Diversity, germplasm information and exchange

Dr. Michel FOK
michel.fok@cirad.fr
Outline

• Germplasm exchange is good
• Diversity: big potential for progress in collections
  • But beware of the bias by exclusive focus on genetics
• Collections: where and what?
• Exchange: low level, why?
• Information on germplasms: impediment to exchange
• ICRA’s initiative to improve germplasm information
• Take-away messages
Germplasm exchange ⇒ Desired variety

• Case of a new variety resistant to Leaf Curl Virus in Pakistan
  • ⇐ a set of 74 accessions obtained from CIRAD
    • Request made formally
    • Accessions provided in 2006
  • Variety CIM-620 approved for commercial release in 2016, in Punjab province
    • Tolerance against CLCuV
    • Light brown color of lint
    • Ginning outturn = 40.2%
    • ...

Germplasm exchange ⇒ basis to relaunch breeding program

• Cote d’Ivoire: cotton research station destroyed at the beginning of a 10-year political crisis
  • Restart ⇔ material by CIRAD
Diversity = big reservoir for progress

- Case of potentially interesting morphological traits
  - Okra leaves for better light penetration
    - Trait exploited, but far from all countries
Diversity = big reservoir for progress

- Case of potentially interesting morphological traits
  - High density of gossypol
    - Exploitation contemplated (China?)
Diversity = big reservoir but beware of the bias on genetics

• Exploitation of an interesting morphological trait: Glandless cotton
  • ± 250,000 ha in West Africa in mid-1990
  • Experience little known
  • Experience: not lasting
    • Adaptation of pest control was overlooked

• Lessons learnt
  • Variety or genetics cannot suffice by itself
  • Better to breed varieties along with cultivation techniques
    • Case seldom encountered
Cotton germplasms, collections : gene banks
Cotton germplasms: where

- All breeding teams have germplasms
  - Size frequently small
- Countries with large public cotton collections
  - USA: several collections, > 10,000 accessions
  - China: a central collection, ± 9,000 accessions
  - India: a central collection + secondary collections
    - ?? accessions
  - Pakistan: a central collection of 5,202 accessions
    - 1,923 accessions of G. hirsutum
    - 3,279 accessions of various Gossypium species
  - Uzbekistan: a central collection, 6000?? accessions
  - France: CIRAD collection, 3069 accessions
24,830 accessions in the US (Public) Cotton germplasms

<table>
<thead>
<tr>
<th>Germplasm Resource</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDA-ARS Beltville Cotton Branch Archive</td>
<td>1,053</td>
</tr>
<tr>
<td>National Centre for genetic Resource preservation, cotton collection</td>
<td>2,685</td>
</tr>
<tr>
<td>Pedigrees of Upland and Pima cultivars</td>
<td>661</td>
</tr>
<tr>
<td>National Plant Germplasm System (NPGS), Crop Science registration</td>
<td>1,082</td>
</tr>
<tr>
<td>NPGS Cotton Plant variety protection</td>
<td>661</td>
</tr>
<tr>
<td>National Chemical Genomics Centre (NCGC) G. barbadense collection</td>
<td>1,549</td>
</tr>
<tr>
<td>NCGC Cotton Wild Species collection</td>
<td>486</td>
</tr>
<tr>
<td>NCGC Panel</td>
<td>10</td>
</tr>
<tr>
<td>NCGC Cotton race collection</td>
<td>2,088</td>
</tr>
<tr>
<td>NCGC Cotton obsolete variety collection</td>
<td>2,850</td>
</tr>
<tr>
<td>NCGC Asiatic cotton collection</td>
<td>1,844</td>
</tr>
<tr>
<td>Germplasm Resource Information Network (GRIN) Cotton collection</td>
<td>9,861</td>
</tr>
</tbody>
</table>
Number of distinct accessions: hard to know

• Redundancy of accessions in collections
  • Within a country
    • Clear case with the USA

• Furthermore redundancy between countries

<table>
<thead>
<tr>
<th>Accessions common to French and Pakistanis collections</th>
<th>Number</th>
<th>% of French total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>G. hirsutum</em></td>
<td>322</td>
<td>11,8</td>
</tr>
<tr>
<td><em>G. barbadense</em></td>
<td>6</td>
<td>0,8</td>
</tr>
<tr>
<td><em>G. arboreum</em></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>G. herbaceum</em></td>
<td>2</td>
<td>3,6</td>
</tr>
</tbody>
</table>
Redundancy in collections is an advantage

- A same accession could have been evaluated in several countries
  - Under various biotic and abiotic stresses
- But advantage not really exploited so far
- Between countries, collections not that much redundant
  - Relevance to increase the redundancy
    - A new wave of exchange between collections is needed
Cotton germplasms: what?

• Little information available, hardly accessible
  • \( \Leftrightarrow \) Management of most cotton collections
    • No cooperation obtained from several countries for this presentation

• CottonGen: A single and remarkable initiative
  • [https://www.cottongen.org/](https://www.cottongen.org/)
  • Possible information on 28,735 accessions
    • 24,830 accessions from US collections
    • 16,880 accessions in 4 major species
      • 12,414 Gossypium hirsutum
      • 2,047 G. barbadense
      • 2,158 G. arboreum
      • 261 G. herbaceum
  • Albeit not yet perfect
Cotton collections integrated into CottonGen

• Several collections involved…
  • China
  • Uzbekistan
  • Public collections in the USA
• ...but only partially except for the USA
  • China: 2,980 accessions out of ±9,000
  • Uzbekistan: 913 accessions out of ±6,000?
Limitations

- Already 78 traits searchable
- But important traits still missing
  - Blue disease
  - Leaf curl virus
  - ...
Low level of exchanges based on CIRAD’s recent experience

- 217 accessions supplied on request over 7 years
  - 42% were for CIRAD’s own use
- 5 countries have benefitted

<table>
<thead>
<tr>
<th></th>
<th>Out of CIRAD</th>
<th>CIRAD</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For rejuvenation</td>
<td>For studies</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>38</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>25</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>2</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>16</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>2019</td>
<td>34</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>65</td>
<td>26</td>
</tr>
</tbody>
</table>
Influential factors of low exchanges

• Attitude of routine from breeders?
  • Need not felt for breeding from enlarged genetic diversity
Influential factors of low exchanges

• Great difficulty to deal with wild species of Gossypium

• Steps followed to achieve variety CIM-620 in Punjab
  • Accession AS-0349 is photo period sensitive
    • no flower formation in Punjab
  • AS-0349 plants maintained by ratooning during 3 years
    • Till flowers were obtained in December 23, 2009
  • Crossings made possible in Breeding Program
    • 3-4 years after access to the original accession and perseverance efforts
Influential factors of low exchanges

Greater difficulty to deal with large genetic diversity

Means and capabilities may lack

• ⇒ rational for a regional/international program to create/manage diversity
• and pass more stabilized material to national teams to finalize country-adapted varieties
Influential factors of low exchanges

• Main factor = lack of information for breeders
  • Where potentially genetic materials are?
  • How interesting materials are?
  • To whom address one’s request?
  • (would my request positively responded?)

• Organized, comprehensive and accessible information is yet to come
  • Despite CottonGen initiative
    • Not all collections are covered
    • Accessions are seldom comprehensively described/evaluated
Germplasm information: impediment to exchanges

• Difficult issue of describing accessions
  • A lot of "descriptors" are required
  • Sets of "descriptors" vary between collections or countries
    • In terms of composition, definition, measurement
      • 78 descriptors identified by CottonGen
      • 22 descriptors informed in Pakistan
        • 20 in CIRAD, France
  • All existing sets of descriptors are not complete
    • No way and no rationale to evaluate comprehensively
    • Missing descriptors pertain e.g. to important region or country-specific diseases or trait (like ginning outturn)
    • ⇒ lack of interest for existing germplasms to countries with emphasis on specific trait
  • A global set of descriptors, desirable, is yet to come
ICRA's idea/initiative: promote information on germplasms

• 'Germplasm Information Sharing Initiative' = GIFI

• Initiative open to organizations/countries willing to join in
  • Pakistan (PCCC)
  • France (CIRAD)
  • Others are expected
    • USA? India? Australia? Uzbekistan? China?

• Objective = sharing information
  • Ownership not shared, remains with existing collections
  • ⇒ address to collections for requests of accessions
2-phase initiative

• Phase 1: Limited fund requirement
  • Towards a harmonized and comprehensive set of descriptors
    • Task of a group of focus scientists from each participating organization
    • Task inspired by CottonGen achievements
2-phase initiative

- Phase 2: More substantial fund requirement
  - Development of an adapted online tool to enable
    - Sharing and consolidating information on accessions managed in various collections
    - Searching on multiple traits
    - Knowing availability and accessibility of accessions
- References to inspire from
  - CottonGen
  - Florilege in France
    - [http://florilege.arcad-project.org/fr/collections](http://florilege.arcad-project.org/fr/collections)
Take-away messages

• Genetic variability in collection: potential for progress to be exploited
• There are collections available for request/exchange
• But request/exchange of low level
  • ⇒ Rationale for regional/international program of variability creation combined with national breeding activities
  • ⇒ Rationale for international initiatives (e.g. ICRA's proposal)
• Germplasm exchange advocated...
  • = Relevant public good to promote...
  • ...but where funding support is?