The Basics of Soil

The foundation of productive organic gardening is building and maintaining a healthy soil in which the plants will grow. It is the soil that provides the nutrients needed by plants and, consequently, much of the effort of the organic gardener is directed toward ensuring the condition of the soil is managed sustainably to enable plants to access those nutrients efficiently from one season to another.

What is soil?

It is soil – the uppermost thin layer of the earth's crust - that has the necessary physical, chemical and biological properties to support the growth of plants. There are five main components of soil; mineral particles, organic matter, air, water and living organisms. For plants to grow well they require their roots to be continuously supplied with balanced proportions of these components.

The layers of soil from the top of the ground to the bedrock are called horizons and it is the uppermost layers – the topsoil and subsoil - that is important to organic growers. References to "soil" in this paper are describing these top layers which contain organic matter and where plant roots grow. In a healthy garden environment, the topsoil should ideally be at least 30 cm deep. In an uncultivated home garden block topsoil may be much less because of earthworks or erosion.

Garden soil will typically contain around 45% mineral particles (in the form of sand and clay), 25% water, 25% air and 5% organic matter. Good garden "loam" is defined as a mixture of sand, silt and clay in loosely bound crumbs with organic matter or humus. The properties of soil are also understood in terms of its structure, texture, chemistry and biology; all of which are interdependent.

Soil texture

Soil texture is a measure of the size of soil particles which fall into three primary categories - sand, silt and clay - the mineral content of which will differ. Soil texture can be felt by rubbing some soil through your fingers to sense whether it is gritty, smooth or silky or somewhere in between. This "feel" of the soil depends on the relative amount of sand, silt and clay. Sand is the coarsest material and clay the finest - as much a thousand times. Soil science categorises texture according to the relative quantity of these three components; between pure sand and pure clay. Good loam is the ideal for gardeners. It will form a coherent cast when moistened with water and still feel spongy with no obvious sandiness or silkiness (from silt). It is the mix of components in garden loam that provides the balance of particle surface area (from clay and silt) for water retention and porosity (from sand) for aeration and drainage.

Soil texture is an indication of the capacity of the soil to store plant nutrients. The very small soil particles (clay and humus) play an important role in the storage of these nutrients and their availability to plant roots. This is because, unlike sand, they are small enough to attract a lot of negatively charged ions that attract a cloud of positively charged nutrient ions. A commonly used measure of this capacity of soil particles is called the Cation Exchange Capacity (CEC). The exchange of ions with those dissolved in soil water is a dynamic process between clay and humus particles (which have a high CEC) and the tiny root hairs through which plants absorb nutrients.

Soil structure

Soil structure is characterised by the way the soil particles stick together to form aggregates or 'crumbs'. These crumbs or peds comprise mineral particles and organic matter that are formed naturally and are resilient through wetting and drying of the soil. The structure they provide to soil

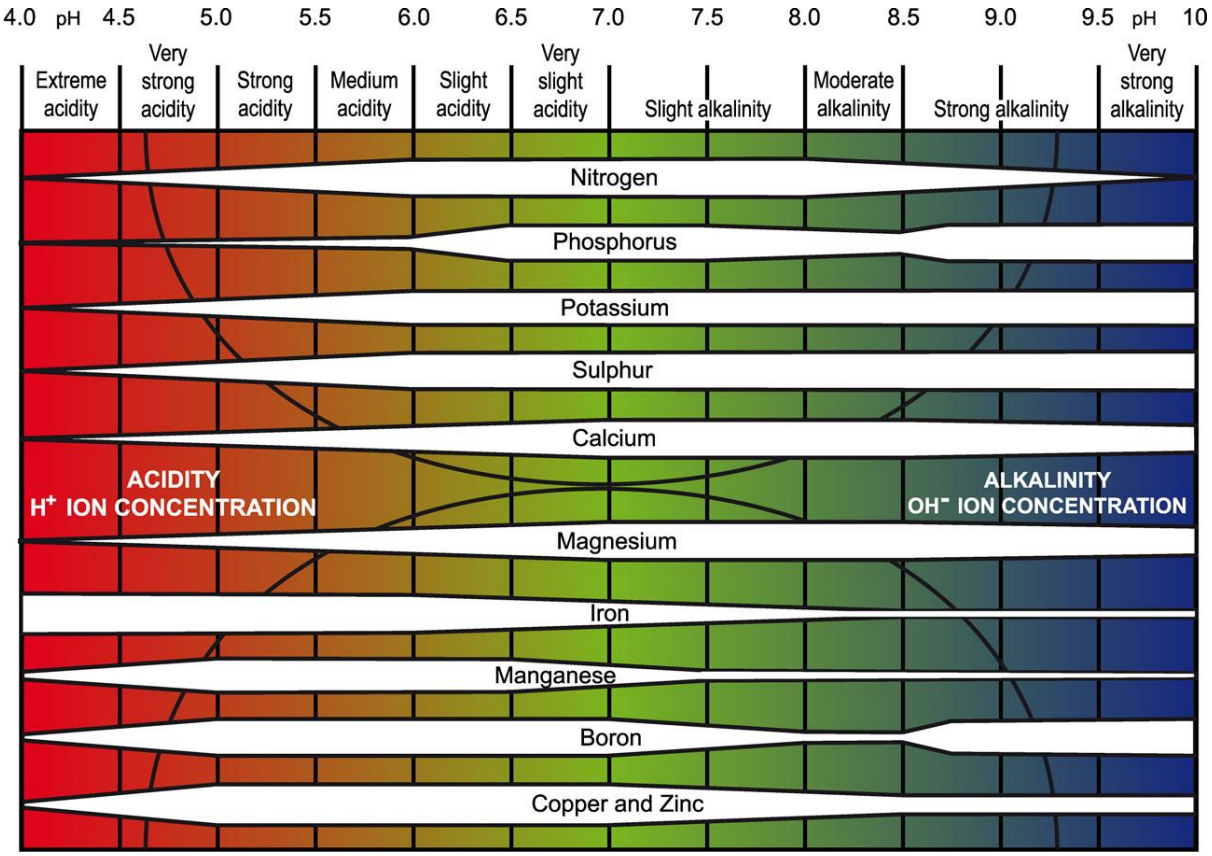
is vital to plant health and growth because of the pore spaces its provides through which roots water and air can penetrate the soil.

Soil with a good structure will be friable and well aerated when wet or dry and be easy to dig with lots of worm channels. Plants will show deep, vigorous root development. Soil with a poor structure will either drain quickly with little or no moisture retention or slowly with a tendency to slump and then dry to a compacted crust. Plants will tend to be shallow rooted. Heavy clay soils have a poor structure because they form large solid clods or lumps through which plant roots and air are unable to penetrate.

Soil chemistry

There are 16 elements known to be essential for the healthy growth of all plants. Of these, only carbon and oxygen are absorbed by plants directly from the atmosphere. Hydrogen and some oxygen come from the soil water absorbed through plant roots. All the other nutrients are absorbed through the roots as ions dissolved in the soil water with the aid of healthy soil web of beneficial bacteria and fungi. It is the chemical reactions within the soil that release nutrients in a form that plants can take up through their root systems. All nutrients are present in the soil to some extent but the proportions of each will vary according to the soil's origin and history.

The amount of a specific nutrient required by a plant varies according to the plant and its stage of growth. The major nutrients are carbon, oxygen, hydrogen, nitrogen, phosphorous, potassium, sulphur and calcium. Those nutrients needed in much smaller quantities (ie trace elements) are magnesium, iron, copper, zinc, manganese, molybdenum, boron and chlorine. Some plants also require traces of aluminium, sodium, silicon, cobalt, nickel and vanadium. While all major and minor nutrients may be present in the soil, their availability is influenced by the soil pH. pH is a measure of the hydrogen (H+) and hydroxyl (OH-) ion concentration in the soil and is influenced by the chemical reactions between soil elements and water. Natural soil pH reflects how the soil was formed, its parent material and the effects of temperature and rainfall on weathering and the leaching of minerals. Most nutrients are readily available in a pH range between 6 and 7 and this suits most vegetables, although some ornamental plants such as azaleas prefer a pH between 4.5 and 6 . At the extremes of acidity or alkalinity plants suffer from toxicity or deficiencies of particular elements and the increased likelihood of disease. Importantly, soil pH influences and is influenced by the types of microorganisms that live in the soil and the associated biological processes that affect plant growth.



Dr Emil Truog's chart on the availability of plant nutrients at varying levels of soil pH.

Soil biology

A healthy soil is teeming with living organisms that are not only beneficial but also essential to the growth of plants. Plants are the centre of the soil food web which includes earthworms, arthropods, bacteria, fungi, nematodes and protozoa. These soil organisms are present in huge numbers and depend on organic matter. They contribute to good soil structure, feed plants and help control disease. Organic gardening is heavily focussed on building good soil through the additional of organic matter and this in turn encourages an active and diverse soil food web. The variety of these micro-organisms in the soil and the balance of bacteria and fungi will be influenced by the soil environment, including the levels and types of this organic matter, moisture, aeration and soil chemistry, including pH. Many of these factors are within the control of organic gardeners and they know what serious negative effects artificial fertilisers, pesticides, herbicides and poor soil cultivation practices have on the health of the soil food web.

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