Contents

USER’S MANUAL: FERTILIZERS .................................................................................. 3

INTRODUCTION ......................................................................................................... 3

CHAPTER I. FERTILIZERS AND AGRICULTURE .................................................. 4
1. Brief history ........................................................................................................... 4
2. Soil and fertilizers ................................................................................................. 4
   2.1 Soil structure .................................................................................................... 4
   2.2 Texture and soil components ........................................................................... 4
   2.2.1 Texture definition ....................................................................................... 5
   2.2.2 Texture and nutrients ................................................................................. 5
2.3 Soil pH ................................................................................................................ 7
3. Terms that describe nutrient element levels ....................................................... 7
4. Fertilizers and composition ................................................................................ 8
   4.1 Fertilizer: Understanding its chemical composition ....................................... 8
   4.1.1 Complete vs. incomplete fertilizers ............................................................ 8
   4.1.2 What do the numbers really mean? ............................................................ 8
   4.2 Fertilizer formulation ...................................................................................... 9
   4.3 Fertilizer application ....................................................................................... 9

CHAPTER II. FERTILIZERS: AGRICULTURAL RESEARCH AND POPULATION GROWTH .................................................................................. 10
2.1 Green revolution and agriculture ...................................................................... 10
2.2 Micro dosing and agriculture ............................................................................ 11

CHAPTER III. CHEMICAL VS. ORGANIC FERTILIZERS .................................. 12
3.1 Fertilizer ........................................................................................................... 12
3.2 Integrated plant nutrition systems (IPNS) ......................................................... 14
3.3 Chemical fertilizers or organic manure .............................................................. 14
3.4 How to use fertilizers ....................................................................................... 14
3.3 Examples of chemical fertilizers used by ACF missions .................................. 15

CHAPTER IV. ACF POSITION ON FERTILIZERS ............................................. 16
4.1 Conclusion ......................................................................................................... 16
4.2 Recommendations ............................................................................................ 17

ANNEXES ON FERTILIZERS .................................................................................. 21
Annex #1. Tips for using chemical fertilizers ......................................................... 21
Annex #2. Soil testing .............................................................................................. 22
USER’S MANUAL: FERTILIZERS

This current “User’s Manual” was produced at the same time as the ACF position on agrochemicals (November 2010). It aims to facilitate the operational roll-out of the positioning and support the field teams in setting up and implementing agricultural projects where the use of fertilizers may be considered.

INTRODUCTION

Agriculture is a key motor of the global economy. It supports the livelihoods and subsistence of the largest number of people worldwide and is vital to rural development and poverty alleviation, as well as production of food and non-food products.

The main challenge for the agriculture sector is to simultaneously secure enough high-quality agricultural production to meet the demand; conserve biodiversity and manage natural resources; and improve human health and well being, especially for the rural poor in developing countries.

As such, agricultural management techniques need to further increase the productivity of existing farmland through good and efficient management practices, while embracing the three pillars\(^1\) of sustainability:

- Environmental pillar: support biodiversity and ecosystems, sustain productive agriculture;
- Social pillar: improve livelihoods by providing high-quality food, feed, fiber and fuel;
- Economic pillar: provide income to rural communities.

Until about four decades ago, agricultural crop yields depended on internal resources, recycling of organic matter, built-in biological control mechanisms and rainfall patterns. Agricultural yields were modest, but stable. Production was safeguarded by growing more than one crop or variety in a field as insurance against pest outbreaks or severe weather. Nitrogen inputs were gained by rotating major field crops with legumes. In turn, crop rotation suppressed insects, weeds and diseases by breaking the life cycles of these pests.

As agricultural modernization progressed, the link between ecology and farming was often broken as ecological principles were ignored and/or overridden. In fact, several agricultural scientists have arrived at a general consensus that modern agriculture is in an environmental crisis. A growing number of people have become concerned about the long-term sustainability of modern food production systems. Evidence has accumulated that while current capital- and technology-intensive farming systems have been extremely productive and competitive; they have also caused a variety of economic, environmental and social problems.

---

CHAPTER I. FERTILIZERS AND AGRICULTURE

1. Brief history

**Origin:** The first chemical fertilizer was phosphorus-based and was invented in the early 19th century. It was composed of a superphosphate made by treating bones with sulphuric acid.

**Early formulation:** The bone material in phosphorous (P) fertilizer was quickly replaced with phosphate rock and coprolites (fossilized animal fecal matter).

**Development:** Potassium (K) fertilizers were first developed in Germany in 1861 and in North America between 1914 and 1919. Use of these fertilizers expanded when potassium deposits were discovered in New Mexico in 1931 and again in the Saskatchewan territory in 1958. The first Nitrogen (N) fertilizer, calcium nitrate, was formulated in 1903.

**Use:** The use of NPK fertilizers (particularly nitrogen and phosphorus) has been steadily increasing since 1945.

2. Soil and fertilizers

It has long been recognized that when crops are harvested, certain plant foods are removed from the soil. Permanent agriculture can be established only when soil fertility is maintained by returning these mineral components to it. The most important of these are potassium, phosphorus, and nitrogen, as practically all arable soil contains an unlimited supply of other mineral plant food. Replenishing these elements requires good tillage methods and the intelligent use of fertilizer, based upon knowledge of the particular soil involved as well as crop requirements. Moreover, as virgin arable land becomes less and less available, the maintenance of soil fertility becomes more important.

2.1 Soil structure

Structure is distinct from soil texture. Structure refers to the clumping together or “aggregation” of sand, silt, and clay particles into larger secondary clusters. Soil structure has a direct impact on air and water circulation in the soil, roots’ ability to grow, and the biodiversity of essential micro-organisms.

How can structure be improved?

Soil structure must hold enough air and water for the plant roots, but must also allow excess water to drain away. It must promote the development of micro-organisms in order to contribute to soil fertility. It can be improved in the following ways:

1. Cement can be added like Ca++ through liming, but this is quite expensive.
2. Bricks of organic matter can be added; humus will always improve soil structure.

2.2 Texture and soil components

Soils have four basic components: minerals, air, water, and organic matter. In most soils, minerals represent around 45% of the total volume, water and air about 25% each, and

---

3 Calcium is a flocculation agent. Lime is mainly composed by Ca2+. Liming is a technique for spreading lime on the field. It has two major impacts:
   - Linking clay particles together, creating flocculation and good structure
   - Replacing fixed Hydrogen ions (H+) that are bad for structure (decreasing acidity)
organic matter from 2% to 5%.

There are three distinct particle sizes of minerals, classified as **sand**, **silt**, or **clay**. Sand is the largest particle, while silt is the medium one and clay the smallest one.

### 2.2.1 Texture definition
Texture refers to the mineral component of the soil, meaning the proportion of sand, **silt** and **clay**.

### Consequences of texture
Soil texture defines the mineral component of soil. It can be considered an inherent soil property.

Texture cannot be affected easily. However, you should be aware of soil texture so that you know the soil’s limitations regarding water, fertility and labour requirements.

### 2.2.2 Texture and nutrients
Most types of clay contain appreciable amounts of plant nutrients >>> fertile
Silt is usually come from riverbeds and contain plant nutrients too >>> fertile
Sand is mainly the mineral quartz that contains no plant nutrients >>> not fertile

**BUT:**
Clay can fix nutrients so that they are not washed out easily. Clay keeps nutrients available for the plant. “Thus, clay soils use fertilizers most effectively”. Silt and sand cannot fix nutrients, and they cannot hold nutrients that are leached out easily by rainfall.

#### How can soil fertility be managed?
Poor soil can become productive if it is managed properly. Manure and compost can improve soil structure, while chemical fertilizer can increase its productive capacity. Home garden managers /farmers should apply plant nutrients to the soil just before planting, making additional applications as the crops grow. The basic method of application is to mix the compost, organic matter, manure or chemical fertilizer into the soil just before planting, and then to apply smaller amounts alongside the plants about every two weeks until harvest.

Soil provides habitat for a plant, so its physical, chemical, and biological properties affect plant growth. Soil’s physical properties largely determine the ways in which it can be used. These include the size, shape, and arrangement of primary soil particles. Another important physical property is the size and shape of the spaces between the particles, or the pore space, which directly affects the movement of air and water, the soil’s ability to supply nutrients to plants, and the amount of water available to the plants.

The proportion of the four major components of soil, inorganic particles, organic materials, water and air, can vary greatly from place to place and with depth. The amount of water and air in soil can also fluctuate from season to season. However, the physical characteristics of soil components, inorganic and organic particles, essentially do not change.

Soils’ chemical properties are important; they work physical and biological properties to regulate plants’ nutrient supplies. If these nutrients are not available from the soil or applied as inorganic fertilizer, organic manure, or other vegetative materials, plants cannot grow.
Soil’s biological properties vary with the macro- and micro-organisms that are present. Good physical and chemical properties supply the right environment and sufficient nutrients for organisms’ optimal biological activity, which, in turn, improves soil structure and nutrient cycling, leading to improved physical and chemical properties.

According to criteria laid down by Arnon and Stout (1939), and cited by Roy R. et al (2006), the growth and full development of higher green plants requires only 16 elements. Criteria for these elements are:

- Deficiency of an essential nutrient makes it impossible for the plant to complete the vegetative or reproductive stage of its life cycle.
- Such a deficiency is specific to the element in question and can be prevented or corrected only by supplying this element.
- The element is involved directly in the nutrition of the plant, and this function is separate from its possible effects on microbiological or chemical conditions in the soil or other medium of cultivation.

N.B. The term “macronutrients” refers to elements that are used in relatively large amounts, whereas the term “micronutrients” refers to elements that are required in relatively small amounts.

Table #1. Essential plant nutrients

<table>
<thead>
<tr>
<th>Supplied from air and water</th>
<th>Supplied from soil and fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Macronutrients</td>
</tr>
<tr>
<td>Carbon</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Phosphorous</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Potassium</td>
</tr>
<tr>
<td></td>
<td>Sulphur</td>
</tr>
<tr>
<td></td>
<td>Calcium</td>
</tr>
<tr>
<td></td>
<td>Magnesium</td>
</tr>
<tr>
<td></td>
<td>Calcium</td>
</tr>
<tr>
<td></td>
<td>Magnesium</td>
</tr>
</tbody>
</table>

Productive, fertile soils offer basic physical support for plants while supplying moisture, air, and nutrients for the roots. Although soil fertility and plant nutrition are important components of crop production, growers often take for granted, or even totally ignore, basic principles for managing these components.

Organic soil fertility management is guided by the philosophy, “feed the soil to feed the plant”.

This basic precept is put into action through a series of practices designed to increase organic matter, biological activity, and nutrient availability in soils.

**Nitrogen** is the element that soil most often lacks, and substantial amounts of phosphorus and potassium are also necessary. For this reason, these elements are always

---

5 Gaskell M et al. 2007. Soil fertility management for organic crops. University of California
included in commercial fertilizers, and fertilizer bags provide information on the content of each.

2.3 Soil pH

Soil pH measurements indicate the amount of hydrogen ion activity in a soil solution. The pH number expresses the degree of acidity or alkalinity, similar to the way in which heat and cold are expressed in degrees of Centigrade or Fahrenheit. The scale ranges from 1 to 14 pH units, with pH 7 being neutral. Values below 7 are acidic while values above 7 are alkaline. The pH scale is logarithmic, not linear. So, a soil with a pH of 8.0 is ten times more alkaline that a soil with a pH of 7.0. Soil with a pH of 5.0 is 100 (not 20) times more acid than a soil with a pH of 7.0.

Soil pH is one of a number of environmental conditions that affect plant growth. Most vegetable prefer soil that is slightly acidic soil. However, some plants can grow at a pH ranging anywhere from 3.5 to 10.0. With some exceptions, a soil pH of 6.0 to 7.0 is ideal for plants. The major impact of pH extremes is related to the availability of plant nutrients and the concentration of toxic elements in the soil.

In strongly acidic soils with a pH <5.5, manganese and aluminium can reach toxic levels. At low pH values, calcium, phosphorous, magnesium, and molybdenum are also less available. Phosphorous, iron, zinc, bron, copper etc. become less available at pH values of 7 and above.

PH values can be adjusted. To decrease soil acidity and increase pH, finely ground agricultural limestone can be added to the soil. The finer the grind, the more rapidly the limestone will neutralize acidity. Different soils will require different amounts of lime to adjust the pH to the proper range, usually 6.5 to 7.0.

3. Terms that describe nutrient element levels

Humans, animals and plants rely on a safe, healthy supply of food and nutrients such as nitrogen (N), phosphorous (P) and potassium (K) for proper growth and development.

Common terms\(^6\) that describe nutrient levels in plants include:

**Deficient:** When levels of an essential element are too low, crop yield is severely limited and more or less distinct deficiency symptoms appear. Extreme deficiencies will kill the plant.

**Insufficient:** When the level of an essential nutrient is below that required for optimum yields or when levels are not balanced with those of another nutrient. Symptoms of this condition are seldom evident.

**Sufficient:** When levels of an essential nutrient are adequate for optimal crop growth.

**Excessive:** When levels of an essential plant nutrient are high enough to cause a corresponding shortage of another nutrient.

**Toxic:** When levels of either essential nutrients or other elements are high enough to impact plant growth. Severe toxicity will kill the plant.

---


User’s manual Fertilizers
© ACF-November 2010
4. Fertilizers and composition

Before the introduction of mineral fertilizers in the nineteenth century, soil fertility was maintained mostly through recycling of organic materials and crop rotation that incorporated nitrogen-fixing leguminous crops (FAO, 2006). However, this system could not prevent periodic famines. At the beginning of the twentieth century, there was particular concern about the availability of nitrogen (N) fertilizer, which at the time was largely dependent on natural Chilean nitrate. However, the invention of the industrial method for fixing atmospheric N resolved this issue. Since the beginning of the 1960s, a large increase in the demand for food, caused by a substantial increase in the world’s population as well as improved diets, has been met largely through improved agricultural productivity in which fertilizers played an important role. World fertilizer use has increased almost fivefold since 1960. Smil (2002) estimates that Nitrogen fertilizer has contributed an estimated 40 percent to the increase in per-capita food production over the past 50 years, although there are local and regional differences and efficiencies vary.

4.1 Fertilizer: Understanding its chemical composition

It is important to select the most appropriate fertilizer; the chemical components of fertilizers vary substantially from one brand to another. The type of fertilizer and amount used will also need to be adjusted to suit plants’ seasonal growth phase.

The choice of fertilizer depends on many factors, including which nutrients are needed, soil structure and chemistry, and method of application. The best way to estimate which nutrient is necessary— and how much should be applied— is soil testing (see Annex #2) and consulting recommendations based on crop and yield goals.

4.1.1 Complete vs. incomplete fertilizers

A fertilizer is considered “complete” when it contains the major nutrients: nitrogen, phosphorous and potassium. Manufacturers of commercial fertilizers are required to label their containers with an explanation of the amount of each essential nutrient it contains, and to guarantee the analysis. Examples of commonly-used fertilizers are 13-13-13, 16-6-12 and 10-20-10. An incomplete fertilizer is missing one of the major nutrients. Examples of incomplete fertilizers include ammonium nitrate (34-0-0), ammonium phosphate (11-48-0).

4.1.2 What do the numbers really mean?

The first thing to understand when selecting fertilizers is the chemical composition code on the container label. These numbers are almost always presented as a sequence of 3 numbers, such as 30-10-10 or 10-50-10.

The first number in the sequence specifies the nitrogen (N) content of the fertilizer, and is given as a percentage. Nitrogen promotes plant growth.

The second number in the sequence specifies its phosphorous (P) content. Phosphorous promotes flowering.

The third number in the sequence refers to the percentage of soluble potash, or K2O.

---

A fertilizer labelled 30-10-10 would therefore contain 30% nitrogen, 10% phosphate, and 10% soluble potash, and would generally be used during a plant’s active growth cycle. A fertilizer labelled as 10-50-10 would contain 10% nitrogen, 50% phosphate, and 10% soluble potash, and would typically be used before and during a plant’s blooming season.

4.2 Fertilizer formulation

Different formulations of fertilizer appropriate for different situations. All formulations must provide the amount of nutrients, and they may tell how quickly a nutrient is available. Some formulations available to homeowners include water soluble powders, slow-release pellets, liquids, and granular materials.

Liquid fertilizer formulations include complete formulas as well as special types that offer just one or two nutrients. All must be diluted with water. Some are concentrated liquids, while others are powders or pellets. Fertilizers will not burn or damage plants if they are applied correctly.

Fertilizers are salts. When a fertilizer is applied to soil, nearby water begins to move very gradually toward the area where fertilizer has been applied. Fertilizer salts begin to diffuse, or move away from, the place where they were applied, diluting the fertilizer and distributing it through a much larger area. The more salt or fertilizer applied, the more water is drawn from nearby roots.

4.3 Fertilizer application

Soil type dictates the frequency of fertilizer application. Sandy soil requires more frequent application and lower amounts of nitrogen and other nutrients than clay soil does. Other factors affecting application frequency include the type of crop and its intended use, the frequency and amount of nitrogen or water applied, type of fertilizer used, and its release rate. Some crops feed more heavily on some nutrients than others do. Root crops require less nitrogen than leafy crops, while sweet corn feeds heavily on nitrogen, and may need to be fertilized two or more times while it grows.
CHAPTER II. FERTILIZERS: AGRICULTURAL RESEARCH AND POPULATION GROWTH

The end of the first century was marked by increasing agricultural dependence on inorganic fertilizers\(^9\) in general, and on synthetic nitrogen compounds in particular.

Continuing growth of the world’s population and the transformation of typical diets are two powerful factors that resulted in higher demand for inorganic fertilizers. Fortunately, there are adequate resources of both minerals and energy to satisfy this demand.

Nobody would have forecast 100 years ago that world agriculture could produce sufficient food, feed and other agricultural commodities for almost four times as many people. This apparently unattainable goal has been achieved through a combination of many factors, the impact of which triggered the so-called Green Revolution\(^10\), when a combination of irrigation, fertilization and high-yielding varieties (HYV) of crops resulted in the greatest progress ever made in food production. While it is difficult to envision another revolution on this scale, further progress is certainly possible. According to Borlaug (1993) cited by Roy (2006): the dilemma is feeding a fertile population from infertile soils in a fragile world.

In the foreseeable future, the majority of affordable food must be produced through soil-based agriculture. In order to maintain increased food production, modern agriculture must be very productive and sustainable\(^11\). There are many definitions of sustainability. The FAO’s definition of sustainable agriculture (1989) is quite relevant to many countries. It states: the goal of sustainable agriculture should be to maintain production at levels necessary to meet the increasing aspirations of an expanding world population without degrading the environment.

No single resource is more important to achieving sustainable agriculture than soil, which contains essential nutrients, stores water for plant growth and provides the medium in which plants grow (FAO, 1989).

Sustainable, high-yield crop production is based on five factors, which must be integrated efficiently. These are:

- Productive crops with high-yield potential, managed properly from seed to harvest;
- Fertile soils that provide the basis for high and sustainable production;
- Adequate water supplies from rainfall or irrigation;
- Adequate nutrient supplies for crops, and efficient use of applied nutrients;
- Protection of crops against weeds, diseases and pests on the field and during post-harvest storage.

2.1 Green revolution and agriculture

Green Revolution (GR) technologies, supported by policies and fuelled by agro-chemicals, machinery and irrigation, have enhanced agricultural production and productivity. While


\(^10\) Green Revolution refers to the transformation of agriculture that began in 1945. The Green Revolution allowed food production to keep pace with worldwide population growth.

these technologies substantially helped developing countries to address their food security and food sovereignty needs, these technologies depend on costly external inputs, greatly increasing the cost of production for smallholder farmers (who are the main targets of ACFIN agricultural programmes), who make up the majority in most developing countries. Most smallholder farmers are challenged by cash shortages and depend on family labour.

The manufacture of fertilizers and pesticides, the two major inputs of GR technologies, requires fossil fuels and/or expensive energy, and is associated with serious environmental and health issues.

It is therefore time to identify and promote agro-technologies that are environmentally benign and can empower smallholder farmers while encouraging sustainable high yields.

2.2 Micro dosing and agriculture

Researchers at the India-based International Crops Research Institute for the Semi-Arid Tropics, better known by its acronym ICRISAT, say 25,000 small-scale farmers in West Africa are thriving by using a technique known as fertilizer micro-dosing.

Results in Niger, Mali, and Burkina Faso show that micro-dosing can potentially help rural farmers throughout sub-Saharan Africa increase crop yields by as much as 120 percent, while boosting household incomes 50 to 130 percent.

Through this technique, seeds are nourished with tiny amounts of strategically-applied fertilizer-- about six grams for each seed. Thus, a farmer with 100 hectares of land would need only half as much fertilizer to grow the same amount of crops as before.

In West Africa, fertilizer micro-dosing is currently used for cereal crops such as sorghum, millet and maize. ICRISAT\(^\text{12}\), which is one of 15 research centers supported by the Consultative Group on International Agricultural Research, says studies are being carried out to determine whether micro-dosing can also be effective for growing beans and vegetables.

---

Small doses of fertilizer can have a big impact in sub-Saharan Africa.

Less can have more impact if the appropriate fertilizer is applied to the crops at the right time, in the right quantity, and at the right spot. In sub-Saharan African countries, the fertilizer micro-dosing technique developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and partners is helping farmers to increase agricultural productivity.

Micro-dosing helps small farmers to realize high yields from affordable quantities of fertilizer.

\(^{12}\) Alisha. R. 2008. Fertilizers Micro-Dosing Boosts Crop Yields in Africa. ICRISAT.
CHAPTER III. CHEMICAL VS. ORGANIC FERTILIZERS

Over the past two decades, it has been increasingly recognized that, in many countries, plants’ nutrient needs can best be met through integrated use of diverse nutrient resources. Through an integrated plant nutrition system (IPNS)\(^{13}\), or integrated nutrient management (INM), plant nutrition and soil fertility management can be adapted to specific site characteristics, combining nutrients from organic, mineral and biofertilizer sources to serve the concurrent needs of food production and economic, environmental and social viability. For the last two decades, FAO has been actively engaged in the development of INM, and through field projects, expert consultations and publications,\(^{14}\) has focused global attention on the need for large-scale adoption of INM. Propagation of the INM concept and methodology application at the level of individual farms requires the understanding of the scientific community, extension workers, decision-makers, and stakeholders concerned with agricultural development.

3. 1 Fertilizer
Fertilizer is defined as any substance-- solid or liquid, inorganic, natural or synthetic, single or combination of materials-- that is applied to soil or to a plant to provide one or more of the essential elements for plant nutrition, growth yield, or quality, or for producing a chemical change in the soil that contributes to improved plant nutrition and growth.

1. **Inorganic fertilizer**: any fertilizer whose properties are determined predominantly by its content of minerals or synthetic chemical compounds. The term also refers to any chemical compound in liquid or solid form that contains considerable amounts of at least one of the essential plant nutrients, such as nitrogen, phosphorous, potassium, secondary macro nutrients and micro nutrients. **Chemical fertilizers (also called inorganic, synthetic, artificial, or manufactured) are an example of these types of fertilizers.**

2. **Organic fertilizer**: any product of plant and/or animal origin that has decomposed through biological, chemical and/or any other process as long as the original materials are no longer recognizable, and free from plant or animal pathogens, are soil-like in texture, contain no less than 20% organic matter, and can supply nutrients to plants. **Many organic fertilizers (such as compost, manure or other organic by-products) are generally less concentrated sources of nutrients than conventional fertilizers.**

**Advantages of organic fertilizers**

1. In addition to releasing nutrients, organic fertilizers improve soil structure and increase its ability to hold water and nutrients as they break down. Over time, organic fertilizers will make soil and plants healthy and strong.
2. Since they are the ultimate slow-release fertilizers, it is very difficult to over-fertilize (and harm) the plants.
3. There is little to no risk of toxic build-up of chemicals and salts, which can be deadly to plants.
4. Organic fertilizers are renewable, biodegradable, sustainable, and environmentally friendly.

---

\(^{13}\) FAO. 1998. Guide to efficient plant nutrition management. Rome
5. Although packaged organic fertilizer is rather expensive, you can make your own by composting or finding inexpensive sources such as local dairy farms that may sell composted manure.

Disadvantages of organic fertilizer
1. Microorganisms are required to break down and release nutrients into the soil. Since they need warmth and moisture to do this, organic fertilizer’s effectiveness is limited seasonally. The good news is that these microorganisms obtain energy from decaying plant and animal matter, so organic fertilizer provides a complete package of nutrients for the soil.
2. Organic fertilizers break down according to nature’s rules, so they may not release nutrients as soon as they are needed. Patience is necessary—improvement will not be obvious over night. In fact, plants may actually manifest a deficiency during the first couple of months until the first application breaks down.
3. Nutrient ratios are often unknown, and the overall percentage is lower than for chemical fertilizers. However, some organic products actually contain higher levels of some nutrients.

Advantages of Chemical Fertilizer:
1. Since nutrients are available to plants immediately, improvement is obvious within days.
2. They are analyzed to produce the exact ratio of nutrients desired.
3. Standardized labelling makes ratios and chemical sources easy to understand.

Disadvantages of Chemical Fertilizer:
1. They are primarily made from non-renewable sources, including fossil fuels. They help grow plants but do nothing to sustain the soil. Fillers do not promote life or soil health, and even packages labelled “complete” do not include the decaying matter necessary to improve soil structure. In fact, chemical fertilizers don’t replace many trace elements that are gradually depleted by repeated crop planting, resulting in long-term damage to the soil.
2. Because nutrients are readily available, there is a danger of over-fertilization. Not only can this kill plants, but it can upset the entire ecosystem.
3. Chemical fertilizers tend to leach, or filter away from the plants, so additional applications are required.
4. Repeated applications may result in a toxic buildup of chemicals such as arsenic, cadmium, and uranium in the soil. These toxic chemicals can eventually make their way into fruits and vegetables.
5. They are expensive.

Long-term use of chemical fertilizer can change soil pH, upset beneficial microbial ecosystems, increase pests, and even contribute to the release of greenhouse gases.

The acceptance of produce can be influenced by the source of the nutrients that helped it grow. In most studies, application of compost has been observed to have a positive effect on soil’s physical and biological properties.
Compost, particularly if it contains animal manure, can be a relatively cost-effective organic source of macro- and micronutrients. The challenge when applying compost is to know its composition and to understand how to use it most efficiently.

### 3.2 Integrated plant nutrition systems (IPNS)

Under IPNS, a holistic approach to plant nutrition, nutrients are obtained from inorganic as well as organic sources. The system helps to maintain and sustain soil fertility and enhance crop productivity in an ecologically compatible, socially acceptable and economically viable way.

Advantages of integration:
- Organic manure sustains soil fertility when production levels are low.
- Chemical fertilizers contain concentrated forms of nutrients. When they are applied to the soil, they bring about leaching as well as the fixation and build-up of certain nutrients at the expense of others, which causes nutrient imbalances.
- Fertilizer Use Efficiency (FUE) is low for both chemical fertilizers and organic manure when they are used alone.
- Combined use of organic manure and chemical fertilizers increases FUE.

<table>
<thead>
<tr>
<th>IPNS helps to maintain or adjust soil fertility and nutrient levels, in order to achieve a given level of crop production. This system optimizes the benefits of all possible sources of all types of fertilizer. The main objectives are to:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- maintain or enhance soil productivity through balanced use of mineral fertilizers with organic and biological sources of plant nutrients;</td>
<td></td>
</tr>
<tr>
<td>- improve the level of plant nutrients in the soil;</td>
<td></td>
</tr>
<tr>
<td>- improve the efficiency of plant nutrients, limiting environmental degradation.</td>
<td></td>
</tr>
</tbody>
</table>

### 3.3 Chemical fertilizers or organic manure

- To sustain crop yields, the rate of nutrient removal must be balanced with amounts added. Although chemical fertilizers may be needed to meet nutrient requirements, yields will suffer unless crop residues are recycled.
- If organic manure is used alone, the land will benefit but yields will be lower.
- Nutrients from organic manure will leach into the soil more slowly.
- Organic manure improves soil’s physical, chemical and biological condition.

### 3.4 How to use fertilizers

There are two main types of fertilizers. The selection of one or the other depends on the desired effect on the soil and on the timing of application.

**Basal fertilization:** Applied while the land is being prepared and/or sowed in order to improve levels of N, P and K for the next agricultural season. Manure or compost fertilizer provides other macro and micro nutrients as well. Mineral fertilizers may also contain calcium or magnesium, which reduces acidity and improves soil structure.

**Micro dosing:** Strategic application technology. Small quantities of fertilizer are applied to the hill of the plant, enabling a small investment in mineral fertilizer to achieve a substantial increase in crop yields.

---


User’s manual Fertilizers
© ACF-November 2010
### 3.3 Examples of chemical fertilizers used by ACF missions

Table #2. Fertilizers within selected ACF-IN missions

<table>
<thead>
<tr>
<th>Mission</th>
<th>Fertilizer type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>Urea, DAP</td>
</tr>
<tr>
<td>Burma</td>
<td>Urea, T-super</td>
</tr>
<tr>
<td>Niger</td>
<td>DAP, Urea</td>
</tr>
<tr>
<td>Mali</td>
<td>KCL, DAP, Urea</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>NPK,</td>
</tr>
<tr>
<td>Philippines</td>
<td>NPK</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>NPK, Ammonium nitrate, Gypsum (calcium sulfate)</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Urea, KCl, TSP, SP36</td>
</tr>
</tbody>
</table>
CHAPTER IV. ACF POSITION ON FERTILIZERS

4.1 Conclusion
Although very few gardeners are aware of this, most chemical fertilizers are highly toxic, and they should take special precautions when applying them in order to preserve the health of their homes and gardens. (See Annex #1: Tips for Using Chemical Fertilizers).

Agricultural specialists and home gardeners alike often debate the benefits of organic versus chemical fertilizers. There are advantages and disadvantages associated with each, but it is necessary to understand the differences between them before wading into the argument.

Nutrient deficiencies in target soils can be a major problem for home gardeners. An advantage of chemical fertilizers is that they contain all three of the most important nutrients: phosphorous, potassium, and nitrogen. Organic fertilizers, on the other hand, may contain either high levels of one of these nutrients or low levels of all three.

On the other hand, organic fertilizers are less expensive and more cost-effective than chemical fertilizers. Home gardeners can create their own organic fertilizers with manure from cows or sheep combined with other organic matter.

A distinct feature of organic fertilizer is that it releases its nutrients slowly, which can either benefit or, potentially, harm the plants. While the slow release of nutrients reduces the risk of over-fertilization organic fertilizer may not provide enough nutrients if they are needed immediately. Chemical fertilizers provide plants with an immediate supply of nutrients when they are required.

A number of chemical fertilizers are highly acid. These acids, which include sulphuric and hydrochloric acids, increase high soil acidity levels, and destroy nitrogen-fixing bacteria, the microorganisms that supply nitrogen needed for plant growth.

Plants don’t know the difference between organic and chemical fertilizers, and their roots will absorb the required nutrients wherever they come from. However, in light of increasing environmental worries, the use of fertilizers as a source of plant nutrients is being questioned. What is ACF’s position regarding the use of chemical fertilizers?
4.2 Recommendations

1. ACF will refrain from systematically using any chemical fertilizers until a nutrient deficiency has been properly identified, particularly for small and marginal farmers whose land holdings are below 0.1 ha.

2. ACF will not accept or distribute any unsolicited, donated chemical fertilizers in either emergency or non-emergency settings.

3. ACF will support micro-dosing for the prosperity of small-scale farmers. Collaboration with local agricultural institutes is highly recommended. Fertilizer micro-dosing involves the application of small quantities of fertilizers on the hills of plants, thereby enhancing fertilizer use efficiency and improving yields. A close collaboration with agricultural institutes located in the area of intervention or in the region is highly recommended to identify appropriate doses of fertilizer.

4. ACF may consider applying chemicals to soil in order to adjust the pH-levels. Ground agricultural limestone can be used when the plot size is >1ha and pH is below or above the ideal zone (6.0 to 7.0).

   Ground agricultural limestone helps to adjust pH levels if values are below or above the ideal zone (6.0 to 7.0), but care should be taken when the soil is slightly acid. Soil texture, organic matter content, and crop type are factors to consider when adjusting pH levels. For example, soils with a low amount of organic matter require less lime to make the same pH change than soils with a high amount.

5. ACF will systematically incorporate crop rotation and intercropping/companion planting systems into its programmes to ensure efficient utilisation of resources.

   Rotation benefits the soil because it helps to replenish supplies of biologically fixed nitrogen, as well as interrupting weed, disease and insect cycles. A livestock programme may be integrated with grain crops, providing animal manure to fertilize crops that can then be foraged by those same animals. Farmers who combine and rotate livestock, crops, animals and other farm resources to optimize production efficiency, nutrient cycling and crop protection can achieve maximum benefits of pasture integration.

6. ACF will adopt an integrated nutrient management system through the complementary use of chemical fertilizers and organic manure (compost).

   Reduction and, especially, elimination of agrochemicals will require major changes (especially where agrochemicals are promoted by the government) to ensure that plants get enough nutrients as well as to control crop pests. Alternative sources of nutrients that maintain soil fertility include manure and other organic wastes, as well as legume crops in rotational sequences. This was a normal practice a few decades ago.

   The choice of fertiliser for growing vegetables will depend on many factors, including nutrient requirements, soil structure and chemistry, and fertiliser application methods. The best method of choosing nutrients to add and estimating amounts is to complete soil testing and examine recommendations based on crop and yield goals. A soil test is done only when the size of the plot is >1ha.
7. ACF will recommend soil testing, especially for farmers (or Cooperatives) who have 3 ha of land or more. A soil test should be performed before any chemical fertilizers are purchased. A guaranteed nutrient analysis should be available on the labels of all fertilizers.

*There is no one fertilizer that is best for vegetables in every area of intervention. Different vegetables use different nutrients at different rates.*

*It is important to be familiar with proper soil sampling procedures, whether the sampling is being done by the gardener or a laboratory. (See Annex #2).*

8. ACF should consider implementing specific activities related to organic soil fertility management, which is guided by the philosophy of feeding the soil to feed the plant by adding organic materials such as cover crops, crop residues, and compost to the soil.

*This basic precept should be implemented through a series of practices that increase the soil’s organic matter, biological activity, and nutrient content. Over time, adding organic materials such as cover crops, crop residues, and compost to cultivated soil builds its organic content and improves its ability to supply nutrients.*
REFERENCES


FAO. 1989. Sustainable development and natural resource management. In: The state of food and agriculture


USEFUL LINKS

www.ifdc.org
http://www.agnet.org/library/list/subcat/E.html
http://www.icrisat.org/New&Events/Smallfertilizer.htm
http://www.ciat.cgiar.org/tsbf_institute/index_tsbf.htm
ANNEXES ON FERTILIZERS

Annex #1. Tips for using chemical fertilizers

Here are some tips for using chemical fertilizers.

- Different chemical fertilizers must be stored in separate places.
- Chemical fertilizers should be stored in a well-ventilated area, away from flammable or combustible objects and fire pits.
- If a fertilizer is stored in a container other than the original, the container should be clearly marked.
- Ventilation masks should always be worn when using powdered fertilizer.
- Gloves that are suitable for chemical fertilizers should always be worn.
- Fertilizers must be kept out of the reach of children.

- There are also two rules to observe specifically when applying fertilizer during hot weather, when the soil is drier than usual:
  1. Do not over-apply nitrogen fertilizers.
  2. Make sure that the soil is adequately moist after applying fertilizers that have a high salt content.

- Proper nutrition is an essential component of satisfactory crop growth and production. Soil tests can help to determine the amount of nutrients available as a first step toward developing fertilizer recommendations. The potential for profit depends on a farmer’s ability to produce enough crops per acre to keep production costs below the selling price. Efficient application of the correct types and amounts of fertilizer is an important condition for achieving profitable yields.

- All fertilizer labels must show the guaranteed nutrient analysis for three main nutrients: nitrogen, phosphate (P₂O₅) (a form of phosphorous) and potash (K₂O) (a form of potassium). This analysis appears as a series of three numbers. For example, if the numbers 10-10-10 appear on a 30 kg bag of fertilizer, it means that the bag contains 10 per cent of each raw material (3 kg of nitrogen, 3 kg of phosphate and 3 kg of potash).

Soil sampling and testing can provide an excellent inventory of the soil’s plant-available nutrients and other chemical factors important for crop production, and provides a basis for recommendations regarding whether additional nutrients should be applied to an individual field.
Annex #2. Soil testing

Nutrients must be applied in the right quantity and at the right time for a specific anticipated yield.

Soil nutrient levels vary from year to year, and frequently within fields, even if they seem to be uniform. Specific steps for soil sampling and testing will help the farmer develop a sound soil fertility management program.

Poor soil sampling techniques can cause variation in fertilizer recommendations. Soil testing is only as good as the quality of the soil samples. Good soil sampling procedures must include:
- A determination of where and how each field should be sampled;
- Use of proper equipment and supplies;
- Sampling at the proper time of year;
- Samples obtained from the correct soil depths;
- Proper handling of soil samples.

Determining where and how to sample soil in each field

Soil samples should be taken from each individual field, and samples from different fields should not be mixed. Begin by evaluating each field to identify representative areas. Hilly fields with knolls, slopes, or depressions should be sampled separately from mid slope positions to ensure that potential sulphur or other nutrient problems are detected.

Major areas within fields that have distinct soil properties, such as different textures, should be sampled and fertilized as separate fields because they will have different nutrient requirements.

Problem areas such as saline spots, poorly drained depressions, and eroded knolls should not be sampled unless they represent a significant portion of the field. If they do, separate samples should be obtained. In addition, other abnormal areas such as old manure piles, burn piles, haystacks, and farmstead sites should be avoided. A good representative sample will include at least 15 to 20 sampling sites from each field.

If samples taken from only four or five sites, inappropriate fertilizer recommendations will often result. There are four methods for taking soil samples:

1. Benchmark soil sampling
Under this method, unique areas within a field are selected based on soil type, topography and crop growth, and each area is sampled separately. The farmer takes soil samples from each specific area each year to use as a guide for fertilizing all similar areas within the field. Farmers who are adopting precision farming techniques could use this method.

2. Grid soil sampling
Under this method, samples are taken in an organized grid. Soil sample frequency may range from one sample for every 0.5 acres to one sample for every 5.0 acres. The smaller the unit becomes, the more accurate the sample will be. The advantage of this method is that a field map for each nutrient can be prepared and used for variable rate fertilization and precision
farming. However, the cost of taking the soil samples and performing the analysis is very high, so this method is not economical for many farmers.

3. Topographic soil sampling
Under this method, a farmer/gardener selects sites based on topography. A set of soil samples is taken from each unique topographic area within a field.

4. Random soil sampling
Under this method, soil samples are taken in a random pattern across a field, generally avoiding unusual or problem soil areas. As a rule, the field should not include more than 80 acres, and should have been cropped uniformly in the past. Normally, samples must be obtained from 15 to 20 sites in order to be representative of the field.

Use proper equipment and supplies
A soil sampling probe is the best tool for taking samples to a depth of 60 cm. Clean, labelled plastic pails should be used to collect samples. Metal pails should not be used if micronutrient testing is being done. Soil sample augers can also be used but it can be difficult to accurately separate soil samples into 0-15, 15-30 and 30-60 cm depths.

Tools may be borrowed from local agriculture district offices, or purchased from soil testing laboratories or fertilizer dealers if there are any in the country of intervention.

Samples should be obtained at the proper time of year, ideally just before seeding.

Soil samples should be obtained from the correct depths. Many soil testing labs suggest that a 0 to 3 cm depth is adequate for developing fertilizer recommendations. However, samples should be taken from depths of 0 to 15 cm and 15 to 30 cm separately, and from 30 to 60 cm, for ideal evaluation of available nutrients. Samples from each depth should be kept in separate containers.

Phosphorus (P) and potassium (K) recommendations are based on measurements of the amounts of each of these nutrients in the 0 to 15 cm sample. Generally, most of the plant-available P in soil is confined to the plough layer, as P is very immobile. Nitrate-nitrogen (NO3-N) and sulphate-sulphur (SO4-S) are both mobile nutrients that may be found in significant amounts to depths as low as 30 to 60 cm. Therefore, N and S fertilizer recommendations based on a sample taken from 0 to 15 cm are usually too high, so recommendations for nitrogen and sulphur are based on samples taken from depths of 0-60 cm.

Handle soil samples properly
As discussed above, soil from each depth should be placed in a separate container. Immediately after the samples have been taken:
- The soil in each container should be mixed thoroughly to make it homogenous.
- Soil should be removed and spread on a piece of clean paper.
- Soil should be allowed to air dry completely at a temperature of not more than 30°C. It should not be dried in an oven or at a high temperature, as this can change the levels of some nutrients.
- Care should be taken to avoid contaminating the samples with commercial fertilizers, manure, salt, water or dust. Samples should not be dried on old fertilizer bags or feed bags or in areas where fertilizers have been handled.
-A fan may be used to enhance drying with constantly flowing air.

Once the samples are thoroughly dry, soil sample cartons should be filled. Each carton should be labelled with the correct field number and sample depth. A completed information sheet on cropping and fertilizer history should be sent to the soil testing laboratory.

**Fertilizer recommendations**

Fertilizer recommendations are based on soil test analysis results and on nutrient requirements of the specific crop, and recommendations regarding the time and method of fertilizer application are also included. Each soil testing lab has its own philosophy for fertilizer recommendations. Two examples are:

-Recommendations for optimal economic yields, based on one or more moisture conditions in the field.
-Target yield recommendations that indicate nutrient requirements for a range of potential yields under the same moisture conditions. With this information, farmers/gardeners can select a fertilizer application rate or target yield best suited to their individual situation.