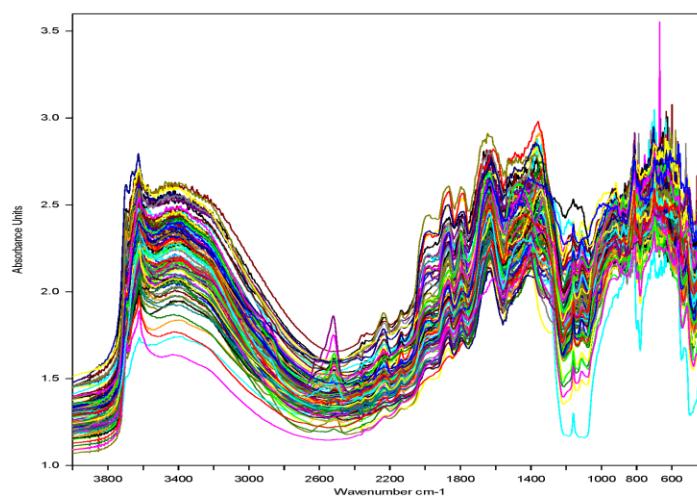# Training Report
Five -Day Training
"Mid-infrared (MIR) spectroscopy"

May 05-11, 2018 – Koronivia Research Station

Report prepared by PRO-Chemistry

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1. Introduction

Soil knowledge is a constraint on the sustainable intensification and resilience of agriculture to future challenges. Current traditional gardening systems in the Pacific Island Countries and Territories (PICTs) have become intensified and resulted in the depletion of the soil nutrient capital. Comprehensive nutrient budgeting is essential for improving farm productivity and agricultural resilience on volcanic islands and sand atolls.

This ACIAR project "Soil management in Pacific Islands: investigating nutrient cycling and development of the soils portal" will enhance soil knowledge and provide a reliable foundation for sustainable intensification of agricultural systems by growers, extension officers and policy makers in Fiji, Tonga, Samoa, Kiribati and Tuvalu.. The establishment of a strong systems-view of the soil nutrient system will enable the most effective interventions to be identified along with the likely cascade of effects on Pacific Island farming systems.

The purchase and installation of the new MIR instrument at the Ministry of Agriculture by the project provides the Fiji and the Pacific Islands enhanced capability to rapidly and economically analyse soils. But it is not only about instrumentation, it is also about our staff. Over the last week Dr Anthony Ringrose-Voase and Dr Ben Macdonald conducted an MIR training course for 11 Ministry of Agriculture Staff here at the research station. During the week the staff installed and setup up the instrument, were trained in its operation and maintenance and data processing. Apparently Dr Ringrose-Voase who is an Excel expert also gave a short course it's use to the team. Additionally the team were introduced to soil survey and sampling methodology and how MIR can contribute with to traditional methods to development of a soil information system for the Pacific Island.

2. Objectives of the training workshop

The specific objectives of the training workshop were;

To train participants in the use of mid-infrared spectroscopy (MIR) to rapidly characterize soil

- Role of rapid soil analysis in a soil survey context
- Operation of MIR
- Calibration of MIR and prediction of soil properties

3. Structure of the workshop

This five day workshop covered the following topics by the trainer from CSIRO.

- ✓ What is MIR spectroscopy?
- ✓ Role of rapid soil analysis in digital soil mapping
- ✓ Setting up MIR spectrometer and software
- ✓ Sample preparation
- ✓ Safety
- ✓ Acquiring MIR spectra from soil specimens
- ✓ Calibration
- ✓ MIR calibration strategies
- ✓ Calibration and optimization
- ✓ Soil property estimation

Participants were given the opportunity to run the samples and build confidence and practices to ensure they operate the instrument and generate data. On the final day of the workshop the participants were awarded with certificate.

Annexure A – agenda of the work shop is attached at the end of the report.

3.1 Participation

Total of 11 participants attended this 5 day training workshop, two came from extension division while others were from chemistry laboratory. Since this workshop was meant for laboratory staff we thought of inviting extension officers as there will be aware of soil sampling requirements and interpretation of final outputs.

Majority of the participants were frontline officers at Senior Technical Assistant and technical officer rank.

For a detailed list of the workshop participants, please refer the *Annexure C* at the end of the report

3.2. Organization of the workshop

The training workshop was organized on the basis of three main conspectuses; as under:

a) Presentations and interactive discussion among the workshop participants especially soil sampling as the equipment required only small quantity of sample to make determinations and the exact location. Soil sample preparation and loading into equipment cup for determination.

b) Through hands on training was provided to all participants after lectures on each aspect of equipment operation. This includes loading samples cups, spectrum calibration and data generation.

4. Main focus of the training

The focus of the training was to enhance the skills and knowledge on new equipment and be proficient with its operating procedures. Improves the quality of the soil results and further improves the service delivery to our clients.

The new equipment was introduced by CSIRO through the funding by ACIAR und the new project titled "Soil management in the Pacific Islands. MIR is used globally in advance laboratory for rapid analysis of soil and is also efficient and reliable. The introduction of MIR is line with Fiji's government's quest to improve quality results and modernise our support service to agriculture research and development.

5. Proceedings of the workshop
5.1 Opening of the workshop
The workshop was opened by Mr. Jone Sovalawa, Actg Deputy Secretary Agricultural Development, Ministry of Agriculture. He welcomed all the training participants and facilitators.
Mr. Jone Sovalawa while officially opening the training at Koronivia Research Station conference room said soil is one of the fundamental resources that we all rely on for survival and Fiji soils are now under threat.

"Mid Infrared spectroscopy is a rapid soil analyzer which gives instant readings. I believe this is the way forward when it comes to decision making and it is very critical for Field Officers to receive quick response from laboratories to be able to make quick and sound decisions in terms of fertilizer requirements or suitable crops to be planted," said Mr. Sovalawa.

"Fiji is blessed to have approximately 13 percent of arable land however, that too is shrinking at an average of 0.45 percent. Most of our productive lands are under threat, Taveuni is a typical example. Before Taveuni used to export 80 percent of the total volume of Fiji's taro worth almost $22m and reject rate is almost 40 percent now,'' said Mr. Sovalawa.

He said the chemical properties of soil such as soil pH, available Phosphorus, Cation Exchange Capacity (CEC), Nitrogen and Carbon

levels are gradually declining and the main causes of land degradation are deforestation, overgrazing, poor agricultural practices such as burning and mechanization, industrialization and urbanization.

"As a responsible Ministry, it is our duty to intervene and ensure appropriate technologies are developed to address the soil fertility issues in Fiji. Technologies that are practical, affordable and resilient to mitigate climate change and improve soil health and fertility,'' said Mr. Sovalawa.

Mr. Sovalawa acknowledged ACIAR for being the collaborative research partners over the years, for the enhancement of agricultural development and capacity building.

5.2 Presentation- Day 1& 2
5.2.1 What is MIR SPECTROSCOPY?

- Infrared light is shone at a finely ground soil specimen
- Infrared light is scattered and reflected by soil
- Reflected infrared light is measured by a detector
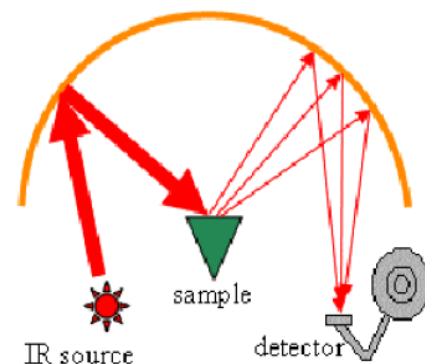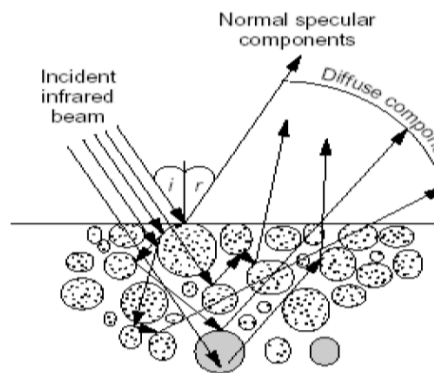
- Some of the infrared light is absorbed by substances in the soil specimen
  - Different substances absorb specific infrared wavelengths
  - Which wavelengths are absorbed depends on chemical bonds of the substance
  - In the infrared light reflected by the specimen, the intensity of these wavelengths is reduced
- Reduction in intensity is proportional to the concentration of the substance
- The reflectance spectrum carries information about the concentrations of the substances in the soil specimen

– Like a fingerprint

5.2.2 Substances that can be estimated in the sample

– Clay
– Silt
– Sand
– Organic carbon
– Total nitrogen
– pH
– Exchangeable cations and CEC
– Iron
- Other properties related to the above **may** be estimated in a given region
  – Phosphorus buffering index (PBI)
  – Plant available water capacity

5.3 Presentation- Day 3 &4
5.3.1 Statistically-based sampling strategy

Soil sampling protocol is important when using MIR. The equipment requires only few grams to be loaded in the cup for determination; therefore it is very critical that soil sampling protocol is followed strictly to ensure correct results are obtained which is representative.

Simplified field procedures that can be carried out by non-experts with an emphasis on soil sampling all sites

Sample Preparation
5.3.2 Purpose of MIR calibration
✓ To correlate measured MIR spectra with soil properties measured by conventional analysis
✓ To use this correlation to estimate these properties for soil samples for which there is no conventional analysis
✓ The whole spectrum is used in correlation
✓ The correlation is done by partial least square regression
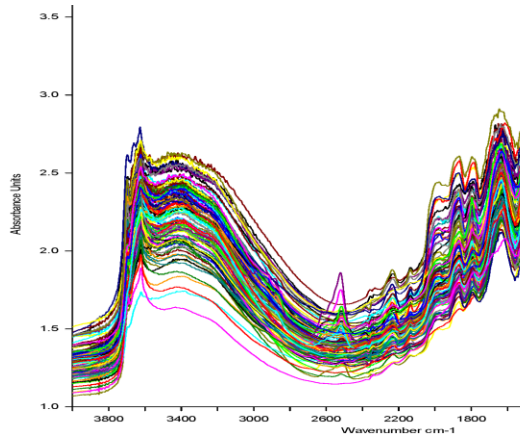
MIR spectra of 104 samples

Calibration process

- ✓ Make a table of spectra of calibration samples
- ✓ Make a table of laboratory results
- ✓ Check match of calibration and lab analysis
- ✓ Calculate calibration
- ✓ Validate
- ✓ Optimize

Staff working on the spectra.

6. Presentation- Day 5 MIR prediction for soil samples

Soil attribute	RPD	Prediction quality	*(Cabulig)*
Organic carbon	2.1	Good quality	*(Analytical quality)*
pH (1:5 H_2O)	2.0	Good quality	*(Good quality)*
Exchangeable Mg	2.1	Good quality	*(Good quality)*
Exchangeable acid	1.7	Indicator	*(Good quality)*
Sum exchangeable cation	3.8	Analytical quality	*(Good quality)*
Clay content	1.8	Indictor	*(Good quality)*
Exchangeable Ca	3.4	Analytical quality	*(Good quality)*
ECEC	3.4	Analytical quality	*(Good quality)*
Sand content	1.7	Indicator	*(Indicator)*
Exchangeable K	1.6	Indicator	*(Indicator)*
Silt	1.4	Poor	*(Poor)*
Olsen P	1.1	Poor	*(Poor)*

7. Closing address by Mr. Vinesh Prasad, Manager ACIAR Pacific

Mr. Vinesh Prasad while closing the training at Koronivia Research Station, said soil knowledge is a constraint on the sustainable intensification and resilience of agriculture to future challenges.

"Current traditional gardening systems in the Pacific Island Countries and Territories (PCTs) have become intensified and resulted in the depletion of the soil nutrient capital. Comprehensive nutrient budgeting is essential for improving farm productivity and agricultural resilience on volcanic islands and sand atolls," said Mr. Prasad.

He said the ACIAR project "Soil Management in the Pacific Islands: investigating nutrient cycling and development of soils portal" will enhance soil knowledge and provide a reliable foundation for sustainable intensification of agricultural systems by growers, extension officers and policy makers.

"The purchase and installation of the new MIR instrument at the Ministry of Agriculture by the project provides enhanced capability to rapidly and economically analyze soil," he said.

He said the MIR instrument will be used to build a new spectral library for archived samples, analyze new samples and work with crop extension to target new areas, work with the project collaborators and dream about how you can undertake innovative research and analysis.

8. Certificate distribution to training participants

Certificate distribution ceremony to the successful participants of the training workshop followed the vote of thanks by Mr. Kemueli Seuseu, Senior Research officer & Government Analyst Food, Koronivia Research Station.

Participants with their certificates

Annexure A

Detailed Program of the Training from 5th - 11th May 2018.

MIR Official Opening Program

Koronivia Research Station

Chemistry Section

Monday 7th April Official Opening.	
9.30	Guest to be seated
9.40	Welcome
9.50	Prayer
10.00	Speech by PSA
10.15	Speech by ACIAR representative
10.30	Presentation by Manager Pacific. ACIAR
11.00	Tea
11.30	Vote of Thanks.

Tentative Program

MIR training

Date	Time	Activity	Facilitator
Monday: 7th April 2018	1.00pm - 4.30pm	Lecture: Course outline Lecture: Introduction to MIR spectroscopy for rapid soil analysis Demonstration of MIR Lecture: Role of rapid soil analysis	Expert
Tuesday: 8th April 2018	AM PM	Setting up MIR spectrometer and software Practical: Sample preparation for MIR Tutorial: Safety Practical: Acquiring MIR spectra from soil samples	Expert
✓ Wednesday: 9th April 2018	✓ 8.30am – 4.30pm	✓ Lecture: Calibration of MIR Practical: Calibration	✓ Expert/ Participants
Thursday :10th April 2018	8.30am – 4.30pm	Practical: Calibration and optimization	Expert/ participants
Friday: 11th April 2018	8.30 – 12.00noon	Practical: Soil property estimation and reporting.	Expert/ participants

Annexure B

List of Participants

- ✓ Akariva Naqo Vesavesa

- ✓ Merewai Bola

- ✓ Paula Qiokata

- ✓ Orisi Dakunivosa

- ✓ Akosita Dovia

- ✓ Radheshni Devi Singh

- ✓ Rozleen Deo

- ✓ Jyotika Deo

- ✓ Rajeshni Devi

- ✓ Sitiveni Waqatabu

- ✓ Waisea Jikowale

- ✓ Ana Sivo

Annexure C

Pictures of the participants and facilitators