INTERNATIONAL COLLABORATIVE RESEARCH NETWORKS FOR RICE BLAST

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Yoshimichi Fukuta is a senior researcher at JIRCAS and an invited professor at the Graduate School of Agricultural Sciences, Tottori University. He started his career in rice breeding at Hokuriku National Agricultural Experiment Station in 1986 and received his doctoral degree in 1993. From 1999 to 2004, he was dispatched to the International Rice Research Institute (IRRI) from the Ministry of Agriculture, Forestry and Fisheries (MAFF) as a seconded scientist. After returning to JIRCAS, he worked as project leader of the "Blast Research Network for Stable Rice production" and "Rice Innovation for Environmentally Sustainable Production Systems"

ABSTRACT

Blast is one of the most serious diseases of rice plants in temperate regions, and it has been found to occur frequently in the rainfed lowlands and uplands in the tropics. Japan International Research Center for Agricultural Sciences (JIRCAS) has been conducting the research project, titled "Blast Research Network for Stable Rice Production," to solve this problem since 2006. Under the research network, an international differential variety set (DVs: monogenic lines) for 23 blast resistance genes; *Pish*, *Pib*, *Pit*, *Pia*, *Pii*, *Pi3*, *Pi5*(t), *Pik-s*, *Pik-m*, *Pi1*, *Pik-h*, *Pik*, *Pik-p*, *Pi7*(t), *Pi9*(t), *Piz*, *Piz-5*, *Piz-t*, *Pita-2*, *Pita*, *Pi12*(t), *Pi19*(t), and *Pi20*(t), and the methods of evaluation for reaction patterns of DVs against blast isolates and designation of blast races, are commonly used among participating nations (Korea, China, Vietnam, Philippines, Indonesia, Lao PDR, Cambodia, Bangladesh, Kenya, and Japan), international agricultural institutes (IRRI and AfricaRice), and university (Yunnan Agricultural U., China). The genetic variations of blast races and of resistance in rice cultivars have been clarified in each country and at the global level. These genetic variations of blast races and of resistance in rice cultivars differ dramatically among the countries, with Japan showing the lowest diversities and south Asia showing the highest. Additionally, highly virulent blast races were found to be distributed at high frequencies in West Africa and northeast China. Additionally, the differential system consisting of DVs and standard differential blast isolates was also developed in each institute, becoming one of many achievements from pathological studies. The differential system is a basic tool for the characterization of resistance genes in rice cultivars and the pathogenicity of blast isolates. Using the differential system developed in each institute, genetic improvement of leading rice cultivars is being conducted through introduction of partial resistance genes, such as *pi21*, *PB1*, *Pi34*, *Pi35*, and *Pi38*. Multiline varieties with genetic backgrounds of Indica Group rice cultivars, IR 64 and IR 49830-7-1-2-2, are also being developed.These differential systems, leading rice cultivars introduced with partial resistance genes, and multiline varieties, will be the key materials toward development of a durable protection system, which will be implemented in harmony with environmental conditions and contributing to sustainability in rice cultivation.


JIRCAS
Intenationla Collaboration Research networks for Stable Rice Production
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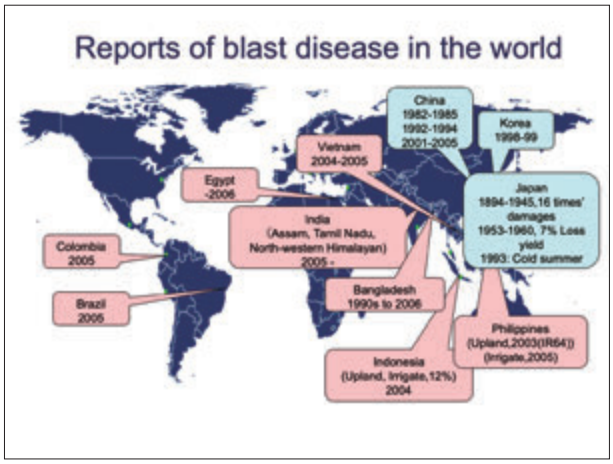
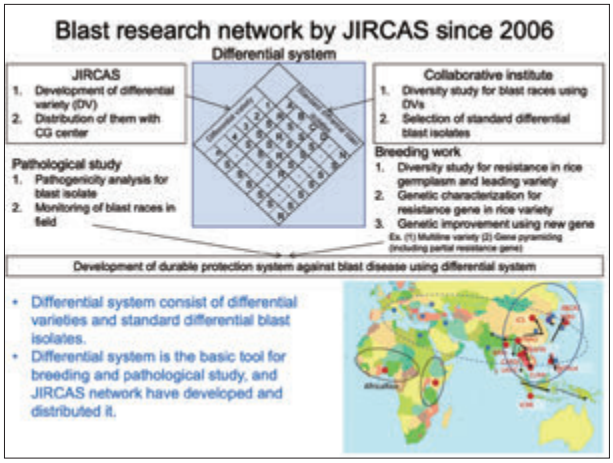
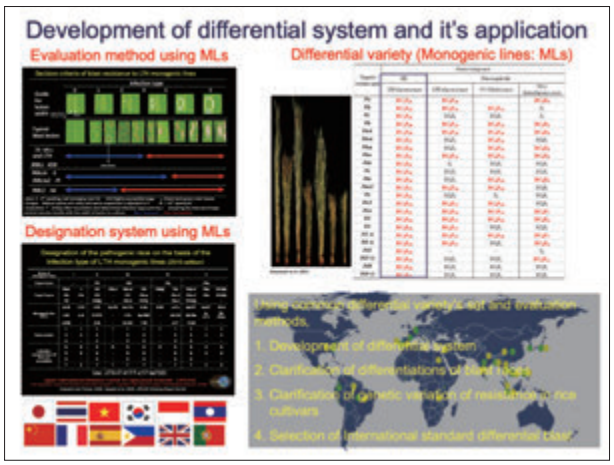
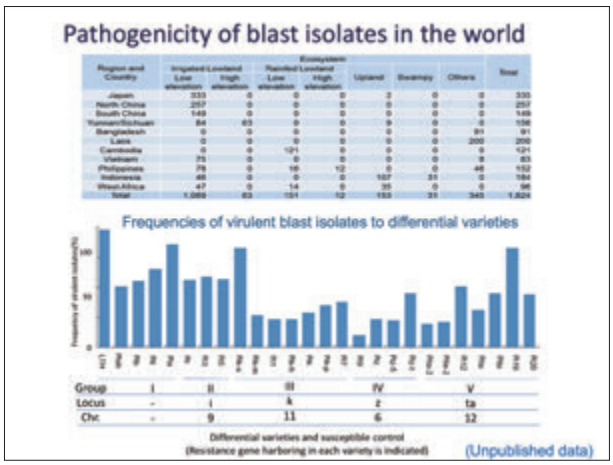
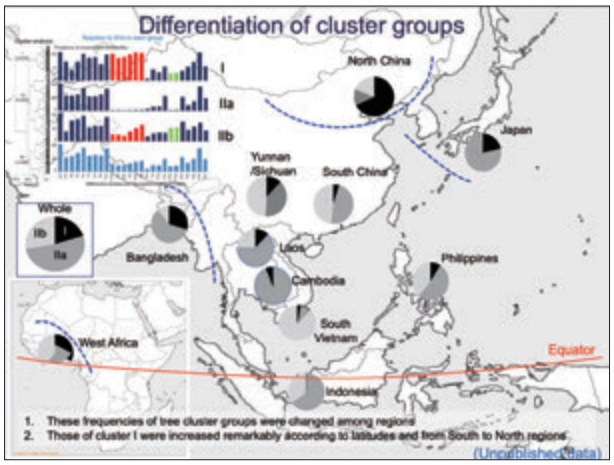

Reports of blast disease in the world
China 1982-1985 1992-1994 2001-2005
Korea 1998-99
Vietnam 2004-2005
Egypt -2006
Japan 1894-1945,16 times' damages 1953-1960, 7% Loss yield 1993: Cold summer
India (Assam, Tamil Nadu, North-western Himalayan) 2005 -
Colombia 2005
Bangladesh 1990s to 2006
Brazil 2005
Philippines (Upland,2003(IR64)) (Irrigate,2005)
Indonesia (Upland, Irrigate,12%) 2004

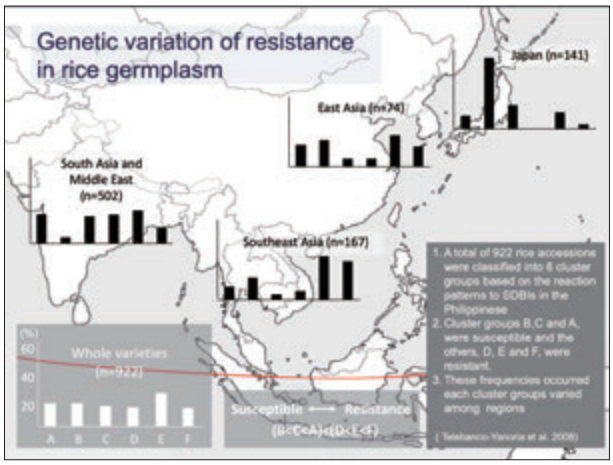

JIRCAS project
Blast Research Network for Stable Rice Production
"Differential System for Blast Resistance for a Stable Rice Production Environment" (29 August 2006)
and Work Plan Meeting for JIRCAS research project -
"Blast Research Network for Stable Rice Production" (30 August 2006)
1st. Phase: 2006-2010, 2nd. Phase: 2011-2015, 3rd: 2016-2020

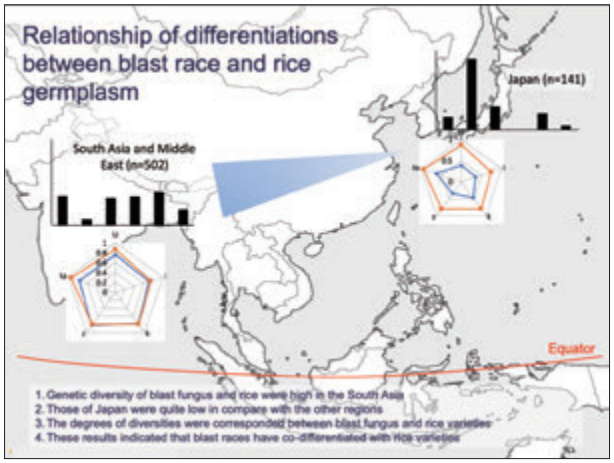

Blast research network by JIRCAS since 2006
Differential system
JIRCAS
1. Development of differential variety (DV)
2. Distribution of them with CG center
Collaborative institute
1. Diversity study for blast races using DVs
2. Selection of standard differential blast isolates
Pathological study
1. Pathogenicity analysis for blast isolate
2. Monitoring of blast races in field
Breeding work
1. Diversity study for resistance in rice germplasm and leading variety
2. Genetic characterization for resistance gene in rice variety
3. Genetic improvement using new gene
Development of durable protection system against blast disease using differential system
• Differential system consist of differential varieties and standard differential blast isolates.
• Differential system is the basic tool for breeding and pathological study, and JIRCAS network have developed and distributed it.

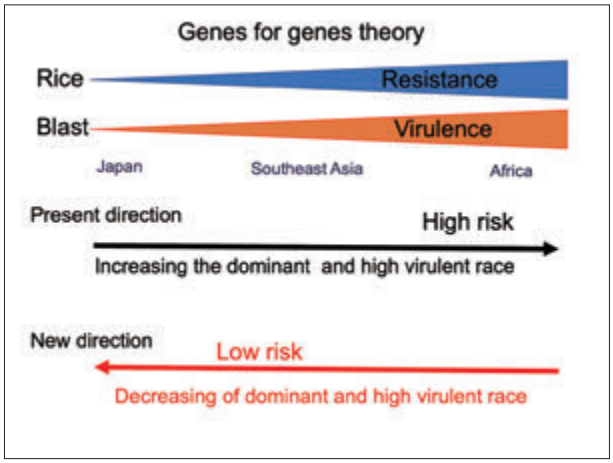

Development of differential system and it's application
Evaluation method using MLs
Differential variety (Monogenic lines: MLs)
Designation system using MLs
1. Development of differential system
2. Clarification of differentiations of blast races
3. Clarification of genetic variation of resistance in rice cultivars
4. Selection of international standard differential cultivars

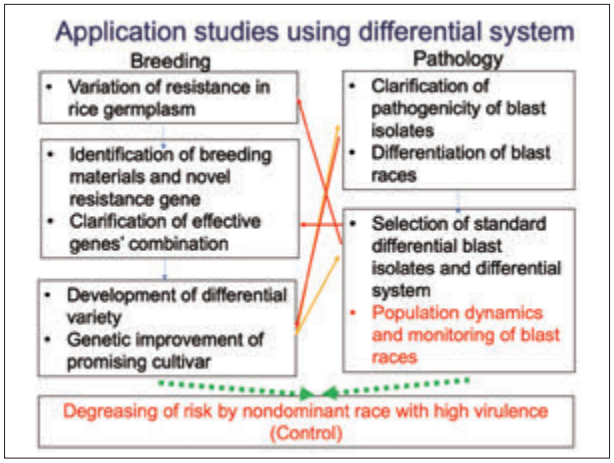

Pathogenicity of blast isolates in the world
Frequencies of virulent blast isolates to differential varieties
Group I II III IV V
Locus - i k z ta
Chr. - 9 11 6 12
(Unpublished data)

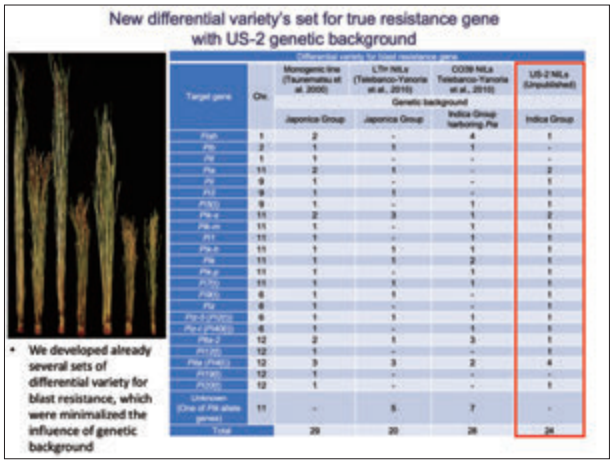

Differentiation of cluster groups
North China
Japan
Yunnan /Sichuan
South China
Whole
Bangladesh
Laos
Cambodia
Philippines
South Vietnam
West Africa
Equator
Indonesia
1. These frequencies of tree cluster groups were changed among regions
2. Those of cluster I were increased remarkably according to latitudes and from South to North regions.
(Unpublished Data)


Genetic variation of resistance in rice germplasm
Japan (n=141)
East Asia (n=74)
South Asia and Middle East (n=502)
Southeast Asia (n=167)
Whole varieties (n=922)
1. A total of 922 rice accessions were classified into 6 cluster groups based on the reaction patterns to SDBIs in the Philippines
2. Cluster groups B,C and A, were susceptible and the others, D, E and F, were resistant
3. These frequencies occurred each cluster groups varied among regions





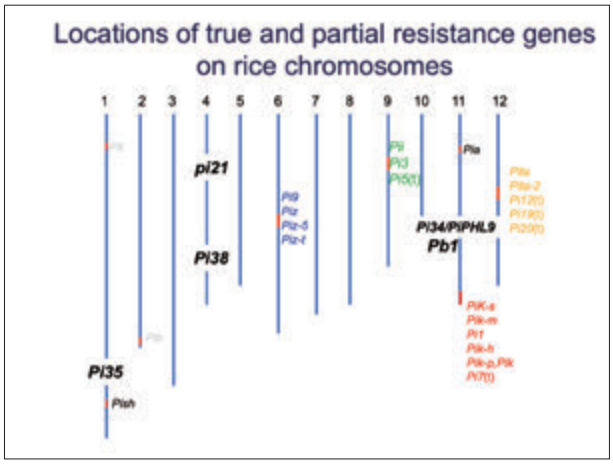


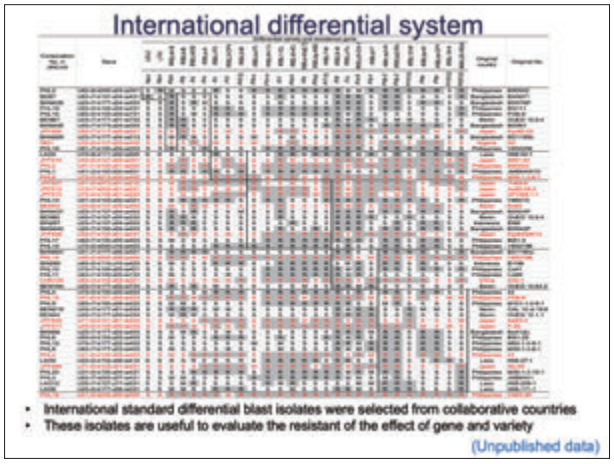


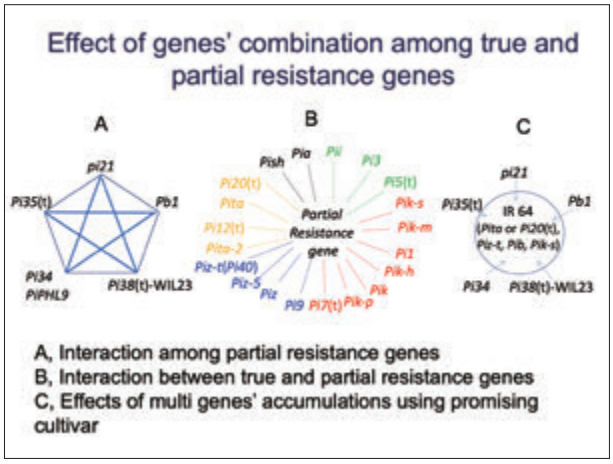
US-2 NILs for partial resistance genes

Target resistance gene	Chr.	Donor	Generation in 2018
PiPHL9(t)	11	Hokkai PL9	BC6F8
pi21	4	Owarihatamochi	BC6F8
Pi35	1	Hokkai188	BC6F9
Pi34	11	Chube 32	BC6F8
		Chugoku 40	BC6F10
Pi38(t)	4	WIL23	BC6F8
Pb1	11	Asano-hikari	BC6F9

Partial gene(s) have been expected that these were resistant against all blast races with intermediate effects.
Near isogenic lines(NILs) for partial resistance genes were developed to confirm the effects.







Genetic improvement of leading variety by introducing of partial resistance gene (C)

Season

1 GB cultivar X NIL*pi21*

2 F1 X BG

3 BC1F1 (MAS selection) X BG

4 BC2F1 (MAS selection: Heterozygote) X BG

5 BC2F2 (MAS selection: Homozygote) — BC3F1 (MAS selection X BG)

Self

6 BC2F3 (Seed amplification) — BC4F1 (MAS selection X BG)

Self

7 BC2F4 (Fixation of plants) — BC5F1 (MAS selection X BG)

Self

8 BC2F5 (Selection) — BC6F1 (MAS selection:)

Self

9-10 BC2F6-7 (Line evaluation) — BC6F2 (MAS selection: Homozygote)

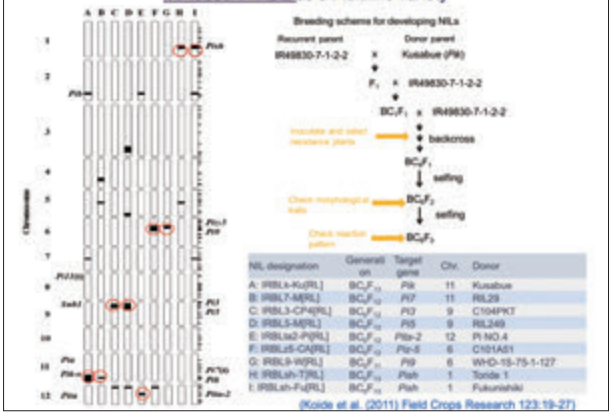
Breeding lines — Evaluation of resistant — Near isogeneic lines

Genetic improvement of rice cultivars using partial resistance genes

Target country and area	Genetic background (Character)	Target country and area	Genetic background (Character)
Asia and Africa	IR 64	Africa and South Asia	Basmati 217 (Aroma)
	YTH183 (High yield)		Basmati 370 (Aroma)
	IR64NIL*DRO1*		Pusa Basmati (Aroma)
	IR64NIL*SPIKE*	Thailand	KDLM105 (Aroma)
	IR64NIL*qRL6.1-Kasalath*	Bangladesh	BRRI dhan 28
	IR64NIL*EMS3*		BRRI dhan 29
	NERICA-L-19 (High yield)		BRRI dhan 34 (Aroma)
Indonesia	Ciherang (High yield)		BRRI dhan 63
	Situ Banerdit		BRRI dhan 64
	Situ Patenggang (Aroma)		BR 11
Philippines	NSIC Rc 152	Vietnam	Thien Un
	NSIC Rc 160 (Eating quality)		BT7
	NSIC Rc 240 (High yield)		BC15
	NSIC Rc 402		OM576
Laos	TDK8 (High yield)	Malaysia	Mashuri
	Xebang Fai (High yield)	Ethiopia	X-Jagna
	Hom Xenbang Fai (Aroma)		

NILs for blast resistance genes with rainfed lowland Indica Group rice

IR 49830-7-1-2-2 as a multiline variety



NIL designation	Generation	Target gene	Chr.	Donor
A: IRBLk-Ku[RL]	BC_4F_{10}	*Pik*	11	Kusabue
B: IRBL7-M[RL]	BC_4F_{10}	*Pi7*	11	RIL29
C: IRBL3-CP4[RL]	BC_4F_{10}	*Pi3*	9	C104PKT
D: IRBL9-M[RL]	BC_4F_{10}	*Pi9*	9	RIL249
E: IRBLta2-Pi[RL]	BC_4F_{10}	*Pita-2*	12	PI NO.4
F: IRBLz5-CA[RL]	BC_4F_{10}	*Piz-5*	6	C101A51
G: IRBL9-W[RL]	BC_4F_{10}	*Pi9*	6	WHD-15-75-1-127
H: IRBLsh-T[RL]	BC_4F_{10}	*Psh*	1	Tonde 1
I: IRBLsh-Fu[RL]	BC_4F_{10}	*Psh*	1	Fukunishiki

(Koide et al. (2011) Field Crops Research 123:19-27)

Key materials and tools for new direction of durable protection system

1. International standard differential blast isolates
2. Partial resistance gene(s)
3. Multiline variety
4. Differential system
5. Collaboration among pathologist, breeder, agronomist and so on
6. International collaboration

Application studies using differential system

Breeding

- Genetic variation of resistance in rice germplasm
- Evaluation of resistance gene
- Novel resistance gene
- Effective genes' combination
- Differential variety
- Genetic improvement of promising cultivar

Pathology

- Pathogenicity of blast isolates
- Differentiation of blast races
- Selection of standard differential blast isolates(Development of differential system)
- Population dynamics and monitoring of blast races

Control of blast races and durable protection system

- No dominant races with high virulence

Thank you for your attentions