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Report of the Banana Collecting Mission to Samoa from July 22nd to August 2nd, 2019

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RESEARCH
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Genebank
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Cover page: Mr. Siasoi Paio holds a bunch of 'Fa'i Samoa Pupuka' (SAMO10), a Samoan Maia Maoli / Popoulu cultivar (AAB).



Collecting team in front of MAF Nu Station building, Apia. From left to right: Mr. Polito Keni (MAF), Ms. Julie Sardos (the Alliance), Mr. Gabriel Sachter-Smith (Consultant for the Alliance), Ms. Arshni Shandil (SPC), Mr. Parate Matalavea (MAF) and Mr. Anesone Vaai (MAF).

Introduction

Pacific Island Countries (PICs) are mother lands of unique varieties of bananas, such as the cooking varieties of the types Maoli-Popoulu (AAB) and Iholena (AAB), and the rare and unique orange-fleshed bananas of the Callimusa (former Australimusa) section known internationally as Fe'i bananas. These three types of bananas have been identified as underrepresented in the Alliance's Musa Germplasm International Transit Centre (ITC), the Global Genebank for banana genetic resources, and generally in other genebanks. This weak coverage of Pacific bananas in *ex-situ* conservation back-up facilities has put this very special diversity at risk. Indeed, nowadays, PICs are subjected to social changes inducing shifts from traditional towards western diets. These changes combined with high frequencies of natural disasters, such as hurricanes, tsunamis and drought episodes, constitute an increasing risk of irreversible loss.

In 2018, the Genebank Platform managed by the Crop Trust launched a call for a collecting campaign to occur in 2019. Given the above, it was decided to organise three banana collecting missions in the Pacific. We report here on the second 2019 banana collection mission that occurred in Samoa from July 22 to August 2, 2019. This mission was co-organised by the Alliance of Bioversity International and the International Centre for Tropical Agriculture (CIAT), hereafter referred to as The Alliance, and the Ministry of Agriculture and Fisheries (MAF) of Samoa, with the essential support of the Pacific Community (SPC).

The Independent State of Samoa (Fig. 1) is composed of two main islands, Upolu and Savai'i, and four smaller ones. It is part of Polynesia and was initially settled during the Austronesian expansion some 3,500 years ago. Nowadays, most of Samoan household livelihoods rely on a combination of subsistence and cash-cropping farming, with a recent increase of the number of households engaged in subsistence farming activities. Agriculture in Samoa is traditionally based on mixed cropping and banana is one of the staple crops (SBS 2016).

Collecting team:

- Dr. Julie Sardos, Genetic Resource Scientist (the Alliance)
- Mr. Gabriel Sachter-Smith, Banana Taxonomy expert (Consultant for the Alliance)
- Ms. Arshni Shandil, Research Technician (CePaCT-SPC)
- Mr. Tolo Iosefa, Assistant Chief Executive Officer (MAF)
- Mr. Parate Matalavea, Principal Research officer (MAF)
- Mr. Anesone Vaai, Tissue Culture senior officer (MAF)
- Mr. Polito Keni, Agronomist Research Officer (MAF)
- Ms. Anne Vezina, ProMusa Science Writer (the Alliance)

Pacific Community (SPC) team:

- Dr. Michel Ghanem, Programme leader (SPC)

ITC team:

- Dr. Nicolas Roux, ITC manager (the Alliance)
- Ms. Ines Van den Houwe, ITC curator (The Alliance)
- Ms. Els Kempnaers, Research Technician (KU Leuven)
- Ms. Annick De Troyer, Research Technician (the Alliance)

Musa Genotyping Centre (MGC) team:

- Prof. Jaroslav Dolezel: Head of the Laboratory of Molecular Cytogenetics and Cytometry (IEB)
- Dr. Eva Hribova: Scientist (IEB)
- Dr. Jana Cizkova: Scientist (IEB)

We also wish to thank administrative staff from the Alliance, MAF and SPC for their hard work in the organization of the mission. Finally, our acknowledgements are going to all farmers in Upolu who kindly accepted to share their plant material with the team and to answer our questions on their bananas.

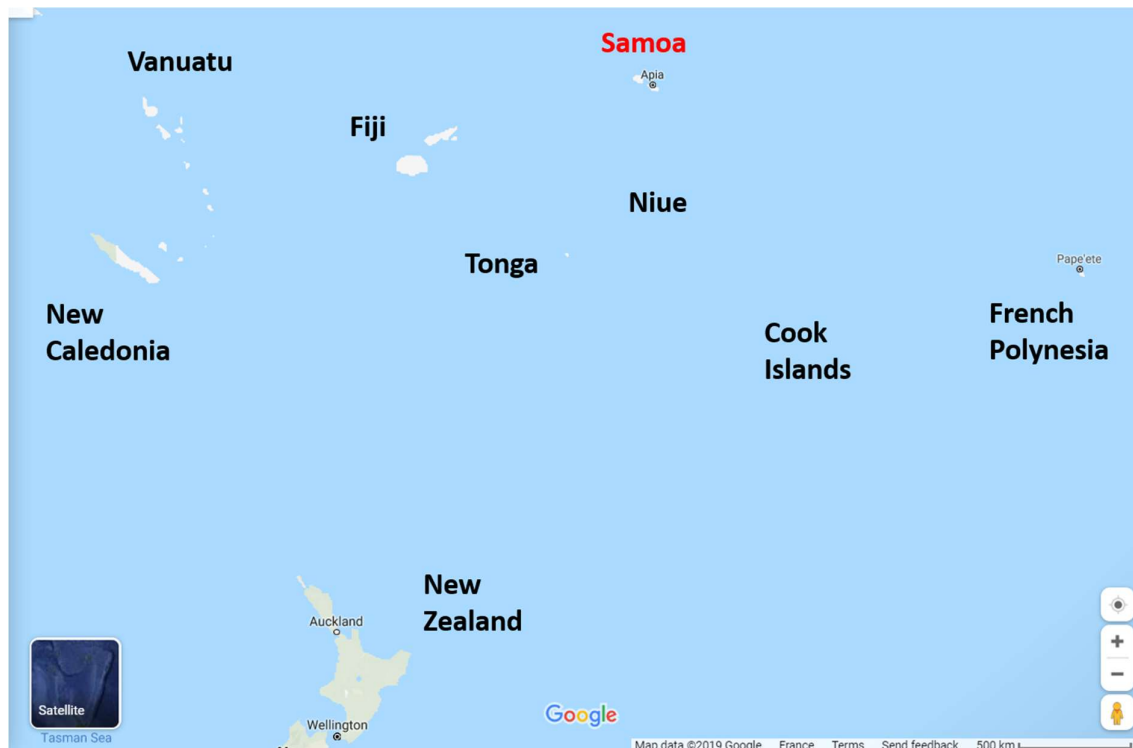


Figure 1: Map of the Pacific Islands.

Collecting plans:

- Day 1-2 (Saturday 20 and Sunday 21 of July), Visiting scientists arrive in Apia.
- Day 3 (Monday 22 of July), Visit to the Ministry of Agriculture and Fisheries; meeting with staff from the Ministry of Agriculture and Fishery; commence with collecting mission; overnight in Apia.
- Day 4-9 (Tuesday 23 to Sunday 28 of July), the activities were focused on Upolu Island (visit and collect banana from the coastal areas, valleys and hills); overnights in Apia; Sending of first batches of suckers and leaves to ITC and MGC respectively.
- Day 10 (Monday, 29 of July), collecting in Upolu, depart by boat to Savai'i in the afternoon, overnight in Savai'i.
- Day 11 (Tuesday, 30 of July), meet with local authorities to inform of the purpose of the visit; commence collecting mission and meet with selected farmers to document traditional knowledge on such bananas;
- Day 12 (Wednesday 31 of July); depart by boat to Upolu, continue with collecting mission on Upolu and documenting of Traditional Knowledge;
- Day 13 (Thursday, 1 of August), paperwork; preparation, treatment and dispatching of suckers
- Day 14 (Friday, 2 of August), restitution to local partners, paperwork, suckers sending, visiting scientists' departure

Implementation of collecting work:

Due to administrative issues, we were not able to follow the workplan agreed upon by MAF and Bioversity International before the mission. The main changes were as follow:

- No collecting occurred on Day 3 due to an exceptional holiday for MAF staff who volunteered to support the organization of the Pacific Games 2019 (Samoa, 7 – 20 of July).
- Suckers and leaf samples collected were all sent at the end of the mission. Also, parcels containing suckers and leaf samples had a long 6 day transit in Apia before being sent, affecting the quality of the plant material upon arrival at IEB and ITC.
- The team was not able to visit Savai'i and all collections occurred in Upolu island.

Other information on practical aspects:

- Quarantine services were contacted at the beginning of the first week in order to sort out requirements to get phytosanitary certificate for the banana suckers to be sent to Belgium. Several emails were exchanged between the ITC curator and Quarantine staff. The phytosanitary certificate was obtained on time for shipment at the end of the mission.
- Taking the opportunity of this mission, MAF collected suckers to enrich its own collection located at Nu station, including internationally known cultivars that were not sent to the ITC.

Method

Based on the knowledge of the local team and on information published by Daniells (1995), complemented by observations at the time of collection, we identified a set of traditional bananas that were unique to Samoa. Once we identified a given landrace, we asked the owners for permission to collect plant material for conservation purposes. Each time suckers were collected, the name of the farmer and passport data (date, place, GPS coordinates, name of the cultivars, classification based on morphology, meaning of name, origin and uses) were recorded. When possible, minimum descriptors for *Musa* (IPGRI-INIBAP / CIRAD 1996; TAG 2010) were also noted and accessions were photo documented (Fig. 2).



Figure 2: banana collecting process, a. identification of Samoa traditional cultivars, b. collection of suckers, c. passport data recording and d. photo documentation.

On day 12 (July 31), suckers were prepared for shipment to the Alliance's ITC, Belgium, according to instructions provided in Annex 1. Once all suckers were properly cut down and cleaned, they were air dried in a lab equipped with air conditioning (Fig. 3).



Figure 3: Shipments preparation, a. and b. preparation of suckers, c. prepared suckers drying and d. silica-dried leaf samples as back up for molecular studies.

Two types of leaf samples were collected: cigar leaf and a square of a young expanded leaf. The cigar leaves were kept in a cooler with ice and then in a fridge while the squares of young expanded leaves were put in tea bags within plastic bags to be silica dried. The fresh cigar leaves were then sent to the *Musa* Genotyping Centre hosted in the Institute of Experimental Botany (IEB) in Czech Republic for ploidy assessment by flow cytometry and microsatellite (SSR) genotyping. The shipment was made according to instructions displayed in Annex 2. Silica dried leaf samples were used as backups (Fig.3 d).

Results

Collecting:

In total, we collected 16 accessions comprising two intentional duplicates as we collected each of the two Fe'i landraces twice for safety duplication. Collected accessions are presented in table 1 and their position on Upolu is presented in Figure 4.

Table 1: Banana accessions collected in Samoa and shipped to the ITC, passport data and results of flow cytometry analysis. RS = Rotten Leaf Sample when arrived at the MGC.

Collecting Date	Code	Island of collection	Place of collection	Genomic composition / species (morpho)	subgroup / subspecies (morpho)	Name	Ploidy (flow cytometry)
24/7/2019	SAMO01	Upolu	Anoamaa district - Solosolo	Fe'i		Au'sulasula	RS
25/7/2019	SAMO02	Upolu	Aana#1 district - Nofoalii	AAB	Laknau	Talima	RS
25/7/2019	SAMO03	Upolu	Aana#1 district - Nofoalii	AAB	Unknown	Mamae Upolu	3x
26/7/2019	SAMO04	Upolu	Safata district - Lotofaga	AAB	Plantain - Horn	Kalua	RS
26/7/2019	SAMO05	Upolu	Safata district - Lotofaga	Fe'i		Au'sulasula	RS
26/7/2019	SAMO06	Upolu	Safata district - Fusi	Fe'i		Soa'a	RS
26/7/2019	SAMO07	Upolu	Safata district - Fusi	AAB	Maoli	Fa'i Samoa Au Lapopoa	RS
26/7/2019	SAMO08	Upolu	Lefaga district - Savai'a	AAB	Iholena	Mamae Samoa	RS
27/7/2019	SAMO09	Upolu	Aana#1 district - Faleasi'u-uta	AAB	Maoli	Fa'i Samoa Lanu Viole	3x
27/7/2019	SAMO10	Upolu	Aana#1 district - Faleasi'u-uta	AAB	Maoli	Fa'i Samoa Pupuka (or Aupupuka)	RS
27/7/2019	SAMO11	Upolu	Aana#1 district - Faleasi'u-uta	AAB	Maoli	Fa'i Samoa Au'malie	3x
29/7/2019	SAMO12	Upolu	Faleata I Sasae district - Siusega	<i>M. acuminata</i>	<i>banksii</i>	Lautaemanu Lalonea	2x
29/7/2019	SAMO13	Upolu	Faleata I Sasae district - Siusega	Fe'i		Soa'a	RS
30/7/2019	SAMO14	Upolu	Anoamaa district - Solosolo	ABB	Kalapua / Saba like	Paka Tonga (or Paka Fua Maualuga)	3x
30/7/2019	SAMO15	Upolu	Luatuanuu	<i>M. acuminata</i>	<i>banksii</i>	Lautaemanu Luatuanuu	2x
30/7/2019	SAMO16	Upolu	Aana#1 district - Nofoalii	AA		Fa'i Fia Misiluki	RS



Figure 4: Positions of the *Musa* accessions collected in Upolu.

According to local farmers, the two Fe'i cultivars 'Au'sulasula' (SAM001 and SAM005) and 'Soa'a' (SAM006 and SAM013) differ from each other in the size of their bunches, 'Soa'a' having a much bigger bunch than 'Au'sulasula', and on the habit of their leaves which may be more erect for 'Au'sulasula'. The shape of their fruits and the size of their pedicels also differs, 'Au'sulasula' having shorter and fatter fruit and longer pedicels than 'Soa'a' (Fig. 5).



Figure 5: Photos of Fe'i banana in Samoa; 'Soa'a' (a. and b.) and 'Ausulasula' (c. and d.).

We collected eight AAB cultivars. In Samoa, Maia Maoli / Popoulu cultivars are named 'Fa'i Samoa'. The team collected four of them. Among those, and according to farmers, 'Fa'i Samoa Lanu Viole'

(SAMO09) whose name means 'Purple Maoli' exhibits purplish young fruits. Unfortunately, we were not able to see it at the time of collection as the bunch was too old. However, we noticed that the male flowers were unusually reddish (Fig. 6).

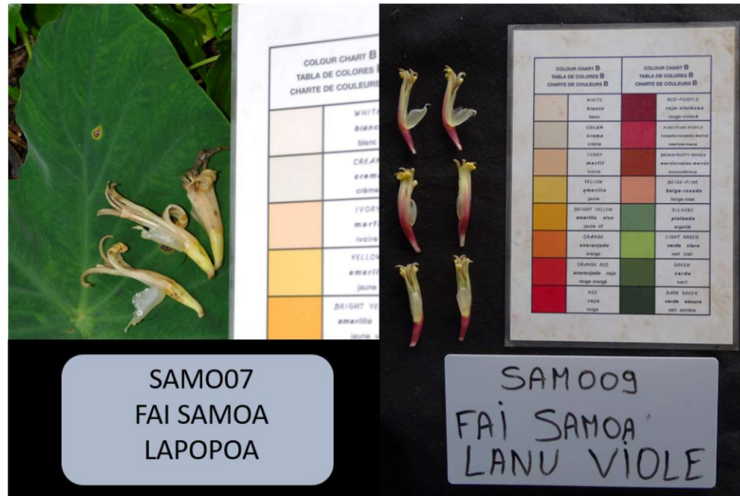


Figure 6: Male flowers of 'Fa'i Samoa Lapopoa' (SAMO07) (left) and of 'Fa'i Samoa Lanu Viole' (SAMO09) (right).

Other genotypes typical to Oceania, Iholenas, are named Mamae in Samoa. We collected two of them but noticed that only 'Mamae Samoa' (SAMO08) exhibited a typical Iholena morphotype while 'Mamae Upolu' (SAMO03) was different (Fig. 7)



Figure 7: a. bunch of the Iholena accession 'Uzakan' (ITC0825) in USDA-ARS in Puerto Rico (Irish et al. 2016) and b. bunch of 'Mamae Upolu' (SAMO03).

Two additional AABs, one Laknau and one Plantain of Horn type named ‘Talima’ (SAMO02) and ‘Kalua’ (SAMO04) respectively, were collected. An ABB potentially related to the Saba cultivars of South-East Asia was also collected (‘Paka Tonga’ SAMO14) along with a diploid AA named ‘Fa’i Fia Misiluki’ (SAMO16), which means ‘Banana Misiluki-like’. ‘Misiluki’ is the generic name for small and sweet dessert bananas, mostly Mysore (AAB genomic composition).

The Samoan islands are the only Pacific Islands Countries, beside Papua New Guinea, where the wild banana *Musa acuminata* ssp. *banksii* is present (Simmonds 1956). It is locally named ‘Lautaemanu’ which literally means ‘Bird poops’, referring to the way its seeds are spread. ‘Lautaemanu’ was used as a trap for bird hunting, which explains why it is sometimes kept in cultivated areas. As stated by Simmonds (1956), all specimens met during the mission had red male buds (Fig. 8). We collected two accessions of ‘Lautaemanu’ (SAMO12 and SAMO15) and we noted that SAMO12 was partially parthenocarpic (Fig. 9).



Figure 8: *M. acuminata* ssp. *banksii* specimen from Samoa.

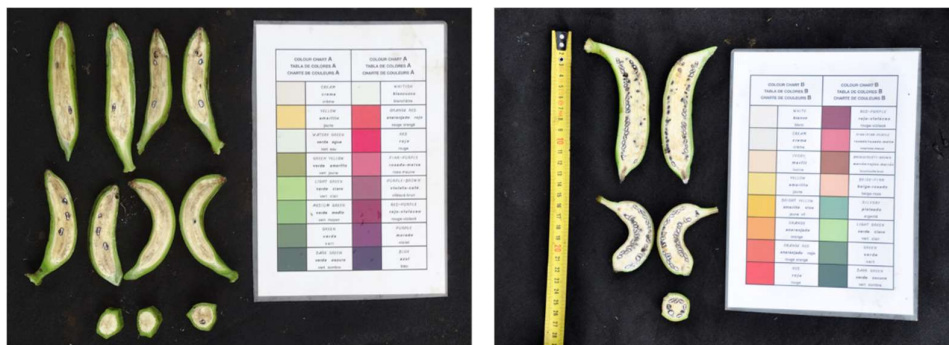


Figure 9: Fruits of *M. acuminata* ssp. *banksii* collected in Samoa. Accession SAMO12 (left) exhibits partially parthenocarpic fruits, i.e. some flesh development despite few seeds. SAMO15 (right) exhibits pollinated and fully developed fruits.

Conclusion:

Traditional bananas of Samoa were not that difficult to find and collect. Overall, traditional crops in Samoa are still cultivated and consumed, as witnessed by the richness and diversity of crops found in Apia’s markets (Fig.10). In addition to keeping their culture, and their crops, alive, Samoan people have also incorporated them into westernized recipes and types of food. It is quite common for example to find taro (*Colocasia esculenta*) fries or banana burgers on restaurant menus. In the same way, Maia Maoli / Popoulu bananas, which have an appealing yellow flesh, are used to produce banana chips (Fig.11).



Figure 10: Yams (*Dioscorea spp.*), breadfruits (*Artocarpus altilis*), taros (*C. esculenta*) and Maoli bananas (*Musa spp.* - AAB) sold in Apia's Fugalei market.

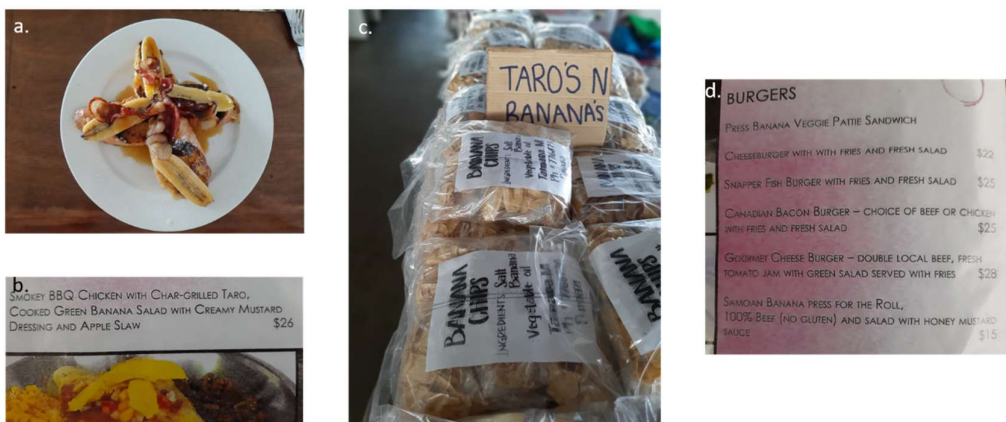


Figure 11: In Apia’s restaurants, a. 'French toasts' topped with cooked 'Misiluki' bananas, b. and d. bananas and taro are incorporated into western recipes. c. Taro and banana chips sold in Apia’s Fugalei market.

An interesting feature in Samoa is the naming of food crop varieties, including bananas. Contrary to what is seen in other Pacific countries, the use of a country, island or region name to designate a given variety is not linked to its presumed origin but to the way it is appreciated by people. Preferred cultivars are given names of Samoa or Samoan places (e.g. 'Mamae Upolu') while less appreciated ones are given names of foreign countries (e.g. 'Paka Tonga'). Therefore, it is important in Samoa not to presume the origin of a cultivar based on its names.

Following this expedition, MAF continued the collection of banana cultivars in the country in order to enrich the banana collection of Nu Station. Administrative issues hampered the visit of Savai'i island by the team but it would be interesting to investigate the diversity of bananas there too.

Photos credit: Unless otherwise specified, photos were taken by G. Sachter-Smith, J. Sardos or A. Shandil.

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Many thanks to all administrative staff of The Alliance and the Ministry of Agriculture and Fisheries of Samoa for their support in organizing this mission. We also thank Mrs. Rachel Chase from The Alliance for final edits and correction of the document. Finally, we acknowledge all donors who supported this work through their contributions to the CGIAR Fund (<https://www.cgiar.org/funders/>), and in particular to the CGIAR Genebank Platform. We also thank the CGIAR Research Program on Roots, Tubers and Bananas (RTB) for its support.

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Annex 1: Guidelines for the shipment of banana's suckers to the International Transit Centre

Select at least two (preferably three) young suckers taken from a healthy mother plant for each of the collected varieties to be duplicated at the ITC.

The suckers should be cleaned: remove all soil, roots and external leaves and cut back to a size of about 10x10x10 cm. Carefully label each individual sucker with the accession name and its collection code.

The suckers should be wrapped individually in a few layers of paper (e.g. newspaper) to absorb moisture. Closed plastic bags are to be avoided as those will enhance the growth of mold on the tissue.

Pack the suckers in a strong cardboard box. Paper cushioning is excellent for filling empty spaces. Enclose inside the box a *packing list*, an *original commercial invoice* and the *original phytosanitary certificate*. Attach to the outside of the box copies of all documents and please send copies of all documents by email to the ITC as soon as the material is dispatched. It is important that the suckers are not exposed to very high or very low temperatures during transportation and that the parcel reaches its destination preferably within one week after its dispatch. Use a courier service (e.g. DHL or FedEx). Air-cargo is suitable too.

Regarding the plant sanitary requirements to import banana suckers into Belgium, no import permit is required, only an original phytosanitary certificate from the exporting country is needed. This document should include the botanical name of the plant material and the number of samples (suckers) to be exported. According to the EU regulations, for banana suckers, the certificate should include an additional statement that:

1.

(a) the plants originate in areas which have been found free from *Pseudomonas solanacearum* (Smith) Smith; or

(b) no symptoms of *Pseudomonas solanacearum* (Smith) Smith have been observed on the plants at the place of production since the beginning of the last complete cycle of vegetation.

2.

(a) the plants originate in a country known to be free from *Radopholus citrophilus* Huettel *et al.* and *Radopholus similis* (Cobb) Thorne; or

(b) representative samples of soil and roots from the place of production have been subject, since the beginning of the last complete cycle of vegetation, to official nematological testing for at least *Radopholus citrophilus* Huettel *et al.* and *Radopholus similis* (Cobb) Thorne and have been found, in these tests, free from those harmful organisms.

Annex 2: Guidelines for shipments of fresh leaf samples to the Musa Genotyping Centre (MGC)

Sending fresh banana material

...step by step...

...Step one...

1. Please, cut fresh cigar leaves (A)
or use young fresh leaves (B)
at required weight



Please, do not use
old leaves (C) !!!!



Step two – preparation leaves for sending

You will need:

- Paper tissue
- Distilled water
- Plastic bag
- Cooling blocks
- Polystyrene box



Wrap the cigar leaves in moistened paper tissue (D) and place them in a not-sealed plastic bag (E, F). Mark the leaves or plastic bag (name of cultivar, accession code, ...).



Do not use sealed bag (G)!!!



...Step three...

Put the bag with banana leaves into a polystyrene box and add cooling blocks to avoid tissue damage (H)



Please, follow our instructions strictly to avoid damage of leaf tissues during the transport. Below are examples of damaged leaves that are not useful for further analysis.

