Research, policy Approaches and implications for market/trade; Pakistan scenario

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Pakistan; food security index

Pakistan's Food and Nutrition Crisis at a Glance

- Food-Insecure population: 37%
- Stunting (Under 5Y): 40.2%
- Wasting (Under 5Y): 17.7%
- Underweight (Under 5Y): 28.9%
- Moderate Anemia in children (Under 5Y): 48%
- Moderate Anemia (women of reproductive age): 41.7%
- E. Coll contamination of drinking water: 36%

225,603 million
Aug 14, 2021
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
Mechanism of CRISPR-Cas System
dsDNA targeting

Low yield
Low quality
Disease susceptibility
Herbicide susceptibility
Intolerance against abiotic factors

CRISPR-Cas mediated improvements

Yield enhancement
Quality improvement
Disease resistance
Herbicide resistance
Tolerance against abiotic factors
Genome Editing to Enhance Crop Yield
Potential Genes Targets in cotton

### Abiotic Stress

<table>
<thead>
<tr>
<th>Drought</th>
<th>Salinity</th>
<th>Temperature</th>
<th>Heavy Metals</th>
<th>Radiation</th>
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<tbody>
<tr>
<td>RGLG2</td>
<td>PagGla</td>
<td>PIF3</td>
<td>OsMATE1</td>
<td>OsGIRP1</td>
</tr>
<tr>
<td>OMTN2</td>
<td>PagGlb</td>
<td></td>
<td>OsMATE2</td>
<td></td>
</tr>
<tr>
<td>OMTN3</td>
<td>GmWRKY13</td>
<td></td>
<td>miRNA399</td>
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</tr>
<tr>
<td>OsiSAP7</td>
<td>ZmWRKY17</td>
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<tr>
<td>GhWRKY17</td>
<td>GmWRKY17</td>
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<tr>
<td>GhWRKY15</td>
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### Biotic Stress

<table>
<thead>
<tr>
<th>Cry1Ac</th>
<th>Cry2Ab</th>
<th>Hvt</th>
<th>Vip3A</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CP4-ESPS</td>
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### Yield

<table>
<thead>
<tr>
<th>GmCIF1</th>
<th>GmC/VIF2</th>
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<tbody>
<tr>
<td>BIG SEEDS1 (BS1)</td>
<td></td>
</tr>
<tr>
<td>TaGW2 A,B,D</td>
<td></td>
</tr>
<tr>
<td>TaTEF-7A</td>
<td></td>
</tr>
<tr>
<td>TaGS5-3A</td>
<td></td>
</tr>
<tr>
<td>WR1</td>
<td></td>
</tr>
<tr>
<td>CPC1</td>
<td></td>
</tr>
<tr>
<td>KTN1</td>
<td></td>
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<tr>
<td>GhHB12</td>
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<tr>
<td>GhMYB24</td>
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</table>
CRISPR/Cas9 based Genome Editing in Rice for Yield Improvement

Rice yield determining traits

1. Number of panicles
2. Number of grains per panicle
3. Grain weight

<table>
<thead>
<tr>
<th>Gene</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td>OsD27</td>
<td>Negatively regulates no. of tillers</td>
</tr>
<tr>
<td>OsGN1a</td>
<td>Negatively regulates no. of grains</td>
</tr>
<tr>
<td>OsTGW6</td>
<td>Negatively regulates grain size</td>
</tr>
<tr>
<td>OsGW2</td>
<td>Negatively regulates grain size</td>
</tr>
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</table>
Integrative Approach Involving Breeding and CRISPR Mediated Genome Editing to Improve Wheat Yield

- Combining two trade-off traits such as grain number and grain size/weight in the hybrid progeny
- Target-specific genome editing through CRISPR/Cas to knockout negatively regulating genes of wheat yield e.g., *TaGW2*, *TaCKX2.1*, *TaCKX2.2*, and *TaD27* genes
- CRISPR/Cas-mediated multiplexing to target such genes simultaneously can improve commercial wheat varieties
Genome Editing to
Counter Diseases
Genome Editing in Potato

Development of Genetic Resistance through CRISPR-Cas9 in *Solanum tuberosum* against PVY

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**Plant-Viruses Interaction**

Plant viruses encode a numbers of integral proteins

- Coat proteins
- Replication enzymes
- Movement protein

Coding capacity depends upon host factors

Translation initiation factors like eIF4E and isoform eIF(iso)4E

Potato plant transformation and generations of edited lines
Genome Editing in Super Basmati Rice for Resistance Against Bacterial Blight

Speed breeding approach can facilitate the process of generation advancement.
Regulatory scenario for genome edited crops

• A positive and enthusiastic response among research community and funding agencies

• Several groups have started work on different crops

• A brain-storming session held at NIBGE with Technical Advisory Committee of NBC

• A case-to-case basis approach for approval was agreed by NBC

• Emphasis is on tissue culture independent approach
Take home message

• Climate change, population increase, and environmental degradation pose major threats
• New breeding technologies offer fast track genetic gain
• Use of speed breeding can reduce the time required for breeding new varieties
• A positive and enthusiastic approach exists in Pakistan