

# 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**'

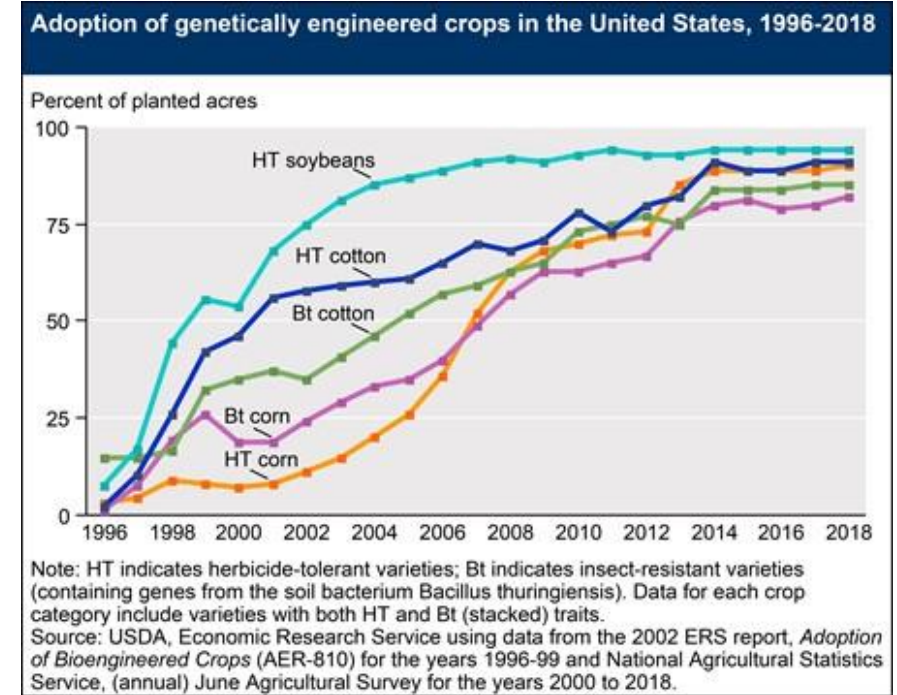
**Historically major increase in wheat, corn, milk, meat and eggs through genetic gain**

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

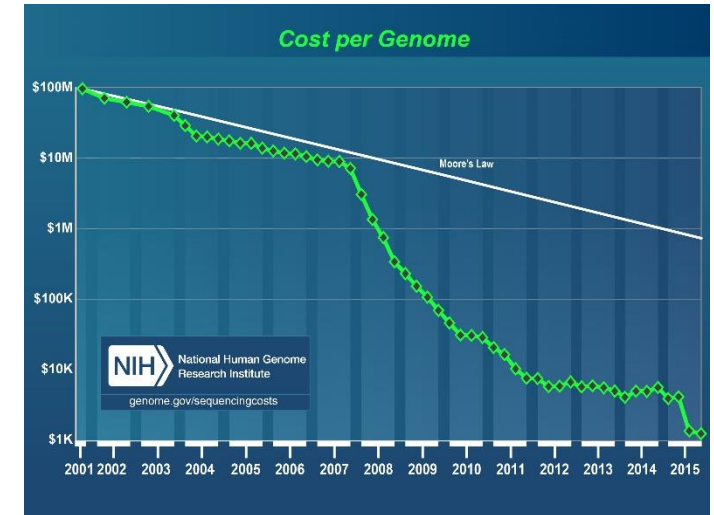
- Rice; yield, better grain, nutritional value, herbicide tolerance
- Potato; virus resistance, sweetening control, stress tolerance
- Wheat; yield, disease resistance, nutritional value
- Cotton; disease resistance, better quality, nutritional value
- Oilseed crops; higher yield, better quality, nutritional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

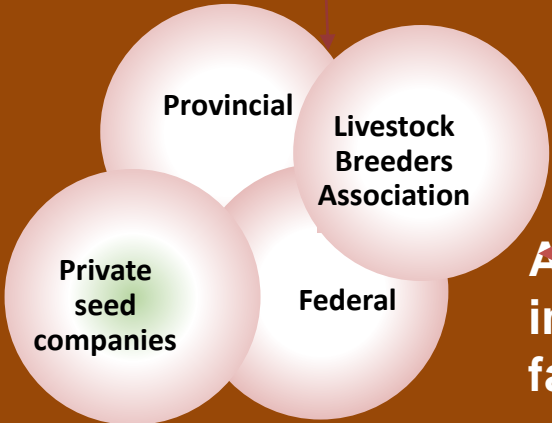
**Platforms**

\* 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**



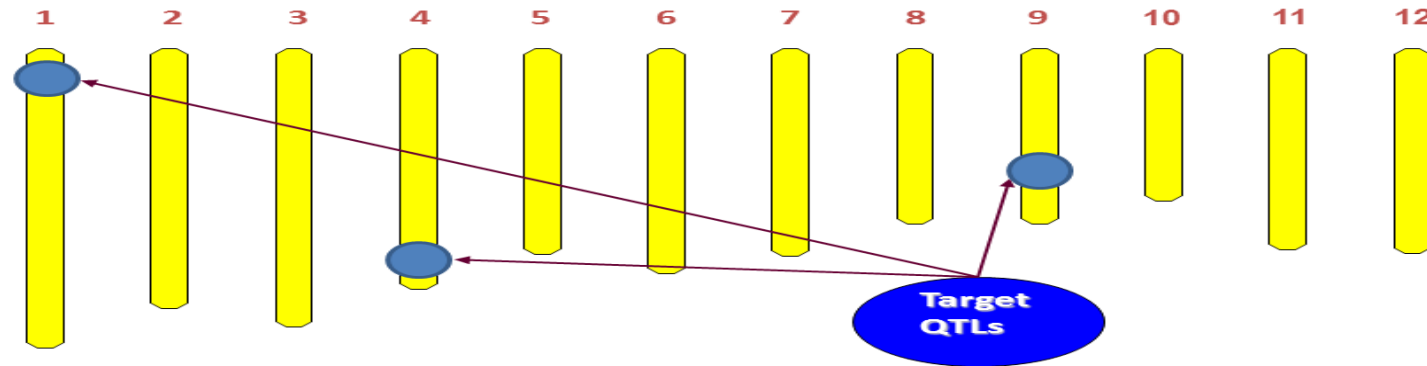
**Stakeholders**

**Approval and provision of improved seeds/livestock to farmers**

Success stories

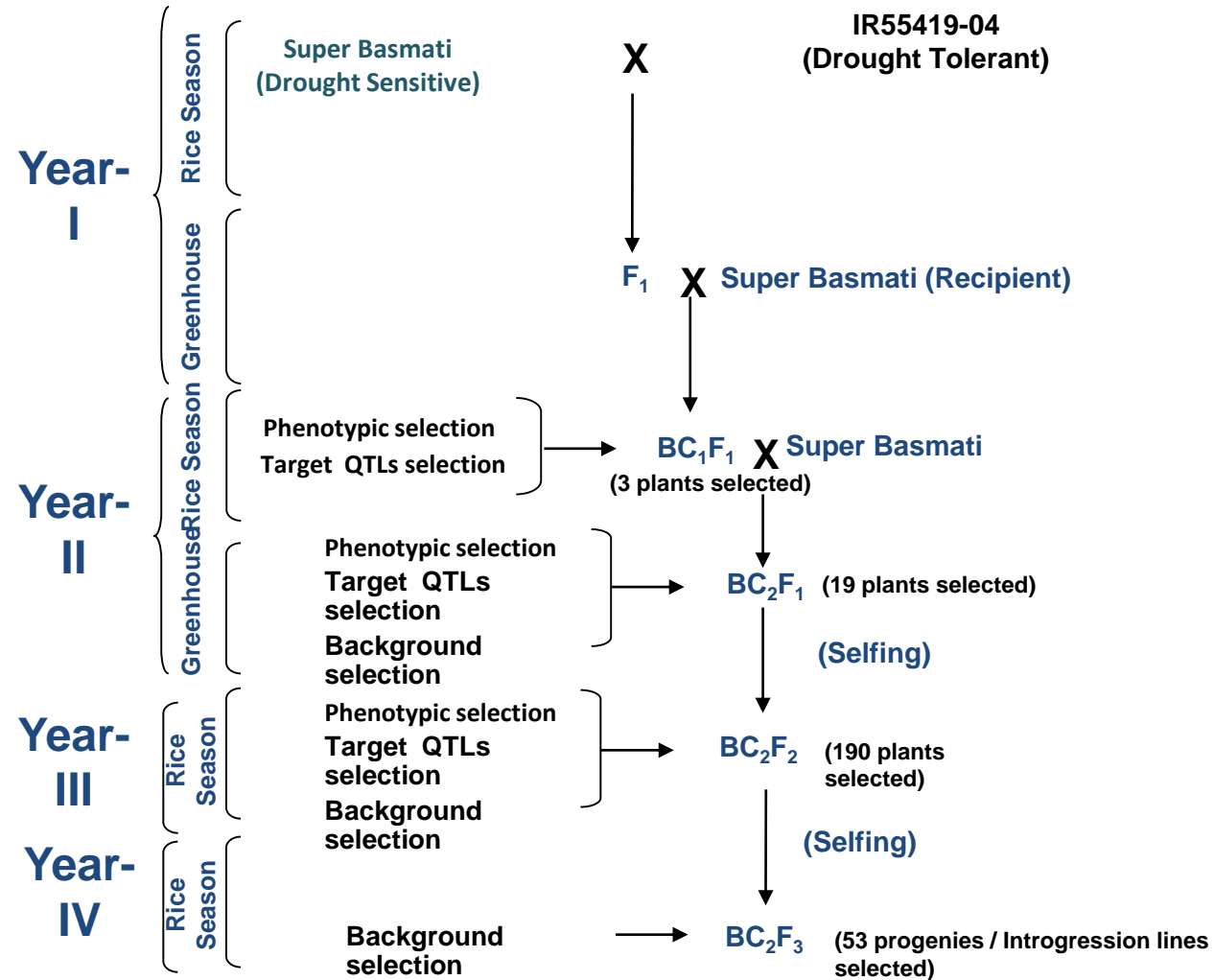
**Introgression of Drought Tolerant QTLs/genes in  
Basmati Rice:  
*A Molecular Breeding Approach***

# 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

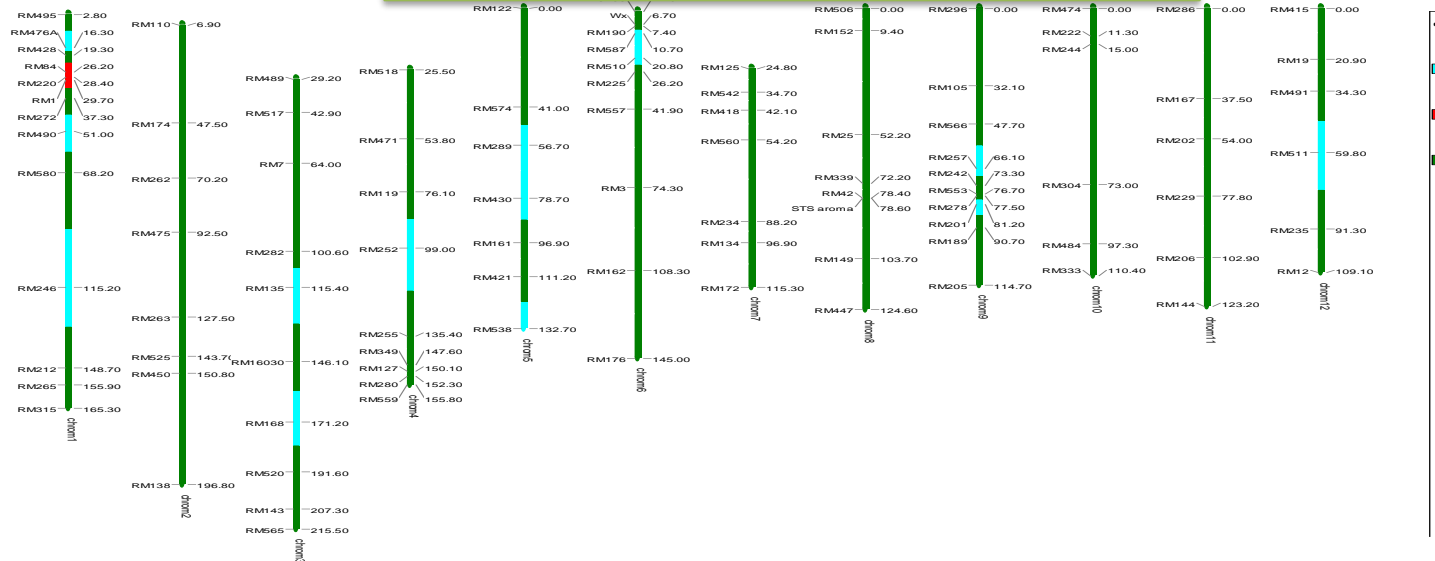


# Field Performance of DT Introgression Line – DTIL60

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

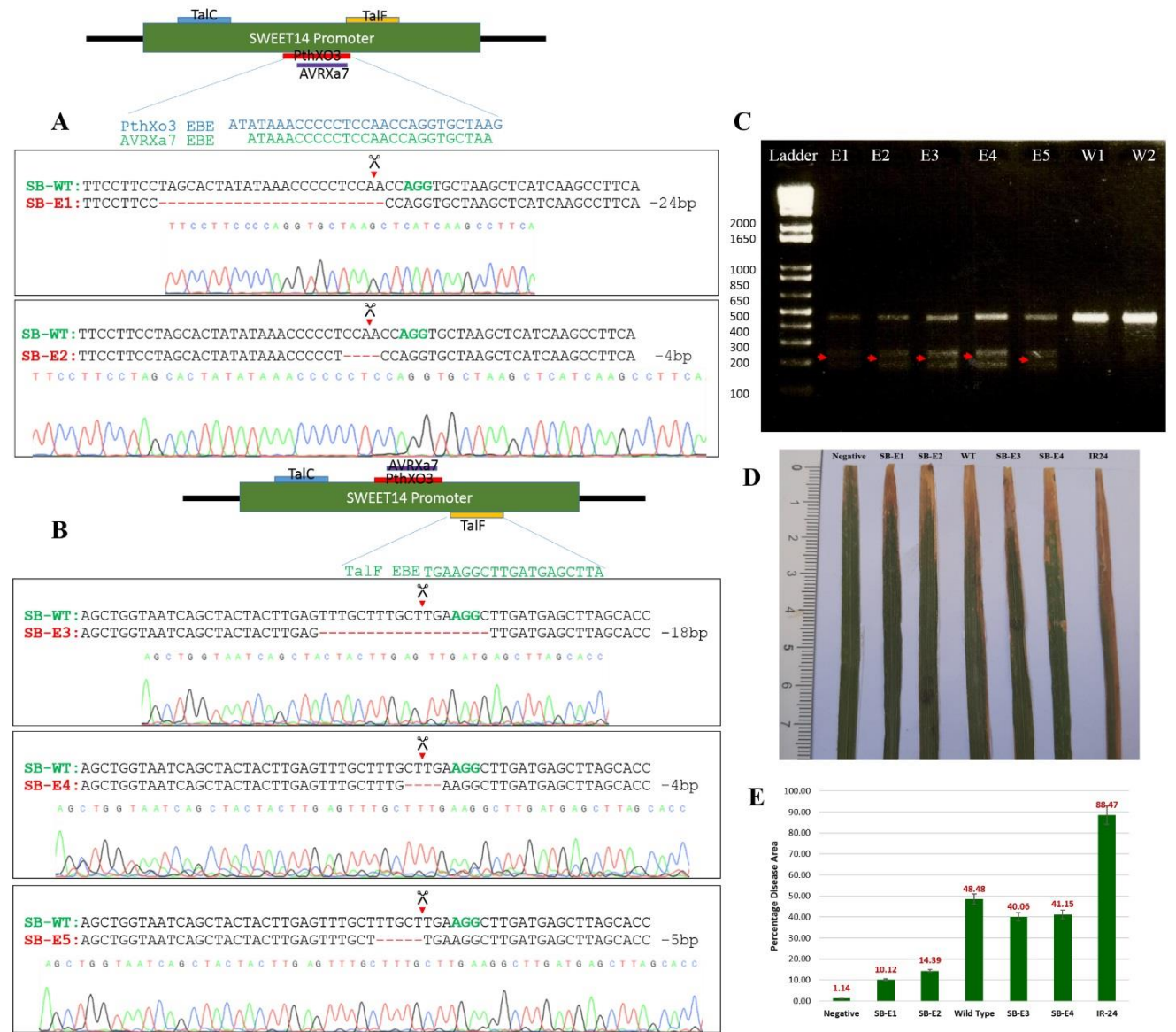


**Genome Recovery = 92.9%**



# 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