



# Report of the Banana Collecting Mission to Rarotonga and Aitutaki, Cook Islands

20 May to 31 May, 2019

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Group picture taken in Takuvaine Valley (Rarotonga), from left to right: Ms. Celine Dyer, Mr. Ngatokorima Maireroa, Ms. Julie Sardos, Mr. Gabriel Sachter-Smith (in front), Mr. Moe Tutira, Mr. Edwin Apera, Mr. Teariki (Sene) Turua. Photo credit: G. Sachter-Smith.

Front cover photo credit: J. Sardos (Utu banana on Rarotonga)

## Introduction

In the last few decades, Pacific Islands Countries (PICs) have experienced serious shifts in their diets, turning from the consumption of traditional, locally grown agricultural products to the consumption of imported foods. This shift in lifestyle has not only impacted nutrition and health, with high prevalence of non-communicable diseases directly linked to the increased consumption of nutrient-poor foods, it has also induced a serious decline in the use of local food varieties, including traditional banana cultivars.

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 orange-fleshed bananas of the *Callimusa* (former *Australimusa*) section known internationally as Fe'i bananas. These three types of bananas have been identified as largely underrepresented in genebanks, including Bioversity's International *Musa* Germplasm Transit Centre (ITC), the global genebank for banana genetic resources. This weak coverage of Pacific bananas in *ex-situ* conservation back-up facilities has put this very special diversity at risk. Moreover, not only subjected to social change, PICs are vulnerable to natural hazards, such as hurricanes, tsunamis and drought episodes, which result in irreversible loss of biodiversity.

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 focus on Pacific bananas and the first collecting expedition of this campaign took place in Cook Islands (Fig. 1) from 20-31 May 2019. The mission was co-organised by Bioversity International and the Ministry of Agriculture of Cook Islands, with the essential support of the Pacific Community (SPC).

We present here a report of the mission, including the shipment, reception and processing at the ITC of the collected accessions. We also present the first results of the molecular characterization obtained by the *Musa* Genotyping Centre (MGC) hosted in the Institute of Experimental Botany (IEB – Czech Republic) to whom fresh leaves were sent concomitantly to the mission.

**Location:**

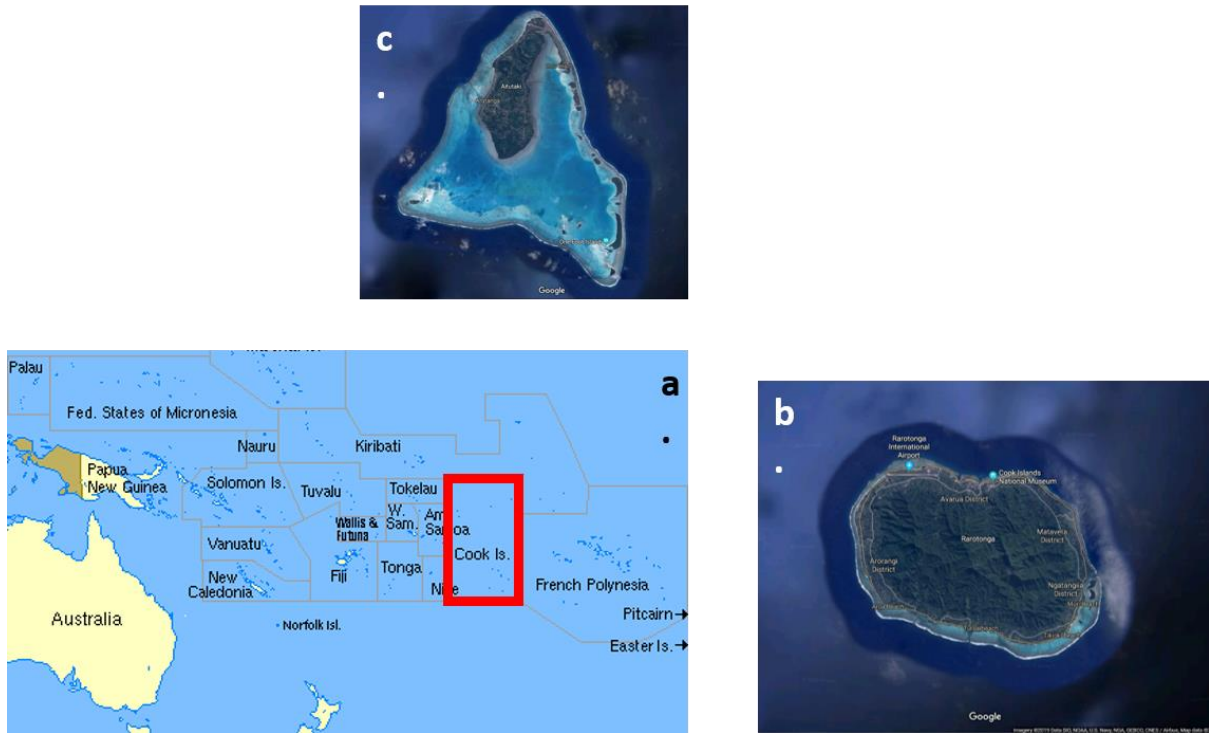


Figure 1: a. Cook Islands in the Pacific region; b. Rarotonga; c. Aitutaki

**Collecting team:**

- Mr. William Wigmore, Director of Crop Research (Ministry of Agriculture of Cook Islands)
- Mr. Teariki (Sene) Turua, Ministry of Agriculture of Cook Islands
- Dr. Julie Sardos, Genetic Resources Scientist (Bioversity International)
- Mr. Gabriel Sachter-Smith, Banana taxonomy expert (Consultant for Bioversity International)
- Dr. Michel Ghanem, Programme leader (SPC) - excused

**ITC team:**

- Dr. Nicolas Roux, Manager (Bioversity International)
- Ms. Ines Van den Houwe, Curator (Bioversity International)
- Ms. Els Kempenaers, Research Technician (KU Leuven)
- Ms. A. De Troyer, Research Technician (Bioversity International)

**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)

### **Supporting teams:**

In Rarotonga, the team benefited from the essential support of Ngatokorima Maireroa, Ngatamariki (Moe) Tutira and Edwin Apera from the Ministry of Agriculture. Ms. Celine Dyer from the Climate Change Office shared her precious knowledge on Fe'i bananas (locally named Utu or Ve'i) growing in Takuvaine valley and allowed the collection of suckers from her private plantation. In Aitutaki, the team was greatly assisted by Fred Charlie, Pepe Raela, Victor Ioane, Ben Samuel and Jamayne Loane from the Agriculture Department of the Aitutaki Island Administration Office. In Mangaia, Mr. Atetu Atetu from the Agriculture Department collected a rare Maoli banana and sent it to the team in Rarotonga (COOK015). According to information received during the final meeting with the Aitutaki Island Council on May 30<sup>th</sup>, the Maoli banana collected by Mr. Atetu Atetu on Mangaia was most likely introduced from Aitutaki during the 1970's. This particular variety is no longer found on Aitutaki.

Overall, we are extremely grateful to all the women and men in Rarotonga and Aitutaki who answered our questions and provided samples and suckers from their plants.

### **Collecting schedule:**

- Day 1 (Sunday 19 May), Visiting scientists arrive in Rarotonga
- Day 2 (Monday 20 May), Visit to the Ministry of Agriculture; meeting with the Secretary and the technicians from the Ministry of Agriculture; commenced with collecting mission; overnight in Rarotonga
- Day 3-9 (Tuesday 21 to Sunday 26 May), the activities were focused on Rarotonga Island (visit and collect banana from the coastal areas, valleys and hills); overnights in Rarotonga
- Day 9 (Monday 27 May), departed at 1030 by plane to Aitutaki, met with the Mayor, Island Council, Executive Officer and Agriculture Manager to inform them of the purpose of the visit; overnight in Aitutaki
- Day 10 (Tuesday 28 May), commenced collecting mission and met with selected farmers to document traditional knowledge on bananas
- Day 11 (Wednesday 29 May), continued with the collecting mission and documenting of traditional knowledge; overnight in Aitutaki
- Day 12 (Thursday 30 May), departed for Rarotonga at 0920, paperwork; preparation, treatment and dispatching of suckers
- Day 13 (Friday 31 May), restitution to local partners, paperwork, suckers sending, visiting scientists' departure

### **Traditional Bananas of Cook Islands:**

According to the preparation work from the Ministry of Agriculture and to literature, we expected to find six landraces belonging to the Maia Maoli and Popoulu types, two varieties belonging to the Plantain group, which is usually a type of banana specific to Africa, and one tetraploid cultivar somewhat similar to 'Giant Kalapua' in PNG (Wigmore, pers. com. on Fig. 2; Daniells, 1995). In

Rarotonga, two types of Fe'i, locally named Utu, were also described in the past, including one with a waxy pseudostem, a very unusual feature for this type. This last Utu variety, named Pou tu, was described as growing not very commonly in the upper valley (Wilder, 1931). In Aitutaki, Fe'i are named Ve'i but we didn't find detailed description of the different cultivars of this type of bananas.

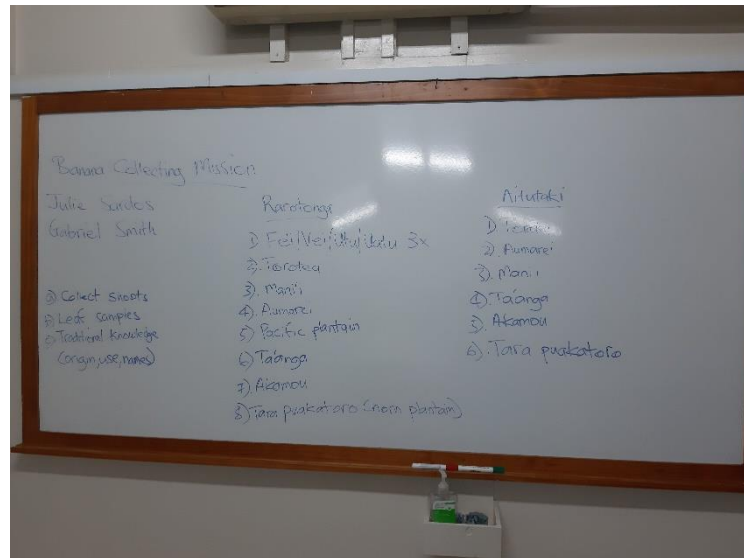


Figure 2: List of banana varieties to collect as set up for the launch meeting of the mission

## Methods:

The diversity of bananas observed in Rarotonga and Aitutaki will be described in a separate catalogue. Here, we will only discuss the varieties that were collected for safety duplication at the ITC. During the mission, suckers were taken from any accession that seemed new or was not conserved in the ITC. In parallel, we also sampled fresh cigar leaves to send to the *Musa* Genotyping Centre (MGC) for flow cytometry and SSR analysis and we silica-dried portions of young leaves to be later processed through Next-Generation sequencing genotyping. Protocols for sending suckers to the ITC and fresh cigar leaves to the MGC are detailed in Annex 1 and Annex 2, respectively. To ensure that both suckers and fresh leaves would arrive in good condition, two shipments were made. One at the end of the first week and the second one at the end of the second week of the mission.

The process for the collection of suckers is described in Figure 3. Based on morphological features and local knowledge, the identity of the banana plant was assessed. In the case of an original variety identified as not safety duplicated in the ITC, suckers were collected and a description was made using the minimum set of descriptors and the minimum set of pictures for banana characterization (TAG, 2010). Suckers were then labelled and stored. Twenty-four hours to two days before shipment, the suckers were cut into pieces of approximately 10 x 10 cm, cleaned of soil, and carefully labelled (both on paper bag and a number was carved on the sucker). Suckers were then air dried using a fan for a minimum of 24 hours. They were finally wrapped into several layers of journal paper for shipment.

### 1 - Identify



### 2 - Collect & describe



### 3 - Prepare & label



### 4 - Air dry



### 5 - Pack & send



Figure 3: Collection process

**Results:**

In total, 18 accessions were collected, including 7 Fe'i, 4 Maoli (AAB), 2 Popoulu (AAB), 2 Plantain (AAB) and an ABB-like tetraploid. A red Mysore (AAB) and a hybrid diploid (AA) were also collected on Rarotonga. Classifications based on plants morphology were confirmed by flow cytometry; SSR genotyping is on-going. The accessions collected, location of collections and flow cytometry results are compiled in Table 1. Locations of the collected accessions are also plotted on Figure 4 (Rarotonga) and Figure 5 (Aitutaki).



*Figure 4: Locations of accessions collected on Rarotonga.*



*Figure 5: Locations of accessions collected in Aitutaki.*



Table 1: Banana accessions collected in the Cook islands

Code	Name	Genomic composition (morpho)	subgroup (morpho)	Island of collection	Place of collection	Ploidy (flow cytometry)
COOK001	Utu Vaairua*	Fe'i		Rarotonga	Turangi district - Ngatangiia	2x
COOK002	Utu Marua*	Fe'i		Rarotonga	Takuvaine valley	2x
COOK003	Utu Anikitao*	Fe'i		Rarotonga	Takuvaine valley	2x
COOK004	Titikaveka red*	AAB	Mysore	Rarotonga	Tikioki - Matapo	3x
COOK005	Utu turoa*	Fe'i		Rarotonga	Turoa village	2x
COOK006	Utu Tekou 1*	Fe'i		Rarotonga	between Takuvaine valley and Tekou peak	2x
COOK007	Utu Tekou 2*	Fe'i		Rarotonga	between Takuvaine valley and Tekou peak	2x
COOK008	Aumarei	AAB	Maoli	Aitutaki	Ureia	3x
COOK009	Torotea	AAB	Maoli	Aitutaki	Ureia	3x
COOK010	Mani'i	AAB	Maoli	Aitutaki	Ureia	3x
COOK011	Ve'i Ooka*	Fe'i		Aitutaki	Ooka	2x
COOK012	Tara Puakatoro	AAB	Plantain - False Horn	Aitutaki	Vaipae	3x
COOK013	Tara Puakanio	AAB	Plantain - French	Aitutaki	Vaipae	3x
COOK014	Akamou	AAB	Popoulu	Rarotonga	Papua (Wigmore's) waterfalls (ancient banana collection)	3x
COOK015	Maori Atetu*	AAB	Maoli	Mangaia		3x
COOK016	Ta'anga	AAB	Popoulu	Rarotonga	Papua (Wigmore's) waterfalls (ancient banana collection)	3x
COOK017	Rekua	ABB-like tetraploid		Rarotonga	Matavura (current banana collection)	4x
COOK018	Indian banana Takuvaine*	AA	likely hybrid from a breeding programme	Rarotonga	Takuvaine	2x

\*Names given by material providers

### Fe'i bananas:

All of the Fe'i but one, COOK011, were collected on Rarotonga.

Ms. Celine Dyer, from the Climate Change Office, had gathered several Fe'i varieties growing feral in the forests located deep in Takuvaine valley and planted them on her private land. Celine mentioned three types of Utu growing on her land, differentiated by their fruits. The first discriminatory characteristic being the occurrence or absence of cracks on the fruits' peel, the second one being the presence of seeds in a variety with crack-peels fruits. Due to the absence of fruits in many plants, we were only able to collect two of these types (COOK002 and COOK003). As no specific names were known for these varieties, COOK002 'Utu Marua' was named after Celine's great grand-mother who used to plant this variety up on the hill and COOK003 'Utu Anikitao' was named after the name of the land where Celine collected it.

Deeper in Takuvaine valley, where extensive populations of feral Fe'i are growing, two suckers were collected (COOK006 and COOK007) but may belong to the same clone. Celine also mentioned a possible variety with very round fruits growing up the mountain, but the place is not currently accessible, and we were not able to find it. However, she was not aware of any Fe'i type bearing a waxy pseudostem as described in the past (Wilder, 1931). Besides Celine's field, we found two mats of Fe'i cultivated nearby houses (COOK001 and COOK005). 'Utu Vaairua' (COOK001) was intentionally planted in the corner of a home garden, in a place where rain water accumulates. Its owner was taking great care of it, adding a lot of organic matter to the mat, as she keeps this banana in memory of her dad, named Vaairua, who was buried next to the mat. 'Utu turoa' (COOK005) was found behind a house, on a mound near a plot of water taro. Several rotten bunches were found on the mat, suggesting it was more or less abandoned. We were not able to strictly assess if these two last accessions were different from the other Fe'i collected, first, because no striking differences were observed on the vegetative parts of the plants and, second, because some differences observed on fruits (Fig. 6), such as size, could be due to the different environments in which they were growing.



Figure 6: Fruits of Utu bananas (Fe'i) collected in Rarotonga. COOK006 had no fruits at the time of collection.

Fe'i bananas are named Ve'i on Aitutaki. Only one Ve'i mat was found in the whole island (Fig. 7). This mat ensued from the only plant that survived the destruction of the last field of Ve'i in the island. No fruits were present at the time of collection. However, the owner of the mat told us that the erected bunch would eventually start going down when the bunch reached an important weight. We didn't observe this feature on Rarotonga and Celine didn't mention it either. In addition, we also noted that the sap of the Ve'i collected on Aitutaki was darker and thicker than the sap of those collected on Rarotonga. We therefore suspect that this plant is a different cultivar than those collected on Rarotonga.



*Figure 7: Last mat of Ve'i banana on Aitutaki.*

#### Maia Maoli, Popoulu and Plantain:

Three of the Maoli bananas collected were collected in Aitutaki: 'Aumarei' (COOK008), 'Torotea' (COOK009) and 'Mani'i' (COOK011) (Fig. 8), all cultivated in the same field. These three cultivars are differentiated by the color of the pseudostem and petioles, as well as by bunch characteristics, such as number of fruits and rachis shape. A fourth Maoli was sent from the island of Mangaia, COOK015

'Maori Atetu' that we named after the person who sent it. This variety is believed to differ from the three others by its more purple pseudostem. It had been introduced in Mangaia from Aitutaki some 40 years ago but we didn't find it on Aitutaki.



*Figure 8: Three Maoli bananas collected in Aitutaki, from left to right: 'Aumarei', 'Mani'i' and 'Torotea'*

We met a man on Aitutaki who used to plant some Popoulu bananas but stopped as “no one would eat them and the bunches were rotten on the plants”. We then met a woman who had just harvested hers (Fig. 9). We finally observed two Popoulu cultivars on Aitutaki, but we could not collect them on site as we were able to find only one specimen of each of the two types. Luckily, the Ministry of Agriculture of the Cook Islands had led a banana collecting exercise 10 years ago and the two cultivars were in their collection in Rarotonga, where we were able to collect them once back to the main island. The two Popoulu accessions are COOK014 'Akamou' that is recognized by a more reddish pseudostem, and COOK016 'Ta'anga' that is recognized by a greener pseudostem. Popoulu bananas are apparently not consumed a lot by locals as they are considered too dry (Wigmore, pers. com.).

The two Plantains were found planted together. One is a false horn, COOK012 'Tara Puakatoro' and its name means “cow horn”. The second one is a French type, COOK013 'Tara Puakanio' and its name means “goat horn”. Both names relate to the shape of the fruits.



Figure 9: On Aitutaki, a woman who is still growing Popoulu bananas (cooked in the dish)

### 'Rekua'

The cultivar 'Rekua' was noted by J. Daniells as an ABBB tetraploid variety from Aitutaki somewhat similar to 'Giant Kalapua' from Papua New Guinea (Daniells, 1995). We therefore investigated its presence on Aitutaki. During the time spent on this island, we had an interview with an elderly man, Mr. Kavae Manapori (Fig. 10), who talked to us about Aitutaki's bananas. During the interview, he mentioned that 'Rekua' (Fig. 11) was a very famous banana type in old times. In addition, he told us there is a chant linked to this variety that the warrior chief Purekua sang before starting a war. "*Papaia 'e Purekua te meika, a'aki koe i tetai tā, te vai ara tetai*". "Purekua beat the banana, you pick one hand, there's another left". This chant perhaps refers to a very large bunch of bananas with too many hands to count, and if you take one, you can be sure there is still another one left. This chant is still taught to kids in Cook Islands but the banana from the chant was difficult to find and Mr. Manapori didn't know where to find it. In Aitutaki, we finally identified one person who was said to cultivate it. Unfortunately, this man refused to let us see the plant and we couldn't check if it was really 'Rekua' or just a dwarf 'Pisang Awak' that can be easily confused with 'Rekua'. After some additional discussion

with the local members of the collecting team, we finally were able to find a 'Rekua' plant in Rarotonga, ironically planted on the property next to the apartment where the international team was hosted. The plant was not bearing fruits, but its vegetative traits suggested that it was a tetraploid, which was later confirmed by flow cytometry. Unfortunately, the plant was not bearing enough suckers to allow its collection. Here again, the collecting work accomplished by the Ministry of Agriculture 10 years ago was very helpful as we finally found out that 'Rekua' was collected at that time and was still growing in the collection. In the collection, the plants were also not bearing fruit but it was later confirmed as a tetraploid by flow cytometry analysis, the only one collected during this mission.



*Figure 10: On Aitutaki, Mr. Kavae Manapori kindly shared his knowledge on local bananas with the team.*



*Figure 11: 'Rekua' (COOK017) growing in a private plot on Rarotonga (left) and in the MoA's collection where it was collected (right).*

#### Plant material reception and establishment in the ITC:

Two batches of suckers were received on average 6 days after they were shipped from Rarotonga. The first shipment, sent at the end of the first week of collecting, contained COOK001 to COOK005. The second batch, sent at the end of the second and last week of the mission, contained accessions COOK006 to COOK018.

Unfortunately, and despite the dry season that normally occurs in May in Cook Islands, the collecting team experienced a lot of rain during the mission. Soils were saturated with water at the time of collection. Despite 24h-36h drying under a fan, the prepared suckers of the first batch arrived with a lot of mold (Fig 12). Upon receipt at the ITC, tissue cultures were initiated from the suckers. The explant material was disinfected, shoot tips were isolated and transferred to sterile growth medium (Fig 13). Cultures obtained from the first batch containing COOK001 to COOK005 were heavily contaminated with bacteria and required an antibiotic treatment to rescue the material. From the second batch, containing COOK006 to COOK018, that arrived in better shape, shoot tip cultures were successfully established.



Figure 12: Arrival of suckers at the ITC, first batch (left) and second batch (right)

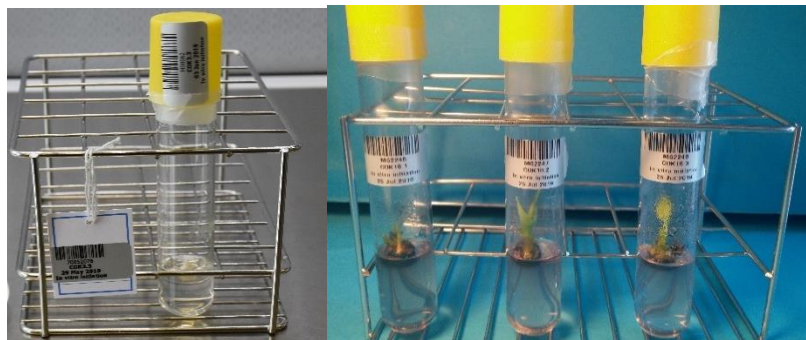


Figure 13: Initiation of shoot tip cultures (left) and shoots obtained after three months in culture (right).

### Discussion-Conclusion:

Bananas are widely cultivated in the Cook Islands. However, many of the banana plants encountered by the team were introduced varieties such as Cavendish (AAA), Pome (AAB) or Bluggoe (ABB). These introduced and widespread cultivars seem to be preferred over traditional bananas. It was reported that Cavendish is not only consumed as dessert but is also consumed cooked, mainly boiled when unripe. Overall, we observed many traditional banana plants with rotten bunches, meaning that nobody is harvesting them. Despite their high cultural value as Polynesian heritage, local traditional bananas do not seem to be valued anymore, even for Maoli / Popoulu types which are varieties with increasing popularity in countries where they were recently introduced, such as Cameroon and the Philippines (Ibobondji, pers.com ; Cuizon, pers.com). The situation of the orange-fleshed Fe'i bananas is also worrying as it is clear that only people of a certain age appreciate them, several informants mentioning that children and young people don't like them. In addition, Fe'i are known to be difficult to grow, needing good irrigation, rich soils and are very sensitive to corm weevil. By chance, the conditions in the remote areas of Takuvaine Valley seem to be favorable for their survival. The personal initiative led by Ms. Celine Dyer also taught us that the diversity of Fe'i bananas in Rarotonga is wider than mentioned in literature and may be even wider than the one observed and collected during the present project. Hopefully, the upcoming molecular analyses will enable us to provide a better overview of the Fe'i diversity collected.

This collecting mission to Cook Islands was a success and the rate of establishment of the accessions to the ITC was very good. However, ex-situ conservation alone may not be sufficient to safeguard the



diversity. Local initiatives to boost the use of these traditional banana varieties in Cook Islands would be necessary to make sure that these precious resources are still grown in the islands.

### **Acknowledgements**

Many thanks to all administrative staff of Bioversity International and the Ministry of Agriculture of Cook Islands for their support in organizing this mission. We also thank Mrs. Rachel Chase from Bioversity International 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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### **Annexes:**

Annex 1: Guidelines for sucker shipment to the ITC

Annex 2: Protocol for shipment of fresh leaf samples to the MGC

## Annex 1

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.

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.

