Resilience Breeding for Food Security

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Agriculture, Pakistan and Food Security

GDP Share 25%

Labour 48%

Export Earnings >80%

Agriculture Dynamics

Food security

- Self sufficient in cereals, sugar, fruits, vegetables
- Importer of edible oil, pulses, cotton, tea, dry milk

Nutritional security

- Around 50% population suffers nutritional deficiency
- Nearly 44% children are stunted

Challenges

- Population
- Water
- Climate change
- Land
- Pest and diseases
- Salinity and water logging

Population Growth

1951 → 41 million

2012 → 185 million

2030 → 261 million

How to Enhance Agriculture Productivity in climate change scenario?

- **Management**

  May involve huge cost

- **Genetic gain**

  Less cost but needs very strong knowledge base

  Major increase in yield came through improved genetics, often termed as **‘genetic gain’**

  Historically major increase in wheat, corn, milk, meat and eggs through genetic gain

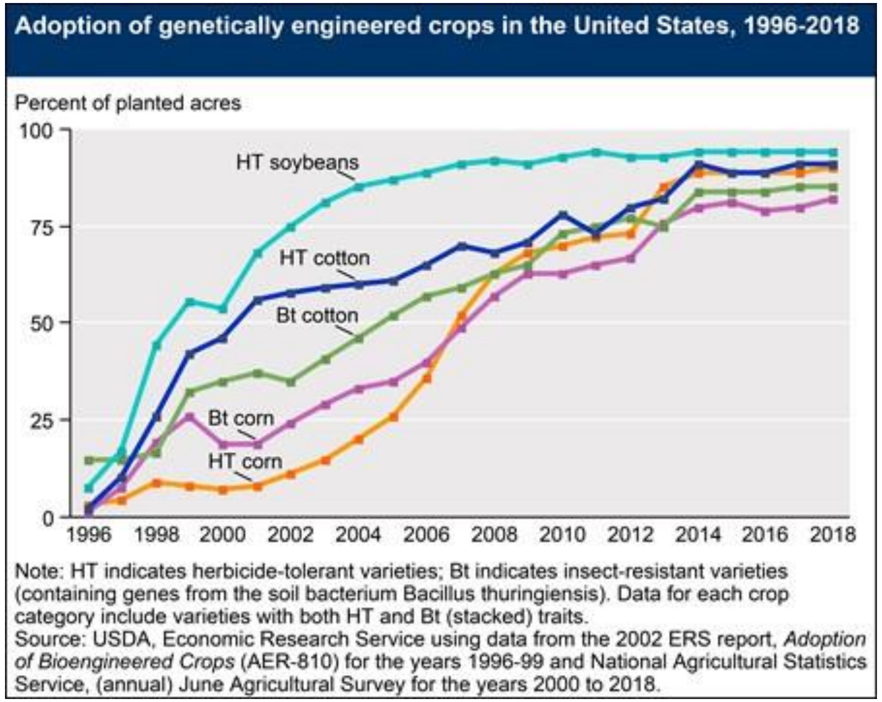
The rate of genetic gain is slow; requires new technologies

Challenges in GM crops;
Only cotton is commercialized

- Regulatory frame work
- Trade issues
- Public acceptance

  Perception from Europe vs North America/South America

  Cotton, oilseed crops, sugar and low lignin trees accepted

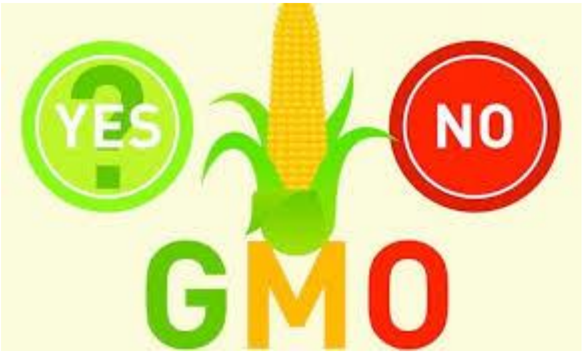


The way out for developing world

- Education of policy makers/masses

- Genomics assisted breeding/speed breeding

- New breeding technologies



New breeding technologies

New breeding technologies (NBTs) include

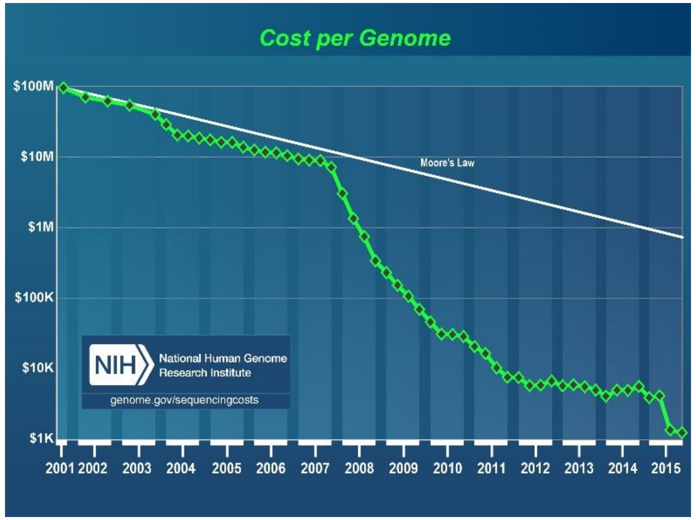
Genome editing/engineering technologies

a) zinc finger nucleases
b) transcriptional activator-like nucleases
c) clustered regularly interspaced short palindromic repeats (CRISPR)/CRISPR-associated Cas9 systems
d) Modified CRISPR/Cas9 for nucleotide change without DNA cutting

Applications in food crops

- Rice; yield, better grain, nutritional value, herbicide tolerance
- Potato; virus resistance, sweetening control, stress tolerance
- Wheat; yield, disease resistance, nutritional value
- Cotton; disease resistance, better quality, nutritional value
- Oilseed crops; higher yield, better quality, nutritional value

Genomics; a silent revolution



Major improvements in sequencing technologies

All major crops/livestock have been sequenced

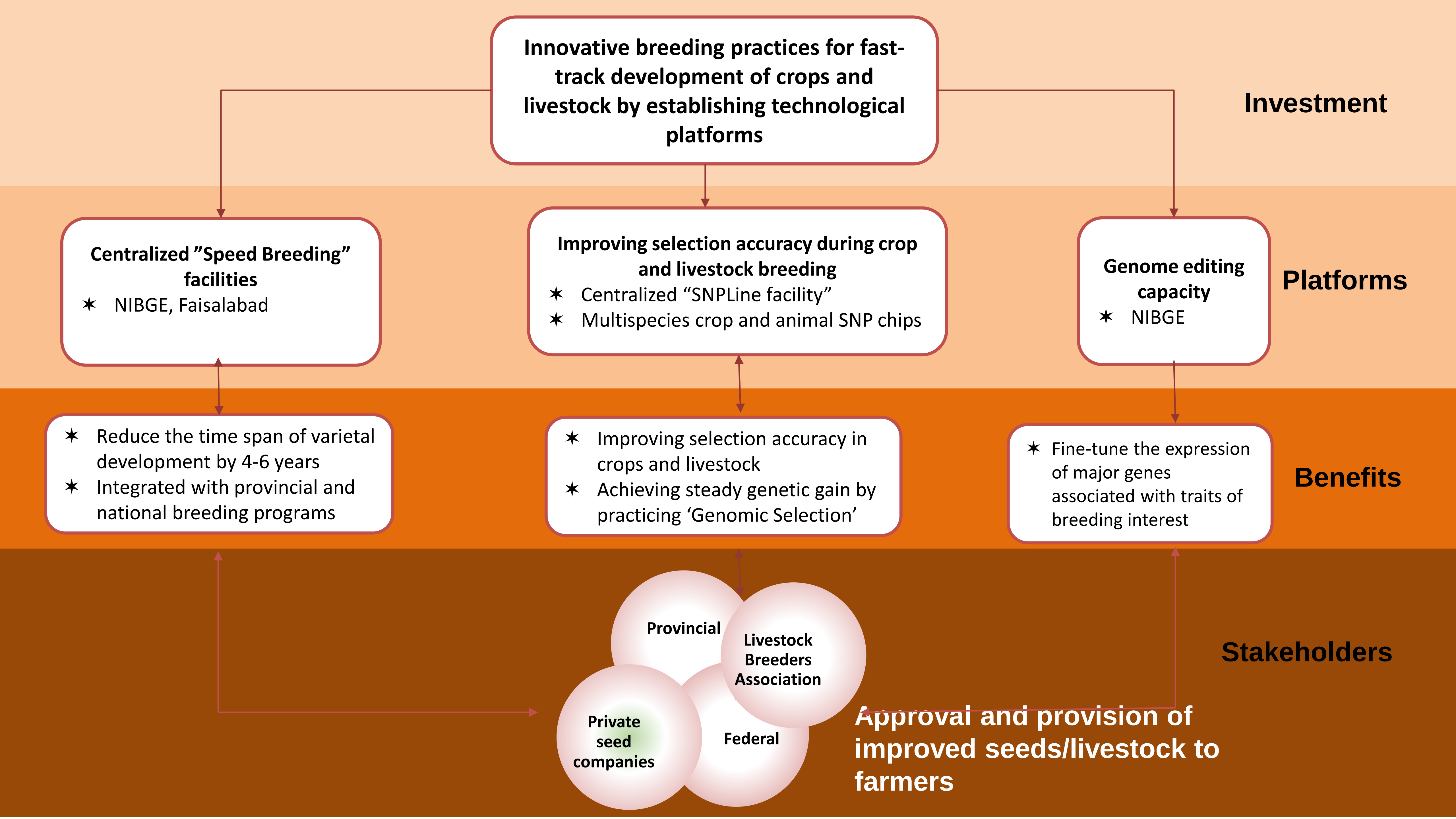
- DNA based marker technologies
- Genotyping by sequencing (GBS);
- Automated phenotyping
- Bioinformatics; Our ability to handle genomic data

Applications

- Genome sequencing of important livestock breeds and crops
- Platform for genomic selection in livestock and plants
- Genome sequencing of microbes selected as microbial factories

New initiatives food security; applications of biotechnology in livestock and poultry sector

- Constitute around 60% of agriculture
- 2.3 trillion Dollar Halal market
- 10-15% growth rate
- Potential to control nutritional deficiency and stunting
- Application of genomics can double milk yield in ten years

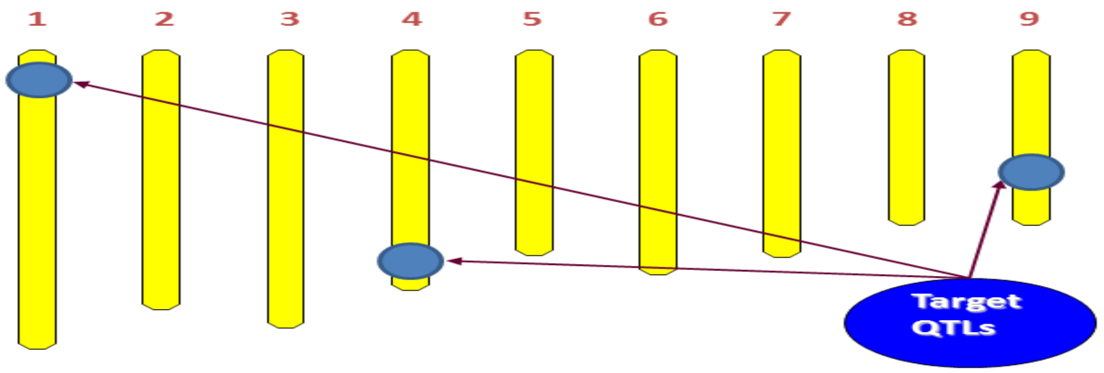

Innovative breeding practices for fast-track development of crops and livestock by establishing technological platforms
Investment
Centralized "Speed Breeding" facilities
✶ NIBGE, Faisalabad
Improving selection accuracy during crop and livestock breeding
✶ Centralized "SNPLine facility"
✶ Multispecies crop and animal SNP chips
Genome editing capacity
✶ NIBGE
Platforms
✶ Reduce the time span of varietal development by 4-6 years
✶ Integrated with provincial and national breeding programs
✶ Improving selection accuracy in crops and livestock
✶ Achieving steady genetic gain by practicing 'Genomic Selection'
✶ Fine-tune the expression of major genes associated with traits of breeding interest
Benefits
Provincial
Livestock Breeders Association
Private seed companies
Federal
Stakeholders
Approval and provision of improved seeds/livestock to farmers

Success stories

Introgression of Drought Tolerant QTLs/genes in Basmati Rice:

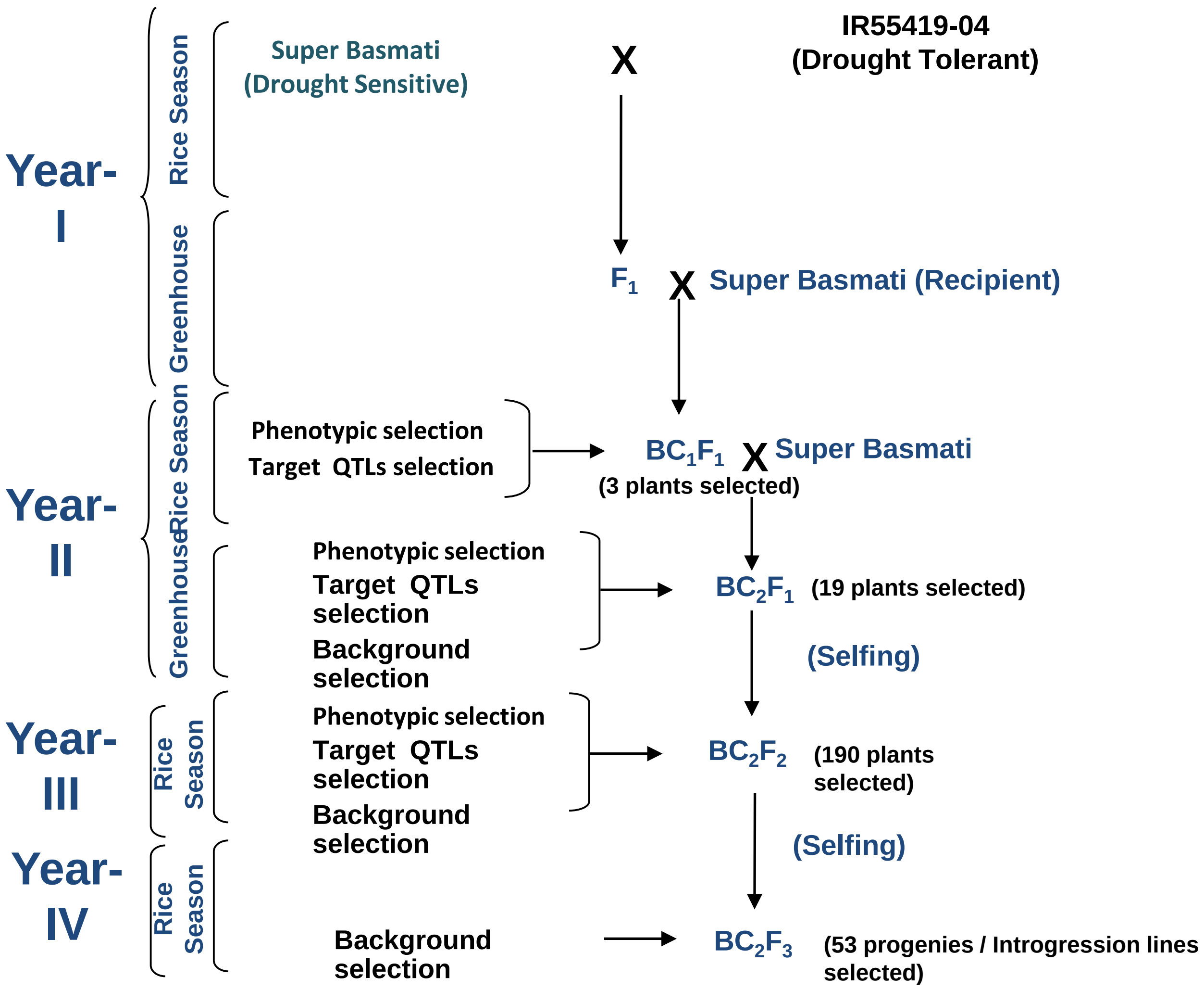
A Molecular Breeding Approach

Drought tolerant QTLs used for Introgression through Marker Assisted Backcrossing



Chromosome	Linked / selectable marker(s)	QTL	Reference
1	RM84 RM220	Osmotic adjustment	Robin et al., 2003 (IR622/IR600 QTL 2003)
4	RM559	deep root dry weight; drought tolerance	IGCN ZYQ18/JX17 DH QTL 1998; TTU IR58821/IR52561 QTL 2002
9	RM201, RM242	Maximum Root length; Root thickness , Relative water content	IR64/Azucena DH Courtius et al, 2000 Price et al, 2002 Steele et al., 2006 Chaitra et al., 2006

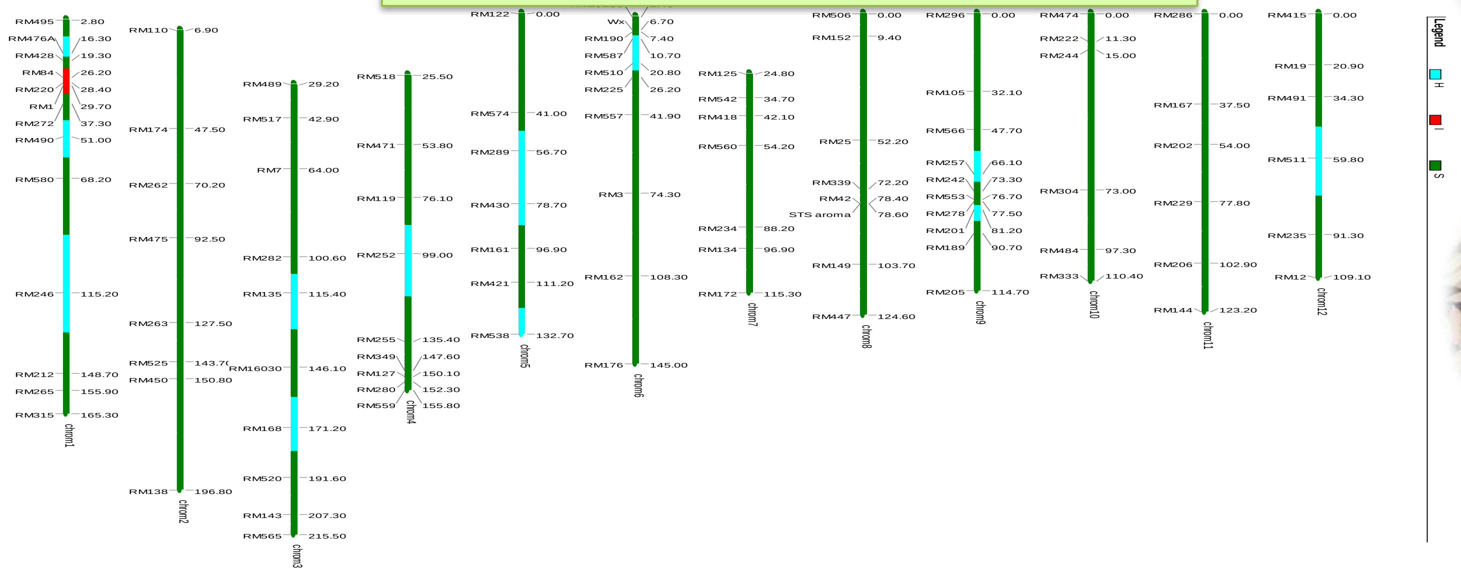
Schematic summary of procedures for introgression of drought tolerant QTLs in Basmati background



Field Performance of DT Introgression Line – DTIL60

Traits		DTIL60 (Q1)	Super Basmati	IR55419-04
Plant height (cm)		111.3	118.8	
Maturity Days		138.3	143.9	
1000 grain wt (g)		20.7	21.5	
Paddy Yield	Well Watered	3466	3735	
(Kg ha^{-1})	Stress	1628*	1186	
	% Reduction	55.1	68.2	
Grain dimensions	Length	7.0	7.5	6.4
(mm)	Width	1.7	1.8	2.3
	Thickness	1.5	1.5	1.67

Genome Recovery = 92.9%



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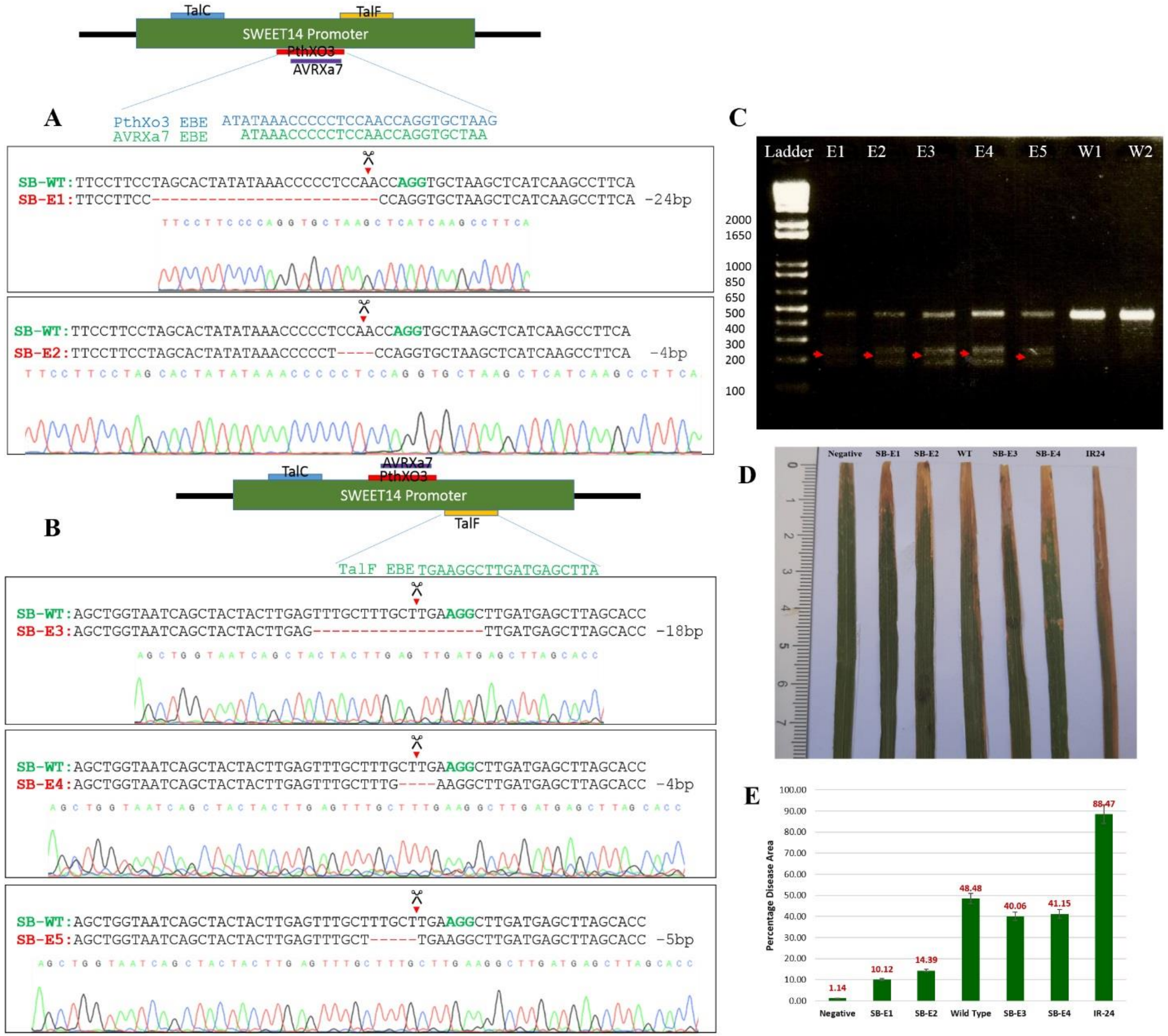
Success story; genome editing in rice for bacterial blight resistance in Super basmati

- SWEET14 is a major susceptibility gene because majority of geographically distant Xoo strains target SWEET 14
- The effector binding elements of 4 TALENS are present in the promoter of this gene
- These TALENs are AVRXa7, PthXO3, TalC and Tal 5
- We designed 3 gRNAs targeting these 4 TALENS (AVRXa7 and PthXO3 are overlapping)
- We were successful in getting



Biofertilizers; reduce chemical fertilizers by 25%

Next generation Biofertilizers

Value additions, e.g., biopesticides, growth promoting hormones, P- solubilization, insecticide and herbicide degradation, new carrier material

Way forward

Coating on chemical fertilizers

Field testing of BioPower

New technologies for future investment

- New breeding technologies (genome editing, CRISPR), speed breeding
- Genomics in improvement of crops, livestock and human health
- Minimize use of chemical fertilizers/pesticides
- Applications of automated phenotyping/satellite imaging
- Microbial technologies
- Synthetic biology

Collaboration

- Rothamsted
- John Innes Centre
- NIAB, Cambridge
- University of Bangor
- Pirbright

Thanks