os04g22270	expressed protein
LOC_Os04g22280	hypothetical protein
LOC_Os04g24200	expressed protein
LOC_Os04g25740	expressed protein
LOC_Os04g25784	expressed protein
LOC_Os04g25900	go35 NBS-LRR, putative, expressed
LOC_Os04g25910	hypothetical protein
LOC_Os04g26440	hypothetical protein
LOC_Os04g27430	terpene synthase, putative, expressed
LOC_Os04g27450	hypothetical protein
LOC_Os04g27670	terpene synthase family, metal binding domain containing protein, expressed
LOC_Os04g27720	terpene synthase, putative, expressed

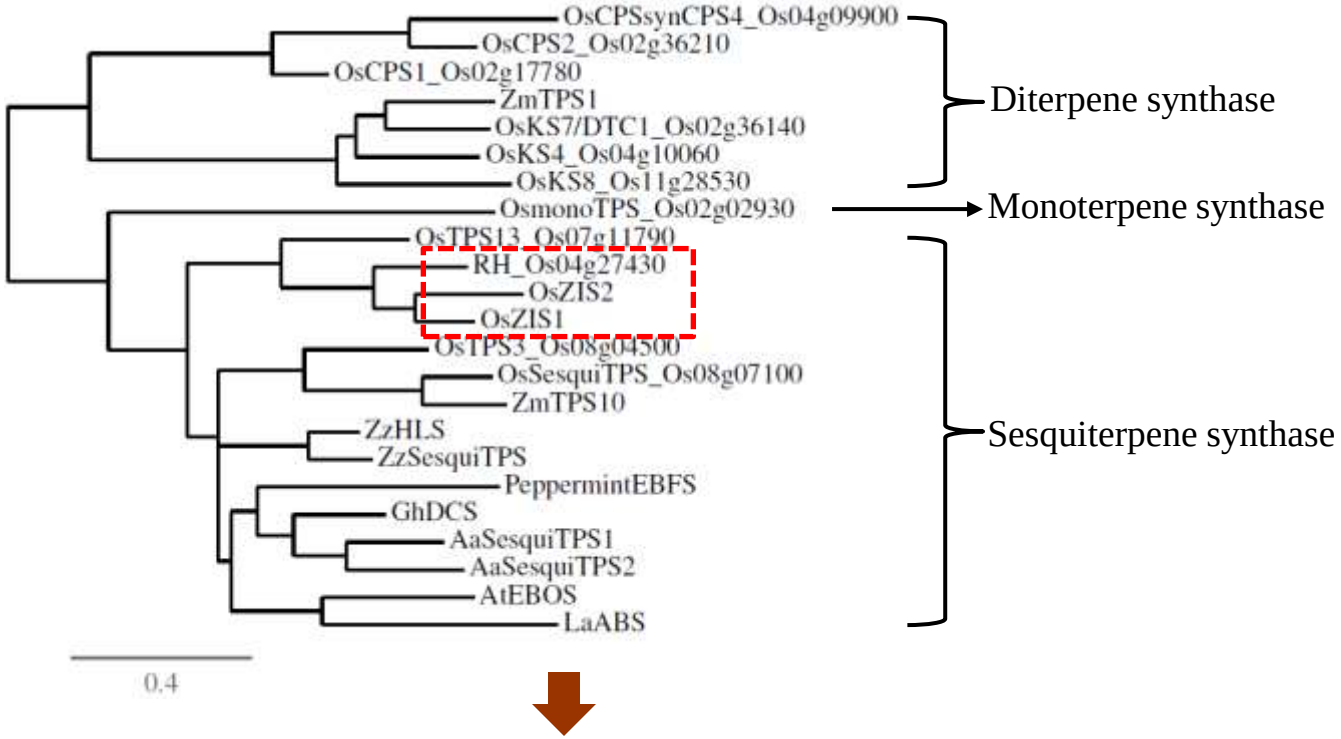
Bph17(t)

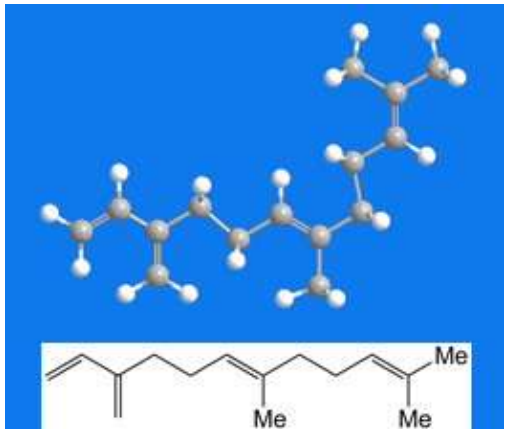
Kamolsukyunyong et al. (2013) Rice
Sun et al. (2005) Breed. Sci.

BROWN PLANTHOPPER

BROWN PLANTHOPPER

Phylogenetic analysis and product





***trans*-β-Farnesene**

HIGH NUTRITION

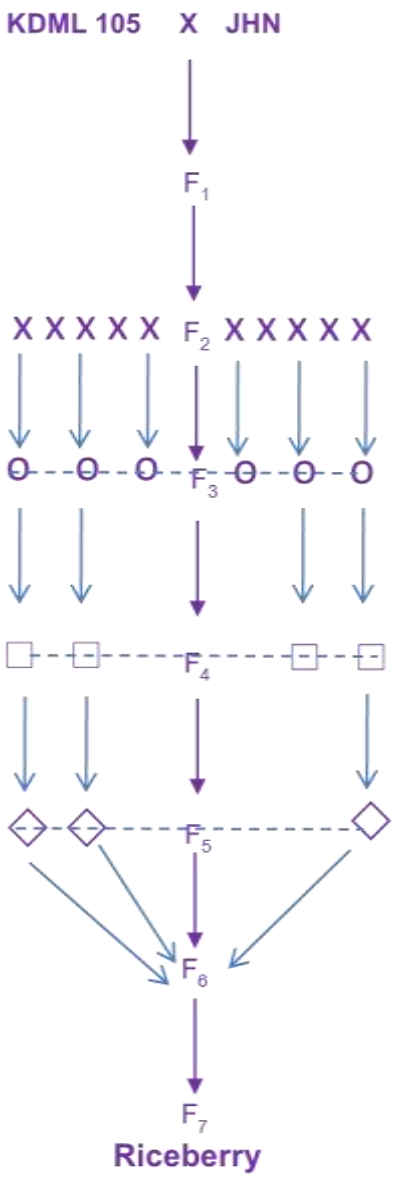
Riceberry

Riceberry

- Anthocyanin
- Carotenoids
- Oryzanol
- Vitamin E/B
- Folate
- GABA
- Antioxidants:
  - 47.5mg ascorbic acid quivalent/100g
  - 33.4 mg trolox equivalent/100 g

Breeding of Riceberry

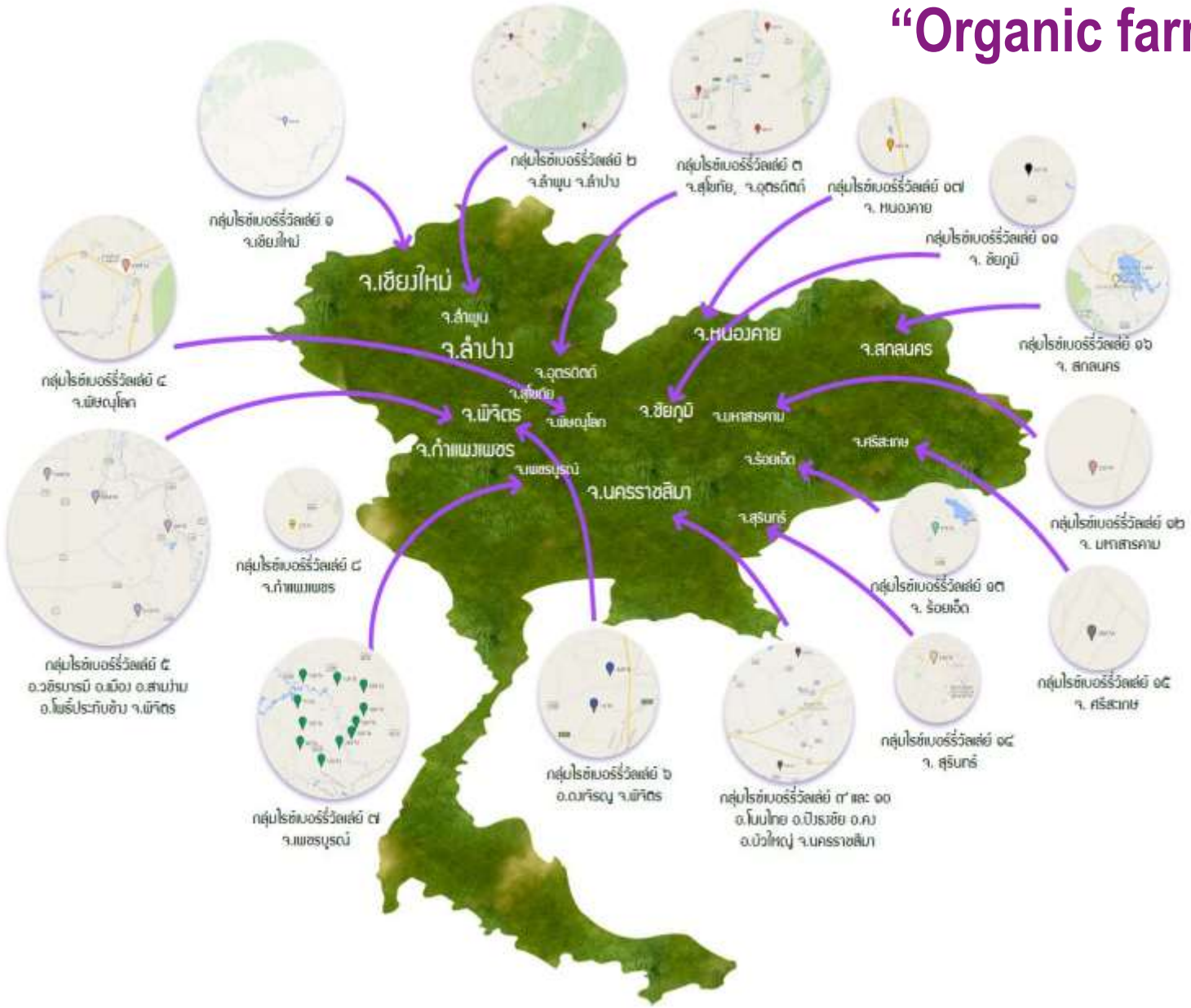
HIGH NUTRITION



2002	Crossing of parental varieties
	Selfing of F_1
	Growing individual F_2 - Marker-assisted selection (MAS) for cooking quality - Visual selection for anthocyanin
2003	Pedigree selection of F_3 - MAS for cooking quality and blast resistance - Visual selection for anthocyanin
2004	Pedigree selection of F_4 - MAS for cooking quality and blast resistance - Visual selection for anthocyanin
	Pedigree selection of F_5
2005	Yield trial of F_6
	Yield trial of F_7

Riceberry growing areas

"Organic farming"

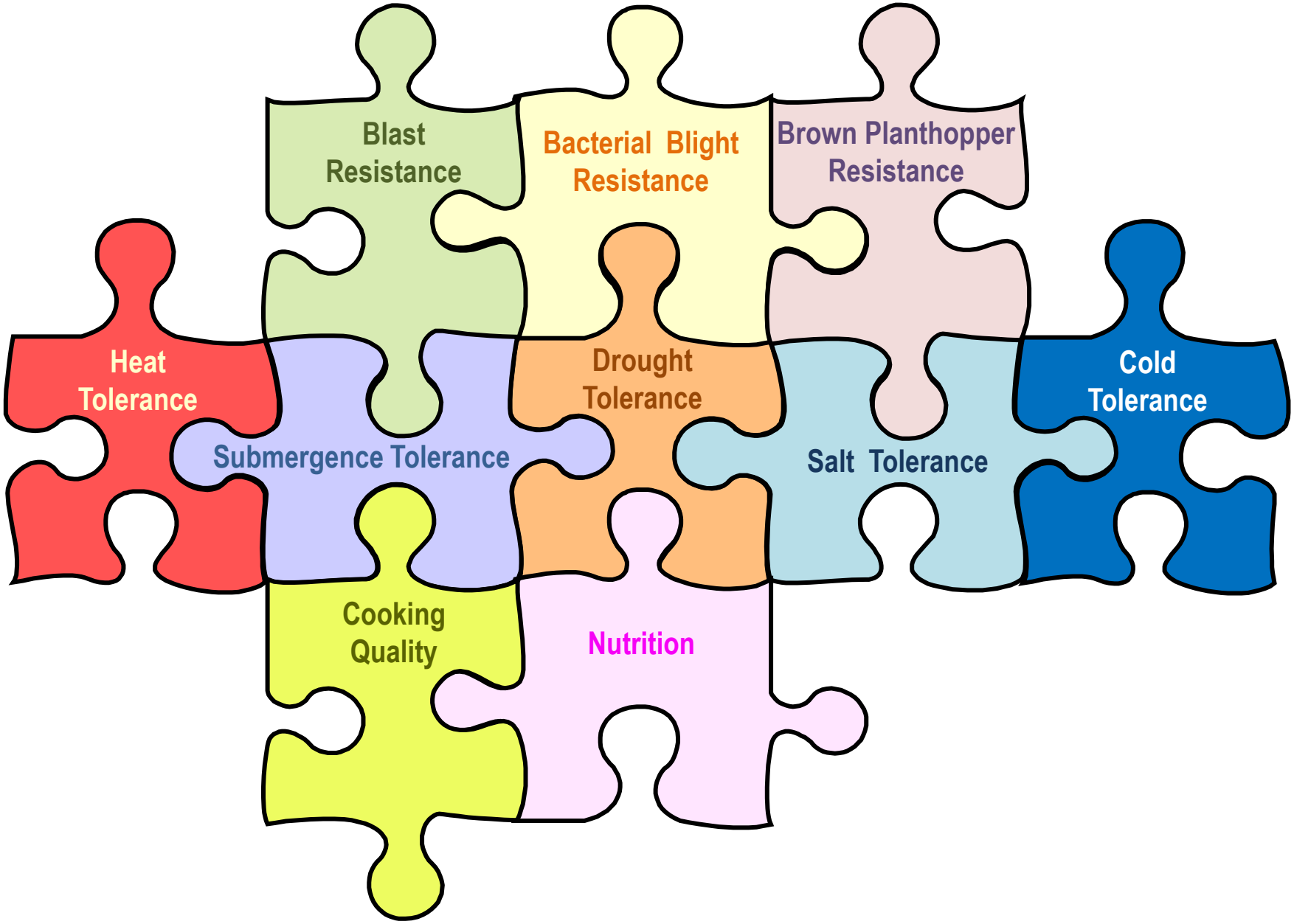


HIGH NUTRITION

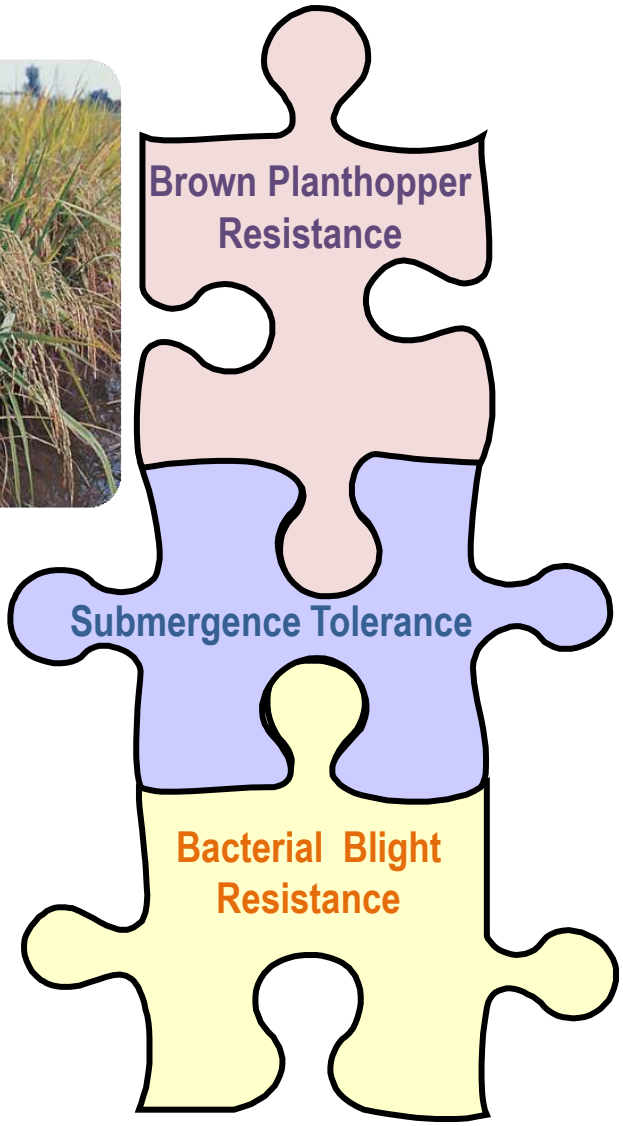
HIGH NUTRITION

Riceberry

Rice Gene pyramiding



Rice Gene pyramiding



Gene	Marker
Bph3	SSR24(SNP)
qBPH6	RM50-RM225
qBPH12	RM277
Sub1	R10785(indel)
xa5	xa5(SNP)
Xa21	Xa21(SNP)
xa33	RM5509-RM7243

International networking & Collaborations

- BIO5 Institute University of Arizona, USA
- CIRAD, France
- IRD, France
- Rice Genome Research Program (RGP), Japan
- International Rice Informatics Consortium, Philippines
- International Rice Functional Genomics Consortium, USA *
- The Global Plant Council, UK
- University of Nottingham, UK *
- Research Institute for Bioresources and Biotecnology Ishikawa Prefectural University, Japan *
- Queen's University Belfast, UK
- Meiji University, Japan *
- The Cambodian Agricultural Research and Development Institute (CARDI), Cambodia
- National Agriculture and Forestry Research Institute (NAFRI), Laos *
- Myanmar Agriculture Service, Myanmar *
- International Food Policy Research Institute, USA
- Japan International Research Center for Agricultural Science (JIRCAS), Japan
- Honda Research Institute, Japan
- International Rice Research Institute (IRRI), Philippines *
- Generation Challenge Programme (GCP), Integrated Breeding Platform (IBP), Maxico *

International networking & Collaborations

collaborations

Improvement of Mekong mega rice varieties challenging for the climate change in Mekong

	THAILAND		MYANMAR		LAOS PDR		CAMBODIA
	KDML105	RD6	Manawthukha	Sin Thwe Latt	TDK1	IR57514	CAR3
Cooking quality			X	X	X	X	X
Submergence tolerance	X	X	X	X	X	X	
Salt tolerance	X	X		X		X	
Drought tolerance	X	X	X		X	X	X
Blast resistance	X	X	X	X	X	X	X
Bacterial blight resistance	X	X	X	X	X	X	X
Brown Planthopper resistance	X	X	X		X		X
High termperature	X	X	X	X	X	X	X
Low temperature	X	X	X		X	X	
Gal midge resistance	X	X			X	X	
Resistance to dirty panicle	X	X		X			X
Nutrition	X	X	X	X	X	X	X
Yield	X	X					X

Acknowledgement

BLAST TEAM
Siripa Korinsak
Chanakarn Wongsaprom
Pilaiporn Plubjapo
Dr. Kanyanat Sirithunya
Dr. Chatchawan Juntrasuriyarut

BACTERIAL BLIGHT TEAM
Siriporn Korinsak
Thunyaporn Upathi
Wannapa Sattayachiti
Kittipong Ravisaya

BROWN PLANTHOPPER TEAM
Dr. Wintai Kamolsukyunyong
Wissarut Sukakhet
Kittaya Saisamai
Mayoori Salanoi
Kitsada Pitija

Dr. Apichart Vanavichit, RGDU Director
Dr. Theerayut Toojinda, RGDL head

THANK YOU