due to the destruction of their soil resource base that was the key of the rise of those civilization.

Characteristics of Soil

Soil is a natural system consisting of four components : mineral matter, organic matter, water, and air. Soil inherits mineral matter from its parent rocks and organic matter from its living or decaying organisms.

Major characteristics of soil are : texture, structure, organic matter, living organisms, aeration, moisture content, pH, and fertility. An understanding of these characteristics is an essential pre requisite to the study of soil profiles, soil types, soil productivity, and soil management.

1. Texture

Mineral particles in soils range in size from submicroscopic clay to large rock fragments such as stones and gravels. The U.S. Departments of Agriculture (USDA) divides soil particles into two major groups based on size : (*i*) the coarse fraction and, (*ii*) the fine earth fraction—which has a greater effect on soil behaviour because it is the most chemically and biologically active. The fine earth fraction is further divided into three main size groups : sand, silt, and clay. The relative proportions of sand, silt, and clay in a soil determines its soil texture. (Table 8.1)

Table 8.1 : Soil Texture

Particle Name	*Diameter Range*	*Particle Name*	*Diameter Range*
Fine Earth Fraction		**Coarse Fraction**	
Sand	2.0—0.05 mm	Gravel	2 mm—7.6 cm
Silt	0.05—.0..2 mm	Cobble	7.6—25 cm
Clay	<0.002 mm	Stone	25—60 cm
		Boulder	> 60 cm.

– According to USDA

Since soils are composed of different percentages of sand, silt and clay, specific terms are used for their textural makeup. There are 12 major soil textural classes a defined by the percentages of sand, silt, and clay as shown in Fig. 8.1.

Soil texture is one of the most important characteristics of the soil because it helps determine soil water permeability and storage, the ease of tilling the soil, the amount of aeration, soil fertility, and roof penetration. For example, a coarse sandy loam or loamy sand is easy to fill, is easily wetted, but it also ries rapidly and easily loses plant nutrients, which are drained away in the rapidly lost water. High clay soils, on the other hand, are difficult to wet, difficult to drain, and difficult to fill.

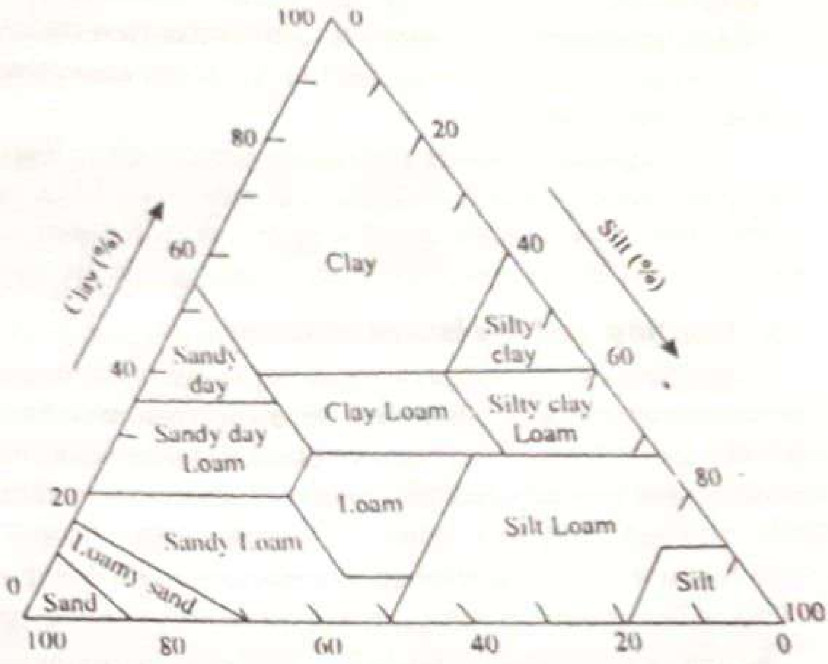

Fig. 8.1 : Soil textureal classes according to USDA

Clay is an important reservoir of plant food. Nutrients such as calcium, potassium, magnesium, zinc and iron form a loose chemical bond with the clay particles; the process is called "adsorption" which is very important from the point of soil fertility. Adsorption prevents the leaching of nutrients from the soil by the action of water. On the other hand, clay particles do not retain negatively charged nitrate ions very well. As such, too much application of nitrogen fertilizer applied to a crop causes leaching of nitrates through the soil and into the ground water, thereby causing contamination.

2. Structure

Soil structure is the arrangement of grouping of soils particles into clusters or aggregates. These aggregates may have a variety of shapes, *e.g.* grannular, blocky prismatic, platy, *etc*. Soil structure affects aeration, water movement, heat transfer, and root growth in a soil to some degree. Other factor affecting soil structure include alternating freezing and thawing, wetting and drying, plant root penetratio burrowing by worms and pocket gophers, addition of slimy secretions from animals, bacterial decay plants and animal remains, and compaction by farm equipment and off-road vehicles.

Granular structure of soil enhances crop production. Plty structure, on the other hand, has a l aeration and water permeability, hence not good for farming. Some soils such as single-grained, l structure. However, soil structure can be improved by adding organic matter such as crop resid compost, and animal manures. The growth and decay of grasses and legumes stimulate aggregation enhance soil structure.

SOIL STRUCTURE

Definition of Soil Structure

The arrangement of soil particles and their *aggregate* into certain defined patterns is called structure.

The primay soil particles – sand, silt and clay – usually occur grouped together in the form of aggregates. Natural *aggregates* are called *peds*, whereas *clod* is an artificially formed soil mass. Structure is studied in the field under natural conditions and it is described under three categories :

1. Type – Shape or form and arrangement pattern of peds.
2. Class – Size of peds.
3. Grade – Degree of distinctness of peds.

Types of Strucutre

There are four principal *forms* of soil structure :

(*a*) **Plate-like.** In this structural type of aggregates are arranged in relatively thin horizontal plates. The horizontal dimensions are much more developed than the vertical. When the units are thick, they are called *platy*, and when thin, *laminar* (Fig. 2.1).

Platy structure is most noticeable in the surface layers of virgin soils but may be present in the sub-soil. Although most structural features are usually a product of soil forming forces, the platy type is often inherited from the parent material, especially those laid down by water.

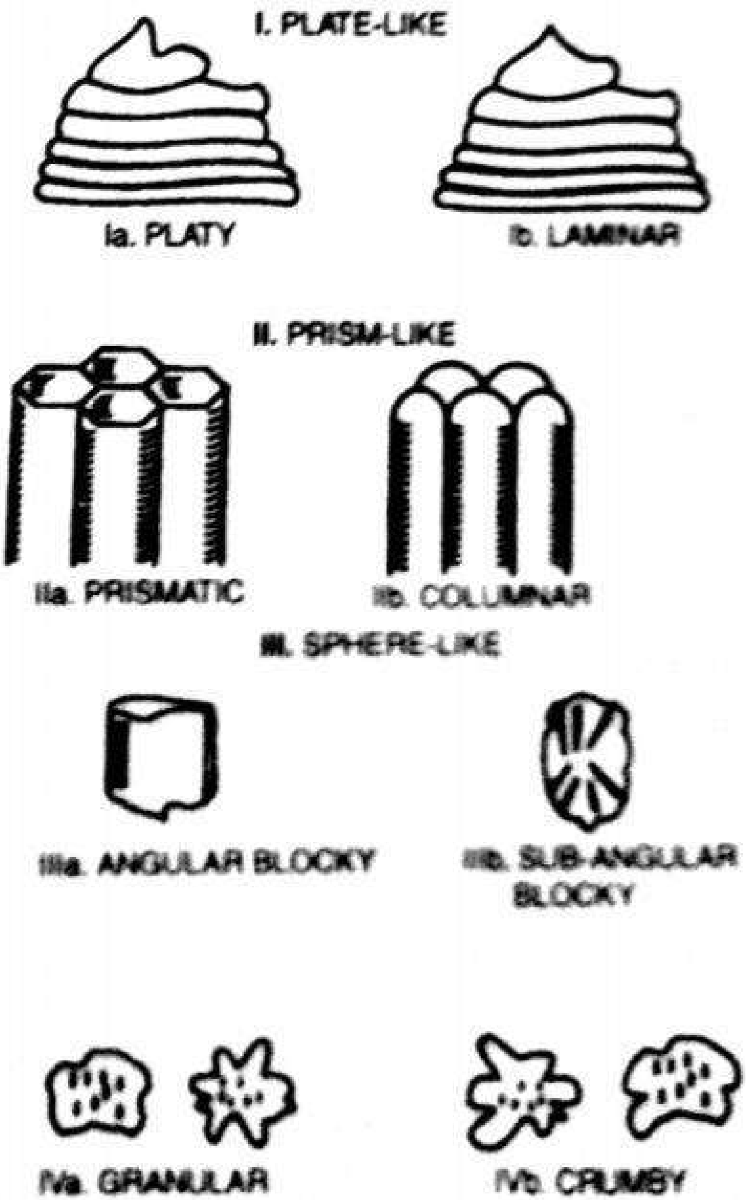

Fig. 2.1. Types of soil structure.

(*b*) **Prism-like.** The vertical axis is more developed than horizontal, giving a pillar-like shape. When the top of such a ped is rounded, the structure is termed as *columnar,* and when flat, *prismatic.* They commonly occur in sub-soil horizons in arid and semi-arid regions.

(*c*) **Block-like.** All these dimensions are about the same size and the peds are cube-like with flat or rounded faces. When the faces are flat and the edges sharp angular, the structure is named as *angular blocky.* When the faces and edges are mainly rounded it is called *sub angular blocky*. These types usually are confined to the sub-soil and characteristics have much to do with soil drainage, aeration and root penetration.

(*d*) **Spheroidal (Sphere-like).** All rounded aggregates (peds) may be placed in this category, although the term more properly refers to those not over 0.5 inch in diameter. These rounded complexes usually lie loosely and saparately [Fig. 2.2 (*a*), 2.2 (*b*) and 2.2 (*c*)]. When wetted, the intervening spaces generally are not closed so readily by swelling as may be the case with a blocky structural condition. Therefore in sphere-like structure infiltration, percolation and aeration are not affected by wetting of soil. The aggregates of this group are usually termed as *granular* which are relatively less porous ; when the granules are very porous, the term used is *crumby.*

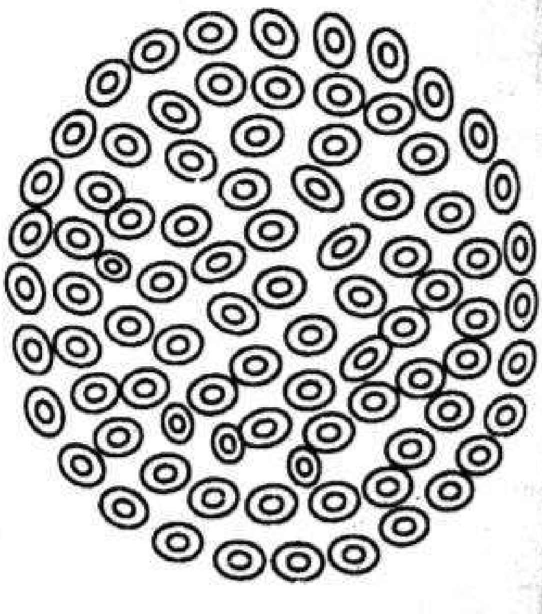

Fig. 2.2. (a) Example of sphere-like soil sstructure.

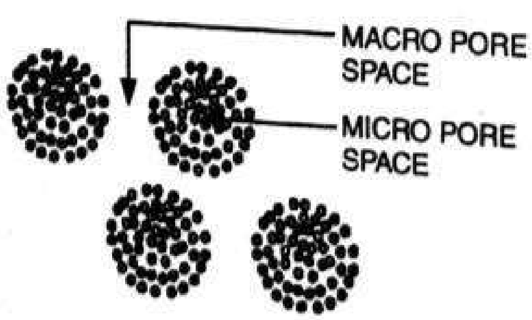

Fig. 2.2. (b) Arrangement of particles in sphere-like soil strucutre.

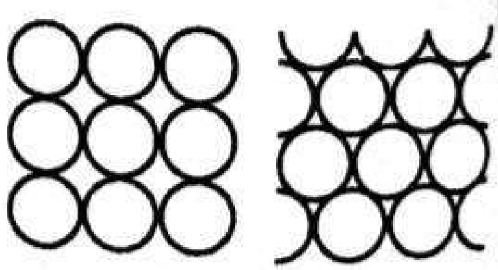

Fig. 2.2. (c) Arrangement of spherical particles in two ways.

Classes of Structure

Each primary structural type of soil is differentiated into 5 size-classes depending upon the size of the individual peds. The terms commonly used for the size classes are :

1. Very fine or very thin
2. Fine or thin
3. Medium
4. Coarse or thick
5. Very coarse or very thick

The terms thin and thick are used for platy types, while the terms fine and coarse are used for other structural types.

Grades of Structure

Grades indicate the degree of distinctness of the individual peds. It is determined by the stability of the aggregates. Grade of structure is influenced by the moisture content of the soil. Grade also depends on organic matter, texture etc. Four terms commonly used to describe the grade of soil structure are :

1. Structureless. There are no noticeable peds, such as conditions exhibited by loose sand or a cement-like condition of some clay soils.

2. Weak structure. Indistinct formation of peds which are not durable.

3. Moderate structure. Moderately well-developed peds which are fairly distinct.

4. Strong structure. Very well-formed peds which are quite durable and distinct.

For naming a soil structure the sequence followed is grade, class and type; for example, strong coarse angular blocky (soil structure).

Examples of sphere-like soil structure :

Grade	Class	Type	Structural Name
1. Strong	fine	granular	strong fine granular
2. Moderate	very coarse	granular	moderate very coarse granular

Often compound structure are met within the soil under natural conditions. For example, large prismatic types may break into medium blocky structure, constitute the compound structure.

Structure Formation

The mechanism of structure (aggregate) formation is quite complex. In aggregate formation a number of primary particles such as sand, silt and clay are brought together by the cementing or binding effect of soil colloidal clay, iron and aluminium hydroxides and organic matter.

The mineral *Colloids* (colloidal clay) by virtue of their properties of adhesion and cohesion, stick together to form aggregates. Sand and silt particles cannot form aggreates as they do not possess the power of adhesion and cohesion. The amount and nature of colloidal clay influence the formation of aggregates. The greater the amount of clay in a soil, the greater is the the tendency to form aggregates. Clay particles smaller than 0.001 mm aggregate very readily. So also clay minerals that have high base exchange capacity form aggregate more readily than those which have a low base exchange capacity.

Iron and *aluminium hydroxides* act as cementing agent is binding the soil particles together. These are also responsible for forming aggregates by cementing sand and silt particles.

Organic matter plays an important part in forming soil aggregates. During decomposition of organic matter, humic acid and other sticky materials are produced which helps to form aggregate. Some fungi and bacteria taking part in the decomposition have also been found to have a cementing effect. Another view of structure formation is that clay particles adsorbed by humus forming a clay-humus complex. It seems that humus absorbs both cations and anions. In normal soil, calcium is the predominant cation and forms calcium humate in combination with humus.

Factors affecting Soil Structure

The development of structure in arable soil depends on the following factors :

1. Climate. Climate has considerable influence on the degree of aggregation as well as on the type of structure. In arid region, there is very little aggregation of primary particles. In semi- arid regions, the degree of aggregation is greater than arid regions.

2. Organic matter. Organic.matter improves the structure of a sandy soil as well as of a clay soil . In a case of sandy soil, the sticky and slimy material produced by the decomposing organic matter and the associated microorganism cement the sand particles to form aggregates. In the case of clayey soil, it modifies the properties of clay by reducing its cohesive power. This helps making clay more crumby.

3. Tillage. Cultivation implements break down of large clods into smaller fragments and aggregates. For ontaining good granular and crumby structure, an optimum moisture content in the soil is necessary. If the moisture content is too high it will form large clods on drying. If it is too low, some of the existing aggregates will be broken down.

4. Plant roots. Large number of granules remain attached to roots and root hairs which help to develop crumb structure. Plant root secretions may also act as cementing agents in binding the soil particles. The plant roots, on decay, may also bring about granulation due to the production of sticky substances.

5. Soil organism. Among the soil fauna, small animals like excessive irrigation leads to saturation of soil.

5. Soil pH

An important property of the soil solution is its reaction, *i.e.* whether it is acid, neutral, or alkaline (basic). Soil scientists use the pH scale to determine a soils reaction. The pH scale ranges from 0 to 14. A pH of 7 is neutral, below 7 the soil is acidic, and above 7 it is alkaline. Soils very in pH from 4.7 to a little above 7 in humid regions and from a little below 7 to 9 in arid regions. Slightly acidic soils are good for growing vegetables, grains, trees, and grasses.

associated with it. Three conditions possible in the soil are : acidity, neutrality and alkalinity.

SOIL pH

Soil reaction is measured by pH (Puissance de Hydrogen) of a suspension of soil in water. The concept of pH may be explained with reference to pure water, which is amphotric, and in which hydrogen and hydroxyl ions are in equilibrium with undissociated water molecules. The reaction of a solution represents the degree of acidity or basicity caused by the relative concentration (or activity) of hydrogen (H^+) or hydroxyl (OH^-) ions present in it. Acidity is due to the excess of H ions over OH ions, and alkalinity is due to the excess of OH ions over H ions. A neutral reaction is produced by an equal activity of H and OH ion (Fig. 7.1). According to the theory of dissociation, the activity is due to the dissociation or ionisation of compounds into ions. The greater the degree of ionisation, the greater is the activity of the ions. Even pure water which is neutral in reaction dissociates into H and OH ions :

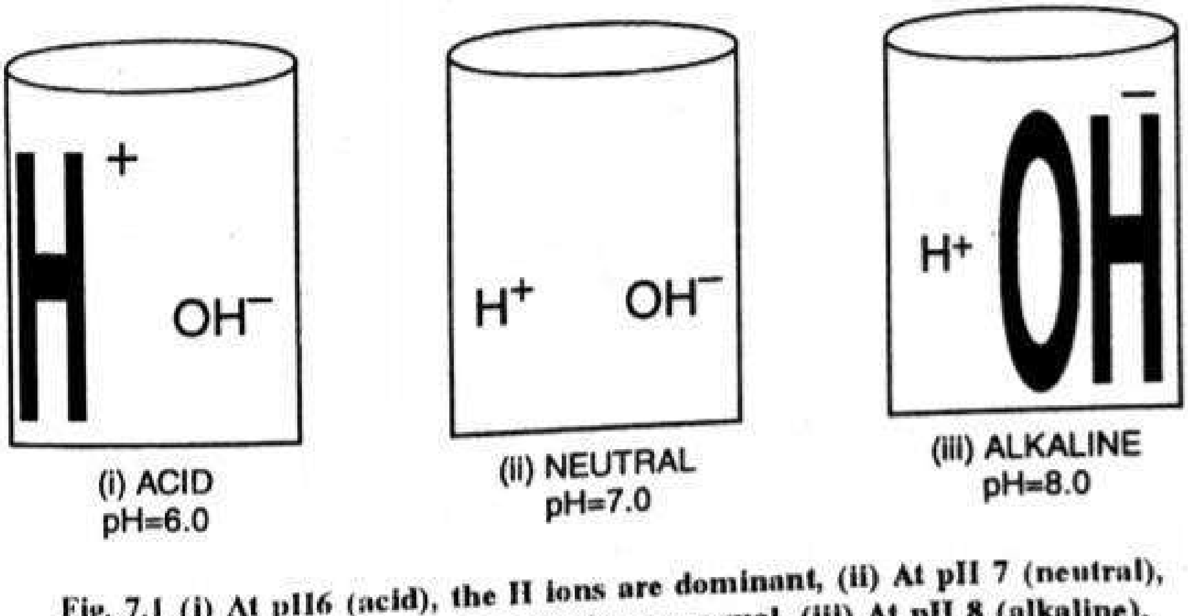

Fig. 7.1 (i) At pH6 (acid), the H ions are dominant, (ii) At pH 7 (neutral), the H ions and OH ions of a solution are equal. (iii) At pH 8 (alkaline), the OH ions are dominant.

$$H_2O \rightleftharpoons H^+ + OH^-$$

as it shows a very slight but definite conductivity.

The most convenient method of expressing the relationship between H^+ and OH^- is pH. pH is defined as the logarithm of the reciprocal (or negative logarithm) of the hydrogen-ion concentration in gram per litre ; represented in equation form as follows :

$$pH = \log \frac{1}{[H^+]}$$

At neutrality, the hydrogen-ion concentration is : 0.0000001 or 1×10^{-7} gram of hydrgoen per litre of solution. Substituting this concentration into the formula,

$$pH = \log \frac{1}{0.0000001}$$

$$pH = \log 10{,}000{,}000 = 7$$ (see Table 7.1 and 7.2)

At a pH of 6, there is 0.0000001 gm of active hydrogen, or 10 times more the concentration of H^+ than at a pH of 7. At each smailer pH units, the H^+ increases by 10 in concentration. It therefore follows that a pH of 6 is 10 times more acidic than a pH of 7; a pH of 5 is 10 times more acid than a pH of 6, and so on.

The pH value, therefore, represents the amount of free or active acidity and not the total quantity of potential (or combined) acidity. In other words, it represents the intensity of acidity of a solution. In this scale, the pH value ranges from 0-14, where pH 0 represents the highest limit of active acidity, and pH 14 the highest degree of basicity (or alkalinity). Neutrality represnets pH 7 (Fig. 7.2). Therefore, pH 7

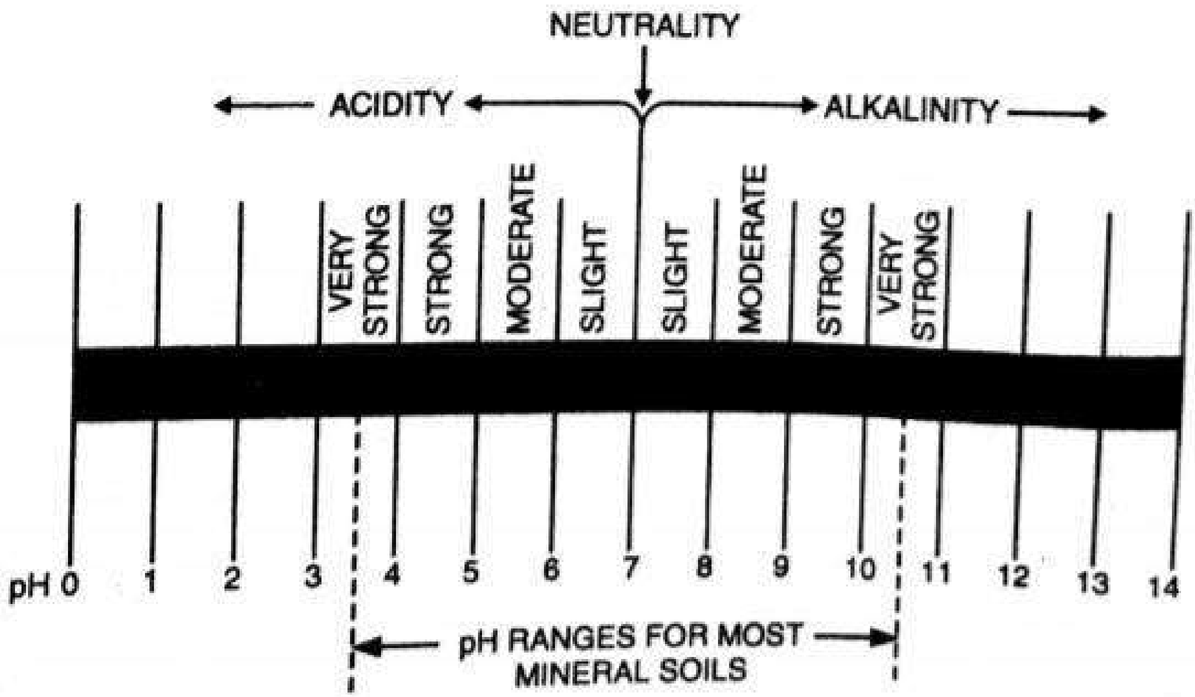

Fig. 7.2 Ranges in pH.

6. Soil Fertility

The fundamental components of soil fertility are the (16) essential nutrients (macro as well as micro) absorbed by plants and utilized for various growth processes. The soil gains nutrients from nitrogen fixation, decomposition of plants and animal remains, animal wastes, weathering of parent materials, and fertilizer. The soil loses nutrients mostly by roof absorption, leaching due to downward movement of water, soil erosion, and volatilization.

NPK stands for "nitrogen, phosphorus, and potassium," the three nutrients that compose complete fertilizers. You may encounter these letters when reading the contents printed on bags of fertilizer. The description of the fertilizer may not expressly say "NPK," but you will at least see a series of three numbers. These numbers correspond, respectively, to the nitrogen content, phosphorus content, and potassium content of that fertilizer. Also implied is a percentage symbol after each number because each of the three numbers represents the percentage of that nutrient in the makeup of the fertilizer.

The Importance of NPK

Not all types of plants have the same nutrient requirements, and you can sometimes do more harm than good when applying chemicals haphazardly. Applying a fertilizer high in nitrogen will cause certain plants to put all their energy into producing foliage at the expense of flowers.

If you do not have a good grasp of how well your soil is meeting the nutritional needs of a plant but still feel the need to feed it at a particular time, you should try one of the following options.

- Use compost instead of chemical fertilizer.
- Get your soil tested.
- Apply a slow-release fertilizer, which is less likely to harm plants to any great degree.

Role of Each Plant Nutrient

To advance this discussion from the academic to the practical, let's take a brief look at the roles that the constituents of NPK play in plant growth.

Nitrogen promotes leaf development because of its role in the plants' coloring and chlorophyll. At the opposite end of the spectrum, gardeners sometimes encounter the problem of nitrogen depletion. The yellowing of typically green plants often indicates a nitrogen deficiency.

Phosphorus and potassium have some overlapping roles. Phosphorus plays a key role in the growth of roots, blooming, and fruiting, which is why it is an essential nutrient for your plants in spring. Potassium also plays a part in root growth as well as in stem development.

To exemplify the balancing act, the product in the picture provided is a Scotts Turf Builder product intended to help your grass in summer. The NPK value is listed as 28-0-8, meaning it contains 28% nitrogen, no phosphorus, and 8% potassium (potash).