Pre-Breeding

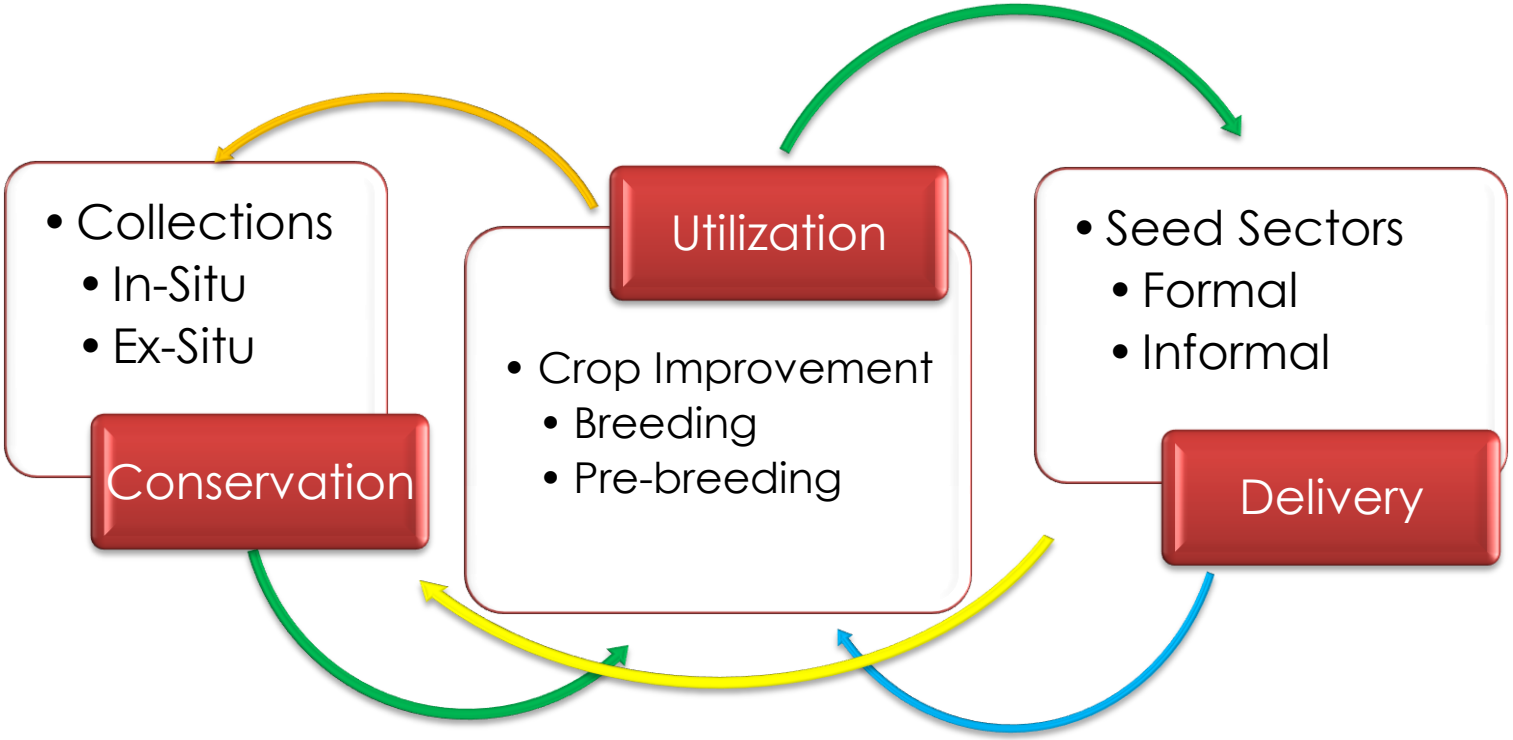
Introduction

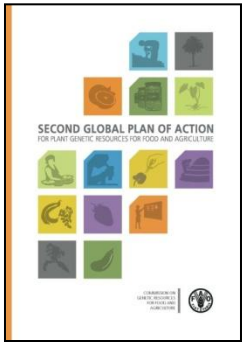
Aim of the module

At the end of the module, we should be able to:

- provide a definition of pre-breeding;
- explain the usefulness and scope of pre-breeding;
- describe the context in which pre-breeding is carried out; and
- identify the situations to which pre-breeding is best applied

Second GPA for PGRFA as template





Introduction

Premise

- Present day agriculture = Evolution + Selections by farmers
- Plant breeding is the science (and art) of combining important traits in varieties of commercial, social or aesthetic interest
- Plant genetic resources for food and agriculture (PGRFA) as building blocks for 'designing' new varieties
- Crop improvement is akin to a pipeline:
  - Ingredients (genes) are fed in at beginning -- blended, tested, selected, tested some more -- and finished product (improved varieties) emerges for farmers to use
- Pre-breeding is the beginning segment of this pipeline

What is pre-breeding?

- Broadly, the management of PGRFA involves two basic components: conservation and use
- Pre-breeding refers to all activities designed to:
  - identify desirable characteristics and/or genes from non-adapted (exotic or semi-exotic) materials, and
  - transfer these traits into an intermediate set of materials
- Plant breeders, should ultimately, be able to manipulate the intermediate materials further to develop new varieties
- Pre-breeding is at the interface of conservation of PGRFA and plant breeding
  - Is therefore a multi-disciplinary endeavor

Stock taking

- Since the beginning of the 20th century, plant breeders have methodically leveraged an ever-increasing set of knowledge, skills and tools to:
  - add value to PGRFA , and
  - hence make crops better for humankind
- But, current crop varieties may be unsuited to the burgeoning set of challenges and opportunities. So,
  - What are the alternatives?
  - How to achieve genetic in the absence of easily exploitable traits (and genes)?
  - How can genes be accessed to address this multiplicity of needs?

Stock taking

- Fortunately, existing variants of most crops have quite a broad genetic base
  - Significant efforts and investments have resulted in the collection, characterization, evaluation, documentation, conservation and distribution of PGRFA
- Most of the world's important crops are in genebanks
- These genebanks are the reservoirs for:
  - different variations of the traits still used by farmers;
  - traits that are no longer needed by farmers;
  - traits that evolved but may never previously have been used by farmers; or
  - traits that have not yet been discovered

Stock taking

- About 7.2 million accessions in over 1300 genebanks[1]
- But these accessions are not used optimally in crop improvement because:
  - Lack of documentation and adequate description of collections
  - Insufficient evaluation of the collection
  - Limited input by breeders during documentation to understand what information would be most valuable
  - Accessions with limited environmental adaptability
  - Accessible materials not always suited to agronomic needs
  - Adequate quantities of seed are not available in a timely manner

[1]The Second Report on the State of the World's PGRFA. FAO. 2010. http://www.fao.org/docrep/013/i1500e/i1500e00.htm

Pre-breeding

Aims at:

- Introgression; or
- base broadening

Pre-breeding vs breeding?

- Generally, in a pre-breeding scheme:
  - By necessity close collaboration between genebank managers and breeders;
  - Greater likelihood of more complex hybridization issues;
  - Linkage drags
  - End product of pre-breeding is raw material for breeding
- Breeding results in a new variety

Pre-breeding

- Rule of thumb – multidisciplinarity and communication between
  - Genebank managers, and
  - Plant breeders
  - They jointly set out a strategy for combining resources and expertise to achieve a common goal
    - Generating intermediate materials utilizable in plant breeding
- The interface includes
  - evaluation for traits of interest & data management,
  - study of reproductive biology,
  - additional multiplication to make materials available for crossing, and
  - collaboration in hybridization

Judicious pre-breeding: 'Decision tree'

- No pre-breeding needed if one of the following is available:
  - Commercially-available adapted and acceptable varieties
  - Advanced selections, well-adapted to the target environment
  - Genebank accessions that are well-adapted to the target environment
- Pre-breeding probably needed if only one of the following is available:
  - Genebank accessions not well-adapted to the target environment
  - Closely related wild species easily crossed with the crop species
  - Wild species less closely related and more difficult to cross

Some Examples of Pre-breeding

- Maize
- Musa
- Sesame
- Cassava
- Sugarcane
- Common bean

Use of CWR in plant breeding

Crop	Pest and disease resistance	Abiotic stress	Yield	Quality	Male sterility or fertility restoration	Total number of contributed traits
Cassava	+	–	–	+	–	3
Wheat	++++++++++	–	+	+	–	9
Millet	+	–	–	–	+	3
Rice	+++++++	+++	+	–	+	12
Maize	+	–	–	–	–	2
Sunflower	+++	+	–	–	+	7
Lettuce	+++	–	–	–	–	2
Banana	++	–	–	–	–	2
Potato	++++++	–	–	–	–	12
Groundnut	+	–	–	–	–	1
Tomato	++++++++++	++	–	++	–	55
Barley	–	+	–	–	–	1
Chickpea	–	+	–	–	–	2

The use of wild relatives in crop improvement: A survey of developments over the last 20 years

Reem Hajjar · Toby Hodgkin

Euphytica (2007) 156:1–13

Natural introgression of traits from CWRs to cultivars, e.g. sorghum in Mali?

Tips …..

Pre-breeding efforts will be enhanced by

- Information on gene pool origins, domestication syndrome traits, molecular diversity, and mapping data of the wild forms;
- Indirect screening for biotic and abiotic stresses; and
- Marker-assisted selection

Conclusions

- Domestication and selections (plant breeding and farmers) have narrowed the genetic base of most of our crop genepools
- But, plant breeding continues to yield gains
- Concerns over long-term sustainability of crop improvement resulting in enhanced conservation and sustainable use of PGRFA
- Use of genebank accessions directly in breeding programmes is fraught with constraints
- Pre-breeding is, in effect, a bridge between genebanks and breeding programmes

Summary

- Pre-breeding should aim to:
  - identify potentially useful genes in a well-organized and documented genebank, and
  - design strategies that lead to development of an improved germplasm ready to use in varietal development
- Pre-breeding is a collaborative endeavour, that is buttressed by communication, between genebank curators and breeders