

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

GCP Project #2

Progress and expected impacts of
Saltol and *Pup1* QTLs on rice
improvement

IRRI



Generation

A CGIAR Challenge Programme

Rice Science for a Better World

Project Breeding Objectives

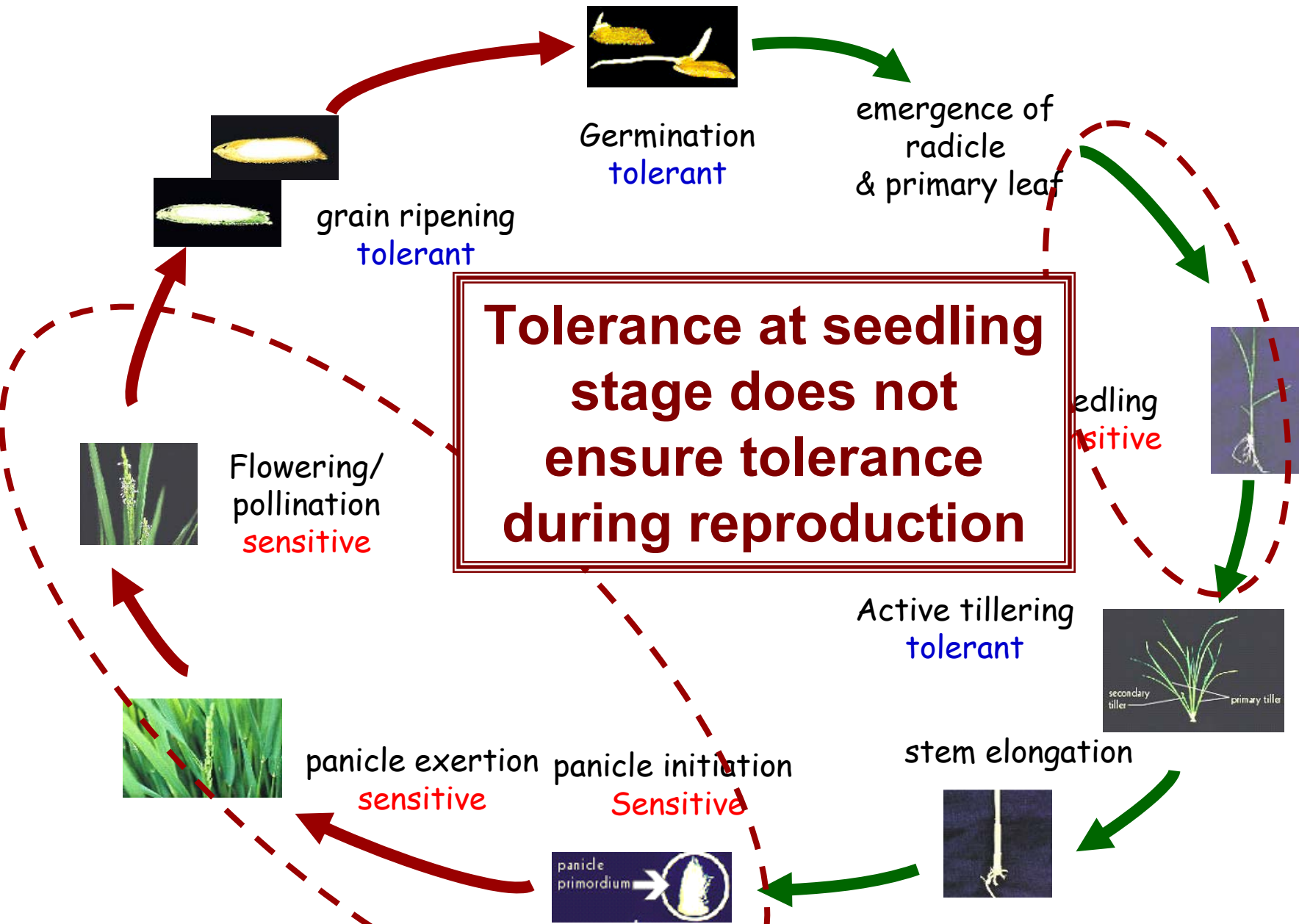
- Precision mapping of *Saltol* & *Pup1* loci
- Develop/validate markers for both QTLs & a MAB system for introgressing them into popular varieties and elite lines
- Identify and validate the candidate genes involved at the two loci
- Functional confirmation and assessment of positive and any negative impacts using NILs
- Strengthen the capacity of NARES partners in MAB and other relevant technologies

Salinity: Crop type and target Regions

- Salinity affect > 21 m ha in S and SE rice areas and considerably reduce productivity
- Target areas:
 - Salt affected coastal areas (coastal Bangladesh)
 - Inland saline and alkaline areas

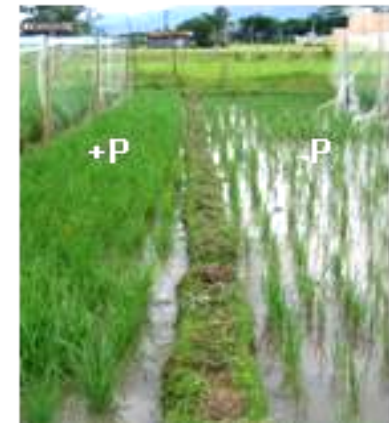
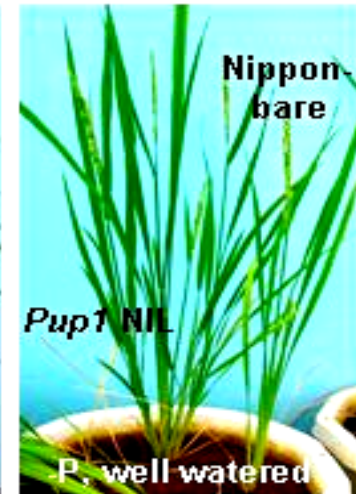
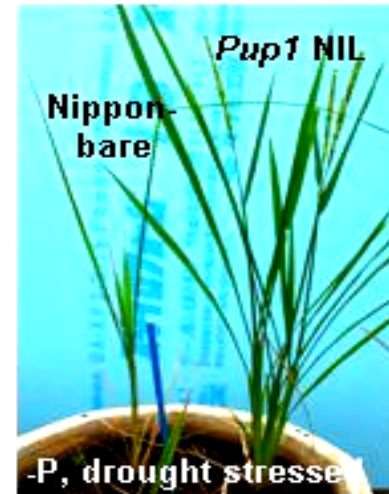


Salt stress in rice



Phosphorus deficiency: Crop type and target Regions

- Phosphorus deficiency affects about 50% of rice areas
- Target areas:
 - Uplands of South and South East Asia (Indonesia)
 - Other P-deficient soils (acid, alkaline, peat soils)
 - Drought-prone areas



Outputs and products

- A Marker Aided Breeding system to incorporate major QTLs associated with tolerance
- Better understanding of tolerance mechanisms
- Efficient large-scale phenotyping system
- Trained NARES capable of applying MAB package in their breeding
- Popular varieties tolerant to salinity and phosphorus deficiency developed and disseminated in target areas

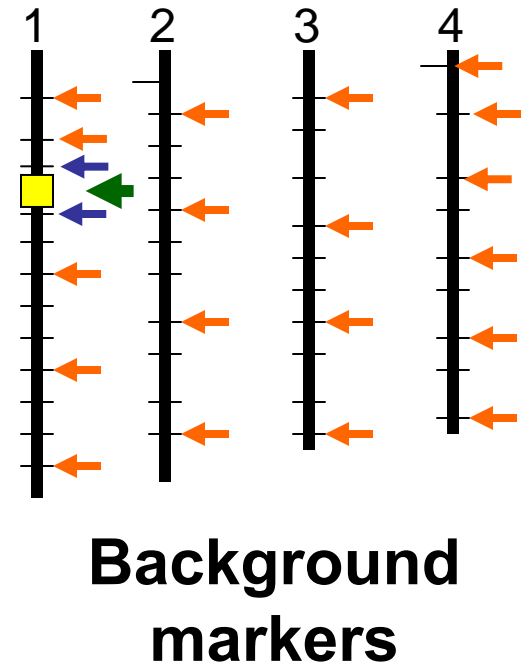
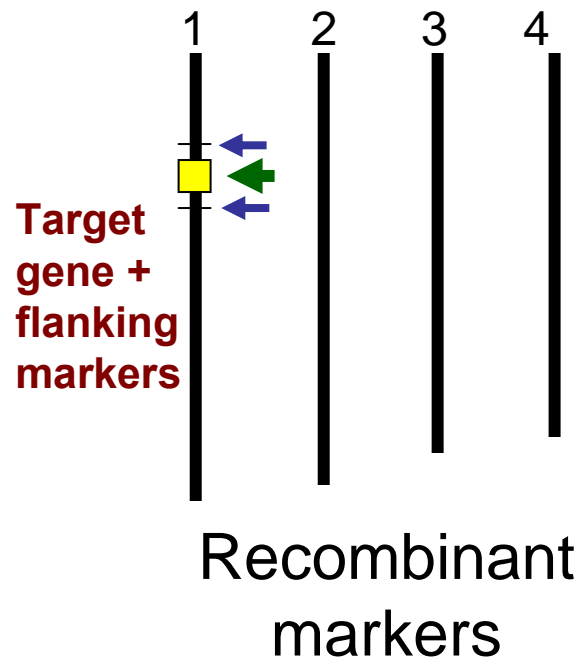
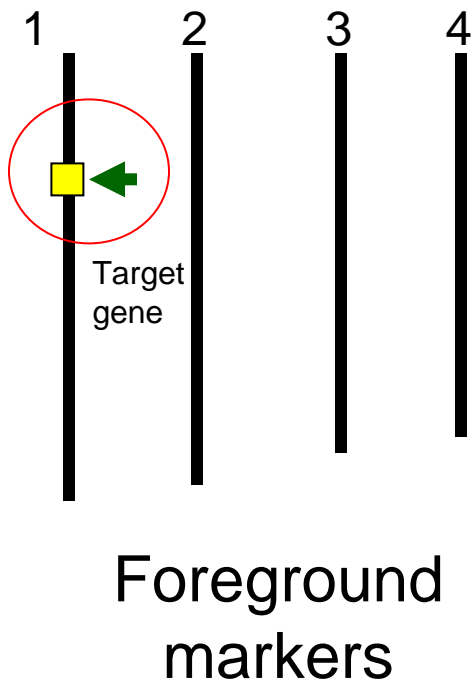
A MAB system for *Pup1* and *Saltol*



➔ Major QTLs identified for both stresses

QTL	Ch	R ²	LOD	Interval
<i>Saltol</i>	1	~ 65%	>8	~ 1.2 Mb
<i>Pup1</i>	12	~ 80%	16.5	~ 0.3 Mb

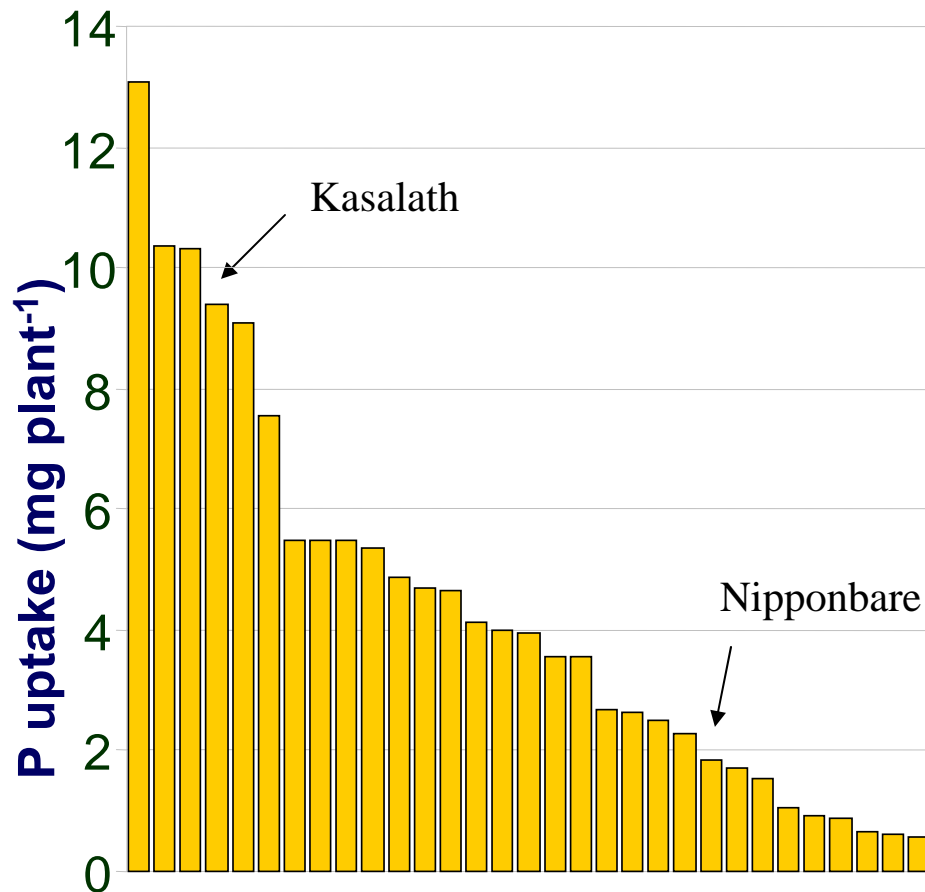
MAB strategy



MAB for P-deficiency tolerance

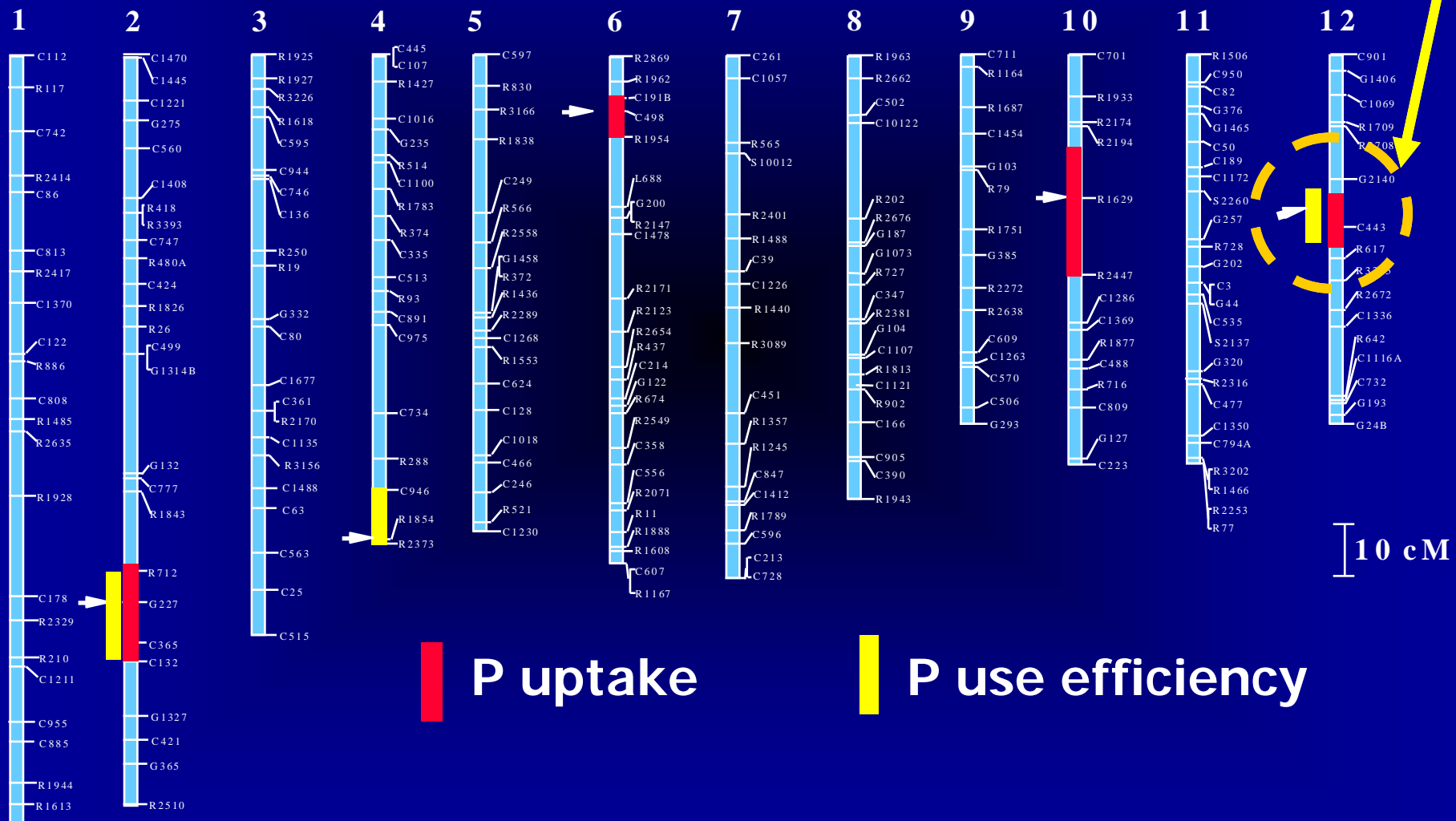
> 20-fold difference in P uptake with traditional varieties being superior

- Mapping population developed from Nipponbare x Kasalath and used in QTL mapping



Four QTLs for P uptake detected on chromosomes 2, 6, 10, 12

Pup1



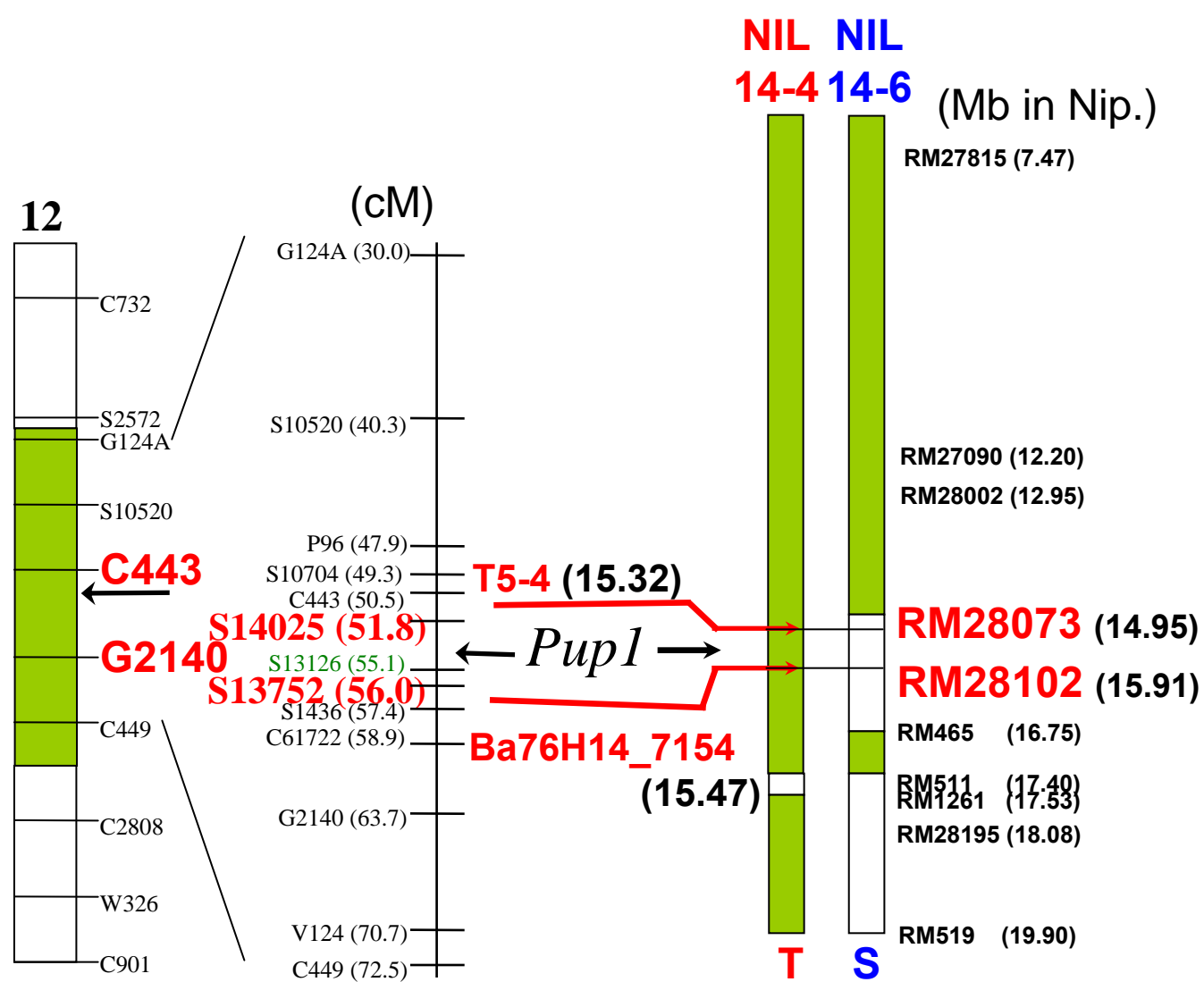
P uptake

P use efficiency



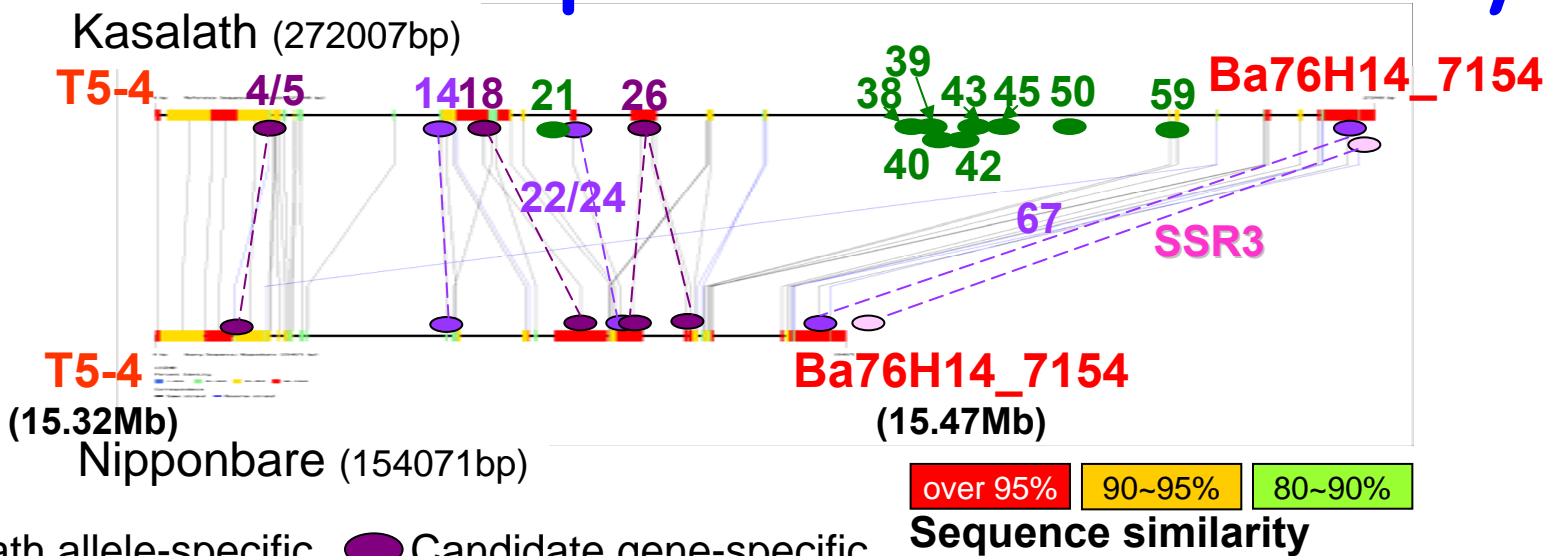
The one on chromosome 12 is a major QTL (~13 cM)

Fine mapping of *Pup1* locus on chr 12



- *Pup1* fine-mapped to within 272 kb and sequenced
- Candidate genes short listed and are being analyzed through RNAi and overexpression

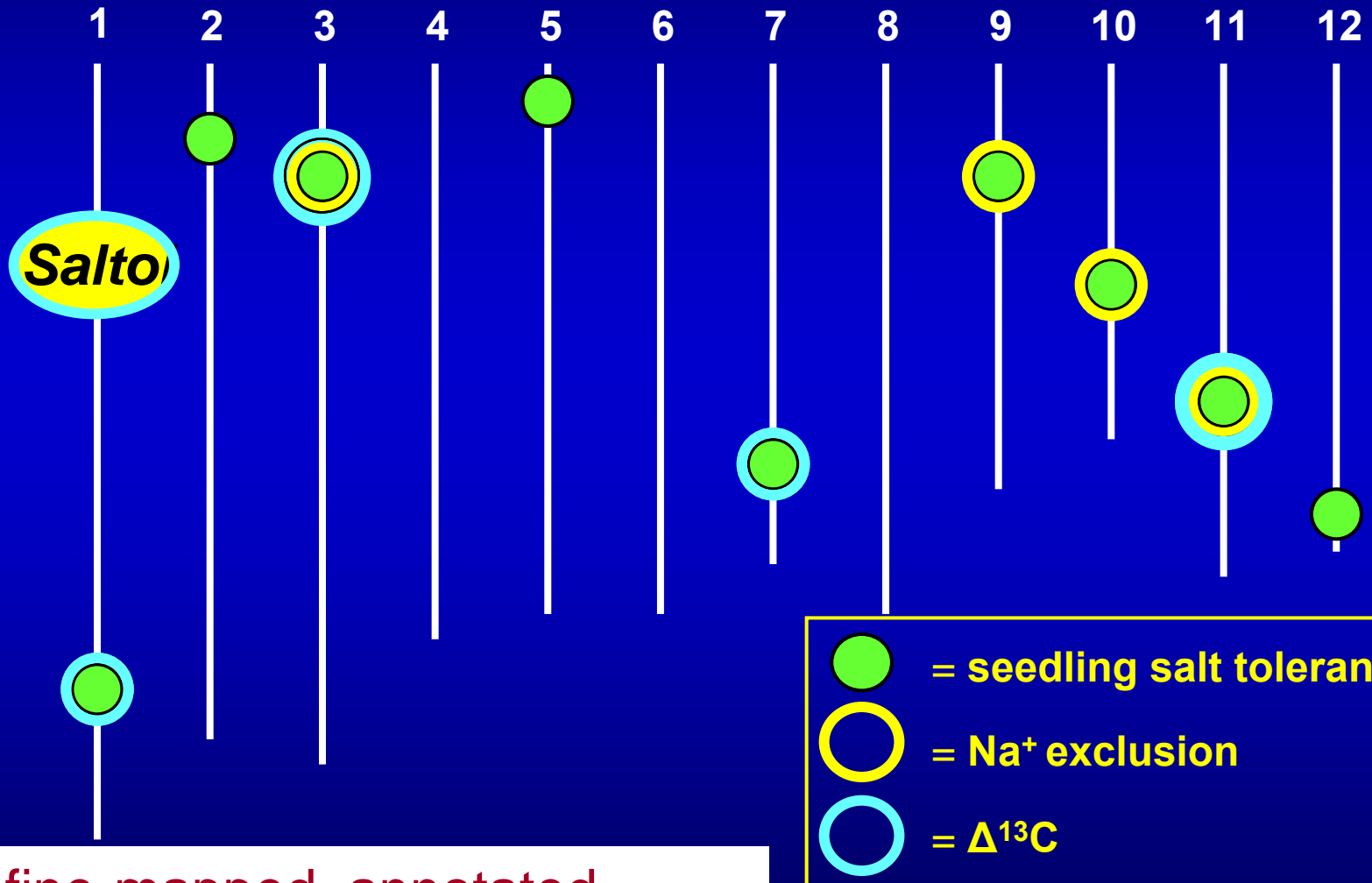
Gene- & allele-specific markers for *Pup1*



- Kasalath allele-specific dominant markers
- Candidate gene-specific Co-dominant markers
- SSR markers developed
- to be developed for candidate genes

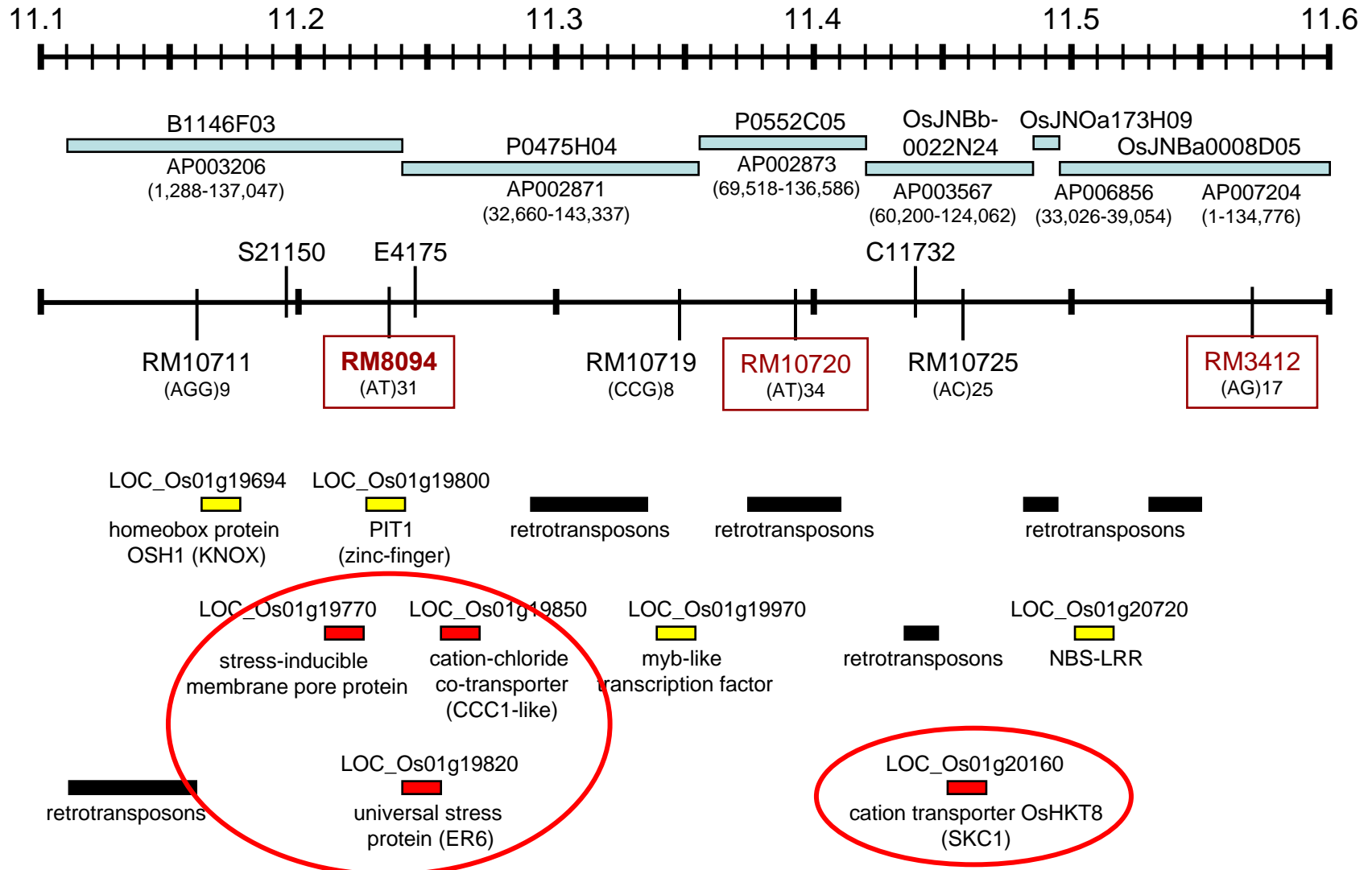
- Markers (SSRs, gene-specific) developed & are being used to transfer *Pup1* into 3 popular upland varieties, Dodokan, Situ Bagendit, and Batur
- Nine sets of crosses made
- BC₁F₁ populations genotyped (Foreground, recombinant & background) and BC₂F₁ developed for further analysis

MAB for salinity tolerance

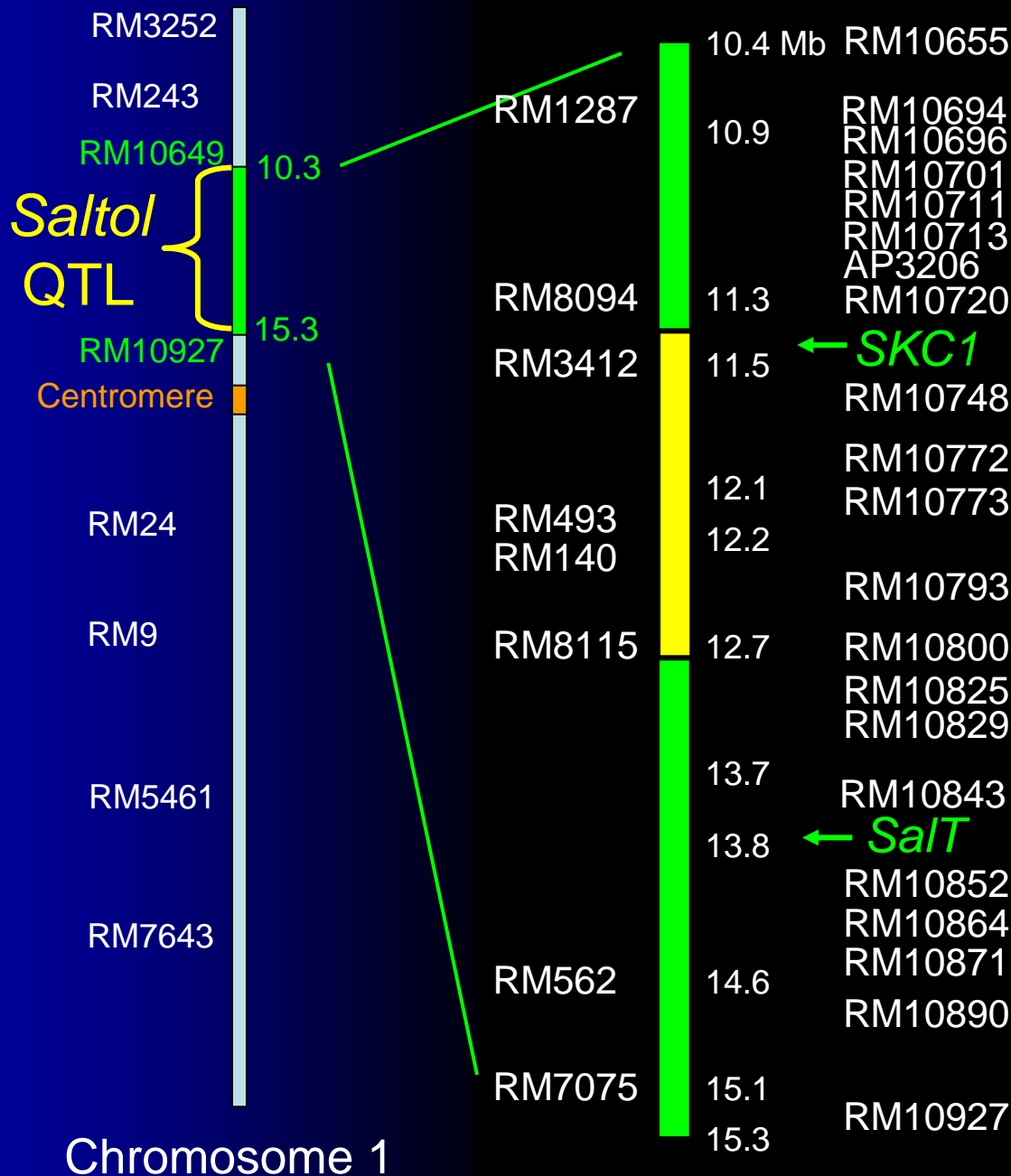


Salto is fine-mapped, annotated genes are being further analyzed

Different types of markers were developed (SSRs, SFPs, gene-specific)



Saltol fine-map



30 SSRs and
gene-based
markers across
the *Saltol* region

Background markers developed for a set of recipient varieties

MAB scheme for *Saltol*

➤ Recipient varieties:

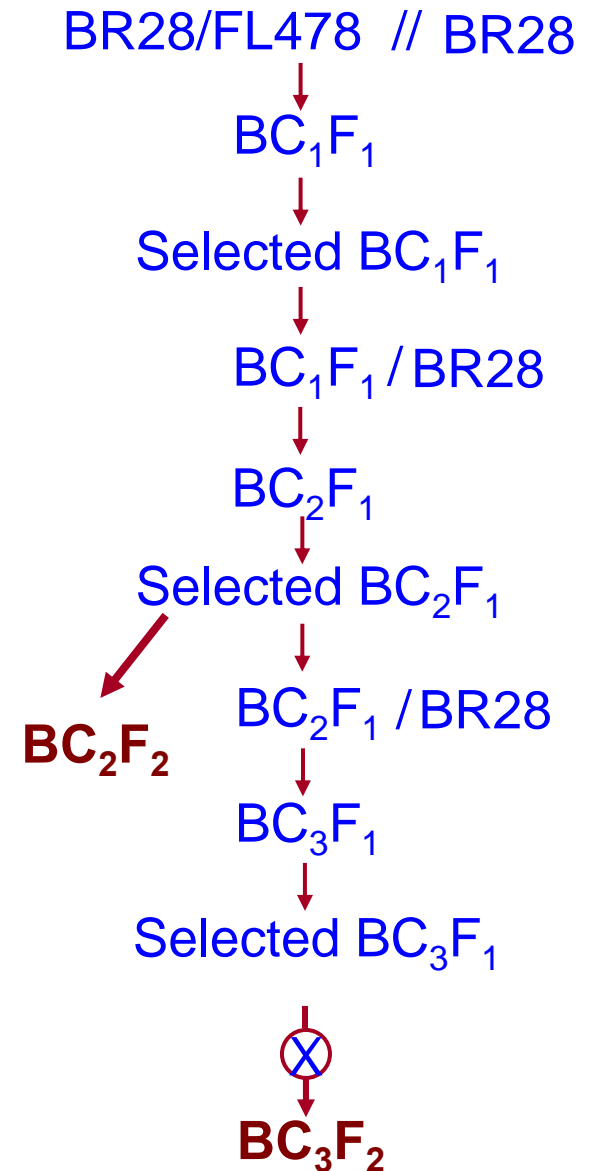
- *IR64* (widely grown), *BR11* and *BRRI dhan 28* (Bangladesh), *swarna*

➤ Donors:

- *Pokkali*, *FL478* and *FL378*

➤ MAB is used to transfer *Saltol*:

- Foreground and recombinant markers used for selection after each cross
- SSRs for background selection



Saltol MAB for BRRI dhan 28

- **Goal:** *Saltol* QTL line with BR28 background
- **Current status:**
 - SSR-selected BC₂F₁ individuals were backcrossed to BR28
 - 1,500 BC₃F₁ plants now growing at IRRI
 - Markers are being used to select individuals to advance to BC₃F₂
- **Confirmation:**
 - BC₃F₂ seeds will be used to confirm the *Saltol* effect in the BR28 background



Saltol MAB for BR11

- **Goal:** Saltol QTL line with BR11 background
- **Current status:**
 - ✦ 90 BC₁F₁ individuals currently being screened for salinity tolerance
 - ✦ Tolerant plants will be rescued and backcrossed to BR11 to BC₂F₁
 - ✦ BC₂F₁ plants will be genotyped with markers for foreground and background selection



Progress in MAB in Bangladesh

Parents:

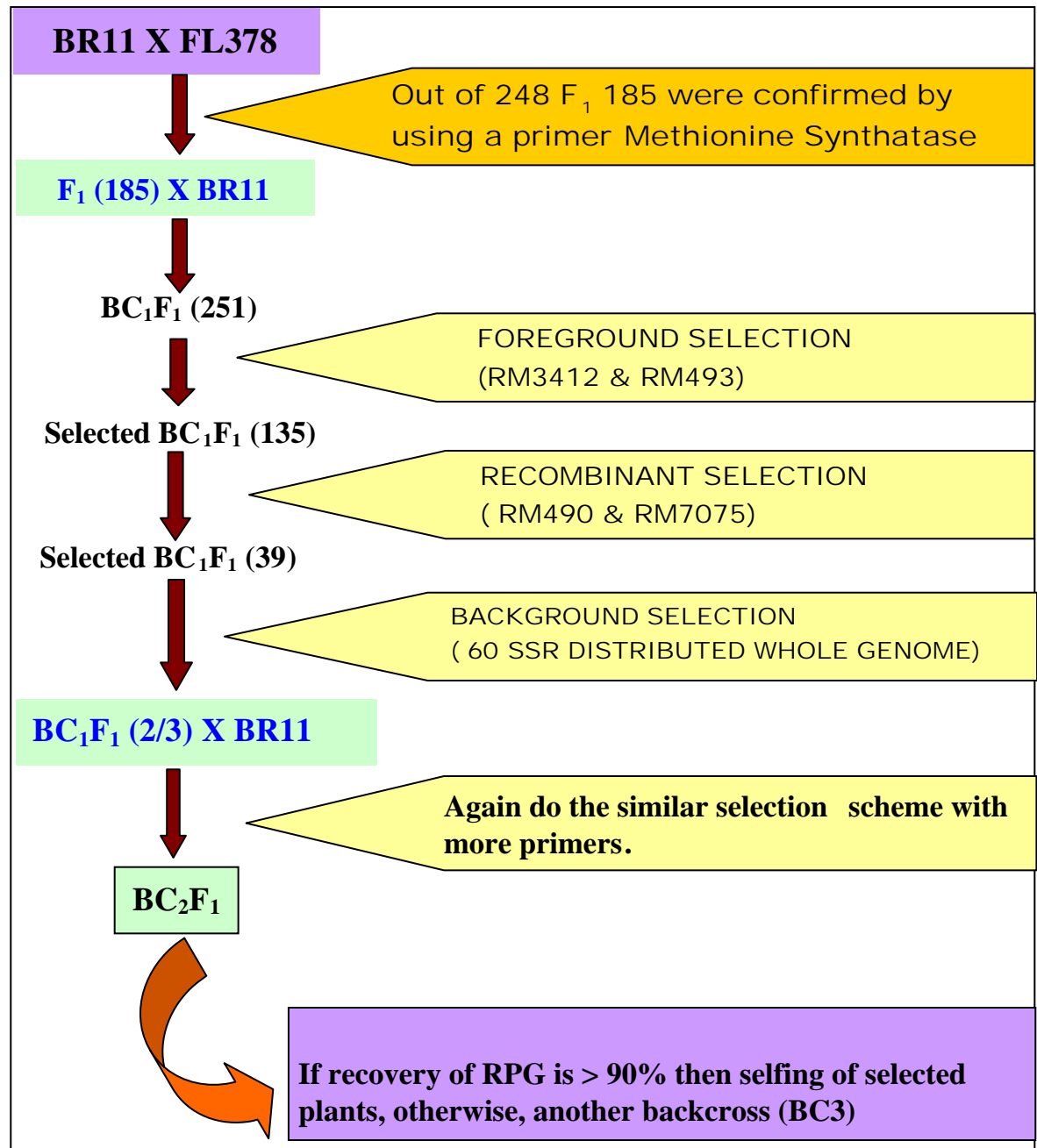
Recurrent:

- ➔ BR11 (T.Aman/WS)
- ➔ BRR1 dhan28 (Boro/DS)

Donor

- ➔ FL378 (NIL from IR29 x Pokkali)

- ➔ Backcrosses: BRR1
- ➔ DNA isolation, marker analysis: DU



Transfer plans

- Training of NARES in MAS and other relevant technologies
 - ◆ Training workshop in MAB (2005)
 - ◆ On-job training
 - ◆ Degree training
- Participatory varietal selection (PVS) networks
 - ◆ INGER
 - ◆ Salinity network
 - ◆ Farmers field days
- Out-scaling and up-scaling
 - ◆ Large-scale seed production and dissemination
 - ◆ Support and involvement of policy makers and development organizations



Constraints to plans of product transfer

- **MAB is efficient but expensive**
- **Capacity of National programs in MAB**
 - Additional degree training
 - In-country workshops
 - Infrastructure (equipments, storage etc)
 - Supplies: availability and funds

Constraints ...

Product delivery

- ✦ Production of sufficient certified seeds for PVS trials
- ✦ Out-scaling on a large scale require varieties to be released first
- ✦ National policies for release of MAB products still the same as that for varieties developed conventionally

IRRI



Rice Science for a Better World

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