Rationale for the IBP

- Large private seed companies have successfully implemented extensive suites of integrated informatics tools to turbocharge their breeding programs.
- Implementation of this integrated informatics in public programs lags behind, especially in developing countries.
- Some tools have been developed at various CGI centers, but implementation has been uneven and they are not integrated into a comprehensive system.
- Most NARS programs still rely on rudimentary tools, from pen and paper to Excel spreadsheets.
- Small SMEs in developing countries typically do not have the resources to acquire available commercial software or to implement breeding IT systems on their own.

Breeding Management System (BMS) – Product Concept

- Simple and easy-to-use application containing all informatics tools needed by a breeder.
- Seamless flow of data between applications.
- Accumulation, sharing and re-use of breeding data.
- Targets routine breeding activities and will not replace research tools.
- Will allow integration of users own tools into the system.
- Implementable as a standalone system.
- Access central and local DB, as well as the BMS on a local PC.
- Will also be implementable as a cloud-based system via iPlant cyber-infrastructure.
- For computationally intensive analyses or large data storage needs.

List Manager Functionality

The List Manager is at the center of all activities in the Breeding Management System:

- First screen you arrive at after opening your Breeding Program.
- New left navigation menu provides direct access to all tools.
- Easily build and work with the lists that are used in each stage of the breeding cycle.
- Key List Manager Features:
  - Ability to browse and modify existing lists.
  - Ability to search for lists and germplasm entries.
  - Ability to create a new list dynamically by pulling from existing lists or germplasm search results.
  - Expanded ability to modify list contents.
  - Ability to export lists for use outside of the Breeding Management System.
Once the strategy and parental material have been identified, the breeder wants to:

- make crosses,
- develop populations,
- track pedigrees,
- track inventory,
- characterize lines

**Breeding Logistics**

**Nursery and Trial Management**

- Breeding Manager configured for different crops
  - Crossing manager, nursery manager, pedigree recording
  - Focused on population development and line selection
  - Nursery advance and seed inventory tracking
- IB Fieldbook
  - Focuses on field trial management for germplasm evaluation
  - Trait selection, field design, labels and sample tracking
- Android-based hand-held device
  - Optimized for use with Samsung Galaxy tablet for field data collection
  - Other Android devices can be used if preferred

Breeding manager and Field books fully integrated into BMS workbench

**Field Testing**

Once populations are developed, the breeder wants to:

- select traits,
- make lists of germplasm,
- generate designs,
- produce fieldbooks,
- collect data,
- check and store data.

**Breeding Management Trait Dictionaries**
Breeding Management

Trait Selector

Tools to be managed (ex. from S)

Breeding Management

Germplasm List Manager

Germplasm list creation

Breeding Management

IBP Fieldbook

Breeding Management

Bar Code labels

Fieldbook connects to Android-based tablet devices for data collection in the field and laboratory

Breeding Management

Tablet Devices

Integrated Breeding Database

- Genealogy Management System (GMS)
- Germplasm nomenclature, chronology, IP and passport data
- Pedigrees and breeding history
- Phenotyping Data Management System (DMS)
- Germplasm characterization and evaluation data
- Annotated with Crop Research and Crop Trait Ontologies
- Genotypic Data Management System (GDMS)
- Medium density fingerprinting data
- Genotyping data for MAS and MABC
- Genotyping data for Marker-trait association analysis

Databases fully integrated into BMS workbench
Query Tools

At the outset of a breeding cycle users want to:

- browse all germplasm information
- review existing characterization and evaluation
- search for adapted germplasm
- perform head to head comparisons

Statistical Analysis of Phenotyping Data

- Breeding View provides easy access to the high throughput analyses routinely required by breeders
- The same interface can be used to access procedures in Genstat or R-scripts and allows analyses to be configured
- Single site analysis is available for complete and incomplete block designs as well as row-column designs and spatial analysis. New designs are being added at each update,
- Analyses can be run in batches over environments and traits
- Two-stage multi-site analysis is available for GxE and stability analysis with or without grouping of environments
- Single pass meta analysis of unbalanced site by season data is being incorporated.

Tools to be fully integrated into the BMS by June 2014

Genotyping

To use molecular technologies, the breeder wants to:

- select population,
- select markers,
- genotype population,
- check and store genotyping data.

Genotyping Data Management

- Single trait linkage analysis (QTL)
  - Quality control phenotypes (summary statistics)
  - Quality control marker data
  - QTL detection – genome wide scan using single and composite IM
  - Output includes profile plots and tables
  - Results available for automatic viewing in Flapjack
  - HTML report of QTL results
- Multiple trait sequential analysis
  - QTL results for each trait combined
  - Single Flapjack view for all traits

Breeding View - QTL analysis
Decision support for Marker implementation

- **OptiMAS**
  Developed at INRA, Le Moulon
  Implementation of markers in a MARS breeding scheme
  Identify and track favorable alleles through cycles of recombination and selection

- **Molecular Breeding Decision Tool (MBDT)**
  Developed by team at ICRISAT
  Implementation of markers in a MAS and MABC context

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**Future Directions**

- Continuous improvement of UI based on user feedback
- Additional analysis methods for expanded experimental designs and genetic analysis
- Seed inventory management system
- LAN based deployment available in January, cloud based deployment available in June
- Data will be stored in a single shareable database with user access roles
- Off-line capability will be supported by a data cache which will synchronize when a connection is available