Climate change and food production in Asia

Home of the Green Revolution

Established 1960

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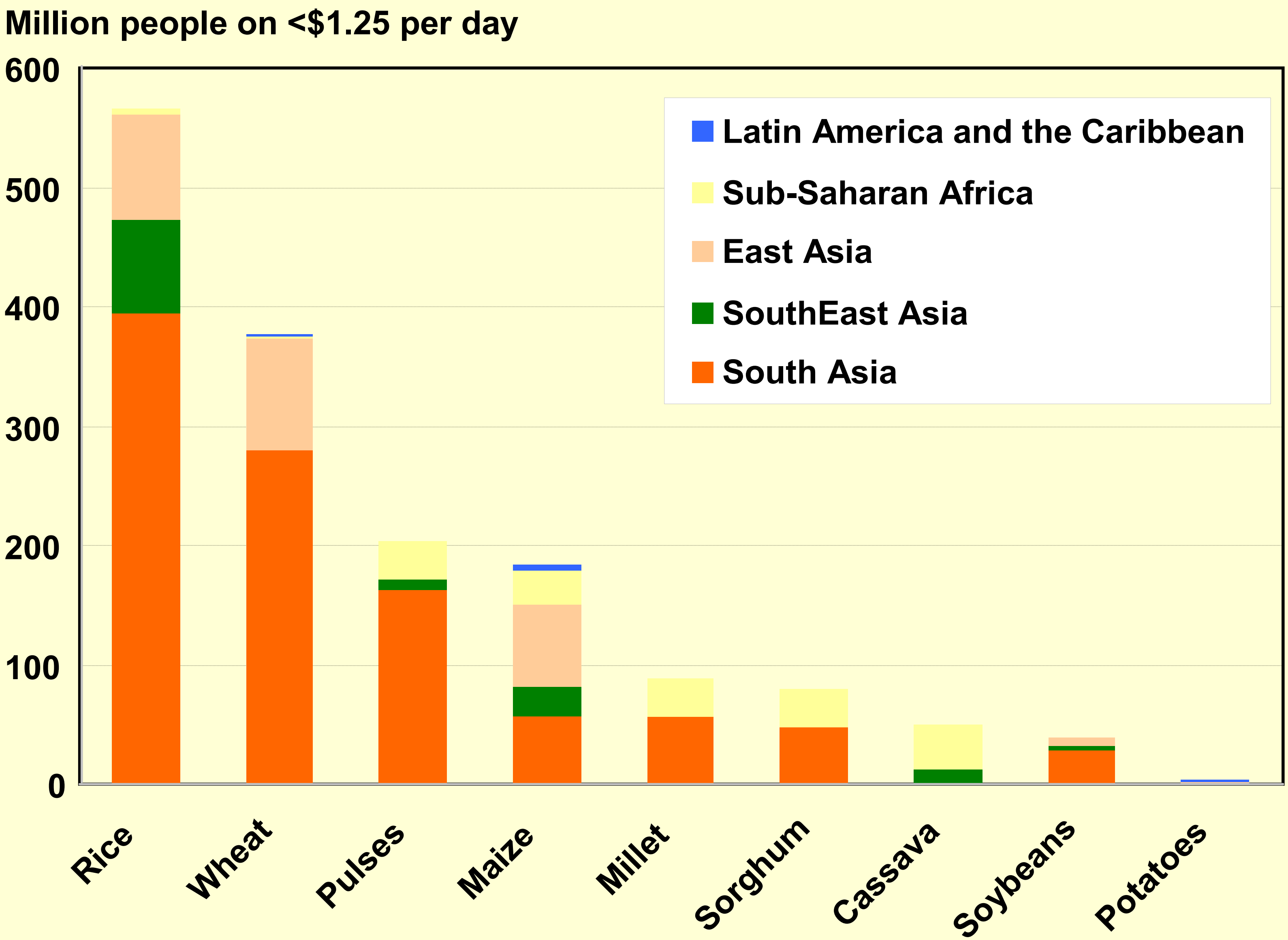
RICE and food security of Asia



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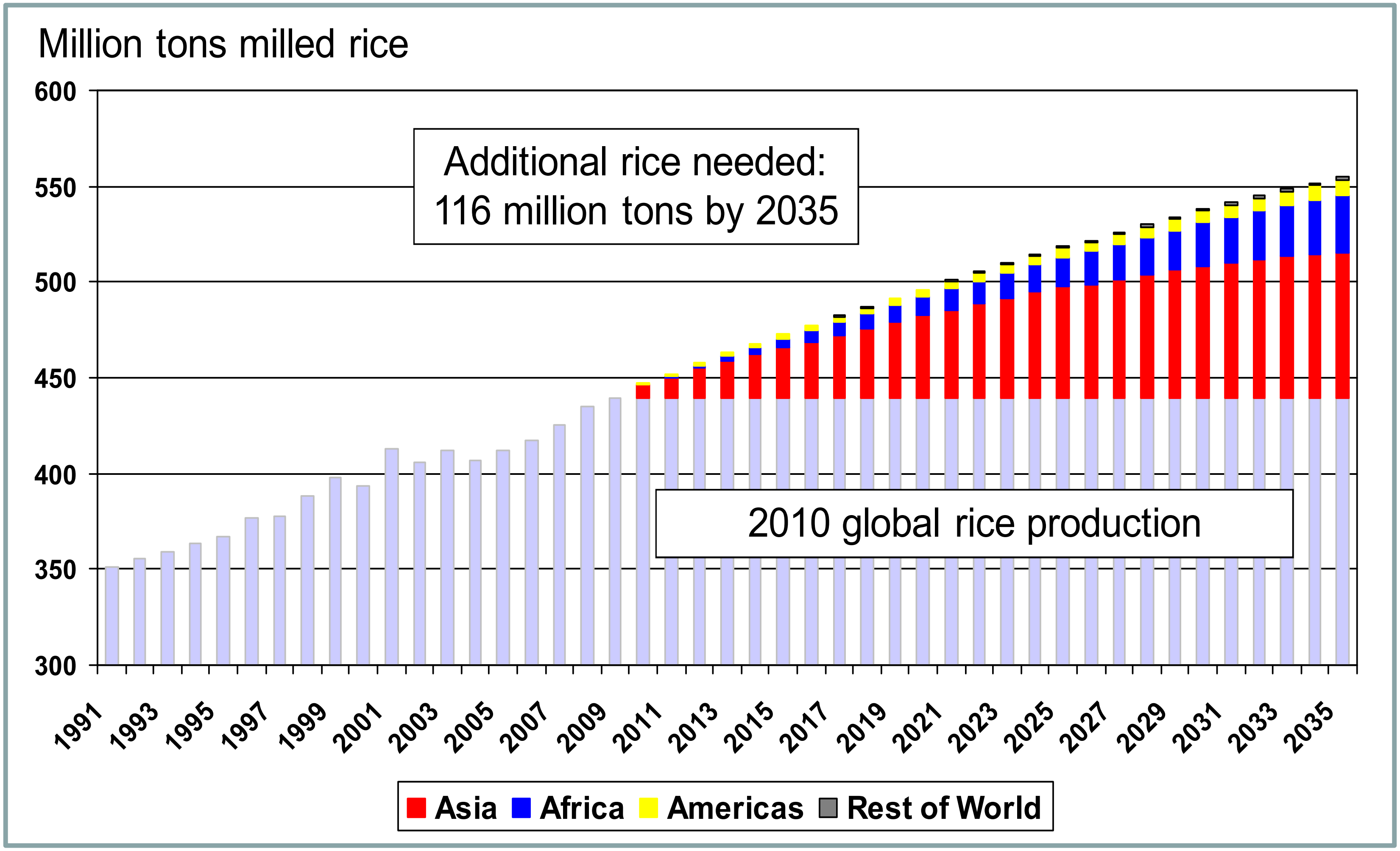
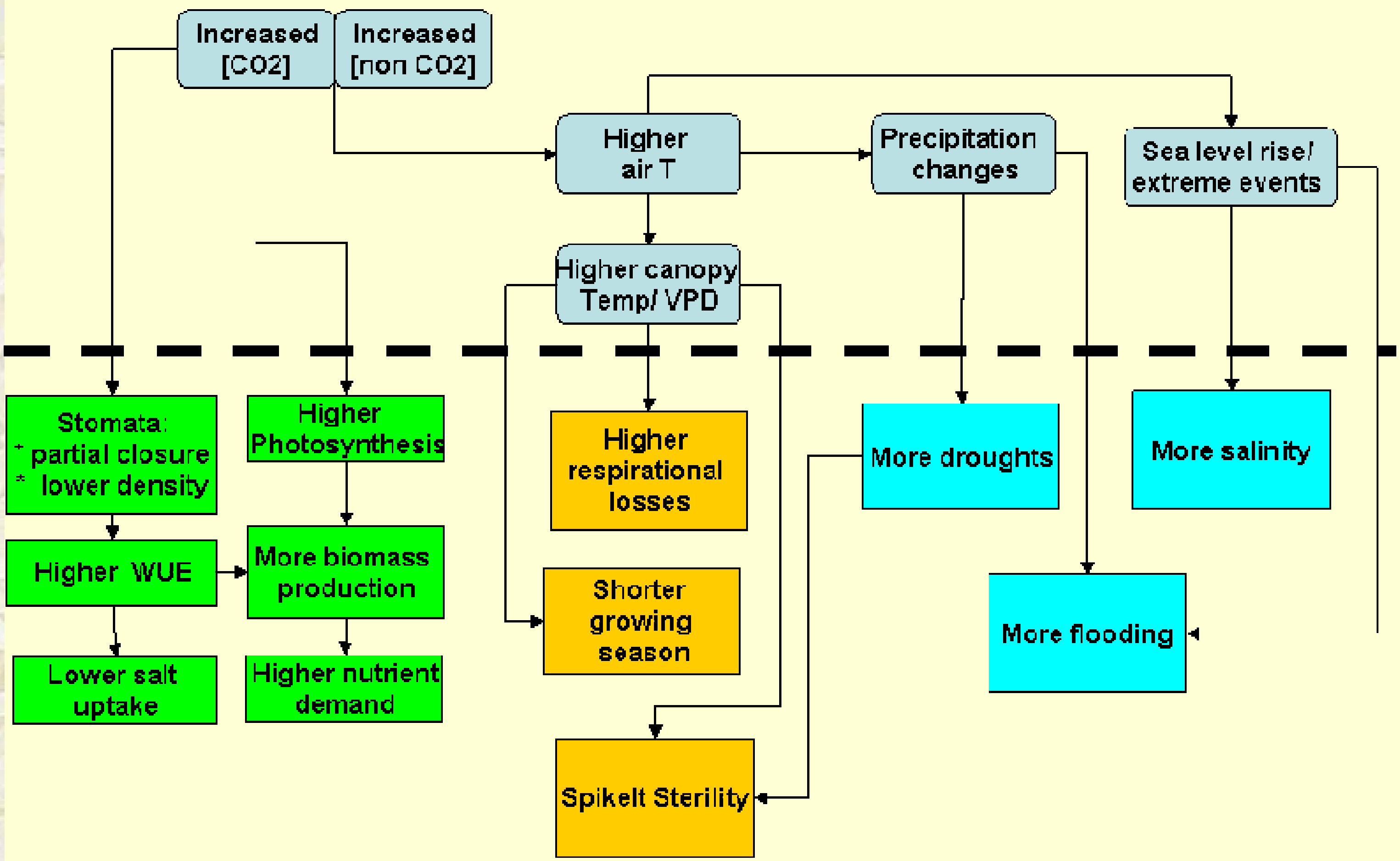
Global rice demand until 2035



Potential effects of elevated CO_2 and high temperatures on rice



Wassmann et al., 2009, Adv. Agron.102, 91-133

Outline

Progress in adapting rice to

- **High temperature stress**
- **Drought stress**
- **Submergence**
- **Salinity**

➢ **Companion stresses**

➢ **Global partnership (GRiSP)**

High temperature stress
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High temperature stress

Progress in adapting rice to

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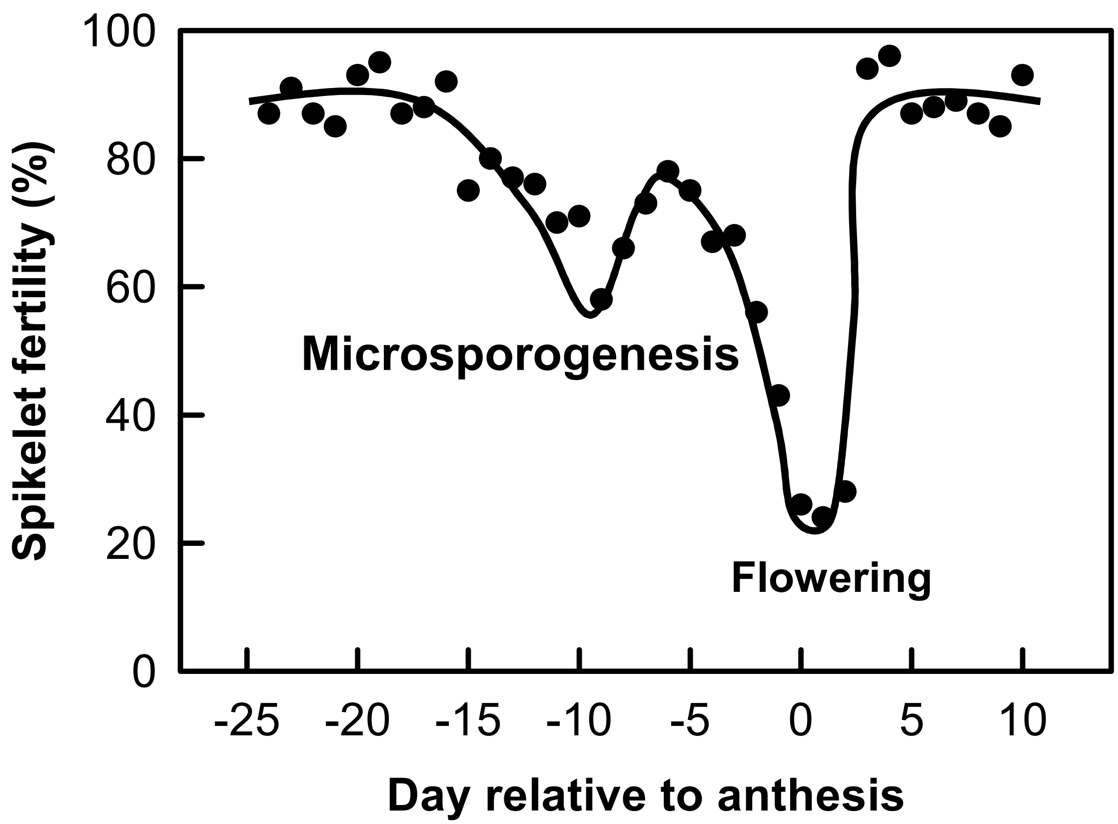
Anthesis and Microsporogenesis – most sensitive stages



Redrawn from Satake & Yoshida, 1978

Is EMF trait useful?

<u>**Shading and staggered sowing**</u>

Materials – Local varieties

Concept – early hours have low radiation and temperature

Comparison – with (EMF) and without (on EMF) shading

Locations – TNAU, IARI-India

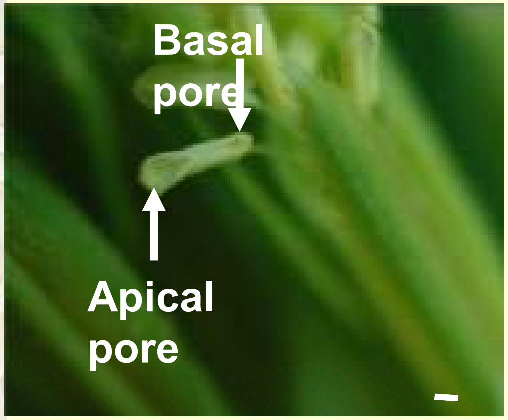
N22 a true high temperature tolerant donor

		30°C	35°C	38°C
Azucena	S	**66.1**	**23.4**	**02.9**
Bala	T	**89.8**	**81.4**	**40.6**
CG 14	MT	**89.6**	**71.7**	**19.1**
Co 39	T	**86.1**	**83.5**	**40.5**
IR 64	MT	**93.2**	**68.3**	**18.7**
Moroberekan	S	**83.3**	**39.9**	**06.4**
N22	**HT**	**95.6**	**91.3**	**63.7**
WAB 56-104	S	**94.6**	**76.0**	**19.2**

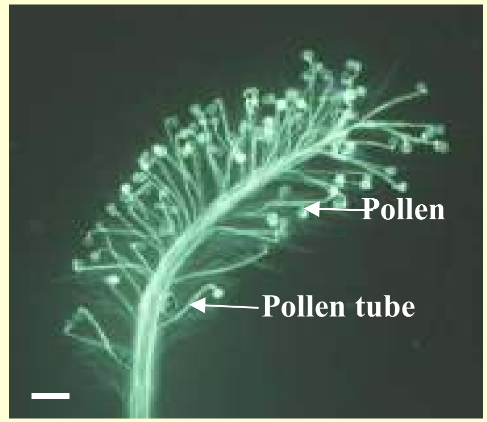
Jagadish et al., 2008, Crop Sci., 48:1140–1146

- **N22 two most tolerant accessions identified**
- **N22 tolerant at microsporogenesis stage**
- **N22 most tolerant to high night temperature under field (Peng et al., UnPub) and under controlled environments (Coast et al., UnPub)**

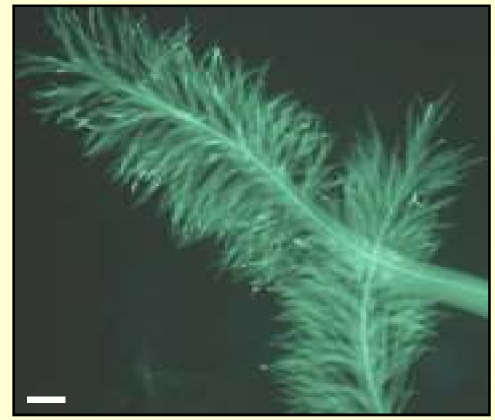
Physiological processes determining spikelet fertility



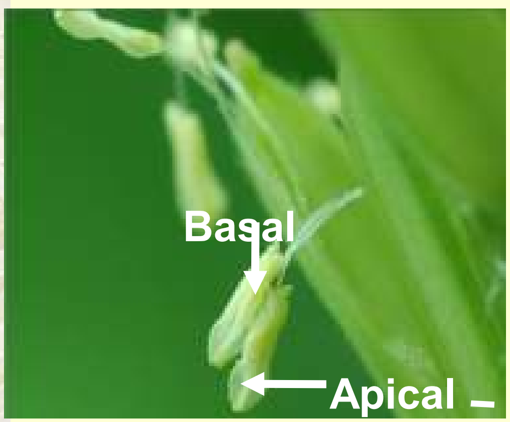
Moroberekan stress



Moroberekan control



Moroberekan stress



N22 stress

N22 control

N22 stress

Jagadish et al., 2010, J Ex Bot, 61, 143–156

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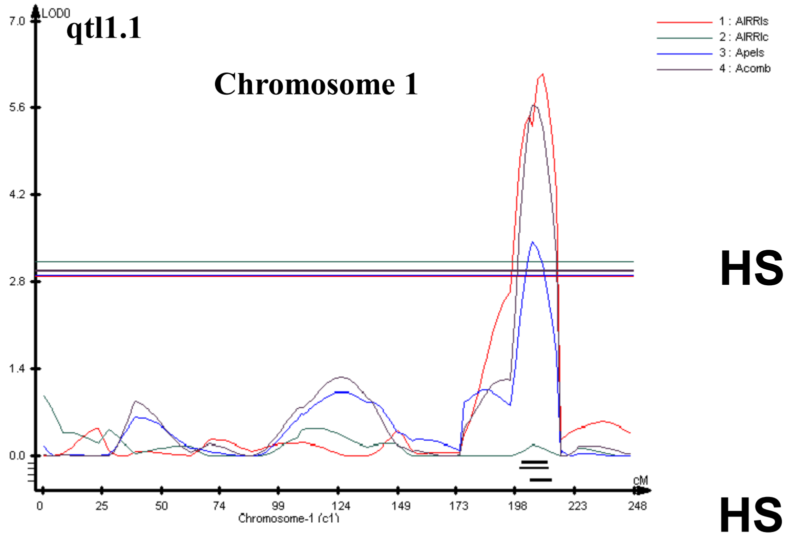
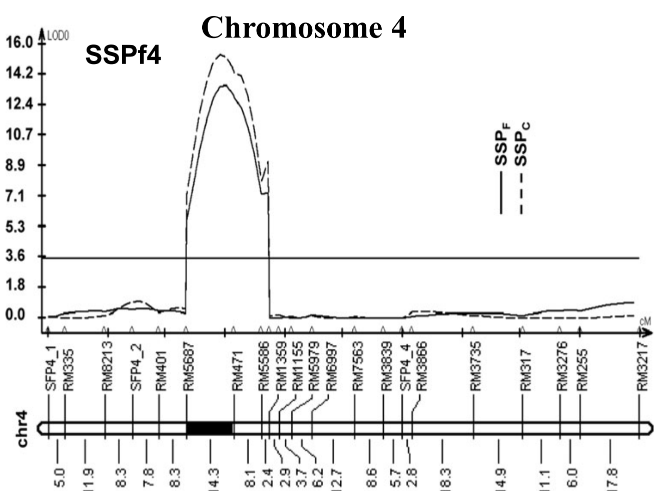
QTLs/proteins for heat tolerance at anthesis

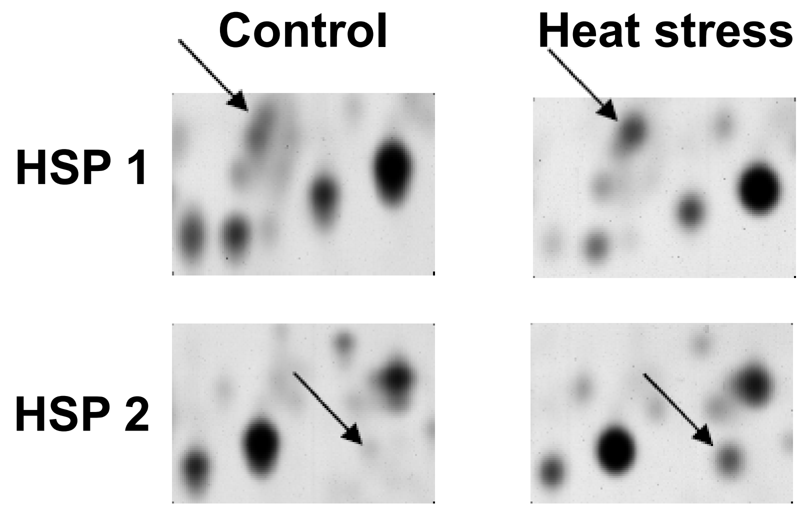


Jagadish et al 2010 – Bala x Azucena

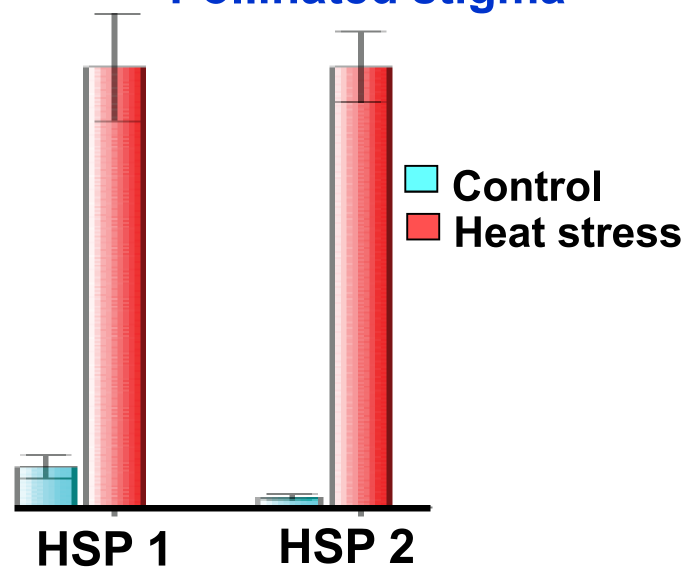


Xiao et al 2010 – 996 × 4628

Spikelet protein expression



Pollinated stigma



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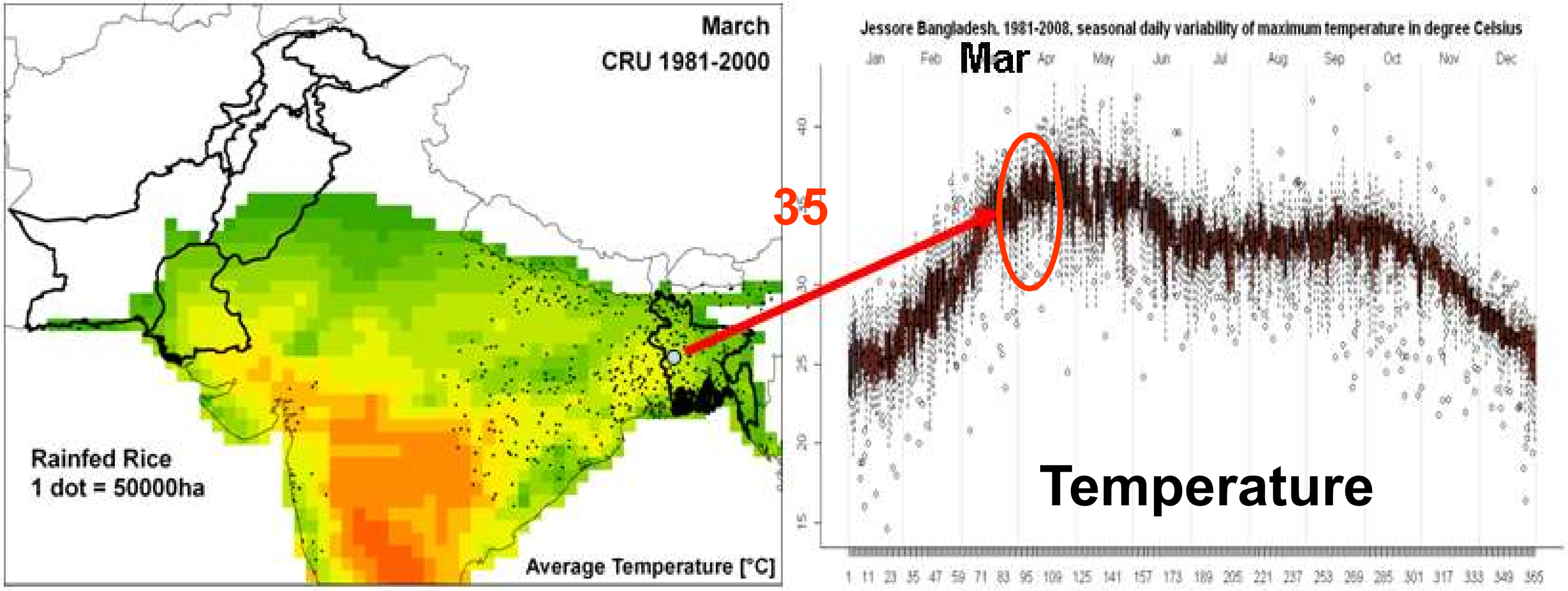
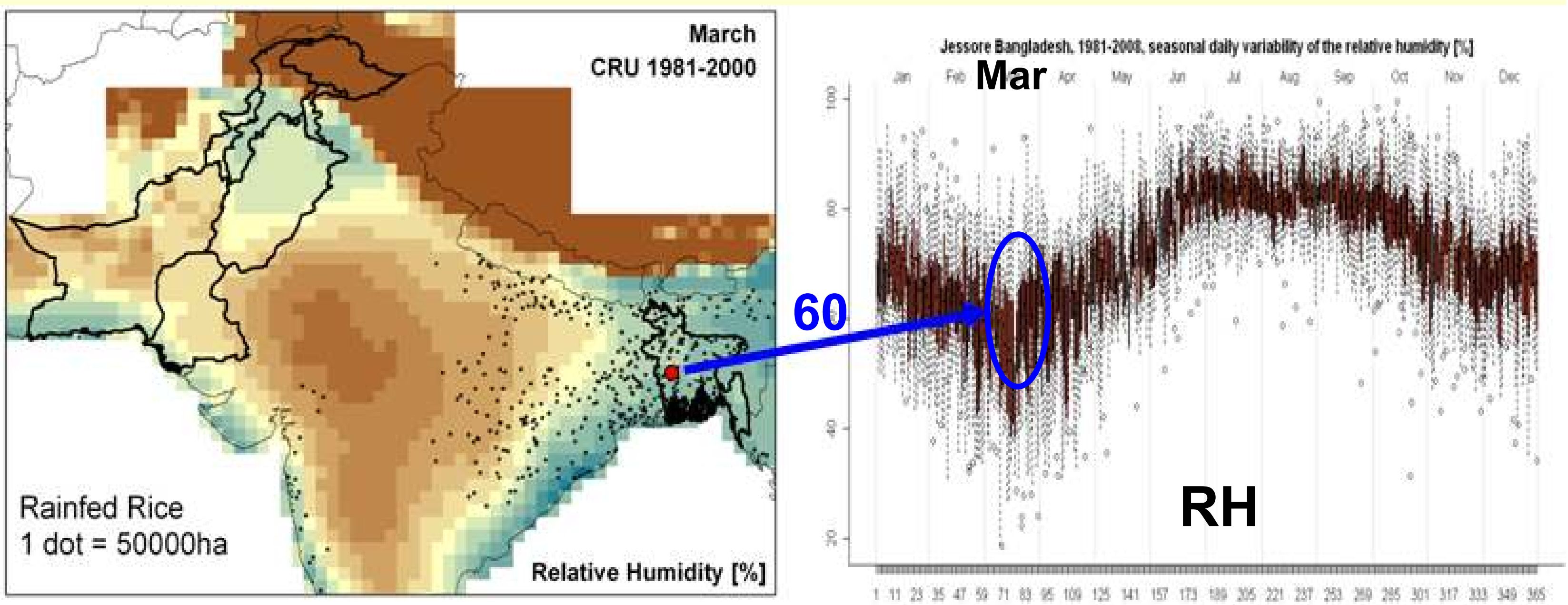
Boro rice at Jessore, Bangladesh





Wassmann et al., 2009, Adv. Agron.102, 91-133

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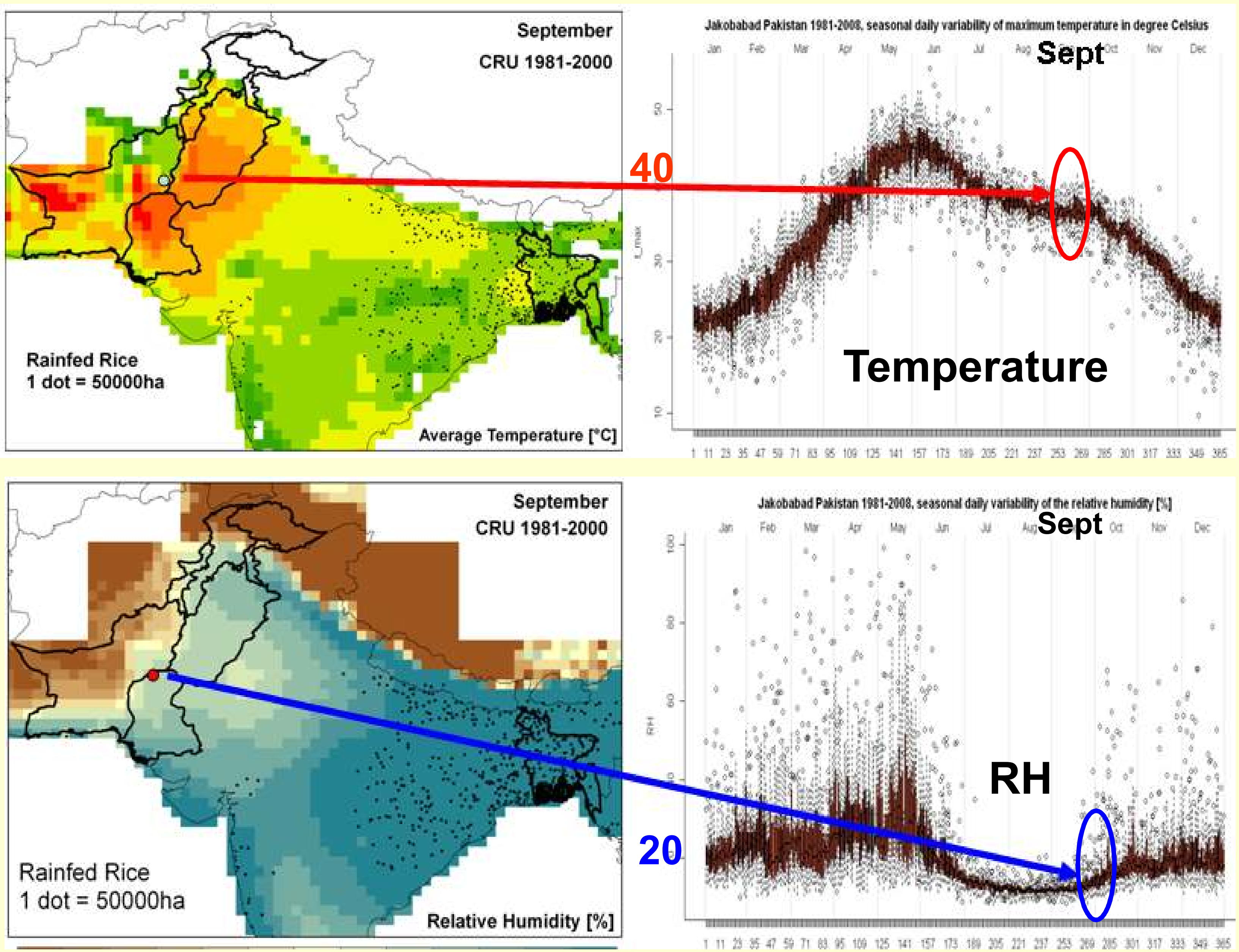
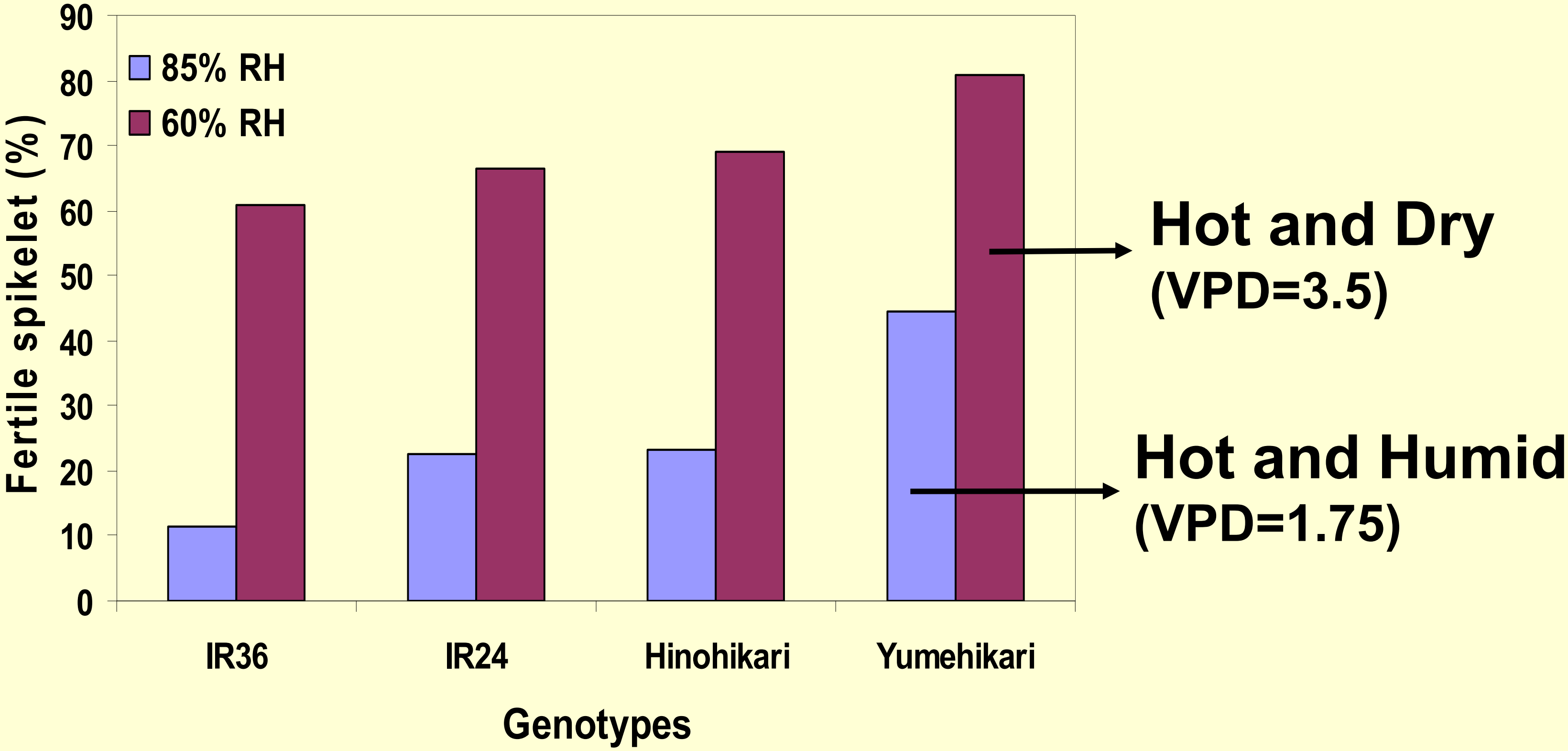
Jakobabad, Pakistan



Wassmann et al., 2009, Adv. Agron.102, 91-133

High temperature and humidity interaction (VPD)



Weerakoon et al., 2008 J. Agron. & Crop Sci., 135-140

….collaborating with NARES network

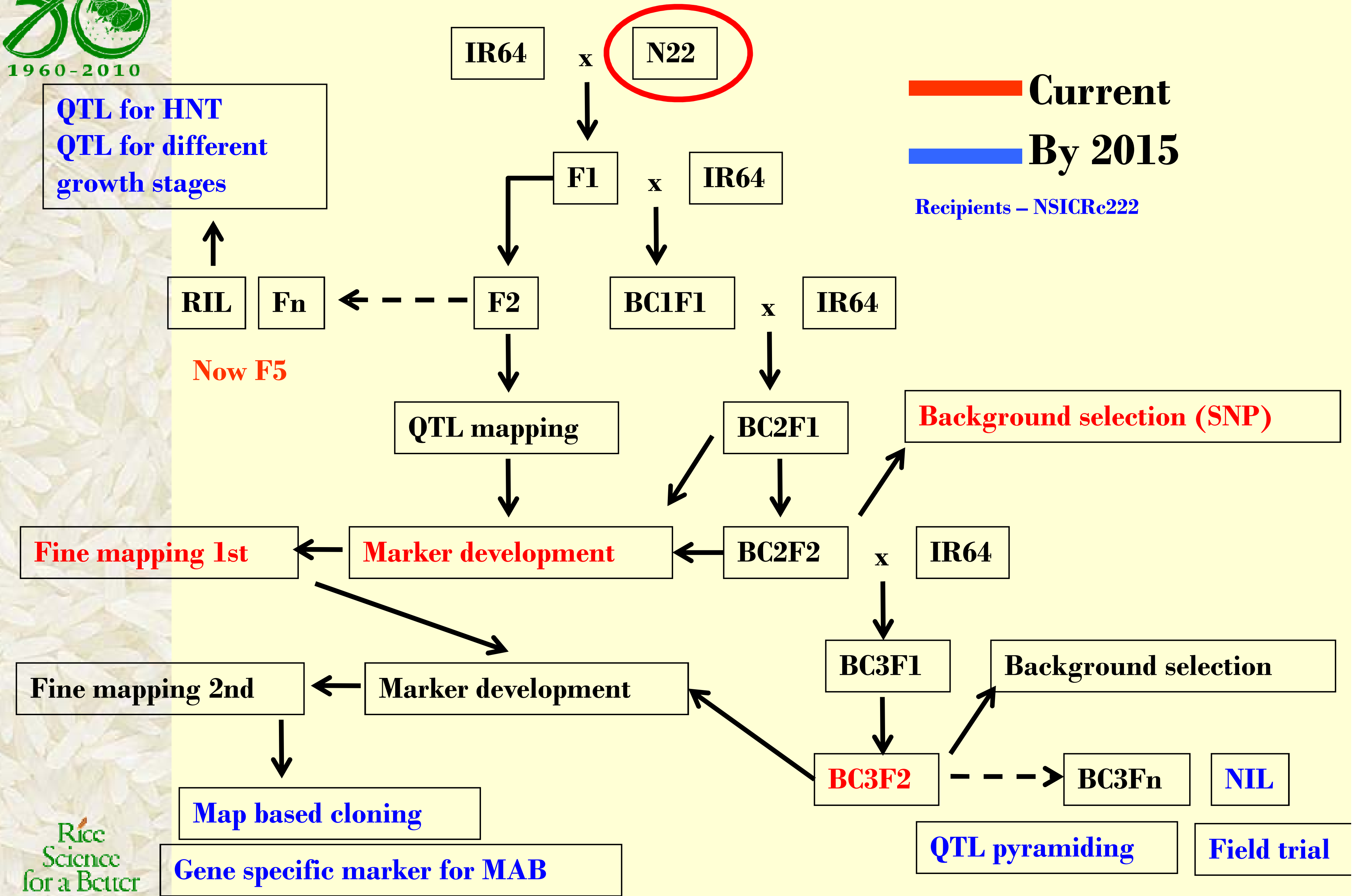
India (Hot and Dry)

Courtesy – S. Sheryl, IRRI

Bangladesh (Hot and humid)

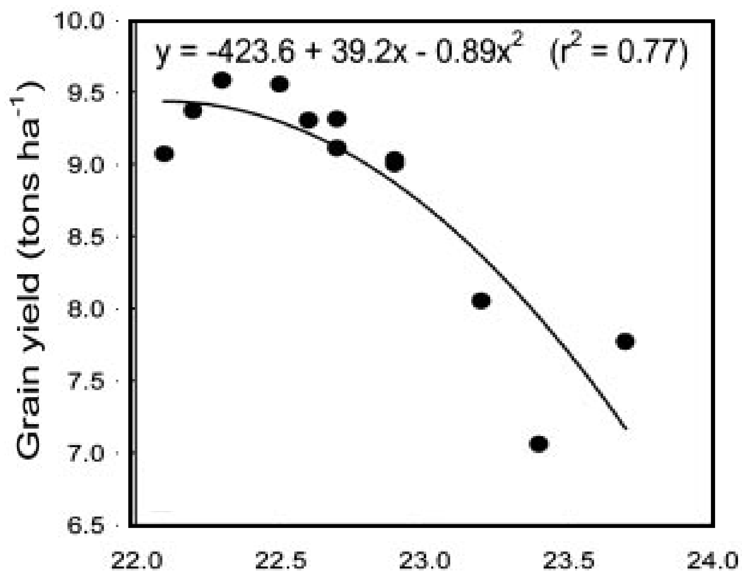
Courtesy – Dr Masuduzzaman, BRRI

When will we have a heat tolerant line?

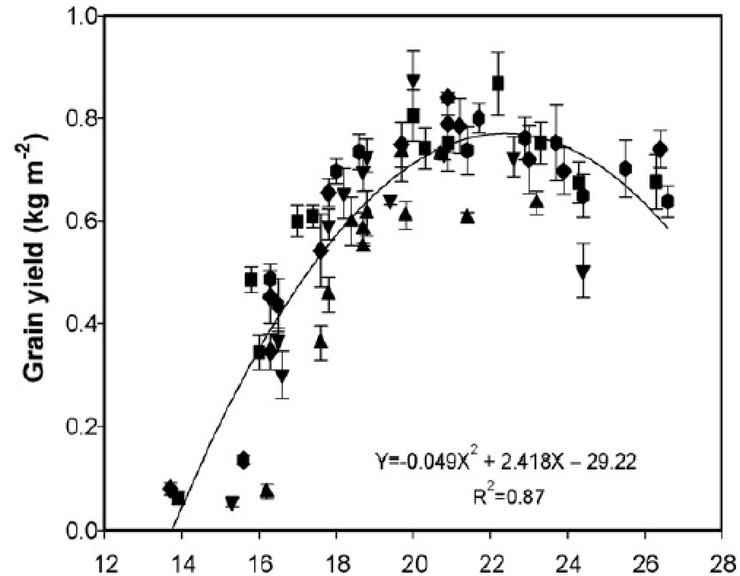


Ye et al.

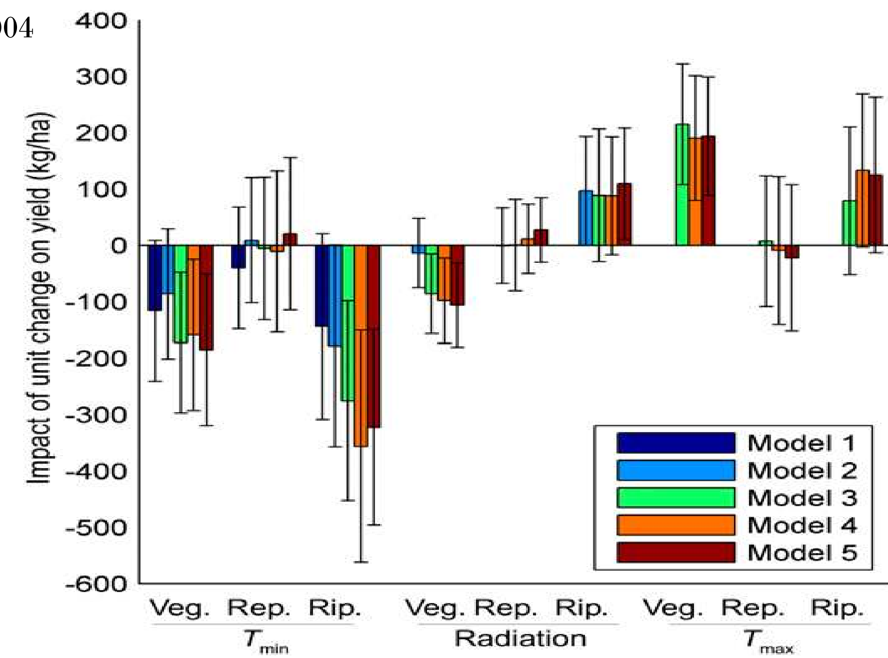
Night temperature and rice



Peng et al., 2004



Nagarajan et al., 2010



Welch et al., 2010

High night temperature and maintenance respiration

High night temperature tents

Recent findings

-43 entries screened

-Contrasting entries identified

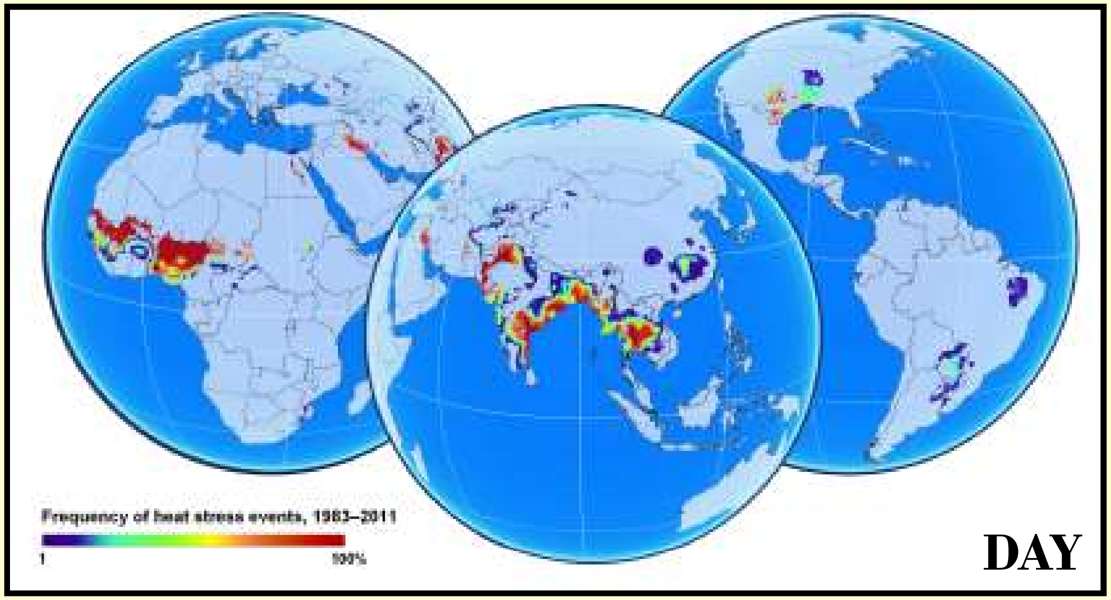
-In susceptible entry

- Spikelet fertility not reduced
- Biomass, N, NSC reduced
- Rate of grain filling reduced
- Grain width reduced
- Quality deteriorated

- Flag leaf and panicles proteomics at 100% flowering and 12 DAF flowering and 43 proteins sequenced

Shi et al., 2013. New Phytologist. 197, 825–837

Rice growing regions vulnerability



Improvements

- Day and night
- Daily temperature
- Global planting dates
- Incorporating RH?

Laborte, Nelson et al.

Drought stress

Progress in adapting rice to

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Drought Research at IRRI: Strategy

Conventional approaches

- Use improved pre-breeding lines as donors
- Direct selection for grain yield
- Combine high yield with good yield under drought
- Confirm performance in multi location testing in target environment-Drought breeding network

Molecular approaches

- Use traditional/wild donors in mapping populations
- Identify major drought yield QTLs
- Introgress QTLs in improved drought susceptible varieties
- Physiological and molecular mechanism of QTLs drought tolerance

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Submergence and Salinity stress

Progress in adapting rice to

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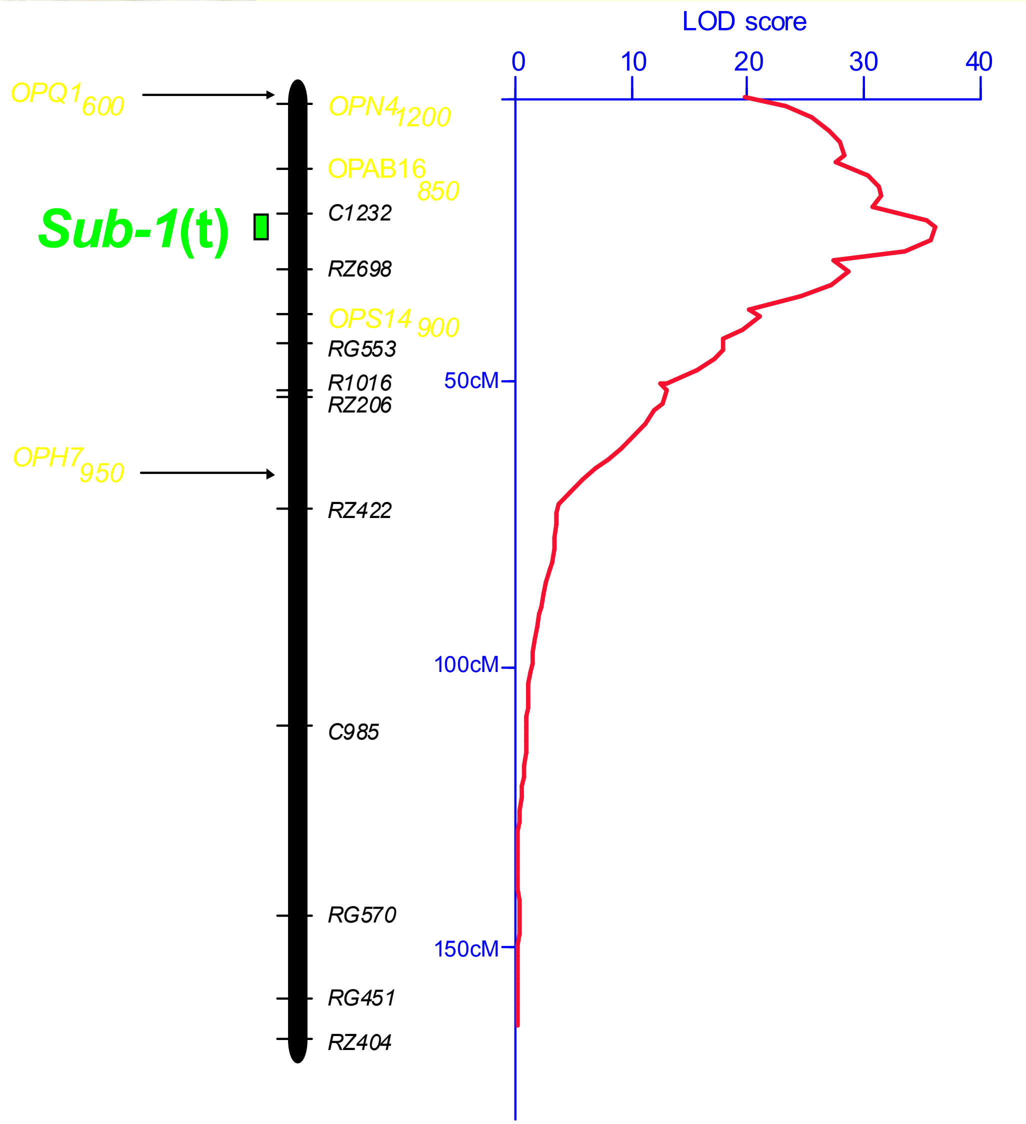
QTL mapping for submergence tolerance



- *SUB1* QTL: R^2 = ~ 70%, Chr. 9, from FR13A (Xu and Mackill, 1996)
- Cloned as a cluster of 3 ERF genes: *SUB1A*, *SUB1B*, and *SUB1C* (Xu et al., 2006)

First six *Sub1* mega-varieties developed

Sub1 variety	Gen.	Fixed line names
Swarna-Sub1	BC2	IR 05F101
	BC3	IR 05F102
Samba Mahsuri-Sub1	BC2	IR 07F101
	BC3	IR 07F287
IR64-Sub1	BC2	IR 07F102
	BC3	IR 07F292
TDK1-Sub1	BC3	IR 07F289
CR1009-Sub1	BC2	IR 07F291
BR11-Sub1	BC2	IR 07F290

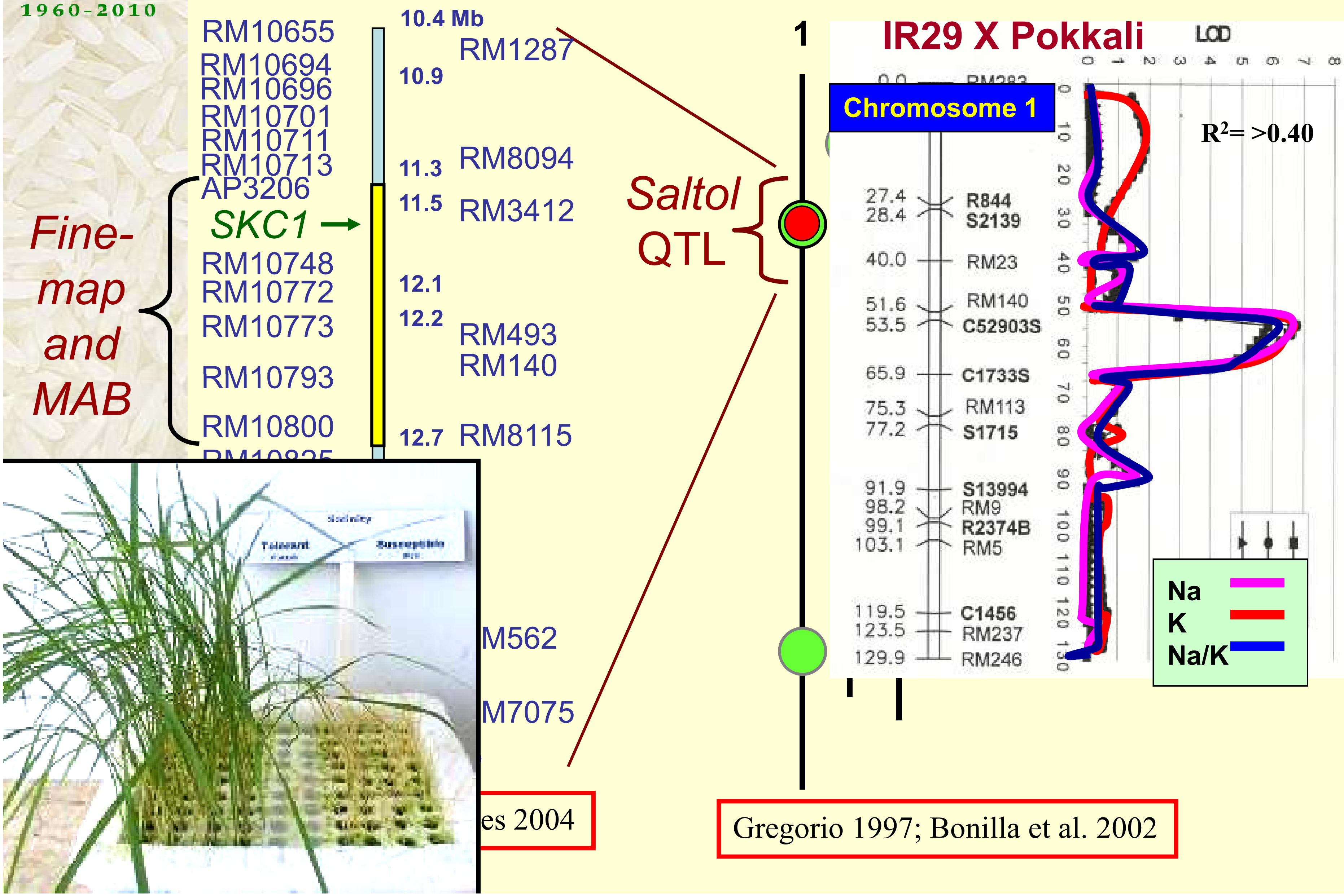
- Swarna-Sub1, IR64-Sub1, BR11-Sub1, Samba Mahsuri-Sub1, and TDK1-Sub1 have been released in several countries
- More Sub1 varieties developed, such as Ciherang-Sub1 and PSBRc18-Sub1

Neeraja et al. TAG (2007)
Septiningsih et al. Ann Bot. (2009)
Iftekharuddaula et al. Euphytica (2011)

Tolerance to anaerobic germination (AG) for direct seeding ecosystem

- Capability of seeds to germinate and elongate under hypoxia (low oxygen) or anoxia (no oxygen).
- Direct seeding is becoming more popular among farmers in both rainfed and irrigated ecosystems.
- An effective means of weed control in irrigated areas.
- Improving crop establishment due to unleveled fields or flash floods after direct seeding.
- Tolerance to AG is independent of *SUB1.*

Major QTL for seedling stage **salinity** tolerance



Multiple abiotic stress tolerance

Progress in adapting rice to

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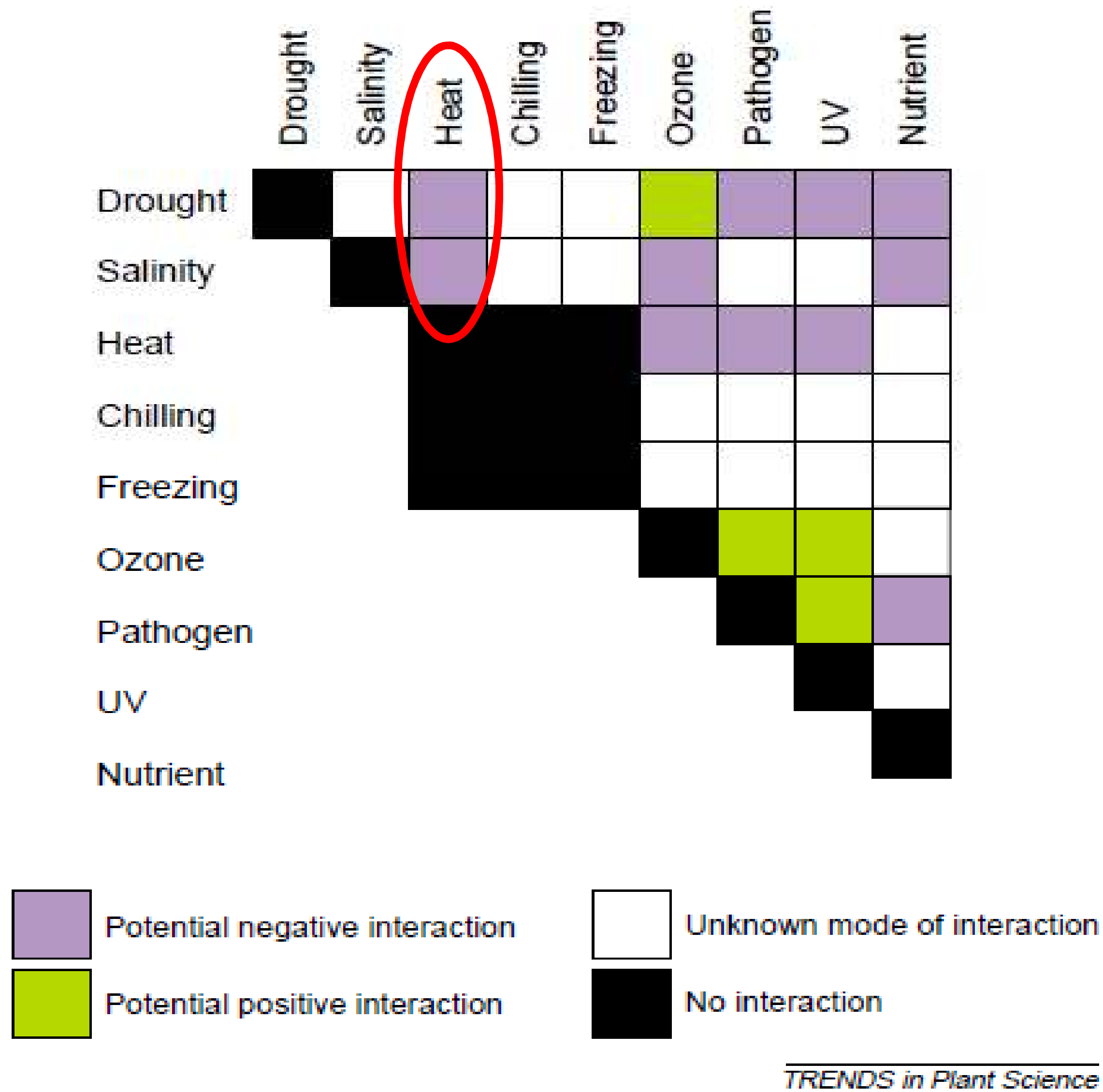
Abiotic and biotic stress interactions



Mittler, 2006

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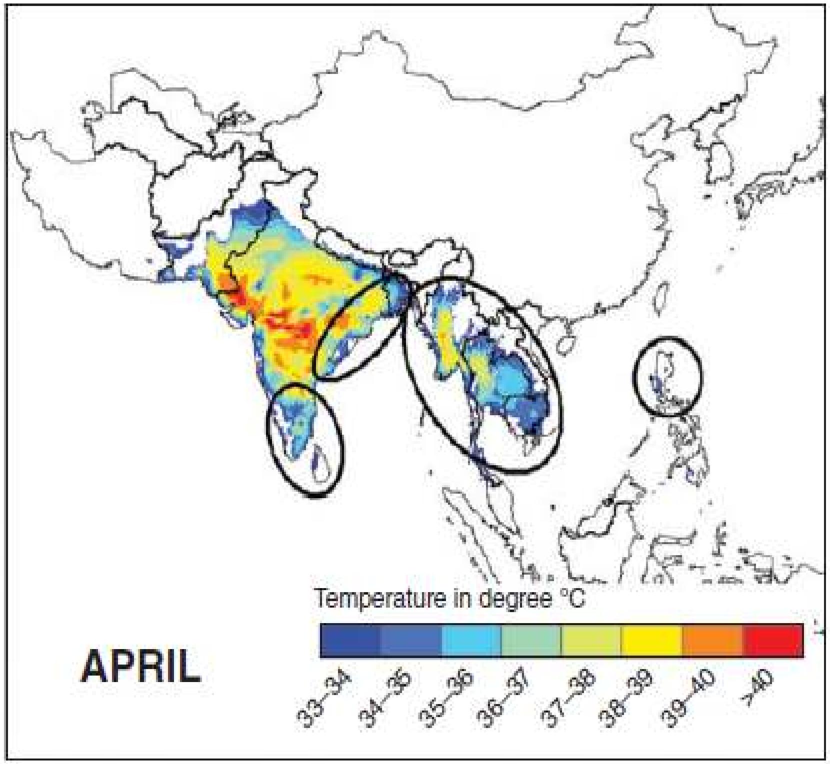
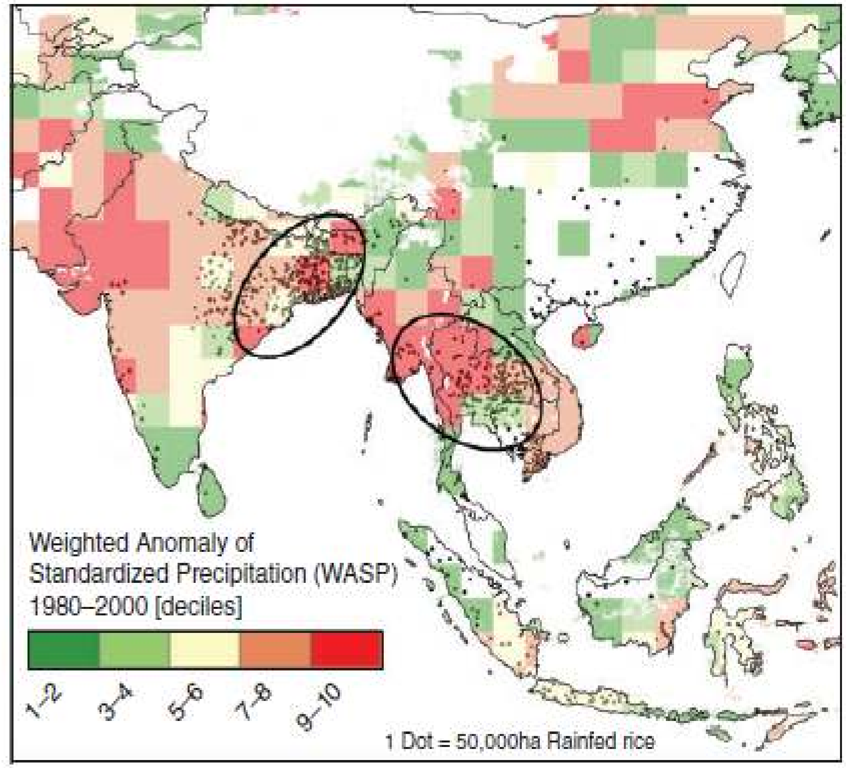
Mapping heat and drought tolerant regions of South and SE Asia



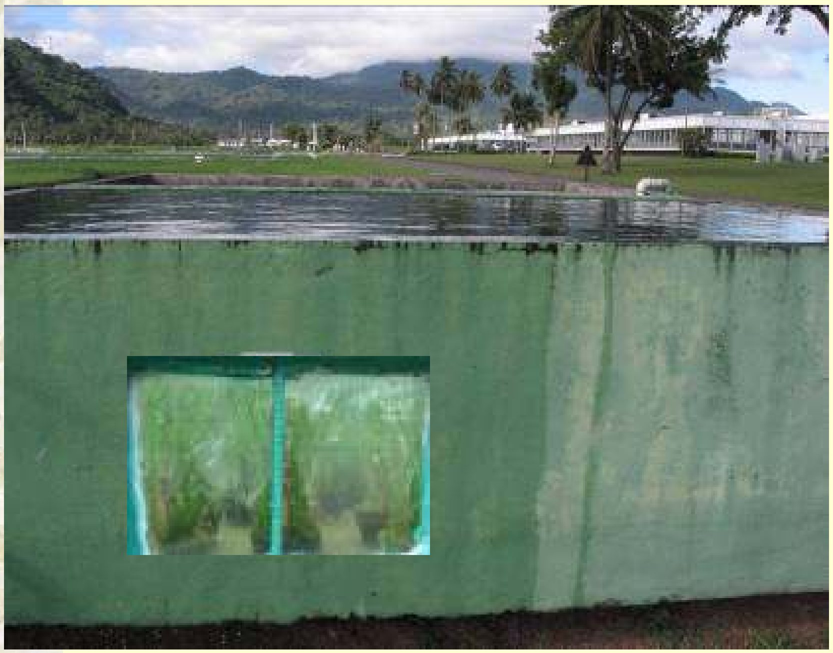


Bangladesh, eastern India, southern Myanmar, and northern Thailand

Jagadish et al., FPB, 2011, 38, 261–269

2 in 1: Submergence + salinity tolerance

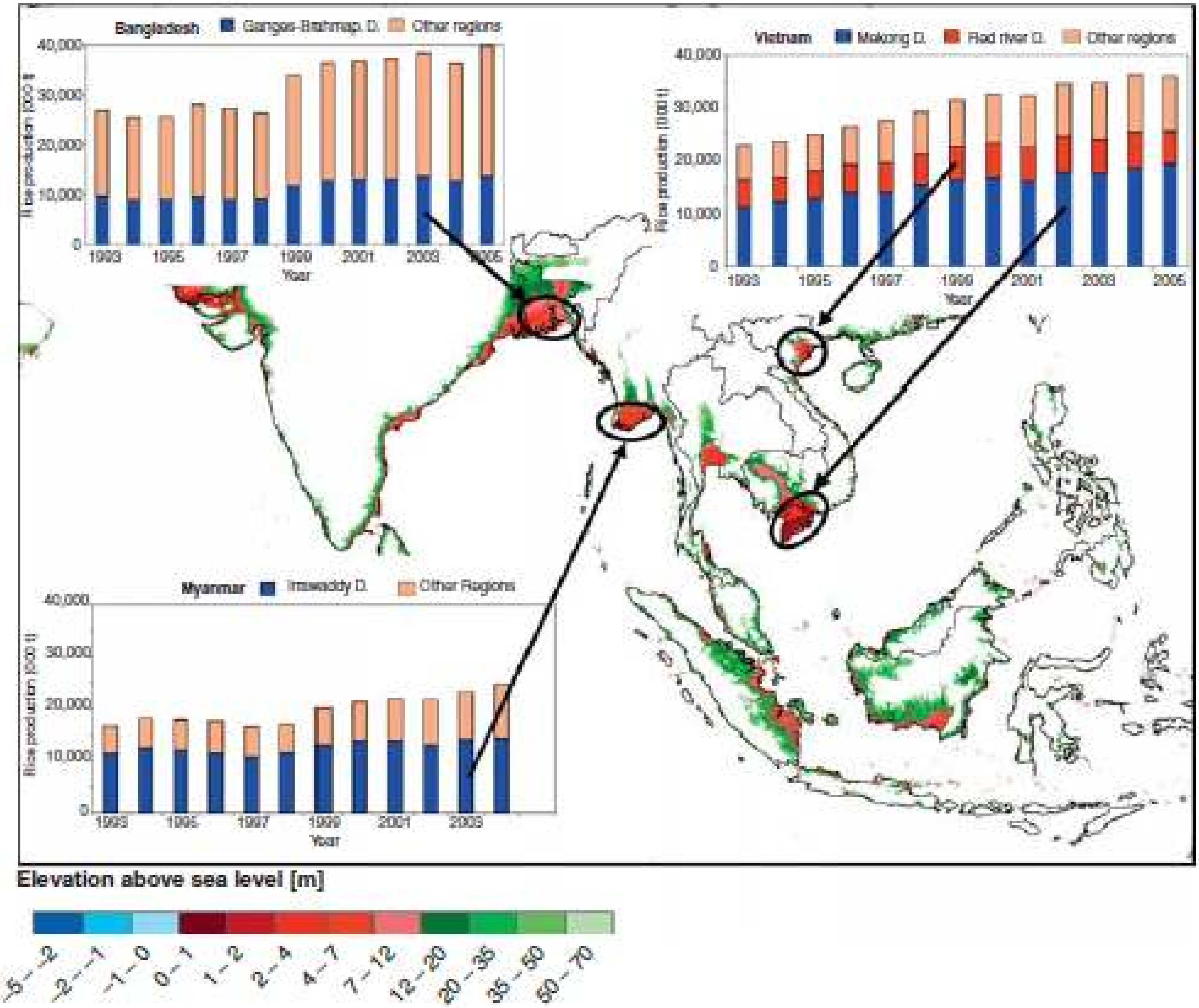
"2-in-1" rice, combined tolerance of salinity and submergence is now being evaluated in target sites in Asia.



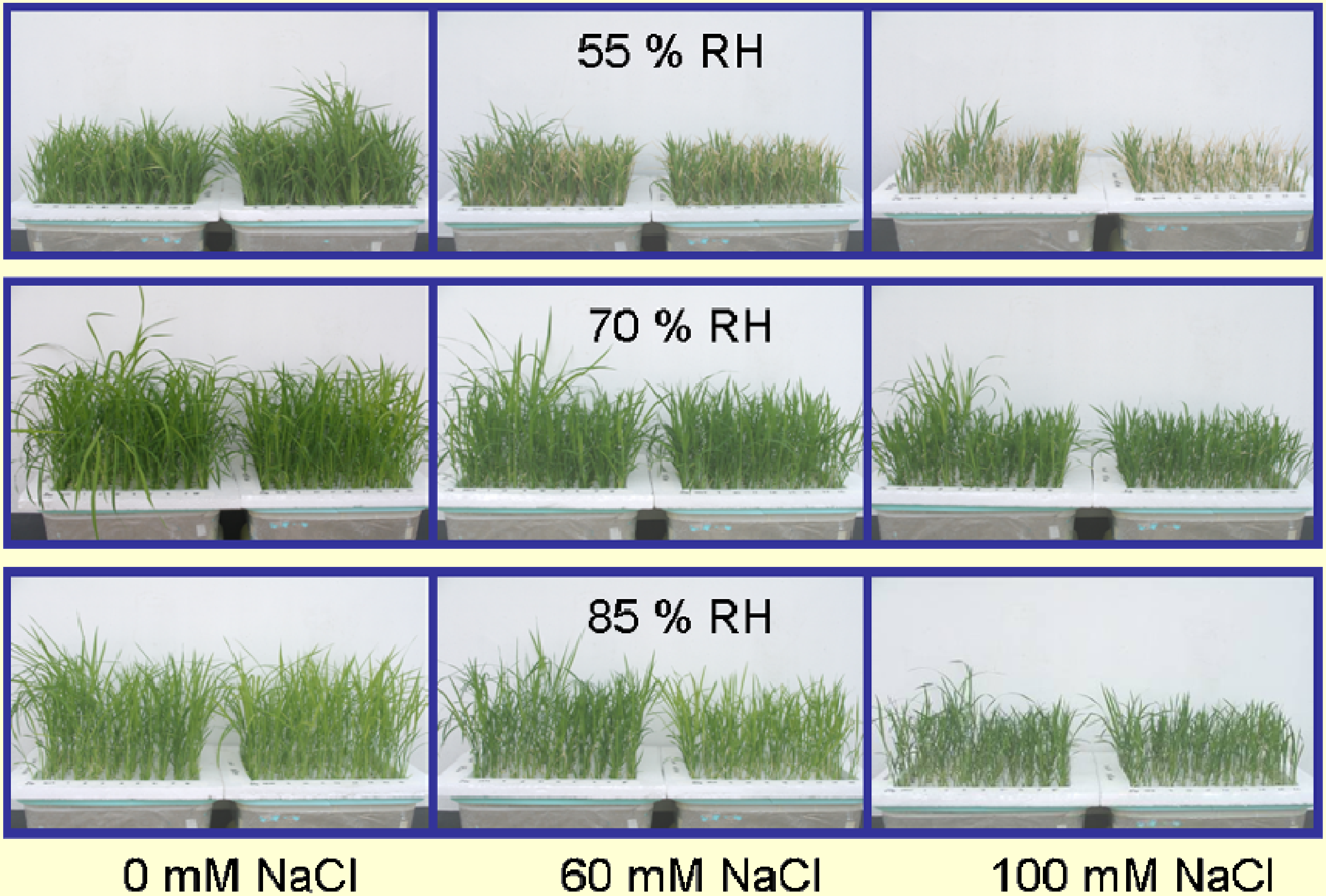
10 days submerged
in saline water

Sub1 only ***SalTol+ Sub1***

Major rice deltas and sea level rise



Different RH regimes and seedling growth under salt stress



Jagadish et al. 2012. J Agron Crop Sci. 198; 360-373

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IRRI

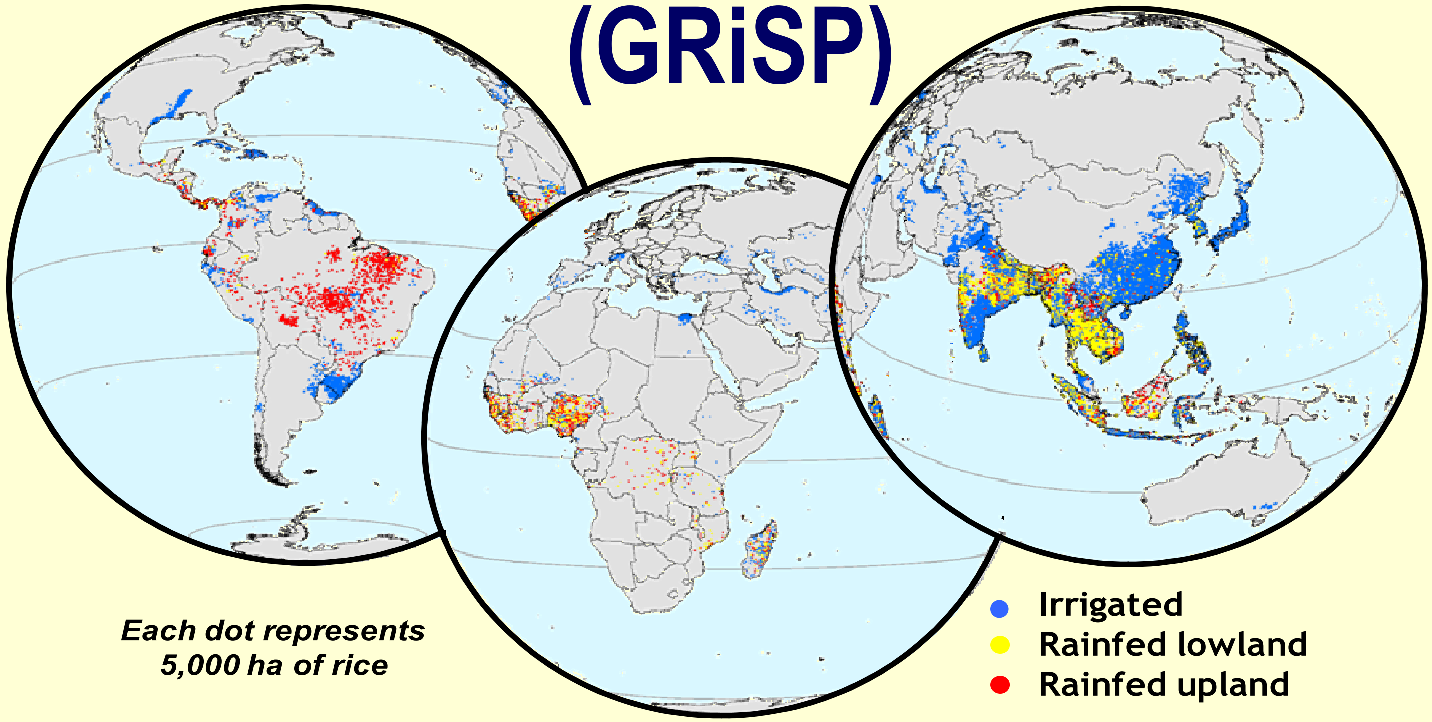
AfricaRice

CIAT

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

CGIAR Thematic Area 3: Sustainable crop productivity increase for global food security

A Global Rice Science Partnership (GRiSP)



An evolving alliance of IRRI, AfricaRice & CIAT with Cirad, IRD, JIRCAS and hundreds of research and development partners worldwide

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Financial support

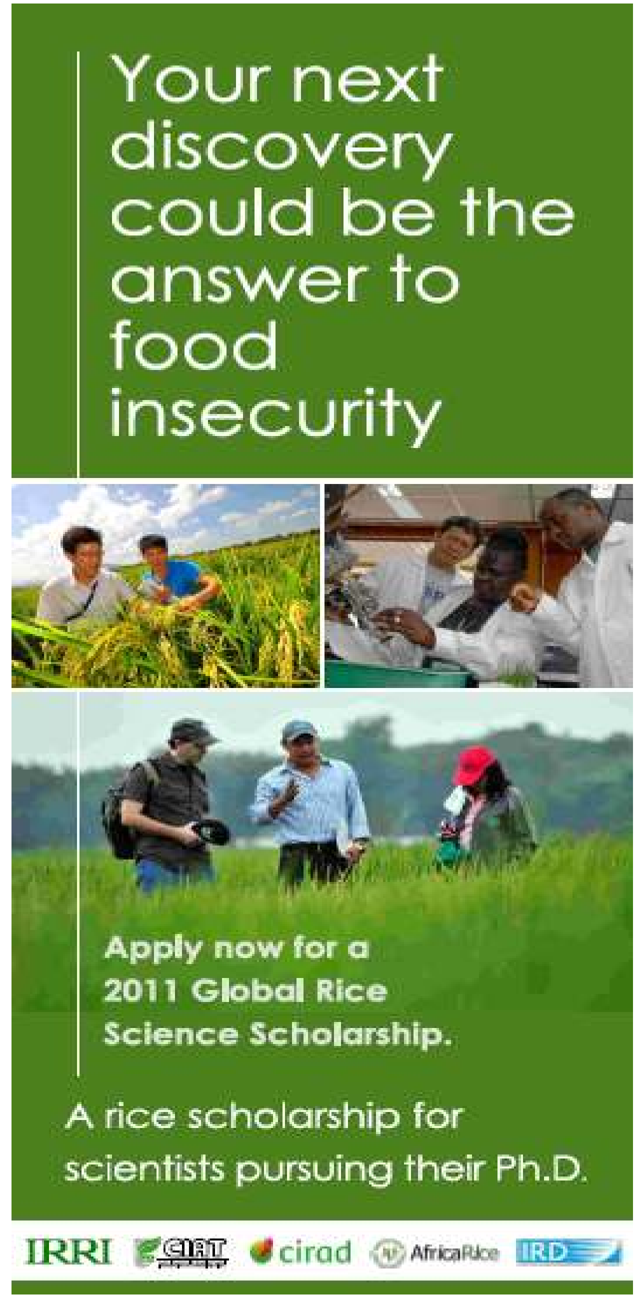
BILL & MELINDA GATES foundation

USAID FROM THE AMERICAN PEOPLE

BMZ Federal Ministry for Economic Cooperation and Development

The Lee Foundation Rice Scholarship Program

http://www.grisp.net



http://grisp.irri.org/Global RiceScience-Scholarships

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