Chapter 1

Introduction

The role of plant nutrients in crop production is well established. There are 16 essential plant nutrients. These are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), sulphur (S), zinc (Zn), manganese (Mn), copper (Cu), boron (B), molybdenum (Mo) and chlorine (Cl). These nutrient elements have to be available to the crops in quantities as required for a yield target. Any limiting or deficient nutrient (or nutrients) will limit crop growth.

The required nutrients may come from various sources, such as the atmosphere, soil, irrigation water, mineral fertilizers, manures and biofertilizers. The combinations, quantities and integration of nutrients to be supplied from various sources (integrated plant nutrient supply) depend on various factors including the type of crop, soils, availability of various resources, and ultimately on economic considerations, such as the level of production and the costs of inputs and outputs.

Integrated nutrient management (INM) is a well-accepted approach for the sustainable management of soil productivity and increased crop production. To implement this approach successfully, well-equipped testing laboratories, among other things, are needed in order to evaluate the nutrient supplying capacities of various sources.

Accurate and timely analysis helps in determining the requirements of plant nutrients so as to arrange their supply through various sources. The analytical facilities required for chemical analysis of soils, plants, water and fertilizers are broadly identical in nature with a few specific requirements in terms of facilities and chemicals for certain estimations. The facilities for biofertilizer assay are of a highly specialized nature and are different from those required for chemical analysis. In view of this, it is possible to set up integrated facilities for soil, plant, water and fertilizer analysis, and a biofertilizer testing facility can be added (as appropriate) in an adjacent or expanded building. A common facility saves on supervision and other costs, such as common equipment and chemicals.

Depending on the need, different types of laboratories can be set up (Table 1). A soil, plant and water testing laboratory with an annual analysing capacity of about 10 000–12 000 samples requires a building space of about 370 m^2. For a fertilizer testing laboratory with an analysing capacity of 2 000 samples, the space requirement is about 185 m^2. A composite laboratory may require about 480 m^2. Annex 1 provides a laboratory floor plan.

A biofertilizer laboratory with an analysing capacity of 1 000 samples and a production of 25–100 tonnes of biofertilizer per year may require an area of about 270 m^2. Annex 2 provides a floor plan for such a laboratory.

Requirements in terms of equipment, glassware and chemicals have been determined separately for laboratories of types A (Annex 3), B (Annex 4) and D (Annex 5). For the setting up of type C and E laboratories, the requirements in terms of the relevant facilities can be added together. Under budget constraints, there would be advantages in ordering the same chemicals in one order, and in using the same glassware and costly equipment, such as a spectrophotometer and an atomic absorption spectrophotometer (AAS). An experienced chemist would be able to decide on the actual reduction and, thus, achieve cost savings in setting up a composite laboratory.

Some of the methods are common for estimating plant nutrients in soils, plants and fertilizers. Annex 6 summarizes the methods described in this publication.

Given the increasing need for analysis of larger numbers of soil, plant, water and fertilizer samples by the service laboratories to serve the farmers more rapidly and more effectively, various types of equipment/techniques capable of multinutrient analysis may be useful. Annex 7 describes some of them, e.g. autoanalysers and inductively coupled plasma–atomic emission spectroscopy (ICP–AES). However, for service laboratories in developing countries that are limited in terms of facilities, skilled personnel and financial resources, such equipment is not advocated.

TABLE 1.
Laboratory types, with analysis capacity

Category	**Laboratory type**	**Type of analysis**	**Capacity-samples per year**
A	Soil, plant & water analysis	Soil	10,000
		Plant	1 000
		Water (irrigation)	500
B	Mineral & organic fertilizer analysis	Mineral fertilizers	1500
		Organic fertilizers	500
C	Soil, plant, water, mineral & organic fertilizers analysis (A+B)	Soil	10,000
		Plant	1 000
		Water	500
		Mineral fertilizers	1500
		Organic fertilizers	500
		Biofertilizer	1000
D	Biofertilizer	Biofertilizer	1 000
E	Soil, plant, water, mineral, organic fertilizer & biofertilizer analysis (C+ D)	Soil	10000
		Plant	1000
		Water (irrigation)	500
		Mineral fertilizers	1500
		Organic fertilizers	500

Chapter 2

The basics of an analytical laboratory

In chemical laboratories, the use of acids, alkalis and some hazardous and explosive chemicals is unavoidable. In addition, some chemical reactions during the analysis process may release toxic gases and, if not handled well, may cause an explosion. Inflammable gases are also used as a fuel/heating source. Thus, work safety in a chemical laboratory calls for special care both in terms of the design and construction of the laboratory building, and in the handling and use of chemicals. For chemical operations, it is also necessary to provide special chambers.

The air temperature of the laboratory and work rooms should be maintained constant at 20–25°C. Humidity should be kept at about 50 percent. Temperature and humidity often affect soil and fertilizer samples. Temperature also affects some chemical operations. Hence, maintaining the temperature and humidity as specified is critical.

Proper air circulation is also important in order to prevent hazardous and toxic fumes and gases from remaining in the laboratory for long. The release of gases and fumes in some specific analytical operations are controlled through fumehoods or trapped in acidic/alkaline solutions and washed through flowing water. The maintaining of a clean and hygienic environment in the laboratory is essential for the good health of the personnel.

Care is required in order to ensure that acids and hazardous chemicals are stored in separate and safe racks. An inventory of all the equipment, chemicals, glassware and miscellaneous items in a laboratory should be maintained (Annex 8 suggests a suitable format). A safe laboratory building should have suitable separate rooms for different purposes and for performing different operations as described below (with a floor plan in Annex 1):

- Room 1. Reception, sample receipt, and dispatch of reports.
- Room 2. Sample storage and preparation room (separate for soil/plant and fertilizers).
- Room 3. Nitrogen digestion/distillation room (with fumehood for digestion).
- Room 4. Instrument room to house:
  - atomic absorption spectrophotometer (AAS);
  - flame photometer;
  - spectrophotometer;
  - pH meter, conductivity meter;
  - ovens;
  - centrifuge;
  - balances;
  - water still.
- Room 5. Chemical analysis room (separate for soil/ plant and fertilizers):
  - to prepare reagents and chemicals, and to carry out their standardization;
  - to carry out extraction of soil and fertilizer samples with appropriate chemicals/reagents;
  - to carry out titration, colour development, precipitation, filtration, etc.;
  - all other types of chemical work.
- Room 6. Storage room for chemicals and spare equipment.
- Room 7. Office room with computers for data processing and record keeping.

LABORATORY SAFETY MEASURES

Special care is required while operating equipment, handling chemicals and in waste disposal.