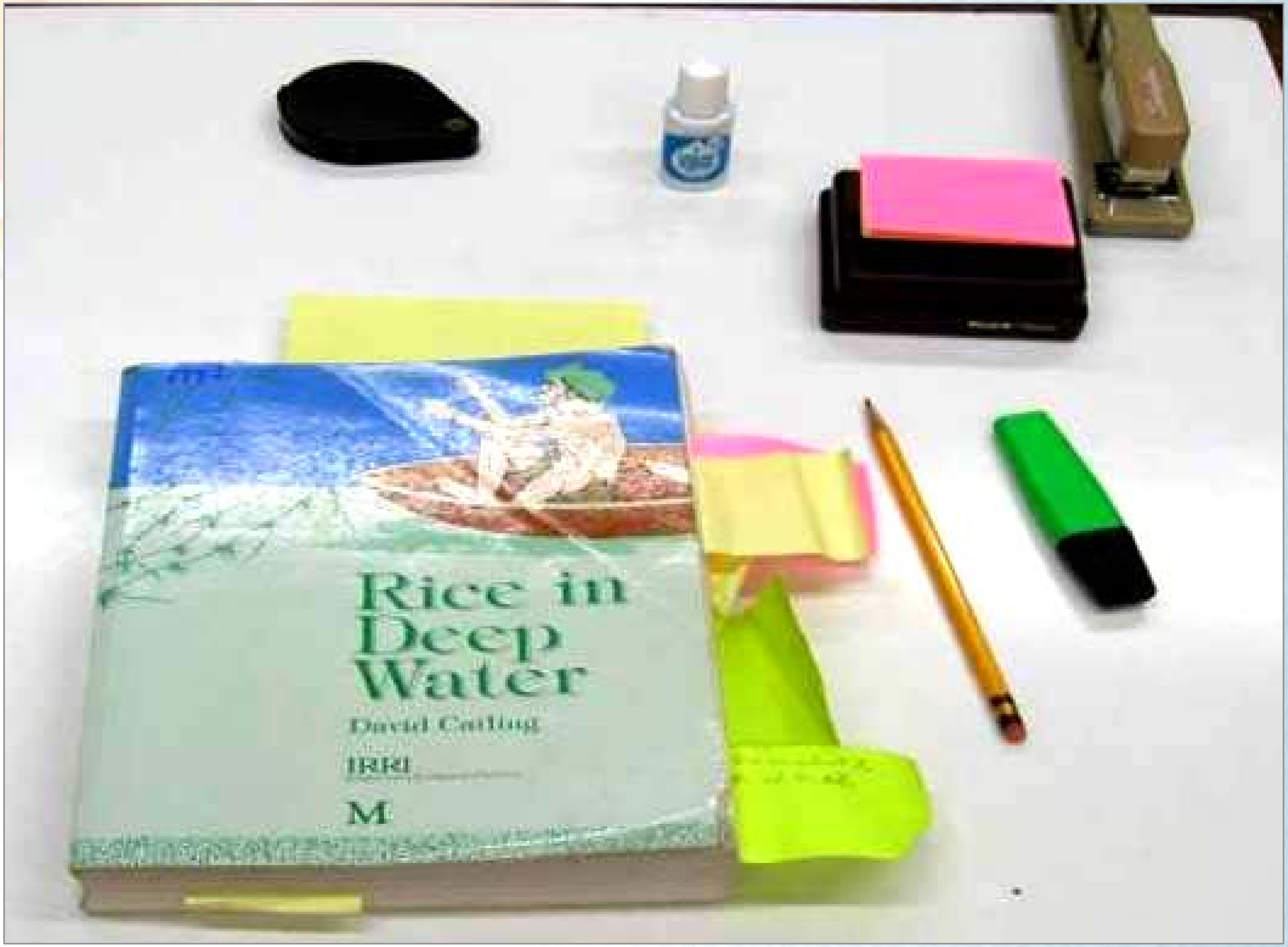
Deep Water Rice Breeding

For breeders course on 21 Aug., 2002

Seiji Yanagihara

IRRI



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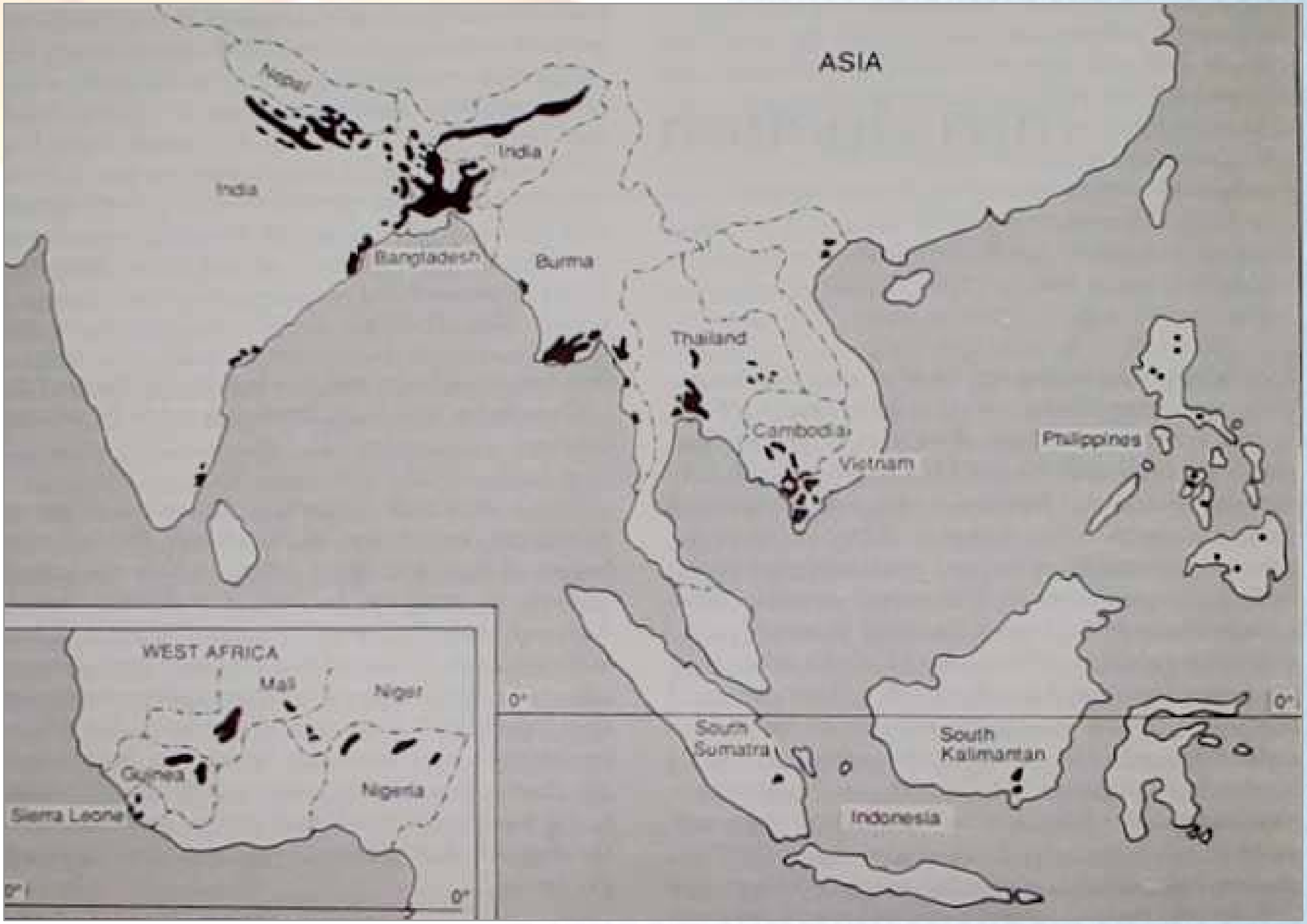

Cited from Catling 1992

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Uniqueness of DWR Compared to Other Types

Plant Character	Irrigated	Rainfed	Tidal Wetland	DWR
Plant type	Dwarf, erect, stiff strawed	Variable	Medium to tall, robust, stiff strawed	Medium to tall, elongating
Plant length	80-120cm	120-140cm	150-180cm	150-200cm
Sustained water depth	5-15cm	10-50cm	20-70cm	50-100cm
Elongation	No	No	No	Yes
Flowering	Insensitive	Sensitive	Sensitive	Sensitive
Growth duration	100-120	110-130	120-150	150-180
Drought tolerance	Poor	Good	Good	Very good
Submergence	Poor	Good	Good	Good
Modern cultivars	Many	Few	Few	Few

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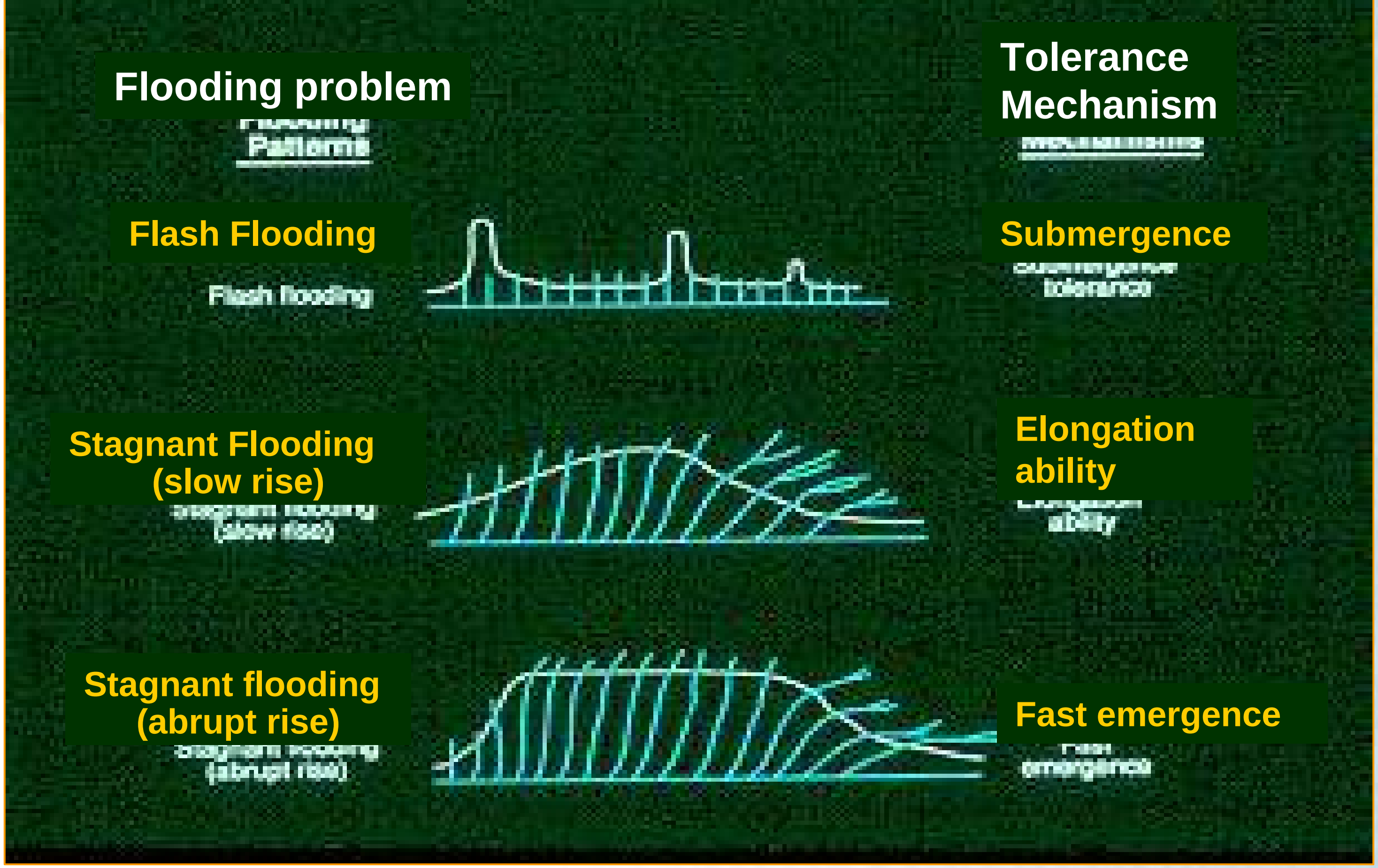
Appropriate Varietal Tolerance Mechanisms for Various Flooding Patterns



Necessary Information for Breeding

Varieties as donor

Genetic information of target traits

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Genetics----scientist's Efforts-------

Submergence

Suprihatno, B.; Coffman, W. R. 1981.
Tolrerance is dominant
At least three dominant genes, two had duplicate gene action, the third is complementary to either of the other two.Broad sence heritability was estimated low.

Mohanty, H. K.; Khush, G. S 1985.
High narrow sence heritability at 0.79 with high general combining ability

Haque, Q. A.;Hillerislambers, D 1989.
F1 showed higher mean survival rate it means dominant.

Tran Duc Thach; 1994.
The gen responsible for submergence tolerance was allelic to one of the two comple-mentary genes controlling elongation.
Elongation was partially dominant over submergence tolerance.
FR13A, Kurkaruppan and Thavalu possess the same dominant gene for submergence, while Goda Heenati has a recessive gene.

Mackill, D. J. 1996.
Sub-1 was detected on chr.9 by using IR40931-26, which has a donor as FR13A. IR40931/PI543851 showed single QTL at about 70% phenotypic variation.

Nandi, S, Subudhi, 1997
5 QTLs were found on chms. 6,7,9,11,12. One on chm9 was Sub-1. Another on chm. 11 was vicnity of Adh-1,Adh-2. Each of 4 out of 5 except Sub-1 explained more than 19% of phenotypic variation.

Important thing for breeder is how to use it!

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Genetics----scientist's Efforts-------

Elongation

Supapoj, N.; 1977.
Elongation si incomplete dominance or ressesive

Hamamura, K., 1979.
Partially dominant with addtive effect of polygene

Nasiruddin, M.;, 1982.
More than two genes for internode elongation or 3-4 dominant genes

Thakur, R, 1988.
Two complementary genes for elongation at additive each other.

Suge, H., 1988.
F1 showed intermidiate elongation ability. F2 showed 9:7 and if GA3 applied, it turned into 3:1

Tripathi, R. S.. 1985.
Early nodal defferentiation is controlling by single dominant gene.

Tran Duc Thach, 1994.
The gene responsible for submergence tolerance was allelic to one of the two complementary genes controlling elongation.
Elongation was partially dominant over submergence tolerance.

Sripongpangkul, K. et al. 2000.
QTLs for plant height increment by flooding were detected on chrm. 1,2,and4.
They were also responsible for internodal length incerement.
One on chrm6 was vicnity of sd-1.

Important thing for breeder is how to use it!

Breeding Strategy

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Target Traits 1

I. Common traits need in both elongating and submergence tolerant lines:

Yield

*	Erect leaves:	efficient utilization of light for better carbon assimilation
*	Wide and thick leaves:	efficient utilization of light for better carbon assimilation
*	Length and weight of panicles:	better yield but with a balance of culm strength
*	High fertility:	for better yield and less risks in unfavorable conditions
*	Threshability:	too much shattering must be avoided
*	Response to inputs:	generally advantageous but may not be practical for deep-water areas. Could be useful in flash-flood areas
*	Awns:	may be advantageous when bird damage is expected, though, not common
***	Seed dormancy:	advantageous when lodging or high humidity prevail just before harvesting

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Target Traits 2

I. Common traits need in both elongating and submergence tolerant lines:

Survival

*	**Early vegetative vigor:**	to compete with weeds especially for direct seeding
*	**Optimum tillering ability:**	but should not be too many especially for elongating rice
*	**Longer leaves:**	fast coming out of water and efficient utilization of light for better carbon assimilation
**	**Maturity:**	depending on the climate of the target environment. About 150 d at IRRI
**	**Photoperiod sensitivity:**	depends on the climate of the target area
**	**Tolerance to other soil stresses**	depends on target site
**	**Drought**	Necessary for rainfed condition
***	**Tolerance to pest:**	depends on prevailing pests in target sites

Ecomomic

*	**Hull and grain color:**	depends on farmers' preference but usually yellow hulls and light brown grains color are preferred
***	**Grain quality:**	less chalkiness is recommended but grain shape depends on farmers' preference
***	**Eating quality:**	depends on farmers' preferences

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Target Traits 3

II. Elongating rice for shallow water and flash flooding

Survival

*	**Facultative elongation ability:**	elongate only with rising water under deep-water condition but remain dwarf otherwise.

Yield

*	**Lodging resistance:**	minimize yield loss and maintain grain quality

III. Elongation

Survival

*	**Slow elongation (5cm/day);**	common elongation ability
*	**Facultative elongation ability:**	elongate only with rising water under deep-water condition but remain dwarf otherwise.
**	**Fast elongation (10cm/day):**	for areas with rapid water increment

Yield

***	**Kneeing ability:**	minimize yield loss and maintain grain quality

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Target Traits 4

IV. Submergence

Survival

*	**Tolerance to single cycle submergence;**	basic submergence tolerance for 10-14 days
**	**Tolerance to series of flash-flooding:**	tolerance to either periodical or series of flash flooding in specific area, e.g. tidal flooding
**	**Glabbrous leaf**	advantageous to turbid water

V. Submergence avoidance(excluding elongation)

Survival

*	**Plant height;**	useful than elongation ability for areas that commonly experience shallow flooding

Yield

*	**Lodging resistance:**	minimize yield loss and maintain grain quality

Method (conventional)

1. Pedigree?
2. Bulk breeding?
3. Or?

Facility

1. Screening field
   *Controlled
   *Uncontrolled

2. Field for observation or generation advancement
   *Normal field
   *Special facility for generation advancement

Breeding Activities at IRRI

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Standard Screening Method for Elongation Ability at IRRI

Field:	Deepwater pond
Transplanting:	21 DAS in DS 21 DAS in WS
Treatment:	30 DAT in DS and WS
Water raise:	5cm/day up to 100 – 120cm
Control:	IR11141, IR42436, Jalnidhi and Jalmagna as DWR IR42 as irrigated rice

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28 DAT. Ready to Put Water.

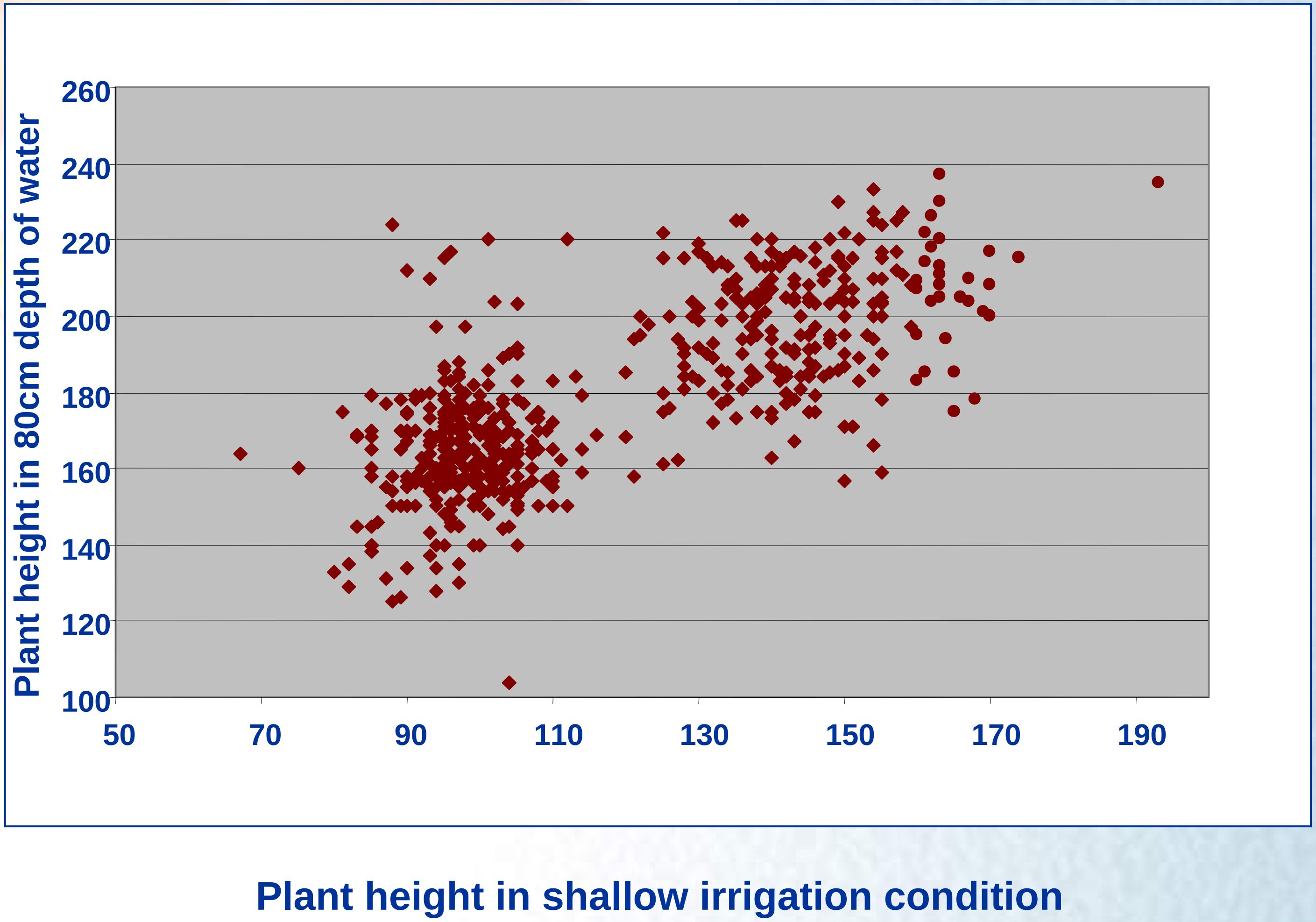

Fig. Elongation Ability of Current germplasm of Deepwater Rice

DWR New Plant Type(ir42436)

Under IR condition **Under DW condition**

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Field Views

Traditional DWR under IR condition

Improved DWR under IR condition

DWR under IR condition

Standard Screening Method for Submergence Tolerance at IRRI

Field:	Submergence tank(artificial pond)
Transplanting:	21DAS
Stage of treatment:	30 DAT or 30 DAS
Duration:	up to 14days at 100 – 120cm
Control:	FR13A, BKNFR76106 as tolerant IR42, IR64, iR72 as irrigated rice

The Art of Killing Plants

Alternative

Shading

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RGA(rapid Generation Advancement)

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Utilization of Biotechnology

MAS techniques for salinity tolerance and related stresses

Trait	Develop mapping Pop'n	Develop Pheno. Tech.	Pheno. pop'n	Study Genetics	Tagged genes/ QTL	Fine map	PCR based MAS	Test MAS	Demo. to NARES
Photosen.									
Salinity Na-K ratio									
P efficiency									
Submergence									
Elongation									
Al tox. Tol.									
Fe tox. Tol.									
Zn effeciency									
Salinity Na exclusion									
Salinity Tissue Tol.									

Gregorio (2002)

Mapping Work

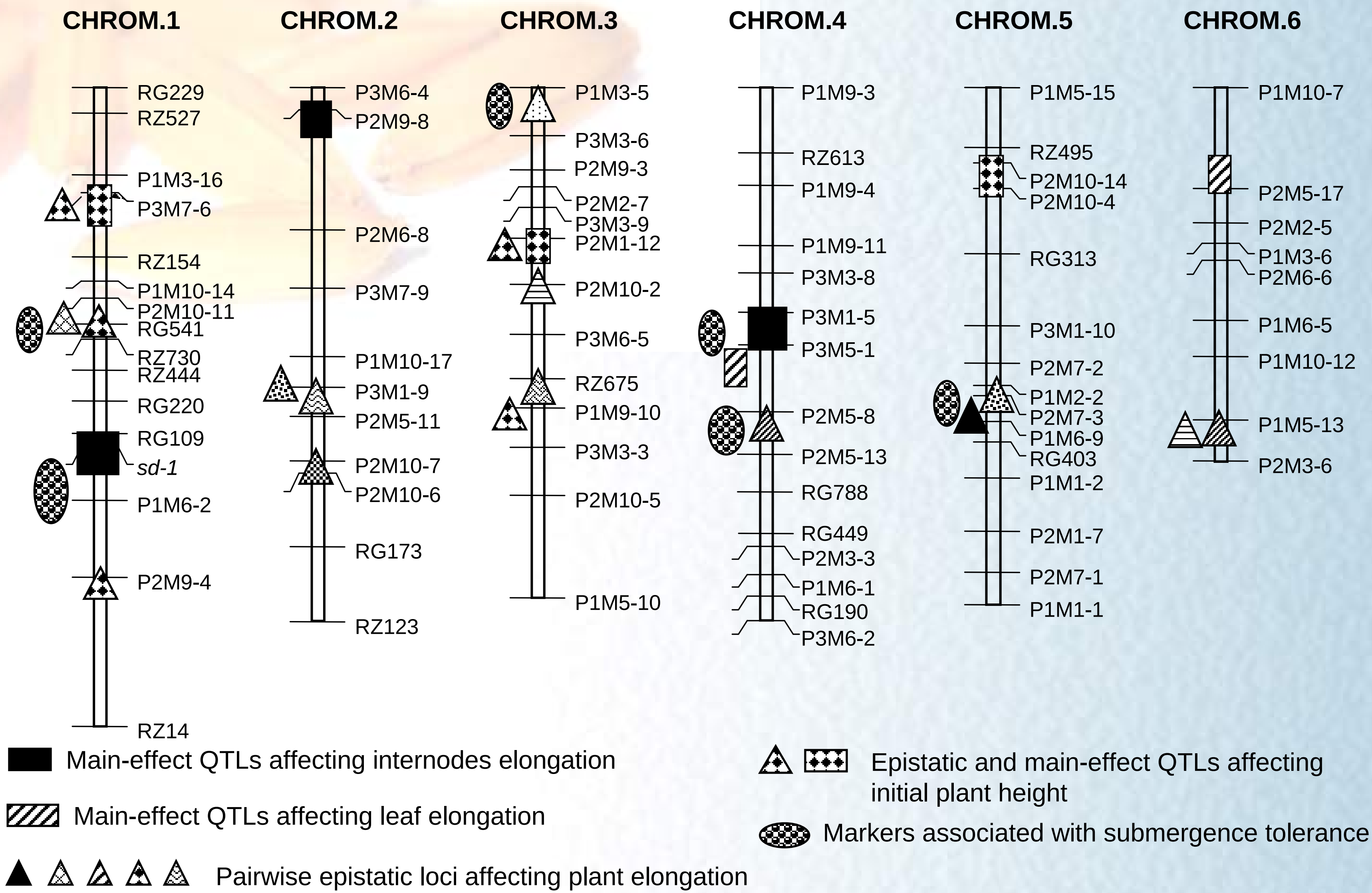
Sripongpangkul *et al.* (2000)

Material:

IR74/Jalmagna

Method:

RFLP anchor markers and AFLP



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CHROM.1
CHROM.2
CHROM.3
CHROM.4
CHROM.5
CHROM.6
RG229
RZ527
P1M3-16
P3M7-6
RZ154
P1M10-14
P2M10-11
RG541
RZ730
RZ444
RG220
RG109
sd-1
P1M6-2
P2M9-4
RZ14
P3M6-4
P2M9-8
P2M6-8
P3M7-9
P1M10-17
P3M1-9
P2M5-11
P2M10-7
P2M10-6
RG173
RZ123
P1M3-5
P3M3-6
P2M9-3
P2M2-7
P3M3-9
P2M1-12
P2M10-2
P3M6-5
RZ675
P1M9-10
P3M3-3
P2M10-5
P1M5-10
P1M9-3
RZ613
P1M9-4
P1M9-11
P3M3-8
P3M1-5
P3M5-1
P2M5-8
P2M5-13
RG788
RG449
P2M3-3
P1M6-1
RG190
P3M6-2
P1M5-15
RZ495
P2M10-14
P2M10-4
RG313
P3M1-10
P2M7-2
P1M2-2
P2M7-3
P1M6-9
RG403
P1M1-2
P2M1-7
P2M7-1
P1M1-1
P1M10-7
P2M5-17
P2M2-5
P1M3-6
P2M6-6
P1M6-5
P1M10-12
P1M5-13
P2M3-6
Main-effect QTLs affecting internodes elongation
Main-effect QTLs affecting leaf elongation
Pairwise epistatic loci affecting plant elongation
Epistatic and main-effect QTLs affecting initial plant height
Markers associated with submergence tolerance

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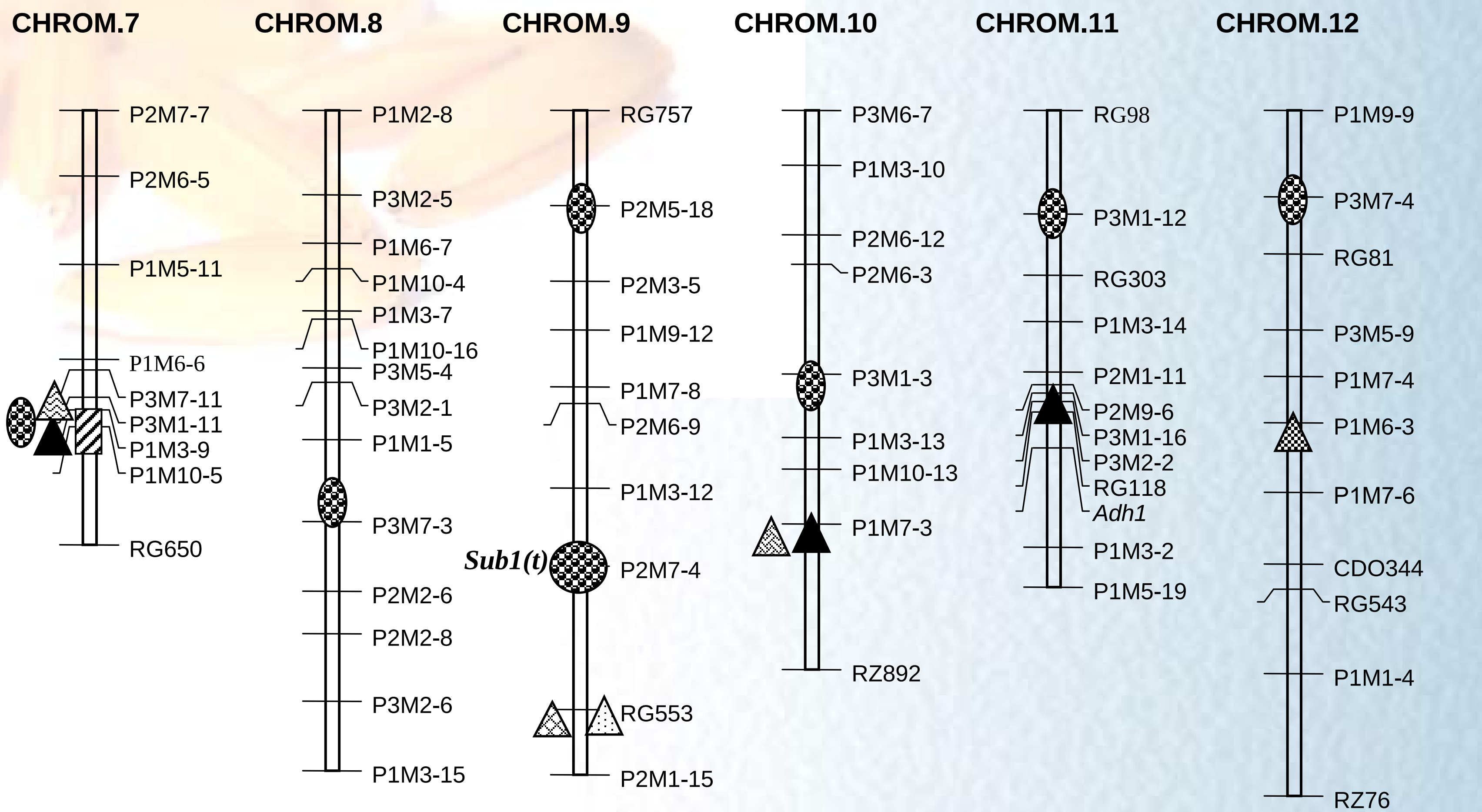

Main-effect QTLs affecting internode elongation

Main-effect QTLs affecting leaf elongation

Pairwise epistatic loci affecting plant elongation

Epistatic and main-effect QTLs affecting initial plant height

Markers associated with submergence tolerance

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Number of Lines Sent to NARES.1993-00.Elongation

YEAR	INGER	GHAG	PUSA	CRRI	ASSAM	PCR	CAM-BODIA	PHI
1993		31	31					
1994		29	29					
1995	8	46	48	44	43			
1996	12	106	108	100	102			
1997		35	32	104	104			
1998	18							
1999	36	2	2	2		9	9	10
2000	36						106	

Good News

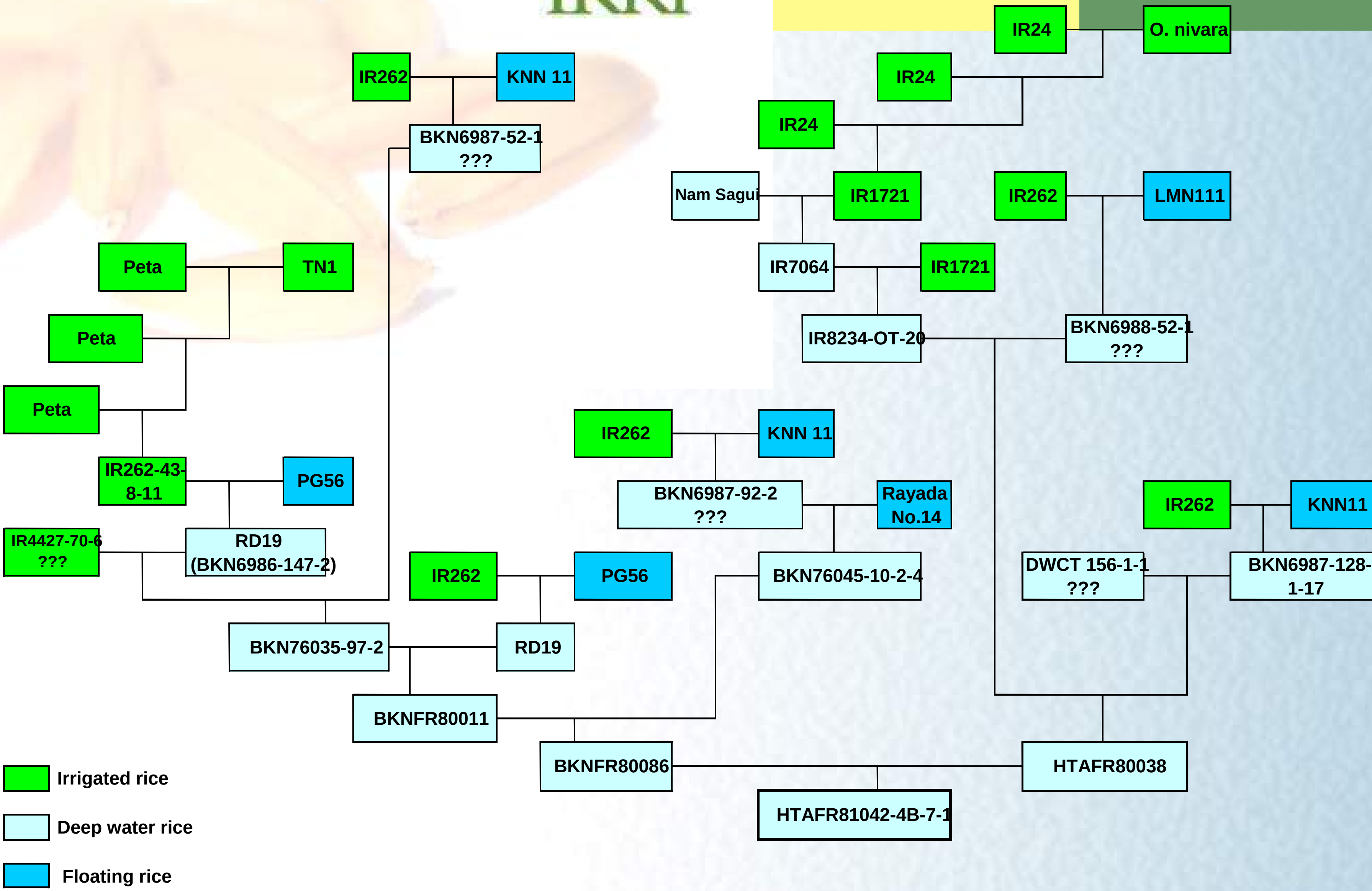

Fig. Pedigree of Prachinburi 2

(From Huntra Rice Research station and modified by Yanagihara)

Now Your Turn