2. SOIL AND PLANT SAMPLING, AND PROCESSING

While the main focus of this manual is to present an easy-to-use methodology for soil testing and, to a lesser extent, for plant analysis, their related aspects are worthy of due emphasis. Therefore, a brief description of such aspects follows.

2.1 Soil

While much attention is given to laboratory procedures, the process of obtaining soil for analysis, i.e., soil sampling, is often *ignored* or *poorly considered.* A good sampling plan should provide a measure of the average fertility level of a field and a measure of how *variable* it is.

If a sample is *not representative* of the field or is *incorrectly* taken, the resulting analytical data would be *meaningless,* or at best, difficult to interpret. The error in *field sampling* is generally *much greater* than that due to chemical analysis. Therefore, obtaining a representative soil sample from a field is the most important step for making a *meaningful* soil analysis.

1. Sampling

A soil sample should be composed of several sub-samples representing a seemingly uniform area or field with similar cropping and management history. There is no *universally* accepted numbers of sub-samples for different field situations. However, the following points can serve as guidelines:

A. Composite Sampling

- At ICARDA, eight sub-samples are taken per hectare (ha) in a diagonal pattern for obtaining one composite sample.
- Other plans range from 5 to 25 borings or sub-samples per composite sample, with sample units varying from 2 to 8 ha.
- Fewer sub-samples are needed where little or no fertilizer has been used. Sampling areas are often traversed in a zig-zag pattern to provide a uniform distribution of sampling sites. Some of these methods are represented in **Figure 1**.
- Correspondingly, more sub-samples are needed where fertility is variable due to hand broadcasting of fertilizers and/or with cropping-livestock systems. Indeed, banding of fertilizer poses serious problems for reliable sampling.

- Thus the number of sub-samples taken by farmers should be *realistic,* considering the particular field situation.

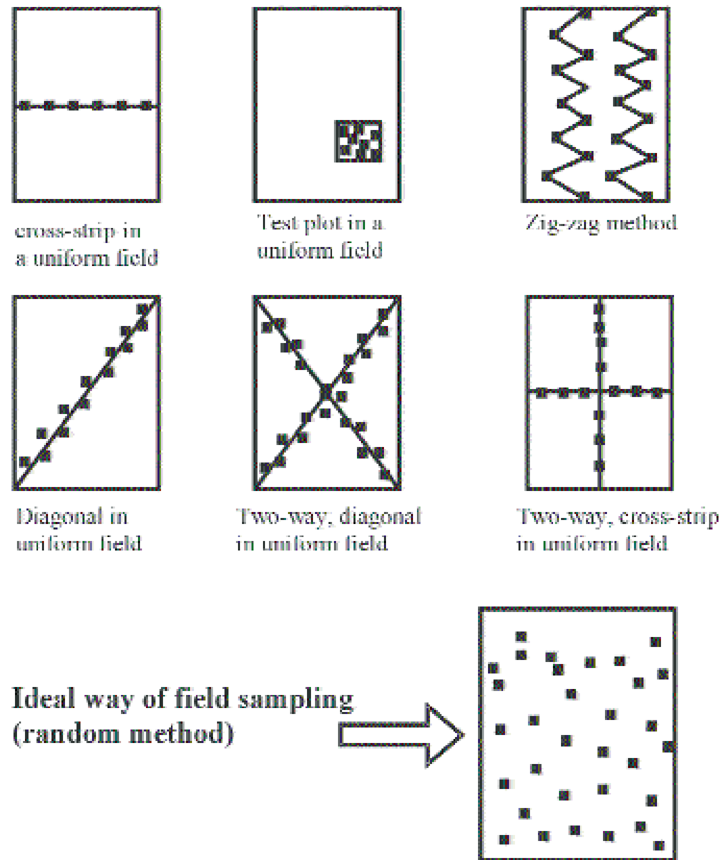

Fig. 1. Some suggested methods for soil sampling.

B. Time of Sampling

- Soil samples can be taken any time that soil conditions permit. However, sampling directly after fertilization or amendment application should be avoided.
- Samples taken during the crop growth period will help in knowing the nutrient status of the soil in which plants are drawing nutrients.
- In the CWANA region, it is recommended that sampling be carried out in autumn (before planting) if fertilization is intended at planting.
- It is important to sample at similar times year after year for comparing analysis at regular time intervals.

C. Depth of Sampling

- For most purposes, soil sampling is done to a depth of about 20-cm. Research in the CWANA region has shown that available P, NO_3 - N, and micronutrients in such samples are related to crop growth, and nutrient uptake.
- In some cases, especially in irrigated areas, sampling to a depth of 60 - 100 cm is desirable, especially for monitoring nitrate (NO_3-N) leaching and salinity.
- Depthwise soil samples should also be taken where there is a concern about B toxicity.

D. Sampling Tools

- There are two important requirements of a sampling tool: first, that a uniform slice should be taken from the surface to the depth of insertion of the tool, and second, that the same volume of soil should be obtained in each sub-sample.
- Augers generally meet these requirements. In areas where the topsoil is dry, e.g., during summer, the topsoil sampling can be done by a metal ring, by digging out the soil inside the ring, because it is almost impossible to sample dry topsoils with an auger.
- Soil samples for micronutrient analysis should be taken using a stainless steel auger, or at least ungalvanized auger (because galvanized coating is zinc oxide).
- Researchers generally use augers for field sampling. Farmers or Extension Agents can use shovels or trowels with almost the same result.

2. Field Processing

- Soil samples must be put in plastic bags (tags and markers are required).
- Soil samples can be transported to the laboratory in cardboard boxes or sacks.

3. Laboratory Processing

- All information about samples is recorded; and each sample is given a laboratory number.
- Samples are put in a freezer for minimizing microbial activity.
- Samples are air-dried or dried in an air-forced oven at 30°C.
- When dried, samples are cleaned off any stones and plant residues.
- Samples are ground in a stainless steel soil grinder and passed through a 2-mm sieve. Samples for particle-size distribution are ground with a pestle and mortar. Some analyses call for use of sieves of a less than 1-mm size fraction.
- The sieved soils are collected, sub-sampled (~500 g), and stored in plastic bottles.
- Laboratory sub-samples are made with a Riffle-type Sample Splitter (**Fig. 2**).
- Laboratory sub-samples are given a number and sent to the laboratory for the requested analyses.

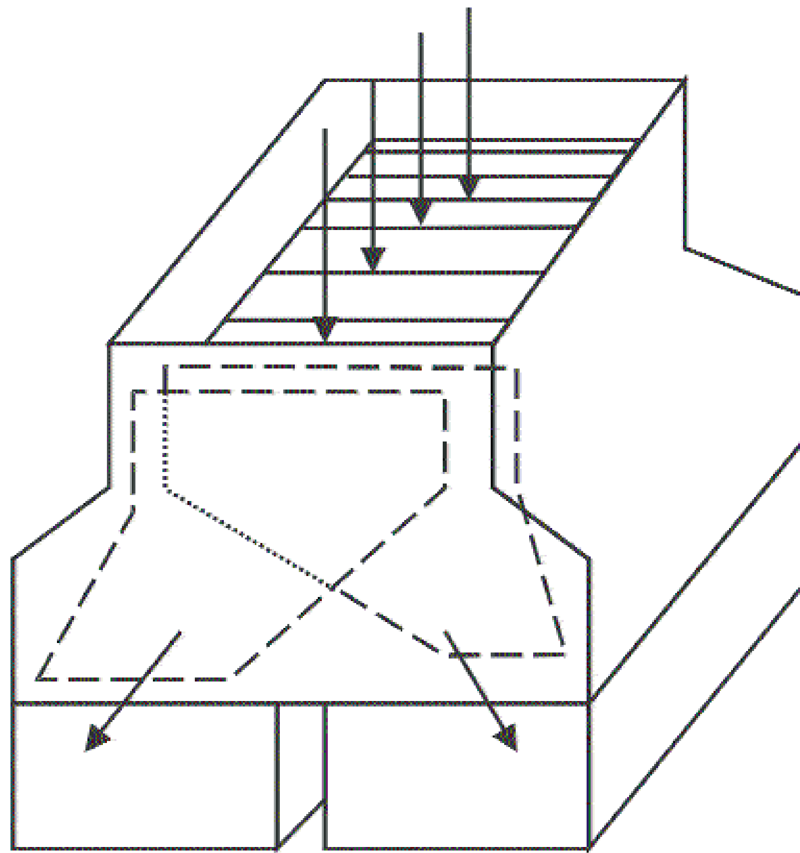

Fig. 2. Riffle-type soil sample splitter.

2.2 Plant

From the nutritional standpoint, plant analysis is based on the principle that the concentration of a nutrient within the plant is an integral value of all the factors that have interacted to affect it. Plant analysis involves the determination of nutrient concentration in diagnostic plant part(s) sampled at recommended growth stage(s) of the crop.

The concentration of some nutrient elements may be *too low for optimum growth,* while of others may be so high as to be *detrimental to the plant's growth.* Overviews such as that of Munson and Nelson (1990) illustrate how nutrient concentrations in plants vary with the element in question, type of plant, specific plant part, growth stage, level of available soil nutrients, expected yield level, and environmental factors.

While laboratory technicians do not normally sample plants, it is important that they be *aware* of the necessity of proper sampling. Otherwise, analyses that they are asked to perform on plant samples may end up to be *meaningless* and a *waste of time*.

1. Plant Sampling

Years of research in soil fertility-plant nutrition have produced reliable sampling criteria and procedures for most of the world's commercial crops: *leaves* are most commonly chosen, but *petioles* are selected in certain cases, e.g., cotton, sugarbeet. *Seeds* are rarely used for analysis, except for assessing of B toxicity and Zn and P deficiency in certain grain crops. In some cases, e.g., cereals, the entire above-ground young plants are sampled.

When leaves are sampled, recently matured ones are taken; both new and old growth is generally avoided. However, *young emerging leaves* are sampled for diagnosing iron chlorosis by determining ferrous (Fe^{++}) content of fresh leaves (Katyal and Sharma, 1980) and B content in certain crops (Bell, 1997). Damaged or diseased leaves are excluded, and plants should not be sampled when the crop is under moisture or temperature stress. Sampling procedures for important dryland crops of the CWANA region are given in **Appendix 10.**

Plant samples should be transported to the laboratory immediately in properly labeled paper bags that allow for transpiration; this reduces the possibility of rotting.

2. Laboratory Processing

Five steps are followed for processing the sampled plant tissues:

1. Cleaning plant tissue to remove dust, pesticide and fertilizer residues: normally by washing the plants with de-ionized water or with 0.1 - 0.3 % P-free detergent, followed by de-ionized (DI) water. If not essentially required, samples for soluble element determination may not be washed, particularly for long periods. However, samples for total iron analysis must be washed.
2. Immediate drying in an oven to stop enzymatic activity, usually at 65°C for 24 hours.
3. Mechanical grinding to produce a material suitable for analysis, usually to pass a 60-mesh sieve; stainless steel mills are preferable, particularly when micronutrient analysis is involved.
4. Since most analytical methods require grinding of a dry sample, careful attention must be given to avoiding contamination with the element to be analyzed. Particular care is required for micronutrients.
5. Final drying at 65°C of ground tissue to obtain a constant weight upon which to base the analysis.

Moisture Factor

Weighing of perfectly oven-dried samples is, however cumbersome (involves continuous oven drying and use of desiccator, and is still prone to error) as plant material may absorb moisture during the weighing process, particularly if relative humidity is high in the laboratory.

To get around this difficulty, use of the Moisture Factor is suggested instead. The Moisture Factor for each batch of samples can be calculated, by oven-drying only a few sub-samples from the lot (e.g., 5 from a batch of 100 - 200 samples).

$$\textit{Moisture Factor} = \frac{\textit{Weight of air dry sample (g)}}{\textit{Weight of oven dry sample (g)}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

Thereafter, air dry samples are weighed, considering the Moisture Factor. For example, if Moisture Factor = 1.09, then weight of oven dry and air dry samples will be as follows:

Oven-dry weight	*Air-dry weight*
------------------------g--------------------	
0.25	*0.27*
0.50	*0.55*
1.00	*1.09*
2.00	*2.18*

The Moisture Factor approach is also used for weighing soil samples, and expressing the analytical results on oven dry soil weight basis.