Genetic differentiations of blast races and rice (*Oryza sativa* L.) germplasm in Lao P.D.R.

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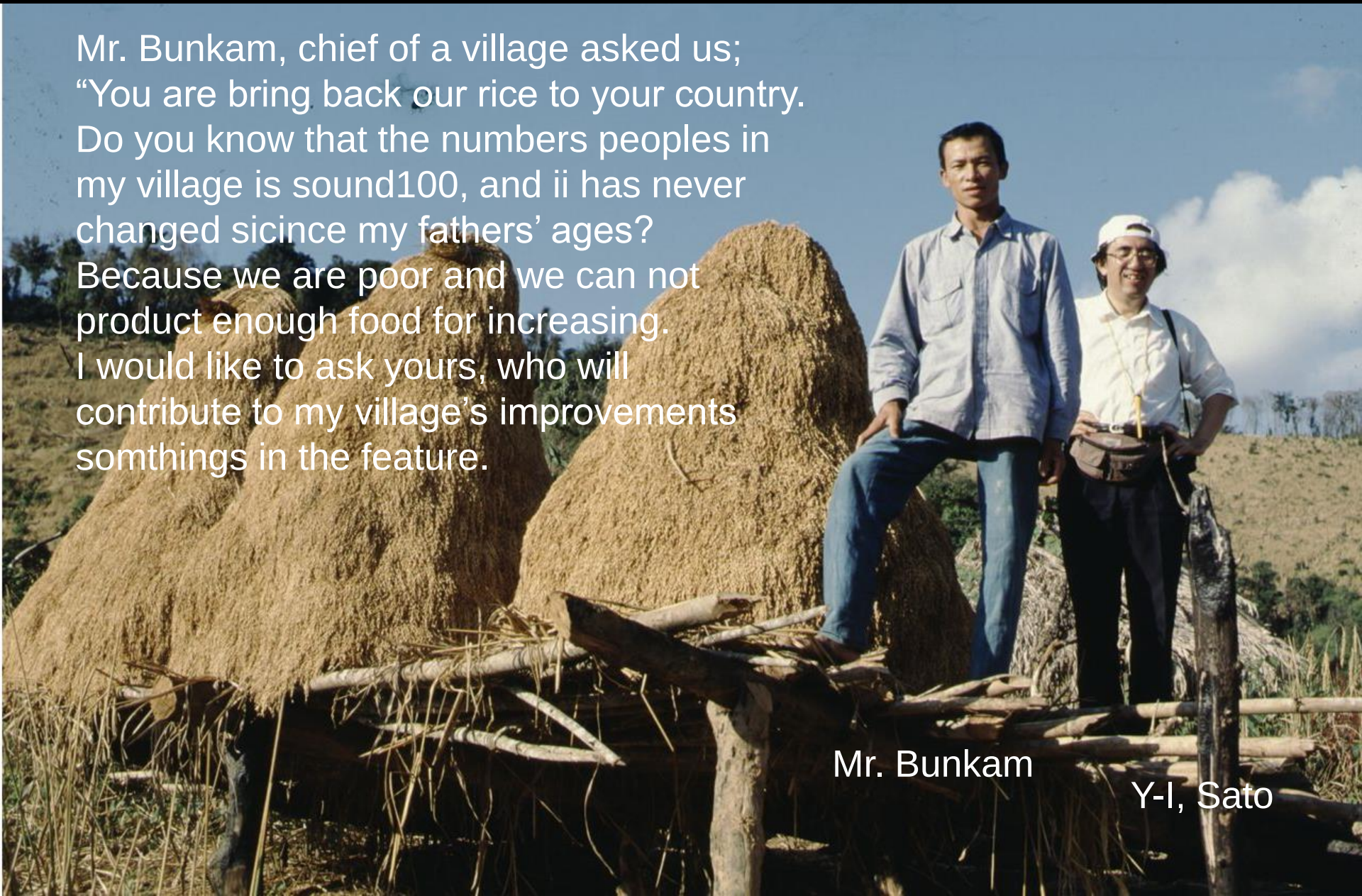
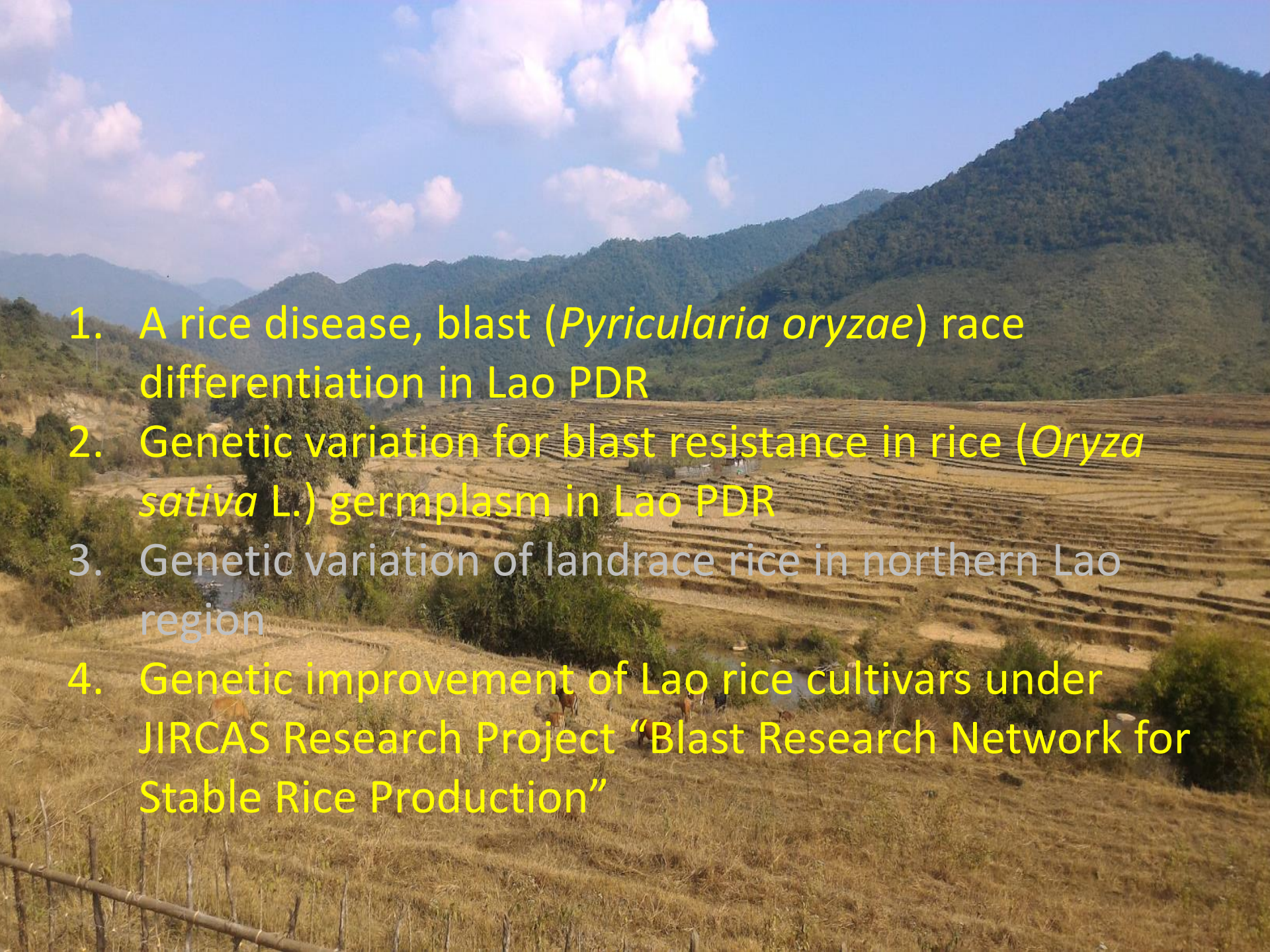
A meeting with young chief at a mountain village in the northern Laos around 25 years ago





1. A rice disease, blast (*Pyricularia oryzae*) race differentiation in Lao PDR
2. Genetic variation for blast resistance in rice (*Oryza sativa* L.) germplasm in Lao PDR
3. Genetic variation of landrace rice in northern Lao region
4. Genetic improvement of Lao rice cultivars under JIRCAS Research Project “Blast Research Network for Stable Rice Production”

Differentiation of blast races in Lao PDR


Leaf blast


Neck blast

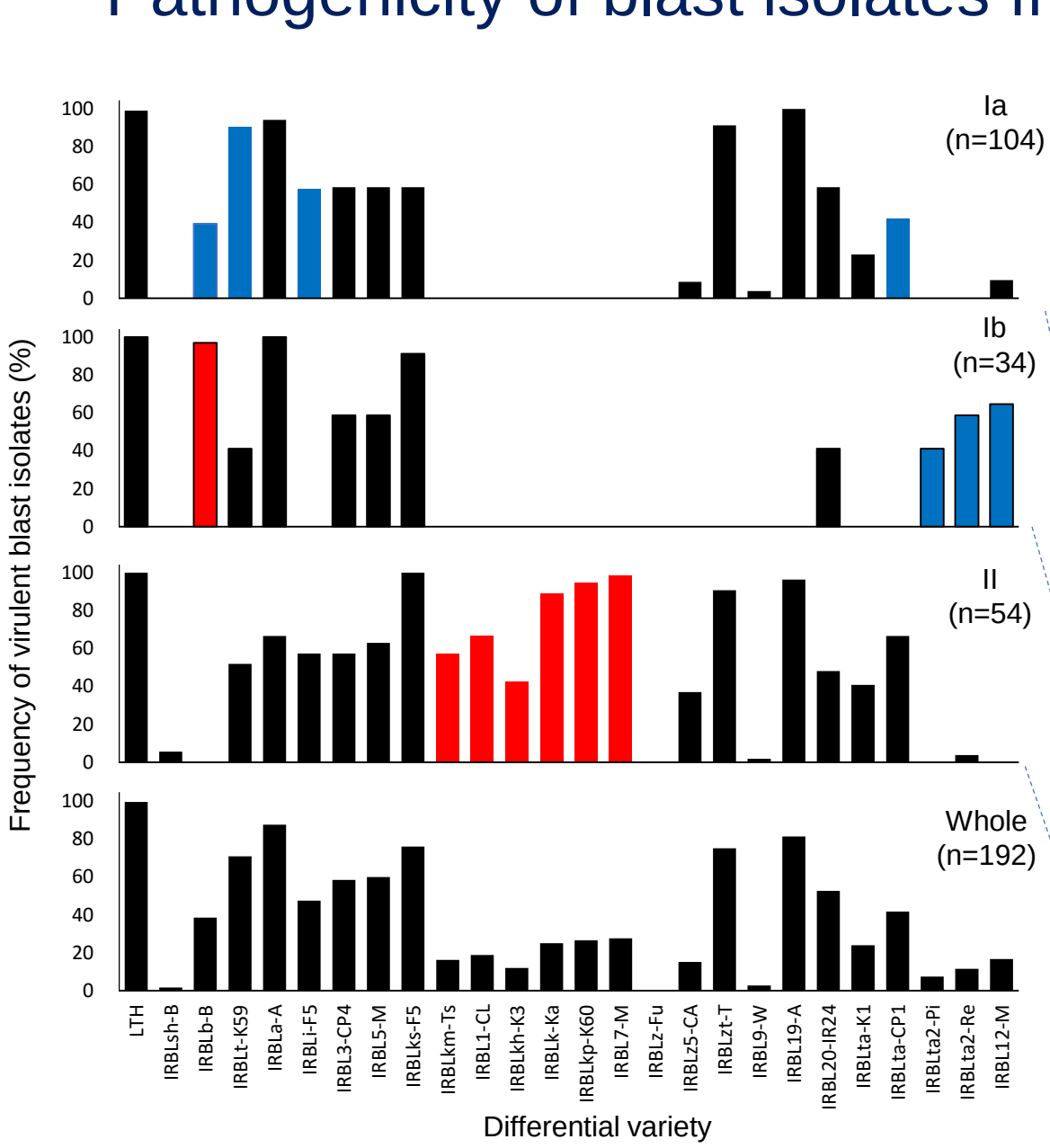
- Blast disease have been one of the latent risks in rice cultivation in Laos.
- Blast infection was reported in the dry-season irrigated environment (Schiller et al.,2001)
- A total of 192 blast isolates were collected fron LAO PDR

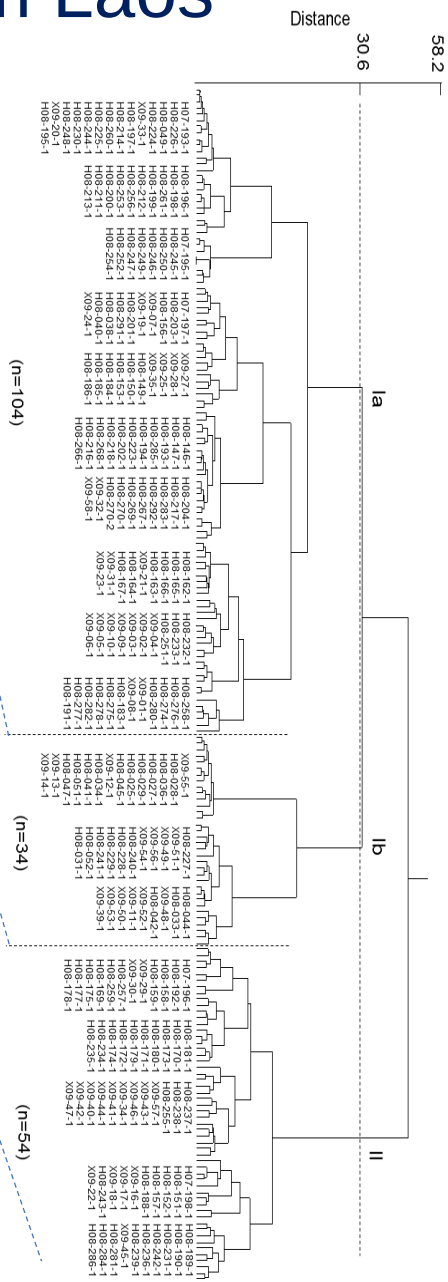
Phet

Phoumi

Sampling of rice plants infected by blast disease

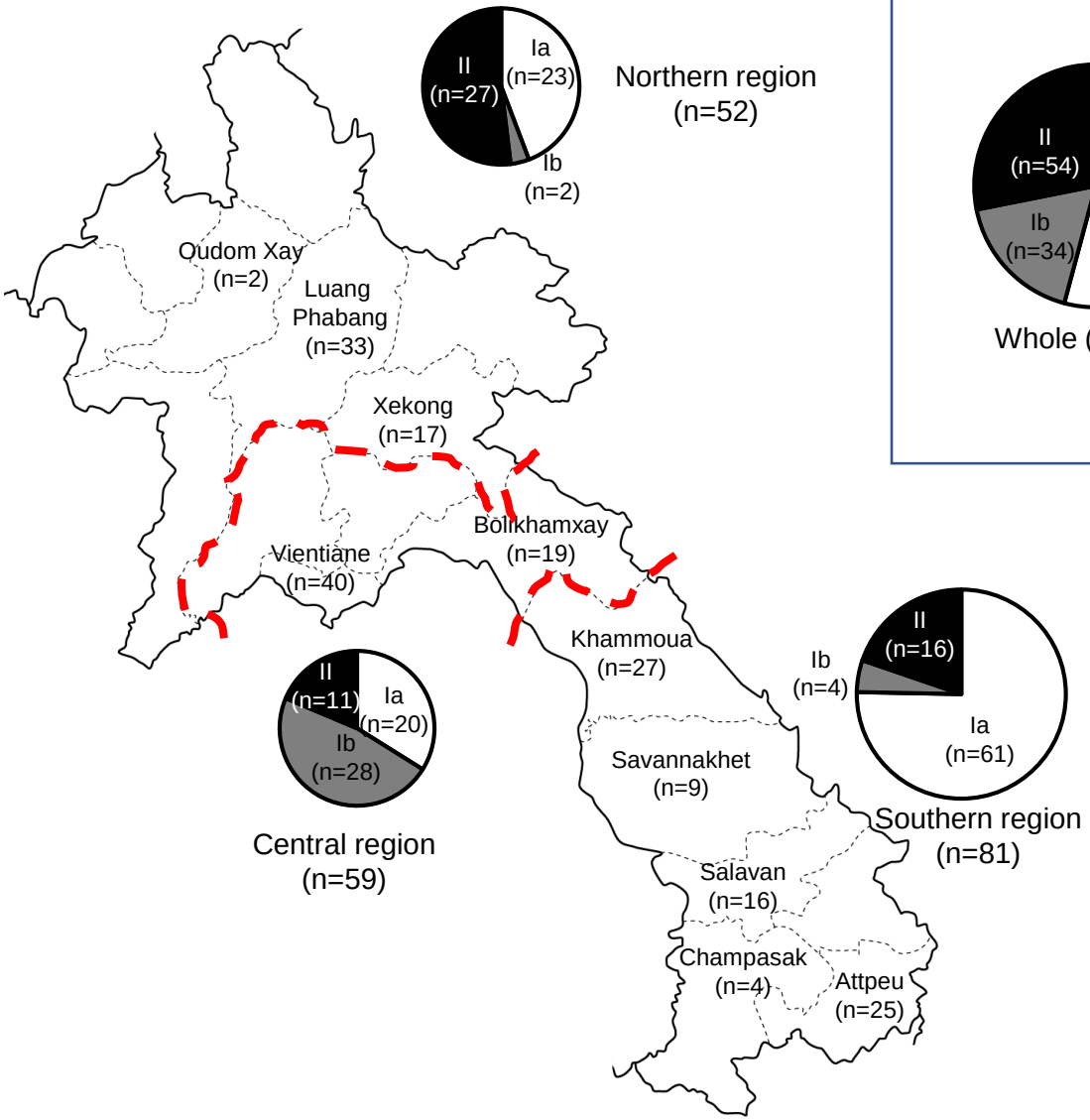
Pathogenicity of blast isolates from Laos

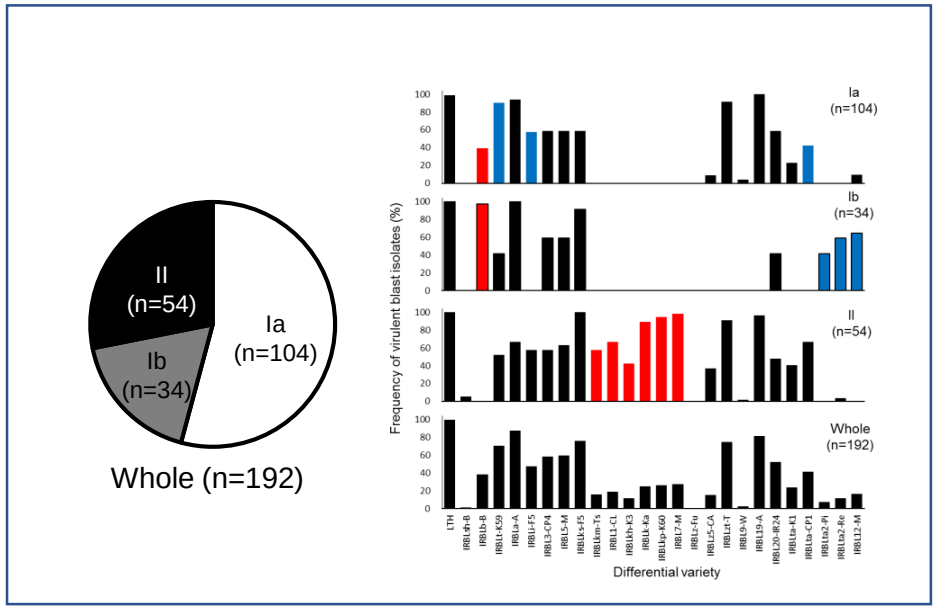




Virulence: Ia, Ib < II

Geographical distributions of cluster groups for blast isolates in three regions of Laos



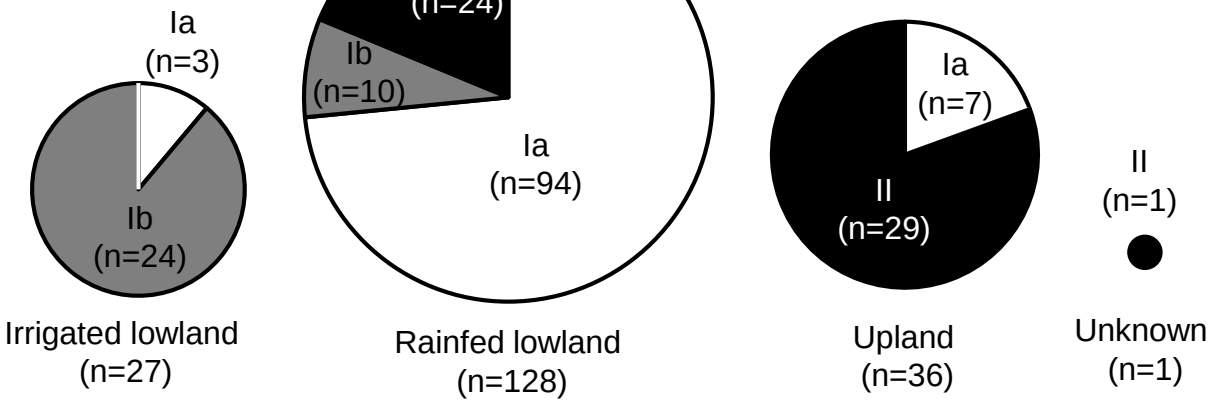


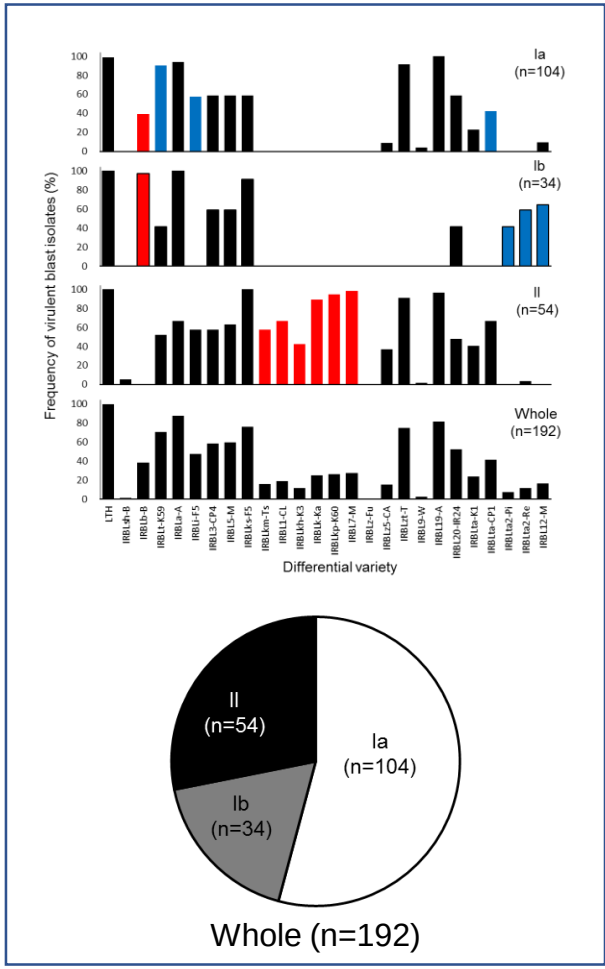
These frequencies of blast isolates in each cluster group were changed among three regions of Laos.

Clusters, Ia, Ib and II showed highest frequencies in Southern, central, and Northern regions, respectively.

High virulence blast isolates were distributed mainly in the northern Laos.

Variation of blast isolates in cluster groups among eco-systems for rice cultivation





The differentiation of blast races were corresponded with eco-systems for rice cultivations in Lao PDR

- Dominant cluster groups of blast isolates were changed among eco-systems for rice cultivation.
- Cluster groups, Ib, Ia, and II were dominant in Irrigated, rainfed, and upland eco-systems, respectively.
- Cluster Ia was included in all eco-systems, and all clusters were in rainfed lowland.
- These results indicated that the cluster Ia might be a basic population of blast isolates in Laos, and the other two clusters were differentiated from it according to the conditions of eco-systems.

Selection of standard differential standard blast isolates and development of differential system in Laos

No	Designation	Region collected	Ecosystems	Rections of standard differentialblast isolates to differential varieties																										
						I				II			III							IV				V						
				US2	LTH	IRBLsh-S	IRBLb-B	IRBLt-K59	IRBLa-A	IRBLi-F5	IRBL3-CP4	IRBL5-M	IRBLks-S	IRBLkm-Ts	IRBL1-CL	IRBLkh-K3	IRBLk-ka	IRBLkp-K60	IRBL7-M	IRBL9-W	IRBLz-Fu	IRBLz5-CA	IRBLzt-T	IRBLta2-Pi	IRBLta2-Re	IRBL12-M	IRBLta-K1	IRBLta-CP1	IRBL19-A	IRBL20-IR24
1	U23-i0-k000-z00-ta500	C	LI	S	S	R	S	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	S	R	R	R	R
2	U41-i7-k106-z04-ta021	C	U	S	S	R	R	S	R	S	S	S	S	R	R	R	R	S	S	R	R	R	S	R	R	R	R	S	S	R
3	U03-i0-k137-z06-ta031	N	U	S	S	R	R	R	S	R	R	R	S	S	S	R	S	S	S	R	R	S	S	R	R	R	S	S	S	R
4	U01-i6-k075-z00-ta000	C	U	S	S	R	R	R	R	R	S	S	R	S	S	S	S	R	S	R	R	R	R	R	R	R	R	R	R	R
5	U01-i1-k104-z04-ta000	C	U	S	S	R	R	R	R	S	R	R	S	R	R	R	R	R	S	R	R	R	S	R	R	R	R	R	R	R
6	U03-i3-k167-z02-ta021	C	L	S	S	R	R	R	S	S	S	R	S	R	S	S	S	S	S	R	R	S	R	R	R	R	R	S	S	R
4	U01-i6-k075-z00-ta000	C	U	S	S	R	R	R	R	R	S	S	R	S	S	S	S	R	S	R	R	R	R	R	R	R	R	R	R	R
2	U41-i7-k106-z04-ta021	C	U	S	S	R	R	S	R	S	S	S	S	R	R	R	R	S	S	R	R	R	S	R	R	R	R	S	S	R
3	U03-i0-k137-z06-ta031	N	U	S	S	R	R	R	S	R	R	R	S	S	S	R	S	S	S	R	R	S	S	R	R	R	S	S	S	R
7	U23-i0-k100-z00-ta002	C	L	S	S	R	S	R	S	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S
8	U41-i7-k177-z06-ta031	N	U	S	S	R	R	S	R	S	S	S	S	S	S	S	S	S	S	R	R	S	S	R	R	R	S	S	S	R
9	U43-i7-k000-z16-ta031	C	L	S	S	R	R	S	S	S	S	S	R	R	R	R	R	R	R	S	R	S	S	R	R	R	S	S	S	R
10	U63-i7-k100-z04-ta103	S	L	S	S	R	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R	R	S	S	R	R	R	R	S	S
11	U63-i6-k100-z00-ta700	C	L	R	S	R	S	S	S	R	S	S	S	R	R	R	R	R	R	R	R	R	R	S	S	S	R	R	R	R
12	U23-i7-k100-z04-ta423	C	U	S	S	R	S	R	S	S	S	S	S	R	R	R	R	R	R	R	R	R	S	R	R	S	R	S	S	S
1	U23-i0-k000-z00-ta500	C	LI	S	S	R	S	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	S	R	R	R	R
13	U43-i0-k177-z06-ta023	C	L	S	S	R	R	S	S	R	R	R	S	S	S	S	S	S	S	R	R	S	S	R	R	R	R	S	S	S
11	U63-i6-k100-z00-ta700	C	L	R	S	R	S	S	S	R	S	S	S	R	R	R	R	R	R	R	R	R	R	S	S	S	R	R	R	R
8	U41-i7-k177-z06-ta031	N	U	S	S	R	R	S	R	S	S	S	S	S	S	S	S	S	S	R	R	S	S	R	R	R	S	S	S	R
14	U23-i0-k100-z00-ta402	C	L	S	S	R	S	R	S	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	S
15	U63-i7-k100-z06-ta021	C	L	S	S	R	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R	S	S	R	R	R	R	S	S	R

A total of 15 standard differential blast isolates were selected for identification of 23 resistance genes. This is the first differential system for blast races and rice resistance genes in Laos, and will be useful for development of pathology and breeding studies.

However, there are some limitations; non-virulent blast isolates for *Pish* and *Piz*, differentiation among three genes; *Pik-m, Pi1*, and *Pik*.

Conclusion 1

The differentiation of blast races were clarified in Laos

- Dominant blast races were changed according to the eco-systems for rice cultivations
- The high virulent blast isolates were mainly found in the upland eco-system in northen Laos

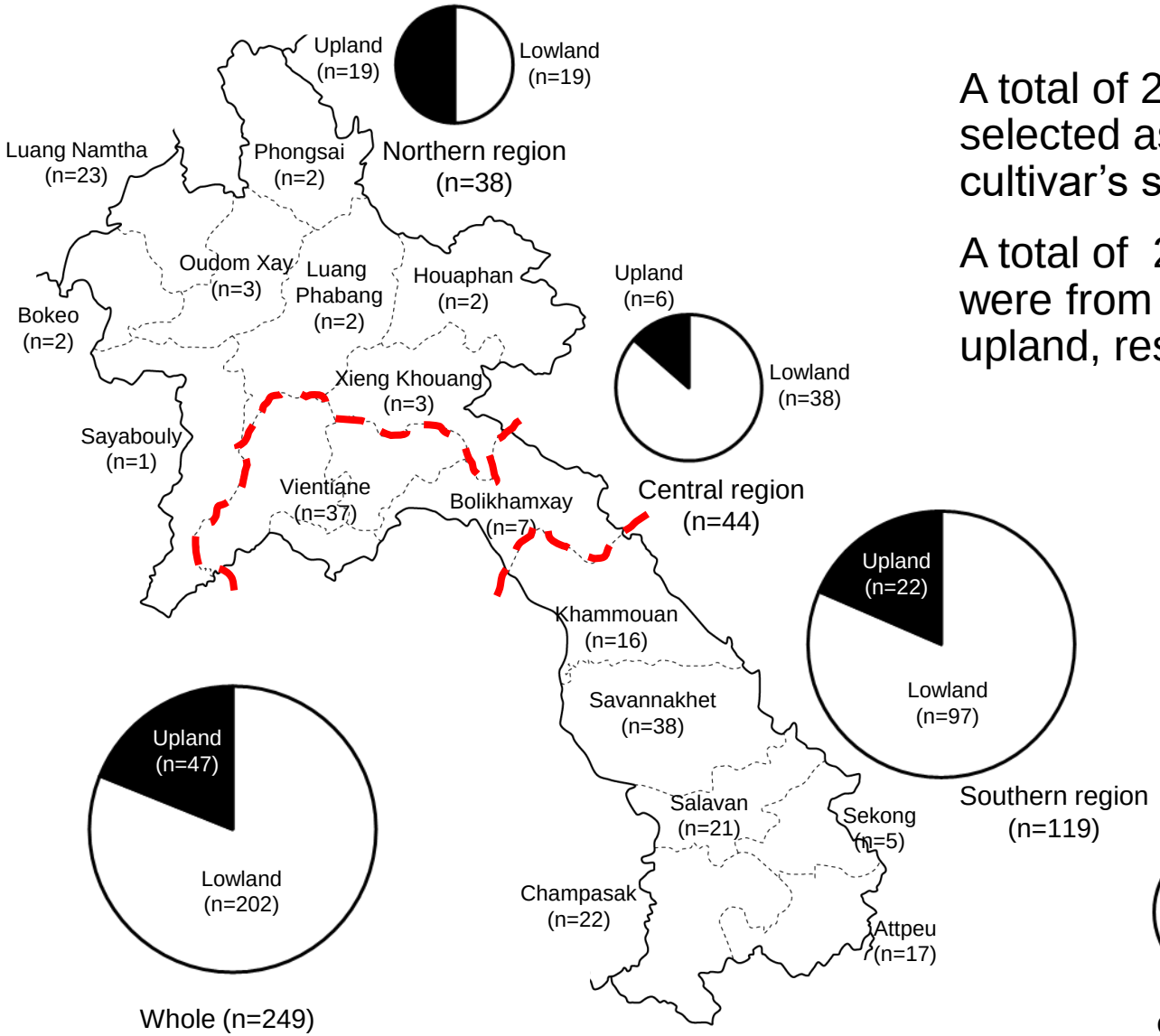
Selection of standard differential blast isolates (SDBIs)

- NAFRI and JIRCAS selected the SDBIs in Laos, and these will be used for the pathological and breeding studies as a differential system.

Genetic variations of Lao rice germplasm

- Polymorphism data of DNA markers
- Blast resistance
- Heading date

Rice germplasm in each eco-system for rice cultivations from three region in Lao P.D.R.



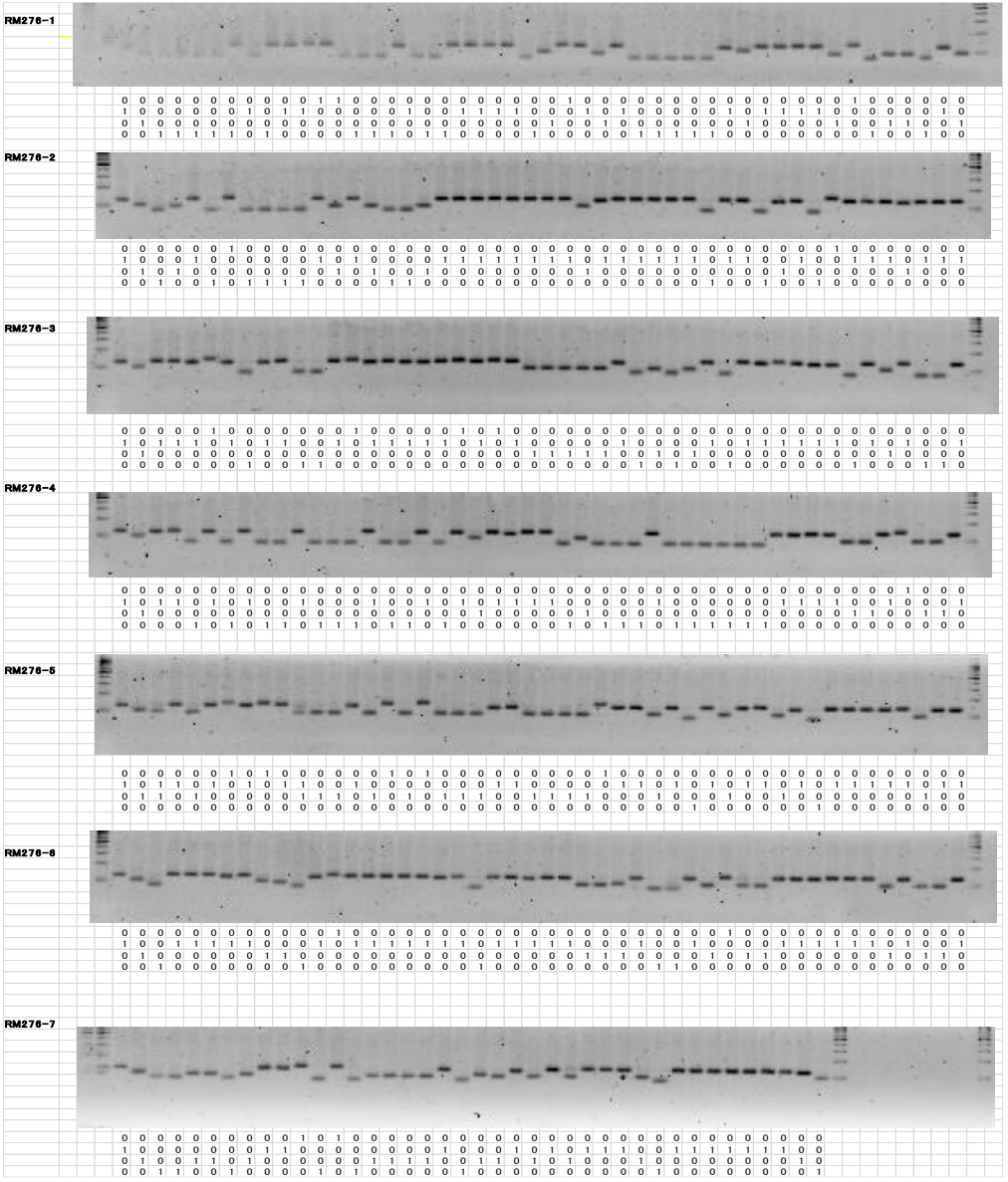
A total of 249 rice accessions were selected as the representative cultivar's set in Lao PDR.

A total of 202 and 47 accessions were from rainfed lowland and upland, respectively.

Upland accessions were increased in the northern region.

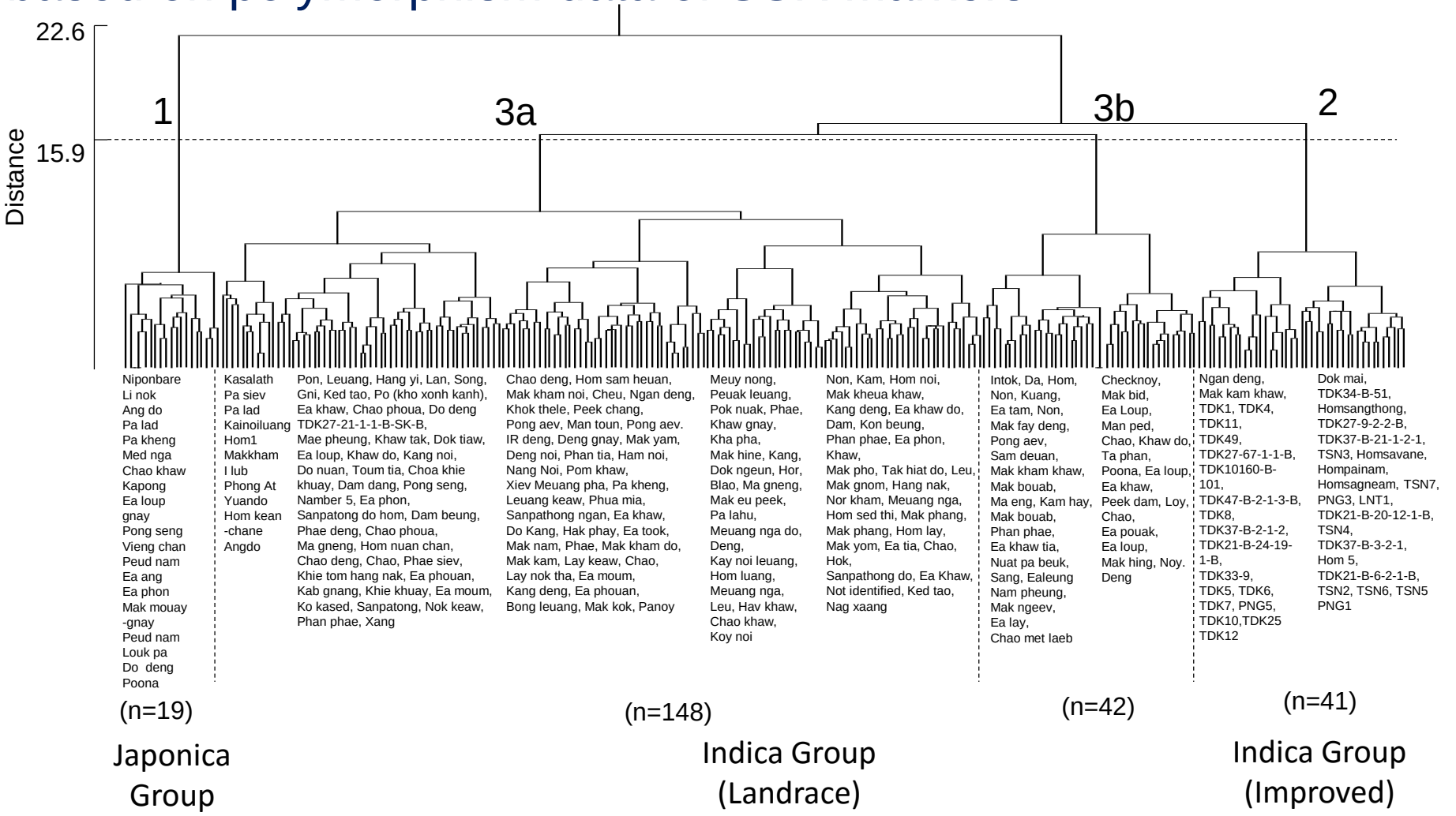
Many improved rice cultivars were included in others

Polymorphism analysis of rice accessions using SSR markers



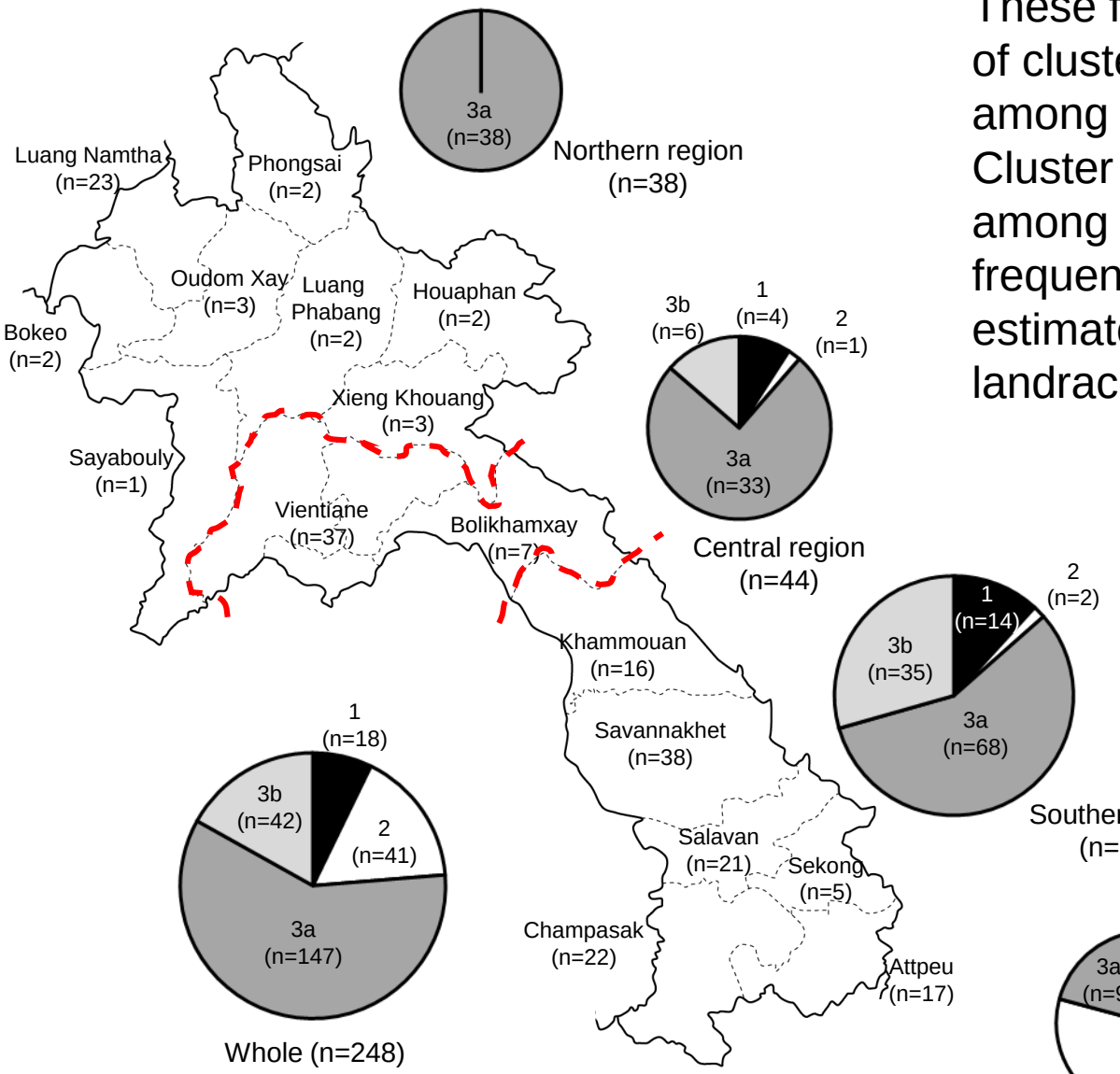
- Polymorphisms‘ data of around 50 SSR markers which were distributed in whole rice genome chromosomes were collected.
- Based on the polymorphism data, rice accessions were characterized.

Classification of rice accessions from Laos by cluster analysis based on polymorphism data of SSR markers



Rice accessions were classified into four cluster groups; 1, 2, 3a, and 3b. Nipponbare and Kasalath were categorized into cluster 1 and 3a, respectively, and cluster 1 and three clusters; 2, 3a, and 3b, were corresponded with Japonica and Indica Groups, respectively. Many improved Indica Group cultivars were included in cluster II.

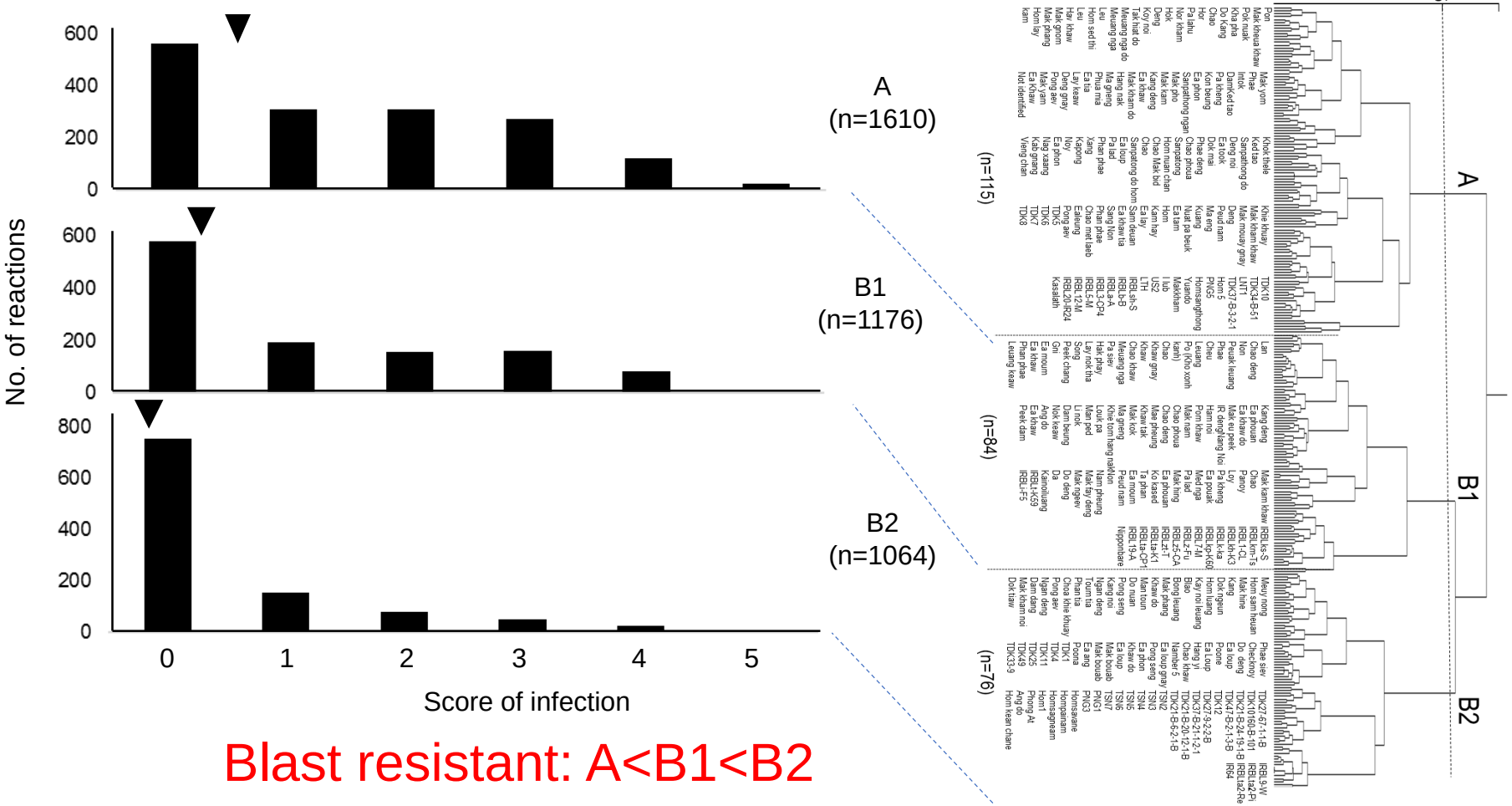
Geographical distributions of rice accessions in each cluster group by polymorphism data of SSR markers



These frequencies of rice accessions of cluster groups were changed among three regions in Laos. Cluster 3a were found commonly among three regions with high frequencies, and this group was estimated as a basic population of landrace rice in Laos.

Cluster 3b was estimated to differentiate from 3b. These accessions from upland were limited in this study, and it will need to add the accessions from upland.

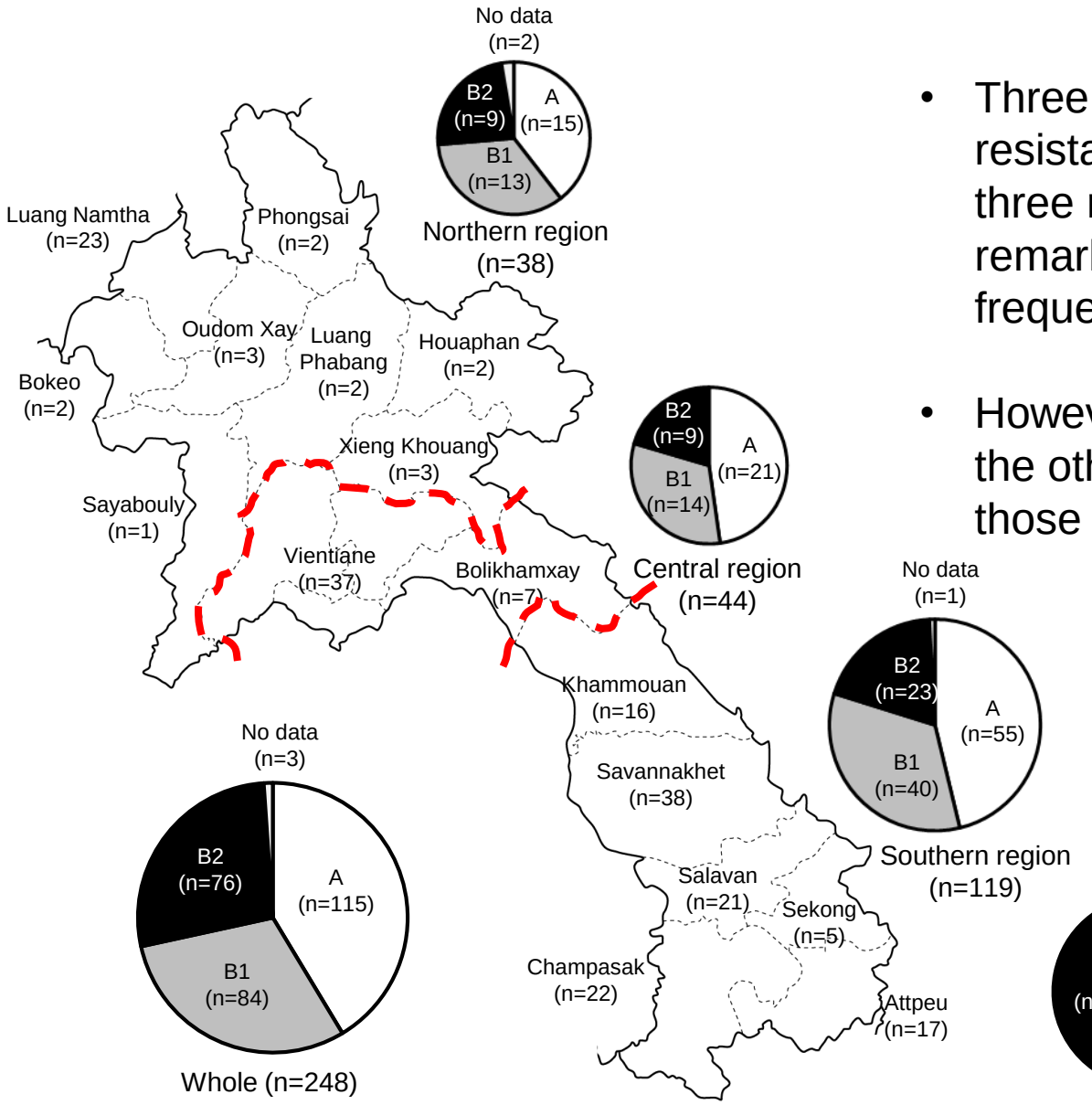
Evaluation of rice accessions from Laos for blast resistance using SDBIs



Blast resistant: A<B1<B2

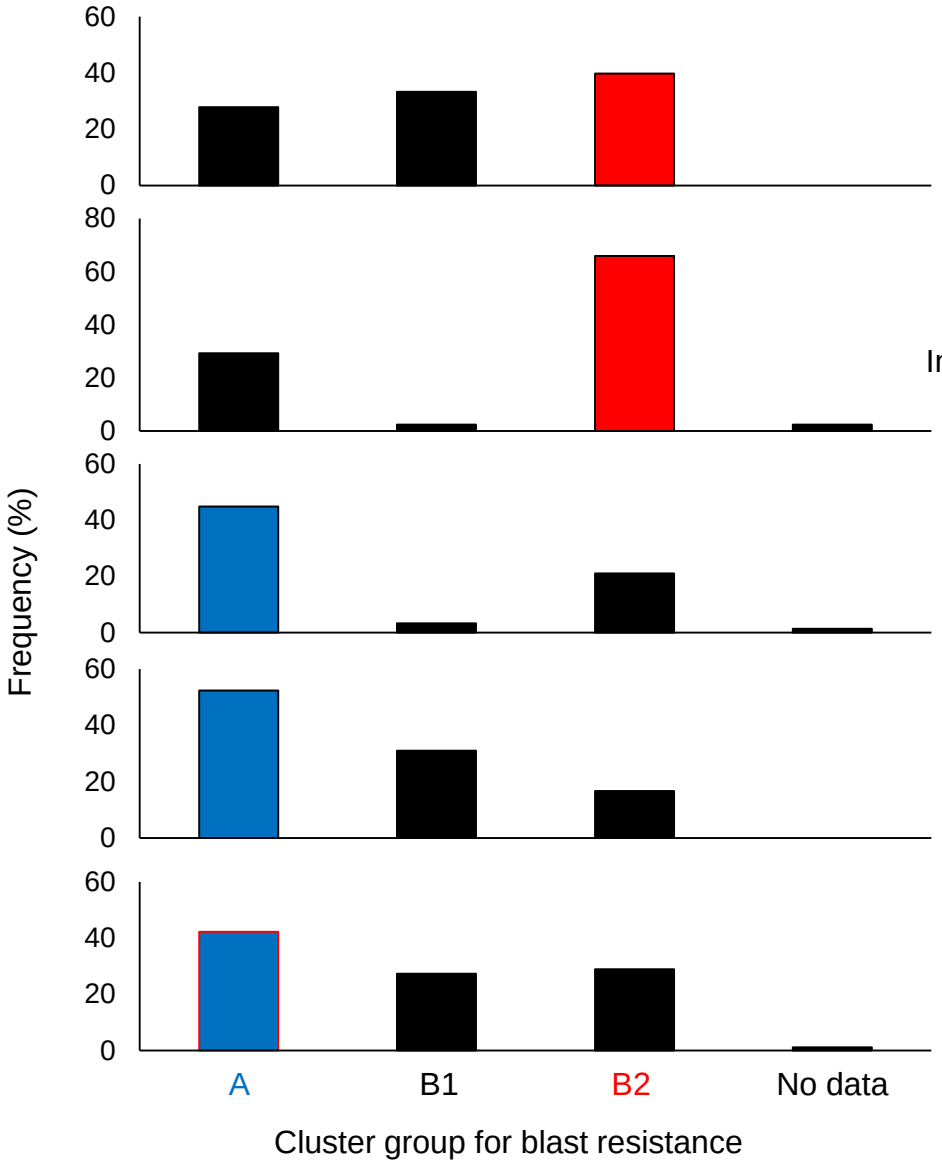
- Cluster group B2 was categorized as the strong resistance, and many improved cultivars were included.
- Several improved cultivars, such as TDK 5, 6, 7, 8, 9, and 10, were classified into susceptible cluster group A

Geographical distributions of rice accessions in each cluster group classified based on reactions to SDBIs



- Three cluster groups for blast resistance were distributed in three regions, and there were not remarkable differences in the frequencies among them.
- However, the frequency of B2 in the other group was higher than those of three cluster groups.
- Ter were many improved rice cultivars were included in the others, and these were categorized into cluster group B2.

Relationships between cluster groups for DNA markers' polymorphism and for blast resistance



- Cluster groups I (Japonica Group) and 2(Improved Indica Group) increased the high resistance accessions.
- In the contrast, cluster group 3b (landrace of Indica Group) increased the susceptible accessions.
- These results indicated that the landrace in Indica Group were susceptible basically, and Japonica Group and improved Indica Group included many resistant accessions.

Blast resistant: A<B1<B2

Conclusion 2

- A wide variation for blast resistance was clarified in the rice germplasm from Lao PDR.
- Many types of resistant rice accession were distributed in all regions of Laos.
- The variation of resistances were different between two cluster groups, I (Japonica Group) and 2(Improved Indica Group) and the other two cluster groups,3a and 3b (Landrace of Indica Group).
- Japonica and improved Indica Groups were included high resistance and landraces of Indica Group were susceptible, basically.
- The relationships between differentiations of blast races and rice cultivars will need to clarify.

Genetic improvement using partial resistance genes under JIRCAS Research Project, "Blast Research Network for Stable Rice Production"

Target country and area	Genetic background (Character)	Target country and area	Genetic background (Character)
Asia and Africa	IR 64 (High yield, eating quality)	Africa and South Asia	Basmati 217 (Aroma)
	YTH183 (High yield)		Basmati 370 (Aroma)
	IR64NIL*DRO1*(Drought)		Pusa Basmati (Aroma)
	IR64NIL*SPIKE* (Stable and high yield)	Thailand	KDLM105 (Aroma)
	IR64NIL*qRL6.1-Kasa* (N uptake)	Bangladesh	BRRI dhan 28
	IR64NIL*EMS3* (Early morning flowering)		BRRI dhan 29
	NERICA-L-19 (High yield)		BRRI dhan 34 (Aroma)
Indinesia	Ciherang (High yield)		BRRI dhan 63
	Situ Banerdit		BRRI dhan 64
	Situ Patenggang (Aroma, Upland)		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 (Stable and high yield)
	Xebang Fai (High yield)		
	Hom Xenbang Fai (Aroma)		

Genetic improvement using partial resistance genes and backcross breeding with MAS method

Season

1 TDK 8 X NIL*pi21*

2 F1 X TDK 8

3 BC1F1 (MAS selection) X TDK 8

4 BC2F1 (MAS selection: Heterozygote) X BG

5 BC2F2 (MAS selection: Homozygote)

Self

6 BC2F3 (Seed amplification)

Self

7 BC2F4 (Fixation of plants)

Self

8 BC2F5 (Selection)

Self

9-10 BC2F6-7 (Line evaluation)

Breeding lines

- Genetic improvement of TDK 8 have been conducted using partaial resistance genes, *pi21* and *PB1*.

Khao Kai noi

“Khao kai noi” is a variety group for Japonica Group glutinous rice. This varieties have been cultivated at lowlands in Houaphan and Xangkhong provinces, in northen Lao PDR.

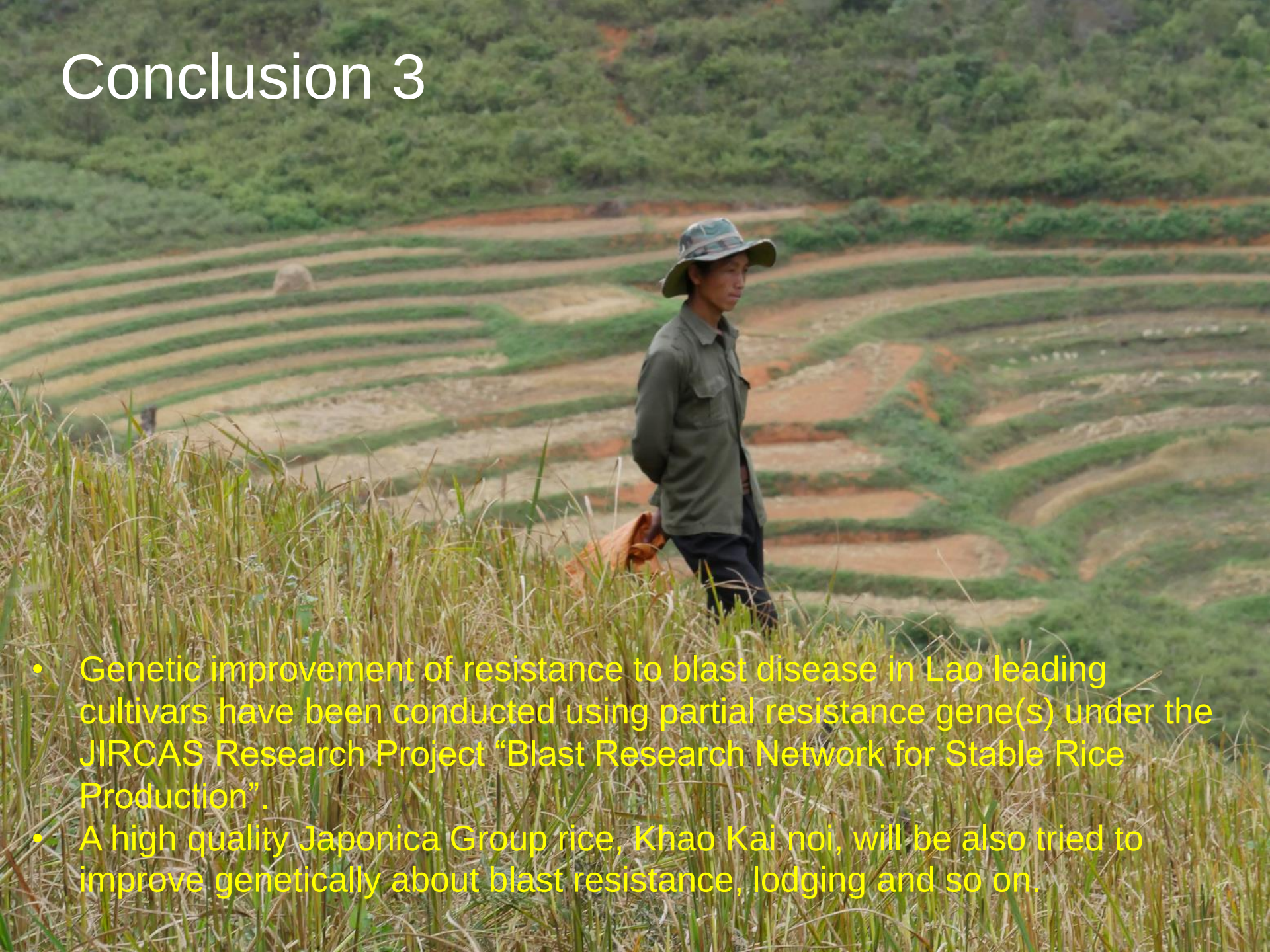
Analysis for genetic variation

- Yield components
- Morphological traits
- Component of amylopectin
- Heading date
- Blast resistance

Genetic improvement

- Lodging
- Modification of plant type
- Heading date
- Blast resistance

Conclusion 3



- Genetic improvement of resistance to blast disease in Lao leading cultivars have been conducted using partial resistance gene(s) under the JIRCAS Research Project “Blast Research Network for Stable Rice Production”.
- A high quality Japonica Group rice, Khao Kai noi, will be also tried to improve genetically about blast resistance, lodging and so on.

We would like to contribute to rice production and food security continuously, based on the germplasm study and genetic improvement of rice cultivars in Lao PDR.

1. A Trans-Disciplinary Study on the Regional Eco-History in Tropical Monsoon Asia: 1945–2005" (2003–2008)
2. Agriculture and Environment Interactions in Eurasia Past, Present and Future (Research Institute of Humanity and Nature, 2006–2010).
3. Analyses were conducted under 3 research projects: Collection and Characteristics Analysis of Plant Genetic Resources (PGRAsia, GRC, NARO, Japan, 2014–2017, 2018-2021)
4. Rice innovation for environmentally sustainable production systems" (2011–2015)
5. Development of technologies for the control of migratory plant pests and transboundary diseases (JIRCAS, 2016-2020).