Present status of soil sampling and testing protocols employed in key regional soil laboratories in the pacific

Introduction

Pacific regional soil laboratories has been analysing soils since long and probably using their own protocols for soil sampling and analysing. Sometime it is difficult to harmonize the data if soils are sampled and analysed by following different protocols. To solve this harmonization problem in future, it is better to follow same soil sampling and analytical protocols in the region for a regional achievement of soil analyses results. In addition, a network of South Pacific Soil Laboratories was developed called South Pacific Agricultural Chemistry Laboratory Network (SPACNET) in November 1992 with the purpose "to enhance the quality of soil and plant analysis of the participating laboratories with specific objectives of developing quality assurance programmes; strengthen soil and plant exchange network; document standard methodologies for soil and plant analysis and quality control; identify two laboratories as centres for the provision of regional analytical services and the training of technicians (Nari, PNG; and Koronivia Research Station, Fiji were selected); develop links with a laboratory in a metropolitan country to support the quality assurance programmes". SPACNET was mostly funded and technical supported by New Zealand. A Soil Analysis Manual was developed by Daly and Wainiqolo (1993) (Methods of Analysis for Agricultural Samples: Soil, Plant, Animal Feed and Water) under the SPACNET project that has been using by the key regional soil laboratories until today. However, the SPACNET activities was stopped on 2014 when New Zealand SPACNET project finished. Purpose of SPACNET establishment still seems very relevant to the region. In view of this, a short survey followed by face-to-face or virtual consultation was carried out to know the present soil sampling and testing protocols used by the key regional soil laboratories in the pacific and their opinion in reviving the SPACNET.

Methodology

A questionnaire was developed having 21 questions covering soil sampling and testing protocols and send to Fiji Agricultural Chemistry Laboratory, SROS (Scientific Research Organization of Samoa) soil laboratory (Appendix 1) and USP soil laboratory. Then, it was further discussed through a face-to-face consultation with SROS, USP and virtually with Fiji Agricultural Chemistry Laboratory.

Key findings

Soil sampling

Short survey and face-to-face/virtual consultation revealed that all the key regional soil laboratories sample soil from surface horizon only (0-15 cm depth) for soil fertility evaluation of field crops(Appendix 1, 2 and 3). None of the laboratory samples soil from sub-surface horizon unless evaluating soil fertility for fruit crops or studying soil profile. They do not consider the rooting depth of the field crops that will be cultivated in the area. Fiji Agricultural Chemistry Laboratory uses less than 10 sub-samples to make a composite sample; however, SROS and USP Soil Laboratories collect more than 10 sub-samples to make a composite sample. All the laboratories use screw type auger for soil sampling. Occasionally they use spade and knife. None of the soil laboratory has knowledge on maximum size of a uniform land area for collecting a composite sample. Fiji Agricultural Chemistry Laboratory uses both zig-zag and grid procedures for collecting sub-samples from a uniform area, however, SROS and USP Soil Laboratories prefer zig-zag procedure. Soil samples are dried properly in all the labs followed by sieving with a 2mm sieve. However, none of the soil laboratory discards collected additional soil samples following proper

protocol if sampled more than a kg. Fiji Agricultural Chemistry Laboratory records only geolocation/GPS reading but does not record sampling depth, date, field history and crop information, village address and farmers/ researcher name. On the other hand, SROS and USP Soil Laboratories record information on sampling depth, date, village address and farmers/ researcher name but occasionally record geolocation.

Soil testing

All the surveyed three laboratories analyse the collected soil samples similar way but following Soil Analysis Manual developed by Daly and Wainiqolo (1993). None of the soil laboratories uses ASPAC method (Green Book; Rayment and Lyons, 2011) for soil analysis. However, all the soil laboratories showed interest in using ASPAC methods in future, if the methods are written like Daly and Wainiqolo (1993). SROS does not have skills on interpretation of soil analytical results and requested for training them on interpretation of soil analytical results.

SPACNET

All the survey laboratories showed a greater interest in reviving the SPACNET activities because the purposes and activities of SPACNET are still very relevant to the region. They consider it was the golden days for Pacific soil laboratories. SPACNET was very vibrant in the region for training technicians, documenting standard methodologies for soil and plant analysis in simplified manner and quality control, strengthening soil and plant exchange network, sharing knowledge and skills among the soil laboratories. Thus, all the laboratories want to re-activate the SPACNET to bring back their golden days.

Gaps

Soil sampling

No documented soil sampling protocols are in place in the region. Soil Analysis Manual that developed by Daly and Wainiqolo (1993) and still followed by the Pacific Soil Laboratories does not have soil sampling protocols. It started with the preparation of soil samples. Therefore, there is variation in soil sampling among the regional laboratories. It indicates that there is a need to develop soil-sampling protocol for the South Pacific region considering their cropping system, soils, biophysical and socio-economic setup.

Soil analysis

Most South Pacific Soil Laboratories are still using the Soil Analysis Manual developed by Daly and Wainiqolo (1993) for analysis of soil. Nonetheless, those laboratories have been participating in soil proficiency tests organized by the Australasian Soil and Plant Analysis Council (ASPAC) for the Pacific region. ASPAC is validating proficiency results of soil analysis using the methods adopted by Rayment and Lyons (2011) (Green Book).

Although South Pacific Soil Laboratories have access to the methods of Rayment and Lyons (2011), however, those were not adopted because they were not simply written as those of Daly and Wainiqolo (1993). ASPAC has been encouraging for use of Rayment and Lyons (2011) methods for a regional

achievement of soil analyses results, which are comparable to those of Australia and New Zealand. Therefore, there is an urgent need to simplify the methods of Rayment and Lyons (2011) by writing them in a format that South Pacific Soil Laboratory technicians and managers can easily understand.

SPACNET

Most South Pacific Soil Laboratories do not know about the present status of SPACNET but they showed greater interest to SPACNET activities. This was evident when consultations were held with the South Pacific Soil Laboratories, their technicians and managers and researchers. One of the major problem seems availability of fund to run SPACNET activities.

Recommendation

1. A soil sampling protocols needs to be developed for the South Pacific Soil Laboratories as well as farmers to properly collect, prepare, bag and tag soil samples for a regional achievement of soil analyses results.
2. There is an urgent need to simplify the methods of Rayment and Lyons (2011) (Green Book) by writing them in a format that South Pacific Soil Laboratory technicians and managers can easily understand.
3. SPACNET needs to be re-activated. In this case, SPC and USP-SAGEONS may jointly lead the SPACNET where SPC may take care administrative and co-ordination part and USP may take care the technical part. All the existing members of SPACNET will be the member with a yearly subscription fee and new soil laboratories in the South Pacific region may join with similar yearly subscription fee. However, it would not be easy for the South Pacific Soil Laboratories to participate SPACNET with a yearly subscription fee unless it is subsidized/waived. In that case, regional donor agencies such as ACIAR and NZAID or Landcare Research could help with financial and technical support like previous. The area of collaboration of SPACNET members should be mostly similar with initial objectives of SPACNET with some adjustment considering the evolution of GLOSLAN and ASPAC supportive activities in the region. SPACNET may work on the following issues in the region:

    a) Enhance the quality of soil and plant analysis of the participating laboratories with specific objectives of developing quality assurance programmes;
    b) Document standard methodologies for soil and plant analysis and quality control;
    c) Arrange training of technicians of Pacific Soil Laboratories
    d) Strengthen soil and plant exchange network if ASPAC do not cover this area. At present ASPAC is sending soil and plant samples to the Pacific Soil Laboratories who are their subscribe members;
    e) develop links with a laboratory in a metropolitan country to support the quality assurance programmes;
    f) Identify laboratories as centers for the provision of regional analytical services; and
    g) Develop links with ASPAC and GLOSLAN and work in collaboration with them.

References

Daly, B. K., Wainiqolo, J. L. (1993). *Methods of Analysis for Agricultural Samples: Soil, Plant, Animal Feed and Water*. Fiji Agricultural Chemistry Laboratory Technical Report 03/93. 115p.

Rayment, G. E., Lyons, D. J. (2011). *Soil Chemical Methods – Australasia, Australia*: CSIRO Publishing. pp. 100-103.

Appendix 1: USP Soil Laboratory Response

Questionnaire

Name of the laboratory: USP Soil Laboratory

Address: USP Samoa Campus, Alafua, Apia

Country: Samoa

Please answer the following questions. There could be several answers for each question.

1. When is the soil sampling carried out?

a. Before planting a crop√
b. As the need arises√
c. Not in the rain√
d. On a sunny day√
e. Other (please write):

2. How deep soil is sampled?

a. Root crops (0-15 cm) √
b. Root crops (0-30 cm)
c. Fruit trees (0-15 cm) √
d. Fruit trees (0-30 cm) √
e. Fruit trees (>30 cm)
f. Profile samples (at the centre of each horizon) √
g. Other (please write):

3. What method of sampling is followed?

a. A zig-zag procedure in each uniform area √
b. A grid procedure in each uniform area
c. Randomly without following any method
d. Avoid unusual areas√
e. Other (please write):

4. How many soil samples are collected from an area?

a. Depends on the size of the area
b. Depends on the variation in terms of slope, vegetation etc. √
c. Take at least one composite sample from every uniform area√
d. Other (please write):

5. How many sub-samples are collected to get a composite sample?

a. <10 core/auger samples to get a composite sample
b. 10–15 core/auger samples to get a composite sample √
c. 15–20 core/auger samples to get a composite sample
d. >20 core/auger samples to get a composite sample
e. Other (please write):

6. How often is soil sampled from an area?

a. At least once every three years (for general agricultural purposes) √
b. At least once a month (for experimental purposes)
c. Depends on the experimental objectives √
d. Other (please write):

7. How are soil samples labelled?

a. Name and address of the researcher/farmer √
b. Name of the area/village/field number√
c. Date of sampling√
d. Depth of sampling√
e. Sample number (if more than one)
f. Field history√
g. Crop(s) to be grown
h. Geolocation of sampling√ (if needed)
i. Other (please write):

8. What tools are used for soil sampling?

a. Auger√
b. Spade
c. Knife
d. Trowel
e. Trowel and spade together
f. Other (please write):

9. How are soil samples dried?

a. Air dried at room temperature√
b. Oven dried at 40 ° C
c. Oven dried at 65 ° C
d. Oven dried at 104 ° C
e. Other (please write):

10. How are soil samples sieved?

a. Sieved with a 2 mm sieve √
b. Sieved with a 1 mm sieve
c. Sieved with a 2 mm sieve followed by a 0.25 mm sieve
d. Other (please write): used other sieves also based on the requirement of analysis

11. What extractant is used to determine soil pH?

a. Water√
b. 0.01 M Calcium chloride
c. 0.01 M Potassium chloride√ (for pH_{KCl})
d. Other (please write):

12. What soil solution ratio is used to determinate soil pH?

a. 1:5√
b. 1:2.5
c. Other (please write):

13. What soil solution ratio is used to determinate soil electrical conductivity (EC)?

a. 1:5√
b. 1:2.5
c. Saturation paste
d. Other (please write):

14. Which method is used to determine soil total N?

a. Semi micro Kjeldhal method√
b. Dumas method√
c. Saturation paste
d. Other (please write):

15. Which extractant is used to determine available P in soil?

a. Bicarbonate extractable P (Colwell P)
b. Olsen extractable P (Olsen P) √
c. Lactate extractable P (Lactate P)
d. Fluoride extractable P (Bray 1 P)
e. Other (please write):

16. Which extractant is used to determine exchangeable cations/base - Ca, Mg, K and Na in soil?

a. 1 M Ammonium chloride
b. 1 M Ammonium acetate√
c. Other (please write):

17. Which extractant is used to determinate Cu and Zn in soil?

a. DTPA√
b. Ammonium bicarbonate /EDTA
c. 0.1 M HCl
d. Other (please write):

18. Which extractant is used determine B in soil?

    a. Calcium chloride√
    b. Other (please write):

19. Which extractant is used determine Mn and Fe in soil?

    a. DTPA√
    b. Other (please write):

20. Which extractant is used to determine Mo in soil?

    a. Calcium chloride
    b. Other (please write):

21. Which method is used to determine soil organic carbon?

    a. Walkley & Black wet oxidation method√
    b. Dumas method√
    c. Loss-on-ignition√
    d. Other (please write):

Appendix 2: Fiji Agricultural Chemistry Laboratory Response

Questionnaire

Name of the laboratory: Fiji Agricultural Chemistry Laboratory

Address: Koronivia Research Station

Country: Fiji

Please answer the following questions. There could be several answers for each question.

1. When is the soil sampling carried out?

f. Before planting a crop
g. As the need arises
h. Not in the rain
i. On a sunny day
j. Other (please write):

2. How deep soil is sampled?

h. Root crops (0-15 cm)
i. Root crops (0-30 cm)
j. Fruit trees (0-15 cm)
k. Fruit trees (0-30 cm)
l. Fruit trees (>30 cm)
m. Profile samples (at the centre of each horizon)
n. Other (please write):

3. What method of sampling is followed?

f. A zig-zag procedure in each uniform area
g. A grid procedure in each uniform area
h. Randomly without following any method
i. Avoid unusual areas
j. Other (please write):

4. How many soil samples are collected from an area?

e. Depends on the size of the area
f. Depends on the variation in terms of slope, vegetation etc.
g. Take at least one composite sample from every uniform area
h. Other (please write):

5. How many sub-samples are collected to get a composite sample?

f. <10 core/auger samples to get a composite sample
g. 10–15 core/auger samples to get a composite sample
h. 15–20 core/auger samples to get a composite sample
i. >20 core/auger samples to get a composite sample
j. Other (please write): depend on site of the sampling site

6. How often is soil sampled from an area?

e. At least once every three years (for general agricultural purposes)
f. At least once a month (for experimental purposes)
g. Depends on the experimental objectives
h. Other (please write): after any natural events such as flooding, tsunami

7. How are soil samples labelled?

j. Name and address of the researcher/farmer
k. Name of the area/village/field number
l. Date of sampling
m. Depth of sampling
n. Sample number (if more than one)
o. Field history
p. Crop(s) to be grown
q. Geolocation of sampling
r. Other (please write): GPS reading

8. What tools are used for soil sampling?

g. Auger
h. Spade
i. Knife
j. Trowel
k. Trowel and spade together
l. Other (please write): buckets, sample plastic bags, Askey

9. How are soil samples dried?

f. Air dried at room temperature
g. Oven dried at 40 ° C
h. Oven dried at 65 ° C
i. Oven dried at 104 ° C
j. Other (please write):

10. How are soil samples sieved?

e. Sieved with a 2 mm sieve
f. Sieved with a 1 mm sieve
g. Sieved with a 2 mm sieve followed by a 0.25 mm sieve
h. Other (please write): 0.25 mm for C and N

11. What extractant is used to determine soil pH?

e. Water
f. 0.01 M Calcium chloride
g. 0.01 M Potassium chloride
h. Other (please write): Buffer 4 and 7 for calibration

12. What soil solution ratio is used to determinate soil pH?

d. 1:5
e. 1:2.5
f. Other (please write):

13. What soil solution ratio is used to determinate soil electrical conductivity (EC)?

e. 1:5
f. 1:2.5
g. Saturation paste
h. Other (please write):

14. Which method is used to determine soil total N?

e. Semi micro Kjeldhal method
f. Dumas method
g. Saturation paste
h. Other (please write):

15. Which extractant is used to determine available P in soil?

f. Bicarbonate extractable P (Colwell P)
g. Olsen extractable P (Olsen P)
h. Lactate extractable P (Lactate P)
i. Fluoride extractable P (Bray 1 P)
j. Other (please write):

16. Which extractant is used to determine exchangeable cations/base - Ca, Mg, K and Na in soil?

d. 1 M Ammonium chloride
e. 1 M Ammonium acetate
f. Other (please write):

17. Which extractant is used to determinate Cu and Zn in soil?

e. DTPA
f. Ammonium bicarbonate /EDTA
g. 0.1 M HCl
h. Other (please write):T.E.A & Calcium Chloride.

18. Which extractant is used determine B in soil?

    c. Calcium chloride
    d. Other (please write):

19. Which extractant is used determine Mn and Fe in soil?

    c. DTPA
    d. Other (please write): T.E.A & CaCl2

20. Which extractant is used to determine Mo in soil?

    c. Calcium chloride
    d. Other (please write):not testing

21. Which method is used to determine soil organic carbon?

    e. Walkley & Black wet oxidation method
    f. Dumas method
    g. Loss-on-ignition
    h. Other (please write):

Appendix 3: SROS Laboratory Response

Questionnaire

Name of the laboratory: SROS Soil Laboratory

Address: PO Box 6597, Apia, Samoa.

Country: Samoa

Please answer the following questions. There could be several answers for each question.

1. When is the soil sampling carried out?

k. Before planting a crop
l. As the need arises
m. Not in the rain
n. On a sunny day
o. Other (please write):

2. How deep soil is sampled?

o. Root crops (0-15 cm)
p. Root crops (0-30 cm)
q. Fruit trees (0-15 cm)
r. Fruit trees (0-30 cm)
s. Fruit trees (>30 cm)
t. Profile samples (at the centre of each horizon)
u. Other (please write):

3. What method of sampling is followed?

k. A zig-zag procedure in each uniform area
l. A grid procedure in each uniform area
m. Randomly without following any method
n. Avoid unusual areas
o. Other (please write):

4. How many soil samples are collected from an area?

i. Depends on the size of the area
j. Depends on the variation in terms of slope, vegetation etc.
k. Take at least one composite sample from every uniform area
l. Other (please write):

5. How many sub-samples are collected to get a composite sample?

k. <10 core/auger samples to get a composite sample
l. 10–15 core/auger samples to get a composite sample
m. 15–20 core/auger samples to get a composite sample
n. >20 core/auger samples to get a composite sample
o. Other (please write):

6. How often is soil sampled from an area?

i. At least once every three years (for general agricultural purposes)
j. At least once a month (for experimental purposes)
k. Depends on the experimental objectives
l. Other (please write):

7. How are soil samples labelled?

s. Name and address of the researcher/farmer
t. Name of the area/village/field number
u. Date of sampling
v. Depth of sampling
w. Sample number (if more than one)
x. Field history
y. Crop(s) to be grown
z. Geolocation of sampling
aa. Other (please write):

8. What tools are used for soil sampling?

m. Auger
n. Spade
o. Knife
p. Trowel
q. Trowel and spade together
r. Other (please write):

9. How are soil samples dried?

k. Air dried at room temperature
l. Oven dried at 40 ° C
m. Oven dried at 65 ° C
n. Oven dried at 104 ° C
o. Other (please write):

10. How are soil samples sieved?

i. Sieved with a 2 mm sieve
j. Sieved with a 1 mm sieve
k. Sieved with a 2 mm sieve followed by a 0.25 mm sieve
l. Other (please write):

11. What extractant is used to determine soil pH?

i. Water
j. 0.01 M Calcium chloride
k. 0.01 M Potassium chloride
l. Other (please write):

12. What soil solution ratio is used to determinate soil pH?

g. 1:5
h. 1:2.5
i. Other (please write):

13. What soil solution ratio is used to determinate soil electrical conductivity (EC)?

i. 1:5
j. 1:2.5
k. Saturation paste
l. Other (please write):

14. Which method is used to determine soil total N?

i. Semi micro Kjeldhal method
j. Dumas method
k. Saturation paste
l. Other (please write):

15. Which extractant is used to determine available P in soil?

k. Bicarbonate extractable P (Colwell P)
l. Olsen extractable P (Olsen P)
m. Lactate extractable P (Lactate P)
n. Fluoride extractable P (Bray 1 P)
o. Other (please write):

16. Which extractant is used to determine exchangeable cations/base - Ca, Mg, K and Na in soil?

g. 1 M Ammonium chloride
h. 1 M Ammonium acetate
i. Other (please write):

17. Which extractant is used to determinate Cu and Zn in soil?

i. DTPA
j. Ammonium bicarbonate /EDTA
k. 0.1 M HCl
l. Other (please write):

18. Which extractant is used determine B in soil?

    e. Calcium chloride
    f. Other (please write):

19. Which extractant is used determine Mn and Fe in soil?

    e. DTPA
    f. Other (please write):

20. Which extractant is used to determine Mo in soil?

    e. Calcium chloride
    f. Other (please write):

21. Which method is used to determine soil organic carbon?

    i. Walkley & Black wet oxidation method
    j. Dumas method
    k. Loss-on-ignition
    l. Other (please write):