MusaNet/Trust joint meeting report

Effective Use of Genetic Diversity for Addressing Emerging Challenges in Banana and Plantain Breeding

Bogor, Indonesia 9-13 July 2012

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Background

The **MusaNet/Trust** joint meeting held in Bogor, Indonesia, on the 9-13 July 2012 enabled 26 *Musa* experts to consider the **Effective Use of Genetic Diversity for Addressing Emerging Challenges in Banana and Plantain Breeding**.

Launched in March 2011, the **Global Musa Genetic Resources Network**, (**MusaNet),** aims at providing a global collaborative framework to cooperatively ensure the long-term conservation and increased use of *Musa* genetic resources through the implementation of the Global Strategy for the Conservation and Use of *Musa* Genetic Resources. MusaNet is composed of 4 Thematic Groups focusing on Diversity, Conservation, Evaluation and Information respectively.

The **Global Initiative on Crop Wild Relatives** (CWRs) for 26 target crops, including *Musa*, is managed by the **Global Crop Diversity Trust** (the **Trust)** and aims, at identifying, collecting, conserving, documenting and using key crop wild relative diversity for climate change adaptation in developing countries.

The **MusaNet/Trust** joint meeting provided the first opportunity for MusaNet members to meet since the 2011 MusaNet launch. Twenty-six taxonomists, breeders, curators and *Musa* geneticists, mainly from the Diversity Thematic Group, and including non-MusaNet members, had the opportunity to work and brainstorm together.

The expected outputs of the meeting were:

- Clear understanding the current breeding approaches and the input of wild taxa and edible diploids (EDs) in pre-breeding
- Definition of the genepools of CWRs and EDs for use in breeding
- Assessment of the genetic diversity of the targeted wild *Musa* taxa and EDs (in *ex situ* collections and gaps identification)
- Agreement on collecting priorities (species and geographical areas) and methodologies
- Prioritized actions in the MusaNet Diversity Thematic Group (DTG) workplan

The present document reports discussions, ideas, and conclusions that emerged from 4 days of intense work divided in 11 sessions. Its goal is to provide the *Musa* research community with a concise, clear and comprehensive report that can be used as a basis for further work.

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DAY 1: Monday 9 July: WHAT NEEDS TO BE ACHIEVED? – Breeding Objectives in view of future challenges (including climate change)

TOPIC 1: Current breeding and pre-breeding objectives and methodologies in *Musa* – key participants report on their experiences, accomplishment, challenges and perspectives on the use of Musa CWRs:

Three Introductory Presentations:

- *Banana Breeding - objectives, techniques, constraints, opportunities* by Jim Lorenzen,
- *Strategies for improvement for banana and plantains* by Uma Subarraya,
- *Combining crop wild relatives and edible varieties to enhance diversity in banana improvement* by Frédéric Bakry

Worldwide *Musa* edible triploid genetic diversity is very limited as it likely ensues from 20 to 25 meiosis events (1 or 2 only in Africa) among which some share at least one parent. *Musa* thus exhibits a very **narrow genetic base** and is a very **fragile** crop while there is a **huge underutilized diversity** within CWRs.

All *Musa* breeding programs are subject to the same **numerous constraints** that are mainly linked to the biology of the crop: low female fertility, low seed viability, polyploid nature of cultivated accessions, poor quality of seedlings, and the possibility of few recombinations .

Different breeding strategies are possible, including or excluding CWRs. Here we focus on the proposed pre-breeding strategies involving CWRs:

i) to develop 3 recurrent populations ensuing from **CWRs pooled by genome structure**,
ii) to create improved diploids from **crosses between cultivars and CWRs** for further use in classical breeding
iii) to apply **chromosome-doubling** for use in crosses to obtain triploids
iv) to **cross triploids ABB and CWRs (AA)** holding selected trait to obtain promising 3X progeny.

Plenary discussion: Major three traits for each country:

India: Fusarium wilt, Sigatoka, drought
Indonesia: Fusarium wilt, Moko, BBTV
Malaysia: Fusarium wilt, Moko, yield
Philippines: BBTV, dwarfism and earliness (for Saba), Fusarium wilt
Thailand: Fusarium wilt, BBTV
Australia: Sigatoka, Fusarium wilt, high yielding
Brazil: Fusarium wilt (preventive), drought tolerance, cold tolerance
French West Indies: Fusarium wilt, Sigatoka, nematodes, productivity, shelf life and quality
West Africa: Fusarium wilt, Sigatoka, quality, weevil, productivity
East Africa: weevil, nematodes, Fusarium wilt, Sigatoka, BBTV, BXW, drought but priorities differ between low and highlands
Hawaii: BBTV, market quality, novel aspects
Pacific (Fe'i bananas): lack of information
China: Fusarium wilt, BBTV, Sigatoka, cold
PNG: threats to the farming system, blood disease, Fusarium wilt
Vietnam: Fusarium wilt, cold, BBTV

North Africa: cold, drought, fruit quality, salinity

Table 1: Priority traits by countries or regions. Traits in orange were quoted as first priority.

	Priority	West Africa	North Africa	East Africa	India	China	Thailand	Vietnam	Malaysia	Philippines	Indonesia	PNG	Australia	Pacific (Fe'i bananas)	Hawaii	French West Indies	Brazil	frequency	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
1	Fusarium wilt	1		1	1	1	1	1	1	1	1	1	1			1	1	13	81.25
2	BBTV			1		1	1	1		1	1				1			7	43.75
3	Sigatoka	1			1	1							1			1		5	31.25
4	Moko/blood disease			1					1		1	1						4	25
4	drought tolerance		1	1	1												1	4	25
4	cold tolerance		1			1		1									1	4	25
4	higher yield	1							1				1			1		4	25
8	fruit quality		1												1	1		3	18.75
9	nematodes			1												1		2	12.5
9	Weevils	1		1														2	12.5
11	BXW			1														1	6.25
11	salt tolerance		1															1	6.25
11	earliness									1								1	6.25
11	dwarfism									1								1	6.25
11	shelf-life															1		1	6.25
11	novel aspects														1			1	6.25
11	threats to farming system											1						1	6.25
11	lack of information													1				1	6.25
	total	4	4	7	3	4	2	3	3	4	3	3	3	1	3	6	3		

Important to note: Think **quality** (adaptation to local needs and tastes) before breeding for tolerance to disease.

Additional topic raised but not answered: What are the requirements in the frame of **functional cropping systems**? Think to **varieties mixture**.

Topic 2: Climate Change (CC) and breeding objectives in Musa

Introductory Presentation:

Challenges to banana production under climate change by Julian Ramirez and Andy Jarvis, presented by Hannes Dempewolf

For *Musa*, and with regard to **heat increase**, CC predicting models anticipate major changes in **Central Africa** where the *Musa* suitability index (i.e. Musa agricultural potential) should undergo a dramatic decrease within the next 30 years. Additionally, authors think that the models likely **under-estimate** the effect of **drought**, especially for **Africa**. A tool has been developed that allows the search of sites currently exhibiting climate similar to the predicted one for a given place (Climate Analogues http://gismap.ciat.cgiar.org/analogues) and from which **adaptation strategies** could be **articulated**.

Discussion following the presentation:

As we do not know which of the models will be the real one, breeding programs in preparation for CC should target **broadly adaptable material**, with emphasis on pests and diseases resistance and/or tolerance.

Group discussions:

1-Which traits should breeding and pre-breeding efforts focus on in the context of CC?

- Wind resistance: shorter plants and strong root system for a better anchorage
- Drought: shorter cycles, early fruiting (avoid drought period)
- Drought: survival (tolerance/resistance), e.g. bigger corms
- Drought: salinity tolerance
- Plasticity regarding variation in rainfalls: succession of drought/flooding

2- What are the desired end-products of pre-breeding in *Musa*?

- Diploid populations well characterized and evaluated (genetic association studies)
- Populations of *Musa* wild relatives
- Broader allele base for specific traits
- Knowledge on the genetics of specific traits

3- What is the role of evaluation and characterization in the context of CC?

- Provide information to enable the selection of right parents
- Ability to select tolerant genotypes
- Need to focus on phenotyping (i.e. the collection of traits specific data across the genebanks involved in evaluation programs)

4- What are the main incentives and obstacles for an increased use of genetic resources in *Musa* breeding and pre-breeding and how can we overcome them?

Obstacles:

- Lack of diploid populations/ lines
- Lack of diversity and difficulty to access it (especially CWRs)
- Lack of knowledge (e.g. ecology of CWRs populations)
- Lack of knowledge on performance in the natural habitats
- Insufficient fundings

How can we overcome them?

- Get support for long-term *Musa* breeding program
- Encourage a broader international collaboration
- Get support from governments (developing countries)
- Select hotspots of primary centre of diversity and collect, study and use this diversity

5- Which strategy?

- A priority-based strategy
- Identify and evaluate wild genetic resources and cross with Edible Diploids
- Locate places to collect new wild species
- Develop segregating populations (diploids) for specific traits

Plenary discussion:

It was emphasized that wild species need to be collected and evaluated before they **disappear**. They should also be studied in all their **different range of habitats**. This should allow avoiding gaps in the diversity collected and facilitating selection for specific traits.

Topic 3: Identification of priorities for Musa pre-breeding and breeding (including CC)

Introductory Presentation:

- *Banana breeding program in EMBRAPA Cassava and Fruits* by Edson Perito Amorim,
- *Identification of priorities for Musa pre-breeding and breeding (including CC)* by Rony Swennen.

In Brazil, priority traits for breeding, apart from fruit quality, are reduced plant height, drought tolerance (early flowering, strong root system, salinity resistance) and pests (nematode) and disease (Yellow and Black Sigatoka, Panama disease) resistance. As the plant-disease/pests complex also includes environmental conditions, **priority traits should not necessarily be addressed separately**. For example, a strategy would be to develop root-branching as this enhances tolerance to drought and also reduces the impact of nematodes. Specifically for drought tolerance but also more generally, **linking laboratory and field characterization and evaluation** is required. As an example, it was emphasized that standard breeding program duration, from parental selection to final product evaluation, was 13 years but that the use of molecular tools allows its reduction to 7 or 8 years. A complementary approach would be to **prospect target areas** with specific climatic and soil conditions to collect multi-adapted local germplasm. Finally, the community should keep in mind that the **"banana ideotype" depends on the targeted farming system**.

Group discussions:

Audience was divided into three groups. Two devoted to dessert banana and one devoted to cooking banana.

It was emphasized that in breeding, **fruit quality** (texture, colour, peel quality) is the prevailing characteristic. Apart from this, priority traits for breeding are linked to **pest and disease resistance**. In addition of these traits and in the context of CC**, drought**, **flooding** and **wind resistance** are high priorities. The problem of breeding AAB was also raised: BSV is incorporated to every single B genome available for the *Musa* community and there is a real **need for virus-free *M. balbisiana***.

DAY 2: Tuesday 10 July: WHAT WE HAVE (materials and information) – Assessment of the current diversity

Topic 4: Description of Musa diversity

Three Introductory Presentations:

- *Musa acuminata, subspecies* and edible diploids by Edmond de Langhe,
- *The origins of edible triploids* by Julie Sardos
- *Musa wild relatives* by Hugo Volkaert.

Subspecies boundaries and intra-subspecies diversity are hardly known in many cases, and even some subspecies have not been duly described and classified. Given their direct role in the generation of the triploids, the edible AA should be considered as primary genetic sources. There is urgent need for classification of the edible AA through a combination of phenotypical and molecular techniques.
Features related to ***Musa* domestication** are presented in figure 1.

Multiple gaps: material, knowledge, taxonomy, representativeness

Very few compared to total wild but multiple parthenocarpy (sterility) events, not all identified

S.E. Asia + Melanesia => hotspots; wide variation that might have partially arose from mutations fixation, wide diffusion by human, cryptic sexual mating in some if not all

Originating from few sexual events, mostly among edible diploids (but not exclusively), some parents common to several clonesets => narrow genetic base, wide diffusion by human

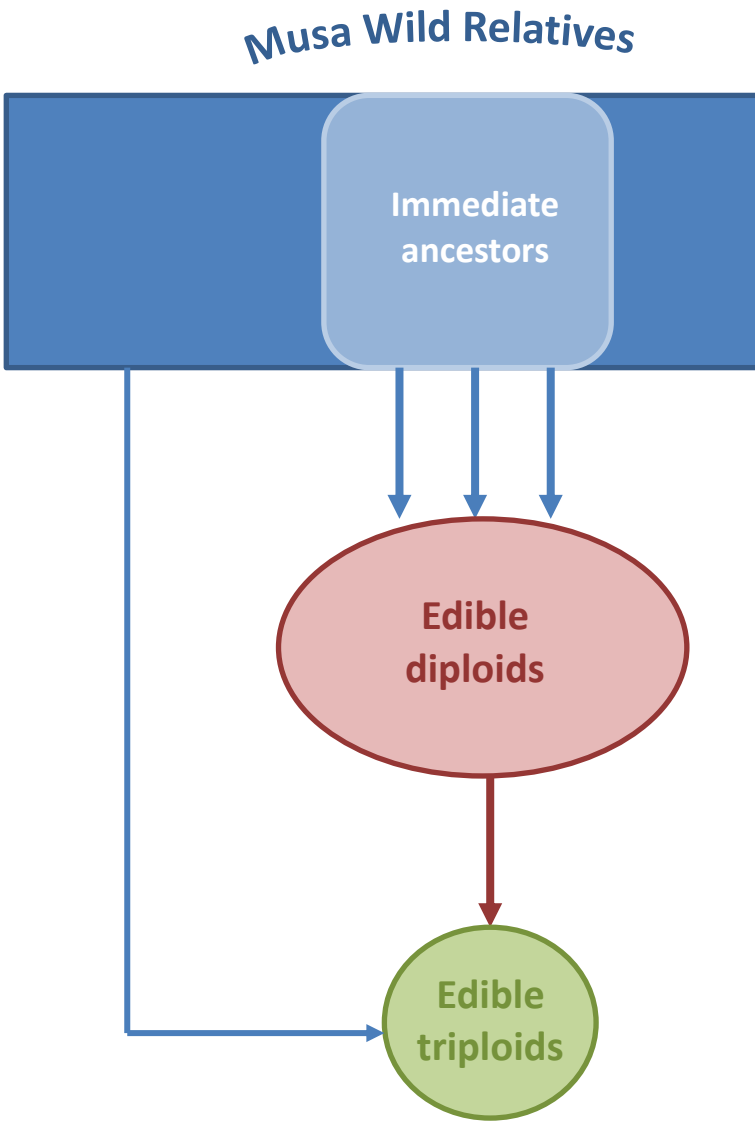

Figure 1: Schematic representation of domestication in *Musa*

If the **distribution areas** of *M. acuminata* subspecies do not overlap, as it is commonly presumed, and since most edible AA seem to be subspecific hybrids, natural hybridizations would have been caused by moving/interacting human populations bringing different subspecies in a same region, due to interest in the wild plants (for fibres e.g.). However, an alternative scheme was raised, which would include wider distribution areas with overlapping zones where admixture, i.e. interbreeding of individuals belonging to two or more different genetic clusters, between *M. acuminata* subspecies could occur. In the same rationale, the distribution area of *M. balbisiana* could be much wider. These issues are important to investigate as the effective distribution areas of *Musa* wild relatives would impact i) our **understanding** of ***Musa* domestication**'s space and time frame, ii) **taxonomic** investigations and iii) future **collecting missions**.

Discussion related to the presentations:

If edible diploids (EDs) are to be considered as the primary genetic resources for triploids, why are we seeking CWRs? Because ***Musa* wild species** have a **broader genetic base** than cultivated ones and that **important traits** can be introduced from wild to cultivated *Musa*. However, to characterize *Musa* diversity is not enough, **evolutionary history** and **plant/human interactions** are also to be considered.

Group discussion: What part of diversity is of particular value for breeding (to identify what we have and what is needed)

Regarding CWRs, a **short-term strategy** would focus on ***M. acuminata malaccensis*** derived AA cultivars and **e-BSV free *M. balbisiana*** while a **long-term strategy** would also include non-*M. acuminata* and non-*M. balbisiana* species in the **Eumusa** and **Rhodochlamys** sections, and why not beyond (e.g. sections **Australimusa** and **Callimusa**). The **CWRs** should be **screened** for disease **resistance** along with **parthenocarpy** and **sterility** alleles. However, **edible** diploids and triploids should also be explored for **food quality** and **good agronomic traits** such as disease resistance, or higher yield. Available passport data and **local knowledge** should be examined.

In genebanks, **at least 25 individuals** of each *M. acuminata* subspecies from a wide geographic range are needed. Regarding the **access to genetic resources**, donors of original germplasm should be rewarded and recognised whenever germplasm is used and quoted in research articles. This could be done through an easiest access to improved germplasm.

Plenary discussion: What research is needed to urgently fill in the gaps in knowledge on the part of most value for breeding?

Geno-geography was proposed. Molecular approach for taxonomic issues might be easier than classical morphological studies as phenotypic variation is too wide and complex to address easily. However, it is important to keep in mind that **molecular markers** used currently have limitations. For example, they **CAN** assign accessions to a group and/or subgroup but **CAN'T** resolve the ID redundancy problem, as differences between phenotypes may not show up in genotypes.

Some questions regarding **CWRs evaluation** were raised: should it occur *in-situ* or *ex-situ*? It was noted that wild accessions' behaviour could change in collection conditions. Should it be done before using them as parents for breeding or should only **progenies** be evaluated? Probably both.

A curator is not a breeder and material maintained in collection, in a diversity purpose, might not be optimum for a breeder in comparison of what might be used on-farm. The contrary is also true.

It was noted that generally **managerial continuity** of *ex-situ* collections is not maintained. New curators should thus be trained for related skills and classification exercise, including morphological description using the international Standard Descriptors.

The last words were made under the form of a non-answered question which requires further consideration: As breeders are under time restraints, how to achieve long-term goals?

Topic 5.a: What is conserved and accessible today?

Introductory presentation:

Available data on ex-situ collections and International Transit Centre by Julie Sardos

In the ITC, *Musa* CWRs represent about 15% of the total number of accessions but **10 taxa are not represented** at all and out of those represented, **82.5% are represented by less than 10 accessions**. It was highlighted that **CWRs** were **not represented** in almost **half** of the field collections surveyed in 2007 (19 out of 40). Additionally, **75%** of the total CWRs were conserved in **6** field collections only. Furthermore, it is not yet possible to identify duplicates between collections. Regarding the clonal nature of *Musa* CWRs maintenance ex-situ, the global **representation of CWRs** in field *ex-situ* collections is here more than likely **over-estimated**.

Plenary discussions: Farmers' practices regarding Musa diversity

It was reported that in some cases, farmers' were **pooling slightly different accessions** under the same name. For example, in India, slight differences in the colour of the fruit peel were reported within the same "landrace". However, **fruit quality and properties** were identical. It was also noted that phenotypic variation within landraces might be due to **phenotypic plasticity** regarding environmental conditions.

Concerning the definition of "landraces": It was argued that this term was referring to populations that were genetically dynamic and that it thus could not be applied to clonal crops. However, it was noted that the term is widely used for other clonal crops such as cassava or sweet potato. It should be realized that, in contrast with the edible bananas, these clones regularly produce attractive seedlings in the field, so that the selected offsprings constitute 'new' populations which are cloned further by many farmers. Nevertheless, and acknowledging that a funding proposal from the Trust targeting the collecting of priority crops' "landraces" (including *Musa*) was recently emitted, we suggest that the *Musa* community follows this trend. In our specific context, the following definition is probably more accurate: landrace is "a group of plants given the same name by farmers".

Plenary discussion: Do you think that the diversity maintained in National Collections is actually representative of the overall diversity portfolio maintained on-farm in your countries?

The answer to this question is globally **no**. The reasons mentioned were i) huge size of countries along with high cultural diversity and lack of **ecologically stratified** germplasm collecting mission, ii) **purpose of existing collections** that are devoted to research or breeding, not to diversity conservation and iii) the **absence of exhaustive national lists** of existing varieties. CWRs were also mentioned. There, the answer was also no. The main reasons evoked were i) the lack of **systematic prospection** and ii) collecting missions *modus operandi* where only individuals located **nearby roadsides and pathways** are collected.

The possibility of creating **national registries of landraces** was raised. However, **homonymy/synonymy** issues are likely to be extremely complex and therefore difficult to resolve in many countries.

The conclusion of this session was done under the form of a statement: If *Musa* germplasm conservation is not a national priority then it should perhaps be an **international priority**.

Topic 5.b: Sampling methodology for collecting missions

Introductory presentation:

From collecting missions to collections and back – disparity and gaps revealed by GIS mapping by Julie Sardos

Germplasm collected during **past collecting missions** is currently being **GIS mapped**. It was the opportunity to highlight two important types of issues to fix. The first one is the **quality of the data** collected along with the germplasm: exact collecting locations are sometimes not well documented (not at all sometimes) and status of accessions, i.e. wild or cultivated, is often not well reported. Additionally, the **use of the term "wild" appears sometimes erroneous** as quite often **seeded cultivated** accessions are registered as "wild" even when collected within home-gardens. The second issue raised is the **traceability of accessions** from the collecting missions to *ex-situ* collections. Out of the 1487 cultivated accessions collected in the field and mapped, only one third has been tracked back to *ex-situ* collections. For now we are not able to determine whether the remaining two thirds of these accessions is lost or not.

Group discussion:

Delegates were split into 4 groups, 2 being devoted to CWRs and 2 being devoted to cultivated *Musa*.

First point to be addressed: Which sampling strategy for collecting mission?

WILD

Both groups agreed on the necessity of collecting **seeds** in addition to **suckers**. However, discrepancy arose on the number of seeds to be collected: 2000 and 10000 were proposed. The **seeds should be sampled from the whole population** rather than from a small amount of individuals. Regarding **sucker sampling**, two approaches were proposed within a given population**: random sampling** or **sampling of selected individuals** exhibiting interesting characteristics. For both groups, **leaf sampling** for DNA extraction was required. In this case, **systematic grid sampling** of population for population genetics was proposed.

CULTIVATED

Emphasis on the **purpose of collecting**: collecting for diversity and collecting for breeding would imply **different sampling strategies**. In the case of collecting for breeding, the traits to focus on would be low height, bunch shape, number of fruits, resistance to diseases, or diploidy If collecting for diversity purposes, the methodology should focus within each village for **systematic leaf-sampling** for DNA extraction and **rationalized sucker-sampling** for conservation.

Second point to be addressed: Towards the revision of the collecting form for banana Musa spp.

WILD

Passport data to document in the case of CWRs are: **photos** of specific characters, **herbarium specimens**, descriptors used in the current form might be not sufficient, **separate forms according to**

the section considered were proposed and the "bunch weight" question should be removed, **vernacular names** of wild specimen should also be recorded along with the **local knowledge** associated.

CULTIVATED

It was proposed to develop an **electronic form** linked to **MGIS** to directly **rationalize the sampling** and avoid redundancy in collections. This last point could also be addressed by integrating a **taxonomist specialized in local *Musa* genetic resources** into the collecting team. Both groups agreed that **pictures** should be used rather than descriptors (see guidelines in Annex 5) mainly because it might be difficult to obtain plants at the good stage of development. The **season** on which the sampling occurs should also be documented. Additionally, a **short socio-economic description** of the village should be provided (e.g. accessibility or distance from important road and urban centres). A number of **open questions** should be asked to farmers and **genders should be separated** for interviews: Has the variety always been there? Is there anything special about this accession? Are you using some other parts than fruits? The **frequency of planting**, e.g. commonly, normally or marginally planted in the village, of the variety should also be reported.

DAY 4: Thursday 12 July: WHAT IS MISSING and HOW TO GET IT (materials and information) – Gap filling and priority collecting

Topic 6: Gap analysis

Introductory presentation

Progress on gap analysis for Musa crop wild relatives prepared by Nora Castaneda and presented by Hannes Dempewolf.

The principle of **gap analysis** is to **compare reports** on the **effective presence** of CWRs, mainly as herbarium specimens, and **germplasm held in collections**. By **georeferencing** herbarium specimens and collecting sites of conserved accessions, it is then possible to address the **representativeness of the material held in collections and to identify geographical locations** where **CWRs are under-represented** in collections. At least 20 occurrence records with coordinates are required for building a robust spatial distribution model. For *Musa* many difficulties arose. First, very **few herbarium specimens** are available and reports should also include a collecting missions' review. Then, the **geographical origin** of most of the **accessions conserved *ex-situ*** is not precisely known. However and for now, the *Musa* taxa analyzed tend to display less germplasm accessions in collections than herbarium specimens.

Plenary discussion:

To address these issues, review of published literature could be useful along with a **deeper on-line search**. However, it is probable that **not all the data** gathered are **published** and **available**. Efforts should be made to gather this unpublished information. A distribution model needs to be built for each taxon, and for Musa, the taxon should correspond at the **species level**. As there are many discrepancies and uncertainty in *Musa* taxonomy, there is **a real need for more research**. As classical

taxonomy is based on morphological characters, a combination with **molecular approach** might be more relevant to address these specific problems.

Topic 7: Needs of the collection managers – diversity and knowledge

Plenary discussion on the following three points.

Point 1: What are the needs of national collections in terms of diversity and knowledge?

Presentations:

Impact of the Musa International Transit Center (ITC), Belgium by Rony Swennen

The ***Musa*** **International Transit Centre** (**ITC**) was established in **1985** under the auspices of FAO and ITGPRFA. Its primary purpose is to **facilitate the international exchange of *Musa* germplasm**. ITC works in **collaboration** with **national and regional genebanks** and is linked to **global information systems** (**MGIS** and **GENESIS**). Accessions are conserved **in-vitro** and **cryoconservation** is also being developed. ITC is currently the **largest *Musa* collection worldwide** from which around **40% is available for distribution**. **In-vitro plants** are multiplied upon request and **distributed free of charge**. Since its creation, ITC has supplied 8353 samples to institutions located in 103 different countries.

Plenary discussion:

It was emphasized that **donor institutions** have the **responsibility for the morphological characterization** of the material shipped to ITC. The possibility of **conserving seeds** at ITC was discussed. This decision should be taken by the *Musa* community rather than ITC alone. Additionally, **technical issues,** as storage and germination conditions, still have to be resolved and a **conservation strategy** has to be developed. Another issue was raised: **will ITC have the funding capacity** to conserve and distribute more than currently done?

Presentation:

Musa genetic resources conservation network in India – Advantages and Limitations by Uma Subarraya

In India, both **on-farm and *ex-situ* strategies** are developed for *Musa* germplasm conservation. The *ex-situ* component of conservation is organized into a **network of 10 main centres** that are under the leadership of NRCB. **Five types of collections** exist: field collections, in-vitro collection, cryoconservation, DNA bank and cell-lines bank. The accessions conserved in local genebanks are **duplicated** in National Institutes (Field in NRCB and in-vitro / cryoconserved in NBPGR). The germplasm network has **increased the efficiency** of the overall conservation efforts. Globally, *Musa* **CWRs are not well represented** in Indian collections, as previous collecting efforts were largely focused on cultivated varieties. The *Musa* germplasm conservation strategy at the National level **strives for merging technical and research** issues along with **users needs**. There is thus a real need for **defining the interface between conservation for users and breeders and biotechnology**.

Plenary discussion:

It was noted that the collecting of Musa CWRs in the North of India was under the jurisdiction of the North-East authorities of India. *In-situ* conservation measures are mainly applied to *Musa* CWRs and edible diploids.

Point 2: What specific materials and information do most collections require?

Presentation

Potential of MGIS to store characterization and evaluation data by Nicolas Roux

The ***Musa*** **Global Information System** (**MGIS**) is already set up to store **passport data**, **morpho-taxonomic data**, **photos** linked to descriptors, **agronomic evaluation data** and **stress evaluation data** (summary). The **on-line upload** of the data (by curators) into MGIS is made by using **normalized Excel files**. A **cross-reference tool** can then be launched to detect the most similar accessions already registered. It is also possible for the curators to link one accession to others by indicating that they are part of the same morphotypes or are the same clones. The quality of the data should be even more improved by **facilitating the use of common descriptors** within the *Musa* community, by **ensuring curators participation**, by **broadening the dataset managed by MGIS** and **facilitate information flow between curators**.

Plenary discussion:

To date, MGIS holds more than 6000 entry from which 1747 are documented with pictures and 2128 are documented with characterization data. It is important to note that each collection is responsible for the quality of its own data.

Point 3: How to make the CWRs useful to breeders?

Plenary discussion:

First, **Musa CWRs** should be **collected**, and then **characterized**. Then**, heritability** tests shall be run as the risk is, when using double-diploids from wild accessions to cross with edible diploids (ED) to obtain triploids, this drastically decreases the chances of **transmitting parthenocarpy to progenies**. It was also noted that the use of **selfing** might be the way to create **heterotic groups**. Additionally and in parallel, it is important to **investigate parthenocarpy** and **sterility** issues by **screening CWRs**. Then these traits must be **genome mapped** before being used for breeding. More generally, **CWRs** can be useful for **gene discovery** but **wider samples are needed** to be screened for traits of interest. CWRs could also be useful for the **discovery of multiple sources of resistance** that could then be combined through breeding. It was agreed that there was a real **lack of *M. balbisiana* accessions** available for investigations.

Topic 8: Collecting priorities for Musa germplasm (including CWRs)

Group discussions:

Point 1: What is the highest taxonomic, geographic and 'traits' priority for fill in the gaps of the entire genepool and specifically for CWRs?

Regarding the **taxonomic uncertainty**, the first step through collecting should allow addressing the **genetic structure of Wild Musa populations**. Once this structure well understood, **prioritization** could occur. An alternative would be to **focus on geographic areas** rather than on specific taxa, specifically for *M. acuminata*. However, there is a real need for ***M. balbisiana*** **prospection**. *M. acuminata* subspecies *sumatrana* and *malaccensis* should be studied for their production characteristics and for Fusarium resistance respectively.

Geographic regions to cover are: **East Indonesia**, **Sumatra**, **Borneo**, **Lesser Sunda Islands** and **Kalimantan**, **South Philippines**, **Myanmar** and **North Eastern India**. **PNG** and **Solomon Islands** were also mentioned for Fe'i banana. Areas outside Asia where banana was introduced a long time ago could also be considered.

Regarding traits to be collected, **collecting of CWRs should not be focused on traits**. It should also **deal with populations** rather than individuals. The screening for traits should occur later in collections conditions.

Point 2: Are there collecting strategies and methodologies specific to these priority materials?

The **material collected** should be deposited in **National collections** and in **ITC**. **Botanical Gardens** were also mentioned where some support networks exist. **Seeds** should also be conserved as a complementary strategy as it is cheaper to maintain than clones. However,an ***in-situ*** **strategy** should not be left aside. The **mapping of wild Musa genetic structure** would allow designating **appropriate areas** for such approaches.

Point 3: What are the necessary pre-conditions for collecting and conserving these priority materials?

The necessary global pre-conditions include the **basic knowledge** regarding i) **CWRs genetic structure**, ii) **CWRs distribution areas** (per taxon), iii) **CWRs populations density** within their distribution areas, iv) **CWRs population dynamics** and **ecology** and v) **threats** on CWRs.

Point 4: Who, when and where?

For now, two "**triangle expeditions**" will be **funded by Bioversity International**. The first one will occur by the end of 2012 and will target North-East Sulawesi, Ternate, Ambom and Seram. The second mission will take place at the beginning of 2013 and will target West Timor and Flores. People participating in these expeditions were selected according to local and international expertise and available funding. Members of Musanet, if interested in organizing/participating to a collecting mission are encouraged to raise their own funds through individual/collaborative projects. When fitting to the priority areas listed in the Diversity Thematic Group's Workplan, Musanet can provide support (expertise, input...) to applicants.

Topic 9: Conservation and distribution of *Musa* germplasm (including CWRs)

Prior the group discussions, an intensive discussion occurred on the **lack of "Core-Collection"** for *Musa*. The **Reference Collection** composed of 34 accessions representative of the **morphological diversity** and created for **taxonomic purposes** was evoked. Other mini core-collections exist but they are devoted to breeding purposes and thus **target specific traits** such as disease resistance. It was emphasized that all these collections were **too small** and that the **selection process** of the accessions would not allow any association studies.

Group discussions:

The delegates were split into four groups. The first two groups had to answer to the questions what to conserve and where to conserve it. The last two groups had to answer the question how to conserve it.

What to conserve?

The priority material to conserve is the material **under threat** or **underrepresented** in collections (Gap).

Conservation of **seeds for CWRs** is an attractive option but requires **prior investigation** to resolve technical issues.

Where to conserve?

The **National collections** should be duplicated at the **International level** for **back-up** and **distribution**. There, ITC has a role to play. In the case of distributed materials, **users** should be encouraged to **feed-back** their results to **genebanks**.

How to conserve?

At the **National** level, effort should focus on both ***ex-situ*** and ***in-situ*/on-farm** conservation. **Back-up** should be done through **medium** (in-vitro) and **long-term** (cryoconservation) **storage**.

DAY 5: Friday 13 July: WHAT WE CAN DO ABOUT IT – MusaNet Thematic Group Workplan and Trust project

Topic 10: Priority for MusaNet and Trust

Presentation of the MusaNet Diversity Thematic Group (DTG) workplan by Edmond De Langhe.

Some misunderstanding about DTG members' participation to workplan elaboration was noted: the workplan is not rigid and should be considered as a basis for discussion. For now it is a draft of what we think should be undertaken. The **final version** should thus result from a **participatory work**, not from a top-down process. Additionally, some expectation of the chair and co-chair were clarified: the persons named in the activity program are **suggested** for the concerned activity because they are possibly interested. Other persons are welcome to provide ideas to be included or to refine some of the activities. Finally, if a member of the group is interested in a given activity then he/she has to advise the group of his/her interest and of the nature of his/her putative contribution.

Examples of how things are already changing were given. In the original workplan draft, the priority order of the exploration mission was 1) the triangle, 2) Myanmar and 3) East Africa islands. From this meeting, it appeared that the priority order should be 1) the triangle, 2) Sumatra and 3) Myanmar while opinions are quite mixed about the East African coast.

Remind the group on the objectives of the other 3 MusaNet Thematic Groups (Conservation, Evaluation and Information) to ensure links and that priorities are well communicated to the other TG by Nicolas Roux.

Project and activities in which Bioversity International involved with partners linked to MusaNet.

- Activities linked to the DTG workplan:

    - 200 accessions of ITC accessions documented and field verified (with FHIA, CIRAD-GDL, BPI, NARO, CARBAP, UPLB, USDA)
    - Diversity studies using molecular markers (SSR/DarT), (with CIRAD and DarT)
    - Exploration and target collecting mission (with ITFRI, Indonesia)
    - Characterization of reference collection, 1st Cycle (with 3/13 NARS)
    - SNP markers for 50 genotypes (from 40 plantains and 10 Cavendish subgroups) with CIRAD, JCVI, KUL, CARBAP)
    - *Musa* genotyping platform in place and validated (with IEB)

- Lists of activities related to the 3 others MusaNet groups

Evaluation:

- EAHB evaluated for their tolerance to FOC TR4 (With IITA, NARO, China)
- Evaluation trait ontology available (With GCP)
- Identification of drought resistant varieties and ITC Core set prepared for evaluation for drought and Black Leaf Streak (Theme 2) (with KUL)
- Acquisition by ITC of promising materials from breeding programmes and national selection/screening programmes for further IMTP trials (Theme 2) (TBRI, CIRAD, EMBRAPA)
- Consumer preferences/fruit characteristics assessed (Theme 2)
- Impact assessment of NRMDCs in 2 countries in Asia, and feasibility study for outscaling to other countries in Asia and other regions (with UPLB, FAVRI,

Information and documentation:

- Annually updated on-line and printed clonal and variety catalogues (Theme2)
- GIS based mapping of *Musa* genepool
- Data sharing agreement established with *Musa* collections contributing to MGIS
- Automatic/manual uploading of data in MGIS

Conservation:

- Inventory of all *Musa* collections
- Obtain seeds of wild banana collections for further seed (medium term and long term) storage experiments (With KUL, USDA, Embrapa, IITA)
- Technical guidelines for safe movement of germplasm (with CIRAD, FUSAGx, QDPI)

Plenary discussion:

The issue of the **incentives for donor countries** to **share their genetic resources** was raised. In **case of publication**, it was globally requested to **acknowledge the origin** of the plant materials in some way. Additionally it was suggested that the **donor** of the plant material was **informed of the uses** and **results** arising from sharing their genetic resources. It was argued that the **International system of exchange** was often perceived as a one way benefit for the recipient. This means that **the bilateralism of the system** has to be improved.

It was also noted **that *Musa* taxonomists** were under threat of extinction as very **few young scientists** were joining this field of investigation. Trainings should be organized.

List of activities of the DTG: comments and opinions

It was raised that the **real gap** in **Musa CWRs** genetic resources was a **gap of knowledge**. As an example, we do not know what could be considered as a **viable population for *Musa***. Ideally, the strategy for prospection should be made in two steps: first a wide sampling for **population genetics** and **genepool identification** and second **targeted missions**. However, funding two successive prospection campaigns to explore the same areas is not realistic.

Topic 11: Implementation of priorities

Attendants' Research priorities for Musa:

The attendants' research priorities were either verbally expressed during the meeting either received by email afterward. These priorities were supposed to be the research priorities related to the DTG workplan. However, attendants appeared also concerned by other topics related to the three other Thematic Groups (Evaluation, Information and Conservation). These priorities are compiled in Table 1. A full text of each participant's priorities is available in annex 4.

ID Number	Priorities	DTG	ETG	ITG	CTG	occurence
6	Students networks for diversity mapping	Obj. 1				1
2	Collecting of CWRs (large sens)	Obj. 1				5
35	Identification of gaps within collection	Obj. 1				1
40	Survey and mapping of the populations of CWRs	Obj. 1				3
22	Collecting of local landraces	Obj. 1				3
3	Molecular characterization (SSR/flow cytometry/ITS/chr. counting) of global and local collection	Obj. 2				1
4	Develop GBS	Obj. 2				2
5	Diversity and structure of Fe'i banana	Obj. 2				1
8	Classical cytogenetics studies	Obj. 2				1
12	Improve phenotyping (for GWAS)	Obj. 2	Obj. 4			1
14	Characterization (morphological and molecular) of local landraces/local collections	Obj. 2				4
20	Research on correlation between natural selection and human selection	Obj. 2				2
37	Investigate nomenclature/synonymy	Obj. 2				3
49	Characterization (for identification) of CWRs already in collections	Obj. 2				1
57	Multidisciplinary approach to reach a better understanding of Musa diversity	Obj. 2				2
60	Reference Collection characterization	Obj. 2				1
61	Conduct training on molecular characterization	Obj. 2				1
38	From priority 14, verification of classification of local landraces/collections	Obj. 3				2
47	Revise wild Musa taxonomy	Obj. 3				1
48	Study of Indonesian ABB and BB	Obj. 3				1
44	Conduct training workshops on Musa taxonomy	Obj. 3				2
56	Research on CWRs population genetics	X				2
21	Research on the genetic relationships between diploids and triploids	X				1
1	Screening of CWRs (large sens, not only immediate ancestors) for desirable traits		Obj. 4			3
23	Evaluation of local landraces/collections/populations (opt. conditions / diff. environment)		Obj. 4			7
31	Phenomic studies (drought, FOC)		Obj. 4			1
9	Research on parthenocarpy		X			2
10	Breeding for resistance (general) (cooking varieties)		X			1
11	Development of breeding pools based on genome-structure		X			1
15	Address diploids' fertility levels		X			1
16	From priority 15, select male parents for breeding		X			1
17	Develop segregating populations for selected traits		X			2

ID Number	Priorities	DTG	ETG	ITG	CTG	occurrence
25	Research on biotic stresses		X			1
26	Research on abiotic stresses (drought)		X			2
30	Identification of diploids suitable for research on drought		X			1
32	Breeding for diversification of commercial bananas		X			1
43	Develop a local banana breeding program		X			1
50	Breeding/in-vitro mutagenesis for Fusarium resistance		X			4
51	Breeding for Moko disease		X			1
52	Breeding for drought		X			1
53	Chromosome doubling		X			2
54	Monitor the spread of bunchy top, TR4 and blood disease in Asia/Pacific		X			1
55	Develop community-based approach to tackle diseases spread		X			1
27	Strengthen networks at International level (notably by contributing to MGIS)			Obj. 1		2
24	Documentation of local landraces/collections			Obj. 6		1
36	Photo documentation			Obj. 6		1
29	Support policy (official document production)			X		1
33	Regeneration of in-vitro germplasm				Obj. 1	1
34	Rationalization of collection				Obj. 1	1
45	Conduct training workshops on Musa germplasm management				Obj. 1	1
28	Strengthen networks at national levels (collection and curators)				Obj. 1	2
62	Develop a system for the systematic deposit of new varieties to ITC				Obj. 1	1
7	Research on seed physiology/storage				X	6
13	Creation of a global in-trust Musa collection of seeds and embryos for CWRs				X	1
39	Complement existing collection with missing germplasm				X	2
42	Alternative conservation strategies (e.g. screenhouses, seeds)				X	1
46	Elaborate prediction maps for In-situ conservation of CWRs				X	2
18	Address the distribution and plantation frequency of landraces on-farm				X	1
19	Address farmers' selection criteria and main drivers for long-term cultivation				X	1
58	Produce a statement to submit to authorities	X	X	X	X	1
59	Identify activities that could be supported by the Trust	X	X	X	X	1

Table 1: Research priorities of the 26 participants to MusaNet/Trust joint meeting held in Bogor (9-13 July 2012). DTG: Diversity Thematic Group, ETG: Evaluation Thematic Group, ITG: Information Thematic Group, CTG: Conservation Thematic Group; Occurrence: number of citations in total for each priority; X: Research priorities not specific to any objectives included in the Workplans (of each Thematic Group respectively); Priorities tagged in all TG are not specific to any Workplan/TG. Research priorities purely dealing with breeding are tagged in the ETG but might also be considered more relevant to the ProMusa Crop Improvement Working Group.

Finally a draft of the official declaration by the expert community on *Musa* research, breeding and conservation was produced. A "task force" was designated: Uma (Chair), Gus, Nicolas, Hugo, Edson, Laani, Catur, Rony and Julie.

What funding may be available for the agreed priorities: within the CG to MusaNet and from the Trust

The CRP-RTB cross-cutting project will fund the Genotyping-by-Sequencing (GBS) of a certain amount of germplasm conserved in National *ex-situ* collections. The number of accessions is still to be determined according to the GBS methodology further selected. The aim of this study is to fill in gaps on the understanding of Musa diversity, wild and cultivated. The target germplasm is thus the one for which no molecular data is currently available. The pre-requisite condition is the concomitant introduction of the genotyped accessions at ITC.

The Trust has a commitment to fund CWRs gap analysis and collecting for the next 3 years. This funding can be used for collecting, performing preliminary prebreeding and support international collection. Additionally, some opportunity for the safety duplication into ITC of National not-CWRs germplasm will be held through a not-CWRs Trust funding.

It was also suggested to produce a white paper that would allow having a peer-reviewed published paper to refer to. The main topic this putative paper would deal with should emerge from the meeting report.

Final session:

Acknowledgements:

We are grateful to the organising committee, Brigitte Laliberte, Edmond De Langhe, Jean-Pierre Horry, Jim Lorenzen, Hannes Dempewolf, Luigi Guarino, Julie Sardos and Nicolas Roux for the preparation of the meeting. We also acknowledge the Trust and Bioversity International for the critical financial support provided for this meeting organization. We are grateful to CIFOR for hosting the workshop and to our Indonesian partners LIPI, IFTRI and Bogor Agricultural University. We also thank Titin Suhartini *and Putri from CIFOR, Suzy Gemma from the Trust and Silvia Araujo de Lima from Bioversity for their logistic support. MusaNet and the Trust would also like to recognise the valuable contribution of all the participants and is appreciative for their keen interest and active involvement during this meeting.*

The expected outputs of the meeting were:

- Clear understanding of the current breeding approaches and the input of wild taxa and edible diploids (EDs) in pre-breeding: This issue was addressed but not in details.

- Definition of the genepools of CWR and EDs for use in breeding: It was highlighted that taxonomic issues and lack of knowledge about *Musa* CWRs was the main obstacle to identifying genepools.
- Assessment of the genetic diversity of the targeted wild *Musa* taxa and EDs (in *ex situ* collections and gaps identification): This issue was addressed but it was also agreed that the main gaps result from the lack of knowledge, particularly for CWRs.
- Agreement on collecting priorities (species and geographical areas) and methodology: This issue was fully addressed.
- Prioritized actions in the MusaNet Diversity Thematic Group (DTG) workplan

Next Steps:

1) Adapting Workplan by the end of September 2012 (Edmond and Jean-Pierre)
2) Finalizing Declaration by the end of September 2012 ("task force")
3) Developing Sampling methodology by the end of September 2012 (Jeff, Agus, Catur, Nicolas, Jaroslav, Julie)

Annex 1: List of participants

	Last name	First name	Institute/Address	Email
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Annex 2: List of presentations

Day	Topic	Title	Presentator	size
1		General Introduction to MusaNet	**Nicolas Roux**	712 KB
1		MusaNet Diversity Thematic Group : Introduction to the DTG Workplan	**Jean-Pierre Horry**	507 KB
1		Introduction to the Trust CWR project and the importance of CWRs	**Hannes Dempewolf & Luigi Guarino**	842 KB
1	1	Banana breeding - objectives, techniques, constraints, opportunities	**Jim Lorenzen**	392 KB
1	1	Strategies for improvement of banana and plantains	**Subbarya Uma**	1394 KB
1	1	Combining Crop Wild Relatives and Edible Varieties to enhance Diversity in Banana Improvement	**Frédéric Bakry**	1071 KB
1	2	Challenges to banana production under climate change	**Hannes Dempewolf**	1603 KB
1	3	Banana breeding program at Embrapa Cassava & Fruits	**Edson Perito Amorim**	1527 KB
1	3	Identification of priorities for *Musa* pre-breeding and breeding (including climate change)	**Rony Swennen**	1651 KB
2	4	Wild Acuminata subspecies	**Edmond De Langhe**	354 KB
2	4	The origins of edible Triploids in *Musa*	**Julie Sardos**	1475 KB
2	4	Musa wild relatives	**Hugo Volkaert**	5703 KB
2	5	Available data on ex-situ collections ITC	**Julie Sardos**	239 KB
2	5	From Collecting Missions to Collections and Back	**Julie Sardos**	1172 KB
4	6	Progress on gap analysis for Musa crop wild relatives	**Hannes Dempewolf**	858 KB
4	7	Impact of the Musa International Transit Centre (ITC), Belgium	**Rony Swennen**	388 KB
4	7	Musa Genetic Resource Conservation Network in India - Advantages and Limitations	**Subbarya Uma**	2335 KB
4	7	Potential of MGIS to store characterization and evaluation data	**Nicolas Roux**	1622 KB

Annex 3: AGENDA

Effective Use of Genetic Diversity for Addressing Emerging Challenges in Banana and Plantain Breeding

MusaNet/Trust joint meeting, 9-13 July 2012, Bogor, Indonesia

Version date: 4 July 2012

Venue: CIFOR campus in Bogor, Indonesia, http://www.cifor.org/about-us/contact-us/headquarters.html

Host organisations: The Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia - LIPI), the Indonesian Tropical Fruit Research Institute (ITFRI) and the Centre for International Forest Research (CIFOR).

Accommodation and travel arrangements: Please refer to your correspondence with Suzy Gemma or Silvia Araujo de Lima, which details your individual arrangements.

The proposed programme is divided into four main parts:

- Day 1 - Monday 9 July: WHAT NEEDS TO BE ACHIEVED – Breeding objectives in view of future challenges (including climate change)
- Day 2 - Tuesday 10 July: WHAT WE HAVE (materials and information) – assessment of the current diversity
- *Day 3* - Wednesday 11 July*: Field trip*
- Day 4 - Thursday 12 July: WHAT IS MISSING and HOW TO GET IT (materials and information) – Gap filling and priority collecting
- Day 5 - Friday 13 July: WHAT WE CAN DO ABOUT IT – MusaNet Thematic Group Workplan and Trust project

Expected outputs of the meeting:

- Clear understanding the current breeding approaches and the input of wild taxa and edible diploids (EDs) in pre-breeding
- Definition of the genepools of CWR and EDs for use in breeding
- Assessment of the genetic diversity of the targeted wild Musa taxa and EDs (in *ex situ* collections and gaps identification)
- Agreement on collecting priorities (species and geographical areas) and methodology
- Prioritized actions in the MusaNet Diversity Thematic Group (DTG) workplan

Time	Topic
DAY1 - Monday 9 July: WHAT NEEDS TO BE ACHIEVED – Breeding objectives in view of future challenges (including climate change)	
9:00-10:30	Welcome address(es) from MusaNet and the Trust – **Nicolas Roux (MusaNet), Hannes Dempewolf (Trust), Catur Hermanto (ITFRI) and Amy Ickowitz (CIFOR)** Introduction of the participants **– Nicolas** General introduction to MusaNet **- Nicolas** Diversity Thematic Group – **Jean-Pierre** Introduction to the Trust CWR project and the importance of CWRs – **Hannes and Luigi** Introduction to the proposed agenda and logistics – **Nicolas**
10:30-11:00	***Coffee break***
11:00-11:40	**TOPIC 1: Current breeding and pre-breeding objectives and methodologies in *Musa*** - key participants report on their experiences, accomplishments, challenges and perspectives on the use of *Musa* CWRs: **Introductory presentations:** Description of breeding methods, main objectives and required inputs for pre-breeding (i.e. principles, methods), including comments on desirable material of CWRs and edible diploids (ED) in pre-breeding, of their respective approaches: • **Jim Lorenzen** (IITA) – *10 minutes* • **Uma Subbaraya** (National Research Centre on Banana, India) – *10 minutes* • **Fred Bakry** (CIRAD) – *10 minutes* **Discussion** on the presentations – *10 minutes*
11:40-12:30	**Breakout groups (3 of 7-8 people in each) - organized by region** – *20 minutes* • Asia/Oceania • Africa • Americas *Europeans self-assign according to continent of greatest interest* Discussing the following key issues: 1. Traits which current breeding efforts focus on 2. Promising *Musa* genetic diversity **Plenary reports of each of the 3 groups and discussion** – *30 minutes*
12:30-14:00	***Lunch and individual interactions***
14:00-14:30	**TOPIC 2: Climate change and breeding objectives in *Musa*** **Introductory presentation:** General presentation on climate change and key issues to be addressed by breeding (presentation prepared by Julian Ramirez-Villegas (CIAT) - **Hannes** - *10 minutes + 10 minutes discussion*

	Meeting the climate change issues: what end-products for what challenge? **Breakout groups** discussing the following questions: (3 groups split randomly) - *40 minutes* 1. Which traits should breeding and pre-breeding efforts focus on in the context of climate change? 2. What are the desired end-products of pre-breeding in *Musa*? 3. What is the role of evaluation and characterization in the context of climate change? 4. What are the main incentives and obstacles for an increased use of genetic resources in *Musa* breeding and pre-breeding (e.g. taxonomical issues; access regimes to PGR; funding constraints; etc.) and how can we overcome them? **Plenary reports** (3) of breakout groups and **discussion** - *30 minutes*
15:30-16:00	***Coffee break***
16:00-16:35	**TOPIC 3: Identification of priorities for *Musa* pre-breeding and breeding** (including climate change) **Introductory presentations:** Priority traits in a *Musa* breeding program • **Edson Perito Amorim** (EMBRAPA) – *10 minutes* • **Rony Swennen** – *10 minutes* • **Jim Lorenzen** - Wrap of Topic 1 – *5 minutes* **Plenary discussion** – *10 minutes*
16:35-17:10	**Breakout groups** – *35 minutes* Dessert banana – 2 groups Cooking banana – 1 group Key issues to discuss: **1.** What are the breeding priorities (traits) for Musa in general (current and future)? **2.** What are the breeding priorities relevant to climate change to be discussed in coming days (2-4-5)?
17:10-18:00	**Plenary reports** (3) of breakout groups and **discussion** – *50 minutes*
18:00-19:00	***Welcome cocktail***

Time	Topic
DAY 2 - Tuesday 10 July: WHAT WE HAVE (materials and information) – assessment of the current diversity	
09:00-09:30	Reflection on Day 1 discussions and issues arising - **Hannes**
09:30-10:30	**TOPIC 4: Description of *Musa* diversity** Review of the *Musa* genepools (CWRs and EDs), with focus on *M. acuminata and M. balbisiana.* Morphological and evaluation perspectives – **Edmond De Langhe** – *15 minutes and 5 minutes discussion* A molecular perspective - current knowledge on the origin of the edible triploids – **Julie Sardos** – *15 minutes and 5 minutes discussion* Musa wild relatives - **Hugo Volkaert -** *15 minutes and 5 minutes discussion*
10:30-11:00	***Coffee break***
11:00-12:30	**Breakout Groups:** – *30 minutes* • What part of that diversity has particular value for breeding (to identify what we have and what is needed) **Plenary reports** (3) of breakout groups and **discussion** – *30 minutes* **Plenary discussion** on the following key issue – *30 minutes* • What research is needed to urgently fill in the gaps in knowledge on the part of the diversity of most value for breeding.
12:30-14:00	***Lunch and individual interactions***
14:00-15:30	**Topic 5: What is conserved and accessible today?** **Introductory presentation:** What is conserved and accessible today: Available data on *ex-situ* collections; ITC: accessibility of material and rationalization - **Julie Sardos** – *15 minutes* **Plenary discussion:** **Point 1:** - *30 minutes* Farmers' practices regarding *Musa* diversity • About their perception of diversity: what a 'landrace' is? • Polyclonal 'landraces': any possibility? **Point 2:** - *30 minutes* Do you think that the diversity maintained in national collections is actually representative of the overall diversity portfolio maintained on-farm in your countries? **Conclusions**: Is the current situation in *ex situ* collection satisfactory and what do we need to focus on day 4? - *15 minutes*
15:30-16:00	***Coffee break***
16:00-16:15	**Topic 5 continued - Sampling methodology for collecting missions**

	Introductory presentation: From collecting missions to collections and back: disparity and gaps revealed through GIS mapping of collected diversity - **Julie Sardos** – *15 minutes*
16:15-17:05	**Breakout Groups:** 2 groups on CWRs and 2 groups on EDs: *compositions still to be decided* **Point 1:** - *30 minutes* Which sampling strategy for collecting missions? • Cultivated: what to collect? In a given village: all or selected accessions? • Wild: population sampling or representative individual sampling? **Plenary reports (point 1) and discussion** – *20 minutes*
17:05-18:00	**Point 2:** - *30 minutes* Towards the revision of the Collecting Form for banana (*Musa* spp.) • Are all morphological descriptors necessary? (GxE interactions, …) • Traditional knowledge associated? **Plenary reports (point 2) and discussion** – *25 minutes*
19:00 onwards	***Social dinner***

Time	Topic
DAY3 - Wednesday 11 July: Field trip and MusaNet meeting	
09:00-14:00	Field trip and lunch
14:00-18:00	MusaNet Diversity Thematic Group meeting (*below are suggestions to be further discussed*): • Discussion on any issues of interest to the members • Discussion on links with other Thematic Groups • Discussion on membership of this group

Time	Topic
DAY 4 - Thursday 12 July: WHAT IS MISSING and HOW TO GET IT (materials and information) – Gap filling and priority collecting	
09:00-09:30	Reflection on Day 2 discussions and issues arising – **Nicolas**
09:30–10:30	**TOPIC 6: Gap analysis** **Introductory presentation:** Towards a gap analysis for Musa CWRs (presentation prepared by Nora Castaneda (CIAT) and delivered by Hannes) - *10 minutes + 10 minutes discussion* **Plenary discussion** on the following 4 questions - *30 minutes:* • Based on what is needed (Day1), what we have (Day 2), what diversity is missing? • What are the taxonomic issues (incl. with regards to CWR)? • What specific CWRs are missing? • What is missing because it has not been collected and what is missing because it is not accessible? **Synthesis of plenary discussion** - *10 minutes*
10:30-11:00	***Coffee break***
11:00-11:30	**TOPIC 7: Needs of the collection managers – diversity and knowledge** **Plenary discussion on the following 3 points** **Point 1:** *30 minutes* What are the needs from key *ex situ* collections (ITC, regional and national) for promoting the use of diversity? • A presentation on the use of ITC accessions based on the ITC impact assessment – 10 minutes • Discussion: What are the needs of the national collections in terms of diversity and knowledge - *20 minutes*
11:30-12:00	**Point 2:** *30 minutes* What specific materials and information do most collections require? • A presentation on the potential of MGIS to store characterization and evaluation data – *Nicolas - 10 minutes* • Discussion: What materials and information does the national collections should store - *20 minutes*
12:00-12:30	**Point 3:** *30 minutes* How to make the CWRs useful to breeders (characterisation and evaluation information)? • A presentation on 'pre-breeding' components of the CWR project – *Hannes - 10 minutes* • Discussion: How this could be done in *Musa* at the national, regional and international level -

	20 minutes
12:30-14:00	***Lunch and individual interactions***
14:00-15:30	**TOPIC 8: Collecting priorities for *Musa* germplasm (including CWRs)** Reflection and summary of discussions on Topic 6 and Topic 7 - Luigi Guarino – *15 minutes* **Plenary discussion** – *75 minutes* 1. What are the highest taxonomic, geographic and 'trait' collecting priorities for filling the gaps of the entire genepool and specifically for the CWRs? 2. Are there collecting methodologies and strategies specific to these priority materials? 3. What are the necessary pre-conditions for collecting and conserving these priority materials? 4. Who, when and where?
15:30-16:00	***Coffee break***
16:00-16:25	**TOPIC 9: Conservation and distribution of *Musa* germplasm (including CWRs)** **Introductory presentation**: The conservation network in India : advantages and limitations - *Uma Subbaraya – 15 minutes and 10 minutes discussion*
16:25-16:55	**Breakout groups:** - *30 minutes* **Group 1+2 discussing:** Strategies for the conservation and use of priority materials.
	What are the highest taxonomic, geographic and 'trait' collecting priorities for filling the gaps of the entire genepool and specifically for the CWRs?
	1. What? Advantages and disadvantages of: • Seed storage (CWR?) • Clone sets (edible and wild? edible only?) **2. Where?** • Among the different options, are there differences regarding the level (national, regional, international) at which each option should be better implemented / adapted? **Group 3+4 discussing:**
	What are the highest taxonomic, geographic and 'trait' collecting priorities for filling the gaps of the entire genepool and specifically for the CWRs?

	How? For long term conservation of genetic diversity, several options are available (proposed list below). Among all these, which ones seem feasible and realistic? Which ones should we as a group prioritize? Which ones should be combined to ensure the most efficient and realistic approach?
	• *In situ* conservation
	• On farm conservation
	• *Ex situ* conservation
	  ○ Field genebank
	  ○ *In vitro* gene bank (long term conservation, cryopreservation)
	  ○ DNA Bank

	○ Cell lines bank
16:55-18:00	**Plenary reports of breakout groups** – *30 minutes* **Plenary discussion** **Point 2:** – *35 minutes* • What are the main issues related to access and dissemination of material and information to all potential users?

Time	**Topic**
Day5 - Friday 13 July: WHAT WE CAN DO ABOUT IT – MusaNet Thematic Group Workplan and Trust project	
09:00-09:30	Reflection on Day 4 discussions and issues arising
09:30-10:30	**TOPIC 10: Priorities for MusaNet and Trust** • Presentation of the MusaNet DTG workplan (modified based on day 1-2-4 to make sure it covers well what has been discussed so far) • Remind the group on the objectives of the other 3 MusaNet Thematic Groups (Conservation, Evaluation and Information) to ensure links and that priorities are well communicated to the other TGs.
10:30-11:00	***Coffee break***
11:00-12:30	• Agreement on the MusaNet DTG workplan priorities • Identification of the Trust's priorities and links with the DTG
12:30-14:00	***Lunch and individual interactions***
14:00-15:30	**TOPIC 11: Implementation of priorities** • What funding may be available for the agreed priorities: within the CG to MusaNet (Nicolas) and from the Trust project (Hannes/Luigi) • Discussion on possible development of a strategic road-map • Discussion on possibly developing a white paper on the importance and use of CWRs for pre-breeding in *Musa* for publication in a peer-reviewed journal • Agreement on the next steps for MusaNet (*including the finalisation of the DTG workplan with lead, teams, timeframes and indication of budget*)
15:30-16:00	***Coffee break***
16:00-17:00	• Agreement on the next steps for the Trust project • Wrap-up and synthesis • Closing of meeting
18:00 onwards	***Social dinner***

Annex 4: MusaNet/Trust joint meeting attendants research priorities

Gabriel Sachter-Smith: The **systematic screening** of all possible wild accessions (those that are currently available and including more as they become available) in an unbiased manner for **desirable traits** to use in banana breeding. By unbiased, I mean that **all taxa** must be considered as potential valuable genetic resources whether they be (Eu)musa, Rhodochlamys, Callimusa, Australimusa, Ingentimusa or otherwise unclassified. We don't know where the useful genes are or how they will be used, so we must not leave any taxa out.

Jaroslav Dolezel: Complete the molecular characterization (**SSR analysis/flow cytometry/chromosome counting/ITS)** of the whole **ITC collection** along with **other accessions** from different countries including those that will be collected during the **triangle exploration**, **conduct training** for partners from collaborating institutions, analyze the **diversity** of the **Fe'i banana**, **clarify vernacular names** and s**ynonyms** and develop **Genotyping-by-Sequencing** (GBS) .

Hugo Volkaert: 1) A thorough **sampling** of the **genetic diversity** of the **not-well known** or **suspected progenitor wild species** (M. schizocarpa for AS bananas, M. yunnanensis, M. sikkimensis as candidates for the X genome). The geographical area to cover would be **all Indonesia**, **Malaysia** and **Philippines**, **Thailand** in some extent and **Myanmar**. To assess the genetic diversity available and to cover such a large area, a **"crowd-sourcing" approach** could be projected by involving high-school students in a science project on genetic diversity, conservation and CWRs. Such items might also be proposed in the Workplan 2) Research on Musa **CWRs** germplasm using **seed storage** (optimal methodology for collecting, pretreatment, storage and germination)

Frédéric Bakry: there is a real need to focus on **classical cytogenetics studies** and to reach a clear **understanding of parthenocarpy** in ED.

Jim Lorenzen: 1) to produce high yielding **cooking varieties** resistant to pests and diseases and acceptable to markets and consumers 2) to **develop breeding pools** based on genome structure for pre-breeding for traits and heterosis, develop better **phenotyping methodology** for the implementation of Genome Wide Association Study (**GWAS**) 3) to **investigate genetic control of parthenocarpy** and **sterility** to enable recreation of domestication 4) to see the creation of **a global in-trust Musa collection** based on **seeds or embryos** for conservation of **wild Musa**

Deborah Karamura: 1) Ensure that all Musa edible diploids and triploid local landraces collected in the region have been **characterized** (both by morphological and molecular methods) 2) Identify **fertility** levels of the diploid genotypes and select the most **suitable males** for breeding 3) Characterize **segregating populations** to enable the selection of some useful breeding traits 4) On-farm, assess the **distribution** and **plantation frequency** of these landraces, investigate the **selection criteria** and main **drivers** for long term cultivation, study the **correlation between natural selection and human selection**, and lastly address the **genetic relationships within the diploids and between the diploid and triploid** landraces.

Lia Hapsari: 1) **Collecting** living material along with pictures (as voucher) of **CWRs** and **local and unique cultivars** 2) **survey**, **document**, **evaluate** and **characterize** (morphological, molecular and phonological) Indonesian Musa diversity 3) research on **stress factors** should focus on **biotic** (Banana

bunchy top disease, blood disease, Fusarium wilt...) and **abiotic** (drought, toxicity...) stresses 4) **Strengthening networks** at **International** (e.g. participate to MGIS) and **National** (Initiate National joint research with other institutions and Botanic Gardens) 5) **Support policy** by providing an **official document** regarding "*Ex situ* Conservation Strategy of *Musa* in Indonesia"

Rony Swennen: 1) Develop a **system** whenever a **new variety** is reported in literature or during a field study, that such a variety will **automatically deposited to ITC** 2) **drought research**, more precisely there is a need to **identify diploids suitable for research on** drought 3) properly **define** what a **population** is and also define **its geographic boundaries** along with the **within population variation** 4) define what the **minimum size of a conservation area** should be for ***in-situ* conservation** and 5) Develop a **protocol** for **seed conservation**.

Uma Subarraya Chetty: 1) Evaluation of more breeding material, especially wild species and ED for important traits such as drought and Fusarium wilt 2) **gap filling explorations** and **collecting** for missing species as *M. Nagensium*, *M. Sikkimensis*, *M. Itinerans*... 3) **Phenomic studies** for important traits such as drought and FOC (if needed initiate research network) 4) develop **mapping populations** for specific traits (FOC, parthenocarpy...) and depth evaluation of existing population at NRCB 5)seed studies (physiology and storage).

Laani Khalid: The priority is to **solve local problems** as Fusarium wilt and moko disease along with the **diversification of the commercial bananas**.

Lavern Gueco: 1) **Regeneration of all in vitro conserved edible Musa germplasm** collection in the field (since some of them have been there for some time) 2) **New characterization and evaluation** of field conserved material under optimal growth conditions, **rationalization** of collection (identify soma-clonal variant, duplicates, mislabelled accessions) and **identification of gaps** within the collection 3) **Photo documentation** using the minimal set of photos (Bioversity International) and information on **synonymy**. Then a catalogue containing the passport, characterization, evaluation and photos published 4) Evaluation of each germplasm for particular traits (example: cooking bananas for processing: chips, flour, bread, etc.) to identify those which offer good potential. If some cultivars will be find useful/valuable, on farm conservation may follow. Evaluation of their resistance to pests and disease is also important for future breeding works 5) **Molecular characterization** and proper **classification/verification** of each accession/variety with respect to sub species, sub group, ploidy, and genome 6) Upload all information in MGIS for the Musa community to know what we have 7) **Gap filling** of **varieties** not represented in the collection, **survey** and **map** the different population of Musa CWRs, **identify vulnerable populations** and **collect** them 8) Different conservation strategies research including alternatives like screenhouse conservation and seed research 9) Develop a **local banana breeding program**.

Agus Sutanto: 1) Identify **Musa collections** (where) and **Musa curators** (who) within the country (especially in Indonesia) 2) Conduct **training workshop** on **Musa taxonomy** and Musa germplasm management and generate a **network** among Musa collections and curators 3) Conduct **Musa exploration** for wild species and cultivars. 4. **Map the distribution sites** of **wild Musa species** and generate a **prediction map for *in situ* conservation** (with national park sites included in the map). 5. Implementation of priority no. 4.

Markku Häkkinen: The main priority is **wild Musa taxonomic issues**. I wish in one of these coming days to revise the taxonomic problems of wild Musa. I have almost all the needed information for it but put everything on the peer-reviewed paper and publish them is another question.

Rita Megia: 1) **Identification** and **classification** into genomic group, subgroup and cultivar/clone set of **Indonesian Musa germplasm** from all *ex-situ* Collection by using morphological, cytological, and molecular tools (Objective 1 and 2) 2) Study **the complex of Indonesian ABB** (more than 20 cvs in Kepok, Batu, Sobo and Sepatu) and **BB** (more than 7 Klutuk)(Objective 3) and 3) For **wild species**, the **identification** of **wild Musa collection** at Bogor Botanical Garden.

Yuyu Poerba: Breeding for Fusarium resistance in banana by 1) Improve diploids parents for Fusarium TR4 resistance, 2) Generate double diploid parents with oryzalin treatment and 3) Select double diploids parents to cross with improved diploids to produce resistant triploid hybrids.

Edson Perito Amorim: 1. **Resistance** to Fusarium wilt race 1 (resistant germplasm - edible diploids e wild diploids) and to tropical race 4 2) enlarge the **plantain germplasm** available for breeding (dwarf and resistant to Black Sigatoka) 3) **Double chromosomes** (secondary triploids) 4) **Drought tolerance** 5) **Evaluation** of Embrapa´s cultivar abroad

Jeff Daniells: There's a great need for some attention to the **spread of bunchy top** [and also TR4 and blood disease] which threatens the unique genetic resources of PNG and also cripples the safe utilization of genetic resources in many collections and countries in Asia/Pacific. I indicated the need to **investigate the potential of community based approaches** to tackle the problem supported by necessary research see paper: *Acta Hort* **828**: 411-416 [page 415 in particular].

Jean-Pierre Horry: reach a **better understanding** of the **wild populations** of Musa by **population genetics** studies and **wide surveys** to **identify genepools**.

Catur: In addition to the proposed research priority for Musa diversity, I would like to raise issue on the "**clarification of vernacular name** and **synonymy** of banana in **Indonesia** through **ethnobotany study**, **morphological characterization** and **molecular approach**" as research priority number 6 (after Agus's).

Maimun Tahir: 1) **Conservation** of Musa Wild Sp. through **research on seed storage** (Right time for seed collection (stage of maturity), Seed pre-treatment, Interaction between storage time and percentage of germination) 2) To **characterize** and **evaluate** the available **CWRs** accessions 3) To **identify special traits** for resistance to disease, dwarfism, plant and fruit size, longer shelf life, etc 4)**development of Pisang Berangan** (Musa acuminate sp.) with **resistance to Fusarium wilt** through **in-vitro mutagenesis**

Edmond De Langhe: The workplan should probably also mentioned **training** (for taxonomic issues?)

Julie Sardos: Interactions between **Musa** (**wild and cultivated**) and **human**: how human behaviour and practices shape Musa diversity.

Hannes Dempewolf: take the opportunity of **being together** to come up with a kind of **statement** that could be further submitted to authorities

Luigi Guarino: Identify which of the **discussed activities** could be **supported** by the **Trust**.

Annex 5: Technical guidelines for taking photos

Introduction

Nowadays, taking photos is a lot easier than in the old days. Digital cameras are now equipped with automatic modes where you can literally point and shoot and the resulting image quality is awesome. There are also a lot of great features and camera settings that you can choose from to help you take better pictures. There are really no firm rules in photography but to take good pictures the basic rule is to know your camera first. You should know how it works, be familiar with its features, as well as its limitations. Here are some tips and suggestions to help you take better photos:

1. Read your camera manual. This will give you a better understanding on how your camera works.

2. Before taking photos, check the camera lens for dust, dirt, rain drops or dew and clean it if necessary.

3. It is advisable to take photos at a high quality setting. Check the camera manual if you do not know how to set it up. As a minimum, a 1600 x 1200 pixels or 2M is recommended but the higher the better. The size of the photos can always be reduced later for different purpose if necessary. Another advantage of having large photos is when a particular part is to be extracted. For example, you photograph an entire plant but need to extract the bunch only. This can be done for large photos by cropping the picture to show only the bunch without much effect in the quality. If the photo has a small size, then the bunch will appear pixelated after cropping.

4. Prepare the samples to be photographed. Ideally, the plants should be grown under optimum growing conditions for them express their full potential as well as their true characteristics. In taking a photo of the whole plant, removing the weeds surrounding the plant as well as the dried leaves before taking the photo is advisable. Remove also other obstacles like dried leaves covering the bunch to get a full view of its appearance. In some cases, using an artificial background such as white or colored paper is advisable, especially for detached plant parts such as the hands, flowers, and fingers.

5. When outdoor in the field, taking photos when the sun is too bright is hard to handle. Whenever applicable, photos should be taken early in the morning or late in the afternoon to prevent the harsh effect of sunlight. If the middle of the day is your only opportunity to take photos, evaluate the shadiest conditions, making sure there are minimal bright spots in your photos. Remember that spots of shade and sunlight register four times as intense on your photos. You should also make sure the background is not too bright. Look for an angle where you will get the best quality of photo possible.

6. Getting closer to the subject instead of zooming in will most of the time give better quality photos. However, if you are photographing entire banana plants, often it is necessary to step back and zoom in.

7. Press the shutter-release button halfway to activate auto focus and exposure. Then press the button completely to take the picture.

8. You can review the photos in the LCD and verify whether something went wrong. Change the settings and make some adjustments if necessary.

9. Take lots of pictures and shoot at different angles. The more photos you take, the more likely you are to get a nice one.

10. Natural light usually looks better most of the time. However, there are cases when a fill flash is needed because of shadows, brightly lit background or when there isn't enough light. You can also experiment by comparing photos taken with and without a flash.

11. Blurred images are usually caused by "shaking hands" resulting in poor quality images. If these cannot be prevented, use a tripod in taking photos.

12. It is also advisable to add an object such as a ruler or a stick with known size to have an idea of the scale. In taking photos of the entire plant, you can even ask someone to stand beside the plant.

13. Using the color chart and including it in the photo can also help to identify the "true color" of the subject. This is especially important for banana pulp, bud and bract colors. Bioversity can supply photographers a standard color chart.

14. Certain photos are also best taken at specific growth stages. In some descriptors, the right stage of development for taking photos is when the rachis have at least 20 nodes (scars). These were all fully explained in the guidelines for documenting the minimum set of descriptors for bananas developed by the Taxonomy Advisory Group.

15. The more photos you take, the more you will get familiar with your camera. Hence, the chance of getting better images in the future increases.

16. Try experimenting of the different settings and navigating on the functions of your camera and you will be on your way of producing excellent photos!

17. The best thing about digital photography now is that it's free and you can easily delete unwanted images. Take lots of photos and check them regularly. Practice makes perfect.

18. Some photos also appear good in the LCD but when they are transferred in the computer they don't look the way we want them to.

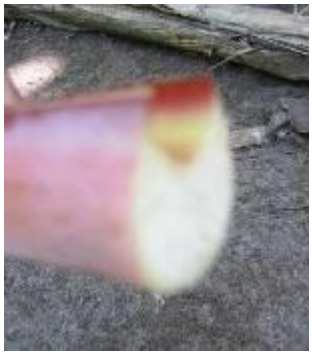
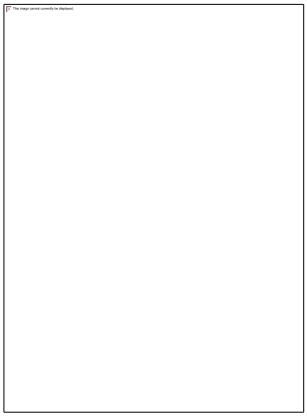
19. There are a lot of post processing softwares where you can edit and sharpen your images. But you can only do so much. Some photos taken with poor quality are just beyond repair.

20. Always carry an extra battery and memory card. This is much cheaper than a missed opportunity.

Some other tips and suggestions:

Background :

The background is an important component of a nice photograph. When taking a photograph in broad daylight, some background may be too bright especially you are shooting against the light (sun). In this case, you will need to find an angle where you could make a good photo without over exposure of the background. You can also use a natural (sky or landscape) or an artificial background (black or velvet paper, bond paper, freshly cut banana leaf, etc.) to make the photos more attractive. In some cases, you can also play with the camera settings to make the foreground in focus and the background blurred. In DSLR cameras, this can be achieved by making the opening of the aperture bigger (low F-stop) and focussing on the subject. In a point-and-shoot camera, this can sometimes be achieved by using the macro setting. Be careful with exposures if you are using black velvet or other dark background, especially if it is a close-up photo. Neutral gray backgrounds are good, even with a little texture; we suggest visiting a sewing store and experimenting with different colors, textures, and degrees of glossiness. You don't want shiny backgrounds, since they reflect incident and flash lighting, making bright spots on your photos.

Good	Not so good
	
	
	

Framing :

The organ of interest must be fully included in the photograph, occupy a substantial part of it and be as centered as possible. In the photos on the below (left): the bunch, male bud, and flower are an example of photos with good framing. The photos below (right) may be good but the parts of interest (bunch, male bud and flower) occupy only a small part in the whole photo. In some cases, cropping the photo will solve the problem if the original photo has a high resolution.

Good	Not so good
	
	
	

Brightness / contrast / color :

The brightness, contrast, and color are also important in making a good photograph. In the photos below, the left photographs were taken with a flash while the right photos without a flash. As a result, the left photos appear better than the right ones. However, the use of flash is always a case to case basis and is not always applicable. There are cases where no flash is better than using a flash. It sometimes results in the over exposure of the subject or background of the picture. Flash should not be used when the resulting photos does not look natural anymore. Experiment with your flash, since more expensive cameras normally have flashes that are effective at larger distances.

Good	Not so good
	

Evaluate the photos below and identify why it is good and not so good?

Whole plant	
Good	Not so good
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Pseudostem	
Good	Not so good
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Neck	
Good	Not so good
  	  

Evaluate the photos below and identify why it is good and not so good?

Petiole	
Good	Not so good
	
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Bunch with rachis and buds	
Good	Not so good
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Male bud shape	
Good	Not so good
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Flowers	
Good	Not so good
	
	
	

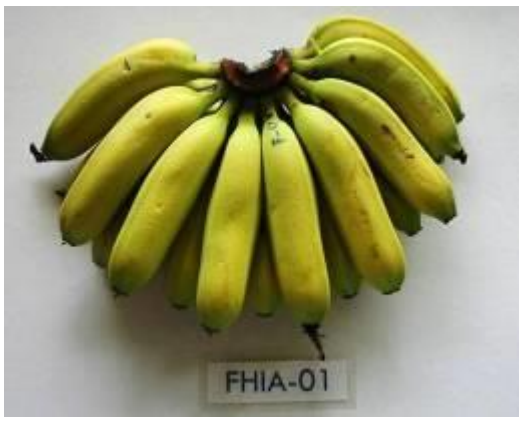
Evaluate the photos below and identify why it is good and not so good?

Bunch close-up	
Good	Not so good
 	 

Evaluate the photos below and identify why it is good and not so good?

Leaves	
Good	Not so good
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Hands/Fruits	
Good	Not so good
	
	
	

Evaluate the photos below and identify why it is good and not so good?

Fingers	
Good	Not so good