Soil Fertility Management

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Introduction

Can agriculture provide for the food needs of a world population projected to exceed 7.5 billion by the year 2020? Concern is growing that it may not. There are indications that the highly productive fertilizer and seed technologies introduced over the past three decades may be reaching a point of diminishing returns. Prospects for expanding low-cost irrigation, one of the driving forces behind yield increases, are also becoming more limited, as are the prospects for converting marginal lands into productive arable land. Furthermore, new technologies such as genetically engineered, yield-increasing plants are not expected to be major factors in food production increases in developing countries during the next two decades. Consequently, keeping pace with population growth and increasing land scarcity will be more difficult than in the recent past.

Because agriculture is a soil-based industry that extracts nutrients from the soil, effective and efficient approaches to slowing that removal and returning nutrients to the soil will be required in order to maintain and increase crop productivity and sustain agriculture for the long term. The overall strategy for increasing crop yields and sustaining them at a high level must include an integrated approach to the management of soil nutrients, along with other complementary measures.

An integrated approach recognizes that soils are the storehouse of most of the plant nutrients essential for plant growth and that the way in which nutrients are managed will have a major impact on plant growth, soil fertility, and agricultural sustainability. Farmers, researchers, institutions, and government all have an important role to play in sustaining agricultural productivity.

Table 1. Impact of different agricultural management practices on cereal yield

Management practices	**Average marginal yield increase with respect to conventional agriculture (%)**	
	Dry	Moist
Agronomy	116	122
Integrated nutrient management	72	118
Tillage and residue management	122	55
Water management	92	164
Agroforestry	81	61

Source: FAO (2011)

High yield of crop is a major determinant of successful farming and is dependent on optimum plant growth, which in turn is controlled by soil fertility and productivity.

Soil fertility

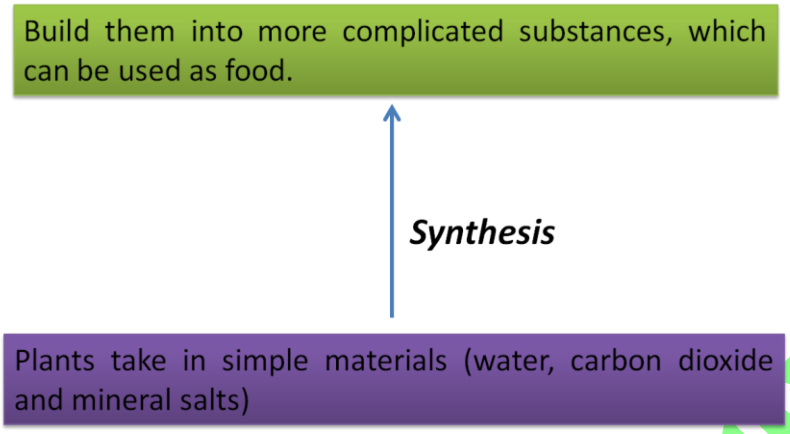
Soil fertility is the capacity/ability of the soil to supply the plant nutrients required by the crop plants in available and balanced forms.

For a soil to be productive, it must of necessity be fertile. Yet, it does not follow that a fertile soil is productive.

Nutrition: Nutrition is the process by which living organisms obtain food materials from their environment.

The supply and absorption of chemical compounds needed for growth and metabolism may also be defined as nutrition while the chemical compounds required by the organism termed nutrients.

Plants take in simple materials (water, carbon dioxide and mineral salts) and build them into more complicated substances, which can be used as food.



From these they build up carbohydrates oil and protein. The process of building up of chemical substances from simpler substances is known as synthesis.

Better management of physical and chemical soil fertility improves soil biological fertility, which in turn can be further enhanced by good agronomic/ cultural practices. Hence, soil fertility is a key to sustainable agriculture.

The plant nutrient balance system

A simplified version of this cycle of plant growth, based on Smaling (1993), is shown in Figure 1. The simplified cycle has two parts: “inputs” that add plant nutrients to the soil and “outputs” that export them from the soil largely in the form of agricultural products. Important input sources include inorganic fertilizers; organic fertilizers such as manure, plant residues, and cover crops; nitrogen generated by leguminous plants; and atmospheric nitrogen deposition. Nutrients are exported from the field through harvested crops and crop residues, as well as through leaching, atmospheric volatilization, and erosion.

In a sustainable agricultural or horticultural system, soil fertility can be considered in terms of the amount of input relative to the amount of output over a long period, using a budgeting approach. This definition is different to one that defines fertility in relation to a maximum level of productivity in the short-term, or at one point in time. A definition that focuses on short-term productivity is based on the capacity of soil to immediately provide plant nutrients. A definition of soil fertility that is inclusive of sustainable land must consider the three components of soil fertility (biological, chemical and physical) equally.

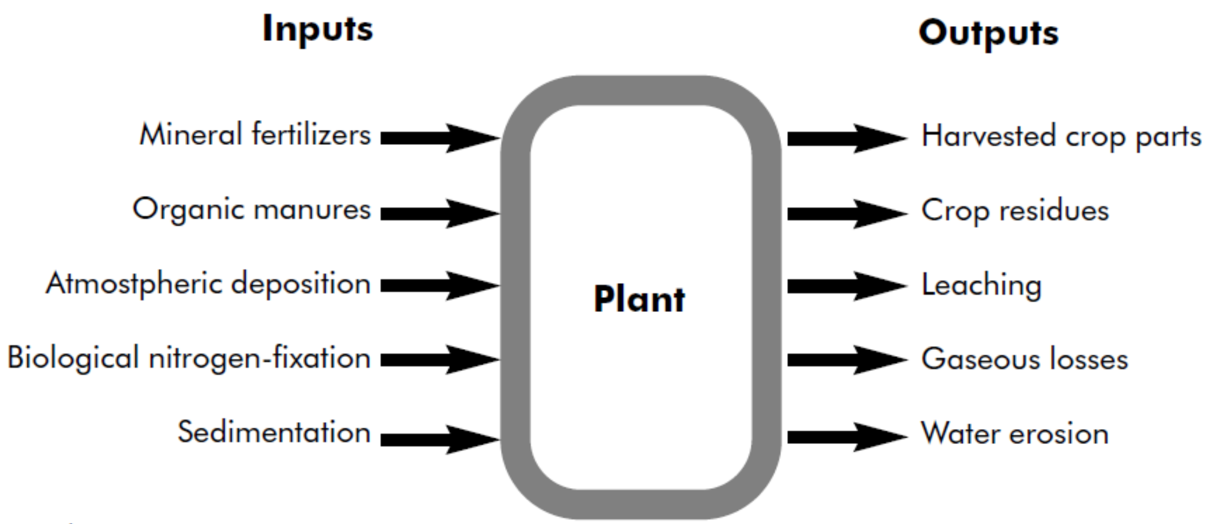


Fig. 1 Major plant nutrient input and output from agricultural systems

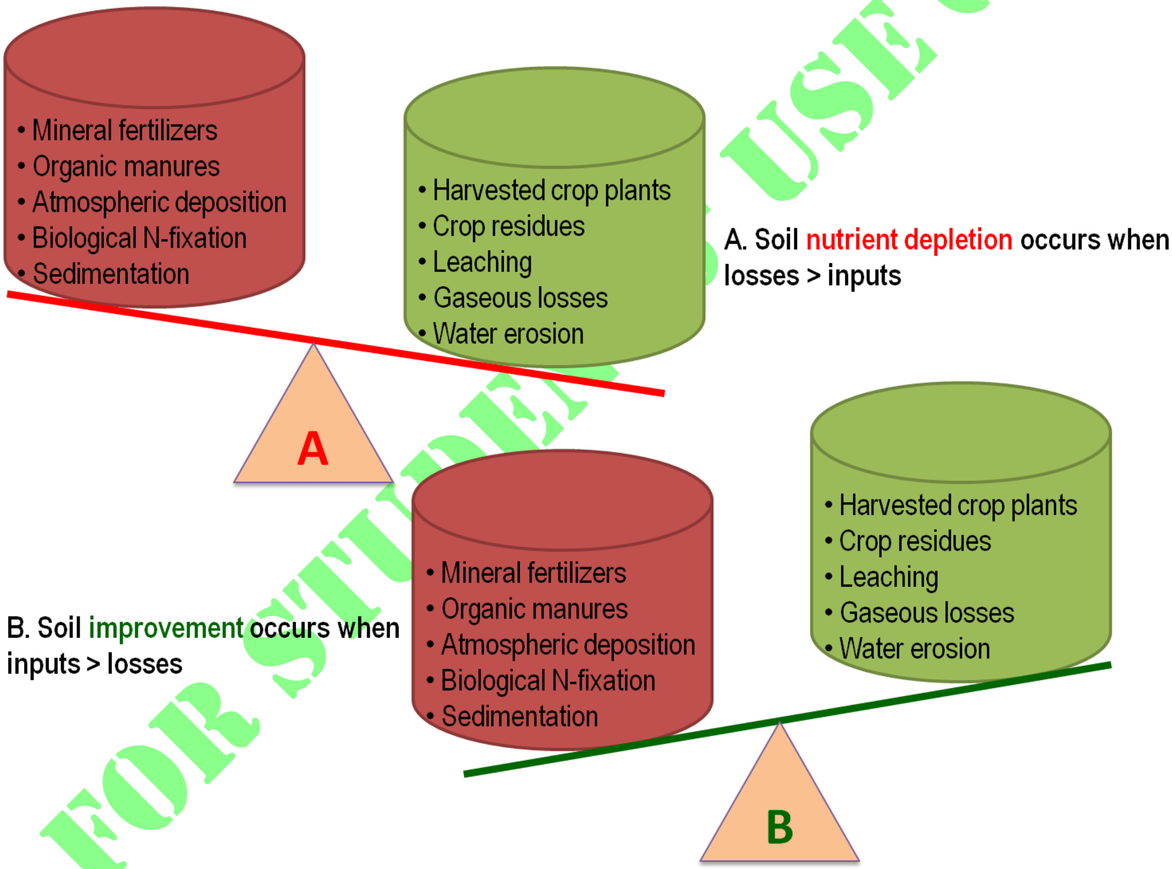


Fig. 2 Equilibrium between inputs and outputs of soil-plant system

Types of soil fertility

Soil fertility is divided into 3 groups, i.e. Physical, Chemical and Biological Soil Fertility, which are inter-related with each other.

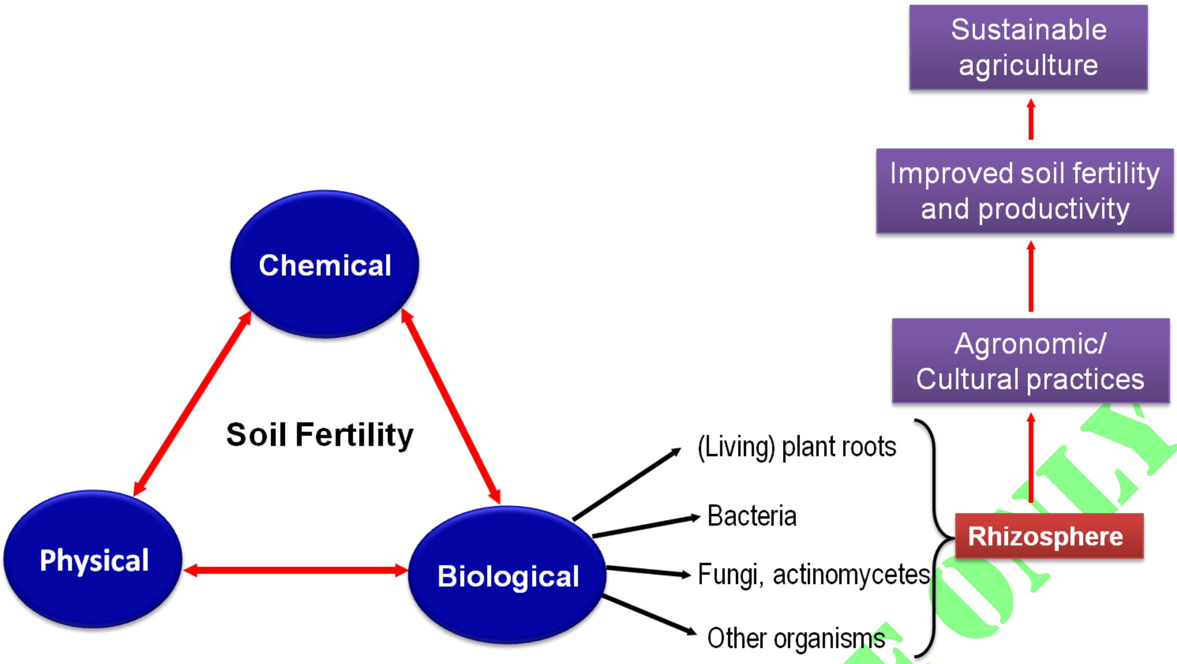


Fig. 3 Different types soil fertility

- **Chemical soil fertility:** The capacity of soil to provide a suitable chemical and nutritional environment for the plants and foraging animals for productivity, reproduction and quality in a way that supports beneficial soil physical and biological processes, including those involved in nutrient cycling.
- **Physical soil fertility:** The capacity of soil to provide physical conditions that support plant productivity, reproduction and quality without leading to loss of soil structure or erosion and supporting soil biological and chemical processes.
- **Biological soil fertility:** The capacity of organisms living in soil to contribute to the nutritional requirements of plants and foraging animals for productivity, reproduction and quality while maintaining biological processes that contribute positively to the physical and chemical state of the soil.

How is soil fertility measured?

Three major *physical components* of soil fertility are measured in terms of soil texture, soil structure and water holding capacity.

The *chemical components* of soil fertility that are most relevant to land management include acidity, alkalinity, salinity and nutrient status. However, the quantity of nutrients in soil is not always related to its fertility as other factors may limit plant growth. An understanding of the methods used in soil and plant analysis is necessary to evaluate the relationship between nutrient levels in soil and soil chemical fertility.

Biological components of soil fertility are generally more difficult to measure than both soil chemical and physical components. Bioassays of some plant pathogens or beneficial organisms can give an important indication of the possible positive or negative contribution of these organisms in soil. One approach to assessing biological components of soil fertility is to determine the number or activity of groups of organisms that perform similar functions.

Factors contributing to soil fertility

The factors that help in maintaining the level of these needs in soils are:

1. Humas: Humus are the decomposing plant and animals bodies that certain soil organisms can convert into Nitrates. Humas increases the fertility of soil.

2. Micro organism: They are helpful in the decomposition of plant and animal bodies into humus and other soil biochemical transformations

3. Air: Oxygen is needed for respiration of growing roots of flowering plants and soil micro organisms

4. Water: All living things need water. Usually, plants roots absorb water from the soil. A lot that hold much water by capillary is therefore potentially fertile.

5. Soil depth: The depth of soil determine the volume of soil accessible to the root system. Most arable crops prefer about one meter without any obstructing layer.

6. Soil structure: It includes the size distribution and aggregation of particles. This determines the distribution of pore sizes which is decisive for the supply of air and water to the roots.

7. Soil texture: soils with good texture (e.g. loamy soil) usually have adequate amounts of water and air that are essential for plants growth.

8. Amount of mineral elements present in the soil: Plants need C, O, K, P, N, S, Ca, Fe, Mg etc. for healthy growth. In most cases, these elements are absorbed from soils by the roots of plants.

9. Soil pH/ reaction: It is an indicator and regulator of chemical processes and equilibria.

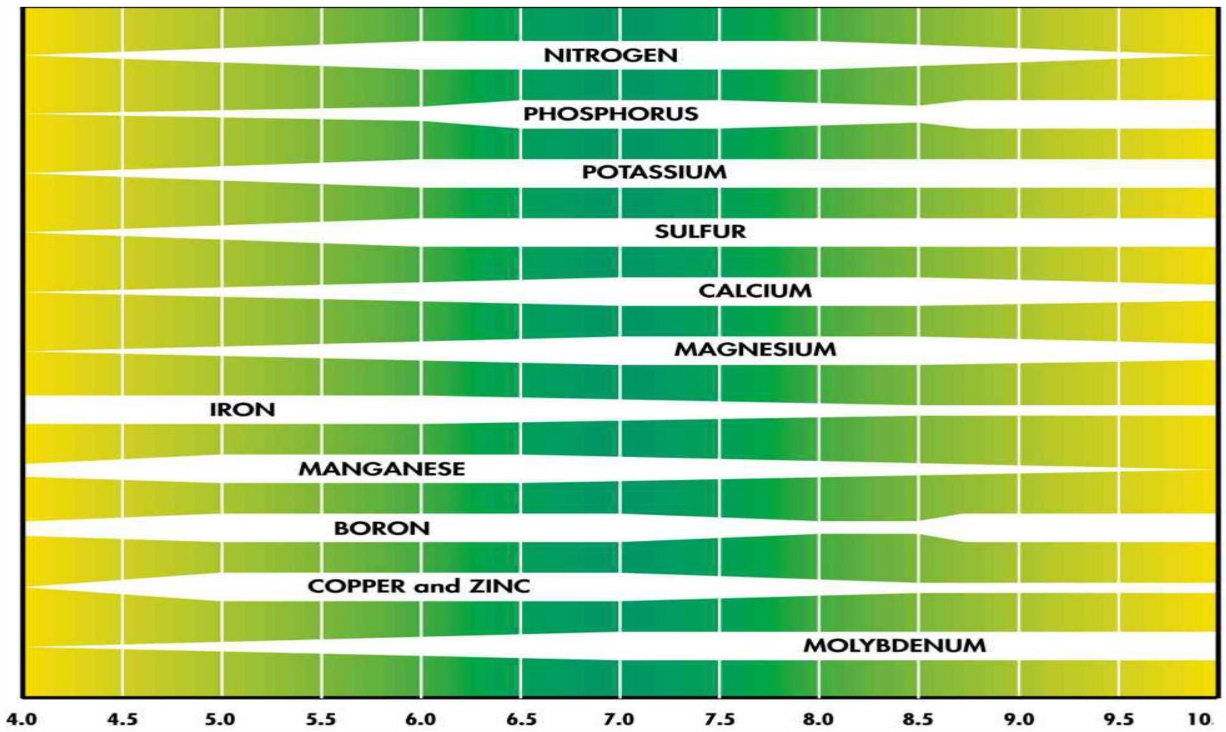


Fig. 4. Availability of nutrients at different soil pH

10. Content of detrimental or toxic substances: Either naturally occurring (e.g. salts in saline soils, aluminium in extremely acid soils) or man-made (e.g. from pollution) toxic substances impair soil fertility.

Importance of soil fertility:

A highly productive soils with high fertility:

- ✓ **mobilize** soil nutrients from the reserves;
- ✓ **transform** fertilizer nutrients into easily available forms;
- ✓ **store** water-soluble nutrients in easily available forms, thus preventing leaching;
- ✓ **offer** the plants a balanced nutrient supply due to its self-regulating system;
- ✓ **store** and supply sufficient water;
- ✓ **maintain** good soil aeration for the oxygen requirements of roots;
- ✓ **not 'fix'** nutrients, i.e. convert them into unavailable form;
- ✓ **improve** crop use efficiency of nutrients and resources such as water and light;
- ✓ **provide** nutrients throughout the growing season and especially during critical peak periods of plant development

Soil fertility vs. Soil productivity

- ✓ Soil productivity is the crop yielding ability of a soil from a unit area.
- ✓ Soil fertility is vital to a productive soil but, a fertile soil is not always a productive one. Poor drainage, weeds, insects, disease, drought and other factors can limit productivity even when fertility is adequate.
- ✓ Fertile soils are not always highly productive, but the productive soils are always fertile.
- ✓ Very fertile and productive soils are rarely found in nature

Adverse effects of Indiscriminate use of chemical fertilizer

The use of high yielding crop varieties and chemical fertilizers has resulted in rapid increase in agricultural production, especially in irrigated areas. But complete reliance on the use of fertilizers ignoring bio-organic materials affect the soil environment. Indiscriminate use of chemical fertilizer will lead to:

1. Widespread nutrient deficiencies in soils,
2. Disturbs soil reaction,
3. Development of nutrient imbalances in plants,
4. Increased susceptibility to pests and diseases,
5. Reduces the soil organic matter,
6. Harmful to beneficial soil micro organisms,
7. Reduces legume root modulation and plant mycorrhizal association
8. Increases environmental pollution.