

**Consultancy Report on Training in the Identification and
Characterization of Banana Varieties and Development of the
Banana Industry in Pohnpei, Federated States of Micronesia:
Prepared for the Island Food Community of Pohnpei
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CONTENTS

| | |
|---|-----------|
| Executive Summary | 3 |
| 1. Introduction | 5 |
| 1.1 Background | 5 |
| 1.2 Duties/Terms of Reference | 5 |
| 1.3 Comment on Terms of Reference..... | 5 |
| 2. Physical Geography of Pohnpei..... | 6 |
| 3. Identification of Pohnpei Banana Varieties..... | 6 |
| 3.1 Background..... | 6 |
| 3.2 Details | 6 |
| 3.3 Constraints on Classification | 9 |
| 3.4 New Subgroup?..... | 10 |
| 3.5 Relationships Between Carotenoid Levels and the Classification of Varieties | 10 |
| 3.6 Management of Pohlengas Site..... | 12 |
| 3.7 Pohnpei Varieties Powerpoint Presentation..... | 13 |
| 4. Methodology for Documenting/Training Staff..... | 13 |
| 4.1 General | 13 |
| 4.2 Publications to Develop..... | 14 |
| 5. Local Banana Production and Disease Control Advice..... | 14 |
| 5.1 The Transport to Export Markets Dilemma..... | 14 |
| 5.2 New Domestic Opportunities for Nutrient-rich Varieties..... | 14 |
| 5.3 Quarantine Issues..... | 16 |
| 5.4 Fusarium Wilt..... | 17 |
| 5.5 Dealing With Black Sigatoka Leaf Disease..... | 18 |
| 5.6 Banana Streak Virus (BSV) in Pohnpei..... | 19 |
| 5.7 New Variety Opportunities..... | 19 |
| 6. Seminars/Training..... | 20 |
| 7. Acknowledgements..... | 20 |
| 8. Contact Details of Persons Met..... | 21 |
| 9. References..... | 22 |
| | |
| Table 1 Classification of Pohnpei banana varieties including those recently introduced from SPC. | 7 |
| Table 2 β -carotene content – all fruit ($\mu\text{g}/100\text{ g}$) – from Englberger <i>et al.</i> 2003a | 11 |
| Table 3 β -carotene content – all fruit ($\mu\text{g}/100\text{ g}$) from Englberger <i>et al.</i> 2003b | 11 |
| Table 4 List of fruit and nuts worthy of importation/evaluation | 16 |
| Table 5 Banana varieties recommended for importation and evaluation | 20 |
| | |
| Appendix 1 Itinerary/Schedule of Activities..... | 24 |
| Appendix 2 Pohnpei Banana Varieties – Possible Meanings of Names..... | 25 |
| Appendix 3 Rapid Field Multiplication of Varieties..... | 27 |
| Appendix 4 Guidelines to Prevent the Spread of Fusarium Wilt by Inspectors... | 28 |
| Appendix 5 Ecoport Web List of Pests and Diseases of Bananas in Pohnpei..... | 29 |
| Appendix 6 List of Photos Taken During the Consultancy | 34 |

Cover Photo – the carotenoid-rich Karat banana

Executive Summary

I visited the state of Pohnpei, Federated States of Micronesia 31 May to 10 June 2004 – the aim being to assist in the identification and characterization of Pohnpei banana varieties and in the development of the banana industry. The consultancy was arranged by the Island Food Community of Pohnpei with funding supplied by UNICEF.

While in Pohnpei I examined the 25 banana varieties in the collection at Pohlangas and an additional 14 varieties elsewhere on the island. I have classified these varieties and indicated where applicable their names in Kosrae and internationally. My classification represents about 80% of those listed by Englberger and Lorens (2004).

Recommendation 1 – That good photos of bunch/male bud and plant features of the remaining varieties be emailed to me as they become available to assist in making the classification of Pohnpei varieties more complete over time.

Recommendation 2 – That a botanical key be prepared for the correct identification of the varieties.

Recommendation 3 – That a colour booklet and CD be prepared describing all the Pohnpei varieties and their uses to further improve their appreciation.

Lois Englberger has discovered that carotenoid levels are high in a range of Pohnpei banana varieties and that the carotenoid levels correspond to the colour intensity with high levels in those with the deeper coloured flesh. However, my classification indicates that there are currently no published determinations available for several subgroups common in Pohnpei including AA Sucrier (Utin Rais), AAA Cavendish (Utin Wai), AAB Mysore (Utin Pihsi), AAB Pome (Preisihl), and ABB Pisang Awak (Kaimana).

Recommendation 4 – That carotenoid data of additional subgroups continue to be collected and synthesized to give a more complete picture of the overall situation regarding banana varieties in Pohnpei. The carotenoid levels of the new introductions from SPC should also be examined.

One purpose of the Pohlangas banana variety collection is to provide planting material of carotenoid-rich varieties to interested people.

Recommendation 5 – That a dedicated block be established of carotenoid-rich varieties for multiplication and dissemination with protocols in place to reduce risk of spread of disease in planting material.

Fusarium wilt of bananas was first identified in Pohnpei in 2001.

Recommendation 6 – That immediate action be taken to locate and to safely kill all Fusarium wilt infected banana stools to reduce disease inoculum levels and thus potential future spread of the disease.

Recommendation 7 – Consideration should be given to setting up a tissue culturing facility in Pohnpei with the capability of distributing guaranteed disease-free planting material of carotenoid-rich banana varieties.

Pohnpei has relative freedom from many important pests and diseases of banana which could seriously jeopardize banana growing. Quarantine procedures are currently in place to minimize the possibility of such incursions but additional activities would be valuable.

Recommendation 8 – That attractive quarantine posters be prepared dealing with the major banana quarantine threats to Pohnpei (and FSM generally) to assist in safeguarding the future production of Pohnpei bananas including carotenoid-rich varieties.

Recommendation 9 – That contingency plans be developed in readiness should any exotic pest/disease incursions occur.

Considerable quantities of ‘western’ foods both fresh and processed are imported and consumed in Pohnpei some of which are contributing to the health problems experienced by Pohnpeians. It is time for Pohnpeians to be more proactive in developing local, tasty, nutritionally-rich alternatives.

Recommendation 10 – Support be given to the further development of Karat banana dessert/ice cream products and their commercial manufacture and marketing.

1. Introduction

1.1 Background

I visited the state of Pohnpei, Federated States of Micronesia (FSM) 31 May to 10 June 2004. The consultancy was arranged by the Island Food Community of Pohnpei with Dr. Lois Englberger (Research Advisor) and Mr. Adelino Lorens (Chief of Agriculture) the main instigators.

Vitamin A deficiency and chronic diseases are serious problems in the Federated States of Micronesia and other Pacific island countries. Lois Englberger has been investigating local food crops in Micronesia since 1998 looking for varieties/crops that are rich sources of provitamin A and other carotenoids and which also have high levels of cultural acceptability. Lois's studies have identified that banana cultivars with yellow and orange colored edible flesh are rich sources of vitamin A precursors. These discoveries then led into the Pacific Agriculture Plant Genetic Resources Network (PAPGREN) project 'Documentation and conservation of traditional staple food crops of Pohnpei' coordinated by SPC and funded by ACIAR and NZAID which has involved collecting and documenting banana varieties in Pohnpei. With the financial assistance of UNICEF I was called upon to provide expert input into the banana component of this endeavour.

1.2 Duties/Terms of Reference

Consult with the Island Food Community of Pohnpei, providing training and assistance with the identification and characterization of banana varieties and development of a sustainable banana industry in Pohnpei, specifically:

- Assist in the identification of the 42 Pohnpei banana varieties that have been named by Pohnpei farmers (also identifying the Pohnpei bananas by Kosrae names) and other banana varieties growing in Pohnpei.
- Assist in the methodology for documenting the 25 Pohnpei banana varieties, which have been planted at the Pilot Farm gene bank collection in Pohlangas.
- Train Pohnpei Agriculture and College of Micronesia - FSM Land Grant staff on standard procedures for documenting morphological characteristics for banana.
- Advise on local banana production and disease control.
- Liaise with other groups who are involved in local banana production and disease control, including the Secretariat of the Pacific Community Plant Protection Project.

1.3 Comment on Terms of Reference

Unfortunately the Peace Corps volunteer Amy Levendusky, who was largely responsible for the documentation of the staple food crops, was called away to the US shortly before my arrival due to a family tragedy and was not present for the duration of my visit. Thus to some extent training of staff in documentation of plant morphological characteristics could not be achieved to the extent originally intended.

2. Physical Geography of Pohnpei

As a political unit, Pohnpei forms part of the geographically far flung Federated States of Micronesia (FSM) which includes 4 states: Yap, Chuuk, Pohnpei and Kosrae. Pohnpei (formerly Ponape) is a high volcanic island located near the eastern end of this Caroline Is. Group in the Pacific Ocean 750 km N of the equator (~7°N) and 900 km SE of Guam (~158°E). It has a land area of 344 square kilometres most of which is steep, rugged mountains, bisected by deep valleys. Pohnpei experiences hot, wet and humid conditions throughout the year with little seasonality. Average daily max and min temperatures are from 23.4 °C to 30.8 °C. It is one of the wettest places in the world with annual averages for rainfall around 4800 mm with higher totals in the mountainous interior.

FSM has only recently emerged from a long history of colonial domination by Spain, Germany, Japan and the United States. This ended when a Compact of Free Association with the US was enacted in 1986. This has created a government-led economy largely reliant on external grants with only a modest private sector. Traditional subsistence farming and fishing still form the dominant economic activity. The potential for a tourist industry exists, but the remote location, lack of adequate facilities, and limited air connections hinder development. The country's medium-term economic outlook appears fragile due not only to the reduction in US assistance but also to the slow growth of the private sector. Geographical isolation and a poorly developed infrastructure remain major impediments to long-term growth.

3. Identification of Pohnpei Banana Varieties

3.1 Background

Until recently there has been no systematic classification of the many banana varieties present in Pohnpei. Listings of variety names have been made in the past including 41 by Bascom (1946) as cited by Merlin *et al.* (1992) and Watson (1993) gave a brief classification of about 9 varieties. Englberger and Lorens (2004) are publishing a booklet showing photographs of 28 Pohnpei varieties and have tabulated a list of 42 varieties prepared at an October 2003 farmers meeting. They classified many of these 42 varieties in consultation with myself.

3.2 Details

While in Pohnpei I visited the banana variety collection established at Pohlengas, Madolenihmw and bananas growing in several locations including Kolonia (Mangat – Horn Plantain; unnamed Maia Maoli/Popoulu), Paies (AA – Peleu; unnamed Maia Maoli/Popoulu-like), Meitik (Tikahp), Kepirohi (Pisang Seribu; Utin Rais), Pohros (Kapakap; Aiko), Iren Kedi (Utiak), Net (Kerenis without male flower/bract retention), P.A.T.S. (Utin Lihli), Salapwuk (unnamed Maia Maoli/Popoulu resembling AAB Peleu in Englberger and Lorens 2004) and Awak (Mangat en Seipahn). The following varieties in the table are classified according to the plants I saw during my visit with a few comments based only on photographs. I briefly visited Kosrae in 2002 and while there classified what varieties I saw. These are included in the table. Other varieties are listed by Englberger and Lorens (2004) but these were either not seen or there were no bunches present. The most popular/common varieties in Pohnpei are Utin Ruk, Kaimana, Inahsio,

Utin Pihsi, Taiwang, Akadahh and Utin Menihle. The very rare ones are Pisang Seribu, Kapakap, Peleu (AA), Utiak, Maia Maoli/Popoulu-like subgroup and Uht Mwas.

Table 1 Classification of Pohnpei banana varieties including those recently introduced from SPC.

| Group | Subgroup | Pohnpei name | Kosrae name | Other names |
|-----------------------|-------------------------------|------------------------------|---------------------|------------------------------|
| Section Eumusa | | | | |
| AA | Sucrier | Kudud/Utin Rais ¹ | - ² | Pisang Mas, Amas, Seniorita |
| | n.d. ³ | Peleu ⁴ | - | - ⁵ |
| AAA | Cavendish | Utin Wai | William's Hybrid | Williams |
| | | Utin Wai | - | Double Banana ⁶ |
| | | - ⁷ | - | Grande Naine |
| | Red | Akadahn Weitahta | Usr Lakuhtan Srusra | Red, Red Dacca |
| | | Akadahn | Usr Lakuhtan | Green Red, Green Dacca |
| | Ibota | - ⁷ | - | Yangambi km5, Kumakuma |
| AAAA | Highgate Hybrid | - ⁷ | - | FHIA-17, SH-3649 |
| | | - ⁷ | - | FHIA-23, SH-3444 |
| | Cavendish Hybrid ⁸ | - ⁷ | - | FHIA-02, SH-3486, Mona Lisa |
| AAAB | Pome Hybrid | - ⁷ | - | FHIA-01, SH-3481, Goldfinger |
| | | - ⁷ | - | FHIA-18, SH-3480, Bananza |
| AAB | Plantain | Mangat | - | Horn Plantain |
| | | Mangat en Seipahn | - ² | False Horn Plantain |
| | Laknau | Mangat ⁹ | - | |
| | | Ihpali ¹⁰ | Usr Wac Es Sie | |
| | Pisang Kelat | Taiwang | Usr Taiwang | King |
| | Pisang Raja | Utin Kerenis ¹¹ | - ² | Pisang Raja |
| | Mysore | Utin Pihsi | Usr Fiji | |

| | Maia Maoli/Popoulu | Karat en Iap | Usr Inyeir ¹² | Tangrat (Yap) |
|---------------------------------|--|---|---------------------------------|-----------------------|
| Group | Subgroup | Pohnpei name | Kosrae name | Other names |
| AAB cont. | | - ² | - | |
| | | - ² (Peleu? ¹³) | - | |
| | Maia Maoli/Popoulu- like ¹⁴ | - ¹⁵ | - | |
| | Silk | Utin Menihle | Usr Kuhfahfah | Sugar, Rasthali |
| | | Utin Kuam ¹⁶ | Usr Kuhfahfah | Sugar, Rasthali |
| | Pome | Preisihl | Usr Kaclfoni | Lady Finger, Prata |
| | n.d. | - ² | - | Pisang Seribu |
| | n.d. | Utiak ¹⁷ | - | |
| AABB | n.d. | - ⁷ | - | FHIA-03, SH-3565 |
| ABB | Bluggoe | Inahsio Poh Rotorot & I. Mweimwei ¹⁸ | Usr Apact Regular | Bluggoe |
| | | Inahsio Pehsehs | Usr Apact (regular) | Silver Bluggoe |
| | Ney Mannan | Dukuru | - ² | Blue Java variant |
| | Pisang Awak | Kaimana | Kuhfahfah Fusus | Ducasse |
| | Saba | Utin Ruk | Apact Fusus | |
| | | Utin Lihli | - | |
| | | Uht Kapakap | - | Inabaniko |
| Section Australimusa | | | | |
| Fe'i | n.d. | Karat Pwehu | - | |
| | | Karat Pako | - | |
| | | Karat Kole | Usr Kuhlalsr | |
| | | Utin Iap | Usr Kuhlohntol ¹⁹ | |
| | | Utihdol | | |
| | | Uht Mwas | | |
| Wild <i>Musa</i> Species | <i>textilis</i> | Tikahp | - ²⁰ | Abaca |

¹ Utin Rais and Kudud may be different but both are the Sucrier subgroup

² Present but no name provided

³ n.d. = none designated

⁴ Peleu has also been used as a name for a variety in the Maia Maoli/Popoulu subgroup

⁵ A typical diploid from Papua New Guinea (PNG). Of the 242 accessions I evaluated in north Queensland in the early 1990's (Arnaud and Horry 1997) none is an exact match! Vudu Beo (PNG 140), Maleng (PNG 188) and Meinje (PNG 237) come closest.

⁶ This is a Williams offtype where the main growing point divides to produce 2 or more main stems, bunches or male buds etc.

⁷ Introduction from SPC

⁸ Thought to be a hybrid of Williams (female) x SH-3393 (male) but there remains some doubt.

⁹ Labelled as Mangat in Pohlangas collection

¹⁰ I am speculating that Ihpali is closely related to Laknau based on similarities in plant characteristics – pseudostem appearance/suckering behaviour

¹¹ Two forms present – the typical one with persistent flowers and bracts below the bunch and one with deciduous flowers and bracts

¹² May be the same as Karat en Iap but requires further study

(Table footnotes cont.)

¹³ Called Peleu in Englberger and Lorens (2004) but entirely different to the AA Peleu in table. I saw a plant/bunch resembling the Maia Maoli/Popoulu Peleu but no name was provided

¹⁴ These are similar to the Maia Maoli/Popoulu cultivars but manifest a few different features (fruit are less blunt, compound tepal yellow/orange) which would warrant the use of the term 'Maia Maoli/Popoulu-like'. I am not aware of them being previously described. Further study is required

¹⁵ This is a new banana brought in by a woman called Aiko. Englberger and Lorens (2004) show photographs of Iemwahn and Kundina but these were not seen during my visit. They appear to belong to this subgroup but whether or not they are different to the banana brought in by Aiko requires further study

¹⁶ Fruit are larger than Utin Menihle and more acid/less sweet. Pseudostem greener/less pink

¹⁷ Utiak is likely an AAB (because of the low intensity of dark coloured blotches on the pseudostem) but I did not see a male bud. The fruit which is quite sour when ripe does not match any designated subgroups. It could well have originated from Papua New Guinea but does not match any of the accessions I evaluated in the 1990's

¹⁸ I suspect that Inahsio Mweimwei and Inahsio Poh Rotorot are the same – the latter displaying greater incidence of freckle disease (spotting) on the fruit

¹⁹ Requires further study to verify that it is the same as Utin Iap

²⁰ Supposed to be present still in the mountains but not seen on my visit and no name provided. 'Poapaga' once given as a name

3.3 Constraints on Classification

My visit to Pohnpei was brief – just 10 days. Because of this it was not possible to locate plants/bunches of all varieties listed by Englberger and Lorens (2004) so that they could be identified and classified. I estimate that I saw and classified 80% of those listed by Englberger and Lorens. An additional 2 varieties (PNG diploid and Pisang Seribu) were also located which are probably not on their list. The recently introduced varieties from SPC are also detailed (some of which are already being planted in backyards and on farms). As already mentioned some of the remaining varieties can be tidied up over time

by email as good plant and bunch/male bud photos become available. Some issues concerning the Pohnpei variety names follow:

- Sometimes no common name was available because the owner was away or it is a new variety or the owner was unknowledgeable on such matters.
- Names may also vary depending on district and where the people originate from.
- Some of the unlocated varieties on the Englberger and Lorens list may be synonyms for some of the unnamed and named varieties located. Some may not even exist.

3.4 New Subgroup?

Interestingly the subgroup of bananas represented by the newly introduced banana brought in by Aiko (AAB, Maia Maoli/Popoulu-like) which I saw during my visit and also by Iehmwahn, and Dukerehda in Englberger Lorens (2004) is new to me and I have not been able to locate them in the literature. They bear many similarities to the Maia Maoli/Popoulu subgroup but with some distinctions – notably the yellow - orange colour of the compound tepal of male flowers and the fruit are less blunt. Thus I have used the term Maia Maoli/Popoulu-like.

The original ‘groupings’ of the subgroups is partly an artifact of what varieties the taxonomists had at their disposal in their collections or had access to. Boundaries they placed on the characteristics of varieties in a particular subgroup may have been different had they had access to all the varieties that exist on the earth. The situation with Laknau (a ‘Mangat’ type) is partly due to the above. Laknau has some distinctions from what we know as the plantain subgroup but had it been available when subgroups were first being drawn up it may have been incorporated in the plantain subgroup.

3.5 Relationships Between Carotenoid Levels and the Classification of Varieties

I was interested in seeing what relationships existed between measured carotenoid levels (Englberger *et al.* 2003a & b) and the classification of varieties. The results are tabulated below in 2 tables representing the 2 studies, drawing from both Pohnpei and Kosrae bananas. Individual variety names have been dispensed with because I wanted to see what effects, if any, groups and subgroups had on carotenoid levels. The Silk, Bluggoe and Saba subgroups have the lower levels whilst the Utin Iap, Ihpali, and Karat have the highest levels. Two subgroups (Laknau and Silk) within the AAB group show a huge difference in carotenoid content which indicates that the group (genome) to which a variety belongs is not necessarily a major determinant of carotenoid levels. The results so far obtained by Lois Englberger in the above two studies are relatively limited in the range of subgroups examined but there are data for additional subgroups presently being synthesized whilst others are still undergoing laboratory analysis. This work should continue until a more complete picture of the situation regarding carotenoid content of banana varieties in Pohnpei is obtained. Where possible greater use should be made of ‘check’/control varieties in future studies. The carotenoid status of the new introductions from SPC should also be investigated. Some of these varieties are higher yielding/more disease resistant but how do they rate for carotenoids?

It should be noted that there are extreme difficulties in arranging carotenoid or other nutrient analyses from Pohnpei because of its relative isolation. Even though further analyses are still needed, to date much has already been achieved with several carotenoid-rich varieties identified and further popularized. Additionally the studies have shown that the carotenoid levels correspond to the colour intensity with high levels in those with the deeper coloured flesh so colour can be used as a guide.

Table 2 β -carotene content– all fruit ($\mu\text{g}/100\text{ g}$) – from Englberger *et al.* 2003a

| AA | AAA | AAB | ABB | Fe'i |
|----|----------------------------------|---|---|---------------------------------------|
| | Red (Usr Lakuhtan) 330 | Laknau (Usr Wac, Ihpali) 2300 & 940 | Bluggoe (Inahsio) 150 | Utin Iap 2780 & 1250 |
| | | Pisang Kelat (Taiwang) 400 & 330 & 270 | Saba (Utin Ruk) 200 & 80 & 150 & 90 | Karat 710 & 520 & 670 & 660 |
| | | Maia Maoli/Popoulu (Usr Inyeir) 340 & 240 | | |
| | | Silk (Utin Menihle) 30 | | |

Table 3 β -carotene content – all fruit ($\mu\text{g}/100\text{ g}$) from Englberger *et al.* 2003b

| AA | AAA | AAB | ABB | Fe'i |
|----|-----------------------------------|--|-----|--------------------------------|
| | Red (Akadahn) 515 & 227 | Laknau (Usr Wac, Ihpali, and Usr Wac Es Sie) 2082 & 1181 & 686 & 309 | | Utin Iap 6360 & 5860 |
| | | Pisang Kelat (Taiwang) 662 & 571 | | Karat 918 & 578 |
| | | Pisang Raja (Utin Kerenis) 310 | | |
| | | Maia Maoli/Popoulu (Usr Inyeir) 421 & 360 | | |
| | | Mysore??? ¹ 56 | | |

¹ It is very doubtful that the 'Fiji' sampled is Mysore

3.6 Management of Pohlangas Site

The banana variety collection at Pohlangas serves the following purposes:

- A germplasm conservation site
- Many varieties growing alongside one another for characterization/evaluation purposes
- Supply of planting material of rare carotenoid-rich varieties

Collections such as this can be expensive to maintain – particularly as more varieties are collected. When the characterization/evaluations are completed consideration should be given to reestablishing the collection on 2-3 cooperating grower's properties – what I call 'community based conservation sites'. The growers can sell fruit and planting material to fund their undertaking and receive some prestige associated with site publicity to do with field days etc. The growers also receive a small bonus each year depending upon how well they look after the collection and relative to any losses or additions they make. Documentation of varieties in these collections (including how to best utilize each variety) is a necessary part of this to enhance their appreciation. If they are to be used as sources of planting material potential disease issues need to be taken into consideration.

The collection is currently laid out in a traditional agroforestry manner. If it is desired to maintain the collection at Pohlangas why not combine it with a range of new agroforestry strategies for farmer demonstration purposes? e.g. regularly pruned leguminous shrubs to boost N levels and productivity or a range of fruit trees etc. Five stools per variety are probably not needed for all varieties – establish more for those in most demand for planting material. Three stools (clumps) are probably sufficient if a few stems are retained as part of each stool.

Regarding the supply of planting material of rare varieties there are some major issues that require attention. Firstly, 'the Agriculture Dept' needs to be sure that it is not contributing to the spread of pests and diseases (primarily of banana) when it is disseminating planting material of the rare varieties rich in carotenoids. The serious disease Fusarium wilt has been located in Pohnpei and is readily spread in infected planting material. There is no evidence that this disease is present at Pohlangas but protocols should be put in place to ensure that this remains the case (see Fusarium wilt pp 16-17 for more comments).

Secondly, it would be preferable that varieties for which planting material is required should come from a dedicated block for this purpose so that it can be managed for maximum multiplication of disease free planting material and without interfering/adversely influencing the characterization/evaluation studies. Such a dedicated block should ideally be cordoned off with footbaths (to decontaminate visitors), be flood-free, planted only with tissue cultured planting material and managed for maximum multiplication of planting material (see Appendix 3). Currently tissue culturing of bananas does not occur in Pohnpei. Consideration should be given to

developing such a capability. Alternatively a cooperative endeavour with Dr. Josekutty's laboratory in Kosrae should be investigated.

I experienced difficulties locating any working plans (maps of layouts of varieties in blocks) for all of the variety blocks I visited (Pohlangas - local and SPC varieties, the old Pohnpei Agriculture Station and the College of Micronesia). This needs to be rectified so that should staff depart, the original identity of material is readily accessible. In many cases the male buds (bells) below the bunch were being removed soon after flowering. The male bud etc. contains a lot of taxonomic information useful for identifying/classifying varieties and should be retained on plants in such collections.

3.7 Pohnpei Varieties PowerPoint Presentation

I have prepared a PowerPoint presentation on CD showing many of the Pohnpei varieties which will be useful for further presentations/discussion by the Island Food Community of Pohnpei. It contains photos of each variety along with its classification and comments. The CD also contains each of the photos as individual files.

4. Methodology for Documenting/Training Staff

4.1 General

Resources are limited for the characterization of the banana varieties in Pohnpei. It is important that investment is made in the areas that will have most benefit for the people of Pohnpei. The publication 'Pohnpei Bananas: a Photo Collection: Carotenoid-Rich Varieties' by Englberger and Lorens (2004) is a great start to increase the people's awareness and appreciation of the local varieties.

The framework for the classification of the Pohnpei varieties has been completed as a result of this consultancy. The important things that remain to be done are

- (i) The preparation of a botanical key for the correct identification of the varieties. This could be prepared as both a hardcopy and CD with the latter in particular that could be profusely illustrated with photographs of important plant features as you work through the key. It is desirable that the key be able to be used for both bunched and unbunched plants. I should be contacted for ongoing assistance in the development of the key.
- (ii) Further collection of photos (including bunch, male bud and plant etc.) so that a more complete set can be published as part of FSM's National Biodiversity Strategy.
- (iii) More detailed characterization of carotenoid-rich varieties including the Mangat subgroup and Karat/Utin Iap types to determine what distinguishing features exist. The Maia Maoli/Popoulu-like subgroup and Utiak varieties should also be characterized in detail to assist further in clarifying their classification.

Currently data and information about Pohnpei banana varieties is being compiled in a spreadsheet. Consideration should be given to upgrading this into a proper database (perhaps INIBAP's MGIS) so that required information can be more readily extracted. Assistance from an expert on the use and setting up of databases is recommended.

4.2 Publications to Develop

Publishing forces staff through the processes of thinking and consolidating information and building on existing knowledge. This is something that needs additional emphasis in Pohnpei and elsewhere in the Pacific. The following publications should be aimed for.

- a) “New insights on banana identification and classification in Pohnpei, FSM” *Plant Genetic Resources Newsletter* (Jeff Daniells to draft)
- b) “Key to the banana varieties of Pohnpei” hardcopy and CD
- c) “The bananas of Pohnpei” colour booklet supported by FSM’s National Biodiversity Strategy
- d) “Historical perspective on banana varieties in Pohnpei with particular emphasis on Fe’i bananas.” *Economic Botany* with Bill Raynor
- e) “Banana varieties in FSM” *Infomusa* (Jeff Daniells to draft)
- f) Article reporting on my consultancy in *Pacific Island Nutrition*

5. Local Banana Production and Disease Control Advice

5.1 The Transport to Export Markets Dilemma

Pohnpei produces bananas for export (mostly Utin Menihle) and domestic sales as well as home consumption. Most export sales are to Guam and these are usually sent by the National Fisheries Corporation (NFC) plane which usually has space for bananas on 1 of the 2 flights each week. However, sometimes the exporters prepare the bananas for shipment and without any notice there is no room for the consignment on the flight. Thus exporters, all too often, sustain significant losses. The high risk associated with this means that costs of production/handling/packaging must be kept to a bare minimum - there is little point in investing in doing the job really well if you are not assured of getting the product to market. Also the high cost of air freight (49c/lb) also means that costs of production must be minimized so that there are adequate profit margins while still being competitive with other bananas in the Guam market. Until something can be done to rectify these 2 issues there is no incentive to improve the way bananas are grown, handled and packaged for export. This type of problem is not new to the Pacific and is almost normal for remote locations. The fortunes of the banana industry will be closely linked to the transport situation.

Sending by air to Guam would not appear to be the solution. Shipping by sea may be a better option. Sea transport to Guam from Pohnpei is 4-5 days and currently ships travel every couple of weeks. What it means is that fruit could be sold more competitively in the Guam market. A study should be conducted to investigate this option – perhaps now is the time that this could be made to come together. I could write a lot more about developing markets but much has already been written for Pohnpei by Richard Bolt (Bolt 1997) in regard to market opportunities and production methods to satisfy them, which is still valid in many aspects and just requires action.

5.2 New Domestic Opportunities for Nutrient-rich Varieties

Considerable quantities of ‘western’ foods ‘fresh’ and processed are imported and consumed in Pohnpei. The consumption of these foods is in part contributing to the health problems experienced by Pohnpeians. It is time for rural industries (in this case Pohnpei) to play a more proactive and innovative role in delivering the health benefits of

local nutrient rich foods to meet this challenge in the market-place (see Heasman 2004 for more detail).

How can Pohnpei come up with products that will have competitive advantage against the imports and also address the nutritional deficiencies which exist amongst members of the population? A quote from Prof. John Ikerd concerning sustainable profits is relevant here. “If you decide to produce exactly the same thing that someone else is producing in the same way they are producing it, and if you succeed, any profits you realize will not be sustainable and neither will theirs. If you expect someone else to provide you with opportunities, you are destined to be disappointed. If you expect someone else to solve your problems, you will be disappointed. You have to do something creative and productive yourself if you expect the market to reward you for having done it. And, if it’s easy to do, it won’t be worth much. If someone else provides you with a market, they – not you, ultimately will realize the benefit. You didn’t create the market – they did. If someone else provides you with a new pest management or fertility program, they – not you, ultimately will realize the benefit. You didn’t increase productivity – they did. You certainly can learn from others and can integrate others’ marketing and production services into ‘your’ production/marketing system.....[But] your uniqueness is the only source of profitability that cannot be competed away, and thus, is the only source of sustainable profits.”

Processing of some of the carotenoid-rich varieties is one such opportunity. Catherine Sundvall of Pohnpei has been developing a range of delicious desserts and ice creams based on the Karat banana. These are I believe unique and would appear to have outstanding potential. Assistance with further development of the product and with commercial scale manufacture and marketing is required. A visit by Richard Beyer, Food Scientist, Suva Fiji (phone 679 3370709; fax 679 3305510; email beyer@connect.com.fj) to Pohnpei would provide very valuable input to this endeavour as well as perhaps providing assistance for other crops. Just imagine the health benefits of significant consumption of such a delicious and vitamin-rich ice cream. Other similar opportunities that should be considered are:

- Freezing ripe peeled vitamin-rich bananas and passing them through a Champion Juicer® to produce a delicious soft serve ice cream. Other fruit and coconut cream can also be mixed in.
- Drying sliced ripe vitamin-rich bananas in food dehydrators. Varieties such as Mangat and Karat en Iap are particularly well suited.

The acquisition of such equipment and its use by the food service industry should be fostered.

- Collection/introduction/popularization of a wider range of fruit and vegetables. This consultancy was specifically on bananas but the whole system must be considered. Frankly the range of local fruit and vegetables is pretty disappointing given the growing conditions available. Significant effort on this subject would bring major rewards in improved human nutrition. I am not a nutrition expert but it is obvious that since Pohnpeians have made shifts from traditional foods to some western foods (mostly processed) they need to also embrace more fruit and

vegetables in their diet to provide more ‘protection’ from ailments via the vitamins, minerals, antioxidants etc. present (AFVC 2004). Many species have been introduced to Pohnpei over the years as indicated by Ragone *et al.* (2001). However, many of these have probably now been lost and much better (sweeter, higher yielding etc.) varieties of many species will these days be available. The fruits in the following table should be considered for importation.

Table 4 List of fruit and nuts worthy of importation/evaluation

| Common name | Species |
|--|---|
| Abiu | <i>Pouteria caimito</i> |
| Carambola | <i>Averrhoa carambola</i> |
| Durian | <i>Durio zibethinus</i> |
| Granadilla | <i>Passiflora quadrangularis</i> |
| Jaboticaba | <i>Myrciaria cauliflora</i> |
| Jakfruit | <i>Artocarpus heterophyllus</i> |
| Langsat | <i>Lansium domesticum</i> |
| Mango (those suited to wet conditions) | <i>Mangifera indica</i> |
| Papaya (improved types) | <i>Carica papaya</i> |
| Passionfruit | <i>Passiflora edulis</i> f. <i>flavicarpa</i> |
| Pitaya | <i>Hylocereus guatamalensis</i> |
| Rambutan | <i>Nephelium lappaceum</i> |
| Sweetsop | <i>Annona squamosa</i> |
| Vi Apple | <i>Spondias cytherea</i> |
| Water Apple | <i>Syzygium aqueum</i> |
| Wax Jambu | <i>Syzygium malaccensis</i> |

Various selections of tropical vegetables are available from the World Vegetable Research Center (www.avrdc.org). The traditional agroforestry system will probably need development/modifications (sunlight and nutrients) to permit better growth and productivity of fruit and vegetables. The Pacific agroforestry guides by Rogers and Thorpe (1999) and Elevitch and Wilkinson (2000) should be consulted.

5.3 Quarantine Issues

Pohnpei has relative freedom from many important pests and diseases of banana. Quarantine procedures are currently in place to minimize the possibility of such incursions. However, more can always be done and it must be stressed that much of this current effort put into the study of nutrient-rich banana varieties will be lost if new exotic diseases should arrive and become established. In particular there is a need for contingency plans to be established in readiness should any incursions occur. A contingency plan contains the correct set of steps that must be followed to contain/eradicate the incursion. It says exactly who (individuals/organizations) is responsible for what and the lines of command. Valuable time is saved by everyone knowing what has to be done beforehand. Also the plan followed is not one which has involved rushed decisions – there has been opportunity for careful planning and ‘peer review’. Other organizations such as Plant Health Australia have already developed some

of these so Pohnpei doesn't have to start from scratch. The major quarantine threats include blood disease and moko disease, bract mosaic, bunchy top, banana skipper (*Erionota thrax*), rust thrips (*Chaetanaphothrips signipennis*) and scab moth (*Nacoleia octasema*). The SPC Plant Protection Project of Micronesia is in place to assist the government in quarantine and plant protection issues.

5.4 *Fusarium Wilt*

Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*) was first recorded from Pohnpei in June 2001 (Linda Smith pers. comm. 2002). It was recovered from the variety Utin Menihle (AAB, Silk). The isolate was VCG 0126 which is similar in many respects to other race 4 VCG's. However, its pathogenicity against different varieties would need to be tested before too much could be said about the range of varieties that would be affected.

Soon after I arrived in Pohnpei I asked what follow-up had occurred when *Fusarium wilt* was confirmed 3 years ago. Much to my amazement nothing had apparently been done at all. I was shown the same diseased stool of Utin Menihle from which the samples had originally been collected which is at the back of the Agriculture office (Adelino Lorens) in the grounds of the College of Micronesia site in Kolonia (back of the nursery). The following actions are recommended:

- 1) The diseased stool and nearby bananas should all be killed by injection with glyphosate – 100 ml of glyphosate per litre of water with 5-15 ml of solution injected per plant (pseudostem) above the growing point; plants taller than 1 m should be injected at 2 points on the pseudostem. Alternatively inject the plants with a similar quantity of kerosene or diesel. The plants should be left to die and decompose on the site and should not be disturbed. A good cover should be allowed to establish on the site and no further bananas planted there. This will dramatically reduce the amount of disease inoculum present so lessening the probability of spread elsewhere. Also no infected planting material will inadvertently be distributed from the site.
- 2) Any other known sites of *Fusarium wilt* should be treated similarly. The source of planting material for any of these diseased sites should be traced back (I understand some plants came from U) to see if the disease is present elsewhere. It is extremely important that protocols are in place during all these operations to ensure that staff involved are not inadvertently spreading the pathogen elsewhere. See Appendix 4 for guidelines.
- 3) SPC Plant Protection Project of Micronesia should continue to survey for pests/diseases including *Fusarium wilt*.
- 4) Consideration should be given to setting up a tissue culturing facility in Pohnpei. Such a capability would offer the following:
 - Ability to distribute guaranteed pest/disease-free planting material
 - Much quicker multiplication and dissemination of carotenoid-rich varieties than possible by conventional means
 - Ability to safely store traditional varieties in the event of a serious disease incursion e.g. blood disease

- 5) Attractive posters should be prepared showing what the major banana quarantine threats (including *Fusarium wilt*) look like, where they currently are, how to keep them out and what to do if you get them. Something similar to those prepared by SPC on invasive weeds of FSM would be good.

Fortunately there does not appear to be much *Fusarium wilt* present in Pohnpei but staff should not be complacent because it can be a devastating disease. If further spread can be prevented then Pohnpei will continue to have a major competitive advantage over many other banana producing areas particularly concerning the production of Utin Menihle which is the main variety exported.

External visual symptoms of the disease include marginal yellowing of the older leaves which later turn brown and dry out. Many bananas by the sides of the roads (mostly Utin Ruk) have symptoms resembling the above. However, plants I examined had no internal discoloration (dark brown to black) of the water conducting tissue in the pseudostem near ground level typical of *Fusarium wilt*. Much of this appears to be potassium deficiency. Other causes may be soil disturbance (roadworks) and the bacterial disease *Erwinia carotovora*.

5.5 Dealing with Black Sigatoka Leaf Disease

Black Sigatoka (*Mycosphaerella fijiensis*) otherwise known as black leaf streak is far and away the most serious pest/disease problem of bananas in Pohnpei. It progressively kills the leaves prematurely so that yield and fruit quality are reduced. Unfortunately there are no magical cures for it in the context of Pohnpei. However, attention to the following points can help minimize its impact. These control strategies are best understood by considering the disease triangle which is made up of the host, the pathogen and the environment. These interact together to manifest the disease in different ways and severity.

- a) The Host
- Choose a resistant variety. e.g. Utin Fiji and Utin Ruk are more resistant than Preisihl and Utin Menihle
 - Bunch trimming – the removal of 1 or 2 of the lower hands at flowering time as well as flower (male bud/bell) removal will help improve fruit quality (fruit size and appearance – ‘bloom’) in the presence of the black Sigatoka i.e. reduce the sink (bunch) size in line with reduced source (leaves) caused by black Sigatoka. This also improves the fruit greenlife (transport life). Bunch trimming and flower removal should be done immediately after flowering for maximum benefit.
 - Ensure where possible that other stresses such as soil waterlogging and nutrient deficiency are minimized.
- b) The Environment
- Unfortunately climatic conditions on Pohnpei are absolutely ideal for disease infection and development – hot, wet and humid all year. Some locations closer to the coastline and smaller offshore islands where relative humidities are not as high will be less affected by the disease than elsewhere.

- Growing mixtures of banana varieties and other crop and fruit tree species as is currently the case in the traditional agroforestry system will be advantageous in reducing disease transfer from nearby plants.
- c) The Pathogen
- Disease severity is influenced by the amount of disease inoculum (airborne spores) which lands on the leaves. Deleafing of diseased leaves onto the ground accelerates the decay of the sporulating tissue. If defoliation is practiced regularly (every 1-2 weeks) before lesions get to stage 4 and this is done on the whole farm and nearby farms it will help lessen the severity of the disease.

5.6 Banana Streak Virus (BSV) in Pohnpei

Typical symptoms of BSV – chlorotic flecking on the leaves, were seen on most plants examined of the variety Utin Pihsi (AAB Mysore). This is not surprising because it is almost always present wherever this variety is grown around the world. Leaf samples containing the chlorotic flecking should be sent to DPI&F's virology section for lab confirmation but this is just a formality. Fortunately the disease does not represent an important threat to banana production in Pohnpei.

5.7 New Variety Opportunities

New varieties should continue to be imported for agronomic, disease, nutritional and market evaluation. Part of this is about preparing/positioning for the future which includes having disease resistant varieties (e.g. blood disease/moko disease) 'waiting in the wings' should there be any new disease incursions. My recommendations are in the following table. Because virus diseases such as bunchy top can be spread via tissue culture any new varieties introduced should be appropriately indexed by an INIBAP accredited laboratory – nothing less!

Table 5 Banana varieties recommended for importation and evaluation

| Genome | Subgroup | Name | Comments |
|--------|--------------------|-----------------------|--|
| AAA | Red | Dwarf Red | Akadahn and Akadahn Weitahta are already popular in Pohnpei. This dwarf form offers management advantages and should be a reasonable source of carotenoids |
| AAAB | Silk Hybrid | ‘Tropical’ (YB 42.21) | This hybrid from Brazil has resistance to Fusarium wilt and is similar in taste to Utin Menihle which is popular in Pohnpei. |
| | Plantain Hybrid | FHIA-20 & FHIA-21 | Both are high yielding plantain hybrids similar in flavour to the Mangat of Pohnpei but resistant to black Sigatoka. |
| | Pome Hybrid | PKZ | Selection from South Africa that is high yielding. Supposed to be an offtype of FHIA-01. |
| AAB | Maia Maoli/Popoulu | Pacific Plantain | High yielding, semidwarf variety which will be a good source of carotenoids. |
| AABB | Pisang Awak Hybrid | FHIA-26 (SH-3776) | Hybrid from Honduras that may have resistance to Fusarium wilt. Taste is similar to Kaimana which is popular in Pohnpei. |
| ABB | Pisang Awak | Kluai Namwa Khom | Dwarf form of Kaimana which offers important crop management advantages. |
| | Pelipita | Pelipita | Persistent male flowers/bracts which confer ‘resistance’ to blood disease/moko disease. Similar in taste to Inahsio which is popular in Pohnpei. |
| | Saba | Pisang Puju | Male bud absent, which confers ‘resistance’ to blood disease/moko disease. Same taste as Utin Ruk which is very popular in Pohnpei. |

6. Seminars/Training

I presented 2 seminars whilst in Pohnpei. The first was on Friday 4 June (2-4pm) which was attended by about 15 people including Island Food Community of Pohnpei members and Agriculture staff. This seminar dealt with the banana varieties of Pohnpei and the basics of banana identification.

The second seminar was on Wednesday 9 June (2-4.30pm) which was attended by about 20 people and dealt with major quarantine issues, black Sigatoka control, Fusarium wilt management, crop management/fruit handling/market opportunities and SPC varieties/other varieties to import.

I also provided several banana posters including some dealing with important pests/diseases (bunchy top and Fusarium wilt) and 2 banana publications (Daniells and Bryde 2001 'Banana varieties the ACIAR years 1987-1996' & Daniells *et al.* 2001 'Musalogue: a catalogue of *Musa* germplasm. Diversity in the genus *Musa*') for Adelino Lorens.

7. Acknowledgements

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| | |
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Appendix 1

Itinerary/Schedule of Activities

| | |
|------------------------|---|
| Sun/Mon 31 May- 1 June | Travel Cairns – Guam – Chuuk – Pohnpei. Met at airport by Adelino Lorens and traveled to his office for preliminary discussions followed by field visits with Mark Kostka in Kolonia to begin identifying Pohnpei banana varieties. |
| Tue 2 June | - Travel with Adelino/Mark/Eddie to Pohlangas Farm to examine collection. Hands-on training in identifying characteristics. Bill Raynor’s property (Kepirohi) identifying varieties and P.A.T.S. |
| Wed 3 June | - Visit Paies and Pohros, Iren Kedi and Net, College of Micronesia at Palikir (SPC collection). |
| Thu 4 June | - Visit Meitik in search of ‘Tikahp’. Library visits. Preparation for Friday seminar. |
| Fri 5 June | - Discussions Adelino Lorens and Lois Englberger on consultancy progress. Seminar given on Pohnpei banana varieties and banana identification/classification basics. |
| Sat 6 June | - R&R Nan Madol/Fishing. |
| Sun 7 June | - Attended Catholic Church Awak, Sokeh’s Ridge, report writing. |
| Mon 8 June | - Discussions Adelino and Lois on Pohnpei bananas booklet, lengthy discussions. Discussions Konrad Englberger (SPC). |
| Tue 9 June | - Visit Salapwuk looking for other varieties. Preparation for Wednesday seminar. |
| Wed 10 June | - Seminar preparations. Seminar given on quarantine threats, disease control, crop management, market opportunities. |
| Thu 11 June | - Debriefing on consultancy with Lois Englberger and Adelino Lorens. Discussion on publications to jointly work towards. Departure, return to Australia with processed fruit sample for analysis at University of Adelaide. |

Appendix 2

Pohnpei Banana Varieties – Possible Meanings of Names

| Variety | Meaning |
|---------------------|---|
| Akadahn | From the name ‘Lakatan’ |
| Akadahn Weitahta | Weitahta = red |
| Dukuru | ? |
| Iemwahn | ? (Yapese) |
| Ihpali | = one-sided (1 hand only) |
| Ihpalihn Palau | Ihpali from Palau |
| Ihpalihn Seipahn | Ihpali from Seipahn (Saipan) |
| Inahsio Mweimwei | Inahsio = someone’s name? Mweimwei = spotting |
| Inahsio Pehsehs | Pehsehs = silver wax |
| Inahsio Poh Rotorot | Poh = colour, Rotorot = dark |
| Kaimana | Someone’s name? |
| Karat Kole | Karat = ? , Kole = round/seed |
| Karat Pako | Pako = shark |
| Karat Pwehu | Pwehu = spotted fish? |
| Karat en Iap | Karat? From Yap |
| Kudud | Short (plenty fingers) |
| Macao | From Macao? |
| Mangat en Alohapw | Mangat = someone’s name, from Alohapw |
| Mangat en Angaur | From Angaur |
| Mangat en Kariki | From Karikari |
| Mangat en Pohnpei | From Pohnpei |
| Mangat en Ruk | From Chuuk |
| Mangat en Seipahn | From Saipan |
| Mangat Kingit | Kingit = ? |
| Peleu | ? |
| Preisihl | = Brazil |
| Sapwtehreng | ? |
| Taiwang | From Taiwan |
| Tikahp | Tik = small, ahp = hand |
| Uht Mwot | Uht = banana, Mwot = short (plant) |
| Utiak en Pohnpei | Utiak = crazy |
| Utiak en Angaur | “ |
| Utihdol | ? Utih = banana, dol = mix |
| Utimwas | Maws = worm |
| Utin Iap | Banana from Yap |
| Utin Kerenis | Kerenis = other/outer island |
| Utin Kuam | Banana from Guam |
| Utin Lihli | Banana for pounding |
| Utin Menihle | Banana from Manila |
| Utin Pihsi | Banana from Fiji |

| | |
|---------------------|--|
| Utin Ruk | Banana from Chuuk |
| Utin Wai | Foreign banana |
| Other Names | |
| Kundina | Someone's name? |
| Karat Pwonopwon | Round |
| Uht Rais | Rais = rice, indicating it cooks quickly |
| Kirihm | ? |
| Utin Koruhr | Smile? |
| Kirou Rohi | Title of a person |
| Uht Laud | Laud = big fingers |
| Ilario | Someone's name |
| Uht Tikitik | Tikitik = small finger |
| Poupoulap | Big plant but small fruit |
| Utin Wai Mwoatomoat | Mwoatomoat = short bunch? |

Appendix 3

Rapid Field Multiplication of Varieties

Some banana varieties are slow to multiply because the suckers are retarded due to apical dominance. This is particularly so for plantains such as Mangat en Seipahn. Also some of the rarer varieties such as the Mangat group are also very susceptible to banana weevil borer (*Cosmopolites sordidus*) and benefit from regular replanting of pest-free planting material. Daniells *et al.* (2001) and Swennen (1990) have described methods to promote sucker growth that involve destroying the apical meristem of the mother plant. Essentially once the mother plant is 5 or 6 months old (> 2 m) the internal growing point should be gouged whilst leaving the leaf canopy intact. This promotes a major flush of suckers for propagation. The growing point may also be killed by injection of 3 ml of a 2% solution of Ethrel® which is less laborious than gouging. The method described here probably has some merit for other varieties also. Certainly if a plant bunches/flowers it should be debunched so as to promote sucker development instead of the bunch.

Daniells, J. W., Lindsay, S. and O'Farrell, P. J. (2001) Nurse suckering – a useful banana crop management option. DPI Note – see www.dpi.qld.gov.au

Swennen, R. (1990) Plantain cultivation under west African conditions – a reference manual. IITA. pp 3-5.

Appendix 4

Guidelines to Prevent the Spread of Fusarium Wilt by Inspectors

- ❖ There is a high risk of spores of Fusarium being spread on vehicles, tools and footwear by inspectors moving between banana plantations.
- ❖ Vehicles should not be taken from a known Fusarium infected site to any other site without a thorough decontamination procedure. Inspections should be programmed to ensure that the vehicle does not travel from a known infected site to a clean site. If an infected site is to be inspected, it should be inspected last.
- ❖ No vehicle should be taken on to a banana plantation or any site where banana plants are grown as crop plants without decontamination of the tyres and under the guards by spraying with methylated spirits.
- ❖ On arrival at a banana plantation or any property on which bananas are cultivated as a crop plant the inspector must decontaminate his boots by either standing in a footbath containing methylated spirits, Farmcleanse (approx. price A\$100 per 20 L - for supply contact kevin.mason@castrol.com.au) or copper oxychloride at the appropriate concentrations or by spraying the boots with one of these disinfectants. Any tools or equipment taken on to the property and which are likely to come into contact with banana plant material or soil (e.g. mattocks, machetes etc.) must be decontaminated by immersion in or thoroughly spraying with one of the disinfectants mentioned above. It is particularly important to disinfect tools if they have previously been used on Fusarium infested plants. The appropriate concentrations for the three disinfectants mentioned above are (a) 100% methylated spirits, (b) 1 part Farmcleanse : 10 parts water and (c) copper oxychloride mixture according to the concentration stipulated on the label.
- ❖ Vehicles used for regulatory activities must be thoroughly treated with high-pressure water to remove adhering mud and plant material whenever a trip is proposed to known Fusarium free districts or plantations. Whenever a vehicle is used on an infected site, other than simply to travel to/from the infected site the vehicle should be cleaned with high-pressure water to remove adhering mud and plant material.

Appendix 5

Ecoport Web List of Pests and Diseases of Bananas in Pohnpei

| | | | | | |
|-----------------------|-------------------------|----------|--|-----------------|---|
| 18129 | Pohnpei | Locality | Parapyricularia musae | Fungus Pathogen | McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the Federated States of Micronesia (FSM). |
| 4122 | Pohnpei | Locality | Eudocima fullonia | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM, and Palau |
| 3232 | Pohnpei | Locality | Cosmopolites sordidus | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 20725 | Pohnpei | Locality | Ramichloridium musae | Fungus Pathogen | McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 10205 | Pohnpei | Locality | Trigonops sp. | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 4289 | Pohnpei | Locality | Ferrisia virgata | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 4033 | Pohnpei | Locality | Eucalymnatus tessellatus | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 15380 | Pohnpei | Locality | Gibberella baccata | Fungus Pathogen | Trujillo EE (1971) A list of diseases of economic plants in the Trust Territory of the Pacific Islands (TTPI). McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 7722 | Pohnpei | Locality | Pentalonia nigronervosa | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 14972 | Pohnpei | Locality | Fusarium moniliforme | Fungus Pathogen | Trujillo EE (1971) A list of diseases of economic plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 379 | Pohnpei | Locality | Aleurodicus dispersus | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |

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| 14643 | Pohnpei | Locality | Erwinia carotovora ssp. carotovora Bacterium Pathogen | Trujillo EE (1971) A list of diseases of economic plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 16069 | Pohnpei | Locality | Guignardia musae Fungus Pathogen | McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 6176 | Pohnpei | Locality | Leptoglossus australis Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 828 | Pohnpei | Locality | Aphis gossypii Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 16895 | Pohnpei | Locality | Marasmiellus inoderma Fungus Pathogen | McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 679 | Pohnpei | Locality | Aonidiella inornata Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 16188 | Pohnpei | Locality | Hemicorynespora mitrata Fungus Pathogen | Matsushima T (1981) N/A McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 13089 | Pohnpei | Locality | Codinaea triseptata Fungus Pathogen | Matsushima T (1981) N/A McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 13259 | Pohnpei | Locality | Colletotrichum musae Fungus Pathogen | Trujillo EE (1971) A list of diseases of economic plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 9258 | Pohnpei | Locality | Saissetia coffeae Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 9708 | Pohnpei | Locality | Spodoptera litura Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |

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| 12052 | Pohnpei | Locality | Ceratosporium gracile | Fungus Pathogen | Matsushima T (1981) N/A McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 8735 | Pohnpei | Locality | Pseudococcus microadonidum | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 8158 | Pohnpei | Locality | Planococcus citri | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 14060 | Pohnpei | Locality | Deightoniella torulosa | Fungus Pathogen | Trujillo EE (1971) A list of diseases of economic plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 13562 | Pohnpei | Locality | Coronospora uniseptata | Fungus Pathogen | Matsushima T (1981) N/A McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 13493 | Pohnpei | Locality | Cordana musae | Fungus Pathogen | Morwood RB (1959) Diseases of plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 8404 | Pohnpei | Locality | Proutista moesta | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 5824 | Pohnpei | Locality | Lamenia caliginea | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 4746 | Pohnpei | Locality | Hemiberlesia lataniae | Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 17462 | Pohnpei | Locality | Mycosphaerella musae | Fungus Pathogen | Trujillo EE (1971) A list of diseases of economic plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 17112 | Pohnpei | Locality | Memnoniella subsimplex | Fungus Pathogen | McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and |

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| | | | | pathogenic algae of the FSM. |
| 17476 | Pohnpei | Locality | Mycosphaerella musicola Fungus Pathogen | Morwood RB (1959) Diseases of plants in the TTPI. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 17420 | Pohnpei | Locality | Mycosphaerella fijiensis Fungus Pathogen | O'Connor BA (1969) Exotic plant pests and diseases. McKenzie EHC, Jackson GVH (1990) The fungi, bacteria and pathogenic algae of the FSM. |
| 1116 | Pohnpei | Locality | Aspidiotus destructor Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM and Palau |
| 5224 | Pohnpei | Locality | Icerya aegyptiaca Arthropod Pest | Nafus DM (1997) Insect Survey of the FSM |

Appendix 6

List of Photos Taken During the Consultancy

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| 047 Karat Pwehu | 361 Karat Pwehu |
| 053 Mangat | 362 Karat Pako |
| 055 Maiola/P | 380 AAB-Peleu |
| 056 Mailoa/P | 381 AAB-Peleu |
| 059 Utin Wai double | 383 Utin Pihsi |
| 061 Preisihl | 390 Utin Pihsi |
| 065 Mangat en Seipahn | 404 Uht Mwas |
| 067 Inahsio | 407 Utiak |
| 069 Utin Iap | 411 Taiwang |
| 076 Laknau | |
| 083 Kuam | |
| 090 Grande Naine | |
| 091 F-3 | |
| 092 Yangambi Km5 | |
| 093 F-17 | |
| 096 F-18 | |
| 099 Seribu | |
| 100 Ihpali | |
| 106 Lihli | |
| 110 AA-Peleu | |
| 111 AA-Peleu | |
| 117 Karat en Iap | |
| 137 Karat | |
| 139 Goldfinger | |
| 147 "Utin Aiko" | |
| 153 Uht Kapakap | |
| 165 "Utin Aiko" | |
| 170 Utiak | |
| 172 Ihahsio Pehsehs | |
| 180 Utin Ruk | |
| 196 Fusarium | |
| 200 Fusarium | |
| 208 Utin Menihle/Kuam | |
| 231 Dukuru | |
| 236 Tikahp | |
| 239 Tikahp | |
| 242 Tikahp | |
| 250 Raja | |
| 258 Utin Wai | |
| 259 Utin Wai | |
| 347 Uht Mwas | |