Improving salinity tolerance in rice, progress in QTL mapping and marker assisted backcrossing

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IRRI

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IRRI

Speeding the Development of Salt-tolerant Rice Varieties through Marker-assisted Selection and their Dissemination in Salt-affected Areas of Bangladesh

Partners:

IRRI

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Bangladesh:

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- Dhaka University (DU): Zeba Seraj
- Bangladesh Institute of Nuclear Agriculture (BINA): Mirza M. Islam

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Building on progress made by the GCP Project G3005.02

Revitalizing Marginal Lands: Discovery of Genes for Tolerance of Saline and P-Deficient Soils to Enhance and Sustain Productivity

Generation
A CGIAR Challenge Programme

Project Rationale

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- **Salt stress currently affects more than 22 m ha in S & SE Asia, about one million ha in Bangladesh**
- **Disproportionately affect resource poor farmers with fewer livelihood options**
- **Rice productivity in these areas is low but can be increased by at least 2 t ha^{-1}**
- **Coexistence of multiple stresses necessitates the need for novel approaches:**
  - Higher levels of tolerance
  - Combining tolerances of multiple stresses
  - More efficient and cheaper marker systems for MABC
- **Progress make in fine-mapping a major QTLS (*Saltol*) associated with tolerance through (CGP-P2)**

Project Activities

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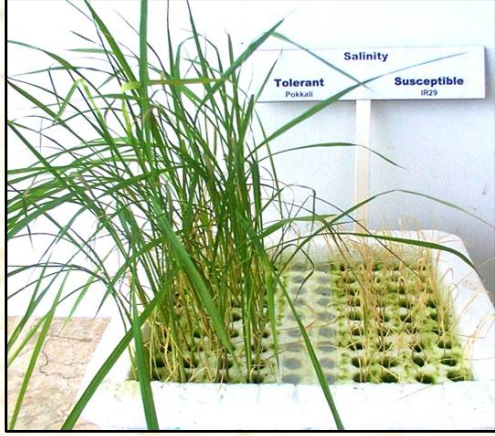
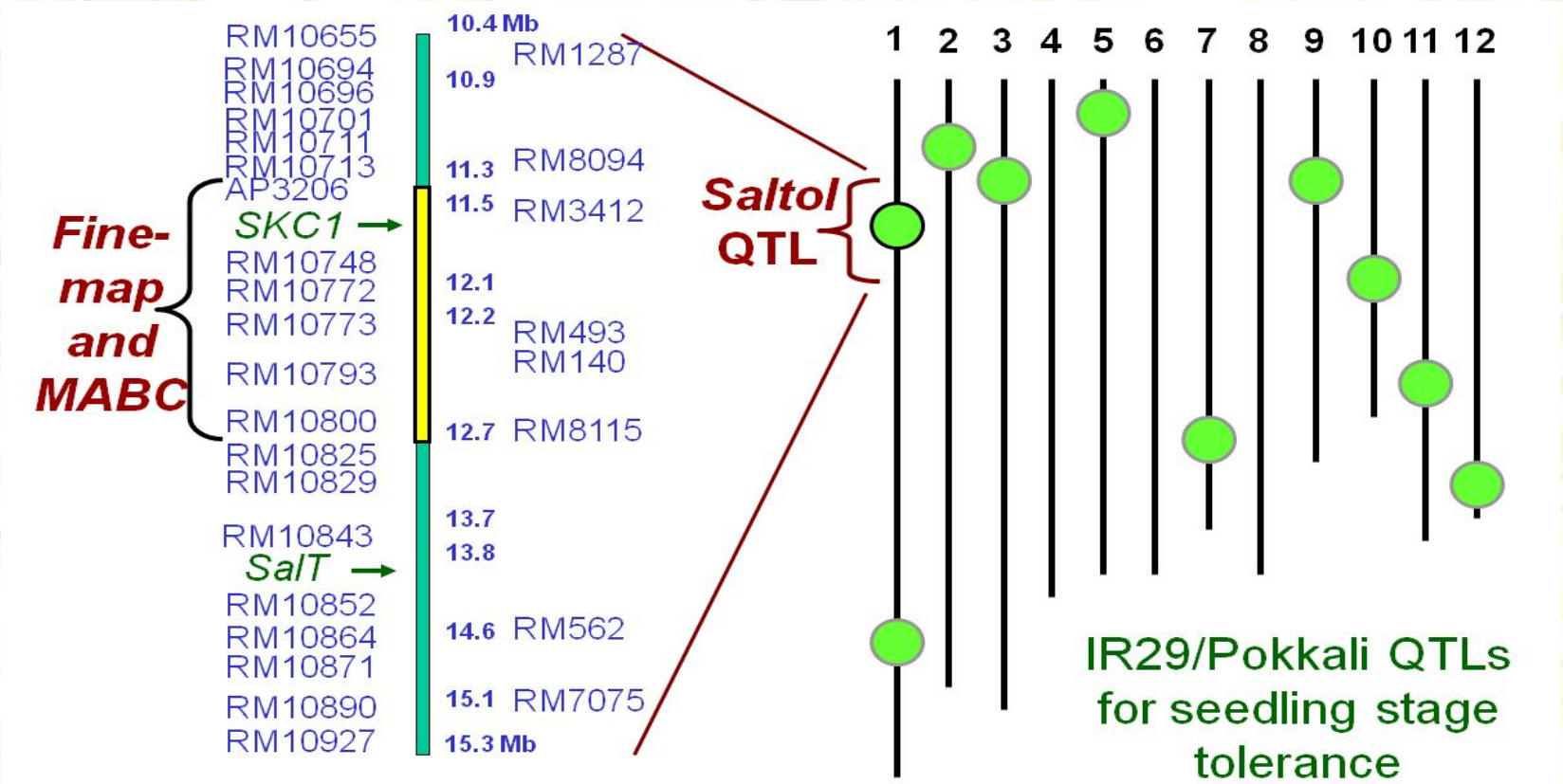
- Introgression of salt-tolerance QTL, *Saltol*, into popular varieties
- Evaluate introgression lines in farmers' fields
- Assess the impact of introgression lines and other tolerant varieties in farmers' fields
- Strengthen the capacity of national research institutions in MABC

1. Introgression of salinity-tolerance QTLs into popular varieties



- **IR29/Pokkali RIL population**
  - Multiple QTLs identified for seedling stage tolerance, Na^+ exclusion and Na^+/K^+ ratio
- ***Saltol* QTL on chromosome 1**
  - Major QTL (R^2 = 45%) Confirmed with SSRs
  - Tolerant RILs FL378 and FL478 identified



1.1. Develop & valide a MABC system for introgression of *Saltol*

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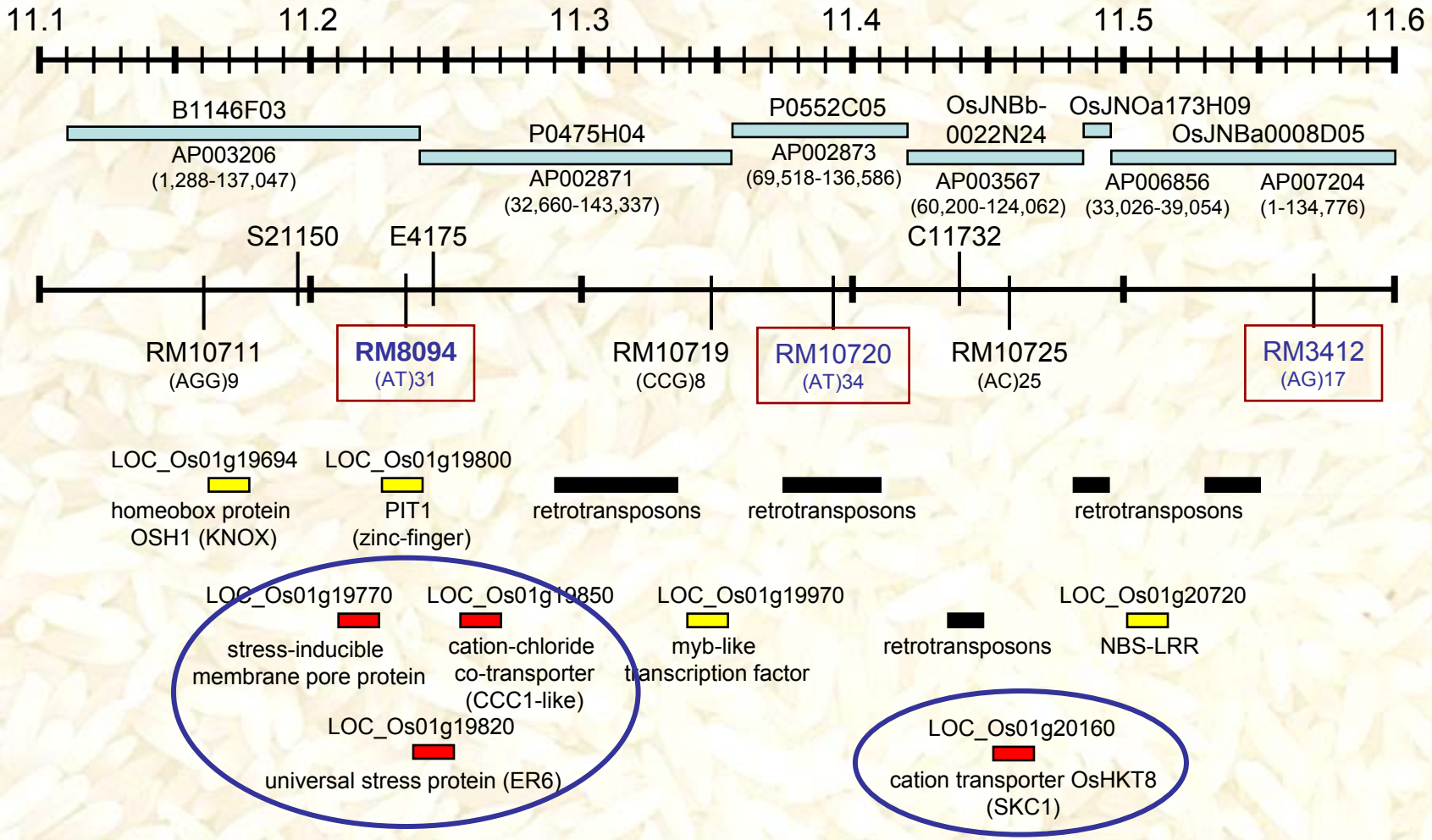
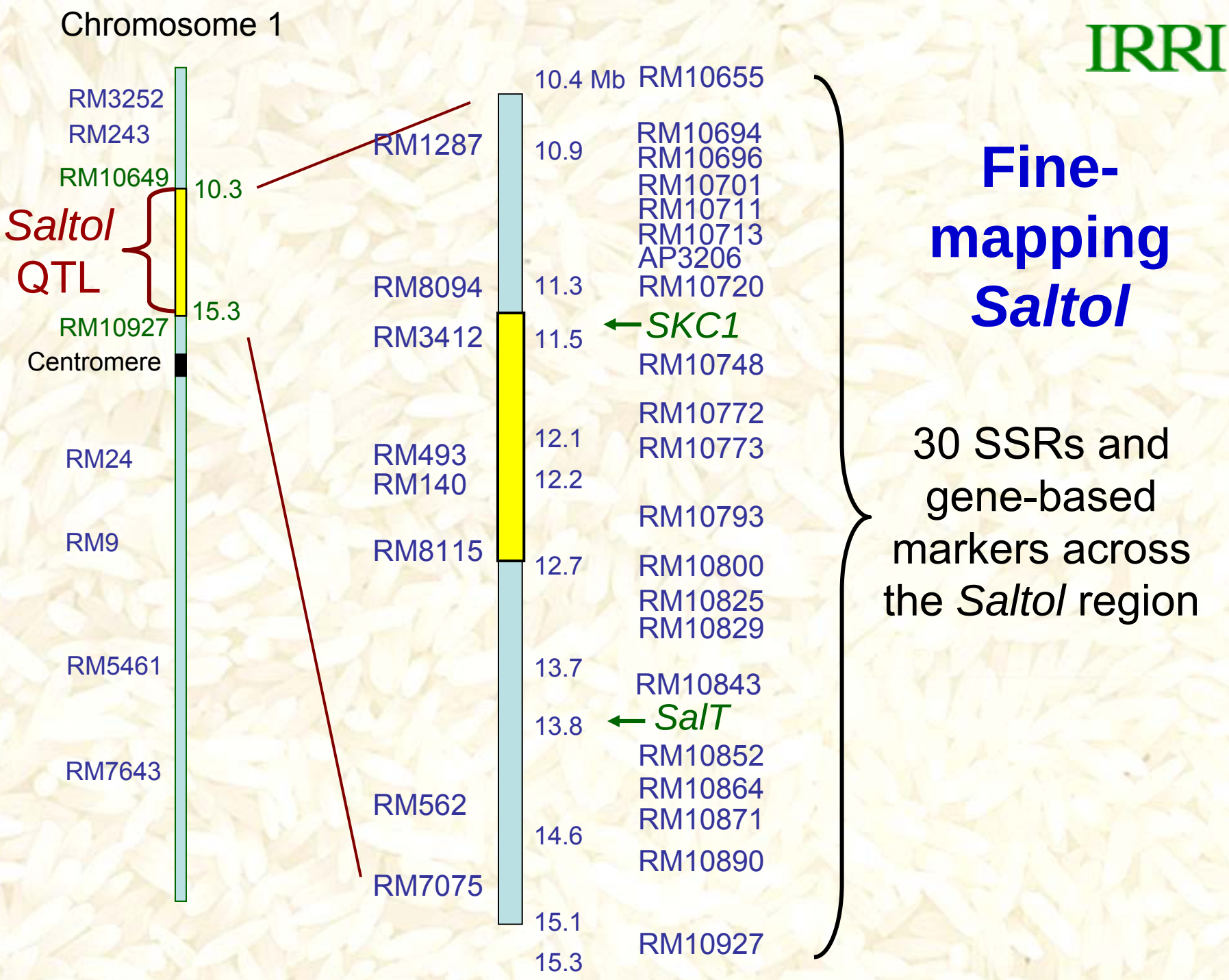
Physical map of *Saltol* region (11.1-11.6 Mb on chr 1)




Chromosome 1
RM3252
RM243
RM10649
10.3
Saltol
QTL
15.3
RM10927
Centromere
RM24
RM9
RM5461
RM7643
RM1287
RM8094
RM3412
RM493
RM140
RM8115
RM562
RM7075
10.4 Mb
10.9
11.3
11.5
12.1
12.2
12.7
13.7
13.8
14.6
15.1
15.3
RM10655
RM10694
RM10696
RM10701
RM10711
RM10713
AP3206
RM10720
SKC1
RM10748
RM10772
RM10773
RM10793
RM10800
RM10825
RM10829
RM10843
SalT
RM10852
RM10864
RM10871
RM10890
RM10927
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Fine-mapping Saltol
30 SSRs and gene-based markers across the Saltol region

1.2. Introgression of *Saltol* into BRRI dhan 28 and BR11

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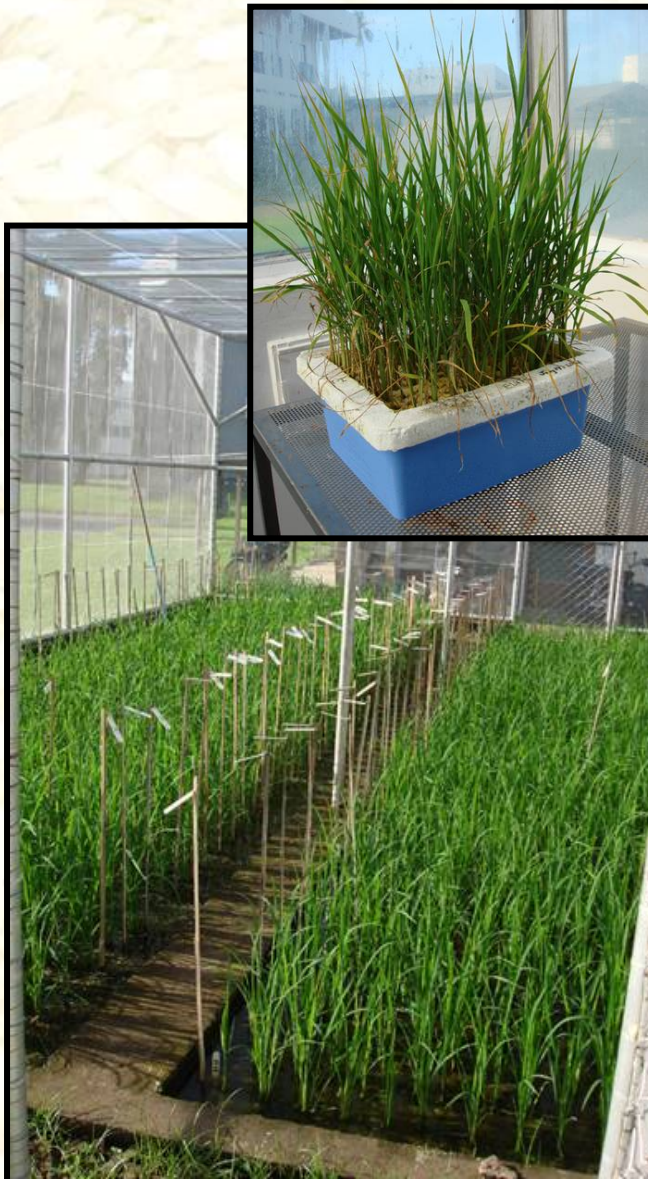
- **Goal:** Rapidly and precisely transfer *Saltol* QTL to popular varieties
- **MABC system**:
  - Foreground markers
  - Recombinant markers
  - Background markers
- **Populations initiated:**
  - FL478 and FL378 tolerant donors
  - **BRRI dhan28, BR11**, IR64, Swarna, Samba Mahsuri



BR28-*Saltol* (BC_3F_2)

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BR28

BR28-*Saltol*

Responses of BR28-*Saltol* and BR28 to salt stress (3 reps, 5 sub-samples/rep)

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Genotype	SES score		% Survival		Concentration (mmol/g dwt)		Na-K ratio
	Exp 1	Exp 2	Exp 1	Exp 1	$[Na^+]$	$[K^+]$	
BR28-*Saltol*	**4.2**	**5.3**	**93.5**	**58.3**	**0.015**	**0.492**	**0.018**
BR28	**7.0**	**9.0**	**63.0**	**0.0**	**0.123**	**0.490**	**0.148**
IR29	8.3	9.0	59.8	0.0	0.196	0.462	0.250
FL 478	3.3	4.3	100.0	91.7	0.008	0.443	0.011
Significance	***	-	-	-	***	***	-
$LSD_{0.05}$	0.69	-	-	-	0.0018	0.008	-

Mechanisms of salinity tolerance: Seedling Stage

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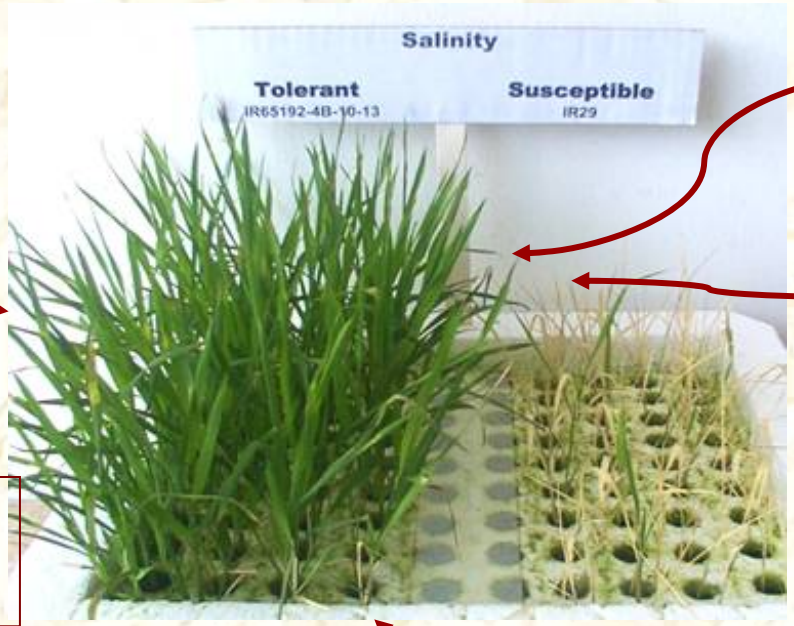
High vigor

Upregulation of antioxidants

Regulation of uptake (Na^+ exclusion)



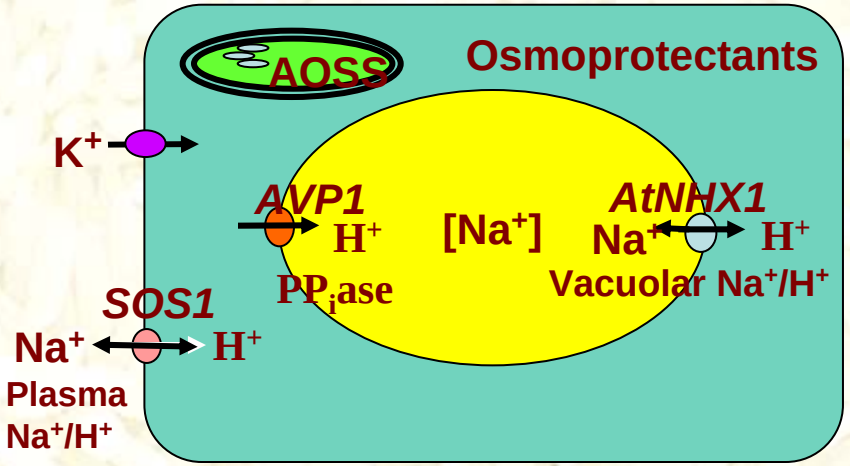
Protective metabolites

Responsive stomata

Compartmentation into older tissue

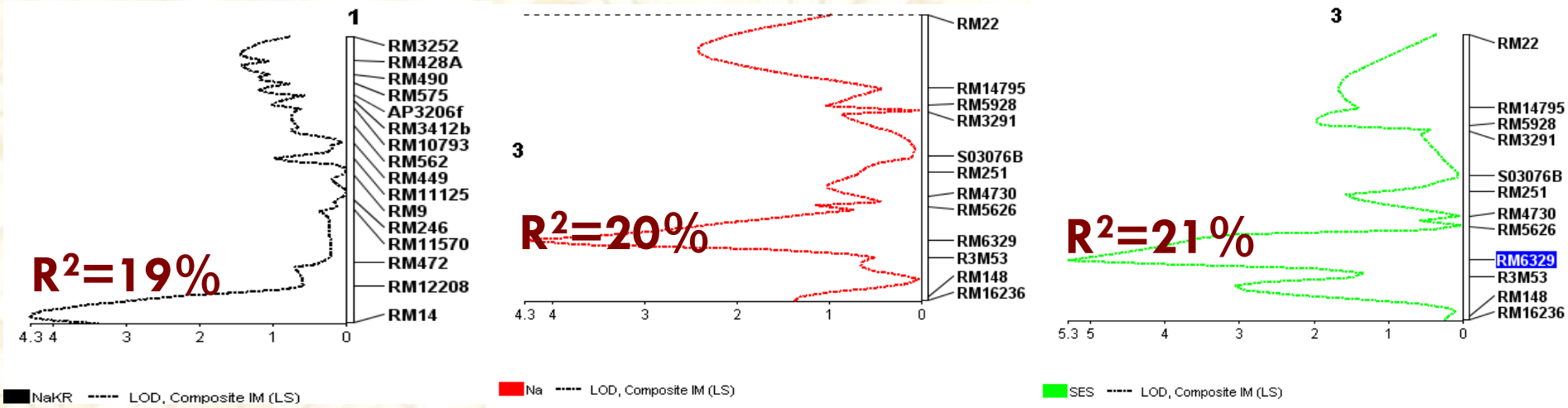
Sequestering Na^+ in vacuoles (tissue tolerance)

Controlled Na^+ transport between roots and shoots



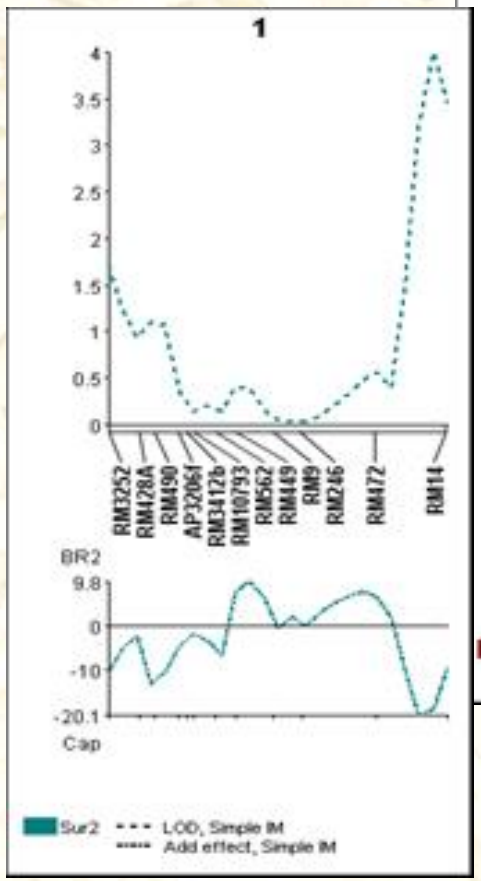
1.3. Mapping of additional QTLs for further targeting through MABC

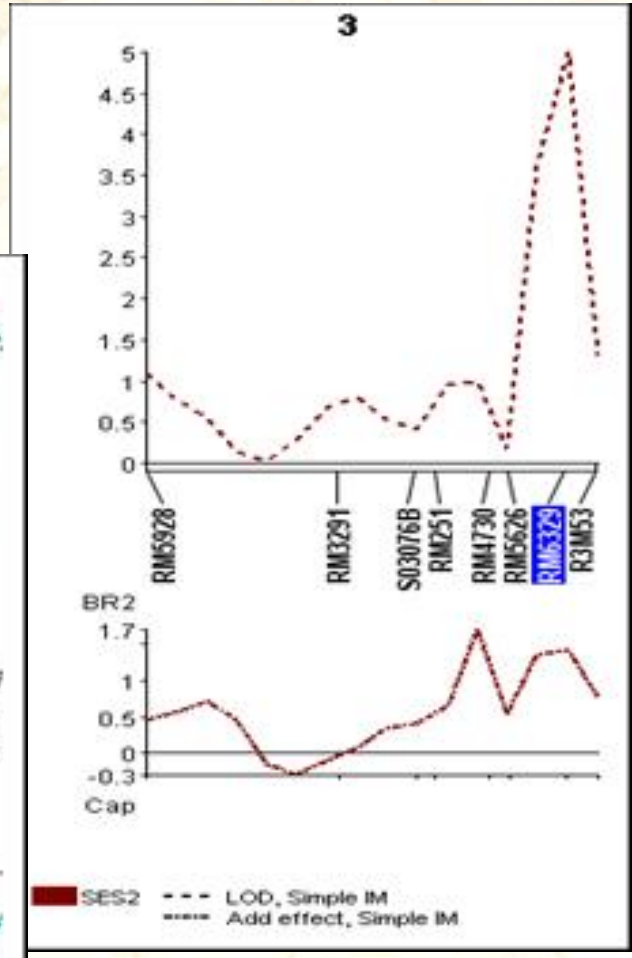
- Non-*Salto* Pokkali QTLs (Chr 2, 9, 12)
- FL478 / Azucena tolerance QTLs (Chr 1, 3, 6)



BRRI dhan29/Casule QTLs

- Capsule is a highly salt tolerant landrace from Bangladesh
- Some QTL have similar locations with those from Pokkali
- New QTLs on long arm of chr. 1 (distinct from *Saltol*) and on chr. 3

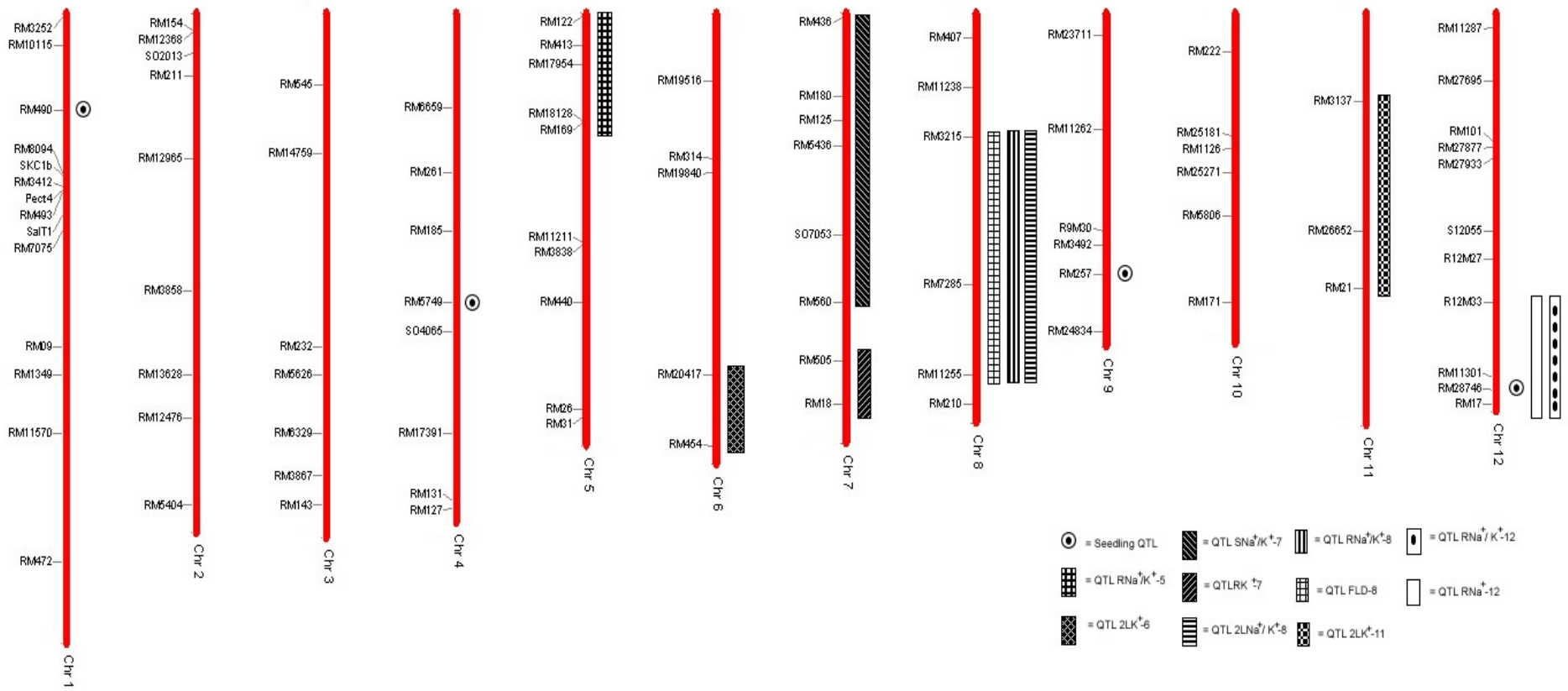




Visual scoring (SES)

Survival under salt stress

Boilam / BRRI dhan27 (Ch 7,8,12)



Seedling and reproductive stage

Dhaka University

2. Seed production and evaluation of *Saltol* lines in farmers' fields

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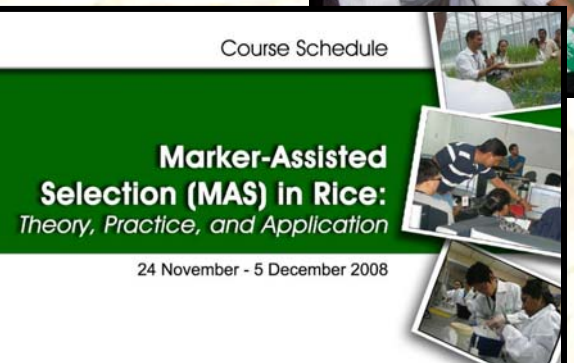
- Seeds of BR28-*Saltol* Shipped from IRRI to Bangladesh
- Field testing will start in the dry season of 2009-2010

- Seeds of BR11-Saltol is being produced in Bangladesh for field evaluation during the wet season of 2010

4. Capacity building for BRRI, BINA & DU

1. A MAS Laboratory completed at BRRI through Capacity Building á la Carte (SP5)
2. Two workshops on MABC at BRRI and IRRI

IRRI (24/11-5/12,) and BRRI (Nov 18-27) diverse topics with hands-on lab training



3. Workshop on Participatory research, seed health and management, & socio-economic data analysis in Bangladesh (Oct-Nov)
4. Degree training: One PhD completed, two ongoing
5. Short visits: 5 participants form India, Bangladesh, Indonesia (SP5)

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Data format and release

- Available data include: genotyping data for (Gel images, Excel summaries); and phenotyping data
- Forms sent to partners to organize their data for deposition in the GCP registry

Link with other projects

- Building on achievements of Project 2 (SP2)
- Challenge program on Water and Food
- BMZ-funded project on gene discovery and developing efficient genotyping systems

Product delivery and impact on users

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Delivery:

- Participatory variety selection Networks
- IRRI networks (CURC, INGER, Breeding networks)

Impact:

- Evaluation and farmers feedback is being solicited every season
- Evaluation of *Saltol* lines will start next year in farmers' fields

Impact in farmers fields: genetic tolerance & proper management:

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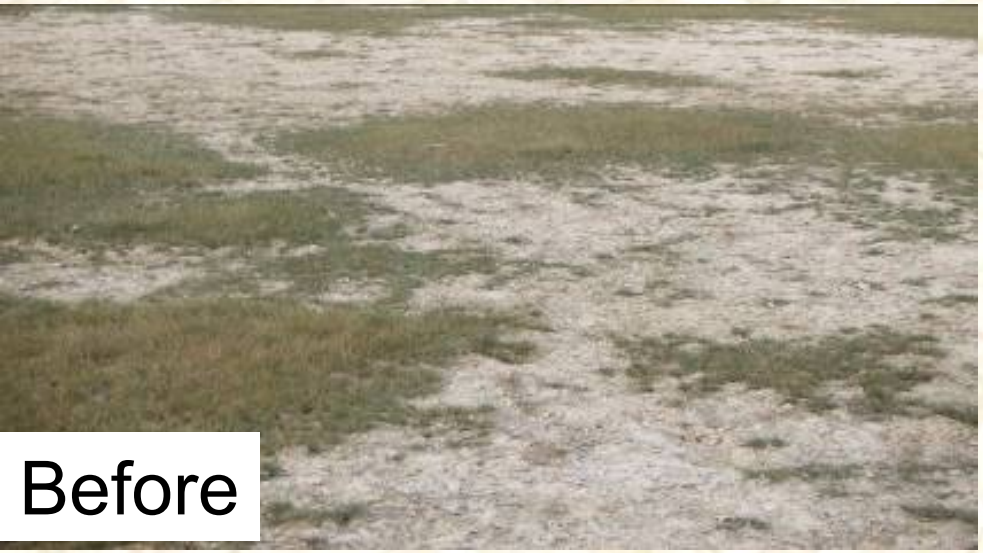

Future activities

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- **Characterize and pyramid multiple QTLs**
  - Combine multiple QTLs for salinity
  - QTLs for stresses that are co-existing (*Saltol+Sub1, Saltol + Zn def. tolerance; Saltol+Pup1)*)
- **Identify additional "novel" QTLs**
  - Use different salt tolerant donors
  - Target reproductive stage tolerance
- **Test new markers and technologies**
  - Develop markers that are easier to use
  - Increase efficiency using high-throughput SNP genotyping