Biotech Crop Adoption and Acceptance in Pakistan

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Agriculture and Pakistan

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
- Soil health

Population Growth

1951 → 41 million

2012 → 185 million

2030 → 261 million

How to Enhance Agricultural Productivity?

- **Management**

  May involve huge cost; around 90% of 309 billion program

- **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

Cotton; NIBGE efforts in developing Bt cotton varieties

Total Approved cotton varieties

1. NIBGE-2—2006
2. IR-NIBGE-1524—2010
3. IR-NIBGE-3701—2010
4. IR-NIBGE-901—2011
5. IR-NIBGE-3—2012
6. NIBGE-115—2012
7. NN-3—2013
8. NIBGE 4
9. NIBGE 6

Time line

2015

2013 — **Upcoming lines**
- IR-NIBGE-5
- IR-NIBGE-6

2011 — **IR-NIBGE-4**
- Completed on year in NCBT
- Tolerance to lodging rotenning

2010 — **IR-NIBGE-3**
- Approved in 2012
- Popular for spring cultivation

2007 — **IR-NIBGE-3701**
- National variety, approved in 2010 & 11
- 25%, 18% area in 2010, 2011, respectively
- 1-1.2 million bale advantage

2006 — **IR-NIBGE-1524**
- National variety approved in 2010 and 2011
- Drought prone area (2%)

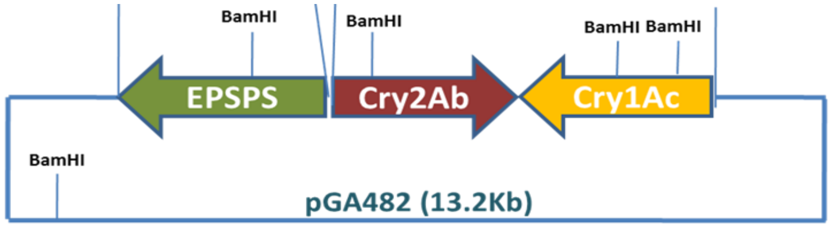
2005 — **Improved IR-NIBGE-901**
- Approved for Sindh in 2011
- 20% (2009 & 2010)
- 25% in 2011

2002 — **IR-FH-901, IR-448 & IR-443**

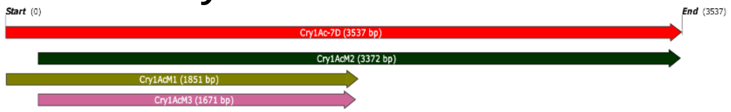
Economic impact; about 400 Rs. 400 billion

Major limiting factors; Pink bollworm, armyworm and weeds

- Pink bollworm has developed resistance against Cry1Ac
- DNA barcoding, a single species of pink bollworm is found in
- Field evaluation, pink bollworm is susceptible to Cry1Ac+Cry2Ab
- Rearing of pink bollworm established at NIBGE
- Complete genome of pink bollworm sequenced, assembly in progress
- Cotton with double gene (Cry1Ac+Cry2Ab) developed
- Resistant to bollworm and armyworm, with breeders at NIBGE, NIAB, NIA
- New gene combinations (Cry2Ab+vip3A) developed
- New mutants of Cry1Ac to avoid binding with cadherin gene developed
- Triple gene cotton (Cry1Ac+Cry2Ab+EPSPS) shared with breeders
- Cotton equivalent to Roundup Ready Flex developed



Cry1Ac mutants



Success and failure of Biotech crop adoption

Success

Import of GM soybean and canola as grain

- Capacity enhancement of solvent oil extraction
- Replacement of imported soybean with locally produced soybean meal

Failure

Refusal of Government to grant permission for GM corn

Biotech crop research in Pakistan

GM Basmati rice

- Bacterial blight resistance, NIBGE, Xa21 gene
- Bt rice, CEMB
- Biosafety law
- Refusal due to major share of rice in export

Wheat Biotechnology at NIBGE

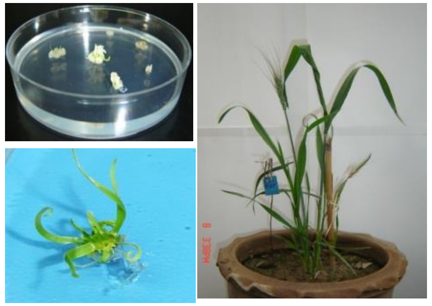
- **Drought tolerance**

Genes	Percent increase
AVP1/AVP1-D	25-30 %
HVA1	13 %
DREB1A	5-10 %

- **Salinity tolerance**

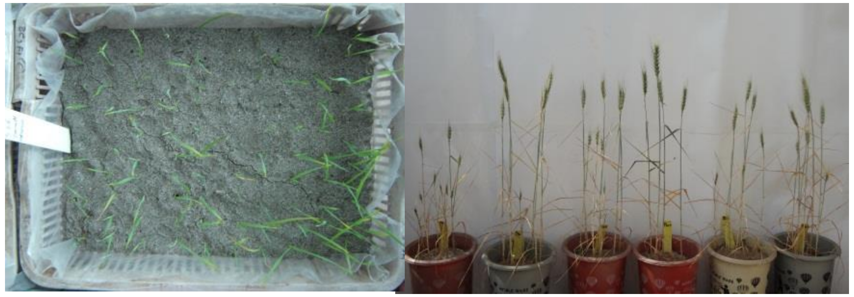
Genes	Percent increase
AtNHX1	15-30 %
HVA1	20 %

Procedure for Transformation of wheat



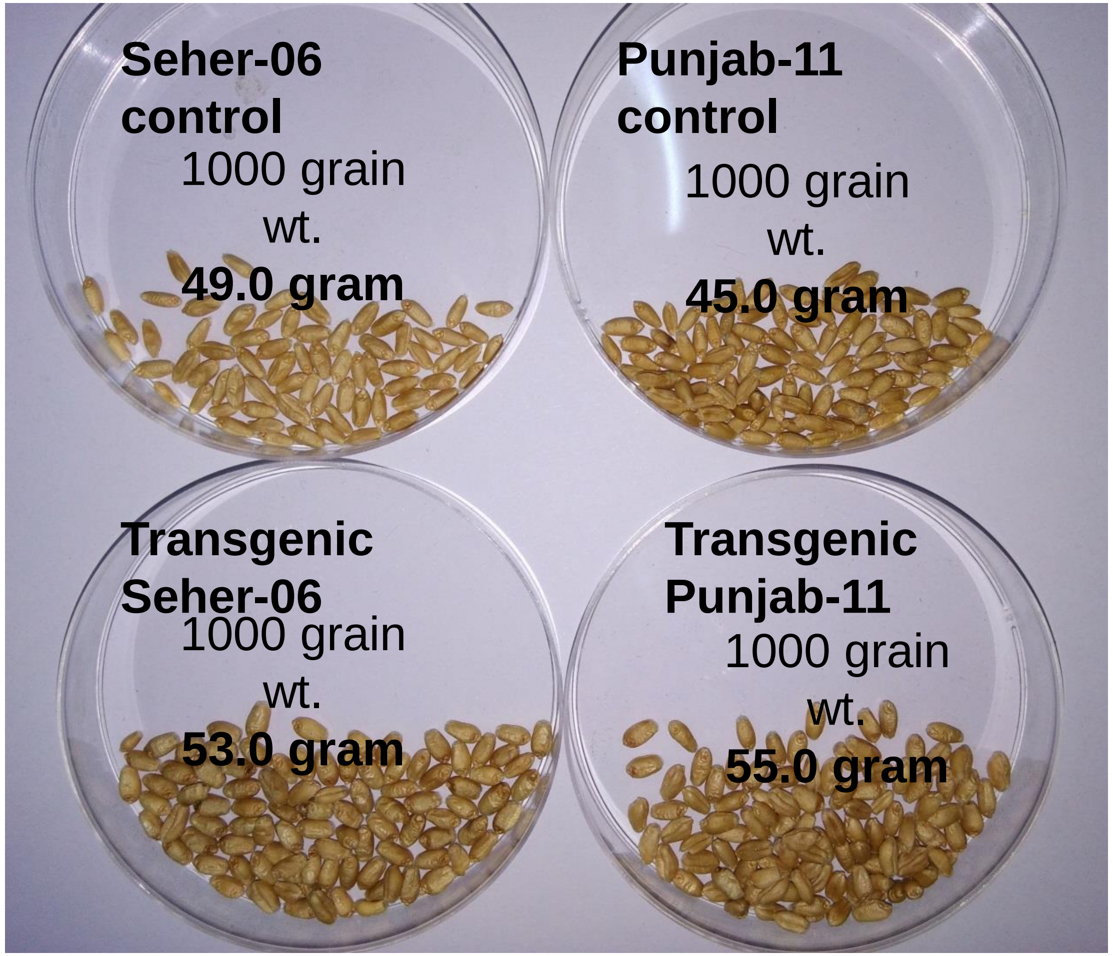
Transgenic drought tolerant wheat AVP1 and AVP1-D genes

Transgenic salt tolerant wheat AtNHX1 and HVA1 genes



Testing of drought and salt tolerant wheat in the field

Better relative grain weight of transgenic lines as compared to non transgenic under drought



Transgenic Punjab-2011 gave 22% higher 1000 grain weight than non-transgenic version under no irrigation and no rain treatment in field

Higher 1000 grain weight of transgenic lines as compared to control under salt stress

1000 grain wt. = 30 g

1000 grain wt. = 43 g

1000 grain wt. = 27 g

1000 grain wt. = 38 g

Economic Impact

Drought Tolerant Wheat

Area under cover (acres) x Yield increase x Price/kg

= 164596.9 x 176.4 x 32.5 = Rs. 943634027.7

= Rs. 943million (One year impact)

Salinity Tolerant Wheat

Area under cover (acres) x yield increase x price/kg

= 0.65x 144 x 32.5

= Rs. 3042 million (One year impact)

Transgenic Sugarcane

Abiotic stress tolerance

Genes

- AVP1 (Drought)
- AtNHX1 (Salt)
- DREB1A (Frost)

Cultivars

CPF-246, HSF-240
US-114, CSSG-668

Economic impact (per year)

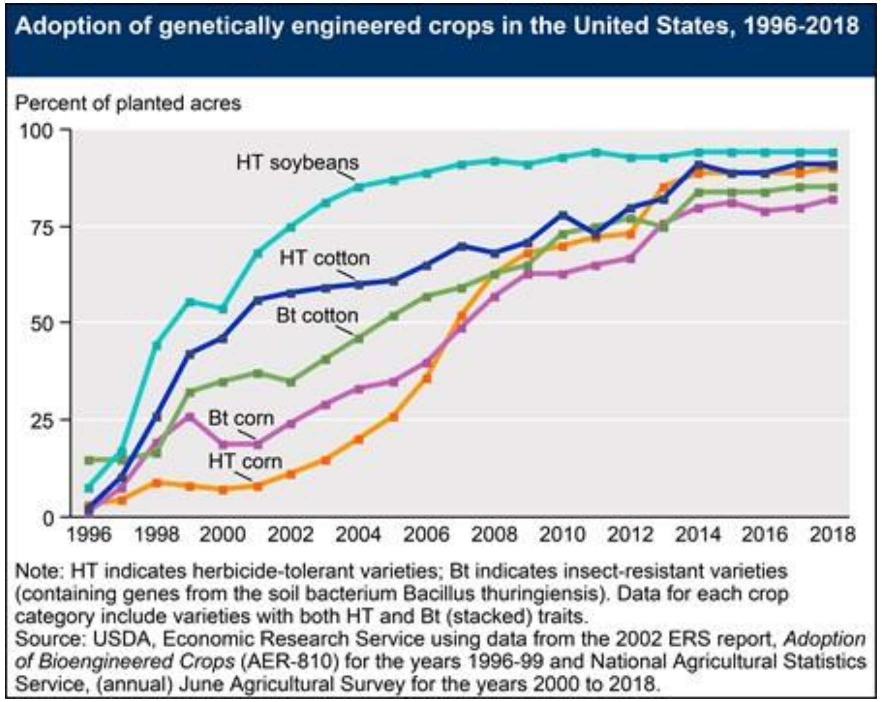
AVP1sugarcane
100% irrigation:13.73 billion; 60% irrigation: 22.78 billion
AtNHX1 sugarcane: salt affected land 25.28 billion
DREB1A sugarcane: 20.61 billion

Challenges in GM crops

- 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
- 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

CRISPR-guided fast forward evolution of traits related to yield, quality and stress tolerance

- Progress in NGS is leading to genome characterization of germplasm
- Germplasm resources provide novel insight into diverse traits
- Biomimicry enables us to learn from nature and develop novel traits
- Germplasm resources of cotton, rice and wheat are being characterized

CRISPR-mediated genome editing has been established at NIBGE
Traits being studied/generated through genome editing

Rice; disease resistance, herbicide tolerance, high iron/zinc, hybrid vigour
Potato; virus resistance, sweetening control, late blight
Wheat; grain size, grain number, rust resistance, zinc and iron biofortification
Cotton; low gossypol, virus resistance, herbicide tolerance

Take home message

- Rate of genetic gain is slow; needs new technologies
- Acceptability of GM crops is limited to fiber, oil and sugar crops
- New breeding technologies offer transgene-free genetic gain
- GM cotton with multiple traits, canola and sugarcane developed
- Genomic selection coupled speed breeding is enhancing genetic gain
- Genome editing has been achieved in rice, potato and wheat

Thanks