The 2016 Global Strategy for the Conservation and Use of *Musa* Genetic Resources – key strategic elements

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Abstract

The Global Strategy for the Conservation and Use of *Musa* Genetic Resources (hereafter referred to as the 'Global Strategy') has been expanded in 2016 by *Musa* genetic resources and breeding experts within the framework of the Global *Musa* Genetic Resources Network, MusaNet. MusaNet's mandate is to oversee the further development and monitoring of the implementation of the Global Strategy. The updated Global Strategy aims to provide a clear framework and roadmap to be used by the *Musa* community for the efficient and effective conservation of the globally important collections of *Musa* and to strengthen the utilization of the genetic resources toward an increased use of available diversity. It includes recommendations and priorities indicated in several consultation processes following the 2006 Global *Musa* Strategy and particularly the expertise and key groups represented, including the Regional Research Networks (BAPNET, BARNESA, Innovate Plantain and MusaLAC) and global networks such as ProMusa. The Global Strategy covers numerous topics dealing with *Musa* genetic resources, with the 12 chapters divided into four main parts: Diversity, Identity, Management and Use. Each chapter contains the sections titled *Where we are now, Where do we want to go and How will we get there*. For *Musa* researchers, including taxonomists and breeders, but also end users such as farmers, decisions on the management of banana diversity are often made with limited information. With this in mind, the Global Strategy is a core reference on the taxonomy, characterization, evaluation and genetic improvement of cultivars, leading to actions such as the selection of new and improved cultivars. The use of a more diverse genepool can lead to higher production while at the same time promote ecosystem services such as resilience to pest and disease and the effects of climate change.

Keywords: Banana, conservation, Genetic Resources, *Musa*, Global Strategy, use

INTRODUCTION

The 2016 Global Strategy for the Conservation and Use of *Musa* Genetic Resources (hereafter referred to as the 'Global Strategy') aims to provide a clear framework and roadmap to be used by the *Musa* community for the efficient and effective conservation of the globally important collections of *Musa* and to strengthen the utilization of the genetic resources. It includes recommendations and priorities indicated in several consultation processes following the first Global Strategy (INIBAP 2006) and particularly by the key groups represented, including the Regional Research Networks BAPNET[1] , BARNESA[2] , InnovatePlantain, MusaLAC[3], and the global

[1] Banana Asia-Pacific Network

network ProMusa[4]. The 2016 Global Strategy therefore builds on the foundation of the 2006 Global Strategy, which mainly focused on *ex situ* conservation, to encompass numerous priority actions in the areas of *in situ* and on-farm conservation, germplasm evaluation and genetic improvement.

The vision of the Global Strategy is a world in which *Musa* genetic diversity is secured, valued and used to support livelihoods of hundreds of millions of farmers through sustainable production and improved food and nutrition security.

To achieve these goals, it includes actions that aim to:

1. assess *Musa* genetic diversity and correctly identify and fill gaps in the conserved diversity
2. conserve the entire *Musa* genepool in perpetuity in *ex situ* collections, *in situ* in the wild and on farms, and enable access to this material
3. maximize the use of genetic diversity through comprehensive characterization and identification of the accessions and their evaluation
4. apply genomics tools to banana to better support breeding and
5. document the conserved germplasm and make the information easily accessible to users.

The Global Strategy proposes a collaborative framework for activities on the conservation and use of *Musa* genetic resources. It covers numerous topics, with the 12 chapters divided into four main parts: *Diversity*, *Identity*, *Management* and *Use* (figure 1). It concludes with a section summarizing actions to be taken, and then a series of annexes of important complementary information.

This article generally follows the structure of the full Global Strategy document, which is published on the MusaNet website (see www.musanet.org). We will focus in this article on two parts: *Where We Are Today* and *How Will We Get There* and then explain how this Global Strategy will be implemented through MusaNet, the Global Network for *Musa* Genetic Resources.

[2] Banana Research Network for Eastern and Southern Africa
[3] Plantain and Banana Research and Development Network for Latin America and the Caribbean
[4] Knowledge sharing platform on bananas (www.promusa.org)

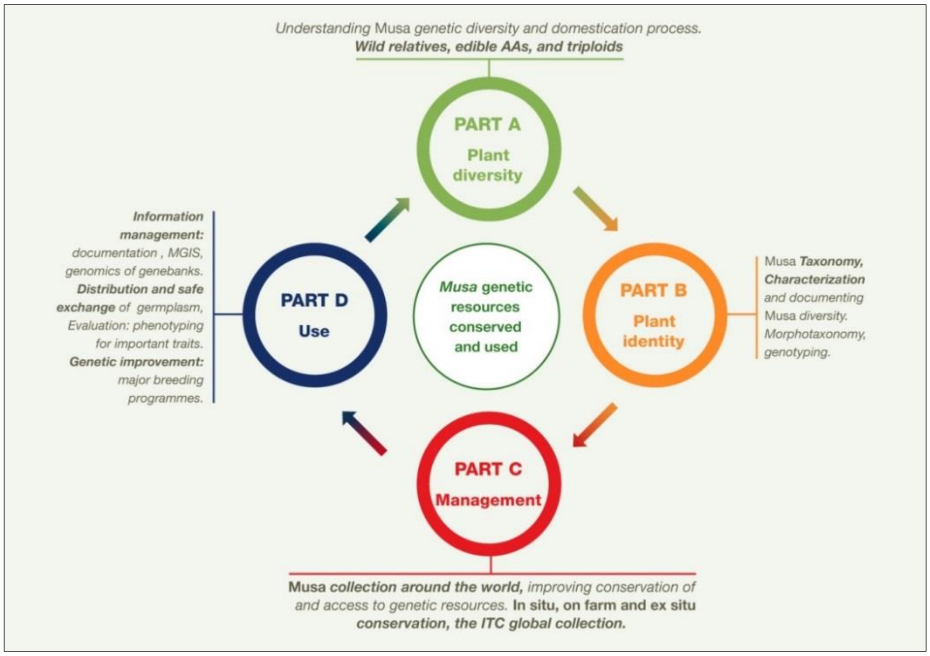

Figure 1. Diagram showing the main components of the Global Strategy.

WHERE WE ARE TODAY

Part A –Diversity

Bananas belong to the genus *Musa*. The wild species are divided in two sections: Musa (formally Eumusa and Rhodochlamys) and Callimusa (formally Callimusa and Australimusa) with origins in Southeast Asia and the Pacific, as shown on figure 2 (Häkkinen et al 2014).

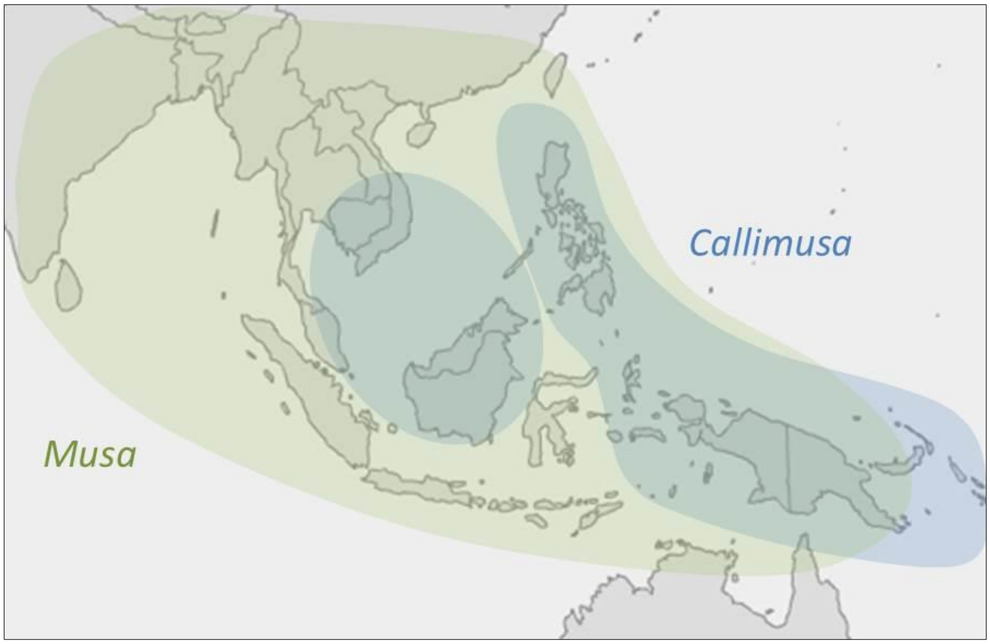

Figure 2. Centres of origin in SE Asia of the two sections of the genus *Musa.*

We estimate that globally there are around 70 species and close to 1,000 cultivars of banana (INIBAP 2006). The process of domestication goes from wild diploids to edible diploids and then triploids. Varieties of the species *Musa acuminata* have been domesticated to eventually produce a non-seeded fruit with sufficient pulp. During this slow process, some descendants crossed with *Musa balbisiana*, and the resulting cultivars commonly contain one or more A or B genomes, classified in genomic groups as diploids (AA and AB), as triploids (AAA, AAB, ABB), and as some rare tetraploids (AAAA, AAAB).

Part B –Identity

Musa taxonomy has been a subject of research since the 19th century. The most important wild ancestor of edible bananas, *M. acuminata*, has been extensively studied; however, the overall classification of the genus is a challenge, for which taxonomists rely on standardized characterization tools. Morphological characterization is the qualitative description of the plant that allows us to classify an accession[5] in a specific group and subgroup[6] using references such as Descriptors for Banana (IPGRI-INIBAP/CIRAD 1996). A Taxonomic Reference Collection (TRC) has been established in field collections in the different regions as a tool to help resolve some taxonomic issues and improve the usability of the morphological descriptors. Molecular characterization aims to find DNA sequences that reveal differences between cultivars and allow for the clustering of similar accessions (see figure 3). Molecular markers speed up the process (e.g. using the SSR, the DArT, and the SNP), but they cannot adequately distinguish differences within subgroups (e.g. Hippolyte et al 2012, Sardos et al. 2016; Christelova et al. 2016).

5 An accession is a new germplasm sample added to an existing collection.
6 Subgroup: For bananas, a subdivision of a Group for a set of cultivars that are assumed to have been generated from a common ancestor by somatic mutation. The ancestor is assumed to be a hybrid between two distinct parents (proved in the case of Cavendish subgroup).

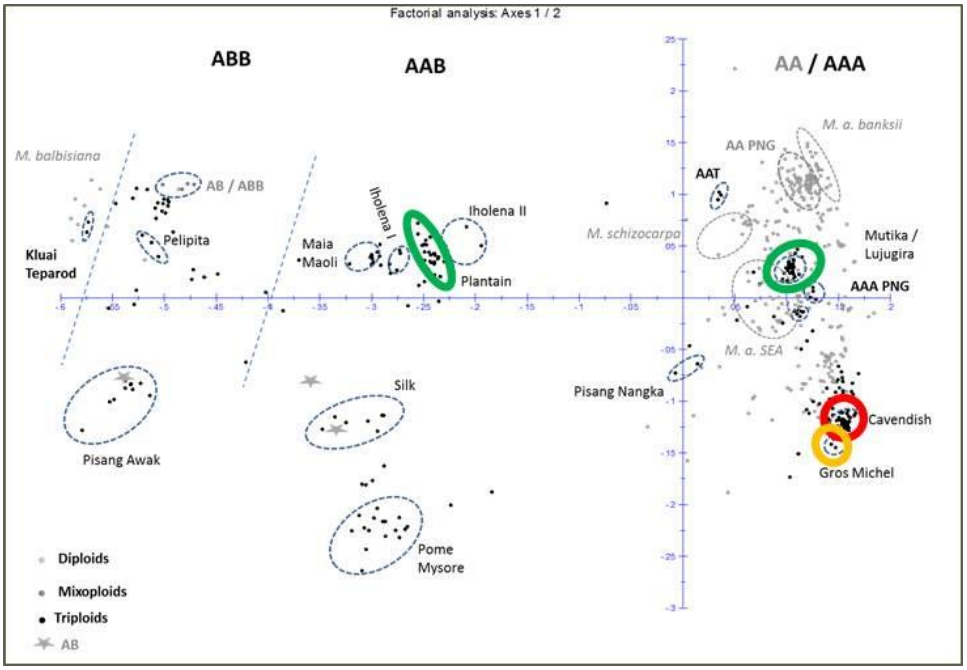

Figure 3**.** Subgroups highlighted using data obtained from the genotyping of 575 *Musa* accessions with 498 DArT markers (Sardos et al. 2016).

Part C – Management

Globally, there are currently around 60 *ex situ* collections conserving ~15,000 *Musa* accessions mainly in the field (Bioversity's Global *Musa* Survey 2012-15). The field collections are important for taxonomic characterization, evaluation, training and breeding purposes, and are therefore an essential part of a global system for the conservation and use of the diversity. Germplasm is managed under a range of conditions and standards, and most have an urgent need for support. For example, field collections are highly vulnerable to pests, diseases, natural and other disasters, or changes in land-use, and need regular replanting (regeneration).

The Bioversity International *Musa* Germplasm Transit Centre (ITC), based at the Katholieke Universiteit Leuven (KULeuven) in Belgium, is the largest *ex situ* collection with ~1,500 accessions stored *in vitro*, ~980 accessions cryopreserved, and a lyophilized leaf tissue bank. It acts as a global safety backup for partner collections and a transit centre for clean, healthy germplasm. It is closely linked with many national collection partners and collaborates on research and capacity building in conservation methods.

In situ and on-farm conservation of *Musa* diversity is critically important as it ensures that the evolutionary processes of wild species and traditional cultivars are maintained in a dynamic way. Unfortunately*, in situ* and on-farm genetic resources have been less studied than *ex situ* resources and they are under threat due to habitat loss. There is clearly a need to link *ex situ* and *in situ* conservation efforts in a more methodical and comprehensive way (Bioversity International 2014).

Part D – Use

A wide range of *Musa* diversity is held in the many collections supported by national research programmes, and the ITC holds the most comprehensive set of banana diversity that is available to all users for which the health status is guaranteed. For conserved material to be exchanged, it first needs to be free of pests and pathogens including fungi, bacteria, viruses and insects. Every country is dependent on genetic resources from other countries for their own needs, and so the International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA), which came into force in 2004, has set out the conditions for access and benefit-sharing in a Standard Material Transfer Agreement (SMTA). However, more needs to be done at the regional and national levels to allow more exchange of clean planting material within the multilateral system.

Plant material is of little use without associated information and the management of this information varies widely among collections. Many tools are used to document collections (e.g. databases, spreadsheets and paper). The *Musa* Germplasm Information System (MGIS) (https://www.crop-diversity.org/mgis) can serve as a data management tool for collections, and its main objective is to share accession-level information with users. Users can also request germplasm from the ITC via the MGIS online ordering tool.

Breeders and other researchers require readily available and comprehensive evaluation data to select germplasm for further studies, for use in breeding programs or for testing with farmers and other end-users. Standardized data on agronomic traits, host reaction to pests and diseases and abiotic constraints, post-harvest characteristics and quality (and an integration of the available knowledge) are crucial to help scientists and potential end-users select the right materials.

The five main breeding programmes described in the Global Strategy are the *Centre Africain de Recherche sur Bananiers et Plantains* (CARBAP, Cameroon), the *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD, Guadeloupe), *Empresa Brasileira de Pesquisa Agropecuária* (EMBRAPA, Brazil), the *Fundación Hondureña de Investigación Agrícola* (FHIA, Honduras) and the International Institute of Tropical Agriculture (IITA, Uganda). Because genetic improvement of banana is a long-term operation, the relative amount of improved hybrids is still low, and is not meeting the multiple needs for better alternatives to the local traditional cultivars where they are needed.

HOW WILL WE GET THERE

Part A – Diversity

There is a need to refine the taxonomic classification of *Musa*. The variation among wild species and subspecies is still poorly known, and there is a need to organise the progressive collection of the complete genetic diversity of wild species from Indonesia, Myanmar, Indonesian New Guinea and East Africa. A priority concerning the taxonomy of wild species is to fully assess the diversity of *M. acuminata* and *M. balbisiana,* as they are the ancestors of most cultivars and thus have great potential influence on genetic improvement.

Part B – Identity

The key to determining the taxonomy of the cultivated subgroups is the standardized characterization of the representative cultivars of each subgroup. Characterization as a tool for classification of taxa should be markedly improved in order to assess the entire *Musa* diversity. Morphological descriptors are being improved and made more specific to subgroups. There are now standard and reliable molecular techniques that reveal the identity of a given accession (e.g. SSR and Dart genotyping); however, markers still need to be developed that can reveal the differences within subgroups. New digital tools are being developed using the improved descriptors to facilitate the identification of cultivars (e.g. MusaID).

Part C – Management

A long-term goal of the *Musa* research community is that the effective conservation of maximum diversity is permanently assured through a functional network of collections that actively contribute to and benefit from shared standards, strengthened technical capacity, and effective germplasm and information exchange.

We also need a core collection of the total *Musa* diversity to be maintained in designated field genebanks, by *in vitro* storage and backed-up in cryopreservation at the ITC. The core collection can be used for local and regional training purposes for better characterization and management of cultivars in specific environments.

It is critically important that the cryopreservation of the entire ITC collection is achieved in the foreseeable future. In addition, capabilities for the long-term conservation of seeds will be expanded.

There will be increased access and targeted use of the ITC collection through continual improvements to MGIS and the online ordering system.

There is a need for better knowledge of *Musa* wild relatives and of landraces cultivated on farm to prioritise conservation. It is also vital to link *in situ* conservation practices with *ex situ* methods and to promote on-farm conservation and utilization of landraces under changing climatic conditions (Bioversity International 2014).

Part D – Use

In terms of safe exchange of germplasm, there will soon be better access to banana diversity as more material becomes available for distribution. This is due to relaxed restrictions on the distribution of ITC accessions having the B genome, based on molecular tools to genotype integrated Banana streak virus (Gayral et al., 2008; Chabannes et al., 2013, MusaNet 2015). Virus-indexing capacity will be also strengthened at the regional level.

Musa collections will be able to improve the capture and storage of germplasm information using new tools . Users will also have access to more complete and higher quality data through MGIS as more collections share their passport data and the number of links to complementary phenotyping and genomics data increase (e.g. link MGIS to the Banana Genome Hub, http://banana-genome-hub.southgreen.fr). For the benefit of its users, more collections need to share their high quality passport data via the MGIS database/portal.

Concerning evaluation, there is a need to encourage the use of banana genetic resources by different end-users, through the evaluation of the important cultivars for traits of interest under diverse environmental conditions. This can be facilitated by capturing the locally important traits using gender-sensitive participatory rural appraisal tools and methods.

Breeding programmes need to broaden their genetic base to address the numerous challenges of banana breeding. With the genome sequence data that is available (D'Hont et al 2012, Martin et al. 2016), researchers will increasingly discover more genes and their functions, which will contribute to genetic improvement. Useful genomic and phenotypic data are brought together on MusaBase (www.musabase.org), a database designed for advanced breeding methods.

IMPLEMENTATION OF THE GLOBAL STRATEGY

To implement the Global Strategy, it is important to have a strong well-organized Genetic Resources Network. MusaNet was established in 2011 and with its current 100 members is committed to overseeing the further development and monitoring of the implementation of the Global Strategy. The 2016 version of the Global Strategy is therefore the fruit of the efforts of many *Musa* scientists, and conservation and use practitioners, and is discussed regularly at regional and MusaNet Expert Committee meetings. To reach its vision (a world with *Musa* genetic resources diversity valued, secured and supporting life of those who most need them), MusaNet is building on the existing strength of national and regional collections by bringing people to optimize their efforts to conserve, add value, and promote the use and safe distribution of a wide range of genetic diversity as a foundation for further breeding or direct use by farmers.

With its five thematic groups (Conservation, Diversity, Evaluation, Genomics and Information) and representatives from all major banana-producing regions (Latin America and the Caribbean, West and Central Africa, East and Southern Africa, Asia and the Pacific), MusaNet aims to ensure the long-term conservation of *Musa* diversity on a cooperative basis, and facilitate the increased utilization of *Musa* genetic resources globally. MusaNet encourages international, regional and national public research organizations, development agencies, NGOs and the private sector to use the priorities set out herein to guide their activities and investment decisions.

The detailed Global Strategy document targeting the research community is available as well as the Global Strategy Summary Booklet. Both documents are downloadable at http://www.musanet.org/global-musa-strategy and a printed copy of the summary booklet can be requested by contacting musanet.secretariat@gmail.com.

CONCLUSION

The Global Strategy allows researchers, policy makers and farmers to make decisions based on solid and complete information on *Musa* diversity, identity, conservation and use. With this in mind, the Global Strategy is a key reference on the taxonomy, characterization, evaluation and genetic improvement of cultivars, leading to actions such as the selection of new and better cultivars. It therefore contributes to the use of a more diverse banana genepool, which can lead to higher production while promoting ecosystem services such as resilience to pest and diseases and mitigating the effects of climate change (e.g. through the use of more drought tolerant varieties).

The Global Strategy highlights some key areas of need regarding *Musa* germplasm conservation and use including: i) promoting greater exchange of clean planting material within the multilateral system; ii) increasing availability of improved hybrids; iii) further refining *Musa* taxonomic classification and characterization (particularly with regard to developing molecular markers): iv) cryopreserving the entire ITC collection; v) expanding capabilities for seed conservation ; vi) more comprehensively linking *ex situ* with *in situ* conservation efforts; vi) improving knowledge of *Musa* wild relatives and of landraces; vii) encouraging the wider use of banana genetic resources, and viii) broadening the genetic base of breeding programmes.

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