MusaNet Strategic Meeting: Global Strategy for the Conservation and Use of Banana and Plantain (*Musa*) Genetic Resources

28 February – 3 March 2011, Agropolis International, Montpellier, France

FULL MEETING REPORT

(20/04/2011)

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Acknowledgements

MusaNet is grateful for the critical financial support provided for this meeting from the Agropolis Fondation, Bioversity International, the Global Crop Diversity Trust and CIRAD. MusaNet would also like to recognise the valuable contribution of all the participants and is appreciative for their keen interest and active involvement in guiding MusaNet in its role and functions.

Executive Summary

Note from VJ: I'm guessing you will eventually include an executive summary , once you have assimilated feedback- but if you want any help with this please let me know.
Summary of action points

DAY 1	**MONDAY 28 February 2011**

Monday 28 February *08:30-09:15*	***Session 1 – Introduction to the meeting*** *Welcome address and logistic information, Introduction to participants and meeting objectives, expected outputs and process*

Introduction

A Global Strategy for the Conservation of Banana and Plantain Genetic Resources was for the first time developed 5 years ago with the involvement of national, regional and international partners. It aimed to protect unique *Musa* germplasm and ensure its sustainable long-term conservation for use. The Global Crop Diversity Trust used the strategy to allocate funding to priority activities identified in the strategy. The Global Strategy aims to set priorities, to engage partners and users and facilitate the sharing of knowledge between researchers and end-users. Stakeholders, including donors, partners, and beneficiaries, have provided extensive input into the development of the strategy. Together with these stakeholders, the MusaNet Strategy meeting will analyze the strengths and weaknesses of current activities, focusing on the delivery of products that can effectively enhance food security, nutrition, and income. Now 5 years later, the Global Strategy needs to be critically reviewed and developed further to strengthen this time the component on germplasm utilization to ensure that key stakeholders can benefit from the secured conservation and maximize the use of genetic resources in improvement and other research programmes. The workshop will therefore review the Global Strategy, its implementation to date and incentives for participation and will agree on the mechanism and its functions to ensure the efficient coordination and implementation of the strategy and stimulate the involvement of partners, i.e. establishment of MusaNet which will be the Steering Committee for the Global Strategy.

The first strategic MusaNet workshop proposed the following goals and objectives:

Meeting goal:

1. To critically review the Global Conservation Strategy for Banana developed in 2006, its implementation to date and incentives for participation.
2. Promote a coordinated approach for the characterization of *Musa* genetic resources.
3. To strengthen the component of the strategy related to increasing the use of *Musa* genetic resources resulting in a comprehensive global conservation and utilizations strategy for *Musa* genetic resources.
4. To agree on the mechanism and its functions to ensure the efficient coordination and implementation of the strategy and stimulate the involvement of partners, i.e. establishment of MusaNet.

Meeting objectives:

1. Review of the status of the strategy implementation - what has been done since 2006 and expectations from banana research programmes
2. Critical analysis of the strategy process and current implementation, lessons learnt and readjustment *vis a vis* priorities, partners and action plan, particularly with regards to a stronger component on use and diffusion.
3. Clear understanding of the incentives and disincentives for collaboration and commitment to implementation to ensure buy-in and ownership of the strategy and its deliverables.

4. Agree on priorities for information sharing, dissemination of results and publication
5. Agree on a concrete and realistic action plan for the strategy, year by year with clear milestones and deliverables.
6. Agree on the coordination mechanism for the strategy, its goal, objectives, expert committee and proposal of advisory groups (i.e. formal establishment of MusaNet), its decision-making process and the involvement and representation of the Musa genetic resources community in the network.
7. Determine the mode of operation of MusaNet (eg. constitution of the network, scope and terms of reference of the groups, and membership).
8. Agree on milestones for the MusaNet network (that should be the workplans of the groups) including a monitoring plan and future meetings.

Programme:
The workshop programme was developed with the guidance of the members of the organisation committee: Nicolas Roux, Edmond De Langhe, Jean Christophe Glaszmann, Jean-Pierre Horry, Robert Domaingue, Rony Swennen and Brigitte Laliberté. For the complete detailed programme, see *Annex 1*.

The logic of the meeting was encapsulated within the following steps:

Day 1:

1. Describe the Global Strategy for the Conservation and Use of *Musa* Genetic Resources (developed in 2004-2006) to all participants, as the overall strategic framework of MusaNet and review its implementation to date
2. Reflect on the global context and partnerships to support the implementation of the global strategy and funding opportunities
3. Understand the keys users and the needs for *Musa* genetic resources

Day 2 and 3

4. Discuss according to 4 major thematic areas the details of a revised global strategy
   - Theme 1: Genetic diversity, taxonomy and characterization(including descriptors and linking morphological and molecular characterization)
   - Theme 2: Germplasm Evaluation (links to users)
   - Theme 3: Germplasm Information and Utilization (distribution and diffusion)
   - Theme 4: Conservation – towards a global partnership to conserve the Musa genepool (safeguarding the genetic diversity): roles of international, regional and national collections.
5. Establish MusaNet as the "Expert Committee" responsible for implementing the Global Strategy and moving forward the plans of the Advisory Groups

Day 4

6. Meetings of the Advisory groups: to further detail the Advisory Groups' workplans based on the key issues and priorities identified by the group
7. Action plan for the Global *Musa* Strategy, MusaNet workplan (including monitoring of implementation) and conclusions of the meeting

Stephan Weise, Director of the Commodity for Livelihoods Programme at Bioversity International welcomed all participants followed by Nicolas Roux, Senior Scientist in Genomics and Genetic Resources and MusaNet Coordinator, who also thanked the

sponsors of the workshop: Bioversity International, Agropolis Fondation and the Global Crop Diversity Trust.

Brigitte Laliberté, workshop facilitator, introduced all the participants. A total of 47 participants attended the meeting, representing different stakeholders' groups, from 21 different institutes, located in 15 different countries. Of these, 13 *Musa* genetic resources collections were represented. Participants also represented different areas of expertise such as breeding and crop improvement (8); germplasm information and documentation (9); molecular biology and genomics (9); phytopathology and post harvest (11); taxonomy and characterisation (morphological and molecular) (8) and policy issues (3). The full list of participants and contact details can be found in *Annex 2.*

Brigitte described the programme to get the group's agreement for the process proposed to achieve the expected outputs of the meeting. She captured the following expectations from participants:

- Clarity on how to organise ourselves, and what will be the action areas as we move forward together.
- Clarity on how different networks work together
- Action points are implemented
- Realistic workplans and milestones for the next 5 years are achieved
- The use aspect of the strategy is clear
- We move forward to secure all accessions in all collections
- We make ample suggestions for funding the collective activities
- Greater diversity is secured and made available
- We get a community feeling – all to input and get output – give-give
- Solutions to address administrative hurdles
- Ways to get more of the Pacific germplasm at the ITC
- Better idea of how the regional networks work together
- Sharing of scientific intentions as genetic resources science should be at the centre of discussions with scientific collaboration

Monday 28 February *09:15-10:00*	***Session 2 - Critical Review of the Global Strategy for the conservation and use of banana and plantain genetic resources (developed in 2004-2006)*** *PRESENTATION: The Global Musa Strategy from its development to now and background to the establishment of MusaNet – Nicolas Roux* *DISCUSSION: Comments and questions on the global strategy and MusaNet*

A session on reviewing the development and implementation of the Global Strategy for the conservation and use of banana and plantain genetic resources (developed in 2004-2006) had the objectives to get a clear understanding of what was done and where we are with the global strategy and to review the strategy and expectations from the banana research community on the further development and implementation of the global strategy. The session was introduced with a presentation from Nicolas Roux on the background on the development of the strategy: why and how it was developed, who was involved and a review of the implementation of the strategy - what has been done since 2006. It introduced MusaNet and its proposed structure and how it may function.

PRESENTATION: The Global Musa Strategy from its development to now and background to the establishment of MusaNet – Nicolas Roux

The background documents for this presentation are the following:
- Global Musa Strategy developed in 2006
- Document on MusaNet – description of role and functions and membership

Presentation Outline
- Global context
- *Musa* Strategy Background
- Implementation to date
- Critical review
- Proposal for MusaNet

Global Context in 2004-2005 Threats to genetic resources:
- Long term funding for collection is scarce
- Field collections deteriorating
- Management limitations in several locations
- A lot of accessions remain unused
- Inadequate information on accessions

- 1996 - FAO Global Plan of Action (GPA) for the Conservation and Sustainable Use of PGRFA (adopted by 150 countries) calls for: "a more rational system based on better planning, coordination and cooperation, so that costs could be reduced and conservation work placed on a scientifically sound and financially sustainable foundation."
- Treaty (ITPGRFA): came into force in 2002 - conservation, sustainable use, fair and equitable sharing of benefits arising out of their use. Musa is one of the 35 crops listed in Annex 1 - Multilateral System of Exchange (MLS).
- Global Crop Diversity Trust: Aiming to provide sustainable funding to ex situ conservation efforts, supporting the development and maintenance of the rational global system. Founded by FAO and Bioversity, acting on behalf of the CGIAR. Funding allocated according to priorities indentified in global and regional *ex situ* conservation strategies.
- Conclusion: time is right for developing a Global *Musa* Strategy to guide the allocation of funds from Trust and to support the GPA and the Treaty implementation

The Global Musa Strategy

Objective: A strategy for the effective conservation and exchange of Musa genetic resources

Expected outputs:
- Genetic diversity is characterized and collections are rationalized
- Global system for safe exchange of germplasm is strengthened
- Entire gene pool is conserved in perpetuity
- Use of genetic diversity is maximized

It was hoped that the strategies will be well utilized by scientists, policy makers, and donors, and be updated as the global system evolves.

Strategy development:

The strategy was developed through a collaborative consultation process bringing together researchers and institutions, under the guidance of a lead crop expert. Prof. Edmond De Langhe:

- 1st Step: Identification of Musa collections and other potential partners
- 2nd Step: Data on collections' status collated, reviewed and proposed model for collaboration discussed.
- 3rd Step: Results of initial consultations incorporated into a first draft strategy document.
- 4th Step: Draft discussed and reviewed by key stakeholders in the regions through the regional networks
- 5th Step: Strategy "finalized" in 2006 but intended to remain a working document to be updated as the global system evolves

Strategy content

- Status of *Musa* diversity
- Existing *ex situ* conservation
- Proposed model for collaboration
- Priority collections for support
- Next steps for implementation

Proposed model for collaboration

Roles and responsibility for the conservation of unique germplasm and improved varieties:

- National collections
- Internationally-recognized collections
- Global collection - ITC
- Service providers

Roles of National Collections

- Collecting and documenting traditional knowledge
- Characterizing and evaluating varieties
- Participatory evaluation of germplasm with farmers/consumers
- Disseminating germplasm at a national level (esp. farmers)
- Expertise and production and use, local cultivars
- Participating in MGIS

Roles of Internationally-recognized collections

- Expertise in taxonomy, germplasm management and multiplication technologies
- Characterizing and evaluating varieties
- Verifying accessions trueness-to-type
- Disseminating germplasm to all collections, breeders and researchers
- Disseminating germplasm at a national level and potentially at a regional level in specific cases
- Participatory evaluation of germplasm with farmers/consumers
- Participating in MGIS

Roles of Global collection - ITC

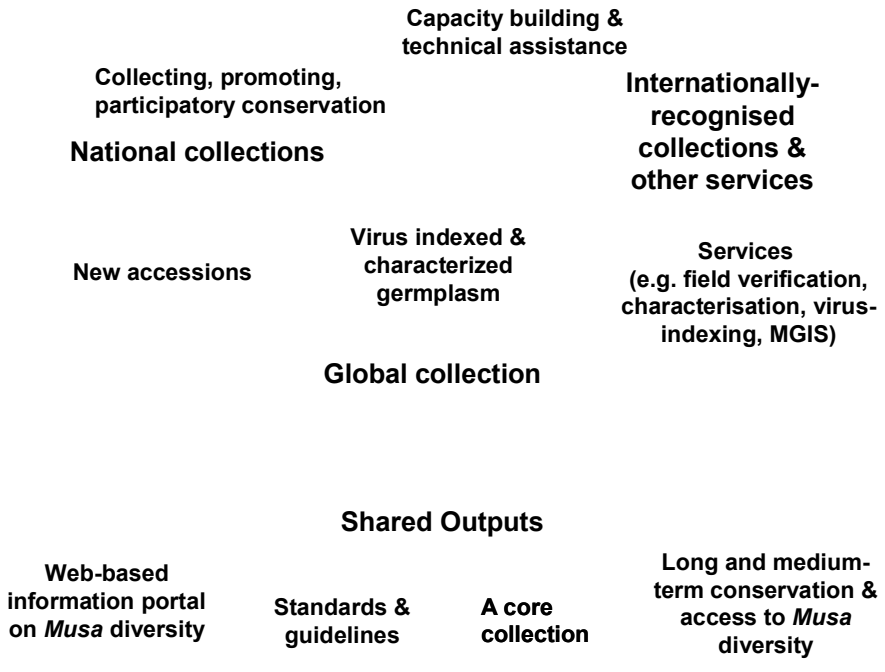
- Maintaining FAO "in trust" collection

- Long- and medium-term conservation of entire gene pool
- Disseminating germplasm to all collections, breeders and researchers
- Expertise in taxonomy, *in vitro* technologies, germplasm exchange & SMTAs, accession information management
- Processing germplasm for virus indexing
- Coordinating and upgrading MGIS

Service providers

- Pre-indexing, Virus Therapy
- Virus-indexing (and quarantine services)
- Ploidy determination / verification
- Roles of the ITC in a global system on *Musa* Genetic Resources

Model of collaboration:



Global System Implementation plan

Three bodies providing oversight:

1. Taxonomy Advisory Group -TAG (taxonomists, breeders, collection managers & molecular experts) for technical backstopping and advice for the implementation of the strategy
2. *Musa* Regional Networks for coordination of activities at a regional level and integration the proposed activities with ongoing initiatives
3. Bioversity for overall coordination and linkages to ProMusa, IMTP and other relevant research programmes and projects

Implementation to date:

- TAG actions: Minimum set of descriptors and photos determined, regeneration guidelines published, reference accessions determined and distributed,
- Cryopreservation of *Musa* accessions – ITC and NBPGR
- Field verification of 820 ITC accessions in 5 sites
- Monitoring genetic integrity of 700 ITC accessions by DArTs

- *Musa* genotyping centre for accession verification coming into the ITC and as a service to any researcher
- Pre-indexing service for pre-screening for material to be sent to virus indexing centre
- MGIS improvements
- Many more from a range of partners…

Critical review- what worked?

- Funding from Trust channelled through the strategy
- Allowed the identification of key players
- Provided leverage for regional partners
- TAG … useful model for establishing expert groups

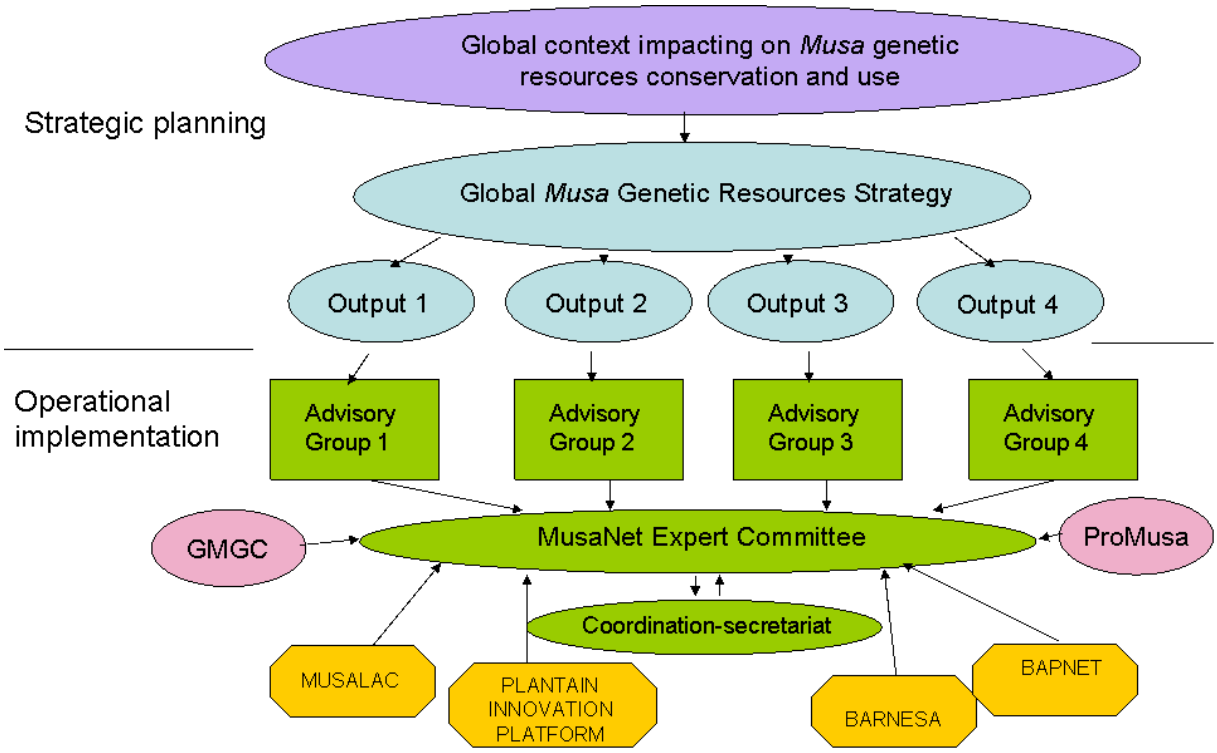
What could be improved?

- TAG action points: Need to move from formulation to accomplishment
- Needs to move from a conservation to a USE strategy
- Needs to move from a concept of a global system to a formalized collaboration framework (with accepted roles and responsibilities)
- Incorporating lessons learnt of the Trust funded projects
- Needs a more formalized operational framework

Proposal for MusaNet

A global collaborative framework for *Musa* genetic resources and a partnership of all key stakeholders, aiming at ensuring the long-term conservation on a cooperative basis, and facilitating the increased utilization of *Musa* genetic resources globally. Main Outputs of MusaNet in line with the outputs of the strategy.

MusaNet structure



Why we are here today

MusaNet workshop: Consultation to improve the global strategy (content and model) and obtain ownership and buy-in from all key stakeholders for its efficient implementation

DISCUSSION: Comments and questions on the global strategy and MusaNet

Summary of the follow-up discussion:

- Nicolas strengthened the point that MusaNet will be based on expertise and has strong links with the Regional *Musa* Research Networks. MusaNet was conceived as network of experts in *Musa* genetic resources. A draft document was put together describing the structure and operation of MusaNet. Some clarity will be needed to better understand all the links between MusaNet and other initiatives and networks and the implementation of activities *vs* MusaNet being only an advisory body. Nicolas explained the experience of the Taxonomy Advisory Group (TAG) which has been used as a model to establish the thematic groups of MusaNet. MusaNet will be expected to help with seeking funding for collaborative activities and to facilitate the exchange of material and support the duplication of materials at the ITC.
- Questions were raised regarding the critical review of the implementation of the strategy and proposed to get a better understanding of why some expected outputs were not achieved.
- Some participants stressed the constraints of access and exchange of germplasm and the lack of documentation and poor quality photos in MGIS for example. It was questioned whether the International Treaty was clear enough.
- It was proposed that this meeting should ensure that we agree on priorities and ensure follow-up actions.

Monday 28 February *10:30-12:00*	***Session 3 – Global context and partnerships to support the implementation of the global strategy and funding opportunities*** *PRESENTATION: Critical links between the Global Strategy and the development of a CGIAR Research Programme on Roots, Tubers and Banana (CRP-RTB) on Banana – Stephan Weise* *PRESENTATION: Review of scientific opportunities: what has been developed and may impact positively on the Strategy – Jean Christophe Glaszmann* *PRESENTATIONS: Musa germplasm-related research priorities in: Brazil - Janay Serejo / Cameroon - Emmanuel Fondi / India - Uma Subbarya / Philippines - Lavernee Gueco* *DISCUSSION: Global context and research priorities*

PRESENTATION: Critical links between the Global Strategy and the development of a CGIAR Research Programme on Bananas Stephan Weise, Bioversity International

The background documents for this presentation are the following:

- Leaflets in English and French also available at: http://rtb-mp3.cgxchange.org/
- Full proposal for the CGIAR Research Programme on Roots, Tubers and Bananas available at: http://rtb-mp3.cgxchange.org/home/documents

Key Principles of the NEW CGIAR

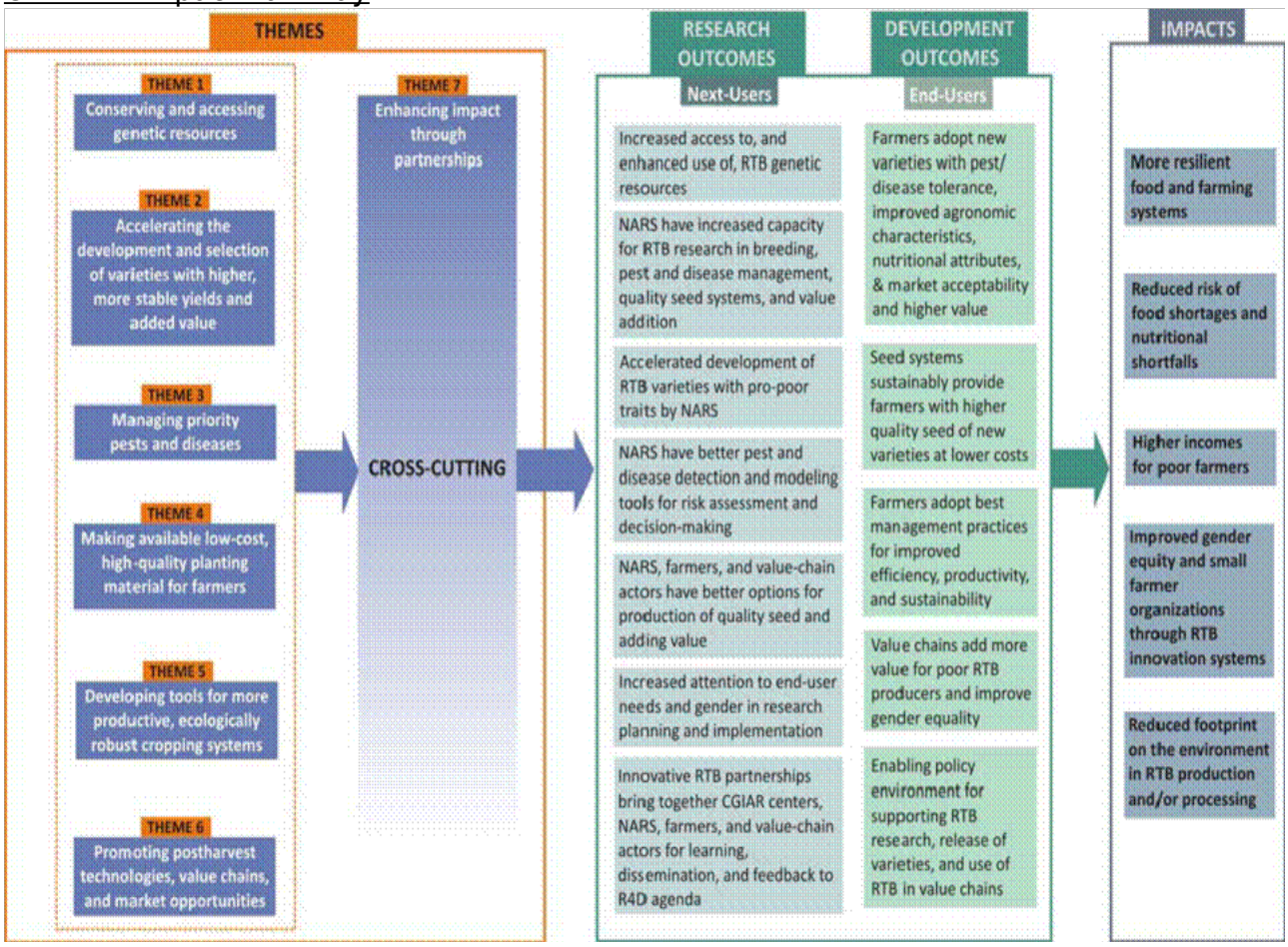
- A harmonized approach for supporting and conducting research through a dual structure, which consists of a Consortium of CGIAR Centres and a new CGIAR Fund

- Management for results in accordance with the Strategy and Results Framework (SRF) and portfolio of CG Research Programs (CRPs) that derive from the SRF
- Effective governance and efficient operations for better provision and use of resources
- Strong collaboration and partnerships with and among funders, implementers, and users of SRF research as well as other external partners supporting the SRF

CRP 3.4 – Roots, tubers and bananas for Food Security and Income (RTB): Themes

- Conserving and accessing genetic resources (!!)
- Accelerating the development and selection of varieties with higher, more stable yield and added value
- Managing priority pests and diseases
- Making available low-cost, high-quality planting material for farmers
- Developing tools for more productive, ecologically robust cropping systems
- Promoting postharvest technologies, value chains, and market opportunities
- Enhancing impact through partnerships (!!)

CRP-RTB Impact Pathway



CRP-RTB Theme 1 - Objectives

- Ensure that the ex-situ conservation of RTB crops is efficient, relevant, and cost effective.
- Strengthen and better understand in-situ conservation and on-farm management towards resilient livelihoods.
- Improve the coverage of in-trust collections.

- Stimulate the use of RTB germplasm thru characterization, description of agronomic features, reaction to pests & diseases, abiotic stresses, nutritional & technological traits.
- Promote the use of germplasm by facilitating access to information.
- Strengthen the global system for the safe exchange of germplasm.
- Advocate proactively for the value of genetic resources to policy makers and donors.

CRP-RTB Impact Pathway – Theme 1

Each theme includes product lines and products with linkages to different research outcomes. These research outcomes feed into development outcomes that in turn contribute to improved food security, income generation, improved gender equity, and reduced environmental footprint as impacts.

An example is detailed here for the product line - Increased coverage of genepool in global genebanks:

- Products: (1) Priority areas for exploration indentified, based on herbarium specimen data, GIS and fingerprinting analysis and (2) international collections integrated into global conservation strategies
- Research outcomes (next users): (1) Better representation of germplasm in ex situ international collections for users and (2) Management of NARS collections improved.
- Together with the other research outcomes, are contributing to the following development outcomes (end users): (1) Farmers accessing more diversity as landraces and incorporating into cropping systems and (2) Farmers accessing more germplasm with improved agronomic and quality traits and broader genetic base as varieties.
- Together with the other development outcomes, are contributing to the following impacts: (1) More productive agrobio-diverse farming systems with resilience to climate shocks (2) Increased income through market diversity and (3) Improved nutrition through consumption of more micronutrient-dense RTB.

MusaNet in CRP-RTB - Box 4.1.7: Global Musa genetic resources network (MusaNet)

The agenda for MusaNet—the network for the conservation and use of *Musa* genetic resources—is guided by a global conservation strategy document developed by Bioversity International, in close collaboration with partners inside and outside the CGIAR. The global *Musa* collection at the International Transit Centre, held “in trust” by Bioversity under the auspices of the FAO, provides the foundation for conservation efforts. The function of the network is to mobilize diverse expertise and different perspectives, define priorities and build consensus around an agreed agenda for joint action. Specialist expertise is provided by the “MusaNet expert committee” acting as an advisory group, while much additional expertise is mobilized through the participation of national banana programs and the activities of the regional banana networks. Networking is vital to the implementation of a global strategy of conservation, both as a means for sharing out the multidisciplinary characterization as for reaching consensus on joint actions to expand the coverage of collections or rationalize them. A key element in understanding the diversity held in collections, managing them efficiently and making the diversity available for use by breeders and other clients, is an efficient genetic resources information system.

In Summary

- MusaNet is built into the CRP-RTB

- Draws on the strength of CGIAR centres and existing partnerships within a coherent programmatic framework
- Links GR resources into a CRP-wide use framework
- Allows for cross-crop synergies and learning
- Allows for linkages to regional research for development platforms
- The CRP is enabling, but will need wider input and support to achieve the MusaNet goals and objectives.

PRESENTATION: Review of scientific opportunities: what has been developed and may impact positively on the Strategy – Jean Christophe Glaszmann

Musa cultivars, a complex genome

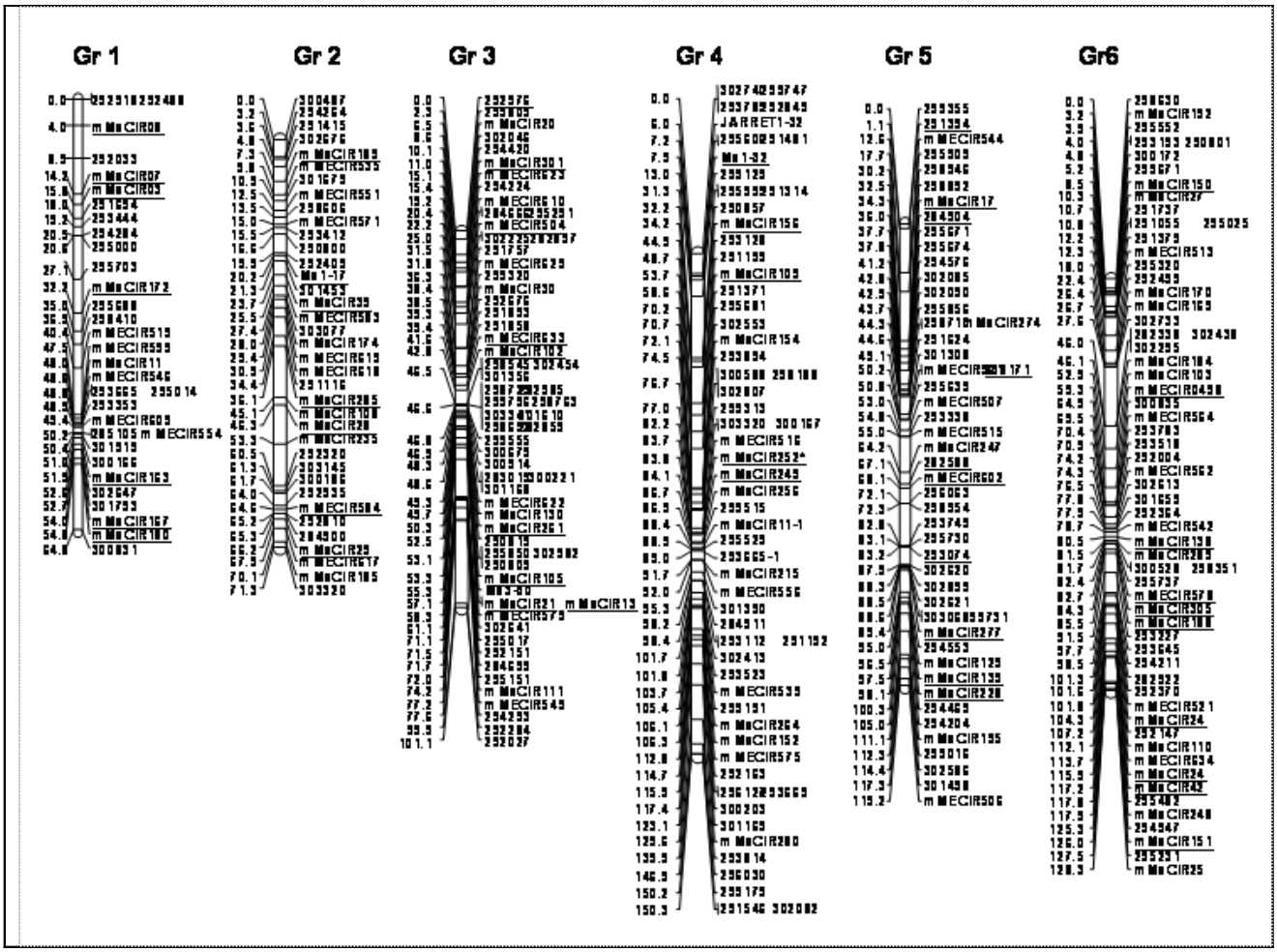
New developments and applications
- Flow cytometry - Ploidy determination
- Genomic differentiation, GISH
  - Genomic determination
  - Pairing behaviour
  - A *vs* B homologous pairing centromeric segregations and intrachromosomal intergenomic recombination

Molecular diversity resolution
- Fingerprinting
- Assignment, classification in diploids
- Origin of triploids
- Gap-filling prospection targets
- Distribution of marker use

Generations of markers
- Flavonoids
- Isozymes
- RFLPs
  - Cytoplasmic
  - Nuclear
- SSRs
- DArTs
- ITS

Genome mapping
- Mapping QTL/genes
- Cytological group typing
- Mining insertions

A first reference map for *Musa acuminata* built from Pisang Lilin and Borneo parental maps and three putative structural polymorphisms have been identified. The map spans 1197 cM, bears 489 markers (167 SSR, 322 DArTs) representing a mean of 1 marker/2.4 cM. Anchor markers are underlined in the figure below.



Note: A tree representation method to investigate structural heterozygosity in parents from a genetic map was also presented.

Structural heterozygosity

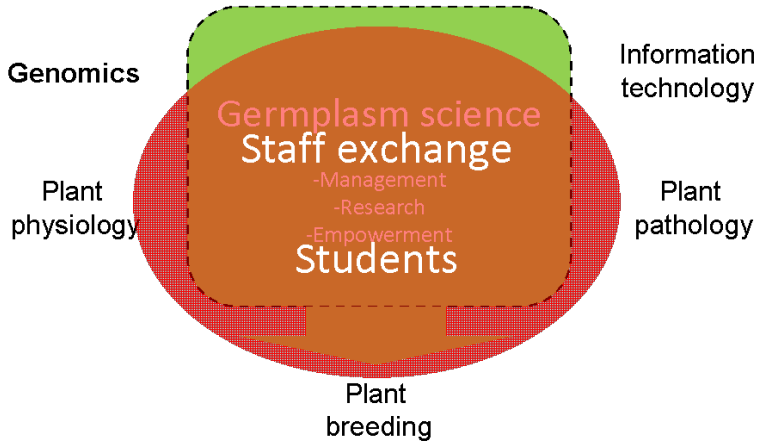
- Genetic map selfed 'Calcutta 4' X 'Madang' (F2)
- Linkage group II
- Two wild diploid *M. acuminata* accessions
  - 'Madang' (*M. a. banksii*)
  - 'Calcutta 4 ' (*M. a. burmannicoides*)

Genome sequencing

- Mining markers (tri-SSR compound = total allelic resolution for any material, possibility to mark each and any chromosome unless IBD (identity by descent) in related materials)
- Mining genes (*Musa* sequence - sd-1 orthologs - somatic variants mutants- ortho sd-1 variation?)

The MusaTract banana genome sequencing project

- Sequence of a Pahang-derived doubled haploid *M. a. malaccensis*
- Full-length cDNA libraries and of cDNA for deep sequencing of Pahang DH
- A mapping population from selfing of Pahang, with SSRs and DArTs to be released in 2011

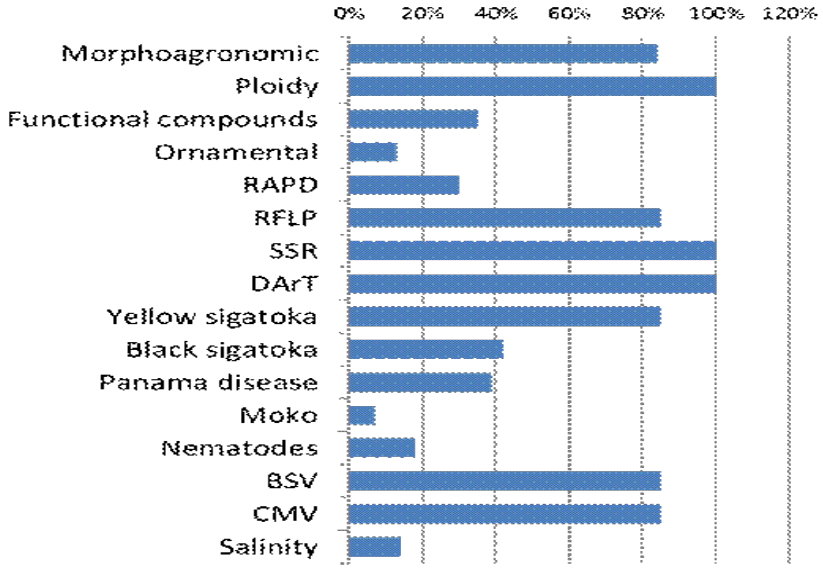


PRESENTATION: Musa germplasm-related research priorities in Brazil - Janay Serejo

Conservation - Sections: Eumusa, Rhodochlamys and Callimusa

Maintenance	**Total No of acces.**	**Wild sp**	**Cultivated**	**Breeding lines**	**Other types**
Field	264	47	187	26	4
In vitro	75	42	29	2	2

Characterization



Uses

Breeding for food

- Productivity
- Resistance to biotic and abiotic stresses
- Plant height
- Functional compounds

Ornamental: 34 accessions and 518 hybrids

- Minifruits
- Cut flower
- Potted plants

- Landscape

Priorities

- Database
- Duplicate identification
- Germplasm enrichment (Plantain)
- *In vitro* conservation and cryopreservation
- Morpho-agronomic evaluation
- Evaluation for resistance
- Sigatoka diseases, Fusarium wilt (including TR4), Nematodes
- Enhancement of functional compounds
- Ornamental
- Climate changes

PRESENTATION: Musa germplasm-related research priorities in Cameroon - Emmanuel Fondi

CARBAP in brief - Created in 2001 - takes over mandate of CARBAP created in 1989

A triple vocation

- Research-innovation
- Support to development and
- Training

A Regional mandate

- CEMAC centre of excellence
- Base centre of CORAF
- Hosting the secretariat of « Plantain innovation platform for west and central Africa » - New orientation from MUSACO

A regional collection: the extent of diversity

Type	**N° of accessions**
Wild types (*acuminata, balbisiana* and others)	33
Desert types : Cavendish, Gros Michel, figues, pisangs, Ibota, pomme, fougamou, ... and others	105
Cooking banana types : Pisangs, Popoulous, Bluggoe, pilipita,... and others	132
Plantains : French types (Giant, medium, dwarf), French horn types (Batard), False horn and true horn types	150
Beer types : East African highland bananas (lijugira)	11
PNG types (mostly edible diploids)	121
Other assorted types currently being introduced (From field verification)	110
The TAG reference collection (34 representative accessions)	-
Hybrids + breeding stock	-
Total	**662**

Recent and current germplasm related activities

Rejuvenation and field verification

- Objective: To verify the conformity of banana germplasm maintained in vitro at the ITC
- Results: More than 300 accessions verified

Regeneration and Safety Duplication of Priority *Musa* Collections

- Objective: To regenerate, duplicate and safeguard threatened *Musa* cultivars to promote access to *Musa* diversity and ensure conservation for perpetuity
- Results: 50 accessions regenerated and characterized, 50 accessions placed *in vitro*, 50 accessions duplicated at the ITC

Musa Reference collection

- Objective: To test the stability of descriptors across environments and help standardize characterization and classification procedure to sub group level
- Results: 34 accessions virus indexed and field planted. Characterization is on-going

Participatory evaluation and selection projects: TARGET, DURAS, FSTP, CORAF

Research priorities

Field maintenance of collections (regional and national) - medium to long term

- Regeneration, fertilizers, pesticides, labour

Capacity building

- Database management and documentation

Pursuing characterization

- Morpho-taxonomic, Post harvest, Molecular

Evaluation and enhancing the use of diversity

- Multi location evaluation
- Participatory evaluation and dissemination (Selected cultivars, Improved varieties and research material)

Development of regional system for the safe exchange (movement) of germplasm

What is needed from global collaboration to better achieve outputs?

- Developing a long term funding mechanism to achieve proper maintenance of the regional collection in CARBAP and the other national collections in the region
- Assist in capacity building and training to ensure proper documentation and maintenance of updated databases to promote regional/international collaboration and use of germplasm
- Support the plantain innovation platform for west and central Africa in the preparation of regional projects and the mobilization of financial resources to address regional needs
- Support CARBAP's tissue culture unit to play its role as the regional germplasm exchange point (updating equipment including virus indexing kits – BBTV)

PRESENTATION: Musa germplasm-related research priorities in India - Uma Subbarya

Critical Review of the Global Strategy

- For the conservation and use of banana and plantain genetic resources
- Clear understanding of what was done and where we are with the global strategy.

Musa conservation strategies

- *In-situ* conservation- Reserve forests
- On- farm conservation- Farming communities
- *Ex-situ* conservation- Under the leadership of NRCB
    - Other National institutes (NBPGR)
    - State agricultural universities (SAUs)
    - State Departments
- *Ex-situ* conservation
    - Field genebank
    - *In-vitro* gene bank
    - DNA Bank

- Cell lines bank

Networking of field genebanks – Under All India Co-ordinated Research Programs

Germplasm status of NRCB Co-ordinated centres –India

AICRP Centres	Breeding	Cultivated	Wild	Others	Total
Arabhavi, Karnataka	6	43	3	8	60
Jalgaon, Maharastra	7	64	3	14	88
Jorhat, Assam		61	11		72
KANNARA, Kerala	15	170	9	58	252
Kovvur, Andhra Pradesh	8	66	6	25	105
MOHANPUR		15	2		17
NRCB, Tamil Nadu	33	229	29	19	310
RAU, Pusa	2	79		22	103
TNAU, Coimbatore	5	151	7	23	186
NBPGR	15	150	30	215	410
	91	1028	100	384	1603

AICRP Centres	GRM	Production tech.	Breeding	Protection Tech.
Arabhavi, Karnataka	☼	☼		☼
Jalgaon, Maharastra	☼	☼		☼
Jorhat, Assam	☼			☼
KANNARA, Kerala	☼	☼	☼	☼
Kovvur, Andhra Pradesh	☼	☼		☼
MOHANPUR	☼	☼		☼
NRCB, Tamil Nadu	☼	☼	☼	☼
RAU, Pusa	☼			
TNAU, Coimbatore	☼	☼	☼	☼
NBPGR	☼			
IIHR, UAS	-	-	-	-

Field genebanks

- A core collection - 364 accessions representing the entire diversity in the Indian sub continent.
  - At Satellite genebank, Agali, NRCB
  - Field genebank, NRCB
- *In-vitro* gene bank
  - Developed *in-vitro* core collection of 148 accessions
- Parallel in-vitro collection At NRCB, Trichy
  - A duplicate set at NBPGR, New Delhi, in a collaborative mode

DNA Bank

- DNA collection 360 accessions
- For molecular works
- Inaccessible Wild species, wild relatives of *Musa*

Cell lines bank

- Genetic transformation and gene programming studies.

At NRCB - suspension cultures -8 commercial varieties

NRCB- NBPGR Collaborative programme for *Ex-situ* and *In-vitro Musa* conservation 410 accessions stored under slow growth conditions comprises cultivated triploids and diploids, wild species

Modalities of working between NRCB and Co-ordinated centres

- NRCB- Lead centres
- NBPGR -Co-operating / Facilitating centre
- SAU's-Active centres
    - Biannual meetings- All Research activities are drafted in consultation with NRCB and reviewed periodically by NRCB.
    - Evaluation and testing of all technologies will be done simultaneously by different centres
    - Under respective agro-climatic conditions
    - Annual reporting of results

Introduction and evaluation of hybrids from breeding programs worldwide

- IMTP for Sigatoka leaf spot - conducted at two stations, i.e. NRCB, Trichy and Thottiam village, Tamil Nadu
- IMTP for Fusarium wilt - conducted at the Banana Research Station, Kovvur, Andhra Pradesh (hot spot for Fusarium wilt)
- IMTP for nematodes - conducted at NRCB, Trichy

Global context and Partnerships

Participation in EPMG (Evaluation of Promising *Musa* Germplasm – BAPNET funded)

- Multiplication of selected, promising IMTP accessions
- Evaluation and field testing of selected IMTP accessions in farmers field

To evaluate consumers' preference for the introduced IMTP accessions

- Saba
- FHIA-03
- FHIA-23

Major Issues in Musa GRM

Slow decline of field germplasm due to BBrMV and CMV

- Latent / never expressed infection
- Varietal differences for infection and expression mode.
- ABB more susceptible for which India has greater diversity.

Working on names and synonyms at national level. Some progress done but not complete.

Issues to be addressed

1. Conservation of priority germplasm under controlled conditions.
2. How to address virus affected valuable germplasm….?
3. Cleaning of germplasm – Cryo, chemo, thermo therapies
4. Alternatively, recollection of germplasm wherever possible.
5. Establishment of regional virus indexing units with rationalised protocols.

From User point of view….

- Information on specific uses … (quality, therapeutic, fibre, processing etc.)
- Evaluation of their suitability to various production systems
- Availability of clean planting material

- Buy back / market for the new introductions
- Anymore expectations will be added in the discussions…

PRESENTATION: Musa germplasm-related research priorities in The Philippines - Lavernee Gueco

Musa Conservation in the Philippines

- NPGRL, University of the Philippines: Field Genebank, *in vitro* and screen-houses
- Bureau of Plant Industry (BPI) of the Department of Agriculture (DA)

Project title: Conserving banana diversity for use in perpetuity: strengthening the network of collections to improve access to wider diversity and safeguard threatened banana cultivars funding: Global Crop Diversity Trust, Duration: Aug 2008 – March 2011

Baseline Data

Maintenance	UPLB		BPI	
	Wild *M. balbisiana*	Edible *Musa*	Wild *M. balbisiana*	Edible *Musa*
Field Collections	108	0	0	87
In-vitro	0	63	0	0

In vitro conservation of *Musa* (NPGRL-UPLB): 98 accessions of edible bananas maintained and 108 wild *M. balbisiana* were placed in cultures

- Severe browning
- Regenerated but later died
- Regenerated 30 accessions

Safety duplication of *Musa* collections

Maintenance	UPLB		BPI	
	Wild *M. balbisiana*	Edible *Musa*	Wild *M. balbisiana*	Edible *Musa*
Field Collections	108	0	103	88
In-vitro	31	98	0	0

Accomplishments

- Documentation and MGIS
- New collections:
  - 4 ornamental *Musa*
    - *M. coccinea*
    - *M. ornata*
    - *M. velutina*
    - *M. laterita*
  - 4 edible *Musa*

Maintenance of healthy germplasm - Virus indexing of wild *Musa balbisiana* at field genebank, IPB-CSC, CA, UPLB disease incidence (%)

BBTV	0
BBrMV	91.67
CMV	22.22
BBrMV + CMV	22.22

Screen-house Conservation

- 14 introduced and 63 local cultivars
- Regularly monitored using visual observations and ELISA (every 6 months)

- All plants are still negative to the viruses.

Safety duplication to ITC: 30 accessions to be shipped in ITC

Other On-going Projects

1. Assessing drought tolerance of wild and edible *Musa balbisiana* germplasm and the impact of drought on the activation of infectious endogenous banana streak virus (BSV) sequences (under the framework of ProMusa). Funding: Global Crop Diversity Trust. Duration: 2008 - 2011
2. Activation of endogenous banana streak virus sequences in *Musa* germplasm from the Philippines (under the framework of ProMusa). Funding: Global Partnership Initiative for Plant Breeding Capacity Building (GIPB). Duration: July 2009- June 2011

DISCUSSION: Global context and research priorities

The presentations from research priorities in Brazil, India, Cameroon and the Philippines was followed by a brief discussion on the following main points

- Documentation and collaboration with MGIS and on germplasm exchange and concerns about cultivar protection in Brazil.
- Quality control mechanisms and ensuring that the Cameroon collection is fully accessible as well as safe movement of materials. There may be the need for a project for the long-term conservation of the collection at the ITC.
- The origin of the material conserved in the Indian collections, its distribution of materials and the administration constraints associated to it, and the links with the breeding programmes.

Monday 28 February *14:00-15:30*	***Session 3 – Global context and partnerships to support the implementation of the global strategy and funding opportunities - continued*** *PRESENTATION: Collective action challenges in the implementation of the Multilateral System of the International Treaty – Sélim Louafi* *PRESENTATION: To serve and conserve: strengthening germplasm evaluation to focus on users' needs – Theo van Hintum* *DISCUSSION**:** Incentives and constraints in implementing the Multi-Lateral System of Germplasm exchange (MLS) and proposed solutions*

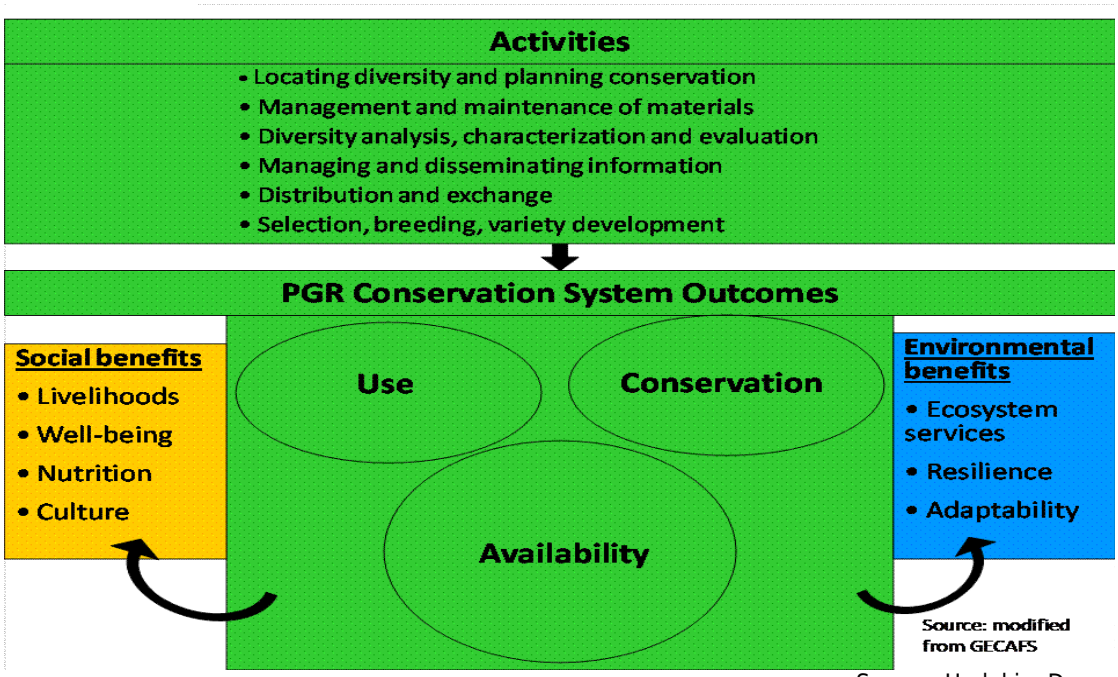
PRESENTATION: Collective action challenges in the implementation of the Multilateral System of the International Treaty – Sélim Louafi

The background documents for this presentation are the following:

- Copies of the International Treaty also available at: http://www.planttreaty.org/texts_en.htm

Objectives of the presentation

1. Where the Treaty fits in PGR conservation and use efforts?
2. What are the Treaty implementation challenges?



Source: Hodgkin, Demers, 2011

What the International Treaty is?

- A cooperative intergovernmental framework which fosters the three outcomes : conservation, use, availability
- General provisions:
  - Art 5 : Conservation of PGRFA
  - Art 6 : Sustainable use of PGRFA
  - Art 9 : Farmers' rights
- Operational mechanism: the Multilateral system of access and benefit sharing (MLS) which aims at facilitating exchange of material worldwide

Basics about the MLS and the SMTA

- Multilateral System of exchange - MLS
  - Collective pooling of material by Contracting Parties (i.e. State governments) and the institutions they control.
  - Samples also come into the gene pool from international and regional institutions as well as natural and legal persons - anyone that is - within the jurisdiction of Contracting Parties.
- Standard Material Agreement - SMTA
  - Administered under a common set of rules specified in a contractual instrument, the SMTA
  - Those facilitated access rules apply to individual transfers of those samples for certain purposes, namely utilization and conservation for research, breeding and training for food and agriculture.

Recognition of the need for international collective action to manage a common resource, plant genetic resources for food and agriculture, in a manner that is more beneficial and efficient to everyone than individual action would be.

Benefit-sharing

- Facilitated access is itself a major benefit
- Exchange of information
- Access to and transfer of technology

- Capacity-building
- The sharing of monetary and other benefits of commercialization

The Treaty recognizes that facilitated access to these plant genetic resources is in itself a major benefit. This makes it possible for farmers and plant breeders, in both the public and private sectors, to have access to the widest possible range of the resources that are crucial for world food security. This will ultimately benefit consumers, by providing a stream of improved and varied agricultural products. And the Treaty will benefit the seed and biotechnology industries, by providing an agreed international framework, within which to plan their investments.

The Treaty also identifies and makes provision for a wide range of other forms of benefit-sharing, including the exchange of information, access to and transfer of technology, capacity-building, and the sharing of the monetary and other benefits of commercialization. The principle aim of the benefit-sharing arrangements is to improve the conservation of, and the potential to sustainably use, plant genetic resources for food and agriculture, particularly for the benefit of farmers in developing countries and countries with economies in transition. Through the realization of those mechanisms, the Treaty could potentially contribute to rebalancing the ex situ conservation focus towards use and *in situ* conservation.

Implementing the MLS

From a technical point of view, implementing the MLS at the national level requires the following actions:

- Identification of material under control and management of the State and in the public domain
- Use of SMTA and define responsibilities for its signature

Other measures include, inter alia:

- Create legal space for Treaty in national ABS legislation
- Encourage legal and natural persons to include material in the MLS

Implementation Challenges

- Awareness and perception
- Administration and regulation
- Political challenges

Awareness and perception

- Lack of appreciation of national dependence on foreign germplasm and on CGIAR´s germplasm and needs for a MLS
- Negative perceptions about germplasm exchange because of claims of biopiracy (Protectionist reactions from countries)
- Perception that the MLS would not benefit the country because lack of capacity for utilizing the resources
- Uncertainty concerning several concepts in the Treaty:
    - Concepts of ABS mechanisms still unclear among scientific community so the benefits involved in the MLS are not well perceived
    - Misperceptions in relation to monetary benefits
    - Unclear how it will benefit farmers as custodians of agrobiodiversity
- Link with IPRs policies

Administration and regulation

- Multiplicity of agencies dealing with PGRFA - Institutional conflicts

- Lack of coordination among research institutions and genebanks
- Dispersal of genebank collections (under different research institutions ´mandates)
- Lack of clear institutional policies on germplasm exchange and ABS in research institutions
- Lack of definition of a Treaty focal point and responsible authorities for the MLS
- Link with IPR policies

Political (collective action) challenges

Coordination of different governance levels

- Vertical redistribution of responsibilities, from local to global

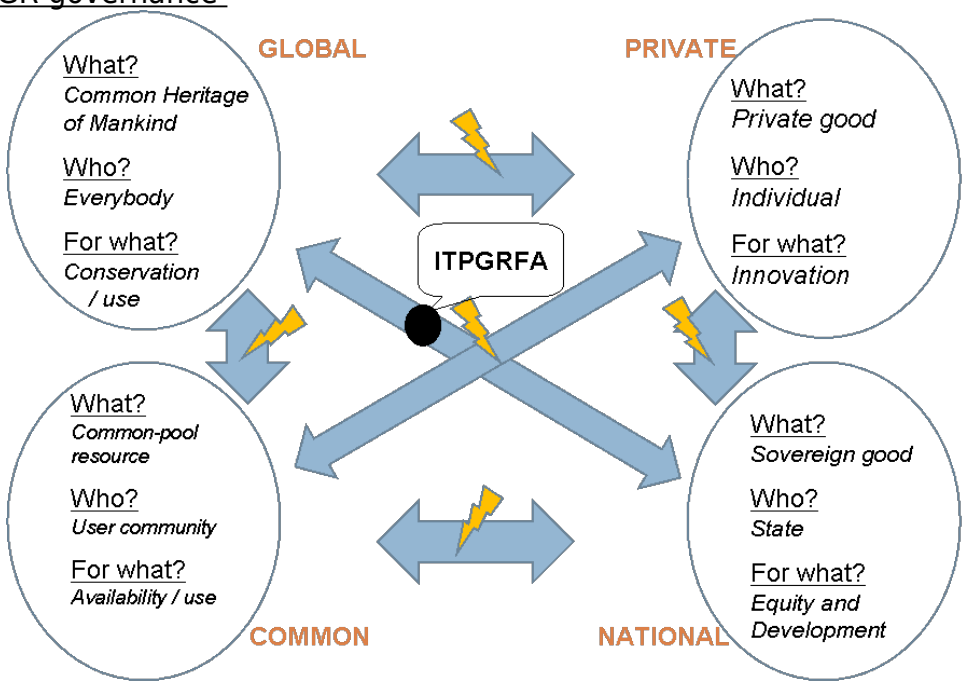
Management of diverging interests and expectations within the PGRFA community

- Attempt to go beyond several divides (conservation/use; in situ/ex situ; North/South; breeders' rights/farmers rights...)

Hierarchy between several global challenges

- Genetic erosion and biodiversity loss; food security; rural poverty of small-holder farmers; Crop adaptation to climate change; bottom-up approach to development policy in agriculture

4 levels of GR governance

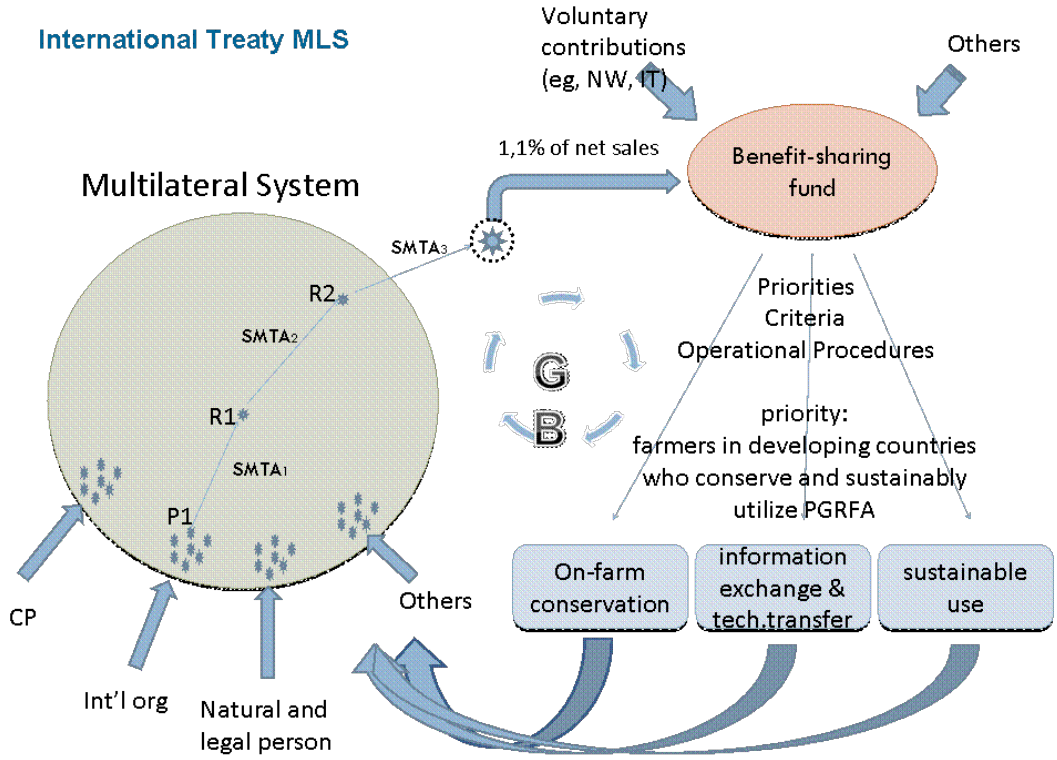


Conclusion

Desired outcome	Potential Crop Network contribution or function	Treaty Mechanisms' Contribution
Conservation	• Representativeness / Completeness • Security • Efficiency of resource use • Sustainability • Responsiveness to global or regional threats	• BS Fund • Non-commercial BS : technology transfer • Article 5

Availability	• Proportion of conserved material available • Extent to which available to all users • Completeness of information System • Accessibility of information to users and exchange of information	• MLS facilitated access • Non commercial BS (exchange of information) • Global information system
Utilization	• Capacity for pre-breeding and breeding • Collaboration on crop improvement and use programmes	• MLS Facilitated access • Non commercial BS

Source: adapted from Hodkins & Demler, 2011



PRESENTATION: To serve and conserve: strengthening germplasm evaluation to focus on users' needs – Theo van Hintum

Serve and Conserve: focus on users' needs

- genebanks are goldmines: we do not have effective mining techniques
- to use PGR a potential user must
    - need new germplasm
    - know about PGR and the PGR collections
    - be able to select material using relevant data
    - request and get high quality and authentic material
- need new germplasm: often new traits are desired - no data available yet and research can show the potential of new germplasm, e.g. results of the advanced backcross work of Tanksley et al.
- know about PGR and the PGR collections: interaction with potential users
- select material using relevant data: a proper web based information system, e.g. EURISCO, Musa germplasm information system MGIS
- request and get high quality and authentic material: confirmed identity and procedural, legal and phytosanitary issues

- most frequent bottleneck: no proper evaluation data for selection
    - new traits are desired but have not been evaluated yet and traits are hidden in an exotic genetic background and can not be evaluated

@CGN (Centre for Genetic Resources, The Netherlands): project 'stimulating use'

- meet with user community with shared interest - breeders of a certain crop
- identify important traits - disease resistances
- organise pre-competitive screening
    - select with participants material to screen
    - distribute the material (in duplo) to participants
    - collect and diffuse results amongst participants
- publish evaluation data after embargo - 5 year
- example lettuce
    - 2000-2006: 1223 accessions (cultivated and wild) were screened in duplo by 7 companies for 28 *Bremia fysiotypes*
    - 2007-2010: 575 accessions were screened for aphid tolerance pathotype Nr:0 and 550 accessions to Nr:1 (Nr:0 was broken in 2008)
- other crops
    - cucumber – virus resistance (CGMMV)
    - sweet pepper – virus resistance (TSWV)
    - onion – *Fusarium* resistance
    - leek – 1 insect tolerance and 3 fungal disease resistances
    - spinach – *Peronospora* resistance
    - potato – *Phytophthora* resistance
- Results
    - breeders using CGN material
    - evaluation data available to the world
    - excellent contact between CGN and (part of) its user community

DISCUSSION: Incentives and constraints in implementing the Multi-Lateral System of Germplasm exchange (MLS) and proposed solutions

A discussion followed the presentations. The main points are summarised here:

- An important step to the implementation of the Treaty is for contracting parties to indicate the collections that are under their control and in the public domain. There is a sample letter of notification for countries to list the collections which fall under this category. There is some variation in the interpretation of what is in the "public domain" and there is no agreed definition. Private persons or organisations fall under Article 11.3 of the Treaty.
- Clarifications on the financial benefits arising from the use of materials were provided, indicating that these benefits from plant genetic resources are not likely to be substantial (and can take a very long time to be realised). The main benefits of sharing germplasm are the use in improvement programme, the sharing of information, technologies and capacity building.
- A discussion on the use of the Standard Material Transfer Agreement (SMTA) provided more information on its objective to facilitate the process of exchange and tracking use of germplasm. No SMTA is necessary for direct use of material by farmers. It was noted that very few of the MusaNet participants use SMTAs. The person responsible for signing SMTAs varies from country to country. In some cases,

this is the Head of the Genetic Resources Units and in other cases the Director of Institutes. In many cases, identifying the right person is still in process.

- The main recommendation made to MusaNet is to focus on what this network of scientists can do to facilitate the exchange of material and ensure that all members benefit from the research and information generated from the use of material to benefit all. The spirit of the Treaty is to benefit mankind and not just one country.

Monday 28 February *16:00-18:00*	***Session 3 – Global context and partnerships to support the implementation of the global strategy and funding opportunities - continued*** *PANEL DISCUSSION: Analysis of the users and their needs of Musa genetic resources and associated information. The following panellists are to represent the following groups of users:* *1. Farmers – (representing the on-farm conservation community) – Deborah Karamura / 2. Pathologists – Gus Molina / 3. Breeders – Jim Lorenzen / 4. Curators – Maurice Wong / 5. National Treaty Implementation – H.P. Singh* *SMALL GROUP DISCUSSION: How to improve the strategy to strengthen the use of Musa genetic resources?*

PANEL DISCUSSION: Analysis of the users and their needs of Musa genetic resources and associated information.

A session on feedback from users groups on the needs for *Musa* genetic resources was held in the form of a panel discussion with 5 MusaNet participants representing different groups of users:

1. Farmers – (representing the on-farm conservation community) – *Deborah Karamura*
2. Breeders – *Jim Lorenzen*
3. Pathologists – *Gus Molina*
4. Curators – *Maurice Wong*
5. National Treaty Implementation – *H.P. Singh*

The five panellists were invited to provide feedback on the following key questions:

1. What are your key needs with *Musa* genetic resources? (i.e. type of materials and related information)
2. What are you, as a user, willing to contribute to a global system? What could be the incentives?
3. What are your major constraints in using (i.e. accessing) the material?

The needs, contributions and constraints are summarised below:

1. Farmers – (representing the on-farm conservation community) – *Deborah Karamura*
    - Farmers have a need for continuous and new source of germplasm to meet various needs of income generation and food supply for the household. The main focus is disease resistance. But specific qualities such as tastes, post-harvest qualities, commercial value and other uses than food production are important requirements. Farmers are interested in testing as many new materials as possible given they have the space for it. Varieties that may not have a market today are still useful as they might use it in the future. Farmers do not easily discard old varieties and keep it to compare with new materials. New materials

mainly come from farmer to farmer and the national programme on crop improvement and field genebanks.
- Farmers are willing to contribute information on cultivation, knowledge about the cultivars and share it with other farmers so that they can benefit from each other experience.

2. Breeders – *Jim Lorenzen*
   - Breeders mainly need genetic resources that are fertile and amenable to breeding. It would be helpful if material were already characterised so breeders could go to a collections and find this material easily.
   - Prioritisation on trait is consistent around the world- black Sigatoka, BBTD, and Fusarium. Material with resistance valuable anywhere. Drought tolerance is the top abiotic trait. Once the traits are evaluated, the material is evaluated for consumer preferences according to regional/ national preferences. Breeding tends to be focussed on commodity types- e.g. Cavendish types. IITA is mainly breeding for West and East Africa for example.
   - A major constraint is accessing materials as exchange of germplasm in most collections does not happen easily. Breeding requires continuous and constant access to new sources of genetic resources. Despite the richness of the ITC collection, we don't know what we are mining so we need to further characterise host-pathogen relationships. Another important goldmine is wild *Musa* in the threatened tropical forests. We need to learn from the past (one variety has dominated for almost 100 years) and pay attention in the future as new hybrids may suddenly become important.

3. Pathologists – *Gus Molina*
   - Pathologists need varieties produced by breeders that have resistance but need to be acceptable in the market place- need to combine disease resistance with commercial acceptability. For example FHIA 25 is high yielding, resistant to black Sigatoka, but does not sell well. If there are no options the consumers will have to change but as we are working with farmers, a lot of varieties are available, evaluated so many for disease resistances- but the quality is very poor in comparison to existing varieties- breeding is very difficult- we look at quality towards the end rather than at the start.
   - An important contribution would be to provide the information from evaluation to MGIS to improve the work and produce suitable varieties. The information generated is useful for breeders and can improve the selection process. There is also a lot of traditional knowledge with some similarities across regions. Partnership is crucial to document information and knowledge from evaluation of varieties understanding the particularities of each community.

4. Curators – *Maurice Wong*
   - Collection curators have a responsibility to curate national biodiversity and farmers need one place to keep their materials. There is an interest from some farmers to get involved in the conservation of varieties and accessing new materials.
   - Characterisation is a challenge to capture all of the traits users are interested in (nutritional, pathology etc). In many cases, the information is incomplete. There are limitations to grow all of the materials in the field to characterise and evaluate. The plants require 2-3 years to grow to fruiting so you need a lot of time to collect and analyse data on all plants of each accession.

- Regional institutes and the ITC can be useful for duplicating material in case of disasters. But not all material is safely duplicated. ITC may have a limit and need to charge after a certain number of accessions.

5. National Treaty Implementation – *H.P. Singh*
   - National programmes of genetic resources oversee many crops. Diversity may be partially covered by the national collections but some characteristics requires to access materials from other partners. Example for *M. balbisiana* where India is rich, but this is not the case for *M. acuminata*. This requires working with networks in the tropics, subtropics and arid tropics particularly with a view to adaptation to climate change.
   - Breeders can access collections but this requires a bi-lateral agreement based on what material and traits are of interest. It is a political issue. In the meantime, some accessions are supplied to the ITC.

SMALL GROUP DISCUSSION: How can the global strategy be improved to optimise utilisation of Musa genetic resources? What are some of the incentives for participation?

The points raised during the small group discussions on the key question "How *to improve the strategy to strengthen the use of Musa genetic resources?"* are summarised below.

What needs to be done?
- Need to look at what has worked well over the past 5 years- learn from our positive experiences.
- Collaboration should be synergistic- so there is an incentive without additional funds. Identify the synergies we can generate within MusaNet- sharing information is the first thing.
- Need to reflect on the role of MusaNet- as a research network, coordinating policy, or to provide funding. We need to be clear on what is expected of the network.
- There is a need for more influence/negotiation by Bioversity with donors and stimulate their interest in banana collecting, characterization, conservation and utilization (Eg of the Australian Centre for International Agricultural Research – ACIAR and AusAID).
- There is also a key issue about funding partners that may not be in a position to fully provide access to the range of genetic diversity they conserve. This has been expressed as a very serious impediment to collaboration and to maximising use of the material for research and breeding.

Focus on users
- Need to better identify the users and their needs.
- Focus on the needs of breeders and phytopathologists for the end users.

Evaluation
- Evaluation should be on priority traits targeting key users' needs. It is not acceptable that we still do not have a list of varieties resistant and susceptible to Black Sigatoka at the ITC.
- Setting realistic objectives for evaluation programme, focusing on high value.
- Where knowledge is lacking, research is needed.

- Clonal selections to find out what good material is already available for use without having to breed.
- Evaluation of newly collected material needs to be supported by a network of partners involving breeders and pathologists for use of wild materials - GXE testing.
- When collecting new germplasm, we need also to collect at that place, pathogens, for example *Mycosphaerella*.

Documentation
- Better monitoring of access to databases.
- An evaluation of MGIS to deliver what the users are expecting.
- Greater involvement of breeders and phytopathologists and consumers in MGIS.
- Improved documentation and better data by developing standards and methodologies.
- Characterisation information of the ITC collection is insufficient and should partner with several field collections to analyse GXE. Select specific sites for this together with breeders and phytopathologists.
- Dedicate time for data sharing in responsibilities – this cannot be done on spare time.

Duplication
- Develop ways to reduce duplication and overlap of material in collections and create core collections.

Access and exchange
- Partnership for increased exchange for better characterised materials and improved evaluation in a range of environments.
- Find incentives for national collections to share the materials and duplicate at the ITC. And increase visibility of those who shared the material.
- Increase access to wild species in national collections.
- Find a system to share the non-monitory benefits.
- Increase the links with farmers, seed systems and multiplication centres. Involve farmers and consumers in meetings.
- Increase public awareness of the importance of *Musa* genetic resources diversity at the global level but also involving schools (the leaders of tomorrow).
- Provide more information on the legal frameworks.

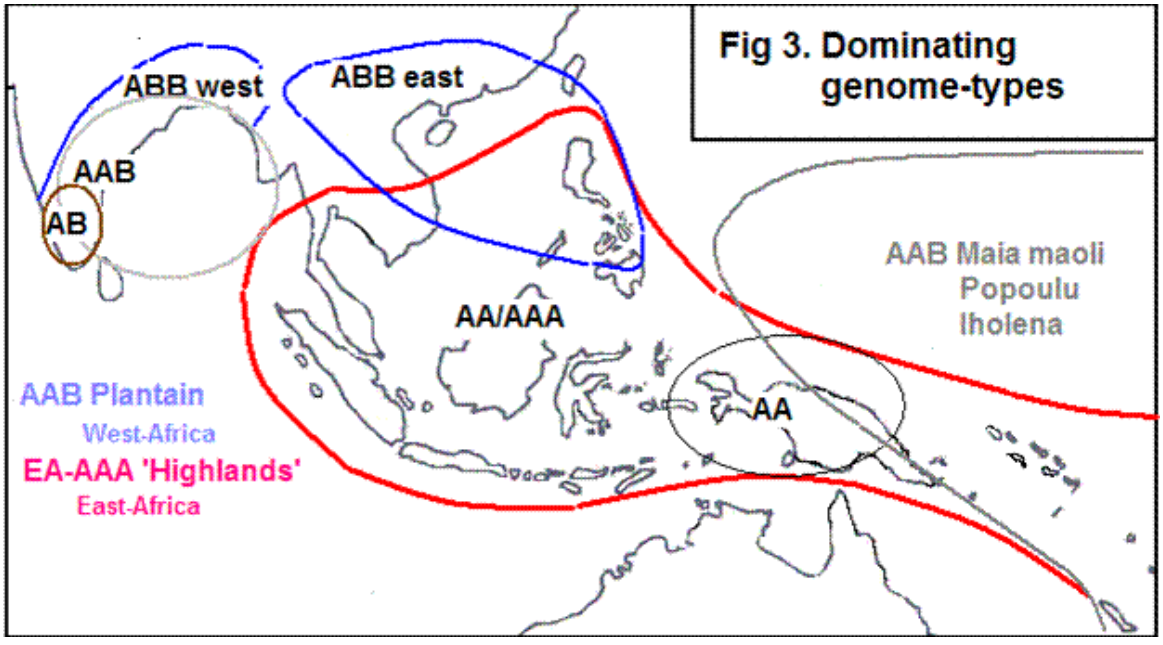
<u>What could be Incentives for collaboration?</u>
- Have a greater access to information and materials. Example of the GMGC and molecular characterisation - core set of satellite markers- DNA samples.
- Material and information providers could benefit from training or be priority partners in global project initiatives.
- Credit to the provider of material and information should be duly acknowledged particularly in publications.
- Data providing should be part of projects to ensure it is done.
- Common methodology and standards tightens the network and provides a basis for attracting funds.
- A strong and focused strategy.

DAY 2	TUESDAY 1 March 2011

Tuesday 1 March 2011 *09:00-12:00*	***Session 4 - Theme 1: Genetic diversity, taxonomy and characterization*** *PRESENTATION: Diversity of the Musa genepool: coverage of ex situ collections and remaining gaps, advances and constraints - Edmond De Langhe* *PRESENTATION: Morphological characterization descriptors: objectives, limits and appropriateness – Jean-Pierre Horry* *PRESENTATION: Pl@ntNet: Plant Computational Identification and Collaborative Information System – Daniel Barthelemy* *PRESENTATION: Genetic integrity of the ITC collection: DArT genotyping – Jean-Pierre Horry* *PRESENTATION: The Musa Genotyping Centre: strengthening the links between morphological and molecular characterization – Jaroslav Dolezel* *PRESENTATION: The Genetic Resources Supply Services (GRSS) of the Generation Challenge Programme (GCP) of the CGIAR - Unlocking genetic diversity for improving food crop adaptation – Jean Christophe Glaszmann* *DISCUSSION: Proposal for future directions with descriptors and a coordinated approach to characterization (morphological and molecular)*

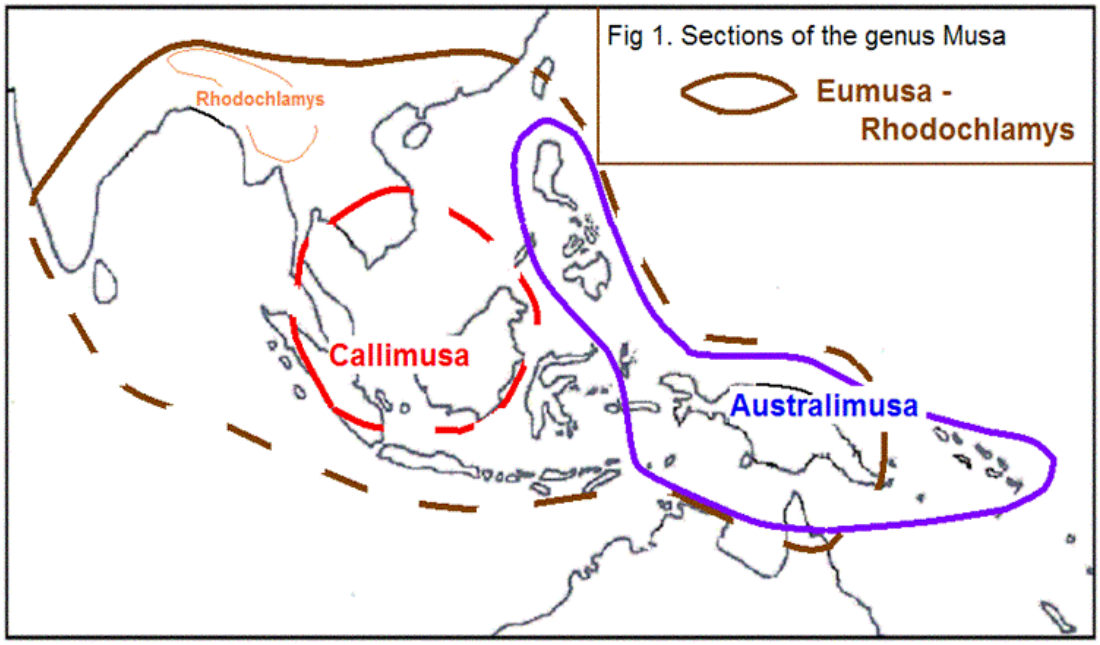
The objective of this session is to present a status of where we are on assessing existing diversity, to what extent this diversity is conserved and safety-duplicated and identifying gaps, with a priority on wild species and to make recommendations for gap-filling priorities. The analysis of the diversity is generating data for documentation and recommendations for a standard methodology and tools would be useful.

PRESENTATION: Diversity of the Musa genepool: coverage of ex situ collections and remaining gaps, advances and constraints - Edmond De Langhe



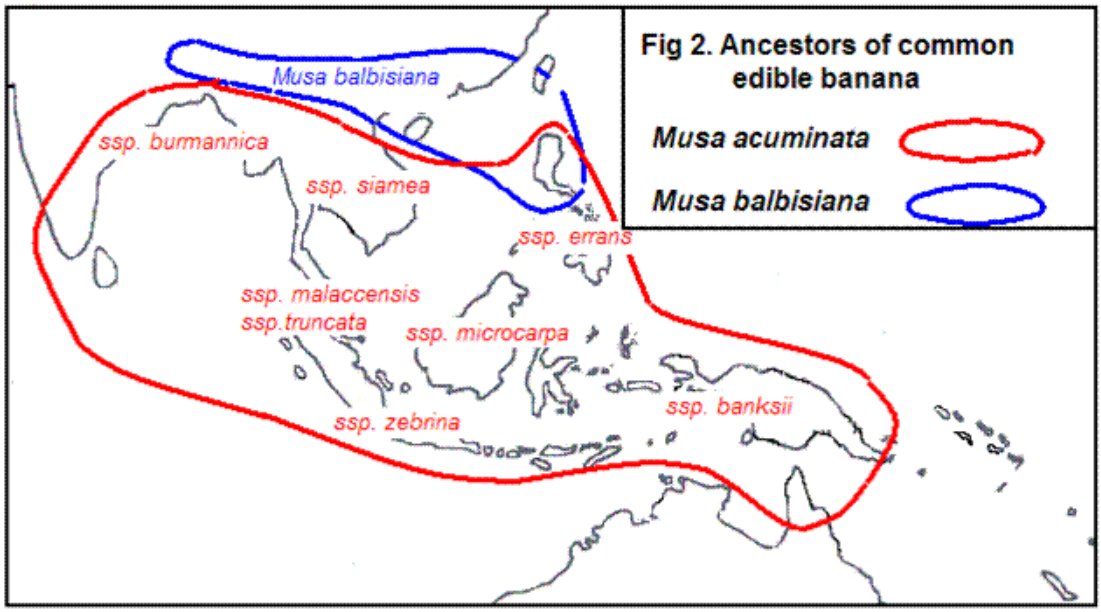
(at ITC) Missing cultivars

1. AA/AAA/AAB?: triangle Sulawesi-Malukku-Lesser Sunda - almost not explored at all - Quid?
2. AAB Pacific Plantains: Pacific (+ triangle?)- mostly collected but not duly classified→ workshop→ ITC
3. AAB African Plantains: same triangle + Philippines - minimally collected (3-4 cvs) among Negrito (Philippines) importance: area of supposed basic (non-African?) cultivars! Quid?
4. ABB East group: mostly collected but not duly classified - Quid?
5. AA in South-India: collected - Quid?



(at ITC) Missing or non-internationally assessed species

6. Callimusa: ca.10 recovered/new sp collected, bot. status to be internationally assessed [importance: phylogenetic relation with Australimusa] - Quid?
7. Rhodochlamys: ca.10 recovered/new sp collected bot. status to be internationally assessed. Quid? [importance: phylogenetic relation with Eumusa] Eumusa, northern highland belt
8. non-or-scarcely explored: Myanmar. [importance: key boundary area of species] - Quid?
9. Collected: Yunnan ca. 10 'recovered' or new species and varieties (all discovered taxa at ITC?)→ non-intern. status assessment Eumusa, elsewhere - Quid?
10. India: collected *M. nagensium*; not-recovered*: M.ochracea; M.flaviflora* - Quid?
10. New South Wales: "*M.thompsonii*-like *acuminata*" in NP? - Quid?



Missing/underexplored subspecies/varieties

Eastern *M. balbisiana*

11. Partly collected; described? (Thailand, Vietnam, Philippines). - Quid?
12. [Importance: eastern ABB, AAB Maoli-Popoulu?]
13. Unexplored: Myanmar (see 'missing species' point 8) - Quid? Western *M. balbisiana*
14. Collected in India - Quid?

M. acuminata

15. Weakly or not explored: triangle Borneo-Malukku-Lesser Sunda: *microcarpa*; transitions to *errans/banksii* (other cvs?) Quid? [importance: missing alleles for breeding]
16. Sumatra: nebulous *sumatrana-truncata-malaccensis* (Kedah) complex
17. Thailand: described and collected *burmannica-siamea-malaccensis* complex (2 univ's) = 8 distinct taxa (morph.unpublished); + "*M.thompsonii*-like *acuminata*"
18. Pemba, Madagascar: to recover, to explore - Quid?

Priorities 1(suggestion)

[Note: 17 issues = Quid? 1 = in action (Pacific plantains workshop)]

1. Triangle Borneo-Malukku-Lesser Sunda.+ Philippines (= issues 1, 3, 15) Exploration, collection → ITC Rich Harvest: *microcarpa*; unknown wild *acuminata* ssp/varieties; their edible derivatives/hybrids; unknown AAB?; original (basic) African Plantain cultivars?
2. Myanmar (issues 8, 13) Exploration, collection → ITC Harvest: meeting region of several Eumusa-Rhodochl. species; transition zone of Western to Eastern *M. balbisiana.* → key to solution of speciation problems
3. India (issues 5, 10, 14) Collected (not at ITC) or not recovered. Harvest: [edAA, western BB, M. nagensium]→ITC; recovery of *M.flaviflora, M.ochracea*; abiotic stress resistance sources (idem for 4)
4. Thailand, Vietnam, Philippines (issues 4, 12) Collected (not at ITC) or partially explored/classified Harvest: [eastern BB; ABB East group]→ITC (the actually different taxa)

Priorities 2 (suggestion)

Long term: International assessment of newly described wild taxa (issues 6,7,9)
Harvest: total *Musa* germplasm classified and under control

Lower Priority?

5. Pemba; Madagascar (= issue 18). Recovery; exploration. Harvest: more wild AA of potential significance for African Highland AAA
6. Sumatra, Thailand, New South-Wales (= issues 11,16,17). Clarification of botanical status of *acuminata* populations; collection→ITC. Harvest: augmenting genetic potential in edible bananas

Methodology

Cultivars

Newly found

- Village or GPS; local name and ethnic group (linguists and cult. anthropologists can help!)
- Tent. description + photos ad hoc;
    - national collection→ description/photos and classification
    - (if not synonym) ITC and Regional Collection.

Collected

- description/photos and classification (retrace where found incl. ethnic group)
    - →(if not synonym) ITC and Regional Collection
    - taxonomy-team to study collections

Wild specimen, newly found

In situ preservation:

- (NP) and GPS; (if local interest) local name and ethnic group;
- Verify population status (beware of specimens along roads! Or intros in NP);
- tentative description/classification + photos

Ex situ:

- In national collection with analogue ecology!
- Verify tent. description and photos: classical description/photos →publication
- →ITC and Regional collection
- international assessment/confirmation of botanical status

PRESENTATION: Morphological characterization descriptors: objectives, limits and appropriateness – Jean-Pierre Horry (presentation prepared by Jean-Pierre Horry and Stephanie Channelière)

The background document for this presentation is the following:

- Technical Guidelines for the Multi-location Characterization of ITC Reference Accessions Date: 14 December 2010– PDF file

Rationale and objectives

- Conservation Strategy for Musa (2006) Expected Output : “genetic diversity is comprehensively characterised and documented, taxonomy is harmonised, and collections are rationalised”
- Taxonomy Advisory group (2006) Implementation of the Strategy : « Limited characterisation is preventing users from rationalising collections, identifying accessions, understanding characteristics of subgroups and optimising the use of *Musa* diversity » (S. Channelière, 2009)
- Characterization: to describe the character of (a biological specimen)

- Identification: to determine the taxonomic position of (a biological specimen) (source WEBSTER quoted by E. de Langhe)

Characterization

Characterization means using the necessary characteristics for unequivocal description of a particular cultivar.

- The descriptors booklet was published in 1996.
- Work from CIRAD/INIBAP/IPGRI, made in consultation with several Musa experts.
- Set of passport data descriptors, 121 morphological descriptors, evaluation descriptors.
- Many *Musa* collections have not been systematically documented ;
- Only limited characterization and evaluation data are available, and information may be scattered between several institutes ;
- The descriptors for *Musa* are often ineffectively applied where curators are working in isolation with little training.

Needs and constraints expressed at TAG

- Significant levels of subjectivity exist in applying descriptors even among experts, leading to different reading of the descriptors;
- Little documentation exists on how to use the descriptors and measure specific traits;
- Illustrations and photographs are missing that would vastly aid characterization;
- Long lists of descriptors are clearly unworkable for 'less detailed' work or for inexperienced researchers - a minimum set of descriptors to ascertain the subgroup may be more appropriate;
- More specific descriptors are needed for characterization within subgroups;
- Further descriptors are needed for wild species.
- Heritability (broad sense) of the descriptors
- A good characterization descriptor must be stable over environments. The stability of the chosen descriptors have not been verified (if not heritable, the descriptors values could be dramatically different over environments)
- Growing conditions are not satisfying to allow a good characterization, fertilization, pests and disease control, irrigation when needed, etc. are required.

Accuracy of the descriptions: the reference collection

A set of reference cultivars representing the main *Musa* subgroups has been agreed at TAG 2006. This reference collection is to act as means for:

- Providing a reference for comprehensive characterization (with photographs) through which all collections may communicate
- Training at a national/sub-national level.
    - G x E studies: find out which are the most robust descriptors across environments
    - Determine which descriptors are the most subjected to a misinterpretation by the observer.
    - Enable the development / validation of a standardized tool for classification to a subgroup level >> use of a 'minimum set of descriptors' for ID to subgroup level.

Accuracy of the descriptions: the reference collection

- Bioversity ITC is in the process of distributing this set of 36 accessions to 13 partner collections. These accessions will be described using the full set of characterization descriptors on the second cycle; a set of photos will be taken to illustrate the characteristics.

- Accuracy of records can vary from person to person by different readings of the descriptors states and different illustrations (photos).

An alternative to the full descriptor list?
In 2006, a minimum set of descriptors, including photos, was developed empirically by TAG experts, as an attempt to establish a standardised procedure for routine morphological characterization of banana plants.

- 30 minimum descriptors + illustrated guideline
- 15 minimum photos

Workplan
Reference collection

- Which are the most robust descriptors among +120 (GxE, misinterpretation)?
- Which are the most discriminating (at least at the subgroup level)? AND

Minimum descriptors

- Do they satisfy the request for a reduction of the number?
- Are they robust?
- Are they sufficient? (their capacity to discriminate* has been questioned)

= Consolidated list of minimum descriptors

Identification

- Identification means using the necessary characteristics (the same descriptors?) for determining the taxonomic position of an observed accession.
- Identification requires far less descriptors than characterization

How?

- Expert knowledge, but few *Musa* taxonomists
- Hierarchical identification: based on Simmonds & Shepherd scoring system + keys to identify within subgroups (a development of this model is proposed by Edmond de Langhe)
- Probabilistic identification software (MUS.AIDwin) : comparison of a specimen to a reference database (MGIS)

Identification: hierarchical identification
“An experienced banana taxonomist, when puzzled about a new accession in collection or a cultivar in a village, will identify this progressively: the specimen belongs to what Group? Then Subgroup? And then only: what cultivar? Why should any other user not learn to follow the same Identification/Determination sequence? “(E. de Langhe)

Hierarchical cultivar identification system
Identification proceeding in three steps:

1. Group (AA/AAA, AAB, ABB…) based on Simmonds and Shepherd scoring system, using an extended list of 22 descriptors
2. Subgroup, using discriminant keys within an identified group
3. Cultivar, using discriminant keys within an identified subgroup

Pro’s/contra’s for developing the technique over the entire cultivar spectrum?

Identification : MUSA.AIDwin
Identification systems:

- global, based on a dissimilarity measure between accessions

- determination keys, based on some discriminant characters

MUS.AIDwin:

- an interactive determination system
- a probabilistic model

Discussion

Characterization

- To facilitate the scoring of the descriptors
  - Generalization of photo illustration?
- To simplify the descriptor list for a wider use
  - Adoption of a minimum set complemented with photos?
- To test the robustness of the descriptors
  - Reference collection project

Identification

- To help non-*Musa* expert in identifying specimen
  - Development of a hierarchical cultivar identification system
  - Generalize the use of MUS.AIDwin
  - Take into account the efficiency of molecular markers

PRESENTATION: Pl@ntNet: Plant Computational Identification and Collaborative Information System – Daniel Barthelemy

Content

- Two major threats: global food crisis, and the "6th extinction" (i.e. biodiversity erosion)
- In both cases, knowledge on plants is crucial and underpins the success of sustainable agriculture & forestry and of biodiversity conservation
- Main bottlenecks concern:
  - Plant identification (shortage of botanists and taxonomists)
  - Accumulation, interoperability and diffusion of basic data models and knowledge on plant distribution and production, (heterogeneous isolated databases and experiences)
- Tropical and Mediterranean regions are the most concerned richest, but least known floras and ecosystems

Pl@ntNet project

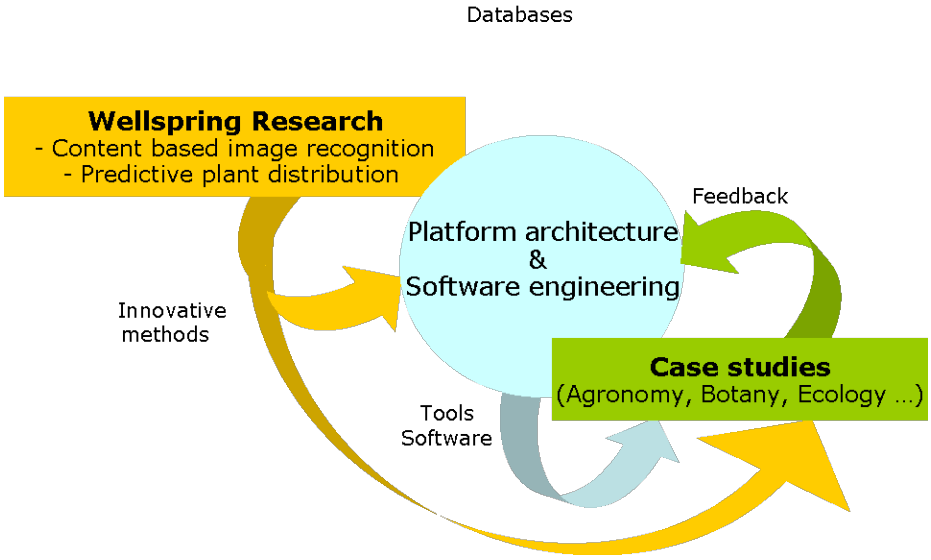
First flagship program of Agropolis Fondation (http://www.agropolis-fondation.fr/, financed for 4 years)

Main objectives:

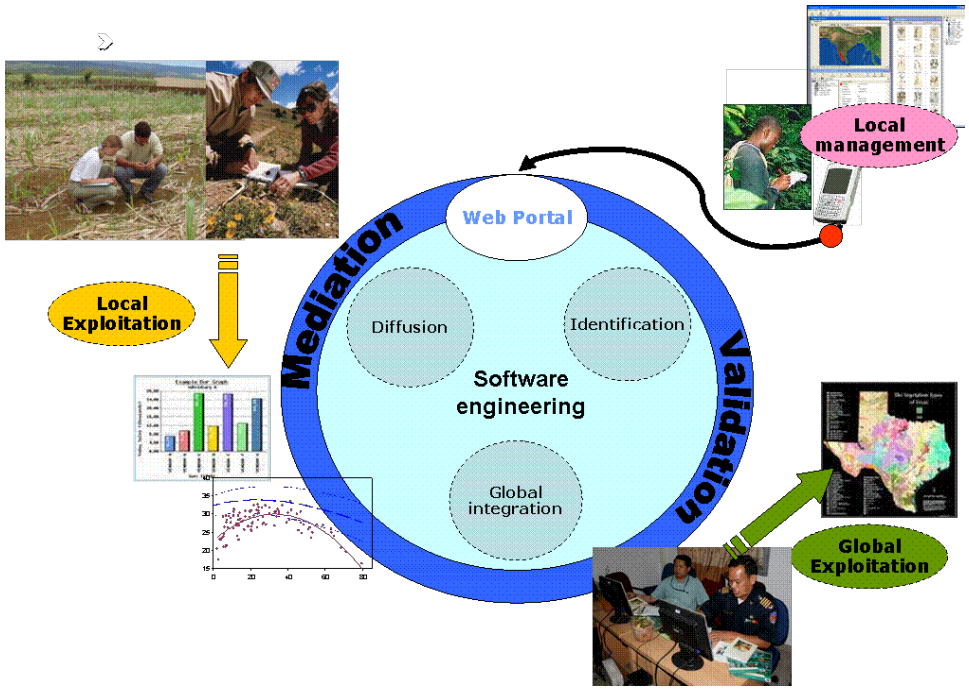
1. to conduct innovative interdisciplinary researches,
2. to develop a computational and web platform and
3. to build a collaborative network (around communities of actors)dedicated to the aggregation of tools and knowledge in Botany.

3 leader teams: AMAP, INRIA, Tela Botanica + A network of national & international partnership: French Institute of Pondicherry, IUCN, CGIAR, Invasive Species Specialist Group ISSG-GISP, Kruger National Park, Univ. Davis (USA), Univ. Central (Venezuela), Umr DIAPC, UM2 Collections Service …

General organisation



Example of use



Selected thematic cases in the fields of tropical agronomy and biodiversity, according to distinct scenarios (diverse combinations of users, objectives and datasets) will provide feedbacks on the tools & methods

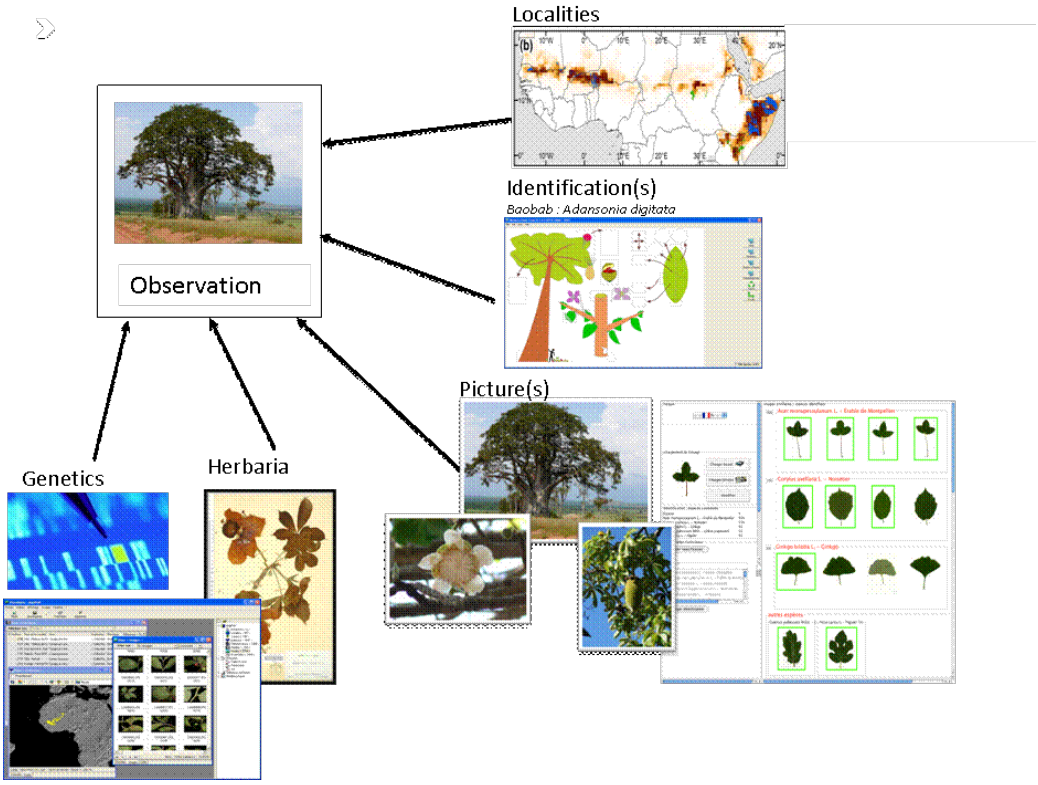
- Pl@ntGhâts: Western Ghats, India
- Pl@ntGrape: French grape varieties
- Pl@ntHerbarium: Herbaria collections
- Pl@ntInvasive-Fot: Invasive species, French overseas territories
- Pl@ntInvasive-Kruger: Invasive species, Kruger Park
- Pl@ntMedit: Mediterranean plant species
- Pl@ntRiceWeed: Rice weeds
- Pl@ntTree-Run: Reunion Island trees
- Pl@ntScan: Tree leaves
- Pl@ntUse: Useful plants
- Pl@ntWood: Wood Anatomy

Collaborative workspaces are tested in order to facilitate share of experiences, methodologies and data through case studies

Based on Tela Botanica experience: Wiki, collaborative data repository, mailing and members lists

Extended to Pl@ntNet Case studies needs: Individual display space and others functions in progress

Organize



- Pl@ntNote software: a freely customizable, multi-purpose tool for plant data collection, management and scientific exploitation
- IDAO software: An easy graphic plant identification tool
- Graphic interface: Obviates need for technical terminology
- Multi-entry identification system: User-defined character choice
- Richly illustrated species description files: Descriptive texts, drawings, photo, distribution maps
- Signals observational errors, tolerates lack of information and allows identification of partial samples
- Identification tool production

Ikona software: An automatic visual identification approach - IKONA (Boujemaa et al., 2001)

- Powerful search engine on images of specific or generic contents
- Colors, shapes and textures descriptions
- Scalable descriptions

Evaluation for taxonomic identification

- On specific botanical picture databases (scan of leaves, wood anatomy, etc.)
- and generic plant pictures collections

Improvement of content extraction
Improvement of content description

Improvement of scalability
Web diffusion of data

- Template personalization
- Visualize and query

Pl@ntScan Demo

1. Collected plant leaf to identify
2. User validation
3. Candidate species sorted by probabilities

Conclusion

- Pl@ntNet: a network of complementary skills targeting plant observation, use and study, to share the fruits of research, knowledge and expertise.
- Project web site : http://www.plantnet-project.org/

PRESENTATION: Genetic integrity of the ITC collection: DArT genotyping – Jean-Pierre Horry *(presentation prepared by Jean-Pierre Horry, Xavier Perrier, Nicolas Roux, Stéphanie Channelière)*

The background documents for this presentation are the following:

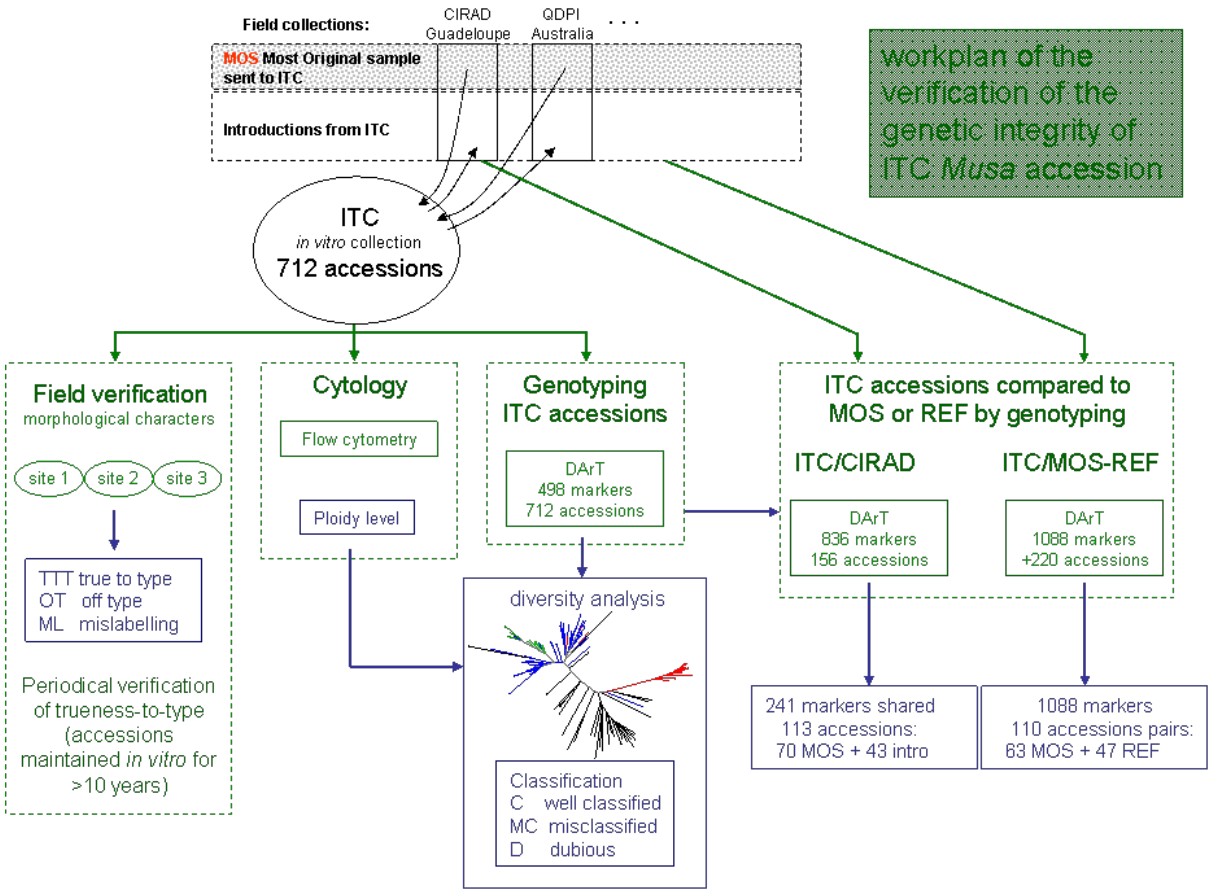
- Development and assessment of Diversity Arrays Technology for high-throughput DNA analyses in *Musa*, *Ange-Marie Risterucci, Isabelle Hippolyte , Xavier Perrier, Ling Xia, Vanessa Caig, Margaret Evers, Eric Huttner, Andrzej Kilian , Jean-Christophe Glaszmann* , 2009 – PDF
- Combining Biological Approaches to Shed Light on the Evolution of Edible Bananas, *Xavier Perrier, Frédéric Bakry, Françoise Carreel, Christophe Jenny, Jean-Pierre Horry, Vincent Lebot and Isabelle Hippolyte,* 2009-PDF

Rationale and objectives

Objective: reducing and managing the loss of genetic integrity of conserved germplasm.

- Genetic integrity: identity of the genetic composition of the sample conserved at ITC to that of the original collected, bred or improved.
- To detect loss of genetic integrity :
  - compare an (ITC) accession to its most original sample (MOS),
  - or be able to determine that the accession doesn't behave as it should.

Bioversity has adopted a workplan to identify accessions that have eventually undergone a genetic change.



<u>Diversity Arrays Technology (DArT)</u>
Publication: Theor Appl Genet (2009) 119:1093–1103, DOI 10.1007/s00122-009-1111-5
Development and assessment of Diversity Arrays Technology for high-throughput DNA analyses in *Musa*. Ange-Marie Risterucci / Isabelle Hippolyte / Xavier Perrier/ Ling Xia / Vanessa Caig / Margaret Evers / Eric Huttner / Andrzej Kilian / Jean-Christophe Glaszmann

<u>GCP: 168 accessions from IITA and CIRAD analysed with 836 DArTs markers :</u>
- «DArTs can be used for genome wide analyses»
- Despite the dominant nature of DArT markers, they can be used to «compare different genomes at a large number of loci in a single assay»
- «The analysis cluster genotypes consistently with the accepted classification knowledge».

<u>Analysis of 712 ITC accessions with DArTs</u>
- 498 DArT markers.
- The phylogenetic tree produced by analyzing the DArT markers show the separation of accessions in species / groups and eventually subspecies/ subgroups, confirming the separation from morphological observations and previous molecular markers (RFLP, SSR).
- DArT markers are able to spot accessions which are not grouping with what was expected. These are clearly misclassified accessions.
- In many cases DArT analysis allowed to complement a classification (eg. the subgroup of a poorly identified accession can be identified).

NJ tree analysis wild *M. acuminata* ssp.
- 44 accessions 468 markers

NJ tree analysis triploids

- 292 accessions, 498 markers, consistent clustering at the group and subgroup level

NJ tree analysis triploids

- 292 accessions, 498 markers consistent clustering at the group and subgroup level

Analysis of 712 ITC accessions with DArTs

Combined with ploidy checking, the analysis of 712
ITC accessions resulted in:

- 582 are well classified (81%)
- classification of 67 accessions has been specified
- 42 (less than 6%) are truly misclassified (e.g. an accession classified AAB while it is a AAA) Include accessions that were introduced under a false identification and errors at ITC.
- 29 (4%) accessions to be eliminated (redundancy)

Comparison of ITC and CIRAD common accessions

Methods

- Joint analysis of 241 DArTs markers in common on 113 genotypes in common in ITC collection and CIRAD Guadeloupe field genebank.
- Dissimilarity index calculated between each pair of accessions of the same genotype

Results

- Definition of a statistical threshold by permutation test
- Estimation of a dissimilarity between ITC and Guadeloupe accessions
- Comparison with field verification results

Dissimilarity index >12% => genetic difference
113 pairs of accessions analysed

- 92 pairs are considered as identical
- 21 pairs have dissimilarities exceeding 12% (include missing data and out groups)

The errors may have occurred at ITC collection or at CIRAD genebank

Comparison with field verification results

- 4 accessions out of 10 considered as mislabelled in the field are not detected by DArTS
- Offtypes are NOT detected by DArTs
- 4 accessions out of 66 considered as true to type in the field are considered different with DArTs

Comparison of ITC and MOS/REF accessions by DArTs - partner collections: CIRAD (France), FAVRI (Vietnam), FHIA (Honduras), IITA (Nigeria), NARI (Papua New Guinea)

AFTD: 110 accession pairs, 1088 DArTs, ITC, 63 MOS and 47 REF

Conclusions

Morphological and molecular characterizations are complementary tools:

- DArT markers are able to detect ‘Mislabelled accessions’ if the exchange has happened between genetically distant accessions but if mislabelling occurs between two accessions from the same subgroup, our observations suggest that DArT markers would not be powerful enough to detect the error.
- DArT markers do not detect ‘Off-types’ that are due to somaclonal variations.
- Morphological observation stays the most precise way to detect any loss of genetic integrity, provided that the modification / mutation affect a visible character.

Recommendations

- Misclassification: use molecular markers and ploidy to check the classification of the accessions before being introduced in the ITC.
- Mislabelling: to regularly analyse accessions by batches, using molecular markers (SSR or DArT), which will allow to detect around half of the Mislabelled accessions.
- Off-types: so far, only the morphological observations can detect somaclonal variations.

PRESENTATION: The Musa Genotyping Centre: strengthening the links between morphological and molecular characterization – Jaroslav Dolezel

The *Musa* Genotyping Centre

The Centre is hosted by the Laboratory of Molecular Cytogenetics and Cytometry of The Institute of Experimental Botany in Olomouc.

Methods applied at MGC:

- Ploidy determination (DNA flow cytometry)
- Chromosome counts
- Molecular markers (19 SSRs/ ABI3730xl)
- ITS sequence analysis
- Analysis of genic sequences (19 unlinked genes)

New methods are being published

- SSRs: Christelová, P., Valárik, M., Hřibová, E., Van den Houwe, I., Chanellière, S., Roux, N., Doležel, J.: A platform for efficient genotyping in Musa using microsatellite markers. – AoB Plants (submitted)
- Genes: Christelová, P., Valárik, M., Hřibová, E., de Langhe, E., Doležel, J.: A multi gene sequence-based phylogeny of the Musaceae (banana) family. - BMC Evolutionary Biology (tentatively accepted)
- ITS: Hřibová, E., Čížková, J., Christelová, P., Taudien, S., de Langhe, E., Doležel, J.: The ITS1-5.8S-ITS2 sequence region in the Musaceae: structure, diversity and use in molecular phylogeny. – PLoS ONE 6: e17863, 2011.

Genotyping using SSR markers

Taxonomic Advisory Group (TAG) Meeting Cameroon, 29 May – 03 June 2006

- Flow cytometry is useful in verifying the ploidy levels of uncertain accessions in national collections
- SSR markers are the most useful molecular tools
- The potential availability of new markers was noted
    - More SSR markers should become available with Musa sequencing
    - SNPs are not yet available

The original vision

- To provide reference gel-electrophoretic profiles to assist on-site molecular characterization of germplasm by the curators Musa collections

2nd meeting of the Taxonomy Advisory Group: Tiruchirapally, India, 20-25 October 2008

- A proposal was made to set up a Musa Genotyping Centre at the Institute of Experimental Botany, Olomouc, Czech Republic

Markers

- Low-cost, easy-to-use (PCR based) markers

- 19 SSR markers enabling distinction between the reference genotypes (Lagoda et al. 1998, Hippolyte et al. 2010) publicly available at http://www.musagenomics.org

Accessions

- Reference DNA collection
  - 65 accessions (54 – high quality DNA samples available)
  - 7 *Musa* species
  - 5 diploid cultivars
  - 32 triploid cultivars
  - 39 diploid species were added

Methods

- PCR with fluorescently labelled primers and capillary electrophoresis analysis of resulting fragments (ABI 3730xl)

Fragment analysis on ABI 3730xl

- Precise estimation of allele size, high resolution.
- High-throughput, possible automation, possible multiplexing (5-dye set)

SSR analysis with DIPLOID accessions

Blind test

- to examine the power of the approach to assess unknown samples
- 9 diploid anonymous samples included in the analysis
- their closest related reference accession identified
- 8 out of the 9 blind samples classified correctly
- 1 blind sample - ITC 0250 not classified correctly

ITS locus sequence analysis revealed that anonymous sample no.4 (ITC 0250) was mislabelled !!!

SSR analysis with TRIPLOID accessions

Blind test

- To examine the power of the approach to assess unknown samples
- 6 triploid anonymous samples included in the analysis
- Their closest related reference accession identified
- All 6 blind samples classified correctly at the subgroup level

Genotyping using SSRs

- SSR genotyping with 19 SSRs enables classification of unknown diploid and triploid Musa samples (4x accessions in the pipeline …)
  - A prior knowledge of ploidy level of an unknown sample is important (can be determined by flow cytometry)
  - In case of uncertain results, ITS sequence analysis can be employed.
- With every new sample analyzed, the reference database of SSR profiles is expanded, leading to increased resolution of the assay
- Building of the database of electrophoretic profiles requires genotyping on one site to guarantee standard genotyping conditions and reproducibility and comparability of results

Identification of cultivars using SSRs?

- Cultivars can be classified using SSRs at subgroup level; identification at cultivar level needs to be verified
- Identification of duplicates:

Accession name	Ref. DNA collection # / ITC code	Accession	DNA sample origin	Identical multilocus genotype	DNA sample origin of the duplicates
M. acuminata ssp. burmannicoides 'Calcutta4'	ref. 8 ITC 0249	*M. acuminata burmannicoides* Calcutta4	Reference DNA collection (CIRAD)	*M. acuminata burmannicoides* Calcutta4 ITC 0249	ITC collection
				M. acuminata burmannica Long Tavoy ITC 0093	ITC collection
M. balbisiana 'Tani'	ref. 21 ITC 1120	*M. balbisiana* Tani	Reference DNA collection (CIRAD)	*M. balbisiana* Tani ITC 1120	ITC collection
				M. balbisiana P. Batu ref. 5	Reference DNA collection (CIRAD)
AB cv. Safet Velchi	ref. 23 ITC 0245	AB cv Safet Velchi	Reference DNA collection (CIRAD)	AB cv Safet Velchi ITC 0245	ITC collection/ lyophilized leaf tissue for the Blind test
AA cv. Pisang Mas	ref. 33 ITC 0653	AA cv Pisang Mas	Reference DNA collection (CIRAD)	AA cv. Pisang Mas ITC 0653	ITC collection/ lyophilized leaf tissue for the Blind test
M. textilis	ref. 50 ITC 1072	*M. textilis*	Reference DNA collection (CIRAD)	*M. textilis* ITC 0539	ITC collection
M. textilis	ITC 1072	*M. textilis*	ITC collection	*M. textilis* ITC 1072	ITC collection/ lyophilized leaf tissue for the Blind test
M. ornata	ITC 0370	*M. ornata*	ITC collection	*M. ornata* ITC 0370	ITC collection/ lyophilized leaf tissue for the Blind test

<u>High-throughput platforms (DArT, GBS, …)</u>

- Low cost per data point, but not per an assay
- Large-scale characterization of genetic diversity
  - Identification of markers shared by all individuals within a cultivar (shared vs. non-shared markers)
  - Where is the line between a cultivar, a derivative clone (somatic mutations?), and an individual?
- Scaling down to single samples
  - Choosing a platform for screening SNPs
  - Converting SNPs to other types of markers

<u>A pragmatic approach to genotyping</u>

New accessions are characterized on a small scale (one to several dozens accessions). High-throughput methods are not economical at this scale

- Musa Genotyping Centre classifies all new Musa accessions for ITC using SSRs (reliable data at subgroup level guaranteed)
- ITS sequence analysis is used to confirm the results (if needed) and to verify genomic constitution in hybrids

High-throughout methods should be used to

- Study genetic diversity at global scale
- Analyze subgroups with extremely low genetic diversity (such as plantains) in order to:
  - Verify the extent of genetic homogeneity

- Understand differences between cultivars
- Facilitate development of specific markers (if needed)

Acknowledgements
Edmond de Langhe / Ines Van den houwe / Nicolas Roux / Stéphanie Channelière / Miroslav Valárik / Jana Čížková / Eva Hřibová / Pavla Christelová

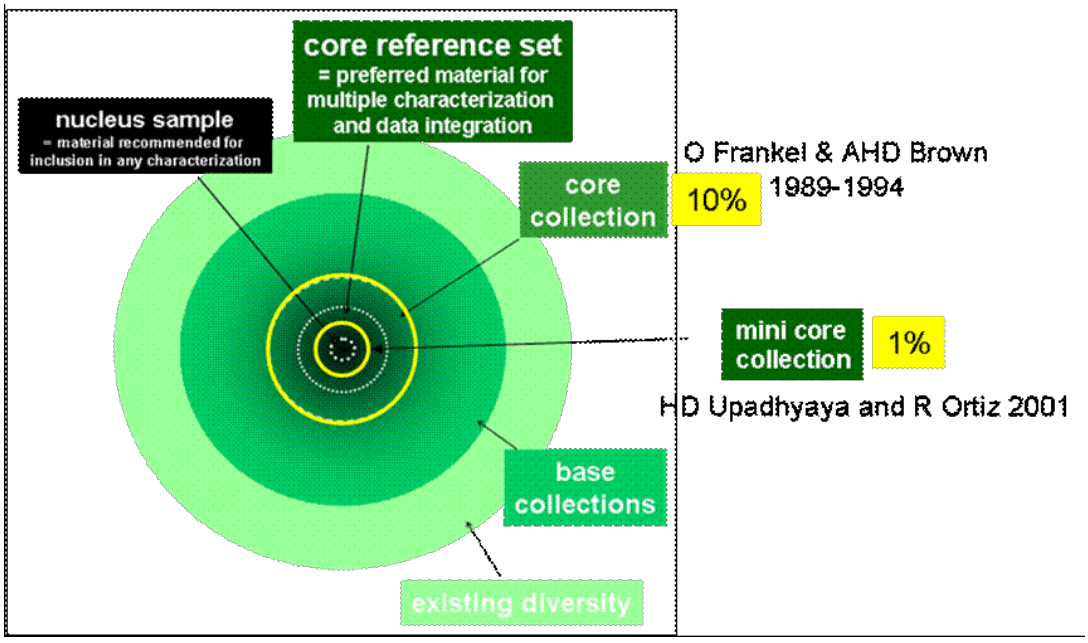
PRESENTATION: The Genetic Resources Supply Services (GRSS) of the Generation Challenge Programme (GCP) of the CGIAR - Unlocking genetic diversity for improving food crop adaptation – Jean Christophe Glaszmann

Three steps to elaborate reference collections in order to mine genes, alleles and markers

Step 1: from passport information, sampling global resources to produce a core sample
- Various collections
- Data collection, Analysis
- Core sample (10%, up to 3000)

Step 2: from molecular data sampling the core sample to produce a reference sample for integrated characterization and evaluation efforts
- Marker development, Genotyping, Sampling
- Core reference set (.00)

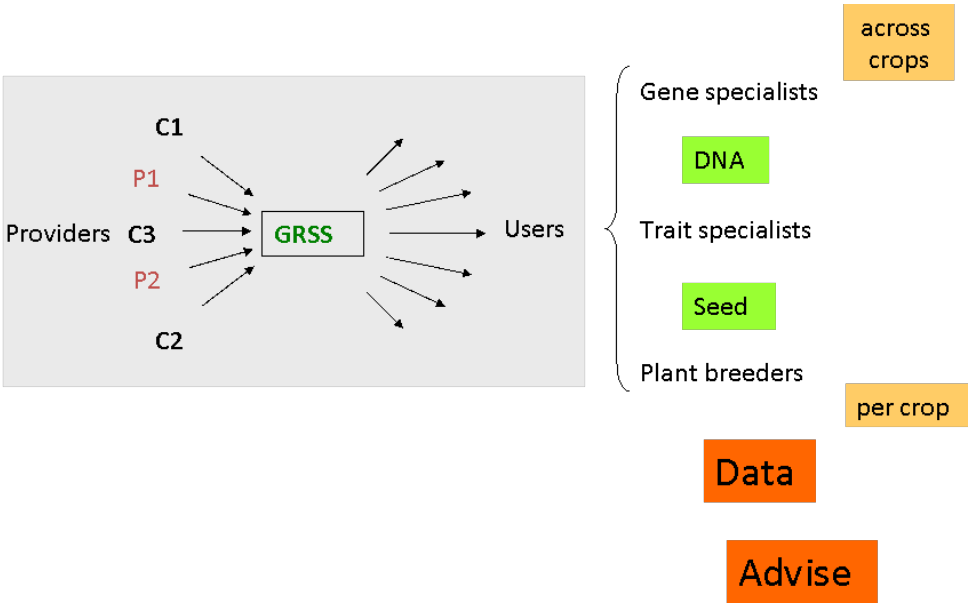
Step 3: Association studies ◊ genes/alleles tagged for marker-assisted breeding
- Genotyping : Functional markers, Anonymous markers
- Phenotyping



The Genetic Resource Support Service

Materials	per crop	today
* reference sets	50 – 1000	CG centers, + GCP
* collection of mutants	?	diverse
* introgression lines	100s	diverse
* mapping populations	1000s	diverse
* near isogenic lines	10s	diverse
* proto-elite populations	10s	diverse

for simulations: 1 major crop = 1 000 reference diverse genotypes
5-10 000 segregating genotypes
1 minor crop = 500 reference diverse genotypes
1 000 segregating genotypes
* genomic resources: BAC libraries, cDNA libraries, markers, etc



ARM 2008, Reference set workshop Nov 2008, ARM 2009, MBP kick-off 2010
Biologists' request:
- complete diversity of traits and adaptive behaviours
- high molecular diversity
- information-rich materials
- highly pure materials
- various numbers

Breeders request:
- trait (as used in selection) specific genetically diverse parents for trait enhancement
- preferably agronomically superior or similar materials so that the progress in breeding is:
  - enhanced by exploitation of additive genetic variance
  - not hampered by unpredictable epistatic interactions

« an opportunity for cooperation »

Molecular breeders request:
- fewer materials with alleles
  - new to him/her (compared to specific contributed materials or to historical founders)
  - marker-tagged (kit) (genomic studies advance)
- preferably agronomically superior or similar

Germplasm curators in CGIAR Centres
- very high success for 'minicore'/reference sets
- higher number of requests, uneven distribution, more frequent regeneration
- specific care, new accessions
- duplication?
- cost recovery? charging!
- DNA banking?

For chickpea, at ICRISAT only 91 germplasm lines have been used to develop 3,548 advanced varieties (ICCV) during 1978-2004.Two lines were most widely used : L 550 (909 times) and K 850 (851 times) (Upadhyaya et al., 2006;Plant Genetic Resources 4:25-35)

Identification

GCP Project Number: **2005-01n**
(give the project number as used by GCP)
Project Name: **Genotyping of composite germplasm set, Tier 1, Musa**
(put the full project name here)
Principal Investigator: **Nicolas Roux, Bioversity International**
(name, affiliation)
Collaborators (name, affiliation): **Isabelle Hippolyte, CIRAD; Maria Kolesnikova, IITA**
(list all collaborators with name, affiliation)
Total Project Budget: **37,117 US$**
(in$)
Grant Period: **Start: January 2005 End: October 2007**
(Start: Month___Year___) (End: Month___Year___)
Reporting period: **Start: January 2005 End: October 2007**
(Start: Month___Year___) (End: Month___Year___)

Report

I. Executive summary

(300 words maximum)

The aim of this project was to genotype the global diversity of Musa held in three important in vivo Musa collections (CIRAD, Guadeloupe; IITA Nigeria and CARBAP, Cameroun). DNA samples were extracted from 549 accessions representing wild Musa acuminata colla (A genome 2n=2x=22) and Musa balbisiana colla (B genome 2n=2x=22) accessions coming from different geographic areas, AB interspecific cultivars, triploid mono or interspecific cultivars (AAA, AAB, ABB) and a few tetraploids. In order to have a broad view of the Musa complex, some species such as Musa basjoo and Musa schizocarpa were added to this study. The phylogenic tree was built using 22 SSR markers. The analyses took into account the difference in ploidy levels of the genotypes. These trees not only confirm previous results obtained with molecular markers and fit with the known botanical classification, but they also have uncovered genetic relationships between triploids and their putative diploid ancestors. An other important output from the analysis is to provide to the international community tools and methods to analyses Musa diversity and give the basis to compare and integrate new results in this global analysis. It will be also useful tool for Musa breeders.

A reference set of 62 accessions was chosen.
It was assembled using

- the GCP criteria regarding the genetic diversity representation,
- the duplication at the Bioversity International Transit Centre (ITC),
- the use in breeding programmes and
- the FAO designation.

44 of the samples chosen were from the composite collection, while the remaining 18 samples was additional material added (such as wild accessions).

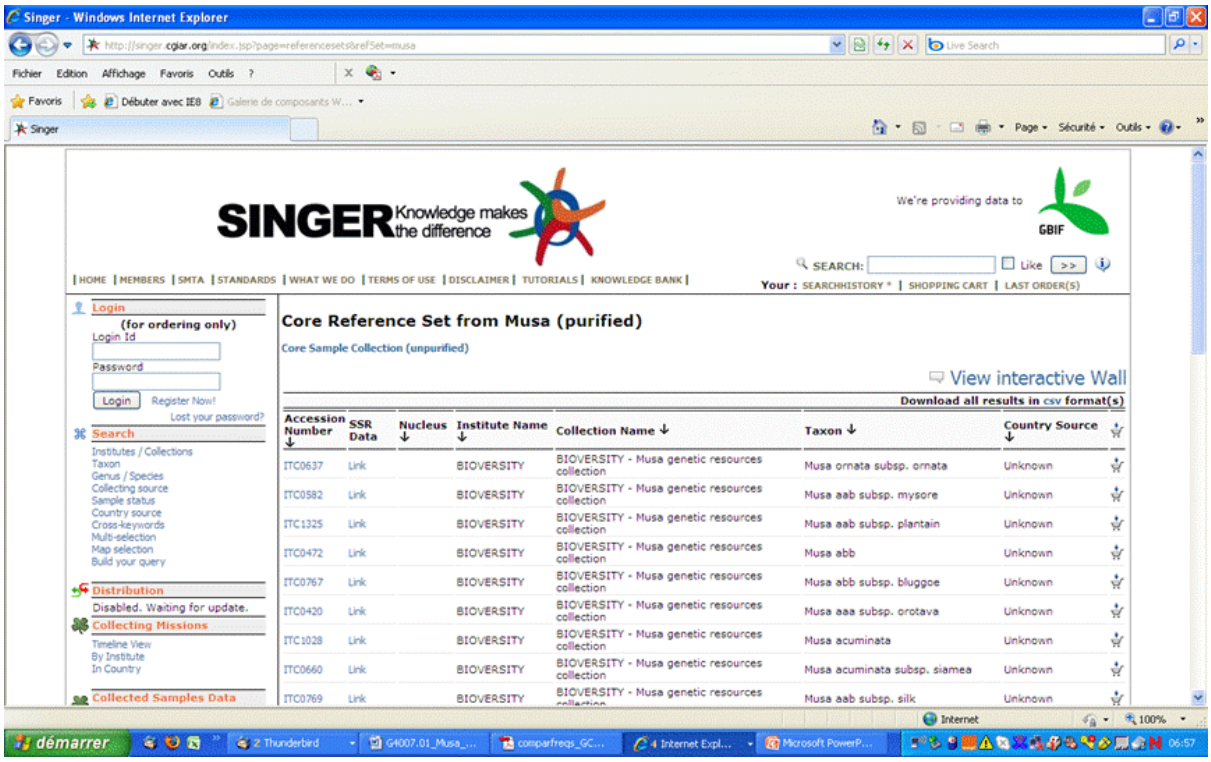
<u>The GCP genotyping data validation project</u> hosted by SP1

- PI JF Rami, now helped by S McGrath and C Billot
- collaborators are GCP genotyping labs + outsider (ADNid, Montpellier)
- repeat analysis for ref set (max 300) and best SSR loci (max 20)

Original data for Musa = Hippolyte et al, Perrier et al

<u>GCP Project Title: Establishing a Genetic Resource Support service (GRSS) for the plant breeding community</u>

- Targeted Subprogram: SP1
- Principal Investigator and Lead Institution: JC Glaszmann, GCP and CIRAD
- Collaborating Scientists and Institutions: Hari Upadhyaya, ICRISAT (co-PI), E Arnaud, Bioversity International (co-PI)
- collaborating projects/programmes: D Williams, Bioversity International, SGRP, JF Rami, CIRAD-Agropolis
- Project start and end dates: 1 July 2009 through 30 June 2011 (2 years)
- appointed in March 2009 as postdoc fellow Sarah McGrath



<u>Why agree on reference materials</u>

Reference material for

- Data compilation in space and time
- Data correlation among specialties

Targeted to diverse users

- Diverse traditional germplasm
- Elite materials
- Trait donors

With statistical/genetic resolution

- Broad and representative (core)
- Including extremes (trait donors)
- Segregating (with documented level of LD)

For practical applications

- Exploration of behavioural diversity
- Statistical associations for (marker-)assisted selection
- Functional associations for biological understanding and beyond

DISCUSSION: Proposal for future directions with descriptors and a coordinated approach to characterization (morphological and molecular)

<u>Summary of points raised:</u>

- Morphological data still important as some characteristics are not identified by molecular techniques. And some characters have cultural importance, eg. The colour red in Polynesia being sacred.
- We need to make decisions on getting rid of duplicates and agree on procedure. There may be economical consequence of not knowing if an accession is a duplicate and false identification of a duplicate. Methodologies are there and decisions could be advised by a group of experts such as the TAG. Getting rid of off-types is also urgent (using Darts) and then ITC can identify probably duplicates. It is proposed to

compare DARTs, SSR and morphological data and for the results be validated by a group of experts. Targeted question can be dealt with SSRs.

- Collections have to be rationalised and it is a balance between conserving everything and the key diversity. According to Simmonds, 500 accessions could represent the entire genetic diversity of *Musa*.
- Conserving and ensuring the access of *Musa* germplasm needs to be based on economics. Immediate reduction of known duplicates should be done and a larger reduction may require a more systematic approach to make responsible decisions. MusaNet could set up protocols. This work is already being carried out by the Taxonomic Advisory Group (TAG) established in 2006. TAG helps with feedback-and validates the results from the field- and proposed 'actions to be taken'.
- IITA has a project to examine the molecular basis of variation with East African Highland bananas which could then be extended to plantains. Plantains have a lot of different expressions, with differences with Darts, work 100s markers but with SNPs go to 1000s. There is a case for developing specific collections targeted to a specific trait from a limited number of genetic backgrounds.

Tuesday 1 March 2011 *14:00-15:30*	***Session 6 - Theme 2: Germplasm evaluation (links to users)*** *PRESENTATION: Germplasm evaluation - beyond characterization and advances and impact on molecular analysis* **-** *Jim Lorenzen* *PRESENTATION: How the International Musa Testing Programme (IMTP) works and evaluation data produced and links with evaluation of germplasm collections - Inge Van den Berg* *PRESENTATION: ProMusa - Mobilizing banana science for sustainable livelihoods: Goal and activities, links with MusaNet, knowledge sharing - Inge Van den Berg* *PRESENTATION: Fusarium phenotyping: linking greenhouse screening to field evaluations and generating information for anticipatory breeding – Miguel Dita* *PRESENTATION: Evaluation of quality traits: post harvest quality of edible banana (Musa sp.) – Sébastien Ricci* *DISCUSSION: Germplasm evaluation and links to breeding*

PRESENTATION: Germplasm evaluation - beyond characterization and advances and impact on molecular analysis - Jim Lorenzen

Banana: Importance in Africa

- #8 food crop in the world
- #3 or 4 food crop in Africa (after cassava, maize, [yam?])
  - (6 M ha ~ 1/2 global area under *Musa*)
- Very important cash crop
- Perennial crop - nutrient recycling, soil stabilization
- Banana is more important in Africa than in its geographic origin of Asia

Ex situ banana collections - an observation

Clonal collections, wild *Musa* not well represented

- Tough choices - define "redundant" or "duplicate"
- Ancient clone sets; interesting phenotypic variability in spite of nearly identical molecular fingerprints
- Use of molecular data to identify "redundant" clones?
- Lessons from other perennial clonal crops?
- Balance between genetic diversity and fascinating collections of ancient clones

Phenotypic & molecular characterization

- Genome status (AA, AB, AAA, AAB, etc.)
- Unique identifiers for accessions
- Genetic background (*M. a. subspp*) with regard to nuclear, cytoplasmic genes
- Probable origins - Note: wild *Musa* not adequately collected for solid conclusions about origins

Other applications

Molecular maps

- Need to generate seed-based populations
- Complicated by genomic structural rearrangements
- Utility greater with sharing populations
- Clone management (erosion, identity)

Association mapping

- Based on many meiotic events
- Appropriate for wild *Musa*, unique seedlings
- Clonal variant sets - which accession is “type” member?

Germplasm evaluation

- Need to focus on priority traits
- Biotic constraints: Fusarium, Mycosphaerella leaf spots, nematodes)
- Abiotic constraints: Drought (nutrient stress, soil, cold)
- Quality: Nutritional factors, “taste”, appearance
- Agronomic traits: Cycle time, height, harvest index, bunch

Biotic constraints

Fusarium

- Need for better definitions of host/pathogen interactions
- race/VCG systems not fully consistent with molecular taxonomy
- Need differentials for unique pathotypes

Mycosphaerella leaf spots

- Global collection of Mycosphaerella?
- Organized resistance screening in genetic "hotspots"

Nematodes

- Collections Radopholus, Pratylenchus spp.

All of the above

- Safe screening against quarantine pathogens
- Breeders can screen (with pathologists), but only with locally available isolates

Abiotic constraint - drought

A primary yield constraint

- Average yield in Uganda restricted about 50% by insufficient water
- Farmer knowledge about cvs. appropriate for drought-prone areas

Progress

- KUL research - physiology, proteomics, candidate genes
- Collaborative work - KUL-IITA - controlled studies - response of selected genotypes to water levels, transcriptomics
- Need to validate observations at higher levels (whole plant, field)
- Mapping root traits

Needs

- Best proxy indicators for key tolerance traits

- High throughput screening methodology

Germplasm evaluation: conducted by whom?
Users are highly interested, breeders are good candidates
- Motivation to share results?
- Coordinated, duplicated effort would be desirable

Some constraints on breeders
- Quarantine pests, diseases
- Requires collaboration where phytosanitary constraints satisfied
- Remote assays need to be validated in field hotspots
- Phytosanitary requirements make large scale hot-spot screening prohibitively expensive - non-production site more desirable
- Coordinated international site desirable

Germplasm evaluation: molecular
Molecular capability essential for breeding program
- Clone management, ID
- Adjust system to reduce mistakes and make more efficient

Marker-assisted selection: highly attractive goal still mostly unrealized by breeding programs
- Allow pre-breeding for quarantine diseases
- Whole-genome selection - eliminate non-productive genotypes early
- Breed for more optimal allele combinations

Gain efficiency through sharing results?!?

PRESENTATION: How the International Musa Testing Programme (IMTP) works and evaluation data produced and links with evaluation of germplasm collections - Inge Van den Berg

The background documents for this presentation are the following:
- Excerpts from: Jones, D.R. 1994. The Improvement and Testing of *Musa*: a Global Partnership. Proceedings of the First Global Conference of the International *Musa* Testing Program held at FHIA, Honduras, 27-30 April 1994.
- The International *Musa* Testing Programme (IMTP)- IPGRI/INIBAP, Brigitte Laliberté, Suzanne Sharrock, Lyndsey Withers, Gisela, Orjeda, Emile Frison, 1999
- The International *Musa* Testing Programme (IMTP) in the spotlight - Highlights from the survey
- IMTP reference documents

The International *Musa* Testing Programme:
Where it fits in the overall evaluation framework, results and outcomes, challenges, what next?
1. Pre-evaluation in collections: based on observations, not “designed” for evaluation, no specialised measurements
2. Trait screening: range of germplasm, for specific trait, specialised measurements, mass-screening
3. Evaluation: selection of materials, for specific trait, specialised measurements, reflecting “real” conditions
4. IMTP-type evaluation: selection of promising materials, for multiple traits, reflecting “real” conditions, many environments

5. Farmers participatory testing: “best” most promising materials, selected for specific characteristics but now testing “the whole”, in specific real-life situation

Outcomes IMTP
- Publicity for new varieties
- Evaluation of varieties that were not immediately selected (cfr. SH-3640)
- Stimulated further testing of new varieties through NEPs / NRMDCs
- Hybrids are tested under local ecological conditions before release to farmers; selection is not just based on information obtained from other locations
- Guidelines (can be used by others)

Challenges
- Lack of funding: to properly carry out experiments, for coordination, ...
- Local partners often insufficient capacity to multiply material (time, quantities)
- Experiments cumbersome, requiring excellent/multidisciplinary skills and facilities (agronomy, pathology, soil, climate, post-harvest, ….)
- Data analysis difficult because of many data gaps and data inconsistencies
- Access to improved materials: IP, breeders’ rights, ...
- BSV

What next?
Materials:
- New improved materials
- Popular landraces

Traits:
- Agronomic
- Biotic and abiotic
- Post-harvest

Steps
- Request new materials from collections and breeding programs; discussion of conditions for use, Material Transfer Agreement
- Virus indexing
- GIS analysis to identify set of field sites, based on climate, soil type, pest/disease pressure, ... and presence of reliable partner
- Review protocols for standardized trials and data collection; develop field log books and data collection sheets
- Training of partners
- Plantlet multiplication (by partners or by contracted lab?) and hardening
- *Ex-ante* impact analysis and stakeholder analysis in target regions
- Field evaluations, data collection and compilation in central database
- Genotype x Environment x Pathogen analysis
- Economic analysis and impact assessment
- Scaling up and scaling out

PRESENTATION: ProMusa - Mobilizing banana science for sustainable livelihoods: Goal and activities, links with MusaNet, knowledge sharing- Inge Van den Berg

ProMusa is a community of scientists and other stakeholders working on bananas

Ultimate goal:

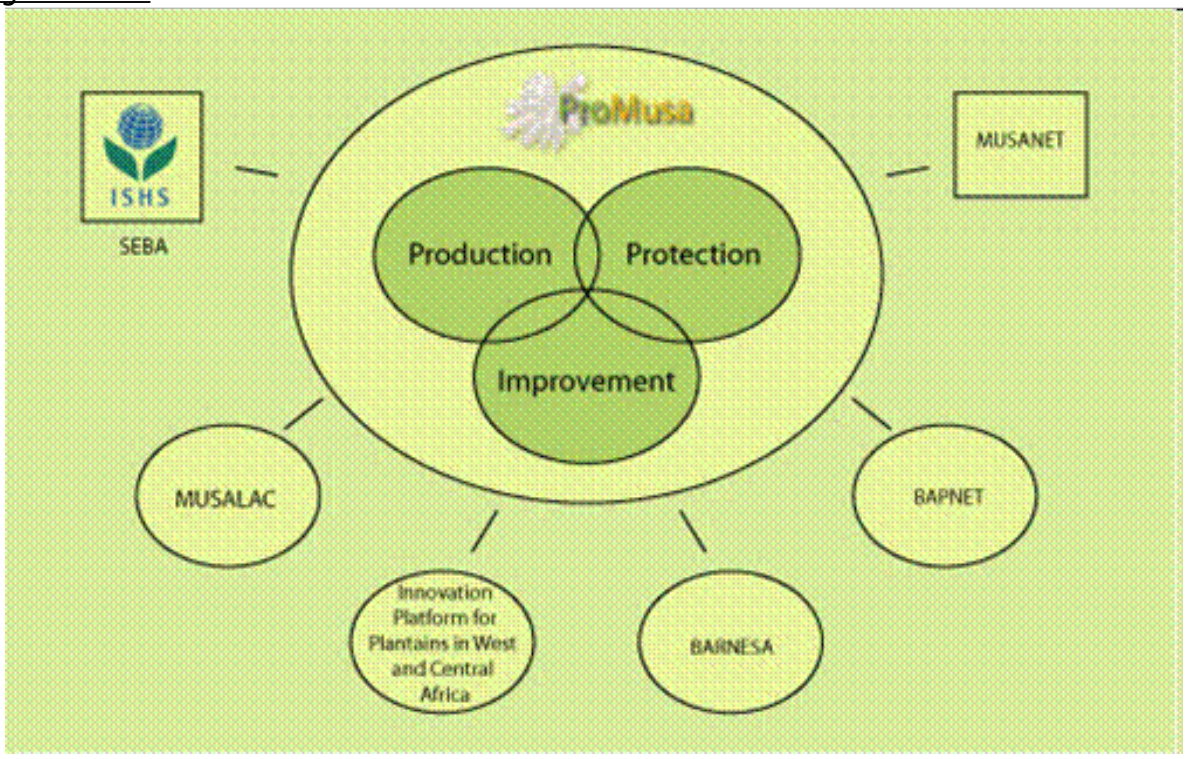
- to enhance the livelihood of people who depend on bananas by mobilizing the best science available

Main activity:

- to promote and facilitate exchange of information, knowledge and know-how:
    - biennial scientific symposium (reported in proceedings)
    - electronic newsletter
    - online compendium of banana knowledge
    - access to images, bibliographic information, and field/lab protocols and tools
    - online discussion forum
    - platform for community engagement
    - mailing lists
    - contacts database

While ProMusa strives to synergize research efforts by identifying opportunities for collaboration and funding, it does not directly implement or endorse research activities, nor fund them.

Organization



Knowledge sharing

- Survey with identified primary and secondary target audiences:
- Scientists and technicians from Research Centres and Universities with limited access to resources
- Students
- Development organizations and local private sector

Knowledge sharing

- MusaPedia: wiki software → collaborative (contributors acknowledged)

- Compile current knowledge on banana
- If knowledge can be found somewhere else in relevant form → link
- If knowledge cannot be found somewhere else in relevant form → build
- Not project- or activities-based, but thematic (takes information from projects and transforms it into knowledge)
- Reviewed by experts – credible
- Example: Subgroup and cultivar cards → Collaboration MusaNet and ProMusa
    - Building the template
    - Then filling the content
    - Link to MGIS
    - Links to pages on pests and diseases, country sheets, …
    - Links to publications, images, …

More information here:

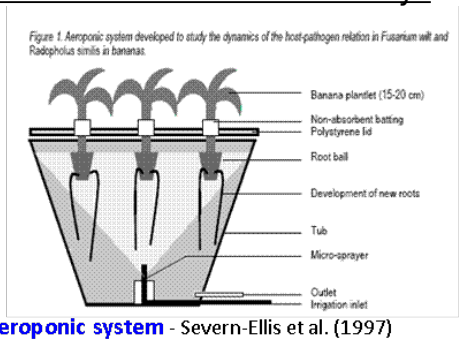
- www.promusa.org
- http://www2.promusa.org/tiki-custom_home.php
- http://www.promusa.org/symposium_2011/index.htm

PRESENTATION: Fusarium phenotyping: linking greenhouse screening to field evaluations and generating information for anticipatory breeding – Miguel Dita

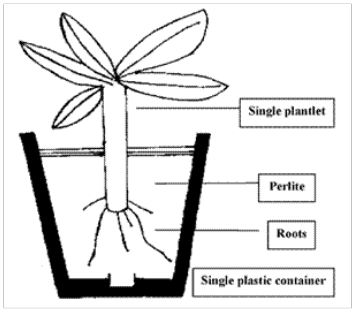
Panama disease /Fusarium Wilt - *Fusarium oxysporum f. sp. cubense* - FOC

- Photos of devastation of a Cavendish plantation in Malaysia by Panama disease (Ploetz, 2001) and of a Typhoon
- FW - Selection field at Embrapa – "INFECTÁRIO"
- Foxy - Geographic distribution (GS +)

Systems used for Foc-banana bioassays

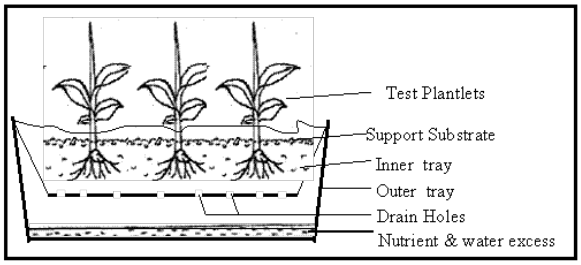


Aeroponic system - Severn-Ellis et al. (1997)

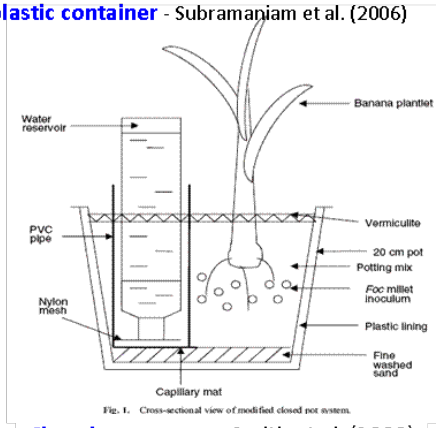


Single plastic container - Subramaniam et al. (2006)

Double tray system



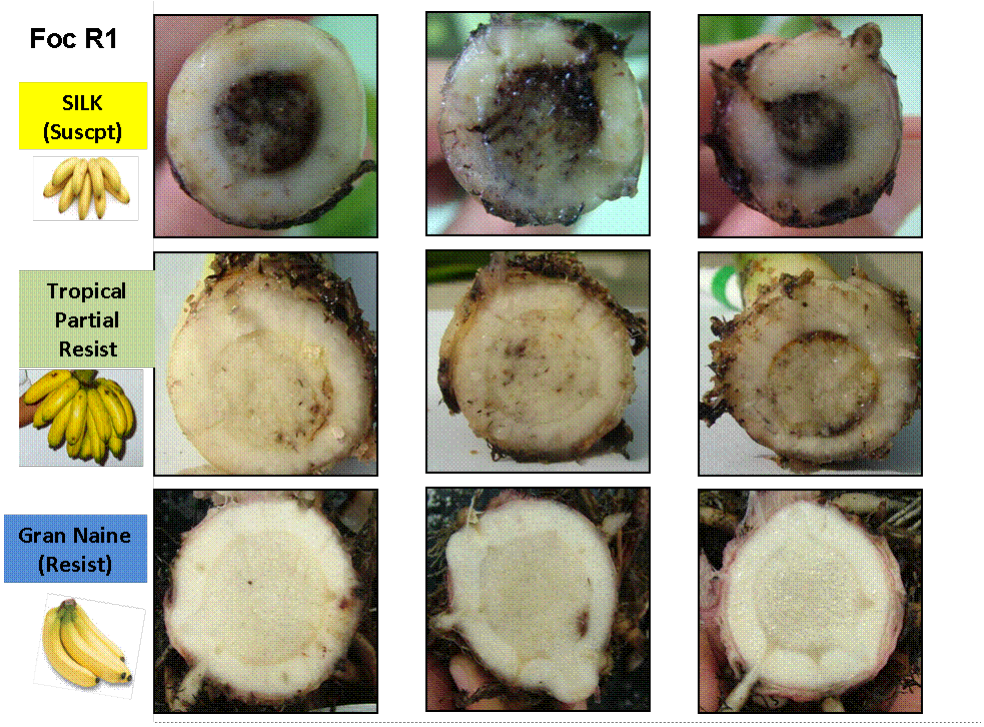
Mohamed et al. (2001)



Closed pot system - Smith et al. (2008)

Developing a bioassay for Foc R1

- Photos of plantlets of Silk, inoculated with Foc (20 dai) grown in 2 different Substrates: Washed river sand and Vermiculite



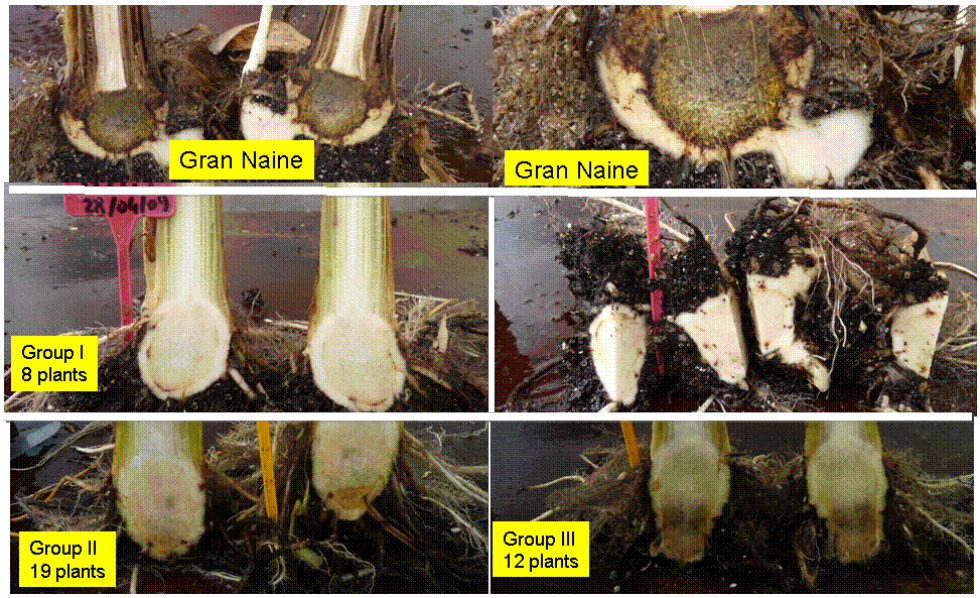
Discrimination of Banana Genotypes for Fusarium Wilt

- Progress of Fusarium wilt in banana plantlets under greenhouse conditions – Effect of inoculum concentration

Development a bioassay for Cavendish-TR4 interaction

- 3.5-month-old plants
- Double-pot system
- FOC TR4 - Inoculum production
- Cv. Grande Naine3.5 months old
- Phenotyping by using *Foc chlamydospores* as inoculum
- Development a bioassay for Cavendish-TR4 interaction
- Foc phenotyping - incompatible vs. compatible interaction
- Foc TR4 Phenotyping

Phenotyping for TR4 resistance - Pahang - segregating population



Conclusions

- Bioassays demonstrated to be rapid and reliable for FOC phenotyping under greenhouse conditions;
- There was a good co-relation between greenhouse results and field reaction in all the tested cultivars
- Inoculum pressure can influence the reaction of cultivars with quantitative resistance;
- Bioassays is an excellent tool to perform high throughput phenotyping screens and also are useful for: detailed plant-pathogen interaction, assessment of biocontrol agents and generate data about mechanism underlying disease resistance;
- The FocTR4 bioassay is an efficient tool for provide information for breeding programmes to assist anticipatory breeding and ex-ante studies.

PRESENTATION: Evaluation of quality traits: post harvest quality of edible banana (Musa sp.) – Sébastien Ricci (presentation prepared by Sébastien Ricci and Olivier Gibert)

Objectives and method

- Investigation of the diversity of edible Musaceae in relation to the traditional preferences & uses
- Investigation of the post-harvest quality
- Differentiation of consumption groups & genotypes on the basis of some « objective » quality traits
- Research needs on post-harvest quality & prospects

Post-harvest diversity and uses

Edible Musaceae production and diversity

Dessert bananas – 69 MT

- AA– Sucrier, Samba,..
- AAA– Cavendish, Gros Michel,..
- AB– Ney Poovan, Kunnan
- AAB – Silk, Pome, Mysore, ..
- ABB– Pisang Awack
- AAAA – FHIA hybrids, ..
- AAAB– FHIA hybrids

Cooking bananas – 41 MT

- AAAea– Lujugira
- AAB– Plantains, Maia maoli,..
- ABB– Bluggoe, Pelipita, Saba,..
- AAT/AT– Féhis
- AAAB– FHIA hybrids,..

Ref. Bakry et al., 2009; Lescot, 2010

Consumption modes and genotypes

Dessert bananas – 50%

Cooking bananas – 50%

- Fried products – about 15%
- Water cooking – about 15%
- Roasting – 5%
- Texturized products - 5%
- Beers & fermented products - 5%
- Flours and starches – 5%

Ref. Noupadja et al., 2001; Englberger, 2004; Ngoh et al., 2005; Quintero et al., 2008; Gibert et al., 2009

Construction of quality - Quality construction from harvest to consumption - 5 to 45 days

- Harvest and packaging
- Transport
- Ripening and marketing
- Processing and consumption

Banana quality defects

- Growth and maturity: Pests, diseases, physiological defects and imperfections
- Harvest and packaging: Pests, miscellaneous defects, dehanding problems and bruising
- Transport: Bruising, ripening problems and storage problems
- Ripening and marketing: Ripening problems, storage problems, storage diseases
- Processing and consumption: Texture, dry matter, soluble sugars, stage of ripeness and aspect & size

Ref. Gibert et al., 2010; De Lapeyre et al., 2010; Lassois et al., 2010; Chillet et al., 2009

Objective quality traits

Some “objective” criteria for the characterization of the post-harvest quality

Dry matter, ash, fibre & minerals

- Amylose & starch content
- Soluble sugars & titratable acidity

Thermal, textural & functional properties

Ref. Therma Gibert et al., JAFC 57, 2009, err. 58, 2010 Dufour et al., JAFC 57, 2009 Gibert et al., JFE, 2010

Prospects

Prospects: post-harvest strategy according to the target

Desert bananas: Quality = physiological strategy x storage

- Reducing post-harvest losses due to improper post-harvest practices
- Better knowledge of local biodiversity for breeding
- Optimization of industrial production

Cooking bananas: Quality = variety X process X maturity

- Industrial healthy “traditional” ready-to-eat foods locally processed
- Valorisation of diversity for consumer acceptability

Other needs and prospects

- Screening & selection of the varieties with optimal “technological profiles” in a germplasm collection, for limitation of non-genetic contributions
- Integration of some “objective” quality traits in the strategy for the conservation and use of banana and plantain genetic resources
- Investigation of the stability of quality traits after breeding

Contact: Olivier Gibert: olivier.gibert@cirad.fr

DISCUSSION: Germplasm evaluation and links to breeding

A brief discussion followed the presentation on ProMusa with the following points raised:

- ProMusa has about 500 members and almost all MusaNet meeting participants are members. Any interested person can subscribe on-line and take part in the working groups.
- ProMusa working groups are mainly forum of discussion and information sharing and do not have the objective of developing specific projects. MusaNet would complement ProMusa in this aspect for the Musa genetic resources activities. There is an important overlap with MusaNet and it was proposed that for example MusaNet could come up with answers to specific questions and ProMusa facilitates the sharing of information.

A brief discussion followed the presentations on post-harvest with the following points raised:

- The question as to whether collection curators get involved in doing any post harvest evaluation was raised. In India, evaluation is done on for storage and nutritional quality, and fibre content for extracting. But for cooking bananas the starch quantity and quality is difficult to evaluate and needs special labs. Often however, information is not feedback in collection management systems.
- At the time of circulating this report, it was commented by Kodjo Tomekpe that 100-150 accessions of CARBAP collection were evaluated for dry matter, firmness, vitamins and mineral composition within the framework of the EU-CARBAP project and the Harvest Plus project (of which the Banana component is coordinated by ProMusa). These data could be shared within MGIS.
- All agree on the difficulty of breeders to meet local preferences. They need to know organoleptic origins and users preferences (e.g. for boiling, frying etc.) need to formalise objective traits. There is a general assumption that taste and post harvest qualities will be there once other traits are prioritised for research such as disease resistance. Need to consider quality from a breeding point of view. Such research could provide a good basis for genetic analysis and transfer better quality traits to our varieties- but need to understand the parameters of quality.
- There is a need to accurately identify what genetic engineers need from banana germplasm as end-users. If genes for pest/disease resistance can be identified from within Musa there is a far greater likelihood of consumer acceptance of the end product than if the genes come from other genera. In theory, a small gene insertion should cause less disruption of the desirable features of the variety being engineered and thus slot more readily into the marketplace.
- Conventional breeding has the problem of its products being mostly different from the variety to be replaced and the difficult task of getting consumers to change. There may be a need for gene mapping using wild diploid populations. We need to know how much is going on along this theme and if we have at our fingertips the required populations conserved for such purposes.
- There is a need for technical guidelines on how to screen materials and there is a need to agree on the same methodology. The ProMusa website will have a collection of guidelines for the community to evaluate, discuss and share.
- The IMTP original objectives were to provide information to the breeders and the question was raised if this objective was achieved.

Tuesday 1 March *16:00-18:00*	***Session 7 - Theme 3: Germplasm Information and Utilization (cross-cutting area across themes)*** *PRESENTATION: Musa Germplasm Information System (MGIS) – Max Ruas* *DISCUSSION: Comments and feedback on MGIS roles and functions.*

PRESENTATION: Musa Germplasm Information System (MGIS) – Max Ruas

Plan
- History
- International Treaty
- Numbers
- Application
- Data workflow
- What is it & what is it not
- Web site
- Others Genetic Resources Information System
- Future

History
- Publication : ''Définition de l'architecture du projet MGIS'', CIRAD, 1995, D. Cassan, T. Helmer, X. Perrier
- MGIS came live in 1997
- MGIS is a software with an embedded database
- This software was distributed via CD-Rom
- MGIS CD-Rom was distributed during training workshop
  - 1st MGIS training Workshop, CIRAD, Guadeloupe, October 1997 (IDRC support)
  - Regional MGIS Training Workshop for Asia and the Pacific, QDPI, Australia, July 1998 (IDRC support)
  - MGIS Regional Training Workshop for Latin America and Caribbean, INIFAT, Cuba, September 1998 (IDRC support)
  - MGIS training workshop for India, NRCB, India, May 2001(NRCB & INIBAP support)
  - MGIS training workshop for Africa, CARBAP, Cameroon, April 2002 (CTA support)
  - MGIS training workshop for East Africa, IRAZ, Burundi, December 2006 (BIOVERSITY support)
- Version 3.0
  - Improvement on the ergonomy of the software
  - MGIS offers the possibility to link one photo to descriptor
  - MGIS offers possibility to add your own descriptor

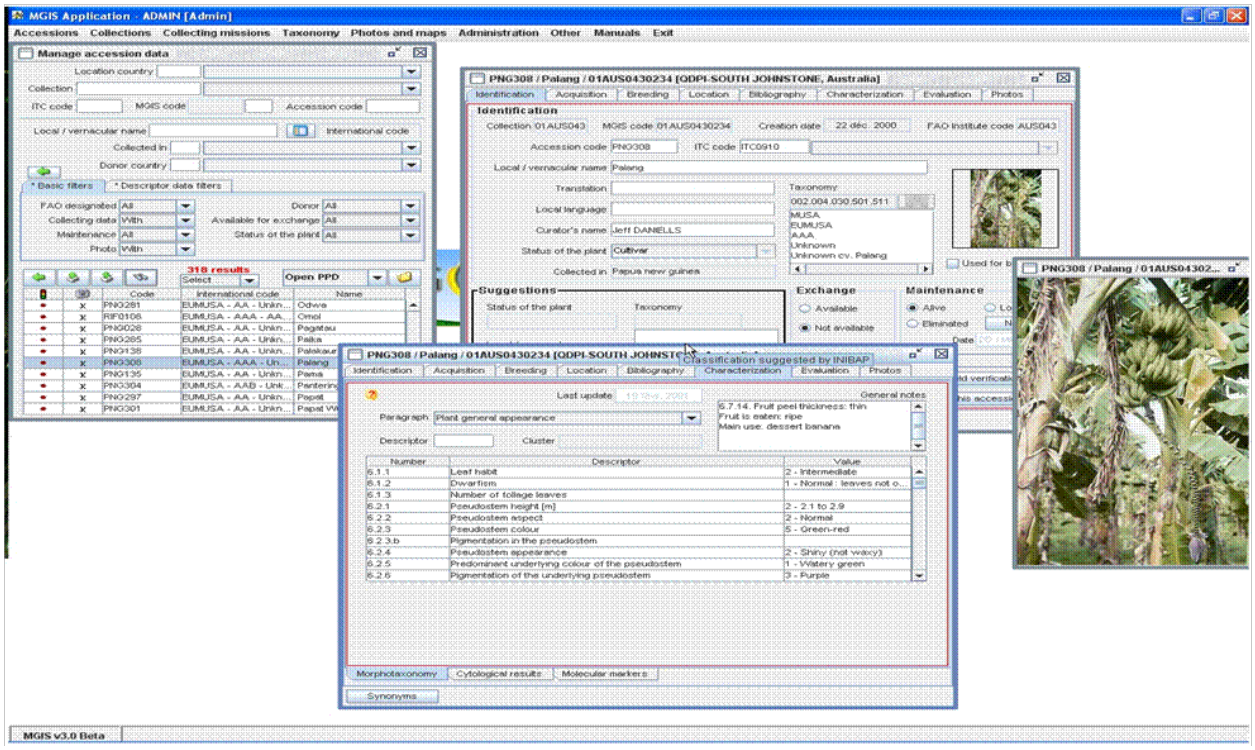
International Treaty
- International Transit Centre (ITC)
  - In 1994, the collection was placed under the auspices of FAO and is held in trust by BIOVERSITY for the benefit of the international community
- The International Treaty (http://www.planttreaty.org/)
  - ITC distributes material using Standard Material Transfer Agreements (SMTA)

Numbers

22 collections

- 5541 accessions
- 1966 accessions characterized (35%) (average 95 descriptors/accessions)
- 1215 accessions with agronomic evaluation cycle 1 (21%)
- 1142 accessions with agronomic evaluation cycle 2 (20%)
- 1748 accessions with photos (30%)
- 3531 photos for descriptors from Field Verification project (average 8 photos/accessions)

Application



Data workflow

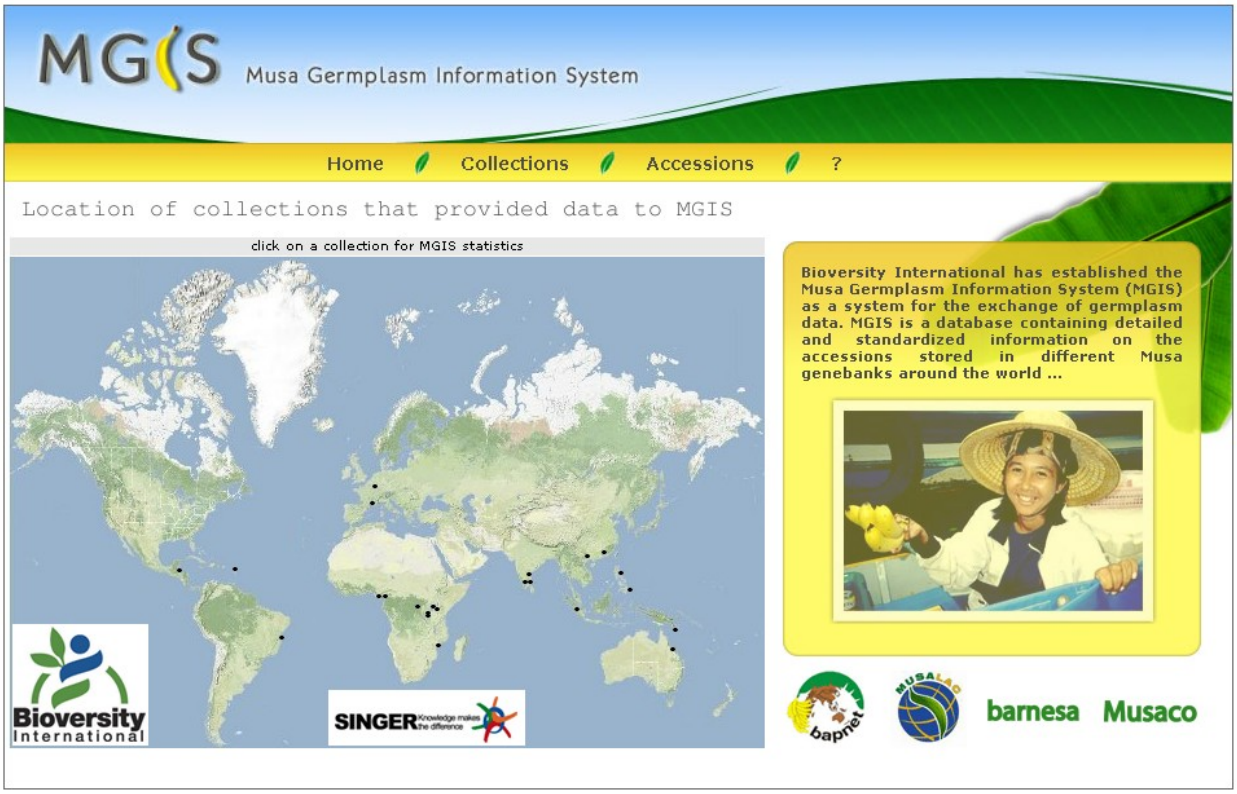
- MGIS software distributed to curators
- Data entry made by curators
- Update send via the application
- Data property of the provider (curator)
- Central database sent back to curators

What it is & what is Not

- MGIS is designed for managing accession level information using commonly agreed descriptors for characterization & agronomic evaluation
- MGIS is not a Gene Bank Management application
- MGIS was not designed for recording raw data from evaluation

Web site

- MGIS web site was released in it first version in 2003
- MGIS web site was redesigned in 2009 to benefit from AJAX technology
- Through MGIS web site it is possible to ''compare'' accessions between collections
- http://www.crop-diversity.org/banana/



Others Genetic Resources Information Systems

- MGIS is linked to *Musa* Gene Bank Management System installed at ITC
- MGIS provides information to SINGER & GENESYS

Future

- *Musa* descriptors have been used for defining the term of the Musa ontology (GCP Project)
- Release a Data sharing agreement to enforce the community
- Improve data quality
- MGIS content should be linked to :
- International *Musa* Testing Project database (IMTP)
- *Musa* Literature database (Musalit)
- Banana Researcher Information System database (BRIS)
- the Knowledge Resources Centre (PROMUSA)
- MGIS will be merged with *Musa* Crop Register to embark cross-referencing tools
- Develop an online upload of excel data sheet
- MGIS should be linked to TropGeneDB (CIRAD)
- MGIS and Pl@ntNet?

MGIS questions

- Is the MGIS output what users expect?
- How to improve ownership?
- How to improve usability?
- How to improve quality of data?

DISCUSSION: Comments and feedback on MGIS roles and functions.

A discussion on MGIS followed in groups discussing the proposed questions by Max:

- Is the MGIS output what users expect?
- How to improve ownership?
- How to improve usability?
- How to improve quality of data?

Is the MGIS output what users expect?

Questions were raised on the complementarities and differences between the information to be found in ProMusa (MusaPedia) versus in MGIS. For example, you can get information on specific varieties from ProMusa and click and go to MGIS for accession-specific information. MusaPedia is to be developed where users can register and change the information. The system will record contributions. Information at the cultivar level is very important and should be compiled in one easy-to-access entry point. This is what MusaLogue (reference on cultivars) was and MusaPedia could be electronic version of this. There is a clear need for factsheet within subgroups. MGIS and ProMusa (MusaPedia) can easily be linked. Many users want more information than the accession-level information. Information providers will also need to know how to provide the information (to MGIS or ProMusa?). Many MGIS users need general taxonomic information to be able to search accessions. In addition, information from IMTP also needs to be accessible.

The following points were also suggested:

- Need to access information from different collections
- MGIS doesn't support genebank management, but others such as GRIN GLOBAL do and it would be useful to harness the potential synergies.
- MGIS should include molecular data (or link to TropGeneDB)
- MGIS should offer analysis tools
- If MGIS offered a mechanism to facilitate requests for samples from ITC (ordering on line) that would be very useful- i.e. information on dissemination.

How to improve quality of data?

The question on how to provide feedback to MGIS was raised and it was suggested to ensure that feedback is provided to and by a person and not to an automatic email system. Users need to know there are people behind these sources of information. And the contact with the collection managers requires a personal approach. This is crucial for motivating data providers and improving the quality in a sustainable way, so that it is cleaned at the source. Hence providing feedback to data providers on data quality is crucial. Max mentioned the tool developed for the Musa Crop Registry for improving quality as an interesting approach.

The following additional points were also suggested:

- There should also be an incentive for data providers and attribution and recognition is very important.
- Have operational projects around reference collections
- Need to ensure data is reliable/ validated- if information is poor quality it will deter users
- Quality photos will generate pride in product/ contribution

- Data quality needs to be managed- see EURISCO or GBIF which have manuals for data quality management

How to improve ownership?

- Create functional links between all collections, curators and MGIS
- Ensure good links with curators to encourage them to provide clean data (both for themselves and for MGIS)
- Have a network connecting all collections' databases
- Curator should receive feedback regarding data use but also need to receive data
- Acknowledge and recognise contributors and contributions. When data analysis from MGIS is published, all contributors should be acknowledged
- Photo should include source captions
- Recognised past curators (and to accommodate past inconsistencies)
- Institutionalise contributions within the university/ institute so less individual liability
- Well maintained collections have good motivation to share information
- Need improved internet access
- Training in taxonomy and database management
- Promote incentive for example: "if you are first, others will follow"
- Need data sharing agreement
- Need to have linkages between collector and users
- Curators TOR doesn't include contributing to MGIS and may need to formally allocate this role

How to improve usability?

- Easy access to publications and verifications
- Be able to print out variety fact sheets
- Reduce bandwidth requirement
- Make friends with the users, sit with them to improve the interface

DAY 3	**WEDNESDAY 2 March 2011**

Wednesday 2 March 2011 *09:00-12:00*	***Session 8 - Theme 4: Conservation – towards a global partnership to conserve and use the Musa genepool*** *(safeguarding the genetic diversity): roles of international, regional and national collections.* *PRESENTATION: A global partnership for the conservation and use the Musa genepool – Nicolas Roux* *PRESENTATION: Biological Resources Centres for Tropical Plants (CRB-PT): example of collaboration between institutions for the conservation of tropical plants collections – Robert Domaingue* *PRESENTATION: The collection of the International Transit Centre (ITC): its mandate as a global public good (overview of its use, activities and impact) – Ines Van den houwe* *PRESENTATION**:** Safe movement of germplasm: possible roles for regional centres and a global centre in virus indexing – John Thomas* *DISCUSSION: Discussion on global partnership to conserve and use the Musa genepool* *GROUP DISCUSSION by REGIONS of roles of international, regional and national collections* *GROUP REPORTS and DISUCSSION on regional and global partnerships*

PRESENTATION: A global partnership for the conservation and use the Musa genepool – Nicolas Roux

Strategy content

- Status of *Musa* diversity
- Existing *ex situ* conservation
- Proposed model for collaboration
- Priority collections for support
- Next steps for implementation

Proposed model for collaboration

Roles and responsibility for the conservation of unique germplasm and improved varieties:

- Global collection - ITC
- Service providers
- Internationally-recognized collections
- National collections

Global collection - ITC

- Maintaining FAO “in trust” collection
- Long- and medium-term conservation of entire gene pool
- Disseminating germplasm to all collections, breeders and researchers
- Expertise in taxonomy, *in vitro* technologies, germplasm exchange & SMTAs, accession information management
- Processing germplasm for virus indexing
- Coordinating and upgrading MGIS

Service providers

- Ploidy determination / genotyping
- Pre-indexing, Virus Therapy
- Virus-indexing (and quarantine services)
- Roles of the ITC in a global system on *Musa* genetic resources

Internationally-recognized collections

- Expertise in taxonomy, germplasm management and multiplication technologies
- Characterizing and evaluating varieties
- Verifying accessions trueness-to-type
- Disseminating germplasm to all collections, breeders and researchers
- Disseminating germplasm at a national level and potentially at a regional level in specific cases
- Participatory evaluation of germplasm with farmers/consumers
- Participating in MGIS

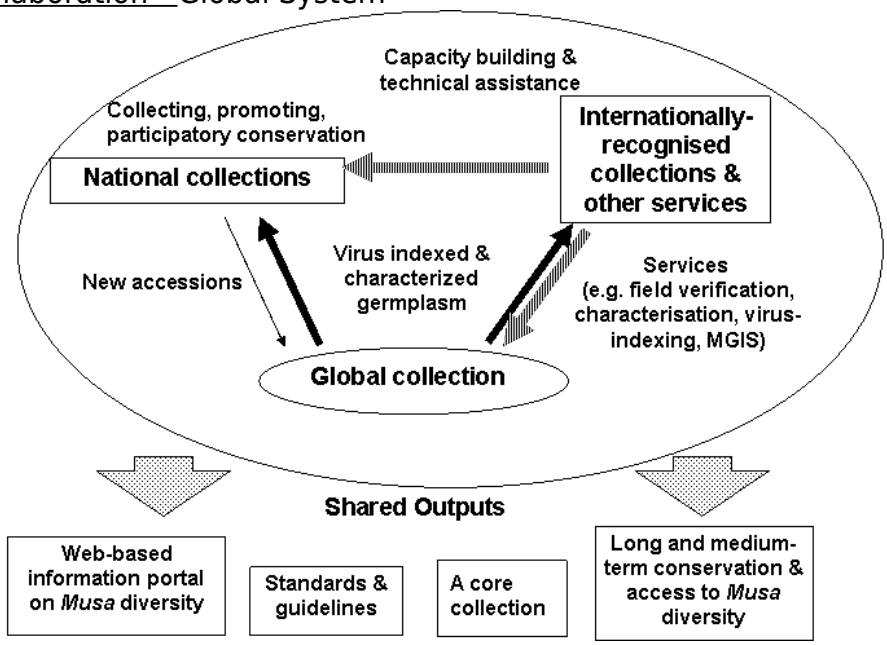
National Collections

- Collecting and documenting traditional knowledge
- Characterizing and evaluating varieties
- Participatory evaluation of germplasm with farmers/consumers
- Disseminating germplasm at a national level (esp. farmers)
- Expertise on production and use, local cultivars
- Participating in MGIS

Existing systems to enhance exchange and collaboration

- Four regional banana Regional Networks
- *Musa* germplasm Information System (MGIS : 22 collections)
- International *Musa* Testing Programme (IMTP)
- ProMusa
- GMGC

Model of collaboration - Global System



Model of collaboration?

- Roles reflect reality?
  - At Global level
  - At Regional level
  - At National level
- Collaboration between collections?
- Model facilitates exchange?
- Model enhances use?

PRESENTATION: Biological Resources Centres for Tropical Plants (BRC-PT): example of collaboration between institutions for the conservation of tropical plants collections – Robert Domaingue *(presentation prepared by Claudie Pavis)*

A Cirad-INRA joint structure, in the French West Indies: The BRC-TP

- Initiated 2006, officially created March 2010
- 6 germplasm collections and associated activities: Banana, Mango, Pineapple, Sugarcane, Yams … Herbarium
- In Guadeloupe and Martinique
- Embedded in 2 research unit (AGAP & ASTRO) and 5 locations
- Regroups 14 permanent staff: A full time director, and a managerial committee, a scientific and technical advisory committee
- Labelled Ibisa

Goals

- To conserve and distribute accessions to scientific teams, to breeders, to extension services, network of farmers
- To deal with sanitary and legal issues
- To produce information on the accessions and make it available

Collections

- Banana 450
- Mango trees 100
- Pineapple 580
- Sugarcane 1 200
- Yams 500
- Herbarium 10 000

Scientific goals and projects

- Sanitation and conservation processes, including cryogeny…
- Studies on molecular viral diversity, and optimisation of viral diagnostics including metagenomics
- Genotyping with common sets of markers in order to compare the diversity of collections of different organisations
- Implementation of phenotyping

Facilities

- 5 field stations with different pedoclimatic conditions
- Greenhouses
- Climatic chambers for phenotyping under controlled conditions
- *In vitro* conservation

- Molecular biology laboratories
- Informatics infrastructures and support on Web applications

Tools for quality and communication

- Quality control of acquisition, conservation, distribution processes
    - implementation of ISO 9001 certification (2012)
- Databases, online catalogue
    - Web site http://collections.antilles.inra.fr

Inter-TROP: the French tropical BRCs network

Web : http://www4.inra.fr/intertrop

- BRC Vanilla La Réunion
- BRC Cocoa, Coffee Hevea French Guyana
- BRC Rice Montpellier
- BRC Coffee Montpellier , La Réunion
- BRC Tropical Plants Guadeloupe, Martinique
- Inter-TROP shares skills and develops common tools in the fields of web accessible databases, ISO certification, safer conservation

Goal of Inter-Trop

- To be recognized as French tropical BRCs, and with improved visibility, the various institutions (Cirad, Inra, IRD) join forces through the Inter-Trop project (2010-2012) - IBiSA.
- The objective are to propose a common web site presenting the various catalogues, aim for certification of activities, and develop common management tools of BRC. Special emphasis is laid on the security issue of the collections.

PRESENTATION: The collection of the International Transit Centre (ITC): its mandate as a global public good (overview of its use, activities and impact) – Ines Van den houwe

The background document for this presentation is the following:

- The impact of the *Musa* International Transit Centre: Review of its services and cost-effectiveness, and recommendations for rationalization of its operations. *Hildegard Garming, Nicolas Roux and Ines Van den houwe*, 2010 - PDF

Role of the ITC collection in a global system on *Musa* GR

- Providing long-term conservation for the entire range of *Musa* diversity
- Maintaining a source of genetic diversity and related information in the public domain (FAO 'in trust' collection)
- Documenting the conserved germplasm and making information available through MGIS
- Processing germplasm for virus indexing
- Providing a service for worldwide distribution of clean germplasm to users

ITC collection holdings - 1329 accessions:

- 989 FAO 'in trust' accessions
- 1320 accessions under IT and 9 'non-annex 1' accessions (*Musa textilis, Ensete* spp.)

Introduced from 57 sources in 37 countries incl.

- major field collections IITA, CIRAD, IRAZ, FHIA, CATIE
- collecting missions PNG(3), Vietnam(2), Tanzania(2), D. R. Congo
- breeding programs CARBAP, CIRAD, EMBRAPA, FHIA, IAEA, IITA, INIVIT, TBRI

Genetic coverage

- 75% Cultivated forms :15 groups, 40 subgroups
- 16% Wild types: 19 species
- 9% Improved varieties: diploids (11), triploids (27), tetraploids (81)

Improve coverage

- Acquisition of 250 accessions from 13 priority collections pending (GCD Trust regeneration project (2009-2011))

Source	genotypes
NRCB, South India	(60) AB, AAB, ABB
SPC, Fiji-Pacific collections	(70) Pacific plantains, Fe'i
BPI, Philippines	(30) ABB, BB
ITFRI, Indonesia	(20) Wild and cvs.
FAVRI, Vietnam	(20) Wild and cvs .
CARBAP, Cameroon	(50) AAB plantain

Rationalization

- Elimination of 'OT', 'ML', duplicate accessions (Field verification and molecular characterization)

Conservation

In vitro active collection (MTS) - 1329 accessions

- safety back-up for field collections
- dissemination of samples to users

Shoot cultures under slow growth conditions: T=16°C and PPF =25 µmol.m-2.s-1 (24h)

Continuous monitoring:

- Annual recycling the tissue cultures
- Five yearly check for endophytic bacteria
- Regeneration of accessions stored for more than 10 years:
    - greenhouse regeneration for rejuvenation of MTS stocks
    - verification of the genetic integrity in partner field collections (BPI, CARBAP, CIRAD, FHIA, NARO)

Cryopreserved base collection (LTS) - 819 accessions

- Safety back-up off-site at IRD
- Research at KULeuven provided knowledge base
- Implemented at ITC and NBPGR, India
    - Droplet vitrification method applied to scalps or individual meristems
    - 3 independently frozen sets per accession (security standard: 95% certainty that min. 1 plant can be regenerated per set)
    - Processing of accessions is labour intensive but once frozen, minimum of maintenance cost

<u>Characterization</u>

- Flow cytometric ploidy determination of 1182 acc.(IEB)
- Morphological characterization of the 820 acc.: ongoing (BPI, CARBAP, CIRAD, FHIA, NARO)
- DArT genotyping of 700 acc. (CIRAD)
- SSR genotyping of new acquisitions: started in 2010 (IEB)
- *Musa* Gene Bank Management System (MGBMS)
    - Passport data
    - Barcoding accessions
    - Genebank operations data
    - Distribution data
    - Field verification data
    - Health testing data
    - Ploidy
- *Musa* Germplasm information system (MGIS)
    - Morphotaxon descriptors
    - DArT genotyping data
    - SSR genotyping data

<u>Health testing</u>

Virus pre-indexing (FUSAGx)

- Pre-entry screening of accession materials to select the ‘cleanest’ sample for introduction in the collection
- PCR detection for 5 viruses

Virus therapy (FUSAGx)

- Routine sanitation from CMV, BBTV and BSV (A-genome acc) and BanMMV
- BBrMV protocol under development

Virus Indexation at Bioversity VIC (DPI&F)

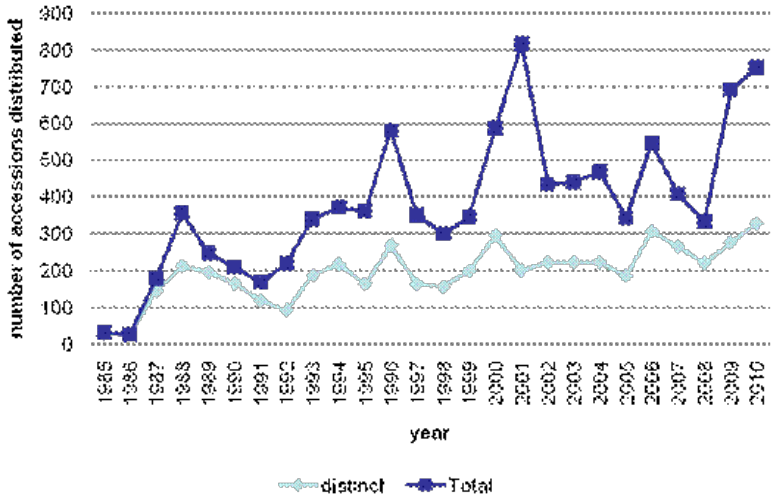
- PCR, ISEM and visual detection for all viruses

Release of clean germplasm for international distribution

- 860 acc tested virus-negative
- 30% is BSV infected (accessions with B-genome) blocked for distribution

Germplasm distribution and use

- Annual distribution of germplasm from 1985 to 2010 (external users)
- Total distribution = samples of 9879 acc
- Users in 103 countries
- Accessions from MTS collection are multiplied on request
- Tissue collection of lyophilized leaves (630 accessions), available for molecular studies
- Legal framework: SMTA according to IT-PGRFA
- Free of charge service
  - Average annual utilization ratio : 33% of virus-negative holdings
  - Cumulative utilization ratio : 82% of holdings available for distribution



Users by type of organisation

- National agricultural research institutes – 40%
- Advanced research institutes/ Universities – 30%
- CGIAR – 11%
- Private sector – 8%
- Regional organizations – 5%
- Other – 3%
- Non-affiliated individuals – 2%

Distribution of germplasm by geographical region

- Americas – 26%
- Europe – 25%
- Asia-Pacific – 23%
- East and Southern Africa – 14%
- West and Central Africa – 12%

Trends in use 2000-2007

Kind of germplasm requested

- Landraces, varieties and cultivars – 63%
- Improved varieties – 20%
- Wild types – 17%

Purpose of germplasm request

- Conservation – 48%
- Applied research – 44%
- Fundamental research – 44%
- Characterisation – 64%

- Evaluation – 80%
- Multiplication / dissemination – 80%
- Breeding – 20%

Traits

- Tolerance to biotic stress - 30%
- Adaptation to specific local conditions/ consumer acceptability - 24%
- Yield characteristics - 15%
- Tolerance to abiotic stress - 13%
- Other traits - 13%
- Pre-breeding evaluation studies - 5%

Future trends in use (rating over 5)

- Increasing demand for wild species and improved varieties
- Important germplasm traits :
  - Tolerance to biotic stress – 4.1
  - Tolerance to abiotic stress – 3.4
  - Agronomic traits – 3.2
  - Nutritional value – 2.5
  - Others – 2.2
  - Post harvest characteristics – 2.1

Outcomes and type of impacts

Germplasm beneficiaries

- Musa research community – 46%
- Farmers – 38%
- No response – 14%
- Consumers – 13%
- Production industries (plants, fruits) – 11%
- Processing industries – 3%

Products of research that have resulted from the use of germplasm: Publications, evaluated varieties released to farmers, intermediate breeding products

Main impacts of the germplasm received from ITC or from research that has been carried out

- Basis for further research / breeding – 29%
- Reducing yield loss from pests/diseases – 26%
- Avoiding introducing diseases in the region – 24%
- Increased yields – 22%
- No results – 14%
- Capacity building – 6%
- Production available for processing – 6%

ITC users' recommendations and concerns

1. Expand the collection, especially with respect to wild species
2. Encourage stakeholders to share germplasm to increase the genetic coverage of the collection
3. Continue cryopreservation for backing-up the whole collection
4. BSV issue
5. Improve the documentation status of the collection. Particularly evaluation data are highly needed

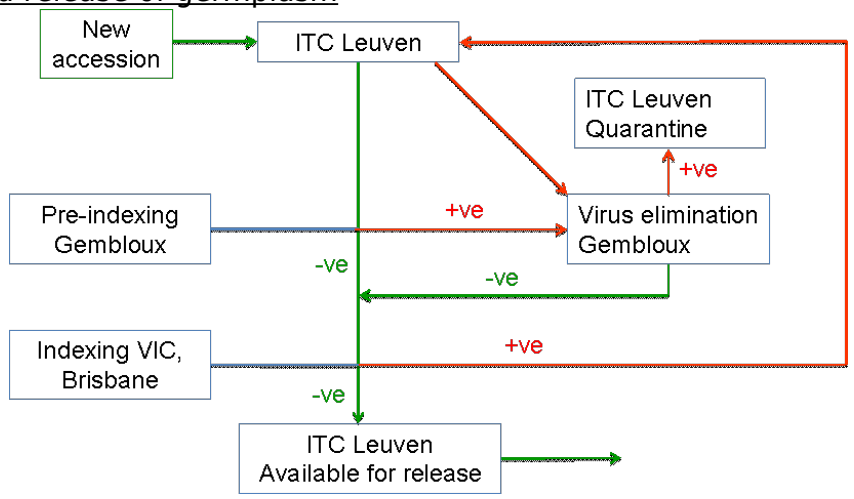
6. More systematic feedback from users about germplasm evaluation results
7. Facilitate access to information (user-friendly MGIS, email-newsletters, ProMusa network)

PRESENTATION: Safe movement of germplasm: possible roles for regional centres and a global centre in virus indexing – John Thomas

Role of Global Virus Indexing Centre

- International Guidelines for the safe movement of *Musa* germplasm – 1989/1996
- Virus indexing of all germplasm deposited into the International Transit Centre, KUL, Leuven
- Based on indexing of a subset of TC plantlets grown in post-entry quarantine
    - Visual examination
    - Molecular and EM tests at 3 and 6 months
- 3 VICs (Brisbane, Montpellier, Taipei), later Pretoria

Indexing and release of germplasm



Current VIC indexing methods

- Plants grown in post-entry quarantine for 6 months
- Non-specific tests (unknowns)
    - Visual inspection for symptoms
    - Minipreps/EM
- Specific tests (knowns)
    - Multiplex PCR for BBTV/CMV/BBrMV
    - Multiplex PCR for BSVs
    - PCR for BanMMV

Virus detections from ITC germplasm over the last three years

Total accessions	-ve	BSV	BanMMV	BSV + BanMMV	other viruses
98	69	**9**	**8**	**12**	0

Regional centres

Goal

- Virus indexing at regional centres to increase efficiency of germplasm acquisition and distribution through ITC

Method:

- Ring test to assess feasibility
  - Demonstration of standard set of indexing protocols at regional laboratories
  - Stocks of primers and antisera, and protocol left at labs
  - Identical set of coded dried leaf cultures of virus-infected and healthy samples and known positive controls sent to each lab
  - Results of “blind tests” collated

<u>Ring test – ideal result</u>

VIRUS	Amplicon size (bp)	Blind samples												Positive control samples							
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
BBTV	513					+	+				+		+						+		
BBrMV	600								+		+				+	+					
CMV	700							+				+					+	+			
BSMySV	589			+										+							
BSV-OL	522													+							
BSV-GF	476													+							
BSV-IM	384													+							
BSV-CaV	782				+							+		+							
BSV-Lac	695													+							
BanMMV	305								+	+	+									+	+

Lab A

VIRUS	Amplicon size (bp)	Blind samples												Positive control samples							
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
BBTV	513					+	+				+	+	-						-		
BBrMV	600								+		+			+	+	+	+	+		+	
CMV	700							-				-					-	-			
BSMySV	589			+					+		+			+							
BSV-OL	522								+		+			+							
BSV-GF	476								+		+			-							
BSV-IM	384								+		+			+							
BSV-CaV	782				-							-		-							
BSV-Lac	695													+							
BanMMV	305				+			+	-	+	-	+								-	-

Correct virus detection False positive False negative

Lab B

VIRUS	Amplicon size (bp)	Blind samples												Positive control samples							
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
BBTV	513					+	+	+	+	+	+	+	+						-		
BBrMV	600								-		-				-	+					
CMV	700							-				-					-	-			
BSMySV	589			-										-							
BSV-OL	522													-							
BSV-GF	476													-							
BSV-IM	384													-							
BSV-CaV	782				+							+		-							
BSV-Lac	695													-							
BanMMV	305								-	-	-									-	-

Lab C

VIRUS	Amplicon size (bp)	Blind samples												Positive control samples							
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
BBTV	513					+	+				+		+								
BBrMV	600								+		+										
CMV	700							-				-									
BSMySV	589			+																	
BSV-OL	522																				
BSV-GF	476																				
BSV-IM	384																				
BSV-CaV	782				+							+									
BSV-LaC	695																				
BanMMV	305								+	+	+									+	

<u>Ring test conclusions</u>

- Results not uniform across all regional centres
- Difficult to establish protocols and define experimental problems in short space of time
- Alternative protocols acceptable, but must be approved and validated
- Once available:
    - Certification for regional movement
    - Initial screening at regional laboratories, with rescreening through MusaNet

<u>Overall conclusions and future directions</u>

Needs:

- Shorten virus indexing time
- Modernise standard indexing protocols
- Decide fate of BSV-infected accessions

Actions:
- Update international guidelines
- Investigate alternative indexing procedures e.g. deep sequencing
- Use leaf samples collected at time of initiation
- Otherwise, multiplication cycles in TC to maximise BSV activation, then rolling circle amplification, RT-PCR or IC-PCR
- BSV infected clones- exporter to provide accurate virus data, importer to assess risk, some times benefits outweigh risks

Future directions
- International guidelines outdated, in urgent need of revision
- Refinement and further development of assays needed
- New detection platforms need to be investigated
- Standardised, validated tests required

DISCUSSION: Discussion on global partnership to conserve and use the Musa genepool

A discussion followed the presentation on global partnerships with the following points raised, mainly related to the revision of the global strategy:

- The strategy needs to include the following sections:
  1. Where we are now
  2. Where we want to be in 5 years
  3. How we propose to get there including quantitative measures of achievements (what we want to collect, conserve, increase use etc.)
- See how existing germplasm can be more widely utilised and on-farm conservation included in the strategy.
- We need to be clear on what is meant by use for each of the users groups (researchers, scientists, pathologists, breeders, farmers, consumers, etc…) and what are the traits targeted and clarify the users' categories: What roles of different types of users? What are their interests?
- Include a description of the different communities of users and distinguish between coordinators, contributors and observers (specialist and amateur notion) and their roles and develop communication mechanisms.
- Each data should be linked to someone for checking/validation. You should always know who to contact to correct errors.
- Regarding the ITC, we need to have a clear strategic plan to reduce duplication.
- ITC potential users of the germplasm need to be alerted to the entry of new available stocks in the collection, possibly by email. This could assist them in finding their way in using the collection of over 1000 accessions.
- Evaluation data: who are the main contributors and how to include and involve them? National programme are evaluating materials. There are methodologies and we need to tap onto this resource.
- MGIS data is increasing but not regarding evaluation data. There should be a link with the IMTP. This may require data capturing methodologies.

A discussion followed the presentation on the ITC with the following points raised:
- A question was asked relating to the use of a quality management system at ITC. The system used by the International Centre for Potato (CIP) has been considered but was very expensive especially to maintain and the ITC would need financial

support it may be too small for such a system but could collaborate with other CG systems.
- It was proposed that the ITC describes better "where it is now" and "where it wants to go or in the future" e.g. in terms of removing redundancies and filling gaps.
- A question on evaluation data was raised asking who are the regional and national actors and who does what and if the information is entered into MGIS. National programme are doing evaluation and there are methodologies in each country. Evaluation data management is difficult for MGIS and needs to be standardised. It needs to clarify definitions and methods within evaluations and capture methodologies.
- The international distribution is mainly from the ITC and there are national distribution centres.
- It was also mentioned that the problem of *in vitro* conservation of plantains (in particular]) because of BSV may require the need for alternative approaches if we are serious about their conservation.

GROUP DISCUSSION by REGIONS of roles of international, regional and national collections

Small group discussions were held, in regional groups (Asia, Americas, Africa, Global), on the proposed roles and functions of national, regional and international collections. The points are summarised below:

National collections:

Diversity:
- Needs to be representative and have complete diversity for that nation and to cover the gaps in the global collections of the ITC.
- All unique genotypes need to be conserved and backed up in national collections or at the ITC.
- It is assumed that not all the national diversity would be covered at the ITC. Ensuring that this diversity is maintained nationally so not to having all eggs in one global basket.
- The reduction of duplicates should be easier if there is a regional collection.
- National collection should also include the reference collection and ensure that diversity is collected.
- In many national collections material is overlapping between the countries. This requires a lot of information to be exchanged between national collections to identify synonyms.

Conservation:
- Conservation is mainly in field genebanks, *in vitro* and screen-houses.
- Each country should have on farm/*in situ* conservation.
- It serves as a backup for the global *in vitro* collection for genetic integrity, true-to-type.

Distribution:
- Purpose of the collection is mainly national distribution and dissemination of the material to farmers and other users at the national level.
- Having the genetic resources in the nation may mean that accessions are more easily accessible.
- Strengthen the capacities of national collections on multiplication.

Characterisation:
- Characterisation and taxonomic identification.

Evaluation:

- Collections should provide material for national evaluation trials.
- Evaluation for targeted traits relevant for the country and ensure that the diversity for these traits is available in the national collections.
- Strengthen the capacities of national collections on virus indexing.

Breeding programmes:

- In the Americas, 4 national collections have breeding programmes which may provide other unique genotypes

Training:

- The national curator or focal point should be trained by the regional network or curator.

Policy and awareness:

- National focal points to create awareness with national policy makers to raise importance of diversity, considering the sensitivities on access, provide an enabling environment, advocacy and lobbying.

Regional collections:

- The regional collection should contain the total diversity plus a reference collection.
- The distribution at the regional level.
- Characterisation, evaluation and documentation.
- Training of national curators in the region should be a key activity.
- Strengthening national capacity on multiplication and virus indexing.
- Characterisation and documentation should be at the regional level.
- Involvement in MGIS and information exchange.

Global collection – ITC

Diversity:

- Broad global diversity but not exhaustive of all cultivars, capture the breadth of diversity in a large core collection.
- The entire gene-pool but should focus on increasing the proportion of wild relatives and therefore should have a seed-based collection.
- Create a core collection (or subsets of collections) defined according to specific use not only based on diversity (e.g. subset for traits such as Fusarium resistance).

Conservation:

- Maintaining FAO in-trust collection, mid and long term conservation.
- Longer-term conservation in perpetuity as cryopreservation.
- Rationalisation of the ITC collections could be based on the cryopreservation collection with a safety backup. Although distribution cryopreserved samples might be expensive and may be easier with *in vitro* samples.

Distribution:

- Facilitate access to disease free hybrids from breeding programmes, without off-types.
- Facilitation of exchange (there is a mental and technical resistance to exchange)
- Provide material should it be lost from either original site or from other places.

Characterisation:

- Validation of authenticity of ITC material molecularly and morphologically.

Evaluation:

- Genotyping and virus indexing takes place when acquiring materials.
- Role in the coordination of mass screening for key traits- e.g. Fusarium TR4 resistance in non-producing countries and provide indexing services.

- There is a need for a coordinating body linked to ITC to ensure key screenings are conducted. E.g. screening of risky traits should be screened in non banana producing countries.
- Securing the link between the ITC and the national and regional field sites.
- IMTP was very useful for partnerships and should be expanded to have more material.

Documentation:

- MGIS is linked to the global collection, but needs to be linked to local cultivar level in national collections and the ProMusa knowledge resource centre.

Policy and awareness:

- ITC can speak for all countries.
- In achieving its mission a global collection should focus more on the non-commercial benefit sharing such as the exchange of information, capacity building and transfer of technologies. These benefits need to be clearly linked to access so that the wider banana community can address global challenges.

Other comments

- Need to clarify the difference between national and regional collections.
- Regional collections will depend on capacity available.
- A workshop with curators to discuss synonyms of the most important (25-30) varieties is very useful. Need to be based on molecular markers, so need DNA fingerprint for each cultivar.

Wednesday 2 March 2011 *14:00-15:30*	***Session 8 – Defining the major outputs and users' needs of the global strategy for conservation and use of Musa genetic resources*** *GROUP DISCUSSION by REGIONS on the major outputs of the global strategy* *GROUP REPORTS and DISUCSSION: Define the Strategy's major outputs and scope of activities.*

Small group discussions were held on what the main goal and outputs of the global strategy for the conservation and use of *Musa* genetic resources should be. The expected outputs in the 2006 strategy version are the following:

- Genetic diversity is characterized and collections are rationalized
- Global system for safe exchange of germplasm is strengthened
- Entire gene pool is conserved in perpetuity
- Use of genetic diversity is maximized

GROUP REPORTS and DISCUSSION: Define the Strategy's major outputs and scope of activities.

Below are the summary points from the 4 group discussions:

Utilisation:

- The revised version of the strategy needs to focus on use of accessible healthy materials including a clear understanding of the users' needs and priorities.
- It should define/describe users (scientists, breeders, curators, farmers, consumers) and their needs/ expectations.
- Use should be the main objective with sub-objectives on conservation, safe exchange and information with a clear methodology on implementation (i.e. main

focus is use and how to achieve this is by conservation, documentation and safe exchange).
- Legal and practical barriers to free exchange are removed.

Conservation:
- The entire gene pool is collected and conserved in perpetuity to increase and expand genetic diversity and promote the safe use of a wide range of diversity.
- The ITC makes it safe and accessible, so the next generations will have same access.
- Collections are rationalised including field and ITC collections.
- Maybe not all diversity should be stored at the ITC. So we should be clear on what the ITC should and should not do and identify who will conserve the rest.
- Genetic diversity is comprehensively characterised and indigenous knowledge is captured.
- Diversity will never be completely sampled so it would be good to have systems to monitor field problems (diseases).

Information and documentation:
- We need quality and quantity information on taxonomy, characterisation, health, accessibility and usefulness.
- We need sound knowledge and data on accessions that is accessible with adequate infrastructure.
- We need to have a knowledge base on taxonomic research, genetic diversity, what is where and where the remaining gaps are.
- Get more information and particularly more photos. Curators have goldmines and part of their work description should include providing information and images.

Networking and community collaboration
- Collaborative platform as an instrument to implementation the strategy (make the wheels turn) with clear definition of where we are going and who is going to do what with clear roles of national collections first, then regional collections and finally the ITC.
- Vibrant community to link to Pl@ntNet to have better information and knowledge.
- We need to work together for example on issues of plantains at the ITC collection. This requires collaboration with field collections.
- Develop an enquiry system where you can contact an expert for specific advice for example of sub-groups and cultivars.
- Network of global collections with expertise.

Wednesday 2 March 2011 *16:00-18:00*	***Session 9: MusaNet establishment as the "Expert Committee" responsible for implementing the Global Strategy*** *PRESENTATION: MusaNet proposed mode of operation – Nicolas Roux* *SMALL GROUP and PLENARY DISCUSSION: Feedback on MusaNet's objectives and functions*

PRESENTATION: MusaNet proposed mode of operation – Nicolas Roux

Musa Genetic Resources Network - MusaNet

What is MusaNet?

- A global collaborative framework for *Musa* GR, bringing people with different expertise together to support the implementation of the Global Strategy.

Goal of MusaNet

- To build upon existing strengths in the global, regional and national collections to optimize effort to conserve and document the *Musa* gene pool and promote use and safe distribution of diversity and related as the foundation for further breeding or direct use by farmers.

Objectives

- Assessing diversity conserved and filling gaps
- Ensure cost-effective long-term conservation of *Musa* GR in public domain.
- Enhance *Musa* GR value for use, through collaborative characterization, pre-evaluation and evaluation.
- Facilitate access to germplasm by users through information.
- Strengthen capacity for management of collections and use of *Musa* GR
- Raise awareness with key partners on importance of *Musa* GR conservation, documentation, exchange and sharing the benefits arising from their use.

MusaNet Outputs

The following major outputs are proposed (subject to change after the MusaNet meeting):

- Genetic diversity is comprehensively characterized (molecular and morphological) and documented, taxonomy is harmonized.
- The global system for the conservation and safe exchange of germplasm is strengthened and rationalized.
- The entire gene pool is conserved in perpetuity (including collecting and conservation of public domain germplasm).
- The use of genetic diversity is maximized through information and database management and germplasm evaluation and enhancement.

Proposed MusaNet structure **–** *see diagram on page 9 presented on Day 1 – introduction to the global strategy and MusaNet.*

Coordination Secretariat

- Ensure implementation of MusaNet activities in accordance with mandate given by Expert Committee.
- Coordinate activities carried out in MusaNet framework
- Be responsible for the financial management of MusaNet.
- Provide support to Advisory Groups and ensure that the agreed workplans are carried out.
- Initiate ad hoc activities in accordance with guidance provided by the Expert Committee.
- Provide progress reports on a regular basis.
- Gather and distribute information.
- Organizing future meetings.

Bioversity International

- Provide scientific and technical advice on issues debated in the AGs and Expert Committee.
- Management of MGIS

- Ensuring cost-effective long-term management of the ITC collection
- Processing germplasm for virus pre-indexing; therapy; indexing and genetic integrity monitoring

Membership
- Membership on an expertise basis and not on institutional or country representation basis.
- Responsibility of members to obtain institutional commitment and support to allow them to contribute to the implementation of the Strategy.

Expert Committee
The Expert Committee is responsible for guiding the MusaNet programme.
- Chair of Each of the Advisory Groups
- Four members from the regional networks: Asia and the Pacific, East and Southern Africa, West and Central Africa and the Americas (initially the four regional coordinators).
- Coordinator

Advisory Groups
The Advisory Groups will be groups of a maximum of 5-10 people with a chair, assisting in:
- Formulation of project proposals
- Search for donors to support particular elements of workplans and ad hoc activities
- Provide a link with other Advisory Groups and Regional Networks;
- Contribute to raising public awareness about MusaNet and its activities
- Undertake any further activity as agreed mutually with the Expert Committee

Nomination of experts in Advisory Groups will be done initially by proposal during the first MusaNet meeting and subsequently by proposal and vote from a range of members.

Links with *Musa* Regional Networks
- A member of each Regional Network should be represented in the Expert Committee and encouraged to participate in the Advisory Group based on expertise.
- MusaNet should be an item at each Regional Network Steering Committee meeting (on a 2-year basis).

Links with related initiatives and networks
- Global *Musa* Genomics Consortium - GMGC
- ProMusa
- Global Crop Diversity Trust
- Secretariat of the ITPGRFA
- CGIAR Research Programmes – CRP-RTB
- Generation Challenge Programme - GCP

PLENARY DISCUSSION: Feedback on MusaNet's objectives and functions

A discussion followed the presentation on MusaNet's objectives and functions, raising the following points summarised:
- Participants asked clarification questions regarding the differences and complementarities between the difference existing network initiatives: ProMusa,

Regional Networks, GMGC, TAG and Bioversity with the ITC. There is a concern that there might be duplication of efforts since the people are the same in all these initiatives and many of these have similar mandates. A frank discussion followed specifically on the links between ProMusa and MusaNet.

- The question about the role of Bioversity in networking was also raised, since the change from INIBAP to Bioversity. Networking was the core business of INIBAP but with a new mode of operation. What should be the role of Bioversity and what are partners expecting, i.e. leadership, facilitation, coordination, contribution etc. This role needs to be clarified.
- There is an important need to clarify who is responsible for the implementation of the strategy and at what level and what is the specific role of each networking initiatives, including MusaNet.
- There were also a proposal to call the "Advisory Groups" "working groups" to emphasise their role in carrying out specific activities and developing project. This was debated as some participants felt that the role of these groups was to focus on providing expert advice and that members of these groups should have a specific expertise.

The following clarifications were provided:

- ProMusa focuses on information and knowledge dissemination and MusaNet would focus on working groups developing joint collaborative activities and projects to solve specific problems and address key research questions.
- Both, MusaNet and the regional networks are working together to implement the global strategy and the MusaNet advisory groups can provide expertise on taxonomy of collected material but also on rationalisation and avoiding/minimising duplication, expertise on evaluation and documentation.
- All members of MusaNet are also members of ProMusa so MusaNet could be considered as a "specialised" group of ProMusa with specific objectives and expected outputs.
- There will be some overlaps but Bioversity should be able to deal with this and ensure good links and communication.
- ProMusa and MusaNet will have to communicate clearly to their members the areas of work and the differences and complementarities.

<u>Regional Musa Research Networks:</u>

- There are currently 4 regional networks:
    1. BAPNET - Banana Asia-Pacific Network.
    2. BARNESA - Banana Research Network for Eastern and Southern Africa
    3. Innovation Platform for Plantains in West and Central Africa (based at CARBAP)
    4. MUSALAC - Plantain and Banana Research and Development Network for Latin America and the Caribbean
- These networks have official institutional representation from each of the countries with a chair.
- Bioversity coordinators act mainly as facilitators and moderators for the networks.
- Regional Networks are important regional platforms for national programmes to agree on regional collaboration for *Musa* research and development and identify priorities to develop and implement projects.
- Regional Networks are key also in the development and implementation of the global strategy and therefore are linked to MusaNet with a representative of each of the 4 networks participating in the Expert Committee, overseeing the coordination and links between the thematic working groups.

MusaNet:

- There is a need for groups of people to work together on *Musa* genetic resources. TAG did solve certain problems, but it lacked legitimacy and if you leave it to evolve it will just fade away.
- We need a more sustained way of working together than going from project to project- we need continuity.
- MusaNet is proposed as a network of scientists with expertise and interest focused on genetic resources management and use, and part of the interest of the National Programmes.
- MusaNet should provide advice and propose collaborative actions.
- MusaNet is intended to be a community based on expertise not necessarily on regions and/or institutions.
- MusaNet is an advisory body, which would be considered as an input into the regional networks.
- MusaNet should not be only providing advice but should also be involved in the development projects and in supporting their implementation.
- Many of the activities proposed will be implemented in partnership with all members mainly the national, regional and global collections and the service providers.
- MusaNet could play a key role in rationalisation of collections. Such a project would involve all partners in its implementation.

ProMusa:

- ProMusa ensures that information and knowledge is proactively disseminated to all interested stakeholders of Musa research and development.
- The ProMusa working groups have a different purpose and mode of operation than MusaNet. There is a need to address specific problems and developing a community that will make a commitment to solving many thematic problems in genetic resources use and conservation and MusaNet can assist in this aspect.
- MusaNet can be part of ProMusa but it would require functioning as an individual group of experts to provide advice on a number of themes and develop actions.
- ProMusa is proposing to look at the members of MusaNet, what ProMusa is and create the appropriate space with MusaNet. This may mean to define the commitments, the content extent and consequences of commitments and to possibly reformulate objectives of ProMusa.
- A representative of ProMusa should be in the MusaNet expert committee.
- There may be a possibility to meet in Brazil at the ISHS symposium.

Bioversity

- There is a global strategy and a group needs to be responsible for the implementation. Should this be Bioversity? MusaNet? Bioversity is the only organisation that has a mandate for *Musa* genetic resources. It was proposed that Bioversity be responsible for implementing the strategy.
- Bioversity is directly responsible for the management of the ITC collection and of MGIS, which are key elements supporting the global strategy.
- Regarding the role of Bioversity, there are the 4 regional networks, MGIS and ITC, so Bioversity should be responsible for how things should be implemented. And to do this, it needs advice from a community of genetic resources experts.
- There are also expectations from donors for Bioversity take the lead with genetic resources conservation strategy.
- Role of Bioversity should be clearly defined in the MusaNet a document.

DAY 4	**THURSDAY 3 March 2011**

Thursday 3 March 2011 *09:00-12:00*	***Session 10: Meetings of the Advisory groups to further detail the Advisory Groups' workplans*** *Summary of Day 3 and issues for Day 4 and nomination of members of the Advisory Groups:* • *ADV GROUP 1: Genetic diversity gap filling, taxonomy and characterization* • *ADV GROUP 2: Germplasm evaluation* • *ADV GROUP 3: Germplasm information and documentation* • *ADV GROUP 4: Conservation – global partnership to conserve the Musa genepool and promote the safe exchange of materials* *Introduction to the Working Group process – logistics and proposed agenda* *ADVISORY GROUPS' WORK: The agreed thematic Advisory Groups to discuss in details proposed workplan and issues/concerns to resolve*

The participants agreed to form 4 different thematic groups to discuss priorities and develop specific workplans for the morning session of Thursday 3 March and to report to the entire group in the afternoon.

The following groups were formed:

- WORKING GROUP 1: Genetic diversity gap filling, taxonomy and characterization
- WORKING GROUP 2: Germplasm evaluation
- WORKING GROUP 3: Germplasm information and documentation
- WORKING GROUP 4: Conservation – global partnership to conserve the *Musa* genepool and promote the safe exchange of materials

The working group proposed process was the following:

- Propose a chair
- Agree on the scope of activities of the working group
- Brainstorm about possible projects / activities / tasks
- Proposed and agree on priorities for the group to address
- Propose collaborative activities and projects
- Develop a workplan (on how to get there)

The following table lists all of the members of the 4 thematic working groups with the proposed chairs and vice-chairs. As agreed this should be further open after the meeting to additional participants:

	Members	Email addresses	Group
Group 1: Genetic diversity gap filling, taxonomy and characterization			
1	**Edmond de Langhe - Chair**	edmond.delanghe@chello.be	1
2	**Jean-Pierre Horry - Co-chair**	jean-pierre.horry@cirad.fr	1
3	Angela Kepler	akk@pacificwideconsulting.com	1
4	Angelique d'Hont	angelique.d'hont@cirad.fr	1
5	Anne Vesina	a.vezina@cgiar.org	1
6	Janay Serejo	janay@cnpmf.embrapa.br	1
7	Jaroslav Dolezel	dolezel@ueb.cas.cz	1
8	Jim Lorenzen	j.lorenzen@cgiar.org	1
9	Kodjo Tomekpe	kodjo.tomekpe@cirad.fr	1
10	Markku Hakkinen	markku.hakkinen@kymp.net	1
11	Pierre Bonnet	pierre.bonnet@cirad.fr	1
12	Uma Subbarya	umabinit@yahoo.co.in	1
Group 2: Germplasm evaluation			
1	**Inge Van den Berg - Chair**	i.vandenbergh@cgiar.org	2
2	**Robert Domaingue – Co-Chair**	robert.domaingue@cirad.fr	2
3	Eldad Karamua	e.karamura@cgiar.org	2
4	Francoise Carreel	francoise.carreel@cirad.fr	2
5	Gus Molina	a.molina@CGIAR.ORG	2
6	Jeff Daniells	Jeff.Daniells@deedi.qld.gov.au	2
7	Miguel Dita	M.Dita@cgiar.org	2
8	Olivier Gibert	olivier.gibert@cirad.fr	2
9	Sebastian Ricci	sebastien.ricci@cirad.fr	2
Group 3: Germplasm information and documentation			
1	**Lavernee Gueco - Chair**	laverngueco@yahoo.com	3
2	**Max Ruas - Co-Chair**	m.ruas@cgiar.org	3
3	Benjamin Liens	benjamin.liens@cirad.fr	3
4	Brian Irish	Brian.Irish@ARS.USDA.GOV	3
5	Daniel Barthelemy	daniel.barthelemy@cirad.fr	3
6	Elizabeth Arnaud	e.arnaud@cgiar.org	3
7	Jean Louis Pham	jean-louis.pham@ird.fr	3
8	Nicolas Roux	n.roux@cgiar.org	3
9	Theo Van Hintum	theo.vanhintum@wur.nl	3
Group 4: Conservation – global partnership to conserve the *Musa* genepool and promote the safe exchange of materials			
1	**John Thomas - Chair**	john.thomas@deedi.qld.gov.au	4
2	**Ines van den Howe - Co-chair**	Ines.VanDenHouwe@biw.kuleuven.be	4
3	Deborah Karamura	d.karamura@cgiar.org	4
4	Emmanuel Fondi	fondien@yahoo.com	4
5	HP Singh	hpsingh2008@gmail.com	4
6	Ludivine Lassois	ludivine.lassois@ulg.ac.be	4
7	Mathieu Chabbanes	matthieu.chabannes@cirad.fr	4

	Members	Email addresses	Group
8	Maurice Wong	maurice.wong@rural.gov.pf	4
9	Rony Swennen	Rony.Swennen@biw.kuleuven.be	4

Thursday 3 March 2011 *14:00-17:30*	***Session 11: Action plan for the Global Musa Strategy, MusaNet workplan (including monitoring of implementation) and conclusions of the meeting*** *PRESENTATIONS: Reports from the MusaNet Advisory Groups: workplans (who, what, when and how)* • *ADV GROUP 1: Genetic diversity gap filling, taxonomy and characterization* • *ADV GROUP 2: Germplasm evaluation* • *ADV GROUP 3: Germplasm information and documentation* • *ADV GROUP 4: Conservation – global partnership to conserve the Musa genepool and promote the safe exchange of materials* *DISCUSSION: on proposed MusaNet workplans for the implementation of the Strategy and a plan for monitoring progress* *NEXT STEPS: Immediate workplan following on from this meeting*

Group 1: Genetic diversity gap filling, taxonomy and characterization

The group focused its attention on two salient topics:

A. Diversity: the missing taxa and how to recover them (priority of future material collecting)
B. Characterisation: how to complete and improve the techniques

A. Diversity - missing taxa and how to recover them

Recommended actions, in order of priority:

	Where	What	How	Who/Funding
1.	Triangle: East Kalimantan-Malukku-Lesser Sunda (+ Philippines (Negrito areas) for more African plantain cultivars)	Unexplored wild AA spp./ varieties and edible AA; basic African plantain cultivars; other AAB?; other taxa -Western range of *M. ac*. spp.. *banksii*; *M. schizocarpa*; Australimusa and its Fe'i.	Exploration	• 2 experienced *Musa* taxonomists + national counterpart • Proposal of Bioversity (to Trust etc)
2.	Pemba-Madagascar	Wild AA; edible AA?	Exploration	Connect to existing activities by e.g. IITA, CIRAD; followed by priority (5)
3.	Northeast India	a) Un/underexplored wild taxa b) Collected wild/ edible AA and BB	a) Exploration b) Send to ITC	NBPGR followed by priority (5)
4	Sumatra-Pen. Malaysia-Thailand	Complex of AA ssp *sumatrana,truncata, malaccensis* (kedah form)	Collect more specimen for clarification	National taxonomists, (with additional earmarked support from Trust?); followed by priority (5)
5	Collections in	• Explored Eumusa	Long-term	• 2 experienced *Musa*

	ecology conform to explored environments	and Calllimusa (China, Borneo) • Harvest of 1,2,3,4	operation at collections	taxonomists + national counterparts, examining said collections • Proposal of Bioversity (to Trust etc)

While exploration/collection in Myanmar is recognised as of high potential, the lasting unfavourable conditions prevent from planning any action.

B. Characterisation - how to complete and improve the techniques

The group generated the following recommendations:

On Morphological characterisation

1. The Hierarchical Identification System, as proposed by Edmond, should be tried out down to the Subgroup level. The Reference Collection should be used for that purpose in some 3-4 field collections with international vocation (on a voluntary base?).
2. A Software should be build in the MGIS for the detection of any inconsistency, among the completed Descriptor Lists sent in by the curators, for each accession of the Reference Collection, and for each descriptor qualification (i.e. the corresponding qualification number). MGIS should signal the respective problems to the curators, who should try to settle the cases in community (e.g. through intensive email correspondence with cc to the MusaNet Expert Committee).

On Molecular characterisation

3. An agreed upon standardised 'Finger printing' technique with microsatellites should be applied to each accession of the Reference Collection with standardised techniques to share results through the platform, by the specialised laboratories of CIRAD (A. d'Hont) and of the Institute of Experimental Botany (J. Dolezel) and NRCB. By comparing the results, these labs should produce the basic molecular characterisation which would complement the morphological one (cfr 2), thus leading to the definitive characterisation of the subgroups (East Highland banana and plantains).

Additional remarks:

- Considering the rapid progress in molecular marker techniques (esp. on the SNP side), some sort of link with the 'taxonomic referential' used by ProMusa would be recommendable.
- The group expressed an interest in the cryopreservation technique in view of an Embryo Gene Bank and cryopreservation of seeds in relation to collecting wild species seeds to fill gaps.
- There was interest expressed to use the Bogor collection and in taking advantage of the Fairchild Botanic Gardens collection in Miami (number one sub-tropical garden in the world).
- There may be a need to collect in the Solomon Islands, Vanuatu and Western Pacific.
- Note from Angela Kepler: more collecting in the Western Pacific: Solomon Islands, Vanuatu, New Britain & Santa Cruz Islands (located between Vanuatu & Solomon Is.). Also we have the D'Entrecasteaux Islands & several other high volcanic islands (such as Fergussen, Long) east of Papua New Guinea. There are many, many islands in these countries. Here we have an unknown no. of cultivars that are sold & eaten every day by thousands of people and are very acceptable to them. On some of the

smaller islands, cooking bananas comprise their major source of calories. These cultivars could be an important source of new cultivars that don't even have to be bred. I suggested that Jeff Daniells be the expedition leader for such forays & he & Maurice agreed that we should do this. I also suggested it in the main meeting.
- This advisory group should meet in one year to monitor progress.

Group 2: Germplasm evaluation

Scope: who are the users: primary users, end users
  - Breeders (specific materials) – interested in specific traits
  - Farmers (broader pools) – interested in types adapted to local conditions
  - Researchers/ scientists – interested in the entire genepool

Global traits:
  - Fusarium
  - BBTV
  - Black leaf streak (BLS)
  - abiotic/biotic drought
  - shelf-life
  - dry-matter
  - vitamins and minerals
  - agronomic – height, yield and finger drop
- Do we need mass *in vitro* screening techniques? Methodologies exists but need validation in field (blind test) and therefore collaborate with ProMusa
- Testing in places like EMBRAPA, Wageningen and links to the field. Note from Jeff Daniels: this was mentioned mostly in the context of a possible Global Foc Screening Centre using methodologies given in Miguel Dita's presentation

Regional traits:
- What type of evaluation would be needed? E.g. West Africa – cooking banana, weevils, BBTV, drought, starch content.
- Have all plantains been evaluated for these traits?
- Need different methodologies than classical breeding e.g. drought evaluation is very complex
- The evaluation needs to include the global community involving regional and national centres.
- There is a role for ProMusa and MusaNet in capacity building.

Other remarks:
- Fusarium testing: start with the information in MGIS (from IMTP) and identify partners working on this (private sector, ProMusa, regional networks).
- Mass screening techniques and IMTP approach: consider feasibility and costs. First step might be a workshop to better understand needs.
- Susceptible plants/ or negative characters- need to be less biased in collecting for new traits- need to correlate molecular diversity to phenotypic diversity, so that targeted collecting for specific traits can be undertaken.

Group 3: Germplasm information and documentation

Scope of the thematic group:

- Should be defined by what users need.
- This is a resource group providing advice to ProMusa and MusaNet.
- Will seek input from all the other 3 working groups to find solutions, act as a development team and a steering committee to MGIS.

Priority

- Field verification, data quality and curation.
- Strategy for adding more characterisation and evaluation data such as the IMTP.
- Update MGIS database to input information from national collections.
- Quality data is an issue due to suboptimal conditions for characterisation.
- Taxa identification tools to improve quality and photos.
- Provide training in characterisation and taxonomy to feel connected to the network and motivated to participate.
- Strengthening the community of data through collaboration with ProMusa, Pl@ntNet, MusaNet (develop a project).

Grin global for Musa - distributed freely

- Feasibility of deployment, testing, feasible to be part of the community.
- Need to ensure germplasm is conserved properly. We may have data but no materials. This requires permanent funding.

Group 4: Conservation – global partnership to conserve the Musa genepool and promote the safe exchange of materials

Conservation

- On farm conservation
- *Ex situ* conservation
- In field conservation
- ITC
- Seed project

Issues:

- Today mainly ITC complemented by field conservation. Do we need on farm conservation? It can add value, knowledge, low cost but not safe. We may need a project to look into this.
- *In vitro* and cryopreservation for all accessions might be ideal but could be very costly and have time constraints.
- Field genebanks: who is conserving what and where? This is a national responsibility. We need to clarify how this should be done and define the links with ITC and field collections.
- Most of the time, material is exchanged without SMTAs, except for ITC, and with very little characterisation data.
- We need to clarify quality control for the safe exchange of materials between field collections to field collections and between field collections to ITC. This is a serious issue – how to have safe movement all around the world.
- Propose to update the BSV guidelines for virus indexing (the last version dates of 1996) as a priority and possibly for all other viruses.
- Need to link suppliers to users/ recipients, especially if via 2nd party like ITC.
- Need to also link with MGIS as suppliers want to know where their materials is going.
- Regional and national collections strategies need to be linked to ITC for data quality and traceability and verification many years later.
- Most national and regional collections do not have any status, no "labelling" indicating these are national collections.
- There are a lot of duplicates and the collections are not used for public awareness like in botanic gardens.
- Good documentation is linked to materials and information available.
- Government support: how can government provide long-term support to field collections? How can the system help these collections?
- May need some labelling, legal and quality control system.

Priorities

1. Safe movement - improve the indexing/ guidelines.
2. Global partnerships and how to label collections.
3. Establish feedback mechanism for MGIS.
4. Update the list of national and regional collections and produce an inventory of what is available.
5. ITC to proactively offer to distribute accessions to collections with specific interest for specific regions.
6. Develop a platform to exchange information between collections with photos and images.
7. Develop guidelines for field collection management - standardise quality control.
8. Develop priority list of accessions for specific collections.

Additional points:

- Screen-house conservation might be considered as an alternative strategy.
- Agree on how many duplicates should be kept.
- Best practices are already on-line (see knowledge base: http://cropgenebank.sgrp.cgiar.org/
- Need to discuss further how to maintain consistent labelling.
- Compiling and making visible what has been done so far, should this be part of information group role? Outreach work- how to make this visible?
- Platform for exchange between curators: a mechanism for sharing information. Information is not shared between curators. It relies on individual pro-activity and that is why we created MusaNet to develop a community of best practice.
- There are a lot of good intentions but we need to clearly identify what did not work so well and learn from these lessons (e.g. 250 accessions in a TRUST project- and 80% were duplicates).
- We should be able to collaborate and use the tools developed in the last 5 years.
- Need to have some of regional collections specialised on a particular part of the diversity.

Proposal for a rationalisation project (across thematic groups):

1. Need to make an inventory of what information is already available, and what has been done.
2. Develop a list of probable duplicates.
3. Communicate this information between collections.

DISCUSSION: on proposed MusaNet workplans for the implementation of the Strategy and a plan for monitoring progress

- Most groups did not cover funding and resources.
- Is forming the proposed thematic groups around projects sufficient for the moment to see how we move forward as a network? What are the missing steps to ensure these ideas move forward?
- The proposal for the 4 groups is a good starting point to keep the momentum going.
- Members should be allowed to participate in more than one thematic group.
- We need to assess whether new group members are needed and invite them to participate.
- We should ensure that communities not yet represented be included in MusaNet.
- We need to ensure consolidation of priorities across the thematic groups.

<u>It was proposed that:</u>

- The issue of duplications needs to be the top priority.
- We need to know well the current situation- head of all the different collections
- It could be beneficial and more effective to draft proposals leading to 2 types of projects:
    - commissioned projects for fundamental needs
    - competitive projects
- Identify activities that would stretch across the groups and regions, involving many disciplines with clear objectives and outputs.
- Projects should include deliverables to ITC, MGIS, etc and could be a condition.
- We need to identify process to go with labelling – contributions to the global system could be one criterion (particularly for the Trust).
- Next steps to operationalise MusaNet, we need to make projects go around these areas.
- Next steps are for each group to detail what needs to be done in a specific project.
- Each working group should define clear term of references.
- Need to indicate which are the main objectives
- Provide prioritisation/ criteria
- Access to donors
- If an activity is started it should align with the strategy
- Wanted to see how the strategy was guiding the functioning of MusaNet.

Next steps: Immediate workplan following on from this meeting and plans for future opportunities of meetings

MusaNet meeting – next steps:

- Meeting report – draft to be circulated soon after the meeting
- Process/ plan to update the Global Strategy
    - Review content
    - Focus on use
    - Identify partners/ contributors
    - Implementation plan and monitoring
- Plan for the process and people involved to be proposed by end of march
- Updating/revising the 2006 version to be circulated widely for feedback, by end of June.
- MusaNet next steps – formalising the network and further development of workplans.
- ProMusa meeting in Savado Brazil, 10-14 October 2011
- Regional banana symposium (BAPNET) in Tapei Taiwan 1st quarter of 2012
- Next ISHS congress will be in Australia in 2014 on pacific banana
- All regional network meetings to discuss MusaNet and the implementation of the strategy.

NOTE: Brigitte proposed the following revised goal, purpose and objectives for the global strategy but there was not time to go through it in details for lack of time:
Goal:

- *Musa genetic resources are secured, valued and used to support livelihoods through sustainable production.*

Purpose:

- *Facilitate use and safe distribution and access to a wide range of genetic diversity and related research efforts, as the foundation for breeding or direct use by farmers.*

Objectives (to facilitate/promote use – how? By having the following):

1. *Material:*
    - *Healthy – safe exchange*
    - *Diverse – covering the genepool*
    - *Accessible – conserved in collections as global public good*
    - *Valuable – data on key traits*
2. *Information documented and accessible in the public domain – organised and useful*
3. *Global, regional and national partnerships to promote, develop and pro-actively disseminate information and materials (i.e. who is doing what)*

MusaNet working groups:

- Develop clear objectives and terms of reference
- Should be involved in the revision of the global strategy
- All working groups should have a common vision with a strong coordination
- Should consider commissioned and competitive projects
- Should prioritise activities across groups and work together for mobilization.
- The roles of all collections should be clearly identified (it is clear for ITC but not so much for the others).

MusaNet name:

- There was some discussion about the name MusaNet and some proposals for a new name were made such as MusAgree, MusaGen and MusaGR. This discussion could continue with the members.
- The terminology for the advisory groups was also questioned and it was proposed that they be described as “working’ groups”, but their role will need to be clearly defined.

Meeting evaluation and feedback and Closing of meeting

The participants were asked to reflect on the meeting and provide feedback on what worked well and what could be improved, by completing the meeting evaluation form. The complied result of the survey is available to anybody interested. In summary the participants were very positive on the meeting organisation, proposed programme and general atmosphere. The objectives were ambitious to attempt to achieve 2 main things: (1) review the global strategy and (2) set up the networking mechanism – MusaNet. There was not enough time for the working group discussions and these will have to keep their enthusiasm and level of commitment high by moving forward as soon as possible with some of the projects proposed. There should be a clear strategy for maximising on complementarities between ProMusa and MusaNet.

Brigitte thanked the organisation committee (Nicolas Roux, Jean-Pierre Horry, Edmond De Langhe, Rony Swennen, Robert Domaingue and Jean Christophe Glaszmann) for their guidance and enthusiasm in developing a good workshop programme. She was very impressed by the very high level of participation. She acknowledged the great support of Janis Thiriet Karen Lehrer and Max Ruas. Nicolas closed the meeting by thanking everybody and particularly the team Karen, Janis, Vincent and Brigitte for their effective support.

Annex 1: MusaNet meeting agenda (*revised based on actual programme*)

DAY 1	MONDAY 28 February 2011
	Session 1 – Introduction to the meeting
08:30-09:15	• Welcome address and logistic information • Introduction to participants and meeting objectives, expected outputs and process
	Session 2 - Critical Review of the Global Strategy for the conservation and use of banana and plantain genetic resources (developed in 2004-2006)
09:15-09:45	PRESENTATION: The Global *Musa* Strategy from its development to now and background to the establishment of MusaNet – *Nicolas Roux*
09:45-10:00	DISCUSSION: Comments and questions on the global strategy and MusaNet
10:00-10:30	***Coffee/tea break***
	Session 3 – Global context and partnerships to support the implementation of the global strategy and funding opportunities
10:30-10:45	PRESENTATION: Critical links between the Global Strategy and the development of a CGIAR Research Programme on Roots, Tubers and Banana (CRP-RTB) on Banana – *Stephan Weise*
10:45-11:00	PRESENTATION: Review of scientific opportunities: what has been developed and may impact positively on the Strategy – *Jean Christophe Glaszmann*
11:00-11:40	PRESENTATIONS: *Musa* germplasm-related research priorities in: Brazil - *Janay Serejo* / Cameroon - *Emmanuel Fondi* / India - *Uma Subbarya* / Philippines - *Lavernee Gueco*
11:40-12:00	DISCUSSION: Global context and research priorities
12:00-14:00	***Lunch and Time for individual meetings, emails and urgent work issues***
14:00-14:15	PRESENTATION: Collective action challenges in the implementation of the Multilateral System of the International Treaty – *Sélim Louafi*
14:15-14:25	PRESENTATION: To serve and conserve: strengthening germplasm evaluation to focus on users' needs – *Theo van Hintum*
14:25-15:30	DISCUSSION***:*** Incentives and constraints in implementing the Multi-Lateral System of Germplasm exchange (MLS) and proposed solutions
15:30-16:00	***Coffee/tea break***
16:00-17:00	PANEL DISCUSSION: Analysis of the users and their needs of *Musa* genetic resources and associated information. The following panellists are to represent the following groups of users: 1. Farmers – (representing the on-farm conservation community) – *Deborah Karamura* / 2. Pathologists – *Gus Molina* / 3. Breeders – *Jim Lorenzen* / 4. Curators – *Maurice Wong* / 5. National Treaty Implementation – *H.P. Singh*
17:00-17:30	SMALL GROUP DISCUSSION: How to improve the strategy to strengthen the use of *Musa* genetic resources?
17:30-18:00	DISCUSSION: Group presentations and plenary discussion
18:30	**Cocktail reception at Agropolis International, ground floor**

DAY 2	**TUESDAY 1 March 2011**
08:30-09:00	Summary of Day 1 and issues for Day 2
	Session 4 - Theme 1: Genetic diversity, taxonomy and characterization
09:00-09:15	PRESENTATION: Diversity of the *Musa* genepool: coverage of *ex situ* collections and remaining gaps, advances and constraints - *Edmond De Langhe*
09:15-09:30	PRESENTATION: Morphological characterization descriptors: objectives, limits and appropriateness – *Jean-Pierre Horry*
09:30-09:45	PRESENTATION: Pl@ntNet: Plant Computational Identification and Collaborative Information – *Daniel Barthelemy*
09:45-10:00	DISCUSSION: Questions and comments on morphological characterization and the presentations
10:00-10:30	***Coffee/tea break***
10:30-10:45	PRESENTATION: Genetic integrity of the ITC collection: DArT genotyping – *Jean-Pierre Horry*
10:45-11:00	PRESENTATION: The *Musa* Genotyping Centre: strengthening the links between morphological and molecular characterization – *Jaroslav Dolezel*
11:00-11:15	PRESENTATION: The Genetic Resources Supply Services (GRSS) of the Generation Challenge Programme (GCP) of the CGIAR - Unlocking genetic diversity for improving food crop adaptation – *Jean Christophe Glaszmann*
11:15-12:00	DISCUSSION: Proposal for future directions with descriptors and a coordinated approach to characterization (*morphological and molecular*)
12:00-14:00	***Lunch and Time for individual meetings, emails and urgent work issues***
	Session 5 - Theme 2: Germplasm evaluation *(links to users)*
14:00-14:10	PRESENTATION: Germplasm evaluation - beyond characterization and advances and impact on molecular analysis **-** *Jim Lorenzen*
14:10-14:20	PRESENTATION: How the International *Musa* Testing Programme (IMTP) works and evaluation data produced and links with evaluation of germplasm collections - *Inge Van den Berg*
14:20-14:25	PRESENTATION: ProMusa - Mobilizing banana science for sustainable livelihoods: Goal and activities, links with MusaNet, knowledge sharing - *Inge Van den Berg*
14:25-14:35	PRESENTATION: *Fusarium* phenotyping: linking greenhouse screening to field evaluations and generating information for anticipatory breeding – *Miguel Dita*
14:35-14:45	PRESENTATION: Evaluation of quality traits: post harvest quality of edible banana (*Musa* sp.) – *Sébastien Ricci*
14:45-15:30	DISCUSSION: Germplasm evaluation and links to breeding
15:30-16:00	***Coffee/tea break***
	Session 6 - Theme 3: Germplasm Information and Utilization *(cross-cutting area across themes)*
16:00-16:45	PRESENTATION: *Musa* Germplasm Information System (MGIS) – *Max Ruas*
16:45-18:00	DISCUSSION: Comments and feedback on MGIS roles and functions.

DAY 3	**WEDNESDAY 2 March 2011**
08:30-09:00	Summary of Day 2 and issues for Day 3
	Session 7 - Theme 4: Conservation – towards a global partnership to conserve and use the *Musa* genepool (safeguarding the genetic diversity): *roles of international, regional and national collections.*
09:00-09:15	PRESENTATION: A global partnership for the conservation and use the Musa genepool – *Nicolas Roux*
09:15-09:30	PRESENTATION: Biological Resources Centres for Tropical Plants (CRB-PT): example of collaboration between institutions for the conservation of tropical plants collections – *Robert Domaingue*
09:30-09:45	PRESENTATION: The collection of the International Transit Centre (ITC): its mandate as a global public good (overview of its use, activities and impact) – *Ines Van den houwe*
09:45-10:00	PRESENTATION***:*** Safe movement of germplasm: possible roles for regional centres and a global centre in virus indexing – *John Thomas*
10:00-10:30	***Coffee/tea break***
10:30-11:00	GROUP DISCUSSION by REGIONS of roles of international, regional and national collections
11:00-12:00	GROUP REPORTS and DISUCSSION on regional and global partnerships
12:00-14:00	***Lunch and Time for individual meetings, emails and urgent work issues***
	Session 8 – Defining the major outputs and users' needs of the global strategy for conservation and use of *Musa* genetic resources
14:00-14:45	GROUP DISCUSSION by REGIONS on the major outputs of the global strategy
14:45-15:30	GROUP REPORTS and DISUCSSION: Define the Strategy's major outputs and scope of activities.
15:30-16:00	***Coffee/tea break***
	Session 9: MusaNet establishment as the "Expert Committee" responsible for implementing the Global Strategy
16:00-16:30	PRESENTATION: MusaNet proposed mode of operation – *Nicolas Roux*
16:30-18:00	SMALL GROUP and PLENARY DISCUSSION: Feedback on MusaNet's objectives and functions
19:45	**Social dinner – Le Pet au Diable restaurant, Departure from Heliotel at 19:45.**

DAY 4	**THURSDAY 3 March 2011**
08:30-09:00	Summary of Day 3 and issues for Day 4 and nomination of members of the Advisory Groups: • ADV GROUP: Genetic diversity gap filling, taxonomy and characterization • ADV GROUP: Germplasm evaluation • ADV GROUP: Germplasm information and documentation • ADV GROUP: Conservation – global partnership to conserve the *Musa* genepool and promote the safe exchange of materials
	Session 10: Meetings of the Advisory groups: to *further detail the Advisory Groups' workplans*
09:00-09:15	PLENARY: Introduction to the Working Group process – logistics and proposed agenda
09:15-10:00	ADVISORY GROUPS' WORK: The agreed thematic Advisory Groups to discuss in details proposed workplan and issues/concerns to resolve
10:00-10:30	***Coffee/tea break***
10:30-12:00	ADVISORY GROUPS' WORK: *continued*
12:00-14:00	***Lunch and Time for individual meetings, emails and urgent work issues***
	Session 10: Action plan for the Global *Musa* Strategy, MusaNet workplan (including monitoring of implementation) **and conclusions of the meeting**
14:00-16:00	PRESENTATIONS: Reports from the MusaNet Advisory Groups: workplans (who, what, when and how) • ADV GROUP 1: Genetic diversity gap filling, taxonomy and characterization • ADV GROUP 2: Germplasm evaluation • ADV GROUP 3: Germplasm information and documentation • ADV GROUP 4: Conservation – global partnership to conserve the *Musa* genepool and promote the safe exchange of materials
16:00-16:30	DISCUSSION: on proposed MusaNet workplans for the implementation of the Strategy and a plan for monitoring progress
16:30-17:00	***Coffee/tea break***
17:00-17:30	***Next steps:*** Immediate workplan following on from this meeting
17:30-18:00	Meeting evaluation and feedback and Closing of meeting by 18:00

Annex 2. List of participants and contact details

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Annex 3: List of background documents

	Document	Document
	MusaNet Strategic Meeting programme – dated 26 February 2011	Word file
2.	List of participants – dated 3 March 2011	Word file
3.	Global Conservation strategy for Banana (May 2006)	PDF file
4.	MusaNet – proposed structure – dated 25 February 2011	Word file
5.	Documents on the CRP-RTB Leaflet – *http://rtb-mp3.cgxchange.org/*	PDF file
6.	Full proposal for the CRP-RTB: *http://rtb-mp3.cgxchange.org/home/documents*	PDF file
7.	International Treaty: *http://www.planttreaty.org/texts_en.htm*	PDF file
8.	Technical Guidelines for the Multi-location Characterization of ITC Reference Accessions Date: 14 December 2010	PDF file
9.	Development and assessment of Diversity Arrays Technology for high-throughput DNA analyses in Musa, *Ange-Marie Risterucci, Isabelle Hippolyte , Xavier Perrier, Ling Xia, Vanessa Caig, Margaret Evers, Eric Huttner, Andrzej Kilian , Jean-Christophe Glaszmann*, 2009	PDF file
10.	Combining Biological Approaches to Shed Light on the Evolution of Edible Bananas, *Xavier Perrier, Frédéric Bakry, Françoise Carreel, Christophe Jenny, Jean-Pierre Horry, Vincent Lebot and Isabelle Hippolyte,* 2009	PDF file
11.	Excerpts from: Jones, D.R. 1994. The Improvement and Testing of Musa: a Global Partnership. Proceedings of the First Global Conference of the International Musa Testing Program held at FHIA, Honduras, 27-30 April 1994.	Word file
12.	The International Musa Testing Programme (IMTP)- IPGRI/INIBAP, Brigitte Laliberte, Suzanne Sharrock, Lyndsey Withers, Gisele, Orjeda, Emile Frison, 1999	PDF file
13.	The International Musa Testing Programme (IMTP) in the spotlight - Highlights from the survey	Word file
14.	IMTP reference documents	Word file
15.	The impact of the Musa International Transit Centre: Review of its services and cost-effectiveness, and recommendations for rationalization of its operations. *Hildegard Garming, Nicolas Roux and Ines Van den houwe*, 2010	PDF file
16.	Complied results of the feedback from the participants in the evaluation forms completed at the end of the meeting, 3 March	Word file

Annex 4: List of presentations made during the MusaNet workshop

1.	The Global *Musa* Strategy from its development to now and background to the establishment of MusaNet and proposed structure: what is MusaNet and how it may function – *Nicolas Roux*
2.	Critical links between the Global Strategy and the development of a CGIAR Research Programme on Roots, Tubers and Banana (CRP-RTB) on Banana – *Stephan Weise*
3.	Review of scientific opportunities: what has been developed and may impact positively on the Strategy – *Jean Christophe Glaszmann*
4.	*Musa* germplasm-related research priorities in India - *Uma Subbarya*
5.	*Musa* germplasm-related research priorities in Brazil - *Janay Serejo*
6.	*Musa* germplasm-related research priorities in Cameroon - *Emmanuel Fondi*
7.	*Musa* germplasm-related research priorities in Philippines - *Lavernee Gueco*
8.	Collective action challenges in the implementation of the Multilateral System of the International Treaty – *Sélim Louafi*
9.	To serve and conserve: strengthening germplasm evaluation to focus on users' needs – *Theo van Hintum*
10.	Diversity of the *Musa* genepool: coverage of *ex situ* collections and remaining gaps, advances and constraints - *Edmond De Langhe*
11.	Morphological characterization descriptors: objectives, limits and appropriateness – *Jean-Pierre Horry*
12.	Pl@ntNet platform and *Musa* as a test case - how could this approach respond to the needs of the *Musa* genetic resources community – *Daniel Barthelemy*
13.	Genetic integrity of the International Transit Centre (ITC) collection: field verification and reference collection – *Jean-Pierre Horry*
14.	The *Musa* Genotyping Centre: strengthening the links between morphological and molecular characterization – *Jaroslav Dolezel*
15.	The Genetic Resources Supply Services (GRSS) of the Generation Challenge Programme (GCP) - *Musa* genetic stocks including core and mini-core collections – *Jean Christophe Glaszmann*
16.	Germplasm evaluation - beyond characterization and advances and impact on molecular analysis **-** *Jim Lorenzen*
17.	How the International *Musa* Testing Programme (IMTP) works and evaluation data produced and links with evaluation of germplasm collections - *Inge Van den Berg*
18.	ProMusa, what it is and how it can complement the MusaNet community by providing links to breeders and other *Musa* genetic resources users - *Inge Van den Berg*
19.	*Fusarium* phenotyping: linking greenhouse screening to field evaluations and generating information for anticipatory breeding – *Miguel Dita*
20.	Evaluation of quality traits: post harvest – *Sébastien Ricci*
21.	*Musa* Germplasm Information System (MGIS) – *Max Ruas*
22.	Global conservation and use system proposed in the strategy – *Nicolas Roux*
23.	Biological Resources Centres for Tropical Plants (CRB-PT): example of collaboration between institutions for the conservation of tropical plants collections – *Robert Domaingue*
24.	The collection of the International Transit Centre (ITC): its mandate as a global public good (overview of its use, activities and impact) – *Ines Van den houwe*
25.	Safe movement of germplasm: possible roles for regional centres and a global centre in virus indexing – *John Thomas*

Annex 5: List of acronyms

ABS	*Access and benefit sharing*
AFLP	*Amplified fragment length polymorphism*
AG	*Advisory Group*
AMAP	*botAnique et bioInforMatique de l'Architecture des Plantes, Montpellier, France*
ARM	*GCP Annual Research Meeting*
BAPNET	*Banana Asia-Pacific Network*
BARNESA	*Banana Research Network for Eastern and Southern Africa*
BBrMV	*Banana Bract Mosaic Virus*
BBTV	*Banana Bunchy Top Virus*
BPI	*Bureau of Plant Industry of the Philippines*
BRC-TP	*Biological Resources Centre – Tropical Plants, France*
BSV	*Banana Streak Virus*
CARBAP	*Centre africain de recherches sur bananiers et plantains, Cameroun*
CATIE	*Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica*
CEMAC	*Commission de la Communauté Economique et Monétaire de l'Afrique Centrale*
CGIAR	*Consultative Group of International Agricultural Research Centres*
CGN	*Centre for Genetic Resources, The Netherlands*
CIRAD	*Centre de coopération internationale en recherche agronomique pour le développement, France*
CMV	*Cucumber Mosaic Virus (affecting banana)*
CORAF	*Conférence des responsables de la recherche agronomique africains et français*
CP	*Contracting Party of the ITPGRFA*
CRB-PT	*Biological Resources Centres for Tropical Plants*
CRP-RTB	*CGIAR Research Programme on Roots, Tubers and Banana*
CTA	*Technical Centre for Agricultural and Rural Cooperation, Wageningen, the Netherlands*
cvs	*Cultivars*
DArT	*Diversity Arrays Technology*
DEEDI	*Queensland Government, Department of Employment, Economic Development and Innovation - DEEDI*
DNA	*Deoxyribonucleic acid*
DURAS	*Promotion du développent durable dans les systèmes de recherché agricoles du sud*
EMBRAPA	*Empresa Brasileira de Pesquisa Agropecuaria*
EURISCO	*Web-based catalogue with information on ex situ plant collections maintained in Europe*
FAO	*Food and Agriculture Organization of the United Nations, Rome, Italy*
FAVRI	*Fruit and Vegetable Research Institute, Vietnam*
FHIA	*Fundacion Hondurena de Investigacion Agricola, Honduras*
FOC	*Fusarium Wilt - Fusarium oxysporum f. sp. cubense*
FSTP	*Food Security Thematic Programme*
GB	*Governing Body of the ITPGRFA*
GCP	*Generation Challenge Programme of the CGIAR*
GENESYS	*Global portal on plant genetic resources information*
GIPB	*Global Partnership Initiative for Plant Breeding Capacity Building*
GIS	*Geographical Information System*
GISH	*Genomic in situ hybridization d*
GMGC	*Global Musa Genomics Consortium*
GPA	*Global Plan of Action*
GPS	*Global Positioning System*
GRSS	*Genetic Resources Supply Services*
GXE	*Genetic and Environment*
ICAR	*Indian Council of Agricultural Research*
IDAO	*IDAO software: a Multimedia Approach to Computer Aided Identification*
IEB	*Institute of Experimental Botany*
IIHR	*Indian Institute of Horticultural Research*
IITA	*International Institute of Tropical Agriculture*
IKONA	*Ikona software: Malware Attack Prevention System*
IMTP	*International Musa Testing Programme*
INIBAP	*International Network for the Improvement of Banana and Plantain*

INRA	*Institut National de la Recherche Agronomique, France*
INRIA	*Institut national de recherche en informatique et en automatique, France*
IPB-CSC	*Institute of Plant Breeding – Crop Science Cluster*
IPGRI	*International Plant Genetic Resources Institute*
IPRs	*Intellectual Property Rights*
IRAZ	*Institut de recherche agronomique et zootechnique, Burundi*
IRD	*Institut de recherche pour le développement, France*
ISEM	*Immunosorbent electron microscopy*
ISHS	*International Society for Horticultural Sciences*
ISO	*ISO 9001 certification (2012)*
ISSG-GISP	*Invasive Species Specialist Group of IUCN*
ITC	*International Transit Centre, Belgium*
ITPGRFA	*International Treaty for Plant Genetic Resources for Food and Agriculture*
ITS	*Internal Transcribed Spacer*
IUCN	*International Union for Conservation of Nature, Switzerland*
KUL	*Katholieke Universiteit Leuven, Belgium*
LTS	*Long-term storage*
MC	*Misclassified*
MGBMS	*Musa Gene bank Management System of the ITC collection*
MGIS	*Musa Germplasm Information System*
MGR	*Musa Genetic Resources*
ML	*Mislabbelling*
MLS	*Multilateral System of Exchange*
MOS	*Most original sample*
MT	*Metric ton*
MTS	*Medium-term storage*
MUSACO	*Réseau Musa pour l'Afrique Centrale et Occidental*
MusaLac	*Plantain and Banana Research and Development Network for Latin America and the Caribbean*
MusaNet	*Network for the conservation and use of Musa genetic resources*
NARS	*National Agricultural Research System*
NBPGR	*National Bureau of Plant Genetic Resources, India*
NEPs	*National Evaluation Programmes*
NRCB	*National Research Center for Banana, India*
NRMDCs	*National Repository, Multiplication and Dissemination Centers*
OT	*Off-type*
PCR	*Polymerase chain reaction*
PGRFA	*Plant Genetic Resources for Food and Agriculture*
Pl@ntNet	*Identification interactive des plantes et système d'information collaboratif, France*
PNG	*Papua New Guinea*
RFLP	*Restriction fragment length polymorphism*
SEBA	*International Society for Horticultural Science (ISHS) – section on banana*
SINGER	*CGIAR System-wide Information Network for Genetic Resources*
SMTA	*Standard Material Agreement of the ITPGRFA*
SNPs	*Single nucleotide polymorphisms*
SRF	*Strategy and Results Framework*
TAG	*Taxonomy Advisory Group*
TARGET	*Technology Applications for Rural Growth and Economic Transformation, a project of CARBAP*
TNAU	*Tamil Nadu Agricultural University, India*
TropGeneDB	*Information system for genetic, molecular and phenotypic data of tropical crop species*
Trust	*Global Crop Diversity Trust, Rome, Italy*
TTT	*True to type*
UPLB	*University of the Philippines Los Baños*
USDA	*United States Department of Agriculture*
VIC	*Virus indexing centre*

Annex 6. Hierarchical system – proposed by Edmond De Langhe

Note: presentation made during the Working Group 1 on Diversity gap filling, taxonomy and characterisation – Thursday 3 March am.

Group Identification

	Descriptor	List	*wildAA*	*wildBB*	Score
Simmonds-Shepherd					
1	Pseudostem colour	6.3.1	2,3,4	1, (5)	
2	Petiole canal	6.3.3	1,2,3	4,5	
3	Peduncle	**6.4.5**	2,3,4	1	
4	Pedicel length	6.7.8	1	3	
5	Ovules	**6.6.26**	1	2	
6	Male Bud shoulder and shape (ex 6.4.15)	6.4.16	1-4	5,6	
7	Bract apex	6.5.2	1,2,3	4,5	
8	Bract outside colour	**6.4.5**	1-4, 6-9	5	
9	Bract inside colour	6.5.5	1-4, 6,7	5	
10	Inside Colour fading towards the base	**6.5.9**	1	2	
11	Bract scars (crowns)	**6.5.8**	1	2	
12	Free tepal corrugation below tip	**6.6.8**	1,3	2	
13	Male flower colour	6.6.24	1,2	4,5	
14	Stigma colour	**6.6.20**	3,4,5	1,2	
Additional					
15	Petiole margins	6.3.4	1,2,3	4,5	
16	Petiole margin colour	6.3.6	**2**,3	1	
17	Petiole rim	6.3.7	1, 2 red/pink	2 black	
18	Bract imbrication	6.5.3	1,2,(3)	(3), 4	
19	Compound tepal colour	6.6.2	1,2, (3?)	5	
20	Free tepal	**6.6.6**	1,2,3	4	
21	Fruit Shape	6.7.4	1-4	1, but plump	
22	**Pedicel fusion**	6.7.11	1	3	

Only three scores for each descriptor:

- "1" = *Acuminata*
- "5" = *Balbisiana*
- "3" = any intermediary state and cases of hesitation

The possible sum of the 22 scores = 22 – 110

- 22-27 = AA/AAA
- 39-49 = AAB
- 61-71 = AB
- 83-93 = ABB
- 105-110 = BBB

Tested in Oman to a popular cultivar, called 'Abu Barak' or "Negal' with strong resemblance to the Indian "Ney Mannan" (ABB).→ 84

Further testing should settle the range extents (e.g. AA/AAA could be 22-32 etc) but large 'voids' between ranges would remain

Subgroup Identification - example AAB

Compound tepal white (6.6.2.1), with variable pink pigmentation (6.6.3.3),

- yellow or orange-yellow lobes (6.6.4.2; 6.6.4.3), bracts and neutral/male flowers
- deciduous (6.4.13.1), (6.6.1.1-3)
- Midribs of younger leaves pinkish purple (6.3.20.4).....**Mysore**
- Midribs green (6.3.20.3)
  Fruit apex blunt (6.7.6.3).....**Maia maoli/Popoulu**
- Fruit bottle-necked (6.7.6.4),
- Mature pulp white (6.7.19.1), mature fruit drops (6.7.20.2).....**Silk**
- Mature pulp creamy (6.7.19.2), fruit persistant (6.7.20.1).....**Pome**

Compound tepal faintly yellow or orange (6.6.2.2,3), no pigment.(6.6.3.1),

- rich-yellow or orange-yellow lobes (6.6.4.2; 6.6.4.3)
- Bracts and neutral/male flowers deciduous (6.4.13.1), (6.6.1.1-3).....**Pisang kelat**
- Bracts and neutral/male flowers persistent (6.4.13.4) (6.6.1.4)
- Mature pulp (flesh) sweet (6.7.22.5).....**Pisang radja**
- Mature pulp (flesh) unpalatable when raw (6.7.22.6)
- Male bud normal (present till near-maturity) (6.4.14.1).....**French Plantain**
- Male bud degenerating well before maturity (6.4.14.2).....**False-horn Plantain**
- Male bud (and rachis) absent (6.4.14.3).....**Horn Plantain**

Note: AAB Iholena not yet inserted.

Cultivar identification - example Maoli-Popoulu (essay Kepler- De Langhe)

1. Compound tepal of male flower: rich yellow, infused with pink-purple on both inner & outer faces. Male bud: at fruit maturity not exhausted. Plant stature: > 40 functional leaves. Fruit: 'sausage-like' but never bulging, 3-4 times longer than wide, with moderate floral scar on rounded apex.

11. Free tepal colourless to pale pink; ovary white + variable amounts of scant pink

111. Fruit pedicel 2-5 cm

1111. Leaf sheath green + minor black blotches..... **Maoli**

1112. Leaf sheath green + large black blotches ..... **Ele'ele Hinupu'a**

1113. Leaf sheath discontinuous black; very waxy ..... **'Ele'ele/Puna**

1114. Leaf sheath continuous black..... **Ele'ele Polua**

1115. Leaf sheath faint to pronounced pink, petiole margins red;

11151. Fruit peel on emergence green ..... **'Ele'ele "Pale"**

11152. Fruit peel on emergence pink-brown, lasting 1-2 days ..... **'Eka**

11153. Fruit peel on emergence pink-brown, lasting 3-4 weeks. **Mānai-'ula**

1116. Leaf sheath and petiole red/burgundy + black..... **'Ele'ele Poni**

1117. Leaf sheath, petiole and fruit peel longitudinally variegated green/white..... **Manini**

112. Fruit pedicel < 0.5cm; imm. fruits twisted, long and narrow..... **Puhi**

12. Free tepal deep rose; ovary greenish-white without any pink

121. Bunch & fruit very large, cylindrical; all fruits evenly oriented upwards, top hand slightly obliquely oriented ..... **Ha'i**

122. Bunch medium sized, irregularly cylindrical; fruits of first hands obliquely oriented

1221. Pseudostem normal stature..... **Kaualau**

1222. Pseudostem shows dwarfism..... **Dwarf Kaualau**

2. Compound tepal of male flower pale yellow, pale red stripes on inner face, margins white. Male bud, Plant stature and Fruit = (1) but fruits may twist significantly .....**Honomanu**

3. Compound tepal of male flower pale yellow, + broad red margins outside and red or pale red coloration on inner face.

Male bud: exhausted well after fruit maturity only. Plant stature: = (1). Fruit: shorter & fatter than (1); bulging trend, over inflated squared-off tips, and relatively large scar;

31. Fruit short (9 x 4.5 cm; ca twice as long as wide)..... .....**Pū-lena**

32. Fruit long (17 x 6 cm; ca three times as long as wide) .....**'Eke-'ula**

4. Compound tepal of male flower pale yellow, with narrow faint-red margins outside and no appreciable colour on inner face.

Male bud exhausted before fruit maturity; pseudo-terminal flower frequently visible.

Plant stature: Medium, 34-36 functional leaves.

Fruit of different length but always bulging, with large floral scar on a rather flat apex

41. Petiole and leaf sheath green without any trace of pink.

411. Male bud exhausted ca. 2 months after flowering. Fruits large but not wide (13 x 4.5 cm) ....**Popo'ulu**

412. Male bud exhausted ca. 1 month after flowering. Fruits large and very wide (12 up to 22 x 5-7 cm)

4121. Ripe fruit peel paper-thin (< 1.2 mm)..... .....**Lahi**

4122. Ripe fruit peel not paper-thin (> 1.6 mm)..... .....**Huamoa**

42. Petiole and leaf sheath basic colour bright lime green, with pinkish petiole margin.

421. Fruits small (3.5-13 x 5 cm). Faint pinkish tinge on petiole and leaf sheath ....**Ka'io**

422. Fruits large and wide (10-18.5 x 6.5).

4221. Pinkish tinge on petiole and leaf sheath pronounced, esp. when young..... .....**Putalinga Hina**

4222. Petiole and leaf sheath prominently pink-red

42221. Normal stature.....**Putalinga Kula**

42222. Dwarf stature.....**Putalinga Nounou**